RL78/G23

SMS Smoke Fire Detection Operation

Introduction

This application note describes how to use the SNOOZE mode sequencer to detect fires.

While the CPU operating clock is stopped, it is possible to control the sensor required for fire detection, measure the sensor output, and judge the measurement result, therefore this can achieve lower power consumption than before.

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

This application note shows how to detect fire by sensing smoke. The smoke sensor is configured a light emitting part, a light receiving part, and an amplifier. If smoke enters between the light emitting part and the light receiving part, the minute voltage of the light receiving part will change. Smoke is sensed by measuring the change in the amplified signal, and the outbreak of a fire is detected.

In the SNOOZE mode sequencer (SMS) processing, sensor control, measurements of sensor outputs and measurement result judgment are performed. When either of the measurement result of two sensors exceeds the threshold values, the CPU starts.

The port function is used to control the sensor, and the A/D converter (ADC) is used to measure the sensor output value to judge the measurement result.

In SMS, port operation, A/D conversion, and processing to judge the conversion result are set in advance. The regular interval at which the sensor is started is generated using the 32-bit interval timer (TML32). After entering STOP mode, SMS is started by a TML32 interrupt (INTITL). By starting SMS, port operation, A/D conversion, and conversion result judgment processing are executed in sequence. If the measurement result exceeds the threshold value, an interrupt request signal (INTSMSE) is issued from SMS to start the CPU.

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

Figure 1-1 System Configuration

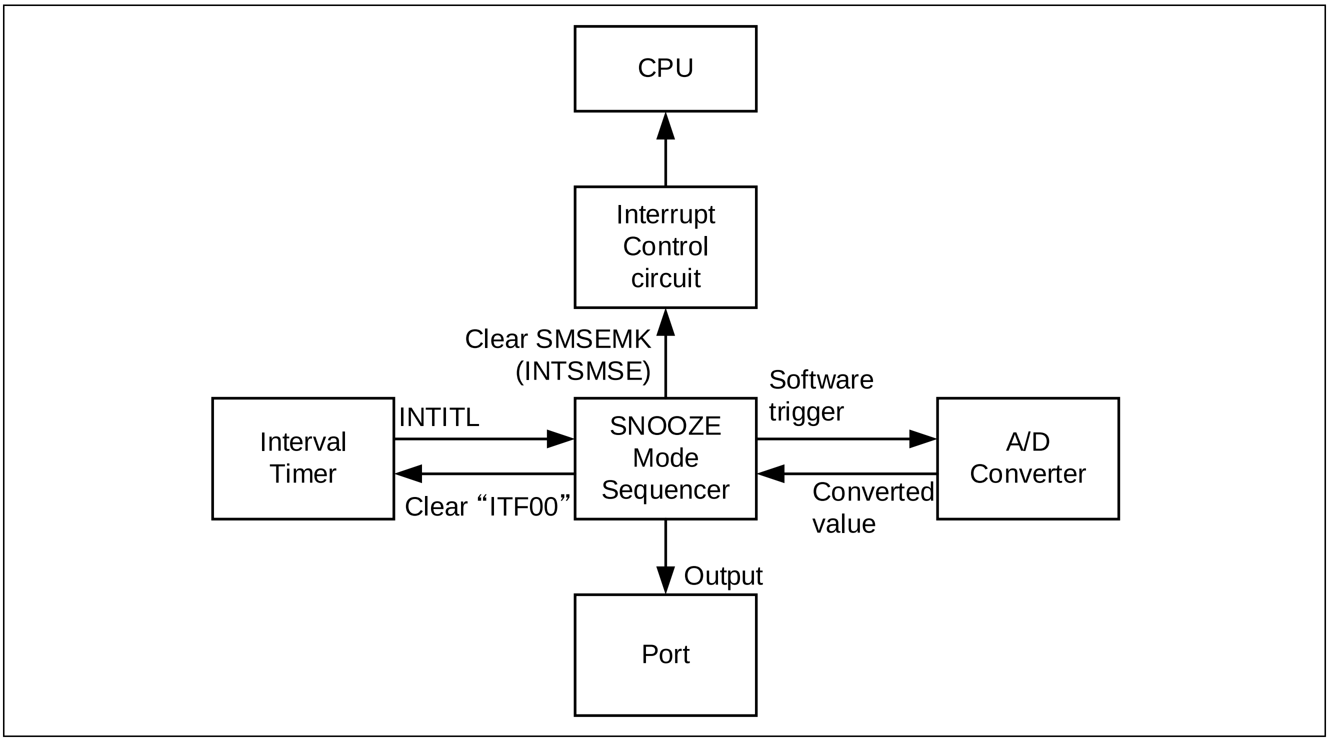
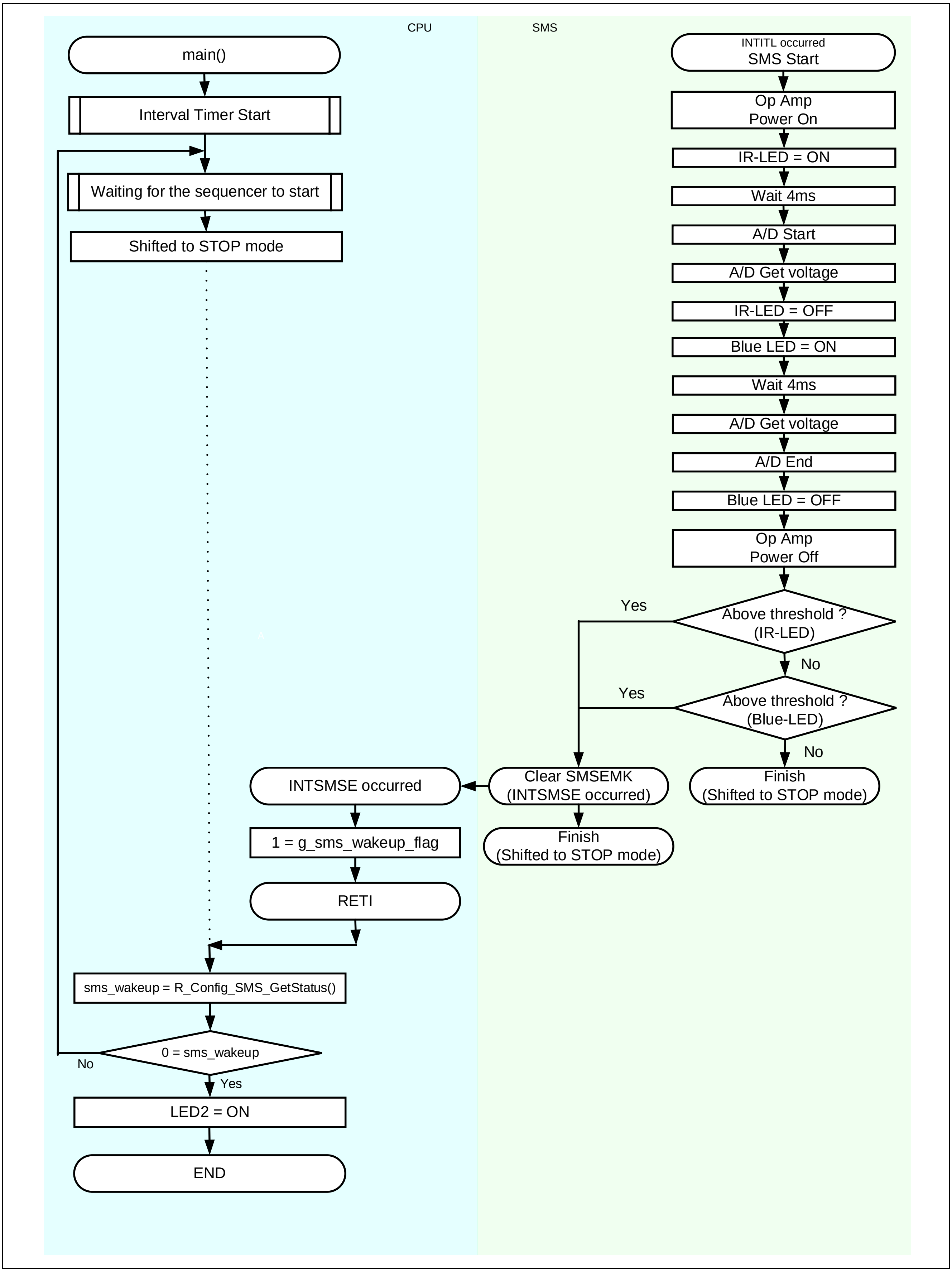


Figure 1-2 Entire Flowchart



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	• 5V • LVD0 operations (V_{LVD0}) : Reset mode Rising edge TYP.1.90V (1.84V-1.95V) Falling edge TYP.1.86V (1.80V-1.91V)
Integrated development environment (CS+)	CS+ for CC V8.06.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.10 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio 2021-07 (21.7.0) 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.1.1.0
Board support package (r_bsp)	V.1.11
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.

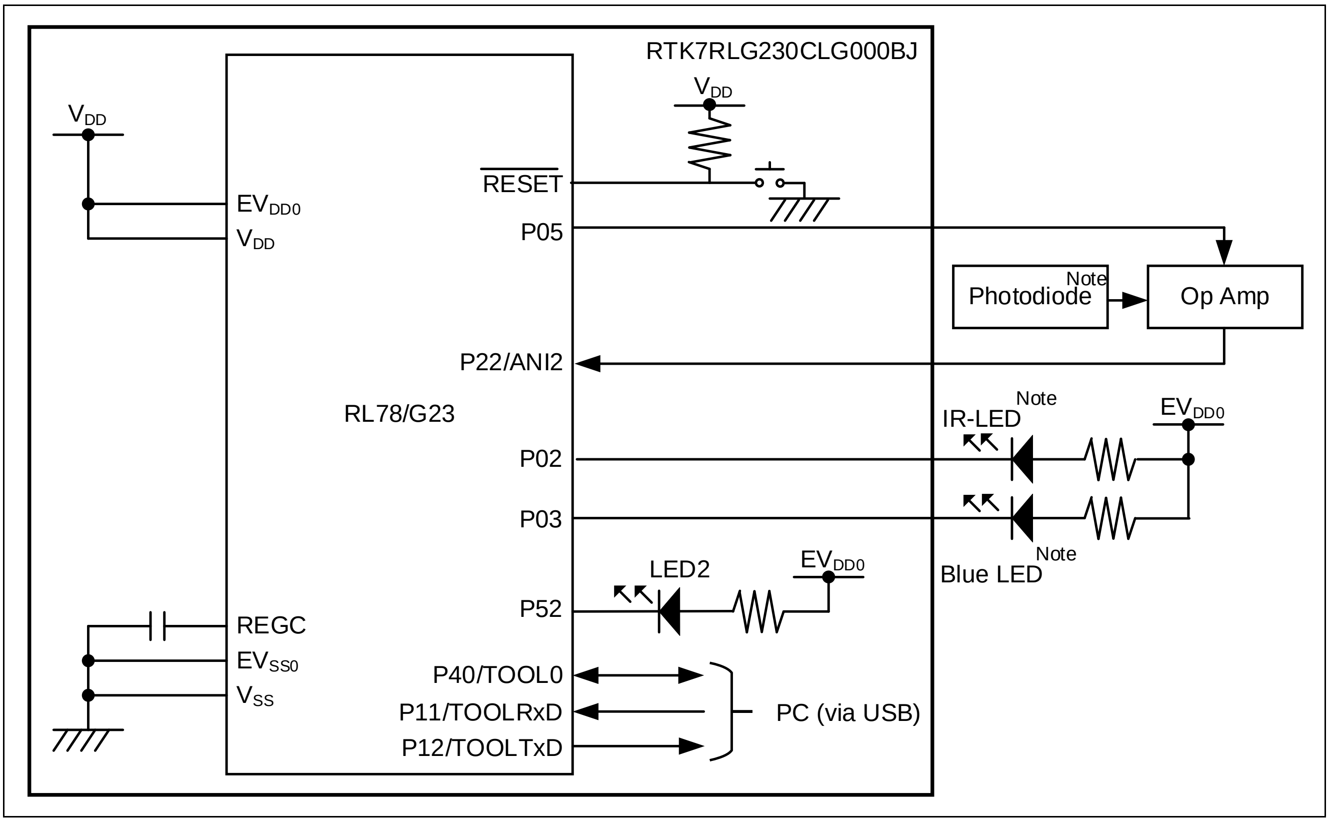
4. Hardware

4.1 Example of Hardware Configuration

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

This application note shows an example of using a light emitting part: infrared and blue LEDs, a light receiving part: photodiode, and an amplifier: operational amplifier as sensors for fire detection.

Figure 4-1 Hardware Configuration



Note. Must be configured outside the board (RTK7RLG230CLG000BJ)

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.

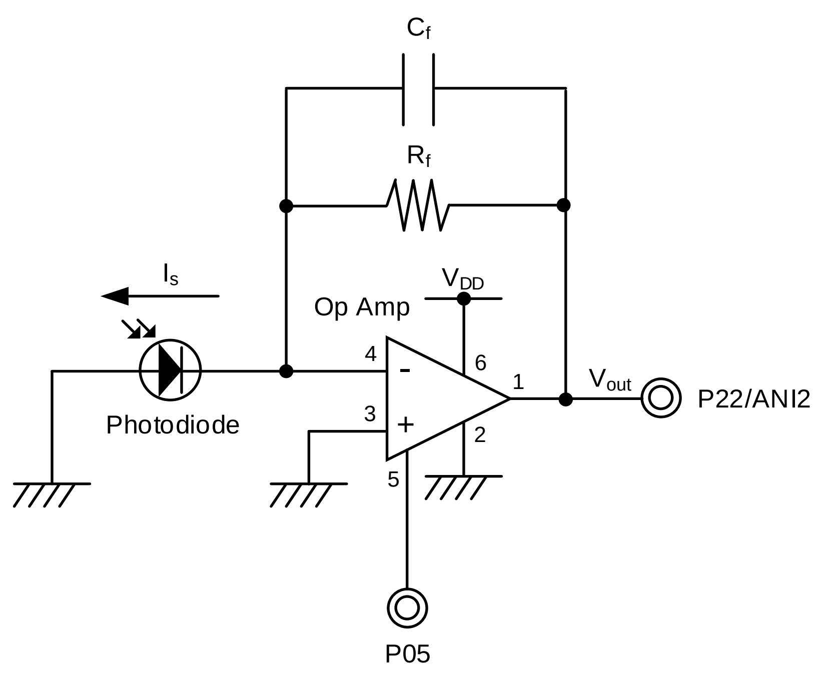
Figure 4-2 shows a reference circuit of optical sensors using a photodiode and operational amplifier.

This circuit is configured an operational amplifier to amplify the output of the optical sensor, a resistor R_f and a capacitor C_f to prevent oscillation. When a photodiode receives light, a small current I_s flows according to the light intensity. The small current I_s is amplified and the voltage ($V_{out} = R_f \times I_s$) which is proportional to I_s is output from the operational amplifier. Oscillation can be prevented by inserting the capacitor C_f when the parasitic capacitance of the photodiode is large and the resistance R_f is large.

The setting values described in Table 5-3 are determined based on the resistance R_f of the operational amplifier that amplifies the light sensor signal, the small current I_s according to the light intensity received by the photodiode in and then the relative spectral sensitivity of the photodiode for the light wavelength of infrared LED and blue LED.

In this application note, as an example, this circuit is configured a resistor R_f = 400kΩ to convert the small current I_s (approximately 9.5µA) that flows when the photodiode receives light to the voltage ($V_{out} = R_f \times I_s$). In order to determine the occurrence of a fire, it is setting the thresholds to detect the voltage of 3.4V or higher for infrared LED and 1.9V or higher for blue LED.

Figure 4-2 Reference Circuit of Photodiode and Operational Amplifier



4.2 Used Pins

Table 4-1 shows list of used pins and assigned functions, and Table 4-2 shows list of used outside components.

Table 4-1 List of Pins and Functions

Pin Name	Input/Output	Function
P02	Output	Infrared LED [Note] (Low Active)
P03	Output	Blue LED [Note] (Low Active)
P05	Output	ON/OFF control of operational amplifier [Note]
P52	Output	LED2 lights (Low Active)
P22/ANI2	Input	Input for A/D conversion

Note. Must be configured outside the RTK7RLG230CLG000BJ. For detail, refer to Table 4-2.

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.

Table 4-2 List of Outside Components

Component Name	Manufacturer	Model Number
Infrared LED	Rohm Semiconductor	SIR-34ST3F
Blue LED	Rohm Semiconductor	SLR343BC4T3F
Photodiode	OSRAM Opto Semiconductors	SFH 203 P
Operational Amplifier	Renesas Electronics America	ISL28194FHZ-T7

5. Software

5.1 Overview of the sample program

In this sample code, the CPU shifts from STOP mode to SNOOZE mode by a 32-bit interval timer (TML32) interrupt request (INTITL). Then the control of the operational amplifier, infrared LED and blue LED that are configured externally, and the A/D conversion and judgment of the operational amplifier output are performed by SMS.

The A/D conversion is measured with setting the supply voltage (V_{DD}) as the reference voltage and the ANI2 as the analog input channel. SMS compares the A/D conversion result with the threshold value, and if it exceeds the threshold value, it determines that a fire has occurred and shifts from SNOOZE mode to normal operation to start the CPU.

Caution. When using the RL78/G23 and LED with the same power supply as in the hardware configuration shown in this application note, the LED may not meet the forward voltage standard of the LED and the LED may not light.

The outline of the processing performed by this sample code is shown below.

(1) Starts counting TML32
(2) Shifts to STOP mode
(3) Shifts to SNOOZE mode with TML32 compare match
(4) Starts the operational amplifier
(5) Turns on the infrared LED
(6) Waits for 4ms
(7) Performs A/D conversion
(8) Turns off the infrared LED
(9) Turns on the blue LED
(10) Waits for 4ms
(11) Performs A/D conversion
(12) Turns off the blue LED
(13) Stops the operational amplifiers
(14) Branches to (15) if A/D conversion result does not exceed threshold (val_adcr_th_ir), else branches (16)
(15) Branches to (2) if A/D conversion result does not exceed threshold (val_adcr_th_blue), else branches (16)
(16) Starts the CPU
(17) Shifts to normal operation from SNOOZE mode
(18) Turns on LED2

(4) to (16) 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**
\r01an6064jj0100_sms_fire_detection_dual <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_ADC<DIR>	Folder for ADC program	√
Config_ADC.c	Source file for ADC	√
Config_ADC.h	Header file for ADC	√
Config_ADC_user.c	Interrupt source file for ADC	√[Note 1]
\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	√
\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 r01an6064jj0100_sms_fire_detection_dual.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)	LVD operating mode: reset mode Rising edge 1.90V (1.84V-1.95V) Falling edge 1.86V (1.80V-1.91V)
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
LED2	P5_bit.no2	P52	main.c
LED_ON	0	Setting value for turning on the LED	
THRESHOLD_IR	0B00H Note	A/D conversion result threshold (infrared LED)	
THRESHOLD_BLUE	0600H Note	A/D conversion result threshold (blue LED)	

Note. When actually designing your circuit, need to change the setting values depending on the hardware environment you are configuring.

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

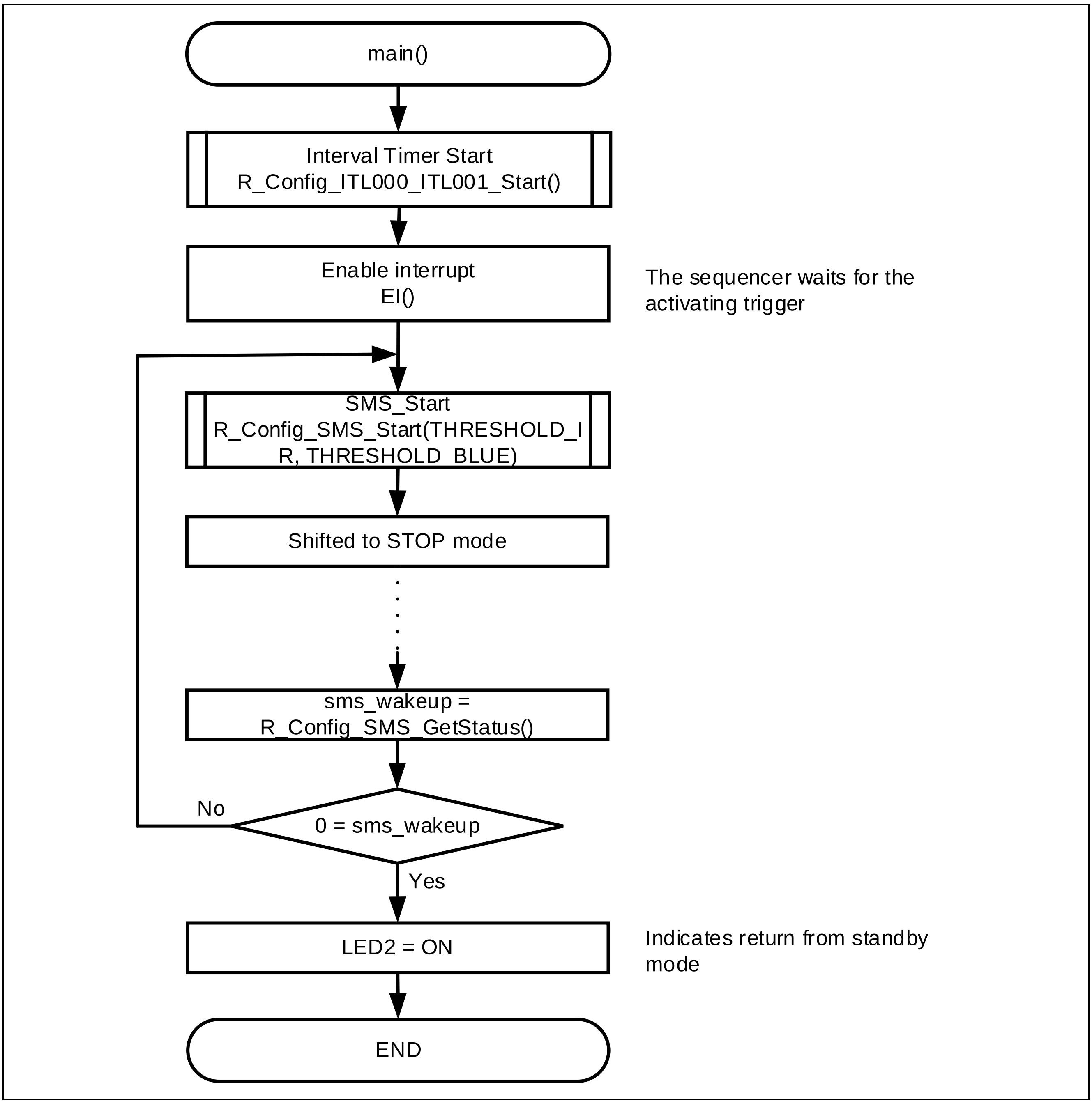
Outline	Main process
Header	r_smc_entry.h
Declaration	void main (void);
Description	This function sets the threshold for starting the CPU from standby mode, then starts TML32 operation and shifts to STOP mode. LED2 lights up when returning from SNOOZE mode.
Arguments	None
Return value	None
Remarks	None

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 starts with TML32 interrupt and uses the port to starts the operational amplifier. Turning on the infrared LED and waits for the voltage amplification time of the operational amplifier. Then, it performs ADC setting and A/D conversion and turns off the infrared LED. Turns on the blue LED and waits for the voltage amplification time of the operational amplifier. Then, it performs the A/D conversion and turns off the blue LED and operational amplifier. Compared the A/D conversion result and the thresholds, and if the result exceeds the threshold, it generates INTSMSE.
Arguments Note1	val_adcr_th_ir, val_adcr_th_blue
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 6.2.16.

Figure 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

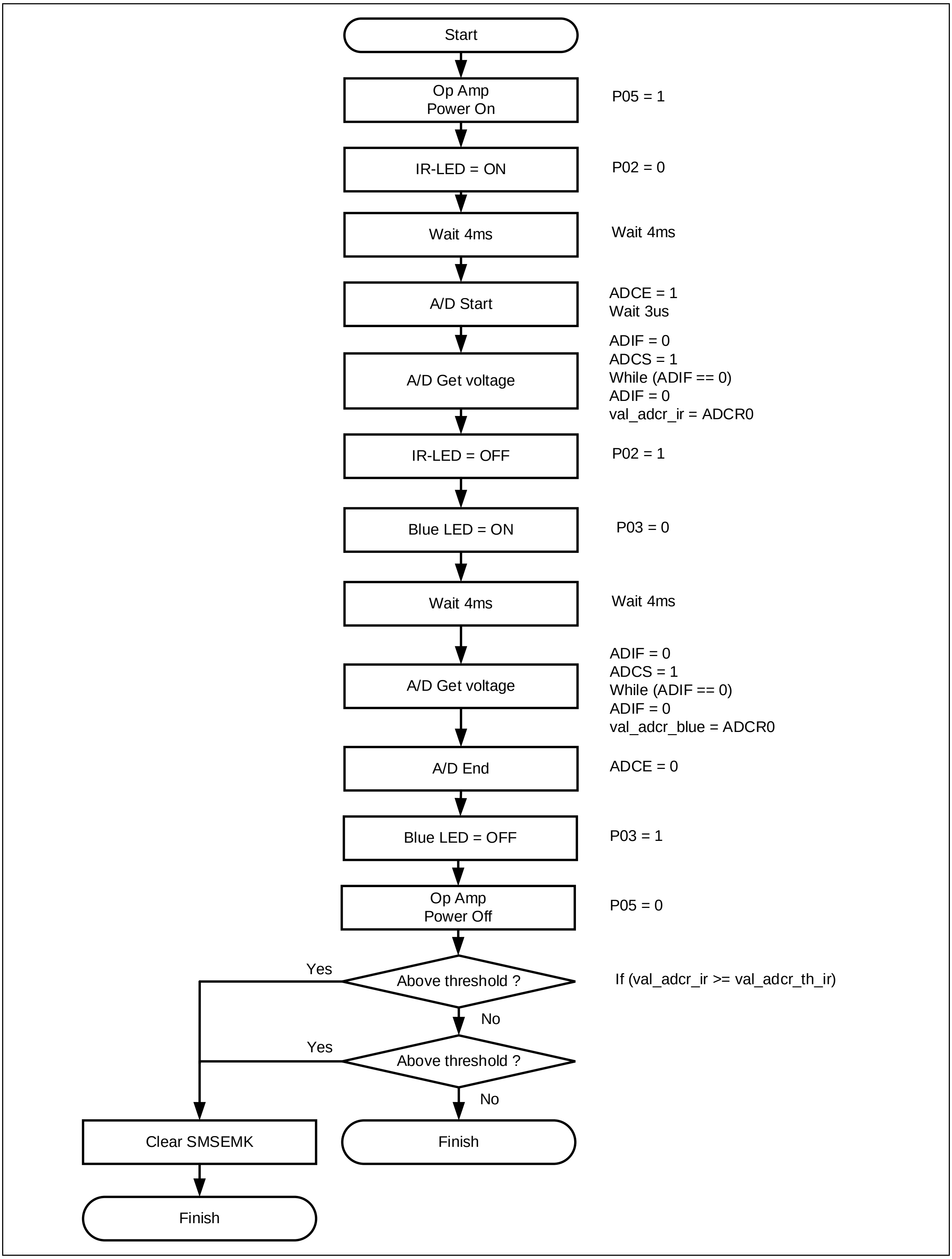


Table 5-5 Sequencer general-purpose registers 0-15

Register Symbol	Setting	Remark
SMSG0	0000H	fixed value: 0000H
SMSG1	0000H	Variable for storing ADCR register: val_adcr_ir
SMSG2	0000H	Variable for storing ADCR register: val_adcr_blue
SMSG3	0000H	Threshold of AD conversion result: val_adcr_th_ir
SMSG4	0000H	Threshold of AD conversion result: val_adcr_th_blue
SMSG5	FFE5H	MK0H address
SMSG6	&ITLS0	ITLS0 address
SMSG7	&P0	P0 address
SMSG8	&ADCR0	ADCR0 address
SMSG9	&ADM0	ADM0 address
SMSG10	&IF1H	IF1H address
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	0600H	MOV [SMSG6+0], SMSG0
SMSI1	4750H	SET1 [SMSG7+0].5
SMSI2	5720H	CLR1 [SMSG7+0].2
SMSI3	9C21H	WAIT 194, 1
SMSI4	5900H	CLR1 [SMSG9+0].0
SMSI5	4870H	SET1 [SMSG8+0].7
SMSI6	B900H	WHILE0 [SMSG9+0].0
SMSI7	5900H	CLR1 [SMSG9+0].0
SMSI8	3510H	MOVW SMSG1, [SMSG5+0]
SMSI9	4720H	SET1 [SMSG7+0].2
SMSI10	5730H	CLR1 [SMSG7+0].3
SMSI11	9C21H	WAIT 194, 1
SMSI12	5900H	CLR1 [SMSG9+0].0
SMSI13	4870H	SET1 [SMSG8+0].7
SMSI14	B900H	WHILE0 [SMSG9+0].0
SMSI15	5900H	CLR1 [SMSG9+0].0
SMSI16	3520H	MOVW SMSG2, [SMSG5+0]
SMSI17	5800H	CLR1 [SMSG8+0].0
SMSI18	4730H	SET1 [SMSG7+0].3
SMSI19	5750H	CLR1 [SMSG7+0].5
SMSI20	7132H	CMPW SMSG1, SMSG3
SMSI21	8051H	BNC $5
SMSI22	7242H	CMPW SMSG2, SMSG4
SMSI23	8021H	BNC $2
SMSI24	F000H	FINISH
SMSI25	5540H	CLR1 [SMSG5+0].4
SMSI26	F000H	FINISH
SMSI27	5540H	CLR1 [SMSG5+0].4
SMSI28	F000H	FINISH
SMSI29-31	0000H	Unused

6. Application example

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

r01an6064jj0100_sms_fire_detection_dual.scfg

r01an6064jj0100_sms_fire_detection_dual.sms

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

6.1 r01an6064jj0100_sms_fire_detection_dual.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 4.0 (V) ~ 5.5 (V) EV_{DD} setting: 4.0V≤ 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}): 1.86 (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: 10000 ms Interrupt setting: unused
	Config_ADC	Components: A/D Converter Comparator operation setting: Stop Resolution setting: 12 bits VREF (+) setting: V_{DD} VREF (-) setting: V_{SS} Trigger mode setting: Software trigger wait mode Operation mode setting: One-shot select mode A/D channel selection: ANI2 Conversion time mode: Normal 1 Conversion time: 102/f_{CLK} Conversion result upper/lower bound value setting: Generates an interrupt request (INTADSL) when ADLL≦ADCRn≦ADUL Upper bound (ADUL) value: 255 Lower bound (ADLL) value: 0 Interrupt setting: unused
	Config_SMS	Components: SNOOZE Mode Sequencer Start trigger: Interval detection interrupt (INTITL)
	Config_PORT	Components: Port Port selection: PORT5 P52: Out (Output 1) Port selection: PORT0 P02: Out (Output 1) P03: Out (Output 1) P05: Out (Output 0)

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.

In this sample code, 32MHz is set for f_{CLK} and the conversion time mode is set to "Standard 1 (2.4 V ≤ V_{DD} ≤ 5.5 V)" with Config_ADC, so the operation mode is "High-speed main mode 4.0 (V) ~ 5.5 (V)”. Note that changing the settings.

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 “Used”.

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_ADC

Initialize the ADC for the sample code.

In the sample code, "VREF (+) setting" is set to V_{DD} and "A/D channel selection" is set to ANI2. It is also possible to change "A/D channel selection" to another ANI pin. And "the internal reference voltage" or "the temperature sensor output voltage" can be selected too. However, the A/D converter reference voltage current and temperature sensor operating current will flow during STOP mode in this case.

In the sample code, A/D conversion is not performed when the device is not in SNOOZE mode, so "Interrupt Settings" is set to “Not Used”. "Interrupt Settings" can also be changed to “Used”. Since INTAD is masked by the R_Config_SMS_Start function, the CPU will not start even if INTAD is generated during STOP or SNOOZE mode. After returning from STOP mode and SNOOZE mode, INTAD is in a masked state, so unmask INTAD if necessary.

6.1.7 Config_SMS

Set the sample code SMS.

For details, refer to "6.2 r01an6064jj0100_sms_fire_detection_dual.sms".

6.1.8 Config_PORT

Set the port of the sample code.

In the sample code, P02 is used to control the infrared LED, P3 is used to control the blue LED, P05 is used to control the operational amplifier and P52 is used to control LED2. P02, P03, and P05 can be changed to other pins, but it is necessary to change the settings in Config_SMS as well. For details, refer to “6.3 Example of changing the output pins with this sample code”.

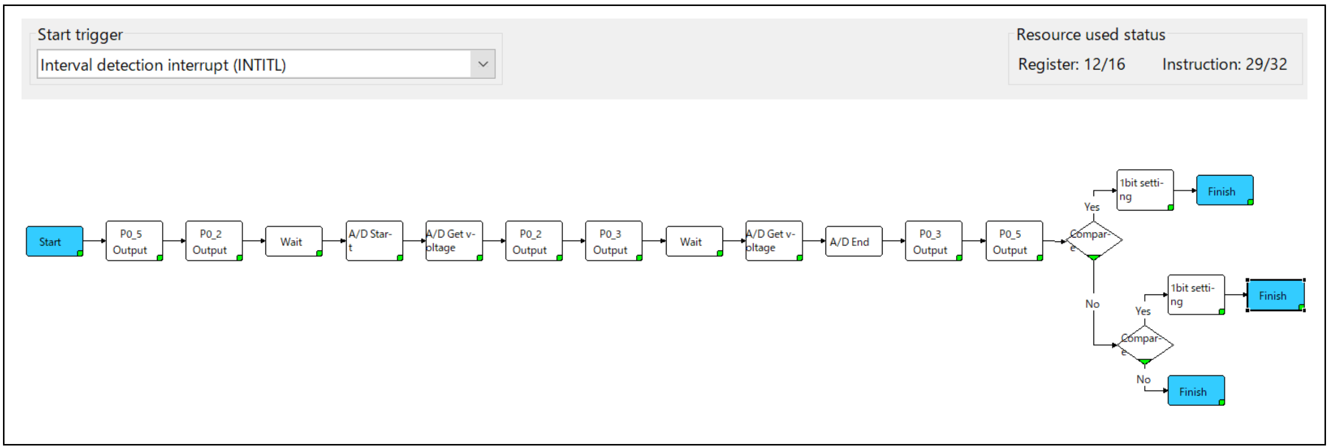
6.2 r01an6064jj0100_sms_fire_detection_dual.sms

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

The r01an6064jj0100_sms_fire_detection_dual.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 "r01an6064jj0100_sms_fire_detection_dual.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

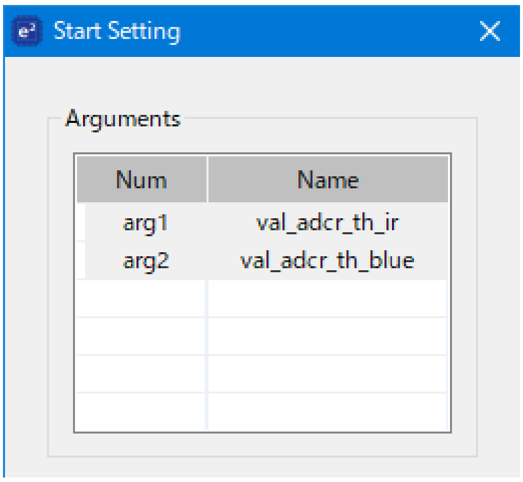


A description of each block is shown below.

6.2.1 Start

When the SMS starts, the values of THRESHOLD_IR and THRESHOLD_BLUE passed as an argument in the SMS start function (R_Config_SMS_Start function) are set to val_adcr_th_ir and val_adcr_th_blue (A/D conversion result thresholds).

Figure 6-2 Start Setting

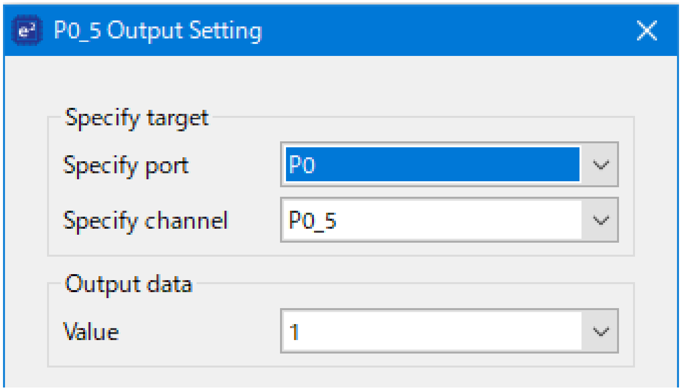


6.2.2 P0_5 Output

Outputs the value of the output data to the target specified port. In the sample code, "1" is output to P0_5. To set the port (e.g., change to output mode), use the Config_Port component.

In the sample code, P0_5 controls the ON of the operational amplifier, so make sure to do this before starting the A/D operation.

Figure 6-3 P0_5 Output Setting

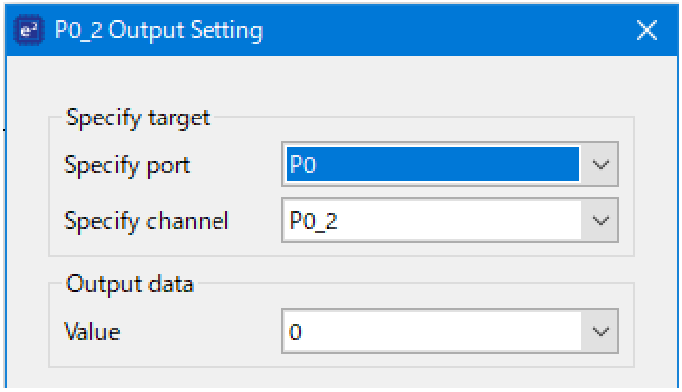


6.2.3 P0_2 Output

Outputs "0" to P0_2.

In the sample code, P0_2 controls the ON of the infrared LED, so make sure to do this before starting the A/D operation.

Figure 6-4 P0_2 Output Setting

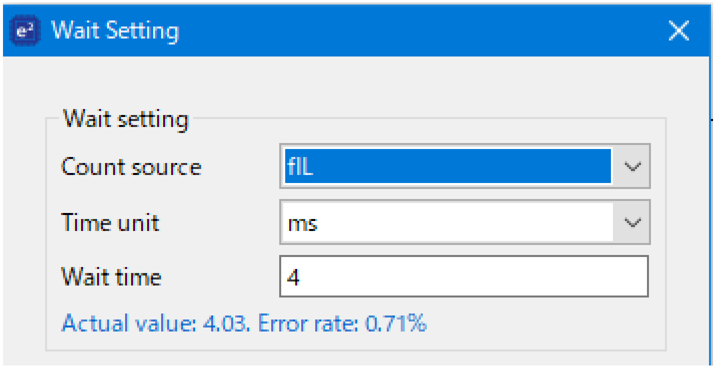


6.2.4 Wait

Wait for the SMS processing for the set wait time. In the sample code, the waiting time required for voltage amplification of the A/D conversion target is set, waits for the processing for 4ms at the count source (f_{IL}).

When changing the waiting time, if you set a value that cannot be set, the value will be in red. Note that changing the waiting time.

Figure 6-5 Wait Setting

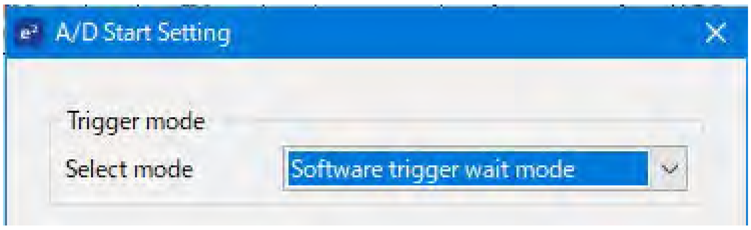


6.2.5 A/D Start

Set the trigger mode for A/D. The waiting time is automatically added according to the mode.

In the sample code, the A/D operation is started without changing the A/D conversion target, but it is also possible to change the A/D conversion target before the A/D operation starts. Before starting the A/D operation, add "A/D Change channel" and change the A/D conversion target.

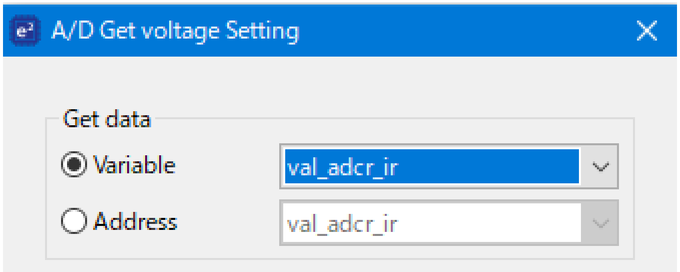
Figure 6-6 A/D Start Setting



6.2.6 A/D Get voltage

Converts A/D and stores the value of the A/D conversion result (ADCR0) in the variable val_adcr_ir.

Figure 6-7 A/D Get voltage Setting

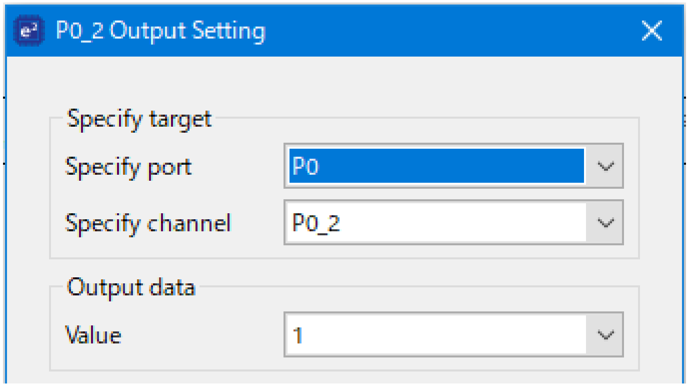


6.2.7 P0_2 Output

Outputs "1" to P0_2.

In the sample code, P0_2 controls the OFF of the infrared LED, so make sure to do this after getting A/D voltage.

Figure 6-8 P0_2 Output Setting

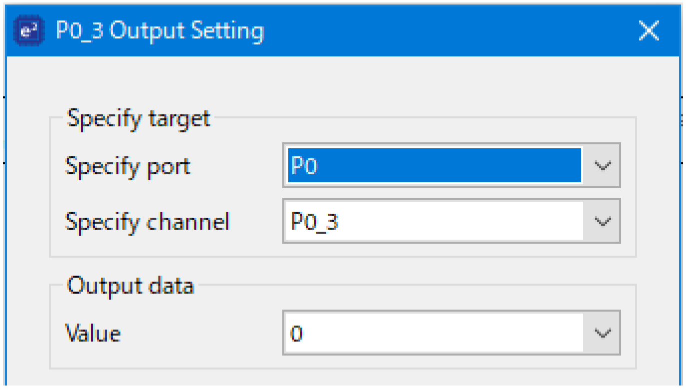


6.2.8 P0_3 Output

Outputs "0" to P0_3.

In the sample code, P0_3 controls the ON of the blue LED, so make sure to do this before getting the A/D voltage.

Figure 6-9 P0_3 Output Setting

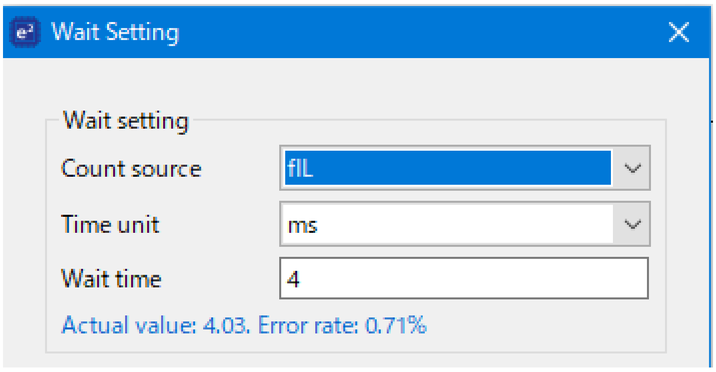


6.2.9 Wait

Wait for the SMS processing for the set wait time. In the sample code, the waiting time required for voltage amplification of the A/D conversion target is set, waits for the processing for 4ms at the count source (f_{IL}).

When changing the waiting time, if you set a value that cannot be set, the value will be in red. Note that changing the waiting time.

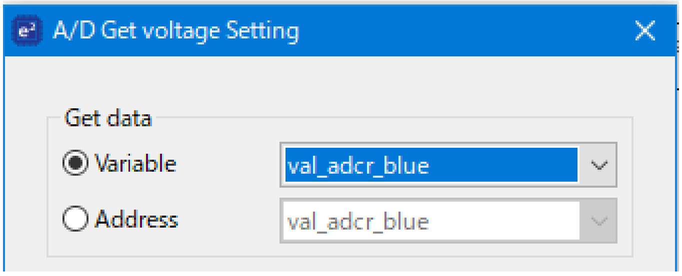
Figure 6-10 Wait Setting



6.2.10 A/D Get voltage

Converts A/D and stores the value of the A/D conversion result (ADCR0) in the variable val_adcr_blue.

Figure 6-11 A/D Get voltage Setting



6.2.11 A/D End

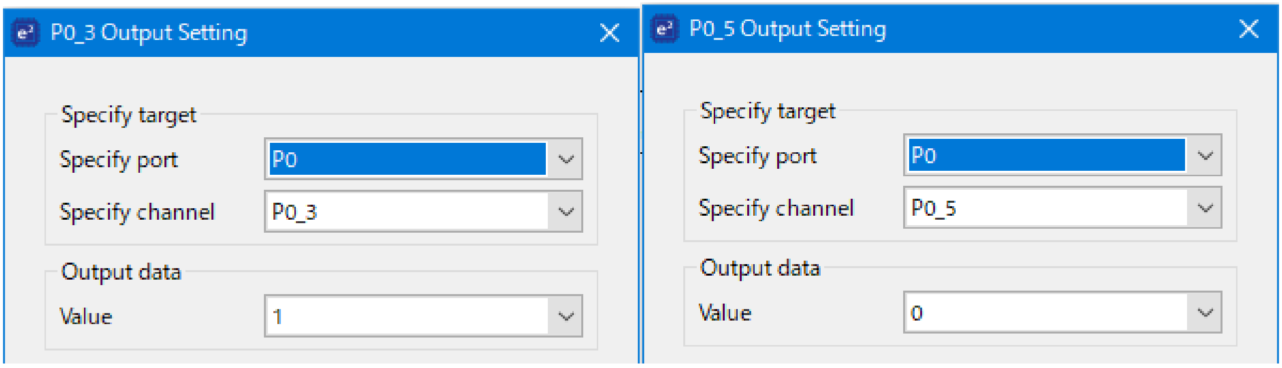
End the A/D conversion (ADCE=0).

6.2.12 Port Output

Output "1" to P0_3 and "0" to P0_5.

In the sample code, P0_3 controls the OFF of the blue LED and P0_5 controls the OFF of the operational amplifier, so be sure to do this after ending the A/D operation.

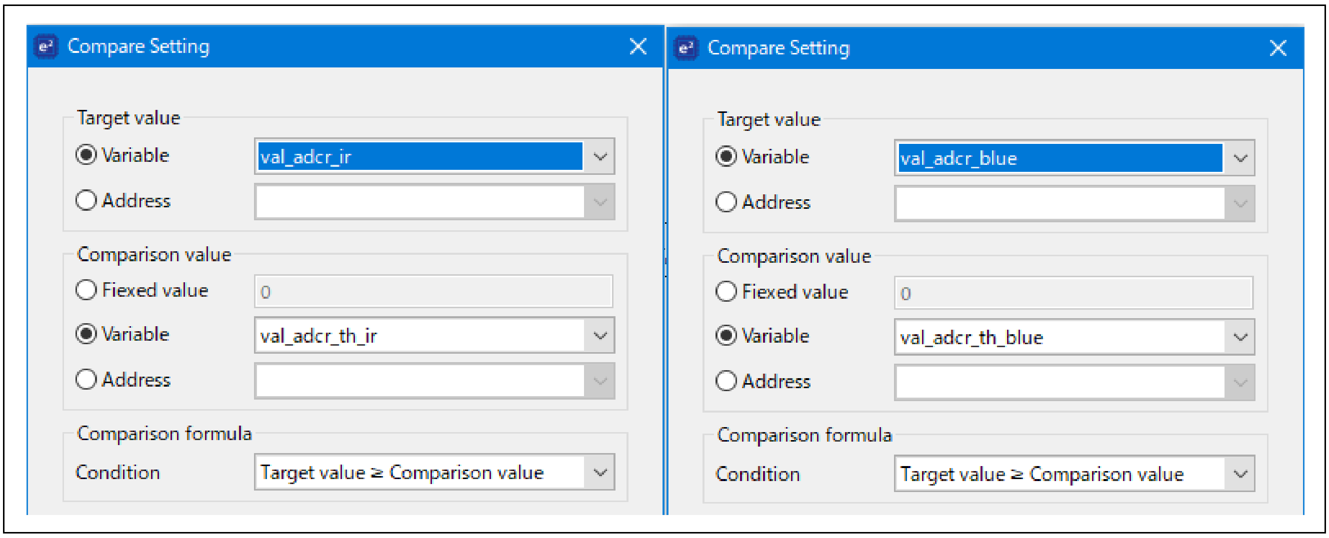
Figure 6-12 P0_3, P0_5 Output Setting



6.2.13 Compare

This function compares whether the A/D conversion result stored in the variable val_adcr_ir and val_adcr_blue are greater than the threshold values stored in the variable val_adcr_th_ir and val_adcr_th_blue. When either val_adcr_ir or val_adcr_blue exceeds threshold value, it judges that the power supply voltage is less than the arbitrary value, and returns to CPU operation mode from SNOOZE mode. If val_adcr_ir and val_adcr_blue are less than the threshold values, the supply voltages are judged to be greater than or equal to the arbitrary values, and the mode shifts to STOP mode.

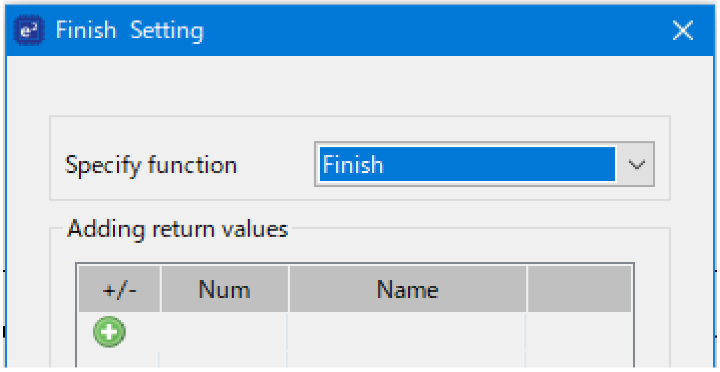
Figure 6-13 Compare Setting



6.2.14 Finish

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

Figure 6-14 Finish Setting



6.2.15 Variable Setting

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

Table 6-3 Variables used in SMS

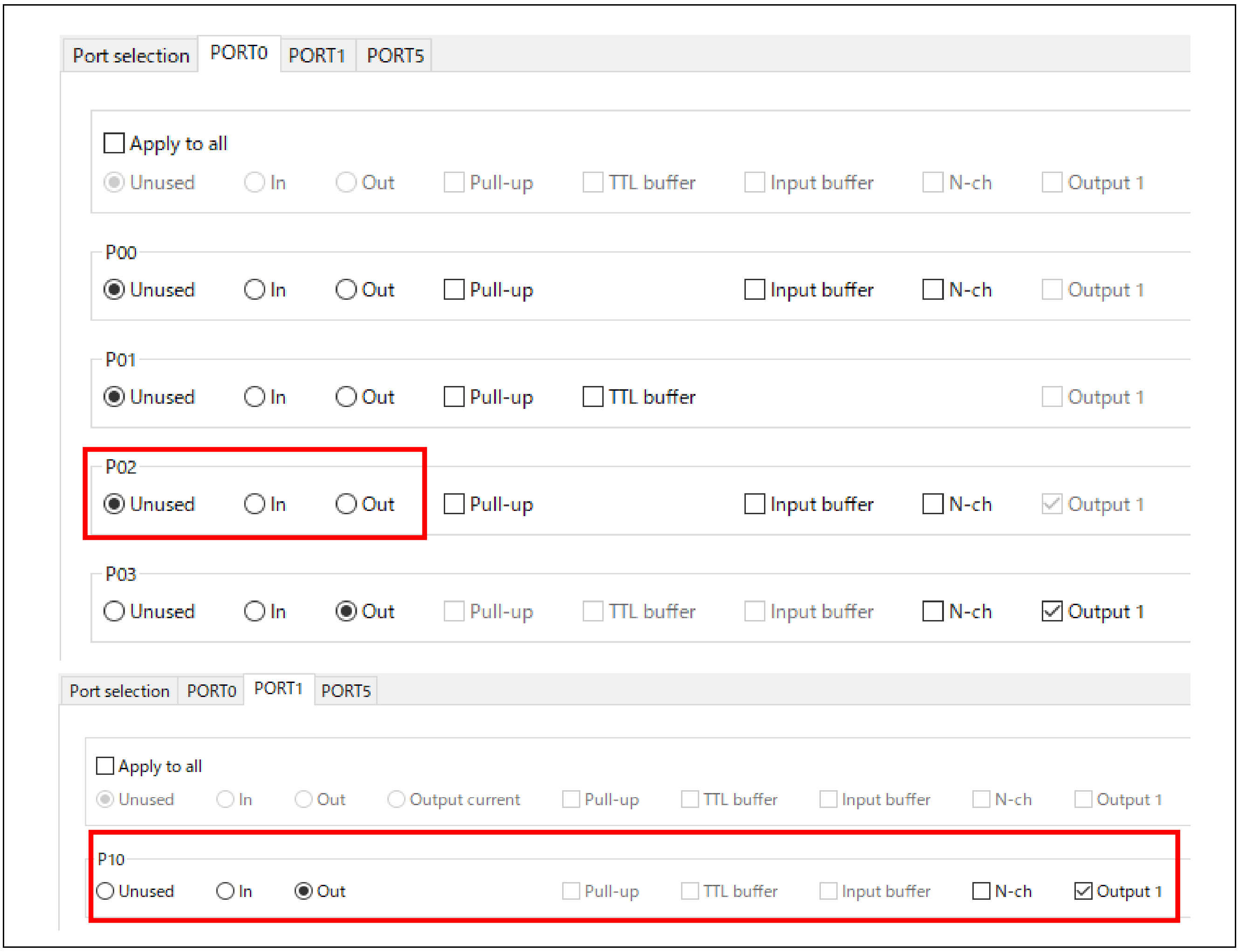
Data name	Initialization mode	Initial value	Description
val_adcr_ir	No initialization	-	Stores the first A/D conversion result.
val_adcr_blue	No initialization	-	Stores the second A/D conversion result.
val_adcr_th_ir	Pass argument via SMS start function	-	Stores the value of the threshold for infrared LED. The value of THESHOLD_IR is set as an argument in the R_Config_SMS_Start function.
val_adcr_th_blue	Pass argument via SMS start function	-	Stores the value of the threshold for blue LED. The value of THESHOLD_BLUE is set as an argument in the R_Config_SMS_Start function.

6.3 Example of changing the output pins with this sample code

The following is an example of changing the output pin P0_2 to P1_0.

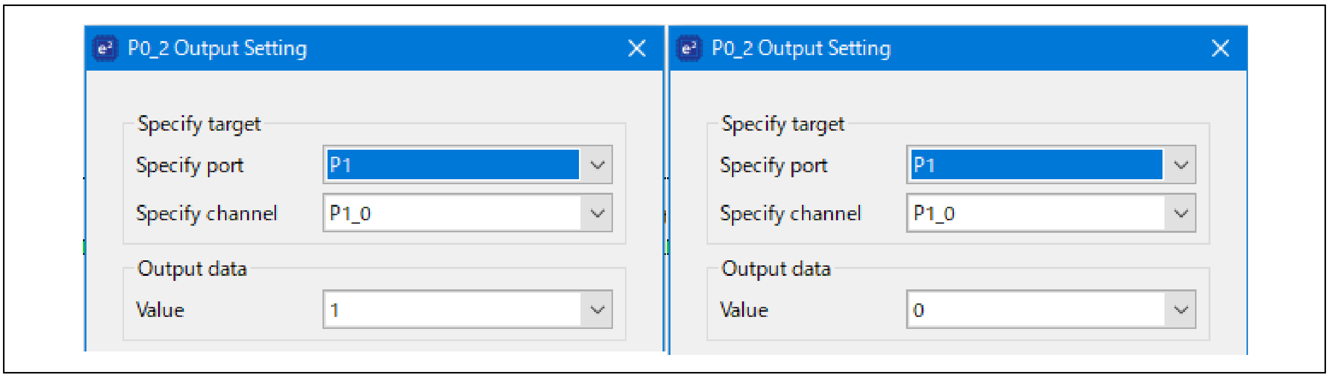
(1) Change the settings of P02 and P10 in Config_PORT as shown in Figure 6-16.

Figure 6-15 Config_PORT Setting



(2) In the Config_SMS flow, change "P0_2 Output" to as shown in Figure 6-17

Figure 6-16 P0_2 Setting



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_adcr_th_ir, uint16_t val_adcr_th_blue)
{
    /* Set the sms data from arguments */
    SMSG3 = val_adcr_th_ir;
    SMSG4 = val_adcr_th_blue;
    /* Initialize SMS data */
    SMSG5 = 65509U;
    /* Disable related interrupts */
    ITLMK = 1U;
    ADMK = 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: e² 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.30.21	-	First edition
1.10	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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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
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