Using Direct Test Mode

BL654PA Series

Application Note *v1.0*

INTRODUCTION

The BL654PA firmware natively supports Direct Test Mode (DTM) commands as specified in the Bluetooth SIG's *Bluetooth Core Specifications v 5.0 vol. 6 part F - Direct Test Mode*, accessible from the following link: www.bluetooth.com/specifications/bluetooth-core-specification

The purpose of DTM is to test the operation of radio at the physical layers such as for transmit power and receiver sensitivity. This is useful for regulatory EMC testing or for co-located radio testing with another radio system.

This radio test can be carried out by dedicated test equipment (such as Anritsu MT8852 or similar) with the BL654PA in DTM mode as the device under test. Alternatively, you can send DTM commands from a PC using a terminal program such as UwTerminalX. In both cases, the DTM commands remain the same.

This document describes BL654PA radio testing using the in-built Direct Test Mode (DTM) firmware and Nordic's nRFgo Studio or Laird BleDtmRfTool.

- Entering DTM mode for the BL654PA
- Using Nordic nRFgoStudio DTM panel (or Laird BleDtmRfTool) to BLE radio test BL654PA in either Transmit or Receive mode.
- Exiting DTM mode for the BL654PA

REQUIREMENTS

To use DTM, you need the following:

- DVK-BL654PA development board
- Windows PC
- UwTerminalX by Laird (available at https://github.com/LairdCP/UwTerminalX/releases)
- Laird BleDtmRfTool – This is available from the Documentation section of the BL654PA product page.
  Note: You must be logged into your Laird account for the BleDtmRfTool to work.
- Nordic nRFgoStudio application software (the complete install found on the Downloads panel at the following link: http://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF52832

Note: Please install the correct version (32- or 64-bit) for your operating system.

Code	Name	Version
nRFgo Studio-Win32	Software tool for nRFgo Starter Kit and Development Kits for 32-bit (x86) Windows XP, Windows Vista, Windows 7, and Windows 8	1.21.2
nRFgo Studio-Win64	Software tool for nRFgo Starter Kit and Development Kits for 64-bit (x64) Windows Vista, Windows 7, and Windows 8	1.21.2

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SETUP

We assume the DVK-BL654PA development kit has its default out-of-the-box settings as described in the BL654PA Quick Start Guide (available from the BL654PA product page. In this mode, it is in AT or interactive mode (no *smart*BASIC application loaded or running) on power up.

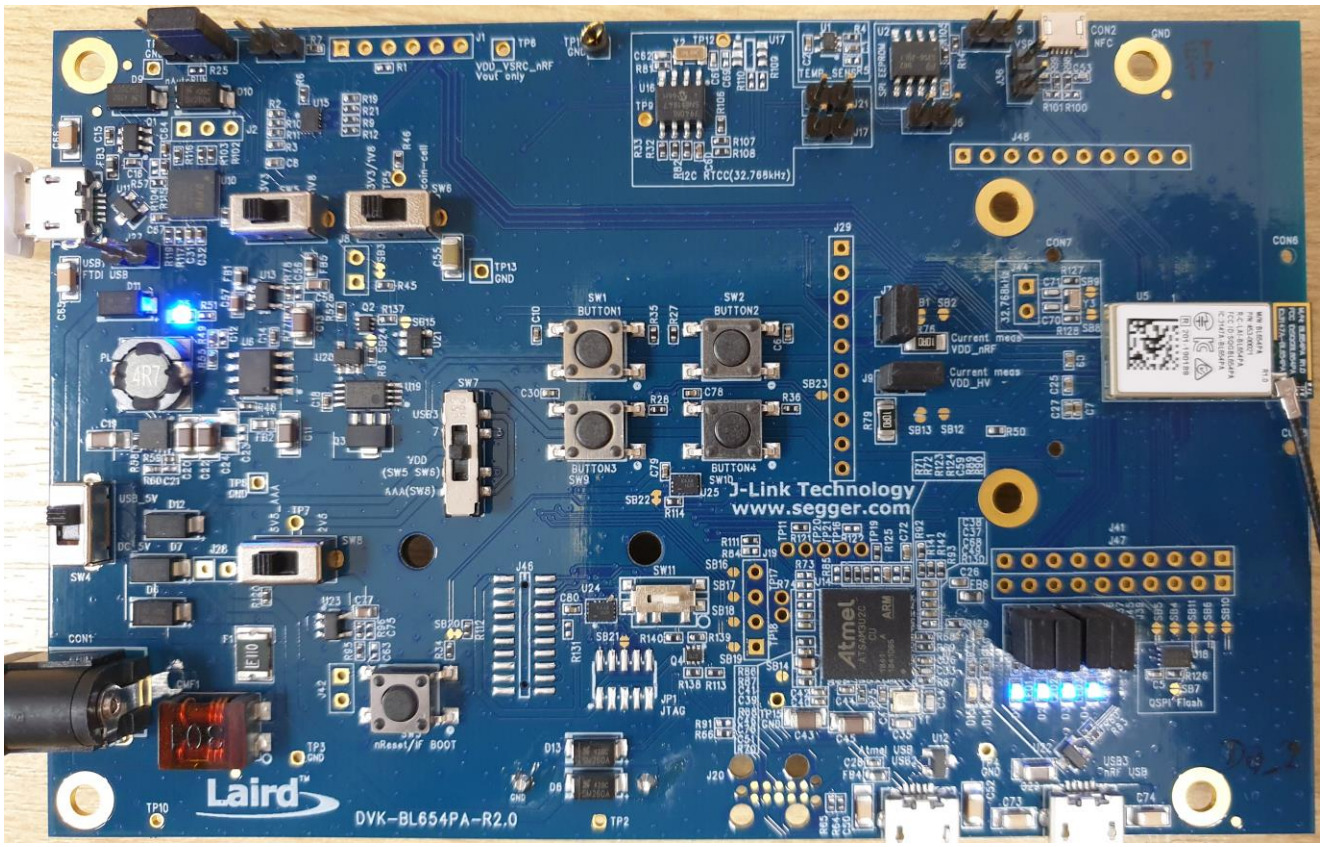

Figure 1: Default DVK-BL654PA devboard switch and jumper settings

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ENTERING DIRECT TEST MODE

To enter DTM, follow these steps:

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 *BL654PA* to populate the default communications settings.
5. Select the correct COM port.
   If you cannot select *BL654PA,* manually select the following UART settings (shown in Figure 2):

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

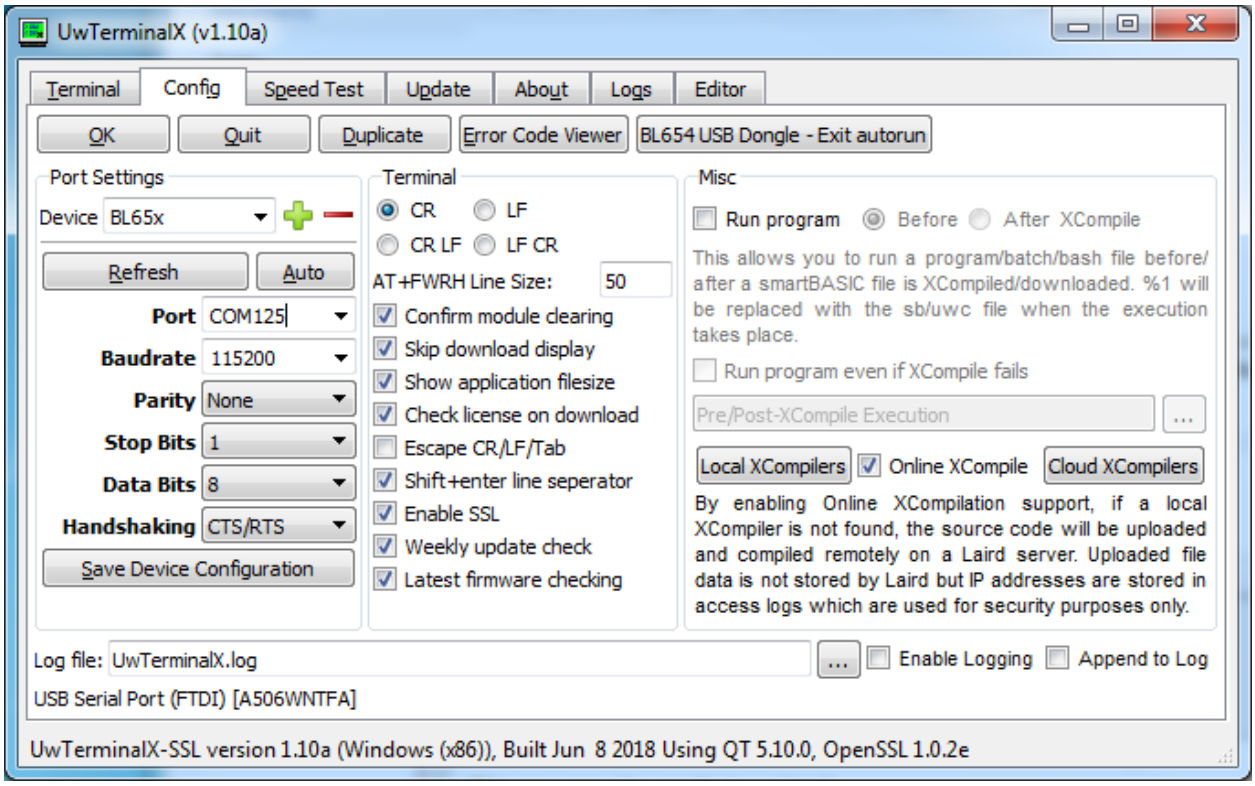

Figure 2: UwTerminalX Settings

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:

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```
AT I 14
```

You should receive a response such as:

```
10     14     01   1234567899ABC
```

Note the characters in the highlighted positions above. In our example in Figure 3, they are DC62 and 7341.

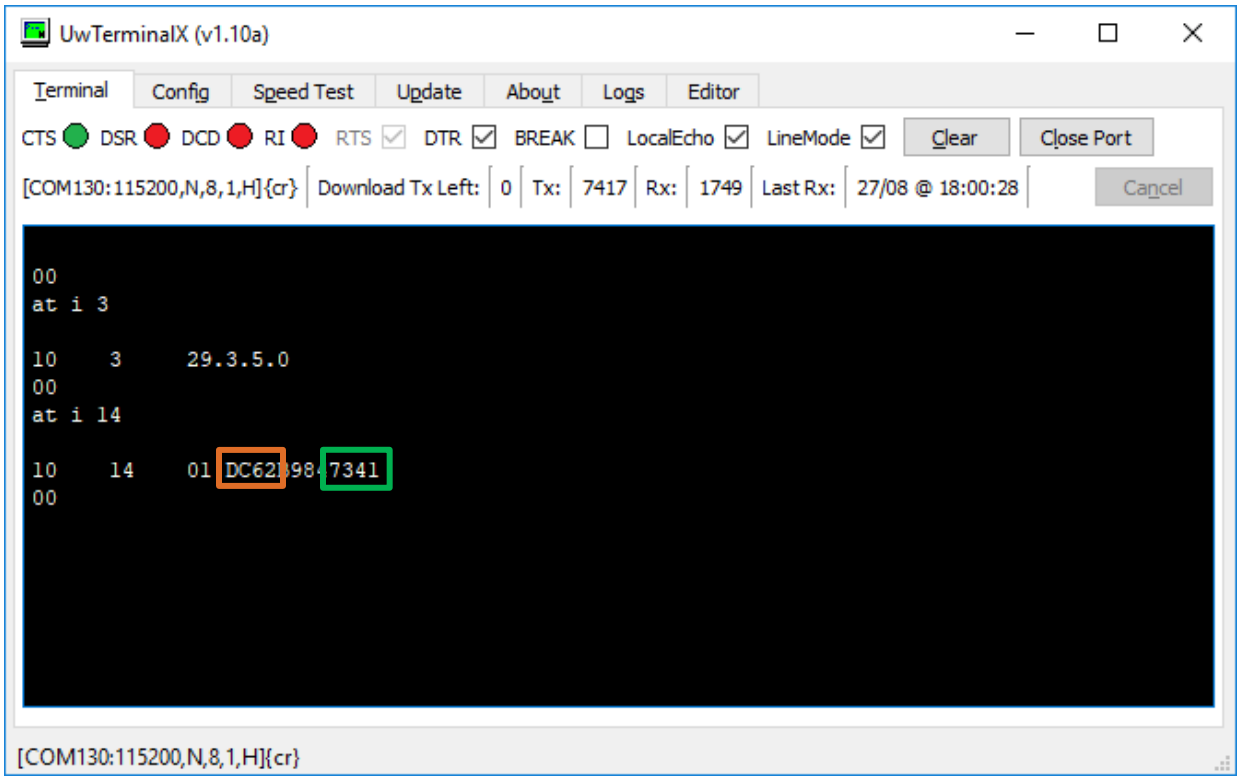

Figure 3: Return from at i 14

8. To enter Direct Test Mode, using the characters you found in the previous steps, issue the AT+DTM command as follows:

```
AT+DTM 0xDC627341
```

The module is now in Direct Test mode.

9. Click **Close Port** to disconnect the development board from UwTerminalX.

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USING DIRECT TEST MODE

Now that the module is in Direct Test Mode, it accepts DTM commands as specified in the *BT SIG Bluetooth Core Specifications*. See *Bluetooth Core Specifications v 4.1 vol. 6 part F - Direct Test Mode*, at https://www.bluetooth.com/specifications/bluetooth-core-specification.

To use Direct Test Mode, you need Nordic's nRFgo Studio, found at: http://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF52832

Once the BL654PA is in DTM mode, you can communicate with the BL654PA over the UART with UwTerminal using the following communications settings:

COM Port	Same as before
Baud Rate	19200
Parity	None
Stop Bits	1
Data Bits	8
Handshaking	CTS/RTS

Configuration of Module Settings (Optional)

Before entering DTM Mode, you may configure TX Power, Baud Rate, and REG1 and REG0 DCDC (REG1 for Normal Voltage Mode and REG0 for High Voltage Mode). Changing these values is optional. However, if you choose, you may set these values as follows:

TX Power (dBm)

Command	AT+DTMCFG 1 n
Values for n	18, 14, 6, 0, -6, -26
Default	18

Note: For BL654PA BLE coded PHY 125 kbps (s=8), the RF TX power is limited to 14 dBm (conducted) to be within the FCC/IC TX power spectral density limit. Hence, when testing BLE coded PHY 125 kbps (s=8) in DTM mode, set TX power to 14 dBm setting.

Baud Rate

Command	AT+DTMCFG 2 *n*
Values for n	9600, 14400, 19200, 38400, 57600, 115200
Default	19200

DCDC REG1 (for Normal Voltage Mode operation)

Command	AT+DTMCFG 3 *n*
Values for n	0 (Disabled), 1 (enabled)
Default	1

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DCDC REG0 (for High Voltage Mode operation)

Command	AT+DTMCFG 11 *n*
Values for n	0 (Disabled), 1 (enabled)
Default	0

Start Direct Test Mode with nRFgo Studio

nRFgoStudio does not allows datarate to be changed and default is 1Mbps and other PHY datarates 2Mbps, coded PHY 500kbps (s=2) and 125kbps (s=8) cannot be selected.

To begin using Direct Test Mode, follow these steps:

1. Open Nordic nRFgo Studio.
2. In nRFgo Studio, click **Direct Test Mode** in the features panel to open the Direct Test Mode panel as shown in Figure 4.

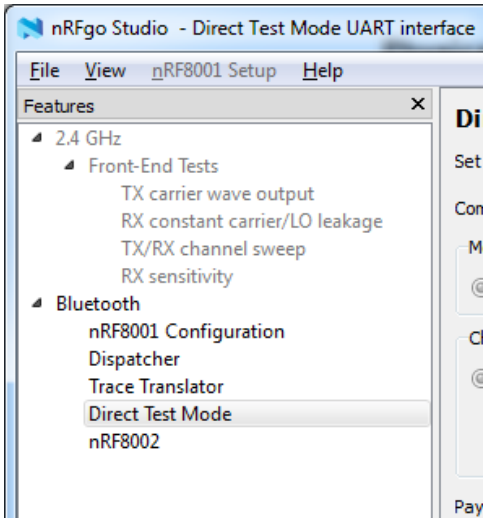

Figure 4: Opening the Direct Test Mode panel

3. From there, you can place the module in constant TX or RX mode. Consult the nRFgo Studio built-in help for more information.

5.2.1 Transmit Test

To conduct a transmit test, configure the options in the Direct Test Mode panel as follows:

COM Port	Same as previous
Mode	Transmit
Channel	19 (2440 MHz)
Payload Model	PRBS9 – If a BLE-modulated TX signal is required -or- Constant Carrier – If a continuous [CW] TX signal is required
Payload Length	37 bytes

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Once configured, click **Start Test**. If successful, no errors should show, as illustrated in Figure 5.

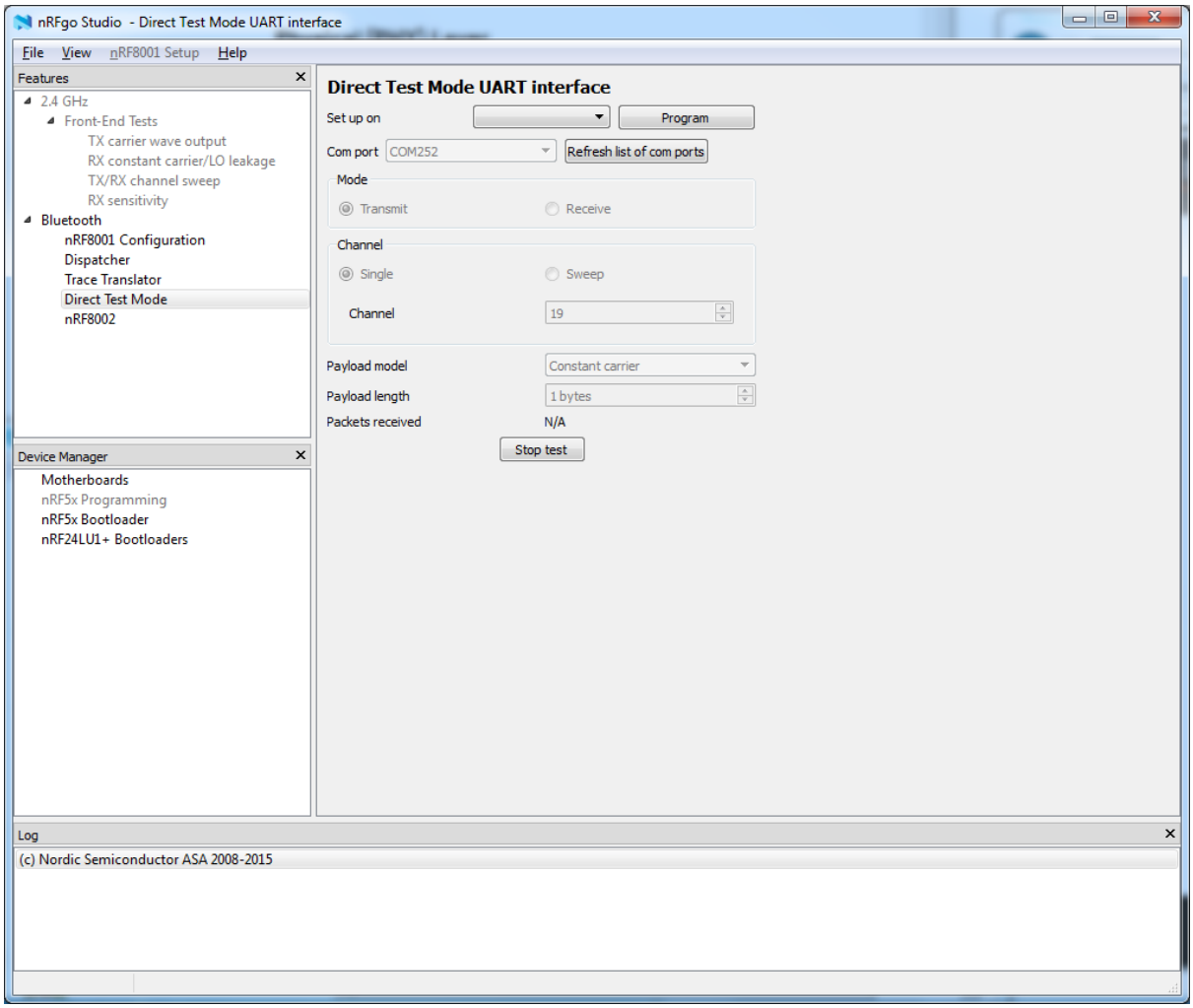

Figure 5: Successful initiation of TX Test

With the module is in a Transmit test, you can measure the signal on a spectrum analyzer.

5.2.2 Receive Test

To conduct a receive test, configure the options in the Direct Test Mode panel as follows:

COM Port	Same as previous
Mode	Receive
Channel	0 (2402 MHz)

Once configured, click **Start Test**. If successful, no errors should show.

Note: Rx Mode produces an RX LO leakage at the following frequency: **2*fRx-1MHz**.

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Start Direct Test Mode Laird BleDtmRfTool

Laird's BleDtmRfTool allows all BT PHY data rates to be tested, 1 Mbps, 2 Mbps and coded PHY 500 kbps (s=2) and 125 kbps (s=8).

To begin using Direct Test Mode, follow these steps:

1. Open Laird BleDtmRfTool (Figure 6).

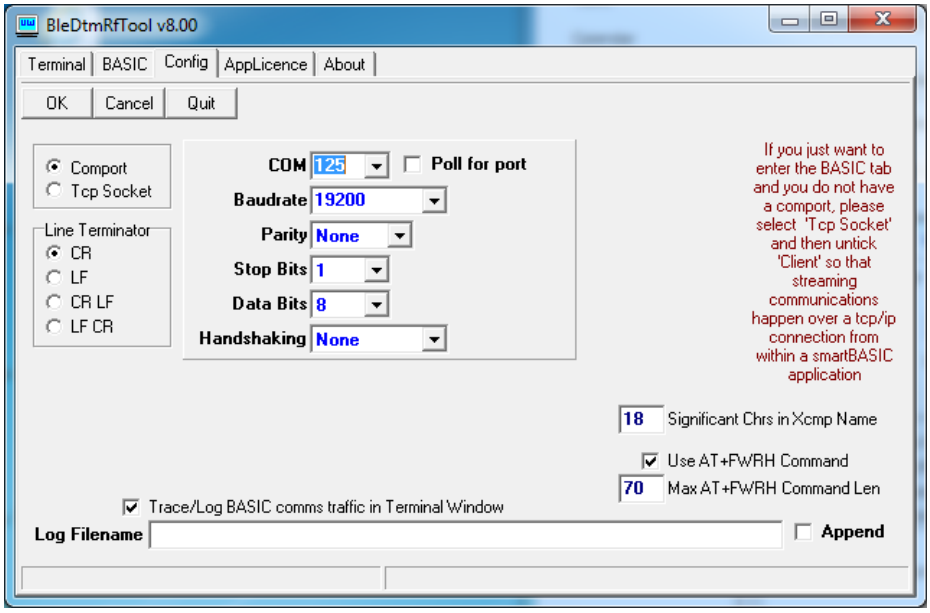

Figure 6: BleDtmRfTool UART communication settings

2. In BleDtmRfTool, click **DTM button** located in the top right to open the Direct Test Mode panel as shown in Figure 7.

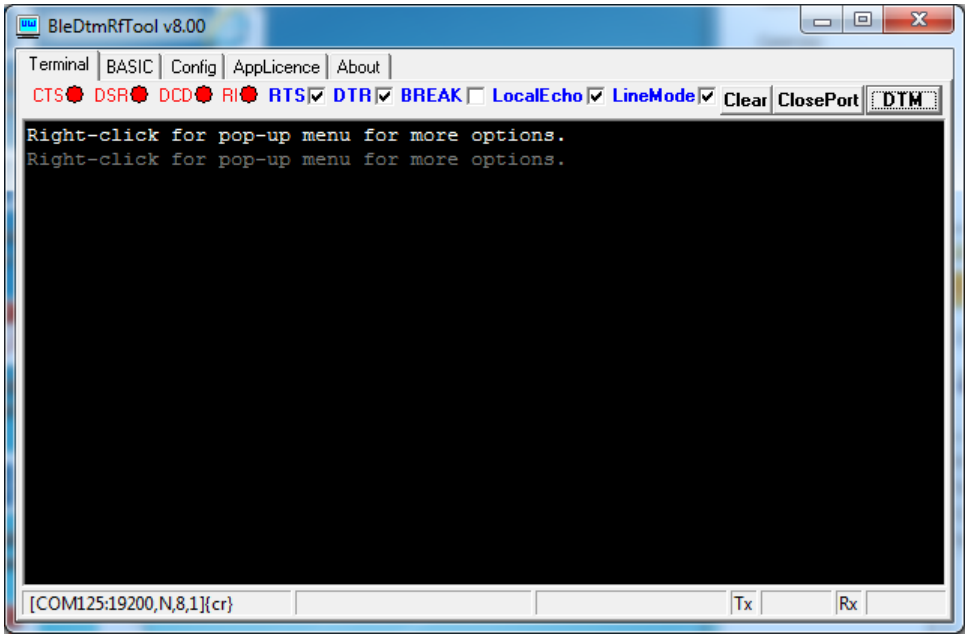

Figure 7: BleDtmRfTool

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3. In BleDtmRfTool DTM panel, there are two ways to use BleDtmRfTool, either manual entry or pressing buttons (Figure 8).

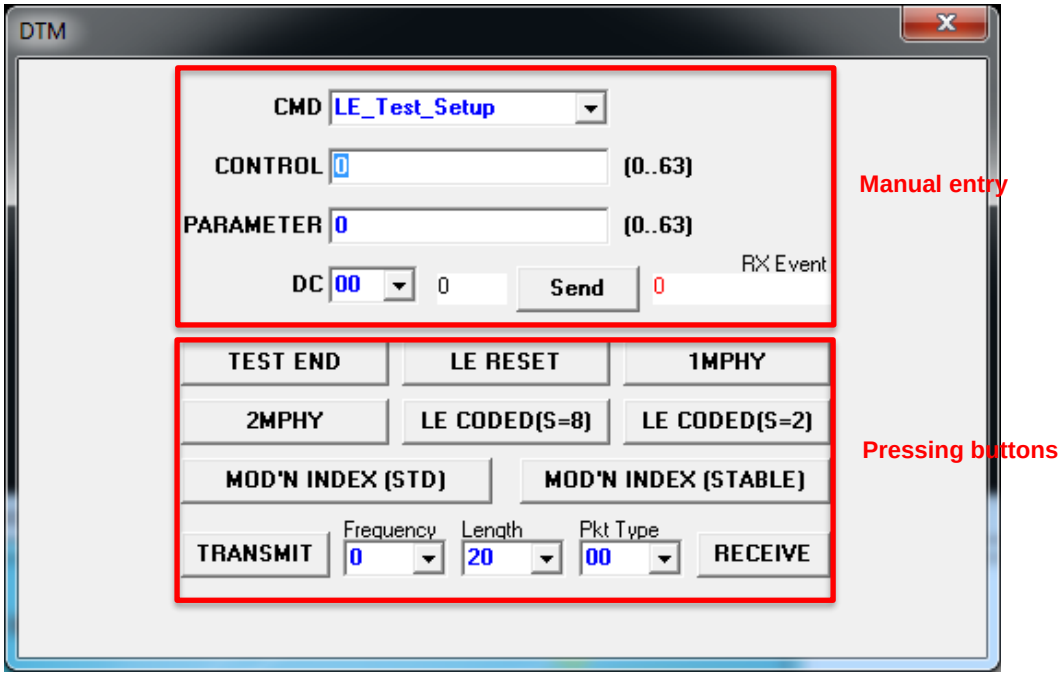

Figure 8: Opening the Direct Test Mode panel in BleDtmRfTool

Transmit Test

To perform a transmit test, follow these steps:

1. Always start by pressing **LE RESET**.
2. Configure the applicable options in the Direct Test Mode. See Figure 9 for an example.

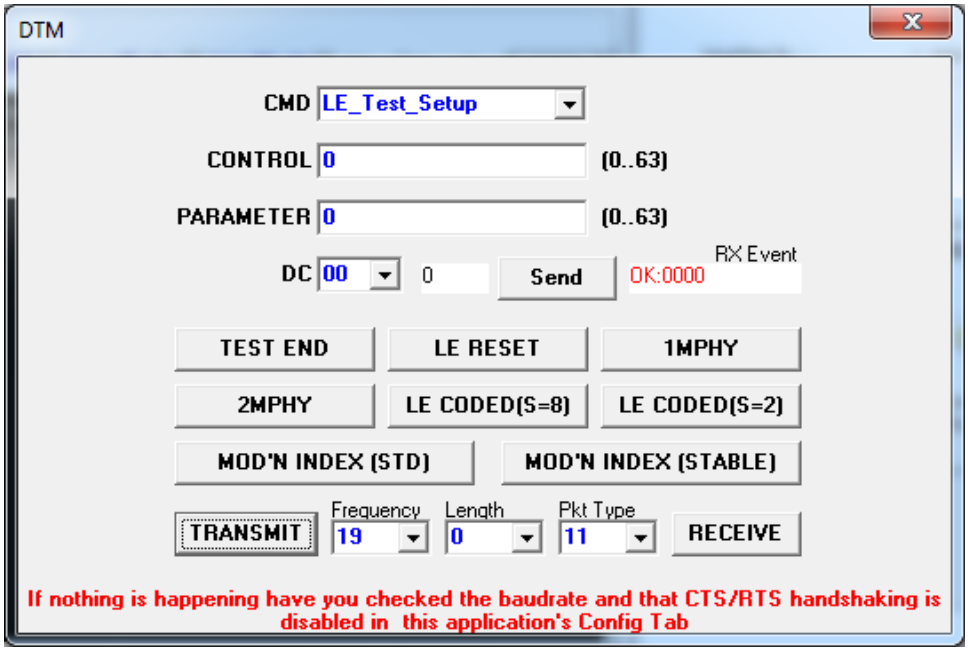

Figure 9: Direct Test Mode options

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COM Port	Same as previous
LE RESET	First start by pressing **LE RESET**.
Data rate	Select data rate from 1 MPHY or 2 MPHY or LE CODED (S=8) or LE CODED (S=2) or selecting continuous CW select 1 MPHY
Standard or Stable Modulation Index	BL654PA series BLE module currently does support standard modulation index, so press **MOD'N INDEX (STD)**
Channel	19 (2440 MHz)
Payload Model i.e. Pkt Type	**Pkt Type Value** / **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 Pkt Type 00 – If a BLE-modulated TX signal is required with PRBS9 Packet payload -or- Pkt Type is 11 – If a continuous [CW] TX signal is required
Payload Length	0 bytes to 63 bytes Set Length to 0 – If a continuous [CW] TX signal is required
TRANSMIT	To start TX test, press **TRANSMIT**.

3. Once configured, click **TRANSMIT**. If successful, no errors should show, as illustrated in Figure 5. Figure 8 shows a TX CW test.

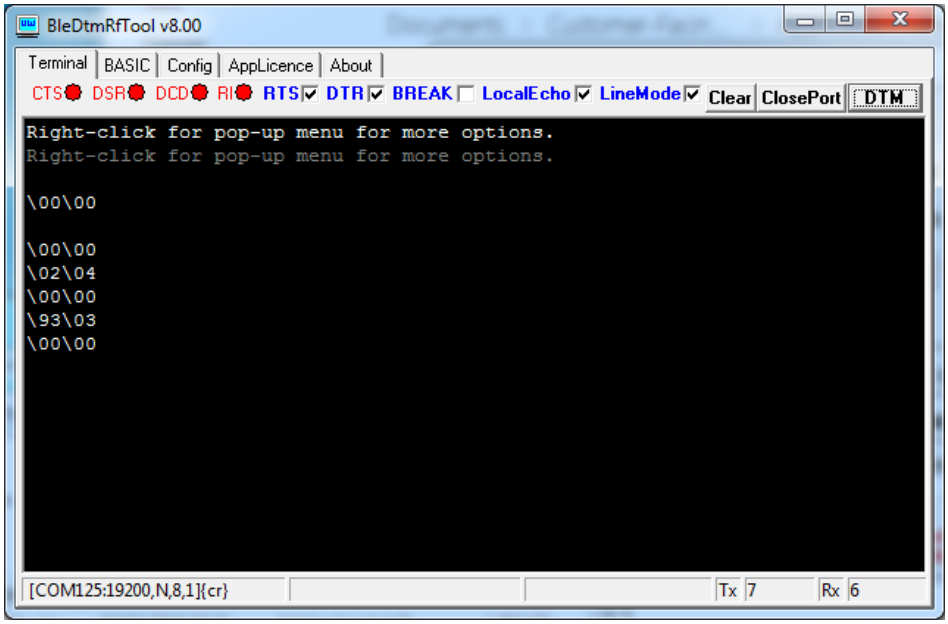

Figure 8: Successful initiation of TX Test

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With the module is in a Transmit test, you can measure the signal on a spectrum analyzer. Check the TX duty cycle of your RF transmission (using zero span mode on the spectrum anlayser).

Receive Test

To conduct a receive test, configure the options in the Direct Test Mode panel as follows:

COM Port	Same as previous
LE RESET	First start by pressing "LE RESET".
Data rate	1MPHY or 2MPHY or LE CODED (S=8) or LE CODED (S=2)
Standard or Stable Modulation Index	BL654PA series BLE module currently does support standard modulation index, so press **MOD'N INDEX (STD)**
Channel (fRx)	19 (2440 MHz)
Payload Model (such as Pkt Type)	**Pkt Type Value** / **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 Pkt Type 00 – If a BLE-modulated RX signal is required with PRBS9 Packet payload
Payload Length	0 bytes to 63 bytes Set Length to 0 – If a continuous [CW] TX signal is required
RECEIVE	To start RX test press **RECEIVE**

Once configured, click **RECEIVE**. If successful, no errors should show. The RX Event shows how many packets are received.

Note: Rx Mode produces an RX LO leakage at the following frequency: **2*fRx-1MHz**.

Exiting DTM Mode

To exit DTM, follow these steps:

1. Open UwTerminalX with the following settings:

COM Port	Same as previous
Baud Rate	19200
Parity	None
Stop Bits	1
Data Bits	8
Handshaking	None

2. Click **OK** to connect.
3. Right-click the terminal screen and in the context menu, click **Automation.**
4. In the following screen, modify the fields as shown in Figure 10.
   - In the first field, enter **\3F\FF**.
   - Tick the box for **De-Escape Strings.**
5. Click **Send**.

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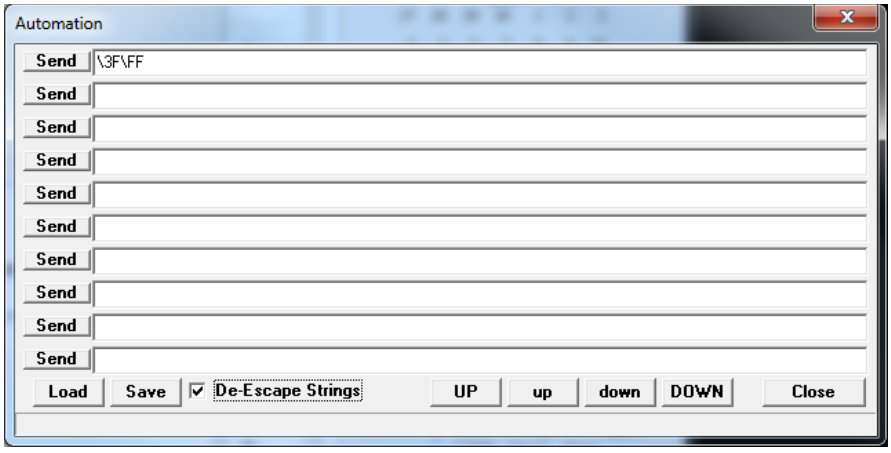

Figure 10: Automation dialogue

6. After this command is complete, close UwTerminalX. Then re-open it and connect to the BL654PA with the following default parameters:

COM Port	Same as previous
Baud Rate	115200
Parity	None
Stop Bits	1
Data Bits	8
Handshaking	CTS/RTS

7. Click **OK** to connect.
8. Check that you get a response by pressing **Enter** in the terminal window. You should the following response:

```
00
```

9. Issue the following command to erase non-volatile data and the module's file system:

```
at&f*
```

The module erases its file system and reboot, as shown in Figure 11.

```
00
at&f*

FFS Erased, Rebooting...
00
```

Figure 11: at&f* to erase and reboot module

REVISION HISTORY

Version	Date	Notes	Contributor(s)	Approver
1.0	29 August 2019	Initial Release	Raj Khatri	Jonathan Kaye

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