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2024 年4 月1 日
ローム株式会社

Bluetooth® low energy Module (MK71511/MK71521)

Application Note

MK71521 Connection distance measurement

Issue Date: Oct. 16, 2020

NOTES

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Preface

This application note describes Connection distance measurement using the MK71521 Evaluation Kit Mini (MK71521EK1) equipped with Bluetooth® 5 compatible Bluetooth low energy module MK71521 made by Lapis Technology. The following related documents are available, so please refer to them if necessary.

< Documents related to MK71521 >

- MK71521 Data Sheet
- MK715x1 Evaluation Kit Mini (MK715x1EK1) Hardware Manual

Note: In this document, MK715x1 refers to both MK71511 and MK71521.

Connection distance measurement uses the nRF5 SDK sample software Experimental: BLE Interactive Command Line Interface Example. Please refer to the related documents as necessary.

<nRF5 SDK related documents>

https://infocenter.nordicsemi.com/topic/sdk_nrf5_v16.0.0/ble_sdk_app_interactive.html

- Bluetooth® is a registered trademark of Bluetooth SIG, Inc.
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Notation

Category	Notation	Description
● Value	0xnn	Represents a hexadecimal number.
	0bnnnn	Represents a binary number.
● Address	0xnnnn_nnnn	Represents a hexadecimal number. (indicates 0xnnnnnnnn)
● Unit	Word, WORD	1 word = 32 bits
	Byte, BYTE	1 byte = 8 bits
	Mega, M	10^6
	Kilo, K	$2^{10} = 1024$
	Kilo, k	$10^3 = 1000$
	Milli, m	10^{-3}
	Micro, μ	10^{-6}
	Nano, n	10^{-9}
● Term	"H" level	Indicates high voltage signal levels V_{IH} and V_{OH} as specified by the electrical characteristics.
	"L" level	Indicates low voltage signal levels V_{IL} and V_{OL} as specified by the electrical characteristics.
● Register Description		
Read/write attribute: R indicates read-enabled; W indicates write-enabled.		
MSB: Most significant bit in an 8-bit register (memory)		
LSB: Least significant bit in an 8-bit register (memory)		

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1. Measurement environment

This chapter describes the environment and preparation for connection distance measurement.

1.1. Overview

The communication distance measurement configuration and environment using MK71521EK1 is shown below.

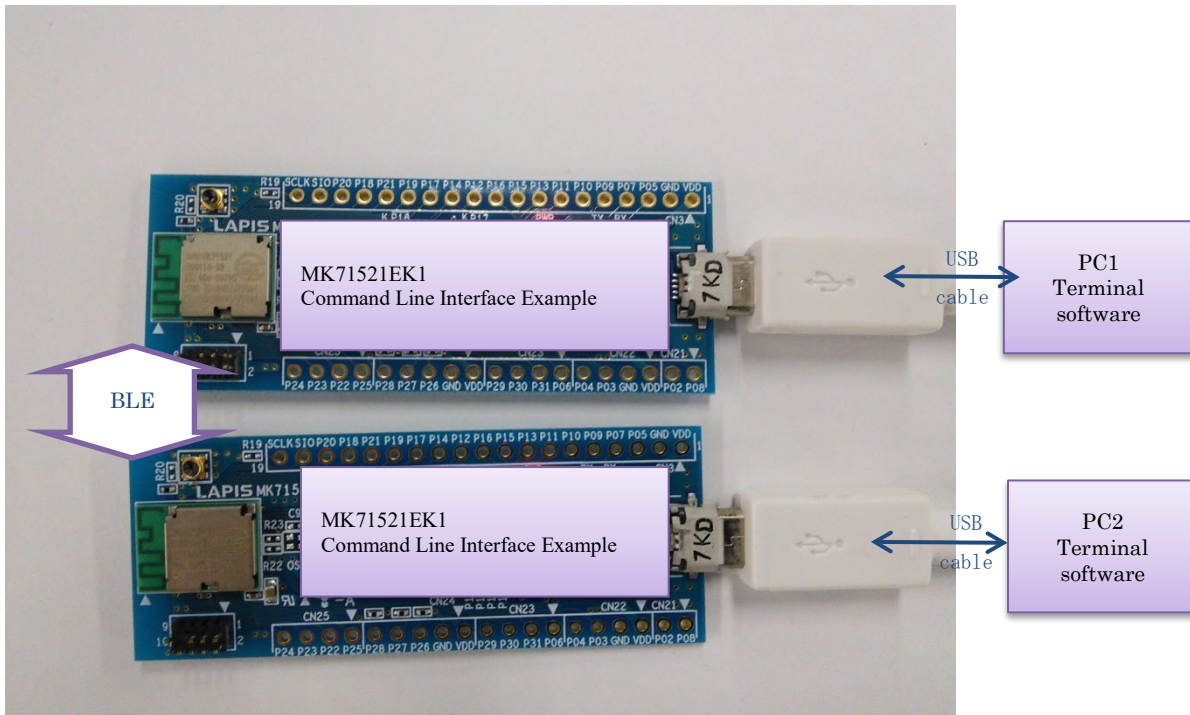


Fig.1-1 Communication distance measurement board

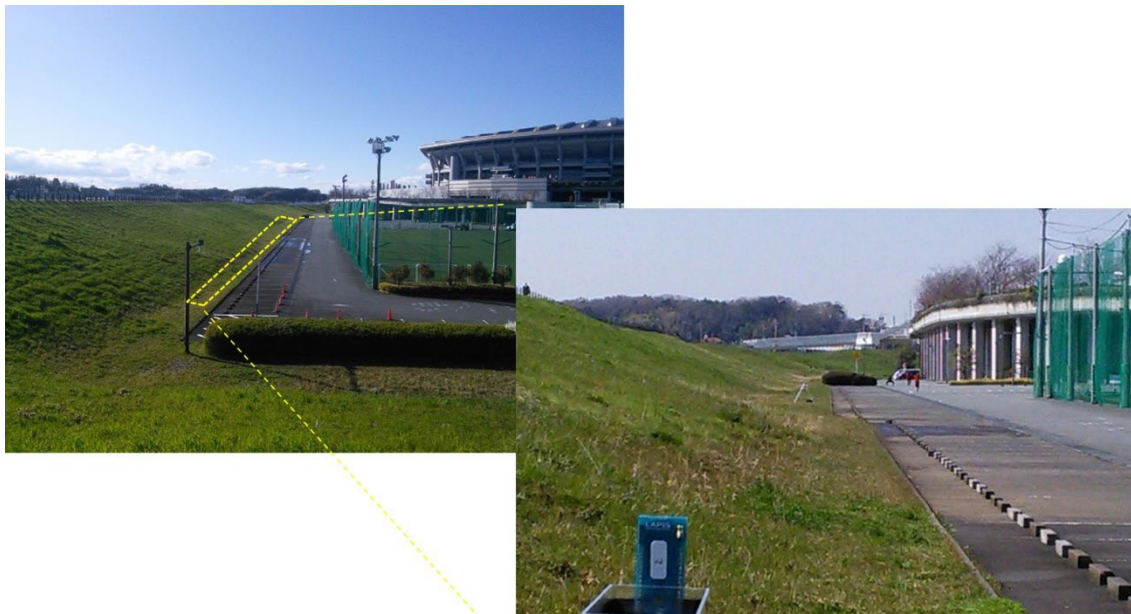


Fig.1-2 Communication distance measurement environment

1.2. Preparation (PC)

FT232RQ driver is required to connect the PC and MK71521EK1 USB connector with a USB cable.

If necessary, please install the driver corresponding to your PC from the following site.

<http://www.ftdichip.com/Drivers/D2XX.htm>

In order to write the built-in firmware from the dedicated tool, download and install the following two.

*If the download and installation procedures differ depending on the tool version, refer to the latest information for each tool.

(1) nRF5 SDK (Nordic)

Download site : <https://www.nordicsemi.com/Software-and-tools/Software/nRF5-SDK>

How to install : Unzip the downloaded ZIP file to any folder.

Note : Please do not use deep-paths and double-byte characters in the extracted folder.

(2) Segger Embedded Studio for ARM & J-Link Device Driver (Segger)

Download site : <https://www.segger.com/downloads/embedded-studio/>

How to install : Run the download file to install Segger Embedded Studio and J-Link Device Driver.
The first time you run it, follow the steps to activate.

1.3. Preparation (MK71521EK1)

Follow the steps below to write the firmware built from the source code from the IDE.

(1) Start Segger Embedded Studio

Windows operation: Start “SEGGER” → select “SEGGER Embedded Studio for ARM”

(2) Open project file

IDE operation: Open the following file from the menu “File” → “Open Solution...”.

Folder: ./<nRF5 SDK folder> /examples/ble_central_and_peripheral/experimental/ble_app_interactive/pca10040/s132/ses

File: ble_app_interactive_s132_pca10040.emProject

(3) Build execution

IDE operation: Select “Build” → “Build ble_app_interactive_s132_pca10040” from the menu (Fig.1-3)

When the build is completed normally, "Build complete" is displayed in the Output window. (Fig. 1-4)

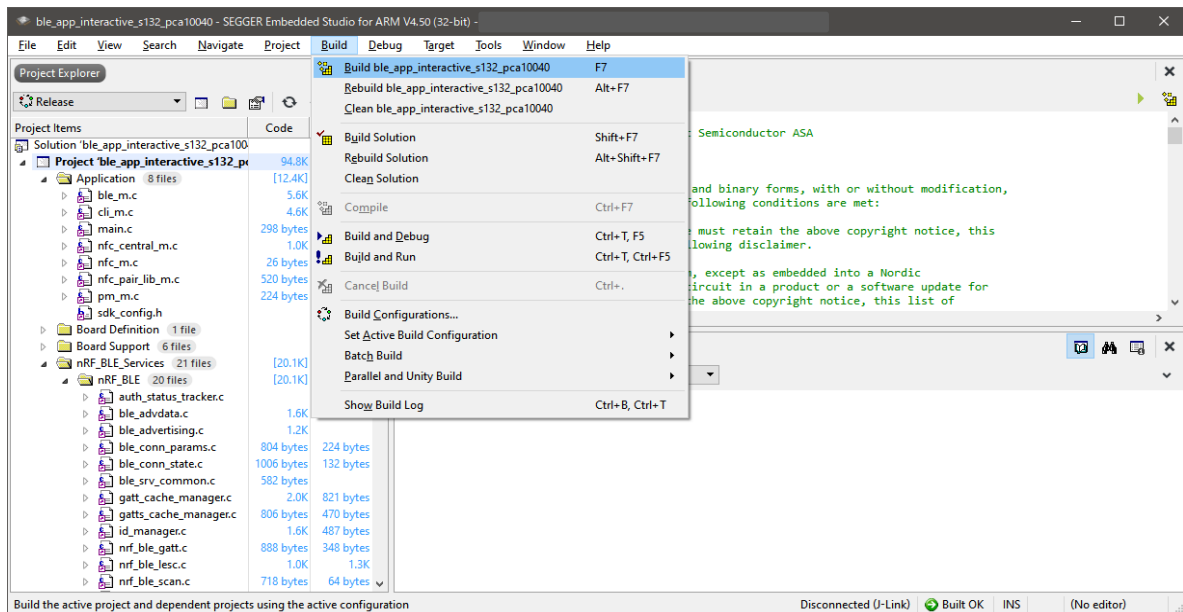


Fig1-3 Sample app build

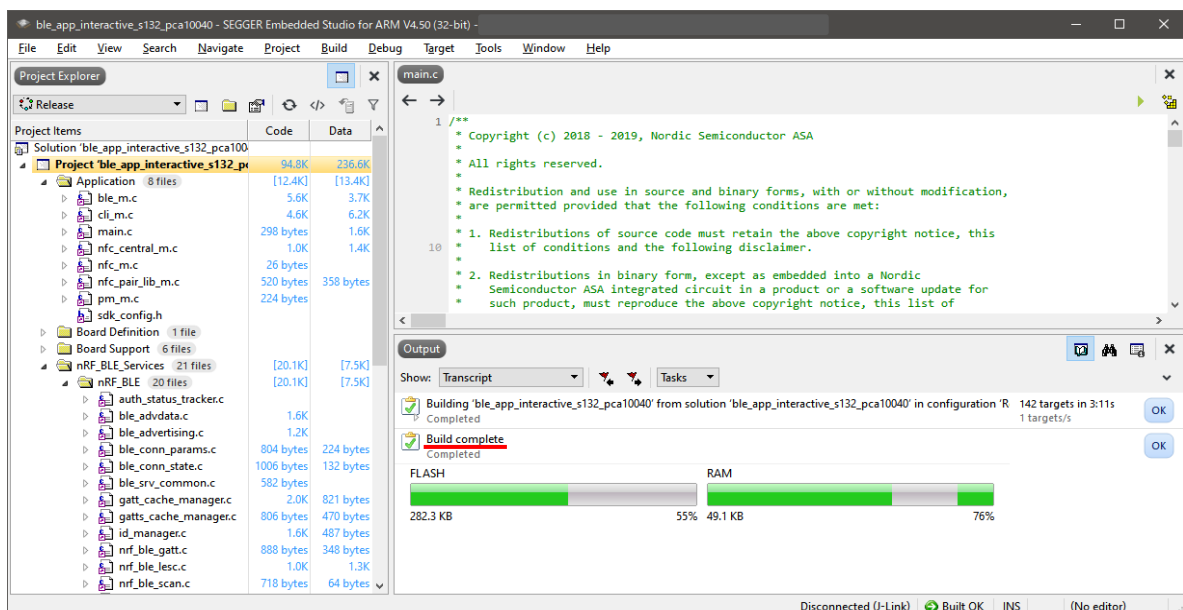


Fig.1-4 Build completed

(4) Connect J-LINK (or J-LINK lite).

Attention to the orientation of the cable (connector). The red line of the flat cable is pin 1.

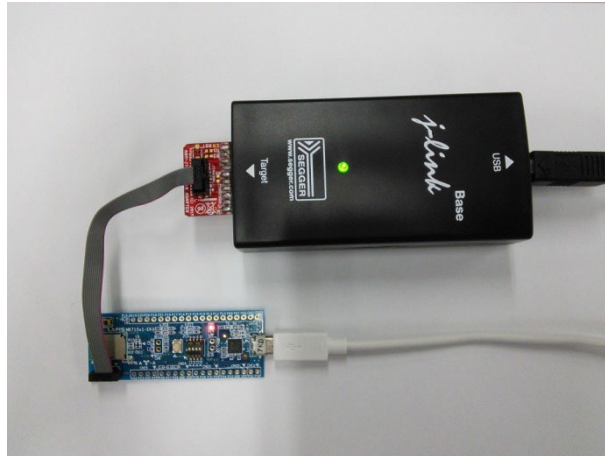


Fig.1-5 J-LINK connection

(5) Erase Flash ROM

IDE operation: Select “Target” → “Connect J-Link” from the menu (Fig. 1-6)

Select “Target” → “Erase All” from the menu (Fig. 1-7)

When Flash ROM erasing is completed,
the erasing execution and time are displayed in the Output window. (Fig. 1-8)

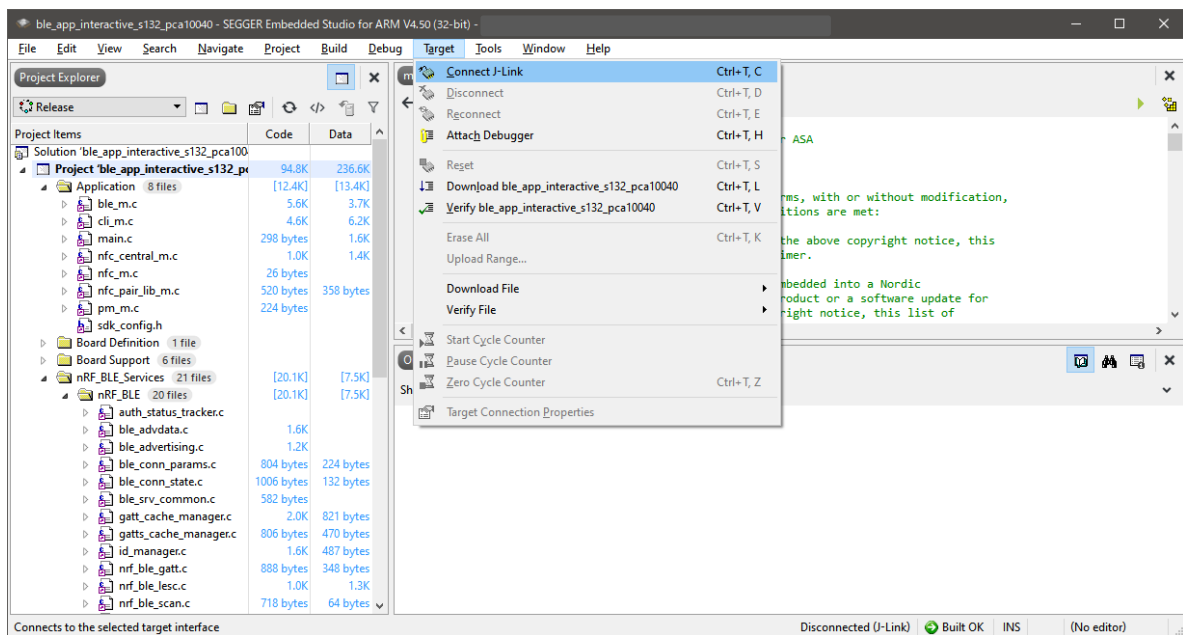


Fig.1-6 Flash ROM erase procedure 1

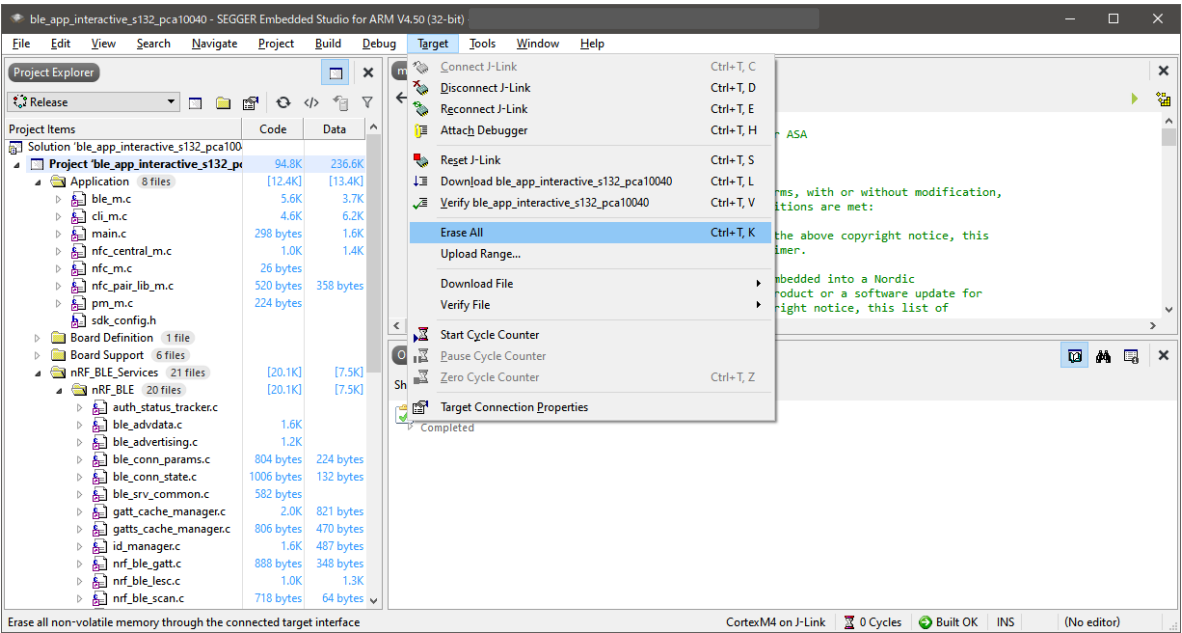


Fig. 1-7 Flash ROM erase procedure 2

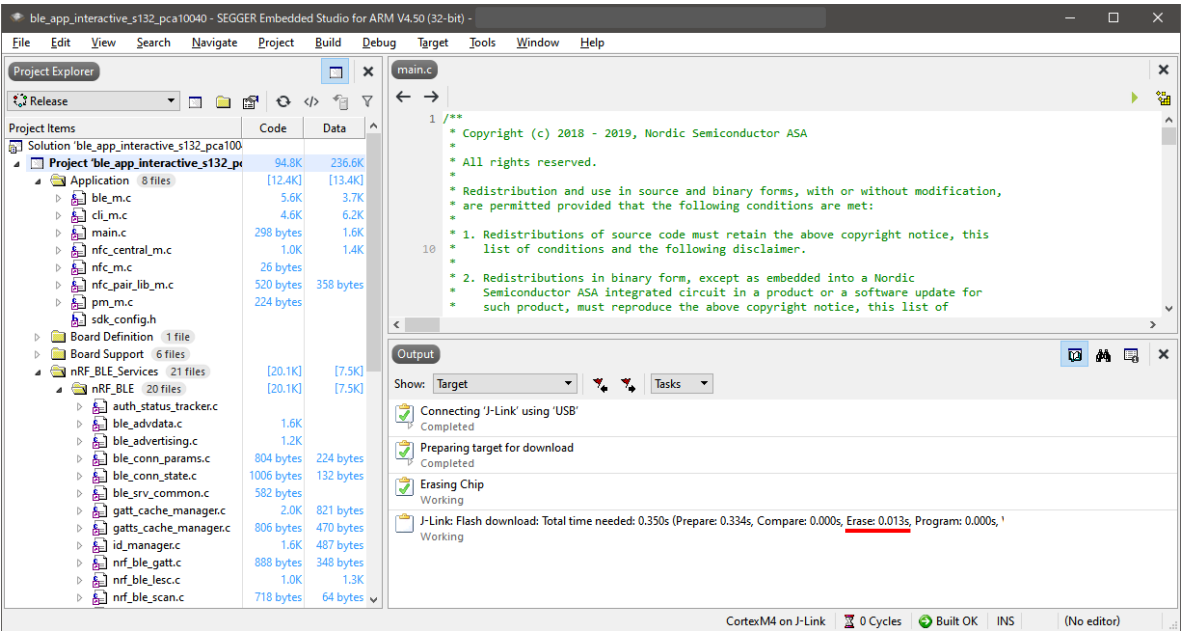


Fig. 1-8 Flash ROM erase complete

(6) Writing the firmware

IDE operation: Select “Target” → “Download ble_app_interactive_s132_pca10040” (Fig. 1-9)

When writing the firmware is completed, the result is displayed in the Output window. (Fig. 1-10)

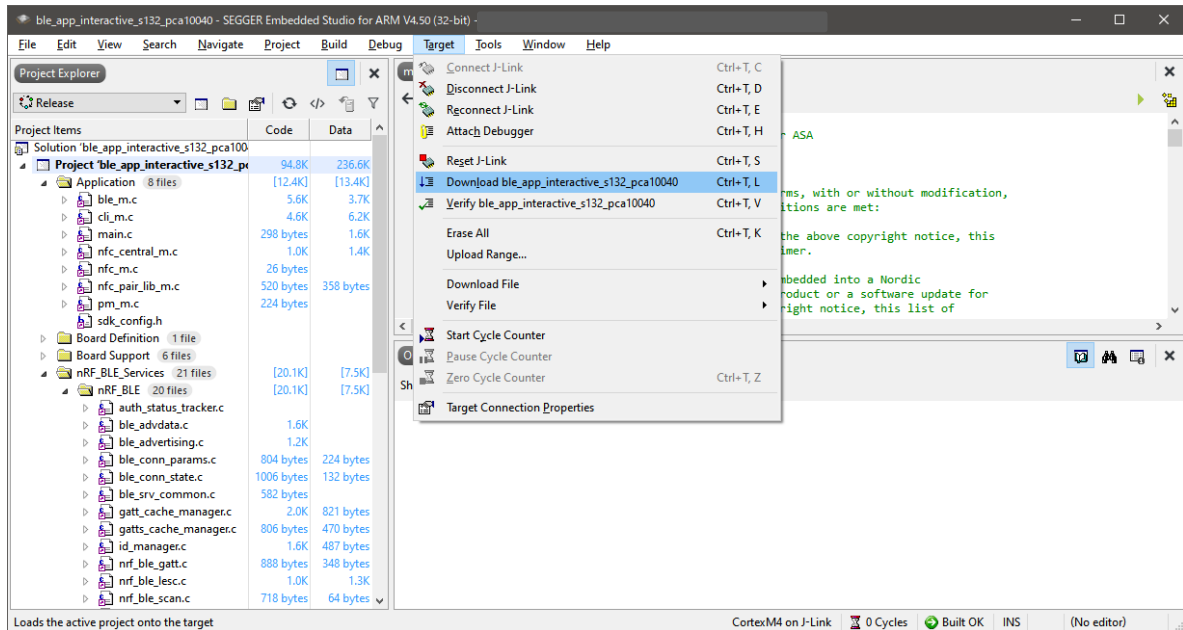


Fig. 1-9 Writing the firmware

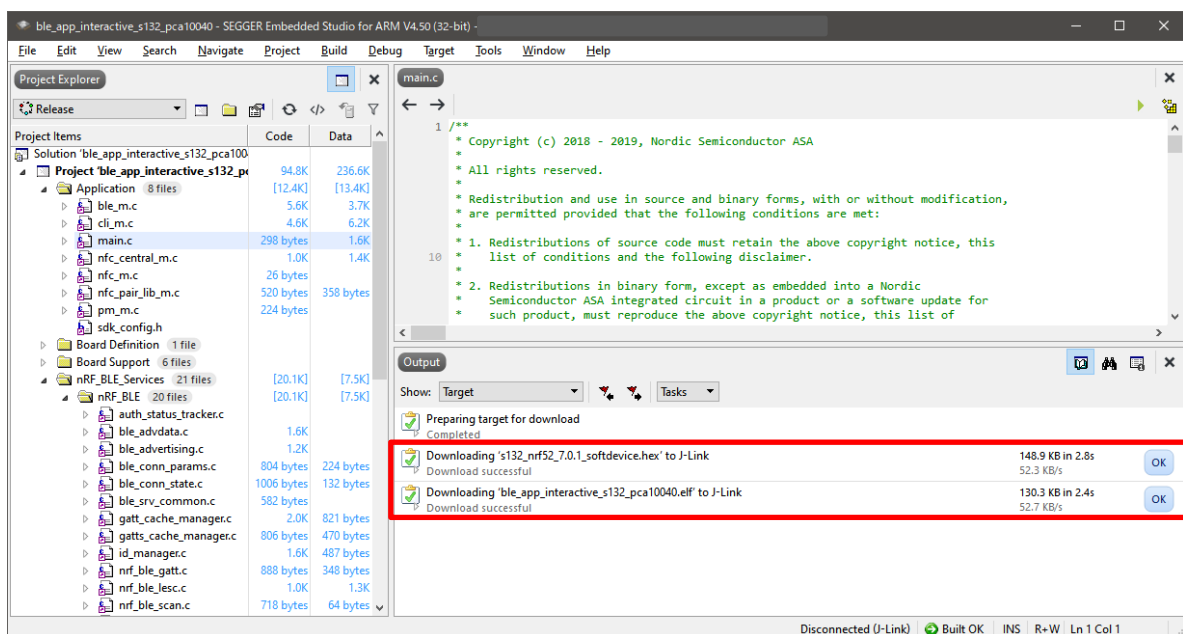


Fig. 1-10 Writing the firmware is complete

(7) Write application code on another MK71521EK1 for communication test.

(8) Segger Embedded Studio end

Select the menu “File” → “Exit” or click the “x” on the upper right of the tool to exit the tool.

2. Measuring method

This chapter describes how to use the sample software.

The sample software (BLE Interactive Command Line Interface Example) can establish connection between devices by command control.

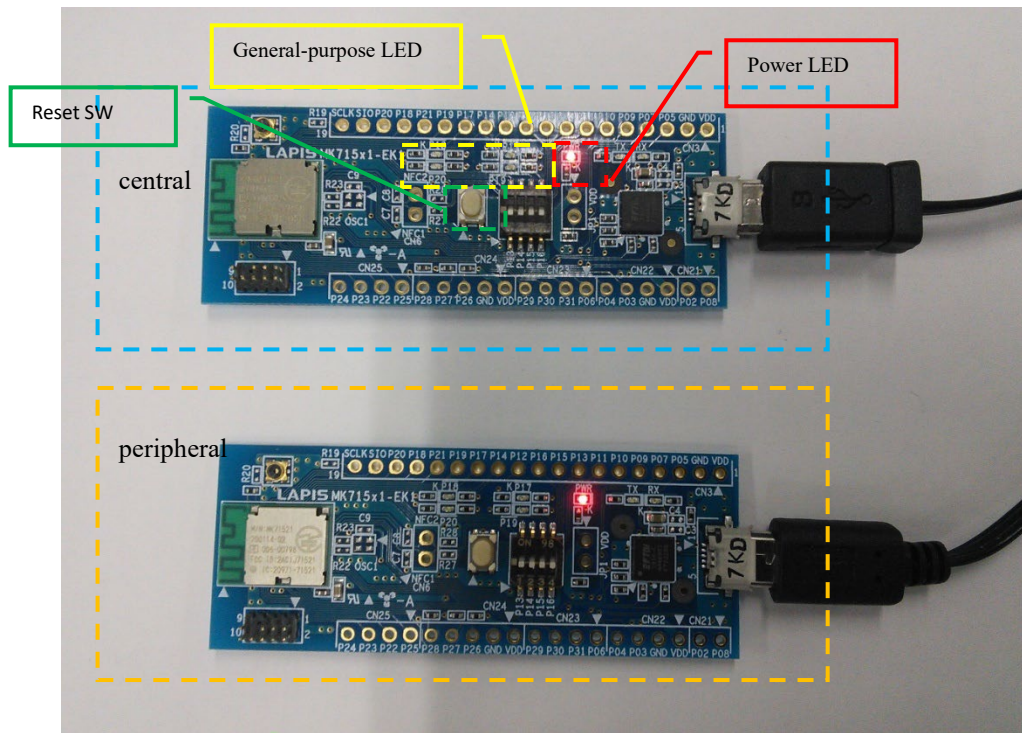


Fig. 2-1 Connection distance measurement board

- (1) Connect MK71521EK1 to PC with USB cable. (Fig. 2-1)
Power LED lights on
- (2) Start the terminal software such as TeraTerm and set the serial port.
Port: Your COM port number
Baud rate: 115,200 bps
Data: 8bit
Parity: None
Stop: 1 bit
Flow control: None
- (3) Push the Reset SW(central/ peripheral)
Start of the sample software is displayed on the terminal software (Fig. 2-2).
The command is displayed by pressing the "tab" key (Fig. 2-2).

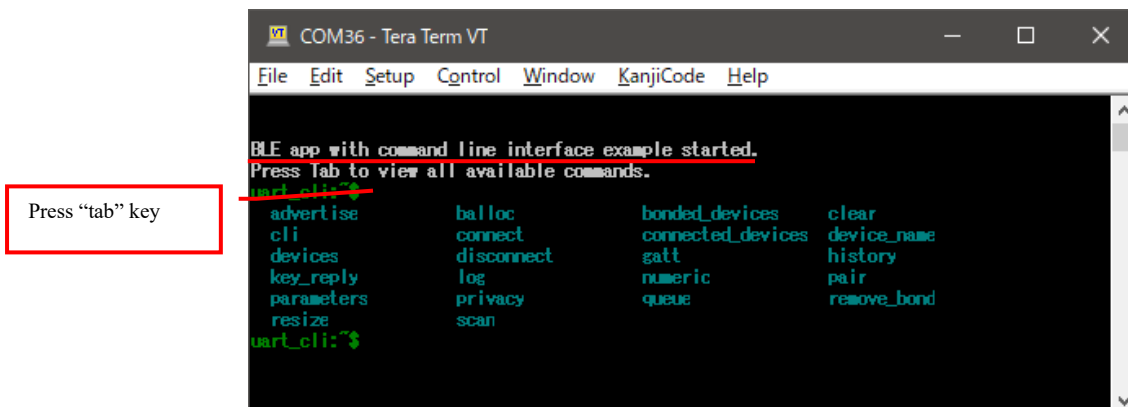


Fig. 2-2 Starting the sample software

- (4) Peripheral: Input the command "advertise on" and press ENTER. Advertisement is executed (Fig. 2-3)
LED3 lights on. (Fig. 2-4)

```

COM37 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
BLE app with command line interface example started.
Press Tab to view all available commands.
uart_cli:~$
advertise      balloc      bonded_devices  clear
cli            connect     connected_devices device_name
devices        disconnect  gatt            history
key_reply      log         numeric         pair
parameters     privacy    queue           remove_bond
resize         scan
uart_cli:~$ advertise on
Advertising enabled
<info> app: Advertising
uart_cli:~$
  
```

Fig. 2-3 Executing advertise



Fig.2-4 Advertisement execution LED

- (5) Central: Input the command "scan on" and press ENTER. The scan will be performed. (Fig. 2-5)
LED1 lights on (Fig. 2-6)

```

COM36 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
BLE app with command line interface example started.
Press Tab to view all available commands.
uart_cli:~$
advertise      balloc      bonded_devices  clear
cli            connect     connected_devices device_name
devices        disconnect  gatt            history
key_reply      log         numeric         pair
parameters     privacy    queue           remove_bond
resize         scan
uart_cli:~$ scan on
Scan started
<info> app: Scanning
uart_cli:~$
  
```

Fig. 2-5 Executing scan

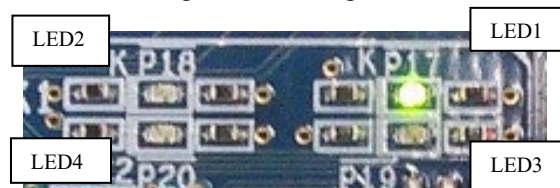


Fig. 2-6 Scan execution LED

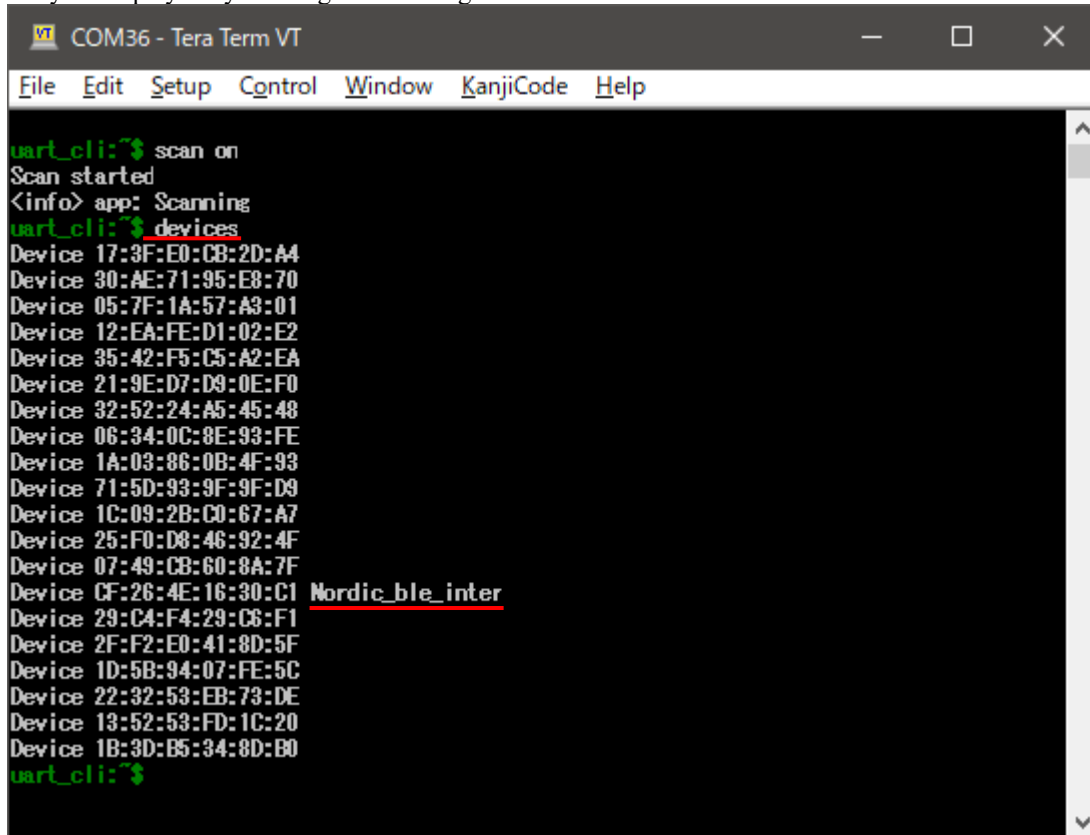
- (6) Central: Enter the command "devices" and press ENTER.

The detected device address/device name is displayed. (Fig. 2-7)

The device name "Nordic~" is the peripheral device.

(DEVICE_NAME on the sample program is "Nordic_ble_interactive")

If there are many Bluetooth devices in the vicinity, the peripheral device may not be displayed,
It may be displayed by entering "devices" again.



```
COM36 - Tera Term VT
File Edit Setup Control Window KanjiCode Help

uart_cli:~$ scan on
Scan started
<info> app: Scanning
uart_cli:~$ devices
Device 17:3F:E0:C8:2D:A4
Device 30:AE:71:95:E8:70
Device 05:7F:1A:57:A3:01
Device 12:EA:FE:D1:02:E2
Device 35:42:F5:C5:A2:EA
Device 21:9E:D7:D9:0E:F0
Device 32:52:24:A5:45:48
Device 06:34:0C:8E:93:FE
Device 1A:03:86:0B:4F:93
Device 71:5D:93:9F:9F:D9
Device 1C:09:2B:C0:67:A7
Device 25:F0:D8:46:92:4F
Device 07:49:CB:60:8A:7F
Device CF:26:4E:16:30:C1 Nordic_ble_inter
Device 29:C4:F4:29:C6:F1
Device 2F:F2:E0:41:8D:5F
Device 1D:5B:94:07:FE:5C
Device 22:32:53:EB:73:DE
Device 13:52:53:FD:1C:20
Device 1B:3D:B5:34:8D:B0
uart_cli:~$
```

Fig. 2-7 Scan execution result display

- (7) central: Enter the command "connect peripheral address" and press ENTER (Fig. 2-8)
LED4 lights on when connection is complete.

```

COM36 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
Device 17:3F:E0:CB:2D:A4
Device 30:AE:71:95:E8:70
Device 05:7F:1A:57:A3:01
Device 12:EA:FE:D1:02:E2
Device 35:42:F5:C5:A2:EA
Device 21:9E:D7:D9:0E:F0
Device 32:52:24:A5:45:48
Device 06:34:0C:8E:93:FE
Device 1A:03:86:0B:4F:93
Device 71:5D:93:9F:9F:D9
Device 1C:09:2B:C0:67:A7
Device 25:F0:D8:46:92:4F
Device 07:49:CB:60:8A:7F
Device CF:26:4E:16:30:C1 Nordic_ble_inter
Device 29:C4:F4:29:C6:F1
Device 2F:F2:E0:41:8D:5F
Device 1D:5B:94:07:FE:5C
Device 22:32:53:EB:73:DE
Device 13:52:53:FD:1C:20
Device 1B:3D:B5:34:8D:B0
uart_cli:~$ connect CF:26:4E:16:30:C1
<info> app: CENTRAL: Connecting...
Connected to address: CF 26 4E 16 30 C1
<info> app: CENTRAL: Connected, handle: 0.
Current MTU: 247
MTU changed successfully
<info> app: Data length updated to 251 bytes.
uart_cli:~$

```

Fig. 2-8 Connection established (central)

LED2 lights on the peripheral side when the connection is completed. (Fig. 2-10)

```

COM37 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
uart_cli:~$ advertise on
Advertising enabled
<info> app: Advertising
uart_cli:~$ advertise off
Advertising disabled
uart_cli:~$ advertise on
Advertising enabled
<info> app: Advertising
Connected to address: C8 9F B5 46 37 FA
<info> app: PERIPHERAL: Connected, handle 3.
<info> app: Data length updated to 251 bytes.
MTU changed successfully
uart_cli:~$

```

Fig. 2-9 Connection establishment (peripheral)

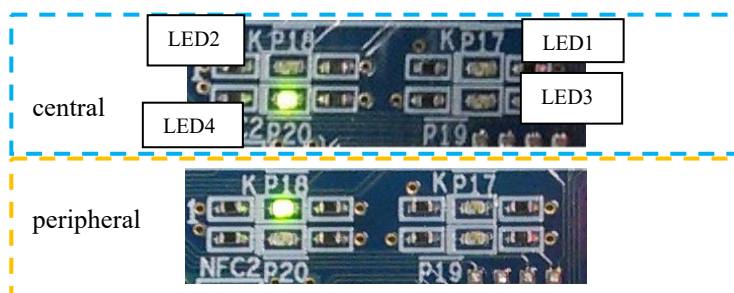


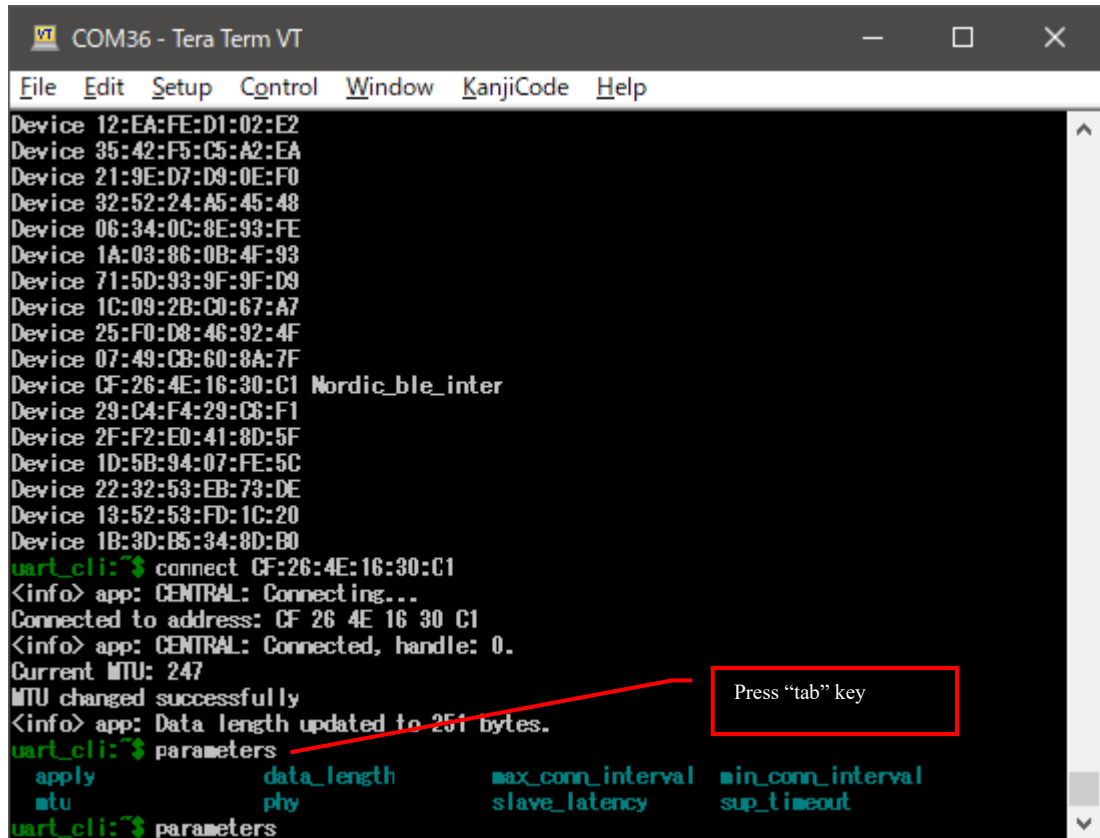
Fig. 2-10 LED display for establishing connection

The parameters for connection are as follows. (Default value of sample software)

C.I : 500msec
S.L : 5
T.O : 6200msec
PHY : 1M

Each parameter can be changed by command. (Not changed in this test)

After entering the command “parameters”, press the tab key to display command candidates (Fig. 2-11)



```

COM36 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
Device 12:EA:FE:D1:02:E2
Device 35:42:F5:C5:A2:EA
Device 21:9E:D7:D9:0E:F0
Device 32:52:24:A5:45:48
Device 06:34:0C:8E:93:FE
Device 1A:03:86:0B:4F:93
Device 71:5D:93:9F:9F:D9
Device 1C:09:2B:C0:67:A7
Device 25:F0:D8:46:92:4F
Device 07:49:CB:60:8A:7F
Device CF:26:4E:16:30:C1 Nordic_ble_inter
Device 29:C4:F4:29:C6:F1
Device 2F:F2:E0:41:8D:5F
Device 1D:5B:94:07:FE:5C
Device 22:32:53:EB:73:DE
Device 13:52:53:FD:1C:20
Device 1B:3D:B5:34:8D:B0
uart_cli:~$ connect CF:26:4E:16:30:C1
<info> app: CENTRAL: Connecting...
Connected to address: CF 26 4E 16 30 C1
<info> app: CENTRAL: Connected, handle: 0.
Current MTU: 247
MTU changed successfully
<info> app: Data length updated to 251 bytes.
uart_cli:~$ parameters
  apply      data_length  max_conn_interval  min_conn_interval
  mtu        phy          slave_latency      sup_timeout
uart_cli:~$ parameters

```

Fig. 2-11 Parameter setting command

- (8) After connecting, make sure that you do not receive disconnection notification due to timeout etc. for a certain period of time. Issue a disconnect request (command "disconnect peripheral address") to confirm that the connection can be completed normally. (Fig. 2-12, 2-13)
- reason 0x8: CONNECTION TIMEOUT
 - reason 0x13: REMOTE USER TERMINATED CONNECTION
 - reason 0x16: CONNECTION TERMINATED BY LOCAL HOST
- After disconnection, the peripheral side resumes sending advertise.

```

COM36 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
Device 07:49:CB:60:8A:7F
Device CF:26:4E:16:30:C1 Nordic_ble_inter
Device 29:C4:F4:29:C6:F1
Device 2F:F2:E0:41:8D:5F
Device 1D:5B:94:07:FE:5C
Device 22:32:53:EB:73:DE
Device 13:52:53:FD:1C:20
Device 1B:3D:B5:34:8D:B0
uart_cli:$ connect CF:26:4E:16:30:C1
<info> app: CENTRAL: Connecting...
Connected to address: CF 26 4E 16 30 C1
<info> app: CENTRAL: Connected, handle: 0.
Current MTU: 247
MTU changed successfully
<info> app: Data length updated to 251 bytes.
uart_cli:$ parameters
  apply      data_length  max_conn_interval  min_conn_interval
  mtu        phy          slave_latency       sup_timeout
uart_cli:$
  advertise   balloc      bonded_devices     clear
  cli         connect    connected_devices  device_name
  devices     disconnect  gatt               history
  key_reply   log        numeric            pair
  parameters  privacy    queue              remove_bond
  resize      scan
uart_cli:$ disconnect CF:26:4E:16:30:C1
<info> app: CENTRAL: Disconnected, handle: 0, reason: 0x16
uart_cli:$

```

Fig. 2-12 Disconnection display (central)

```

COM37 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
Advertising disabled
uart_cli:$ advertise on
Advertising enabled
<info> app: Advertising
Connected to address: C8 9F B5 46 37 FA
<info> app: PERIPHERAL: Connected, handle 3.
<info> app: Data length updated to 251 bytes.
MTU changed successfully
uart_cli:$ parameters
  apply      data_length  max_conn_interval  min_conn_interval
  mtu        phy          slave_latency       sup_timeout
<info> app: PERIPHERAL: Disconnected, handle 3, reason 0x13.
uart_cli:$

```

Fig. 2-13 Disconnection display (peripheral)

- (9) Change the distance between central/peripheral and repeat steps ⑤ to check the connectable distance.

3. Measurement data

The connection distance measurement data of MK71521EK1 is shown below.

	Distance (m)
Connection distance (Maintain connection)	95
Detection distance	150

* The communication distance changes depending on the measurement environment.
It does not guarantee communication performance.

Connection maintenance confirmation time: 1 min
Equipment orientation: Z-Plane-0° facing (Fig. 3-1)
Equipment height: 1.5m (Fig. 3-2)

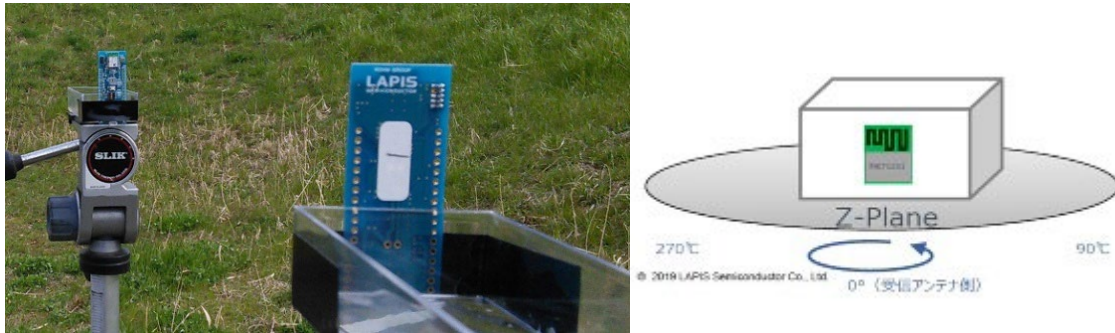


Fig.3-1 Equipment direction during measurement

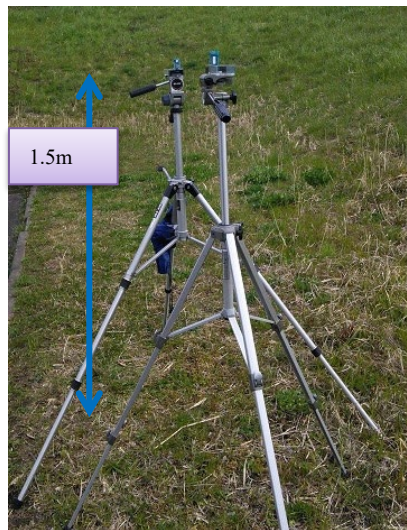


Fig.3-2 Height of equipment during measurement

Revision history

Document No.	Issue date	Page		Remarks
		Before revision	After revision	
FEXK715x1_AN_Distance-01	Oct. 16, 2020	—	—	First edition