RL78/G23

LED burst dimming control using ELCL

Introduction

This application note describes how to implement the LED burst dimming using the logic and event link controller (ELCL). Burst dimming control is a method that finely control of LED light intensity. It can be applied to control indicators and lighting using LEDs.

Target Device

RL78/G23

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Contents

1. Specifications

In this application note, which is described how to implement a LED burst dimming using ELCL.

Burst dimming control is possible by taking the logical AND two PWM outputs (TO01, TO02) with different duty cycle and PWM output (TO05). Assuming constant current control (switching control) of the DC/DC converter, TO05 is set to a higher frequency (100 kHz or higher) than TO01 and TO02.

And TO01 and TO02 are assumed to be PWM output for controlling the overall light intensity, and set to a frequency (~1 kHz) that does not flicker in the human eye. The combination of these two frequencies provides finely tuned dimming control.

Figure 1-1 shows the system configuration for implement a burst dimming of two LEDs at the same time using ELCL.

Figure 1-1 System Configuration

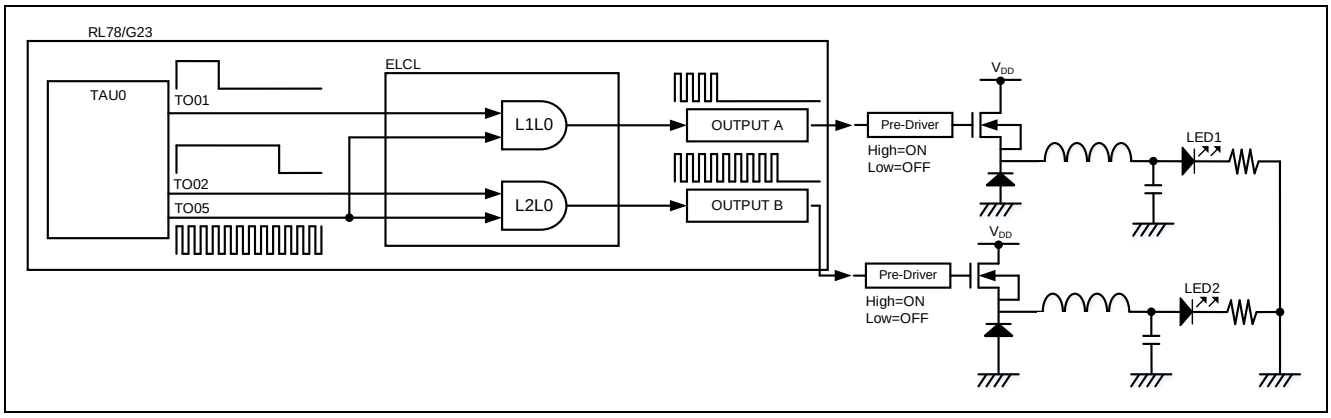
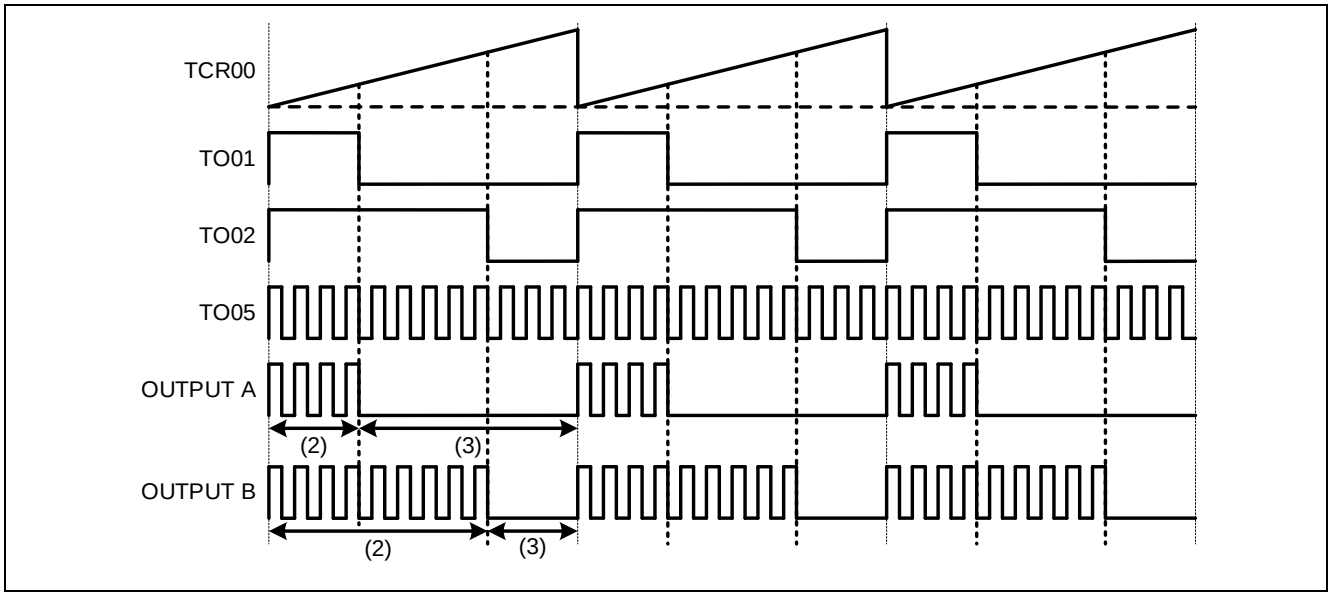


Figure 1-2 shows the timing chart.

(1) Set TAU01, TAU02 and TAU05 to a PWM output.
(2) While TO01 is High level, the PWM output from TO05 is enabled and output from OUTPUT A. In a similar way, while TO02 is High level, the output from OUTPUT B is enabled.
(3) While TO01 is Low level, the output of OUTPUT A is fixed to Low level. In a similar way, the output of OUTPUT B is fixed to Low level while TO02 is Low level.

Figure 1-2 Timing chart



2. Conditions for Operation Confirmation Test

The sample code with this application note runs properly under the condition below.

Table 2-1 Operation Confirmation Conditions

Items	Contents
MCU	RL78/G23 (R7F100GLG)
Operating frequencies	High-speed on-chip oscillator clock: 32MHz CPU/peripheral hardware clock: 32MHz
Operating voltage	3.3V LVD0 operations (V_{LVD0}): Reset mode Rising edge TYP. 1.90V Falling edge TYP. 1.86V
Integrated development environment (CS+)	CS+ for CC V8.08.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.11 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio 2022-07 (22.07.0) from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.11 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 v4.21.1 from IAR Systems
C compiler (IAR)	
Smart Configurator	V.1.3.0
Board support package (r_bsp)	V.1.20
Emulator	CS+、e^2 studio: COM port IAR: E2 Emulator Lite
Board	RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)

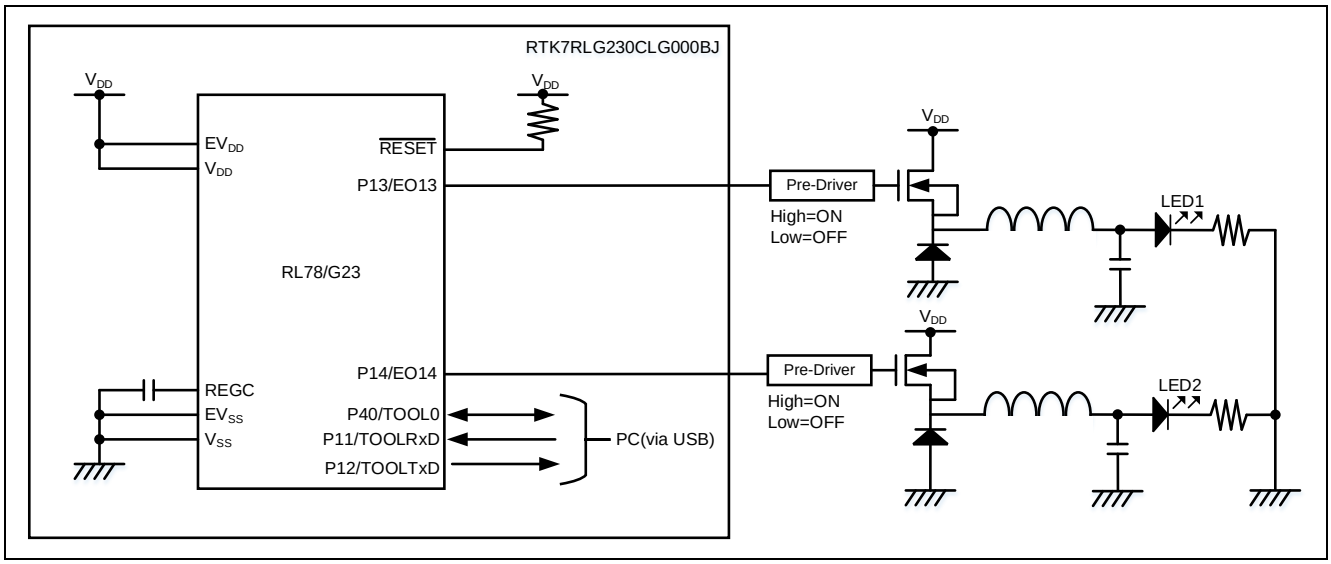
3. Hardware

3.1 Example of Hardware Configuration

Figure 3-1 shows an example of the hardware configuration in this application.

LED1 and LED2 connected to P13 and P14 are configured using LEDs external to the board.

Figure 3-1 Hardware Configuration



Caution 1. This simplified circuit diagram was created to show an overview of connections only. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements. (Connect each input-only port to V_{DD} or V_{SS} through a resistor.)

Caution 2. Connect the EV_{SS} pin to V_{SS} and the EV_{DD} pin to V_{DD}.

Caution 3. V_{DD} must be held at not lower than the reset release voltage (V_{LVD0}) that is specified as LVD.

3.2 Used Pins

Table 3-1 shows list of used pins and assigned functions.

Table 3-1 List of Pins and Functions

Pin name	Input/Output	Function
P13/EO13	Output	ELCL output signal (LED1 control[Note])
P14/EO14	Output	ELCL output signal (LED2 control[Note])

Note. Please configure outside the RTK7RLG230CLG000BJ.

Caution. In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

4. Software

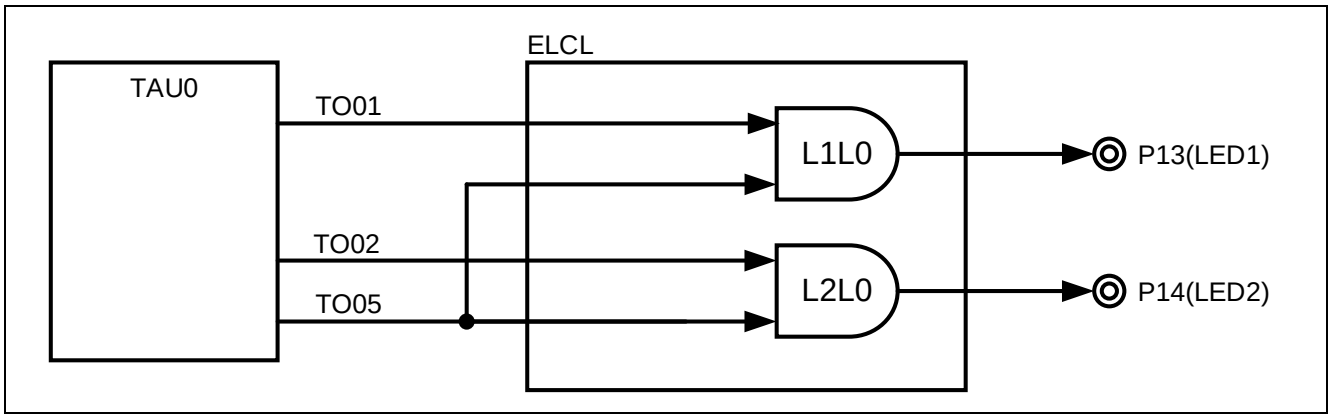
4.1 Overview of the sample program

In this sample code, burst dimming control for two LEDs using PWM output from TAU0 and two ELCL module "AND"s. The signals generated by the burst dimming control circuit are output to P13 and P14.

Figure 4-1shows the system configuration of the sample code.

Three PWM output signals (TO01, TO02 and TO05) from TAUA0 are input to ELCL modules. In the ELCL module, link the three PWM output to the two ANDs (L1L0 and L2L0), and the result of the ANDs of the PWM output of TO05 and PWM outputs of TO01 and TO02 is output. It is possible to check the burst dimming control signal by selecting P13 and P14 as the link destination of the ELCL output signal. TO01 and TO02 are set to different duty cycle, and two LEDs with different dimming rates are illuminated.

Figure 4-1 System configuration of the sample code



4.2 Folder Configuration

Table 4-1 shows folder configuration of source file and header files using by sample code except the files generated by integrated development environment and the files in the bsp environment.

Table 4-1 Folder configuration

Folder/File configuration	Outline	Created by Smart configurator
¥r01an6566_elcl_ dimming <DIR> Note2	Root folder of this sample code	
¥src<DIR>	Folder for program source	
main.c	Sample code source file	
main.h	Sample code header file	
¥smc_gen<DIR>	Folder created by Smart Configurator	√
¥Config_TAU0_0<DIR>	Folder for TAU00 program	√
Config_TAU0_0.c	Source file for TAU00	√
Config_TAU0_0.h	Header file for TAU00	√
Config_TAU0_0_user.c	Interrupt source file for TAU00	√Note 1
¥Config_TAU0_4<DIR>	Folder for TAU04 program	√
Config_TAU0_4.c	Source file for TAU04	√
Config_TAU0_4.h	Header file for TAU04	√
Config_TAU0_4_user.c	Interrupt source file for TAU04	√Note 1
¥Config_AND<DIR>	Folder for AND program	√
Config_AND.c	Source file for AND	√
Config_AND.h	Header file for AND	√
Config_AND_user.c	Interrupt source file for AND	√Note 1
¥general<DIR>	Folder for initialize or common program	√
¥r_bsp<DIR>	Folder for BSP program	√
¥r_config<DIR>	Folder for program	√

Note. <DIR> means directory.

Note 1. Not used in this sample code.

Note 2. The IAR version of the sample code contains r01an6566_elcl_ dimming.ipcf. For the ipcf file, refer to "RL78 Smart Configurator User Guide: IAR (R20AN0581)"

4.3 Option Byte Settings

Table 4-2 shows the option byte settings.

Table 4-2 Option Byte Settings

Address	Setting Value	Contents
000C0H/040C0H	1110 1111B (EFH)	Operation of Watchdog timer is stopped (counting is stopped after reset)
000C1H/040C1H	1111 1110B (FEH)	LVD0 operating mode: reset mode Detection voltage: Rising edge 1.90V Falling edge 1.86V
000C2H/040C2H	1110 1000B (E8H)	Flash operating mode: HS mode High-speed on-chip oscillator clock: 32MHz
000C3H/040C3H	1000 0101B (85H)	On-chip debugging is enabled

4.4 Constants

Constants are not used in this sample code.

4.5 Variables

Global variables are not used in this sample code.

4.6 Functions

Table 4-3 shows the functions used in the sample code. However, the unchanged functions generated by the Smart Configurator are excluded.

Table 4-3 Functions

Function name	Outline	Source file
main	Main process	main.c

4.7 Function Specifications

This part describes function specifications of the sample code.

[Function name] main

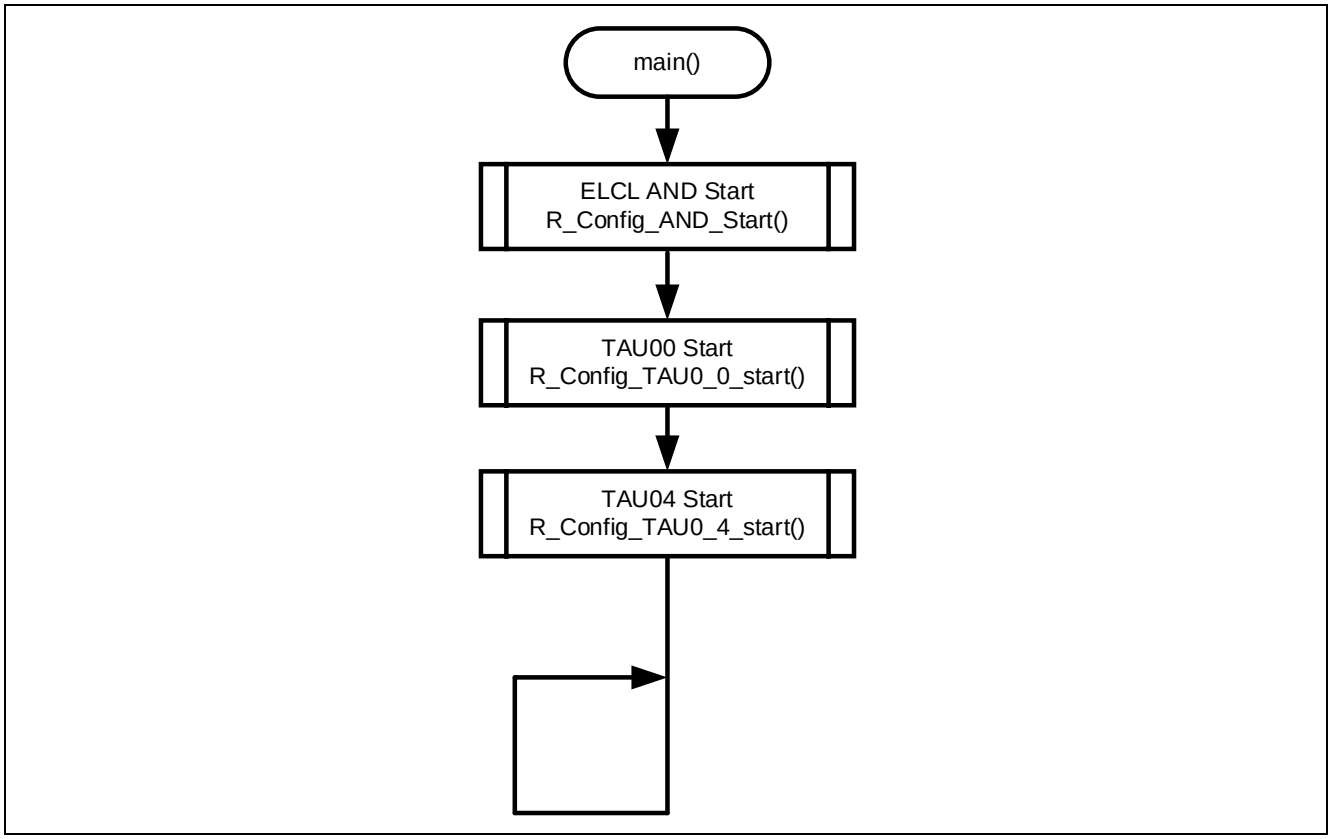
Outline	Main process
Header	r_smc_entry.h, elcl.h
Declaration	void main (void);
Description	This function sets ELCL output and starts the operation of TAU0 channel 0, 1, 2, 4 and 5.
Arguments	None
Return value	None
Remarks	None

4.8 Flow Charts

4.8.1 Main Process

Figure 4-2 shows flowchart of main process

Figure 4-2 Main process



5. Application example

In addition to the sample code, this application note contains the following Smart Configurator configuration files

r01an6566_elcl_dimming.scfg

The following is a description of the file and examples of settings and notes for use.

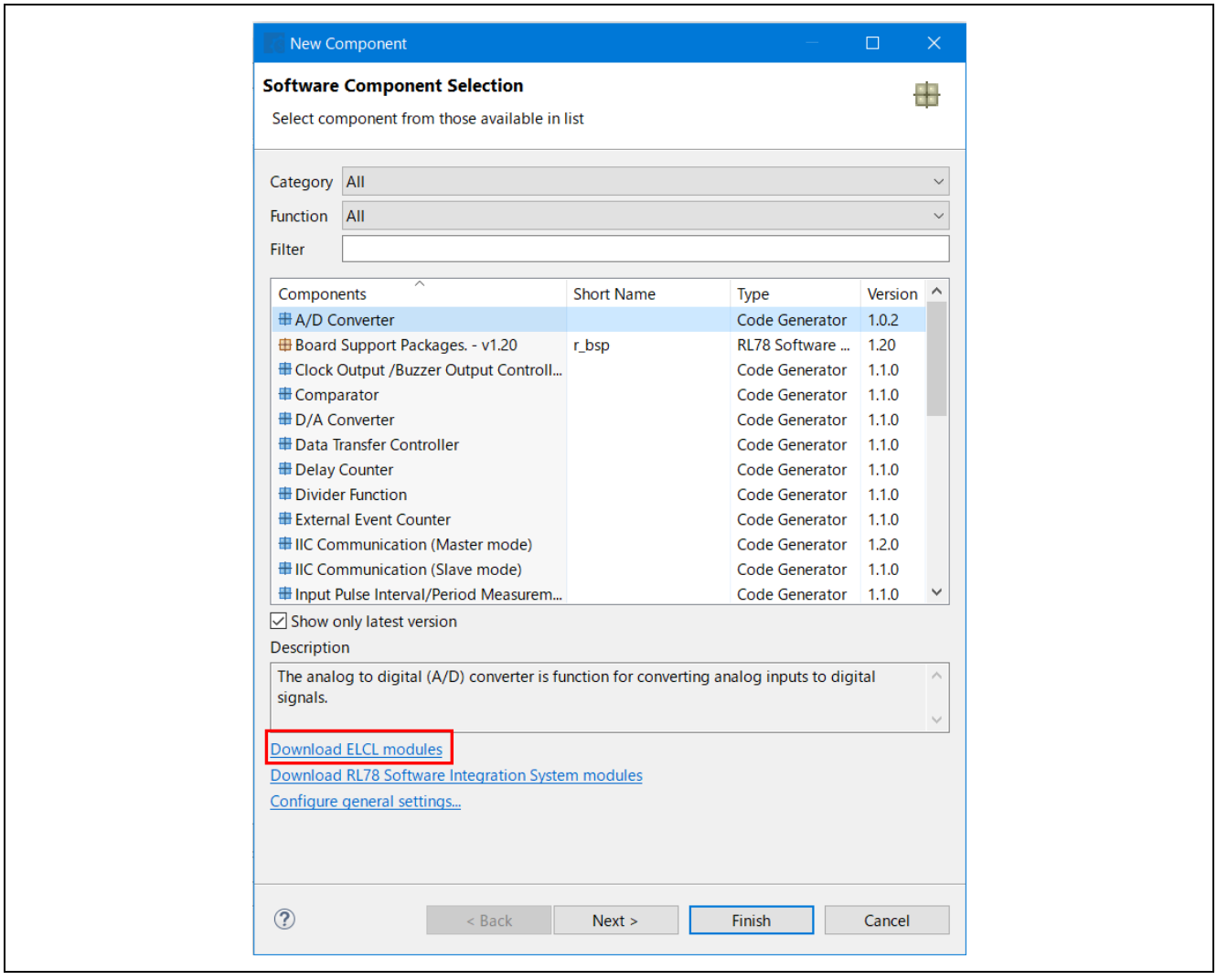
5.1 Setting up the ELCL components

To use the ELCL component, you need to install the ELCL content file.

The procedure is shown below.

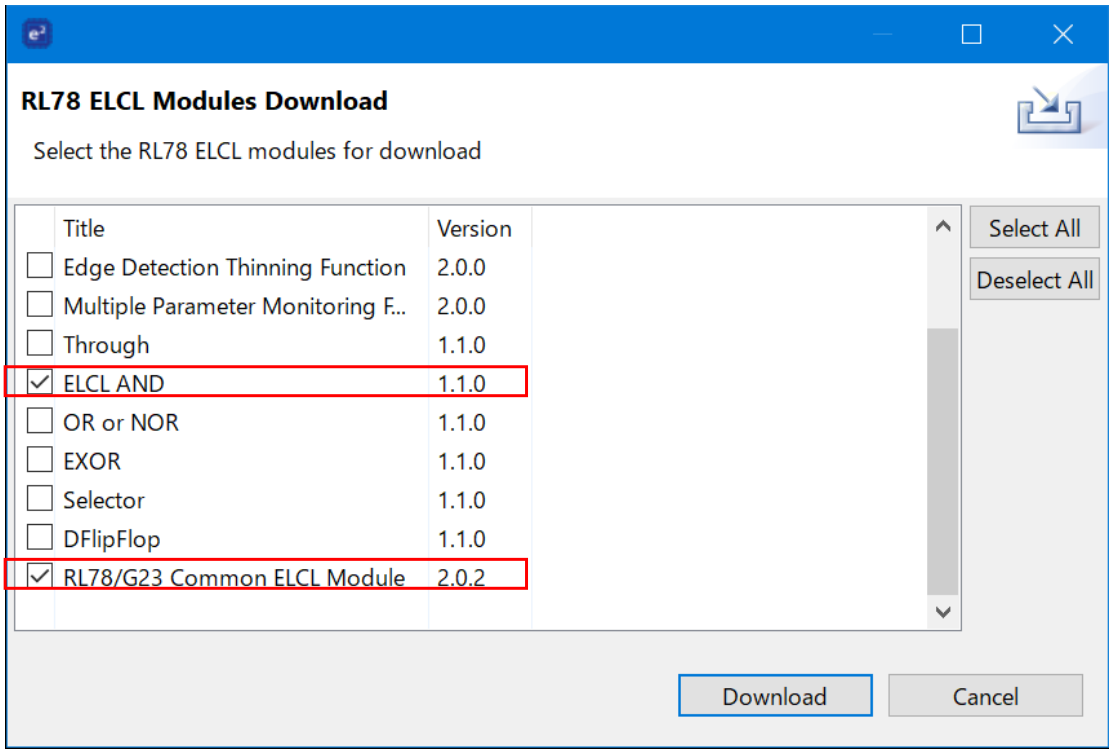
1. Start the Smart Configurator.
2. Click on the "Components" tag, and then click "Add component".
3. When the "New Component" window shown in Figure 5-1opens, click on "Download ELCL modules".

Figure 5-1 Add component



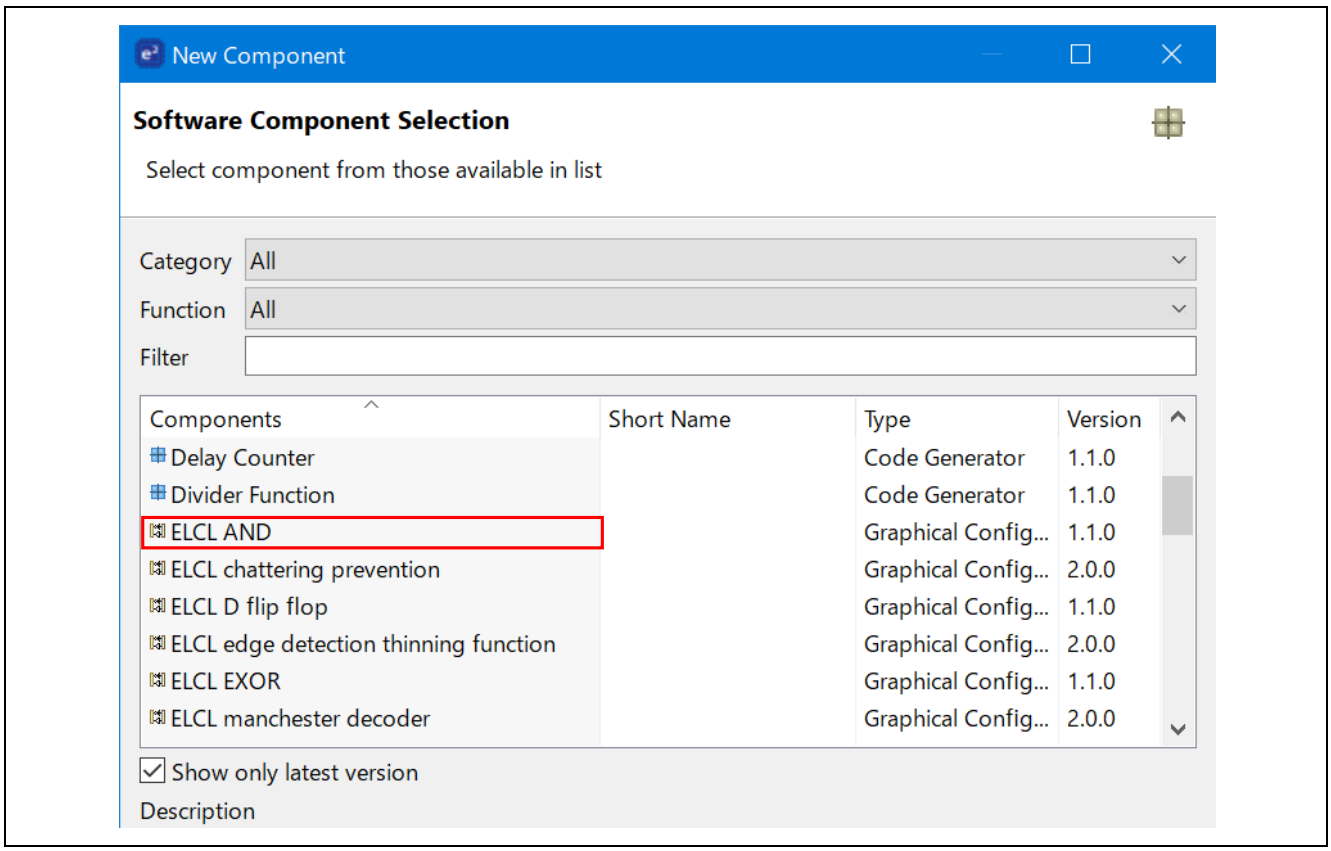
4. Select "AND" and download it. Please download the common setting file "RL78/G23 Common ELCL Module" as well.

Figure 5-2 Download the module



5. After the download is complete, make sure that "ELCL AND" is available for selection.

Figure 5-3 Select the module



5.2 r01an6566_elcl_dimming.scfg

This is the Smart Configurator configuration file used in the sample code. It contains all the features configured in the Smart Configurator. The sample code settings are as follows.

Table 5-1 Parameters of Smart Configurator

Tag name	Component	Contents
Clocks	-	Operation mod: High-speed main mode 2.4 (V) ~ 5.5 (V) EV_{DD} setting: $1.8V \leqq EV_{DD0} < 5.5V$ High-speed on-chip oscillator: 32MHz f_{IHP}: 32MHz f_{CLK}: 32000kHz (High-speed on-chip oscillator) f_{SXP}: 32.768kHz (Low-speed on-chip oscillator)
System	-	On-chip debug operation setting: COM port Note Pseudo-RRM/DMM function setting: Used Start/Stop function setting: Unused Trace function setting: Used Security ID setting: Use security ID Security ID: 0x00000000000000000000 Security ID authentication failure setting: Do not erase flash memory data
Components	r_bsp	Start up select : Enable (use BSP startup) Control of invalid memory access detection : Disable RAM guard space (GRAM0-1) : Disabled Guard of control registers of port function (GPORT) : Disabled Guard of registers of interrupt function (GINT) : Disabled Guard of control registers of clock control function, voltage detector, and RAM parity error detection function (GCSC) : Disabled Data flash access control (DFLEN) : Disables Initialization of peripheral functions by Code Generator/Smart Configurator : Enable API functions disable : Enable Parameter check enable : Enable Setting for starting the high-speed on-chip oscillator at the times of release from STOP mode and of transitions to SNOOZE mode : High-speed Enable user warm start callback (PRE) : Unused Enable user warm start callback (POST) : Unused Watchdog Timer refresh enable : Unused
	Config_LVD0	Operation mode setting: Reset mode Voltage detection setting: Reset generation level (V_{LVD0}): 1.86 (V)

Note. When using IAR, use the following settings.
On-chip debug operation setting: Use emulator
Emulator setting: E2 Emulator Lite

Table 5-2 Parameters of Smart Configurator

Tag name	Component	Contents
Components	Config_TAU0_0	Components: PWM Output Resource: TAU0_0 Operation clock: CK00 Clock source: $f_{CLK}/2^6$ Cycle value: 50µs Interrupt setting: unused (slave1) Duty value: 20% Initial output value: 1 Output level: Active-high Interrupt setting: unused (slave2) Duty value: 70% Initial output value: 0 Output level: Active-high Interrupt setting: unused
	Config_TAU0_4	Components: PWM Outout Resource: TAU0_4 Operation clock: CK01 Cycle value: f_{CLK} Cycle value: 2µs Interrupt setting: unused (slave5) Duty value: 50% Initial output value: 0 Output level: Active-high Interrupt setting: unused
	Config_AND	Components: ELCL AND Common setting: L1L0,L2L0 (Detail setting: L1L) Input signal selector: ELISEL_0 , TO01 ELISEL_1 , TO05 Application: AND Output signal selector: P13 (Detail setting: L2L0) Input signal selector: ELISEL_2 , TO02 ELISEL_3 , TO05 Application: AND Output signal selector: P14

5.2.1 Clocks

Set the clock used in the sample code.

5.2.2 System

Set the on-chip debug of the sample code.

"Control of on-chip debug operation" and "Security ID authentication failure setting" affect "On-chip debugging is enabled" in "Table 4-2 Option Byte Settings". Note that changing the settings.

5.2.3 r_bsp

Set the startup of the sample code.

5.2.4 Config_LVD0

Set the power management of the sample code.

Affects "Setting of LVD0" in "Table 4-2 Option Byte Settings". Note that changing the settings.

5.2.5 Config_TAU0_0

Set the TAU00 in the sample code.

In the sample code, two PWM outputs with different duty cycle are used for dimming control. The LED brightness can be controlled by changing the duty cycle for each channel.

Interrupt is not used.

5.2.6 Config_TAU0_4

Set the TAU04 in the sample code.

In the sample code, PWM output with a duty cycle of 50% is used as a LED drive signal.

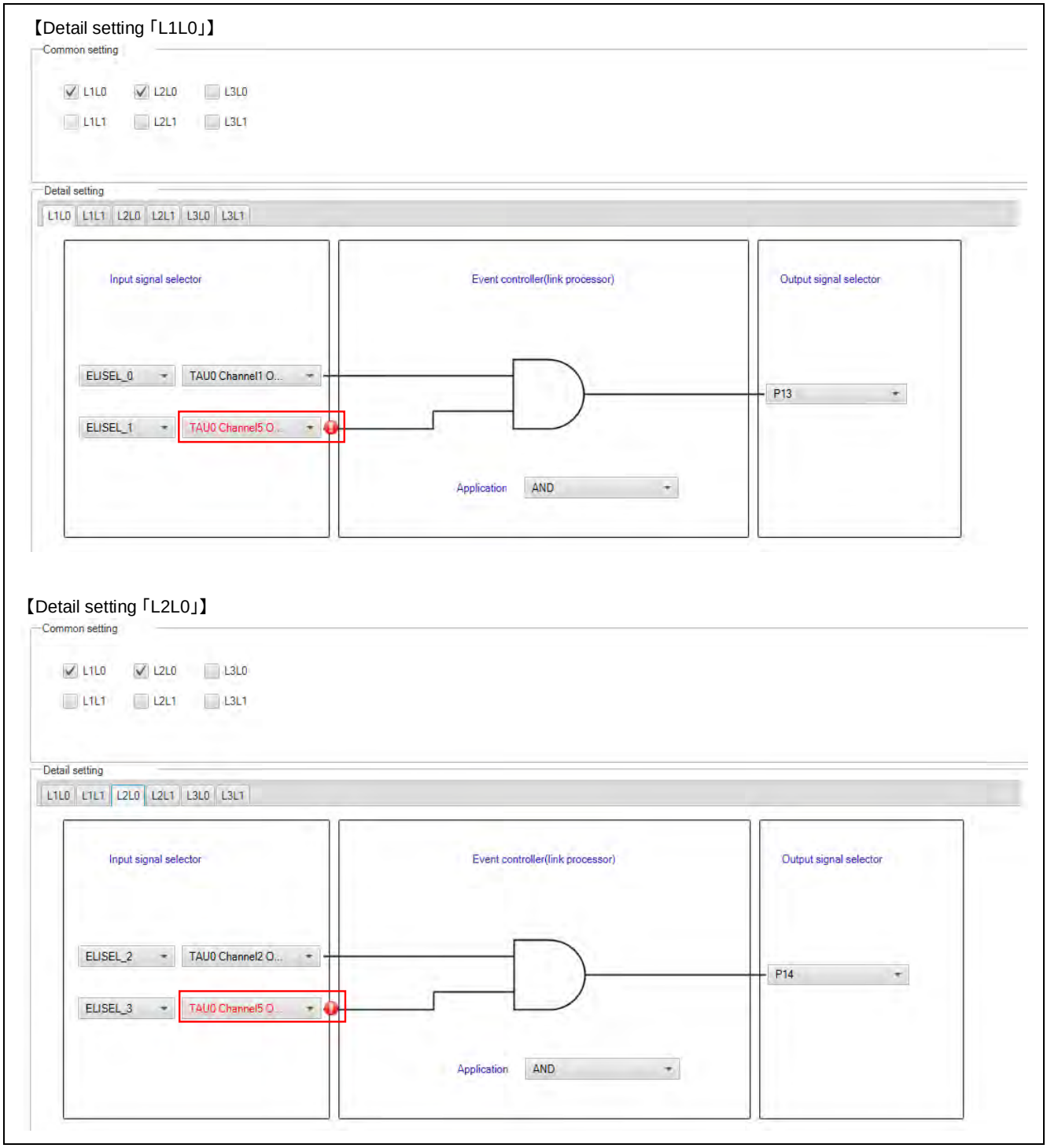
Interrupt is not used.

5.2.7 Config_AND

Set the input/output of the ELCL module “AND” in the sample code.

In this sample code, Use L1L0 and L2L0, and select PWM output for their input signal. At this time, because the same channel selects for the input signal of the two modules, a setting error is displayed as shown in the red frame in the Figure 5-4 due to ELCL specifications. Simultaneous use of some contents (single functions) and signals is possible with an understanding of the specifications. In this sample code, does not affect the movement of the program. There is not a problem in generating the code as is.

Figure 5-4 ELCL ”AND” setting



6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference

RL78/G23 User's Manual: Hardware (R01UH0896E)

RL78 Family User's Manual: Software (R01US0015E)

RL78 Smart Configurator User's Guide: CS+ (R20AN0580E)

RL78 Smart Configurator User's Guide: e^2 studio (R20AN0579E)

RL78 Smart Configurator User's Guide: IAREW (R20AN0581E)

(The latest version can be downloaded from the Renesas Electronics website.)

Technical Update / Technical News

(The latest version can be downloaded from the Renesas Electronics website.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep.26.22	–	First edition

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/.