RX Family

Lightweight IP (lwIP) Module Using Firmware Integration Technology

Introduction

This application note describes the lightweight IP (lwIP) FIT module (r_lwip_rx), which is compliant with the firmware integration technology (FIT) concept.

In this application note, software of the lightweight IP (lwIP) FIT module is generally referred to as “the lwIP FIT module” or “this FIT module”. For specific information on the lwIP version used for this FIT module, see section 1.2.

Target Devices

RX65N group
RX72M group
RX72N group
RX64M group
RX71M group
RX66N group

When applying the material covered in this application note on another microcontroller, modify the descriptions or code to suit the specifications of the target microcontroller and extensively evaluate operation following the modifications.

Documents for Reference

1 Firmware Integration Technology User’s Manual (R01AN1833)
2 RX Family: Board Support Package Module Using Firmware Integration Technology (R01AN1685)
3 Adding Firmware Integration Technology Modules to Projects (R01AN1723)
4 Adding Firmware Integration Technology Modules to CS+ Projects (R01AN1826)
5 Renesas e^2 studio Smart Configurator User's Guide (R20AN0451)
6 lwIP - A Lightweight TCP/IP stack (link)
7 Lightweight IP stack (link)
8 lwip-tcpip GitHub (link)
9 Lightweight IP (lwIP) Driver Using Firmware Integration Technology (R20AN0788)

Contents

1. Overview

1.1 What is the “lwIP FIT Module”?

This FIT module is used by including it as a set of API functions for use in a project. For details on how to include this FIT module, see section 2.11, Including the FIT Module in Your Project.

1.2 Overview of the lwIP FIT Module

This FIT module is generated from lightweight IP (lwIP), which is released as open-source software, by using the FIT.

The lwIP version used for this FIT module is v2.2.1 (STABLE-2_2_1_RELEASE). Refer to the “README” section for details.

2. API Information

The operation of this FIT module has been confirmed under the conditions listed below.

2.1 Hardware Requirements

The microcontroller to be used must include the following modules.

- None are specifically required.

2.2 Software Requirements

This FIT module is dependent on the following FIT modules.

- r_bsp (Board support package FIT module, see document 2)
- r_lwip_driver_rx (lwIP driver FIT module, see document 9)

2.3 Supported Toolchains

The operation of this FIT module has been confirmed with the toolchains indicated in section 4.1, Environments for Confirming Operation.

2.4 Interrupt Vectors to be Used

None

2.5 Header File

For details on API functions for use with this FIT module, refer to document 7 under the heading “Documents for Reference” on the first page.

2.6 Integer Types

This FIT module uses ANSI C99 integer types, which are defined in stdint.h.

2.7 Settings for Compilation

The configuration options for this FIT module are defined in r_lwip_rx_config.h. r_lwip_rx_config.h is included from the lwipopts.h configuration header file for use with lwIP.

The option names and settings are described in Table 2.1. Refer to document 7 under the heading “Documents for Reference” on the first page for details.

Table 2.1 Configuration Options (r_lwip_rx_config.h)

Configuration Options in r_lwip_rx_config.h	
NO_SYS *The default setting is 1.	Selects whether or not an OS is to be used. Be sure to set 1. The setting 0 (OS used) is not supported. 0: OS used; 1: OS not used
SYS_LIGHTWEIGHT_PROT *The default setting is 0.	Selects whether to enable or disable protection between tasks (and protection against interrupts of tasks) for the specific critical areas during the allocation and release of buffers and the allocation of memory. If the setting of this macro is 1 (enabled) and that of the NO_SYS macro is 1, the I flag of the CPU in the critical section in lwIP is set to 0 (prohibiting interrupts). 0: Disabled; 1: Enabled
MEM_ALIGNMENT *The default setting is 4.	Sets memory alignment for the CPU. A change to the setting is not required. An attempted change to the setting may lead to incorrect operation of this FIT module due to incorrectly aligned access to data in memory.
MEM_SIZE *The default setting is 20*1024.	Sets the size of heap memory.
MEMP_NUM_PBUF *The default setting is 50.	Set the number of pbufs for the memp structure.
MEMP_NUM_UDP_PCB *The default setting is 6.	Sets the number of UDP control blocks.
MEMP_NUM_TCP_PCB *The default setting is 10.	Sets the number of TCP connections.
MEMP_NUM_TCP_PCB_LISTEN *The default setting is 5.	Sets the number of TCP connections in the listening state.
MEMP_NUM_TCP_SEG *The default setting is 16.	Sets the number of TCP segments the queue can hold.
MEMP_NUM_SYS_TIMEOUT *The default setting is LWIP_NUM_SYS_TIMEOUT_INTERNAL.	Sets the number of timeouts to be used by this FIT module.
PBUF_POOL_SIZE *The default setting is 16.	Sets the number of buffers in the pbuf pool.
LWIP_ARP *The default setting is 1.	Selects whether to enable or disable the ARP function. 0: Disabled; 1: Enabled
LWIP_IPV4 *The default setting is 1.	Selects whether to enable or disable IPv4. 0: Disabled; 1: Enabled
LWIP_ICMP *The default setting is 1.	Selects whether to enable or disable the ICMP module. 0: Disabled; 1: Enabled
LWIP_DHCP *The default setting is 0.	Selects whether to enable or disable the DHCP module. 0: Disabled; 1: Enabled
LWIP_IGMP *The default setting is 1.	Selects whether to enable or disable the IGMP module. 0: Disabled; 1: Enabled

LWIP_UDP *The default setting is 1.	Selects whether to enable or disable the UDP. 0: Disabled; 1: Enabled
UDP_TTL *The default setting is IP_DEFAULT_TTL.	Sets the default value for time-to-live.
LWIP_TCP *The default setting is 1.	Selects whether to enable or disable the TCP. 0: Disabled; 1: Enabled
TCP_TTL *The default setting is IP_DEFAULT_TTL.	Sets the default value for time-to-live.
TCP_WND *The default setting is 4 * TCP_MSS.	Sets the size of the TCP window.
TCP_QUEUE_OOSEQ *The default setting is 0.	Selects whether to enable or disable queuing of TCP segments that arrive out of order when such segments are received. 0: Disabled; 1: Enabled
TCP_MSS *The default setting is 1500 - 40 (= 1460).	Sets the maximum size of a TCP segment.
TCP_SND_BUF *The default setting is 4 * TCP_MSS.	Sets the TCP transmission buffer space in bytes.
TCP_SND_QUEUELEN *The default setting is 2 * TCP_SND_BUF/TCP_MSS.	Sets the TCP transmission buffer space with the pbuf size as the unit.
PBUF_POOL_BUFSIZE *The default setting is LWIP_MEM_ALIGN_SIZE(TCP_MSS+PBUF_IP_HLEN+ PBUF_TRANSPORT_HLEN+ PBUF_LINK_ENCAPSULATION_HLEN+ PBUF_LINK_HLEN).	Sets the size of each pbuf in the pbuf pool.
LWIP_NETIF_LINK_CALLBACK *The default setting is 0.	Selects whether to enable or disable a callback function for notification of a change to the link state. 0: Disabled; 1: Enabled
LWIP_NETCONN *The default setting is 0.	Selects whether to enable or disable Netconn API functions. 0: Disabled; 1: Enabled
LWIP_SOCKET *The default setting is 0.	Selects whether to enable or disable socket API functions. 0: Disabled; 1: Enabled
LWIP_STATS *The default setting is 0.	Selects whether to enable or disable statistics collection in lwip_stats. 0: Disabled; 1: Enabled

2.8 Code Size

Table 2.2 lists the ROM and RAM sizes and the maximum stack usage for this FIT module.

The configuration options listed in section 2.7, Settings for Compilation, during the build process determine the actual ROM (code and constants) and RAM (global data) sizes.

The values listed in Table 2.2 have been confirmed under the following conditions.

FIT module revision: r_lwip_rx rev1.00
Compiler version: Renesas Electronics C/C++ Compiler Package for RX Family V3.07.00
(The “-lang = c99” option was added to the default settings of the integrated development environment.)
Compilation options: Default settings

Table 2.2 Code Size

Code Sizes of ROM, RAM, and Stack			
Device	**Category**	**Memory Used**	**Remarks**
RX65N	ROM	Approximately 41k bytes	-
	RAM	Approximately 49k bytes	-
	Maximum stack usage	Approximately 700 bytes	This is a value measured using the sample project included with the package for lwIP driver FIT module (see document 9). This value includes the stack usage of other FIT modules including the lwIP driver FIT module that this FIT module calls.

2.9 Arguments

For details on the arguments for the API functions of this FIT module, refer to document 7 under the heading “Documents for Reference” on the first page.

2.10 Return Values

For details on the return values for the API functions of this FIT module, refer to document 7 under the heading “Documents for Reference” on the first page.

2.11 Including the FIT Module in Your Project

This FIT module must be included in each project where it is to be used. Renesas recommends using the Smart Configurator in the way described in (1), (3), or (5) below. However, the Smart Configurator only supports this for some RX devices. If the RX device in use is not supported, use the method described in either (2) or (4).

(1) Including the FIT module in your project by using the Smart Configurator in the e^2 studio
Using the Smart Configurator in the e^2 studio allows the automatic inclusion of the FIT module in your project. Refer to the application note *RX Smart Configurator User’s Guide: e² studio* (R20AN0451) for details.

(2) Including the FIT module in your project by using the FIT Configurator in the e^2 studio
Using the FIT Configurator in the e^2 studio allows the automatic inclusion of the FIT module in your project. Refer to the application note *RX Family: Adding Firmware Integration Technology Modules to Projects* (R01AN1723) for details.

(3) Including the FIT module in your project by using the Smart Configurator in CS+
Using the standalone version of the Smart Configurator in CS+ allows the automatic inclusion of the FIT module in your project. Refer to the application note *RX Smart Configurator User’s Guide: CS+* (R20AN0470) for details.

(4) Including the FIT module in your project in CS+
Manually include the FIT module in your project in CS+. Refer to the application note *RX Family: Adding Firmware Integration Technology Modules to CS+ Projects* (R01AN1826) for details.

(5) Including the FIT module in your project by using the Smart Configurator with the IAR Embedded Workbench (IAREW)
Using the standalone version of the Smart Configurator allows the automatic inclusion of the FIT module in your project. Refer to the application note *RX Smart Configurator User’s Guide: IAREW* (R20AN0535) for details.

3. API Functions

3.1 API Functions

This FIT module is generated from lwIP, which is released on the associated Web page as open-source software, by using the FIT. For details on the specifications of the lwIP API functions, refer to the official documentation at the destination of the link next to Lightweight IP stack (link), which is listed as document 7 under the heading “Documents for Reference” on the first page.

4. Appendix

4.1 Environments for Confirming Operation

Table 4.1 lists the environments used in confirming operation of this FIT module.

Table 4.1 Environments for Confirming Operation

Item		Description
Integrated development environment		e^2 studio Ver.2025-01 from Renesas Electronics
Compiler	CC-RX	C/C++ Compiler for RX Family V3.07.00 from Renesas Electronics Compilation options: The following option was added to the default settings of the integrated development environment. -lang = c99
	GCC	GCC for Renesas RX 8.3.0.202411
Endian for operation		Little
Revision number of this FIT module		Rev. 1.00
Board used		Renesas CK-RX65N v2 (part number: RTK5CK65N0S08xxxBE) Renesas RX72N Envision Kit (part number: RTK5RX72N0C00000BJ) Renesas Starter Kit+ for RX72M (part number: RTK5572MNxSx0000BE)
FIT	BSP FIT	Ver. 7.52
	Ethernet FIT	Ver. 1.23
	CMT FIT	Ver. 5.70
	LWIP driver FIT	Ver. 1.00

5. Reference Documents

User's Manual: Hardware
(The latest version can be downloaded from the Renesas Electronics Web site.)

Technical Updates/Technical News
(The latest information can be downloaded from the Renesas Electronics Web site.)

User's Manual: Development Environment
RX Family CC-RX Compiler User's Manual (R20UT3248)
(The latest version can be downloaded from the Renesas Electronics Web site.)

GNU-RX Compiler Manual
(The latest version can be downloaded from the following Web site.)
https://llvm-gcc-renesas.com/ja/gnu-tools-manuals/gnu-compiler/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun.20.25	-	First edition issued.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.