RL78/G23

SMS LED Blinking Dimming Control

Introduction

This application note describes how to control the LEDs using the SNOOZE mode sequencer and the 32-bit interval timer.

The SNOOZE mode sequencer is started for each 32-bit interval timer interrupt, changing the LED brightness from 100% to 0%, and controlling the LED so that it gradually darkens.

By controlling the PWM output required for LED control with the SNOOZE mode sequencer, lower power consumption can be achieved than with CPU control.

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

During the HALT mode (CPU operating clock: stop), the SNOOZE mode sequencer (SMS) controls the PWM output and gradually reduces the LED brightness.

The PWM output function of the timer array unit (TAU) controls the LED brightness. In SMS, processing to change the duty ratio of the PWM output is set in advance. The interval that controls the PWM output is set using a 32-bit interval timer (TML32), and SMS is started by a TML32 interrupt (INTITL). By SMS starting, the duty ratio of the PWM output changes and the LED brightness is controlled.

Figure 1-1 shows the system configuration, and Figure 1-2 shows the flowchart of the entire system.

Figure 1-1 System Configuration

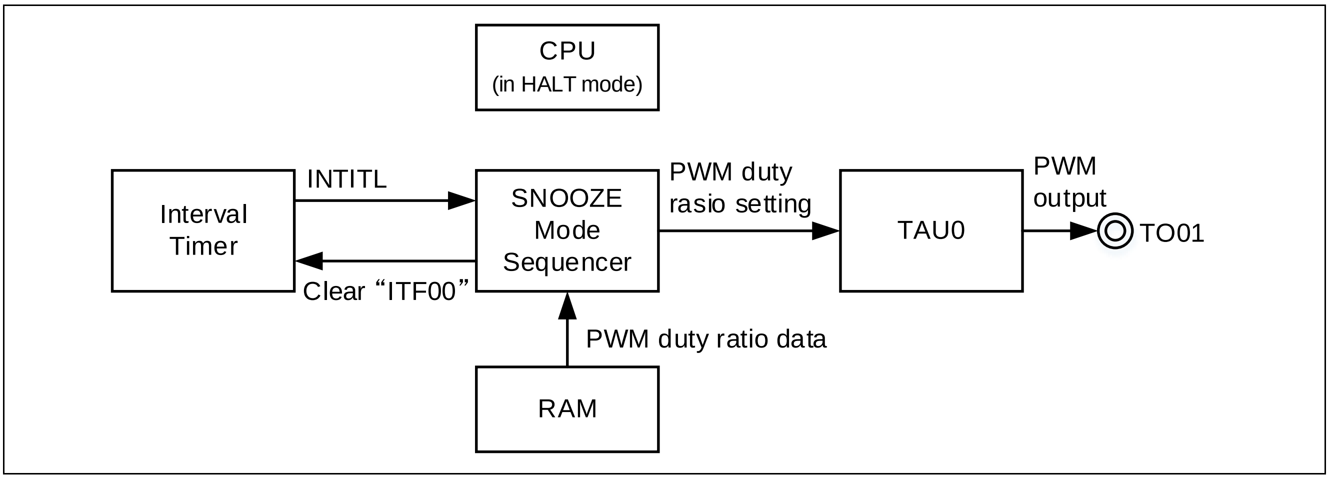
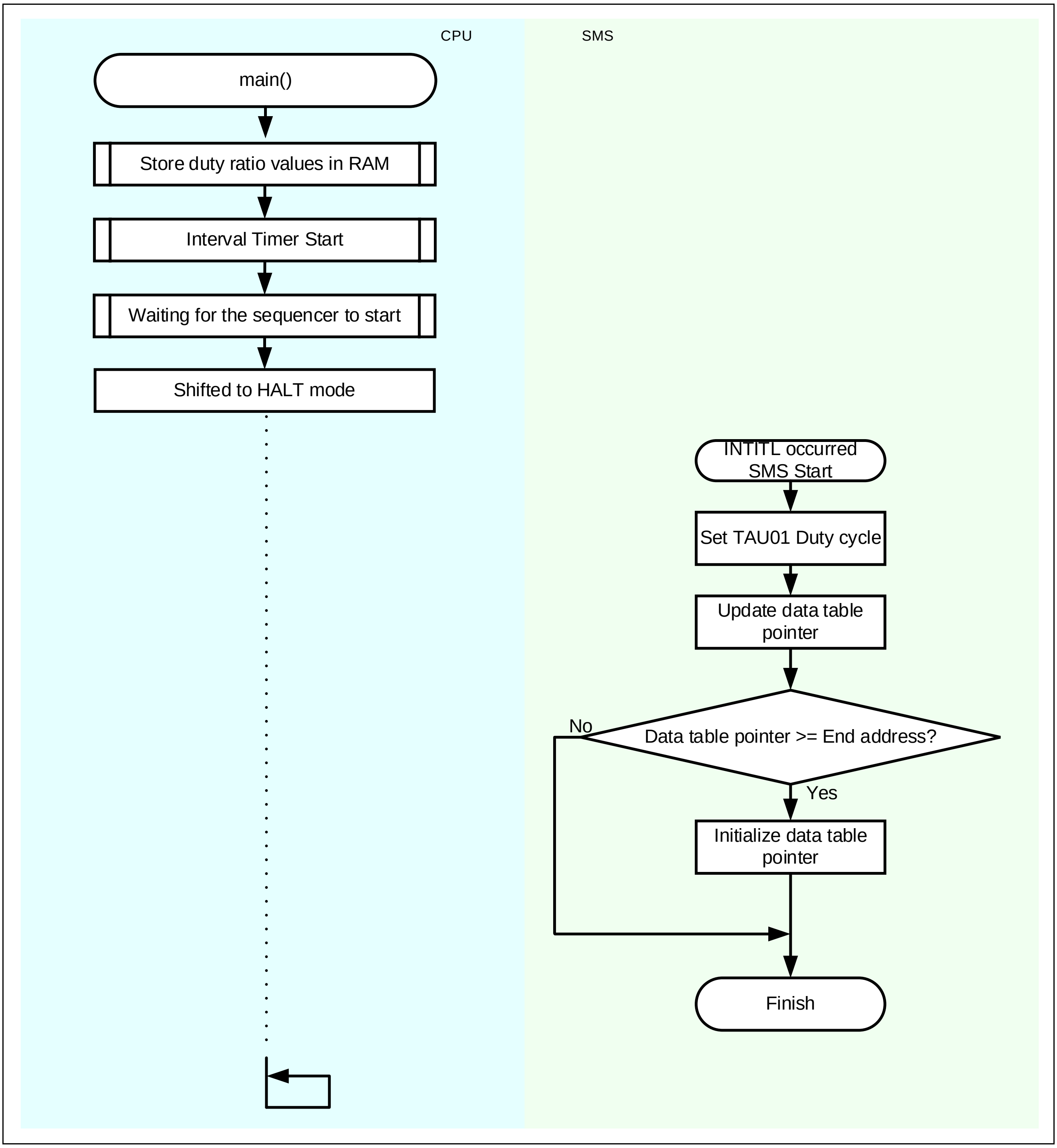


Figure 1-2 Entire Flowchart



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: 32 MHz • CPU/peripheral hardware clock: 32 MHz
Operating voltage	• 3.3V • LVD0 operations (V_{LVD0}) : Reset mode Rising edge TYP.1.875V Falling edge TYP.1.835V
Integrated development environment (CS+)	CS+ for CC V8.05.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.10 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio 2021-04 (21.4.0) from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.10 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.1.0.1
Board support package (r_bsp)	V.1.10
Emulator	CS＋, e^2 studio: COM port IAR: E2 Emulator Lite
Board	RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)

3. Related application note

The following application note is related to this application note.

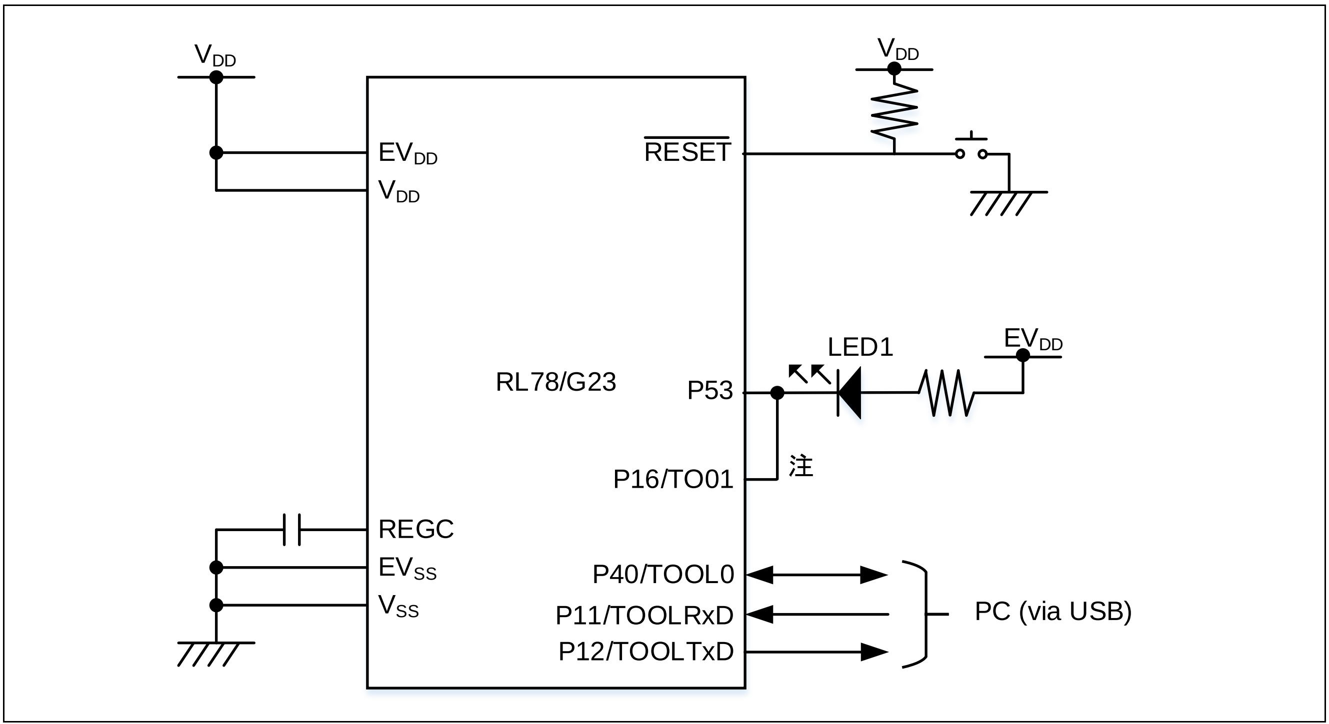
Please refer to them as well.

4. Hardware

4.1 Example of Hardware Configuration

Figure 4-1 shows an example of the hardware configuration in this application.

Figure 4-1 Hardware Configuration



Note In this application note, P16 and P53 are connected externally because the LED on the board (RTK7RLG230CLG000BJ) is used. Change the circuit if necessary.

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.

4.2 Used Pins

Table 6-1Table 4-1 shows list of used pins and assigned functions.

Table 4-1 List of Pins and Functions

Pin name	Input/Output	Function
P16	Output	PWM Output (LED1 control)
P53	Input	Prohibit P53 output

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.

5. Software

5.1 Overview of the sample program

In this sample code, The 32-bit interval timer (TML32) interrupt request (INTITL) starts the SNOOZE mode sequencer (SMS), and SMS changes the duty ratio of the PWM output of the timer array unit (TAU).

The LED brightness is changed by changing the duty ratio of the PWM output. By fixing the PWM output period to 1ms and increasing the duty ratio from 0% to 100% in 32 steps, the LED brightness is gradually reduced. The duty ratio value is stored in RAM in advance. SMS reads the value stored in RAM and writes it to the timer data register (TDR).

In addition, after the initial setting, it shifts to HALT mode to reduce power consumption.

The following is an overview of the features of this sample code.

(1) Creates a data table for setting the duty ratio of PWM output
(2) Starts counting TAU
(3) Starts counting TML32
(4) Shifts HALT mode
(5) Starts SMS with TML32 compare match
(6) Writes the data table value indicated by the pointer to the timer data register
(7) Branches to (8) if the pointer advances to the end of the data table, else branches (9)
(8) Sets the pointer to the start address of the data table
(9) SMS shifts to standby state and go to (5)

(6) to (9) are processed by SMS.

5.2 Folder Configuration

Table 5-1 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 5-1 Folder configuration

Folder/File configuration	Outline	Created by Smart configurator
¥r01an5611_sms_led_dimming<DIR>	Root folder of this sample code	
¥src<DIR>	Folder for program source	
main.c	Sample code source file	
¥smc_gen<DIR>Note 2	Folder created by Smart Configurator	√
¥Config_ITL000_ITL001<DIR>	Folder for TML32 program	√
Config_ITL000_ITL001.c	Source file for TML32	√
Config_ITL000_ITL001.h	Header file for TML32	√
Config_ITL000_ITL001_user.c	Interrupt source file for TML32	√Note 1
¥Config_PORT<DIR>	Folder for PORT program	√
Config_PORT.c	Source file for PORT	√
Config_PORT.h	Header file for PORT	√
Config_PORT_user.c	Interrupt source file for PORT	√Note 1
¥Config_SMS<DIR>	Folder for SMS program	√
Config_SMS.c	Source file for SMS	√
Config_SMS.h	Header file for SMS	√
Config_SMS_ASM.smsasm	ASM source file for SMS	√
Config_SMS_user.c	Interrupt source file for SMS	√Note 1
¥Config_TAU0_0<DIR>	Folder for TAU program	√
Config_TAU0_0.c	Source file for TAU	√
Config_TAU0_0.h	Header file for TAU	√
Config_TAU0_0_user.c	Interrupt source file for TAU	√Note 1
¥general<DIR>	Folder for initialize or common program	√
¥r_bsp<DIR>	Folder for BSP program	√
¥r_config<DIR>	Folder for BSP_CFG program	√

Note. <DIR> means directory.

Note 1. Not used in this sample code.

Note 2. The sample code of the IAR version has a different configuration. Check the sample code of the IAR version for details. In addition, stores r01an5611_sms_led_dimming.ipcf. For details, refer to "RL78 Smart Configurator User’s Guide: IAREW (R20AN0581)".

5.3 Option Byte Settings

Table 5-2 shows the option byte settings.

Table 5-2 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 1.875V Falling edge 1.835V
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

5.4 Constants

Table 5-3 shows the constants that are used in this sample code.

Table 5-3 Constants used in the sample code

Constant Name	Setting Value	Contents	File
BRIGHTNESS_RANK	32	Number of steps to change the duty ratio	main.c

5.5 Variables

Global variables are not used in this sample code.

5.6 Functions

Table 5-4 shows the functions used in the sample code. However, the unchanged functions generated by the Smart Configurator are excluded.

Table 5-4 Functions

Function name	Outline	Source file
main	Main process	main.c

5.7 Function Specifications

This part describes function specifications of the sample code.

[Function name] main

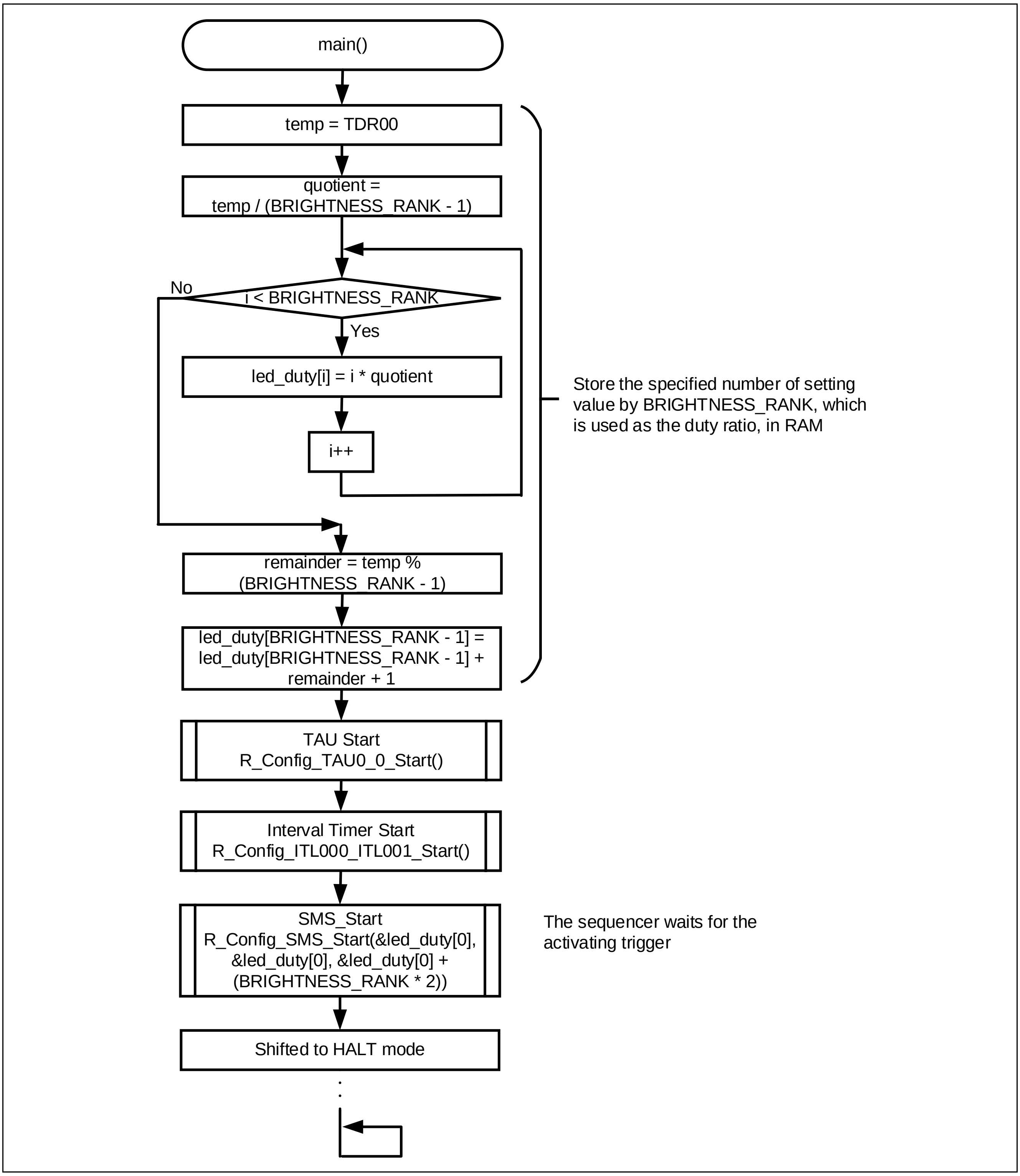
Outline	Main process
Header	r_smc_entry.h
Declaration	void main (void);
Description	This function defines the duty ratio value as a data table, then starts TML32 and TAU operation and shifts to HALT mode.
Arguments	None
Return value	None
Remarks	None

5.8 Flow Charts

5.8.1 Main Process

Figure 5-1 shows flowchart of main process.

Figure 5-1 Main process



5.9 SNOOZE Mode Sequencer settings

When the event set in the start trigger occurs, SMS executes the processing commands stored in the sequencer instruction register (SMSI0-31) in order. When executing a processing command, the Sequencer general-purpose register (SMSG0-15) is used to store the source address, destination address, calculated data, and so on.

SMSI0-31 and SMSG0-15 are set by writing the SMS program (.SMSASM file) in assembly language. The SMS program can also be created by combining processing blocks using the SNOOZE mode sequencer component of the Smart Configurator. The created SMS program is converted to a C language file by the SMS assembler and incorporated into the program.

The specifications of SMS processing executed by the sample code are shown below.

Outline	SMS process
Description	SMS is started by TML32 interrupt, gets data from the data table that defines the duty ratio of the PWM output, and writes it to the timer data register of the TAU.
Arguments [Note1]	val_ram_d, val_ram_s, val_ram_e
Return value	None
Remarks	None

Note1. Argument to be specified in the R_Config_SMS_Start function setting. For details, refer to 6.2.1 and 6.2.7.

Table 5-2 shows flowchart of SMS process.
Table 5-5 to Table 5-6 show the register settings that control the SNOOZE mode sequencer.

Figure 5-2 SMS process

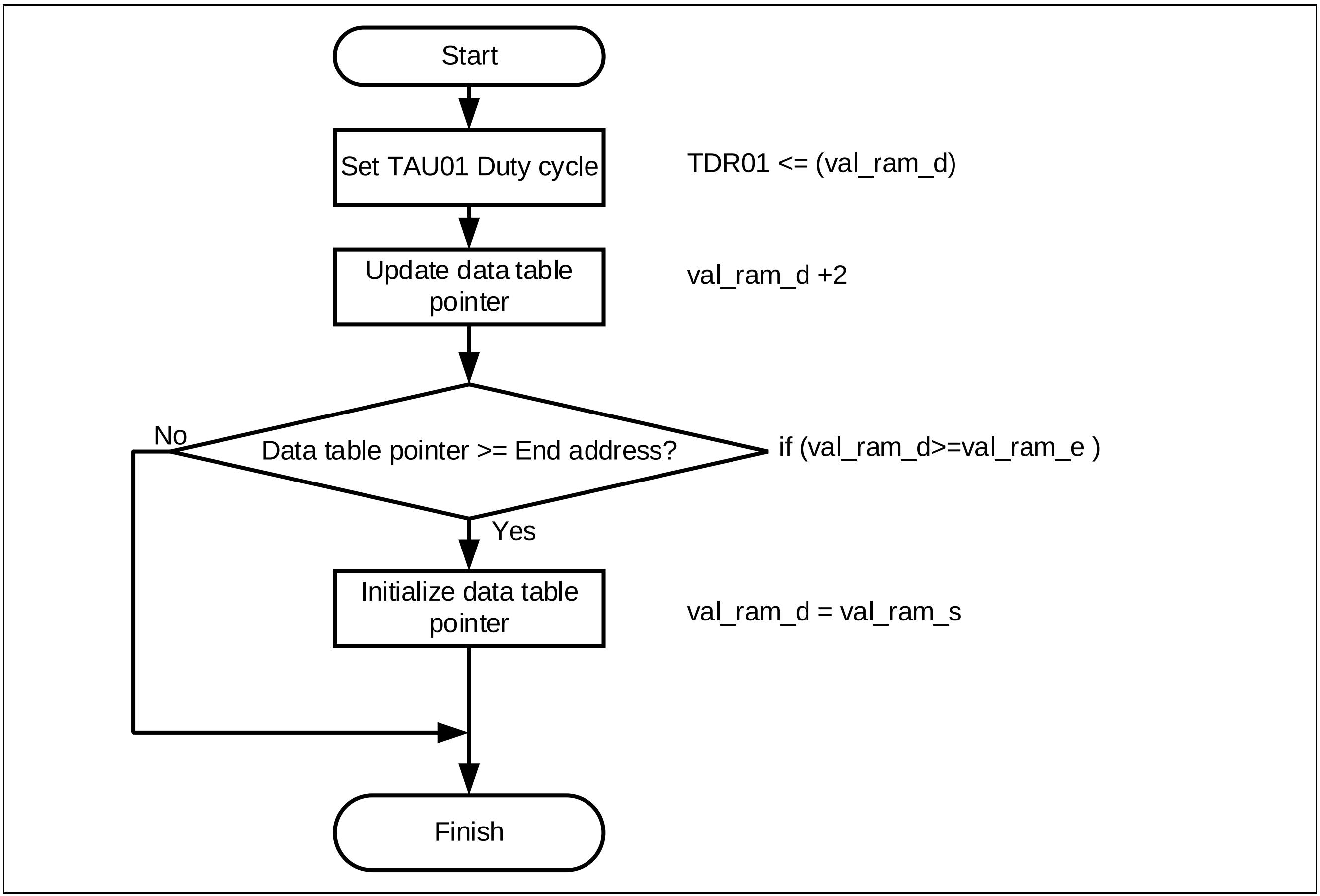


Table 5-5 Sequencer general-purpose registers 0-15

Register Symbol	Setting	Remark
SMSG0	0000H	fixed value: 0000H
SMSG1	0000H	Data table pointer: val_ram_d
SMSG2	0000H	Data table end address: val_ram_e
SMSG3	0000H	Data table start address: val_ram_s
SMSG4	&ITLS0	ITLS0 address
SMSG5	&SMSG1	SMSG1 address
SMSG6	&TDR01	TDR01 address
SMSG7	2	fixed value: 2
SMSG8	0000H	SMS internal variable
SMSG9	0000H	unused
SMSG10	0000H	unused
SMSG11	0000H	unused
SMSG12	0000H	unused
SMSG13	0000H	unused
SMSG14	0000H	unused
SMSG15	FFFFH	fixed value: FFFFH

Table 5-6 Sequencer instruction registers 0-31

Register Symbol	Setting	Remark
SMSI0	0400H	MOV [SMSG4+0], SMSG0
SMSI1	3180H	MOVW SMSG8, [SMSG1+0]
SMSI2	2680H	MOVW [SMSG6+0], SMSG8
SMSI3	7170H	ADDW SMSG1, SMSG7
SMSI4	7122H	CMPW SMSG1, SMSG2
SMSI5	8020H	BC $2
SMSI6	2530H	MOVW [SMSG5+0], SMSG3
SMSI7	F000H	FINISH
SMSI8-31	0000H	unused

6. Application example

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

r01an5611_sms_led_dimming.scfg

r01an5611_sms_led_dimming.sms

The following is a description of the file and setting examples and precautions for use.

6.1 r01an5611_sms_led_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 6-1 Parameters of Smart Configurator

Tag name	Components	Contents
Clocks	-	Operation mod: High-speed main mode 2.4 (V) ~ 5.5 (V) EV_{DD} setting: 1.8V≦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 1 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}): 1.835 (V)

Table 6-2 Parameters of Smart Configurator

Tag name	Components	Contents
Components	Config_ITL000_ITL001	Components: Interval timer Operation mode: 16 bit count mode Resource: ITL000_ITL001 Operation clock: f_{SXP} Clock source: $f_{ITL0}/128$ Interval value: 125 ms Interrupt setting: unused
	Config_TAU0_0	Components: PWM Output Resource: TAU0_0 Operation clock: CK00 Clock source: $f_{CLK}/2^8$ Cycle value: 1 ms Interrupt setting: unused (INTTM00) PWM Slave select setting: Channel 1 slave Duty value: 0% Output level: Active-high Interrupt setting: unused (INTTM01)
	Config_SMS	Components: SNOOZE Mode Sequencer Start trigger: Interval detection interrupt (INTITL)
	Config_PORT	Components: Port Port selection: PORT5 P53: In

Note 1. When using IAR, use the following settings.
On-chip debug operation setting: Use emulator
Emulator setting: E2 Emulator Lite

6.1.1 Clocks

Set the clock used in the sample code.

6.1.2 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 5-2 Option Byte Settings". Note that changing the settings.

6.1.3 r_bsp

Set the startup of the sample code.

6.1.4 Config_LVD0

Set the power management of the sample code.

Affects "Setting of LVD0" in "Table 5-2 Option Byte Settings". Note that changing the settings

6.1.5 Config_IT000_ITL001

Initialize the interval timer for the sample code.

The interval timer interrupt (INTITL) is used to start the SMS in the sample code. Therefore, "Interrupt setting" is set to "Not used". "Interrupt Settings" can also be changed to "Use".

Since INTITL is masked by the R_Config_SMS_Start function, the CPU will not start even if INTITL is generated during STOP or SNOOZE mode. After returning from STOP mode and SNOOZE mode, INTITL is in a masked state, so unmask INTITL if necessary.

6.1.6 Config_TAU0_0

Set TAU00 of the sample code.

6.1.7 Config_SMS

Set the sample code SMS.

For details, refer to "6.2 r01an5611_sms_led_dimming.sms".

6.1.8 Config_PORT

Set the port of the sample code.

In the sample code, P53 is used to control LED1.

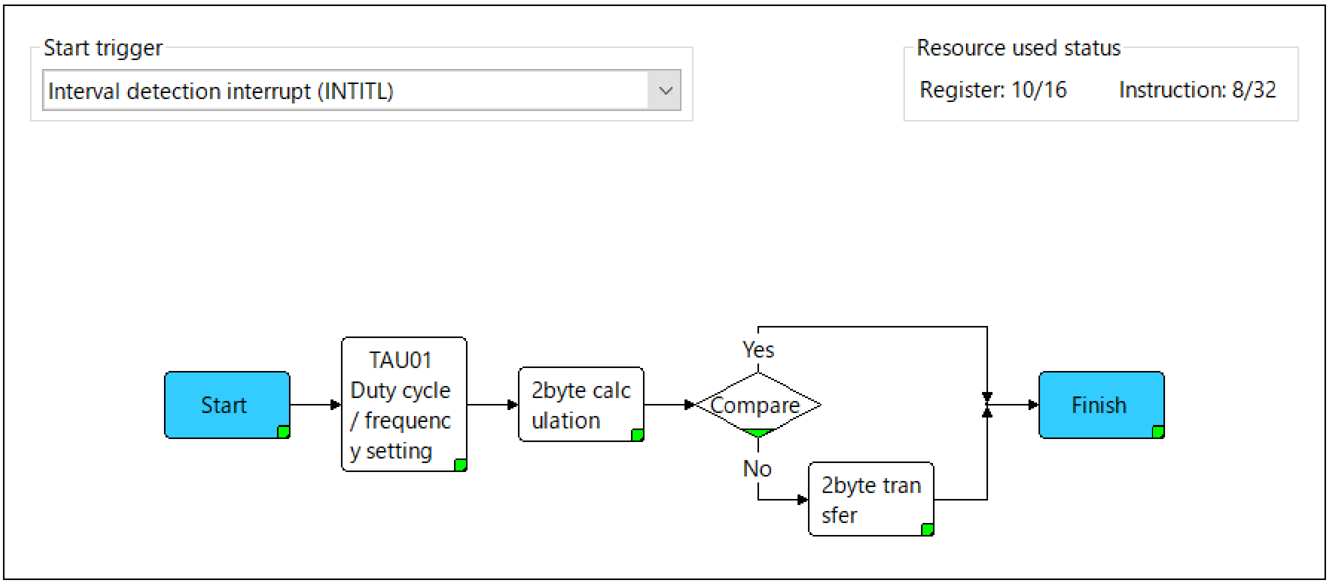
6.2 r01an5611_sms_led_dimming.sms

This is the data for Config_SMS alone. In the sample code, the interrupt of the interval timer is used to start SMS, and TAU is used in the operation of SMS. Note that it is necessary to set the interval timer and TAU separately.

The r01an5611_sms_led_dimming.sms can also be imported into the Smart Configurator of another project. After setting up the SMS component in another project, go to [Import SMS Sequence] -> [Browse] and select "r01an5611_sms_led_dimming.sms" to import it.

When imported into the smart configurator, the flow chart will be as shown in Figure 6-1. This flow chart is the same as "Figure 5-2 SMS process".

Figure 6-1 Config_SMS flow chart

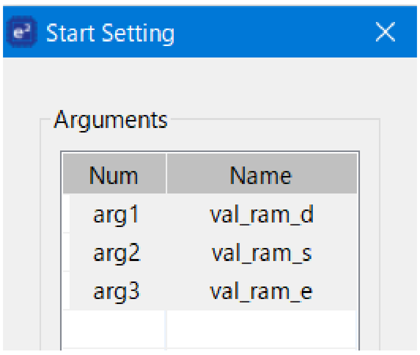


A description of each block is shown below.

6.2.1 Start

When the SMS starts, the values passed as arguments in the SMS start function (R_Config_SMS_Start function) are set to val_ram_d (data table pointer), val_ram_s (data table start address), and val_ram_e (data table end address).

Figure 6-2 Start Setting

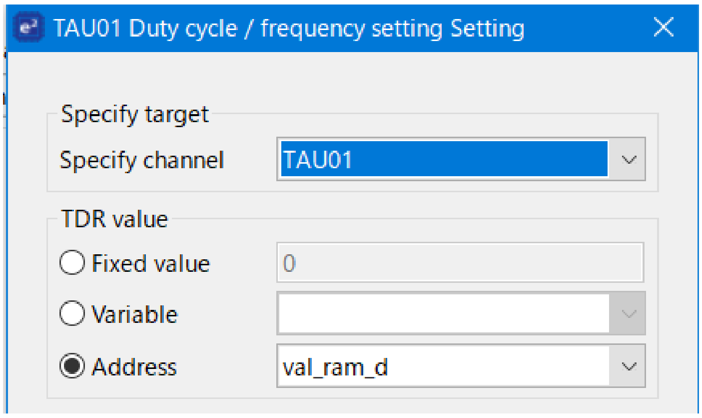


6.2.2 TAU Duty cycle / frequency setting

Changes the duty ratio of the TAU. Stores the value of val_ram_d (data table pointer) in the TDR register of the channel-specified TAU01.

In the sample code, TAU01 is set as the channel designation because PWM output is performed using TAU00 and TAU01, but the channel designation can be set from among TAU00 to TAU07.

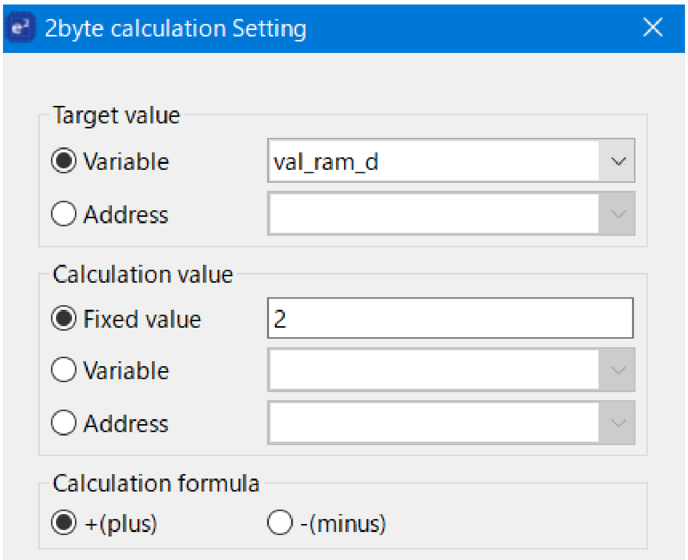
Figure 6-3 TAU01 Duty cycle frequency Setting



6.2.3 2byte calculation

Add "2" to val_ram_d where the duty ratio is stored, and store the result in val_ram_d. This will change the pointer to the data table that contains the next duty ratio.

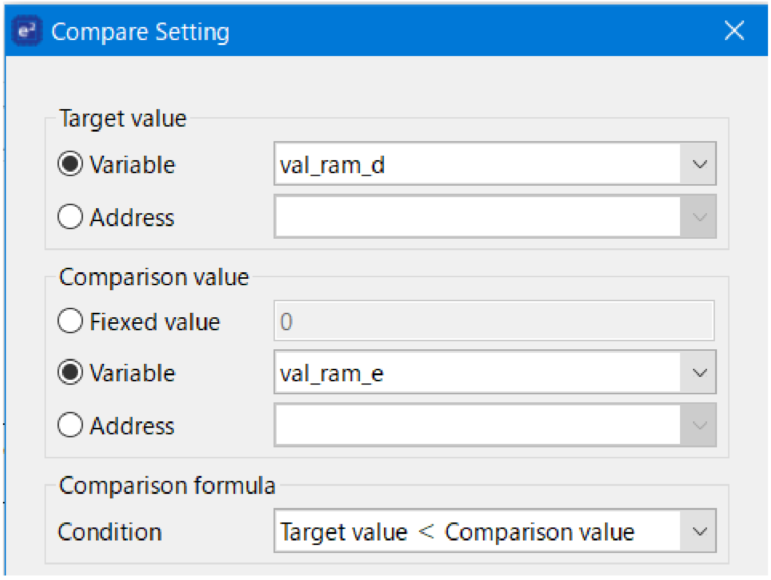
Figure 6-4 2byte calculation Setting



6.2.4 Compare

Compare whether the data table pointer stored in val_ram_d is smaller than the threshold value stored in val_ram_e (the last address of the data table). If val_ram_d is smaller than the threshold value, it will shift to HALT mode. If val_ram_d is larger than the threshold value, it performs the next 2-byte transfer and updates val_ram_d.

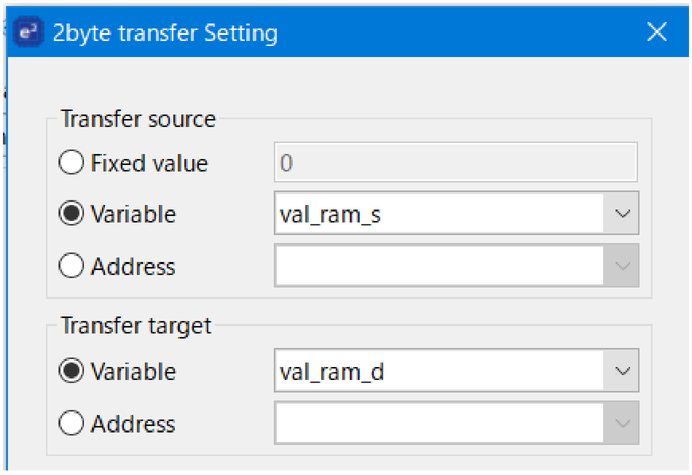
Figure 6-5 Compare Setting



6.2.5 2byte transfer Setting

Store the value of val_ram_s (data table start address) in the transfer target val_ram_d.

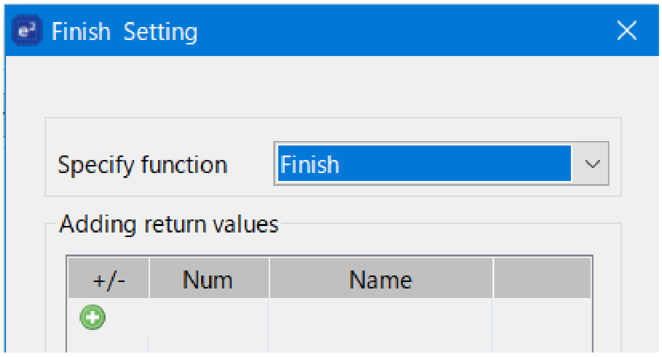
Figure 6-6 2byte transfer Setting



6.2.6 Finish

It shifts to HALT mode. In the sample code, the return value is not used.

Figure 6-7 Finish Setting



6.2.7 Variable Setting

The settings of the variables used in SMS are shown below.

Table 6-3 Variables used in SMS

Data name	Initialization mode	Initial value	Description
val_ram_d	Pass argument via SMS start function	-	Stores the pointer to the data table that stores the duty ratio. The pointer to led_duty[0] is set as an argument in the R_Config_SMS_Start function.
val_ram_s	Pass argument via SMS start function	-	Stores the start address of the data table to store the duty ratio. The address of led_duty[0] is set as an argument in the R_Config_SMS_Start function.
val_ram_e	Pass argument via SMS start function	-	Stores the last address of the data table that stores the duty ratio. The address of "&led_duty[0] + (BRIGHTNESS_RANK * 2)" is set as an argument in the R_Config_SMS_Start function.

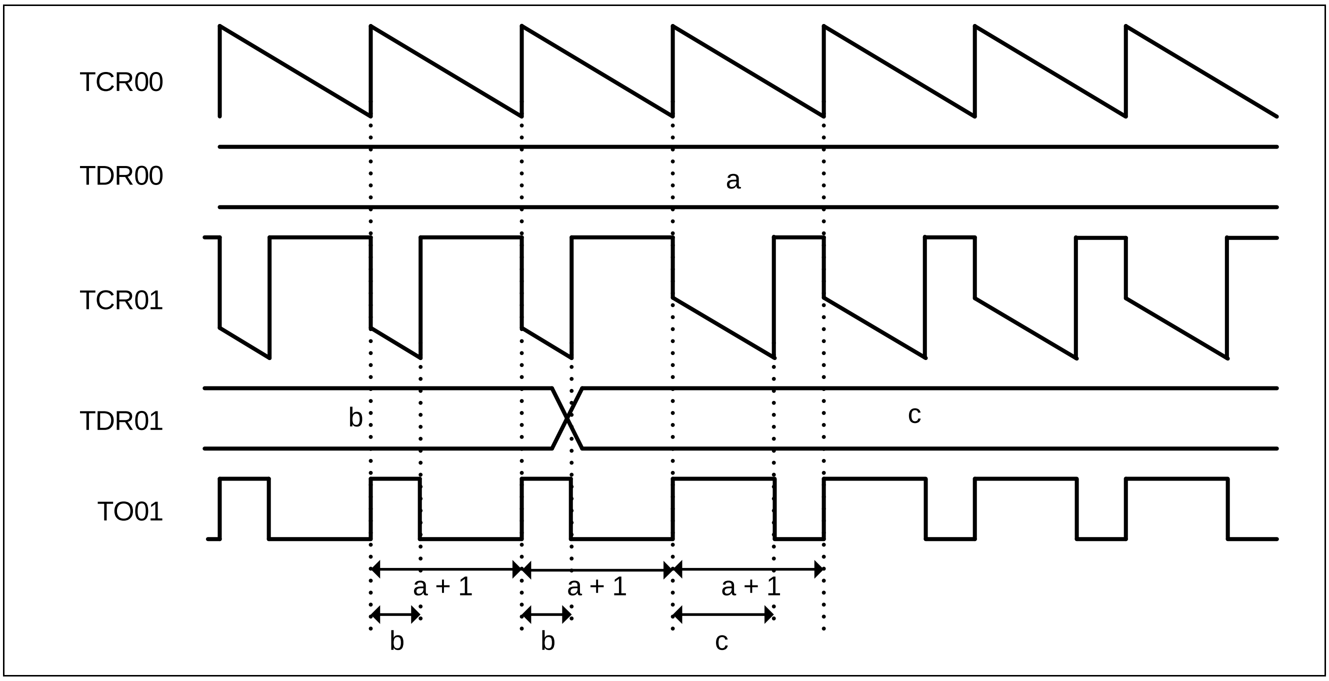
6.3 Example of changing the LED blinking time

Figure 6-8 shows an example of PWM operation timing of the sample code. When SMS stars, Duty cycle of TO01 is changed by changing the value of TDR01. After the initial setting value is determined by Config_TAU0_0, TDR00 is not changed. The value set for TDR01 is determined by how many divisions (BRIGHTNESS_RANK) of the cycle (TDR00) are made in main.c.

In the sample code, 32 is set as shown below, so a value divided into 32 is set. When this value is changed, the LED blinking time is changed.

```
#define BRIGHTNESS_RANK    (32U)
```

Figure 6-8 Timing example of PWM operation



7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

Furthermore, if you regenerate the code with Smart Configurator, please modify the R_Config_SMS_Start function as indicated in the red frame below.

```
void R_Config_SMS_Start(uint16_t val_ram_d, uint16_t val_ram_s, uint16_t val_ram_e)
{
    /* Set the sms data from arguments */
    SMSG1 = val_ram_d;
    SMSG3 = val_ram_s;
    SMSG2 = val_ram_e;
    /* Disable related interrupts */
    ITLMK = 1U;
    TMMK01 = 1U;
    /* Start sms */
    //SMSEIF = 0U; /* clear INTSMSE interrupt flag */
    //SMSEMK = 0U; /* enable INTSMSE interrupt */
    SMSEMK = 1U; /* disable INTSMSE interrupt */
    SMSEIF = 1U; /* set INTSMSE interrupt flag */
    g_sms_wakeup_flag = 0U;
    ITLS0 = _00_INTITL_CLEAR;
    SMSSTART = 1U;
}
```

8. Reference

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

RL78 Family User’s Manual: Software (R01US0015E)

SMS assembler User’s Manual (R20UT4792J)

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	Apr.13.21	-	First edition
1.10	Jun.1.21	6	Updated tool version Table 2-1 Operation Confirmation Conditions Integrated development environment (CS+) : E8.05.00f -> V8.05.00 C compiler (CS+) : V1.09.00 -> V1.10 Integrated development environment (e^2 studio) : 2021-01 (21.01.0) -> 2021-04 (21.4.0) C compiler (e^2 studio) : V1.09.00 -> V1.10 Integrated development environment (IAR) : V4.20.1 -> V4.21.1 Smart Configurator : V.1.0.0 -> V.1.0.1 Board support package (r_bsp) : V.1.0.0 -> V.1.10
		6, 8 16, 17	Changed due to COM port support Table 2-1 Operation Confirmation Conditions Emulator: E2 Emulator Lite -> CS＋, e^2 studio: COM port IAR: E2 Emulator Lite Figure 4-1 Hardware Configuration Added P11/TOOLRxD and P12/TOOLTxD Table 6-1 Smart Configurator Settings Note 1 added
		10, 11	Changed due to IAR version sample code update Table 5-1 Folder configuration Added the note about reference documents in folder configuration 5.7 Function Specifications [Function name] main, Header e^2 studio, CS+ : r_smc_entry.h IAR : ior7f100g.h, ior7f100g_ext.h, r_cg_macrodriver.h, Config_SMS.h, Config_ITL000_ITL001.h, Config_TAU0_0.h -> r_smc_entry.h
		16, 17	Changed clock abbreviation Table 6-1 Parameters of Smart Configurator Clocks : f_{SXL} -> f_{SXP} Table 6-2 Parameters of Smart Configurator Operation clock : f_{SXL} -> f_{SXP}
		24	Added of RL78 Smart Configurator User's Guide 8. Reference 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)
1.20	Jan.9.24	-	Changed the flowchart for SMS processing

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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