M4G Group (1)
Application Note
I²C Interface
(I2C-B)

Outlines

This application note is a reference material for developing products using I²C interface (I2C) function of M4G group (1).
This document helps the user check operation of the product and develop its program.

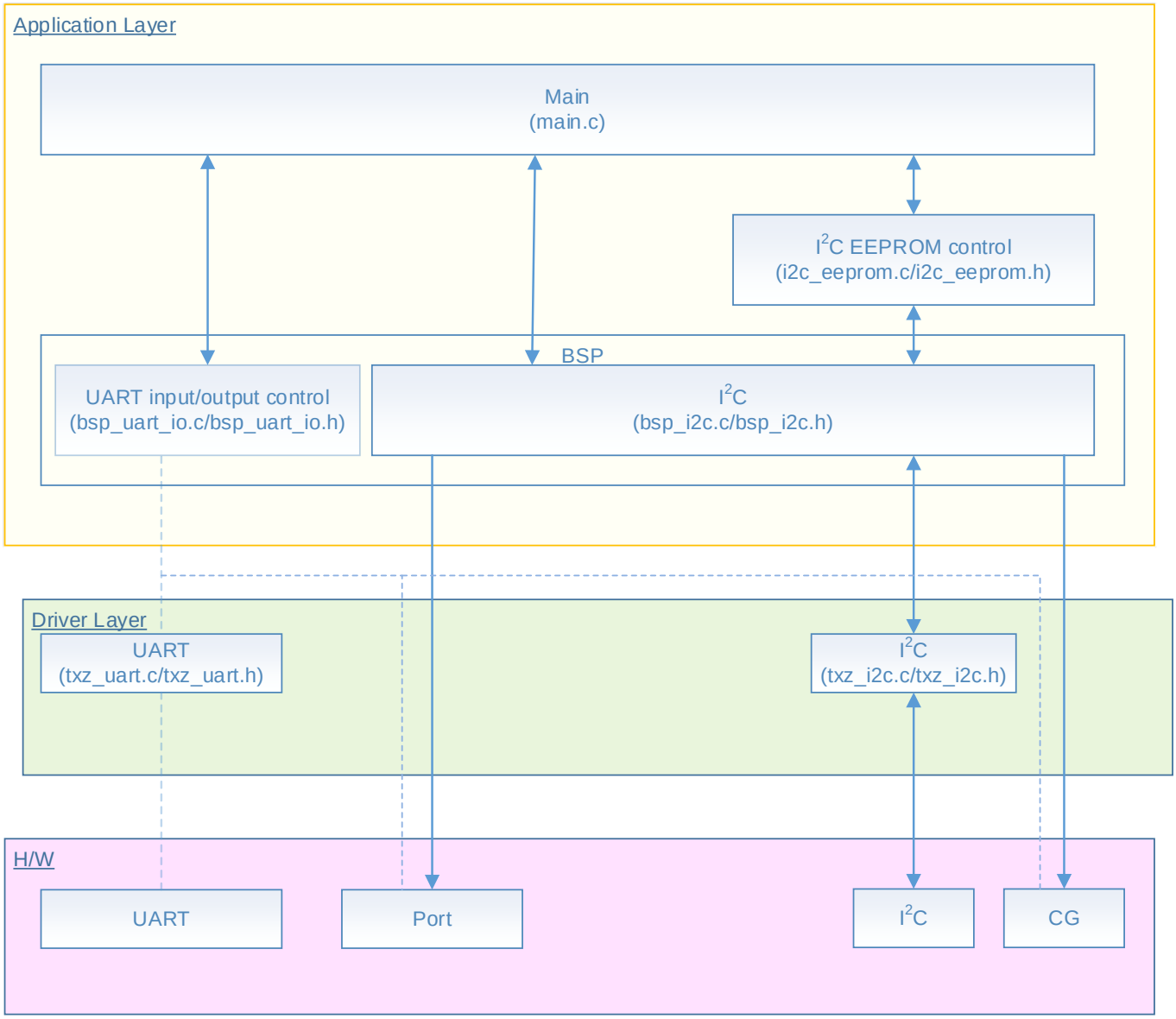
Target sample program: I2C_EEPROM

Table of Contents

1. Preface

This sample program should be used to check the operation of the I²C interface.
Read or write of the I²C EEPROM is done by input of a corresponding command to the terminal software.

Structure diagram of Sample program



2. Reference Document

- Datasheet
  TMPM4G group (1) datasheet Rev1.0 (Japanese edition)
- Reference manual
  I^2C Interface (I2C-B) Rev2.1 (Japanese edition)
  Asynchronous Serial Communication Circuit (UART-C) Rev3.0 (Japanese edition)
- Application note
  M4G group (1) Application Note Startup (CMSIS System & Clock Configuration) Rev1.0
- Other reference document
  TMPM4G (1) Group Peripheral Driver User Manual (Doxygen)

3. Function to Use

IP	Channel	Port	Function/Operation mode
Asynchronous Serial Communication Circuit	ch0	PE2 (UT0RXD) PE3 (UT0TXDA)	UART mode
I^2C Interface	ch3	PJ6 (I2C3SDA)	I^2C mode
		PJ7 (I2C3SCL)	

4. Target Device

The target devices of this application note are as follows;

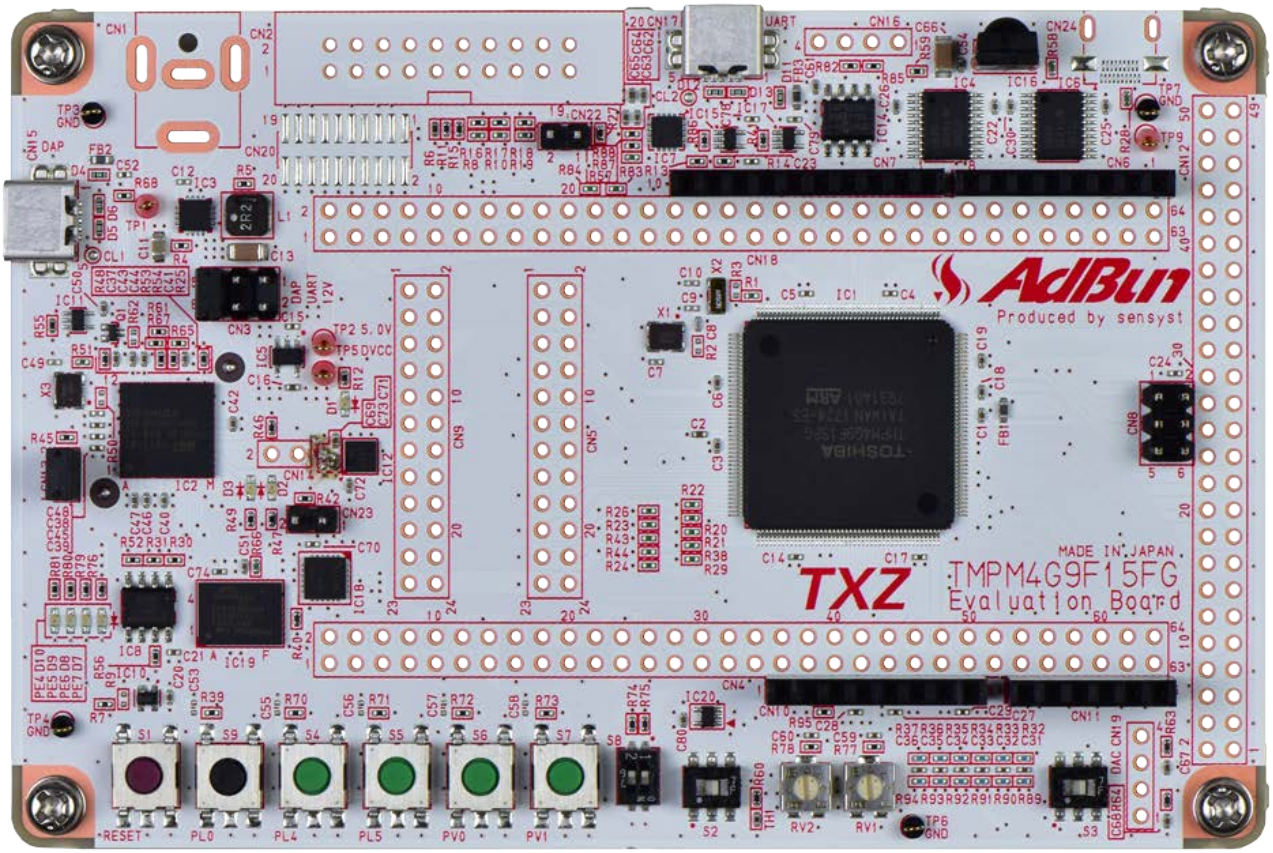
TMPM4G9F15FG	TMPM4G9F10FG	TMPM4G9FEFG	TMPM4G9FDFG
TMPM4G9F15XBG	TMPM4G9F10XBG	TMPM4G9FEXBG	TMPM4G9FDXBG
TMPM4G8F15FG	TMPM4G8F10FG	TMPM4G8FEFG	TMPM4G8FDFG
TMPM4G8F15XBG	TMPM4G8F10XBG	TMPM4G8FEXBG	TMPM4G8FDXBG
	TMPM4G7F10FG	TMPM4G7FEFG	TMPM4G7FDFG
	TMPM4G6F10FG	TMPM4G6FEFG	TMPM4G6FDFG

* This sample program operates on the evaluation board of TMPM4G9F15FG.
If other function than the TMPM4G9F15 one is checked, it is necessary that CMSIS Core related files (C startup file and I/O header file) should be changed properly.
The BSP related file is dedicated to the evaluation board (TMPM4G9F15). If other function than the TMPM4G9F15 one is checked, the BSP related file should be changed properly.

5. Operation Confirmation Condition

Used microcontroller	TMPM4G9F15FG
Used board	TMPM4G9F15FG Evaluation Board by Sensyst
Unified development environment	IAR Embedded Workbench for ARM 8.11.2.13606
Unified development environment	µVision MDK Version 5.24.2.0
Terminal software	Tera Term V4.96
Sample program	V1000

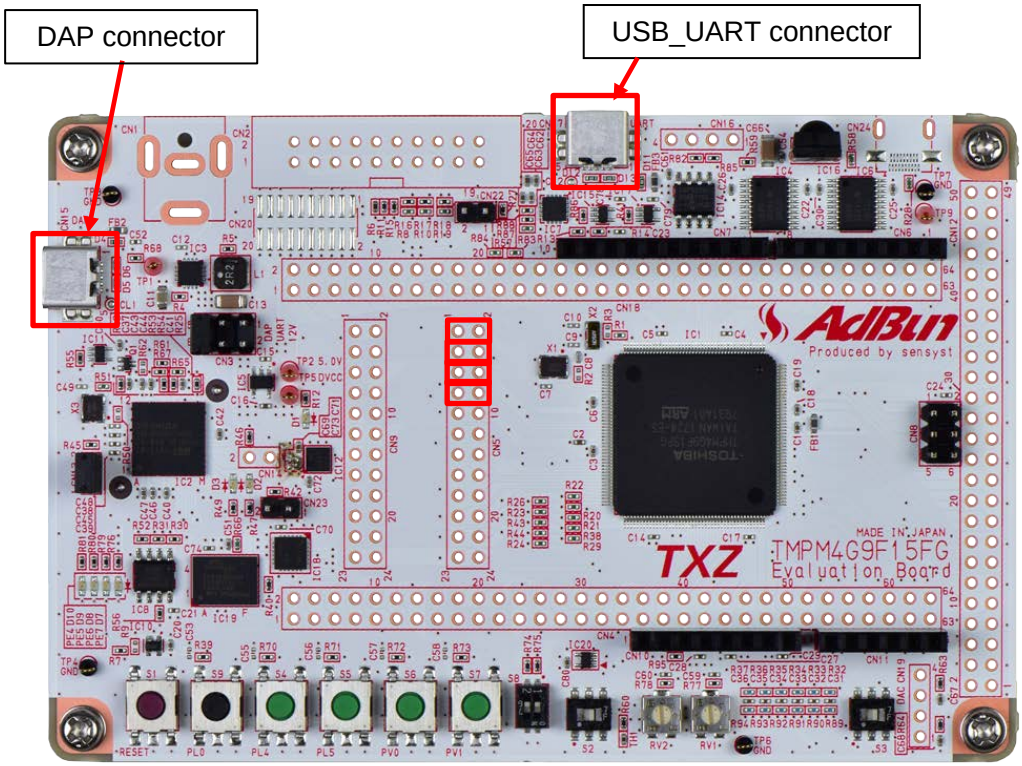
Evaluation board (TMPM4G9F15FG Evaluation Board) Top view



6. Evaluation Board Setting

The following pin connections should be done on the evaluation board.

CN5		
Board function	Through-hole No.	Through-hole No.
USB UART conversion	1: USB_UT_RX	2: PE2
USB UART conversion	3: USB_UT_TX	4: PE3
I^2C interface	5: EEPROM_I2C_SCL	6: PJ7
I^2C interface	7: EEPROM_I2C_SDA	8: PJ6



7. Operation of Evaluation Board

PC and the USB_UART are connected for communication with the terminal software.
The terminal software (Tera Term) is started up, and the setting of the communication should be done.
The reset button should be pushed down on the evaluation board.
The communication starts according to an input command.
For the details of the input operation of a command, refer to the section “Sample Program Main Operation”.

8. Outline of I²C Function

The I²C can operate as a transceiver circuit of 1ch (SCL, SDA) in 1 unit circuit. The list of the functions is shown below.

Function classification (Note1)	Function	A Functional Description or the range
Transmission speed Control	prescaler dividing selection	It is dividing about a prescaler clock to 1/1, 1/2, 1/3 to 1/30, 1/31 and 1/32.
	Clock source	A selection setup of the HIGH/LOW time of SCL is possible in master mode.
	The maximum transfer rate	1Mbps (it corresponds to Fm+) (fsys = 8 to 200 MHz)
Communication Format	I²C bus format	Selection of Addressing/Data Free Format is possible. Selection of a master/slave is possible.
	Data length	1 to 8 bits
	acknowledge	The existence of acknowledging can be chosen.
	Start/stop condition	Generating of start/stop condition is possible.
	Slave address	Only a 7-bit addressing format. 2 sets of slave addresses can be set up. (1st/2nd Slave Address)
	General call	Detection of a general call is possible in slave mode.
Transmission and reception Control	Arbitration	Multi-master Clock synchronization Existence selection of Arbitration lost detection is possible.
	Repetitive start detection, generating	Detection of a repetitive start of a bus line (at the time of slave mode) and generating (at the time of master mode) are possible.
	Noise cancellation	Digital
Ganged control	Interruption	4 kinds (The completion interruption of transmission, Arbitration lost detection interruption, Bus free detection interruption, NACK reception detection interruption
	DMA request	A setup according to transmission and reception is possible.
	Software reset	Reset by the software of an I²C circuit is possible.
	Bus terminal state monitor function	The level monitor of SDA and a SCL pin
	Address match Wakeup function	Slave address match detection can use the release factor for the Low power consumption mode release.

Note1: It does not support HS (High Speed) mode, 10-bit addressing, and a START byte.
Note2: There is a function in which it cannot support depending on products, such as slope control, I/O correspondence at the time of the power supply OFF, an Input voltage (VIH/VIL), and an Output voltage (VOL=0.4V, VDD>2V).Please refer to the "Product Information" of the reference manual for details.

9. Sample Program

The sample program executes according to the command (“write” or “read”) which is input to the terminal software. The “write” command stores an input character to the I^{2}C EEPROM. And the “read command” reads data from the I^{2}C EEPROM and displays the data on the terminal software.

9.1. Initialization

The following initialization is done after power is supplied.
The initialization of each clock setting and the setting of the watchdog timer are done.

9.2. Sample Program Main Operation

The BSP (Board Support Package) is initialized.
As initialization of the application software, the UART initialization and the UART interrupt enable are done.
The I^{2}C is initialized, and the initialization of the connection of the EEPROM is done.

After the above procedure completes, the followings should be executed on the terminal software (Tera Term) in the PC.
"command >" is displayed on the Tera Term. “write” command or “read” command should be input according to the following format.
“write” command: The input character is stored to the I^{2}C EEPROM (address: 0x0).
“read” command: I^{2}C EEPROM (address: 0x0) is read. The read data is displayed on the Tera Term.

- Command format:
  “write” command
    write␣X X: Any character
  “read” command
    read

  1-Byte write command
    bw␣address␣X X: Any character
  1-Byte read command
    br␣address

Used memory	I^{2}C EEPROM: 24FC256-I/SN
Used port	SCL: PJ7 and SDA: PJ6

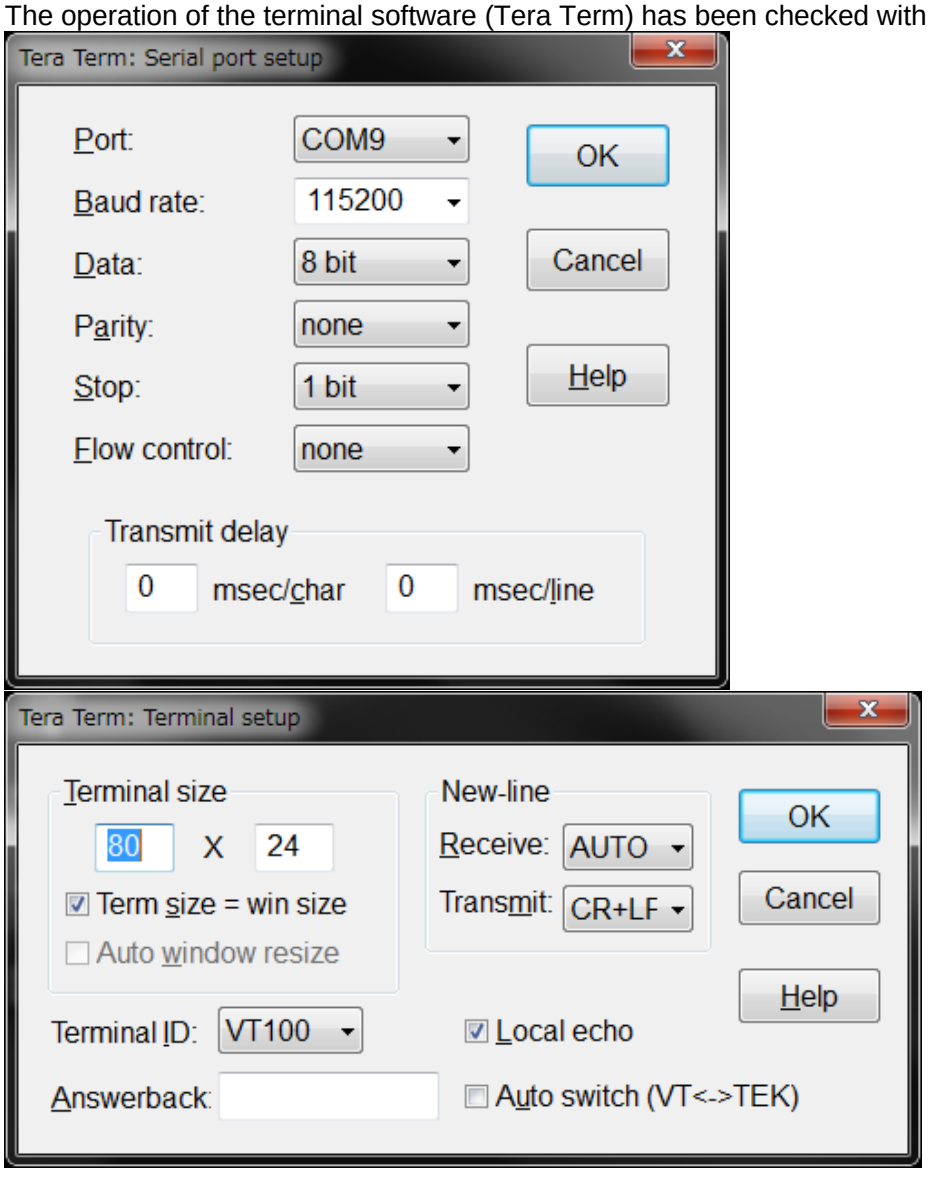
9.3. Output Example of Sample Program

When the sample program executes, the command input and the result are displayed as shown in the following figure.

```
command > write toshiba
write data > toshiba

command > read
read data > toshiba

command > bw 1000 a
byte write data > a

command > bw 1001 b
byte write data > b

command > bw 1002 c
byte write data > c

command > br 1000
byte read data > a

command > br 1001
byte read data > b

command > br 1002
byte read data > c
```

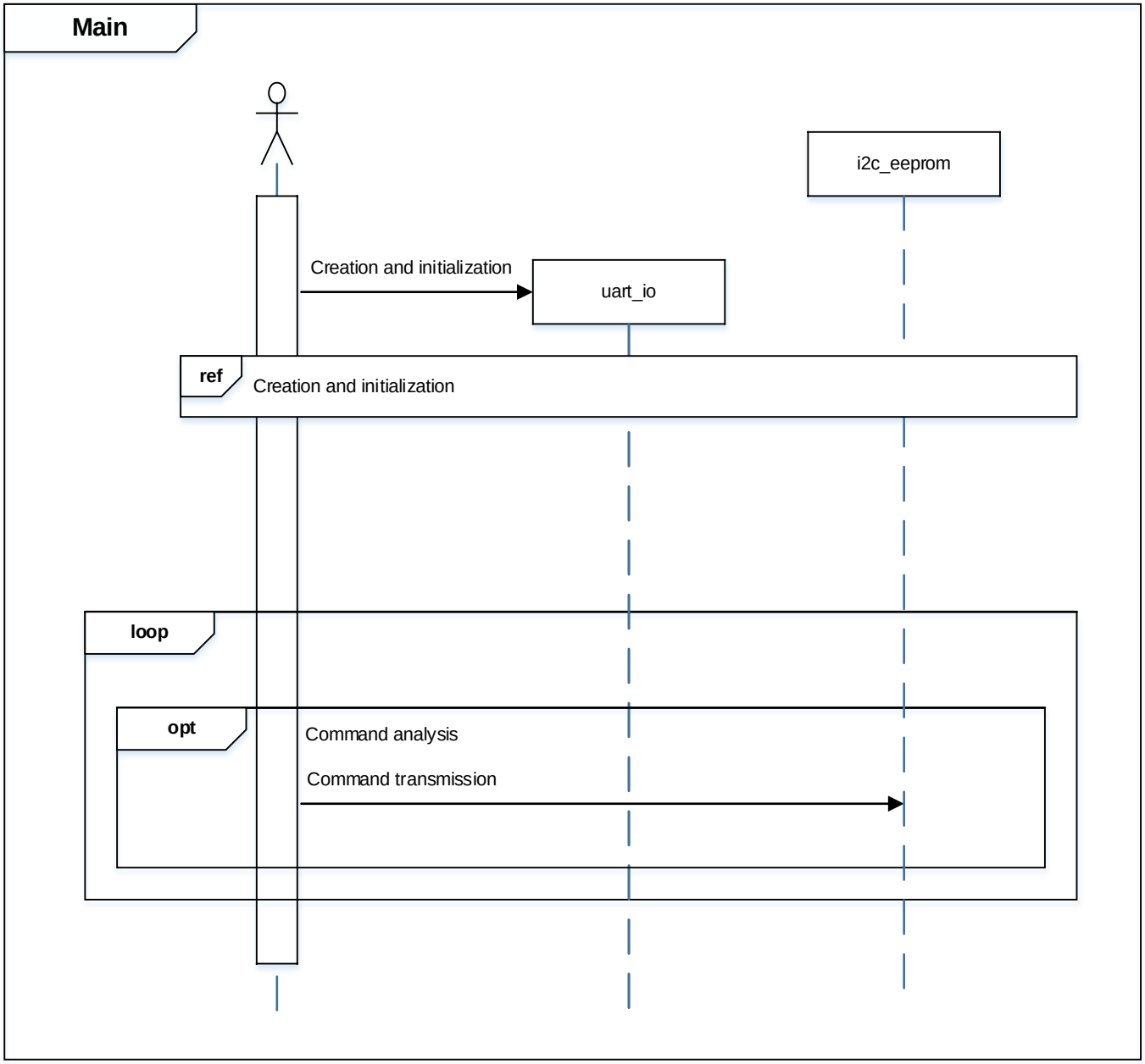
9.3.1. Setting Example of Terminal Software

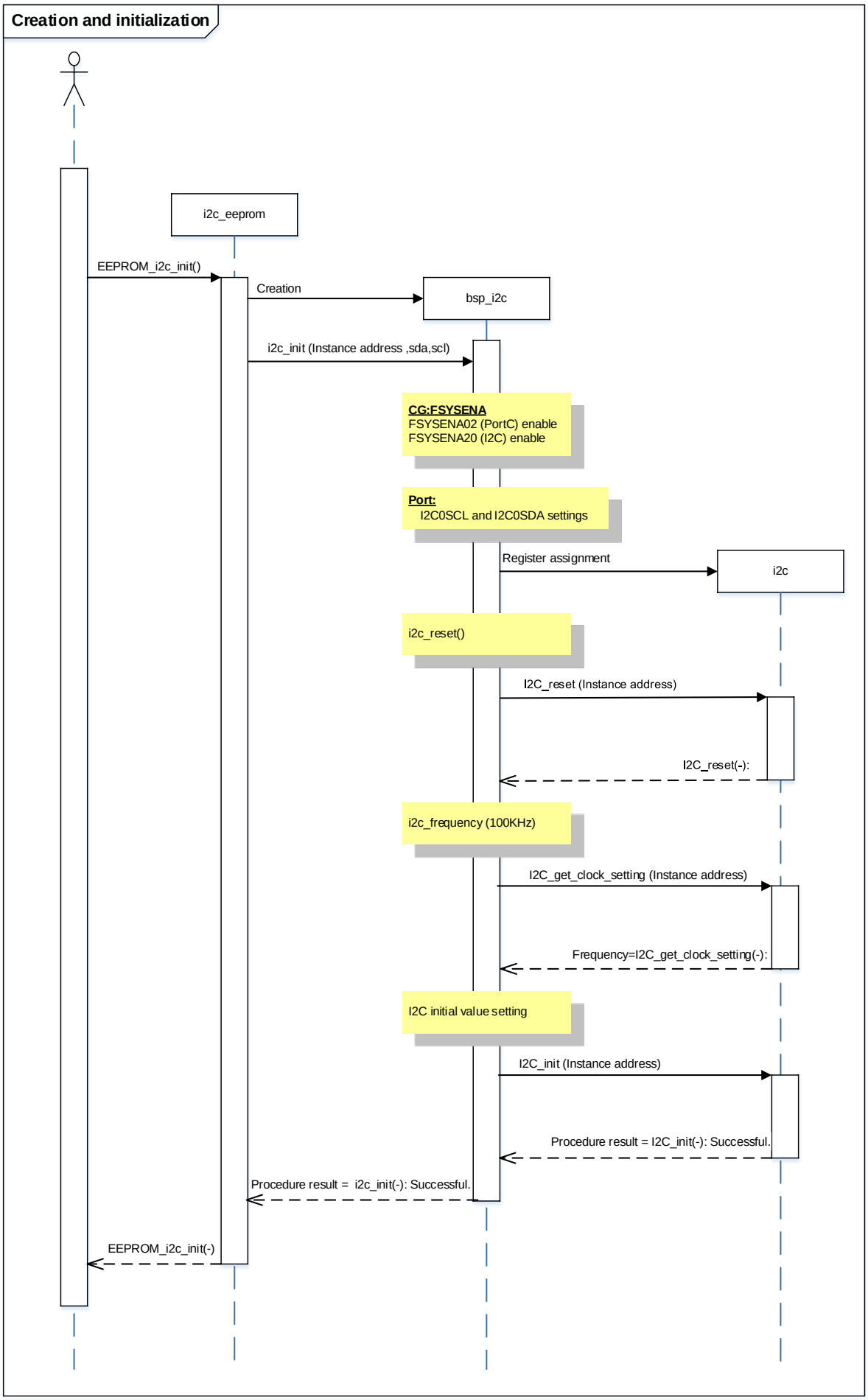
The operation of the terminal software (Tera Term) has been checked with the following settings.

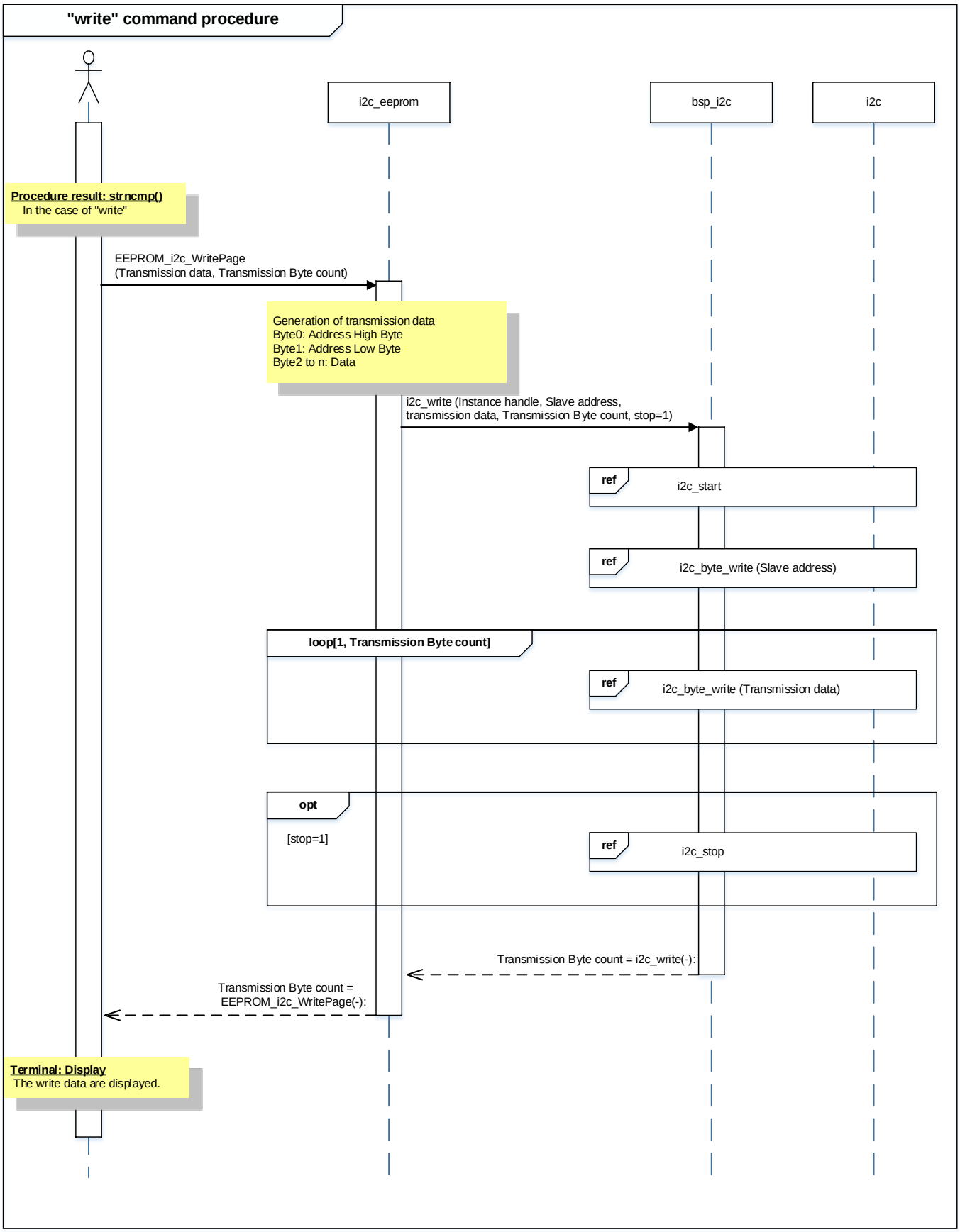


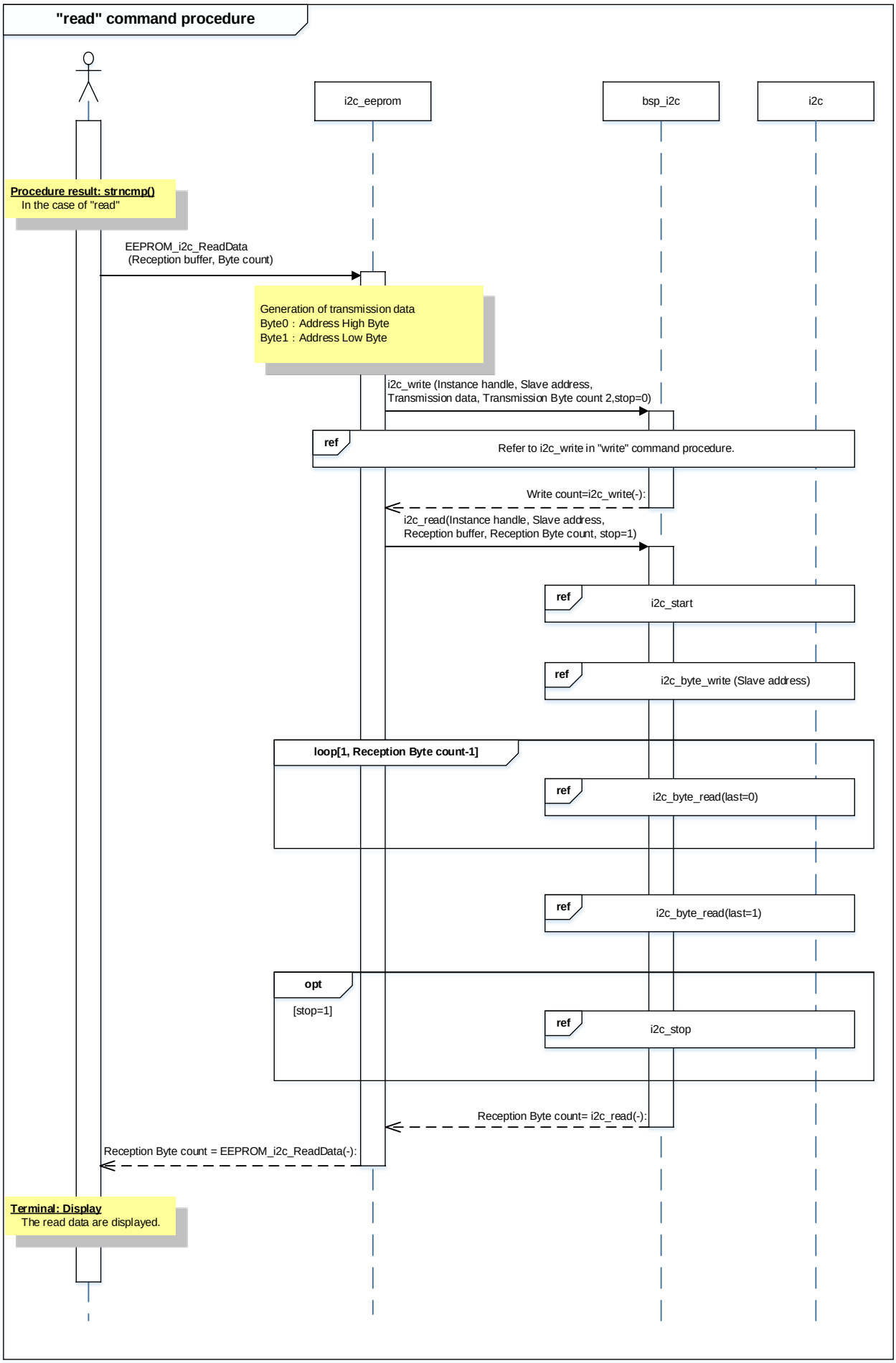
9.4. Operating Flow of Sample Program

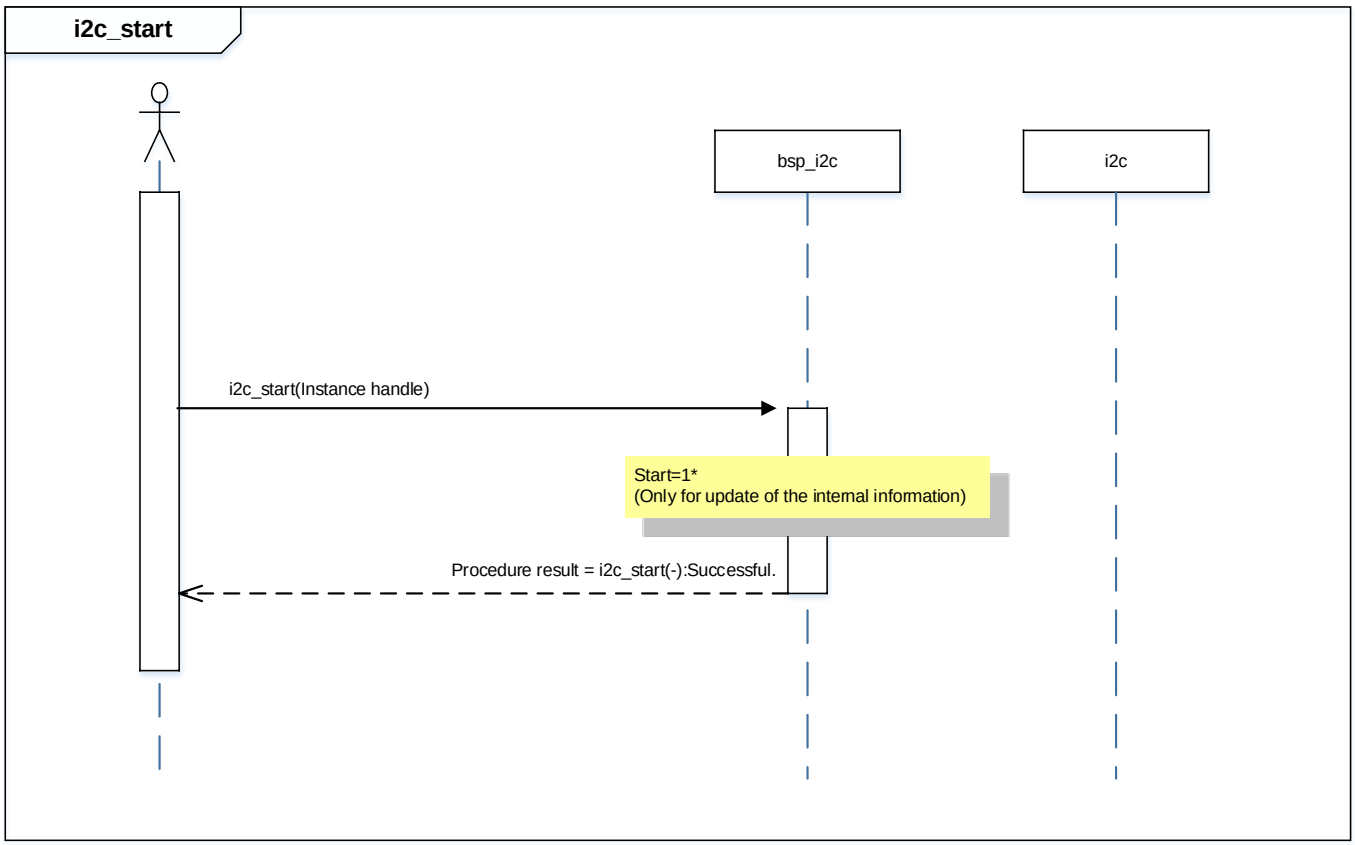
The basic operating flows of the sample program are shown in the following;

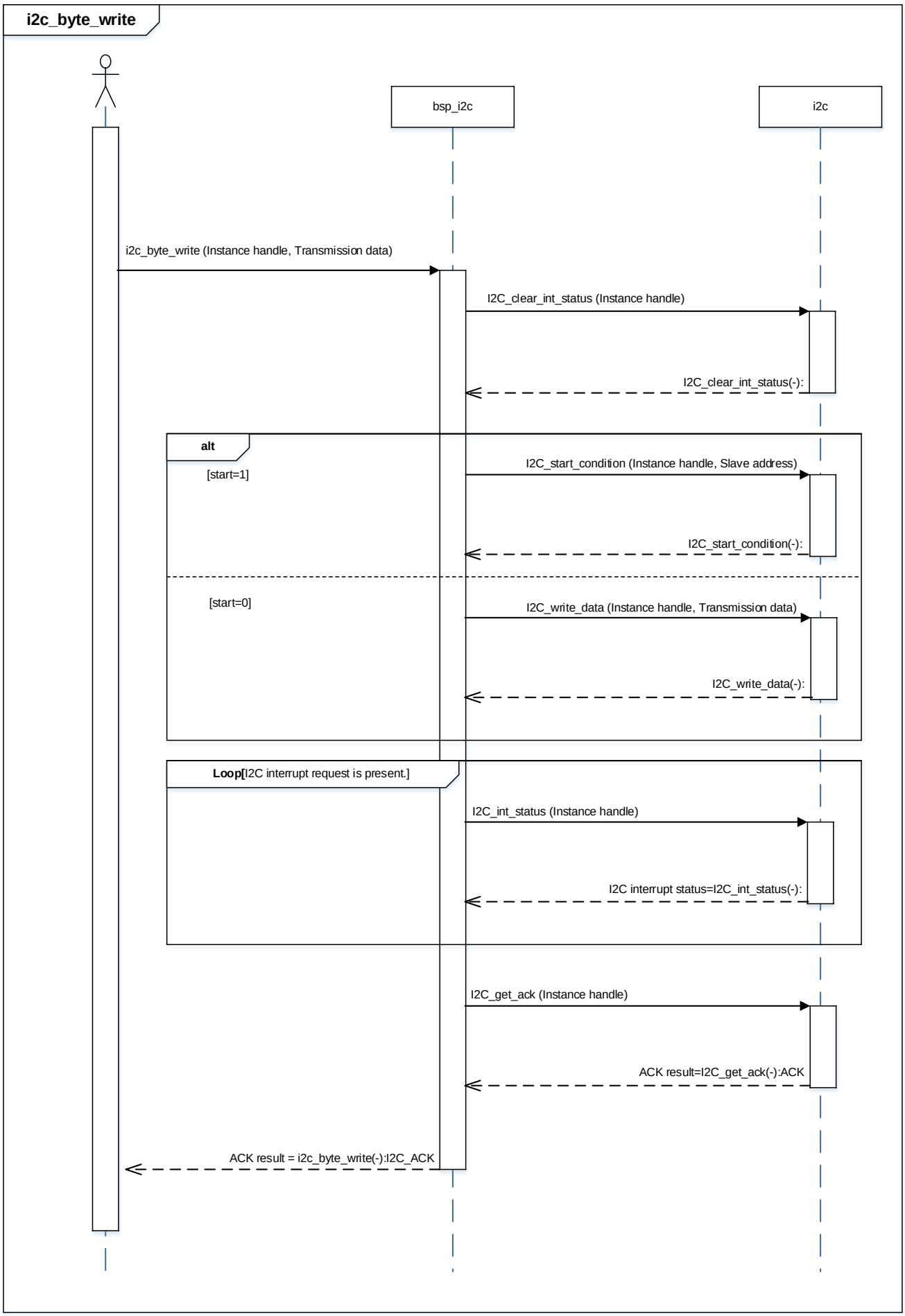


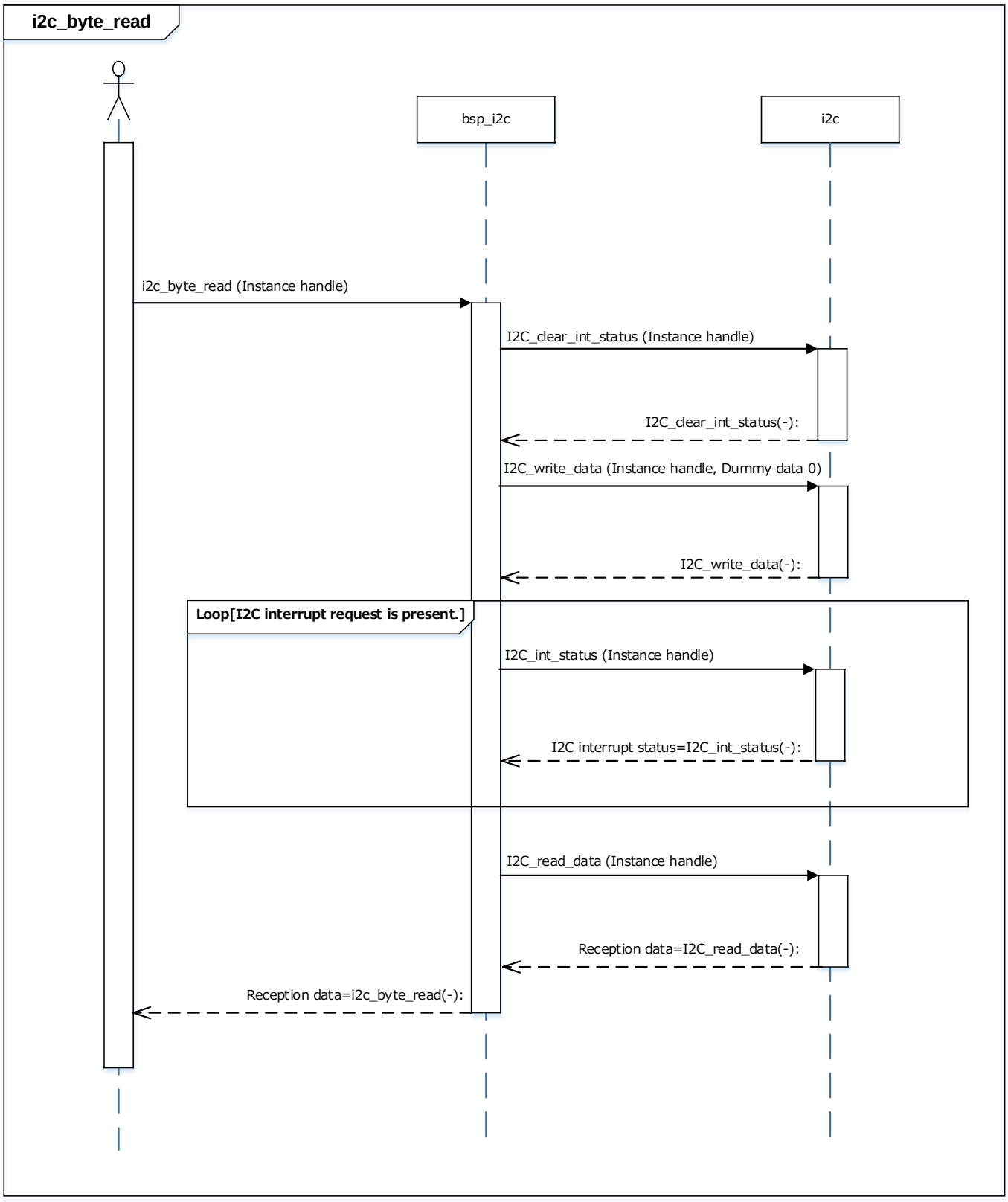

Creation and initialization
i2c_eeprom
EEPROM_i2c_init()
Creation
bsp_i2c
i2c_init (Instance address ,sda,scl)
CG:FSYSENA
FSYSENA02 (PortC) enable
FSYSENA20 (I2C) enable
Port:
I2C0SCL and I2C0SDA settings
Register assignment
i2c
i2c_reset()
I2C_reset (Instance address)
I2C_reset(-):
i2c_frequency (100KHz)
I2C_get_clock_setting (Instance address)
Frequency=I2C_get_clock_setting(-):
I2C initial value setting
I2C_init (Instance address)
Procedure result = I2C_init(-): Successful.
Procedure result = i2c_init(-): Successful.
EEPROM_i2c_init(-)

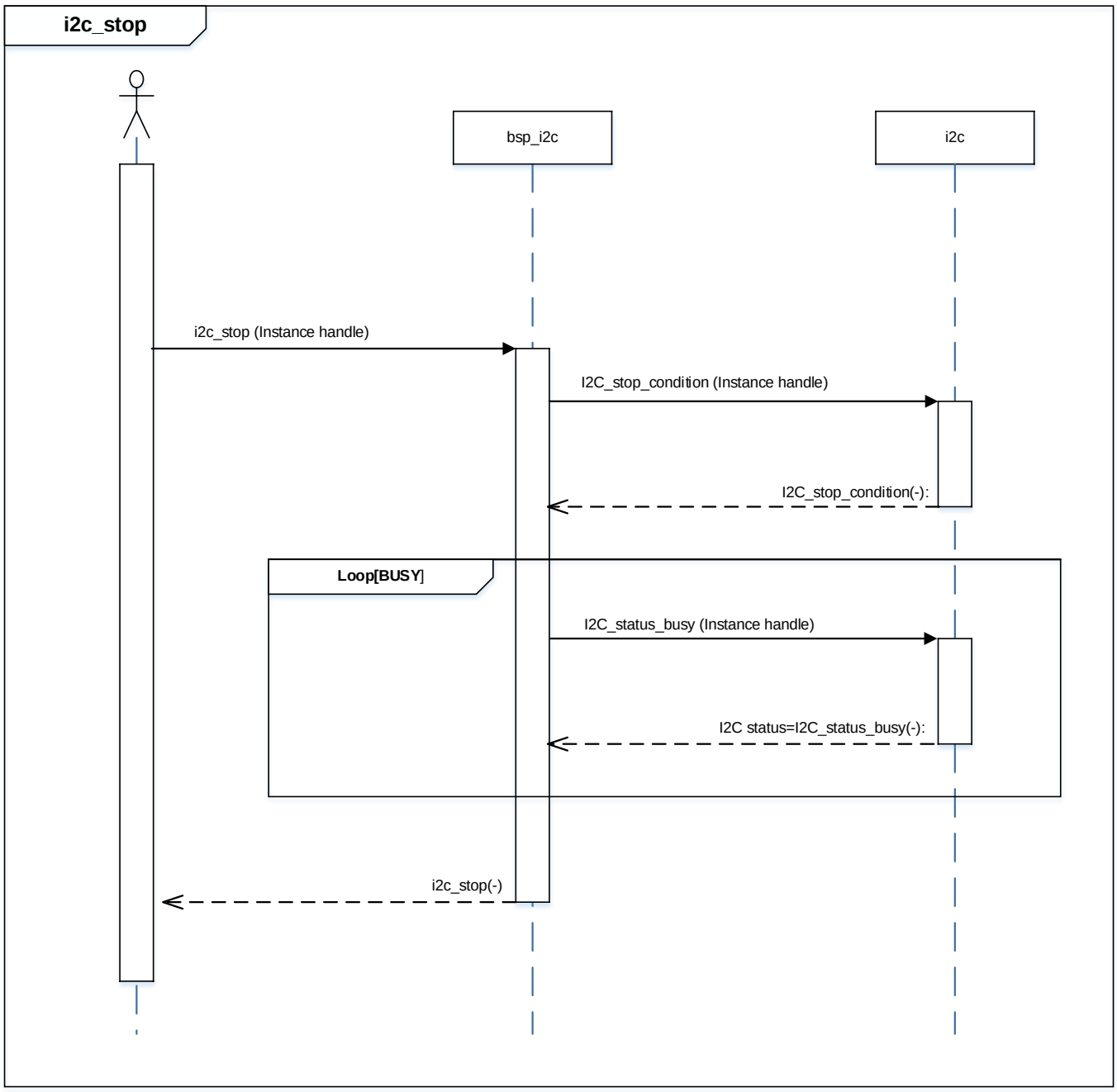

"write" command procedure
i2c_eeprom
bsp_i2c
i2c
Procedure result: strncmp()
In the case of "write"
EEPROM_i2c_WritePage
(Transmission data, Transmission Byte count)
Generation of transmission data
Byte0: Address High Byte
Byte1: Address Low Byte
Byte2 to n: Data
i2c_write (Instance handle, Slave address,
transmission data, Transmission Byte count, stop=1)
ref
i2c_start
ref
i2c_byte_write (Slave address)
loop[1, Transmission Byte count]
ref
i2c_byte_write (Transmission data)
opt
[stop=1]
ref
i2c_stop
Transmission Byte count = i2c_write(-):
Transmission Byte count =
EEPROM_i2c_WritePage(-):
Terminal: Display
The write data are displayed.


"read" command procedure
i2c_eeprom
bsp_i2c
i2c
Procedure result: strncmp()
In the case of "read"
EEPROM_i2c_ReadData
(Reception buffer, Byte count)
Generation of transmission data
Byte0 : Address High Byte
Byte1 : Address Low Byte
i2c_write (Instance handle, Slave address,
Transmission data, Transmission Byte count 2,stop=0)
ref
Refer to i2c_write in "write" command procedure.
Write count=i2c_write(-):
i2c_read(Instance handle, Slave address,
Reception buffer, Reception Byte count, stop=1)
ref
i2c_start
ref
i2c_byte_write (Slave address)
loop[1, Reception Byte count-1]
ref
i2c_byte_read(last=0)
ref
i2c_byte_read(last=1)
opt
[stop=1]
ref
i2c_stop
Reception Byte count= i2c_read(-):
Reception Byte count = EEPROM_i2c_ReadData(-):
Terminal: Display
The read data are displayed.


i2c_start
bsp_i2c
i2c
i2c_start(Instance handle)
Start=1*
(Only for update of the internal information)
Procedure result = i2c_start(-):Successful.


i2c_byte_write
bsp_i2c
i2c
i2c_byte_write (Instance handle, Transmission data)
I2C_clear_int_status (Instance handle)
I2C_clear_int_status(-):
alt
[start=1]
I2C_start_condition (Instance handle, Slave address)
I2C_start_condition(-):
[start=0]
I2C_write_data (Instance handle, Transmission data)
I2C_write_data(-):
Loop[I2C interrupt request is present.]
I2C_int_status (Instance handle)
I2C interrupt status=I2C_int_status(-):
I2C_get_ack (Instance handle)
ACK result=I2C_get_ack(-):ACK
ACK result = i2c_byte_write(-):I2C_ACK


i2c_byte_read
bsp_i2c
i2c
i2c_byte_read (Instance handle)
I2C_clear_int_status (Instance handle)
I2C_clear_int_status(-):
I2C_write_data (Instance handle, Dummy data 0)
I2C_write_data(-):
Loop[I2C interrupt request is present.]
I2C_int_status (Instance handle)
I2C interrupt status=I2C_int_status(-):
I2C_read_data (Instance handle)
Reception data=I2C_read_data(-):
Reception data=i2c_byte_read(-):


i2c_stop
bsp_i2c
i2c
i2c_stop (Instance handle)
I2C_stop_condition (Instance handle)
I2C_stop_condition(-):
Loop[BUSY]
I2C_status_busy (Instance handle)
I2C status=I2C_status_busy(-):
i2c_stop(-)

10. Precaution

When using the sample program with CPU other than TMPM4G9F15, please check operation sufficiently.

11. Revision History

Rev	Date	Page	Description
1.0	2018-12-10	—	First release

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