True Low Power™ Platform for 8-/16-bit Applications

RL78/I1D Microcontrollers

Introducing the RL78/I1D Group – Analog Integration with New Low Power Capabilities and Fast Wake-up

RL78/I1D Block Diagram

VDD = 1.6 to 3.6V
Ta = -40 to 105°C

Memory
- Program Flash: 8 to 32 KB
- SRAM: 0.7 to 3 KB
- Data Flash: 2 KB

System
- DTC: 23 sources, 24 sets
- Data Operation Circuit
- Interrupt Controller: 4 Levels
- Clock Generation: Internal, External
- POR, LVD
- Event Link Controller
- Debug w/trace: Single-wire

Safety
- RAM, SFR: Parity, Protection, Invalid
- ADC: Self-diagnostic
- Clock Monitoring
- Memory CRC
- I/O Port Read back

Analog
- ADC: 12-bit, 17 ch
- Internal Vref: 1.8V, all modes
- Temperature Sensor: 1.8V, all modes
- Comparator: 2 ch
- Op-Amp: 4 ch

Timers
- 16-bit TAU: 16-bit, 4 ch
- PWM: 3 ch
- Interval Timer: 12-bit, 1 ch
- Interval Timer 8-bit, 4 ch: (16-bit, 2 ch)
- WDT: 17-bit, 1 ch
- RTC: Calendar

Power Management
- HALT: RTC, DTC Enabled
- SNOOZE: Serial, ADC Enabled
- STOP: SRAM On
- Fast Wake-up: 4 µsec

Communications
- 2 x I²C Master
- 2 x CSI/SPI 7-, 8-bit
- 1 x UART 7-, 8-, 9-bit

Analog Integrations
- 12-bit ADC has up to 17 channels; it completes a conversion in 3.375 µs
- OpAmp (4 channels) has two modes: High Speed (1.7 MHz GBW, 140 µA) and Low Power (0.04 MHz GBW, 2.5 µA)
- Comparator (2 channels) offers a Window mode
- Internal voltage reference and temperature sensor operate down to 1.8V
- ADC and OpAmp can be started up by an ELC trigger from a timer, comparator or external interrupt

True Low Power Enhancement
- New LP mode and mid-speed on-chip oscillator (MOCO) combine to enable extremely low power operation (124 µA at 1 MHz) with a fast wake-up capability: 4 µs (max.)
- Using the DTC, ELC, and DOC in Snooze mode implements a low-power configuration that handles tasks without CPU intervention
- New timer generates intervals up to 9 minutes long using the 15 kHz low-speed on-chip oscillator (LOCO) and consumes just 0.52 µA; up to 5 channels are available

Ideal for applications that require analog functions and low power usage, such as smoke and CO detectors, as well as motion and glass break detectors.

Flash
- 32 KB
- 16 KB
- 8 KB

RAM
- 3 K
- 2 K
- 2 K
- 2 K

Note: 2 KB when self-programming function and data flash are used.

Renesas Electronics America
www.renesas.com
I1D Low power ahead of competitors

RL78-series MCUs are the low-power champions in the 8/16-bit MCU market, achieving exceptional power consumption efficiency. Now an innovative power-saving design allows the new MCUs in the RL78/I1D group to perform better. They provide good task handling capabilities with miniscule current drain, exhibiting exceptional efficiency gains at clock speeds in the 1 to 4 MHz range.

Software can be used to select on the fly the best RL78/I1D speeds and operating modes (HS, LS, LV or LP) to meet variations in an application’s computing requirements. A new MOCO (1/2/4 MHz) provides extra flexibility in this regard. Extraordinarily long system battery lifetimes can be achieved by taking advantage of the MCU’s operating modes, available clock sources and speeds, and the run/standby/shutdown controls for on-chip functions.

Faster wake-up times decrease system power consumption in many applications in which the MCU is inactive for extended periods, but periodically goes to Run mode to perform brief bursts of tasks. This type of operation is common in motion detectors and glass break detectors, for example. RL78/I1D MCUs have fast wake-up times and consume small amounts of current during the wake-up process. They draw less current during the Run and Halt/Snooze modes, too. In many situations, the overall current consumption of an RL78/I1D chip is much less than that of older devices such as the RL78/G13.

<table>
<thead>
<tr>
<th>Operation Frequency</th>
<th>RL78/G13</th>
<th>RL78/I1D</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 MHz Run</td>
<td>3.7 mA – 154 μA/MHz (HS mode, HOCO)</td>
<td>3.2 mA – 125 μA/MHz (HS mode, HOCO)</td>
<td>-14%</td>
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<tr>
<td>8 MHz Run</td>
<td>1.2 mA – 150 μA/MHz (LS mode, HOCO)</td>
<td>1.1 mA – 138 μA/MHz (LS mode, HOCO)</td>
<td>-8%</td>
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<tr>
<td>4 MHz Run</td>
<td>800 μA – 200 μA/MHz (LS mode, HOCO)</td>
<td>580 μA – 145 μA/MHz (LS mode, MOCO)</td>
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<tr>
<td>1 MHz Run</td>
<td>380 μA (LS mode, HOCO)</td>
<td>124 μA (LP mode, MOCO)</td>
<td>-68%</td>
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<tr>
<td>8 MHz Halt/Snooze</td>
<td>260 μA (LS mode, HOCO)</td>
<td>250 μA (LS mode, HOCO)</td>
<td>-4%</td>
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<tr>
<td>4 MHz Halt/Snooze</td>
<td>230 μA (LS mode, HOCO)</td>
<td>40 μA (LS mode, MOCO)</td>
<td>-83%</td>
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<tr>
<td>1 MHz Halt/Snooze</td>
<td>210 μA (LS mode, HOCO)</td>
<td>27 μA (LP mode, MOCO)</td>
<td>-87%</td>
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<tr>
<td>Stop</td>
<td>0.23 μA</td>
<td>0.22 μA</td>
<td>-4%</td>
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</table>

Flexible clocking solutions

The new 4 MHz MOCO is a key factor in enabling RL78/I1D-based embedded systems to deliver low power operation and fast wake-up times. Whenever a higher-accuracy on-chip oscillator (OCO) is required (for instance, for UART communication), software can switch from the MOCO to the high-speed on-chip oscillator (HOCO), which inherently delivers ±1% accuracy over the MCU’s voltage and temperature range. When the CPU executes instructions in the 15 kHz Run mode, it consumes only 1.8 μA (120 μA/MHz), allowing the use of a lower-cost power regulator. Additionally, RL78/I1D MCUs with 30-, 32- and 48-pin packages (including those in the 5x5 mm, 32-pin QFN) provide 32 kHz clock input pins for a calendar function.
Analog integrations facilitate remote sensing

Embedded systems that connect to sensors are simplified by MCUs that incorporate analog functions, which deliver good performance, are flexible and consume low power. RL78/I1D MCUs integrate 4-channel OpAmps (each with 2 inputs and 1 output) that can be used to implement amplifiers and filters. Their outputs can be connected directly to the MCU’s built-in 12-bit ADC and comparators. That reduces pin counts, allowing smaller packages. The OpAmp and Comparators have a lower power mode, so the system can be in a low-power standby mode when they are enabled. The comparators have two reference inputs; they can be configured as window comparators with upper and lower limit settings. After a comparator-driven interrupt wakes up the MCU, the analog signal from the sensor can be checked in high resolution by using the ADC and OpAmp in its high-performance operating modes.

DTC, ELC, DOC and Snooze mode minimize the sensor system’s power consumption

Operation flow example – The sensor’s analog output value is captured periodically using the MCU’s on-chip OpAmp and ADC.

- **a.** 8-bit interval timer turns on the OpAmp and sensor.
- **b.** 12-bit interval timer establishes a delay long enough for the OpAmp and sensor to stabilize.
- **c.** 12-bit ADC measures the amplified sensor value after the stabilization time.
- **d.** DTC saves the measured sensor value to RAM.
- **e.** DOC judges measured result; if that result is outside the specified limits, it generates an interrupt to wake up CPU to set an alarm, etc.

On-chip voltage reference operates down to 1.8V

Many embedded systems use an external regulator just to provide a stable reference voltage for the MCU’s ADC. RL78/I1D MCUs have an on-chip voltage reference that eliminates the need for that external device, reducing system complexity and cost. A built-in temperature sensor is another cost-reduction feature. Additionally, inexpensive alkaline batteries can power RL78/I1D-based designs. These MCUs can use the full capacity of such batteries, obtaining maximum battery life, because they support the voltage reference, ADC and temperature sensor functions, among others – as well as the LS, LV and LP operating modes – at supply voltages down to 1.8V.

Long interval timers are valuable in many low power systems

RL78/I1D MCUs have enhanced timing features:

- Four channels of 8-bit interval timers with prescalers down to 1/128. Two of the timer channels can be cascaded to operate as a 16-bit counter. That configuration generates intervals up to 9.3 minutes long and can create as many as five interrupt sources simultaneously. Each interrupt can be executed factor by factor. This simplifies software code and speeds up system operations. This approach reduces the system’s overall power consumption.
Extensive Renesas Development Ecosystem

Hardware Tools

Explore → Evaluate → Develop → Manufacture

Detector Reference Design

CPU Board
P/N: RTE5117GC0TGB00000R

E1 Debugger and Programmer
P/N: R0E000010KCE00

Programmer
P/N: PG-FP5-EA

IDE/Compiler

IAR Embedded Workbench (EWRL78)

Renesas e2 studio

IAR & GNU build phase plug-in support, E1/ECUBE debug phase plug-in support

Code Generator

Applilet®

Royalty-free Windows®-based code generator

Real Time OS

Micrium

µC/OS-II and µC/OS-III

CMX SYSTEMS

RTX

Free RTOS

embOS

Detector Reference Designs

The RL78/I1D Group

<table>
<thead>
<tr>
<th>Pin Count</th>
<th>Package</th>
<th>Memory (Kb)</th>
<th>RAM (Kb)</th>
<th>Data Flash (Kb)</th>
<th>CPU Frequency (MHz)</th>
<th>GPIO (Kb)</th>
<th>16-bit Timers</th>
<th>12-bit Timer</th>
<th>8-bit Timer</th>
<th>Watchdog</th>
<th>RTC</th>
<th>ADC</th>
<th>Operational Amplifier</th>
<th>Comparator</th>
<th>CAN</th>
<th>UART</th>
<th>Master I2C</th>
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Note 1: Only 2 KB when self-programming function and data flash are used.