RL78/G23

SMS HS300x Humidity sensor control by I2C communication

Introduction

This application note describes an example of controlling a humidity sensor (HS300x) with RL78/G23 to measure indoor air quality. It uses the SNOOZE mode sequencer (SMS), data transfer controller (DTC) and serial interface IICA (IICA) to control the HS300x with the I^{2}C communication protocol during SNOOZE mode.

I^{2}C communication via SMS allows communication with lower power consumption than when processed by the CPU.

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

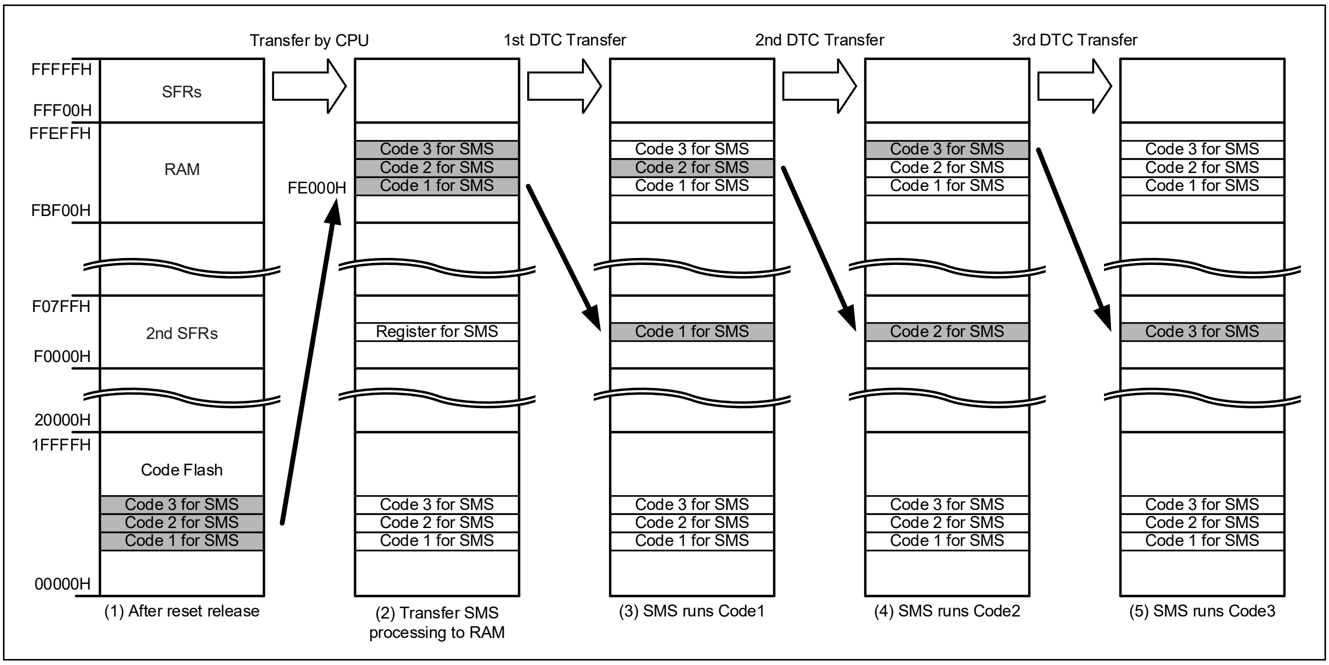
1. Specifications

The SMS sequentially executes up to 32 processes set in the sequencer instruction register SMSI0 to SMSI31 in advance. However, the processing according to the general I^{2}C communication standard is 32 steps or more. Therefore, this application note shows how to perform I^{2}C communication by dividing the processes to be executed in the SMS into three and sequentially updating the SMSI register during the SMS operation. The DTC is used to update the SMSI register.

Figure 1-1 shows the memory map. SMSI0 to SMSI31 are assigned to the extended special function register (2nd SFR) area.

The process to be used by the SMS is stored in RAM in advance ((1), (2) in Figure 1-1). The interval for I^{2}C communication is set using the interval timer (TML32), and SMS is started by a TML32 interrupt (INTITL). After the SMS is started, the DMATRG instruction starts the DTC and transfers the data from RAM to the registers of the SMS. The SMS executes the transferred processes sequentially and performs I^{2}C communication ((3) - (5) in Figure 1-1).

Figure 1-1 Memory map



The humidity sensor (HS300x) used in this application note can determine the humidity from the received data (Humidity[13:0]) using the following equation.

$$\text{Humidity}[\%\text{RH}] = \left(\frac{\text{Humidity}[13:0]}{2^{14}-1}\right) * 100$$

The sample code compares the value of Humidity[13:8] of the received data with the threshold value. The threshold value in the sample code is set to 20H, which corresponds to 50% humidity.

For details on HS300x, refer to the HS300x manual.

Figure 1-2 shows an example of the system configuration, and Figure 1-3 shows the flowchart of the entire system.

Figure 1-2 System Configuration

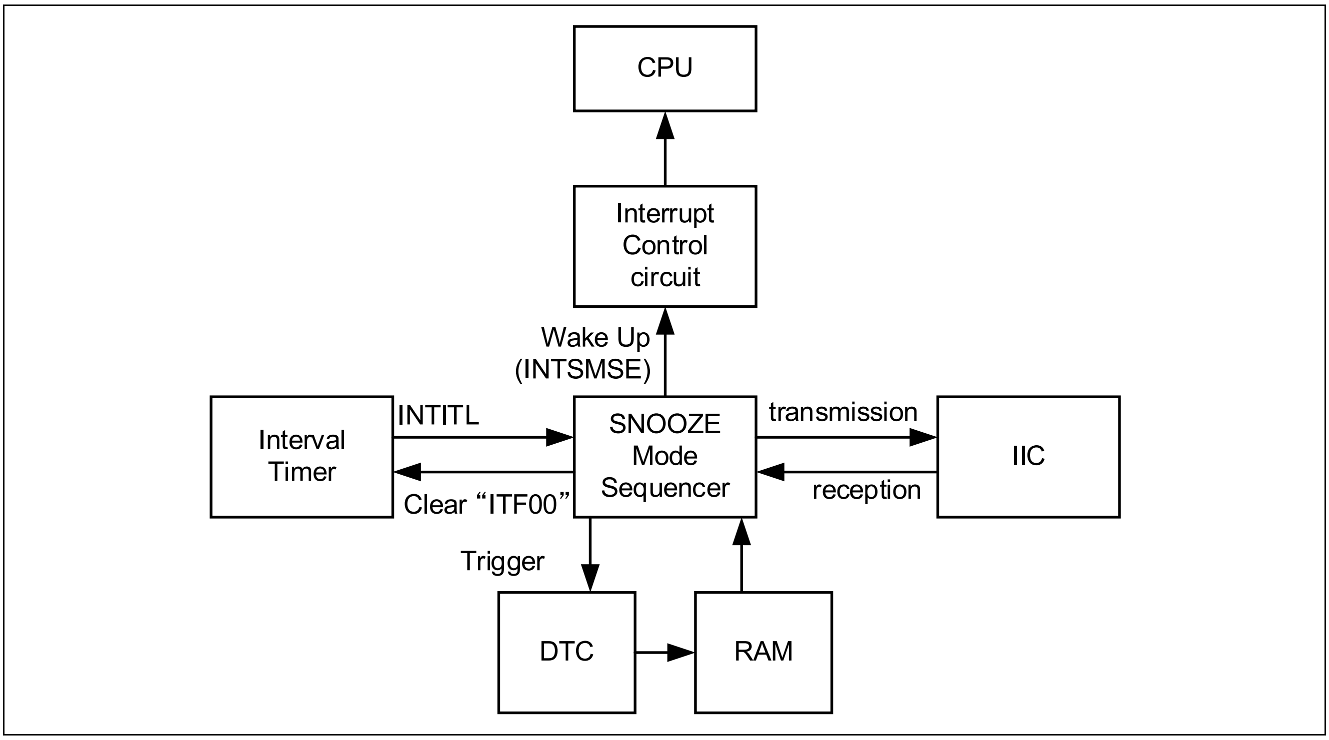
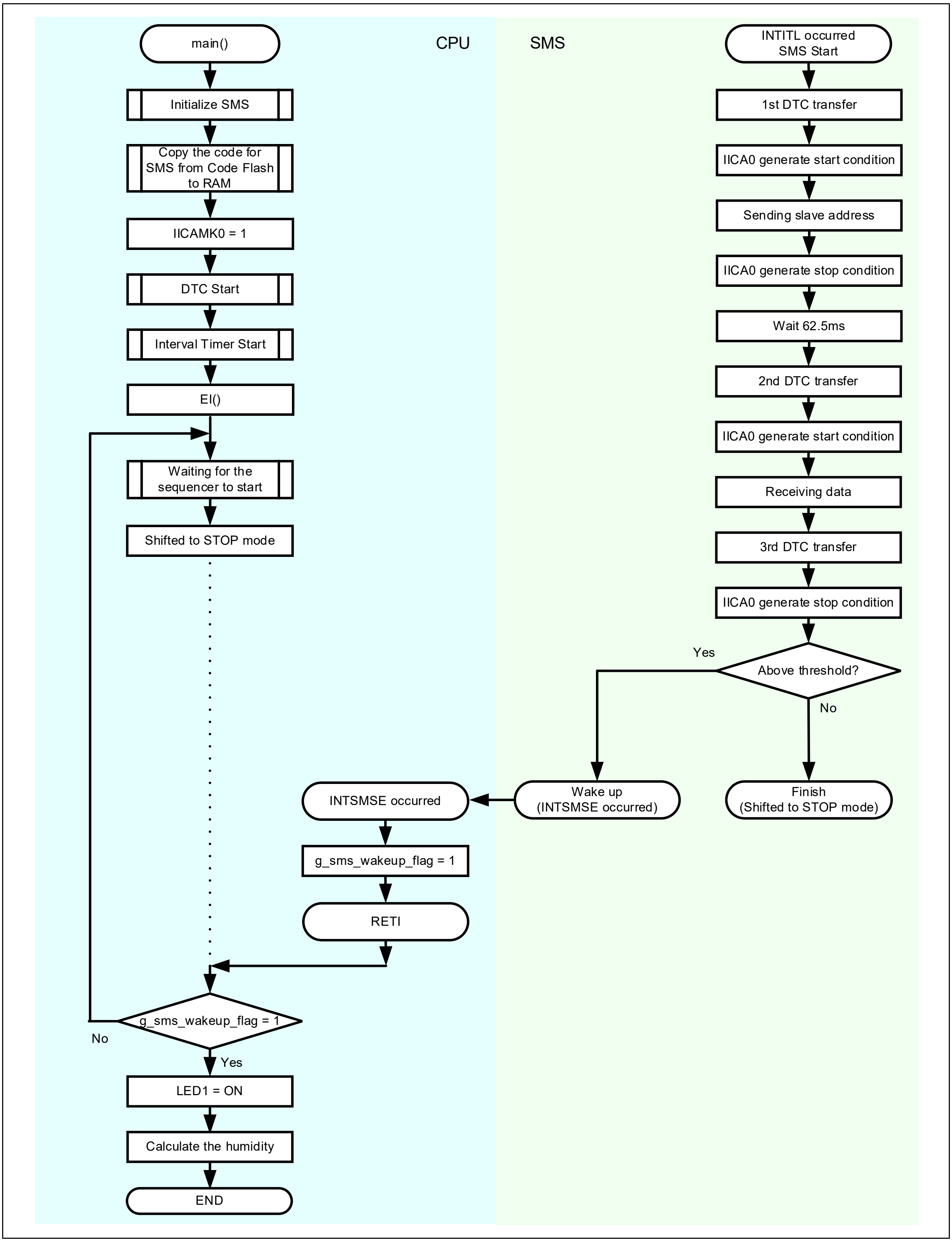


Figure 1-3 Entire Flowchart



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.1.90V (1.84V-1.95V) Falling edge TYP.1.86V (1.80V-1.91V)
Integrated development environment (CS+)	CS+ for CC V 8.07.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.11 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio 2022-01 (22.1.0) 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.1.2.0
Board support package (r_bsp)	V.1.13
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.

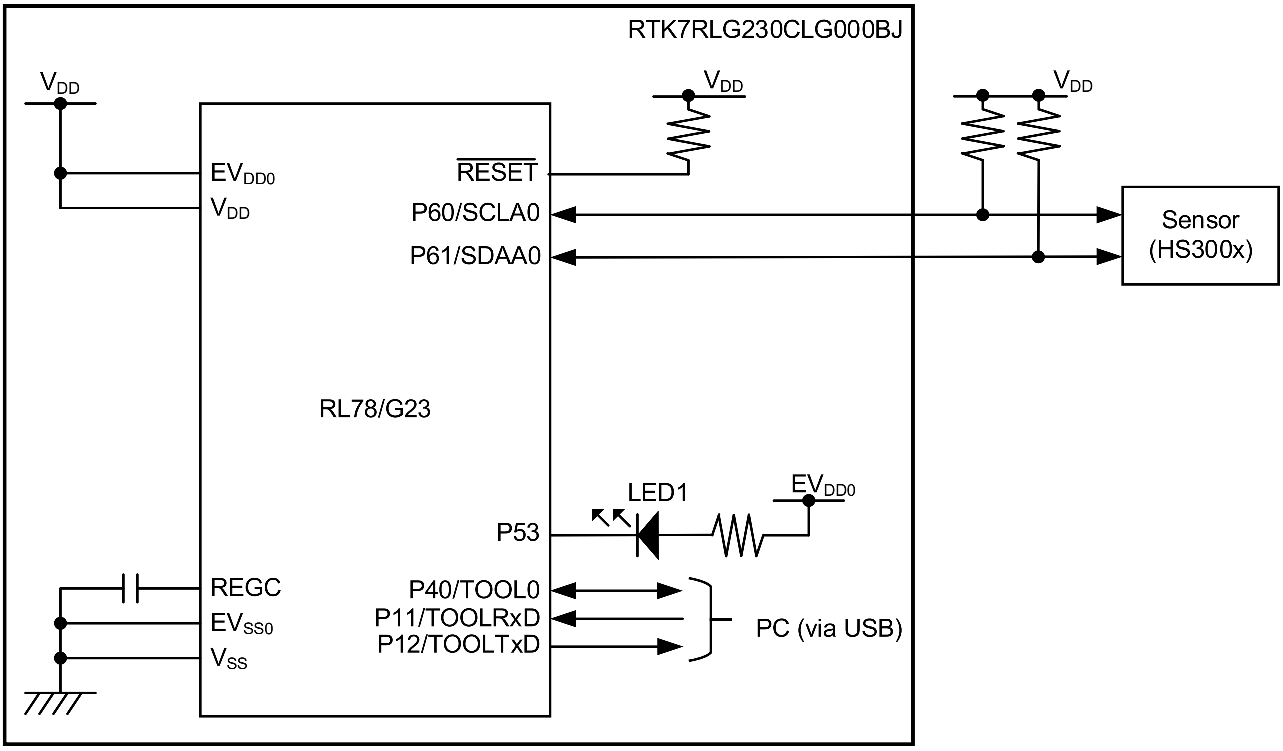
Please refer to them as well.

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



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.

This application note uses a humidity sensor (HS300x). For details on HS300x, refer to the HS300x manual.

4.2 Used Pins

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

Table 4-1 List of Pins and Functions

Pin Name	Input/Output	Function
P53	Output	LED1 lights (Low Active)
P60	Input/Output	Clock I/O pin of serial interfaces IICA0
P61	Input/Output	Serial data I/O pin of serial interfaces IICA0

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, an interrupt request (INTITL) from the 32-bit interval timer (TML32) causes the device to shift from STOP mode to SNOOZE mode, and starts the DTC from the SNOOZE mode sequencer (SMS). The DTC transfers the code stored in RAM in advance to the sequencer instruction register p (SMSIp (p = 3-31)). The SMS executes the transferred code and performs I^2C communication to acquire data from the sensor and compare it with the threshold value. If the threshold value is exceeded, the SMS outputs an interrupt request signal (INTSMSE) to activate the CPU.

Table 5-1 shows an overview of the operation of this sample code.

Table 5-1 Operation Overview

No.	Operation of each function		
	CPU	**SMS**	**DTC**
(1)	Stores code for SMS from Code Flash to RAM	-	-
(2)	Starts counting TML32	Waits for startup trigger	Waits for startup trigger
(3)	Shifts to STOP mode	↑	↑
(4)	During STOP	Starts SMS with TML32 compare match	↑
(5)	↑	Runs the DTC startup process	↑
(6)	↑	Waits for completion of DTC transfer	Transfers data from RAM to SMSIp register
(7)	↑	Sends MR command to the sensor and wait 62.5ms	Waits for startup trigger
(8)	↑	Runs the DTC startup process	↑
(9)	↑	Waits for completion of DTC transfer	Transfers data from RAM to SMSIp register
(10)	↑	Receives data from sensor and store in RAM	Waits for startup trigger
(11)	↑	Runs the DTC startup process	↑
(12)	↑	Waits for completion of DTC transfer	Transfers data from RAM to SMSIp register
(13)	↑	Branches to (14) if the received result does not exceed the threshold, else branches (15)	Waits for startup trigger
(14)	↑	SMS shifts to standby state and shifts to (5)	↑
(15)	↑	Starts the CPU	↑
(16)	Turns on LED1	-	-
(17)	Calculates humidity from data stored in RAM	-	-

5.2 Folder Configuration

Table 5-2 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 5-2 Folder configuration

Folder/File configuration	Outline	Created by Smart configurator
\ r01an6065jj0110_sms_humidity_sensor<DIR>	Root folder of this sample code	
\src<DIR>	Folder for program source	
main.c	Sample code source file	
sms_p.c	Code storage file for SMS	
\SMS<DIR>	Folder for SMS program	
r_sms.c	Source file for SMS	
r_sms.h	Header file for SMS	
r_sms_ASM.smsasm	ASM source file for SMS	
\smc_gen<DIR>Note 2	Folder created by Smart Configurator	√
\Config_DTC <DIR>	Folder for DTC program	√
Config_DTC.c	Source file for DTC	√
Config_DTC.h	Header file for DTC	√
Config_DTC_user.c	Interrupt source file for DTC	√Note 1
\Config_IICA0<DIR>	Folder for IICA0 program	√
Config_IICA0.c	Source file for IICA0	√
Config_IICA0.h	Header file for IICA0	√
Config_IICA0_user.c	Interrupt source file for IICA0	√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
\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 r01an6065jj0110_sms_humidity_sensor.ipcf. For details, refer to "RL78 Smart Configurator User's Guide: IAREW (R20AN0581)".

5.3 Option Byte Settings

Table 5-3 shows the option byte settings.

Table 5-3 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 5-4 shows the constants that are used in this sample code.

Table 5-4 Constants used in the sample code

Constant Name	Setting Value	Contents	File
LED1	P5_bit.no3	P53	main.c
LED_ON	0	Setting value for turning on the LED	main.c
THRESHOLD	20H	Humidity threshold (Upper 2 bytes)	main.c
DATA_BYTE	27*2*3	Number of bytes of code to be transferred to SMS (27*2byte)*3times = 162	main.c
NUMBER_OF_DATA	4	Sensor data (bytes)	main.c
ERROR	FFFFH	Value at communication error	main.c
NO_DATA	-1	Value at communication error	main.c
sensor_add[]	88H	Address of the sensor (for sending)	main.c
	89H	Address of the sensor (for receiving)	
g_dtc_data[]	Note	Code to transfer to the SMS	sms_p.c

Note. For details, refer to Table 5-7 - Table 5-10.

5.5 Variables

Table 5-5 shows the global variables used in this sample code.

Table 5-5 Global variables used in the sample code

Type	Variable name	contents	Functions used in
float	g_result	Humidity calculation results	main.c
uint8_t	g_sms_wakeup_flag	SMS wakeup flag	r_sms_getstatus r_sms_start r_sms_interrupt
uint16_t	g_communication_status	IICA0 status flag	r_iica0_getstatus

5.6 Functions

Table 5-6 shows the functions used in the sample code. However, the unchanged functions generated by the Smart Configurator are excluded.

Table 5-6 Functions

Function name	Outline	Source file
main	Main process	main.c
r_sms_create	SMS initialization process	r_SMS.c
r_sms_start	SMS operation start processing	r_SMS.c
r_sms_getstatus	SMS status confirmation process	r_SMS.c
r_sms_interrupt	SMS interrupt process	r_SMS.c
r_iica0_getstatus	IICA0 status confirmation process	Config_IICA0_user.c
memcpy_ff [Note]	Data copy process	main.c

Note. IAR version only. CC-RL version uses the standard function "_COM_memcpy_ff".

5.7 Function Specifications

This part describes function specifications of the sample code.

[Function name] main

Outline	Main process
Header	r_smc_entry.h, string.h, r_sms.h
Declaration	void main (void);
Description	Initializes the SMS and transfers the code (g_dtc_data[]) to be transferred by the DTC at SMS startup from the code flash area to RAM. Starts the operation of the TML32, puts the DTC in the trigger waiting state, and shifts to the STOP mode. When returning from standby mode, the process shifts to checking the CPU boot request flag. If the CPU boot request flag (g_sms_wakeup_flag) is not set, the mode shifts to STOP mode again, else if the CPU boot request flag is set, LED1 lights up.
Arguments	None
Return value	None
Remarks	None

[Function name] r_sms_create

Outline	Initialization process for SMS
Header	r_SMS.h, r_cg_macrodriver.h, r_cg_userdefine.h, r_SMS_ASM.h
Declaration	void r_sms_create (void)
Description	Initializes the SMS module before controlling it, including SMS configuration, copying SMS instructions, and copying SMS data.
Arguments	None
Return value	None
Remarks	None

[Function name] r_sms_start

Outline	Start SMS operation
Header	r_SMS.h, r_cg_macrodriver.h, r_cg_userdefine.h, r_SMS_ASM.h
Declaration	void r_sms_start (uint16_t addr_iic_sl, uint16_t addr_iic_rx_s, uint16_t addr_iic_rx_e, uint16_t val_threshold)
Description	Sets the SMS data from the argument and starts the SMS module operation.
Arguments	addr_iic_sl, addr_iic_rx_s, addr_iic_rx_e, val_threshold
Return value	None
Remarks	None

[Function name] r_sms_getstatus

Outline	Check the status of SMS wakeup
Header	r_SMS.h, r_cg_macrodriver.h, r_cg_userdefine.h, r_SMS_ASM.h
Declaration	uint8_t r_sms_getstatus (void)
Description	Checks the status of SMS wakeup.
Arguments	None
Return value	None
Remarks	None

[Function name] r_sms_interrupt

Outline	INTSMSE Interrupt process
Header	r_SMS.h, r_cg_macrodriver.h, r_cg_userdefine.h, r_SMS_ASM.h
Declaration	#pragma interrupt r_sms_interrupt(vect=INTSMSE)
Description	Sets g_sms_wakeup_flag = 1.
Arguments	None
Return value	None
Remarks	None

[Function name] r_iica0_getstatus

Outline	IICA0 status confirmation process
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_IICA0.h
Declaration	uint16_t r_iica0_getstatus (void) (void)
Description	Checks the status of IICA0.
Arguments	None
Return value	None
Remarks	None

[Function name] memcpy_ff

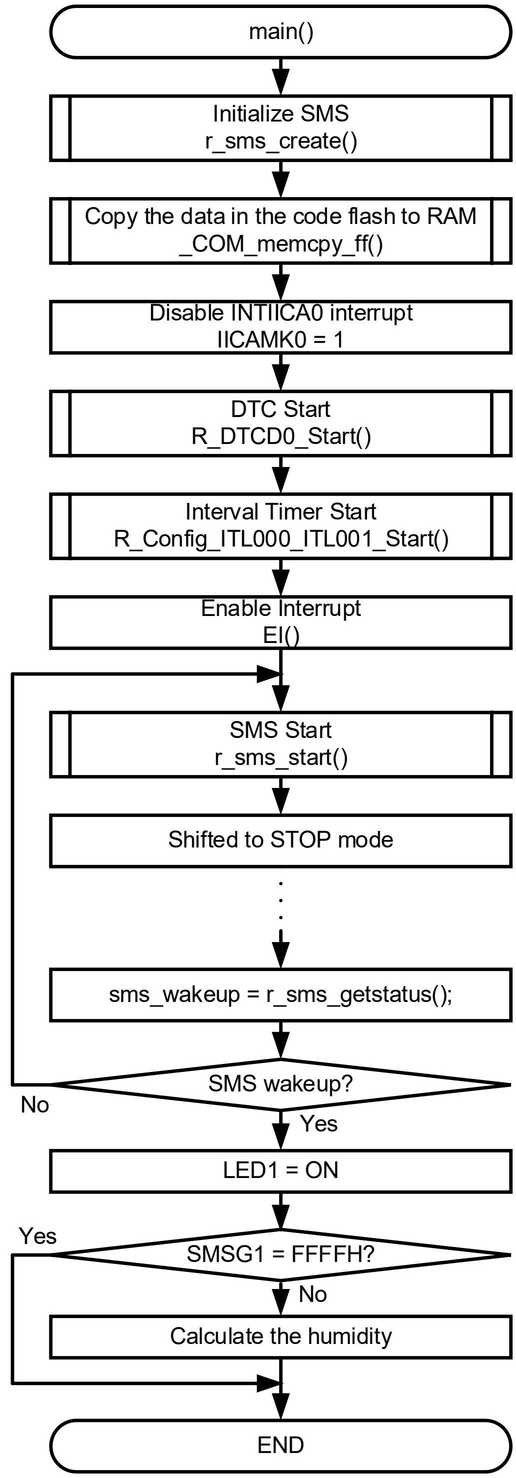
Outline	Copy Data
Header	r_smc_entry.h, r_SMS.h
Declaration	__far_func void __far * memcpy_ff(void __near *_Restrict s1, const void __far *_Restrict s2, uint32_t n)
Description	Copies the data in s2 to s1 for n bytes.
Arguments	s1, s2, n
Return value	None
Remarks	None

5.8 Flow Charts

Main Process

Figure 5-1 shows flowchart of main process.

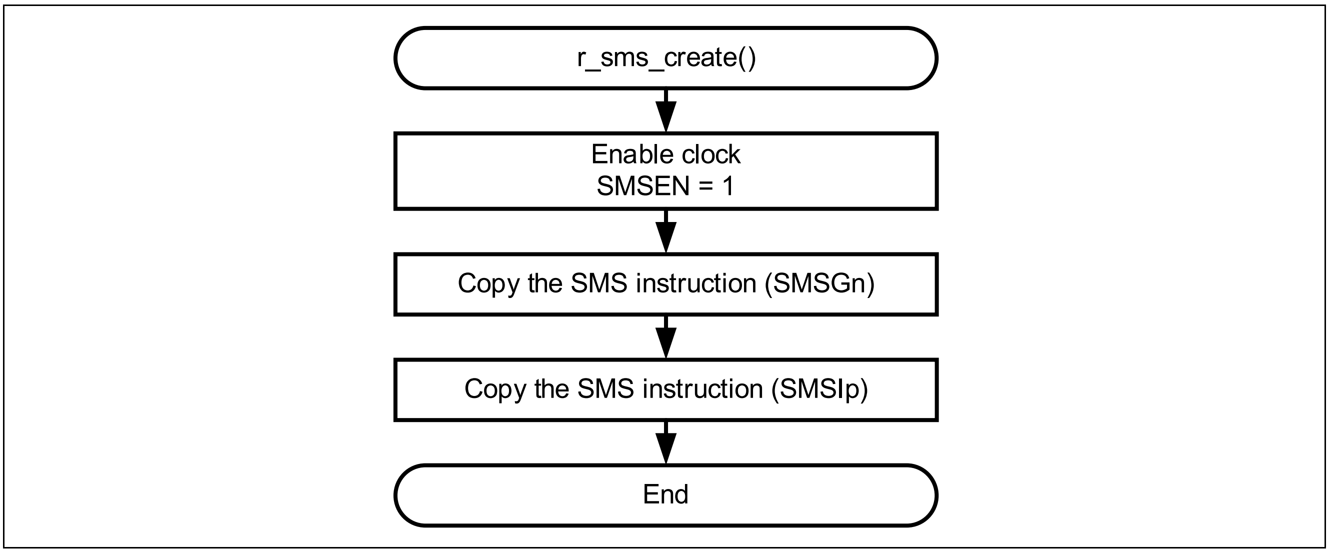
Figure 5-1 Main process



SMS initialization process

Figure 5-2 shows flowchart of SMS initialization process.

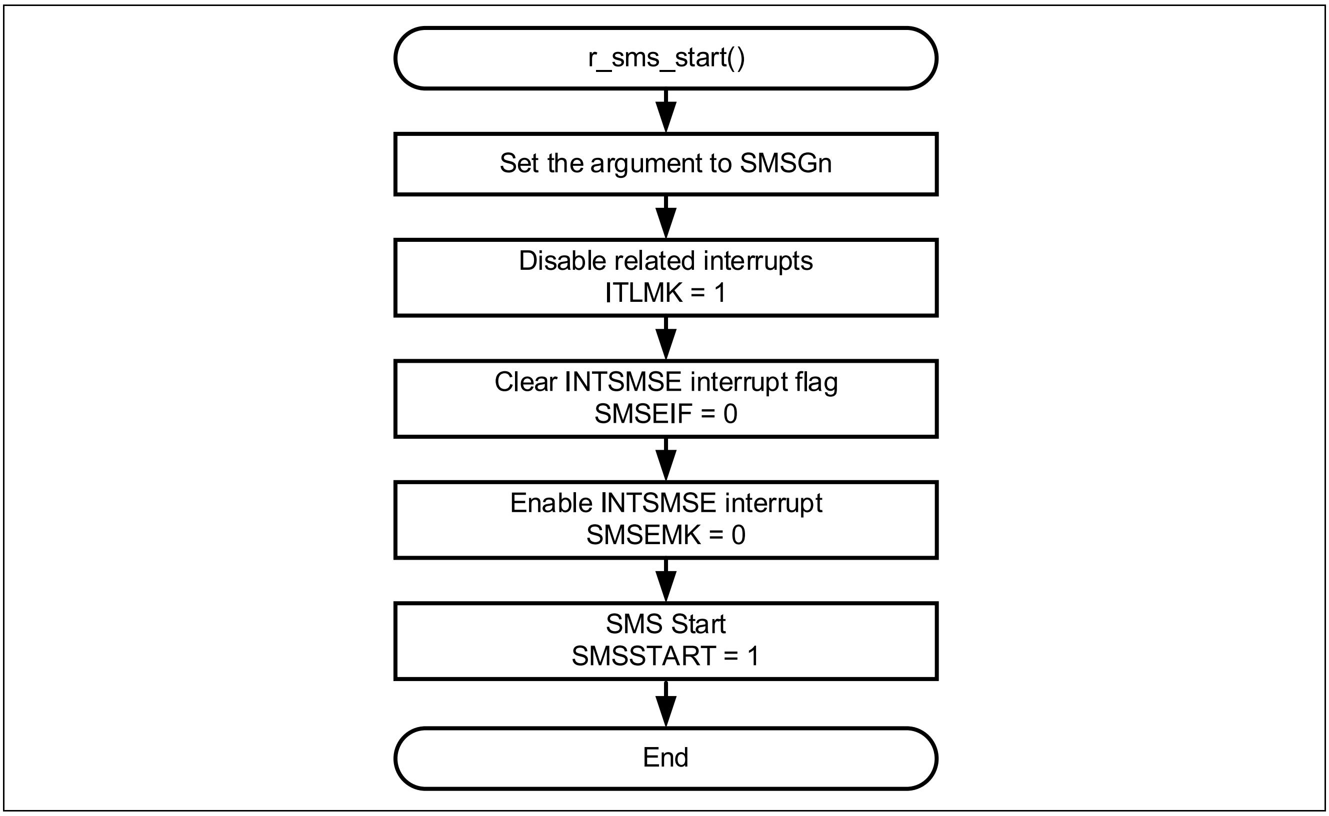
Figure 5-2 SMS initialization process



5.8.1 SMS operation start processing

Figure 5-3 shows flowchart of SMS operation start processing.

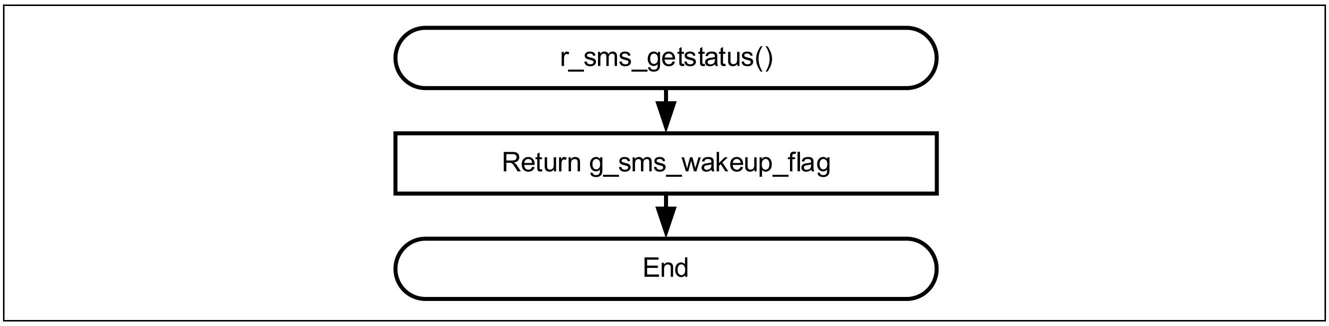
Figure 5-3 SMS operation start processing



5.8.2 SMS status confirmation process

Figure 5-4 shows flowchart of SMS status confirmation process.

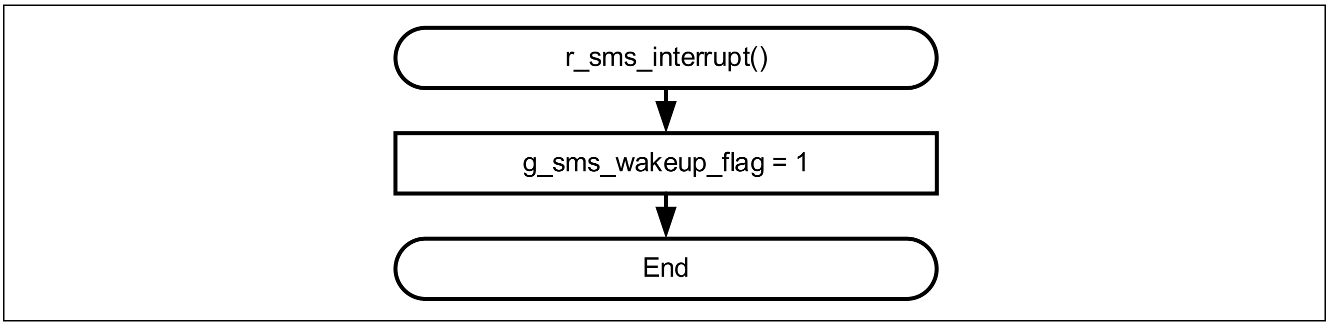
Figure 5-4 SMS status confirmation process



5.8.3 SMS interrupt process

Figure 5-5 shows flowchart of SMS interrupt process.

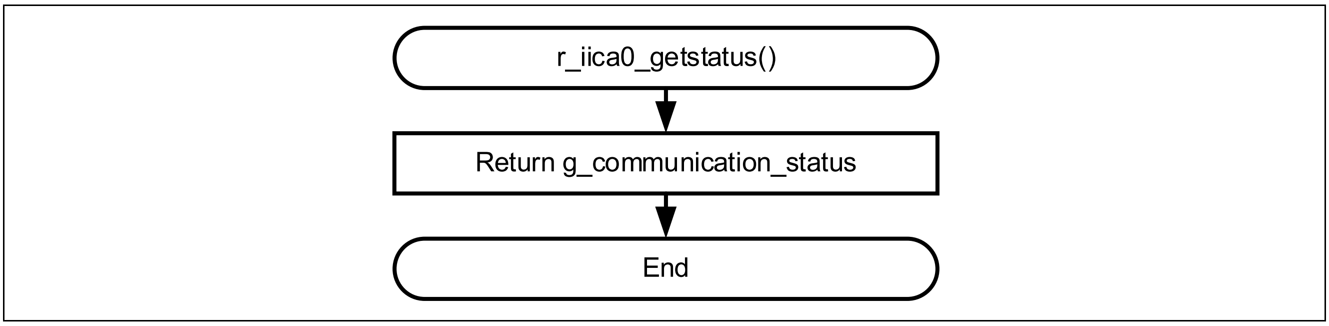
Figure 5-5 SMS interrupt process



5.8.4 IICA0 status confirmation process

Figure 5-6 shows flowchart of IICA0 status confirmation process.

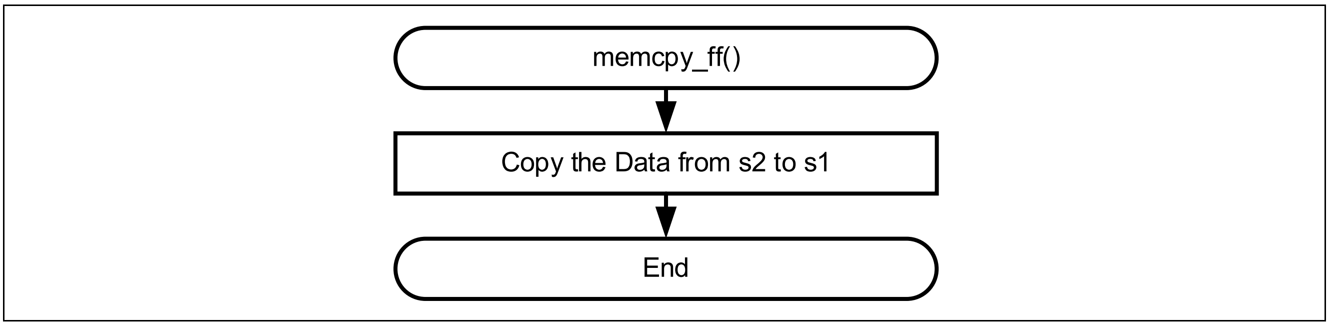
Figure 5-6 IICA0 status confirmation process



5.8.5 Data copy process

Figure 5-7 shows flowchart of Data copy process.

Figure 5-7 Data copy 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 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	The SMS is activated by the TML32 interrupt, sends MR commands to the sensor, and waits for 62.5ms for the sensor to stabilize its operation. After waiting for 4 seconds, it obtains the measurement results from the sensor and stores them in RAM. If the humidity data stored in RAM is greater than the threshold value, the CPU is activated. If it is less than the threshold value, the SMS process is terminated and the device shifts to STOP mode again. The instructions to process I^2C communication are stored in RAM in advance, and then transferred and executed in three separate times by DTC.
Arguments Note1	addr_iic_sl: The start address of the buffer that stores the slave address of the sensor addr_iic_rx_s: Start address of data storage area addr_iic_rx_e: End address of data storage area val_threshold: Threshold value of humidity data
Return value	None
Remarks	None

Note1. Argument to be specified in the r_sms_start function setting.

Figure 5-8 shows the flow chart of SMS process.

Table 5-7 to Table 5-10 show the register settings that control the SNOOZE mode sequencer.

The SMS is controlled according to the HS300x protocol using I^2C communication. For details on the HS300x protocol, refer to the HS300x manual.

Figure 5-8 SMS process

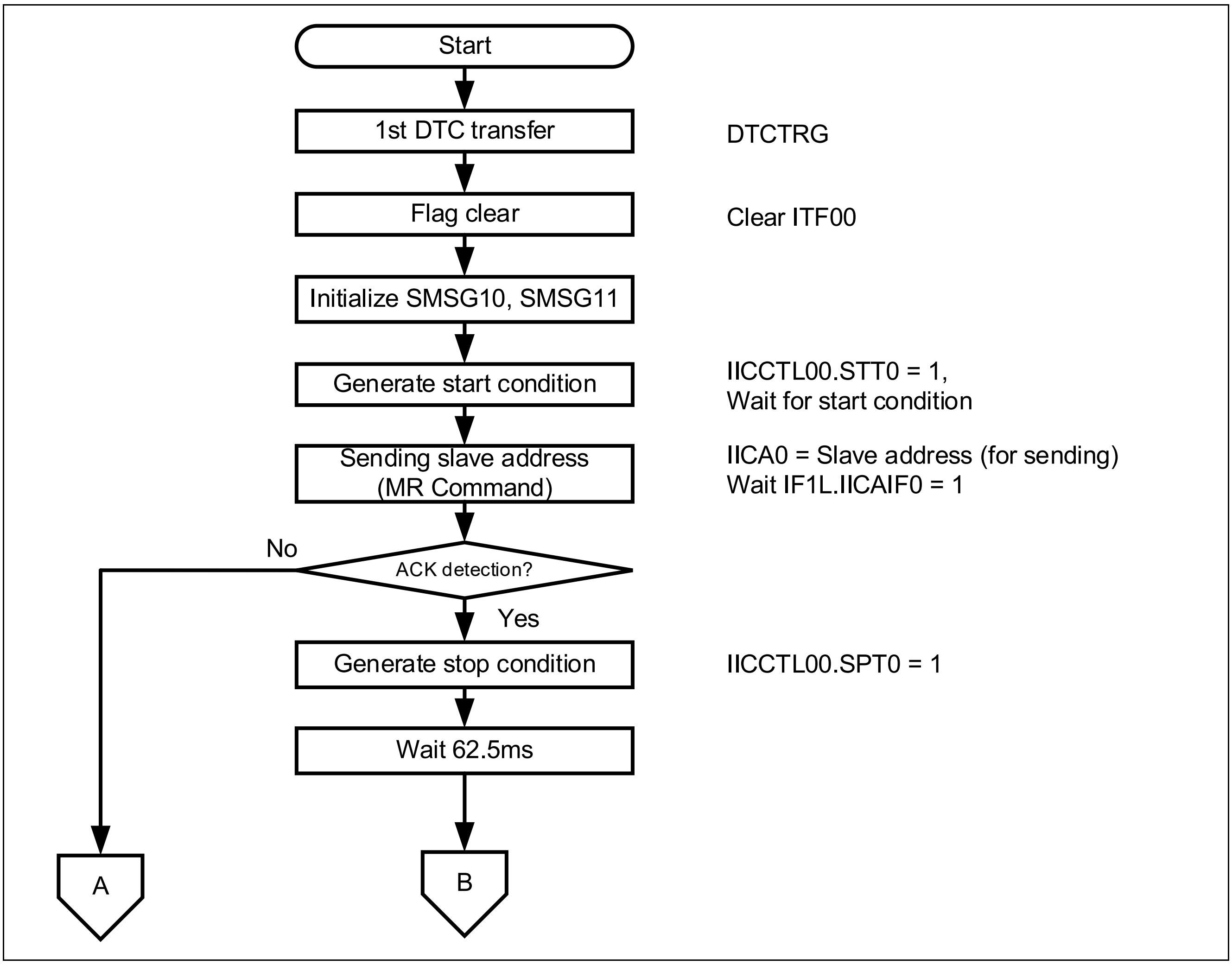


Figure 5-9 SMS process

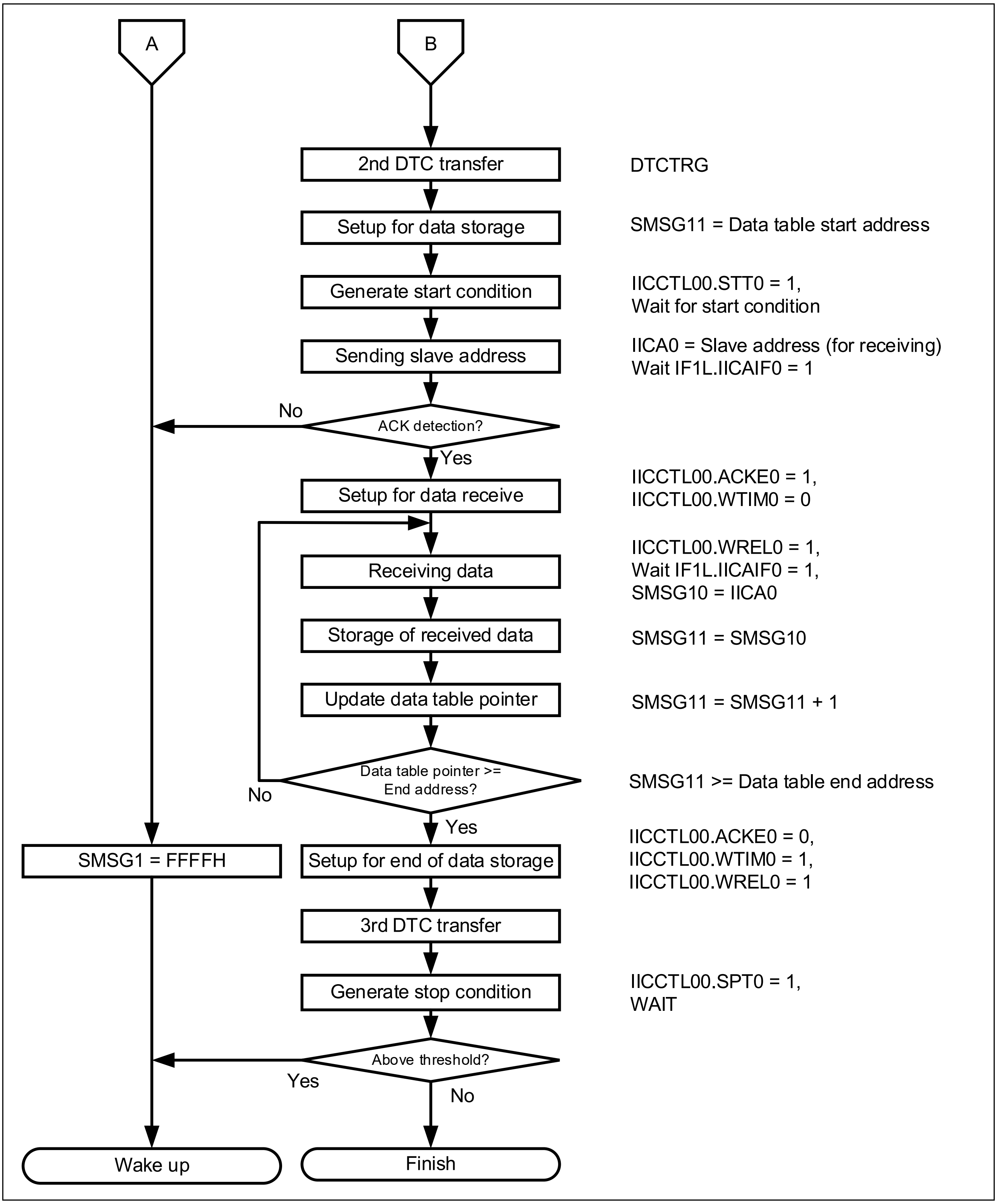


Table 5-7 Sequencer general-purpose registers 0-15

Register Symbol	Setting	Remark
SMSG0	0000H	fixed value: 0000H
SMSG1	&ITLS0	ITLS0 address
SMSG2	&IICCTL00	IICCTL00 address
SMSG3	&IF1L	IF1L address
SMSG4	&IICA0	IICA0 address
SMSG5	0000H	Slave address of sensor
SMSG6	0000H	Data table start address
SMSG7	0000H	Data table end address
SMSG8	1	fixed value: 1
SMSG9	0000H	Humidity threshold
SMSG10	0000H	for calculation
SMSG11	0000H	for calculation
SMSG12	&SMSG1	SMSG1 address
SMSG13	&SMSI28	SMSI28 address
SMSG14	&SMSG11	SMSG11 address
SMSG15	FFFFH	fixed value: FFFFH

Table 5-8 Sequencer instruction registers 0-31 (After the first DTC transfer)

Register Symbol	Setting	Contents	Remark
SMSI0	2DF2H	MOVW [SMSG13+2], SMSG15	SMSI29 <- FFFFH
SMSI1	F002H	DTCTRG	DTC startup
SMSI2	AD02H	WHILE1 [SMSG13+2].0	Waiting for DTC transfer completion
SMSI3	0100H	MOV [SMSG1+0], SMSG0	ITLS0 <- 00H
SMSI4	30A0H	MOVW SMSG10, [SMSG0+0]	Initialization of SMSG10
SMSI5	30B0H	MOVW SMSG11, [SMSG0+0]	Initialization of SMSG11
SMSI6	4210H	SET1 [SMSG2+0].1	IICCTL00.STT0 <- 1
SMSI7	9640H	WAIT 100, 0	Waiting for start condition
SMSI8	15A0H	MOV SMSG10, [SMSG5+0]	SMSG10 <- For sending slave address
SMSI9	04A0H	MOV [SMSG4+0], SMSG10	IICAn <- SMSG10
SMSI10	B330H	WHILE0 [SMSG3+0].3	Wait until IFxx.IICAIFn = 1
SMSI11	5330H	CLR1 [SMSG3+0].3	IF1L.IICAIF0 <- 0
SMSI12	6421H	MOV1 SCY, [SMSG4+1].2	SCY <- IICS0.ACKD0
SMSI13	8051H	BNC 5	If ACK=0, branch to SMSI25
SMSI14	4200H	SET1 [SMSG2+0].0	IICCTLn0.SPT0 <- 1
SMSI15	9804H	WAIT 128, 4	Wait 62.5ms
SMSI16	7FF2H	CMPW SMSG15, SMSG15	Comparison for branching to SMSI0
SMSI17	8EF2H	BZ -17	Branch to SMSI0
SMSI18	2CF0H	MOVW [SMSG12+0], SMSG15	SMSG1 <- FFFFH
SMSI19	F001H	WAKEUP	WAKEUP
SMSI20	0000H	Unused	-
SMSI21	0000H	Unused	-
SMSI22	0000H	Unused	-
SMSI23	0000H	Unused	-
SMSI24	0000H	Unused	-
SMSI25	0000H	Unused	-
SMSI26	0000H	Unused	-
SMSI27	0000H	Unused	-
SMSI28	0000H	Unused	-
SMSI29	0000H	Unused	-
SMSI30	0000H	Unused	-
SMSI31	0000H	Unused	-

Note. The setting values for SMSI0 to SMSI2 are set in r_SMS_ASM.smsasm.
The data of SMSI3 to SMSI29 transferred by DTC is stored in g_dtc_data.

Table 5-9 Sequencer instruction registers 0-31 (After the second DTC transfer)

Register Symbol	Setting	Contents	Remark
SMSI0	2DF2H	MOVW [SMSG13+2], SMSG15	SMSI29 <- FFFFH
SMSI1	F002H	DTCTRG	DTC startup
SMSI2	AD02H	WHILE1 [SMSG13+2].0	Waiting for DTC transfer completion
SMSI3	2E60H	MOVW [SMSG14+0]. SMSG6	SMSG11 <- Value of SMSG6
SMSI4	4210H	SET1 [SMSG2+0]. 1	IICCTL00.STT0 <- 1
SMSI5	9640H	WAIT 100, 0	Waiting for start condition
SMSI6	15A1H	MOV SMSG10, [SMSG5+1]	SMSG10 <- For sending slave address
SMSI7	04A0H	MOV [SMSG4+0], SMSG10	IICAn <- SMSG10
SMSI8	B330H	WHILE0 [SMSG3+0]. 3	Wait until IFxx.IICAIFn = 1
SMSI9	5330H	CLR1 [SMSG3+0].3	IF1L.IICAIF0 <- 0
SMSI10	6421H	MOV1 SCY, [SMSG4+1].2	SCY <- IICS0.ACKD0
SMSI11	8101H	BNC 16	If ACK=0, branch to SMSI27
SMSI12	4220H	SET1 [SMSG2+0].2	IICCTL00.ACKE0 <- 1
SMSI13	5230H	CLR1 [SMSG2+0].3	IICCTL00.WTIM0 <- 0
SMSI14	4250H	SET1 [SMSG2+0].5	IICCTL00.WREL0 <- 1
SMSI15	B330H	WHILE0 [SMSG3+0].3	Wait until IFxx.IICAIFn = 1
SMSI16	5330H	CLR1 [SMSG3+0].3	IF1L.IICAIF0 <- 0
SMSI17	14A0H	MOV SMSG10, [SMSG4+0]	SMSG10 <- IICAn
SMSI18	0BA0H	MOV [SMSG11+0], SMSG10	Stored Address <- SMSG10
SMSI19	7B80H	ADDW SMSG11, SMSG8	SMSG11 <- SMSG11 + 1
SMSI20	7B72H	CMPW SMSG11, SMSG7	When SMSG11＜SMSG7
SMSI21	8F90H	BC -7	Branch to SMSI14
SMSI22	5220H	CLR1 [SMSG2+0].2	IICCTL00.ACKE0 <- 0
SMSI23	4230H	SET1 [SMSG2+0].3	IICCTL00.WTIM0 <- 1
SMSI24	4250H	SET1 [SMSG2+0].5	IICCTL00.WREL0 <- 1
SMSI25	7FF2H	CMPW SMSG15, SMSG15	Comparison for branching to SMSI0
SMSI26	8E62H	BZ -26	Branch to SMSI0
SMSI27	2CF0H	MOVW [SMSG12+0], SMSG15	SMSG1 <- FFFFH
SMSI28	F001H	WAKEUP	WAKEUP
SMSI29	0000H	Unused	-
SMSI30	0000H	Unused	-
SMSI31	0000H	Unused	-

Note. The setting values for SMSI0 to SMSI2 are set in r_SMS_ASM.smsasm.
The data of SMSI3 to SMSI29 transferred by DTC is stored in g_dtc_data.

Table 5-10 Sequencer instruction registers 0-31 (After the third DTC transfer)

Register Symbol	Setting	Contents	Remark
SMSI0	2DF2H	MOVW [SMSG13+2], SMSG15	SMSI29 <- FFFFH
SMSI1	F002H	DTCTRG	DTC startup
SMSI2	AD02H	WHILE1 [SMSG13+2].0	Waiting for DTC transfer completion
SMSI3	B330H	WHILE0 [SMSG3+0].3	Wait until IFxx.IICAIFn = 1
SMSI4	5330H	CLR1 [SMSG3+0].3	IF1L.IICAIF0 <- 0
SMSI5	4200H	SET1 [SMSG2+0].0	IICCTLn0.SPT0 <- 1
SMSI6	9A10H	WAIT 161, 0	Waiting for stop condition
SMSI7	16A0H	MOV SMSG10, [SMSG6+0]	SMSG10 <- humi_h
SMSI8	79A2H	CMPW SMSG9, SMSG10	When threshold < humi_h
SMSI9	8020H	BC 2	Branch to SMSI11
SMSI10	F000H	FINISH	FINISH
SMSI11	F001H	WAKEUP	WAKEUP
SMSI12	0000H	Unused	-
SMSI13	0000H	Unused	-
SMSI14	0000H	Unused	-
SMSI15	0000H	Unused	-
SMSI16	0000H	Unused	-
SMSI17	0000H	Unused	-
SMSI18	0000H	Unused	-
SMSI19	0000H	Unused	-
SMSI20	0000H	Unused	-
SMSI21	0000H	Unused	-
SMSI22	0000H	Unused	-
SMSI23	0000H	Unused	-
SMSI24	0000H	Unused	-
SMSI25	0000H	Unused	-
SMSI26	0000H	Unused	-
SMSI27	0000H	Unused	-
SMSI28	0000H	Unused	-
SMSI29	0000H	Unused	-
SMSI30	0000H	Unused	-
SMSI31	0000H	Unused	-

Note. The setting values for SMSI0 to SMSI2 are set in r_SMS_ASM.smsasm.
The data of SMSI3 to SMSI29 transferred by DTC is stored in g_dtc_data.

6. Application example

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

r01an6065jj0110_sms_humidity_sensor.scfg

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

6.1 r01an6065jj0110_sms_humidity_sensor.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}: 32MHz (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_DTC	DTC base address: 0xFFD00 Control data0 (DTCD0): Event output from the SNOOZE mode sequencer [DTCD0] Transfer mode setting: Repeat mode Transfer data size setting: 16 bits Repeat mode interrupt setting: Disable Repeat area setting: Transfer source Transfer source address: 0xE000 Transfer destination address: 0x0386 Address fixed Transfer count: 3 Transfer block size: 54
	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: 5000 ms Interrupt setting: unused
	Config_PORT	Components: Port Port selection: PORT5 P53: Out (Output 1)
	Config_IICA0	Clock mode setting: f_{CLK}/2 Address: 16 Operation mode setting: Standard Transfer clock (f_{SCL}): 100000 (bps) Communication end interrupt priority: Level 3 (low) Callback function setting: Master transmission end, Master reception end

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 5-3 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 5-3 Option Byte Settings". Note that changing the settings

6.1.5 Config_DTC

Set the DTC used in the sample code.

The sample code uses control data 0 to transfer the SMS process, which was stored in RAM in advance (Transfer source address: FE000H (set value: 0xE000)), to the SMS register (Transfer destination address: F0386H (set value: 0x0386)). main.c will store the data in RAM.

6.1.6 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.

6.1.7 Config_PORT

Set the port of the sample code.

In the sample code, P53 is used to control LED1 and P52 is used to control LED2.

6.1.8 Config_IICA0

Set IICA0 of the sample code.

7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

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)

HS300x Datasheet

(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	Feb.15.22	3	The threshold value in the sample code is set to 2CH, which corresponds to 70% humidity. -> The threshold value in the sample code is set to 20H, which corresponds to 50% humidity.
		5	Figure 1-3 Entire Flowchart Wait 4s -> Wait 62.5ms
		6	Updated tool version Table 2-1 Operation Confirmation Conditions Integrated development environment (CS+) : CS+ for CC V8.06.00 -> V8.07.00 C compiler (CS+) : CC-RL V1.10 -> V1.11 Integrated development environment (e2 studio) ： e^2 studio 2021-07 (21.7.0) -> 2022-01 (22.1.0) C compiler (e^2 studio) : CC-RL V1.10 -> V1.11 Smart Configurator : V.1.0.1 -> V.1.2.0 Board support package (r_bsp) : V.1.11 -> V.1.13
		10	Table 5-1 Operation Overview 4 seconds -> 62.5ms
		11	Update folder name
		12	Table 5-4 Constants used in the sample code THRESHOLD : 2CH -> 20H Removed dtc_init[]
		13	[Function name] main float.h -> r_sms.h
		14	[Function name] r_sms_start Removed addr_dtc_init
		20	waits for 4 seconds -> waits for 62.5ms
		21	Figure 5-8 SMS process Initialize SMSG11, SMSG12 -> Initialize SMSG10, SMSG11 Wait 4s -> 62.5ms
		22	Figure 5-9 SMS process SMSG12 -> SMSG11 SMSG11 -> SMSG10
		23	Table 5-7 Sequencer general-purpose registers 0-15 Update with sample program update
		24 - 26	Table 5-8 Sequencer instruction registers 0-31 Table 5-1 Sequencer instruction registers 0-31 Table 5-2 Sequencer instruction registers 0-31 Update with sample program update
		27	Update file name

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.

Corporate Headquarters

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

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/.