Embedded System Solutions for Medical Electronics

Fitness/Health
Diagnostics
Imaging
Patient Monitoring
Mobility
Portable and Wearable Devices
Renesas Electronics is the recognized world leader in microcontrollers and embedded system solutions. Our innovative semiconductor technology supports requirements for advanced connectivity, low power operation, data security and more. The 11 wafer fabrication plants and 17 test and assembly plants owned and operated worldwide by Renesas ensure predictability in supply management and product life cycle. Additionally, tight quality assurance is enforced during design, manufacturing and testing so that you receive exceptionally reliable products.

Member of Industry Alliances
Renesas Electronics is an active member in key organizations that support the medical electronics industry, including the Continua Health Alliance and the ANT+ Alliance.

A Complete Portfolio of Components, Tools and Solutions

Microcontrollers
A large portfolio of low-power, high-performance MCUs with DSP capability, safety features, and scalable memory

<table>
<thead>
<tr>
<th>MCU Family</th>
<th>Unique Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>32-bit</td>
<td></td>
</tr>
<tr>
<td>SH-2A</td>
<td>VGA Video support, FPU</td>
</tr>
<tr>
<td>RX600</td>
<td>High-Performance, Direct-Drive TFT, FPU</td>
</tr>
<tr>
<td>RX200</td>
<td>Low Power with 50MHz operating speed</td>
</tr>
<tr>
<td>V850ES/Jx3-L</td>
<td>Low Power with up to 1MB Flash</td>
</tr>
<tr>
<td>8/16-bit</td>
<td></td>
</tr>
<tr>
<td>RL78</td>
<td>Low Power, Snooze Mode for wearable sensors</td>
</tr>
<tr>
<td>78K0R/Lx3</td>
<td>12-bit ADC, 12-bit DAC, LCD MCU</td>
</tr>
<tr>
<td>R8C/3xT</td>
<td>Special hardware supporting Capacitive Touch</td>
</tr>
</tbody>
</table>

System Components
EEPROM, protection diodes and power MOSFETs

Memory and Power Unique Attributes
Serial EEPROMs 2Kbit to 1Mbit density, I2C or SPI interface
Zener Diodes Single-device-package, multiple-device package, small package size
Power MOSFETs Low RDS(on) for fast control

Solutions
Wired and wireless connectivity, cost-effective displays, and enhanced user interfaces

Vast Ecosystem and Third-Party Tools
Compiler, debugger and complete development tools are complemented with industry-leading FDA compliance solution, RTOS and other third party tools
Innovation, Quality and Longevity

Connected medical devices
Personal medical devices increasingly automate the transfer of information to medical professionals. Renesas MCUs have proven on-chip connectivity features that simplify system designs.

- USB
- WiFi
- Ethernet
- Bluetooth LE
- Continua Standard
- ANT+

Hospital/Clinic
Portable Medical Devices for Personal Use
Connectivity
Low Power Consumption
High Integration
High Performance

Battery-powered portable devices and wearable sensors
Mobile medical devices and wearable sensors require greater computing performance within limited power budgets. Renesas has many MCUs with suitable features and capabilities.

- MCUs with low µA/DMIPS do more work with less current
- Low supply voltage extends battery life
- Small packages for wearable sensors

Medical safety issues
The combination of safety regulation and standards demands a high level of fail detection mechanism. Renesas MCUs integrate a number of features to simplify compliance.

- Specialized RAM and Flash check to ensure data and code integrity
- Memory Protection Unit to detect illegal memory access
- Clock monitor for detecting clock anomalies

Protection from cloning and hacking
Complicated medical supply chains and device hacking have become important security concerns. Tampered and cloned devices with degraded capabilities can damage a brand’s reputation. Renesas’ proven authentication solutions provide flexibility for ensuring product authenticity and proper operation.

- Anti-tamper mechanism
- Authentication of genuine equipment
- Enforcement of expiration dates and other usage controls

Signal processing to support improved sensing for better diagnostics
The increased signal acquisition accuracy requires sophisticated digital signal processing (DSP) to improve diagnostics. Renesas MCUs have DSP functions such as a double precision floating point unit. They can accelerate algorithm computation.

- Integrated FPU with high operating frequency to maintain precision
- Fast multiplication operation to speed up algorithm
- Optimized architecture for high throughput

Battery-powered portable devices and wearable sensors

Enhanced user interfaces
Medical equipment that incorporates video, audio and touch technology is simpler to operate and more intuitive to control. Renesas has a line of solutions, including support for VGA video, OpenVG 2D animation, cost-optimized WVGA TFT, and capacitive touch key with tactile haptic feedback capability.

- VGA support with Video In/Video Out
- Hardware assisted OpenVG for 2D animation
- Cost optimized WVGA TFT solution
- Capacitive touch with haptic feedback for improved control capability


Medical Solutions
Connected medical and fitness devices apply diverse technologies to form networks. The Continua Health Alliance has proposed an end-to-end architecture that deploys multiple connectivity technologies, from USB, Bluetooth® and ZigBee® in medical devices, to other industrial standards that govern exchange protocols in the Medical IT infrastructure.

Inside hospitals today, the predominant networking technologies are WiFi and Ethernet. And for health and fitness equipment, the ANT+ low-power radio technology is a popular choice for simple data exchanges, such as between a heart-rate monitor and a sports watch.

Renesas MCUs support a wide variety of connectivity solutions and industry standards.

Low Power 16-bit RL78 MCU for Wearable Sensors

- Multiple modes for activating specific functions only when needed
- Snooze mode that enables serial interfaces and/or ADC when CPU is off
- Power-saving capability for radio networking and vital-sign monitoring

The innovative Snooze Mode featured on RL78 MCUs can reduce average power by as much as 30%

Low Power 32-bit MCUs for handheld portable devices

<table>
<thead>
<tr>
<th>Family</th>
<th>Application</th>
<th>Special Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX200</td>
<td>Low power with high processing</td>
<td>- 50MHz CPU and Flash means no wasted energy in pre-fetch logic compared to other</td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td>architecture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Memory Protection Unit for OS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Single cycle MAC to support DSP algorithm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Up to 512KB Flash with a roadmap to 1MB</td>
</tr>
<tr>
<td>V850ES/Jx3-L</td>
<td>Low power with large code size</td>
<td>- 20MHz CPU and Flash</td>
</tr>
<tr>
<td></td>
<td>and USB requirements</td>
<td>- 1MB Flash is available today</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Integrated USB connectivity</td>
</tr>
</tbody>
</table>

Portability makes medical devices much more useful, eliminating the need to handle and move bulky equipment. Increasingly, new products are handheld or wearable, so system designers demand low power consumption and greater energy efficiency from the MCUs.

The RL78 is suitable for wearable sensors and coin-cell operated devices because of its snooze mode and a low operating voltage. For portable devices, where processing level is higher, the RX200 is a great option. And for portable applications that require USB connectivity, V850ES/Jx3-L is an excellent choice.
Integrated FPU in RX600 Simplifies Algorithm Design, Implementation and Support

Traditional MCU System Architecture
- Develop algorithm on PC in floating point
- Convert floating point to fixed point MCU

Problems
- Lengthy development process
- Algorithm development remained in floating point
- Difficult to upgrade

Benefits
- Fast implementation
- Easy to maintain
- Easy to upgrade

RX600 MCU System Architecture
- Develop algorithm on PC in floating point
- Iteratively refine algorithm
- When algorithm is good

Signal Processing
Signal acquisition has improved dramatically in recent years. Today a capable signal-processing engine is needed to handle and analyze the data to improve diagnostic results.

One Renesas solution is the single-precision floating-point unit (FPU) built into our 32-bit RX600 MCUs. It allows an algorithm to be implemented in floating point, a method that’s easy to implement, maintain and upgrade.

For applications where analog functions integrated in the MCU are important, we offer the 16-bit 78K0R/Lx3 MCUs that provide a 12-bit ADC, 12-bit DAC, and op-amp.

User Interface
Video, display and sound technology enhancements have enabled improvements in medical equipment control and operating procedures, saving time and reducing user errors. To simplify the implementation, Renesas offers a wide range of solutions that take advantage of the specialized hardware in the microcontrollers.

- VGA video support with video in/out
- OpenVG support for manipulation of 2D graphics
- Cost-optimized direct-drive WVGA TFT solution
- Integrated LCD segment display driver
- Capacitive Touch Key and Haptic solution
- Audio playback support

RX600 MCU TFT-LCD Direct-Drive Capability
- On-chip circuit eliminates external TFT driver
- MCU supports up to WVQGA displays

Capacitive Touch Key with Haptic Feedback
- Hardware-assisted to give CPU more cycles for algorithm processing
- Haptic feedback to improve operator control of sensing activity

SH-2A MPU Supports OpenVG for Enhanced 2D Graphics
- Enables scrolling, zoom in/out and other 2D graphic manipulation
- On-chip hardware to accelerate OpenVG library
Complex medical supply chains make it difficult to prevent the introduction of fake and refurbished equipment that doesn’t perform to OEM specifications, thus creating medical risks and potentially damaging corporate reputations.

The robust, sophisticated Renesas Board ID solution uses a modern public/private key algorithm that mandates proper authentication and ensures the application of only genuine, authorized equipment. Additionally, this security scheme supports important usage controls such as duration of operation.

Safety has always been a major focus in the design of medical electronic devices, and it necessitates special system design features and thorough product testing.

Renesas MCUs are ideal for medical applications because they provide dedicated hardware features for detecting operational anomalies that might cause erroneous equipment operation. The rapid detection of such problems can be used to activate functions to gracefully shut down a device and, if possible, recover the system so the medical device can deliver its full, uncorrupted capabilities.

Additionally, to simplify medical device testing, Renesas has assembled a strong ecosystem of third-party support tools.

### Renesas MCU Safety Features

- **CPU**
  - Illegal memory access generates internal reset
  - Trap instruction “FF” generates internal reset

- **Clock**
  - Stop detection made possible by Watchdog Timer (WDT)
  - Frequency check enabled by a timer function

- **RAM**
  - Parity check for internal reset when error detected on Read or Write
  - Write Protection for safeguarding critical code or data

- **CRC Hardware**
  - Error detection for Flash memory
  - Error detection for serial communication interface

- **System Registers**
  - Write protection for setting ports, interrupts, clock, and Low Voltage Detection
  - Prevents unintended updates to system critical registers

- **ADC**
  - Specialized features to facilitate self-test with Internal Vref (1.4V typ) and temperature sensor

### Highlights of the Medical Ecosystem and Third-Party Support

- **coverity®**
  - Development Testing tools with out-of-the-box FDA compliance solutions
  - www.coverity.com

- **Micrium**
  - Real Time Operating Systems serving the medical device community for over a decade
  - www.micrium.com

- **LDRA**
  - Embedded systems lifecycle management to meet safety-critical compliance needs
  - www.ldra.com

1. Implementation and support vary between MCU Families
Listed here is a small sample selection of applications and suggested MCUs and components that Renesas offers to support them. Please visit our Medical Solutions web page for a more complete overview of our products and solutions.

<table>
<thead>
<tr>
<th>Applications and Trends</th>
<th>Renesas Microcontroller Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood Glucose Meter</strong></td>
<td>V850ES/JG3-L, 78K0R/Lx3</td>
</tr>
<tr>
<td>– Continua standard support</td>
<td></td>
</tr>
<tr>
<td>– Low power</td>
<td></td>
</tr>
<tr>
<td>– Chip-on-glass or LCD display</td>
<td></td>
</tr>
<tr>
<td>– Multi-language support</td>
<td></td>
</tr>
<tr>
<td><strong>Continuous Blood Glucose</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Wireless Patch Unit</strong></td>
<td>RL78/G13, 78K0R/Kx3-A</td>
</tr>
<tr>
<td>– Low power</td>
<td></td>
</tr>
<tr>
<td>– Small package</td>
<td></td>
</tr>
<tr>
<td><strong>Display Unit</strong></td>
<td>78K0R/Lx3, V850ES/JG3-L</td>
</tr>
<tr>
<td>– Continua standard support</td>
<td></td>
</tr>
<tr>
<td>– Chip-on-glass or LCD display</td>
<td></td>
</tr>
<tr>
<td>– Advanced graphic support</td>
<td></td>
</tr>
<tr>
<td><strong>Blood Pressure Monitor</strong></td>
<td>78K0R/Lx3, RX200</td>
</tr>
<tr>
<td>– Chip-on-glass or LCD display</td>
<td></td>
</tr>
<tr>
<td>– Voice playback</td>
<td></td>
</tr>
<tr>
<td>– Support for Continua</td>
<td></td>
</tr>
<tr>
<td>– Advanced ADC/DAC for more accurate sensing</td>
<td></td>
</tr>
<tr>
<td><strong>Oximeter &amp; Heart Rate Monitor</strong></td>
<td>RL78/G13, 78K0R/Lx3, RX600</td>
</tr>
<tr>
<td>– Wireless operation to eliminate wiring such as in hospital beds and in ambulances</td>
<td></td>
</tr>
<tr>
<td>– Faster and more accurate signal processing from higher quality analog front end</td>
<td></td>
</tr>
<tr>
<td>– Reliable storage for calibration, operation statistics</td>
<td></td>
</tr>
<tr>
<td><strong>ECG/AED</strong></td>
<td>RX600</td>
</tr>
<tr>
<td>– Advanced signal processing</td>
<td></td>
</tr>
<tr>
<td>– Active analysis and data logging</td>
<td></td>
</tr>
<tr>
<td>– TFT display for instruction</td>
<td></td>
</tr>
<tr>
<td><strong>Patient Monitor</strong></td>
<td>SuperH</td>
</tr>
<tr>
<td>– Video and audio for better presentation</td>
<td></td>
</tr>
<tr>
<td>– Graphic support</td>
<td>200MHz with 400 DMIPS,</td>
</tr>
<tr>
<td>– Increase the amount of patient data</td>
<td>UP to 1.5MB SRAM for frame buffer</td>
</tr>
<tr>
<td>– Data processing</td>
<td>for video</td>
</tr>
<tr>
<td>– Active analysis and data logging</td>
<td>BT656 Video In/16-bit RGB Video out</td>
</tr>
<tr>
<td>– Monitor pressure and moisture</td>
<td></td>
</tr>
<tr>
<td><strong>CPAP Machine</strong></td>
<td>RX600</td>
</tr>
<tr>
<td>– Quiet, variable speed motor control</td>
<td></td>
</tr>
<tr>
<td>– Active analysis and data logging</td>
<td>FPU to support advanced motor control</td>
</tr>
<tr>
<td>– Monitor pressure and moisture</td>
<td>Large RAM to support data analysis</td>
</tr>
<tr>
<td>– Data processing</td>
<td>12-bit ADC for data acquisition</td>
</tr>
</tbody>
</table>

Please visit our Medical Solutions web page for a more complete overview of our products and solutions.

am.renesas.com/medical
The table only lists a few memory configurations and package sizes of the highlighted microcontrollers. For more options, please refer to the product brochure and our web site.

### Direct Third-party Support for Your Applications

The Renesas ecosystem includes many products and services from third-party vendors, complementing the system development tools Renesas provides. This ecosystem also encompasses long-term support programs.

### RTOS and Middleware

<table>
<thead>
<tr>
<th>RTOS</th>
<th>Micrium</th>
<th>embOS RTOS</th>
<th>freeRTOS is available</th>
<th>RTX RTOS support</th>
<th>CMX Systems</th>
</tr>
</thead>
</table>

### Renesas MCU Ecosystem

© 2012 Renesas Electronics America Inc. (REA). All rights reserved. All trademarks are the property of their respective owners. Renesas product warranties and limitations are expressly set out in the Renesas Electronics America Inc. Standard terms and conditions of sale. Renesas expressly disclaims all other warranties, express or implied, including without limitation any implied warranties of merchantability and fitness for a particular purpose and any warranty against infringement and any implied warranty arising from course of performance, course of dealing, usage of trade, or otherwise, with respect to materials or services provided under these terms or to the product, material or documentation or any use thereof. Renesas products are not authorized for use in any application or purpose that poses a direct threat to human life, including but not limited to medical or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention without the express prior written consent of Renesas Electronics America Inc. Renesas shall not be responsible or in any way liable for any damage or loss incurred arising from use of any Renesas product in any such application or purpose where Renesas prior written consent has not been obtained by the buyer or user.