TESCOM

TC-3000C BLE Manual(Low Energy)

User Manual

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Preface

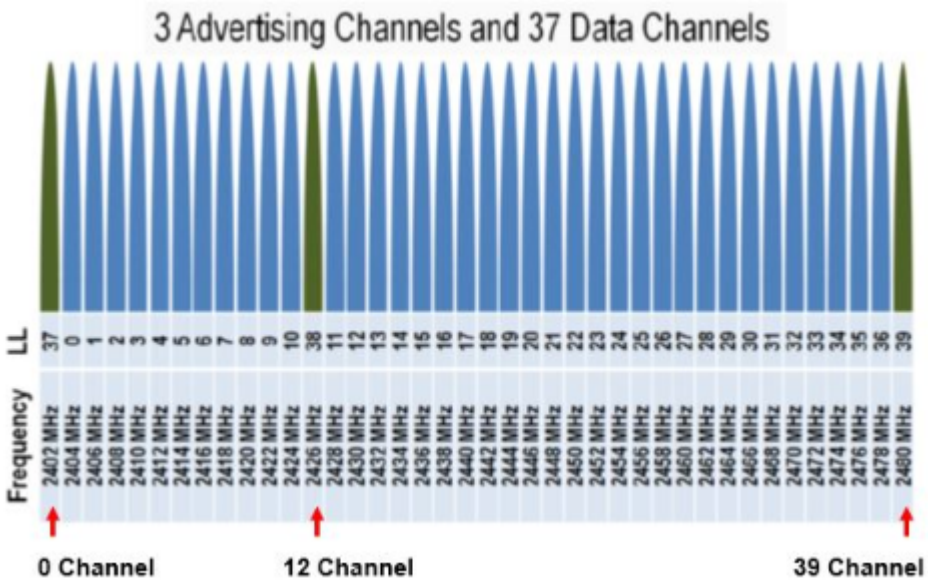
PART 1. Bluetooth Low Energy Introduction

1. Getting Started

1.1 Introduction to Bluetooth Low Energy

A technology, Bluetooth Low Energy (BLE), of Bluetooth has been added to Bluetooth Specification versiono 4.0. "Bluetooth Smart" typically reduces Bluetooth Low Energy also known as call by BLE.

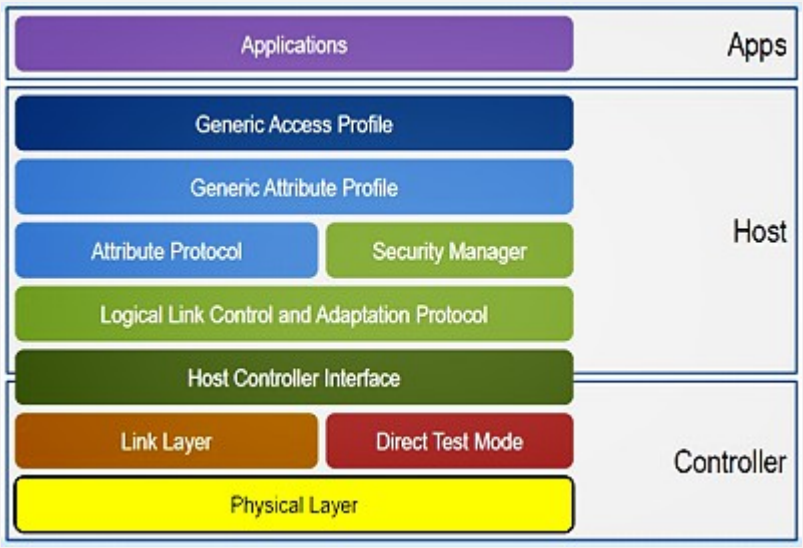
As it is recognized from its name, low energy and low cost are the main concern, so it is specially designed to be operated even by coin-cell battery. As a result, Bluetooth Low Energy (BLE) makes devices to be developed with low cost.
Also, Bluetooth Low Energy (BLE) is designed to be operated with existing Bluetooth devices.
It is operated on 40 channels, which constitutes with interval of 2 MHz, in ISM band of 2.4 GHz. It provides data transmission rate of 1 Mbps within range of 10 meters using GFSK modulation. As well as existing Bluetooth (Classic Bluetooth), BLE uses frequency hopping but as it uses adaptive frequency hopping, hopping speed is slower than existing Bluetooth's hopping speed. BLE performs 'Advertise' function, which discovers devices using 3 channels among 40 channels. If devices are discovered, it sends and receives data using rest of 37 channels.



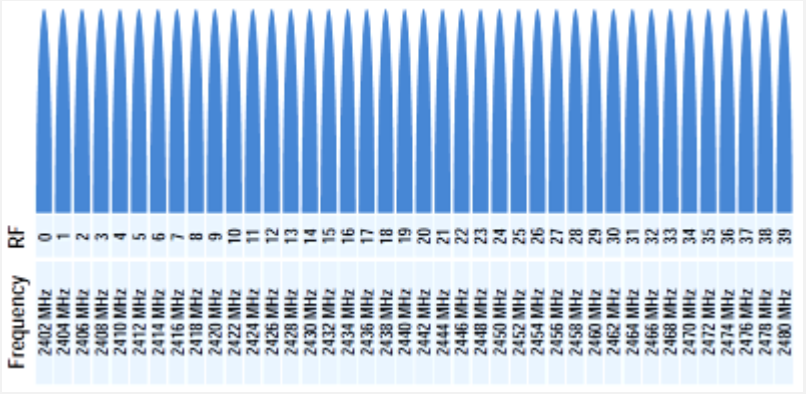
NOTICE

Advertising Channel

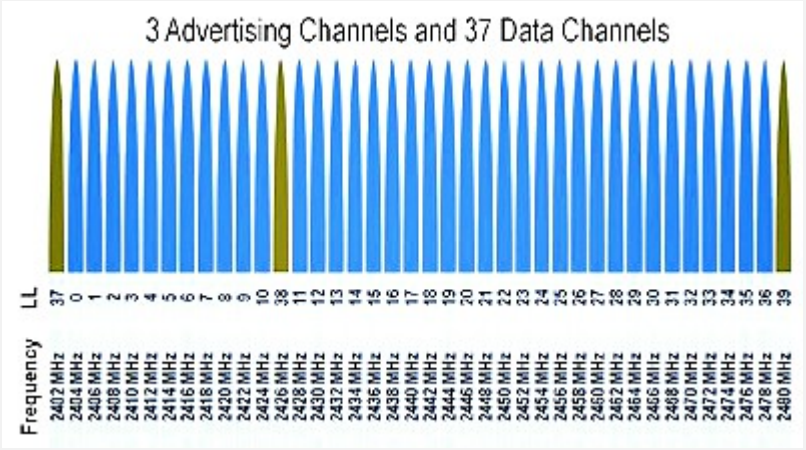
There are Link Layer (LL) and Physical Layer under BLE Protocol Stack as shown in the image below.



Channels in the Physical Layer means RF Channels as shown in the image below.



And Channels in the Link Layer means LL Channels as shown in the image below and operates differently from Physical Channels (RF Channel) above.



1.1.1 Data Length Extension of Bluetooth 4.2

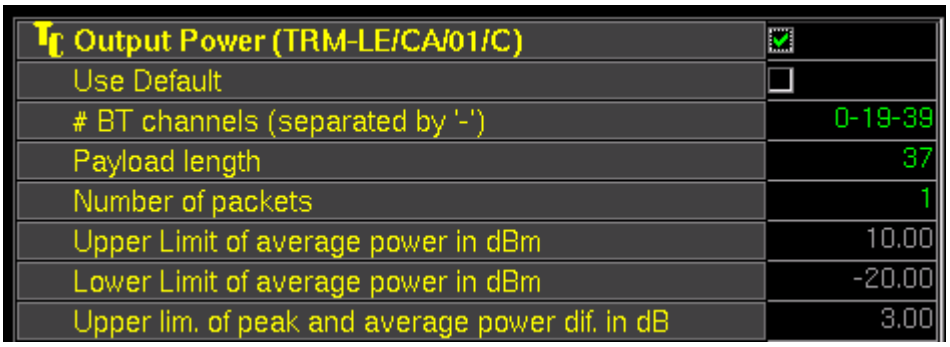
In TC-3000C, Data Length Extension test, which is introduced in BLE (Bluetooth Low Energy) standard specification among Bluetooth Core 4.2 spec, is available.

NOTICE

BLE Data Length Extension test is available in TC-3000C's firmware version V3.60 or newer. Customers who already purchased TC-3000C's BLE option can perform BLE Data Length Extension test free of charge by updating firmware.

As BLE data packet length has been expended from 37 bytes to 255 bytes, data transmitting speed has been increased 2.5 times comparing to previous 4.0 standard. Especially, the volume of packet, which can be transmitted at a time has been increased 10 times, so transmit error and battery consumption has been decreased. Therefore, efficient data transmit is available.

BLE Data Length Extension test can be performed by changing 'Payload length under 7 BT LE Test Cases that TC-3000C supports.



Please refer to the Bluetooth 4.2 Standard in the Bluetooth SIG website for further explanation and better understanding.

1.1.2 Bluetooth Version 5.0

TC-3000C is capable of testing the following features introduced in the BLE (Bluetooth Low Energy) standard of the Bluetooth Core 5.0 specification.

- Double the speed (2Msym/s PHY for LE)
- LE Long range (BLE Coded S=8/S=2 packet)

1.1.2.1 Physical Layer Change

1. Transmission Max power
   A. Maximum transmit power in Bluetooth 5 is defined to be +20 dBm, while in the Bluetooth 4 specification this level was defined at +10 dBm.
   - Maximum output power [LE v4.0,4.1,4.2] => 10 mW (+10 dBm)
   - Maximum output power [LE v5.0] => 100 mW (+20 dBm)

< LE v4.0, v4.1, v4.2 >

Minimum Output Power	Maximum Output Power
0.01 mW (-20 dBm)	10 mW (+10 dBm)

Power Class	Maximum Output Power (Pmax)	Nominal Output Power	Minimum Output Power[1]	Power Control
1	100 mW (20 dBm)	N/A	1 mW (0 dBm)	Pmin<+4 dBm to Pmax Optional: Pmin[2] to Pmax
2	2.5 mW (4 dBm)	1 mW (0 dBm)	0.25 mW (-6 dBm)	Optional: Pmin[2] to Pmax
3	1 mW (0 dBm)	N/A	N/A	Optional: Pmin[2] to Pmax

Table 3.1: Power classes

1. Minimum output power at maximum power setting.
2. The lower power limit Pmin<-30dBm is suggested but is not mandatory, and may be chosen according to application needs.

< LE v5.0 >

Minimum Output Power	Maximum Output Power
0.01 mW (-20 dBm)	100 mW (+20 dBm)

Power Class	Maximum Output Power (P_{max})	Minimum Output Power[1]
1	100 mW (+20 dBm)	10 mW (+10 dBm)
1.5	10 mW (+10 dBm)	0.01 mW (-20 dBm)
2	2.5 mW (+4 dBm)	0.01 mW (-20 dBm)
3	1 mW (0 dBm)	0.01 mW (-20 dBm)

2. Added Stable Modulation Index (hereinafter referred to as "SMI")
   A. Standard Modulation Index : 0.5 ± 1 % (0.450 ~ 0.550)

3. In-band Spurious Emission (Spectrum Mask)
   A. Transmit Spectrum Mask (1 Msym/s modulation)

Frequency offset	Spurious Power
2 MHz (|M-N| = 2)	-20 dBm
3 MHz or greater (|M-N| ≥ 3)	-30 dBm

   B. Transmit Spectrum Mask (2 Msym/s modulation)

Frequency offset	Spurious Power
4 MHz (|M-N| = 4)	-20 dBm
5 MHz (|M-N| = 5)	-20 dBm
6 MHz or greater (|M-N| ≥ 6)	-30 dBm

4. Sensitivity Level

A. Sensitivity BER by maximum payload length

Maximum Supported Payload Length (bytes)	BER (%)
≤ 37	0.1
≥ 38 and ≤ 63	0.064
≥ 64 and ≤ 127	0.034
≥ 128	0.017

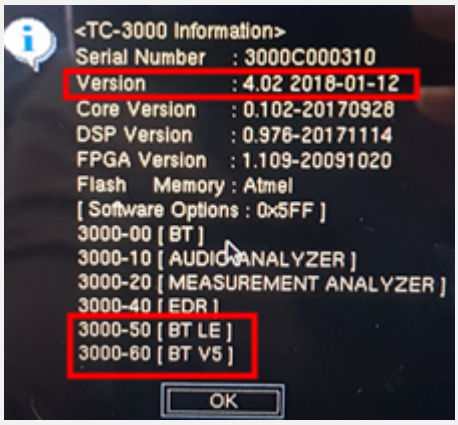
B. Sensitivity level of the receiver

PHY	Sensitivity (dBm)
LE Uncoded PHYs	≤ -70
LE Coded PHY with S=2 coding	≤ -75
LE Coded PHY with S=8 coding	≤ -82

For more information of the Bluetooth 5.0 specification, please visit Bluetooth SIG homepage.

NOTICE

To test Bluetooth v5.0, TC-3000C S/W option "3000-50 BT LE" and "3000-60 BT V5" should be installed and TC-3000C Firmware Version should be v4.00 or higher.
If the 3000-50 option is included, only 3000-60 BT V5 can be purchased.



1.2 Bluetooth Low Energy Testing

DUT with Bluetooth LE support provides three main test methods as follows:

This document provides a description of each test method and the test procedures.

- Direct Test Mode(DTM) (Refer to 2. Direct Test Mode)
- Non-Signaling Test (Refer to 3. Non-Signaling Test)
- Advertising Test (Refer to 4. Advertising Test)

PART 2. Bluetooth Low Energy Testing

2. Direct Test Mode

DTM is a standard mode in the BLE 4.1 specification (Vol 6, Part F) that allows testing of the radio's Physical Layer (PHY) by transmitting and receiving sequences of test packets. This is often used in compliance and production-line testing, without the need of going through the complete BLE Protocol Stack, i.e. it skips the Host Stack and talks directly to the radio in an isolated manner.

Another layer in the BLE specification is the **Host Controller Interface (HCI)** - a standard-defined interface to exchange data between the BLE Host Stack and the radio Controller.

In Direct Test mode, the test packets required for DUT are sent to TC-3000C and DUT through HCI or 2-Wire UART interfaces, and the received packet counts are reported.

There are two test methods for Direct Test Mode.

1. Test through HCI Interface (UART or USB)
2. Test through 2-wire UART Interface

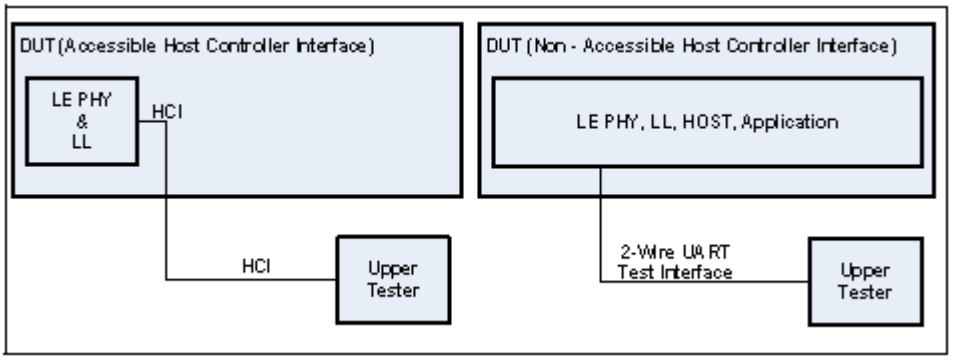


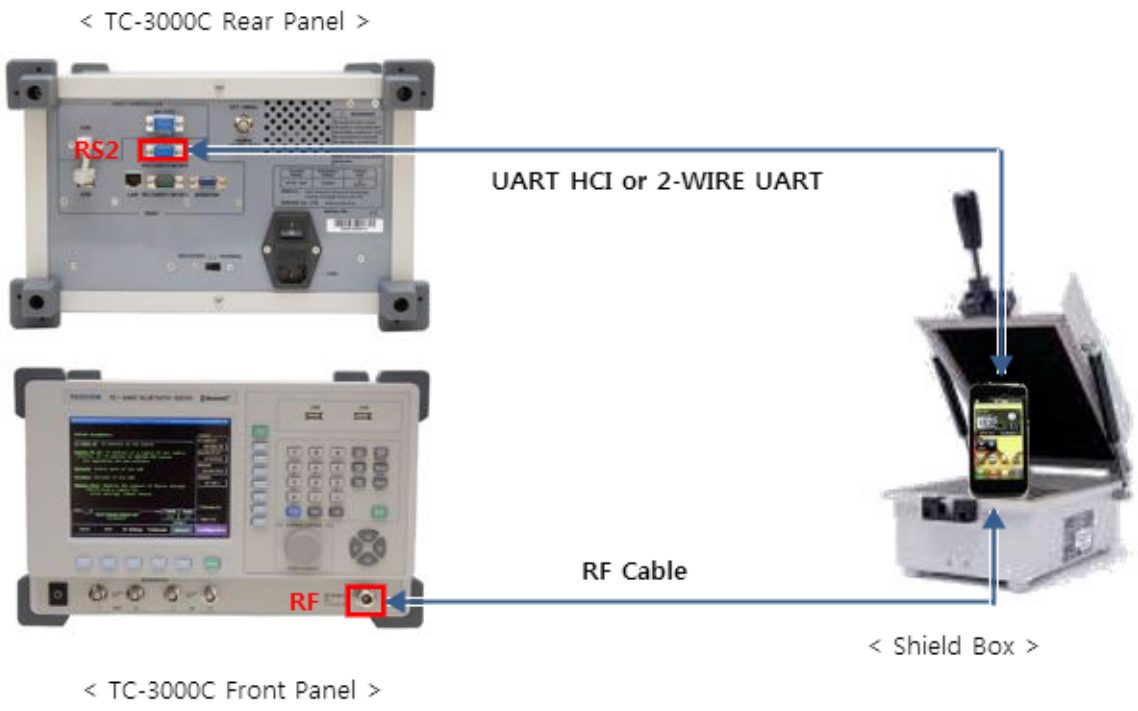
Figure 2-1 Direct Test Mode Setup : HCI Interface(left), 2-wire UART Interface(right)

TC-3000C supports UART HCI, USB HCI, and 2-Wire UART required in BT LE Direct Test Mode.

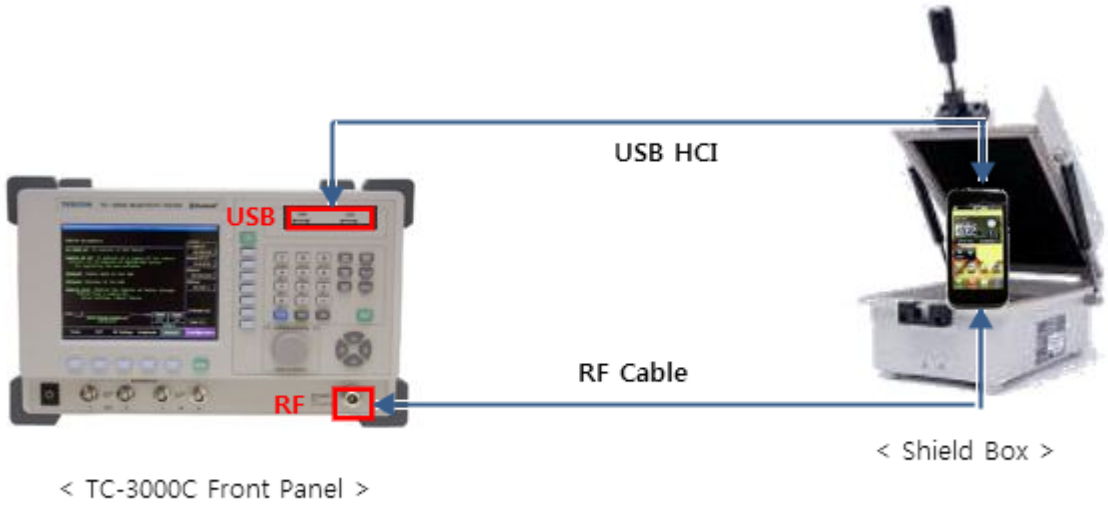
2.1 Setup

2.1.1 General Setup for Direct Test Mode

1. When DUT supports UART HCI and 2-Wire UART Interface:



2. When the HCI port supports USB:



- **DUT Preparation**: Connect HCI (UART or USB) and 2-wire UART Interface to TC-3000C.

- **Shield Box**: For reliable measurement report, use a shield box to prevent electromagnetic interferences. Depending on the DUT type, directly connect to the RF cable or create a radiation environment using the antenna coupler.

- **TC-3000C**: Select the BT LE Mode. (See 2.1.2 TC-3000C Setup)

2.1.2 TC-3000C Setup

1. BT LE Mode Setup
   - Select MENU -> Configuration -> DUT(M2) -> DUT Type(F2) -> BT LE

> **NOTICE**
> After TC-3000C Firmware Version 4.00, it will take less than 10 seconds to switch from BT to BT LE mode.

2. HCI Port Setup: Set up the HCI port for DUT.
   - Select MENU -> Configuration -> DUT(M2) -> (F3) -> USB2 or UART2 or 2WIRE2

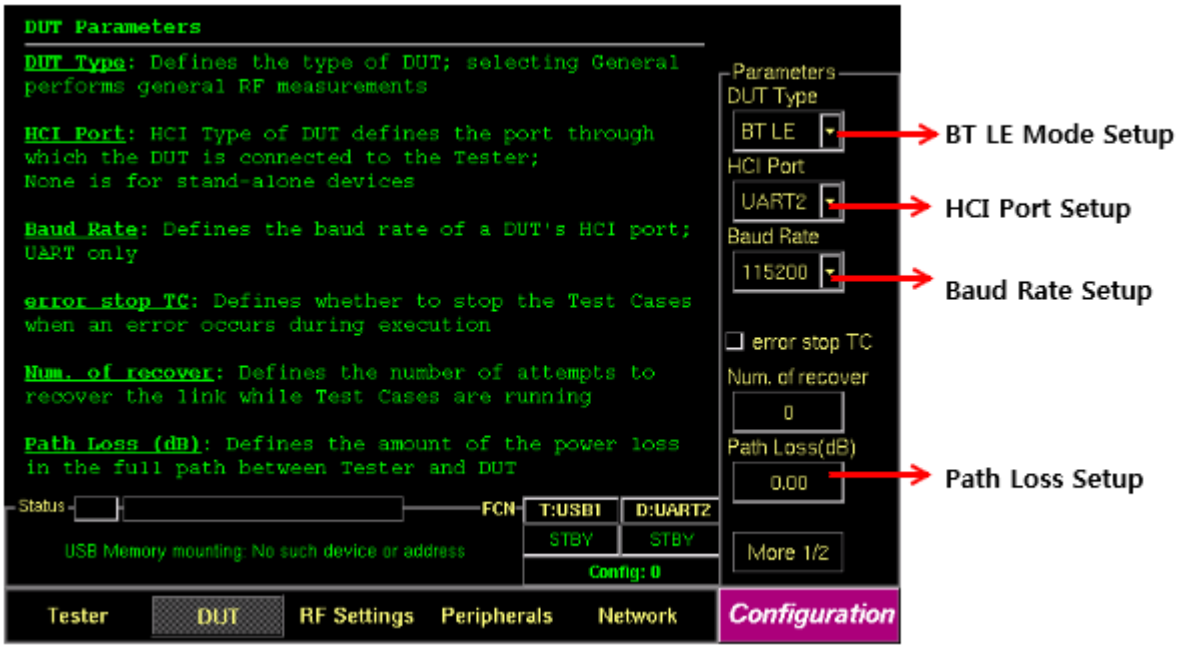
> **NOTICE**
> When setting up the HCI port, use UART2 or 2WIRE2 because the UART1 or 2WIRE1 port is used for PC remote programs.

3. Baud Rate Setup: Set up the Baud rate for DUT.
   - Select Menu -> Configuration -> DUT (M2) -> Baud Rate (F4) and choose between 2400 and 115200.

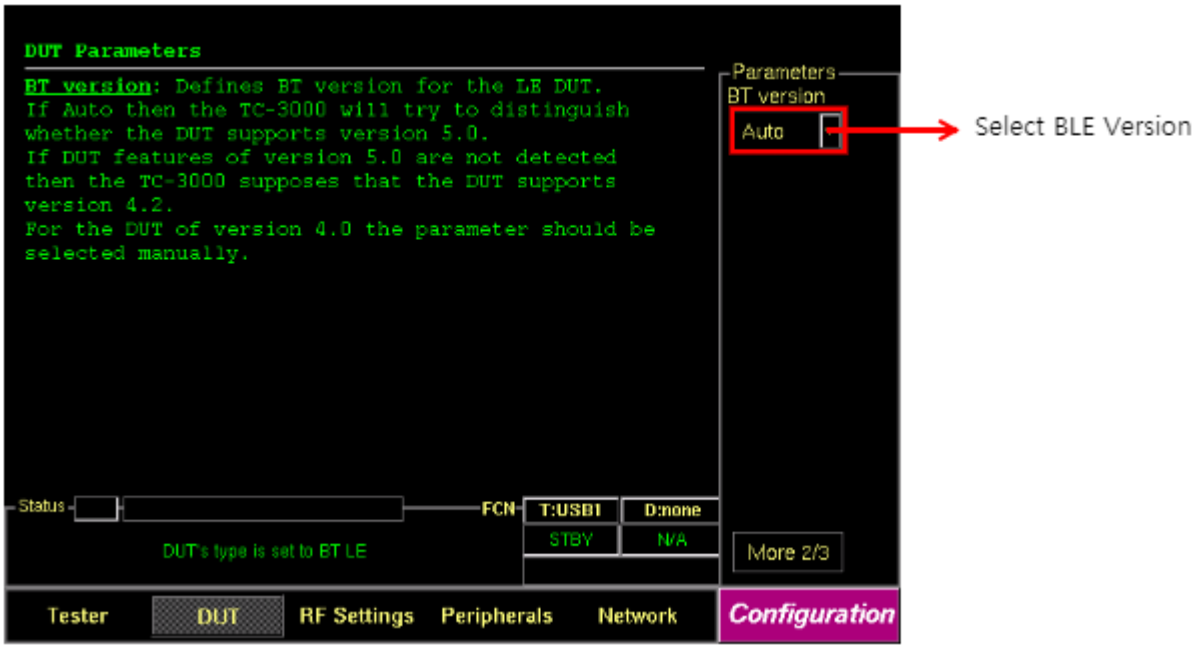
> **NOTICE**
> When USB connection is used, Baud Rate does not need to be selected.

4. Path Loss Setup
   - Menu -> Configuration -> DUT (M2) -> Path Loss (F7)
   - Measure path loss from TC-3000C to DUT.

5. Input Level Setup
   - Menu -> Configuration -> RF Settings (M3) -> RX ATT (F3)
   - Set up the range for the DUT output level. (RX ATT Off: -80 ~ -10 dBm, RX ATT On: -30 ~+20 dBm)



6. BT version Select
   - MENU -> Configuration -> DUT -> BT version(F2) -> version Select
   - Select BLE specification version (Auto/v4.0/v4.2/v5.0)
   - Set to "Auto", TC-3000C determines whether the DUT supports BT v5.0. If not, the TC-3000C will work with v4.2.



NOTICE

BT version setting menu is available from the TC-3000C firmware version v4.00 or later

2.2 Functions

2.2.1 RF Test Cases

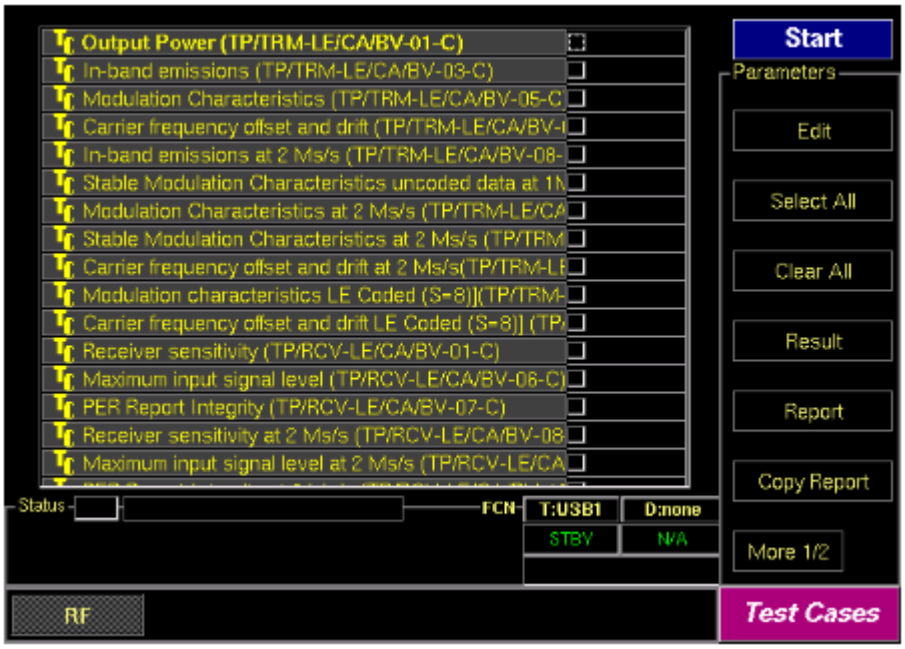
Direct Test Mode supports 31 BT LE Test Cases including Quick Test, which can shorten the measuring time for improved productivity.

TX Test

- Output Power (TP/TRM-LE/CA/BV-01-C)
- In-band emissions (TP/TRM-LE/CA/BV-03-C)
- Modulation characteristics (TP/TRM-LE/CA/BV-05-C)
- Carrier frequency offset and drift (TP/TRM-LE/CA/BV-06-C)
- In-band emissions at 2Ms/s (TP/TRM-LE/CA/BV-08-C)
- Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)
- Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)
- Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)
- Carrier frequency offset and drift at 2Ms/s (TP/TRM-LE/CA/BV-12-C)
- Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)
- Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)
- Quick (OP+MOD+CFOD)

RX Test

- Receiver sensitivity (TP/RCV-LE/CA/BV-01-C)
- Maximum input signal level (TP/RCV-LE/CA/BV-06-C)
- PER Report Integrity (TP/RCV-LE/CA/BV-07-C)
- Receiver sensitivity at 2Ms/s (TP/RCV-LE/CA/BV-08-C)
- Maximum input signal level at 2Ms/s (TP/RCV-LE/CA/BV-12-C)
- PER Report Integrity at 2Ms/s (TP/RCV-LE/CA/BV-13-C)
- Receiver sensitivity, uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-14-C)
- Maximum input signal level, uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-18-C)
- PER Report Integrity , uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-19-C)
- Receiver sensitivity at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-20-C)
- Maximum input signal level at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-24-C)
- PER Report Integrity at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-25-C)
- Receiver sensitivity, LE Coded (S=2) (TP/RCV-LE/CA/BV-26-C)
- Receiver sensitivity, LE Coded (S=8) (TP/RCV-LE/CA/BV-27-C)
- PER Report Integrity, LE Coded (S=2) (TP/RCV-LE/CA/BV-30-C)
- PER Report Integrity, LE Coded (S=8) (TP/RCV-LE/CA/BV-31-C)
- Receiver sensitivity, LE Coded (S=2), Stable Modulation Index (TP/RCV-LE/CA/BV-32-C)
- Receiver sensitivity, LE Coded (S=8), Stable Modulation Index (TP/RCV-LE/CA/BV-33-C)
- PER Report Integrity, LE Coded (S=2), Stable Modulation Index (TP/RCV-LE/CA/BV-36-C)
- PER Report Integrity, LE Coded (S=8), Stable Modulation Index (RCV-LE/CA/37-C)



2.2.2 Menu Setup Method

Start

Starts the selected test case item; changed into Stop key during execution, which can stop the test case

Edit

Move the cursor to the item to be changed and select Edit. The Edit mode will be enabled. The user can exit the Edit mode by selecting the key again.

Select All

Select to test all items. Setup is not prohibited during execution.

Clear All

Clears all test items; setup is not prohibited during execution

Result

Displays the result on the popup window

Report

Select the Report key to view the measurement details. The report file is saved as text or csv file (Configuration Tester Report Format).

Copy Report

This saves the report file to USB. Insert the USB memory into the front slot and press Copy Report (F7) and OK. The report will then be stored on USB.

Num of iteration

Set up the measurement repetition time of the test case.
If multiple test cases are selected, all test cases will be tested, and testing of all cases will be repeated.

2.2.3 Test Procedure

1. Set up the BT LE mode and the RF environment on TC-3000C. (See 2.1.2 TC-3000C Setup)

2. Select the RF test cases.
   - Select Menu -> Test Cases and test items. (Rotate and press the rotary encoder.)
   - Select Edit to check the test conditions and edit according to the test conditions. (For more information on setting the conditions of the test item, see 2.3 Test Items

3. Test Start: Start Select the Start key.

4. Test Result Checking
   - Check the result or report.
   - If necessary, save the result to USB by clicking the Copy Report button.

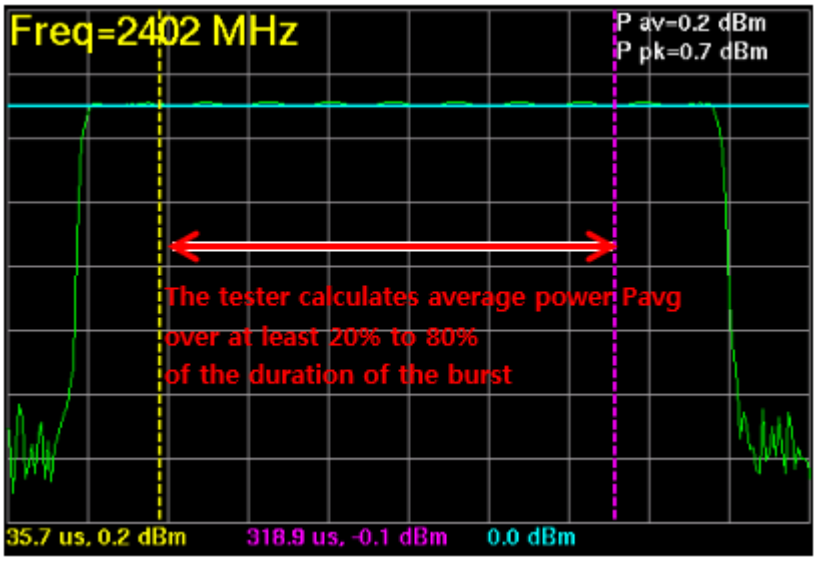
2.3 Test Items

2.3.1 Transmitter Tests (TP/TRM-LE)

2.3.1.1 Output Power

(TP/TRM-LE/CA/BV-01-C) Output Power

1. Objective: To measure the average and maximum power of DUT



2. Settings on DUT
   - Payload : PRBS9 / Maximum packet length
   - TX Power : Maximum power

3. Settings on Tester

Output Power (TP/TRM-LE/CA/BV-01-C)

Output Power (TP/TRM-LE/CA/BV-01-C)	☑
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	37
Number of packets	1
Upper Limit of average power in dBm	10.00
Lower Limit of average power in dBm	-20.00
Upper lim. of peak and average power dif. in dB	3.00

NOTICE

Parameter description of the test case selected by the Edit key.

* **Use Default**: When this is checked, all parameters will be ignored. Instead, the default will be used for measurement.
* **BT Channels**: TX frequency channel selected for the test; the selected channel shall be separated by "-"
* **Payload length**: Defines the length of a payload (in bytes)
* **Number of Packets**: Number of packets to be used for the calculation of the maximum peak and average RF output
* **Number of Sweeps**: Decide how often the entire span is swept.

4. Specification

> -20 dBm ≤ Pavg ≤ +10 dBm (BLE core v4.2 or earlier versions)
> -20 dBm ≤ Pavg ≤ +20 dBm (BLE core v5.0)
> Ppk ≤ Pavg + 3 dB
> * Pavg: average power, Ppk: peak power

2.3.1.2 In-band Emissions

(TP/TRM-LE/CA/BV-03-C) In-band emissions, uncoded data at 1 Ms/s
(TP/TRM-LE/CA/BV-08-C) In-band emissions at 2Ms/s

1. Objective: To measure adjacent channel power within the band and to check the channel interferences

2. Settings on DUT
   - Payload : PRBS9 / Maximum packet length
   - TX Power : Maximum power.

3. Settings on Tester

NOTICE

The AGC default value for tester is ON; when measuring In-band emissions, however, the AGC value is changed to OFF, and the value is measured since the receiving gain section of the tester is set to (RX Power) -10 ~ 0 dBm. If DUT's transmitting Power is notably larger or smaller than -10 ~ 0 dBm, there may be an error in the measured value.

In-band emissions, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-03-C)

In-band emissions (TP/TRM-LE/CA/BV-03-C)	☑
Use Default	☐
# BT channels (separated by '-')	2-19-37
Payload length	37
Number of sweeps	10
Upper Limit of the power in a channel M-N=2 in dBm	-20.00
Upper Limit of the power in a channel M-N>=3 in dBm	-30.00
Max. number of excepted channels	3
Upper Limit of the power in excepted channels in dBm	-20.00

In-band emissions at 2Ms/s (TP/TRM-LE/CA/BV-08-C)

In-band emissions at 2 Ms/s (TP/TRM-LE/CA/BV-08	☐
Use Default	☐
# BT channels (separated by '-')	2-19-37
Payload length	31
Number of sweeps	10
Upper Limit of the power in a channel M-N=4&5 in dBm	-20.00
Upper Limit of the power in a channe M-N>=6 in d	-30.00
Max. number of excepted channels	3
Upper Limit of the power in excepted channels in dBm	-20.00

4. Specification

1. **In-band Emission (TP/TRM-LE/CA/BV-03-C)**

   * $P_{Tx} \leq -20$ dBm for ($f_{Tx} \pm 2$ MHz)
   * $P_{Tx} \leq -30$ dBm for ($f_{Tx} \pm$ [3+n] MHz); where n=0,1,2…
   * For each operating frequency, up to three bands of 1 MHz width

(as defined in the measurement) can be exempted from the requirements.

The excepted values shall however comply with an absolute value of P TX ≤ -20 dBm.

2. **In-band Emission at 2 Ms/s (TP/TRM-LE/CA/BV-08-C)**

   * $P_{Tx} \leq -20$ dBm for ($f_{Tx} \pm 4$ MHz)
   * $P_{Tx} \leq -20$ dBm for ($f_{Tx} \pm 5$ MHz)
   * $P_{Tx} \leq -30$ dBm for ($f_{Tx} \pm$ [6+n] MHz); where n=0,1,2…
   * For each operating frequency, up to three bands of 1 MHz width

(as defined in the measurement) can be exempted from the requirements.

The excepted values shall however comply with an absolute value of P TX ≤ -20 dBm.

2.3.1.3 Modulation Characteristics

```
(TP/TRM-LE/CA/BV-05-C) Modulation characteristics, uncoded data at 1 Ms/s
(TP/TRM-LE/CA/BV-09-C) Stable Modulation characteristics, uncoded data at 1Ms/s
(TP/TRM-LE/CA/BV-10-C) Modulation characteristics at 2Ms/s
(TP/TRM-LE/CA/BV-11-C) Stable Modulation characteristics at 2Ms/s
(TP/TRM-LE/CA/BV-13-C) Modulation Characteristics, LE Coded (S=8)
```

Table 2-1 Specifications for modulation characteristics

Test Number (TP/TRM-LE/CA/BV-XX-C)		$\Delta f1_{avg}$	$\Delta f2$ Pass rate ≥ 99.9 %	$\Delta f2_{avg}$ / $\Delta f1_{avg}$
05	LE 1M	225 kHz ≤ Δf1avg ≤ 275 kHz	> 185 kHz	≥ 0.8
09	LE 1M, Stable Modulation Index	247.5 kHz ≤ Δf1avg ≤ 252.5 kHz	> 185 kHz	≥ 0.8
10	LE 2M	450 kHz ≤ Δf1avg ≤ 550 kHz	> 370 kHz	≥ 0.8
11	LE 2M, Stable Modulation Index	495 kHz ≤ Δf1avg ≤ 505 kHz	> 370 kHz	≥ 0.8
13	LE Coded, S=8	225 kHz ≤ Δf1avg ≤ 275 kHz	> 185 kHz	None

2.3.1.3.1 Modulation characteristics, uncoded data at 1 Ms/s(TP/TRM-LE/CA/BV-05-C)

2.3.1.3.2 Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)

1. Objective: This test verifies that the modulation characteristics of the transmitted signal are correct when the transmitter is operating with uncoded data at 1 Ms/s.

2. Settings on DUT
   - Payload
     - Two different patterns: 11110000(df1), 10101010(df2)
     - Maximum packet length
   - TX Power : Maximum power

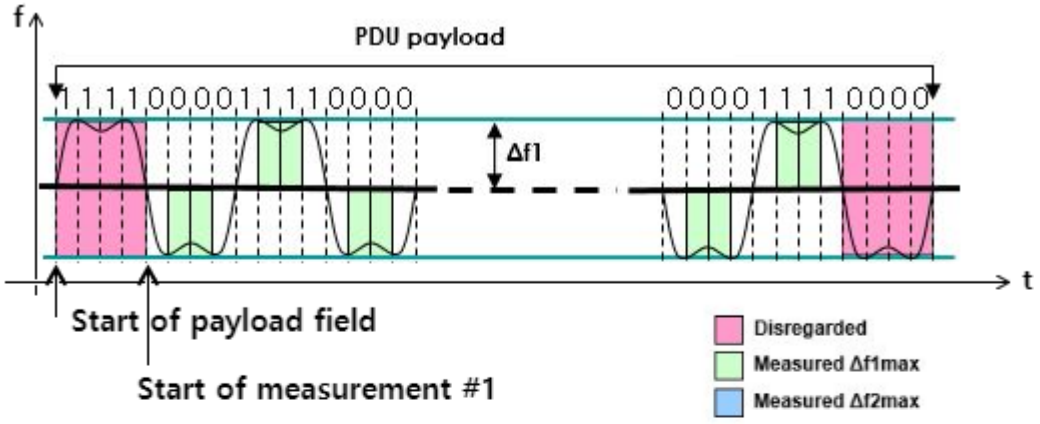
3. Settings on Tester

Modulation characteristics (TRM-LE/CA/05/C)

Modulation characteristics (TRM-LE/CA/05/C)	☑
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	37
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in KHz	275.0
Low. Lim. of freq. deviat. for 11110000 in KHz	225.0
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)

Stable Modulation Characteristics uncoded data a	☑
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	37
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	252.5
Low. Lim. of freq. deviat. for 11110000 in kHz	247.5
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80



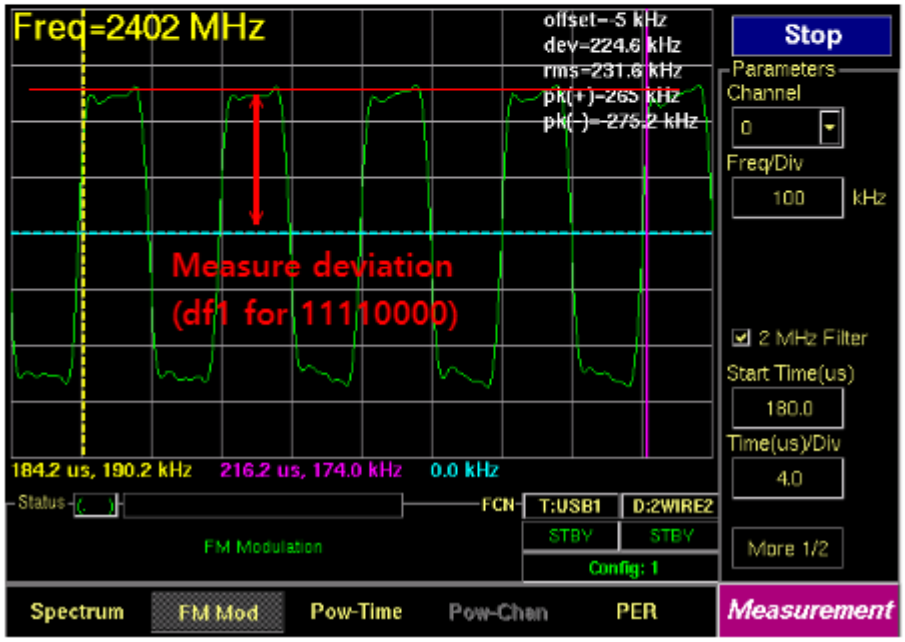


Figure 2-2 Modulation measurement principle for 11110000-payload sequence

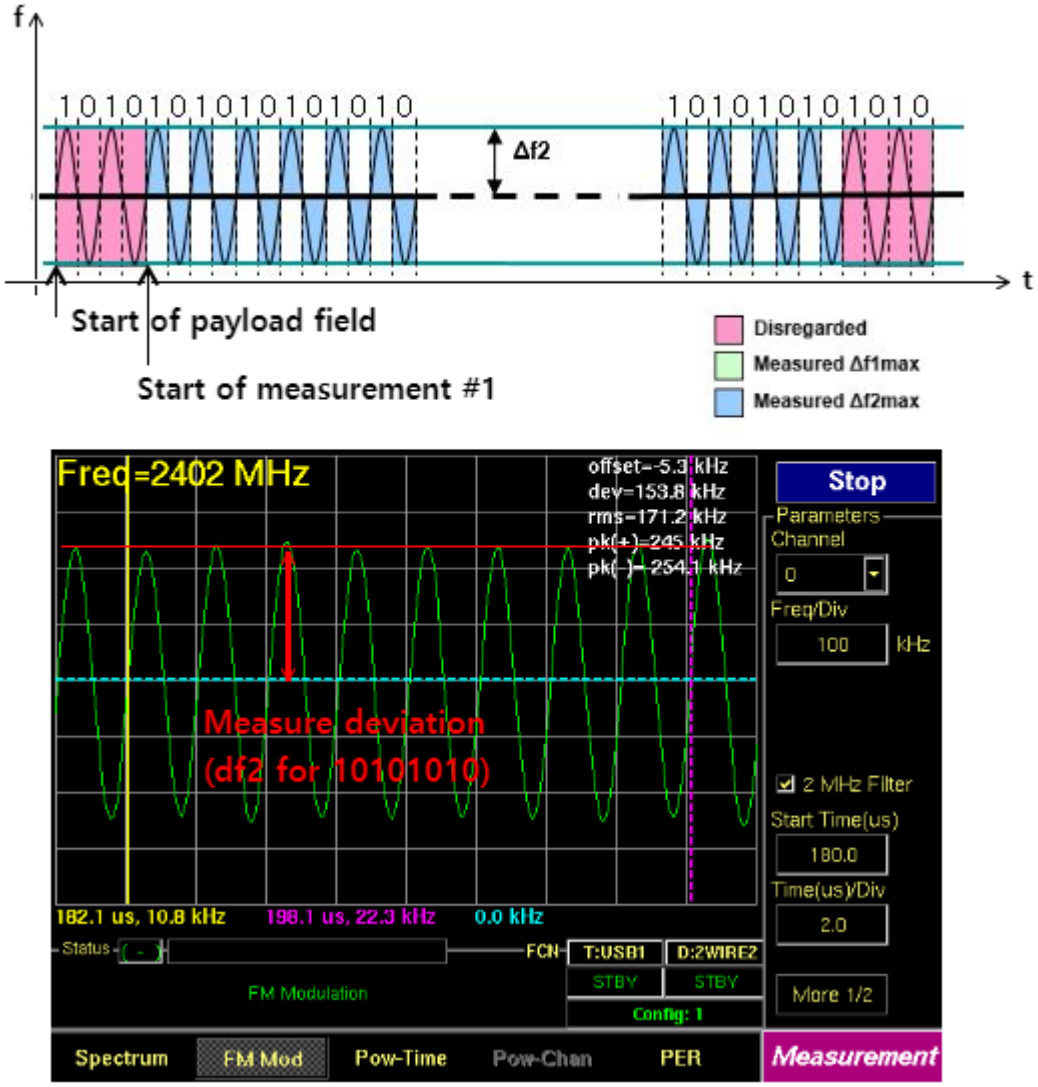


Figure 2-3 Modulation measurement principle for 10101010-payload sequence

4. Specification

> 1. Modulation characteristics (TP/TRM-LE/CA/BV-05-C)
>
> * 225 kHz ≤ Δf1avg ≤ 275 kHz
> * 99.9 % of Δf2max must be greater than 185 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8
>
> 2. Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)
>
> * 247.5 kHz ≤ Δf1avg ≤ 252.5 kHz
> * 99.9 % of Δf2max must be greater than 185 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8

2.3.1.3.3 Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)

2.3.1.3.4 Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)

1. Objective: This test verifies that the modulation characteristics of the transmitted signal are correct when the transmitter is operating at 2 Ms/s.

2. Settings on DUT
   - Payload
     - Two different patterns: 11110000(df1), 10101010(df2)
     - MAX_TX_LENGTH_2M : 31 byte
   - TX Power : Maximum power

3. Settings on Tester

Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)

Modulation Characteristics at 2 Ms/s (TP/TRM-LE/	☑
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	31
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	550.0
Low. Lim. of freq. deviat. for 11110000 in kHz	450.0
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)

Stable Modulation Characteristics at 2 Ms/s (TP/TI	☐
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	31
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	505.0
Low. Lim. of freq. deviat. for 11110000 in kHz	495.0
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

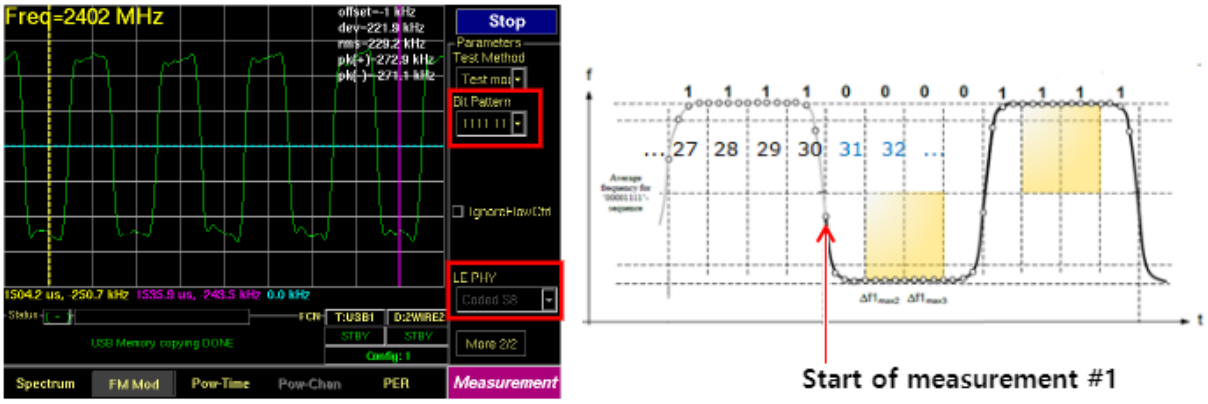
4. Specification

> **1. Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)**
>
> * 450 kHz ≤ Δf1avg ≤ 550 kHz
> * 99.9 % of Δf2max must be greater than 370 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8
>
> **2. Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)**
>
> * 495 kHz ≤ Δf1avg ≤ 505 kHz
> * 99.9 % of Δf2max must be greater than 370 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8

2.3.1.3.5 Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)

1. Objective: This test verifies that the modulation characteristics of the transmitted signal are correct for an LE Coded signal (S=8).

2. Settings on DUT
   - Payload : 'Coded, S=8' packet, payload consisting of a repetitive sequence of 0xFF octets(binary '11111111'in transmission order)
     - '11111111' (S=8 encoding → '00111100' symbols)
   - MAX_TX_LENGTH_CODED_S8 : 31
   - TX Power : Maximum power



* The measurement shall start at the beginning of the 31 st symbol in the payload.
* The last 34 symbols in the payload shall be disregarded.

Figure 2-4 Modulation measurement principle for Coded (S=8)

3. Settings on Tester

Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)

Modulation Characteristics LE Coded (S=8) (TP/TF	☐
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	31
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	275.0
Low. Lim. of freq. deviat. for 11110000 in kHz	225.0
Max.num.of deviat.for 11110000 < low.lim. in %	0.100

4. Specification

```
1. Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)
   * 225 kHz ≤ Δf1avg ≤ 275 kHz
   * 99.9 % of Δf1max must be greater than 185 kHz
```

2.3.1.4 Carrier frequency offset and drift

```
(TP/TRM-LE/CA/BV-06-C) Carrier frequency offset and drift, uncoded data at 1 Ms/s
(TP/TRM-LE/CA/BV-12-C) Carrier frequency offset and drift at 2 Ms/s
(TP/TRM-LE/CA/BV-14-C) Carrier frequency offset and drift, LE Coded (S=8)
```

Table 2-2 Specifications for carrier frequency offset and drift

Test Number (TP/TRM-LE/CA/BV-XX-C)		| fTX - f[n] |	| f0 -fn |	| f1 -f0 | or | f0 -f3 |	| fn -fn-5 | or | fn -f(n-3) |
06	LE 1M	≤ 150 kHz	≤ 50 kHz	≤ 23 kHz	≤ 20 kHz
12	LE 2M	≤ 150 kHz	≤ 50 kHz	≤ 23 kHz	≤ 20 kHz
14	LE Coded, S=8	≤ 150 kHz	≤ 50 kHz	≤ 19.2 kHz	≤ 19.2 kHz

2.3.1.4.1 Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C)

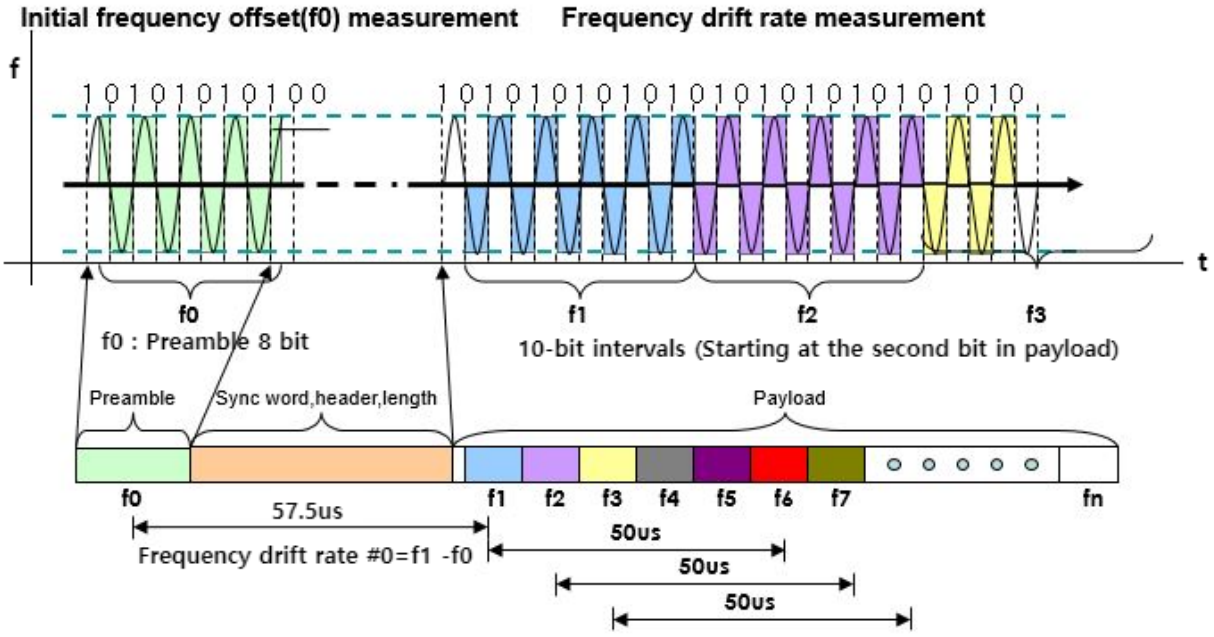
1. Objective: This test verifies that the carrier frequency offset and carrier drift of the transmitted signal with uncoded data at 1 Ms/s is within specified limits at normal operating conditions.

2. Settings on DUT
   - Payload
     - Repetitive sequence of 55_{hex} octets (10101010)
     - Maximum packet length : 37 byte
   - TX Power : Maximum power

3. Settings on Tester

Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C)

Carrier frequency offset and drift (TP/TRM-LE/CA/E	
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	37
Number of packets	10
Upper lim. of |fTX-f[n]| in kHz	150.0
Upper lim. of |f[1]-f[0]| in kHz	23.0
Up. lim. of max. freq.drift in kHz	50.0
Up. lim. of max. drift rate in kHz/50us	20.0



f0 : The tester is to Integrate the frequency of the FM demodulated signal from the center of the first preamble bit to the center of the first bit following the 8th preamble bit, 8 bits in total.

fn : The tester integrate the frequency of the FM demodulated signal in 10-bit intervals, starting at the second bit in the payload.

Figure 2-5 Frequency drift rate measurement principle

4. Specification

$$f_{Tx} - 150\ kHz \leq fn \leq f_{Tx} + 150\ kHz\ (n=0,1,\cdots,k)$$
$$|f_0 - f_n| \leq 50\ kHz\ (n=2,3,4,\cdots k)$$
$$|f_1 - f_0| \leq 23\ kHz \text{ and}$$
$$|f_n - f_{n-5}|_{n=6,7,8,\cdots k} \leq 20\ kHz$$

2.3.1.4.2 Carrier frequency offset and drift at 2 Ms/s (TP/TRM-LE/CA/BV-12-C)

1. Objective: This test verifies that the carrier frequency offset and carrier drift of the transmitted signal at 2 Ms/s is within specified limits at normal operating conditions.

2. Settings on DUT
   - Payload
     - Repetitive sequence of 55_{hex} octets (10101010)
     - MAX_TX_LENGTH_2M : 31 byte
   - TX Power : Maximum power

3. Settings on Tester
   - f0 : The tester is to Integrate the frequency of the FM demodulated signal from the center of the first preamble bit to the center of the first bit following the 16th preamble bit, 16 bits in total.
   - fn : The tester integrate the frequency of the FM demodulated signal in 20-bit intervals.

Carrier frequency offset and drift at 2 Ms/s (TP/TRM-LE/CA/BV-12-C)

Carrier frequency offset and drift at 2 Ms/s (TP/TRI	☐
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	31
Number of packets	10
Upper lim. of |fTX-f[n]| in kHz	150.0
Upper lim. of |f[1]-f[0]| in kHz	23.0
Up. lim. of max. freq.drift in kHz	50.0
Up. lim. of max. drift rate in kHz/50us	20.0

4. Specification

$$f_{Tx} - 150\ kHz \le fn \le f_{Tx} + 150\ kHz\ (n=0,1,\cdots,k)$$
$$|f_0 - f_n| \le 50\ kHz\ (n=2,3,4,\cdots k)$$
$$|f_1 - f_0| \le 23\ kHz\ \text{and}$$
$$|f_n - f_{n-5}|_{n=6,7,8,\cdots k} \le 20\ kHz$$

2.3.1.4.3 Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

1. Objective: This test verifies that the carrier frequency offset and carrier drift of the transmitted signal is within specified limits at normal operating conditions for LE Coded PHY with S=8.

2. Settings on DUT
   - Payload : 'Coded, S=8' packet, payload consisting of a repetitive sequence of 0xFF octets(binary '11111111'in transmission order)
     - '11111111' (S=8 encoding → '00111100' symbols)
   - MAX_TX_LENGTH_CODED_S8 : 31
   - TX Power : Maximum power

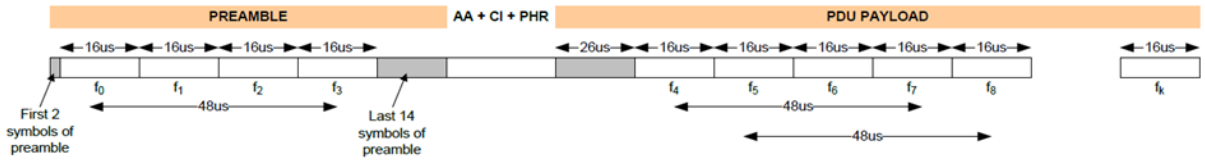


Figure 2-6 Frequency drift rate measurement principle for S=8

- f0 ~ f3 : The measurement shall start at the beginning of the 3rd symbol of the preamble field in the transmitted packet. The tester integrates the frequency of the FM demodulated signal in groups of 16 symbols. The last 14 symbols of the preamble shall be disregarded.
- f4~k : The tester integrates the frequency of the FM demodulated signals in 16-symbol intervals, starting at the 27th symbol in the PDU payload.

3. Settings on Tester

Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

Carrier frequency offset and drift LE Coded (S=8) (	☐
Use Default	☐
# BT channels (separated by '-')	0-19-39
Payload length	31
Number of packets	10
Upper lim. of |fTX-f[n]| in kHz	150.0
Upper lim. of |f[0]-f[3]| in kHz	19.20
Up. lim. of max. freq.drift in kHz	50.0
Up. lim. of max. drift rate in kHz/48us	19.10

4. Specification

1. Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

* f_{Tx} - 150 kHz ≤ fn ≤ f_{Tx} + 150 kHz (n=0,1,2,3⋯,k)
* | f_0 - f_n | ≤ 50 kHz (n= 1,2,3,⋯k)
* | f_0 - f_3 | ≤ 19.2 kHz
* | f_n - $f_{(n-3)}$ | ≤ 19.2 kHz (n=7,8,9,...k)

2.3.2 Receiver Tests (RCV-LE)

The Packet Error Rate (PER) measurement is used in all measurements testing receiver characteristics in the Bluetooth low energy RF PHY test specification.

The packet error rate is defined as follows:

$$PER = \left(1 - \frac{Number\ of\ packets\ received\ by\ the\ EUT\ passing\ CRC}{Total\ number\ of\ packets\ transmitted\ by\ the\ tester}\right) * 100\%$$

The sensitivity level based on BER measurements is defined as the input power level at which a BER of value specified in Table 2-3 BER to PER Mapping

Table 2-3 BER to PER Mapping

Maximum Supported Payload Length in Receiver (bytes)	BER (%)	PER (%)
37	0.1	30.8
≥38 and ≤63	0.064	21.4 ~ 30.8
≥64 and ≤127	0.034	18 ~ 30.9
≥128 and ≤255	0.017	17 ~ 30.2

Maximum Supported Payload Length in Receiver (bytes)	PER
37	30.8%
38	21.4%
39	21.8%
40	22.2%
41	22.6%
42	23.0%
43	23.4%
44	23.8%
45	24.2%
46	24.5%
47	24.9%
48	25.3%
49	25.7%
50	26.1%

Maximum Supported Payload Length in Receiver (bytes)	PER
51	26.5%
52	26.8%
53	27.2%
54	27.6%
55	27.9%
56	28.3%
57	28.7%
58	29.0%
59	29.4%
60	29.8%
61	30.1%
62	30.5%
63	30.8%
64	18.0%

Maximum Supported Payload Length in Receiver (bytes)	PER
65	18.2%
66	18.5%
67	18.7%
68	18.9%
69	19.1%
70	19.3%
71	19.6%
72	19.8%
73	20.0%
74	20.2%
75	20.4%
76	20.6%
77	20.9%
78	21.1%
79	21.3%

Maximum Supported Payload Length in Receiver (bytes)	PER
80	21.5%
81	21.7%
82	21.9%
83	22.1%
84	22.4%
85	22.6%
86	22.8%
87	23.0%
88	23.2%
89	23.4%
90	23.6%
91	23.8%
92	24.0%
93	24.2%
94	24.4%
95	24.6%
96	24.8%
97	25.1%
98	25.3%
99	25.5%
100	25.7%
101	25.9%
102	26.1%
103	26.3%
104	26.5%
105	26.7%
106	26.9%
107	27.1%
108	27.3%
109	27.5%
110	27.7%
111	27.9%
112	28.0%
113	28.2%
114	28.4%
115	28.6%
116	28.8%
117	29.0%
118	29.2%
119	29.4%
120	29.6%
121	29.8%
122	30.0%
123	30.2%
124	30.4%
125	30.5%
126	30.7%
127	30.9%
128	17.0%
129	17.1%
130	17.2%
131	17.3%
132	17.5%
133	17.6%
134	17.7%
135	17.8%
136	17.9%
137	18.0%
138	18.1%
139	18.2%
140	18.3%
141	18.5%
142	18.6%
143	18.7%
144	18.8%
145	18.9%

Maximum Supported Payload Length in Receiver (bytes)	PER
146	19.0%
147	19.1%
148	19.2%
149	19.3%
150	19.4%
151	19.6%
152	19.7%
153	19.8%
154	19.9%
155	20.0%
156	20.1%
157	20.2%
158	20.3%
159	20.4%
160	20.5%
161	20.6%
162	20.8%
163	20.9%
164	21.0%
165	21.1%
166	21.2%
167	21.3%
168	21.4%
169	21.5%
170	21.6%
171	21.7%
172	21.8%
173	21.9%
174	22.0%
175	22.1%
176	22.2%
177	22.4%
178	22.5%
179	22.6%
180	22.7%
181	22.8%
182	22.9%
183	23.0%
184	23.1%
185	23.2%
186	23.3%
187	23.4%
188	23.5%
189	23.6%
190	23.7%
191	23.8%
192	23.9%
193	24.0%
194	24.1%
195	24.2%
196	24.3%
197	24.4%
198	24.5%
199	24.6%
200	24.7%
201	24.8%
202	24.9%
203	25.0%
204	25.2%
205	25.3%
206	25.4%
207	25.5%
208	25.6%
209	25.7%
210	25.8%
211	25.9%

Maximum Supported Payload Length in Receiver (bytes)	PER
212	26.0%
213	26.1%
214	26.2%
215	26.3%
216	26.4%
217	26.5%
218	26.6%
219	26.7%
220	26.8%
221	26.9%
222	27.0%
223	27.1%
224	27.2%
225	27.3%
226	27.4%
227	27.5%
228	27.6%
229	27.7%
230	27.8%
231	27.9%
232	27.9%
233	28.0%
234	28.1%
235	28.2%
236	28.3%
237	28.4%
238	28.5%
239	28.6%
240	28.7%
241	28.8%
242	28.9%
243	29.0%
244	29.1%
245	29.2%
246	29.3%
247	29.4%
248	29.5%
249	29.6%
250	29.7%
251	29.8%
252	29.9%
253	30.0%
254	30.1%
255	30.2%

Figure 2-7 PER level by maximum payload length in receiver

2.3.2.1 Receiver Sensitivity

```
(TP/RCV-LE/CA/BV-01-C) Receiver sensitivity, uncoded data at 1 Ms/s
(TP/RCV-LE/CA/BV-08-C) Receiver sensitivity at 2Ms/s
(TP/RCV-LE/CA/BV-14-C) Receiver sensitivity, uncoded data at 1Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-20-C) Receiver sensitivity at 2Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-26-C) Receiver sensitivity, LE Coded (S=2)
(TP/RCV-LE/CA/BV-27-C) Receiver sensitivity, LE Coded (S=8)
(TP/RCV-LE/CA/BV-32-C) Receiver sensitivity, LE Coded (S=2), Stable Modulation Index
(TP/RCV-LE/CA/BV-33-C) Receiver sensitivity, LE Coded (S=8), Stable Modulation Index
```

1. Objective: To measure the reception sensitivity in a weak electric field as Packet Error Rate (PER)

2. Settings on DUT
   - Payload : PRBS9 / MAX_RX_LENGTH
   - Center frequency : 2402, 2440, 2480 [MHz] ... (CH Num. 0, 19, 39)
   - Number of Test Packet : (minimum) 1500
   - Dirty ON, Additional frequency drift

3. Settings on Tester
   - Number of Test Packet : (minimum) 1500
   - Dirty ON, Additional frequency drift

Receiver sensitivity, uncoded data at 1 Ms/s (TP/RCV-LE/CA/BV-01-C)

Receiver sensitivity (TP/RCV-LE/CA/BV-01-C)	
Use Default	☐
# BT channels (separated by '-')	0-19-39
Dirty TX Mode	ON
RX power in dBm	-70.00
Payload length	37
Number of packets to send	1500
PER limit mode	Spec.
Upper limit of the PER in %	30.801

Receiver sensitivity at 2Ms/s (TP/RCV-LE/CA/BV-08-C)

Receiver sensitivity at 2 Ms/s (TP/RCV-LE/CA/BV-(	
Use Default	☐
# BT channels (separated by '-')	0-19-39
Dirty TX Mode	ON
RX power in dBm	-70.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Upper limit of the PER in %	30.801

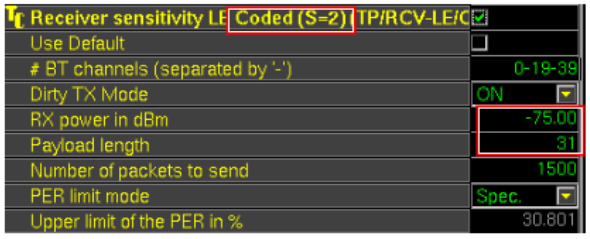
Receiver sensitivity, uncoded data at 1Ms/s,
Stable Modulation Index (TP/RCV-LE/CA/BV-14-C)

Receiver Sensitivity uncoded data at 1 Ms/s Stabl	☑
Use Default	☐
# BT channels (separated by '-')	0-19-39
Dirty TX Mode	ON
RX power in dBm	-70.00
Payload length	37
Number of packets to send	1500
PER limit mode	Spec.
Upper limit of the PER in %	30.801

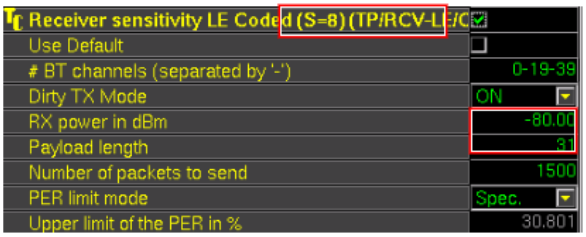
Receiver sensitivity at 2Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-20-C)

Receiver sensitivity at 2 Ms/s Stable Modulation I	☑
Use Default	☐
# BT channels (separated by '-')	0-19-39
Dirty TX Mode	ON
RX power in dBm	-70.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Upper limit of the PER in %	30.801

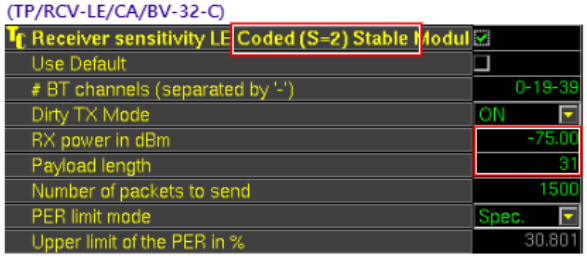
Receiver sensitivity, LE Coded (S=2) (TP/RCV-LE/CA/BV-26-C)



Receiver sensitivity, LE Coded (S=8) (TP/RCV-LE/CA/BV-27-C)



Receiver sensitivity, LE Coded (S=2), Stable Modulation Index (TP/RCV-LE/CA/BV-32-C)



Receiver sensitivity, LE Coded (S=8), Stable Modulation Index (TP/RCV-LE/CA/BV-33-C)

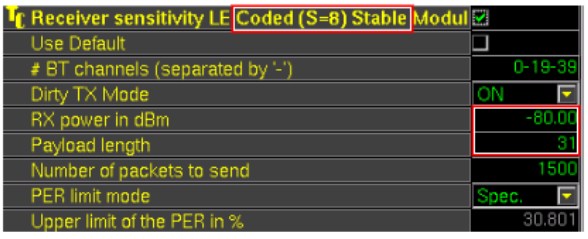


Table 2-4 Transmitter parameter settings for PER test

Test run	Carrier frequency offset	Modulation index	Stable Modulation Index	Symbol timing error
1	100 kHz	0.45	0.495	-50 ppm
2	19 kHz	0.48	0.498	-50 ppm
3	-3 kHz	0.46	0.496	+50 ppm
4	1 kHz	0.52	0.502	+50 ppm
5	52 kHz	0.53	0.503	+50 ppm
6	0 kHz	0.54	0.504	-50 ppm
7	-56 kHz	0.47	0.497	-50 ppm
8	97 kHz	0.5	0.5	-50 ppm
9	-25 kHz	0.45	0.495	-50 ppm
10	-100 kHz	0.55	0.505	+50 ppm

⚠CAUTION

The RF output power range of TC-3000C is 0 to -80 dBm. In order to transmit lower power below -80 dBm, the additional 10 dB Attenuator should be attached. (G99912A, 10 dB Attenuator will be provided)

Attenuator being used, Path Loss must be input to the TC-3000C by Attenuator value.

Refer to TC-3000C Setup for setting Path Loss, 2.1.2 TC-3000C Setup

⚠CAUTION

Receiver Sensitivity for the 'TP/RCV-LE/CA/BV-27-C, LE Coded (S=8)' and the 'TP/RCV-LE/CA/BV-33-C), LE Coded (S=8), Stable Modulation Index', test must be performed with the attaching the attenuator.

4. Specification

> 1. Pass Verdict
> * PER ≤ 30.8 %

Table 2-5 Receiver sensitivity level

Test Number (TP/RCV-LE/CA/BV-XX-C)		Sensitivity Level
01	LE 1M	-70 dBm
08	LE 2M	
14	LE 1M, Stable Modulation Index	
20	LE 2M, Stable Modulation Index	
26	LE Coded, S=2	-75 dBm
32	LE Coded, S=2, Stable Modulation Index	
27	LE Coded, S=8	-82 dBm
33	LE Coded, S=8, Stable Modulation Index	

2.3.2.2 Maximum input signal level

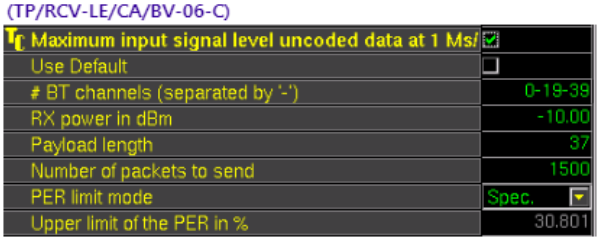
(TP/RCV-LE/CA/BV-06-C) Maximum input signal level, uncoded data at 1Ms/s
(TP/RCV-LE/CA/BV-12-C) Maximum input signal level at 2Ms/s
(TP/RCV-LE/CA/BV-18-C) Maximum input signal level, uncoded data at 1Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-24-C) Maximum input signal level at 2Ms/s, Stable Modulation Index

1. Objective: To measure the performance of the receiver at the maximum input level

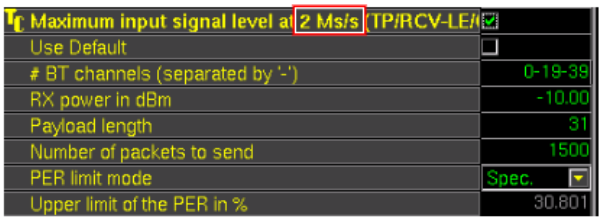
2. Settings on DUT
   - Payload : PRBS9 / MAX_RX_LENGTH
   - Center frequency : 2402, 2440, 2480 [MHz] ... (CH Num. 0, 19, 39)

3. Settings on Tester
   - TX Power : -10 dBm
   - Number of Test Packet : (minimum) 1500

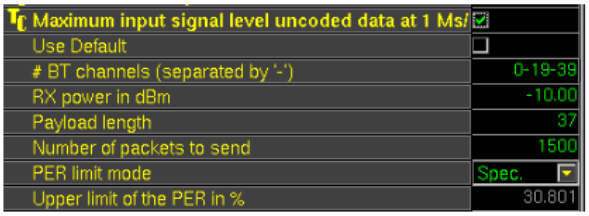
Maximum input signal level, uncoded data at 1Ms/s (TP/RCV-LE/CA/BV-06-C)



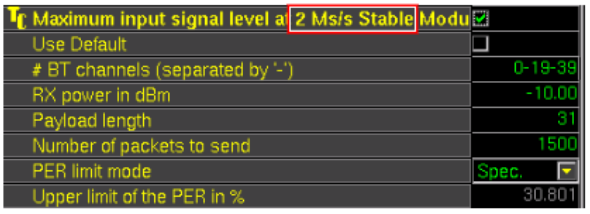
Maximum input signal level at 2Ms/s (TP/RCV-LE/CA/BV-12-C)



Maximum input signal level, uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-18-C)



Maximum input signal level at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-24-C)



4. Specification

> PER ≤ 30.8 % (RX power in -10 dBm)

2.3.2.3 PER Report Integrity

```
(TP/RCV-LE/CA/BV-07-C) PER Report Integrity, uncoded data at 1Ms/s
(TP/RCV-LE/CA/BV-13-C) PER Report Integrity at 2Ms/s
(TP/RCV-LE/CA/BV-19-C) PER Report Integrity, uncoded data at 1Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-25-C) PER Report Integrity at 2Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-30-C) PER Report Integrity, LE Coded (S=2)
(TP/RCV-LE/CA/BV-31-C) PER Report Integrity, LE Coded (S=8)
(TP/RCV-LE/CA/BV-36-C) PER Report Integrity, LE Coded (S=2), Stable Modulation Index
(TP/RCV-LE/CA/BV-37-C) PER Report Integrity, LE Coded (S=8), Stable Modulation Index
```

1. Objective: This test verifies that the DUT PER report mechanism reports the correct number of received packets to the tester

2. Settings on DUT
   - Payload : PRBS9 / MAX_RX_LENGTH
   - Center frequency : 2402, 2440, 2480 [MHz] ... (CH Num. 0, 19, 39)
   - TX Power : -30 dBm
   - Number of Test Packet : 100 ≤ Even Random Number ≤ 1500
     - Transmit normal CRC and error CRC alternately to DUT.
     - Total 3 times test.

3. Settings on Tester

PER Report Integrity, uncoded data at 1Ms/s(TP/RCV-LE/CA/BV-07-C)

PER Report Integrity (TP/RCV-LE/CA/BV-07-C)	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-70.00
Payload length	37
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity at 2Ms/s (TP/RCV-LE/CA/BV-13-C)

PER Report Integrity at 2 Ms/s (TP/RCV-LE/CA/BV	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity, uncoded data at 1Ms/s,
Stable Modulation Index (TP/RCV-LE/CA/BV-19-C)

PER Report Integrity uncoded data at 1 Ms/s Stab	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	37
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity at 2Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-25-C)

PER Report Integrity a 2 Ms/s Stable Modulation	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity, LE Coded (S=2) (TP/RCV-LE/CA/BV-30-C)

PER Report Integrity LE Coded (S=2) (TP/RCV-LE/	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity, LE Coded (S=8) (TP/RCV-LE/CA/BV-31-C)

PER Report Integrity LE Coded (S=8) (TP/RCV-LE/	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity, LE Coded (S=2), Stable Modulation Index
(TP/RCV-LE/CA/BV-36-C)

PER Report Integrity LE Coded (S=2) Stable Modu	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

PER Report Integrity, LE Coded (S=8), Stable Modulation Index
(TP/RCV-LE/CA/BV-37-C)

PER Report Integrity LE Coded (S=8) Stable Modu	
Use Default	
# BT channels (separated by '-')	0-19-39
RX power in dBm	-30.00
Payload length	31
Number of packets to send	1500
PER limit mode	Spec.
Lower limit of the PER in %	50.000
Upper limit of the PER in %	65.401

4. Specification

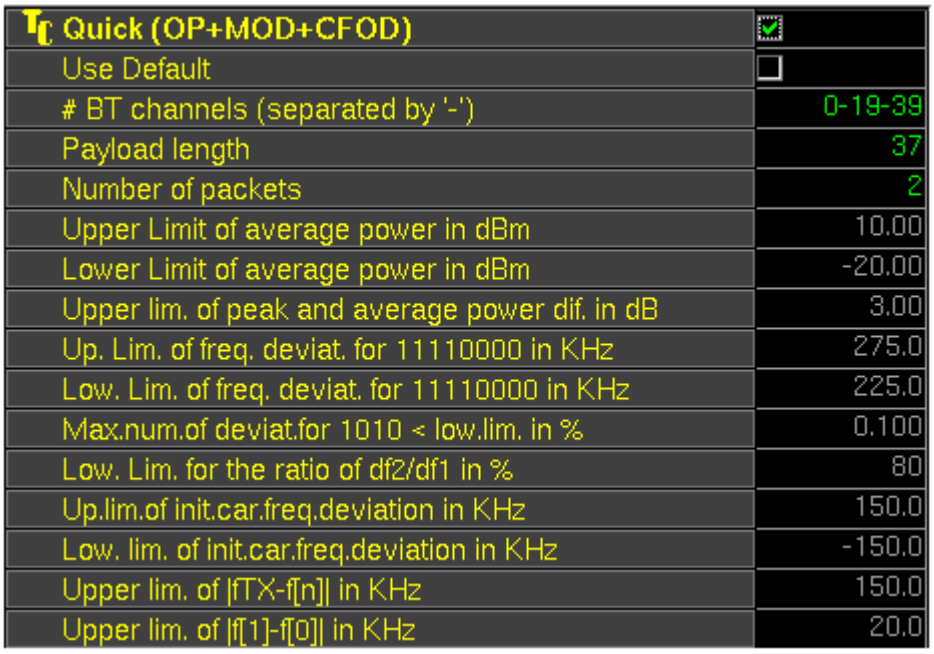
> * 50 % ≤ PER(3times) ≤ 65.4 %
>
> 50% ≤ PER(3 times) ≤ (50 + P/2)% , for each individual measurement.
> (P is the appropriate PER value taken from Figure 2-7 PER level by maximum payload length in receiver)
> ex) (37 byte length) 50% ≤ PER ≤ (50+ 30.8/2)%

2.3.3 Quick Test

1. Objective: To measure the TX test items with similar test conditions in the production line (output power, modulation characteristics, carrier frequency offset and drift) for shorter testing time (for mass production)

2. Set up parameters.

Parameter	Range	Default
Use Default		Unchecked
BT Channels	0 ~ 39	0-19-39
Payload length	0 ~ 255	37
Number of packets		2



2.4 Use of Measurement

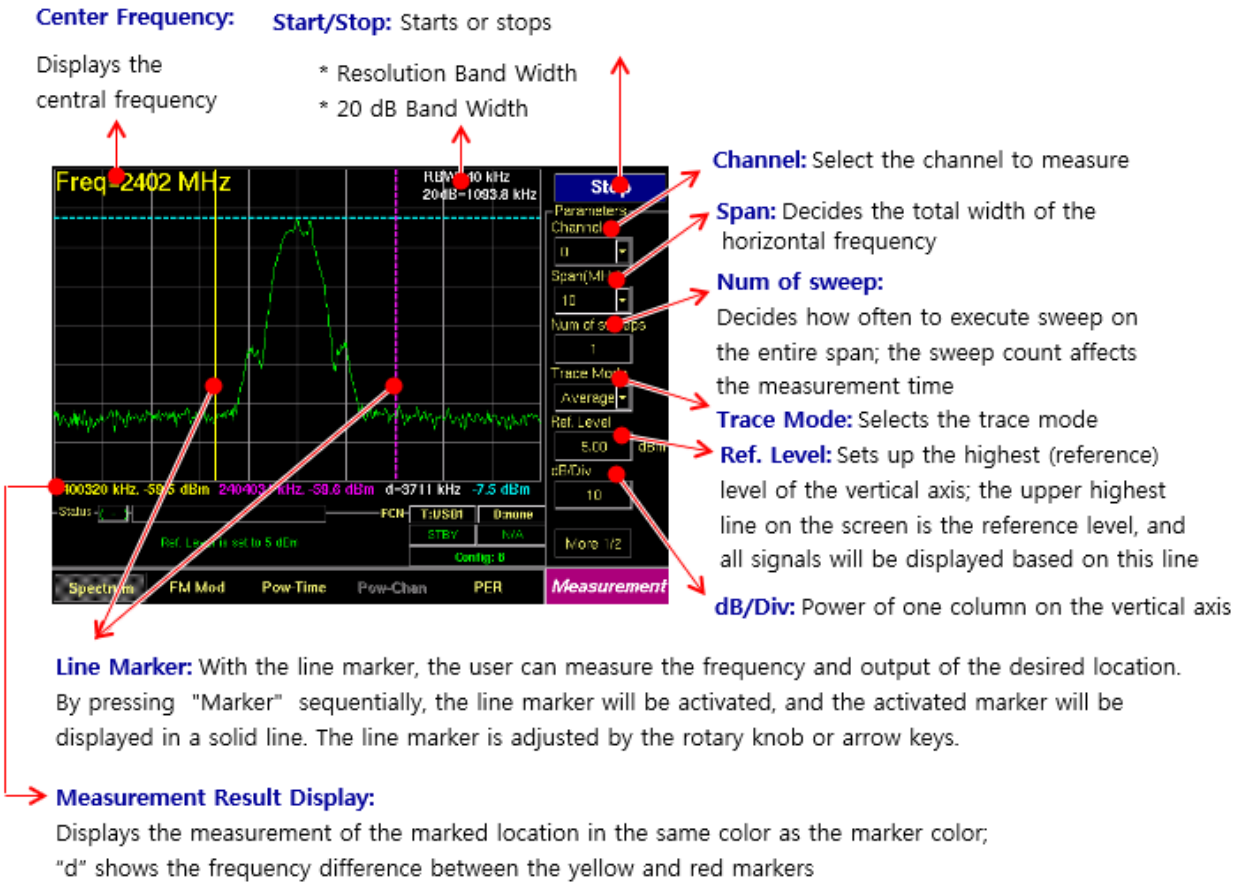
Measurement functions are specialized for Bluetooth. The user can monitor the spectrum, modulation characteristics, hourly power, and RX-PER of the terminal. The various waveform analysis functions of TC-3000C allow for efficient RF performance monitoring of the terminal and troubleshooting.

2.4.1 Measurement Screen Selection

- Select **Menu** -> popup menu and choose “Measurement” followed by **ENT** or rotary knob.
- Select Measurement and **F1** (Start). TC-3000C will connect to the initially detected DUT and perform measurement.

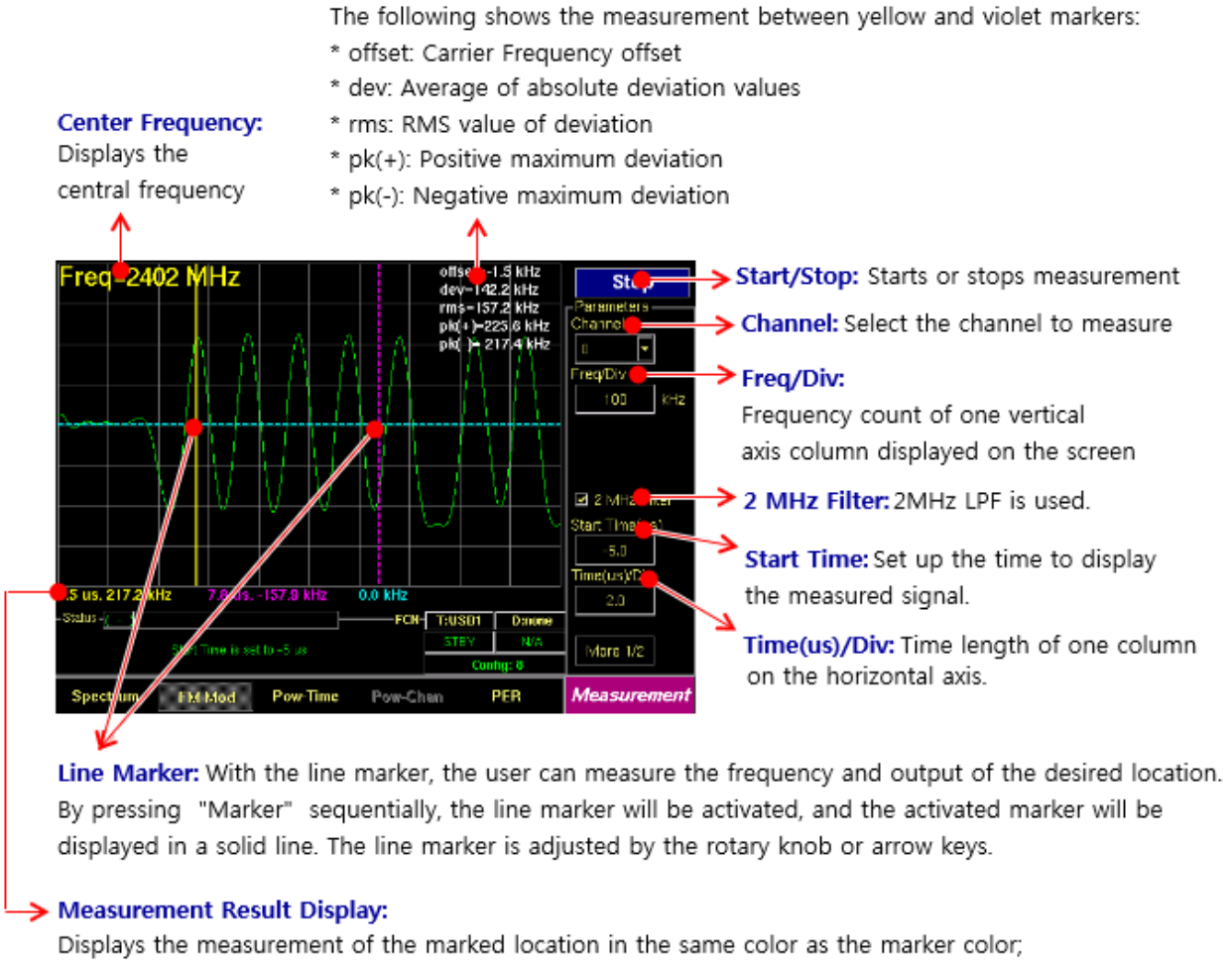
2.4.2 RF Characteristics Measurement

1. Spectrum: Displays the spectrum analysis screen for the TX signal of DUT; select the **M 1** key to go to the spectrum analyzer screen



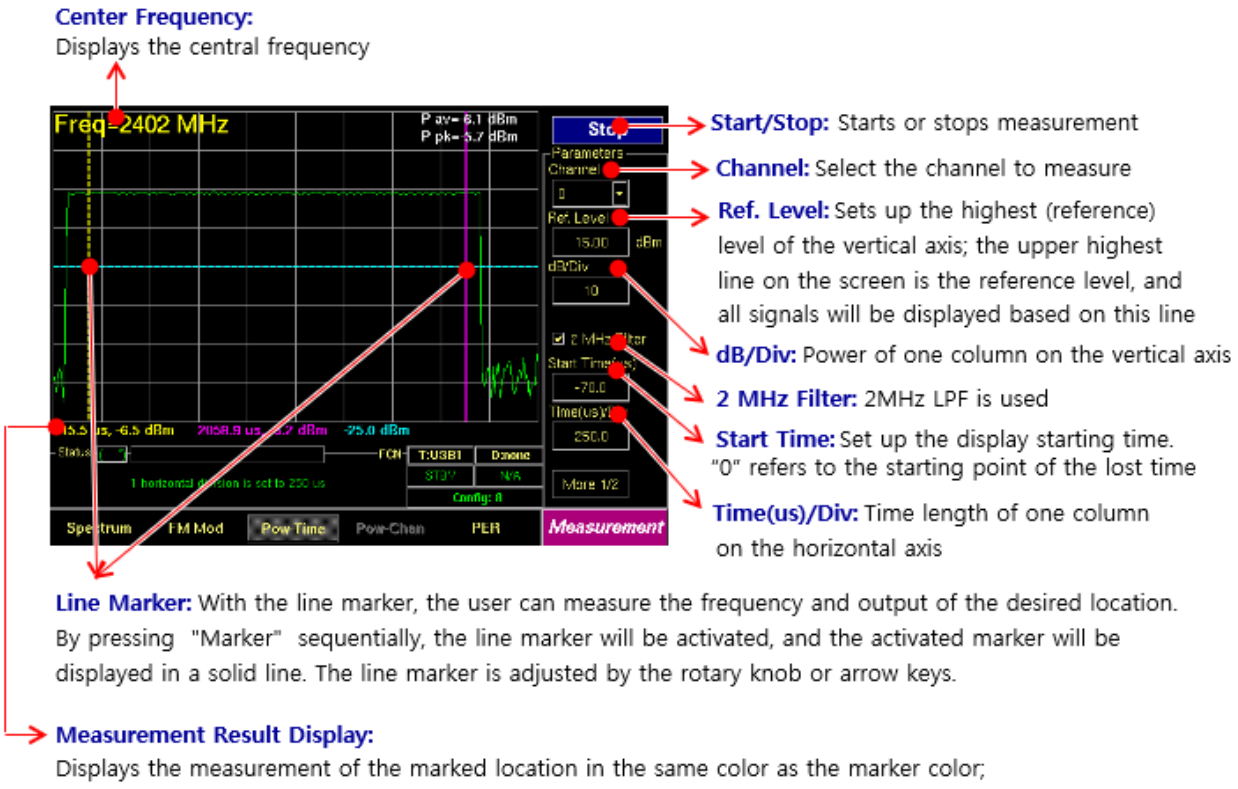
Parameter	Range	Default
Channel	0 ~ 39	0
Span (MHz)	1, 1.25, 2, 2.5, 5, 10	10
Num of sweeps	1 ~ 50	1
Trace Mode	Average / Max hold	Average
Ref. Level (dBm)	-80~ 40	-80 + Path Loss ~ 40 + Path Loss
dB/div	1 ~ 20	10

2. **FM Mod**: Displays the characteristics of signal modulation; press the **M2** key to go to the FM modulation screen



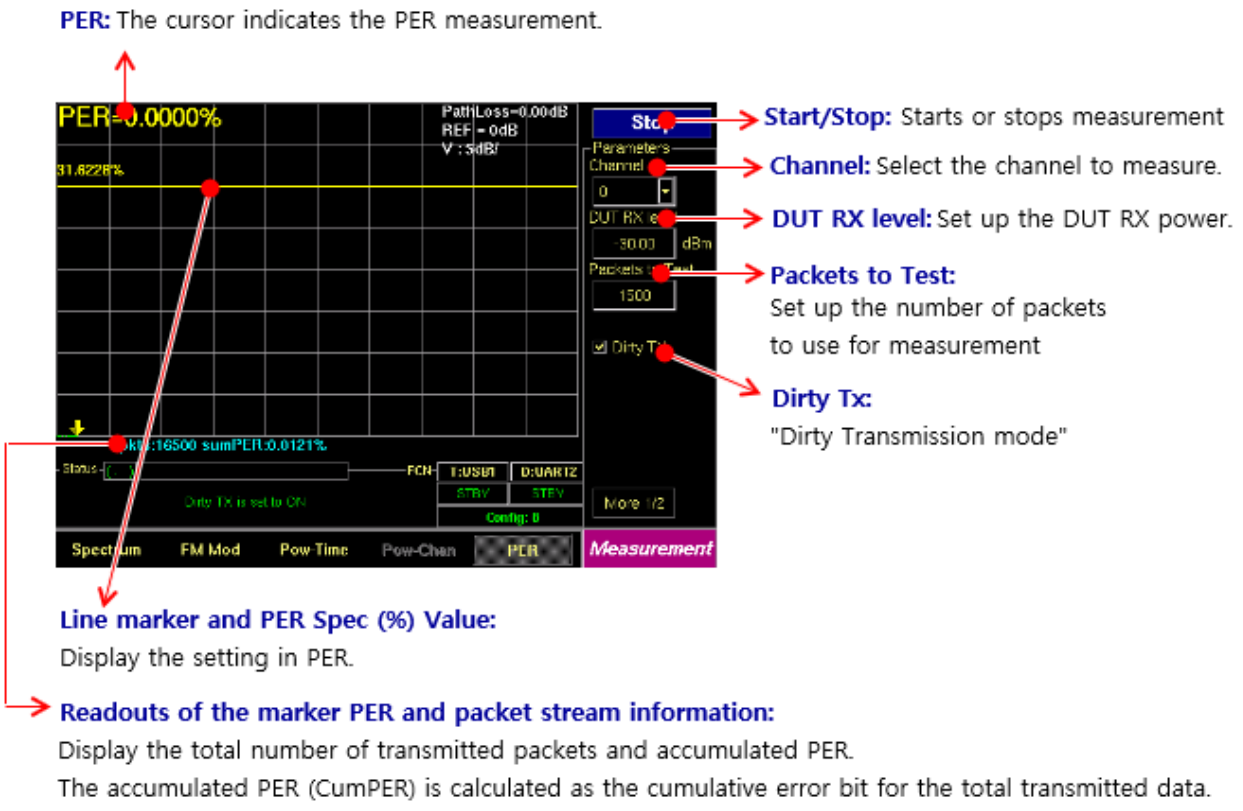
Parameter	Range	Default
BT Channels	0 ~ 39	0
Freq/Div. (kHz)	10 ~ 1000	100
2 MHz Filter		Checked
Start Time. (us)	-70 ~ 475	250
Time(us)/div	0.1 ~ 300	50

3. **Power-Time**: Shows the power-time characteristics of the signal; press the **M3** key to go to the power-time screen



Parameter	Range	Default
Channel	0 ~ 39	0
Ref. Level (dBm)	-80 ~ 40	-80 + Path Loss ~ 40 + Path Loss
dB/div	1 ~ 20	10
2 MHz Filter		Checked
Start Time (us)	-70 ~ 125	
Time (us)/div	0.1 ~ 300 @ 1 slot packet	15

4. **PER (Packet Error Rate)**: Measures the reception sensitivity of DUT; press the **M5** key to go to the PER measurement screen

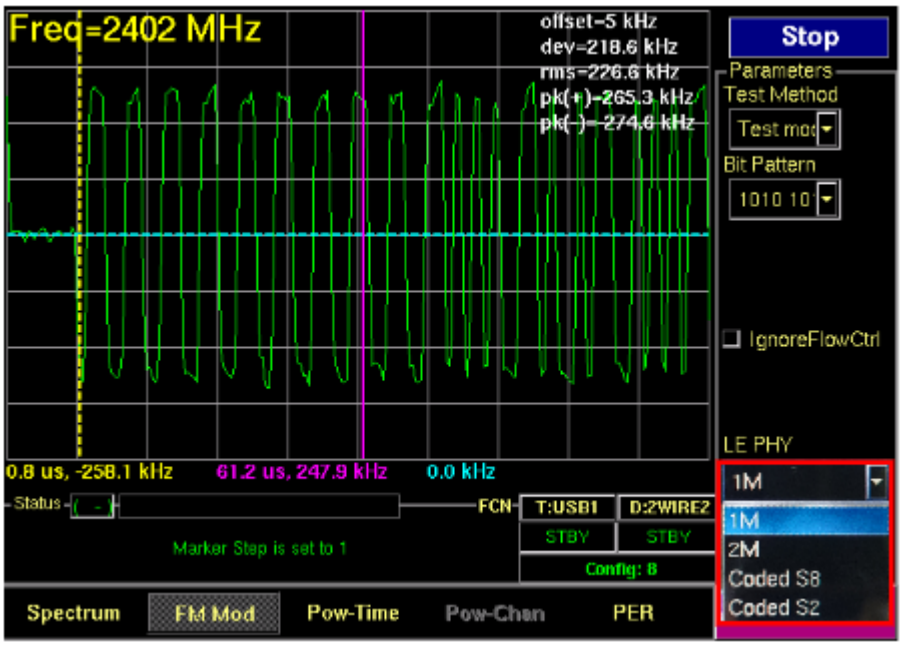


Parameter	Range	Default
Channel	0 ~ 39	0
DUT RX level (dBm)	-80 ~ 0	0
Packets to Test	50 ~ 50000	1500
Dirty TX		Unchecked

5. Setting for LE PHY in Measurement

Select the physical layer (PHY) of the Bluetooth 5.0 LE.

- 1M : PHY used in Bluetooth v4.0 / v4.1 / v4.2
- 2M : 2 Mbps LE PHY
- Coded S8 : 125 kbps
- Coded S2 : 500 kbps

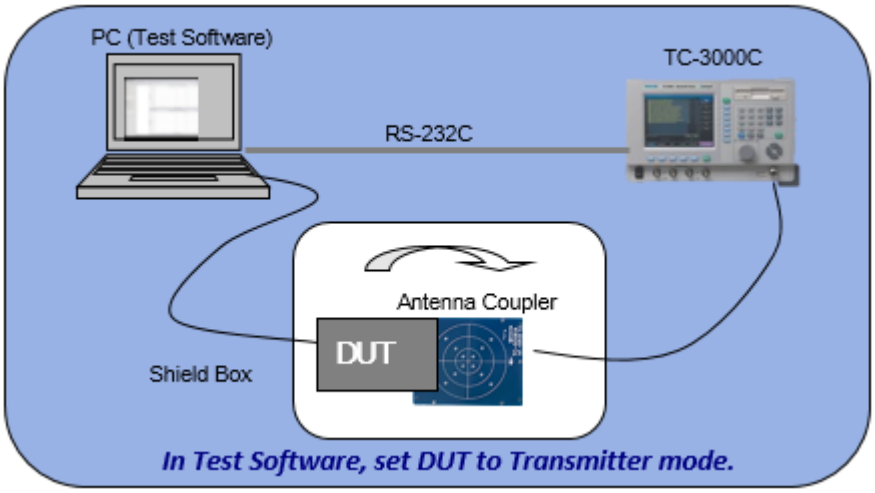

Freq=2402 MHz
offset=5 kHz
dev=218.6 kHz
rms=226.6 kHz
pk(+)=265.3 kHz
pk(-)=274.6 kHz
Stop
Parameters
Test Method
Test mod
Bit Pattern
1010 10
IgnoreFlowCtrl
LE PHY
1M
1M
2M
Coded S8
Coded S2
0.8 us, -258.1 kHz
61.2 us, 247.9 kHz
0.0 kHz
Status
FCN
T:USB1
D:2WIRE2
STBY
STBY
Marker Step is set to 1
Config: 8
Spectrum
FM Mod
Pow-Time
Pow-Chan
PER

3. Non-Signaling Test

For chips that do not support the Direct Test mode, the user can conduct a non-signaling test by sending packets to DUT or reporting the received packets using the chip vendor-provided software and using TC-3000C for the test.

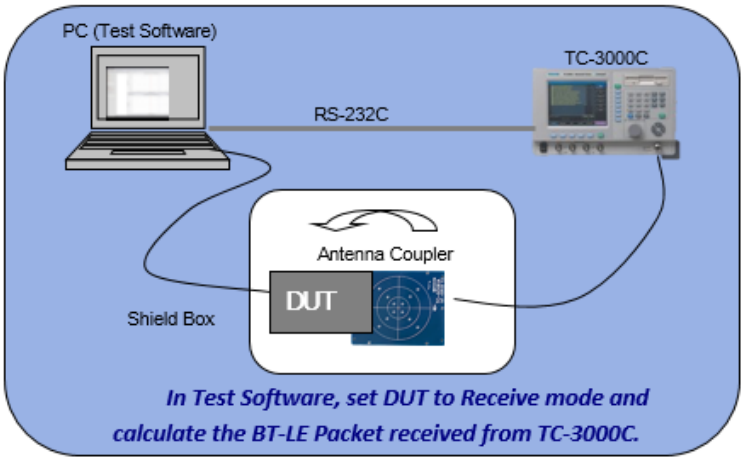
DUT's TX Test (Test for DUT's transmitting efficiency)

By using the Test Control Software provided by the Chipset company, set DUT to transmit the LE packet required for test and measure DUT's TX efficiency with TC-3000.



DU's RX Test (Test for DUT's receiving efficiency)

TC-3000 sends the LE standard packet to DUT, which then reports the number of packets received normally using the Test Control Software provided by the Chipset company.



3.1 Set up

3.1.1 General Non-Signaling Test Setup

- **DUT Preparation**: Depending on DUT, use the test control software provided by the Bluetooth chip vendor or use the terminal to enter the test mode. In test mode, the user can set up the channels to measure, packet lengths, packet count, and bit pattern.

- **Shield Box**: For reliable measurement report, use a shield box to prevent electromagnetic interferences. Depending on the DUT type, directly connect using the RF cable or create a radiation environment using the antenna coupler.

- **TC-3000C**: TC-3000C displays the measurement result on the front LCD window.

- **Control PC**: For DUT control, connect DUT to PC and run the test control software provided by the chip vendor.

3.1.2 TC-3000C Setup

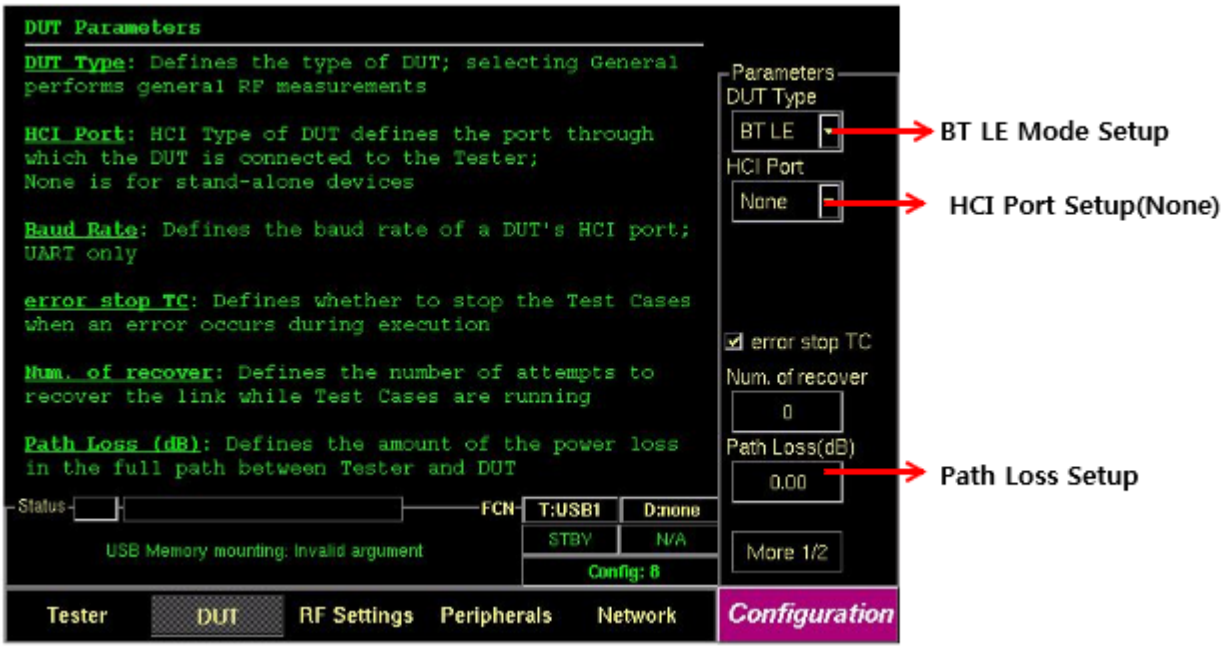
1. BT LE Mode Setup
   - Select MENU -> Configuration -> DUT(M2) -> DUT Type(F2) -> BT LE

2. HCI Port Setup: For the Non-Signaling test, set the HCI port to None
   - Select MENU -> Configuration -> DUT(M2) -> (F3) -> None

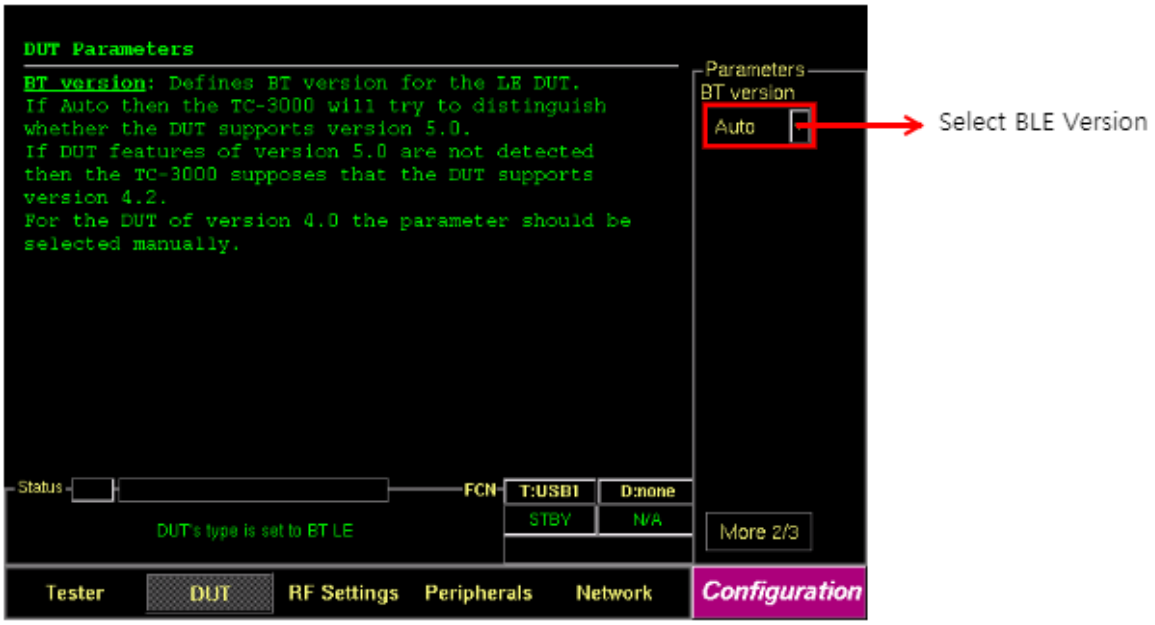
3. Path Loss Setup
   - Menu -> Configuration -> DUT (M2) -> Path Loss (F7)

- Measure path loss from TC-3000C to DUT.

4. Input Level Setup
   - Menu -> Configuration -> RF Settings (M3) -> RX ATT (F3)
   - Set up the range for the DUT output level. (RX ATT Off: -80 ~ -10 dBm, RX ATT On: -30 ~+20 dBm)



5. BT version Select
   - MENU -> Configuration -> DUT -> BT version(F2) -> version Select
   - Select BLE specification version (Auto/v4.0/v4.2/v5.0)
   - Set to "Auto", TC-3000C determines whether the DUT supports BT v5.0. If not, the TC-3000C will work with v4.2.



NOTICE

BT version setting menu is available from the TC-3000C firmware version v4.00 or later

3.2 Functions

3.2.1 RF Test Cases

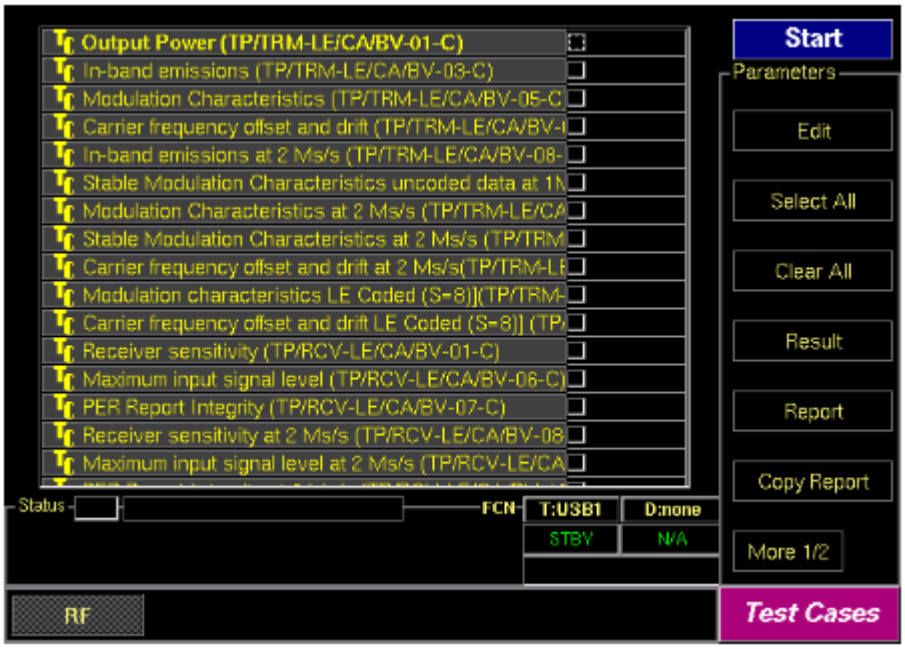
In Non-Signaling Test mode, 6 out of 7 LE Test Cases can be tested.

TX Test

- Output Power (TP/TRM-LE/CA/BV-01-C)
- In-band emissions, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-03-C)
- Modulation characteristics, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-05-C)
- Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C)
- In-band emissions at 2Ms/s (TP/TRM-LE/CA/BV-08-C)
- Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)
- Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)
- Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)
- Carrier frequency offset and drift at 2Ms/s (TP/TRM-LE/CA/BV-12-C)
- Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)
- Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

RX Test

- Receiver sensitivity, uncoded data at 1 Ms/s (TP/RCV-LE/CA/BV-01-C)
- Maximum input signal level, uncoded data at 1 Ms/s (TP/RCV-LE/CA/BV-06-C)
- PER Report Integrity, uncoded data at 1 Ms/s (TP/RCV-LE/CA/BV-07-C)
- Receiver sensitivity at 2Ms/s (TP/RCV-LE/CA/BV-08-C)
- Maximum input signal level at 2Ms/s (TP/RCV-LE/CA/BV-12-C)
- PER Report Integrity at 2Ms/s (TP/RCV-LE/CA/BV-13-C)
- Receiver sensitivity, uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-14-C)
- Maximum input signal level, uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-18-C)
- PER Report Integrity , uncoded data at 1Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-19-C)
- Receiver sensitivity at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-20-C)
- Maximum input signal level at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-24-C)
- PER Report Integrity at 2Ms/s, Stable Modulation Index (TP/RCV-LE/CA/BV-25-C)
- Receiver sensitivity, LE Coded (S=2) (TP/RCV-LE/CA/BV-26-C)
- Receiver sensitivity, LE Coded (S=8) (TP/RCV-LE/CA/BV-27-C)
- PER Report Integrity, LE Coded (S=2) (TP/RCV-LE/CA/BV-30-C)
- PER Report Integrity, LE Coded (S=8) (TP/RCV-LE/CA/BV-31-C)
- Receiver sensitivity, LE Coded (S=2), Stable Modulation Index (TP/RCV-LE/CA/BV-32-C)
- Receiver sensitivity, LE Coded (S=8), Stable Modulation Index (TP/RCV-LE/CA/BV-33-C)
- PER Report Integrity, LE Coded (S=2), Stable Modulation Index (TP/RCV-LE/CA/BV-36-C)
- PER Report Integrity, LE Coded (S=8), Stable Modulation Index (RCV-LE/CA/37-C)



3.2.2 Menu Setup Method

Start

Starts the selected test case item; changed into Stop key during execution, which can stop the test case

Edit

Move the cursor to the item to be changed and select Edit. The Edit mode will be enabled. The user can exit the Edit mode by selecting the key again.

- Use Default: When this is selected, the Edit Mode parameter values are the default values.
- BT Channels: Set up the DUT TX channel (0 ~ 39). (Set up only one channel.)
- Number of Packets: Set up the number of packets to send.

Select All

Select to test all items. Setup is not prohibited during execution.

Clear All

Clears all test items; setup is not prohibited during execution

Result

Displays the result on the popup window

Report

Select the Report key to view the measurement details. The report file is saved as text or csv file (Configuration Tester Report Format).

Copy Report

This saves the report file to USB. Insert the USB memory into the front slot and press Copy Report (F7) and OK. The report will then be stored on USB.

Num of iteration

Set up the measurement repetition time of the test case.
If multiple test cases are selected, all test cases will be tested, and testing of all cases will be repeated.

3.2.3 Test Procedure

1. Set up the BT LE mode and the RF environment on TC-3000C. (See 3.1.2 TC-3000C Setup)

2. Select the RF test cases.
   - Select Menu -> Test Cases and test items. (Rotate and press the rotary encoder.)
   - Select Edit to check the test conditions and edit according to the test conditions. (For more information on setting the conditions of the test item, see 3.3 Test Items)

3. DUT Test Condition Setup
   - Set up the BT LE channel, packet lengths, and bit pattern using the chip vendor-provided software.

4. TC-3000C Test Condition Setup
   - Set up the parameters of each test case. See 3.3 Test Items.

5. Test Start: Start Select the Start key.

6. Test Result Checking
   - Check the result or report.
   - If necessary, save the result to USB by clicking the Copy Report button.

3.3 Test Items

3.3.1 Transmitter Tests (TP/TRM-LE)

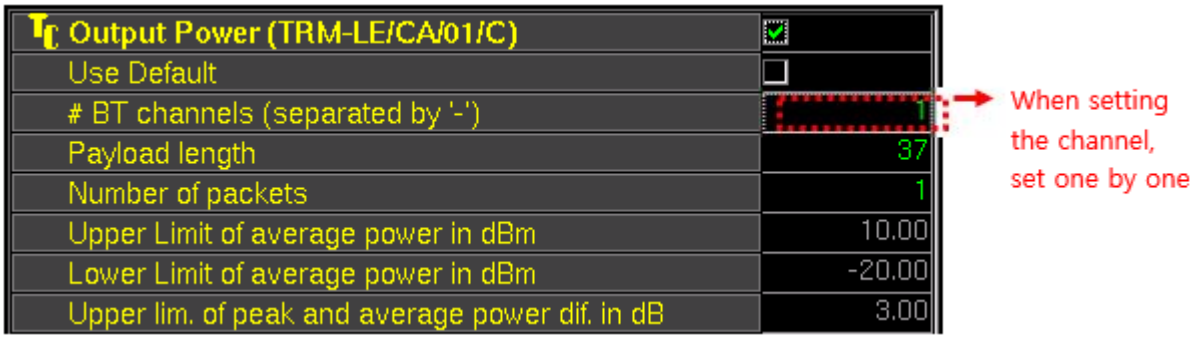
3.3.1.1 Output Power

(TP/TRM-LE/CA/BV-01-C) Output Power

1. Objective: To measure the average and maximum power of DUT

2. Settings on DUT
   - Payload : PRBS9 / MAX_TX_LENGTH
   - DUT TX Power : Maximum power

3. Settings on Tester



NOTICE

In the Non-Signaling test, it is difficult to test multiple channels (for example, 0-19-39) at the same time when setting up BT channels. Setting up and testing each channel are recommended.

4. Measurement Method
   - A. By using the Test Control Software provided by the Chip vendor, set the BT LE Channel, Packet Length, and Payload Type, and then have DUT send LE standard Packets. Set “PRBS9” for the DUT packet type.
   - B. In the test case of TC-3000, select the output power and press Edit key.
   - C. Set TC-3000C with the same BT channel set for DUT in A.
   - D. On TC-3000C, select Start to start the test.
   - E. After the test, check the test result on TC-3000C.

5. Specification

> −20 dBm ≤ Pavg[(1)] ≤ +10 dBm (BLE core v4.2 or earlier versions)
> −20 dBm ≤ Pavg ≤ +20 dBm (BLE core v5.0)
> Ppk[(2)] ≤ Pavg + 3 dB

3.3.1.2 In-band Emissions, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-03-C)

```
(TP/TRM-LE/CA/BV-03-C) In-band emissions, uncoded data at 1 Ms/s
(TP/TRM-LE/CA/BV-08-C) In-band emissions at 2Ms/s
```

1. Objective: To measure adjacent channel power within the band and to check the channel interferences

2. Settings on DUT
   - Payload : PRBS9 / Maximum packet length
   - TX Power : Maximum power.

3. Settings on Tester

In-band emissions, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-03-C)

In-band emissions (TP/TRM-LE/CA/BV-03-C)	☑
Use Default	☐
# BT channels (separated by '-')	2 or 19 or 39
Payload length	37
Number of sweeps	10
Upper Limit of the power in a channel M-N=2 in dBm	-20.00
Upper Limit of the power in a channel M-N>=3 in dBm	-30.00
Max. number of excepted channels	3
Upper Limit of the power in excepted channels in dBm	-20.00

In-band emissions at 2Ms/s (TP/TRM-LE/CA/BV-08-C)

In-band emissions at 2 Ms/s TP/TRM-LE/CA/BV-08	☑
Use Default	☐
# BT channels (separated by '-')	2
Payload length	31
Number of sweeps	10
Upper Limit of the power in a channel M-N=4&5 in dBm	-20.00
Upper Limit of the power in a channel M-N>=6 in dBm	-30.00
Max. number of excepted channels	3
Upper Limit of the power in excepted channels in dBm	-20.00

(1) PAVG : average power
(2) Ppk : peak power

4. Measurement Method

A. By using the Test Control Software provided by the Chip vendor, set the BT LE Channel, Packet Length, and Payload Type, and then have DUT send LE standard Packets. Set “PRBS9” for the DUT packet type.

B. In the test case of TC-3000, select the “In-band emissions” and press Edit

C. Set TC-3000C with the same BT channel set for DUT in A.

D. On TC-3000C, select Start to start the test.

E. After the test, check the test result on TC-3000C.

5. Specification

1. **In-band Emission (TP/TRM-LE/CA/BV-03-C)**

* $P_{Tx} \leq$ -20 dBm for (f_{Tx} ± 2 MHz)
* $P_{Tx} \leq$ -30 dBm for (f_{Tx} ± [3+n] MHz); where n=0,1,2…
* For each operating frequency, up to three bands of 1 MHz width

(as defined in the measurement) can be exempted from the requirements.
The excepted values shall however comply with an absolute value of P TX ≤ -20 dBm.

2. **In-band Emission at 2 Ms/s (TP/TRM-LE/CA/BV-08-C)**

* $P_{Tx} \leq$ -20 dBm for (f_{Tx} ± 4 MHz)
* $P_{Tx} \leq$ -20 dBm for (f_{Tx} ± 5 MHz)
* $P_{Tx} \leq$ -30 dBm for (f_{Tx} ± [6+n MHz]; where n=0,1,2…
* For each operating frequency, up to three bands of 1 MHz width

(as defined in the measurement) can be exempted from the requirements.
The excepted values shall however comply with an absolute value of P TX ≤ -20 dBm.

NOTICE

The AGC default value for tester is ON; when measuring In-band emissions, however, the AGC value is changed to OFF, and the value is measured since the receiving gain section of the tester is set to (RX Power) -10 ~ 0 dBm. If DUT’s transmitting Power is notably larger or smaller than -10 ~ 0 dBm, there may be an error in the measured value.

3.3.1.3 Modulation Characteristics

(TP/TRM-LE/CA/BV-05-C) Modulation characteristics, uncoded data at 1 Ms/s
(TP/TRM-LE/CA/BV-09-C) Stable Modulation characteristics, uncoded data at 1Ms/s
(TP/TRM-LE/CA/BV-10-C) Modulation characteristics at 2Ms/s
(TP/TRM-LE/CA/BV-11-C) Stable Modulation characteristics at 2Ms/s
(TP/TRM-LE/CA/BV-13-C) Modulation Characteristics, LE Coded (S=8)

3.3.1.3.1 Modulation characteristics, uncoded data at 1 Ms/s(TP/TRM-LE/CA/BV-05-C)

3.3.1.3.2 Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)

1. Objective: This test verifies that the modulation characteristics of the transmitted signal are correct when the transmitter is operating with uncoded data at 1 Ms/s.

2. Settings on DUT
   - Payload
     - Two different patterns: 11110000(df1), 10101010(df2)
     - Maximum packet length
   - TX Power : Maximum power

3. Settings on Tester

Modulation characteristics (TP/TRM-LE/CA/BV-05-C)

Modulation Characteristics (TP/TRM-LE/CA/BV-05	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	37
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	275.0
Low. Lim. of freq. deviat. for 11110000 in kHz	225.0
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

Stable Modulation characteristics (TP/TRM-LE/CA/BV-09-C)

Stable Modulation Characteristics uncoded data a	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	37
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	252.5
Low. Lim. of freq. deviat. for 11110000 in kHz	247.5
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

4. Measurement Method (Measure Δf1 and Δf2 and calculate the measurement result.)
   A. By using the Test Control Software provided by the Chip vendor, set the BT LE Channel, Packet Length, and Payload Type, and then have DUT send LE standard Packets. Set “00001111” for the DUT packet type.
   B. Select “modulation characteristics” for the test case of TC-3000C followed by the Edit key.
   C. Set TC-3000C with the same BT channel set for DUT in A.

D. In TC-3000C, press **Start** to measure Δf1.

E. To measure the Δf2 value, set the Payload data type of the Packet sent by DUT to "10101010" using the Test Control Software provided by the Chip vendor.

F. In TC-3000C, press **Start** to measure Δf2.

G. Select the **Report** key. From the following measurement result, calculate Δf1avg, Δf2avg, and Δf2max rate and judge Pass/Fail based on the specification described in D :

NOTICE

Calculation on Report File (Example)

```
1 RF test cases started: Tue Feb 20 10:59:53 2018
_____Modulation Characteristics (TP/TRM-LE/CA/BV-05-C)
Initial conditions:
        Hopping:              off
        Payload:              11110000 and 1010 bit patterns
        Payload's length:     37 bytes
        Number of packets:    10
Limits:
        225.0KHz <= df1_avg <= 275.0KHz, df2_pass_rate >= 99.90%, df2/df1 >= 0.80
Results (frequency deviations in KHz):
#ch     f(MHz) df1_avg  df2_avg  df2_min  df2_rate(%)  df2/df1  Verdict
0       2402   250.8    257.4    229.1    100.00       1.03     PASSED
Test time:      1 sec.
1 RF test cases completed: Tue Feb 20 10:59:54 2018
Total test time: 1 sec.
```

```
1 RF test cases started: Tue Feb 20 11:00:21 2018
_____Modulation Characteristics (TP/TRM-LE/CA/BV-05-C)
Initial conditions:
        Hopping:              off
        Payload:              11110000 and 1010 bit patterns
        Payload's length:     37 bytes
        Number of packets:    10
Limits:
        225.0KHz <= df1_avg <= 275.0KHz, df2_pass_rate >= 99.90%, df2/df1 >= 0.80
Results (frequency deviations in KHz):
#ch     f(MHz) df1_avg  df2_avg  df2_min  df2_rate(%)  df2/df1  Verdict
0       2402   156.4    244.1    225.1    100.00       1.56     FAILED
Test time:      1 sec.
1 RF test cases completed: Tue Feb 20 11:00:22 2018
Total test time: 1 sec.
```

Interpreting the Measurement Results: Use the values of red-boxed area shown above

* Δf1avg : 250.8, Δf2avg: 244.1,
* Δf2_rate (%) : 100.00 % => PASS
* Δf2avg / Δf1avg = 244.1 / 250.8 = 0.97 => PASS

5. Specification

> 1. Modulation characteristics (TP/TRM-LE/CA/BV-05-C)
> * 225 kHz ≤ Δf1avg ≤ 275 kHz
> * 99.9 % of Δf2max must be greater than 185 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8
> 2. Stable Modulation characteristics, uncoded data at 1Ms/s (TP/TRM-LE/CA/BV-09-C)
> * 247.5 kHz ≤ Δf1avg ≤ 252.5 kHz
> * 99.9 % of Δf2max must be greater than 185 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8

Table 3-1 Specifications for modulation characteristics

Test Number (TP/TRM-LE/CA/BV-XX-C)		$\Delta f1_{avg}$	Δf2 Pass rate ≥ 99.9 %	$\Delta f2_{avg}$ / $\Delta f1_{avg}$
05	LE 1M	225 kHz ≤ Δf1avg ≤ 275 kHz	> 185 kHz	≥ 0.8
09	LE 1M, Stable Modulation Index	247.5 kHz ≤ Δf1avg ≤ 252.5 kHz	> 185 kHz	≥ 0.8
10	LE 2M	450 kHz ≤ Δf1avg ≤ 550 kHz	> 370 kHz	≥ 0.8
11	LE 2M, Stable Modulation Index	495 kHz ≤ Δf1avg ≤ 505 kHz	> 370 kHz	≥ 0.8
13	LE Coded, S=8	225 kHz ≤ Δf1avg ≤ 275 kHz	> 185 kHz	None

3.3.1.3.3 Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)

3.3.1.3.4 Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)

1. Objective: This test verifies that the modulation characteristics of the transmitted signal are correct when the transmitter is operating at 2 Ms/s.

2. Settings on DUT
   - Payload
     - Two different patterns: 11110000(df1), 10101010(df2)
     - MAX_TX_LENGTH_2M : 31 byte
   - TX Power : Maximum power

3. Settings on Tester

Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)

Modulation Characteristics at 2 Ms/s (TP/TRM-LE/	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	31
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	550.0
Low. Lim. of freq. deviat. for 11110000 in kHz	450.0
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)

Stable Modulation Characteristics at 2 Ms/s (TP/TI	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	31
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	505.0
Low. Lim. of freq. deviat. for 11110000 in kHz	495.0
Max.num.of deviat.for 1010 < low.lim. in %	0.100
Low. Lim. for the ratio of df2/df1 in %	80

4. Measurement Method (Measure Δf1 and Δf2 and calculate the measurement result.)
   A. By using the Test Control Software provided by the Chip vendor, set the BT LE Channel, Packet Length, and Payload Type, and then have DUT send LE standard Packets. Set “00001111” for the DUT packet type.
   B. Select “modulation characteristics” for the test case of TC-3000C followed by the Edit key.
   C. Set TC-3000C with the same BT channel set for DUT in A.
   D. In TC-3000C, press Start to measure Δf1.
   E. To measure the Δf2 value, set the Payload data type of the Packet sent by DUT to “10101010” using the Test Control Software provided by the Chip vendor.
   F. In TC-3000C, press Start to measure Δf2.
   G. Select the Report key. From the following measurement result, calculate Δf1avg, Δf2avg, and Δf2max rate and judge Pass/Fail based on the specification described in D :

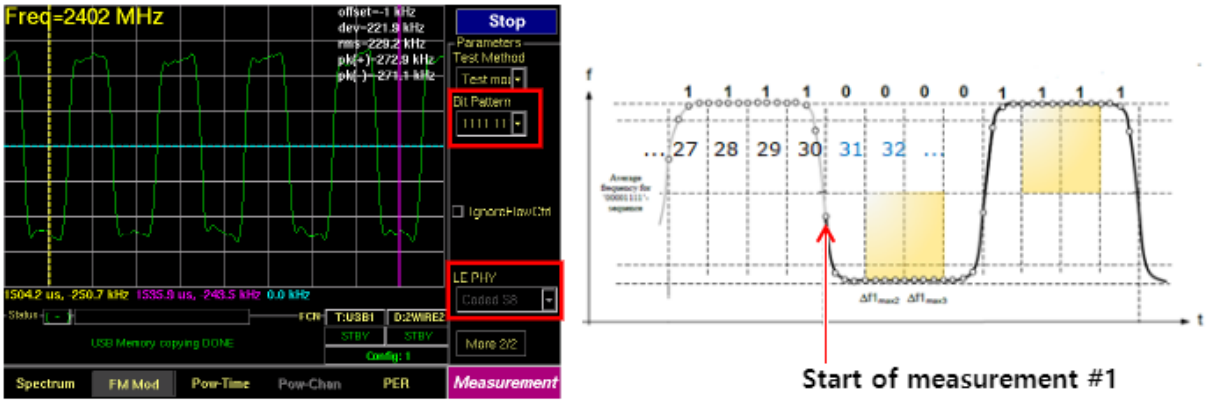
5. Specification

> **1. Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-10-C)**
>
> * 450 kHz ≤ Δf1avg ≤ 550 kHz
> * 99.9 % of Δf2max must be greater than 370 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8
>
> **2. Stable Modulation characteristics at 2Ms/s (TP/TRM-LE/CA/BV-11-C)**
>
> * 495 kHz ≤ Δf1avg ≤ 505 kHz
> * 99.9 % of Δf2max must be greater than 370 kHz
> * (Δf2avg/Δf1avg) ≥ 0.8

3.3.1.3.5 Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)

1. Objective: This test verifies that the modulation characteristics of the transmitted signal are correct for an LE Coded signal (S=8).

2. Settings on DUT
   - Payload : 'Coded, S=8' packet, payload consisting of a repetitive sequence of 0xFF octets(binary '11111111'in transmission order)
     - '11111111' (S=8 encoding → '00111100' symbols)
   - MAX_TX_LENGTH_CODED_S8 : 31
   - TX Power : Maximum power



* The measurement shall start at the beginning of the 31 st symbol in the payload.
* The last 34 symbols in the payload shall be disregarded.

Figure 3-1 Modulation measurement principle for Coded (S=8)

3. Settings on Tester

Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)

Modulation Characteristics LE Coded (S=8) (TP/TF	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	31
Number of packets	10
Up. Lim. of freq. deviat. for 11110000 in kHz	275.0
Low. Lim. of freq. deviat. for 11110000 in kHz	225.0
Max.num.of deviat.for 11110000 < low.lim. in %	0.100

4. Specification

> **1. Modulation Characteristics, LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)**
>
> * 225 kHz ≤ Δf1avg ≤ 275 kHz
> * 99.9 % of Δf1max must be greater than 185 kHz

3.3.1.4 Carrier frequency offset and drift

```
(TP/TRM-LE/CA/BV-06-C) Carrier frequency offset and drift, uncoded data at 1 Ms/s
(TP/TRM-LE/CA/BV-12-C) Carrier frequency offset and drift at 2 Ms/s
(TP/TRM-LE/CA/BV-14-C) Carrier frequency offset and drift, LE Coded (S=8)
```

Table 3-2 Specifications for carrier frequency offset and drift

Test Number (TP/TRM-LE/CA/BV-XX-C)		| fTX - f[n] |	| f0 -fn |	| f1 -f0 | or | f0 -f3 |	| fn -fn-5 | or | fn -f(n-3) |
06	LE 1M	≤ 150 kHz	≤ 50 kHz	≤ 23 kHz	≤ 20 kHz
12	LE 2M	≤ 150 kHz	≤ 50 kHz	≤ 23 kHz	≤ 20 kHz
14	LE Coded, S=8	≤ 150 kHz	≤ 50 kHz	≤ 19.2 kHz	≤ 19.2 kHz

3.3.1.4.1 Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C)

1. Objective: This test verifies that the carrier frequency offset and carrier drift of the transmitted signal with uncoded data at 1 Ms/s is within specified limits at normal operating conditions.

2. Settings on DUT
   - Payload
     - Repetitive sequence of 55_{hex} octets (10101010)
     - Maximum packet length : 37 byte
   - TX Power : Maximum power
   - Symbol rate : 1 Ms/s
   - Modulation Index : Standard modulation Index

3. Settings on Tester
   - f0 : The tester is to Integrate the frequency of the FM demodulated signal from the center of the first preamble bit to the center of the first bit following the 8th preamble bit, 8 bits in total.
   - fn : The tester integrate the frequency of the FM demodulated signal in 10-bit intervals, starting at the second bit in the payload.

Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C)

Carrier frequency offset and drift (TP/TRM-LE/CA/E	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	37
Number of packets	10
Upper lim. of |fTX-f[n]| in kHz	150.0
Upper lim. of |f[1]-f[0]| in kHz	23.0
Up. lim. of max. freq.drift in kHz	50.0
Up. lim. of max. drift rate in kHz/50us	20.0

4. Measurement Method
   A. By using the Test Control Software provided by the Chip vendor, set the BT LE Channel, Packet Length, and Payload Type, and then have DUT send LE standard Packets. Set “10101010” for the DUT packet type.
   B. In the test case of TC-3000C, select “Carrier Frequency Offset and Drift” and press the Edit key.
   C. Set TC-3000C with the same BT channel set for DUT in A.
   D. Start the test by pressing Start on TC-3000C
   E. After the test, judge Pass/Fail on TC-3000C

5. Specification

$$f_{Tx} - 150\ kHz \leq fn \leq f_{Tx} + 150\ kHz\ (n=0,1,\cdots,k)$$
$$|f_0 - f_n| \leq 50\ kHz\ (n=2,3,4,\cdots k)$$
$$|f_1 - f_0| \leq 23\ kHz\ and$$
$$|f_n - f_{n-5}|_{n=6,7,8,\cdots k} \leq 20\ kHz$$

3.3.1.4.2 Carrier frequency offset and drift at 2 Ms/s (TP/TRM-LE/CA/BV-12-C)

1. Objective: This test verifies that the carrier frequency offset and carrier drift of the transmitted signal at 2 Ms/s is within specified limits at normal operating conditions.

2. Settings on DUT
   - Set as described in 3.3.1.4.1 Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C) .
   - Symbol rate : 2 Ms/s

3. Settings on Tester
   - f0 : The tester is to Integrate the frequency of the FM demodulated signal from the center of the first preamble bit to the center of the first bit following the 16th preamble bit, 16 bits in total.
   - fn : The tester integrate the frequency of the FM demodulated signal in 20-bit intervals.

Carrier frequency offset and drift, uncoded data at 1 Ms/s (TP/TRM-LE/CA/BV-06-C)

Carrier frequency offset and drift at 2 Ms/s (TP/TRI	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	31
Number of packets	10
Upper lim. of |fTX-f[n]| in kHz	150.0
Upper lim. of |f[1]-f[0]| in kHz	23.0
Up. lim. of max. freq.drift in kHz	50.0
Up. lim. of max. drift rate in kHz/50us	20.0

4. Specification

> f_{Tx} - 150 kHz ≤ fn ≤ f_{Tx} + 150 kHz (n=0,1,⋯,k)
> | f_0 - f_n | ≤ 50 kHz (n=2,3,4,⋯k)
> | f_1 - f_0 | ≤ 23 kHz and
> | f_n - f_{n-5} | $n=_{6,7,8,\cdots k}$ ≤ 20 kHz

3.3.1.4.3 Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

1. Objective: This test verifies that the carrier frequency offset and carrier drift of the transmitted signal is within specified limits at normal operating conditions for LE Coded PHY with S=8.

2. Settings on DUT
   - Payload : 'Coded, S=8' packet, payload consisting of a repetitive sequence of 0xFF octets(binary '11111111'in transmission order)
     - '11111111' (S=8 encoding → '00111100' symbols)
   - MAX_TX_LENGTH_CODED_S8 : 31
   - TX Power : Maximum power

3. Settings on Tester
   - f0 ~ f3 : The measurement shall start at the beginning of the 3rd symbol of the preamble field in the transmitted packet. The tester integrates the frequency of the FM demodulated signal in groups of 16 symbols. The last 14 symbols of the preamble shall be disregarded.
   - f4~k : The tester integrates the frequency of the FM demodulated signals in 16-symbol intervals, starting at the 27th symbol in the PDU payload.

Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

Carrier frequency offset and drift LE Coded (S=8) (	☑
Use Default	☐
# BT channels (separated by '-')	0
Payload length	31
Number of packets	10
Upper lim. of |fTX-f[n]| in kHz	150.0
Upper lim. of |f[0]-f[3]| in kHz	19.20
Up. lim. of max. freq.drift in kHz	50.0
Up. lim. of max. drift rate in kHz/48us	19.10

4. Specification

> **1. Carrier frequency offset and drift, LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)**
> * f_{Tx} - 150 kHz ≤ f_n ≤ f_{Tx} + 150 kHz (n=0,1,2,3⋯,k)
> * | f0 - fn | ≤ 50 kHz (n= 1,2,3,⋯k)
> * | f0 - f3 | ≤ 19.2 kHz
> * | fn - f(n-3) | ≤ 19.2 kHz (n=7,8,9,...k)

3.3.2 Receiver Tests (RCV-LE)

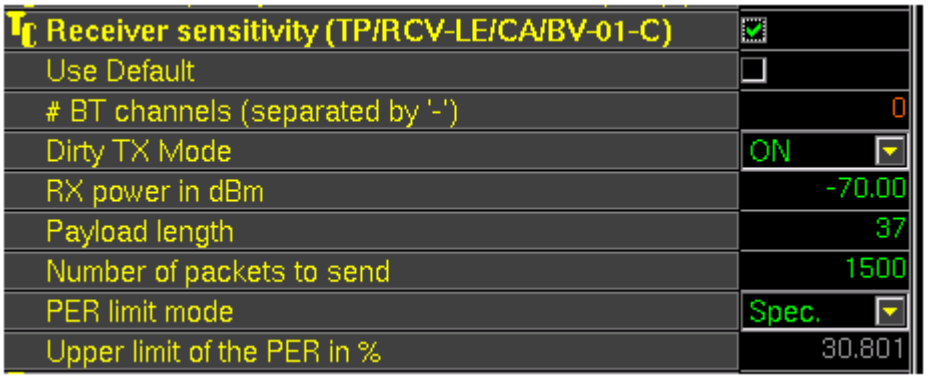
3.3.2.1 Receiver Sensitivity

```
(TP/RCV-LE/CA/BV-01-C) Receiver sensitivity, uncoded data at 1 Ms/s
(TP/RCV-LE/CA/BV-08-C) Receiver sensitivity at 2Ms/s
(TP/RCV-LE/CA/BV-14-C) Receiver sensitivity, uncoded data at 1Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-20-C) Receiver sensitivity at 2Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-26-C) Receiver sensitivity, LE Coded (S=2)
(TP/RCV-LE/CA/BV-27-C) Receiver sensitivity, LE Coded (S=8)
(TP/RCV-LE/CA/BV-32-C) Receiver sensitivity, LE Coded (S=2), Stable Modulation Index
(TP/RCV-LE/CA/BV-33-C) Receiver sensitivity, LE Coded (S=8), Stable Modulation Index
```

1. Objective: To measure the reception sensitivity in a weak electric field as Packet Error Rate (PER)

2. Settings on DUT
   - Payload : PRBS9 / MAX_RX_LENGTH
   - Center frequency : 2402, 2440, 2480 [MHz] ... (CH Num. 0, 19, 39)

3. Settings on Tester
   - Number of Test Packet : (minimum) 1500
   - Dirty ON, Additional frequency drift



4. Measurement Method
   A. In the test case of TC-3000C, select “Receiver Sensitivity” and press the Edit key.
   B. Set up TC-3000C similar to the setting done in Step 2).
   C. Have DUT enter the Receive mode using the test control software of DUT or through a separate test mode. Then, set DUT with the BT channel set on TC-3000C in B.
   D. Start the test by pressing Start on TC-3000C
   E. Calculate the LE packets received by the DUT test control software.

F. Calculate the Packet Error Rate and judge Pass/Fail according to the specifications in 5.

5. Specification

```
1. Pass Verdict
  * PER ≤ 30.8 %
```

Table 3-3 Receiver sensitivity level

Test Number (TP/RCV-LE/CA/BV-XX-C)		Sensitivity Level
01	LE 1M	-70 dBm
08	LE 2M	
14	LE 1M, Stable Modulation Index	
20	LE 2M, Stable Modulation Index	
26	LE Coded, S=2	-75 dBm
32	LE Coded, S=2, Stable Modulation Index	
27	LE Coded, S=8	-82 dBm
33	LE Coded, S=8, Stable Modulation Index	

⚠CAUTION

The RF output power range of TC-3000C is 0 to -80 dBm. In order to transmit lower power below -80 dBm, the additional 10 dB Attenuator should be attached. (G99912A, 10 dB Attenuator will be provided)
Attenuator being used, Path Loss must be input to the TC-3000C by Attenuator value.
Refer to TC-3000C Setup for setting Path Loss, 2.1.2 TC-3000C Setup

⚠CAUTION

Receiver Sensitivity for the 'TP/RCV-LE/CA/BV-27-C, LE Coded (S=8)' and the 'TP/RCV-LE/CA/BV-33-C), LE Coded (S=8), Stable Modulation Index', test must be performed with the attaching the attenuator.

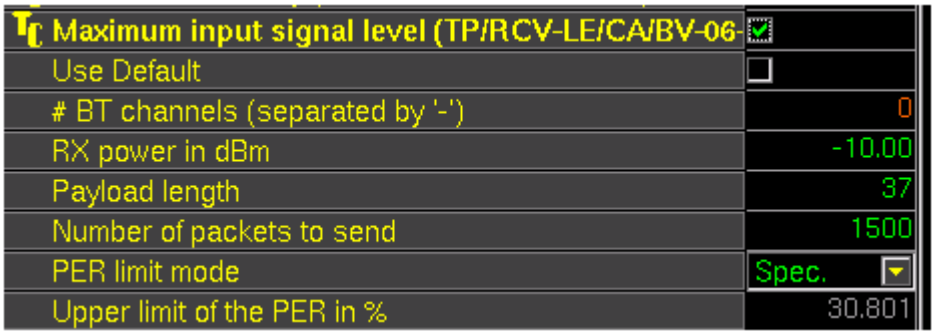
3.3.2.2 Maximum input signal level

```
(TP/RCV-LE/CA/BV-06-C) Maximum input signal level, uncoded data at 1Ms/s
(TP/RCV-LE/CA/BV-12-C) Maximum input signal level at 2Ms/s
(TP/RCV-LE/CA/BV-18-C) Maximum input signal level, uncoded data at 1Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-24-C) Maximum input signal level at 2Ms/s, Stable Modulation Index
```

1. Objective: To measure the performance of the receiver at the maximum input level

2. Settings on DUT
   - Payload : PRBS9 / MAX_RX_LENGTH
   - Center frequency : 2402, 2440, 2480 [MHz] ... (CH Num. 0, 19, 39)

3. Settings on Tester
   - Number of Test Packet : (minimum) 1500
   - TX Power : -10 dBm
   - Dirty ON, Additional frequency drift



4. Measurement Method
   - Same as the measuring method for 3.3.2.1 Receiver Sensitivity

5. Specification

> PER ≤ 30.8 % (RX power in -10 dBm)

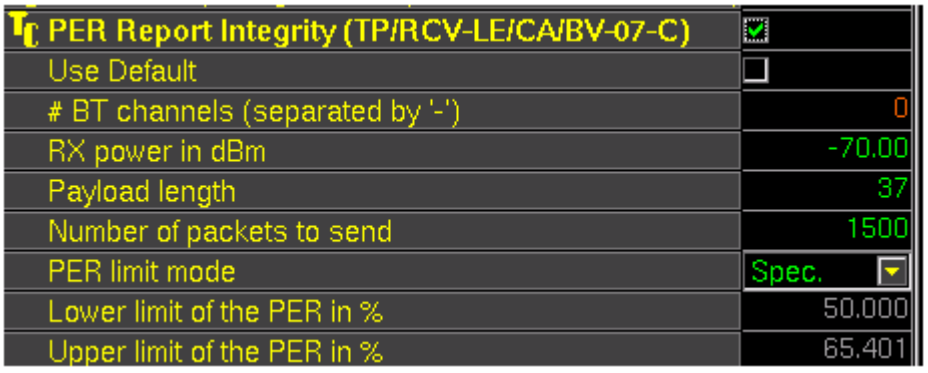
3.3.2.3 PER Report Integrity

```
(TP/RCV-LE/CA/BV-07-C) PER Report Integrity, uncoded data at 1Ms/s
(TP/RCV-LE/CA/BV-13-C) PER Report Integrity at 2Ms/s
(TP/RCV-LE/CA/BV-19-C) PER Report Integrity, uncoded data at 1Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-25-C) PER Report Integrity at 2Ms/s, Stable Modulation Index
(TP/RCV-LE/CA/BV-30-C) PER Report Integrity, LE Coded (S=2)
(TP/RCV-LE/CA/BV-31-C) PER Report Integrity, LE Coded (S=8)
(TP/RCV-LE/CA/BV-36-C) PER Report Integrity, LE Coded (S=2), Stable Modulation Index
(TP/RCV-LE/CA/BV-37-C) PER Report Integrity, LE Coded (S=8), Stable Modulation Index
```

1. Objective: This test verifies that the DUT PER report mechanism reports the correct number of received packets to the tester

2. Settings on DUT
   - Payload : PRBS9 / MAX_RX_LENGTH
   - Center frequency : 2402, 2440, 2480 [MHz] ... (CH Num. 0, 19, 39)

3. Settings on Tester
   - Number of Test Packet : 100 ≤ Even Random Number ≤ 1500
     - Transmit normal CRC and error CRC alternately to DUT.
     - Total 3 times test.

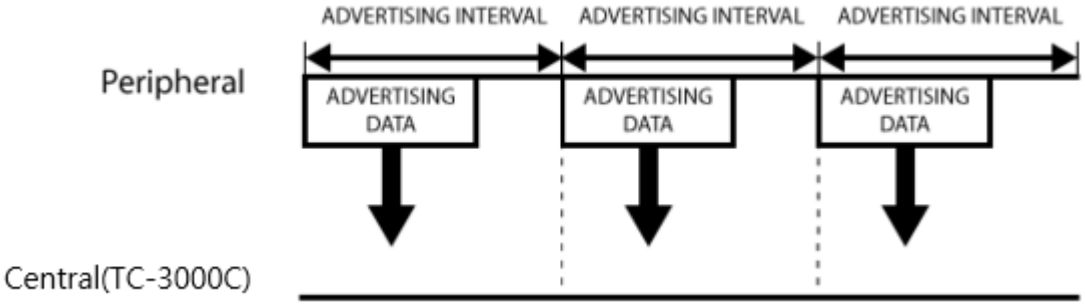


4. Specification

> * 50 % ≤ PER(3times) ≤ 65.4 %
>
> 50% ≤ PER(3 times) ≤ (50 + P/2)% , for each individual measurement.
> (P is the appropriate PER value taken from Figure 2-7 PER level by maximum payload length in receiver)
> ex) (37 byte length) 50% ≤ PER ≤ (50+ 30.8/2)%

4. Advertising Test

Advertising data packet is transmitted continuously from DUT (peripheral) through Advertising Channel(0,12,39) in order for Central device can recognize. DUT (peripheral) transmits Advertising Data packet within certain period **(Advertising Interval).** In TC-3000C, RF characteristics can be simply tested by analyzing Advertising packet that DUT transmits.



NOTICE

* **Peripheral** is usually small, operates with low energy, and has limited resources. It is designed to operate to be connected to Central device that has plenty of resource.
* **Central** has enough power and memory, such as mobile phone or tablet. TC-3000C is also described as Central.

This method involves measuring only the quality of the TX signal at the radiation status without using the external interfaces of DUT (for production).

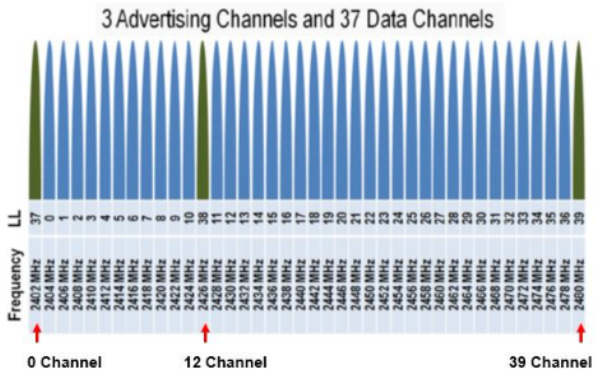
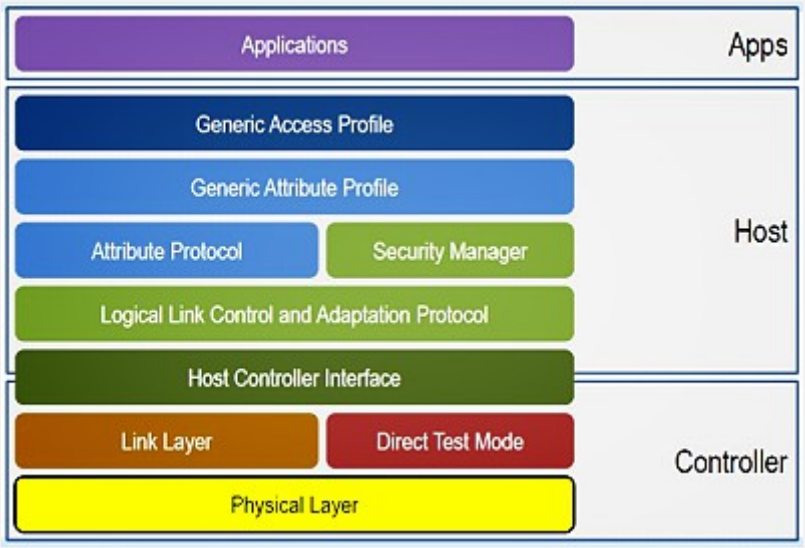


Figure 4-1 Advertising Channel Description

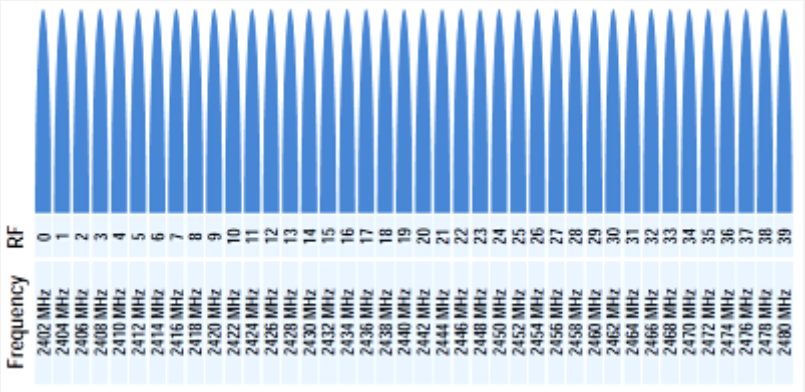
NOTICE

Advertising Channel

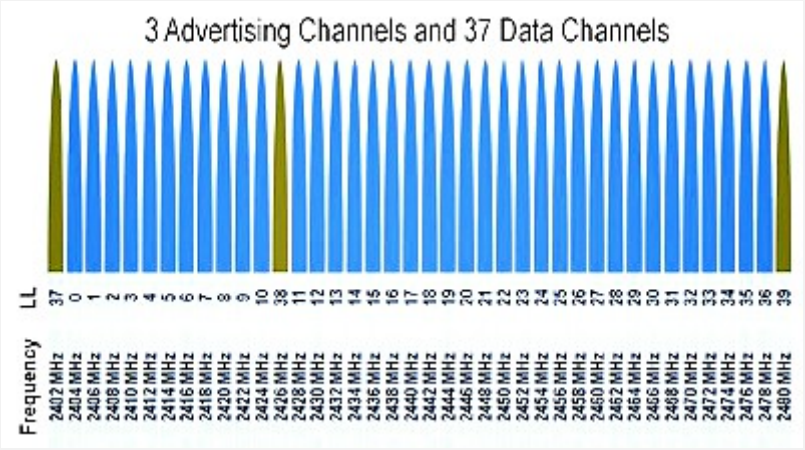
There are Link Layer (LL) and Physical Layer under BLE Protocol Stack as shown in the image below.



Channels in the Physical Layer means RF Channels as shown in the image below.



And Channels in the Link Layer means LL Channels as shown in the image below and operates differently from Physical Channels (RF Channel) above.



4.1 Setup

4.1.1 Advertising Test Setup

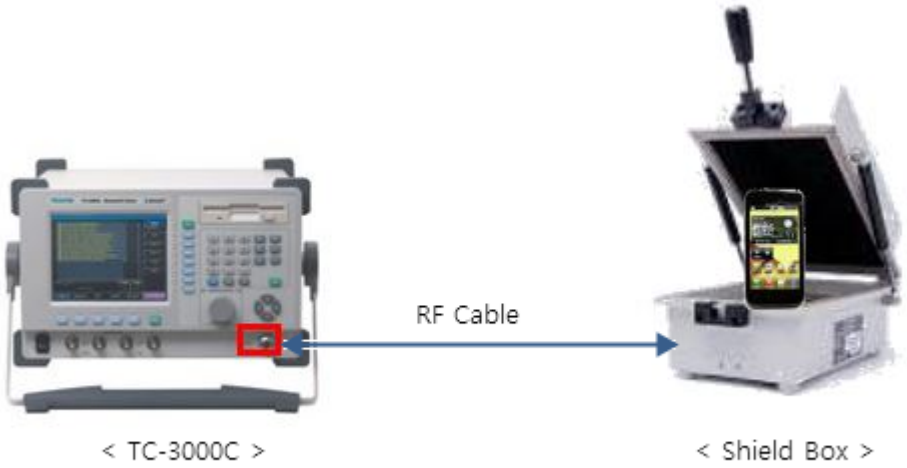


Figure 4-2 Advertising test setup

- **DUT Preparation**: Set up to send signals through the advertising channel in mode.

- **Shield Box**: For reliable measurement report, use a shield box to prevent electromagnetic interferences. Depending on the DUT type, directly connect to the RF cable or create a radiation environment using the antenna coupler.

- **TC-3000C**: TC-3000C displays the measurement result on the front LCD window.

4.1.2 TC-3000C Setup

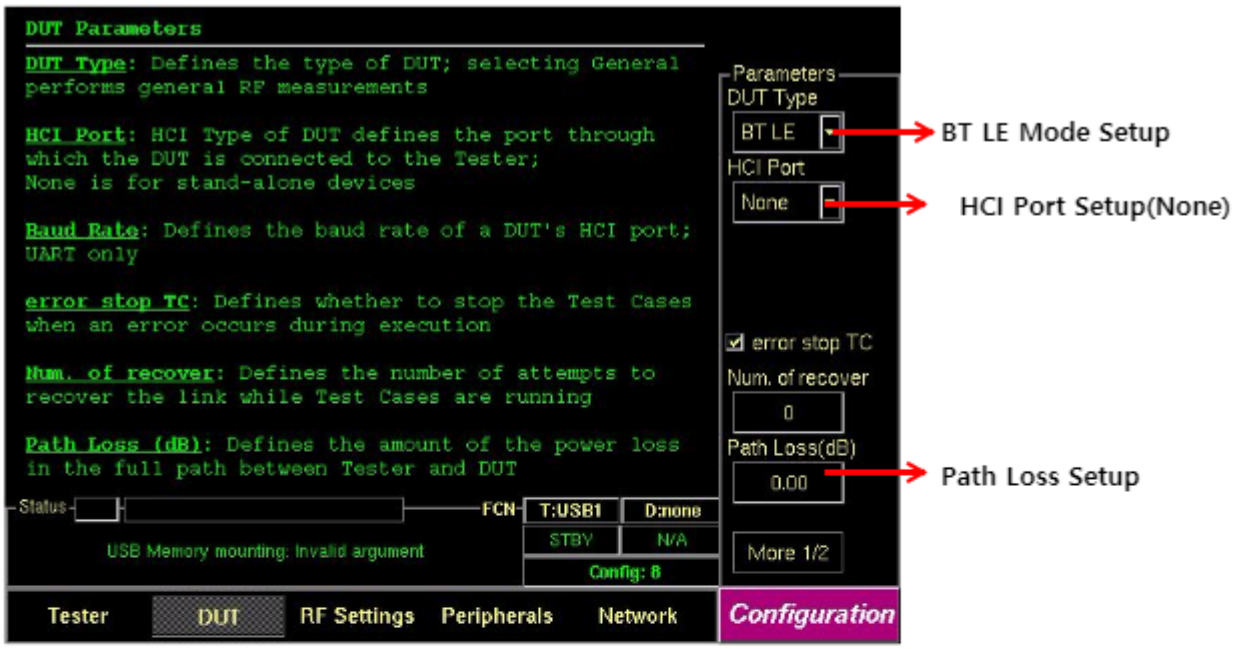
1. BT LE Mode Setup
   - Select MENU -> Configuration -> DUT(M2) -> DUT Type(F2) -> BT LE

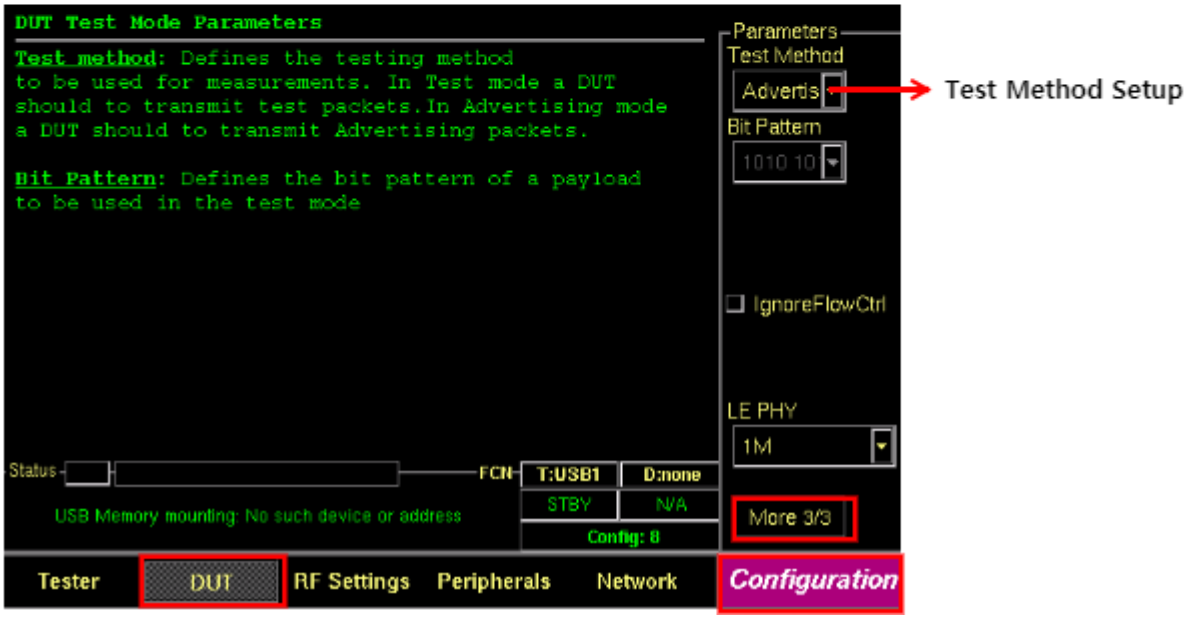
2. HCI Port Setup: For the Advertising test, set the HCI port to None
   - Select MENU -> Configuration -> DUT(M2) -> HCI Port(F3) -> None

3. Path Loss Setup
   - Menu -> Configuration -> DUT (M2) -> Path Loss (F7)
   - Measure path loss from TC-3000C to DUT.

4. Advertising Test Mode Setup
   - Menu -> Configuration -> DUT(M2) -> More 3/3 (F8) -> Test Method (F2) -> Advertising Setup

5. Input Level Setup
   - Menu -> Configuration -> RF Settings (M3) -> RX ATT (F3)
   - Set up the range for the DUT output level. (RX ATT Off: -80 ~ -10 dBm, RX ATT On: -30 ~+20 dBm)





4.2 Functions

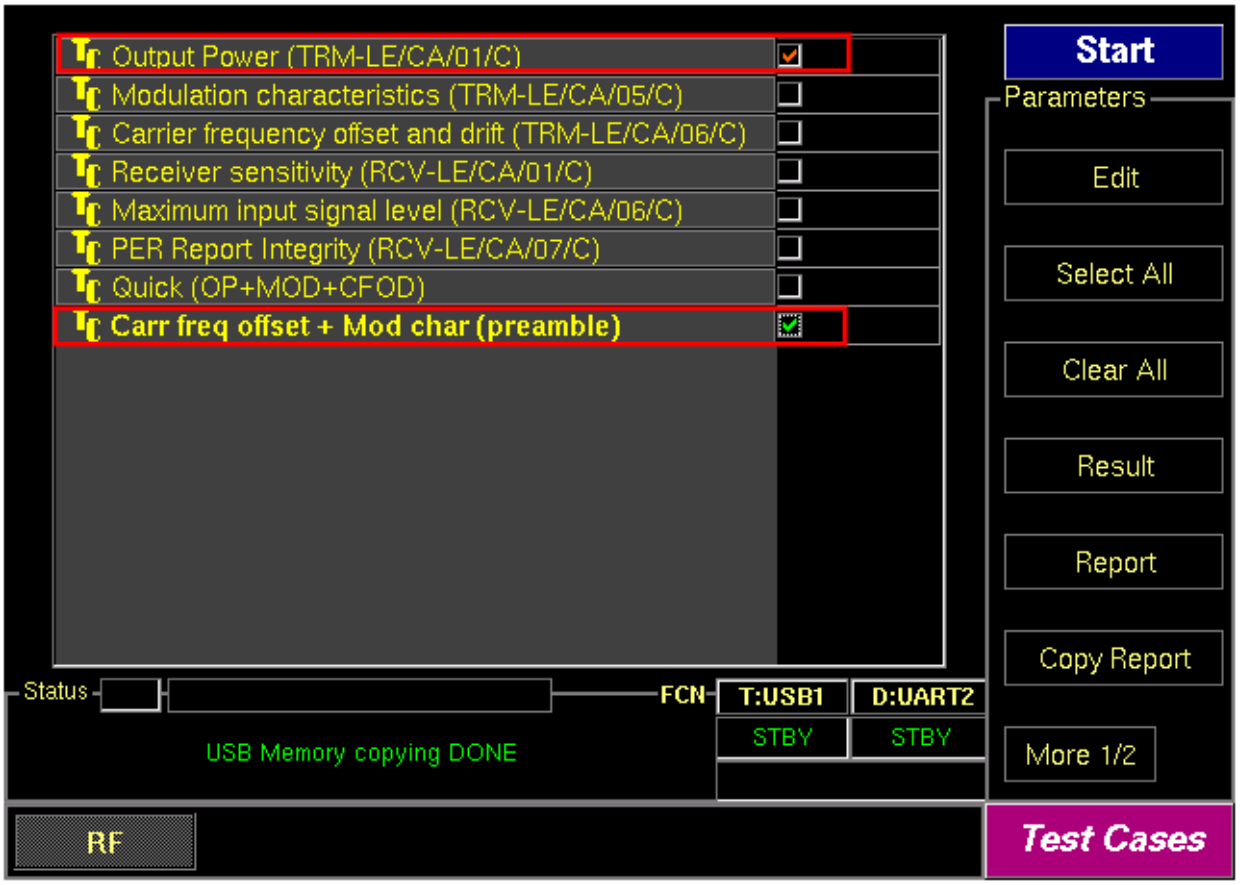
4.2.1 RF Test Cases

In Advertising Test Mode, Output Power, Carrier frequency offset, and Modulation characteristics can be measured by analyzing DUT's TX signal for the following Advertising Channels: 0, 12, and 39.

Since the measurement result for Carr freq offset + Mod char (preamble) test is gained by only sampling values of the Preamble section out of DUT's TX signal, it can differ from the measurement value of RF Test Cases.

TX Test

- Output Power (TRM-LE/CA/01/C)
- Carr freq offset + Mod char(preamble)



4.2.2 Menu Setup Method

- See 2.2.2 Menu Setup Method

4.2.3 Test Procedure

1. Set up the BT LE mode and the RF environment on TC-3000C. (See 4.1.2 TC-3000C Setup)

2. Select the RF test cases.
   - Select Menu -> Test Cases and test items. (Rotate and press the rotary encoder.)

3. TC-3000C Test Condition Setup
   - For the setup of parameters for the test cases, see parameter setup or test items of 4.3 Test Items

4. Send TX signals from DUT through the advertising channel.

5. Test Start: 

Select the Start key.

6. Test Result Checking
   - Check the result or report.₩
   - If necessary, save the result to USB by clicking the 

button.

4.3 Test Items

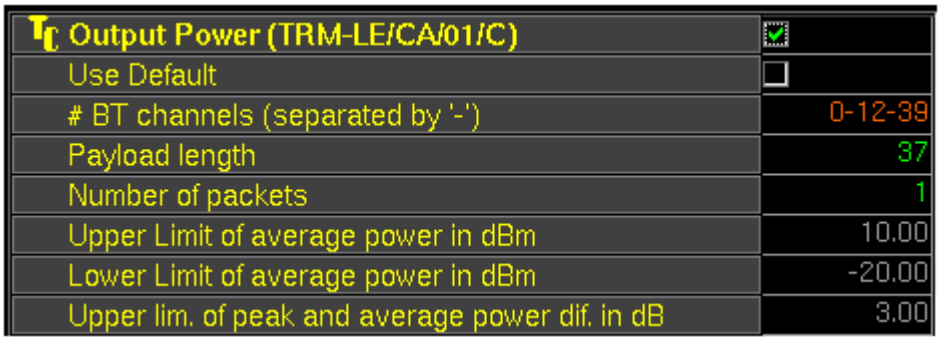
4.3.1 Output Power

1. Objective: To measure the average and maximum power of DUT

> **NOTICE**
> Since the Advertising mode conducts tests in advertising packet, the test result may differ from the test done in Direct Test or Non-Signaling Test.

2. Set up parameters.

Parameter	DUT	TC-3000C
BT Channels		0-12-39
Payload Length(octets)		0 ~ 255
Number of packets		1



3. Measurement Method

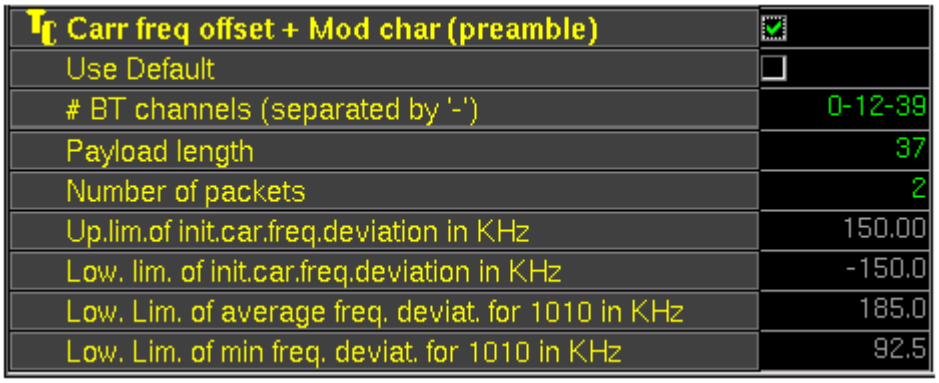
A. In the test case of TC-3000, select the output power and press Edit key .
B. Set up TC-3000C similar to the setting done in Step 2.
C. Set DUT to send TX signal to the Advertising Channel.
D. On TC-3000C, select Start to start the test.
E. After the test, measure the average and maximum power of the packet sent by DUT from TC-3000C and judge Pass/Fail.

4.3.2 Carr freq offset + Mod char (preamble)

1. Object: To measure the stability level of the initial frequency and Modulation index by analyzing Data for the preamble section of the LE Packet sent by DUT.

2. Set up parameters.

Parameter	DUT	TC-3000C
BT Channels		0-12-39
Payload Length(octets)		0 ~ 255
Number of packets		2



3. Measurement Method
   A. In the test case of TC-3000, select the Select Carr freq offset + Mod char (preamble) and press Edit key .
   B. Set up TC-3000C similar to the setting done in Step 2.
   C. Set DUT to send TX signal to the Advertising Channel.
   D. On TC-3000C, select Start to start the test.
   E. When testing is completed, check the measurement result on TC-3000C.

4.4 Use of Measurement

In Non-Signaling test, the user can check the spectrum, FM Mod, and Power-Time characteristics. For details, see 2.4 Use of Measurement

PART 3. Programming Guide

5. Programming Guide

To test the Bluetooth low energy, RS-232C commands are used to control TC-3000C remotely.

Remote Control through RS-232C (Host)

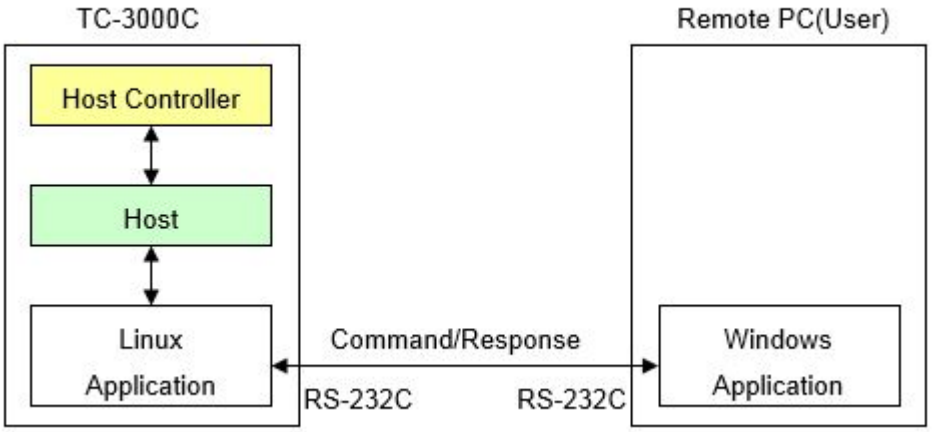


Figure 5-1 Remote Control through RS-232C(Host)

System Requirements

The following development environment is necessary for the development of an application program:

- OS: Microsoft Windows, ME, 2000, XP, Vista, Windows 7
- Development Tool: Microsoft Visual C++.NET, Visual C++, Visual Basic, Boland C++ Builder, National Instrument LabWindows/CVI, LabView, etc.

5.1 Basic Guide to RS-232C Commands

All RS-232C commands sent to the measurement device shall end with <new line> characters. In this case, the measurement device will send the response message with <carriage return> and <new line> in a sequential manner. All commands are basically processed after the response is received except when “EXEC:STOP” is used.

RS-232C Data Transmission Directioon	Command and Response(example)	Description
PC → TC-3000C	“EXEC:RESET₩n”	"₩n" is for new line or line feed
TC-3000C → PC	“OK₩r₩n”	"₩r" is for carriage return

In case development is done on VC^{++}6.0, if the user program sends the “EXEC:RESET₩n” command, the measurement device will reply “OK₩r₩n” after normal execution. “₩n” refers to a “new line,” and it is expressed as “0x0A.” Similarly, “₩r” refers to “carriage return”; it is expressed as “0x0D.”

In case of VB6 user, if the “EXEC:RESET” & Chr (10) command is sent, the measurement device will reply “OK” & Chr (13) & Chr (10) after normal execution. Chr (10) refers to “new line,” and it is expressed as “0x0A.” Similarly, Chr (13) refers to “carriage return”; it is expressed as “0x0D.” For details, see the sample program.

5.1.1 RS-232C Connection Method

To control the measurement device using RS-232C, the user is advised to use the RS-232C cable included in the package. Otherwise, configure the connection as shown below.

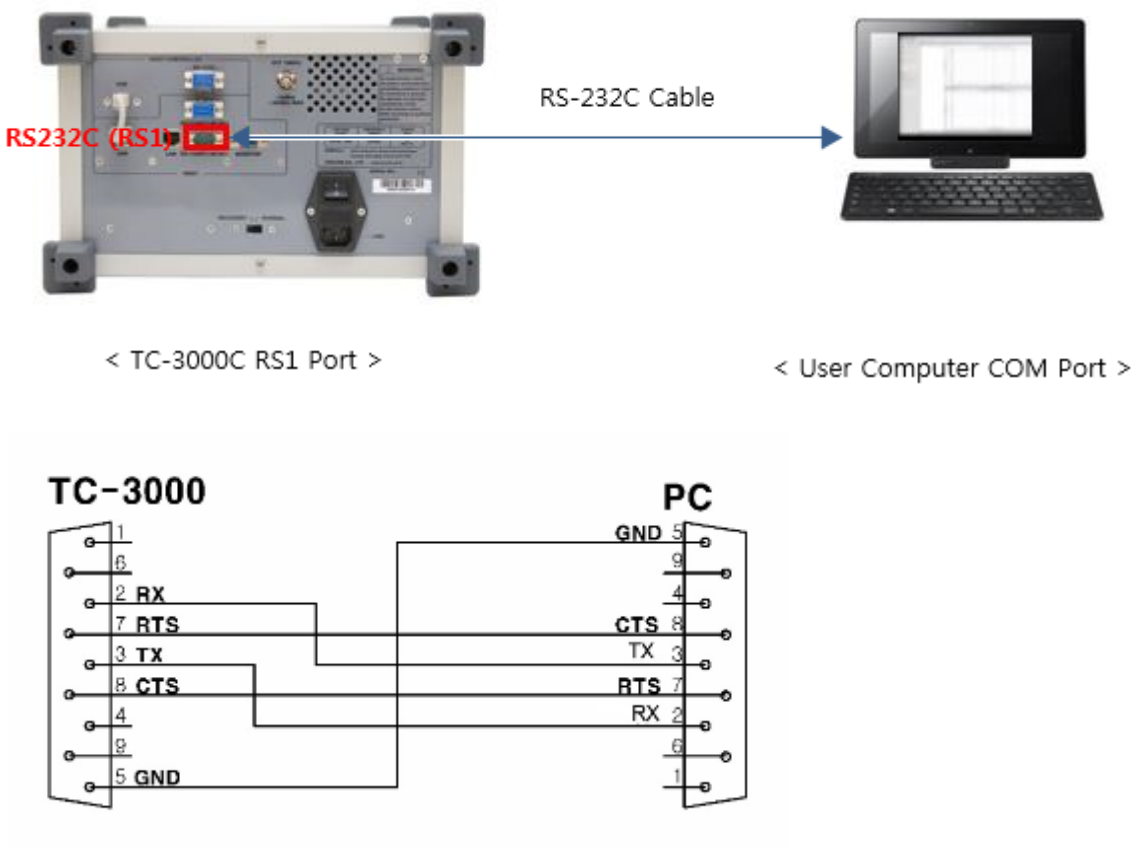


Figure 5-2 RS-232C Cabling Method

5.1.2 RS-232C Setup Method

1. MENU -> Configuration -> Network(M5) -> More1/3(F8)

2. Set up TC-3000C as shown below and check the connection status using the Hyper Terminal.

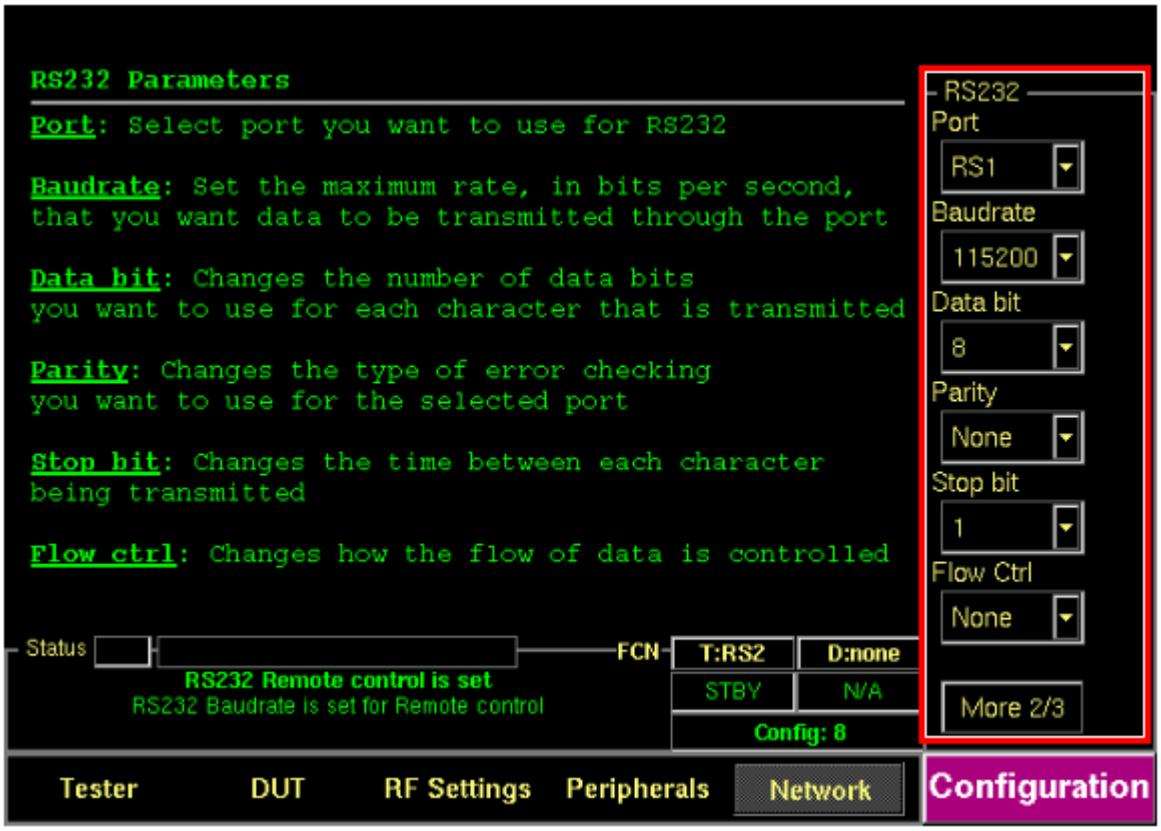


Table 5-1 TC-3000C RS232 Setting

Parameter	Value
Port	RS1
Baudrate	115200
Data bit	8
Parity	None
Stop bit	1
Flow Ctrl	None

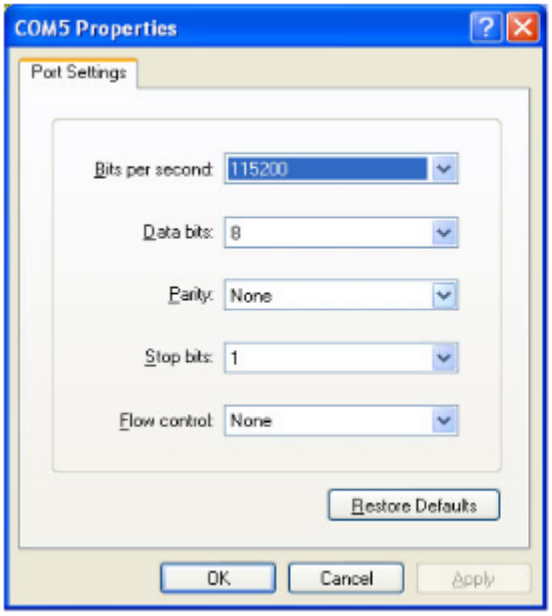
NOTICE

* In most cases, Flow Ctrl (Flow Control) is “None.” If necessary, however, set flow control to “RTSCTS” to prevent data loss. In this case, the user program must be set up accordingly.

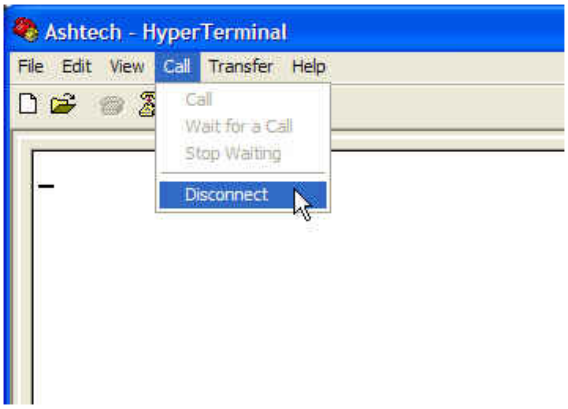
5.1.3 RS-232C Connection Status Checking Method

To check the connection status between PC and TC-3000C, use the Hyper Terminal Program provided by Microsoft Windows.

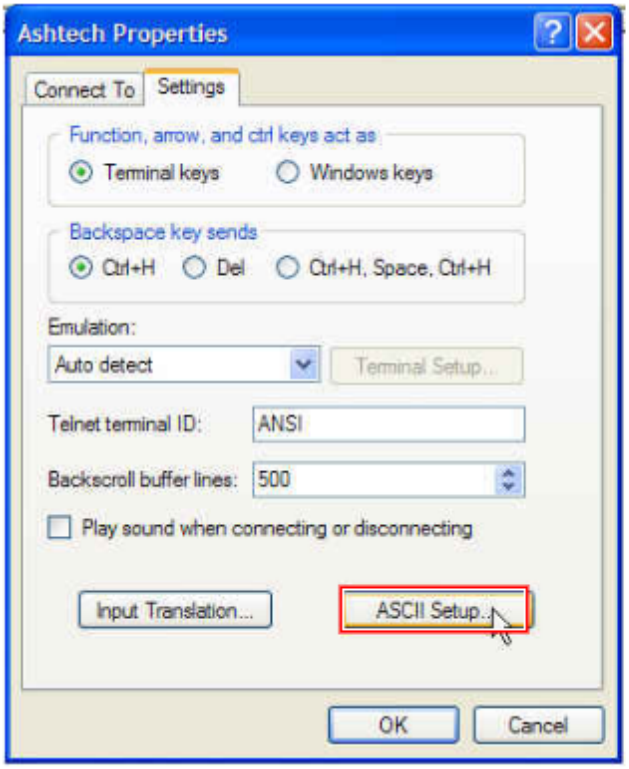
1. Select Start -> Program -> Auxiliary Programs -> Communication -> Hyper Terminal.
2. Enter “RS-232C Test” in the New Connection field and click OK.
3. Set up the modem to use and select OK.
4. Set up the port as shown below and click OK.



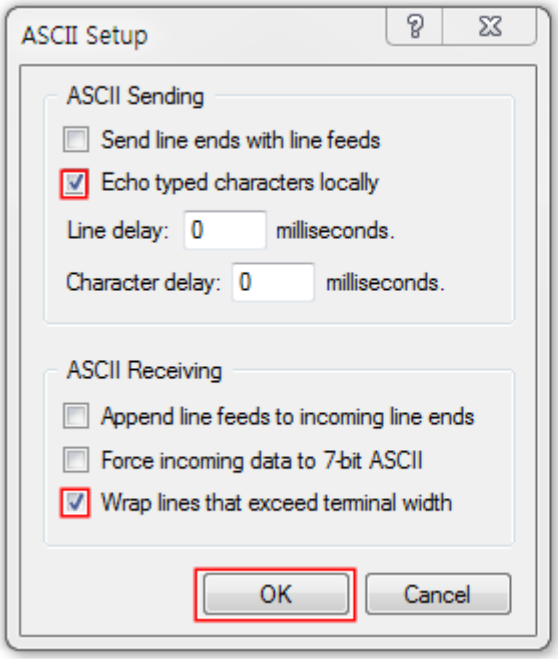
5. Select Call - Disconnect.



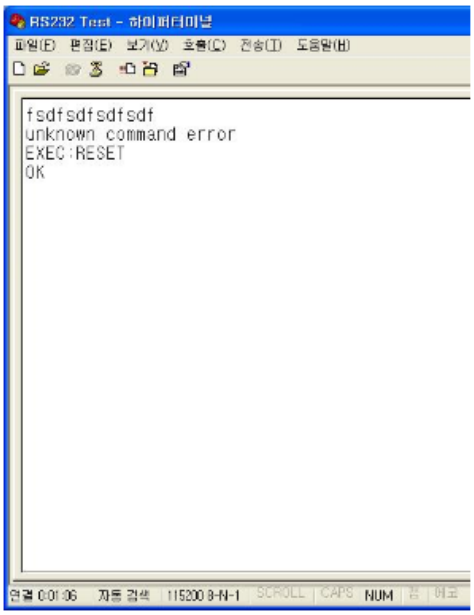
6. Select File -> Properties and Setting tab. Afterward, click the ASCII Setup button.



7. Select Add Line Feed (Line Feed) to the End of the Line and Display Inputted Characters.



8. Type any character and press Enter. In normal connection, an unknown command error must be displayed as a response message. If a command such as EXEC:RESET is inputted, and Enter is pressed, an OK response message will be displayed.


RS232 Test - 하이퍼터미널
파일(F) 편집(E) 보기(V) 호출(C) 전송(T) 도움말(H)
fsdfsdfsdfsdf
unknown command error
EXEC:RESET
OK
연결 0:01:06 자동 감지 115200 8-N-1 SCROLL CAPS NUM 캡 에코

5.1.4 Notes on RS-232C Commands

1. In most simple setup commands (e.g., “CONF:SYS:TESTER:L2CAP_TO 5000”), the response message (“OK”) will be immediately displayed. For commands that try to connect to DUT (e.g., “EXEC:RFTC:”), the response message (“OK”) will arrive after the connection is established. Therefore, the user must receive the response message and the ending characters (“₩r₩n”) for such command before sending the next command.

2. To cancel the command that has already been sent, use the “EXEC:STOP” command. In this case, two types of response message may arrive; further processing depends on the response message type.
   - In case “EXEC:STOP” is sent after a response to the command is received: The “OK” response will immediately arrive.
   - In case “EXEC:STOP” is sent while the command is being executed, and no response has arrived: “OK” as a response to EXEC:STOP will arrive; the command execution will be canceled, and the “User Terminated Process” message will be displayed.

3. In case the user sends a command whose execution takes a while such as “EXEC:RFTC:OP:RUN” and sends the same command again before receiving a response, “Still Working! Please wait!” will be displayed for the second command. After the first command is normally executed, an “OK” message will arrive.

4. The user may directly write the production program using the application program timer. For example, if trouble occurs in DUT with L2CAP Timeout set to five seconds (default), L2CAP timeout will occur after five seconds. Assuming that a normal DUT establishes connection within three seconds, however, the user may change the timeout setting to three seconds. In case connection is not made within 3 seconds, the “EXEC:STOP” command will be sent, and Fail will be judged with connection error as the cause.

5. To get the measurement result, the user must send the RUN command and READ command. For example, to get three measurements, a pair of RUN and READ must be sent three times. For example, “EXEC:RFTC:OP:RUN” must be sent first, and “READ:RFTC:OP:P_AVG?” must be sent later. To read the result, the user must send “EXEC:RFTC:OP:RUN” and “READ:RFTC:OP:P_AVG?”

5.2 Low Energy Command List

5.2.1 Configuration Command

1. READ:SYS:DUT:DUT_TYPE?
   - Definition: Read the DUT type to test.
   - Response: GENERAL, BT, BT_LE

2. CONF:SYS:DUT:DUT_TYPE <Value>
   - Definition: Set up the DUT type to test.
   - Value: GENERAL, BT, BT_LE

3. READ:CONN_DUT_BD_ADDR?
   - Definition: By using 'HCI Port'(USB, UART) to read BD address of the BLE DUT. (TC-3000C firmware version 3.50 or later)
   - Response: String, No data availbale

4. READ:SYS:DUT:LE_TEST_METHOD?
   - Definition: Read the test status during the BT LE test.
   - Response: TEST_MODE, ADVERTISING_MODE

5. CONF:SYS:DUT:LE_TEST_METHOD <Value>
   - Definition: Set up the test status during the BT LE test.
   - Value: TEST_MODE, ADVERTISING_MODE

6. READ:SYS:TESTER:HCI_TO?
   - Definition: Read the timeout of HCI command language every millisecond.
   - Response : 1 ~ 65535

7. CONF:SYS:TESTER:HCI_TO
   - Definition: Set the timeout of HCI command language every millisecond.
   - Value : 1 ~ 65535, 2000(default)

8. READ:SYS:DUT:HCI_TYPE?
   - Definition: Read the type of DUT's HCI transport layer and port number.
   - Response : None(default), USB1, USB2, RS1, RS2, UART1, UART2, 2WIRE1, 2WIRE2, BCSP1, BCSP2

9. CONF:SYS:DUT:HCI_TYPE
   - Definition : Set the type of DUT's HCI transport layer and port number.
   - Value : None(default), USB1, USB2, RS1, RS2, UART1, UART2, 2WIRE1, 2WIRE2, BCSP1, BCSP2

10. READ:SYS:DUT:PATH_LOSS?
    - Definition : Read the path loss
    - Response : 0 ~ 80, 0(defalult)

11. CONF:SYS:DUT:PATH_LOSS
    - Definition : Setup the path loss
    - Value : 0 ~ 80, 0(default)

12. READ:SYS:DUT:BAUDRATE?
    - Definition: Read the transfer rate according to DUT's HCI transport layer type.
    - Response : 2400 ~ 115200

13. CONF:SYS:DUT:BAUDRATE
    - Definition: Set up the transfer rate according to DUT's HCI transport layer type; may be set only in case of UART or BCSP, 2WIRE
    - Value : 2400 ~ 115200

14. READ:SYS:DUT:IGNORE_FLOWCTRL?
    - Definition: Read the 'Ignore_flowctrl' parameter
    - Response : ON, OFF

15. CONF:SYS:DUT:IGNORE_FLOWCTRL
    - Definition: When the tester send 'le_transmitter_test' or 'le_receive_test' command, 'Num_HCI_Command_Packet(zero)' parameters corresponding value to 'command Complete Event' is set to be effective or disregarded. (TC-3000C firmware version 3.50 or later and TI CC254X BLE Software Stack users should set this parameter "ON") Value : ON, OFF
    - ON: Operates via parameter
    - OFF: disregards the parameter

The commands that contain "LE" is exclusive commands for BT_LE. If DUT_TYPE value is BT or GENERAL, "unknown command error" message will be returned. DUT_TYPE has to be changed to BT_LE before using commands that contains "LE".
(`CONF:SYS:DUT:DUT_TYPE BT_LE`)

5.2.2 Output Power(OP) Command

1. EXEC:LE_RFTC:OP:RUN
    - Definition: Start the test. Measure the maximum and average output power.

2. EXEC:LE_RFTC:OP:STOP

- Definition: Stop the test.

3. READ:LE_RFTC:OP:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:OP:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:OP:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:OP:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:OP:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:OP:PACK_NUM <Value>
   - Definition: Set up the test packet count.
   - Value: 1 (Default)

9. READ:LE_RFTC:OP:P_AVG?
   - Definition: Read the average power.

10. READ:LE_RFTC:OP:P_MIN?
    - Definition: Read the minimum power.

11. READ:LE_RFTC:OP:P_MAX?
    - Definition: Read the maximum power.

5.2.3 In-band Emissions(IBE) Command

1. EXEC:LE_RFTC:IBE:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:IBE:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:IBE:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:IBE:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~37, 2-19-37 (Default)

5. READ:LE_RFTC:IBE:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:IBE:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:IBE:SWP_NUM?
   - Definition: Read the test sweep count.

8. CONF:LE_RFTC:IBE:SWP_NUM <Value>
   - Definition: Set up the test sweep count.
   - Value: 10 (Default)

9. READ:LE_RFTC:IBE:P_TX?
   - Definition: Read the power for the reference frequency.

5.2.4 In-band Emissions(IBE_2M) at 2Ms/s Command

1. EXEC:LE_RFTC:IBE_2M:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:IBE_2M:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:IBE_2M:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:IBE_2M:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~37, 2-19-37 (Default)

5. READ:LE_RFTC:IBE_2M:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:IBE_2M:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:IBE_2M:SWP_NUM?
   - Definition: Read the test sweep count.

8. CONF:LE_RFTC:IBE_2M:SWP_NUM <Value>
   - Definition: Set up the test sweep count.
   - Value: 10 (Default)

9. READ:LE_RFTC:IBE_2M:P_TX?
   - Definition: Read the power for the reference frequency.

5.2.5 Modulation Characteristics(MOD) Command

5.2.5.1 Modulation Characteristics(MOD) Command

1. EXEC:LE_RFTC:MOD:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:MOD:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:MOD:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MOD:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MOD:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MOD:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:MOD:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MOD:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 10 (Default)

9. READ:LE_RFTC:MOD:DF1_AVG?
   - Definition: Read the average of Δf1 measurement.

10. READ:LE_RFTC:MOD:DF2_AVG?
    - Definition: Read the average of Δf2 measurement.

11. READ:LE_RFTC:MOD:DF2_MIN?
    - Definition: Read the minimum of Δf2 measurement.

12. READ:LE_RFTC:MOD:DF2_RATE?
    - Definition: Read the frequency in which the maximum of Δf2 measurement passes the specifications.

5.2.5.2 Stable Modulation Characteristics, uncoded data at 1Ms/s (MOD_SMI) Command

1. EXEC:LE_RFTC:MOD_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:MOD_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:MOD_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MOD_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MOD_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MOD_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:MOD_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MOD_SMI:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 10 (Default)

9. READ:LE_RFTC:MOD_SMI:DF1_AVG?
    - Definition: Read the average of Δf1 measurement.

10. READ:LE_RFTC:MOD_SMI:DF2_AVG?

- Definition: Read the average of Δf2 measurement.

11. READ:LE_RFTC:MOD_SMI:DF2_MIN?
    - Definition: Read the minimum of Δf2 measurement.

12. READ:LE_RFTC:MOD_SMI:DF2_RATE?
    - Definition: Read the frequency in which the maximum of Δf2 measurement passes the specifications.

5.2.5.3 Modulation Characteristics at 2Ms/s (MOD_2M) Command

1. EXEC:LE_RFTC:MOD_2M:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:MOD_2M:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:MOD_2M:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MOD_2M:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MOD_2M:PLD_LEN?
    - Definition: Read the length of payload’s data.

6. CONF:LE_RFTC:MOD_2M:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:MOD_2M:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MOD_2M:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 10 (Default)

9. READ:LE_RFTC:MOD_2M:DF1_AVG?
    - Definition: Read the average of Δf1 measurement.

10. READ:LE_RFTC:MOD_2M:DF2_AVG?
    - Definition: Read the average of Δf2 measurement.

11. READ:LE_RFTC:MOD_2M:DF2_MIN?
    - Definition: Read the minimum of Δf2 measurement.

12. READ:LE_RFTC:MOD_2M:DF2_RATE?
    - Definition: Read the frequency in which the maximum of Δf2 measurement passes the specifications.

5.2.5.4 Stable Modulation Characteristics at 2Ms/s (MOD_2M_SMI) Command

1. EXEC:LE_RFTC:MOD_2M_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:MOD_2M_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:MOD_2M_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MOD_2M_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MOD_2M_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MOD_2M_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:MOD_2M_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MOD_2M_SMI:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 10 (Default)

9. READ:LE_RFTC:MOD_2M_SMI:DF1_AVG?
    - Definition: Read the average of Δf1 measurement.

10. READ:LE_RFTC:MOD_2M_SMI:DF2_AVG?
    - Definition: Read the average of Δf2 measurement.

11. READ:LE_RFTC:MOD_2M_SMI:DF2_MIN?

- Definition: Read the minimum of Δf2 measurement.

12. READ:LE_RFTC:MOD_2M_SMI:DF2_RATE?
    - Definition: Read the frequency in which the maximum of Δf2 measurement passes the specifications.

5.2.5.5 Modulation Characteristics, LE Coded (S=8) (MOD_CS8) Command

1. EXEC:LE_RFTC:MOD_CS8:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:MOD_CS8:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:MOD_CS8:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MOD_CS8:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MOD_CS8:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MOD_CS8:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:MOD_CS8:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MOD_CS8:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 10 (Default)

9. READ:LE_RFTC:MOD_CS8:DF1_AVG?
    - Definition: Read the average of Δf1 measurement.

10. READ:LE_RFTC:MOD_CS8:DF1_MIN?
    - Definition: Read the minimum of Δf1 measurement.

11. READ:LE_RFTC:MOD_CS8:DF1_RATE?
    - Definition: Read the frequency in which the maximum of Δf1 measurement passes the specifications.

5.2.6 Carrier Firquency Offset and Drift(CFOD) Command

5.2.6.1 Carrier frequency offset and drift, uncoded data at 1 Ms/s (CFOM) Command

1. EXEC:LE_RFTC:CFOD:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:CFOD:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:CFOD:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:CFOD:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:CFOD:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:CFOD:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:CFOD:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:CFOD:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 10 (Default)

9. READ:LE_RFTC:CFOD:FTX_FN?
   - Definition: Read FTX-FN for the transmission frequency of DUT.

10. READ:LE_RFTC:CFOD:F0_FN?
    - Definition: Read F1-F0 for the transmission frequency of DUT.

11. READ:LE_RFTC:CFOD:F1_F0?
    - Definition: Read F1-f0 for the transmission frequency of DUT.

12. READ:LE_RFTC:CFOD:FN_FN5?
    - Definition: Read fn -fn-5 for the transmission frequency of DUT.

5.2.6.2 Carrier frequency offset and drift, LE Coded (S=8) (CFOD_CS8) Command

1. EXEC:LE_RFTC:CFOD_CS8:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:CFOD_CS8:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:CFOD_CS8:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:CFOD_CS8:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:CFOD_CS8:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:CFOD_CS8:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:CFOD_CS8:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:CFOD_CS8:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 10 (Default)

9. READ:LE_RFTC:CFOD_CS8:FTX_FN?
   - Definition: Read FTX-FN for the transmission frequency of DUT.

10. READ:LE_RFTC:CFOD_CS8:F0_FN?
    - Definition: Read F1-F0 for the transmission frequency of DUT.

11. READ:LE_RFTC:CFOD_CS8:F0_F3?
    - Definition: Read F0-f3 for the transmission frequency of DUT.

12. READ:LE_RFTC:CFOD_CS8:FN_FN3?
    - Definition: Read fn -fn-3 for the transmission frequency of DUT.

5.2.7 Sensitivity(SENS) Command

5.2.7.1 Receiver sensitivity, uncoded data at 1 Ms/s (SENS)

1. EXEC:LE_RFTC:SENS:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:SENS:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:SENS:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:SENS:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:SENS:DIRTY_TX?
   - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.

- Value: -70 (Default)

13. READ:LE_RFTC:SENS:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.2 Receiver sensitivity, at 2 Ms/s (SENS_2M)

1. EXEC:LE_RFTC:SENS_2M:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:SENS_2M:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:SENS_2M:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_2M:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_2M:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_2M:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:SENS_2M:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_2M:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_2M:DIRTY_TX?
    - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_2M:DIRTY_TX <Value>

- Definition: Set up the dirty mode in the tester.
- Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_2M:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_2M:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -70 (Default)

13. READ:LE_RFTC:SENS_2M:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_2M:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_2M:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.3 Receiver sensitivity, uncoded data at 1Ms/s, Stable Modulation Index (SENS_UC_SMI)

1. EXEC:LE_RFTC:SENS_UC_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:SENS_UC_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:SENS_UC_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_UC_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_UC_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_UC_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:SENS_UC_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_UC_SMI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_UC_SMI:DIRTY_TX?
   - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_UC_SMI:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_UC_SMI:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_UC_SMI:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -70 (Default)

13. READ:LE_RFTC:SENS_UC_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_UC_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_UC_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.4 Receiver sensitivity at 2Ms/s, Stable Modulation Index (SENS_2M_SMI)

1. EXEC:LE_RFTC:SENS_2M_SMI:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:SENS_2M_SMI:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:SENS_2M_SMI:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_2M_SMI:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_2M_SMI:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_2M_SMI:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:SENS_2M_SMI:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_2M_SMI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_2M_SMI:DIRTY_TX?
   - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_2M_SMI:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_2M_SMI:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_2M_SMI:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -70 (Default)

13. READ:LE_RFTC:SENS_2M_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_2M_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_2M_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.5 Receiver sensitivity, LE Coded (S=2) (SENS_CS2)

1. EXEC:LE_RFTC:SENS_CS2:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:SENS_CS2:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:SENS_CS2:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_CS2:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_CS2:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_CS2:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:SENS_CS2:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_CS2:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_CS2:DIRTY_TX?
   - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_CS2:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_CS2:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_CS2:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -75 (Default)

13. READ:LE_RFTC:SENS_CS2:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_CS2:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_CS2:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.6 Receiver sensitivity, LE Coded (S=8) (SENS_CS8)

1. EXEC:LE_RFTC:SENS_CS8:RUN

- Definition: Start the test.

2. EXEC:LE_RFTC:SENS_CS8:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:SENS_CS8:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_CS8:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_CS8:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_CS8:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:SENS_CS8:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_CS8:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_CS8:DIRTY_TX?
   - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_CS8:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_CS8:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_CS8:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -80 (Default)

13. READ:LE_RFTC:SENS_CS8:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_CS8:PACK_SENT?

- Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_CS8:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.7 Receiver sensitivity, LE Coded (S=2), Stable Modulation Index (SENS_CS2_SMI)

1. EXEC:LE_RFTC:SENS_CS2_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:SENS_CS2_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:SENS_CS2_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_CS2_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_CS2_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_CS2_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:SENS_CS2_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_CS2_SMI:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_CS2_SMI:DIRTY_TX?
    - Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_CS2_SMI:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_CS2_SMI:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_CS2_SMI:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -75 (Default)

13. READ:LE_RFTC:SENS_CS2_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_CS2_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_CS2_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.7.8 Receiver sensitivity, LE Coded (S=8), Stable Modulation Index (SENS_CS8_SMI)

1. EXEC:LE_RFTC:SENS_CS8_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:SENS_CS8_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:SENS_CS8_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:SENS_CS8_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:SENS_CS8_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:SENS_CS8_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:SENS_CS8_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:SENS_CS8_SMI:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 1500 (Default)

9. READ:LE_RFTC:SENS_CS8_SMI:DIRTY_TX?

- Definition: Read the dirty mode in the tester.

10. CONF:LE_RFTC:SENS_CS8_SMI:DIRTY_TX <Value>
    - Definition: Set up the dirty mode in the tester.
    - Value: ON (Default), OFF

11. READ:LE_RFTC:SENS_CS8_SMI:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit.

12. CONF:LE_RFTC:SENS_CS8_SMI:RX_LEV
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit.
    - Value: -80 (Default)

13. READ:LE_RFTC:SENS_CS8_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

14. READ:LE_RFTC:SENS_CS8_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.

15. READ:LE_RFTC:SENS_CS8_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.8 Maximum Input Signal Level(MISL) Command

5.2.8.1 Maximum input signal level, uncoded data at 1Ms/s (MISL)

1. EXEC:LE_RFTC:MISL:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:MISL:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:MISL:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MISL:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MISL:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MISL:PLD_LEN <Value>

- Definition: Set up the length of payload's data.
- Value: 0~255, 37 (Default)

7. READ:LE_RFTC:MISL:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MISL:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:MISL:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (tester의 TX power)

10. CONF:LE_RFTC:MISL:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -10 (Default)

11. READ:LE_RFTC:MISL:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:MISL:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:MISL:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.8.2 Maximum input signal level at 2Ms/s (MISL_2M)

1. EXEC:LE_RFTC:MISL_2M:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:MISL_2M:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:MISL_2M:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MISL_2M:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MISL_2M:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MISL_2M:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:MISL_2M:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MISL_2M:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:MISL_2M:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (tester의 TX power)

10. CONF:LE_RFTC:MISL_2M:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -10 (Default)

11. READ:LE_RFTC:MISL_2M:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:MISL_2M:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:MISL_2M:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.8.3 Maximum input signal level, uncoded data at 1Ms/s, Stable Modulation Index (MISL_UC_SMI)

1. EXEC:LE_RFTC:MISL_UC_SMI:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:MISL_UC_SMI:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:MISL_UC_SMI:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MISL_UC_SMI:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MISL_UC_SMI:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MISL_UC_SMI:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:MISL_UC_SMI:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MISL_UC_SMI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:MISL_UC_SMI:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (tester의 TX power)

10. CONF:LE_RFTC:MISL_UC_SMI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -10 (Default)

11. READ:LE_RFTC:MISL_UC_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:MISL_UC_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:MISL_UC_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.8.4 Maximum input signal level at 2Ms/s, Stable Modulation Index (MISL_2M_SMI)

1. EXEC:LE_RFTC:MISL_2M_SMI:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:MISL_2M_SMI:STOP

- Definition: Stop the test.

3. READ:LE_RFTC:MISL_2M_SMI:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:MISL_2M_SMI:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:MISL_2M_SMI:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:MISL_2M_SMI:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:MISL_2M_SMI:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:MISL_2M_SMI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:MISL_2M_SMI:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (tester의 TX power)

10. CONF:LE_RFTC:MISL_2M_SMI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -10 (Default)

11. READ:LE_RFTC:MISL_2M_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:MISL_2M_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:MISL_2M_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9 PER Report Integrity(PRI) Command

5.2.9.1 PER Report Integrity, uncoded data at 1 Ms/s(PRI) Command

1. EXEC:LE_RFTC:PRI:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:PRI:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:PRI:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:PRI:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:PRI:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.2 PER Report Integrity at 2Ms/s (PRI_2M) Command

1. EXEC:LE_RFTC:PRI_2M:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_2M:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:PRI_2M:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_2M:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_2M:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI_2M:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:PRI_2M:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_2M:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 1500 (Default)

9. READ:LE_RFTC:PRI_2M:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_2M:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_2M:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_2M:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_2M:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.3 PER Report Integrity, uncoded data at 1Ms/s, Stable Modulation Index (PRI_UC_SMI) Command

1. EXEC:LE_RFTC:PRI_UC_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_UC_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:PRI_UC_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_UC_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_UC_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI_UC_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:PRI_UC_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_UC_SMI:PACK_NUM <Value>
    - Definition: Read the number of packets tested.
    - Value: 1500 (Default)

9. READ:LE_RFTC:PRI_UC_SMI:RX_LEV?
    - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_UC_SMI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_UC_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_UC_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_UC_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.4 PER Report Integrity at 2Ms/s, Stable Modulation Index (PRI_2M_SMI) Command

1. EXEC:LE_RFTC:PRI_2M_SMI:RUN
    - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_2M_SMI:STOP
    - Definition: Stop the test.

3. READ:LE_RFTC:PRI_2M_SMI:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_2M_SMI:CH <Value>
    - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
    - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_2M_SMI:PLD_LEN?
    - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI_2M_SMI:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:PRI_2M_SMI:PACK_NUM?
    - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_2M_SMI:PACK_NUM <Value>
    - Definition: Read the number of packets tested.

- Value: 1500 (Default)

9. READ:LE_RFTC:PRI_2M_SMI:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_2M_SMI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_2M_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_2M_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_2M_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.5 PER Report Integrity, LE Coded (S=2) (PRI_CS2) Command

1. EXEC:LE_RFTC:PRI_CS2:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_CS2:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:PRI_CS2:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_CS2:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_CS2:PLD_LEN?
   - Definition: Read the length of payload’s data.

6. CONF:LE_RFTC:PRI_CS2:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:PRI_CS2:PACK_NUM?

- Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_CS2:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:PRI_CS2:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_CS2:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_CS2:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_CS2:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_CS2:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.6 PER Report Integrity, LE Coded (S=8) (PRI_CS8) Command

1. EXEC:LE_RFTC:PRI_CS8:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_CS8:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:PRI_CS8:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_CS8:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_CS8:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI_CS8:PLD_LEN <Value>

- Definition: Set up the length of payload's data.
- Value: 0~255, 31 (Default)

7. READ:LE_RFTC:PRI_CS8:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_CS8:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:PRI_CS8:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_CS8:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_CS8:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_CS8:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_CS8:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.7 PER Report Integrity, LE Coded (S=2), Stable Modulation Index (PRI_CS2_SMI) Command

1. EXEC:LE_RFTC:PRI_CS2_SMI:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_CS2_SMI:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:PRI_CS2_SMI:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_CS2_SMI:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_CS2_SMI:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI_CS2_SMI:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:PRI_CS2_SMI:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_CS2_SMI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:PRI_CS2_SMI:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_CS2_SMI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_CS2_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_CS2_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_CS2_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.9.8 PER Report Integrity, LE Coded (S=8), Stable Modulation Index (PRI_CS8_SMI) Command

1. EXEC:LE_RFTC:PRI_CS8_SMI:RUN
   - Definition: Start the test.

2. EXEC:LE_RFTC:PRI_CS8_SMI:STOP
   - Definition: Stop the test.

3. READ:LE_RFTC:PRI_CS8_SMI:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:PRI_CS8_SMI:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:PRI_CS8_SMI:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:PRI_CS8_SMI:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 31 (Default)

7. READ:LE_RFTC:PRI_CS8_SMI:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:PRI_CS8_SMI:PACK_NUM <Value>
   - Definition: Read the number of packets tested.
   - Value: 1500 (Default)

9. READ:LE_RFTC:PRI_CS8_SMI:RX_LEV?
   - Definition: The receiving end of DUT reads the reception power in 0.01dBm unit. (TX power of the tester)

10. CONF:LE_RFTC:PRI_CS8_SMI:RX_LEV <Value>
    - Definition: The receiving end of DUT sets up the reception power in 0.01dBm unit. (TX power of the tester)
    - Value: -30 (Default)

11. READ:LE_RFTC:PRI_CS8_SMI:PER?
    - Definition: Read the Packet Error Rate (PER).

12. READ:LE_RFTC:PRI_CS8_SMI:PACK_SENT?
    - Definition: Read the number of packets sent by the tester for the PER test.
    - Value: 1500 (Default)

13. READ:LE_RFTC:PRI_CS8_SMI:PACK_RCVD?
    - Definition: Read the number of packets normally received among the packets sent by the tester.

5.2.10 Quick(OPMOD) Command

1. EXEC:LE_RFTC:OPMOD:RUN
   - Definition: Start the test. Measure the maximum and average output power.

2. EXEC:LE_RFTC:OPMOD:STOP

- Definition: Stop the test.

3. READ:LE_RFTC:OPMOD:CH?
   - Definition: Read the channel received by the tester. (Transmission channel of DUT)

4. CONF:LE_RFTC:OPMOD:CH <Value>
   - Definition: Set up the channel received by the tester. (Transmission channel of DUT)
   - Value: 0~39, 0-19-39 (Default)

5. READ:LE_RFTC:OPMOD:PLD_LEN?
   - Definition: Read the length of payload's data.

6. CONF:LE_RFTC:OPMOD:PLD_LEN <Value>
   - Definition: Set up the length of payload's data.
   - Value: 0~255, 37 (Default)

7. READ:LE_RFTC:OPMOD:PACK_NUM?
   - Definition: Read the number of packets tested.

8. CONF:LE_RFTC:OPMOD:PACK_NUM <Value>
   - Definition: Set up the test packet count.
   - Value: 2 (Default)

9. READ:LE_RFTC:OPMOD:P_AVG?
   - Definition: Read the average power.

10. READ:LE_RFTC:OPMOD:P_MIN?
    - Definition: Read the minimum power.

11. READ:LE_RFTC:OPMOD:P_MAX?
    - Definition: Read the maximum power.

12. READ:LE_RFTC:OPMOD:DF1_AVG?
    - Definition: Read the average of Δf1 measurement.

13. READ:LE_RFTC:OPMOD:DF2_AVG?
    - Definition: Read the average of Δf2 measurement.

14. READ:LE_RFTC:OPMOD:DF2_MIN?
    - Definition: Read the minimum of Δf2 measurement.

15. READ:LE_RFTC:OPMOD:DF2_RATE?
    - Definition: Read the frequency in which the maximum of Δf2 measurement passes the specifications.

16. READ:LE_RFTC:OPMOD:FTX_FN?
    - Definition: Read RTX_FN for the transmission frequency of DUT.

17. READ:LE_RFTC:OPMOD:F0_FN?
    - Definition: Read F1-F0 for the transmission frequency of DUT.

18. READ:LE_RFTC:OPMOD:F1_F0?
    - Definition: Read F1-f0 for the transmission frequency of DUT.

19. READ:LE_RFTC:OPMOD:FN_FN5?
    - Definition: Read fn -fn-5 for the transmission frequency of DUT.

5.2.11 Carr freq offset + Mod char(preamble)

1. EXEC:LE_RFTC:CFOM:RUN
    - Definition : Start the test.

2. EXEC:LE_RFTC:CFOM:STOP
    - Definition : Stop the test.

3. READ:LE_RFTC:CFOM:PLD_LEN?
    - Definition: Read the length of payload's data.

4. CONF:LE_RFTC:CFOM:PLD_LEN <Value>
    - Definition: Set up the length of payload's data.
    - Value: 0~255, 37 (Default)

5. READ:LE_RFTC:CFOM:PACK_NUM?
    - Definition : Read the number of packets tested.

6. CONF:LE_RFTC:CFOM:PACK_NUM <Value>
    - Definition : Set up the test packet count
    - Value : 2(Default)

7. READ:LE_RFTC:CFOM:CH?
    - Definition: Read the channel received by the tester. (Transmission channel of DUT)

8. CONF:LE_RFTC:CFOM:CH <Value>
    - Definition : Set up the channel received by the tester. (Transmission channel of DUT)
    - Value : 0~39, 0-19-39(Default)

9. READ:LE_RFTC:CFOM:DF0_MIN?
    - Definition : Read the minimum of Δf0 measurement.

10. READ:LE_RFTC:CFOM:DF0_MAX?
    - Definition : Read the maximum of Δf0 measurement

11. READ:LE_RFTC:CFOM:DF0_AVG?
    - Definition : Read the average of Δf0 measurement.

12. READ:LE_RFTC:CFOM:DF2_MIN?
    - Definition : Read the minimum of Δf2 measurement

13. READ:LE_RFTC:CFOM:DF2_AVG?
    - Definition : Read the maximum of Δf2 measurement