BUILDING AUTOMATION
Leading-edge IoT solutions for HVAC, fire/safety, building security, and lighting
BUILDING AUTOMATION

BRINGING COMFORT, SAFETY, AND ENERGY SAVINGS TO PEOPLE, BUILDINGS, AND COMMUNITIES WITH SOLUTIONS TO CONNECT, PROTECT, AND CONSERVE

By connecting air conditioning, disaster prevention, crime prevention, and lighting equipment via networks, buildings can be made more convenient, secure, and energy efficient. Renesas leverages advanced technologies in connectivity, sensing, user interface, and low-power to enable the next generation of advancements in building automation.

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RENASAS TECHNOLOGY FOR BUILDING AUTOMATION

Building Automation Solution Devices and Platform

Renesas provides solutions for building systems (HVAC*, fire and safety, building security, and lighting). Each solution includes components such as devices, evaluation boards, development tools, and documentation to provide total support for customers’ development efforts.

The Renesas Synergy™ platform provides three types of value to developers of complex embedded systems in fields such as building automation: shorter development time, reduced total cost of ownership, and elimination of barriers to starting development.

* HVAC: Heating, Ventilation, and Air Conditioning

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<td>DALI communication solutions</td>
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In April 2019 Renesas merged with IDT. This means that we can now supply both sensors and the MCUs needed to control them. Providing a comfortable building environment and achieving energy savings are both becoming increasingly important aspects of building management. To confirm and maintain comfort it is necessary to measure elements such as temperature, humidity, air quality, and light, and then to link this data to the control of HVAC, lighting, and other systems. In addition, energy savings can be achieved through network connectivity and optimized control of the system overall. Moving forward, Renesas and IDT will continue to make advances in sensors and MCUs, contributing to the advancement of building automation and improving the global environment.

**Key Building Automation Technologies: Sensors**

In April 2019 Renesas merged with IDT. This means that we can now supply both sensors and the MCUs needed to control them. Providing a comfortable building environment and achieving energy savings are both becoming increasingly important aspects of building management. To confirm and maintain comfort it is necessary to measure elements such as temperature, humidity, air quality, and light, and then to link this data to the control of HVAC, lighting, and other systems. In addition, energy savings can be achieved through network connectivity and optimized control of the system overall. Moving forward, Renesas and IDT will continue to make advances in sensors and MCUs, contributing to the advancement of building automation and improving the global environment.

**Sensors in the Building Environment**

Nowadays there are a variety of sensors at various locations throughout the interior of a typical building, and demand for such sensors is expected to increase. Here we highlight some of the locations and specific applications in which sensors from Renesas and IDT are used.
Features of Renesas and IDT Sensors

Renesas and IDT sensors include compact products offering superior sensitivity and accuracy. Evaluation boards are also available, making it easy to assess the performance of these products.

### Temperature and Humidity Sensors

**Representative Product**

HS3001

**Features**

- Wide measurement range (0% to 100% RH)
- High measurement accuracy (±1.5% RH, ±0.2°C)
- Compact package (3.0 × 2.4 × 0.8 mm)
- I2C interface for easy connections

**Evaluation Board Product Name**

SDAH02

**Application Example**

Temperature and humidity measurement in HVAC systems and thermostats

### Flow Volume and Airflow Sensors

**Representative Products**

FS2012, FS1012

**Features**

- Detects the flow volume of gases and liquids.
- Superior acid and alkali tolerance
- Vibration resistant
- High sensitivity

**Evaluation Board Product Names**

SDAWIR, SDAF0x

**Application Example**

Flow volume and airflow measurement in HVAC systems

### Air Quality (Gas) Sensors

**Representative Products**

ZMOD4410, ZMOD4510

**Features**

- Detects total volatile organic compounds (TVOC). (Supports estimated carbon dioxide (eCO₂) calculation.)
- Extensible via firmware updates.
- Supports IAQ-grade detection conforming to German Environment Agency (UBA) standards.
- Detects emissions of ozone and NOx (ZMOD4510 only).

**Evaluation Board Product Name**

ZMOD4410-EVK

**Application Example**

Air quality measurement in thermostats

### Light and Color Sensors

**Representative Products**

ISL29035 (lux), ISL29125 (color)

**Features**

- High resolution (16-bit)
- Wide dynamic range
- Sensor characteristics similar to human vision
- Compact package (1.65mm square, or less)

**Evaluation Board Product Names**

ISL29035EVAL1Z, ISL29125EVAL1Z

**Application Examples**

Lighting brightness, color temperature measurement

Use in Conjunction with an MCU

Renesas offers MCU products that are the perfect match for sensors. By choosing an MCU with support for various communication interfaces, it is possible to transfer sensor data over a network. Example uses of sensors in conjunction with MCUs to implement building automation applications are presented here.

<table>
<thead>
<tr>
<th>Example</th>
<th>Sensors</th>
<th>Recommended MCUs</th>
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<tbody>
<tr>
<td>Thermostat with wireless functionality</td>
<td>ZMOD4410 air quality sensor and HS3001 temperature and humidity sensor</td>
<td>RL78/G1H (sub-GHz RF), RL78/G1D (BLE), and RX100 or RX200 Series (HMI)</td>
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<tr>
<td>Light sensor with DALI communication support</td>
<td>ISL29035 light sensor</td>
<td>RL78/I1A (DALI interface)</td>
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<tr>
<td>HVAC refrigerant sensor</td>
<td>FS1012 flow sensor</td>
<td>RL78/G Series (system control)</td>
</tr>
<tr>
<td>Gas alarm</td>
<td>SGDAS711 gas sensor</td>
<td>RL78/G12 (system control)</td>
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For the latest information on using sensors in conjunction with MCUs, visit the Winning Combinations webpage (https://www.renesas.com/us/en/solutions/idt.html).
As illustrated in Figure 1, in a central air conditioning system a heat source in a single location is used to circulate air, water, or steam to the various rooms, and exchange heat, in order to cool or heat each room to the specified temperature. The chiller refrigerates water for use as a refrigerant, circulates it to the various rooms, and exchanges heat. The cooling water gradually becomes warmer, and in the cooling tower on the roof it is chilled through contact with air and then reused. Pumps are used to recirculate the water. The heat source (boiler) is powered by gas, oil, or electricity. It heats water in a vessel to produce hot water or steam. To heat the rooms, this hot water or steam is circulated through the rooms, and heat exchange takes place. Either a pair of two pipes or a set of four pipes can be used to circulate the cold or hot water. There are outgoing and incoming hot-water and cold-water pipes used to distribute the hot and cold water to air handling units (AHUs), fan coil units (FCUs), etc. In a two-pipe system the same pipes are used for both hot and cold water, switching from one to the other depending on the season and whether heating or cooling is required. This means heating and cooling operation cannot take place at the same time. On the other hand, if the cooling and heating coils built into the AHUs, FCUs, etc., are each equipped with their own outgoing and incoming pipes, simultaneous heating and cooling operation is possible within the same building. Such an arrangement is called a four-pipe system from the total number of pipes used. An outdoor-air processing unit (or total heat exchanger) extracts the heat or cold from indoor air that expelled to the outside (exhaust) and transfers it to fresh air from outside, thereby minimizing the difference in temperature between the indoor air and the fresh air from outside. ACU or air handling unit uses cold water, hot water, or steam supplied by the heat source unit to adjust the temperature and humidity of the air, which is then supplied to the rooms. HVAC systems use air, water, or refrigerant as the medium for heat exchange. Some central air conditioning systems use a method called variable air volume (VAV), in which valves connected to the AHU are used to adjust the volume of cool (or warm) air passing through the ducts. In a water-cooled system cold or hot water is circulated via pipes, and FCUs perform heat exchange to adjust the temperature of each room.
Individual Air Conditioning System

In an individual air conditioning system refrigerant gas is circulated and exchanges heat. One typical example (Figure 2) is a building multiple air conditioner system. The temperature can be set for each room, and simultaneous heating and cooling operation are possible. Sometimes central air conditioning and individual air conditioning are used in combination, depending on the size of the building and its purpose.

HVAC Motor Control

Table 1 and Table 2 list the units requiring motor control that are used in the two types of air conditioning system. The use of inverters and brushless DC motors is increasing in variable speed motor control applications requiring energy efficiency. In addition, an individual indoor unit or outdoor unit may contain multiple motors requiring control. Renesas offers development kits for the control systems most appropriate for three motor types: induction motors, brushless DC motors, and stepping motors.

HVAC Communication Network

Regardless of the type of air conditioning system, generally speaking the various units are connected to a wired or wireless network to facilitate control and state management. In the context of building automation in particular, BACnet* is used to connect HVAC devices from different manufacturers and configure the building management system. Figure 3 shows conceptual diagrams of HVAC system communication in a central air conditioning system and an individual air conditioning system, respectively. In the central air conditioning system, digital signals (DI and DO) and analog signals (4-20mA) are used for communication between sensors, VAV units, and general-purpose controllers. Due to the long distances involved and need for noise tolerance, Renesas offers communication solutions that employ power line communication (PLC).

HVAC User Interface

Some remote controllers for indoor unit temperature setting utilize screen-based interfaces. The recent trend is away from using conventional mechanical keys (mechanical switches) and toward the use of touch panels. These touch panels must be able to withstand demanding environmental conditions, including high noise levels, water, dirt, and temperature variations. Renesas offers HMI solutions that meet these challenges.

*BACnet (Building Automation and Control Networking protocol) is an open protocol established in 1995 by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). In 2003 it was adopted as the international standard ISO 16484-5.
In the context of building automation, fire and safety systems are designed to detect the outbreak of fires and provide warning, for example by sounding alarm bells throughout the building. An automatic fire alarm system for buildings has a receiver that detects when one of the sensors connected by wires is triggered by a fire. The system then alerts the building occupants by sounding alarm bells or voice alarms throughout the building. Fire alarms used in buildings and in homes employ the same sensing methods, but they differ in that building systems are connected to networks while home systems are independent and sound the alarm individually. Figure 1 illustrates examples of sensing and notification types.

**Automatic Fire Alarm Systems**

An automatic fire alarm system comprises a receiver, automatic sensors, manual transmitters, sound devices, fire doors, fire shutters, smoke shutters, and network devices to which they are connected.

The receiver is installed in a fire protection center or management office within the building. It receives signals from the sensors if a fire breaks out, and controls such things as the display of indications of where the outbreak occurred and the sounding of audible alarms such as bells or voice messages. The receiver also supplies power to the system as a whole. It normally operates on the AC 100V power supply, but it is equipped with a backup power supply in case of a power failure. Figure 2 shows an example type-R receiver and peripheral system. The receiver is connected to automatic sensors, alarms, etc., via a relay, or it may be connected to the building’s central monitoring system.

The automatic sensors are installed in the various alarm zones throughout the building. They automatically detect the outbreak of fire from the heat, smoke, or flame, and send a signal to the receiver. Figure 3 shows a photoelectric spot sensor for detecting smoke. When smoke enters the sensor, the light emitted by the emitter (LED) is diffused by the smoke particles, and this is detected by the receiver.

The sound devices are installed in various locations throughout the building. These emergency alarm units sound a bell or a voice warning when they receive a signal from the receiver. Each of these devices is connected to the network via a wired or wireless communication system. Wired networks use the RS-485 data transfer standard over dedicated wires, and wireless networks use the 426MHz band, BLE, or Sub-GHz band, among others.

Renesas offers the following solutions for fire and safety systems.

**Controllers for Detection and Communication**

**Recommended devices**
- RL78/I1D and RL78/G11: analog function (amp, CMP), low power consumption
- RL78/G10, RL78/G12, and RL78/G13: general-purpose MCUs with low power consumption
- RL78/G1H and RL78/G1D: RF communication
- R9A06G037: PLC modem IC for NB-IoT communication

**Analog Products**

**Recommended devices**
- SGAS7xx Series gas sensors
- ISL85415 step-down regulator
- ISL9001A low-dropout regulator (LDO)
In the context of building automation, a security systems is composed of two constituent elements. Figure 4 is a conceptual diagram. The first is a monitoring systems that oversees what is going on in and around the building by means of cameras and sensors of various types. The second is a crime prevention systems that performs ingress and egress management and control based on the information from the monitoring systems.

**Monitoring Systems**
Monitoring systems may include motion sensors for ingress monitoring and fire detectors, carbon monoxide detectors, and the like to monitor for emergencies within the building (Figure 5). The monitored information is sent via the network to a supervisor in the form of emergency signals and images. This information can also be stored and managed on a security data server, if needed.

**Crime Prevention Systems**
Crime prevention systems may incorporate sensors such as door open-close detectors and glass break detectors to detect emergencies as well as ingress and egress management functions to enforce entrance and exit regulations and keep logs of those entering and leaving. They control the entrance and exit of persons to and from the building in conjunction with the information from the monitoring systems (Figure 5).

**Communication Networks of Security Systems**
Via the network, the large volumes of data making up the security logs, operation logs, and entrance and exit logs from the monitoring and crime prevention systems are tracked on security monitoring PCs and stored and managed on security data servers. This information may also be linked via a network to other building automation systems (air conditioning systems, lighting systems, etc.) to enable more efficient building security management.

Renesas offers the following solutions for building security applications and provides support to developers as well.

**Sensing (Sensors for Monitoring and Crime Prevention)**
Motion detectors / Smoke detectors / Carbon monoxide detectors / Glass break detectors

**Connectivity (Networks Linking Units and Systems)**
Power line communication (PLC) / Bluetooth low energy (BLE) / Sub-GHz

**HMI (Ingress and Egress Management)**
Human-machine interface (HMI) / Capacitive touch keys
In recent years, there is increased demand in building lighting for reduced installation and operating costs as well as energy efficiency, low maintenance, and attractiveness (the ability to adjust the brightness and color of the light) in order to attract tenants and users. The keys to achieving these things are network support, task/ambient lighting, brightness and color adjustment, and digitization. One building management network standard that is gaining worldwide adoption is the BACnet communication protocol. BACnet supports integrated management of building automation systems for air conditioning, lighting, crime prevention, disaster prevention, and more. In addition, it makes it possible to reduce the energy consumption of the building overall. The Renesas Synergy™ Platform provides solutions that support BACnet.

A variety of connected communication devices support the subsystems that run under BACnet. Among these communication standards, Digital Addressable Lighting Interface (DALI) is an open standard that supports lighting systems.

**DALI Communication**

DALI is an international communication standard for lighting specified in IEC 62386. Communication takes place between a master (control device) and slaves (control gear). The DALI standard supports a single control device, which can control up to 64 items of control gear.

One feature of DALI is that the entire setup is standardized systematically. Data transfer route basics are covered by 101, control gear by 102, control devices by 103, and so on. Control devices include routers, switches, and motion or light sensors. Control gear includes lighting fixtures. There are also upper-level standard numbers (2xx and 3xx) that cover characteristics specific to individual devices. This means that a variety of lighting products can be developed on a shared foundation. A second feature is that DALI is an open standard. Products from different manufacturers can connect to each other, to adjust the brightness and color for example. Thus, it is possible to centrally manage the entire lighting system and implement control in a way that saves energy. DALI lets users maximize the energy efficiency of the building’s lighting system.

**Advancing to DALI-2**

A new DALI standard, DALI-2, is currently coming into use. DALI-2 defines new applications, adds new functions, and improves compatibility to better meet the lighting requirements of customers. Also, a device must pass an official test to receive certification of compliance with the standard. Renesas was the first semiconductor device manufacturer to join the DALI standardization organization. This enables us to deliver solutions that track the latest trends in the standard and include a tested protocol stack by official DALI tester.

**Implementing Task/Ambient Lighting with DALI**

“Task/ambient lighting” means that different types of lighting are used for “tasks” such as desks and for “ambient” areas such as floors and corridors. Some features of task/ambient lighting are that it can boost work efficiency by allowing adjustment of the brightness and hue to match individual preferences, and that it can boost energy efficiency by providing only the amount of night needed in each location. Further energy savings can be achieved by, for example, using motion sensors to detect when people are around, allowing the lights to be extinguished automatically when not needed, or using light sensors to detect light from outside, which can be taken into account when controlling brightness. Figure 3 shows an example of task/ambient lighting using DALI.

This task/ambient lighting configuration allows individual control of the lighting of task areas such as desks and of ambient areas such as floors and corridors. The lighting fixtures, sensors, and switches are all connected via DALI, and alternatively a unit such as a lighting controller can be used to provide centralized management. In this way DALI can be used to link and control all essential devices, making it easy to implement task/ambient lighting.
Digital Power Supplies for Lighting Fixtures

LED lighting product development cycles are growing shorter due to efforts to respond to new market needs. In particular, development of the power supply block, where several functions are concentrated, is a key point. One way to make development more efficient is to digitize the power supply. Digital power supplies provide three major features.

- Fewer Components
  Since software can be used to tune the performance of a digital power supply, there is no need for the hardware tuning components previously required. In addition, MCUs designed for digital power supplies integrate essential peripheral functions on-chip, so the cost of external IC devices is greatly reduced.

- Shorter Development Time
  It is possible to modify the operation of a digital power supply simply by making changes to the software (parameters). This means that creating a platform based on a common board and software makes it easy to derive new products from existing ones. In addition, there is a high affinity with communication functions, making it possible to develop DALI-conformant products that match market needs in a short period of time.

- Improved Power Supply Performance
  When a sudden change in load occurs, it is possible to keep the output variation smaller with a digital configuration than with an analog one. This means that there is no longer any need for capacitors to suppress LED flicker when dimming the brightness or as a countermeasure for ripple currents. In addition, digital power supply technologies such as variable gain and auto-tuning can be used to increase responsiveness, maintain stability, and suppress variability in ways that are not possible using analog devices.

Renesas Solutions

Renesas offers many solutions that provide powerful support for customers’ product development efforts in areas such as networking and digital power supplies.

- HMI solutions (page 13)
- Connectivity solutions (page 14)
- Sensing solutions (page 16)
MOTOR CONTROL SOLUTIONS

Renesas motor control solutions aim to make buildings more efficient by reducing the power consumption of motors. A number of motor control methods are used to accommodate various product applications, and each poses its own difficulties during development. Renesas offers motor control solutions for both induction and brushless DC motors. They include environments for trying out V/F control with induction motors, and for experimenting with 120-degree conduction control and vector control with brushless DC motors. A wide variety of sample programs, documentation, and development support tools are available, providing total support for customers’ development efforts.

Induction Motor Control Solution

Outline
This solution enables single-phase or three-phase induction motor inverter control (V/F control) using a microcontroller.

Configuration
- Motor control evaluation system for use with RL78/G14.
- Induction motor control software for the target microcontroller is available for download on the Renesas website and can be used in conjunction with inverter boards from our partner vendors.

Applications
- Induction motor control for fans, pumps, compressors, etc., in HVAC units.

Brushless DC Motor Control Solution

Outline
This solution supports multiple control methods for driving brushless DC motors and includes hardware, control software, and development support tools. It provides an easier way to evaluate sensorless vector control, which enables motor drive with high efficiency and at low cost.

Configuration
- The motor control evaluation board (RX23T) includes a board and a motor for evaluating motor control.
- Motor control software for the target microcontroller is available for download on the Renesas website.
- It is possible to perform evaluation using different microcontrollers for motor control use simply by swapping CPU cards.
- Supports the Renesas Motor Workbench development support tool.
  - Automatic tuning function for vector control (Tuner)
  - Debugging functions optimized for motor control (Analyzer)

Available Software (Devices, Control Methods)

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<th>Rotor Detection</th>
<th>RX 23T</th>
<th>RX 24T</th>
<th>RX 24U</th>
<th>RX 66T</th>
<th>RL78 G1F</th>
<th>RL78 G1G</th>
<th>RL78 G14</th>
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<tr>
<td>Vector control</td>
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<td>120-degree conduction</td>
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<td>Hall sensor</td>
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Note: For detailed information, please contact a Renesas sales representative.

Applications
- Brushless DC motor control for fans, pumps, compressors, etc., in HVAC units.
USER INTERFACE SOLUTIONS

Renesas HMI solutions comprise microcontrollers incorporating exclusive touch panel sensing technology and a custom development environment that facilitates quick development of high-grade products. There are also solutions that can be used to boost legibility and ease of use with interfaces supporting video and 3D-graphics. These solutions support the efforts of customers to develop systems providing high affinity between human and machine and allow users to make the most of the functions they offer. AE-CAP1, with support for capacitive touch, and PE-HMI1, with support for HMI, are available as solutions through the Renesas Synergy™ Platform. For details, refer to Renesas Synergy™ Platform Solutions on page 22.

Capacitive Touch Panel Solution

Outline
With the capacitive touch panel solution customers can use the RX130 or RX231 to develop product interfaces employing touch panels instead of conventional mechanical switches. This solution supports customer's efforts to develop products that can withstand water, dirt, and temperature variations while providing an attractive and sophisticated design.

Configuration
• Comprises RX130 or RX231 evaluation system and QE for Capacitive Touch GUI tool.
• Using the board and software included in the RX130 evaluation system you can get started with evaluation right away.
• The RX231 evaluation system integrates segment LCD display, audio playback, and touch panel circuits, allowing development and evaluation of HMIs and application products.

HMI Solutions

Outline
These human-machine interface solutions incorporate RZ/G2E and RZ/G2M microcontrollers and enable customers to create new value through sensing. Designed for use in system evaluation and development, they support multi-plane video processing, 3D graphics, and a variety of high-speed interfaces.

Configuration
• The RZ/G2E and RZ/G2M evaluation boards each support a Verified Linux Package (VLP).
• The VLP utilizes an industrial grade Linux Civil Infrastructure Platform (CIP) providing 10 years or more of long-term support.
• The product package includes middleware that has been verified on the evaluation board. This enables customers to develop applications in a stable operating environment.

Applications
For use in the HMI block of HVAC, fire and safety, building security, or lighting systems.

Capacitive Touch Panel Solution

RX130 Evaluation System
RX231 HMI Solution Kit

Applications
For use in the HMI block of HVAC, fire and safety, building security, or lighting systems.
Renesas connectivity solutions are available for wireless communication (BLE and Sub-GHz) and wired communication (PLC) applications. They enable customers to build networks linking devices and systems without the need to install new wiring. Evaluation boards, sample software, evaluation tools, and documentation are provided to provide total support for customers’ development efforts.

**Bluetooth Low Energy Solution**

**Outline**
Bluetooth® low energy (BLE) enables low-power data links with devices including smartphones. Customers can use the evaluation board to develop new BLE applications with a BLE system employing the RL78/G1D. The evaluation board is FCC, IC, CE, KC, SRRRC, and MIC (Japan) certified.

**Configuration**
- RL78/G1D evaluation board and BLE control (GUI) tool
  - BLE protocol stack
  - Bluetooth Developer Studio (BDS) plugin
  - GATTBrowser smartphone app for BLE operation confirmation

**RS-485 Communication Solution**

**Outline**
RS-485 uses differential signaling to enable long-distance data transfer, even under noisy conditions. It also aims to improve and extend the functionality of the earlier RS-422 standard. With RS-485 up to 32 devices can share a single data line. Any slave device on the RS-485 bus can communicate with the other 31 devices without the need to connect via a master device.

**Features of Renesas Products**
- Extensive product lineup to meet an array of system requirements
- High-speed communication support (up to 100Mbps)
  - PROFINBUS® support
  - Isolated products
  - Operation at 125°C
- Highest level of noise tolerance and ESD protection

**Product Examples**
- High speed (RS-485)
  ISL3159E: PROFINBUS support, high-speed (40Mbps), operation at 125°C
  ISL3259E: Ultra-high speed (100Mbps)
- Overvoltage protection (RS-485)
  ISL3245XE: ±60V overvoltage protection, among the best in the industry
- High output voltage/high noise tolerance (RS485)
  ISL315XE: Output voltage of 2.4V (min.), 3.1V (typ.)
- Isolation (RS-485)
  ISL32741E/5E: High isolation voltage (6kVrms), High-speed (40Mbps)
  ISL32740E: Small QSOP package, High-speed (40Mbps), 125°C operation

**Sub-GHz Solution**

**Outline**
Provides support for the Wi-SUN for ECHONET Lite Profile, an international wireless communication standard established by the Wi-SUN Alliance, to enable home energy management applications such as smart meters or home energy management systems (HEMS) to use the ECHONET Lite communication standard wirelessly on the 920MHz frequency band.

**Configuration**
- RL78/G1H evaluation board as low-power solution
- RX651 + RAA604S00 evaluation board as advanced functionality solution
- Both products include RF driver/MAC stack, IP stack, and RF characteristics evaluation program.

**Applications**
Used for induction motor control for fans, pumps, compressors, etc., in HVAC units.
Power Line Communication (PLC) Solutions

Outline
The R9A06G037 PLC modem chip supports the G3-PLC and PRIME powerline communication standards, and the Renesas protocol stack is certified by both alliances. Under G3-PLC support can be added for different regional modem standards (Japan, Europe, and North America) by changing to the appropriate software library (supplied). Available development tools include evaluation boards, protocol stacks, and sample application software.

System Block Diagram

Evaluation Kits
These evaluation kits can be used to develop software for the R9A06G037 PLC modem chip and to evaluate systems using it. Separate kits are available for AC and DC.

• High-Voltage Version: AC 100 to 230V
This kit is certified as special carrier system digital transmission equipment (technically compatible), allowing it to be used as a power line communication device under Article 44, Paragraph 1 of the Japanese Radio Law Enforcement Regulation.

J70D2 (RTK0EE0003D02002BJ)

Board Configuration
This product comprises the following three boards:
1) PLC board: PLC modem chip and AFE device
2) Base board: Power supply circuit and control microcontroller (RX631)
3) Filter board: Filter circuit compliant with G3-ARIB standard

Applications
For communication functions in air conditioner systems, LED lighting systems, solar panel monitoring systems; voice communication functions in alarms, water heaters, etc.; communication between boards in multifunction office machines; etc.

• Low-Voltage Version: AC 24V or DC 48V
This kit is a PLC evaluation kit for use with DC power lines. There is also a kit with support for audio communication solutions.

J80D2 (RTK0EE0007D02001BJ)

Board Configuration
This product comprises the following three boards:
1) PLC board: PLC modem chip and AFE device
2) RL78/G13 MCU board: Control microcontroller board (RL78/G13)
3) Power supply filter board: Impedance booster and PLC signal elimination filter for DC power supply source

J80D1 (RTK0EE0007D01001BJ) Note: Audio support

Board Configuration
This product comprises the following four boards:
1) PLC board: PLC modem chip and AFE device
2) RX651 board: Control microcontroller board (RX651)
3) Audio board: Audio input board
4) Power supply filter board: Impedance booster and PLC signal elimination filter for DC power supply source

Voice Communication Solution
A RX651 library is provided to enable use of the R9A06G037 PLC modem chip to realize a voice communication solution. Voice data can be encoded and decoded, and sent and received over power lines via the R9A06G037. The J80D1 evaluation kit is supported. In addition, a GUI tool can be used to easily control and check the status of voice communications.
SENSING SOLUTIONS

These solutions are suitable for building security systems and deliver low cost and power efficiency alongside highly accurate measurement. Using these reference boards contributes to significantly shorter development time. The core devices of these solutions are RL78/I1x microcontrollers. They combine the exclusive architecture and superior power performance of the RL78 Family of microcontrollers with analog functions ideal for sensing applications. For details, visit the RL78/I1x Series page on the Renesas website.

Glass Break Detector Solution

**RL78/I1D Detect it!**

**Outline/Features**
This solution uses a microphone to detect when the glass is broken. Active filtering for the microphone is implemented using the microcontroller’s on-chip low-power op-amp. Reduces costs while achieving extended operation on battery power.

**Configuration**
- Microcontroller: RL78/I1D low-power analog microcontroller
- Solution board: RL78/I1D Detect it! glass break detector board
  Circuit diagrams, parts lists, and sample programs are available.

Applications
Crime prevention products

Smoke Detector Solution

**RL78/I1D Detect it!**

**Outline/Features**
This solution uses an infrared LED and an optical receiver to detect the presence of smoke. The low-power RL78/I1D with on-chip sensor amplifier helps reduce system cost while achieving extended operation on battery power.

**Configuration**
- Microcontroller: RL78/I1D low-power microcontroller
- Solution board: RL78/I1D Detect it! smoke detector board
  Circuit diagrams, parts lists, and sample programs are available.

Applications
Sensors, alarms

Carbon Monoxide Detector Solutions

1) **RL78/I1D Detect it!**

**Outline/Features**
This sensing solution uses a carbon monoxide canister. It enables detection of carbon monoxide at concentrations of 100ppm ±10ppm.

**Configuration**
- Microcontroller: RL78/I1D low-power analog microcontroller
- Solution board: RL78/I1D Detect it! carbon monoxide detector board
  Circuit diagrams, parts lists, and sample programs are available.

Applications
Carbon monoxide warning systems, carbon monoxide detectors

2) **RL78 Quick Solution**

**Outline/Features**
This is a reference design for a carbon monoxide alarm for home use. The output of a carbon monoxide canister is amplified by the ISL28113 op-amp, and A/D conversion is performed on the compact, low-pin-count RL78/G10 MCU to determine the concentration of carbon monoxide.

**Configuration**
- Microcontroller: Compact, low-pin-count RL78/G10 MCU
- Op-amp: ISL28113

Applications
Carbon monoxide alarm for home use
**Motion Sensor Solutions**

1) RL78/I1D Detect it!

**Outline/Features**

This solution uses pyroelectric motion sensors to detect the movement of persons. Two sensors are used to allow detection of the direction of movement. The microcontroller’s on-chip low-power op-amp reduces the system cost.

**Configuration**

- Microcontroller: RL78/I1D low-power analog microcontroller
- Solution board: RL78/I1D Detect it! motion detector board

Circuit diagrams, parts lists, and sample programs are available.

---

**Portable PM2.5 Measuring Device Solution**

**RL78 Quick Solution**

**Outline/Features**

This portable measuring device detects and measures the concentration of PM2.5 in the air in real time. The air quality is indicated by the color of an LED (red, green, or blue) and an LCD panel. The system also provides charging and power supply functionality as a mobile battery, and displays the battery capacity using LEDs. If the PM2.5 concentration exceeds a preset threshold or the battery voltage drops below 2.8V, a buzzer sounds.

This solution utilizes the I/O port, A/D converter, buzzer, LCD controller, and STOP mode functions of the RL78/L12, a microcontroller ideally suited for small home appliances. In addition, the ISL97656 (DC-DC converter chip) controls battery discharge and the ISL6294 (battery charger chip) controls charging. The threshold value and PM2.5 concentration data are saved in EEPROM. (If there is less than 2KB of data, it can be stored in the on-chip data flash of the RL78/L12.)

**Configuration**

- User’s manual, source code, circuit diagram, PCB, and BOM are available.

---

2) RL78 Quick Solution

**Outline/Features**

This Infrared Human Sensor reference design detects human presence/absence using an infrared sensor, and turns on/off a high brightness LED automatically. It can be applied to a wide range of applications including office lights and automatic doors.

**Configuration**

- User’s manual, source code, circuit diagram, PCB, and BOM are available.

---

**Applications**

Crime prevention units, lighting systems
Renesas lighting solutions provide powerful support for your development efforts. They make it possible to develop lighting applications in a short period of time in response to market demand for functionality such as network connectivity, digital power supply, and brightness or color adjustment. These solutions consist of an LED lighting evaluation environment, software development environment, communication evaluation environment, and application notes containing detailed information on how to use them.

### LED Lighting Evaluation Environment

- **Digitization of the power supply enables reduction of development workload and cost by creating a platform.**
- **Single-stage-converter 1-channel type**
  - Reduces costs, and digital control prevents flicker.
  - Applications: Down lights, tube lights
- **Two-stage-converter 1-channel type**
  - Low-brightness, multistage, high-performance dimming.
  - Applications: Base lights, ceiling lights
- **Two-stage-converter 3-channel type**
  - Support for full-color hue adjustment.
  - Applications: Base lights, stage lighting

### Software Development Environment

- Automatic Software Generation Tool
- DALI Protocol Stack Library

### Application Notes

- LED control
- PFC control
- Lighting communication (transmission)
- Lighting communication (reception)
- And More

### Communication Evaluation Environment

- DALI- and DMX512-compatible GUI
- Note: Available for download free of charge on the Renesas website.

### LED Lighting Evaluation Environments and Communication Evaluation Environments

LED lighting evaluation environments consist mainly of reference solutions for developers of LED lighting fixtures. Several evaluation boards with different topologies and dimmer interfaces including DALI are available for a variety of customer applications. All boards support digital power supplies. Communication evaluation environments provide reference solutions for developers of products such as dimmers with communication capabilities (communication masters, DALI switches, sensors). They can be used to evaluate communication with lighting fixtures. Visit the Renesas website for details of each board.

<table>
<thead>
<tr>
<th>LED Lighting Evaluation Environment and Communication Evaluation Environments</th>
<th>RL78/I1A DC/DC LED Control Evaluation Board (EZ-0012)</th>
<th>AC/DC Single-Stage-Converter 1-Channel Output (TPW-RL7811A-1C)</th>
<th>AC/DC Two-Stage-Converter 1-Channel Output (TPW-RL7811A-2C)</th>
<th>AC/DC Two-Stage-Converter 3-Channel Output (TPW-RL7811A-3C)</th>
<th>Lighting Communication Master Evaluation Board (TCM-RL7811A)</th>
<th>Renesas Synergy™ S128 DALI-2 Solution Board</th>
<th>Synergy S128 DALI-2 Solution Board</th>
<th>RL78/I1A DALI-2 Solution Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>DC 5V</td>
<td>AC100-240V</td>
<td>AC100-240V</td>
<td>AC100-240V</td>
<td>DC5V</td>
<td>DC 5V or USB</td>
<td>8 to 24V</td>
<td>8 to 24V</td>
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<tr>
<td>AC/DC</td>
<td>Flyback (DCM-PFC)</td>
<td>Boost (CRM-PFC)</td>
<td>Flyback (CRM-PFC)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>DC/DC</td>
<td>Buck (high-side drive)</td>
<td>Buck (low-side drive)</td>
<td>Buck (high-side drive)</td>
<td>—</td>
<td>—</td>
<td>PWM chopper</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Output (max.)</td>
<td>5V 350mA</td>
<td>60V, 200mA 1-channel (LED single-color applications)</td>
<td>200V, 250mA 1-channel (LED single-color applications)</td>
<td>90V/channel, 350mA/ channel 2-channel (LED full-color applications)</td>
<td>—</td>
<td>—</td>
<td>2A/20V</td>
<td>—</td>
</tr>
<tr>
<td>Dimmer type (min, dimmer value)</td>
<td>Current dimmer</td>
<td>Current dimmer (5%)</td>
<td>Current + burst dimmer (0.4%)</td>
<td>Current dimmer (1%)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0-10V</td>
</tr>
<tr>
<td>Dimmer interface</td>
<td>DALI/DMX512/IR/Volume</td>
<td>Volume SW</td>
<td>DALI/IR</td>
<td>DALI/DMX512/IR</td>
<td>DALI/DMX512/IR</td>
<td>DALI</td>
<td>DALI</td>
<td>DALI</td>
</tr>
<tr>
<td>Automatic Software Generation Tool</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>—</td>
</tr>
<tr>
<td>Unit size (W x D x H)</td>
<td>65 x 115mm</td>
<td>190.4 x 107.6 x 63.8mm</td>
<td>190.4 x 110.6 x 63.8mm</td>
<td>240 x 195 x 70mm</td>
<td>120 x 120mm</td>
<td>140 x 160mm</td>
<td>55 x 86mm</td>
<td>50 x 86mm</td>
</tr>
</tbody>
</table>
Easily generate DALI communication or digital power control software using a GUI. Reduces the development workload and costs.

I'm new to programming…
I'm not confident about developing new software…
I'd like to refer to sample programs…

Single-converter board Dual-converter boards

Automatic Software Generation tool

Note: Available for download free of charge on the Renesas website.

(1) Generate software automatically by operating a mouse.

(2) Program the unmodified result to the board for evaluation.

Software Development Environment

**Applilet EZ for HCD**

This tool can be used to create sample code for LED lighting and communication software and to program this software to hardware. Simply specify dimmer operations or communication modes in the GUI to generate digital power control (PFC, DC/DC) or DALI/DMX512 communication software code. The software created in this way can then be programmed automatically to the MCU’s flash memory via a USB cable so that you can check its operation on the evaluation board. Applilet EZ for HCD is available for download free of charge on the Renesas website.

**Features**

- Dramatically reduces the workload required to develop and evaluate LED control and communication software.
- Allows evaluation of LED lighting or illumination systems without requiring an extensive knowledge of MCUs and MCU environments.
- Generated program code can be edited in an integrated development environment (IDE).

**DALI Protocol Stack Library**

Renesas is a member of the Digital Illumination Interface Alliance (DiiA). We have offered MCU products, evaluation boards, and protocol stacks supporting the DALI interface for over a decade, and a large number of customers in many countries have adopted these products. DALI protocol stack components from Renesas have been tested*1 by official DALI tester, who must all be members of the DiiA, so customers can use them with confidence. A number of library versions have also been developed by partner vendors working closely with Renesas. Moving forward, Renesas is committed to fostering the widespread adoption of DALI by supporting the development work of customers in collaboration with our partner vendors.

**Features**

- Tested by official testers.*1
- Versions are available to match specific MCU products.
- Substantially reduces the workload and time associated with development.
- Application notes providing a basic understanding of DALI are available.

---

**Protocol Stack Library Versions (as of October 2019)**

<table>
<thead>
<tr>
<th>IEC 62386 Standard</th>
<th>Applications</th>
<th>Details</th>
<th>RL78</th>
<th>Synergy*2</th>
</tr>
</thead>
<tbody>
<tr>
<td>102 ed.1.0</td>
<td>Lighting fixtures, PWM converters, etc.</td>
<td>Control gear (general requirements)</td>
<td>✓</td>
<td>—</td>
</tr>
<tr>
<td>207 ed.1.0</td>
<td>LED modules (particular requirements)</td>
<td>✓</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>102 ed.2.0</td>
<td>Control gear (general requirements)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>207 ed.2.0</td>
<td>LED modules (particular requirements)</td>
<td>Under development**</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>103 ed.1.0</td>
<td>Control devices (general requirements)</td>
<td>✓**</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>301 ed.1.0</td>
<td>Pushbuttons (particular requirements)</td>
<td>Under development**</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

---

*1. Official testers and test sequences are used to confirm the operation of the communication components of DALI products.

*2. CS-Lab GMBH

*3. Tessera Technology Inc.

*4. A simplified version has been released by Renesas. A version for input devices is under development by Tessera Technology Inc.
An array of power management solutions suitable for various systems and devices.

Renesas offers an extensive product lineup as high-performance power supply solutions for system processors, controllers, DSPs, FPGAs, CPLDs, DDR memory, and other loads. Such Renesas products include general-purpose linear regulators, highly flexible PWM controllers and regulators, and fully integrated power modules, each of which is designed to meet a particular need that arises during power supply development.
Analog Controllers

Advantages and Main Features

Stability and high performance
- Wide range of protection functions (OCP, OVP, OTP, SCP)
- Pre-bias startup, external compensation

Extensive product lineup
- Wide input voltage range up to 72V
- Multiple settings possible (single-output, multi-output, multi-phase)
- Wide frequency range: 100kHz to 2.5MHz
- Many package options (DFN, QFN, HTSSOP, QSOP, etc.)

High degree of integration
- On-chip MOSFET driver
- On-chip bootstrap diode
- Internal compensation

Switching Regulators

Advantages and Main Features

Stability and high performance
- Power-good, enable, variable software start
- Wide range of protection functions (OCP, OVP, OTP, SCP)
- External frequency synchronization

High degree of integration
- On-chip HS/LS FET
- Internal compensation

Target applications
- POL converters for servers and infrastructure
- Industrial PCs, factory automation, PLC
- General-purpose POL converters
- Communication and networking systems

Power Modules

Advantages and Main Features

Superior ease of use
- Completely integrated design that reduces complexity and simplifies design

Full functionality
- Numerous functions such as software start, fault protection, parallel modules, and multi-phasing

Renesas power modules

<table>
<thead>
<tr>
<th>PWM controller</th>
<th>MOSFET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductor</td>
<td>Compensation</td>
</tr>
</tbody>
</table>

High power density
- Ability to realize up to 250W POL output in a single package

Heat-resistant package technology
- Use of thermoplastic compounds for more efficient heat dispersion
- Large copper pads to improve thermal efficiency
- Full-load operation over wide temperature range
- Pin access via lead package

Not heat sink, no airflow
Direct heat transfer via copper lead frame
Renesas Synergy™ Platform Solutions for the Building Automation Market

Renesas Synergy™ Platform comprises software packages whose operation is warranted by Renesas, scalable microcontrollers, and integrated development tools. The platform is certified for quality, and also includes extensive eco-friendly systems. Renesas Synergy™ Platform provides developers of highly sophisticated embedded applications such as building automation an effective means to bring innovative new products to market quickly.

Reasons to Choose the Renesas Synergy™ Platform

Faster Development
Renesas takes care of the development of low level code up to the API. Customers can focus on innovating and differentiating their own end-products.

Lower Overall Costs
Software whose operation is warranted by Renesas lets developers minimize risks and reduce overall costs, including maintenance.

Lower Barriers to Entry
Since there is no need to start from zero with initial costs and complex licensing fees, developers can focus on innovation.

General Structure of Renesas Synergy™ Platform

Renesas Synergy™ Platform is composed of a solution gallery, software, and hardware. The solution gallery features software, tools, kits, application projects, and services from Renesas and partner vendors that are compatible with Renesas Synergy™ Platform. At the core of the platform is the Synergy Software Package (SSP) and development environment (tools). Both are available at no additional charge to purchasers of Renesas Synergy™ microcontrollers.

Scalable and Compatible Microcontrollers
Renesas Synergy™ Family microcontrollers are based on Arm® Cortex®-M CPU cores and designed for scalability and the ability to reuse code between series. They offer connectivity functions and human-machine interface features facilitating easy implementation, alongside robust security and safety functions as well as numerous peripheral functions suitable for a variety of embedded systems.
Features of SSP: Application Frameworks and VSAs (Verified Software Add-ons)

**Application Frameworks**

SSP has a rich set of Application Frameworks that provide a set of uniform Application Program Interfaces (APIs) that are useful for the development of target system. These APIs will free developers from worrying about the low-level software such as drivers, middleware or network stacks.

**Messaging framework:** High-level APIs for inter-thread communication and synchronization that give superior usability than traditional message queueing supported by real-time OS.

**GUIX™ interface framework:** APIs to leverage the performance advantage of Synergy Microcontroller graphic accelerators while using the GUIX runtime library.

**Wi-Fi framework:** APIs to easily integrate Wi-Fi connectivity solutions from various module and chipset providers into the user application.

**Capacitive touch sensing framework:** APIs to easily access the Capacitive touch sensing unit (CTSU). Also available is a Capacitive Touch Workbench for Renesas Synergy™ software tool to tune sensitivity of the touch sensors.

---

**VSAs (Verified Software Add-Ons)**

Developers who adopt SSP for building automation applications can also utilize verified software add-ons (VSAs) from third-party partners to implement a variety of functions. VSAs are pre-tested and verified by Renesas to be compatible with SSP.

**BACnet Stack:** BACnet stack compliant to CIA specifications. Available from CS Lab.

**Skkynet ETK:** Stack to connect device and cloud. Available from Skkynet.

**DALI 2.0 lighting control:** Stack compatible with the Digital Addressable Lighting Interface 2 (DALI-2) standard. Supplied by CS Lab.

**Medium One Cloud Agent:** Easily connect to cloud and access services. Available from Medium One.

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**Product Example (PE), Application Example (AE)**

Synergy Solutions are examples of actual products that adopt the platform (PE) or demonstrate a group of technologies that are implemented with the platform (AE). Following are solutions useful for BA.

**PE-HMI1**
- Connected Human Machine Interface
- Based on S7G2 Group MCU
- WVGA LCD display
- Wi-Fi, Bluetooth™ (BT), & wired connectivity

**AE-CLOUD1**
- Hardware kit for evaluating cloud connectivity
- Support for two cloud solutions (Synergy Enterprise Cloud Toolbox (SECT) and Renesas IoT Sandbox), enabling quick implementation of cloud connectivity
- Based on S5D9 Group MCU
- Many analog input functions suitable for a variety of sensor input types

**AE-CAP1**
- Capacitive Touch Evaluation and Tuning
- Based on S124 or S3A7 Group MCU
- Buttons, sliders, wheels

Other Available Synergy Kits: SK-S7G2, PK-S5D9, TB-S5D5, TB-S3A1, TB-S3A6, TB-S3A3, DK-S7G2, DK-S3A7, DK-S128, DK-S124
The Synergy Platform provides technologies that support the applications demanded by the building automation segment. It makes it possible to quickly deliver optimized solutions to meet constantly changing technology needs such as performance, power efficiency, and design flexibility.

**Synergy Platform Technology Matrix for the Building Automation Market**

<table>
<thead>
<tr>
<th>Building Automation Subsegment</th>
<th>Motor Control Solutions</th>
<th>User Interface Solutions</th>
<th>Connectivity Solutions</th>
<th>Sensing Solutions</th>
<th>Synergy MCU Series*</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC systems</td>
<td>&lt; PWM timer</td>
<td>&lt; Graphic LCD controller</td>
<td>&lt; Wired connection interface</td>
<td>&lt; Temperature sensor</td>
<td>S1 S3 S5 S7</td>
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<tr>
<td></td>
<td>&lt; DALI direct access to timer functions [SSP]</td>
<td>&lt; Capacitive touch sensing unit [MCU]</td>
<td>&lt; Wi-Fi framework</td>
<td>&lt; Analog data collection framework</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; A/D converter, D/A converter, comparator</td>
<td></td>
<td>&lt; Renesas RL76/G1D BLE chipset</td>
<td>&lt; Digital sensor interface</td>
<td></td>
</tr>
<tr>
<td>Fire and safety systems</td>
<td>&lt; Graphic LCD controller</td>
<td>&lt; Segment LCD controller [SSP]</td>
<td>&lt; Wired connection interface</td>
<td>&lt; Temperature sensor</td>
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<tr>
<td></td>
<td>&lt; Graphic LCD interface</td>
<td>&lt; Capacitive touch sensing unit [MCU]</td>
<td>&lt; Wi-Fi framework</td>
<td>&lt; Analog data collection framework</td>
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<tr>
<td></td>
<td>&lt; Capacitive touch solution [MCU]</td>
<td></td>
<td>&lt; BACnet stack VSA [VSA]</td>
<td>&lt; A/D converter, D/A converter, PGA, comparator</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&lt; Renesas RL76/G1D BLE chipset</td>
<td>&lt; Digital sensor interface</td>
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<td>Building security systems</td>
<td>&lt; Graphic LCD controller</td>
<td>&lt; Segment LCD controller [SSP]</td>
<td>&lt; Wired connection interface</td>
<td>&lt; Temperature sensor</td>
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<tr>
<td></td>
<td>&lt; Capacitive touch sensing unit [MCU]</td>
<td>&lt; Capacitive touch solution [MCU]</td>
<td>&lt; Wi-Fi framework</td>
<td>&lt; Analog data collection framework</td>
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<td></td>
<td></td>
<td></td>
<td>&lt; BACnet stack VSA [VSA]</td>
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<td>&lt; Renesas RL76/G1D BLE chipset</td>
<td>&lt; Digital sensor interface</td>
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<td>Lighting systems</td>
<td>&lt; General-purpose I/O ports</td>
<td>&lt; General-purpose I/O ports</td>
<td>&lt; General-purpose I/O ports</td>
<td>&lt; Temperature sensor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; Capacitive touch sensing unit</td>
<td>&lt; Capacitive touch solution</td>
<td>&lt; Serial interfaces (SPI, O SPI, I2C, UART)</td>
<td>&lt; Analog data collection framework</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt; DALI communication interface</td>
<td>&lt; A/D converter, D/A converter, PGA, comparator</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt; DALI 2.0 lighting control VSA</td>
<td>&lt; Digital sensor interface</td>
<td></td>
</tr>
</tbody>
</table>

* Refer to the block diagrams below for the recommended Synergy MCU Series for each subsegment.

1. **User Interface Solutions**
   - Graphic LCD, segment LCD control [MCU]
   - GUIX™ runtime library [SSP]
   - PE-HMI1 [PE]
   - Capacitive touch sensing unit [MCU]
   - Capacitive touch sensing framework [SSP]
   - Touch sensing workbench [SSP]

2. **Connectivity Solutions**
   - Wired connection: Single/dual Ethernet
   - USB, serial interfaces (SPI, QSPI, I2C, UART), SDIO
   - Wireless connection: Wi-Fi framework [SSP] for connection to various Wi-Fi devices and chipsets
   - BACnet protocol [VSA]
   - DALI 2.0 lighting control [VSA]
   - TLS/MOTT [SSP]

3. **Sensing Solutions**
   - Interfaces for data collection from analog sensors or digital sensors [MCU]
   - Op-amp, A/D converter, D/A converter, comparator [MCU]
   - Low-power operating mode for intermittent operation

4. **Motor Control Solutions**
   - High-precision timer, PGA, A/D converter, and D/A converter for motor control [MCU]
   - Direct access to MCU control registers for real-time control

5. **Embedded Security (Common Technology Across Subsegments)**
   - Encryption, security key generation and storage [MCU]
   - Security function library [SSP/MCU]

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**Building Security System Solution Block Diagram**

- Synergy S7 or S5 MCU Series acts as the primary controller for the hub (main controller).
- Synergy S3 or S1 MCU Series acts as the controller for the nodes.
- Connectivity to the cloud via Ethernet or Wi-Fi.
- BLE connectivity between nodes and the hub.
**Lighting System Solution Block Diagram**

- Synergy S7 or S5 MCU Series acts as the primary controller for the hub (main controller).
- Synergy S3 or S1 MCU Series acts as the controller for the nodes.
- Connectivity to the cloud via Ethernet or Wi-Fi.

**HVAC System Solution Block Diagram**

- Synergy S7 or S5 MCU Series acts as primary controller for Zone Control.
- Synergy S5 or S3 MCU Series for the Thermostat.
- Synergy S1 MCU Series acts as the controller for the nodes.
- Connectivity to the supervisory BAS system using BACnet.

**Fire and Safety System Solution Block Diagram**

- Synergy S7 or S5 MCU Series acts as the primary controller for the control panel.
- Synergy S3 or S1 MCU Series acts as the controller for the local sensing nodes.
- Connectivity to the cloud via Ethernet or Wi-Fi.
- BLE connectivity between nodes and the hub.
RECOMMENDED DEVICES FOR BUILDING AUTOMATION

The RL78 family is the new generation of power-efficient microcontrollers from Renesas. It enables customers to build compact and energy-efficient systems at lower cost.

**RL78**

The RL78 family is the new generation of power-efficient microcontrollers from Renesas. It enables customers to build compact and energy-efficient systems at lower cost.

### Comprehensive Development Environment
- Integrated development environment for more efficient development
- Support for powerful tools from Renesas partners

### Low Power Consumption
- 45.5μA/MHz operation
- 0.57μA (RTC + LVD)
- New SNOOZE mode

Note: 1. Power supply current value during basic RL78/G10 operation

### Reliable Safety Functions
- Memory with ECC
- Compliant with Safety Standard for Household Appliances (IEC 60730)
- Support for high operating temperatures (up to 150°C)
- Abnormal operation detection/avoidance function

### Reduced System Cost
- 32MHz ±1% high-precision on-chip oscillator
- On-chip power-on reset, low-voltage detection circuit, temperature sensor, data flash memory, etc.

### Broad Scalability
- 10 to 144 pins/1 to 512 KB
- Extensive product lineup to meet a broad range of requirements
- Pin compatibility
- Ability to reassign peripheral function pins

### High Performance
- High processing performance of 1.6 DMIPS/MHz
- Support for power supply voltages from 1.6V to 5.5V
- Max. 32 MHz operation

RL: Renesas Low Power
RL products deliver reduced power consumption.

### Roadmap of RL 78

![Roadmap of RL 78](image)

#### RL78/I1x Series
This series of microcontrollers provides functionality ideal for use in products for building systems and industrial applications. It is particularly well suited for applications involving sensing, energy control, measurement, and detection.

### Main Features

**Feature 1: Powerful analog functions**
Integrated ΔΣ ADC, CMP, PGA, etc., for reduced total cost

**Feature 2: Reduced power consumption**
The most advanced low-power functionality in the RL78 Family

**Feature 3: High-temperature tolerance**
Operation at up to 125°C

Note: Functions differ depending on the product.

<table>
<thead>
<tr>
<th></th>
<th>10bit SAR ADC</th>
<th>12bit SAR ADC</th>
<th>24bit ΔΣ ADC</th>
<th>DAC</th>
<th>Comparator</th>
<th>Temperature Sensor</th>
<th>Op-Amp (PGA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL78/I1A</td>
<td>*</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>RL78/I1B</td>
<td>*</td>
<td>*</td>
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<tr>
<td>RL78/I1C</td>
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<td>RL78/I1D</td>
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</tr>
<tr>
<td>RL78/I1E</td>
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</tbody>
</table>
ASSP for LED Lighting Power Supplies

**RL78/I1A**

**Features**
- Basic peripheral functions for lighting power supplies
  - Timers for LED control and PFC control
  - Analog feedback functions (PGA, comparator)
  - Operation temperatures up to 105°C or 125°C
- Robust connectivity functions
  - Communication functions (DALI, PMBus, SMBus, DMX512, UART, I2C, CSI)

**Peripheral functions specifically for intelligent and highly efficient operation**
- Dithering function (0.98ns pseudo-resolution), soft start function, maximum frequency limit function, interleaved PFC, communication standby

**Main Applications**
- LED lighting
- Digital power supplies
- Illumination fixtures
- Laser printers
- Microwave ovens
- Vacuum cleaners
- Communication devices

ASSP for Power Meters

**RL78/I1B, I1C**

**Features**
- ΔΣ ADC with enhanced functionality for power meters
  - Implementation in hardware of functionality essential for measurement
- Low power consumption
  - Low power consumption during both metering operation and backup operation

**High-speed on-chip oscillator with ±0.05% accuracy**
- Implementation in a single-crystal system of precision needed for metering operation
- Enhanced security functions and antithetic operation performance
  - Industry’s first hardware implementation of AES GCM mode for DLMS standard (I1C)

**Main Applications**
- Smart meters
- Eco-friendly meters

ASSP for Sensors and Detectors

**RL78/I1D**

**Features**
- Low power consumption for extended operation on battery power
  - Fast recovery from STOP mode in 3.4μs, and low 124μA operating current at 1MHz
  - Support for peripheral circuit operation bypassing the CPU (sensor activation, amplification, acquisition of A/D conversion results), determination of whether or not the CPU needs to be activated based on A/D conversion results

**On-chip integration of analog functions needed by sensors and detectors**
- General-purpose op-amp, 12-bit A/D converter, comparator

**Main Applications**
- Sensors, detectors
- Other crime prevention devices
- Battery-powered devices
- Sensor applications

ASSP for High-Precision Sensing

**RL78/I1E**

**Features**
- Analog functions for high-precision sensors
  - 24-bit ΔΣ A/D converter × 4 channels
  - 10-bit SAR-A/D converter ×10 channels
  - Configurable amplifier ×3 channel
  - 12-bit D/A converter ×1 channel
  - Sensor power supply ×1 channel

**Compact package, contributing to more compact sensor products**
- 4mm-square: 36-pin FBGA
- 5mm-square: 32-pin VQFN
- High-temperature tolerance
  - -40 to 125°C

**Main Applications**
- Measuring devices
- Sensor applications
- Vacuum cleaners
- Communication devices
PLC transfers communication signals by overlaying them on power lines, turning them into communication lines. No new wiring is required, and the use of power lines enables communication through barriers, such as walls and ceilings, that can block wireless signals. This is why PLC is gaining attention as a key communication tool for use with smart meters (Advanced Metering Infrastructure), HEMS, BEMS, and solar panel monitoring systems that will play key roles in realizing the “smart society” of the future. Both AC and DC power supply lines can be used for data transfer. This provides an effective way to reduce cable installation costs associated with building automation.

Renesas PLC modem IC support both the G3-PLC and PRIME specifications. The Renesas protocol stack is certified by the G3-PLC and PRIME specifications. The Renesas PLC modem IC support both the G3-PLC and PRIME specifications.

All sorts of products that impact people’s lives in areas such as household appliances, industrial equipment, building management, power networks, and transport are gaining intelligent functions, and the cloud-connected “smart society” is fast becoming a reality. In addition to high-performance and low-power control, today’s microcontrollers are now expected to have sophisticated capabilities that would be difficult to implement with earlier microcontrollers, such as biometric authentication, face recognition, barcode scanners, white goods, AC servo drivers, robots, industrial controllers, industrial motors, patient monitoring, surveillance robots, service robots, and smart speakers. The RZ Family delivers features not available elsewhere and brings new value to customer’s applications.

### RZ Family Roadmap

<table>
<thead>
<tr>
<th>Model</th>
<th>Year</th>
<th>Device</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>RZ/N1</td>
<td>2015</td>
<td>276MHz/256KB</td>
<td>CENELEC/ARIB 1.3.6/1.4(CEN.A) (PHY/MAC/ADP/…)</td>
</tr>
<tr>
<td>RZ/N2</td>
<td>2017</td>
<td>240MHz/512KB</td>
<td>CENELEC/ARIB 1.3.6/1.4(Full band) (PHY/MAC/ADP/…)</td>
</tr>
<tr>
<td>RZ/T1</td>
<td>2019</td>
<td>Cortex®-A9 (400MHz)</td>
<td>32MB, WXGA, 2D</td>
</tr>
</tbody>
</table>

### RZ/G Series Application Fields
- Centralized building management (HVAC)
- Security panels, signage
- Entrance/exit gates
- Elevator monitoring
- Surveillance cameras, multi-camera systems
- Intercoms, VOIP, videoconferencing
- Equalizers, karaoke machines
- Patient monitoring, surveillance robots, service robots

### RZ/A Series Application Fields
- White goods
- Barcode scanners
- Biometric authentication, face recognition
- Banknote detection
- Communication robots
- Intercoms
- Smart speakers

### RZ/T Series Application Fields
- Industrial motors
- Industrial controllers
- Robots
- AC servodrivers
The RX Family is built around an advanced CPU core exclusive to Renesas. This 32-bit CPU core benefits from all the exclusive technology amassed by Renesas over the years and adds enhancements to boost responsiveness and improve power efficiency. It achieves small code size typical of 16-bit CPUs while delivering top-class 32-bit arithmetic operation performance and low power consumption. Many technologies built by Renesas are integrated into the RX Family. It aims to be the ultimate family of 32-bit microcontrollers with on-chip flash for the industrial, home appliance, and OA/ICT fields.

### RX Family Features

**RX Family Lineup**

<table>
<thead>
<tr>
<th>Series</th>
<th>Speed</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX700 Series</td>
<td>~240MHz</td>
<td>4MB Flash, Max Dual Bank, EtherCAT, IEE1588, Ethernet, USB, CAN, SDHI, LCDC, Security and safety functions, Motor control</td>
</tr>
<tr>
<td>RX600 Series</td>
<td>~160MHz</td>
<td>4MB Flash, Max Dual Bank, IEE1588, Ethernet, USB, CAN, SDHI, LCDC, Security and safety functions, Motor control</td>
</tr>
<tr>
<td>RX200 Series</td>
<td>~80MHz</td>
<td>1MB Flash Max, 1.8 to 5.5V 0.12mA/MHz 0.8µA/standby, USB, CAN, SDHI, Security and safety functions, Motor control, Capacitive touch, IA sensors</td>
</tr>
<tr>
<td>RX100 Series</td>
<td>~32MHz</td>
<td>512KB Flash Max, 1.8 to 5.5V 0.1mA/MHz 0.35µA/standby, USB, Segment LCD, safety functions, Motor control, Capacitive touch</td>
</tr>
</tbody>
</table>

### Recommended Products

<table>
<thead>
<tr>
<th>Recommended Products</th>
<th>For motors</th>
<th>For sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX72M</td>
<td>RX72T</td>
<td>RXv3</td>
</tr>
<tr>
<td>RX65N/1</td>
<td>RX66T</td>
<td>RXv3</td>
</tr>
<tr>
<td>RX231/T</td>
<td>RX24U/T</td>
<td>RXv3</td>
</tr>
<tr>
<td>RX130</td>
<td>RX23T</td>
<td>RXv2</td>
</tr>
<tr>
<td>RX23E-A</td>
<td>RXv2</td>
<td>RXv2</td>
</tr>
</tbody>
</table>

### RX Family Lineup

#### Flagship

- **RX700 Series:**
  - RX71M: 240MHz, Up to 4MB Flash, Dual Bank Flash memory, LCD, Security (Trusted Secure IP)
  - RX72M: 240MHz, Up to 4MB Flash, Dual Bank Flash memory, LCD, Security (Trusted Secure IP)

#### Main Stream

- **RX600 Series:**
  - RX610, RX621, RX630, RX631: 100MHz, Up to 2MB Flash, LCD, Security (Trusted Secure IP)
  - RX64N, RX641: 120MHz, Up to 2MB Flash, LCD, Security (Trusted Secure IP)

#### Best-Mix

- **RX200 Series:**
  - RX210, RX220, RX23A: 50MHz, 32MHz, Up to 512KB Flash, Touch-key, Security (Trusted Secure IP Lite)

#### Entry-Level

- **RX100 Series:**
  - RX130, RX131, RX113, RX110, RX111: 32MHz, Up to 512KB Flash, High Precision A/D

#### For Motor

- **RX-T Series:**
  - RX23T, RX24T, RX23U: 80MHz, Up to 1MB Flash, CAN, PGA, Security (Trusted Secure IP Lite)
  - RX24U, RX24T: 80MHz, Up to 512KB Flash, CAN, PGA
  - RX23T: 40MHz, Up to 128KB Flash, USB, CAN, Security (Trusted Secure IP Lite)
  - RX24U, RX24T: 80MHz, Up to 512KB Flash, CAN, PGA
  - RX23E-A: 32MHz, Up to 256KB Flash, High Precision A/D

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In Planning

- **RX72M:**
  - RXv3
- **RX65N/1:**
  - RXv3
- **RX231/T:**
  - RXv3
- **RX24U/T:**
  - RXv3
- **RX130:**
  - RXv3
- **RX23E-A:**
  - RXv2
For more information, please contact buildingautomation@renesas.com
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