RX FAMILY

Renesas 32-Bit Microcontrollers
Mid-range 32-bit microcontrollers built around an exclusive CPU core developed by Renesas

Maintaining and Advancing the Renesas Tradition

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The following new products have been added:
RX700 Series: RX72M, RX72N, RX72T
RX600 Series: RX66N, RX66T
RX200 Series: RX23W, RX23E-A
RX100 Series: RX13T

Information on the following solutions has been added:
Resolver position control solution
Cloud solutions
Information on the RXv3 core has been added.
RX Family MCUs are built around advanced CPU cores packed with innovations unique to Renesas. Based on proprietary technology amassed over many years, they are designed to deliver improved responsiveness and power efficiency in all aspects while combining excellent operation performance and low power consumption. The RX Family brings together a variety of technical innovations from Renesas and aims to define the ultimate in 32-bit MCUs with on-chip flash memory for the industrial, home electronics, office automation, and ICT*1 fields.

Note: 1. ICT: Information and Communication Technology

Power and functionality poised to dominate the market:
The four powerful product series that compose the RX Family

The RX Family of 32-bit microcontrollers are built around Renesas’ exclusive RX CPU core and combine excellent operation performance with superior power efficiency.

The family consists of four product series: the flagship RX700 Series, with the fastest performance and most advanced functions; the mainstream RX600 Series; the RX200 Series, which delivers an optimal balance of power efficiency and high performance; and the entry-level RX100 Series, with extremely low power consumption. These four series encompass a range of products that provide seamless scalability from small-scale to large-scale applications.
With a proven track record and superior reliability, the RX family of 32-bit microcontrollers is suitable for a wide range of applications in the industrial and home electronics fields and supports the full lineup of customer products with a seamless range of operating frequencies from 32MHz to 240MHz.

Positioning of the RX Family

8/16bit MCU
- Renesas Core
- Low Power
  - Features: Ultra-low energy, Low pin count lineup available
  - Operating frequency: 20~32MHz
  - Applications: General-purpose, Sensor, Motor Control, LCD Display, Bluetooth® Low Energy, Sub-GHz Wireless Communication, Security

32bit MCU
- Power Efficiency
  - Features: Superior power efficiency, High-capacity flash memories, Broad lineup
  - Operating frequency: 32~240MHz
  - Applications: General-purpose, Motor Control, Security, Capacitive Touch, Battery Powered, LCD Control, Industrial Network, Cloud Connectivity

32/64bit MPU
- Arm® Core
- High Performance
  - Features: Multi-core up to 8 cores, Linux or RTOS available, High-capacity on-chip RAM, DRP* image processing acceleration
  - Operating frequency: 125MHz~1.5GHz

Features of the Four Series Composing the RX Family

RX700 Series
- Up to 240MHz
- The flagship of the RX Family, with the highest speed and best performance
- Features: Ultra-low energy, Low pin count lineup available
- Applications: General-purpose, Sensor, Motor Control, LCD Display, Bluetooth®, Sub-GHz Wireless Communication, Security

RX600 Series
- Up to 160MHz
- The mainstream of the RX Family, with high performance and an extensive product lineup
- Features: Superior power efficiency, High-capacity flash memories, Broad lineup
- Applications: General-purpose, Motor Control, Security, Capacitive Touch, Battery Powered, LCD Control, Industrial Network, Cloud Connectivity

RX200 Series
- Up to 80MHz
- The best balance between power efficiency and high performance
- Features: Qualified software and tools
- Applications: Motor Control, LCD Control, Network, IoT Devices, Security

RX100 Series
- Up to 32MHz
- The entry-level series designed for ultra-low power consumption
- Features: Qualified software and tools
- Applications: Motor Control, LCD Control, Network, IoT Devices, Security
# RX Family Lineup

<table>
<thead>
<tr>
<th>Flagship RX700</th>
<th>Mainstream RX600</th>
<th>Best Mix RX200</th>
<th>Entry RX100</th>
<th>For Motor RX-T</th>
</tr>
</thead>
<tbody>
<tr>
<td>RXv2 RX71N, RX72M</td>
<td>RXv2 RX63N, RX631, RX62N, RX621, RX630, RX610</td>
<td>RXv2 RX23W, RX210, RX220</td>
<td>RXv1 RX130, RX110, RX111</td>
<td>RXv1 RX63T, RX62T, RX62G</td>
</tr>
<tr>
<td>240MHz</td>
<td>120MHz</td>
<td>50MHz</td>
<td>100MHz</td>
<td>100MHz</td>
</tr>
<tr>
<td>RXv2 Double Precision FPU</td>
<td>RXv2 Double Precision FPU</td>
<td>RX231, RX230</td>
<td>RXv1 RX23E-A</td>
<td>RXv2 3-4 Motors</td>
</tr>
<tr>
<td>RX72N</td>
<td>RX65N, RX651</td>
<td>50MHz</td>
<td>32MHz</td>
<td>RX72T</td>
</tr>
<tr>
<td>240MHz</td>
<td>54MHz</td>
<td>32MHz</td>
<td>32MHz</td>
<td>100MHz</td>
</tr>
<tr>
<td>Up to 4MB Flash Register Bank Save</td>
<td>Up to 4MB Flash Register Bank Save</td>
<td>For Bluetooth</td>
<td>Up to 512KB Flash, Capacitive Touch Security (Trusted Secure IP Lite)</td>
<td>Up to 1MB Flash Register Bank Save, TFU USB/CAN, PGA Security (Trusted Secure IP Lite)</td>
</tr>
</tbody>
</table>

**Recommended Product**

- **RX Family Lineup**
- **In Planning**
- **Next-Generation RX7xx**
- **Next-Generation RX6xx**
- **Next-Generation RX2xx**
- **Next-Generation RX1xx**
- **Next-Generation RXxxT**

**Common Features**

- Dual Bank flash memory
- Ethernet
- USB/CAN
- LCD
- Security (Trusted Secure IP)

**Additional Features**

- For Motor: 3-4 Motors, 1 Motor
- For Sensor: Double Precision FPU
- For Bluetooth: 5V Support, Capacitive Touch
- For Sensor: High Precision AFE
- For Sensor: USB/CAN, PGA
- For Sensor: CAN, PGA
- For Sensor: 1 Motor
- For Sensor: Touch Key
- For Sensor: USB, LCD, Capacitive Touch
- For Sensor: 1 Motor
- For Sensor: 50MHz
- For Sensor: 80MHz
- For Sensor: 40MHz
- For Sensor: Security (Trusted Secure IP)
### RX Family Memory/Pin Lineup

#### Industrial, Home Appliances, and OA/ICT

<table>
<thead>
<tr>
<th>Flash memory</th>
<th>Pin</th>
<th>32</th>
<th>48</th>
<th>52</th>
<th>56</th>
<th>64</th>
<th>80</th>
<th>85</th>
<th>100</th>
<th>144/145</th>
<th>176/177</th>
<th>224</th>
</tr>
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<tbody>
<tr>
<td>RX700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RX600</td>
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<td></td>
<td></td>
<td>RX600</td>
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<tr>
<td>RX200</td>
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<td></td>
<td></td>
<td>RX200</td>
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<tr>
<td>RX100</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>RX100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Motor

<table>
<thead>
<tr>
<th>Flash memory</th>
<th>Pin</th>
<th>32</th>
<th>48</th>
<th>52</th>
<th>56</th>
<th>64</th>
<th>80</th>
<th>85</th>
<th>100</th>
<th>112/120</th>
<th>144</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX700</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>RX600</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>RX600</td>
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<tr>
<td>RX200</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>RX200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RX100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RX100</td>
<td></td>
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</tr>
</tbody>
</table>

### Contributing to the Development of Platforms in a Variety of Fields

Wide performance range from 32MHz to 240MHz, abundant peripheral functions for many applications, and excellent compatibility.
The RX Family is designed for compatibility across products in terms of CPU instructions, pin assignments, and functions.

- The instruction sets of the RXv1, RXv2, and RXv3 cores are intercompatible.
- The functions of RX Family MCUs are based on common IP cores, allowing for easy migration between RX products.
- The pin assignments of RX Family MCUs are fundamentally consistent with those of earlier Renesas products.
- Pin positions for digital peripheral functions can be selected from among multiple locations, simplifying the development of printed circuit boards.
- Compatibility among development environments has been enhanced, reducing the development burden and cost of tools while simplifying program management.

### RX Family Compatibility

<table>
<thead>
<tr>
<th>Pin assignments</th>
<th>Functions</th>
<th>Integrated development environments</th>
<th>On-chip debugging emulators</th>
<th>Compiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial in some cases</td>
<td>RX CPU</td>
<td>CS+/e² studio</td>
<td>E2 emulator/E2 emulator Lite</td>
<td>RX Compiler</td>
</tr>
<tr>
<td>Pin compatibility</td>
<td></td>
<td></td>
<td>E20 emulator</td>
<td></td>
</tr>
</tbody>
</table>

#### Pin Compatibility between Series for Power Supply, Analog, and USB

Analog and USB pins are pin compatible. Power supply pins are compatible except in some devices which require additional pins.

#### Existing Products and RX Extensibility

- The RX Family covers the performance range of a variety of CPU cores utilized in earlier Renesas products.
- Improved software reusability and unification of development environments allow the RX Family to provide seamless scalability when developing products over the entire model range from low- to high-end.
RX FAMILY SOLUTIONS

Functional Safety Solution for Industrial Automation

In the industrial equipment field, the importance of “functional safety,” which aims to maintain safety even when malfunctions occur, is increasing as a way to prevent the adverse effect of breakdowns and accidents on plant operation, the adverse effect of injuries to personnel on society, and the associated economic losses. The European Union’s Machinery Directive also requires that equipment meet functional safety standards.

In response to the need for functional safety certification in a range of industrial fields, Renesas provides RX Functional Safety as a one-stop solution designed to reduce the burden on customers at the development and functional safety certification stages.

RX Functional Safety

IEC 61508 SIL 3 core technology comprises three components: self-test software kits, SIL3 system software kits, and functional safety certified compilers. A self-test software kit is an MCU self-diagnostic software product package for examining the CPU, ROM, and RAM internal to the MCU. An SIL3 system software kit is a functional safety platform software product package for mutual diagnostics in MCUs with redundant configurations or controlling the behavior of user applications.

IEC 61508 SIL 3 reference kits include the results of cases where Renesas has drawn up the safety specifications and implementation specifications, and then implemented a detailed design, failure analysis, and diagnostics for an MCU redundant configuration system based on these cases. Both reference documents and reference hardware are available. To assist customers’ efforts to obtain certification, Renesas provides a wide range of support to match every development stage and situation, from individual seminars to design consulting and contracted software development.

Solution Application Examples

Motor Control Application

Remote IO Application

Remote IO Application

Solution Application Examples

Motor Control Application

Remote IO Application

Functional Safety Solution Products for Industrial Automation

Self-Test Software Kit

SIL3 System Software Kit

RX Functional Safety

Certification Support

IEC61508 SIL3 Reference Kit

SIL3 System Software Kit

Self-Test Software Kit

IAR Embedded Workbench® for RX FS

CC-RX Compiler

SIL3 System Software Kit

Full document set (total 19 volumes) common to all RX

RTK0EF0005Z11001ZJ

Set for concept phase (excepts in 4 volumes) common to all RX

RTK0EF0031Z11001ZJ

Reference Hardware

for RX71M-RX651

RTK0EF0058D01001BJ

for RX111-RX199

RTK0EF0061F32001SJ

(The functions of the product version and evaluation version are identical, but the evaluation version software is not subject to functional safety certification.)

Functional Safety Solution Products for Industrial Automation

Self-Test Software Kit

for CC-RX compiler

RTK0EF0054F32001SJ

for RX71M-RX651

RTK0EF0054F36001SJ

for RX111-RX199

RTK0EF0054F37001SJ

for RXv2 core evaluation version

RTK0EF0061F32001SJ

for RXv2 core product version

RTK0EF0061F22001SJ

(Renewal and transfer performed from 3 years to 1 year)
In recent years, the creation of new added value for the Internet of Things (IoT) has been gaining attention. On the other hand, since IoT devices connect to the Internet, they are exposed to risks such as eavesdropping, tampering, and viruses, and such harmful incidents are also seeing an increase in number. Consequently, the demand for security features is increasing for devices that previously didn’t need them.

Robust Security with Trusted Secure IP
RX security solutions implement Root of Trust for IoT devices using encryption by key data that is protected by a strong Trusted Secure IP and an authentication program using a memory-protection function. By implementing security functions using an RX microcontroller (MCU), you can easily and strongly protect IoT devices against threats. The RX65N and RX231 with Trusted Secure IP are CAVP certified under the FIPS 140-2 standard of the National Institute of Standards and Technology (NIST) of the United States, so the encryption algorithm employed can be used with confidence.

Hardware-Based Security Features of RX

<table>
<thead>
<tr>
<th>MCU Group</th>
<th>Function</th>
<th>Encryption</th>
<th>Memory Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX23W/RX231</td>
<td>Trusted Secure IP</td>
<td>AES, RSA, ECC, SHA, TRNG, Code Protect</td>
<td>Trusted memory, Area Protection, Memory Protection Unit</td>
</tr>
<tr>
<td>RX66T/RX72T</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>RX65N/RX66N/RX72M/RX72N</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Threats</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eavesdropping</td>
<td>Encrypted communication</td>
</tr>
<tr>
<td>Tampering</td>
<td>Secure updating</td>
</tr>
<tr>
<td>Virus</td>
<td>Secure boot</td>
</tr>
</tbody>
</table>

Secure updating: Authentication for program updating detects and prevents tampering
Secure boot: Authentication for program execution detects and prevents tampering

Components of Communication Security Evaluation Kit
Reference solutions for communication and security are available. Start implementing security features in your project immediately using one of these one-stop solutions.

Security Hardware Implementing Root of Trust

RX MCU

CPU

Threats

Eavesdropping

Tampering

Virus

Power supply failure

Illegal operation

Eavesdropping

Tampering

Virus

Hijack

Security Hardware Implementing Root of Trust

Study of security

Algorithm consideration

Key material consideration

Creation of security software

Communication startup

Implementation in communication

Approx. 18 months

Speed up Time-To-Market
You can greatly speed up the time-to-market of your security and communication project using these ready-to-use security evaluation kits.

Device Lifecycle Management (DLM) to Ensure Security from Manufacture to Decommissioning of IoT Devices
In recent years it has become necessary to ensure security over the entire lifecycle of a product. This process is called Device Lifecycle Management (DLM). By making use of RX security functionality to implement a root of trust, customers can implement robust and sophisticated security management that extends over the entire lifecycle of a device.

For details, visit the following webpage:
https://www.renesas.com/rx-security-solution
Renesas offers motor control solutions incorporating microcontrollers and analog products that are designed to enable reduced power consumption and quieter operation when driving brushless DC motors (permanent magnet synchronous motor) and stepping motors. Development tools optimized for each stage in the customer’s development workflow are available. They help shorten the time needed for development.

Development Workflow

- Specification design
- Circuit design
- Software design
- Device selection
- Debugging and tuning
- Evaluation
- Mass production
- Analysis of issues

Motor Control Starter Kit (Renesas Solution Starter Kit)
Just connect a power supply to get started checking your motor drive application.
This kit consists of a motor and an inverter board.*1
The provided “sample programs” are ideal for learning about different control methods.

Motor Control Development Support Tool  Renesas Motor Workbench
Analyzer function reduces the debugging workload. Tuner function enables simple vector control, even if you have no specialized knowledge.

Motor Control Starter Kit
- Motor control board (populated with MCU, power elements, etc.)
  - Target MCUs: RX23T, RX24T, RX24U, RX66T, RX72T, RX13T
- Brushless DC motor (permanent-magnet synchronous motor, 24V)*2
- Kit user’s manual and sample software are available on the website.
  - Available on website: Kit user’s manual, circuit diagrams, parts lists, application notes, sample software

Related URL
Renesas motor control solutions: https://www.renesas.com/solutions/motor

Notes:
1. The RX23T kit does not include the E1 or a power supply. These must be provided by the customer. The RX62T kit includes the E1.
2. The specifications of the supplied motor differ depending on the kit. For details, refer to the product specifications of specific kit.
Resolver Solution Features

- Low current consumption and low heat generation: Uses the minimum current necessary for torque control, and cuts current consumption in standby mode.
  - Reduced energy consumption, allowing for simplified cooling
- Low noise and low vibration: Server control reduces torque ripple, for reduced noise and vibration.
  - Ability to reduce cost of mechanical elements such as dampers
- Reduced motor size: Server control eliminates the need for a step-out margin and increases the usable torque.
  - Ability to achieve the same torque with a smaller motor

### Position Sensor Comparison

<table>
<thead>
<tr>
<th>Comparison Item</th>
<th>Magnetic Encoder</th>
<th>Optical Encoder</th>
<th>Resolver + RDC IC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position resolution (P/R)</td>
<td>Average</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Environmental resistance (dust, vibration, impacts, magnetism, moisture/oil)</td>
<td>Average</td>
<td>Bad *</td>
<td>Good Environmental resistance</td>
</tr>
<tr>
<td>Cost</td>
<td>Good Magnet + magnetic sensor + magnetic shielding and housing</td>
<td>Bad</td>
<td>Good Resolver + RDC IC</td>
</tr>
<tr>
<td>Overall evaluation</td>
<td>Average Suitable only for certain applications</td>
<td>Average Cost and environmental resistance</td>
<td>Good Performance, cost, environmental resistance</td>
</tr>
</tbody>
</table>

### Kit Information

- Renesas Motor Workbench
- Development Support Tool
- RDC Driver Motor Control
- Sample Code

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**Selected Products**

<table>
<thead>
<tr>
<th>Product</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU</td>
<td>RX24T 80/100-pin</td>
</tr>
<tr>
<td>RDC-IC</td>
<td>RAA3064002GFP LQFP48</td>
</tr>
</tbody>
</table>
| S/W     | - RDC Driver  
          - Motor Control Certified Sample |
| H/W     | Solution Board For evaluation Includes MCU, RDC, Inverter |
| Doc     | Application Note |
RX FAMILY SOLUTIONS

Capacitive Touch Solutions

RX Capacitive Touch Functionality

- Support for two capacitive touch technologies on a single chip:
  - Self-capacitance, which provides high sensitivity and proximity sensing, and mutual-capacitance, which provides superior water resistance.
  - Accurate touch input even in harsh environments and excellent design flexibility.
  - QE for Capacitive Touch program simplifies development by letting you easily adjust the sensitivity of touch sensors, previously a complex task, and control system operation.

<table>
<thead>
<tr>
<th>Features</th>
<th>Advantages for the User</th>
<th>Self-capacitance</th>
<th>Mutual-capacitance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High sensitivity/improved noise tolerance</td>
<td>Support for thick overlay panels or wood panels, operation when wearing gloves, and air gaps.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Improved water resistance</td>
<td>Enables capacitive touch operation in wet environments or outdoors.</td>
<td>✓</td>
<td>—</td>
</tr>
<tr>
<td>Simple development</td>
<td>The development tool can generate detection programs automatically, provides self-calibration functions to shorten development time, and reduces resource requirements.</td>
<td>—</td>
<td>✓</td>
</tr>
</tbody>
</table>

Roadmap

- More products with capacitive touch functions will be added to the RX Family moving forward.
- The RX130 group with small ROM capacity and low pin count can handle input from multiple touch controls.
- The RX113 Group has integrated LCD functions that can be combined with a touch panel to create an HMI.
- The RX231 and RX230 Groups combine the RX2 core with enhanced DSP and FPU with low-power-consumption technology for superior power efficiency.
- RX23W Group with Bluetooth 5 (QE for Capacitive Touch support only).

<table>
<thead>
<tr>
<th>CPU core</th>
<th>Touch generation</th>
<th>Development tools</th>
<th>Functions</th>
<th>Target applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL78/R8C core (16-bit)</td>
<td>1st generation capacitive touch IP</td>
<td>Workbench5</td>
<td>Simple functions, 5V operation</td>
<td>Electric home appliances, measurement</td>
</tr>
<tr>
<td>RX130</td>
<td>2nd generation capacitive touch IP</td>
<td>RXv2, 54MHz, improved DSP and FPU</td>
<td>5V operation, HMI</td>
<td>Electric home appliances, measurement, healthcare</td>
</tr>
<tr>
<td>RX113</td>
<td>QE for Capacitive Touch IP</td>
<td>USB, LCD</td>
<td>Healthcare, EMS, BA, HA, measurement devices</td>
<td></td>
</tr>
<tr>
<td>RX231</td>
<td>RX230</td>
<td>RX23W</td>
<td>RX23W</td>
<td></td>
</tr>
</tbody>
</table>

Product Lineup

- Lineup of packages with pin counts from 48 to 100 pins to accommodate the number of touch controls required by the system and the mounting area.
- Many ROM size options ranging from 64KB to 512KB to match the required scale of system control.

Capacitive Touch Evaluation System with RX130

Start evaluating your capacitive touch system right away. Evaluation of custom electrodes can be accomplished easily through development on the application board side. For details, refer to www.renesas.com/RTK0EG0003S02001BJ.

- **CPU board populated with RX130**
- **Touch application board**
  - Self-capacitance evaluation board
  - Allows evaluation of controls such as wheels, sliders, and buttons employing self-capacitance.
  - Mutual-capacitance matrix key + self-capacitance proximity sensor evaluation board
  - Self-capacitance and mutual-capacitance controls can operate at the same time, opening up possibilities for a wide range of applications.
- **USB cable**
- **Quick start guide**

The following items are available on the Renesas website:
- QE for Capacitive Touch, sample software, application notes, user’s manual, circuit diagrams, pattern diagrams
Alongside the rapid pace of technical innovations in networking, the emergence of IoT devices is accelerating in an array of fields and applications. By making use of a variety of sensor technologies data can be managed device by device, and it is now possible to obtain more types of device data than ever before. On the other hand, cloud-based services have become essential in order to efficiently process the enormous volumes of data involved.

Many manufacturers are deploying new technology to implement communications with the cloud, but the barriers to development are considered high. Renesas offers solutions that enable customers to easily build and evaluate cloud-based communication environments, allowing even customers with little experience in the development of IoT devices to get started with development work without delay.

### Renesas RX65N Cloud Kit

This all-in-one evaluation kit is intended for use in the development and evaluation of devices that communicate with Amazon Web Services (AWS). It includes a board mounted with three types of sensors and Wi-Fi communication functions as well as a standard software program for transmitting sensor data to the AWS cloud at regular intervals.

[www.renesas.com/rx65n-cloud](http://www.renesas.com/rx65n-cloud)

1. Certified for FreeRTOS.
2. Available from Renesas sales agents.
3. Wireless communication using Silex Wi-Fi module.
4. Send three types of sensor data (temperature/humidity, brightness, and three-axis accelerometer) to the AWS cloud and view a graphical display on Renesas Dashboard.*

*Renesas Dashboard: A Renesas system that allows users to view data sent to the cloud in graphical format on a web browser.

### Renesas Starter Kit+ for RX65N-2MB

Enables customers to evaluate the AWS cloud by programming FreeRTOS, an embedded OS provided by AWS for IoT devices, to the RSK. *

1. Certified for FreeRTOS.
2. Free download from GitHub.
3. Ethernet communication via wireless LAN.
4. Ability to use RX65N functions on RSK.*

*RSK: Renesas Starter Kit+ for RX65N-2MB

### e² studio with FreeRTOS Support

Use e² studio, the integrated development environment from Renesas, to download the latest verified FreeRTOS projects from GitHub and get started with development work right away. [www.renesas.com/e2studio](http://www.renesas.com/e2studio)

1. Generate and build the latest FreeRTOS sample projects from GitHub.
2. Provides assistance with network stack component library settings.
3. Easily add drivers and middleware to support USB, file systems, etc.
RX FAMILY SOLUTIONS

Human-Machine Interface (HMI) Solutions

RX231 HMI Evaluation Kit (R0K5RX231D000BR)

www.renesas.com/rx231hmi

This reference solution simplifies the process of developing user interfaces for home appliances, industrial equipment, healthcare equipment, or office equipment. It enables you to create attractive designs and user-friendly interfaces.

- Highly power efficient 32-bit RX231 microcontroller with integrated capacitive touch and USB functionality
- SAIC101 Smart Analog IC for controlling 16-bit A/D converter, amplifier gain, etc., allowing evaluation of the following functions:
  - Capacitive touch functions
  - Audio recording and playback functions (audio middleware)
  - LCD panel (character)
  - Pyroelectric infrared sensor, accelerometer

Release notes (User’s manual, circuit diagrams, parts lists, etc., are available for download on the Renesas website.)

RX65N/RX72N HMI Evaluation Kit (Envision kit)

www.renesas.com/envision

An all-in-one kit equipped with a WQVGA TFT-LCD makes it easy for customers to get started with GUI development.

- A debugger is provided, so a USB cable is all you need to perform debugging.
- Just launch the preinstalled demo to experience the capabilities of the 2D drawing engine.
- Segger emWin GUI tools are available for use free of charge.
- The RX72N version provides even higher performance and a larger memory capacity.
  Standard functions include onboard Wi-Fi, audio DSP, MEMS microphone, Ethernet, SD slot, and more.
- Includes sample code and video on GUI creation.

Visit the Renesas website for details.

Topics (Target Board for RX)

RX Evaluation Kit Entry Model (Target Board for RX130, RX231, RX23W, and RX65N)

www.renesas.com/rtxb

Two types of RX evaluation board are available to match the needs of different users: a Renesas Starter Kit board or an RX Family target board. The RX Family target board is an entry model intended for new users of RX products and is mounted with an MCU and an on-chip debugger only. It can be used for inexpensive and simple RX MCU evaluation using free sample code such as FIT modules available on the Renesas website. In addition to the previously available RX130, RX231, and RX65N versions, a new RX23W version with Bluetooth® Low Energy has now been added to the lineup.

[RX23W Target Board]

- Built-in emulator circuit:
  There is no need for the E2 Emulator or E2 Emulator Lite to perform application development.
- Ability to access all MCU signal pins:
  Pin header through holes are provided, allowing access to all MCU signal pins.
- Arduino interface:
  Arduino interface pin headers are provided to ensure expandability.
RX CORE FEATURES

RX Core Roadmap

The need for increasing added value and system complexity demands higher microcontroller performance. At the same time, energy saving and longer battery life is also needed, so lower power consumption is also demanded. The RX core continues to evolve even further to meet these demands.

RX Family Features:

Comparison of RX Cores

<table>
<thead>
<tr>
<th>Item</th>
<th>RXv1</th>
<th>RXv2</th>
<th>RXv3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>32-bit CISC, Harvard architecture</td>
<td>Downward compatible with RXv1</td>
<td>Downward compatible with RXv1/RXv2</td>
</tr>
<tr>
<td>General purpose registers</td>
<td>32bit × 16ch</td>
<td>109 instructions (90 RXv1 instructions + 19 instructions)</td>
<td>113 instructions (109 RXv2 instructions + 4 instructions)</td>
</tr>
<tr>
<td>Compatibility</td>
<td>RXv1</td>
<td>Downward compatible with RXv1</td>
<td>Downward compatible with RXv1/RXv2</td>
</tr>
<tr>
<td>Instruction set</td>
<td>90 instructions</td>
<td>109 instructions (90 RXv1 instructions + 19 instructions)</td>
<td>113 instructions (109 RXv2 instructions + 4 instructions)</td>
</tr>
<tr>
<td>Pipeline</td>
<td>5-stage</td>
<td>Improved 5-stage pipeline</td>
<td>Improved 5-stage pipeline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improved IPC through enhanced pipeline (enhanced performance through parallel execution of memory access and operations)</td>
<td>Improved IPC through enhanced pipeline (enhanced performance through improved combination of simultaneously executable instructions)</td>
</tr>
<tr>
<td>DSP function instructions</td>
<td>Single-cycle MAC instructions (16-bit), Accumulator × 1</td>
<td>Single-cycle MAC instructions (16-bit, 32-bit), Accumulator × 2</td>
<td>Single-cycle MAC instructions (16-bit, 32-bit), Accumulator × 2</td>
</tr>
<tr>
<td>Performance</td>
<td>Up to 3.12 CoreMark/MHz</td>
<td>Up to 4.55 CoreMark/MHz</td>
<td>Up to 5.82 CoreMark/MHz</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>-</td>
<td>Register bank save function (optional)</td>
</tr>
</tbody>
</table>

*Availibility of optional functions depends on product specifications
RX core combining advantages of CISC and RISC

- Combines the variable byte-length instructions of CISC with the general-purpose register machine, architecture, and pipelines of RISC. The RX CPU core brings together Renesas technology accumulated over many years.

**Feature 1: Original CPU That Inherits the Strengths of Its Predecessors**

- Variable-byte-length instructions
- Multiplier/divider and multiply-and-accumulate (MAC) units
- Register-relative addressing
- FPU
- 2 stack pointers

**RISC methods to boost speed**
- Harvard architecture
- 5-stage pipeline
- Out-of-order completion
- Optimization by the compiler

**General-purpose register machine**
- Multiplier/divider and multiply-and-accumulate (MAC) units
- Array and pointer addressing
- Support for bi-endian data access

**Feature 2: RX CPU Core with Industry-Top-Class Performance**

- Harvard architecture enabling parallel execution of instruction fetches and data accesses.
- Five-stage pipeline configuration and out-of-order completion for even faster execution. (Allows no-wait execution of later instructions when there is no dependency between later and earlier instructions.)

### Pipeline Stage Configuration

- 5-stage pipeline for faster processing
- Through benchmark testing of various types of application software, processing performance was more than doubled compared with earlier products.

- Instruction fetch stage (IF)
- Decode stage (D)
- Execution stage (E)
- Memory access stage (M)
- Write-back stage (WB)

<table>
<thead>
<tr>
<th>Instruction fetch stage (IF)</th>
<th>Decode stage (D)</th>
<th>Execution stage (E)</th>
<th>Memory access stage (M)</th>
<th>Write-back stage (WB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction fetch processing</td>
<td>Instruction decode processing</td>
<td>Operation processing, address calculation</td>
<td>Memory access processing</td>
<td>Write-back processing</td>
</tr>
</tbody>
</table>

The memory access stage is only used when accessing the memory.

### CoreMark score per operating frequency

<table>
<thead>
<tr>
<th>CoreMark/MHz</th>
<th>RXv1</th>
<th>Cortex®-M0</th>
<th>Cortex®-M0+</th>
<th>RXv2</th>
<th>Cortex®-M3</th>
<th>Cortex®-M4</th>
<th>RXv3</th>
<th>Cortex®-M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.12</td>
<td>No.1</td>
<td>2.33</td>
<td>2.46</td>
<td>4.55</td>
<td>3.34</td>
<td>3.42</td>
<td>5.82</td>
<td>5.01</td>
</tr>
</tbody>
</table>

CoreMark/MHz value = 5.82
Superior embedded performance and power efficiency
RX core features
- CPU developed in-house for high operational efficiency.
- Five-stage superscalar architecture.
- Optimized for power efficiency and high performance.
- Processing capability and code efficiency on par with RISC.
- Improved interrupt responsiveness and FPU/DSP instructions.

### Feature 3: Pipeline Stage Configuration

- Out-of-Order Completion
  - Out-of-order completion boosts the efficiency and speed of instruction execution.

<table>
<thead>
<tr>
<th>Order Completion</th>
<th>1MOV(R1), R2</th>
<th>2ADD R4, R5</th>
<th>3SUB R6, R7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-of-Order Completion</td>
<td>1MOV(R1), R2</td>
<td>2ADD R4, R5</td>
<td>3SUB R6, R7</td>
</tr>
</tbody>
</table>

If they have no dependencies on later instructions, no stall occurs in the pipeline for the next and subsequent instructions.

* Cortex®-M is the nominal value of Arm
**RXv2 CORE FEATURES**

**RXv2 Core: CPU Block Diagram**

Further enhancements while maintaining compatibility with the RXv1 core
- Improved pipeline for substantial increase in the number of instructions per cycle (IPC)
- Advanced fetch unit with improved interface to on-chip flash memory. Reduces re-fetching of instructions due to penalty imposed by branch instructions and reduces the number of flash memory accesses. Achieves improved CPU performance alongside reduced power consumption.
- Improved instructions for DSP and FPU functions.

**Feature 1: Pipeline Enhancements**

**RXv2 Pipeline Processing Stage Configuration**

<table>
<thead>
<tr>
<th>Instruction fetch stage (IF)</th>
<th>Decode stage (D)</th>
<th>Execution stage (E)</th>
<th>Memory access stage (M)</th>
<th>Write-back stage (WB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction fetch processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floating-point operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAC/LH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAC/LH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load/store</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory access</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The memory access stage is only used when accessing the memory.

Improved pipeline processing and parallel execution of floating-point operations
- Floating-point operations take place in parallel during execution stages and memory access stages.
- Integer operation instructions and memory access or FPU instructions can execute at the same time.
- Contributes to improved FPU execution speed and CPU performance.

**Feature 2: FPU and DSP Enhancements**

Enhanced FPU and DSP functions
- Reduced execution cycle count for existing instructions and addition of new instructions.
- The number of accumulators with dedicated buffers has been increased from one to two for more efficient DSP operations.
- Performance in filter operations has been boosted fourfold.

**FPU functions (new instructions added, existing instructions speeded up)**

<table>
<thead>
<tr>
<th>New instructions</th>
<th>FSQRT (√), FTOU, UTOF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (cycles)</td>
<td>FADD/FSUB: 4 cycles → 2 cycles</td>
</tr>
<tr>
<td></td>
<td>FMUL: 3 cycles → 2 cycles</td>
</tr>
<tr>
<td>Single-cycle throughput</td>
<td>Pipelined FPU</td>
</tr>
</tbody>
</table>

**DSP functions (new instructions added, accumulator for operations added)**

| 32×32=acc, acc | EMULA, EMACA, EMSBA |
| 16×16=acc, acc | HULLH, MACLH, MSB (LH, HI, LO) |
| Accumulator rounding instructions | RDACW, RDACL, RACL |
| Accumulator added | 1 → 2 |
RXv3 CORE FEATURES

The successor to the RXv2 core, the RXv3 core boosts performance with new functions while adding a double-precision FPU and a register bank save function. These improvements enable it to achieve a score of 5.82 CoreMark/MHz on the EEMBC CoreMark® benchmark test, among the best CPU performance levels in the industry. The RXv3 core contributes to extremely fast and efficient operations in a wide array of applications requiring real-time processing.

**Feature 1: Register Bank Save Function**

Dedicated memory for improved interrupt responsiveness
- Faster saving/restoring data to/from CPU registers and improved interrupt responsiveness.
- “Register save banks” provided as dedicated memory for register saves.
- Dedicated instructions (SAVE and RSTR) for accessing the register save banks.
- Number of register save bank areas: 16 (RX72T)**

Note: 1. Number of banks differs among products.

Comparison with conventional product (saving data to all registers)

**Feature 2: Double-Precision FPU Support**

- First RX Family CPU core with a double-precision floating-point processor.
- Greatly improved processing performance in double-precision floating-point operations (up to eight times better).

---

**Note:**

 acos  asin  atan  atan2  cos  sin  tan  cosh  sinh  tanh  exp  frexp  ldexp  log  log10  modf  pow  sqrt  ceil  fabs  floor  hypot  fmod
RX700/RX600 SERIES

Features of RX700/RX600 Series

- **High-performance, High-speed response**
  - 1396CoreMark @240MHz
  - Double precision FPU coprocessor
  - Trigonometric functions arithmetic unit
  - Register bank save function

- **Large-capacity**
  - 4MB Flash (Dual bank function)
  - 1MB SRAM

- **Numerous peripheral functions**
  - Various communication interfaces
  - 3-phase complementary PWM timer
  - 12-bit A/D converter
  - TFT LCD controller
  - 2D rendering engine
  - Trusted Secure IP

- **Various solutions**
  - HMI
  - Cloud
  - Security
  - Functional safety

Main Applications of RX700 and RX600 Series

<table>
<thead>
<tr>
<th>Industrial</th>
<th>Office Automation</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robots, Machine tools</td>
<td>Copiers Printers</td>
<td>Camera body</td>
</tr>
<tr>
<td>Power conditioner</td>
<td></td>
<td>Lens</td>
</tr>
<tr>
<td>General-purpose inverters</td>
<td></td>
<td>Air conditioner</td>
</tr>
<tr>
<td>HVAC controller</td>
<td></td>
<td>(outdoor unit, indoor unit)</td>
</tr>
<tr>
<td>Security controller</td>
<td></td>
<td>Projector</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Audiovisual equipment</td>
</tr>
</tbody>
</table>

Lineup of RX700 and RX600 Series

<table>
<thead>
<tr>
<th>RX72M</th>
<th>240MHz, 4MB Flash, 1MB SRAM</th>
<th>176/224-pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>RXv3</td>
<td>Double precision FPU</td>
<td>Register bank save</td>
</tr>
<tr>
<td></td>
<td>Trigonometric functions</td>
<td>IEEE1588</td>
</tr>
<tr>
<td></td>
<td>arithmetic unit</td>
<td>EtherCAT slave</td>
</tr>
<tr>
<td>RX72N</td>
<td>240MHz, 4MB Flash, 1MB SRAM</td>
<td>100/144/145/176/224-pin</td>
</tr>
<tr>
<td>RXv3</td>
<td>Double precision FPU</td>
<td>Register bank save</td>
</tr>
<tr>
<td></td>
<td>Trigonometric functions</td>
<td>IEEE1588</td>
</tr>
<tr>
<td>RX66N</td>
<td>120MHz, 4MB Flash, 1MB SRAM</td>
<td>100/144/145/176/224-pin</td>
</tr>
<tr>
<td>RXv3</td>
<td>Double precision FPU</td>
<td>Register bank save</td>
</tr>
<tr>
<td>RX65N/</td>
<td>Single precision FPU</td>
<td></td>
</tr>
<tr>
<td>RX651</td>
<td>120MHz, 2MB Flash, 640KB SRAM</td>
<td>64/100/144/145/176/177-pin</td>
</tr>
<tr>
<td>RXv2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Common functions

- Dual bank
- Quad SPI
- Ethernet
- GLCDC
- USB
- Trusted Secure IP
- CAN
- 12-bit ADC
- SD host I/F
RX72M and RX72N: Flagship Models with Support for a Variety of Industrial Networking Standards

- EtherCAT slave control* and high-precision time synchronization control for multiple industrial motors implemented on a single chip, enabling more compact product design.
- Full 1MB of on-chip SRAM. Enables high speed execution of middleware for TCP/IP, web server, file system, etc., without need for external memory.
- Supports a variety of industrial network protocol stacks in addition to EtherCAT. Flexible support for diversifying protocol requirements.

* EtherCAT slave controller (ESC) available on RX72M only.

Software from Partners

Renesas Software

Renesas Hardware

User application

RX72M
4MB Flash
1MB SRAM
EtherCAT Slave

RX72N
4MB Flash
1MB SRAM
EtherCAT Slave

4MB flash memory, 1MB SRAM, and EtherCAT slave controller* on-chip.

Protocol stacks from Renesas and from partner vendors provide coverage for major industrial network standards.

RX66N: Successor to RX65N and RX651 with Enhanced CPU and On-Chip Memory

- The industry’s only MCU to combine 4MB of flash memory and 1MB of SRAM. Ability to implement a broad range of functions without external memory.
- Dual-plane SRAM (512KB + 512KB) configuration, allowing smooth display performance on WVGA (800 × 480, 8bpp) displays.
- The RXv3 core delivers excellent performance per unit of operating frequency, achieving performance when operating at 120MHz equivalent to that of competing MCUs operating at 200MHz.

RX65N and RX651: A Broad Lineup of Mainstream Models

- Broad lineup with 512KB, 768KB, 1MB, 1.5MB, or 2MB of flash memory and pin counts of 64, 100, 144, 157, or 177 pins.
- Large memory capacity in a 4.5mm-square, 64-pin ultracompact package. Reduces the number of components required in compact IoT devices with limited mounting area.
- High-performance RXv2 core and state-of-the-art 40nm process deliver excellent performance and overwhelmingly superior power efficiency compared with competing MCUs.
RX200 SERIES

Features of RX200 Series

- Both low power consumption and high performance
  - 54MHz, 0.12mA/MHz operation
- Wide voltage range and external bus
  - 1.8-5.5V, 8/16-bit external bus
- Robust security and networking/sensors
  - Trusted secure IP
  - Bluetooth
  - Industrial sensor
- Various solutions
  - Functional safety
  - HMI
  - Capacitive touch
  - Security

Main Applications of RX200 Series

- Consumer (battery drive)
  - Digital cameras
  - Gadgets
- Healthcare
  - Wearable devices
  - Blood glucose meter
- Industrial
  - Power meters
  - Pressure, temperature, and flow volume meters
  - Inverters
  - Air conditioners
  - Refrigerators
  - Washing machines

Lineup of RX200 Series

**RX23W**
- 54MHz, 512KB Flash
- RXv2
- Single precision FPU
- CAN
- USB
- SDHI
- Capacitive touch
- Security
- Bluetooth

**RX3E-A**
- 32MHz, 256KB Flash
- RXv2
- Single precision FPU
- CAN
- USB
- SDHI
- High-precision AFE

**RX231**
- 54MHz, 512KB Flash
- RXv2
- Single precision FPU
- CAN
- USB
- SDHI
- Capacitive touch
- Security

**RX230**
- 54MHz, 256KB Flash
- RXv2
- Single precision FPU
- Capacitive touch

Excellent Balance of Low Power Consumption and High Performance

Excellent Balance of Low Power Consumption (0.12 mA/MHz) and High Performance (4.33 CoreMark/MHz)

**Power consumption**
- During operation
  - 0.12mA/MHz*
- During standby with RAM contents retained
  - 0.8µA
- Fast recovery
  - Min. 5μs*

**Processing performance**
- RXv2 core
  - 4.33 CoreMark/MHz
- DSP/FPU instruction extension*

* Example of RX231, details of other products differ.

Peripheral Functions for Home Electronics, Industrial, and IoT Applications

Equipped with functions suitable for capacitive touch, communication, and motor control applications. In addition to support for control and manipulation, implementation of IoT capabilities is simplified.
**RX23W Concept and Platform**

High Performance CPU, Security, and Wireless Communications on a Single Chip

www.renesas.com/rxble

High performance RXv2 core capable of controlling multiple systems, Trusted Secure IP implementing robust security functions, and Bluetooth 5.0 Low Energy with enhanced connectivity functions, all on a single chip.

- High Performance RXv2 Core
- Trusted Secure IP
- Bluetooth 5.0 Low Energy Full Function

Application development platform

- BLE software
  - Profiles
  - GATT DB
- BLE protocol stack
- BLE Driver
- Hardware

GATTBrowser

Smartphone app to communicate with RX23W

Also displays definition information exclusive to Renesas.

**RX23W Evaluation of RF Performance: Certified Under Radio Law**

- RX23W Target Board
  - Includes on-chip debugger and provides access to all MCU signal pins.

Bluetooth Trial Tool Suite

Evaluation tool to control RX23W

**RX23E-A Concept and Target**

High-Precision AFE and High-Performance MCU on a Single Chip

- High-precision AFE ideal for industrial applications such as temperature and distortion measurement.
- High-performance MCU suitable for digital signal processing.
- Rich communication interface provides more freedom in system and board design.

For Sensor Devices Demanding High-Precision Analog Characteristics

Sensor devices requiring an ADC with low noise, low drift, and high effective resolution are the target.

**Application Example (Force Sensor)**

The amount and direction of force are calculated from data input from a distortion gauge and sent to the control system.

Input referred noise

1µVrms
10µVrms
100µVrms

Low

Thermostat Co2Detector
HA/Communication/BA/OA
Industry: FA/PA

Temp. & humidity
Photoelectric
Pulse wave
Pulse oximeter
Sphygmomanometer
Thermal flowmeter
Electronic scale
Pressure gauge
Temp. controller
Recorder
Weight scale
Force sensor
Differential pressure transmitter
Temp. transmitter
Thermopile (Temperature)
Middle Computing performance
High

High-Precision AFE and High-Performance MCU on a Single Chip

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For Sensor Devices Demanding High-Precision Analog Characteristics

Sensor devices requiring an ADC with low noise, low drift, and high effective resolution are the target.
**RX100 SERIES**

### Features of RX100 Series

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption among the lowest in the industry</td>
<td>32MHz, 0.35μA standby</td>
</tr>
<tr>
<td>5V power supply support Segment LCD support</td>
<td>5V power supply support Segment LCD support</td>
</tr>
<tr>
<td>Superior cost/performance ratio</td>
<td>Low-pin-count/ small-ROM-capacity versions Integration of peripheral ICs</td>
</tr>
<tr>
<td>Various solutions</td>
<td>Functional safety Capacitive touch</td>
</tr>
</tbody>
</table>

### Main Applications of RX100 Series

<table>
<thead>
<tr>
<th>Application</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer (battery drive)</td>
<td>Sensor hubs (smartphones, game consoles, PCs, tablets), digital cameras, digital camcorders</td>
</tr>
<tr>
<td>Healthcare</td>
<td>Healthcare devices, wearable devices</td>
</tr>
<tr>
<td>Home appliances</td>
<td>Cooking appliances, water heaters</td>
</tr>
<tr>
<td>Industrial</td>
<td>Power meters, detectors (smoke detectors, etc.), pressure gauges, thermostats</td>
</tr>
</tbody>
</table>

### Lineup of RX100 Series

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Features</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX130</td>
<td>32MHz, 512KB Flash</td>
<td>Capacitive touch, 5V</td>
<td>Sensor hubs, digital cameras, digital camcorders</td>
</tr>
<tr>
<td>RX113</td>
<td>32MHz, 512KB Flash</td>
<td>USB, Segment LCD, Capacitive touch</td>
<td>Healthcare devices, wearable devices</td>
</tr>
<tr>
<td>RX111</td>
<td>32MHz, 512KB Flash</td>
<td>USB</td>
<td>Cooking appliances, water heaters</td>
</tr>
<tr>
<td>RX110</td>
<td>32MHz, 128KB Flash</td>
<td>Capacitive touch</td>
<td>Healthcare devices, wearable devices</td>
</tr>
</tbody>
</table>
Power Consumption Among the Lowest in the Industry

Ultralow current consumption during standby and during operation
- Standby current: 0.35μA
- Normal operation current: 0.1mA/MHz
- Recovery time: 4.8μs

Low-Power Timer (LPT) for Reduced Standby Current During Intermittent Operation
- LPT generates wakeup events to recover from standby mode.
- Current can be transitioned to standby state in standby periods during intermittent operation.

Essential Peripheral Functions for Measuring Equipment and Household Appliances
- Integrates peripheral functions suitable for measuring equipment and household appliances, such as capacitive touch/LCD, communication, and 12-bit ADC.
- Support for applications ranging from system control in household appliances or industrial equipment to user interfaces for wet environments.

Superior Cost/Performance Ratio
- Performance reduced to cut power consumption and lower costs.
- Lineup includes low-cost products with low pin count and small ROM capacity.
- Integration of peripheral functions reduces BOM cost.

Function Lineup Selected for Enhanced Flexibility
- Water heaters
- Control panels for wet environments
- Healthcare
- Control/display devices
- Measuring equipment
- Home appliances
- Sub-controllers for office equipment
- Portable products

Comparison with the Competitors
- RX100 microcontroller with ultra-low power consumption
- RX130 microcontroller with low power consumption and high performance

Comparison of Current Consumption in RX Family
- RX100: Standby current: 0.35μA
- RX200: Standby current: 1.8μA

Integration of Peripheral Functions for Reduced Cost
- Reduced system cost
- Up to 1/3** smaller mounting area

Notes:
1. Current value during all peripheral operation at 32MHz on the RX130.
2. Current value including LPT operating current (0.37μA) on the RX130.

Notes:
1. The 5V-tolerant ports of the RX110, RX111, and RX113 are compatible. The RX130 has a maximum power supply voltage of 5.5V, so all its ports are compatible.
2. The RX110 has no E2 data flash.
3. Comparison with Renesas system product.
RX FOR MOTOR CONTROL (RX-T)

Features of RX for Motor Control (RX-T)

- Broad lineup
  - RX72T: 32MHz to 200MHz
  - RX66T: 160MHz to 400MHz
  - RX66T: 160MHz to 400MHz
  - RX24U: 80MHz to 128KB Flash
  - RX24T: 80MHz to 128KB Flash
  - RX23T: 40MHz, 128KB Flash
  - RX13T: 32MHz, 128KB Flash

- 5V power supply support
  - External bus

- 5V power supply support
  - External bus

- Analog circuit to extract full performance potential
  - Three-channel simultaneous sample-and-hold circuit
  - PGA
  - Comparator

- Specialized motor control functions
  - Three-phase complementary
  - PWM output
  - Timer output emergency stop
  - Trigonometric function unit

Main Applications of RX for Motor Control (RX-T)

- Industrial
  - Robots, Machine tools
  - General-purpose inverters
  - Meters
  - Building automation

- Office Automation
  - Copiers
  - Printers

- Home appliances
  - Air conditioners
  - Refrigerators
  - Washing machines

Lineup of RX for Motor Control (RX-T)

- RX72T
  - 200MHz, 1MB Flash
  - RXv3
    - Single precision FPU
    - Motors 3 to 4
    - Pseudo-differential PGA
    - Register bank save
    - Trigonometric functions arithmetic unit
    - CAN
    - USB
    - Security

- RX66T
  - 160MHz, 1MB Flash
  - RXv3
    - Single precision FPU
    - Motors 3 to 4
    - Pseudo-differential PGA

- RX24U
  - 80MHz, 512KB Flash
  - RXv2
    - Single precision FPU
    - Motors 2 to 3
    - Pseudo-differential PGA

- RX24T
  - 80MHz, 512KB Flash
  - RXv2
    - Single precision FPU
    - Motors 2 to 3
    - PGA

- RX23T
  - 40MHz, 128KB Flash
  - RXv2
    - Single precision FPU
    - Motors 1

- RX13T
  - 32MHz, 128KB Flash
  - RXv1
    - Single precision FPU
    - Motors 1
    - PGA
**RX for Motor Control (RX-T) Product Lineup**

### Allocation of Resources Specially for Motor Control

- **Three-phase complementary PWM output**
- **Analog functions**
  - 12-bit ADC
  - PGA function provided on all products, except RX23T and RX63T (some product versions).
  - PGA (pseudo differential input mode) reduces common noise substantially.

### Application Example: Controlling Multiple Motors with a Single Chip

1. **Control 3 inverters in a single chip**
   - GPTW timer for multiple 3-phase complementary PWM outputs
   - MTU3d+GPTW can drive up to 4 inverters
   - MTU3d can also drive 2 inverters (only 112/144-pin)

2. **Enable 3-shunt x 2 current detection at the same time**
   - Can control 3-shunt inverters with 3 S/H x 6 at the same time
   - PGA (pseudo differential input mode) reduces common noise substantially.
   - ADC 3 unit

3. **Less external parts required**
   - Including reset circuit, E2PROM, op-amp, comparator

4. **Designed to improve safety**
   - Comparator 6-ch for PWM forced cutoff
   - Output protection circuit dedicated to GPTW

5. **Support function safety**
   - Functions to support IEC60730 Safety Standard for Household Appliances class B (Fail-safe)
   - System fail-safe with less software load

**Target Application**:
- High-end air conditioner / washing machine
- General-purpose inverter, robot, etc.

---

*PGA: Programmable gain amp, S/H: sample & hold circuit
*The left figure only shows an image, not the actual layout.
## RX FAMILY MOTOR CONTROL

### Motor Types and Recommended Microcontrollers

<table>
<thead>
<tr>
<th>Consumer/office equipment</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners</td>
<td>Washing machines</td>
</tr>
<tr>
<td>BLDC IM</td>
<td>BLDC IM</td>
</tr>
</tbody>
</table>

### Motor Types, Control Methods, and Recommended RX Series

<table>
<thead>
<tr>
<th>Motor type</th>
<th>Control method</th>
<th>Necessary functions</th>
<th>Performance required by application and recommended RX microcontroller</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brushless DC motor</strong></td>
<td>Vector control (180-degree conducting control)</td>
<td>PWM × 6, dead time generation, POE, A/D converter (PWM link)</td>
<td>Compact industrial motors</td>
</tr>
<tr>
<td></td>
<td>Square wave control (120-degree conducting control)</td>
<td>PWM × 6, A/D converter</td>
<td>Refrigerators, fans, compact robots</td>
</tr>
<tr>
<td><strong>AC induction motor</strong></td>
<td>Vector control</td>
<td>PWM × 6, dead time generation, POE, A/D converter (PWM link)</td>
<td>Industrial pumps</td>
</tr>
<tr>
<td></td>
<td>V/f control</td>
<td>POE, A/D converter</td>
<td>Refrigrators, fans, washing machines pumps</td>
</tr>
<tr>
<td><strong>Stepping motor</strong></td>
<td>Pulse output</td>
<td>Port or PWM control</td>
<td>Printers/multifunction units, surveillance cameras</td>
</tr>
<tr>
<td></td>
<td>Vector control (resolver)</td>
<td>PWM × 4, dead time generation, POE, A/D converter</td>
<td>Compact robots, carrier machine, textile machine, printers/multifunction units</td>
</tr>
</tbody>
</table>

BLDC: Brushless DC motor, IM: AC induction motor, STM: Stepping motor
**Motor Control by RX**

RX delivers high-speed arithmetic performance alongside MTU2 or MTU3, GPT timer, 12-bit A/D converter, and POE functions to simplify the process of implementing motor control.

<table>
<thead>
<tr>
<th>High-speed arithmetic operations (RX core)</th>
<th>Waveform control/feedback control (MTU2 and MTU3, GPT, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-speed vector calculations</td>
<td>PW M waveform output</td>
</tr>
<tr>
<td>▪ High-speed processing at 240MHz</td>
<td>▪ PW M output with 0 to 100% duty</td>
</tr>
<tr>
<td>▪ FP U for high-speed floating point</td>
<td>▪ 3-phase complementary PWM waveform output</td>
</tr>
<tr>
<td>operations</td>
<td>▪ Automatic insertion of dead time</td>
</tr>
<tr>
<td>▪ TF U for high-speed trigonometric</td>
<td>▪ A/D activation at user-defined timing for 1-shunt current</td>
</tr>
<tr>
<td>functions</td>
<td>detection</td>
</tr>
<tr>
<td>▪ Single-precision floating point</td>
<td>Feedback control</td>
</tr>
<tr>
<td>▪ Sin, cos, arctan, sqrt (s(x+y))</td>
<td>▪ Acquisition of feedback information (position/rotation</td>
</tr>
<tr>
<td>▪ Fast/fix ed cycle operation</td>
<td>rate) from encoder</td>
</tr>
</tbody>
</table>

*Only RX72T/RX72M/RX72N supports TFU

<table>
<thead>
<tr>
<th>Disable control output signals (POE)</th>
<th>Feedback control (high-speed 12-bit A/D converter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disable output signals for the MTU and</td>
<td>Acquisition of feedback information using motor</td>
</tr>
<tr>
<td>the GPT without using software.</td>
<td>current</td>
</tr>
<tr>
<td>▪ Forcibly disable complementary PWM</td>
<td>▪ High-speed (1.0µs) 12-bit A/D converter</td>
</tr>
<tr>
<td>output and realize fail-safe</td>
<td>▪ Simultaneous sampling of three tracks for 3-shunt</td>
</tr>
<tr>
<td></td>
<td>current detection</td>
</tr>
<tr>
<td></td>
<td>▪ Reduce BOM by using built-in comparator and PGA</td>
</tr>
<tr>
<td></td>
<td>(some products)</td>
</tr>
</tbody>
</table>

**Examples of Motor Control Functions Provided by RX**

<table>
<thead>
<tr>
<th>Description</th>
<th>For motor control</th>
<th>For General-Purpose, Sensor, and Network Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waveform output control</td>
<td>RX23T/RX24T/RX24U</td>
<td>RX111/RX113/RX114/RX210/RX210E/RX211/RX212/RX213/RX214/RX65</td>
</tr>
<tr>
<td>PWM waveform output</td>
<td>✓ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Synchronous output on multiple channels</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Chopping or level waveform output in AC synchronous motor drive mode</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>3-phase complementary PWM output with dead time (left-right symmetric dead time amplitude)</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>3-phase complementary PWM output with dead time (left-right asymmetric dead time amplitude)</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>High-resolution PWM output</td>
<td></td>
<td>✔ ✔</td>
</tr>
<tr>
<td>Feedback detection</td>
<td>RX111/RX113/RX114/RX210/RX210E/RX211/RX212/RX213/RX214/RX65</td>
<td>RX130/RX220/RX230/RX231/RX23E/RX23W/RX651/RX65N/RX66M/RX72N</td>
</tr>
<tr>
<td>Phase counting mode</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>High-speed 12-bit A/D converter using sequential conversion</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>A/D converter activation requests at user-defined timing (for 1-shunt current detection)</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>12-bit A/D converter double-trigger function (storage of data from two conversions in separate registers)</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>12-bit A/D converter with simultaneous sampling of three tracks</td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Acceleration</td>
<td>RX111/RX113/RX114/RX210/RX210E/RX211/RX212/RX213/RX214/RX65</td>
<td>RX130/RX220/RX230/RX231/RX23E/RX23W/RX651/RX65N/RX66M/RX72N</td>
</tr>
<tr>
<td>Compare match and A/D conversion start request skipping function</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>FPU for high-speed arithmetic operations</td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Double buffering function (provision of two register buffer stages for compare match operation)</td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Safety functions</td>
<td>RX111/RX113/RX114/RX210/RX210E/RX211/RX212/RX213/RX214/RX65</td>
<td>RX130/RX220/RX230/RX231/RX23E/RX23W/RX651/RX65N/RX66M/RX72N</td>
</tr>
<tr>
<td>Error detection and PWM output auto-cutoff using port output enable</td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Other</td>
<td>RX111/RX113/RX114/RX210/RX210E/RX211/RX212/RX213/RX214/RX65</td>
<td>RX130/RX220/RX230/RX231/RX23E/RX23W/RX651/RX65N/RX66M/RX72N</td>
</tr>
<tr>
<td>5V power supply</td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>32-bit counter support</td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Trigonometric functions arithmetic unit</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Renesas supports all stages of the development of RX applications by supplying integrated development environments, real-time OSes, middleware, and programming tools that dramatically enhance the development process. Renesas integrated development environments enable you to accomplish coding, building, and debugging tasks quickly and easily, helping to reduce system development time.

**Introduction**

Free evaluation versions of tools, sample software, application notes
Low price. Target board with emulator

**Development**

Renesas offers two integrated development environments to match the customer’s system.

**Integrated development environment e² studio**

Provides a large number of functions. Development environment based on Eclipse. Supports compilers from IAR Systems and the GNU Project in addition to Renesas. Now supports FreeRTOS.

**Integrated development environment CS+**

A stable, proprietary Renesas development environment initially developed nearly a decade ago. Supports Renesas compiler. Will continue to support Renesas devices in the years ahead.

**Build**

Renesas C/C++ Compiler Package for RX Family (CC-RX) (node locked and floating license versions)
Compiler from IAR Systems
GNU compiler

**Coding (OS)**

Embedded OS with the best established track record in Japan and conformant with μITORN standard (RU600V4 and RU600PX)
FreeRTOS, which supports connecting to AWS
Software tools that make development even faster

[Smart configurator]
Tool that automatically generates device drivers

[On-chip debugging emulators]
Choose from the low-cost E2 Emulator Lite; the E2 Emulator, which lets you measure current consumption right on the emulator; and the E20 Emulator, with advanced functions.

[Middleware]
Support for communication environments, security, image processing, and signal processing

Debug

[QE for Current Consumption]
Using just the E2 Emulator you can measure current consumption and detect abnormal current flows.

[QE for Capacitive Touch]
Supports embedded systems employing capacitive touch sensors. Easily implement touch and slider operations in applications.

Renesas Flash Programmer
flash memory programming software

[Smart configurator]
Tool that automatically generates device drivers

[QE (Quick and Effective tool)]
Tools suitable for a variety of applications

[On-chip debugging emulators]
Choose from the low-cost E2 Emulator Lite; the E2 Emulator, which lets you measure current consumption right on the emulator; and the E20 Emulator, with advanced functions.

[Middleware]
Support for communication environments, security, image processing, and signal processing

Renesas Flash Programmer
flash memory programming software
RX FAMILY DEVELOPMENT TOOLS

Software and Support Tools You Can Use Immediately with the RX Family

Available software packages include board-specific programs, peripheral function drivers, middleware, and documents and application examples illustrating usage procedures. Users can also use Smart Configurator to easily incorporate the above Renesas software components into their own projects, automatically generate I/O drivers for MCU peripheral functions, and more. This makes it possible to boost the efficiency of the development process overall.

Searching for Information in Sample Code or Manuals
From within the integrated development environment you can search for and display sample code, middleware, and Renesas product information on the web, as well as downloading and installing sample code.

Making Complex Pin Settings and Embedding Drivers
You can add and verify middleware and drivers for USB, file system, and other functions from within the integrated development environment. You can also make complex and time-consuming pin settings from the built-in GUI, and when conflicts are detected you can resolve them with a single click.

Assistance for Coding and Debugging
From within the integrated development environment you can reference register information and perform coding and debugging. The development knowhow that allows you to begin development of a variety of applications with a few simple settings can significantly reduce overall development time.

RX Family Middleware Driver Package (RX Driver Package)

The RX Driver Package is a software package that enables use of basic functions such as MCU visualization, flash self-programming, timer control, UART communication, and A/D conversion, as well as applied functions such as USB and Ethernet.

- Makes it possible to start using RX MCU peripheral functions right away, greatly reducing the time customers must spend considering prototypes.
- Applications that make use of Firmware Integration Technology (FIT) can be reused on MCUs across the RX Family. This significantly reduces the software development cost burden for customers extending their product lines.

RX Driver Package

Renesas Middleware Usage Examples

Medical and Healthcare Devices
TCP/IP, voice recording and playback, FAT file system, SPI serial EEPROM, I/C serial EEPROM, SD memory card driver, drivers for various memory types, etc.

Industrial Devices
TCP/IP, voice recording and playback, DSP, FAT file system, SPI serial EEPROM, I/C serial EEPROM, SD memory card driver, drivers for various memory types, etc.

Information Terminals
Graphics, FAT file system, SD memory card driver, etc.

Digital AV
AAC encoder/decoder, aacPlus decoder, MP3 encoder/decoder, FAT file system, SD memory card driver, encryption, etc.

Home Networks
TCP/IP, HTTP server, FTP server, SMTP/POP3, DHCP client, file system, encryption, security, etc.

Security Systems
Encryption, security, graphics, audio, communication, file system, etc.
Smart Configurator provides functionality that makes it easy for users to incorporate Renesas drivers into their projects. The following functions support driver integration:

- Importing sample code (FIT)
  Download and import sample code, and use it in combination with generated driver code.
- Generating driver code
  Enter peripheral function settings via the GUI, and driver code is generated automatically according to the settings.
- Checking for pin conflicts
  Check in real time for conflicts among pins used by the driver code and FIT modules.

Plenty of Convenient Functions to Assist Application Development

QE Development Support Tools for Many Application Types

“I’ve imported this application but it doesn’t work! What should I do?” Has this ever happened to you? QE development support tools add development knowhow (functionality) to applications within the integrated development environment, helping to minimize the application development workload.

QE for BLE Development Support Tool for Bluetooth® Low Energy Applications

This development support tool is designed for embedded systems employing Bluetooth® Low Energy. It is compatible with the e² studio integrated development environment and allows users to try out communication functions based on the Bluetooth® specification without delay. Devices using BLE for communication must use the same profile, but QE for BLE makes it a simple matter to define the correct profile.

QE for Display Development Support Tool for Display Applications

Using QE for Display for embedded system development utilizing the image display functions of the RX Family’s graphic LCD controller (GLCDC) greatly simplifies initial screen calibration of the display, reducing the time required for development.

QE for Capacitive Touch Development Support Tool for Capacitive Touch Sensor Applications

Using QE for Capacitive Touch in the development of embedded systems that utilize the capacitive touch sensor functions of RX Family MCUs simplifies making initial touch interface settings and tuning sensitivity, reducing the time required for development.
### R5

- **Renesas MCU**
- **ROM Type**
  - F: Flash
  - S: ROM LESS
- **data flash capacity (KB)**

### RX Family

<table>
<thead>
<tr>
<th>Product Group</th>
<th>72M</th>
<th>72N</th>
<th>71M</th>
<th>66N</th>
<th>65N</th>
<th>651</th>
<th>64M</th>
<th>63N</th>
<th>631</th>
<th>62N</th>
<th>621</th>
<th>634</th>
<th>630</th>
<th>610</th>
<th>23W</th>
<th>23E</th>
<th>231</th>
</tr>
</thead>
<tbody>
<tr>
<td>72M RX72M</td>
<td>230</td>
<td>RX230</td>
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<td>72N RX72N</td>
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<tr>
<td>71M RX71M</td>
<td>210</td>
<td>RX210</td>
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<td>66N RX66N</td>
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<td>RX21A</td>
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<td>65N RX65N</td>
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<td>RX130</td>
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<tr>
<td>651 RX651</td>
<td>113</td>
<td>RX113</td>
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#### Operating ambient temperature
- **N** -20°C to 85°C
- **D** -40°C to 85°C
- **G** -40°C to 105°C

#### Chip Original info

- **ROM/RAM/ data flash capacity (KB)**

#### Packing specification

- **Tray** *(HWQFN, WFLGA, TFLGA, LFBGA, WFBGA)*
- **Tray** *(LFQFP, LOFP)*

#### Package type/pin count/pitch

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**Example of product information for RX72M (176-pin), product No. R5F572MNHGFC#V0**

This guide lists the values for individual product numbers. For information on the actual product lineup, refer to the relevant user’s manual.

**Note:** This information is different for each RX group. Refer to the relevant user’s manual for details.
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