RL78 Family

RSA Library: Introduction Guide

Introduction

This document explains RSA Library for RL78 Family (hereafter referred to as "RSA Library") that depends on MCUs. The RSA Library is the software library incorporated in the RL78 Family and includes the data encryption/decryption functions that use the RSA encryption technology. Also it is designed in dedicated algorithm and fully-tuned up by assembly language.

Please refer to each User's Manual to know how to use RSA Library software library.

Target Device

RL78/G14, RL78/G23

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Contents

1. Structure of product

This product includes the following data.

Table 1 RSA Library product files(1)

Name						Description
sample program(r20an0326xx0201-rl78-rsa)						
	workspace <DIR>					
		Document (doc) <DIR>				
			English (en)			
				r20uw0115ej0200-rsa.pdf		User's manual
				r20an0326ej0201-rl78-rsa.pdf		Introduction Guide (this document)
			Japanese (ja)			
				r20uw0115jj0200-rsa.pdf		User's manual
				r20an0326jj0201-rl78-rsa.pdf		Introduction Guide
	libsrc <DIR>					Driver storage folder
		rsa <DIR>				RSA Library
			src <DIR>			RSA Library source
				rsa_api.c		RSA API function
				mc_lib.c		Multi-byte length arithmetic function
				mc_lib.h		Multibyte length arithmetic function header file
				rsa_internal_header.h		Internal header file for RSA library
				r_rsa_version.c		version file
			include <DIR>			RSA library header
				r_rsa.h		RSA library header file
				r_mw_version.h		Version data header file
				r_stdint.h		typedef header file

Table 2 RSA Library product files(2)

Name						Description
sample program (r20an0326xx0201-rl78-rsa)						
	workspace <DIR>					
		CS+ <DIR>				CS+ project folder
			rsa_rl78_sim_sample <DIR>			G23 sample project folder
				src <DIR>		program storage folder
					main.c	sample main
					main.h	sample main header
					r_sample_key.c	sample RSA key
					r_sample_key.h	sample RSA key header
					r_sample_modexp.c	sample Modular exponentiation
					r_sample_modexp.h	sample Modular exponentiation header
					r_sample_rsa_if.c	sample User Definition
					r_sample_rsa_if.h	sample User Definition header
					r_sample_sig_gen_vrfy.c	sample RSASSA-PKCS1-V1_5
					r_sample_sig_gen_vrfy.h	sample RSASSA-PKCS1-V1_5 header
					libsrc <DIR>	link to libsrc
					smc_gen <DIR>	Smart configurator auto-generated folder
						general	Common header file / source file storage folder
						r_bsp	Initialization code register definition storage folder
						r_config	Driver initialization config header storage folder
		e² studio <DIR>				e² studio project folder
			CCRL			sample project for CCRL
				rsa_rl78_sim_sample <DIR>		sample project for G23
			LLVM			sample project for LLVM
				rsa_rl78_sim_sample <DIR>		sample project for G23
		IAR				IAR project folder
			rsa_rl78_sim_sample <DIR>			sample project for G23

2. Product Specifications

2.1 API Function

RSA Library supports the following functions.

Table 3 Library Functions (API)

API	Outline
R_rsa_signature_generate_pkcs	RSA Signature Generation (RSASSA-PKCS1-V1_5)
R_rsa_signature_verify_pkcs	RSA Signature Verification (RSASSA-PKCS1-V1_5)
R_rsa_mod_exp	Modular Exponentiation

3. CC-RL

3.1   Development environment

Please use the same or a later version of the toolchain listed below:

- Integrated Development Environment:
    CS+ for CC V8.05.00

    e^2 studio 2021-04 (21.4.0)

- C compiler:
    CC-RL V1.09.00

3.2   ROM / RAM / Stack size / Performance

The various sizes and processing cycles when building with the following options are described for reference.

Compiler options

-cpu=S3 -memory_model=medium –Odefault

Link options

-NOOPtimize

Table 4 ROM, RAM size

library file name	ROM size [byte] (Notes 1)	RAM size [byte] (Notes 2)
rsa_api.c	1,310	0
mc_lib.c	2,728	

Notes 1   At least, one R_RSA_WORK_t and one R_RSA_KEY_t and two R_RSA_BYTEDATA_t variables are needed for work..
2   Since the API functions use the functions defined in mc_lib.c, the sum of the ROM sizes of the two files is required.

Each structures size are below.

Table 5 Memory for Structure Variable

Structure	Memory for one structure variable [byte]
R_RSA_WORK_t	3680
R_RSA_BYTEDATA_t	4
R_RSA_KEY_t	8

Table 6 Stack Size

API	stack size [byte] (Notes 1)
R_rsa_signature_generate_pkcs	144
R_rsa_signature_verify_pkcs	144
R_rsa_mod_exp	124

Notes 1   This value is sample program stack size. If use changes the user definition function, stack size will be changed.

3.3 Performance

Table 7 RSA Library Performance

Function	Key Type	Processing Time [second] RL78/G23@32MHz (Note1)
R_rsa_signature_generate_pkcs (Note2)	Private Key	About 184.82(Note3)
R_rsa_signature_verify_pkcs (Note2)	Public Key	About 1.07
R_rsa_mod_exp	Public Key	About 1.07

Note1: This is the value when the sample program using the 2048-bit key is executed. The number of cycles changes when the user changes the key data or changes the implementation of the user-defined function.

2: User function R_rsa_if_hash() returns the fixed values in sample program. If add the hash calculate function, processing time is added to the above time.

3: If the watchdog timer is enabled, a reset may occur due to a timeout, so check the settings.

4.   IAR Embedded Workbench

4.1   Development environment

Please use the same or a later version of the toolchain listed below:

- Integrated Development Environment:
     IAR Embedded Workbench for Renesas RL78 version 4.21.1

- C compiler:
     IAR C/C++ Compiler for Renesas RL78 : 4.20.1.2260 (4.20.1.2260)

4.2   ROM / RAM / Stack Size / Performance

The various sizes and processing cycles when building with the following options are described for reference.

Compiler options

   --core=S3 --code_model=far --data_model=near --near_const_location=rom0 -e -Oh

   --calling_convention=v2

Table 8 ROM, RAM size

library file name	ROM size [byte] (Notes 1)	RAM size [byte] (Notes 2)
rsa_api.c	1,352	0
mc_lib.c	2,629	0

Notes 1   RSA needs 276 bytes (max) for mirror area.
          In case, user does not use version information or, user uses large model, the memory size for mirror area requires 144 bytes.
       2   At least, one R_RSA_WORK_t and one R_RSA_KEY_t and two R_RSA_BYTEDATA_t variables are needed for work.

Each structures size are below.

Table 9 Memory for Structure Variable

Structure	Memory for one structure variable [byte]
R_RSA_WORK_t	920
R_RSA_BYTEDATA_t	4
R_RSA_KEY_t	8

Table 10   Stack Size

API	stack size [byte] (Notes 1) (Notes 2)
R_rsa_signature_generate_pkcs	152
R_rsa_signature_verify_pkcs	152
R_rsa_mod_exp	132

Notes 1   stack size is same in all libraries.
       2   This value is sample program stack size. If use changes the user definition function, stack size will be changed.

4.3 Performance

Table 11   RSA Library Performance

Function	Key Type	Processing Time [second] RL78/G23@32MHz (Note1)
R_rsa_signature_generate_pkcs	Private Key	About 336.828 (Note2)
R_rsa_signature_verify_pkcs	Public Key	About 1.98
R_rsa_mod_exp	Public Key	About 1.98

Note1: This is the value when the sample program is executed. The number of cycles changes when the user changes the key data or changes the implementation of the user-defined function.

2: If the watchdog timer is enabled, a reset may occur due to a timeout, so check the settings.

5. LLVM

5.1 Development environment

Please use the same or a later version of the toolchain listed below:

- Integrated Development Environment:
    e² studio 2022-01 (22.1.0)

- C compiler:
    LLVM for Renesas RL78 10.0.0.202203

5.2 ROM / RAM / Stack size / Performance

The various sizes and processing cycles when building with the following options are described for reference.

Compiler options

CPU Type : S3-core

Optimization Level : Optimize size (-Os)

Table 12 ROM, RAM size

library file name	ROM size [byte] (Notes 1)	RAM size [byte] (Notes 2)
rsa_api.c	1,543	0
mc_lib.c	3,068	

Notes 1 At least, one R_RSA_WORK_t and one R_RSA_KEY_t and two R_RSA_BYTEDATA_t variables are needed for work..
2 Since the API functions use the functions defined in mc_lib.c, the sum of the ROM sizes of the two files is required.

Each structures size are below.

Table 13 Memory for Structure Variable

Structure	Memory for one structure variable [byte]
R_RSA_WORK_t	3680
R_RSA_BYTEDATA_t	4
R_RSA_KEY_t	8

Table 14 Stack Size

API	stack size [byte] (Notes 1)
R_rsa_signature_generate_pkcs	132
R_rsa_signature_verify_pkcs	132
R_rsa_mod_exp	112

Notes 1 This value is sample program stack size. If use changes the user definition function, stack size will be changed.

5.3 Performance

Table 15 RSA Library Performance

Function	Key Type	Processing Time [second] RL78/G23@32MHz (Note1)
R_rsa_signature_generate_pkcs (Note2)	Private Key	About 418(Note3)
R_rsa_signature_verify_pkcs (Note2)	Public Key	About 2.4
R_rsa_mod_exp	Public Key	About 2.4

Note1: This is the value when the sample program using the 2048-bit key is executed. The number of cycles changes when the user changes the key data or changes the implementation of the user-defined function.

2: User function R_rsa_if_hash() returns the fixed values in sample program. If add the hash calculate function, processing time is added to the above time.

3: If the watchdog timer is enabled, a reset may occur due to a timeout, so check the settings.

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep 01, 2016	—	First edition issued
1.01	Sep 10, 2018	—	Added chapter 4 CS+ for CC.
1.02	Nov 12, 2018	—	Added chapter 5 IAR Embedded Workbench
2.00	Apr 21, 2021	—	Changed the library provision form from Lib. Format to C source Delete CS + for CA
2.01	Jun 30, 2022	—	Supported LLVM.

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.

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(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
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