White Paper

Low-End MCUs: RL78/G23 Meets the Demands of the IoT Age

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April 2021

Abstract

The RL78/G23 MCU, launched in April 2021, reflects today's needs with significant advances over existing RL78 products. RL78/G23 MCUs meet the broad requirements of low-end MCUs in this age of IoT: low-power consumption, intelligent functions, and user-friendly development. This white paper discusses how RL78/G23 MCUs fulfill such challenging demands.

Introduction

A stable and constant market environment for 8/16-bit MCUs, otherwise known as low-end MCUs, is expected for the foreseeable future for endpoint applications such as home appliances and IoT devices. The Renesas RL78 family of low-end MCUs has been used in myriad devices, popular for its low-power consumption and extensive product lineup. Now, as the IoT era enters its prime, our expanded and advanced RL78 MCUs meet the sophisticated needs of IoT applications. RL78/G23 is the next generation of RL78 family MCUs, offering enhanced energy efficiency while realizing high performance and intelligent operations.

RL78/G23 MCU Characteristics Meet the Demands of the IoT World

In the IoT age, where everything is connected to a network, endpoint device components increasingly require lightweight, compact batteries boasting low-power consumption for prolonged use, as well as robust security for safe and wireless firmware updates. Improved software efficiency is needed to reduce the CPU load, along with an urgent demand introduced by the COVID-19 pandemic for human interface with contactless controls. Shorter development time expediting product-to-market remains a key issue. RL78/G23 MCUs are advanced versions of conventional RL78 MCUs, reflecting all of these needs in

solutions and resolving user problems through lower power consumption, more intelligent functions, and a friendlier development environment. This paper introduces and clarifies the following features:

- Outstanding power performance contributes to longer usage of battery-powered IoT devices
  - New development process reduces power consumption
  - Fewer wasteful CPU operations due to faster startup
  - Faster CPU processing time with SNOOZE Mode Sequencer (SMS)

- Intelligent functions realize data protection and efficient operations
  - Enhanced security functions
  - SNOOZE Mode Sequencer (SMS) enables processing, judgement, and peripheral functions bypassing use of the CPU
  - Supports software/hardware field updates
  - Logic and event link controller enables user to link events and logic (AND, OR, EX-OR, D flip-flop, etc.)

- Advanced development environment shortens development period
  - Smart configurator simplifies development, offering GUI settings for initial software settings, and also driver, middleware and library settings as well
  - Easy-to-use and user-friendly tool interface
  - Arduino library availability

- Reduced system BOM costs through built-in peripherals and compatibility ensuring seamless migration
  - Maintains compatibility with existing RL78 MCUs (pin assignment, CPU core, peripheral functions)
  - System BOM cost reductions (built-in peripheral functions)
    - Output current control port
    - 40mA output port
    - Capacitive touch sensors

Outstanding Power Performance Extends Usage of Battery-Powered IoT Devices

New Development Process Reduces Power Consumption

The semiconductor process technology used for conventional RL78 MCUs was modified for the RL78/G23 MCU. The following comparison of RL78/G13 and RL78/G23 MCUs shows a 30% reduction in current consumption in Run mode.

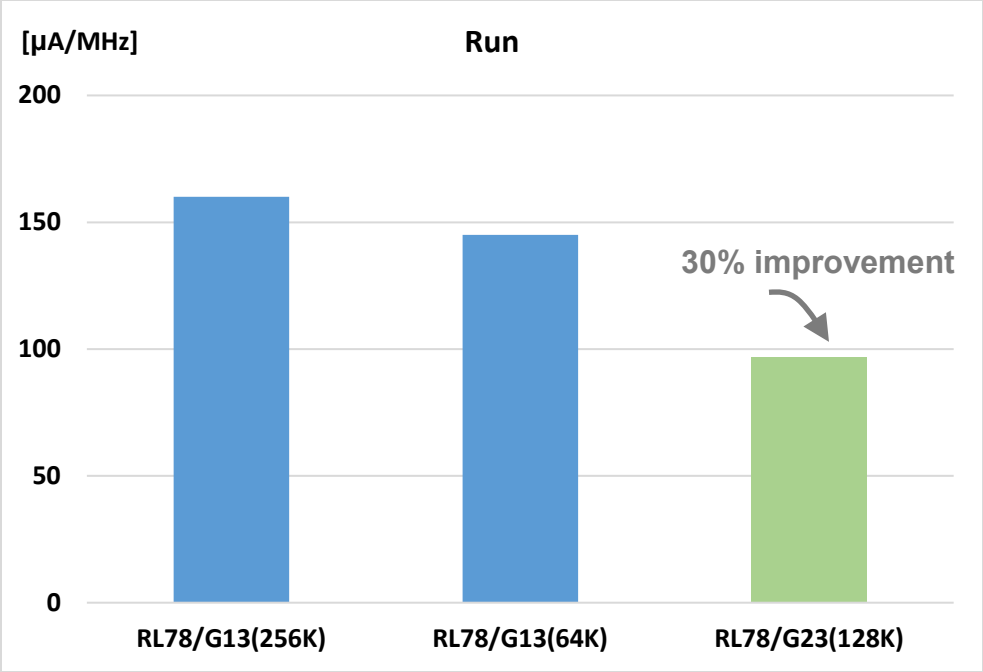

Figure 1: Low Power Consumption with Modified Semiconductor Process

Fewer Wasteful CPU Operations Due to Faster Startup

RL78/G23 MCUs feature an improved version of the RL78/G13 transition time from standby (STOP mode) to wake-up mode in on-chip clock operations. When using the high-speed on-chip oscillator, this results in shortening the RL78/G13 MCU's 18 to 65µS transition time to 1µS between the two modes. This shorter transition time not only reduces operational delays, but also cuts total power consumption by increasing standby time in applications with repeated intermittent standby and Run mode operations.

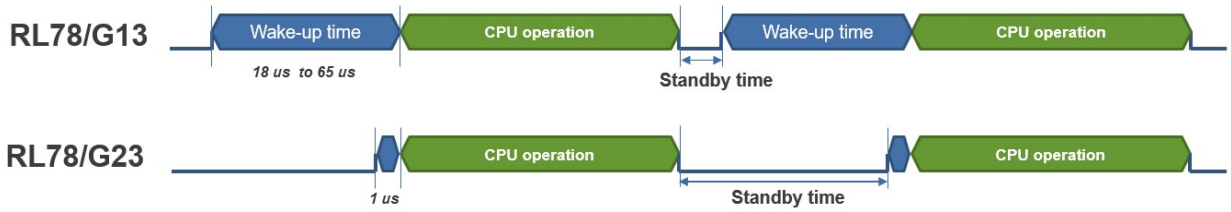

Figure 2: Shorter Wake-Up Time Reduces Power Consumption

The new, intelligent SNOOZE Mode Sequencer (SMS) function further lowers power consumption, as described in the next section.

Intelligent Functions Realize Data Protection and Efficient Operations

Enhanced Security Functions

Potential RL78/G23 MCU use cases include connecting a device to networks through other ICs, to the main controller, or to a sensor control device. Enhanced security functions help prevent unauthorized access issues such as data leaks ensuring safe connections in these cases.

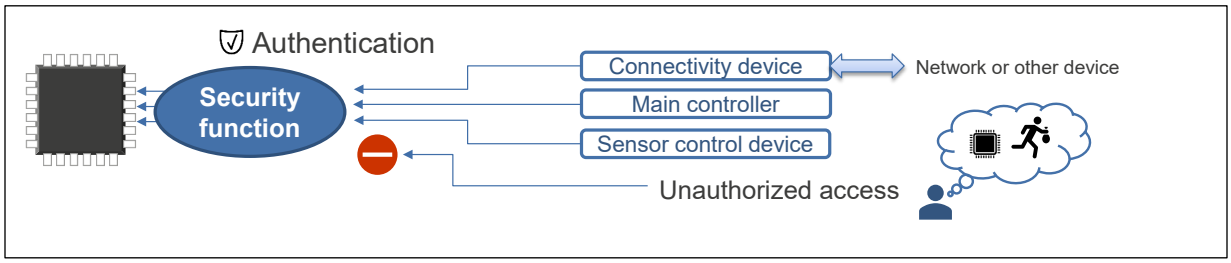

Figure 3: Use Cases Requiring Security Measures

RL78/G23 MCUs feature a secure system achieved with a True Random Number Generator (TRNG), a device-dependent Unique ID that cannot be overwritten, and a Customer ID function allowing the customer to set an ID number (an arbitrary value stored in a non-rewritable area). The Unique ID is randomly seeded and can be used for product tracing after field deployment. The Customer ID can be used as an encryption key, for judging product authenticity or system verification. Both IDs are valuable security authentication tools.

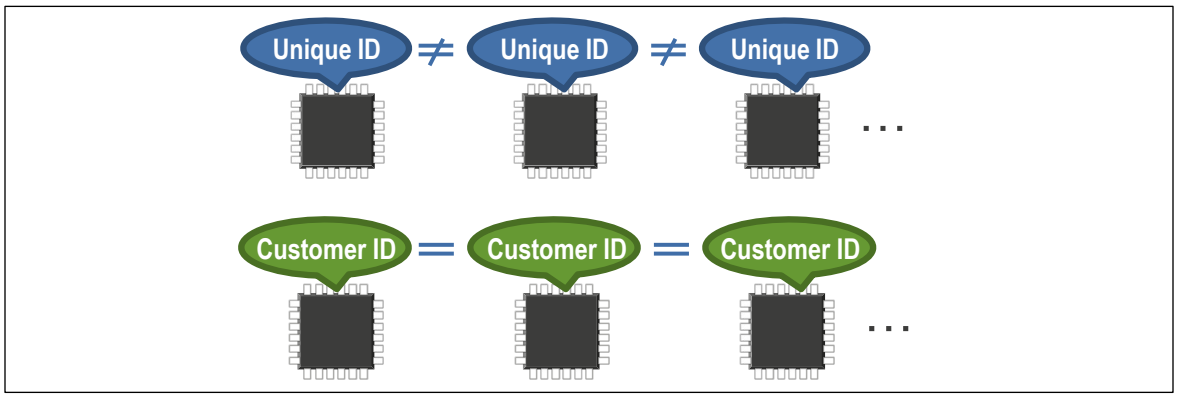

Figure 4: Unique ID and Customer ID

In addition, the RL78/G23 MCUs work with an AES software library for encryption of transmission data. The AES software library is optimized for the RL78 family assembler code and provides efficient AES-compliant encryption and decryption. The library also supports the AES-GCM standard for use in the field of smart meters. Use of the encryption software library also enables secure boot and secure updates.

Built-In SNOOZE Mode Sequencer (SMS)

SNOOZE mode activities in conventional RL78 MCUs were limited to A/D conversion and the serial receive function.

When the RL78/G23's new built-in SNOOZE Mode Sequencer is running, various processes can be executed, and peripherals accessed by bypassing the CPU. As a result, additional CPU standby time reduces power consumption. The SNOOZE Mode Sequencer enables control of the following calculations, judgements, and peripheral functions while the CPU is stopped:

- Sequential execution of 32 processes selected from 21 processing types
- Process execution in CPU standby mode
- CPU wake-up capability in standby mode
- Direct startup of Data Transfer Controller (DTC)
- Access to RAM and SFR of peripheral functions
- 16-bit addition and subtraction calculations
- Branch processing
- Extended wait enabled by automatically switching wait-processing clock to low-speed, on-chip oscillator

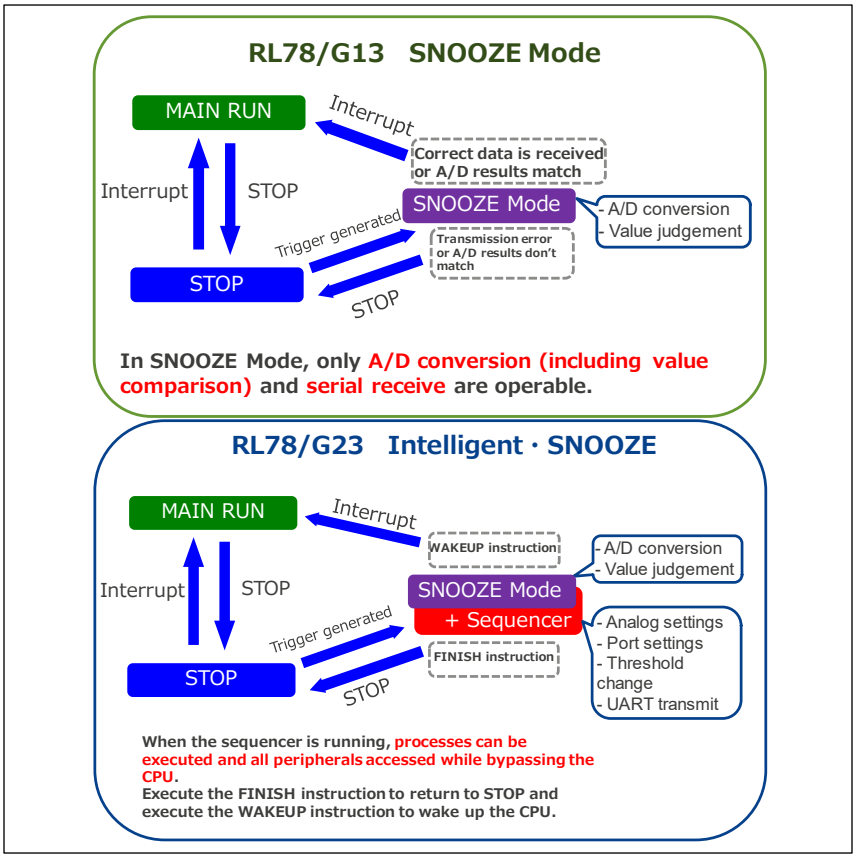

Figure 5: Differences Between RL78/G13 and RL78/G23 MCUs

The figures below show that controlling these processes—calculations, judgements, and peripheral functions—without the CPU enables low-power operations in actual applications.

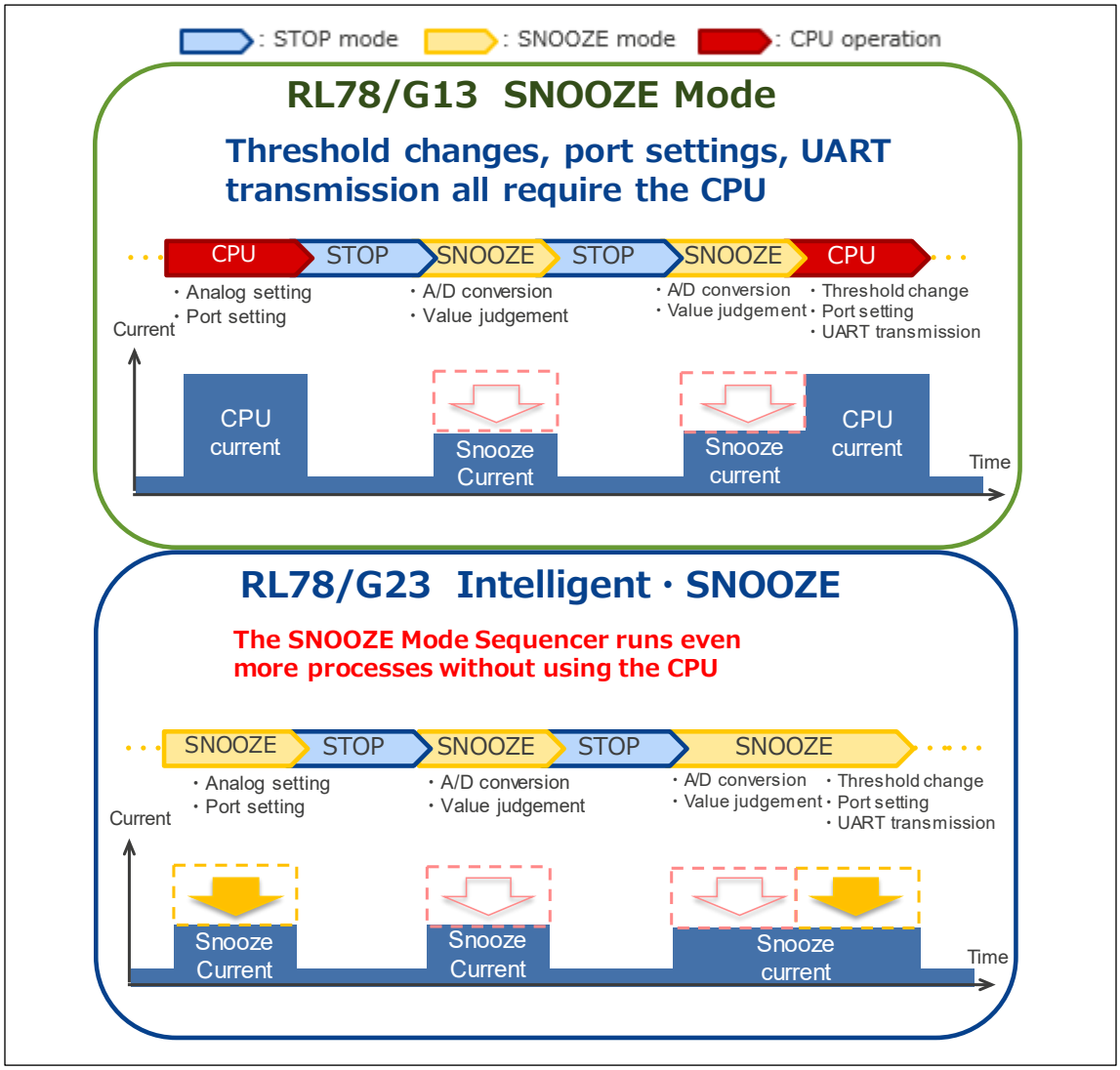

Figure 6: SNOOZE Mode Sequencer: Low-Power Consumption Operations Bypassing CPU

For additional information on SNOOZE mode operation, please see our application notes that describe functions such as power source monitoring, long/short button push detection, multiple LED ON/OFF control, fire detection operation, and applications for moving average calculations.

Supports Software/Hardware Field Updates

The code flash memory boot area in RL78 MCUs comprises boot cluster 0 and boot cluster 1 and includes a boot swap function. When a boot area rewrite using self-programming fails due to a momentary power interruption, the swap function allows the boot program to be swapped with the new program after the system is rebooted and the new program is successfully written.

RL78/G23 MCUs have increased the boot cluster areas from 4K bytes of the RL78/G13 MCUs boot to 16K bytes. The larger size means programs packed with more functions can be written to the boot clusters, further simplifying software field updates.

Logic and Event Link Controller

RL78/G23 MCUs add a logic function to the RL78/G14's event link controller function which allows direct links from events to peripheral functions while bypassing the CPU. This addition enables the user to link events and logic (AND, OR, EX-OR, D flip-flop, etc.). Embedding the logic eliminates the need for external logic, allowing direct connection between peripheral functions without impacting the CPU load.

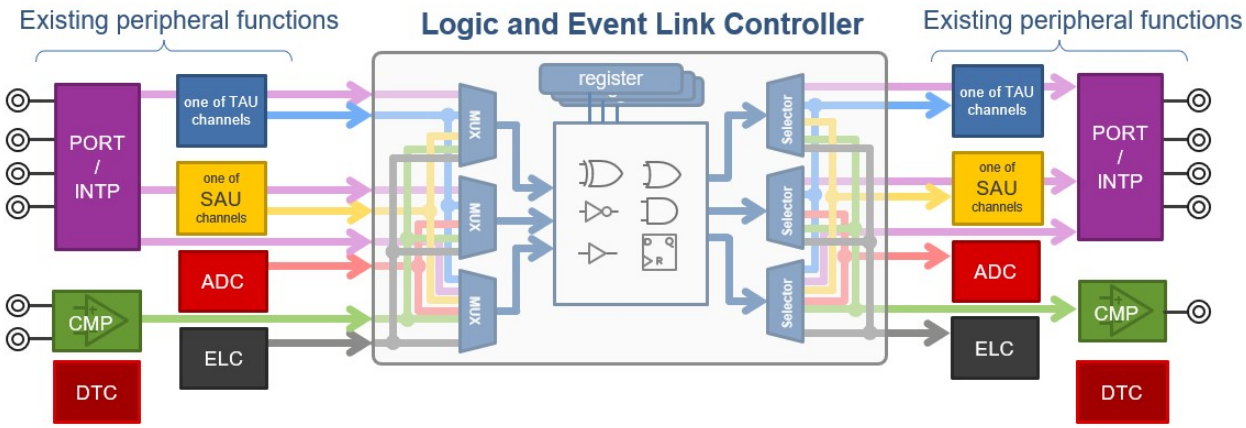

Figure 7: Logic and Event Link Controller Overview

The following figures show sample usage of the logic and event link controller: simple signal logic switching and the addition of a circuit to encode from NRZ signal to RZ signal. This can also be used to respond to specific requests such as adjusting the timing of the timer or executing output to a port according to interrupt timing.

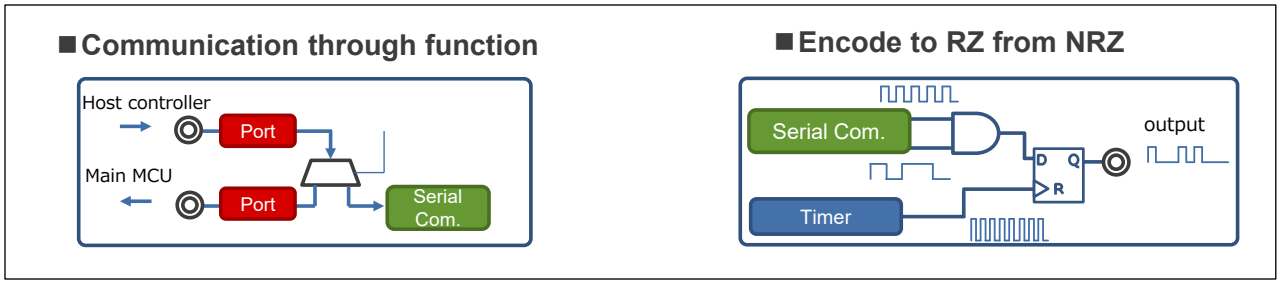

Figure 8: Logic and Event Link Controller Usage Examples

Renesas offers many other application notes describing sample logic and event link controller applications, such as multiple parameter monitoring, slave select pin (4-wire type SPI), anti-chattering circuit, and canny edge detection.

Advanced Development Environment Shortens Development Time

Smart Configurator Simplifies Development

RL78/G23 comes with a fortified code configurator. This smart configurator with “manual-free” tool interface is a utility conceptualized around “freestyle software configuration.”

In addition to initial software settings, the configurator GUI can be used to set middleware and libraries, including peripheral function drivers, touch key software, and security software. The smart configurator also handles use of MCU pins, clocks, interrupts, timers and more, and manages resources to mediate conflicting processes. These features enable building of a startup routine and facilitate the smooth import of middleware and other programs. In addition, customized board information can be output based on the reference board.

The GUI also assists settings related to the SNOOZE Mode Sequencer function, such as the selection of startup trigger and the combination of operation blocks used in the development. The user configures the operation by setting and confirming resources (selected from 32 sequencing commands and other options), outputs the results in assembly, and implements into the program.

We offer an extension file for the logic and event link controller functions on the Renesas website. We invite you to download and import the file to simplify software design when adding new peripheral functions to the MCU.

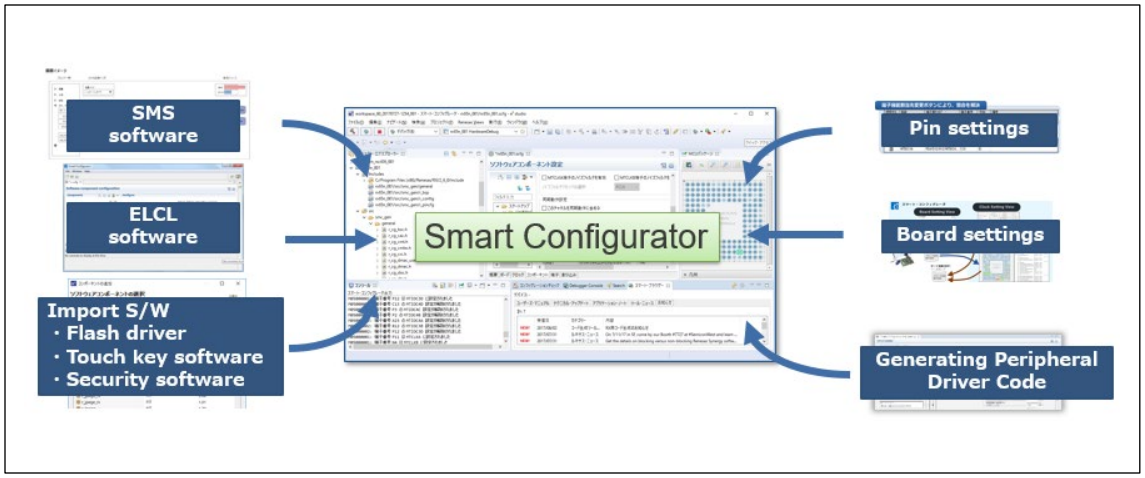

Figure 9: Smart Configurator Overview

Arduino Library Usage

Renesas has also prepared an Arduino library in order to simplify the development process using the RL78/G23 Fast Prototyping Board for evaluation. With the IDE running on your computer, you can create, compile, and debug your program using the Arduino language. Then simply transfer the program to the RL78/G23 Fast Prototyping Board and test operations.

Reduced System BOM Costs Through Built-In Peripherals and Compatibility Ensuring Seamless Migration

Maintains Compatibility with existing RL78 MCUs

Renesas has strived to maintain compatibility with conventional RL78 MCUs to ensure an easy migration to RL78/G23 for current users. RL78/G23 integrates the same CPU core as RL78/G14 and pin assignments, packaging, etc., are compatible with RL78/G14. The RL78/G23 peripheral function IP follows that of the conventional RL78, with the exception of newly added and newly improved functions.

System BOM Cost Reductions (Built-In Peripheral Functions)

RL78/G23 MCUs offer newly built-in functions often requested by users as a way to reduce system BOM costs.

- Output current control port

Many users requested fewer current-limiting resistors normally required for controlling LEDs. In response, we added an output current control port. This port allows the user to select the output level, from 2, 5, 10 and 15mA, enabling us to reduce the number of current-limiting resistors.

- 40mA output port

We also added an output port that can drive up to 40mA. This allows external circuit control of larger current flows, eliminating the need for an external transistor.

- Capacitive touch sensor

Capacitive touch sensors have been added in response to requests for on-chip touch sensors to provide a human-machine interface. With our 3rd generation touch key IP ensuring highly touch sensitive and superior noise-immune characteristics, users can take advantage of both self- and mutual-capacitance touch methods to develop waterproof, matrix, and proximity-sensing products.

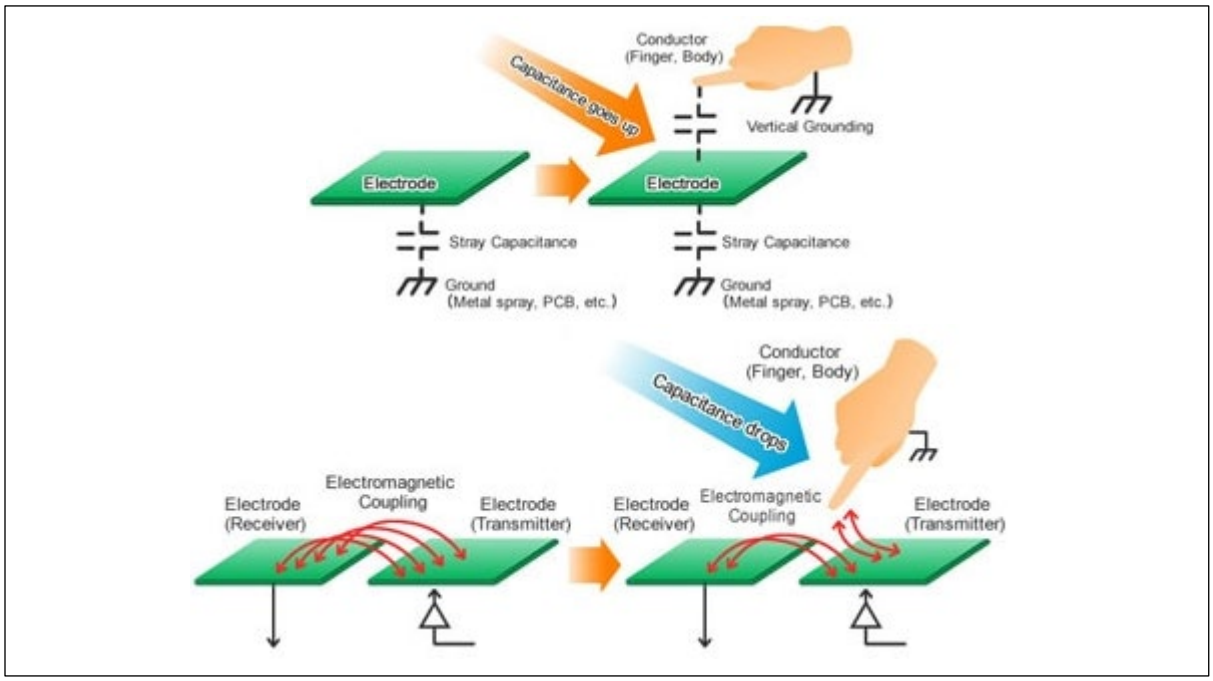

Figure 10: Self-Capacitance and Mutual-Capacitance Touch Methods

The self-capacitance and mutual-capacitance touch methods each have unique features and should be selected based on the target application.

	Self-capacitance touch method	Mutual-capacitance touch method
Layout	Easy	Limited
Water resistant	Weak	Strong
Matrix	Limited	Available
Proximity sensing	Easy	More challenging than self-capacitance touch method

The merits of built-in capacitive touch sensors:

- Cost reduction: users only need to arrange electrodes (PCB pattern)
- Improved durability: less physical wear and tear means better durability
- No need for dust/water countermeasures: electrodes are housed inside the unit, well-protected from contaminants

- Added product value: easy product maintenance thanks to the flat unit surface
- Enhanced design attributes: touch keys can remain hidden by linking to LEDs

Capacitive touch sensors are increasingly used in applications at every level, from high-end appliances to household electronics and health care devices, along with industrial and housing equipment. These useful sensors will appear in an expanding range of devices.

Renesas offers QE (Quick and Effective) for Capacitive Touch, a development support tool for capacitive touch sensors simplifying their development and adjustment. The tool's GUI automates many tasks, streamlining initial settings and sensitivity tuning of touch interfaces even for beginners, while shortening the normal development time for embedded systems using capacitive touch sensors.

Conclusion

RL78/G23, the RL78 Family's newest MCU, adds many new features while maintaining compatibility with existing products for a smooth migration. The MCUs boast expanded memory and functions while using the same CPU core and pin configurations for peripheral functions.

The lineup features new functions, including the SNOOZE Mode Sequencer and logic and event link controller, a large current port and capacitive touch sensors, as well as augmented security functions. Users can easily migrate their existing RL78 designs with simple software migration while taking advantage of these new functions to enhance performance, reduce power consumption, and add new features to the end product. RL78/G23 MCUs offer enhanced energy efficiency while realizing high performance and intelligent operations—the optimum MCU for the IoT age.

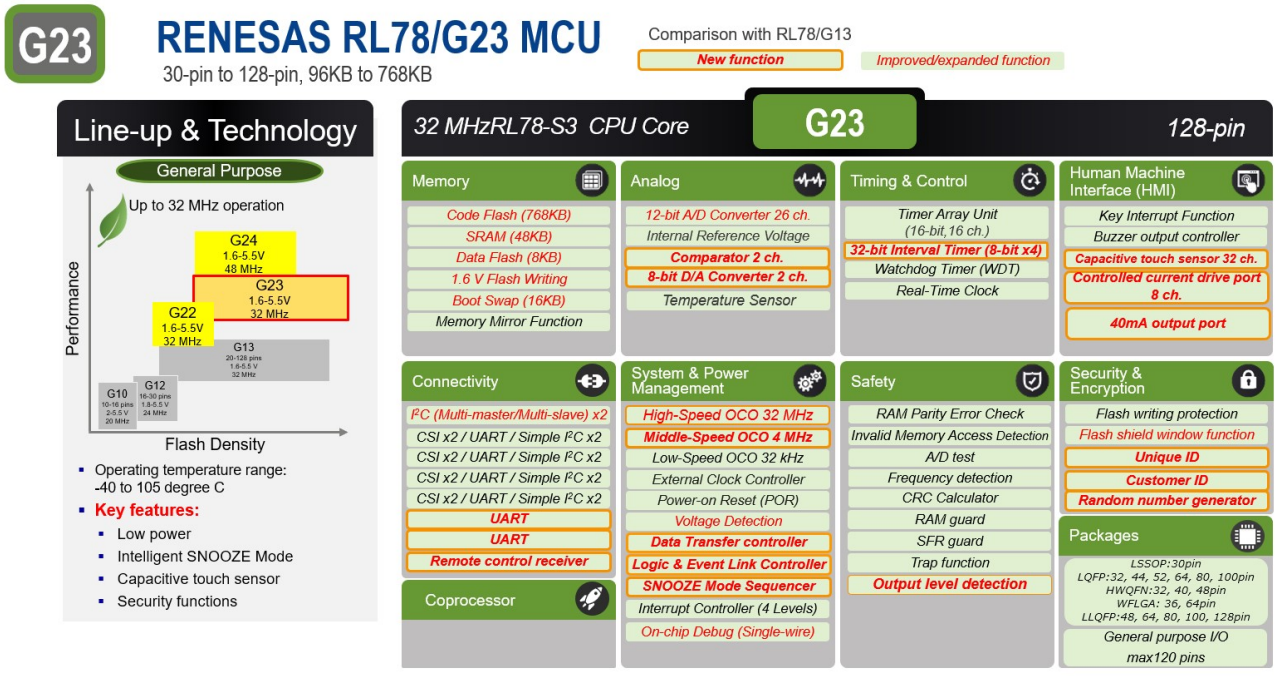

Figure 11: RL78/G23 Block Diagram

Learn More

1. RL78/G23 Family of 16-bit Microcontrollers
2. RL78/G23-64p Fast Prototyping Board Evaluation board to start prototyping without additional hardware tools
3. Smart Configurator Simplify the embedding of Renesas drivers