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H8S Family

Multi-Master Mode Communications Using I²C Bus Interface 2 (IIC2)

Introduction

This application note describes the usage of the I²C bus interface 2 (IIC2) module in the multi-master mode.

Target Device

H8S/2378

Contents

1. Specifications

- Figure 1 shows the connections for communications using the I²C bus interface 2 in multi-master mode. The slave addresses and settings for the SAR_0 registers of the individual devices are listed in table 1.
- The multi-master system in this sample task consists of two master devices and one slave device.
- The I²C bus transfer rate is 98.2 kbits/s (kHz).
- When communications from master 1 and master 2 are attempted simultaneously, the master that loses the arbitration will stop processing.

The following describes the procedures for the operation of this sample task.

1. The I²C bus interface multi-master transfer starts on the input of the low trigger to the $\overline{\text{IRQ0}}$ pin of the master side.
2. The master side transmits 128 bytes of data, which have been prepared in the on-chip ROM in advance, to the on-chip RAM on the slave side.
3. The slave device returns the 128 bytes of data received in step 2 from its on-chip RAM to the on-chip RAM on the master side.
4. The master side compares the received data in its on-chip RAM with the data transmitted from its on-chip ROM, and confirms whether the two match.
5. Based on the results of this comparison and the state of arbitration lost, the master side outputs levels on the PE2 to PE0 pins that indicate the result of operation.
6. From the value of the first byte of received data on the slave side, the slave judges whether the partner in communications is master 1 or master 2, and outputs levels on pins P15 and P14 that indicate the state of operation.

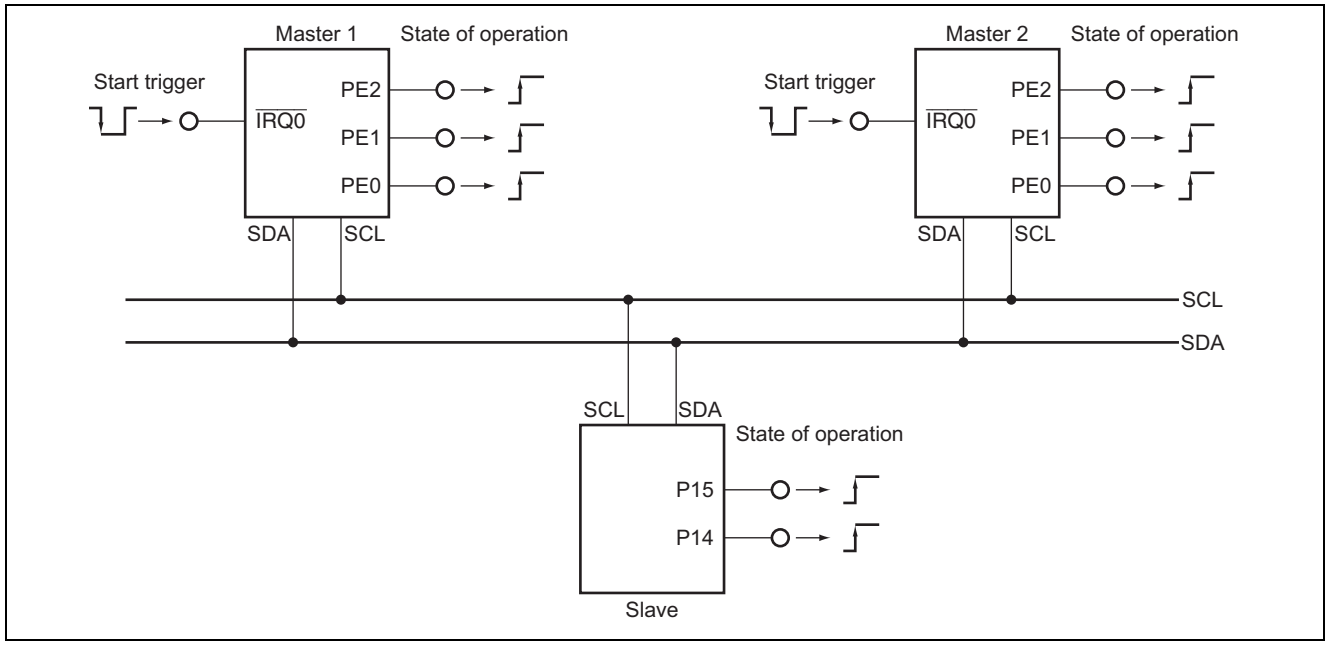


Figure 1 Connections for I²C Bus Interface 2 Multi-Master Mode Communication

Table 1 Slave Addresses

Device	Slave Address	SAR_0 Setting
Master 1	1	H'02
Master 2	2	H'04
Slave	3	H'06

2. Applicable Conditions

Table 2 Applicable Conditions

Items	Description
Operating frequency	Input clock: 8.25 MHz System clock (ϕ): 33 MHz Peripheral module clock: 33 MHz
Mode of operation	Mode 7 (MD2 = 1, MD1 = 1, MD0 = 1)
Development tool	High-performance Embedded Workshop ver. 4.02.00
C/C++ compiler	Manufactured by Renesas Technology Corp. H8S, H8/300 Series C/C++ Compiler Ver6.01.02
Compiler options	-cpu = 2000a:24, -code = machinecode, -optimize = 1, -regparam = 3, -speed = (register, shift, struct, expression)
C/C++ compiler	Manufactured by Renesas Technology Corp. H8S, H8/300 Series C/C++ Compiler Ver6.01.02
Evaluation boards	Master 1: HSB8S2378ST Master 2: HSB8S2378ST Slave: HSB8S2378RE

Table 3 Section Settings

Address	Section Name	Description
H'001000	P	Program area
	C	Data table
H'FF6000	B	Non-initialized data area (RAM area)

3. Description of Functions

3.1 Description of I²C Bus Interface 2 (IIC2)

An I²C bus interface 2 is used in multi-master operation to demonstrate bi-directional communications between in master mode and slave mode.

3.2 Watchdog Timer (WDT)

To make the I²C bus interface escape from hung states, the watchdog timer is used in the interval timer mode. Once the specified interval has elapsed, a WDT interrupt is generated, and error recovery processing for the I²C bus interface proceeds.

3.3 Master Side $\overline{\text{IRQ0}}$ Pin

The trigger to start master transmission and master reception is input to the $\overline{\text{IRQ0}}$ pin on the master side. IRQ0 starts the processing of the I²C bus interface communications on the input of a rising edge on the $\overline{\text{IRQ0}}$ pin.

The master judges whether or not the $\overline{\text{IRQ0}}$ pin has received the start trigger by polling the IRQ status flag. The IRQ interrupt is not used.

3.4 Master Side PE2 to PE0 Pins

As indicated in table 4, the pins PE2 to PE0 on the master side indicate the state of I²C bus interface communications (reset state or result of operations).

Table 4 Output Values of Master Side Pins and State of Operations

PE2	PE1	PE0	State of Operation
0	0	0	Reset
x	0	1	Data mismatch
x	1	0	Data match
1	x	x	Arbitration lost generated.

3.5 Slave Side P15 and P14 Pins

As indicated in table 5, pins P15 and P14 on the slave side indicate the state of I²C bus interface communications (reset state or result of operations).

Table 5 Output Values of Slave Side Pins and State of Operations

P15	P14	State of Operation
0	0	Reset
0	1	Master 1 (The first byte of received data is H'81.)
1	0	Master 2 (The first byte of received data is H'82.)
1	1	Error (The first byte of received data is neither H'81 nor H'82.)

4. Description of Operations

4.1 Timing of Operations in Master Transmit Mode

Figure 2 shows the timing of operations of the I²C bus interface 2 in master transmit mode. Table 6 describes processing by hardware and software at the numbered points in figure 2.

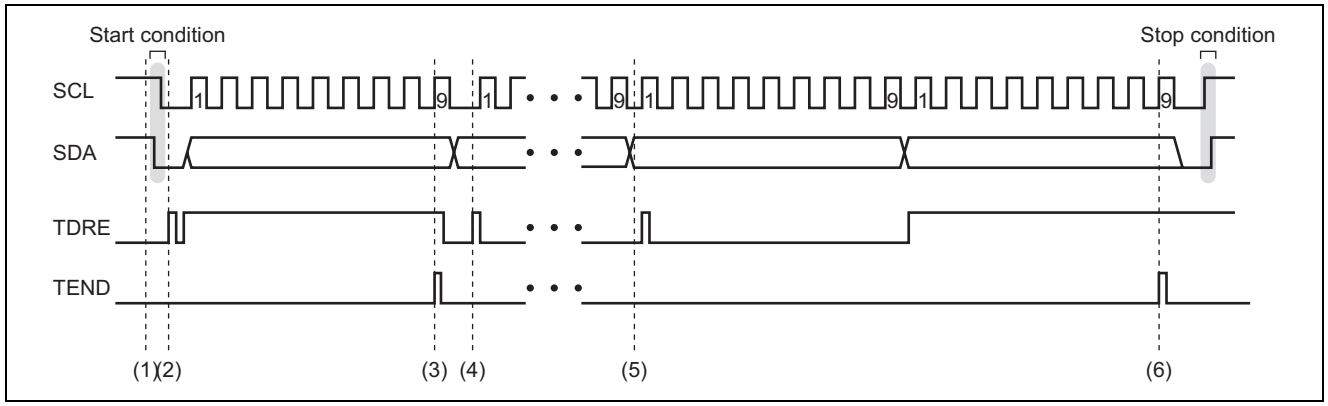


Figure 2 Timing of Operations in Master Transmit Mode

Table 6 Description of Processing

	Hardware Processing	Software Processing
(1)	No processing	a. Set the TIE bit to 1, enabling the data empty interrupt. Set the TDRE bit to 1 for interrupt generation. b. Issue the start condition.
(2)	a. Generation of transmit-data empty interrupt The start condition is detected and the TDRE is set to 1.	a. Write the slave-side address and data-direction bit (R/$\overline{W}$) to ICDRT, then transmit this data. Writing to ICDRT clears the TDRE and TEND flags. b. Set the TIE bit to 0, disabling the transmit-data empty interrupts. c. Set the TEIE to 1, enabling the transmit-end interrupt. When the TEND bit is set to 1, the interrupt will be generated.
(3)	a. Generation of transmit-end interrupt On the rising edge of the ninth cycle of SCL, the TEND bit is set to 1.	a. Write the data for transmission to ICDRT and transmit the data. Writing to ICDRT clears the TDRE and TEND flags. b. Set the TIE bit to 1, enabling the data-empty interrupt. When the TDRE bit is set to 1, the interrupt will be generated. c. Set the TEIE bit to 0, disabling the transmit-end interrupt.
(4)	a. Generation of transmit-data empty interrupt Data are transferred from ICDRT to ICDRS, and ICDRT becomes empty. Then, the TDRE bit is set to 1.	a. Write the data for transmission to ICDRT, then transmit the data. Writing to ICDRT clears the TDRE and TEND flags.

	Hardware Processing	Software Processing
(5)	a. Generation of transmit-data empty interrupt Data are transferred from ICDRT to ICDRS, and ICDRT becomes empty. Then, the TDRE bit is set to 1.	a. Write the last transmit data to ICDRT, then transmit the data. Writing to ICDRT clears the TDRE and TEND flags. b. Set the TIE bit to 0, disabling the transmit-data empty interrupt. c. Set the TEIE bit to 1, enabling the transmit-end interrupt. When the TEND bit is set to 1, the interrupt will be generated.
(6)	a. Generation of transmit-end interrupt On the rising edge of the ninth cycle of SCL, the TEND bit is set to 1.	a. Clear the TEND flag. b. Confirm that the SCL signal is at the low level and then issue the stop condition.

4.2 Timing of Operations in Master Receive Mode

Figures 3 and 4 show the timing of operations of the I²C bus interface 2 in master receive mode. Tables 7 and 8 describe processing by hardware and software at the numbered points in figures 3 and 4.

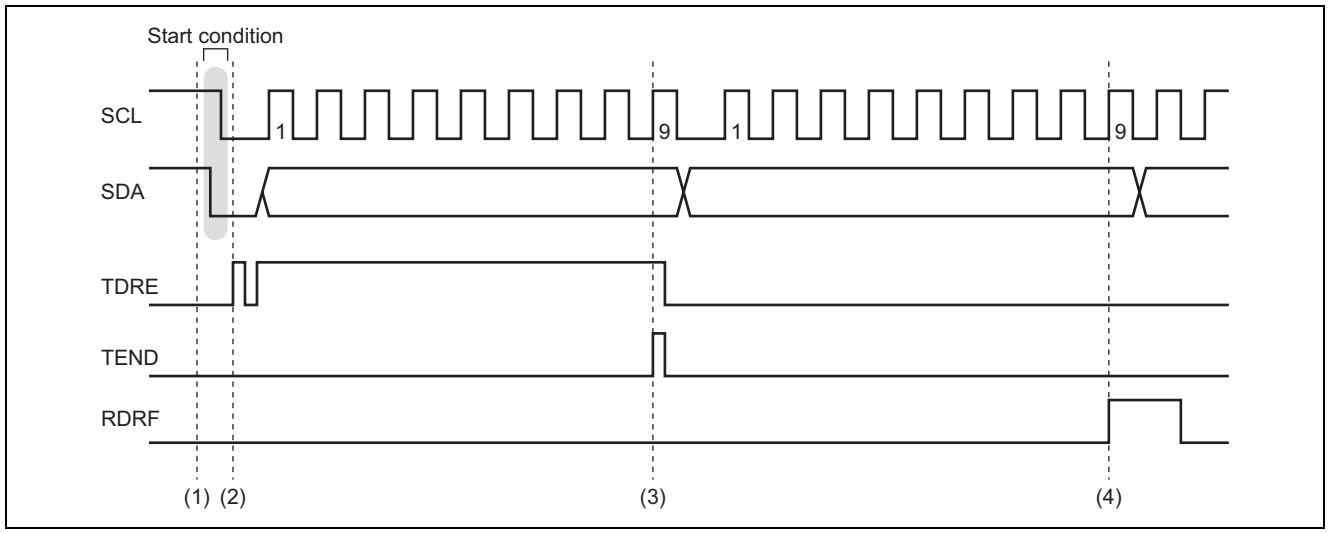


Figure 3 Timing of Operations in Master Receive Mode 1

Table 7 Description of Processing

	Hardware Processing	Software Processing
(1)	No processing	a. Set the TIE bit to 1, enabling the data empty interrupts. When the TDRE bit is set to 1, an interrupt is generated. b. Issue the start condition.
(2)	a. Generation of transmit-data empty interrupt Start condition is detected and the TDRE is set to 1.	a. Write the slave-side address and data-direction bit (R/$\overline{W}$) to ICDRT, then transmit this data. Writing to ICDRT clears the TDRE and TEND flags. b. Set the TIE bit to 0, disabling the transmit-data empty interrupt. c. Set the TEIE bit to 1, enabling the transmit-end interrupt. When the TEND bit is set to 1, the interrupt will be generated.
(3)	a. Generation of transmit-end interrupt On the rising edge of the ninth cycle of SCL, the TEND bit is set to 1.	a. Set the TEIE bit to 0, disabling the transmit-end interrupt. b. Set the RIE bit to 1, enabling the receive-data full interrupt. c. Set the RCVD bit to 1, disabling the next receive operation. d. Clear the TEND flag. e. Set the TRS bit to 0, selecting receive mode. f. Clear the TDRE flag. g. Set the ACKBT bit to 0, so that 0 is output at the timing of acknowledgement output. h. Execute a dummy read of ICDRR. Reading from ICDRR clears the RDRF bit.
(4)	a. Generation of receive-data interrupt Receiving frame data is completed. On the rising edge of the ninth cycle of SCL, the RDRF bit is set to 1.	a. First byte of data for reception is read from ICDRR and saved in RAM. Reading from ICDRR clears the RDRF bit.

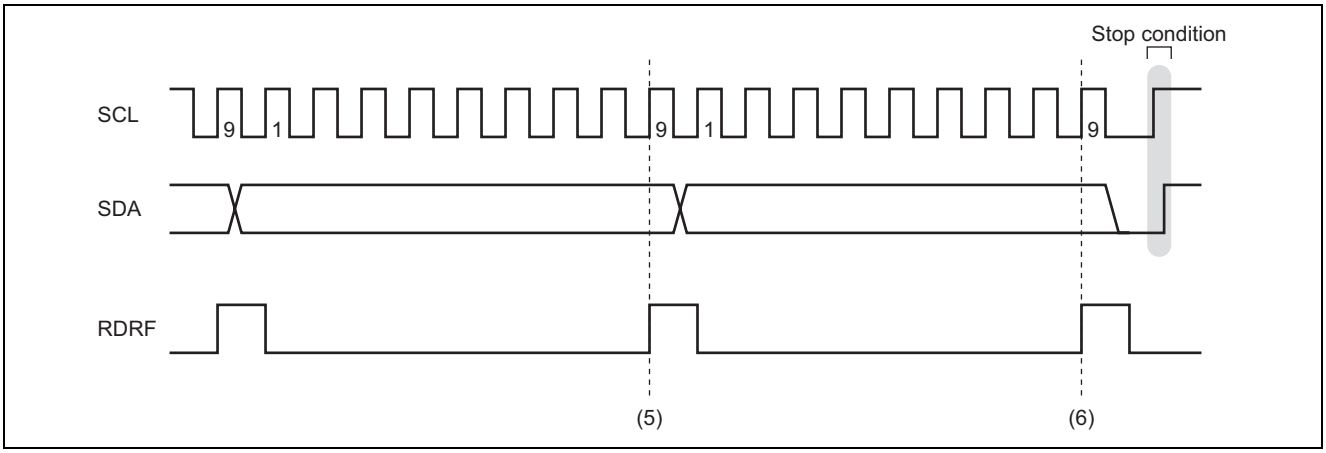


Figure 4 Timing of Operations in Master Receive Mode 2

Table 8 Content of Processing

	Hardware Processing	Software Processing
(5)	a. Generation of receive-data interrupt. Receiving frame data is completed. On the rising edge of the ninth cycle of SCL, the RDRF bit is set to 1.	a. Set the ACKBT bit to 1, so that 1 is output at the timing of acknowledge output. b. Data for reception is read from ICDRR and saved in RAM. Reading from ICDRR clears the RDRF bit.
(6)	a. Generation of receive-data interrupt. Receiving frame data is completed. On the rising edge of the ninth cycle of SCL, the RDRF bit is set to 1.	a. Last byte of data for reception is read from ICDRR and saved in RAM. Reading from ICDRR clears the RDRF bit. b. Set the RIE bit to 0, disabling the receive-data full interrupt. c. Confirm that the SCL signal is at the low level and then issue the stop condition.

4.3 Description of Bus Arbitration Operation

The I²C bus interface 2 in this LSI performs bus arbitration as illustrated in figures 5 and 6. Loss of arbitration by the LSI is detected in the following two cases.

- Loss of bus arbitration when the start condition is detected
  When the interface is in master mode, bus arbitration is lost if the SDA pin is at the high level when the start condition is detected.
- Loss of bus arbitration during data transmission
  When the interface is in master transmit mode, bus arbitration is lost in the case of a mismatch between the internal SDA signal and the level of the SDA pin on a rising edge of SCL. Each master device monitors the bus line on rising edges of SCL. When the master detects that the level of its internal SDA signal does not match the bus line's SCA level, it turns off its data-output stage.

4.3.1 Loss of Bus Arbitration When the Start Condition is Detected

Figure 5 illustrates an example of the loss of bus arbitration when the start condition is detected. The start condition from master 1 is output after that from master 2.
When the start condition is output from master 2, i.e. the level on the SDA0 pin of master 2 becomes low, the level on the SDA bus line also becomes low. In this case, the signal from master 2 and the signal on the bus line match, so master 2 takes the possession of bus.
When output of the start condition to the bus line sets the SDA signal to the low level, the SDA0 pin of master 1 will still be at the high level and thus will not output a start condition. That is, since the SDA of master 1 and the SDA of the bus line do not match, master 1 loses arbitration.

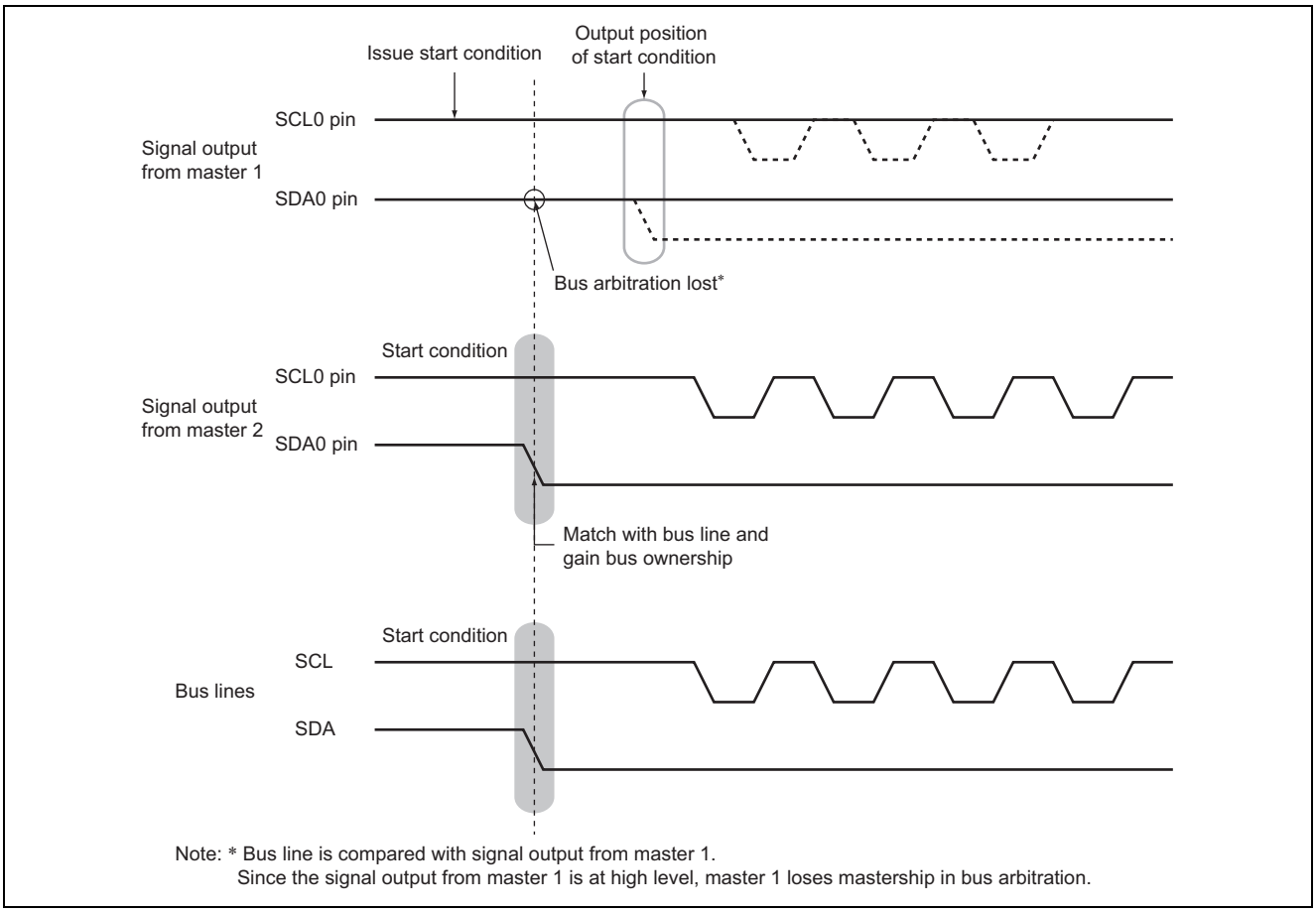


Figure 5 Loss of Bus Arbitration when the Start Condition is Detected

4.3.2 Bus Arbitration Lost when Data is in Transmission

When master 1 and master 2 start transmitting data simultaneously, the data are compared. When a collision is thus detected, master 1 gains bus mastership because it holds the data line (SDA) at the low level (by transmitting H'03) for longer than master 2 (which transmits H'05). As a result, master 1 gains bus mastership.

In this case, master 2 has lost in bus arbitration and automatically enters the idle mode. In order to use master 2 in master transmit mode, master 2 needs to be set again, and the data that was not transmitted must again be written to ICDR.

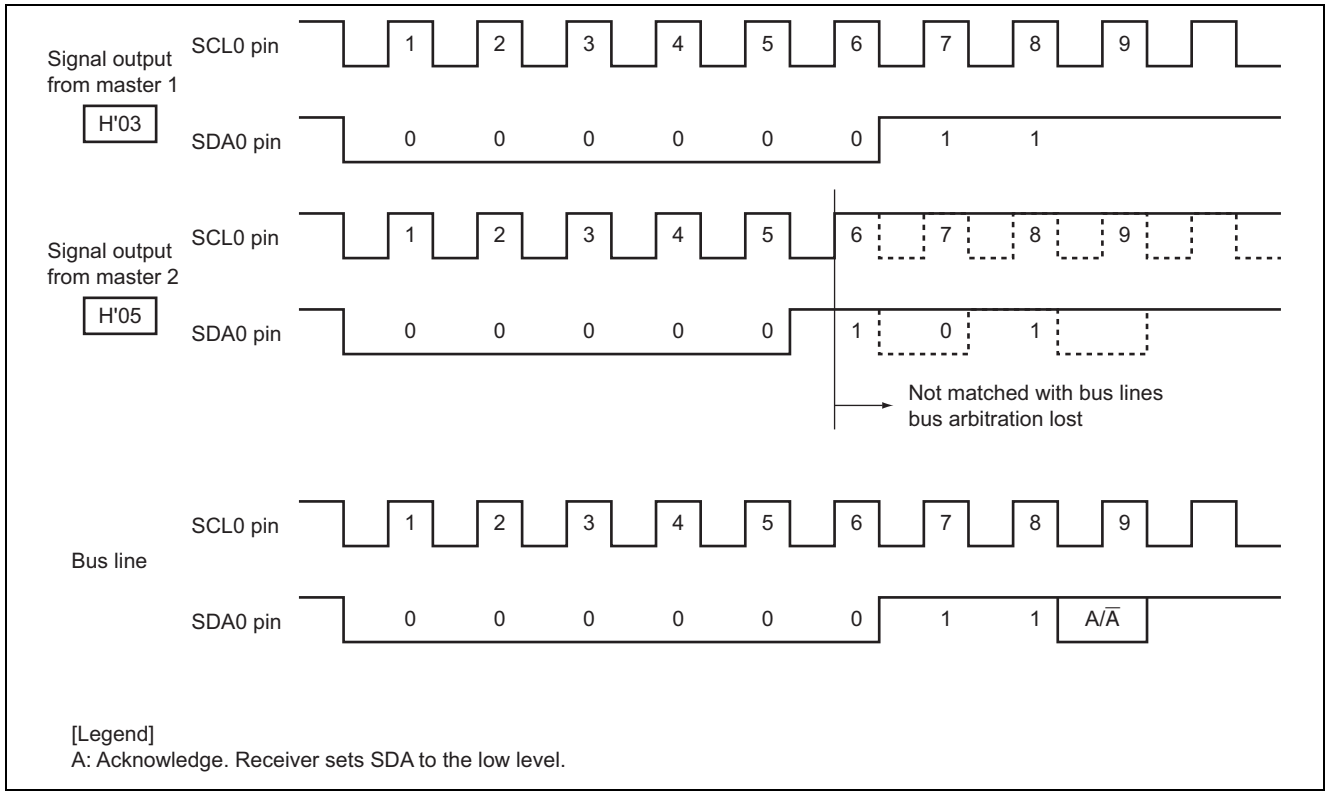


Figure 6 Loss of Bus Arbitration During Data Transmission

4.4 State Transition Diagram

Figure 7 is a state-transition diagram for this sample task. In this sample task, the idle mode is selected as the default.

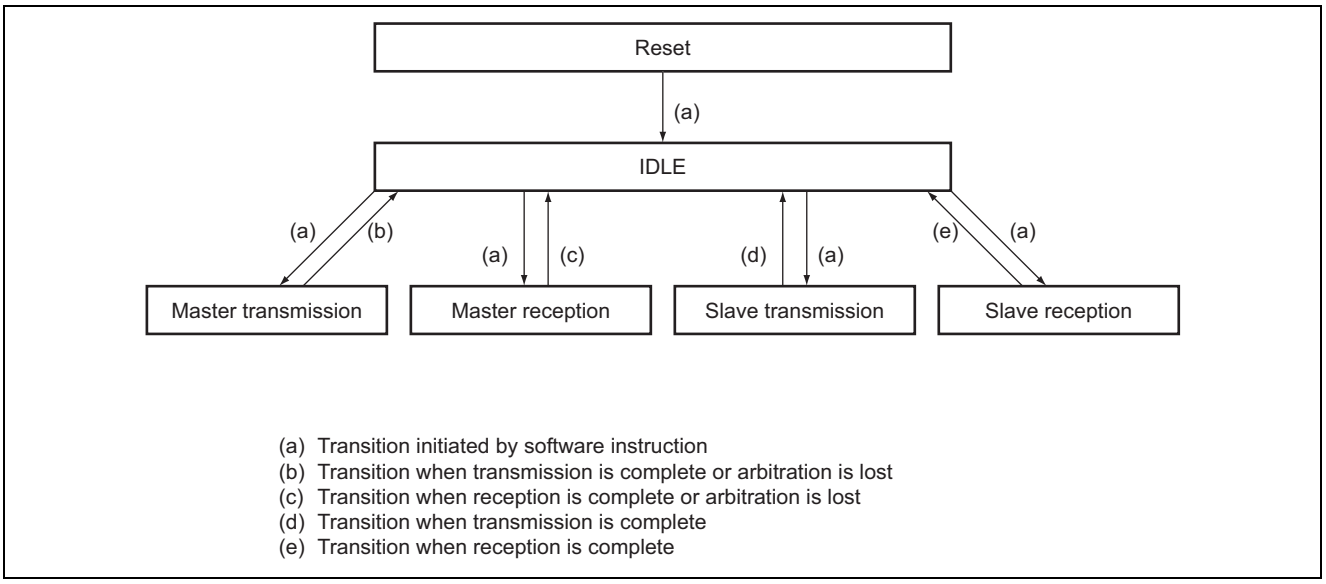


Figure 7 State Transition Diagram

5. Description of Software

5.1 List of Functions

Table 9 List of Functions: main.c file

Function	Description
init	Initialization routine Sets the CCR and clock, releases IIC module 0 from module stop mode, and calls function "main".
main	Main routine • Defining macro for MASTER1 and MASTER2 Selects master mode operation, judges the state of the $\overline{\text{IRQ0}}$ pin, and handles master transmission/reception processing. • Defining macro for SLAVE Selects slave mode operation and handles slave transmission/reception processing.
wovi_int	WDT interval timer interrupt

Table 10 List of Functions: iic.c file

Function	Description
iic_init	I²C bus interface initialization routine
mtrs_start	Sets I²C bus interface master transmission. Issues the start condition.
mrcv_start	Sets I²C bus interface master reception. Issues the start condition.
iici0_int	Handler for I²C bus interface interrupts. According to the state of operations, the functions for receiving the stop condition, master transmission, master reception, slave transmission, and slave reception are called from this function.
receive_stop_condition	Detects the stop condition.
master_transfer	When the state of operation of this sample task is master transmission, this function for master-transmission processing is called from the I²C bus interface interrupt handler. One byte of data is transferred per call of this function. When arbitration is lost, this function is transited to idle mode operation.
master_receive	When the state of operation of this sample task is master reception, this function for master-reception processing is called from the I²C bus interface interrupt handler. One byte of data is received per call of this function. When arbitration is lost, this function is transited to idle mode operation.
slave_transfer	When the state of operation of this sample task is slave transmission, this function for slave-transmission processing is called from the I²C bus interface interrupt handler. One byte of data is transferred per call of this function.
slave_receive	When the state of operation of this sample task is slave reception, this function for slave-reception processing is called from the I²C bus interface interrupt handler. One byte of data is received per call of this function.

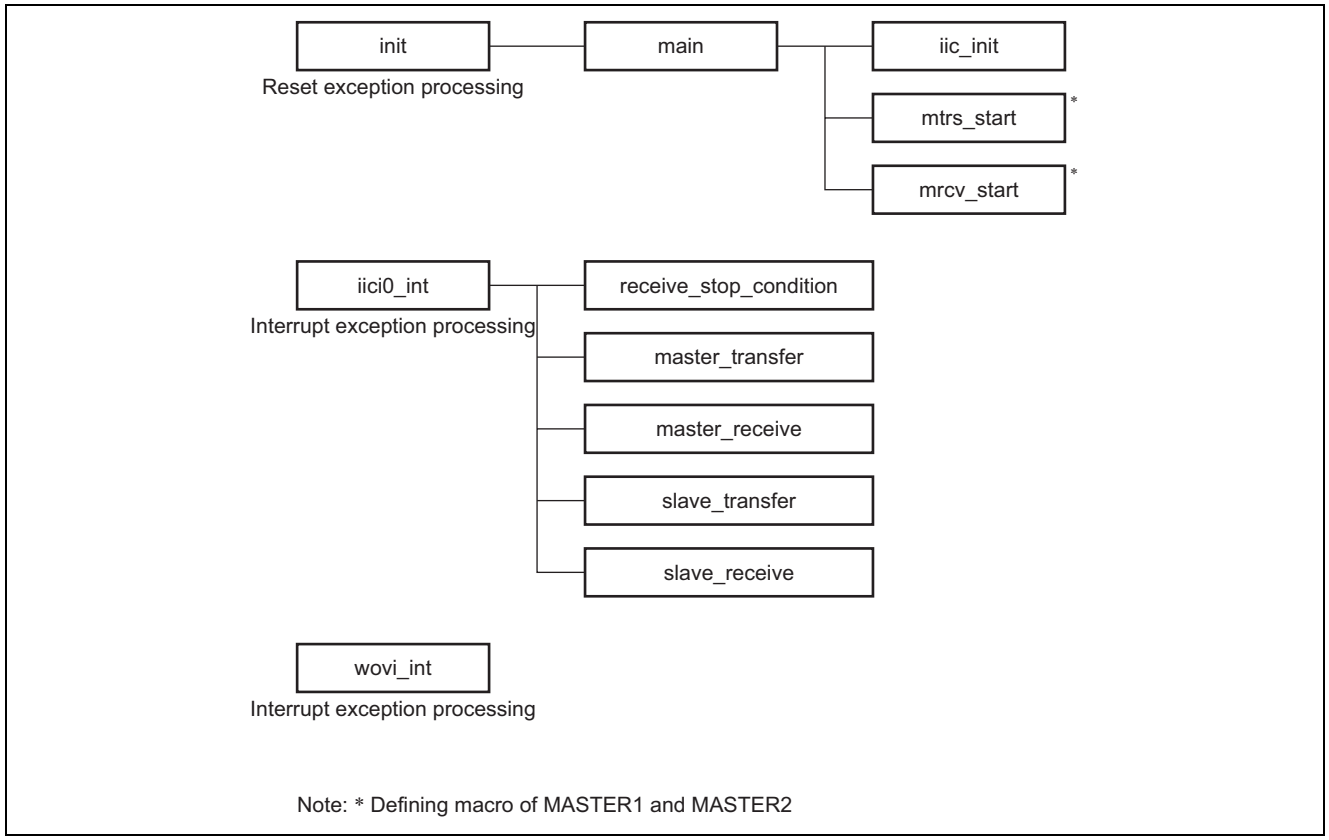


Figure 8 Hierarchy of Calls in the User Program

5.2 Vector Table

Table 11 Exception Handling Vector Table

Origin of Exception	Vector Number	Vector Table Address	Target Function of the Vector
Task "Reset"	0	H'000000	main
WDT interrupt	33	H'000084	wovi_int
IICI0 interrupt	116	H'0001D0	iici0_int

5.3 RAM Usage

Table 12 Description of RAM Usage

Type	Name of Variable	Description	Usage in Functions
unsigned char	iic_mode	Sets state of processing by this sample task.	iic_int mtrs_start mrcv_start iici0_int receive_stop_condition master_transfer master_receive
unsigned short	mt_cnt	Counter used for master transmission	main iic_init mtrs_start master_transfer
unsigned short	mr_cnt	Counter used for master reception	main iic_init mrcv_start master_receive
unsigned short	st_cnt	Counter used for slave transmission	main iic_init slave_transfer
unsigned short	sr_cnt	Counter used for slave reception	main iic_init slave_receive
unsigned char	alcnt	Counter used for number of generation of arbitration lost	main master_transfer master_receive
unsigned short	mt_num	Number of bytes for master transmission	mtrs_start master_transfer
unsigned short	mr_num	Number of bytes for master reception	mrcv_start master_receive
unsigned short	st_num	Number of bytes for slave transmission	main slave_transfer
unsigned char	*mt_data	Pointer to data for transmission	mtrs_start master_transfer
unsigned char	*mr_data	Pointer to data for reception	mrcv_start master_receive
unsigned char	MRcv_dt[128]	Master-side receive area	main
unsigned char	SRcv_dt[128]	Slave-side receive area	main

5.4 Constants

Table 13 Constants

Type	Name of Variable	Setting	Description	Usage in Function
unsigned char	MTrs_dt[128]	H'81, H'01, H'02 … …… H'7E, H'7F	Data for master transmission 1 when defining macro of MASTER1.	master_transfer
unsigned char	MTrs_dt[128]	H'82, H'01, H'02 … …… H'7E, H'7F	Data for master transmission 2 when defining macro of MASTER2.	master_transfer

5.5 Macro Definition

Table 14 Macro Definition

Identifier	Description	Function Used
MASTER1	Generates program of master 1	main
MASTER2	Generates program of master 2	main
SLAVE	Generates program of slave	main

5.6 Macro Constants

Table 15 Macro Constants

Name of Variable	Setting	Description	Function Used
DTNUM	128	Number of data for transmission/reception	main
SLAVE_ADDR	Defining macro of MASTER1: H'02 Defining macro of MASTER2: H'04 Defining macro of SLAVE: H'06	Slave address	iic_init
MT_ID	H'06	Slave address + R/$\overline{W}$ bit for master transmission Slave-side slave address + 0 (transmission to the slave)	master_transfer
MR_ID	H'07	Slave address + R/$\overline{W}$ bit for master reception Slave-side slave address + 1 (reception from the slave)	master_receive
MODE_MT	4	State of processing of this sample task: Master transmission	mtrs_start iici0_int
MODE_MR	3	State of processing of this sample task: Master reception	mrcv_start iici0_int receive_stop_condition
MODE_ST	2	State of processing of this sample task: Slave transmission	iici0_int
MODE_SR	1	State of processing of this sample task: Slave reception	iici0_int
MODE_IDLE	0	State of processing of this sample task: Idle	main iic_init mtrs_start mrcv_start iici0_int receive_stop_condition master_transfer master_receive

5.7 Functions of File main.c

5.7.1 Function init

1. Overview
   This initialization routine releases I²C bus interface 0 from module stop mode, sets the clock, and calls function "main".
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- System clock control register (SCKCR) Address: H'FFFF3B

Bit	Bit Name	Setting	R/W	Function
3	STCS	1	R/W	Frequency Multiplication Factor Switching Mode Select Selects the operation when the PLL circuit frequency multiplication factor is changed. 0: Specified multiplication factor is valid after transition to software standby mode. 1: Specified multiplication factor is valid immediately after STC1 and STC0 bits are rewritten.
2	SCK2	0	R/W	System clock select 2 to 0
1	SCK1	0	R/W	Selects the clock division ratio.
0	SCK0	0	R/W	000: 1/1

- Mode control register (MDCR) Address: H'FFFF3E

Bit	Bit Name	Setting	R/W	Function
2	MDS2	—*	R	Mode Select 2 to 0
1	MDS1	—*	R	Indicate the input levels at pins MD2 to MD0 (the current operating mode). Bits MDS2 to MDS0 correspond to pins MD2 to MD0. MDS2 to MDS0 are read-only bits, and cannot be modified. The levels being input on the mode pins (MD2 to MD0) are latched into these bits when MDCR is read. The latching is released by a power-on reset.
0	MDS0	—*	R	

Note: * Determined by the levels on pins MDS2 to MDS0.

MSTPCRH and MSTPCRL control the module stop mode. Setting a bit in these registers places the corresponding module in the module stop mode. Clearing a bit takes the module out of module stop mode.

- Module stop control register H (MSTPCRH) Address: H'FFFF40

Bit	Bit Name	Setting	R/W	Function
15	ACSE	0	R/W	All-Module-Clocks-Stop Mode Enable Enables or disables transition to all-module-clocks-stop mode, when a SLEEP instruction is executed after all internal peripheral functions controlled by MSTPCR or internal peripheral functions except for TMR are set in module stop mode. 0: Disables all-module-clocks-stop mode. 1: Enables all-module-clocks-stop mode.
14	MSTP14	1	R/W	EXDMA controller (EXDMAC)
13	MSTP13	1	R/W	DMA controller (DMAC)
12	MSTP12	1	R/W	Data transfer controller (DTC)
11	MSTP11	1	R/W	16-bit timer pulse unit (TPU)
10	MSTP10	1	R/W	Programmable pulse generator (PPG)
9	MSTP9	1	R/W	D/A converter (channels 0 and 1)
8	MSTP8	1	R/W	D/A converter (channels 2 and 3)

- Module stop control register L (MSTPCRL) Address: H'FFFF41

Bit	Bit Name	Setting	R/W	Function
7	MSTP7	1	R/W	D/A converter (channels 4 and 5)
6	MSTP6	1	R/W	A/D converter
5	MSTP5	1	R/W	Serial communication interface_4 (SCI_4)
4	MSTP4	1	R/W	Serial communication interface_3 (SCI_3)
3	MSTP3	1	R/W	Serial communication interface_2 (SCI_2)
2	MSTP2	1	R/W	Serial communication interface_1 (SCI_1)
1	MSTP1	1	R/W	Serial communication interface_0 (SCI_0)
0	MSTP0	1	R/W	8-bit timer (TMR)

EXMSTPCR performs all-module-clocks-stop mode control with MSTPCR. Entering all-module-clocks-stop mode places EXMSTPCR to H'FFFF. Otherwise, EXMSTPCR is set to H'FFFD.

- Extension module stop control register H (EXMSTPCRH) Address: H'FFFF42

Bit	Bit Name	Setting	R/W	Function
15 to 12	—	1	R/W	Reserved Enables reading/writing. 1 should be written in writing.

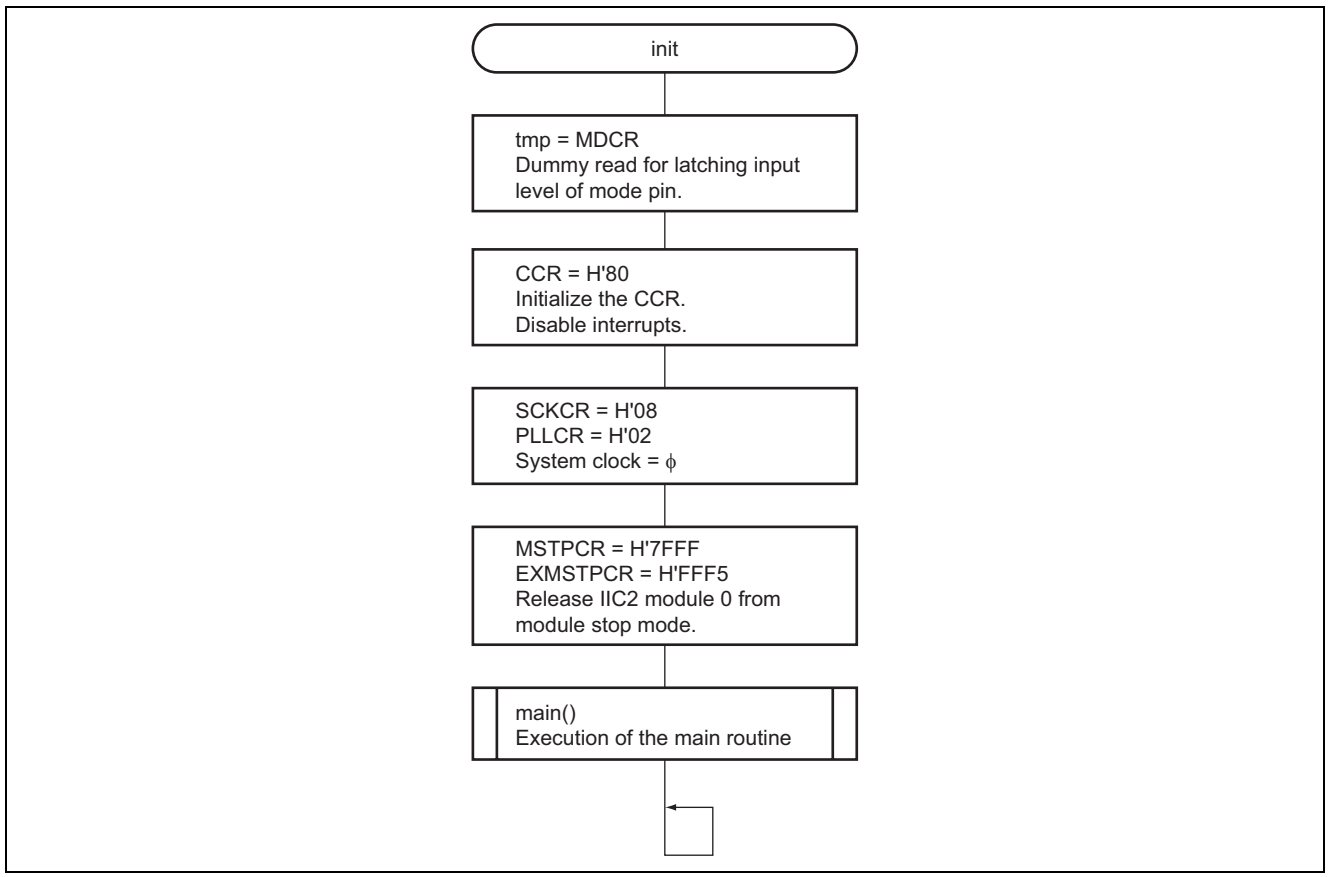
- Extension module stop control register L (EXMSTPCRL) Address: H'FFFF43

Bit	Bit Name	Setting	R/W	Function
4	MSTP20	1	R/W	I²C Bus Interface 2_1 (IIC2_1)
3	MSTP19	0	R/W	I²C Bus Interface 2_0 (IIC2_0)
1	MSTP17	0	R/W	—

- PLL control register (PLLCR) Address: H'FFFF45

Bit	Bit Name	Setting	R/W	Function
1	STC1	1	R/W	Frequency Multiplication Factor
0	STC0	0	R/W	Specify the frequency multiplication factor used by the PLL circuit. 10: × 4

5. Flowchart



5.7.2 Function main (Defining Macro of MASTER1 and MASTER2)

1. Overview
   — On falling edges of the $\overline{\text{IRQ0}}$ signal, this function performs 128-byte master transmission and 128-byte master reception.
   — Compares the master-transmission data with the master-reception data, and outputs an indicator of the results of comparison to pins PE2 to PE0.

2. Arguments
   None

3. Return value
   None

4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used for this sample task, and are not initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
7	ICE	0	R/W	I²C Bus Interface Enable 0: Disables the IIC2 module. 1: Enables transfer via the IIC2 module (pins SCL and SDA are driving the bus).
5	MST	0	R/W	Master/Slave Select
4	TRS	0	R/W	00: Slave receive mode

- I²C bus control register B_0 (ICCRB_0) Address: H'FFFD59

Bit	Bit Name	Setting	R/W	Function
5	SDAO	0/1	R	Monitors the level of signal output from SDA. When the SDAO bit is set to 1 in reading, the signal output from SDA is at high level. When the SDAO bit is set to 0 in reading, the signal output from SDA is at low level.
3	SCLO	0	R	Monitors level of signal output from SCL. When the SCLO bit is set to 1 in reading, the signal output from SCL is at high level. When the SCLO bit is set to 0 in reading, the signal output from SCL is at low level.

- IRQ sense control register L (ISCRL) Address: H'FFFE1C

Bit	Bit Name	Setting	R/W	Function
1	IRQ0SR	0	R/W	IRQ0 Sense Control Rise
0	IRQ0SF	1	R/W	IRQ0 Sense Control Fall 01: Generation of an interrupt request at the falling edge of $\overline{\text{IRQ0}}$ input.

- Port E data direction register (PEDDR) Address: H'FFFE2D

Bit	Bit Name	Setting	R/W	Function
2	PE2DDR	1	R/W	0: Sets the PE2 pin as an input pin. 1: Sets the PE2 pin as an output pin.
1	PE1DDR	1	R/W	0: Sets the PE1 pin as an input pin. 1: Sets the PE1 pin as an output pin.
0	PE0DDR	1	R/W	0: Sets the PE0 pin as an input pin. 1: Sets the PE0 pin as an output pin.

- IRQ status register (ISR) Address: H'FFFF34

Bit	Bit Name	Setting	R/W	Function
0	IRQ0F	0	R/(W)*	IRQ0 Enable 0: No generation of an IRQ0 interrupt 1: Generation of an IRQ0 interrupt

Note: * Only 0 can be written here, to clear the flag.

- Port E data register (PEDR) Address: H'FFFF6D

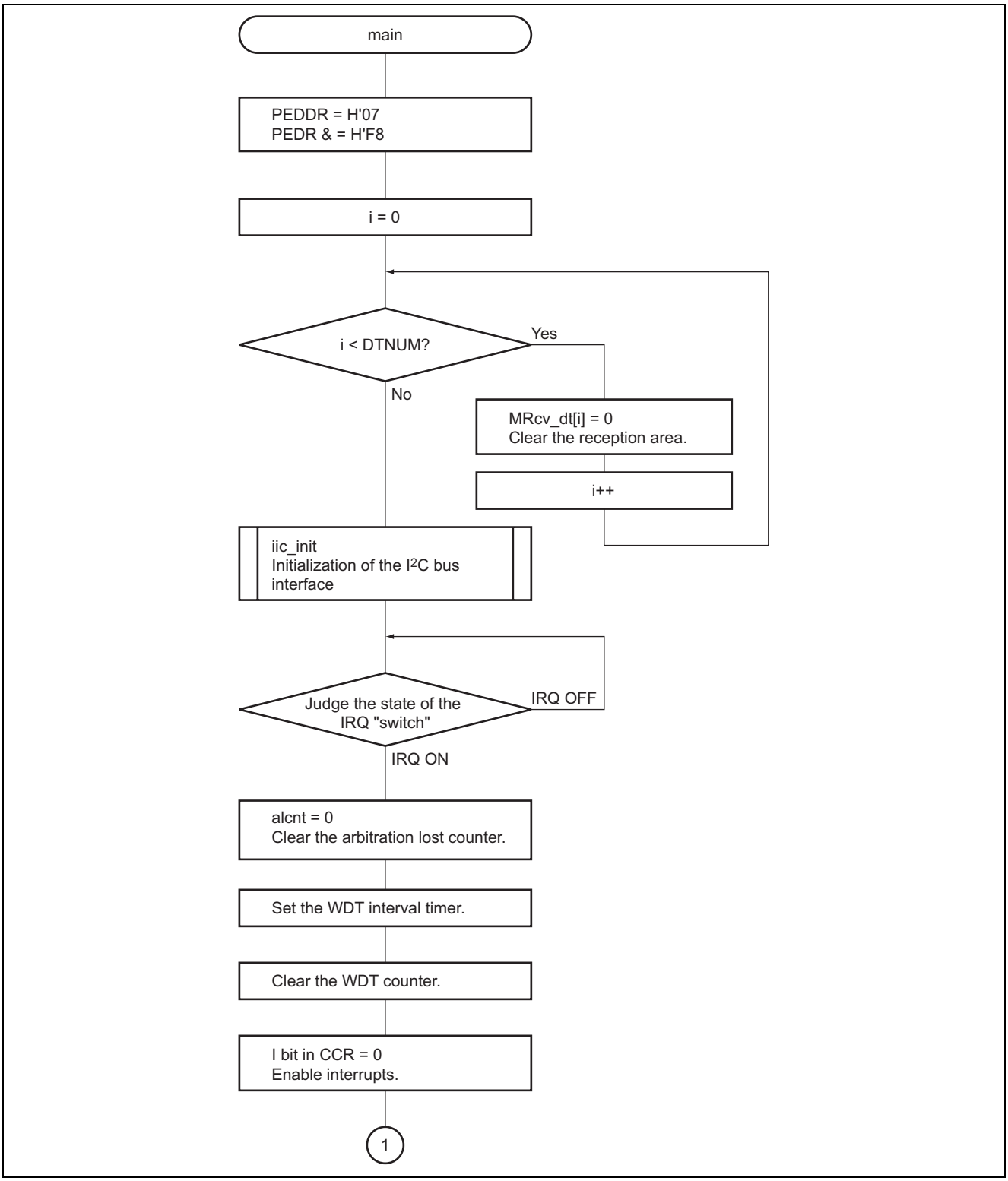
Bit	Bit Name	Setting	R/W	Function
2	PE2DR	0/1	R/W	0: PE2 pin is set to the low level. 1: PE2 pin is set to the high level.
1	PE1DR	0/1	R/W	0: PE1 pin is set to the low level. 1: PE1 pin is set to the high level.
0	PE0DR	0/1	R/W	0: PE0 pin is set to the low level. 1: PE0 pin is set to the high level.

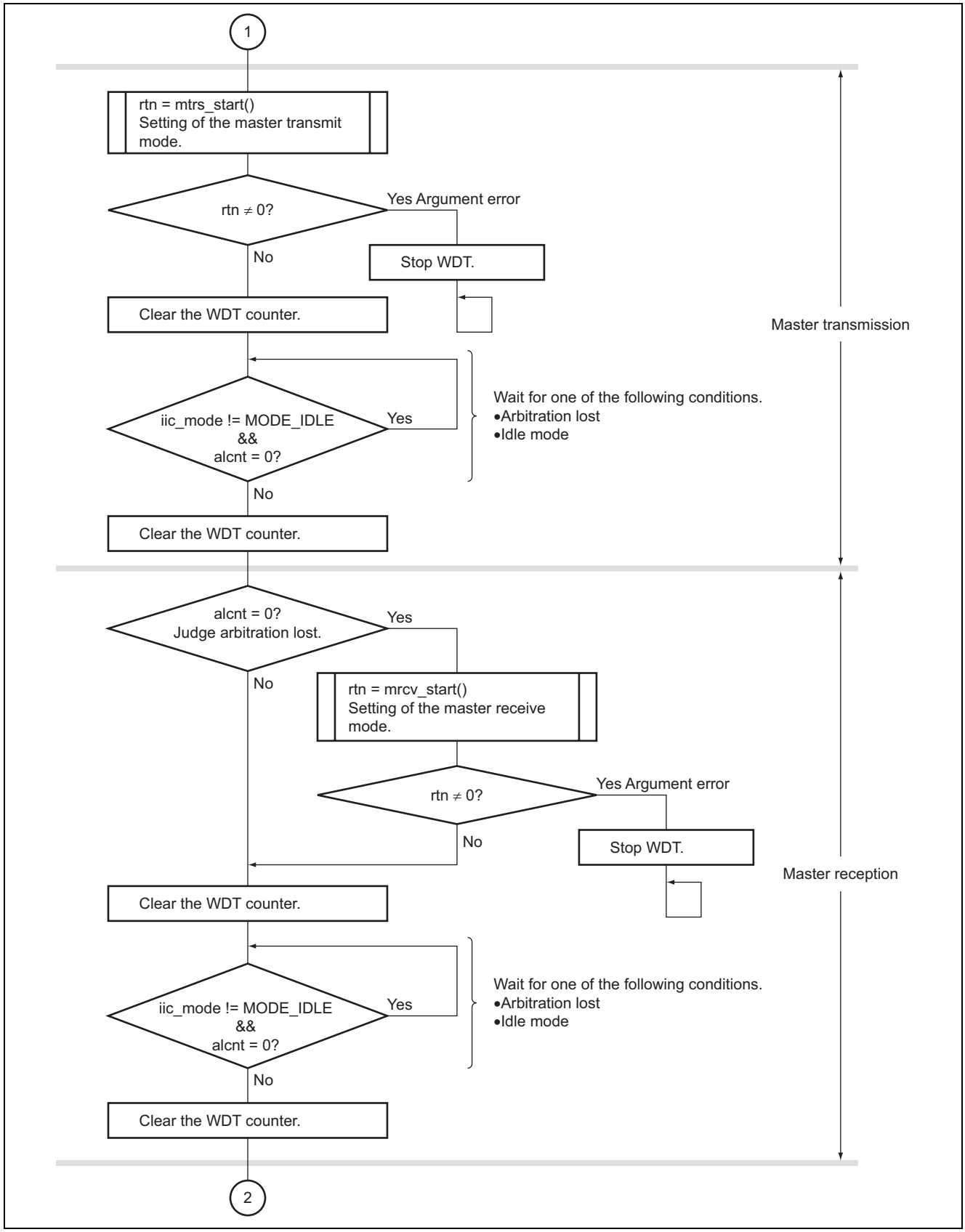
- Timer control/status register (TCSR) Address: H'FFFFBC

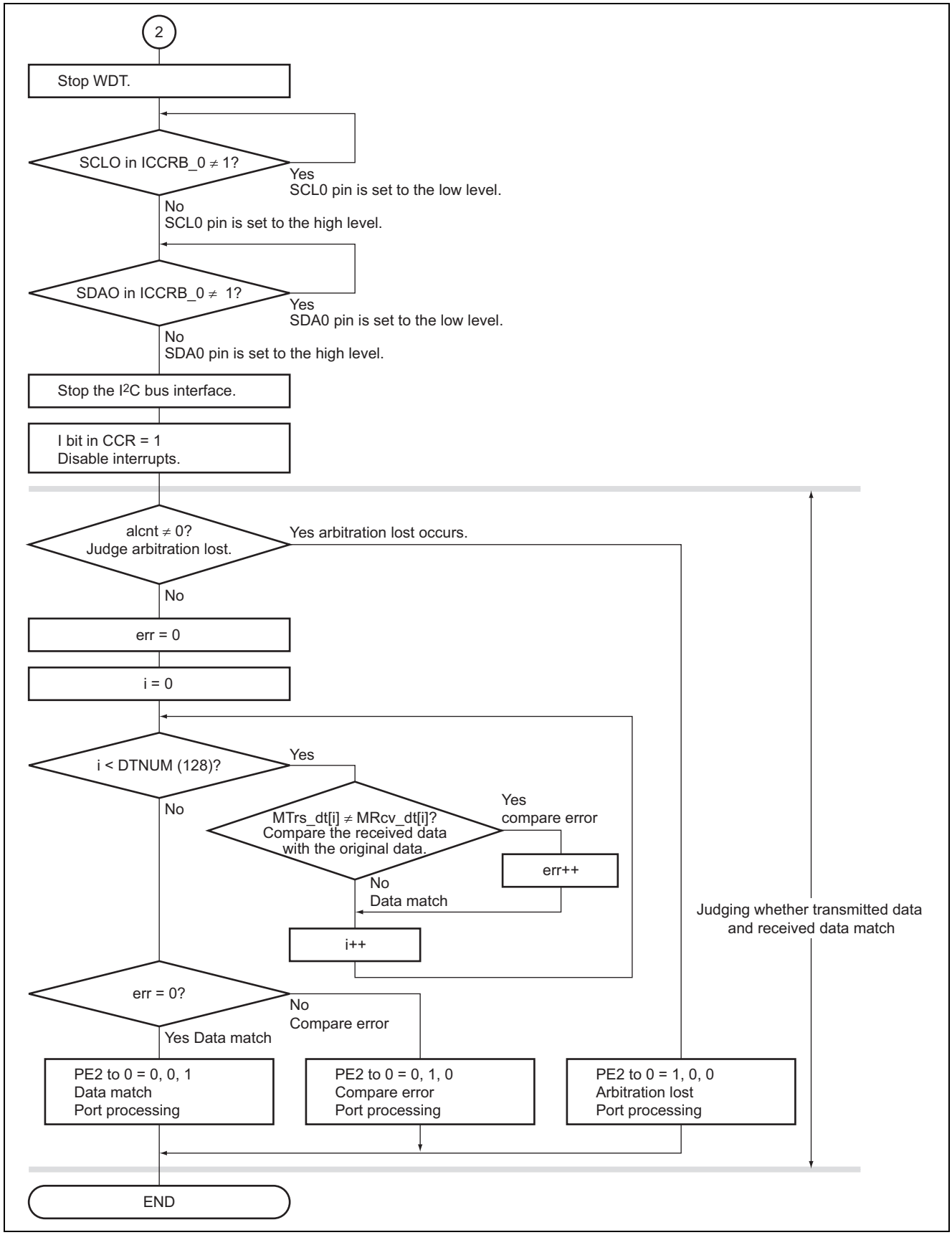
Bit	Bit Name	Setting	R/W	Function
6	WT/$\overline{IT}$	0	R/W	Timer Mode Select 0: Used as interval timer mode. 1: Used as watchdog timer mode.
5	TME	1	R/W	Timer Enable 0: TCNT stops counting and is initialized to H'00. 1: TCNT starts counting.
2	CKS2	1	R/W	Clock Select 2 to 0
1	CKS1	1	R/W	Select clocks for input to TCNT.
0	CKS0	0	R/W	110:Clock Pϕ/32768. When Pϕ is 33 MHz, overflow period is 254.2 ms.

- Timer counter (TCNT) Address: H'FFFFBC (in writing) and H'FFFFBD (in reading)
  This bit is an 8-bit readable and writable up-counter.
  Setting: H'00

5. Flowchart


main
PEDDR = H'07
PEDR & = H'F8
i = 0
i < DTNUM?
Yes
No
MRcv_dt[i] = 0
Clear the reception area.
i++
iic_init
Initialization of the I²C bus interface
Judge the state of the IRQ "switch"
IRQ OFF
IRQ ON
alcnt = 0
Clear the arbitration lost counter.
Set the WDT interval timer.
Clear the WDT counter.
I bit in CCR = 0
Enable interrupts.
1


1
rtn = mtrs_start()
Setting of the master transmit mode.
rtn ≠ 0?
Yes Argument error
Stop WDT.
No
Clear the WDT counter.
iic_mode != MODE_IDLE
&&
alcnt = 0?
Yes
No
Wait for one of the following conditions.
•Arbitration lost
•Idle mode
Clear the WDT counter.
Master transmission
alcnt = 0?
Judge arbitration lost.
Yes
No
rtn = mrcv_start()
Setting of the master receive mode.
rtn ≠ 0?
Yes Argument error
Stop WDT.
No
Clear the WDT counter.
iic_mode != MODE_IDLE
&&
alcnt = 0?
Yes
No
Wait for one of the following conditions.
•Arbitration lost
•Idle mode
Clear the WDT counter.
Master reception
2


2
Stop WDT.
SCLO in ICCRB_0 ≠ 1?
Yes
SCL0 pin is set to the low level.
No
SCL0 pin is set to the high level.
SDAO in ICCRB_0 ≠ 1?
Yes
SDA0 pin is set to the low level.
No
SDA0 pin is set to the high level.
Stop the I²C bus interface.
I bit in CCR = 1
Disable interrupts.
alcnt ≠ 0?
Judge arbitration lost.
Yes arbitration lost occurs.
No
err = 0
i = 0
i < DTNUM (128)?
Yes
No
MTrs_dt[i] ≠ MRcv_dt[i]?
Compare the received data
with the original data.
Yes
compare error
err++
No
Data match
i++
Judging whether transmitted data
and received data match
err = 0?
No
Compare error
Yes Data match
PE2 to 0 = 0, 0, 1
Data match
Port processing
PE2 to 0 = 0, 1, 0
Compare error
Port processing
PE2 to 0 = 1, 0, 0
Arbitration lost
Port processing
END

5.7.3 Function main (Defining Macro of SLAVE)

1. Overview
   — Receives 128 bytes of data from master side and transmits the 128-byte received data to master side.
   — Judges the first byte of received data. When the address is H'81, outputs P14 = 1. When the address is H'82, outputs P15 = 1.

2. Arguments
   None

3. Return value
   None

4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used for this sample task, and are not initial settings.

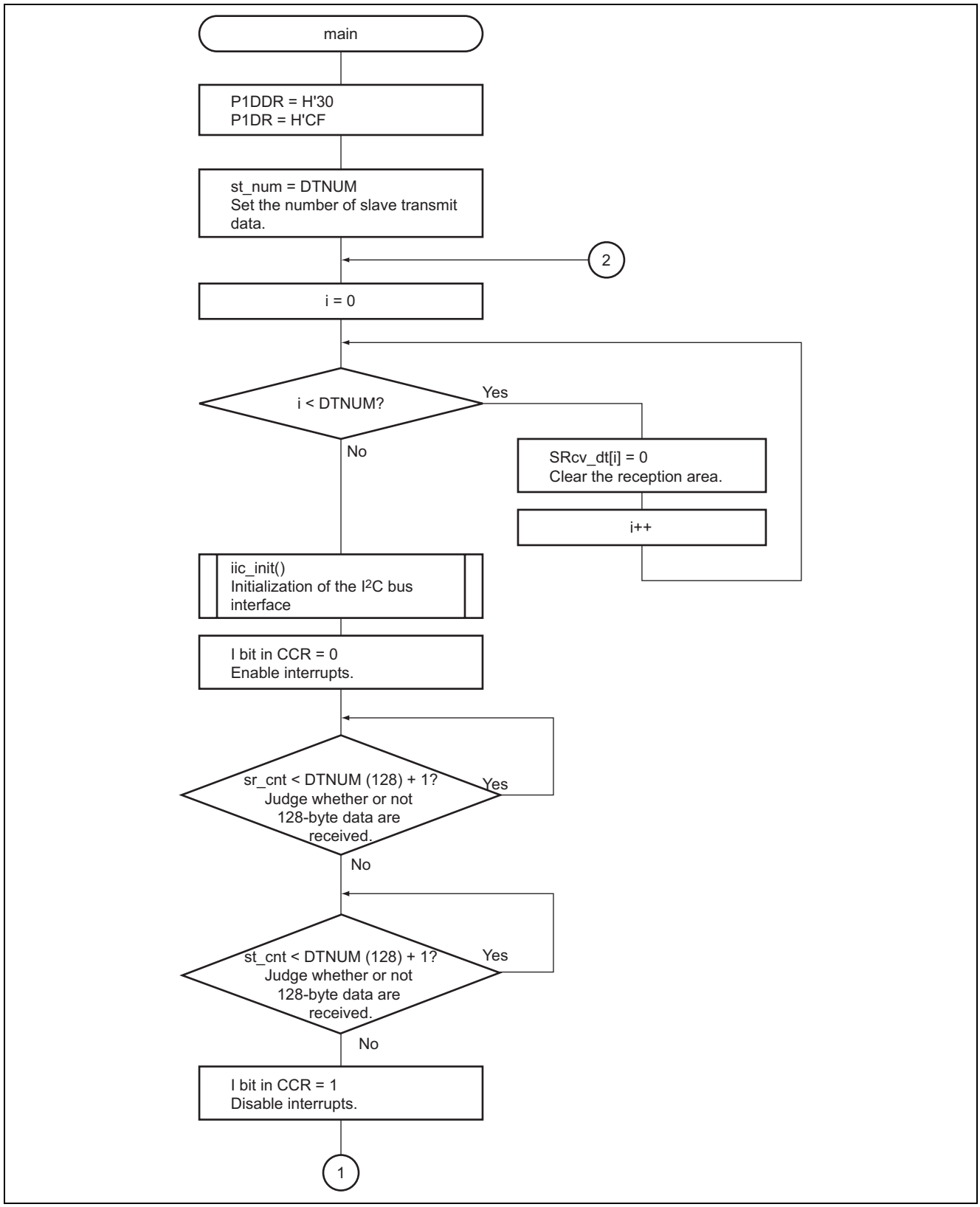
- Port 1 data direction register (P1DDR) Address: H'FFFE20

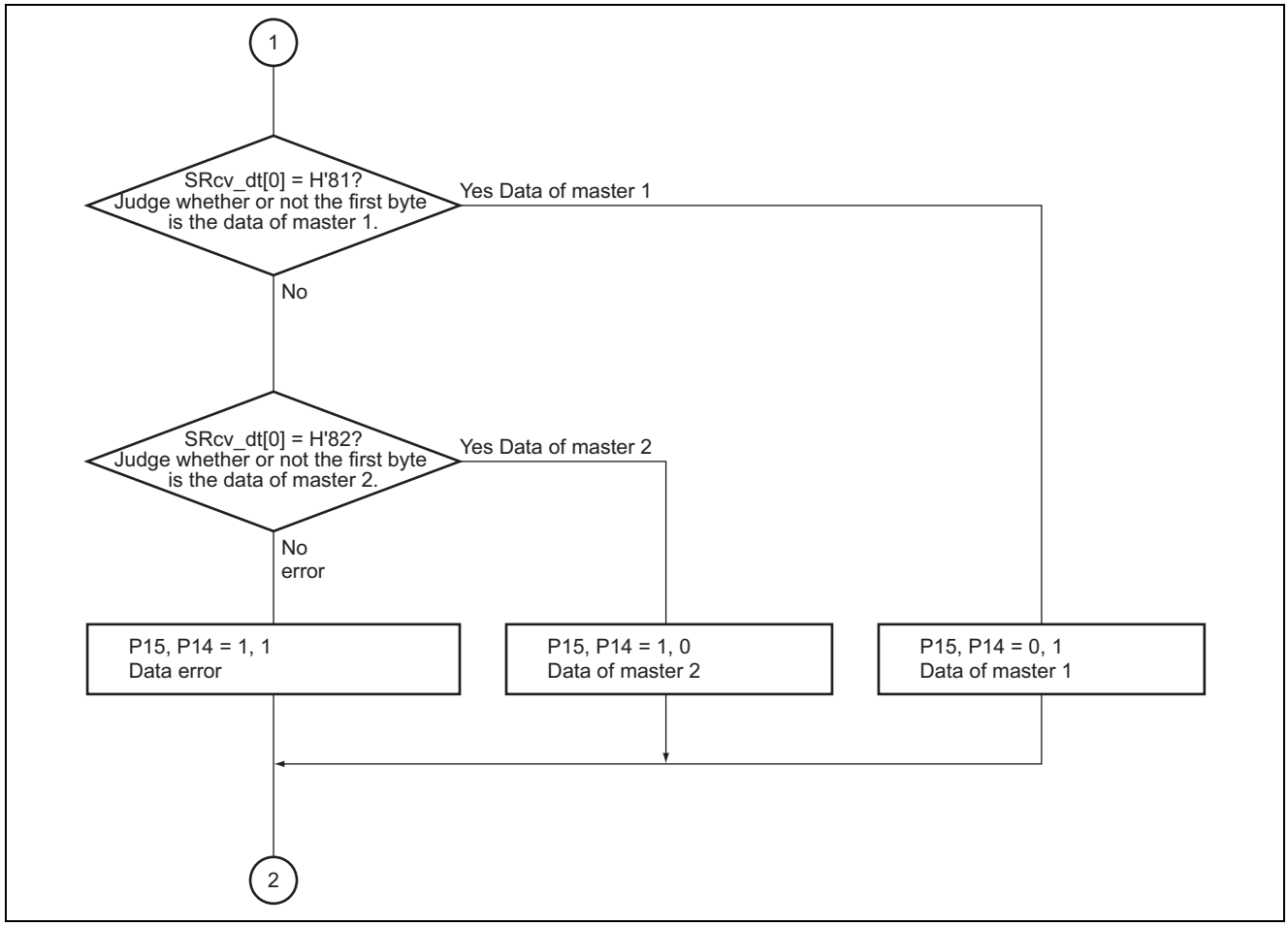
Bit	Bit Name	Setting	R/W	Function
5	P15DDR	1	R/W	0: Sets the P15 pin is set as input pin. 1: Sets the P15 pin is set as output pin.
4	P14DDR	1	R/W	0: Sets the P14 pin is set as input pin. 1: Sets the P14 pin is set as output pin.

- Port 1 data register (P1DR) Address: H'FFFF60

Bit	Bit Name	Setting	R/W	Function
5	P15DR	0/1	R/W	0: P15 pin is set to the low level. 1: P15 pin is set to the high level.
4	P14DR	0/1	R/W	0: P14 pin is set to the low level. 1: P14 pin is set to the high level.

5. Flowchart


main
P1DDR = H'30
P1DR = H'CF
st_num = DTNUM
Set the number of slave transmit data.
2
i = 0
i < DTNUM?
Yes
No
SRcv_dt[i] = 0
Clear the reception area.
i++
iic_init()
Initialization of the I2C bus interface
I bit in CCR = 0
Enable interrupts.
sr_cnt < DTNUM (128) + 1?
Judge whether or not 128-byte data are received.
Yes
No
st_cnt < DTNUM (128) + 1?
Judge whether or not 128-byte data are received.
Yes
No
I bit in CCR = 1
Disable interrupts.
1


1
SRcv_dt[0] = H'81?
Judge whether or not the first byte is the data of master 1.
Yes Data of master 1
No
SRcv_dt[0] = H'82?
Judge whether or not the first byte is the data of master 2.
Yes Data of master 2
No
error
P15, P14 = 1, 1
Data error
P15, P14 = 1, 0
Data of master 2
P15, P14 = 0, 1
Data of master 1
2

5.7.4 Function wovi_int

1. Overview
   This is the handler for the WDT interval timer overflow interrupt. When the I²C bus interface hangs because of noise or some other factor, the WDT counter will overflow, generating the interrupt. The handler executes recovery processing for the I²C bus interface.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used for this sample task, and are not initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
7	ICE	1	R/W	I²C Bus Interface Enable 0: Disables the IIC2 module. 1: Enables transfer via the IIC2 module (pins SCL and SDA are driving the bus).
5	MST	1	R/W	Master/Slave Select
4	TRS	1	R/W	11: Master transmit mode

- I²C bus control register B_0 (ICCRB_0) Address: H'FFFD59

Bit	Bit Name	Setting	R/W	Function
7	BBSY	0/1	R/W	Bus Busy The BBSY flag can be read to check whether the I²C bus (SCL, SDA) is busy or free. In master mode, this bit is also used to issue start and stop conditions. A high-to-low transition of SDA while SCL is high is recognized as a start condition, setting BBSY to 1. A low-to-high transition of SDA while SCL is high is recognized as a stop condition, clearing BBSY to 0. Using a MOV instruction to write 1 in BBSY and 0 in SCP issues a start condition. A start condition is issued in the same way. Using a MOV instruction to write 0 in BBSY and SCP issues a stop condition.
6	SCP	0	R/W	Start Condition/Stop Condition Prohibit Bit Controls the issuing of start and stop conditions in master mode. Writing 1 in BBSY and 0 in SCP issues a start condition. A retransmit start condition is issued in the same way. Writing 0 in BBSY and SCP issues a stop condition. This bit is always read as 1. Writing of 1 has no effect.
1	IICRST	1	R/W	I²C Bus Interface Control Part Reset This bit resets control parts except for I²C registers. If this bit is set to 1 when hang-up is occurred because of communication failure during I²C operation, I²C control part can be reset without setting ports and initializing registers.

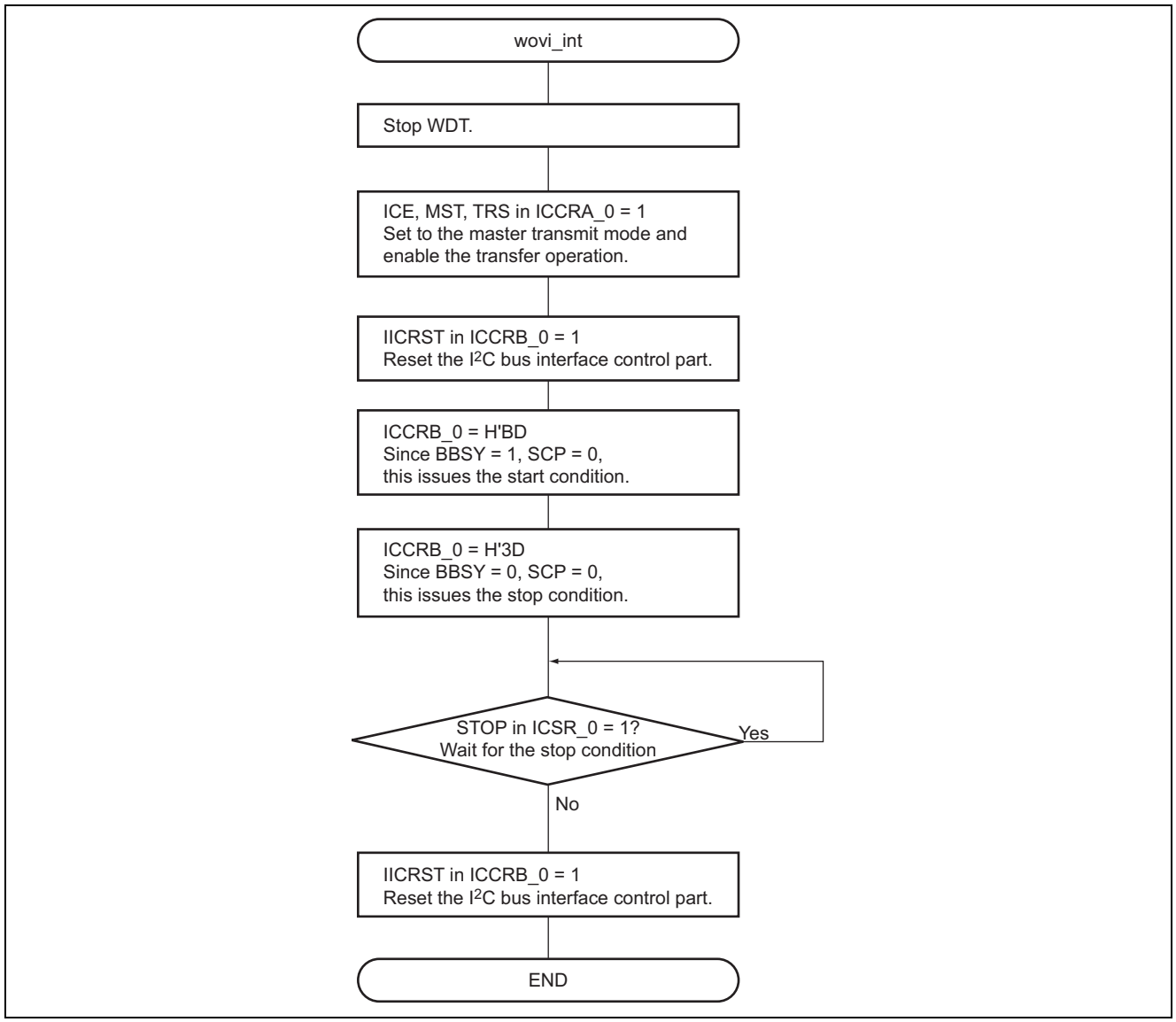
- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

Bit	Bit Name	Setting	R/W	Function
3	STOP	Undecided	R/W	Stop Condition Detection Flag [Setting condition] • Detection of a stop condition after completion of frame transfer in master mode • Detection of a stop condition after match of the first-byte address after general call and detection of start condition and address set in SAR in slave mode [Clearing condition] • Writing 0 to this bit after reading it as 1.

- Timer control/status register (TCSR) Address: H'FFFFBC

Bit	Bit Name	Setting	R/W	Function
5	TME	0	R/W	Timer Enable 0: TCNT stops counting and is initialized to H'00. 1: TCNT starts counting.

5. Flowchart


wovi_int
Stop WDT.
ICE, MST, TRS in ICCRA_0 = 1
Set to the master transmit mode and
enable the transfer operation.
IICRST in ICCRB_0 = 1
Reset the I2C bus interface control part.
ICCRB_0 = H'BD
Since BBSY = 1, SCP = 0,
this issues the start condition.
ICCRB_0 = H'3D
Since BBSY = 0, SCP = 0,
this issues the stop condition.
STOP in ICSR_0 = 1?
Wait for the stop condition
Yes
No
IICRST in ICCRB_0 = 1
Reset the I2C bus interface control part.
END

5.8 Functions of File iic.c

5.8.1 Function iic_init

1. Overview
   I²C bus interface initialization routine
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used for this sample task, and are not initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
7	ICE	1	R/W	I²C Bus Interface Enable 0: Disables the IIC2 module. 1: Enables transfer via the IIC2 module (pins SCL and SDA are driving the bus).
6	RCVD	0	R/W	Reception Disable Enables or disables the next operation when TRS is 0 and ICDRR is read. 0: Enables the next reception. 1: Disables the next reception.
5	MST	0	R/W	Master/Slave Select
4	TRS	0	R/W	00: Slave receive mode
3	CKS3	1	R/W	Transfer Clock Select 3 to 0
2	CKS2	1	R/W	1100: Transfer rate is 98.2 kbits/s with ϕ = 33 MHz
1	CKS1	0	R/W	
0	CKS0	0	R/W	

- I²C bus mode register_0 (ICMR_0) Address: H'FFFD5A

Bit	Bit Name	Setting	R/W	Function
6	WAIT	0	R/W	Wait Insertion Bit This bit selects whether to insert a wait on completion of data transfer other than the acknowledge bit. When WAIT is set to 1, after the falling edge of the clock cycle for the final data bit, the low period is extended for two cycles of the transfer clock. When WAIT is cleared to 0, data and acknowledge bits are transferred consecutively with no wait inserted. The setting of this bit is invalid in slave mode. Note that in usage with WAIT set to 1, when the slave device pulls SCL to the low level after the low period of SDA in the eighth and ninth clock cycles has extended for at least two cycles of the transfer clock, the high period of the ninth cycle of the transfer clock may be shortened. In such cases, the WAIT setting in this situation should be changed to 0. Except under this condition, however, there is no problem with usage.

- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	1	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1. 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).
6	TEIE	0	R/W	Transmit End Interrupt Enable Enables or disables the transmit end interrupt (TEI) at the rising of the ninth clock while the TDRE bit in ICSR is 1. TEI can be canceled by clearing the TEND bit or the TEIE bit to 0. 0: Disables the transmit end interrupt request (TEI). 1: Enables the transmit end interrupt request (TEI).
5	RIE	1	R/W	Receive Interrupt Enable Enables or disables the receive data full interrupt request (RXI) when a received data is transferred from ICDRS to ICDRR and the RDRF bit in ICSR is set to 1. RXI can be canceled by clearing the RDRF or RIE bit to 0. 0: Disables the receive data full interrupt request (RXI). 1: Enables the receive data full interrupt request (RXI).
4	NAKIE	1	R/W	NACK Receive Interrupt Enable Enables or disables the NACK receive interrupt request (NAKI) when the NACKF and AL bits in ICSR are set to 1. NAKI can be canceled by clearing the NACKF, AL, or NAKIE bit to 0. 0: Disables the NACK receive interrupt request (NAKI). 1: Enables the NACK receive interrupt request (NAKI).
3	STIE	1	R/W	Stop Condition Detection Interrupt Enable 0: Disables the stop condition detection interrupt request (STPI). 1: Enables the stop condition detection interrupt request (STPI).
2	ACKE	1	R/W	Acknowledge Bit Judgment Select 0: The value of the acknowledge bit is ignored, and continuous transfer is performed. 1: When the acknowledge bit is 1, continuous transfer is interrupted.
0	ACKBT	0	R/W	Transmit Acknowledge Specifies the bit to be sent at the acknowledge timing in receive mode. 0: 0 is output at acknowledge timing. 1: 1 is output at acknowledge timing.

- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

Bit	Bit Name	Setting	R/W	Function
7	TDRE	0	R/W	Transmit Data Register Empty [Setting condition] • Transferring of data from ICDRT to ICDRS and having ICDRT empty • Setting of TRS • Issuing of a start condition (including retransmission) • Transition from the receive mode to the transmit mode has been made in the slave mode [Clearing conditions] • Writing of 0 in TDRE after reading TDRE as 1 • Writing of data in ICDRT
6	TEND	0	R/W	Transmit End [Setting conditions] • Rising of the ninth clock of SCL while the TDRE flag is 1 [Clearing conditions] • Writing 0 in TEND after reading TEND as 1 • Writing of data in ICDRT
5	RDRF	0	R/W	Receive Data Register Full [Setting condition] • Transferring of received data from ICDRS to ICDRR [Clearing conditions] • Writing of 0 in RDRF after reading RDRF as 1 • Reading of data from ICDRR
4	NACKF	0	R/W	No Acknowledge Detection Flag [Setting condition] • Detection of no acknowledge from the receive device in transmission while the ACKE bit in ICIER is 1 [Clearing condition] • Writing of 0 in NACKF after reading NACKF as 1.
3	STOP	0	R/W	Stop Condition Detection Flag [Setting condition] • Detection of a stop condition after completion of frame transfer in master mode • Detection of a stop condition after match of the first-byte address after general call and detection of start condition and address set in SAR in slave mode [Clearing condition] • Writing of 0 to this bit after reading it as 1.
2	AL	0	R/W	Arbitration Lost Flag Indicates that arbitration was lost in the master mode. When two or more master devices attempt to seize the bus at nearly the same time, if the I²C bus interface detects data differing from the data it sent, it sets AL to 1 to indicate that the bus has been taken by another master. [Setting conditions] • Different values for the internal SDA signal and SDA pin on a rising edge of SCL in master transmit mode • The SDA pin being at the high level in master mode while a start condition is detected [Clearing condition] • Writing of 0 to this bit after reading it as 1

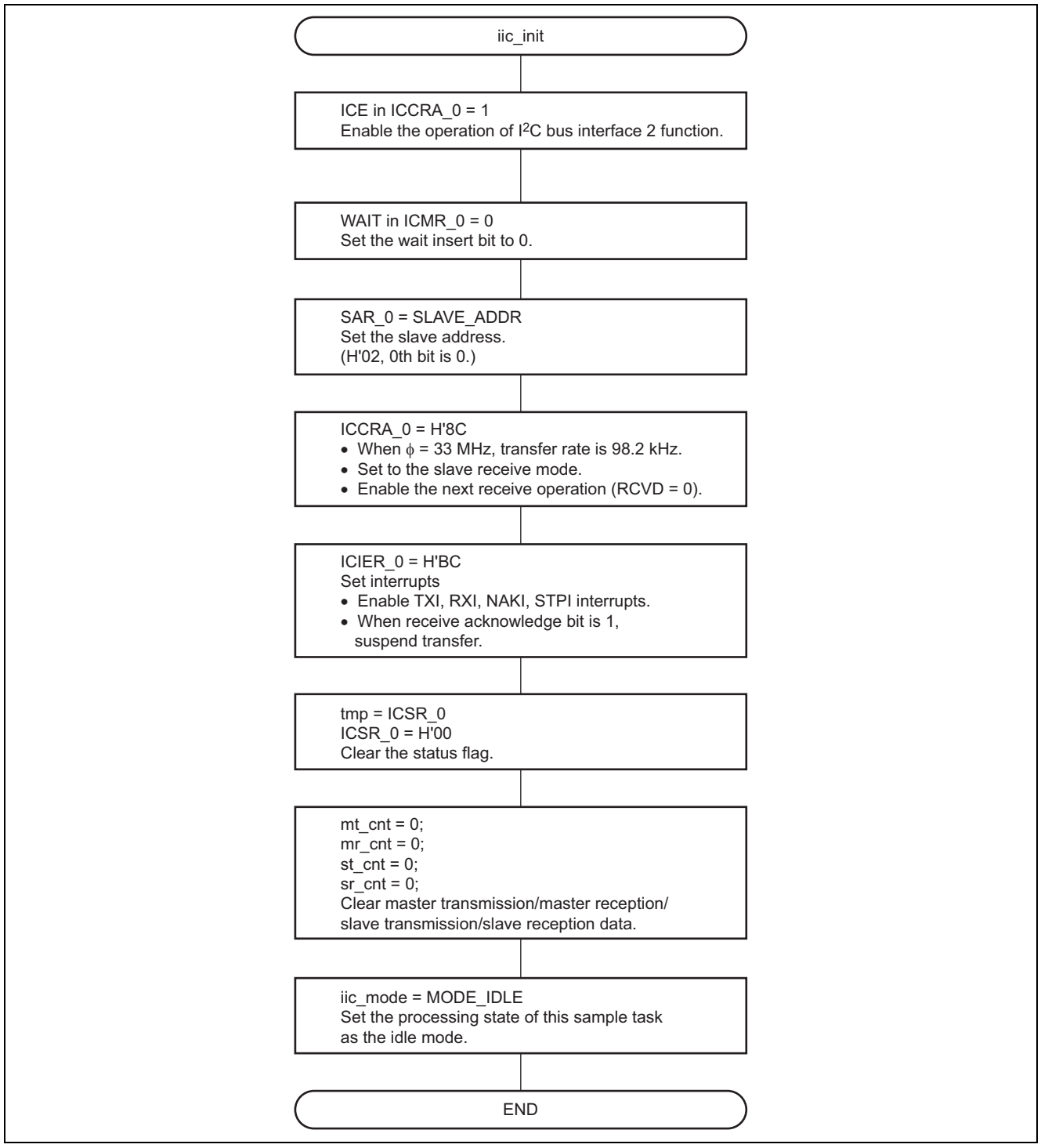
Bit	Bit Name	Setting	R/W	Function
1	AAS	0	R/W	Slave Address Recognition Flag In slave receive mode, this flag is set to 1 when the first frame following a start condition matches bits SVA6 to SVA0 in SAR. [Setting condition] • Detection of the slave address in slave receive mode. • Detection of the general call address in the slave receive mode. [Clearing condition] • Writing of 0 to this bit after reading it as 1

- Slave address register_0 (SAR_0) Address: H'FFFD5D

The slave address is set in the SAR bits. An interface in slave mode responds as the slave device when the 7 higher-order bits of SAR match the 7 higher-order bits of the first frame received after a start condition.

Bit	Bit Name	Setting	R/W	Function
7 to1	SVA6 to SVA0	SLAVE_ADDR	R/W	Slave Address 6 to 0 Unique address setting (address differing from the addresses of other slave devices connected to the I²C bus) for the device.
0	—		R/W	Reserved This bit is readable/writable. 1 should be written in writing.

5. Flowchart


iic_init
ICE in ICCRA_0 = 1
Enable the operation of I2C bus interface 2 function.
WAIT in ICMR_0 = 0
Set the wait insert bit to 0.
SAR_0 = SLAVE_ADDR
Set the slave address.
(H'02, 0th bit is 0.)
ICCRA_0 = H'8C
• When ϕ = 33 MHz, transfer rate is 98.2 kHz.
• Set to the slave receive mode.
• Enable the next receive operation (RCVD = 0).
ICIER_0 = H'BC
Set interrupts
• Enable TXI, RXI, NAKI, STPI interrupts.
• When receive acknowledge bit is 1,
suspend transfer.
tmp = ICSR_0
ICSR_0 = H'00
Clear the status flag.
mt_cnt = 0;
mr_cnt = 0;
st_cnt = 0;
sr_cnt = 0;
Clear master transmission/master reception/
slave transmission/slave reception data.
iic_mode = MODE_IDLE
Set the processing state of this sample task
as the idle mode.
END

5.8.2 Function mtrs_start

1. Overview

This function sets up the task for I²C bus interface master transmission and issues the start condition.

2. Arguments

Type	Name of Variable	Description
const unsigned char	*dtadd	First address of data for transmission
unsigned short	dtnum	Number of data to be transmitted

3. Return value

Type	Description
unsigned char	0: Starts normal transmission. 1: Transmission in progress 2: Bus busy 3: Argument error

4. Internal registers used

The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
5	MST	1	R/W	Master/Slave Select
4	TRS	1	R/W	11: Master transmit mode

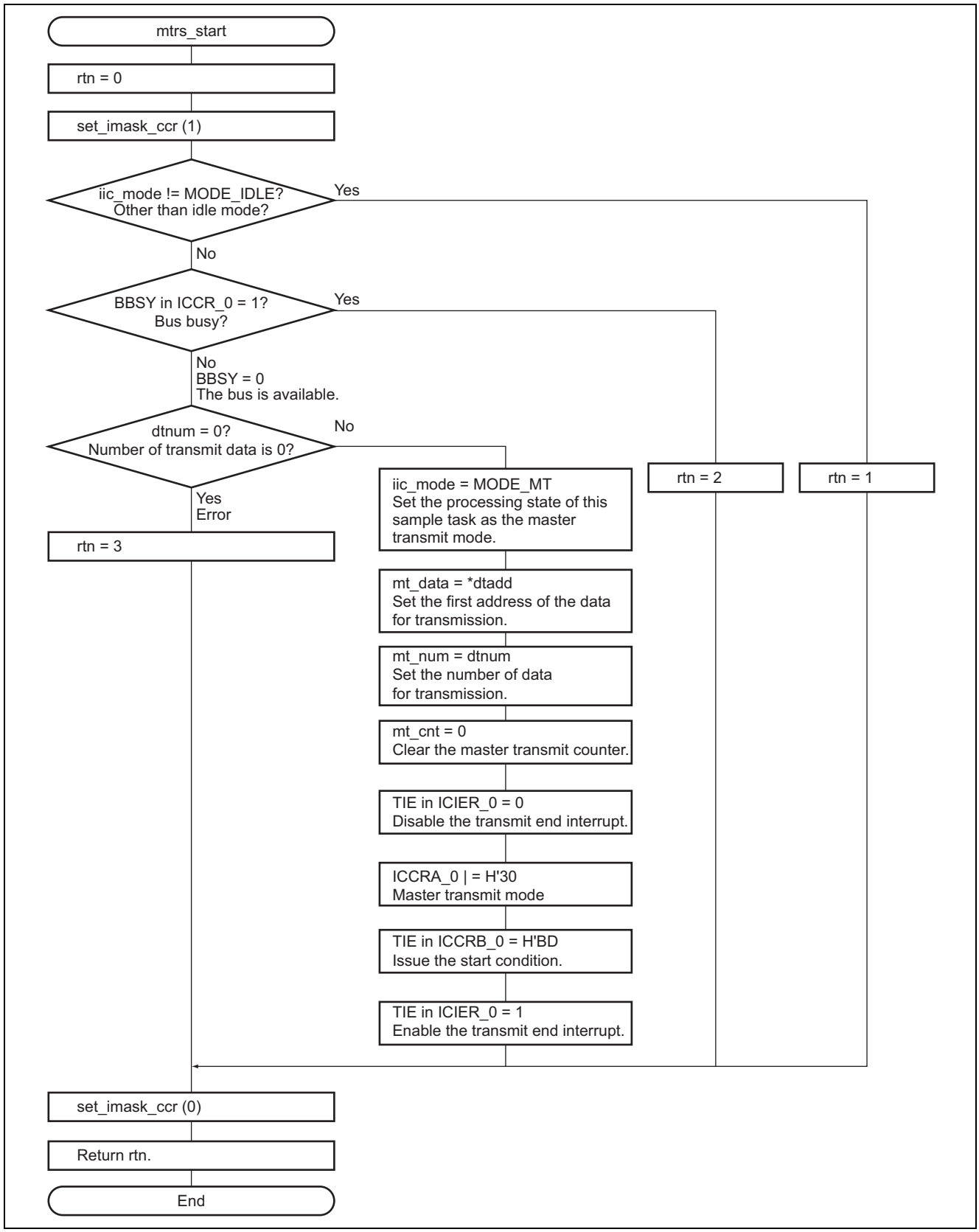
- I²C bus control register B_0 (ICCRB_0) Address: H'FFFD59

Bit	Bit Name	Setting	R/W	Function
7	BBSY	1	R/W	Bus Busy The BBSY flag can be read to check whether the I²C bus (SCL, SDA) is busy or free. In master mode, this bit is also used to issue start and stop conditions. A high-to-low transition of SDA while SCL is high is recognized as a start condition, setting BBSY to 1. A low-to-high transition of SDA while SCL is high is recognized as a stop condition, clearing BBSY to 0. Using a MOV instruction to write 1 in BBSY and 0 in SCP issues a start condition. A start condition is issued in the same way. Using a MOV instruction to write 0 in BBSY and SCP issues a stop condition.
6	SCP	0	R/W	Start Condition/Stop Condition Prohibit Bit Controls the issuing of start and stop conditions in master mode. Writing 1 in BBSY and 0 in SCP issues a start condition. A retransmit start condition is issued in the same way. Writing 0 in BBSY and SCP issues a stop condition. This bit is always read as 1. Writing of 1 has no effect.

- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	1	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1. 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).

5. Flowchart


mtrs_start
rtn = 0
set_imask_ccr (1)
iic_mode != MODE_IDLE?
Other than idle mode?
Yes
No
BBSY in ICCR_0 = 1?
Bus busy?
Yes
No
BBSY = 0
The bus is available.
dtnum = 0?
Number of transmit data is 0?
No
Yes
Error
rtn = 3
iic_mode = MODE_MT
Set the processing state of this sample task as the master transmit mode.
mt_data = *dtadd
Set the first address of the data for transmission.
mt_num = dtnum
Set the number of data for transmission.
mt_cnt = 0
Clear the master transmit counter.
TIE in ICIER_0 = 0
Disable the transmit end interrupt.
ICCRA_0 | = H'30
Master transmit mode
TIE in ICCRB_0 = H'BD
Issue the start condition.
TIE in ICIER_0 = 1
Enable the transmit end interrupt.
rtn = 2
rtn = 1
set_imask_ccr (0)
Return rtn.
End

5.8.3 Function mrcv_start

1. Overview

This function sets up the task for I²C bus interface master reception and issues the start condition.

2. Arguments

Type	Name of Variable	Description
const unsigned char	*dtadd	First address of received data
unsigned short	dtnum	Number of data (bytes) received

3. Return value

Type	Description
unsigned char	0: Starts normal transmission. 1: Transmission in progress 2: Bus busy 3: Argument error

4. Internal registers used

The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
5	MST	1	R/W	Master/Slave Select
4	TRS	1	R/W	11: Master transmit mode

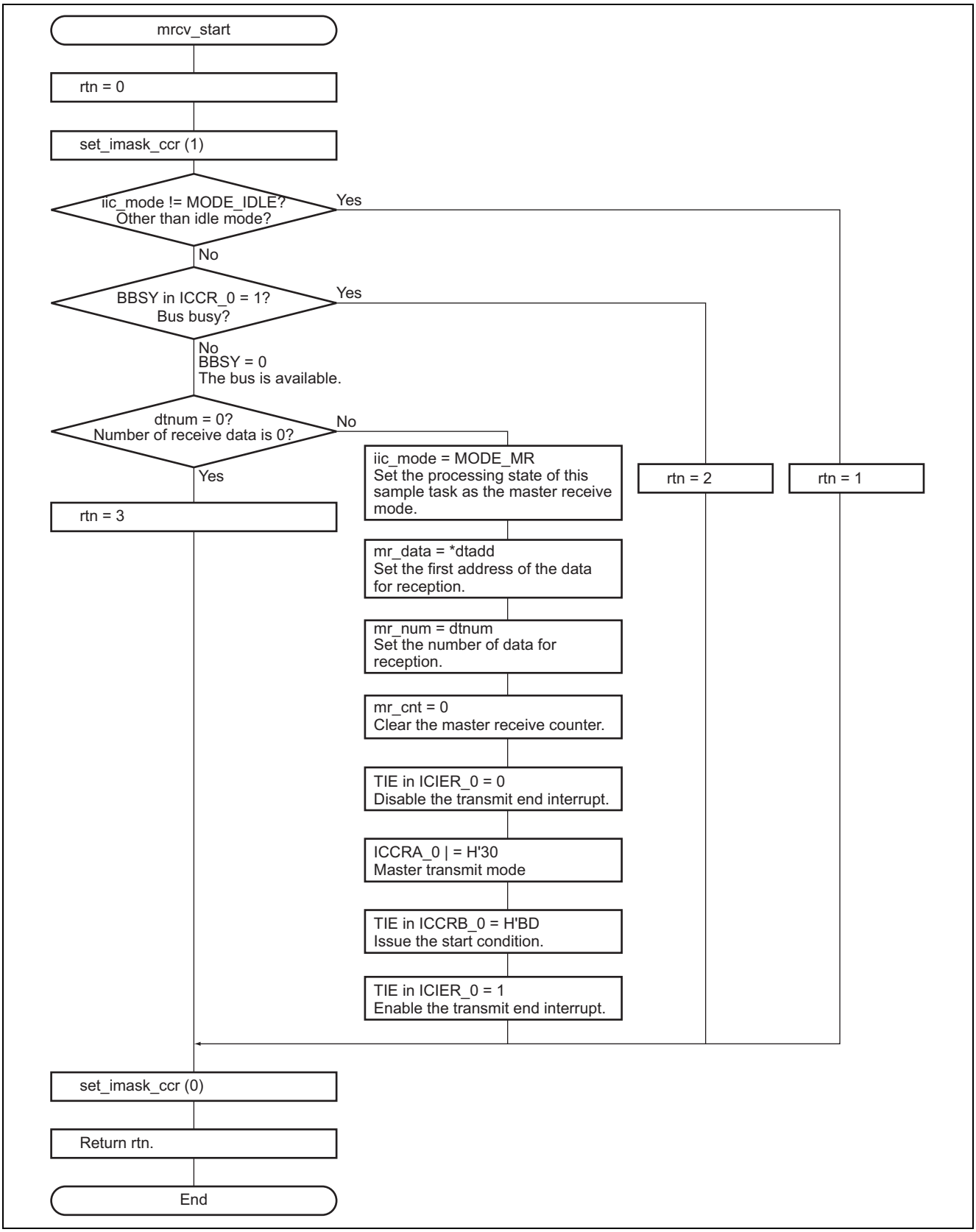
- I²C bus control register B_0 (ICCRB_0) Address: H'FFFD59

Bit	Bit Name	Setting	R/W	Function
7	BBSY	1	R/W	Bus Busy The BBSY flag can be read to check whether the I²C bus (SCL, SDA) is busy or free. In master mode, this bit is also used to issue start and stop conditions. A high-to-low transition of SDA while SCL is high is recognized as a start condition, setting BBSY to 1. A low-to-high transition of SDA while SCL is high is recognized as a stop condition, clearing BBSY to 0. Using a MOV instruction to write 1 in BBSY and 0 in SCP issues a start condition. A start condition is issued in the same way. Using a MOV instruction to write 0 in BBSY and SCP issues a stop condition.
6	SCP	0	R/W	Start Condition/Stop Condition Prohibit Bit Controls the issuing of start and stop conditions in master mode. Writing 1 in BBSY and 0 in SCP issues a start condition. A retransmit start condition is issued in the same way. Writing 0 in BBSY and SCP issues a stop condition. This bit is always read as 1. Writing of 1 has no effect.

- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	1	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1. 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).

5. Flowchart


mrcv_start
rtn = 0
set_imask_ccr (1)
iic_mode != MODE_IDLE?
Other than idle mode?
Yes
No
BBSY in ICCR_0 = 1?
Bus busy?
Yes
No
BBSY = 0
The bus is available.
dtnum = 0?
Number of receive data is 0?
No
Yes
rtn = 3
iic_mode = MODE_MR
Set the processing state of this sample task as the master receive mode.
mr_data = *dtadd
Set the first address of the data for reception.
mr_num = dtnum
Set the number of data for reception.
mr_cnt = 0
Clear the master receive counter.
TIE in ICIER_0 = 0
Disable the transmit end interrupt.
ICCRA_0 | = H'30
Master transmit mode
TIE in ICCRB_0 = H'BD
Issue the start condition.
TIE in ICIER_0 = 1
Enable the transmit end interrupt.
rtn = 2
rtn = 1
set_imask_ccr (0)
Return rtn.
End

5.8.4 Function iici0_int

1. Overview
   Handler for I²C bus interface interrupts. According to the state of operations, this function calls the functions for receiving the stop condition, master transmission, and master reception, slave transmission, and slave reception.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

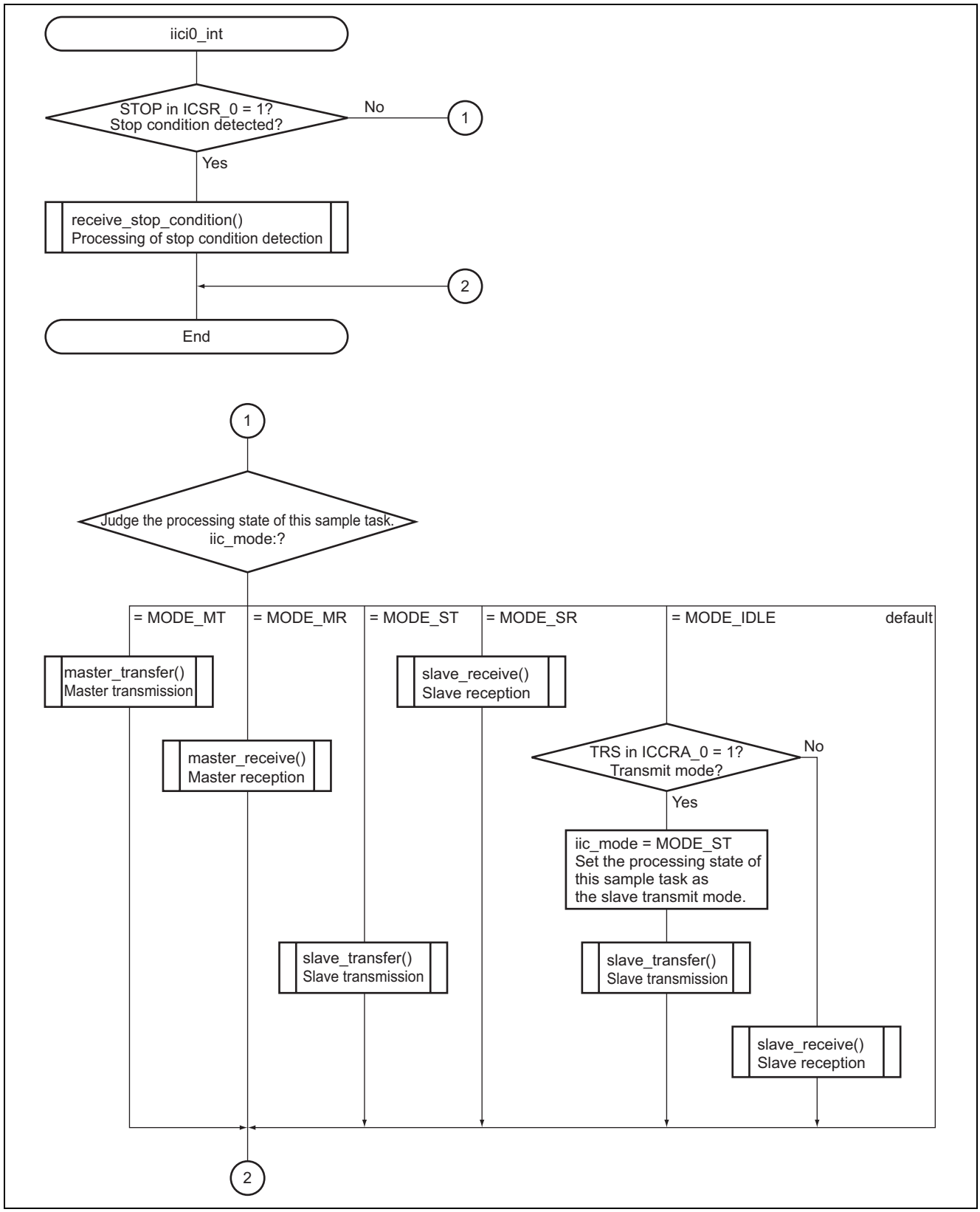
- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
4	TRS	Undefined	R/W	Master/Slave Select 0: Receive mode 1: Transmit mode

- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

Bit	Bit Name	Setting	R/W	Function
3	STOP	Undefined	R/W	Stop Condition Detection Flag [Setting condition] • Detection of a stop condition after completion of frame transfer in master mode • Detection of a stop condition after match of the first-byte address after general call and detection of start condition and address set in SAR in slave mode [Clearing condition] • Writing 0 to this bit after reading it as 1.

5. Flowchart


iici0_int
STOP in ICSR_0 = 1?
Stop condition detected?
No
1
Yes
receive_stop_condition()
Processing of stop condition detection
2
End
1
Judge the processing state of this sample task.
iic_mode:?
= MODE_MT
= MODE_MR
= MODE_ST
= MODE_SR
= MODE_IDLE
default
master_transfer()
Master transmission
master_receive()
Master reception
slave_receive()
Slave reception
TRS in ICCRA_0 = 1?
Transmit mode?
No
Yes
iic_mode = MODE_ST
Set the processing state of
this sample task as
the slave transmit mode.
slave_transfer()
Slave transmission
slave_transfer()
Slave transmission
slave_receive()
Slave reception
2

5.8.5 Function receive_stop_condition

1. Overview
   This function handles processing on detection of the stop condition.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
6	RCVD	0	R/W	Reception Disable Enables or disables the next operation when TRS is 0 and ICDRR is read. 0: Enables the next reception. 1: Disables the next reception.
5	MST	0	R/W	Master/Slave Select
4	TRS	0	R/W	00: Slave receive mode

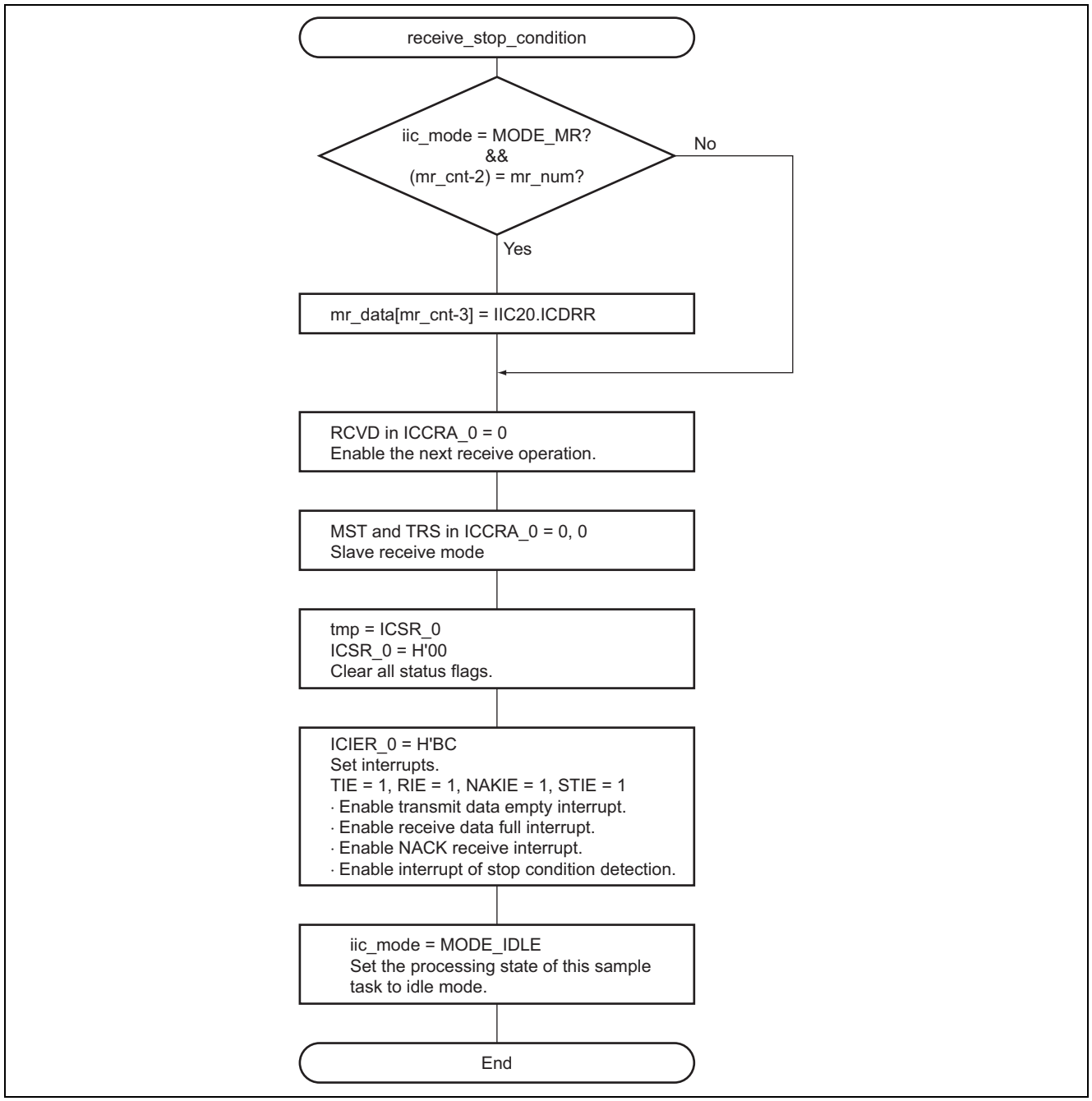
- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	1	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).
6	TEIE	0	R/W	Transmit End Interrupt Enable Enables or disables the transmit end interrupt (TEI) at the rising of the ninth clock while the TDRE bit in ICSR is 1. TEI can be canceled by clearing the TEND bit or the TEIE bit to 0. 0: Disables the transmit end interrupt request (TEI). 1: Enables the transmit end interrupt request (TEI).
5	RIE	1	R/W	Receive Interrupt Enable Enables or disables the receive data full interrupt request (RXI) when a received data is transferred from ICDRS to ICDRR and the RDRF bit in ICSR is set to 1. RXI can be canceled by clearing the RDRF or RIE bit to 0. 0: Disables the receive data full interrupt request (RXI). 1: Enables the receive data full interrupt request (RXI).
4	NAKIE	1	R/W	NACK Receive Interrupt enable Enables or disables the NACK receive interrupt request (NAKI) when the NACKF and AL bits in ICSR are set to 1. NAKI can be canceled by clearing the NACKF, AL, or NAKIE bit to 0. 0: Disables the NACK receive interrupt request. 1: Enables the NACK receive interrupt request.
3	STIE	1	R/W	Stop Condition Detection Interrupt Enable 0: Disables the stop condition detection interrupt request (STPI). 1: Enables the stop condition detection interrupt request (STPI).
2	ACKE	1	R/W	Acknowledge Bit Judgment Select 0: The value of the acknowledge bit is ignored, and continuous transfer is performed. 1: When the acknowledge bit is 1, continuous transfer is interrupted.
0	ACKBT	0	R/W	Transmit Acknowledge Specifies the bit to be sent at the acknowledge timing in receive mode. 0: 0 is output at acknowledge timing. 1: 1 is output at acknowledge timing.

- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

Bit	Bit Name	Setting	R/W	Function
7	TDRE	0	R/W	Transmit Data Register Empty [Setting condition] • Transferring of data from ICDRT to ICDRS and having ICDRT empty. • Setting of TRS. • Issuing of a start condition (including retransmission). • Transition from the receive mode to the transmit mode has been made in the slave mode. [Clearing conditions] • Writing of 0 in TDRE after reading it as 1 • Writing of data in ICDRT.
4	NACKF	0	R/W	No Acknowledge Detection Flag [Setting condition] • Detection of no acknowledge from the receive device in transmission while the ACKE bit in ICIER is 1. [Clearing condition] • Writing of 0 in NACKF after reading it as 1.
1	AAS	0	R/W	Slave Address Recognition Flag In slave receive mode, this flag is set to 1 when the first frame following a start condition matches bits SVA6 to SVA0 in SAR. [Setting condition] • Detection of the slave address in slave receive mode. • Detection of the general call address in the slave receive mode. [Clearing condition] • Writing of 0 in AAS after reading it as 1.

5. Flowchart


receive_stop_condition
iic_mode = MODE_MR?
&&
(mr_cnt-2) = mr_num?
No
Yes
mr_data[mr_cnt-3] = IIC20.ICDRR
RCVD in ICCRA_0 = 0
Enable the next receive operation.
MST and TRS in ICCRA_0 = 0, 0
Slave receive mode
tmp = ICSR_0
ICSR_0 = H'00
Clear all status flags.
ICIER_0 = H'BC
Set interrupts.
TIE = 1, RIE = 1, NAKIE = 1, STIE = 1
· Enable transmit data empty interrupt.
· Enable receive data full interrupt.
· Enable NACK receive interrupt.
· Enable interrupt of stop condition detection.
iic_mode = MODE_IDLE
Set the processing state of this sample task to idle mode.
End

5.8.6 Function master_transfer

1. Overview
   Master-transmission processing which is called from the I²C bus interface interrupt handler. In this case, the interrupt source will be the transmit data empty interrupt for each byte of transmitted data. When arbitration is lost, it places the interface in slave receive mode.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C bus control register B_0 (ICCRB_0) Address: H'FFFD59

Bit	Bit Name	Setting	R/W	Function
7	BBSY	0	R/W	Bus Busy The BBSY flag can be read to check whether the I²C bus (SCL, SDA) is busy or free. In master mode, this bit is also used to issue start and stop conditions. A high-to-low transition of SDA while SCL is high is recognized as a start condition, setting BBSY to 1. A low-to-high transition of SDA while SCL is high is recognized as a stop condition, clearing BBSY to 0. Using a MOV instruction to write 1 in BBSY and 0 in SCP issues a start condition. A start condition is issued in the same way. Using a MOV instruction to write 0 in BBSY and SCP issues a stop condition.
6	SCP	0	R/W	Start Condition/Stop Condition Prohibit Bit Controls the issuing of start and stop conditions in master mode. Writing 1 in BBSY and 0 in SCP issues a start condition. A retransmit start condition is issued in the same way. Writing 0 in BBSY and SCP issues a stop condition. This bit is always read as 1. Writing of 1 has no effect.
3	SCLO	Undefined	R	Monitors level of signal output from SCL. When the SCLO bit is set to 1 in reading, the signal output from SCL is at high level. When the SCLO bit is set to 0 in reading, the signal output from SCL is at low level.

- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	0/1	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).
6	TEIE	0/1	R/W	Transmit End Interrupt Enable Enables or disables the transmit end interrupt (TEI) at the rising of the ninth clock while the TDRE bit in ICSR is 1. TEI can be canceled by clearing the TEND bit or the TEIE bit to 0. 0: Disables the transmit end interrupt request (TEI). 1: Enables the transmit end interrupt request (TEI).

- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

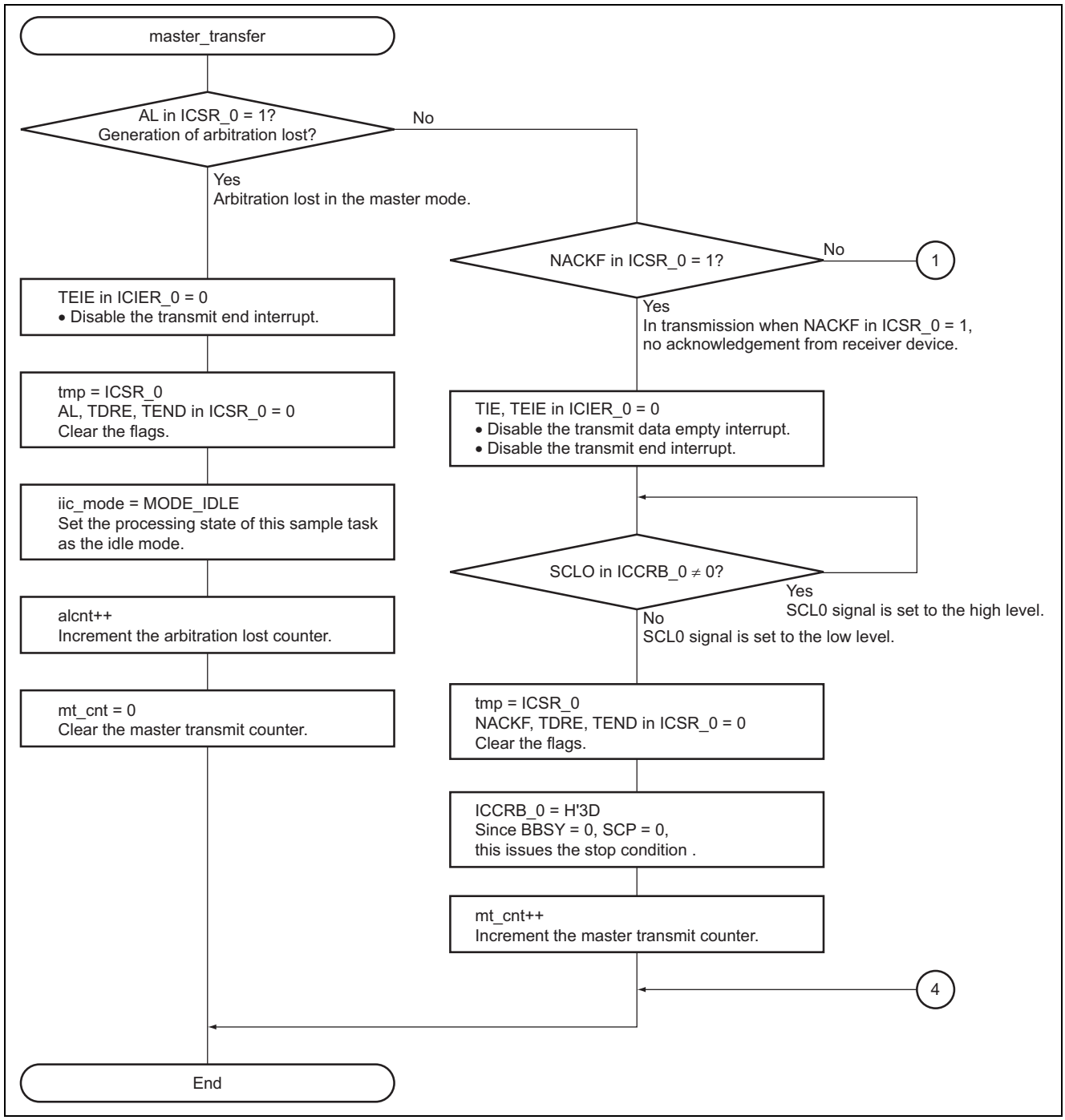
Bit	Bit Name	Setting	R/W	Function
7	TDRE	0	R/W	Transmit Data Register Empty [Setting condition] • Transferring of data from ICDRT to ICDRS and having ICDRT empty. • Setting of TRS. • Issuing of a start condition (including retransmission). • Transition from the receive mode to the transmit mode has been made in the slave mode. [Clearing conditions] • Writing of 0 in TDRE after reading it as 1 • Writing of data in ICDRT.
6	TEND	0	R/W	Transmit End [Setting conditions] • Rising of the ninth clock of SCL while the TDRE flag is 1 [Clearing conditions] • Writing 0 in TEND after reading it as 1 • Writing of data in ICDRT
4	NACKF	0	R/W	No Acknowledge Detection Flag [Setting condition] • Detection of no acknowledge from the receive device in transmission while the ACKE bit in ICIER is 1 [Clearing condition] • Writing of 0 in NACKF after reading it as 1
2	AL	0	R/W	Arbitration Lost Flag Indicates that arbitration was lost in the master mode. When two or more master devices attempt to seize the bus at nearly the same time, if the I²C bus interface detects data differing from the data it sent, it sets AL to 1 to indicate that the bus has been taken by another master. [Setting conditions] • Different values for the internal SDA signal and SDA pin on a rising edge of SCL in master transmit mode • The SDA pin being at the high level in master mode while a start condition is detected [Clearing condition] • Writing of 0 to this bit after reading it as 1

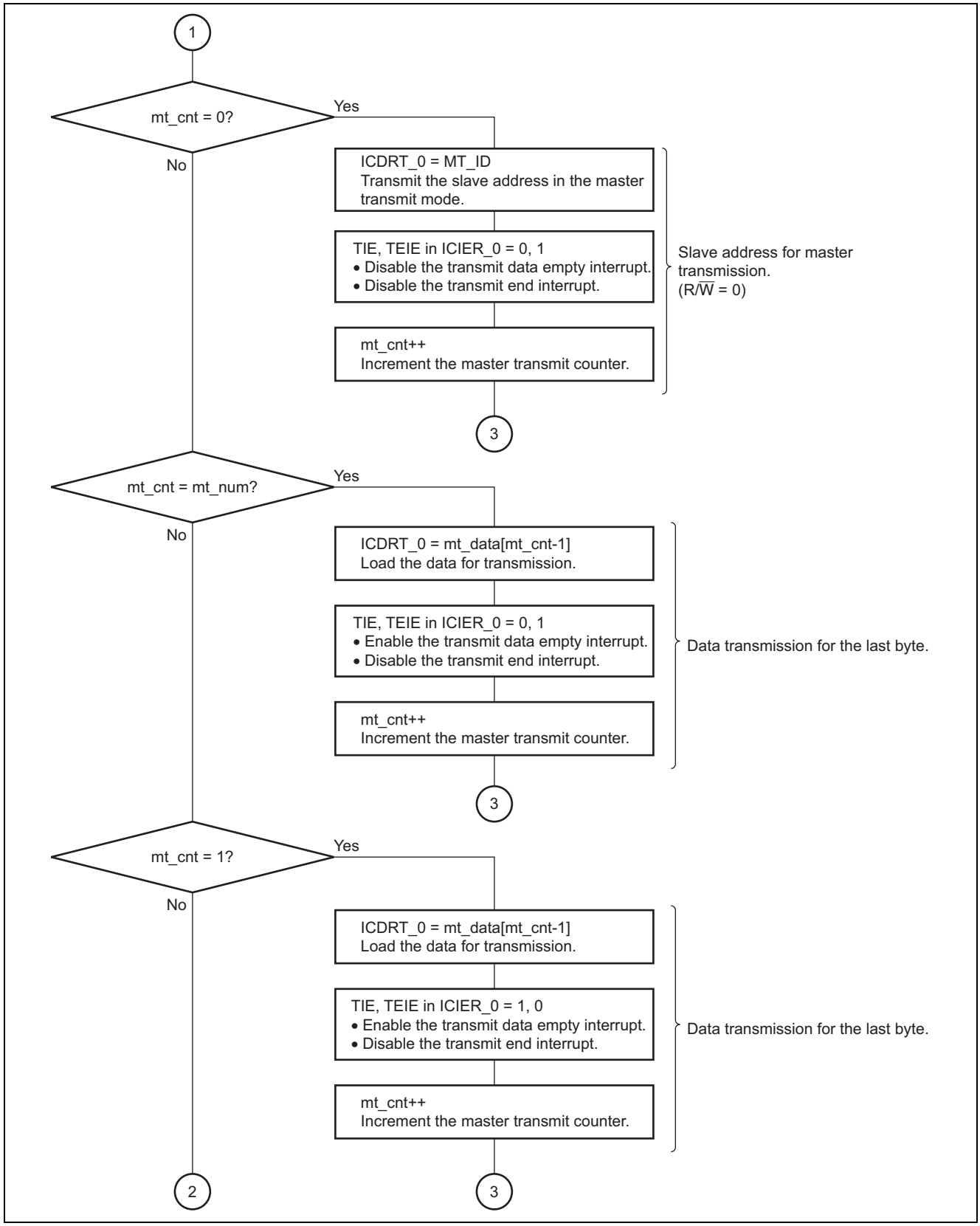
- I²C bus transmit data register_0 (ICDRT_0) Address: H'FFFD5E

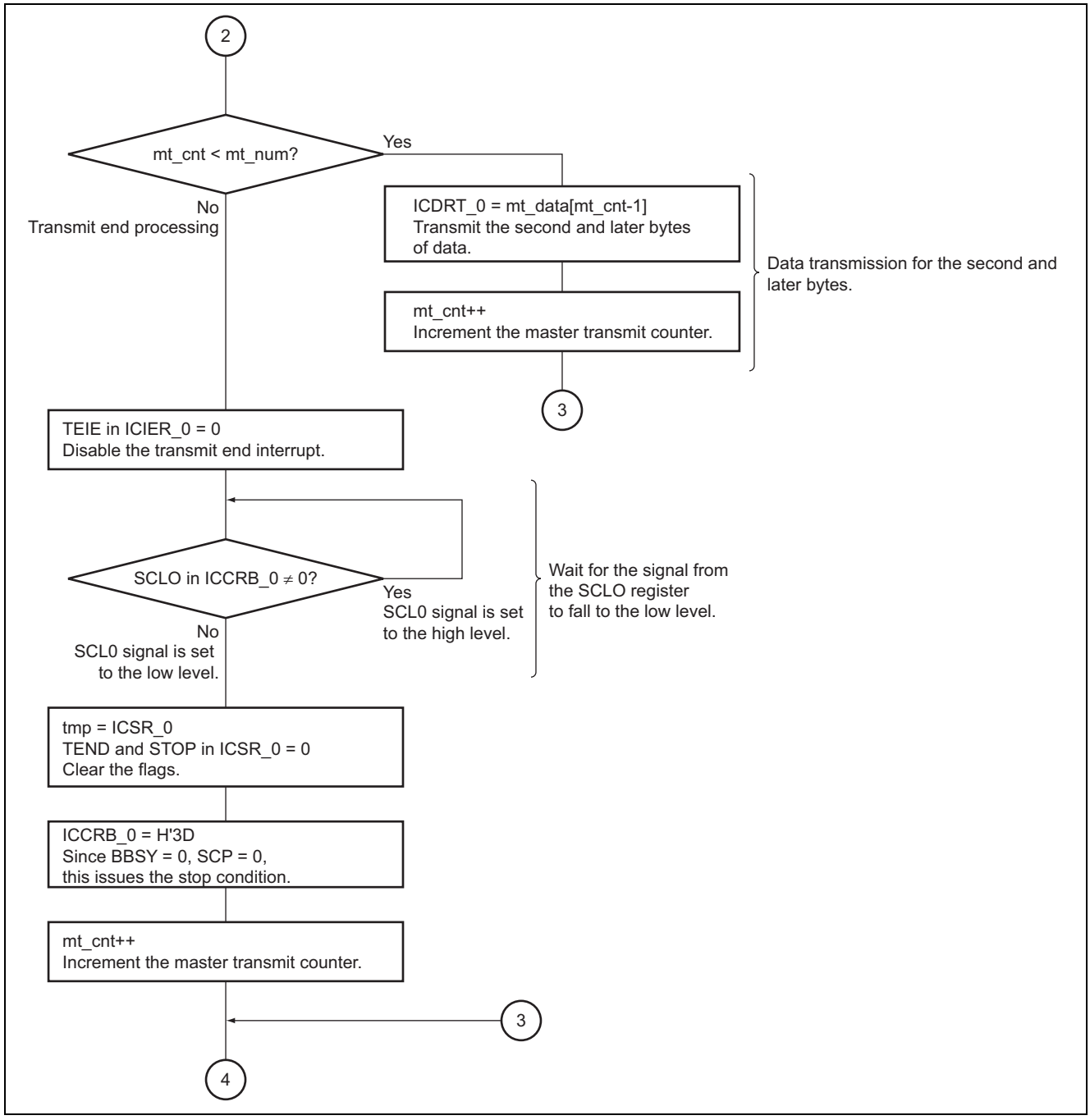
  Function: ICDRT is an 8-bit readable/writable register that stores the transmit data. When ICDRT detects the space in the I²C bus shift register (ICDRS), it transfers the transmit data which is written in ICDRT to ICDRS and starts transferring data. When the next transfer data is written to ICDRT during transferring data of ICDRS, continuous transfer is possible. The initial value of ICDRT is H'FF.

  Setting: MT_ID, mt_data[mt_cnt-1]

5. Flowchart




1
mt_cnt = 0?
Yes
No
ICDRT_0 = MT_ID
Transmit the slave address in the master transmit mode.
TIE, TEIE in ICIER_0 = 0, 1
• Disable the transmit data empty interrupt.
• Disable the transmit end interrupt.
mt_cnt++
Increment the master transmit counter.
Slave address for master transmission.
(R/W = 0)
3
mt_cnt = mt_num?
Yes
No
ICDRT_0 = mt_data[mt_cnt-1]
Load the data for transmission.
TIE, TEIE in ICIER_0 = 0, 1
• Enable the transmit data empty interrupt.
• Disable the transmit end interrupt.
mt_cnt++
Increment the master transmit counter.
Data transmission for the last byte.
3
mt_cnt = 1?
Yes
No
ICDRT_0 = mt_data[mt_cnt-1]
Load the data for transmission.
TIE, TEIE in ICIER_0 = 1, 0
• Enable the transmit data empty interrupt.
• Disable the transmit end interrupt.
mt_cnt++
Increment the master transmit counter.
Data transmission for the last byte.
2
3


2
mt_cnt < mt_num?
Yes
No
Transmit end processing
ICDRT_0 = mt_data[mt_cnt-1]
Transmit the second and later bytes of data.
mt_cnt++
Increment the master transmit counter.
Data transmission for the second and later bytes.
3
TEIE in ICIER_0 = 0
Disable the transmit end interrupt.
SCLO in ICCRB_0 ≠ 0?
Yes
SCL0 signal is set to the high level.
Wait for the signal from the SCLO register to fall to the low level.
No
SCL0 signal is set to the low level.
tmp = ICSR_0
TEND and STOP in ICSR_0 = 0
Clear the flags.
ICCRB_0 = H'3D
Since BBSY = 0, SCP = 0, this issues the stop condition.
mt_cnt++
Increment the master transmit counter.
3
4

5.8.7 Function master_receive

1. Overview
   Master-reception processing which is called by the I²C bus interface interrupt handler. In this case, the interrupt source will be the receive data full interrupt for each byte of received data.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
6	RCVD	1	R/W	Reception Disable Enables or disables the next operation when TRS is 0 and ICDRR is read. 0: Enables the next reception. 1: Disables the next reception.
4	TRS	0	R/W	Master/Slave Select 0: Receive mode 1: Transmit mode

- I²C bus control register B_0 (ICCRB_0) Address: H'FFFD59

Bit	Bit Name	Setting	R/W	Function
7	BBSY	0	R/W	Bus Busy The BBSY flag can be read to check whether the I²C bus (SCL, SDA) is busy or free. In master mode, this bit is also used to issue start and stop conditions. A high-to-low transition of SDA while SCL is high is recognized as a start condition, setting BBSY to 1. A low-to-high transition of SDA while SCL is high is recognized as a stop condition, clearing BBSY to 0. To issue a start condition, use a MOV instruction to write 1 in BBSY and 0 in SCP. A start condition is issued in the same way. To issue a stop condition, use a MOV instruction to write 0 in BBSY and 0 in SCP.
6	SCP	0	R/W	Start Condition/Stop Condition Prohibit Bit Controls the issuing of start and stop conditions in master mode. Writing 1 in BBSY and 0 in SCP issues a start condition. A retransmit start condition is issued in the same way. Writing 0 in BBSY and SCP issues a stop condition. This bit is always read as 1. Writing of 1 has no effect.
3	SCLO	Undefined	R	Monitors level of signal output from SCL. When the SCLO bit is set to 1 in reading, the signal output from SCL is at high level. When the SCLO bit is set to 0 in reading, the signal output from SCL is at low level.

- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	0	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).
6	TEIE	0/1	R/W	Transmit End Interrupt Enable Enables or disables the transmit end interrupt (TEI) at the rising of the ninth clock while the TDRE bit in ICSR is 1. TEI can be canceled by clearing the TEND bit or the TEIE bit to 0. 0: Disables the transmit end interrupt request (TEI). 1: Enables the transmit end interrupt request (TEI).
5	RIE	0/1	R/W	Receive Interrupt Enable Enables or disables the receive data full interrupt request (RXI) when a received data is transferred from ICDRS to ICDRR and the RDRF bit in ICSR is set to 1. RXI can be canceled by clearing the RDRF or RIE bit to 0. 0: Disables the receive data full interrupt request (RXI). 1: Enables the receive data full interrupt request (RXI).
0	ACKBT	0/1	R/W	Transmit acknowledge Specifies the bit to be sent at the acknowledge timing in receive mode. 0: 0 is output at acknowledge timing. 1: 1 is output at acknowledge timing.

- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

Bit	Bit Name	Setting	R/W	Function
7	TDRE	0	R/W	Transmit Data Register Empty [Setting condition] • Transferring of data from ICDRT to ICDRS and having ICDRT empty. • Setting of TRS. • Issuing of a start condition (including retransmission). • Transition from the receive mode to the transmit mode has been made in the slave mode. [Clearing conditions] • Writing of 0 in TDRE after reading it as 1 • Writing of data in ICDRT.
6	TEND	0	R/W	Transmit End [Setting conditions] • Rising of the ninth clock of SCL while the TDRE flag is 1 [Clearing conditions] • Writing of 0 in TEND after reading it as 1 • Writing of data in ICDRT
4	NACKF	0	R/W	No Acknowledge Detection Flag [Setting condition] • Detection of no acknowledge from the receive device in transmission while the ACKE bit in ICIER is 1 [Clearing condition] • Writing of 0 in NACKF after reading it as 1
2	AL	0	R/W	Arbitration Lost Flag Indicates that arbitration was lost in the master mode. When two or more master devices attempt to seize the bus at nearly the same time, when the I²C bus interface detects data differing from the data it sent, it sets AL to 1 to indicate that the bus has been taken by another master. [Setting conditions] • Different values for the internal SDA signal and SDA pin on a rising edge of SCL in master transmit mode • The SDA pin being at the high level in master mode while a start condition is detected [Clearing condition] • Writing of 0 to this bit after reading it as 1

- I²C bus transmit data register_0 (ICDRT_0) Address: H'FFFD5E

  Function: ICDRT is an 8-bit readable/writable register that stores the transmit data. When ICDRT detects the space in the I²C bus shift register (ICDRS), it transfers the transmit data which is written in ICDRT to ICDRS and starts transferring data. When the next transfer data is written to ICDRT during transferring data of ICDRS, continuous transfer is possible. The initial value of ICDRT is H'FF.

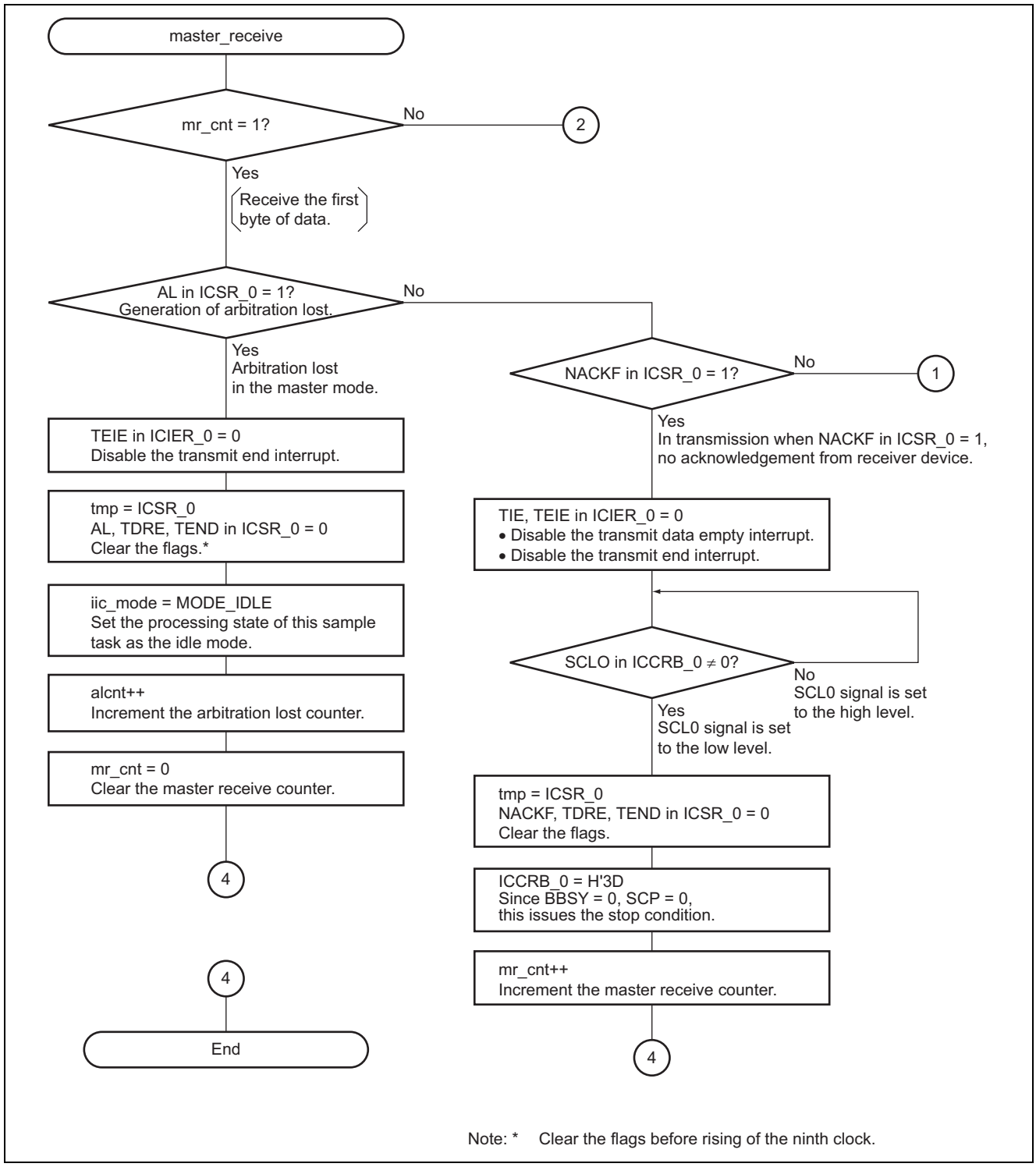
  Setting: MR_ID

- I²C bus receive data register_0 (ICDRR_0) Address: H'FFFD5F

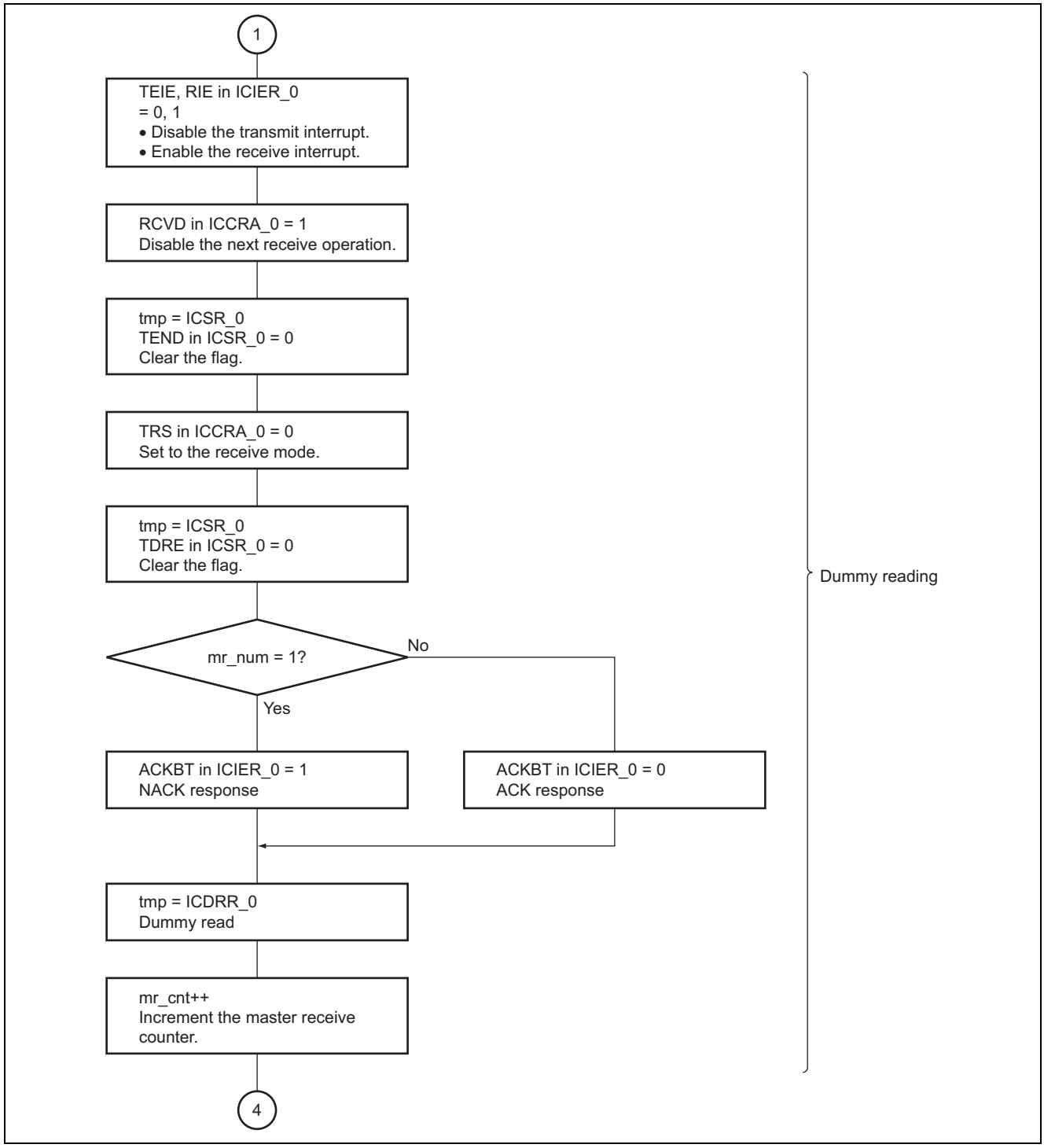
  Function: ICDRR is an 8-bit register that stores the receive data. When data of one byte is received, ICDRR transfers the received data from ICDRS to ICDRR and the next data can be received. ICDRR is a receive-only register, therefore the CPU cannot be written to this register. The initial value of ICDRR is H'FF.

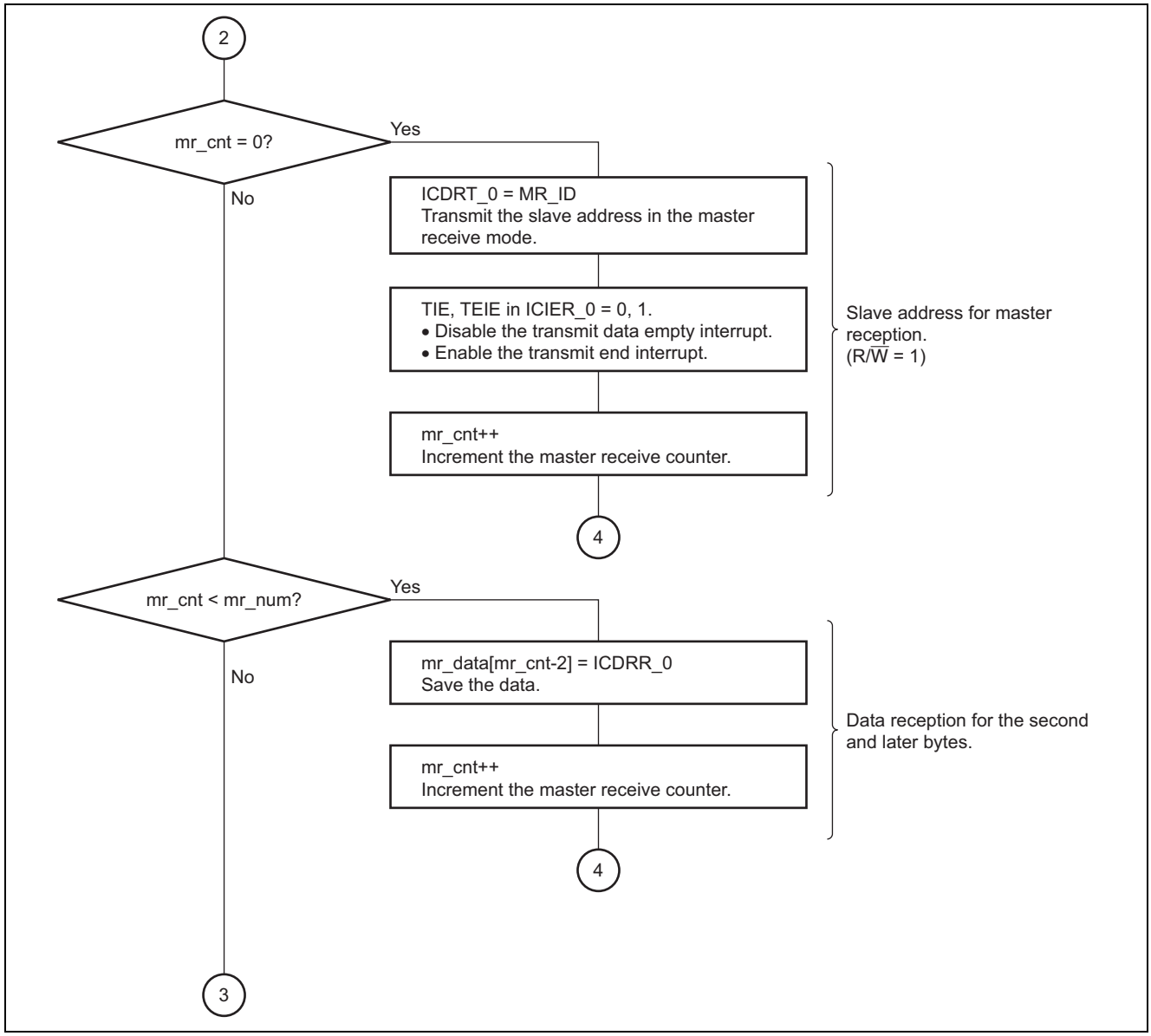
  Setting: Undecided

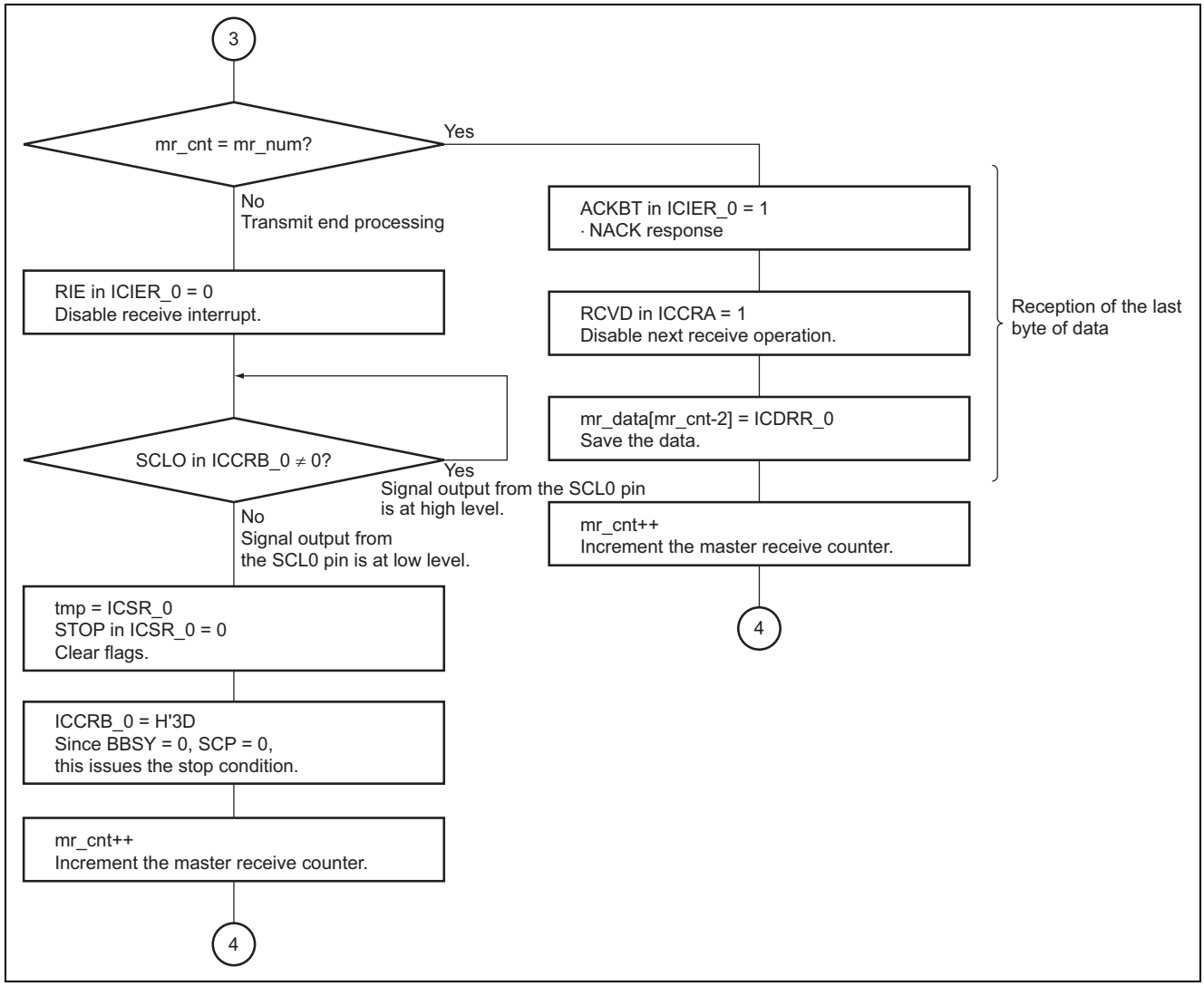
5. Flowchart



Note: * Clear the flags before rising of the ninth clock.


1
TEIE, RIE in ICIER_0
= 0, 1
• Disable the transmit interrupt.
• Enable the receive interrupt.
RCVD in ICCRA_0 = 1
Disable the next receive operation.
tmp = ICSR_0
TEND in ICSR_0 = 0
Clear the flag.
TRS in ICCRA_0 = 0
Set to the receive mode.
tmp = ICSR_0
TDRE in ICSR_0 = 0
Clear the flag.
mr_num = 1?
No
Yes
ACKBT in ICIER_0 = 1
NACK response
ACKBT in ICIER_0 = 0
ACK response
tmp = ICDRR_0
Dummy read
mr_cnt++
Increment the master receive
counter.
4
Dummy reading


2
mr_cnt = 0?
Yes
No
ICDRT_0 = MR_ID
Transmit the slave address in the master receive mode.
TIE, TEIE in ICIER_0 = 0, 1.
• Disable the transmit data empty interrupt.
• Enable the transmit end interrupt.
mr_cnt++
Increment the master receive counter.
Slave address for master reception.
(R/W = 1)
4
mr_cnt < mr_num?
Yes
No
mr_data[mr_cnt-2] = ICDRR_0
Save the data.
mr_cnt++
Increment the master receive counter.
Data reception for the second and later bytes.
4
3


3
mr_cnt = mr_num?
Yes
No
Transmit end processing
ACKBT in ICIER_0 = 1
· NACK response
RIE in ICIER_0 = 0
Disable receive interrupt.
RCVD in ICCRA = 1
Disable next receive operation.
Reception of the last byte of data
mr_data[mr_cnt-2] = ICDRR_0
Save the data.
SCLO in ICCRB_0 ≠ 0?
Yes
Signal output from the SCL0 pin is at high level.
mr_cnt++
Increment the master receive counter.
No
Signal output from the SCL0 pin is at low level.
4
tmp = ICSR_0
STOP in ICSR_0 = 0
Clear flags.
ICCRB_0 = H'3D
Since BBSY = 0, SCP = 0,
this issues the stop condition.
mr_cnt++
Increment the master receive counter.
4

5.8.8 Function slave_transfer

1. Overview
   Slave-transmission processing which is called from the I²C bus interface handler. In this case, the interrupt source will be the transmit data empty interrupt for each byte of transmitted data.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C bus control register A_0 (ICCRA_0) Address: H'FFFD58

Bit	Bit Name	Setting	R/W	Function
4	TRS	0	R/W	Transmit/Receive Select 0: Receive mode 1: Transmit mode

- I²C bus interrupt enable register_0 (ICIER_0) Address: H'FFFD5B

Bit	Bit Name	Setting	R/W	Function
7	TIE	1	R/W	Transmit Interrupt Enable Enables or disables the transmit data empty interrupt (TXI) when the TDRE bit in ICSR is set to 1. 0: Disables the transmit data empty interrupt request (TXI). 1: Enables the transmit data empty interrupt request (TXI).
6	TEIE	0	R/W	Transmit End Interrupt Enable Enables or disables the transmit end interrupt (TEI) at the rising of the ninth clock while the TDRE bit in ICSR is 1. TEI can be canceled by clearing the TEND bit or the TEIE bit to 0. 0: Disables the transmit end interrupt request (TEI). 1: Enables the transmit end interrupt request (TEI).

- I²C bus status register_0 (ICSR_0) Address: H'FFFD5C

Bit	Bit Name	Setting	R/W	Function
7	TDRE	0	R/W	Transmit Data Register Empty [Setting condition] • Transferring of data from ICDRT to ICDRS and having ICDRT empty. • Setting of TRS. • Issuing of a start condition (including retransmission). • Transition from the receive mode to the transmit mode has been made in the slave mode. [Clearing conditions] • Writing of 0 in TDRE after reading it as 1 • Writing of data in ICDRT.
6	TEND	0	R/W	Transmit End [Setting conditions] • Rising of the ninth clock of SCL while the TDRE flag is 1 [Clearing conditions] • Writing 0 in TEND after reading it as 1 • Writing of data in ICDRT
4	NACKF	0	R/W	No Acknowledge Detection Flag [Setting condition] • Detection of no acknowledge from the receive device in transmission while the ACKE bit in ICIER is 1 [Clearing condition] • Writing of 0 in NACKF after reading it as 1

- I²C bus transmit data register_0 (ICDRT_0) Address: H'FFFD5E

  Function: ICDRT is an 8-bit readable/writable register that stores the transmit data. When ICDRT detects the space in the I²C bus shift register (ICDRS), it transfers the transmit data which is written in ICDRT to ICDRS and starts transferring data. When the next transfer data is written to ICDRT during transferring data of ICDRS, continuous transfer is possible. The initial value of ICDRT is H'FF.

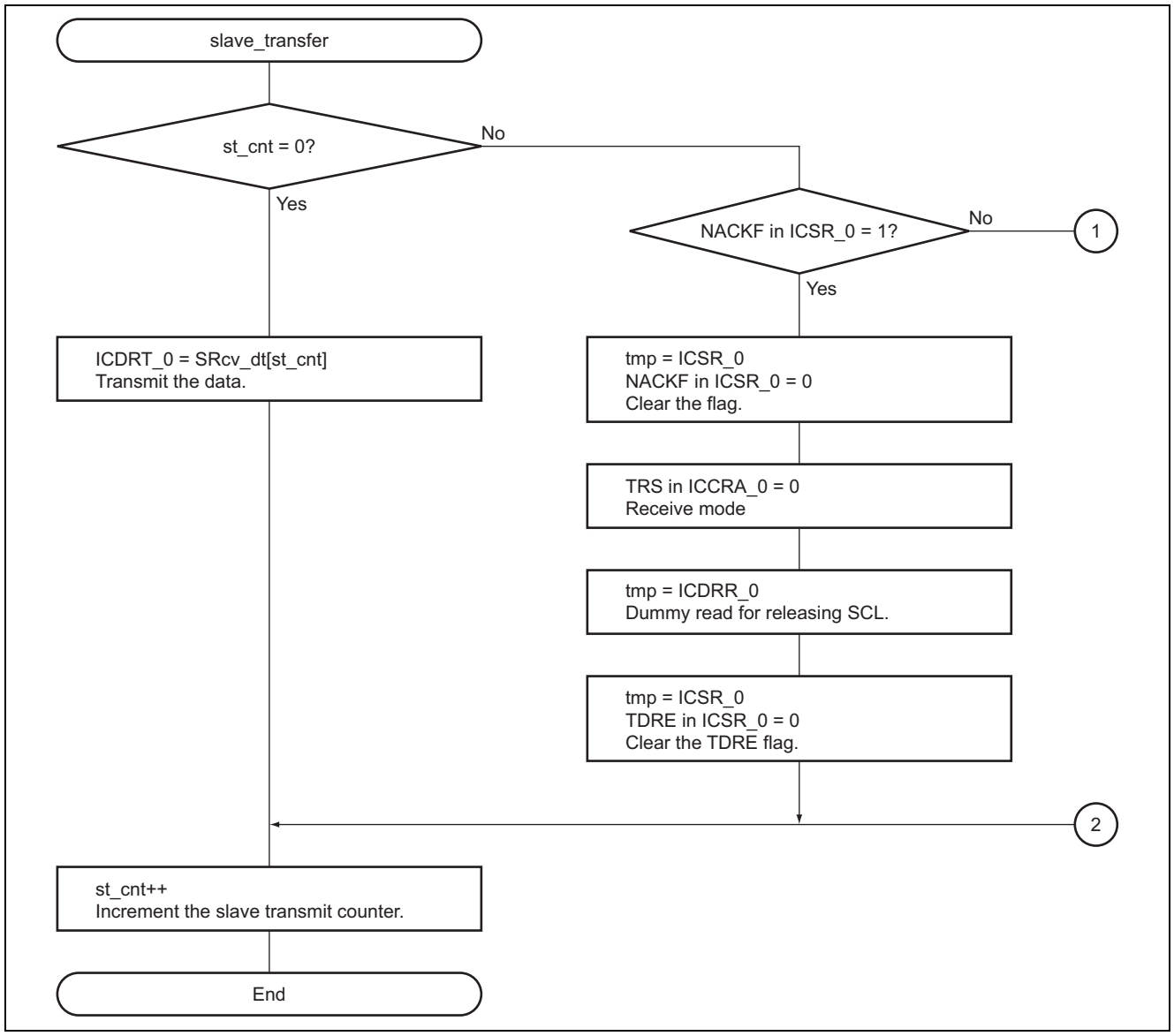
  Setting: SRcv_dt[st_cnt]

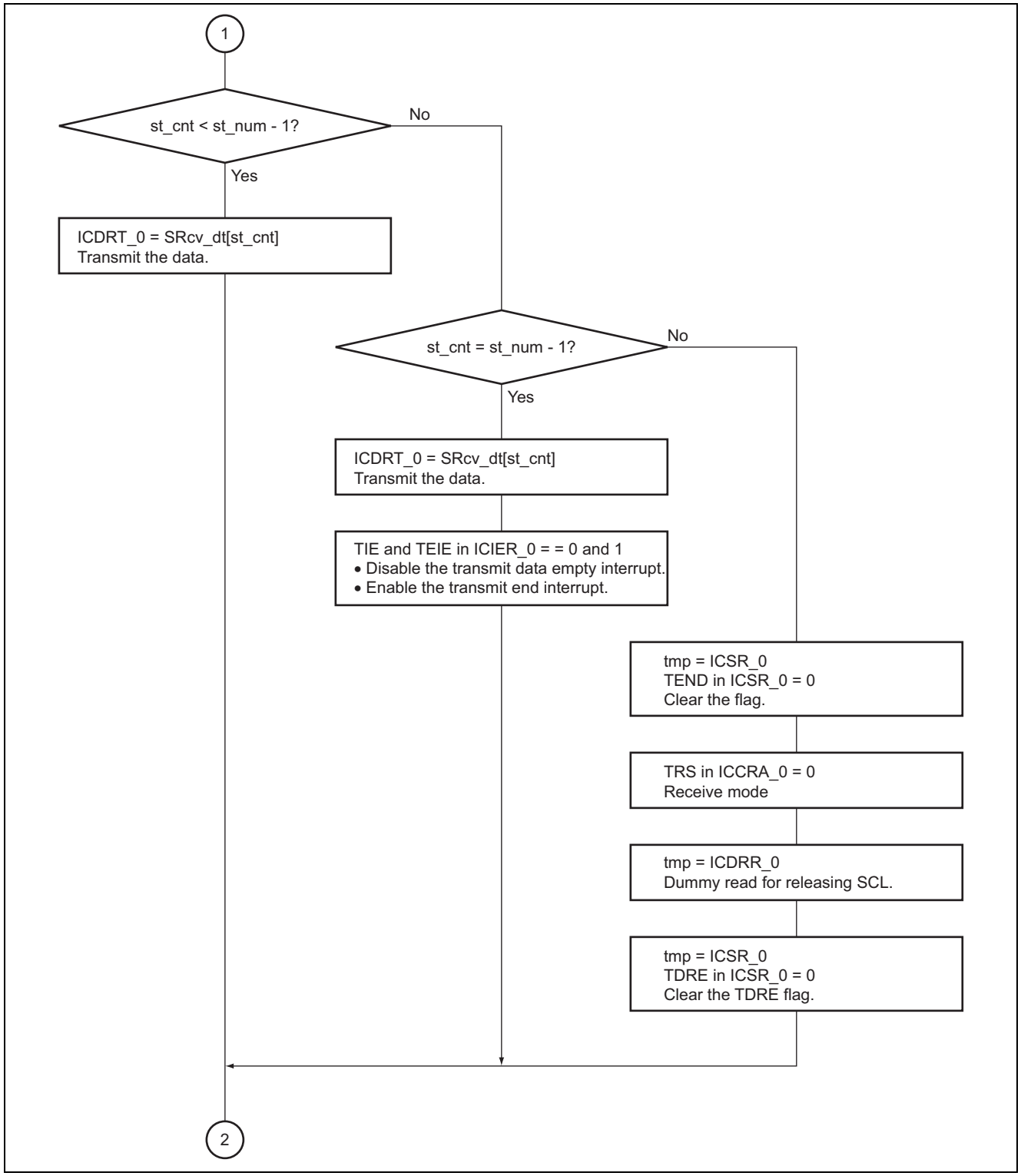
- I²C bus receive data register_0 (ICDRR_0) Address: H'FFFD5F

  Function: ICDRR is an 8-bit register that stores the receive data. When data of one byte is received, ICDRR transfers the received data from ICDRS to ICDRR and the next data can be received. ICDRR is a receive-only register, therefore the CPU cannot be written to this register. The initial value of ICDRR is H'FF.

  Setting: Undecided

5. Flowchart


slave_transfer
st_cnt = 0?
No
Yes
NACKF in ICSR_0 = 1?
No
1
Yes
ICDRT_0 = SRcv_dt[st_cnt]
Transmit the data.
tmp = ICSR_0
NACKF in ICSR_0 = 0
Clear the flag.
TRS in ICCRA_0 = 0
Receive mode
tmp = ICDRR_0
Dummy read for releasing SCL.
tmp = ICSR_0
TDRE in ICSR_0 = 0
Clear the TDRE flag.
2
st_cnt++
Increment the slave transmit counter.
End


1
st_cnt < st_num - 1?
No
Yes
ICDRT_0 = SRcv_dt[st_cnt]
Transmit the data.
st_cnt = st_num - 1?
No
Yes
ICDRT_0 = SRcv_dt[st_cnt]
Transmit the data.
TIE and TEIE in ICIER_0 = = 0 and 1
• Disable the transmit data empty interrupt.
• Enable the transmit end interrupt.
tmp = ICSR_0
TEND in ICSR_0 = 0
Clear the flag.
TRS in ICCRA_0 = 0
Receive mode
tmp = ICDRR_0
Dummy read for releasing SCL.
tmp = ICSR_0
TDRE in ICSR_0 = 0
Clear the TDRE flag.
2

5.8.9 Function slave_receive

1. Overview
   Slave-reception processing which is called by the I²C bus interface interrupt handler. In this case, the interrupt source will be the receive data full interrupt for each byte of received data.
2. Arguments
   None
3. Return value
   None
4. Internal registers used
   The following describes internal registers used in this sample task. The settings are those used in this sample task rather than the initial settings.

- I²C interrupt enable register_0 (ICIER_0) Address: H'FFFD58

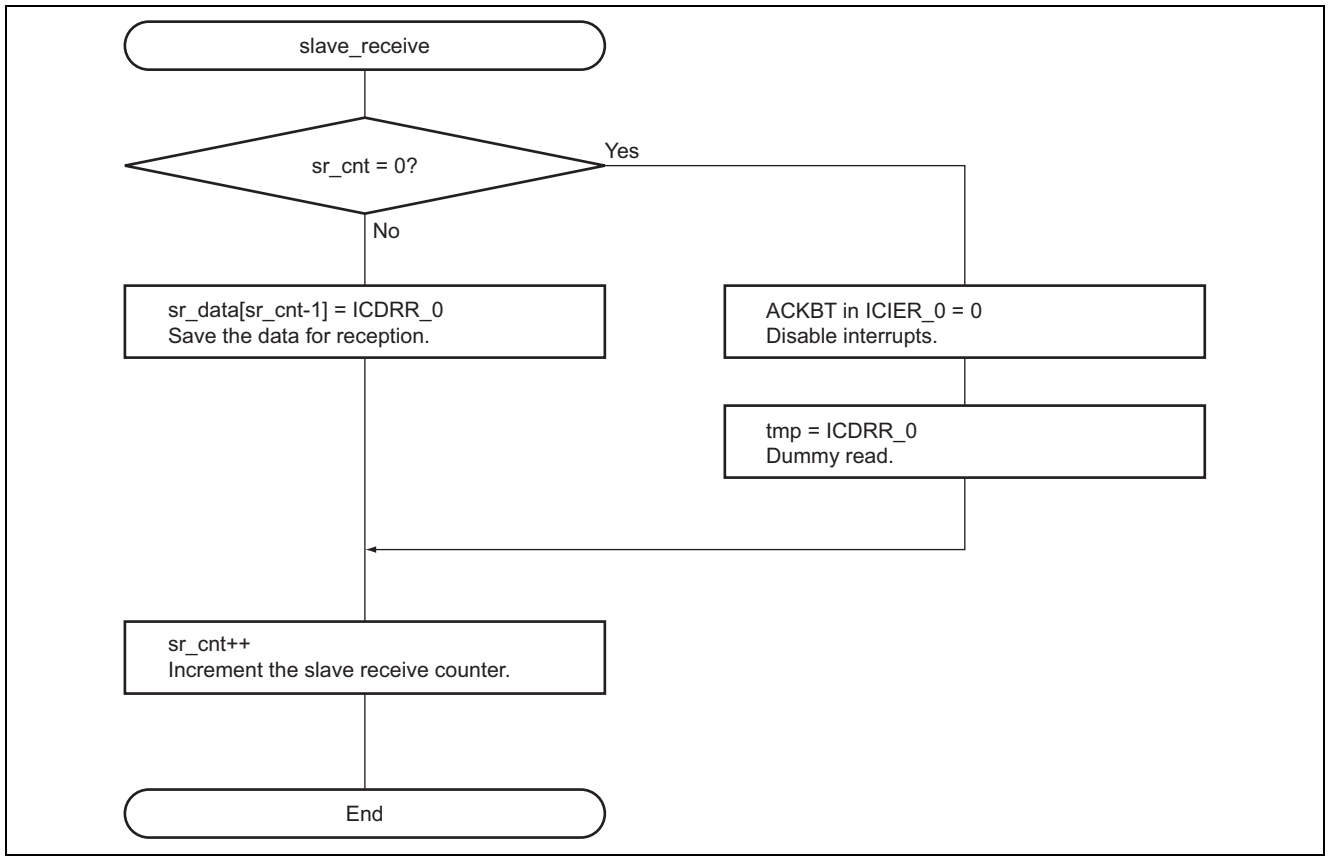
Bit	Bit Name	Setting	R/W	Function
0	ACKBT	0	R/W	Transmit Acknowledge Specifies the bit to be sent at the acknowledge timing in receive mode. 0: 0 is output at acknowledge timing. 1: 1 is output at acknowledge timing.

- I²C bus receive data register_0 (ICDRR_0) Address: H'FFFD5F

  Function: ICDRR is an 8-bit register that stores the receive data. When data of one byte is received, ICDRR transfers the received data from ICDRS to ICDRR and the next data can be received. ICDRR is a receive-only register, therefore the CPU cannot be written to this register. The initial value of ICDRR is H'FF.

  Setting: Undecided

5. Flowchart


slave_receive
sr_cnt = 0?
Yes
No
sr_data[sr_cnt-1] = ICDRR_0
Save the data for reception.
ACKBT in ICIER_0 = 0
Disable interrupts.
tmp = ICDRR_0
Dummy read.
sr_cnt++
Increment the slave receive counter.
End

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Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Jan.31.07	—	First edition issued
2.00	Sep.25.07	2, 3, 10 to 12, 16, 17, 19, 21 to 23, 26, 31, 35 to 39, 41, 45, 49, 51, 56, and 59	Corrections on content and program source due to an additional item, idle mode

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