Cypress Semiconductor Corporation, 198 Champion Court, San Jose, CA 95134. Tel: (408) 943-2600

# PRODUCT CHANGE NOTIFICATION

**PCN:** PCN193601 **Date:** September 04, 2019

**Subject:** Qualification of XMC as an Additional Wafer Fab Site for Automotive GL-S NOR Flash Memory Products

**To:** FUTURE ELECTRONICS
FUTURE ELE
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**Change Type:** Major

**Description of Change:**
Cypress announces the qualification of Wuhan Xinxin Semiconductor Manufacturing Co., Ltd. (XMC, 18 Gaoxin 4TH Road, East Lake High-Tech Development Zone, Wuhan, Hubei, China) as an additional wafer fab site for GL-S automotive NOR Flash Memory products that are currently fabricated at Fab 25 (5204 East Ben White Boulevard, Austin, TX 78741, USA).

**Benefit of Change:**
Qualification of alternate manufacturing sites is part of the ongoing flexible manufacturing initiative announced by Cypress. The goal of the flexible manufacturing initiative is to provide the means for Cypress to continue to meet delivery commitments through dynamic, changing market conditions.

**Part Numbers Affected:** 263
See the attached 'Affected Parts List' file for the list of part numbers affected by this change. The 'Affected Parts List' includes the customer PPAP Part number (marketing part number) and the corresponding sample part number. Note that any new parts that are introduced after the publication of this PCN will include all changes outlined in this PCN.

**Qualification Status:**
The change has been qualified through a series of tests documented in Qualification Test Plans summarized in the table below. The QTP reports can be found as attachments to this notification.

| QTP Number | PBO Qualification Test Plan |
|---|---|
| 002-28003 | PBO Protection Layer for S29GLXXXS, 65nm, XMC |
| 184906 | GL01GS XMC PBO Qualification |

**Sample Status:**
Qualification samples are not built ahead of time for all part numbers affected by this change. Please refer to the affected parts list file for a list of affected part numbers with their associated sample ordering part numbers. If you require qualification samples, please contact your sales representative as soon as possible, but within 60 days of the date of this PCN. Estimated lead time for qualified samples is 2 – 4 weeks from order entry.

**Approximate Implementation Date:**
Effective 90 days from the date of notification or upon customer approval, whichever comes first, all shipments of Automotive non-PPAP part numbers in the attached file will be supplied from XMC.

For Automotive PPAP part numbers, this change will be effective upon customer approval.

**Anticipated Impact:**
Products fabricated at the new site are completely compatible with existing products from form, fit, functional, parametric and quality performance perspectives.

Cypress also recommends that customers take this opportunity to review these changes against current application notes, system design considerations and customer environment conditions to assess impact (if any) to their application.

**Method of Identification:**
Cypress maintains traceability of product to wafer level, including wafer fabrication location, through the lot number marked on the package.

**Response Required:**
No response is required.

For additional information regarding this change, contact your local sales representative or contact the PCN Administrator at pcn_adm@cypress.com.

Sincerely,

Cypress PCN Administration

# Cypress Semiconductor
# Reliability Qualification Report

## QTP# 184906, 185103, 185104, 185105, 185106 Version **

# Qualification of XMC PBO for GL-S Products

**Qualification of S29GL-S, 1G, 3.0 Volt-only Page Mode Flash Memory featuring 65 nm MirrorBit® Eclipse process technology**

**FOR ANY QUESTIONS ON THIS REPORT, PLEASE CONTACT**
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# I.A. Product and Package Information

**Product Description:** S29GL01GS **Cypress Division:** Memory Product Division

1G, 3.0 Volt-only Page Mode Flash Memory featuring 65 nm MirrorBit® Eclipse process technology

| | | | | | |
|---|---|---|---|---|---|
| **Package:** | TS056 | **QTP:** | 184906 | | |
| **Description:** | (20 x 14 x 1.2mm) 56 Lead, Thin Small Outline Package (TSOP) | | | **Flammability:** | **O2 Index:** |
| **Assembly:** | Cypress Thailand | **Molding Compound:** | Hitachi CEL 9200HF10-U | UL-V0 | >28 |
| **Electrical Test:** | Cypress Thailand | | | | |
| **Substrate/Leadframe:** | Copper Leadframe | **Die Attachment:** | Ablestik 8340 | | |
| **Lead Finish:** | 100% Matte Sn Plating | **Bond Wire:** | Copper | | |
| **Comments:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Est. Field Temperature:** | 55 | °C | **Life Test Temperature:** | 125 | °C |
| **Est. DC Field Current:** | 25 | mA | **Life Test Dynamic Current:** | 10 | mA |
| **Est. Field Voltage:** | 3.0 | V | **Life Test Voltage:** | 3.6 | V |
| **Est. Field Power Dissipation:** | 75 | mWatts | **Est. Stress Power Dissipation:** | 36 | mWatts |

| | | | |
|---|---|---|---|
| **Die:** | 98661B2 | **Die Size:** | 6.80 x 7.45 mm |
| **Process:** | CS239LS (65nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

# I.B. Product and Package Information

**Product Description:** S29GL01GS

**Cypress Division:** Memory Product Division

1G, 3.0 Volt-only Page Mode Flash Memory featuring 65 nm MirrorBit® Eclipse process technology

| | | | | | |
|---|---|---|---|---|---|
| **Package:** | LAE064 | **QTP:** | 185103 | | |
| **Description:** | (9 x 9 x 1.4mm) 64 Ball, Fortified Ball Grid Array Package (fFBGA) | | | **Flammability:** | **O2 Index:** |
| **Assembly:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA | UL-V0 | >28 |
| **Electrical Test:** | Cypress Thailand | | | | |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 | | |
| **Lead Finish:** | 96.5Sn3.0Ag0.5Cu Spheres | **Bond Wire:** | Copper | | |
| **Comments:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Est. Field Temperature:** | 55 | °C | **Life Test Temperature:** | 125 | °C |
| **Est. DC Field Current:** | 25 | mA | **Life Test Dynamic Current:** | 10 | mA |
| **Est. Field Voltage:** | 3.0 | V | **Life Test Voltage:** | 3.6 | V |
| **Est. Field Power Dissipation:** | 75 | mWatts | **Est. Stress Power Dissipation:** | 36 | mWatts |

| | | | |
|---|---|---|---|
| **Die:** | 98661B2 | **Die Size:** | 6.80 x 7.45 mm |
| **Process:** | CS239LS (65nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

# I.C. Product and Package Information

**Product Description:** S29GL01GS **Cypress Division:** Memory Product Division

1G, 3.0 Volt-only Page Mode Flash Memory featuring 65 nm MirrorBit® Eclipse process technology

| | | | | | |
|---|---|---|---|---|---|
| **Package:** | TS056 | **QTP:** | 185104 | | |
| **Description:** | (20 x 14 x 1.2mm) 56 Lead, Thin Small Outline Package (TSOP) | | | **Flammability:** | **O2 Index:** |
| **Assembly:** | Cypress Thailand | **Molding Compound:** | Hitachi CEL 9200HF10-U | UL-V0 | >28 |
| **Electrical Test:** | Cypress Thailand | | | | |
| **Substrate/Leadframe:** | Copper Leadframe | **Die Attachment:** | Ablestik 8340 | | |
| **Lead Finish:** | 100% Matte Sn Plating | **Bond Wire:** | Copper | | |
| **Comments:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Est. Field Temperature:** | 55 | °C | **Life Test Temperature:** | 125 | °C |
| **Est. DC Field Current:** | 25 | mA | **Life Test Dynamic Current:** | 10 | mA |
| **Est. Field Voltage:** | 3.0 | V | **Life Test Voltage:** | 3.6 | V |
| **Est. Field Power Dissipation:** | 75 | mWatts | **Est. Stress Power Dissipation:** | 36 | mWatts |

| | | | |
|---|---|---|---|
| **Die:** | 98661B2 | **Die Size:** | 6.80 x 7.45 mm |
| **Process:** | CS239LS (65nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

# I.D. Product and Package Information

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL512S | **Cypress Division:** | Memory Product Division |
| | 1G, 3.0 Volt-only Page Mode Flash Memory featuring 65 nm MirrorBit® Eclipse process technology | | |

| | | | | | |
|---|---|---|---|---|---|
| **Package:** | VBU056 | **QTP:** | 185105 | | |
| **Description:** | (9.0 x 7.0 x 1.0mm) 56 Ball, Very Thin Fine Pitch Ball Grid Array Package (FBGA) | | | **Flammability:** | **O2 Index:** |
| **Assembly:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA | UL-V0 | >28 |
| **Electrical Test:** | Cypress Thailand | | | | |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 | | |
| **Lead Finish:** | 96.5Sn3.0Ag0.5Cu Spheres | **Bond Wire:** | Copper | | |
| **Comments:** | | | | | |

| | | | |
|---|---|---|---|
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125 °C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0 V | **Life Test Voltage:** | 3.6 V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |

| | | | |
|---|---|---|---|
| **Die:** | 98290B2 | **Die Size:** | 6.80 x 5.02 mm |
| **Process:** | CS239LS (65nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 512M |

# I.E. Product and Package Information

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL01GS | **Cypress Division:** | Memory Product Division |
| | 1G, 3.0 Volt-only Page Mode Flash Memory featuring 65 nm MirrorBit® Eclipse process technology | | |

| | | | | | |
|---|---|---|---|---|---|
| **Package:** | LAA064 | **QTP:** | 185106 | | |
| **Description:** | (13.0 x 11.0 x 1.4mm) 64 Ball, Fortified Ball Grid Array Package (FBGA) | | | **Flammability:** | **O2 Index:** |
| **Assembly:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA | UL-V0 | >28 |
| **Electrical Test:** | Cypress Thailand | | | | |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 | | |
| **Lead Finish:** | 96.5Sn3.0Ag0.5Cu Spheres | **Bond Wire:** | Copper | | |
| **Comments:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Est. Field Temperature:** | 55 | °C | **Life Test Temperature:** | 125 | °C |
| **Est. DC Field Current:** | 25 | mA | **Life Test Dynamic Current:** | 10 | mA |
| **Est. Field Voltage:** | 3.0 | V | **Life Test Voltage:** | 3.6 | V |
| **Est. Field Power Dissipation:** | 75 | mWatts | **Est. Stress Power Dissipation:** | 36 | mWatts |

| | | | |
|---|---|---|---|
| **Die:** | 98661B2 | **Die Size:** | 6.80 x 7.45 mm |
| **Process:** | CS239LS (65nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

## II. Summary of Stress Test Results

| Stress Test | Stress Condition | Package Type | Sample Size | Num. of Lots | Num. of Fails | Failure Rate % | Comments |
|---|---|---|---|---|---|---|---|
| **Data From Qualification 184906, 185103, 185104, 185105, 185106:** | | | | | | | |
| **ELFR** | (3.6V, 150°C) | TS056 [1] | 348 | 3 | 0 | 0.00 | 48 hours |
| **HTOL (EL)** | (3.6V, 150°C) | TS056 [1] | 348 | 3 | 0 | 0.00 | 168 hours |
| **HTOL (IL)** | (3.6V, 150°C) | TS056 [1] | 348 | 3 | 0 | 0.00 | 500 Hours |
| | (3.6V, 150°C) | TS056 [1] | 231 | 3 | 0 | 0.00 | 1000 hours |
| **LTOL** | (-40°C, 3.6V) | TS056 [1] | 64 | 1 | 0 | 0.00 | 1000 hours |
| **ESD CDM** | N/A | LAE064 [2] | 6 | 1 | Passed 500V | | |
| | N/A | TS056 [3] | 18 | 3 | Pass 500V | | |
| | N/A | VBU056 [4] | 6 | 1 | Passed 500V | | |
| | N/A | LAA064 [5] | 18 | 3 | Passed 500V | | |
| **Endurance (10k)** | (105°C, 3.6V) | TS056 [1] | 240 | 3 | 0 | 0.00 | 10k cycles |
| **Endurance (100k)** | (105°C, 3.6V) | TS056 [1] | 239 | 3 | 0 | 0.00 | 100k cycles |
| **Decade Cycling + DRB** | (25°C, 3.6V, DRB 500h @ 25°C) | TS056 [1] | 239 | 3 | 0 | 0.00 | 100k cycles |
| | (85°C, 3.6V, DRB 105h @ 150°C) | TS056 [1] | 192 | 3 | 0 | 0.00 | 100k cycles |
| **Preconditioning** | (PC2/260°C, +0°C/-5°C) | LAE064 [2] | 77 | 1 | Passed Jedec L3 | | |
| | (PC2/260°C, +0°C/-5°C) | TS056 [3] | 552 | 3 | Passed Jedec L3 | | |
| | (PC2/260°C, +0°C/-5°C) | VBU056 [4] | 77 | 1 | Passed Jedec L3 | | |
| | (PC2/260°C, +0°C/-5°C) | LAA064 [5] | 552 | 3 | Passed Jedec L3 | | |
| **Precon+Temp Cycle** | (PC2/260°C, -65°C/150°C) | TS056 [3] | 291 | 3 | 0 | 0.00 | 500 cycles |
| | (PC2/260°C, -65°C/150°C) | LAA064 [5] | 291 | 3 | 0 | 0.00 | 500 cycles |
| **Precon+Temp Cycle (Ext.)** | (PC2/260°C, -65°C/150°C) | TS056 [3] | 260 | 3 | 0 | 0.00 | 1000 cycles |
| | (PC2/260°C, -65°C/150°C) | LAA064 [5] | 260 | 3 | 0 | 0.00 | 1000 cycles |
| **Precon+HAST** | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [3] | 261 | 3 | 0 | 0.00 | 96 hours |
| | (PC2/260°C, Biased, 110°C/85% RH) | LAA064 [5] | 261 | 3 | 0 | 0.00 | 264 hours |
| **Precon+HAST (Ext.)** | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [3] | 143 | 3 | 0 | 0.00 | 192 hours |
| | (PC2/260°C, Biased, 110°C/85% RH) | LAA064 [5] | 231 | 3 | 0 | 0.00 | 528 hours |
| **3x Reflow+HTS** | (175°C) | TS056 [3] | 163 | 3 | 0 | 0.00 | 500 hours |
| | (175°C) | TS056 [3] | 132 | 3 | 0 | 0.00 | 1000 hours |
| | (150°C) | LAA064 [5] | 128 | 3 | 0 | 0.00 | 2000 hours |
| | (150°C) | LAA064 [5] | 159 | 3 | 0 | 0.00 | 1000 hours |
| **Decade Cycling + HTOL** | (85°C, 3.6V, 125C HTOL@1000hrs) | TS056 [1] | 238 | 3 | 0 | 0.00 | 100k cycles |

## Generic Reference Data:

| | | | | | |
|---|---|---|---|---|---|
| **Preconditioning** | (PC2/260°C, +0°C/-5°C) | TS056 [6] | 77 | 1 | Passed Jedec L3 |
| | (PC2/260°C, +0°C/-5°C) | TS056 [7] | 77 | 1 | Passed Jedec L3 |
| | (PC2/260°C, +0°C/-5°C) | TS056 [8] | 77 | 1 | Passed Jedec L3 |
| **Precon+HAST** | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [6] | 77 | 1 | 96 hours |
| | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [7] | 77 | 1 | 96 hours |
| | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [8] | 77 | 1 | 96 hours |
| **Precon+HAST (Ext.)** | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [6] | 70 | 1 | 192 hours |
| | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [7] | 70 | 1 | 192 hours |
| | (PC2/260°C, Biased, 130°C/85% RH) | TS056 [8] | 70 | 1 | 192 hours |

**Notes / Justification:**
1) Results from Qual 184906, S29GL01GS, CS239LS (65nm) MirrorBit Eclipse in 56 Lead TSOP (20 x 14 x 1.2mm)
2) Results from Qual 185103, S29GL01GS, CS239LS (65nm) MirrorBit Eclipse in 64 Ball fFBGA (9 x 9 x 1.4mm)
3) Results from Qual 185104, S29GL01GS, CS239LS (65nm) MirrorBit Eclipse in 56 Lead TSOP (20 x 14 x 1.2mm)
4) Results from Qual 185105, S29GL512S, CS239LS (65nm) MirrorBit Eclipse in 56 Ball vFBGA (9 x 7 x 1mm)
5) Results from Qual 185106, S29GL01GS, CS239LS (65nm) MirrorBit Eclipse in 64 Ball fFBGA (13 x 11 x 1.4mm)
6) Results from Qual 185105c, S29GL512S in 56 Lead TSOP (20 x 14 x 1.2mm) - Same XMC PBO GL-S Product in TSOP56
7) Results from Qual 185105d, S29GL256S in 56 Lead TSOP (20 x 14 x 1.2mm) - Same XMC PBO GL-S Product in TSOP56
8) Results from Qual 185105e, S29GL128S in 56 Lead TSOP (20 x 14 x 1.2mm) - Same XMC PBO GL-S Product in TSOP56

**Preconditioning Flows:** PC2 (JEDEC L3): Bake 125°C, 24hr => Soak @ 30°C/60%RH, 192hr => 3x Reflow

**Reliability Tests Performed per Specification Requirements**

| Stress | Condition | Specification Reference |
|---|---|---|
| 3x Reflow+HTS | (150°C) | JESD22-A117 |
| 3x Reflow+HTS | (175°C) | JESD22-A117 |
| Decade Cycling + DRB | (25°C, 3.6V, DRB 500h @ 25°C) | JESD47 / JESD22-A117 / AEC-Q100 /AEC-Q100-005 |
| Decade Cycling + DRB | (85°C, 3.6V, DRB 105h @ 150°C) | JESD47 / JESD22-A117 / AEC-Q100 /AEC-Q100-005 |
| Decade Cycling + HTOL | (85°C, 3.6V, 125C HTOL@1000hrs) | JESD47 / JESD22-A117 / AEC-Q100 /AEC-Q100-005 |
| ELFR | (3.6V, 150°C) | JESD22-A108 / AEC-Q100-008 |
| Endurance (100k) | (105°C, 3.6V) | JESD47 / JESD22-A117 / AEC-Q100 /AEC-Q100-005 |
| Endurance (10k) | (105°C, 3.6V) | JESD47 / JESD22-A117 / AEC-Q100 /AEC-Q100-005 |
| ESD CDM | N/A | JS002 / AEC-Q100-011 |
| HTOL (EL) | (3.6V, 150°C) | JESD22-A108 |
| HTOL (IL) | (3.6V, 150°C) | JESD22-A108 |
| LTOL | (-40°C, 3.6V) | JESD22-A108 |
| Precon+HAST | (PC2/260°C, Biased, 110°C/85% RH) | JESD22-A110 |
| Precon+HAST | (PC2/260°C, Biased, 130°C/85% RH) | JESD22-A110 |
| Precon+HAST (Ext.) | (PC2/260°C, Biased, 110°C/85% RH) | JESD22-A110 |
| Precon+HAST (Ext.) | (PC2/260°C, Biased, 130°C/85% RH) | JESD22-A110 |
| Precon+Temp Cycle | (PC2/260°C, -65°C/150°C) | JESD22-A104 |
| Precon+Temp Cycle (Ext.) | (PC2/260°C, -65°C/150°C) | JESD22-A104 |
| Preconditioning | (PC2/260°C, +0°C/-5°C) | J-STD-020 |

# III. Revision History

**Document Number:** 002-27990

**Document Title:** Qualification of XMC PBO for GL-S Products

| Rev. | Issue Date | ECN# | Originator | Description |
|---|---|---|---|---|
| ** | 7/24/2019 | 6635304 | EKNG | Initial Release. |

**Trademarks and Notice**

# S29GL01GS/S29GL512S
# S29GL256S/S29GL128S

## 1-Gbit (128 Mbyte)/512-Mbit (64 Mbyte)/ 256-Mbit (32 Mbyte)/128-Mbit (16 Mbyte), 3.0 V, GL-S Flash Memory

## General Description

The Cypress® S29GL01G/512/256/128S are MirrorBit® Eclipse flash products fabricated on 65 nm process technology. These devices offer a fast page access time as fast as 15 ns with a corresponding random access time as fast as 90 ns. They feature a Write Buffer that allows a maximum of 256 words/512 bytes to be programmed in one operation, resulting in faster effective programming time than standard programming algorithms. This makes these devices ideal for today's embedded applications that require higher density, better performance and lower power consumption.

## Distinctive Characteristics

- CMOS 3.0 Volt Core with Versatile I/O
- 65 nm MirrorBit Eclipse Technology
- Single supply ($V_{CC}$) for read / program / erase (2.7 V to 3.6 V)
- Versatile I/O Feature
  – Wide I/O voltage range ($V_{IO}$): 1.65 V to $V_{CC}$
- ×16 data bus
- Asynchronous 32-byte Page read
- 512-byte Programming Buffer
  – Programming in Page multiples, up to a maximum of 512 bytes
- Single word and multiple program on same word options
- Automatic Error Checking and Correction (ECC) – internal hardware ECC with single bit error correction
- Sector Erase
  – Uniform 128-kbyte sectors
- Suspend and Resume commands for Program and Erase operations
- Status Register, Data Polling, and Ready/Busy pin methods to determine device status
- Advanced Sector Protection (ASP)
  – Volatile and non-volatile protection methods for each sector
- Separate 1024-byte One Time Program (OTP) array with two lockable regions
- Common Flash Interface (CFI) parameter table
- Temperature Range / Grade
  – Industrial (-40 °C to +85 °C)
  – Industrial Plus(-40 °C to +105 °C)
  – Automotive, AEC-Q100 Grade 3 (-40 °C to +85 °C)
  – Automotive, AEC-Q100 Grade 2 (-40 °C to +105 °C)
- 100,000 Program / Erase Cycles
- 20 Years Data Retention
- Packaging Options
  – 56-pin TSOP
  – 64-ball LAA Fortified BGA, 13 mm × 11 mm
  – 64-ball LAE Fortified BGA, 9 mm × 9 mm
  – 56-ball VBU Fortified BGA, 9 mm × 7 mm

# Performance Summary

| Maximum Read Access Times | | | | | |
|---|---|---|---|---|---|
| **Density** | **Voltage Range** | **Random Access Time ($t_{ACC}$)** | **Page Access Time ($t_{PACC}$)** | **CE# Access Time ($t_{CE}$)** | **OE# Access Time ($t_{OE}$)** |
| 128 Mb | Full $V_{CC} = V_{IO}$ | 90 | 15 | 90 | 25 |
| | VersatileIO $V_{IO}$ | 100 | 25 | 100 | 35 |
| 256 Mb | Full $V_{CC} = V_{IO}$ | 90 | 15 | 90 | 25 |
| | VersatileIO $V_{IO}$ | 100 | 25 | 100 | 35 |
| 512 Mb | Full $V_{CC} = V_{IO}$ | 100 | 15 | 100 | 25 |
| | VersatileIO $V_{IO}$ | 110 | 25 | 110 | 35 |
| 1 Gb | Full $V_{CC} = V_{IO}$ | 100 | 15 | 100 | 25 |
| | VersatileIO $V_{IO}$ | 110 | 25 | 110 | 35 |

| Typical Program and Erase Rates | |
|---|---|
| Buffer Programming (512 bytes) | 1.5 MB/s |
| Sector Erase (128 kbytes) | 477 kB/s |

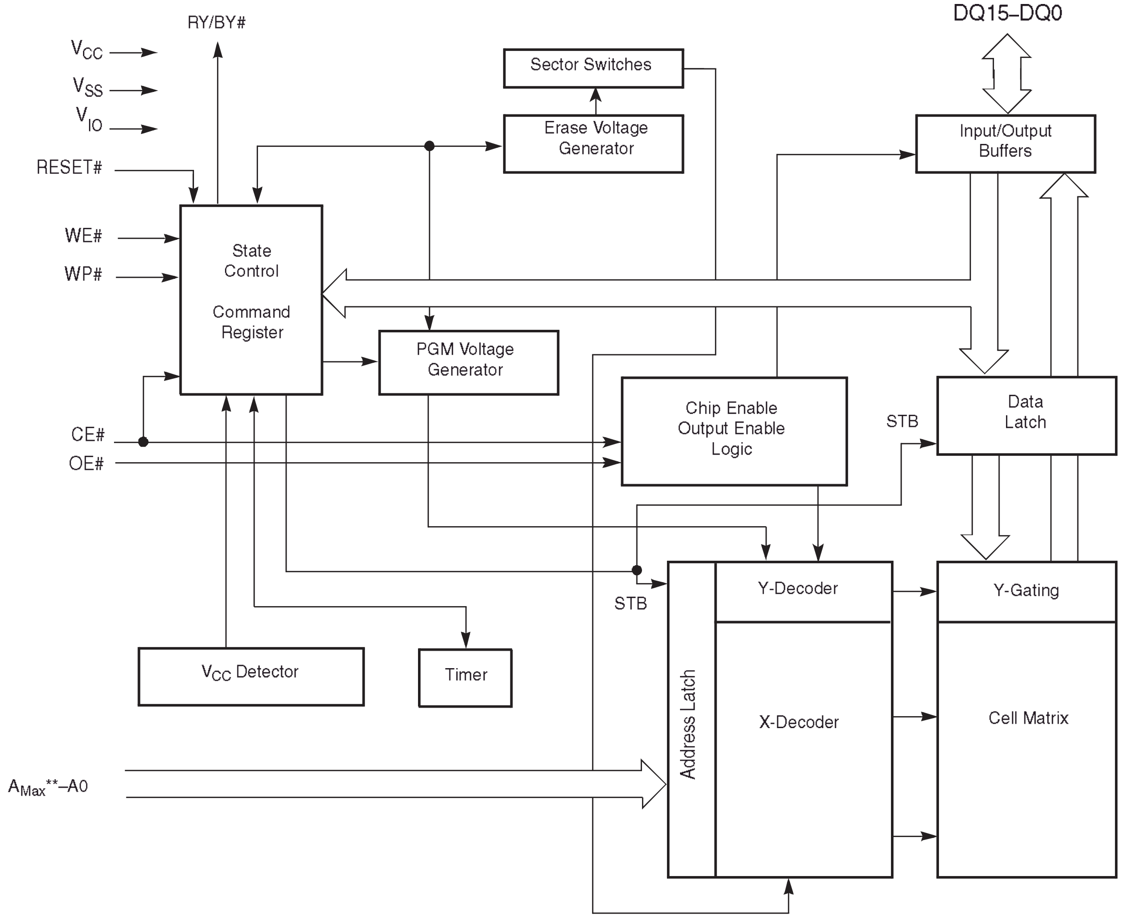
| Maximum Current Consumption | |
|---|---|
| Active Read at 5 MHz, 30 pF | 60 mA |
| Program | 100 mA |
| Erase | 100 mA |
| Standby | 100 µA |

# Contents

# 1. Product Overview

The GL-S family consists of 128-Mbit to 1Gbit, 3.0 V core, Versatile I/O, non-volatile, flash memory devices. These devices have a 16-bit (word) wide data bus and use only word boundary addresses. All read accesses provide 16 bits of data on each bus transfer cycle. All writes take 16 bits of data from each bus transfer cycle.

**Figure 1.1** Block Diagram




***Note:***
*** $A_{MAX}$ GL01GS = A25, $A_{MAX}$ GL512S = A24, $A_{MAX}$ GL256S = A23, $A_{MAX}$ GL128S = A22*

The GL-S family combines the best features of eXecute In Place (XIP) and Data Storage flash memories. This family has the fast random access of XIP flash along with the high density and fast program speed of Data Storage flash.

Read access to any random location takes 90 ns to 120 ns depending on device density and I/O power supply voltage. Each random (initial) access reads an entire 32-byte aligned group of data called a Page. Other words within the same Page may be read by changing only the low order 4 bits of word address. Each access within the same Page takes 15 ns to 30 ns. This is called Page Mode read. Changing any of the higher word address bits will select a different Page and begin a new initial access. All read accesses are asynchronous.

**Table 1.1** S29GL-S Address Map

| Type | Count | Addresses |
|---|---|---|
| Address within Page | 16 | A3–A0 |
| Address within Write Buffer | 256 | A7–A0 |
| Page | 4096 | A15–A4 |
| Write-Buffer-Line | 256 | A15–A8 |
| Sector | 1024 (1 Gb)<br>512 (512 Mb)<br>256 (256 Mb)<br>128 (128 Mb) | $A_{MAX}$–A16 |

The device control logic is subdivided into two parallel operating sections, the Host Interface Controller (HIC) and the Embedded Algorithm Controller (EAC). HIC monitors signal levels on the device inputs and drives outputs as needed to complete read and write data transfers with the host system. HIC delivers data from the currently entered address map on read transfers; places write transfer address and data information into the EAC command memory; notifies the EAC of power transition, hardware reset, and write transfers. The EAC looks in the command memory, after a write transfer, for legal command sequences and performs the related Embedded Algorithms.

Changing the non-volatile data in the memory array requires a complex sequence of operations that are called Embedded Algorithms (EA). The algorithms are managed entirely by the device internal EAC. The main algorithms perform programming and erase of the main array data. The host system writes command codes to the flash device address space. The EAC receives the commands, performs all the necessary steps to complete the command, and provides status information during the progress of an EA.

The erased state of each memory bit is a logic 1. Programming changes a logic 1 (High) to a logic 0 (Low). Only an Erase operation is able to change a 0 to a 1. An erase operation must be performed on an entire 128-kbyte aligned and length group of data call a Sector. When shipped from Cypress all Sectors are erased.

Programming is done via a 512-byte Write Buffer. It is possible to write from 1 to 256 words, anywhere within the Write Buffer before starting a programming operation. Within the flash memory array, each 512-byte aligned group of 512 bytes is called a Line. A programming operation transfers volatile data from the Write Buffer to a non-volatile memory array Line. The operation is called Write Buffer Programming.

As the device transfers each 32-byte aligned page of data that was loaded into the Write buffer to the 512-byte Flash array line, internal logic programs an ECC Code for the Page into a portion of the memory array not visible to the host system software. The internal logic checks the ECC information during the initial access of every array read operation. If needed, the ECC information corrects a one bit error during the initial access time.

The Write Buffer is filled with 1's after reset or the completion of any operation using the Write Buffer. Any locations not written to a 0 by a Write to Buffer command are by default still filled with 1's. Any 1's in the Write Buffer do not affect data in the memory array during a programming operation.

As each Page of data that was loaded into the Write Buffer is transferred to a memory array Line.

Sectors may be individually protected from program and erase operations by the Advanced Sector Protection (ASP) feature set. ASP provides several, hardware and software controlled, volatile and non-volatile, methods to select which sectors are protected from program and erase operations.

# Software Interface

## 2. Address Space Maps

There are several separate address spaces that may appear within the address range of the flash memory device. One address space is visible (entered) at any given time.

- Flash Memory Array: the main non-volatile memory array used for storage of data that may be randomly accessed by asynchronous read operations.
- ID/CFI: a memory array used for Cypress factory programmed device characteristics information. This area contains the Device Identification (ID) and Common Flash Interface (CFI) information tables.
- Secure Silicon Region (SSR): a One Time Programmable (OTP) non-volatile memory array used for Cypress factory programmed permanent data, and customer programmable permanent data.
- Lock Register: an OTP non-volatile word used to configure the ASP features and lock the SSR.
- Persistent Protection Bits (PPB): a non-volatile flash memory array with one bit for each Sector. When programmed, each bit protects the related Sector from erasure and programming.
- PPB Lock: a volatile register bit used to enable or disable programming and erasure of the PPB bits.
- Password: an OTP non-volatile array used to store a 64-bit password used to enable changing the state of the PPB Lock Bit when using Password Mode sector protection.
- Dynamic Protection Bits (DYB): a volatile array with one bit for each Sector. When set, each bit protects the related Sector from erasure and programming.
- Status Register: a volatile register used to display Embedded Algorithm status.
- Data Polling Status: a volatile register used as an alternate, legacy software compatible, way to display Embedded Algorithm status.
- ECC Status: provides the status of any error detection or correction action taken when reading the selected Page.

The main Flash Memory Array is the primary and default address space but, it may be overlaid by one other address space, at any one time. Each alternate address space is called an Address Space Overlay (ASO).

Each ASO replaces (overlays) the entire flash device address range. Any address range not defined by a particular ASO address map, is reserved for future use. All read accesses outside of an ASO address map returns non-valid (undefined) data. The locations will display actively driven data but the meaning of whatever 1's or 0's appear are not defined.

There are four device operating modes that determine what appears in the flash device address space at any given time:

- Read Mode
- Data Polling Mode
- Status Register (SR) Mode
- Address Space Overlay (ASO) Mode

In Read Mode the entire Flash Memory Array may be directly read by the host system memory controller. The memory device Embedded Algorithm Controller (EAC), puts the device in Read mode during Power-on, after a Hardware Reset, after a Command Reset, or after an Embedded Algorithm (EA) is suspended. Read accesses and command writes are accepted in read mode. A subset of commands are accepted in read mode when an EA is suspended.

While in any mode, the Status Register read command may be issued to cause the Status Register ASO to appear at every word address in the device address space. In this Status Register ASO Mode, the device interface waits for a read access and, any write access is ignored. The next read access to the device accesses the content of the status register, exits the Status Register ASO, and returns to the previous (calling) mode in which the Status Register read command was received.

In EA mode the EAC is performing an Embedded Algorithm, such as programming or erasing a non-volatile memory array. While in EA mode, none of the main Flash Memory Array is readable because the entire flash device address space is replaced by the Data Polling Status ASO. Data Polling Status will appear at every word location in the device address space.

While in EA mode, only a Program / Erase suspend command or the Status Register Read command will be accepted. All other commands are ignored. Thus, no other ASO may be entered from the EA mode.

When an Embedded Algorithm is suspended, the Data Polling ASO is visible until the device has suspended the EA. When the EA is suspended the Data Polling ASO is exited and Flash Array data is available. The Data Polling ASO is reentered when the suspended EA is resumed, until the EA is again suspended or finished. When an Embedded Algorithm is completed, the Data Polling ASO is exited and the device goes to the previous (calling) mode (from which the Embedded Algorithm was started).

In ASO mode, one of the remaining overlay address spaces is entered (overlaid on the main Flash Array address map). Only one ASO may be entered at any one time. Commands to the device affect the currently entered ASO. Only certain commands are valid for each ASO. These are listed in the Table 7.1 on page 55, in each ASO related section of the table.

The following ASOs have non-volatile data that may be programmed to change 1's to 0's:

- Secure Silicon Region
- Lock Register
- Persistent Protection Bits (PPB)
- Password
- Only the PPB ASO has non-volatile data that may be erased to change 0's to 1's

When a program or erase command is issued while one of the non-volatile ASOs is entered, the EA operates on the ASO. The ASO is not readable while the EA is active. When the EA is completed the ASO remains entered and is again readable. Suspend and Resume commands are ignored during an EA operating on any of these ASOs.

## 2.1 Flash Memory Array

The S29GL-S family has uniform sector architecture with a sector size of 128 kB. Table 2.1 to Table 2.4 shows the sector architecture of the four devices.

**Table 2.1** S29GL01GS Sector and Memory Address Map

| Sector Size (kbyte) | Sector Count | Sector Range | Address Range (16-Bit) | Notes |
|---|---|---|---|---|
| 128 | 1024 | SA00 | 0000000h–000FFFFh | Sector Starting Address |
| | | : | : | – |
| | | SA1023 | 3FF0000h–3FFFFFFh | Sector Ending Address |

**Table 2.2** S29GL512S Sector and Memory Address Map

| Sector Size (kbyte) | Sector Count | Sector Range | Address Range (16-Bit) | Notes |
|---|---|---|---|---|
| 128 | 512 | SA00 | 0000000h–000FFFFh | Sector Starting Address |
| | | : | : | – |
| | | SA511 | 1FF0000h–1FFFFFFh | Sector Ending Address |

**Table 2.3** S29GL256S Sector and Memory Address Map

| Sector Size (kbyte) | Sector Count | Sector Range | Address Range (16-Bit) | Notes |
|---|---|---|---|---|
| 128 | 256 | SA00 | 0000000h–000FFFFh | Sector Starting Address |
| | | : | : | – |
| | | SA255 | 0FF0000h–0FFFFFFh | Sector Ending Address |

**Table 2.4** S29GL128S Sector and Memory Address Map

| Sector Size (kbyte) | Sector Count | Sector Range | Address Range (16-Bit) | Notes |
|---|---|---|---|---|
| 128 | 128 | SA00 | 0000000h–000FFFFh | Sector Starting Address |
| | | : | : | – |
| | | SA127 | 07F0000h–07FFFFFh | Sector Ending Address |

**Note:** These tables have been condensed to show sector related information for an entire device on a single page Sectors and their address ranges that are not explicitly listed (such as SA001-SA510) have sectors starting and ending addresses that form the same pattern as all other sectors of that size. For example, all 128 kB sectors have the pattern XXX0000h–XXXFFFFh.

## 2.2 Device ID and CFI (ID-CFI) ASO

There are two traditional methods for systems to identify the type of flash memory installed in the system. One has traditionally been called Autoselect and is now referred to as Device Identification (ID). The other method is called Common Flash Interface (CFI).

For ID, a command is used to enable an address space overlay where up to 16 word locations can be read to get JEDEC manufacturer identification (ID), device ID, and some configuration and protection status information from the flash memory. The system can use the manufacturer and device IDs to select the appropriate driver software to use with the flash device.

CFI also uses a command to enable an address space overlay where an extendable table of standard information about how the flash memory is organized and operates can be read. With this method the driver software does not have to be written with the specifics of each possible memory device in mind. Instead the driver software is written in a more general way to handle many different devices but adjusts the driver behavior based on the information in the CFI table.

Traditionally these two address spaces have used separate commands and were separate overlays. However, the mapping of these two address spaces are non-overlapping and so can be combined in to a single address space and appear together in a single overlay. Either of the traditional commands used to access (enter) the Autoselect (ID) or CFI overlay will cause the now combined ID-CFI address map to appear.

The ID-CFI address map appears within, and overlays the Flash Array data of, the sector selected by the address used in the ID-CFI enter command. While the ID-CFI ASO is entered the content of all other sectors is undefined.

The ID-CFI address map starts at location 0 of the selected sector. Locations above the maximum defined address of the ID-CFI ASO to the maximum address of the selected sector have undefined data. The ID-CFI enter commands use the same address and data values used on previous generation memories to access the JEDEC Manufacturer ID (Autoselect) and Common Flash Interface (CFI) information, respectively. See Figure 11.16 on page 87 for ASO Entry timing requirements.

**Table 2.5** ID-CFI Address Map Overview

| Word Address | Description | Read / Write |
|---|---|---|
| (SA) + 0000h to 000Fh | Device ID<br>(traditional Autoselect values) | Read Only |
| (SA) + 0010h to 0079h | CFI data structure | Read Only |
| (SA) + 0080h to FFFFh | Undefined | Read Only |

For the complete address map see Table 7.2 on page 58.

## 2.3 Device ID and Common Flash Interface (ID-CFI) ASO Map — Automotive Only

| Word Address | Data Field | # of bytes | Data Format | Example of Actual Data | Hex Read Out of Example Data |
|---|---|---|---|---|---|
| (SA) + 0080h | Size of Electronic Marking | 1 | Hex | 19 | 0013h |
| (SA) + 0081h | Revision of Electronic Marking | 1 | Hex | 1 | 0001h |
| (SA) + 0082h | Fab Lot # | 7 | Ascii | LD87270 | 004Ch, 0044h, 0038h, 0037h, 0032h, 0037h, 0030h |
| (SA) + 0089h | Wafer # | 1 | Hex | 23 | 0017h |
| (SA) + 008Ah | Die X Coordinate | 1 | Hex | 10 | 000Ah |
| (SA) + 008Bh | Die Y Coordinate | 1 | Hex | 15 | 000Fh |
| (SA) + 008Ch | Class Lot # | 7 | Ascii | BR33150 | 0042h, 0052h, 0033h, 0033h, 0031h, 0035h, 0030h |
| (SA) + 0093h | Reserved for Future | 13 | n/a | n/a | undefined |

Fab Lot # + Wafer # + Die X Coordinate + Die Y Coordinate gives a unique ID for each device.

### 2.3.1 Device ID

The Joint Electron Device Engineering Council (JEDEC) standard JEP106T defines the manufacturer ID for a compliant memory. Common industry usage defined a method and format for reading the manufacturer ID and a device specific ID from a memory device. The manufacturer and device ID information is primarily intended for programming equipment to automatically match a device with the corresponding programming algorithm. Cypress has added additional fields within this 32-byte address space.

The original industry format was structured to work with any memory data bus width e. g. ×8, ×16, ×32. The ID code values are traditionally byte wide but are located at bus width address boundaries such that incrementing the device address inputs will read successive byte, word, or double word locations with the ID codes always located in the least significant byte location of the data bus. Because the device data bus is word wide each code byte is located in the lower half of each word location. The original industry format made the high order byte always 0. Cypress has modified the format to use both bytes in some words of the address space. For the detail description of the Device ID address map see Table 7.2 on page 58.

### 2.3.2 Common Flash Memory Interface

The JEDEC Common Flash Interface (CFI) specification (JESD68.01) defines a standardized data structure that may be read from a flash memory device, which allows vendor-specified software algorithms to be used for entire families of devices. The data structure contains information for system configuration such as various electrical and timing parameters, and special functions supported by the device. Software support can then be device-independent, Device ID-independent, and forward-and-backward-compatible for entire Flash device families.

The system can read CFI information at the addresses within the selected sector as shown in Device ID and Common Flash Interface (ID-CFI) ASO Map on page 58.

Like the Device ID information, CFI information is structured to work with any memory data bus width e. g. ×8, ×16, ×32. The code values are always byte wide but are located at data bus width address boundaries such that incrementing the device address reads successive byte, word, or double word locations with the codes always located in the least significant byte location of the data bus. Because the data bus is word wide each code byte is located in the lower half of each word location and the high order byte is always 0.

For further information, please refer to the *Cypress CFI Specification, Version 1.4* (or later), and the *JEDEC publications JEP137-A and JESD68.01*. Please contact JEDEC (http://www.jedec.org) for their standards and the Cypress CFI Specification may be found at the Cypress Website (http://www.cypress.com/cypressappnotes) at the time of this document's publication), or contact the local Cypress sales office listed in the website.

## 2.4 Status Register ASO

The Status Register ASO contains a single word of registered volatile status for Embedded Algorithms. When the Status Register read command is issued, the current status is captured (by the rising edge of WE#) into the register and the ASO is entered. The Status Register content appears on all word locations. The first read access exits the Status Register ASO (with the rising edge of CE# or OE#) and returns to the address space map in use when the Status Register read command was issued. Write commands will not exit the Status Register ASO state.

## 2.5 Data Polling Status ASO

The Data Polling Status ASO contains a single word of volatile memory indicating the progress of an EA. The Data Polling Status ASO is entered immediately following the last write cycle of any command sequence that initiates an EA. Commands that initiate an EA are:

- Word Program
- Program Buffer to Flash
- Chip Erase
- Sector Erase
- Erase Resume / Program Resume
- Program Resume Enhanced Method
- Blank Check
- Lock Register Program
- Password Program
- PPB Program
- All PPB Erase

Engineering Note: The reset and write buffer abort reset commands require very short time to execute so data polling is not supported for these commands.The Data Polling Status word appears at all word locations in the device address space. When an EA is completed the Data Polling Status ASO is exited and the device address space returns to the address map mode where the EA was started.

## 2.6 Secure Silicon Region ASO

The Secure Silicon Region (SSR) provides an extra flash memory area that can be programmed once and permanently protected from further changes i. e. it is a One Time Program (OTP) area. The SSR is
1024 bytes in length. It consists of 512 bytes for Factory Locked Secure Silicon Region and 512 bytes for Customer Locked Secure Silicon Region.

The sector address supplied during the Secure Silicon Entry command selects the Flash Memory Array sector that is overlaid by the Secure Silicon Region address map. See Figure 11.16 on page 87 for ASO Entry timing requirements. The SSR is overlaid starting at location 0 in the selected sector. Use of the sector 0 address is recommended for future compatibility. While the SSR ASO is entered the content of all other sectors is undefined. Locations above the maximum defined address of the SSR ASO to the maximum address of the selected sector have undefined data.

**Table 2.6** Secure Silicon Region

| Word Address Range | Content | Size |
|---|---|---|
| (SA) + 0000h to 00FFh | Factory Locked Secure Silicon Region | 512 bytes |
| (SA) + 0100h to 01FFh | Customer Locked Secure Silicon Region | 512 bytes |
| (SA) + 0200h to FFFFh | Undefined | 127 kbytes |

## 2.7 Sector Protection Control

### 2.7.1 Lock Register ASO

The Lock register ASO contains a single word of OTP memory. When the ASO is entered the Lock Register appears at all word locations in the device address space. See Figure 11.16 on page 87 for ASO Entry timing requirements. However, it is recommended to read or program the Lock Register only at location 0 of the device address space for future compatibility.

### 2.7.2 Persistent Protection Bits (PPB) ASO

The PPB ASO contains one bit of a Flash Memory Array for each Sector in the device. When the PPB ASO is entered, the PPB bit for a sector appears in the Least Significant Bit (LSB) of each address in the sector. See Figure 11.16 on page 87 for ASO Entry timing requirements. Reading any address in a sector displays data where the LSB indicates the non-volatile protection status for that sector. However, it is recommended to read or program the PPB only at address 0 of the sector for future compatibility. If the bit is 0 the sector is protected against programming and erase operations. If the bit is 1 the sector is not protected by the PPB. The sector may be protected by other features of ASP.

### 2.7.3 PPB LOCK ASO

The PPB Lock ASO contains a single bit of volatile memory. The bit controls whether the bits in the PPB ASO may be programmed or erased. If the bit is 0 the PPB ASO is protected against programming and erase operations. If the bit is 1 the PPB ASO is not protected. When the PPB Lock ASO is entered the PPB Lock bit appears in the Least Significant Bit (LSB) of each address in the device address space. See Figure 11.16 on page 87 for ASO Entry timing requirements. However, it is recommended to read or program the PPB Lock only at address 0 of the device for future compatibility.

### 2.7.4 Password ASO

The Password ASO contains four words of OTP memory. When the ASO is entered the Password appears starting at address 0 in the device address space. See Figure 11.16 on page 87 for ASO Entry timing requirements. All locations above the forth word are undefined.

### 2.7.5 Dynamic Protection Bits (DYB) ASO

The DYB ASO contains one bit of a volatile memory array for each Sector in the device. When the DYB ASO is entered, the DYB bit for a sector appears in the Least Significant Bit (LSB) of each address in the sector. See Figure 11.16 on page 87 for ASO Entry timing requirements. Reading any address in a sector displays data where the LSB indicates the non-volatile protection status for that sector. However, it is recommended to read, set, or clear the DYB only at address 0 of the sector for future compatibility. If the bit is 0 the sector is protected against programming and erase operations. If the bit is 1 the sector is not protected by the DYB. The sector may be protected by other features of ASP.

## 2.8 ECC Status ASO

The system can access the ECC Status ASO by issuing the ECC Status entry command sequence during Read Mode. The ECC Status ASO provides the status of a Single Bit Error correction when reading the selected page. *Automatic ECC* on page 22 describes the ECC function in more detail. See Figure 11.16 on page 87 for ASO Entry timing requirements.

The ECC Status ASO allows the following activities:

- Read ECC Status for the selected page.
- ASO Exit.

### 2.8.1 ECC Status

The contents of the ECC Status ASO indicates, for the selected ECC page, whether ECC protection has corrected an error in the eight-bit error correction code or the 16 Words of data in the ECC page. The address specified in the ECC Status Read Command, provided in Table 7.1 on page 55 selects the ECC Page.

**Table 2.7 ECC Status Word – Upper Byte**

| Bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Name | RFU | RFU | RFU | RFU | RFU | RFU | RFU | RFU |
| Value | X | X | X | X | X | X | X | X |

**Table 2.8 ECC Status Word – Lower Byte**

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RFU | RFU | RFU | RFU | RFU | Single Bit Error corrected in the 8-bit error correction code | Single Bit Error corrected in 16 words of data | RFU |
| Value | X | X | X | X | X | 0 = No Error Corrected<br>1 = Single Bit Error Corrected | 0 = No Error Corrected<br>1 = Single Bit Error Corrected | X |

# 3. Data Protection

The device offers several features to prevent malicious or accidental modification of any sector via hardware means.

## 3.1 Device Protection Methods

### 3.1.1 Power-Up Write Inhibit

RESET#, CE#, WE#, and, OE# are ignored during Power-On Reset (POR). During POR, the device can not be selected, will not accept commands on the rising edge of WE#, and does not drive outputs. The Host Interface Controller (HIC) and Embedded Algorithm Controller (EAC) are reset to their standby states, ready for reading array data, during POR. CE# or OE# must go to $V_{IH}$ before the end of POR ($t_{VCS}$).

At the end of POR the device conditions are:

- all internal configuration information is loaded,
- the device is in read mode,
- the Status Register is at default value,
- all bits in the DYB ASO are set to un-protect all sectors,
- the Write Buffer is loaded with all 1's,
- the EAC is in the standby state.

### 3.1.2 Low $V_{CC}$ Write Inhibit

When $V_{CC}$ is less than $V_{LKO}$, the HIC does not accept any write cycles and the EAC resets. This protects data during $V_{CC}$ power-up and power-down. The system must provide the proper signals to the control pins to prevent unintentional writes when $V_{CC}$ is greater than $V_{LKO}$.

## 3.2 Command Protection

Embedded Algorithms are initiated by writing command sequences into the EAC command memory. The command memory array is not readable by the host system and has no ASO. Each host interface write is a command or part of a command sequence to the device. The EAC examines the address and data in each write transfer to determine if the write is part of a legal command sequence. When a legal command sequence is complete the EAC will initiate the appropriate EA.

Writing incorrect address or data values, or writing them in an improper sequence, will generally result in the EAC returning to its Standby state. However, such an improper command sequence may place the device in an unknown state, in which case the system must write the reset command, or possibly provide a hardware reset by driving the RESET# signal Low, to return the EAC to its Standby state, ready for random read.

The address provided in each write may contain a bit pattern used to help identify the write as a command to the device. The upper portion of the address may also select the sector address on which the command operation is to be performed. The Sector Address (SA) includes $A_{MAX}$ through A16 flash address bits (system byte address signals $a_{max}$ through a17). A command bit pattern is located in A10 to A0 flash address bits (system byte address signals a11 through a1).

The data in each write may be: a bit pattern used to help identify the write as a command, a code that identifies the command operation to be performed, or supply information needed to perform the operation. See Table 7.1 on page 55 for a listing of all commands accepted by the device.

## 3.3 Secure Silicon Region (OTP)

The Secure Silicon Region (SSR) provides an extra flash memory area that can be programmed once and permanently protected from further changes i. e. it is a One Time Program (OTP) area. The SSR is 1024 bytes in length. It consists of 512 bytes for Factory Locked Secure Silicon Region and 512 bytes for Customer Locked Secure Silicon Region.

## 3.4 Sector Protection Methods

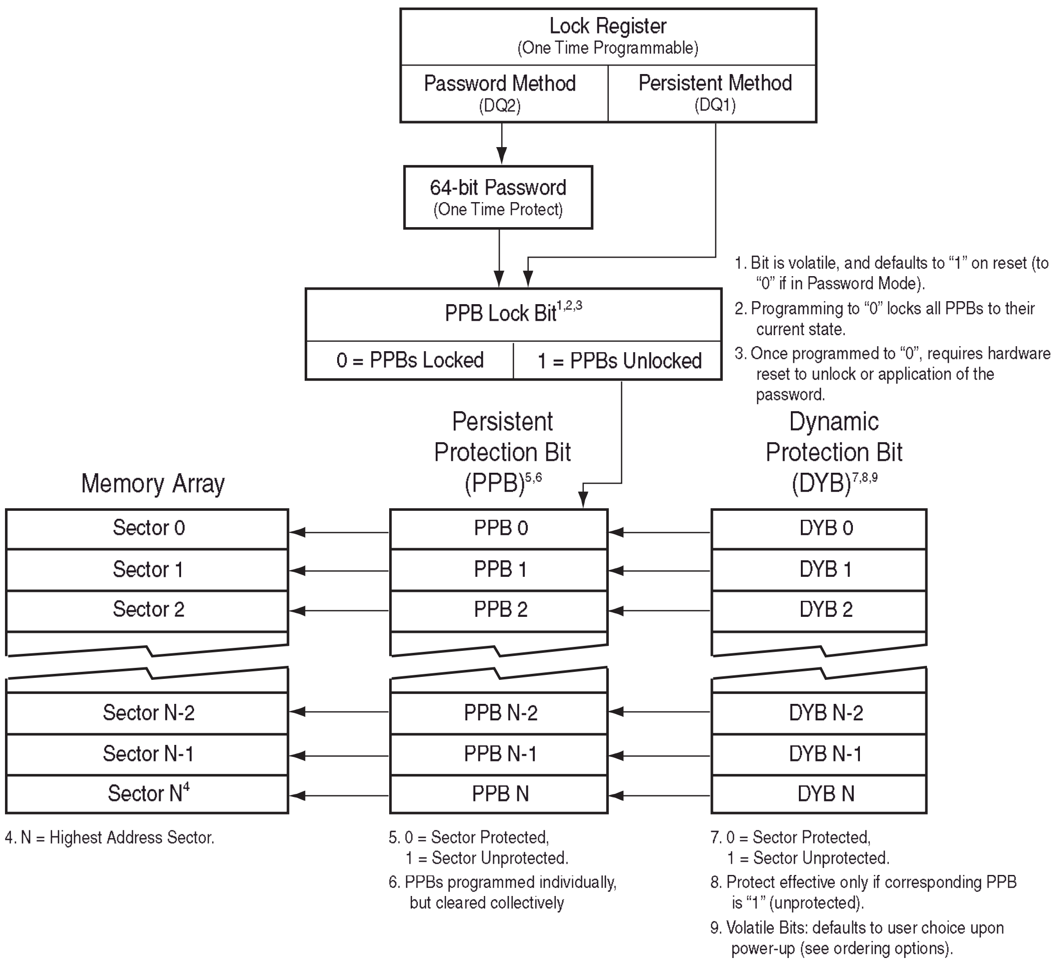
### 3.4.1 Write Protect Signal

If WP# = $V_{IL}$, the lowest or highest address sector is protected from program or erase operations independent of any other ASP configuration. Whether it is the lowest or highest sector depends on the device ordering option (model) selected. If WP# = $V_{IH}$, the lowest or highest address sector is not protected by the WP# signal but it may be protected by other aspects of ASP configuration. WP# has an internal pull-up; when unconnected, WP# is at $V_{IH}$.

### 3.4.2 ASP

Advanced Sector Protection (ASP) is a set of independent hardware and software methods used to disable or enable programming or erase operations, individually, in any or all sectors. This section describes the various methods of protecting data stored in the memory array. An overview of these methods is shown in Figure 3.1.

**Figure 3.1** Advanced Sector Protection Overview




Every main flash array sector has a non-volatile (PPB) and a volatile (DYB) protection bit associated with it. When either bit is 0, the sector is protected from program and erase operations.

The PPB bits are protected from program and erase when the PPB Lock bit is 0. There are two methods for managing the state of the PPB Lock bit, Persistent Protection and Password Protection.

The Persistent Protection method sets the PPB Lock to 1 during POR or Hardware Reset so that the PPB bits are unprotected by a device reset. There is a command to clear the PPB Lock bit to 0 to protect the PPB bits. There is no command in the Persistent Protection method to set the PPB Lock bit therefore the PPB Lock bit will remain at 0 until the next power-off or hardware reset. The Persistent Protection method allows boot code the option of changing sector protection by programming or erasing the PPB, then protecting the PPB from further change for the remainder of normal system operation by clearing the PPB Lock bit. This is sometimes called Boot-code controlled sector protection.

The Password method clears the PPB Lock bit to 0 during POR or Hardware Reset to protect the PPB. A 64-bit password may be permanently programmed and hidden for the password method. A command can be used to provide a password for comparison with the hidden password. If the password matches the PPB Lock bit is set to 1 to unprotect the PPB. A command can be used to clear the PPB Lock bit to 0.

The selection of the PPB Lock management method is made by programming OTP bits in the Lock Register so as to permanently select the method used.

The Lock Register also contains OTP bits, for protecting the SSR.

The PPB bits are erased so that all main flash array sectors are unprotected when shipped from Cypress. The Secured Silicon Region can be factory protected or left unprotected depending on the ordering option (model) ordered.

### 3.4.3 PPB Lock

The Persistent Protection Bit Lock is a volatile bit for protecting all PPB bits. When cleared to 0, it locks all PPBs and when set to 1, it allows the PPBs to be changed. There is only one PPB Lock Bit per device.

The PPB Lock command is used to clear the bit to 0. The PPB Lock Bit must be cleared to 0 only after all the PPBs are configured to the desired settings.

In Persistent Protection mode, the PPB Lock is set to 1 during POR or a hardware reset. When cleared, no software command sequence can set the PPB Lock, only another hardware reset or power-up can set the PPB Lock bit.

In the Password Protection mode, the PPB Lock is cleared to 0 during POR or a hardware reset. The PPB Lock can only set to 1 by the Password Unlock command sequence. The PPB Lock can be cleared by the PPB Lock Bit Clear command.

### 3.4.4 Persistent Protection Bits (PPB)

The Persistent Protection Bits (PPB) are located in a separate nonvolatile flash array. One of the PPB bits is assigned to each sector. When a PPB is 0 its related sector is protected from program and erase operations. The PPB are programmed individually but must be erased as a group, similar to the way individual words may be programmed in the main array but an entire sector must be erased at the same time. Preprogramming and verification prior to erasure are handled by the EAC.

Programming a PPB bit requires the typical word programming time. During a PPB bit programming operation or PPB bit erasing, Data polling Status DQ6 Toggle Bit I will toggle until the operation is complete. Erasing all the PPBs requires typical sector erase time.

If the PPB Lock is 0, the PPB Program or erase commands do not execute and time-out without programming or erasing the PPB.

The protection state of a PPB for a given sector can be verified by executing a PPB Status Read command when entered in the PPB ASO.

### 3.4.5 Dynamic Protection Bits (DYB)

Dynamic Protection Bits are volatile and unique for each sector and can be individually modified. DYBs only control protection for sectors that have their PPBs erased. By issuing the DYB Set or Clear command sequences, the DYB are set to 0 or cleared to 1, thus placing each sector in the protected or unprotected state respectively, if the PPB for the Sector is 1. This feature allows software to easily protect sectors against inadvertent changes, yet does not prevent the easy removal of protection when changes are needed.

The DYB can be set to 0 or cleared to 1 as often as needed.

### 3.4.6 Sector Protection States Summary

Each sector can be in one of the following protection states:

- Unlocked – The sector is unprotected and protection can be changed by a simple command. The protection state defaults to unprotected after a power cycle or hardware reset.
- Dynamically Locked – A sector is protected and protection can be changed by a simple command. The protection state is not saved across a power cycle or hardware reset.
- Persistently Locked – A sector is protected and protection can only be changed if the PPB Lock Bit is set to 1. The protection state is non-volatile and saved across a power cycle or hardware reset. Changing the protection state requires programming or erase of the PPB bits.

**Table 3.1** Sector Protection States

| Protection Bit Values | | | Sector State |
|---|---|---|---|
| PPB Lock | PPB | DYB | |
| 1 | 1 | 1 | Unprotected - PPB and DYB are changeable |
| 1 | 1 | 0 | Protected - PPB and DYB are changeable |
| 1 | 0 | 1 | Protected - PPB and DYB are changeable |
| 1 | 0 | 0 | Protected - PPB and DYB are changeable |
| 0 | 1 | 1 | Unprotected - PPB not changeable, DYB is changeable |
| 0 | 1 | 0 | Protected - PPB not changeable, DYB is changeable |
| 0 | 0 | 1 | Protected - PPB not changeable, DYB is changeable |
| 0 | 0 | 0 | Protected - PPB not changeable, DYB is changeable |

### 3.4.7 Lock Register

The Lock Register holds the non-volatile OTP bits for controlling protection of the SSR, and determining the PPB Lock bit management method (protection mode).

**Table 3.2** Lock Register

| Bit | Default Value | Name |
|---|---|---|
| 15-9 | 1 | Reserved |
| 8 | 0 | Reserved |
| 7 | X | Reserved |
| 6 | 1 | SSR Region 1 (Customer) Lock Bit |
| 5 | 1 | Reserved |
| 4 | 1 | Reserved |
| 3 | 1 | Reserved |
| 2 | 1 | Password Protection Mode Lock Bit |
| 1 | 1 | Persistent Protection Mode Lock Bit |
| 0 | 0 | SSR Region 0 (Factory) Lock Bit |

The Secure Silicon Region (SSR) protection bits must be used with caution, as once locked, there is no procedure available for unlocking the protected portion of the Secure Silicon Region and none of the bits in the protected Secure Silicon Region memory space can be modified in any way. Once the Secure Silicon Region area is protected, any further attempts to program in the area will fail with status indicating the area being programmed is protected. The Region 0 Indicator Bit is located in the Lock Register at bit location 0 and Region 1 in bit location 6.

As shipped from the factory, all devices default to the Persistent Protection method, with all sectors unprotected, when power is applied. The device programmer or host system can then choose which sector protection method to use. Programming either of the following two, one-time programmable, non-volatile bits, locks the part permanently in that mode:

- Persistent Protection Mode Lock Bit (DQ1)
- Password Protection Mode Lock Bit (DQ2)

If both lock bits are selected to be programmed at the same time, the operation will abort. Once the Password Mode Lock Bit is programmed, the Persistent Mode Lock Bit is permanently disabled and no changes to the protection scheme are allowed. Similarly, if the Persistent Mode Lock Bit is programmed, the Password Mode is permanently disabled.

If the password mode is to be chosen, the password must be programmed prior to setting the corresponding lock register bit. Setting the Password Protection Mode Lock Bit is programmed, a power cycle, hardware reset, or PPB Lock Bit Set command is required to set the PPB Lock bit to 0 to protect the PPB array.

The programming time of the Lock Register is the same as the typical word programming time. During a Lock Register programming EA, Data polling Status DQ6 Toggle Bit I will toggle until the programming has completed. The system can also determine the status of the lock register programming by reading the Status Register. See Status Register on page 34 for information on these status bits.

The user is not required to program DQ2 or DQ1, and DQ6 or DQ0 bits at the same time. This allows the user to lock the SSR before or after choosing the device protection scheme. When programming the Lock Bits, the Reserved Bits must be 1 (masked).

### 3.4.8 Persistent Protection Mode

The Persistent Protection method sets the PPB Lock to 1 during POR or Hardware Reset so that the PPB bits are unprotected by a device reset. There is a command to clear the PPB Lock bit to 0 to protect the PPB. There is no command in the Persistent Protection method to set the PPB Lock bit to 1 therefore the PPB Lock bit will remain at 0 until the next power-off or hardware reset.

### 3.4.9 Password Protection Mode

#### 3.4.9.1 PPB Password Protection Mode

PPB Password Protection Mode allows an even higher level of security than the Persistent Sector Protection Mode, by requiring a 64-bit password for setting the PPB Lock. In addition to this password requirement, after power up and reset, the PPB Lock is cleared to 0 to ensure protection at power-up. Successful execution of the Password Unlock command by entering the entire password sets the PPB Lock to 1, allowing for sector PPB modifications.

Password Protection Notes:

- The Password Program Command is only capable of programming 0's.
- The password is all 1's when shipped from Cypress. It is located in its own memory space and is accessible through the use of the Password Program and Password Read commands.
- All 64-bit password combinations are valid as a password.
- Once the Password is programmed and verified, the Password Mode Locking Bit must be set in order to prevent reading or modification of the password.
- The Password Mode Lock Bit, once programmed, prevents reading the 64-bit password on the data bus and further password programming. All further program and read commands to the password region are disabled (data is read as 1's) and these commands are ignored. There is no means to verify what the password is after the Password Protection Mode Lock Bit is programmed. Password verification is only allowed before selecting the Password Protection mode.
- The Password Mode Lock Bit is not erasable.
- The exact password must be entered in order for the unlocking function to occur.
- The addresses can be loaded in any order but all 4 words are required for a successful match to occur.

- The Sector Addresses and Word Line Addresses are compared while the password address/data are loaded. If the Sector Address don't match than the error will be reported at the end of that write cycle. The status register will return to the ready state with the Program Status Bit set to 1, Program Status Register Bit set to 1, and Write Buffer Abort Status Bit set to 1 indicating a failed programming operation. It is a failure to change the state of the PPB Lock bit because it is still protected by the lack of a valid password. The data polling status will remain active, with DQ7 set to the complement of the DQ7 bit in the last word of the password unlock command, and DQ6 toggling. RY/BY# will remain low.
- The specific address and data are compared after the Program Buffer To Flash command has been given. If they don't match to the internal set value than the status register will return to the ready state with the Program Status Bit set to 1 and Program Status Register Bit set to 1 indicating a failed programming operation. It is a failure to change the state of the PPB Lock bit because it is still protected by the lack of a valid password. The data polling status will remain active, with DQ7 set to the complement of the DQ7 bit in the last word of the password unlock command, and DQ6 toggling. RY/BY# will remain low.
- The device requires approximately 100 µs for setting the PPB Lock after the valid 64-bit password is given to the device.
- The Password Unlock command cannot be accepted any faster than once every 100 µs ± 20 µs. This makes it take an unreasonably long time (58 million years) for a hacker to run through all the 64-bit combinations in an attempt to correctly match a password. The EA status checking methods may be used to determine when the EAC is ready to accept a new password command.
- If the password is lost after setting the Password Mode Lock Bit, there is no way to clear the PPB Lock.

# 4. Read Operations

## 4.1 Asynchronous Read

Each read access may be made to any location in the memory (random access). Each random access is self-timed with the same latency from CE# or address to valid data ($t_{ACC}$ or $t_{CE}$).

## 4.2 Page Mode Read

Each random read accesses an entire 32-byte Page in parallel. Subsequent reads within the same Page have faster read access speed. The Page is selected by the higher address bits ($A_{MAX}$–A4), while the specific word of that page is selected by the least significant address bits A3–A0. The higher address bits are kept constant and only A3–A0 changed to select a different word in the same Page. This is an asynchronous access with data appearing on DQ15-DQ0 when CE# remains Low, OE# remains Low, and the asynchronous Page access time ($t_{PACC}$) is satisfied. If CE# goes High and returns Low for a subsequent access, a random read access is performed and time is required ($t_{ACC}$ or $t_{CE}$).

# 5. Embedded Operations

## 5.1 Embedded Algorithm Controller (EAC)

The EAC takes commands from the host system for programming and erasing the flash memory array and performs all the complex operations needed to change the non-volatile memory state. This frees the host system from any need to manage the program and erase processes.

There are four EAC operation categories:

- Standby (Read Mode)
- Address Space Switching
- Embedded Algorithms (EA)
- Advanced Sector Protection (ASP) Management

### 5.1.1 EAC Standby

In the standby mode current consumption is greatly reduced. The EAC enters its standby mode when no command is being processed and no Embedded Algorithm is in progress. If the device is deselected
(CE# = High) during an Embedded Algorithm, the device still draws active current until the operation is completed ($I_{CC3}$). $I_{CC4}$ in DC Characteristics on page 72 represents the standby current specification when both the Host Interface and EAC are in their Standby state.

### 5.1.2 Address Space Switching

Writing specific address and data sequences (command sequences) switch the memory device address space from the main flash array to one of the Address Space Overlays (ASO).

Embedded Algorithms operate on the information visible in the currently active (entered) ASO. The system continues to have access to the ASO until the system issues an ASO Exit command, performs a Hardware RESET, or until power is removed from the device. An ASO Exit Command switches from an ASO back to the main flash array address space. The commands accepted when a particular ASO is entered are listed between the ASO enter and exit commands in the command definitions table. See Command Summary on page 55 for address and data requirements for all command sequences.

### 5.1.3 Embedded Algorithms (EA)

Changing the non-volatile data in the memory array requires a complex sequence of operations that are called Embedded Algorithms (EA). The algorithms are managed entirely by the device internal Embedded Algorithm Controller (EAC). The main algorithms perform programming and erasing of the main array data and the ASO's. The host system writes command codes to the flash device address space. The EAC receives the commands, performs all the necessary steps to complete the command, and provides status information during the progress of an EA.

## 5.2 Program and Erase Summary

Flash data bits are erased in parallel in a large group called a sector. The Erase operation places each data bit in the sector in the logical 1 state (High). Flash data bits may be individually programmed from the erased 1 state to the programmed logical 0 (low) state. A data bit of 0 cannot be programmed back to a 1. A succeeding read shows that the data is still 0. Only erase operations can convert a 0 to a 1. Programming the same word location more than once with different 0 bits will result in the logical AND of the previous data and the new data being programmed.

The duration of program and erase operations is shown in Embedded Algorithm Performance Table on page 43.

Program and erase operations may be suspended.

- An erase operation may be suspended to allow either programming or reading of another sector (not in the erase sector). No other erase operation can be started during an erase suspend.
- A program operation may be suspended to allow reading of another location (not in the Line being programmed).
- No other program or erase operation may be started during a suspended program operation - program or erase commands will be ignored during a suspended program operation.
- After an intervening program operation or read access is complete the suspended erase or program operation may be resumed. The resume can happen at any time after the suspend assuming the device is not in the process of executing another command.
- Program and Erase operations may be interrupted as often as necessary but in order for a program or erase operation to progress to completion there must be some periods of time between resume and the next suspend commands greater than or equal to $t_{PRS}$ or $t_{ERS}$ in Embedded Algorithm Performance Table on page 43.
- When an Embedded Algorithm (EA) is complete, the EAC returns to the operation state and address space from which the EA was started (Erase Suspend or EAC Standby).

The system can determine the status of a program or erase operation by reading the Status Register or using Data Polling Status. Refer to Status Register on page 34 for information on these status bits. Refer to Data Polling Status on page 35 for more information.

Any commands written to the device during the Embedded Program Algorithm are ignored except the Program Suspend, and Status Read command.

Any commands written to the device during the Embedded Erase Algorithm are ignored except Erase Suspend and Status Read command.

A hardware reset immediately terminates any in progress program / erase operation and returns to read mode after $t_{RPH}$ time. The terminated operation should be reinitiated once the device has returned to the idle state, to ensure data integrity.

For performance and reliability reasons reading and programming is internally done on full 32-byte Pages.

$I_{CC3}$ in DC Characteristics on page 72 represents the active current specification for a write (Embedded Algorithm) operation.

### 5.2.1 Program Granularity

The S29GL-S supports two methods of programming, Word or Write Buffer Programming. Each Page can be programmed by either method. Pages programmed by different methods may be mixed within a Line for the Industrial Temperature version (–40 °C to +85 °C). For the In-Cabin version (–40 °C to +105 °C) the device will only support one programming operation on each 32-byte page between erase operations and Single Word Programming command is not supported.

Word programming examines the data word supplied by the command and programs 0’s in the addressed memory array word to match the 0’s in the command data word.

Write Buffer Programming examines the write buffer and programs 0’s in the addressed memory array Pages to match the 0’s in the write buffer. The write buffer does not need to be completely filled with data. It is allowed to program as little as a single bit, several bits, a single word, a few words, a Page, multiple Pages, or the entire buffer as one programming operation. Use of the write buffer method reduces host system overhead in writing program commands and reduces memory device internal overhead in programming operations to make Write Buffer Programming more efficient and thus faster than programming individual words with the Word Programming command.

### 5.2.2 Incremental Programming

The same word location may be programmed more than once, by either the Word or Write Buffer Programming methods, to incrementally change 1's to 0's. Note that if additional programming is performed on a page its ECC coverage is disabled.

## 5.3 Automatic ECC

### 5.3.1 ECC Overview

The Automatic ECC feature works transparently with normal program, erase, and read operations. As the device transfers each Page of data from the Write Buffer is to the memory array, internal ECC logic programs ECC Code for the Page into a portion of the memory array that is not visible to the host system. The device evaluates the Page data and the ECC Code during each initial Page access. If needed, the internal ECC logic corrects a one bit error during the initial access.

Programming more than once to a particular Page will disable the ECC function for that Page. The ECC function will remain disabled for that Page until the next time the host system erases the Sector containing that Page. The host system may read data stored in that Page following multiple programming operations; however, ECC is disabled and an error in that Page will not be detected or corrected.

### 5.3.2 Program and Erase Summary

For performance and reliability reasons, GL-S devices perform reading and programming on full 32-byte Pages in parallel. The GL-S device provides ECC on each Page by adding an ECC Code to each Page when it is first programmed. The ECC Code is automatic and transparent to the host system.

### 5.3.3 ECC Implementation

Each 32-byte Page in the main flash array and OTP regions features an associated ECC Code. The ECC Code, in combination with ECC logic, is able to detect and correct any single bit error found in a Page during a read access.

The first Write Buffer program operation applied to a Page programs the ECC Code for that Page. Subsequent programming operations that occur more than once on a particular Page disable the ECC function for that Page. This allows bit or word programming; however, note that multiple programming operations to the same Page will disable the ECC function on the Page where incremental programming occurs. An erase of the Sector containing a Page with ECC disabled will re-enable the ECC function for that Page.

The ECC function is automatic and transparent to the user. The transparency of the Automatic ECC function enhances data integrity for typical programming operations that write data once to each Page. The ECC function also facilitates software compatibility to previous generations of GL Family products by allowing single word programming and bit walking where the same Page or word is programmed more than once. When a Page has Automatic ECC disabled, the ECC function will not detect or correct an error on a data read from that Page.

### 5.3.4 Word Programming

Word programming programs a single word anywhere in the main Flash Memory Array. Programming multiple words in the same 32-byte page disables Automatic ECC protection on that Page. A sector erase of the sector containing that Page will re-enable Automatic ECC following word programming on that Page.

### 5.3.5 Write Buffer Programming

Each Write Buffer Program operation allows for programming of 1 bit up to 512 bytes. A 32-byte Page is the smallest program granularity that features Automatic ECC protection. Programming the same Page more than once will disable the Automatic ECC on that Page. Cypress recommends that a Write Buffer programming operation program multiple Pages in an operation and write each Page only once. This keeps the Automatic ECC protection enabled on each Page. For the very best performance, program in full Lines of 512 bytes aligned on 512-byte boundaries.

## 5.4 Command Set

### 5.4.1 Program Methods

#### 5.4.1.1 Word Programming

Word programming is used to program a single word anywhere in the main Flash Memory Array.

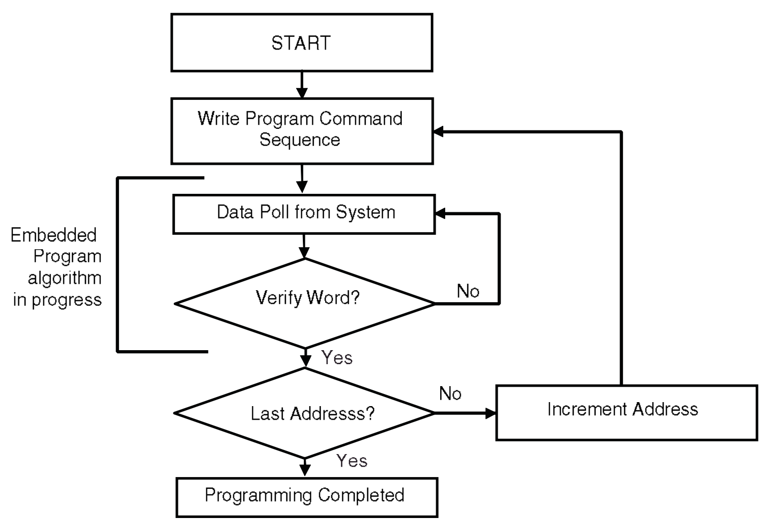
The Word Programming command is a four-write-cycle sequence. The program command sequence is initiated by writing two unlock write cycles, followed by the program set up command. The program address and data are written next, which in turn initiate the Embedded Word Program algorithm. The system is not required to provide further controls or timing. The device automatically generates the program pulses and verifies the programmed cell margin internally. When the Embedded Word Program algorithm is complete, the EAC then returns to its standby mode.

The system can determine the status of the program operation by using Data Polling Status, reading the Status Register, or monitoring the RY/BY# output. See Status Register on page 34 for information on these status bits. See Data Polling Status on page 35 for information on these status bits. See Figure 5.1 on page 23 for a diagram of the programming operation.

Any commands other than Program Suspend written to the device during the Embedded Program algorithm are ignored. Note that a hardware reset (RESET# = $V_{IL}$) immediately terminates the programming operation and returns the device to read mode after $t_{RPH}$ time. To ensure data integrity, the Program command sequence should be reinitiated once the device has completed the hardware reset operation.

A modified version of the Word Programming command, without unlock write cycles, is used for programming when entered into the Lock Register, Password, and PPB ASOs. The same command is used to change volatile bits when entered in to the PPB Lock, and DYB ASOs. See Table 7.1 on page 55 for program command sequences.

**Figure 5.1** Word Program Operation



#### 5.4.1.2 Write Buffer Programming

A write buffer is used to program data within a 512-byte address range aligned on a 512-byte boundary (Line). Thus, a full Write Buffer Programming operation must be aligned on a Line boundary. Programming operations of less than a full 512 bytes may start on any word boundary but may not cross a Line boundary. At the start of a Write Buffer programming operation all bit locations in the buffer are all 1's (FFFFh words) thus any locations not loaded will retain the existing data. See Product Overview on page 4 for information on address map.

Write Buffer Programming allows up to 512 bytes to be programmed in one operation. It is possible to program from 1 bit up to 512 bytes in each Write Buffer Programming operation. It is recommended that a multiple of Pages be written and each Page written only once. For the very best performance, programming should be done in full Lines of 512 bytes aligned on 512-byte boundaries.

Write Buffer Programming is supported only in the main flash array or the SSR ASO.

The Write Buffer Programming operation is initiated by first writing two unlock cycles. This is followed by a third write cycle of the Write to Buffer command with the Sector Address (SA), in which programming is to occur. Next, the system writes the number of word locations minus 1. This tells the device how many write buffer addresses are loaded with data and therefore when to expect the Program Buffer to flash confirm command. The Sector Address must match in the Write to Buffer command and the Write Word Count command. The Sector to be programmed must be unlocked (unprotected).

The system then writes the starting address / data combination. This starting address is the first address / data pair to be programmed, and selects the write-buffer-Line address. The Sector address must match the Write to Buffer Sector Address or the operation will abort and return to the initiating state. All subsequent address / data pairs must be in sequential order. All write buffer addresses must be within the same Line. If the system attempts to load data outside this range, the operation will abort and return to the initiating state.

The counter decrements for each data load operation. Note that while counting down the data writes, every write is considered to be data being loaded into the write buffer. No commands are possible during the write buffer loading period. The only way to stop loading the write buffer is to write with an address that is outside the Line of the programming operation. This invalid address will immediately abort the Write to Buffer command.

Once the specified number of write buffer locations has been loaded, the system must then write the Program Buffer to Flash command at the Sector Address. The device then goes busy. The Embedded Program algorithm automatically programs and verifies the data for the correct data pattern. The system is not required to provide any controls or timings during these operations. If an incorrect number of write buffer locations have been loaded the operation will abort and return to the initiating state. The abort occurs when anything other than the Program Buffer to Flash is written when that command is expected at the end of the word count.

The write-buffer embedded programming operation can be suspended using the Program Suspend command. When the Embedded Program algorithm is complete, the EAC then returns to the EAC standby or Erase Suspend standby state where the programming operation was started.

The system can determine the status of the program operation by using Data Polling Status, reading the Status Register, or monitoring the RY/BY# output. See Status Register on page 34 for information on these status bits. See Data Polling Status on page 35 for information on these status bits. See Figure 5.2 on page 25 for a diagram of the programming operation.

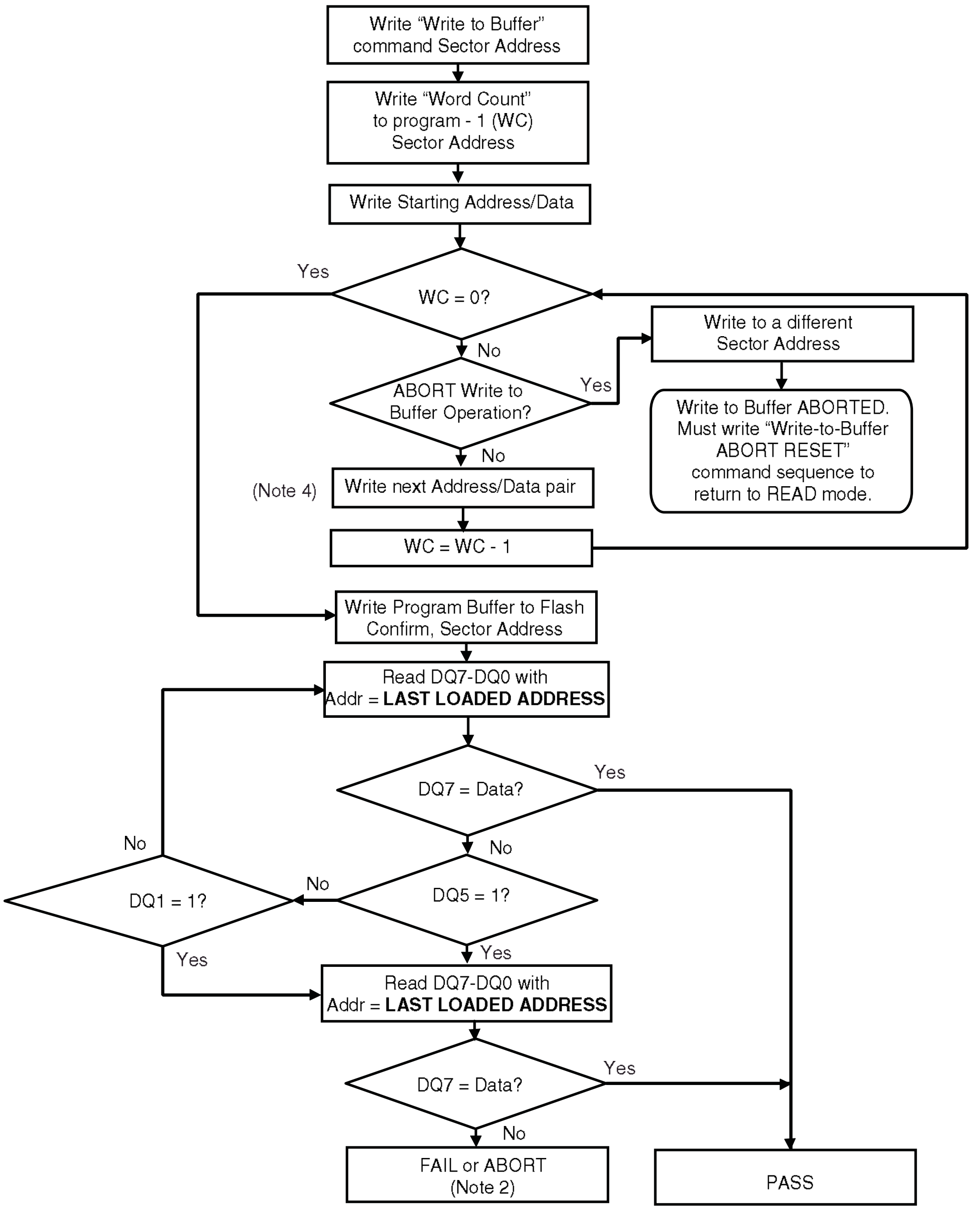
The Write Buffer Programming Sequence will be Aborted under the following conditions:

- Load a Word Count value greater than the buffer size (255).
- Write an address that is outside the Line provided in the Write to Buffer command.
- The Program Buffer to Flash command is not issued after the Write Word Count number of data words is loaded.

When any of the conditions that cause an abort of write buffer command occur the abort will happen immediately after the offending condition, and will indicate a Program Fail in the Status Register at bit location 4 (PSB = 1) due to Write Buffer Abort bit location 3 (WBASB = 1). The next successful program operation will clear the failure status or a Clear Status Register may be issued to clear the PSB status bit.

The Write Buffer Programming Sequence can be stopped by the following: Hardware Reset or Power cycle. However, these using either of these methods may leave the area being programmed in an intermediate state with invalid or unstable data values. In this case the same area will need to be reprogrammed with the same data or erased to ensure data values are properly programmed or erased.

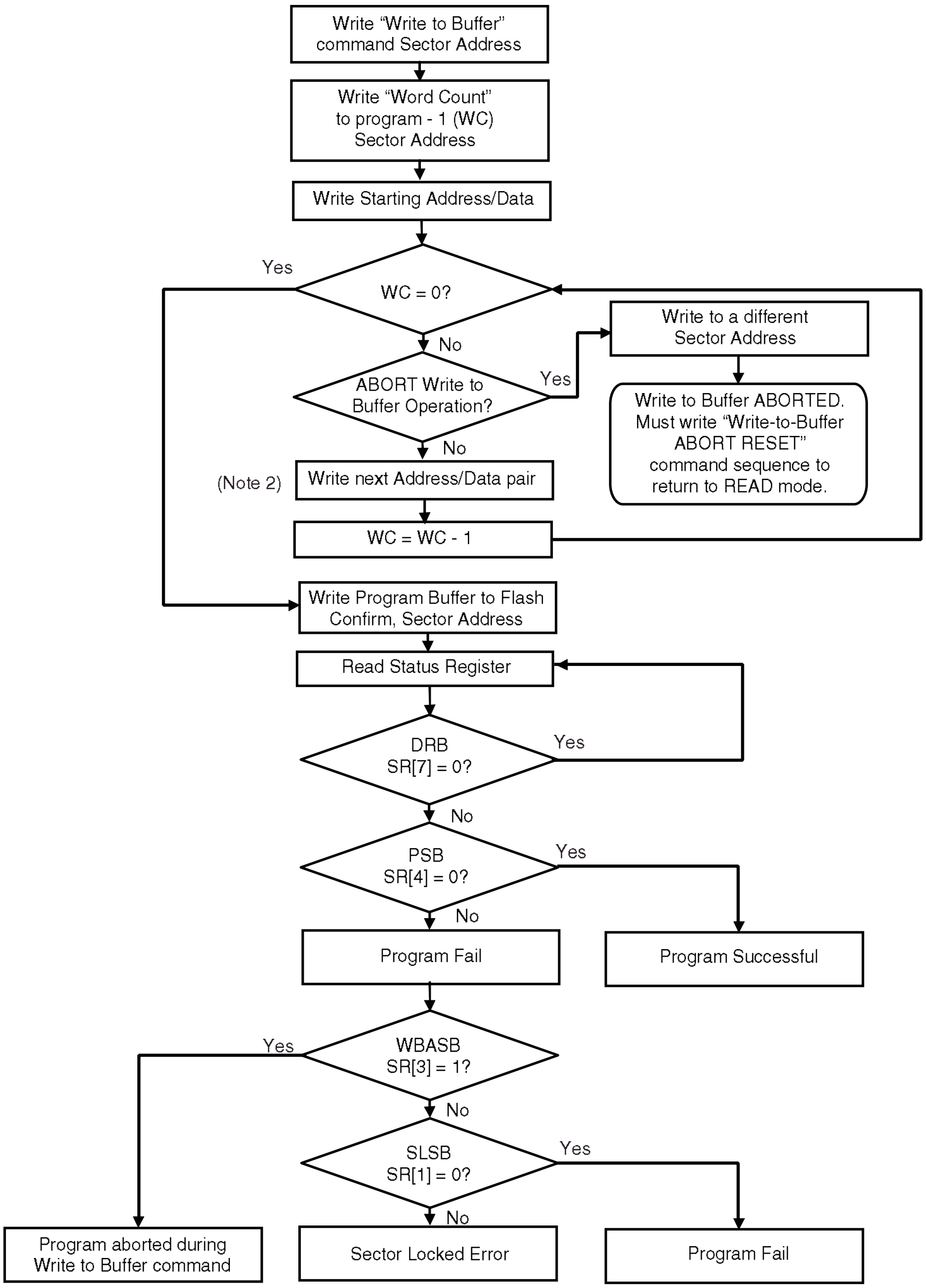
**Figure 5.2** Write Buffer Programming Operation with Data Polling Status




**Notes:**

1. *DQ7 should be rechecked even if DQ5 = 1 because DQ7 may change simultaneously with DQ5.*
2. *If this flowchart location was reached because DQ5 = 1, then the device FAILED. If this flowchart location was reached because DQ1 = 1, then the Write Buffer operation was ABORTED. In either case the proper RESET command must be written to the device to return the device to READ mode. Write-Buffer-Programming-Abort-Rest if DQ1 = 1, either Software RESET or Write-Buffer-Programming-Abort-Reset if DQ5 = 1.*
3. *See* Table 7.1 on page 55 for the command sequence as required for Write Buffer Programming.
4. *When Sector Address is specified, any address in the selected sector is acceptable. However, when loading Write-Buffer address locations with data, all addresses MUST fall within the selected Write-Buffer Page.*

**Figure 5.3** Write Buffer Programming Operation with Status Register




***Notes:***
1. *See* Table 7.1 on page 55 for the command sequence as required for Write Buffer Programming.
2. *When Sector Address is specified, any address in the selected sector is acceptable. However, when loading Write-Buffer address locations with data, all addresses MUST fall within the selected Write-Buffer Page.*

**Table 5.1** Write Buffer Programming Command Sequence

| Sequence | Address | Data | Comment |
|---|---|---|---|
| Issue Unlock Command 1 | 555/AAA | AA | |
| Issue Unlock Command 2 | 2AA/555 | 55 | |
| Issue Write to Buffer Command at Sector Address | SA | 0025h | |
| Issue Number of Locations at Sector Address | SA | WC | WC = number of words to program - 1 |
| Example: WC of 0 = 1 words to pgm | | | |
| WC of 1 = 2 words to pgm | | | |
| Load Starting Address / Data pair | Starting Address | PD | Selects Write-Buffer-Page and loads first Address/Data Pair. |
| Load next Address / Data pair | WBL | PD | All addresses MUST be within the selected write-buffer-page boundaries, and have to be loaded in sequential order. |
| Load LAST Address/Data pair | WBL | PD | All addresses MUST be within the selected write-buffer-page boundaries, and have to be loaded in sequential order. |
| Issue Write Buffer Program Confirm at Sector Address | SA | 0029h | This command MUST follow the last write buffer location loaded, or the operation will ABORT. |
| Device goes busy. | | | |

***Legend:***
SA = Sector Address (Non-Sector Address bits are don't care. Any address within the Sector is sufficient.)
WBL = Write Buffer Location (MUST be within the boundaries of the Write-Buffer-Line specified by the Starting Address.)
WC =Word Count
PD = Program Data

### 5.4.2 Program Suspend / Program Resume Commands

The Program Suspend command allows the system to interrupt an embedded programming operation so that data can read from any non-suspended Line. When the Program Suspend command is written during a programming process, the device halts the programming operation within $t_{PSL}$ (program suspend latency) and updates the status bits. Addresses are don't-cares when writing the Program Suspend command.

There are two commands available for program suspend. The legacy combined Erase / Program suspend command (B0h command code) and the separate Program Suspend command (51h command code). There are also two commands for Program resume. The legacy combined Erase / Program resume command (30h command code) and the separate Program Resume command (50h command code). It is recommended to use the separate program suspend and resume commands for programming and use the legacy combined command only for erase suspend and resume.

After the programming operation has been suspended, the system can read array data from any non-suspended Line. The Program Suspend command may also be issued during a programming operation while an erase is suspended. In this case, data may be read from any addresses not in Erase Suspend or Program Suspend.

After the Program Resume command is written, the device reverts to programming and the status bits are updated. The system can determine the status of the program operation by reading the Status Register or using Data Polling. Refer to Status Register on page 34 for information on these status bits. Refer to Data Polling Status on page 35 for more information.

Accesses and commands that are valid during Program Suspend are:

- Read to any other non-erase-suspended sector
- Read to any other non-program-suspended Line
- Status Read command
- Exit ASO or Command Set Exit
- Program Resume command

The system must write the Program Resume command to exit the Program Suspend mode and continue the programming operation. Further writes of the Program Resume command are ignored. Another Program Suspend command can be written after the device has resumed programming.

Program operations can be interrupted as often as necessary but in order for a program operation to progress to completion there must be some periods of time between resume and the next suspend command greater than or equal to $t_{PRS}$ in Embedded Algorithm Controller (EAC) on page 20.

Program suspend and resume is not supported while entered in an ASO. While in program suspend entry into ASO is not supported.

### 5.4.3 Blank Check

The Blank Check command will confirm if the selected main flash array sector is erased. The Blank Check command does not allow for reads to the array during the Blank Check. Reads to the array while this command is executing will return unknown data.

To initiate a Blank Check on a Sector, write 33h to address 555h in the Sector, while the EAC is in the standby state

The Blank Check command may not be written while the device is actively programming or erasing or suspended.

Use the Status Register read to confirm if the device is still busy and when complete if the sector is blank or not. Bit 7 of the Status Register will show if the device is performing a Blank Check (similar to an erase operation). Bit 5 of the Status Register will be cleared to 0 if the sector is erased and set to 1 if not erased.

As soon as any bit is found to not be erased, the device will halt the operation and report the results.

Once the Blank Check is completed, the EAC will return to the Standby State.

### 5.4.4 Erase Methods

#### 5.4.4.1 Chip Erase

The chip erase function erases the entire main Flash Memory Array. The device does not require the system to preprogram prior to erase. The Embedded Erase algorithm automatically programs and verifies the entire memory for an all 0 data pattern prior to electrical erase. After a successful chip erase, all locations within the device contain FFFFh. The system is not required to provide any controls or timings during these operations. The chip erase command sequence is initiated by writing two unlock cycles, followed by a set up command. Two additional unlock write cycles are then followed by the chip erase command, which in turn invokes the Embedded Erase algorithm. When WE# goes high, at the end of the 6th cycle, the RY/BY# goes low.

When the Embedded Erase algorithm is complete, the EAC returns to the standby state. Note that while the Embedded Erase operation is in progress, the system can not read data from the device. The system can determine the status of the erase operation by reading RY/BY#, the Status Register or using Data Polling. Refer to Status Register on page 34 for information on these status bits. Refer to Data Polling Status on page 35 for more information.

Once the chip erase operation has begun, only a Status Read, Hardware RESET or Power cycle are valid. All other commands are ignored. However, a Hardware Reset or Power Cycle immediately terminates the erase operation and returns to read mode after $t_{RPH}$ time. If a chip erase operation is terminated, the chip erase command sequence must be reinitiated once the device has returned to the idle state to ensure data integrity.

See Table 5.4 on page 43, Asynchronous Write Operations on page 82 and Alternate CE# Controlled Write Operations on page 88 for parameters and timing diagrams.

Sectors protected by the ASP DYB and PPB lock bits will not be erased. See ASP on page 14. If a sector is protected during chip erase, chip erase will skip the protected sector and continue with next sector erase. The status register erase status bit and sector lock bit are not set to 1 by a failed erase on a protected sector.

#### 5.4.4.2 Sector Erase

The sector erase function erases one sector in the memory array. The device does not require the system to preprogram prior to erase. The Embedded Erase algorithm automatically programs and verifies the entire sector for an all 0 data pattern prior to electrical erase. After a successful sector erase, all locations within the erased sector contain FFFFh. The system is not required to provide any controls or timings during these operations. The sector erase command sequence is initiated by writing two unlock cycles, followed by a set up command. Two additional unlock write cycles are then followed by the address of the sector to be erased, and the sector erase command. When WE# goes high, at the end of the 6th cycle, the RY/BY# goes low.

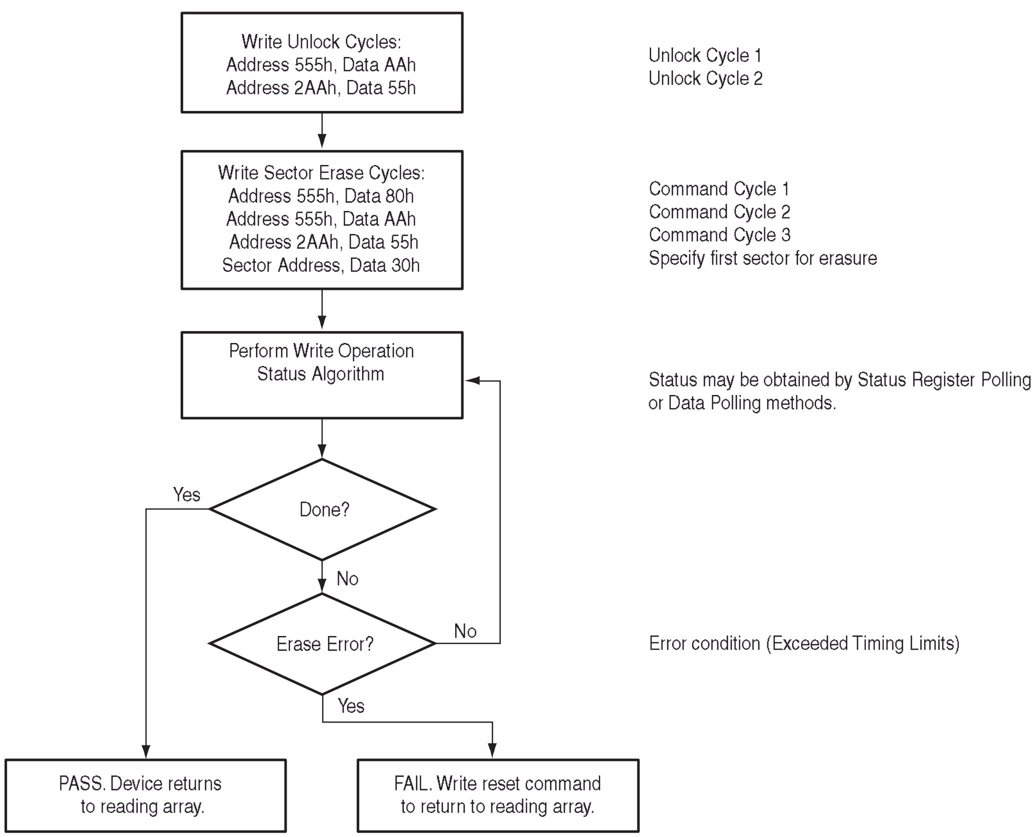
The system can determine the status of the erase operation by reading the Status Register or using Data Polling. Refer to Status Register on page 34 for information on these status bits. Refer to Data Polling Status on page 35 for more information.

Once the sector erase operation has begun, the Status Register Read and Erase Suspend commands are valid. All other commands are ignored. However, note that a hardware reset immediately terminates the erase operation and returns to read mode after $t_{RPH}$ time. If a sector erase operation is terminated, the sector erase command sequence must be reinitiated once the device has reset operation to ensure data integrity.

See Embedded Algorithm Controller (EAC) on page 20 for parameters and timing diagrams.

Sectors protected by the ASP DYB and PPB lock bits will not be erased. See ASP on page 14.

**Figure 5.4** Sector Erase Operation



### 5.4.5 Erase Suspend / Erase Resume

The Erase Suspend command allows the system to interrupt a sector erase operation and then read data from, or program data to, the main flash array. This command is valid only during sector erase or program operation. The Erase Suspend command is ignored if written during the chip erase operation.

When the Erase Suspend command is written during the sector erase operation, the device requires a maximum of $t_{ESL}$ (erase suspend latency) to suspend the erase operation and update the status bits.

After the erase operation has been suspended, the part enters the erase-suspend mode. The system can read data from or program data to the main flash array. Reading at any address within erase-suspended sectors produces undetermined data. The system can determine if a sector is actively erasing or is erase-suspended by reading the Status Register or using Data Polling. Refer to Status Register on page 34 for information on these status bits. Refer to Data Polling Status on page 35 for more information.

After an erase-suspended program operation is complete, the EAC returns to the erase-suspend state. The system can determine the status of the program operation by reading the Status Register, just as in the standard program operation.

If a program failure occurs during erase suspend the Clear or Reset commands will return the device to the erase suspended state. Erase will need to be resumed and completed before again trying to program the memory array.

Accesses and commands that are valid during Erase Suspend are:

- Read to any other non-suspended sector
- Program to any other non-suspended sector
- Status Register Read
- Status Register Clear
- Enter DYB ASO
- DYB Set
- DYB Clear
- DYB Status Read
- Exit ASO or Command Set Exit
- Erase Resume command

To resume the sector erase operation, the system must write the Erase Resume command. The device will revert to erasing and the status bits will be updated. Further writes of the Resume command are ignored. Another Erase Suspend command can be written after the chip has resumed erasing.

Erase suspend and resume is not supported while entered in an ASO. While in erase suspend entry into ASO is not supported.

### 5.4.6 ASO Entry and Exit

#### 5.4.6.1 ID-CFI ASO

The system can access the ID-CFI ASO by issuing the ID-CFI Entry command sequence during Read Mode. This entry command uses the Sector Address (SA) in the command to determine which sector will be overlaid and which sector's protection state is reported in word location 2h. See the detail description Table 7.2 on page 58.

The ID-CFI ASO allows the following activities:

- Read ID-CFI ASO, using the same SA as used in the entry command.
- Read Sector Protection State at Sector Address (SA) + 2h. Location 2h provides volatile information on the current state of sector protection for the sector addressed. Bit 0 of the word at location 2h shows the logical NAND of the PPB and DYB bits related to the addressed sector such that if the sector is protected by either the PPB=0 or the DYB=0 bit for that sector the state shown is protected. (1= Sector protected, 0= Sector unprotected). This protection state is shown only for the SA selected when entering ID-CFI ASO. Reading other SA provides undefined data. To read a different SA protection state ASO exit command must be used and then enter ID-CFI ASO again with the new SA.
- ASO Exit.

The following is a C source code example of using the CFI Entry and Exit functions. Refer to the *Cypress Low Level Driver User's Guide* (available on www.cypress.com) for general information on Cypress flash memory software development guidelines.

```
/* Example: CFI Entry command */
*( (UINT16 *)base_addr + 0x55 ) = 0x0098; /* write CFI entry command */

/* Example: CFI Exit command */
*( (UINT16 *)base_addr + 0x000 ) = 0x00F0; /* write cfi exit command */
```

#### 5.4.6.2 Status Register ASO

The Status Register ASO contains a single word of registered volatile status for Embedded Algorithms. When the Status Register read command is issued, the current status is captured (by the rising edge of WE#) into the register and the ASO is entered. The Status Register content appears on all word locations. The first read access exits the Status Register ASO (with the rising edge of CE# or OE#) and returns to the address space map in use when the Status Register read command was issued. Write commands will not exit the Status Register ASO state.

#### 5.4.6.3 Secure Silicon Region ASO

The system can access the Secure Silicon Region by issuing the Secure Silicon Region Entry command sequence during Read Mode. This entry command uses the Sector Address (SA) in the command to determine which sector will be overlaid.

The Secure Silicon Region ASO allows the following activities:

- Read Secure Silicon Regions.
- Programming the customer Secure Silicon Region is allowed using the Word or Write Buffer Programming commands.
- ASO Exit using legacy Secure Silicon Exit command for backward software compatibility.
- ASO Exit using the common exit command for all ASO - alternative for a consistent exit method.

#### 5.4.6.4 Lock Register ASO

The system can access the Lock Register by issuing the Lock Register entry command sequence during Read Mode. This entry command does not use a sector address from the entry command. The Lock Register appears at word location 0 in the device address space. All other locations in the device address space are undefined.

The Lock Register ASO allows the following activities:

- Read Lock Register, using device address location 0.
- Program the customer Lock Register using a modified Word Programming command.
- ASO Exit using legacy Command Set Exit command for backward software compatibility.
- ASO Exit using the common exit command for all ASO - alternative for a consistent exit method.

#### 5.4.6.5 Password ASO

The system can access the Password ASO by issuing the Password entry command sequence during Read Mode. This entry command does not use a sector address from the entry command. The Password appears at word locations 0 to 3 in the device address space. All other locations in the device address space are undefined.

The Password ASO allows the following activities:

- Read Password, using device address location 0 to 3.
- Program the Password using a modified Word Programming command.
- Unlock the PPB Lock bit with the Password Unlock command.
- ASO Exit using legacy Command Set Exit command for backward software compatibility.
- ASO Exit using the common exit command for all ASO - alternative for a consistent exit method.

#### 5.4.6.6 PPB ASO

The system can access the PPB ASO by issuing the PPB entry command sequence during Read Mode. This entry command does not use a sector address from the entry command. The PPB bit for a sector appears in bit 0 of all word locations in the sector.

The PPB ASO allows the following activities:

- Read PPB protection status of a sector in bit 0 of any word in the sector.
- Program the PPB bit using a modified Word Programming command.
- Erase all PPB bits with the PPB erase command.
- ASO Exit using legacy Command Set Exit command for backward software compatibility.
- ASO Exit using the common exit command for all ASO - alternative for a consistent exit method.

#### 5.4.6.7 PPB Lock ASO

The system can access the PPB Lock ASO by issuing the PPB Lock entry command sequence during Read Mode. This entry command does not use a sector address from the entry command. The global PPB Lock bit appears in bit 0 of all word locations in the device.

The PPB Lock ASO allows the following activities:

- Read PPB Lock protection status in bit 0 of any word in the device address space.
- Set the PPB Lock bit using a modified Word Programming command.
- ASO Exit using legacy Command Set Exit command for backward software compatibility.
- ASO Exit using the common exit command for all ASO - alternative for a consistent exit method.

#### 5.4.6.8 DYB ASO

The system can access the DYB ASO by issuing the DYB entry command sequence during Read Mode. This entry command does not use a sector address from the entry command. The DYB bit for a sector appears in bit 0 of all word locations in the sector.

The DYB ASO allows the following activities:

- Read DYB protection status of a sector in bit 0 of any word in the sector.
- Set the DYB bit using a modified Word Programming command.
- Clear the DYB bit using a modified Word Programming command.
- ASO Exit using legacy Command Set Exit command for backward software compatibility.
- ASO Exit using the common exit command for all ASO - alternative for a consistent exit method.

#### 5.4.6.9 Software (Command) Reset / ASO exit

Software reset is part of the command set (See Table 7.1 on page 55) that also returns the EAC to standby state and must be used for the following conditions:

- Exit ID/CFI mode
- Clear timeout bit (DQ5) for data polling when timeout occurs

Software Reset does not affect EA mode. Reset commands are ignored once programming or erasure has begun, until the operation is complete. Software Reset does not affect outputs; it serves primarily to return to Read Mode from an ASO mode or from a failed program or erase operation.

Software Reset may cause a return to Read Mode from undefined states that might result from invalid command sequences. However, a Hardware Reset may be required to return to normal operation from some undefined states.

There is no software reset latency requirement. The reset command is executed during the $t_{WPH}$ period.

#### 5.4.6.10 ECC Status ASO

The system can access the ECC Status ASO by issuing the ECC Status entry command sequence during Read Mode. The contents of the ECC Status ASO indicates, for the selected ECC page, whether ECC protection has corrected an error in the eight-bit error correction code or the 16 Words of data in the ECC page.

The ECC Status ASO allows the following activities:

- Read ECC Status for the selected page.

## 5.5 Status Monitoring

There are three methods for monitoring EA status. Previous generations of the S29GL flash family used the methods called Data Polling and Ready/Busy# (RY/BY#) Signal. These methods are still supported by the S29GL-S family. One additional method is reading the Status Register.

### 5.5.1 Status Register

The status of program and erase operations is provided by a single 16-bit status register. The status is receiver by writing the Status Register Read command followed by a read access. When the Status Register read command is issued, the current status is captured (by the rising edge of WE#) into the register and the ASO is entered. The contents of the status register is aliased (overlaid) on the full memory address space. Any valid read (CE# and OE# low) access while in the Status Register ASO will exit the ASO (with the rising edge of CE# or OE# for $t_{CEPH}/t_{OEPH}$ time) and return to the address space map in use when the Status Register Read command was issued.

The status register contains bits related to the results - success or failure - of the most recently completed Embedded Algorithms (EA):

- Erase Status (bit 5),
- Program Status (bit 4),
- Write Buffer Abort (bit 3),
- Sector Locked Status (bit 1),
- RFU (bit 0).

and, bits related to the current state of any in process EA:

- Device Busy (bit 7),
- Erase Suspended (bit 6),
- Program Suspended (bit 2),

The current state bits indicate whether an EA is in process, suspended, or completed.

The upper 8 bits (bits 15:8) are reserved. These have undefined High or Low value that can change from one status read to another. These bits should be treated as don't care and ignored by any software reading status.

The Soft Reset Command will clear to 0 bits [5, 4, 1, 0] of the status register if Status Register bit 3 =0. It will not affect the current state bits. The Clear Status Register Command will clear to 0 the results related bits of the status register but will not affect the current state bits.

**Table 5.2** Status Register

| Bit # | 15:8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Bit Description | Reserved | Device Ready Bit | Erase Suspend Status Bit | Erase Status Bit | Program Status Bit | Write Buffer Abort Status Bit | Program Suspend Status Bit | Sector Lock Status Bit | Reserved |
| Bit Name | | DRB | ESSB | ESB | PSB | WBASB | PSSB | SLSB | |
| Reset Status | X | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Busy Status | Invalid | 0 | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid |
| Ready Status | X | 1 | 0 = No Erase in Suspension<br>1 = Erase in Suspension | 0 = Erase successful<br>1 = Erase fail | 0 = Program successful<br>1 = Program fail | 0 = Program not aborted<br>1 = Program aborted during Write to Buffer command | 0 = No Program in suspension<br>1 = Program in suspension | 0 = Sector not locked during operation<br>1 = Sector locked error | X |

***Notes:***
1. *Bits 15 thru 8, and 0 are reserved for future use and may display as 0 or 1. These bits should be ignored (masked) when checking status.*
2. *Bit 7 is 1 when there is no Embedded Algorithm in progress in the device.*
3. *Bits 6 thru 1 are valid only if Bit 7 is 1.*
4. *All bits are put in their reset status by cold reset or warm reset.*

5. *Bits 5, 4, 3, and 1 are cleared to 0 by the Clear Status Register command or Reset command.*
6. *Upon issuing the Erase Suspend Command, the user must continue to read status until DRB becomes 1.*
7. *ESSB is cleared to 0 by the Erase Resume Command.*
8. *ESB reflects success or failure of the most recent erase operation.*
9. *PSB reflects success or failure of the most recent program operation.*
10. *During erase suspend, programming to the suspended sector, will cause program failure and set the Program status bit to 1.*
11. *Upon issuing the Program Suspend Command, the user must continue to read status until DRB becomes 1.*
12. *PSSB is cleared to 0 by the Program Resume Command.*
13. *SLSB indicates that a program or erase operation failed because the sector was locked.*
14. *SLSB reflects the status of the most recent program or erase operation.*

### 5.5.2 Data Polling Status

During an active Embedded Algorithm the EAC switches to the Data Polling ASO to display EA status to any read access. A single word of status information is aliased in all locations of the device address space. In the status word there are several bits to determine the status of an EA. These are referred to as DQ bits as they appear on the data bus during a read access while an EA is in progress. DQ bits 15 to 8, DQ4, and DQ0 are reserved and provide undefined data. Status monitoring software must mask the reserved bits and treat them as don't care. Table 5.3 on page 39 and the following subsections describe the functions of the remaining bits.

#### 5.5.2.1 DQ7: Data# Polling

The Data# Polling bit, DQ7, indicates to the host system whether an Embedded Algorithm is in progress or has completed. Data# Polling is valid after the rising edge of the final WE# pulse in the program or erase command sequence. Note that the Data# Polling is valid only for the last word being programmed in the write-buffer-page during Write Buffer Programming. Reading Data# Polling status on any word other than the last word to be programmed in the write-buffer-page will return false status information.

During the Embedded Program algorithm, the device outputs on DQ7 the complement of the data bit programmed to DQ7. This DQ7 status also applies to programming during Erase Suspend. When the Embedded Program algorithm is complete, the device outputs the data bit programmed to bit 7 of the last word programmed. In case of a Program Suspend, the device allows only reading array data. If a program address falls within a protected sector, Data# Polling on DQ7 is active for approximately 20 µs, then the device returns to reading array data.

During the Embedded Erase or Blank Check algorithms, Data# Polling produces a 0 on DQ7. When the algorithm is complete, or if the device enters the Erase Suspend mode, Data# Polling produces a 1 on DQ7. This is analogous to the complement / true datum output described for the Embedded Program algorithm: the erase function changes all the bits in a sector to 1; prior to this, the device outputs the complement or '0'. The system must provide an address within the sector selected for erasure to read valid status information on DQ7.

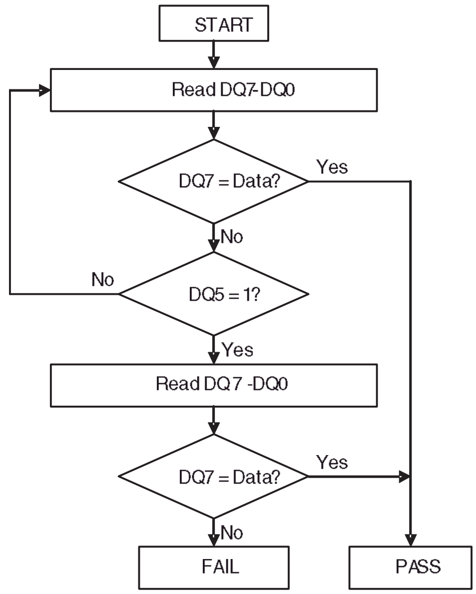
After an erase command sequence is written, if the sector selected for erasing is protected, Data# Polling on DQ7 is active for approximately 100 µs, then the device returns to reading array data.

When the system detects DQ7 has changed from the complement to true data, it can read valid data at DQ15-DQ0 on the following read cycles. This is because DQ7 may change asynchronously with DQ6-DQ0 while Output Enable (OE#) is asserted Low. This is illustrated in Figure 11.17 on page 87. Table 5.3 on page 39 shows the outputs for Data# polling on DQ7. Figure 5.2 on page 25 shows the Data# polling algorithm use in Write Buffer Programming.

Valid DQ7 data polling status may only be read from:

- the address of the last word loaded into the Write Buffer for a Write Buffer programming operation;
- the location of a single word programming operation;
- or a location in a sector being erased or blank checked;
- or a location in any sector during chip erase.

Figure 5.5 Data# Polling Algorithm




***Note:***

*1. DQ7 should be rechecked even if DQ5 = 1 because DQ7 may change simultaneously with DQ5.*

### 5.5.2.2 DQ6: Toggle Bit I

Toggle Bit I on DQ6 indicates whether an Embedded Program or Erase algorithm is in progress or complete, or whether the device has entered the Program Suspend or Erase Suspend mode. Toggle Bit I may be read at any address, and is valid after the rising edge of the final WE# pulse in the command sequence (prior to the program or erase operation).

During an Embedded Program or Erase algorithm operation, successive read cycles to any address cause DQ6 to toggle. (The system may use either OE# or CE# to control the read cycles). When the operation is complete, DQ6 stops toggling.

After an erase command sequence is written, if the sector selected for erasing is protected, DQ6 toggles for approximately 100 µs, then the EAC returns to standby (Read Mode). If the selected sector is not protected, the Embedded Erase algorithm erases the unprotected sector.

The system can use DQ6 and DQ2 together to determine whether a sector is actively erasing or erase-suspended. When the device is actively erasing (that is, the Embedded Erase algorithm is in progress), DQ6 toggles. When the device enters the Program Suspend mode or Erase Suspend mode, DQ6 stops toggling. However, the system must also use DQ2 to determine which sectors are erasing, or erase-suspended. Alternatively, the system can use DQ7 (see DQ7: Data# Polling on page 35).

DQ6 also toggles during the erase-suspend-program mode, and stops toggling once the Embedded Program algorithm is complete.

Table 5.3 on page 39 shows the outputs for Toggle Bit I on DQ6. Figure 5.6 on page 37 shows the toggle bit algorithm in flowchart form, and the Reading Toggle Bits DQ6/DQ2 on page 37 explains the algorithm. Figure 5.6 on page 37 shows the toggle bit timing diagrams. Figure 5.2 on page 25 shows the differences between DQ2 and DQ6 in graphical form. See also DQ2: Toggle Bit II on page 37.

### 5.5.2.3 DQ3: Sector Erase Timer

After writing a sector erase command sequence, the system may read DQ3 to determine whether or not erasure has begun. See Sector Erase on page 29 for more details.

After the sector erase command is written, the system should read the status of DQ7 (Data# Polling) or DQ6 (Toggle Bit I) to ensure that the device has accepted the command sequence, and then read DQ3. If DQ3 is 1, the Embedded Erase algorithm has begun; all further commands (except Erase Suspend) are ignored until the erase operation is complete. Table 5.3 on page 39 shows the status of DQ3 relative to the other status bits.

#### 5.5.2.4 DQ2: Toggle Bit II

Toggle Bit II on DQ2, when used with DQ6, indicates whether a particular sector is actively erasing (that is, the Embedded Erase algorithm is in progress), or whether that sector is erase-suspended. Toggle Bit II is valid after the rising edge of the final WE# pulse in the command sequence.

DQ2 toggles when the system reads at addresses within the sector selected for erasure. (The system may use either OE# or CE# to control the read cycles). But DQ2 cannot distinguish whether the sector is actively erasing or is erase-suspended. DQ6, by comparison, indicates whether the device is actively erasing, or is in Erase Suspend, but cannot distinguish if the sector is selected for erasure. Thus, both status bits are required for sector and mode information. Refer to Table 5.3 on page 39 to compare outputs for DQ2 and DQ6. Figure 5.5 on page 36 shows the toggle bit algorithm in flowchart form, and the Reading Toggle Bits DQ6/DQ2 on page 37 explains the algorithm. See also Figure 5.6 on page 37 shows the toggle bit timing diagram. Figure 5.2 on page 25 shows the differences between DQ2 and DQ6 in graphical form.

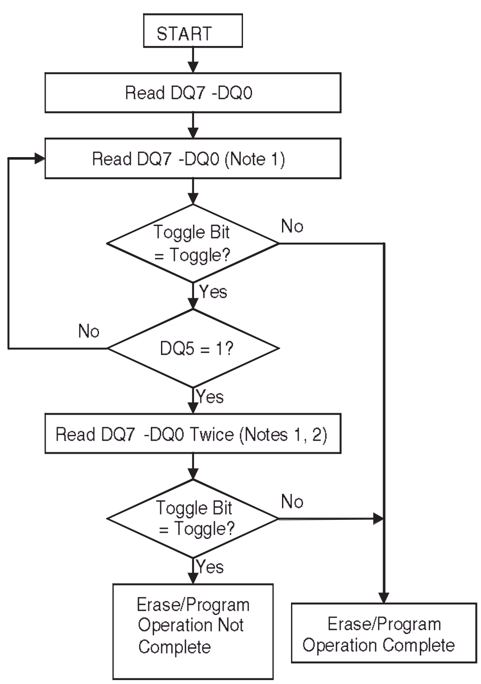
#### 5.5.2.5 Reading Toggle Bits DQ6/DQ2

Refer to Figure 5.5 on page 36 for the following discussion. Whenever the system initially begins reading toggle bit status, it must read DQ7-DQ0 at least twice in a row to determine whether a toggle bit is toggling. Typically, the system would note and store the value of the toggle bit after the first read. After the second read, the system would compare the new value of the toggle bit with the previous value. If the toggle bit is not toggling, the device has completed the program or erases operation. The system can read array data on DQ15-DQ0 on the following read cycle.

However, if after the initial two read cycles, the system determines that the toggle bit is still toggling, the system also should note whether the value of DQ5 is High (see DQ5: Exceeded Timing Limits on page 38). If it is, the system should then determine again whether the toggle bit is toggling, since the toggle bit may have stopped toggling just as DQ5 went High. If the toggle bit is no longer toggling, the device has successfully completed the program or erase operation. If it is still toggling, the device did not complete the operation successfully, and the system must write the reset command to return to reading array data.

The remaining scenario is that the system initially determines that the toggle bit is toggling and DQ5 has not gone High. The system may continue to monitor the toggle bit and DQ5 through successive read cycles, determining the status as described in the previous paragraph. Alternatively, it may choose to perform other system tasks. In this case, the system must start at the beginning of the algorithm when it returns to determine the status of the operation (top of Figure 5.6 on page 37).

**Figure 5.6** Toggle Bit Program




***Notes:***
1. *Read toggle bit twice to determine whether or not it is toggling. See text.*
2. *Recheck toggle bit because it may stop toggling as DQ5 changes to 1. See text.*

#### 5.5.2.6 DQ5: Exceeded Timing Limits

DQ5 indicates whether the program or erase time has exceeded a specified internal pulse count limit. Under these conditions DQ5 produces a 1. This is a failure condition that indicates the program or erase cycle was not successfully completed. The system must issue the reset command to return the device to reading array data.

When a timeout occurs, the software must send a reset command to clear the timeout bit (DQ5) and to return the EAC to read array mode. In this case, it is possible that the flash will continue to communicate busy for up to 2 µs after the reset command is sent.

#### 5.5.2.7 DQ1: Write-to-Buffer Abort

DQ1 indicates whether a Write-to-Buffer operation was aborted. Under these conditions DQ1 produces a 1. The system must issue the Write-to-Buffer-Abort-Reset command sequence to return the EAC to standby (Read Mode) and the Status Register failed bits are cleared. See Write Buffer Programming on page 24 for more details.

**Table 5.3** Data Polling Status

| Operation | | DQ7 (Note 2) | DQ6 | DQ5 (Note 1) | DQ3 | DQ2 (Note 2) | DQ1 (Note 4) | RY/BY# |
|---|---|---|---|---|---|---|---|---|
| Standard Mode | Embedded Program Algorithm | DQ7# | Toggle | 0 | N/A | No Toggle | 0 | 0 |
| | Reading within Erasing Sector | 0 | Toggle | 0 | 1 | Toggle | N/A | 0 |
| | Reading Outside erasing Sector | 0 | Toggle | 0 | 1 | No Toggle | N/A | 0 |
| Program Suspend Mode (Note 3) | Reading within Program Suspended Sector | INVALID (Not Allowed) | INVALID (Not Allowed) | INVALID (Not Allowed) | INVALID (Not Allowed) | INVALID (Not Allowed) | INVALID (Not Allowed) | 1 |
| | Reading within Non-Program Suspended Sector | Data | Data | Data | Data | Data | Data | 1 |
| Erase Suspend Mode | Reading within Erase Suspended Sector | 1 | No Toggle | 0 | N/A | Toggle | N/A | 1 |
| | Reading within Non-Erase Suspend Sector | Data | Data | Data | Data | Data | Data | 1 |
| | Programming within Non-Erase Suspended Sector | DQ7# | Toggle | 0 | N/A | N/A | N/A | 0 |
| Write-to-Buffer (Notes 4, 5) | BUSY State | DQ7# | Toggle | 0 | N/A | No Toggle | 0 | 0 |
| | Exceeded Timing Limits | DQ7# | Toggle | 1 | N/A | N/A | 0 | 0 |
| | ABORT State | DQ7# | Toggle | 0 | N/A | N/A | 1 | 0 |

***Notes:***
1. *DQ5 switches to '1' when an Embedded Program or Embedded Erase operation has exceeded the maximum timing limits. See DQ5: Exceeded Timing Limits on page 38 for more information.*
2. *DQ7 and DQ2 require a valid address when reading status information. Refer to the appropriate subsection for further details.*
3. *Data are invalid for addresses in a Program Suspended Line. All addresses other than the program suspended line can be read for valid data.*
4. *DQ1 indicates the Write-to-Buffer ABORT status during Write-Buffer-Programming operations.*
5. *Applies only to program operations.*

## 5.6 Error Types and Clearing Procedures

There are three types of errors reported by the embedded operation status methods. Depending on the error type, the status reported and procedure for clearing the error status is different. Following is the clearing of error status:

- If an ASO was entered before the error the device remains entered in the ASO awaiting ASO read or a command write.
- If an erase was suspended before the error the device returns to the erase suspended state awaiting flash array read or a command write.
- Otherwise, the device will be in standby state awaiting flash array read or a command write.

### 5.6.1 Embedded Operation Error

If an error occurs during an embedded operation (program, erase, blank check, or password unlock) the device (EAC) remains busy. The RY/BY# output remains Low, data polling status continues to be overlaid on all address locations, and the status register shows ready with valid status bits. The device remains busy until the error status is detected by the host system status monitoring and the error status is cleared.

During embedded algorithm error status the Data Polling status will show the following:

- DQ7 is the inversion of the DQ7 bit in the last word loaded into the write buffer or last word of the password in the case of the password unlock command. DQ7 = 0 for an erase or blank check failure
- DQ6 continues to toggle
- DQ5 = 1; Failure of the embedded operation
- DQ4 is RFU and should be treated as don't care (masked)
- DQ3 = 1 to indicate embedded sector erase in progress
- DQ2 continues to toggle, independent of the address used to read status
- DQ1 = 0; Write buffer abort error
- DQ0 is RFU and should be treated as don't care (masked)

During embedded algorithm error status the Status Register will show the following:

- SR[7] = 1; Valid status displayed
- SR[6] = X; May or may not be erase suspended during the EA error
- SR[5] = 1 on erase or blank check error; else = 0
- SR[4] = 1 on program or password unlock error; else = 0
- SR[3] = 0; Write buffer abort
- SR[2] = 0; Program suspended
- SR[1] = 0; Protected sector
- SR[0] = X; RFU, treat as don't care (masked)

When the embedded algorithm error status is detected, it is necessary to clear the error status in order to return to normal operation, with RY/BY# High, ready for a new read or command write. The error status can be cleared by writing:

- Reset command
- Status Register Clear command

Commands that are accepted during embedded algorithm error status are:

- Status Register Read
- Reset command
- Status Register Clear command

### 5.6.2 Protection Error

If an embedded algorithm attempts to change data within a protected area (program, or erase of a protected sector or OTP area) the device (EAC) goes busy for a period of 20 to 100 µs then returns to normal operation. During the busy period the RY/BY# output remains Low, data polling status continues to be overlaid on all address locations, and the status register shows not ready with invalid status bits (SR[7] = 0).

During the protection error status busy period the data polling status will show the following:

- DQ7 is the inversion of the DQ7 bit in the last word loaded into the write buffer. DQ7 = 0 for an erase failure
- DQ6 continues to toggle, independent of the address used to read status
- DQ5 = 0; to indicate no failure of the embedded operation during the busy period
- DQ4 is RFU and should be treated as don't care (masked)
- DQ3 = 1 to indicate embedded sector erase in progress
- DQ2 continues to toggle, independent of the address used to read status
- DQ1 = 0; Write buffer abort error
- DQ0 is RFU and should be treated as don't care (masked)

Commands that are accepted during the protection error status busy period are:

- Status Register Read

When the busy period ends the device returns to normal operation, the data polling status is no longer overlaid, RY/BY# is High, and the status register shows ready with valid status bits. The device is ready for flash array read or write of a new command.

After the protection error status busy period the Status Register will show the following:

- SR[7] = 1; Valid status displayed
- SR[6] = X; May or may not be erase suspended after the protection error busy period
- SR[5] = 1 on erase error, else = 0
- SR[4] = 1 on program error, else = 0
- SR[3] = 0; Program not aborted
- SR[2] = 0; No Program in suspension
- SR[1] = 1; Error due to attempting to change a protected location
- SR[0] = X; RFU, treat as don't care (masked)

Commands that are accepted after the protection error status busy period are:

- Any command

### 5.6.3 Write Buffer Abort

If an error occurs during a Write to Buffer command the device (EAC) remains busy. The RY/BY# output remains Low, data polling status continues to be overlaid on all address locations, and the status register shows ready with valid status bits. The device remains busy until the error status is detected by the host system status monitoring and the error status is cleared.

During write to buffer abort (WBA) error status the Data Polling status will show the following:

- DQ7 is the inversion of the DQ7 bit in the last word loaded into the write buffer
- DQ6 continues to toggle, independent of the address used to read status
- DQ5 = 0; to indicate no failure of the programming operation. WBA is an error in the values input by the Write to Buffer command before the programming operation can begin
- DQ4 is RFU and should be treated as don’t care (masked)
- DQ3 is don't care after program operation as no erase is in progress. If the Write Buffer Program operation was started after an erase operation had been suspended then DQ3 = 1. If there was no erase operation in progress then DQ3 is a don't care and should be masked.
- DQ2 does not toggle after program operation as no erase is in progress. If the Write Buffer Program operation was started after an erase operation had been suspended then DQ2 will toggle in the sector where the erase operation was suspended and not in any other sector. If there was no erase operation in progress then DQ2 is a don't care and should be masked.
- DQ1 = 1: Write buffer abort error
- DQ0 is RFU and should be treated as don’t care (masked)

During embedded algorithm error status the Status Register will show the following:

- SR[7] = 1; Valid status displayed
- SR[6] = X; May or may not be erase suspended during the WBA error status
- SR[5] = 0; Erase successful
- SR[4] = 1; Programming related error
- SR[3] = 1; Write buffer abort
- SR[2] = 0; No Program in suspension
- SR[1] = 0; Sector not locked during operation
- SR[0] = X; RFU, treat as don’t care (masked)

When the WBA error status is detected, it is necessary to clear the error status in order to return to normal operation, with RY/BY# High, ready for a new read or command write. The error status can be cleared and device returned to normal operation by writing:

- Write Buffer Abort Reset command

  –Clears the status register and returns to normal operation
- Status Register Clear command

Commands that are accepted during embedded algorithm error status are:

- Status Register Read
- Write Buffer Abort Reset command
- Status Register Clear command

## 5.7 Embedded Algorithm Performance Table

**Table 5.4** Embedded Algorithm Characteristics (-40°C to +85°C)

| Parameter | | Typ (Note 2) | Max (Note 3) | Unit | Comments |
|---|---|---|---|---|---|
| Sector Erase Time 128 kbyte | | 275 | 1100 | ms | Includes pre-programming prior to erasure (Note 5) |
| Single Word Programming Time (Note 1) | | 125 | 400 | µs | |
| Buffer Programming Time | 2-byte (Note 1) | 125 | 750 | µs | |
| | 32-byte (Note 1) | 160 | 750 | | |
| | 64-byte (Note 1) | 175 | 750 | | |
| | 128-byte (Note 1) | 198 | 750 | | |
| | 256-byte (Note 1) | 239 | 750 | | |
| | 512-byte | 340 | 750 | | |
| Effective Write Buffer Program Operation per Word | 512-byte | 1.33 | – | µs | |
| Sector Programming Time 128 kB (full Buffer Programming) | | 108 | 192 | ms | (Note 6) |
| Erase Suspend/Erase Resume ($t_{ESL}$) | | – | 40 | µs | |
| Program Suspend/Program Resume ($t_{PSL}$) | | – | 40 | µs | |
| Erase Resume to next Erase Suspend ($t_{ERS}$) | | 100 | – | µs | Minimum of 60 ns but ≥ typical periods are needed for Erase to progress to completion. |
| Program Resume to next Program Suspend ($t_{PRS}$) | | 100 | – | µs | Minimum of 60 ns but ≥ typical periods are needed for Program to progress to completion. |
| Blank Check | | 6.2 | 8.5 | ms | |
| NOP (Number of Program-operations, per Line) | | – | 256 | | |

***Notes:***
1. *Not 100% tested.*
2. *Typical program and erase times assume the following conditions: 25 °C, 3.0 V $V_{CC}$, 10,000 cycle, and a random data pattern.*
3. *Under worst case conditions of 90 °C, $V_{CC}$ = 2.70 V, 100,000 cycles, and a random data pattern.*
4. *Effective write buffer specification is based upon a 512-byte write buffer operation.*
5. *In the pre-programming step of the Embedded Erase algorithm, all words are programmed to 0000h before Sector and Chip erasure.*
6. *System-level overhead is the time required to execute the bus-cycle sequence for the program command. See Table 7.1 on page 55 for further information on command definitions.*

**Table 5.5** Embedded Algorithm Characteristics (-40°C to +105°C)

| Parameter | | Typ (Note 2) | Max (Note 3) | Unit | Comments |
|---|---|---|---|---|---|
| Sector Erase Time 128 kbyte | | 275 | 1100 | ms | Includes pre-programming prior to erasure (Note 5) |
| Single Word Programming Time (Note 1) | | 125 | 400 | µs | |
| Buffer Programming Time | 2-byte (Note 1) | 150 | 1050 | µs | |
| | 32-byte (Note 1) | 200 | 1050 | | |
| | 64-byte (Note 1) | 220 | 1050 | | |
| | 128-byte (Note 1) | 250 | 1050 | | |
| | 256-byte (Note 1) | 320 | 1050 | | |
| | 512-byte | 420 | 1050 | | |
| Effective Write Buffer Program Operation per Word | 512-byte | 1.64 | – | µs | |
| Sector Programming Time 128 kB (full Buffer Programming) | | 108 | 269 | ms | (Note 6) |
| Erase Suspend/Erase Resume ($t_{ESL}$) | | – | 50 | µs | |
| Program Suspend/Program Resume ($t_{PSL}$) | | – | 50 | µs | |
| Erase Resume to next Erase Suspend ($t_{ERS}$) | | 100 | – | µs | Minimum of 60 ns but ≥ typical periods are needed for Erase to progress to completion. |
| Program Resume to next Program Suspend ($t_{PRS}$) | | 100 | – | µs | Minimum of 60 ns but ≥ typical periods are needed for Program to progress to completion. |
| Blank Check | | 7.6 | 9.0 | ms | |
| NOP (Number of Program-operations, per Line) | | – | 1 per 16 word | | |

***Notes:***
1. *Not 100% tested.*
2. *Typical program and erase times assume the following conditions: 25 °C, 3.0 V $V_{CC}$, 10,000 cycle, and a random data pattern.*
3. *Under worst case conditions of 105 °C, $V_{CC}$ = 2.70 V, 100,000 cycles, and a random data pattern.*
4. *Effective write buffer specification is based upon a 512-byte write buffer operation.*
5. *In the pre-programming step of the Embedded Erase algorithm, all words are programmed to 0000h before Sector and Chip erasure.*
6. *System-level overhead is the time required to execute the bus-cycle sequence for the program command. See Table 7.1 on page 55 for further information on command definitions.*

### 5.7.1 Command State Transitions

**Table 5.6** Read Command State Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Blank Check | CFI Entry |
|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h | (SA)555h | (SA)55h |
| | Data | RD | xF0h | x70h | x71h | xAAh | x33h | x98h |
| READ | – | READ | READ | READSR (READ) | READ | READUL1 | – | CFI |
| | Read Protect = False | | | | | | BLCK | |
| READSR | – | (return) | – | – | – | – | – | – |

**Table 5.7** Read Unlock Command State Transition

| Current State | Command and Condition | Read | Status Register Read Enter | Unlock 2 | Word Program Entry | Write to Buffer Enter | Erase Enter | ID (Auto-select) Entry | SSR Entry | Lock Register Entry | Password ASO Entry | PPB Entry | PPB Lock Entry | DYB ASO Entry |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | x555h | x2AAh | x555h | (SA)xh | x555h | (SA)555h | (SA)555h | x555h | x555h | x555h | x555h | x555h |
| | Data | RD | x70h | x55h | xA0h | x25h | x80h | x90h | x88h | x40h | x60h | xC0h | x50h | xE0h |
| READUL1 | – | READUL1 | READSR (READ) | READUL2 | – | – | – | – | – | – | – | – | – | – |
| READUL2 | Read Protect = True | READUL2 | READSR (READ) | – | – | – | – | CFI | – | – | PP | – | – | – |
| | Read Protect = False | | | | PG1 | WB | ER | | SSR | LR | | | PPBLB | DYB |
| | Read Protect = False and LR(8) = 0 | | | | | | | | | | | PPB | | |

**Table 5.8** Erase State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Unlock 2 | Chip Erase Start | Sector Erase Start | Erase Suspend Enhanced Method (2) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h | x2AAh | x555h | (SA)xh | xh |
| | Data | RD | xF0h | x70h | x71h | xAAh | x55h | x10h | x30h | xB0h |
| ER | – | ER | – | READSR (READ) | – | ERUL1 | – | – | – | – |
| ERUL1 | – | ERUL1 | – | READSR (READ) | – | – | ERUL2 | – | – | – |
| ERUL2 | – | ERUL2 | – | READSR (READ) | – | – | – | CER | SER | – |
| CER (1) | – | CER | – | ERSR (CER) | – | – | – | – | – | – |
| SER (1) | SR(7) = 0 | SER | – | ERSR (SER) | – | – | – | – | – | ESR (ES) |
| | SR(7) = 1 | | READ | | READ | | | | | |
| BLCK (1) | SR(7) = 0 | BLCK | – | ERSR (BLCK) | – | – | – | – | – | – |
| | SR(7) = 1 | | READ | | READ | | | | | |
| ERSR | – | (return) | – | – | – | – | – | – | – | – |

***Notes:***
1. *State will automatically move to READ state at the completion of the operation.*
2. *Also known as Erase Suspend/Program Suspend Legacy Method.*

**Table 5.9** Erase Suspend State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Sector Erase Start |
|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h | (SA)xh |
| | Data | RD | xF0h | x70h | x71h | xAAh | x30h |
| ESR (1) | – | ESR | – | ERSR (ESR) | – | – | – |
| ES | SR(7) = 0 | ES | ES | ESSR (ES) | ES | ESUL1 | – |
| | SR(7) = 1 | | | | | | SER |
| ESSR | – | (return) | – | – | – | – | – |

**Note:**

1. *State will automatically move to ES state by $t_{ESL}$.*

**Table 5.10** Erase Suspend Unlock State Command Transition

<table>
<tr><th>Current State</th><th>Command and Condition</th><th>Read</th><th>Software Reset / ASO Exit</th><th>Status Register Read Enter</th><th>Unlock 1</th><th>Word Program Entry</th><th>Write to Buffer Enter</th><th>Write-to-Buffer-Abort Reset Start</th><th>Erase Resume Enhanced Method (1)</th><th>DYB ASO Entry</th><th colspan="4">NOT a valid “Write-to-Buffer-Abort Reset” Command</th></tr>
<tr><td></td><td>Address</td><td>RA</td><td>xh</td><td>x555h</td><td>x2AAh</td><td>x555h</td><td>(SA)xh</td><td>x555h</td><td>xh</td><td>x555h</td><td>NOT x555h</td><td>xh</td><td>NOT x2AAh</td><td>xh</td></tr>
<tr><td></td><td>Data</td><td>RD</td><td>xF0h</td><td>x70h</td><td>x55h</td><td>xA0h</td><td>x25h</td><td>xF0h</td><td>x30h</td><td>xE0h</td><td>xh</td><td>NOT xF0h</td><td>xh</td><td>NOT x55h</td></tr>
<tr><td rowspan="3">ESUL1</td><td>–</td><td rowspan="3">ESUL1</td><td rowspan="3">–</td><td rowspan="3">ESSR (ES)</td><td rowspan="3">ESUL2</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td>–</td><td>–</td></tr>
<tr><td>SR(3) = 1</td><td rowspan="2">ESPG</td><td rowspan="2">ESPG</td></tr>
<tr><td>DQ(1) = 1</td></tr>
<tr><td rowspan="4">ESUL2</td><td>–</td><td rowspan="4">ESUL2</td><td rowspan="2">ES</td><td rowspan="4">ESSR (ES)</td><td rowspan="4">–</td><td rowspan="4">ESPG1</td><td rowspan="4">ES_WB</td><td rowspan="2">–</td><td rowspan="4">SER</td><td>–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="4">–</td><td rowspan="4">–</td></tr>
<tr><td>Read Protect = False</td><td>ESDYB</td></tr>
<tr><td>SR(3) = 1</td><td rowspan="2">–</td><td rowspan="2">ES</td><td rowspan="2">–</td><td rowspan="2">ESPG</td><td rowspan="2">ESPG</td></tr>
<tr><td>DQ(1) = 1</td></tr>
</table>

**Note:**

1. *Also known as Erase Resume/Program Resume Legacy Method.*

**Table 5.11** Erase Suspend - DYB State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Command Set Exit Entry | Command Set Exit | DYB Set/ Clear Entry | Password Word Count |
|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | xh | xh | xh | xh |
| | Data | RD | xF0h | x70h | x71h | x90h | x00h | xA0h | x03h |
| ESDYB | – | ESDYB | ES | ESSR (ESDYB) | ESDYB | ESDYBEXT | – | ESDYBSET | – |
| ESDYBSET | – | ESDYBSET | – | – | – | – | – | – | – |
| ESDYBEXT | – | ESDYBEXT | – | – | – | – | ES | – | ES |

**Table 5.12** Erase Suspend - Program Command State Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Erase Suspend Enhanced Method (1) | ProgramSuspend Enhanced Method | Write Data |
|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h | xh | xh | xh |
| | Data | RD | xF0h | x70h | x71h | xAAh | xB0h | x51h | xh |
| ES_WB | WC > 256 or SA ≠ SA | ES_WB | – | – | – | – | – | – | ESPG |
| | WC ≤ 256 and SA = SA | | | | | | | | ES_WB_D |
| ES_WB_D | WC < 0 or Write Buffer ≠ Write Buffer | ES_WB_D | – | – | – | – | – | – | ESPG |
| | WC > 0 and Write Buffer = Write Buffer | | | | | | | | ES_WB_D |
| ESPG1 | – | ESPG1 | – | – | – | – | – | – | ESPG |
| ESPG | SR(7) = 0 | ESPG | – | ESPGSR (ESPG) | – | – | ESPSR (ESPG) | ESPSR (ESPG) | ESPG |
| | SR(7) = 1 | | ES | | ES | ESUL1 | | | |
| ESPGSR | – | (return) | – | – | – | – | – | – | (return) |

*Note:*
1. *Also known as Erase Suspend/Program Suspend Legacy Method.*

**Table 5.13** Erase Suspend - Program Suspend Command State Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Unlock 2 | Erase Resume Enhanced Method (2) | Program Resume Enhanced Method |
|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h | x2AAh | xh | xh |
| | Data | RD | xF0h | x70h | x71h | xAAh | x55h | x30h | x50h |
| ESPSR (1) | – | ESPSR | – | ESPGSR (ESPSR) | – | – | – | – | – |
| ESPS | – | ESPS | ESPS | ESPSSR (ESSP) | ESPS | ESPSUL1 | – | ESPG | ESPG |
| ESPSSR | – | (return) | – | – | – | – | – | – | – |
| ESPSUL1 | – | ESPSUL1 | – | ESPSSR (ESPS) | – | – | ESPSUL2 | – | – |
| ESPSUL2 | – | ESPSUL2 | – | ESPSSR (ESPS) | – | – | – | ESPG | ESPG |

*Notes:*
1. *State will automatically move to ESPS state by $t_{PSL}$.*
2. *Also known as Erase Resume/Program Resume Legacy Method.*

**Table 5.14** Program State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Program Buffer to flash (confirm) | Erase Suspend Enhanced Method (2) | Program Suspend Enhanced Method | Write Data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h | (SA)xh | xh | xh | xh |
| | Data | RD | xF0h | x70h | x71h | xAAh | x29h | xB0h | x51h | xh |

**Table 5.14** Program State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 | Program Buffer to flash (confirm) | Erase Suspend Enhanced Method (2) | Program Suspend Enhanced Method | Write Data |
|---|---|---|---|---|---|---|---|---|---|---|
| WB | WC > 256 or SA ≠ SA | WB | – | – | – | – | – | – | – | PG |
| | WC ≤ 256 and SA = SA | | | | | | | | | WB_D |
| WB_D | Write Buffer ≠ Write Buffer | WB_D | – | – | – | – | – | – | – | PG |
| | WC = 0 | | | | | | | | | PBF |
| | WC > 0 and Write Buffer = Write Buffer | | | | | | | | | WB_D |
| PBF | – | – | – | – | – | – | PG | – | – | PG |
| PG1 | – | PG1 | – | – | – | – | – | – | – | PG |
| PG (1) | SR(7) = 0 | PG | – | PGSR (PG) | – | – | – | PSR (PG) | PSR (PG) | PG |
| | SR(7) = 1 | | READ | | READ | WBUL1 | | – | – | |
| | SR(7) = 1 and SR(1) = 0 | | | | | | | | | |

***Notes:***
1. *State will automatically move to READ state at the completion of the operation.*
2. *Also known as Erase Suspend/Program Suspend Legacy Method.*

**Table 5.15** Program Unlock State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Unlock 2 | NOT a valid "Write-to-Buffer-Abort Reset" Command | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x2AAh | NOT x555h | xh | NOT x2AAh | xh |
| | Data | RD | xF0h | x70h | x55h | xh | NOT xF0h | xh | NOT x55h |
| WBUL1 | – | WBUL1 | – | – | WBUL2 | – | – | – | – |
| | SR(3) = 1 | | | | | | | PG | PG |
| | DQ(1) = 1 | | | | | | | | |
| WBUL2 | - | WBUL2 | READ | – | – | – | – | – | – |
| | SR(3) = 1 | | | | | PG | PG | | |
| | DQ(1) = 1 | | | | | | | | |
| PGSR | – | (return) | – | – | – | – | – | – | – |

**Table 5.16** Program Suspend State Command Transition

| Current State | Command and Condition | Read | Status Register Read Enter | Status Register Clear | Erase Resume Enhanced Method (2) | Program Resume Enhanced Method |
|---|---|---|---|---|---|---|
| | Address | RA | x555h | x555h | xh | xh |
| | Data | RD | x70h | x71h | x30h | x50h |
| PSR (1) | – | PSR | PGSR (PSR) | – | – | – |
| PS | – | PS | PSSR (PS) | PS | PG | PG |
| PSSR | – | (return) | – | – | – | – |

***Notes:***
1. *State will automatically move to PS state by $t_{PSL}$.*
2. *Also known as Erase Resume/Program Resume Legacy Method.*

**Table 5.17** Lock Register State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Command Set Exit Entry | Command Set Exit | PPB Lock Bit Set Entry | Password Word Count |
|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | xh | xh | xh | Xh |
| | Data | RD | xF0h | x70h | x71h | x90h | x00h | xA0h | x03h |
| LR | – | LR | READ | LRSR (LR) | LR | LREXT | – | LRPG1 | – |
| LRPG1 | – | LRPG1 | – | – | – | – | – | – | – |
| LRPG | – | LRPG | – | LRSR (LRPG) | – | – | – | – | – |
| LRSR | – | (return) | – | – | – | – | – | – | – |
| LREXT | – | LREXT | – | – | – | – | READ | – | READ |

**Table 5.18** CFI State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear |
|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h |
| | Data | RD | xF0h | x70h | x71h |
| CFI | – | CFI | READ | CFISR (CFI) | CFI |
| CFISR | – | (return) | – | – | – |

**Table 5.19** Secure Silicon Sector State Command Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Unlock 1 |
|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | x555h |
| | Data | RD | xF0h | x70h | x71h | xAAh |
| SSR | – | SSR | READ | SSRSR (SSR) | SSR | SSRUL1 |

**Table 5.20** Secure Silicon Sector Unlock State Command Transition

<table>
<tr><th>Current State</th><th>Command and Condition</th><th>Read</th><th>Software Reset / ASO Exit</th><th>Status Register Read Enter</th><th>Unlock 2</th><th>Word Program Entry</th><th>Write to Buffer Enter</th><th>Command Set Exit Entry</th><th colspan="4">NOT a valid “Write-to-Buffer-Abort Reset” Command</th></tr>
<tr><td></td><td>Address</td><td>RA</td><td>xh</td><td>x555h</td><td>x2AAh</td><td>x555h</td><td>(SA)xh</td><td>x555h</td><td>NOT x555h</td><td>xh</td><td>NOT x2AAh</td><td>xh</td></tr>
<tr><td></td><td>Data</td><td>RD</td><td>xF0h</td><td>x70h</td><td>x55h</td><td>xA0h</td><td>x25h</td><td>x90h</td><td>xh</td><td>NOT xF0h</td><td>xh</td><td>NOT x55h</td></tr>
<tr><td rowspan="3">SSRUL1</td><td>–</td><td rowspan="3">SSRUL1</td><td rowspan="3">READ</td><td rowspan="3">SSRSR (SSR)</td><td rowspan="3">SSRUL2</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">–</td><td>–</td><td>–</td></tr>
<tr><td>DQ(1) = 1</td><td rowspan="2">SSRPG</td><td rowspan="2">SSRPG</td></tr>
<tr><td>SR(3) = 1</td></tr>
<tr><td rowspan="3">SSRUL2</td><td>–</td><td rowspan="3">SSRUL2</td><td rowspan="3">SSR</td><td rowspan="3">–</td><td rowspan="3">–</td><td rowspan="3">SSRPG1</td><td rowspan="3">SSR_WB</td><td rowspan="3">SSREXT</td><td>–</td><td>–</td><td rowspan="3">–</td><td rowspan="3">–</td></tr>
<tr><td>DQ(1) = 1</td><td rowspan="2">SSRPG</td><td rowspan="2">SSRPG</td></tr>
<tr><td>SR(3) = 1</td></tr>
</table>

**Table 5.21** Secure Silicon Sector Program State Command Transition

<table>
<tr><th>Current State</th><th>Command and Condition</th><th>Read</th><th>Software Reset / ASO Exit</th><th>Status Register Read Enter</th><th>Status Register Clear</th><th>Unlock 1</th><th>Command Set Exit</th></tr>
<tr><td></td><td>Address</td><td>RA</td><td>xh</td><td>x555h</td><td>x555h</td><td>x555h</td><td>xh</td></tr>
<tr><td></td><td>Data</td><td>RD</td><td>xF0h</td><td>x70h</td><td>x71h</td><td>xAAh</td><td>x00h</td></tr>
<tr><td>SSRPG1</td><td>–</td><td>SSRPG1</td><td>–</td><td>–</td><td>SSRPG1</td><td>–</td><td>–</td></tr>
<tr><td rowspan="2">SSR_WB</td><td>WC > 256 or SA ≠ SA</td><td rowspan="2">SSR_WB</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td></tr>
<tr><td>WC ≤ 256 and SA = SA</td></tr>
<tr><td rowspan="2">SSR_WB_D</td><td>WC < 0 or Write Buffer ≠ Write Buffer</td><td rowspan="2">SSR_WB_D</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td></tr>
<tr><td>WC > 0 and Write Buffer = Write Buffer</td></tr>
<tr><td rowspan="5">SSRPG</td><td>SR(7) = 0</td><td rowspan="5">SSRPG</td><td rowspan="2">–</td><td rowspan="5">SSRSR (SSRPG)</td><td>–</td><td rowspan="3">–</td><td rowspan="5">–</td></tr>
<tr><td>SR(7) = 1</td><td rowspan="2">SSR</td></tr>
<tr><td>SR(7) = 1 and DQ(1) = 0</td><td>READ</td></tr>
<tr><td>DQ(1) = 1</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">SSRUL1</td></tr>
<tr><td>SR(3) = 1</td></tr>
<tr><td>SSRSR</td><td>–</td><td>(return)</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>SSREXT</td><td>–</td><td>SSREXT</td><td>–</td><td>SSRSR (SSR)</td><td>–</td><td>–</td><td>READ</td></tr>
</table>

**Table 5.22** Password Protection Command State Transition

<table>
<tr><th>Current State</th><th>Command and Condition</th><th>Read</th><th>Software Reset / ASO Exit</th><th>Status Register Read Enter</th><th>Status Register Clear</th><th>Password ASO Unlock Enter</th><th>Password ASO Unlock Start</th><th>Command Set Exit Entry</th><th>Command Set Exit</th><th>Program Entry</th><th>Password Word Count</th></tr>
<tr><td></td><td>Address</td><td>RA</td><td>xh</td><td>x555h</td><td>x555h</td><td>0h</td><td>0h</td><td>xh</td><td>xh</td><td>xh</td><td>Xh</td></tr>
<tr><td></td><td>Data</td><td>RD</td><td>xF0h</td><td>x70h</td><td>x71h</td><td>x25h</td><td>x29h</td><td>x90h</td><td>x00h</td><td>xA0h</td><td>x03h</td></tr>
<tr><td>PP</td><td>–</td><td>PP</td><td>READ</td><td>PPSR (PP)</td><td>PP</td><td>PPWB25</td><td>–</td><td>PPEXT</td><td>–</td><td>PPPG1</td><td>–</td></tr>
<tr><td>PPWB25</td><td>–</td><td>PPWB25</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>PPD</td></tr>
<tr><td rowspan="2">PPD</td><td>WC > 0</td><td>PPD</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td>–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td></tr>
<tr><td>WC ≤ 0</td><td>-</td><td>PPPG</td></tr>
<tr><td>PPPG1</td><td>–</td><td>PPPG1</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>PPPG</td><td>–</td><td>PPPG</td><td>–</td><td>PPSR (PPPG)</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>PPSR</td><td>–</td><td>(return)</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>PPEXT</td><td>–</td><td>PPEXT</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>READ</td><td>–</td><td>–</td></tr>
</table>

**Table 5.23** Non-Volatile Protection Command State Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Command Set Exit Entry | Command Set Exit | Program Entry | DYB Set Start | All PPB Erase Enter | All PPB Erase Start |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | xh | xh | xh | (SA)xh | Xh | 0h |
| | Data | RD | xF0h | x70h | x71h | x90h | x00h | xA0h | x00h | x80h | x30h |
| PPB | – | PPB | READ | PPBSR (PPB) | PPB | PPBEXT | – | PPBPG1 | – | PPBPG1 | – |
| PPBPG1 | – | PPBPG1 | READ | – | – | – | PPBPG | – | PPB | – | PPBER |
| PPBPG | SR(7) = 0 | PPBPG | – | PPBSR (PPBPG) | – | – | – | – | – | – | – |
| | SR(7) = 1 | | READ | | READ | | | | | | |
| PPBER | SR(7) = 0 | PPBER | – | PPBSR (PPBER) | – | – | – | – | – | – | – |
| | SR(7) = 1 | | READ | | READ | | | | | | |
| PPBSR | – | (return) | – | – | – | – | – | – | – | – | – |
| PPBEXT | – | PPBEXT | – | – | – | – | READ | - | - | – | – |

**Table 5.24** PPB Lock Bit Command State Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Command Set Exit Entry | Command Set Exit | Program Entry |
|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | xh | xh | xh |
| | Data | RD | xF0h | x70h | x71h | x90h | x00h | xA0h |
| PPBLB | – | PPBLB | READ | PPBLBSR (PPBLB) | PPBLB | PPBLBEXT | – | PPBLBSET |
| PPBLBSR | – | (return) | – | – | – | – | – | – |
| PPBLBSET | – | PPBLBSET | – | – | – | – | PPBLB | – |
| | LR(2) = 0 and LR(5) = 0 | | | | | | | |
| PPBLBEXT | – | PPBLBEXT | – | – | – | – | READ | – |

**Table 5.25** Volatile Sector Protection Command State Transition

| Current State | Command and Condition | Read | Software Reset / ASO Exit | Status Register Read Enter | Status Register Clear | Command Set Exit Entry | Command Set Exit | Program Entry | DYB Set Start | DYB Clear Start |
|---|---|---|---|---|---|---|---|---|---|---|
| | Address | RA | xh | x555h | x555h | xh | xh | xh | (SA)xh | (SA)xh |
| | Data | RD | xF0h | x70h | x71h | x90h | x00h | xA0h | x00h | x01h |
| DYB | – | DYB | READ | DYBSR (DYB) | DYB | DTBEXT | – | DYBSET | – | – |
| DYBSR | – | (return) | – | – | – | – | – | – | – | – |
| DYBSET | – | DYBSET | – | – | – | – | – | – | DYB | DYB |
| DYBEXT | – | DYBEXT | – | – | – | – | READ | – | – | – |

**Table 5.26** State Transition Definitions

| Current State | Command Transition | Definition |
|---|---|---|
| BLCK | Table 5.8 | Blank Check |
| CER | Table 5.8 | Chip Erase Start |
| CFI | Table 5.18 | ID (Autoselect) |
| CFISR | Table 5.18 | ID (Autoselect) - Status Register Read |
| DYB | Table 5.25 | DYB ASO |
| DYBEXT | Table 5.25 | DYB ASO - Command Exit |
| DYBSET | Table 5.25 | DYB ASO - Set |
| DYBSR | Table 5.25 | DYB ASO - Status Register Read |
| ER | Table 5.8 | Erase Enter |
| ERSR | Table 5.8 | Erase - Status Register Read |
| ERUL1 | Table 5.8 | Erase - Unlock Cycle 1 |
| ERUL2 | Table 5.8 | Erase - Unlock Cycle 2 |
| ES | Table 5.9 | Erase Suspended |
| ESDYB | Table 5.11 | Erase Suspended - DYB ASO |
| ESDYBEXT | Table 5.11 | Erase Suspended - DYB Command Exit |
| ESDYBSET | Table 5.11 | Erase Suspended - DYB Set/Clear |
| ESPG | Table 5.12 | Erase Suspended - Program |
| ESPGSR | Table 5.12 | Erase Suspended - Program - Status Register Read |
| ESPG1 | Table 5.12 | Erase Suspended - Word Program |
| ESPS | Table 5.13 | Erase Suspended - Program Suspended |
| ESPSR | Table 5.13 | Erase Suspended - Program Suspend |
| ESPSSR | Table 5.13 | Erase Suspended - Program Suspend - Status Register Read |
| ESPSUL1 | Table 5.13 | Erase Suspended - Program Suspend - Unlock 1 |
| ESPSUL2 | Table 5.13 | Erase Suspended - Program Suspend - Unlock 2 |
| ESR | Table 5.9 | Erase Suspend Request |
| ESSR | Table 5.9 | Erase Suspended - Status Register Read |
| ESUL1 | Table 5.10 | Erase Suspended - Unlock Cycle 1 |
| ESUL2 | Table 5.10 | Erase Suspended - Unlock Cycle 2 |
| ES_WB | Table 5.12 | Erase Suspended - Write to Buffer |
| ES_WB_D | Table 5.12 | Erase Suspended - Write to Buffer Data |
| LR | Table 5.17 | Lock Register |
| LREXT | Table 5.17 | Lock Register - Command Exit |
| LRPG | Table 5.17 | Lock Register - Program |
| LRPG1 | Table 5.17 | Lock Register - Program Start |
| LRSR | Table 5.17 | Lock Register - Status Register Read |
| PBF | Table 5.14 | Page Buffer Full |
| PG | Table 5.14 | Program |
| PGSR | Table 5.15 | Program - Status Register Read |
| PG1 | Table 5.14 | Word Program |

**Table 5.26** State Transition Definitions (Continued)

| Current State | Command Transition | Definition |
|---|---|---|
| PP | Table 5.22 | Password ASO |
| PPB | Table 5.23 | PPB |
| PPBER | Table 5.23 | PPB - Erase |
| PPBEXT | Table 5.23 | PPB - Command Exit |
| PPBLB | Table 5.24 | PPB Lock Bit |
| PPBLBEXT | Table 5.24 | PPB Lock Bit - Command Exit |
| PPBLBSET | Table 5.24 | PPB Lock Bit - Set |
| PPBLBSR | Table 5.24 | PPB Lock Bit - Status Register Read |
| PPBPG | Table 5.23 | PPB - Program |
| PPBPG1 | Table 5.23 | PPB - Program Request |
| PPBSR | Table 5.23 | PPB - Status Register Read |
| PPD | Table 5.22 | Password ASO - Data |
| PPEXT | Table 5.22 | Password ASO - Command Exit |
| PPPG | Table 5.22 | Password ASO - Program |
| PPPG1 | Table 5.22 | Password ASO - Program Request |
| PPSR | Table 5.22 | Password ASO - Status Register Read |
| PS | Table 5.16 | Program Suspended |
| PSR | Table 5.16 | Program Suspend Request |
| PSSR | Table 5.16 | Program Suspended - Status Register Read |
| PPWB25 | Table 5.22 | Password ASO - Unlock |
| READ | Table 5.6 | Read Array |
| READSR | Table 5.6 | Read Status Register |
| READUL1 | Table 5.7 | Read - Unlock Cycle 1 |
| READUL2 | Table 5.7 | Read - Unlock Cycle 2 |
| SER | Table 5.8 | Sector Erase Start |
| SSR | Table 5.19 | Secure Silicon |
| SSREXT | Table 5.21 | Secure Silicon - Command Exit |
| SSRPG | Table 5.21 | Secure Silicon - Program |
| SSRPG1 | Table 5.21 | Secure Silicon - Word Program |
| SSRSR | Table 5.21 | Secure Silicon - Status Register Read |
| SSRUL1 | Table 5.20 | Secure Silicon - Unlock Cycle 1 |
| SSRUL2 | Table 5.20 | Secure Silicon - Unlock Cycle 2 |
| SSR_WB | Table 5.21 | Secure Silicon - Write to Buffer |
| SSR_WB_D | Table 5.21 | Secure Silicon - Write to Buffer - Write Data |
| WB | Table 5.14 | Write to Buffer |
| WBUL1 | Table 5.15 | Write Buffer - Unlock Cycle 1 |
| WBUL2 | Table 5.15 | Write Buffer - Unlock Cycle 2 |
| WB_D | Table 5.14 | Write to Buffer Write Data |

# 6. Data Integrity

## 6.1 Erase Endurance

**Table 6.1** Erase Endurance

| Parameter | Minimum | Unit |
|---|---|---|
| Program/Erase cycles per main Flash array sectors | 100K | P/E cycle |
| Program/Erase cycles per PPB array or non-volatile register array | 100K | P/E cycle |

***Note:***
1. *Each write command to a non-volatile register causes a P/E cycle on the entire non-volatile register array. OTP bits and registers internally reside in a separate array that is not P/E cycled.*

## 6.2 Data Retention

**Table 6.2** Data Retention

| Parameter | Test Conditions | Minimum Time | Unit |
|---|---|---|---|
| Data Retention Time | 10K Program/Erase Cycles | 20 | Years |
| | 100K Program/Erase Cycles | 2 | Years |

Contact Cypress Sales or an FAE representative for additional information on the data integrity. An application note is available at http://www.cypress.com/appnotes.

# 7. Software Interface Reference

## 7.1 Command Summary

**Table 7.1** Command Definitions

| Command Sequence (Note 1) | | Cycles | Bus Cycles (Notes 2–5) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | First | | Second | | Third | | Fourth | | Fifth | | Sixth | | Seventh | |
| | | | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data |
| Read (Note 6) | | 1 | RA | RD | | | | | | | | | | | | |
| Reset/ASO Exit (Notes 7, 16) | | 1 | XXX | F0 | | | | | | | | | | | | |
| Status Register Read | | 2 | 555 | 70 | XXX | RD | | | | | | | | | | |
| Status Register Clear | | 1 | 555 | 71 | | | | | | | | | | | | |
| Word Program | | 4 | 555 | AA | 2AA | 55 | 555 | A0 | PA | PD | | | | | | |
| Write to Buffer | | 6 | 555 | AA | 2AA | 55 | SA | 25 | SA | WC | WBL | PD | WBL | PD | | |
| Program Buffer to Flash (confirm) | | 1 | SA | 29 | | | | | | | | | | | | |
| Write-to-Buffer-Abort Reset (Note 11) | | 3 | 555 | AA | 2AA | 55 | 555 | F0 | | | | | | | | |
| Chip Erase | | 6 | 555 | AA | 2AA | 55 | 555 | 80 | 555 | AA | 2AA | 55 | 555 | 10 | | |
| Sector Erase | | 6 | 555 | AA | 2AA | 55 | 555 | 80 | 555 | AA | 2AA | 55 | SA | 30 | | |
| Erase Suspend/Program Suspend Legacy Method (Note 9) | | 1 | XXX | B0 | | | | | | | | | | | | |
| Erase Suspend Enhanced Method | | | | | | | | | | | | | | | | |
| Erase Resume/Program Resume Legacy Method (Note 10) | | 1 | XXX | 30 | | | | | | | | | | | | |
| Erase Resume Enhanced Method | | | | | | | | | | | | | | | | |
| Program Suspend Enhanced Method | | 1 | XXX | 51 | | | | | | | | | | | | |
| Program Resume Enhanced Method | | 1 | XXX | 50 | | | | | | | | | | | | |
| Blank Check | | 1 | (SA) 555 | 33 | | | | | | | | | | | | |
| ID-CFI (Autoselect) ASO | ID (Autoselect) Entry | 3 | 555 | AA | 2AA | 55 | (SA) 555 | 90 | | | | | | | | |
| | CFI Enter (Note 8) | 1 | (SA) 55 | 98 | | | | | | | | | | | | |
| | ID-CFI Read | 1 | RA | RD | | | | | | | | | | | | |
| | Reset/ASO Exit (Notes 7, 16) | 1 | XXX | F0 | | | | | | | | | | | | |
| **Secure Silicon Region Command Definitions** | | | | | | | | | | | | | | | | |
| Secure Silicon Region (SSR) ASO | SSR Entry | 3 | 555 | AA | 2AA | 55 | (SA) 555 | 88 | | | | | | | | |
| | Read (Note 6) | 1 | RA | RD | | | | | | | | | | | | |
| | Word Program | 4 | 555 | AA | 2AA | 55 | 555 | A0 | PA | PD | | | | | | |
| | Write to Buffer | 6 | 555 | AA | 2AA | 55 | SA | 25 | SA | WC | WBL | PD | WBL | PD | | |
| | Program Buffer to Flash (confirm) | 1 | SA | 29 | | | | | | | | | | | | |
| | Write-to-Buffer-Abort Reset (Note 11) | 3 | 555 | AA | 2AA | 55 | 555 | F0 | | | | | | | | |
| | SSR Exit (Note 11) | 4 | 555 | AA | 2AA | 55 | 555 | 90 | XX | 0 | | | | | | |
| | Reset/ASO Exit (Notes 7, 16) | 1 | XXX | F0 | | | | | | | | | | | | |

**Table 7.1** Command Definitions (Continued)

| | Command Sequence (Note 1) | Cycles | Bus Cycles (Notes 2–5) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | First | | Second | | Third | | Fourth | | Fifth | | Sixth | | Seventh | |
| | | | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data |
| **Lock Register Command Set Definitions** | | | | | | | | | | | | | | | | |
| Lock Register ASO | Lock Register Entry | 3 | 555 | AA | 2AA | 55 | 555 | 40 | | | | | | | | |
| Lock Register ASO | Program (Note 15) | 2 | XXX | A0 | XXX | PD | | | | | | | | | | |
| Lock Register ASO | Read (Note 15) | 1 | 0 | RD | | | | | | | | | | | | |
| Lock Register ASO | Command Set Exit (Notes 12, 16) | 2 | XXX | 90 | XXX | 0 | | | | | | | | | | |
| Lock Register ASO | Reset/ASO Exit (Notes 7, 16) | 1 | XXX | F0 | | | | | | | | | | | | |
| **Password Protection Command Set Definitions** | | | | | | | | | | | | | | | | |
| Password ASO | Password ASO Entry | 3 | 555 | AA | 2AA | 55 | 555 | 60 | | | | | | | | |
| Password ASO | Program (Note 14) | 2 | XXX | A0 | PWAx | PWDx | | | | | | | | | | |
| Password ASO | Read (Note 13) | 4 | 0 | PWD0 | 1 | PWD1 | 2 | PWD2 | 3 | PWD 3 | | | | | | |
| Password ASO | Unlock | 7 | 0 | 25 | 0 | 3 | 0 | PWD0 | 1 | PWD 1 | 2 | PWD2 | 3 | PWD 3 | 0 | 29 |
| Password ASO | Command Set Exit (Notes 12, 16) | 2 | XXX | 90 | XXX | 0 | | | | | | | | | | |
| Password ASO | Reset/ASO Exit (Notes 7, 16) | 1 | XXX | F0 | | | | | | | | | | | | |
| **Non-Volatile Sector Protection Command Set Definitions** | | | | | | | | | | | | | | | | |
| PPB (Non-Volatile Sector Protection) | PPB Entry | 3 | 555 | AA | 2AA | 55 | 555 | C0 | | | | | | | | |
| PPB (Non-Volatile Sector Protection) | PPB Program (Note 17) | 2 | XXX | A0 | SA | 0 | | | | | | | | | | |
| PPB (Non-Volatile Sector Protection) | All PPB Erase (Note 17) | 2 | XXX | 80 | 0 | 30 | | | | | | | | | | |
| PPB (Non-Volatile Sector Protection) | PPB Read (Note 17) | 1 | SA | RD (0) | | | | | | | | | | | | |
| PPB (Non-Volatile Sector Protection) | Command Set Exit (Notes 12, 16) | 2 | XXX | 90 | XXX | 0 | | | | | | | | | | |
| PPB (Non-Volatile Sector Protection) | Reset/ASO Exit (Notes 7, 16) | 1 | XXX | F0 | | | | | | | | | | | | |
| **Global Non-Volatile Sector Protection Freeze Command Set Definitions** | | | | | | | | | | | | | | | | |
| PPB Lock Bit | PPB Lock Entry | 3 | 555 | AA | 2AA | 55 | 555 | 50 | | | | | | | | |
| PPB Lock Bit | PPB Lock Bit Cleared | 2 | XXX | A0 | XXX | 0 | | | | | | | | | | |
| PPB Lock Bit | PPB Lock Status Read (Note 17) | 1 | XXX | RD (0) | | | | | | | | | | | | |
| PPB Lock Bit | Command Set Exit (Notes 12, 16) | 2 | XXX | 90 | XXX | 0 | | | | | | | | | | |
| PPB Lock Bit | Reset/ASO Exit (Note 16) | 1 | XXX | F0 | | | | | | | | | | | | |

**Table 7.1** Command Definitions (Continued)

| | Command Sequence (Note 1) | Cycles | Bus Cycles (Notes 2–5) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | First | | Second | | Third | | Fourth | | Fifth | | Sixth | | Seventh | |
| | | | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data | Addr | Data |
| **Volatile Sector Protection Command Set Definitions** | | | | | | | | | | | | | | | | |
| DYB (Volatile Sector Protection) ASO | DYB ASO Entry | 3 | 555 | AA | 2AA | 55 | 555 | E0 | | | | | | | | |
| | DYB Set (Note 17) | 2 | XXX | A0 | SA | 0 | | | | | | | | | | |
| | DYB Clear (Note 17) | 2 | XXX | A0 | SA | 1 | | | | | | | | | | |
| | DYB Status Read (Note 17) | 1 | SA | RD (0) | | | | | | | | | | | | |
| | Command Set Exit (Notes 12, 16) | 2 | XXX | 90 | XXX | 0 | | | | | | | | | | |
| | Reset/ASO Exit (Note 16) | 1 | XXX | F0 | | | | | | | | | | | | |
| **Command Set Definitions ECC** | | | | | | | | | | | | | | | | |
| ECC ASO | ECC ASO Entry | 3 | 555 | AA | 2AA | 55 | 555 | 75 | | | | | | | | |
| | ECC Status Read | 1 | RA | RD | | | | | | | | | | | | |
| | Command Set Exit (Notes 12, 16) | 1 | XXX | F0 | | | | | | | | | | | | |

***Legend:***

*X = Don't care.*

*RA = Address of the memory to be read.*

*RD = Data read from location RA during read operation.*

*PA = Address of the memory location to be programmed.*

*PD = Data to be programmed at location PA.*

*SA = Address of the sector selected. Address bits $A_{MAX}$–A16 uniquely select any sector.*

*WBL = Write Buffer Location. The address must be within the same Line.*

*WC = Word Count is the number of write buffer locations to load minus 1.*

*PWAx = Password address for word0 = 00h, word1 = 01h, word2 = 02h, and word3 = 03h.*

*PWDx = Password data word0, word1, word2, and word3.*

***Notes:***

1. *See Table 9.1 on page 66 for description of bus operations.*
2. *All values are in hexadecimal.*
3. *Except for the following, all bus cycles are write cycle: read cycle during Read, ID/CFI Read (Manufacturing ID / Device ID), Indicator Bits, Secure Silicon Region Read, SSR Lock Read, and 2nd cycle of Status Register Read .*
4. *Data bits DQ15–DQ8 are don't care in command sequences, except for RD, PD, WC and PWD.*
5. *Address bits $A_{MAX}$–A11 are don't cares for unlock and command cycles, unless SA or PA required. ($A_{MAX}$ is the Highest Address pin.).*
6. *No unlock or command cycles required when reading array data.*
7. *The Reset command is required to return to reading array data when device is in the ID-CFI (autoselect) mode, or if DQ5 goes High (while the device is providing status data).*
8. *Command is valid when device is ready to read array data or when device is in ID-CFI (autoselect) mode.*
9. *The system can read and program/program suspend in non-erasing sectors, or enter the ID-CFI ASO, when in the Erase Suspend mode. The Erase Suspend command is valid only during a sector erase operation.*
10. *The Erase Resume/Program Resume command is valid only during the Erase Suspend/Program Suspend modes.*
11. *Issue this command sequence to return to READ mode after detecting device is in a Write-to-Buffer-Abort state. IMPORTANT: the full command sequence is required if resetting out of ABORT.*
12. *The Exit command returns the device to reading the array.*
13. *The password portion can be entered or read in any order as long as the entire 64-bit password is entered or read.*
14. *For PWDx, only one portion of the password can be programmed per each A0 command. Portions of the password must be programmed in sequential order (PWD0–PWD3).*
15. *All Lock Register bits are one-time programmable. The program state = 0 and the erase state = 1. Also, both the Persistent Protection Mode Lock Bit and the Password Protection Mode Lock Bit cannot be programmed at the same time or the Lock Register Bits Program operation aborts and returns the device to read mode. Lock Register bits that are reserved for future use are undefined and may be 0's or 1's.*
16. *If any of the Entry commands was issued, an Exit command must be issued to reset the device into read mode.*
17. *Protected State = 00h, Unprotected State = 01h. The sector address for DYB set, DYB clear, or PPB Program command may be any location within the sector - the lower order bits of the sector address are don't care.*

## 7.2 Device ID and Common Flash Interface (ID-CFI) ASO Map

The Device ID portion of the ASO (word locations 0h to 0Fh) provides manufacturer ID, device ID, Sector Protection State, and basic feature set information for the device.

ID-CFI Location 02h displays sector protection status for the sector selected by the sector address (SA) used in the ID-CFI enter command. To read the protection status of more than one sector it is necessary to exit the ID ASO and enter the ID ASO using the new SA. The access time to read location 02h is always $t_{ACC}$ and a read of this location requires CE# to go High before the read and return Low to initiate the read (asynchronous read access). Page mode read between location 02h and other ID locations is not supported. Page mode read between ID locations other than 02h is supported.

For additional information see ID-CFI ASO on page 31.

**Table 7.2** ID (Autoselect) Address Map

| Description | Address | Read Data |
|---|---|---|
| Manufacture ID | (SA) + 0000h | 0001h |
| Device ID | (SA) + 0001h | 227Eh |
| Protection Verification | (SA) + 0002h | Sector Protection State (1= Sector protected, 0 = Sector unprotected). This protection state is shown only for the SA selected when entering ID-CFI ASO. Reading other SA provides undefined data. To read a different SA protection state ASO exit command must be used and then enter ID-CFI ASO again with the new SA. |
| Indicator Bits | (SA) + 0003h | DQ15-DQ08 = 1 (Reserved)<br>DQ7 - Factory Locked Secure Silicon Region<br>1 = Locked,<br>0 = Not Locked<br>DQ6 - Customer Locked Secure Silicon Region<br>1 = Locked<br>0 = Not Locked<br>DQ5 = 1 (Reserved)<br>DQ4 - WP# Protects<br>0 = lowest address Sector<br>1 = highest address Sector<br>DQ3 - DQ0 = 1 (Reserved) |
| RFU | (SA) + 0004h | Reserved |
| | (SA) + 0005h | Reserved |
| | (SA) + 0006h | Reserved |
| | (SA) + 0007h | Reserved |
| | (SA) + 0008h | Reserved |
| | (SA) + 0009h | Reserved |
| | (SA) + 000Ah | Reserved |
| | (SA) + 000Bh | Reserved |

**Table 7.2** ID (Autoselect) Address Map (Continued)

| Description | Address | Read Data |
|---|---|---|
| Lower Software Bits | (SA) + 000Ch | Bit 0 - Status Register Support<br>1 = Status Register Supported<br>0 = Status Register not supported<br>Bit 1 - DQ polling Support<br>1 = DQ bits polling supported<br>0 = DQ bits polling not supported<br>Bit 3–2 - Command Set Support<br>11 = reserved<br>10 = reserved<br>01 = Reduced Command Set<br>00 = Classic Command set<br>Bits 4–15 - Reserved = 0 |
| Upper Software Bits | (SA) + 000Dh | Reserved |
| Device ID | (SA) + 000Eh | 2228h = 1 Gb<br>2223h = 512 Mb<br>2222h = 256 Mb<br>2221h = 128 Mb |
| Device ID | (SA) + 000Fh | 2201h |

**Table 7.3** CFI Query Identification String

| Word Address | Data | Description |
|---|---|---|
| (SA) + 0010h<br>(SA) + 0011h<br>(SA) + 0012h | 0051h<br>0052h<br>0059h | Query Unique ASCII string “QRY” |
| (SA) + 0013h<br>(SA) + 0014h | 0002h<br>0000h | Primary OEM Command Set |
| (SA) + 0015h<br>(SA) + 0016h | 0040h<br>0000h | Address for Primary Extended Table |
| (SA) + 0017h<br>(SA) + 0018h | 0000h<br>0000h | Alternate OEM Command Set<br>(00h = none exists) |
| (SA) + 0019h<br>(SA) + 001Ah | 0000h<br>0000h | Address for Alternate OEM Extended Table<br>(00h = none exists) |

**Table 7.4** CFI System Interface String

| Word Address | Data | Description |
|---|---|---|
| (SA) + 001Bh | 0027h | $V_{CC}$ Min. (erase/program) (D7–D4: volts, D3–D0: 100 mV) |
| (SA) + 001Ch | 0036h | $V_{CC}$ Max. (erase/program) (D7–D4: volts, D3–D0: 100 mV) |
| (SA) + 001Dh | 0000h | $V_{PP}$ Min. voltage (00h = no $V_{PP}$ pin present) |
| (SA) + 001Eh | 0000h | $V_{PP}$ Max. voltage (00h = no $V_{PP}$ pin present) |
| (SA) + 001Fh | 0008h | Typical timeout per single word write $2^N$ µs |
| (SA) + 0020h | 0009h | Typical timeout for max multi-byte program, $2^N$ µs (00h = not supported) |
| (SA) + 0021h | 0008h | Typical timeout per individual block erase $2^N$ ms |
| (SA) + 0022h | 0012h (1 Gb)<br>0011h (512 Mb)<br>0010h (256 Mb)<br>000Fh (128 Mb) | Typical timeout for full chip erase $2^N$ ms (00h = not supported) |
| (SA) + 0023h | 0001h | Max. timeout for single word write $2^N$ times typical |
| (SA) + 0024h | 0002h | Max. timeout for buffer write $2^N$ times typical |
| (SA) + 0025h | 0003h | Max. timeout per individual block erase $2^N$ times typical |
| (SA) + 0026h | 0003h | Max. timeout for full chip erase $2^N$ times typical (00h = not supported) |

**Table 7.5** CFI Device Geometry Definition

| Word Address | Data | Description |
|---|---|---|
| (SA) + 0027h | 001Bh (1 Gb)<br>001Ah (512 Mb)<br>0019h (256 Mb)<br>0018h (128 Mb) | Device Size = $2^N$ byte; |
| (SA) + 0028h | 0001h | Flash Device Interface Description 0 = ×8-only, 1 = ×16-only, 2 = ×8/×16 capable |
| (SA) + 0029h | 0000h | |
| (SA) + 002Ah | 0009h | Max. number of byte in multi-byte write = $2^N$ (00 = not supported) |
| (SA) + 002Bh | 0000h | |
| (SA) + 002Ch | 0001h | Number of Erase Block Regions within device<br>1 = Uniform Device, 2 = Boot Device |
| (SA) + 002Dh | 00XXh | Erase Block Region 1 Information (refer to JEDEC JESD68-01 or JEP137 specifications)<br>00FFh, 0003h, 0000h, 0002h =1 Gb<br>00FFh, 0001h, 0000h, 0002h = 512 Mb<br>00FFh, 0000h, 0000h, 0002h = 256 Mb<br>007Fh, 0000h, 0000h, 0002h = 128 Mb |
| (SA) + 002Eh | 000Xh | |
| (SA) + 002Fh | 0000h | |
| (SA) + 0030h | 000Xh | |
| (SA) + 0031h | 0000h | Erase Block Region 2 Information (refer to CFI publication 100) |
| (SA) + 0032h | 0000h | |
| (SA) + 0033h | 0000h | |
| (SA) + 0034h | 0000h | |

**Table 7.5** CFI Device Geometry Definition (Continued)

| Word Address | Data | Description |
|---|---|---|
| (SA) + 0035h | 0000h | Erase Block Region 3 Information (refer to CFI publication 100) |
| (SA) + 0036h | 0000h | |
| (SA) + 0037h | 0000h | |
| (SA) + 0038h | 0000h | |
| (SA) + 0039h | 0000h | Erase Block Region 4 Information (refer to CFI publication 100) |
| (SA) + 003Ah | 0000h | |
| (SA) + 003Bh | 0000h | |
| (SA) + 003Ch | 0000h | |
| (SA) + 003Dh | FFFFh | Reserved |
| (SA) + 003Eh | FFFFh | Reserved |
| (SA) + 003Fh | FFFFh | Reserved |

**Table 7.6** CFI Primary Vendor-Specific Extended Query

| Word Address | Data | Description |
|---|---|---|
| (SA) + 0040h | 0050h | Query-unique ASCII string “PRI” |
| (SA) + 0041h | 0052h | |
| (SA) + 0042h | 0049h | |
| (SA) + 0043h | 0031h | Major version number, ASCII |
| (SA) + 0044h | 0035h | Minor version number, ASCII |
| (SA) + 0045h | 001Ch | Address Sensitive Unlock (Bits 1–0)<br>00b = Required<br>01b = Not Required<br>Process Technology (Bits 5–2)<br>0000b = 0.23 µm Floating Gate<br>0001b = 0.17 µm Floating Gate<br>0010b = 0.23 µm MirrorBit<br>0011b = 0.13 µm Floating Gate<br>0100b = 0.11 µm MirrorBit<br>0101b = 0.09 µm MirrorBit<br>0110b = 0.09 µm Floating Gate<br>0111b = 0.065 µm MirrorBit Eclipse<br>1000b = 0.065 µm MirrorBit<br>1001b = 0.045 µm MirrorBit |
| (SA) + 0046h | 0002h | Erase Suspend<br>0 = Not Supported<br>1 = Read Only<br>2 = Read and Write |
| (SA) + 0047h | 0001h | Sector Protect<br>00 = Not Supported<br>X = Number of sectors in smallest group |
| (SA) + 0048h | 0000h | Temporary Sector Unprotect<br>00 = Not Supported<br>01 = Supported |

**Table 7.6** CFI Primary Vendor-Specific Extended Query (Continued)

| Word Address | Data | Description |
|---|---|---|
| (SA) + 0049h | 0008h | Sector Protect/Unprotect Scheme<br>04 = High Voltage Method<br>05 = Software Command Locking Method<br>08 = Advanced Sector Protection Method |
| (SA) + 004Ah | 0000h | Simultaneous Operation<br>00 = Not Supported<br>X = Number of banks |
| (SA) + 004Bh | 0000h | Burst Mode Type<br>00 = Not Supported<br>01 = Supported |
| (SA) + 004Ch | 0003h | Page Mode Type<br>00 = Not Supported<br>01 = 4 Word Page<br>02 = 8 Word Page<br>03 = 16 Word Page |
| (SA) + 004Dh | 0000h | ACC (Acceleration) Supply Minimum<br>00 = Not Supported<br>D7–D4: Volt<br>D3–D0: 100 mV |
| (SA) + 004Eh | 0000h | ACC (Acceleration) Supply Maximum<br>00 = Not Supported<br>D7–D4: Volt<br>D3–D0: 100 mV |
| (SA) + 004Fh | 0004h (Bottom)<br>0005h (Top) | WP# Protection<br>00h = Flash device without WP Protect (No Boot)<br>01h = Eight 8 kB Sectors at TOP and Bottom with WP (Dual Boot)<br>02h = Bottom Boot Device with WP Protect (Bottom Boot)<br>03h = Top Boot Device with WP Protect (Top Boot)<br>04h = Uniform, Bottom WP Protect (Uniform Bottom Boot)<br>05h = Uniform, Top WP Protect (Uniform Top Boot)<br>06h = WP Protect for all sectors<br>07h = Uniform, Top and Bottom WP Protect |
| (SA) + 0050h | 0001h | Program Suspend<br>00 = Not Supported<br>01 = Supported |
| (SA) +0051h | 0000h | Unlock Bypass<br>00 = Not Supported<br>01 = Supported |
| (SA) + 0052h | 0009h | Secured Silicon Sector (Customer OTP Area) Size $2^N$ (bytes) |
| (SA) + 0053h | 008Fh | Software Features<br>bit 0: status register polling (1 = supported, 0 = not supported)<br>bit 1: DQ polling (1 = supported, 0 = not supported)<br>bit2: new program suspend/resume commands (1=supported, 0=not supported)<br>bit 3: word programming (1 = supported, 0 = not supported)<br>bit 4: bit-field programming (1 = supported, 0 = not supported)<br>bit 5: autodetect programming (1 = supported, 0 = not supported)<br>bit 6: RFU<br>bit 7: multiple writes per Line (1 = supported, 0 = not supported) |

**Table 7.6** CFI Primary Vendor-Specific Extended Query (Continued)

| Word Address | Data | Description |
|---|---|---|
| (SA) + 0054h | 0005h | Page Size = $2^N$ bytes |
| (SA) + 0055h | 0006h | Erase Suspend Timeout Maximum < $2^N$ (µs) |
| (SA) + 0056h | 0006h | Program Suspend Timeout Maximum < $2^N$ (µs) |
| (SA) + 0057h<br>to<br>(SA) + 0077h | FFFFh | Reserved |
| (SA) + 0078h | 0006h | Embedded Hardware Reset Timeout Maximum < $2^N$ (µs)<br>Reset with Reset Pin |
| (SA) + 0079h | 0009h | Non-Embedded Hardware Reset Timeout Maximum < $2^N$ (µs)<br>Power on Reset |

## 7.3 Device ID and Common Flash Interface (ID-CFI) ASO Map

**Table 7.7** Device ID and Common Flash Interface (ID-CFI) ASO Map

| Word Address | Data Field | # of bytes | Data Format | Example of Actual Data | Hex Read Out of Example Data |
|---|---|---|---|---|---|
| (SA) + 0080h | Size of Electronic Marking | 1 | Hex | 19 | 0013h |
| (SA) + 0081h | Revision of Electronic Marking | 1 | Hex | 1 | 0001h |
| (SA) + 0082h | Fab Lot # | 7 | Ascii | LD87270 | 004Ch, 0044h, 0038h, 0037h, 0032h, 0037h, 0030h |
| (SA) + 0089h | Wafer # | 1 | Hex | 23 | 0017h |
| (SA) + 008Ah | Die X Coordinate | 1 | Hex | 10 | 000Ah |
| (SA) + 008Bh | Die Y Coordinate | 1 | Hex | 15 | 000Fh |
| (SA) + 008Ch | Class Lot# | 7 | Ascii | BR33150 | 0042h, 0052h, 0033h, 0033h, 0031h, 0035h, 0030h |
| (SA) + 0093h | Reserved for Future | 13 | n/a | n/a | undefined |
| Fab Lot # + Wafer # + Die X Coordinate + Die Y Coordinate gives a unique ID for each device. | | | | | |

# Hardware Interface

## 8. Signal Descriptions

### 8.1 Address and Data Configuration

Address and data are connected in parallel (ADP) via separate signal inputs and I/Os.

### 8.2 Input/Output Summary

**Table 8.1** I/O Summary

| Symbol | Type | Description |
|---|---|---|
| RESET# | Input | Hardware Reset. At $V_{IL}$, causes the device to reset control logic to its standby state, ready for reading array data. |
| CE# | Input | Chip Enable. At $V_{IL}$, selects the device for data transfer with the host memory controller. |
| OE# | Input | Output Enable. At $V_{IL}$, causes outputs to be actively driven. At $V_{IH}$, causes outputs to be high impedance (High-Z). |
| WE# | Input | Write Enable. At $V_{IL}$, indicates data transfer from host to device. At $V_{IH}$, indicates data transfer is from device to host. |
| $A_{MAX}$–A0 | Input | Address inputs.<br>A25–A0 for S29GL01GS<br>A24–A0 for S29GL512S<br>A23–A0 for S29GL256S<br>A22–A0 for S29GL128S |
| DQ15–DQ0 | Input/Output | Data inputs and outputs |
| WP# | Input | Write Protect. At $V_{IL}$, disables program and erase functions in the lowest or highest address 64-kword (128-kB) sector of the device. At $V_{IH}$, the sector is not protected. WP# has an internal pull up; When unconnected WP# is at $V_{IH}$. |
| RY/BY# | Output - open drain | Ready/Busy. Indicates whether an Embedded Algorithm is in progress or complete. At $V_{IL}$, the device is actively engaged in an Embedded Algorithm such as erasing or programming. At High-Z, the device is ready for read or a new command write - requires external pull-up resistor to detect the High-Z state. Multiple devices may have their RY/BY# outputs tied together to detect when all devices are ready. |
| $V_{CC}$ | Power Supply | Core power supply |
| $V_{IO}$ | Power Supply | Versatile IO power supply. |
| $V_{SS}$ | Power Supply | Power supplies ground |
| NC | No Connect | Not Connected internally. The pin/ball location may be used in Printed Circuit Board (PCB) as part of a routing channel. |
| RFU | No Connect | Reserved for Future Use. Not currently connected internally but the pin/ball location should be left unconnected and unused by PCB routing channel for future compatibility. The pin/ball may be used by a signal in the future. |
| DNU | Reserved | Do Not Use. Reserved for use by Cypress. The pin/ball is connected internally. The input has an internal pull down resistance to $V_{SS}$. The pin/ball can be left open or tied to $V_{SS}$ on the PCB. |

## 8.3 Versatile I/O Feature

The maximum output voltage level driven by, and input levels acceptable to, the device are determined by the $V_{IO}$ power supply. This supply allows the device to drive and receive signals to and from other devices on the same bus having interface signal levels different from the device core voltage.

## 8.4 Ready/Busy# (RY/BY#)

RY/BY# is a dedicated, open drain output pin that indicates whether an Embedded Algorithm, Power-On Reset (POR), or Hardware Reset is in progress or complete. The RY/BY# status is valid after the rising edge of the final WE# pulse in a command sequence, when $V_{CC}$ is above $V_{CC}$ minimum during POR, or after the falling edge of RESET#. Since RY/BY# is an open drain output, several RY/BY# pins can be tied together in parallel with a pull up resistor to $V_{IO}$.

If the output is Low (Busy), the device is actively erasing, programming, or resetting. (This includes programming in the Erase Suspend mode). If the output is High (Ready), the device is ready to read data (including during the Erase Suspend mode), or is in the standby mode.

Table 5.3, Data Polling Status on page 39 shows the outputs for RY/BY# in each operation.

If an Embedded algorithm has failed (Program / Erase failure as result of max pulses or Sector is locked),
RY/BY# will stay Low (busy) until status register bits 4 and 5 are cleared and the reset command is issued. This includes Erase or Programming on a locked sector.

## 8.5 Hardware Reset

The RESET# input provides a hardware method of resetting the device to standby state. When RESET# is driven Low for at least a period of $t_{RP}$, the device immediately:

- terminates any operation in progress,
- exits any ASO,
- tristates all outputs,
- resets the Status Register,
- resets the EAC to standby state.
- CE# is ignored for the duration of the reset operation ($t_{RPH}$).
- To meet the Reset current specification ($I_{CC5}$) CE# must be held High.

To ensure data integrity any operation that was interrupted should be reinitiated once the device is ready to accept another command sequence.

# 9. Signal Protocols

The following sections describe the host system interface signal behavior and timing for the 29GL-S family flash devices.

## 9.1 Interface States

Table 9.1 describes the required value of each interface signal for each interface state.

**Table 9.1** Interface States

| Interface State | $V_{CC}$ | $V_{IO}$ | RESET# | CE# | OE# | WE# | $A_{MAX}$-A0 | DQ15-DQ0 |
|---|---|---|---|---|---|---|---|---|
| Power-Off with Hardware Data Protection | $< V_{LKO}$ | $\leq V_{CC}$ | X | X | X | X | X | High-Z |
| Power-On (Cold) Reset | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | X | X | X | X | X | High-Z |
| Hardware (Warm) Reset | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | L | X | X | X | X | High-Z |
| Interface Standby | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | H | H | X | X | X | High-Z |
| Automatic Sleep (Notes 1, 3) | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | H | L | X | X | Valid | Output Available |
| Read with Output Disable (Note 2) | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | H | L | H | H | Valid | High-Z |
| Random Read | $\geq V_{CC}$ min | $\geq V_{IO}$ min | H | L | L | H | Valid | Output Valid |
| Page Read | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | H | L | L | H | $A_{MAX}$–A4 Valid<br>A3–A0 Modified | Output Valid |
| Write | $\geq V_{CC}$ min | $\geq V_{IO}$ min $\leq V_{CC}$ | H | L | H | L | Valid | Input Valid |

***Legend:***
*L = $V_{IL}$*
*H = $V_{IH}$*
*X = either $V_{IL}$ or $V_{IH}$*
*L/H = rising edge*
*H/L = falling edge*
*Valid = all bus signals have stable L or H level*
*Modified = valid state different from a previous valid state*
*Available = read data is internally stored with output driver controlled by OE#*

***Notes:***
1. *WE# and OE# can not be at $V_{IL}$ at the same time.*
2. *Read with Output Disable is a read initiated with OE# High.*
3. *Automatic Sleep is a read/write operation where data has been driven on the bus for an extended period, without CE# going High and the device internal logic has gone into standby mode to conserve power.*

## 9.2 Power-Off with Hardware Data Protection

The memory is considered to be powered off when the core power supply ($V_{CC}$) drops below the lock-out voltage ($V_{LKO}$). When $V_{CC}$ is below $V_{LKO}$, the entire memory array is protected against a program or erase operation. This ensures that no spurious alteration of the memory content can occur during power transition. During a power supply transition down to Power-Off, $V_{IO}$ should remain less than or equal to $V_{CC}$.

If $V_{CC}$ goes below $V_{RST}$ (Min) then returns above $V_{RST}$ (Min) to $V_{CC}$ minimum, the Power-On Reset interface state is entered and the EAC starts the Cold Reset Embedded Algorithm.

## 9.3 Power Conservation Modes

### 9.3.1 Interface Standby

Standby is the default, low power, state for the interface while the device is not selected by the host for data transfer (CE# = High). All inputs are ignored in this state and all outputs except RY/BY# are high impedance. RY/BY# is a direct output of the EAC, not controlled by the Host Interface.

### 9.3.2 Automatic Sleep

The automatic sleep mode reduces device interface energy consumption to the sleep level ($I_{CC6}$) following the completion of a random read access time. The device automatically enables this mode when addresses remain stable for $t_{ACC}$ + 30 ns. While in sleep mode, output data is latched and always available to the system. Output of the data depends on the level of the OE# signal but, the automatic sleep mode current is independent of the OE# signal level. Standard address access timings ($t_{ACC}$ or $t_{PACC}$) provide new data when addresses are changed. $I_{CC6}$ in DC Characteristics on page 72 represents the automatic sleep mode current specification.

Automatic sleep helps reduce current consumption especially when the host system clock is slowed for power reduction. During slow system clock periods, read and write cycles may extend many times their length versus when the system is operating at high speed. Even though CE# may be Low throughout these extended data transfer cycles, the memory device host interface will go to the Automatic Sleep current at $t_{ACC}$ + 30 ns. The device will remain at the Automatic Sleep current for $t_{ASSB}$. Then the device will transition to the standby current level. This keeps the memory at the Automatic Sleep or standby power level for most of the long duration data transfer cycles, rather than consuming full read power all the time that the memory device is selected by the host system.

However, the EAC operates independent of the automatic sleep mode of the host interface and will continue to draw current during an active Embedded Algorithm. Only when both the host interface and EAC are in their standby states is the standby level current achieved.

## 9.4 Read

### 9.4.1 Read With Output Disable

When the CE# signal is asserted Low, the host system memory controller begins a read or write data transfer. Often there is a period at the beginning of a data transfer when CE# is Low, Address is valid, OE# is High, and WE# is High. During this state a read access is assumed and the Random Read process is started while the data outputs remain at high impedance. If the OE# signal goes Low, the interface transitions to the Random Read state, with data outputs actively driven. If the WE# signal is asserted Low, the interface transitions to the Write state. Note, OE# and WE# should never be Low at the same time to ensure no data bus contention between the host system and memory.

### 9.4.2 Random (Asynchronous) Read

When the host system interface selects the memory device by driving CE# Low, the device interface leaves the Standby state. If WE# is High when CE# goes Low, a random read access is started. The data output depends on the address map mode and the address provided at the time the read access is started.

The data appears on DQ15-DQ0 when CE# is Low, OE# is Low, WE# remains High, address remains stable, and the asynchronous access times are satisfied. Address access time ($t_{ACC}$) is equal to the delay from stable addresses to valid output data. The chip enable access time ($t_{CE}$) is the delay from stable CE# to valid data at the outputs. In order for the read data to be driven on to the data outputs the OE# signal must be Low at least the output enable time ($t_{OE}$) before valid data is available.

At the completion of the random access time from CE# active ($t_{CE}$), address stable ($t_{ACC}$), or OE# active ($t_{OE}$), whichever occurs latest, the data outputs will provide valid read data from the currently active address map mode. If CE# remains Low and any of the $A_{MAX}$ to A4 address signals change to a new value, a new random read access begins. If CE# remains Low and OE# goes High the interface transitions to the Read with Output Disable state. If CE# remains Low, OE# goes High, and WE# goes Low, the interface transitions to the Write state. If CE# returns High, the interface goes to the Standby state. Back to Back accesses, in which CE# remains Low between accesses, requires an address change to initiate the second access. See Asynchronous Read Operations on page 78.

### 9.4.3 Page Read

After a Random Read access is completed, if CE# remains Low, OE# remains Low, the $A_{MAX}$ to A4 address signals remain stable, and any of the A3 to A0 address signals change, a new access within the same Page begins. The Page Read completes much faster ($t_{PACC}$) than a Random Read access.

## 9.5 Write

### 9.5.1 Asynchronous Write

When WE# goes Low after CE is Low, there is a transition from one of the read states to the Write state. If WE# is Low before CE# goes Low, there is a transition from the Standby state directly to the Write state without beginning a read access.

When CE# is Low, OE# is High, and WE# goes Low, a write data transfer begins. Note, OE# and WE# should never be Low at the same time to ensure no data bus contention between the host system and memory. When the asynchronous write cycle timing requirements are met the WE# can go High to capture the address and data values in to EAC command memory.

Address is captured by the falling edge of WE# or CE#, whichever occurs later. Data is captured by the rising edge of WE# or CE#, whichever occurs earlier.

When CE# is Low before WE# goes Low and stays Low after WE# goes High, the access is called a WE# controlled Write. When WE# is High and CE# goes High, there is a transition to the Standby state. If CE# remains Low and WE# goes High, there is a transition to the Read with Output Disable state.

When WE# is Low before CE# goes Low and remains Low after CE# goes High, the access is called a CE# controlled Write. A CE# controlled Write transitions to the Standby state.

If WE# is Low before CE# goes Low, the write transfer is started by CE# going Low. If WE# is Low after CE# goes High, the address and data are captured by the rising edge of CE#. These cases are referred to as CE# controlled write state transitions.

Write followed by Read accesses, in which CE# remains Low between accesses, requires an address change to initiate the following read access.

Back to Back accesses, in which CE# remains Low between accesses, requires an address change to initiate the second access.

The EAC command memory array is not readable by the host system and has no ASO. The EAC examines the address and data in each write transfer to determine if the write is part of a legal command sequence. When a legal command sequence is complete the EAC will initiate the appropriate EA.

### 9.5.2 Write Pulse "Glitch" Protection

Noise pulses of less than 5 ns (typical) on WE# will not initiate a write cycle.

### 9.5.3 Logical Inhibit

Write cycles are inhibited by holding OE# at $V_{IL}$, or CE# at $V_{IH}$, or WE# at $V_{IH}$. To initiate a write cycle, CE# and WE# must be Low ($V_{IL}$) while OE# is High ($V_{IH}$).

# 10. Electrical Specifications

## 10.1 Absolute Maximum Ratings

**Table 10.1** Absolute Maximum Ratings

| | |
|---|---|
| Storage Temperature Plastic Packages | -65 °C to +150 °C |
| Ambient Temperature with Power Applied | -65 °C to +125 °C |
| Voltage with Respect to Ground | |
| All pins other than RESET# (Note 1) | -0.5 V to ($V_{IO}$ + 0.5 V) |
| RESET# (Note 1) | -0.5 V to ($V_{CC}$ + 0.5 V) |
| Output Short Circuit Current (Note 2) | 100 mA |
| $V_{CC}$ | -0.5 V to +4.0 V |
| $V_{IO}$ | -0.5 V to +4.0 V |

***Notes:***
1. *Minimum DC voltage on input or I/O pins is –0.5 V. During voltage transitions, input or I/O pins may undershoot $V_{SS}$ to –2.0 V for periods of up to 20 ns. See Figure 10.3 on page 71. Maximum DC voltage on input or I/O pins is $V_{CC}$ + 0.5 V. During voltage transitions, input or I/O pins may overshoot to $V_{CC}$ + 2.0 V for periods up to 20 ns. See Figure 10.4 on page 71*
2. *No more than one output may be shorted to ground at a time. Duration of the short circuit should not be greater than one second.*
3. *Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational sections of this data sheet is not implied. Exposure of the device to absolute maximum rating conditions for extended periods may affect device reliability.*

## 10.2 Latchup Characteristics

This product complies with JEDEC standard JESD78C latchup testing requirements.

## 10.3 Thermal Resistance

**Table 10.2** Thermal Resistance

| Parameter | Description | LAA064 | LAE064 | TS056 | Unit |
|---|---|---|---|---|---|
| Theta Ja | Thermal resistance (junction to ambient) | 25 | 27.3 | 46.2 | °C/W |

## 10.4 Operating Ranges

### 10.4.1 Temperature Ranges

| Parameter | Symbol | Device | Spec | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| Ambient Temperature | $T_A$ | Industrial (I) | –40 | +85 | °C |
| | | Industrial Plus (V) | –40 | +105 | |
| | | Automotive, AEC-Q100 Grade 3 (A) | –40 | +85 | |
| | | Automotive, AEC-Q100 Grade 2 (B) | –40 | +105 | |

### 10.4.2 Power Supply Voltages

| | |
|---|---|
| $V_{CC}$ | 2.7 V to 3.6 V |
| $V_{IO}$ | 1.65 V to $V_{CC}$ +200 mV |

Operating ranges define those limits between which the functionality of the device is guaranteed.

### 10.4.3 Power-Up and Power-Down

During power-up or power-down $V_{CC}$ must always be greater than or equal to $V_{IO}$ ($V_{CC} \geq V_{IO}$).

The device ignores all inputs until a time delay of $t_{VCS}$ has elapsed after the moment that $V_{CC}$ and $V_{IO}$ both rise above, and stay above, the minimum $V_{CC}$ and $V_{IO}$ thresholds. During $t_{VCS}$ the device is performing power on reset operations.

During power-down or voltage drops below $V_{CC}$ Lockout maximum ($V_{LKO}$), the $V_{CC}$ and $V_{IO}$ voltages must drop below $V_{CC}$ Reset ($V_{RST}$) minimum for a period of $t_{PD}$ for the part to initialize correctly when $V_{CC}$ and $V_{IO}$ again rise to their operating ranges. See Figure 10.2 on page 71. If during a voltage drop the $V_{CC}$ stays above $V_{LKO}$ maximum the part will stay initialized and will work correctly when $V_{CC}$ is again above $V_{CC}$ minimum. If the part locks up from improper initialization, a hardware reset can be used to initialize the part correctly.

Normal precautions must be taken for supply decoupling to stabilize the $V_{CC}$ and $V_{IO}$ power supplies. Each device in a system should have the $V_{CC}$ and $V_{IO}$ power supplies decoupled by a suitable capacitor close to the package connections (this capacitor is generally on the order of 0.1 µF). At no time should $V_{IO}$ be greater then 200 mV above $V_{CC}$ ($V_{CC} \geq V_{IO}$ –200 mV).

**Table 10.3** Power-Up/Power-Down Voltage and Timing

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{CC}$ | $V_{CC}$ Power Supply | 2.7 | 3.6 | V |
| $V_{LKO}$ | $V_{CC}$ level below which re-initialization is required (Note 1) | 2.25 | 2.5 | V |
| $V_{RST}$ | $V_{CC}$ and $V_{IO}$ Low voltage needed to ensure initialization will occur (Note 1) | 1.0 | – | V |
| $t_{VCS}$ | $V_{CC}$ and $V_{IO} \geq$ minimum to first access (Note 1) | 300 | – | µs |
| $t_{PD}$ | Duration of $V_{CC} \leq V_{RST}$(min) (Note 1) | 15 | – | µs |

***Note:***
*1. Not 100% tested.*

**Figure 10.1** Power-up

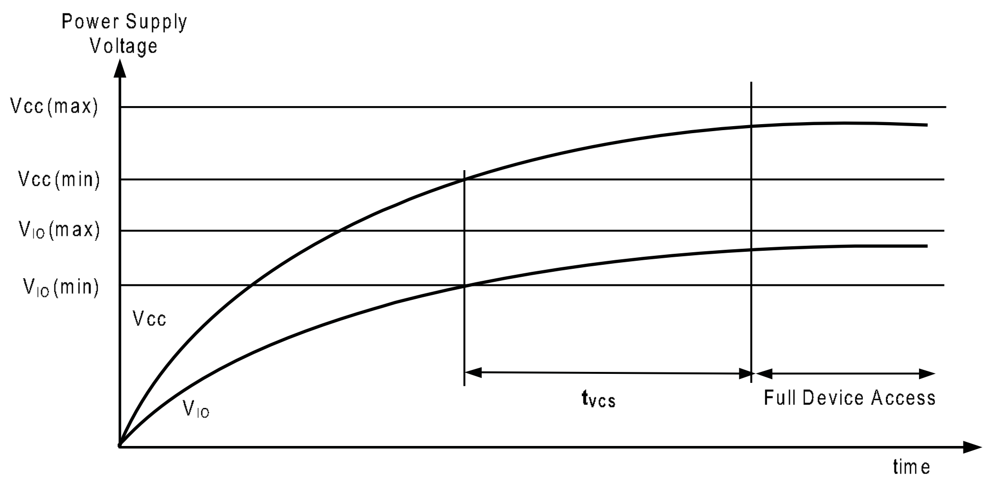
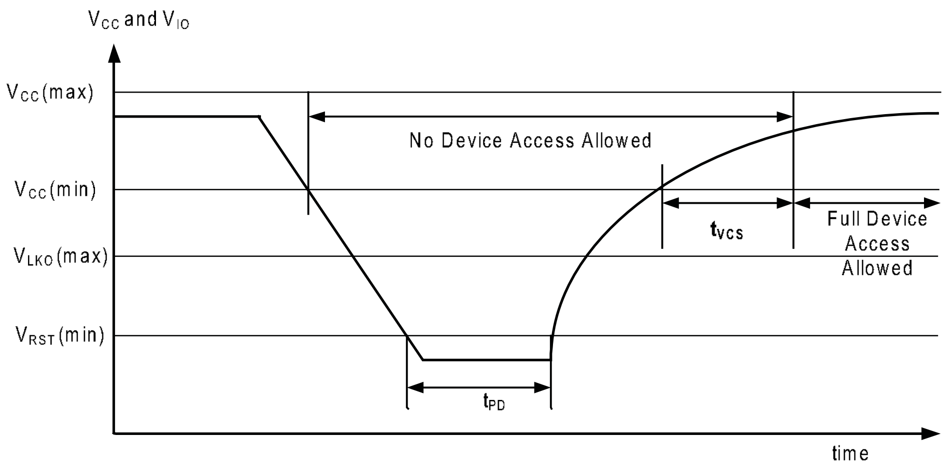


**Figure 10.2** Power-down and Voltage Drop




## 10.4.4 Input Signal Overshoot

**Figure 10.3** Maximum Negative Overshoot Waveform

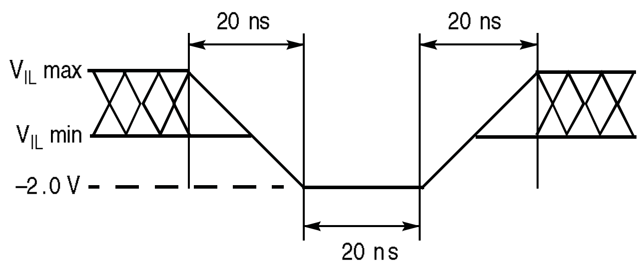
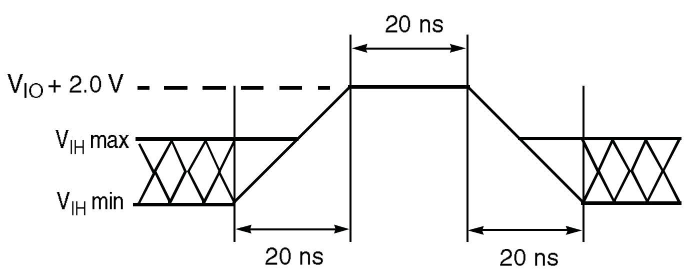



**Figure 10.4** Maximum Positive Overshoot Waveform



## 10.5 DC Characteristics

**Table 10.4** DC Characteristics (–40 °C to +85 °C)

| Parameter | Description | Test Conditions | Min | Typ (Note 2) | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{LI}$ | Input Load Current | $V_{IN} = V_{SS}$ to $V_{CC}$, $V_{CC} = V_{CC}$ max | – | +0.02 | ±1.0 | µA |
| $I_{LO}$ | Output Leakage Current | $V_{OUT} = V_{SS}$ to $V_{CC}$, $V_{CC} = V_{CC}$ max | – | +0.02 | ±1.0 | µA |
| $I_{CC1}$ | $V_{CC}$ Active Read Current | CE# = $V_{IL}$, OE# = $V_{IH}$, Address switching @ 5 MHz, $V_{CC} = V_{CC}$ max | – | 55 | 60 | mA |
| $I_{CC2}$ | $V_{CC}$ Intra-Page Read Current | CE# = $V_{IL}$, OE# = $V_{IH}$, Address switching @ 33 MHz, $V_{CC} = V_{CC}$ max | – | 9 | 25 | mA |
| $I_{CC3}$ | $V_{CC}$ Active Erase/Program Current (Notes 1, 2) | CE# = $V_{IL}$, OE# = $V_{IH}$, $V_{CC} = V_{CC}$ max | – | 45 | 100 | mA |
| $I_{CC4}$ | $V_{CC}$ Standby Current | CE#, RESET#, OE# = $V_{IH}$, $V_{IH} = V_{IO}$ $V_{IL} = V_{SS}$, $V_{CC} = V_{CC}$ max | – | 70 | 100 | µA |
| $I_{CC5}$ | $V_{CC}$ Reset Current (Notes 2, 7) | CE# = $V_{IH}$, RESET# = $V_{IL}$, $V_{CC} = V_{CC}$ max | – | 10 | 20 | mA |
| $I_{CC6}$ | Automatic Sleep Mode (Note 3) | $V_{IH} = V_{IO}$, $V_{IL} = V_{SS}$ , $V_{CC} = V_{CC}$ max, $t_{ACC}$ + 30 ns | – | 3 | 6 | mA |
| | | $V_{IH} = V_{IO}$, $V_{IL} = V_{SS}$, $V_{CC} = V_{CC}$ max, $t_{ASSB}$ | – | 100 | 150 | µA |
| $I_{CC7}$ | $V_{CC}$ Current during power up (Notes 2, 6) | RESET# = $V_{IO}$, CE# = $V_{IO}$, OE# = $V_{IO}$, $V_{CC} = V_{CC}$ max, | – | 53 | 80 | mA |
| $V_{IL}$ | Input Low Voltage (Note 4) | | –0.5 | – | 0.3 × $V_{IO}$ | V |
| $V_{IH}$ | Input High Voltage (Note 4) | | 0.7 × $V_{IO}$ | – | $V_{IO}$ + 0.4 | V |
| $V_{OL}$ | Output Low Voltage (Notes 4, 8) | $I_{OL}$ = 100 µA for DQ15–DQ0; $I_{OL}$ = 2 mA for RY/BY# | – | – | 0.15 × $V_{IO}$ | V |
| $V_{OH}$ | Output High Voltage (Note 4) | $I_{OH}$ = 100 µA | 0.85 × $V_{IO}$ | – | – | V |
| $V_{LKO}$ | Low $V_{CC}$ Lock-Out Voltage (Note 2) | | 2.25 | – | 2.5 | V |
| $V_{RST}$ | Low $V_{CC}$ Power on Reset Voltage (Note 2) | | – | 1.0 | – | V |

***Notes:***

1. *$I_{CC}$ active while Embedded Algorithm is in progress.*
2. *Not 100% tested.*
3. *Automatic sleep mode enables the lower power mode when addresses remain stable for the specified designated time.*
4. *$V_{IO}$ = 1.65V to $V_{CC}$ or 2.7V to $V_{CC}$ depending on the model.*
5. *$V_{CC}$ = 3V and $V_{IO}$ = 3V or 1.8V. When $V_{IO}$ is at 1.8V, I/O pins cannot operate at >1.8V.*
6. *During power-up there are spikes of current demand, the system needs to be able to supply this current to insure the part initializes correctly.*
7. *If an embedded operation is in progress at the start of reset, the current consumption will remain at the embedded operation specification until the embedded operation is stopped by the reset. If no embedded operation is in progress when reset is started, or following the stopping of an embedded operation, $I_{CC5}$ will be drawn during the remainder of $t_{RPH}$. After the end of $t_{RPH}$ the device will go to standby mode until the next read or write.*
8. *The recommended pull-up resistor for RY/BY# output is 5k to 10k Ohms.*

**Table 10.5** DC Characteristics (-40°C to +105°C)

| Parameter | Description | Test Conditions | Min | Typ (Note 2) | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{LI}$ | Input Load Current | $V_{IN} = V_{SS}$ to $V_{CC}$, $V_{CC} = V_{CC}$ max | – | +0.02 | ±1.0 | µA |
| $I_{LO}$ | Output Leakage Current | $V_{OUT} = V_{SS}$ to $V_{CC}$, $V_{CC} = V_{CC}$ max | – | +0.02 | ±1.0 | µA |
| $I_{CC1}$ | $V_{CC}$ Active Read Current | CE# = $V_{IL}$, OE# = $V_{IH}$, Address switching @ 5 MHz, $V_{CC} = V_{CC}$ max | – | 55 | 60 | mA |
| $I_{CC2}$ | $V_{CC}$ Intra-Page Read Current | CE# = $V_{IL}$, OE# = $V_{IH}$, Address switching @ 33 MHz, $V_{CC} = V_{CC}$ max | – | 9 | 25 | mA |
| $I_{CC3}$ | $V_{CC}$ Active Erase/Program Current (Notes 1, 2) | CE# = $V_{IL}$, OE# = $V_{IH}$, $V_{CC} = V_{CC}$ max | – | 45 | 100 | mA |
| $I_{CC4}$ | $V_{CC}$ Standby Current | CE#, RESET#, OE# = $V_{IH}$, $V_{IH} = V_{IO}$ $V_{IL} = V_{SS}$, $V_{CC} = V_{CC}$ max | – | 70 | 200 | µA |
| $I_{CC5}$ | $V_{CC}$ Reset Current (Notes 2, 7) | CE# = $V_{IH}$, RESET# = $V_{IL}$, $V_{CC} = V_{CC}$ max | – | 10 | 20 | mA |
| $I_{CC6}$ | Automatic Sleep Mode (Note 3) | $V_{IH} = V_{IO}$, $V_{IL} = V_{SS}$ , $V_{CC} = V_{CC}$ max, $t_{ACC}$ + 30 ns | – | 3 | 6 | mA |
| | | $V_{IH} = V_{IO}$, $V_{IL} = V_{SS}$, $V_{CC} = V_{CC}$ max, $t_{ASSB}$ | – | 100 | 200 | µA |
| $I_{CC7}$ | $V_{CC}$ Current during power-up (Notes 2, 6) | RESET# = $V_{IO}$, CE# = $V_{IO}$, OE# = $V_{IO}$, $V_{CC} = V_{CC}$ max, | – | 53 | 80 | mA |
| $V_{IL}$ | Input Low Voltage (Note 4) | | –0.5 | – | 0.3 × $V_{IO}$ | V |
| $V_{IH}$ | Input High Voltage (Note 4) | | 0.7 × $V_{IO}$ | – | $V_{IO}$ + 0.4 | V |
| $V_{OL}$ | Output Low Voltage (Notes 4, 8) | $I_{OL}$ = 100 µA for DQ15–DQ0; $I_{OL}$ = 2 mA for RY/BY# | – | – | 0.15 × $V_{IO}$ | V |
| $V_{OH}$ | Output High Voltage (Note 4) | $I_{OH}$ = 100 µA | 0.85 × $V_{IO}$ | – | – | V |
| $V_{LKO}$ | Low $V_{CC}$ Lock-Out Voltage (Note 2) | | 2.25 | – | 2.5 | V |
| $V_{RST}$ | Low $V_{CC}$ Power on Reset Voltage (Note 2) | | – | 1.0 | – | V |

***Notes:***

1. *$I_{CC}$ active while Embedded Algorithm is in progress.*
2. *Not 100% tested.*
3. *Automatic sleep mode enables the lower power mode when addresses remain stable for the specified designated time.*
4. *$V_{IO}$ = 1.65 V to $V_{CC}$ or 2.7 V to $V_{CC}$ depending on the model.*
5. *$V_{CC}$ = 3 V and $V_{IO}$ = 3 V or 1.8 V. When $V_{IO}$ is at 1.8 V, I/O pins cannot operate at >1.8 V.*
6. *During power-up there are spikes of current demand, the system needs to be able to supply this current to insure the part initializes correctly.*
7. *If an embedded operation is in progress at the start of reset, the current consumption will remain at the embedded operation specification until the embedded operation is stopped by the reset. If no embedded operation is in progress when reset is started, or following the stopping of an embedded operation, $I_{CC7}$ will be drawn during the remainder of $t_{RPH}$. After the end of $t_{RPH}$ the device will go to standby mode until the next read or write.*
8. *The recommended pull-up resistor for RY/BY# output is 5k to 10k Ohms.*

## 10.6 Capacitance Characteristics

**Table 10.6** Connector Capacitance for FBGA (LAA) Package

| Parameter Symbol | Parameter Description | Test Setup | Typ | Max | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Input Capacitance | $V_{IN} = 0$ | 8 | 9 | pF |
| $C_{OUT}$ | Output Capacitance | $V_{OUT} = 0$ | 5 | 7 | pF |
| $C_{IN2}$ | Control Pin Capacitance | $V_{IN} = 0$ | 4 | 8 | pF |
| RY/BY# | Output Capacitance | $V_{OUT} = 0$ | 3 | 4 | pF |

***Notes:***
1. *Sampled, not 100% tested.*
2. *Test conditions $T_A$ = 25 °C, f = 1.0 MHz.*

**Table 10.7** Connector Capacitance for FBGA (LAE) Package

| Parameter Symbol | Parameter Description | Test Setup | Typ | Max | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Input Capacitance | $V_{IN} = 0$ | 7 | 8 | pF |
| $C_{OUT}$ | Output Capacitance | $V_{OUT} = 0$ | 5 | 6 | pF |
| $C_{IN2}$ | Control Pin Capacitance | $V_{IN} = 0$ | 3 | 7 | pF |
| RY/BY# | Output Capacitance | $V_{OUT} = 0$ | 3 | 4 | pF |

***Notes:***
1. *Sampled, not 100% tested.*
2. *Test conditions $T_A$ = 25 °C, f = 1.0 MHz.*

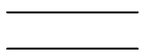
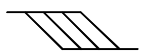
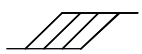
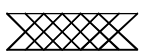
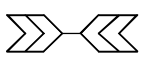
**Table 10.8** Connector Capacitance for TSOP Package

| Parameter Symbol | Parameter Description | Test Setup | Typ | Max | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Input Capacitance | $V_{IN} = 0$ | 7 | 8 | pF |
| $C_{OUT}$ | Output Capacitance | $V_{OUT} = 0$ | 5 | 6 | pF |
| $C_{IN2}$ | Control Pin Capacitance | $V_{IN} = 0$ | 3 | 7 | pF |
| RY/BY# | Output Capacitance | $V_{OUT} = 0$ | 3 | 4 | pF |

***Notes:***
1. *Sampled, not 100% tested.*
2. *Test conditions $T_A$ = 25 °C, f = 1.0 MHz.*

# 11. Timing Specifications

## 11.1 Key to Switching Waveforms

| Waveform | Inputs | Outputs |
|---|---|---|
|  | Steady | |
|  | Changing from H to L | |
|  | Changing from L to H | |
|  | Don't Care, Any Change Permitted | Changing, State Unknown |
|  | Does Not Apply | Center Line is High Impedance State (High-Z) |

## 11.2 AC Test Conditions

**Figure 11.1** Test Setup

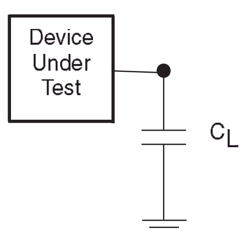



**Table 11.1** Test Specification

| Parameter | All Speeds | Units |
|---|---|---|
| Output Load Capacitance, $C_L$ | 30 | pF |
| Input Rise and Fall Times (Note 1) | 1.5 | ns |
| Input Pulse Levels | 0.0–$V_{IO}$ | V |
| Input timing measurement reference levels | $V_{IO}/2$ | V |
| Output timing measurement reference levels | $V_{IO}/2$ | V |

***Note:***
1. *Measured between $V_{IL}$ max and $V_{IH}$ min.*

**Figure 11.2** Input Waveforms and Measurement Levels


## 11.3 Power-On Reset (POR) and Warm Reset

Normal precautions must be taken for supply decoupling to stabilize the $V_{CC}$ and $V_{IO}$ power supplies. Each device in a system should have the $V_{CC}$ and $V_{IO}$ power supplies decoupled by a suitable capacitor close to the package connections (this capacitor is generally on the order of 0.1 µF).

**Table 11.2** Power ON and Reset Parameters

| Parameter | Description | Limit | Value | Unit |
|---|---|---|---|---|
| $t_{VCS}$ | $V_{CC}$ Setup Time to first access (Notes 1, 2) | Min | 300 | µs |
| $t_{VIOS}$ | $V_{IO}$ Setup Time to first access (Notes 1, 2) | Min | 300 | µs |
| $t_{RPH}$ | RESET# Low to CE# Low | Min | 35 | µs |
| $t_{RP}$ | RESET# Pulse Width | Min | 200 | ns |
| $t_{RH}$ | Time between RESET# (High) and CE# (low) | Min | 50 | ns |
| $t_{CEH}$ | CE# Pulse Width High | Min | 20 | ns |

***Notes:***
1. *Not 100% tested.*
2. *Timing measured from $V_{CC}$ reaching $V_{CC}$ minimum and $V_{IO}$ reaching $V_{IO}$ minimum to $V_{IH}$ on Reset and $V_{IL}$ on CE#.*
3. *RESET# Low is optional during POR. If RESET is asserted during POR, the later of $t_{RPH}$, $t_{VIOS}$, or $t_{VCS}$ will determine when CE# may go Low. If RESET# remains Low after $t_{VIOS}$, or $t_{VCS}$ is satisfied, $t_{RPH}$ is measured from the end of $t_{VIOS}$, or $t_{VCS}$. RESET must also be High $t_{RH}$ before CE# goes Low.*
4. *$V_{CC} \geq V_{IO}$ - 200 mV during power-up.*
5. *$V_{CC}$ and $V_{IO}$ ramp rate can be non-linear.*
6. *Sum of $t_{RP}$ and $t_{RH}$ must be equal to or greater than $t_{RPH}$.*

### 11.3.1 Power-On (Cold) Reset (POR)

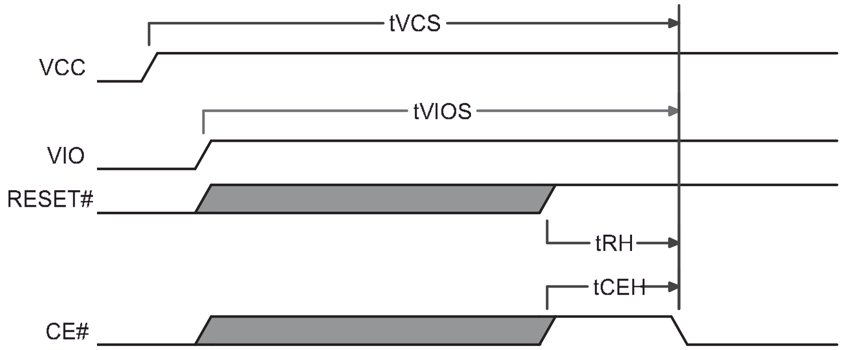
During the rise of power supplies the $V_{IO}$ supply voltage must remain less than or equal to the $V_{CC}$ supply voltage. $V_{IH}$ also must remain less than or equal to the $V_{IO}$ supply.

The Cold Reset Embedded Algorithm requires a relatively long, hundreds of µs, period ($t_{VCS}$) to load all of the EAC algorithms and default state from non-volatile memory. During the Cold Reset period all control signals including CE# and RESET# are ignored. If CE# is Low during $t_{VCS}$ the device may draw higher than normal POR current during $t_{VCS}$ but the level of CE# will not affect the Cold Reset EA. CE# or OE# must transition from High to Low after $t_{VCS}$ for a valid read or write operation. RESET# may be High or Low during $t_{VCS}$. If RESET# is Low during $t_{VCS}$ it may remain Low at the end of $t_{VCS}$ to hold the device in the Hardware Reset state. If RESET# is High at the end of $t_{VCS}$ the device will go to the Standby state.

When power is first applied, with supply voltage below $V_{RST}$ then rising to reach operating range minimum, internal device configuration and warm reset activities are initiated. CE# is ignored for the duration of the POR operation ($t_{VCS}$ or $t_{VIOS}$). RESET# Low during this POR period is optional. If RESET# is driven Low during POR it must satisfy the Hardware Reset parameters $t_{RP}$ and $t_{RPH}$. In which case the Reset operations will be completed at the later of $t_{VCS}$ or $t_{VIOS}$ or $t_{RPH}$.

During Cold Reset the device will draw $I_{CC7}$ current.

**Figure 11.3** Power-Up Diagram




### 11.3.2 Hardware (Warm) Reset

During Hardware Reset ($t_{RPH}$) the device will draw $I_{CC5}$ current.

When RESET# continues to be held at $V_{SS}$, the device draws CMOS standby current ($I_{CC4}$). If RESET# is held at $V_{IL}$, but not at $V_{SS}$, the standby current is greater.

If a Cold Reset has not been completed by the device when RESET# is asserted Low after $t_{VCS}$, the Cold Reset# EA will be performed instead of the Warm RESET#, requiring $t_{VCS}$ time to complete.

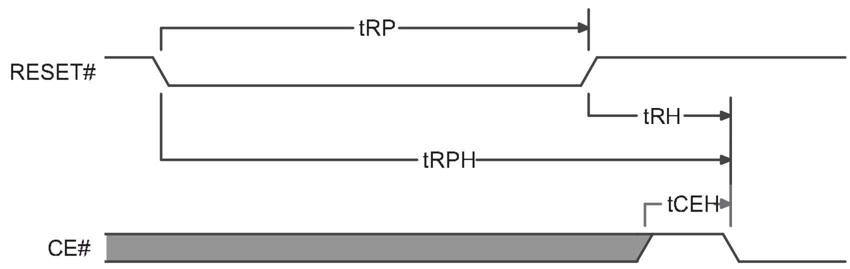
See Figure 11.4 on page 77.

After the device has completed POR and entered the Standby state, any later transition to the Hardware Reset state will initiate the Warm Reset Embedded Algorithm. A Warm Reset is much shorter than a Cold Reset, taking tens of µs ($t_{RPH}$) to complete. During the Warm Reset EA, any in progress Embedded Algorithm is stopped and the EAC is returned to its POR state without reloading EAC algorithms from non-volatile memory. After the Warm Reset EA completes, the interface will remain in the Hardware Reset state if RESET# remains Low. When RESET# returns High the interface will transit to the Standby state. If RESET# is High at the end of the Warm Reset EA, the interface will directly transit to the Standby state.

If POR has not been properly completed by the end of $t_{VCS}$, a later transition to the Hardware Reset state will cause a transition to the Power-on Reset interface state and initiate the Cold Reset Embedded Algorithm. This ensures the device can complete a Cold Reset even if some aspect of the system Power-On voltage ramp-up causes the POR to not initiate or complete correctly. The RY/BY# pin is Low during cold or warm reset as an indication that the device is busy performing reset operations.

Hardware Reset is initiated by the RESET# signal going to $V_{IL}$.

**Figure 11.4** Hardware Reset



## 11.4 AC Characteristics

### 11.4.1 Asynchronous Read Operations

**Table 11.3** Read Operation $V_{IO} = V_{CC}$ = 2.7 V to 3.6 V (–40 °C to +85 °C)

<table>
<tr><th colspan="2">Parameter</th><th rowspan="2" colspan="2">Description</th><th rowspan="2" colspan="2">Test Setup</th><th colspan="3">Speed Option</th><th rowspan="2">Unit</th></tr>
<tr><th>JEDEC</th><th>Std</th><th>90</th><th>100</th><th>110</th></tr>
<tr><td rowspan="2">$t_{AVAV}$</td><td rowspan="2">$t_{RC}$</td><td rowspan="2" colspan="2">Read Cycle Time (Note 1)</td><td>128 Mb, 256 Mb</td><td rowspan="2">Min</td><td>90</td><td>100</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>100</td><td>110</td></tr>
<tr><td rowspan="2">$t_{AVQV}$</td><td rowspan="2">$t_{ACC}$</td><td rowspan="2">Address to Output Delay</td><td rowspan="2">CE# = $V_{IL}$<br>OE# = $V_{IL}$</td><td>128 Mb, 256 Mb</td><td rowspan="2">Max</td><td>90</td><td>100</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>100</td><td>110</td></tr>
<tr><td rowspan="2">$t_{ELQV}$</td><td rowspan="2">$t_{CE}$</td><td rowspan="2">Chip Enable to Output Delay</td><td rowspan="2">OE# = $V_{IL}$</td><td>128 Mb, 256 Mb</td><td rowspan="2">Max</td><td>90</td><td>100</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>100</td><td>110</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">$t_{PACC}$</td><td rowspan="2" colspan="2">Page Access Time</td><td>128 Mb, 256 Mb</td><td rowspan="2">Max</td><td>15</td><td>20</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>15</td><td>20</td></tr>
<tr><td>$t_{GLQV}$</td><td>$t_{OE}$</td><td colspan="2">Output Enable to Output Delay</td><td></td><td>Max</td><td colspan="3">25</td><td>ns</td></tr>
<tr><td>$t_{AXQX}$</td><td>$t_{OH}$</td><td colspan="2">Output Hold time from addresses, CE# or OE#, Whichever Occurs First</td><td></td><td>Min</td><td colspan="3">0</td><td>ns</td></tr>
<tr><td>$t_{EHQZ}$</td><td>$t_{DF}$</td><td colspan="2">Chip Enable or Output Enable to Output High-Z (Note 1)</td><td></td><td>Max</td><td colspan="3">15</td><td>ns</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">$t_{OEH}$</td><td rowspan="2">Output Enable Hold Time (Note 1)</td><td>Read</td><td></td><td>Min</td><td colspan="3">0</td><td>ns</td></tr>
<tr><td>Toggle and Data# Polling</td><td></td><td>Min</td><td colspan="3">10</td><td>ns</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">$t_{ASSB}$</td><td rowspan="2" colspan="2">Automatic Sleep to Standby time (Note 1)</td><td rowspan="2">CE# = $V_{IL}$, Address stable</td><td>Typ</td><td colspan="3">5</td><td>µs</td></tr>
<tr><td>Max</td><td colspan="3">8</td><td>µs</td></tr>
</table>

***Note:***
*1. Not 100% tested.*

**Table 11.4** Read Operation $V_{IO}$ = 1.65 V to $V_{CC}$, $V_{CC}$ = 2.7 V to 3.6 V (–40 °C to +85 °C)

<table>
<tr><th colspan="2">Parameter</th><th rowspan="2" colspan="2">Description</th><th rowspan="2" colspan="2">Test Setup</th><th colspan="3">Speed Options</th><th rowspan="2">Unit</th></tr>
<tr><th>JEDEC</th><th>Std</th><th>100</th><th>110</th><th>120</th></tr>
<tr><td rowspan="2">$t_{AVAV}$</td><td rowspan="2">$t_{RC}$</td><td rowspan="2" colspan="2">Read Cycle Time (Note 1)</td><td>128 Mb, 256 Mb</td><td rowspan="2">Min</td><td>100</td><td>110</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>110</td><td>120</td></tr>
<tr><td rowspan="2">$t_{AVQV}$</td><td rowspan="2">$t_{ACC}$</td><td rowspan="2">Address to Output Delay</td><td rowspan="2">CE# = $V_{IL}$<br>OE# = $V_{IL}$</td><td>128 Mb, 256 Mb</td><td rowspan="2">Max</td><td>100</td><td>110</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>110</td><td>120</td></tr>
<tr><td rowspan="2">$t_{ELQV}$</td><td rowspan="2">$t_{CE}$</td><td rowspan="2">Chip Enable to Output Delay</td><td rowspan="2">OE# = $V_{IL}$</td><td>128 Mb, 256 Mb</td><td rowspan="2">Max</td><td>100</td><td>110</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>110</td><td>120</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">$t_{PACC}$</td><td rowspan="2" colspan="2">Page Access Time</td><td>128 Mb, 256 Mb</td><td rowspan="2">Max</td><td>25</td><td>30</td><td>–</td><td rowspan="2">ns</td></tr>
<tr><td>512 Mb, 1 Gb</td><td>–</td><td>25</td><td>30</td></tr>
<tr><td>$t_{GLQV}$</td><td>$t_{OE}$</td><td colspan="2">Output Enable to Output Delay</td><td></td><td>Max</td><td colspan="3">35</td><td>ns</td></tr>
<tr><td>$t_{AXQX}$</td><td>$t_{OH}$</td><td colspan="2">Output Hold time from addresses, CE# or OE#, Whichever Occurs First</td><td></td><td>Min</td><td colspan="3">0</td><td>ns</td></tr>
<tr><td>$t_{EHQZ}$</td><td>$t_{DF}$</td><td colspan="2">Chip Enable or Output Enable to Output High-Z (Note 1)</td><td></td><td>Max</td><td colspan="3">20</td><td>ns</td></tr>
</table>

**Table 11.4** Read Operation $V_{IO}$ = 1.65 V to $V_{CC}$, $V_{CC}$ = 2.7 V to 3.6 V (–40 °C to +85 °C) (Continued)

| Parameter | | Description | | Test Setup | | Speed Options | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | 100 | 110 | 120 | |
| | $t_{OEH}$ | Output Enable Hold Time (Note 1) | Read | | Min | 0 | | | ns |
| | | | Toggle and Data# Polling | | Min | 10 | | | ns |
| | $t_{ASSB}$ | Automatic Sleep to Standby time (Note 1) | | CE# = $V_{IL}$, Address stable | Typ | 5 | | | µs |
| | | | | | Max | 8 | | | µs |

***Note:***
*1. Not 100% tested.*

**Table 11.5** Read Operation $V_{IO}$ = $V_{CC}$ = 2.7 V to 3.6 V (–40 °C to +105 °C)

| Parameter | | Description | | Test Setup | | Speed Option | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | 100 | 110 | 120 | |
| $t_{AVAV}$ | $t_{RC}$ | Read Cycle Time (Note 1) | | 128 Mb, 256 Mb | Min | 100 | 110 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 110 | 120 | |
| $t_{AVQV}$ | $t_{ACC}$ | Address to Output Delay | CE# = $V_{IL}$ OE# = $V_{IL}$ | 128 Mb, 256 Mb | Max | 100 | 110 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 110 | 120 | |
| $t_{ELQV}$ | $t_{CE}$ | Chip Enable to Output Delay | OE# = $V_{IL}$ | 128 Mb, 256 Mb | Max | 100 | 110 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 110 | 120 | |
| | $t_{PACC}$ | Page Access Time | | 128 Mb, 256 Mb | Max | 15 | 20 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 15 | 20 | |
| $t_{GLQV}$ | $t_{OE}$ | Output Enable to Output Delay | | | Max | 25 | | | ns |
| $t_{AXQX}$ | $t_{OH}$ | Output Hold time from addresses, CE# or OE#, Whichever Occurs First | | | Min | 0 | | | ns |
| $t_{EHQZ}$ | $t_{DF}$ | Chip Enable or Output Enable to Output High-Z (Note 1) | | | Max | 15 | | | ns |
| | $t_{OEH}$ | Output Enable Hold Time (Note 1) | Read | | Min | 0 | | | ns |
| | | | Toggle and Data# Polling | | Min | 10 | | | ns |
| | $t_{ASSB}$ | Automatic Sleep to Standby time (Note 1) | | CE# = $V_{IL}$, Address stable | Typ | 5 | | | µs |
| | | | | | Max | 8 | | | µs |

***Note:***
*1. Not 100% tested.*

**Table 11.6** Read Operation $V_{IO}$ = 1.65 V to $V_{CC}$, $V_{CC}$ = 2.7 V to 3.6 V (–40 °C to +105 °C)

| Parameter | | Description | | Test Setup | | Speed Option | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | 110 | 120 | 130 | |
| $t_{AVAV}$ | $t_{RC}$ | Read Cycle Time (Note 1) | | 128 Mb, 256 Mb | Min | 110 | 120 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 120 | 130 | |
| $t_{AVQV}$ | $t_{ACC}$ | Address to Output Delay | CE# = $V_{IL}$ OE# = $V_{IL}$ | 128 Mb, 256 Mb | Max | 110 | 120 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 120 | 130 | |
| $t_{ELQV}$ | $t_{CE}$ | Chip Enable to Output Delay | OE# = $V_{IL}$ | 128 Mb, 256 Mb | Max | 110 | 120 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 120 | 130 | |

**Table 11.6** Read Operation $V_{IO}$ = 1.65 V to $V_{CC}$, $V_{CC}$ = 2.7 V to 3.6 V (–40 °C to +105 °C) (Continued)

| Parameter | | Description | | Test Setup | | Speed Option | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | 110 | 120 | 130 | |
| | $t_{PACC}$ | Page Access Time | | 128 Mb, 256 Mb | Max | 25 | 30 | – | ns |
| | | | | 512 Mb, 1 Gb | | – | 25 | 30 | |
| $t_{GLQV}$ | $t_{OE}$ | Output Enable to Output Delay | | | Max | 35 | | | ns |
| $t_{AXQX}$ | $t_{OH}$ | Output Hold time from addresses, CE# or OE#, Whichever Occurs First | | | Min | 0 | | | ns |
| $t_{EHQZ}$ | $t_{DF}$ | Chip Enable or Output Enable to Output High-Z (Note 1) | | | Max | 20 | | | ns |
| | $t_{OEH}$ | Output Enable Hold Time (Note 1) | Read | | Min | 0 | | | ns |
| | | | Toggle and Data# Polling | | Min | 10 | | | ns |
| | $t_{ASSB}$ | Automatic Sleep to Standby time (Note 1) | | CE# = $V_{IL}$, Address stable | Typ | 5 | | | µs |
| | | | | | Max | 8 | | | µs |

*Note:*
*1. Not 100% tested.*

**Figure 11.5** Back to Back Read ($t_{ACC}$) Operation Timing Diagram

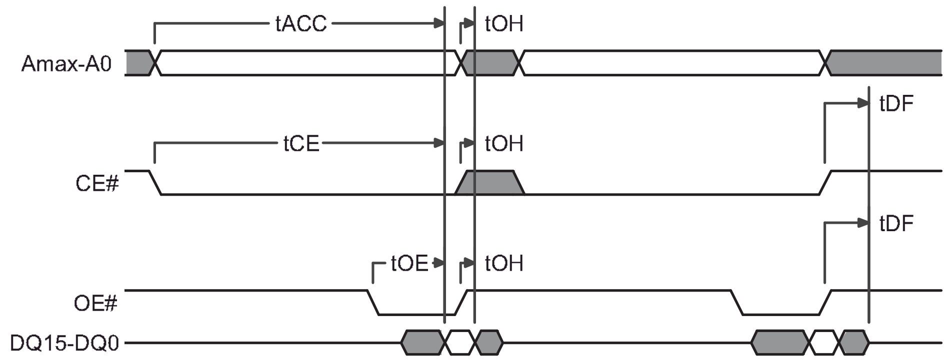
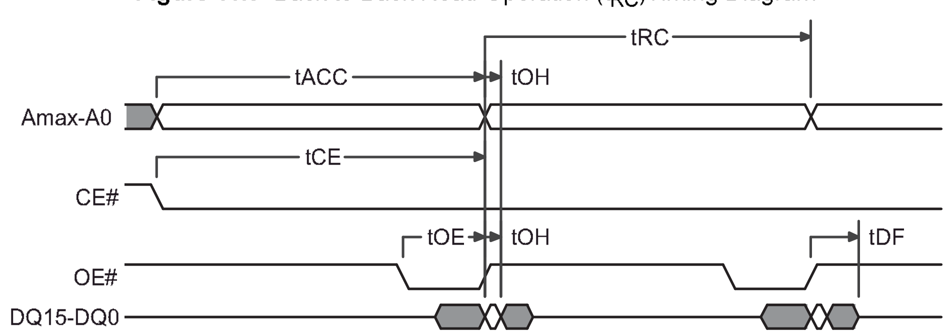



**Figure 11.6** Back to Back Read Operation ($t_{RC}$)Timing Diagram




*Note:*
*Back to Back operations, in which CE# remains Low between accesses, requires an address change to initiate the second access.*

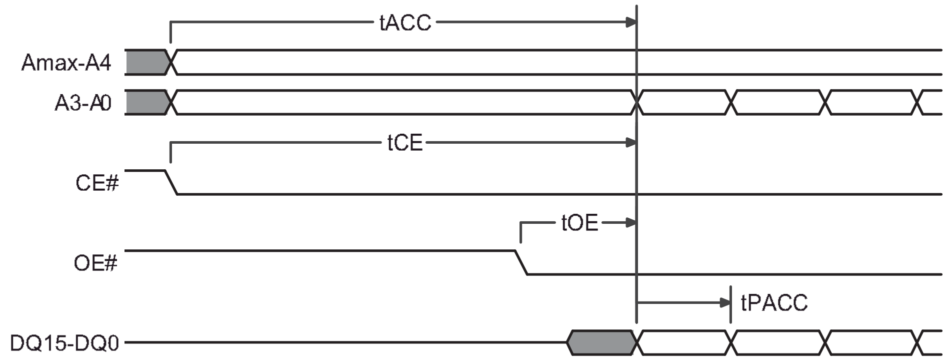



**Figure 11.7** Page Read Timing Diagram

***Note:***
*Word Configuration: Toggle A0, A1, A2, and A3.*

### 11.4.2 Asynchronous Write Operations

**Table 11.7** Write Operations

| Parameter | | Description | | $V_{IO}$ = 2.7 V to $V_{CC}$ | $V_{IO}$ = 1.65 V to $V_{CC}$ | Unit |
|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | |
| $t_{AVAV}$ | $t_{WC}$ | Write Cycle Time (Note 1) | Min | 60 | | ns |
| $t_{AVWL}$ | $t_{AS}$ | Address Setup Time | Min | 0 | | ns |
| | $t_{ASO}$ | Address Setup Time to OE# Low during toggle bit polling | Min | 15 | | ns |
| $t_{WLAX}$ | $t_{AH}$ | Address Hold Time | Min | 45 | | ns |
| | $t_{AHT}$ | Address Hold Time From CE# or OE# High during toggle bit polling | Min | 0 | | ns |
| $t_{DVWH}$ | $t_{DS}$ | Data Setup Time | Min | 30 | | ns |
| $t_{WHDX}$ | $t_{DH}$ | Data Hold Time | Min | 0 | | ns |
| | $t_{OEPH}$ | Output Enable High during toggle bit polling or following status register read. | Min | 20 | | ns |
| $t_{GHWL}$ | $t_{GHWL}$ | Read Recovery Time Before Write (OE# High to WE# Low) | Min | 0 | | ns |
| $t_{ELWL}$ | $t_{CS}$ | CE# Setup Time | Min | 0 | | ns |
| $t_{WHEH}$ | $t_{CH}$ | CE# Hold Time | Min | 0 | | ns |
| $t_{WLWH}$ | $t_{WP}$ | WE# Pulse Width | Min | 25 | | ns |
| $t_{WHWL}$ | $t_{WPH}$ | WE# Pulse Width High | Min | 20 | | ns |

***Note:***
*1. Not 100% tested.*

**Figure 11.8** Back to Back Write Operation Timing Diagram

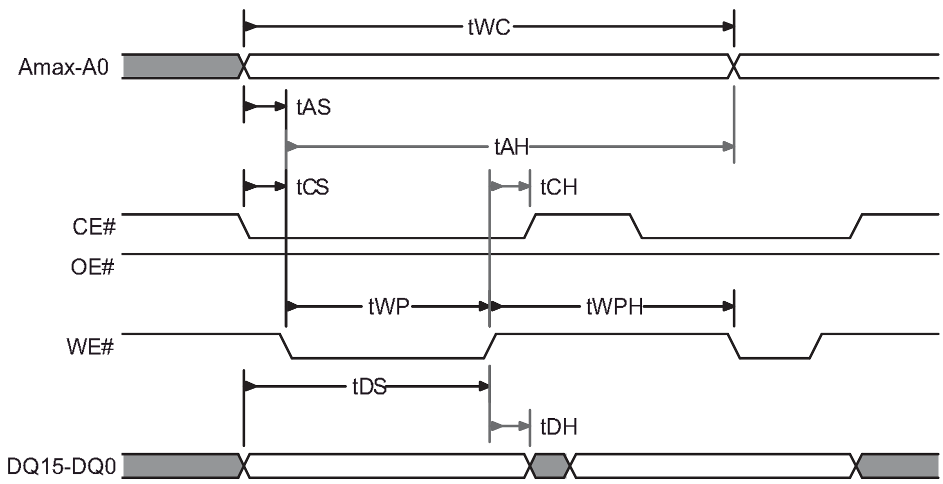


**Figure 11.9** Back to Back (CE#VIL) Write Operation Timing Diagram

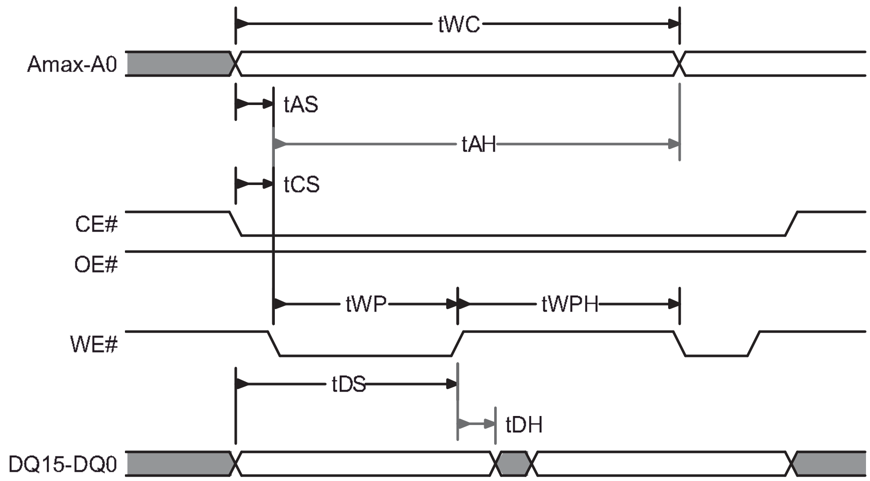



**Figure 11.10** Write to Read ($t_{ACC}$) Operation Timing Diagram

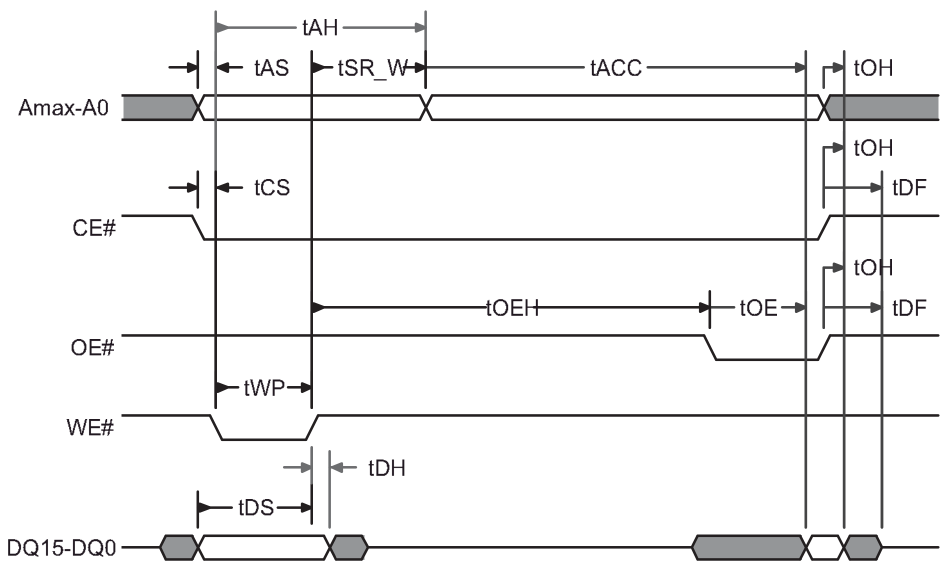


**Figure 11.11** Write to Read ($t_{CE}$) Operation Timing Diagram

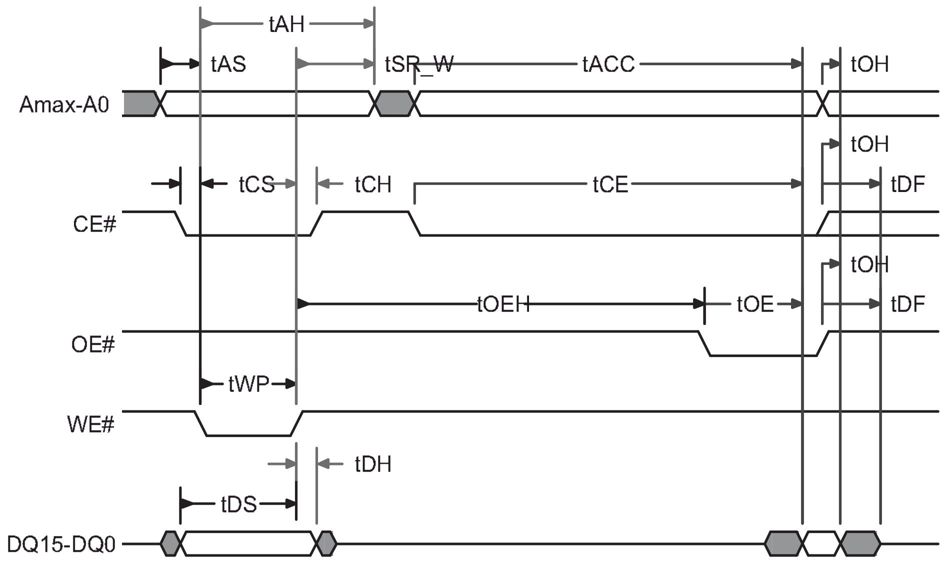



**Figure 11.12** Read to Write (CE# $V_{IL}$) Operation Timing Diagram

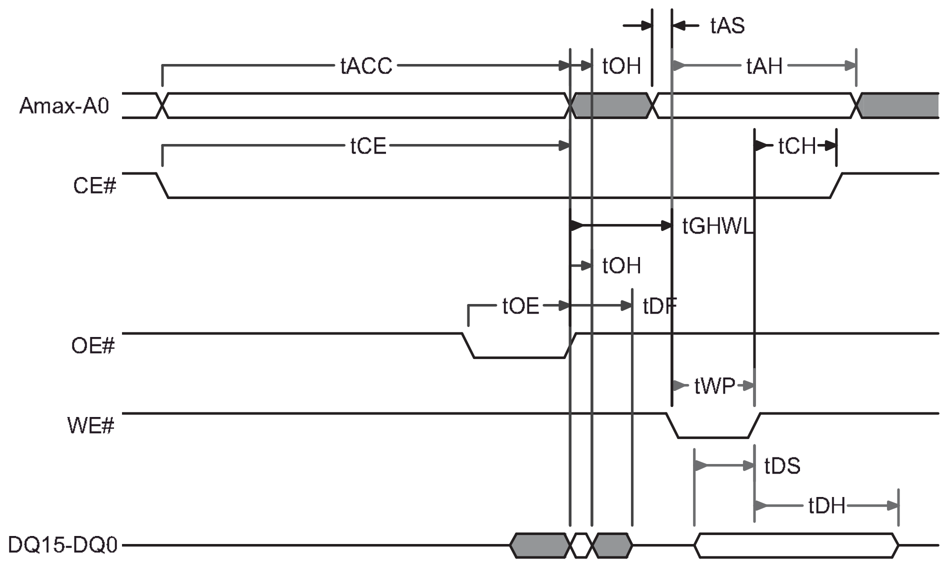


**Figure 11.13** Read to Write (CE# Toggle) Operation Timing Diagram

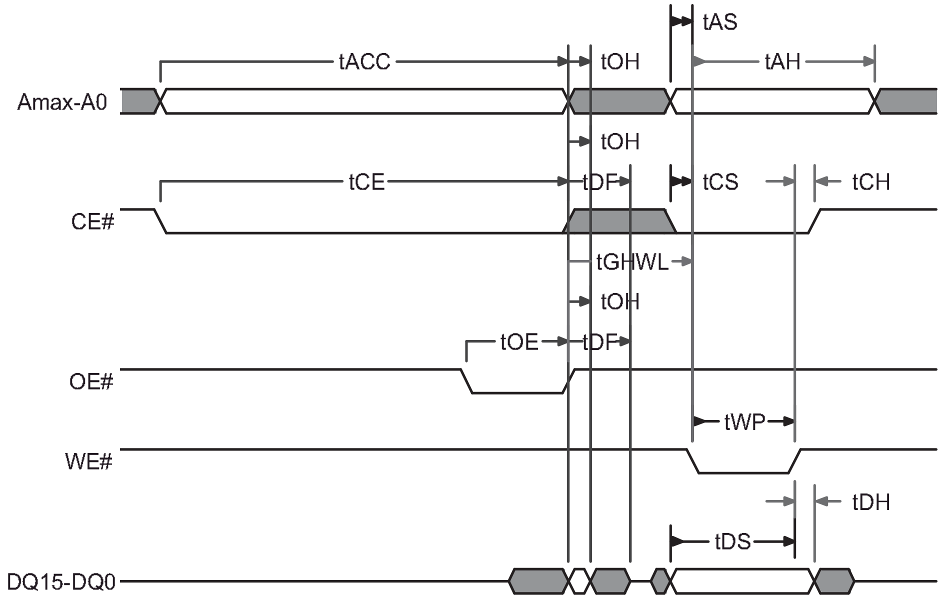
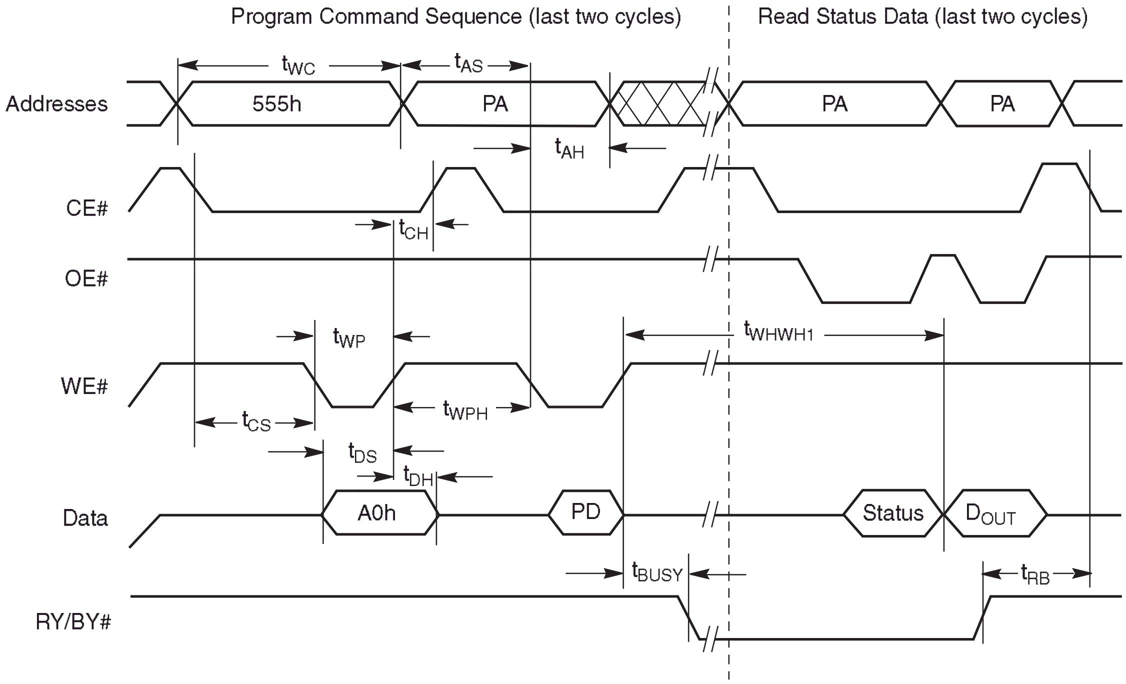



**Table 11.8** Erase/Program Operations

| Parameter JEDEC | Parameter Std | Description | | $V_{IO}$ = 2.7 V to $V_{CC}$ | $V_{IO}$ = 1.65 V to $V_{CC}$ | Unit |
|---|---|---|---|---|---|---|
| $t_{WHWH1}$ | $t_{WHWH1}$ | Write Buffer Program Operation | Typ | (Note 3) | | µs |
| | | Effective Write Buffer Program Operation per Word | Typ | (Note 3) | | µs |
| | | Program Operation per Word or Page | Typ | (Note 3) | | µs |
| $t_{WHWH2}$ | $t_{WHWH2}$ | Sector Erase Operation (Note 1) | Typ | (Note 3) | | ms |
| | $t_{BUSY}$ | Erase/Program Valid to RY/BY# Delay | Max | 80 | | ns |
| | $t_{SR/W}$ | Latency between Read and Write operations (Note 2) | Min | 10 | | ns |
| | $t_{ESL}$ | Erase Suspend Latency | Max | (Note 3) | | µs |
| | $t_{PSL}$ | Program Suspend Latency | Max | (Note 3) | | µs |
| | $t_{RB}$ | RY/BY# Recovery Time | Min | 0 | | µs |

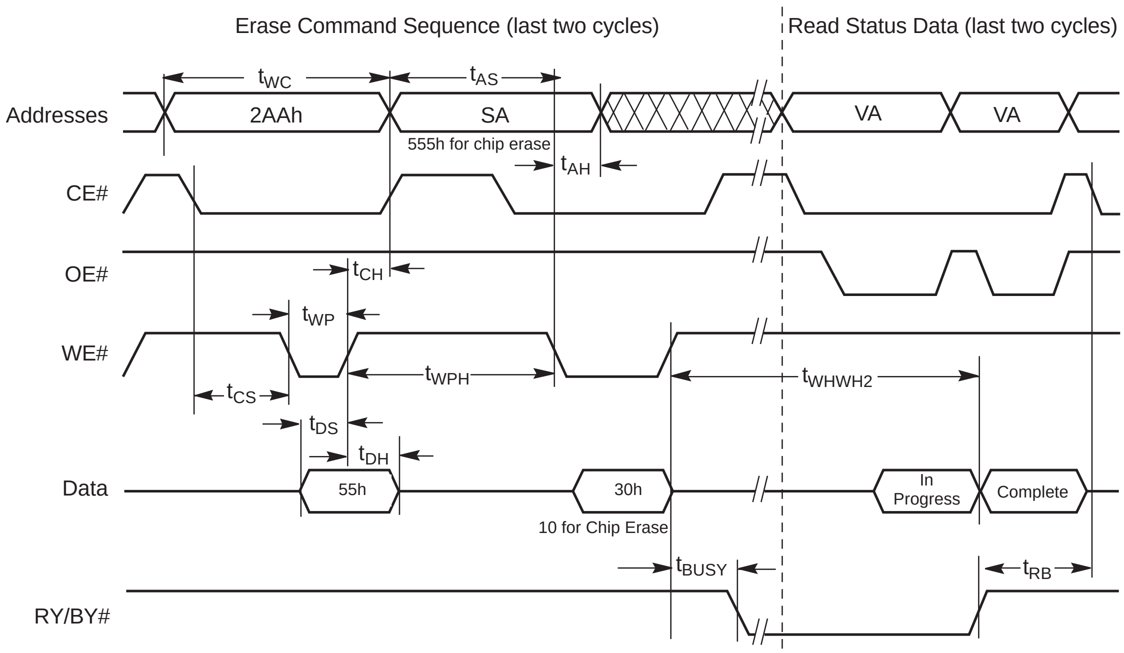
***Notes:***
1. *Not 100% tested.*
2. *Upon the rising edge of WE#, must wait $t_{SR/W}$ before switching to another address.*
3. *See Table 5.4 on page 43 and Table 5.5 on page 44 for specific values.*

**Figure 11.14** Program Operation Timing Diagram




*Note:*
1. *PA = program address, PD = program data, $D_{OUT}$ is the true data at the program address.*

**Figure 11.15** Chip/Sector Erase Operation Timing Diagram



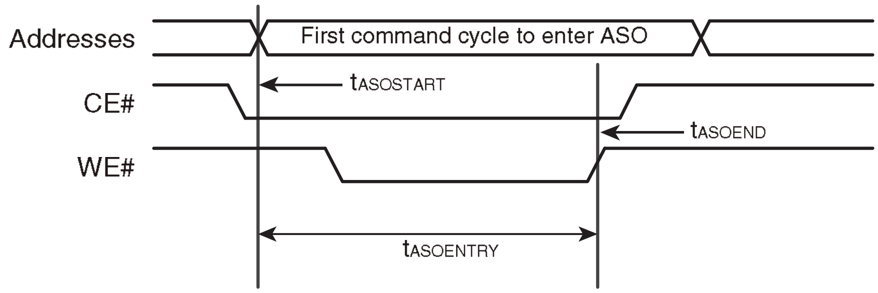

*Note:*
1. *SA = sector address (for sector erase), VA = valid address for reading status data.*

**Table 11.9** ASO Entry Timing

| | |
|---|---|
| $t_{ASOSTART}$ | Falling edge of CE# or address change whichever comes last |
| $t_{ASOEND}$ | Rising edge of CE# or Rising edge of WE# whichever comes first |
| $t_{ASOENTRY}$ | 25 ns < $t_{ASOENTRY}$ < 50 ns or $t_{ASOENTRY}$ > 150 ns |

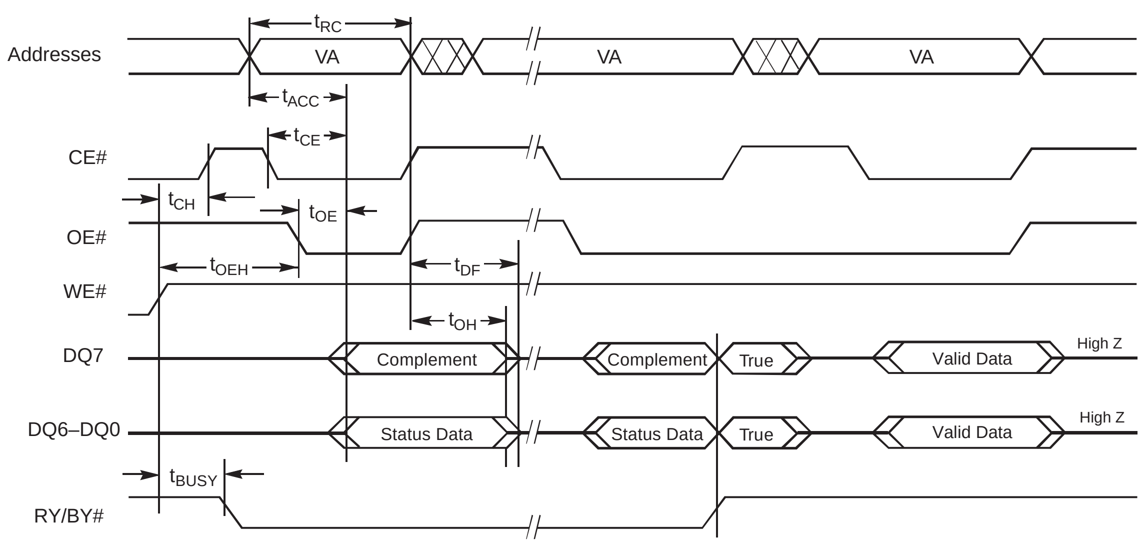
***Note:***
1. *If this timing cannot be achieved, perform the following steps immediately after ASO Exit and before resuming normal processing: read one word from each of 64 unique 32 byte-aligned pages.*

**Figure 11.16** ASO Entry Timing



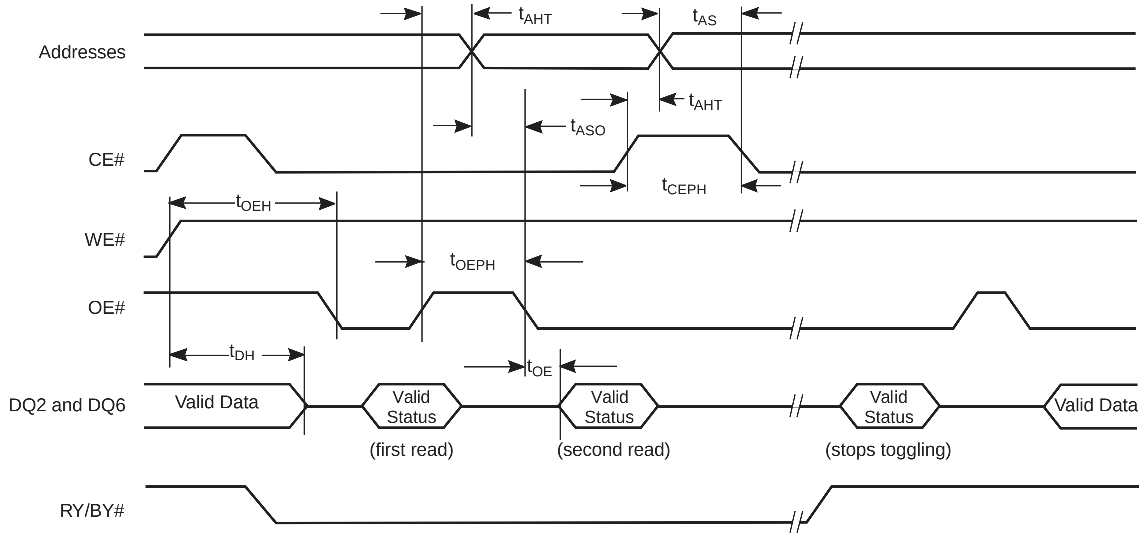

***Note:***
1. *Applicable to any ASO entry command.*

**Figure 11.17** Data# Polling Timing Diagram (During Embedded Algorithms)



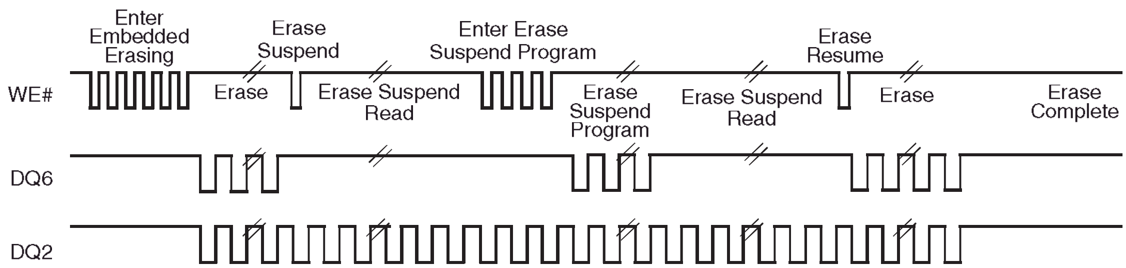

***Note:***
1. *VA = Valid address. Illustration shows first status cycle after command sequence, last status read cycle, and array data read cycle.*

**Figure 11.18** Toggle Bit Timing Diagram (During Embedded Algorithms)




***Note:***
*1. DQ6 will toggle at any read address while the device is busy. DQ2 will toggle if the address is within the actively erasing sector.*

**Figure 11.19** DQ2 vs. DQ6 Relationship Diagram




***Note:***
*1. The system may use OE# or CE# to toggle DQ2 and DQ6. DQ2 toggles only when read at an address within the erase-suspended sector.*

## 11.4.3 Alternate CE# Controlled Write Operations

**Table 11.10** Alternate CE# Controlled Write Operations

| Parameter | | Description | | $V_{IO}$ = 2.7 V to $V_{CC}$ | $V_{IO}$ = 1.65 V to $V_{CC}$ | Unit |
|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | |
| $t_{AVAV}$ | $t_{WC}$ | Write Cycle Time (Note 1) | Min | 60 | | ns |
| $t_{AVWL}$ | $t_{AS}$ | Address Setup Time | Min | 0 | | ns |
| | $t_{ASO}$ | Address Setup Time to OE# Low during toggle bit polling | Min | 15 | | ns |
| $t_{WLAX}$ | $t_{AH}$ | Address Hold Time | Min | 45 | | ns |
| | $t_{AHT}$ | Address Hold Time From CE# or OE# High during toggle bit polling | Min | 0 | | ns |
| $t_{DVWH}$ | $t_{DS}$ | Data Setup Time | Min | 30 | | ns |
| $t_{WHDX}$ | $t_{DH}$ | Data Hold Time | Min | 0 | | ns |
| | $t_{CEPH}$ | CE# High during toggle bit polling | Min | 20 | | ns |
| | $t_{OEPH}$ | OE# High during toggle bit polling | Min | 20 | | ns |

**Table 11.10** Alternate CE# Controlled Write Operations (Continued)

| Parameter | | Description | | $V_{IO}$ = 2.7 V to $V_{CC}$ | $V_{IO}$ = 1.65 V to $V_{CC}$ | Unit |
|---|---|---|---|---|---|---|
| JEDEC | Std | | | | | |
| $t_{GHEK}$ | $t_{GHEL}$ | Read Recovery Time Before Write (OE# High to WE# Low) | Min | 0 | | ns |
| $t_{WLEL}$ | $t_{WS}$ | WE# Setup Time | Min | 0 | | ns |
| $t_{ELWH}$ | $t_{WH}$ | WE# Hold Time | Min | 0 | | ns |
| $t_{ELEH}$ | $t_{CP}$ | CE# Pulse Width | Min | 25 | | ns |
| $t_{EHEL}$ | $t_{CPH}$ | CE# Pulse Width High | Min | 20 | | ns |

***Note:***
*1. Not 100% tested.*

**Figure 11.20** Back to Back (CE#) Write Operation Timing Diagram

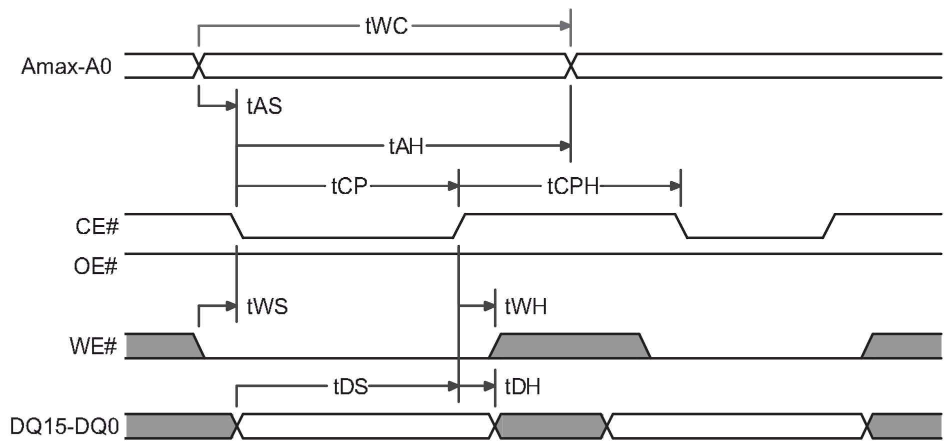
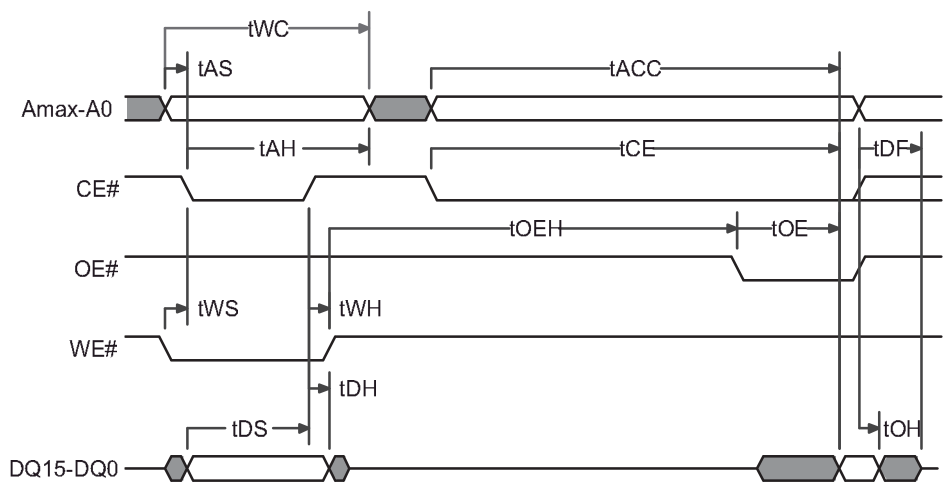



**Figure 11.21** (CE#) Write to Read Operation Timing Diagram

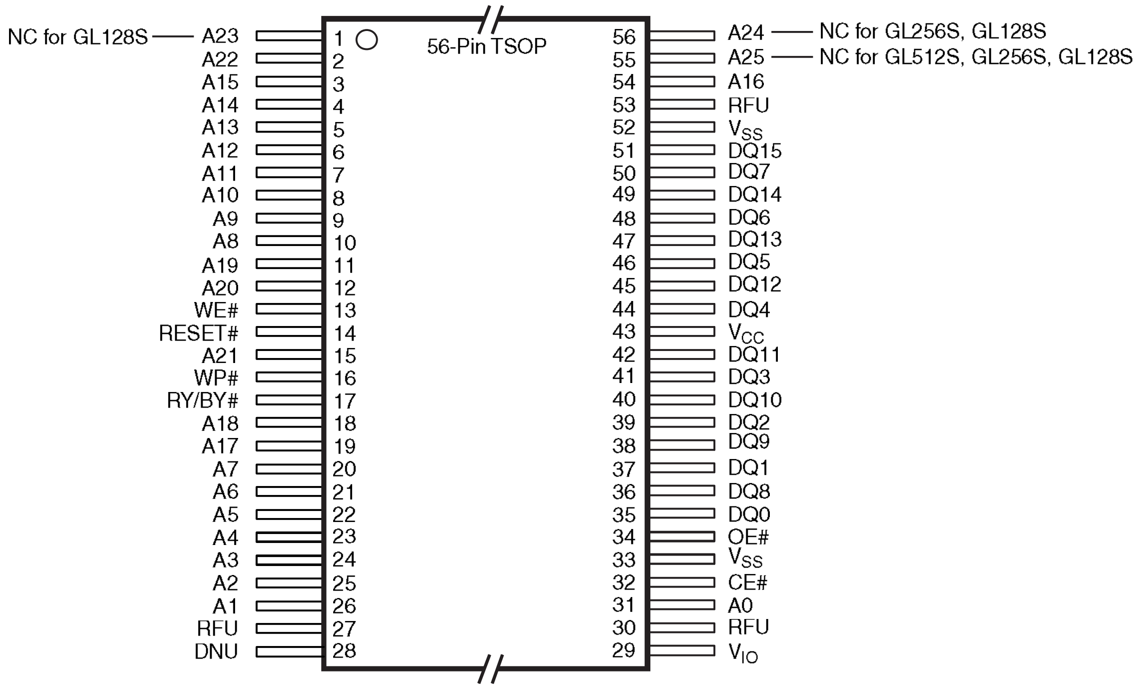


# 12. Physical Interface

## 12.1 56-pin TSOP

### 12.1.1 Connection Diagram

**Figure 12.1** 56-pin Standard TSOP

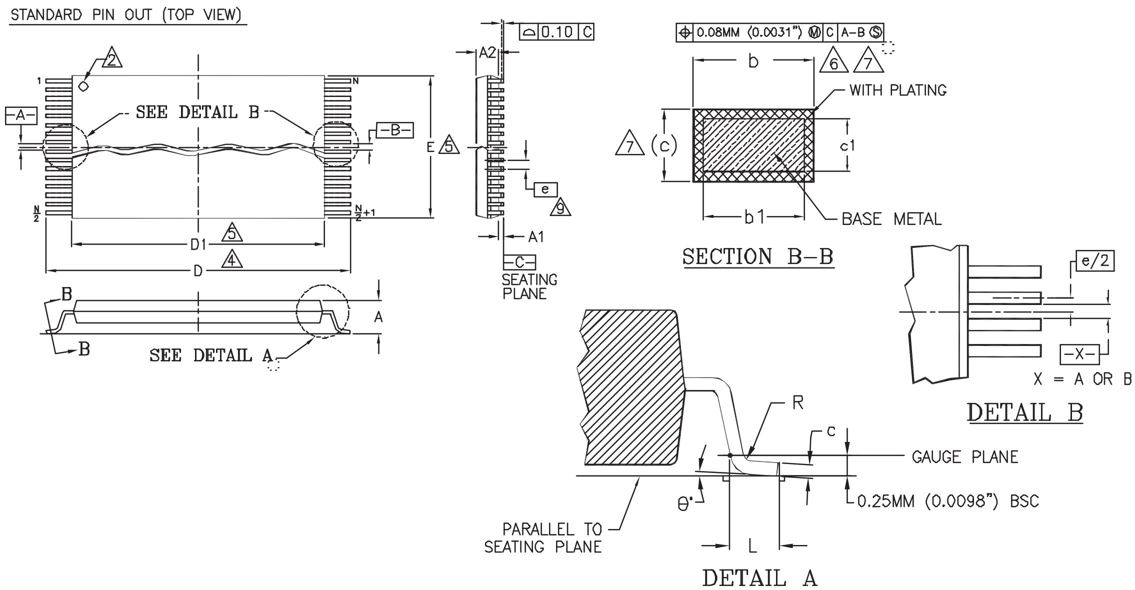



***Notes:***

1. *Pin 28, Do Not Use (DNU), a device internal signal is connected to the package connector. The connector may be used by Cypress for test or other purposes and is not intended for connection to any host system signal. Do not use these connections for PCB Signal routing channels. Though not recommended, the ball can be connected to $V_{CC}$ or $V_{SS}$ through a series resistor.*
2. *Pin 27, 30, and 53 Reserved for Future Use (RFU).*

### 12.1.2 Physical Diagram

**Figure 12.2** 56-pin Thin Small Outline Package (TSOP), 14 × 20 mm




| PACKAGE | TS 56 | | |
|---|---|---|---|
| JEDEC | MO-142 (B) EC | | |
| SYMBOL | MIN. | NOM. | MAX. |
| A | --- | --- | 1.20 |
| A1 | 0.05 | --- | 0.15 |
| A2 | 0.95 | 1.00 | 1.05 |
| b1 | 0.17 | 0.20 | 0.23 |
| b | 0.17 | 0.22 | 0.27 |
| c1 | 0.10 | --- | 0.16 |
| c | 0.10 | --- | 0.21 |
| D | 19.80 | 20.00 | 20.20 |
| D1 | 18.30 | 18.40 | 18.50 |
| E | 13.90 | 14.00 | 14.10 |
| e | 0.50 BASIC | | |
| L | 0.50 | 0.60 | 0.70 |
| ø | 0° | - | 8° |
| R | 0.08 | --- | 0.20 |
| N | 56 | | |

NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (mm). (DIMENSIONING AND TOLERANCING CONFORMS TO ANSI Y14.5M-1982.)
2. PIN 1 IDENTIFIER FOR STANDARD PIN OUT (DIE UP).
3. TO BE DETERMINED AT THE SEATING PLANE -C- . THE SEATING PLANE IS DEFINED AS THE PLANE OF CONTACT THAT IS MADE WHEN THE PACKAGE LEADS ARE ALLOWED TO REST FREELY ON A FLAT HORIZONTAL SURFACE.
4. DIMENSIONS D1 AND E DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE MOLD PROTUSION IS 0.15 mm PER SIDE.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTUSION. ALLOWABLE DAMBAR PROTUSION SHALL BE 0.08 mm TOTAL IN EXCESS OF b DIMENSION AT MAX MATERIAL CONDITION. MINIMUM SPACE BETWEEN PROTRUSION AND AN ADJACENT LEAD TO BE 0.07 mm.
6. THESE DIMESIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.10 mm AND 0.25 mm FROM THE LEAD TIP.
7. LEAD COPLANARITY SHALL BE WITHIN 0.10 mm AS MEASURED FROM THE SEATING PLANE.
8. DIMENSION "e" IS MEASURED AT THE CENTERLINE OF THE LEADS.

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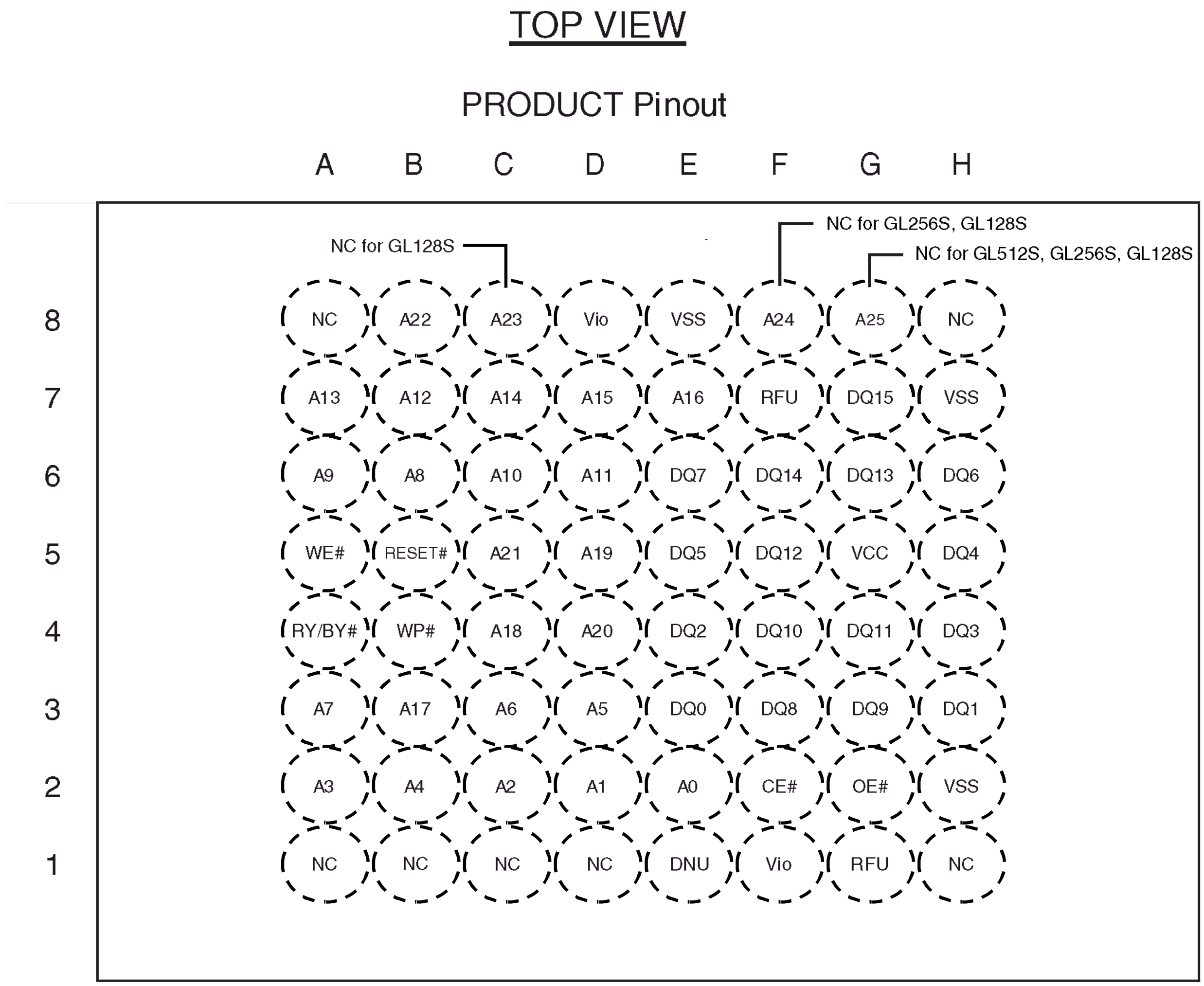
## 12.2 64-Ball FBGA

### 12.2.1 Connection Diagram

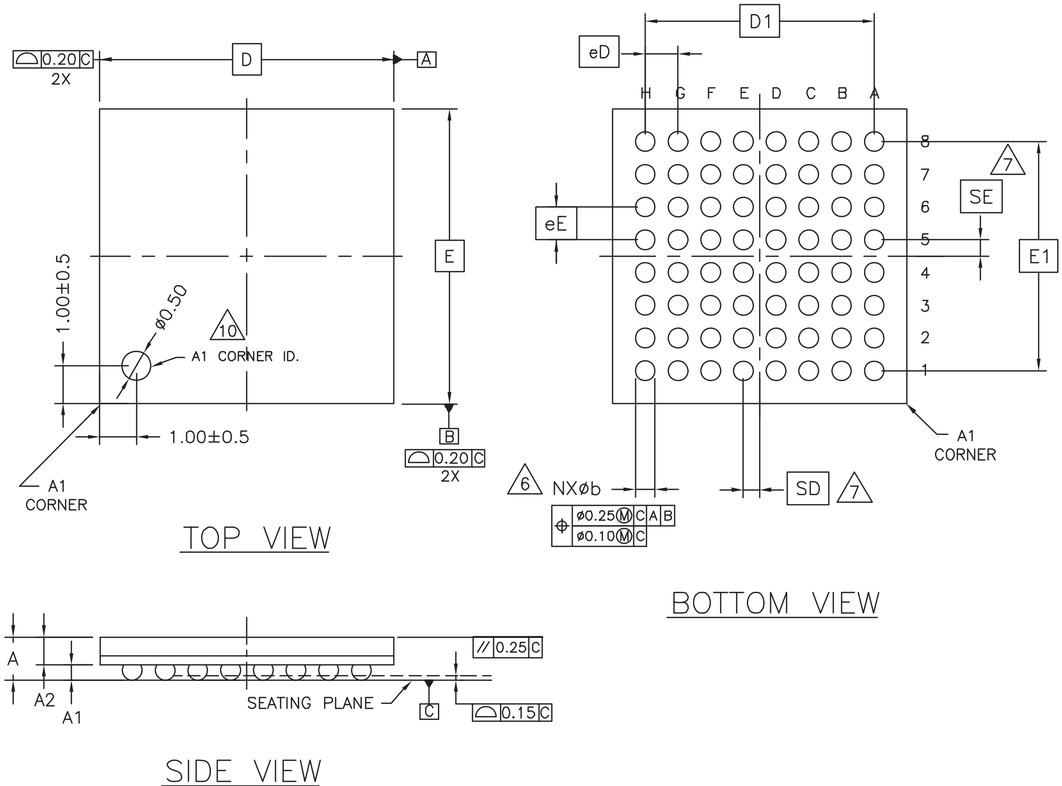
**Figure 12.3** 64-ball Fortified Ball Grid Array




***Notes:***
1. *Ball E1, Do Not Use (DNU), a device internal signal is connected to the package connector. The connector may be used by Cypress for test or other purposes and is not intended for connection to any host system signal. Do not use these connections for PCB Signal routing channels. Though not recommended, the ball can be connected to $V_{CC}$ or $V_{SS}$ through a series resistor.*
2. *Balls F7 and G1, Reserved for Future Use (RFU).*
3. *Balls A1, A8, C1, D1, H1, and H8, No Connect (NC).*

### 12.2.2 Physical Diagram – LAE064

**Figure 12.4** LAE064—64-ball Fortified Ball Grid Array (FBGA), 9 × 9 mm




| PACKAGE | LAE 064 | | | |
|---|---|---|---|---|
| JEDEC | N/A | | | |
| | 9.00 mm x 9.00 mm PACKAGE | | | |
| SYMBOL | MIN | NOM | MAX | NOTE |
| A | --- | --- | 1.40 | PROFILE HEIGHT |
| A1 | 0.40 | --- | --- | STANDOFF |
| A2 | 0.60 | --- | --- | BODY THICKNESS |
| D | | 9.00 BSC. | | BODY SIZE |
| E | | 9.00 BSC. | | BODY SIZE |
| D1 | | 7.00 BSC. | | MATRIX FOOTPRINT |
| E1 | | 7.00 BSC. | | MATRIX FOOTPRINT |
| MD | | 8 | | MATRIX SIZE D DIRECTION |
| ME | | 8 | | MATRIX SIZE E DIRECTION |
| N | | 64 | | BALL COUNT |
| b | 0.50 | 0.60 | 0.70 | BALL DIAMETER |
| eD | | 1.00 BSC. | | BALL PITCH - D DIRECTION |
| eE | | 1.00 BSC. | | BALL PITCH - E DIRECTION |
| SD / SE | | 0.50 BSC. | | SOLDER BALL PLACEMENT |
| ? | | NONE | | DEPOPULATED SOLDER BALLS |

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. BALL POSITION DESIGNATION PER JESD 95-1, SPP-010? EXCEPT AS NOTED).
4. e REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL ROW MATRIX SIZE IN THE "D" DIRECTION.

   SYMBOL "ME" IS THE BALL COLUMN MATRIX SIZE IN THE "E" DIRECTION.

   N IS THE TOTAL NUMBER OF SOLDER BALLS.
6. DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.
7. SD AND SE ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW.

   WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN ? THE OUTER ROW PARALLEL TO THE D OR E DIMENSION, RESPECTIVELY, SD OR SE = 0.000.

   WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, SD OR SE = e/2
8. NOT USED.
9. "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED BALLS.

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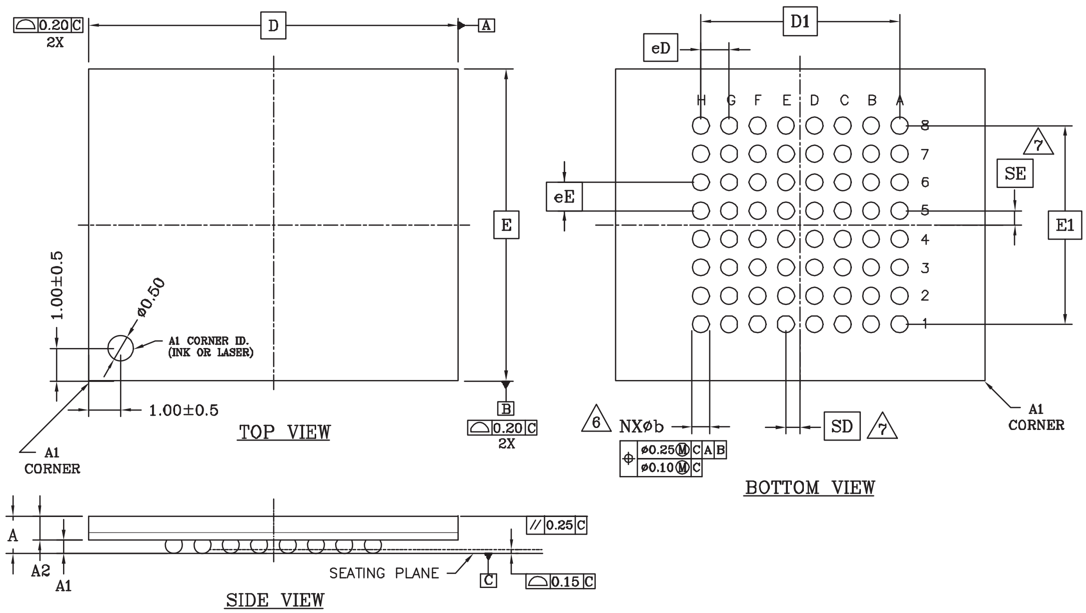
### 12.2.3 Physical Diagram – LAA064




| PACKAGE | LAA 064 | | | |
|---|---|---|---|---|
| JEDEC | N/A | | | |
| | 13.00 mm x 11.00 mm PACKAGE | | | |
| SYMBOL | MIN | NOM | MAX | NOTE |
| A | --- | --- | 1.40 | PROFILE HEIGHT |
| A1 | 0.40 | --- | --- | STANDOFF |
| A2 | 0.60 | --- | --- | BODY THICKNESS |
| D | 13.00 BSC. | | | BODY SIZE |
| E | 11.00 BSC. | | | BODY SIZE |
| D1 | 7.00 BSC. | | | MATRIX FOOTPRINT |
| E1 | 7.00 BSC. | | | MATRIX FOOTPRINT |
| MD | 8 | | | MATRIX SIZE D DIRECTION |
| ME | 8 | | | MATRIX SIZE E DIRECTION |
| N | 64 | | | BALL COUNT |
| φb | 0.50 | 0.60 | 0.70 | BALL DIAMETER |
| eD | 1.00 BSC. | | | BALL PITCH - D DIRECTION |
| eE | 1.00 BSC. | | | BALL PITCH - E DIRECTION |
| SD / SE | 0.50 BSC. | | | SOLDER BALL PLACEMENT |
| | NONE | | | DEPOPULATED SOLDER BALLS |

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. BALL POSITION DESIGNATION PER JESD 95-1, SPP-010 (EXCEPT AS NOTED).
4. e REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL ROW MATRIX SIZE IN THE "D" DIRECTION.

   SYMBOL "ME" IS THE BALL COLUMN MATRIX SIZE IN THE "E" DIRECTION.

   N IS THE TOTAL NUMBER OF SOLDER BALLS.

6. DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.
7. SD AND SE ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW.

   WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW PARALLEL TO THE D OR E DIMENSION, RESPECTIVELY, SD OR SE = 0.000.

   WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, SD OR SE = e/2

8. NOT USED.
9. "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED BALLS.

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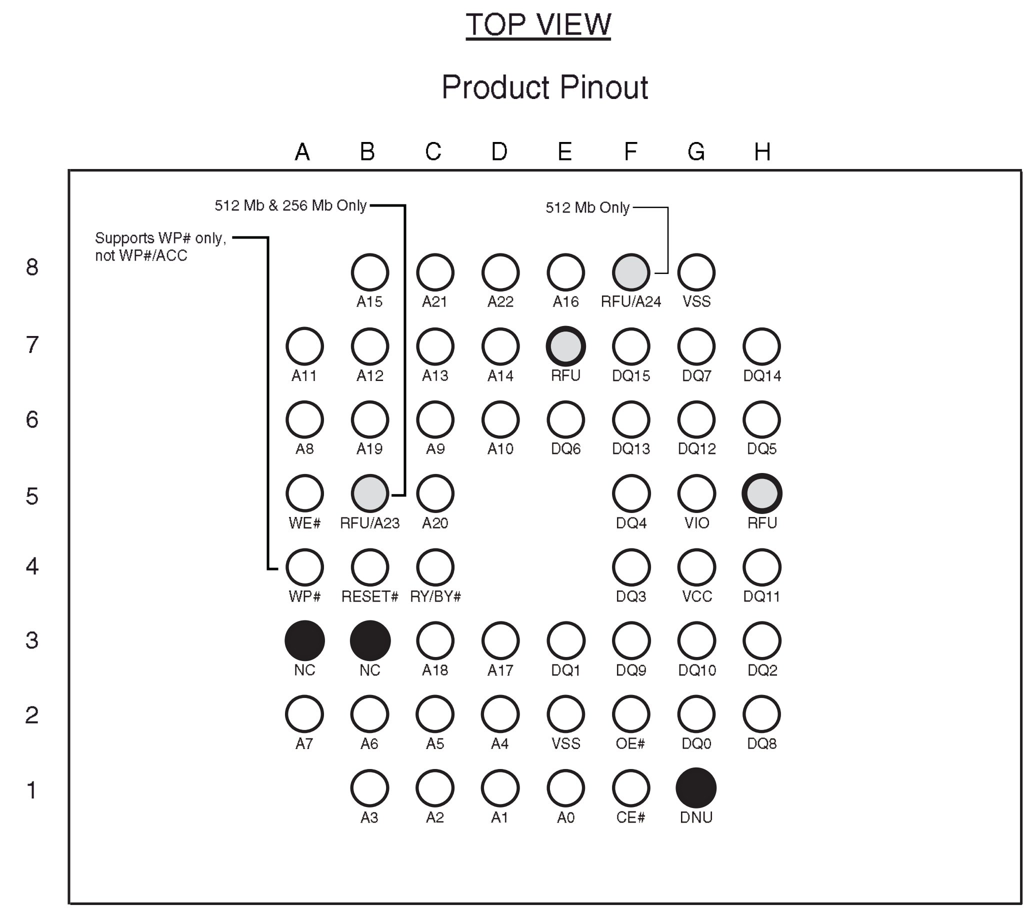
## 12.3 56-Ball FBGA

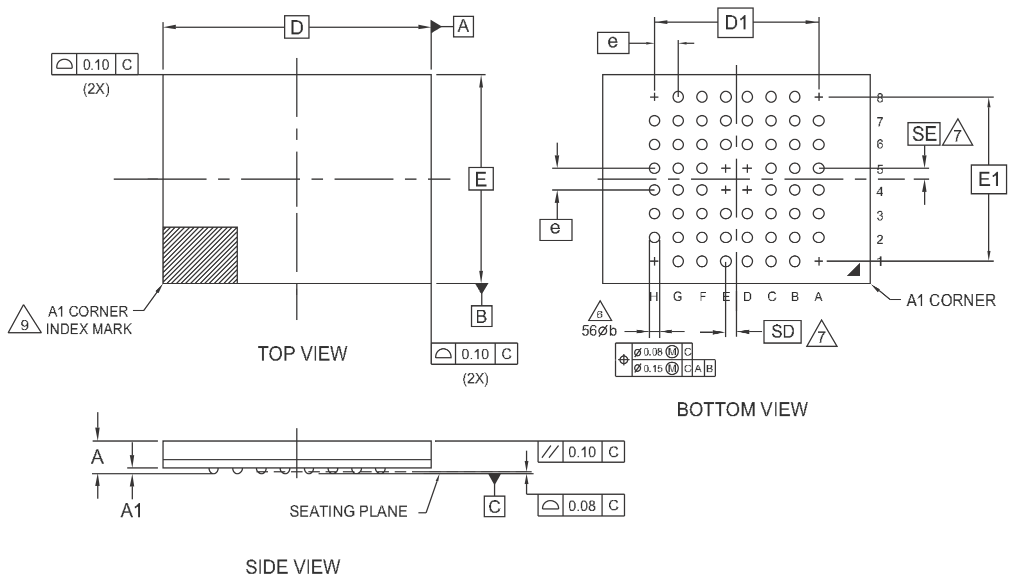
### 12.3.1 Connection Diagram

**Figure 12.5** 56-ball Fortified Ball Grid Array




***Notes:***
1. *Ball G1, Do Not Use (DNU), a device internal signal is connected to the package connector. The connector may be used by Cypress® for test or other purposes and is not intended for connection to any host system signal. Do not use these connections for PCB Signal routing channels. Though not recommended, the ball can be connected to $V_{CC}$ or $V_{SS}$ through a series resistor.*
2. *Balls E7, F8, and H5, Reserved for Future Use (RFU).*
3. *Balls A3 and B3, No Connect (NC).*

### 12.3.2 Physical Diagram - VBU 056




| PACKAGE | VBU 056 | | | |
|---|---|---|---|---|
| JEDEC | N/A | | | |
| | 9.00 mm x 7.00 mm NOM PACKAGE | | | |
| SYMBOL | MIN | NOM | MAX | NOTE |
| A | --- | --- | 1.00 | OVERALL THICKNESS |
| A1 | 0.17 | --- | --- | BALL HEIGHT |
| D | | 9.00 BSC. | | BODY SIZE |
| E | | 7.00 BSC. | | BODY SIZE |
| D1 | | 5.60 BSC. | | BALL FOOTPRINT |
| E1 | | 5.60 BSC. | | BALL FOOTPRINT |
| MD | | 8 | | ROW MATRIX SIZE D DIRECTION |
| ME | | 8 | | ROW MATRIX SIZE E DIRECTION |
| N | | 56 | | TOTAL BALL COUNT |
| Øb | 0.35 | 0.40 | 0.45 | BALL DIAMETER |
| e | | 0.80 BSC. | | BALL PITCH |
| SD/SE | | 0.40 BSC. | | SOLDER BALL PLACEMENT |
| | | A1,A8,D4,D5,E4,E5,H1,H8 | | DEPOPULATED SOLDER BALLS |

NOTES:

1. DIMENSIONING AND TOLERANCING METHODS PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. BALL POSITION DESIGNATION PER JEP95, SECTION 4.3, SPP-010.
4. e REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL MATRIX SIZE IN THE "D" DIRECTION.

   SYMBOL "ME" IS THE BALL MATRIX SIZE IN THE "E" DIRECTION.

   N IS THE TOTAL NUMBER OF POPULATED SOLDER BALL POSITIONS FOR MATRIX SIZE MD X ME.
6. DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.
7. SD AND SE ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW.

   WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW SD OR SE = 0.000.

   WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, SD OR SE = e/2
8. "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED BALLS.
9. A1 CORNER TO BE IDENTIFIED BY CHAMFER, LASER OR INK MARK, METALLIZED MARK INDENTATION OR OTHER MEANS.
10. OUTLINE AND DIMENSIONS PER CUSTOMER REQUIREMENT.

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## 13. Special Handling Instructions for FBGA Package

Special handling is required for Flash Memory products in FBGA packages.

Flash memory devices in FBGA packages may be damaged if exposed to ultrasonic cleaning methods. The package and/or data integrity may be compromised if the package body is exposed to temperatures above 150 °C for prolonged periods of time.

# 14. Ordering Information

### Valid Combinations — Standard

Table 14.1 lists configurations planned to be available in volume. The table will be updated as new combinations are released. Consult your local sales representative to confirm availability of specific combinations and to check on newly released combinations.

**Table 14.1** S29GL-S Valid Combinations — Standard

| S29GL-S Valid Combinations — Standard | | | | | |
|---|---|---|---|---|---|
| **Base OPN** | **Speed (ns)** | **Package and Temperature** | **Model Number** | **Packing Type** | **Ordering Part Number (yy = Model Number, x = Packing Type)** |
| S29GL01GS | 100 | DHI, FAI, FHI, TFI (Note 1) | 01, 02 | 0, 3 (Note 2) | S29GL01GS10DHIyyx<br>S29GL01GS10FAIyyx<br>S29GL01GS10FHIyyx<br>S29GL01GS10TFIyyx |
| | 110 | DHV, TFV (Note 1) | 01, 02 | | S29GL01GS11DHVyyx<br>S29GL01GS11TFVyyx |
| | | DHI, FHI, TFI (Note 1) | V1, V2 | | S29GL01GS11DHIyyx<br>S29GL01GS11FHIyyx<br>S29GL01GS11TFIyyx |
| | 120 | DHV, TFV (Note 1) | V1, V2 | | S29GL01GS12DHVyyxx<br>S29GL01GS12TFVyyxx |
| S29GL512S | 100 | DHI, FAI, FHI, GHI, SFI, TFI (Note 1) | 01, 02 | 0, 3 (Note 2) | S29GL512S10DHIyyx<br>S29GL512S10FAIyyx<br>S29GL512S10FHIyyx<br>S29GL512S10GHIyyx<br>S29GL512S10SFIyyx<br>S29GL512S10TFIyyx |
| | 110 | GHI (Note 1) | 01, 02 | | S29GL512S11GHIyyx |
| | | DHV, TFV (Note 1) | 01, 02 | | S29GL512S11DHVyyx<br>S29GL512S11TFVyyx |
| | | DHI, FHI, TFI (Note 1) | V1, V2 | | S29GL512S11DHIyyx<br>S29GL512S11FHIyyx<br>S29GL512S11TFIyyx |
| | 120 | DHV, TFV (Note 1) | V1, V2 | | S29GL512S12DHVyyxx<br>S29GL512S12TFVyyxx |
| S29GL256S | 90 | DHI, FHI, GHI, TFI (Note 1) | 01, 02 | 0, 3 (Note 2) | S29GL256S90DHIyyx<br>S29GL256S90FHIyyx<br>S29GL256S90GHIyyx<br>S29GL256S90TFIyyx |
| | 100 | DHV, TFV (Note 1) | 01, 02 | | S29GL256S10DHVyyx<br>S29GL256S10TFVyyx |
| | | DHI, FAI, FHI, TFI (Note 1) | V1, V2 | | S29GL256S10DHIyyx<br>S29GL256S10FAIyyx<br>S29GL256S10FHIyyx<br>S29GL256S10TFIyyx |
| | 110 | DHV, TFV (Note 1) | V1, V2 | | S29GL256S11DHVyyxx<br>S29GL256S11TFVyyxx |

**Table 14.1** S29GL-S Valid Combinations — Standard (Continued)

| S29GL-S Valid Combinations — Standard | | | | | |
|---|---|---|---|---|---|
| **Base OPN** | **Speed (ns)** | **Package and Temperature** | **Model Number** | **Packing Type** | **Ordering Part Number (yy = Model Number, x = Packing Type)** |
| S29GL128S | 90 | DHI, FAI, FHI, GHI, TFI (Note 1) | 01, 02 | 0, 3 (Note 2) | S29GL128S90DHIyyx<br>S29GL128S90FAIyyx<br>S29GL128S90FHIyyx<br>S29GL128S90GHIyyx<br>S29GL128S90TFIyyx |
| | 100 | DHV, TFV (Note 1) | 01, 02 | | S29GL128S10DHVyyx<br>S29GL128S10TFVyyx |
| | | DHI, FAI, FHI, TFI (Note 1) | V1, V2 | | S29GL128S10DHIyyx<br>S29GL128S10FAIyyx<br>S29GL128S10FHIyyx<br>S29GL128S10TFIyyx |
| | 110 | DHV, TFV, FHV (Note 1) | V1, V2 | | S29GL128S11DHVyyx<br>S29GL128S11TFVyyx<br>S29GL128S11FHVyyx |

***Notes:***
1. *Additional speed, package, and temperature options maybe offered in the future. Check with your local sales representative for availability.*
2. *Package Type 0 is standard option.*

### Valid Combinations — Automotive Grade / AEC-Q100

Table 14.2 and Table 14.3 list configurations that are Automotive Grade / AEC-Q100 qualified and are planned to be available in volume. The table will be updated as new combinations are released. Consult your local sales representative to confirm availability of specific combinations and to check on newly released combinations.

Production Part Approval Process (PPAP) support is only provided for AEC-Q100 grade products.

Products to be used in end-use applications that require ISO/TS-16949 compliance must be AEC-Q100 grade products in combination with PPAP. Non–AEC-Q100 grade products are not manufactured or documented in full compliance with ISO/TS-16949 requirements.

AEC-Q100 grade products are also offered without PPAP support for end-use applications that do not require ISO/TS-16949 compliance.

**Table 14.2** S29GL-S Valid Combinations — Automotive Grade (-40 °C to +85 °C)

| S29GL-S Valid Combinations — Automotive Grade (-40 °C to +85 °C) | | | | | |
|---|---|---|---|---|---|
| **Base OPN** | **Speed (ns)** | **Package and Temperature** | **Model Number** | **Packing Type** | **Ordering Part Number (yy = Model Number, x = Packing Type)** |
| S29GL01GS | 100, 110 | DHA, FHA, TFA (Note 1) | 01, 02 | 0, 3 (Note 2) | S29GL01GS10DHAyyx<br>S29GL01GS10FHAyyx<br>S29GL01GS10TFAyyx<br>S29GL01GS11DHAyyx<br>S29GL01GS11FHAyyx<br>S29GL01GS11TFAyyx |
| | 110 | | V1, V2 | | S29GL01GS11DHAyyx<br>S29GL01GS11FHAyyx<br>S29GL01GS11TFAyyx |
| S29GL512S | 100 | | 01, 02 | | S29GL512S10DHAyyx<br>S29GL512S10FHAyyx<br>S29GL512S10TFAyyx |
| | 110 | | V1, V2 | | S29GL512S11DHAyyx<br>S29GL512S11FHAyyx<br>S29GL512S11TFAyyx |
| S29GL256S | 90 | | 01, 02 | | S29GL256S90DHAyyx<br>S29GL256S90FHAyyx<br>S29GL256S90TFAyyx |
| | 100 | | V1, V2 | | S29GL256S10DHAyyx<br>S29GL256S10FHAyyx<br>S29GL256S10TFAyyx |
| S29GL128S | 90 | | 01, 02 | | S29GL128S90DHAyyx<br>S29GL128S90FHAyyx<br>S29GL128S90TFAyyx |
| | 100 | | V1, V2 | | S29GL128S10DHAyyx<br>S29GL128S10FHAyyx<br>S29GL128S10TFAyyx |

***Notes:***
1. *Additional speed, package, and temperature options maybe offered in the future. Check with your local sales representative for availability.*
2. *Package Type 0 is standard option.*

**Table 14.3** S29GL-S Valid Combinations — Automotive Grade (-40 °C to +105 °C)

| S29GL-S Valid Combinations — Automotive Grade (-40 °C to +105 °C) | | | | | |
|---|---|---|---|---|---|
| **Base OPN** | **Speed (ns)** | **Package and Temperature** | **Model Number** | **Packing Type** | **Ordering Part Number (yy = Model Number, x = Packing Type)** |
| S29GL01GS | 110 | DHB, FHB, TFB, GHB (Note 1) | 01, 02 | 0, 3 (Note 2) | S29GL01GS11DHByyx<br>S29GL01GS11FHByyx<br>S29GL01GS11TFByyx |
| | 120 | | V1, V2 | | S29GL01GS12DHByyx<br>S29GL01GS12FHByyx<br>S29GL01GS12TFByyx |
| S29GL512S | 110 | | 01, 02 | | S29GL512S11DHByyx<br>S29GL512S11FHByyx<br>S29GL512S11GHByyx<br>S29GL512S11TFByyx |
| | 120 | | V1, V2 | | S29GL512S12DHByyx<br>S29GL512S12FHByyx<br>S29GL512S12GHByyx<br>S29GL512S12TFByyx |
| S29GL256S | 100 | | 01, 02 | | S29GL256S10DHByyx<br>S29GL256S10FHByyx<br>S29GL256S10TFByyx<br>S29GL256S10GHByyx |
| | 110 | | V1, V2 | | S29GL256S11DHByyx<br>S29GL256S11FHByyx<br>S29GL256S11TFByyx |
| S29GL128S | 100 | | 01, 02 | | S29GL128S10DHByyx<br>S29GL128S10FHByyx<br>S29GL128S10TFByyx<br>S29GL128S10GHByyx |
| | 110 | | V1, V2 | | S29GL128S11DHByyx<br>S29GL128S11FHByyx<br>S29GL128S11TFByyx |

***Notes:***
1. *Additional speed, package, and temperature options maybe offered in the future. Check with your local sales representative for availability.*
2. *Package Type 0 is standard option.*

The ordering part number for the General Market device is formed by a valid combination of the following:

**S29GL01GS 10 D H I 01 0**

**Packing Type**
0 = Tray
3 = 13” Tape and Reel

**Model Number ($V_{IO}$ and $V_{CC}$ Range)**
01 = $V_{IO}$ = $V_{CC}$ = 2.7 to 3.6V, highest address sector protected
02 = $V_{IO}$ = $V_{CC}$ = 2.7 to 3.6V, lowest address sector protected
V1 = $V_{IO}$ = 1.65 to $V_{CC}$, $V_{CC}$ = 2.7 to 3.6V, highest address sector protected
V2 = $V_{IO}$ = 1.65 to $V_{CC}$, $V_{CC}$ = 2.7 to 3.6V, lowest address sector protected

**Temperature Range / Grade**
I = Industrial (-40 °C to +85 °C)
V = Industrial Plus (-40 °C to +105 °C)
A = Automotive, AEC-Q100 Grade 3 (-40 °C to +85 °C)
B = Automotive, AEC-Q100 Grade 2 (-40 °C to +105 °C)

**Package Materials Set**
A = Leaded (Sn/Pb) balls - BGA only
F = Halogen-free, Lead (Pb)-free (1)
H = Halogen-free, Lead (Pb)-free (1)

**Package Type**
D = Fortified Ball-Grid Array Package (LAE064) 9 mm x 9 mm
F = Fortified Ball-Grid Array Package (LAA064) 13 mm x 11 mm
G = Fortified Ball-Grid Array Package (VBU056) 9 mm x 7 mm
S = 70-pin Shrink Small Outline Package
T = Thin Small Outline Package (TSOP) Standard Pinout

**Speed Option**
90 = 90 ns random access time
10 = 100 ns random access time
11 = 110 ns random access time
12 = 120 ns random access time

**Device Number/Description**
S29GL01GS, S29GL512S, S29GL256S, S29GL128S
3.0 Volt Core, with $V_{IO}$ Option, 1024, 512, 256, 128 Megabit Page-Mode Flash Memory,
Manufactured on 65 nm MirrorBit Eclipse Process Technology

***Note:***
1. *Halogen-free definition is in accordance with IEC 61249-2-21 specification.*

# 15. Other Resources

## 15.1 Cypress Flash Memory Roadmap

http://www.cypress.com/Flash-Roadmap

## 15.2 Links to Software

http://www.cypress.com/software-and-drivers-cypress-flash-memory

## 15.3 Links to Application Notes

http://www.cypress.com/cypressappnotes

# 16. Revision History

## Document History Page

| Document Title: S29GL01GS/S29GL512S/S29GL256S/S29GL128S,<br>1-Gbit (128 Mbyte)/512-Mbit (64 Mbyte)/256-Mbit (32 Mbyte)/128-Mbit (16 Mbyte), 3.0 V, GL-S Flash Memory<br>Document Number: 001-98285 | | | | |
|---|---|---|---|---|
| **Rev.** | **ECN No.** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| ** | – | BWHA | 02/11/2011 | Initial release. |
| *A | – | BWHA | 03/21/2011 | **Global:**<br>Modified document from “Advance Information” to “Preliminary”<br>**OPN:**<br>Added FBGA package offering for V1 & V2 Model Number<br>Removed KGD information, which is documented in a separate Supplement<br>**Command Definitions Table:**<br>Removed duplicated commands<br>Changed the number of command cycles for a CFI Enter from 3 to 1<br>**Physical Interface:**<br>Updated 56-pin TSOP pinout figure<br>Updated 64-ball FBGA pinout figure<br>**Other Resources:**<br>Added additional application notes in “Links to Application Notes”<br>**Lock Register Table:**<br>Changed the default value of bit 7 in the Lock register |
| *B | – | BWHA | 07/08/2011 | **Performance Summary:**<br>Updated table: Typical Program and Erase Rates<br>**Secure Silicon Region ASO:**<br>Corrected table: Secure Silicon Region<br>**DQ1: Write-to-Buffer Abort:**<br>Corrected table: Data Polling Status<br>**Embedded Algorithm Performance Table:**<br>Updated table: Embedded Algorithm Characteristics<br>**Command State Transitions:**<br>Corrected tables: changed Software Reset/ASO Exit Data value to from 00F0h to xF0h<br>Corrected table: Erase Suspend Unlock State Command Transition<br>Corrected table: Erase Suspend - DYB State Command Transition<br>Corrected table: Program Unlock State Command Transition<br>Corrected table: Lock Register State Command Transition<br>Corrected table: Secure Silicon Sector Program State Command Transition<br>Corrected table: Password Protection Command State Transition<br>Corrected table: Non-Volatile Protection Command State Transition<br>Corrected table: PPB Lock Bit Command State Transition<br>Corrected table: Volatile Sector Protection Command State Transition<br>**Device ID and Common Flash Interface (ID-CFI) ASO Map:**<br>Corrected table: Corrected CFI Primary Vendor-Specific Extended Query description for Word Address (SA) + 0045h |

## Document History Page (Continued)

| Document Title: S29GL01GS/S29GL512S/S29GL256S/S29GL128S,<br>1-Gbit (128 Mbyte)/512-Mbit (64 Mbyte)/256-Mbit (32 Mbyte)/128-Mbit (16 Mbyte), 3.0 V, GL-S Flash Memory<br>Document Number: 001-98285 | | | | |
|---|---|---|---|---|
| **Rev.** | **ECN No.** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| *B (cont) | – | BWHA | 07/08/2011 | **DC Characteristics:**<br>Updated VIL Max<br>Updated Note<br>**Power-On Reset (POR) and Warm Reset:**<br>Updated table: added row to bottom of table<br>**Power-On (Cold) Reset (POR):**<br>Updated text<br>Updated figure: Power-Up Diagram<br>**Hardware (Warm) Reset:**<br>Updated figure: Hardware Reset<br>**Asynchronous Write Operations:**<br>Added figure: Back to Back (CE#VIL) Write Operation Timing Diagram<br>Updated table: Erase/Program Operations<br>**Physical Diagram - LAA064:**<br>Added figure |
| *C | – | BWHA | 10/03/2011 | **Power-Up Write Inhibit:**<br>Minor correction<br>**PPB Password Protection Mode:**<br>Minor correction<br>**Embedded Algorithm Characteristics table:**<br>Updated Buffer Programming Time maximum limits<br>**Absolute Maximum Ratings table:**<br>Added clarification<br>**DC Characteristics table:**<br>Output High Voltage clarification<br>**Power-Up/Power-Down Voltage and Timing table:**<br>Added clarification<br>**Power-Up figure:**<br>Added clarification<br>**Power-On (Cold) Reset (POR):**<br>Added clarification<br>**Valid Combinations table:**<br>Updated table |
| *D | – | BWHA | 12/14/2011 | **Global:**<br>Data sheet designation changed from Preliminary to Full Production<br>Sector Erase: Updated Typical Erase Time<br>**Capacitance Characteristics:**<br>Updated section<br>**Ordering Information:**<br>Corrected note designation in valid combination table |
| *E | – | BWHA | 03/16/2012 | **Global:**<br>Added 9 mm x 7 mm package<br>Added 105°C offering<br>**Ordering Information:**<br>Updated Valid Combinations |

## Document History Page (Continued)

| Document Title: S29GL01GS/S29GL512S/S29GL256S/S29GL128S,<br>1-Gbit (128 Mbyte)/512-Mbit (64 Mbyte)/256-Mbit (32 Mbyte)/128-Mbit (16 Mbyte), 3.0 V, GL-S Flash Memory<br>Document Number: 001-98285 | | | | |
|---|---|---|---|---|
| **Rev.** | **ECN No.** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| *F | – | BWHA | 12/21/2012 | **Distinctive Characteristics:**<br>Added In-Cabin temperature range<br>**Status Register ASO:**<br>Added clarification<br>**Advanced Sector Protection Overview:**<br>Updated figure<br>**PPB Lock:**<br>Added clarification<br>**Persistent Protection Bits (PPB):**<br>Added clarification<br>**Dynamic Protection Bits (DYB):**<br>Added clarification<br>**PPB Password Protection Mode:**<br>Added clarification<br>**Chip Erase:**<br>Added clarification<br>**Sector Erase:**<br>Added clarification<br>**Erase Suspend / Erase Resume:**<br>Added clarification<br>**Status Register ASO:**<br>Added clarification<br>**Status Register:**<br>Added clarification<br>**DQ7: Data# Polling:**<br>Added clarification<br>**DQ1: Write-to-Buffer Abort:**<br>Added clarification<br>**Data Polling Status:**<br>Updated table<br>**Embedded Operation Error:**<br>Added clarification<br>**Protection Error:**<br>Added clarification<br>**Write Buffer Abort:**<br>Added clarification<br>**Performance Table:**<br>Updated Embedded Algorithm Characteristics (-40°C to +105°C) table<br>**Device ID and Common Flash Interface (ID-CFI) ASO Map:**<br>Updated CFI Device Geometry Definition table<br>Updated CFI Primary Vendor-Specific Extended Query table<br>**Asynchronous Read Operations:**<br>Added Read Operation VIO = 1.65 (-40°C to +105°C) table<br>**Asynchronous Write Operations:**<br>Updated Read to Write (CE# VIL) figure<br>Updated Read to Write (CE# Toggle) figure |
| *G | – | BWHA | 10/09/2013 | **S29GL-S Valid Combinations Table:**<br>Added VIO Models for Automotive In Cabin Temperature Range |
| *H | 4871480 | BWHA | 08/13/2015 | Updated to Cypress template. |

## Document History Page (Continued)

| Document Title: S29GL01GS/S29GL512S/S29GL256S/S29GL128S, 1-Gbit (128 Mbyte)/512-Mbit (64 Mbyte)/256-Mbit (32 Mbyte)/128-Mbit (16 Mbyte), 3.0 V, GL-S Flash Memory<br>Document Number: 001-98285 | | | | |
|---|---|---|---|---|
| **Rev.** | **ECN No.** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| *I | 5162387 | RYSU | 03/04/2016 | Updated Ordering Information on page 97:<br>Updated Table 14.1 on page 97:<br>Updated part numbers.<br>Replaced "In Cabin" with "Industrial Plus" in Ordering Code Definitions below Table 14.1 on page 97.<br>Updated to new template. |
| *J | 5428780 | BWHA | 09/06/2016 | Updated Timing Specifications on page 75:<br>Updated AC Characteristics on page 78:<br>Updated Asynchronous Write Operations on page 82:<br>Updated Table 11.9 on page 87.<br>Updated Figure 11.16 on page 87. |
| *K | 5446870 | BWHA | 11/10/2016 | Added Automotive Grade related information in all instances across the document.<br>Updated Address Space Maps on page 6:<br>Added ECC Status ASO on page 11.<br>Updated Embedded Operations on page 20:<br>Added Automatic ECC on page 22.<br>Updated Command Set on page 23:<br>Added ECC Status ASO on page 33.<br>Updated Data Integrity on page 54:<br>Added Erase Endurance on page 54.<br>Added Data Retention on page 54.<br>Updated Software Interface Reference on page 55:<br>Removed "Address and Data Configuration".<br>Updated Command Summary on page 55:<br>Updated Table 7.1 on page 55 (to include ECC ASO Commands).<br>Updated Electrical Specifications on page 69:<br>Added Thermal Resistance on page 69.<br>Updated Ordering Information on page 97:<br>Added Valid Combinations — Automotive Grade / AEC-Q100 on page 99.<br>Updated Other Resources on page 102:<br>Added Cypress Flash Memory Roadmap on page 102.<br>Updated Links to Software on page 102:<br>Updated description.<br>Updated Links to Application Notes on page 102:<br>Updated description.<br>Removed "Specification Bulletins".<br>Removed "Contacting Cypress". |
| *L | 5724042 | NFB / PRIT | 05/03/2017 | Updated Software Interface Reference on page 55:<br>Added Device ID and Common Flash Interface (ID-CFI) ASO Map on page 63.<br>Updated Ordering Information on page 97:<br>Updated Valid Combinations — Standard on page 97:<br>Updated Table 14.1 on page 97:<br>Updated part numbers.<br>Updated to new template. |

## Document History Page (Continued)

| Document Title: S29GL01GS/S29GL512S/S29GL256S/S29GL128S,<br>1-Gbit (128 Mbyte)/512-Mbit (64 Mbyte)/256-Mbit (32 Mbyte)/128-Mbit (16 Mbyte), 3.0 V, GL-S Flash Memory<br>Document Number: 001-98285 | | | | |
|---|---|---|---|---|
| **Rev.** | **ECN No.** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| *M | 5776117 | SZZX | 06/16/2017 | Updated Software Interface Reference on page 55:<br>Updated Command Summary on page 55:<br>Updated Table 7.1 on page 55:<br>Replaced “2” with “1” in “Cycles” column corresponding to “Command Set Exit” under “ECC ASO” Command Sequence. |
| *N | 5827786 | PRIT | 07/21/2017 | Updated Address Space Maps on page 6:<br>Updated ECC Status ASO on page 11:<br>Updated description.<br>Updated ECC Status on page 11:<br>Updated description.<br>Updated Table 2.8 on page 12 (Updated “Name” corresponding to Bit 2 and Bit 1).<br>Updated Embedded Operations on page 20:<br>Updated Command Set on page 23:<br>Updated ASO Entry and Exit on page 31:<br>Updated ECC Status ASO on page 33:<br>Updated description.<br>Completing Sunset Review. |
| *O | 5891084 | PRIT | 09/19/2017 | Updated Ordering Information on page 97:<br>Updated Valid Combinations — Standard on page 97:<br>Updated Table 14.1 on page 97:<br>Updated part numbers. |
| *P | 6061893 | PRIT | 03/30/2018 | Updated Ordering Information on page 97:<br>Updated Valid Combinations — Standard on page 97:<br>Updated Table 14.1 on page 97:<br>Updated part numbers.<br>Updated Valid Combinations — Automotive Grade / AEC-Q100 on page 99:<br>Updated Table 14.3 on page 100:<br>Updated part numbers.<br>Updated to new template. |
| *Q | 6199062 | PRIT | 06/06/2018 | Updated Electrical Specifications on page 69:<br>Updated Thermal Resistance on page 69:<br>Updated Table 10.2 on page 69:<br>Changed value of Theta Ja parameter from 20.4 °C/W to 27.3 °C/W corresponding to “LAE064” package. |
| *R | 6214196 | PRIT | 06/21/2018 | Updated Ordering Information on page 97:<br>Updated details corresponding to “F” and “H” under “Package Materials Set” in the diagram.<br>Added a note “Halogen free definition is in accordance with IEC 61249-2-21 specification” and referred the same note in “F” and “H”. |

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# Cypress Semiconductor
# Automotive Reliability Qualification Report

## AEC-Q100 Automotive Qualification Test Plan Report for

**PBO Protection Layer for S29GLXXXS, 65nm, XMC, Grade 3 -40 to 85C**

**Contents:**

# Q100 Qualification Test Plan

**Automotive Grade Level = 3 -40 to +85C** **MSL = 3**

| | | | | | |
|---|---|---|---|---|---|
| **Supplier Name:** | CYPRESS | | **General Specification:** | AEC-Q100 Rev. H | |
| **Supplier Code:** | | | **Supplier Wafer Fabrication:** | XMC (China) | |
| **Supplier Part Number:** | S29GLXXXS | | **Supplier Wafer Test:** | TEST25 (Austin) | |
| **Supplier Contact:** | | | **Supplier Assembly Site:** | CYPRESS BKK (Thailand) (TS056, LAE064, VBU056, LAA064) | |
| **Supplier Family Type:** | TS056, LAE064,VBU056, LAA064 | | **Supplier Final Test Site:** | CYPRESS BKK (Thailand) | |
| **Device Description:** | CS239LS 65nm CMOS 3.0 Volt-only Flash Memory | | **Supplier Reliability Signature:** | | |
| **PPAP Submission Date:** | | | **Customer Test ID:** | | |
| **Reason for Qualification:** | New Part Qualification (XMC PBO) | | **Customer Part Number:** | | |
| **Prepared by Signature:** | EKNG | Date: 24-07-19 | **Customer Approval Signature:** | | Date: |

| Test | # | Reference | Test Conditions | Lots | S.S. | Total | Results Lot/Pass/Fail | Comments: (N/A =Not Applicable) |
|---|---|---|---|---|---|---|---|---|
| **TEST GROUP A – ACCELERATED ENVIRONMENT STRESS TESTS** | | | | | | | | |
| PC | A1 | JESD22 A113<br>J-STD-020 | Preconditioning: (Test @ Rm)<br>SMD only; Moisture Preconditioning for THB/HAST, AC/UHST, TC, & PTC; Peak Reflow Temp = 260C,0/-5C | Min. MSL = 3 | | | MSL = 3 | |
| THB or HAST | A2 | JESD22 A101<br>JESD22 A110 | Temperature Humidity Bias: (Test @ Rm/Hot)<br>Highly Accelerated Stress Test: (Test @ Rm/Hot/)<br>130C/85%RH, 3.0V, 96Hrs, 192Hrs (TSOP)<br>110C/85%RH, 3.0V, 264Hrs, 528Hrs (FBGA) | 3 | 77 | 231 | 0 of 231 | a. Results (TS056) = 3 lots / 231 Units/ 0 Fails<br>b. Results (VBU056) = 3 lots/ 231 Units/ 0 Fails<br>c. Results (LAA064/LAE064) = 3 lots/ 231 Units/ 0 Fails |
| AC or UHST or TH | A3 | JESD22 A102<br>JESD22 A118<br>or JESD22-A101 | Autoclave: (Test @ Rm)<br>Unbiased Highly Accelerated Stress Test: (Test @ Rm)<br>Temperature Humidity without Bias: (Test @ Rm)<br>130C/85%RH, 96Hrs | 3 | 77 | 231 | 0 of 231 | a. Results (TS056) = 3 lots / 231 Units/ 0 Fails<br>b. Results (VBU056) = 3 lots/ 231 Units/ 0 Fails<br>c. Results (LAA064/LAE064/VBU056) = 3 lots/ 231 Units/ 0 Fails |

| Test | # | Reference | Test Conditions | Lots | S.S. | Total | Results Lot/Pass/Fail | Comments: (N/A =Not Applicable) |
|---|---|---|---|---|---|---|---|---|
| TC | A4 | JESD22 A104 | Temperature Cycle: (Test @ Hot)<br>- 65C to 150C, 500 and 1000 Cycles<br>WBP Test after TC 500 Cycles and 1000 Cycles | 3 | 77 | 231 | 0 of 231 | a. Results (TS056) = 3 lots / 231 Units/ 0 Fails<br>b. Results (LAA064/LAE064/VBU056) = 3 lots/ 231 Units/ 0 Fails<br>* Note: Wire pull results: Passed |
| PTC | A5 | JESD22 A105 | Power Temperature Cycle: (Test @ Rm/Hot) | 1 | 45 | 45 | of | N/A. |
| HTSL | A6 | JESD22 A103 | High Temperature Storage Life: (Test @ Rm/Hot)<br>150C, 1000, 2000 Hrs and 175C, 500, 1000hrs | 1 | 45 | 45 | 0 of 180 | a. Results (TS056) = 3 lots / 135 Units/ 0 Fails<br>b. Results (LAA064/LAE064/VBU056) = 3 lots/ 135 Units/ 0 Fails |

## TEST GROUP B – ACCELERATED LIFETIME SIMULATION TESTS

| Test | # | Reference | Test Conditions | Lots | S.S. | Total | Results Lot/Pass/Fail | Comments: (N/A =Not Applicable) |
|---|---|---|---|---|---|---|---|---|
| HTOL | B1 | JESD22 A108 | High Temp Operating Life: (Test @ Rm/Cold/Hot)<br>125C, 3.6V, 1000 Hrs | 3 | 77 | 231 | 0 of 231 | a. Results= 3 lots / 231 Units / 0 Fails. |
| ELFR | B2 | AEC-Q100-008 | Early Life Failure Rate: (Test @ Rm/Hot)<br>48 Hrs. @ 125C, 3.6V | 3 | 800 | 2400 | 0 of 2400 | a. Results= various lots/ 2400 Units/ 0 Fails |
| EDR | B3 | AEC-Q100-005 | NVM Endurance & Data Retention Test: (Test @ Rm/Hot)<br>a.85C 100k cycles + 150C Bake (Meet 2years after 100k cycles at 55C, 20years after 10k cycles at 55C)<br>b.85C 100k cycles + 125C HTOL 1khrs<br>c.25C 100k cycles + 25C bake 1khrs | 3 | 77 | 231 | 0 of 231 | a. Results = 3 lots / 231 Units / 0 Fails<br>b. Results = 3 lots / 231 Units / 0 Fails<br>c. Results = 3 lots / 231 Units / 0 Fails |

## TEST GROUP C – PACKAGE ASSEMBLY INTEGRITY TESTS

| Test | # | Reference | Test Conditions | Lots | S.S. | Total | Results Lot/Pass/Fail | Comments: (N/A =Not Applicable) |
|---|---|---|---|---|---|---|---|---|
| WBS | C1 | AEC-Q100-001<br>AEC-Q003 | Wire Bond Shear Test: (Cpk > 1.67) | 30 bonds | 5 parts Min. | bonds | 0 of 30 | a. Results (TS056) =30 Bonds/ 0 Fails<br>b. Results (LAE064/LAA064/VBU056) =30 Bonds/ 0 Fails |
| WBP | C2 | Mil-STD-883, Method 2011<br>AEC-Q003 | Wire Bond Pull: (Cpk > 1.67); Each bonder used | 30 bonds | 5 parts Min. | bonds | 0 of 30 | a. Results (TS056) =30 Bonds/ 0 Fails<br>b. Results (LAE064/LAA064/VBU056) =30 Bonds/ 0 Fails |
| SD | C3 | JESD22 B102<br>JSTD-002D | Solderability: (>95% coverage)<br>8hr steam aging prior to testing | 1 | 15 | 15 | 0 of 15 | a. Results (TS056) =1 lots / 15 Units/ 0 Fails |
| PD | C4 | JESD22 B100,<br>JESD22 B108<br>AEC-Q003 | Physical Dimensions: (Cpk > 1.67) | 3 | 10 | 30 | 0 of 30 | a. Results (TS056) = 3 lots/ 30 Units/ 0 Fails<br>b. Results (LAE064) =3 lots/ 30 Units/ 0 Fails<br>c. Results (VBU056) = 3 lots/ 30 Units/ 0 Fails<br>d. Results (LAA064) = 3 lots/ 30 Units/ 0 Fails |

| Test | # | Reference | Test Conditions | Lots | S.S. | Total | Results Lot/Pass/Fail | Comments: (N/A =Not Applicable) |
|---|---|---|---|---|---|---|---|---|
| SBS | C5 | AEC-Q100-010<br>AEC-Q003 | Solder Ball Shear: (Cpk > 1.67); 5 balls from min. of 10 devices | 3 | 50 balls | 150 | 0 of 150 | a. Results (LAA064/LAE064/VBU064) = 150 Balls / 0 Fails |
| LI | C6 | JESD22 B105 | Lead Integrity: (No lead cracking or breaking); Through-hole only; 10 leads from each of 5 devices | 1 | 50 leads | 50 | 0 of 50 | a. Results (TS056) = 50 Leads, 0 Fails |

## TEST GROUP D – DIE FABRICATION RELIABILITY TESTS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| EM | D1 | JESD61 | Electromigration:<br>Constant current 0.8MA/cm2 and 1.2MA/cm2 at 225C and 175C | - | - | - | | Data Available<br>TQ Generic Data Results = Pass 100khr operating equivalent |
| TDDB | D2 | JESD35 | Time Dependant Dielectric Breakdown:<br>: Constant voltage 6-9MV/cm at 130C | - | - | - | | Data Available<br>TQ Generic Data Results = Pass 100khr operating equivalent |
| HCI | D3 | JESD60 & 28 | Hot Carrier Injection:<br>Vg at Isubmax with 3 Vds conditions | - | - | - | | Data Available<br>TQ Generic Data Results = Pass 100khr operating equivalent |
| NBTI | D4 | JESD90 | Negative Bias Temperature Instability: | - | - | - | | Data Available<br>TQ Generic Data Results = Pass 100khr operating equivalent |
| SM | D5 | JESD61, 87, & 202 | Stress Migration: | - | - | - | | Data Available<br>TQ Generic Data Results = Pass 100khr operating equivalent |

## TEST GROUP E- ELECTRICAL VERIFICATION

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TEST | E1 | User/Supplier Specification | Pre and Post Stress Electrical Test:<br>Test at 25C, 85C, & -40C | All | All | All | of | a. Performed on all qualification units |
| HBM | E2 | AEC-Q100-002 | Electrostatic Discharge, Human Body Model:<br>(Test @ Rm/Hot); (2KV HBM / Class 2 or better)<br>HBM (100pF, 1,500 ohms) | 1 | 42 | 42 | 0 of 168<br><br>ESD Level = 2 | a. RQ Results (LAE064) = 1 lots/ 42 Units/ 0 Fails<br><br>Pass +/-2.0kV HBM. |
| CDM | E3 | AEC-Q100-011 | Electrostatic Discharge, Charged Device Model:<br>(Test @ Rm/Hot); (750V corner leads, 500V all other leads / Class C4B or better) | 1 | 12 | 12 | 0 of 12<br><br>ESD Level = C4B | a. Results (TS056) = 1 lots/ 12 Units/ 0 Fails<br>b. Results (LAE064) = 1 lots/12 Units/0 Fails<br>c. Results (LAA064) = 1 lot/ 12 Units/ 0 Fails<br>d. Results (VBU056) = 1 lot/ 12 Units/0 Fails<br><br>Pass 500V/750V CDM |
| LU | E4 | AEC-Q100-004 | Latch-Up: (Test @ Rm/Hot)<br>125C +/- 100mA Class II | 1 | 6 | 6 | 0 of 6 | a. Result LAE064= 1 lots/ 6 units/ 0 fails |

| Test | # | Reference | Test Conditions | Lots | S.S. | Total | Results Lot/Pass/Fail | Comments: (N/A =Not Applicable) |
|---|---|---|---|---|---|---|---|---|
| ED | E5 | AEC-Q100-009<br>AEC-Q003 | Electrical Distributions: (Test @ Rm/Hot/Cold)<br>(where applicable, Cpk >1.67)<br>(Test at 25C, 85C, & -40C Pre- and Post-) | 3 | 30 | 90 | of | Refer to characterization data in QDB |
| FG | E6 | AEC-Q100-007 | Fault Grading: | - | - | - | Fault Grade | N/A. But Cypress screens out the failures through Internal test mode and 100% tested to sort and class tests. |
| CHAR | E7 | AEC-Q003 | Characterization: (Test @ Rm/Hot/Cold)<br>(at 25C, 85C, & -40C) | - | - | - | Requested Data | N/A |
| EMC | E9 | SAE J1752/3 | Electromagnetic Compatibility (Radiated Emissions): | 1 | 1 | 1 | 1 | Data available upon request |
| SC | E10 | AEC Q100-012 | Short Circuit Characterization | 3 | 10 | 30 | | Applicable for smart power device only per AEC Q100. |
| SER | E11 | JESD89-1<br>JESD89-2<br>JESD89-3 | Soft Error Rate | 1 | 3 | 3 | | N/A. But, Cypress performed some accelerated neutron irradiation tests on our product. Refer separate document for more information |
| LF | E12 | AEC-Q005 | Lead (Pb) Free: (see AEC-Q005) | - | - | - | | Pass. |

## TEST GROUP F – DEFECT SCREENING TESTS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PAT | F1 | AEC-Q001 | Process Average Testing: (see AEC-Q001) | All | All | All | Reject units outside Avg. | Cypress incorporates the principle of PAT methodology |
| SBA | F2 | AEC-Q002 | Statistical Bin/Yield Analysis: (see AEC-Q002) | All | All | All | Reject units outside criteria | Cypress incorporates the principle of SBA methodology |

## TEST GROUP G – CAVITY PACKAGE INTEGRITY TESTS (for Ceramic Package testing only)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MS | G1 | JESD22 B104 | Mechanical Shock: (Test @ Rm) | 1 | 15 | 15 | of | N/A. Applicable for ceramic package only |
| VFV | G2 | JESD22 B103 | Variable Frequency Vibration: (Test @ Rm) | 1 | 15 | 15 | of | N/A. Applicable for ceramic package only |
| CA | G3 | MIL-STD-883<br>Method 2001 | Constant Acceleration: (Test @ Rm) | 1 | 15 | 15 | of | N/A. Applicable for ceramic package only |

| **Test** | **#** | **Reference** | **Test Conditions** | **Lots** | **S.S.** | **Total** | **Results Lot/Pass/Fail** | **Comments: (N/A =Not Applicable)** |
|---|---|---|---|---|---|---|---|---|
| GFL | G4 | MIL-STD-883 Method 1014 | Gross and Fine Leak: | 1 | 15 | 15 | of | N/A. Applicable for ceramic package only |
| DROP | G5 | ------------------ | Drop Test: (Test @ Rm)<br>MEMS cavity parts only. Drop part on each of 6 axes once from a height of 1.2m onto a concrete surface. | 1 | 5 | 5 | of | N/A. Applicable for ceramic package only |
| LT | G6 | MIL-STD-883 Method 2004 | Lid Torque: | 1 | 5 | 5 | of | N/A. Applicable for ceramic package only |
| DS | G7 | MIL-STD-883 Method 2019 | Die Shear: | 1 | 5 | 5 | of | N/A. Applicable for ceramic package only |
| IWV | G8 | MIL-STD-883 Method 1018 | Internal Water Vapor: | 1 | 5 | 5 | of | N/A. Applicable for ceramic package only |

## Document History Page

Document Title: AEC-Q100 Automotive Qualification Test Plan Report for PBO Protection Layer for S29GLXXXS, 65nm, XMC Grade 3 –40 to 85C
Document Number: 002-28003

| Rev. | ECN No. | Orig. of Change | Description of Change |
|---|---|---|---|
| ** | 6636270 | EKNG | New Qualification report for PBO Protection Layer for S29GLXXXS, 65nm, XMC, Grade 3 -40 to 85C |

# S29GL512S (XMC 85C 105C)

***Qualification Database***

**Notice:** The material in this report is confidential. It is prepared to assist in the qualification of our product. It is intended for the internal use of our customers only, and may be modified to meet the needs of specific customers.

Additionally, the package details (material set, assembly location, etc.) are specific to the qualification vehicle used. Alternate material sets and assembly locations may be qualified for the product. Production material can be assembled with any qualified material set and at any qualified assembly location.

**Cypress Semiconductor Corporation** • 198 Champion Court • San Jose, CA 95134-1709 • 408-943-2600
Document Number: 002-00479 Rev. *D Revised August 02, 2019

# Contents

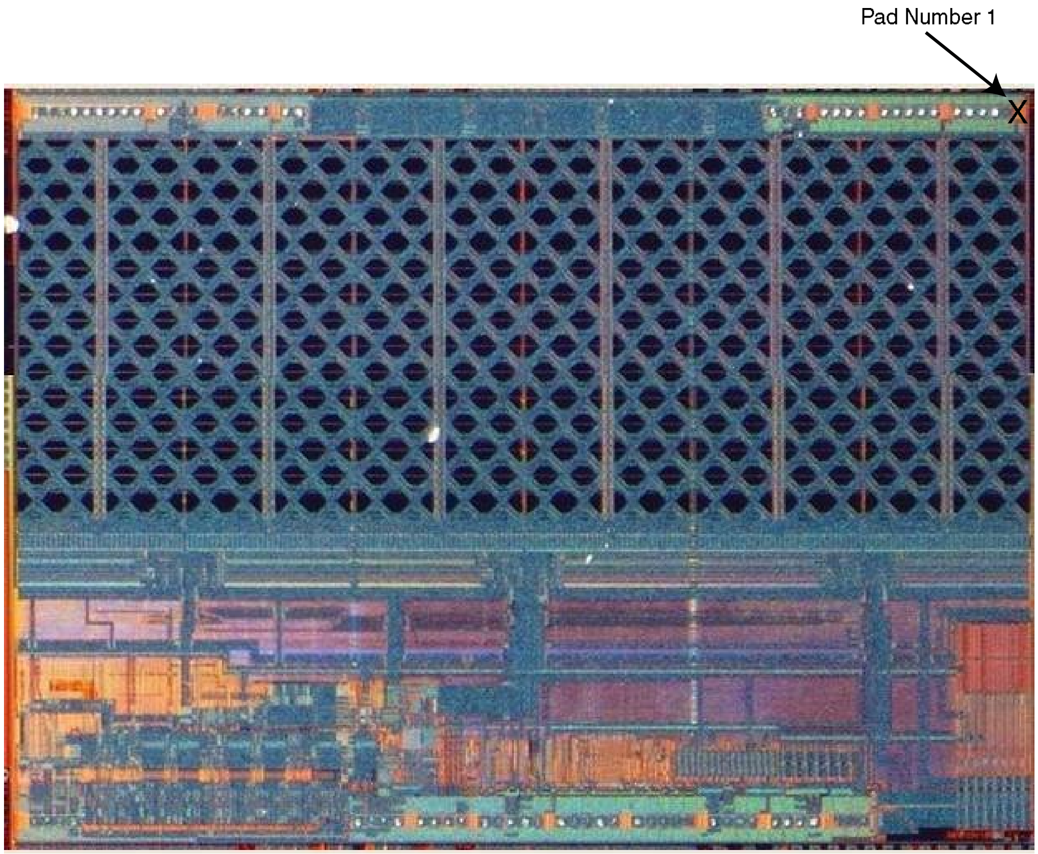
# Figures

# 1. Introduction

The Cypress S29GL512S flash memory device has a die size of 6.803 x 5.027 mm.

# 2. Die Photograph

**Figure 2.1** Die Photograph




***Note:***
*1. X in the diagram is pad #1. Count counter clockwise.*

# 3. Pad Definition Table

| Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA | Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA |
|---|---|---|---|---|---|---|---|
| 1 | NC | | | 38 | VCC | 43 | G5 |
| 2 | A23 | 1 | C8 | 39 | VSS | 33, 52 | H7 |
| 3 | A22 | 2 | B8 | 40 | VCC | 43 | G5 |
| 4 | A15 | 3 | D7 | 41 | VSS | 33, 52 | H7 |
| 5 | A14 | 4 | C7 | 42 | VSS | 33, 52 | H7 |
| 6 | A13 | 5 | A7 | 43 | VCC | 43 | G5 |
| 7 | A12 | 6 | B7 | 44 | A0 | 31 | E2 |
| 8 | A11 | 7 | D6 | 45 | CE# | 32 | F2 |
| 9 | A10 | 8 | C6 | 46 | OE# | 34 | G2 |
| 10 | A9 | 9 | A6 | 47 | NC | | |
| 11 | A8 | 10 | B6 | 48 | DQ0 | 35 | E3 |
| 12 | A19 | 11 | D5 | 49 | DQ8 | 36 | F3 |
| 13 | A20 | 12 | D4 | 50 | VSS | 33, 52 | H2, E8 |
| 14 | WE# | 13 | A5 | 51 | VIO | 29 | F1, D8 |
| 15 | VSS | 33, 52 | H7 | 52 | DQ1 | 37 | H3 |
| 16 | VCC | 43 | G5 | 53 | DQ9 | 38 | G3 |
| 17 | VSS | 33, 52 | H7 | 54 | DQ2 | 39 | E4 |
| 18 | VCC | 43 | G5 | 55 | DQ10 | 40 | F4 |
| 19 | NC | | | 56 | DQ3 | 41 | H4 |
| 20 | RESET# | 14 | B5 | 57 | DQ11 | 42 | G4 |
| 21 | A21 | 15 | C5 | 58 | DQ4 | 44 | H5 |
| 22 | WP# | 16 | B4 | 59 | DQ12 | 45 | F5 |
| 23 | RY/BY# | 17 | A4 | 60 | DQ5 | 46 | E5 |
| 24 | VIO | 29 | D8, F1 | 61 | DQ13 | 47 | G6 |
| 25 | VSS | 33, 52 | H7 | 62 | NC | | |
| 26 | A18 | 18 | C4 | 63 | VSS | 33, 52 | H7 |
| 27 | A17 | 19 | B3 | 64 | VCC | 43 | G5 |
| 28 | A7 | 20 | A3 | 65 | DQ6 | 48 | H6 |
| 29 | A6 | 21 | C3 | 66 | DQ14 | 49 | F6 |
| 30 | A5 | 22 | D3 | 67 | DQ7 | 50 | E6 |
| 31 | A4 | 23 | B2 | 68 | DQ15 | 51 | G7 |
| 32 | A3 | 24 | A2 | 69 | VIO | 29 | D8, F1 |
| 33 | A2 | 25 | C2 | 70 | VSS | 33, 52 | E8, H2 |
| 34 | A1 | 26 | D2 | 71 | A16 | 54 | E7 |
| 35 | DNU | 28 | E1 | 72 | NC | | |
| 36 | VCC | 43 | G5 | 73 | A24 | 56 | F8 |
| 37 | VSS | 33, 52 | H7 | | | | |

# 4. Physical Sector Layout

**Figure 4.1** Physical Sector Layout

| Internal Use Row 43 | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Row 42 | 504 | 505 | 506 | 507 | 508 | 509 | 510 | 511 | Internal Use | Internal Use | Internal Use | Internal Use |
| Row 41 | 492 | 493 | 494 | 495 | 496 | 497 | 498 | 499 | 500 | 501 | 502 | 503 |
| ... | | | | | | | | | | | | |
| Row 3 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| Row 2 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| Row 1 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Row 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| VerticalBank | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| Bank | 0 | | | | 1 | | | | 2 | | | |

# 5. Sector Enlargement

**Figure 5.1** Sector Enlargement

**IO Organization**

| | Internal Use | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M3BL | 0-7 | 0-63 | 64-127 | 128-191 | 192-255 | 256-319 | 320-383 | 384-447 | 448-511 | 512-575 | 576-639 | 640-703 |
| M1BL | 8-15 | 0-127 | 128-255 | 256-383 | 384-511 | 512-639 | 640-767 | 768-895 | 896-1023 | 1024-1151 | 1152-1279 | 1280-1407 |

| | 11 | 12 | 13 | 14 | 15 | Internal Use | Internal Use | Internal Use | Internal Use |
|---|---|---|---|---|---|---|---|---|---|
| M3BL | 704-767 | 768-831 | 832-895 | 896-959 | 960-1023 | 1024-1063 | 1064-1071 | 1072-1079 | 0-7 |
| M1BL | 1408-1535 | 1536-1663 | 1664-1791 | 1792-1919 | 1920-2047 | 2048-2127 | 2128-2143 | 2144-2159 | 0-7 |

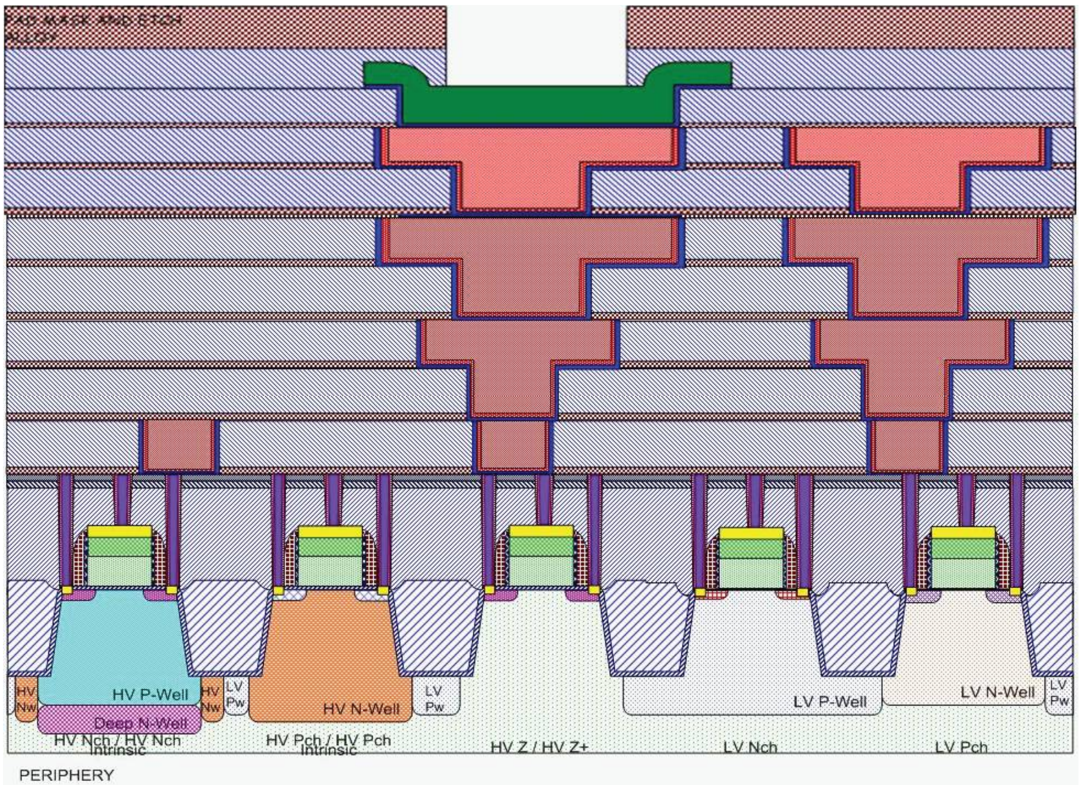
# 6. Die Processing Summary

The Cypress S29GL512S flash memory device is manufactured using the 65 nm MirrorBit® Eclipse™ process technology.

The device is processed at WXIC, a 12-inch CMOS manufacturing facility located in Wuhan, China.

The device is manufactured on the highly reliable CS239LS process.

**Figure 6.1** Die Process



## 6.1 Key Features of the 65 nm MirrorBit Eclipse Process Technology

### A. Technology

- CMOS Triple-well process
- Proven reliable Flash MirrorBit Eclipse Technology

### B. Transistor Types

- n-channel enhancement
- n-channel intrinsic
- p-channel enhancement
- MirrorBit Eclipse core cell

### C. Process Features

- ONO (oxide - nitride - oxide) gate dielectric
- Silicon Nitride (SiN) data storage layer

### D. Cypress Highlights

- Volume Production Fab
- Solely dedicated to Non-Volatile Memories
- Ongoing Statistical Process Control program

# 7. Assembly Packaging Summary

## 7.1 LAE064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL512S<br>512-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | LAE064 | **Qualification:** | Q100156 |
| **Description:** | (9 x 9 x 1.4 mm) 64-ball, Fortified Ball Grid Array Package (fFBGA) | | |
| **Con-code:** | B40780KV-DWR-001 | **Theta Ja / Psi Jt:** | 30.4 °C/W / 17 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125 °C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9 °C | **Est. Stress Delta Tj:** | 126.4 °C |
| **Die:** | 98290B | **Die Size:** | 6.803 x 5.027 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 512M |

## 7.2 TS056

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL512S<br>512-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | TS056 | **Qualification:** | Q100125 |
| **Description:** | (18.4 x 14.0 x 1.0 mm) 56-lead, Thin Small Outline Package (TSOP) | | |
| **Con-code:** | A40786EF-TXA-001 | **Theta Ja / Psi Jt:** | 44 °C/W / 17 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | Hitachi CEL 9200HF10-U |
| **Substrate/Leadframe:** | Copper Leadframe | **Die Attachment:** | Ablebond 8340 |
| **Lead Finish:** | 100% Matte Sn Plating | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 58.0 °C | **Est. Stress Delta Tj:** | 126.4 °C |
| **Die:** | 98290B | **Die Size:** | 6.803 x 5.027 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 512M |

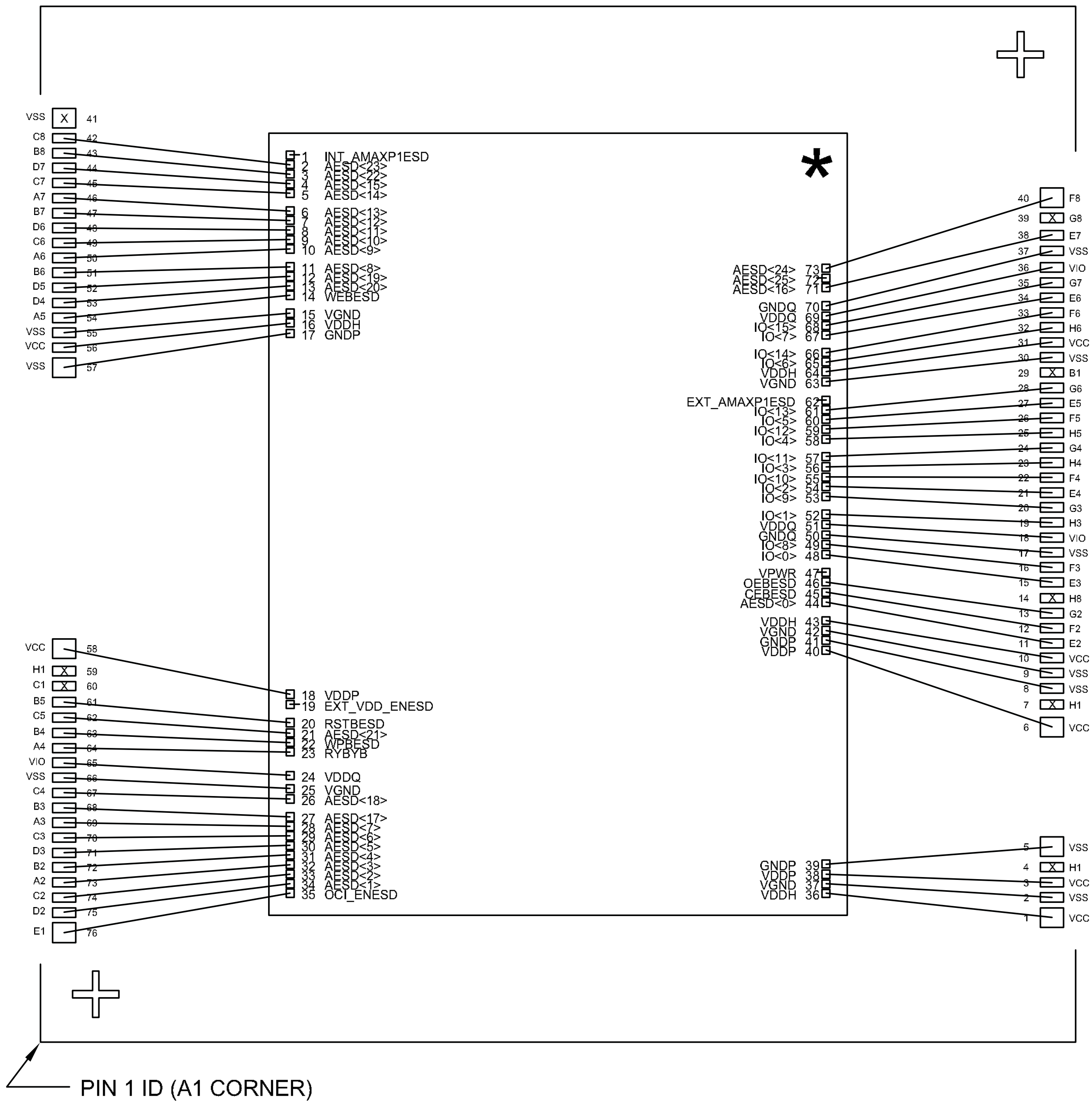
## 7.3 LAA064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL512S<br>512-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | LAA064 | **Qualification:** | Q100226 |
| **Description:** | (13.0 x 11.0 x 1.4 mm) 64-ball, Fortified Ball Grid Array Package (FBGA) | | |
| **Con-code:** | B40781KV-DWR-001 | **Theta Ja / Psi Jt:** | 22.2 °C/W / 11 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9 °C | **Est. Stress Delta Tj:** | 126.4 °C |
| **Die:** | 98290B | **Die Size:** | 6.803 x 5.027 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 512M |

# 8. Assembly Bonding Diagram

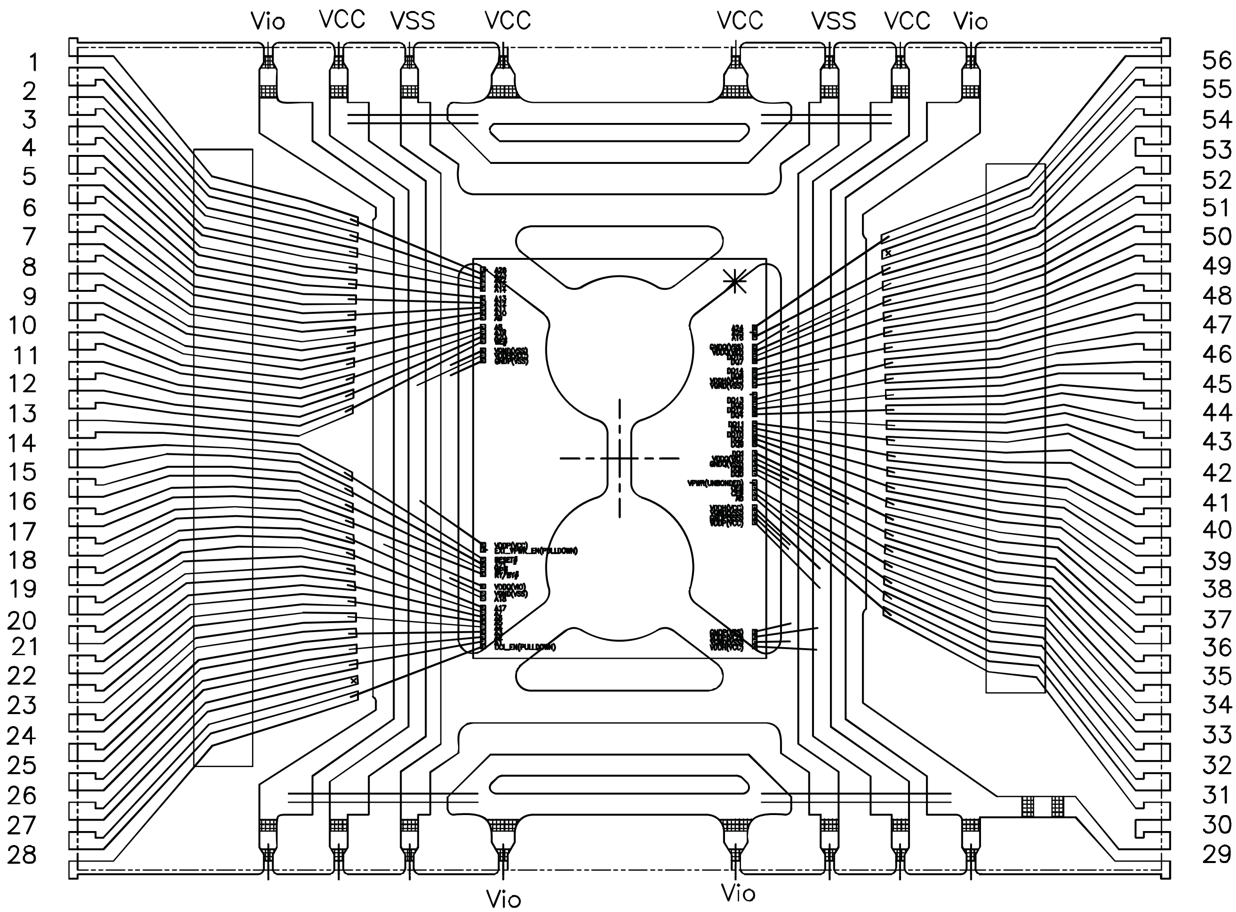
## 8.1 LAE064 Package

Figure 8.1 64-Ball—LAE064 Package



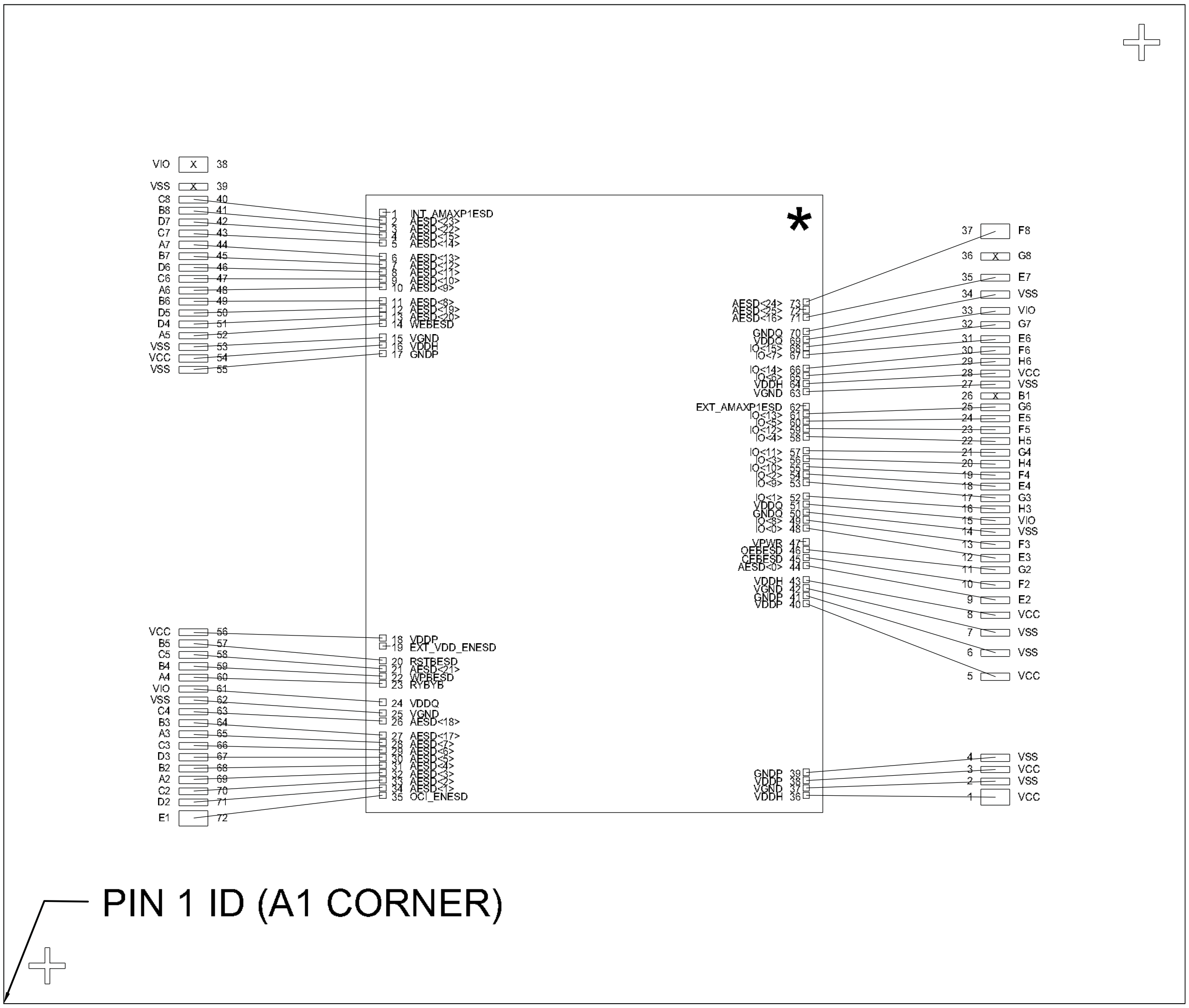
## 8.2 TS056 Package

Figure 8.2 56-Pin—TS056 Package



## 8.3 LAA064 Package

**Figure 8.3** 64-Ball—LAA064 Package



# 9. Test Methodology

### Testing includes

- 4 hour, 250°C Data Retention Bake (in wafer form)
- Special test mode for extended life operation
- Proprietary screens for endurance

### Wafer Sort (Austin, Texas, USA)

At Wafer Sort, all die experience 100% testing for:

- DC Parametrics
- AC Functionality
- Programmability
- Erasability

### Class Test (Bangkok, Thailand)

At Class Test, all devices are tested for:

- DC Parametrics
- AC Functionality
- AC Speed
- Programmability
- Erasability

### Test Coverage

All parameters specified in the data sheet are 100% tested in production unless otherwise specified. Those parameters not tested in production are guaranteed by characterization or correlation to other tests. AC speed testing is performed at class test.

### Test Correlation and Guard Banding

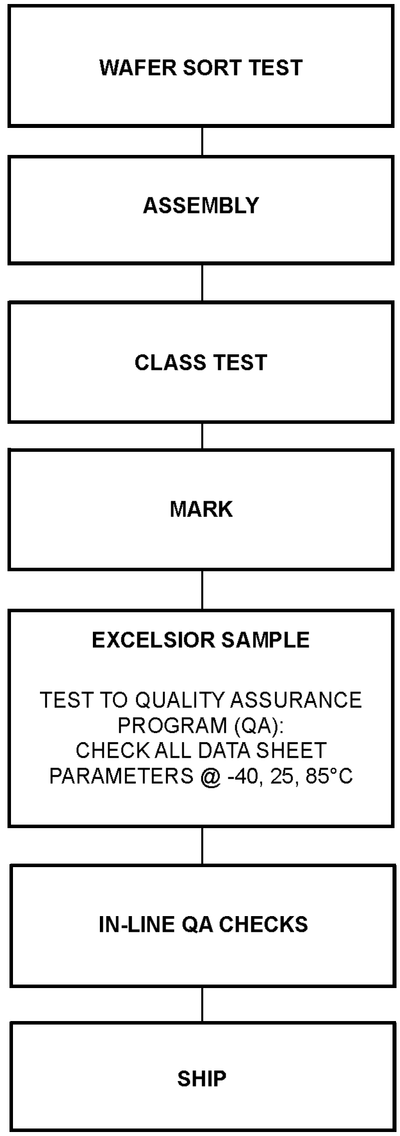
Tester correlation to bench set-up has been completed for all tested parameters. Tester repeatability studies have been run. These results have been evaluated and incorporated into the tester guard band strategy. Guard bands have been implemented which demonstrate acceptable yield, quality assurance and customer satisfaction.

### Test Flow

See the generalized Test Flow for the S29GL512S in Section 10.

# 10. Generalized Test Flow

The S29GL512S Generalized Test Flow for Industrial Temperature Range:



# 11. Quality and Reliability Data

## 11.1 S29GL512S High Temperature Operating Life Test Configuration

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 1 | A23 | 2.7K | CLK23 |
| 2 | A22 | 2.7K | CLK22 |
| 3 | A15 | 2.7K | CLK15 |
| 4 | A14 | 2.7K | CLK14 |
| 5 | A13 | 10K | CLK13 |
| 6 | A12 | 2.7K | CLK12 |
| 7 | A11 | 2.7K | CLK11 |
| 8 | A10 | 2.7K | CLK10 |
| 9 | A9 | 2.7K | CLK9 |
| 10 | A8 | 2.7K | CLK8 |
| 11 | A19 | 2.7K | CLK19 |
| 12 | A20 | 2.7K | CLK20 |
| 13 | WE# | 2.7K | VCC |
| 14 | RESET# | 2.7K | VCC |
| 15 | A21 | 2.7K | CLK21 |
| 16 | WP# | 2.7K | VCC |
| 17 | RY/BY# | 2.7K | VCC |
| 18 | A18 | 2.7K | CLK18 |
| 19 | A17 | 2.7K | CLK17 |
| 20 | A7 | 2.7K | CLK7 |
| 21 | A6 | 2.7K | CLK6 |
| 22 | A5 | 2.7K | CLK5 |
| 23 | A4 | 2.7K | CLK4 |
| 24 | A3 | 2.7K | CLK3 |
| 25 | A2 | 2.7K | CLK2 |
| 26 | A1 | 2.7K | CLK1 |
| 27 | RFU | | NC |
| 28 | RFU | | NC |

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 56 | A24 | 2.7K | CLK24 |
| 55 | RFU | | NC |
| 54 | A16 | 2.7K | CLK16 |
| 53 | RFU | | NC |
| 52 | VSS | | GND |
| 51 | DQ15 | 2.7K | VCC |
| 50 | DQ7 | 2.7K | VCC |
| 49 | DQ14 | 2.7K | VCC |
| 48 | DQ6 | 2.7K | VCC |
| 47 | DQ13 | 2.7K | VCC |
| 46 | DQ5 | 2.7K | VCC |
| 45 | DQ12 | 2.7K | VCC |
| 44 | DQ4 | 2.7K | VCC |
| 43 | VCC | | VCC |
| 42 | DQ11 | 2.7K | VCC |
| 41 | DQ3 | 2.7K | VCC |
| 40 | DQ10 | 2.7K | VCC |
| 39 | DQ2 | 2.7K | VCC |
| 38 | DQ9 | 2.7K | VCC |
| 37 | DQ1 | 2.7K | VCC |
| 36 | DQ8 | 2.7K | VCC |
| 35 | DQ0 | 2.7K | VCC |
| 34 | OE# | 2.7K | VCC |
| 33 | VSS | | GND |
| 32 | CE# | 2.7K | GND |
| 31 | A0 | 2.7K | CLK0 |
| 30 | RFU | | NC |
| 29 | VIO | 2.7K | VCC |

## 11.2 CS239/L Life Test Failure Rate Calculation

### HTOL Stress Temperature @ 125°C

| Failure Mechanisms | Read Points / Test Results | | | Modeling Parameters @ 55°C | | | | | Average Failure Rate FITS @ 55°C, 60% Conf. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 24 hrs | 168 hrs | 1000 hrs | Ea eV | TAF | VAF | OAF | MTTF (yrs) | Early Life | Inherent Life |
| **PLASTIC** | | | | | | | | | | |
| Sample Size | 1745 | 3025 | 345 | | | | | | | |
| Zero fails, Process ave. Ea | 0 (1) | 0 | 0 | 0.66 | 53 | 1 | 53 | | 87 | 23 |
| Totals | 0 | 0 | 0 | | | | | 4963 | 87 | 23 |

***Note:***
1. *Contributes to Early Life FITS.*

### Data Retention Bake @ 150°C

| Reliability Stress | Number of Rejects | Sample Size | Failure Rate % | Failure Mechanism |
|---|---|---|---|---|
| 500 hrs | 0 | 300 | 0.00 | No Failures |
| 1000 hrs | 0 | 300 | 0.00 | No Failures |

**Table 11.1** Summary of Stress Test Results

| Stress Test | Condition | Package Type | Samples Size | Num. of Lots | Number of Fails | Failure Rate % | Comments |
|---|---|---|---|---|---|---|---|
| **Data From Qualification Q100125, Q100226, Q100156:** | | | | | | | |
| **HTOL (EL)** | 3.6V, 125°C | LAE064 (3) | 77 | 1 | 0 | 0.00 | 168 hrs |
| **ESD CDM** | N/A | TS056 (1) | 15 | 1 | Passed 1.0 kV | | |
| | N/A | LAA064 (2) | 15 | 1 | Passed 1.0 kV | | |
| | N/A | LAE064 (3) | 15 | | Passed 1.0 kV | | |
| **ESD HBM** | (100 pF, 1500 Ohms) | LAE064 (3) | 84 | 1 | Passed 2.0 kV | | |
| **Latch Up** | 125°C, ±100 mA | LAE064 (3) | 6 | 1 | Passed | | |
| **Endurance (10k)** | –40°C, 3.6V | LAE064 (3) | 64 | 1 | 0 | 0.00 | 10k cycles |
| | 90°C, 3.6V | LAE064 (3) | 128 | 1 | 0 | 0.00 | 10k cycles |
| | 105°C, 3.6V | TS056 (4) | 240 | 3 | 0 | 0.00 | 10k cycles |
| **Generic Reference Data** | | | | | | | |
| **Preconditioning** | PC9/260°C, +0°C / –5°C | LAE064 (5) | 230 | 1 | Passed Jedec L3 (Accel.) | | |
| | PC9/260°C, +0°C / –5°C | TS056 (6) | 77 | 1 | Passed Jedec L3 (Accel.) | | |
| **Preconditioning + Temp Cycle** | PC9/260°C, –40°C / 150°C | LAE064 (5) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| | PC9/260°C, –40°C / 150°C | TS056 (6) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| **Preconditioning + HAST** | PC9/260°C, Biased, 110°C / 85% RH | LAE064 (5) | 77 | 1 | 0 | 0.00 | 264 hrs |
| **Preconditioning + uHAST** | PC9/260°C, Unbiased, 130°C / 85% RH | LAE064 (5) | 76 | 1 | 0 | 0.00 | 96 hrs |

***Notes:***

1. *Results from Qual Q100125, S29GL512S, 512M 65 nm MirrorBit Eclipse in 56 Lead TSOP (18.4 x 14 x 1 mm).*
2. *Results from Qual Q100226, S29GL512S, 512M CS239LS (65 nm) MirrorBit Eclipse in 64 Ball fFBGA (13 x 11 x 1.4 mm).*
3. *Results from Qual Q100156, S29GL512S, 512M CS239LS (65 nm) MirrorBit Eclipse in 64 Ball fFBGA (9 x 9 x 1.4 mm).*
4. *Results from QTP#184906, S29GL01GS in 56 Lead TSOP (18.4 x 14 x 1 mm) - Same TS056 Package, Same Product and Process Technology at Fab25.*
5. *Results from Qual Q100127, S29GL01GS in 64 Ball fFBGA (9 x 9 x 1.4 mm) - Same LAE064 package, Same Process Technology, Same Fab Location, Similar Product.*
6. *Results from Qual Q99990, S29GL512S in 56 Lead TSOP (18.4 x 14 x 1 mm) - Same TS056 package, Same Process Technology and Product from Fab25.*

***Preconditioning Flows***

*PC9 (Accelerated JEDEC L3 / JEITA Rank E): Bake 125°C, 24hr --> Soak @ 60°C/70%RH, 72hr => 3x Reflow.*

# 12. Characterization Test Results

The data is pattern is “Random pattern” unless otherwise indicated.

## 12.1 DC Parameter Summary, 25°C

### Room Temperature, 25°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 92.01 | 86.17 | 96.34 | 1.82 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 48.87 | 46.53 | 50.68 | 0.78 | > 5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.72 | 5.26 | 6.17 | 0.15 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.77 | 5.32 | 6.16 | 0.15 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.83 | 5.38 | 6.25 | 0.15 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.90 | 5.43 | 6.33 | 0.15 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 45.64 | 42.17 | 49.41 | 1.23 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 40.76 | 36.41 | 45.96 | 1.99 | > 5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 17.70 | 9.44 | 56.77 | 7.62 | 3.6 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.02 | 0.01 | 0.06 | 0.01 | > 5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 17.65 | 9.46 | 56.53 | 7.61 | > 5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.000 | -0.013 | 0.012 | 0.0 | > 5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.001 | -0.010 | 0.011 | 0.0 | > 5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 261.3 | 173.0 | 616.0 | 32.8 | > 5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 355.1 | 200.0 | 468.0 | 29.2 | 4.5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 281.4 | 226.0 | 387.0 | 24.2 | > 5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 243.4 | 198.0 | 336.0 | 21.1 | > 5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 233.0 | 179.0 | 309.0 | 31.3 | > 5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 231.7 | 166.0 | 302.0 | 36.5 | > 5 |
| Single Word Program Time (1 word) | 150 | 400 | µs | 183.0 | 150.0 | 279.0 | 25.2 | > 5 |

***Notes:***
1. *Data was collected from 300 units.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.2 DC Parameter Summary, 85°C

### Hot Temperature, 85°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 96.9 | 52.9 | 102.3 | 3.1 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 51.3 | 40.5 | 53.9 | 1.0 | > 5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 6.100 | 5.570 | 6.340 | 1.270 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 6.130 | 5.620 | 6.400 | 1.220 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 6.210 | 5.720 | 6.460 | 1.220 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 6.280 | 5.750 | 6.540 | 1.210 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 48.4 | 0.5 | 51.9 | 3.0 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 42.8 | 10.0 | 48.2 | 2.8 | > 5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 55.7 | 32.1 | 90.3 | 12.0 | 1.2 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.06 | 0.03 | 0.09 | 0.01 | > 5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 55.1 | 31.7 | 91.0 | 12.0 | > 5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.000 | -0.015 | 0.012 | 0.0 | > 5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.000 | -0.008 | 0.011 | 0.0 | > 5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 193.4 | 136.0 | 339.0 | 18.2 | > 5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 328.0 | 191.0 | 437.0 | 24.1 | > 5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 263.3 | 212.0 | 337.0 | 20.3 | > 5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 223.6 | 185.0 | 285.0 | 16.9 | > 5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 217.9 | 164.0 | 286.0 | 23.4 | > 5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 210.3 | 154.0 | 267.0 | 25.3 | > 5 |
| Single Word Program Time (1 word) | 150 | 400 | µs | 165.0 | 139.0 | 273.0 | 14.8 | 5.3 |

***Notes:***
1. *Data was collected from 300 units.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.3 DC Parameter Summary, 105°C

### Hot Temperature, 105°C, 3V, $V_{CC} = V_{IO}$ Summary

| Data Sheet Parameters | Spec | | | Average | | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | -40 | 25 | 85 | 105 | | | | | |
| **DC Parameters** | | | | | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 91.4 | 92.0 | 96.9 | 93.7 | 93.7 | 89.2 | 99.3 | 2.0 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 48.0 | 48.9 | 51.3 | 49.1 | 49.1 | 46.8 | 52.1 | 1.1 | 3.3 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.5 | 5.7 | 6.1 | 6.1 | 6.1 | 5.5 | 6.8 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.6 | 5.8 | 6.1 | 6.0 | 6.0 | 5.4 | 6.7 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.6 | 5.8 | 6.2 | 5.9 | 5.9 | 5.4 | 6.6 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.7 | 5.9 | 6.3 | 5.9 | 5.9 | 5.3 | 6.6 | 0.2 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 42.2 | 45.6 | 48.4 | 51.4 | 51.4 | 49.2 | 54.3 | 1.1 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 37.6 | 40.8 | 42.8 | 46.7 | 46.7 | 42.3 | 49.9 | 1.7 | > 5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 15.2 | 17.7 | 55.7 | 63.0 | 63.0 | 29.8 | 195.9 | 24.3 | 1.9 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.0 | 0.0 | 0.1 | 0.1 | 0.063 | 0.030 | 0.192 | 0.024 | > 5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 15.1 | 17.7 | 55.1 | 61.6 | 61.6 | 29.9 | 110.5 | 19.6 | 2.4 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.0 | 0.0 | 0.0 | 0.0 | 0.005 | –0.008 | 0.244 | 0.021 | > 5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.0 | 0.0 | 0.0 | 0.0 | 0.002 | –0.009 | 0.156 | 0.004 | > 5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | | | | | 189.5 | 136.0 | 264.0 | 14.2 | > 5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | | | | | 333.1 | 281.0 | 394.0 | 19.1 | > 5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | | | | | 272.2 | 233.0 | 324.0 | 14.0 | > 5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | | | | | 231.7 | 200.0 | 267.0 | 10.8 | > 5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | | | | | 205.6 | 181.0 | 234.0 | 9.2 | > 5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | | | | | 185.1 | 165.0 | 209.0 | 7.7 | > 5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | | | | | 183.0 | 163.0 | 211.0 | 8.0 | > 5 |

***Notes:***
1. *Data was collected from 70 units from lots 5877960 and 5877980 (wflot : LDU6301, wf5, wflot : LDU6301, wf13).*
2. *Sector Erase data excludes Random data pattern programming prior to erasure.*

## 12.4 DC Parameter Summary, -40°C

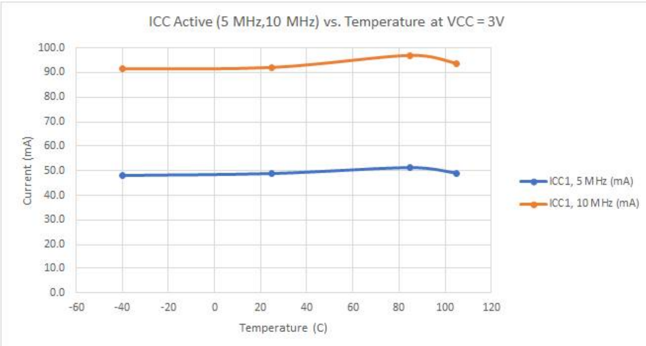
### Cold Temperature, -40°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 91.40 | 86.59 | 96.76 | 1.84 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 48.02 | 45.64 | 50.63 | 0.89 | > 5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.52 | 4.94 | 5.91 | 0.16 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.58 | 4.99 | 5.98 | 0.16 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.63 | 5.03 | 6.01 | 0.16 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.70 | 5.13 | 6.09 | 0.17 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 42.19 | 38.69 | 45.26 | 1.17 | > 5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 37.61 | 33.41 | 42.89 | 1.87 | > 5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 15.18 | 8.69 | 55.86 | 6.97 | 4.1 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.02 | 0.01 | 0.06 | 0.01 | > 5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 15.06 | 8.59 | 56.63 | 7.00 | > 5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.000 | -0.013 | 0.011 | 0.0 | > 5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.001 | -0.011 | 0.013 | 0.0 | > 5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 309.6 | 209.0 | 618.0 | 36.4 | > 5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 344.5 | 204.0 | 485.0 | 27.0 | > 5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 270.2 | 154.0 | 380.0 | 20.8 | > 5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 231.2 | 155.0 | 305.0 | 15.5 | > 5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 207.7 | 143.0 | 272.0 | 15.3 | > 5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 192.0 | 131.0 | 265.0 | 12.8 | > 5 |
| Single Word Program Time (1 word) | 150 | 400 | µs | 169.8 | 144.0 | 227.0 | 9.5 | > 5 |

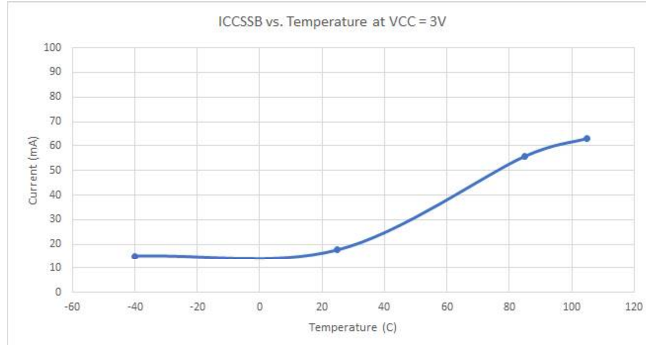
***Notes:***
1. *Data was collected from 300 units.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

# 13. DC Device Characterization Data

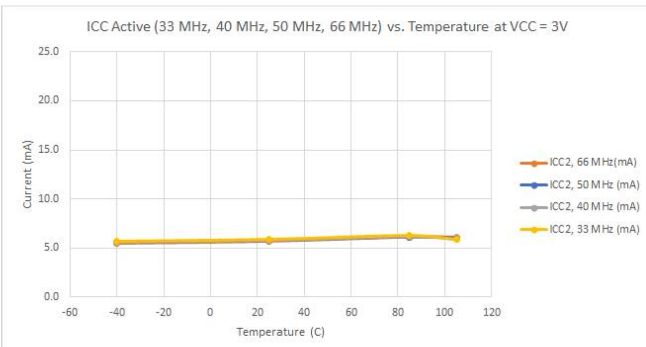
ICC1 (Asynchronous Read) vs. Temperature



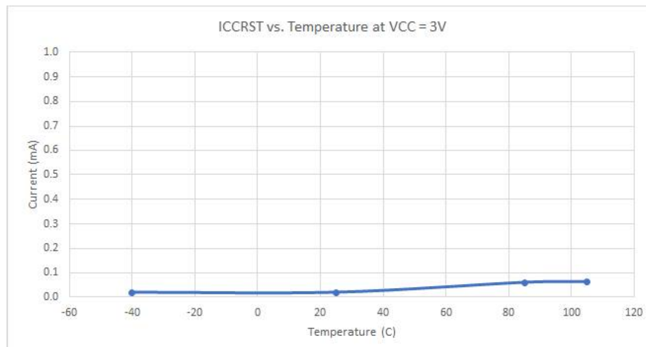

ICC4 (Standby Current) vs. Temperature



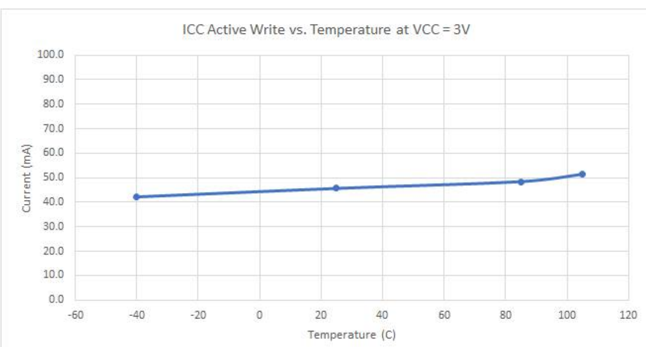

ICC2 (Page Read) vs. Temperature



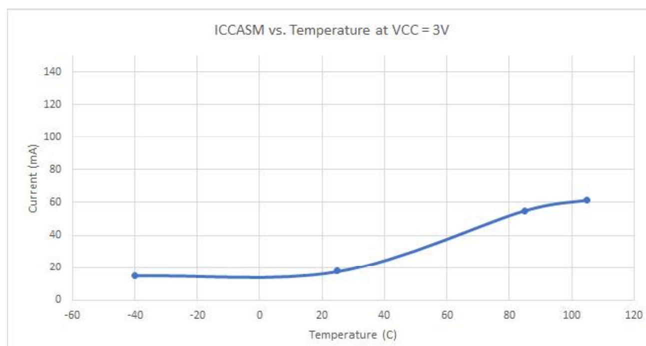

ICC5 (Reset Current) vs. Temperature




ICC3 (Active Write) vs. Temperature

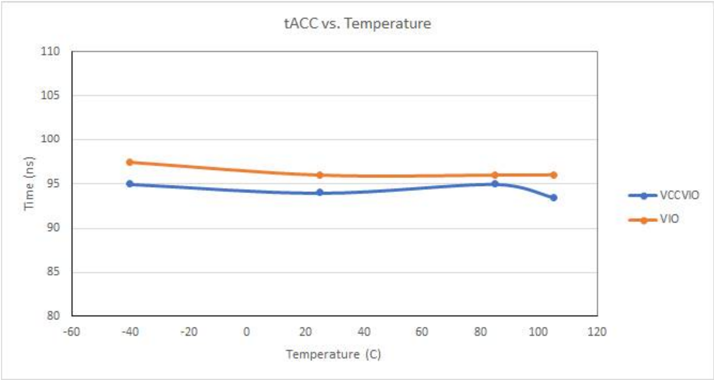



ICC6 (CMOSASM) vs. Temperature

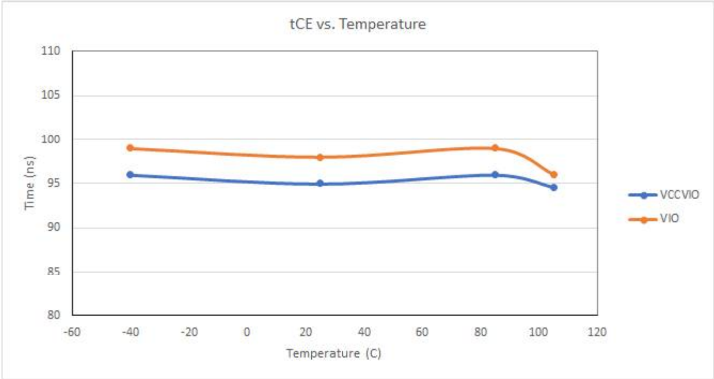


# 14. AC Device Characterization Data

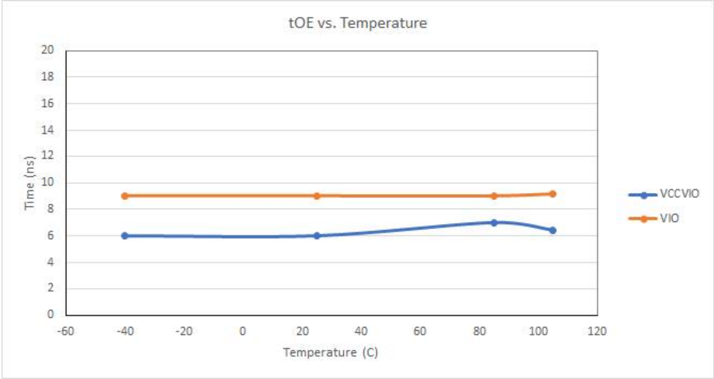
tACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



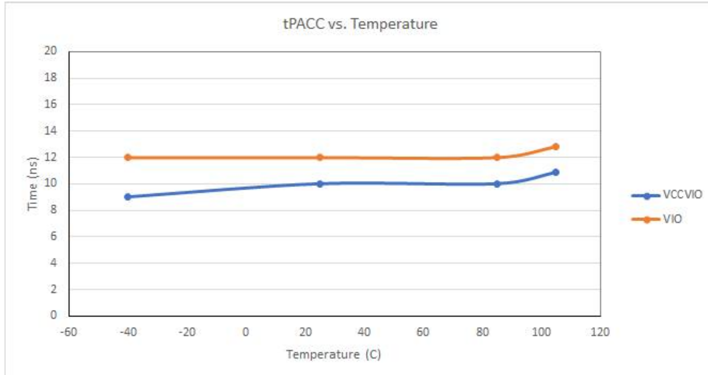

tCE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



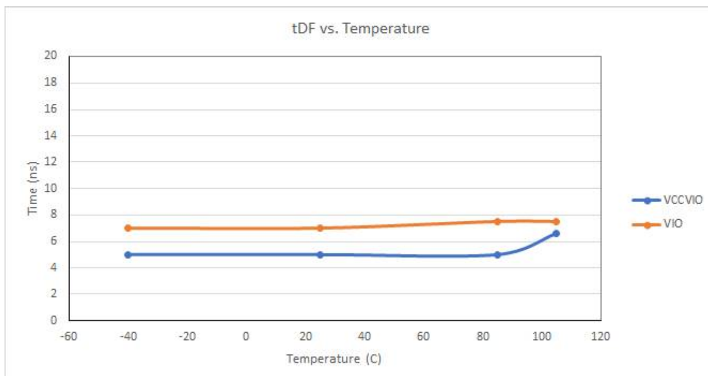

tOE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



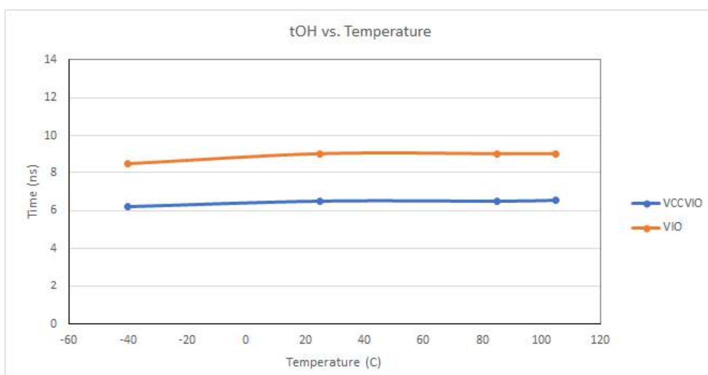
tPACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



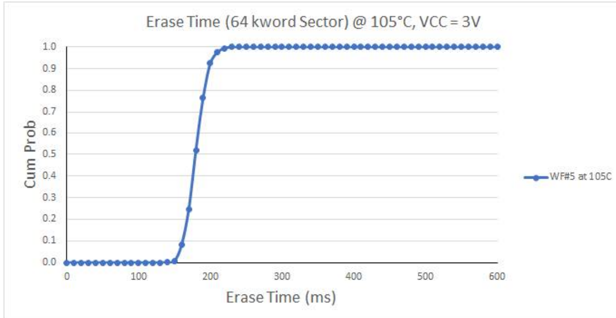

tDF vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



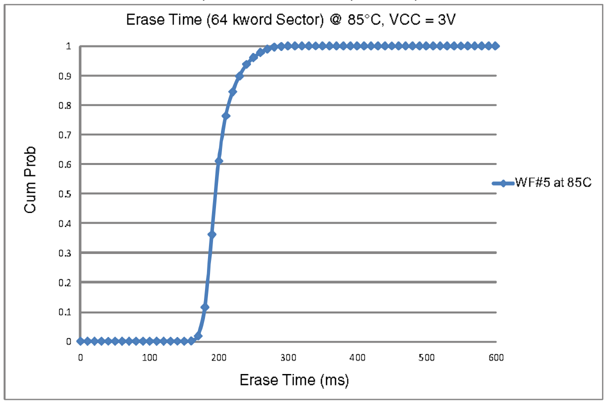

tOH vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



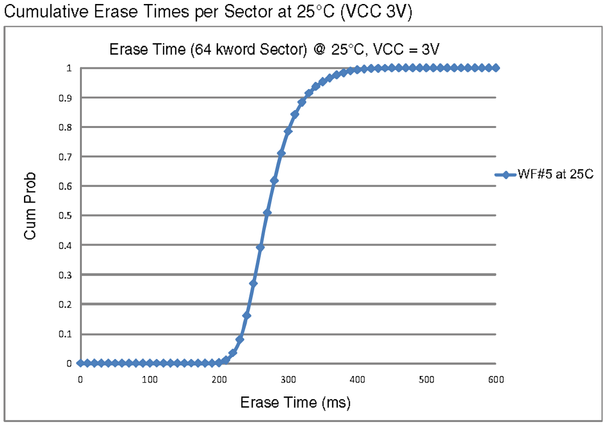
Cumulative Erase Times per Sector at 105°C (VCC 3V)



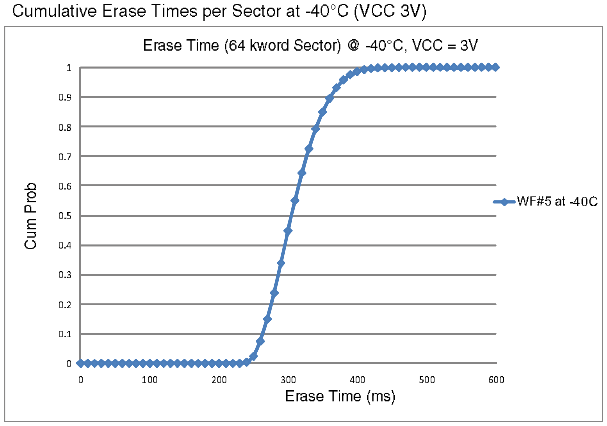

Cumulative Erase Times per Sector at 85°C (VCC 3V)



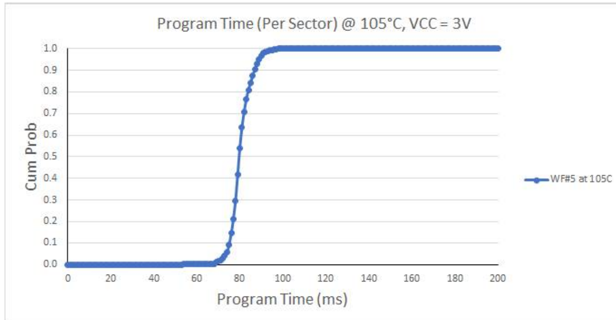

Cumulative Erase Times per Sector at 25°C (VCC 3V)



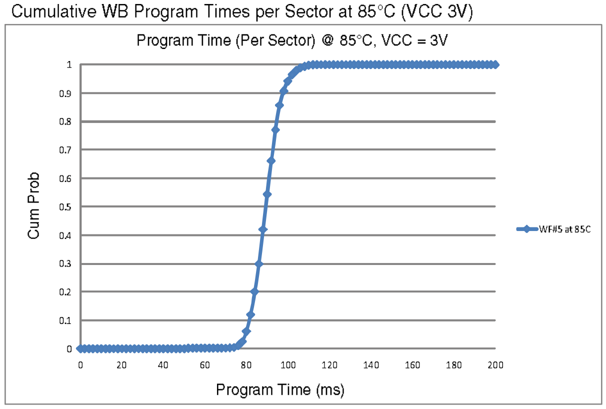

Cumulative Erase Times per Sector at -40°C (VCC 3V)



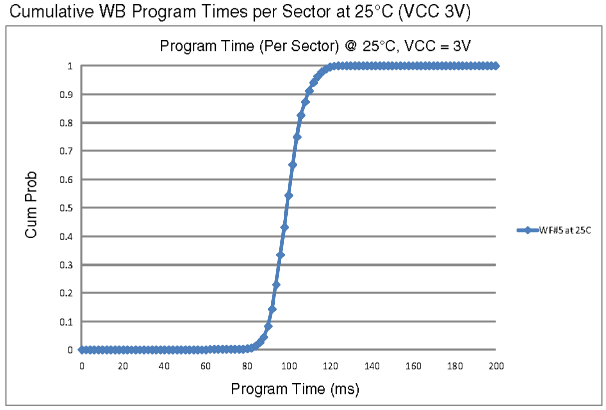
Cumulative WB Program Times per Sector at 105°C (VCC 3V)



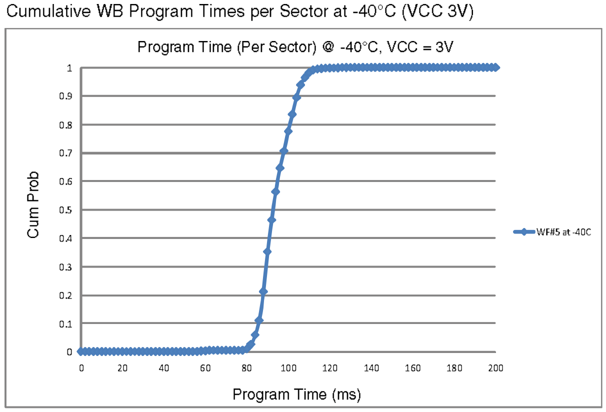

Cumulative WB Program Times per Sector at 85°C (VCC 3V)



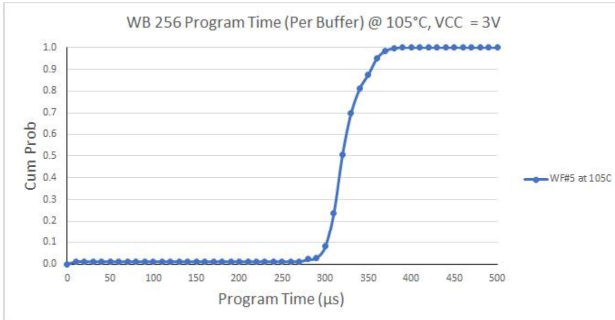

Cumulative WB Program Times per Sector at 25°C (VCC 3V)



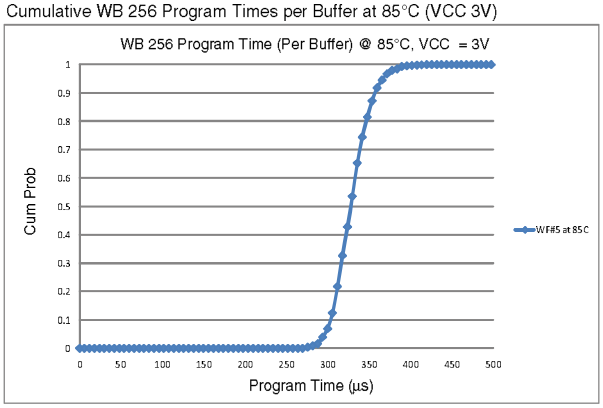

Cumulative WB Program Times per Sector at -40°C (VCC 3V)



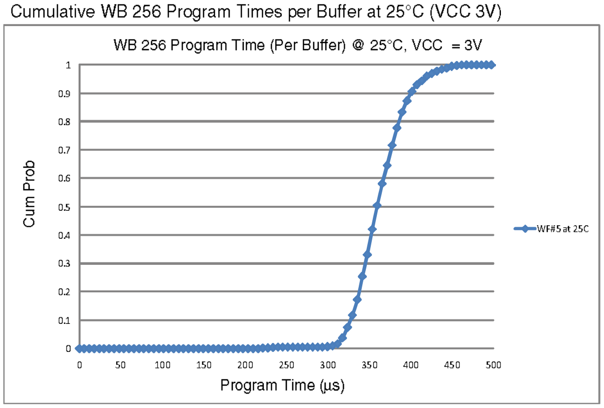
Cumulative WB 256 Program Times per Buffer at 105°C (VCC 3V)



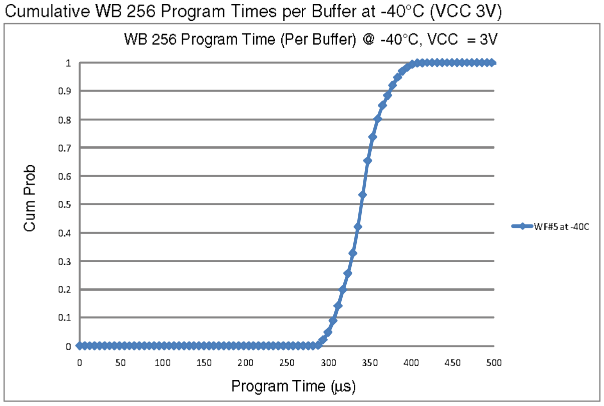

Cumulative WB 256 Program Times per Buffer at 85°C (VCC 3V)



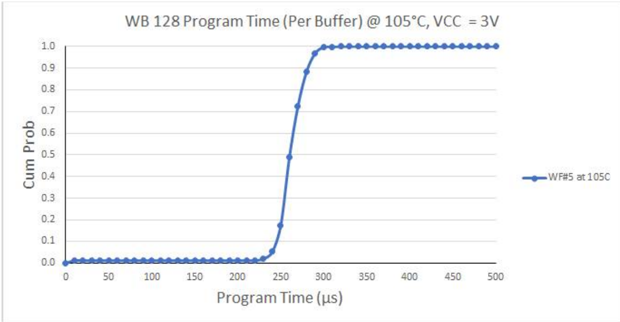

Cumulative WB 256 Program Times per Buffer at 25°C (VCC 3V)



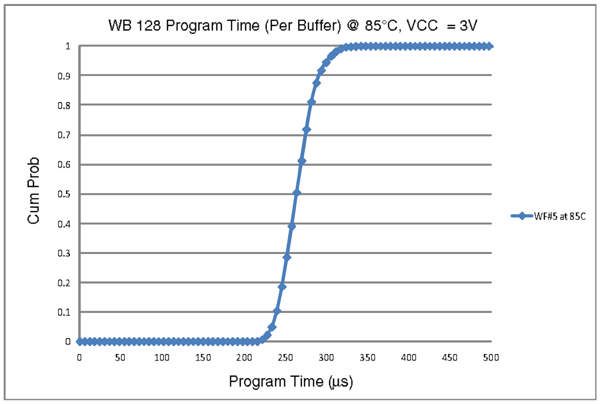

Cumulative WB 256 Program Times per Buffer at -40°C (VCC 3V)



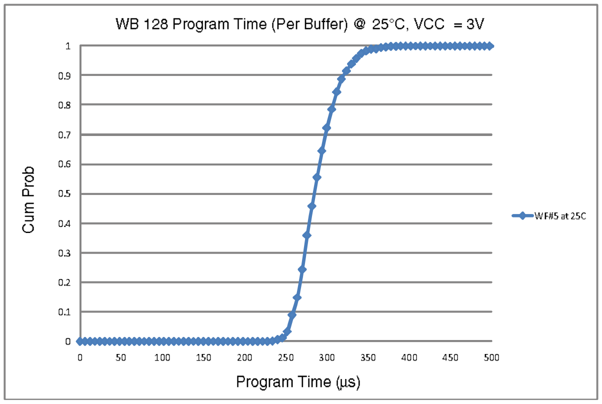
Cumulative WB 128 Program Times per Buffer at 105°C (VCC 3V)



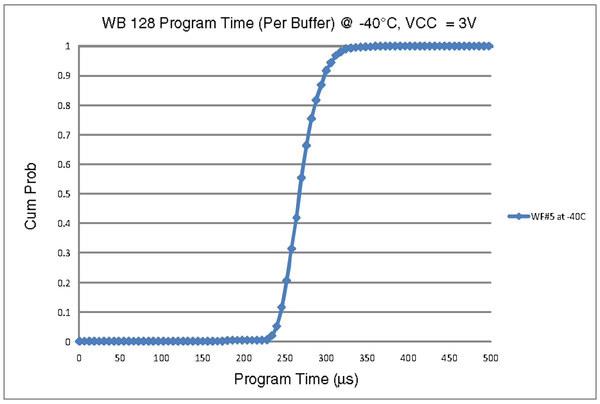

Cumulative WB 128 Program Times per Buffer at 85°C (VCC 3V)



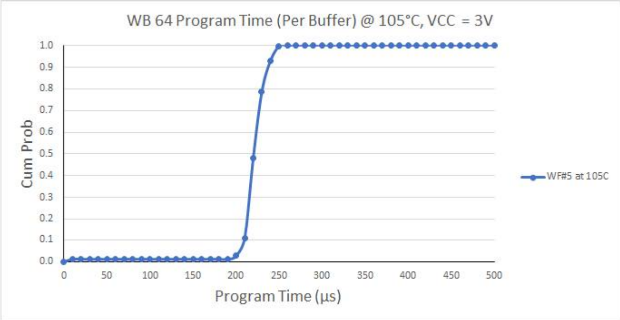

Cumulative WB 128 Program Times per Buffer at 25°C (VCC 3V)



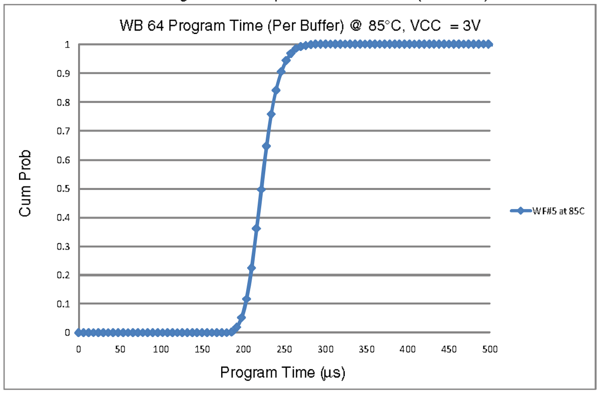

Cumulative WB 128 Program Times per Buffer at -40°C (VCC 3V)



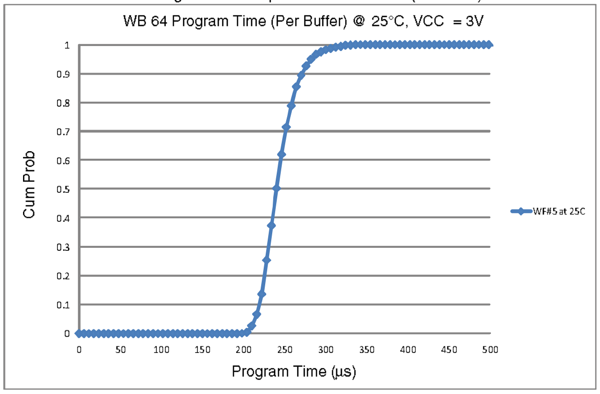
Cumulative WB 64 Program Times per Buffer at 105°C (VCC 3V)



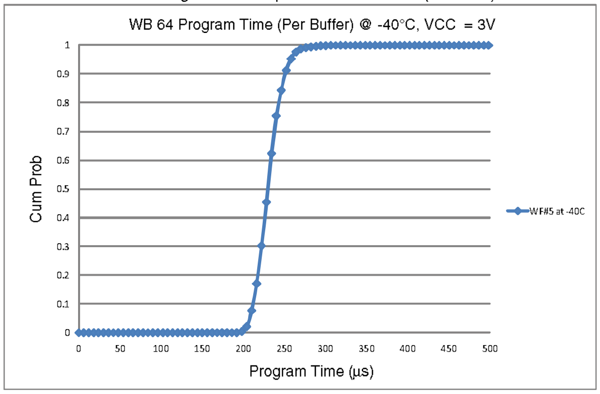

Cumulative WB 64 Program Times per Buffer at 85°C (VCC 3V)



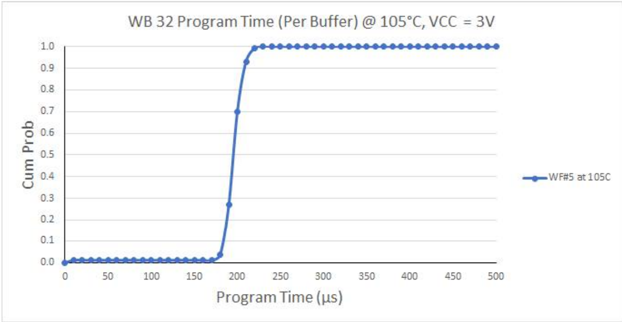

Cumulative WB 64 Program Times per Buffer at 25°C (VCC 3V)



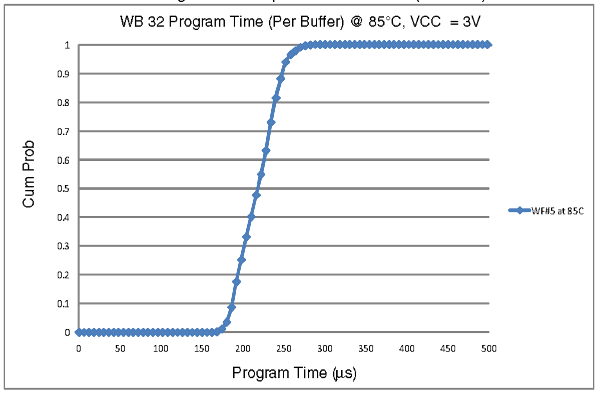

Cumulative WB 64 Program Times per Buffer at -40°C (VCC 3V)



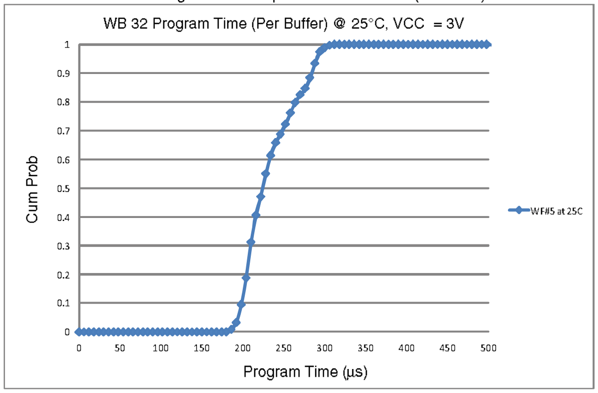
Cumulative WB 32 Program Times per Buffer at 105°C (VCC 3V)



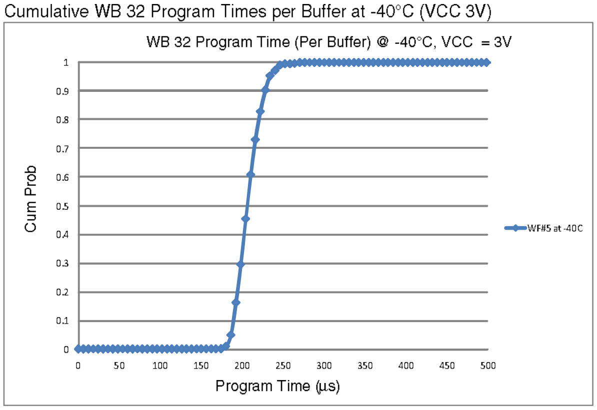

Cumulative WB 32 Program Times per Buffer at 85°C (VCC 3V)



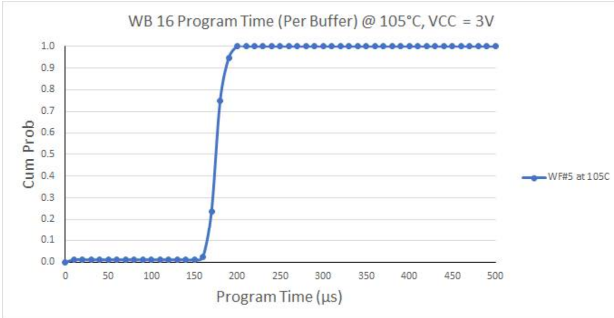

Cumulative WB 32 Program Times per Buffer at 25°C (VCC 3V)



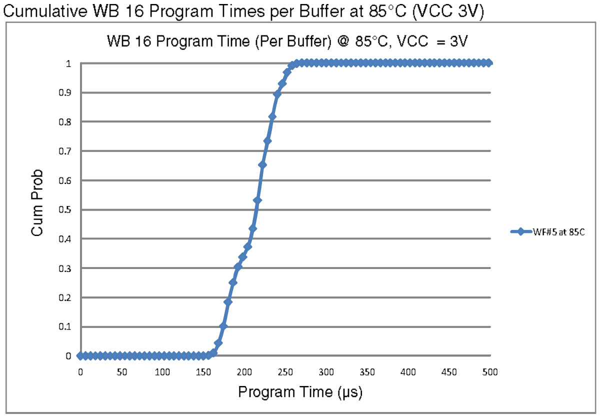

Cumulative WB 32 Program Times per Buffer at -40°C (VCC 3V)



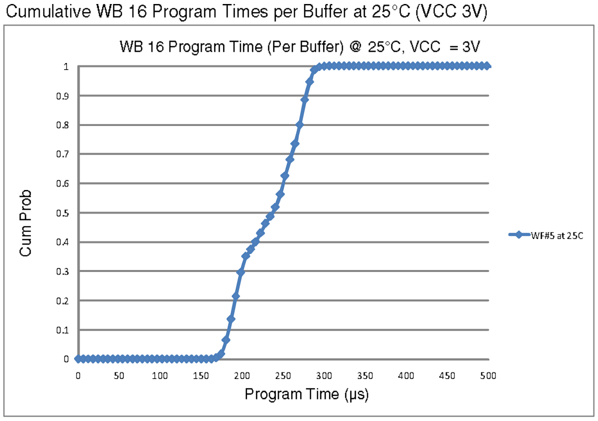
Cumulative WB 16 Program Times per Buffer at 105°C (VCC 3V)



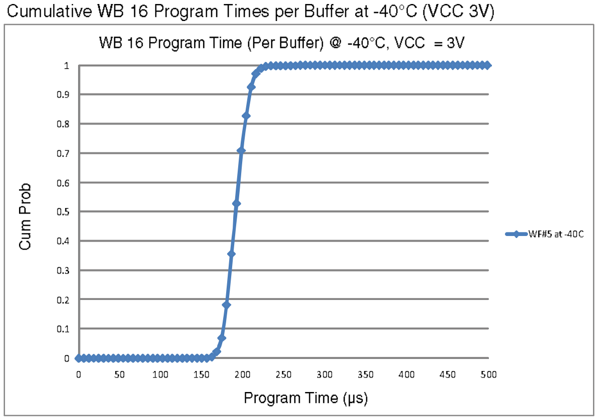

Cumulative WB 16 Program Times per Buffer at 85°C (VCC 3V)



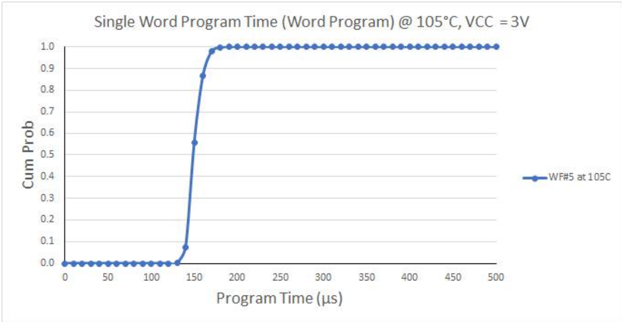

Cumulative WB 16 Program Times per Buffer at 25°C (VCC 3V)



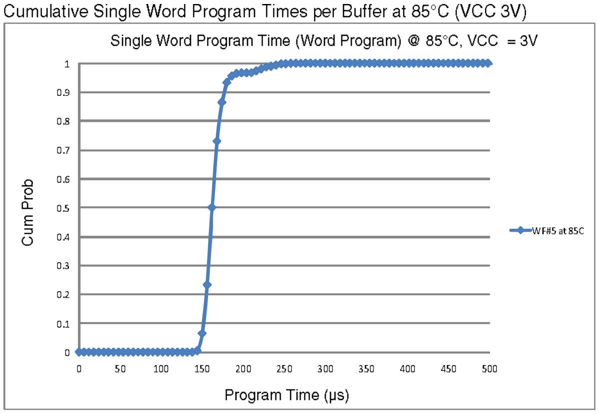

Cumulative WB 16 Program Times per Buffer at -40°C (VCC 3V)



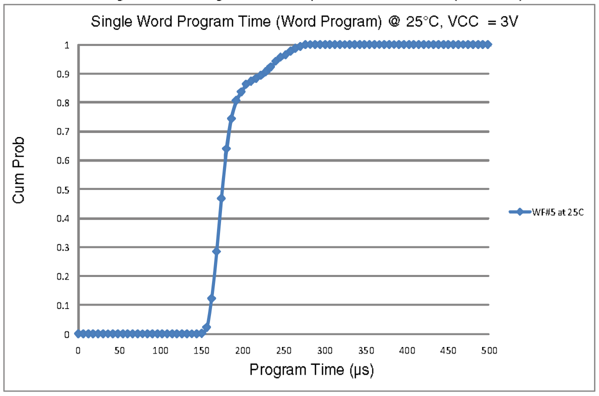
Cumulative Single Word Program Times per Buffer at 105°C (VCC 3V)



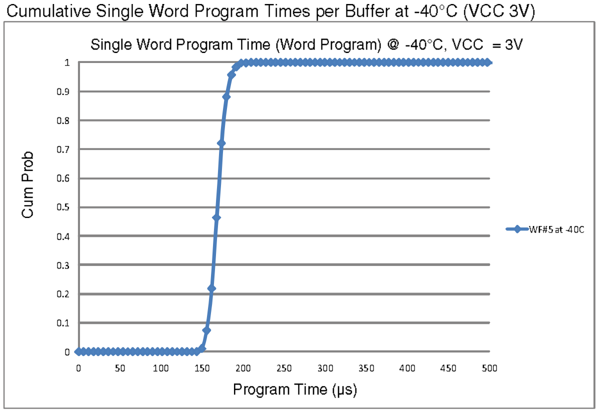

Cumulative Single Word Program Times per Buffer at 85°C (VCC 3V)




Cumulative Single Word Program Times per Buffer at 25°C (VCC 3V)




Cumulative Single Word Program Times per Buffer at -40°C (VCC 3V)



# 15. Shmoo Plots

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       80.0      90.0      100.0     110.0      first pass data
      |+----,----+----,----+----,----+|
3.650 |..............*****************|         94.0
3.600 |..............*****************|         94.0
3.550 |..............*****************|         94.0
3.500 |..............*****************|         94.0
3.450 |..............*****************|         94.0
3.400 |..............*****************|         94.0
3.350 |..............*****************|         94.0
3.300 |..............*****************|         94.0
3.250 |..............*****************|         94.0
3.200 |..............*****************|         94.0
3.150 |..............*****************|         94.0
3.100 |..............*****************|         94.0
3.050 |..............*****************|         94.0
3.000 |..............*****************|         94.0
2.950 |..............*****************|         94.0
2.900 |..............*****************|         94.0
2.850 |..............*****************|         94.0
2.800 |..............*****************|         94.0
2.750 |..............*****************|         94.0
2.700 |..............*****************|         94.0
2.650 |..............*****************|         94.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       80.0      90.0      100.0     110.0      first pass data
      |+----,----+----,----+----,----+|
3.650 |..............*****************|         94.0
3.600 |..............*****************|         94.0
3.550 |..............*****************|         94.0
3.500 |..............*****************|         94.0
3.450 |..............*****************|         94.0
3.400 |..............*****************|         94.0
3.350 |..............*****************|         94.0
3.300 |..............*****************|         94.0
3.250 |..............*****************|         94.0
3.200 |...............****************|         95.0
3.150 |...............****************|         95.0
3.100 |...............****************|         95.0
3.050 |...............****************|         95.0
3.000 |...............****************|         95.0
2.950 |...............****************|         95.0
2.900 |...............****************|         95.0
2.850 |...............****************|         95.0
2.800 |...............****************|         95.0
2.750 |...............****************|         95.0
2.700 |...............****************|         95.0
2.650 |...............****************|         95.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
        80.0      90.0      100.0     110.0        first pass data
       |+----;----+----;----+----;----+|
 3.500 |..............*****************|           94.0
 3.600 |..............*****************|           94.0
 3.550 |..............*****************|           94.0
 3.500 |..............*****************|           94.0
 3.450 |..............*****************|           94.0
 3.400 |..............*****************|           94.0
 3.350 |..............*****************|           94.0
 3.300 |..............*****************|           94.0
 3.250 |..............*****************|           94.0
 3.200 |..............*****************|           94.0
 3.150 |..............*****************|           94.0
 3.100 |..............*****************|           94.0
 3.050 |..............*****************|           94.0
 3.000 |..............*****************|           94.0
 2.950 |..............*****************|           94.0
 2.900 |..............*****************|           94.0
 2.850 |...............****************|           95.0
 2.800 |...............****************|           95.0
 2.750 |...............****************|           95.0
 2.700 |...............****************|           95.0
 2.650 |...............****************|           95.0
       |+----;----+----;----+----;----+|
        80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
        80.0      90.0      100.0     110.0        first pass data
       |+----,----+----,----+----,----+|
 3.650 |..............*****************|           94.0
 3.600 |..............*****************|           94.0
 3.550 |...............****************|           95.0
 3.500 |..............*****************|           94.0
 3.450 |..............*****************|           94.0
 3.400 |..............*****************|           94.0
 3.350 |..............*****************|           94.0
 3.300 |..............*****************|           94.0
 3.250 |...............****************|           95.0
 3.200 |...............****************|           95.0
 3.150 |...............****************|           95.0
 3.100 |...............****************|           95.0
 3.050 |...............****************|           95.0
 3.000 |...............****************|           95.0
 2.950 |...............****************|           95.0
 2.900 |...............****************|           95.0
 2.850 |...............****************|           95.0
 2.800 |...............****************|           95.0
 2.750 |...............****************|           95.0
 2.700 |...............****************|           95.0
 2.650 |...............****************|           95.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

## $t_{ACC}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
       80.0      90.0      100.0     110.0        first pass data
      |+----,----+----,----+----,----+|
3.000 |..............*****************|           94.0
2.950 |..............*****************|           94.0
2.900 |..............*****************|           94.0
2.850 |..............*****************|           94.0
2.800 |..............*****************|           94.0
2.750 |..............*****************|           94.0
2.700 |..............*****************|           94.0
2.650 |..............*****************|           94.0
2.600 |..............*****************|           94.0
2.550 |..............*****************|           94.0
2.500 |..............*****************|           94.0
2.450 |..............*****************|           94.0
2.400 |..............*****************|           94.0
2.350 |..............*****************|           94.0
2.300 |..............*****************|           94.0
2.250 |..............*****************|           94.0
2.200 |...............****************|           95.0
2.150 |...............****************|           95.0
2.100 |...............****************|           95.0
2.050 |...............****************|           95.0
2.000 |...............****************|           95.0
1.950 |...............****************|           95.0
1.900 |...............****************|           95.0
1.850 |...............****************|           95.0
1.800 |................***************|           96.0
1.750 |................***************|           96.0
1.700 |................***************|           96.0
1.650 |.................**************|           97.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

## $t_{ACC}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
       80.0      90.0      100.0     110.0        first pass data
      |+----,----+----,----+----,----+|
3.000 |...............****************|           95.0
2.950 |...............****************|           95.0
2.900 |...............****************|           95.0
2.850 |...............****************|           95.0
2.800 |...............****************|           95.0
2.750 |...............****************|           95.0
2.700 |...............****************|           95.0
2.650 |...............****************|           95.0
2.600 |...............****************|           95.0
2.550 |...............****************|           95.0
2.500 |...............****************|           95.0
2.450 |...............****************|           95.0
2.400 |...............****************|           95.0
2.350 |...............****************|           95.0
2.300 |...............****************|           95.0
2.250 |...............****************|           95.0
2.200 |...............****************|           95.0
2.150 |................***************|           96.0
2.100 |................***************|           96.0
2.050 |................***************|           96.0
2.000 |................***************|           96.0
1.950 |................***************|           96.0
1.900 |................***************|           96.0
1.850 |................***************|           96.0
1.800 |.................**************|           97.0
1.750 |.................**************|           97.0
1.700 |.................**************|           97.0
1.650 |.................**************|           97.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
        80.0      90.0      100.0     110.0      first pass data
       |+----;----+----;----+----;----+|
 3.000 |..............*****************|          94.0
 2.950 |..............*****************|          94.0
 2.900 |..............*****************|          94.0
 2.850 |..............*****************|          94.0
 2.800 |..............*****************|          94.0
 2.750 |..............*****************|          94.0
 2.700 |...............****************|          95.0
 2.650 |...............****************|          95.0
 2.600 |...............****************|          95.0
 2.550 |...............****************|          95.0
 2.500 |...............****************|          95.0
 2.450 |...............****************|          95.0
 2.400 |...............****************|          95.0
 2.350 |...............****************|          95.0
 2.300 |...............****************|          95.0
 2.250 |...............****************|          95.0
 2.200 |...............****************|          95.0
 2.150 |...............****************|          95.0
 2.100 |...............****************|          95.0
 2.050 |...............****************|          95.0
 2.000 |................***************|          96.0
 1.950 |................***************|          96.0
 1.900 |................***************|          96.0
 1.850 |................***************|          96.0
 1.800 |................***************|          96.0
 1.750 |................***************|          96.0
 1.700 |.................**************|          97.0
 1.650 |.................**************|          97.0
       |+----;----+----;----+----;----+|
        80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
        80.0      90.0      100.0     110.0       first pass data
       |+----,----+----,----+----,----+|
 3.000 |...............****************|           95.0
 2.950 |...............****************|           95.0
 2.900 |...............****************|           95.0
 2.850 |...............****************|           95.0
 2.800 |...............****************|           95.0
 2.750 |...............****************|           95.0
 2.700 |...............****************|           95.0
 2.650 |...............****************|           95.0
 2.600 |...............****************|           95.0
 2.550 |...............****************|           95.0
 2.500 |...............****************|           95.0
 2.450 |...............****************|           95.0
 2.400 |...............****************|           95.0
 2.350 |...............****************|           95.0
 2.300 |...............****************|           95.0
 2.250 |...............****************|           95.0
 2.200 |...............****************|           95.0
 2.150 |................***************|           96.0
 2.100 |................***************|           96.0
 2.050 |................***************|           96.0
 2.000 |................***************|           96.0
 1.950 |................***************|           96.0
 1.900 |................***************|           96.0
 1.850 |................***************|           96.0
 1.800 |.................**************|           97.0
 1.750 |.................**************|           97.0
 1.700 |.................**************|           97.0
 1.650 |..................*************|           98.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

**$t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C**

```
         80.0      90.0      100.0     110.0        first pass data
        |+----,----+----,----+----,----+|
  3.650 |..............*****************|           94.0
  3.600 |..............*****************|           94.0
  3.550 |..............*****************|           94.0
  3.500 |..............*****************|           94.0
  3.450 |..............*****************|           94.0
  3.400 |..............*****************|           94.0
  3.350 |..............*****************|           94.0
  3.300 |..............*****************|           94.0
  3.250 |..............*****************|           94.0
  3.200 |...............****************|           95.0
  3.150 |...............****************|           95.0
  3.100 |...............****************|           95.0
  3.050 |...............****************|           95.0
  3.000 |...............****************|           95.0
  2.950 |...............****************|           95.0
  2.900 |...............****************|           95.0
  2.850 |...............****************|           95.0
  2.800 |...............****************|           95.0
  2.750 |...............****************|           95.0
  2.700 |...............****************|           95.0
  2.650 |...............****************|           95.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

**$t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C**

```
         80.0      90.0      100.0     110.0        first pass data
        |+----,----+----,----+----,----+|
  3.650 |...............****************|           95.0
  3.600 |...............****************|           95.0
  3.550 |...............****************|           95.0
  3.500 |...............****************|           95.0
  3.450 |...............****************|           95.0
  3.400 |...............****************|           95.0
  3.350 |...............****************|           95.0
  3.300 |...............****************|           95.0
  3.250 |...............****************|           95.0
  3.200 |...............****************|           95.0
  3.150 |...............****************|           95.0
  3.100 |................***************|           96.0
  3.050 |................***************|           96.0
  3.000 |................***************|           96.0
  2.950 |................***************|           96.0
  2.900 |................***************|           96.0
  2.850 |................***************|           96.0
  2.800 |................***************|           96.0
  2.750 |................***************|           96.0
  2.700 |................***************|           96.0
  2.650 |................***************|           96.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
         80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+|
 3.650  |.............******************|          93.0
 3.600  |.............******************|          93.0
 3.550  |.............******************|          93.0
 3.500  |.............******************|          93.0
 3.450  |.............******************|          93.0
 3.400  |.............******************|          93.0
 3.350  |.............******************|          93.0
 3.300  |.............******************|          93.0
 3.250  |.............******************|          93.0
 3.200  |.............******************|          93.0
 3.150  |.............******************|          93.0
 3.100  |.............******************|          93.0
 3.050  |.............******************|          93.0
 3.000  |.............******************|          93.0
 2.950  |.............******************|          93.0
 2.900  |.............******************|          93.0
 2.850  |.............******************|          93.0
 2.800  |..............*****************|          94.0
 2.750  |..............*****************|          94.0
 2.700  |..............*****************|          94.0
 2.650  |..............*****************|          94.0
        |+----;----+----;----+----;----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
 3.650  |...............****************|           95.0
 3.600  |...............****************|           95.0
 3.550  |...............****************|           95.0
 3.500  |...............****************|           95.0
 3.450  |...............****************|           95.0
 3.400  |................***************|           96.0
 3.350  |................***************|           96.0
 3.300  |................***************|           96.0
 3.250  |................***************|           96.0
 3.200  |................***************|           96.0
 3.150  |................***************|           96.0
 3.100  |................***************|           96.0
 3.050  |................***************|           96.0
 3.000  |................***************|           96.0
 2.950  |................***************|           96.0
 2.900  |................***************|           96.0
 2.850  |................***************|           96.0
 2.800  |................***************|           96.0
 2.750  |................***************|           96.0
 2.700  |................***************|           96.0
 2.650  |................***************|           96.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0        first pass data
        |+----,----+----,----+----,----+|
  3.000 |...............****************|           95.0
  2.950 |...............****************|           95.0
  2.900 |...............****************|           95.0
  2.850 |...............****************|           95.0
  2.800 |...............****************|           95.0
  2.750 |...............****************|           95.0
  2.700 |...............****************|           95.0
  2.650 |...............****************|           95.0
  2.600 |...............****************|           95.0
  2.550 |...............****************|           95.0
  2.500 |...............****************|           95.0
  2.450 |...............****************|           95.0
  2.400 |...............****************|           95.0
  2.350 |...............****************|           95.0
  2.300 |...............****************|           95.0
  2.250 |...............****************|           95.0
  2.200 |...............****************|           95.0
  2.150 |...............****************|           95.0
  2.100 |...............****************|           95.0
  2.050 |...............****************|           95.0
  2.000 |................***************|           96.0
  1.950 |................***************|           96.0
  1.900 |................***************|           96.0
  1.850 |................***************|           96.0
  1.800 |.................**************|           97.0
  1.750 |.................**************|           97.0
  1.700 |..................*************|           98.0
  1.650 |..................*************|           98.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0        first pass data
        |+----,----+----,----+----,----+|
  3.000 |................***************|           96.0
  2.950 |................***************|           96.0
  2.900 |................***************|           96.0
  2.850 |................***************|           96.0
  2.800 |................***************|           96.0
  2.750 |................***************|           96.0
  2.700 |................***************|           96.0
  2.650 |................***************|           96.0
  2.600 |................***************|           96.0
  2.550 |................***************|           96.0
  2.500 |................***************|           96.0
  2.450 |................***************|           96.0
  2.400 |................***************|           96.0
  2.350 |................***************|           96.0
  2.300 |................***************|           96.0
  2.250 |................***************|           96.0
  2.200 |................***************|           96.0
  2.150 |................***************|           96.0
  2.100 |.................**************|           97.0
  2.050 |.................**************|           97.0
  2.000 |.................**************|           97.0
  1.950 |.................**************|           97.0
  1.900 |.................**************|           97.0
  1.850 |.................**************|           97.0
  1.800 |..................*************|           98.0
  1.750 |..................*************|           98.0
  1.700 |...................************|           99.0
  1.650 |...................************|           99.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
        80.0      90.0      100.0     110.0      first pass data
       |+----;----+----;----+----;----+|
 3.000 |.............******************|           93.0
 2.950 |.............******************|           93.0
 2.900 |.............******************|           93.0
 2.850 |.............******************|           93.0
 2.800 |.............******************|           93.0
 2.750 |..............*****************|           94.0
 2.700 |..............*****************|           94.0
 2.650 |..............*****************|           94.0
 2.600 |..............*****************|           94.0
 2.550 |..............*****************|           94.0
 2.500 |..............*****************|           94.0
 2.450 |..............*****************|           94.0
 2.400 |..............*****************|           94.0
 2.350 |..............*****************|           94.0
 2.300 |..............*****************|           94.0
 2.250 |..............*****************|           94.0
 2.200 |..............*****************|           94.0
 2.150 |..............*****************|           94.0
 2.100 |..............*****************|           94.0
 2.050 |...............****************|           95.0
 2.000 |...............****************|           95.0
 1.950 |...............****************|           95.0
 1.900 |...............****************|           95.0
 1.850 |................***************|           96.0
 1.800 |................***************|           96.0
 1.750 |................***************|           96.0
 1.700 |.................**************|           97.0
 1.650 |.................**************|           97.0
       |+----;----+----;----+----;----+|
        80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0       first pass data
       |+----,----+----,----+----,----+|
 3.000 |................***************|            96.0
 2.950 |................***************|            96.0
 2.900 |................***************|            96.0
 2.850 |................***************|            96.0
 2.800 |................***************|            96.0
 2.750 |................***************|            96.0
 2.700 |................***************|            96.0
 2.650 |................***************|            96.0
 2.600 |................***************|            96.0
 2.550 |................***************|            96.0
 2.500 |................***************|            96.0
 2.450 |................***************|            96.0
 2.400 |................***************|            96.0
 2.350 |................***************|            96.0
 2.300 |................***************|            96.0
 2.250 |.................**************|            97.0
 2.200 |.................**************|            97.0
 2.150 |.................**************|            97.0
 2.100 |.................**************|            97.0
 2.050 |.................**************|            97.0
 2.000 |.................**************|            97.0
 1.950 |.................**************|            97.0
 1.900 |..................*************|            98.0
 1.850 |..................*************|            98.0
 1.800 |..................*************|            98.0
 1.750 |..................*************|            98.0
 1.700 |...................************|            99.0
 1.650 |...................************|            99.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

## $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
          0.0       10.0      20.0         first pass data
         |+----,----+----,----+|
 3.650   |......***************|           6.0
 3.600   |......***************|           6.0
 3.550   |......***************|           6.0
 3.500   |......***************|           6.0
 3.450   |......***************|           6.0
 3.400   |......***************|           6.0
 3.350   |......***************|           6.0
 3.300   |......***************|           6.0
 3.250   |......***************|           6.0
 3.200   |......***************|           6.0
 3.150   |......***************|           6.0
 3.100   |......***************|           6.0
 3.050   |......***************|           6.0
 3.000   |......***************|           6.0
 2.950   |......***************|           6.0
 2.900   |......***************|           6.0
 2.850   |......***************|           6.0
 2.800   |......***************|           6.0
 2.750   |......***************|           6.0
 2.700   |......***************|           6.0
 2.650   |......***************|           6.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

## $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
          0.0       10.0      20.0         first pass data
         |+----,----+----,----+|
 3.650   |......***************|           6.0
 3.600   |......***************|           6.0
 3.550   |......***************|           6.0
 3.500   |......***************|           6.0
 3.450   |......***************|           6.0
 3.400   |......***************|           6.0
 3.350   |......***************|           6.0
 3.300   |......***************|           6.0
 3.250   |......***************|           6.0
 3.200   |......***************|           6.0
 3.150   |......***************|           6.0
 3.100   |......***************|           6.0
 3.050   |......***************|           6.0
 3.000   |.......**************|           7.0
 2.950   |.......**************|           7.0
 2.900   |.......**************|           7.0
 2.850   |.......**************|           7.0
 2.800   |.......**************|           7.0
 2.750   |.......**************|           7.0
 2.700   |.......**************|           7.0
 2.650   |.......**************|           7.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

## $t_{OE}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
        0.0       10.0      20.0             first pass data
       |+----;----+----;----+----;|
 3.650 |.......*******************|          7.0
 3.600 |.......*******************|          7.0
 3.550 |.......*******************|          7.0
 3.500 |.......*******************|          7.0
 3.450 |.......*******************|          7.0
 3.400 |.......*******************|          7.0
 3.350 |.......*******************|          7.0
 3.300 |.......*******************|          7.0
 3.250 |.......*******************|          7.0
 3.200 |.......*******************|          7.0
 3.150 |.......*******************|          7.0
 3.100 |.......*******************|          7.0
 3.050 |........******************|          8.0
 3.000 |........******************|          8.0
 2.950 |........******************|          8.0
 2.900 |........******************|          8.0
 2.850 |........******************|          8.0
 2.800 |........******************|          8.0
 2.750 |........******************|          8.0
 2.700 |........******************|          8.0
 2.650 |........******************|          8.0
       |+----;----+----;----+----;|
        0.0       10.0      20.0
```

## $t_{OE}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
        0.0       10.0      20.0         first pass data
       |+----,----+----,----+|
 3.650 |......***************|           6.0
 3.600 |......***************|           6.0
 3.550 |......***************|           6.0
 3.500 |......***************|           6.0
 3.450 |......***************|           6.0
 3.400 |......***************|           6.0
 3.350 |......***************|           6.0
 3.300 |......***************|           6.0
 3.250 |......***************|           6.0
 3.200 |......***************|           6.0
 3.150 |......***************|           6.0
 3.100 |......***************|           6.0
 3.050 |......***************|           6.0
 3.000 |......***************|           6.0
 2.950 |......***************|           6.0
 2.900 |......***************|           6.0
 2.850 |......***************|           6.0
 2.800 |......***************|           6.0
 2.750 |......***************|           6.0
 2.700 |......***************|           6.0
 2.650 |......***************|           6.0
       |+----,----+----,----+|
        0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
        0.0       10.0      20.0        first pass data
       |+----,----+----,----+|
 3.000 |......***************|          6.0
 2.950 |......***************|          6.0
 2.900 |......***************|          6.0
 2.850 |......***************|          6.0
 2.800 |......***************|          6.0
 2.750 |......***************|          6.0
 2.700 |......***************|          6.0
 2.650 |......***************|          6.0
 2.600 |......***************|          6.0
 2.550 |......***************|          6.0
 2.500 |......***************|          6.0
 2.450 |.......**************|          7.0
 2.400 |.......**************|          7.0
 2.350 |.......**************|          7.0
 2.300 |.......**************|          7.0
 2.250 |.......**************|          7.0
 2.200 |.......**************|          7.0
 2.150 |.......**************|          7.0
 2.100 |.......**************|          7.0
 2.050 |.......**************|          7.0
 2.000 |.......**************|          7.0
 1.950 |........*************|          8.0
 1.900 |........*************|          8.0
 1.850 |........*************|          8.0
 1.800 |........*************|          8.0
 1.750 |........*************|          8.0
 1.700 |.........************|          9.0
 1.650 |.........************|          9.0
       |+----,----+----,----+|
        0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
        0.0       10.0      20.0        first pass data
       |+----,----+----,----+|
 3.000 |.......**************|          7.0
 2.950 |.......**************|          7.0
 2.900 |.......**************|          7.0
 2.850 |.......**************|          7.0
 2.800 |.......**************|          7.0
 2.750 |.......**************|          7.0
 2.700 |.......**************|          7.0
 2.650 |.......**************|          7.0
 2.600 |.......**************|          7.0
 2.550 |.......**************|          7.0
 2.500 |.......**************|          7.0
 2.450 |.......**************|          7.0
 2.400 |.......**************|          7.0
 2.350 |.......**************|          7.0
 2.300 |.......**************|          7.0
 2.250 |.......**************|          7.0
 2.200 |.......**************|          7.0
 2.150 |.......**************|          7.0
 2.100 |.......**************|          7.0
 2.050 |........*************|          8.0
 2.000 |........*************|          8.0
 1.950 |........*************|          8.0
 1.900 |........*************|          8.0
 1.850 |........*************|          8.0
 1.800 |........*************|          8.0
 1.750 |.........************|          9.0
 1.700 |.........************|          9.0
 1.650 |.........************|          9.0
       |+----,----+----,----+|
        0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0            first pass data
         |+----;----+----;----+----;|
   3.000 |........******************|            8.0
   2.950 |........******************|            8.0
   2.900 |........******************|            8.0
   2.850 |........******************|            8.0
   2.800 |........******************|            8.0
   2.750 |........******************|            8.0
   2.700 |........******************|            8.0
   2.650 |........******************|            8.0
   2.600 |........******************|            8.0
   2.550 |........******************|            8.0
   2.500 |........******************|            8.0
   2.450 |........******************|            8.0
   2.400 |........******************|            8.0
   2.350 |........******************|            8.0
   2.300 |........******************|            8.0
   2.250 |........******************|            8.0
   2.200 |........******************|            8.0
   2.150 |........******************|            8.0
   2.100 |.........*****************|            9.0
   2.050 |.........*****************|            9.0
   2.000 |.........*****************|            9.0
   1.950 |.........*****************|            9.0
   1.900 |.........*****************|            9.0
   1.850 |.........*****************|            9.0
   1.800 |..........****************|            10.0
   1.750 |..........****************|            10.0
   1.700 |..........****************|            10.0
   1.650 |..........****************|            10.0
         |+----;----+----;----+----;|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.000 |......***************|           6.0
   2.950 |......***************|           6.0
   2.900 |......***************|           6.0
   2.850 |......***************|           6.0
   2.800 |......***************|           6.0
   2.750 |......***************|           6.0
   2.700 |......***************|           6.0
   2.650 |......***************|           6.0
   2.600 |......***************|           6.0
   2.550 |......***************|           6.0
   2.500 |......***************|           6.0
   2.450 |......***************|           6.0
   2.400 |......***************|           6.0
   2.350 |......***************|           6.0
   2.300 |......***************|           6.0
   2.250 |......***************|           6.0
   2.200 |......***************|           6.0
   2.150 |.......**************|           7.0
   2.100 |.......**************|           7.0
   2.050 |.......**************|           7.0
   2.000 |.......**************|           7.0
   1.950 |.......**************|           7.0
   1.900 |.......**************|           7.0
   1.850 |........*************|           8.0
   1.800 |........*************|           8.0
   1.750 |........*************|           8.0
   1.700 |........*************|           8.0
   1.650 |.........************|           9.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |..........***********|          10.0
   3.600 |..........***********|          10.0
   3.550 |..........***********|          10.0
   3.500 |..........***********|          10.0
   3.450 |..........***********|          10.0
   3.400 |..........***********|          10.0
   3.350 |..........***********|          10.0
   3.300 |..........***********|          10.0
   3.250 |..........***********|          10.0
   3.200 |..........***********|          10.0
   3.150 |..........***********|          10.0
   3.100 |..........***********|          10.0
   3.050 |..........***********|          10.0
   3.000 |..........***********|          10.0
   2.950 |..........***********|          10.0
   2.900 |..........***********|          10.0
   2.850 |..........***********|          10.0
   2.800 |..........***********|          10.0
   2.750 |..........***********|          10.0
   2.700 |..........***********|          10.0
   2.650 |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |..........***********|          10.0
   3.600 |..........***********|          10.0
   3.550 |..........***********|          10.0
   3.500 |..........***********|          10.0
   3.450 |..........***********|          10.0
   3.400 |..........***********|          10.0
   3.350 |..........***********|          10.0
   3.300 |..........***********|          10.0
   3.250 |..........***********|          10.0
   3.200 |..........***********|          10.0
   3.150 |..........***********|          10.0
   3.100 |..........***********|          10.0
   3.050 |..........***********|          10.0
   3.000 |..........***********|          10.0
   2.950 |..........***********|          10.0
   2.900 |..........***********|          10.0
   2.850 |..........***********|          10.0
   2.800 |..........***********|          10.0
   2.750 |..........***********|          10.0
   2.700 |..........***********|          10.0
   2.650 |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          0.0       10.0      20.0       first pass data
         |+----;----+----;----+|
   3.650 |............*********|         12.0
   3.600 |............*********|         12.0
   3.550 |............*********|         12.0
   3.500 |............*********|         12.0
   3.450 |............*********|         12.0
   3.400 |............*********|         12.0
   3.350 |............*********|         12.0
   3.300 |............*********|         12.0
   3.250 |............*********|         12.0
   3.200 |............*********|         12.0
   3.150 |............*********|         12.0
   3.100 |............*********|         12.0
   3.050 |............*********|         12.0
   3.000 |............*********|         12.0
   2.950 |............*********|         12.0
   2.900 |............*********|         12.0
   2.850 |............*********|         12.0
   2.800 |............*********|         12.0
   2.750 |............*********|         12.0
   2.700 |............*********|         12.0
   2.650 |............*********|         12.0
         |+----;----+----;----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |.........************|          9.0
   3.600 |.........************|          9.0
   3.550 |.........************|          9.0
   3.500 |.........************|          9.0
   3.450 |.........************|          9.0
   3.400 |.........************|          9.0
   3.350 |.........************|          9.0
   3.300 |.........************|          9.0
   3.250 |.........************|          9.0
   3.200 |.........************|          9.0
   3.150 |.........************|          9.0
   3.100 |.........************|          9.0
   3.050 |.........************|          9.0
   3.000 |.........************|          9.0
   2.950 |.........************|          9.0
   2.900 |.........************|          9.0
   2.850 |.........************|          9.0
   2.800 |.........************|          9.0
   2.750 |..........***********|          10.0
   2.700 |..........***********|          10.0
   2.650 |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
         0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.000 |..........***********|          10.0
   2.950 |..........***********|          10.0
   2.900 |..........***********|          10.0
   2.850 |..........***********|          10.0
   2.800 |..........***********|          10.0
   2.750 |..........***********|          10.0
   2.700 |..........***********|          10.0
   2.650 |..........***********|          10.0
   2.600 |..........***********|          10.0
   2.550 |..........***********|          10.0
   2.500 |..........***********|          10.0
   2.450 |..........***********|          10.0
   2.400 |..........***********|          10.0
   2.350 |..........***********|          10.0
   2.300 |..........***********|          10.0
   2.250 |..........***********|          10.0
   2.200 |..........***********|          10.0
   2.150 |..........***********|          10.0
   2.100 |..........***********|          10.0
   2.050 |..........***********|          10.0
   2.000 |..........***********|          10.0
   1.950 |...........**********|          11.0
   1.900 |...........**********|          11.0
   1.850 |...........**********|          11.0
   1.800 |...........**********|          11.0
   1.750 |............*********|          12.0
   1.700 |............*********|          12.0
   1.650 |............*********|          12.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.000 |..........***********|          10.0
   2.950 |..........***********|          10.0
   2.900 |..........***********|          10.0
   2.850 |..........***********|          10.0
   2.800 |..........***********|          10.0
   2.750 |..........***********|          10.0
   2.700 |..........***********|          10.0
   2.650 |..........***********|          10.0
   2.600 |..........***********|          10.0
   2.550 |..........***********|          10.0
   2.500 |..........***********|          10.0
   2.450 |..........***********|          10.0
   2.400 |...........**********|          11.0
   2.350 |...........**********|          11.0
   2.300 |...........**********|          11.0
   2.250 |...........**********|          11.0
   2.200 |...........**********|          11.0
   2.150 |...........**********|          11.0
   2.100 |...........**********|          11.0
   2.050 |...........**********|          11.0
   2.000 |...........**********|          11.0
   1.950 |...........**********|          11.0
   1.900 |...........**********|          11.0
   1.850 |............*********|          12.0
   1.800 |............*********|          12.0
   1.750 |............*********|          12.0
   1.700 |............*********|          12.0
   1.650 |............*********|          12.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
          0.0        10.0       20.0        first pass data
         |+----;----+----;----+|
   3.000 |............*********|            12.0
   2.950 |............*********|            12.0
   2.900 |............*********|            12.0
   2.850 |............*********|            12.0
   2.800 |............*********|            12.0
   2.750 |............*********|            12.0
   2.700 |............*********|            12.0
   2.650 |............*********|            12.0
   2.600 |............*********|            12.0
   2.550 |............*********|            12.0
   2.500 |............*********|            12.0
   2.450 |............*********|            12.0
   2.400 |............*********|            12.0
   2.350 |............*********|            12.0
   2.300 |.............********|            13.0
   2.250 |.............********|            13.0
   2.200 |.............********|            13.0
   2.150 |.............********|            13.0
   2.100 |.............********|            13.0
   2.050 |.............********|            13.0
   2.000 |.............********|            13.0
   1.950 |.............********|            13.0
   1.900 |.............********|            13.0
   1.850 |.............********|            13.0
   1.800 |.............********|            13.0
   1.750 |..............*******|            14.0
   1.700 |..............*******|            14.0
   1.650 |..............*******|            14.0
         |+----;----+----;----+|
          0.0        10.0       20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
          0.0        10.0       20.0         first pass data
         |+----,----+----,----+|
   3.000 |.........************|             9.0
   2.950 |.........************|             9.0
   2.900 |.........************|             9.0
   2.850 |.........************|             9.0
   2.800 |.........************|             9.0
   2.750 |.........************|             9.0
   2.700 |.........************|             9.0
   2.650 |.........************|             9.0
   2.600 |.........************|             9.0
   2.550 |..........***********|             10.0
   2.500 |..........***********|             10.0
   2.450 |..........***********|             10.0
   2.400 |..........***********|             10.0
   2.350 |..........***********|             10.0
   2.300 |..........***********|             10.0
   2.250 |..........***********|             10.0
   2.200 |..........***********|             10.0
   2.150 |..........***********|             10.0
   2.100 |..........***********|             10.0
   2.050 |..........***********|             10.0
   2.000 |..........***********|             10.0
   1.950 |..........***********|             10.0
   1.900 |...........**********|             11.0
   1.850 |...........**********|             11.0
   1.800 |...........**********|             11.0
   1.750 |............*********|             12.0
   1.700 |............*********|             12.0
   1.650 |............*********|             12.0
         |+----,----+----,----+|
          0.0        10.0       20.0
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       1.000     1.500     2.000     2.500     3.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |.......................******************|         2.150
3.600 |......................*******************|         2.100
3.550 |......................*******************|         2.100
3.500 |.....................********************|         2.050
3.450 |....................*********************|         2.000
3.400 |....................*********************|         2.000
3.350 |...................**********************|         1.950
3.300 |..................***********************|         1.900
3.250 |..................***********************|         1.900
3.200 |.................************************|         1.850
3.150 |.................************************|         1.850
3.100 |................*************************|         1.800
3.050 |................*************************|         1.800
3.000 |...............**************************|         1.750
2.950 |..............***************************|         1.700
2.900 |..............***************************|         1.700
2.850 |.............****************************|         1.650
2.800 |.............****************************|         1.650
2.750 |............*****************************|         1.600
2.700 |............*****************************|         1.600
2.650 |...........******************************|         1.550
      |+----,----+----,----+----,----+----,----+|
       1.000     1.500     2.000     2.500     3.000
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       1.000     1.500     2.000     2.500     3.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |.......................******************|         2.150
3.600 |......................*******************|         2.100
3.550 |.....................********************|         2.050
3.500 |.....................********************|         2.050
3.450 |....................*********************|         2.000
3.400 |....................*********************|         2.000
3.350 |...................**********************|         1.950
3.300 |..................***********************|         1.900
3.250 |..................***********************|         1.900
3.200 |.................************************|         1.850
3.150 |.................************************|         1.850
3.100 |................*************************|         1.800
3.050 |................*************************|         1.800
3.000 |...............**************************|         1.750
2.950 |..............***************************|         1.700
2.900 |..............***************************|         1.700
2.850 |.............****************************|         1.650
2.800 |.............****************************|         1.650
2.750 |............*****************************|         1.600
2.700 |...........******************************|         1.550
2.650 |...........******************************|         1.550
      |+----,----+----,----+----,----+----,----+|
       1.000     1.500     2.000     2.500     3.000
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
       1.000     1.500     2.000     2.500     3.000      first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |...................**********************|       1.950
3.600 |...................**********************|       1.950
3.550 |..................***********************|       1.900
3.500 |.................************************|       1.850
3.450 |.................************************|       1.850
3.400 |.................************************|       1.850
3.350 |................*************************|       1.800
3.300 |................*************************|       1.800
3.250 |...............**************************|       1.750
3.200 |..............***************************|       1.700
3.150 |..............***************************|       1.700
3.100 |.............****************************|       1.650
3.050 |.............****************************|       1.650
3.000 |............*****************************|       1.600
2.950 |............*****************************|       1.600
2.900 |...........******************************|       1.550
2.850 |...........******************************|       1.550
2.800 |..........*******************************|       1.500
2.750 |..........*******************************|       1.500
2.700 |.........********************************|       1.450
2.650 |.........********************************|       1.450
      |+----;----+----;----+----;----+----;----+|
       1.000     1.500     2.000     2.500     3.000
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       1.000     1.500     2.000     2.500     3.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |.......................******************|        2.150
3.600 |.......................******************|        2.150
3.550 |......................*******************|        2.100
3.500 |.....................********************|        2.050
3.450 |.....................********************|        2.050
3.400 |....................*********************|        2.000
3.350 |....................*********************|        2.000
3.300 |...................**********************|        1.950
3.250 |..................***********************|        1.900
3.200 |..................***********************|        1.900
3.150 |.................************************|        1.850
3.100 |................*************************|        1.800
3.050 |................*************************|        1.800
3.000 |...............**************************|        1.750
2.950 |...............**************************|        1.750
2.900 |..............***************************|        1.700
2.850 |.............****************************|        1.650
2.800 |.............****************************|        1.650
2.750 |............*****************************|        1.600
2.700 |............*****************************|        1.600
2.650 |...........******************************|        1.550
      |+----,----+----,----+----,----+----,----+|
       1.000     1.500     2.000     2.500     3.000
```

## $V_{IL}$ vs. $V_{CC}$ =$V_{IO}$ @ 25°C

```
         0.000     0.500     1.000     1.500     2.000        first pass data
        |+----,----+----,----+----,----+----,----+|
  3.650 |*****************************............|         1.450
  3.600 |****************************.............|         1.400
  3.550 |****************************.............|         1.400
  3.500 |****************************.............|         1.400
  3.450 |***************************..............|         1.350
  3.400 |***************************..............|         1.350
  3.350 |***************************..............|         1.350
  3.300 |**************************...............|         1.300
  3.250 |**************************...............|         1.300
  3.200 |**************************...............|         1.300
  3.150 |**************************...............|         1.300
  3.100 |*************************................|         1.250
  3.050 |*************************................|         1.250
  3.000 |*************************................|         1.250
  2.950 |************************.................|         1.200
  2.900 |************************.................|         1.200
  2.850 |***********************..................|         1.150
  2.800 |***********************..................|         1.150
  2.750 |***********************..................|         1.150
  2.700 |**********************...................|         1.100
  2.650 |**********************...................|         1.100
        |+----,----+----,----+----,----+----,----+|
         0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$ =$V_{IO}$ @ 85°C

```
         0.000     0.500     1.000     1.500     2.000        first pass data
        |+----,----+----,----+----,----+----,----+|
  3.650 |*****************************............|         1.450
  3.600 |****************************.............|         1.400
  3.550 |****************************.............|         1.400
  3.500 |****************************.............|         1.400
  3.450 |***************************..............|         1.350
  3.400 |***************************..............|         1.350
  3.350 |**************************...............|         1.300
  3.300 |**************************...............|         1.300
  3.250 |**************************...............|         1.300
  3.200 |**************************...............|         1.300
  3.150 |*************************................|         1.250
  3.100 |*************************................|         1.250
  3.050 |************************.................|         1.200
  3.000 |************************.................|         1.200
  2.950 |***********************..................|         1.150
  2.900 |************************.................|         1.200
  2.850 |***********************..................|         1.150
  2.800 |***********************..................|         1.150
  2.750 |**********************...................|         1.100
  2.700 |**********************...................|         1.100
  2.650 |**********************...................|         1.100
        |+----,----+----,----+----,----+----,----+|
         0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |******************************...........|         1.450
3.600 |******************************...........|         1.450
3.550 |******************************...........|         1.450
3.500 |*****************************............|         1.400
3.450 |*****************************............|         1.400
3.400 |*****************************............|         1.400
3.350 |****************************.............|         1.350
3.300 |****************************.............|         1.350
3.250 |****************************.............|         1.350
3.200 |***************************..............|         1.300
3.150 |***************************..............|         1.300
3.100 |***************************..............|         1.300
3.050 |**************************...............|         1.250
3.000 |**************************...............|         1.250
2.950 |**************************...............|         1.250
2.900 |*************************................|         1.200
2.850 |*************************................|         1.200
2.800 |*************************................|         1.200
2.750 |************************.................|         1.150
2.700 |************************.................|         1.150
2.650 |************************.................|         1.150
      |+----;----+----;----+----;----+----;----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       0.000     0.500     1.000     1.500     2.000         first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |******************************...........|          1.450
3.600 |*****************************............|          1.400
3.550 |*****************************............|          1.400
3.500 |*****************************............|          1.400
3.450 |*****************************............|          1.400
3.400 |*****************************............|          1.400
3.350 |****************************.............|          1.350
3.300 |****************************.............|          1.350
3.250 |****************************.............|          1.350
3.200 |***************************..............|          1.300
3.150 |***************************..............|          1.300
3.100 |**************************...............|          1.250
3.050 |**************************...............|          1.250
3.000 |**************************...............|          1.250
2.950 |**************************...............|          1.250
2.900 |*************************................|          1.200
2.850 |*************************................|          1.200
2.800 |*************************................|          1.200
2.750 |************************.................|          1.150
2.700 |************************.................|          1.150
2.650 |***********************..................|          1.100
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |********************************.........|        3.550
3.600 |*******************************..........|        3.500
3.550 |******************************...........|        3.450
3.500 |*****************************............|        3.400
3.450 |*****************************............|        3.400
3.400 |***************************..............|        3.300
3.350 |**************************...............|        3.250
3.300 |*************************................|        3.200
3.250 |************************.................|        3.150
3.200 |***********************..................|        3.100
3.150 |**********************...................|        3.050
3.100 |**********************...................|        3.050
3.050 |*********************....................|        3.000
3.000 |********************.....................|        2.950
2.950 |*******************......................|        2.900
2.900 |******************.......................|        2.850
2.850 |*****************........................|        2.800
2.800 |****************.........................|        2.750
2.750 |***************..........................|        2.700
2.700 |**************...........................|        2.650
2.650 |*************............................|        2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|        3.600
3.600 |*******************************..........|        3.500
3.550 |******************************...........|        3.450
3.500 |*****************************............|        3.400
3.450 |****************************.............|        3.350
3.400 |****************************.............|        3.350
3.350 |***************************..............|        3.300
3.300 |**************************...............|        3.250
3.250 |*************************................|        3.200
3.200 |************************.................|        3.150
3.150 |***********************..................|        3.100
3.100 |**********************...................|        3.050
3.050 |*********************....................|        3.000
3.000 |********************.....................|        2.950
2.950 |*******************......................|        2.900
2.900 |******************.......................|        2.850
2.850 |*****************........................|        2.800
2.800 |****************.........................|        2.750
2.750 |***************..........................|        2.700
2.700 |**************...........................|        2.650
2.650 |*************............................|        2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

### $V_{OH}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
       2.000     2.500     3.000     3.500     4.000      first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |********************************.........|          3.550
3.600 |*******************************..........|          3.500
3.550 |******************************...........|          3.450
3.500 |*****************************............|          3.400
3.450 |****************************.............|          3.350
3.400 |***************************..............|          3.300
3.350 |**************************...............|          3.250
3.300 |*************************................|          3.200
3.250 |************************.................|          3.150
3.200 |***********************..................|          3.100
3.150 |**********************...................|          3.050
3.100 |*********************....................|          3.000
3.050 |********************.....................|          2.950
3.000 |*******************......................|          2.900
2.950 |******************.......................|          2.850
2.900 |*****************........................|          2.800
2.850 |****************.........................|          2.750
2.800 |***************..........................|          2.700
2.750 |**************...........................|          2.650
2.700 |*************............................|          2.600
2.650 |************.............................|          2.550
      |+----;----+----;----+----;----+----;----+|
       2.000     2.500     3.000     3.500     4.000
```

### $V_{OH}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |********************************.........|           3.550
3.600 |*******************************..........|           3.500
3.550 |******************************...........|           3.450
3.500 |*****************************............|           3.400
3.450 |****************************.............|           3.350
3.400 |***************************..............|           3.300
3.350 |**************************...............|           3.250
3.300 |**************************...............|           3.250
3.250 |************************.................|           3.150
3.200 |************************.................|           3.150
3.150 |**********************...................|           3.050
3.100 |**********************...................|           3.050
3.050 |*********************....................|           3.000
3.000 |********************.....................|           2.950
2.950 |*******************......................|           2.900
2.900 |******************.......................|           2.850
2.850 |*****************........................|           2.800
2.800 |****************.........................|           2.750
2.750 |***************..........................|           2.700
2.700 |**************...........................|           2.650
2.650 |*************............................|           2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

### $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
         0.000      0.500      1.000        first pass data
        |+----,----+----,----+|
  3.650 |.********************|             0.050
  3.600 |.********************|             0.050
  3.550 |.********************|             0.050
  3.500 |.********************|             0.050
  3.450 |.********************|             0.050
  3.400 |.********************|             0.050
  3.350 |.********************|             0.050
  3.300 |.********************|             0.050
  3.250 |.********************|             0.050
  3.200 |.********************|             0.050
  3.150 |.********************|             0.050
  3.100 |.********************|             0.050
  3.050 |.********************|             0.050
  3.000 |.********************|             0.050
  2.950 |.********************|             0.050
  2.900 |.********************|             0.050
  2.850 |.********************|             0.050
  2.800 |.********************|             0.050
  2.750 |.********************|             0.050
  2.700 |.********************|             0.050
  2.650 |.********************|             0.050
        |+----,----+----,----+|
         0.000      0.500      1.000
```

### $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
        0.000      0.500      1.000        first pass data
        |+----,----+----,----+|
  3.650 |.********************|             0.050
  3.600 |.********************|             0.050
  3.550 |.********************|             0.050
  3.500 |.********************|             0.050
  3.450 |.********************|             0.050
  3.400 |.********************|             0.050
  3.350 |.********************|             0.050
  3.300 |.********************|             0.050
  3.250 |.********************|             0.050
  3.200 |.********************|             0.050
  3.150 |.********************|             0.050
  3.100 |.********************|             0.050
  3.050 |.********************|             0.050
  3.000 |.********************|             0.050
  2.950 |.********************|             0.050
  2.900 |.********************|             0.050
  2.850 |.********************|             0.050
  2.800 |.********************|             0.050
  2.750 |.********************|             0.050
  2.700 |.********************|             0.050
  2.650 |.********************|             0.050
        |+----,----+----,----+|
         0.000      0.500      1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
         0.000     0.500     1.000       first pass data
        |+----;----+----;----+|
  3.650 |.********************|          0.050
  3.600 |.********************|          0.050
  3.550 |.********************|          0.050
  3.500 |.********************|          0.050
  3.450 |.********************|          0.050
  3.400 |.********************|          0.050
  3.350 |.********************|          0.050
  3.300 |.********************|          0.050
  3.250 |.********************|          0.050
  3.200 |.********************|          0.050
  3.150 |.********************|          0.050
  3.100 |.********************|          0.050
  3.050 |.********************|          0.050
  3.000 |.********************|          0.050
  2.950 |.********************|          0.050
  2.900 |.********************|          0.050
  2.850 |.********************|          0.050
  2.800 |.********************|          0.050
  2.750 |.********************|          0.050
  2.700 |.********************|          0.050
  2.650 |.********************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
         0.000     0.500     1.000        first pass data
        |+----,----+----,----+|
  3.650 |.********************|           0.050
  3.600 |.********************|           0.050
  3.550 |.********************|           0.050
  3.500 |.********************|           0.050
  3.450 |.********************|           0.050
  3.400 |.********************|           0.050
  3.350 |.********************|           0.050
  3.300 |.********************|           0.050
  3.250 |.********************|           0.050
  3.200 |.********************|           0.050
  3.150 |.********************|           0.050
  3.100 |.********************|           0.050
  3.050 |.********************|           0.050
  3.000 |.********************|           0.050
  2.950 |.********************|           0.050
  2.900 |.********************|           0.050
  2.850 |.********************|           0.050
  2.800 |.********************|           0.050
  2.750 |.********************|           0.050
  2.700 |.********************|           0.050
  2.650 |.********************|           0.050
        |+----,----+----,----+|
         0.000     0.500     1.000
```

### $V_{IH}$ vs. $V_{IO}$ @ 25°C

```
       0.500     1.000     1.500     2.000       first pass data
      |+----,----+----,----+----,----+|
3.000 |.........................******|          1.750
2.950 |........................*******|          1.700
2.900 |........................*******|          1.700
2.850 |.......................********|          1.650
2.800 |.......................********|          1.650
2.750 |......................*********|          1.600
2.700 |......................*********|          1.600
2.650 |.....................**********|          1.550
2.600 |....................***********|          1.500
2.550 |....................***********|          1.500
2.500 |...................************|          1.450
2.450 |...................************|          1.450
2.400 |..................*************|          1.400
2.350 |..................*************|          1.400
2.300 |.................**************|          1.350
2.250 |.................**************|          1.350
2.200 |................***************|          1.300
2.150 |...............****************|          1.250
2.100 |...............****************|          1.250
2.050 |..............*****************|          1.200
2.000 |..............*****************|          1.200
1.950 |.............******************|          1.150
1.900 |............*******************|          1.100
1.850 |............*******************|          1.100
1.800 |...........********************|          1.050
1.750 |...........********************|          1.050
1.700 |..........*********************|          1.000
1.650 |.........**********************|          0.950
      |+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000
```

### $V_{IH}$ vs. $V_{IO}$ @ 85°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |.........................****************|          1.750
2.950 |........................*****************|          1.700
2.900 |........................*****************|          1.700
2.850 |.......................******************|          1.650
2.800 |.......................******************|          1.650
2.750 |......................*******************|          1.600
2.700 |.....................********************|          1.550
2.650 |.....................********************|          1.550
2.600 |....................*********************|          1.500
2.550 |....................*********************|          1.500
2.500 |...................**********************|          1.450
2.450 |...................**********************|          1.450
2.400 |..................***********************|          1.400
2.350 |..................***********************|          1.400
2.300 |.................************************|          1.350
2.250 |................*************************|          1.300
2.200 |................*************************|          1.300
2.150 |...............**************************|          1.250
2.100 |...............**************************|          1.250
2.050 |..............***************************|          1.200
2.000 |..............***************************|          1.200
1.950 |.............****************************|          1.150
1.900 |............*****************************|          1.100
1.850 |............*****************************|          1.100
1.800 |...........******************************|          1.050
1.750 |...........******************************|          1.050
1.700 |..........*******************************|          1.000
1.650 |.........********************************|          0.950
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

## $V_{IH}$ vs. $V_{IO}$ @ 105°C

```
       0.500     1.000     1.500     2.000     2.500      first pass data
      |+----;----+----;----+----;----+----;----+|
3.000 |......................*******************|         1.600
2.950 |......................*******************|         1.600
2.900 |.....................********************|         1.550
2.850 |.....................********************|         1.550
2.800 |....................*********************|         1.500
2.750 |....................*********************|         1.500
2.700 |...................**********************|         1.450
2.650 |...................**********************|         1.450
2.600 |..................***********************|         1.400
2.550 |..................***********************|         1.400
2.500 |.................************************|         1.350
2.450 |................*************************|         1.300
2.400 |................*************************|         1.300
2.350 |................*************************|         1.300
2.300 |...............**************************|         1.250
2.250 |..............***************************|         1.200
2.200 |..............***************************|         1.200
2.150 |..............***************************|         1.200
2.100 |.............****************************|         1.150
2.050 |.............****************************|         1.150
2.000 |............*****************************|         1.100
1.950 |............*****************************|         1.100
1.900 |...........******************************|         1.050
1.850 |...........******************************|         1.050
1.800 |..........*******************************|         1.000
1.750 |..........*******************************|         1.000
1.700 |..........*******************************|         1.000
1.650 |.........********************************|         0.950
      |+----;----+----;----+----;----+----;----+|
       0.500     1.000     1.500     2.000     2.500
```

## $V_{IH}$ vs. $V_{IO}$ @ -40°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |.........................****************|          1.750
2.950 |.........................****************|          1.750
2.900 |........................*****************|          1.700
2.850 |........................*****************|          1.700
2.800 |.......................******************|          1.650
2.750 |......................*******************|          1.600
2.700 |......................*******************|          1.600
2.650 |.....................********************|          1.550
2.600 |.....................********************|          1.550
2.550 |....................*********************|          1.500
2.500 |....................*********************|          1.500
2.450 |...................**********************|          1.450
2.400 |..................***********************|          1.400
2.350 |..................***********************|          1.400
2.300 |.................************************|          1.350
2.250 |.................************************|          1.350
2.200 |................*************************|          1.300
2.150 |................*************************|          1.300
2.100 |...............**************************|          1.250
2.050 |..............***************************|          1.200
2.000 |..............***************************|          1.200
1.950 |.............****************************|          1.150
1.900 |.............****************************|          1.150
1.850 |............*****************************|          1.100
1.800 |...........******************************|          1.050
1.750 |..........*******************************|          1.000
1.700 |..........*******************************|          1.000
1.650 |.........********************************|          0.950
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

## $V_{IL}$ vs. $V_{IO}$ @ 25°C

```
        0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |*************************...............|        1.250
2.950 |*************************...............|        1.250
2.900 |************************................|        1.200
2.850 |************************................|        1.200
2.800 |***********************.................|        1.150
2.750 |***********************.................|        1.150
2.700 |**********************..................|        1.100
2.650 |**********************..................|        1.100
2.600 |**********************..................|        1.100
2.550 |*********************...................|        1.050
2.500 |*********************...................|        1.050
2.450 |*********************...................|        1.050
2.400 |********************....................|        1.000
2.350 |********************....................|        1.000
2.300 |********************....................|        1.000
2.250 |********************....................|        1.000
2.200 |*******************.....................|        0.950
2.150 |*******************.....................|        0.950
2.100 |******************......................|        0.900
2.050 |******************......................|        0.900
2.000 |******************......................|        0.900
1.950 |*****************.......................|        0.850
1.900 |*****************.......................|        0.850
1.850 |*****************.......................|        0.850
1.800 |*****************.......................|        0.850
1.750 |*****************.......................|        0.850
1.700 |****************........................|        0.800
1.650 |****************........................|        0.800
      |+----,----+----,----+----,----+----,----+|
        0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ @ 85°C

```
        0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |************************................|        1.200
2.950 |************************................|        1.200
2.900 |************************................|        1.200
2.850 |***********************.................|        1.150
2.800 |***********************.................|        1.150
2.750 |***********************.................|        1.150
2.700 |**********************..................|        1.100
2.650 |**********************..................|        1.100
2.600 |*********************...................|        1.050
2.550 |*********************...................|        1.050
2.500 |*********************...................|        1.050
2.450 |*********************...................|        1.050
2.400 |********************....................|        1.000
2.350 |********************....................|        1.000
2.300 |********************....................|        1.000
2.250 |*******************.....................|        0.950
2.200 |*******************.....................|        0.950
2.150 |*******************.....................|        0.950
2.100 |******************......................|        0.900
2.050 |******************......................|        0.900
2.000 |******************......................|        0.900
1.950 |******************......................|        0.900
1.900 |*****************.......................|        0.850
1.850 |*****************.......................|        0.850
1.800 |*****************.......................|        0.850
1.750 |*****************.......................|        0.850
1.700 |****************........................|        0.800
1.650 |****************........................|        0.800
      |+----,----+----,----+----,----+----,----+|
        0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{IO}$ @ 105°C

```
         0.000     0.500     1.000     1.500     2.000      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |*************************................|         1.250
  2.950 |*************************................|         1.250
  2.900 |************************.................|         1.200
  2.850 |************************.................|         1.200
  2.800 |************************.................|         1.200
  2.750 |***********************..................|         1.150
  2.700 |***********************..................|         1.150
  2.650 |***********************..................|         1.150
  2.600 |**********************...................|         1.100
  2.550 |**********************...................|         1.100
  2.500 |**********************...................|         1.100
  2.450 |*********************....................|         1.050
  2.400 |*********************....................|         1.050
  2.350 |*********************....................|         1.050
  2.300 |********************.....................|         1.000
  2.250 |********************.....................|         1.000
  2.200 |********************.....................|         1.000
  2.150 |*******************......................|         0.950
  2.100 |*******************......................|         0.950
  2.050 |*******************......................|         0.950
  2.000 |******************.......................|         0.900
  1.950 |******************.......................|         0.900
  1.900 |******************.......................|         0.900
  1.850 |*****************........................|         0.850
  1.800 |*****************........................|         0.850
  1.750 |*****************........................|         0.850
  1.700 |****************.........................|         0.800
  1.650 |****************.........................|         0.800
        |+----;----+----;----+----;----+----;----+|
         0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{IO}$ @ -40°C

```
         0.000     0.500     1.000     1.500     2.000       first pass data
        |+----,----+----,----+----,----+----,----+|
  3.000 |*************************................|          1.250
  2.950 |*************************................|          1.250
  2.900 |************************.................|          1.200
  2.850 |************************.................|          1.200
  2.800 |************************.................|          1.200
  2.750 |***********************..................|          1.150
  2.700 |***********************..................|          1.150
  2.650 |***********************..................|          1.150
  2.600 |**********************...................|          1.100
  2.550 |**********************...................|          1.100
  2.500 |**********************...................|          1.100
  2.450 |*********************....................|          1.050
  2.400 |*********************....................|          1.050
  2.350 |*********************....................|          1.050
  2.300 |********************.....................|          1.000
  2.250 |********************.....................|          1.000
  2.200 |********************.....................|          1.000
  2.150 |*******************......................|          0.950
  2.100 |*******************......................|          0.950
  2.050 |******************.......................|          0.900
  2.000 |******************.......................|          0.900
  1.950 |******************.......................|          0.900
  1.900 |******************.......................|          0.900
  1.850 |*****************........................|          0.850
  1.800 |*****************........................|          0.850
  1.750 |*****************........................|          0.850
  1.700 |****************.........................|          0.800
  1.650 |****************.........................|          0.800
        |+----,----+----,----+----,----+----,----+|
         0.000     0.500     1.000     1.500     2.000
```

## $V_{OH}$ vs. $V_{IO}$ @ 25°C

```
      1.500     2.000     2.500     3.000     3.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |******************************...........|          2.950
2.950 |*****************************............|          2.900
2.900 |****************************.............|          2.850
2.850 |***************************..............|          2.800
2.800 |**************************...............|          2.750
2.750 |*************************................|          2.700
2.700 |************************.................|          2.650
2.650 |***********************..................|          2.600
2.600 |**********************...................|          2.550
2.550 |*********************....................|          2.500
2.500 |********************.....................|          2.450
2.450 |*******************......................|          2.400
2.400 |******************.......................|          2.350
2.350 |*****************........................|          2.300
2.300 |****************.........................|          2.250
2.250 |***************..........................|          2.200
2.200 |**************...........................|          2.150
2.150 |*************............................|          2.100
2.100 |************.............................|          2.050
2.050 |***********..............................|          2.000
2.000 |**********...............................|          1.950
1.950 |*********................................|          1.900
1.900 |********.................................|          1.850
1.850 |*******..................................|          1.800
1.800 |******...................................|          1.750
1.750 |*****....................................|          1.700
1.700 |****.....................................|          1.650
1.650 |***......................................|          1.600
      |+----,----+----,----+----,----+----,----+|
       1.500     2.000     2.500     3.000     3.500
```

## $V_{OH}$ vs. $V_{IO}$ @ 85°C

```
      1.500     2.000     2.500     3.000     3.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |******************************...........|          2.950
2.950 |*****************************............|          2.900
2.900 |****************************.............|          2.850
2.850 |***************************..............|          2.800
2.800 |**************************...............|          2.750
2.750 |*************************................|          2.700
2.700 |************************.................|          2.650
2.650 |***********************..................|          2.600
2.600 |**********************...................|          2.550
2.550 |*********************....................|          2.500
2.500 |********************.....................|          2.450
2.450 |*******************......................|          2.400
2.400 |******************.......................|          2.350
2.350 |*****************........................|          2.300
2.300 |****************.........................|          2.250
2.250 |***************..........................|          2.200
2.200 |**************...........................|          2.150
2.150 |*************............................|          2.100
2.100 |************.............................|          2.050
2.050 |***********..............................|          2.000
2.000 |**********...............................|          1.950
1.950 |*********................................|          1.900
1.900 |********.................................|          1.850
1.850 |*******..................................|          1.800
1.800 |******...................................|          1.750
1.750 |*****....................................|          1.700
1.700 |****.....................................|          1.650
1.650 |***......................................|          1.600
      |+----,----+----,----+----,----+----,----+|
       1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ @ 105°C

```
        1.500     2.000     2.500     3.000     3.500       first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |*****************************............|           2.900
 2.950 |****************************.............|           2.850
 2.900 |***************************..............|           2.800
 2.850 |**************************...............|           2.750
 2.800 |*************************................|           2.700
 2.750 |************************.................|           2.650
 2.700 |***********************..................|           2.600
 2.650 |**********************...................|           2.550
 2.600 |*********************....................|           2.500
 2.550 |********************.....................|           2.450
 2.500 |*******************......................|           2.400
 2.450 |******************.......................|           2.350
 2.400 |*****************........................|           2.300
 2.350 |****************.........................|           2.250
 2.300 |***************..........................|           2.200
 2.250 |**************...........................|           2.150
 2.200 |*************............................|           2.100
 2.150 |************.............................|           2.050
 2.100 |***********..............................|           2.000
 2.050 |**********...............................|           1.950
 2.000 |*********................................|           1.900
 1.950 |********.................................|           1.850
 1.900 |********.................................|           1.850
 1.850 |******...................................|           1.750
 1.800 |*****....................................|           1.700
 1.750 |****.....................................|           1.650
 1.700 |****.....................................|           1.650
 1.650 |***......................................|           1.600
       |+----;----+----;----+----;----+----;----+|
         1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ @ -40°C

```
        1.500     2.000     2.500     3.000     3.500       first pass data
       |+----,----+----,----+----,----+----,----+|
 3.000 |******************************...........|            2.950
 2.950 |*****************************............|            2.900
 2.900 |****************************.............|            2.850
 2.850 |***************************..............|            2.800
 2.800 |**************************...............|            2.750
 2.750 |*************************................|            2.700
 2.700 |************************.................|            2.650
 2.650 |***********************..................|            2.600
 2.600 |**********************...................|            2.550
 2.550 |*********************....................|            2.500
 2.500 |********************.....................|            2.450
 2.450 |*******************......................|            2.400
 2.400 |******************.......................|            2.350
 2.350 |*****************........................|            2.300
 2.300 |****************.........................|            2.250
 2.250 |***************..........................|            2.200
 2.200 |**************...........................|            2.150
 2.150 |*************............................|            2.100
 2.100 |************.............................|            2.050
 2.050 |***********..............................|            2.000
 2.000 |**********...............................|            1.950
 1.950 |*********................................|            1.900
 1.900 |********.................................|            1.850
 1.850 |*******..................................|            1.800
 1.800 |******...................................|            1.750
 1.750 |*****....................................|            1.700
 1.700 |****.....................................|            1.650
 1.650 |***......................................|            1.600
       |+----,----+----,----+----,----+----,----+|
         1.500     2.000     2.500     3.000     3.500
```

## $V_{OL}$ vs. $V_{IO}$ @ 25°C

```
          0.000     0.500     1.000       first pass data
          |+----,----+----,----+|
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
   2.600 |.********************|          0.050
   2.550 |.********************|          0.050
   2.500 |.********************|          0.050
   2.450 |.********************|          0.050
   2.400 |.********************|          0.050
   2.350 |.********************|          0.050
   2.300 |.********************|          0.050
   2.250 |.********************|          0.050
   2.200 |.********************|          0.050
   2.150 |.********************|          0.050
   2.100 |.********************|          0.050
   2.050 |.********************|          0.050
   2.000 |.********************|          0.050
   1.950 |.********************|          0.050
   1.900 |.********************|          0.050
   1.850 |.********************|          0.050
   1.800 |.********************|          0.050
   1.750 |.********************|          0.050
   1.700 |.********************|          0.050
   1.650 |.********************|          0.050
          |+----,----+----,----+|
           0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ 85°C

```
           0.000     0.500     1.000       first pass data
          |+----,----+----,----+|
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
   2.600 |.********************|          0.050
   2.550 |.********************|          0.050
   2.500 |.********************|          0.050
   2.450 |.********************|          0.050
   2.400 |.********************|          0.050
   2.350 |.********************|          0.050
   2.300 |.********************|          0.050
   2.250 |.********************|          0.050
   2.200 |.********************|          0.050
   2.150 |.********************|          0.050
   2.100 |.********************|          0.050
   2.050 |.********************|          0.050
   2.000 |.********************|          0.050
   1.950 |.********************|          0.050
   1.900 |.********************|          0.050
   1.850 |.********************|          0.050
   1.800 |.********************|          0.050
   1.750 |.********************|          0.050
   1.700 |.********************|          0.050
   1.650 |.********************|          0.050
          |+----,----+----,----+|
           0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ 105°C

```
          0.000     0.500     1.000      first pass data
         |+----;----+----;----+|
   3.000 |.********************|         0.050
   2.950 |.********************|         0.050
   2.900 |.********************|         0.050
   2.850 |.********************|         0.050
   2.800 |.********************|         0.050
   2.750 |.********************|         0.050
   2.700 |.********************|         0.050
   2.650 |.********************|         0.050
   2.600 |.********************|         0.050
   2.550 |.********************|         0.050
   2.500 |.********************|         0.050
   2.450 |.********************|         0.050
   2.400 |.********************|         0.050
   2.350 |.********************|         0.050
   2.300 |.********************|         0.050
   2.250 |.********************|         0.050
   2.200 |.********************|         0.050
   2.150 |.********************|         0.050
   2.100 |.********************|         0.050
   2.050 |.********************|         0.050
   2.000 |.********************|         0.050
   1.950 |.********************|         0.050
   1.900 |.********************|         0.050
   1.850 |.********************|         0.050
   1.800 |.********************|         0.050
   1.750 |.********************|         0.050
   1.700 |.********************|         0.050
   1.650 |.********************|         0.050
         |+----;----+----;----+|
          0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ -40°C

```
          0.000     0.500     1.000       first pass data
         |+----,----+----,----+|
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
   2.600 |.********************|          0.050
   2.550 |.********************|          0.050
   2.500 |.********************|          0.050
   2.450 |.********************|          0.050
   2.400 |.********************|          0.050
   2.350 |.********************|          0.050
   2.300 |.********************|          0.050
   2.250 |.********************|          0.050
   2.200 |.********************|          0.050
   2.150 |.********************|          0.050
   2.100 |.********************|          0.050
   2.050 |.********************|          0.050
   2.000 |.********************|          0.050
   1.950 |.********************|          0.050
   1.900 |.********************|          0.050
   1.850 |.********************|          0.050
   1.800 |.********************|          0.050
   1.750 |.********************|          0.050
   1.700 |.********************|          0.050
   1.650 |.********************|          0.050
         |+----,----+----,----+|
          0.000     0.500     1.000
```

# 16. Quality Assurance Guidelines

Cypress is totally committed to shipping the highest quality product to its customers.

To assure this quality commitment, each commercial manufacturing lot must meet the requirements defined in all of the specifications listed below:

| Procedure | Test Method | Quality Test |
|---|---|---|
| Electrical Classification Tests | Guard banded to Data Sheet Specification | 100% |
| Mark | Cypress F16-018 | 100% |
| Lead Scan / Straighten | Cypress F16-049 | 100% |
| Visual / Mechanical Inspection | Cypress F16-049 | 100% |
| QA Documentation / Test verification | Cypress F06-027 | 100% |
| QA - Visual / Mechanical<br>Excelsior Monitor (See Below)<br>Qualification Maintenance Program | Cypress F06-027<br>Cypress F00-006<br>Cypress F01-002.18 | Sample<br>Sample<br>Sample |

## 16.1 Excelsior Quality Monitor

Cypress's Excelsior Quality Program is an in-line monitor of electrical, visual/mechanical, solderability and marking permanency quality. Data from Excelsior Electrical Monitor may be made available to customers on request. Samples are selected from production lots and subjected to data sheet electrical temperature requirements. Any failures are analyzed by product engineering and appropriate corrective action is implemented. The excelsior quality levels are summarized by each product line on a monthly basis. This monitor has proven to be instrumental in Cypress's drive to attain the highest quality levels in the industry.

## 16.2 Advance Change Notification

The Cypress Advance Change Notification System aims to notify the customer of major product changes 90 days prior to the implementation of that change. A change is considered to be major if it affects the application, performance, quality, reliability, parameter distribution, form, fit or function of the product. In addition we may also notify changes such as relocation of manufacturing sites, certain Data Sheet items, or other changes that may affect use or acceptance of the product.

It should be noted that all changes are fully evaluated and qualified in accordance with well established and rigorous procedures. The changed product is not released for production or shipment until satisfactory qualification results, consistent with stable processes, predictable distributions and satisfactory and expected reliability figures and yields are achieved. Often shipment is recommended before the formal qualification report is available. The actual qualification tests, however, are completed and approved prior to shipment.

## 16.3 Customer Corrective Action Request

Cypress's Customer Corrective Action Request (CCAR) system provides a means for submitting customer perceived product problems to Cypress's factory for analysis. The analysis may be comprised of several stages, usually an initial analysis and follow-up analysis. A summary of Cypress's findings are issued. These may include corrective actions, requests for additional information or detailed failure analysis results.

# 17. Qualification Maintenance Program

The Cypress Qualification Maintenance Program (QMP) is used to measure the reliability of all process families on a regular basis. As it is not feasible to monitor the reliability of each of the literally hundreds of device types that Cypress produces, devices representative of the wafer fabrication process and the generic device grouping are selected on the basis of complexity, production volume, and strategic importance. These samples are subjected to the typical accelerated stress tests listed below on a monthly basis. Any failures encountered are analyzed by product engineering and appropriate corrective action is implemented. The results of this testing are summarized in the Cypress Quarterly Reliability Report (QRR).

## 17.1 Types of Stress

Several different process technology groups have been identified based on similarity of process parameters. Representative product types for each of these groups are listed in the Cypress QRR. Failure rates are tabulated for defective sub-populations and competing failure mechanisms. Two common measures of failure rates are early life failure rate (EL) and inherent life failure rate (IL). The early life period corresponds to approximately the first 4,000 hours at field use conditions. The inherent life corresponds to the useful life beyond the first 4000 of field operation. For these calculations, device operation temperature is assumed to be 55°C ambient unless otherwise noted. Voltage acceleration factors are used in the analysis wherever noted.

## 17.2 Reliability Monitor Stress Conditions

| Stress | Package | Typical Duration | Target Sample Size | Typical Conditions |
|---|---|---|---|---|
| Early Life | All | 24, 168 hours | 350 | 125°C or 150°C, $V_{CC}$ max |
| Inherent Life | All | 1000 hours | 120 | 125°C or 150°C, $V_{CC}$ max |
| Endurance Cycling | All | 10000 cycles | 64 | 90°C |
| Data Retention Bake | All | 1000 hours | 64 | 150°C |
| Preconditioning (PC) | All | 216 hours | 231 | 30°C/70% RH Soak,<br>3X Reflow @ 260°C |
| PC + Temperature Cycle | Discrete, 2 die MCP | 1000 cycles | 77 | –40°C to 150°C |
| | > 2 die MCP | 1000 cycles | 77 | –55°C to 125°C |
| PC + Biased HAST | BGA | 264 hours | 77 | 110°C, 85% RH, $V_{CC}$ max alt. bias |
| | Lead Frame | 96 hours | 77 | 130°C, 85% RH, $V_{CC}$ max alt. bias |
| PC + Unbiased HAST | All | 96 hours | 77 | 110°C, 85% RH, no bias |

# 18. Statistical Process Management

Statistical Process Management is used extensively throughout manufacturing and engineering areas in Cypress to help in reducing process variation and optimizing product/process performance. Examples of the tools used are Statistical Process Control (SPC), Process Capability Studies, Design of Experiments, Measurement Systems Analysis, Systematic Problem Solving, Structured project management, and statistical yield analysis, etc.

Some highlights of our SPC program include:

- Ubiquitous and intelligent use of problem solving methodologies
- SPC is 100% automated in all manufacturing areas using both statistically and economically derived Control Limits
- Out of Control Trouble Shooting Guides
- Statistical Equipment Control, (monitoring and control of input variables)
- Advanced Process Control (model based, active run-to-run control of processes during wafer fabrication)
- Suppliers are encouraged to implement SPC
- Six-Sigma target for critical processes

## 18.1 Kaizen + Program

All the training of statistical analysis tools, as well as other hard and soft improvement skills such as FMEA, Lean, Error Proofing, Structured Teamwork, are provided to employees as a part of Cypress's Kaizen+ (continuous improvement) program. The program involves all functional groups by establishing a structure that consists of a Champion, internal/external certified Black, Brown, Green and Yellow Belts in each organization to drive for improvement projects. The results are shared in a Project Sharing Conference twice per year. Statistical thinking and use of statistical methods are a part of Cypress's Kaizen+ culture.

# 19. Document History

| Document Title: S29GL512S (XMC 85C 105C) Qualification Database<br>Document Number: 002-00479 | | | | |
|---|---|---|---|---|
| **Revision** | **ECN** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| ** | – | – | 12/21/2011 | Initial release. |
| *A | – | – | 01/27/2012 | **Characterization Test Results:**<br>Typical Program Time, $I_{LI}$, $I_{LO}$ and $I_{CC2}$ values updated. |
| *B | – | – | 01/27/2015 | **CS239/L Life Test Failure Rate Calculation:**<br>Summary of Stress Test Results table: corrected 'Number of Fails' and 'Failure Rate %' for Endurance (10k) at 90°C. |
| *C | 6070150 | CNSO | 02/22/2018 | Updated Assembly Packaging Summary:<br>Updated LAE064:<br>Updated details under "Theta Ja / Psi Jt" and "Assembly Location".<br>Updated TS056:<br>Updated details under "Theta Ja / Psi Jt" and "Assembly Location".<br>Updated LAA064:<br>Updated details under "Theta Ja / Psi Jt" and "Assembly Location".<br>Updated Test Methodology:<br>Replaced "Class Test (Bangkok, Thailand; Kuala Lumpur, Malaysia)" with "Class Test (Bangkok, Thailand)".<br>Updated to Cypress template. |
| *D | 6609547 | CNSO | 08/02/2019 | Updated Document Title to read as "S29GL512S (XMC 85C 105C) Qualification Database".<br>Added 105°C Temperature Range related information in all instances across the document.<br>Updated to new template. |

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# S29GL256S (WXIC)

*Qualification Database*

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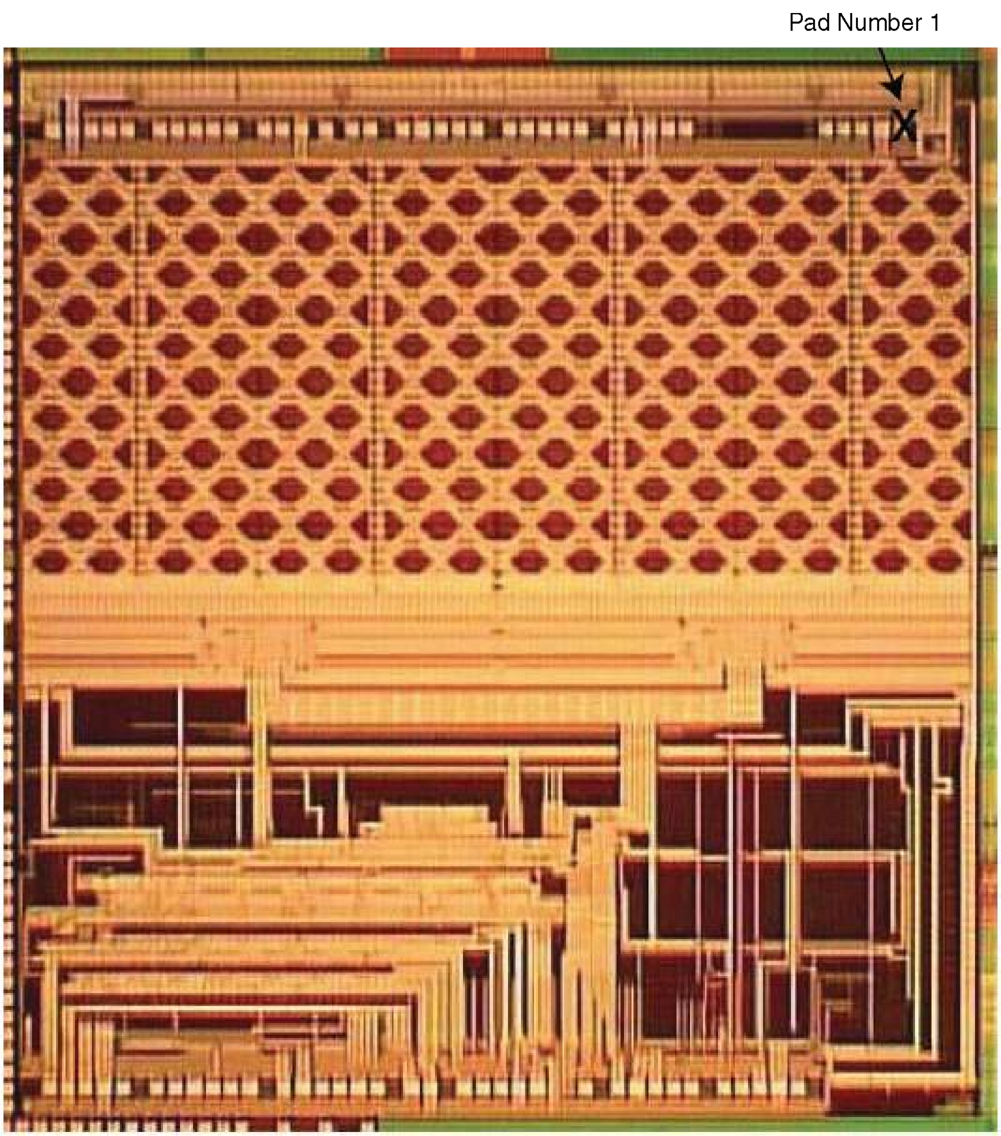
# Figures

# 1. Introduction

The Cypress® S29GL256S flash memory device has a die size of 4.589 × 5.104 mm.

# 2. Die Photograph

**Figure 2.1 Die Photograph**




***Note:***
*1. X in the diagram is pad #1. Count counter clockwise.*

# 3. Pad Definition Table

| Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA | Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA |
|---|---|---|---|---|---|---|---|
| 1 | VSS | 33,52 | H7 | 37 | VCC | 43 | G5 |
| 2 | VCC | 43 | G5 | 38 | VSS | 33,52 | H7 |
| 3 | A23 | 1 | C8 | 39 | VCC | 43 | G5 |
| 4 | A22 | 2 | B8 | 40 | VSS | 33, 52 | H7 |
| 5 | A15 | 3 | D7 | 41 | A0 | 31 | E2 |
| 6 | A14 | 4 | C7 | 42 | CE# | 32 | F2 |
| 7 | A13 | 5 | A7 | 43 | OE# | 34 | G2 |
| 8 | VSS | 33, 52 | H7 | 44 | DQ0 | 35 | E3 |
| 9 | VCC | 43 | G5 | 45 | DQ8 | 36 | F3 |
| 10 | A12 | 6 | B7 | 46 | DQ1 | 37 | H3 |
| 11 | A11 | 7 | D6 | 47 | DQ9 | 38 | G3 |
| 12 | A10 | 8 | C6 | 48 | VSS | 33, 52 | H2, E8 |
| 13 | A9 | 9 | A6 | 49 | VIO | 29 | F1, D8 |
| 14 | A8 | 10 | B6 | 50 | DQ2 | 39 | E4 |
| 15 | A19 | 11 | D5 | 51 | DQ10 | 40 | F4 |
| 16 | A20 | 12 | D4 | 52 | DQ3 | 41 | H4 |
| 17 | WE# | 13 | A5 | 53 | DQ11 | 42 | G4 |
| 18 | NC | | | 54 | VCC | 43 | G5 |
| 19 | RESET# | 14 | B5 | 55 | VSS | 33, 52 | H7 |
| 20 | A21 | 15 | C5 | 56 | DQ4 | 44 | H5 |
| 21 | WP# | 16 | B4 | 57 | DQ12 | 45 | F5 |
| 22 | RY/BY# | 17 | A4 | 58 | DQ5 | 46 | E5 |
| 23 | VIO | 29 | D8, F1 | 59 | VSS | 33, 52 | H7 |
| 24 | VSS | 33, 52 | H7 | 60 | VCC | 43 | G5 |
| 25 | A18 | 18 | C4 | 61 | DQ13 | 47 | G6 |
| 26 | A17 | 19 | B3 | 62 | NC | | |
| 27 | A7 | 20 | A3 | 63 | VSS | 33, 52 | E8, H2 |
| 28 | A6 | 21 | C3 | 64 | VIO | 29 | D8, F1 |
| 29 | A5 | 22 | D3 | 65 | DQ6 | 48 | H6 |
| 30 | A4 | 23 | B2 | 66 | DQ14 | 49 | F6 |
| 31 | A3 | 24 | A2 | 67 | DQ7 | 50 | E6 |
| 32 | A2 | 25 | C2 | 68 | DQ15 | 51 | G7 |
| 33 | A1 | 26 | D2 | 69 | VCC | 43 | G5 |
| 34 | DNU | 28 | E1 | 70 | VSS | 33, 52 | H7 |
| 35 | VCC | 43 | G5 | 71 | A16 | 54 | E7 |
| 36 | VSS | 33, 52 | H7 | | | | |

# 4. Physical Sector Layout

**Figure 4.1 Physical Sector Layout**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Internal Use Row (33) | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use |
| Internal Use Row (32) | | | | | Internal Use | Internal Use | Internal Use | Internal Use |
| Row 31 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 |
| Row 30 | 240 | 241 | 242 | 243 | 244 | 245 | 246 | 247 |
| ... | | | | | | | | |
| Row 3 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| Row 2 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Row 1 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Row 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| VerticalBank | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| Bank | 0 | | | | 1 | | | |

# 5. Sector Enlargement

**Figure 5.1 Sector Enlargement**

**IO Organization**

| | Internal Use | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M3BL | 0-7 | 0-63 | 64-127 | 128-191 | 192-255 | 256-319 | 320-383 | 384-447 | 448-511 | 512-575 | 576-639 | 640-703 |
| M1BL | 8-15 | 0-127 | 128-255 | 256-383 | 384-511 | 512-639 | 640-767 | 768-895 | 896-1023 | 1024-1151 | 1152-1279 | 1280-1407 |

| | 11 | 12 | 13 | 14 | 15 | Internal Use | Internal Use | Internal Use | Internal Use |
|---|---|---|---|---|---|---|---|---|---|
| M3BL | 704-767 | 768-831 | 832-895 | 896-959 | 960-1023 | 1024-1063 | 1064-1071 | 1072-1079 | 0-7 |
| M1BL | 1408-1535 | 1536-1663 | 1664-1791 | 1792-1919 | 1920-2047 | 2048-2127 | 2128-2143 | 2144-2159 | 0-7 |

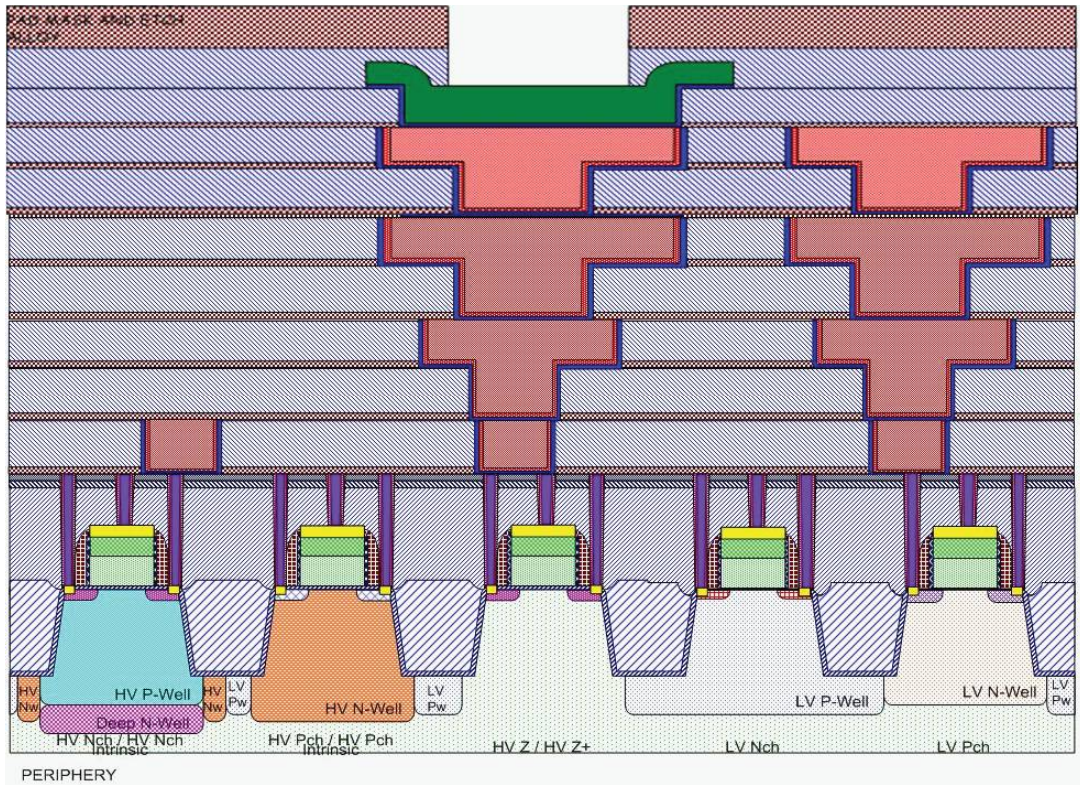
# 6. Die Processing Summary

The Cypress S29GL256S flash memory device is manufactured using the 65 nm MirrorBit® Eclipse™ process technology.

The device is processed at WXIC, a 12-inch CMOS manufacturing facility located in Wuhan, China.

The device is manufactured on the highly reliable CS239LS process.

**Figure 6.1 Die Process**



## 6.1 Key Features of the 65 nm MirrorBit Eclipse Process Technology

### A. Technology

- CMOS Triple-well process
- Proven reliable Flash MirrorBit Eclipse Technology

### B. Transistor Types

- n-channel enhancement
- n-channel intrinsic
- p-channel enhancement
- MirrorBit Eclipse core cell

### C. Process Features

- ONO (oxide - nitride - oxide) gate dielectric
- Silicon Nitride (SiN) data storage layer

### D. Cypress Highlights

- Volume Production Fab
- Solely dedicated to Non-Volatile Memories
- Ongoing Statistical Process Control program

# 7. Assembly Packaging Summary

## 7.1 LAE064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL256S<br>256-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | LAE064 | **Qualification:** | Q100199 |
| **Description:** | (9 x 9 x 1.4 mm) 64-ball, Fortified Ball Grid Array Package (fFBGA) | | |
| **Theta Ja:** | 33°C/W | **Psi Jt:** | 0.07°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | Paste |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98223B | **Die Size:** | 4.58 x 5.10 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 256M |

## 7.2 LAA064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL256S<br>256-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | LAA064 | **Qualification:** | Q100227 |
| **Description:** | (13.0 x 11.0 x 1.4 mm) 64-ball, Fortified Ball Grid Array Package (FBGA) | | |
| **Theta Ja:** | 24.1°C/W | **Psi Jt:** | 0.07°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | Paste |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98223B | **Die Size:** | 4.58 x 5.10 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 256M |

## 7.3 TS056

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL256S<br>256-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | TS056 | **Qualification:** | Q100239 |
| **Description:** | (18.4 x 14.0 x 1.0 mm) 56-lead, Thin Small Outline Package (TSOP) | | |
| **Theta Ja:** | 46°C/W | **Psi Jt:** | 0.21°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Copper Leadframe | **Die Attachment:** | Paste |
| **Lead Finish:** | 100% Matte Sn Plating | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 58.0°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98223B | **Die Size:** | 4.58 x 5.10 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 256M |

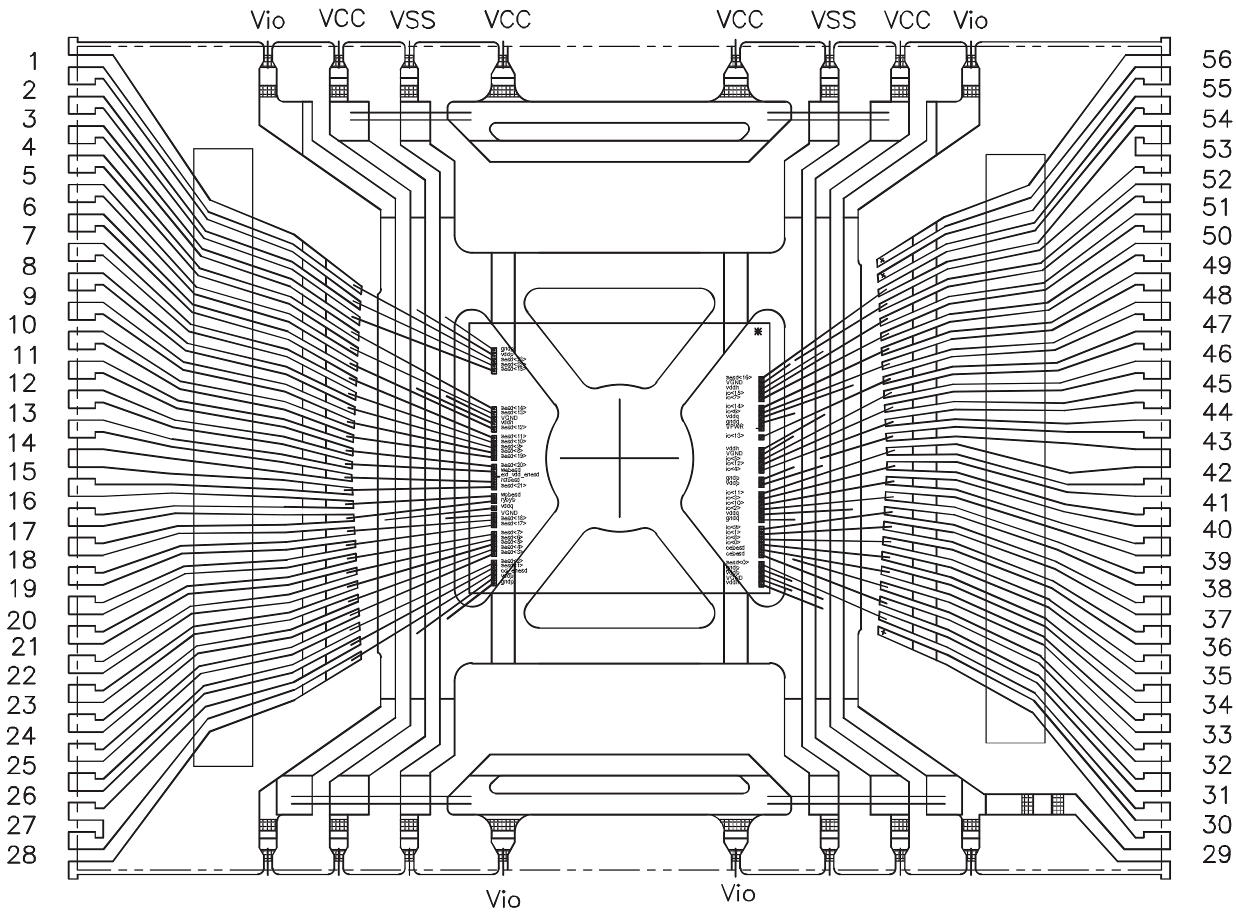
## 7.4 VBU056

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL256S<br>256-Mb, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse Process Technology | | |
| **Package:** | VBU056 | **Qualification:** | Q100373 |
| **Description:** | (9.0 x 7.0 x 1.0 mm) 56-ball, Very Thin Fine Pitch Ball Grid Array Package (FBGA) | | |
| **Theta Ja:** | 34.5°C/W | **Psi Jt:** | 0.10°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | Paste |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98223B | **Die Size:** | 4.58 x 5.10 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 256M |

# 8. Assembly Bonding Diagram

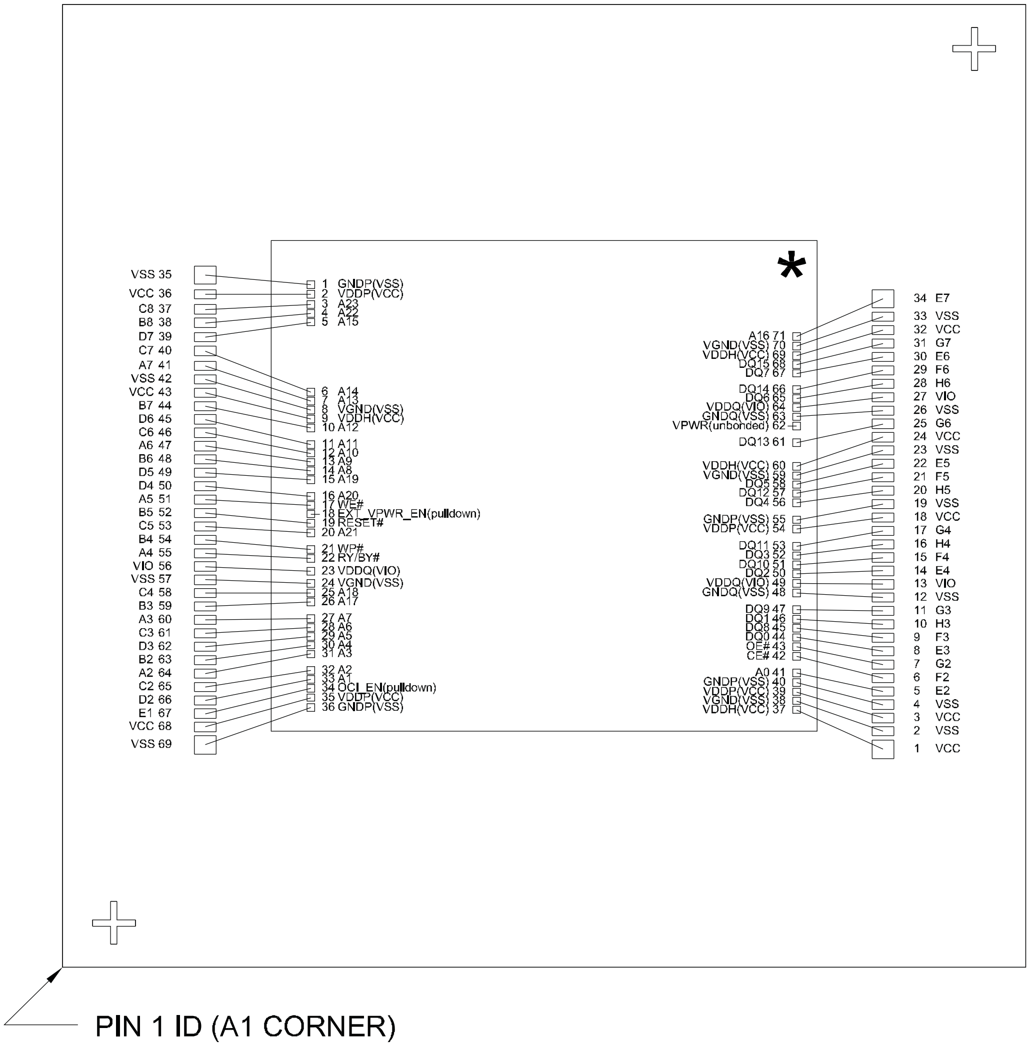
## 8.1 TS056 Package

Figure 8.1 56-Pin — TS056 Package



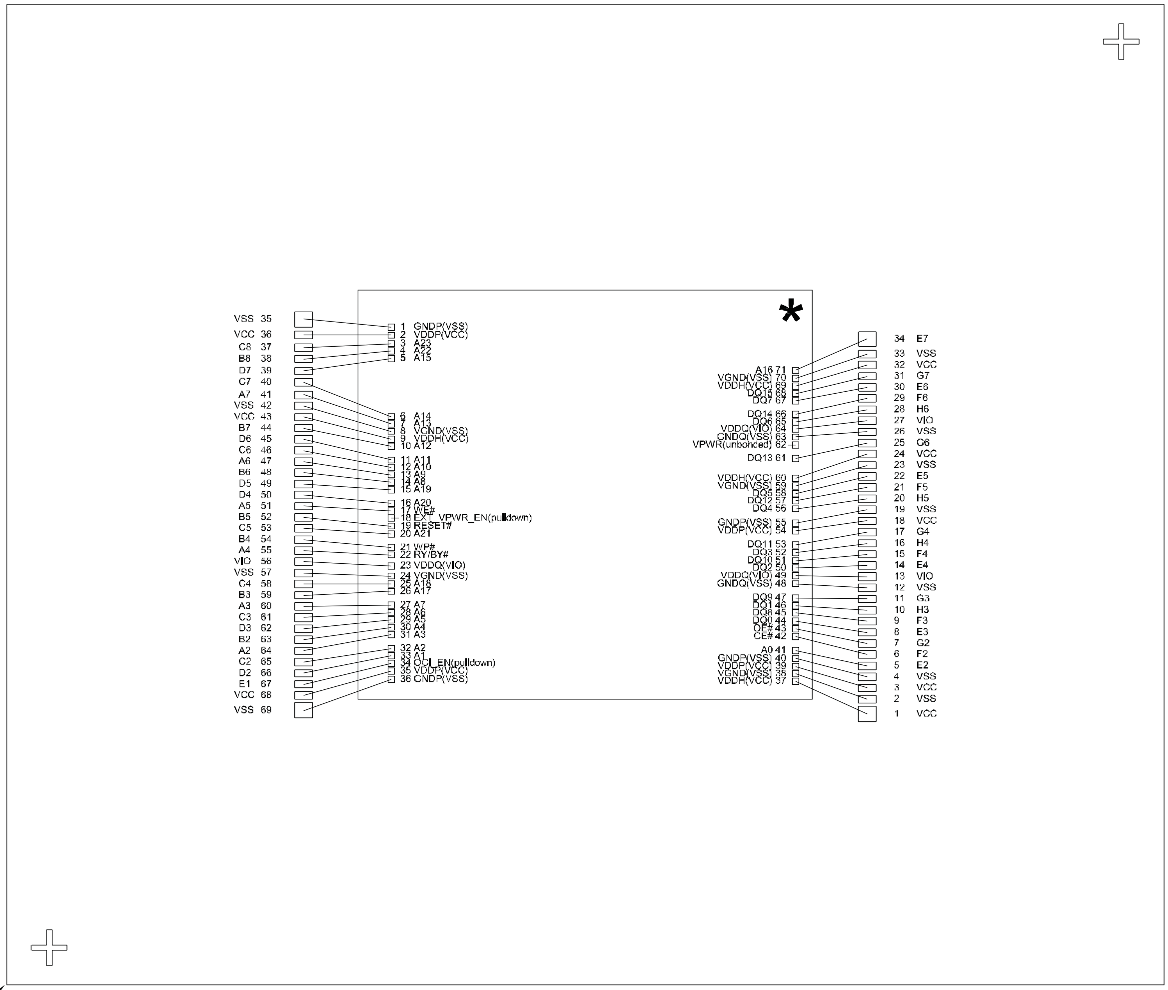
## 8.2 LAE064 Package

**Figure 8.2 64-Ball — LAE064 Package**



## 8.3 LAA064 Package

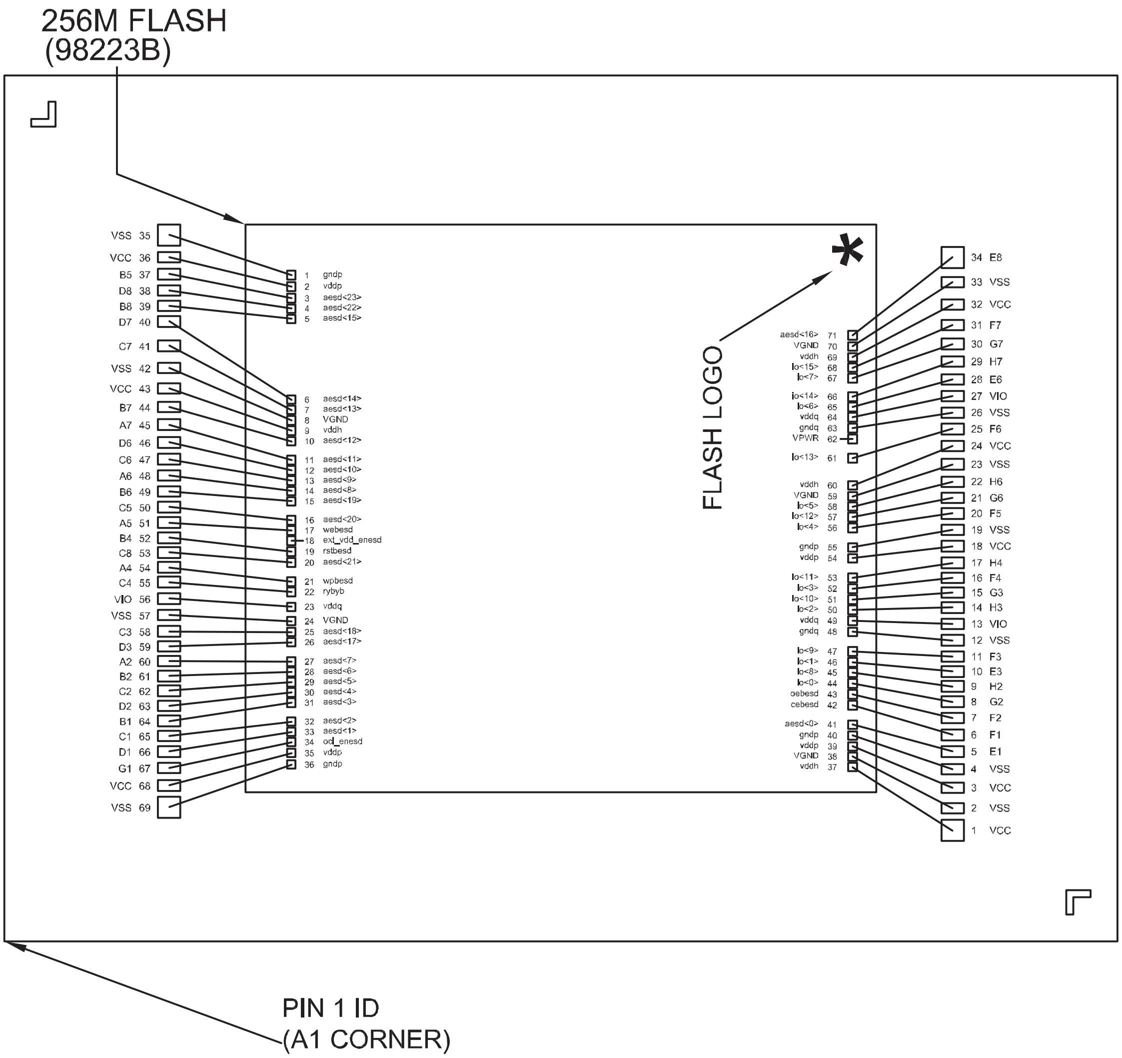
**Figure 8.3 64-Ball — LAA064 Package**



PIN 1 ID (A1 CORNER)

## 8.4 VBU056 Package

**Figure 8.4 56-Ball — VBU056 Package**



# 9. Test Methodology

### Testing includes

- 4 hour, 250°C Data Retention Bake (in wafer form)
- Special test mode for extended life operation
- Proprietary screens for endurance

### Wafer Sort (Austin, Texas, USA)

At Wafer Sort, all die experience 100% testing for:

- DC Parametrics
- AC Functionality
- Programmability
- Erasability

### Class Test (Bangkok, Thailand)

At Class Test, all devices are tested for:

- DC Parametrics
- AC Functionality
- AC Speed
- Programmability
- Erasability

### Test Coverage

All parameters specified in the data sheet are 100% tested in production unless otherwise specified. Those parameters not tested in production are guaranteed by characterization or correlation to other tests. AC speed testing is performed at class test.

### Test Correlation and Guard Banding

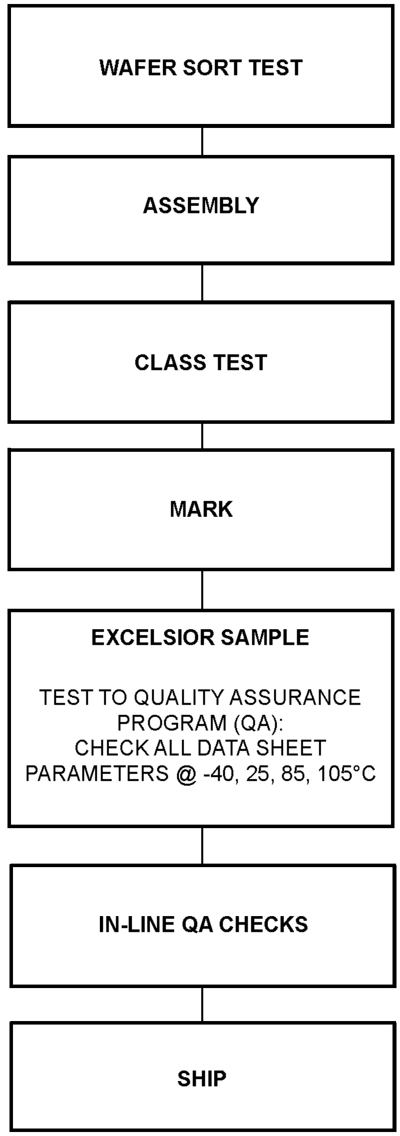
Tester correlation to bench set-up has been completed for all tested parameters. Tester repeatability studies have been run. These results have been evaluated and incorporated into the tester guard band strategy. Guard bands have been implemented which demonstrate acceptable yield, quality assurance and customer satisfaction.

### Test Flow

See the generalized Test Flow for the S29GL256S in Section 10.

# 10. Generalized Test Flow

The S29GL256S Generalized Test Flow for Industrial Temperature Range:



# 11. Quality and Reliability Data

## 11.1 S29GL256S High Temperature Operating Life Test Configuration

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 1 | A23 | 2.7K | CLK23 |
| 2 | A22 | 2.7K | CLK22 |
| 3 | A15 | 2.7K | CLK15 |
| 4 | A14 | 2.7K | CLK14 |
| 5 | A13 | 10K | CLK13 |
| 6 | A12 | 2.7K | CLK12 |
| 7 | A11 | 2.7K | CLK11 |
| 8 | A10 | 2.7K | CLK10 |
| 9 | A9 | 2.7K | CLK9 |
| 10 | A8 | 2.7K | CLK8 |
| 11 | A19 | 2.7K | CLK19 |
| 12 | A20 | 2.7K | CLK20 |
| 13 | WE# | 2.7K | VCC |
| 14 | RESET# | 2.7K | VCC |
| 15 | A21 | 2.7K | CLK21 |
| 16 | WP# | 2.7K | VCC |
| 17 | RY/BY# | 2.7K | VCC |
| 18 | A18 | 2.7K | CLK18 |
| 19 | A17 | 2.7K | CLK17 |
| 20 | A7 | 2.7K | CLK7 |
| 21 | A6 | 2.7K | CLK6 |
| 22 | A5 | 2.7K | CLK5 |
| 23 | A4 | 2.7K | CLK4 |
| 24 | A3 | 2.7K | CLK3 |
| 25 | A2 | 2.7K | CLK2 |
| 26 | A1 | 2.7K | CLK1 |
| 27 | RFU | | NC |
| 28 | RFU | | NC |

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 56 | NC | | |
| 55 | NC | | |
| 54 | A16 | 2.7K | CLK16 |
| 53 | RFU | | NC |
| 52 | VSS | | GND |
| 51 | DQ15 | 2.7K | VCC |
| 50 | DQ7 | 2.7K | VCC |
| 49 | DQ14 | 2.7K | VCC |
| 48 | DQ6 | 2.7K | VCC |
| 47 | DQ13 | 2.7K | VCC |
| 46 | DQ5 | 2.7K | VCC |
| 45 | DQ12 | 2.7K | VCC |
| 44 | DQ4 | 2.7K | VCC |
| 43 | VCC | | VCC |
| 42 | DQ11 | 2.7K | VCC |
| 41 | DQ3 | 2.7K | VCC |
| 40 | DQ10 | 2.7K | VCC |
| 39 | DQ2 | 2.7K | VCC |
| 38 | DQ9 | 2.7K | VCC |
| 37 | DQ1 | 2.7K | VCC |
| 36 | DQ8 | 2.7K | VCC |
| 35 | DQ0 | 2.7K | VCC |
| 34 | OE# | 2.7K | VCC |
| 33 | VSS | | GND |
| 32 | CE# | 2.7K | GND |
| 31 | A0 | 2.7K | CLK0 |
| 30 | RFU | | NC |
| 29 | VIO | 2.7K | VCC |

## 11.2 CS239/L Life Test Failure Rate Calculation

### HTOL Stress Temperature @ 125°C

| Failure Mechanisms | Read Points / Test Results | | | Modeling Parameters @ 55°C | | | | | Average Failure Rate FITS @ 55°C, 60% Conf. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 24 hrs | 168 hrs | 1000 hrs | Ea eV | TAF | VAF | OAF | MTTF (yrs) | Early Life | Inherent Life |
| **PLASTIC** | | | | | | | | | | |
| Sample Size | 4950 | 4615 | 842 | | | | | | | |
| Zero fails, Process ave. Ea | 0 | 0 (1) | 0 | 0.66 | 53 | 1 | 53 | | 48 | 11 |
| Totals | 0 | 0 | 0 | | | | | 10378 | 48 | 11 |

***Note:***
*1. Contributes to Early Life FITS.*

### Data Retention Bake @ 150°C

| Reliability Stress | Number of Rejects | Sample Size | Failure Rate % | Failure Mechanism |
|---|---|---|---|---|
| 500 hrs | 0 | 1735 | 0.00 | No Failures |
| 1000 hrs | 0 | 1208 | 0.00 | No Failures |

**Table 11.1 Summary of Stress Test Results**

| Stress Test | Condition | Package Type | Samples Size | Num. of Lots | Number of Fails | Failure Rate % | Comments |
|---|---|---|---|---|---|---|---|
| **Data From Qualification Q100227, Q100239, Q100199:** | | | | | | | |
| **HTOL (EL)** | 3.6V, 125°C | LAE064 (3) | 154 | 2 | 0 | 0.00 | 168 hrs |
| **HTOL (IL)** | 3.6V, 125°C | LAE064 (3) | 154 | 2 | 0 | 0.00 | 504 hrs |
| **ESD CDM** | N/A | LAA064 (1) | 15 | 1 | Passed 1.0 kV | | |
| | N/A | TS056 (2) | 15 | 1 | Passed 1.0 kV | | |
| | N/A | LAE064 (3) | 15 | | Passed 1.0 kV | | |
| **ESD HBM** | (100 pF, 1500 Ohms) | LAE064 (3) | 84 | 1 | Passed 2.0 kV | | |
| **Latch Up** | ±100 mA | LAE064 (3) | 10 | 1 | Passed | | |
| **Endurance (10k)** | 105°C, 3.6V | LAE064 (3) | 64 | 1 | 0 | 0.00 | 10k cycles |
| | –40°C, 3.6V | LAE064 (3) | 64 | 1 | 0 | 0.00 | 10k cycles |
| | 90°C, 3.6V | LAE064 (3) | 64 | 1 | 0 | 0.00 | 10k cycles |
| **Generic Reference Data** | | | | | | | |
| **ESD CDM** | N/A | VBU056 (4) | 15 | 1 | Passed 1.0 kV | | |
| **Preconditioning** | PC9/260°C, +0°C / –5°C | VBU056 (4) | 77 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| | PC1/260°C, +0°C / –5°C | LAE064 (5) | 231 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| | PC9/260°C, +0°C / –5°C | TS056 (6) | 164 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| **Preconditioning + Temp Cycle** | PC9/260°C, –40°C / 150°C | VBU056 (4) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| | PC1/260°C, –40°C / 150°C | LAE064 (5) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| | PC9/260°C, –40°C / 150°C | TS056 (6) | 87 | 1 | 0 | 0.00 | 500 cycles |
| **Preconditioning + HAST** | PC1/260°C, Biased, 110°C / 85% RH | LAE064 (5) | 77 | 1 | 0 | 0.00 | 264 hrs |
| | PC9/260°C, Biased, 130°C / 85% RH | TS056 (6) | 77 | 1 | 0 | 0.00 | 96 hrs |
| **Preconditioning + uHAST** | PC1/260°C, Unbiased, 130°C / 85% RH | LAE064 (5) | 76 | 1 | 0 | 0.00 | 96 hrs |

***Notes:***

1. *Results from Qual Q100227, S29GL256S, 256M CS239LS (65 nm) MirrorBit Eclipse in 64-Ball fFBGA (13 x 11 x 1.4 mm).*
2. *Results from Qual Q100239, S29GL256S, 256M CS239LS (65 nm) MirrorBit Eclipse in 56-Lead TSOP (18.4 x 14 x 1 mm).*
3. *Results from Qual Q100199, S29GL256S, 256M CS239LS (65 nm) MirrorBit Eclipse in 64-Ball fFBGA (9 x 9 x 1.4 mm).*
4. *Results from Qual Q100333, S29GL512S in 56-Ball vFBGA (9 x 7 x 1 mm) - Same VBU056 Package and Technology.*
5. *Results from Qual Q100167, S29GL01GS in 64-Ball fFBGA (9 x 9 x 1.4 mm) - Same LAE064 Package (Similar to LAA064), Technology and Fab location (WXIC).*
6. *Results from Qual Q100013, S29GL256S in 56-Lead TSOP (18.4 x 14 x 1 mm) - Same TSOP package and Technology, Same die from a different fab.*

***Preconditioning Flows***

*PC1 (Exceeds JEDEC L3 and JEITA Rank E): Bake 125°C, 24hr --> Soak @ 30°C/70%RH, 216hr => 3x Reflow.*
*PC9 (Accelerated JEDEC L3 / JEITA Rank E): Bake 125°C, 24hr --> Soak @ 60°C/70%RH, 72hr => 3x Reflow.*

# 12. Characterization Test Results

The data is pattern is “Random pattern” unless otherwise indicated.

## 12.1 DC Parameter Summary, 105°C

### Hot Temperature, 105°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 93.74 | 89.65 | 97.56 | 1.28 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 49.20 | 47.00 | 51.01 | 0.67 | >5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 15.13 | 14.53 | 15.70 | 0.22 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 16.45 | 15.98 | 16.91 | 0.21 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 18.13 | 17.70 | 18.53 | 0.19 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 19.19 | 17.00 | 20.33 | 0.82 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 50.97 | 45.72 | 55.07 | 1.83 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 42.26 | 37.12 | 46.95 | 1.78 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 64.72 | 50.35 | 102.89 | 9.56 | 1.2 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.06 | 0.05 | 0.10 | 0.01 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 64.35 | 49.51 | 100.66 | 9.55 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.220 | 0.030 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | -0.020 | -0.020 | 0.010 | 0.000 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64-kword sector) | 275 | 1100 | ms | 187.54 | 115.00 | 323.00 | 12.45 | >5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | 329.39 | 271.00 | 410.00 | 19.80 | >5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | 257.11 | 220.00 | 291.00 | 13.87 | >5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | 218.31 | 189.00 | 246.00 | 11.57 | >5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | 194.13 | 169.00 | 218.00 | 10.15 | >5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | 173.97 | 154.00 | 200.00 | 7.81 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 321.41 | 167.00 | 405.00 | 20.03 | 1.3 |

***Notes:***
1. *Data were collected from 300 units (LD10133, #23), lot no. 5824180 LAA064.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.2 DC Parameter Summary, 85°C

### Hot Temperature, 85°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 92.24 | 87.96 | 95.94 | 1.30 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 48.37 | 46.16 | 50.28 | 0.68 | >5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 14.71 | 14.14 | 15.16 | 0.23 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 16.00 | 15.55 | 16.37 | 0.18 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 17.66 | 17.21 | 18.32 | 0.16 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 18.60 | 16.57 | 20.23 | 0.83 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 51.23 | 48.48 | 54.29 | 0.83 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 41.83 | 37.68 | 46.63 | 1.89 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 39.94 | 30.00 | 74.59 | 8.84 | 2.3 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.04 | 0.03 | 0.07 | 0.01 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 39.71 | 30.10 | 74.22 | 8.92 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.220 | 0.030 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.010 | 0.000 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64-kword sector) | 275 | 1100 | ms | 197.40 | 134.00 | 302.00 | 15.45 | >5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 343.14 | 297.00 | 414.00 | 23.33 | >5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 272.21 | 241.00 | 326.00 | 18.33 | >5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 230.01 | 205.00 | 270.00 | 14.67 | >5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 204.37 | 182.00 | 240.00 | 12.57 | >5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 180.53 | 161.00 | 207.00 | 10.17 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 334.05 | 180.00 | 409.00 | 23.54 | 0.9 |

***Notes:***
1. *Data were collected from 300 units (LD10133, #23), lot no. 5824180 LAA064.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.3 DC Parameter Summary, 25°C

### Room Temperature, 25°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 88.66 | 84.26 | 92.43 | 1.38 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 46.41 | 44.16 | 48.26 | 0.70 | >5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 14.22 | 13.75 | 14.77 | 0.20 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 15.54 | 14.77 | 15.94 | 0.19 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 17.12 | 16.77 | 17.50 | 0.15 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 17.94 | 15.94 | 19.11 | 0.64 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 48.06 | 44.54 | 50.47 | 1.07 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 40.16 | 35.86 | 44.19 | 2.03 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 16.06 | 9.11 | 46.29 | 7.62 | 3.7 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.02 | 0.01 | 0.05 | 0.01 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 16.20 | 9.04 | 54.64 | 7.67 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.290 | 0.030 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.010 | 0.000 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64-kword sector) | 275 | 1100 | ms | 261.11 | 176.00 | 411.00 | 22.91 | >5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 393.35 | 345.00 | 467.00 | 16.19 | >5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 305.97 | 272.00 | 354.00 | 13.57 | >5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 256.35 | 228.00 | 290.00 | 11.04 | >5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 226.15 | 203.00 | 254.00 | 9.49 | >5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 198.89 | 180.00 | 222.00 | 7.74 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 381.81 | 70.00 | 448.00 | 19.53 | 0.3 |

***Notes:***
1. *Data were collected from 300 units (LD10133, #23), lot no. 5824180 LAA064.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.4 DC Parameter Summary, –40°C

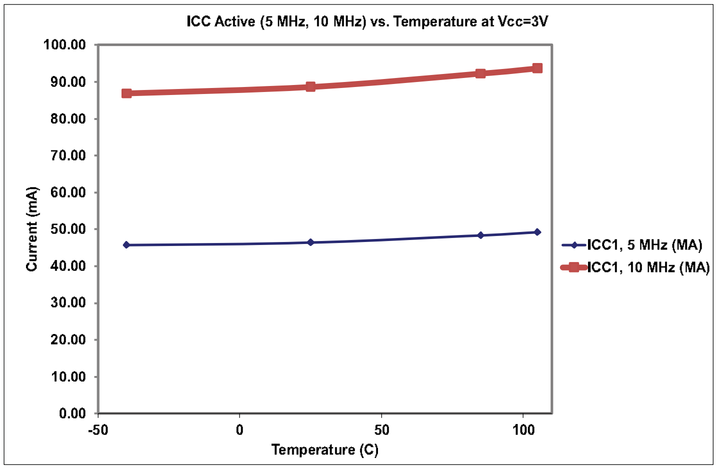
### Cold Temperature, –40°C, 3V, $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 86.85 | 81.15 | 92.90 | 1.92 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 45.76 | 43.04 | 51.24 | 0.93 | >5 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 13.89 | 13.41 | 14.43 | 0.20 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 15.10 | 14.58 | 15.50 | 0.18 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 16.67 | 16.14 | 17.01 | 0.17 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 17.27 | 15.30 | 18.53 | 0.77 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase Current) | 45 | 100 | mA | 43.11 | 39.88 | 46.03 | 1.01 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program Current) | 45 | 100 | mA | 35.87 | 32.09 | 40.50 | 1.83 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 13.73 | 7.96 | 42.98 | 6.59 | 4.4 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.01 | 0.01 | 0.04 | 0.01 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 13.85 | 7.96 | 50.95 | 6.74 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.270 | 0.040 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | -0.010 | -0.010 | 0.010 | 0.000 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64-kword sector) | 275 | 1100 | ms | 353.77 | 219.00 | 605.00 | 42.59 | >5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 390.67 | 319.00 | 471.00 | 23.80 | 5.0 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 303.91 | 250.00 | 353.00 | 18.25 | >5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 253.69 | 208.00 | 295.00 | 14.70 | >5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 224.48 | 185.00 | 258.00 | 12.51 | >5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 201.72 | 166.00 | 236.00 | 10.74 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 390.44 | 196.00 | 476.00 | 26.37 | 0.1 |

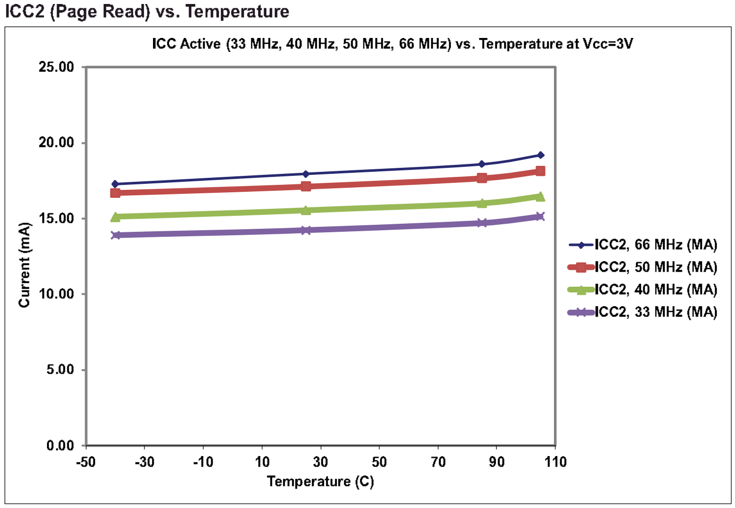
***Notes:***
1. *Data were collected from 300 units (LD10133, #23), lot no. 5824180 LAA064.*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

# 13. DC Device Characterization Data

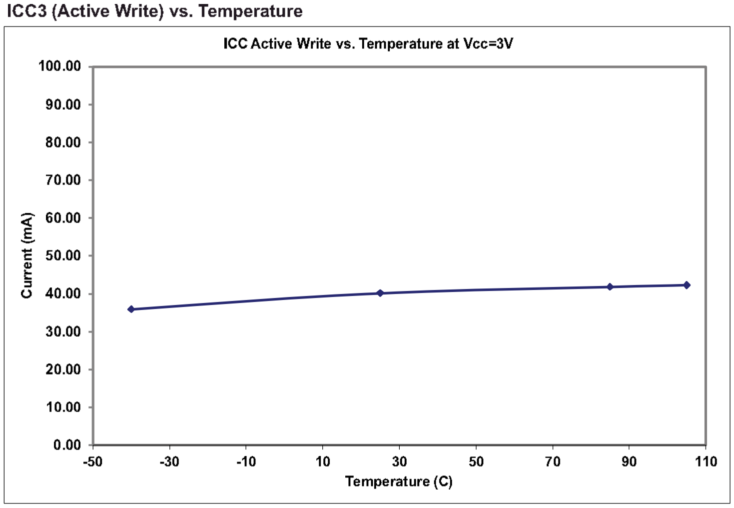
ICC1 (Asynchronous Read) vs. Temperature



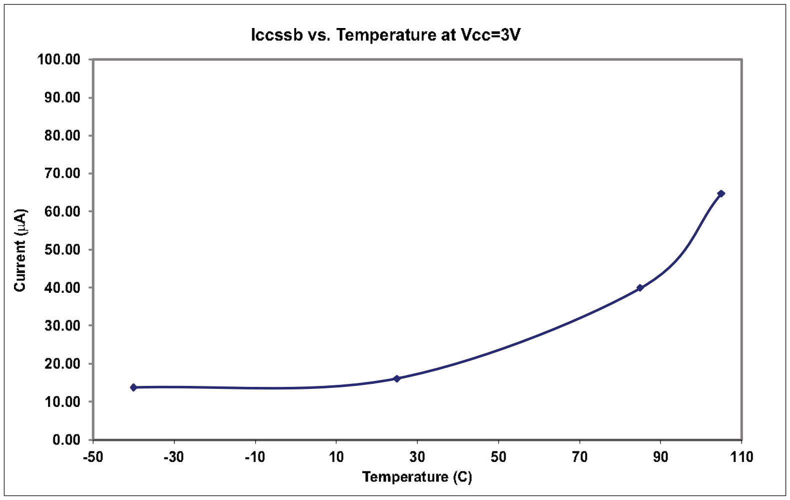

ICC2 (Page Read) vs. Temperature



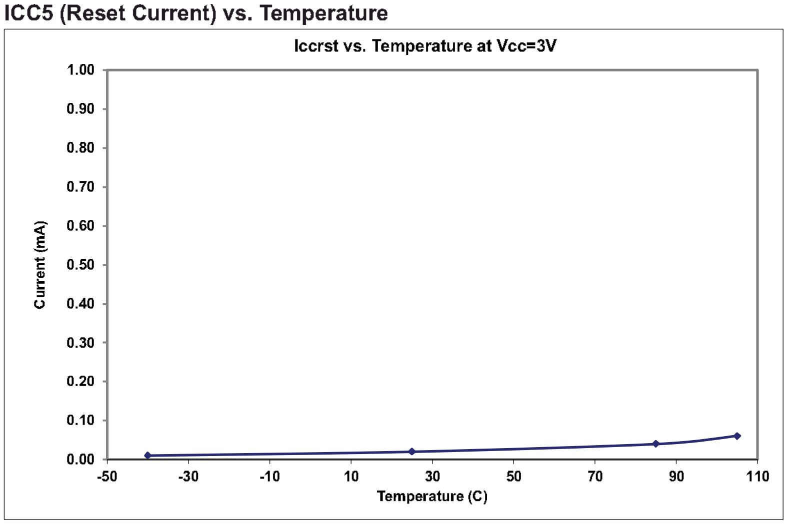

ICC3 (Active Write) vs. Temperature



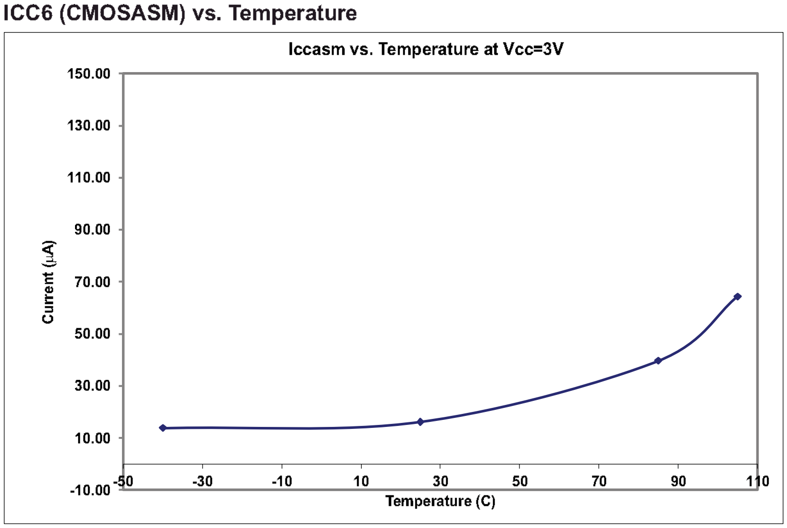
**ICC4 (Standby Current) vs. Temperature**




**ICC5 (Reset Current) vs. Temperature**

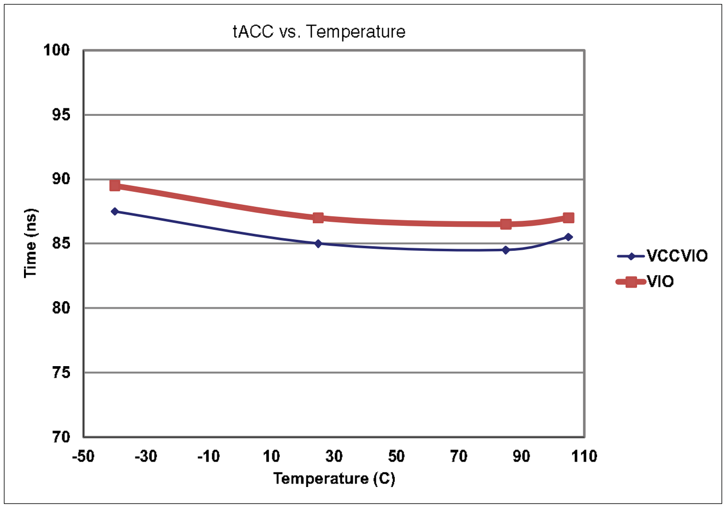



**ICC6 (CMOSASM) vs. Temperature**

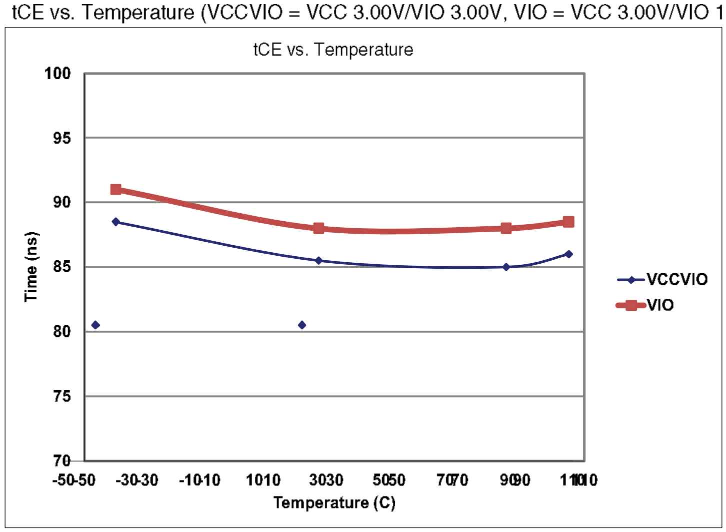


# 14. AC Device Characterization Data

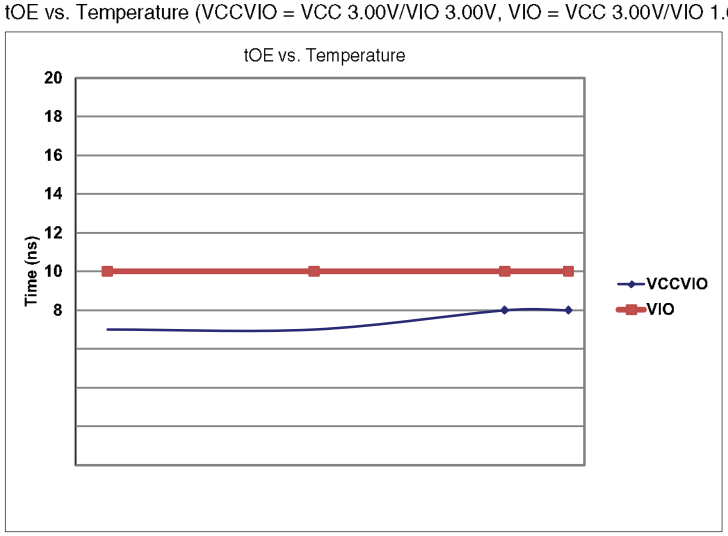
tACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



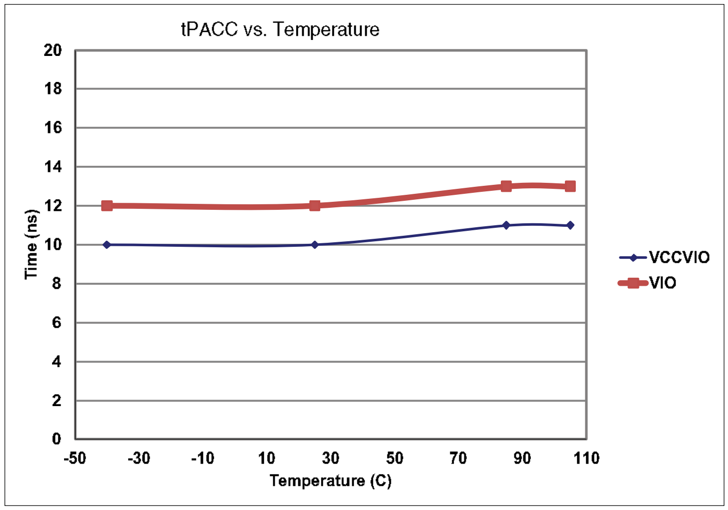

tCE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



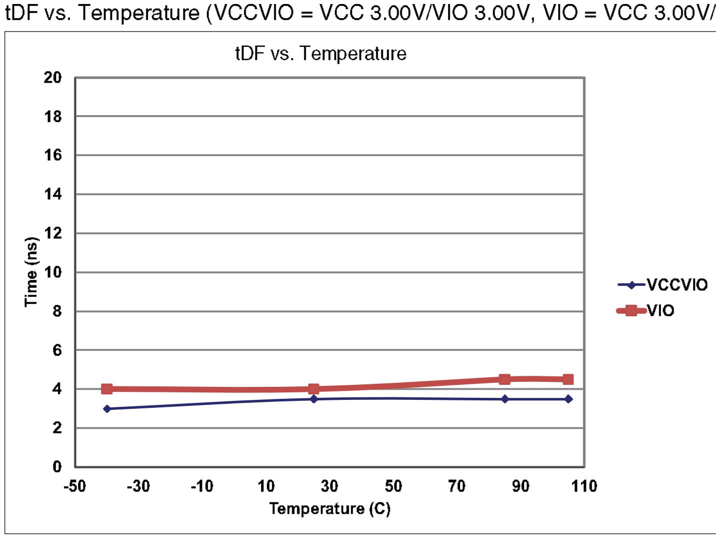

tOE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



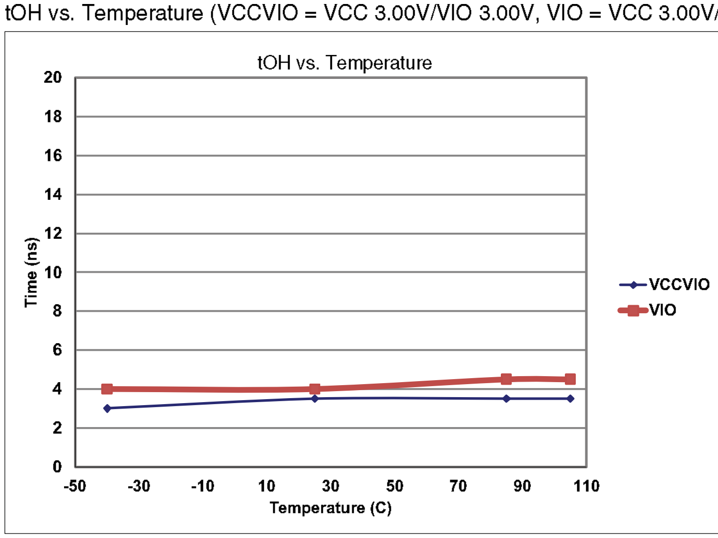
tPACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



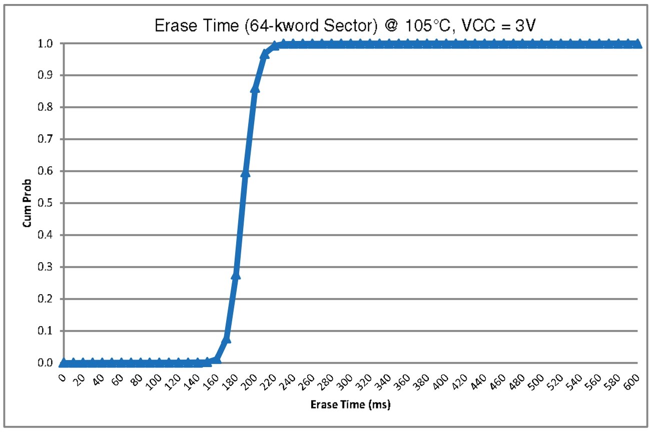

tDF vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



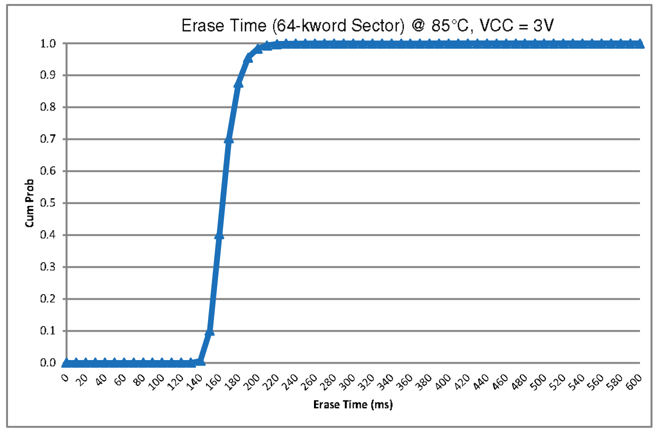

tOH vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



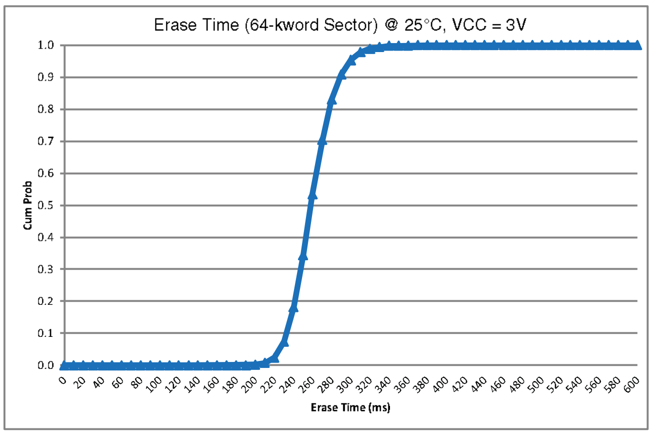
**Cumulative Erase Times per Sector at 105°C (VCC 3V)**



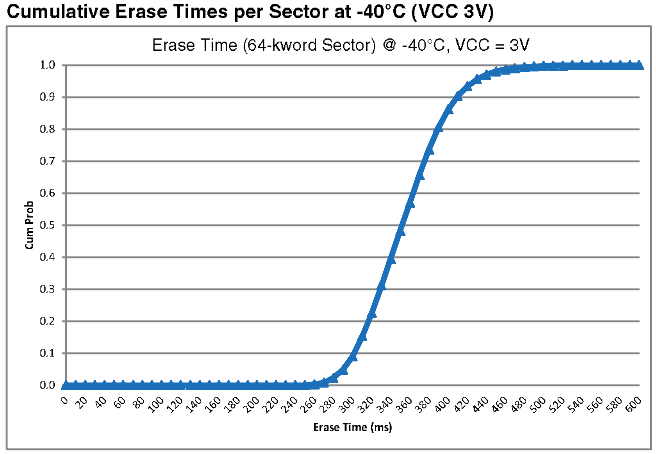

**Cumulative Erase Times per Sector at 85°C (VCC 3V)**



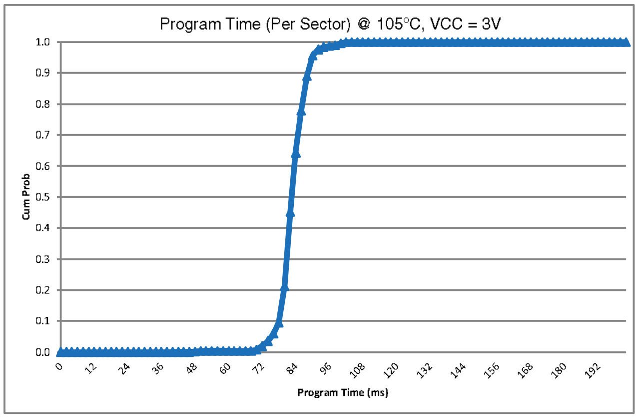

**Cumulative Erase Times per Sector at 25°C (VCC 3V)**



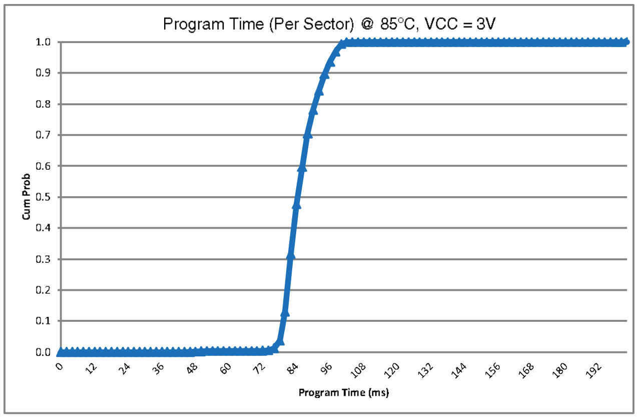

**Cumulative Erase Times per Sector at -40°C (VCC 3V)**



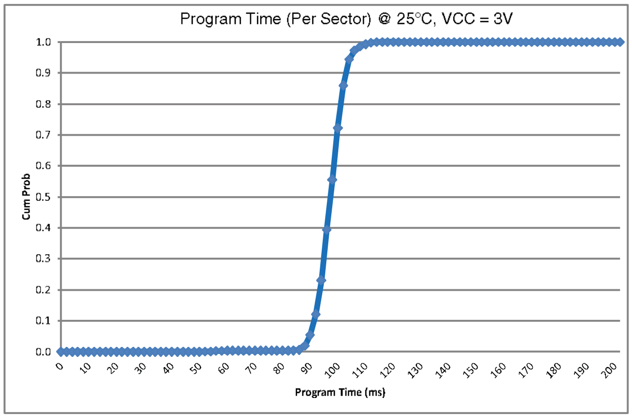
Cumulative WB Program Times per Sector at 105°C (VCC 3V)



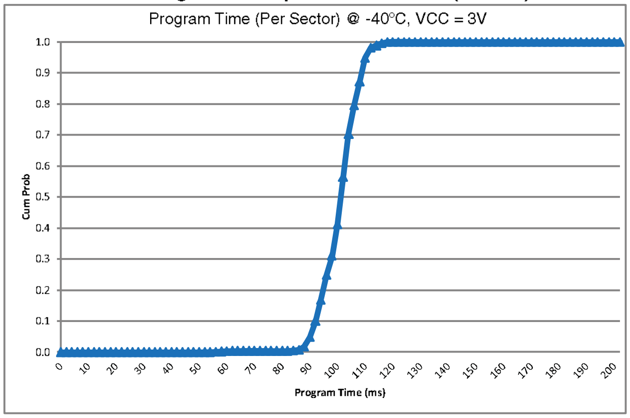

Cumulative WB Program Times per Sector at 85°C (VCC 3V)



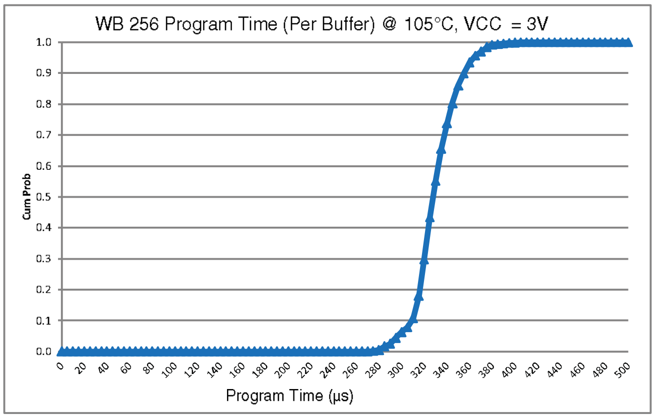

Cumulative WB Program Times per Sector at 25°C (VCC 3V)



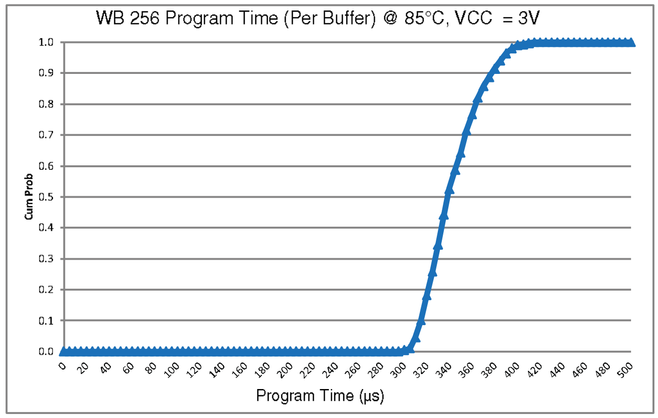

Cumulative WB Program Times per Sector at -40°C (VCC 3V)



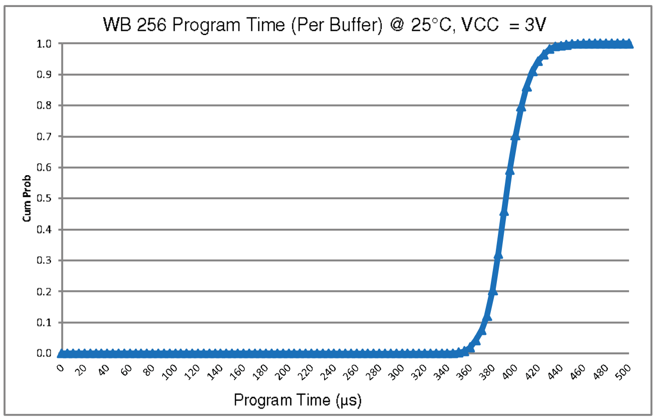
**Cumulative WB 256 Program Times per Buffer at 105°C (VCC 3V)**



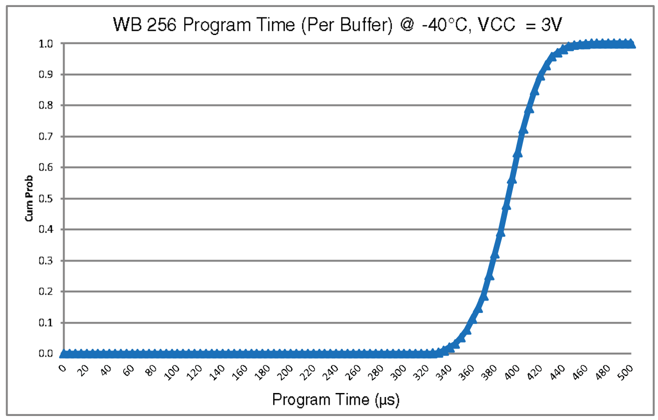

**Cumulative WB 256 Program Times per Buffer at 85°C (VCC 3V)**



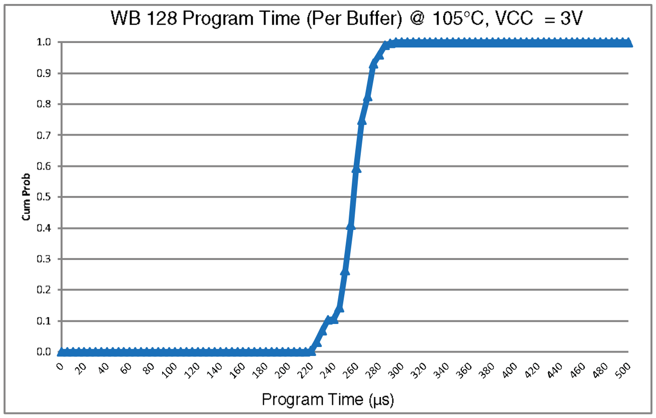

**Cumulative WB 256 Program Times per Buffer at 25°C (VCC 3V)**



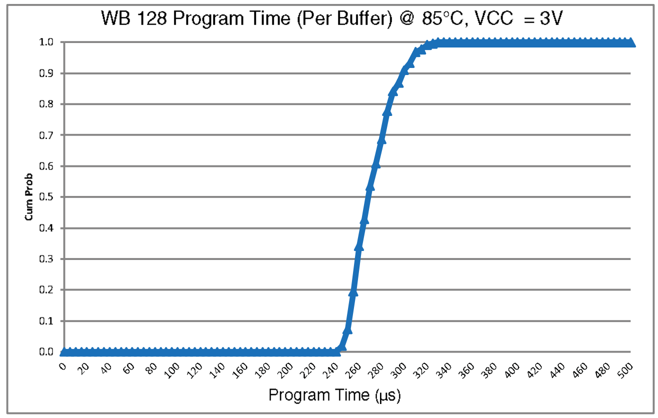

**Cumulative WB 256 Program Times per Buffer at -40°C (VCC 3V)**



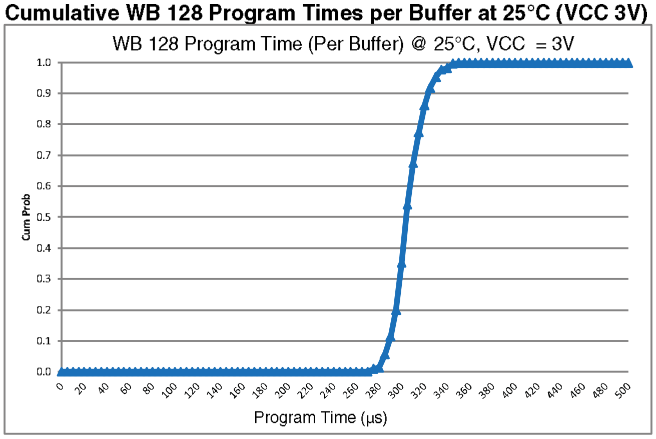
**Cumulative WB 128 Program Times per Buffer at 105°C (VCC 3V)**



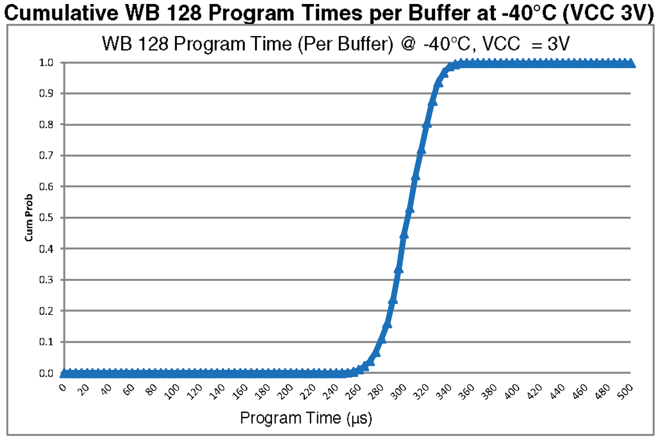

**Cumulative WB 128 Program Times per Buffer at 85°C (VCC 3V)**



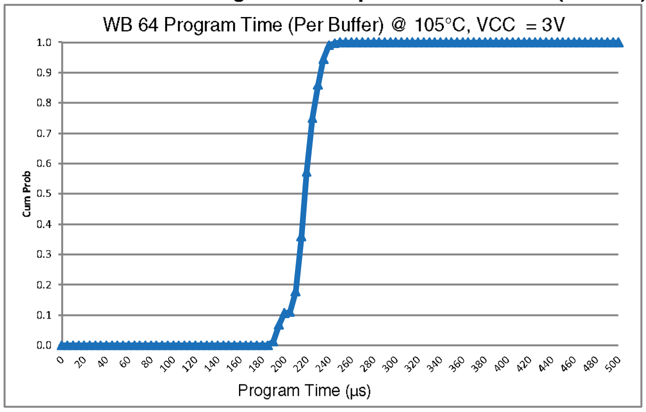

**Cumulative WB 128 Program Times per Buffer at 25°C (VCC 3V)**



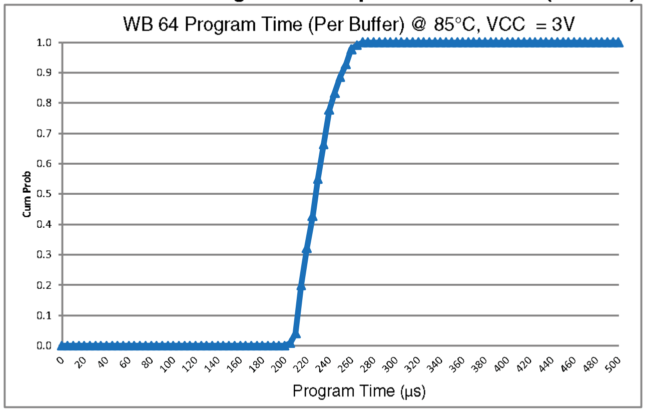

**Cumulative WB 128 Program Times per Buffer at -40°C (VCC 3V)**



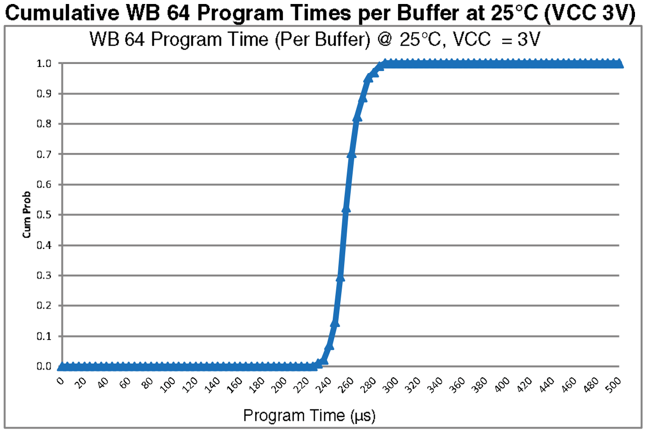
**Cumulative WB 64 Program Times per Buffer at 105°C (VCC 3V)**



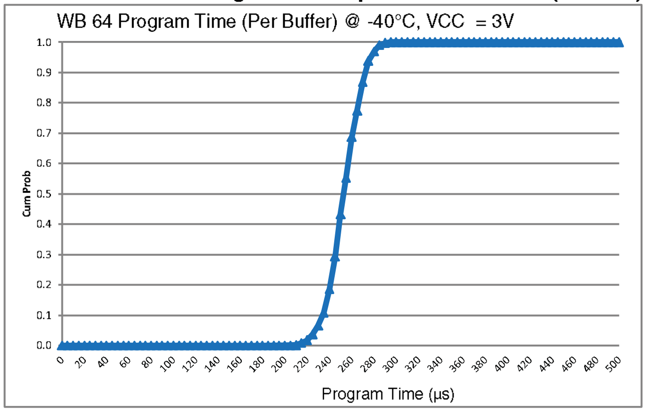

**Cumulative WB 64 Program Times per Buffer at 85°C (VCC 3V)**



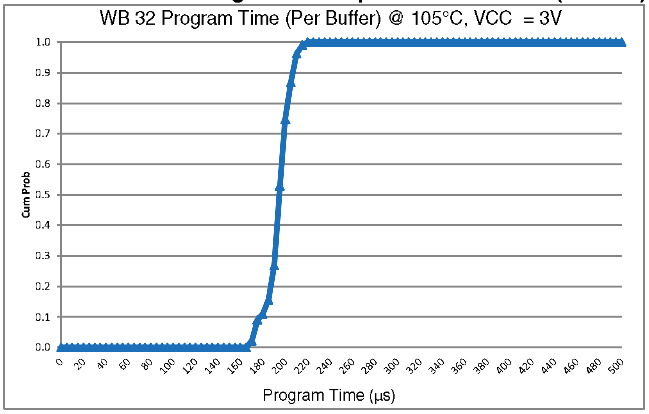

**Cumulative WB 64 Program Times per Buffer at 25°C (VCC 3V)**



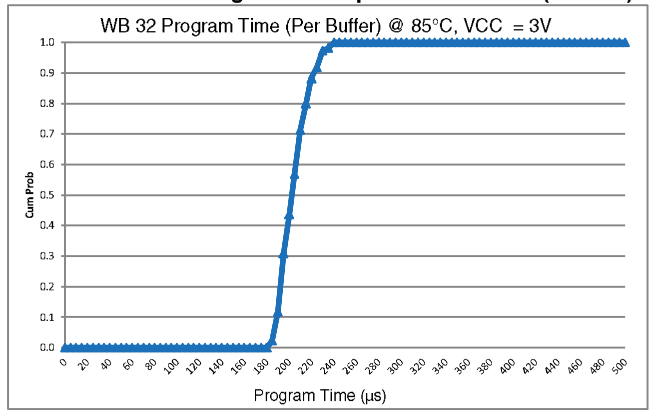

**Cumulative WB 64 Program Times per Buffer at -40°C (VCC 3V)**



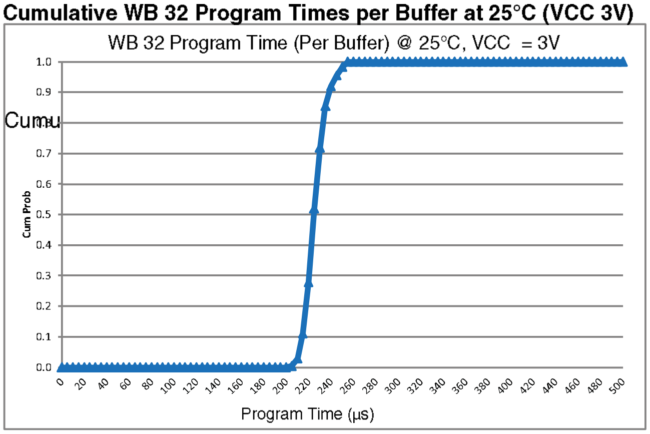
**Cumulative WB 32 Program Times per Buffer at 105°C (VCC 3V)**



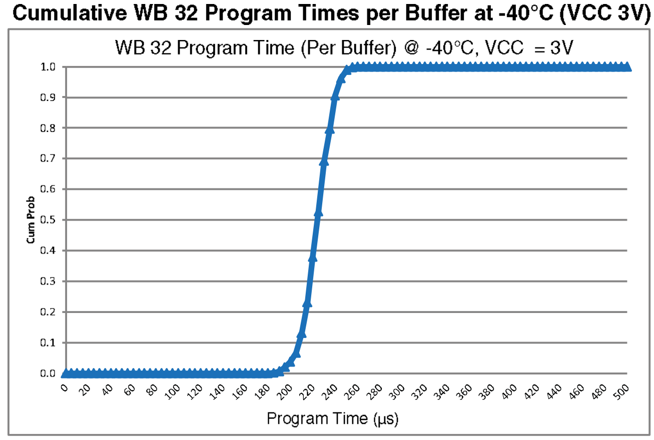

**Cumulative WB 32 Program Times per Buffer at 85°C (VCC 3V)**



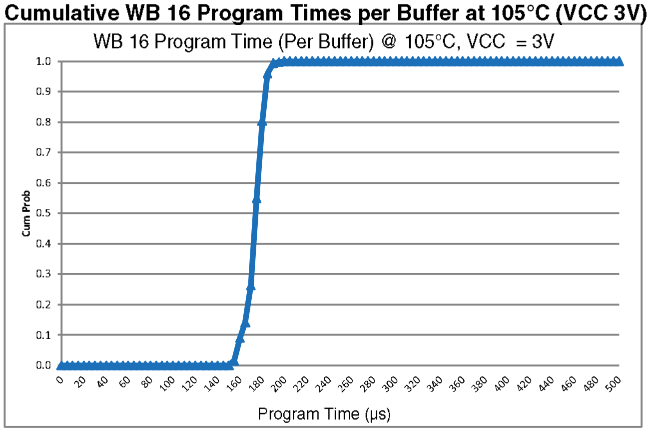

**Cumulative WB 32 Program Times per Buffer at 25°C (VCC 3V)**



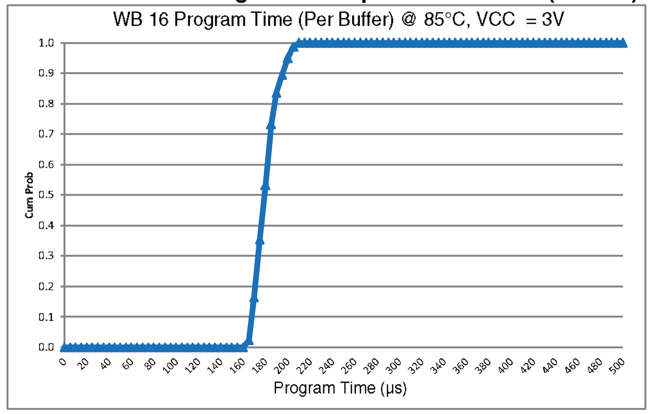

**Cumulative WB 32 Program Times per Buffer at -40°C (VCC 3V)**



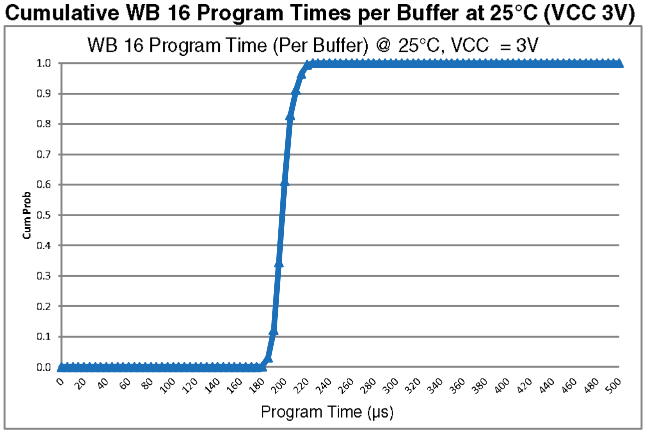
**Cumulative WB 16 Program Times per Buffer at 105°C (VCC 3V)**



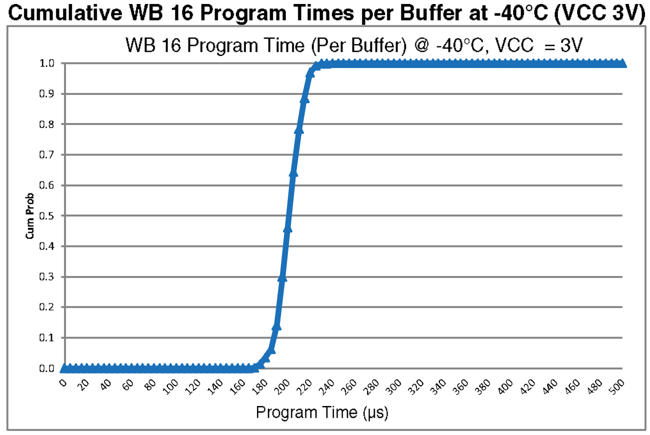

**Cumulative WB 16 Program Times per Buffer at 85°C (VCC 3V)**



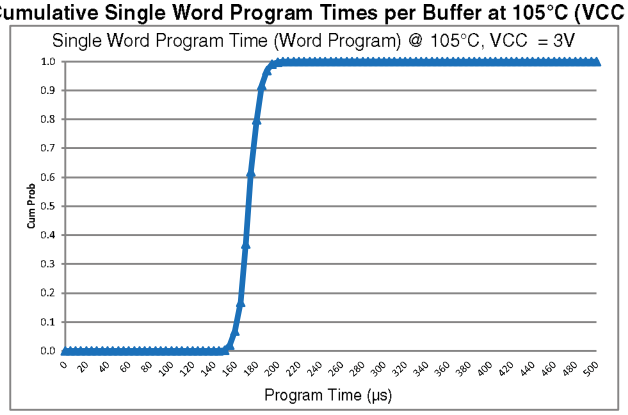

**Cumulative WB 16 Program Times per Buffer at 25°C (VCC 3V)**



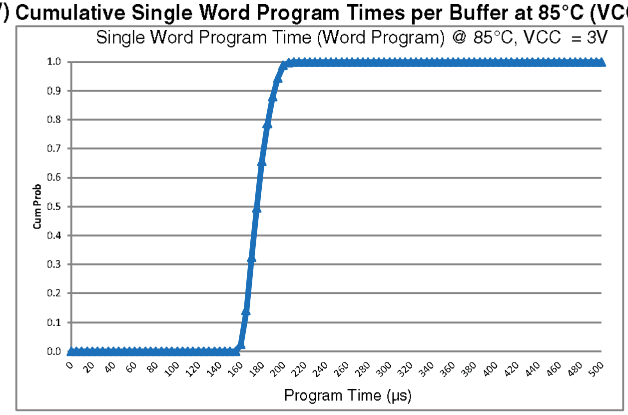

**Cumulative WB 16 Program Times per Buffer at -40°C (VCC 3V)**



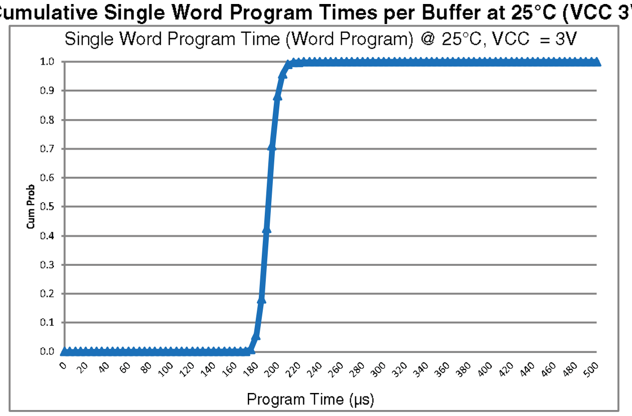
**Cumulative Single Word Program Times per Buffer at 105°C (VCC 3V)**



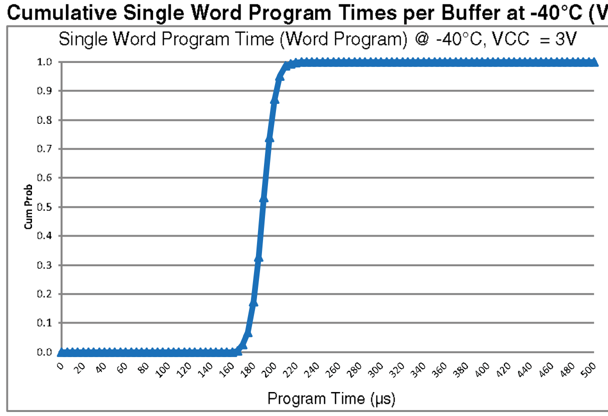

**Cumulative Single Word Program Times per Buffer at 85°C (VCC 3V)**




**Cumulative Single Word Program Times per Buffer at 25°C (VCC 3V)**




**Cumulative Single Word Program Times per Buffer at -40°C (VCC 3V)**



# 15. Shmoo Plots

### $t_{ACC}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.650 |.....**************************|          85.0
  3.600 |.....**************************|          85.0
  3.550 |.....**************************|          85.0
  3.500 |.....**************************|          85.0
  3.450 |.....**************************|          85.0
  3.400 |.....**************************|          85.0
  3.350 |.....**************************|          85.0
  3.300 |.....**************************|          85.0
  3.250 |.....**************************|          85.0
  3.200 |.....**************************|          85.0
  3.150 |.....**************************|          85.0
  3.100 |.....**************************|          85.0
  3.050 |.....**************************|          85.0
  3.000 |.....**************************|          85.0
  2.950 |.....**************************|          85.0
  2.900 |.....**************************|          85.0
  2.850 |.....**************************|          85.0
  2.800 |......*************************|          86.0
  2.750 |......*************************|          86.0
  2.700 |......*************************|          86.0
  2.650 |......*************************|          86.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}=V_{IO}$ @ 85°C

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.650 |....***************************|          84.0
  3.600 |....***************************|          84.0
  3.550 |....***************************|          84.0
  3.500 |....***************************|          84.0
  3.450 |....***************************|          84.0
  3.400 |....***************************|          84.0
  3.350 |....***************************|          84.0
  3.300 |....***************************|          84.0
  3.250 |....***************************|          84.0
  3.200 |....***************************|          84.0
  3.150 |....***************************|          84.0
  3.100 |....***************************|          84.0
  3.050 |....***************************|          84.0
  3.000 |....***************************|          84.0
  2.950 |....***************************|          84.0
  2.900 |....***************************|          84.0
  2.850 |....***************************|          84.0
  2.800 |....***************************|          84.0
  2.750 |....***************************|          84.0
  2.700 |.....**************************|          85.0
  2.650 |.....**************************|          85.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}=V_{IO}$ @ 25°C

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.650 |....***************************|          84.0
  3.600 |....***************************|          84.0
  3.550 |....***************************|          84.0
  3.500 |....***************************|          84.0
  3.450 |....***************************|          84.0
  3.400 |....***************************|          84.0
  3.350 |....***************************|          84.0
  3.300 |....***************************|          84.0
  3.250 |....***************************|          84.0
  3.200 |....***************************|          84.0
  3.150 |....***************************|          84.0
  3.100 |....***************************|          84.0
  3.050 |....***************************|          84.0
  3.000 |....***************************|          84.0
  2.950 |....***************************|          84.0
  2.900 |....***************************|          84.0
  2.850 |....***************************|          84.0
  2.800 |....***************************|          84.0
  2.750 |....***************************|          84.0
  2.700 |....***************************|          84.0
  2.650 |....***************************|          84.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.650 |......*************************|          86.0
  3.600 |......*************************|          86.0
  3.550 |......*************************|          86.0
  3.500 |......*************************|          86.0
  3.450 |......*************************|          86.0
  3.400 |......*************************|          86.0
  3.350 |......*************************|          86.0
  3.300 |......*************************|          86.0
  3.250 |......*************************|          86.0
  3.200 |......*************************|          86.0
  3.150 |......*************************|          86.0
  3.100 |......*************************|          86.0
  3.050 |......*************************|          86.0
  3.000 |......*************************|          86.0
  2.950 |......*************************|          86.0
  2.900 |......*************************|          86.0
  2.850 |......*************************|          86.0
  2.800 |......*************************|          86.0
  2.750 |......*************************|          86.0
  2.700 |.......************************|          87.0
  2.650 |.......************************|          87.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 105°C

```
        80.0      90.0      100.0     110.0         first pass data
       |+----,----+----,----+----,----+|
 3.000 |......*************************|            86.0
 2.950 |......*************************|            86.0
 2.900 |......*************************|            86.0
 2.850 |......*************************|            86.0
 2.800 |......*************************|            86.0
 2.750 |......*************************|            86.0
 2.700 |......*************************|            86.0
 2.650 |......*************************|            86.0
 2.600 |......*************************|            86.0
 2.550 |......*************************|            86.0
 2.500 |......*************************|            86.0
 2.450 |......*************************|            86.0
 2.400 |......*************************|            86.0
 2.350 |......*************************|            86.0
 2.300 |......*************************|            86.0
 2.250 |......*************************|            86.0
 2.200 |......*************************|            86.0
 2.150 |......*************************|            86.0
 2.100 |......*************************|            86.0
 2.050 |......*************************|            86.0
 2.000 |......*************************|            86.0
 1.950 |......*************************|            86.0
 1.900 |.......************************|            87.0
 1.850 |.......************************|            87.0
 1.800 |.......************************|            87.0
 1.750 |.......************************|            87.0
 1.700 |.......************************|            87.0
 1.650 |.......************************|            87.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 85°C

```
        80.0      90.0      100.0     110.0         first pass data
       |+----,----+----,----+----,----+|
 3.000 |.....**************************|            85.0
 2.950 |.....**************************|            85.0
 2.900 |.....**************************|            85.0
 2.850 |.....**************************|            85.0
 2.800 |.....**************************|            85.0
 2.750 |.....**************************|            85.0
 2.700 |.....**************************|            85.0
 2.650 |.....**************************|            85.0
 2.600 |.....**************************|            85.0
 2.550 |.....**************************|            85.0
 2.500 |.....**************************|            85.0
 2.450 |.....**************************|            85.0
 2.400 |.....**************************|            85.0
 2.350 |.....**************************|            85.0
 2.300 |.....**************************|            85.0
 2.250 |.....**************************|            85.0
 2.200 |.....**************************|            85.0
 2.150 |......*************************|            86.0
 2.100 |......*************************|            86.0
 2.050 |......*************************|            86.0
 2.000 |......*************************|            86.0
 1.950 |......*************************|            86.0
 1.900 |......*************************|            86.0
 1.850 |......*************************|            86.0
 1.800 |......*************************|            86.0
 1.750 |......*************************|            86.0
 1.700 |......*************************|            86.0
 1.650 |.......************************|            87.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 25°C

```
        80.0      90.0      100.0     110.0        first pass data
       |+----,----+----,----+----,----+|
 3.000 |....***************************|           84.0
 2.950 |.....**************************|           85.0
 2.900 |.....**************************|           85.0
 2.850 |.....**************************|           85.0
 2.800 |.....**************************|           85.0
 2.750 |.....**************************|           85.0
 2.700 |.....**************************|           85.0
 2.650 |.....**************************|           85.0
 2.600 |.....**************************|           85.0
 2.550 |.....**************************|           85.0
 2.500 |.....**************************|           85.0
 2.450 |.....**************************|           85.0
 2.400 |.....**************************|           85.0
 2.350 |.....**************************|           85.0
 2.300 |.....**************************|           85.0
 2.250 |.....**************************|           85.0
 2.200 |.....**************************|           85.0
 2.150 |.....**************************|           85.0
 2.100 |.....**************************|           85.0
 2.050 |.....**************************|           85.0
 2.000 |.....**************************|           85.0
 1.950 |......*************************|           86.0
 1.900 |......*************************|           86.0
 1.850 |......*************************|           86.0
 1.800 |......*************************|           86.0
 1.750 |......*************************|           86.0
 1.700 |......*************************|           86.0
 1.650 |.......************************|           87.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ -40°C

```
        80.0      90.0      100.0     110.0        first pass data
       |+----,----+----,----+----,----+|
 3.000 |.......************************|           87.0
 2.950 |.......************************|           87.0
 2.900 |.......************************|           87.0
 2.850 |.......************************|           87.0
 2.800 |.......************************|           87.0
 2.750 |.......************************|           87.0
 2.700 |.......************************|           87.0
 2.650 |........***********************|           88.0
 2.600 |........***********************|           88.0
 2.550 |........***********************|           88.0
 2.500 |........***********************|           88.0
 2.450 |........***********************|           88.0
 2.400 |........***********************|           88.0
 2.350 |........***********************|           88.0
 2.300 |........***********************|           88.0
 2.250 |........***********************|           88.0
 2.200 |........***********************|           88.0
 2.150 |........***********************|           88.0
 2.100 |........***********************|           88.0
 2.050 |........***********************|           88.0
 2.000 |........***********************|           88.0
 1.950 |........***********************|           88.0
 1.900 |........***********************|           88.0
 1.850 |.........**********************|           89.0
 1.800 |.........**********************|           89.0
 1.750 |.........**********************|           89.0
 1.700 |.........**********************|           89.0
 1.650 |..........*********************|           90.0
       |+----,----+----,----+----,----+|
        80.0      90.0      100.0     110.0
```

## $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          80.0      90.0      100.0     110.0       first pass data
         |+----,----+----,----+----,----+|
  3.650  |......*************************|           86.0
  3.600  |......*************************|           86.0
  3.550  |......*************************|           86.0
  3.500  |......*************************|           86.0
  3.450  |......*************************|           86.0
  3.400  |......*************************|           86.0
  3.350  |......*************************|           86.0
  3.300  |......*************************|           86.0
  3.250  |......*************************|           86.0
  3.200  |......*************************|           86.0
  3.150  |......*************************|           86.0
  3.100  |......*************************|           86.0
  3.050  |......*************************|           86.0
  3.000  |......*************************|           86.0
  2.950  |......*************************|           86.0
  2.900  |......*************************|           86.0
  2.850  |......*************************|           86.0
  2.800  |.......************************|           87.0
  2.750  |.......************************|           87.0
  2.700  |.......************************|           87.0
  2.650  |.......************************|           87.0
         |+----,----+----,----+----,----+|
          80.0      90.0      100.0     110.0
```

## $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
          80.0      90.0      100.0     110.0       first pass data
         |+----,----+----,----+----,----+|
  3.650  |.....**************************|           85.0
  3.600  |.....**************************|           85.0
  3.550  |.....**************************|           85.0
  3.500  |.....**************************|           85.0
  3.450  |.....**************************|           85.0
  3.400  |.....**************************|           85.0
  3.350  |.....**************************|           85.0
  3.300  |.....**************************|           85.0
  3.250  |.....**************************|           85.0
  3.200  |.....**************************|           85.0
  3.150  |.....**************************|           85.0
  3.100  |......*************************|           86.0
  3.050  |......*************************|           86.0
  3.000  |......*************************|           86.0
  2.950  |......*************************|           86.0
  2.900  |......*************************|           86.0
  2.850  |......*************************|           86.0
  2.800  |......*************************|           86.0
  2.750  |......*************************|           86.0
  2.700  |......*************************|           86.0
  2.650  |......*************************|           86.0
         |+----,----+----,----+----,----+|
          80.0      90.0      100.0     110.0
```

## $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       80.0      90.0      100.0     110.0        first pass data
      |+----,----+----,----+----,----+|
3.650 |....***************************|             84.0
3.600 |....***************************|             84.0
3.550 |....***************************|             84.0
3.500 |....***************************|             84.0
3.450 |....***************************|             84.0
3.400 |....***************************|             84.0
3.350 |....***************************|             84.0
3.300 |....***************************|             84.0
3.250 |.....**************************|             85.0
3.200 |.....**************************|             85.0
3.150 |.....**************************|             85.0
3.100 |.....**************************|             85.0
3.050 |.....**************************|             85.0
3.000 |.....**************************|             85.0
2.950 |.....**************************|             85.0
2.900 |.....**************************|             85.0
2.850 |.....**************************|             85.0
2.800 |.....**************************|             85.0
2.750 |......*************************|             86.0
2.700 |......*************************|             86.0
2.650 |......*************************|             86.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

## $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       80.0      90.0      100.0     110.0        first pass data
      |+----,----+----,----+----,----+|
3.650 |.......************************|             87.0
3.600 |.......************************|             87.0
3.550 |.......************************|             87.0
3.500 |.......************************|             87.0
3.450 |.......************************|             87.0
3.400 |.......************************|             87.0
3.350 |.......************************|             87.0
3.300 |.......************************|             87.0
3.250 |.......************************|             87.0
3.200 |.......************************|             87.0
3.150 |.......************************|             87.0
3.100 |........***********************|             88.0
3.050 |........***********************|             88.0
3.000 |........***********************|             88.0
2.950 |........***********************|             88.0
2.900 |........***********************|             88.0
2.850 |........***********************|             88.0
2.800 |........***********************|             88.0
2.750 |.........**********************|             89.0
2.700 |.........**********************|             89.0
2.650 |.........**********************|             89.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 105°C

```
       80.0      90.0      100.0     110.0        first pass data
      |+----,----+----,----+----,----+|
3.000 |......*************************|           86.0
2.950 |......*************************|           86.0
2.900 |......*************************|           86.0
2.850 |......*************************|           86.0
2.800 |......*************************|           86.0
2.750 |......*************************|           86.0
2.700 |......*************************|           86.0
2.650 |......*************************|           86.0
2.600 |......*************************|           86.0
2.550 |.......************************|           87.0
2.500 |.......************************|           87.0
2.450 |.......************************|           87.0
2.400 |.......************************|           87.0
2.350 |.......************************|           87.0
2.300 |.......************************|           87.0
2.250 |.......************************|           87.0
2.200 |.......************************|           87.0
2.150 |.......************************|           87.0
2.100 |.......************************|           87.0
2.050 |.......************************|           87.0
2.000 |.......************************|           87.0
1.950 |........***********************|           88.0
1.900 |........***********************|           88.0
1.850 |........***********************|           88.0
1.800 |........***********************|           88.0
1.750 |........***********************|           88.0
1.700 |.........**********************|           89.0
1.650 |.........**********************|           89.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 85°C

```
       80.0      90.0      100.0     110.0        first pass data
      |+----,----+----,----+----,----+|
3.000 |......*************************|           86.0
2.950 |......*************************|           86.0
2.900 |......*************************|           86.0
2.850 |......*************************|           86.0
2.800 |......*************************|           86.0
2.750 |......*************************|           86.0
2.700 |......*************************|           86.0
2.650 |......*************************|           86.0
2.600 |......*************************|           86.0
2.550 |......*************************|           86.0
2.500 |......*************************|           86.0
2.450 |......*************************|           86.0
2.400 |......*************************|           86.0
2.350 |......*************************|           86.0
2.300 |......*************************|           86.0
2.250 |......*************************|           86.0
2.200 |......*************************|           86.0
2.150 |......*************************|           86.0
2.100 |......*************************|           86.0
2.050 |......*************************|           86.0
2.000 |......*************************|           86.0
1.950 |.......************************|           87.0
1.900 |.......************************|           87.0
1.850 |.......************************|           87.0
1.800 |.......************************|           87.0
1.750 |........***********************|           88.0
1.700 |........***********************|           88.0
1.650 |........***********************|           88.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 25°C

```
       80.0      90.0      100.0     110.0          first pass data
      |+----,----+----,----+----,----+|
3.000 |.....**************************|             85.0
2.950 |.....**************************|             85.0
2.900 |.....**************************|             85.0
2.850 |.....**************************|             85.0
2.800 |.....**************************|             85.0
2.750 |.....**************************|             85.0
2.700 |.....**************************|             85.0
2.650 |.....**************************|             85.0
2.600 |.....**************************|             85.0
2.550 |.....**************************|             85.0
2.500 |.....**************************|             85.0
2.450 |.....**************************|             85.0
2.400 |.....**************************|             85.0
2.350 |.....**************************|             85.0
2.300 |.....**************************|             85.0
2.250 |.....**************************|             85.0
2.200 |.....**************************|             85.0
2.150 |......*************************|             86.0
2.100 |......*************************|             86.0
2.050 |......*************************|             86.0
2.000 |......*************************|             86.0
1.950 |......*************************|             86.0
1.900 |......*************************|             86.0
1.850 |......*************************|             86.0
1.800 |.......************************|             87.0
1.750 |.......************************|             87.0
1.700 |.......************************|             87.0
1.650 |........***********************|             88.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ -40°C

```
        80.0      90.0      100.0     110.0          first pass data
      |+----,----+----,----+----,----+|
3.000 |........***********************|             88.0
2.950 |........***********************|             88.0
2.900 |........***********************|             88.0
2.850 |........***********************|             88.0
2.800 |........***********************|             88.0
2.750 |........***********************|             88.0
2.700 |........***********************|             88.0
2.650 |........***********************|             88.0
2.600 |........***********************|             88.0
2.550 |........***********************|             88.0
2.500 |........***********************|             88.0
2.450 |........***********************|             88.0
2.400 |........***********************|             88.0
2.350 |........***********************|             88.0
2.300 |.........**********************|             89.0
2.250 |.........**********************|             89.0
2.200 |.........**********************|             89.0
2.150 |.........**********************|             89.0
2.100 |.........**********************|             89.0
2.050 |.........**********************|             89.0
2.000 |.........**********************|             89.0
1.950 |.........**********************|             89.0
1.900 |.........**********************|             89.0
1.850 |.........**********************|             89.0
1.800 |..........*********************|             90.0
1.750 |..........*********************|             90.0
1.700 |..........*********************|             90.0
1.650 |...........********************|             91.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.650  |........*************|           8.0
  3.600  |........*************|           8.0
  3.550  |........*************|           8.0
  3.500  |........*************|           8.0
  3.450  |........*************|           8.0
  3.400  |........*************|           8.0
  3.350  |........*************|           8.0
  3.300  |........*************|           8.0
  3.250  |........*************|           8.0
  3.200  |........*************|           8.0
  3.150  |........*************|           8.0
  3.100  |........*************|           8.0
  3.050  |........*************|           8.0
  3.000  |........*************|           8.0
  2.950  |........*************|           8.0
  2.900  |........*************|           8.0
  2.850  |........*************|           8.0
  2.800  |........*************|           8.0
  2.750  |........*************|           8.0
  2.700  |........*************|           8.0
  2.650  |........*************|           8.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.650  |........*************|           8.0
  3.600  |........*************|           8.0
  3.550  |........*************|           8.0
  3.500  |........*************|           8.0
  3.450  |........*************|           8.0
  3.400  |........*************|           8.0
  3.350  |........*************|           8.0
  3.300  |........*************|           8.0
  3.250  |........*************|           8.0
  3.200  |........*************|           8.0
  3.150  |........*************|           8.0
  3.100  |........*************|           8.0
  3.050  |........*************|           8.0
  3.000  |........*************|           8.0
  2.950  |........*************|           8.0
  2.900  |........*************|           8.0
  2.850  |........*************|           8.0
  2.800  |........*************|           8.0
  2.750  |........*************|           8.0
  2.700  |........*************|           8.0
  2.650  |........*************|           8.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
         0.0       10.0      20.0        first pass data
        |+----,----+----,----+|
3.650   |.......**************|          7.0
3.600   |.......**************|          7.0
3.550   |.......**************|          7.0
3.500   |.......**************|          7.0
3.450   |.......**************|          7.0
3.400   |.......**************|          7.0
3.350   |.......**************|          7.0
3.300   |.......**************|          7.0
3.250   |.......**************|          7.0
3.200   |.......**************|          7.0
3.150   |.......**************|          7.0
3.100   |.......**************|          7.0
3.050   |.......**************|          7.0
3.000   |.......**************|          7.0
2.950   |.......**************|          7.0
2.900   |.......**************|          7.0
2.850   |.......**************|          7.0
2.800   |.......**************|          7.0
2.750   |.......**************|          7.0
2.700   |.......**************|          7.0
2.650   |.......**************|          7.0
        |+----,----+----,----+|
         0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
         0.0       10.0      20.0        first pass data
        |+----,----+----,----+|
3.650   |.......**************|          7.0
3.600   |.......**************|          7.0
3.550   |.......**************|          7.0
3.500   |.......**************|          7.0
3.450   |.......**************|          7.0
3.400   |.......**************|          7.0
3.350   |.......**************|          7.0
3.300   |.......**************|          7.0
3.250   |.......**************|          7.0
3.200   |.......**************|          7.0
3.150   |.......**************|          7.0
3.100   |.......**************|          7.0
3.050   |.......**************|          7.0
3.000   |.......**************|          7.0
2.950   |.......**************|          7.0
2.900   |.......**************|          7.0
2.850   |.......**************|          7.0
2.800   |.......**************|          7.0
2.750   |.......**************|          7.0
2.700   |.......**************|          7.0
2.650   |.......**************|          7.0
        |+----,----+----,----+|
         0.0       10.0      20.0
```

## $t_{OE}$ vs. $V_{IO}$ @ 105°C

```
       0.0       10.0      20.0        first pass data
      |+----,----+----,----+|
3.000 |........*************|          8.0
2.950 |........*************|          8.0
2.900 |........*************|          8.0
2.850 |........*************|          8.0
2.800 |........*************|          8.0
2.750 |........*************|          8.0
2.700 |........*************|          8.0
2.650 |........*************|          8.0
2.600 |........*************|          8.0
2.550 |........*************|          8.0
2.500 |........*************|          8.0
2.450 |........*************|          8.0
2.400 |........*************|          8.0
2.350 |........*************|          8.0
2.300 |.........************|          9.0
2.250 |.........************|          9.0
2.200 |.........************|          9.0
2.150 |.........************|          9.0
2.100 |.........************|          9.0
2.050 |.........************|          9.0
2.000 |.........************|          9.0
1.950 |.........************|          9.0
1.900 |.........************|          9.0
1.850 |.........************|          9.0
1.800 |..........***********|          10.0
1.750 |..........***********|          10.0
1.700 |..........***********|          10.0
1.650 |..........***********|          10.0
      |+----,----+----,----+|
       0.0       10.0      20.0
```

## $t_{OE}$ vs. $V_{IO}$ @ 85°C

```
       0.0       10.0      20.0        first pass data
      |+----,----+----,----+|
3.000 |........*************|          8.0
2.950 |........*************|          8.0
2.900 |........*************|          8.0
2.850 |........*************|          8.0
2.800 |........*************|          8.0
2.750 |........*************|          8.0
2.700 |........*************|          8.0
2.650 |........*************|          8.0
2.600 |........*************|          8.0
2.550 |........*************|          8.0
2.500 |........*************|          8.0
2.450 |........*************|          8.0
2.400 |........*************|          8.0
2.350 |........*************|          8.0
2.300 |........*************|          8.0
2.250 |........*************|          8.0
2.200 |........*************|          8.0
2.150 |.........************|          9.0
2.100 |.........************|          9.0
2.050 |.........************|          9.0
2.000 |.........************|          9.0
1.950 |.........************|          9.0
1.900 |.........************|          9.0
1.850 |.........************|          9.0
1.800 |.........************|          9.0
1.750 |..........***********|          10.0
1.700 |..........***********|          10.0
1.650 |..........***********|          10.0
      |+----,----+----,----+|
       0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 25°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.000 |.......**************|          7.0
   2.950 |.......**************|          7.0
   2.900 |.......**************|          7.0
   2.850 |.......**************|          7.0
   2.800 |.......**************|          7.0
   2.750 |.......**************|          7.0
   2.700 |.......**************|          7.0
   2.650 |........*************|          8.0
   2.600 |........*************|          8.0
   2.550 |........*************|          8.0
   2.500 |........*************|          8.0
   2.450 |........*************|          8.0
   2.400 |........*************|          8.0
   2.350 |........*************|          8.0
   2.300 |........*************|          8.0
   2.250 |........*************|          8.0
   2.200 |........*************|          8.0
   2.150 |........*************|          8.0
   2.100 |........*************|          8.0
   2.050 |........*************|          8.0
   2.000 |........*************|          8.0
   1.950 |........*************|          8.0
   1.900 |.........************|          9.0
   1.850 |.........************|          9.0
   1.800 |.........************|          9.0
   1.750 |.........************|          9.0
   1.700 |.........************|          9.0
   1.650 |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ -40°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.000 |.......**************|          7.0
   2.950 |.......**************|          7.0
   2.900 |.......**************|          7.0
   2.850 |.......**************|          7.0
   2.800 |.......**************|          7.0
   2.750 |.......**************|          7.0
   2.700 |.......**************|          7.0
   2.650 |.......**************|          7.0
   2.600 |.......**************|          7.0
   2.550 |.......**************|          7.0
   2.500 |.......**************|          7.0
   2.450 |.......**************|          7.0
   2.400 |.......**************|          7.0
   2.350 |.......**************|          7.0
   2.300 |.......**************|          7.0
   2.250 |.......**************|          7.0
   2.200 |.......**************|          7.0
   2.150 |........*************|          8.0
   2.100 |........*************|          8.0
   2.050 |........*************|          8.0
   2.000 |........*************|          8.0
   1.950 |........*************|          8.0
   1.900 |........*************|          8.0
   1.850 |........*************|          8.0
   1.800 |.........************|          9.0
   1.750 |.........************|          9.0
   1.700 |.........************|          9.0
   1.650 |.........************|          9.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.650 |..........**********|            11.0
  3.600 |..........**********|            11.0
  3.550 |..........**********|            11.0
  3.500 |..........**********|            11.0
  3.450 |..........**********|            11.0
  3.400 |..........**********|            11.0
  3.350 |..........**********|            11.0
  3.300 |..........**********|            11.0
  3.250 |..........**********|            11.0
  3.200 |..........**********|            11.0
  3.150 |..........**********|            11.0
  3.100 |..........**********|            11.0
  3.050 |..........**********|            11.0
  3.000 |..........**********|            11.0
  2.950 |..........**********|            11.0
  2.900 |..........**********|            11.0
  2.850 |..........**********|            11.0
  2.800 |..........**********|            11.0
  2.750 |..........**********|            11.0
  2.700 |..........**********|            11.0
  2.650 |..........**********|            11.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ 85°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.650 |..........**********|            11.0
  3.600 |..........**********|            11.0
  3.550 |..........**********|            11.0
  3.500 |..........**********|            11.0
  3.450 |..........**********|            11.0
  3.400 |..........**********|            11.0
  3.350 |..........**********|            11.0
  3.300 |..........**********|            11.0
  3.250 |..........**********|            11.0
  3.200 |..........**********|            11.0
  3.150 |..........**********|            11.0
  3.100 |..........**********|            11.0
  3.050 |..........**********|            11.0
  3.000 |..........**********|            11.0
  2.950 |..........**********|            11.0
  2.900 |..........**********|            11.0
  2.850 |..........**********|            11.0
  2.800 |..........**********|            11.0
  2.750 |..........**********|            11.0
  2.700 |..........**********|            11.0
  2.650 |..........**********|            11.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ 25°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.650  |..........***********|          10.0
  3.600  |..........***********|          10.0
  3.550  |..........***********|          10.0
  3.500  |..........***********|          10.0
  3.450  |..........***********|          10.0
  3.400  |..........***********|          10.0
  3.350  |..........***********|          10.0
  3.300  |..........***********|          10.0
  3.250  |..........***********|          10.0
  3.200  |..........***********|          10.0
  3.150  |..........***********|          10.0
  3.100  |..........***********|          10.0
  3.050  |..........***********|          10.0
  3.000  |..........***********|          10.0
  2.950  |..........***********|          10.0
  2.900  |..........***********|          10.0
  2.850  |..........***********|          10.0
  2.800  |..........***********|          10.0
  2.750  |..........***********|          10.0
  2.700  |..........***********|          10.0
  2.650  |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.650  |..........***********|          10.0
  3.600  |..........***********|          10.0
  3.550  |..........***********|          10.0
  3.500  |..........***********|          10.0
  3.450  |..........***********|          10.0
  3.400  |..........***********|          10.0
  3.350  |..........***********|          10.0
  3.300  |..........***********|          10.0
  3.250  |..........***********|          10.0
  3.200  |..........***********|          10.0
  3.150  |..........***********|          10.0
  3.100  |..........***********|          10.0
  3.050  |..........***********|          10.0
  3.000  |..........***********|          10.0
  2.950  |..........***********|          10.0
  2.900  |..........***********|          10.0
  2.850  |..........***********|          10.0
  2.800  |..........***********|          10.0
  2.750  |..........***********|          10.0
  2.700  |..........***********|          10.0
  2.650  |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 105°C

```
              0.0       10.0      20.0        first pass data
             |+----,----+----,----+|
       3.000 |...........**********|           11.0
       2.950 |...........**********|           11.0
       2.900 |...........**********|           11.0
       2.850 |...........**********|           11.0
       2.800 |...........**********|           11.0
       2.750 |...........**********|           11.0
       2.700 |...........**********|           11.0
       2.650 |...........**********|           11.0
       2.600 |...........**********|           11.0
       2.550 |............*********|           12.0
       2.500 |............*********|           12.0
       2.450 |............*********|           12.0
       2.400 |............*********|           12.0
       2.350 |............*********|           12.0
       2.300 |............*********|           12.0
       2.250 |............*********|           12.0
       2.200 |............*********|           12.0
       2.150 |............*********|           12.0
       2.100 |............*********|           12.0
       2.050 |............*********|           12.0
       2.000 |............*********|           12.0
       1.950 |............*********|           12.0
       1.900 |............*********|           12.0
       1.850 |............*********|           12.0
       1.800 |............*********|           12.0
       1.750 |.............********|           13.0
       1.700 |.............********|           13.0
       1.650 |.............********|           13.0
             |+----,----+----,----+|
               0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 85°C

```
               0.0       10.0      20.0        first pass data
             |+----,----+----,----+|
       3.000 |...........**********|           11.0
       2.950 |...........**********|           11.0
       2.900 |...........**********|           11.0
       2.850 |...........**********|           11.0
       2.800 |...........**********|           11.0
       2.750 |...........**********|           11.0
       2.700 |...........**********|           11.0
       2.650 |...........**********|           11.0
       2.600 |...........**********|           11.0
       2.550 |...........**********|           11.0
       2.500 |...........**********|           11.0
       2.450 |...........**********|           11.0
       2.400 |...........**********|           11.0
       2.350 |...........**********|           11.0
       2.300 |...........**********|           11.0
       2.250 |...........**********|           11.0
       2.200 |............*********|           12.0
       2.150 |............*********|           12.0
       2.100 |............*********|           12.0
       2.050 |............*********|           12.0
       2.000 |............*********|           12.0
       1.950 |............*********|           12.0
       1.900 |............*********|           12.0
       1.850 |............*********|           12.0
       1.800 |............*********|           12.0
       1.750 |............*********|           12.0
       1.700 |............*********|           12.0
       1.650 |.............********|           13.0
             |+----,----+----,----+|
               0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 25°C

```
         0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.000  |..........***********|          10.0
  2.950  |..........***********|          10.0
  2.900  |..........***********|          10.0
  2.850  |..........***********|          10.0
  2.800  |..........***********|          10.0
  2.750  |..........***********|          10.0
  2.700  |..........***********|          10.0
  2.650  |..........***********|          10.0
  2.600  |..........***********|          10.0
  2.550  |..........***********|          10.0
  2.500  |..........***********|          10.0
  2.450  |...........**********|          11.0
  2.400  |...........**********|          11.0
  2.350  |...........**********|          11.0
  2.300  |...........**********|          11.0
  2.250  |...........**********|          11.0
  2.200  |...........**********|          11.0
  2.150  |...........**********|          11.0
  2.100  |...........**********|          11.0
  2.050  |...........**********|          11.0
  2.000  |...........**********|          11.0
  1.950  |...........**********|          11.0
  1.900  |...........**********|          11.0
  1.850  |...........**********|          11.0
  1.800  |............*********|          12.0
  1.750  |............*********|          12.0
  1.700  |............*********|          12.0
  1.650  |............*********|          12.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ -40°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.000  |..........***********|          10.0
  2.950  |..........***********|          10.0
  2.900  |..........***********|          10.0
  2.850  |..........***********|          10.0
  2.800  |..........***********|          10.0
  2.750  |..........***********|          10.0
  2.700  |..........***********|          10.0
  2.650  |..........***********|          10.0
  2.600  |..........***********|          10.0
  2.550  |..........***********|          10.0
  2.500  |..........***********|          10.0
  2.450  |..........***********|          10.0
  2.400  |..........***********|          10.0
  2.350  |..........***********|          10.0
  2.300  |..........***********|          10.0
  2.250  |..........***********|          10.0
  2.200  |..........***********|          10.0
  2.150  |..........***********|          10.0
  2.100  |..........***********|          10.0
  2.050  |..........***********|          10.0
  2.000  |..........***********|          10.0
  1.950  |..........***********|          10.0
  1.900  |...........**********|          11.0
  1.850  |...........**********|          11.0
  1.800  |...........**********|          11.0
  1.750  |...........**********|          11.0
  1.700  |...........**********|          11.0
  1.650  |............*********|          12.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
        1.000     1.500     2.000     2.500     3.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |......................*******************|           2.100
3.600 |.....................********************|           2.050
3.550 |.....................********************|           2.050
3.500 |....................*********************|           2.000
3.450 |...................**********************|           1.950
3.400 |...................**********************|           1.950
3.350 |..................***********************|           1.900
3.300 |..................***********************|           1.900
3.250 |.................************************|           1.850
3.200 |.................************************|           1.850
3.150 |................*************************|           1.800
3.100 |...............**************************|           1.750
3.050 |...............**************************|           1.750
3.000 |..............***************************|           1.700
2.950 |..............***************************|           1.700
2.900 |.............****************************|           1.650
2.850 |.............****************************|           1.650
2.800 |............*****************************|           1.600
2.750 |............*****************************|           1.600
2.700 |...........******************************|           1.550
2.650 |..........*******************************|           1.500
      |+----,----+----,----+----,----+----,----+|
        1.000     1.500     2.000     2.500     3.000
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
        1.000     1.500     2.000     2.500     3.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |......................*******************|           2.100
3.600 |.....................********************|           2.050
3.550 |.....................********************|           2.050
3.500 |....................*********************|           2.000
3.450 |....................*********************|           2.000
3.400 |...................**********************|           1.950
3.350 |..................***********************|           1.900
3.300 |..................***********************|           1.900
3.250 |.................************************|           1.850
3.200 |.................************************|           1.850
3.150 |................*************************|           1.800
3.100 |................*************************|           1.800
3.050 |...............**************************|           1.750
3.000 |..............***************************|           1.700
2.950 |..............***************************|           1.700
2.900 |.............****************************|           1.650
2.850 |.............****************************|           1.650
2.800 |............*****************************|           1.600
2.750 |............*****************************|           1.600
2.700 |...........******************************|           1.550
2.650 |..........*******************************|           1.500
      |+----,----+----,----+----,----+----,----+|
        1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
     1.000     1.500     2.000     2.500     3.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |......................*******************|        2.100
3.600 |.....................********************|        2.050
3.550 |....................*********************|        2.000
3.500 |....................*********************|        2.000
3.450 |...................**********************|        1.950
3.400 |...................**********************|        1.950
3.350 |..................***********************|        1.900
3.300 |..................***********************|        1.900
3.250 |.................************************|        1.850
3.200 |................*************************|        1.800
3.150 |................*************************|        1.800
3.100 |...............**************************|        1.750
3.050 |...............**************************|        1.750
3.000 |..............***************************|        1.700
2.950 |..............***************************|        1.700
2.900 |.............****************************|        1.650
2.850 |.............****************************|        1.650
2.800 |............*****************************|        1.600
2.750 |............*****************************|        1.600
2.700 |...........******************************|        1.550
2.650 |..........*******************************|        1.500
      |+----,----+----,----+----,----+----,----+|
     1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
     1.000     1.500     2.000     2.500     3.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |......................*******************|        2.100
3.600 |.....................********************|        2.050
3.550 |.....................********************|        2.050
3.500 |....................*********************|        2.000
3.450 |....................*********************|        2.000
3.400 |...................**********************|        1.950
3.350 |..................***********************|        1.900
3.300 |..................***********************|        1.900
3.250 |.................************************|        1.850
3.200 |.................************************|        1.850
3.150 |................*************************|        1.800
3.100 |................*************************|        1.800
3.050 |...............**************************|        1.750
3.000 |..............***************************|        1.700
2.950 |..............***************************|        1.700
2.900 |.............****************************|        1.650
2.850 |.............****************************|        1.650
2.800 |............*****************************|        1.600
2.750 |............*****************************|        1.600
2.700 |...........******************************|        1.550
2.650 |...........******************************|        1.550
      |+----,----+----,----+----,----+----,----+|
     1.000     1.500     2.000     2.500     3.000
```

## $V_{IL}$ vs. $V_{CC}$ = $V_{IO}$ @ 105°C

```
        0.000     0.500     1.000     1.500     2.000        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |******************************...........|          1.450
 3.600 |******************************...........|          1.450
 3.550 |*****************************............|          1.400
 3.500 |*****************************............|          1.400
 3.450 |*****************************............|          1.400
 3.400 |****************************.............|          1.350
 3.350 |****************************.............|          1.350
 3.300 |****************************.............|          1.350
 3.250 |****************************.............|          1.350
 3.200 |***************************..............|          1.300
 3.150 |***************************..............|          1.300
 3.100 |***************************..............|          1.300
 3.050 |**************************...............|          1.250
 3.000 |**************************...............|          1.250
 2.950 |**************************...............|          1.250
 2.900 |*************************................|          1.200
 2.850 |*************************................|          1.200
 2.800 |************************.................|          1.150
 2.750 |************************.................|          1.150
 2.700 |***********************..................|          1.100
 2.650 |************************.................|          1.150
       |+----,----+----,----+----,----+----,----+|
        0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$ = $V_{IO}$ @ 85°C

```
        0.000     0.500     1.000     1.500     2.000        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |*******************************..........|          1.500
 3.600 |******************************...........|          1.450
 3.550 |******************************...........|          1.450
 3.500 |******************************...........|          1.450
 3.450 |*****************************............|          1.400
 3.400 |*****************************............|          1.400
 3.350 |*****************************............|          1.400
 3.300 |****************************.............|          1.350
 3.250 |****************************.............|          1.350
 3.200 |***************************..............|          1.300
 3.150 |***************************..............|          1.300
 3.100 |***************************..............|          1.300
 3.050 |***************************..............|          1.300
 3.000 |**************************...............|          1.250
 2.950 |*************************................|          1.200
 2.900 |*************************................|          1.200
 2.850 |*************************................|          1.200
 2.800 |*************************................|          1.200
 2.750 |************************.................|          1.150
 2.700 |************************.................|          1.150
 2.650 |************************.................|          1.150
       |+----,----+----,----+----,----+----,----+|
        0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$ =$V_{IO}$ @ 25°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*******************************..........|          1.500
3.600 |*******************************..........|          1.500
3.550 |******************************...........|          1.450
3.500 |*****************************............|          1.400
3.450 |*****************************............|          1.400
3.400 |*****************************............|          1.400
3.350 |****************************.............|          1.350
3.300 |*****************************............|          1.400
3.250 |****************************.............|          1.350
3.200 |***************************..............|          1.300
3.150 |***************************..............|          1.300
3.100 |***************************..............|          1.300
3.050 |***************************..............|          1.300
3.000 |**************************...............|          1.250
2.950 |**************************...............|          1.250
2.900 |**************************...............|          1.250
2.850 |**************************...............|          1.250
2.800 |*************************................|          1.200
2.750 |*************************................|          1.200
2.700 |************************.................|          1.150
2.650 |************************.................|          1.150
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*******************************..........|          1.500
3.600 |*******************************..........|          1.500
3.550 |******************************...........|          1.450
3.500 |******************************...........|          1.450
3.450 |******************************...........|          1.450
3.400 |******************************...........|          1.450
3.350 |*****************************............|          1.400
3.300 |*****************************............|          1.400
3.250 |****************************.............|          1.350
3.200 |****************************.............|          1.350
3.150 |****************************.............|          1.350
3.100 |***************************..............|          1.300
3.050 |***************************..............|          1.300
3.000 |***************************..............|          1.300
2.950 |**************************...............|          1.250
2.900 |**************************...............|          1.250
2.850 |**************************...............|          1.250
2.800 |*************************................|          1.200
2.750 |*************************................|          1.200
2.700 |*************************................|          1.200
2.650 |************************.................|          1.150
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
       2.000     2.500     3.000     3.500     4.000      first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|         3.600
3.600 |********************************.........|         3.550
3.550 |*******************************..........|         3.500
3.500 |******************************...........|         3.450
3.450 |*****************************............|         3.400
3.400 |****************************.............|         3.350
3.350 |***************************..............|         3.300
3.300 |**************************...............|         3.250
3.250 |*************************................|         3.200
3.200 |************************.................|         3.150
3.150 |***********************..................|         3.100
3.100 |**********************...................|         3.050
3.050 |*********************....................|         3.000
3.000 |********************.....................|         2.950
2.950 |*******************......................|         2.900
2.900 |******************.......................|         2.850
2.850 |*****************........................|         2.800
2.800 |****************.........................|         2.750
2.750 |***************..........................|         2.700
2.700 |**************...........................|         2.650
2.650 |*************............................|         2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       2.000     2.500     3.000     3.500     4.000      first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|         3.600
3.600 |********************************.........|         3.550
3.550 |*******************************..........|         3.500
3.500 |******************************...........|         3.450
3.450 |*****************************............|         3.400
3.400 |****************************.............|         3.350
3.350 |***************************..............|         3.300
3.300 |**************************...............|         3.250
3.250 |*************************................|         3.200
3.200 |************************.................|         3.150
3.150 |***********************..................|         3.100
3.100 |**********************...................|         3.050
3.050 |*********************....................|         3.000
3.000 |********************.....................|         2.950
2.950 |*******************......................|         2.900
2.900 |******************.......................|         2.850
2.850 |*****************........................|         2.800
2.800 |****************.........................|         2.750
2.750 |***************..........................|         2.700
2.700 |**************...........................|         2.650
2.650 |*************............................|         2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       2.000     2.500     3.000     3.500     4.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|         3.600
3.600 |********************************.........|         3.550
3.550 |*******************************..........|         3.500
3.500 |******************************...........|         3.450
3.450 |*****************************............|         3.400
3.400 |****************************.............|         3.350
3.350 |***************************..............|         3.300
3.300 |**************************...............|         3.250
3.250 |*************************................|         3.200
3.200 |************************.................|         3.150
3.150 |***********************..................|         3.100
3.100 |**********************...................|         3.050
3.050 |*********************....................|         3.000
3.000 |********************.....................|         2.950
2.950 |*******************......................|         2.900
2.900 |******************.......................|         2.850
2.850 |*****************........................|         2.800
2.800 |****************.........................|         2.750
2.750 |***************..........................|         2.700
2.700 |**************...........................|         2.650
2.650 |*************............................|         2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       2.000     2.500     3.000     3.500     4.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|         3.600
3.600 |********************************.........|         3.550
3.550 |*******************************..........|         3.500
3.500 |******************************...........|         3.450
3.450 |*****************************............|         3.400
3.400 |****************************.............|         3.350
3.350 |***************************..............|         3.300
3.300 |**************************...............|         3.250
3.250 |*************************................|         3.200
3.200 |************************.................|         3.150
3.150 |***********************..................|         3.100
3.100 |**********************...................|         3.050
3.050 |*********************....................|         3.000
3.000 |********************.....................|         2.950
2.950 |*******************......................|         2.900
2.900 |******************.......................|         2.850
2.850 |*****************........................|         2.800
2.800 |****************.........................|         2.750
2.750 |***************..........................|         2.700
2.700 |**************...........................|         2.650
2.650 |*************............................|         2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
         0.000      0.500      1.000        first pass data
        |+----,----+----,----+|
  3.650 |.********************|             0.050
  3.600 |.********************|             0.050
  3.550 |.********************|             0.050
  3.500 |.********************|             0.050
  3.450 |.********************|             0.050
  3.400 |.********************|             0.050
  3.350 |.********************|             0.050
  3.300 |.********************|             0.050
  3.250 |.********************|             0.050
  3.200 |.********************|             0.050
  3.150 |.********************|             0.050
  3.100 |.********************|             0.050
  3.050 |.********************|             0.050
  3.000 |.********************|             0.050
  2.950 |.********************|             0.050
  2.900 |.********************|             0.050
  2.850 |.********************|             0.050
  2.800 |.********************|             0.050
  2.750 |.********************|             0.050
  2.700 |.********************|             0.050
  2.650 |.********************|             0.050
        |+----,----+----,----+|
         0.000      0.500      1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
        0.000      0.500      1.000        first pass data
        |+----,----+----,----+|
  3.650 |.********************|             0.050
  3.600 |.********************|             0.050
  3.550 |.********************|             0.050
  3.500 |.********************|             0.050
  3.450 |.********************|             0.050
  3.400 |.********************|             0.050
  3.350 |.********************|             0.050
  3.300 |.********************|             0.050
  3.250 |.********************|             0.050
  3.200 |.********************|             0.050
  3.150 |.********************|             0.050
  3.100 |.********************|             0.050
  3.050 |.********************|             0.050
  3.000 |.********************|             0.050
  2.950 |.********************|             0.050
  2.900 |.********************|             0.050
  2.850 |.********************|             0.050
  2.800 |.********************|             0.050
  2.750 |.********************|             0.050
  2.700 |.********************|             0.050
  2.650 |.********************|             0.050
        |+----,----+----,----+|
         0.000      0.500      1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
        0.000      0.500      1.000        first pass data
       |+----,----+----,----+|
 3.650 |.********************|             0.050
 3.600 |.********************|             0.050
 3.550 |.********************|             0.050
 3.500 |.********************|             0.050
 3.450 |.********************|             0.050
 3.400 |.********************|             0.050
 3.350 |.********************|             0.050
 3.300 |.********************|             0.050
 3.250 |.********************|             0.050
 3.200 |.********************|             0.050
 3.150 |.********************|             0.050
 3.100 |.********************|             0.050
 3.050 |.********************|             0.050
 3.000 |.********************|             0.050
 2.950 |.********************|             0.050
 2.900 |.********************|             0.050
 2.850 |.********************|             0.050
 2.800 |.********************|             0.050
 2.750 |.********************|             0.050
 2.700 |.********************|             0.050
 2.650 |.********************|             0.050
       |+----,----+----,----+|
        0.000      0.500      1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
        0.000      0.500      1.000        first pass data
       |+----,----+----,----+|
 3.650 |.********************|             0.050
 3.600 |.********************|             0.050
 3.550 |.********************|             0.050
 3.500 |.********************|             0.050
 3.450 |.********************|             0.050
 3.400 |.********************|             0.050
 3.350 |.********************|             0.050
 3.300 |.********************|             0.050
 3.250 |.********************|             0.050
 3.200 |.********************|             0.050
 3.150 |.********************|             0.050
 3.100 |.********************|             0.050
 3.050 |.********************|             0.050
 3.000 |.********************|             0.050
 2.950 |.********************|             0.050
 2.900 |.********************|             0.050
 2.850 |.********************|             0.050
 2.800 |.********************|             0.050
 2.750 |.********************|             0.050
 2.700 |.********************|             0.050
 2.650 |.********************|             0.050
       |+----,----+----,----+|
        0.000      0.500      1.000
```

## $V_{IH}$ vs. $V_{IO}$ @ 105°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |........................*****************|          1.700
2.950 |........................*****************|          1.700
2.900 |.......................******************|          1.650
2.850 |.......................******************|          1.650
2.800 |......................*******************|          1.600
2.750 |......................*******************|          1.600
2.700 |.....................********************|          1.550
2.650 |....................*********************|          1.500
2.600 |....................*********************|          1.500
2.550 |...................**********************|          1.450
2.500 |...................**********************|          1.450
2.450 |..................***********************|          1.400
2.400 |..................***********************|          1.400
2.350 |.................************************|          1.350
2.300 |.................************************|          1.350
2.250 |................*************************|          1.300
2.200 |................*************************|          1.300
2.150 |...............**************************|          1.250
2.100 |..............***************************|          1.200
2.050 |..............***************************|          1.200
2.000 |..............***************************|          1.200
1.950 |.............****************************|          1.150
1.900 |............*****************************|          1.100
1.850 |............*****************************|          1.100
1.800 |............*****************************|          1.100
1.750 |...........******************************|          1.050
1.700 |..........*******************************|          1.000
1.650 |..........*******************************|          1.000
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

## $V_{IH}$ vs. $V_{IO}$ @ 85°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |........................*****************|          1.700
2.950 |........................*****************|          1.700
2.900 |.......................******************|          1.650
2.850 |.......................******************|          1.650
2.800 |......................*******************|          1.600
2.750 |......................*******************|          1.600
2.700 |.....................********************|          1.550
2.650 |....................*********************|          1.500
2.600 |....................*********************|          1.500
2.550 |...................**********************|          1.450
2.500 |...................**********************|          1.450
2.450 |..................***********************|          1.400
2.400 |..................***********************|          1.400
2.350 |.................************************|          1.350
2.300 |.................************************|          1.350
2.250 |................*************************|          1.300
2.200 |................*************************|          1.300
2.150 |...............**************************|          1.250
2.100 |...............**************************|          1.250
2.050 |..............***************************|          1.200
2.000 |.............****************************|          1.150
1.950 |.............****************************|          1.150
1.900 |............*****************************|          1.100
1.850 |............*****************************|          1.100
1.800 |...........******************************|          1.050
1.750 |...........******************************|          1.050
1.700 |..........*******************************|          1.000
1.650 |..........*******************************|          1.000
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ @ 25°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |........................*****************|          1.700
2.950 |........................*****************|          1.700
2.900 |.......................******************|          1.650
2.850 |.......................******************|          1.650
2.800 |......................*******************|          1.600
2.750 |......................*******************|          1.600
2.700 |.....................********************|          1.550
2.650 |....................*********************|          1.500
2.600 |....................*********************|          1.500
2.550 |...................**********************|          1.450
2.500 |...................**********************|          1.450
2.450 |..................***********************|          1.400
2.400 |..................***********************|          1.400
2.350 |.................************************|          1.350
2.300 |.................************************|          1.350
2.250 |................*************************|          1.300
2.200 |................*************************|          1.300
2.150 |...............**************************|          1.250
2.100 |..............***************************|          1.200
2.050 |..............***************************|          1.200
2.000 |.............****************************|          1.150
1.950 |.............****************************|          1.150
1.900 |............*****************************|          1.100
1.850 |............*****************************|          1.100
1.800 |...........******************************|          1.050
1.750 |...........******************************|          1.050
1.700 |..........*******************************|          1.000
1.650 |.........********************************|          0.950
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ @ -40°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |........................*****************|          1.700
2.950 |........................*****************|          1.700
2.900 |.......................******************|          1.650
2.850 |.......................******************|          1.650
2.800 |......................*******************|          1.600
2.750 |......................*******************|          1.600
2.700 |.....................********************|          1.550
2.650 |.....................********************|          1.550
2.600 |....................*********************|          1.500
2.550 |...................**********************|          1.450
2.500 |...................**********************|          1.450
2.450 |..................***********************|          1.400
2.400 |..................***********************|          1.400
2.350 |.................************************|          1.350
2.300 |.................************************|          1.350
2.250 |................*************************|          1.300
2.200 |................*************************|          1.300
2.150 |...............**************************|          1.250
2.100 |...............**************************|          1.250
2.050 |..............***************************|          1.200
2.000 |..............***************************|          1.200
1.950 |.............****************************|          1.150
1.900 |............*****************************|          1.100
1.850 |............*****************************|          1.100
1.800 |...........******************************|          1.050
1.750 |..........*******************************|          1.000
1.700 |..........*******************************|          1.000
1.650 |.........********************************|          0.950
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

## $V_{IL}$ vs. $V_{IO}$ @ 105°C

```
        0.000     0.500     1.000     1.500     2.000        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.000 |**************************...............|         1.250
 2.950 |**************************...............|         1.250
 2.900 |*************************................|         1.200
 2.850 |*************************................|         1.200
 2.800 |************************.................|         1.150
 2.750 |************************.................|         1.150
 2.700 |************************.................|         1.150
 2.650 |***********************..................|         1.100
 2.600 |***********************..................|         1.100
 2.550 |***********************..................|         1.100
 2.500 |***********************..................|         1.100
 2.450 |**********************...................|         1.050
 2.400 |**********************...................|         1.050
 2.350 |*********************....................|         1.000
 2.300 |*********************....................|         1.000
 2.250 |*********************....................|         1.000
 2.200 |********************.....................|         0.950
 2.150 |********************.....................|         0.950
 2.100 |*******************......................|         0.900
 2.050 |*******************......................|         0.900
 2.000 |*******************......................|         0.900
 1.950 |******************.......................|         0.850
 1.900 |******************.......................|         0.850
 1.850 |******************.......................|         0.850
 1.800 |******************.......................|         0.850
 1.750 |******************.......................|         0.850
 1.700 |******************.......................|         0.850
 1.650 |*****************........................|         0.800
       |+----,----+----,----+----,----+----,----+|
        0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ @ 85°C

```
        0.000     0.500     1.000     1.500     2.000        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.000 |**************************...............|         1.250
 2.950 |**************************...............|         1.250
 2.900 |*************************................|         1.200
 2.850 |*************************................|         1.200
 2.800 |*************************................|         1.200
 2.750 |************************.................|         1.150
 2.700 |************************.................|         1.150
 2.650 |************************.................|         1.150
 2.600 |***********************..................|         1.100
 2.550 |***********************..................|         1.100
 2.500 |***********************..................|         1.100
 2.450 |**********************...................|         1.050
 2.400 |**********************...................|         1.050
 2.350 |*********************....................|         1.000
 2.300 |*********************....................|         1.000
 2.250 |*********************....................|         1.000
 2.200 |********************.....................|         0.950
 2.150 |********************.....................|         0.950
 2.100 |********************.....................|         0.950
 2.050 |*******************......................|         0.900
 2.000 |*******************......................|         0.900
 1.950 |*******************......................|         0.900
 1.900 |******************.......................|         0.850
 1.850 |******************.......................|         0.850
 1.800 |******************.......................|         0.850
 1.750 |******************.......................|         0.850
 1.700 |*****************........................|         0.800
 1.650 |*****************........................|         0.800
       |+----,----+----,----+----,----+----,----+|
        0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ @ 25°C

```
       0.000     0.500     1.000     1.500     2.000      first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |***************************..............|          1.300
2.950 |**************************...............|          1.250
2.900 |**************************...............|          1.250
2.850 |**************************...............|          1.250
2.800 |*************************................|          1.200
2.750 |*************************................|          1.200
2.700 |************************.................|          1.150
2.650 |************************.................|          1.150
2.600 |************************.................|          1.150
2.550 |***********************..................|          1.100
2.500 |***********************..................|          1.100
2.450 |***********************..................|          1.100
2.400 |**********************...................|          1.050
2.350 |**********************...................|          1.050
2.300 |*********************....................|          1.000
2.250 |*********************....................|          1.000
2.200 |*********************....................|          1.000
2.150 |********************.....................|          0.950
2.100 |********************.....................|          0.950
2.050 |*******************......................|          0.900
2.000 |*******************......................|          0.900
1.950 |*******************......................|          0.900
1.900 |******************.......................|          0.850
1.850 |******************.......................|          0.850
1.800 |******************.......................|          0.850
1.750 |******************.......................|          0.850
1.700 |*****************........................|          0.800
1.650 |*****************........................|          0.800
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ @ -40°C

```
       0.000     0.500     1.000     1.500     2.000      first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |***************************..............|          1.300
2.950 |**************************...............|          1.250
2.900 |**************************...............|          1.250
2.850 |**************************...............|          1.250
2.800 |*************************................|          1.200
2.750 |*************************................|          1.200
2.700 |*************************................|          1.200
2.650 |************************.................|          1.150
2.600 |************************.................|          1.150
2.550 |************************.................|          1.150
2.500 |***********************..................|          1.100
2.450 |***********************..................|          1.100
2.400 |***********************..................|          1.100
2.350 |**********************...................|          1.050
2.300 |**********************...................|          1.050
2.250 |*********************....................|          1.000
2.200 |*********************....................|          1.000
2.150 |*********************....................|          1.000
2.100 |********************.....................|          0.950
2.050 |********************.....................|          0.950
2.000 |*******************......................|          0.900
1.950 |*******************......................|          0.900
1.900 |*******************......................|          0.900
1.850 |******************.......................|          0.850
1.800 |******************.......................|          0.850
1.750 |******************.......................|          0.850
1.700 |******************.......................|          0.850
1.650 |*****************........................|          0.800
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{OH}$ vs. $V_{IO}$ @ 105°C

```
       1.500     2.000     2.500     3.000     3.500        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |******************************...........|          2.950
2.950 |*****************************............|          2.900
2.900 |****************************.............|          2.850
2.850 |***************************..............|          2.800
2.800 |**************************...............|          2.750
2.750 |*************************................|          2.700
2.700 |************************.................|          2.650
2.650 |***********************..................|          2.600
2.600 |**********************...................|          2.550
2.550 |*********************....................|          2.500
2.500 |********************.....................|          2.450
2.450 |*******************......................|          2.400
2.400 |******************.......................|          2.350
2.350 |*****************........................|          2.300
2.300 |****************.........................|          2.250
2.250 |***************..........................|          2.200
2.200 |**************...........................|          2.150
2.150 |*************............................|          2.100
2.100 |************.............................|          2.050
2.050 |***********..............................|          2.000
2.000 |**********...............................|          1.950
1.950 |*********................................|          1.900
1.900 |********.................................|          1.850
1.850 |*******..................................|          1.800
1.800 |******...................................|          1.750
1.750 |*****....................................|          1.700
1.700 |****.....................................|          1.650
1.650 |***......................................|          1.600
      |+----,----+----,----+----,----+----,----+|
        1.500     2.000     2.500     3.000     3.500
```

## $V_{OH}$ vs. $V_{IO}$ @ 85°C

```
       1.500     2.000     2.500     3.000     3.500        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |******************************...........|          2.950
2.950 |*****************************............|          2.900
2.900 |****************************.............|          2.850
2.850 |***************************..............|          2.800
2.800 |**************************...............|          2.750
2.750 |*************************................|          2.700
2.700 |************************.................|          2.650
2.650 |***********************..................|          2.600
2.600 |**********************...................|          2.550
2.550 |*********************....................|          2.500
2.500 |********************.....................|          2.450
2.450 |*******************......................|          2.400
2.400 |******************.......................|          2.350
2.350 |*****************........................|          2.300
2.300 |****************.........................|          2.250
2.250 |***************..........................|          2.200
2.200 |**************...........................|          2.150
2.150 |*************............................|          2.100
2.100 |************.............................|          2.050
2.050 |***********..............................|          2.000
2.000 |**********...............................|          1.950
1.950 |*********................................|          1.900
1.900 |********.................................|          1.850
1.850 |*******..................................|          1.800
1.800 |******...................................|          1.750
1.750 |*****....................................|          1.700
1.700 |****.....................................|          1.650
1.650 |***......................................|          1.600
      |+----,----+----,----+----,----+----,----+|
        1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ @ 25°C

```
       1.500     2.000     2.500     3.000     3.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |******************************...........|         2.950
2.950 |*****************************............|         2.900
2.900 |****************************.............|         2.850
2.850 |***************************..............|         2.800
2.800 |**************************...............|         2.750
2.750 |*************************................|         2.700
2.700 |************************.................|         2.650
2.650 |***********************..................|         2.600
2.600 |**********************...................|         2.550
2.550 |*********************....................|         2.500
2.500 |********************.....................|         2.450
2.450 |*******************......................|         2.400
2.400 |******************.......................|         2.350
2.350 |*****************........................|         2.300
2.300 |****************.........................|         2.250
2.250 |***************..........................|         2.200
2.200 |**************...........................|         2.150
2.150 |*************............................|         2.100
2.100 |************.............................|         2.050
2.050 |***********..............................|         2.000
2.000 |**********...............................|         1.950
1.950 |*********................................|         1.900
1.900 |********.................................|         1.850
1.850 |*******..................................|         1.800
1.800 |******...................................|         1.750
1.750 |*****....................................|         1.700
1.700 |****.....................................|         1.650
1.650 |***......................................|         1.600
      |+----,----+----,----+----,----+----,----+|
       1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ @ -40°C

```
       1.500     2.000     2.500     3.000     3.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |******************************...........|         2.950
2.950 |*****************************............|         2.900
2.900 |****************************.............|         2.850
2.850 |***************************..............|         2.800
2.800 |**************************...............|         2.750
2.750 |*************************................|         2.700
2.700 |************************.................|         2.650
2.650 |***********************..................|         2.600
2.600 |**********************...................|         2.550
2.550 |*********************....................|         2.500
2.500 |********************.....................|         2.450
2.450 |*******************......................|         2.400
2.400 |******************.......................|         2.350
2.350 |*****************........................|         2.300
2.300 |****************.........................|         2.250
2.250 |***************..........................|         2.200
2.200 |**************...........................|         2.150
2.150 |*************............................|         2.100
2.100 |************.............................|         2.050
2.050 |***********..............................|         2.000
2.000 |**********...............................|         1.950
1.950 |*********................................|         1.900
1.900 |********.................................|         1.850
1.850 |*******..................................|         1.800
1.800 |******...................................|         1.750
1.750 |*****....................................|         1.700
1.700 |****.....................................|         1.650
1.650 |***......................................|         1.600
      |+----,----+----,----+----,----+----,----+|
       1.500     2.000     2.500     3.000     3.500
```

## $V_{OL}$ vs. $V_{IO}$ @ 105°C

```
         0.000      0.500      1.000        first pass data
        |+----,----+----,----+|
  3.000 |.********************|              0.050
  2.950 |.********************|              0.050
  2.900 |.********************|              0.050
  2.850 |.********************|              0.050
  2.800 |.********************|              0.050
  2.750 |.********************|              0.050
  2.700 |.********************|              0.050
  2.650 |.********************|              0.050
  2.600 |.********************|              0.050
  2.550 |.********************|              0.050
  2.500 |.********************|              0.050
  2.450 |.********************|              0.050
  2.400 |.********************|              0.050
  2.350 |.********************|              0.050
  2.300 |.********************|              0.050
  2.250 |.********************|              0.050
  2.200 |.********************|              0.050
  2.150 |.********************|              0.050
  2.100 |.********************|              0.050
  2.050 |.********************|              0.050
  2.000 |.********************|              0.050
  1.950 |.********************|              0.050
  1.900 |.********************|              0.050
  1.850 |.********************|              0.050
  1.800 |.********************|              0.050
  1.750 |.********************|              0.050
  1.700 |.********************|              0.050
  1.650 |.********************|              0.050
        |+----,----+----,----+|
          0.000      0.500      1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ 85°C

```
          0.000      0.500      1.000        first pass data
        |+----,----+----,----+|
  3.000 |.********************|              0.050
  2.950 |.********************|              0.050
  2.900 |.********************|              0.050
  2.850 |.********************|              0.050
  2.800 |.********************|              0.050
  2.750 |.********************|              0.050
  2.700 |.********************|              0.050
  2.650 |.********************|              0.050
  2.600 |.********************|              0.050
  2.550 |.********************|              0.050
  2.500 |.********************|              0.050
  2.450 |.********************|              0.050
  2.400 |.********************|              0.050
  2.350 |.********************|              0.050
  2.300 |.********************|              0.050
  2.250 |.********************|              0.050
  2.200 |.********************|              0.050
  2.150 |.********************|              0.050
  2.100 |.********************|              0.050
  2.050 |.********************|              0.050
  2.000 |.********************|              0.050
  1.950 |.********************|              0.050
  1.900 |.********************|              0.050
  1.850 |.********************|              0.050
  1.800 |.********************|              0.050
  1.750 |.********************|              0.050
  1.700 |.********************|              0.050
  1.650 |.********************|              0.050
        |+----,----+----,----+|
          0.000      0.500      1.000
```

### $V_{OL}$ vs. $V_{IO}$ @ 25°C

```
          0.000     0.500     1.000        first pass data
         |+----,----+----,----+|
  3.000  |.********************|           0.050
  2.950  |.********************|           0.050
  2.900  |.********************|           0.050
  2.850  |.********************|           0.050
  2.800  |.********************|           0.050
  2.750  |.********************|           0.050
  2.700  |.********************|           0.050
  2.650  |.********************|           0.050
  2.600  |.********************|           0.050
  2.550  |.********************|           0.050
  2.500  |.********************|           0.050
  2.450  |.********************|           0.050
  2.400  |.********************|           0.050
  2.350  |.********************|           0.050
  2.300  |.********************|           0.050
  2.250  |.********************|           0.050
  2.200  |.********************|           0.050
  2.150  |.********************|           0.050
  2.100  |.********************|           0.050
  2.050  |.********************|           0.050
  2.000  |.********************|           0.050
  1.950  |.********************|           0.050
  1.900  |.********************|           0.050
  1.850  |.********************|           0.050
  1.800  |.********************|           0.050
  1.750  |.********************|           0.050
  1.700  |.********************|           0.050
  1.650  |.********************|           0.050
         |+----,----+----,----+|
          0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{IO}$ @ -40°C

```
          0.000     0.500     1.000        first pass data
         |+----,----+----,----+|
  3.000  |.********************|           0.050
  2.950  |.********************|           0.050
  2.900  |.********************|           0.050
  2.850  |.********************|           0.050
  2.800  |.********************|           0.050
  2.750  |.********************|           0.050
  2.700  |.********************|           0.050
  2.650  |.********************|           0.050
  2.600  |.********************|           0.050
  2.550  |.********************|           0.050
  2.500  |.********************|           0.050
  2.450  |.********************|           0.050
  2.400  |.********************|           0.050
  2.350  |.********************|           0.050
  2.300  |.********************|           0.050
  2.250  |.********************|           0.050
  2.200  |.********************|           0.050
  2.150  |.********************|           0.050
  2.100  |.********************|           0.050
  2.050  |.********************|           0.050
  2.000  |.********************|           0.050
  1.950  |.********************|           0.050
  1.900  |.********************|           0.050
  1.850  |.********************|           0.050
  1.800  |.********************|           0.050
  1.750  |.********************|           0.050
  1.700  |.********************|           0.050
  1.650  |.********************|           0.050
         |+----,----+----,----+|
          0.000     0.500     1.000
```

# 16. Quality Assurance Guidelines

Cypress is totally committed to shipping the highest quality product to its customers.

To assure this quality commitment, each commercial manufacturing lot must meet the requirements defined in all of the specifications listed below:

| Procedure | Test Method | Quality Test |
|---|---|---|
| Electrical Classification Tests | Guard banded to Data Sheet Specification | 100% |
| Mark | Cypress F16-018 | 100% |
| Lead Scan / Straighten | Cypress F16-049 | 100% |
| Visual / Mechanical Inspection | Cypress F16-049 | 100% |
| QA Documentation / Test verification | Cypress F06-027 | 100% |
| QA - Visual / Mechanical<br>Excelsior Monitor (See Below)<br>Qualification Maintenance Program | Cypress F06-027<br>Cypress F00-006<br>Cypress F01-002.18 | Sample<br>Sample<br>Sample |

## 16.1 Excelsior Quality Monitor

Cypress's Excelsior Quality Program is an in-line monitor of electrical, visual/mechanical, solderability and marking permanency quality. Data from Excelsior Electrical Monitor may be made available to customers on request. Samples are selected from production lots and subjected to data sheet electrical temperature requirements. Any failures are analyzed by product engineering and appropriate corrective action is implemented. The excelsior quality levels are summarized by each product line on a monthly basis. This monitor has proven to be instrumental in Cypress's drive to attain the highest quality levels in the industry.

## 16.2 Process Change Notification

The Cypress Process Change Notification System aims to notify the customer of major product changes 90 days prior to the implementation of that change. A change is considered to be major if it affects the application, performance, quality, reliability, parameter distribution, form, fit or function of the product. In addition we may also notify changes such as relocation of manufacturing sites, certain Data Sheet items, or other changes that may affect use or acceptance of the product. It should be noted that all changes are fully evaluated and qualified in accordance with well established and rigorous procedures. The changed product is not released for production or shipment until satisfactory qualification results, consistent with stable processes, predictable distributions and satisfactory and expected reliability figures and yields are achieved. Often shipment is recommended before the formal qualification report is available. The actual qualification tests, however, are completed and approved prior to shipment.

## 16.3 Customer Corrective Action Request

Cypress's Customer Corrective Action Request (CCAR) system provides a means for submitting customer perceived product problems to Cypress's factory for analysis. The analysis may be comprised of several stages, usually an initial analysis and follow-up analysis. A summary of Cypress's findings are issued. These may include corrective actions, requests for additional information or detailed failure analysis results.

# 17. Qualification Maintenance Program

The Cypress Qualification Maintenance Program (QMP) is used to measure the reliability of all process families on a regular basis. As it is not feasible to monitor the reliability of each of the literally hundreds of device types that Cypress produces, devices representative of the wafer fabrication process and the generic device grouping are selected on the basis of complexity, production volume, and strategic importance. These samples are subjected to the typical accelerated stress tests listed below on a monthly basis. Any failures encountered are analyzed by product engineering and appropriate corrective action is implemented. The results of this testing are summarized in the Cypress Quarterly Reliability Report (QRR).

## 17.1 Types of Stress

Several different process technology groups have been identified based on similarity of process parameters. Representative product types for each of these groups are listed in the Cypress QRR. Failure rates are tabulated for defective sub-populations and competing failure mechanisms. Two common measures of failure rates are early life failure rate (EL) and inherent life failure rate (IL). The early life period corresponds to approximately the first 4,000 hours at field use conditions. The inherent life corresponds to the useful life beyond the first 4000 of field operation. For these calculations, device operation temperature is assumed to be 55°C ambient unless otherwise noted. Voltage acceleration factors are used in the analysis wherever noted.

## 17.2 Reliability Monitor Stress Conditions

| Stress | Package | Typical Duration | Target Sample Size | Typical Conditions |
|---|---|---|---|---|
| Early Life | All | 24, 168 hours | 350 | 125°C or 150°C, $V_{CC}$ max |
| Inherent Life | All | 1000 hours | 120 | 125°C or 150°C, $V_{CC}$ max |
| Endurance Cycling | All | 10000 cycles | 64 | 90°C |
| Data Retention Bake | All | 1000 hours | 64 | 150°C |
| Preconditioning (PC) | All | 216 hours | 231 | 30°C/70% RH Soak,<br>3X Reflow @ 260°C |
| PC + Temperature Cycle | Discrete, 2 die MCP | 1000 cycles | 77 | –40°C to 150°C |
| | > 2 die MCP | 1000 cycles | 77 | –55°C to 125°C |
| PC + Biased HAST | BGA | 264 hours | 77 | 110°C, 85% RH, $V_{CC}$ max alt. bias |
| | Lead Frame | 96 hours | 77 | 130°C, 85% RH, $V_{CC}$ max alt. bias |
| PC + Unbiased HAST | All | 96 hours | 77 | 110°C, 85% RH, no bias |

# 18. Statistical Process Management

Statistical Process Management is used extensively throughout manufacturing and engineering areas in Cypress to help in reducing process variation and optimizing product/process performance. Examples of the tools used are Statistical Process Control (SPC), Process Capability Studies, Design of Experiments, Measurement Systems Analysis, Systematic Problem Solving, Structured project management, and statistical yield analysis, etc.

Some highlights of our SPC program include:

- Ubiquitous and intelligent use of problem solving methodologies
- SPC is 100% automated in all manufacturing areas using both statistically and economically derived Control Limits
- Out of Control Trouble Shooting Guides
- Statistical Equipment Control, (monitoring and control of input variables)
- Advanced Process Control (model based, active run-to-run control of processes during wafer fabrication)
- Suppliers are encouraged to implement SPC
- Six-Sigma target for critical processes

## 18.1 Kaizen + Program

All the training of statistical analysis tools, as well as other hard and soft improvement skills such as FMEA, Lean, Error Proofing, Structured Teamwork, are provided to employees as a part of Cypress's Kaizen+ (continuous improvement) program. The program involves all functional groups by establishing a structure that consists of a Champion, internal/external certified Black, Brown, Green and Yellow Belts in each organization to drive for improvement projects. The results are shared in a Project Sharing Conference twice per year. Statistical thinking and use of statistical methods are a part of Cypress's Kaizen+ culture.

# 19. Revision History

| Section | Description |
|---|---|
| **Revision 01 (June 20, 2013)** | |
| | Initial release |

| **Document Title: S29GL256S (WXIC) Qualification Database<br>Document Number: 002-00606** | | | | |
|---|---|---|---|---|
| **Revision** | **ECN** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| ** | – | – | 06/20/2013 | Initial release |
| *A | 6204461 | CNSO | 06/12/2018 | Updated *Assembly Packaging Summary on page 10*:<br>Updated *LAE064 on page 10*:<br>Changed value of Theta Ja from 39°C/W to 33°C/W.<br>Changed value of Psi Jt from 11°C/W to 0.07°C/W.<br>Updated *LAA064 on page 10*:<br>Changed value of Theta Ja from 39°C/W to 24.1°C/W.<br>Changed value of Psi Jt from 11°C/W to 0.07°C/W.<br>Updated *TS056 on page 11*:<br>Changed value of Theta Ja from 40°C/W to 46°C/W.<br>Changed value of Psi Jt from 17°C/W to 0.21°C/W.<br>Updated *VBU056 on page 11*:<br>Changed value of Theta Ja from 39°C/W to 34.5°C/W.<br>Changed value of Psi Jt from 11°C/W to 0.10°C/W.<br>Updated *Quality Assurance Guidelines on page 69*:<br>Updated *Process Change Notification on page 69*:<br>Replaced “Advance Change Notification” with “Process Change Notification” in heading.<br>Updated description.<br>Updated to Cypress template.<br>Completing Sunset Review. |

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# S29GL01GS (XMC 85C 105C)

*Qualification Database*

**Notice:** The material in this report is confidential. It is prepared to assist in the qualification of our product. It is intended for the internal use of our customers only, and may be modified to meet the needs of specific customers.

Additionally, the package details (material set, assembly location, etc.) are specific to the qualification vehicle used. Alternate material sets and assembly locations may be qualified for the product. Production material can be assembled with any qualified material set and at any qualified assembly location.

# Contents

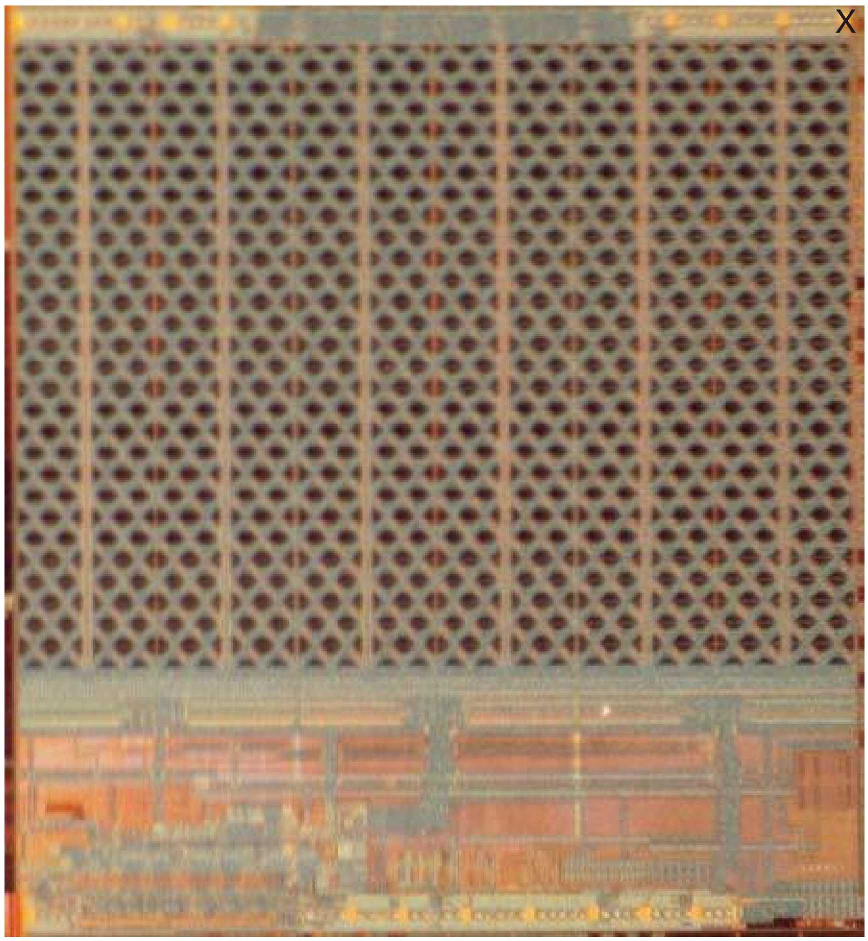
# Figures

# 1. Introduction

The Cypress® S29GL01GS flash memory device has a die size of 6.803 × 7.455 mm.

# 2. Die Photograph

**Figure 1. Die Photograph**




***Note:***
*1. X in the diagram is pad #1. Count counter clockwise.*

# 3. Pad Definition

| Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA | Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA |
|---|---|---|---|---|---|---|---|
| 1 | NC | | | 38 | VCC | 43 | G5 |
| 2 | A23 | 1 | C8 | 39 | VSS | 33,52 | H7 |
| 3 | A22 | 2 | B8 | 40 | VCC | 43 | G5 |
| 4 | A15 | 3 | D7 | 41 | VSS | 33,52 | H7 |
| 5 | A14 | 4 | C7 | 42 | VSS | 33,52 | H7 |
| 6 | A13 | 5 | A7 | 43 | VCC | 43 | G5 |
| 7 | A12 | 6 | B7 | 44 | A0 | 31 | E2 |
| 8 | A11 | 7 | D6 | 45 | CE# | 32 | F2 |
| 9 | A10 | 8 | C6 | 46 | OE# | 34 | G2 |
| 10 | A9 | 9 | A6 | 47 | NC | | |
| 11 | A8 | 10 | B6 | 48 | DQ0 | 35 | E3 |
| 12 | A19 | 11 | D5 | 49 | DQ8 | 36 | F3 |
| 13 | A20 | 12 | D4 | 50 | VSS | 33,52 | H2, E8 |
| 14 | WE# | 13 | A5 | 51 | VIO | 29 | F1, D8 |
| 15 | VSS | 33, 52 | H7 | 52 | DQ1 | 37 | H3 |
| 16 | VCC | 43 | G5 | 53 | DQ9 | 38 | G3 |
| 17 | VSS | 33, 52 | H7 | 54 | DQ2 | 39 | E4 |
| 18 | VCC | 43 | G5 | 55 | DQ10 | 40 | F4 |
| 19 | NC | | | 56 | DQ3 | 41 | H4 |
| 20 | RESET# | 14 | B5 | 57 | DQ11 | 42 | G4 |
| 21 | A21 | 15 | C5 | 58 | DQ4 | 44 | H5 |
| 22 | WP# | 16 | B4 | 59 | DQ12 | 45 | F5 |
| 23 | RY/BY# | 17 | A4 | 60 | DQ5 | 46 | E5 |
| 24 | VIO | 29 | D8, F1 | 61 | DQ13 | 47 | G6 |
| 25 | VSS | 33, 52 | H7 | 62 | NC | | |
| 26 | A18 | 18 | C4 | 63 | VSS | 33,52 | H7 |
| 27 | A17 | 19 | B3 | 64 | VCC | 43 | G5 |
| 28 | A7 | 20 | A3 | 65 | DQ6 | 48 | H6 |
| 29 | A6 | 21 | C3 | 66 | DQ14 | 49 | F6 |
| 30 | A5 | 22 | D3 | 67 | DQ7 | 50 | E6 |
| 31 | A4 | 23 | B2 | 68 | DQ15 | 51 | G7 |
| 32 | A3 | 24 | A2 | 69 | VIO | 29 | D8, F1 |
| 33 | A2 | 25 | C2 | 70 | VSS | 33, 52 | E8, H2 |
| 34 | A1 | 26 | D2 | 71 | A16 | 54 | E7 |
| 35 | DNU | 28 | E1 | 72 | A25 | 55 | G8 |
| 36 | VCC | 43 | G5 | 73 | A24 | 56 | F8 |
| 37 | VSS | 33, 52 | H7 | | | | |

# 4. Physical Sector Layout

**Figure 2. Physical Sector Layout**

| Internal Use Row 86 | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Row 85 | 1020 | 1021 | 1022 | 1023 | | | | | Internal Use | Internal Use | Internal Use | Internal Use |
| Row 84 | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | 1017 | 1018 | 1019 |
| ... | | | | | | | | | | | | |
| Row 3 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
| Row 2 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
| Row 1 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Row 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Vertical Bank | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| Bank | 0 | | | | 1 | | | | 2 | | | |

# 5. Sector Enlargement

**Figure 3. Sector Enlargement**

**IO Organization**

| | Internal Use | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **M3BL** | 0-7 | 0-63 | 64-127 | 128-191 | 192-255 | 256-319 | 320-383 | 384-447 | 448-511 | 512-575 | 576-639 |
| **M1BL** | 8-15 | 0-127 | 128-255 | 256-383 | 384-511 | 512-639 | 640-767 | 768-895 | 896-1023 | 1024-1151 | 1152-1279 |

| | 10 | 11 | 12 | 13 | 14 | 15 | Internal Use | Internal Use | Internal Use | Internal Use |
|---|---|---|---|---|---|---|---|---|---|---|
| **M3BL** | 640-703 | 704-767 | 768-831 | 832-895 | 896-959 | 960-1023 | 1024-1063 | 1064-1071 | 1072-1079 | 0-7 |
| **M1BL** | 1280-1407 | 1408-1535 | 1536-1663 | 1664-1791 | 1792-1919 | 1920-2047 | 2048-2127 | 2128-2143 | 2144-2159 | 0-7 |

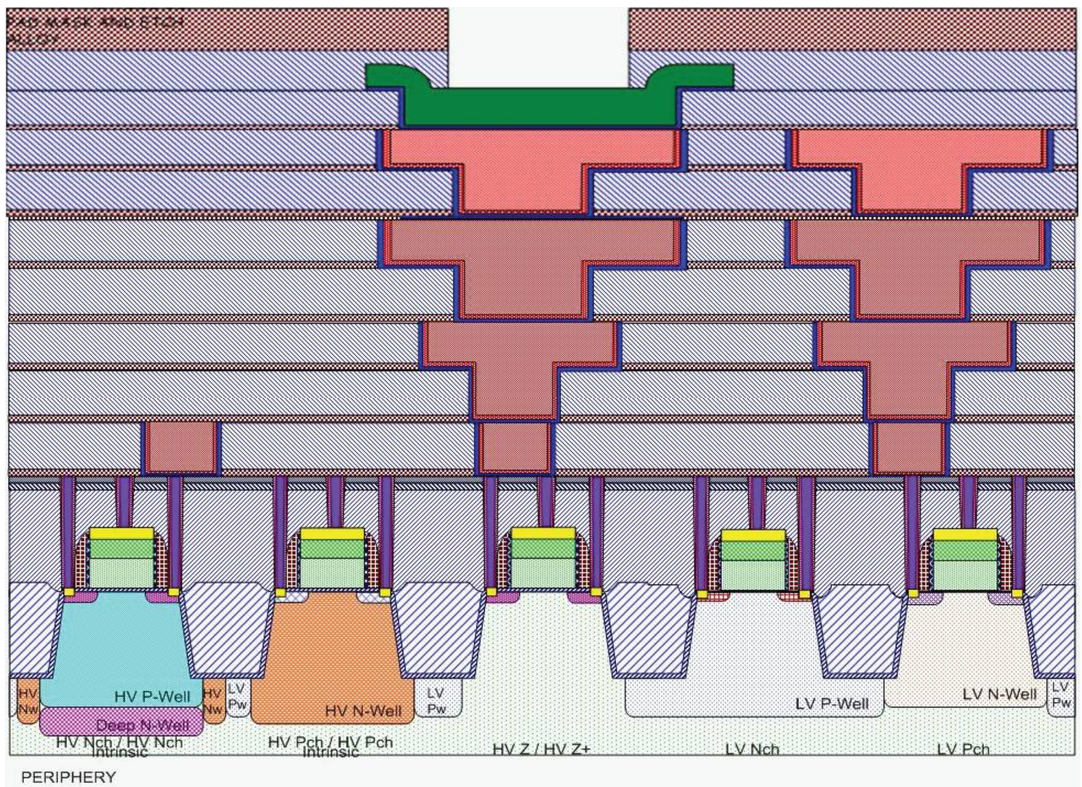
# 6. Die Processing Summary

The Cypress S29GL01GS flash memory device is manufactured using the 65 nm MirrorBit® Eclipse™ process technology.

The device is processed at WXIC, a 12-inch CMOS manufacturing facility located in Wuhan, China.

The device is manufactured on the highly reliable CS239LS process.

**Figure 4. Die Process**



## 6.1 Key Features of the CS239LS MirrorBit Eclipse Process Technology

**A. Technology**

- CMOS Triple-well process
- Proven reliable Flash MirrorBit Eclipse Technology

**B. Transistor Types**

- n-channel enhancement
- n-channel intrinsic
- p-channel enhancement
- MirrorBit core cell

**C. Process Features**

- ONO (oxide - nitride - oxide) gate dielectric
- Silicon Nitride (SiN) data storage layer

**D. Cypress Highlights**

- Volume Production Fab
- Solely dedicated to Non-Volatile Memories
- Ongoing Statistical Process Control program

# 7. Assembly Packaging Summary

## 7.1 LAE064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL01GS<br>1-Gigabit, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse process technology | | |
| **Package:** | LAE064 | **Qualification:** | Q100127 |
| **Description:** | (9 x 9 x 1.4 mm) 64-ball, Fortified Ball Grid Array Package (fFBGA) | | |
| **Con-code:** | 40780KV-DWR | **Theta Ja / Psi Jt:** | 27.3°C/W / 0.6°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98661B | **Die Size:** | 6.803 x 7.455 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

## 7.2 TS056

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL01GS<br>1-Gigabit, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse process technology | | |
| **Package:** | TS056 | **Qualification:** | Q100127a |
| **Description:** | (18.4 x 14.0 x 1.0 mm) 56-lead, Thin Small Outline Package (TSOP) | | |
| **Con-code:** | 40694EF-TXA | **Theta Ja / Psi Jt:** | 38°C/W / 0.21°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | Hitachi CEL 9200HF10-U |
| **Substrate/Leadframe:** | Copper Leadframe | **Die Attachment:** | Ablebond 8340 |
| **Lead Finish:** | 100% Matte Sn Plating | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 72°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 75.0°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98661B | **Die Size:** | 6.803 x 7.455 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

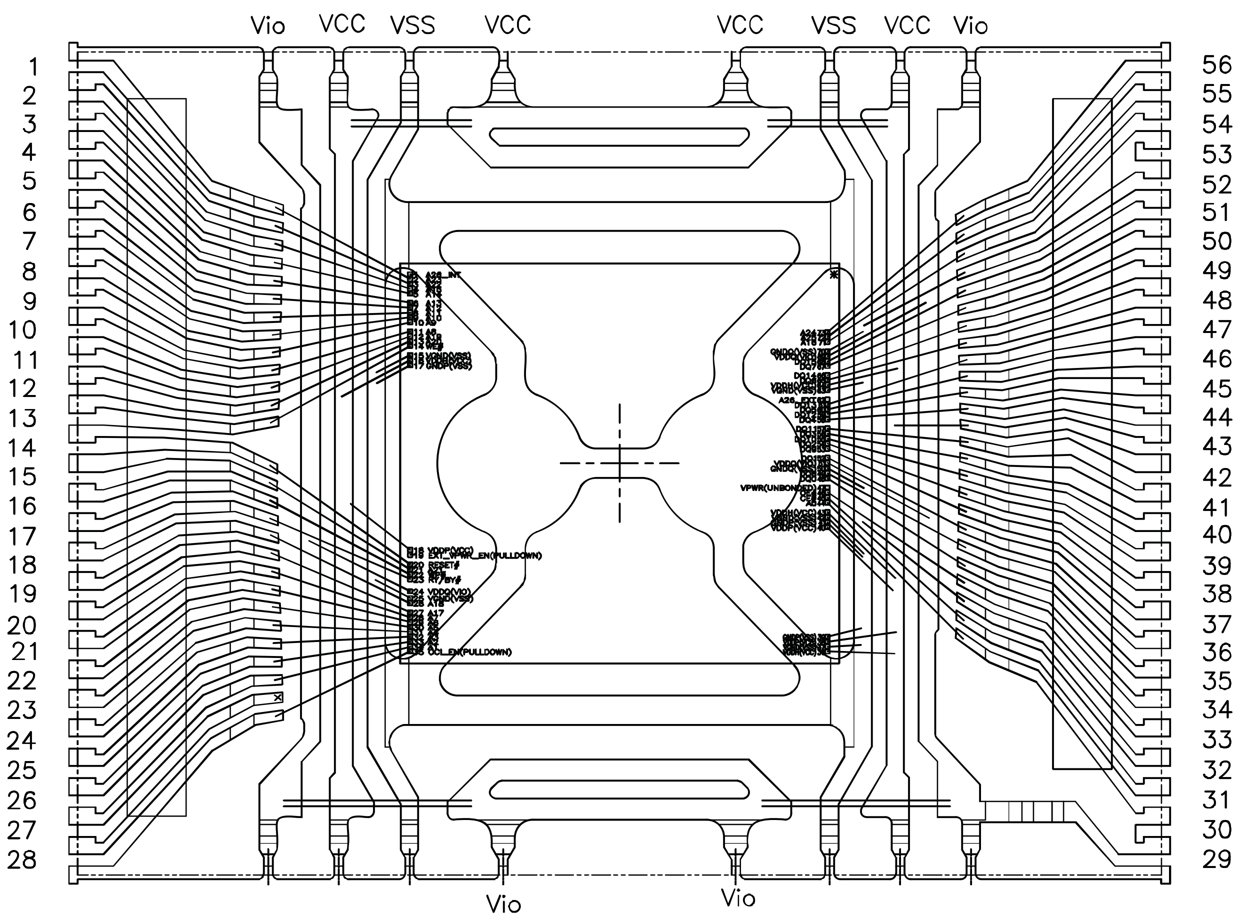
## 7.3 LAA064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL01GS<br>1-Gigabit, 3.0 Volt-Only Page Mode Flash Memory featuring 65 nm MirrorBit Eclipse process technology | | |
| **Package:** | LAA064 | **Qualification:** | Q100127b |
| **Description:** | (13.0 x 11.0 x 1.4 mm) 64-ball, Fortified Ball Grid Array Package (FBGA) | | |
| **Con-code:** | 40781KV-DWR | **Theta Ja / Psi Jt:** | 19°C/W / 0.6°C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | ShinEtsu KMC 3580LVA |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | QMI 546 |
| **Lead Finish:** | 96.5Sn 3.0Ag 0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55°C | **Life Test Temperature:** | 125°C |
| **Est. DC Field Current:** | 25 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0V | **Life Test Voltage:** | 3.6V |
| **Est. Field Power Dissipation:** | 75 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 57.9°C | **Est. Stress Delta Tj:** | 126.4°C |
| **Die:** | 98661B | **Die Size:** | 6.803 x 7.455 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 1G |

# 8. Assembly Bonding Diagram

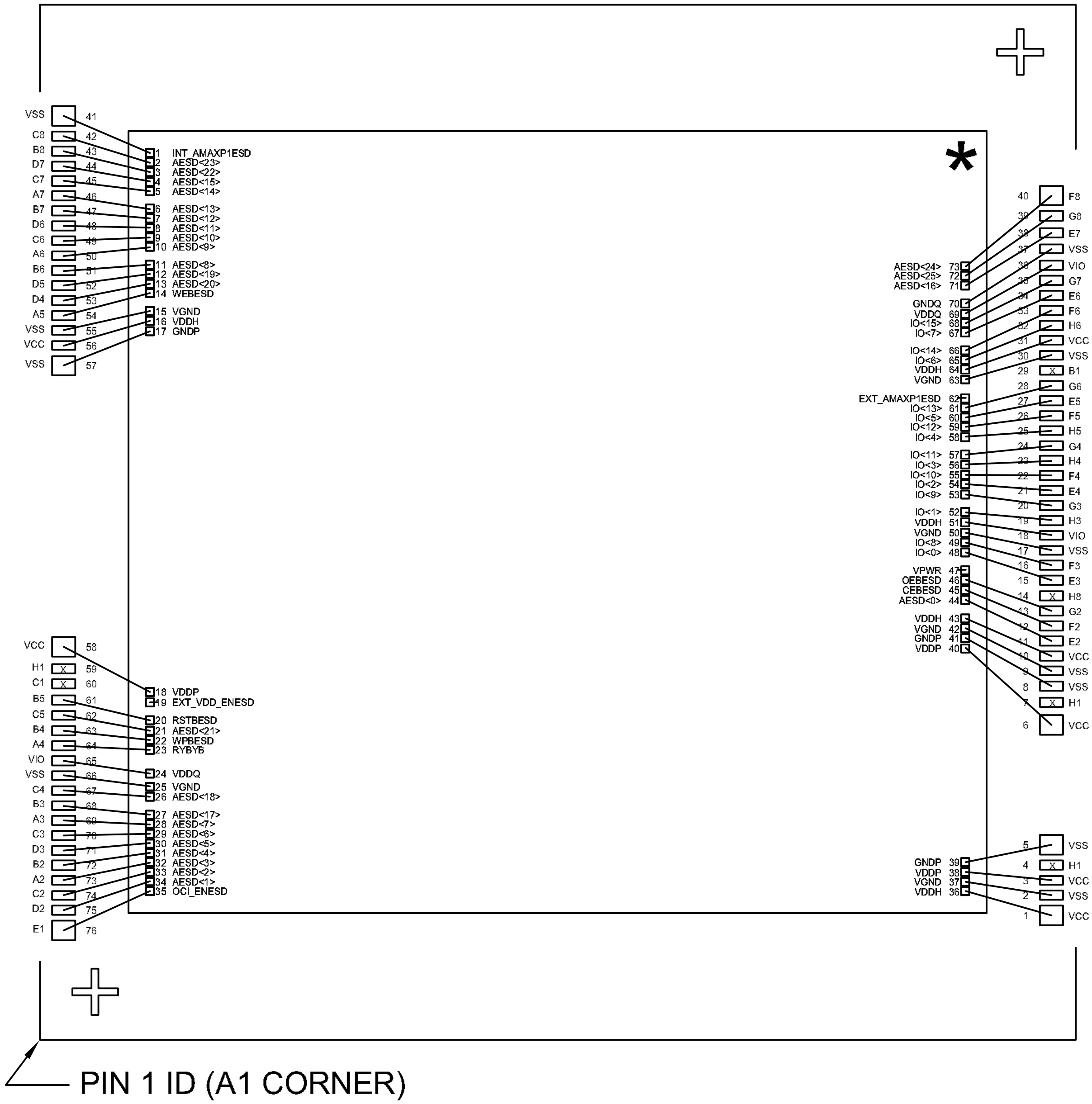
## 8.1 TS056 Package

Figure 5. 56-Pin—TS056 Package



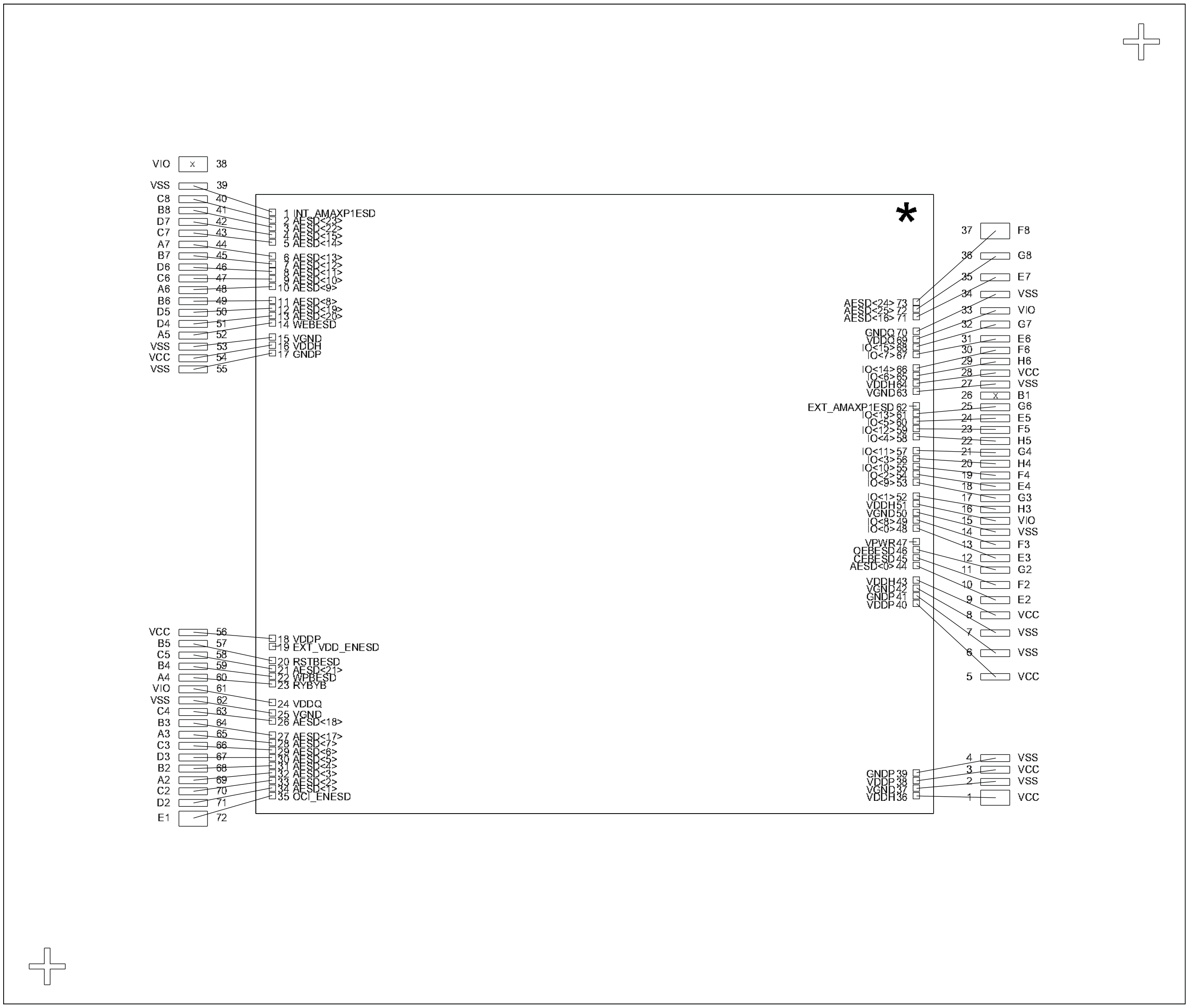
## 8.2 LAE064 Package

**Figure 6. 64-Ball—LAE064 Package**



## 8.3 LAA064 Package

**Figure 7. 64-Ball—LAA064 Package**



# 9. Test Methodology

### Testing includes

- 4 hour, 250°C Data Retention Bake (in wafer form)
- Special test mode for extended life operation
- Proprietary screens for endurance

### Wafer Sort (Austin, Texas, USA)

At Wafer Sort, all die experience 100% testing for:

- DC Parametrics
- AC Functionality
- Programmability
- Erasability

### Class Test (Bangkok, Thailand)

At Class Test, all devices are tested for:

- DC Parametrics
- AC Functionality
- AC Speed
- Programmability
- Erasability

### Test Coverage

All parameters specified in the data sheet are 100% tested in production unless otherwise specified. Those parameters not tested in production are guaranteed by characterization or correlation to other tests. AC speed testing is performed at class test.

### Test Correlation and Guard Banding

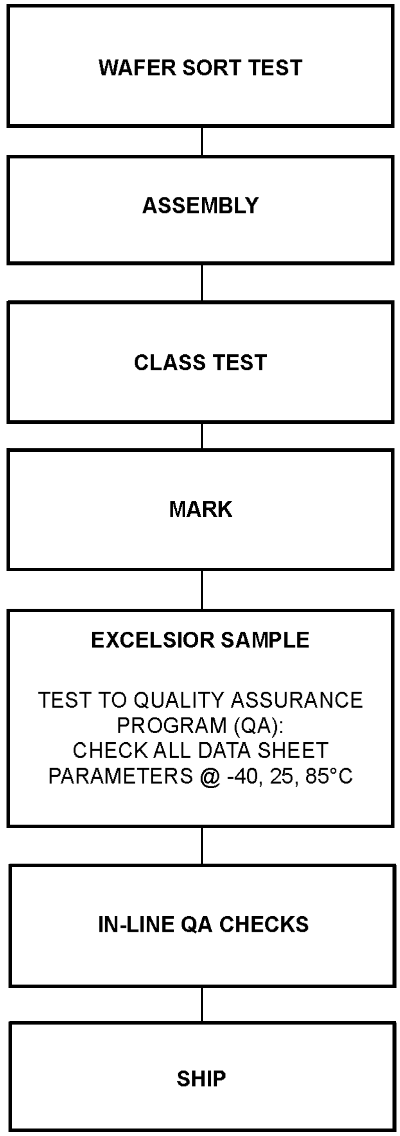
Tester correlation to bench set-up has been completed for all tested parameters. Tester repeatability studies have been run. These results have been evaluated and incorporated into the tester guard band strategy. Guard bands have been implemented which demonstrate acceptable yield, quality assurance and customer satisfaction.

### Test Flow

See the generalized Test Flow for the S29GL01GS in Section 10.

# 10. Generalized Test Flow

The S29GL01GS Generalized Test Flow for Industrial Temperature Range:



# 11. Quality and Reliability Data

## 11.1 S29GL01GS High Temperature Operating Life Test Configuration

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 1 | A23 | 2.7K | CLK23 |
| 2 | A22 | 2.7K | CLK22 |
| 3 | A15 | 2.7K | CLK15 |
| 4 | A14 | 2.7K | CLK14 |
| 5 | A13 | 10K | CLK13 |
| 6 | A12 | 2.7K | CLK12 |
| 7 | A11 | 2.7K | CLK11 |
| 8 | A10 | 2.7K | CLK10 |
| 9 | A9 | 2.7K | CLK9 |
| 10 | A8 | 2.7K | CLK8 |
| 11 | A19 | 2.7K | CLK19 |
| 12 | A20 | 2.7K | CLK20 |
| 13 | WE# | 2.7K | VCC |
| 14 | RESET# | 2.7K | VCC |
| 15 | A21 | 2.7K | CLK21 |
| 16 | WP# | 2.7K | VCC |
| 17 | RY/BY# | 2.7K | VCC |
| 18 | A18 | 2.7K | CLK18 |
| 19 | A17 | 2.7K | CLK17 |
| 20 | A7 | 2.7K | CLK7 |
| 21 | A6 | 2.7K | CLK6 |
| 22 | A5 | 2.7K | CLK5 |
| 23 | A4 | 2.7K | CLK4 |
| 24 | A3 | 2.7K | CLK3 |
| 25 | A2 | 2.7K | CLK2 |
| 26 | A1 | 2.7K | CLK1 |
| 27 | RFU | | NC |
| 28 | RFU | | NC |

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 56 | A24 | 2.7K | CLK24 |
| 55 | A25 | 2.7K | CLK25 |
| 54 | A16 | 2.7K | CLK16 |
| 53 | RFU | | NC |
| 52 | VSS | | GND |
| 51 | DQ15 | 2.7K | VCC |
| 50 | DQ7 | 2.7K | VCC |
| 49 | DQ14 | 2.7K | VCC |
| 48 | DQ6 | 2.7K | VCC |
| 47 | DQ13 | 2.7K | VCC |
| 46 | DQ5 | 2.7K | VCC |
| 45 | DQ12 | 2.7K | VCC |
| 44 | DQ4 | 2.7K | VCC |
| 43 | VCC | | VCC |
| 42 | DQ11 | 2.7K | VCC |
| 41 | DQ3 | 2.7K | VCC |
| 40 | DQ10 | 2.7K | VCC |
| 39 | DQ2 | 2.7K | VCC |
| 38 | DQ9 | 2.7K | VCC |
| 37 | DQ1 | 2.7K | VCC |
| 36 | DQ8 | 2.7K | VCC |
| 35 | DQ0 | 2.7K | VCC |
| 34 | OE# | 2.7K | VCC |
| 33 | VSS | | GND |
| 32 | CE# | 2.7K | GND |
| 31 | A0 | 2.7K | CLK0 |
| 30 | RFU | | NC |
| 29 | VIO | 2.7K | VCC |

## 11.2 CS239/L Life Test Failure Rate Calculation

### HTOL Stress Temperature @ 125°C

| Failure Mechanisms | Read Points / Test Results | | | Modeling Parameters @ 55°C | | | | | Average Failure Rate FITS @ 55°C, 60% Conf. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 24 hrs | 168 hrs | 1000 hrs | Ea eV | TAF | VAF | OAF | MTTF (yrs) | Early Life | Inherent Life |
| **PLASTIC** | | | | | | | | | | |
| Sample Size | 1745 | 3025 | 345 | | | | | | | |
| Zero fails, Process ave. Ea | 0 (1) | 0 | 0 | 0.66 | 53 | 1 | 53 | | 87 | 23 |
| Totals | 0 | 0 | 0 | | | | | 4963 | 87 | 23 |

***Note:***
*1. Contributes to Early Life FITS.*

### Data Retention Bake @ 150°C

| Reliability Stress | Number of Rejects | Sample Size | Failure Rate % | Failure Mechanism |
|---|---|---|---|---|
| 500 hrs | 0 | 300 | 0.00 | No Failures |
| 1000 hrs | 0 | 300 | 0.00 | No Failures |

Table 1. Summary of Stress Test Results

| Stress Test | Condition | Package Type | Samples Size | Num. of Lots | Number of Fails | Failure Rate % | Comments |
|---|---|---|---|---|---|---|---|
| Data From Qualification Q100127 | | | | | | | |
| **HTOL (EL)** | 3.6V, 125°C | LAE064 (1) | 192 | 2 | 0 | 0.00 | 168 hrs |
| **HTOL (IL)** | 3.6V, 125°C | LAE064 (1) | 192 | 2 | 0 | 0.00 | 500 hrs |
| **Data Retention Bake** | 150°C | LAE064 (1) | 118 | 2 | 0 | 0.00 | 500 hrs |
| **ESD CDM** | N/A | LAE064 (1) | 30 | 2 | Passed 1.0 kV | | |
| **ESD HBM** | (100 pF, 1500 Ohms) | LAE064 (1) | 168 | 2 | Passed 2.0 kV | | |
| **Latch Up** | 125°C, ±100 mA | LAE064 (1) | 12 | 2 | Passed | | |
| **Endurance (10k)** | 90°C, 3.6V | LAE064 (1) | 100 | 2 | 0 | 0.00 | 10k cycles |
| **Endurance (10k)** | 105°C, 3.6V | TS056 (2) | 240 | 3 | 0 | 0.00 | 10k cycles |
| **Endurance (100k)** | 90°C, 3.6V | LAE064 (1) | 50 | 1 | 0 | 0.00 | 100k cycles |
| **Endurance (100k)** | 105°C, 3.6V | TS056 (2) | 240 | 3 | 0 | 0.00 | 100k cycles |
| **Preconditioning** | PC9/260°C +0°C / –5°C | LAE064 (1) | 230 | 1 | Passed Jedec L3 (Accel.) | | |
| **Preconditioning + Temp Cycle** | PC9/260°C , –40°C / 150°C | LAE064 (1) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| **Preconditioning + HAST** | PC9/260°C, Biased, 110°C / 85% RH | LAE064 (1) | 77 | 1 | 0 | 0.00 | 264 hrs |
| **Preconditioning + uHAST** | PC9/260°C, Unbiased, 130°C / 85% RH | LAE064 (1) | 77 | 1 | 0 | 0.00 | 96 hrs |
| Generic Reference Data | | | | | | | |
| **Preconditioning** | PC1/260°C, +0°C / –5°C | TS056 (3) | 67 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| | PC9/260°C, +0°C / –5°C | LAA064 (4) | 77 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| **Preconditioning + Temp Cycle** | PC1/260°C, –40°C / 150°C | TS056 (3) | 67 | 1 | 0 | 0.00 | 1000 cycles |

***Notes:***

1. *Results from Qual Q100127, S29GL01GS, 1G CS239LS (65 nm) MirrorBit Eclipse in 64 Ball fFBGA (9 x 9 x 1.4 mm).*
2. *Results from QTP#184906, S29GL01GS in 56 Lead TSOP (18.4 x 14 x 1 mm) - Same TS056 Package, Same Product and Process Technology at Fab25.*
3. *Results from Qual Q100181a, S29GL01GS in 56 Lead TSOP (18.4 x 14 x 1 mm) - Same TS056 Package, Same Product and Process Technology at Fab25.*
4. *Results from Qual Q100182, S29GL01GS in 64 Ball fFBGA (13 x 11 x 1.4 mm) - Same LAA064 Package, Same Product and Process Technology at Fab25.*

***Preconditioning Flows***

*PC1 (Exceeds JEDEC Level 3 and JEITA Rank E) = Bake 125°C, 24hr --> Soak @ 30°C/70%RH, 216hr --> 3x Reflow.*
*PC9 (Accelerated JEDEC L3 / JEITA Rank E): Bake 125°C, 24hr => Soak @ 60°C/70%RH, 72hr => 3x Reflow.*

# 12. Characterization Test Results

The data is pattern is “Random pattern” unless otherwise indicated.

## 12.1 DC Parameter Summary, 25°C

### Room Temperature, 25°C, 3V $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 97.3 | 91.1 | 103.1 | 2.1 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 51.6 | 49.1 | 54.2 | 0.9 | 3.1 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 6.0 | 5.5 | 6.3 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.9 | 0.0 | 6.3 | 0.4 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.9 | 5.4 | 6.2 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.8 | 5.4 | 6.1 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase/Program Current) | 45 | 100 | mA | 44.8 | 39.4 | 48.2 | 1.8 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 18.2 | 9.8 | 47.6 | 8.1 | 3.4 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.018 | 0.010 | 0.048 | 0.0 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 18.3 | 9.8 | 48.9 | 8.0 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.005 | 0.000 | 0.218 | 0.0 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.001 | 0.000 | 0.011 | 0.0 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 306.9 | 198.0 | 701.0 | 37.5 | >5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 390.4 | 336.9 | 475.8 | 25.2 | 4.8 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 298.6 | 256.3 | 358.3 | 17.5 | >5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 247.9 | 215.6 | 297.1 | 13.5 | >5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 218.9 | 189.3 | 258.3 | 11.6 | >5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 196.4 | 171.9 | 229.2 | 10.5 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 185.8 | 163.1 | 224.3 | 10.0 | >5 |

***Notes:***

1. *Data was collected from 300 units with 3 different lots 5817940, 5817960, 5817970 (wlot : LD95284, wfno : 5 / wlot : LD95223, wfno : 16 wlot : LD95309, wfno : 24).*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.2 DC Parameter Summary, 85°C

### Hot Temperature, 85°C, 3V $V_{CC} = V_{IO}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 102.25 | 96.96 | 107.72 | 1.93 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 54.11 | 51.56 | 56.60 | 0.92 | 2.1 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 6.29 | 5.89 | 6.71 | 0.14 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 6.21 | 5.79 | 6.63 | 0.14 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 6.15 | 5.73 | 6.54 | 0.14 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 6.09 | 5.67 | 6.53 | 0.14 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase/Program Current) | 45 | 100 | mA | 47.27 | 43.40 | 51.69 | 1.61 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 50.50 | 29.12 | 81.63 | 11.87 | 1.4 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.05 | 0.03 | 0.09 | 0.01 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 51.01 | 29.89 | 81.99 | 11.96 | 2.8 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.005 | 0.000 | 0.375 | 0.0 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.001 | 0.000 | 0.011 | 0.0 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 220.7 | 147.0 | 385.0 | 22.4 | >5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 343.5 | 281.6 | 404.9 | 22.9 | >5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 265.2 | 216.5 | 323.3 | 16.5 | >5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 221.7 | 184.5 | 259.3 | 13.4 | >5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 195.8 | 162.2 | 228.2 | 11.3 | >5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 176.8 | 153.4 | 202.9 | 9.7 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 170.8 | 146.6 | 199.1 | 9.4 | >5 |

***Notes:***
1. *Data was collected from 300 units with 3 different lots 5817940, 5817960, 5817970 (wlot : LD95284, wfno : 5 / wlot : LD95223, wfno : 16 wlot : LD95309, wfno : 24).*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

## 12.3 DC Parameter Summary, 105°C

### Hot Temperature, 105°C, 3V $V_{CC}$ = $V_{IO}$ Summary

| Data Sheet Parameters | Spec | | | Average | | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | -40 | 25 | 85 | 105 | | | | | |
| **DC Parameters** | | | | | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 96.6 | 97.3 | 102.3 | 105.0 | 105.0 | 99.7 | 113.4 | 2.0 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 50.8 | 51.6 | 54.1 | 55.0 | 55.0 | 52.4 | 57.0 | 0.9 | 1.8 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.8 | 6.0 | 6.3 | 6.4 | 6.4 | 5.8 | 6.7 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.7 | 5.9 | 6.2 | 6.3 | 6.3 | 5.7 | 6.6 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.7 | 5.9 | 6.2 | 6.2 | 6.2 | 5.6 | 6.5 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.6 | 5.8 | 6.1 | 6.2 | 6.2 | 5.6 | 6.5 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase/Program Current) | 45 | 100 | mA | 41.2 | 44.8 | 47.3 | 54.9 | 54.9 | 52.5 | 57.1 | 1.0 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 15.4 | 18.2 | 50.5 | 81.4 | 81.4 | 41.0 | 132.5 | 19.9 | 2.0 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.0 | 0.0 | 0.1 | 0.1 | 0.081 | 0.042 | 0.131 | 0.020 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 15.6 | 18.3 | 51.0 | 80.8 | 80.8 | 42.0 | 131.5 | 19.8 | 2.0 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.0 | 0.0 | 0.0 | 0.0 | 0.004 | -0.020 | 0.186 | 0.021 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.0 | 0.0 | 0.0 | 0.0 | 0.001 | -0.009 | 0.013 | 0.003 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | | | | | |
| Sector Erase Time (64k word sector) | 275 | 1100 | ms | | | | | 179.8 | 114.0 | 297.0 | 13.9 | >5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | | | | | 313.8 | 269.0 | 383.0 | 16.6 | >5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | | | | | 244.0 | 209.0 | 288.0 | 12.6 | >5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | | | | | 205.3 | 178.0 | 243.0 | 10.6 | >5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | | | | | 182.5 | 162.0 | 217.0 | 9.2 | >5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | | | | | 164.1 | 144.0 | 196.0 | 7.9 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | | | | | 159.5 | 139.0 | 191.0 | 8.2 | >5 |

***Notes:***
1. *Data was collected from 70 units with 2 different lots 5877040 (wflot : LDW3821, wf14, wflot : LDW3961, wf14).*
2. *Sector Erase data excludes Random data pattern programming prior to erasure.*

## 12.4 DC Parameter Summary, -40°C

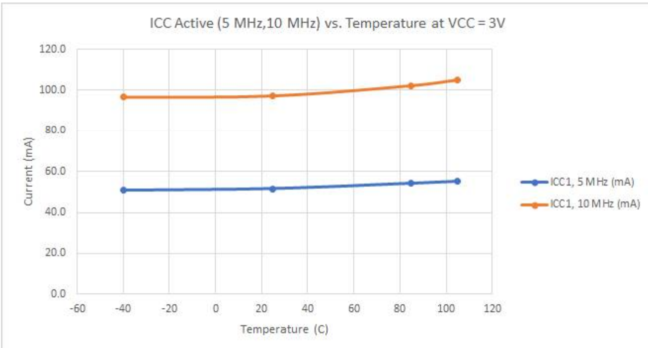
### Cold Temperature, -40°C, 3V $V_{CC}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 96.6 | 90.5 | 102.0 | 2.2 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 50.8 | 47.9 | 53.5 | 1.0 | 2.9 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.8 | 5.4 | 6.3 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.7 | 5.3 | 6.2 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.7 | 5.3 | 6.1 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.6 | 5.2 | 6.1 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Erase/Program Current) | 45 | 100 | mA | 41.2 | 37.1 | 44.9 | 1.6 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 100 | µA | 15.4 | 8.9 | 34.2 | 6.2 | 4.5 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.016 | 0.009 | 0.046 | 0.0 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 150 | µA | 15.6 | 8.8 | 34.7 | 6.1 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.005 | 0.000 | 0.232 | 0.0 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.002 | 0.000 | 0.012 | 0.0 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 363.4 | 225.0 | 815.0 | 46.9 | >5 |
| Buffer Program Time (256 word) | 340 | 750 | µs | 373.7 | 313.0 | 469.0 | 23.1 | >5 |
| Buffer Program Time (128 word) | 239 | 750 | µs | 286.2 | 245.0 | 343.0 | 16.4 | >5 |
| Buffer Program Time (64 word) | 198 | 750 | µs | 239.0 | 206.0 | 285.0 | 13.2 | >5 |
| Buffer Program Time (32 word) | 175 | 750 | µs | 212.1 | 183.0 | 258.0 | 11.2 | >5 |
| Buffer Program Time (16 word) | 160 | 750 | µs | 194.0 | 166.0 | 233.0 | 10.2 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 183.0 | 161.0 | 220.0 | 9.1 | >5 |

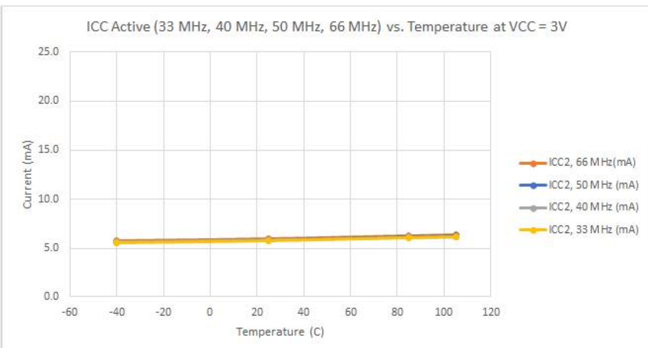
***Notes:***
1. *Data was collected from 300 units with 3 different lots 5817940, 5817960, 5817970 (wlot : LD95284, wfno : 5 / wlot : LD95223, wfno : 16 wlot : LD95309, wfno : 24).*
2. *Sector Erase excludes Random data pattern programming prior to erasure.*

# 13. DC Device Characterization Data

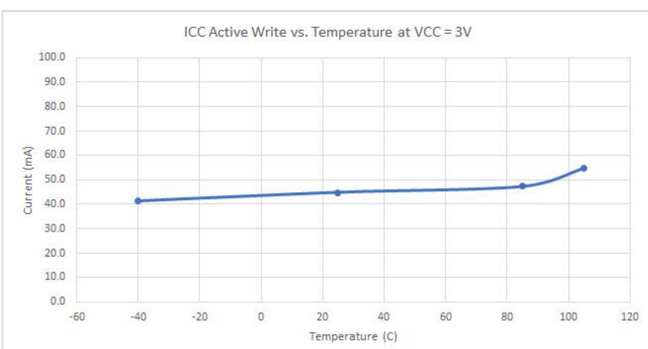
ICC1 (Asynchronous Read) vs. Temperature



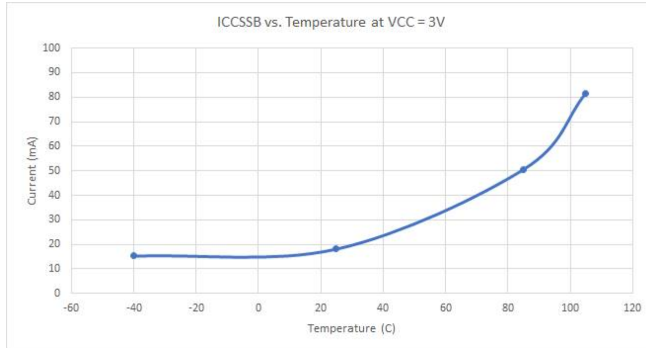

ICC2 (Page Read) vs. Temperature



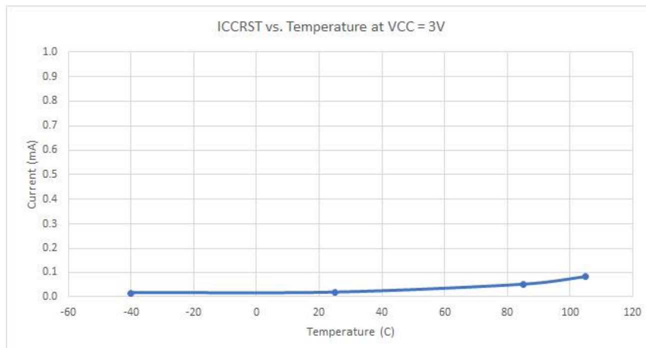

ICC3 (Active Write) vs. Temperature



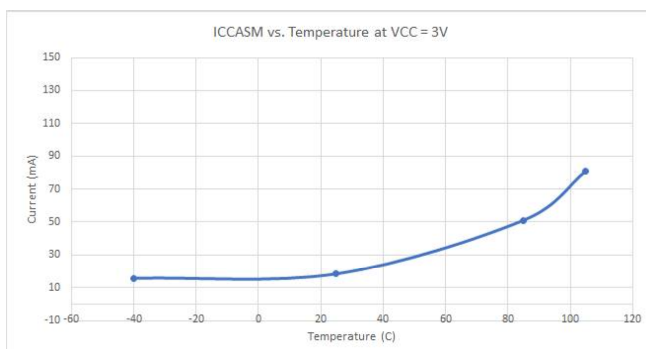

ICC4 (Standby Current) vs. Temperature




ICC5 (Reset Current) vs. Temperature

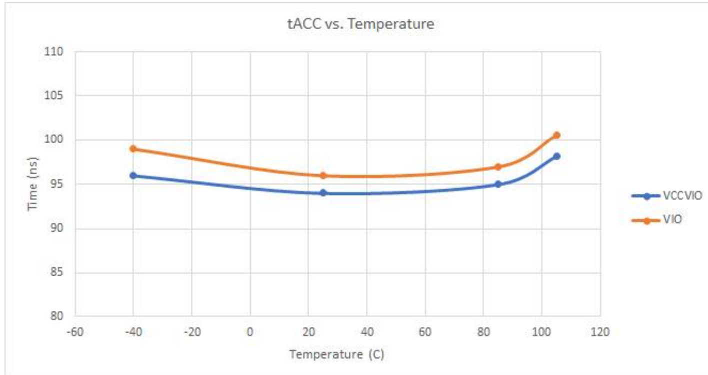



ICC6 (CMOSASM) vs. Temperature

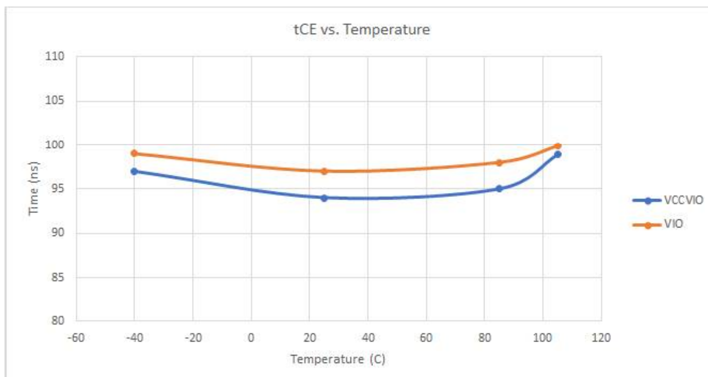


# 14. AC Device Characterization Data

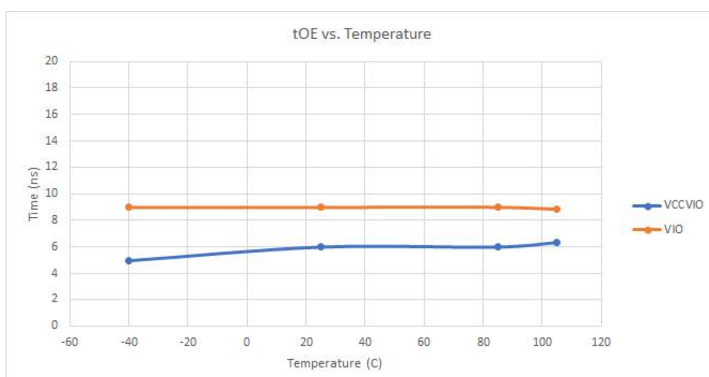
tACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



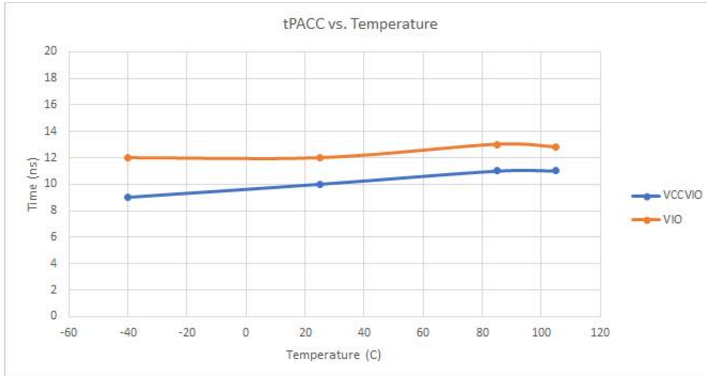

tCE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



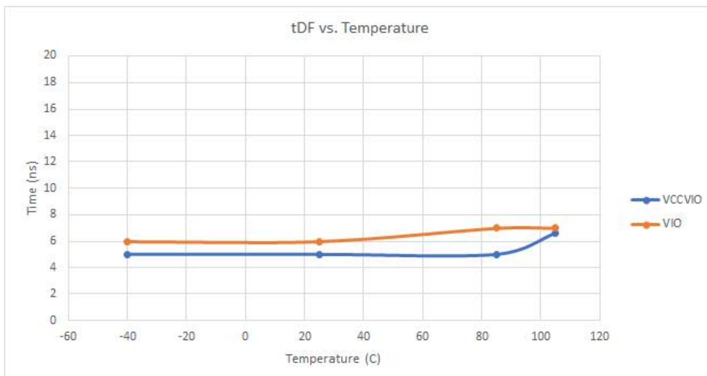

tOE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



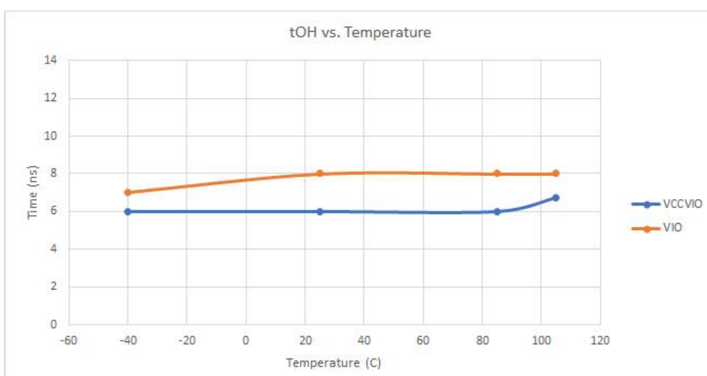
tPACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



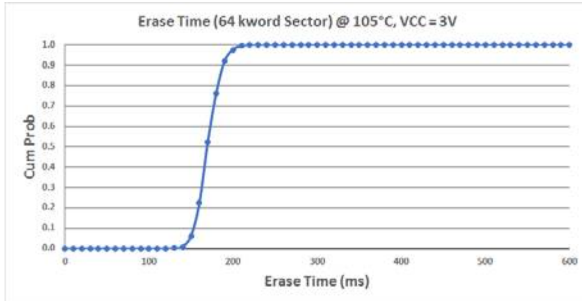

tDF vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



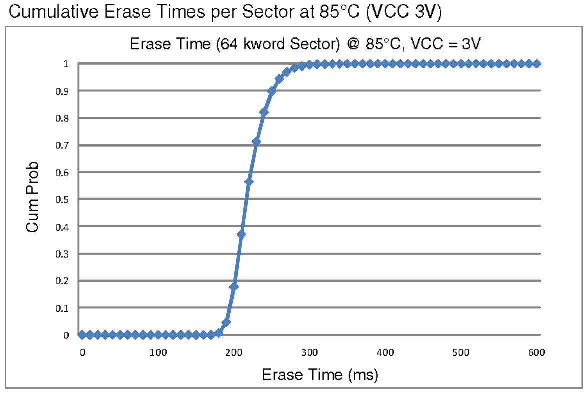

tOH vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



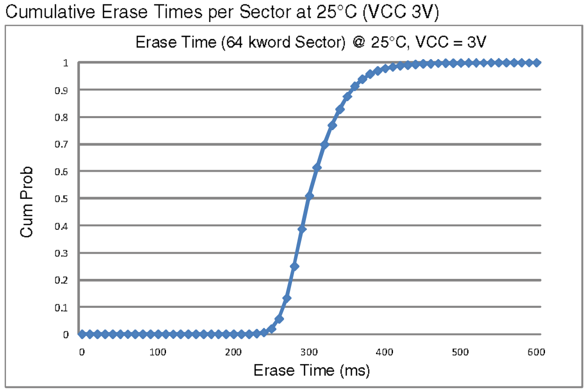
Cumulative Erase Times per Sector at 105°C (VCC 3V)



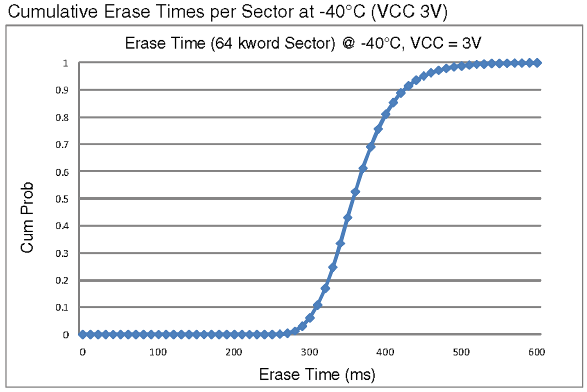

Cumulative Erase Times per Sector at 85°C (VCC 3V)



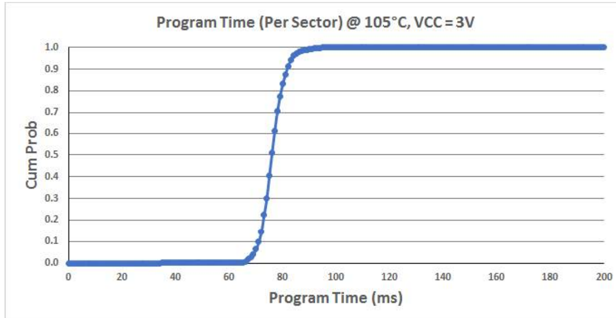

Cumulative Erase Times per Sector at 25°C (VCC 3V)



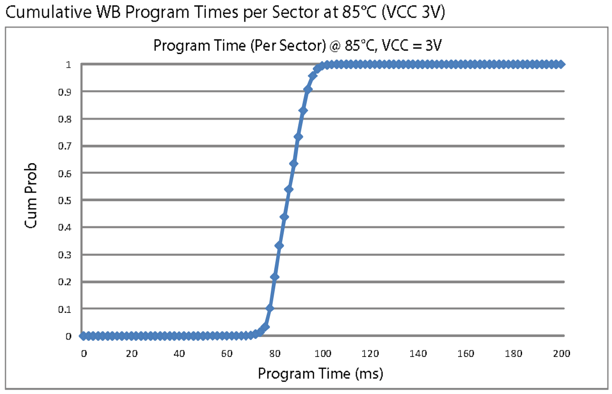

Cumulative Erase Times per Sector at -40°C (VCC 3V)



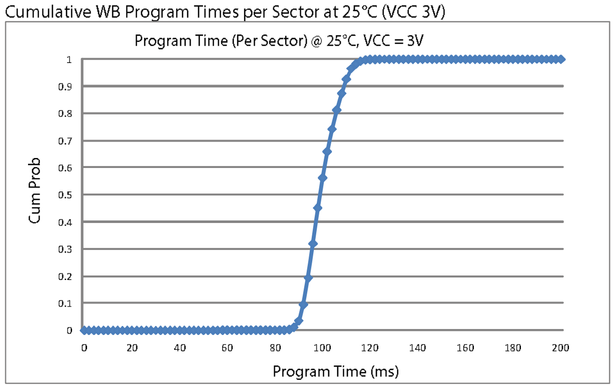
Cumulative WB Program Times per Sector at 105°C (VCC 3V)



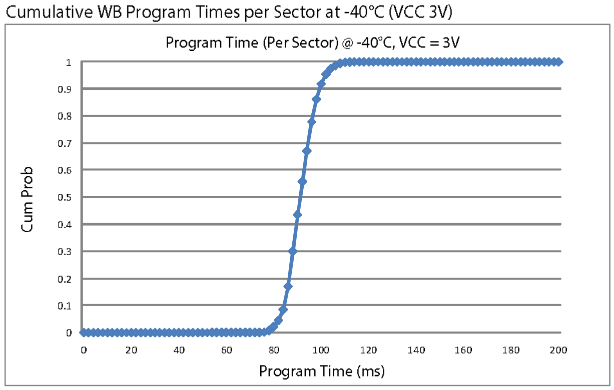

Cumulative WB Program Times per Sector at 85°C (VCC 3V)



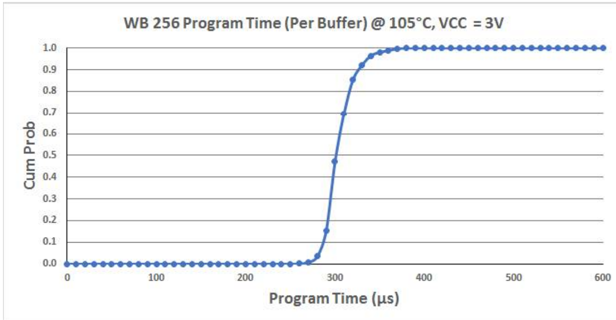

Cumulative WB Program Times per Sector at 25°C (VCC 3V)



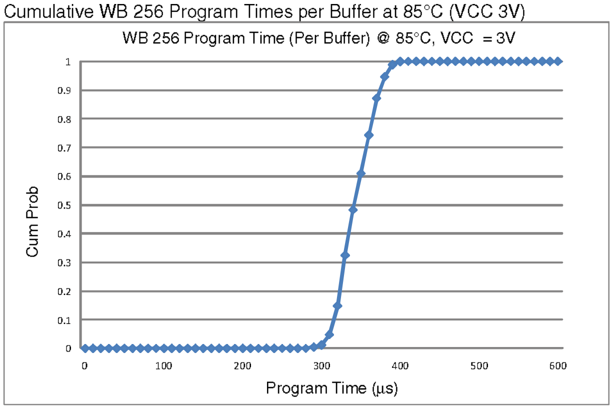

Cumulative WB Program Times per Sector at -40°C (VCC 3V)



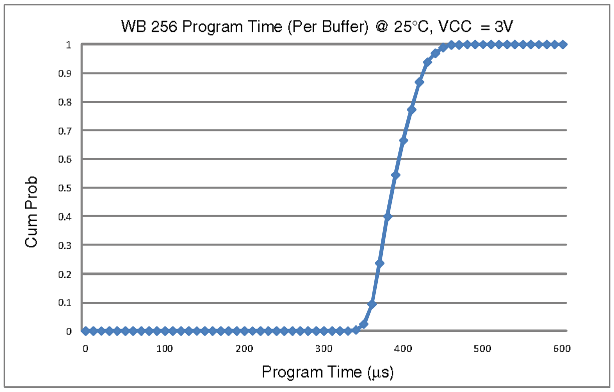
Cumulative WB 256 Program Times per Buffer at 105°C (VCC 3V)



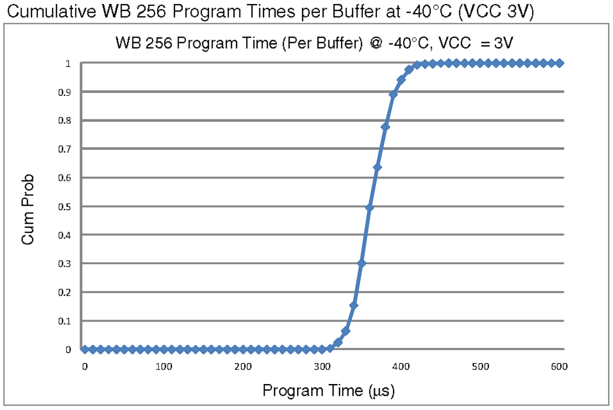

Cumulative WB 256 Program Times per Buffer at 85°C (VCC 3V)



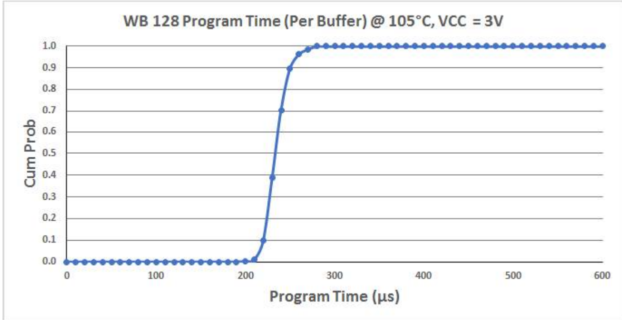

Cumulative WB 256 Program Times per Buffer at 25°C (VCC 3V)



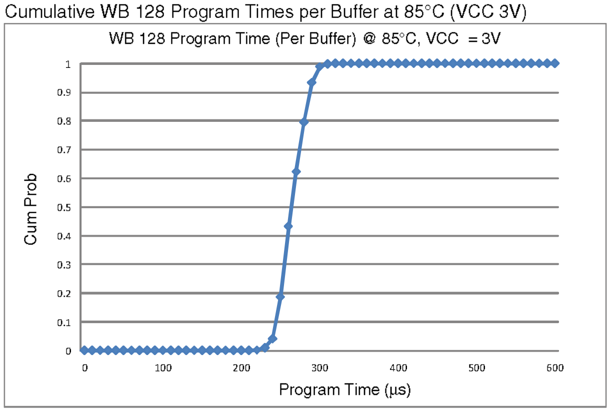

Cumulative WB 256 Program Times per Buffer at -40°C (VCC 3V)



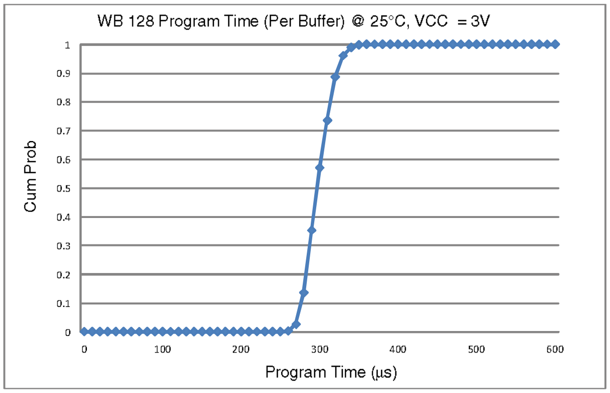
Cumulative WB 128 Program Times per Buffer at 105°C (VCC 3V)



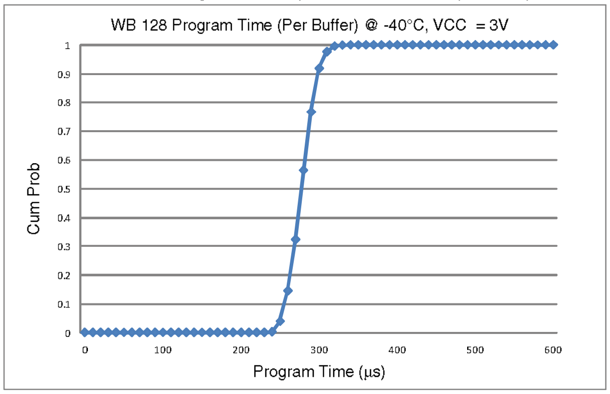

Cumulative WB 128 Program Times per Buffer at 85°C (VCC 3V)



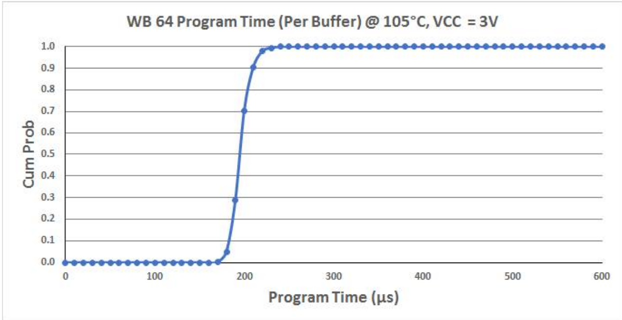

Cumulative WB 128 Program Times per Buffer at 25°C (VCC 3V)



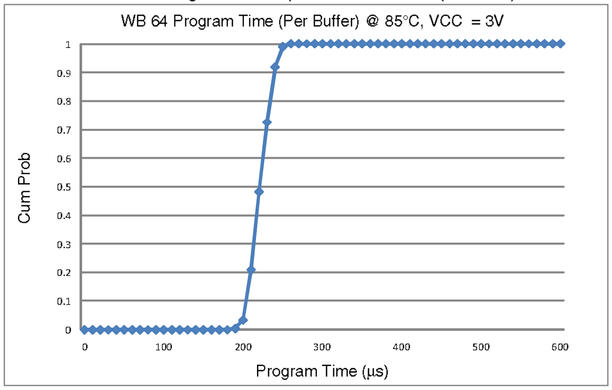

Cumulative WB 128 Program Times per Buffer at -40°C (VCC 3V)



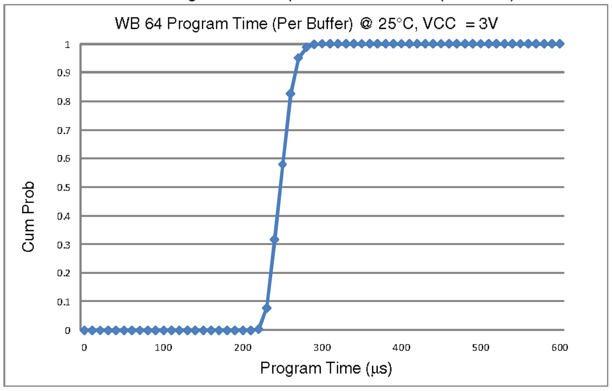
Cumulative WB 64 Program Times per Buffer at 105°C (VCC 3V)



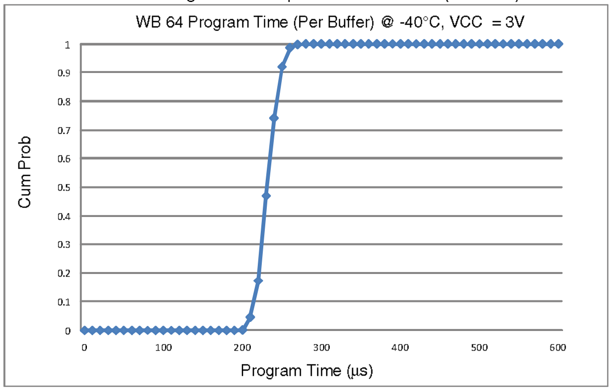

Cumulative WB 64 Program Times per Buffer at 85°C (VCC 3V)



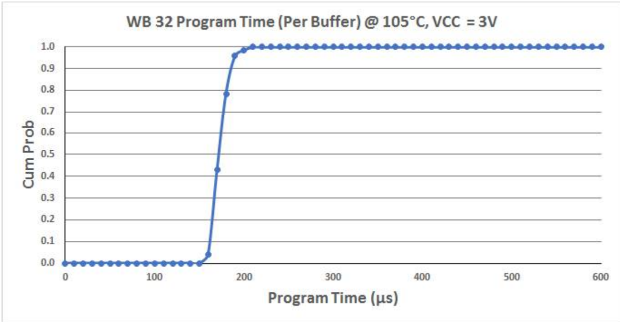

Cumulative WB 64 Program Times per Buffer at 25°C (VCC 3V)



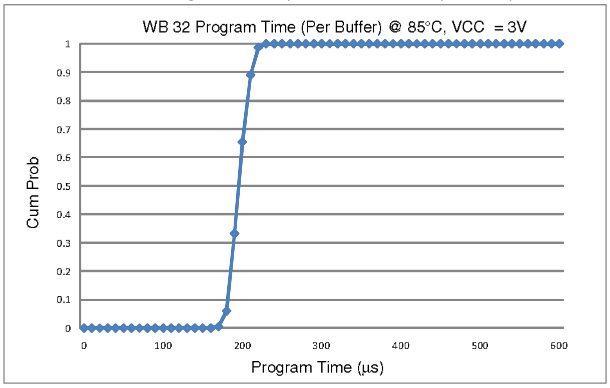

Cumulative WB 64 Program Times per Buffer at -40°C (VCC 3V)



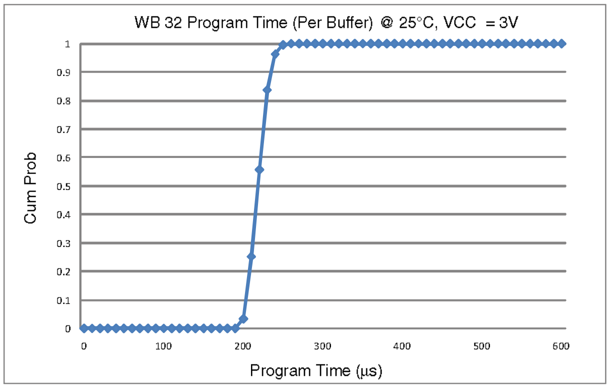
Cumulative WB 32 Program Times per Buffer at 105°C (VCC 3V)



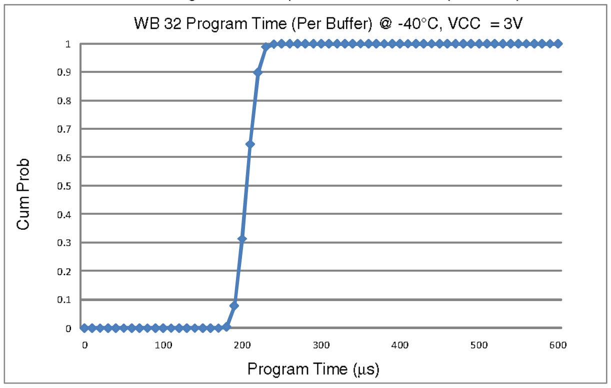

Cumulative WB 32 Program Times per Buffer at 85°C (VCC 3V)



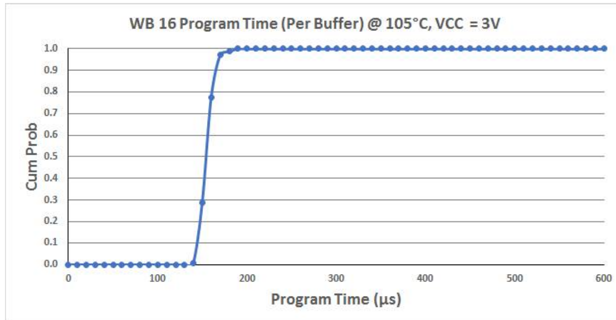

Cumulative WB 32 Program Times per Buffer at 25°C (VCC 3V)



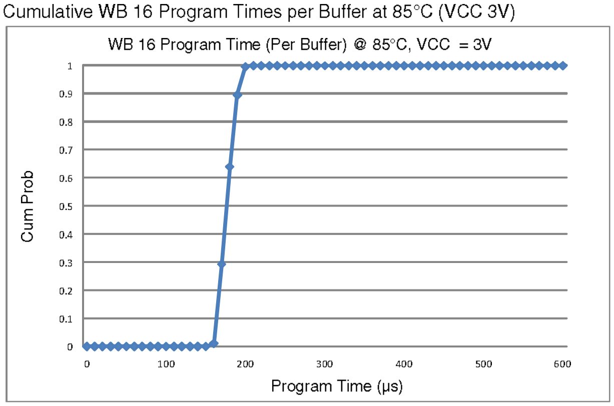

Cumulative WB 32 Program Times per Buffer at -40°C (VCC 3V)



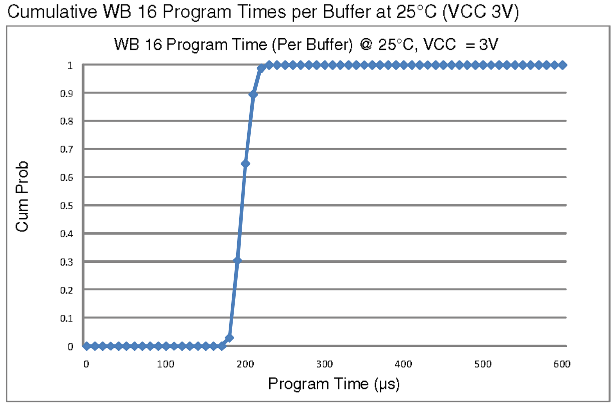
Cumulative WB 16 Program Times per Buffer at 105°C (VCC 3V)



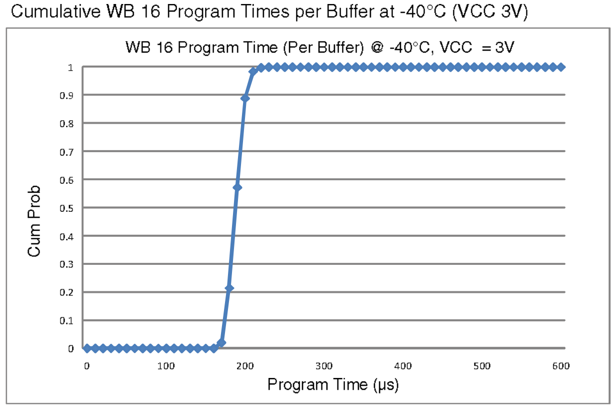

Cumulative WB 16 Program Times per Buffer at 85°C (VCC 3V)



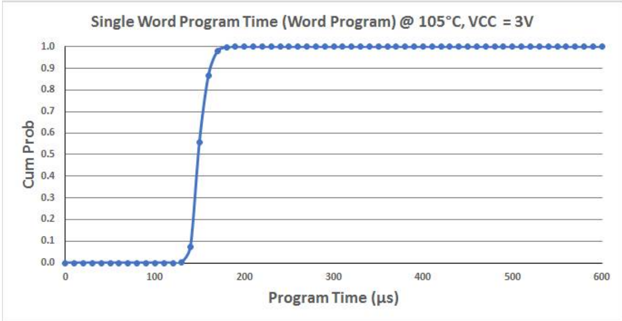

Cumulative WB 16 Program Times per Buffer at 25°C (VCC 3V)



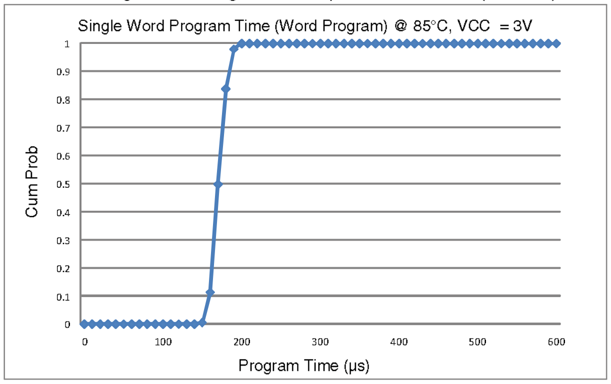

Cumulative WB 16 Program Times per Buffer at -40°C (VCC 3V)



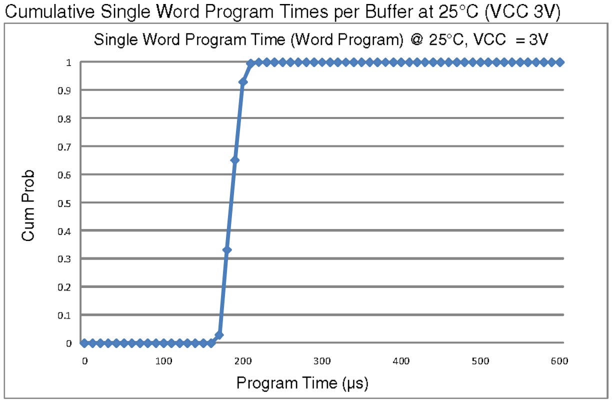
Cumulative Single Word Program Times per Buffer at 105°C (VCC 3V)



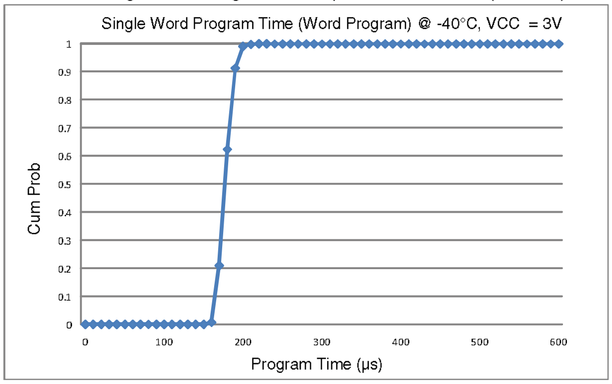

Cumulative Single Word Program Times per Buffer at 85°C (VCC 3V)




Cumulative Single Word Program Times per Buffer at 25°C (VCC 3V)




Cumulative Single Word Program Times per Buffer at -40°C (VCC 3V)



# 15. Shmoo Plots

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
           80.0      90.0      100.0     110.0        first pass data
          |+----,----+----,----+----,----+|
   3.650  |.............******************|           93.0
   3.600  |.............******************|           93.0
   3.550  |.............******************|           93.0
   3.500  |.............******************|           93.0
   3.450  |.............******************|           93.0
   3.400  |.............******************|           93.0
   3.350  |.............******************|           93.0
   3.300  |.............******************|           93.0
   3.250  |..............*****************|           94.0
   3.200  |..............*****************|           94.0
   3.150  |..............*****************|           94.0
   3.100  |..............*****************|           94.0
   3.050  |..............*****************|           94.0
   3.000  |..............*****************|           94.0
   2.950  |..............*****************|           94.0
   2.900  |..............*****************|           94.0
   2.850  |..............*****************|           94.0
   2.800  |..............*****************|           94.0
   2.750  |..............*****************|           94.0
   2.700  |..............*****************|           94.0
   2.650  |..............*****************|           94.0
          |+----,----+----,----+----,----+|
           80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
           80.0      90.0      100.0     110.0        first pass data
          |+----,----+----,----+----,----+|
   3.650  |..............*****************|           94.0
   3.600  |...............****************|           95.0
   3.550  |..............*****************|           94.0
   3.500  |...............****************|           95.0
   3.450  |...............****************|           95.0
   3.400  |...............****************|           95.0
   3.350  |...............****************|           95.0
   3.300  |...............****************|           95.0
   3.250  |...............****************|           95.0
   3.200  |...............****************|           95.0
   3.150  |...............****************|           95.0
   3.100  |...............****************|           95.0
   3.050  |...............****************|           95.0
   3.000  |...............****************|           95.0
   2.950  |...............****************|           95.0
   2.900  |...............****************|           95.0
   2.850  |...............****************|           95.0
   2.800  |...............****************|           95.0
   2.750  |...............****************|           95.0
   2.700  |...............****************|           95.0
   2.650  |...............****************|           95.0
          |+----,----+----,----+----,----+|
           80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          80.0      90.0      100.0     110.0        first pass data
        |+----,----+----,----+----,----+|
  3.650 |................***************|            96.0
  3.600 |................***************|            96.0
  3.550 |................***************|            96.0
  3.500 |................***************|            96.0
  3.450 |................***************|            96.0
  3.400 |................***************|            96.0
  3.350 |................***************|            96.0
  3.300 |................***************|            96.0
  3.250 |................***************|            96.0
  3.200 |................***************|            96.0
  3.150 |................***************|            96.0
  3.100 |................***************|            96.0
  3.050 |................***************|            96.0
  3.000 |................***************|            96.0
  2.950 |.................**************|            97.0
  2.900 |.................**************|            97.0
  2.850 |.................**************|            97.0
  2.800 |.................**************|            97.0
  2.750 |.................**************|            97.0
  2.700 |.................**************|            97.0
  2.650 |.................**************|            97.0
        |+----,----+----,----+----,----+|
          80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
          80.0      90.0      100.0     110.0        first pass data
        |+----,----+----,----+----,----+|
  3.650 |................***************|            96.0
  3.600 |................***************|            96.0
  3.550 |................***************|            96.0
  3.500 |................***************|            96.0
  3.450 |................***************|            96.0
  3.400 |................***************|            96.0
  3.350 |................***************|            96.0
  3.300 |................***************|            96.0
  3.250 |................***************|            96.0
  3.200 |................***************|            96.0
  3.150 |................***************|            96.0
  3.100 |................***************|            96.0
  3.050 |................***************|            96.0
  3.000 |................***************|            96.0
  2.950 |................***************|            96.0
  2.900 |................***************|            96.0
  2.850 |................***************|            96.0
  2.800 |................***************|            96.0
  2.750 |................***************|            96.0
  2.700 |.................**************|            97.0
  2.650 |..................*************|            98.0
        |+----,----+----,----+----,----+|
          80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.000 |..............*****************|           94.0
  2.950 |..............*****************|           94.0
  2.900 |..............*****************|           94.0
  2.850 |..............*****************|           94.0
  2.800 |..............*****************|           94.0
  2.750 |..............*****************|           94.0
  2.700 |..............*****************|           94.0
  2.650 |..............*****************|           94.0
  2.600 |..............*****************|           94.0
  2.550 |..............*****************|           94.0
  2.500 |..............*****************|           94.0
  2.450 |..............*****************|           94.0
  2.400 |..............*****************|           94.0
  2.350 |..............*****************|           94.0
  2.300 |..............*****************|           94.0
  2.250 |..............*****************|           94.0
  2.200 |..............*****************|           94.0
  2.150 |..............*****************|           94.0
  2.100 |..............*****************|           94.0
  2.050 |...............****************|           95.0
  2.000 |...............****************|           95.0
  1.950 |...............****************|           95.0
  1.900 |...............****************|           95.0
  1.850 |...............****************|           95.0
  1.800 |...............****************|           95.0
  1.750 |................***************|           96.0
  1.700 |................***************|           96.0
  1.650 |................***************|           96.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.000 |...............****************|           95.0
  2.950 |...............****************|           95.0
  2.900 |...............****************|           95.0
  2.850 |...............****************|           95.0
  2.800 |...............****************|           95.0
  2.750 |...............****************|           95.0
  2.700 |...............****************|           95.0
  2.650 |...............****************|           95.0
  2.600 |...............****************|           95.0
  2.550 |...............****************|           95.0
  2.500 |...............****************|           95.0
  2.450 |...............****************|           95.0
  2.400 |...............****************|           95.0
  2.350 |...............****************|           95.0
  2.300 |...............****************|           95.0
  2.250 |...............****************|           95.0
  2.200 |................***************|           96.0
  2.150 |................***************|           96.0
  2.100 |................***************|           96.0
  2.050 |................***************|           96.0
  2.000 |................***************|           96.0
  1.950 |................***************|           96.0
  1.900 |................***************|           96.0
  1.850 |................***************|           96.0
  1.800 |................***************|           96.0
  1.750 |.................**************|           97.0
  1.700 |.................**************|           97.0
  1.650 |.................**************|           97.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
       80.0      90.0      100.0     110.0       first pass data
      |+----,----+----,----+----,----+|
3.000 |.................**************|          97.0
2.950 |................***************|          96.0
2.900 |.................**************|          97.0
2.850 |.................**************|          97.0
2.800 |.................**************|          97.0
2.750 |.................**************|          97.0
2.700 |.................**************|          97.0
2.650 |.................**************|          97.0
2.600 |.................**************|          97.0
2.550 |.................**************|          97.0
2.500 |.................**************|          97.0
2.450 |.................**************|          97.0
2.400 |.................**************|          97.0
2.350 |.................**************|          97.0
2.300 |.................**************|          97.0
2.250 |.................**************|          97.0
2.200 |.................**************|          97.0
2.150 |.................**************|          97.0
2.100 |.................**************|          97.0
2.050 |.................**************|          97.0
2.000 |..................*************|          98.0
1.950 |..................*************|          98.0
1.900 |..................*************|          98.0
1.850 |..................*************|          98.0
1.800 |..................*************|          98.0
1.750 |..................*************|          98.0
1.700 |..................*************|          98.0
1.650 |...................************|          99.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
       80.0      90.0      100.0     110.0       first pass data
      |+----,----+----,----+----,----+|
3.000 |................***************|          96.0
2.950 |................***************|          96.0
2.900 |................***************|          96.0
2.850 |................***************|          96.0
2.800 |................***************|          96.0
2.750 |................***************|          96.0
2.700 |................***************|          96.0
2.650 |................***************|          96.0
2.600 |................***************|          96.0
2.550 |................***************|          96.0
2.500 |.................**************|          97.0
2.450 |.................**************|          97.0
2.400 |.................**************|          97.0
2.350 |.................**************|          97.0
2.300 |.................**************|          97.0
2.250 |.................**************|          97.0
2.200 |.................**************|          97.0
2.150 |.................**************|          97.0
2.100 |.................**************|          97.0
2.050 |.................**************|          97.0
2.000 |.................**************|          97.0
1.950 |.................**************|          97.0
1.900 |..................*************|          98.0
1.850 |..................*************|          98.0
1.800 |..................*************|          98.0
1.750 |..................*************|          98.0
1.700 |...................************|          99.0
1.650 |...................************|          99.0
      |+----,----+----,----+----,----+|
       80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
          80.0      90.0      100.0     110.0       first pass data
         |+----,----+----,----+----,----+|
   3.650 |.............******************|          93.0
   3.600 |.............******************|          93.0
   3.550 |.............******************|          93.0
   3.500 |..............*****************|          94.0
   3.450 |..............*****************|          94.0
   3.400 |..............*****************|          94.0
   3.350 |..............*****************|          94.0
   3.300 |..............*****************|          94.0
   3.250 |..............*****************|          94.0
   3.200 |..............*****************|          94.0
   3.150 |..............*****************|          94.0
   3.100 |..............*****************|          94.0
   3.050 |..............*****************|          94.0
   3.000 |..............*****************|          94.0
   2.950 |..............*****************|          94.0
   2.900 |..............*****************|          94.0
   2.850 |..............*****************|          94.0
   2.800 |..............*****************|          94.0
   2.750 |..............*****************|          94.0
   2.700 |..............*****************|          94.0
   2.650 |..............*****************|          94.0
         |+----,----+----,----+----,----+|
          80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
          80.0      90.0      100.0     110.0       first pass data
         |+----,----+----,----+----,----+|
   3.650 |...............****************|          95.0
   3.600 |...............****************|          95.0
   3.550 |...............****************|          95.0
   3.500 |...............****************|          95.0
   3.450 |...............****************|          95.0
   3.400 |...............****************|          95.0
   3.350 |...............****************|          95.0
   3.300 |...............****************|          95.0
   3.250 |...............****************|          95.0
   3.200 |...............****************|          95.0
   3.150 |...............****************|          95.0
   3.100 |...............****************|          95.0
   3.050 |...............****************|          95.0
   3.000 |...............****************|          95.0
   2.950 |...............****************|          95.0
   2.900 |...............****************|          95.0
   2.850 |...............****************|          95.0
   2.800 |................***************|          96.0
   2.750 |................***************|          96.0
   2.700 |................***************|          96.0
   2.650 |................***************|          96.0
         |+----,----+----,----+----,----+|
          80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
             80.0      90.0      100.0     110.0        first pass data
            |+----,----+----,----+----,----+|
      3.650 |...............****************|           95.0
      3.600 |...............****************|           95.0
      3.550 |...............****************|           95.0
      3.500 |...............****************|           95.0
      3.450 |...............****************|           95.0
      3.400 |...............****************|           95.0
      3.350 |...............****************|           95.0
      3.300 |...............****************|           95.0
      3.250 |...............****************|           95.0
      3.200 |...............****************|           95.0
      3.150 |...............****************|           95.0
      3.100 |...............****************|           95.0
      3.050 |...............****************|           95.0
      3.000 |...............****************|           95.0
      2.950 |...............****************|           95.0
      2.900 |...............****************|           95.0
      2.850 |...............****************|           95.0
      2.800 |...............****************|           95.0
      2.750 |................***************|           96.0
      2.700 |................***************|           96.0
      2.650 |................***************|           96.0
            |+----,----+----,----+----,----+|
             80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
             80.0      90.0      100.0     110.0        first pass data
            |+----,----+----,----+----,----+|
      3.650 |................***************|           96.0
      3.600 |................***************|           96.0
      3.550 |................***************|           96.0
      3.500 |................***************|           96.0
      3.450 |................***************|           96.0
      3.400 |................***************|           96.0
      3.350 |................***************|           96.0
      3.300 |................***************|           96.0
      3.250 |................***************|           96.0
      3.200 |................***************|           96.0
      3.150 |................***************|           96.0
      3.100 |................***************|           96.0
      3.050 |................***************|           96.0
      3.000 |.................**************|           97.0
      2.950 |.................**************|           97.0
      2.900 |.................**************|           97.0
      2.850 |.................**************|           97.0
      2.800 |.................**************|           97.0
      2.750 |.................**************|           97.0
      2.700 |.................**************|           97.0
      2.650 |.................**************|           97.0
            |+----,----+----,----+----,----+|
             80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0      first pass data
        |+----,----+----,----+----,----+|
  3.000 |..............*****************|          94.0
  2.950 |..............*****************|          94.0
  2.900 |..............*****************|          94.0
  2.850 |..............*****************|          94.0
  2.800 |..............*****************|          94.0
  2.750 |..............*****************|          94.0
  2.700 |..............*****************|          94.0
  2.650 |..............*****************|          94.0
  2.600 |..............*****************|          94.0
  2.550 |..............*****************|          94.0
  2.500 |..............*****************|          94.0
  2.450 |..............*****************|          94.0
  2.400 |..............*****************|          94.0
  2.350 |..............*****************|          94.0
  2.300 |...............****************|          95.0
  2.250 |...............****************|          95.0
  2.200 |...............****************|          95.0
  2.150 |...............****************|          95.0
  2.100 |...............****************|          95.0
  2.050 |...............****************|          95.0
  2.000 |...............****************|          95.0
  1.950 |...............****************|          95.0
  1.900 |...............****************|          95.0
  1.850 |...............****************|          95.0
  1.800 |................***************|          96.0
  1.750 |................***************|          96.0
  1.700 |.................**************|          97.0
  1.650 |.................**************|          97.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
         80.0      90.0      100.0     110.0      first pass data
        |+----,----+----,----+----,----+|
  3.000 |...............****************|          95.0
  2.950 |...............****************|          95.0
  2.900 |...............****************|          95.0
  2.850 |...............****************|          95.0
  2.800 |...............****************|          95.0
  2.750 |...............****************|          95.0
  2.700 |...............****************|          95.0
  2.650 |...............****************|          95.0
  2.600 |...............****************|          95.0
  2.550 |................***************|          96.0
  2.500 |................***************|          96.0
  2.450 |................***************|          96.0
  2.400 |................***************|          96.0
  2.350 |................***************|          96.0
  2.300 |................***************|          96.0
  2.250 |................***************|          96.0
  2.200 |................***************|          96.0
  2.150 |................***************|          96.0
  2.100 |................***************|          96.0
  2.050 |................***************|          96.0
  2.000 |................***************|          96.0
  1.950 |................***************|          96.0
  1.900 |.................**************|          97.0
  1.850 |.................**************|          97.0
  1.800 |.................**************|          97.0
  1.750 |.................**************|          97.0
  1.700 |..................*************|          98.0
  1.650 |..................*************|          98.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
           80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.000 |...............****************|           95.0
  2.950 |...............****************|           95.0
  2.900 |...............****************|           95.0
  2.850 |...............****************|           95.0
  2.800 |...............****************|           95.0
  2.750 |...............****************|           95.0
  2.700 |...............****************|           95.0
  2.650 |...............****************|           95.0
  2.600 |...............****************|           95.0
  2.550 |...............****************|           95.0
  2.500 |...............****************|           95.0
  2.450 |................***************|           96.0
  2.400 |................***************|           96.0
  2.350 |................***************|           96.0
  2.300 |................***************|           96.0
  2.250 |................***************|           96.0
  2.200 |................***************|           96.0
  2.150 |................***************|           96.0
  2.100 |................***************|           96.0
  2.050 |................***************|           96.0
  2.000 |................***************|           96.0
  1.950 |................***************|           96.0
  1.900 |.................**************|           97.0
  1.850 |.................**************|           97.0
  1.800 |.................**************|           97.0
  1.750 |.................**************|           97.0
  1.700 |..................*************|           98.0
  1.650 |..................*************|           98.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
           80.0      90.0      100.0     110.0       first pass data
        |+----,----+----,----+----,----+|
  3.000 |.................**************|           97.0
  2.950 |.................**************|           97.0
  2.900 |.................**************|           97.0
  2.850 |.................**************|           97.0
  2.800 |.................**************|           97.0
  2.750 |.................**************|           97.0
  2.700 |.................**************|           97.0
  2.650 |.................**************|           97.0
  2.600 |.................**************|           97.0
  2.550 |.................**************|           97.0
  2.500 |.................**************|           97.0
  2.450 |.................**************|           97.0
  2.400 |.................**************|           97.0
  2.350 |.................**************|           97.0
  2.300 |.................**************|           97.0
  2.250 |.................**************|           97.0
  2.200 |.................**************|           97.0
  2.150 |.................**************|           97.0
  2.100 |.................**************|           97.0
  2.050 |..................*************|           98.0
  2.000 |..................*************|           98.0
  1.950 |..................*************|           98.0
  1.900 |..................*************|           98.0
  1.850 |..................*************|           98.0
  1.800 |..................*************|           98.0
  1.750 |...................************|           99.0
  1.700 |...................************|           99.0
  1.650 |...................************|           99.0
        |+----,----+----,----+----,----+|
         80.0      90.0      100.0     110.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       0.0       10.0      20.0            first pass data
      |+----,----+----,----+----,|
3.650 |......********************|         6.0
3.600 |......********************|         6.0
3.550 |......********************|         6.0
3.500 |......********************|         6.0
3.450 |......********************|         6.0
3.400 |......********************|         6.0
3.350 |......********************|         6.0
3.300 |......********************|         6.0
3.250 |......********************|         6.0
3.200 |......********************|         6.0
3.150 |......********************|         6.0
3.100 |......********************|         6.0
3.050 |......********************|         6.0
3.000 |......********************|         6.0
2.950 |......********************|         6.0
2.900 |......********************|         6.0
2.850 |......********************|         6.0
2.800 |......********************|         6.0
2.750 |......********************|         6.0
2.700 |......********************|         6.0
2.650 |......********************|         6.0
      |+----,----+----,----+----,|
       0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       0.0       10.0      20.0            first pass data
      |+----,----+----,----+----,|
3.650 |......********************|         6.0
3.600 |......********************|         6.0
3.550 |......********************|         6.0
3.500 |......********************|         6.0
3.450 |......********************|         6.0
3.400 |......********************|         6.0
3.350 |......********************|         6.0
3.300 |......********************|         6.0
3.250 |......********************|         6.0
3.200 |......********************|         6.0
3.150 |......********************|         6.0
3.100 |......********************|         6.0
3.050 |......********************|         6.0
3.000 |......********************|         6.0
2.950 |......********************|         6.0
2.900 |......********************|         6.0
2.850 |......********************|         6.0
2.800 |......********************|         6.0
2.750 |......********************|         6.0
2.700 |.......*******************|         7.0
2.650 |.......*******************|         7.0
      |+----,----+----,----+----,|
       0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          0.0        10.0       20.0              first pass data
         |+----,----+----,----+----,|
   3.650 |......********************|             6.0
   3.600 |......********************|             6.0
   3.550 |......********************|             6.0
   3.500 |......********************|             6.0
   3.450 |......********************|             6.0
   3.400 |......********************|             6.0
   3.350 |......********************|             6.0
   3.300 |......********************|             6.0
   3.250 |......********************|             6.0
   3.200 |......********************|             6.0
   3.150 |......********************|             6.0
   3.100 |......********************|             6.0
   3.050 |......********************|             6.0
   3.000 |......********************|             6.0
   2.950 |......********************|             6.0
   2.900 |......********************|             6.0
   2.850 |......********************|             6.0
   2.800 |......********************|             6.0
   2.750 |......********************|             6.0
   2.700 |......********************|             6.0
   2.650 |......********************|             6.0
         |+----,----+----,----+----,|
          0.0        10.0       20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
          0.0        10.0       20.0              first pass data
         |+----,----+----,----+----,|
   3.650 |.....*********************|             5.0
   3.600 |.....*********************|             5.0
   3.550 |.....*********************|             5.0
   3.500 |.....*********************|             5.0
   3.450 |.....*********************|             5.0
   3.400 |.....*********************|             5.0
   3.350 |.....*********************|             5.0
   3.300 |.....*********************|             5.0
   3.250 |.....*********************|             5.0
   3.200 |.....*********************|             5.0
   3.150 |.....*********************|             5.0
   3.100 |.....*********************|             5.0
   3.050 |.....*********************|             5.0
   3.000 |.....*********************|             5.0
   2.950 |.....*********************|             5.0
   2.900 |......********************|             6.0
   2.850 |......********************|             6.0
   2.800 |......********************|             6.0
   2.750 |......********************|             6.0
   2.700 |......********************|             6.0
   2.650 |......********************|             6.0
         |+----,----+----,----+----,|
          0.0        10.0       20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
         0.0       10.0      20.0          first pass data
        |+----,----+----,----+----,|
  3.000 |......********************|        6.0
  2.950 |......********************|        6.0
  2.900 |......********************|        6.0
  2.850 |......********************|        6.0
  2.800 |......********************|        6.0
  2.750 |......********************|        6.0
  2.700 |......********************|        6.0
  2.650 |......********************|        6.0
  2.600 |......********************|        6.0
  2.550 |......********************|        6.0
  2.500 |......********************|        6.0
  2.450 |......********************|        6.0
  2.400 |......********************|        6.0
  2.350 |......********************|        6.0
  2.300 |.......*******************|        7.0
  2.250 |.......*******************|        7.0
  2.200 |.......*******************|        7.0
  2.150 |.......*******************|        7.0
  2.100 |.......*******************|        7.0
  2.050 |.......*******************|        7.0
  2.000 |.......*******************|        7.0
  1.950 |.......*******************|        7.0
  1.900 |.......*******************|        7.0
  1.850 |........******************|        8.0
  1.800 |........******************|        8.0
  1.750 |........******************|        8.0
  1.700 |.........*****************|        9.0
  1.650 |.........*****************|        9.0
        |+----,----+----,----+----,|
         0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
         0.0       10.0      20.0          first pass data
        |+----,----+----,----+----,|
  3.000 |......********************|        6.0
  2.950 |......********************|        6.0
  2.900 |......********************|        6.0
  2.850 |......********************|        6.0
  2.800 |......********************|        6.0
  2.750 |......********************|        6.0
  2.700 |.......*******************|        7.0
  2.650 |.......*******************|        7.0
  2.600 |.......*******************|        7.0
  2.550 |.......*******************|        7.0
  2.500 |.......*******************|        7.0
  2.450 |.......*******************|        7.0
  2.400 |.......*******************|        7.0
  2.350 |.......*******************|        7.0
  2.300 |.......*******************|        7.0
  2.250 |.......*******************|        7.0
  2.200 |.......*******************|        7.0
  2.150 |.......*******************|        7.0
  2.100 |.......*******************|        7.0
  2.050 |.......*******************|        7.0
  2.000 |........******************|        8.0
  1.950 |........******************|        8.0
  1.900 |........******************|        8.0
  1.850 |........******************|        8.0
  1.800 |........******************|        8.0
  1.750 |........******************|        8.0
  1.700 |.........*****************|        9.0
  1.650 |.........*****************|        9.0
        |+----,----+----,----+----,|
         0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0                first pass data
         |+----,----+----,----+----,|
   3.000 |......********************|             6.0
   2.950 |......********************|             6.0
   2.900 |......********************|             6.0
   2.850 |......********************|             6.0
   2.800 |......********************|             6.0
   2.750 |......********************|             6.0
   2.700 |......********************|             6.0
   2.650 |......********************|             6.0
   2.600 |......********************|             6.0
   2.550 |......********************|             6.0
   2.500 |......********************|             6.0
   2.450 |......********************|             6.0
   2.400 |......********************|             6.0
   2.350 |......********************|             6.0
   2.300 |.......*******************|             7.0
   2.250 |.......*******************|             7.0
   2.200 |.......*******************|             7.0
   2.150 |.......*******************|             7.0
   2.100 |.......*******************|             7.0
   2.050 |.......*******************|             7.0
   2.000 |.......*******************|             7.0
   1.950 |.......*******************|             7.0
   1.900 |........******************|             8.0
   1.850 |........******************|             8.0
   1.800 |........******************|             8.0
   1.750 |........******************|             8.0
   1.700 |........******************|             8.0
   1.650 |........******************|             8.0
         |+----,----+----,----+----,|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0                first pass data
         |+----,----+----,----+----,|
   3.000 |.....*********************|             5.0
   2.950 |.....*********************|             5.0
   2.900 |......********************|             6.0
   2.850 |......********************|             6.0
   2.800 |......********************|             6.0
   2.750 |......********************|             6.0
   2.700 |......********************|             6.0
   2.650 |......********************|             6.0
   2.600 |......********************|             6.0
   2.550 |......********************|             6.0
   2.500 |......********************|             6.0
   2.450 |......********************|             6.0
   2.400 |......********************|             6.0
   2.350 |......********************|             6.0
   2.300 |......********************|             6.0
   2.250 |......********************|             6.0
   2.200 |......********************|             6.0
   2.150 |......********************|             6.0
   2.100 |......********************|             6.0
   2.050 |.......*******************|             7.0
   2.000 |.......*******************|             7.0
   1.950 |.......*******************|             7.0
   1.900 |.......*******************|             7.0
   1.850 |.......*******************|             7.0
   1.800 |........******************|             8.0
   1.750 |........******************|             8.0
   1.700 |........******************|             8.0
   1.650 |.........*****************|             9.0
         |+----,----+----,----+----,|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ 25°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |.........***********|           10.0
   3.600 |.........***********|           10.0
   3.550 |.........***********|           10.0
   3.500 |.........***********|           10.0
   3.450 |.........***********|           10.0
   3.400 |.........***********|           10.0
   3.350 |.........***********|           10.0
   3.300 |.........***********|           10.0
   3.250 |.........***********|           10.0
   3.200 |.........***********|           10.0
   3.150 |.........***********|           10.0
   3.100 |.........***********|           10.0
   3.050 |.........***********|           10.0
   3.000 |.........***********|           10.0
   2.950 |.........***********|           10.0
   2.900 |.........***********|           10.0
   2.850 |.........***********|           10.0
   2.800 |.........***********|           10.0
   2.750 |.........***********|           10.0
   2.700 |.........***********|           10.0
   2.650 |.........***********|           10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ 85°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |..........**********|           11.0
   3.600 |..........**********|           11.0
   3.550 |..........**********|           11.0
   3.500 |..........**********|           11.0
   3.450 |..........**********|           11.0
   3.400 |..........**********|           11.0
   3.350 |..........**********|           11.0
   3.300 |..........**********|           11.0
   3.250 |..........**********|           11.0
   3.200 |..........**********|           11.0
   3.150 |..........**********|           11.0
   3.100 |..........**********|           11.0
   3.050 |..........**********|           11.0
   3.000 |..........**********|           11.0
   2.950 |..........**********|           11.0
   2.900 |..........**********|           11.0
   2.850 |..........**********|           11.0
   2.800 |..........**********|           11.0
   2.750 |..........**********|           11.0
   2.700 |..........**********|           11.0
   2.650 |..........**********|           11.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |...........**********|          11.0
   3.600 |...........**********|          11.0
   3.550 |...........**********|          11.0
   3.500 |...........**********|          11.0
   3.450 |...........**********|          11.0
   3.400 |...........**********|          11.0
   3.350 |...........**********|          11.0
   3.300 |...........**********|          11.0
   3.250 |...........**********|          11.0
   3.200 |...........**********|          11.0
   3.150 |...........**********|          11.0
   3.100 |...........**********|          11.0
   3.050 |...........**********|          11.0
   3.000 |...........**********|          11.0
   2.950 |...........**********|          11.0
   2.900 |...........**********|          11.0
   2.850 |...........**********|          11.0
   2.800 |...........**********|          11.0
   2.750 |...........**********|          11.0
   2.700 |...........**********|          11.0
   2.650 |...........**********|          11.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
   3.650 |..........***********|          10.0
   3.600 |..........***********|          10.0
   3.550 |.........************|          9.0
   3.500 |..........***********|          10.0
   3.450 |.........************|          9.0
   3.400 |.........************|          9.0
   3.350 |.........************|          9.0
   3.300 |.........************|          9.0
   3.250 |.........************|          9.0
   3.200 |.........************|          9.0
   3.150 |.........************|          9.0
   3.100 |.........************|          9.0
   3.050 |.........************|          9.0
   3.000 |.........************|          9.0
   2.950 |..........***********|          10.0
   2.900 |..........***********|          10.0
   2.850 |.........************|          9.0
   2.800 |.........************|          9.0
   2.750 |..........***********|          10.0
   2.700 |..........***********|          10.0
   2.650 |..........***********|          10.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 25°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.000  |..........***********|           10.0
  2.950  |..........***********|           10.0
  2.900  |..........***********|           10.0
  2.850  |..........***********|           10.0
  2.800  |..........***********|           10.0
  2.750  |..........***********|           10.0
  2.700  |..........***********|           10.0
  2.650  |..........***********|           10.0
  2.600  |..........***********|           10.0
  2.550  |..........***********|           10.0
  2.500  |..........***********|           10.0
  2.450  |..........***********|           10.0
  2.400  |..........***********|           10.0
  2.350  |..........***********|           10.0
  2.300  |..........***********|           10.0
  2.250  |..........***********|           10.0
  2.200  |..........***********|           10.0
  2.150  |...........**********|           11.0
  2.100  |...........**********|           11.0
  2.050  |...........**********|           11.0
  2.000  |...........**********|           11.0
  1.950  |...........**********|           11.0
  1.900  |...........**********|           11.0
  1.850  |...........**********|           11.0
  1.800  |...........**********|           11.0
  1.750  |............*********|           12.0
  1.700  |............*********|           12.0
  1.650  |............*********|           12.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 85°C ($V_{CC}$ = 3V)

```
          0.0       10.0      20.0        first pass data
         |+----,----+----,----+|
  3.000  |...........**********|           11.0
  2.950  |...........**********|           11.0
  2.900  |...........**********|           11.0
  2.850  |...........**********|           11.0
  2.800  |...........**********|           11.0
  2.750  |...........**********|           11.0
  2.700  |...........**********|           11.0
  2.650  |...........**********|           11.0
  2.600  |...........**********|           11.0
  2.550  |...........**********|           11.0
  2.500  |...........**********|           11.0
  2.450  |...........**********|           11.0
  2.400  |...........**********|           11.0
  2.350  |...........**********|           11.0
  2.300  |...........**********|           11.0
  2.250  |...........**********|           11.0
  2.200  |...........**********|           11.0
  2.150  |...........**********|           11.0
  2.100  |...........**********|           11.0
  2.050  |...........**********|           11.0
  2.000  |...........**********|           11.0
  1.950  |...........**********|           11.0
  1.900  |............*********|           12.0
  1.850  |............*********|           12.0
  1.800  |............*********|           12.0
  1.750  |............*********|           12.0
  1.700  |............*********|           12.0
  1.650  |.............********|           13.0
         |+----,----+----,----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ 105°C ($V_{CC}$ = 3V)

```
             0.0       10.0      20.0        first pass data
            |+----,----+----,----+|
      3.000 |...........**********|          11.0
      2.950 |...........**********|          11.0
      2.900 |...........**********|          11.0
      2.850 |...........**********|          11.0
      2.800 |...........**********|          11.0
      2.750 |...........**********|          11.0
      2.700 |...........**********|          11.0
      2.650 |...........**********|          11.0
      2.600 |...........**********|          11.0
      2.550 |...........**********|          11.0
      2.500 |...........**********|          11.0
      2.450 |...........**********|          11.0
      2.400 |...........**********|          11.0
      2.350 |...........**********|          11.0
      2.300 |............*********|          12.0
      2.250 |............*********|          12.0
      2.200 |............*********|          12.0
      2.150 |............*********|          12.0
      2.100 |............*********|          12.0
      2.050 |............*********|          12.0
      2.000 |............*********|          12.0
      1.950 |............*********|          12.0
      1.900 |............*********|          12.0
      1.850 |............*********|          12.0
      1.800 |............*********|          12.0
      1.750 |.............********|          13.0
      1.700 |.............********|          13.0
      1.650 |.............********|          13.0
            |+----,----+----,----+|
             0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ @ -40°C ($V_{CC}$ = 3V)

```
             0.0       10.0      20.0        first pass data
            |+----,----+----,----+|
      3.000 |.........************|          9.0
      2.950 |..........***********|          10.0
      2.900 |.........************|          9.0
      2.850 |.........************|          9.0
      2.800 |.........************|          9.0
      2.750 |.........************|          9.0
      2.700 |..........***********|          10.0
      2.650 |..........***********|          10.0
      2.600 |..........***********|          10.0
      2.550 |..........***********|          10.0
      2.500 |..........***********|          10.0
      2.450 |..........***********|          10.0
      2.400 |..........***********|          10.0
      2.350 |..........***********|          10.0
      2.300 |..........***********|          10.0
      2.250 |..........***********|          10.0
      2.200 |..........***********|          10.0
      2.150 |..........***********|          10.0
      2.100 |..........***********|          10.0
      2.050 |..........***********|          10.0
      2.000 |..........***********|          10.0
      1.950 |..........***********|          10.0
      1.900 |...........**********|          11.0
      1.850 |...........**********|          11.0
      1.800 |...........**********|          11.0
      1.750 |...........**********|          11.0
      1.700 |............*********|          12.0
      1.650 |............*********|          12.0
            |+----,----+----,----+|
             0.0       10.0      20.0
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
        1.000     1.500     2.000     2.500     3.000         first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |....................*********************|         2.000
 3.600 |....................*********************|         2.000
 3.550 |...................**********************|         1.950
 3.500 |...................**********************|         1.950
 3.450 |..................***********************|         1.900
 3.400 |..................***********************|         1.900
 3.350 |.................************************|         1.850
 3.300 |.................************************|         1.850
 3.250 |................*************************|         1.800
 3.200 |...............**************************|         1.750
 3.150 |...............**************************|         1.750
 3.100 |..............***************************|         1.700
 3.050 |..............***************************|         1.700
 3.000 |.............****************************|         1.650
 2.950 |.............****************************|         1.650
 2.900 |............*****************************|         1.600
 2.850 |............*****************************|         1.600
 2.800 |...........******************************|         1.550
 2.750 |...........******************************|         1.550
 2.700 |..........*******************************|         1.500
 2.650 |.........********************************|         1.450
       |+----,----+----,----+----,----+----,----+|
        1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
        1.000     1.500     2.000     2.500     3.000         first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |....................*********************|         2.000
 3.600 |....................*********************|         2.000
 3.550 |...................**********************|         1.950
 3.500 |...................**********************|         1.950
 3.450 |..................***********************|         1.900
 3.400 |..................***********************|         1.900
 3.350 |.................************************|         1.850
 3.300 |................*************************|         1.800
 3.250 |................*************************|         1.800
 3.200 |...............**************************|         1.750
 3.150 |...............**************************|         1.750
 3.100 |..............***************************|         1.700
 3.050 |..............***************************|         1.700
 3.000 |.............****************************|         1.650
 2.950 |.............****************************|         1.650
 2.900 |............*****************************|         1.600
 2.850 |............*****************************|         1.600
 2.800 |...........******************************|         1.550
 2.750 |..........*******************************|         1.500
 2.700 |..........*******************************|         1.500
 2.650 |.........********************************|         1.450
       |+----,----+----,----+----,----+----,----+|
        1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
        1.000     1.500     2.000     2.500     3.000        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |....................*********************|           2.000
 3.600 |...................**********************|           1.950
 3.550 |...................**********************|           1.950
 3.500 |..................***********************|           1.900
 3.450 |..................***********************|           1.900
 3.400 |.................************************|           1.850
 3.350 |.................************************|           1.850
 3.300 |................*************************|           1.800
 3.250 |................*************************|           1.800
 3.200 |...............**************************|           1.750
 3.150 |...............**************************|           1.750
 3.100 |..............***************************|           1.700
 3.050 |.............****************************|           1.650
 3.000 |.............****************************|           1.650
 2.950 |............*****************************|           1.600
 2.900 |............*****************************|           1.600
 2.850 |...........******************************|           1.550
 2.800 |...........******************************|           1.550
 2.750 |..........*******************************|           1.500
 2.700 |..........*******************************|           1.500
 2.650 |.........********************************|           1.450
       |+----,----+----,----+----,----+----,----+|
        1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
        1.000     1.500     2.000     2.500     3.000        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |.....................********************|           2.050
 3.600 |....................*********************|           2.000
 3.550 |....................*********************|           2.000
 3.500 |...................**********************|           1.950
 3.450 |..................***********************|           1.900
 3.400 |..................***********************|           1.900
 3.350 |.................************************|           1.850
 3.300 |.................************************|           1.850
 3.250 |................*************************|           1.800
 3.200 |................*************************|           1.800
 3.150 |...............**************************|           1.750
 3.100 |...............**************************|           1.750
 3.050 |..............***************************|           1.700
 3.000 |.............****************************|           1.650
 2.950 |.............****************************|           1.650
 2.900 |............*****************************|           1.600
 2.850 |............*****************************|           1.600
 2.800 |...........******************************|           1.550
 2.750 |...........******************************|           1.550
 2.700 |..........*******************************|           1.500
 2.650 |..........*******************************|           1.500
       |+----,----+----,----+----,----+----,----+|
        1.000     1.500     2.000     2.500     3.000
```

## $V_{IL}$ vs. $V_{CC}$ =$V_{IO}$ @ 25°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |********************************.........|          1.550
3.600 |*******************************..........|          1.500
3.550 |*******************************..........|          1.500
3.500 |*******************************..........|          1.500
3.450 |******************************...........|          1.450
3.400 |******************************...........|          1.450
3.350 |******************************...........|          1.450
3.300 |*****************************............|          1.400
3.250 |*****************************............|          1.400
3.200 |*****************************............|          1.400
3.150 |****************************.............|          1.350
3.100 |****************************.............|          1.350
3.050 |****************************.............|          1.350
3.000 |***************************..............|          1.300
2.950 |***************************..............|          1.300
2.900 |**************************...............|          1.250
2.850 |**************************...............|          1.250
2.800 |**************************...............|          1.250
2.750 |*************************................|          1.200
2.700 |*************************................|          1.200
2.650 |*************************................|          1.200
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$ =$V_{IO}$ @ 85°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*******************************..........|          1.500
3.600 |*******************************..........|          1.500
3.550 |*******************************..........|          1.500
3.500 |******************************...........|          1.450
3.450 |******************************...........|          1.450
3.400 |*****************************............|          1.400
3.350 |*****************************............|          1.400
3.300 |*****************************............|          1.400
3.250 |****************************.............|          1.350
3.200 |****************************.............|          1.350
3.150 |****************************.............|          1.350
3.100 |***************************..............|          1.300
3.050 |***************************..............|          1.300
3.000 |***************************..............|          1.300
2.950 |**************************...............|          1.250
2.900 |**************************...............|          1.250
2.850 |**************************...............|          1.250
2.800 |*************************................|          1.200
2.750 |*************************................|          1.200
2.700 |*************************................|          1.200
2.650 |************************.................|          1.150
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*******************************..........|          1.500
3.600 |*******************************..........|          1.500
3.550 |******************************...........|          1.450
3.500 |******************************...........|          1.450
3.450 |******************************...........|          1.450
3.400 |*****************************............|          1.400
3.350 |*****************************............|          1.400
3.300 |*****************************............|          1.400
3.250 |****************************.............|          1.350
3.200 |****************************.............|          1.350
3.150 |****************************.............|          1.350
3.100 |***************************..............|          1.300
3.050 |***************************..............|          1.300
3.000 |**************************...............|          1.250
2.950 |**************************...............|          1.250
2.900 |**************************...............|          1.250
2.850 |*************************................|          1.200
2.800 |*************************................|          1.200
2.750 |*************************................|          1.200
2.700 |************************.................|          1.150
2.650 |************************.................|          1.150
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |********************************.........|          1.550
3.600 |********************************.........|          1.550
3.550 |********************************.........|          1.550
3.500 |*******************************..........|          1.500
3.450 |*******************************..........|          1.500
3.400 |******************************...........|          1.450
3.350 |******************************...........|          1.450
3.300 |******************************...........|          1.450
3.250 |*****************************............|          1.400
3.200 |*****************************............|          1.400
3.150 |*****************************............|          1.400
3.100 |****************************.............|          1.350
3.050 |****************************.............|          1.350
3.000 |****************************.............|          1.350
2.950 |***************************..............|          1.300
2.900 |***************************..............|          1.300
2.850 |***************************..............|          1.300
2.800 |**************************...............|          1.250
2.750 |**************************...............|          1.250
2.700 |*************************................|          1.200
2.650 |*************************................|          1.200
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

### $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|        3.600
3.600 |********************************.........|        3.550
3.550 |*******************************..........|        3.500
3.500 |******************************...........|        3.450
3.450 |*****************************............|        3.400
3.400 |****************************.............|        3.350
3.350 |***************************..............|        3.300
3.300 |**************************...............|        3.250
3.250 |*************************................|        3.200
3.200 |************************.................|        3.150
3.150 |***********************..................|        3.100
3.100 |**********************...................|        3.050
3.050 |*********************....................|        3.000
3.000 |********************.....................|        2.950
2.950 |*******************......................|        2.900
2.900 |******************.......................|        2.850
2.850 |*****************........................|        2.800
2.800 |****************.........................|        2.750
2.750 |***************..........................|        2.700
2.700 |**************...........................|        2.650
2.650 |*************............................|        2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

### $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----,----+----,----+----,----+----,----+|
3.650 |*********************************........|        3.600
3.600 |********************************.........|        3.550
3.550 |*******************************..........|        3.500
3.500 |******************************...........|        3.450
3.450 |*****************************............|        3.400
3.400 |****************************.............|        3.350
3.350 |***************************..............|        3.300
3.300 |**************************...............|        3.250
3.250 |*************************................|        3.200
3.200 |************************.................|        3.150
3.150 |***********************..................|        3.100
3.100 |**********************...................|        3.050
3.050 |*********************....................|        3.000
3.000 |********************.....................|        2.950
2.950 |*******************......................|        2.900
2.900 |******************.......................|        2.850
2.850 |*****************........................|        2.800
2.800 |****************.........................|        2.750
2.750 |***************..........................|        2.700
2.700 |**************...........................|        2.650
2.650 |*************............................|        2.600
      |+----,----+----,----+----,----+----,----+|
       2.000     2.500     3.000     3.500     4.000
```

### $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
        2.000     2.500     3.000     3.500     4.000       first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |*********************************........|          3.600
 3.600 |********************************.........|          3.550
 3.550 |*******************************..........|          3.500
 3.500 |******************************...........|          3.450
 3.450 |*****************************............|          3.400
 3.400 |****************************.............|          3.350
 3.350 |***************************..............|          3.300
 3.300 |**************************...............|          3.250
 3.250 |*************************................|          3.200
 3.200 |************************.................|          3.150
 3.150 |***********************..................|          3.100
 3.100 |**********************...................|          3.050
 3.050 |*********************....................|          3.000
 3.000 |********************.....................|          2.950
 2.950 |*******************......................|          2.900
 2.900 |******************.......................|          2.850
 2.850 |*****************........................|          2.800
 2.800 |****************.........................|          2.750
 2.750 |***************..........................|          2.700
 2.700 |**************...........................|          2.650
 2.650 |*************............................|          2.600
       |+----,----+----,----+----,----+----,----+|
        2.000     2.500     3.000     3.500     4.000
```

### $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
        2.000     2.500     3.000     3.500     4.000       first pass data
       |+----,----+----,----+----,----+----,----+|
 3.650 |*********************************........|          3.600
 3.600 |********************************.........|          3.550
 3.550 |*******************************..........|          3.500
 3.500 |******************************...........|          3.450
 3.450 |*****************************............|          3.400
 3.400 |****************************.............|          3.350
 3.350 |***************************..............|          3.300
 3.300 |**************************...............|          3.250
 3.250 |*************************................|          3.200
 3.200 |************************.................|          3.150
 3.150 |***********************..................|          3.100
 3.100 |**********************...................|          3.050
 3.050 |*********************....................|          3.000
 3.000 |********************.....................|          2.950
 2.950 |*******************......................|          2.900
 2.900 |******************.......................|          2.850
 2.850 |*****************........................|          2.800
 2.800 |****************.........................|          2.750
 2.750 |***************..........................|          2.700
 2.700 |**************...........................|          2.650
 2.650 |*************............................|          2.600
       |+----,----+----,----+----,----+----,----+|
        2.000     2.500     3.000     3.500     4.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
          0.000     0.500     1.000        first pass data
         |+----,----+----,----+|
   3.650 |.********************|           0.050
   3.600 |.********************|           0.050
   3.550 |.********************|           0.050
   3.500 |.********************|           0.050
   3.450 |.********************|           0.050
   3.400 |.********************|           0.050
   3.350 |.********************|           0.050
   3.300 |.********************|           0.050
   3.250 |.********************|           0.050
   3.200 |.********************|           0.050
   3.150 |.********************|           0.050
   3.100 |.********************|           0.050
   3.050 |.********************|           0.050
   3.000 |.********************|           0.050
   2.950 |.********************|           0.050
   2.900 |.********************|           0.050
   2.850 |.********************|           0.050
   2.800 |.********************|           0.050
   2.750 |.********************|           0.050
   2.700 |.********************|           0.050
   2.650 |.********************|           0.050
         |+----,----+----,----+|
          0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
         0.000     0.500     1.000        first pass data
         |+----,----+----,----+|
   3.650 |.********************|           0.050
   3.600 |.********************|           0.050
   3.550 |.********************|           0.050
   3.500 |.********************|           0.050
   3.450 |.********************|           0.050
   3.400 |.********************|           0.050
   3.350 |.********************|           0.050
   3.300 |.********************|           0.050
   3.250 |.********************|           0.050
   3.200 |.********************|           0.050
   3.150 |.********************|           0.050
   3.100 |.********************|           0.050
   3.050 |.********************|           0.050
   3.000 |.********************|           0.050
   2.950 |.********************|           0.050
   2.900 |.********************|           0.050
   2.850 |.********************|           0.050
   2.800 |.********************|           0.050
   2.750 |.********************|           0.050
   2.700 |.********************|           0.050
   2.650 |.********************|           0.050
         |+----,----+----,----+|
          0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
       0.000     0.500     1.000       first pass data
      |+----,----+----,----+|
3.650 |.********************|          0.050
3.600 |.********************|          0.050
3.550 |.********************|          0.050
3.500 |.********************|          0.050
3.450 |.********************|          0.050
3.400 |.********************|          0.050
3.350 |.********************|          0.050
3.300 |.********************|          0.050
3.250 |.********************|          0.050
3.200 |.********************|          0.050
3.150 |.********************|          0.050
3.100 |.********************|          0.050
3.050 |.********************|          0.050
3.000 |.********************|          0.050
2.950 |.********************|          0.050
2.900 |.********************|          0.050
2.850 |.********************|          0.050
2.800 |.********************|          0.050
2.750 |.********************|          0.050
2.700 |.********************|          0.050
2.650 |.********************|          0.050
      |+----,----+----,----+|
       0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       0.000     0.500     1.000       first pass data
      |+----,----+----,----+|
3.650 |.********************|          0.050
3.600 |.********************|          0.050
3.550 |.********************|          0.050
3.500 |.********************|          0.050
3.450 |.********************|          0.050
3.400 |.********************|          0.050
3.350 |.********************|          0.050
3.300 |.********************|          0.050
3.250 |.********************|          0.050
3.200 |.********************|          0.050
3.150 |.********************|          0.050
3.100 |.********************|          0.050
3.050 |.********************|          0.050
3.000 |.********************|          0.050
2.950 |.********************|          0.050
2.900 |.********************|          0.050
2.850 |.********************|          0.050
2.800 |.********************|          0.050
2.750 |.********************|          0.050
2.700 |.********************|          0.050
2.650 |.********************|          0.050
      |+----,----+----,----+|
       0.000     0.500     1.000
```

### $V_{IH}$ vs. $V_{IO}$ @ 25°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |.......................******************|       1.650
2.950 |.......................******************|       1.650
2.900 |......................*******************|       1.600
2.850 |......................*******************|       1.600
2.800 |.....................********************|       1.550
2.750 |.....................********************|       1.550
2.700 |....................*********************|       1.500
2.650 |....................*********************|       1.500
2.600 |...................**********************|       1.450
2.550 |..................***********************|       1.400
2.500 |..................***********************|       1.400
2.450 |.................************************|       1.350
2.400 |.................************************|       1.350
2.350 |................*************************|       1.300
2.300 |................*************************|       1.300
2.250 |...............**************************|       1.250
2.200 |...............**************************|       1.250
2.150 |..............***************************|       1.200
2.100 |..............***************************|       1.200
2.050 |.............****************************|       1.150
2.000 |.............****************************|       1.150
1.950 |............*****************************|       1.100
1.900 |............*****************************|       1.100
1.850 |...........******************************|       1.050
1.800 |...........******************************|       1.050
1.750 |..........*******************************|       1.000
1.700 |.........********************************|       0.950
1.650 |.........********************************|       0.950
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ @ 85°C

```
       0.500     1.000     1.500     2.000     2.500       first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |.......................******************|       1.650
2.950 |.......................******************|       1.650
2.900 |......................*******************|       1.600
2.850 |.....................********************|       1.550
2.800 |.....................********************|       1.550
2.750 |....................*********************|       1.500
2.700 |....................*********************|       1.500
2.650 |...................**********************|       1.450
2.600 |...................**********************|       1.450
2.550 |..................***********************|       1.400
2.500 |..................***********************|       1.400
2.450 |.................************************|       1.350
2.400 |.................************************|       1.350
2.350 |................*************************|       1.300
2.300 |................*************************|       1.300
2.250 |...............**************************|       1.250
2.200 |...............**************************|       1.250
2.150 |..............***************************|       1.200
2.100 |..............***************************|       1.200
2.050 |.............****************************|       1.150
2.000 |.............****************************|       1.150
1.950 |............*****************************|       1.100
1.900 |............*****************************|       1.100
1.850 |...........******************************|       1.050
1.800 |...........******************************|       1.050
1.750 |..........*******************************|       1.000
1.700 |..........*******************************|       1.000
1.650 |.........********************************|       0.950
      |+----,----+----,----+----,----+----,----+|
       0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ @ 105°C

```
        0.500     1.000     1.500     2.000     2.500        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.000 |.......................******************|           1.650
 2.950 |......................*******************|           1.600
 2.900 |......................*******************|           1.600
 2.850 |.....................********************|           1.550
 2.800 |.....................********************|           1.550
 2.750 |....................*********************|           1.500
 2.700 |....................*********************|           1.500
 2.650 |...................**********************|           1.450
 2.600 |...................**********************|           1.450
 2.550 |..................***********************|           1.400
 2.500 |..................***********************|           1.400
 2.450 |.................************************|           1.350
 2.400 |.................************************|           1.350
 2.350 |................*************************|           1.300
 2.300 |................*************************|           1.300
 2.250 |...............**************************|           1.250
 2.200 |...............**************************|           1.250
 2.150 |..............***************************|           1.200
 2.100 |..............***************************|           1.200
 2.050 |.............****************************|           1.150
 2.000 |.............****************************|           1.150
 1.950 |............*****************************|           1.100
 1.900 |............*****************************|           1.100
 1.850 |...........******************************|           1.050
 1.800 |...........******************************|           1.050
 1.750 |..........*******************************|           1.000
 1.700 |..........*******************************|           1.000
 1.650 |.........********************************|           0.950
       |+----,----+----,----+----,----+----,----+|
        0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ @ -40°C

```
        0.500     1.000     1.500     2.000     2.500        first pass data
       |+----,----+----,----+----,----+----,----+|
 3.000 |.......................******************|           1.650
 2.950 |.......................******************|           1.650
 2.900 |......................*******************|           1.600
 2.850 |......................*******************|           1.600
 2.800 |.....................********************|           1.550
 2.750 |.....................********************|           1.550
 2.700 |....................*********************|           1.500
 2.650 |....................*********************|           1.500
 2.600 |...................**********************|           1.450
 2.550 |...................**********************|           1.450
 2.500 |..................***********************|           1.400
 2.450 |..................***********************|           1.400
 2.400 |.................************************|           1.350
 2.350 |................*************************|           1.300
 2.300 |................*************************|           1.300
 2.250 |...............**************************|           1.250
 2.200 |...............**************************|           1.250
 2.150 |..............***************************|           1.200
 2.100 |..............***************************|           1.200
 2.050 |.............****************************|           1.150
 2.000 |.............****************************|           1.150
 1.950 |............*****************************|           1.100
 1.900 |............*****************************|           1.100
 1.850 |...........******************************|           1.050
 1.800 |..........*******************************|           1.000
 1.750 |..........*******************************|           1.000
 1.700 |.........********************************|           0.950
 1.650 |.........********************************|           0.950
       |+----,----+----,----+----,----+----,----+|
        0.500     1.000     1.500     2.000     2.500
```

### $V_{IL}$ vs. $V_{IO}$ @ 25°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |**************************...............|         1.300
2.950 |**************************...............|         1.300
2.900 |*************************................|         1.250
2.850 |*************************................|         1.250
2.800 |*************************................|         1.250
2.750 |************************.................|         1.200
2.700 |************************.................|         1.200
2.650 |************************.................|         1.200
2.600 |***********************..................|         1.150
2.550 |***********************..................|         1.150
2.500 |**********************...................|         1.100
2.450 |**********************...................|         1.100
2.400 |**********************...................|         1.100
2.350 |*********************....................|         1.050
2.300 |*********************....................|         1.050
2.250 |*********************....................|         1.050
2.200 |********************.....................|         1.000
2.150 |********************.....................|         1.000
2.100 |*******************......................|         0.950
2.050 |*******************......................|         0.950
2.000 |*******************......................|         0.950
1.950 |******************.......................|         0.900
1.900 |******************.......................|         0.900
1.850 |******************.......................|         0.900
1.800 |*****************........................|         0.850
1.750 |*****************........................|         0.850
1.700 |*****************........................|         0.850
1.650 |*****************........................|         0.850
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{IO}$ @ 85°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |**************************...............|         1.300
2.950 |*************************................|         1.250
2.900 |*************************................|         1.250
2.850 |*************************................|         1.250
2.800 |************************.................|         1.200
2.750 |************************.................|         1.200
2.700 |************************.................|         1.200
2.650 |***********************..................|         1.150
2.600 |***********************..................|         1.150
2.550 |**********************...................|         1.100
2.500 |**********************...................|         1.100
2.450 |**********************...................|         1.100
2.400 |*********************....................|         1.050
2.350 |*********************....................|         1.050
2.300 |*********************....................|         1.050
2.250 |********************.....................|         1.000
2.200 |********************.....................|         1.000
2.150 |*******************......................|         0.950
2.100 |*******************......................|         0.950
2.050 |*******************......................|         0.950
2.000 |******************.......................|         0.900
1.950 |******************.......................|         0.900
1.900 |******************.......................|         0.900
1.850 |******************.......................|         0.900
1.800 |*****************........................|         0.850
1.750 |*****************........................|         0.850
1.700 |*****************........................|         0.850
1.650 |*****************........................|         0.850
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ @ 105°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |*************************................|           1.250
2.950 |*************************................|           1.250
2.900 |*************************................|           1.250
2.850 |************************.................|           1.200
2.800 |************************.................|           1.200
2.750 |************************.................|           1.200
2.700 |***********************..................|           1.150
2.650 |***********************..................|           1.150
2.600 |***********************..................|           1.150
2.550 |**********************...................|           1.100
2.500 |**********************...................|           1.100
2.450 |*********************....................|           1.050
2.400 |*********************....................|           1.050
2.350 |*********************....................|           1.050
2.300 |********************.....................|           1.000
2.250 |********************.....................|           1.000
2.200 |********************.....................|           1.000
2.150 |*******************......................|           0.950
2.100 |*******************......................|           0.950
2.050 |*******************......................|           0.950
2.000 |******************.......................|           0.900
1.950 |******************.......................|           0.900
1.900 |******************.......................|           0.900
1.850 |*****************........................|           0.850
1.800 |*****************........................|           0.850
1.750 |*****************........................|           0.850
1.700 |*****************........................|           0.850
1.650 |****************.........................|           0.800
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ @ -40°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----,----+----,----+----,----+----,----+|
3.000 |***************************..............|           1.350
2.950 |**************************...............|           1.300
2.900 |**************************...............|           1.300
2.850 |**************************...............|           1.300
2.800 |*************************................|           1.250
2.750 |*************************................|           1.250
2.700 |************************.................|           1.200
2.650 |************************.................|           1.200
2.600 |************************.................|           1.200
2.550 |***********************..................|           1.150
2.500 |***********************..................|           1.150
2.450 |**********************...................|           1.100
2.400 |**********************...................|           1.100
2.350 |**********************...................|           1.100
2.300 |*********************....................|           1.050
2.250 |*********************....................|           1.050
2.200 |********************.....................|           1.000
2.150 |********************.....................|           1.000
2.100 |********************.....................|           1.000
2.050 |*******************......................|           0.950
2.000 |*******************......................|           0.950
1.950 |*******************......................|           0.950
1.900 |******************.......................|           0.900
1.850 |******************.......................|           0.900
1.800 |******************.......................|           0.900
1.750 |*****************........................|           0.850
1.700 |*****************........................|           0.850
1.650 |*****************........................|           0.850
      |+----,----+----,----+----,----+----,----+|
       0.000     0.500     1.000     1.500     2.000
```

### $V_{OH}$ vs. $V_{IO}$ @ 25°C

```
          1.500     2.000     2.500     3.000     3.500       first pass data
         |+----,----+----,----+----,----+----,----+|
   3.000 |******************************...........|           2.950
   2.950 |*****************************............|           2.900
   2.900 |****************************.............|           2.850
   2.850 |***************************..............|           2.800
   2.800 |**************************...............|           2.750
   2.750 |*************************................|           2.700
   2.700 |************************.................|           2.650
   2.650 |***********************..................|           2.600
   2.600 |**********************...................|           2.550
   2.550 |*********************....................|           2.500
   2.500 |********************.....................|           2.450
   2.450 |*******************......................|           2.400
   2.400 |******************.......................|           2.350
   2.350 |*****************........................|           2.300
   2.300 |****************.........................|           2.250
   2.250 |***************..........................|           2.200
   2.200 |**************...........................|           2.150
   2.150 |*************............................|           2.100
   2.100 |************.............................|           2.050
   2.050 |***********..............................|           2.000
   2.000 |**********...............................|           1.950
   1.950 |*********................................|           1.900
   1.900 |********.................................|           1.850
   1.850 |*******..................................|           1.800
   1.800 |******...................................|           1.750
   1.750 |*****....................................|           1.700
   1.700 |****.....................................|           1.650
   1.650 |***......................................|           1.600
         |+----,----+----,----+----,----+----,----+|
           1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ @ 85°C

```
          1.500     2.000     2.500     3.000     3.500       first pass data
         |+----,----+----,----+----,----+----,----+|
   3.000 |******************************...........|           2.950
   2.950 |*****************************............|           2.900
   2.900 |****************************.............|           2.850
   2.850 |***************************..............|           2.800
   2.800 |**************************...............|           2.750
   2.750 |*************************................|           2.700
   2.700 |************************.................|           2.650
   2.650 |***********************..................|           2.600
   2.600 |**********************...................|           2.550
   2.550 |*********************....................|           2.500
   2.500 |********************.....................|           2.450
   2.450 |*******************......................|           2.400
   2.400 |******************.......................|           2.350
   2.350 |*****************........................|           2.300
   2.300 |****************.........................|           2.250
   2.250 |***************..........................|           2.200
   2.200 |**************...........................|           2.150
   2.150 |*************............................|           2.100
   2.100 |************.............................|           2.050
   2.050 |***********..............................|           2.000
   2.000 |**********...............................|           1.950
   1.950 |*********................................|           1.900
   1.900 |********.................................|           1.850
   1.850 |*******..................................|           1.800
   1.800 |******...................................|           1.750
   1.750 |*****....................................|           1.700
   1.700 |****.....................................|           1.650
   1.650 |***......................................|           1.600
         |+----,----+----,----+----,----+----,----+|
           1.500     2.000     2.500     3.000     3.500
```

## $V_{OH}$ vs. $V_{IO}$ @ 105°C

```
             1.500     2.000     2.500     3.000     3.500       first pass data
            |+----,----+----,----+----,----+----,----+|
      3.000 |******************************...........|        2.950
      2.950 |*****************************............|        2.900
      2.900 |****************************.............|        2.850
      2.850 |***************************..............|        2.800
      2.800 |**************************...............|        2.750
      2.750 |*************************................|        2.700
      2.700 |************************.................|        2.650
      2.650 |***********************..................|        2.600
      2.600 |**********************...................|        2.550
      2.550 |*********************....................|        2.500
      2.500 |********************.....................|        2.450
      2.450 |*******************......................|        2.400
      2.400 |******************.......................|        2.350
      2.350 |*****************........................|        2.300
      2.300 |****************.........................|        2.250
      2.250 |***************..........................|        2.200
      2.200 |**************...........................|        2.150
      2.150 |*************............................|        2.100
      2.100 |************.............................|        2.050
      2.050 |***********..............................|        2.000
      2.000 |**********...............................|        1.950
      1.950 |*********................................|        1.900
      1.900 |********.................................|        1.850
      1.850 |*******..................................|        1.800
      1.800 |******...................................|        1.750
      1.750 |*****....................................|        1.700
      1.700 |****.....................................|        1.650
      1.650 |***......................................|        1.600
            |+----,----+----,----+----,----+----,----+|
              1.500     2.000     2.500     3.000     3.500
```

## $V_{OH}$ vs. $V_{IO}$ @ -40°C

```
             1.500     2.000     2.500     3.000     3.500       first pass data
            |+----,----+----,----+----,----+----,----+|
      3.000 |******************************...........|        2.950
      2.950 |*****************************............|        2.900
      2.900 |****************************.............|        2.850
      2.850 |***************************..............|        2.800
      2.800 |**************************...............|        2.750
      2.750 |*************************................|        2.700
      2.700 |************************.................|        2.650
      2.650 |***********************..................|        2.600
      2.600 |**********************...................|        2.550
      2.550 |*********************....................|        2.500
      2.500 |********************.....................|        2.450
      2.450 |*******************......................|        2.400
      2.400 |******************.......................|        2.350
      2.350 |*****************........................|        2.300
      2.300 |****************.........................|        2.250
      2.250 |***************..........................|        2.200
      2.200 |**************...........................|        2.150
      2.150 |*************............................|        2.100
      2.100 |************.............................|        2.050
      2.050 |***********..............................|        2.000
      2.000 |**********...............................|        1.950
      1.950 |*********................................|        1.900
      1.900 |********.................................|        1.850
      1.850 |*******..................................|        1.800
      1.800 |******...................................|        1.750
      1.750 |*****....................................|        1.700
      1.700 |****.....................................|        1.650
      1.650 |***......................................|        1.600
            |+----,----+----,----+----,----+----,----+|
              1.500     2.000     2.500     3.000     3.500
```

## $V_{OL}$ vs. $V_{IO}$ @ 25°C

```
        0.000     0.500     1.000       first pass data
       |+----,----+----,----+|
 3.000 |.********************|           0.050
 2.950 |.********************|           0.050
 2.900 |.********************|           0.050
 2.850 |.********************|           0.050
 2.800 |.********************|           0.050
 2.750 |.********************|           0.050
 2.700 |.********************|           0.050
 2.650 |.********************|           0.050
 2.600 |.********************|           0.050
 2.550 |.********************|           0.050
 2.500 |.********************|           0.050
 2.450 |.********************|           0.050
 2.400 |.********************|           0.050
 2.350 |.********************|           0.050
 2.300 |.********************|           0.050
 2.250 |.********************|           0.050
 2.200 |.********************|           0.050
 2.150 |.********************|           0.050
 2.100 |.********************|           0.050
 2.050 |.********************|           0.050
 2.000 |.********************|           0.050
 1.950 |.********************|           0.050
 1.900 |.********************|           0.050
 1.850 |.********************|           0.050
 1.800 |.********************|           0.050
 1.750 |.********************|           0.050
 1.700 |.********************|           0.050
 1.650 |.********************|           0.050
       |+----,----+----,----+|
        0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ 85°C

```
        0.000     0.500     1.000       first pass data
       |+----,----+----,----+|
 3.000 |.********************|           0.050
 2.950 |.********************|           0.050
 2.900 |.********************|           0.050
 2.850 |.********************|           0.050
 2.800 |.********************|           0.050
 2.750 |.********************|           0.050
 2.700 |.********************|           0.050
 2.650 |.********************|           0.050
 2.600 |.********************|           0.050
 2.550 |.********************|           0.050
 2.500 |.********************|           0.050
 2.450 |.********************|           0.050
 2.400 |.********************|           0.050
 2.350 |.********************|           0.050
 2.300 |.********************|           0.050
 2.250 |.********************|           0.050
 2.200 |.********************|           0.050
 2.150 |.********************|           0.050
 2.100 |.********************|           0.050
 2.050 |.********************|           0.050
 2.000 |.********************|           0.050
 1.950 |.********************|           0.050
 1.900 |.********************|           0.050
 1.850 |.********************|           0.050
 1.800 |.********************|           0.050
 1.750 |.********************|           0.050
 1.700 |.********************|           0.050
 1.650 |.********************|           0.050
       |+----,----+----,----+|
        0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ 105°C

```
         0.000     0.500     1.000       first pass data
        |+----,----+----,----+|
  3.000 |.********************|          0.050
  2.950 |.********************|          0.050
  2.900 |.********************|          0.050
  2.850 |.********************|          0.050
  2.800 |.********************|          0.050
  2.750 |.********************|          0.050
  2.700 |.********************|          0.050
  2.650 |.********************|          0.050
  2.600 |.********************|          0.050
  2.550 |.********************|          0.050
  2.500 |.********************|          0.050
  2.450 |.********************|          0.050
  2.400 |.********************|          0.050
  2.350 |.********************|          0.050
  2.300 |.********************|          0.050
  2.250 |.********************|          0.050
  2.200 |.********************|          0.050
  2.150 |.********************|          0.050
  2.100 |.********************|          0.050
  2.050 |.********************|          0.050
  2.000 |.********************|          0.050
  1.950 |.********************|          0.050
  1.900 |.********************|          0.050
  1.850 |.********************|          0.050
  1.800 |.********************|          0.050
  1.750 |.********************|          0.050
  1.700 |.********************|          0.050
  1.650 |.********************|          0.050
        |+----,----+----,----+|
         0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{IO}$ @ -40°C

```
         0.000     0.500     1.000       first pass data
        |+----,----+----,----+|
  3.000 |.********************|          0.050
  2.950 |.********************|          0.050
  2.900 |.********************|          0.050
  2.850 |.********************|          0.050
  2.800 |.********************|          0.050
  2.750 |.********************|          0.050
  2.700 |.********************|          0.050
  2.650 |.********************|          0.050
  2.600 |.********************|          0.050
  2.550 |.********************|          0.050
  2.500 |.********************|          0.050
  2.450 |.********************|          0.050
  2.400 |.********************|          0.050
  2.350 |.********************|          0.050
  2.300 |.********************|          0.050
  2.250 |.********************|          0.050
  2.200 |.********************|          0.050
  2.150 |.********************|          0.050
  2.100 |.********************|          0.050
  2.050 |.********************|          0.050
  2.000 |.********************|          0.050
  1.950 |.********************|          0.050
  1.900 |.********************|          0.050
  1.850 |.********************|          0.050
  1.800 |.********************|          0.050
  1.750 |.********************|          0.050
  1.700 |.********************|          0.050
  1.650 |.********************|          0.050
        |+----,----+----,----+|
         0.000     0.500     1.000
```

# 16. Quality Assurance Guidelines

Cypress is totally committed to shipping the highest quality product to its customers.

To assure this quality commitment, each commercial manufacturing lot must meet the requirements defined in all of the specifications listed below:

| Procedure | Test Method | Quality Test |
|---|---|---|
| Electrical Classification Tests | Guard banded to Data Sheet Specification | 100% |
| Mark | Cypress F16-018 | 100% |
| Lead Scan / Straighten | Cypress F16-049 | 100% |
| Visual / Mechanical Inspection | Cypress F16-049 | 100% |
| QA Documentation / Test verification | Cypress F06-027 | 100% |
| QA - Visual / Mechanical<br>Excelsior Monitor (See Below)<br>Qualification Maintenance Program | Cypress F06-027<br>Cypress F00-006<br>Cypress F01-002.18 | Sample<br>Sample<br>Sample |

## 16.1 Excelsior Quality Monitor

Cypress's Excelsior Quality Program is an in-line monitor of electrical, visual/mechanical, solderability and marking permanency quality. Data from Excelsior Electrical Monitor may be made available to customers on request. Samples are selected from production lots and subjected to data sheet electrical temperature requirements. Any failures are analyzed by product engineering and appropriate corrective action is implemented. The excelsior quality levels are summarized by each product line on a monthly basis. This monitor has proven to be instrumental in Cypress's drive to attain the highest quality levels in the industry.

## 16.2 Advance Change Notification

The Cypress Advance Change Notification System aims to notify the customer of major product changes 90 days prior to the implementation of that change. A change is considered to be major if it affects the application, performance, quality, reliability, parameter distribution, form, fit or function of the product. In addition we may also notify changes such as relocation of manufacturing sites, certain Data Sheet items, or other changes that may affect use or acceptance of the product.

It should be noted that all changes are fully evaluated and qualified in accordance with well established and rigorous procedures. The changed product is not released for production or shipment until satisfactory qualification results, consistent with stable processes, predictable distributions and satisfactory and expected reliability figures and yields are achieved. Often shipment is recommended before the formal qualification report is available. The actual qualification tests, however, are completed and approved prior to shipment.

## 16.3 Customer Corrective Action Request

Cypress's Customer Corrective Action Request (CCAR) system provides a means for submitting customer perceived product problems to Cypress's factory for analysis. The analysis may be comprised of several stages, usually an initial analysis and follow-up analysis. A summary of Cypress's findings are issued. These may include corrective actions, requests for additional information or detailed failure analysis results.

# 17. Qualification Maintenance Program

The Cypress Qualification Maintenance Program (QMP) is used to measure the reliability of all process families on a regular basis. As it is not feasible to monitor the reliability of each of the literally hundreds of device types that Cypress produces, devices representative of the wafer fabrication process and the generic device grouping are selected on the basis of complexity, production volume, and strategic importance. These samples are subjected to the typical accelerated stress tests listed below on a monthly basis. Any failures encountered are analyzed by product engineering and appropriate corrective action is implemented. The results of this testing are summarized in the Cypress Quarterly Reliability Report (QRR).

## 17.1 Types of Stress

Several different process technology groups have been identified based on similarity of process parameters. Representative product types for each of these groups are listed in the Cypress QRR. Failure rates are tabulated for defective sub-populations and competing failure mechanisms. Two common measures of failure rates are early life failure rate (EL) and inherent life failure rate (IL). The early life period corresponds to approximately the first 4,000 hours at field use conditions. The inherent life corresponds to the useful life beyond the first 4000 of field operation. For these calculations, device operation temperature is assumed to be 55°C ambient unless otherwise noted. Voltage acceleration factors are used in the analysis wherever noted.

## 17.2 Reliability Monitor Stress Conditions

| Stress | Package | Typical Duration | Target Sample Size | Typical Conditions |
|---|---|---|---|---|
| Early Life | All | 24, 168 hours | 350 | 125°C or 150°C, $V_{CC}$ max |
| Inherent Life | All | 1000 hours | 120 | 125°C or 150°C, $V_{CC}$ max |
| Endurance Cycling | All | 10000 cycles | 64 | 90°C |
| Data Retention Bake | All | 1000 hours | 64 | 150°C |
| Preconditioning (PC) | All | 216 hours | 231 | 30°C/70% RH Soak,<br>3X Reflow @ 260°C |
| PC + Temperature Cycle | Discrete, 2 die MCP | 1000 cycles | 77 | –40°C to 150°C |
| | > 2 die MCP | 1000 cycles | 77 | –55°C to 125°C |
| PC + Biased HAST | BGA | 264 hours | 77 | 110°C, 85% RH, $V_{CC}$ max alt. bias |
| | Lead Frame | 96 hours | 77 | 130°C, 85% RH, $V_{CC}$ max alt. bias |
| PC + Unbiased HAST | All | 96 hours | 77 | 110°C, 85% RH, no bias |

# 18. Statistical Process Management

Statistical Process Management is used extensively throughout manufacturing and engineering areas in Cypress to help in reducing process variation and optimizing product/process performance. Examples of the tools used are Statistical Process Control (SPC), Process Capability Studies, Design of Experiments, Measurement Systems Analysis, Systematic Problem Solving, Structured project management, and statistical yield analysis, etc.

Some highlights of our SPC program include:

- Ubiquitous and intelligent use of problem solving methodologies
- SPC is 100% automated in all manufacturing areas using both statistically and economically derived Control Limits
- Out of Control Trouble Shooting Guides
- Statistical Equipment Control, (monitoring and control of input variables)
- Advanced Process Control (model based, active run-to-run control of processes during wafer fabrication)
- Suppliers are encouraged to implement SPC
- Six-Sigma target for critical processes

## 18.1 Kaizen + Program

All the training of statistical analysis tools, as well as other hard and soft improvement skills such as FMEA, Lean, Error Proofing, Structured Teamwork, are provided to employees as a part of Cypress's Kaizen+ (continuous improvement) program. The program involves all functional groups by establishing a structure that consists of a Champion, internal/external certified Black, Brown, Green and Yellow Belts in each organization to drive for improvement projects. The results are shared in a Project Sharing Conference twice per year. Statistical thinking and use of statistical methods are a part of Cypress's Kaizen+ culture.

# 19. Revision History

| Section | Description |
|---|---|
| **Revision 01 (December 20, 2011)** | |
| | Initial release |

| **Document Title: S29GL01GS (XMC 85C 105C) Qualification Database<br>Document Number: 002-00861** | | | | |
|---|---|---|---|---|
| **Revision** | **ECN** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| ** | – | – | 12/20/2011 | Initial release. |
| *A | 6639209 | CNSO | 08/01/2019 | Updated Document Title to read as "S29GL01GS (XMC 85C 105C) Qualification Database".<br>Added 105°C Temperature Range related information in all instances across the document.<br>Updated Assembly Packaging Summary:<br>Updated LAE064:<br>Updated details under "Theta Ja / Psi Jt".<br>Updated TS056:<br>Updated details under "Assembly Location" and "Theta Ja / Psi Jt".<br>Updated LAA064:<br>Updated details under "Theta Ja / Psi Jt".<br>Updated Test Methodology:<br>Replaced "Class Test (Bangkok, Thailand; Kuala Lumpur, Malaysia)" with "Class Test (Bangkok, Thailand)".<br>Updated to Cypress template. |

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# S29GL128S (XMC 85C 105C)

## *Qualification Database*

**Notice:** The material in this report is confidential. It is prepared to assist in the qualification of our product. It is declassified for the internal use of our customers only, and may be modified to meet the needs of specific customers. It also serves as a record of full qualification according to JESD47 and AEC-Q100 requirements.

Additionally, the package details (material set, assembly location, etc.) are specific to the qual vehicle used for the qualification. Alternate material sets and assembly locations may be qualified for the product. Production material can be assembled with any qualified material set and at any qualified assembly location. Tests are performed in accordance with AEC-Q100 and relevant JEDEC specifications.

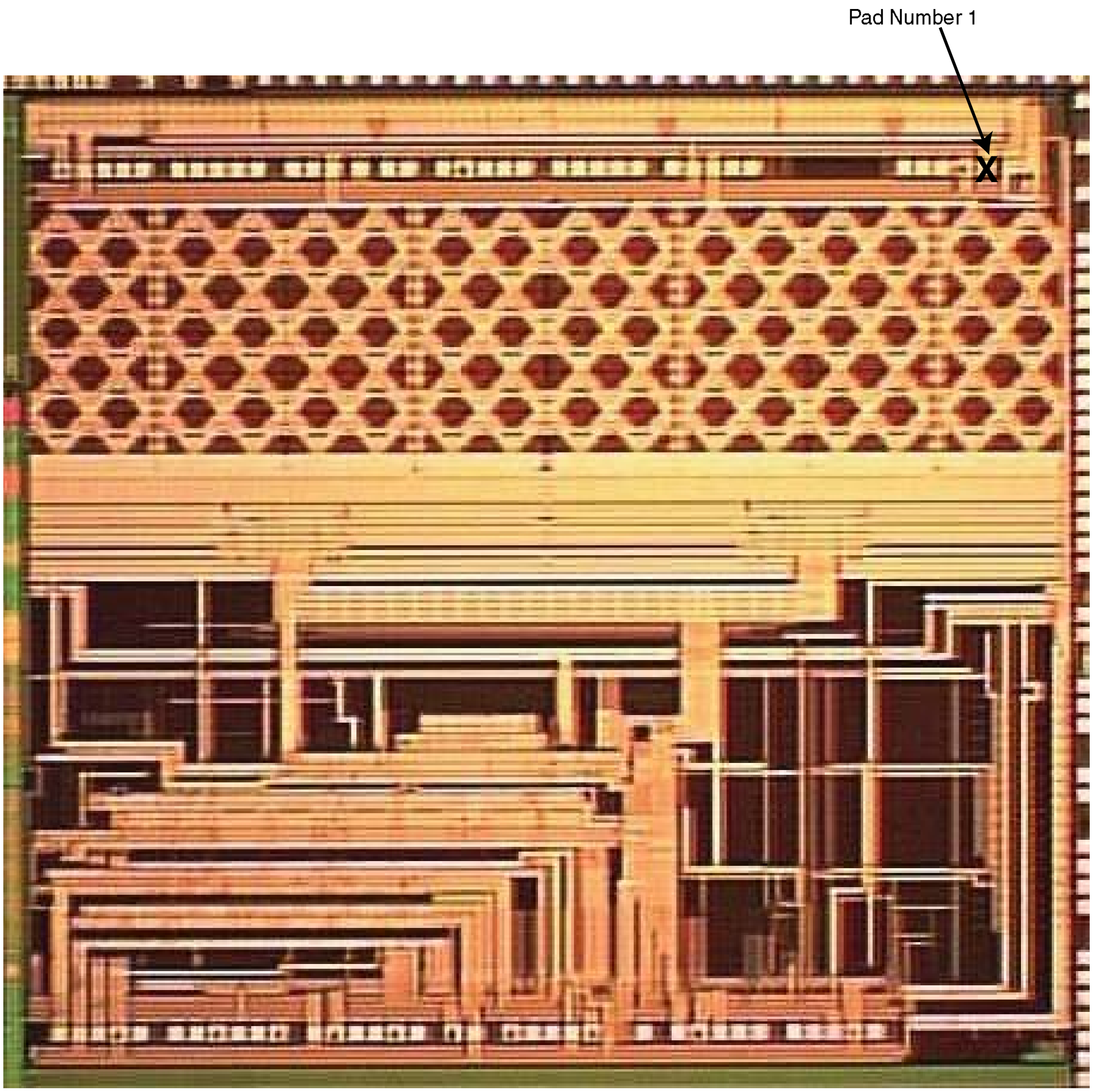
# Contents

# 1. Introduction

The Cypress S29GL128S flash memory device has a die size of 4.589 × 4.201 mm.

# 2. Die Photograph

**Figure 2.1** Die Photograph




***Note:***
1. *X in the diagram is pad #1. Count counter clockwise.*

# 3. Pad Definition Table

| Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA | Die Pad Index | Pad Name | Pin # TSOP | Pin # BGA |
|---|---|---|---|---|---|---|---|
| 1 | VSS | 33, 52 | H7 | 37 | VCC | 43 | G5 |
| 2 | VCC | 43 | G5 | 38 | VSS | 33, 52 | H7 |
| 3 | NC | | | 39 | VCC | 43 | G5 |
| 4 | A22 | 2 | B8 | 40 | VSS | 33, 52 | H7 |
| 5 | A15 | 3 | D7 | 41 | A0 | 31 | E2 |
| 6 | A14 | 4 | C7 | 42 | CE# | 32 | F2 |
| 7 | A13 | 5 | A7 | 43 | OE# | 34 | G2 |
| 8 | VSS | 33, 52 | H7 | 44 | DQ0 | 35 | E3 |
| 9 | VCC | 43 | G5 | 45 | DQ8 | 36 | F3 |
| 10 | A12 | 6 | B7 | 46 | DQ1 | 37 | H3 |
| 11 | A11 | 7 | D6 | 47 | DQ9 | 38 | G3 |
| 12 | A10 | 8 | C6 | 48 | VSS | 33, 52 | H2, E8 |
| 13 | A9 | 9 | A6 | 49 | VIO | 29 | F1, D8 |
| 14 | A8 | 10 | B6 | 50 | DQ2 | 39 | E4 |
| 15 | A19 | 11 | D5 | 51 | DQ10 | 40 | F4 |
| 16 | A20 | 12 | D4 | 52 | DQ3 | 41 | H4 |
| 17 | WE# | 13 | A5 | 53 | DQ11 | 42 | G4 |
| 18 | NC | | | 54 | VCC | 43 | G5 |
| 19 | RESET# | 14 | B5 | 55 | VSS | 33, 52 | H7 |
| 20 | A21 | 15 | C5 | 56 | DQ4 | 44 | H5 |
| 21 | WP# | 16 | B4 | 57 | DQ12 | 45 | F5 |
| 22 | RY/BY# | 17 | A4 | 58 | DQ5 | 46 | E5 |
| 23 | VIO | 29 | D8, F1 | 59 | VSS | 33, 52 | H7 |
| 24 | VSS | 33, 52 | H7 | 60 | VCC | 43 | G5 |
| 25 | A18 | 18 | C4 | 61 | DQ13 | 47 | G6 |
| 26 | A17 | 19 | B3 | 62 | NC | | |
| 27 | A7 | 20 | A3 | 63 | VSS | 33, 52 | E8, H2 |
| 28 | A6 | 21 | C3 | 64 | VIO | 29 | D8, F1 |
| 29 | A5 | 22 | D3 | 65 | DQ6 | 48 | H6 |
| 30 | A4 | 23 | B2 | 66 | DQ14 | 49 | F6 |
| 31 | A3 | 24 | A2 | 67 | DQ7 | 50 | E6 |
| 32 | A2 | 25 | C2 | 68 | DQ15 | 51 | G7 |
| 33 | A1 | 26 | D2 | 69 | VCC | 43 | G5 |
| 34 | DNU | 28 | E1 | 70 | VSS | 33, 52 | H7 |
| 35 | VCC | 43 | G5 | 71 | A16 | 54 | E7 |
| 36 | VSS | 33, 52 | H7 | | | | |

# 4. Physical Sector Layout

**Figure 4.1** Physical Sector Layout

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Internal Use Row (17) | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use | Internal Use |
| Internal Use Row (16) | | | | | Internal Use | Internal Use | Internal Use | Internal Use |
| Row 15 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 |
| Row 14 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 |
| ... | | | | | | | | |
| Row 3 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| Row 2 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Row 1 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Row 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| VerticalBank | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| Bank | 0 | | | | 1 | | | |

# 5. Sector Enlargement

**Figure 5.1** Sector Enlargement

**IO Organization**

| | Internal Use | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **M3BL** | 0-7 | 0-63 | 64-127 | 128-191 | 192-255 | 256-319 | 320-383 | 384-447 | 448-511 | 512-575 | 576-639 |
| **M1BL** | 8-15 | 0-127 | 128-255 | 256-383 | 384-511 | 512-639 | 640-767 | 768-895 | 896-1023 | 1024-1151 | 1152-1279 |

| | 10 | 11 | 12 | 13 | 14 | 15 | Internal Use | Internal Use | Internal Use | Internal Use |
|---|---|---|---|---|---|---|---|---|---|---|
| **M3BL** | 640-703 | 704-767 | 768-831 | 832-895 | 896-959 | 960-1023 | 1024-1063 | 1064-1071 | 1072-1079 | 0-7 |
| **M1BL** | 1280-1407 | 1408-1535 | 1536-1663 | 1664-1791 | 1792-1919 | 1920-2047 | 2048-2127 | 2128-2143 | 2144-2159 | 0-7 |

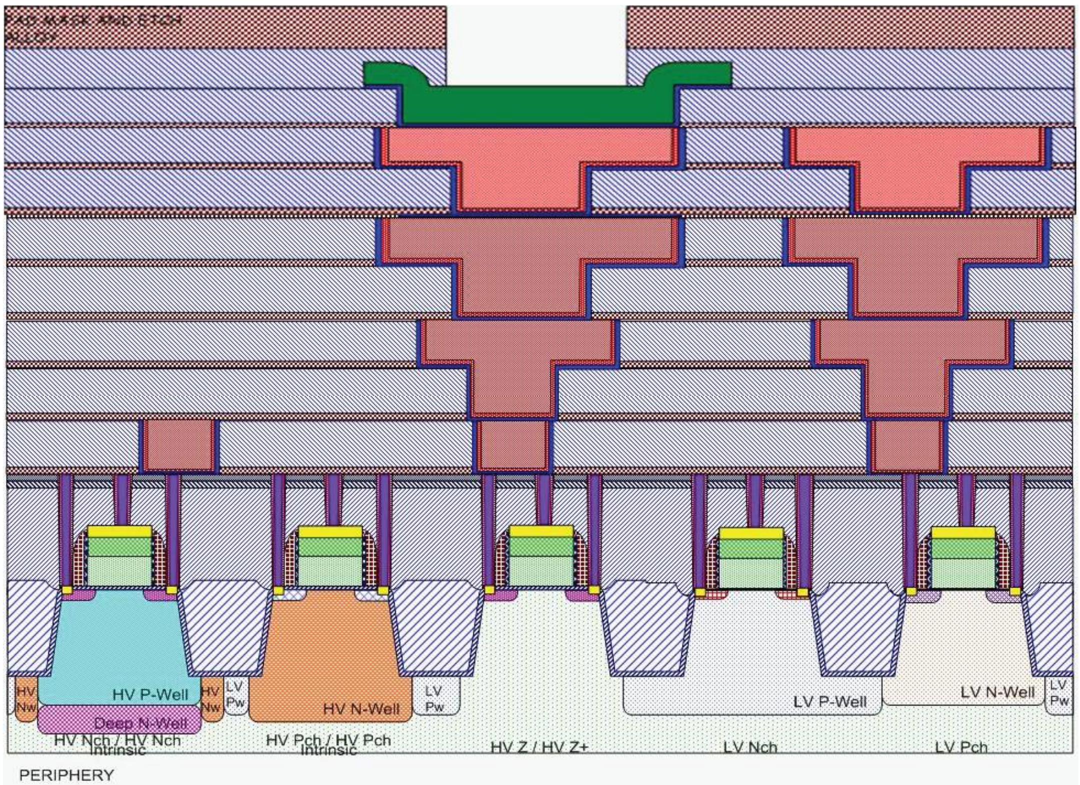
# 6. Die Processing Summary

The Cypress S29GL128S flash memory device is manufactured using the 65 nm MirrorBit® Eclipse™ process technology.

The device is processed at WXIC, a 12-inch CMOS manufacturing facility located in Wuhan, China.

The device is manufactured on the highly reliable CS239LS process.

**Figure 6.1** Die Process



## 6.1 Key Features of the CS239LS MirrorBit Eclipse Process Technology

**A. Technology**

- CMOS Triple-well process
- Proven reliable Flash MirrorBit Eclipse Technology

**B. Transistor Types**

- n-channel enhancement
- n-channel intrinsic
- p-channel enhancement
- MirrorBit core cell

**C. Process Features**

- ONO (oxide - nitride - oxide) gate dielectric
- Silicon Nitride (SiN) data storage layer

**D. Spansion Highlights**

- Volume Production Fab
- Solely dedicated to Non-Volatile Memories
- Ongoing Statistical Process Control program

# 7. Product Information

## 7.1 LAE064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL128S<br>128-Mbit, 3.0 Volt-only Page Mode Flash Memory Featuring 65nm MirrorBit Eclipse Process Technology | | |
| **Package:** | LAE064 | **Qualification:** | Q100255 |
| **Description:** | (9 x 9 x 1.4 mm) 64 Ball, Fortified Ball Grid Array Package (fFBGA) | | |
| **Theta Ja:** | 34.1 °C/W | **Psi Jt:** | 0.1 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | Paste |
| **Lead Finish:** | 96.5Sn3.0Ag0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125 °C |
| **Est. DC Field Current:** | 55 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0 V | **Life Test Voltage:** | 3.6 V |
| **Est. Field Power Dissipation:** | 165 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 61.4 °C | **Est. Stress Delta Tj:** | 126.4 °C |
| **Die:** | 98741B | **Die Size:** | 4.58 × 4.20 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 128M |

## 7.2 LAA064

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL128S<br>128-Mbit, 3.0 Volt-only Page Mode Flash Memory Featuring 65nm MirrorBit Eclipse Process Technology | | |
| **Package:** | LAA064 | **Qualification:** | Q100313 |
| **Description:** | (13.0 x 11.0 x 1.4 mm) 64 Ball, Fortified Ball Grid Array Package (FBGA) | | |
| **Theta Ja:** | 25.2 °C/W | **Psi Jt:** | 0.1 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | Paste |
| **Lead Finish:** | 96.5Sn3.0Ag0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125 °C |
| **Est. DC Field Current:** | 55 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0 V | **Life Test Voltage:** | 3.6 V |
| **Est. Field Power Dissipation:** | 165 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 61.4 °C | **Est. Stress Delta Tj:** | 126.4 °C |
| **Die:** | 98741B | **Die Size:** | 4.58 × 4.20 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 128M |

## 7.3 VBU056

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL256S<br>128-Mbit, 3.0 Volt-only Page Mode Flash Memory Featuring 65nm MirrorBit Eclipse Process Technology | | |
| **Package:** | VBU056 | **Qualification:** | Q100373 |
| **Description:** | (9.0 x 7.0 x 1.0 mm) 56 Ball, Very Thin Fine Pitch Ball Grid Array Package (FBGA) | | |
| **Theta Ja:** | 36.0 °C/W | **Psi Jt:** | 0.1 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Laminate Substrate | **Die Attachment:** | Paste |
| **Lead Finish:** | 96.5Sn3.0Ag0.5Cu Spheres | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125 °C |
| **Est. DC Field Current:** | 55 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0 V | **Life Test Voltage:** | 3.6 V |
| **Est. Field Power Dissipation:** | 165 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 61.4 °C | **Est. Stress Delta Tj:** | 126.4 °C |
| **Die:** | 98741B | **Die Size:** | 4.58 x 4.20 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 128M |

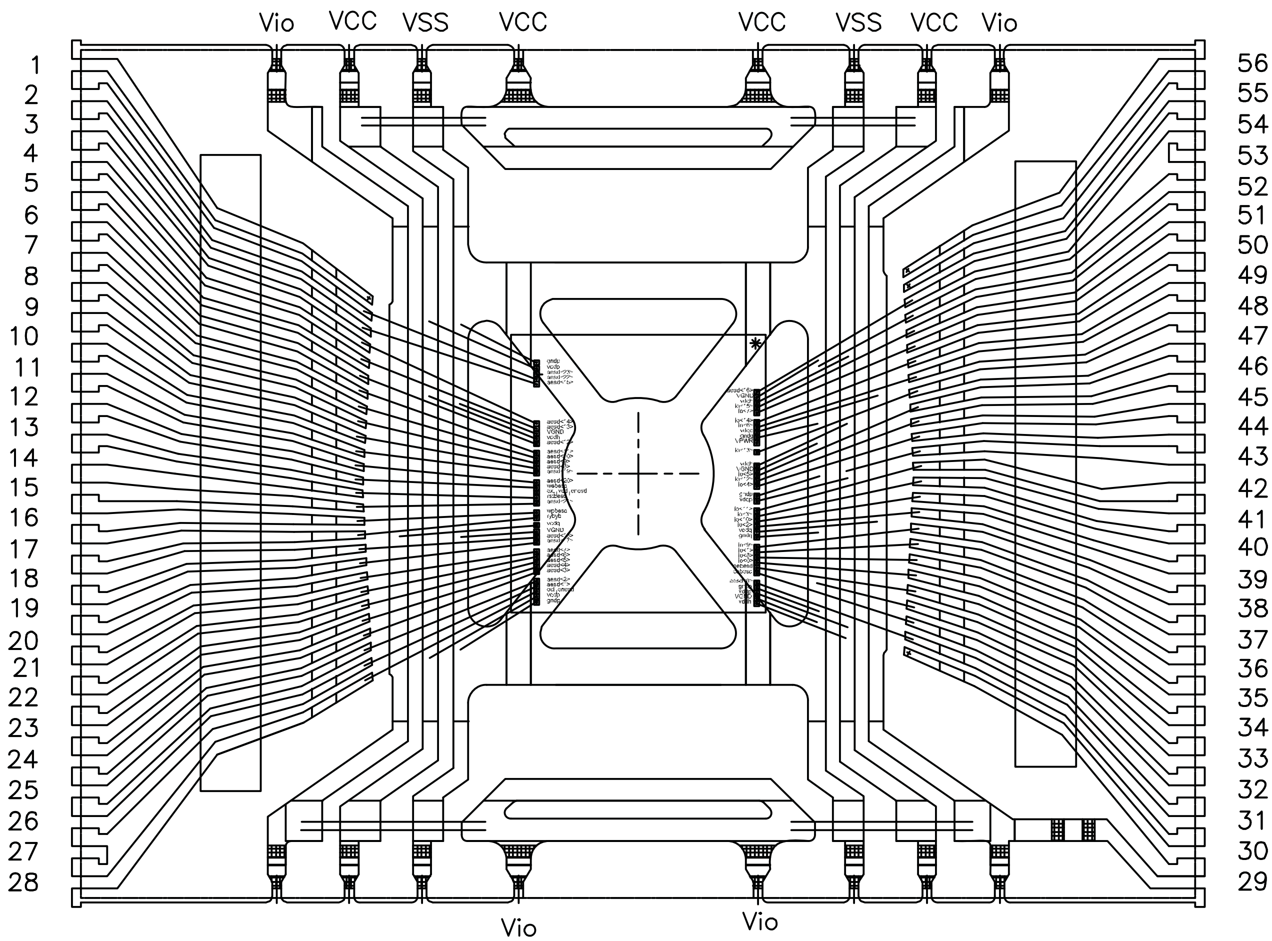
## 7.4 TS056

| | | | |
|---|---|---|---|
| **Product Description:** | S29GL128SH<br>128-Mbit, 3.0 Volt-only Page Mode Flash Memory Featuring 65nm MirrorBit Eclipse Process Technology | | |
| **Package:** | TS056 | **Qualification:** | Q100315 |
| **Description:** | (20.0 x 14.0 x 1.2 mm) 56 Lead, Thin Small Outline Package (TSOP) | | |
| **Theta Ja:** | 61.7 °C/W | **Psi Jt:** | 0.21 °C/W |
| **Assembly Location:** | Cypress Thailand | **Molding Compound:** | RoHS Compliant Epoxy Resin |
| **Substrate/Leadframe:** | Copper Leadframe | **Die Attachment:** | Paste |
| **Lead Finish:** | 100% Matte Sn Plating | **Bond Wire:** | Copper |
| **Comments:** | | | |
| **Est. Field Temperature:** | 55 °C | **Life Test Temperature:** | 125 °C |
| **Est. DC Field Current:** | 55 mA | **Life Test Dynamic Current:** | 10 mA |
| **Est. Field Voltage:** | 3.0 V | **Life Test Voltage:** | 3.6 V |
| **Est. Field Power Dissipation:** | 165 mWatts | **Est. Stress Power Dissipation:** | 36 mWatts |
| **Est. Field Delta Tj:** | 68.8 °C | **Est. Stress Delta Tj:** | 128.0 °C |
| **Die:** | 98741B | **Die Size:** | 4.58 × 4.20 mm |
| **Process:** | CS239LS (65 nm) | **Fab:** | WXIC |
| **Type:** | MirrorBit Eclipse | **Density:** | 128M |

# 8. Assembly Bonding Diagram

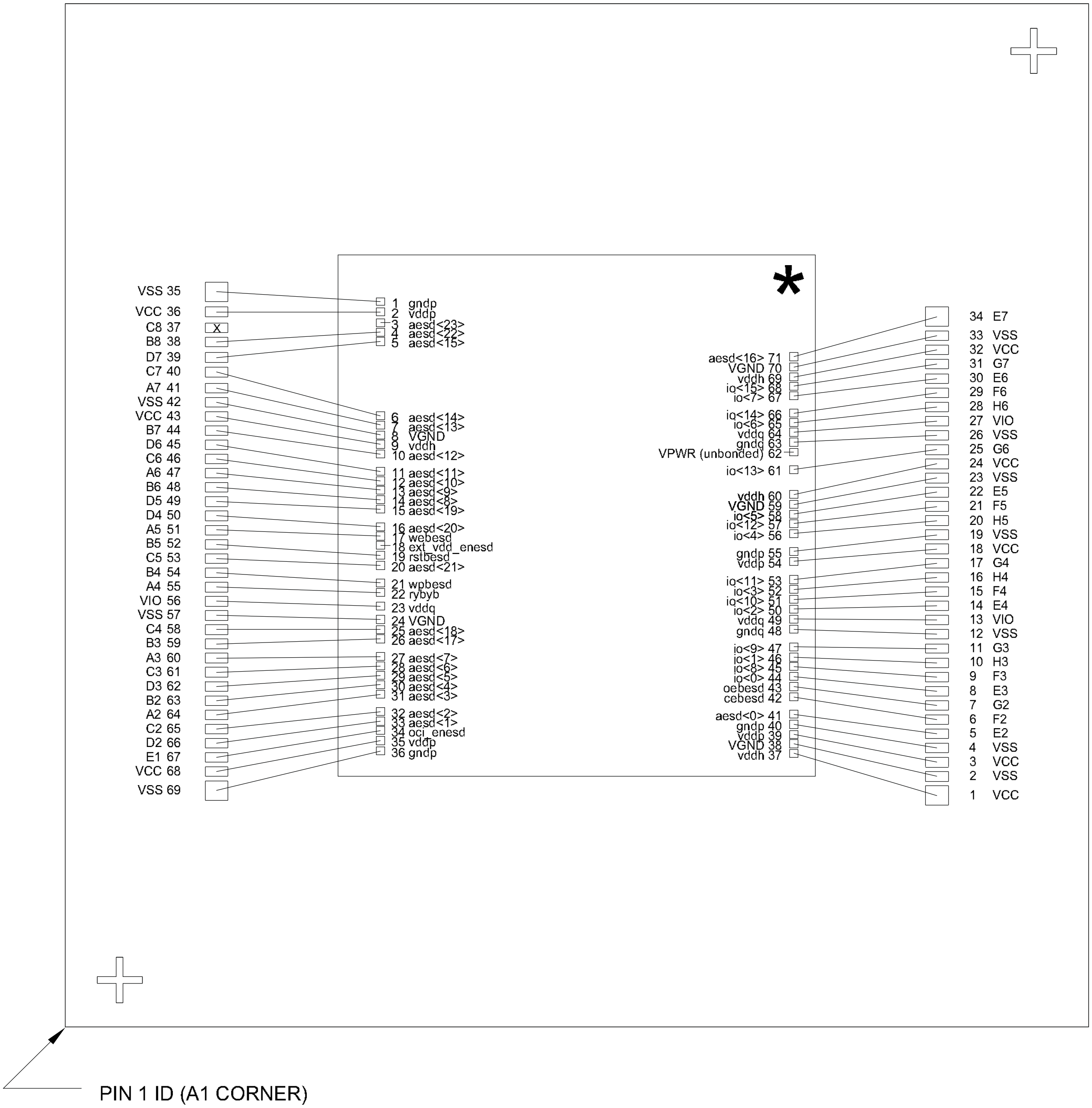
## 8.1 TS056 Package

**Figure 8.1** 56-Pin—TS056 Package



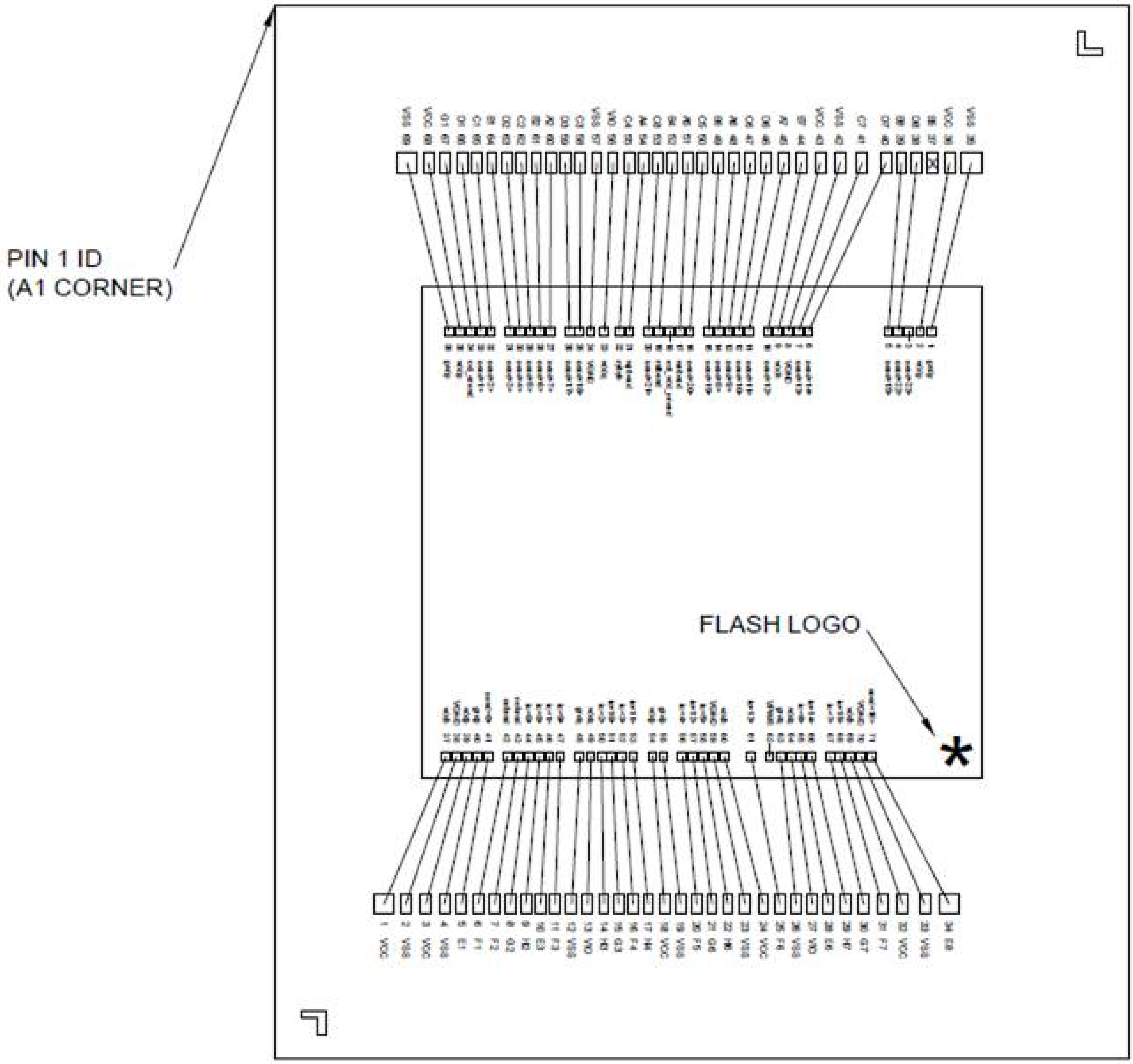
## 8.2 LAE064/LAA064 Package

**Figure 8.2** 64-Ball—LAE064/LAA064 Package



## 8.3 VBU056 Package

**Figure 8.3** 56-pin—VBU056 Package



# 9. Test Methodology

### Testing includes

- 4 hour, 250°C Data Retention Bake (in wafer form)
- Special test mode for extended life operation
- Proprietary screens for endurance

### Wafer Sort (Austin, Texas, USA)

At Wafer Sort, all die experience 100% testing for:

- DC Parametrics
- AC Functionality
- Programmability
- Erasability

### Class Test (Bangkok, Thailand)

At Class Test, all devices are tested for:

- DC Parametrics
- AC Functionality
- AC Speed
- Programmability
- Erasability

### Test Coverage

All parameters specified in the data sheet are 100% tested in production unless otherwise specified. Those parameters not tested in production are guaranteed by characterization or correlation to other tests. AC speed testing is performed at class test.

### Test Correlation and Guard Banding

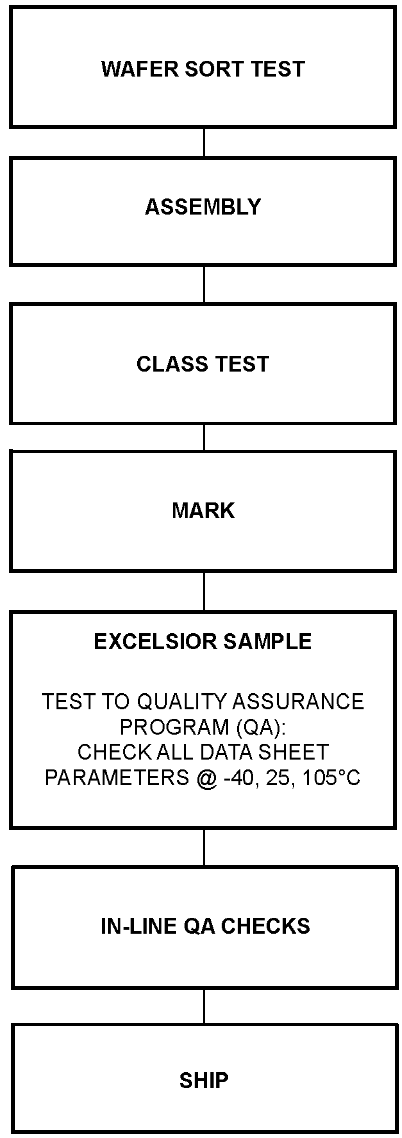
Tester correlation to bench set-up has been completed for all tested parameters. Tester repeatability studies have been run. These results have been evaluated and incorporated into the tester guard band strategy. Guard bands have been implemented which demonstrate acceptable yield, quality assurance and customer satisfaction.

### Test Flow

See the generalized Test Flow for the S29GL128S in Section 10.

# 10. Generalized Test Flow

The S29GL128S Generalized Test Flow for Industrial Temperature Range:



# 11. Quality and Reliability Data

## 11.1 S29GL128S High Temperature Operating Life Test Configuration

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 1 | NC | | NC |
| 2 | A22 | 2.7K | CLK22 |
| 3 | A15 | 2.7K | CLK15 |
| 4 | A14 | 2.7K | CLK14 |
| 5 | A13 | 10K | CLK13 |
| 6 | A12 | 2.7K | CLK12 |
| 7 | A11 | 2.7K | CLK11 |
| 8 | A10 | 2.7K | CLK10 |
| 9 | A9 | 2.7K | CLK9 |
| 10 | A8 | 2.7K | CLK8 |
| 11 | A19 | 2.7K | CLK19 |
| 12 | A20 | 2.7K | CLK20 |
| 13 | WE# | 2.7K | VCC |
| 14 | RESET# | 2.7K | VCC |
| 15 | A21 | 2.7K | CLK21 |
| 16 | WP# | 2.7K | VCC |
| 17 | RY/BY# | 2.7K | VCC |
| 18 | A18 | 2.7K | CLK18 |
| 19 | A17 | 2.7K | CLK17 |
| 20 | A7 | 2.7K | CLK7 |
| 21 | A6 | 2.7K | CLK6 |
| 22 | A5 | 2.7K | CLK5 |
| 23 | A4 | 2.7K | CLK4 |
| 24 | A3 | 2.7K | CLK3 |
| 25 | A2 | 2.7K | CLK2 |
| 26 | A1 | 2.7K | CLK1 |
| 27 | RFU | | NC |
| 28 | RFU | | NC |

| Pin/Pad # | Function | Resistor | Bias/CLK |
|---|---|---|---|
| 56 | NC | | NC |
| 55 | NC | | NC |
| 54 | A16 | 2.7K | CLK16 |
| 53 | RFU | | NC |
| 52 | VSS | | GND |
| 51 | DQ15 | 2.7K | VCC |
| 50 | DQ7 | 2.7K | VCC |
| 49 | DQ14 | 2.7K | VCC |
| 48 | DQ6 | 2.7K | VCC |
| 47 | DQ13 | 2.7K | VCC |
| 46 | DQ5 | 2.7K | VCC |
| 45 | DQ12 | 2.7K | VCC |
| 44 | DQ4 | 2.7K | VCC |
| 43 | VCC | | VCC |
| 42 | DQ11 | 2.7K | VCC |
| 41 | DQ3 | 2.7K | VCC |
| 40 | DQ10 | 2.7K | VCC |
| 39 | DQ2 | 2.7K | VCC |
| 38 | DQ9 | 2.7K | VCC |
| 37 | DQ1 | 2.7K | VCC |
| 36 | DQ8 | 2.7K | VCC |
| 35 | DQ0 | 2.7K | VCC |
| 34 | OE# | 2.7K | VCC |
| 33 | VSS | | GND |
| 32 | CE# | 2.7K | GND |
| 31 | A0 | 2.7K | CLK0 |
| 30 | RFU | | NC |
| 29 | VIO | 2.7K | VCC |

## 11.2 CS239LS Life Test Failure Rate Calculation

### HTOL Stress Temperature @ 125 °C

| Failure Mechanisms | Read Points / Test Results | | | | Modeling Parameters @ 55°C | | | | | Average Failure Rate FITS @ 55°C, 60% Conf. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 24 hrs | 168 hrs | 1000 hrs | 2000 hrs | Ea eV | TAF | VAF | OAF | MTTF (yrs) | Early Life | Inherent Life |
| **PLASTIC** | | | | | | | | | | | |
| Sample Size | 4950 | 4615 | 842 | 50 | | | | | | | |
| Zero fails, Process ave. Ea | 0 | 0 (1) | 0 | 0 | 0.66 | 53 | 1 | 53 | | 48 | 11 |
| **Totals** | **0** | **0** | **0** | **0** | | | | | **10378** | **48** | **11** |

***Note:***
*1. Contributes to Early Life FITS.*

### Data Retention Bake @ 150 °C

| Reliability Stress | Number of Rejects | Sample Size | Failure Rate% | Failure Mechanism |
|---|---|---|---|---|
| 500 hrs | 0 | 1735 | 0.00 | No Failures |
| 1000 hrs | 0 | 1208 | 0.00 | No Failures |

# 12. Summary of Stress Test Results

**Table 12.1** Summary of Stress Test Results

| Stress Test | Stress Condition | Package Type | Samples Size | Number of Lots | Number of Fails | Failure Rate% | Comments |
|---|---|---|---|---|---|---|---|
| **Data From Qualification Q100255, Q100313, Q100315:** | | | | | | | |
| **HTOL (EL)** | 3.6 V, 125 °C | LAE064 (1) | 154 | 2 | 0 | 0.00 | 168 hrs |
| **HTOL (IL)** | 3.6 V, 125 °C | LAE064 (1) | 154 | 2 | 0 | 0.00 | 504 hrs |
| **HTOL (XL)** | 3.6 V, 125 °C | LAE064 (1) | 154 | 2 | 0 | 0.00 | 1000 hrs |
| **ESD CDM** | N/A | LAE064 (1) | 15 | 1 | Passed 1.0 kV | | |
| | N/A | LAA064 (2) | 15 | 1 | Passed 1.0 kV | | |
| | N/A | WND008 (3) | 15 | 1 | Passed 1.0 kV | | |
| **ESD HBM** | 100 pF, 1500 Ohms | LAE064 (1) | 84 | 2 | Passed 2.0 kV | | |
| **Latch Up** | 125 °C, ±100 mA | LAE064 (1) | 6 | 1 | Passed | | |
| **Endurance (10k)** | 105 °C, 3.6 V | LAE064 (1) | 64 | 1 | 0 | 0.00 | 10k cycles |
| | -40 °C, 3.6 V | LAE064 (1) | 64 | 1 | 0 | 0.00 | 10k cycles |
| | 90 °C, 3.6 V | LAE064 (1) | 64 | 1 | 0 | 0.00 | 10k cycles |
| **Endurance (100k)** | 105 °C, 3.6 V | LAE064 (1) | 40 | 1 | 0 | 0.00 | 100k cycles |
| | 90 °C, 3.6 V | LAE064 (1) | 60 | 1 | 0 | 0.00 | 100k cycles |
| **Generic Reference Data** | | | | | | | |
| **High Temp Bake (200 °C)** | 200 °C | LAE064 (5) | 45 | 1 | 0 | 0.00 | 500 hrs |
| | 200 °C | TS048 (7) | 45 | 1 | 0 | 0.00 | 350 hours |
| **ESD CDM** | N/A | LAE064 (4) | 15 | 1 | Passed 1.0 kV | | |
| **Preconditioning** | PC1/260 °C, +0 °C / -5 °C | LAE064 (5) | 231 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| | PC9/260 °C, +0 °C / -5 °C | LAA064 (6) | 77 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| | PC9/260 °C, +0 °C / -5 °C | TS048 (7) | 392 | 2 | Passed Jedec L3 / Jeita Rank E | | |
| | PC1/260 °C, +0 °C / -5 °C | FAB024 (8) | 154 | 1 | Passed Jedec L3 / Jeita Rank E | | |
| **Preconditioning + Temp Cycle** | PC1/260 °C, -40 °C / 150 °C | LAE064 (5) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| | PC9/260 °C, -40 °C / 150 °C | TS048 (7) | 154 | 2 | 0 | 0.00 | 1000 cycles |
| | PC1/260 °C, -40 °C / 150 °C | FAB024 (8) | 77 | 1 | 0 | 0.00 | 1000 cycles |
| **Preconditioning + HAST** | PC1/260 °C, Biased, 110 °C / 85% RH | LAE064 (5) | 77 | 1 | 0 | 0.00 | 264 hrs |
| | PC9/260 °C, Biased, 130 °C / 85% RH | TS048 (7) | 84 | 2 | 0 | 0.00 | 96 hrs |
| **Preconditioning + uHAST** | PC1/260 °C, Unbiased, 130 °C / 85% RH | LAE064 (5) | 76 | 1 | 0 | 0.00 | 96 hrs |
| | PC9/260 °C, Unbiased, 130 °C / 85% RH | TS048 (7) | 154 | 2 | 0 | 0.00 | 96 hrs |
| | PC1/260 °C, Unbiased, 130 °C / 85% RH | FAB024 (8) | 77 | 1 | 0 | 0.00 | 96 hrs |

***Notes / Justification:***

1. *Results from Qual Q100255, S29GL128S, CS239LS (65 nm) MirrorBit Eclipse in 64 Ball fFBGA (9 x 9 x 1.4 mm).*
2. *Results from Qual Q100313, S29GL128S, CS239LS (65 nm) MirrorBit Eclipse in 64 Ball fFBGA (13 x 11 x 1.4 mm).*
3. *Results from Qual Q100315, S29GL128SH, CS239LS (65 nm) MirrorBit Eclipse in 56 Lead TSOP (20 x 14 x 1.2 mm).*
4. *Results from Qual Q100314, S29GL128SH in 64 Ball fFBGA (9 x 9 x 1.4 mm).*
5. *Results from Qual Q100167, S29GL01GS in 64 Ball fFBGA (9 x 9 x 1.4 mm) - Same Fab location and Same Flash.*
6. *Results from Qual Q100182, S29GL01GS in 64 Ball fFBGA (13 x 11 x 1.4 mm) - Same Package and Package BOM.*
7. *Results from Qual Q100252, 3ML01G12 in 48 Lead TSOP (20 x 12 x 1.2 mm) - Same Package and Package BOM.*
8. *Results from Qual Q100087, S25FL256S in 24 Ball FBGA (8 x 6 x 1.2 mm) - Same Package and Same Package BOM.*

***Preconditioning Flows***

*PC1 (Exceeds JEDEC L3 and JEITA Rank E) = Bake 125 °C, 24 hr --> Soak @ 30 °C/70%RH, 216 hr --> 3x Reflow.*
*PC9 (Accelerated JEDEC L3 / JEITA Rank E): Bake 125 °C, 24 hr => Soak @ 60 °C/70%RH, 72 hr => 3x Reflow.*

# 13. Characterization Test Results

The data pattern is “Random pattern” unless otherwise indicated.

## 13.1 DC Parameter Summary, 25°C

### Room Temperature, 25°C, 3V, $V_{CC}$=$V_{IO}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 87.6 | 81.3 | 95.4 | 2.5 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 46.4 | 44.2 | 49.4 | 1.1 | 4.0 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.7 | 4.8 | 6.1 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.6 | 4.8 | 6.0 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.5 | 4.7 | 5.9 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.5 | 4.7 | 5.9 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program/Erase Current) | 45 | 100 | mA | 46.9 | 44.5 | 49.7 | 1.2 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 14.5 | 8.5 | 68.3 | 9.7 | >5 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.015 | 0.008 | 0.068 | 0.010 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 14.7 | 8.5 | 68.5 | 9.9 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.006 | -0.012 | 0.395 | 0.025 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.002 | -0.006 | 0.014 | 0.003 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 262 | 1100 | ms | 282.0 | 178.0 | 479.0 | 36.4 | >5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | 390.3 | 349.0 | 443.0 | 16.1 | >5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | 313.1 | 280.0 | 351.0 | 11.2 | >5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | 265.3 | 242.0 | 298.0 | 8.9 | >5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | 236.7 | 215.0 | 265.0 | 8.1 | >5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | 214.3 | 197.0 | 239.0 | 7.2 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 206.5 | 186.0 | 241.0 | 7.7 | >5 |

***Notes:***
1. *Data was collected from 70 units with 2 different lots 5878180 and 5878200 (wflot: LD00647, wf14, wflot: LD00647, wf17).*
2. *Sector Erase data excludes Random data pattern programming prior to erasure.*

## 13.2 DC Parameter Summary, 85°C

### Hot Temperature, 85°C, 3V, $V_{CC}$=$V_{IO}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 92.5 | 88.2 | 99.5 | 2.4 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 48.4 | 46.2 | 51.5 | 1.1 | 3.4 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.9 | 5.5 | 6.3 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.8 | 5.4 | 6.2 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.8 | 5.4 | 6.1 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.7 | 5.3 | 6.1 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program/Erase Current) | 45 | 100 | mA | 49.8 | 47.6 | 52.3 | 0.9 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 32.1 | 17.3 | 93.5 | 11.1 | >5 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.032 | 0.018 | 0.093 | 0.011 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 32.1 | 17.3 | 93.5 | 11.2 | 5.0 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.005 | -0.018 | 0.181 | 0.022 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.001 | -0.008 | 0.013 | 0.003 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 262 | 1100 | ms | 199.4 | 141.0 | 298.0 | 20.1 | >5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | 332.9 | 279.0 | 426.0 | 19.4 | >5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | 275.7 | 242.0 | 339.0 | 14.2 | >5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | 236.0 | 206.0 | 288.0 | 11.4 | >5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | 210.7 | 186.0 | 254.0 | 10.0 | >5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | 190.1 | 168.0 | 225.0 | 8.2 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 185.7 | 165.0 | 219.0 | 8.7 | >5 |

***Notes:***
1. *Data was collected from 70 units with 2 different lots 5878180 and 5878200 (wflot: LD00647, wf14, wflot: LD00647, wf17).*
2. *Sector Erase data excludes Random data pattern programming prior to erasure.*

## 13.3 DC Parameter Summary, 105°C

### Hot Temperature, 105°C, 3V, $V_{CC}$=$V_{IO}$ Summary

| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 93.9 | 88.4 | 99.3 | 2.3 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 48.9 | 46.1 | 51.7 | 1.2 | 3.1 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 6.0 | 5.3 | 6.5 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.9 | 5.3 | 6.4 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.8 | 5.2 | 6.3 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.8 | 5.1 | 6.3 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program/Erase Current) | 45 | 100 | mA | 50.3 | 48.0 | 52.4 | 0.9 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 40.2 | 21.9 | 98.8 | 14.7 | 3.6 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.041 | 0.022 | 0.099 | 0.016 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 40.9 | 16.7 | 99.0 | 15.5 | 3.4 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.005 | -0.013 | 0.226 | 0.022 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.002 | -0.008 | 0.057 | 0.003 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 275 | 1100 | ms | 195.7 | 137.0 | 305.0 | 18.5 | >5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | 338.4 | 281.0 | 423.0 | 19.8 | >5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | 278.1 | 230.0 | 338.0 | 14.9 | >5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | 238.5 | 198.0 | 288.0 | 12.0 | >5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | 213.1 | 181.0 | 256.0 | 10.1 | >5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | 193.4 | 172.0 | 229.0 | 8.3 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 191.0 | 168.0 | 229.0 | 9.2 | >5 |

***Notes:***

1. *Data was collected from 70 units with 2 different lots 5878180 and 5878200 (wflot: LD00647, wf14, wflot: LD00647, wf17).*
2. *Sector Erase data excludes Random data pattern programming prior to erasure.*

## 13.4 DC Parameter Summary, -40°C

### Cold Temperature, -40°C, 3V, $V_{CC}$=$V_{IO}$ Summary

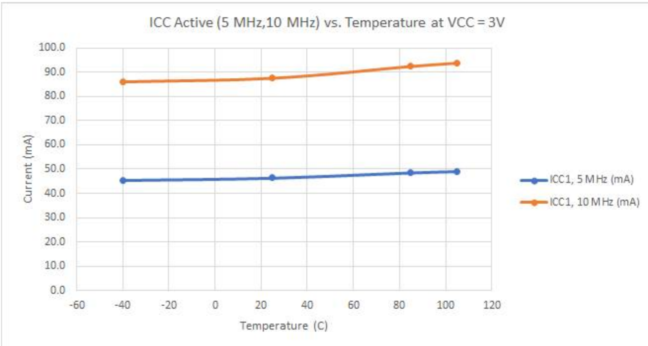
| Data Sheet Parameters | Spec | | | Average | Min | Max | Sigma | Cpk |
|---|---|---|---|---|---|---|---|---|
| | Typ | Max | Unit | | | | | |
| **DC Parameters** | | | | | | | | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 10 MHz | | | mA | 86.1 | 78.3 | 93.7 | 3.0 | |
| $I_{CC1}$ ($V_{CC}$ Active Read Current) 5 MHz | 55 | 60 | mA | 45.5 | 42.5 | 48.6 | 1.3 | 3.8 |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 66 MHz | | | mA | 5.4 | 4.7 | 5.9 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 50 MHz | | | mA | 5.4 | 4.6 | 5.8 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 40 MHz | | | mA | 5.3 | 4.6 | 5.7 | 0.2 | |
| $I_{CC2}$ ($V_{CC}$ Intra-Page Read Current) 33 MHz | 9 | 25 | mA | 5.3 | 4.6 | 5.7 | 0.2 | >5 |
| $I_{CC3}$ ($V_{CC}$ Active Program/Erase Current) | 45 | 100 | mA | 41.5 | 38.9 | 45.9 | 1.4 | >5 |
| $I_{CC4}$ ($V_{CC}$ Standby Current) | 70 | 200 | µA | 13.1 | 8.1 | 65.4 | 9.1 | >5 |
| $I_{CC5}$ ($V_{CC}$ Reset Current) | 10 | 20 | mA | 0.013 | 0.008 | 0.065 | 0.009 | >5 |
| $I_{CC6}$ ($V_{CC}$ Automatic Sleep Mode Current) | 100 | 200 | µA | 13.5 | 8.1 | 65.1 | 9.6 | >5 |
| $I_{LI}$ (Input Leakage Current) | 0.02 | ±1 | µA | 0.006 | -0.051 | 0.220 | 0.026 | >5 |
| $I_{LO}$ (Output Leakage Current) | 0.02 | ±1 | µA | 0.002 | -0.021 | 0.013 | 0.003 | >5 |
| **Average Sector Erase/Pre-programming Time** | | | | | | | | |
| Sector Erase Time (64 kword sector) | 262 | 1100 | ms | 374.6 | 232.0 | 501.0 | 45.7 | >5 |
| Buffer Program Time (256 word) | 420 | 1050 | µs | 393.5 | 181.0 | 509.0 | 33.9 | >5 |
| Buffer Program Time (128 word) | 320 | 1050 | µs | 316.1 | 195.0 | 417.0 | 25.1 | >5 |
| Buffer Program Time (64 word) | 250 | 1050 | µs | 269.1 | 173.0 | 339.0 | 18.5 | >5 |
| Buffer Program Time (32 word) | 220 | 1050 | µs | 240.7 | 159.0 | 296.0 | 14.7 | >5 |
| Buffer Program Time (16 word) | 200 | 1050 | µs | 222.7 | 201.0 | 266.0 | 9.5 | >5 |
| Single Word Program Time (1 word) | 125 | 400 | µs | 210.3 | 191.0 | 260.0 | 8.8 | >5 |

***Notes:***

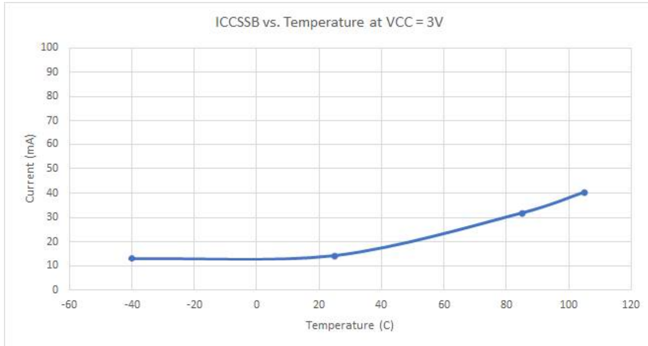
1. *Data was collected from 70 units with 2 different lots 5878180 and 5878200 (wflot: LD00647, wf14, wflot: LD00647, wf17).*
2. *Sector Erase data excludes Random data pattern programming prior to erasure.*

# 14. DC Device Characterization Data

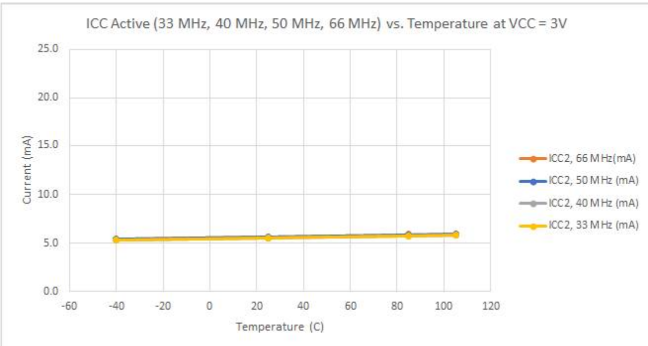
ICC1 (Asynchronous Read) vs. Temperature



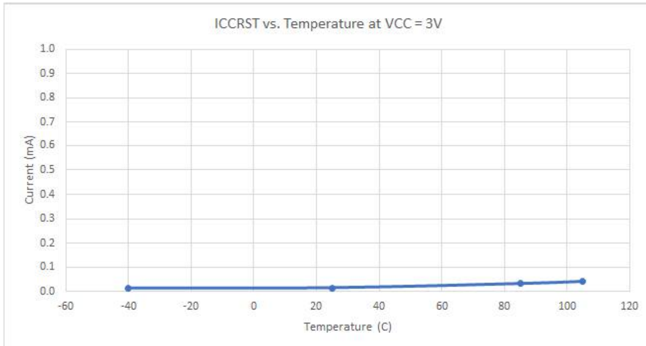

ICC4 (Standby Current) vs. Temperature



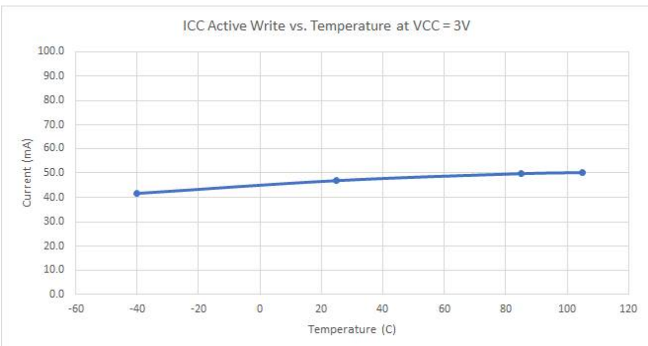

ICC2 (Page Read) vs. Temperature



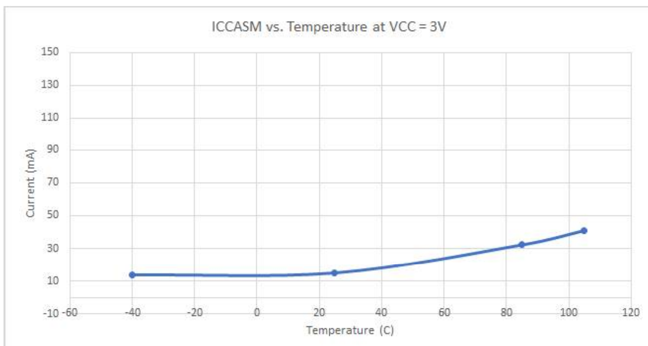

ICC5 (Reset Current) vs. Temperature




ICC3 (Active Write) vs. Temperature

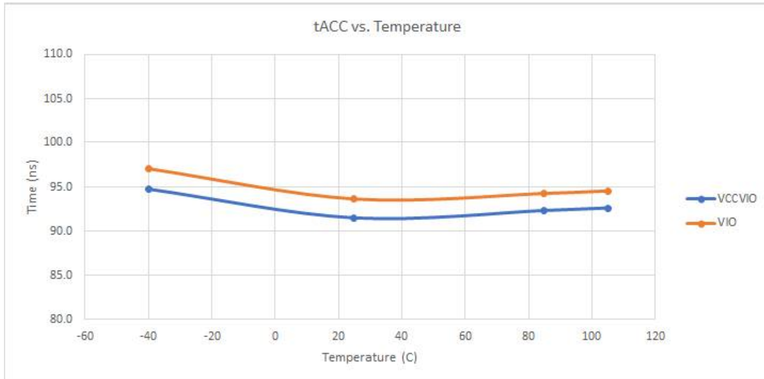



ICC6 (CMOSASM) vs. Temperature

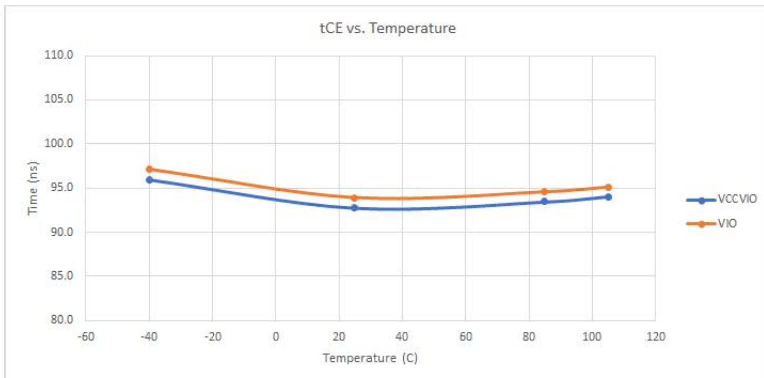


# 15. AC Device Characterization Data

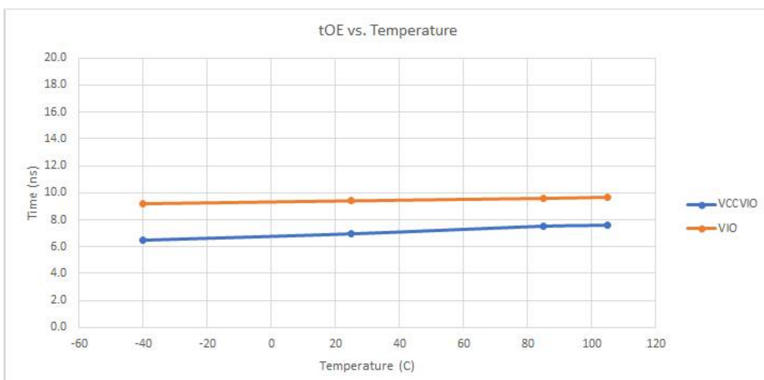
tACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



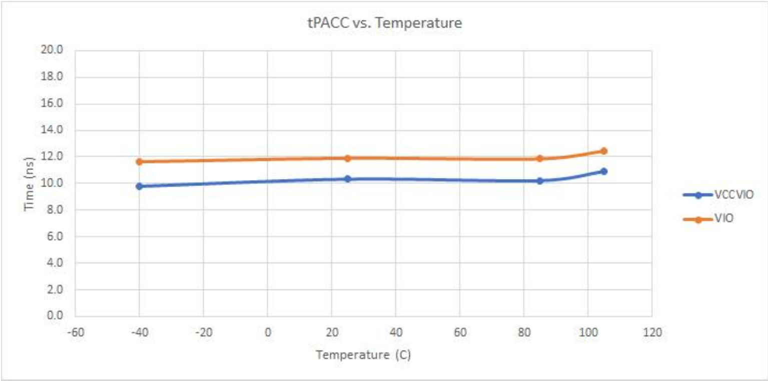

tCE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



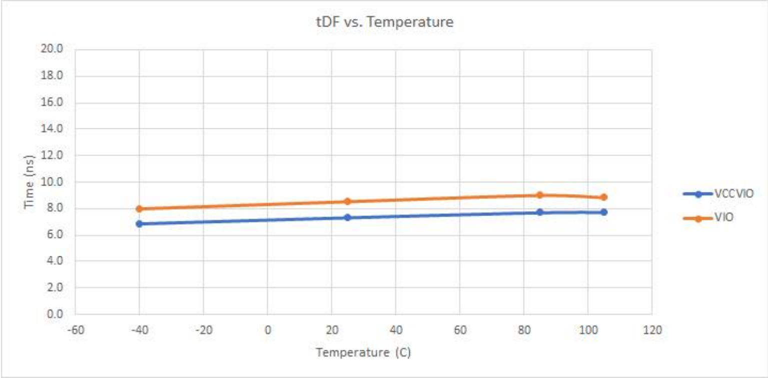

tOE vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



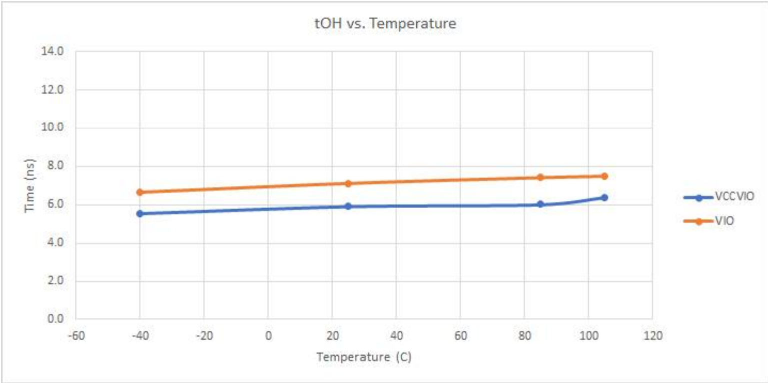
tPACC vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



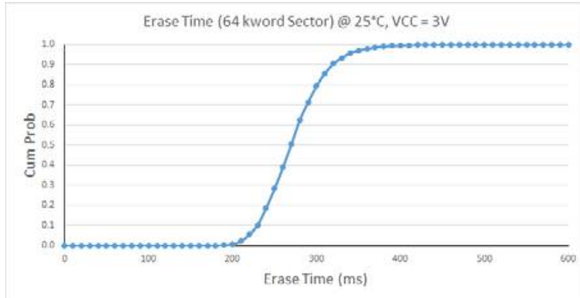

tDF vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



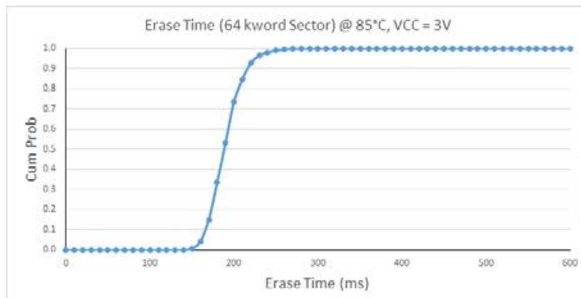

tOH vs. Temperature (VCCVIO = VCC 3.00V/VIO 3.00V, VIO = VCC 3.00V/VIO 1.65V)



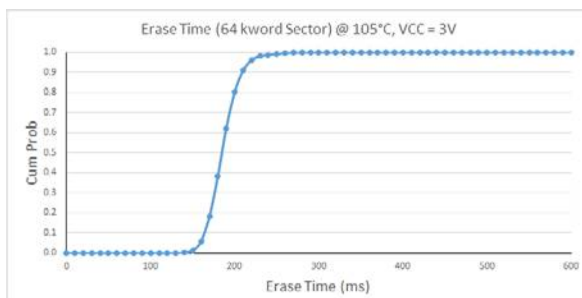
Cumulative Erase Times per Sector at 25°C (VCC 3V)



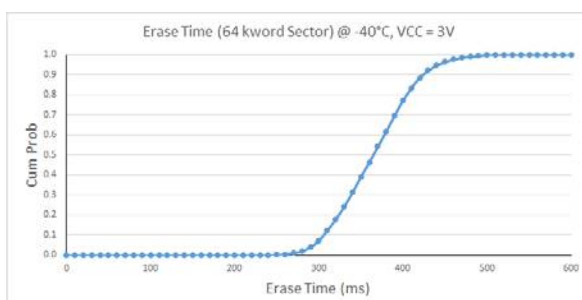

Cumulative Erase Times per Sector at 85°C (VCC 3V)



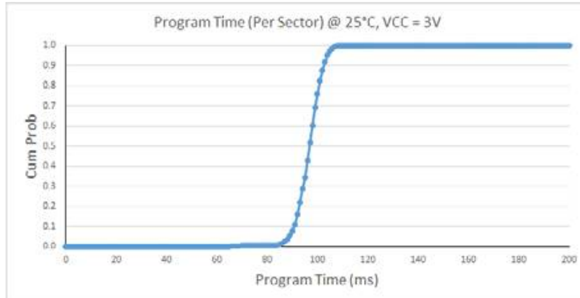

Cumulative Erase Times per Sector at 105°C (VCC 3V)



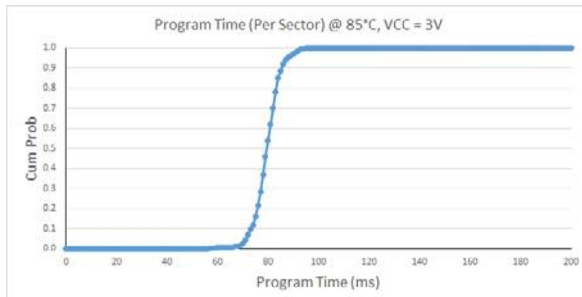

Cumulative Erase Times per Sector at -40°C (VCC 3V)



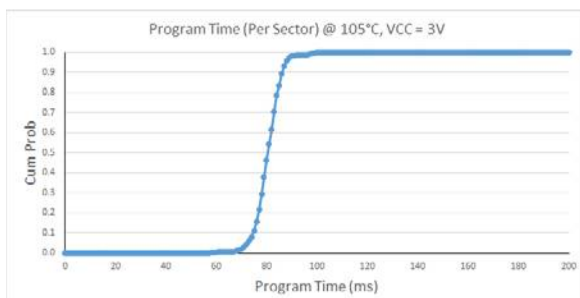
Cumulative WB Program Times per Sector at 25°C (VCC 3V)



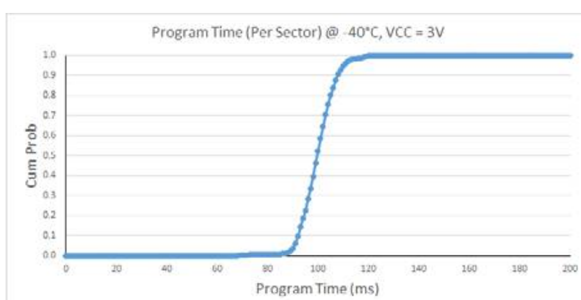

Cumulative WB Program Times per Sector at 85°C (VCC 3V)



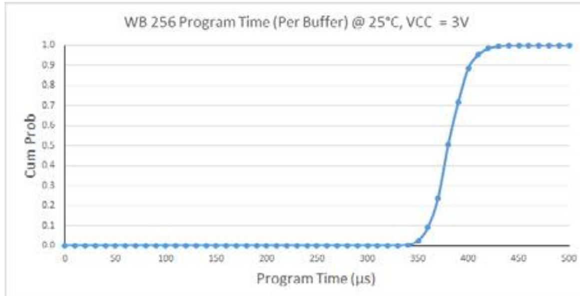

Cumulative WB Program Times per Sector at 105°C (VCC 3V)



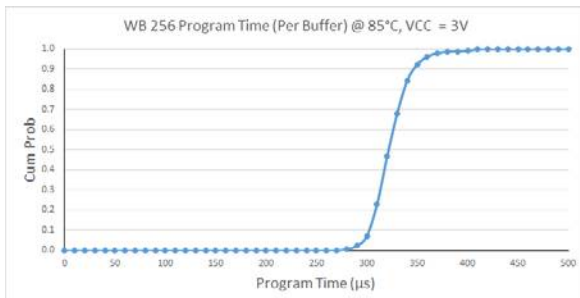

Cumulative WB Program Times per Sector at -40°C (VCC 3V)



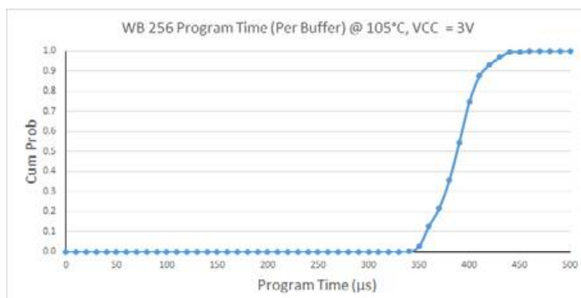
Cumulative WB 256 Program Times per Buffer at 25°C (VCC 3V)



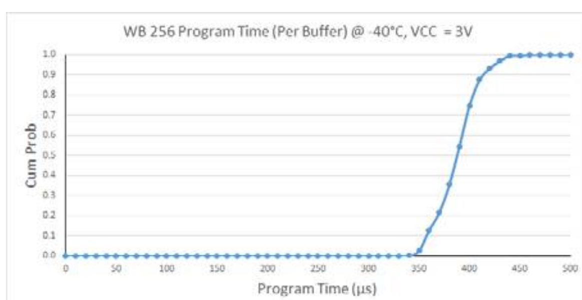

Cumulative WB 256 Program Times per Buffer at 85°C (VCC 3V)



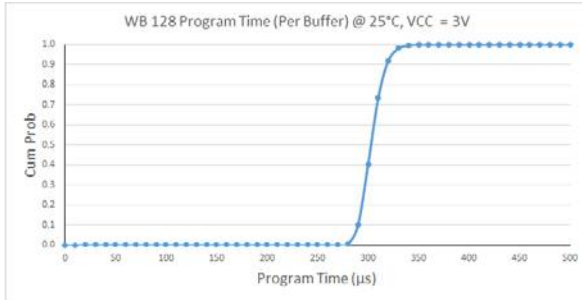

Cumulative WB 256 Program Times per Buffer at 105°C (VCC 3V)



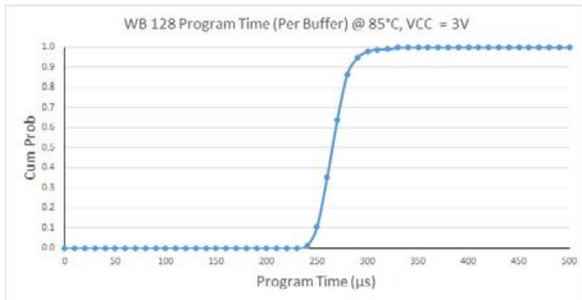

Cumulative WB Program Times per Sector at -40°C (VCC 3V)



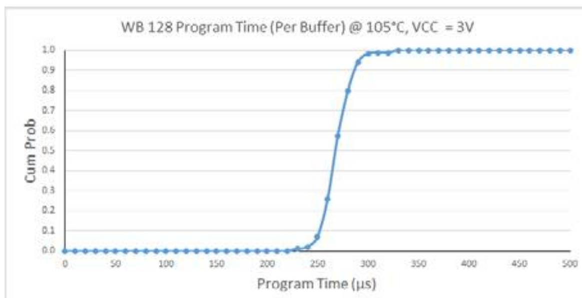
Cumulative WB 128 Program Times per Buffer at 25°C (VCC 3V)



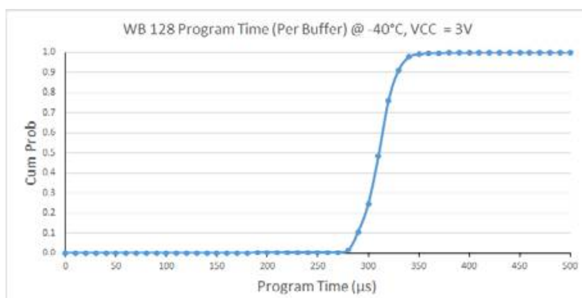

Cumulative WB 128 Program Times per Buffer at 85°C (VCC 3V)



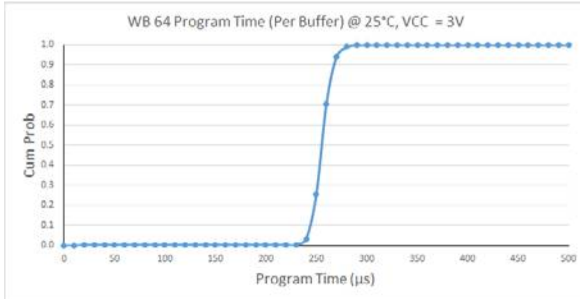

Cumulative WB 128 Program Times per Buffer at 105°C (VCC 3V)



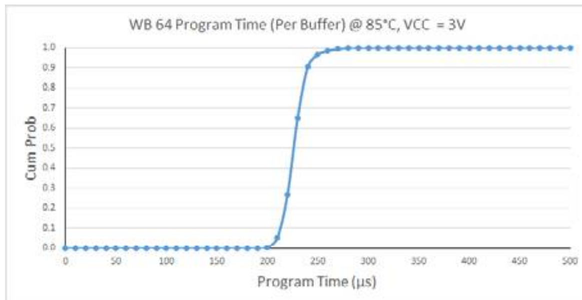

Cumulative WB 128 Program Times per Buffer at -40°C (VCC 3V)



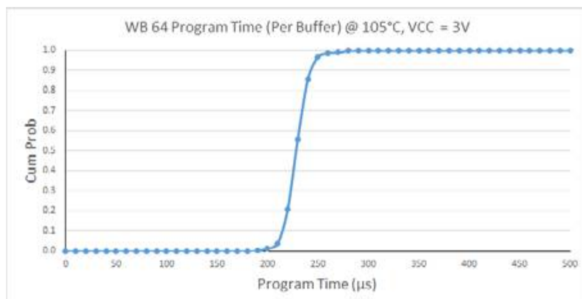
Cumulative WB 64 Program Times per Buffer at 25°C (VCC 3V)



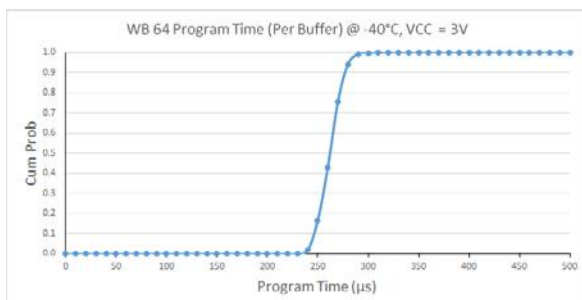

Cumulative WB 64 Program Times per Buffer at 85°C (VCC 3V)



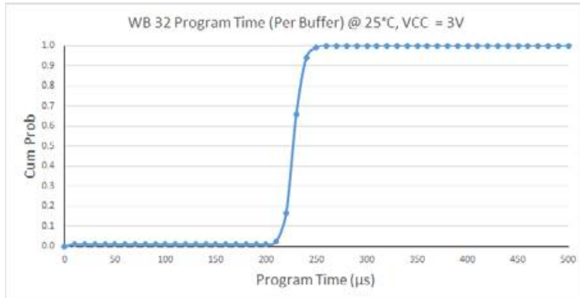

Cumulative WB 64 Program Times per Buffer at 105°C (VCC 3V)



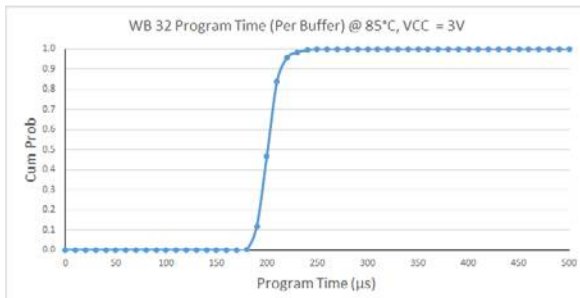

Cumulative WB 64 Program Times per Buffer at -40°C (VCC 3V)



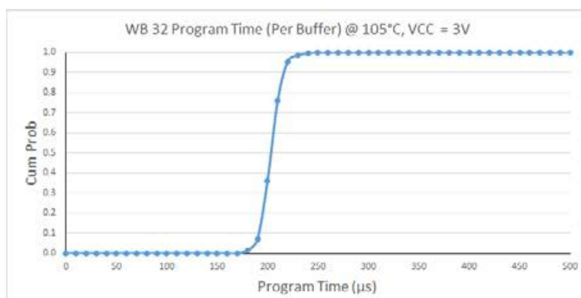
Cumulative WB 32 Program Times per Buffer at 25°C (VCC 3V)



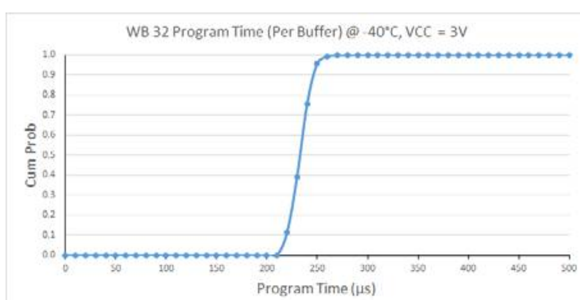

Cumulative WB 32 Program Times per Buffer at 85°C (VCC 3V)



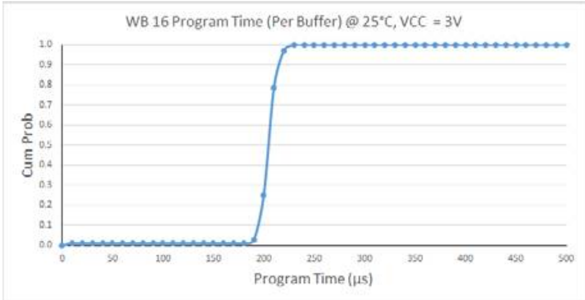

Cumulative WB 32 Program Times per Buffer at 105°C (VCC 3V)



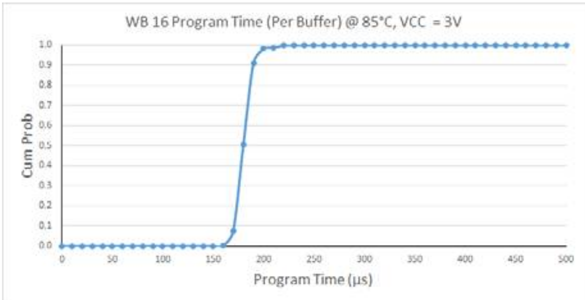

Cumulative WB 32 Program Times per Buffer at -40°C (VCC 3V)



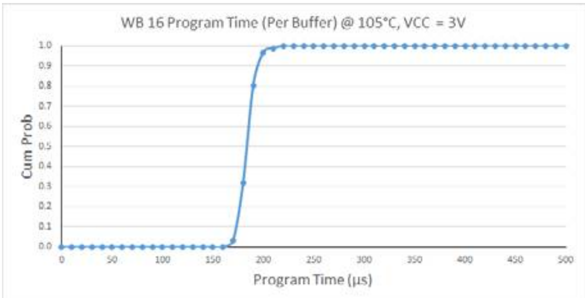
Cumulative WB 16 Program Times per Buffer at 25°C (VCC 3V)



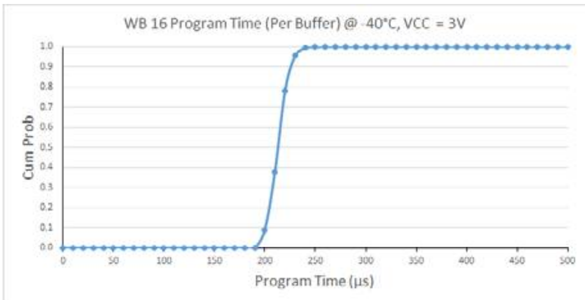

Cumulative WB 16 Program Times per Buffer at 85°C (VCC 3V)



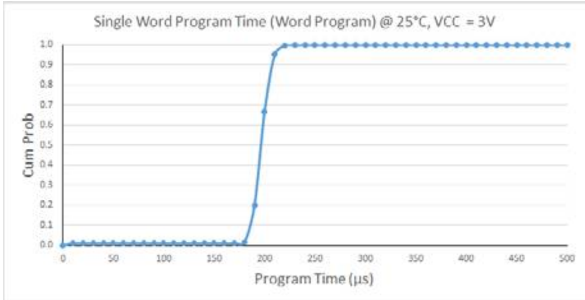

Cumulative WB 16 Program Times per Buffer at 105°C (VCC 3V)



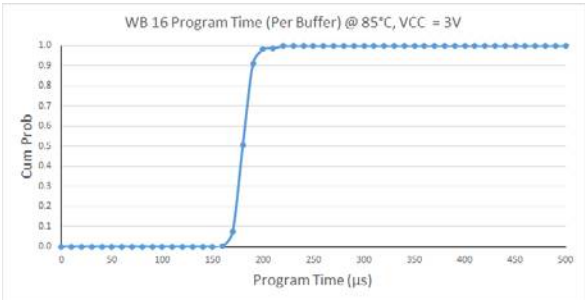

Cumulative WB 16 Program Times per Buffer at -40°C (VCC 3V)



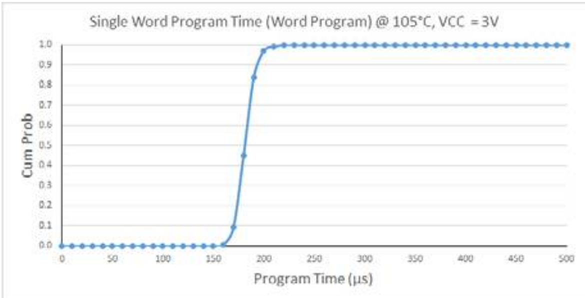
Cumulative Single Word Program Times per Buffer at 25°C (VCC 3V)



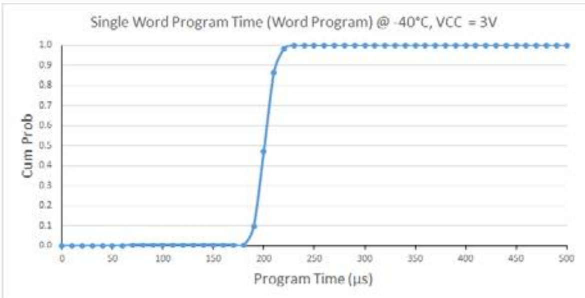

Cumulative Single Word Program Times per Buffer at 85°C (VCC 3V)




Cumulative Single Word Program Times per Buffer at 105°C (VCC 3V)




Cumulative Single Word Program Times per Buffer at -40°C (VCC 3V)



# 16. Shmoo Plots

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.650 |......................*******************|          92
  3.600 |......................*******************|          92
  3.550 |......................*******************|          92
  3.500 |......................*******************|          92
  3.450 |......................*******************|          92
  3.400 |......................*******************|          92
  3.350 |......................*******************|          92
  3.300 |......................*******************|          92
  3.250 |.......................******************|          93
  3.200 |.......................******************|          93
  3.150 |.......................******************|          93
  3.100 |.......................******************|          93
  3.050 |.......................******************|          93
  3.000 |.......................******************|          93
  2.950 |.......................******************|          93
  2.900 |.......................******************|          93
  2.850 |.......................******************|          93
  2.800 |.......................******************|          93
  2.750 |.......................******************|          93
  2.700 |.......................******************|          93
  2.650 |.......................******************|          93
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.650 |.....................********************|          91
  3.600 |.....................********************|          91
  3.550 |.....................********************|          91
  3.500 |.....................********************|          91
  3.450 |.....................********************|          91
  3.400 |.....................********************|          91
  3.350 |.....................********************|          91
  3.300 |.....................********************|          91
  3.250 |.....................********************|          91
  3.200 |.....................********************|          91
  3.150 |......................*******************|          92
  3.100 |......................*******************|          92
  3.050 |......................*******************|          92
  3.000 |......................*******************|          92
  2.950 |......................*******************|          92
  2.900 |......................*******************|          92
  2.850 |......................*******************|          92
  2.800 |......................*******************|          92
  2.750 |......................*******************|          92
  2.700 |......................*******************|          92
  2.650 |......................*******************|          92
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

## $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
       70.0      80.0      90.0      100.0     110.0       first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |.......................******************|          93
3.600 |.......................******************|          93
3.550 |.......................******************|          93
3.500 |.......................******************|          93
3.450 |.......................******************|          93
3.400 |.......................******************|          93
3.350 |.......................******************|          93
3.300 |.......................******************|          93
3.250 |.......................******************|          93
3.200 |.......................******************|          93
3.150 |.......................******************|          93
3.100 |........................*****************|          94
3.050 |........................*****************|          94
3.000 |........................*****************|          94
2.950 |........................*****************|          94
2.900 |........................*****************|          94
2.850 |........................*****************|          94
2.800 |........................*****************|          94
2.750 |........................*****************|          94
2.700 |........................*****************|          94
2.650 |.........................****************|          95
      |+----;----+----;----+----;----+----;----+|
       70.0      80.0      90.0      100.0     110.0
```

## $t_{ACC}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
       70.0      80.0      90.0      100.0     110.0       first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |...........................**************|          97
3.600 |...........................**************|          97
3.550 |...........................**************|          97
3.500 |...........................**************|          97
3.450 |...........................**************|          97
3.400 |...........................**************|          97
3.350 |...........................**************|          97
3.300 |...........................**************|          97
3.250 |...........................**************|          97
3.200 |...........................**************|          97
3.150 |...........................**************|          97
3.100 |...........................**************|          97
3.050 |...........................**************|          97
3.000 |...........................**************|          97
2.950 |...........................**************|          97
2.900 |...........................**************|          97
2.850 |...........................**************|          97
2.800 |...........................**************|          97
2.750 |...........................**************|          97
2.700 |...........................**************|          97
2.650 |............................*************|          98
      |+----;----+----;----+----;----+----;----+|
       70.0      80.0      90.0      100.0     110.0
```

## $t_{ACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
        70.0      80.0      90.0      100.0     110.0      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |.......................******************|          93
 2.950 |.......................******************|          93
 2.900 |.......................******************|          93
 2.850 |.......................******************|          93
 2.800 |.......................******************|          93
 2.750 |.......................******************|          93
 2.700 |.......................******************|          93
 2.650 |.......................******************|          93
 2.600 |.......................******************|          93
 2.550 |.......................******************|          93
 2.500 |.......................******************|          93
 2.450 |.......................******************|          93
 2.400 |.......................******************|          93
 2.350 |.......................******************|          93
 2.300 |.......................******************|          93
 2.250 |.......................******************|          93
 2.200 |.......................******************|          93
 2.150 |.......................******************|          93
 2.100 |.......................******************|          93
 2.050 |.......................******************|          93
 2.000 |........................*****************|          94
 1.950 |........................*****************|          94
 1.900 |........................*****************|          94
 1.850 |........................*****************|          94
 1.800 |........................*****************|          94
 1.750 |........................*****************|          94
 1.700 |.........................****************|          95
 1.650 |.........................****************|          95
       |+----;----+----;----+----;----+----;----+|
        70.0      80.0      90.0      100.0     110.0
```

## $t_{ACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
        70.0      80.0      90.0      100.0     110.0      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |......................*******************|          92
 2.950 |......................*******************|          92
 2.900 |......................*******************|          92
 2.850 |......................*******************|          92
 2.800 |......................*******************|          92
 2.750 |......................*******************|          92
 2.700 |......................*******************|          92
 2.650 |......................*******************|          92
 2.600 |......................*******************|          92
 2.550 |......................*******************|          92
 2.500 |......................*******************|          92
 2.450 |......................*******************|          92
 2.400 |......................*******************|          92
 2.350 |......................*******************|          92
 2.300 |......................*******************|          92
 2.250 |......................*******************|          92
 2.200 |......................*******************|          92
 2.150 |......................*******************|          92
 2.100 |......................*******************|          92
 2.050 |......................*******************|          92
 2.000 |.......................******************|          93
 1.950 |.......................******************|          93
 1.900 |.......................******************|          93
 1.850 |.......................******************|          93
 1.800 |.......................******************|          93
 1.750 |.......................******************|          93
 1.700 |.......................******************|          93
 1.650 |........................*****************|          94
       |+----;----+----;----+----;----+----;----+|
        70.0      80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
3.000   |........................*****************|         94
2.950   |........................*****************|         94
2.900   |........................*****************|         94
2.850   |........................*****************|         94
2.800   |........................*****************|         94
2.750   |........................*****************|         94
2.700   |........................*****************|         94
2.650   |........................*****************|         94
2.600   |........................*****************|         94
2.550   |........................*****************|         94
2.500   |........................*****************|         94
2.450   |........................*****************|         94
2.400   |........................*****************|         94
2.350   |........................*****************|         94
2.300   |........................*****************|         94
2.250   |........................*****************|         94
2.200   |........................*****************|         94
2.150   |........................*****************|         94
2.100   |........................*****************|         94
2.050   |.........................****************|         95
2.000   |.........................****************|         95
1.950   |.........................****************|         95
1.900   |.........................****************|         95
1.850   |.........................****************|         95
1.800   |.........................****************|         95
1.750   |.........................****************|         95
1.700   |.........................****************|         95
1.650   |.........................****************|         95
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{ACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
3.000   |...........................**************|         97
2.950   |...........................**************|         97
2.900   |...........................**************|         97
2.850   |...........................**************|         97
2.800   |...........................**************|         97
2.750   |...........................**************|         97
2.700   |...........................**************|         97
2.650   |...........................**************|         97
2.600   |...........................**************|         97
2.550   |...........................**************|         97
2.500   |...........................**************|         97
2.450   |...........................**************|         97
2.400   |...........................**************|         97
2.350   |...........................**************|         97
2.300   |............................*************|         98
2.250   |............................*************|         98
2.200   |............................*************|         98
2.150   |............................*************|         98
2.100   |............................*************|         98
2.050   |............................*************|         98
2.000   |............................*************|         98
1.950   |............................*************|         98
1.900   |............................*************|         98
1.850   |............................*************|         98
1.800   |.............................************|         99
1.750   |.............................************|         99
1.700   |.............................************|         99
1.650   |.............................************|         99
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
           70.0      80.0      90.0      100.0     110.0        first pass data
          |+----;----+----;----+----;----+----;----+|
    3.650 |.....................********************|             91
    3.600 |.....................********************|             91
    3.550 |.....................********************|             91
    3.500 |.....................********************|             91
    3.450 |......................*******************|             92
    3.400 |......................*******************|             92
    3.350 |......................*******************|             92
    3.300 |......................*******************|             92
    3.250 |......................*******************|             92
    3.200 |......................*******************|             92
    3.150 |......................*******************|             92
    3.100 |......................*******************|             92
    3.050 |......................*******************|             92
    3.000 |......................*******************|             92
    2.950 |......................*******************|             92
    2.900 |......................*******************|             92
    2.850 |......................*******************|             92
    2.800 |......................*******************|             92
    2.750 |......................*******************|             92
    2.700 |......................*******************|             92
    2.650 |......................*******************|             92
          |+----;----+----;----+----;----+----;----+|
           70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
           70.0      80.0      90.0      100.0     110.0        first pass data
          |+----;----+----;----+----;----+----;----+|
    3.650 |.....................********************|             91
    3.600 |.....................********************|             91
    3.550 |.....................********************|             91
    3.500 |.....................********************|             91
    3.450 |.....................********************|             91
    3.400 |.....................********************|             91
    3.350 |.....................********************|             91
    3.300 |.....................********************|             91
    3.250 |.....................********************|             91
    3.200 |.....................********************|             91
    3.150 |.....................********************|             91
    3.100 |.....................********************|             91
    3.050 |.....................********************|             91
    3.000 |.....................********************|             91
    2.950 |.....................********************|             91
    2.900 |.....................********************|             91
    2.850 |.....................********************|             91
    2.800 |.....................********************|             91
    2.750 |.....................********************|             91
    2.700 |.....................********************|             91
    2.650 |.....................********************|             91
          |+----;----+----;----+----;----+----;----+|
           70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.650 |......................*******************|         92
  3.600 |......................*******************|         92
  3.550 |......................*******************|         92
  3.500 |.......................******************|         93
  3.450 |.......................******************|         93
  3.400 |.......................******************|         93
  3.350 |.......................******************|         93
  3.300 |.......................******************|         93
  3.250 |.......................******************|         93
  3.200 |.......................******************|         93
  3.150 |.......................******************|         93
  3.100 |.......................******************|         93
  3.050 |.......................******************|         93
  3.000 |.......................******************|         93
  2.950 |.......................******************|         93
  2.900 |.......................******************|         93
  2.850 |.......................******************|         93
  2.800 |.......................******************|         93
  2.750 |.......................******************|         93
  2.700 |.......................******************|         93
  2.650 |........................*****************|         94
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.650 |...........................**************|         97
  3.600 |...........................**************|         97
  3.550 |...........................**************|         97
  3.500 |...........................**************|         97
  3.450 |...........................**************|         97
  3.400 |...........................**************|         97
  3.350 |...........................**************|         97
  3.300 |...........................**************|         97
  3.250 |...........................**************|         97
  3.200 |...........................**************|         97
  3.150 |...........................**************|         97
  3.100 |...........................**************|         97
  3.050 |...........................**************|         97
  3.000 |...........................**************|         97
  2.950 |...........................**************|         97
  2.900 |...........................**************|         97
  2.850 |...........................**************|         97
  2.800 |...........................**************|         97
  2.750 |...........................**************|         97
  2.700 |............................*************|         98
  2.650 |............................*************|         98
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |......................*******************|         92
  2.950 |......................*******************|         92
  2.900 |......................*******************|         92
  2.850 |......................*******************|         92
  2.800 |......................*******************|         92
  2.750 |......................*******************|         92
  2.700 |......................*******************|         92
  2.650 |......................*******************|         92
  2.600 |......................*******************|         92
  2.550 |......................*******************|         92
  2.500 |......................*******************|         92
  2.450 |......................*******************|         92
  2.400 |......................*******************|         92
  2.350 |......................*******************|         92
  2.300 |.......................******************|         93
  2.250 |.......................******************|         93
  2.200 |.......................******************|         93
  2.150 |.......................******************|         93
  2.100 |.......................******************|         93
  2.050 |.......................******************|         93
  2.000 |.......................******************|         93
  1.950 |.......................******************|         93
  1.900 |.......................******************|         93
  1.850 |........................*****************|         94
  1.800 |........................*****************|         94
  1.750 |........................*****************|         94
  1.700 |.........................****************|         95
  1.650 |.........................****************|         95
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
         70.0      80.0      90.0      100.0     110.0      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |.....................********************|         91
  2.950 |.....................********************|         91
  2.900 |.....................********************|         91
  2.850 |.....................********************|         91
  2.800 |.....................********************|         91
  2.750 |.....................********************|         91
  2.700 |.....................********************|         91
  2.650 |.....................********************|         91
  2.600 |.....................********************|         91
  2.550 |.....................********************|         91
  2.500 |.....................********************|         91
  2.450 |.....................********************|         91
  2.400 |.....................********************|         91
  2.350 |.....................********************|         91
  2.300 |......................*******************|         92
  2.250 |......................*******************|         92
  2.200 |......................*******************|         92
  2.150 |......................*******************|         92
  2.100 |......................*******************|         92
  2.050 |......................*******************|         92
  2.000 |......................*******************|         92
  1.950 |......................*******************|         92
  1.900 |......................*******************|         92
  1.850 |.......................******************|         93
  1.800 |.......................******************|         93
  1.750 |.......................******************|         93
  1.700 |.......................******************|         93
  1.650 |........................*****************|         94
        |+----;----+----;----+----;----+----;----+|
         70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
        70.0      80.0      90.0      100.0     110.0      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |.......................******************|         93
 2.950 |.......................******************|         93
 2.900 |.......................******************|         93
 2.850 |.......................******************|         93
 2.800 |.......................******************|         93
 2.750 |.......................******************|         93
 2.700 |.......................******************|         93
 2.650 |.......................******************|         93
 2.600 |.......................******************|         93
 2.550 |.......................******************|         93
 2.500 |.......................******************|         93
 2.450 |.......................******************|         93
 2.400 |.......................******************|         93
 2.350 |.......................******************|         93
 2.300 |........................*****************|         94
 2.250 |........................*****************|         94
 2.200 |........................*****************|         94
 2.150 |........................*****************|         94
 2.100 |........................*****************|         94
 2.050 |........................*****************|         94
 2.000 |........................*****************|         94
 1.950 |........................*****************|         94
 1.900 |.........................****************|         95
 1.850 |.........................****************|         95
 1.800 |.........................****************|         95
 1.750 |.........................****************|         95
 1.700 |..........................***************|         96
 1.650 |..........................***************|         96
       |+----;----+----;----+----;----+----;----+|
        70.0      80.0      90.0      100.0     110.0
```

### $t_{CE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
        70.0      80.0      90.0      100.0     110.0      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |...........................**************|         97
 2.950 |...........................**************|         97
 2.900 |...........................**************|         97
 2.850 |...........................**************|         97
 2.800 |...........................**************|         97
 2.750 |...........................**************|         97
 2.700 |...........................**************|         97
 2.650 |...........................**************|         97
 2.600 |...........................**************|         97
 2.550 |...........................**************|         97
 2.500 |...........................**************|         97
 2.450 |...........................**************|         97
 2.400 |............................*************|         98
 2.350 |............................*************|         98
 2.300 |............................*************|         98
 2.250 |............................*************|         98
 2.200 |............................*************|         98
 2.150 |............................*************|         98
 2.100 |............................*************|         98
 2.050 |............................*************|         98
 2.000 |............................*************|         98
 1.950 |.............................************|         99
 1.900 |.............................************|         99
 1.850 |.............................************|         99
 1.800 |..............................***********|         100
 1.750 |..............................***********|         100
 1.700 |...............................**********|         101
 1.650 |...............................**********|         101
       |+----;----+----;----+----;----+----;----+|
        70.0      80.0      90.0      100.0     110.0
```

## $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
          0.0       10.0      20.0            first pass data
         |+----;----+----;----+----;|
   3.650 |........******************|         8
   3.600 |........******************|         8
   3.550 |........******************|         8
   3.500 |........******************|         8
   3.450 |........******************|         8
   3.400 |........******************|         8
   3.350 |........******************|         8
   3.300 |........******************|         8
   3.250 |........******************|         8
   3.200 |........******************|         8
   3.150 |........******************|         8
   3.100 |........******************|         8
   3.050 |........******************|         8
   3.000 |........******************|         8
   2.950 |........******************|         8
   2.900 |........******************|         8
   2.850 |........******************|         8
   2.800 |........******************|         8
   2.750 |........******************|         8
   2.700 |........******************|         8
   2.650 |........******************|         8
         |+----;----+----;----+----;|
          0.0       10.0      20.0
```

## $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
          0.0       10.0      20.0            first pass data
         |+----;----+----;----+----;|
   3.650 |.......*******************|         7
   3.600 |.......*******************|         7
   3.550 |.......*******************|         7
   3.500 |.......*******************|         7
   3.450 |.......*******************|         7
   3.400 |.......*******************|         7
   3.350 |.......*******************|         7
   3.300 |.......*******************|         7
   3.250 |.......*******************|         7
   3.200 |.......*******************|         7
   3.150 |.......*******************|         7
   3.100 |.......*******************|         7
   3.050 |.......*******************|         7
   3.000 |.......*******************|         7
   2.950 |.......*******************|         7
   2.900 |.......*******************|         7
   2.850 |.......*******************|         7
   2.800 |.......*******************|         7
   2.750 |.......*******************|         7
   2.700 |.......*******************|         7
   2.650 |.......*******************|         7
         |+----;----+----;----+----;|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          0.0       10.0      20.0            first pass data
         |+----;----+----;----+----;|
   3.650 |.........*****************|          9
   3.600 |.........*****************|          9
   3.550 |.........*****************|          9
   3.500 |.........*****************|          9
   3.450 |.........*****************|          9
   3.400 |.........*****************|          9
   3.350 |.........*****************|          9
   3.300 |.........*****************|          9
   3.250 |.........*****************|          9
   3.200 |.........*****************|          9
   3.150 |.........*****************|          9
   3.100 |.........*****************|          9
   3.050 |.........*****************|          9
   3.000 |.........*****************|          9
   2.950 |.........*****************|          9
   2.900 |.........*****************|          9
   2.850 |.........*****************|          9
   2.800 |.........*****************|          9
   2.750 |.........*****************|          9
   2.700 |.........*****************|          9
   2.650 |.........*****************|          9
         |+----;----+----;----+----;|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
          0.0       10.0      20.0            first pass data
         |+----;----+----;----+----;|
   3.650 |.......*******************|          7
   3.600 |.......*******************|          7
   3.550 |.......*******************|          7
   3.500 |.......*******************|          7
   3.450 |.......*******************|          7
   3.400 |.......*******************|          7
   3.350 |.......*******************|          7
   3.300 |.......*******************|          7
   3.250 |........******************|          8
   3.200 |........******************|          8
   3.150 |........******************|          8
   3.100 |........******************|          8
   3.050 |........******************|          8
   3.000 |........******************|          8
   2.950 |........******************|          8
   2.900 |........******************|          8
   2.850 |........******************|          8
   2.800 |........******************|          8
   2.750 |........******************|          8
   2.700 |........******************|          8
   2.650 |........******************|          8
         |+----;----+----;----+----;|
          0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
         0.0       10.0      20.0             first pass data
        |+----;----+----;----+----;|
  3.000 |........*****************|           8
  2.950 |........*****************|           8
  2.900 |........*****************|           8
  2.850 |........*****************|           8
  2.800 |........*****************|           8
  2.750 |........*****************|           8
  2.700 |........*****************|           8
  2.650 |........*****************|           8
  2.600 |........*****************|           8
  2.550 |........*****************|           8
  2.500 |........*****************|           8
  2.450 |........*****************|           8
  2.400 |........*****************|           8
  2.350 |........*****************|           8
  2.300 |.........****************|           9
  2.250 |.........****************|           9
  2.200 |.........****************|           9
  2.150 |.........****************|           9
  2.100 |.........****************|           9
  2.050 |.........****************|           9
  2.000 |.........****************|           9
  1.950 |.........****************|           9
  1.900 |.........****************|           9
  1.850 |..........***************|           10
  1.800 |..........***************|           10
  1.750 |..........***************|           10
  1.700 |..........***************|           10
  1.650 |..........***************|           10
        |+----;----+----;----+----;|
         0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
         0.0       10.0      20.0             first pass data
        |+----;----+----;----+----;|
  3.000 |.......******************|           7
  2.950 |.......******************|           7
  2.900 |.......******************|           7
  2.850 |.......******************|           7
  2.800 |.......******************|           7
  2.750 |.......******************|           7
  2.700 |.......******************|           7
  2.650 |.......******************|           7
  2.600 |.......******************|           7
  2.550 |.......******************|           7
  2.500 |.......******************|           7
  2.450 |.......******************|           7
  2.400 |.......******************|           7
  2.350 |.......******************|           7
  2.300 |........*****************|           8
  2.250 |........*****************|           8
  2.200 |........*****************|           8
  2.150 |........*****************|           8
  2.100 |........*****************|           8
  2.050 |........*****************|           8
  2.000 |........*****************|           8
  1.950 |........*****************|           8
  1.900 |........*****************|           8
  1.850 |........*****************|           8
  1.800 |.........****************|           9
  1.750 |.........****************|           9
  1.700 |.........****************|           9
  1.650 |.........****************|           9
        |+----;----+----;----+----;|
         0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
         0.0       10.0      20.0            first pass data
        |+----;----+----;----+----;|
  3.000 |.........*****************|         9
  2.950 |.........*****************|         9
  2.900 |.........*****************|         9
  2.850 |.........*****************|         9
  2.800 |.........*****************|         9
  2.750 |.........*****************|         9
  2.700 |.........*****************|         9
  2.650 |.........*****************|         9
  2.600 |.........*****************|         9
  2.550 |.........*****************|         9
  2.500 |.........*****************|         9
  2.450 |.........*****************|         9
  2.400 |.........*****************|         9
  2.350 |.........*****************|         9
  2.300 |.........*****************|         9
  2.250 |.........*****************|         9
  2.200 |.........*****************|         9
  2.150 |.........*****************|         9
  2.100 |.........*****************|         9
  2.050 |..........****************|         10
  2.000 |..........****************|         10
  1.950 |..........****************|         10
  1.900 |..........****************|         10
  1.850 |..........****************|         10
  1.800 |..........****************|         10
  1.750 |..........****************|         10
  1.700 |..........****************|         10
  1.650 |...........***************|         11
        |+----;----+----;----+----;|
         0.0       10.0      20.0
```

### $t_{OE}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
         0.0       10.0      20.0            first pass data
        |+----;----+----;----+----;|
  3.000 |........******************|         8
  2.950 |........******************|         8
  2.900 |........******************|         8
  2.850 |........******************|         8
  2.800 |........******************|         8
  2.750 |........******************|         8
  2.700 |........******************|         8
  2.650 |........******************|         8
  2.600 |........******************|         8
  2.550 |........******************|         8
  2.500 |........******************|         8
  2.450 |........******************|         8
  2.400 |........******************|         8
  2.350 |........******************|         8
  2.300 |........******************|         8
  2.250 |........******************|         8
  2.200 |........******************|         8
  2.150 |........******************|         8
  2.100 |........******************|         8
  2.050 |.........*****************|         9
  2.000 |.........*****************|         9
  1.950 |.........*****************|         9
  1.900 |.........*****************|         9
  1.850 |.........*****************|         9
  1.800 |.........*****************|         9
  1.750 |..........****************|         10
  1.700 |..........****************|         10
  1.650 |..........****************|         10
        |+----;----+----;----+----;|
         0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
         0.0       10.0      20.0        first pass data
        |+----;----+----;----+|
  3.650 |............*********|          12
  3.600 |............*********|          12
  3.550 |............*********|          12
  3.500 |............*********|          12
  3.450 |............*********|          12
  3.400 |............*********|          12
  3.350 |............*********|          12
  3.300 |............*********|          12
  3.250 |............*********|          12
  3.200 |............*********|          12
  3.150 |............*********|          12
  3.100 |............*********|          12
  3.050 |............*********|          12
  3.000 |............*********|          12
  2.950 |............*********|          12
  2.900 |............*********|          12
  2.850 |............*********|          12
  2.800 |............*********|          12
  2.750 |............*********|          12
  2.700 |............*********|          12
  2.650 |............*********|          12
        |+----;----+----;----+|
         0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
         0.0       10.0      20.0        first pass data
        |+----;----+----;----+|
  3.650 |..........***********|          10
  3.600 |..........***********|          10
  3.550 |..........***********|          10
  3.500 |..........***********|          10
  3.450 |..........***********|          10
  3.400 |..........***********|          10
  3.350 |..........***********|          10
  3.300 |..........***********|          10
  3.250 |..........***********|          10
  3.200 |..........***********|          10
  3.150 |..........***********|          10
  3.100 |..........***********|          10
  3.050 |..........***********|          10
  3.000 |..........***********|          10
  2.950 |..........***********|          10
  2.900 |..........***********|          10
  2.850 |..........***********|          10
  2.800 |..........***********|          10
  2.750 |..........***********|          10
  2.700 |..........***********|          10
  2.650 |..........***********|          10
        |+----;----+----;----+|
         0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
           0.0       10.0      20.0         first pass data
          |+----;----+----;----+|
   3.650  |............*********|           12
   3.600  |............*********|           12
   3.550  |............*********|           12
   3.500  |............*********|           12
   3.450  |............*********|           12
   3.400  |............*********|           12
   3.350  |............*********|           12
   3.300  |............*********|           12
   3.250  |............*********|           12
   3.200  |............*********|           12
   3.150  |............*********|           12
   3.100  |............*********|           12
   3.050  |............*********|           12
   3.000  |............*********|           12
   2.950  |............*********|           12
   2.900  |............*********|           12
   2.850  |............*********|           12
   2.800  |............*********|           12
   2.750  |............*********|           12
   2.700  |............*********|           12
   2.650  |............*********|           12
          |+----;----+----;----+|
           0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
           0.0       10.0      20.0         first pass data
          |+----;----+----;----+|
   3.650  |...........**********|           11
   3.600  |...........**********|           11
   3.550  |...........**********|           11
   3.500  |...........**********|           11
   3.450  |...........**********|           11
   3.400  |...........**********|           11
   3.350  |...........**********|           11
   3.300  |...........**********|           11
   3.250  |...........**********|           11
   3.200  |...........**********|           11
   3.150  |...........**********|           11
   3.100  |...........**********|           11
   3.050  |...........**********|           11
   3.000  |...........**********|           11
   2.950  |...........**********|           11
   2.900  |...........**********|           11
   2.850  |...........**********|           11
   2.800  |...........**********|           11
   2.750  |...........**********|           11
   2.700  |...........**********|           11
   2.650  |...........**********|           11
          |+----;----+----;----+|
           0.0       10.0      20.0
```

## $t_{PACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
         0.0       10.0      20.0       first pass data
        |+----;----+----;----+|
  3.000 |............*********|         12
  2.950 |............*********|         12
  2.900 |............*********|         12
  2.850 |............*********|         12
  2.800 |............*********|         12
  2.750 |............*********|         12
  2.700 |............*********|         12
  2.650 |............*********|         12
  2.600 |............*********|         12
  2.550 |............*********|         12
  2.500 |............*********|         12
  2.450 |............*********|         12
  2.400 |............*********|         12
  2.350 |............*********|         12
  2.300 |............*********|         12
  2.250 |............*********|         12
  2.200 |............*********|         12
  2.150 |............*********|         12
  2.100 |............*********|         12
  2.050 |............*********|         12
  2.000 |............*********|         12
  1.950 |............*********|         12
  1.900 |............*********|         12
  1.850 |.............********|         13
  1.800 |.............********|         13
  1.750 |.............********|         13
  1.700 |.............********|         13
  1.650 |.............********|         13
        |+----;----+----;----+|
         0.0       10.0      20.0
```

## $t_{PACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
         0.0       10.0      20.0       first pass data
        |+----;----+----;----+|
  3.000 |..........***********|         10
  2.950 |..........***********|         10
  2.900 |..........***********|         10
  2.850 |..........***********|         10
  2.800 |..........***********|         10
  2.750 |..........***********|         10
  2.700 |..........***********|         10
  2.650 |..........***********|         10
  2.600 |..........***********|         10
  2.550 |..........***********|         10
  2.500 |..........***********|         10
  2.450 |..........***********|         10
  2.400 |..........***********|         10
  2.350 |..........***********|         10
  2.300 |..........***********|         10
  2.250 |..........***********|         10
  2.200 |..........***********|         10
  2.150 |..........***********|         10
  2.100 |..........***********|         10
  2.050 |...........**********|         11
  2.000 |...........**********|         11
  1.950 |...........**********|         11
  1.900 |...........**********|         11
  1.850 |...........**********|         11
  1.800 |...........**********|         11
  1.750 |...........**********|         11
  1.700 |...........**********|         11
  1.650 |...........**********|         11
        |+----;----+----;----+|
         0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
          0.0       10.0      20.0        first pass data
         |+----;----+----;----+|
   3.000 |............*********|          12
   2.950 |............*********|          12
   2.900 |............*********|          12
   2.850 |............*********|          12
   2.800 |............*********|          12
   2.750 |............*********|          12
   2.700 |............*********|          12
   2.650 |............*********|          12
   2.600 |............*********|          12
   2.550 |............*********|          12
   2.500 |............*********|          12
   2.450 |............*********|          12
   2.400 |............*********|          12
   2.350 |............*********|          12
   2.300 |............*********|          12
   2.250 |.............********|          13
   2.200 |.............********|          13
   2.150 |.............********|          13
   2.100 |.............********|          13
   2.050 |.............********|          13
   2.000 |.............********|          13
   1.950 |.............********|          13
   1.900 |.............********|          13
   1.850 |.............********|          13
   1.800 |.............********|          13
   1.750 |.............********|          13
   1.700 |..............*******|          14
   1.650 |..............*******|          14
         |+----;----+----;----+|
          0.0       10.0      20.0
```

### $t_{PACC}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
          0.0       10.0      20.0        first pass data
         |+----;----+----;----+|
   3.000 |...........**********|          11
   2.950 |...........**********|          11
   2.900 |...........**********|          11
   2.850 |...........**********|          11
   2.800 |...........**********|          11
   2.750 |...........**********|          11
   2.700 |...........**********|          11
   2.650 |...........**********|          11
   2.600 |...........**********|          11
   2.550 |...........**********|          11
   2.500 |...........**********|          11
   2.450 |...........**********|          11
   2.400 |...........**********|          11
   2.350 |...........**********|          11
   2.300 |...........**********|          11
   2.250 |...........**********|          11
   2.200 |...........**********|          11
   2.150 |...........**********|          11
   2.100 |...........**********|          11
   2.050 |............*********|          12
   2.000 |............*********|          12
   1.950 |............*********|          12
   1.900 |............*********|          12
   1.850 |............*********|          12
   1.800 |............*********|          12
   1.750 |............*********|          12
   1.700 |.............********|          13
   1.650 |.............********|          13
         |+----;----+----;----+|
          0.0       10.0      20.0
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
        1.000     1.500     2.000     2.500     3.000        first pass data
       |+----;----+----;----+----;----+----;----+|
 3.650 |....................*********************|         2.000
 3.600 |....................*********************|         2.000
 3.550 |...................**********************|         1.950
 3.500 |..................***********************|         1.900
 3.450 |..................***********************|         1.900
 3.400 |.................************************|         1.850
 3.350 |.................************************|         1.850
 3.300 |................*************************|         1.800
 3.250 |................*************************|         1.800
 3.200 |...............**************************|         1.750
 3.150 |...............**************************|         1.750
 3.100 |..............***************************|         1.700
 3.050 |..............***************************|         1.700
 3.000 |.............****************************|         1.650
 2.950 |............*****************************|         1.600
 2.900 |............*****************************|         1.600
 2.850 |...........******************************|         1.550
 2.800 |...........******************************|         1.550
 2.750 |..........*******************************|         1.500
 2.700 |..........*******************************|         1.500
 2.650 |.........********************************|         1.450
       |+----;----+----;----+----;----+----;----+|
        1.000     1.500     2.000     2.500     3.000
```

## $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
        1.000     1.500     2.000     2.500     3.000        first pass data
       |+----;----+----;----+----;----+----;----+|
 3.650 |....................*********************|         2.000
 3.600 |....................*********************|         2.000
 3.550 |...................**********************|         1.950
 3.500 |...................**********************|         1.950
 3.450 |..................***********************|         1.900
 3.400 |..................***********************|         1.900
 3.350 |.................************************|         1.850
 3.300 |................*************************|         1.800
 3.250 |................*************************|         1.800
 3.200 |...............**************************|         1.750
 3.150 |...............**************************|         1.750
 3.100 |..............***************************|         1.700
 3.050 |..............***************************|         1.700
 3.000 |.............****************************|         1.650
 2.950 |.............****************************|         1.650
 2.900 |............*****************************|         1.600
 2.850 |...........******************************|         1.550
 2.800 |...........******************************|         1.550
 2.750 |..........*******************************|         1.500
 2.700 |..........*******************************|         1.500
 2.650 |.........********************************|         1.450
       |+----;----+----;----+----;----+----;----+|
        1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
         1.000     1.500     2.000     2.500     3.000        first pass data
        |+----;----+----;----+----;----+----;----+|
   3.650 |....................*********************|         2.000
   3.600 |....................*********************|         2.000
   3.550 |...................**********************|         1.950
   3.500 |..................***********************|         1.900
   3.450 |..................***********************|         1.900
   3.400 |.................************************|         1.850
   3.350 |.................************************|         1.850
   3.300 |................*************************|         1.800
   3.250 |................*************************|         1.800
   3.200 |...............**************************|         1.750
   3.150 |...............**************************|         1.750
   3.100 |..............***************************|         1.700
   3.050 |.............****************************|         1.650
   3.000 |.............****************************|         1.650
   2.950 |............*****************************|         1.600
   2.900 |............*****************************|         1.600
   2.850 |...........******************************|         1.550
   2.800 |...........******************************|         1.550
   2.750 |..........*******************************|         1.500
   2.700 |..........*******************************|         1.500
   2.650 |.........********************************|         1.450
        |+----;----+----;----+----;----+----;----+|
         1.000     1.500     2.000     2.500     3.000
```

### $V_{IH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
         1.000     1.500     2.000     2.500     3.000        first pass data
        |+----;----+----;----+----;----+----;----+|
   3.650 |....................*********************|         2.000
   3.600 |....................*********************|         2.000
   3.550 |...................**********************|         1.950
   3.500 |...................**********************|         1.950
   3.450 |..................***********************|         1.900
   3.400 |..................***********************|         1.900
   3.350 |.................************************|         1.850
   3.300 |................*************************|         1.800
   3.250 |................*************************|         1.800
   3.200 |...............**************************|         1.750
   3.150 |...............**************************|         1.750
   3.100 |..............***************************|         1.700
   3.050 |..............***************************|         1.700
   3.000 |.............****************************|         1.650
   2.950 |.............****************************|         1.650
   2.900 |............*****************************|         1.600
   2.850 |............*****************************|         1.600
   2.800 |...........******************************|         1.550
   2.750 |..........*******************************|         1.500
   2.700 |..........*******************************|         1.500
   2.650 |.........********************************|         1.450
        |+----;----+----;----+----;----+----;----+|
         1.000     1.500     2.000     2.500     3.000
```

## $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       0.000     0.500     1.000     1.500     2.000       first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |********************************.........|         1.550
3.600 |********************************.........|         1.550
3.550 |*******************************..........|         1.500
3.500 |*******************************..........|         1.500
3.450 |*******************************..........|         1.500
3.400 |******************************...........|         1.450
3.350 |******************************...........|         1.450
3.300 |******************************...........|         1.450
3.250 |*****************************............|         1.400
3.200 |*****************************............|         1.400
3.150 |*****************************............|         1.400
3.100 |****************************.............|         1.350
3.050 |****************************.............|         1.350
3.000 |***************************..............|         1.300
2.950 |***************************..............|         1.300
2.900 |***************************..............|         1.300
2.850 |**************************...............|         1.250
2.800 |**************************...............|         1.250
2.750 |**************************...............|         1.250
2.700 |*************************................|         1.200
2.650 |*************************................|         1.200
      |+----;----+----;----+----;----+----;----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       0.000     0.500     1.000     1.500     2.000       first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |********************************.........|         1.550
3.600 |*******************************..........|         1.500
3.550 |*******************************..........|         1.500
3.500 |*******************************..........|         1.500
3.450 |******************************...........|         1.450
3.400 |******************************...........|         1.450
3.350 |******************************...........|         1.450
3.300 |*****************************............|         1.400
3.250 |*****************************............|         1.400
3.200 |*****************************............|         1.400
3.150 |****************************.............|         1.350
3.100 |****************************.............|         1.350
3.050 |****************************.............|         1.350
3.000 |***************************..............|         1.300
2.950 |***************************..............|         1.300
2.900 |**************************...............|         1.250
2.850 |**************************...............|         1.250
2.800 |**************************...............|         1.250
2.750 |*************************................|         1.200
2.700 |*************************................|         1.200
2.650 |*************************................|         1.200
      |+----;----+----;----+----;----+----;----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}=V_{IO}$ @ 105°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |********************************.........|        1.550
3.600 |*******************************..........|        1.500
3.550 |*******************************..........|        1.500
3.500 |******************************...........|        1.450
3.450 |******************************...........|        1.450
3.400 |******************************...........|        1.450
3.350 |*****************************............|        1.400
3.300 |*****************************............|        1.400
3.250 |*****************************............|        1.400
3.200 |****************************.............|        1.350
3.150 |****************************.............|        1.350
3.100 |****************************.............|        1.350
3.050 |***************************..............|        1.300
3.000 |***************************..............|        1.300
2.950 |***************************..............|        1.300
2.900 |**************************...............|        1.250
2.850 |**************************...............|        1.250
2.800 |**************************...............|        1.250
2.750 |*************************................|        1.200
2.700 |*************************................|        1.200
2.650 |************************.................|        1.150
      |+----;----+----;----+----;----+----;----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{CC}=V_{IO}$ @ -40°C

```
       0.000     0.500     1.000     1.500     2.000        first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |*********************************........|        1.600
3.600 |********************************.........|        1.550
3.550 |********************************.........|        1.550
3.500 |********************************.........|        1.550
3.450 |*******************************..........|        1.500
3.400 |*******************************..........|        1.500
3.350 |*******************************..........|        1.500
3.300 |******************************...........|        1.450
3.250 |******************************...........|        1.450
3.200 |******************************...........|        1.450
3.150 |*****************************............|        1.400
3.100 |*****************************............|        1.400
3.050 |*****************************............|        1.400
3.000 |****************************.............|        1.350
2.950 |****************************.............|        1.350
2.900 |****************************.............|        1.350
2.850 |***************************..............|        1.300
2.800 |***************************..............|        1.300
2.750 |**************************...............|        1.250
2.700 |**************************...............|        1.250
2.650 |**************************...............|        1.250
      |+----;----+----;----+----;----+----;----+|
       0.000     0.500     1.000     1.500     2.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |*********************************........|        3.600
3.600 |********************************.........|        3.550
3.550 |*******************************..........|        3.500
3.500 |******************************...........|        3.450
3.450 |*****************************............|        3.400
3.400 |****************************.............|        3.350
3.350 |***************************..............|        3.300
3.300 |**************************...............|        3.250
3.250 |*************************................|        3.200
3.200 |************************.................|        3.150
3.150 |***********************..................|        3.100
3.100 |**********************...................|        3.050
3.050 |*********************....................|        3.000
3.000 |********************.....................|        2.950
2.950 |*******************......................|        2.900
2.900 |******************.......................|        2.850
2.850 |*****************........................|        2.800
2.800 |****************.........................|        2.750
2.750 |***************..........................|        2.700
2.700 |**************...........................|        2.650
2.650 |*************............................|        2.600
      |+----;----+----;----+----;----+----;----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
       2.000     2.500     3.000     3.500     4.000       first pass data
      |+----;----+----;----+----;----+----;----+|
3.650 |*********************************........|        3.600
3.600 |********************************.........|        3.550
3.550 |*******************************..........|        3.500
3.500 |******************************...........|        3.450
3.450 |*****************************............|        3.400
3.400 |****************************.............|        3.350
3.350 |***************************..............|        3.300
3.300 |**************************...............|        3.250
3.250 |*************************................|        3.200
3.200 |************************.................|        3.150
3.150 |***********************..................|        3.100
3.100 |**********************...................|        3.050
3.050 |*********************....................|        3.000
3.000 |********************.....................|        2.950
2.950 |*******************......................|        2.900
2.900 |******************.......................|        2.850
2.850 |*****************........................|        2.800
2.800 |****************.........................|        2.750
2.750 |***************..........................|        2.700
2.700 |**************...........................|        2.650
2.650 |*************............................|        2.600
      |+----;----+----;----+----;----+----;----+|
       2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
          2.000     2.500     3.000     3.500     4.000        first pass data
         |+----;----+----;----+----;----+----;----+|
   3.650 |*********************************........|        3.600
   3.600 |********************************.........|        3.550
   3.550 |*******************************..........|        3.500
   3.500 |******************************...........|        3.450
   3.450 |*****************************............|        3.400
   3.400 |****************************.............|        3.350
   3.350 |***************************..............|        3.300
   3.300 |**************************...............|        3.250
   3.250 |*************************................|        3.200
   3.200 |************************.................|        3.150
   3.150 |***********************..................|        3.100
   3.100 |**********************...................|        3.050
   3.050 |*********************....................|        3.000
   3.000 |********************.....................|        2.950
   2.950 |*******************......................|        2.900
   2.900 |******************.......................|        2.850
   2.850 |*****************........................|        2.800
   2.800 |****************.........................|        2.750
   2.750 |***************..........................|        2.700
   2.700 |**************...........................|        2.650
   2.650 |*************............................|        2.600
         |+----;----+----;----+----;----+----;----+|
          2.000     2.500     3.000     3.500     4.000
```

## $V_{OH}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
          2.000     2.500     3.000     3.500     4.000        first pass data
         |+----;----+----;----+----;----+----;----+|
   3.650 |*********************************........|        3.600
   3.600 |********************************.........|        3.550
   3.550 |*******************************..........|        3.500
   3.500 |******************************...........|        3.450
   3.450 |*****************************............|        3.400
   3.400 |****************************.............|        3.350
   3.350 |***************************..............|        3.300
   3.300 |**************************...............|        3.250
   3.250 |*************************................|        3.200
   3.200 |************************.................|        3.150
   3.150 |***********************..................|        3.100
   3.100 |**********************...................|        3.050
   3.050 |*********************....................|        3.000
   3.000 |********************.....................|        2.950
   2.950 |*******************......................|        2.900
   2.900 |******************.......................|        2.850
   2.850 |*****************........................|        2.800
   2.800 |****************.........................|        2.750
   2.750 |***************..........................|        2.700
   2.700 |**************...........................|        2.650
   2.650 |*************............................|        2.600
         |+----;----+----;----+----;----+----;----+|
          2.000     2.500     3.000     3.500     4.000
```

### $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 25°C

```
         0.000     0.500     1.000      first pass data
        |+----;----+----;----+|
   3.650 |.********************|          0.050
   3.600 |.********************|          0.050
   3.550 |.********************|          0.050
   3.500 |.********************|          0.050
   3.450 |.********************|          0.050
   3.400 |.********************|          0.050
   3.350 |.********************|          0.050
   3.300 |.********************|          0.050
   3.250 |.********************|          0.050
   3.200 |.********************|          0.050
   3.150 |.********************|          0.050
   3.100 |.********************|          0.050
   3.050 |.********************|          0.050
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 85°C

```
         0.000     0.500     1.000      first pass data
        |+----;----+----;----+|
   3.650 |.********************|          0.050
   3.600 |.********************|          0.050
   3.550 |.********************|          0.050
   3.500 |.********************|          0.050
   3.450 |.********************|          0.050
   3.400 |.********************|          0.050
   3.350 |.********************|          0.050
   3.300 |.********************|          0.050
   3.250 |.********************|          0.050
   3.200 |.********************|          0.050
   3.150 |.********************|          0.050
   3.100 |.********************|          0.050
   3.050 |.********************|          0.050
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ 105°C

```
         0.000     0.500     1.000       first pass data
        |+----;----+----;----+|
  3.650 |.********************|          0.050
  3.600 |.********************|          0.050
  3.550 |.********************|          0.050
  3.500 |.********************|          0.050
  3.450 |.********************|          0.050
  3.400 |.********************|          0.050
  3.350 |.********************|          0.050
  3.300 |.********************|          0.050
  3.250 |.********************|          0.050
  3.200 |.********************|          0.050
  3.150 |.********************|          0.050
  3.100 |.********************|          0.050
  3.050 |.********************|          0.050
  3.000 |.********************|          0.050
  2.950 |.********************|          0.050
  2.900 |.********************|          0.050
  2.850 |.********************|          0.050
  2.800 |.********************|          0.050
  2.750 |.********************|          0.050
  2.700 |.********************|          0.050
  2.650 |.********************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

## $V_{OL}$ vs. $V_{CC}$=$V_{IO}$ @ -40°C

```
         0.000     0.500     1.000       first pass data
        |+----;----+----;----+|
  3.650 |.********************|          0.050
  3.600 |.********************|          0.050
  3.550 |.********************|          0.050
  3.500 |.********************|          0.050
  3.450 |.********************|          0.050
  3.400 |.********************|          0.050
  3.350 |.********************|          0.050
  3.300 |.********************|          0.050
  3.250 |.********************|          0.050
  3.200 |.********************|          0.050
  3.150 |.********************|          0.050
  3.100 |.********************|          0.050
  3.050 |.********************|          0.050
  3.000 |.********************|          0.050
  2.950 |.********************|          0.050
  2.900 |.********************|          0.050
  2.850 |.********************|          0.050
  2.800 |.********************|          0.050
  2.750 |.********************|          0.050
  2.700 |.********************|          0.050
  2.650 |.********************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

### $V_{IH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
         0.500     1.000     1.500     2.000     2.500      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |......................******************|           1.650
  2.950 |.....................*******************|           1.600
  2.900 |.....................*******************|           1.600
  2.850 |....................********************|           1.550
  2.800 |....................********************|           1.550
  2.750 |...................*********************|           1.500
  2.700 |...................*********************|           1.500
  2.650 |..................**********************|           1.450
  2.600 |..................**********************|           1.450
  2.550 |.................***********************|           1.400
  2.500 |.................***********************|           1.400
  2.450 |................************************|           1.350
  2.400 |................************************|           1.350
  2.350 |...............*************************|           1.300
  2.300 |...............*************************|           1.300
  2.250 |..............**************************|           1.250
  2.200 |..............**************************|           1.250
  2.150 |.............***************************|           1.200
  2.100 |............****************************|           1.150
  2.050 |............****************************|           1.150
  2.000 |...........*****************************|           1.100
  1.950 |...........*****************************|           1.100
  1.900 |..........******************************|           1.050
  1.850 |..........******************************|           1.050
  1.800 |.........*******************************|           1.000
  1.750 |.........*******************************|           1.000
  1.700 |........********************************|           0.950
  1.650 |........********************************|           0.950
        |+----;----+----;----+----;----+----;----+|
         0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
         0.500     1.000     1.500     2.000     2.500      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |......................******************|           1.650
  2.950 |......................******************|           1.650
  2.900 |.....................*******************|           1.600
  2.850 |.....................*******************|           1.600
  2.800 |....................********************|           1.550
  2.750 |...................*********************|           1.500
  2.700 |...................*********************|           1.500
  2.650 |..................**********************|           1.450
  2.600 |..................**********************|           1.450
  2.550 |.................***********************|           1.400
  2.500 |.................***********************|           1.400
  2.450 |................************************|           1.350
  2.400 |................************************|           1.350
  2.350 |...............*************************|           1.300
  2.300 |...............*************************|           1.300
  2.250 |..............**************************|           1.250
  2.200 |..............**************************|           1.250
  2.150 |.............***************************|           1.200
  2.100 |.............***************************|           1.200
  2.050 |............****************************|           1.150
  2.000 |............****************************|           1.150
  1.950 |...........*****************************|           1.100
  1.900 |..........******************************|           1.050
  1.850 |..........******************************|           1.050
  1.800 |.........*******************************|           1.000
  1.750 |.........*******************************|           1.000
  1.700 |........********************************|           0.950
  1.650 |........********************************|           0.950
        |+----;----+----;----+----;----+----;----+|
         0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
       0.500     1.000     1.500     2.000     2.500        first pass data
      |+----;----+----;----+----;----+----;----+|
3.000 |.......................******************|         1.650
2.950 |......................*******************|         1.600
2.900 |......................*******************|         1.600
2.850 |.....................********************|         1.550
2.800 |.....................********************|         1.550
2.750 |....................*********************|         1.500
2.700 |....................*********************|         1.500
2.650 |...................**********************|         1.450
2.600 |...................**********************|         1.450
2.550 |..................***********************|         1.400
2.500 |..................***********************|         1.400
2.450 |.................************************|         1.350
2.400 |.................************************|         1.350
2.350 |................*************************|         1.300
2.300 |................*************************|         1.300
2.250 |...............**************************|         1.250
2.200 |..............***************************|         1.200
2.150 |..............***************************|         1.200
2.100 |.............****************************|         1.150
2.050 |.............****************************|         1.150
2.000 |............*****************************|         1.100
1.950 |............*****************************|         1.100
1.900 |...........******************************|         1.050
1.850 |...........******************************|         1.050
1.800 |..........*******************************|         1.000
1.750 |..........*******************************|         1.000
1.700 |..........*******************************|         1.000
1.650 |.........********************************|         0.950
      |+----;----+----;----+----;----+----;----+|
       0.500     1.000     1.500     2.000     2.500
```

### $V_{IH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
       0.500     1.000     1.500     2.000     2.500        first pass data
      |+----;----+----;----+----;----+----;----+|
3.000 |.......................******************|         1.650
2.950 |.......................******************|         1.650
2.900 |......................*******************|         1.600
2.850 |......................*******************|         1.600
2.800 |.....................********************|         1.550
2.750 |....................*********************|         1.500
2.700 |....................*********************|         1.500
2.650 |...................**********************|         1.450
2.600 |...................**********************|         1.450
2.550 |..................***********************|         1.400
2.500 |..................***********************|         1.400
2.450 |.................************************|         1.350
2.400 |.................************************|         1.350
2.350 |................*************************|         1.300
2.300 |................*************************|         1.300
2.250 |...............**************************|         1.250
2.200 |...............**************************|         1.250
2.150 |..............***************************|         1.200
2.100 |.............****************************|         1.150
2.050 |.............****************************|         1.150
2.000 |............*****************************|         1.100
1.950 |............*****************************|         1.100
1.900 |...........******************************|         1.050
1.850 |...........******************************|         1.050
1.800 |..........*******************************|         1.000
1.750 |.........********************************|         0.950
1.700 |.........********************************|         0.950
1.650 |.........********************************|         0.950
      |+----;----+----;----+----;----+----;----+|
       0.500     1.000     1.500     2.000     2.500
```

## $V_{IL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
         0.000     0.500     1.000     1.500     2.000      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |***************************..............|          1.300
  2.950 |***************************..............|          1.300
  2.900 |***************************..............|          1.300
  2.850 |**************************...............|          1.250
  2.800 |**************************...............|          1.250
  2.750 |**************************...............|          1.250
  2.700 |*************************................|          1.200
  2.650 |*************************................|          1.200
  2.600 |*************************................|          1.200
  2.550 |************************.................|          1.150
  2.500 |************************.................|          1.150
  2.450 |***********************..................|          1.100
  2.400 |***********************..................|          1.100
  2.350 |***********************..................|          1.100
  2.300 |**********************...................|          1.050
  2.250 |**********************...................|          1.050
  2.200 |*********************....................|          1.000
  2.150 |*********************....................|          1.000
  2.100 |*********************....................|          1.000
  2.050 |********************.....................|          0.950
  2.000 |********************.....................|          0.950
  1.950 |*******************......................|          0.900
  1.900 |*******************......................|          0.900
  1.850 |*******************......................|          0.900
  1.800 |*******************......................|          0.900
  1.750 |******************.......................|          0.850
  1.700 |******************.......................|          0.850
  1.650 |*****************........................|          0.800
        |+----;----+----;----+----;----+----;----+|
         0.000     0.500     1.000     1.500     2.000
```

## $V_{IL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
         0.000     0.500     1.000     1.500     2.000      first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |***************************..............|          1.300
  2.950 |***************************..............|          1.300
  2.900 |**************************...............|          1.250
  2.850 |**************************...............|          1.250
  2.800 |**************************...............|          1.250
  2.750 |*************************................|          1.200
  2.700 |*************************................|          1.200
  2.650 |*************************................|          1.200
  2.600 |************************.................|          1.150
  2.550 |************************.................|          1.150
  2.500 |************************.................|          1.150
  2.450 |***********************..................|          1.100
  2.400 |***********************..................|          1.100
  2.350 |**********************...................|          1.050
  2.300 |**********************...................|          1.050
  2.250 |**********************...................|          1.050
  2.200 |*********************....................|          1.000
  2.150 |*********************....................|          1.000
  2.100 |********************.....................|          0.950
  2.050 |********************.....................|          0.950
  2.000 |********************.....................|          0.950
  1.950 |*******************......................|          0.900
  1.900 |*******************......................|          0.900
  1.850 |*******************......................|          0.900
  1.800 |*******************......................|          0.900
  1.750 |******************.......................|          0.850
  1.700 |******************.......................|          0.850
  1.650 |*****************........................|          0.800
        |+----;----+----;----+----;----+----;----+|
         0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
        0.000     0.500     1.000     1.500     2.000      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |**************************...............|          1.300
 2.950 |**************************...............|          1.300
 2.900 |*************************................|          1.250
 2.850 |*************************................|          1.250
 2.800 |*************************................|          1.250
 2.750 |************************.................|          1.200
 2.700 |************************.................|          1.200
 2.650 |***********************..................|          1.150
 2.600 |***********************..................|          1.150
 2.550 |***********************..................|          1.150
 2.500 |**********************...................|          1.100
 2.450 |**********************...................|          1.100
 2.400 |**********************...................|          1.100
 2.350 |*********************....................|          1.050
 2.300 |*********************....................|          1.050
 2.250 |********************.....................|          1.000
 2.200 |********************.....................|          1.000
 2.150 |********************.....................|          1.000
 2.100 |*******************......................|          0.950
 2.050 |*******************......................|          0.950
 2.000 |*******************......................|          0.950
 1.950 |******************.......................|          0.900
 1.900 |******************.......................|          0.900
 1.850 |******************.......................|          0.900
 1.800 |*****************........................|          0.850
 1.750 |*****************........................|          0.850
 1.700 |****************.........................|          0.800
 1.650 |****************.........................|          0.800
       |+----;----+----;----+----;----+----;----+|
        0.000     0.500     1.000     1.500     2.000
```

### $V_{IL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
        0.000     0.500     1.000     1.500     2.000      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |***************************..............|          1.350
 2.950 |***************************..............|          1.350
 2.900 |**************************...............|          1.300
 2.850 |**************************...............|          1.300
 2.800 |**************************...............|          1.300
 2.750 |*************************................|          1.250
 2.700 |*************************................|          1.250
 2.650 |*************************................|          1.250
 2.600 |************************.................|          1.200
 2.550 |************************.................|          1.200
 2.500 |***********************..................|          1.150
 2.450 |***********************..................|          1.150
 2.400 |***********************..................|          1.150
 2.350 |**********************...................|          1.100
 2.300 |**********************...................|          1.100
 2.250 |*********************....................|          1.050
 2.200 |*********************....................|          1.050
 2.150 |*********************....................|          1.050
 2.100 |********************.....................|          1.000
 2.050 |********************.....................|          1.000
 2.000 |*******************......................|          0.950
 1.950 |*******************......................|          0.950
 1.900 |*******************......................|          0.950
 1.850 |******************.......................|          0.900
 1.800 |******************.......................|          0.900
 1.750 |*****************........................|          0.850
 1.700 |*****************........................|          0.850
 1.650 |*****************........................|          0.850
       |+----;----+----;----+----;----+----;----+|
        0.000     0.500     1.000     1.500     2.000
```

## $V_{OH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
        1.500     2.000     2.500     3.000     3.500      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |******************************...........|         2.950
 2.950 |*****************************............|         2.900
 2.900 |****************************.............|         2.850
 2.850 |***************************..............|         2.800
 2.800 |**************************...............|         2.750
 2.750 |*************************................|         2.700
 2.700 |************************.................|         2.650
 2.650 |***********************..................|         2.600
 2.600 |**********************...................|         2.550
 2.550 |*********************....................|         2.500
 2.500 |********************.....................|         2.450
 2.450 |*******************......................|         2.400
 2.400 |******************.......................|         2.350
 2.350 |*****************........................|         2.300
 2.300 |****************.........................|         2.250
 2.250 |***************..........................|         2.200
 2.200 |**************...........................|         2.150
 2.150 |*************............................|         2.100
 2.100 |************.............................|         2.050
 2.050 |***********..............................|         2.000
 2.000 |**********...............................|         1.950
 1.950 |*********................................|         1.900
 1.900 |********.................................|         1.850
 1.850 |*******..................................|         1.800
 1.800 |******...................................|         1.750
 1.750 |*****....................................|         1.700
 1.700 |****.....................................|         1.650
 1.650 |***......................................|         1.600
       |+----;----+----;----+----;----+----;----+|
        1.500     2.000     2.500     3.000     3.500
```

## $V_{OH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
        1.500     2.000     2.500     3.000     3.500      first pass data
       |+----;----+----;----+----;----+----;----+|
 3.000 |******************************...........|         2.950
 2.950 |*****************************............|         2.900
 2.900 |****************************.............|         2.850
 2.850 |***************************..............|         2.800
 2.800 |**************************...............|         2.750
 2.750 |*************************................|         2.700
 2.700 |************************.................|         2.650
 2.650 |***********************..................|         2.600
 2.600 |**********************...................|         2.550
 2.550 |*********************....................|         2.500
 2.500 |********************.....................|         2.450
 2.450 |*******************......................|         2.400
 2.400 |******************.......................|         2.350
 2.350 |*****************........................|         2.300
 2.300 |****************.........................|         2.250
 2.250 |***************..........................|         2.200
 2.200 |**************...........................|         2.150
 2.150 |*************............................|         2.100
 2.100 |************.............................|         2.050
 2.050 |***********..............................|         2.000
 2.000 |**********...............................|         1.950
 1.950 |*********................................|         1.900
 1.900 |********.................................|         1.850
 1.850 |*******..................................|         1.800
 1.800 |******...................................|         1.750
 1.750 |*****....................................|         1.700
 1.700 |****.....................................|         1.650
 1.650 |***......................................|         1.600
       |+----;----+----;----+----;----+----;----+|
        1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
         1.500     2.000     2.500     3.000     3.500       first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |******************************...........|       2.950
  2.950 |*****************************............|       2.900
  2.900 |****************************.............|       2.850
  2.850 |***************************..............|       2.800
  2.800 |**************************...............|       2.750
  2.750 |*************************................|       2.700
  2.700 |************************.................|       2.650
  2.650 |***********************..................|       2.600
  2.600 |**********************...................|       2.550
  2.550 |*********************....................|       2.500
  2.500 |********************.....................|       2.450
  2.450 |*******************......................|       2.400
  2.400 |******************.......................|       2.350
  2.350 |*****************........................|       2.300
  2.300 |****************.........................|       2.250
  2.250 |***************..........................|       2.200
  2.200 |**************...........................|       2.150
  2.150 |*************............................|       2.100
  2.100 |************.............................|       2.050
  2.050 |***********..............................|       2.000
  2.000 |**********...............................|       1.950
  1.950 |*********................................|       1.900
  1.900 |********.................................|       1.850
  1.850 |*******..................................|       1.800
  1.800 |******...................................|       1.750
  1.750 |*****....................................|       1.700
  1.700 |****.....................................|       1.650
  1.650 |***......................................|       1.600
        |+----;----+----;----+----;----+----;----+|
         1.500     2.000     2.500     3.000     3.500
```

### $V_{OH}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
         1.500     2.000     2.500     3.000     3.500       first pass data
        |+----;----+----;----+----;----+----;----+|
  3.000 |******************************...........|       2.950
  2.950 |*****************************............|       2.900
  2.900 |****************************.............|       2.850
  2.850 |***************************..............|       2.800
  2.800 |**************************...............|       2.750
  2.750 |*************************................|       2.700
  2.700 |************************.................|       2.650
  2.650 |***********************..................|       2.600
  2.600 |**********************...................|       2.550
  2.550 |*********************....................|       2.500
  2.500 |********************.....................|       2.450
  2.450 |*******************......................|       2.400
  2.400 |******************.......................|       2.350
  2.350 |*****************........................|       2.300
  2.300 |****************.........................|       2.250
  2.250 |***************..........................|       2.200
  2.200 |**************...........................|       2.150
  2.150 |*************............................|       2.100
  2.100 |************.............................|       2.050
  2.050 |***********..............................|       2.000
  2.000 |**********...............................|       1.950
  1.950 |*********................................|       1.900
  1.900 |********.................................|       1.850
  1.850 |*******..................................|       1.800
  1.800 |******...................................|       1.750
  1.750 |*****....................................|       1.700
  1.700 |****.....................................|       1.650
  1.650 |***......................................|       1.600
        |+----;----+----;----+----;----+----;----+|
         1.500     2.000     2.500     3.000     3.500
```

### $V_{OL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 25°C

```
          0.000     0.500     1.000      first pass data
         |+----;----+----;----+|
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
   2.600 |.********************|          0.050
   2.550 |.********************|          0.050
   2.500 |.********************|          0.050
   2.450 |.********************|          0.050
   2.400 |.********************|          0.050
   2.350 |.********************|          0.050
   2.300 |.********************|          0.050
   2.250 |.********************|          0.050
   2.200 |.********************|          0.050
   2.150 |.********************|          0.050
   2.100 |.********************|          0.050
   2.050 |.********************|          0.050
   2.000 |.********************|          0.050
   1.950 |.********************|          0.050
   1.900 |.********************|          0.050
   1.850 |.********************|          0.050
   1.800 |.********************|          0.050
   1.750 |.********************|          0.050
   1.700 |.********************|          0.050
   1.650 |.********************|          0.050
         |+----;----+----;----+|
          0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 85°C

```
          0.000     0.500     1.000      first pass data
         |+----;----+----;----+|
   3.000 |.********************|          0.050
   2.950 |.********************|          0.050
   2.900 |.********************|          0.050
   2.850 |.********************|          0.050
   2.800 |.********************|          0.050
   2.750 |.********************|          0.050
   2.700 |.********************|          0.050
   2.650 |.********************|          0.050
   2.600 |.********************|          0.050
   2.550 |.********************|          0.050
   2.500 |.********************|          0.050
   2.450 |.********************|          0.050
   2.400 |.********************|          0.050
   2.350 |.********************|          0.050
   2.300 |.********************|          0.050
   2.250 |.********************|          0.050
   2.200 |.********************|          0.050
   2.150 |.********************|          0.050
   2.100 |.********************|          0.050
   2.050 |.********************|          0.050
   2.000 |.********************|          0.050
   1.950 |.********************|          0.050
   1.900 |.********************|          0.050
   1.850 |.********************|          0.050
   1.800 |.********************|          0.050
   1.750 |.********************|          0.050
   1.700 |.********************|          0.050
   1.650 |.********************|          0.050
         |+----;----+----;----+|
          0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ 105°C

```
         0.000     0.500     1.000      first pass data
        |+----;----+----;----+|
   3.000 |.*******************|          0.050
   2.950 |.*******************|          0.050
   2.900 |.*******************|          0.050
   2.850 |.*******************|          0.050
   2.800 |.*******************|          0.050
   2.750 |.*******************|          0.050
   2.700 |.*******************|          0.050
   2.650 |.*******************|          0.050
   2.600 |.*******************|          0.050
   2.550 |.*******************|          0.050
   2.500 |.*******************|          0.050
   2.450 |.*******************|          0.050
   2.400 |.*******************|          0.050
   2.350 |.*******************|          0.050
   2.300 |.*******************|          0.050
   2.250 |.*******************|          0.050
   2.200 |.*******************|          0.050
   2.150 |.*******************|          0.050
   2.100 |.*******************|          0.050
   2.050 |.*******************|          0.050
   2.000 |.*******************|          0.050
   1.950 |.*******************|          0.050
   1.900 |.*******************|          0.050
   1.850 |.*******************|          0.050
   1.800 |.*******************|          0.050
   1.750 |.*******************|          0.050
   1.700 |.*******************|          0.050
   1.650 |.*******************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

### $V_{OL}$ vs. $V_{IO}$ ($V_{CC}$ = 3V) @ -40°C

```
         0.000     0.500     1.000      first pass data
        |+----;----+----;----+|
   3.000 |.*******************|          0.050
   2.950 |.*******************|          0.050
   2.900 |.*******************|          0.050
   2.850 |.*******************|          0.050
   2.800 |.*******************|          0.050
   2.750 |.*******************|          0.050
   2.700 |.*******************|          0.050
   2.650 |.*******************|          0.050
   2.600 |.*******************|          0.050
   2.550 |.*******************|          0.050
   2.500 |.*******************|          0.050
   2.450 |.*******************|          0.050
   2.400 |.*******************|          0.050
   2.350 |.*******************|          0.050
   2.300 |.*******************|          0.050
   2.250 |.*******************|          0.050
   2.200 |.*******************|          0.050
   2.150 |.*******************|          0.050
   2.100 |.*******************|          0.050
   2.050 |.*******************|          0.050
   2.000 |.*******************|          0.050
   1.950 |.*******************|          0.050
   1.900 |.*******************|          0.050
   1.850 |.*******************|          0.050
   1.800 |.*******************|          0.050
   1.750 |.*******************|          0.050
   1.700 |.*******************|          0.050
   1.650 |.*******************|          0.050
        |+----;----+----;----+|
         0.000     0.500     1.000
```

# 17. Revision History

| Document Title: S29GL128S (XMC 85C 105C) Qualification Database<br>Document Number: 002-21356 | | | | |
|---|---|---|---|---|
| **Revision** | **ECN** | **Orig. of Change** | **Submission Date** | **Description of Change** |
| ** | – | – | 03/31/2013 | Initial release. |
| *A | 5896366 | NFB | 09/26/2017 | Updated to Cypress template. |
| *B | 6650400 | CNSO | 08/09/2019 | Updated Document Title to read as “S29GL128S (XMC 85C 105C) Qualification Database”.<br>Added “Introduction”.<br>Added “Die Photograph”.<br>Added “Pad Definition Table”.<br>Added “Physical Sector Layout”.<br>Added “Sector Enlargement”.<br>Added “Die Processing Summary”.<br>Updated Product Information:<br>Updated LAE064:<br>Updated details under “Theta Ja” and “Psi Jt”.<br>Updated LAA064:<br>Updated details under “Theta Ja” and “Psi Jt”.<br>Updated VBU056:<br>Updated details under “Product Description”, “Theta Ja”, “Psi Jt”, “Die”, “Die Size” and “Density”.<br>Updated TS056:<br>Updated details under “Theta Ja” and “Psi Jt”.<br>Added “Assembly Bonding Diagram”.<br>Added “Test Methodology”.<br>Added “Generalized Test Flow”.<br>Updated Quality and Reliability Data:<br>Added “S29GL128S High Temperature Operating Life Test Configuration”.<br>Added “Characterization Test Results”.<br>Added “DC Device Characterization Data”.<br>Added “AC Device Characterization Data”.<br>Added “Shmoo Plots”.<br>Updated to new template. |

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| P770020C-F5C000 | S29GL01GS11DHB020-002 | 2-4 weeks lead time |

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| S29GL01GS10TFA023 | S29GL01GS10TFA020-002 | 2-4 weeks lead time |
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| S29GL128S10TFB023 | S29GL128S10TFB020-002 | 2-4 weeks lead time |
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| S29GL512S11DHA010 | S29GL512S11DHA010-002 | 2-4 weeks lead time |
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| S29GL512S11DHA020 | S29GL512S11DHA020-002 | 2-4 weeks lead time |
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| TN949587-9970 | S29GL256S90TFA010-002 | 2-4 weeks lead time |
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