R8C/35C Group

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I^{2}C bus Single Master Control Program (Master Transmit/Receive)

I^{2}C Communication for Issuing Restart Condition

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1. Abstract

This document describes the I^{2}C bus single master control program (transmit/receive processes) that can issue the restart condition by using the R8C/35C Group I^{2}C bus Interface.

The sample code given here controls the digital color sensor (S11059-02 DT) supporting the I^{2}C bus Interface, for an example.

2. Introduction

The application example described in this document applies to the following microcomputer (MCU) and parameter:

• MCU	: R8C/35C Group
• High-Speed On-Chip Oscillator Clock	: 20MHz

This application note can be used with other R8C Family MCUs which have the same special function registers (SFRs) as the above group. Check the manual for any modifications to functions. Careful evaluation is recommended before using the program described in this application note.

3. Application Example

3.1 Program Outline

To conform to the communication format of the digital color sensor (S11059-02DT), a slave address and 8-byte data are sent in master transmission, and a slave address is sent and then 8-byte data is received in master reception. Master transmission and master reception are repeated alternately.

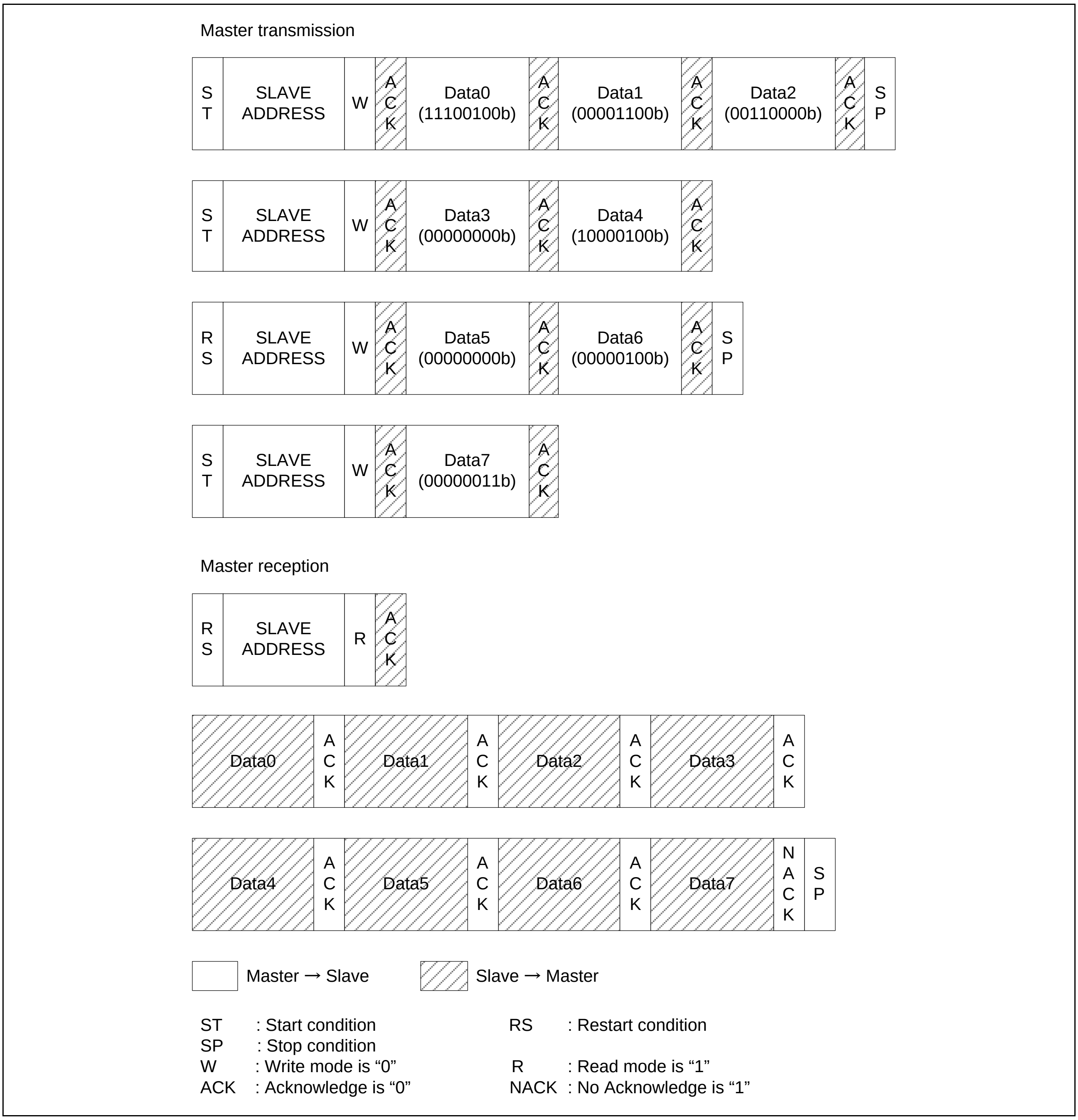
The sample code given here supports issuance of the restart condition. In master transmission, after fifth byte data is transmitted, the restart condition is issued without issuing the stop condition, and then the sixth byte is transmitted. After eighth byte data is transmitted, the restart condition is issued without issuing the stop condition to switch to the master reception mode.

Issuing the restart condition enables data transmission conforming to the communication format of the connection destination device, and also switching of data transmission direction to allow data reception from the connection destination device after the data transmission.

This transmission procedure conforms to the I^{2}C bus communication protocol when used under the following conditions:

- Slave address : 7 bits
- Transfer rate : Approximately 357 kHz (Standard-mode and Fast-mode supported)
- Transfer data length : 1 to 255 bytes (not including the slave address)
- Single master communication (multimaster is not supported)

Figure 3.1 shows the Communication Format, Figure 3.2 shows the Block Diagram, Figure 3.3 to Figure 3.4 show Outline Flowcharts, and Figure 3.5 to Figure 3.7 show Timing Diagrams.


Master transmission
ST | SLAVE ADDRESS | W | ACK | Data0 (11100100b) | ACK | Data1 (00001100b) | ACK | Data2 (00110000b) | ACK | SP
ST | SLAVE ADDRESS | W | ACK | Data3 (00000000b) | ACK | Data4 (10000100b) | ACK
RS | SLAVE ADDRESS | W | ACK | Data5 (00000000b) | ACK | Data6 (00000100b) | ACK | SP
ST | SLAVE ADDRESS | W | ACK | Data7 (00000011b) | ACK
Master reception
RS | SLAVE ADDRESS | R | ACK
Data0 | ACK | Data1 | ACK | Data2 | ACK | Data3 | ACK
Data4 | ACK | Data5 | ACK | Data6 | ACK | Data7 | NACK | SP
Master → Slave
Slave → Master

ST : Start condition
SP : Stop condition
W : Write mode is “0”
ACK : Acknowledge is “0”

RS : Restart condition
R : Read mode is “1”
NACK : No Acknowledge is “1”

Figure 3.1 Communication Format

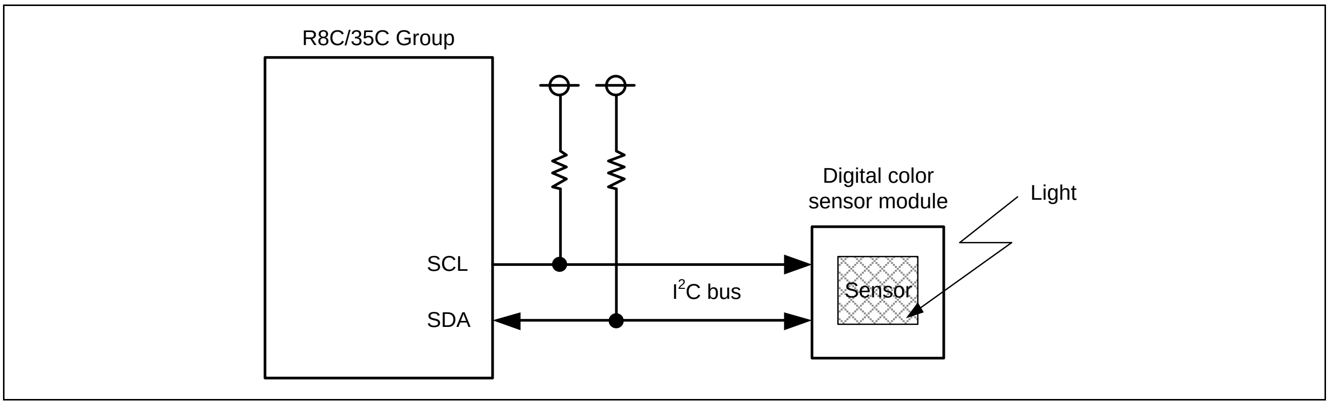


Figure 3.2 Block Diagram

The numbers in Figure 3.3 and Figure 3.4 correspond to the numbers indicated in the program processing in the operating timing charts in Figure 3.5 to Figure 3.7.

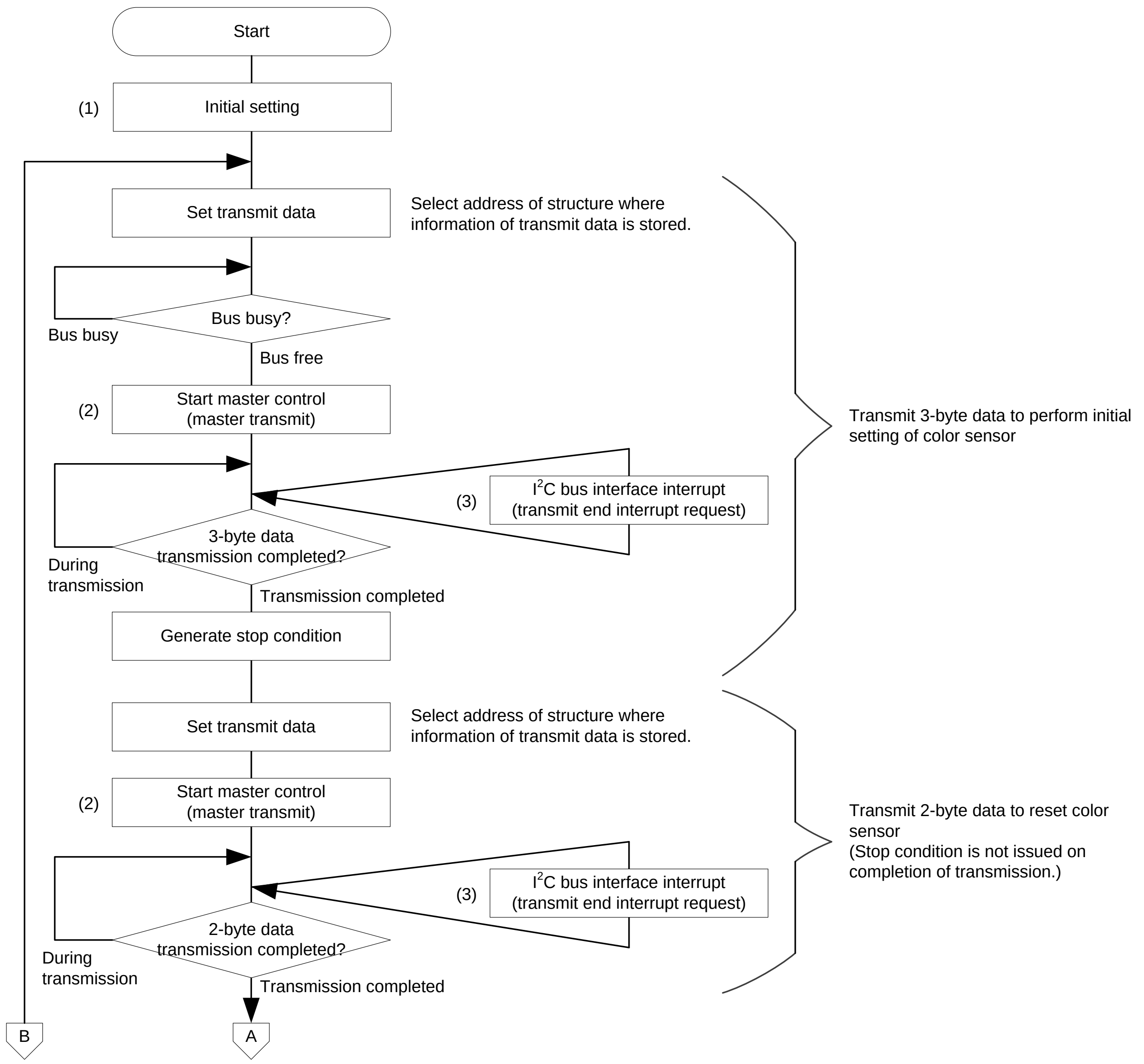

Start
(1)
Initial setting
Set transmit data
Select address of structure where information of transmit data is stored.
Bus busy?
Bus busy
Bus free
(2)
Start master control (master transmit)
(3)
I²C bus interface interrupt (transmit end interrupt request)
3-byte data transmission completed?
During transmission
Transmission completed
Generate stop condition
Transmit 3-byte data to perform initial setting of color sensor
Set transmit data
Select address of structure where information of transmit data is stored.
(2)
Start master control (master transmit)
(3)
I²C bus interface interrupt (transmit end interrupt request)
2-byte data transmission completed?
During transmission
Transmission completed
Transmit 2-byte data to reset color sensor
(Stop condition is not issued on completion of transmission.)
B
A

Figure 3.3 Outline Flowchart (1/2)

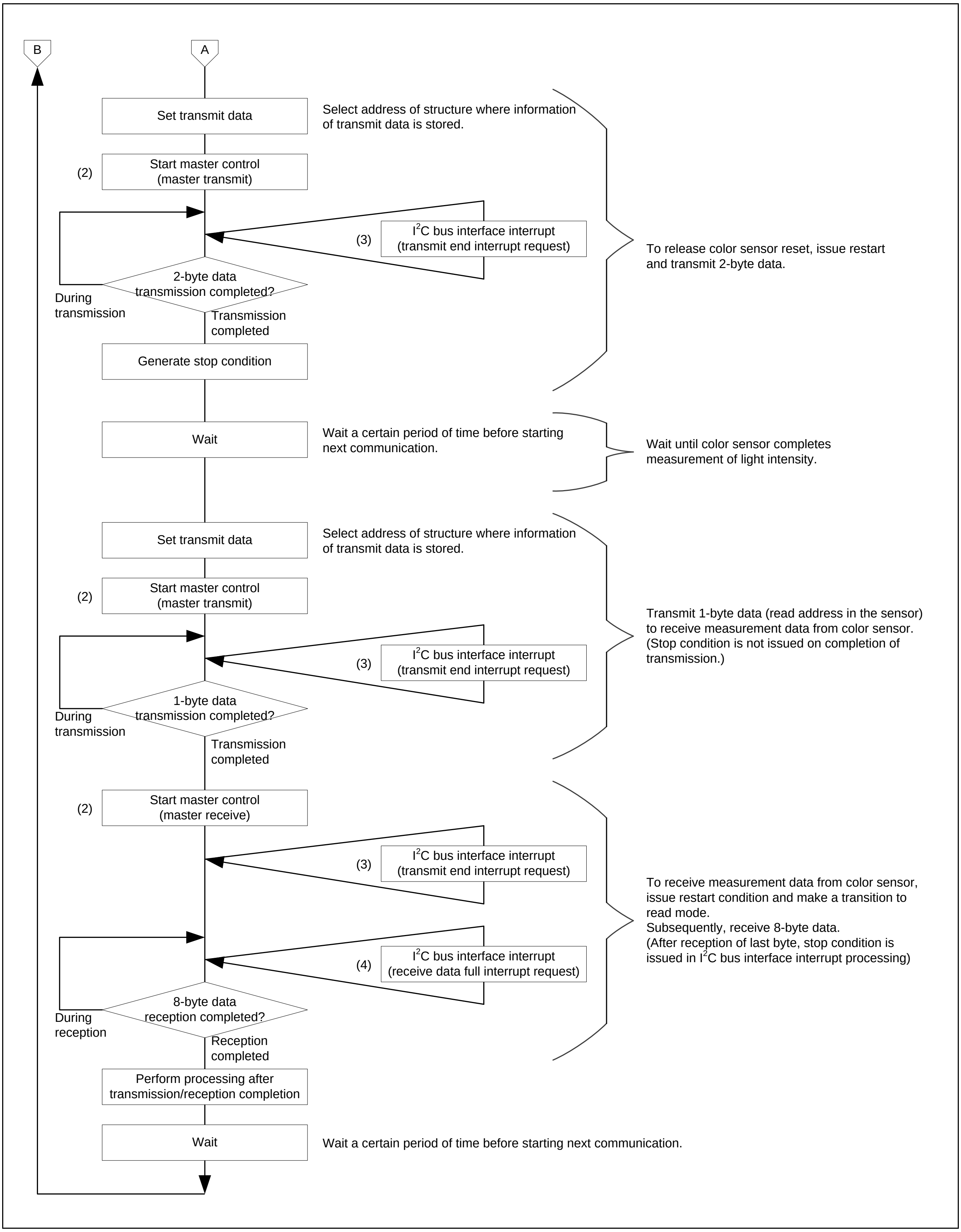

B
A
Set transmit data
Select address of structure where information of transmit data is stored.
(2)
Start master control (master transmit)
(3)
I²C bus interface interrupt (transmit end interrupt request)
To release color sensor reset, issue restart and transmit 2-byte data.
2-byte data transmission completed?
During transmission
Transmission completed
Generate stop condition
Wait
Wait a certain period of time before starting next communication.
Wait until color sensor completes measurement of light intensity.
Set transmit data
Select address of structure where information of transmit data is stored.
(2)
Start master control (master transmit)
Transmit 1-byte data (read address in the sensor) to receive measurement data from color sensor. (Stop condition is not issued on completion of transmission.)
(3)
I²C bus interface interrupt (transmit end interrupt request)
1-byte data transmission completed?
During transmission
Transmission completed
(2)
Start master control (master receive)
(3)
I²C bus interface interrupt (transmit end interrupt request)
To receive measurement data from color sensor, issue restart condition and make a transition to read mode.
Subsequently, receive 8-byte data.
(After reception of last byte, stop condition is issued in I²C bus interface interrupt processing)
(4)
I²C bus interface interrupt (receive data full interrupt request)
8-byte data reception completed?
During reception
Reception completed
Perform processing after transmission/reception completion
Wait
Wait a certain period of time before starting next communication.

Figure 3.4 Outline Flowchart (2/2)

A process outline is described as follows:

(1) Initial setting
Initialize the system clock, I^{2}C bus Interface associated SFRs, and variables used.

(2) Start master control
Generate a start condition.
Enable the I^{2}C bus Interface interrupt (transmit end interrupt request) and transmit the slave address.

(3) I^{2}C bus Interface interrupt (transmit end interrupt request)
An interrupt is generated at the rising edge of the ninth bit of the SCL clock.

At master transmit
- Determine ACK/NACK and set the next byte transmit data.

At master receive
- Disable the transmit end interrupt request and enable the receive data full interrupt request.

(4) I^{2}C bus Interface interrupt (receive data full interrupt request)
An interrupt is generated at the rising edge of the ninth bit of the SCL clock at master receive.
Set the next byte ACK/NACK and read the receive data.
To end communication, issue the stop condition and disable the receive data full interrupt request.

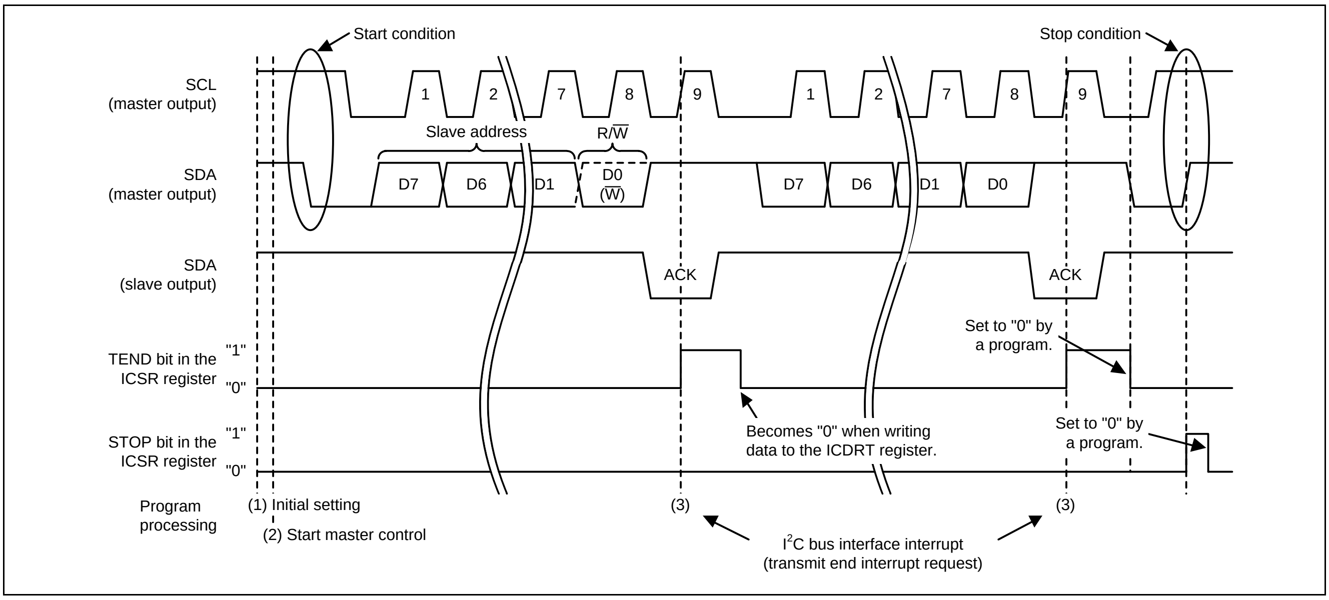


Figure 3.5 Master Transmit Timing

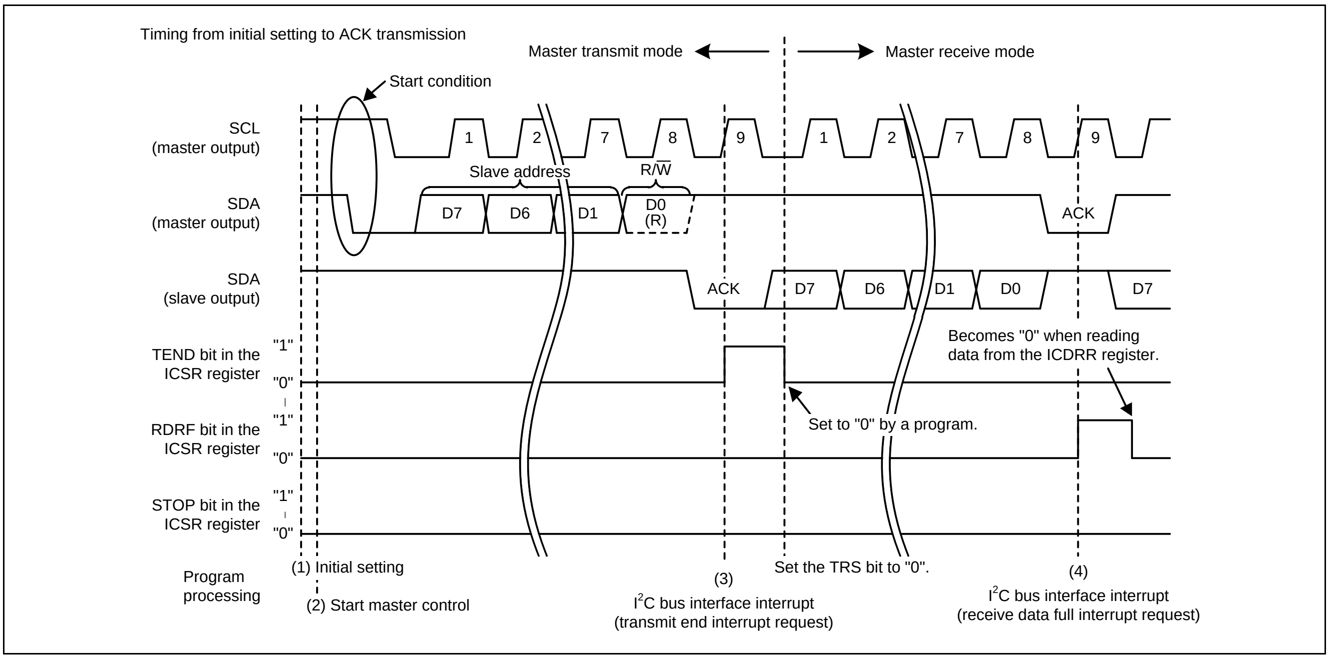

Timing from initial setting to ACK transmission
Master transmit mode
Master receive mode
Start condition
SCL
(master output)
1
2
7
8
9
1
2
7
8
9
Slave address
R/W
SDA
(master output)
D7
D6
D1
D0
(R)
ACK
SDA
(slave output)
ACK
D7
D6
D1
D0
D7
TEND bit in the ICSR register
"1"
"0"
Becomes "0" when reading data from the ICDRR register.
RDRF bit in the ICSR register
"1"
"0"
Set to "0" by a program.
STOP bit in the ICSR register
"1"
"0"
Program processing
(1) Initial setting
(2) Start master control
(3)
I2C bus interface interrupt
(transmit end interrupt request)
Set the TRS bit to "0".
(4)
I2C bus interface interrupt
(receive data full interrupt request)

Figure 3.6 Master Receive Timing (1/2)

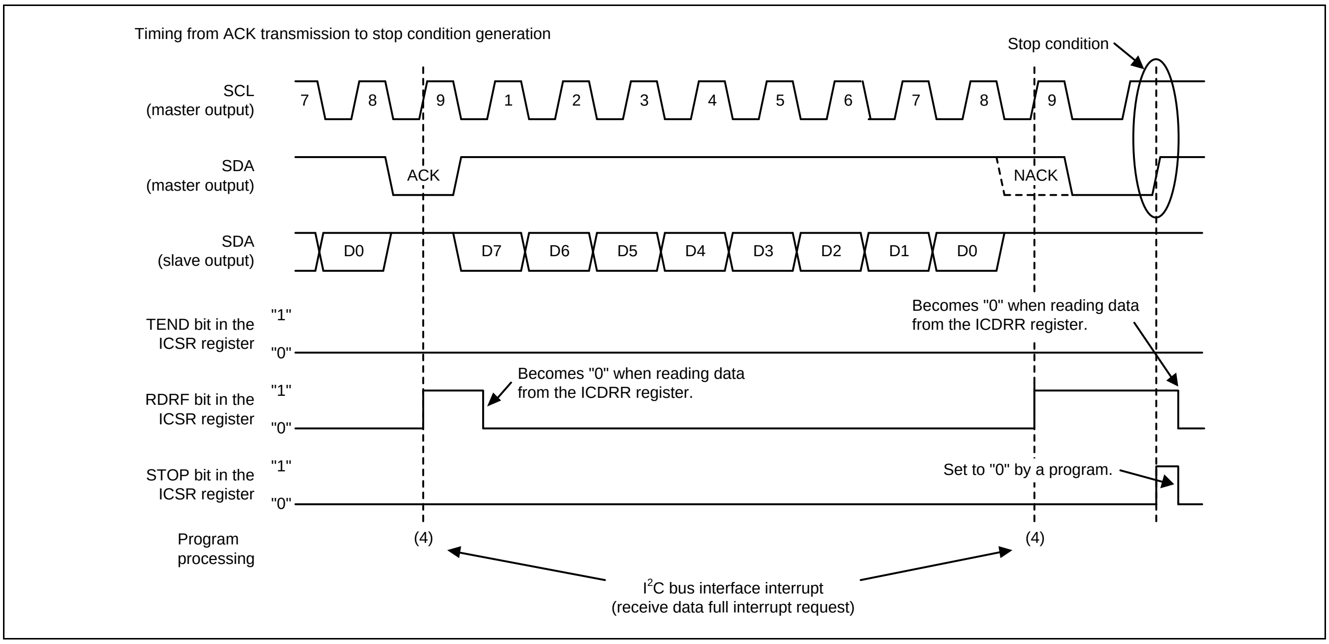

Timing from ACK transmission to stop condition generation
Stop condition
SCL
(master output)
7
8
9
1
2
3
4
5
6
7
8
9
SDA
(master output)
ACK
NACK
SDA
(slave output)
D0
D7
D6
D5
D4
D3
D2
D1
D0
TEND bit in the ICSR register
"1"
"0"
Becomes "0" when reading data from the ICDRR register.
RDRF bit in the ICSR register
"1"
"0"
Becomes "0" when reading data from the ICDRR register.
STOP bit in the ICSR register
"1"
"0"
Set to "0" by a program.
Program processing
(4)
(4)
I2C bus interface interrupt
(receive data full interrupt request)

Figure 3.7 Master Receive Timing (2/2)

3.1.1 Peripheral Functions

The I^{2}C bus Interface mode of the I^{2}C bus Interface is used under the following setting conditions:

- I^{2}C bus format is used.
- f1/56 is used for the transfer clock (approximately 357 kHz is set as the transfer rate).
- No wait states are set (data and the acknowledge bit are transferred consecutively).
- MSB first is used for the transfer format.
- 3 × f1 cycles are used for the SDA digital delay value.
- The receive acknowledge bit (ACKBR bit) is used to determine an acknowledge signal.
- The receive data full interrupt request is used.
- The transmit end interrupt request is used.
- The stop condition detection interrupt request is not used.
- The transmit data empty interrupt request is not used.
- The NACK receive interrupt request and arbitration lost/overrun error interrupt request are not used.

Calculating the transfer rate

Transfer rate = Bits CKS3 to CKS0 in the ICCR1 register setting

= 20 MHz (f1) / 56

≈ 357.142 kHz

Table 3.1 Pins Used and Their Functions

Pin	I/O	Function
P3_5/SCL	I/O	I^{2}C bus clock I/O pin
P3_7/SDA	I/O	I^{2}C bus data I/O pin

3.1.2 Notes on Using the Attached Sample Program

Note the following when using the program included with this application note:

- Do not use multiple interrupts.
- When setting the system clock to anything other than the 20 MHz High-Speed On-Chip Oscillator Clock, change the setting value of bits CKS3 to CKS0 according to the transfer rate calculation shown in "3.1.1 Peripheral Functions".

3.2 Memory

Table 3.2 Memory

Memory	Size	Remarks
ROM	2146 bytes	—
RAM	317 bytes	—
Maximum user stack	37 bytes	—
Maximum interrupt stack	25 bytes	—

Usage memory size varies depending on C compiler version and compile options. The above applies under the following conditions:

C compiler : M16C Series, R8C Family Compiler V.5.45 Release 01

Compile options : -c -finfo -dir "$(CONFIGDIR)" -R8C

4. Software

This section shows the program example to set the example described in section 3. Application Example. Refer to the latest "R8C/35C Group User's Manual Hardware" for details on individual registers.

4.1 Usage Variables

Table 4.1 Definition File Name: r01an3378_src.c (1/4)

Variable Name		Size		Description
iic_stat_fcb iic_comstat		5 bytes in total		Structure for storing communication status
Structure members	unsigned char iic_status	1 byte		Communication status
			b0	Communication direction flag 0: Master transmission 1: Master reception
			b1	Address mismatch flag 0: No address mismatch 1: Address mismatch
			b2 and b3	Only used on command error occurrence (undefined)
			b4	Error flag 0: Normal completion 1: Error
			b5	Not used (undefined)
			b6	Only used for command request (undefined)
			b7	Communication in progress flag 0: Communication completed 1: Communication in progress
	unsigned char iic_slave_addr	1 byte		Slave address (7-bit address, value of b0 is "0")
	unsigned char far *iic_data_addr	2 bytes		Transmit/receive buffer address
	unsigned char iic_num_byte	1 byte		Number of transmit/receive data (in bytes)
Functional Description of Structure				
Acquires values set to structures iic_set_str1 to iic_set_str5 (see Table 4.3) and uses the values for communication.				
Functional Description of Structure Member iic_status				
Structure member iic_status indicates transmission instruction command/communication status. - Before starting communication Value of member iic_str_command of structures iic_set_str1 to iic_set_str5 (command) (see Table 4.3) is stored. - After starting communication Value of iic_status is updated and communication status is indicated.		<Commands> 0x40 (CWRITEMODE) : Master transmission command 0x41 (CREADMODE) : Master reception command <Status> 0x80 (CINWRITE) : Transmission is in progress 0x81 (CINREAD) : Reception is in progress 0x00 (CSUCCESSW) : Transmission has completed normally 0x01 (CSUCCESSR) : Reception has completed normally 0x11 (CBUSBUSY) : I^{2}C bus error 0x12 (CSLAVEBUSY) : Slave busy (NACK in address) 0x13 (CNOACK) : Data transmission error (NACK in data) 0x1f (CCOMERROR) : Command error		

Table 4.2 Definition File Name: r01an3378_src.c (2/4)

Variable Name	Size	Description
static unsigned char iic_tx1[TX1_BUFSIZE]	3 bytes	Transmit buffer 1
static unsigned char iic_tx2[TX2_BUFSIZE]	2 bytes	Transmit buffer 2
static unsigned char iic_tx3[TX3_BUFSIZE]	2 bytes	Transmit buffer 3
static unsigned char iic_tx4[TX4_BUFSIZE]	1 byte	Transmit buffer 4
static unsigned char iic_rx1[RX1_BUFSIZE]	8 bytes	Receive buffer 1

Table 4.3 Definition File Name: r01an3378_src.c (3/4)

Variable Name		Size	Description
static iic_set_fcb iic_set_str1, iic_set_str2, iic_set_str3, iic_set_str4, iic_set_str5		5 bytes in total	Structure for storing communication setting parameters
Structure members	unsigned char iic_str_command	1 byte	Transmission/reception commands 0x40 (CWRITEMODE) : Master transmission command 0x41 (CREADMODE) : Master reception command
	unsigned char iic_str_slave_addr	1 byte	Slave address (7-bit address, value of b0 is "0")
	unsigned char far *iic_str_data_addr	2 bytes	Transmit/receive buffer address (See Table 4.2 for transmit/receive buffer.)
	unsigned char iic_str_num_byte	1 byte	Number of transmit/receive data (in bytes)

Table 4.4 Definition File Name: r01an3378_src.c (4/4)

Variable Name	Size	Description
static unsigned int iic_red_data	2 bytes	Red light data
static unsigned int iic_green_data	2 bytes	Green light data
static unsigned int iic_blue_data	2 bytes	Blue light data
static unsigned int iic_ir_data	2 bytes	Infrared light data

Table 4.5 Definition File Name: iic.c

Variable Name	Size	Description
static unsigned char iic_status_buf	1 byte	Status buffer
static unsigned char far *iic_data_pointer	2 bytes	Pointer to transmit/receive buffer
static unsigned char iic_num_byte_buf	1 byte	Transmit/receive data count buffer
static unsigned char iic_start_cond_flag	1 byte	Start condition flag

Table 4.6 Definition File Name: tra.c

Variable Name	Size	Description
static unsigned int tra_wait_dwncnt	2 bytes	Variable for timer counting

4.2 Function Tables

Declaration	void main (void)		
Outline	Main Processing		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	After the initial setting of the system clock, I^{2}C bus Interface, and timer RA, executes master transmission and reception. After master transmission and reception are completed, resumes communication after inserting a given length of wait time, and repeats master transmission and reception.		

Declaration	void mcu_init (void)		
Outline	System Clock Setting		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Sets the system clock (High-Speed On-Chip Oscillator Clock).		

Declaration	void port_init (void)		
Outline	Initial Setting of I/O Ports		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Initializes I/O Ports to use I^{2}C bus Interface.		

Declaration	void iic_init (void)		
Outline	Initial Setting of I^{2}C Bus Interface		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Initializes SFRs to use I^{2}C bus Interface.		

Declaration	void tra_init (void)		
Outline	Initial Setting of Timer RA		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Initializes SFRs to use Timer RA.		

Declaration	unsigned char iic_sensor_init (unsigned char far *iic_set_str)		
Outline	Initializing Color Sensor		
Argument	Argument name		Meaning
	unsigned char far *iic_set_str		Pointer to structure for storing communication setting parameters
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
Returned value	Type	Value	Meaning
	unsigned char	0	Communication error
		1	Successful communication
Function	This function is called from the Main Processing. Performs processing to initialize the color sensor. Calls the iic_copy_parameter function to acquire the transmit data, and calls the iic_start function to start communication. During communication, checks the communication status of the structure iic_comstat and waits for completion of data transmission. To end communication, calls the iic_stop_cond function to perform the communication end processing. If the status checking shows a communication error, calls the iic_stop_cond function to stop the communication.		

Declaration	static void iic_copy_parameter (unsigned char far *iic_set_str)		
Outline	Copying Communication Parameters		
Argument	Argument name		Meaning
	unsigned char far *iic_set_str		Pointer to structure for storing communication setting parameters
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called before starting communication. Copies the communication data to (structure) iic_comstat to acquire the parameters required for communication.		

Declaration	static void iic_start (void)		
Outline	Starting I^{2}C Communication		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
	static unsigned char iic_status_buf		Buffer for storing communication status during communication
	static unsigned char far *iic_data_pointer		Pointer to indicate transmit/receive data during communication
	static unsigned char iic_num_byte_buf		Buffer for indicating number of remaining data during communication
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called to start communication. Performs processing to start communication. After calling the iic_start_cond function to issue the start condition, transmits the slave address. In the function header, confirms that the bus is not being used by any external device and checks the transmit/receive commands and variable iic_num_byte_buf. If the checking shows an error, does not perform the communication start processing.		

Declaration	static void iic_start_cond (void)		
Outline	Issuing Start Condition		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	static unsigned char iic_start_cond_flag		Start condition flag
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Starting I2C Communication processing. Issues the start condition and sets the start condition flag.		

Declaration	static void iic_stop_cond (void)		
Outline	Issuing Stop Condition		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called to stop communication. Performs processing to issue the stop condition. In the function header, checks the bus status. - When the bus is busy Performs processing to issue the stop condition. - When the bus is free Does not perform processing to issue the stop condition.		

Declaration	unsigned char iic_sensor_reset (unsigned char far *iic_set_str, unsigned char far *iic_set_str_2nd)		
Outline	Resetting Color Sensor		
Argument	Argument name		Meaning
	unsigned char far *iic_set_str		Pointer to structure for storing communication setting parameters
	unsigned char far *iic_set_str_2nd		Pointer to structure for storing communication setting parameters
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
Returned value	Type	Value	Meaning
	unsigned char	0	Communication error
		1	Successful communication
Function	This function is called from the Main Processing. Performs processing to reset the color sensor. Calls the iic_copy_parameter function to acquire the transmit data, and calls the iic_start function to start communication. During communication, checks the communication status of the structure iic_comstat and waits for completion of data transmission. To end communication, calls the iic_stop_cond function to perform the communication end processing. If the status checking shows a communication error, calls the iic_stop_cond function to stop the communication.		

Declaration	void tra_measure_wait (void)		
Outline	Waiting for Light Intensity Measurement Completion		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	static unsigned int tra_wait_dwncnt		Timer count value
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Performs processing to wait for the color sensor to complete measurement of the light intensity. Sets the timer count to the variable tra_wait_dwncnt and calls the tra_start function to start the timer RA. While the timer RA is running, checks the timer RA count status flag (TCSTF) and waits for the timer RA to stop. The variable tra_wait_dwncnt is updated and timer RA is stopped in the timer RA interrupt handling.		

Declaration	static void tra_start (void)		
Outline	Starting Timer RA Operation		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called to run the timer RA. Performs processing to run the timer RA.		

Declaration	unsigned char iic_sensor_read (unsigned char far *iic_set_str, unsigned char far *iic_set_str_2nd)		
Outline	Reading Measurement Data		
Argument	Argument name		Meaning
	unsigned char far *iic_set_str		Pointer to structure for storing communication setting parameters
	unsigned char far *iic_set_str_2nd		Pointer to structure for storing communication setting parameters
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
Returned value	Type	Value	Meaning
	unsigned char	0	Communication error
		1	Successful communication
Function	This function is called from the Main Processing. Performs processing to read out the measurement data of the color sensor. Calls the iic_copy_parameter function to acquire the transmit data, and calls the iic_start function to start communication. During communication, checks the communication status of the structure iic_comstat and waits for completion of data transmission/reception. After receiving the last byte, issues the stop condition in the I2C bus Interface Interrupt Handling to end communication. If the status checking shows a communication error, calls the iic_stop_cond function to stop the communication.		

Declaration	void iic_measure_result (unsigned char far *iic_rx, unsigned char iic_rx_size, unsigned int far *iic_red_data, unsigned int far *iic_green_data, unsigned int far *iic_blue_data, unsigned int far *iic_ir_data)		
Outline	Processing Measurement Results		
Argument	Argument name		Meaning
	unsigned char far *iic_rx		Pointer to receive buffer
	unsigned char iic_rx_size		Size of receive buffer
	unsigned int far *iic_red_data		Pointer to variable for storing measurement data of red light
	unsigned int far *iic_green_data		Pointer to variable for storing measurement data of green light
	unsigned int far *iic_blue_data		Pointer to variable for storing measurement data of blue light
	unsigned int far * ic_ir_data		Pointer to variable for storing measurement data of infrared light
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Performs processing to store the receive data in the receive buffer into the variables indicating the measurement data of each color light.		

Declaration	void tra_next_com_wait (void)		
Outline	Waiting for Communication Restart		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	static unsigned int tra_wait_dwncnt		Timer count value
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing. Performs processing to wait for the next communication to be resumed. Sets the timer count to the variable tra_wait_dwncnt and calls the tra_start function to start the timer RA. While the timer RA is running, checks the timer RA count status flag (TCSTF) and waits for the timer RA to stop. The variable tra_wait_dwncnt is updated and timer RA is stopped in the timer RA interrupt handling.		

Declaration	void iic_error (void)		
Outline	Processing I^{2}C Communication Error		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	None		—
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the Main Processing when a communication error is detected. Ends without any processing. To process an error, add the appropriate program.		

Declaration	void iic_int (void)		
Outline	I^{2}C bus Interface Interrupt Handling		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
	static unsigned char iic_status_buf		Buffer for storing communication status during communication
	static unsigned char iic_start_cond_flag		Start condition flag
Returned value	Type	Value	Meaning
	None	—	—
Function	An interrupt is generated at the rising edge of the 9th bit of the SCL clock. In the function header, checks the variable iic_status_buf to see if the start condition has been issued immediately before data transmission. When the start condition has been issued, calls the iic_data_trs_int function in transmit mode, and calls the iic_set_rcv_int function in receive mode. When the start condition has not been issued, calls the iic_cont_data_trs_int function in transmit mode, and calls the iic_data_rcv_int function in receive mode. When a communication error is detected, calls the iic_error_exit_int function to end communication.		

Declaration	static void iic_data_trs_int (void)		
Outline	Data Transmission		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	static unsigned char far *iic_data_pointer		Pointer to indicate transmit/receive data during communication
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the I2C bus Interface Interrupt Handling. Transmits the data in the transmit buffer pointed to by the pointer iic_data_pointer. Also updates the pointer iic_data_pointer to perform the next transmission.		

Declaration	static void iic_cont_data_trs_int (void)		
Outline	Continuous Data Transmission		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
	static unsigned char iic_status_buf		Buffer for storing communication status during communication
	static unsigned char iic_num_byte_buf		Buffer for indicating number of remaining data during communication
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the I2C bus Interface Interrupt Handling. In the function header, checks if ACK has been detected. - ACK detected After updating the variable iic_num_byte_buf, checks the number of remaining transmit data bytes. When there is any data to be transmitted, calls the iic_data_trs_int function to perform the data transmit processing. When there is no data to be transmitted, updates the communication status of the structure iic_comstat to indicate the end of communication. - NACK detected Calls the iic_error_exit_int function to end the communication.		

Declaration	static void iic_set_rcv_int (void)		
Outline	Reception Settings		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	static unsigned char iic_num_byte_buf		Buffer for indicating number of remaining data during communication
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the I2C bus Interface Interrupt Handling. Switches from master transmit mode to master receive mode and enables the receive data full interrupt request. In the function, checks the variable iic_num_byte_buf to see the number of receive data bytes to be received. - When the number of data bytes to be received is 1 Sets so that "1" (NACK) is transmitted at the acknowledge timing and disables reception following the next data reception. - When the number of data bytes to be received is 2 or more Sets so that "0" (ACK) is transmitted at the acknowledge timing and enables reception following the next data reception.		

Declaration	static void iic_data_rcv_int (void)		
Outline	Data Reception		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
	static unsigned char far *iic_data_pointer		Pointer to indicate transmit/receive data during communication
	static unsigned char iic_num_byte_buf		Buffer for indicating number of remaining data during communication
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called from the I2C bus Interface Interrupt Handling. Stores the receive data into the receive buffer area pointed to by the pointer iic_data_pointer and updates the pointer iic_data_pointer to perform the next reception. Also updates the variable iic_num_byte_buf and checks the number of remaining receive data bytes. - When the number of data bytes to be received is 0 To end communication, issues the stop condition, disables the receive data full interrupt request, and updates the communication status of the structure iic_comstat. - When the number of data bytes to be received is 1 Sets so that "1" (NACK) is transmitted at the acknowledge timing and disables reception following the next data reception.		

Declaration	static void iic_error_exit_int (void)		
Outline	Communication Error End Processing		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	(structure) iic_comstat		Communication status
	static unsigned char iic_status_buf		Buffer for storing communication status during communication
	static unsigned char iic_num_byte_buf		Buffer for indicating number of remaining data during communication
Returned value	Type	Value	Meaning
	None	—	—
Function	This function is called if a communication error is detected during execution of the I2C bus Interface Interrupt Handling. To end the communication, updates the communication status of the structure iic_comstat and the number of transmit/receive data bytes.		

Declaration	void tra_int (void)		
Outline	Timer RA Interrupt Handling		
Argument	Argument name		Meaning
	None		—
Variable (global)	Variable name		Contents
	static unsigned int tra_wait_dwncnt		Timer count value
Returned value	Type	Value	Meaning
	None	—	—
Function	An interrupt is generated due to a timer RA underflow at 25-ms intervals. This function decrements the variable tra_wait_dwncnt and checks the result. When the variable tra_wait_dwncnt is "0", stops Timer RA counting operation.		

4.3 Main Processing

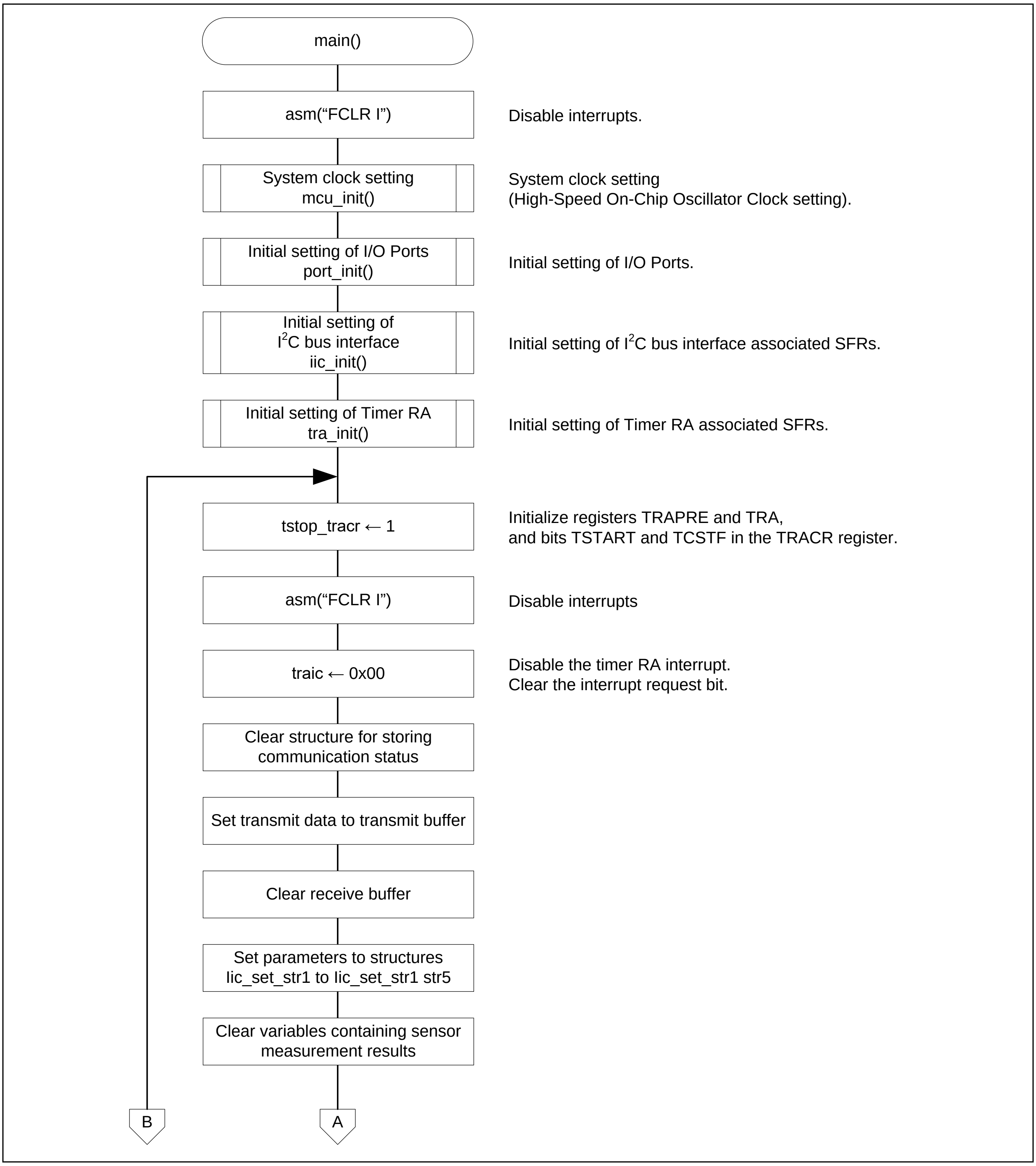

main()
asm(“FCLR I”)
Disable interrupts.
System clock setting
mcu_init()
System clock setting
(High-Speed On-Chip Oscillator Clock setting).
Initial setting of I/O Ports
port_init()
Initial setting of I/O Ports.
Initial setting of
I^{2}C bus interface
iic_init()
Initial setting of I^{2}C bus interface associated SFRs.
Initial setting of Timer RA
tra_init()
Initial setting of Timer RA associated SFRs.
tstop_tracr ← 1
Initialize registers TRAPRE and TRA,
and bits TSTART and TCSTF in the TRACR register.
asm(“FCLR I”)
Disable interrupts
traic ← 0x00
Disable the timer RA interrupt.
Clear the interrupt request bit.
Clear structure for storing communication status
Set transmit data to transmit buffer
Clear receive buffer
Set parameters to structures
Iic_set_str1 to Iic_set_str1 str5
Clear variables containing sensor measurement results
B
A

Figure 4.1 Main Processing (1/2)

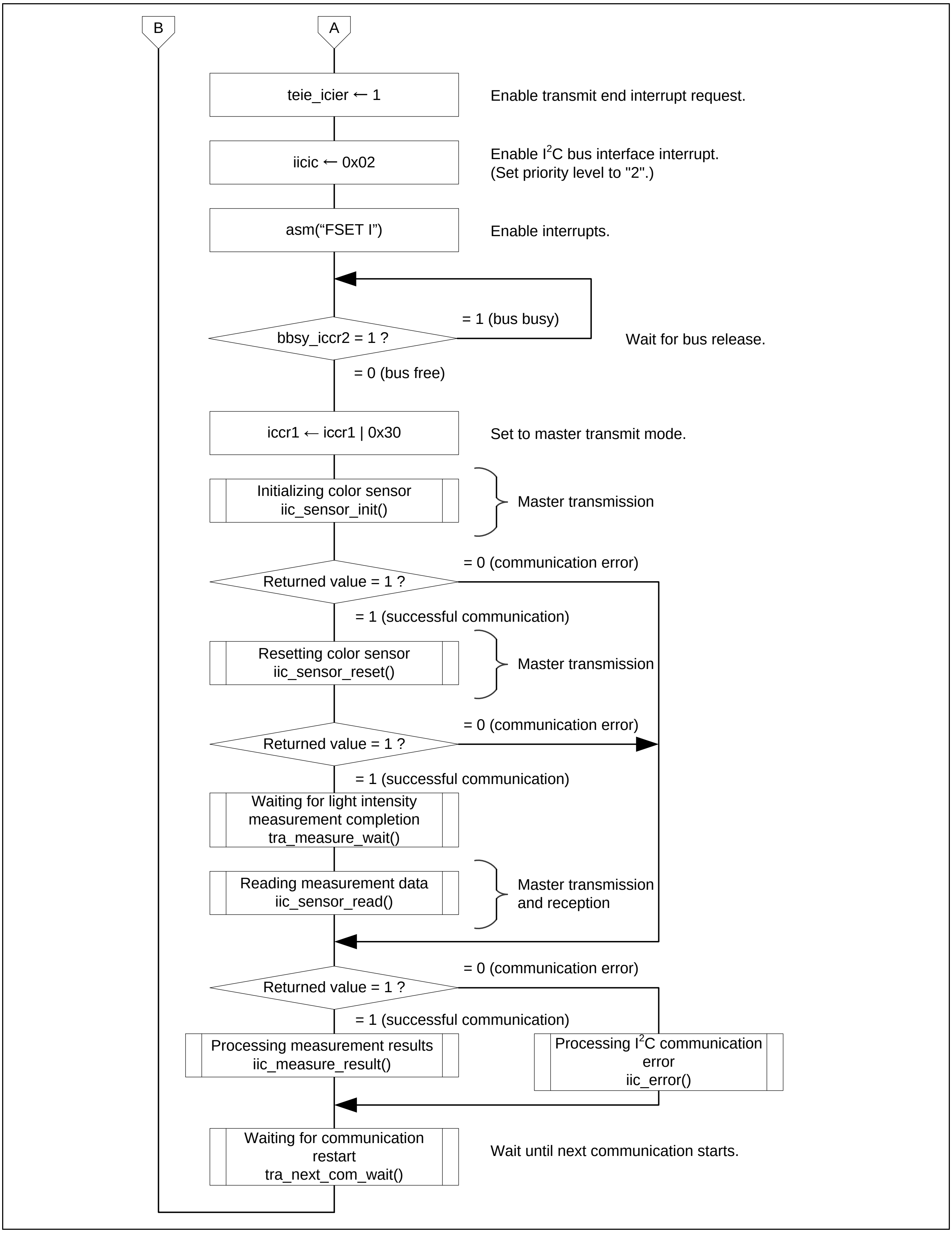


Figure 4.2 Main Processing (2/2)

4.4 System Clock Setting

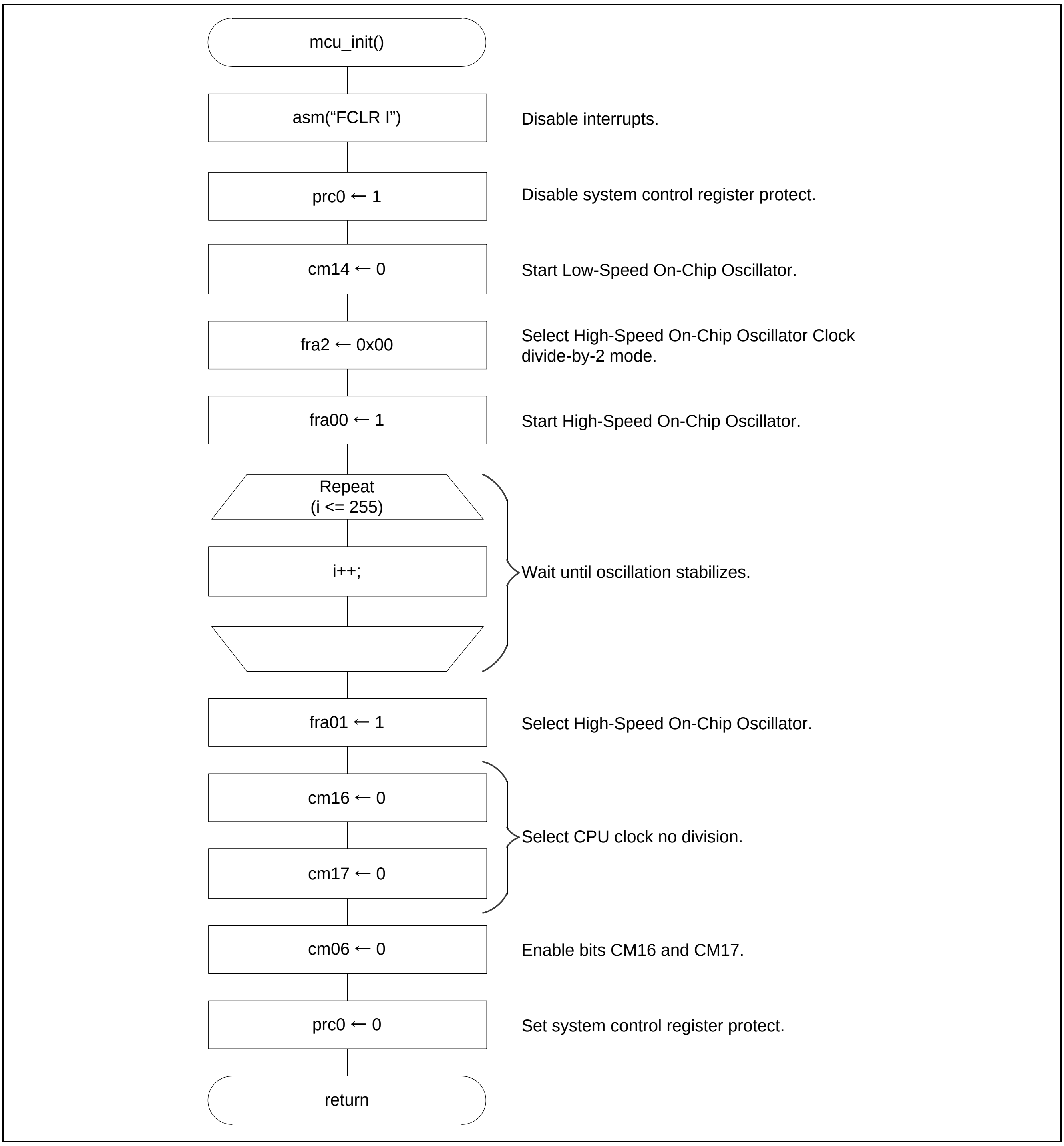

mcu_init()
asm(“FCLR I”)
Disable interrupts.
prc0 ← 1
Disable system control register protect.
cm14 ← 0
Start Low-Speed On-Chip Oscillator.
fra2 ← 0x00
Select High-Speed On-Chip Oscillator Clock divide-by-2 mode.
fra00 ← 1
Start High-Speed On-Chip Oscillator.
Repeat (i <= 255)
i++;
Wait until oscillation stabilizes.
fra01 ← 1
Select High-Speed On-Chip Oscillator.
cm16 ← 0
cm17 ← 0
Select CPU clock no division.
cm06 ← 0
Enable bits CM16 and CM17.
prc0 ← 0
Set system control register protect.
return

Figure 4.3 System Clock Setting

4.5 Initial Setting of I/O Ports

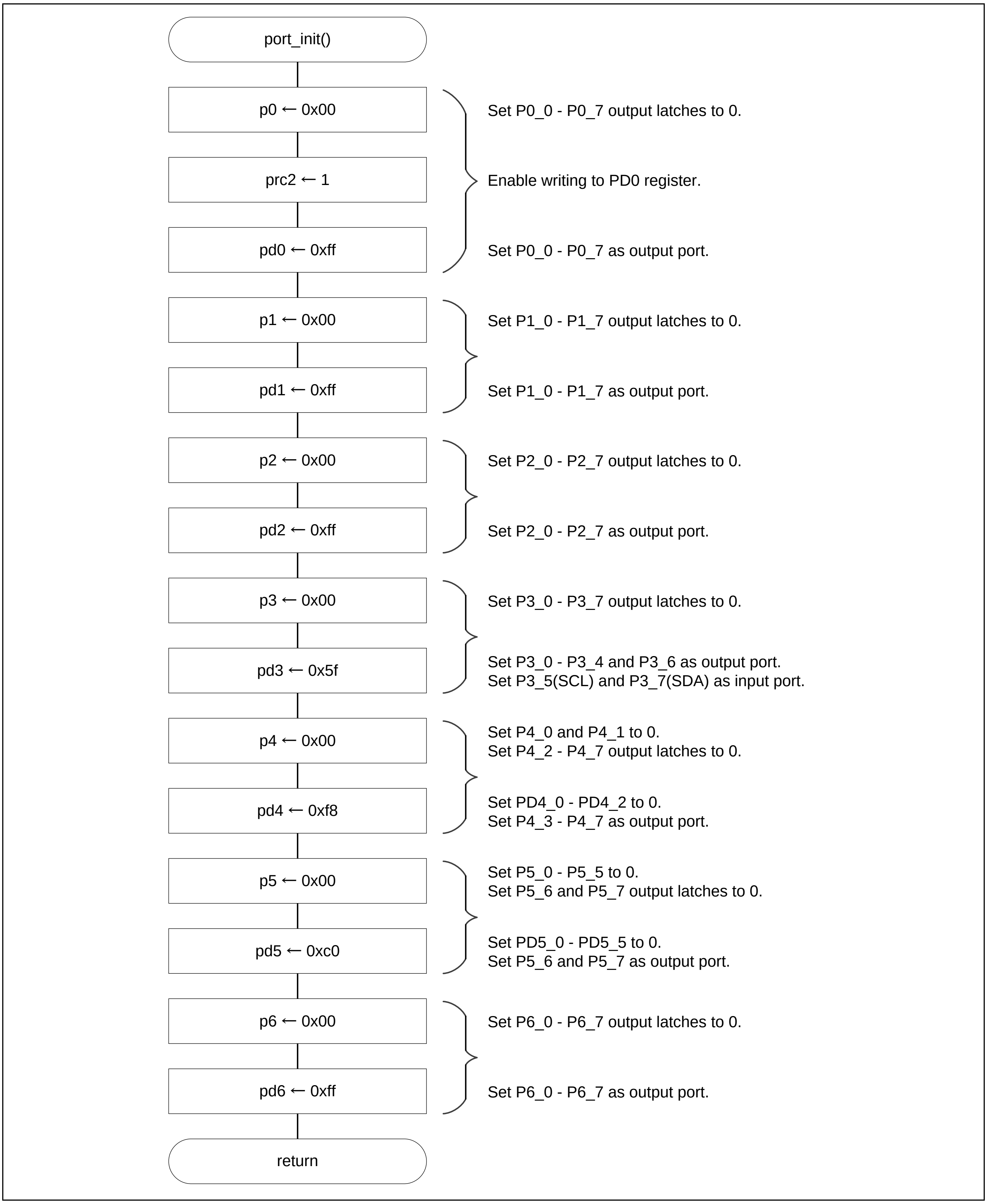
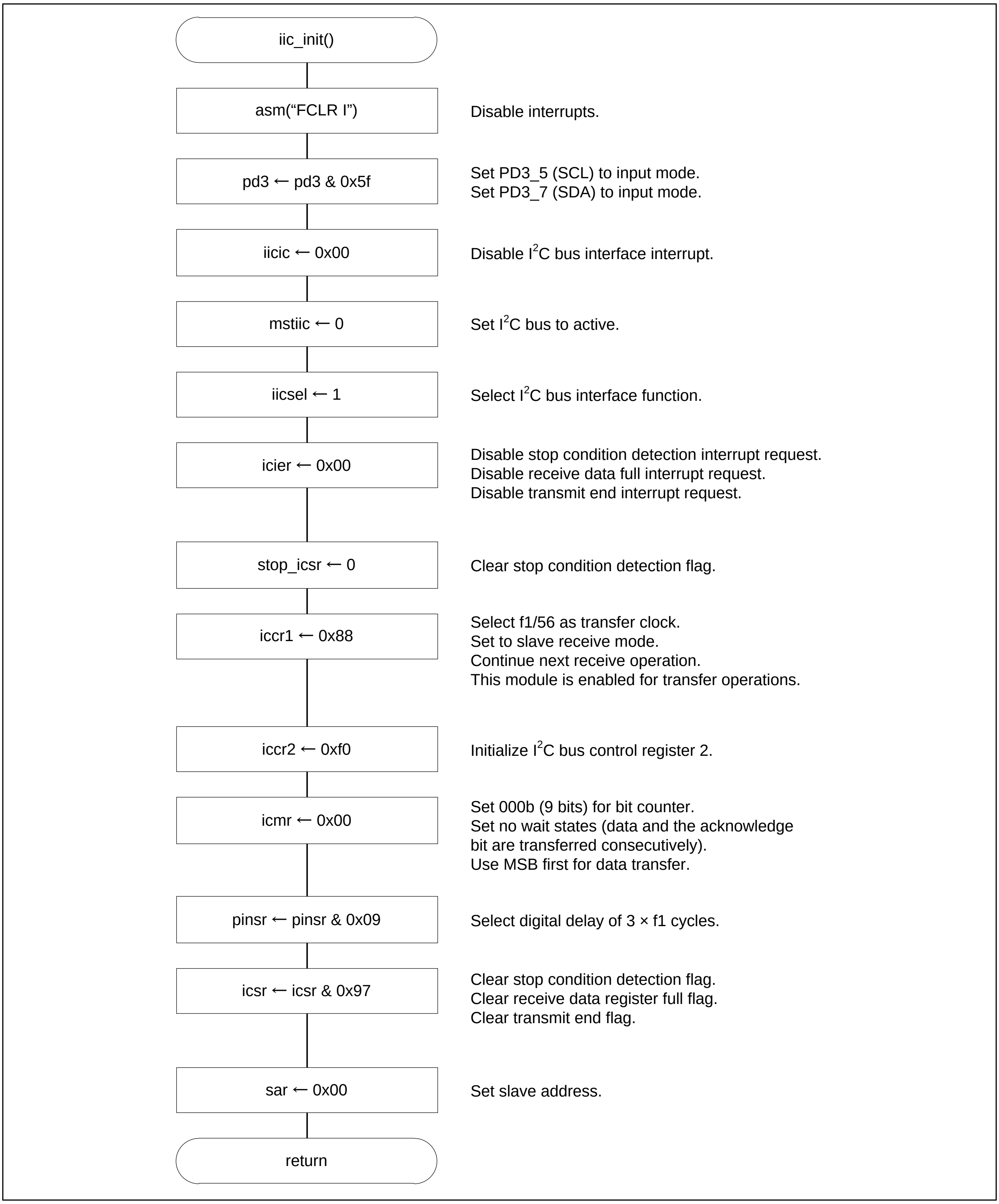

port_init()
p0 ← 0x00
prc2 ← 1
pd0 ← 0xff
p1 ← 0x00
pd1 ← 0xff
p2 ← 0x00
pd2 ← 0xff
p3 ← 0x00
pd3 ← 0x5f
p4 ← 0x00
pd4 ← 0xf8
p5 ← 0x00
pd5 ← 0xc0
p6 ← 0x00
pd6 ← 0xff
return
Set P0_0 - P0_7 output latches to 0.
Enable writing to PD0 register.
Set P0_0 - P0_7 as output port.
Set P1_0 - P1_7 output latches to 0.
Set P1_0 - P1_7 as output port.
Set P2_0 - P2_7 output latches to 0.
Set P2_0 - P2_7 as output port.
Set P3_0 - P3_7 output latches to 0.
Set P3_0 - P3_4 and P3_6 as output port.
Set P3_5(SCL) and P3_7(SDA) as input port.
Set P4_0 and P4_1 to 0.
Set P4_2 - P4_7 output latches to 0.
Set PD4_0 - PD4_2 to 0.
Set P4_3 - P4_7 as output port.
Set P5_0 - P5_5 to 0.
Set P5_6 and P5_7 output latches to 0.
Set PD5_0 - PD5_5 to 0.
Set P5_6 and P5_7 as output port.
Set P6_0 - P6_7 output latches to 0.
Set P6_0 - P6_7 as output port.

Figure 4.4 Initial setting of I/O Ports

4.6 Initial Setting of I^{2}C Bus Interface



Disable interrupts.

Set PD3_5 (SCL) to input mode.
Set PD3_7 (SDA) to input mode.

Disable I^{2}C bus interface interrupt.

Set I^{2}C bus to active.

Select I^{2}C bus interface function.

Disable stop condition detection interrupt request.
Disable receive data full interrupt request.
Disable transmit end interrupt request.

Clear stop condition detection flag.

Select f1/56 as transfer clock.
Set to slave receive mode.
Continue next receive operation.
This module is enabled for transfer operations.

Initialize I^{2}C bus control register 2.

Set 000b (9 bits) for bit counter.
Set no wait states (data and the acknowledge bit are transferred consecutively).
Use MSB first for data transfer.

Select digital delay of 3 × f1 cycles.

Clear stop condition detection flag.
Clear receive data register full flag.
Clear transmit end flag.

Set slave address.

Figure 4.5 Initial Setting of I^{2}C Bus Interface

4.7 Initial Setting of Timer RA

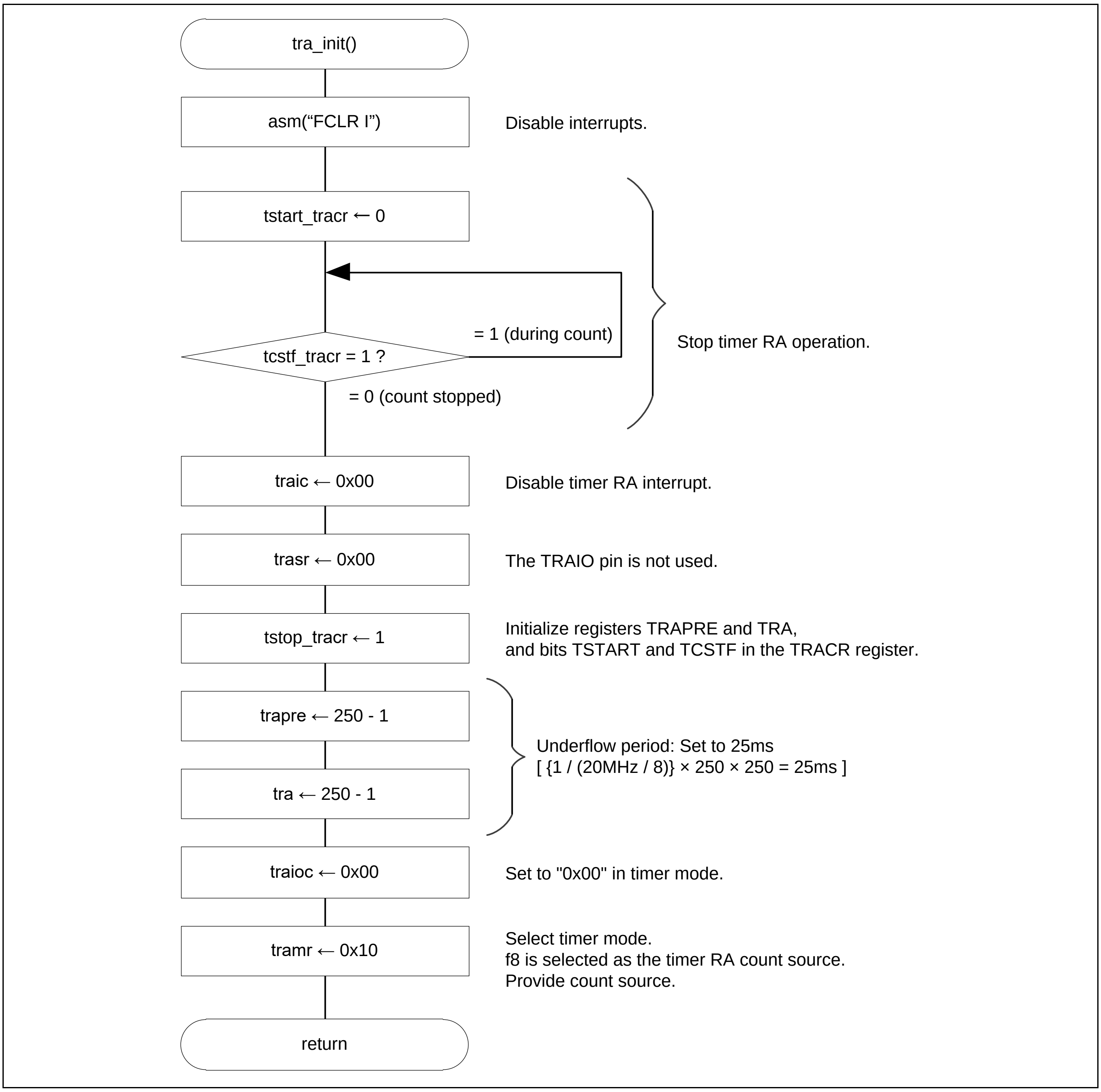

tra_init()
asm(“FCLR I”)
Disable interrupts.
tstart_tracr ← 0
tcstf_tracr = 1 ?
= 1 (during count)
= 0 (count stopped)
Stop timer RA operation.
traic ← 0x00
Disable timer RA interrupt.
trasr ← 0x00
The TRAIO pin is not used.
tstop_tracr ← 1
Initialize registers TRAPRE and TRA,
and bits TSTART and TCSTF in the TRACR register.
trapre ← 250 - 1
tra ← 250 - 1
Underflow period: Set to 25ms
[{1 / (20MHz / 8)} × 250 × 250 = 25ms]
traioc ← 0x00
Set to "0x00" in timer mode.
tramr ← 0x10
Select timer mode.
f8 is selected as the timer RA count source.
Provide count source.
return

Figure 4.6 Initial setting of Timer RA

4.8 Initializing Color Sensor

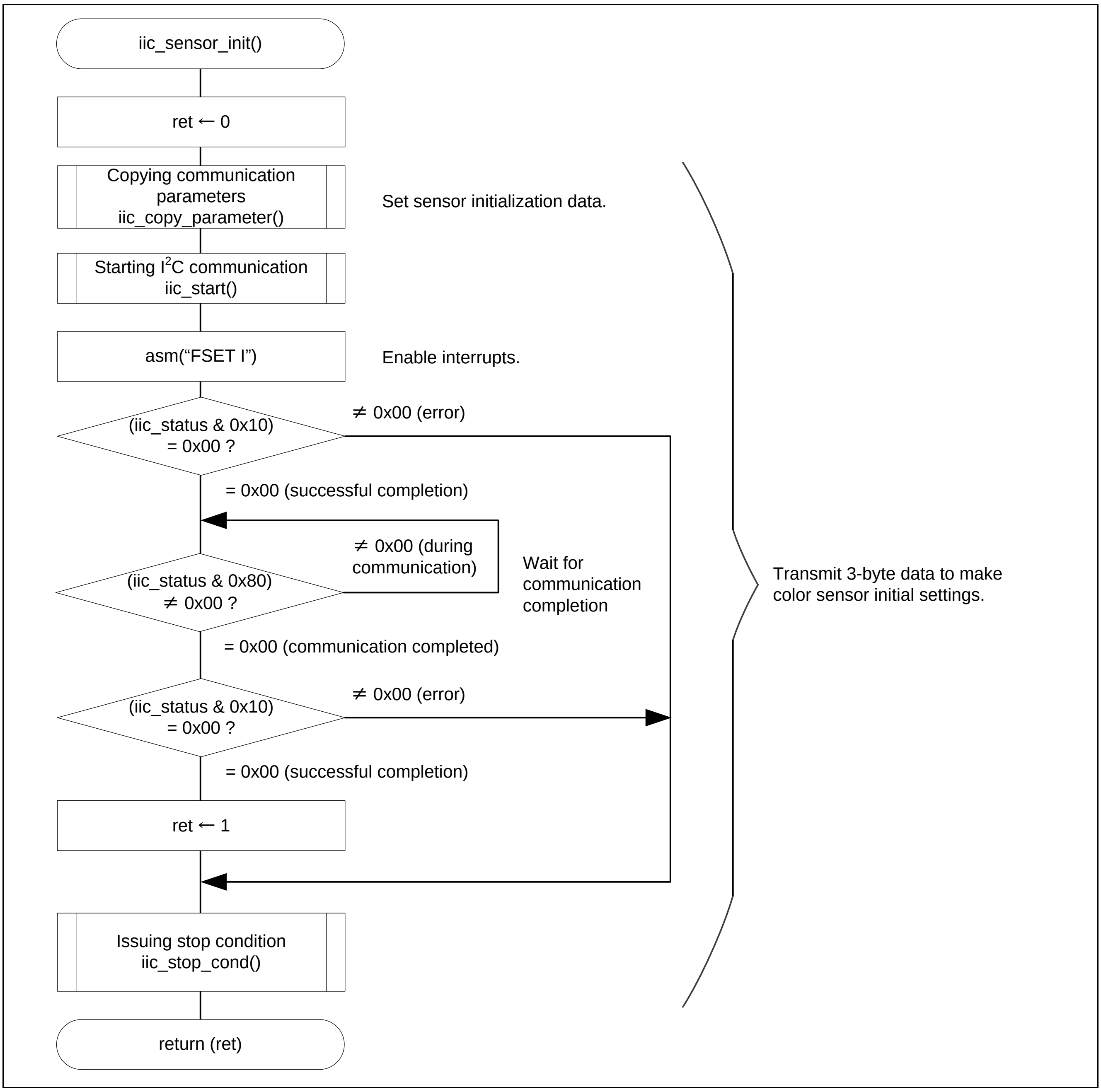

iic_sensor_init()
ret ← 0
Copying communication parameters
iic_copy_parameter()
Set sensor initialization data.
Starting I2C communication
iic_start()
asm(“FSET I”)
Enable interrupts.
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
(iic_status & 0x80) ≠ 0x00 ?
≠ 0x00 (during communication)
Wait for communication completion
= 0x00 (communication completed)
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
ret ← 1
Issuing stop condition
iic_stop_cond()
return (ret)
Transmit 3-byte data to make color sensor initial settings.

Figure 4.7 Initializing Color Sensor

4.9 Copying Communication Parameters

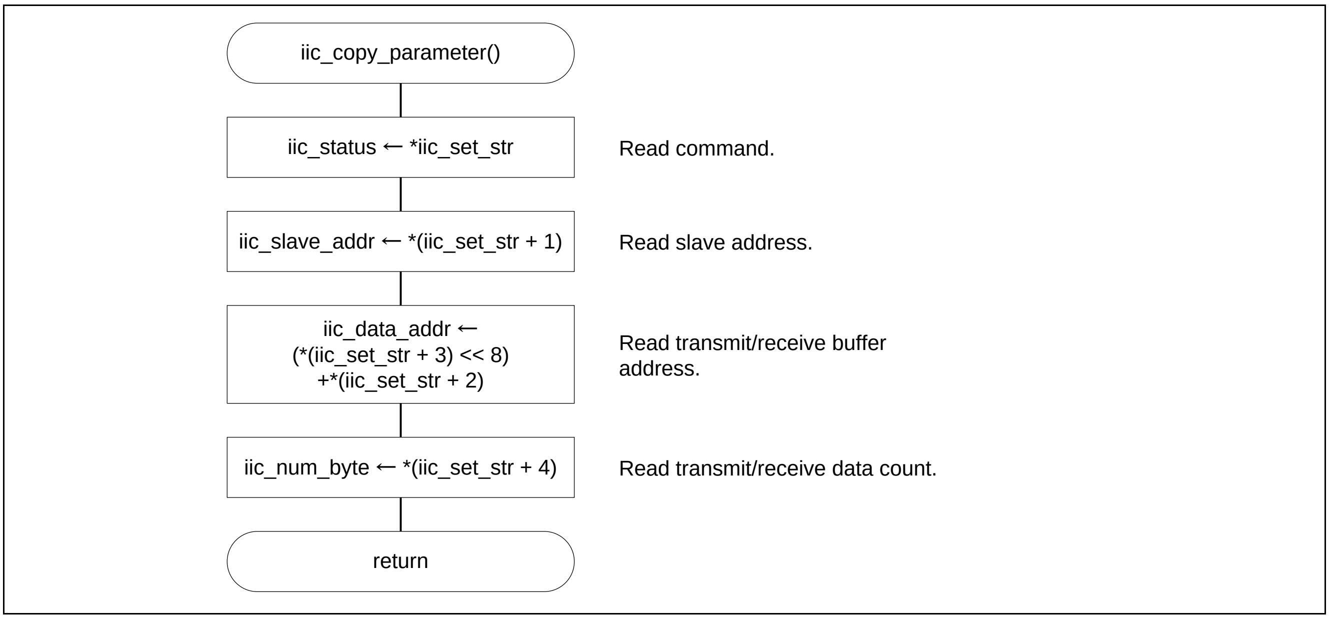

iic_copy_parameter()
iic_status ← *iic_set_str
Read command.
iic_slave_addr ← *(iic_set_str + 1)
Read slave address.
iic_data_addr ← (*(iic_set_str + 3) << 8) +*(iic_set_str + 2)
Read transmit/receive buffer address.
iic_num_byte ← *(iic_set_str + 4)
Read transmit/receive data count.
return

Figure 4.8 Copying Communication Parameters

4.10 Starting I²C Communication

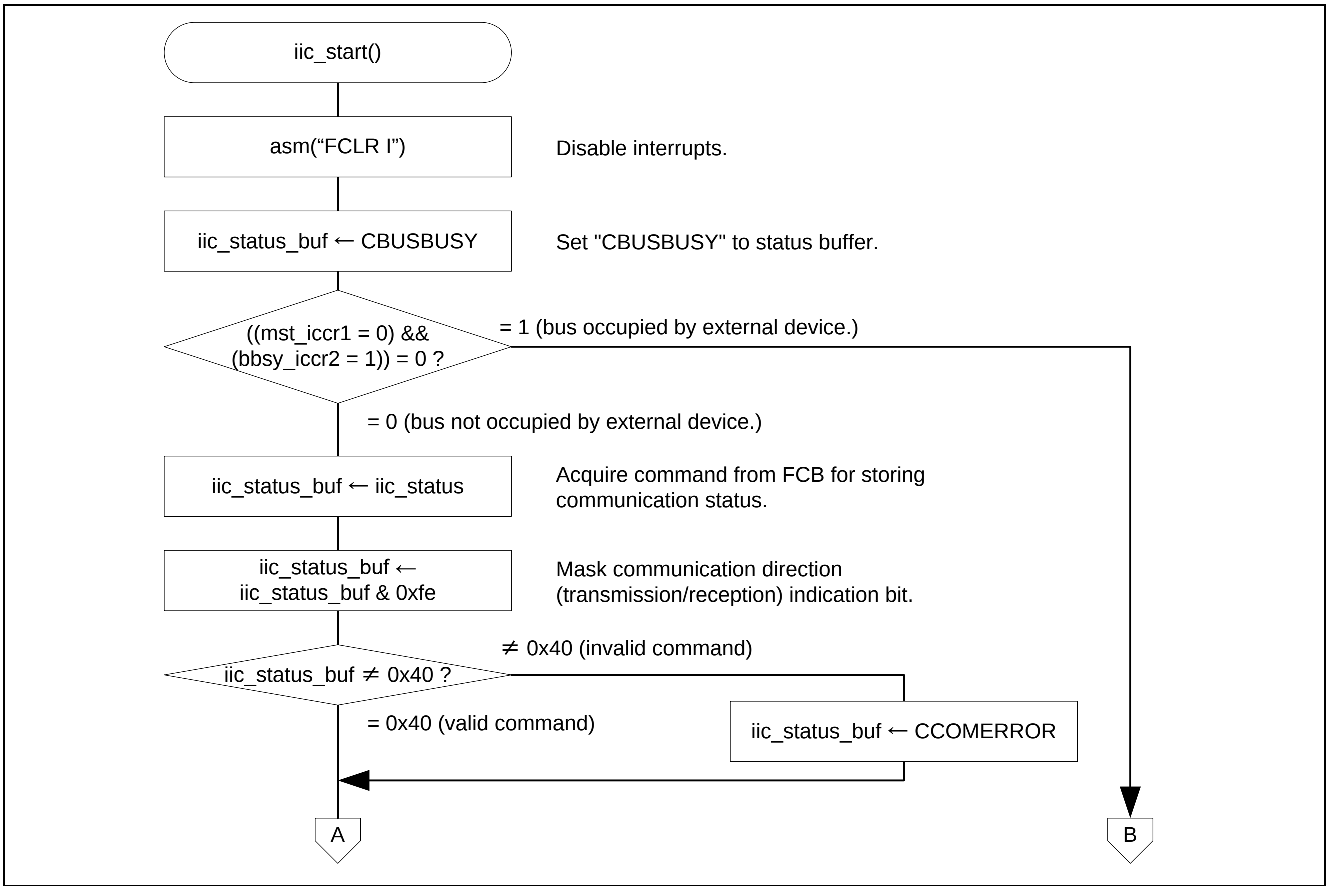

iic_start()
asm("FCLR I")
Disable interrupts.
iic_status_buf ← CBUSBUSY
Set "CBUSBUSY" to status buffer.
((mst_iccr1 = 0) && (bbsy_iccr2 = 1)) = 0 ?
= 1 (bus occupied by external device.)
= 0 (bus not occupied by external device.)
iic_status_buf ← iic_status
Acquire command from FCB for storing communication status.
iic_status_buf ← iic_status_buf & 0xfe
Mask communication direction (transmission/reception) indication bit.
iic_status_buf ≠ 0x40 ?
≠ 0x40 (invalid command)
= 0x40 (valid command)
iic_status_buf ← CCOMERROR
A
B

Figure 4.9 Starting I²C Communication (1/2)

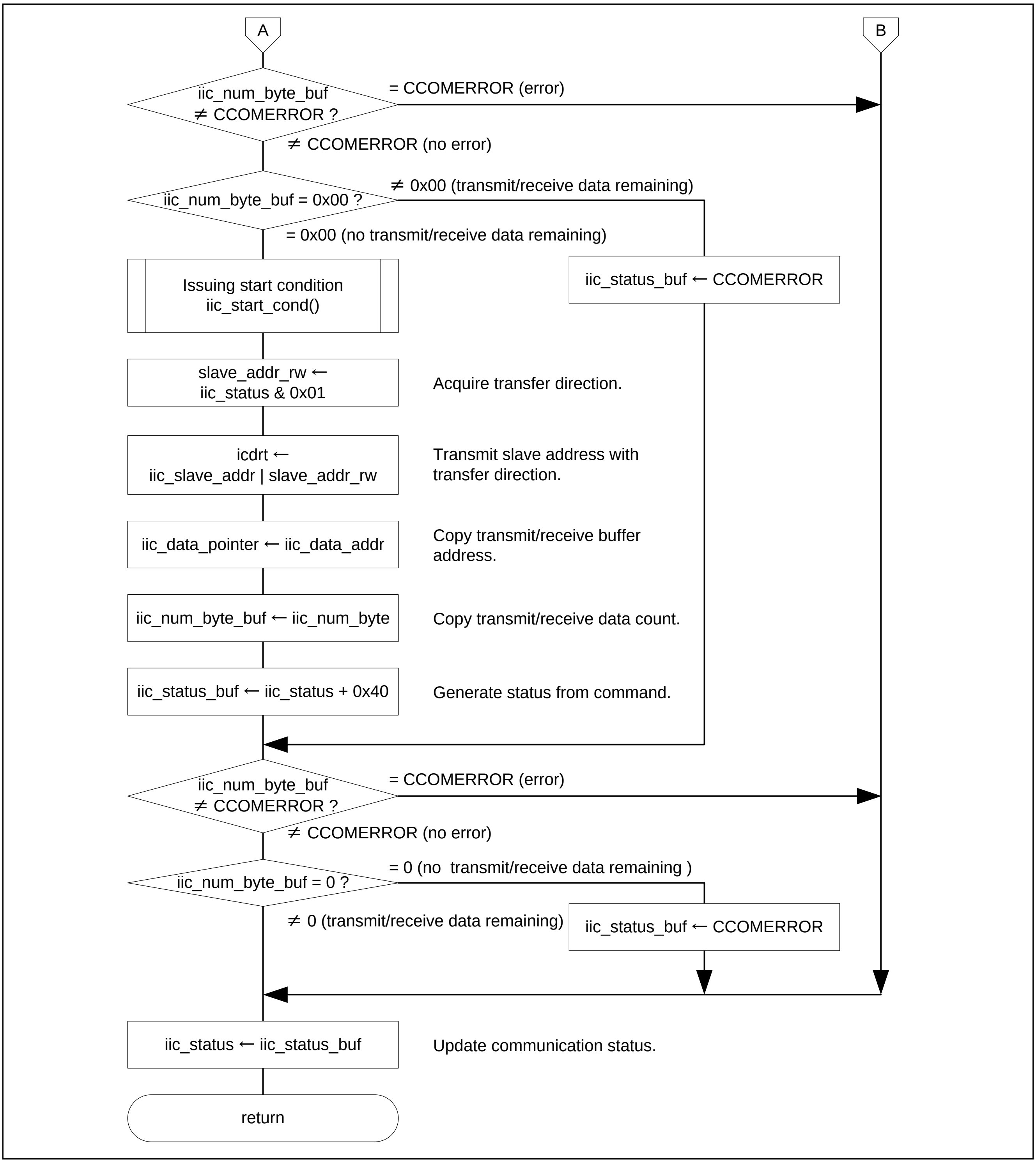

A
B
iic_num_byte_buf
≠ CCOMERROR ?
= CCOMERROR (error)
≠ CCOMERROR (no error)
iic_num_byte_buf = 0x00 ?
≠ 0x00 (transmit/receive data remaining)
= 0x00 (no transmit/receive data remaining)
Issuing start condition
iic_start_cond()
iic_status_buf ← CCOMERROR
slave_addr_rw ←
iic_status & 0x01
Acquire transfer direction.
icdrt ←
iic_slave_addr | slave_addr_rw
Transmit slave address with transfer direction.
iic_data_pointer ← iic_data_addr
Copy transmit/receive buffer address.
iic_num_byte_buf ← iic_num_byte
Copy transmit/receive data count.
iic_status_buf ← iic_status + 0x40
Generate status from command.
iic_num_byte_buf
≠ CCOMERROR ?
= CCOMERROR (error)
≠ CCOMERROR (no error)
iic_num_byte_buf = 0 ?
= 0 (no transmit/receive data remaining)
≠ 0 (transmit/receive data remaining)
iic_status_buf ← CCOMERROR
iic_status ← iic_status_buf
Update communication status.
return

Figure 4.10 Starting I^{2}C Communication (2/2)

4.11 Issuing Start Condition

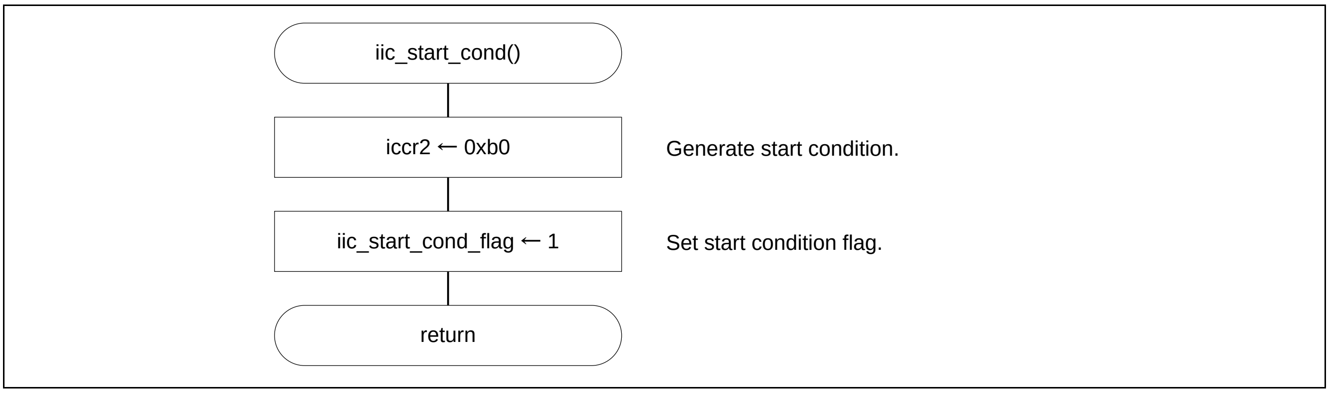


Figure 4.11 Issuing Start Condition

4.12 Issuing Stop Condition

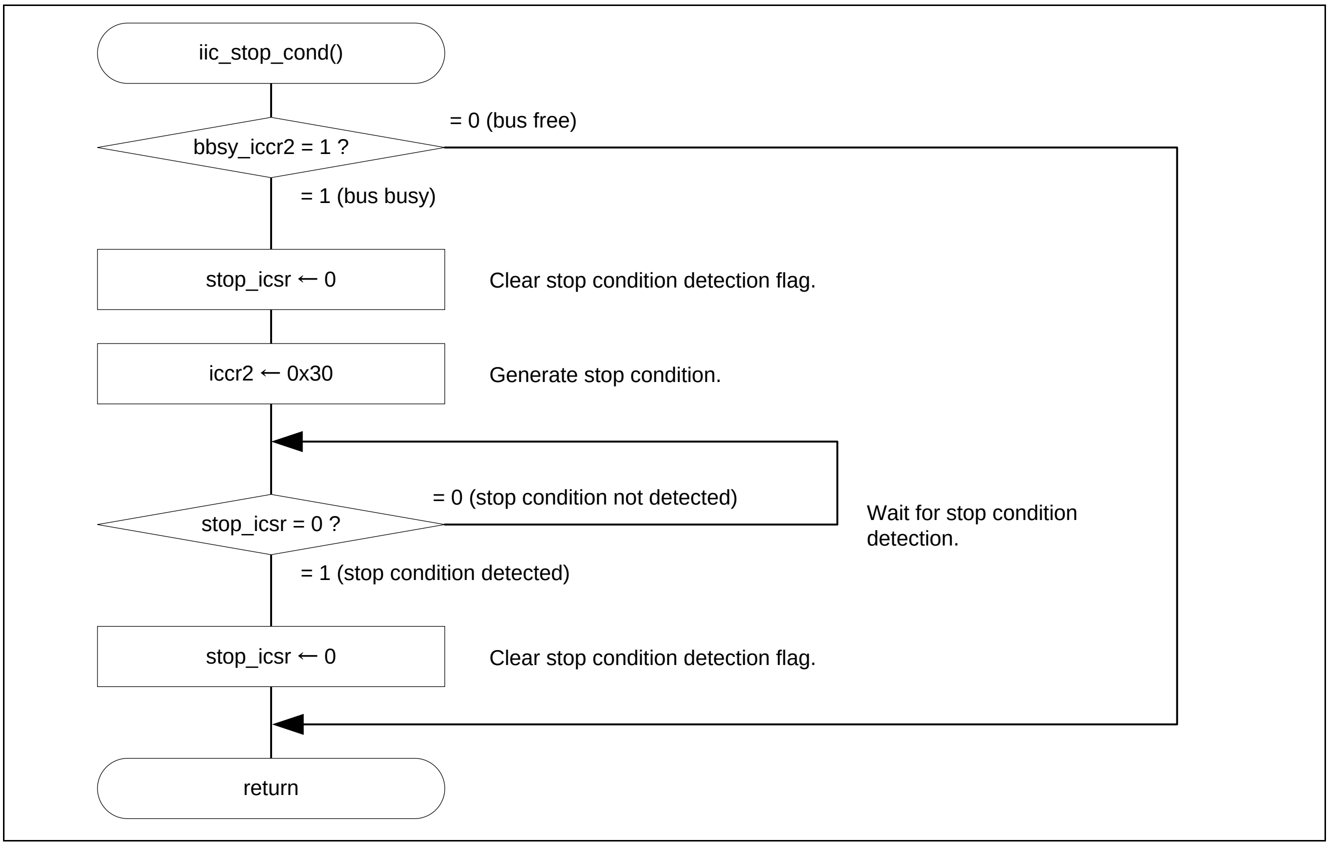

iic_stop_cond()
bbsy_iccr2 = 1 ?
= 0 (bus free)
= 1 (bus busy)
stop_icsr ← 0
Clear stop condition detection flag.
iccr2 ← 0x30
Generate stop condition.
= 0 (stop condition not detected)
stop_icsr = 0 ?
Wait for stop condition detection.
= 1 (stop condition detected)
stop_icsr ← 0
Clear stop condition detection flag.
return

Figure 4.12 Issuing Stop Condition

4.13 Resetting Color Sensor

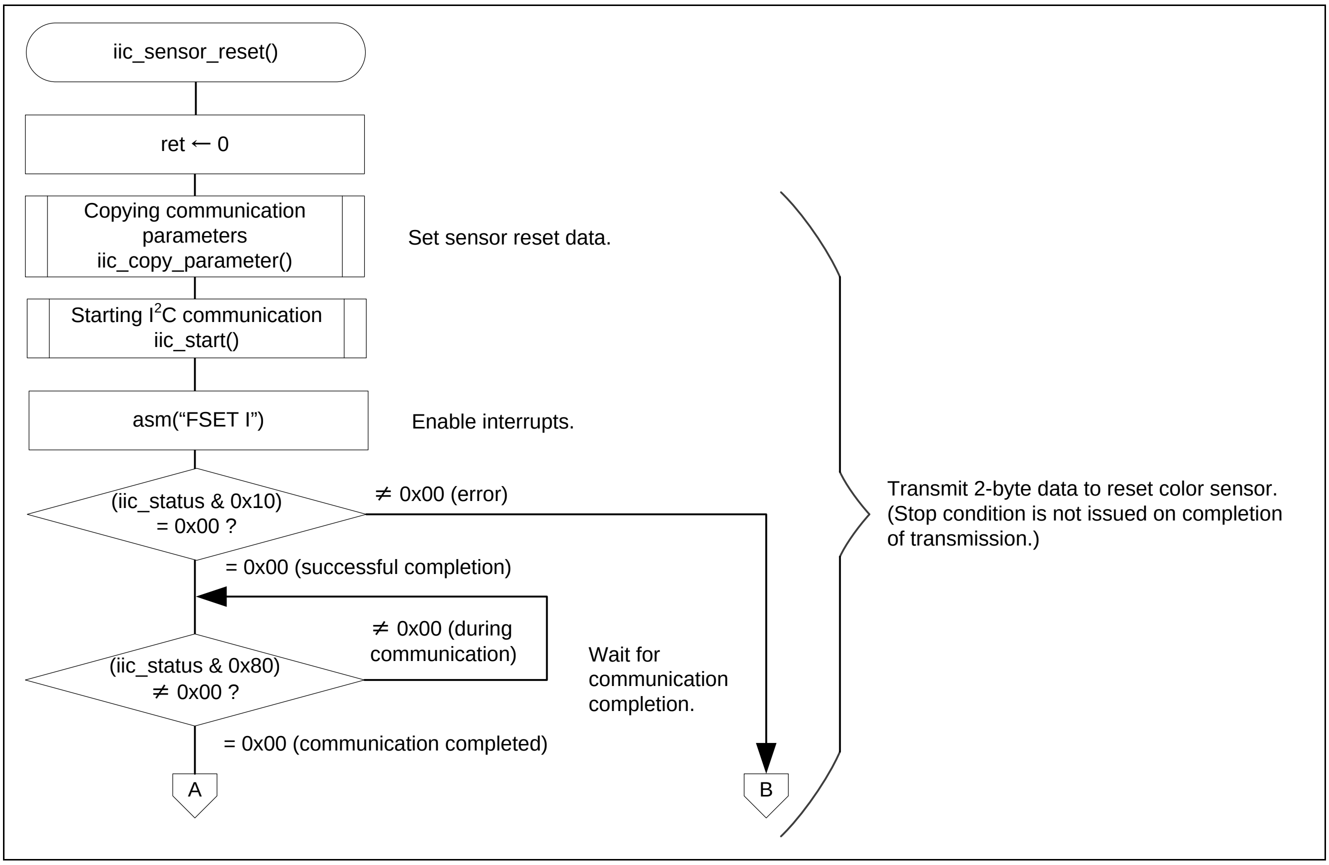

iic_sensor_reset()
ret ← 0
Copying communication parameters iic_copy_parameter()
Set sensor reset data.
Starting I2C communication iic_start()
asm(“FSET I”)
Enable interrupts.
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
≠ 0x00 (during communication)
(iic_status & 0x80) ≠ 0x00 ?
Wait for communication completion.
= 0x00 (communication completed)
A
B
Transmit 2-byte data to reset color sensor. (Stop condition is not issued on completion of transmission.)

Figure 4.13 Resetting Color Sensor (1/2)

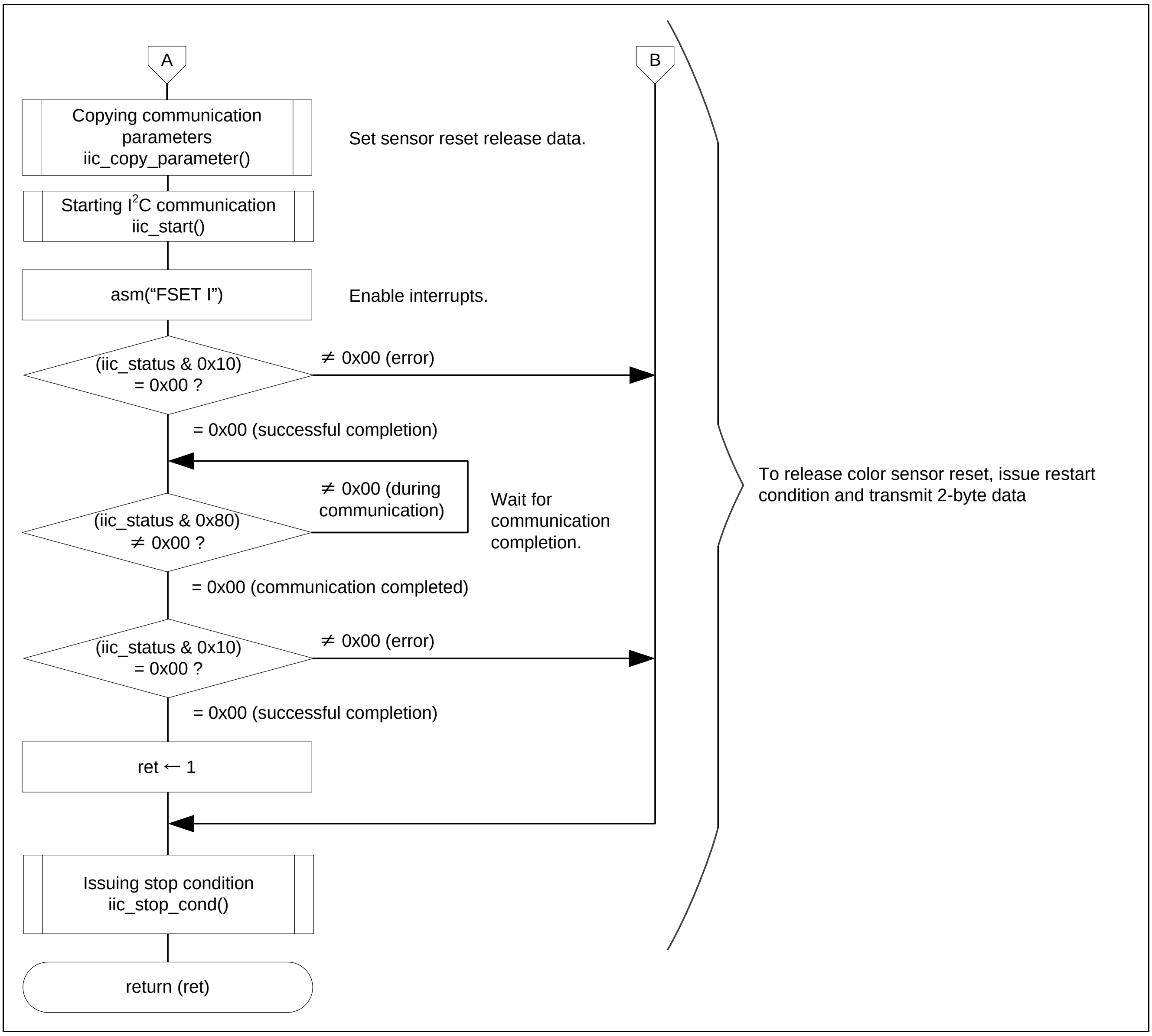

A
B
Copying communication parameters iic_copy_parameter()
Set sensor reset release data.
Starting I^{2}C communication iic_start()
asm("FSET I")
Enable interrupts.
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
(iic_status & 0x80) ≠ 0x00 ?
≠ 0x00 (during communication)
Wait for communication completion.
= 0x00 (communication completed)
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
ret ← 1
Issuing stop condition iic_stop_cond()
return (ret)
To release color sensor reset, issue restart condition and transmit 2-byte data

Figure 4.14 Resetting Color Sensor (2/2)

4.14 Waiting for Light Intensity Measurement Completion

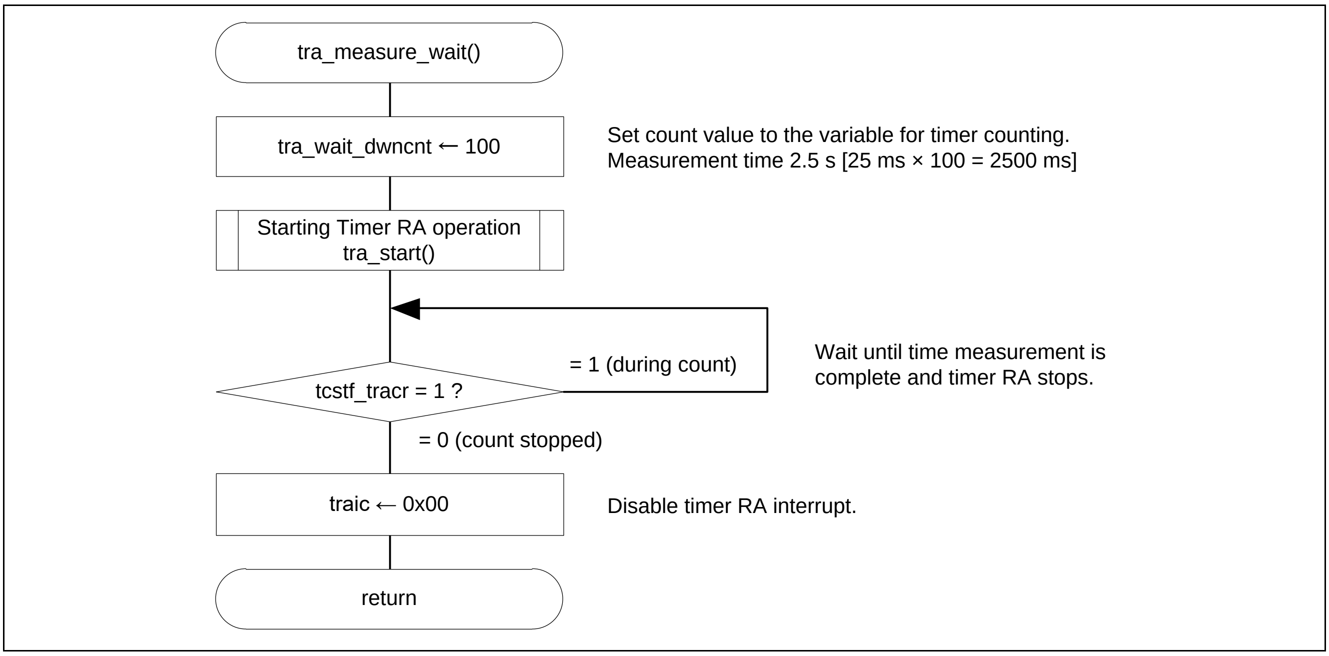

tra_measure_wait()
tra_wait_dwncnt ← 100
Set count value to the variable for timer counting.
Measurement time 2.5 s [25 ms × 100 = 2500 ms]
Starting Timer RA operation
tra_start()
= 1 (during count)
Wait until time measurement is
complete and timer RA stops.
tcstf_tracr = 1 ?
= 0 (count stopped)
traic ← 0x00
Disable timer RA interrupt.
return

Figure 4.15 Waiting for Light Intensity Measurement Completion

4.15 Starting Timer RA Operation

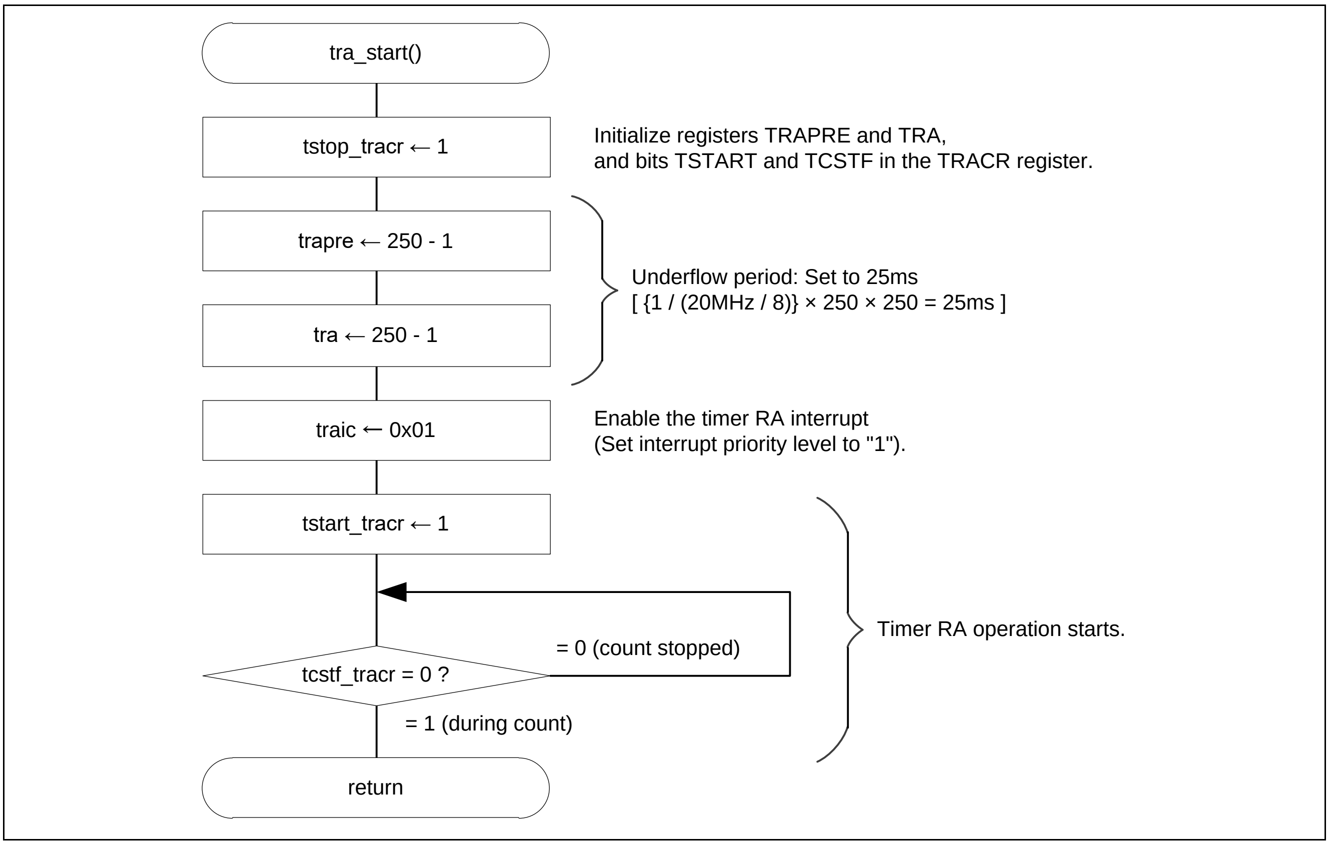

tra_start()
tstop_tracr ← 1
Initialize registers TRAPRE and TRA,
and bits TSTART and TCSTF in the TRACR register.
trapre ← 250 - 1
Underflow period: Set to 25ms
[{1 / (20MHz / 8)} × 250 × 250 = 25ms]
tra ← 250 - 1
traic ← 0x01
Enable the timer RA interrupt
(Set interrupt priority level to "1").
tstart_tracr ← 1
Timer RA operation starts.
= 0 (count stopped)
tcstf_tracr = 0 ?
= 1 (during count)
return

Figure 4.16 Starting Timer RA Operation

4.16 Reading Measurement Data

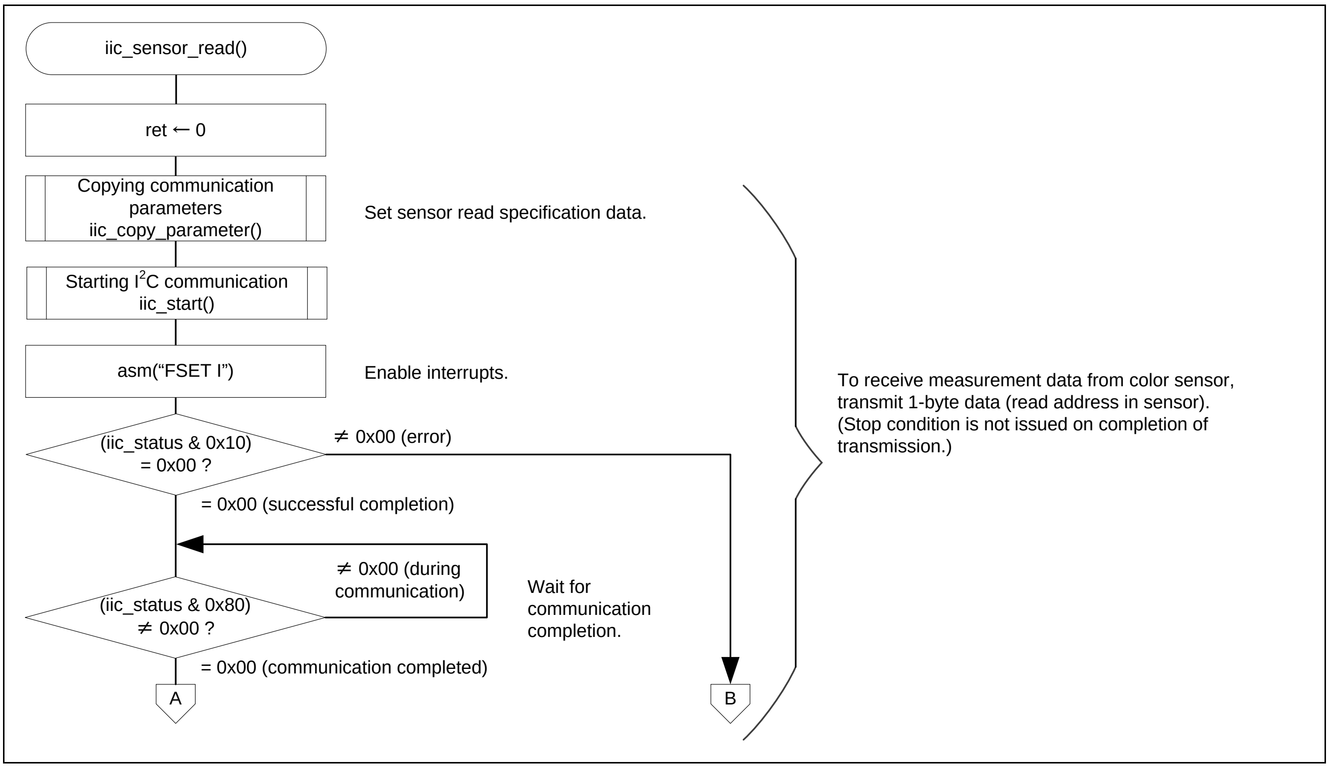

iic_sensor_read()
ret ← 0
Copying communication parameters iic_copy_parameter()
Set sensor read specification data.
Starting I2C communication iic_start()
asm("FSET I")
Enable interrupts.
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
≠ 0x00 (during communication)
(iic_status & 0x80) ≠ 0x00 ?
Wait for communication completion.
= 0x00 (communication completed)
A
B
To receive measurement data from color sensor, transmit 1-byte data (read address in sensor). (Stop condition is not issued on completion of transmission.)

Figure 4.17 Reading Measurement Data (1/2)

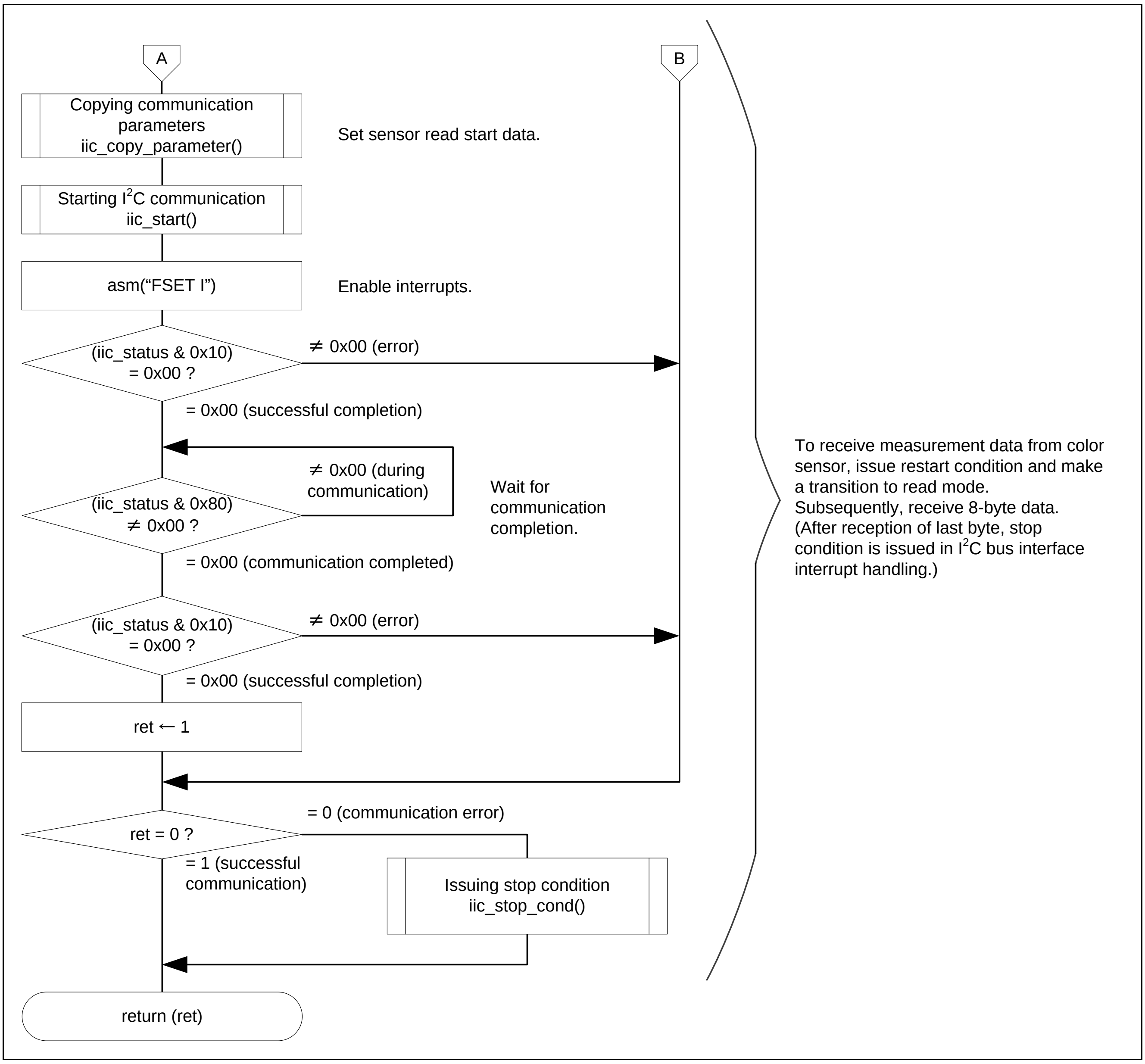
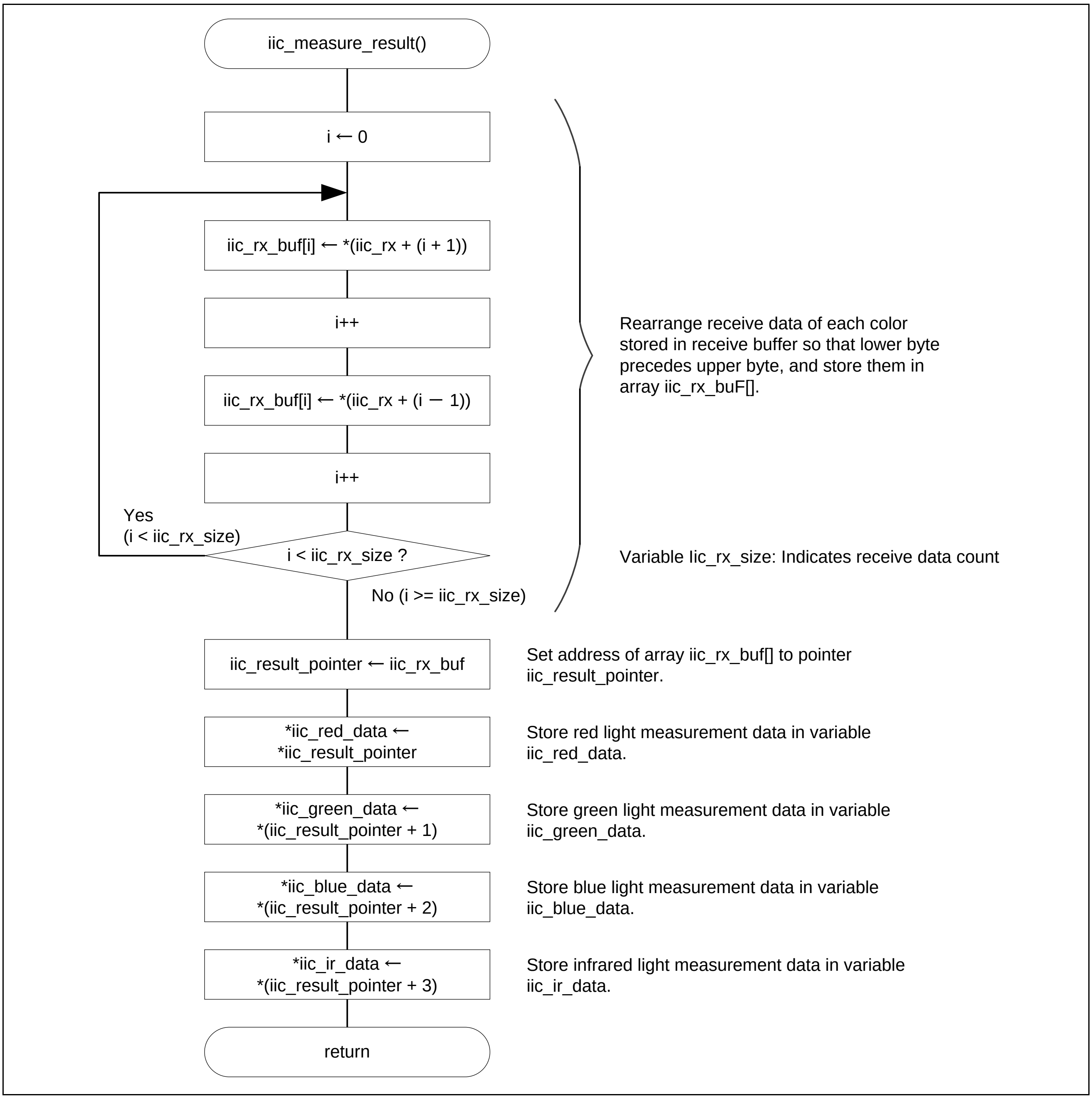

A
B
Copying communication parameters iic_copy_parameter()
Set sensor read start data.
Starting I²C communication iic_start()
asm("FSET I")
Enable interrupts.
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
(iic_status & 0x80) ≠ 0x00 ?
≠ 0x00 (during communication)
Wait for communication completion.
= 0x00 (communication completed)
(iic_status & 0x10) = 0x00 ?
≠ 0x00 (error)
= 0x00 (successful completion)
ret ← 1
ret = 0 ?
= 0 (communication error)
= 1 (successful communication)
Issuing stop condition iic_stop_cond()
return (ret)
To receive measurement data from color sensor, issue restart condition and make a transition to read mode.
Subsequently, receive 8-byte data.
(After reception of last byte, stop condition is issued in I²C bus interface interrupt handling.)

Figure 4.18 Reading Measurement Data (2/2)

4.17 Processing Measurement Results


iic_measure_result()
i ← 0
iic_rx_buf[i] ← *(iic_rx + (i + 1))
i++
iic_rx_buf[i] ← *(iic_rx + (i − 1))
i++
Yes
(i < iic_rx_size)
i < iic_rx_size ?
No (i >= iic_rx_size)
iic_result_pointer ← iic_rx_buf
*iic_red_data ←
*iic_result_pointer
*iic_green_data ←
*(iic_result_pointer + 1)
*iic_blue_data ←
*(iic_result_pointer + 2)
*iic_ir_data ←
*(iic_result_pointer + 3)
return

Rearrange receive data of each color stored in receive buffer so that lower byte precedes upper byte, and store them in array iic_rx_buF[].

Variable Iic_rx_size: Indicates receive data count

Set address of array iic_rx_buf[] to pointer iic_result_pointer.

Store red light measurement data in variable iic_red_data.

Store green light measurement data in variable iic_green_data.

Store blue light measurement data in variable iic_blue_data.

Store infrared light measurement data in variable iic_ir_data.

Figure 4.19 Processing Measurement Results

4.18 Waiting for Communication Restart

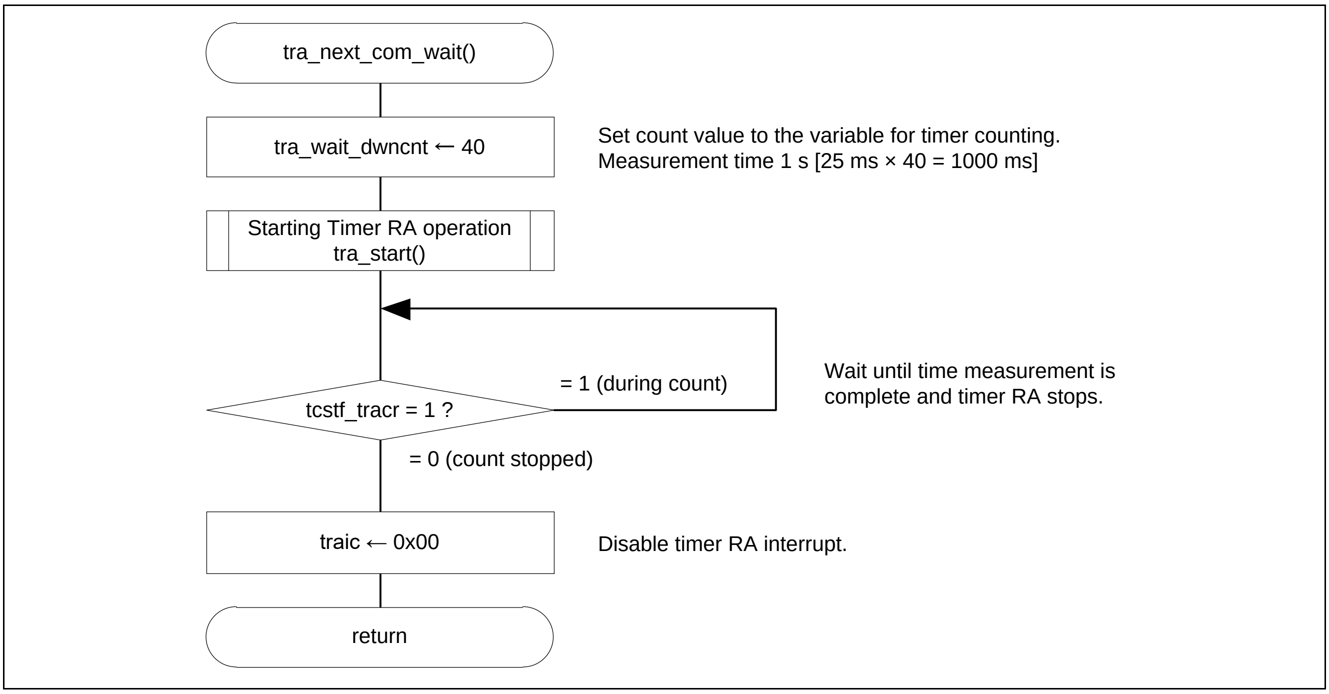

tra_next_com_wait()
tra_wait_dwncnt ← 40
Set count value to the variable for timer counting.
Measurement time 1 s [25 ms × 40 = 1000 ms]
Starting Timer RA operation
tra_start()
= 1 (during count)
Wait until time measurement is complete and timer RA stops.
tcstf_tracr = 1 ?
= 0 (count stopped)
traic ← 0x00
Disable timer RA interrupt.
return

Figure 4.20 Waiting for Communication Restart

4.19 Processing I^{2}C Communication Error

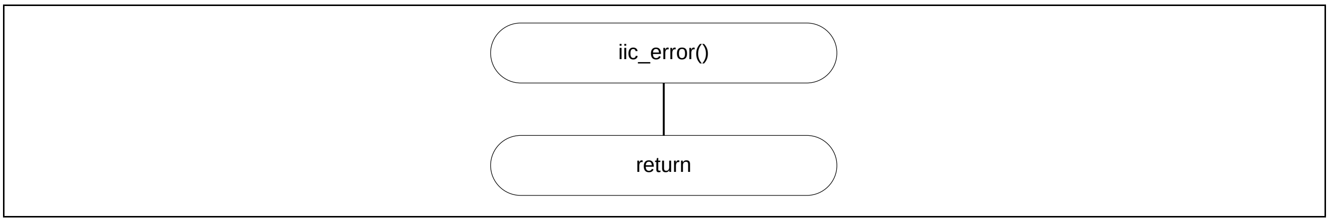


Figure 4.21 Processing I^{2}C Communication Error

4.20 I^{2}C bus Interface Interrupt Handling

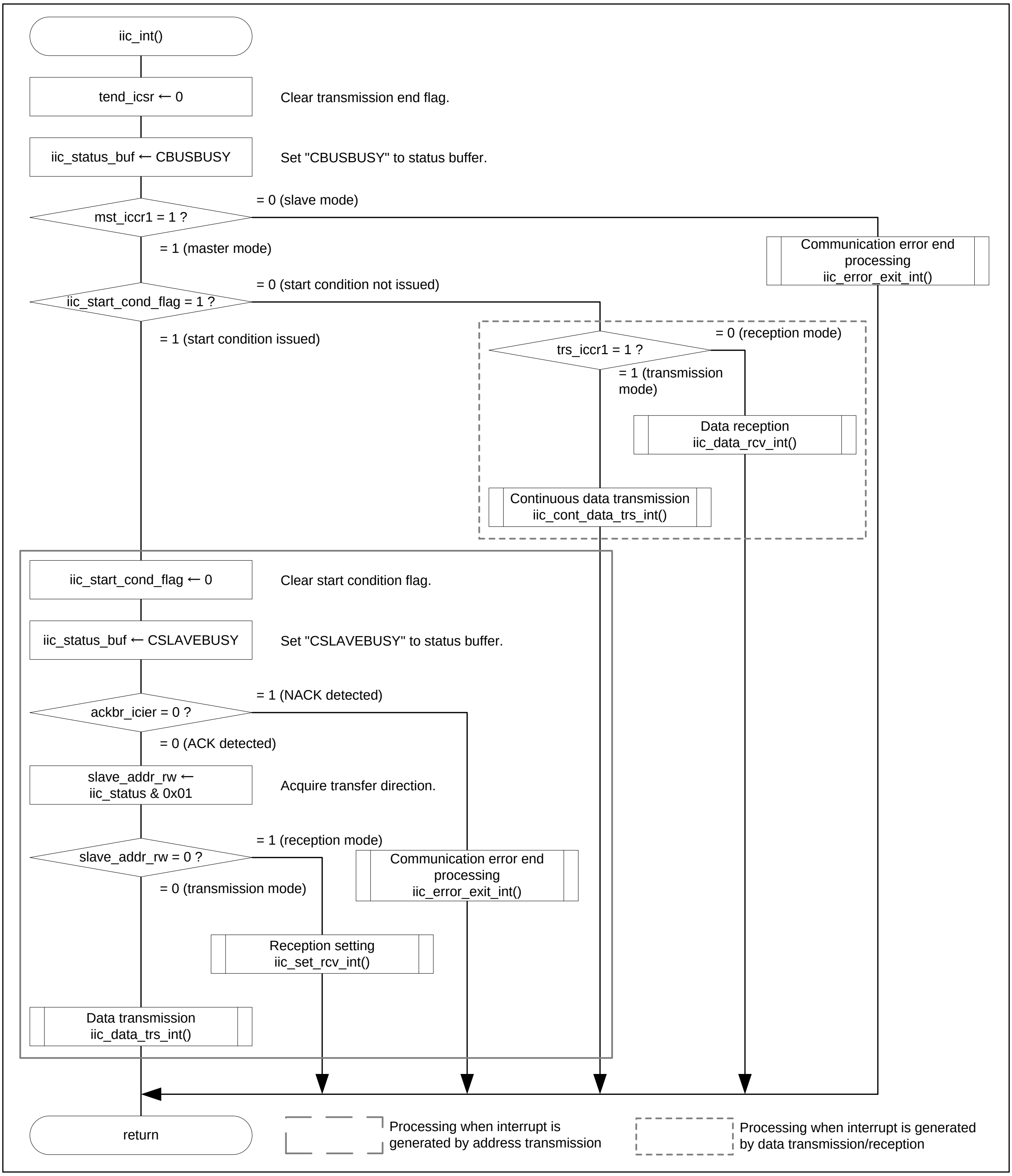

iic_int()
tend_icsr ← 0
Clear transmission end flag.
iic_status_buf ← CBUSBUSY
Set "CBUSBUSY" to status buffer.
mst_iccr1 = 1 ?
= 0 (slave mode)
= 1 (master mode)
Communication error end processing
iic_error_exit_int()
iic_start_cond_flag = 1 ?
= 0 (start condition not issued)
= 1 (start condition issued)
trs_iccr1 = 1 ?
= 0 (reception mode)
= 1 (transmission mode)
Data reception
iic_data_rcv_int()
Continuous data transmission
iic_cont_data_trs_int()
iic_start_cond_flag ← 0
Clear start condition flag.
iic_status_buf ← CSLAVEBUSY
Set "CSLAVEBUSY" to status buffer.
ackbr_icier = 0 ?
= 1 (NACK detected)
= 0 (ACK detected)
slave_addr_rw ← iic_status & 0x01
Acquire transfer direction.
slave_addr_rw = 0 ?
= 1 (reception mode)
= 0 (transmission mode)
Communication error end processing
iic_error_exit_int()
Reception setting
iic_set_rcv_int()
Data transmission
iic_data_trs_int()
return
Processing when interrupt is generated by address transmission
Processing when interrupt is generated by data transmission/reception

Figure 4.22 I^{2}C bus Interface Interrupt Handling

4.21 Data Transmission

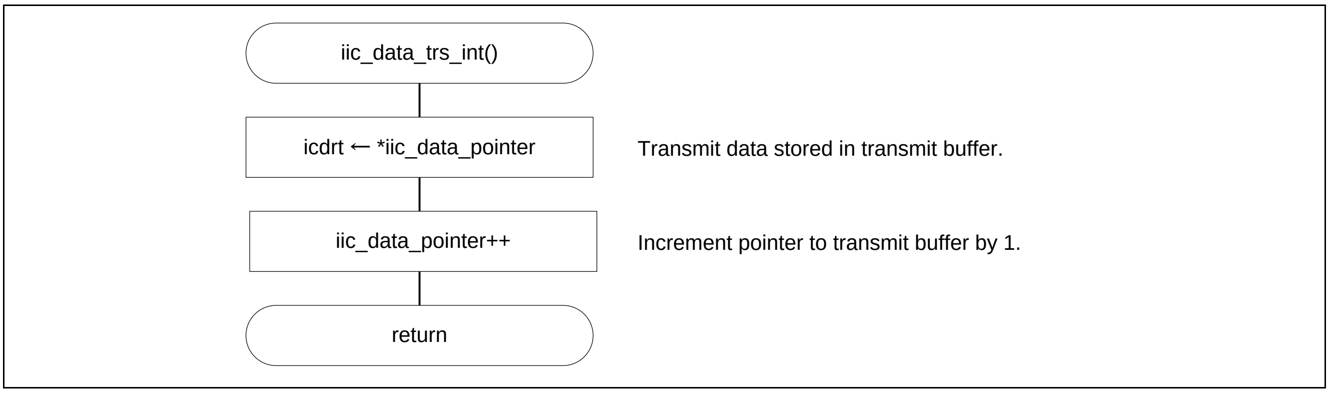

iic_data_trs_int()
icdrt ← *iic_data_pointer
Transmit data stored in transmit buffer.
iic_data_pointer++
Increment pointer to transmit buffer by 1.
return

Figure 4.23 Data Transmission

4.22 Continuous Data Transmission

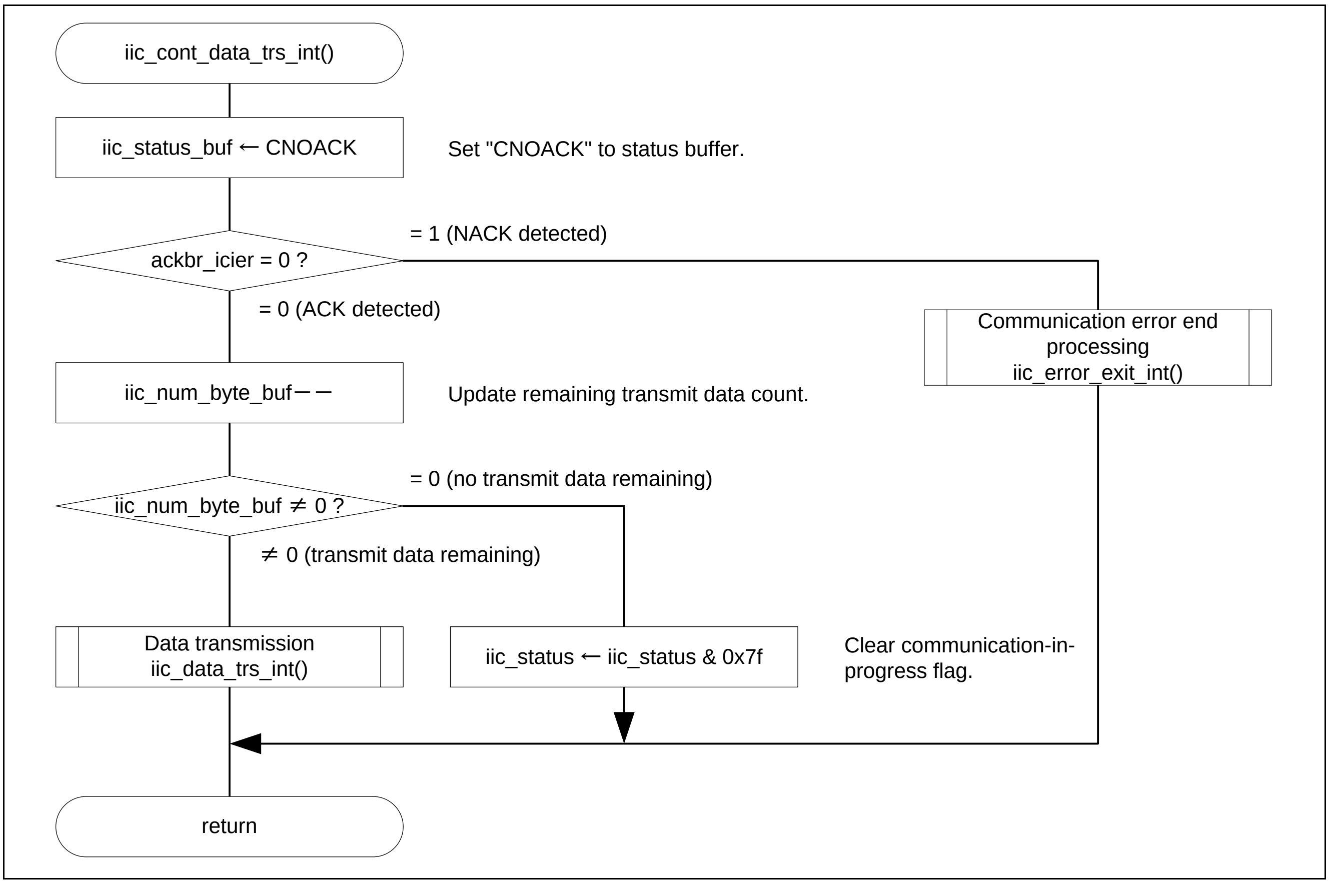

iic_cont_data_trs_int()
iic_status_buf ← CNOACK
Set "CNOACK" to status buffer.
= 1 (NACK detected)
ackbr_icier = 0 ?
= 0 (ACK detected)
Communication error end processing
iic_error_exit_int()
iic_num_byte_buf− −
Update remaining transmit data count.
= 0 (no transmit data remaining)
iic_num_byte_buf ≠ 0 ?
≠ 0 (transmit data remaining)
Data transmission
iic_data_trs_int()
iic_status ← iic_status & 0x7f
Clear communication-in-progress flag.
return

Figure 4.24 Continuous Data Transmission

4.23 Reception Settings

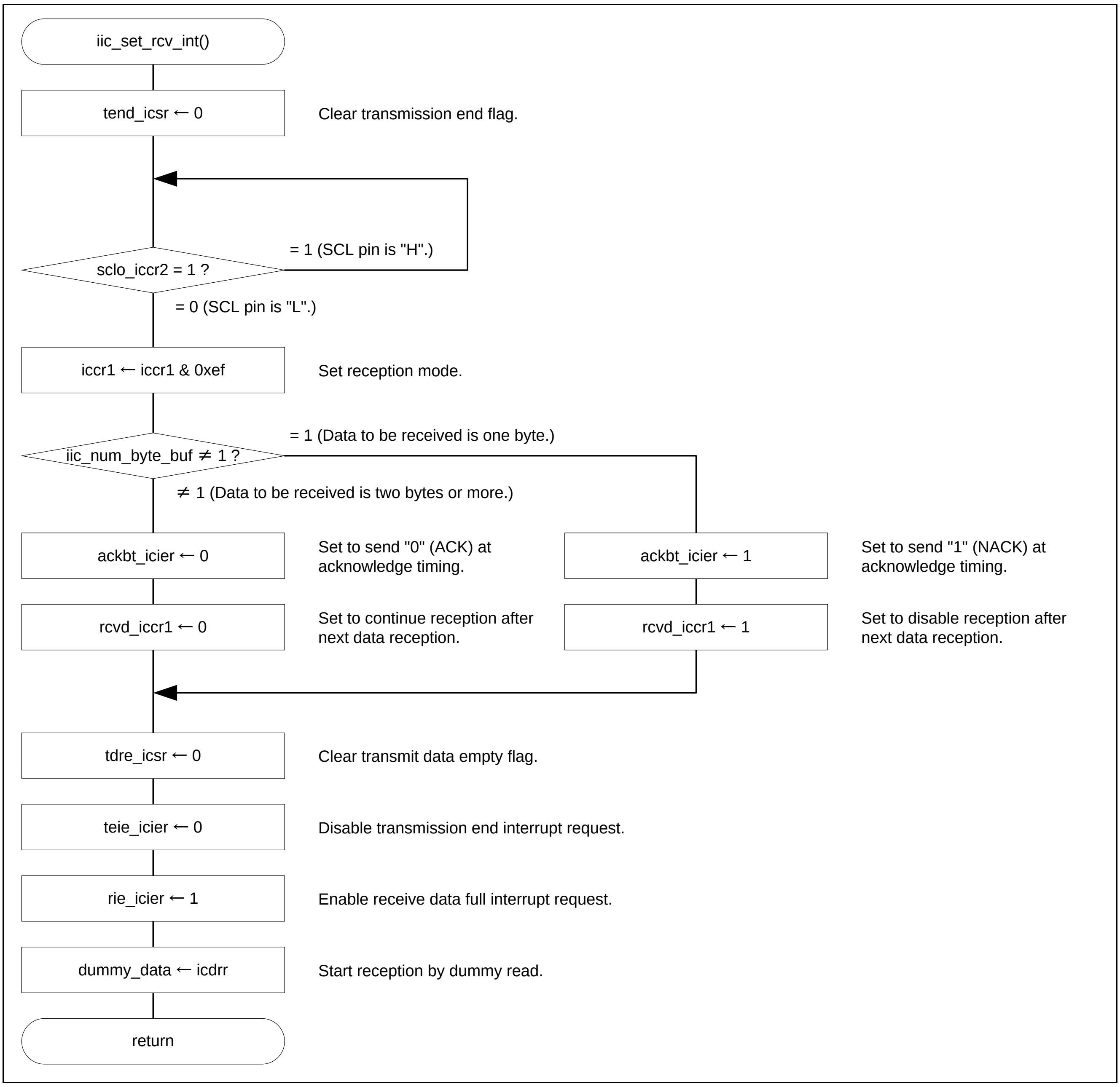

iic_set_rcv_int()
tend_icsr ← 0
Clear transmission end flag.
= 1 (SCL pin is "H".)
sclo_iccr2 = 1 ?
= 0 (SCL pin is "L".)
iccr1 ← iccr1 & 0xef
Set reception mode.
= 1 (Data to be received is one byte.)
iic_num_byte_buf ≠ 1 ?
≠ 1 (Data to be received is two bytes or more.)
ackbt_icier ← 0
Set to send "0" (ACK) at acknowledge timing.
ackbt_icier ← 1
Set to send "1" (NACK) at acknowledge timing.
rcvd_iccr1 ← 0
Set to continue reception after next data reception.
rcvd_iccr1 ← 1
Set to disable reception after next data reception.
tdre_icsr ← 0
Clear transmit data empty flag.
teie_icier ← 0
Disable transmission end interrupt request.
rie_icier ← 1
Enable receive data full interrupt request.
dummy_data ← icdrr
Start reception by dummy read.
return

Figure 4.25 Reception Settings

4.24 Data Reception

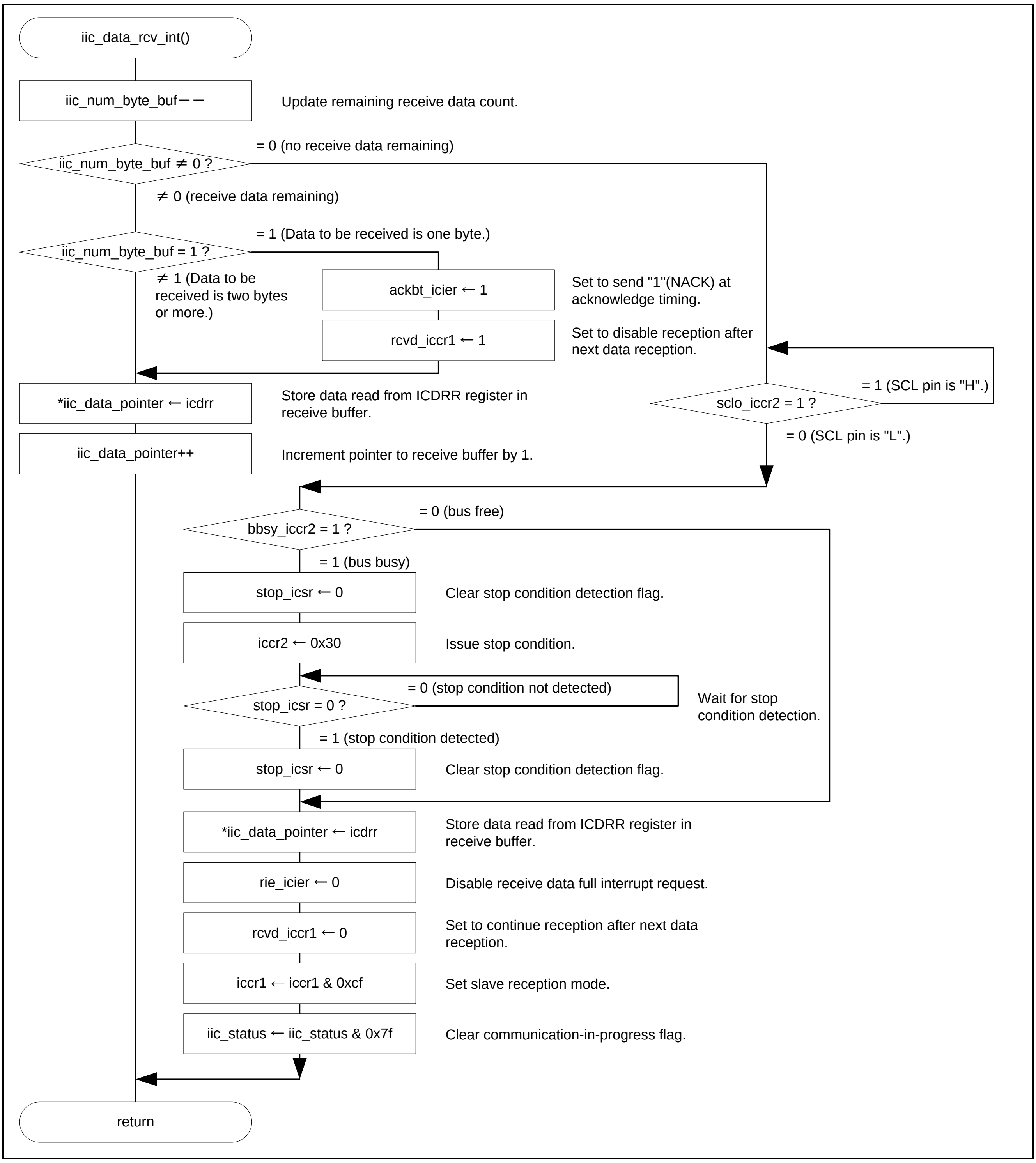

iic_data_rcv_int()
iic_num_byte_buf− −
Update remaining receive data count.
iic_num_byte_buf ≠ 0 ?
= 0 (no receive data remaining)
≠ 0 (receive data remaining)
iic_num_byte_buf = 1 ?
= 1 (Data to be received is one byte.)
≠ 1 (Data to be received is two bytes or more.)
ackbt_icier ← 1
Set to send "1"(NACK) at acknowledge timing.
rcvd_iccr1 ← 1
Set to disable reception after next data reception.
sclo_iccr2 = 1 ?
= 1 (SCL pin is "H".)
= 0 (SCL pin is "L".)
*iic_data_pointer ← icdrr
Store data read from ICDRR register in receive buffer.
iic_data_pointer++
Increment pointer to receive buffer by 1.
bbsy_iccr2 = 1 ?
= 0 (bus free)
= 1 (bus busy)
stop_icsr ← 0
Clear stop condition detection flag.
iccr2 ← 0x30
Issue stop condition.
stop_icsr = 0 ?
= 0 (stop condition not detected)
Wait for stop condition detection.
= 1 (stop condition detected)
stop_icsr ← 0
Clear stop condition detection flag.
*iic_data_pointer ← icdrr
Store data read from ICDRR register in receive buffer.
rie_icier ← 0
Disable receive data full interrupt request.
rcvd_iccr1 ← 0
Set to continue reception after next data reception.
iccr1 ← iccr1 & 0xcf
Set slave reception mode.
iic_status ← iic_status & 0x7f
Clear communication-in-progress flag.
return

Figure 4.26 Data Reception

4.25 Communication Error End Processing

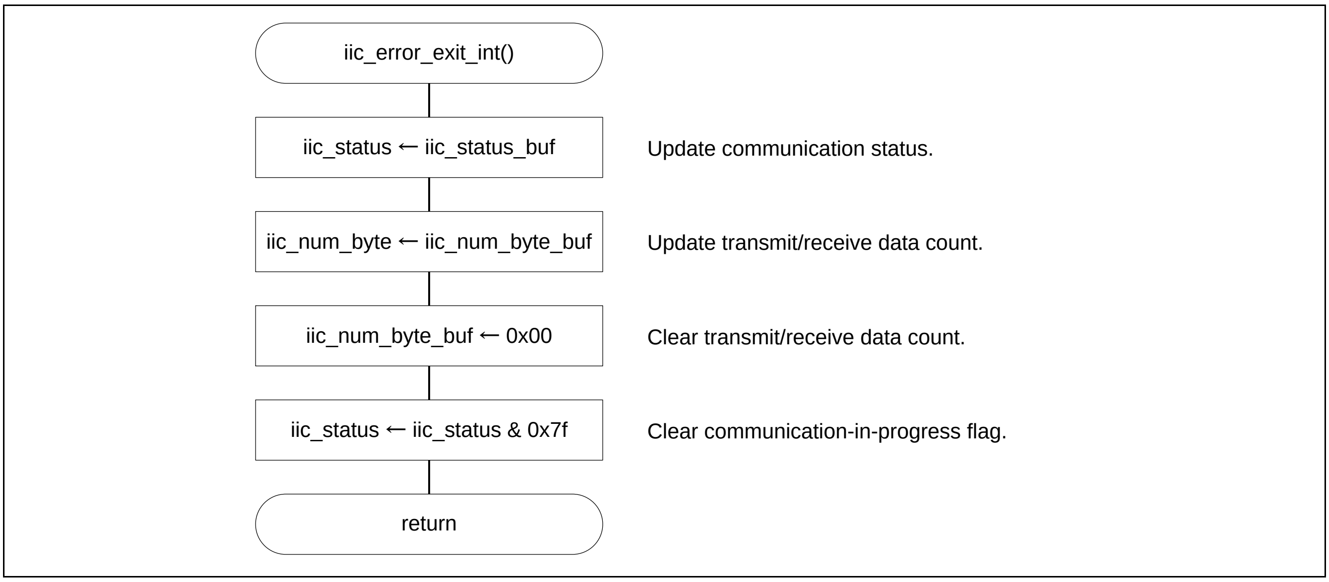

iic_error_exit_int()
iic_status ← iic_status_buf
Update communication status.
iic_num_byte ← iic_num_byte_buf
Update transmit/receive data count.
iic_num_byte_buf ← 0x00
Clear transmit/receive data count.
iic_status ← iic_status & 0x7f
Clear communication-in-progress flag.
return

Figure 4.27 Communication Error End Processing

4.26 Timer RA Interrupt Handling

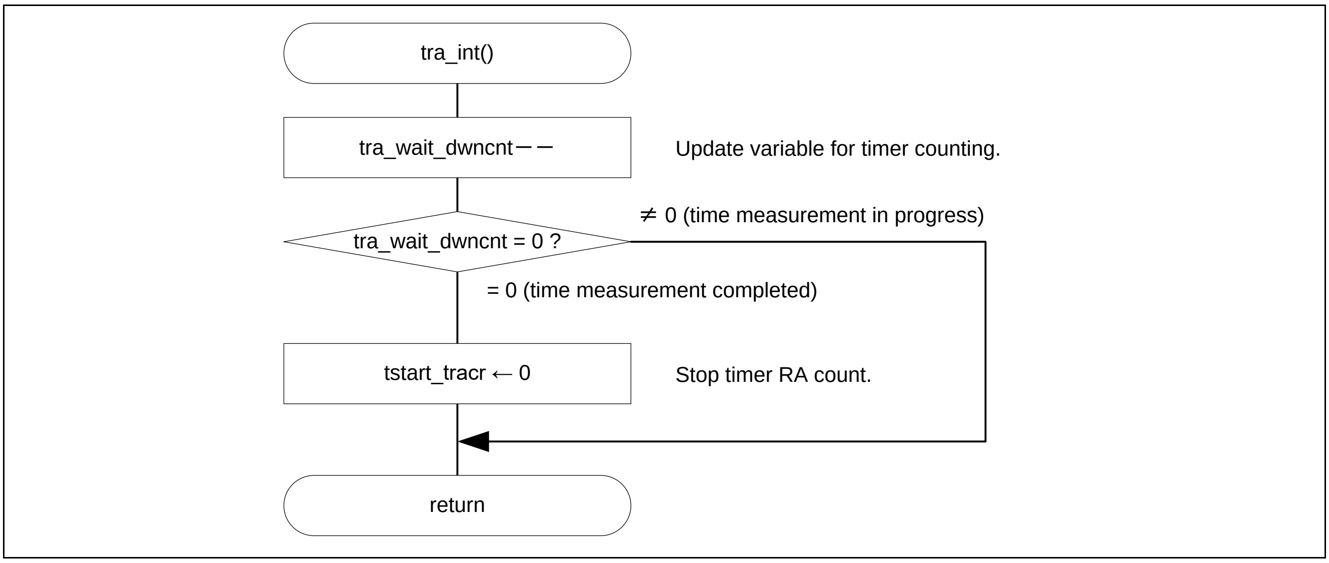

tra_int()
tra_wait_dwncnt− −
Update variable for timer counting.
tra_wait_dwncnt = 0 ?
≠ 0 (time measurement in progress)
= 0 (time measurement completed)
tstart_tracr ← 0
Stop timer RA count.
return

Figure 4.28 Timer RA Interrupt Handling

5. Sample Program

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

R8C/35C Group User’s Manual Hardware Rev.1.00

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

Technical Update/Technical News

The latest information can be downloaded from the Renesas Electronics website.

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Renesas Electronics website

http://japan.renesas.com/

Inquiries

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	May 11, 2017	—	First edition issued

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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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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