Wireless communication is a key aspect in the realization of the Internet of Things (IoT). Data needs to flow from end equipment to other devices or to a cloud-based backend in order to provide meaningful use. Especially for the many mobile devices that people use, a wired connection is cumbersome or even impossible to use. But for many industrial applications as well, a wireless interface is a common requirements nowadays.

There is a plethora of competing and complementary wireless technologies each of which has its specific characteristics. One way to separate the many different technologies is to look at the range of the communication that the technology is mostly used in.

Close range communication is commonly referred to as personal area networking (PAN). For this use case, Bluetooth — specifically in its Low Energy (LE) mode of operation — is the most widely applied technology. Due to its presence in smart phones and tablets, a huge ecosystem has developed over the past years from wearable devices to smart speakers and even home appliances like coffee machines. With its expansion to support Mesh networking, Bluetooth LE has started to compete with other technologies used in the home automation space which include all protocols based on the IEEE802.15.4 standard, namely ZigBee and Thread.

For use cases that require a higher data rate in the home, users can resort to local area networking (LAN), a market that is dominated by Wi-Fi technology based on the IEEE802.11 series of standards. In addition to its presence in users’ homes for the local internet connection, Wi-Fi is similarly present in cell phones and tablet computers that can act as gateways to a cloud.

Sometimes, a direct connection for the device to the cloud is desired. In these cases, users can utilize low power wide area networking (LPWAN), specifically cellular-based technologies like LTE Cat-M1.
**Wearables**

Many devices exist that consumers can wear on their body: from wristbands like fitness trackers or smart watches to smart garments or smart shoes even. All these collect data and pass it to a smart phone for storing and processing. And since they are battery-powered, low power consumption is key and hence Bluetooth Low Energy is the preferred communication method.

---

**Smoke Alarms**

Homes need to be made safe and many countries have mandated smoke detectors in private and public buildings. There are already devices that can be configured from a smart phone via Bluetooth LE, but for larger buildings there is the requirement to pass events to a central location. For this use case, Bluetooth Mesh provides an increasingly popular solution.

---

**Metering**

Classic metering has moved from people reading the actual consumption data in person from the meter to a more automated way. While more recent solutions are based on local networking over powerlines or mesh networking like Wi-SUN, the lower management effort of a direct connection to each meter has driven cellular LTE communication to be the new solution.

---

**Charge Poles**

With the increasing number of electric vehicles, charging infrastructure becomes an important asset. Drivers needing to charge their cars must find a charge pole in their vicinity. Poles can signal their availability via LTE to a central server that drivers can access. The actual charging may be unlocked via Bluetooth LE and the payment data is also passed via LTE.
Bluetooth LE wireless technology is designed for very low power operation and is optimized to short burst data transmission. In order to achieve reliable communication in the 2.4GHz frequency band, it employs a robust frequency hopping spread spectrum method that transmits data over 40 channels.

The Bluetooth LE wireless technology provides great flexibility to developers with data rates from 125Kb/s to 2Mb/s, multiple PHY options that support power levels from 1mW to 100mW, and multiple high-level security options required by government agencies.

LE supports multiple network topologies such as “Point-to-Point” used for data transfer, “Broadcast” used for location services, and “Mesh” used for building large-scale device networks.

The benefit of LE is that it can communicate with applications for smartphones or tablets. LE is already used in many applications such as for healthcare and fitness, home electric appliances, home automation, gadgets, accessories, and location systems.

The Bluetooth wireless technology includes the LE standard and the BR/EDR standard that supports the Basic Rate and Enhanced Data Rate that are the classic standards.

Devices are classified into types that support LE only, BR/EDR only, and both LE and BR/EDR. Renesas devices (RA4W1, RX23W, RL78/G1D) are the types that support only LE.

Applications using Bluetooth LE wireless technology have spread from healthcare devices and continue to expand into a wide variety of fields such as sports and fitness, smart homes, industrial equipment, and beacon applications.

### Product Selection Guide

<table>
<thead>
<tr>
<th>Product</th>
<th>CPU Core</th>
<th>LE Data Length Extensions</th>
<th>2Mbps</th>
<th>LE Coded PHY (Long Range)</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA4W1</td>
<td>Arm®</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Touch, Security, USB</td>
</tr>
<tr>
<td>RX23W</td>
<td>RX</td>
<td>Not Supported</td>
<td>Supported</td>
<td>Not Supported</td>
<td>Bluetooth Mesh, Touch, Security, USB</td>
</tr>
<tr>
<td>RL78/G1D</td>
<td>RL78</td>
<td>Not Supported</td>
<td>Not Supported</td>
<td>Not Supported</td>
<td>Low System Power, Beacon</td>
</tr>
</tbody>
</table>

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The Renesas RA4W1 is the first Bluetooth 5.0 Low Energy fully compliant with 2Mbit High-Throughput (HT) and Long Range (LR) support in a single chip MCU of Renesas RA4 product series for IoT applications that require a high-performance Arm® Cortex®-M4 core at a very attractive price point.

The RA4W1 is built on a highly efficient low power process and is supported by an open and flexible ecosystem concept, called Flexible Software Package (FSP), using FreeRTOS as base.

RA4W1 is geared towards IoT application requiring Security, large embedded RAM and low power consumption.

**Target Applications**
- Security (Fire Detection, Burglar Detection, Panel control)
- Metering (Electricity, Automated Meter Reading)
- Industry (Robotics, Door Openers, Sewing Machines, Vending machines, UPS)
- Health and Wearables Body Sensors
- Smart Home and Remote Control Toys

**Features**
- 48MHz Arm® Cortex®-M4
- 512KB Flash Memory and 96KB SRAM
- 8KB DataFlash to store data as in EEPROM
- 7 x 7mm QFN 56 pin package
- Capacitive Touch Sensing Unit
- Segment LCD Controller
- USB 2.0 Full Speed (Host/Device)
- CAN 2.0B
- SCI (UART, Simple SPI, Simple I²C)
- SPI/ I²C Multimaster Interface
- 2.4GHz radio with Bluetooth 5.0 Low Energy
- Advertising Extension and Long Range support
- Secure Crypto Engine (AES128 / 256, GHASH, TRNG)

**Evaluation Kit**
- Full MCU evaluation including On-Chip debugger
- Part name: RTK7EKA4W1S00000BJ

For more details, please visit https://www.renesas.com/RA4W1
The Renesas RX23W Bluetooth LE MCU offers the full functions of Bluetooth 5.0 LE and the built-in security functions essential to IoT devices, as well as rich peripheral features such as touch keys, USB and CAN. As a result, system control for devices and wireless communication can be realized on a single chip.

The RX23W also provide a dedicated library that complies with the Bluetooth Mesh Networking specification for multipoint-to-multipoint communication.

**Target Applications**
- Security (Fire Detection, Burglar Detection, Panel control)
- Metering (Electricity, Automated Meter Reading)
- Industry (Robotics, Door Openers, Sewing Machines, Vending machines, UPS)
- Health and Wearables Body Sensors
- Smart Home and Remote Control Toys

**Features**
- RXv2 core 54MHz operation (4.33 CoreMark/MHz) 1.8V to 3.6V operation
- Operating temperature –40°C to 85°C
- Program Flash up to 512KB, SRAM up to 64KB
- Communications
- Bluetooth Low Energy (one channel)
- USB 2.0 Host/Function/OTG (one channel)
- CAN (one channel)
- SD Host I/F (on channel)
- Capacitive Touch Sensing
- Enhanced analog
- Trusted Secure IP Lite (AES/TRNG)

**Evaluation Kit**
- Full MCU evaluation including On-Chip debugger
- Part name: RTK5RX23W0C00000BJ

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Flash</th>
<th>RAM</th>
<th>Data Flash</th>
<th>Operating Temperature</th>
<th>Package</th>
<th>Package Dimension</th>
<th>Pin Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5FS23WxADBL</td>
<td>512KB</td>
<td>64KB</td>
<td>8KB</td>
<td>–40 to +85°C</td>
<td>BGA 85pin</td>
<td>5.5 × 5.5mm</td>
<td>0.5mm</td>
</tr>
<tr>
<td>R5FS23WxBDBL</td>
<td>384KB</td>
<td>64KB</td>
<td>8KB</td>
<td>–40 to +85°C</td>
<td>BGA 85pin</td>
<td>5.5 × 5.5mm</td>
<td>0.5mm</td>
</tr>
<tr>
<td>R5FS23WxADNG</td>
<td>512KB</td>
<td>64KB</td>
<td>8KB</td>
<td>–40 to +85°C</td>
<td>QFN 56pin</td>
<td>7 × 7mm</td>
<td>0.4mm</td>
</tr>
<tr>
<td>R5FS23WxBDNG</td>
<td>384KB</td>
<td>64KB</td>
<td>8KB</td>
<td>–40 to +85°C</td>
<td>QFN 56pin</td>
<td>7 × 7mm</td>
<td>0.4mm</td>
</tr>
</tbody>
</table>

- x-8: Flash 512KB. 7: Flash 384KB
- 4th digit from the back: A: Neither the security function nor an antenna included, B: Security function included, an antenna not included

For more details, please visit https://www.renesas.com/RX23W
The RL78/G1D low-power 16-bit MCU support Bluetooth LE and enable reliable connections with current consumption levels among the lowest in the industry. We also have a “beacon stack” that pursues low current consumption.

Renesas also provide a module that can use the abundant function pins of the RL78/G1D as it is, with a built-in antenna and RF circuit.

**Target Applications**
- Office
- Home Appliance
- Health and Wearables Body Sensors
- Smart Home and Remote Control Toys
- Beacon application

**Features**
- CPU: RL78 core, Max. 32MHz
- Voltage: 1.6V to 3.6V
- Package: 48-pin HWQFN
- Memory: SRAM Max. 20KB, Program Flash Max. 256KB
- Timer: 16-bit Timer (ch) × 8, 8-bit Timer (ch) × 8, Watchdog Timer (ch) × 1, 12-bit Interval Timer × 1ch
- PWM: PWM Output × 7
- Analog function: 10-bit A/D Converter (ch) × 8
- On-chip Oscillator Freq. (MHz): High-Speed: 32, 24, 16, 12, 8, 4, 1MHz
- Low-speed: 15kHz
- Others: RTC, Power-On Reset, Low Voltage Detection

**Evaluation Kit**
- This evaluation board is best suited for the for evaluation of the Renesas’ RL78/G1D microcontroller device, operation evaluation of Bluetooth Low Energy, and use as a prototype.
- Part name: RTK0EN0001D01001BZ

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Flash</th>
<th>RAM</th>
<th>Data Flash</th>
<th>Operating Temperature</th>
<th>Package</th>
<th>Package Dimension</th>
<th>Pin Pitch</th>
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</thead>
<tbody>
<tr>
<td>R5F11AGxANB</td>
<td>256KB</td>
<td>20KB</td>
<td>8KB</td>
<td>−40 to +85°C</td>
<td>QFN 48pin</td>
<td>6 × 6mm</td>
<td>0.4mm</td>
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<tr>
<td>R5F11AGxDNB</td>
<td>192KB</td>
<td>16KB</td>
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<td></td>
<td>128KB</td>
<td>12KB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- x: J: Flash 256KB and RAM 20KB H: Flash 192KB and RAM 16KB, G: Flash 128KB and 12KB
- 3th digit from the back: A: Consumer applications, operating ambient temperature, D: Industrial applications, operating ambient temperature

For more details, please visit [https://www.renesas.com/RL78G1D](https://www.renesas.com/RL78G1D)
Renesas also has a lineup of the world’s smallest module products with built-in antennas and oscillators.

To facilitate quicker development times, Renesas provides pre-tested and pre-certified modules based on its Bluetooth MCU lineup.

Customers can use these modules to quickly build on the existing RF certifications and Bluetooth qualification acquired for these module. Renesas also provides guidelines for customers on how to achieve Bluetooth qualification for their end products.

### Bluetooth LE Modules

- **RX23W Module**
  - Full integration of RX23W Bluetooth LE MCU
  - Integrated antenna
  - Module package size: 6.1 × 9.5mm, 0.5mm pitch (83-pin LGA)
  - Evaluation kit: RTK5RX23W0C01000BJ
  - Bluetooth qualified design: QDID 134349

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Flash</th>
<th>RAM</th>
<th>Data Flash</th>
<th>Operating Temperature</th>
<th>Package</th>
<th>Package Dimension</th>
<th>Pin Pitch</th>
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<tr>
<td>R5F523W8xDLN</td>
<td>512KB</td>
<td>64KB</td>
<td>8KB</td>
<td>–40 to +85°C</td>
<td>LGA 83pin</td>
<td>6.1 × 9.5mm</td>
<td>0.5mm</td>
</tr>
</tbody>
</table>

- x: C. Security function not included, D: Security function included

For more details, please visit [https://www.renesas.com/RX23W](https://www.renesas.com/RX23W)

- **RY7011 Module**
  - Full integration of RL78/G1D Bluetooth LE MCU
  - Printed antenna
  - Module package size: 8.95 × 13.35mm, 0.85mm pitch (42-pin LGA)
  - Bluetooth qualified design: QDID 82194 or 122047

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Flash</th>
<th>RAM</th>
<th>Data Flash</th>
<th>Operating Temperature</th>
<th>Package</th>
<th>Package Dimension</th>
<th>Pin Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>RY7011A0000DZ00</td>
<td>256KB</td>
<td>20KB</td>
<td>8KB</td>
<td>–25 to +75°C</td>
<td>LGA 42pin</td>
<td>8.95 × 13.35mm</td>
<td>0.85mm</td>
</tr>
</tbody>
</table>

For more details, please visit [https://www.renesas.com/RL78G1D](https://www.renesas.com/RL78G1D)
Bluetooth LE Tools

iOS/Android Application GATTBrowser

GATTBrowser is an iOS / Android application for checking the operation of Bluetooth LE. Scan commercially available Bluetooth LE devices operating in the vicinity, connect to the detected devices, and data communication is possible. It can also be used as an evaluation tool for application development embedded in our microcomputers and modules. GATTBrowser can be downloaded from each store of App Store / Google Play.

QE for BLE: Development Assistance Tool for Bluetooth Low Energy

The QE for BLE is a dedicated tool for developing embedded software in systems which support the Bluetooth® Low Energy protocol stack. This tool makes it easy to test the communications features of Bluetooth Low Energy of Renesas MCU, thus reducing development periods up to products being placed on the market.

This product is a plug-in which extends the Renesas IDE “e² studio”.

Smartphone Application: TryBT

TryBT is a smartphone sample application that supports features for communicating with Bluetooth LE products. You can check communication with the firmware preinstalled in Target Board for RX23W. Also, you can use RA4W1, too.

In addition, icon images as well as a project for Android Studio and source code are provided, so you can use this sample application as a base for developing Bluetooth LE communication application in a proof-of-concept phase.

For more details, please visit https://www.renesas.com/solutions/bluetooth
Low-power wide-area networks (LPWANs) are the perfect companion to technologies providing short-range communication. While local applications can query, diagnose or configure an IoT device, the actual connection to the cloud requires gateways and/or routers which add an additional impact to development and set up of the infrastructure.

Eliminating the need for gateways, IoT devices with cellular connectivity based on the 3GPP Long Term Evolution (LTE) standard can simplify the design and interface to the backend where data is being processed. Additionally, compared to other more-or-less proprietary LPWAN technologies, cellular connectivity can be employed everywhere in the world where there is a mobile LTE network, thus avoiding the need to build up your own infrastructure.

There are different categories of cellular IoT in LTE depending on the need for data rates, latencies and cost. Together with its partners, Renesas provides an ever-expanding portfolio of solutions to meet all customer needs.
The Renesas RYZ014A module is an all-in-one, single-mode LTE category M1 module with worldwide deployment and roaming capability.

The module comprises an LTE Cat-M1 platform and all other elements necessary for a complete LTE Cat-M1 modem system. These include an LTE-optimized transceiver, a single complete RF front-end to support LTE Cat-M1 bands worldwide, and key interfaces, all in a single compact LGA package.

The RYZ014A module also includes a carrier-proven LTE Cat-M1 protocol stack and a comprehensive software package for over-the-air device management and packet routing.

**Features**

- Integrated Cellular IoT module for LTE Cat-M1
- 3GPP Release 13
- Field proven LTE Cat-M1 software stack
- uSIM Interface
- Voltage 3.1V to 4.5V
- High output power supporting 23dBm
- AT Command Interface
- 20.25 × 21.35mm² LGA package with 108 pads
- RoHS-compliant, halogen-free
- 1μA current (Deep Sleep) with eDRX and PSM

**Target Applications**

- Metering (Electricity/Gas/Water, Automated Meter Reading)
- Smart Home (HVAC, Thermostat)
- Infrastructure (Charge Poles, Parking Systems)
- Industry (Pumps)
- Agriculture
- Wearables & Trackers

**Evaluation Kit**

- Cellular modem evaluation kit based on Renesas module
- Usage and possible operations
  - Connecting to a host PC (Windows / Linux) through an external Serial Terminal Emulator Software
  - Sending AT commands to the kit
  - Connecting the EVK to a testing equipment or a commercial network
  - Sending data through PPP

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Description</th>
<th>Shipping Packaging</th>
<th>Operating Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>RYZ014A000FZ00H0</td>
<td>LTE Cat-M1 Module</td>
<td>Tape &amp; Reel</td>
<td>-30 to +85°C</td>
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<tr>
<td>RYZ014A-NA-EVK</td>
<td>RYZ014A Evaluation Kit (North America)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RYZ014A-GB-EVK</td>
<td>RYZ014A Evaluation Kit (Global)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For more details, please visit [https://www.renesas.com/RYZ014A](https://www.renesas.com/RYZ014A)
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