EU067 Automatic Plant Watering System

System Overview
This is a reference design for automatic watering systems for large fields of plants and crops. It uses a combination of moisture sensor + bistatic water valve per plant, controlled by a Bluetooth® (BT) mesh network and powered by energy harvesting. The communications system consists of BT low power nodes, BT mesh routers and an optional edge router for IoT connectivity.

System Benefits
- No wiring
- No complex routing setup
- Option for remote visualization / control via IoT connection to LTE-M

Target Applications
- Automatic, adaptive watering for large plots of plants or crops with option for central control or visualization

Device Category | P/N | Orderable P/N | Key Features |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU</td>
<td>RA4W1</td>
<td>RFFA4W1D2CNG</td>
<td>48-MHz ARM® Cortex® M4 Core for BLE 5.0</td>
</tr>
<tr>
<td></td>
<td>RA6M3</td>
<td>RFFA6M2AH5CFC</td>
<td>Ultra-Low Power 120-MHz ARM® Cortex® M4 Core</td>
</tr>
<tr>
<td></td>
<td>RYZ14A</td>
<td>RY2014A00725</td>
<td>LTE-M module</td>
</tr>
<tr>
<td>Power</td>
<td>ISL9111A</td>
<td>ISL9111E8H5Z-T</td>
<td>Low Input Voltage, High Efficiency Synchronous Boost Converter with 1A Switch</td>
</tr>
<tr>
<td></td>
<td>ISL9122A</td>
<td>ISL9122AE8HZ-T</td>
<td>Ultra-Low I2 Buck Regulator with Bypass</td>
</tr>
<tr>
<td></td>
<td>ISL5301</td>
<td>ISL301AE8HZ-T</td>
<td>Li-ion Charger w/ integrated Power Management (single cell)</td>
</tr>
<tr>
<td></td>
<td>ISL97519A</td>
<td>ISL97519X8HZ-T</td>
<td>DC/DC Boost Regulator, 2.3-35V, 2Apk</td>
</tr>
<tr>
<td>Analog</td>
<td>ISL29020</td>
<td>ISL29020H80Z-T</td>
<td>Wide Range Ambient Light Sensor</td>
</tr>
</tbody>
</table>

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RA4W1 – 48-MHZ ARM® CORTEX®- M4 CORE FOR BLE 5.0
BLUE TOOTH® 5.0 LOW ENERGY SINGLE CHIP MCU FOR IOT APPLICATIONS

High Performance
- 48MHz 32-bit Arm® Cortex®-M4 core with FPU
- 512KB Flash, 96KB SRAM and 8KB Data Flash

Full Functionality of Bluetooth 5.0 Low Energy
- 2.4 GHz radio with Bluetooth 5.0 Low Energy
- LE 1M, 2M, Coded PHY, and LE advertising extension
- Secure Crypto Engine (AES128 / 256, GHASH, TRNG)

Highly Integrated Capabilities
- 14-Bit ADC (8 ch.)
- 12-Bit DAC (1 ch.) and temperature sensor
- Low power analog comparator (2 ch.), OPAMP x 1
- USB 2.0 (Full Speed)/CAN/SCI x 4/SPI x 2/IIC x 2
- GPT 32-bit (4 ch.)/GPT 16-bit (3 ch.)/AGT 16-bit (2 ch.)/WDT/RTC

HMI Interface and Small Package
- Capacitive Touch Sensing Unit (11 ch.)
- Segment LCD Controller - up to 9 segments x 4 commons
- 7x7mm QFN 56 pin package

<table>
<thead>
<tr>
<th>Part #</th>
<th>Flash Memory</th>
<th>RAM</th>
<th>Temp</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>R7FA4W1AD2CNG</td>
<td>512KB</td>
<td>96KB</td>
<td>40~85°C</td>
<td>56 QFN</td>
</tr>
</tbody>
</table>
RA6M3 – ULTRA-LOW POWER 120-MHZ ARM® CORTEX®- M4 CORE
FULL FEATURED FOR APPLICATIONS NEEDING HMI/CONTROL/ SECURITY/GRAPHICAL AND CAPACITIVE TOUCH

High Performance
- 120MHz Arm® Cortex®-M4 CPU

Highly integrated capabilities
- 1MB-2MB Flash Memory and 640kB SRAM
- 128-bit unique ID
- 12-Bit ADC (x2)
- 12-Bit DAC

Communication interfaces
- USB 2.0(Full Speed/ High Speed)
- Ethernet Controller with DMA
- SCI x10/SPIx2/IICx3

HMI Interface
- Capacitive Touch Sensing Unit (18ch.)
- Graphics LCD Controller

Security and Encryption
- AES128/192/256, 3DES/ARC4, SHA1/SHA224/SHA256/MD5, GHASH, RSA/DSA/ECC
- True Random Number Generator (TRNG)

<table>
<thead>
<tr>
<th>Flash Memory</th>
<th>RAM</th>
<th>Temp</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>R7FA6M3AH3CFC#AA0</td>
<td>2MB</td>
<td>640KB</td>
<td>40～105℃</td>
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<tr>
<td>R7FA6M3AF3CFC#AA0</td>
<td>1MB</td>
<td>640KB</td>
<td>40～105℃</td>
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</table>
RYZ014A – LTE Cat-M1 Cellular IoT Module
Globally deployable module with ultra-low power sleep and extended output power modes

World-wide band support in a single design:
- Worldwide Single SKU™ design
- 699 – 2200MHz (incl. bands 1,2,3,4,5,8,12,13,14,17,18,19,20,25,26,28,66,85)

Ultra-low power saving mode:
- Down to 1µA current consumption in deep sleep
- Significant benefit over competition for longer eDRX cycles

23dBm High Output Power Mode:
- Alignment with deployed cell sizes
- Less transmission retries in longer distances or indoor applications

Intellectual property protection:
- Warranty that no implementation IP is infringed
- Indemnification against Standard-Essential Patent infringement at customer’s discretion

<table>
<thead>
<tr>
<th>Part #</th>
<th>Operating Temperature</th>
<th>Operating Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>RYZ014A000FZ00#HD0</td>
<td>-40°C to +85°C</td>
<td>3.1V to 4.5V</td>
</tr>
</tbody>
</table>

RYZ014A Module Dimensions

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RYZ014A – LTE Cat-M1 Cellular IoT Module
Globally deployable module with ultra-low power sleep and extended output power modes

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<tr>
<th>Part #</th>
<th>Operating Temperature</th>
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</tr>
</thead>
<tbody>
<tr>
<td>RYZ014A000FZ00#HD0</td>
<td>-40°C to +85°C</td>
<td>3.1V to 4.5V</td>
</tr>
</tbody>
</table>

RYZ014A Module Dimensions
ISL9111/A – LOW VOLTAGE 1A BOOST CONVERTER
LOW INPUT VOLTAGE HIGH EFFICIENCY SYNCHRONOUS BOOST CONVERTER

High Performance and Efficiency
- Up to 97% Efficiency at Typical Operating Conditions
- 20µA quiescent current with less than 1µA shutdown current
- Minimum Operating Voltage: 0.7V (ISL9111), 0.5V (ISL9111A)

Compact for Space Limited Application
- 6 Ld SOT-23 Package
- 1.2MHz switching frequency, allowing for the use of small inductors and ceramic capacitors

Excellent Safety
- Output Disconnect During Shutdown
- Undervoltage Lockout (ISL9111 Only)
- Fault Protection: OVP (ADJ Version Only), OTP, Short Circuit

<table>
<thead>
<tr>
<th>Part #</th>
<th>Vout (V)</th>
<th>Min Operation Voltage</th>
<th>Temp.(°C)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISL9111EH30Z-T</td>
<td>3.0</td>
<td>0.7V</td>
<td>-20 to 85</td>
<td>6 Ld SOT-23</td>
</tr>
<tr>
<td>ISL9111EH33Z-T</td>
<td>3.3</td>
<td>0.7V</td>
<td>-20 to 85</td>
<td>6 Ld SOT-23</td>
</tr>
<tr>
<td>ISL9111EH50Z-T</td>
<td>5.0</td>
<td>0.7V</td>
<td>-20 to 85</td>
<td>6 Ld SOT-23</td>
</tr>
<tr>
<td>ISL9111EHADJZ-T</td>
<td>ADJ</td>
<td>0.7V</td>
<td>-20 to 85</td>
<td>6 Ld SOT-23</td>
</tr>
<tr>
<td>ISL9111AEH30Z-T</td>
<td>3.0</td>
<td>0.5V</td>
<td>-20 to 85</td>
<td>6 Ld SOT-23</td>
</tr>
<tr>
<td>ISL9111AEH33Z-T</td>
<td>3.3</td>
<td>0.5V</td>
<td>-20 to 85</td>
<td>6 Ld SOT-23</td>
</tr>
</tbody>
</table>

Fixed 5V Efficiency
ISL9122A – ULTRA-LOW Iq BUCK REGULATOR WITH BYPASS
SPACE LIMITED BATTERY POWERED APPLICATIONS

Ultra Low and Efficient Power
- Ultra Low Iq = 1.3μA
- 80% efficiency at 10μA load
- 96% peak efficiency

Feature Rich
- Dynamically adjustable output voltage with 25mV increments
- Settable forced PWM mode eliminates noise interference issues

Small Solution Size
- Small 1.8mmx1.0mm WLCSP and 8 Ld DFN
- 2.5MHz switching frequency → small inductor
- Input voltage: 1.8V to 5.5V / Output voltage: 1.8V to 5.375V
- Output current: up to 500mA (Vin = 3.6V, Vout = 3.3V)

Typical Operating Circuits
Evaluation Board

<table>
<thead>
<tr>
<th>Part #</th>
<th>Default</th>
<th>VOUT</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISL9122AIINZ-T</td>
<td>3.3V</td>
<td>8 Bump WLCSP</td>
<td></td>
</tr>
<tr>
<td>ISL9122AIRNZ-T</td>
<td>3.3V</td>
<td>8 Ld DFN</td>
<td></td>
</tr>
<tr>
<td>ISL9122AIIVZ-T</td>
<td>3.6V</td>
<td>8 Bump WLCSP</td>
<td></td>
</tr>
<tr>
<td>ISL9122AIRVZ-T</td>
<td>3.6V</td>
<td>8 Ld DFN</td>
<td></td>
</tr>
<tr>
<td>ISL9122AIIMZ-T</td>
<td>3.0V</td>
<td>8 Bump WLCSP</td>
<td></td>
</tr>
<tr>
<td>ISL9122AIRMZ-T</td>
<td>3.0V</td>
<td>8 Ld DFN</td>
<td></td>
</tr>
</tbody>
</table>

Efficiency vs Load current
**ISL9301 - CHARGER FOR SINGLE-CELL LI-ION/POLYMER BATTERIES**

**HIGH INPUT VOLTAGE CHARGER WITH POWER PATH MANAGEMENT**

**Fully Integrated with Power Path Management**
- Complete Charger for Single-Cell Li-ion/Polymer Batteries
- Integrated Disconnect Switch to Disconnect the Battery
- Power Path Management Optimize Charge and System Currents

**High Performance**
- 1% Charger Output Voltage Accuracy
- 28V Maximum Voltage at VIN pin

**Programmable /Easy Control**
- Programmable Charge Current & End-of-Charge Current
- Power Presence and Charge Indications

**Safety & Battery Protection**
- Charge Current Thermal Foldback for Thermal Protection
- Trickle Charge for Fully Discharged Batteries
- Intelligent Timeout Interval Based on Actual Charge Current

<table>
<thead>
<tr>
<th>Part #</th>
<th>Temp Range (°C)</th>
<th>Package</th>
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</thead>
<tbody>
<tr>
<td>ISL9301IRZ</td>
<td>-40 to +85</td>
<td>10 Ld 3x3 DFN</td>
</tr>
<tr>
<td>ISL9301IRZ-T</td>
<td>-40 to +85</td>
<td>10 Ld 3x3 DFN</td>
</tr>
</tbody>
</table>

Typical Application Circuit

Typical Charger Cycle
Simple and Flexible Use
- Wide VOUT range (1.1VIN to 25V)
- 2.3V~5.5V input
- 2A MOSFET current capability

High Efficient and Integrated Features
- 92% peak efficiency
- Selectable frequency (600kHz, 1.2MHz)
- Adjustable soft-start

<table>
<thead>
<tr>
<th>Part #</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISL97519AIUZ-T</td>
<td>8 Ld MSOP</td>
</tr>
</tbody>
</table>
ISL29020 - DIGITAL AMBIENT LIGHT SENSOR WITH INTERRUPT
LOW POWER, HIGH SENSITIVITY, INTEGRATED LIGHT SENSOR WITH I2C (SMBUS COMPATIBLE) INTERFACE

Integrated functions and small package
- Variable Conversion Resolution up to 16-bits
- I²C(SMBus compatible) Output Interface
- 2.0mmx2.1mmx0.7mm 6 Ld ODFN Package

Easy to Use
- Adjustable Sensitivity up to 65 Counts per lux
- Measurement range: 0.015 to 64,000 lux with four selectable ranges
- Simple Output Code Directly Proportional to lux
- No Complex Algorithms Needed
- Works Under Various Light Sources, Including Sunlight
- Operation across -40 to +85°C

Low Power Design
- 65μA Max Operating Current
- 0.5μA Max Shutdown Current
- Software Shutdown and Automatic Shutdown
- Ideal Spectral Response
- Close to Human Eye Response
- Excellent IR and UV Rejection

<table>
<thead>
<tr>
<th>Part #</th>
<th>ALS Sensing</th>
<th>Interrupt Pin</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISL29020IROZ-T7</td>
<td>Yes</td>
<td>No</td>
<td>6 Ld 2x2.1 ODFN</td>
</tr>
</tbody>
</table>
EU067-1 Automatic Plant Watering System w/ BT5 + EH

Overview

For a widely distributed automatic plant watering system with many nodes an Energy Harvest powered system is proposed, which communicates via BT5 Mesh, measures the moisture of the soil at each plant and opens / closes valves by bi-static solenoid.

For optimum deployment and low power requirements, most nodes are BT5 Mesh Low Power Nodes.
To further extend ranging, BT Mesh Routers are foreseen.
And to connect to the IoT an Edge Router can be used, like LTE-M or Ethernet.

Key Features:

- No cabling, no battery replacement
  - Most nodes powered by Energy Harvesting, e.g. solar cell, thermal or micro-turbine harvester
- Excellent range due to low cost BT5 Mesh communication within the system
  - Implicit automatic routing (n* point-to-point range); no complex routing setup required
- Only one Edge Router needs paid connection to IoT (LTE-M or Ethernet)
  - Further Edge Routers can be used for redundancy reasons
EU067-1A Automatic Plant Watering System w/ BT5 + EH
Low Power Node

Thermal Harvester
(Small) Solar Cell
Micro-Turbine Harvester
RF Harvester

ISL9111A Low Iq Boost
Energy Harvest Boost
>0.5V

ISL9301 Lilion Charger w/ PowerMgmt

RA4W1*
BT5 MCU

ISL97519A Boost

ISL97519A Boost

ISL9122A Low Iq Buck/Boost

Power Switch

3.3V ISL9301
LiIon Charger w/ PowerMgmt

4.2Vtyp Power Switch

ISL9111A Low Iq Boost

Vdd

BLE5.0 PHY

GPIO

Energy Harvest Boost

12V 0.5Amax

*alternatively RX23W

2.4GHz Antenna

50R

Bistatic / pulsed
Solenoid to open/close water valve, lock/unlock door ...

ISL29020 Light Sensor

Light Sensor

I2C

75uAavg

Moisture Electrodes

ISL29020

12V

0.5Amax

Charge

<1µA

0V

RF Osc.

32MHz

PR

NL

NR

Drive Low

Drive Mid

Drive High

12ch CapTouch

ACC

IIC

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EU067-1A
Apr 2021
EU067-1B Automatic Plant Watering System w/ BT5 + EH
Mesh Router Node

Larger Solar Cell

>0.5V

Energy Harvest Boost

ISL9111A
Low Iq Boost

ISL9301
Lilon Charger w/ PowerMgmt

ISL9122A
Low Iq Buck/Boost

ISL97519A
Boost

Power Switch

3.3V

ISL9111A
Low Iq Boost

ISL9122A
Low Iq Buck/Boost

ISL97519A
Boost

Power Switch

2.4GHz

Antenna

BLE5.0 PHY

12ch

CapTouch

DAC

ADC

ISL97519A
Boost

Power Switch

12V

0.5Amax

BT5 MCU

RA4W1*

GPIO

Drive_Low

Drive_Mid

Drive_Hi

Enable

RF Osc.

32MHz

GPIO

GPIO

GPIO

GPIO

RF Osc.

32MHz

GPIO

GPIO

GPIO

GPIO

GPIO

GPIO

GPIO

12h. Caplouch

ISL29020
Light Sensor

75μAavg

Moisture Electrodes

27R

mF

3A

5VR

ISL9301
Lilon Charger w/ PowerMgmt

LiIon Charger

w/ PowerMgmt

Li Ion Backup Battery

Bistatic / pulsed
Solenoid to
open/close water valve,
lock/unlock door ...

Dual-MOSFET

Dual-MOSFET

Dual-MOSFET

Moisture Electrodes

EU067-1B
Apr 2021

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EU067-1C Automatic Plant Watering System w/ BT5 + EH Edge Router node

EU067-1C
Apr 2021
## EU067-1 Automatic Plant Watering System w/ BT5 + EH

**BOM  Bill Of Materials**

<table>
<thead>
<tr>
<th>Device Category</th>
<th>P/N</th>
<th>Orderable P/N</th>
<th>Key Features</th>
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<tbody>
<tr>
<td><strong>MCU</strong></td>
<td>RA4W1</td>
<td>R7FA4W1AD2CNG</td>
<td>48-MHz Arm®Cortex®- M4 Core for BLE 5.0</td>
</tr>
<tr>
<td>RA6M3</td>
<td>R7FA6M3AH3CFC</td>
<td>Ultra-Low Power 120-MHz Arm® Cortex®- M4 Core</td>
<td></td>
</tr>
<tr>
<td>RYZ014A</td>
<td>RYZ014A000FZ00</td>
<td>LTE-M module</td>
<td></td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>ISL9111A</td>
<td>ISL9111EH50Z-T</td>
<td>Low Input Voltage, High Efficiency Synchronous Boost Converter with 1A Switch</td>
</tr>
<tr>
<td>ISL9122A</td>
<td>ISL9122AIRNZ-T</td>
<td>Ultra-Low Iq Buck Regulator with Bypass</td>
<td></td>
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<tr>
<td>ISL9301</td>
<td>ISL9301IRZ-T</td>
<td>Li-Ion Charger w/ integrated Power Management (single cell)</td>
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<tr>
<td>ISL97519A</td>
<td>ISL97519AIUZ-T</td>
<td>DC/DC Boost Regulator, 2.3-5Vin, 2Aout</td>
<td></td>
</tr>
<tr>
<td><strong>Analog</strong></td>
<td>ISL29020</td>
<td>ISL29020IROZ-T7</td>
<td>Wide Range Ambient Light Sensor</td>
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<th>Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCU</strong></td>
<td>RA4W1 (RX23W)</td>
<td>R7FA4W1AD2CNG</td>
<td>48-MHz Arm® Cortex®-M4 Core for BLE 5.0 (54MHz RXv2 / 32bit MCU with integrated BT5.0)</td>
</tr>
<tr>
<td></td>
<td>RA6M3 (RA6M4) (RX65N)</td>
<td>R7FA6M3AH3CF</td>
<td>Ultra-Low Power 120-MHz Arm® Cortex®-M4 Core</td>
</tr>
<tr>
<td></td>
<td>RYZ014A</td>
<td>RYZ014A000FZ00</td>
<td>Ultra-Low Power 200-MHz Arm® Cortex®-M4 Core (120MHz RXv2 / 32bit MCU for (cloud) connectivity)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>ISL9111A</td>
<td>ISL9111EH50Z-T</td>
<td>Low Input Voltage, High Efficiency Synchronous Boost Converter with 1A Switch</td>
</tr>
<tr>
<td></td>
<td>ISL9122A</td>
<td>ISL9122AIRNZ-T</td>
<td>Ultra-Low I\textsubscript{D} Buck Regulator with Bypass</td>
</tr>
<tr>
<td></td>
<td>ISL9301</td>
<td>ISL9301IRZ-T</td>
<td>Li-Ion Charger w/ integrated Power Management (single cell)</td>
</tr>
<tr>
<td></td>
<td>ISL97519A</td>
<td>ISL97519AIUZ-T</td>
<td>DC/DC Boost Regulator, 2.3-5V\textsubscript{in}, 2A\textsubscript{out}</td>
</tr>
<tr>
<td><strong>Analog</strong></td>
<td>ISL29020</td>
<td>ISL29020IROZ-T7</td>
<td>Wide Range Ambient Light Sensor</td>
</tr>
</tbody>
</table>
Support for Multiple Communication Functions

- Bluetooth Low Energy (1Channel)
- An RF transceiver and link layer compliant with the Bluetooth 5.0 Low Energy specification, also supports Bluetooth 4.2
- LE 1M PHY, LE 2M PHY, LE Coded PHY (125 kbps and 500 kbps), and LE Advertising extension support
- On-chip Bluetooth-dedicated AES-CCM (128-bit blocks) encryption circuit
- USB 2.0 host/function/On-The-Go (OTG) (one channel), full-speed = 12 Mbps, low-speed = 1.5 Mbps, isochronous transfer, and Battery Charger supported
- CAN (one channel) compliant to ISO11898-1: Transfer at up to 1 Mbps

High Performance and Low Power Design

- Operation from single 1.8 to 3.6V supply, up to 512KB Flash and 64KB RAM
- Capacitive Touch Sensing Unit: 12Keys (Self), 36 Keys (Mutual)
- Max. operating frequency: 54 MHz, Capable of 88.56 DMIPS in operation at 54 MHz
- Enhanced DSP and FPU modules
- RTC capable of operating on the battery backup power supply
- Security: 128- or 256-bit key length of AES for ECB, CBC, GCM, others. TRNG and Safe management of Keys, IEC60730 Compliant

RX/23W – 32-BIT MCU FOR BLUETOOTH 5.0 LOW ENERGY
54 MHZ RXV2 CORE WITH FPU, LOW POWER DESIGN, RTC AND ENCRYPTION FUNCTIONS

<table>
<thead>
<tr>
<th>Part #</th>
<th>ROM (Kbytes)</th>
<th>RAM (Kbytes)</th>
<th>Security Functions</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5F523W8ADNG#30</td>
<td>512</td>
<td>64</td>
<td>N/A</td>
<td>QFN/56/0.4</td>
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<tr>
<td>R5F523W7ADNG#30</td>
<td>384</td>
<td>64</td>
<td>N/A</td>
<td>QFN/56/0.4</td>
</tr>
<tr>
<td>R5F523W8BDNG#30</td>
<td>512</td>
<td>64</td>
<td>Available</td>
<td>QFN/56/0.4</td>
</tr>
<tr>
<td>R5F523W7BDNG#30</td>
<td>384</td>
<td>64</td>
<td>Available</td>
<td>QFN/56/0.4</td>
</tr>
</tbody>
</table>

Target Board for RX23W – RTK5RX23W0C00000B
RA6M4 – HIGH PERFORMANCE 200-MHZ ARM® CORTEX®- M33 CORE
APPLICATIONS FOR IOT ENDPOINTS SUCH AS WHITE GOODS, METERS, AND OTHER INDUSTRIAL AND CONSUMER

High Performance
- 200MHz Arm® Cortex®-M33 CPU

Highly integrated capabilities
- 512KB-1MB Flash Memory and 256KB SRAM
- 12-Bit ADC (x2), 12-Bit DAC (x2)
- GPT 32-BIT(4 ch)/GPT 16-bit(6 ch)/Low power GPT(6 ch)

Communication interfaces
- USB 2.0 (Full Speed/ High Speed)
- Ethernet Controller with DMA
- SCI x10/ SPI x2/ IIC x2/ QSPI/ SDHI/ SSI/ CAN x2

HMI Interface
- Capacitive Touch Sensing Unit (20 ch.)

Security and Encryption
- AES128/192/256, SHA224/SHA256, GHASH, RSA (incl. 3K/4K)/DSA/ECC
- True Random Number Generator (TRNG), 128-bit unique ID

<table>
<thead>
<tr>
<th>Part #</th>
<th>Flash Memory</th>
<th>RAM</th>
<th>Temp</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>R7FA6M4AF3CFB#AA0</td>
<td>1MB</td>
<td>256KB</td>
<td>40~105°C</td>
<td>144 LQFP</td>
</tr>
<tr>
<td>R7FA6M4AE3CFP#AA0</td>
<td>768KB</td>
<td>256KB</td>
<td>40~105°C</td>
<td>100 LQFP</td>
</tr>
<tr>
<td>R7FA6M4AD3CFM#AA0</td>
<td>512KB</td>
<td>256KB</td>
<td>40~105°C</td>
<td>64 LQFP</td>
</tr>
</tbody>
</table>

RA6M4 Block Diagram
200MHz 32-Bit Arm® Cortex®-M33 Core

<table>
<thead>
<tr>
<th>Memory</th>
<th>Analogue</th>
<th>Timers</th>
<th>System</th>
<th>Safety</th>
<th>Security</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code Flash</td>
<td>12-bit ADC (x2)</td>
<td>12-bit ADC (x2)</td>
<td>DMA</td>
<td>Memory Protection Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32-Bit Flash</td>
<td>12-bit DAC (x2)</td>
<td>12-bit DAC (x2)</td>
<td>Clock Generation</td>
<td>ECC</td>
<td>Key Management</td>
<td></td>
</tr>
<tr>
<td>ROM</td>
<td>12-bit DAC</td>
<td></td>
<td></td>
<td></td>
<td>ECC</td>
<td>Octa Memory</td>
</tr>
<tr>
<td>SRAM</td>
<td>Temperature Sensor</td>
<td>GPT 32-bit (x4)</td>
<td>Low Power GPT (6 ch)</td>
<td>Data Operation Circuit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>512KB-1MB</td>
<td>GPT 16-bit (6 ch)</td>
<td></td>
<td></td>
<td></td>
<td>TRNG</td>
<td></td>
</tr>
<tr>
<td>SRAM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tamper Resistance</td>
<td></td>
</tr>
<tr>
<td>256KB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NPA/TPA/Enhanced Resistance</td>
<td></td>
</tr>
<tr>
<td>Data Flash</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LQFP 64, 100, 144</td>
</tr>
</tbody>
</table>

Major Enhancements in RA6 Series With CM33

- ARM® Cortex®-M33® Core
- Power consumption
- Wake-up time

- Connectivity:
  - QSPI
  - SDHI
  - CAN FD
- Octa Memory

- Crypto Module with cryptography accelerator and TRNG
- Crypto Module supports Key management
- TrustZone and Tamper resistance
RX651/RX65N – 120MHZ RXV2 CORE MCU

FUNCTIONS REQUIRED FOR IOT DEVICES ARE INTEGRATED INTO ONE CHIP

Realize High performance and Low power consumption

- Included High performance RXv2core@120MHz(max)
- Achieve the High-power efficiency in industry’s highest score, 34.7CoreMark/mA. Life of battery powered devices can be extended.

Rich Peripheral/Security Functions

- Communication : Ethernet MAC and SD Host I/F suitable for connection with Wireless LAN modules
- Security : AES, RSA, ECC, SHA Encryption engine, Encryption key protect function, Area protection function to prevent unauthorized rewrite of flash memory.
- HMI : TFT LCD Controller, 2D Graphic engine, CMOS Camera I/F
- Dual Bank Flash Memory : The dual-bank structure makes a safe update possible in cases where programming is suspended.

Package Lineup

- Nine types of packages are available to flexibly support to IoT devices.

<table>
<thead>
<tr>
<th>Part #</th>
<th>ROM</th>
<th>RAM</th>
<th>Data Flash</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5F56514xDxx</td>
<td>512K</td>
<td>256k</td>
<td>None</td>
<td>64-LFQFP*, 64-LFBGA*, 100-LFQFP, 100-TFLGA, 144-LFQFP, 145-TFLGA</td>
</tr>
<tr>
<td>R5F565N4xDxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R5F56517xDxx</td>
<td>768K</td>
<td>256k</td>
<td>None</td>
<td>64-LFQFP*, 64-LFBGA*, 100-LFQFP, 100-TFLGA, 144-LFQFP, 145-TFLGA</td>
</tr>
<tr>
<td>R5F565N7xDxx</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>R5F56519xDxx</td>
<td>1M</td>
<td>256k</td>
<td>None</td>
<td>64-LFQFP*, 64-LFBGA*, 100-LFQFP, 100-TFLGA, 144-LFQFP, 145-TFLGA</td>
</tr>
<tr>
<td>R5F565N9xDxx</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R5F565NCxDxx</td>
<td>1.5M</td>
<td>640k</td>
<td>32K</td>
<td>64-LFQFP*, 64-LFBGA*, 100-LFQFP, 100-TFLGA, 144-LFQFP, 145-TFLGA,176-LFQFP, 176-LPBF, 177-TFLGA</td>
</tr>
<tr>
<td>R5F565NExDxx</td>
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</tr>
<tr>
<td>R5F565NExDxx</td>
<td>2M</td>
<td>640k</td>
<td>32K</td>
<td>64-LFQFP*, 64-LFBGA*, 100-LFQFP, 100-TFLGA, 144-LFQFP, 145-TFLGA,176-LFQFP, 176-LPBF, 177-TFLGA</td>
</tr>
</tbody>
</table>

*: RX651 only