

# DTM Configuration Using AT Commands

## BL65x Series

Application Note

v1.0

### 1 INTRODUCTION

This application note describes how to use AT Commands to put the BL65x module in Direct Test Mode (DTM) and what commands are used for frequency selection and configuration when running a test. Refer to [Application Note – Using Direct Test Mode – BL654](#) for more background information. This note can be considered a supplement to that application note and focuses on using AT commands while referencing [Bluetooth Core Specification v 5.3 vol. 6 part F - Direct Test Mode: SIG Core Specification 5.3](#).

As described in the [BL654 Direct Test Mode application note](#), setup and configuration use a UART port and Serial terminal Utility such as UwTerminalX to enter AT commands to configure the BL65x module for DTM. Once the module is configured for DTM, the Nordic nRF Connect for Desktop Direct Test Mode tool is used to configure and control BLE radio transmit or receive tests. However, some designs may not have access to the BL65x UART port, e.g. if an external host processor in the design communicates with the module using AT commands via the UART port. This application note will describe how commands adhering to the Direct Test Mode (DTM) as specified in the Bluetooth SIG's Core Specification v 5.3 can be completed by the host processor.

Given the BL654 EVK provides a UART interface to the module via USB to Serial FTDI chip, this application note uses UwTerminalX to issue commands. The commands are the same from an application point of view and a host processor will send these same commands to the BL65x over the UART interface. DTM firmware programmed on the BL65x module is based on 2-byte sequences, so the \00\00 format that will be used in UwTerminalX is 2 raw hex bytes, which is 0x00 and 0x00 (\ is an escape sequence, \ab\cd would be 0xab and 0xcd) from a host processors perspective.

### 2 REQUIREMENTS

The following equipment and resources are needed:

- DVK-BL65x development board.
- Windows PC
- UwTerminalX by Laird Connectivity (available at <https://github.com/LairdCP/UwTerminalX/releases>)
- Bluetooth Core Specification v 5.3 vol. 6 Part F - Direct Test Mode

### 3 SETUP

Ensure the DVK-BL65x development kit has its default out-of-the-box settings as described in the DVK-BL65x User Guide. In our examples we will be working with DVK-BL654.

- [BL654 Quick Start Guide](#)
- [User Guide BL654PA DVK](#)
- [User Guide BL653 Development Kit](#)
- [User Guide BL652 Development Kit](#)

In the default out-of-the-box settings, the module is in AT or interactive mode (no smartBASIC application loaded or running) on power-up.

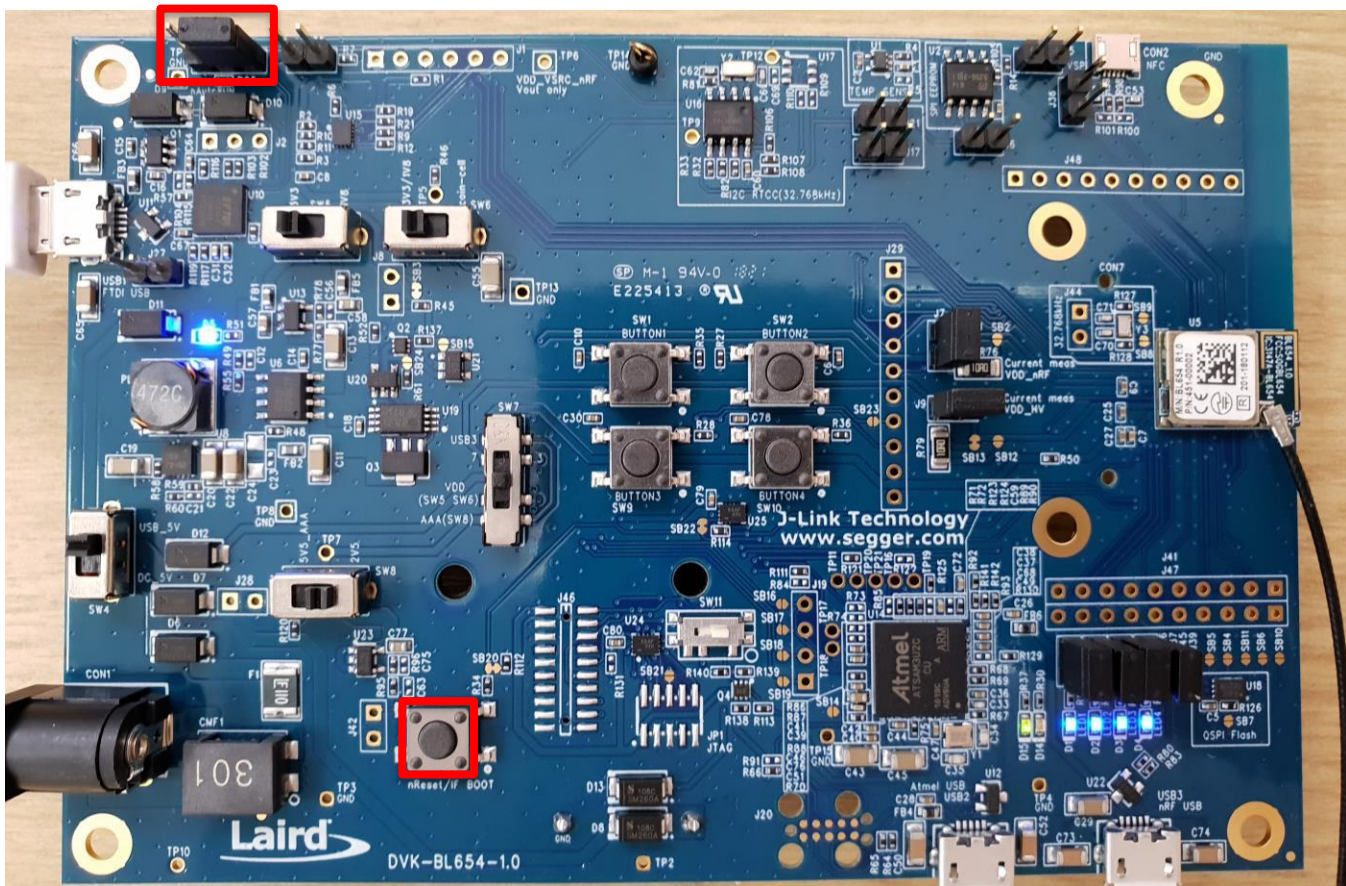


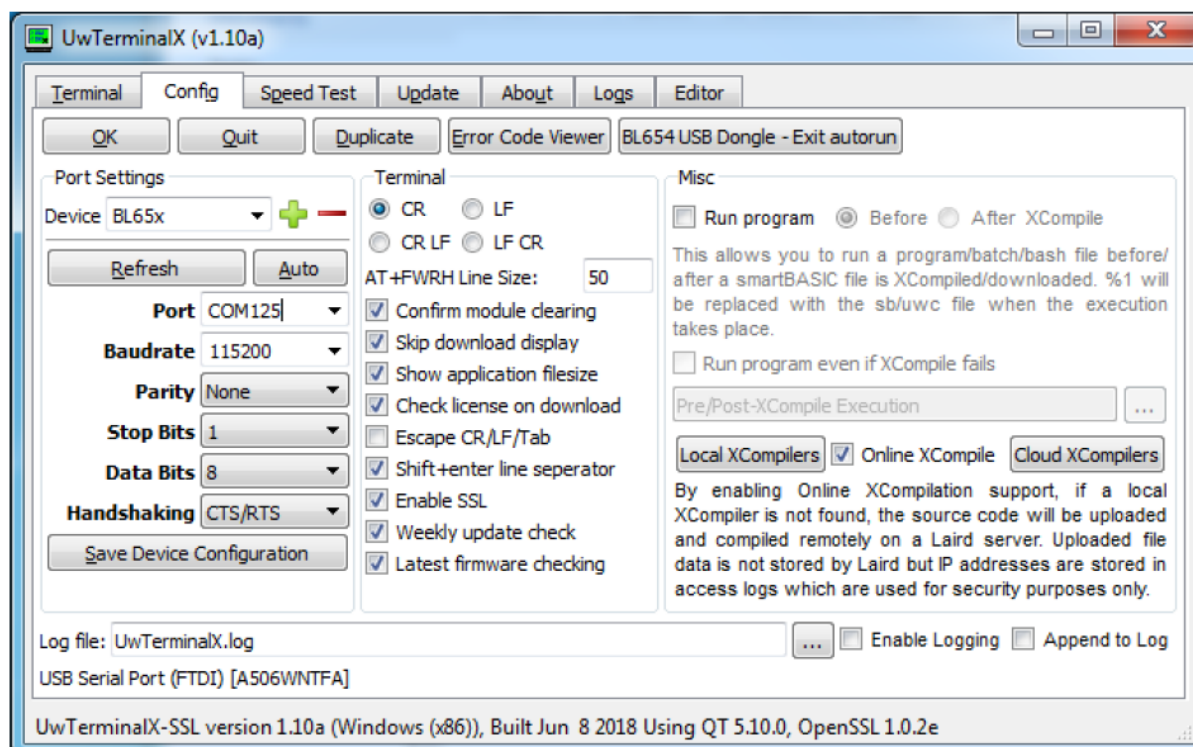
Figure 1: J12 fitted over pins 1 and 2, and SW3 (reset button)

## 4 ENTERING DIRECT TEST MODE

To enter DTM, follow these steps. As a reminder, this app note uses UwTerminalX for serial commands. Commands would be completed by a host processor over the UART interface in the same manner.

1. Open UwTerminalX.
2. Ensure you're using the latest version of UwTerminalX by clicking the Update tab and then, in the UwTerminalX panel, click **Check for Updates**.
3. When you're running the newest version of UwTerminalX, open the *Config* tab.
4. In the device drop down, select *BL65x* to populate the default communications settings.
5. Select the correct COM port. If you cannot select *BL65x*, manually select the following UART settings (shown in [Figure 2: UwTerminalX Settings](#)):

<b>COM Port</b>	Port corresponding to your development kit
<b>Baud Rate</b>	115200
<b>Parity</b>	None
<b>Stop Bits</b>	1
<b>Data Bits</b>	8
<b>Handshaking</b>	CTS/RTS

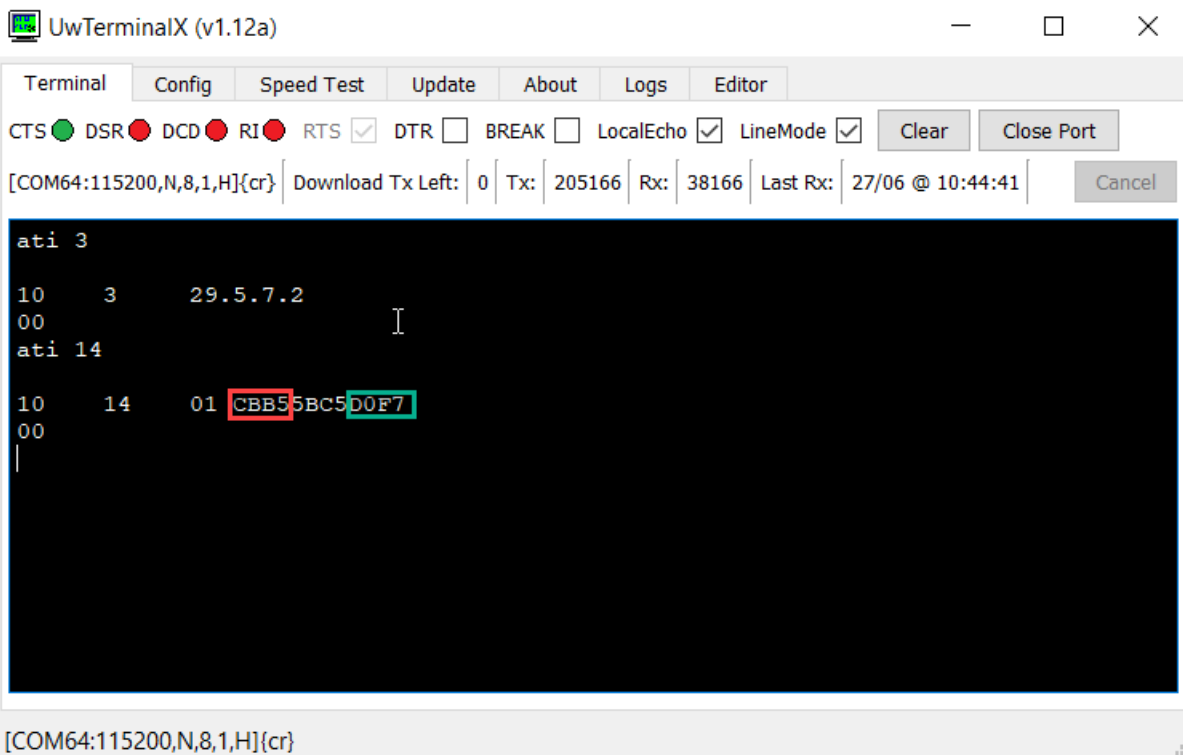


**Figure 2: UwTerminalX Settings**

6. Click **OK** to connect
7. Set up the module into Direct Test Mode, you will need to retrieve two sets of four characters each which function as a unique passcode to enter direct test mode. To retrieve the characters, issue the following command:

```
ATI 14
```

Note the characters in the highlighted positions below. In our example in [Figure 3: Return from ati 14](#), they are: **CBB5** and **D0F7**.



**Figure 3: Return from ati 14**

8. To enter Direct Test Mode, using the characters you found in the previous steps, issue the AT+DTM command as follows:  
AT+DTM 0xCBB5D0F7
9. Click **Close Port** to disconnect the development board from UwTerminalX.

## 5 DTM COMMANDS

Now that the module is in Direct Test Mode it accepts DTM commands as specified in the [BT SIG Core Specification v5.3 vol. 6 part F - Direct Test Mode: SIG Core Specification 5.3](#).

DTM mode on the BL65x uses a UART Baud Rate of 19200. The host processor will now need to reconfigure its UART rate to accommodate this rate.

Communication with the BL654 over the UART using UwTerminalX can be done via the following communications settings:

<b>COM Port</b>	Same as before
<b>Baud Rate</b>	19200
<b>Parity</b>	None
<b>Stop Bits</b>	1
<b>Data Bits</b>	8
<b>Handshaking</b>	None

**Figure 4: UART Parameters**

UART Interface Characteristics are specified in the BT SIG Core Specification v 5.3 vol. 6 part F Section 3.1 - Direct Test Mode

## 5.1 UART Interface Characteristics

The UART interface characteristics shall be set to use the following parameters:

- Baud rate: One of the following shall be supported by the DUT:
  - 1200, 2400, 9600, 14400, 19200, 38400, 57600, 115200
- Number of data bits: 8
- No parity
- 1 stop bit
- No flow control (RTS or CTS)

The smartBASIC FW is configured for Baud Rate 19200 as shown above in [Figure 4: UART Parameters](#). The host processor must operate with these same parameters for proper communication. As shown in section 5.1 in [Application Note – Using Direct Test Mode – BL654](#) the baud rate that will be used when in DTM mode can be changed before entering DTM by using the following AT command:

### *Baud Rate*

<b>Command</b>	AT+DTMCFG 2 <i>n</i>
<b>Values for n</b>	9600, 14400, 19200, 38400, 57600, 115200
<b>Default</b>	19200

**Figure 5: UART Baud Rate**

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**Note:** If Baud Rate or any other parameters are changed prior to entering DTM mode then the command **AT+DTMCFG 19 1** must be entered to allow the radio to operate.

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## 6 BT CORE SPEC COMMANDS AND EVENTS

This section will outline the commands and their format as defined in DTM section 3.3 of v5.3 BT Core Spec. This section of the spec must be followed by a host processor when issuing commands while in DTM mode.

### 6.1 Command and Event Definitions

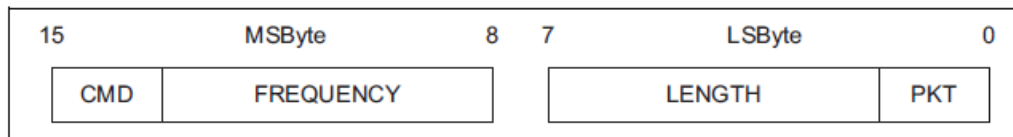
The following table from the Bluetooth Core Specification v5.3 Vol 6 Part F lists commands that can be received by the device under test and the response events that may be returned.

Command (DUT RXD)	Event (DUT TXD)
LE_Test_Setup	LE_Test_Status SUCCESS LE_Test_Status FAIL
LE_Receiver_Test	LE_Test_Status SUCCESS LE_Test_Status FAIL
LE_Transmitter_Test	LE_Test_Status SUCCESS LE_Test_Status FAIL
LE_Test_End	LE_Packet_Report LE_Test_Status FAIL

**Figure 6: 2-Wire command and event behavior**

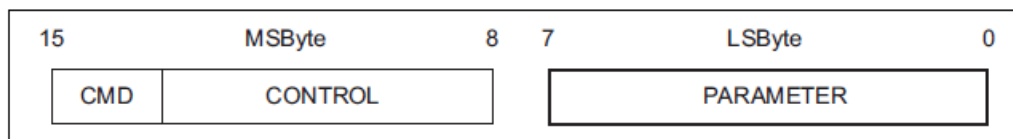
### 6.2 Command Packet Format

The following are the packet formats for LE\_Transmitter\_Test and LE\_Receiver\_Test commands as illustrated in the Bluetooth Core Specification v5.3 Vol 6 Part F.



**Figure 7: LE Transmitter Test and LE Receiver Test packet formats**

The following are the packet formats for LE\_Test\_Setup and LE\_Test\_End commands as illustrated in the Bluetooth Core Specification v5.3 Vol 6 Part F.



**Figure 8: LE Test Setup and LE Test End packet formats**

## 6.3 CMD Values for Command Packet

**CMD (command):**

**Size: 2 bits**

Value $b_1b_0$	Parameter Description
00	LE_Test_Setup command
01	LE_Receiver_Test command
10	LE_Transmitter_Test command
11	LE_Test_End command

### 6.3.1 LE Test Setup Control and Parameter Values

**Test Setup command:**

**Size: 14 bits**

Control (6 bits)	Parameter (8 bits)	Description
0x00	0x00 to 0x03	RESET; the upper 2 bits of the data length for any LE_Transmitter_Test or LE_Receiver_Test commands following are set to 00, the PHY is set to LE 1M, the receiver assumes the transmitter has a standard modulation index, and no Constant Tone Extension is present.
	Any other value	Reserved for future use
0x01	0x00 to 0x0F	Set the upper 2 bits of the data length for any LE_Transmitter_Test or LE_Receiver_Test commands following to bits 2 and 3 of the parameter (to enable a length greater than 0x3F to be used)
	Any other value	Reserved for future use
0x02	0x04 to 0x07	PHY set to LE 1M
	0x08 to 0x0B	PHY set to LE 2M
	0x0C to 0x0F	PHY set to LE Coded; transmitter is to use S=8 data coding
	0x10 to 0x13	PHY set to LE Coded; transmitter is to use S=2 data coding
	Any other value	Reserved for future use
0x03	0x00 to 0x03	Receiver assumes transmitter has a standard modulation index
	0x04 to 0x07	Receiver assumes transmitter has a stable modulation index
	Any other value	Reserved for future use
0x04	0x00 to 0x03	Read the test case supported features.  The LE_Test_Status event will return the state of the test case supported features as detailed in the LE_Test_Status event (Section 3.4.1).
	Any other value	Reserved for future use

Control (6 bits)	Parameter (8 bits)	Description
0x05	0x00 to 0x03	Read supportedMaxTxOctets (see [Vol 6] Part B, Section 4.5.10)
	0x04 to 0x07	Read supportedMaxTxTime (see [Vol 6] Part B, Section 4.5.10)
	0x08 to 0x0B	Read supportedMaxRxOctets (see [Vol 6] Part B, Section 4.5.10)
	0x0C to 0x0F	Read supportedMaxRxTime (see [Vol 6] Part B, Section 4.5.10)
	0x10	Read maximum length of Constant Tone Extension supported
	Any other value	Reserved for future use
0x06	0x00	No Constant Tone Extension
	Any other value	CTEInfo (see [Vol 6] Part B, Section 2.5.2)
0x07	0x01	Sample Constant Tone Extension with 1 $\mu$ s slots
	0x02	Sample Constant Tone Extension with 2 $\mu$ s slots
	Any other value	Reserved for future use
0x08	Bits 0 to 6: 0x01 to 0x4B	Number of antennae in the antenna array
	Any other value	Reserved for future use
	Bit 7: 0	Antenna switching pattern A: 1, 2, 3, ..., n, 1, 2, 3, ..., n, ... (where n is the number of antennae in the antenna array)
	1	Antenna switching pattern B: 1, 2, 3, ..., n, n-1, n-2, ..., 1, ... (where n is the number of antennae in the antenna array)
0x09	-127 to +20	Set transmitter to the specified or the nearest transmit power level Units: dBm
	0x7E	Set transmitter to minimum transmit power level
	0x7F	Set transmitter to maximum transmit power level
	All other values	Reserved for future use

### 6.3.2 LE Test End Control and Parameter Values

*LE\_Test\_End command:*

*Size: 14 bits*

Control (6 bits)	Parameter (8 bits)	Description
0x00	0x00 to 0x03	LE_Test_End command
0x00	Any other value	Reserved for future use
0x01 to 0x3F	Any value	Reserved for future use



**Frequency:**

**Size: 6 bits**

Value	Parameter Description
0x00 to 0x27	The frequency to be used; a value of N represents a frequency of (2N+2402) MHz (the available range is therefore even values from 2402 MHz to 2480 MHz)
0x28 to 0x3F	Reserved for future use

**Length:**

**Size: 6 bits**

Value	Parameter Description
0x00 to 0x3F	The lower 6 bits of the packet length in bytes of payload data in each packet (the top two bits are set by the LE_Test_Setup command)

**PKT (Packet Type):**

**Size: 2 bits**

Value $b_1b_0$	Parameter Description
00	PRBS9 Packet Payload
01	11110000 Packet Payload
10	10101010 Packet Payload
11	On the LE Uncoded PHYs: Vendor Specific On the LE Coded PHY: 11111111

## 6.4 Host Commands for Test Configuration

In this section host commands are sent to configure the test to continuously transmit on channel 17 (2440MHz) with TX Power 8dBm, 1M Phy Rate, Packet Length 37 bytes and PRBS Packet Payload.

### 6.4.1 Reset

Start with a reset command:

Command: **0x00 0x00**

15 14 13	MSByte	8	7	LSByte	0
CMD	Control			Parameter	
00	000000			00000000	

**Test Setup command:**

**Size: 14 bits**

Control (6 bits)	Parameter (8 bits)	Description
0x00	0x00 to 0x03	RESET; the upper 2 bits of the data length for any LE_Transmitter_Test or LE_Receiver_Test commands following are set to 00, the PHY is set to LE 1M, the receiver assumes the transmitter has a standard modulation index, and no Constant Tone Extension is present.
	Any other value	Reserved for future use

A successful result returns 00s as follows:

0x00 0x00

## 6.4.2 Tx Power

Tx Power is part of the LE Transmitter Test. The PKT is 0x3 which is vendor specific. The vendor specific command code (Length field) is 0x2 and the Tx power is specified in the vendor specific data (frequency field). At the bit level this would be:

10xxxxx00001011 where x's indicate the power level. For Tx Power setting of 8dBm the bit level is specified as shown below.

Tx power: 8dBm

Command: **0x88 0x0B**

15 14 13	MSByte	8	7	LSByte	2 1 0
CMD	Frequency		Length	PKT	
10	001000		000010	11	

A successful result returns 00s as follows:

0x00 0x00

## 6.4.3 PHY Rate Selection

Select 1M PHY.

Command: **0x02 0x04**

15 14 13	MSByte	8	7	LSByte	0
CMD	Control		Parameter		
00	000010		00000100		

Test Setup command:

Size: 14 bits

Control (6 bits)	Parameter (8 bits)	Description
0x02	0x04 to 0x07	PHY set to LE 1M
	0x08 to 0x0B	PHY set to LE 2M
	0x0C to 0x0F	PHY set to LE Coded; transmitter is to use S=8 data coding
	0x10 to 0x13	PHY set to LE Coded; transmitter is to use S=2 data coding
	Any other value	Reserved for future use

A successful result returns 00s as follows:

0x00 0x00

## 6.4.4 Start Test

Starting the test.

- Transmitter CMD with frequency: 2440
- Transmitter CMD with length: 37
- Transmitter CMD with packet type: 0

Command: **0x93 0x94**

15 14 13	MSByte	8	7	LSByte	2 1 0
CMD	Frequency		Length	PKT	
10	010011		100101	00	

Frequency:

Size: 6 bits

Value	Parameter Description
0x00 to 0x27	The frequency to be used; a value of N represents a frequency of (2N+2402) MHz (the available range is therefore even values from 2402 MHz to 2480 MHz)
0x28 to 0x3F	Reserved for future use

Length:

Size: 6 bits

Value	Parameter Description
0x00 to 0x3F	The lower 6 bits of the packet length in bytes of payload data in each packet (the top two bits are set by the LE_Test_Setup command)

PKT (Packet Type):

Size: 2 bits

Value b <sub>1</sub> b <sub>0</sub>	Parameter Description
00	PRBS9 Packet Payload

A successful result returns 00s as follows:

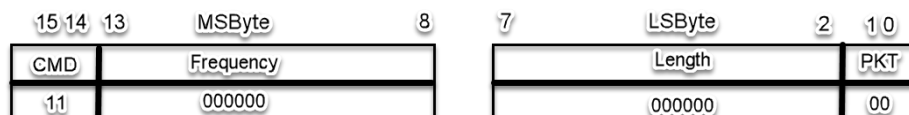
0x00 0x00

## 6.4.5 End Test

Ending the test.

- Create test end CMD

Command: **0xC0 0x00**



LE\_Test\_End command:

Size: 14 bits

Control (6 bits)	Parameter (8 bits)	Description
0x00	0x00 to 0x03	LE_Test_End command
0x00	Any other value	Reserved for future use
0x01 to 0x3F	Any value	Reserved for future use

A successful result returns 80 00 as follows:

0x80 0x00

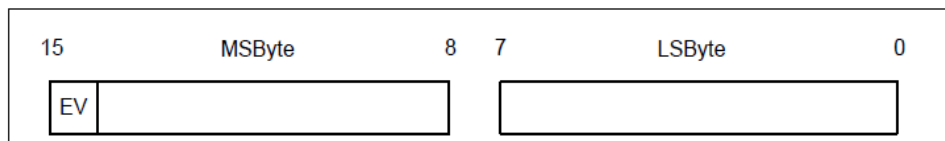
## 6.5 Events

There are two types of events sent by the DUT. As shown in the above examples a return of 0x00 0x00 is returned upon successful LE Test Status Event and a result code of 0x80 0x00 is returned upon successful LE Packet Report Event.

1. LE\_Test\_Status event
2. LE\_Packet\_Report event

The event packet format is shown below [Figure 9: LE Events](#). This packet format is used for both LE\_Test\_Status events and LE\_Packet\_Report events.

The event packet format is as follows:

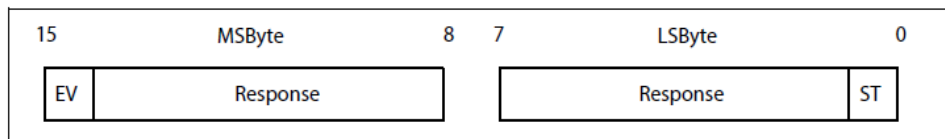


**EV (event):**

**Size: 1 bit**

Value	Parameter Description
0	LE_Test_Status event
1	LE_Packet_Report event

The LE\_Test\_Status event packet is as follows:



**ST (status):**

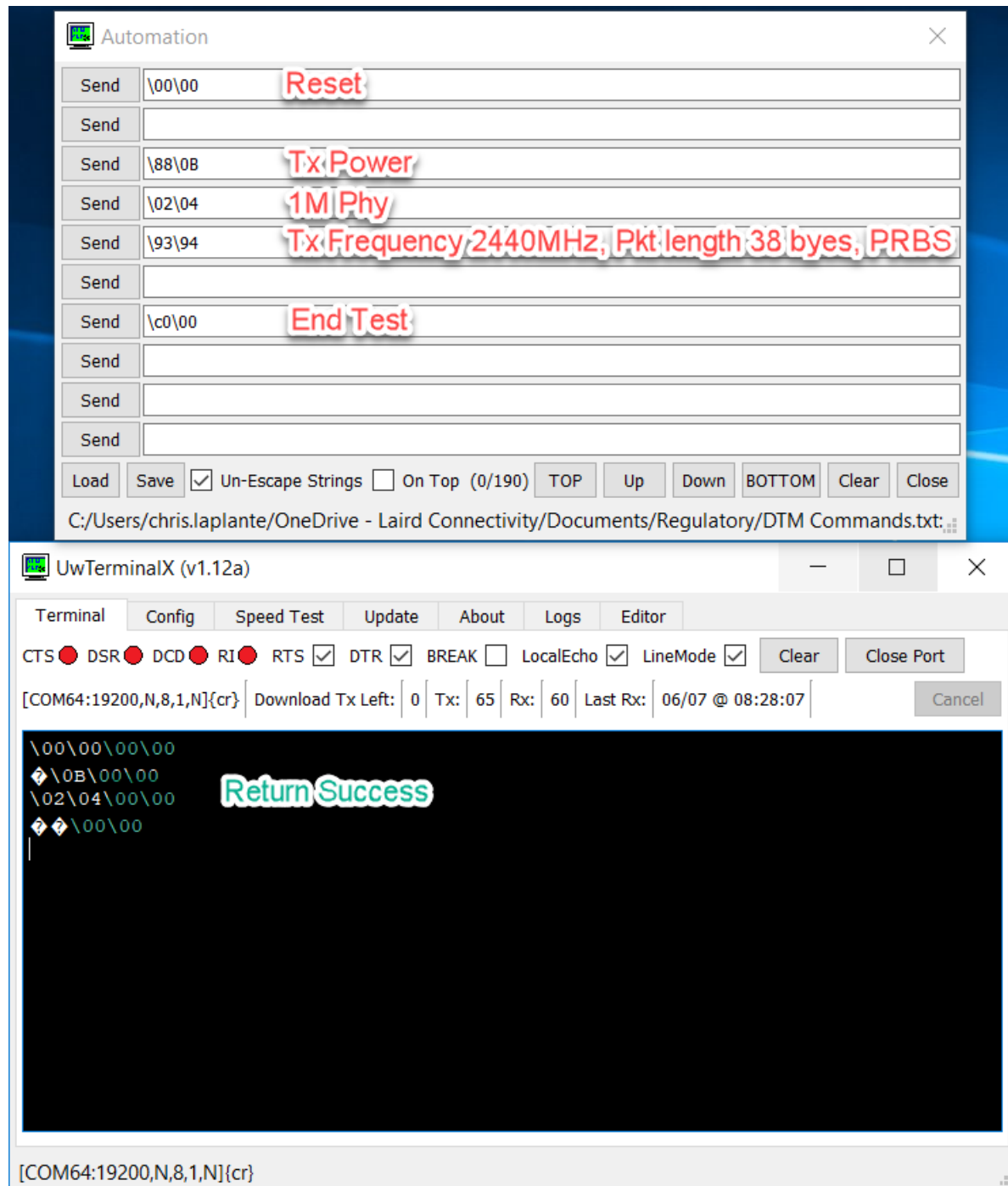
**Size: 1 bit**

Value	Parameter Description
0	Success
1	Error

**Figure 9: LE Events**

## 6.6 Host Commands Using BL65x DVK

Refer to [Application Note – Using Direct Test Mode – BL654](#) section 6 DTM Command to Produce CW RF Tx Signal for further detail on setup and using Automation window in UwTterminalX.



## 6.7 Exiting DTM Mode

Exiting DTM is described in [Application Note – Using Direct Test Mode – BL654](#) section 7 Exiting DTM Mode and more detailed information can be found there.

To temporarily go back into smartBASIC interactive mode (which will go back to DTM mode after a reset or power cycle) send command:

Command: **0x3F 0xFF**

To permanently exit DTM mode and return to smartBASIC interactive mode, enter command

Command: **0x3F 0xFE**

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**Note:** This feature is only available in firmware versions 29.5.7.2 or newer.

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## 7 REVISION HISTORY

Version	Date	Notes	Contributor(s)	Approver
1.0	14 Sept 2022	Initial Release	Chris Laplante	Dave Drogowski