

**Bluetooth® low energy Module
(MK71511/MK71521)
Application Note**

MK71521 Throughput measurement

Issue Date: Nov. 16, 2020

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Preface

This application note describes throughput 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.

Throughput measurement uses the nRF5 SDK sample software “Experimental: ATT_MTU Throughput 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_att_mtu.html

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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}
• Term	Nano, n	10^{-9}
	Second, s (lowercase)	Second
• 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 throughput measurement.

1.1. Overview

The configuration of the throughput measurement environment using MK71521EK1 is shown below.

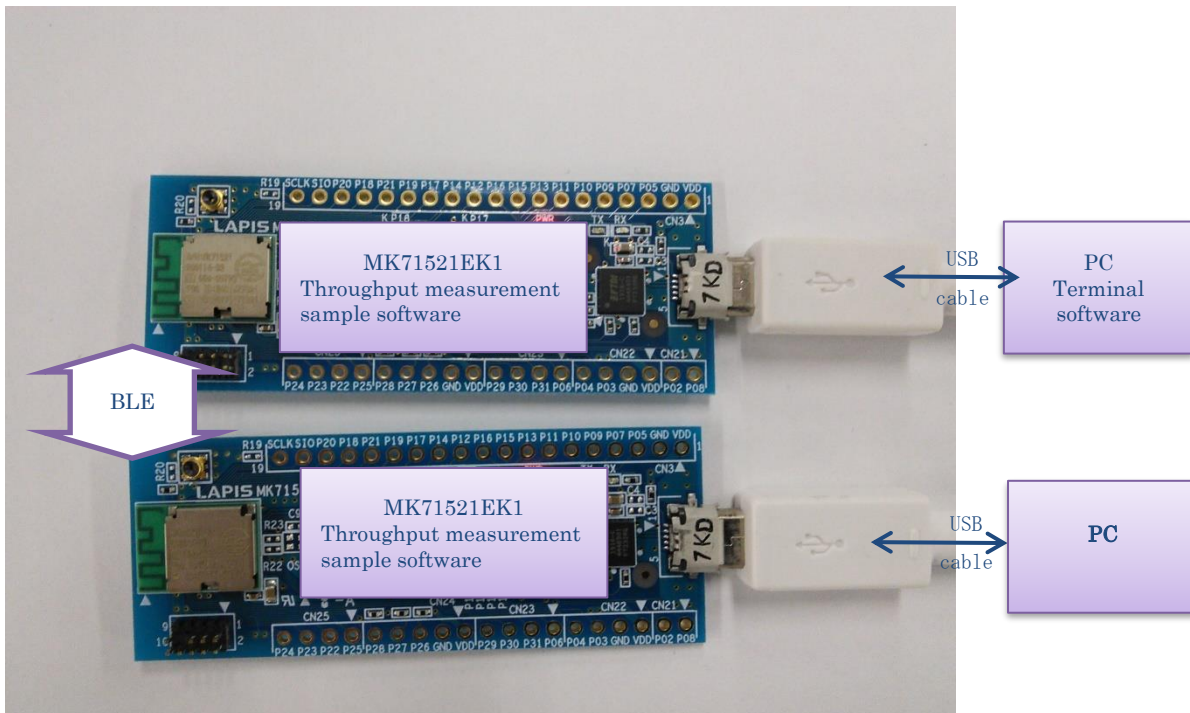


Fig. 1-1 Throughput measurement configuration

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 pre-built 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>

Download file : nRF5_SDK_16.0.0_98a08e2.zip (nRF5 Version 16.0.0)

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) nRFgo Studio (Nordic) & J-Link Device Driver (Segger)

Download site : <https://www.nordicsemi.com/Software-and-tools/Development-Tools/nRFgo-Studio>

Download file : nrfgostudiowinXXXXXXinstaller.msi ※*Latest version

How to install : Run the download file to install nRFgo Studio and J-Link Device Driver.

1.3. Preparation (MK71521EK1)

Follow the procedure below to write the built firmware to the MK71521EK1 using the dedicated tool.

(1) Connect J-LINK (or J-LINK lite). (Fig.1-2)



Fig.1-2 J-LINK connection

(2) Start nRFgo Studio

Windows operation : Start “Nordic Semiconductor” → select “nRFgo Studio”

(3) Write screen display

Tool operation : "Device Manager" window → select "nRF5x Programming" (③ in Fig.1-3)

(4) Erase Flash ROM

Tool operation : Click the "Erase All" button (④ in Fig.1-3)

When the Erase is completed, "Erase completed" will be displayed in the Log window. (Fig. 1-4)

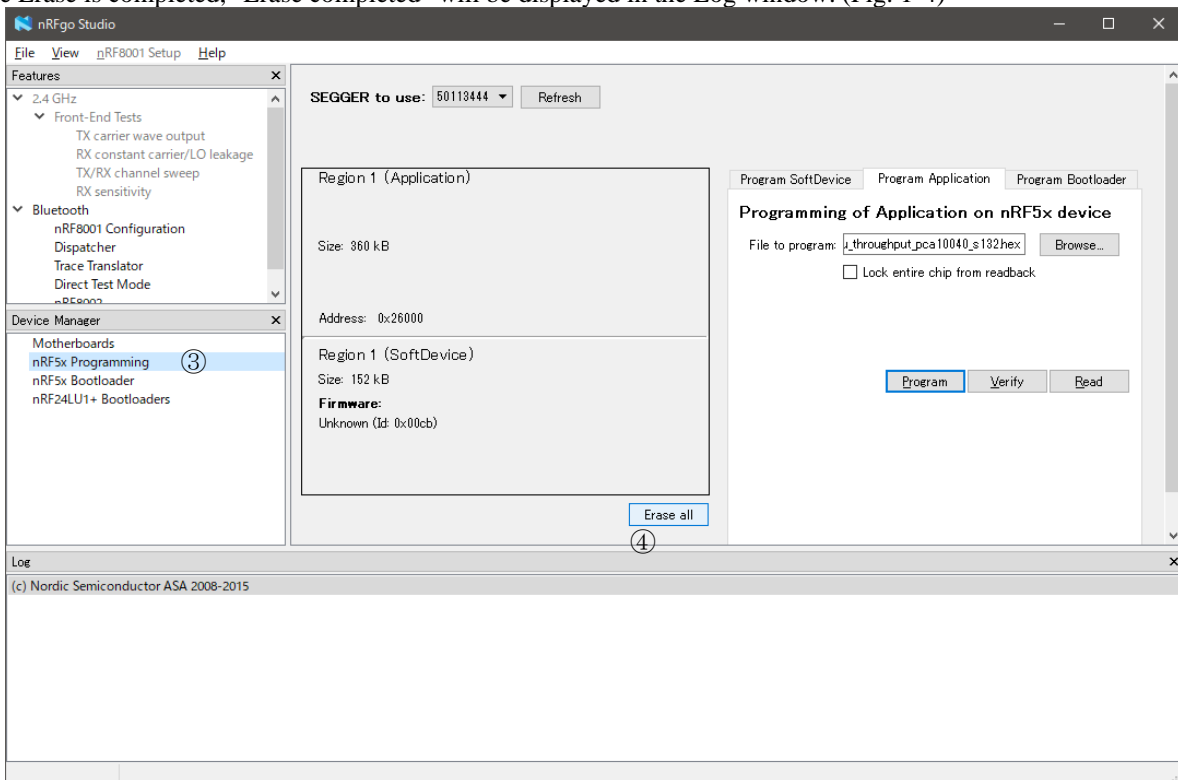


Fig. 1-3 nRFgo Studio Operation 1 (Flash ROM erase)

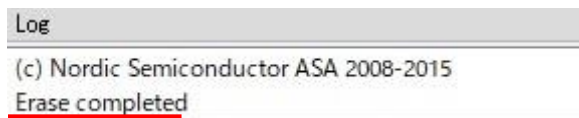


Fig. 1-4 Erase completion display

(5) Write application code (⑤ in Fi.1-5)

Tool operation: Select the "Program Application" tab, click the "Browse..." button,
 After selecting the Hex file of the application code below, click the "Program" button.
 "Programming application" is displayed during writing. (Fig. 1-6)
 When writing is completed, the result is displayed in the Log window. (Fig. 1-5)

App code folder: ¥<nRF5 SDK folder>

¥examples¥ble_central_and_peripheral¥experimental¥ble_app_att_mtu_throughput¥hex

Hex file: ble_app_att_mtu_throughput_pca10040_s132.hex

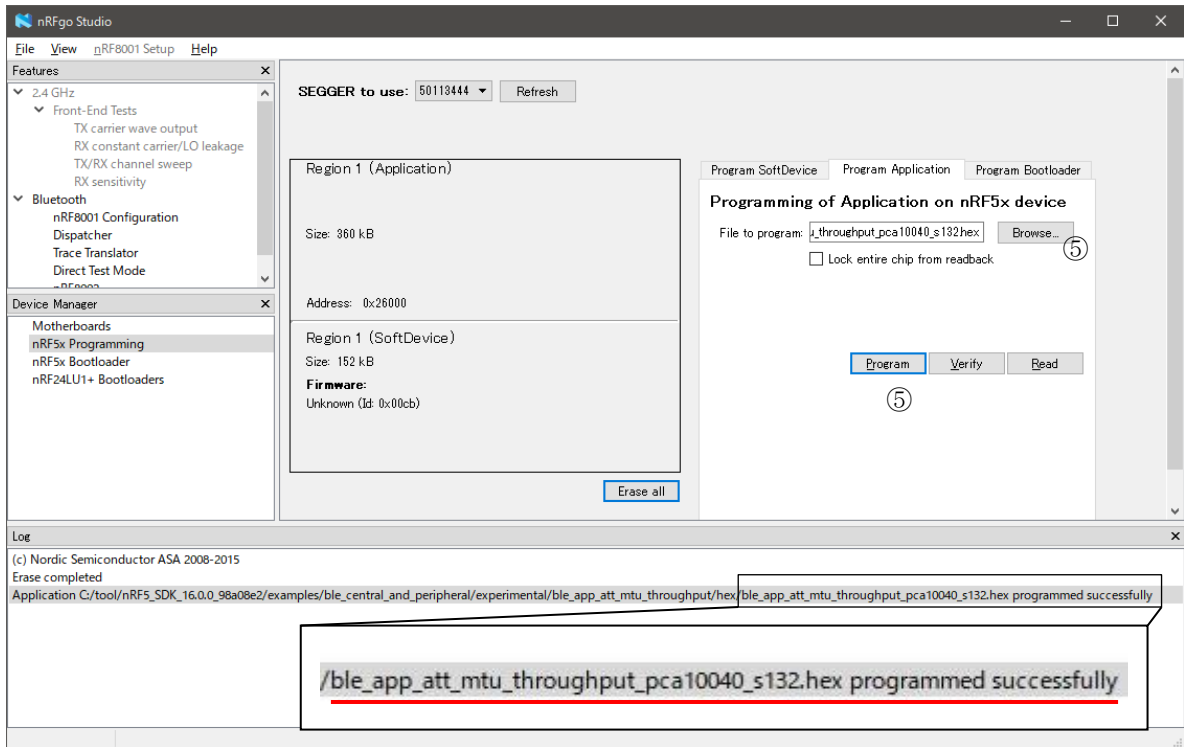


Fig. 1-5 nRFGo Studio Operation 2 (writing application code)



Fig. 1-6 Application writing display

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

(7) Exit nRFGo Studio

Select the menu "File" → "Exit" or click the "×" on the upper right of the tool to exit the tool.

2. Measuring method

This chapter describes the throughput measurement method (using the sample software).

- (1) Set all DIP-SW to off (Fig. 2-1)

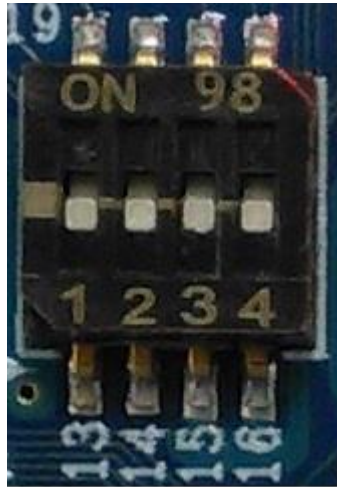


Fig.2-1 DIP-SW initial settings

- (2) Tester side: Connect MK71521EK1 to PC with USB cable. (Fig. 2-2)
 Power LED lights on

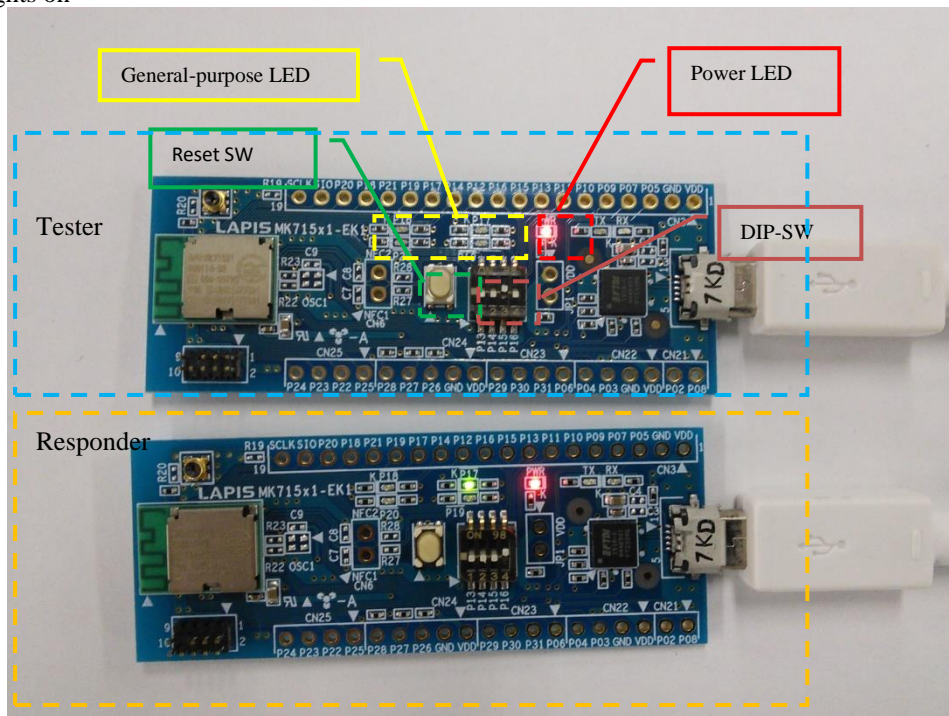


Fig. 2-2 Throughput measurement environment

- (3) Tester side: Start the terminal software such as TeraTerm and set the serial port.
 - Port : Your COM port number
 - Baud rate : 115,200 bps
 - Data : 8 bit
 - Parity : None
 - Stop : 1 bit
 - Flow control : None

- (4) Tester side: Push the reset SW

The start-up of the sample software is displayed on the terminal software (Fig. 2-3).

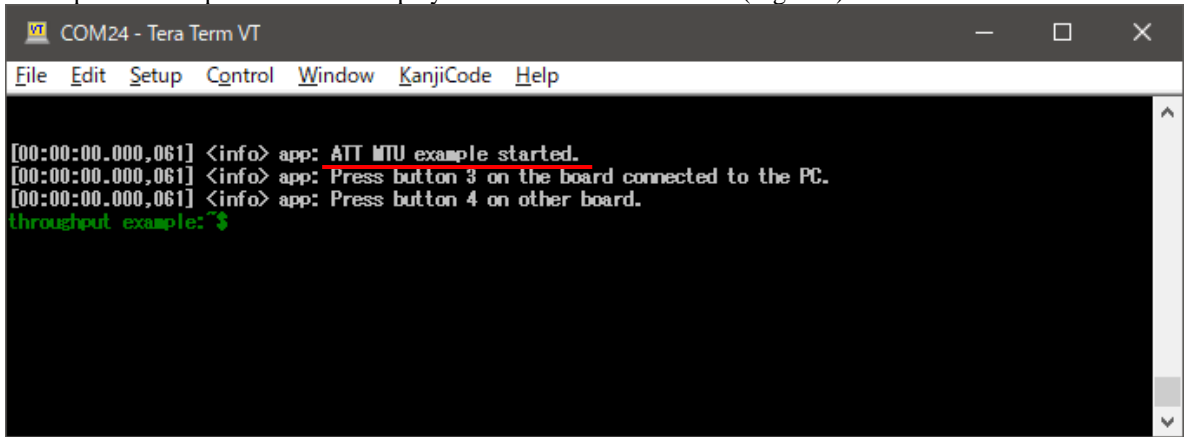


Fig. 2-3 Starting the sample software

- (5) Tester side: Set DIP-SW3 from OFF to ON (Fig. 2-4)

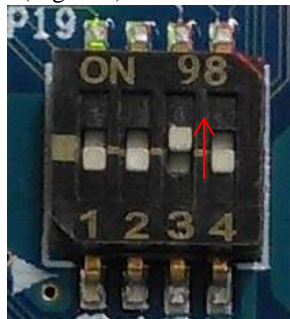


Fig.2-4 DIP-SW setting (Tester)

The start of Tester is displayed on the terminal software (Fig. 2-5).

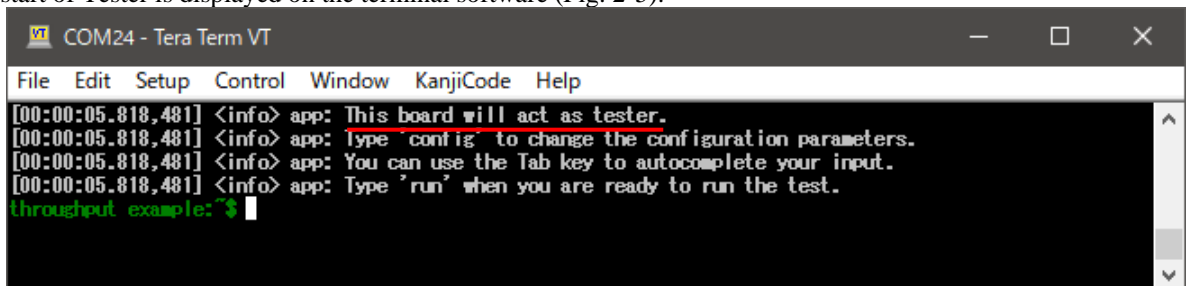


Fig. 2-5 Start Tester

- (6) Responder side: Connect MK71521EK1 to PC with USB cable. (Fig. 2-2)
- (7) Responder side: Set DIP-SW4 from OFF to ON (Fig. 2-6).

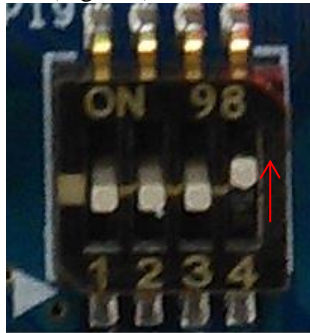


Fig.2-6 DIP-SW settings (Responder)

LED1 flashing: Indicates the execution of advertise(Fig. 2-7)



Fig.2-7 LED display

- (8) Tester side: Input the following command to set parameters (Fig. 2-8)
- ```
config conn_interval :400
config phy :2M
config data_length :251
config att_mtu :247
```

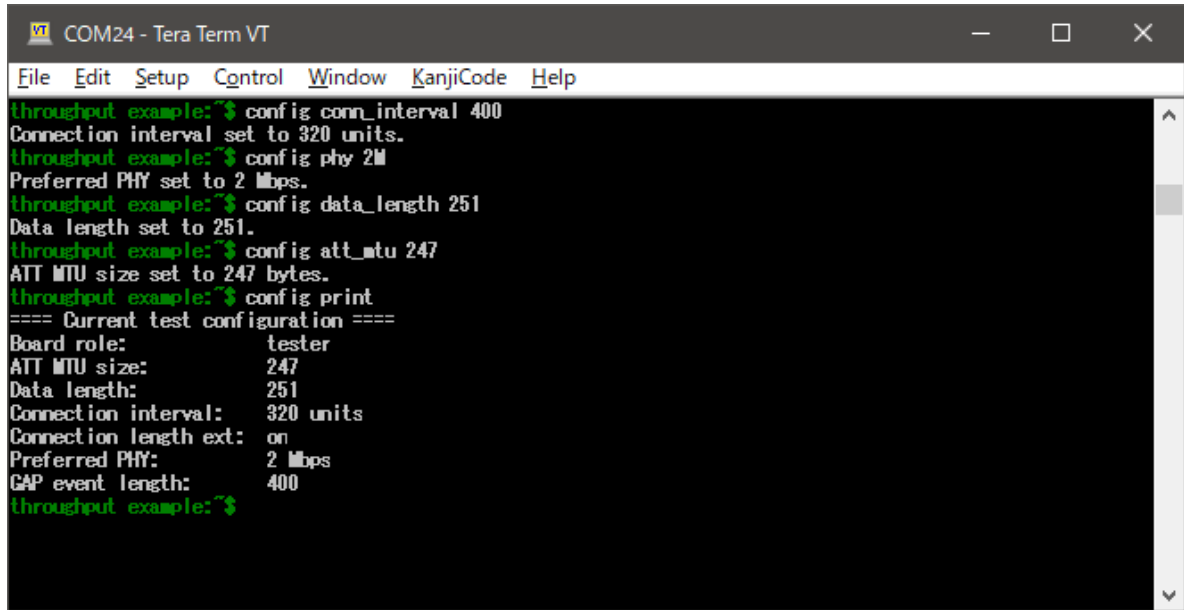


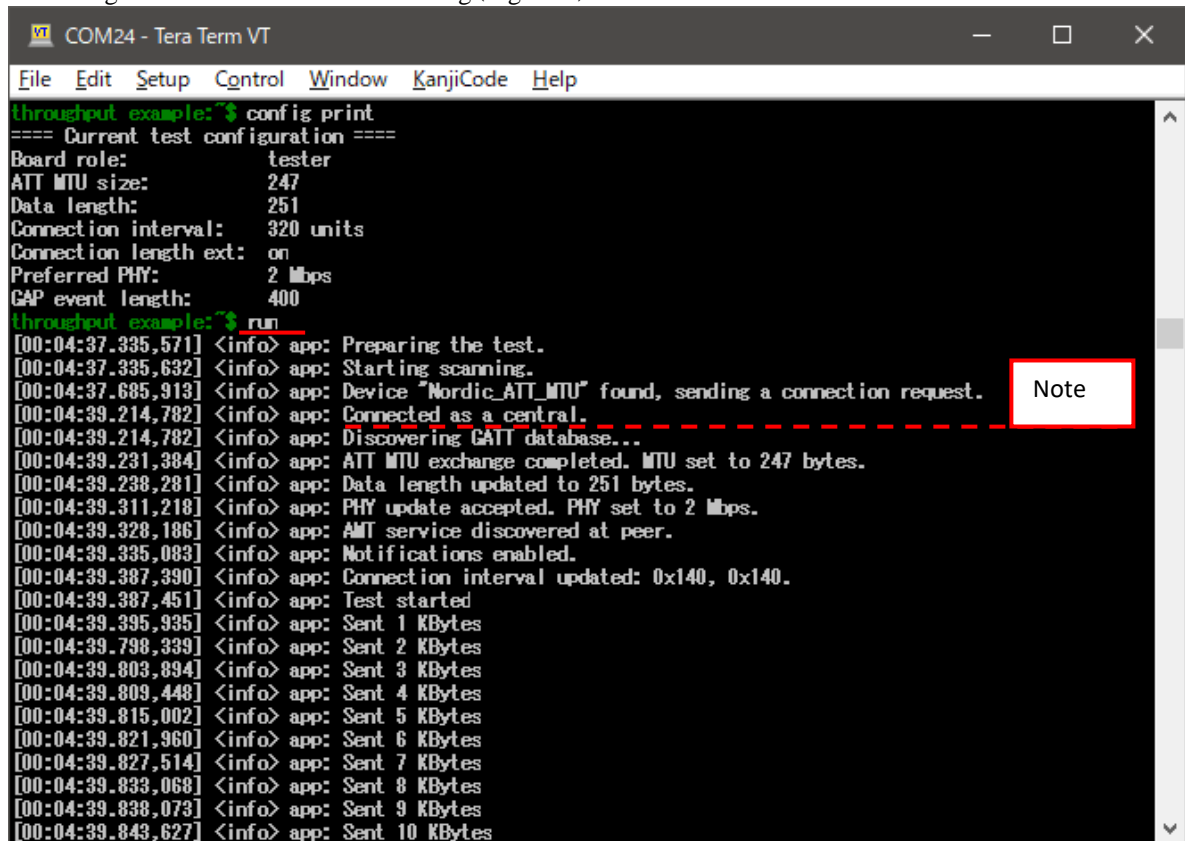
Fig. 2-8 Setting parameters

The commands used for throughput measurement are shown below. There is a space between the command and parameter.

Table.2-1 Command list

| Command | Parameter 1   | Parameter 2 | Function                   |
|---------|---------------|-------------|----------------------------|
| Config  | att_mtu       | 23~247      | ATT_MTU size (bytes)       |
|         | data_length   | 27~251      | Data length (bytes)        |
|         | conn_interval | 7.5/50/400  | Connection interval (msec) |
|         | phy           | 2M/1M       | PHY data rate              |
|         | print         | -           | Set value display          |
| Run     | -             | -           | Test execution             |

- (9) Tester side: Starts the test by executing the run command. (Fig. 2-9)  
LED2 lights on: Indicates connection establishment (Fig.2-10)  
LED3 flashing: Indicates that the test is running (Fig.2-10)



```

COM24 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
throughput example:~$ config print
==== Current test configuration ====
Board role: tester
ATT MTU size: 247
Data length: 251
Connection interval: 320 units
Connection length ext: on
Preferred PHY: 2 Mbps
GAP event length: 400
throughput example:~$ run
[00:04:37.335,571] <info> app: Preparing the test.
[00:04:37.335,632] <info> app: Starting scanning.
[00:04:37.685,913] <info> app: Device "Nordic_ATT_MTU" found, sending a connection request.
[00:04:39.214,782] <info> app: Connected as a central.
[00:04:39.214,782] <info> app: Discovering GATT database...
[00:04:39.231,384] <info> app: ATT MTU exchange completed. MTU set to 247 bytes.
[00:04:39.238,281] <info> app: Data length updated to 251 bytes.
[00:04:39.311,218] <info> app: PHY update accepted. PHY set to 2 Mbps.
[00:04:39.328,186] <info> app: ANT service discovered at peer.
[00:04:39.335,083] <info> app: Notifications enabled.
[00:04:39.387,390] <info> app: Connection interval updated: 0x140, 0x140.
[00:04:39.387,451] <info> app: Test started
[00:04:39.395,935] <info> app: Sent 1 KBytes
[00:04:39.798,339] <info> app: Sent 2 KBytes
[00:04:39.803,894] <info> app: Sent 3 KBytes
[00:04:39.809,448] <info> app: Sent 4 KBytes
[00:04:39.815,002] <info> app: Sent 5 KBytes
[00:04:39.821,960] <info> app: Sent 6 KBytes
[00:04:39.827,514] <info> app: Sent 7 KBytes
[00:04:39.833,068] <info> app: Sent 8 KBytes
[00:04:39.838,073] <info> app: Sent 9 KBytes
[00:04:39.843,627] <info> app: Sent 10 KBytes

```

Fig. 2-9 Start of throughput measurement

Note: The sample software runs scans and advertise in both Tester and Responder.  
When it finds the desired device, it issues a connection request and becomes central.  
Therefore, Tester can be either central/peripheral.  
In the example in Figure 2-5, the connection request is issued and it operates as central, but it is not always central.

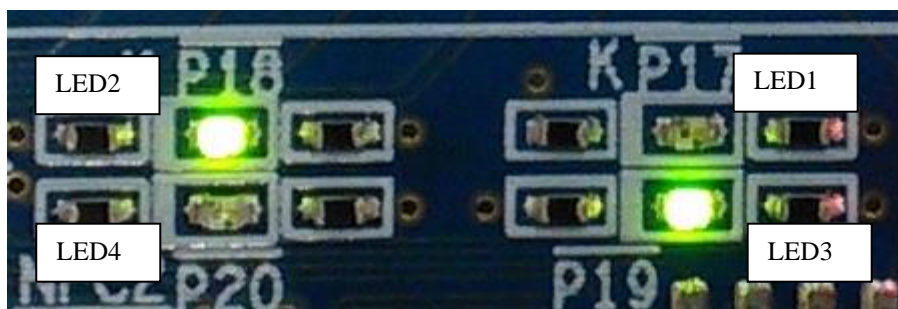
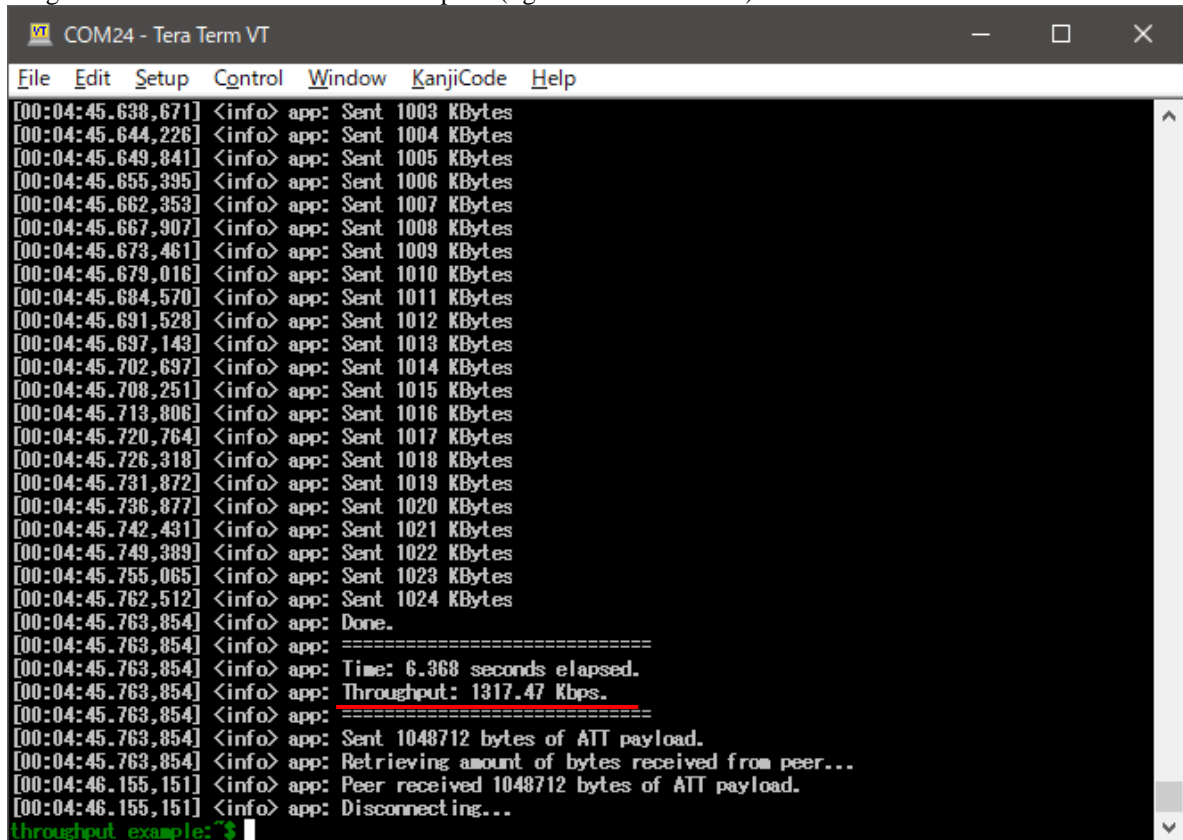


Fig.2-10 LED display during throughput measurement

- (10) Tester side: After the test is completed, the result is displayed. (Fig. 2-11)  
LED4 lights on: Indicates that the test is complete (lights off after a while)

A screenshot of a terminal window titled "COM24 - Tera Term VT". The window displays a series of log messages from an application. The messages show the application sending data in 1KB increments from 1003 KB to 1024 KB. After the final send, it reports "Done.", "Time: 6.368 seconds elapsed.", and "Throughput: 1317.47 Kbps." (underlined). It then reports "Sent 1048712 bytes of ATT payload.", "Retrieving amount of bytes received from peer...", "Peer received 1048712 bytes of ATT payload.", and "Disconnecting...". The prompt "throughput example: \$" is visible at the bottom.

```
COM24 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
[00:04:45.638,671] <info> app: Sent 1003 KBytes
[00:04:45.644,226] <info> app: Sent 1004 KBytes
[00:04:45.649,841] <info> app: Sent 1005 KBytes
[00:04:45.655,395] <info> app: Sent 1006 KBytes
[00:04:45.662,353] <info> app: Sent 1007 KBytes
[00:04:45.667,907] <info> app: Sent 1008 KBytes
[00:04:45.673,461] <info> app: Sent 1009 KBytes
[00:04:45.679,016] <info> app: Sent 1010 KBytes
[00:04:45.684,570] <info> app: Sent 1011 KBytes
[00:04:45.691,528] <info> app: Sent 1012 KBytes
[00:04:45.697,143] <info> app: Sent 1013 KBytes
[00:04:45.702,697] <info> app: Sent 1014 KBytes
[00:04:45.708,251] <info> app: Sent 1015 KBytes
[00:04:45.713,806] <info> app: Sent 1016 KBytes
[00:04:45.720,764] <info> app: Sent 1017 KBytes
[00:04:45.726,318] <info> app: Sent 1018 KBytes
[00:04:45.731,872] <info> app: Sent 1019 KBytes
[00:04:45.736,877] <info> app: Sent 1020 KBytes
[00:04:45.742,431] <info> app: Sent 1021 KBytes
[00:04:45.749,389] <info> app: Sent 1022 KBytes
[00:04:45.755,065] <info> app: Sent 1023 KBytes
[00:04:45.762,512] <info> app: Sent 1024 KBytes
[00:04:45.763,854] <info> app: Done.
[00:04:45.763,854] <info> app: =====
[00:04:45.763,854] <info> app: Time: 6.368 seconds elapsed.
[00:04:45.763,854] <info> app: Throughput: 1317.47 Kbps.
[00:04:45.763,854] <info> app: =====
[00:04:45.763,854] <info> app: Sent 1048712 bytes of ATT payload.
[00:04:45.763,854] <info> app: Retrieving amount of bytes received from peer...
[00:04:46.155,151] <info> app: Peer received 1048712 bytes of ATT payload.
[00:04:46.155,151] <info> app: Disconnecting...
throughput example: $
```

Fig. 2-11 Throughput measurement completed

### 3. Measurement data

The throughput measurement data of MK71521EK1 is shown below.

|             | conn_interval(msec) | PHY | att_mtu | data_length | Throughput (kbps) |
|-------------|---------------------|-----|---------|-------------|-------------------|
| Parameter 1 | 400                 | 2M  | 247     | 251         | 1317.47           |
| Parameter 2 | 400                 | 1M  | 247     | 251         | 758.63            |
| Parameter 3 | 400                 | 1M  | 23      | 27          | 234.91            |

\*Throughput varies depending on the measurement environment. It does not guarantee communication performance.

**Revision history**

| Document No.            | Issue date    | Page            |                | Remarks       |
|-------------------------|---------------|-----------------|----------------|---------------|
|                         |               | Before revision | After revision |               |
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