Wi-Fi enabled Demonstration & Evaluation Kit with Low-power RL78/G14MCU Provides Extensive HW/SW Features and Includes Digital Sensors

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Abstract

Renesas supports customers for its latest microcontrollers (MCUs) by providing feature-rich demonstration and evaluation kits called Renesas Demonstration Kits (RDKs). These system-board based kits highlight not only key MCU device features such as large arrays of embedded Flash and SRAM, low-power modes, and advanced on-chip peripherals, but also the latest board-level peripherals, external memories, user interfaces, sensor Interfaces, and other hardware features. On the software side, our RDKs are supported by major software tool vendors and include many software evaluation packages.

Recently we’ve seen a definite design trend toward embedded systems that require a way to connect sensors to a wireless network, to the Internet in general, and even to specific Cloud services—a connectivity imperative loosely called “Internet of things”. This paper highlights the capabilities of a new RDK that addresses that trend. It allows system engineers to quickly explore the technologies behind Embedded Wi-Fi and the Cloud connectivity. Further, it enables them to quickly implement setups for reporting sensor status to the Cloud, and to easily connect one or several RDKs to the “Internet of things”.

Up to four onboard digital sensors (for light, temperature, motion and voice) can be read on the new RL78/G14 RDK, processed locally on the board and also monitored remotely via the Cloud. These capabilities are valuable in many markets and applications, including biometrics, remote sensing, telematics, security systems, retail equipment, and energy management systems.

Introduction

In the second half of 2012, Renesas America Inc. worked diligently with many of its ecosystem partners to develop one of the industry’s most advanced, most connected low-cost evaluation kits for an economical 16-bit MCU: the RL78/G14 Renesas Demonstration Kit (RDK).
Up to 14 technology partners, expert firms in the Renesas Alliance partner program and ecosystem, contributed to or collaborated on the design, manufacturing and testing of this new demonstration and evaluation kit. The RL78/G14 RDK functions not only as a stand-alone MCU evaluation board, but also as a cloud-connected device. It incorporates Wi-Fi technology from Gainspan Corp. and Cloud service provider Exosite. Final test and integration are performed by our system design partner, Future Design Inc.

Several thousand units have been manufactured, each with a unique network identifier based on the board’s MAC address, allowing a broad dissemination. These RDKs can be used to create unique network nodes. They also enable seamless wireless connections between any number of sensor-rich RDK boards and the Internet.

The low-cost RL78/G14 RDK is available from Renesas distributors (see links to resources at the end of this document).

**Powered by a best-in-class, power-saving 16-bit RL78 MCU**

The Renesas RL78 Family of MCUs offers exceptional low-power features and has an architecture that lets system designers achieve high MCU processing performance. Its miniscule current drain in standby modes saves power for extended operating time in battery-powered systems. The design of the new RDK allows the RL78/G14 MCU to enter each of its power-down modes and shows power mode status on a dedicated on-board display (E Ink).

**Figure #1** shows the power an RL78/G14 MCU consumes in Stop mode with only the Watchdog Timer and Low-Voltage Detect units active: a mere **0.31µA**. This is much less than the power used by other architectures in the Stop mode.

![Stop Mode: WDT + LVD](image)

**Figure #1: Stop-mode current of the RL78/G14 MCU and chips from other suppliers.**
Feature-rich MCU family

The RL78/G14 MCU is an upgrade of the RL78/G13 chip. It adds features such as a faster 16-bit timer with RJ/RD/RG modes, a 2-channel 8-bit DAC, additional MAC instructions, an improved DMA engine and a 2-channel analog comparator. Performance of this 16-bit MCU is rated at 44DMIPS at 32MHz.

The MCU version used in the new wireless-enabled RDK provides large amounts of on-chip memory:

- Program Flash: 256KB
- Data Flash: 8KB
- SRAM: 24KB

Figure #2 shows the block diagram of the 100-pin MCU used in the RL78/G14 RDK:
Major features of the new RDK’s circuit board

The RL78/G14 RDK has many user interfaces, sensors and communication interfaces. Figure #3 shows these hardware features, which include some unique solutions:

- A low-cost graphics LCD matrix by Okaya
- A zero-power electronic-ink segmented display by E Ink
- Power interfaces built with Renesas MOSFETs and TRIACs
- Four digital and MEMS sensors for light, temperature, motion and voice by ADI
- An integrated 802.11b/g Wi-Fi module by Gainspan
- PMOD connectors for up to two PMOD daughter-cards

![Figure #3: Features of the RL78/G14 RDK circuit board.](image)

The low-power wireless embedded solution

The engineering team that developed the RL78/G14 RDK wanted to use a low-power solution for the Wi-Fi module. So Gainspan recommended the use of the power-efficient $\text{GS1011MIPS}$ module, which has an optimized power footprint at all times. It is compatible with the IEEE 802.11b standard (up to 11Mbit/s) and has been certified by the Wi-Fi Alliance.

Like other Renesas evaluation kits in the RDK family, the Wi-Fi enabled R78/G14 RDK can run from a 500-mA USB source. This holds for even its most active Wi-Fi modes, which include power-hungry transmission bursts.
Progressing from a Wi-Fi add-on approach to an “Embedded Wi-Fi” design

Previous RDK units could support Wi-Fi connectivity only by using a separate plug-in daughter-card from Gainspan Corp. That company’s **WAB-GW-GS1011MIP** external Wi-Fi adapter, for example, is shown in picture #4, plugged into an RL78/G13 RDK to implement a wireless link:

![Plug-in Wi-Fi daughter-card added to an RL78/G13 RDK.](image)

**Figure 4: Plug-in Wi-Fi daughter-card added to an RL78/G13 RDK.**

Because embedded Wi-Fi is becoming a natural interface for connecting embedded systems to the Internet, the integration of GainSpan’s **GS1011MIPS** Wi-Fi module was a smart and natural choice for the RL78/G14 RDK. It facilitated hardware/software integrations and helped minimize the overall development and production cost of the new wireless-enabled kit.

The picture of the **RL78/G14 RDK** circuit board (see Figure #5) shows the position of the compact, fully integrated **GS1011MIPS** module, which incorporates an internal antenna:

![RL78/G14 RDK with on-board Wi-Fi module.](image)

**Figure # 5: RL78/G14 RDK with on-board Wi-Fi module.**

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Integration of the Wi-Fi support and Wireless demos

Building on previous experience with a daughter-card Wi-Fi connectivity solution, the integration of the **GS1011MIPS** Wi-Fi module circuitry into the main RDK board was quite straightforward. The module’s many capabilities—onboard power regulation, integrated oscillators, multiple ICs (flash memories, etc.) and built-in antenna—allow a compact footprint on the host board of only 1.2 x 0.75 inches.

The factory demo code provided with the TL78/G14 RDK gives users all the tools and applications needed to set up and demonstrate Wi-Fi and Cloud operations, including a complete Cloud-connectivity client mode designed by Exosite. This mode is entered by pressing pushbutton #1 plus Reset on the RDK. This operation is shown in Figure #6, which also describes how to initiate the other three factory demo modes. The picture shows the mode instructions displayed on the RDK board’s LCD.

<table>
<thead>
<tr>
<th><strong>GainSpan Embedded Web Server Demo</strong></th>
<th>Default demo at power-up; don’t press any switch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provisioning Mode</strong></td>
<td>Press <strong>Switch 2</strong> and toggle RESET switch, then release <strong>Switch 2</strong></td>
</tr>
<tr>
<td><strong>Exosite Cloud Demo</strong></td>
<td>Press <strong>Switch 1</strong> and toggle RESET switch, then release <strong>Switch 1</strong></td>
</tr>
<tr>
<td><strong>Over the Air Firmware Update (OTAFU)</strong></td>
<td>Press <strong>Switch 3</strong> and toggle RESET switch, then release <strong>Switch 3</strong></td>
</tr>
</tbody>
</table>

![Figure #6: Four Factory Demo modes and LCD copy.](image)

The User can boot up the RDK board as an embedded Web Server, providing sensor feedback locally. Pressing **Switch #2** is the way to enter the provisioning mode, while pressing **Switch #3** allows the user to perform a Flash update or Wi-Fi module update via a wireless link. The cloud connectivity demo provided by Exosite is entered by pressing **switch #1**. It gives the RDK a secure website dashboard at [https://renesas.exosite.com](https://renesas.exosite.com).

Any RDK User can sign up for a free account at [https://renesas.exosite.com/signup](https://renesas.exosite.com/signup).

This online dashboard portal can be used to display multiple sensor data collected from an RDK. It can also be used to send control data to the RDK and to connect and manage multiple RDK systems.

Software source code for the RDK (from Micrium, Renesas and other projects) is at the RDK software download website: [am.renesas.com/RDKRL78G14/software](am.renesas.com/RDKRL78G14/software). It can be applied to many different connected-device applications.
Setting up a user-friendly Wi-Fi enabled demonstration/evaluation system

A major development goal for the RK78/G14 RDK was to make the Wi-Fi configuration procedure very user-friendly. This aim was achieved by building a simple **web server** that helps users complete the entire provisioning process just by progressing through several steps in click-thru on-screen setup menus.

The **Wi-Fi provisioning** procedure encompasses selecting and connecting to a Wi-Fi Access Point (AP) so applications running on the embedded system can interact wirelessly with resources available on the Internet. For the RL78/G14 RDK, this procedure is exactly the same as the familiar one used to connect a laptop PC to a Wi-Fi access point. It involves scanning all the present APs and selecting the ones with which the system will work. Three selected APs are being scanned in **Figure #7**, for example:

![Figure #7: RDK scanning multiple access points from the list of possible connections.](image)

After allowed APs have been selected, the RDK stores those settings into its permanent memory (an EEPROM chip) and then re-uses them whenever the boot is initiated or the RDK is powered up.

**Interfacing with onboard digital sensors and reporting in the Cloud**

The RL78/G14 RDK incorporates physical sensors produced by ADI and Renesas:

- Temperature: ADT7410, connected via I²C (more data is on the ADI [website](https:))
- Acceleration: ADXL345, connected via I²C (more data is on the ADI [website](https:))
- Microphone: ADMP401, connected via an ADC input (more data is on the ADI [website](https:))
- Light: PH5551A2NA1, connected via I²C (more data is on the Renesas [website](https:))
Here are sample screens depicting how sensor data are formatted on the partner clouds:

Sample of Project examples provided by Renesas and its technology partner experts.

Various firmware projects are available for the RL78/G14 RDK. They showcase the operation of internal MCU peripherals such as UARTs and timers and also highlight board-level circuitry such as the triac interface and the Wi-Fi operation. Additional RTOS demo packages are available from our ecosystems partners. They can be obtained from the RDK’s download site:

http://am.renesas.com/RDKRL78G14/software

- **Renesas software**
  - ADC Oneshot/Repeat
  - Async/Sync Serial
  - DMAC
  - IIC Slave/Master
  - LIN
  - LVD, RTC, WDT
  - Timers
  - Low power sensor demo
  - Motor control
  - EEPROM demo/driver
  - SD card demo
  - Triac demo
  - FET demo
  - Graphics
  - Accelerometer demo

- **Partner software**
  - Micrium
  - SEGGER
  - IAR
  - CMX Systems
  - FreeRTOS
  - Quadros
  - RoweBots
  - Redpine Wi-Fi
  - GainSpan Wi-Fi
  - ADPCM
  - Temp sensor and Light sensor
  - PMOD support
  - IR demo
  - Exosite Cloud connectivity
  - Bug Labs Cloud connectivity
  - Analog Devices
  - Theremin (PWM audio) demo
Other chipset solutions offered by Renesas ecosystem partners

The design of the low-cost wireless-enabled RDK incorporates contributions from many suppliers of ICs and discrete semiconductor devices. Each of their circuits that are built into the RDK board is a reference design tailored for the features and performance of the RL78/G14 MCU chip.

The chart shown below gives an overview of the chipset solutions included in this RDK:

<table>
<thead>
<tr>
<th>IC description</th>
<th>Desig.</th>
<th>Partner/Vendor</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>OKAYA 96X64, PE9664WRF-004-I02</td>
<td>LCD</td>
<td>Okaya</td>
<td>RE9664WRF-004-I02Q</td>
</tr>
<tr>
<td>SPEAKER, NDT-03C</td>
<td>LS1</td>
<td>STAR MICRONICS</td>
<td>NDT-03C</td>
</tr>
<tr>
<td>RS-232 transceiver, QSO16, ADM3101E</td>
<td>U14</td>
<td>ANALOG DEVICE</td>
<td>ADM3101EARQZ</td>
</tr>
<tr>
<td>MICROPHONE AMP, MSOP10, SSM2167-1RMZ-REEL</td>
<td>U9</td>
<td>ANALOG DEVICES</td>
<td>SSM2167-1RMZ-REEL</td>
</tr>
<tr>
<td>ACCELEROMETER, SPI/I²C, 3AX, 3G LGA14, ADXL345</td>
<td>U13</td>
<td>ANALOG DEVICES</td>
<td>ADXL345BCCZ-RL</td>
</tr>
<tr>
<td>DIGITAL MICROPHONE, LGA_CAV6, ADMP401</td>
<td>U10</td>
<td>ANALOG DEVICES</td>
<td>ADMP401ACEZ-RL7</td>
</tr>
<tr>
<td>MUX/DEMUX, QUAD, QSO16, ADG3257BRQZ</td>
<td>U27</td>
<td>ANALOG DEVICES</td>
<td>ADG3257BRQZ</td>
</tr>
<tr>
<td>AMBIENT LIGHT SENSOR, PH5551A2NA1, PH5551A2NA1</td>
<td>U4</td>
<td>CEL</td>
<td>PH5551A2NA1</td>
</tr>
<tr>
<td>AUDIO AMPLIFIER, MONO, 2.5W, WLCSP9</td>
<td>U8</td>
<td>ANALOG DEVICES</td>
<td>SSM2377ACBZ</td>
</tr>
<tr>
<td>TEMP SENSOR, I²C, 0.5DEG, SO8</td>
<td>U12</td>
<td>ANALOG DEVICES</td>
<td>ADT7410TRZ</td>
</tr>
<tr>
<td>TEMP SENSOR, I²C, 2DEG, DNL, SO8</td>
<td>(U11)</td>
<td>ANALOG DEVICES</td>
<td>ADT75ARZ</td>
</tr>
<tr>
<td>8Mbit SERIAL EEPROM, SO8WB</td>
<td>U18</td>
<td>MICRON</td>
<td>M25P80-VMW6TG</td>
</tr>
<tr>
<td>OPTI-COUPLOTR AC, SOP4</td>
<td>U3</td>
<td>CEL</td>
<td>PS2705A-1-F3-A</td>
</tr>
<tr>
<td>AUDIO AMP, STEREO, 0.090W, TSSOP14</td>
<td>U7</td>
<td>ON SEMI</td>
<td>NCP2811ADTBR2G</td>
</tr>
<tr>
<td>12MHZ, NX3225GA</td>
<td>X1</td>
<td>NDK</td>
<td>NX3225GA 12M EX500A-CG02994</td>
</tr>
<tr>
<td>32.768KHZ, NX3215SA</td>
<td>X2</td>
<td>NDK</td>
<td>NX3215SA 32.768kHz EX500A-MU00158</td>
</tr>
<tr>
<td>16MHZ, NX3225SA</td>
<td>X3</td>
<td>NDK</td>
<td>NX3225SA 16M EX500A-CS04990</td>
</tr>
<tr>
<td>E INK</td>
<td>DISP1</td>
<td>E INK</td>
<td>CONSIGNED</td>
</tr>
<tr>
<td>GS1011MIPS (on board)</td>
<td>U16</td>
<td>GAINSPAN</td>
<td>GS1011MIPS</td>
</tr>
</tbody>
</table>

Conclusions

This White Paper has described key features of a new Renesas low-cost, wireless-enabled evaluation kit. This support tool for designers of embedded systems allows investigations of and experiments with multiple technologies, from a best-in-class low-power microcontroller (the RL78/G14 MCU) to onboard peripherals and sensors, and, importantly, also to Wi-Fi and Cloud connectivity. The hardware and software integrated into the RL78/G14 RDK, plus the software that can be downloaded, combine to give system engineers an exceptionally productive out-of-the-box experience for jump-starting projects that take advantage of the latest design trends and market opportunities.
References and Resources

RL78 home page:
http://am.renesas.com/products/mpumcu/rl78/index.jsp

RL78-family tools page:
http://am.renesas.com/products/mpumcu/rl78/peer/tools.html

RL78/G14 MCU demonstration kit:
http://www.renesas.com/RDKRL78G14

RL78/G14 SW download page:
http://am.renesas.com/RDKRL78G14/software

RL78/G14 RDK manuals:
http://am.renesas.com/products/tools/introductory_evaluation_tools/renesas_demo_kits/yrdrkl78g14/sub/doc_child.jsp

Gainspan RDK page (Wi-Fi solutions):
http://www.gainspan.com/

Exosite main site (Cloud services):
http://exosite.com/

Bug Labs main site (Cloud services):
http://www.buglabs.net/ and https://github.com/buglabs/bugwarm-renesas

Team FDI site (Assembly turnkey):
http://www.teamfdi.com/