JP129
Industrial Ether Connectable IoT Sensor Hub

August 2020

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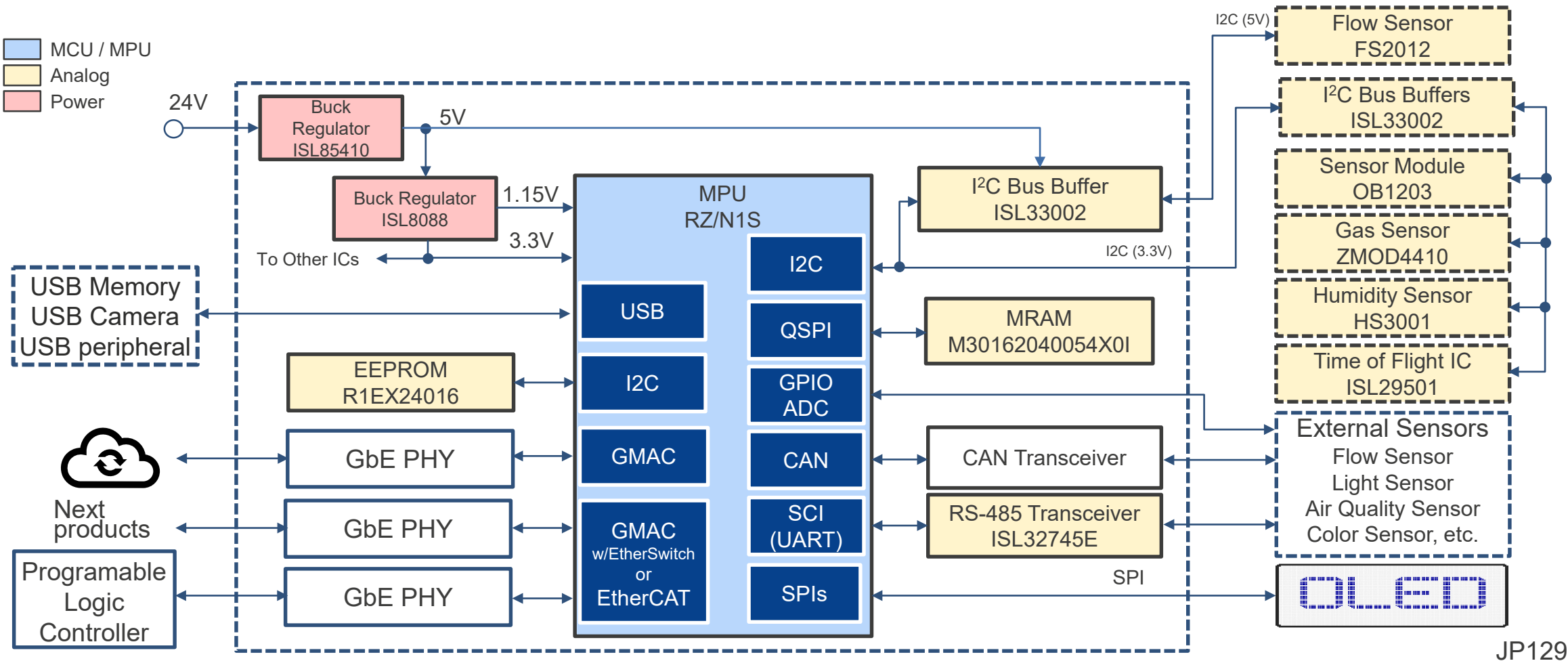# Industrial Ether Connectable IoT Sensor Hub

- **Overview**

  This reference design features an easy-to-build industrial ether connectable sensor hub solution that utilizes Renesas' RZ/N1S microprocessor (MPU), power products and sensors. The solution can collect data from sensors connected to the RZ/N1S MPU and send it to a programmable logic controller (PLC) and/or controllers, which comply with specific industrial ether protocols.

- **System Benefits**

  – Send data to a PLC and/or controllers, complying with industrial ether protocols: EtherCAT, Ethernet/IP, PROFINET, Modbus-TCP, and OPC UA are all applicable for the solution, as well as IO-Link

  – Sensors can be connected by several interfaces, such as CAN, RS-485 and I^2C

  – The RZ/N1S MPU has dual CPU cores: Arm® Cortex®-A7 and Arm® Cortex®-M3, so it can implement communication software on the Arm® Cortex®-M3 core and application software on Arm® Cortex®-A7 core separately

  – The RZ/N1S MPU has features that help reduce bill-of-materials (BOM) and the size of the PCB

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Device Category	Orderable P/N	Key Features
MPU	RZ/N1S	Industrial Ethernet MPU. Arm® Cortex®-A7 + Cortex®-M3 core.
Power	ISL85410	1A synchronous buck with integrated FETs. Supports 3V-40V input voltage range for buck output.
	ISL8088	Dual 800mA low Iq synchronous buck regulator. Test & measurement, Li-Ion battery power devices, μC/μP, FPGA and DSP Power.
Analog	R1EX24016	16KB industry-grade EEPROM. I^2C interface series EEPROM for industrial segment.
	ISL33002	I^2C bus buffer / level shifter. I^2C bus buffer with rise time accelerators & hot swap capability.
	M3016204	Non-volatile 16Mb high-performance MRAM, 3.0V
	ISL32745E	6kV VDE-reinforced isolated 40Mbps full-duplex RS-485 transceiver
	FS2012	High performance flow sensor module. Applications for process controls, oil and gas leak detection, CPAP and respirator devices
	OB1203	All-in-one bio and light sensor. Fully integrated clinical-grade calibrated module.
	ZMOD4410	Indoor Air Quality sensor platform. TVOC sensor for Indoor Air Quality applications.
	HS3001	Relative humidity and temperature sensor. High accuracy humidity and temperature measurement for environmental monitoring.
	ISL29501	Time of Flight (ToF) signal processing IC. Low cost, low power, and long range optical distance sensing.

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RZ/N1S Industrial Ethernet MPU

Arm® Cortex®-A7 + Cortex®-M3

500 MHz Cortex®-A7 + R-IN Engine 125 MHz Cortex®-M3
- Proven R-IN engine as HW accelerator for Industrial Ethernet communication
- Internal oscillator for 40MHz crystal, i.e. no external clock required

6MB SRAM Integrated
- Additional RAM can be attached by QSPI, but in many cases not needed

Integrated up to 5 Port Ethernet Switches

External Storage Interface
- 2x QSPI, 2x SDIO/eMMC
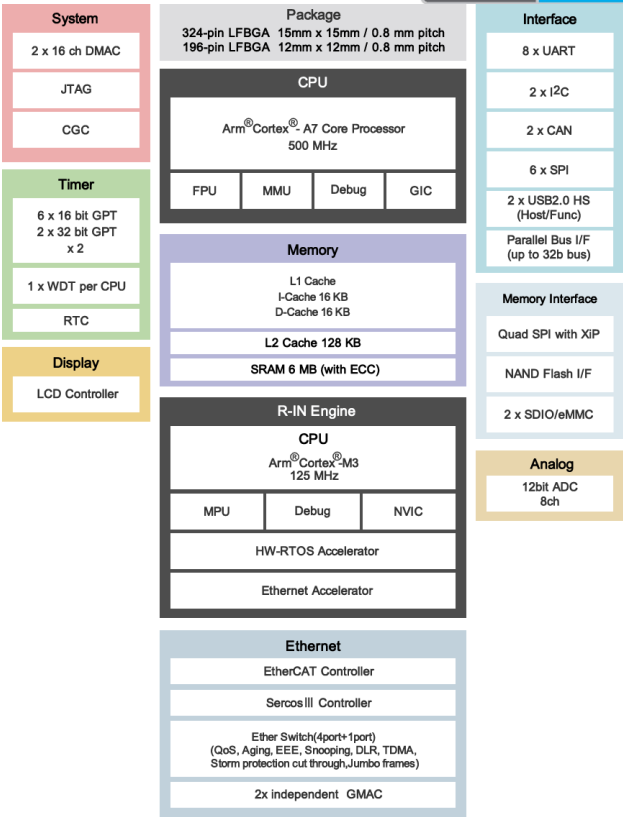- Several storage devices can be chosen based on application requests

LCD Controller, Multiple Timers, RTC

Rich Interfaces
- Up to 2x USB2.0, 2x CAN, 8x UART, 6x SPI etc.

Temperature range -40..+110°C

P/N	Package	PRP IEC62439-3
R9A06G033VGBA	196BGA	--
R9A06G033NGBG	324BGA	PRP compliant

System
- 2 x 16 ch DMAC
- JTAG
- CGC

Timer
- 6 x 16 bit GPT
- 2 x 32 bit GPT x 2
- 1 x WDT per CPU
- RTC

Display
- LCD Controller

Package
- 324-pin LFBGA 15mm x 15mm / 0.8 mm pitch
- 196-pin LFBGA 12mm x 12mm / 0.8 mm pitch

CPU
- Arm® Cortex®-A7 Core Processor 500 MHz
- FPU | MMU | Debug | GIC

Memory
- L1 Cache I-Cache 16 KB D-Cache 16 KB
- L2 Cache 128 KB
- SRAM 6 MB (with ECC)

R-IN Engine
- CPU Arm® Cortex®-M3 125 MHz
- MPU | Debug | NVIC
- HW-RTOS Accelerator
- Ethernet Accelerator

Ethernet
- EtherCAT Controller
- Sercos III Controller
- Ether Switch(4port+1port) (QoS, Aging, EEE, Snooping, DLR, TDMA, Storm protection cut through, Jumbo frames)
- 2x independent GMAC

Interface
- 8 x UART
- 2 x I2C
- 2 x CAN
- 6 x SPI
- 2 x USB2.0 HS (Host/Func)
- Parallel Bus I/F (up to 32b bus)

Memory Interface
- Quad SPI with XiP
- NAND Flash I/F
- 2 x SDIO/eMMC

Analog
- 12bit ADC 8ch

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WINNING COMBOS

ISL85410 – 1A Synchronous Buck with Integrated FETs
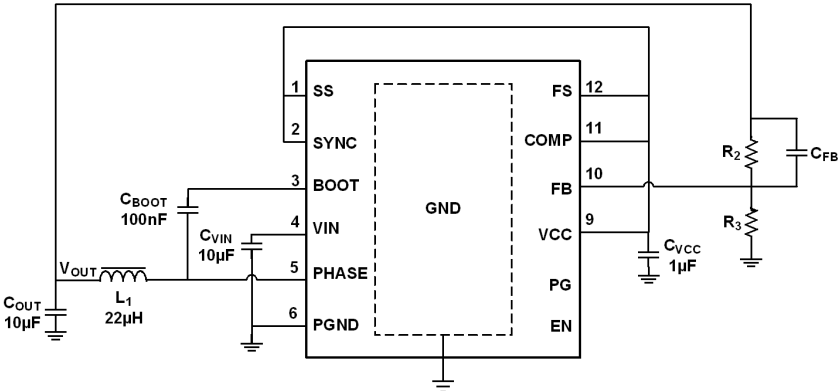## Supports 3V-40V Input Voltage Range for Buck Output

Wide Working Range and Space-Limited Applications

- Power input voltage range from 3V to 40V
- Up to 1A load over full temperature range
- 4mm x 3mm DFN package
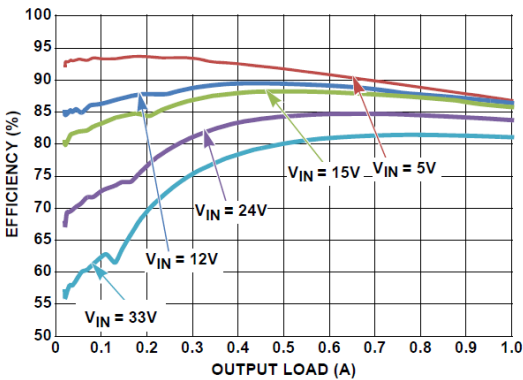- Minimal external components required

High Efficiency and Performance

- Synchronous operation for high efficiency
- No compensation required
- Integrated High-side and Low-side NMOS devices
- Selectable PFM or forced PWM mode at light loads
- Internal fixed (500kHz) or adjustable switching frequency 300kHz to 2MHz

Typical Application Circuit

Efficiency vs Load, PFM, V_{OUT} = 3.3V

ISL8541xDEMO1Z Evaluation Board

Part #	V_{IN} Range(V)	Temp.(℃)	Package
ISL85410FRZ	3 to 40	-40 to 125	12 Ld DFN 4x3

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ISL8088 - Dual 800mA Low Iq Synchronous Buck Regulator
Test & Measurement, Li-ion Battery-Powered Devices, µC/µP, FPGA and DSP power

High Performance

- Dual 800mA outputs
- 100% Maximum duty cycle for lowest dropout
- Selectable forced PWM mode or PFM mode
- Supply voltage range of 2.75V to 5.5V

High Efficiency in a Small Package

- Up to 97% efficiency
- In PFM mode of operation, both channels draw a total quiescent current of only 30µA in order to maximize battery life
- Small 3x3mm DFN package

Typical Application Circuit
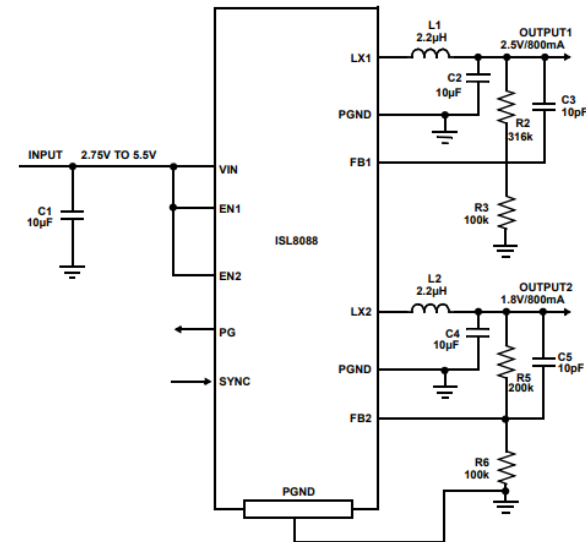
ISL8088EVALxZ Eval Board

Part #	T&R count	Package
ISL8088IRZ-T7A	250	10Ld 3 x 3mm DFN
ISL8088IRZ	1000	10Ld 3 x 3mm DFN

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R1EX24016ASAS0I – 16KB Industry Grade EEPROM

I²C Interface Series EEPROM for Industrial Segment

High Speed Memory

- Clock frequency: 400 kHz (1.8 V to 5.5 V)
- Automatic page write: 16-byte/page
- Write cycle time: 5 ms

Robust Industry Grade

- Endurance: 1,000k or more Cycles@25°C
- Data retention: 100 or more Years@25°C

Low Power Mode

- Power dissipation:
  - Standby: 2.0 µA (max)
  - Active (Read): 1.0 mA (max)
  - Active (Write): 3.0 mA (max)

8-pin SOP/8-pin TSSOP

(Top view)

Pin assignment

Part #	Reel	Lead Free	Halogen Free	Package
R1EX24016ATAS0I	3,000	#U0, #S0	#S0	8 Ld TSSOP
R1EX24016ASAS0I	2,500	#U0, #S0	#S0	8 Ld SOP

Block Diagram

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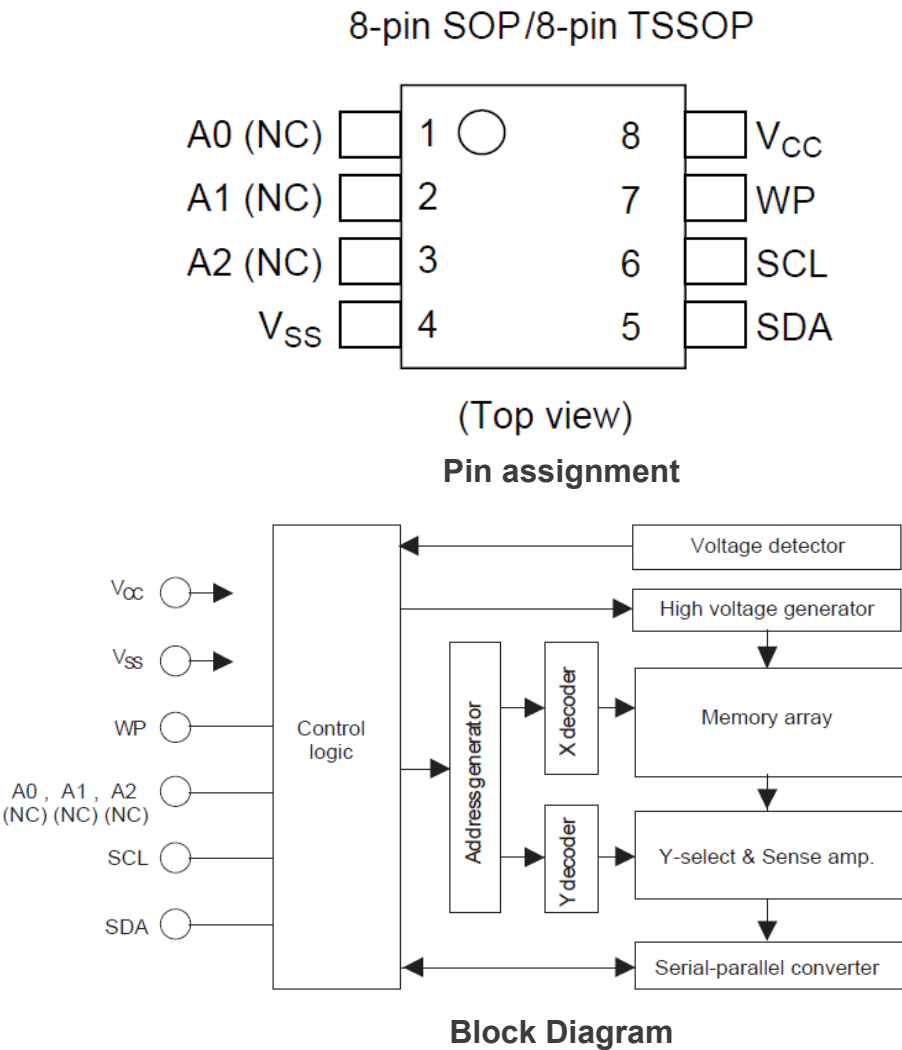
ISL33001/2/3 – I²C Bus Buffer / Level Shifter

I²C Bus Buffer with Rise Time Accelerators & Hot Swap Capability

Applications

- I²C bus extender and capacitance buffering
- Server racks for telecom, datacom, and computer servers
- Desktop computers
- Hot-swap board insertion and bus isolation

Features

- 2 Channel I²C compatible bi-directional buffer
- +2.3VDC to +5.5VDC supply range, >400kHz operation
- Bus capacitance buffering / Rise time accelerators
- Hot swapping capability
- ±6kV Class 3 HBM ESD protection on all pins
- ±12kV HBM ESD protection on SDA/SCL pins
- Low quiescent current 2.1mA$_{typ}$, low shutdown current 0.5µA$_{typ}$

Part Number	Package
ISL33003IRTZ	TDFN8, 0.65mm pitch
ISL33002IRT2Z	TDFN8, 0.5mm pitch
ISL33003IUZ	MSOP8
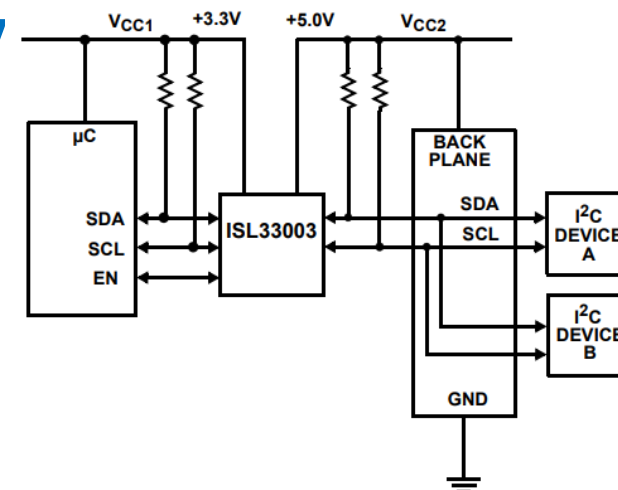
FIGURE 1. TYPICAL OPERATING CIRCUIT

Typical Operating Circuits

ISL33003
(8 LD TDFN)
TOP VIEW

ISL33003
(8 LD MSOP)
TOP VIEW
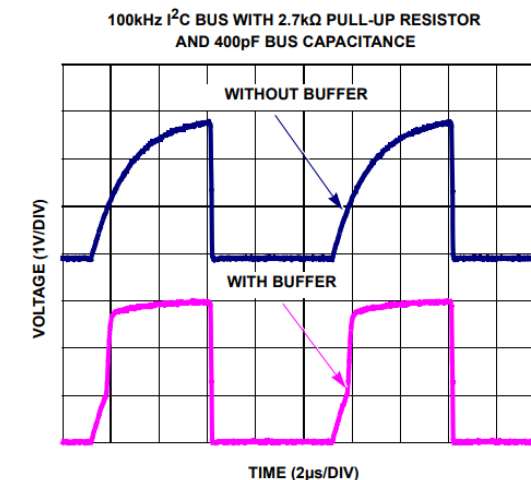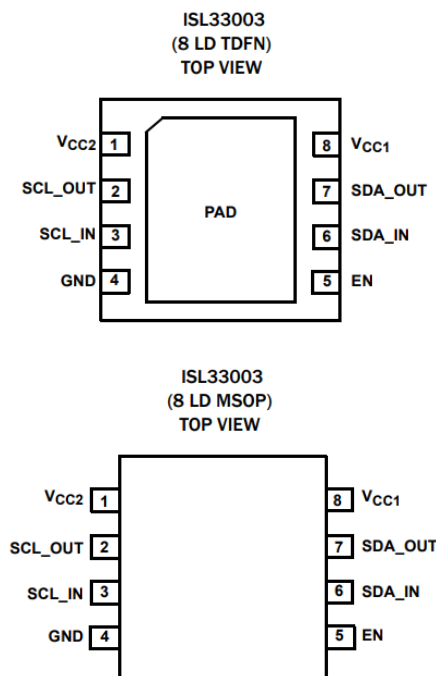
FIGURE 2. BUS ACCELERATOR PERFORMANCE

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M1000/M3000 Series MRAM

High-Speed Non-Volatile Memory for Real-Time Data Storage and Quick Back-Up Data Retrieval

Fast Magnetoresistive Memory Requires no Battery Back-Up

- Read and write speeds up to 108Mhz SDR
- Low active read and write currents
- High memory density from 4Mb to 16Mb

### High Endurance and Data Retention for Long Term Storage

- Endurance for 10E16 write and read cycles
- Long data retention >20 years (at 85C)
- Operating temperatures from -40C to 105C

Widest Range of SPI Interface MRAM products

- Configurable serial interfaces for SPI, DPI, QPI with SDR and DDR modes, supporting 1.71V to 3.6V

Product	Feature	Package
M1016204	Non-Volatile 16Mb MRAM 1.8V	5.2x5.2 8SOIC, 5x6 8DFN
M3016204	Non-Volatile 16Mb MRAM 3.0V	5.2x5.2 8SOIC, 5x6 8DFN
M3016-EVK	Evaluation Board w/16Mb MRAM	

M1000/3000 MRAM Block Diagram
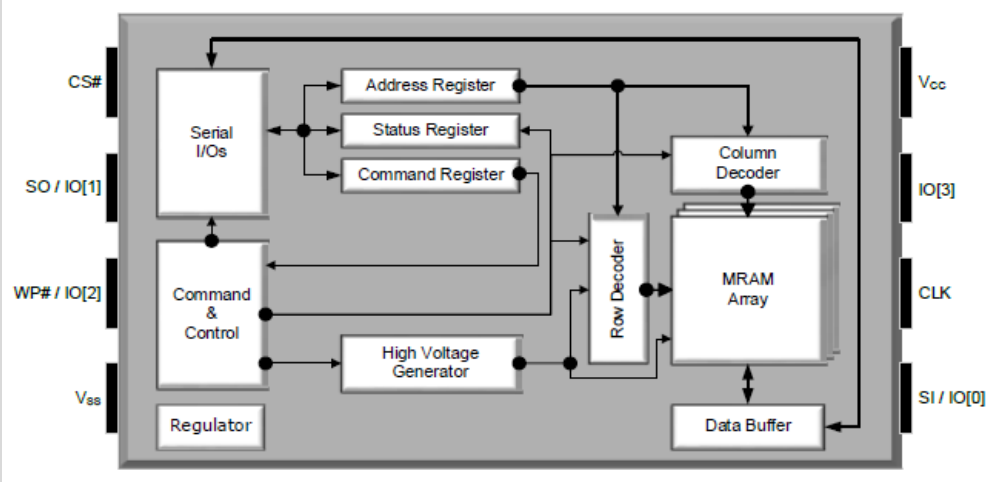
M3016-EVK

- Evaluation board with 16Mbit MRAM, SOIC package
- Arduino with standardized UNO R3 compatible headers

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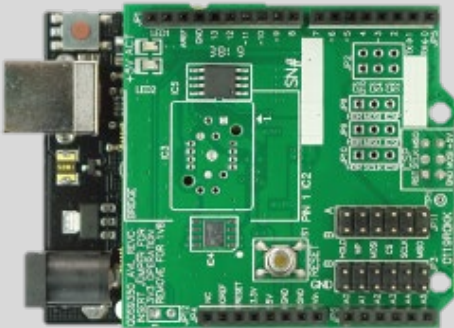
ISL32745E – High Isolation, High-speed RS-485 Transceiver
## Full-Duplex, 40MHz High-Speed, 6kV Isolation Differential Bus Transceiver

High Speed
- 40Mbps data rate

High Performance and Reliability
- Industry leading 6kV$_{RMS}$ fully reinforced isolation with 44,000 year barrier life
- 12.8kV surge immunity and 1,000 volts working voltage
- Emissions satisfies CISPR25, FCC-B and EN55022
- 20ns propagation delay/5ns pulse skew
- 10kV HBM ESD bus-pin protection
- 50kV/µs (typical), 30kV/µs (minimum) common-mode transient immunity
- +3V to +5V Operation

Industry Standard
- UL 1577 recognized
- VDE V0884-10 certified
- Meets or exceeds ANSI RS-485 and ISO 8482:1987(E)
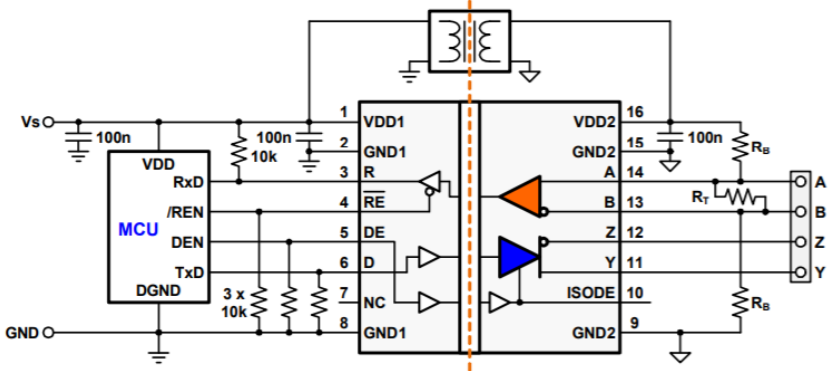
Typical Operating Circuits
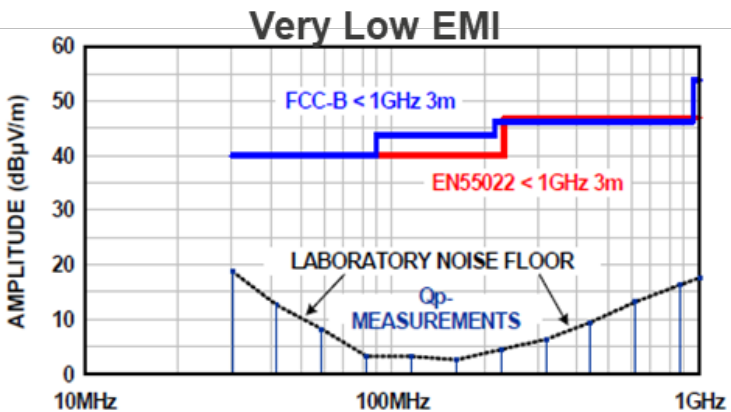
| Part #	HALF/FULL DUPLEX	Temp. Rang	Data Rate Mbps	Isolation Rating	Package
ISL32745EIBZ	Full	-40 to +85	40	6.0kV	16 Ld SOICW
ISL32745EIBZ-T	Full	-40 to +85	40	6.0kV	16 Ld SOICW
ISL32745EIBZ-T7A	Full	-40 to +85	40	6.0kV	16 Ld SOICW

FS2012 – High Performance Flow Sensor Module
Applications for Process Controls, Oil and Gas Leak Detection, CPAP and Respirator Devices

High Accuracy and Fully Calibrated Output

- Accuracy error down to 2% of reading (typical)
- Full calibrated output

High Performance and Easy to Use

- Robust solid isolation technology
- Resistant to surface contamination
- No cavity to cause clogging
- Resistant to vibration and pressure shock
- Support analog output: 0V to 5V, digital output: I^{2}C
- Supply voltage: 5V (Typ)
- Module operating temperature range: 0°C to +85°C
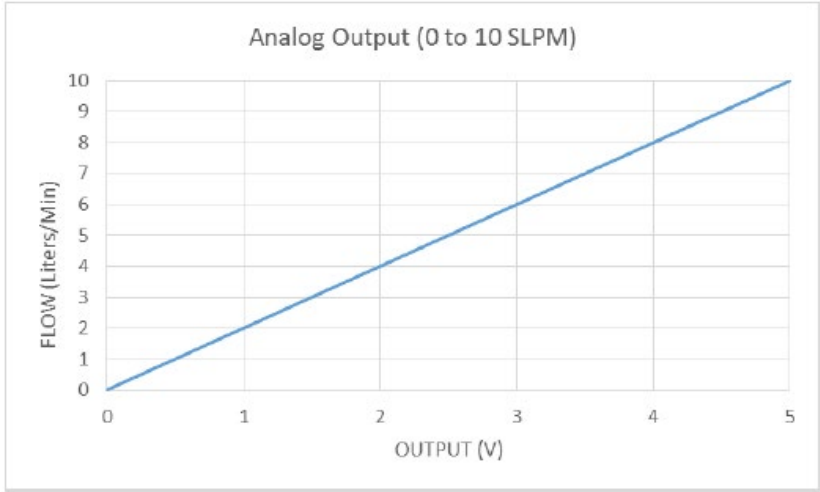
Analog Output Example

Part #	Parameter	Description
FS2012-1020-NG	Gas Flow	0 to 2 SLPM
FS2012-1100-NG	Gas Flow	0 to 10 SLPM
FS2012-1001-LQ	Liquid Flow	0 to 0.5(500) SLPM(SCCM)
FS2012-1002-LQ	Liquid Flow	0 to 1.0(1000) SLPM(SCCM)

SLPM: Standard liter per minute.
SCCM: Standard cubic centimeter per minute.
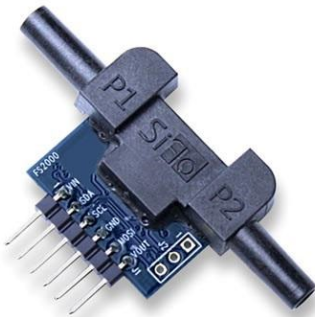
FS2012 Module (front)

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OB1203 All-In-One Bio and Light Sensor

Fully Integrated Clinical-Grade Calibrated Module

Fully Integrated Module

- Color, ambient light, proximity and biosensor in a single module
- No external components needed
- Factory calibrated to clinical grade accuracy

Virtually Invisible

- Sensor works behind IR-ink
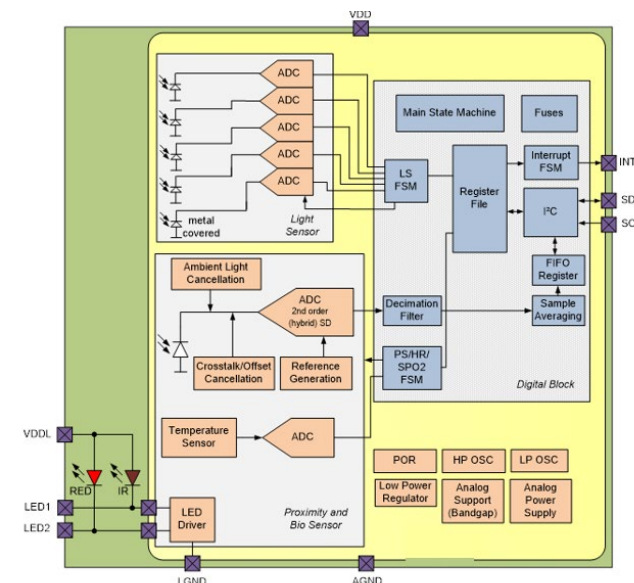- Improved industrial Design

Smallest Form Factor

- Smallest biosensor module – 4.2 x 2 x 1.2mm
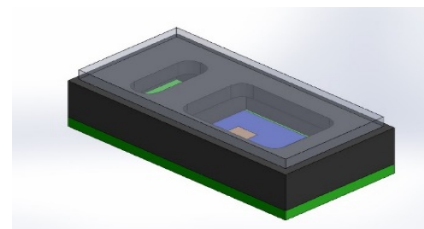- Optimized optical package with low cross talk

Complete Solution

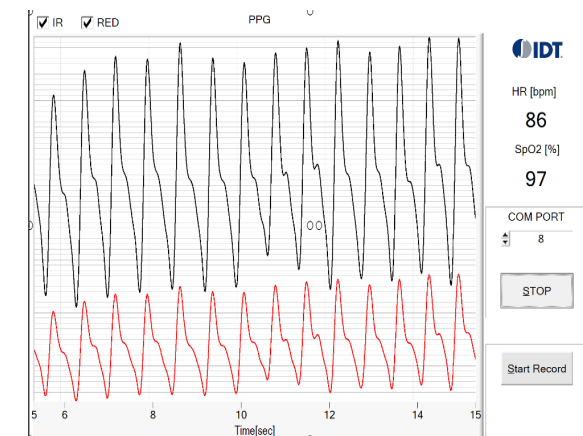- Includes PulsOx algorithm
- Other algorithms can be added

OB1203 block diagram

Package 4.2 x 2 x 1.2mm

Part #	Feature	Package
OB1203SD-C4	All-In-One Biosensor	14 pin 4.2x 2.0x1.2mm

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ZMOD4410 – Indoor Air Quality Sensor Platform
TVOC Sensor for Indoor Air Quality Application

Flexible Measure Target
- Measurement of total organic compounds (TVOC)
- Concentrations and indoor air quality (IAQ)
- Module algorithm estimates carbon dioxide level (eCO$_2$)
- Algorithm to set a control signal to trigger an external action based on IAQ and odor change
- Configurable alarm/interrupt output with static and adaptive Levels

Low Power
- Very low average power consumption down to 1mW
- Excellent for low-voltage and low-power battery applications

Easy to Use
- ZMOD4410 Evaluation Kit
- Manuals, application notes, blog, and white papers
- Instructional videos
- Programming libraries, example codes, and algorithm support to optimize performance
- Third-party certification for compliance with well-accepted international IAQ standards

Part #	Operation Condition	Package
ZMOD4410AI1V ZMOD4410AI1R	1.7-3.6V -40° to +65° Est. CO2 400-5000ppm Ethanol in air 0-1000ppm	3.0 × 3.0 × 0.7mm, 12-LGA
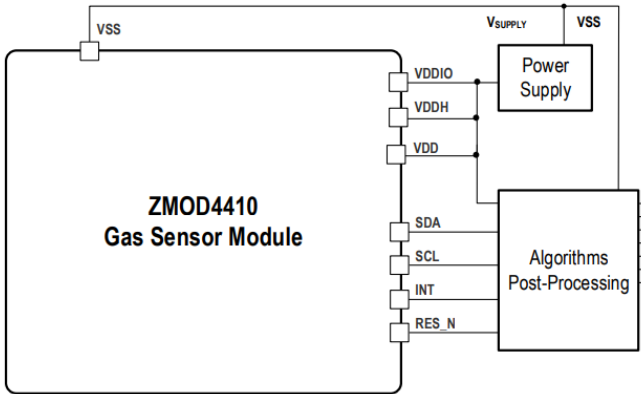
ZMOD4410 typical application
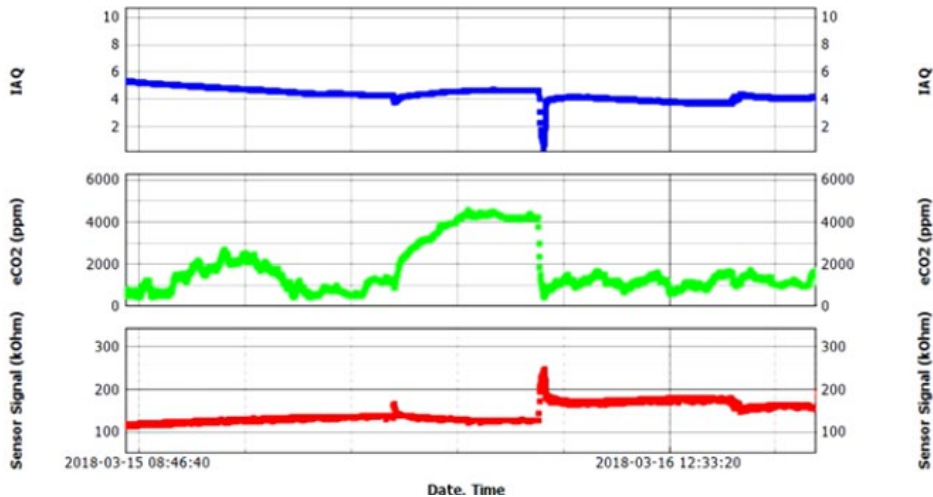
Measuring IAQ and Est CO$_2$ level with ZMOD4410

HS300x – Relative Humidity and Temperature Sensor
High Accuracy Humidity and Temperature Measurement for Environmental Monitoring

High Accuracy
- ±1.5%RH accuracy (HS3001)
- ±0.2°C temperature accuracy (HS3001, HS3002)

Excellent Stability
- 0.1%RH per year drift
- MEMS silicon-carbide sensor technology

Fast Response
- Less than 4 seconds humidity response, in still air
- Less than 2 seconds temperature response

Extended Supply Voltage
- 2.3V to 5.5V, 24.4µA at 3.3V (one RH+Temp per second)
- 1.8V custom order

Part #	Feature	Package
HS3001	±1.5%RH	3×2.41×0.8 LGA
HS3002	±1.8%RH	3×2.41×0.8 LGA
HS3003	±2.8%RH	3×2.41×0.8 LGA
HS3004	±3.8%RH	3×2.41×0.8 LGA

Typical Operating Circuit

R_P = Pull-up resistor (2.2kΩ typical)
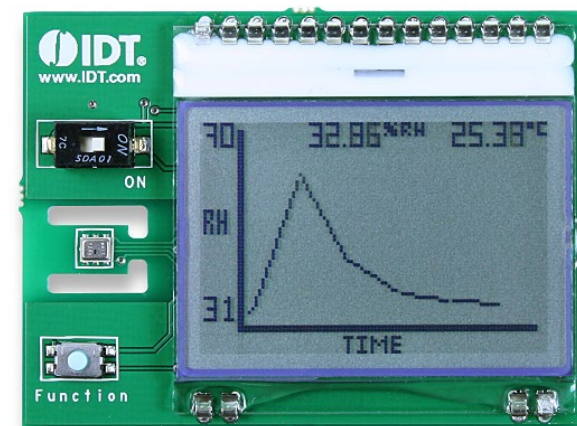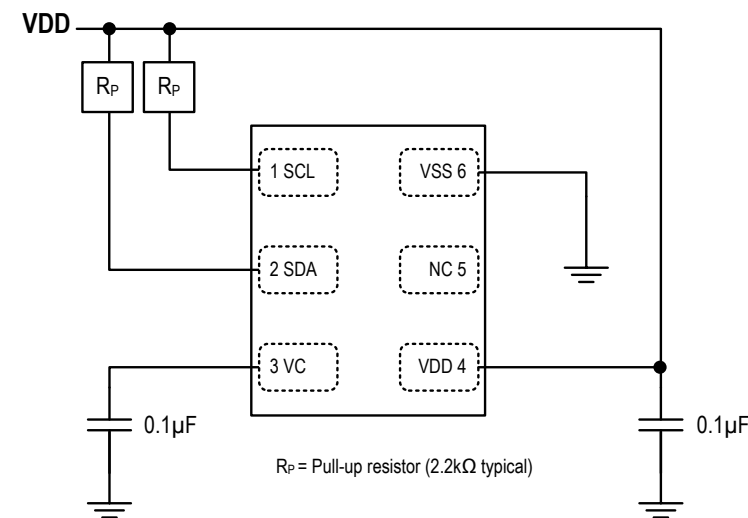
SDAH02 Evaluation Kit

ISL29501-Time of Flight (ToF) Signal Processing IC
Low cost, Low power, and Long Range Optical Distance Sensing
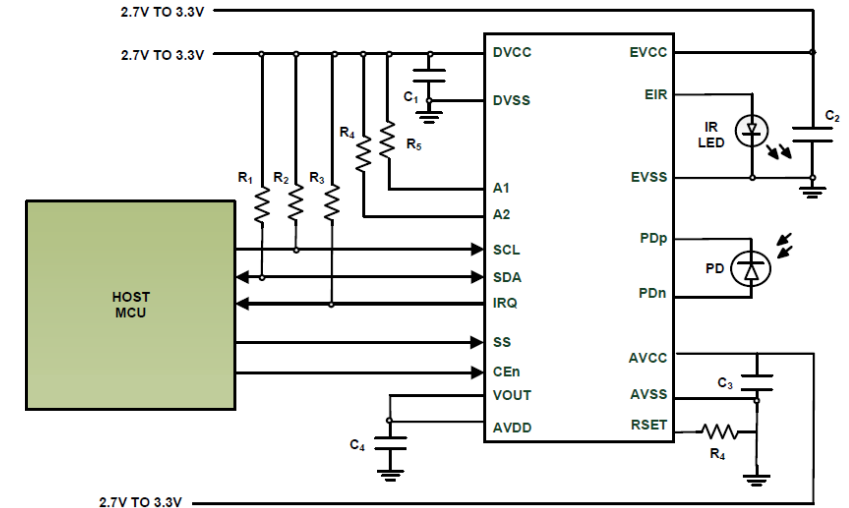
Application-Level Integrated
- On-chip Digital Signal Processor calculates the time of flight
- Built-in current DAC circuit that drives LED or laser
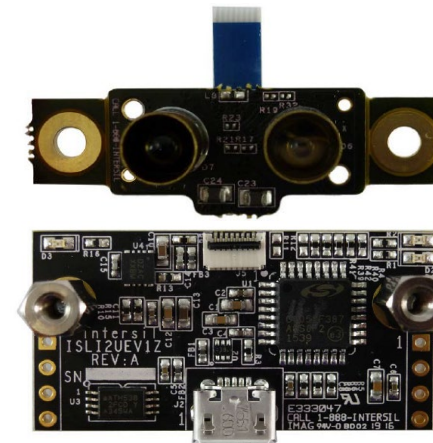- On-chip active ambient light rejection

Easy Control
- I2C interface for configuration and control.
- Operates in Continuous and Single Shot mode
- Auto gain control mechanism
- Interrupt controller
- Modulation frequency of 4.5MHz

Suitable for Different Design
- Enables proximity detection and distance measurement
- allows to optimize for performance/ power/distance, etc
- Wavelength agnostic
- Emitter DAC with programmable current up to 255mA
- I2C interface supporting 1.8V and 3.3V bus
- Low profile 24 Ld 4x5 QFN package

Part #	VDD RANGE (V)	TEMP RANGE (°C)	Package
ISL29501IRZ-T7	2.7V to 3.3V	-40 to +85	24 Ld QFN
ISL29501IRZ-T7A	2.7V to 3.3V	-40 to +85	24 Ld QFN

Typical Application Circuit

ISL29501-CS-EVKIT1Z Cat Shark

ISL29501-ST-EV1Z Sand Tiger

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