# UM2288
# User manual

## STM32CubeMonitor-RF software tool for wireless performance measurements

## Introduction

STM32CubeMonitor-RF (STM32CubeMonRF) is a software tool, which helps designers to test their products based on STMicroelectronics STM32 wireless microcontrollers.

The tool performs the following operations:

- It sends and receives test packets to check the efficiency of radio frequency boards and compute the packet error rate (PER) on Bluetooth® LE and IEEE 802.15.4 technologies.
- It sends commands to the Bluetooth® LE controller for standardized tests.
- It sends and receives Bluetooth® LE commands for fast application prototyping.
- It configures a variety of beacons via Bluetooth® LE commands.
- It transfers data over-the-air (OTA) from one device to another, to configure or program a wireless remote device.
- It sends commands to an OpenThread device for application prototyping.
- It explores a Thread network and displays it with all the relevant information.
- It provides a sniffer tool to analyze IEEE 802.15.4 frames with Wireshark®.

This user manual applies to STM32CubeMonitor-RF version 2.18.0 and later.

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# 1 Getting started

STM32CubeMonitor-RF supports the STM32WB, STM32WBA, and STM32WB0 series microcontrollers based on the Arm®(a) Cortex®-M processor.
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## 1.1 Download and setup

STM32CubeMonitor-RF is compatible with Windows®(b), Linux®(c), and macOS®(d) operating systems.

The information on how to install the application is described in the release note, which explains the compatibilities and new features available in the tool.

Refer to the STM32CubeMonRF release note (RN0104) to install and configure the application.

a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

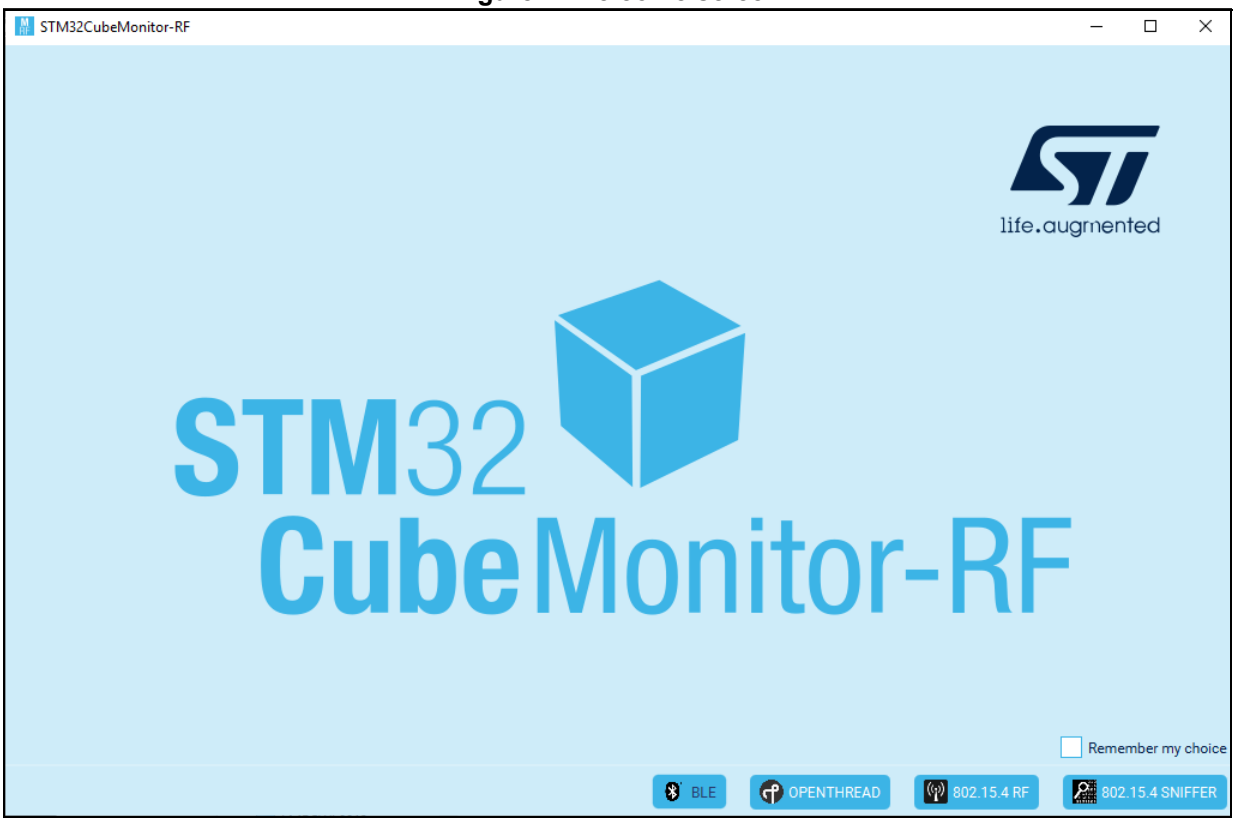
b. Windows is a trademark of the Microsoft group of companies.

c. Linux® is a registered trademark of Linus Torvalds.

d. macOS® is a trademark of Apple Inc., registered in the U.S. and other countries and regions.

## 1.2 Welcome screen

**Figure 1. Welcome screen**



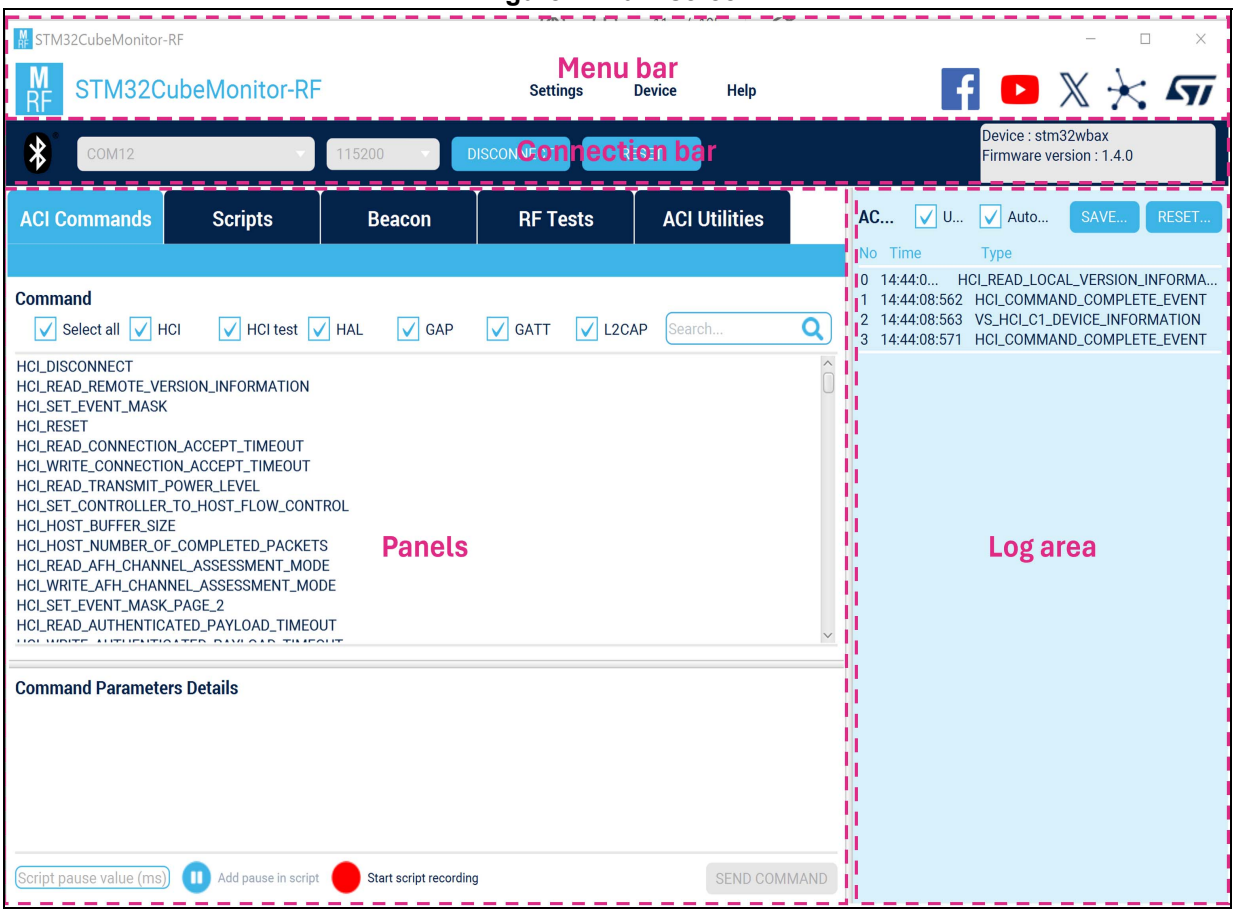

Launching the application opens the welcome screen, where the users select the mode they want to use: Bluetooth® LE, OpenThread, 802.15.4 RF, or 802.15.4 sniffer.

The checkbox *Remember my choice* memorizes the selection so that the next application launch directly opens it, without the welcome screen, except for the 802.15.4 sniffer.

## 1.3 Main screen

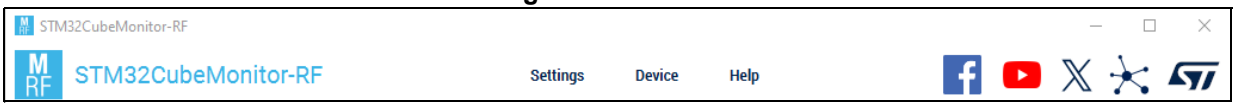
The main screen of the tool is divided into four sections: the menu bar, the connection bar, the panels, and the log area.

**Figure 2. Main screen**



### 1.3.1 Menu bar

**Figure 3. Menu bar**




The application header includes a menu bar for specific tools and displays useful information.

The *Settings* menu allows users to change the mode and reset the default mode selection. Resetting the selection causes the welcome screen to reappear.

The *Device* menu provides information and actions for the connected board.

The *Help* menu provides details about the tool version in use.

The social network links are available in the upper-right corner. This area includes five shortcuts to access social networks:

- The Facebook™ icon leads to the official STMicroelectronics Facebook page.
- The YouTube™ icon leads to the official STMicroelectronics YouTube page.
- The X icon leads to the official STMicroelectronics X page.
- The Share icon leads to the ST community website.
- The STMicroelectronics icon leads to the STMicroelectronics website.

### 1.3.2 Connection bar

**Figure 4. Connection bar**


The connection bar shows information about the device connected to the application.

The icon on the left side shows the selected mode.

The first picklist is used to select the COM port.

The second picklist is used to select the serial baud rate.

Buttons enable connecting to, disconnecting from, or resetting the target.

Information about the connected component is displayed on the right.

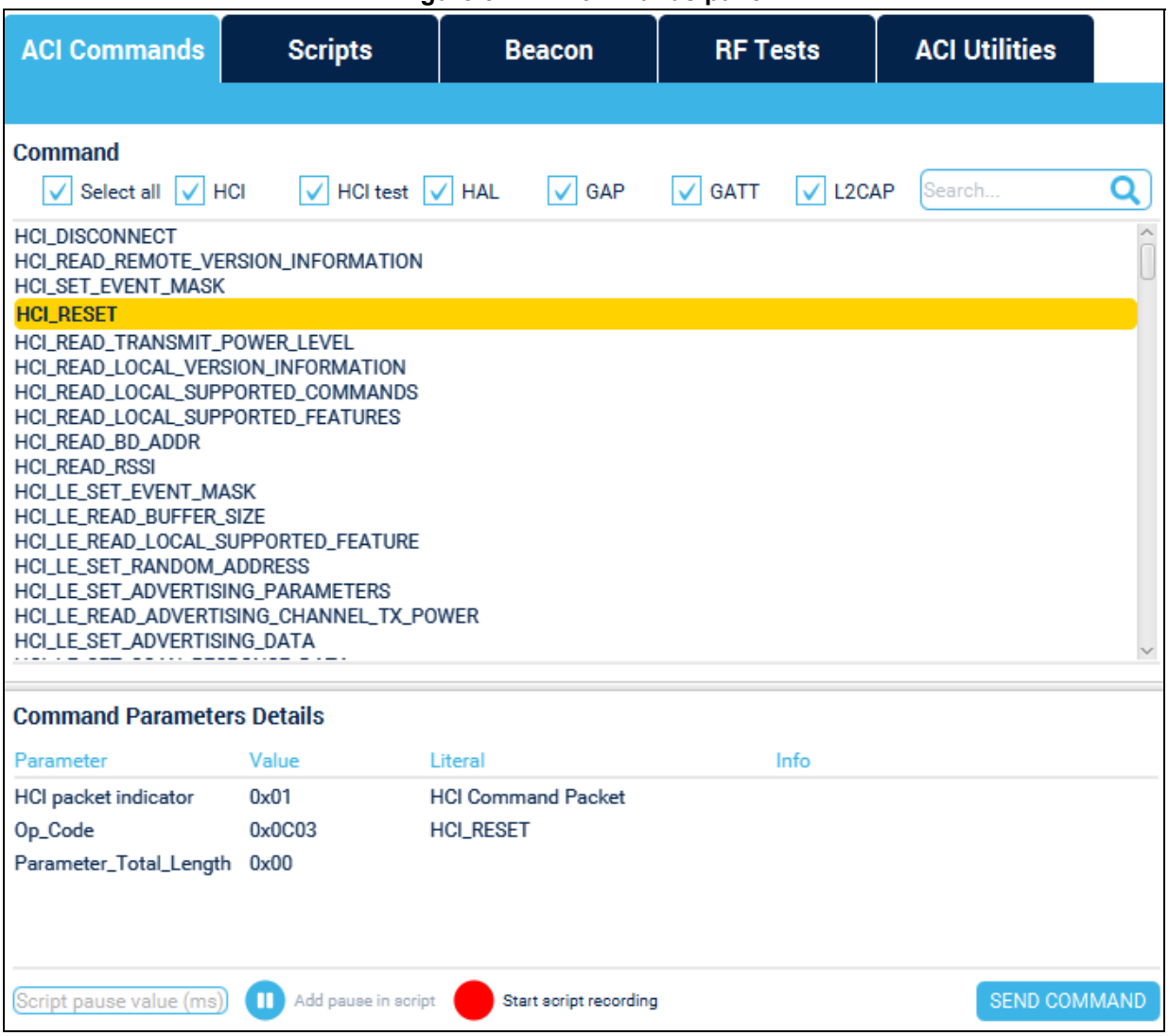
The *RESET* button is used to reinitialize the Bluetooth® LE wireless stack. When many tests are performed, the button must be used to reset the stack at the start of each test.

CM0 and CM4 information for the Arm® Cortex®-M0+ and Cortex®-M4 cores only applies to STM32WB microcontrollers. For STM32WBA microcontrollers, the hardware and firmware versions are displayed, while only the firmware version is displayed for STM32WB0 microcontrollers.

### 1.3.3 Panels

The panels are used to perform specific operations. Each panel groups different functions. The *ACI Commands* panel example is illustrated in *Figure 5*.

**Figure 5. ACI Commands panel**

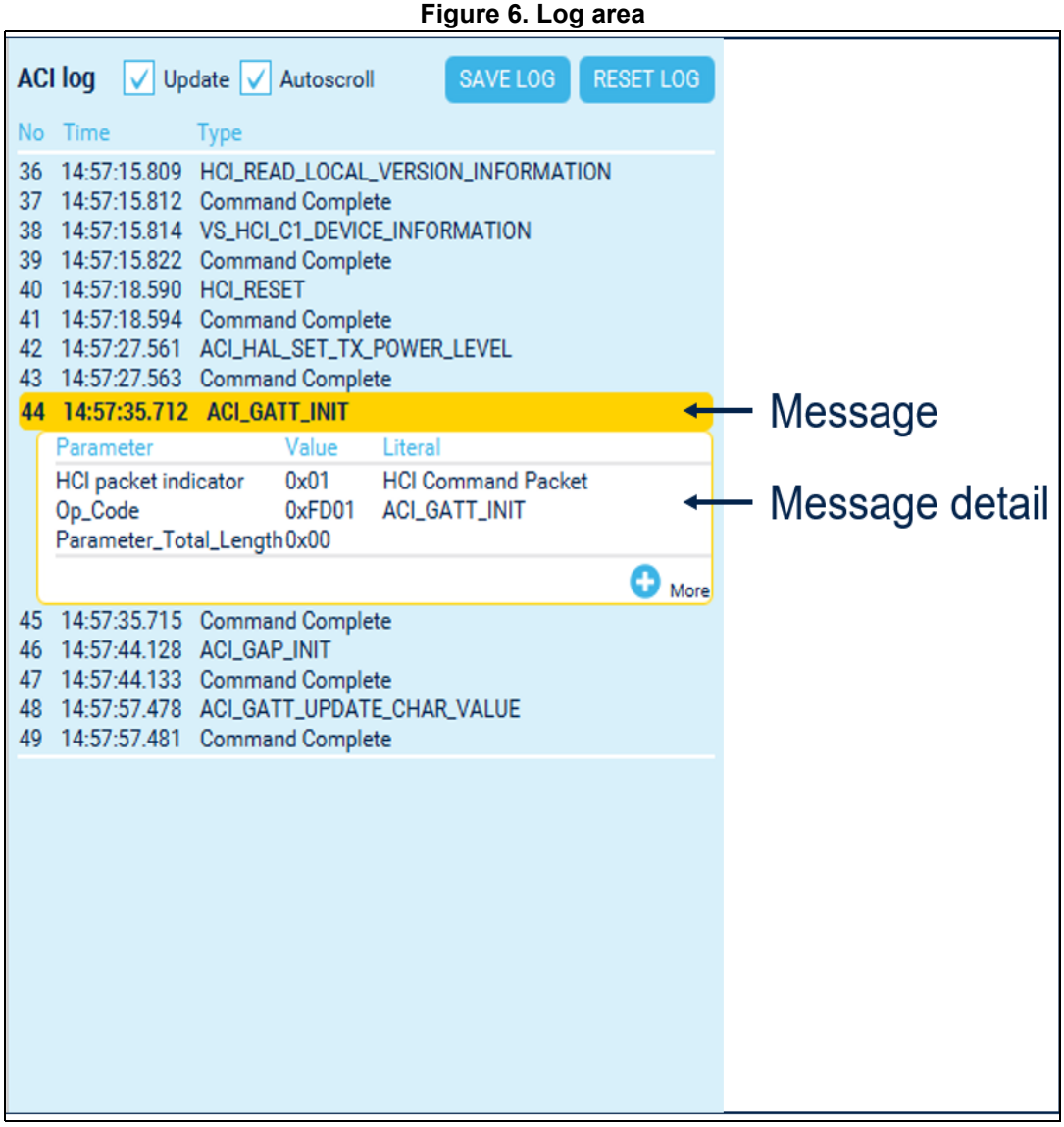



The main panels are *ACI Commands*, *Scripts*, *Beacon*, *RF Tests*, and *ACI Utilities*. Each panel is detailed in a specific section of the document:

- *Section 3.3: ACI Commands panel*
- *Section 3.5: Scripts*
- *Section 3.8: Beacon*
- *Section 3.4: RF test panel*
- *Section 3.9: ACI Utilities*

### 1.3.4 Log area

**Figure 6. Log area**




The log area shows the messages exchanged between the application and the connected devices. The list shows all message names and details. The log area is described in *Section 3.3.5*.

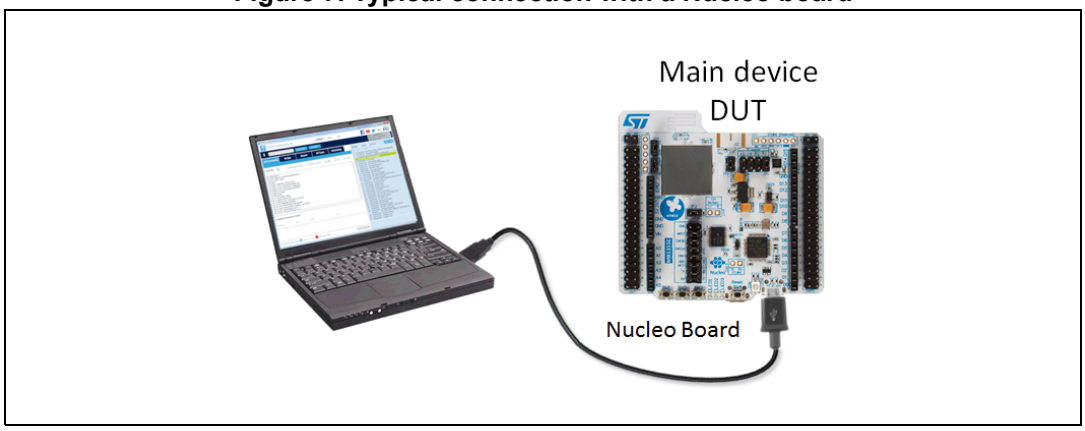
# 2 Connection to target

## 2.1 Use case descriptions and definitions

STM32CubeMonitor-RF usually connects to one STM32WB, STM32WBA, or STM32WB0 device. The connection is performed through a UART, either by a physical port or a Virtual COM port (VCP).

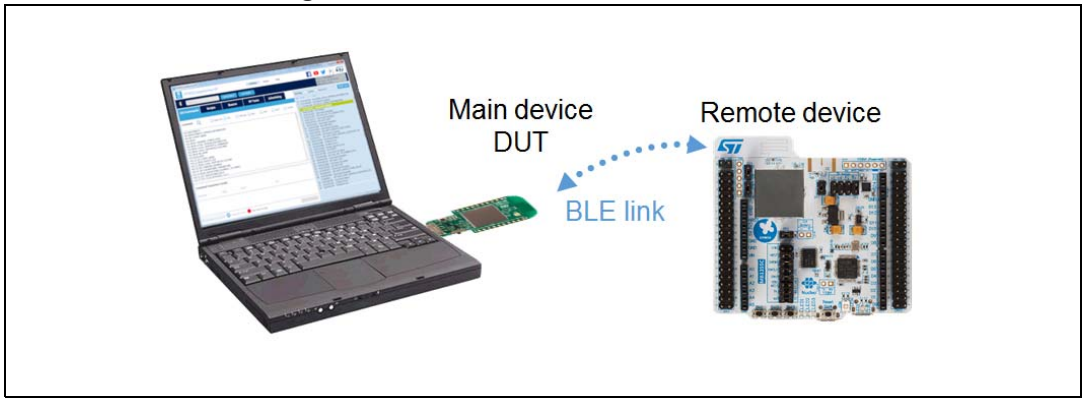
The device connected is usually named the *main device*. This is the board that the user wants to exercise with the tool. It is also called the device under test (DUT).

**Figure 7. Typical connection with a Nucleo board**



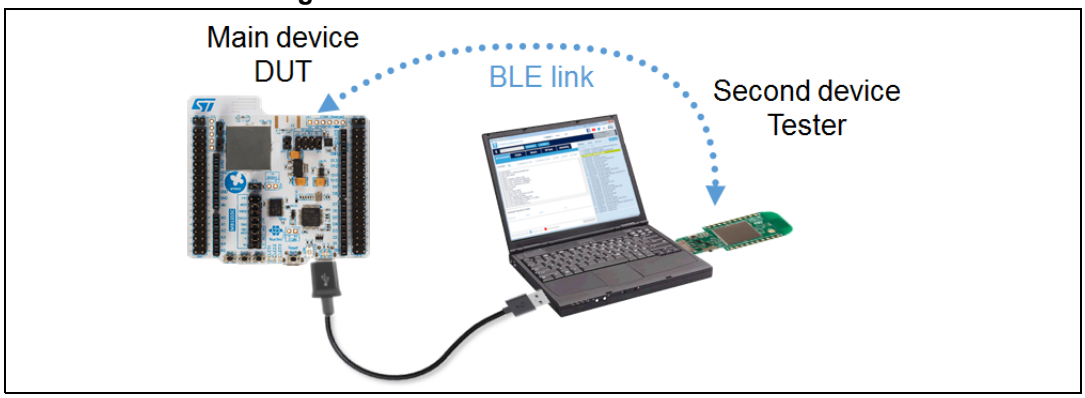

Some operations, like downloading over-the-air, involve communication with another device. This other device is referred to as the *remote device* in this document.

**Figure 8. Connection with a remote device**



One RF test uses two boards to measure the error rate of a packet transfer. For such a test, a second device is connected; it is named the *second device*. This latter device is the tester, the main device being the device to evaluate (DUT).

**Figure 9. Connection with a second device**



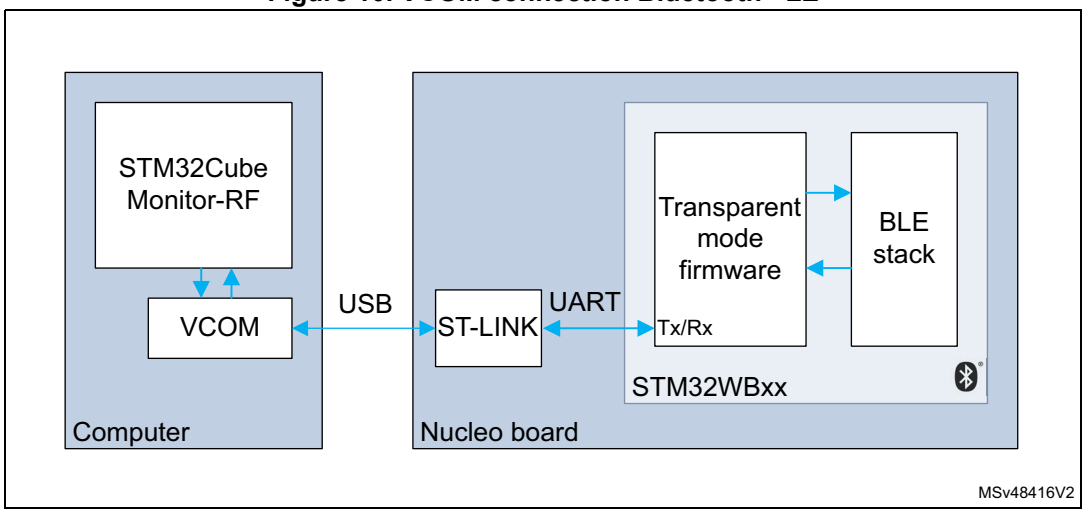

## 2.2 VCOM/UART connection

The connection must transfer the host controller interface (HCI) or command-line interface (CLI) commands between STM32CubeMonitor-RF and the wireless stack in the STM32WB, STM32WBA, or STM32WB0 device. HCI commands are used for Bluetooth® LE applications. CLI commands are used for Thread and 802.15.4 RF tests. The application opens a serial port (virtual or physical) and communicates with the target through this link. Many configurations are possible. The most common ones are described in this section.

### 2.2.1 VCOM connection

The connection with a Nucleo board uses a Virtual COM port and goes through ST-LINK. It is highly recommended to regularly update ST-LINK firmware to the latest available version.

**Figure 10. VCOM connection Bluetooth® LE**




The application opens the Virtual COM port and sends the data to the VCOM driver.

When a byte is sent, the VCOM transfers the data over USB to the ST-LINK embedded in the Nucleo board. The ST-LINK transfers the data on UART lines to the STM32WB, STM32WBA, or STM32WB0 microcontroller.

For Bluetooth® LE, a special firmware in the STM32WB, STM32WBA, or STM32WB0 microcontroller, called Transparent mode, copies the data received on the Rx pin to the Bluetooth® LE stack. Data sent back by the Bluetooth® LE stack follows the reverse path.

The Transparent mode firmware is available in the STM32CubeWB firmware package (refer to folder *\Projects\xxx\Applications\BLE\BLE_TransparentMode.*).

For the STM32WB devices, the wireless *stack* firmware *stm32wb5x_BLE_Stack_full_extended_fw.bin* is available in *\Projects\STM32WB_Copro_Wireless_Binaries*.

For information on Transparent Mode firmware loading for the STM32WB05xN network coprocessor, refer to the UM3406 user manual.

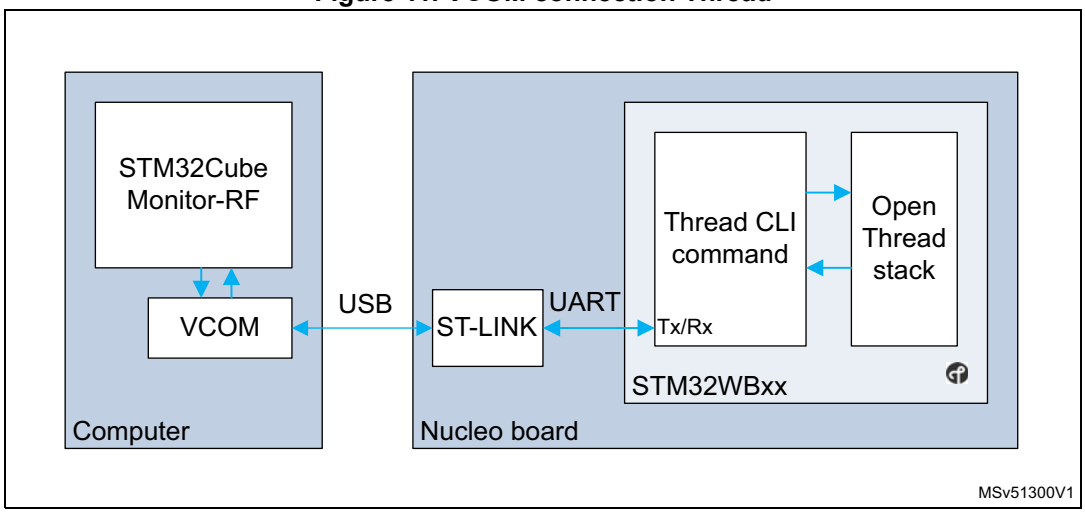
For more information, refer to *Section 3.2.*

For Thread, the *Thread_Cli_cmd* firmware copies the data from the UART to the OpenThread command-line interpreter. Data sent back by the interpreter are forwarded to the UART.

For STM32WB devices, the CLI firmware source code is available in the STM32CubeWB firmware package (refer to the *|Projects|xxx|Applications|Thread|Thread_Cli_Cmd* folder). The wireless stack firmware *stm32wbxx_Thread_FTD_fw.bin* is available in *|Projects|STM32WB_Copro_Wireless_Binaries*.

For STM32WBA devices, the source is available in the STM32CubeWBA firmware package (refer to *|Projects|NUCLEO-WBAxxxx|Applications|Thread|Thread_Cli_Cmd* folder).

**Figure 11. VCOM connection Thread**




For 802.15.4 RF tests, the Cli_Phy_802_15_4 firmware transfers the data from the UART to the 802.15.4 wireless stack. Data sent back by the stack follows the reverse path.

For STM32WB devices, the Phy_802_15_4_Cli source is available in the STM32CubeWB firmware package (refer to the *\Projects\P-NUCLEO-WB55.Nucleo\Applications\Phy_802_15_4\Phy_802_15_4_Cli* folder). The wireless stack firmware *stm32wb5x_Phy_802_15_4_fw.bin* is available in the *\Projects\STM32WB_Copro_Wireless_Binaries* folder.

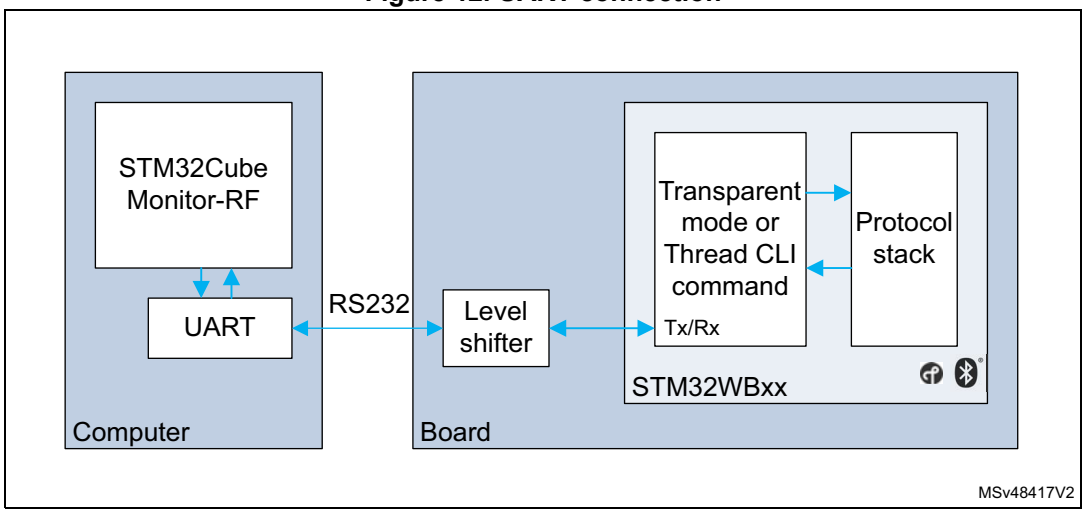
For STM32WBA devices, the source is available in the STM32CubeWBA firmware package ( *|Projects|NUCLEO-WBAxxxx|Applications|Phy_802_15_4|Phy_Cli* folder).

When a USB-to-serial converter replaces the ST-LINK part, the VCOM driver might be installed automatically on the computer. For the converter without an automatic driver setup, the user must install the VCOM driver manually.

### 2.2.2 UART connection

It is possible to use a physical UART link to connect directly to any board.

**Figure 12. UART connection**




In this case, data are sent directly in serial mode through the level shifter. Refer to the Transparent mode or CLI command release note for UART configuration.

The UART connection can be used to connect an STM32WB55 USB dongle for 802.15.4 RF tests.

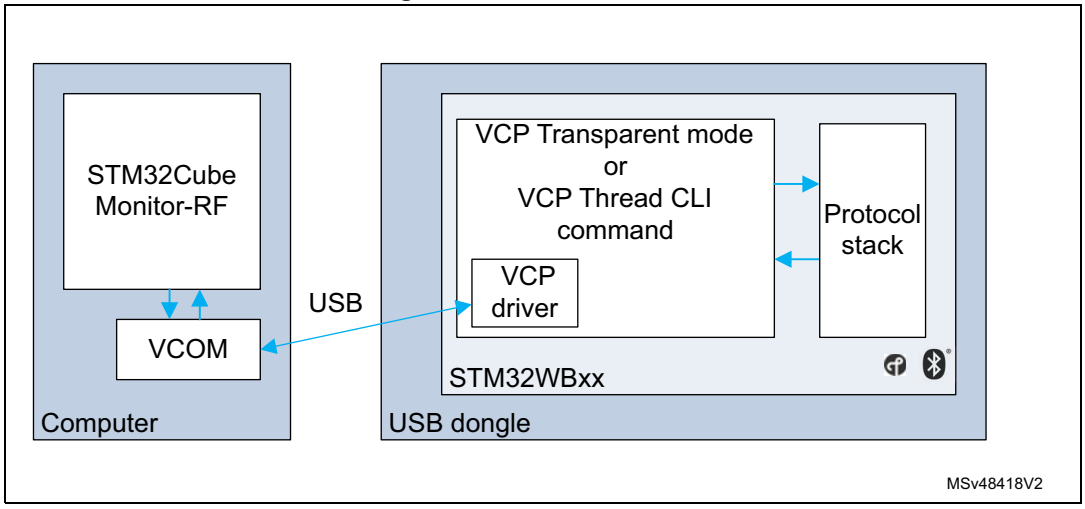
To configure the USB dongle for the 802.15.4 test:

1. Build the Nucleo firmware *Phy_802_15_4_Cli* and flash it. (*STM32Cube_FW_WB_Vx.x.x\Projects\P-NUCLEO-WB55.Nucleo\Applications\Phy_802_15_4\Phy_802_15_4_Cli*)
2. Flash with DFU the wireless stack *stm32wb5x_Phy_802_15_4_fw.bin* in the dongle (binary in *Projects\STM32WB_Copro_Wireless_Binaries*).
3. Move solder bridge SB2 to SB6 (connection of PB7 to CN2.7).
4. Connect the serial cable to PB7 (PC Tx) and PB6 (PC Rx), PB7 is on CN2.7 and PB6 on CN2.6.

### 2.2.3 VCP device

In this case, no UART is involved. The data goes directly from the computer to the microcontroller through the USB.

**Figure 13. VCP connection**




A special VCP firmware is used. It implements a VCP driver to copy the data from the USB port to the protocol stack. The VCOM driver might be installed automatically on the computer or the user needs to install it manually. This configuration is used with the STM32WB55 USB dongle reference board and the Nucleo sniffer configuration.

1. For Bluetooth® LE:
   The firmware is in
   *\Projects\NUCLEO WB55.USBDongle\Applications\BLE\BLE_TransparentModeVCP*.
   The wireless stack is in:
   *\Projects\STM32WB_Copro_Wireless_Binaries\STM32WB5x\stm32wb5x_BLE_Stack_full_extended_fw.bin*
   For more information, refer to *Section 3.2*.
2. For Thread:
   The firmware source code is in
   *\Projects\NUCLEO WB55.USBDongle\Applications\Thread\Thread_Cli_Cmd*.
   The wireless stack is in the
   *\Projects\STM32WB_Copro_Wireless_Binaries\STM32WB5x\stm32wb5x_Thread_FTD_fw.bin* folder.
3. For the 802.15.4 sniffer:
   The wireless stack is in the
   *\Projects\STM32WB_Copro_Wireless_Binaries\STM32WB5x\stm32wb5x_Mac_802_15_4_fw.bin* folder. The firmware binaries are *Mac_802_15_4_Sniffer_Dongle.bin* and *Mac_802_15_4_Sniffer_Nucleo.bin*. The location changes with the operating system.
   a) For Windows®, the firmware is in the
   *<Public documents>\STMicroelectronics\STM32CubeMonitor-RF\sniffer* folder,

which means *C:\Users\Public\Documents\STMicroelectronics\STM32CubeMonitor-RF\firmwares*.

b) For Linux®, the firmware is in the *<userhome>/STMicroelectronics/STM32CubeMonitor-RF/sniffer folder*.

c) For macOS®, the firmware is inside the document folder provided in the setup package: *\Users\Public\Documents\STMicroelectronics\STM32CubeMonitor-RF\firmwares\Mac_802_15_4_Sniffer.bin*

## 2.3 Opening COM

To start using the application, connect it to the device under test in the connection bar.

**Figure 14. Opening COM**


The procedure is:

- Connect the board to the computer. If VCOM or VCP is used, a driver must be installed. It might take a few seconds at the first connection. For some devices, drivers need to be installed manually.
- Select the serial port to use in the picklist (*Comx* on Windows® and *ttyACMx* on Linux® and Mac®). On a Mac® computer, the port *cu.Bluetooth-Incoming-Port* is the Mac Bluetooth® adapter. This port is not connected to the STM32 device and must not be used).
- Select the serial baud rate in the picklist. This picklist is only accessible in the Bluetooth® mode. 921600 is recommended for STM32WB0 devices while 115200 must be used for other STM32WB or STM32WBA devices.
- Click *CONNECT*

The board is connected, and the version is displayed on the right side of the bar.

**Figure 15. Successful COM**


When the *CONNECT* button is pressed, the software attempts to communicate with the device to read the firmware and hardware versions. If the connection is not working, the tool displays an error and disconnects the COM port.

**Caution:** In the case of a connection error, the user must check these points:

- At first board connection, driver loading might take some time, or the driver might not install automatically. If the tool is not showing the COM port in the list, check that the drivers are properly installed.
- When a user tries to open a device with the wrong mode or an unsupported baud rate, for example, open a Bluetooth® LE device in Thread mode, the device cannot decode the command sent and might freeze or crash the target software. In this case, it is necessary to unplug/replug the board to reset it.
- Delay on Ubuntu®[(a)]:
  - On Ubuntu, the *modemmanager* process checks the COM port when the board is plugged in. Due to this activity, the COM port is busy for a few seconds, and STM32CubeMonitor-RF cannot connect.
  - The user must wait for the end of the *modemmanager* activity before opening the COM port.
  - If the user does not need *modemmanager*, it can be uninstalled with *sudo apt-get purge modemmanager*.
- Port not visible or connectable on Linux®:
  - The user might not have the proper access rights for ttyACM. Ubuntu requires adding the user to the dial-out group with the *sudo adduser <username> dialout* command (replace username with user name).
- If another application opens the port, the tool is unable to connect.
- When a USB device is removed, the Virtual COM port is not closed automatically, and the software might not be informed of the disconnection. If a USB device is inserted when the Virtual COM port is already opened, the board is not mounted in the system. To solve this, close the COM port on STM32CubeMonitor-RF, disconnect the USB cable, and reinsert it. In some rare cases, it is mandatory to enable or disable the COM port in the OS device manager.

a. Ubuntu is a registered trademark of Canonical Ltd.

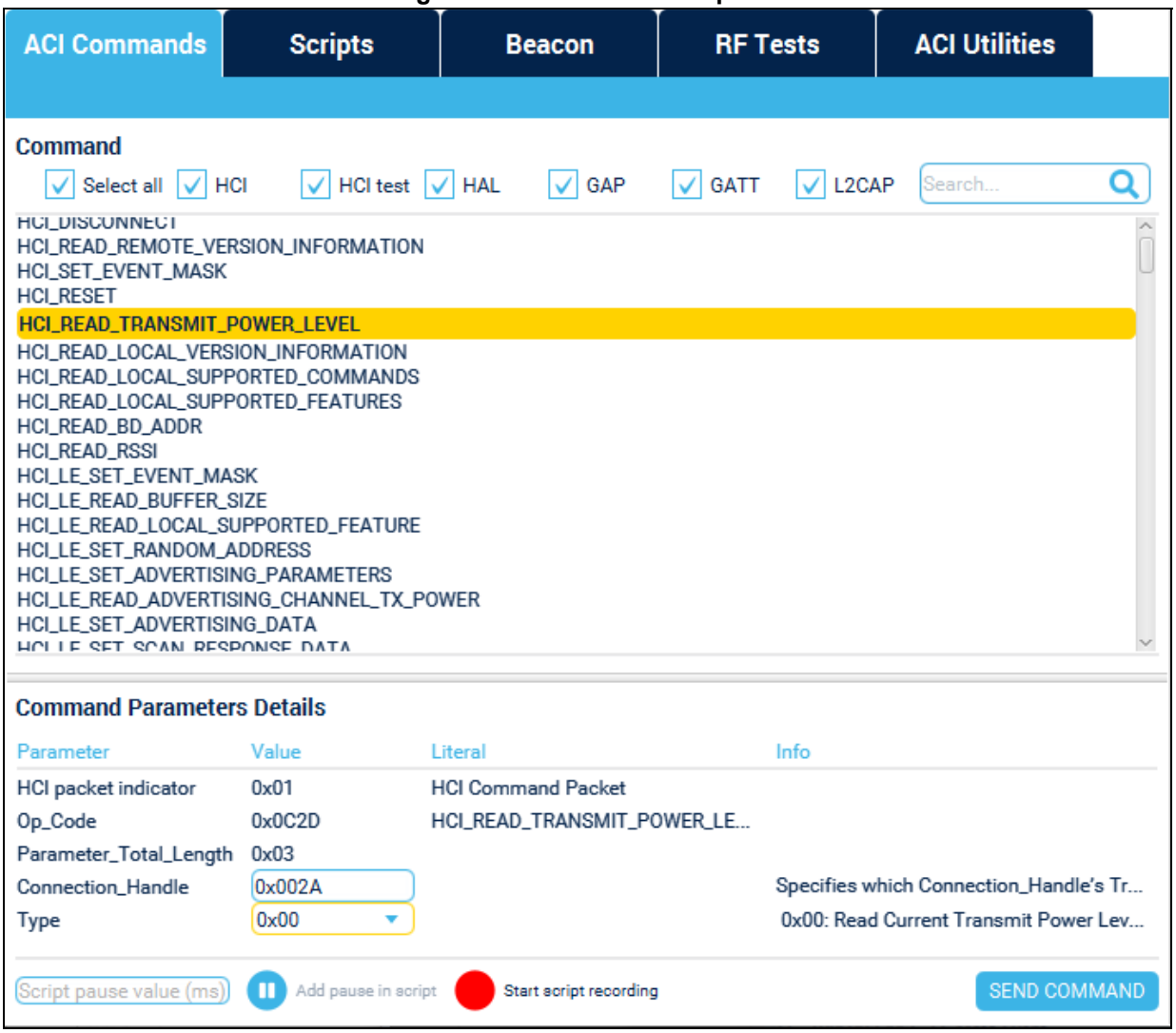
# 3 Bluetooth® LE mode

## 3.1 Presentation

### 3.1.1 Panels

The panels are used to perform a specific operation. Each panel regroups different functions, as *Figure 16* shows when the *ACI Commands* panel is selected.

**Figure 16. ACI Commands panel**




The main panels are *ACI Commands*, *Scripts*, *Beacon*, *RF Tests*, and *ACI Utilities*. They are detailed in the next section.

## 3.2 Bluetooth® LE stack

From STM32Cube_FW_WB_V1.14.0, there are some STM32WB_Copro_Wireless_Binaries variants. STM32CubeMonitor-RF needs to use *stm32wb5x_BLE_Stack_full_extended_fw.bin*.

For more information, refer to https://github.com/STMicroelectronics/STM32CubeWB/tree/master/Projects/STM32WB_Copro_Wireless_Binaries.

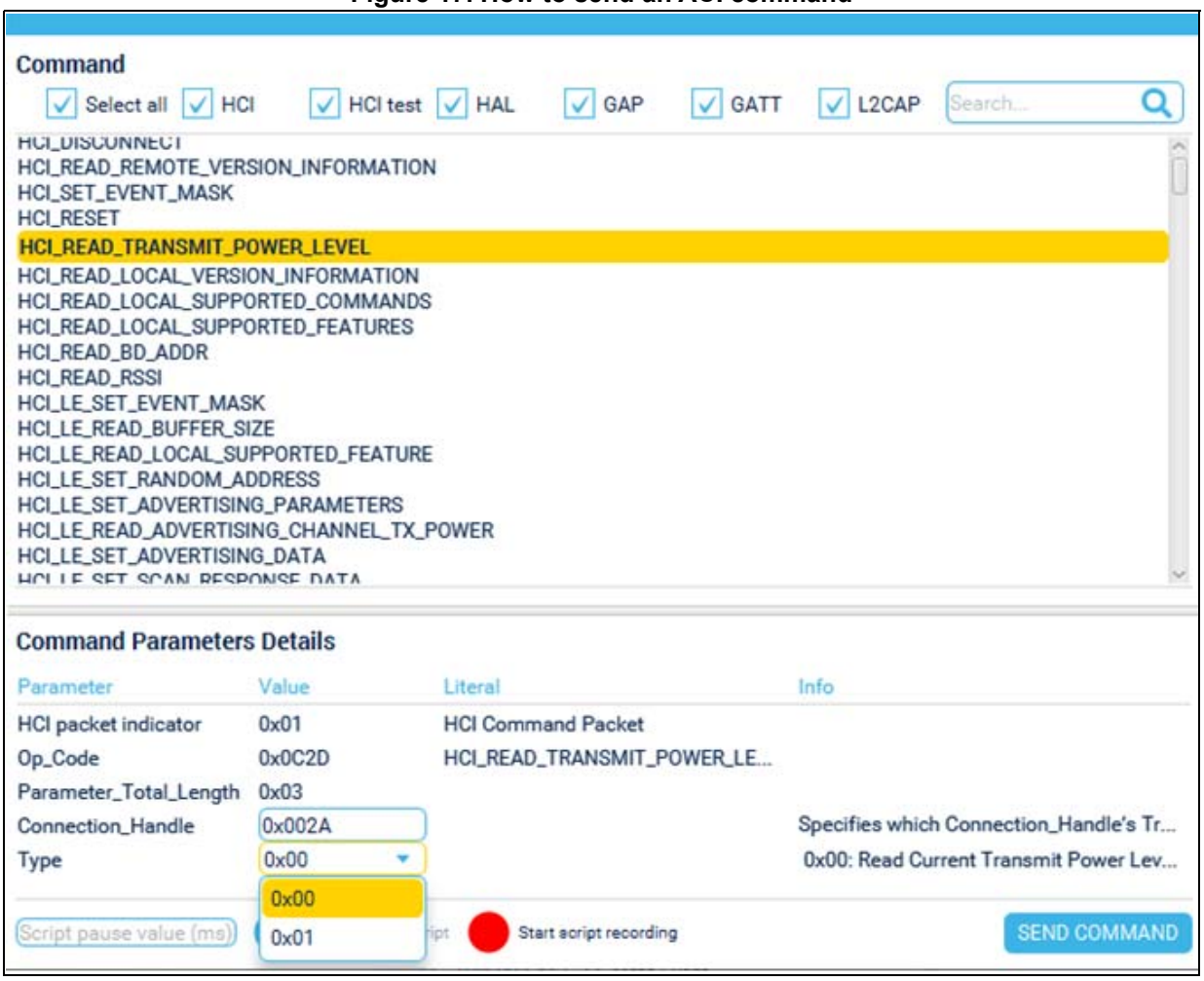
For the STM32WBA devices, there exist different variants for the Bluetooth® LE stack, such as *Full*, *Basic*, *Link Layer Only*, and *Link Layer Only Basic*. Note that the default *BLE_TransparentMode.bin* firmware is based on the Basic feature variant and does not support all commands. A new build is required to support extra commands such as extended advertising. Refer to *\Middlewares\ST\STM32_WPAN\ble\stack\doc\STM32WBA_BLE_Stack_User_Manual.html* for more details.

## 3.3 ACI Commands panel

The application command interface (ACI) panel is used to send commands to the main device Bluetooth® LE stack. Categories group commands. These commands allow the user to configure the Bluetooth® LE stack and activate communication with remote devices.

### 3.3.1 How to send an ACI command

**Figure 17. How to send an ACI command**




Before sending any command to the main device, the device must be connected.

To send an ACI command:

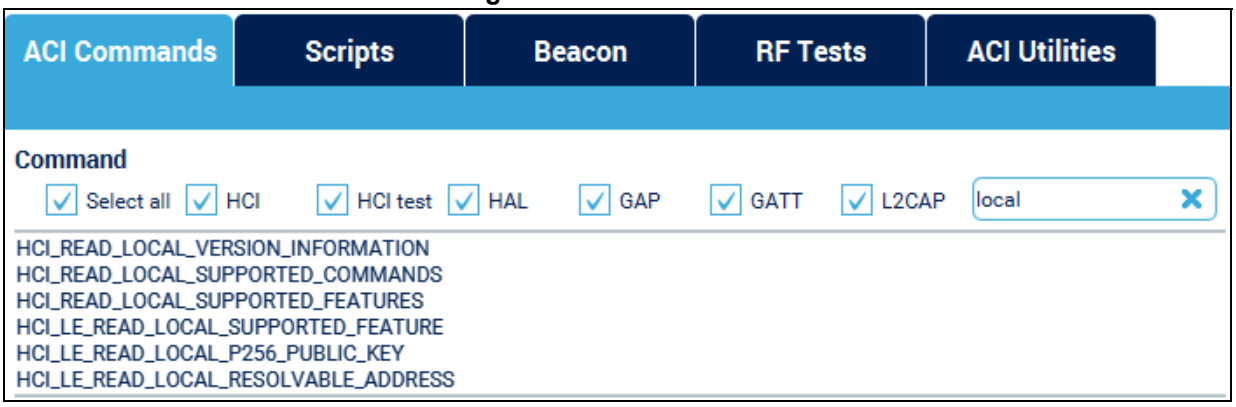
1. Select a command name in the command list (for example HCI_READ_TRANSMIT_POWER_LEVEL).
   The command parameters are displayed in the *Command Parameters Details* area.
2. Fill in the parameters of the command. Default values are used otherwise.
3. Click on *SEND COMMAND*. The command is sent to the main device.

### 3.3.2 Search function

The search icon is used quickly to select a command in the list:

- Click on the magnifier icon. A text box is created
- Type the name to search. As soon as a character is entered, matching commands are filtered in the list. The match might be any part of the command name. It is not necessary to start from the beginning.
- Click once on the command to select it (do not use double-click).

Figure 18. Search button




### 3.3.3 Filter usage

This features group and name the commands. The groups are:

- HCI
- HCI test
- HAL
- GATT
- GAP
- L2CAP

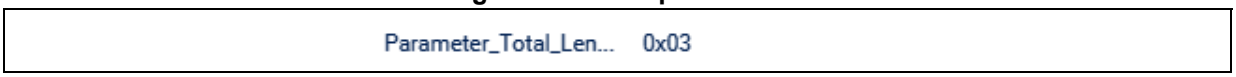
The picklist at the top of the area allows seeing only some groups to find the commands more easily. Click on *Select all* to see all the commands in the list.

### 3.3.4 How to fill parameters. Fixed field/editable field

Some parameters have fixed values and are not editable, while others are free or take only some values. The tool guides the user to fill in the parameters:

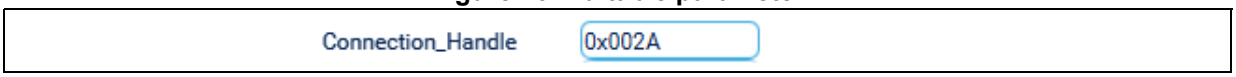
- Fixed parameter: this parameter is not editable. The specification or logic defines the value. This applies to the *length* value automatically computed by the tool.

Figure 19. Fixed parameter



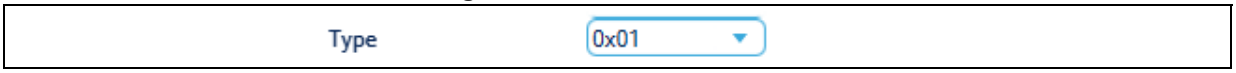

- Editable parameter: the editable parameter is surrounded by a blue rounded box. The value is editable inside the field. Edit is blocked if the value is too long for the field.

Figure 20. Editable parameter



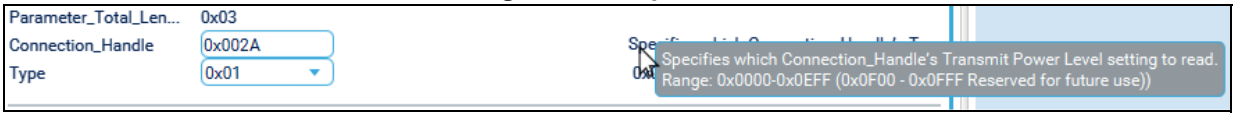

- Predefined values: when the choice is limited, a picklist is displayed to help the user select the values.

Figure 21. Predefined values



For some parameters, some help is available in the column *Info*. To see the help details, put the pointer on the wanted parameter info, and a bubble displays the details.

**Figure 22. Help details**




### 3.3.5 Log functionalities

The log area is on the right part of the screen. It displays the messages exchanged with the boards.

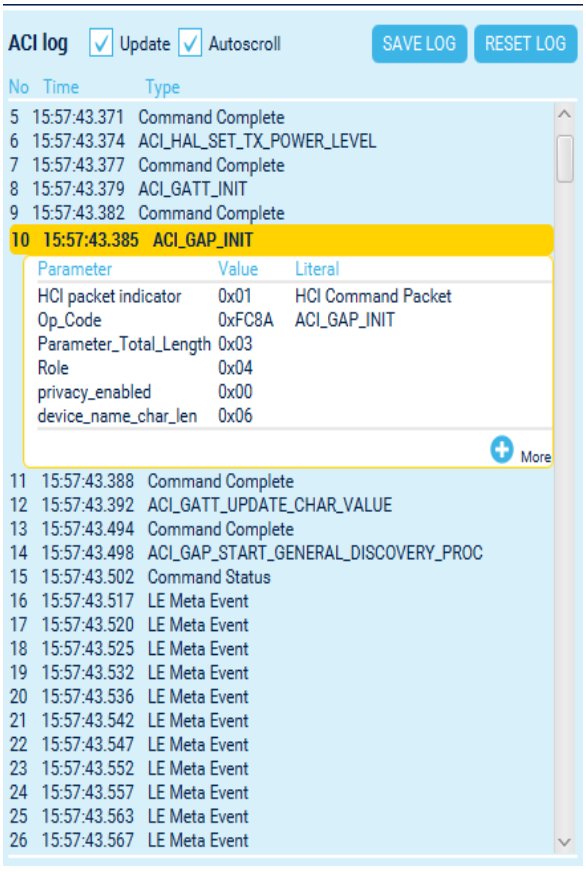
When a command is sent, most of the time an immediate answer comes from the board. It is a *Command Status* or a *Command Complete*.

The commands with *Command Status* usually have other events coming later. These events are also displayed in the log area.

Some asynchronous events might come from the device and be displayed in this area.

The tool keeps the last 1000 lines. When the limit is reached, the oldest lines are automatically discarded.

**Figure 23. Log functionalities**



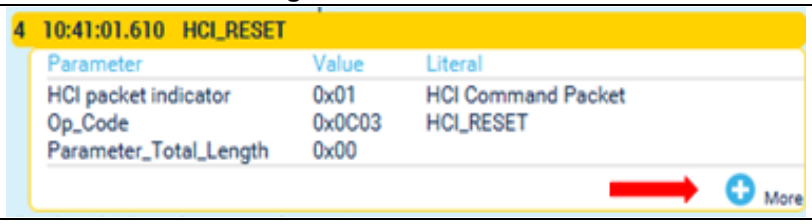

The user can scroll through the list using the scroll bar on the right-hand side.

When a line is selected, the content of the selected message is displayed in the green area, with one line for each parameter.

The text ends with … when it is not possible to display the complete text. It is possible to change the log area width to display longer texts.

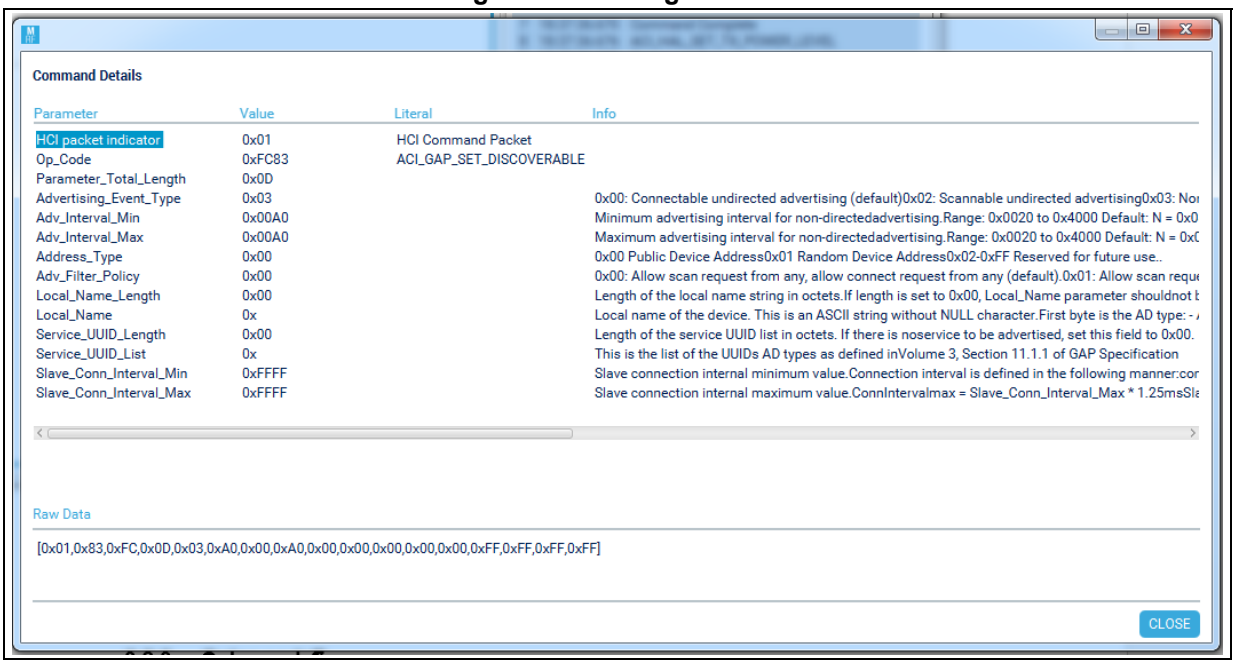
### Details

**Figure 24. More button**




Sometimes, all the information in a message does not fit in the area used for the log. The button shown in *Figure 24* opens a new window showing the message details:

**Figure 25. Message details**




The details show all decoded message parameters. The *Literal* column shows a predefined text for the parameter values (opcode and others). The *Info* column provides some description of the parameter content.

The raw data in the bottom part is the data sent/received over UART, without decoding.

In this window, it is possible to copy information to paste it into other windows.

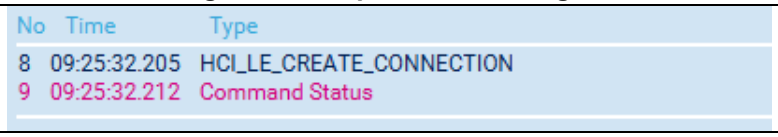
An efficient solution to compare two messages is to open multiple detail windows at the same time.

### Color code

The logs use a color code to identify the device used and highlight errors.

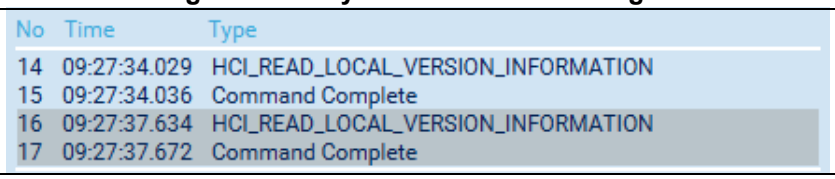
A line with purple text shows that the status in the message is different from zero, which indicates an error.

**Figure 26. Purple error messages**




A log on a dark gray background comes from a second board. When the two boards are connected, the main device (DUT) has a normal color log while the second device tester has a darker background. This is helpful to understand the sequences involving the two devices.

**Figure 27. Gray second board messages**




### Update button

When the *Update* tick box is not selected, the messages are not added to the log area. The line number continues to increase anyway but is not displayed until the *Update* tick box is enabled.

### Auto-scroll

When the *Auto-scroll* box is ticked, the log area always displays the last log received. To check the log history, untick the box that disables the auto-scroll.

### Reset log

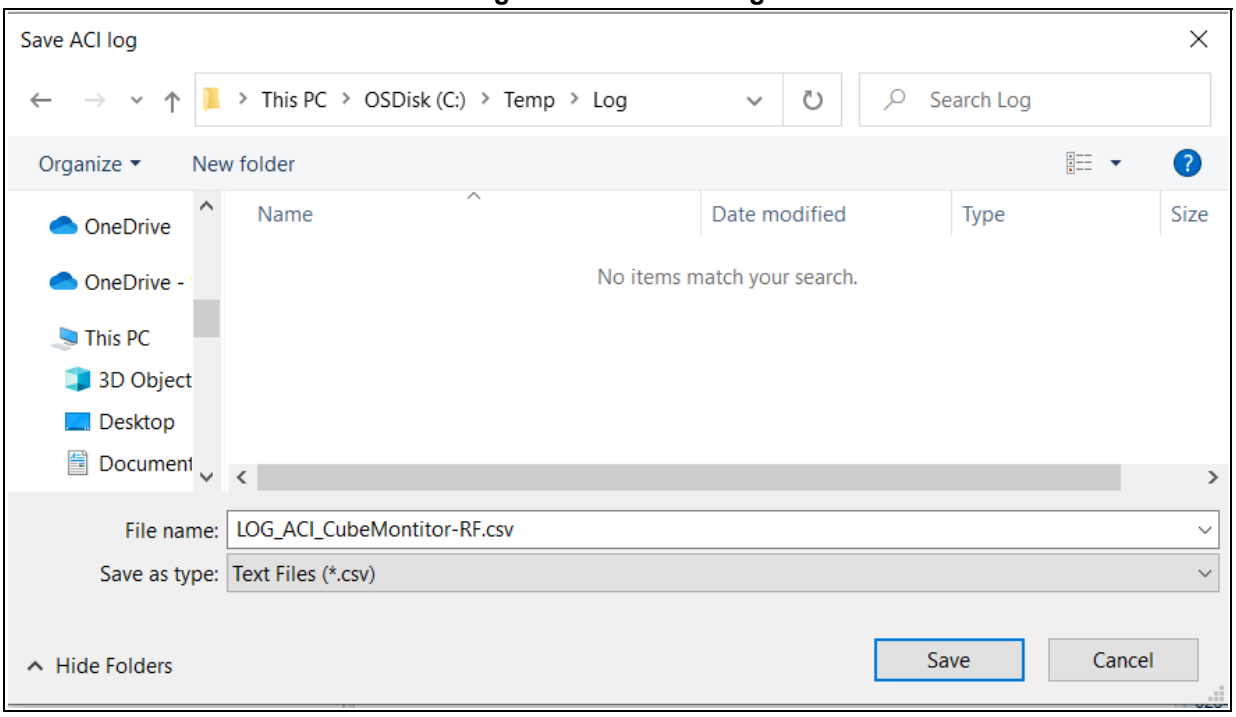
The *RESET LOG* button allows wiping the log displayed in the log area. The line number is not affected, but the memory used by older logs is made free.

The *RESET LOG* button resets the ACI log buffer used for log saving executed by the SAVE LOG action described just after

### Save log

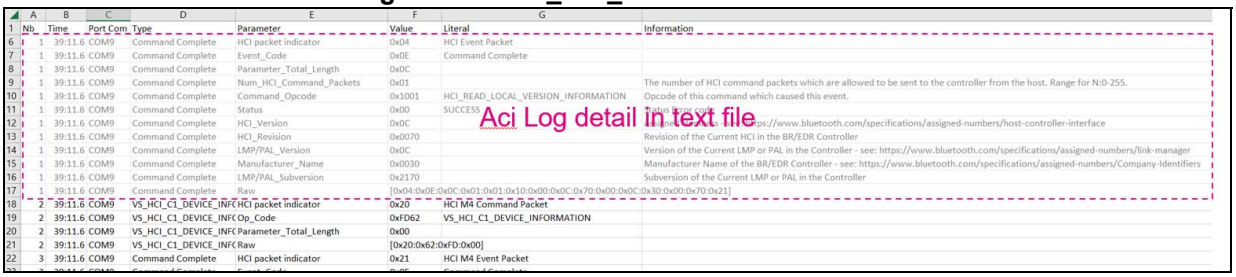
The *SAVE LOG* button allows saving the ACI log text file in csv format.

**Figure 28. Save ACI log**




In the csv file, there is one line per parameter. Then there are several lines per type of command. The number, the time, as well as the type fields are repeated for each parameter. Refer to *Figure 29* as an example.

**Figure 29. LOG_ACI_CubeMonitor-RF.csv**




The *SAVE LOG* button does not reset the buffer. A further *SAVE LOG* action saves not only the ACI log generated from the last *SAVE LOG* action but also the anterior-generated ACI log.

The buffer is erased only on the *Reset log* action.

## 3.4 RF test panel

The RF test panel is used to perform the radio frequency tests on the main device. The RF tests are grouped into three test modes: Transmitter (TX), Receiver (RX), and Packet error rate (PER):

- The TX test is dedicated to radio frequency emission, for tones and packets.
- The RX test is for packet reception.
- The PER test is a quality transmission test between two devices.

**Figure 30. Test mode selection**


The first action after connecting a device is to select the mode to test and then click on the *SELECT TEST MODE* button.

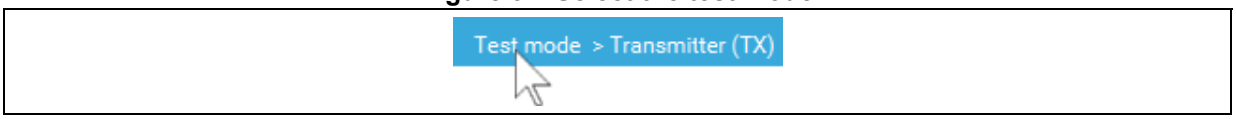
When the user selects a test mode, it is mandatory to go back to the selection page to change the test mode:

- Click on the *Change test mode*

**Figure 31. Change the test mode**


- Click on *test mode* in the top bar.

**Figure 32. Select the test mode**

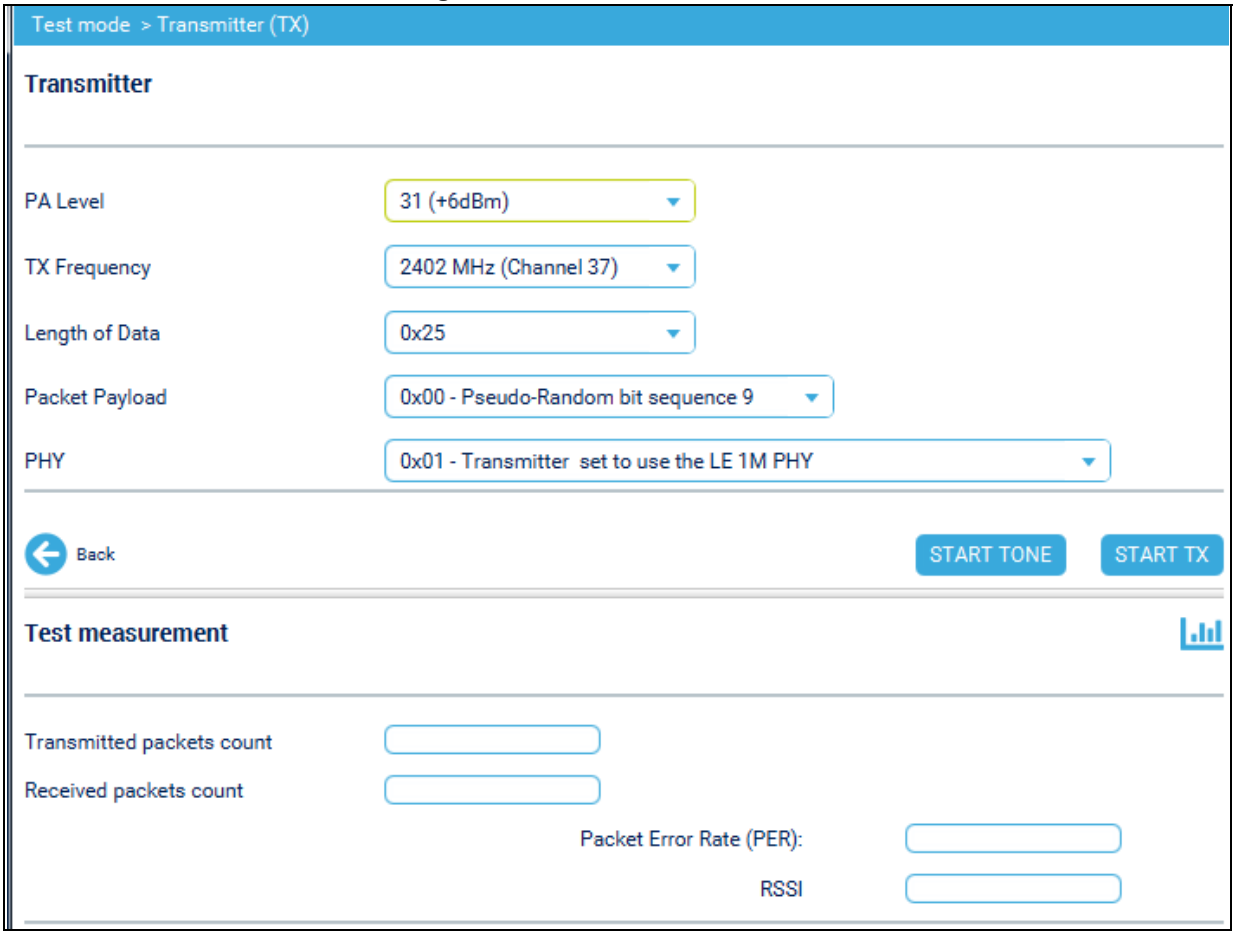



*Note: To avoid incorrect configuration of the device, the test mode is unchangeable when transmission or reception is ongoing. The user must first stop the transmission and then change the test mode.*

### 3.4.1 Transmitter test mode (TX)

The TX mode is used to set the Bluetooth® LE transmitter in emission. Two transmission modes are defined: *transmission of data*, or *emission of tone*.

**Figure 33. Transmitter test mode**




#### Tone generation

The tone generation performs the emission of a continuous sinus wave on the RF. The parameters for the tone are tone power level and tone frequency. The power level is the power at the chip output.

To start tone generation:

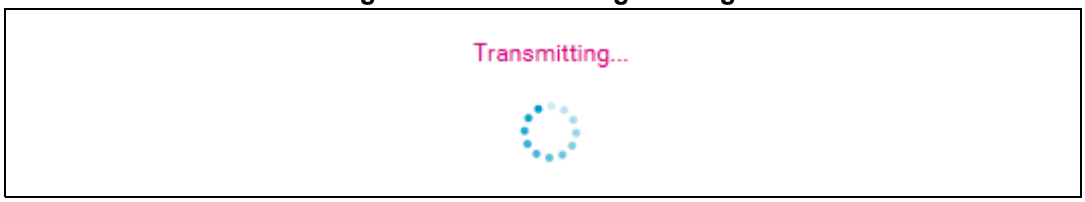
1. Enter the Transmitter panel test mode.
2. Select the power level with the picklist.
3. Select the frequency with the TX frequency picklist. The list is sorted by frequency; the data/advertising channel index is indicated in parentheses. The advertising channel index does not follow the frequency order. Channels 37, 38, and 39 are the advertising

channels. Refer to the BLUETOOTH SPECIFICATION version 4.2 [Vol 6 part B] chapter 1.4.1 for details.

4. Select the PHY modulation to use (the unsupported modulations by the device are not listed).
5. Click on the *START TONE* button.

The emission starts, the *START TONE* button is changed to *STOP TONE*, and *Transmitting information* is displayed.

**Figure 34. Transmitting message**




6. To stop the tone generation, click on *STOP TONE,* and the emission stops.

It is mandatory to stop transmission to change to another test mode.

### Packet transmission

It is possible to send some data packets in test mode. The parameters are power level, transmission frequency, length, and content of the data to send.

Power and level parameters are the same as tone parameters.

The packet data is selected in the *Packet payload* picklist. Eight types of payloads are available:

- A pseudo-random bit sequence 9 (PRBS9)
- A pattern of alternating bits *0b11110000*
- A pattern of alternating bits *0b10101010*
- A pseudo-random bit sequence 15 (PRBS15)
- A pattern of fixed bits *0b11111111*
- A pattern of fixed bits *0b00000000*
- A pattern of alternating bits *0b00001111*
- A pattern of alternating bits *0b01010101*

The *Length of data* picklist defines the sequence length. This is the length of the data payload in bytes. The PHY box is used to select the modulation.

To start packet emission:

- Select the power level with the picklist.
- Select the frequency with the TX frequency picklist.
- Select the length of the packet to send
- Select the content of the packet payload
- Click on *START TX*
  The emission starts, the start button is changed to *STOP TX*, and Transmitting is displayed. The sequence is repeated until the test is stopped.

To stop the transmission, click on *STOP TX*. The number of packets transmitted during the test is displayed in the test measurement area.

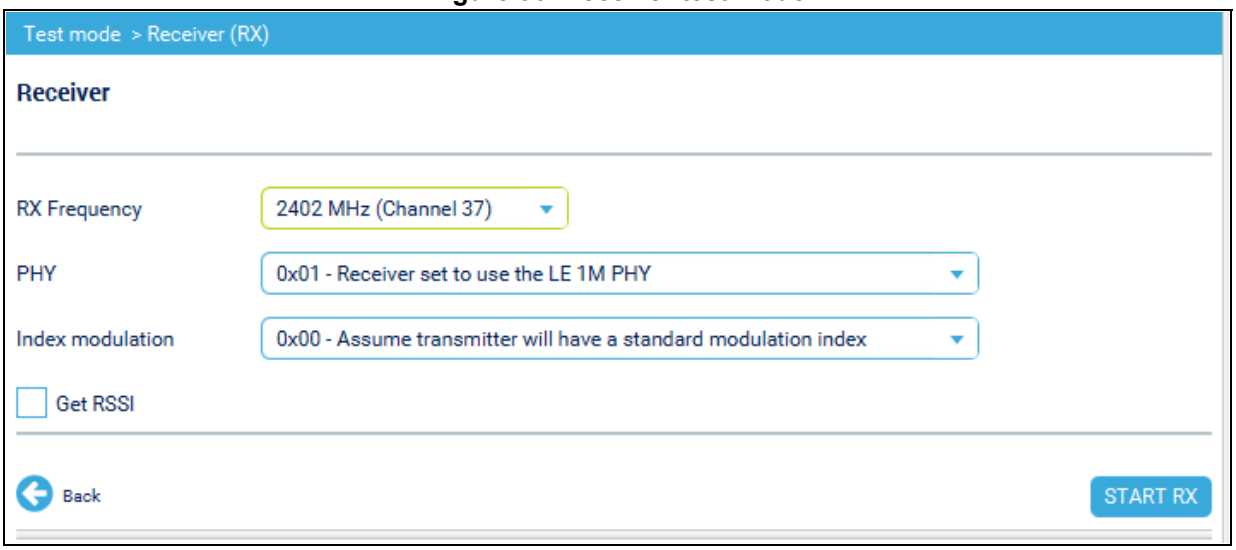
**Figure 35. Transmitted packets count**


If the number of packets received by the reception device is known, it is manually entered in the *Received Packet Number* box. The *Packet Error Rate* is automatically computed (refer to *Section 3.4.3: PER* for details).

### 3.4.2 Receiver test mode (RX)

The Receiver mode is used to put the main device in Reception mode and count packets received.

**Figure 36. Receiver test mode**




#### Packets reception

- Select the frequency to use.
- Select the PHY and the modulation index to be used.
- Click on *START RX*. The reception starts, *Receiving* is displayed with an animation, and the button changes to *STOP RX*.

To stop reception, click on *STOP RX*. The count of received packets is retrieved from the main device and displayed in the *Received packet number*.

If the number of transmitted packets is known, it might be entered manually in the *Transmitted packet number*. The *Packet Error Rate (PER)* is automatically computed (refer to *Section 3.4.3* for details).

If the *Get RSSI* checkbox is selected, the tool performs an RSSI measurement.

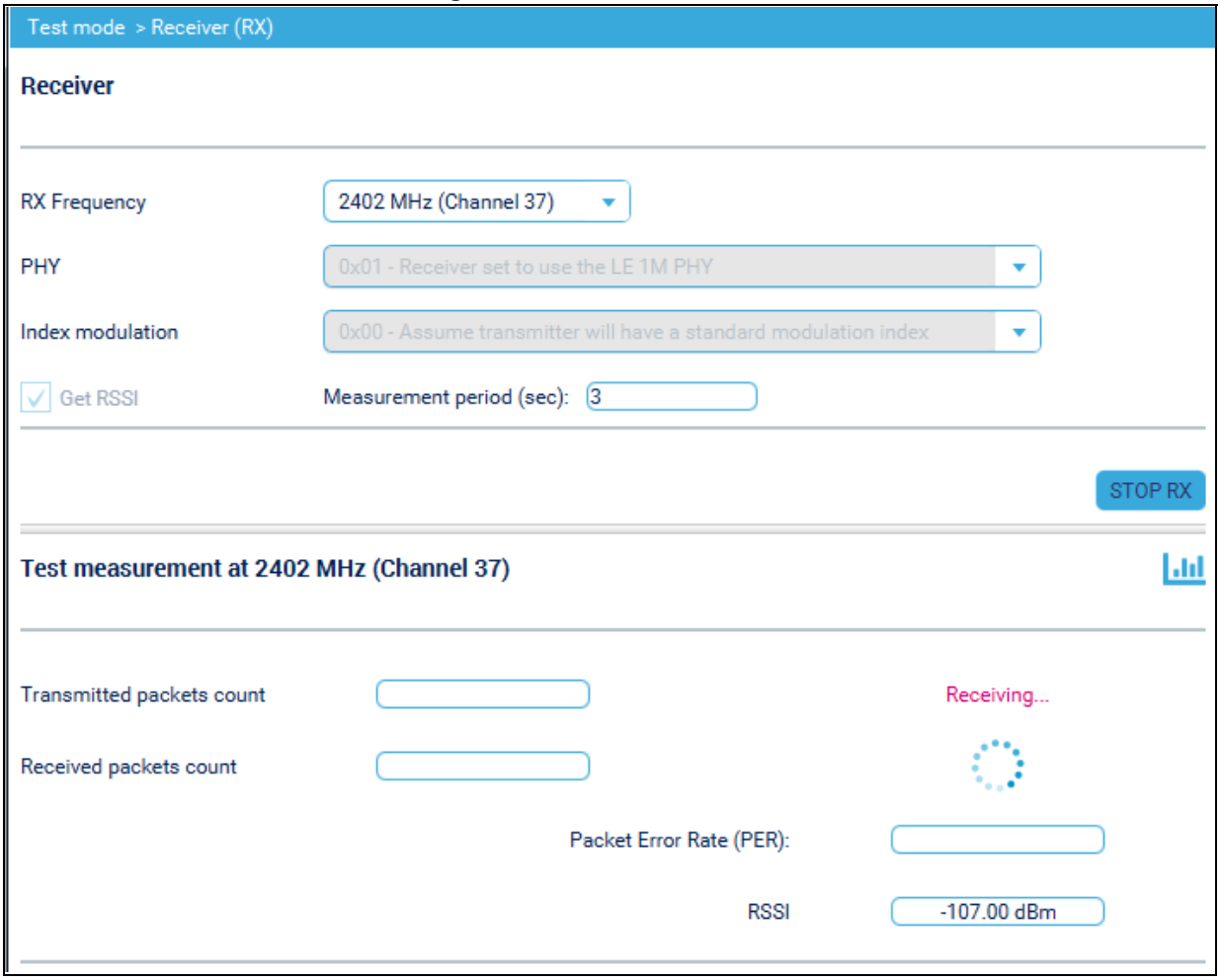
#### RSSI measurement

The RSSI indicates the signal level received by the RF. The value reported by the RF is not an absolute value because the reception level is dependent on the board layout and antenna design. Note that only the STM32WB devices support RSSI measurement.

When the RSSI option is selected, the user must define the measurement interval. The default value is 3 seconds. The RSSI value is displayed at the end of each measurement period.

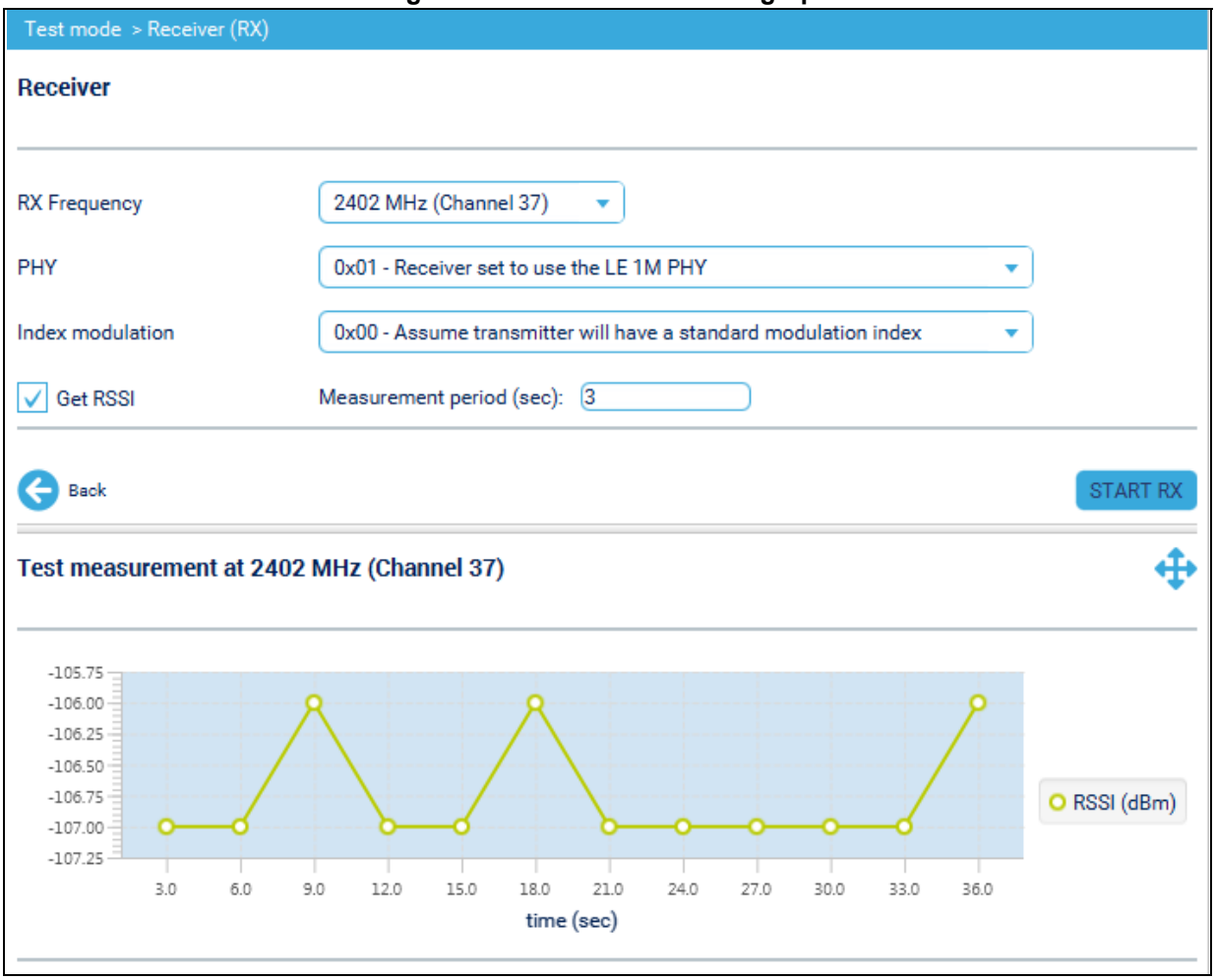
It is possible to switch between detailed value, plot view, and display, with the blue button on the right (bar chart, arrows, or blue lines).

**Figure 37. RSSI measurement**



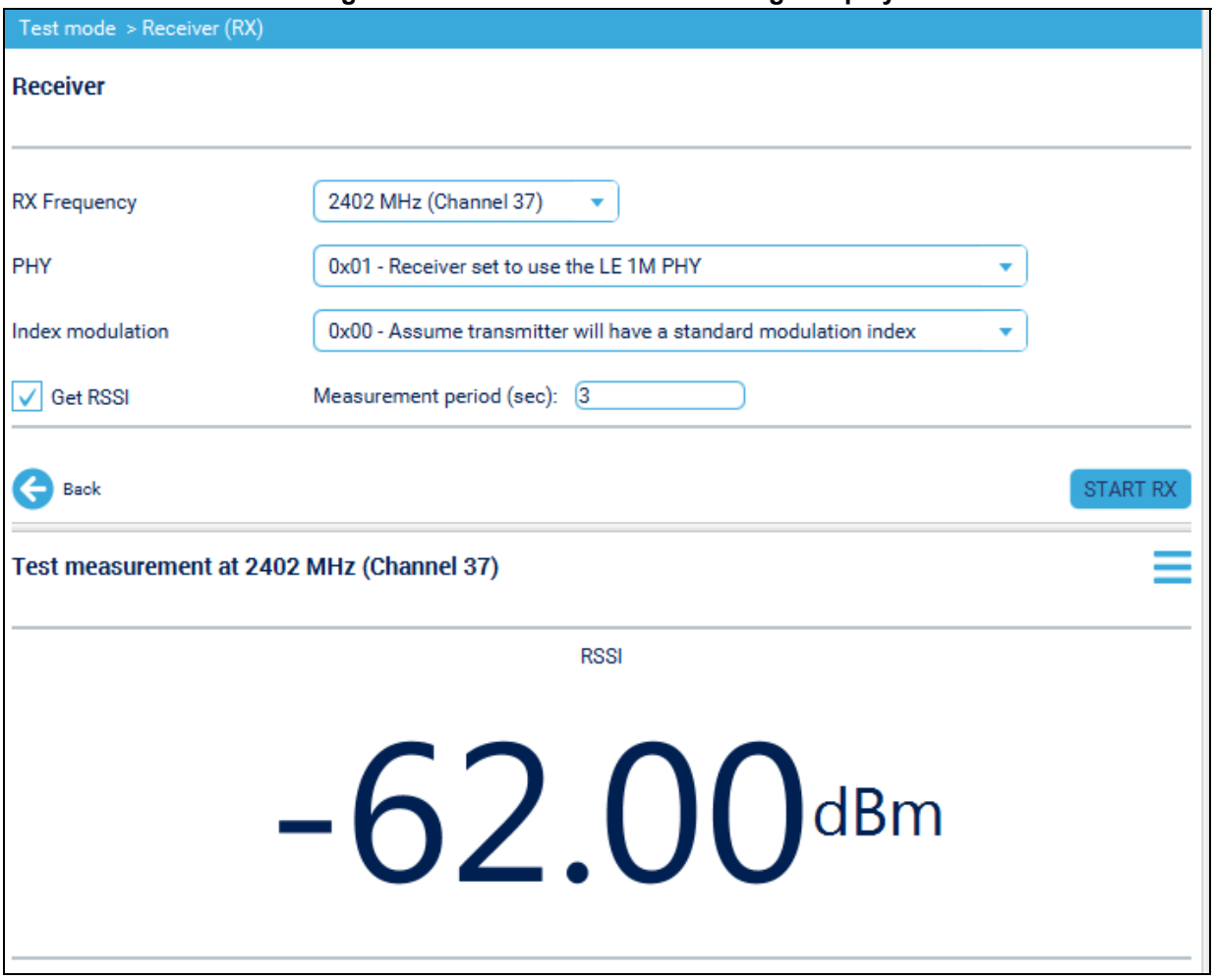

*Note: When the RSSI measurement is performed, the number of received packets is not available in the tool. When the measurement is stopped, the Received packet number field is cleared, and an information message is displayed.*

**Figure 38. RSSI measurement graph**




*Note: The graph length is limited to 250 points. When the limit is reached, the oldest points are discarded.*

Figure 39. RF RSSI measurement large display




### 3.4.3 PER

#### PER definition

The packet error rate (PER) is an indicator of the quality of transmission between the two devices. The measurement proposed in the tool covers the whole transmission chain from the transmitter to the receiver.

The packet error rate is computed with the number of packets sent and the number of packets received. A good transmission gives a low PER. A high PER means that the transmission is not good.

Figure 40. PER definition

$$PER = 100 \times \frac{Ntx - Nrx}{Ntx} \%$$

Ntx: Number of packets sent. Nrx: Number of packets received. PER: The result is in percent.

A bad PER might be an issue from the transmitter or the receiver and depends on parameters like the distance between devices, antennas, PCB design, and interferences. To limit the parameters influencing the measurements, it is advised to use one reference board with well-known performances in the setup.

### PER test mode

The tool provides a special test mode dedicated to the PER test. In this mode, two devices need to be connected to the computer:

- The first device under test (DUT)
- The second device acts as a packet generator (tester)

After the connection of the DUT (main device, connected in the application top bar), the PER test mode is selectable on the RF test page.

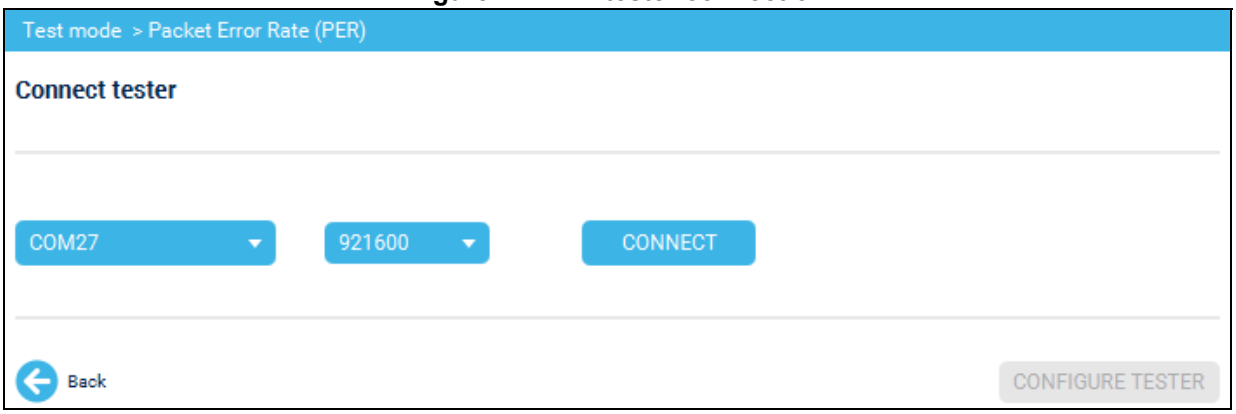
The configuration of the PER test is done with a sequence of panels:

- Tester connection
- Tester configuration
- DUT configuration
- Test parameters

The first step is to connect the tester:

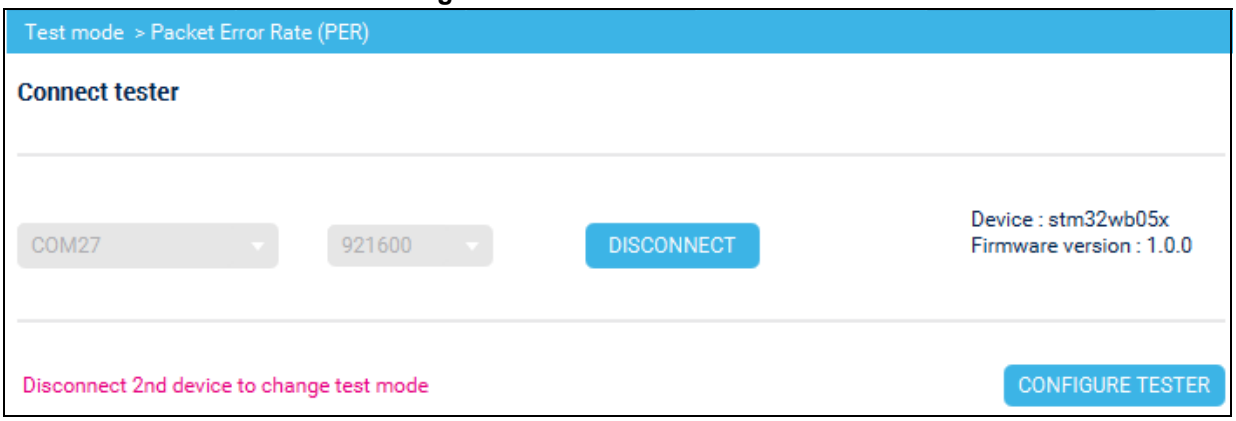
PER tester connection

**Figure 41. PER tester connection**




- Plug the device into the computer with the same requirements as the first device. Refer to *Section 2.2*.
- Select the serial port to use in the picklist.
- Click on the *CONNECT* button.

**Figure 42. PER tester connected**

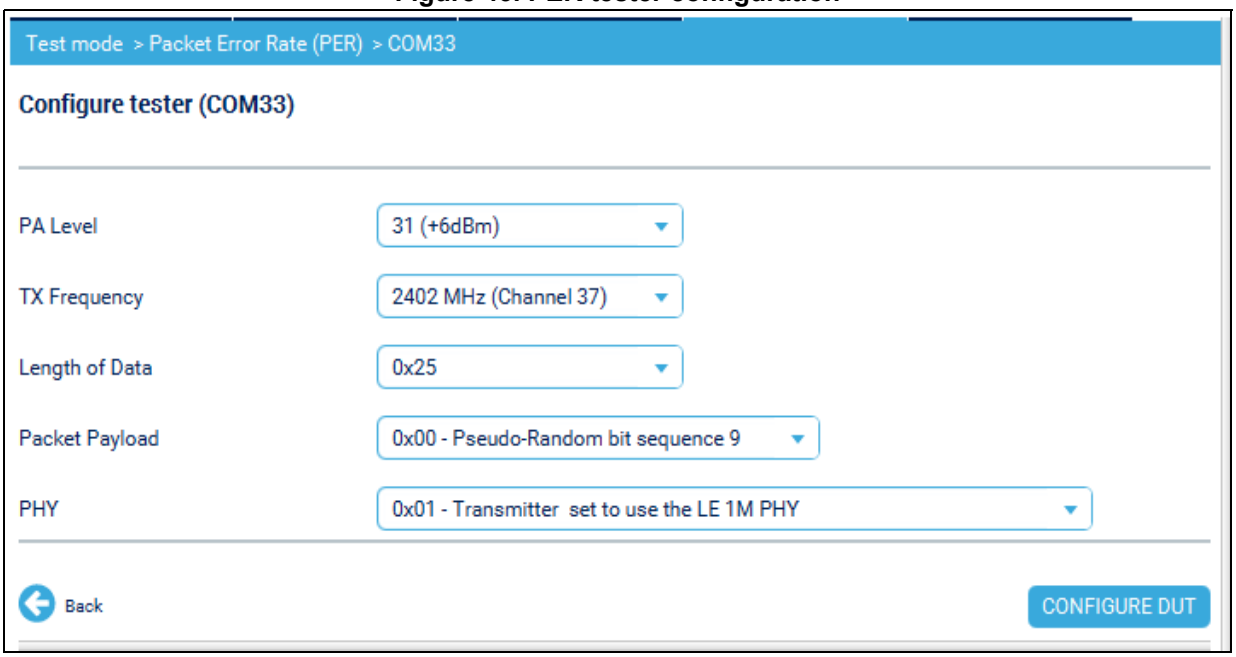



- The board information is displayed on the right.

When the second device is connected, it is not possible to change the mode. Disconnect the device first, and then use the *back* button.

Click on *CONFIGURE TESTER* to set the tester parameters:

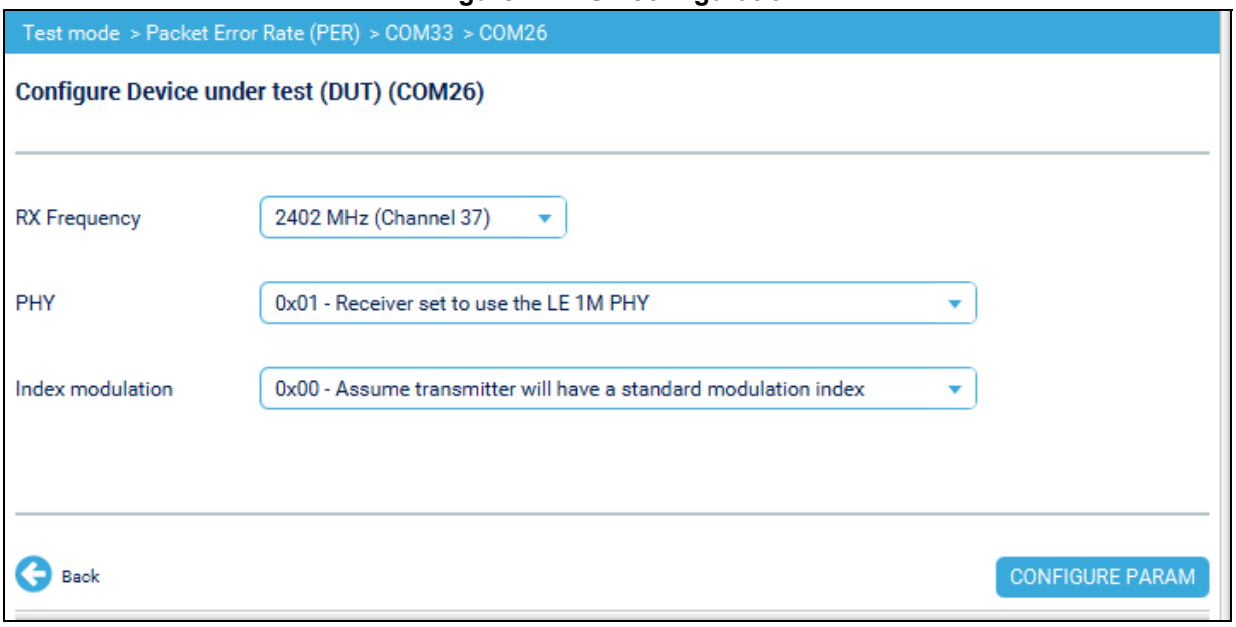
**Figure 43. PER tester configuration**




- Select the TX power level with the picklist.
- Select the transmission frequency with the *TX Frequency* picklist.
- Select the length of the packet to send (the same as the TX test).
- Select the content of the packet payload. For the PER test, it is recommended to use the *Pseudo-Random bit sequence 9* reference pattern. Patterns containing only 0 or 1 must not be used for PER. Other patterns can be used.
- Select the PHY to use.

Click on *CONFIGURE DUT* to set the *Device Under Test* configuration:

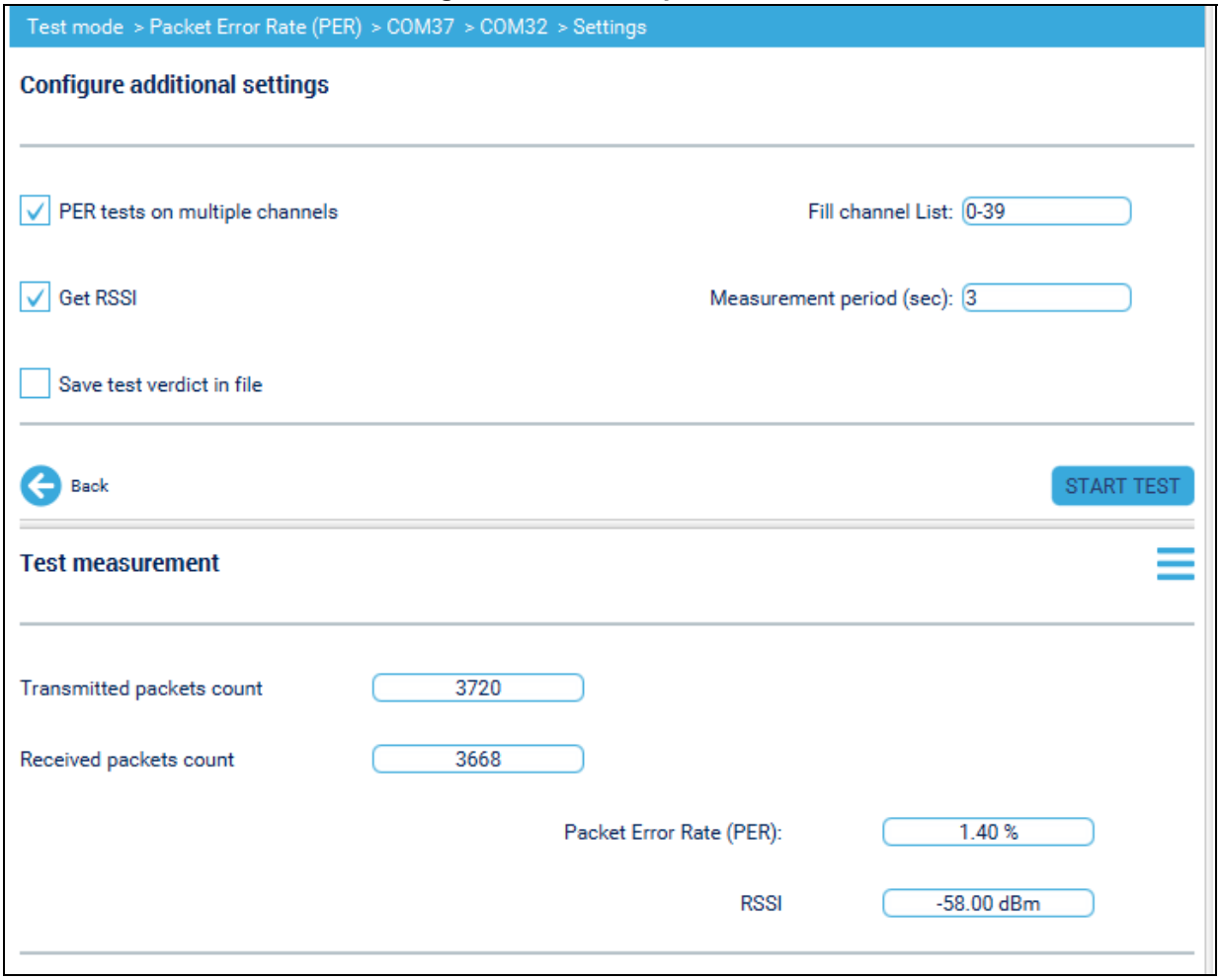
**Figure 44. DUT configuration**




Select the reception frequency, the PHY, and the modulation index for the receiver board. The tool uses by default the same frequency as the tester, but the user might modify it.

Click on *CONFIGURE PARAM* to set the test configuration:

**Figure 45. PER test parameters**




- *PER tests on multiple channels*: when this option is selected, the PER test is performed on a list of predefined channels. When the box is ticked, the *Channel list* is displayed. The *Value 0-39* indicates all channels from 0 to 39. It is also possible to put values separated by a comma: *0,1,5* or to mix: *0,1,10-15*.
  The measurement period is the time of each PER test to be performed.
- *Get RSSI*: this option adds some RSSI measurement between each PER measurement. When activated, the tool performs a PER test for the measurement period, computes PER, and then makes an RSSI check. Note that RSSI measurement is not supported for STM32WB0x devices.
- *Save test verdict in file*: this option generates a test report of the measurements. When the option is selected, a *SELECT FILE* button is displayed. The user must select the report file before starting the tests. The report is saved at the end of the tests.

When the option has been configured, click on the *START TEST* button:

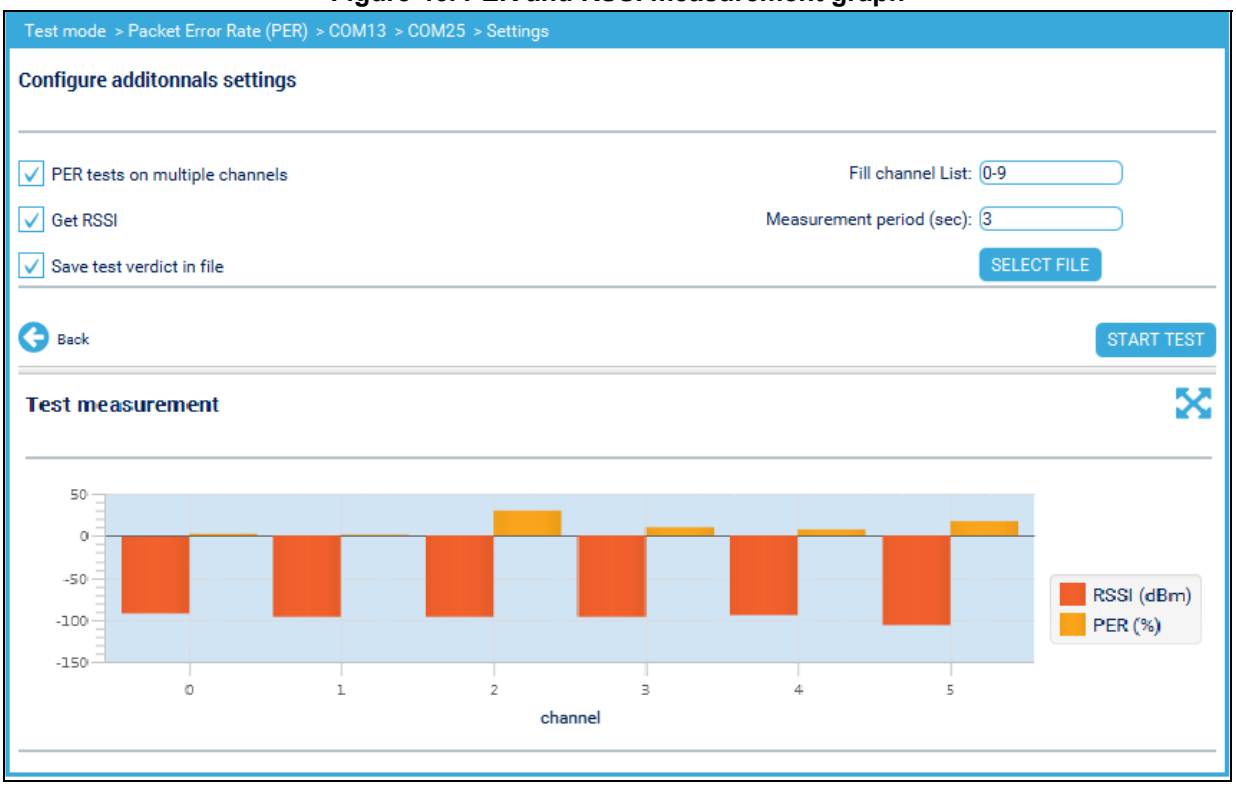
- The DUT is set in Reception mode,
- Then the tester starts.

The button is changed to *STOP* and *Testing…* is displayed.

The test continues until the user presses the *STOP* button, or after all channels are measured for multichannel tests.

The result is displayed in the bottom part. It is possible to switch between the numerical values and the chart with the blue bar icon.

**Figure 46. PER and RSSI measurement graph**

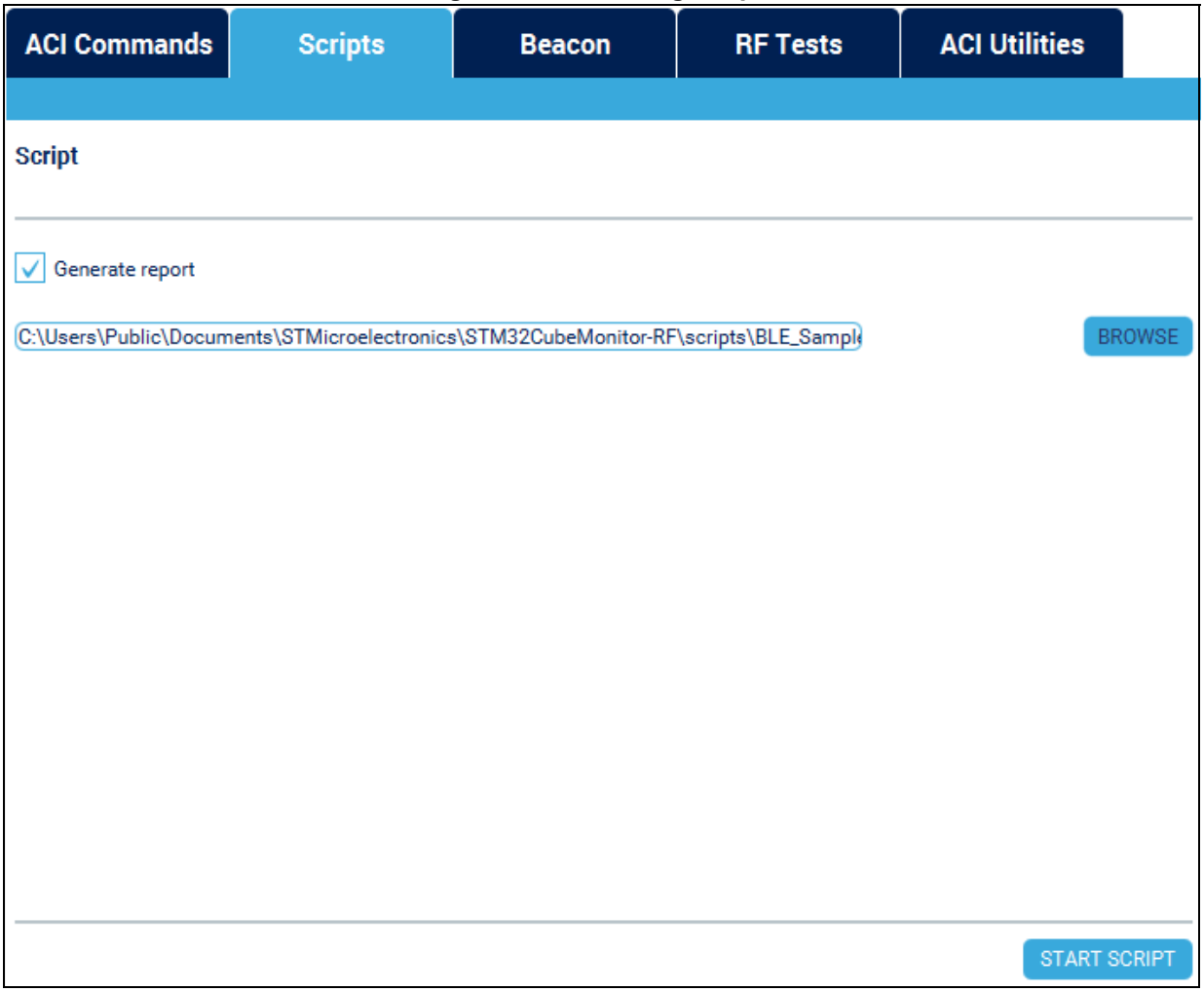


## 3.5 Scripts

Scripts are used to execute in sequence some commands stored in a text file. Scripts help avoid entering each command manually for repetitive tasks.

### 3.5.1 Launching scripts

**Figure 47. Launching scripts**

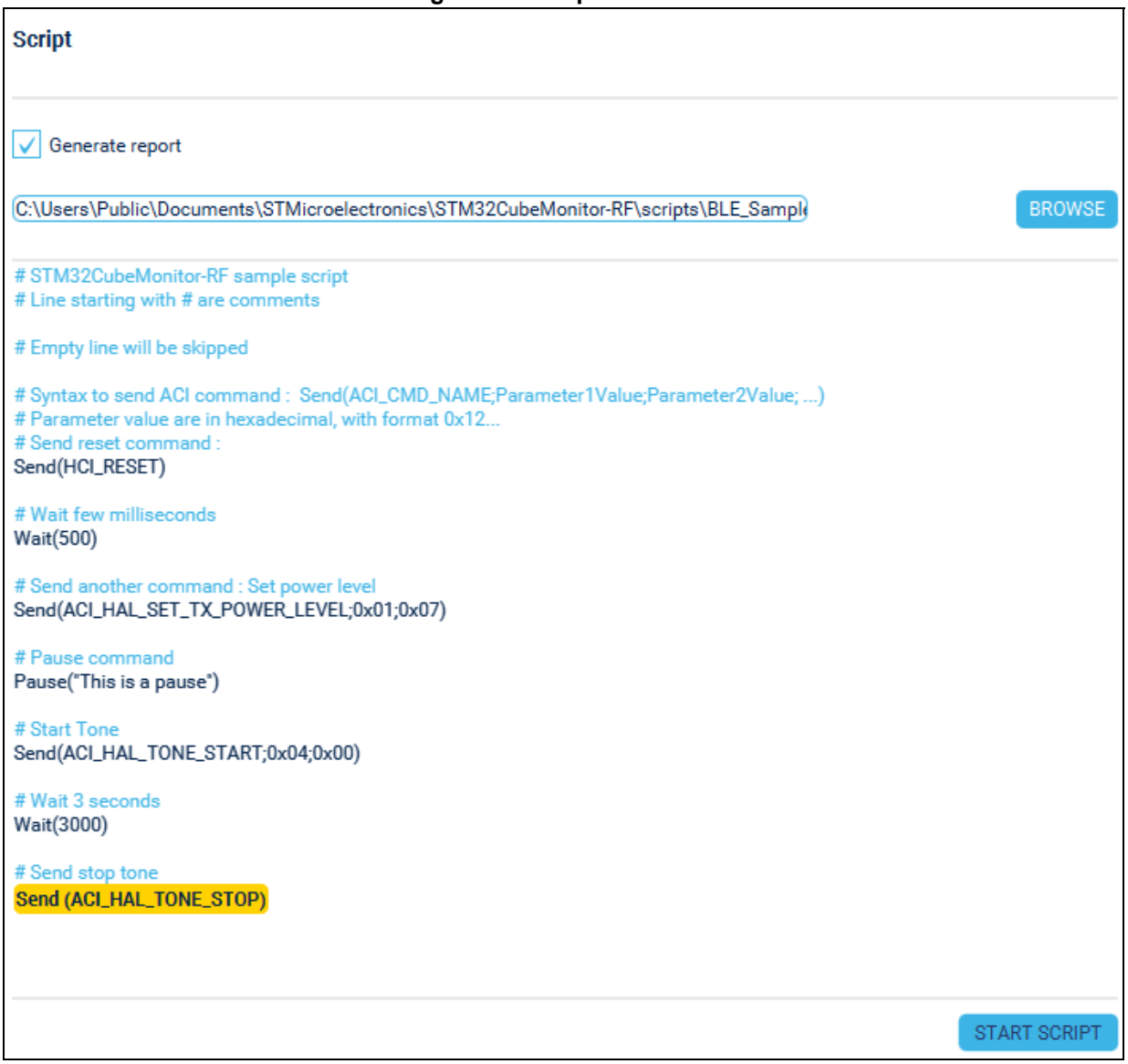



Scripts are stored in text files and are editable with any text editor.

To execute a script:

- Select the script file with the browse button or directly enter the file name.
- Click on the *Start script* button.
- The script is displayed and executed. The line in execution is highlighted in green. The ACI results are updated in the log area.
- The script is manually stopped with the *Stop script* button.

**Figure 48. Script execution**




Script examples are provided with the tool, such as sample script, loop, and beacon creation.

For Windows, scripts are in the

*C:\Users\Public\Documents\STMicroelectronics\STM32CubeMonitor-RF\scripts* (public documents) folder.

For Linux, they are in *<userhome>/STMicroelectronics/STM32CubeMonitor-RF/scripts*.

For macOS, it is inside the document folder provided in the setup package.

### 3.5.2 Script recording

The ACI commands used in the ACI panel are directly recorded in a script. Some script buttons are located at the bottom of the ACI panel:

**Figure 49. Script recording buttons**


Use the red button to start recording. Pause is inserted with the *Add pause in script* button.

At the end of the recording, click the *Stop* button. The tool asks for the script name before saving.

### 3.5.3 Scripts modification

The script is created or modified with a text editor. It uses a simple syntax to list the ACI command to send and the action to perform.

**Figure 50. Sample script**

```
# Send reset command:
Send(HCI_RESET)

# Wait a few milliseconds
Wait(500)

# Send another command: Set power level
Send(ACI_HAL_SET_TX_POWER_LEVEL;0x01;0x07)

# Start tone
Send(ACI_HAL_TONE_START; 0x00)

# Wait 3 seconds
Wait(3000)

# Send stop tone
Send (ACI_HAL_TONE_STOP)

# Pause command
Pause("End of script")
```

The lines starting with # are comments ignored by the tool. Empty lines are skipped.

Other lines are commands. The line starts with the command name, followed by parameters in brackets separated by a semicolon.

### 3.5.4 Script report

It is possible to have a script report generated at the end of script execution. The script report stores the status of each ACI command executed by the script.

**Figure 51. Script report**

```
SCRIPT REPORT

Script name: SampleScript.txt

Test date: 18/12/2017 17:27:52

Verdict: SUCCESS    No error detected


Command                       | Sent | ACI status | ACI raw result

HCI_RESET                     | OK   | 0x00       |
[0x04,0x0E,0x04,0x01,0x03,0x0C,0x00]

ACI_HAL_SET_TX_POWER_LEVEL    | OK   | 0x00       |
[0x04,0x0E,0x04,0x01,0x0F,0xFC,0x00]

ACI_HAL_TONE_START            | OK   | 0x00       |
[0x04,0x0E,0x04,0x01,0x15,0xFC,0x00]

ACI_HAL_TONE_STOP             | OK   | 0x00       |
[0x04,0x0E,0x04,0x01,0x16,0xFC,0x00]

END of report
```

The result is stored in a new file, in the same path as the script, with a name in the form: *verdict_SampleScript_18-12-2017_17-27-52*. The name is built with the concatenation of:

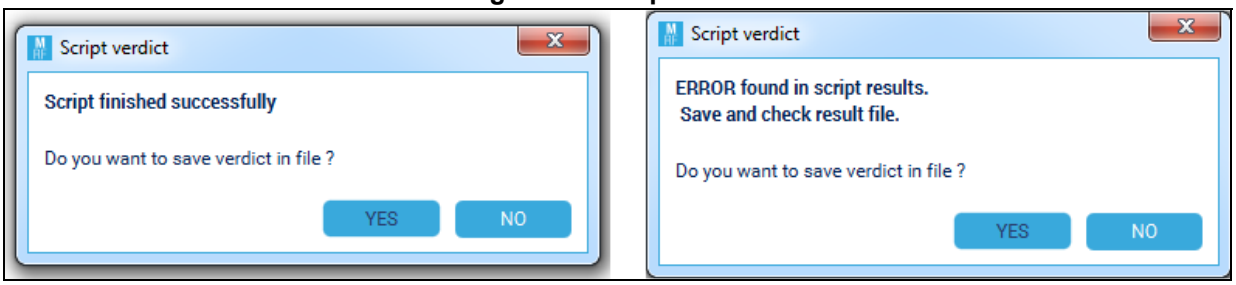
- *Verdict_*
- Script name
- Current date
- Current time
- .txt extension

In the report, the *Sent* column holds the status of the command transfer to the board. If parameters are missing, the command is not sent.

The *ACI status* column has the status of the ACI response. *0x00* is a success status while other values are errors.

At the end of script execution, a popup with the verdict (error found or finish successfully) is displayed and asks if the report must be saved:

Figure 52. Script verdict




If the user presses *yes*, the report is generated in the folder of the current script. If the user presses *no*, the report is not saved.

If the *Generate report* tick box is not checked, no report is generated at the end of the script. The script successfully means that there is no error in the script syntax, and the status of operations is *OK* (error code = 0). The value measured and the performance are not verified, there is no PASS/FAIL criterion on the results.

## 3.5.5 List of script commands

### Send an ACI command

The ACI commands are sent with the instruction *Send*: `Send (ACI_CMD_NAME; Parameter1Value; Parameter2Value...)`

The elements inside the parenthesis are separated by semicolons.

The first element is the command name. It is the name as it is displayed in the tool.

The next elements are the parameters. The value must be entered in hexadecimal format and start with *0x*. The optional parameters can be left empty. The length is dependent on the size parameter in the ACI command.

*Note: The Command Packet Type, Opcode, and Parameter Total Length are filled in by the application. They must not be added to the parameters.*

### Wait for a specific time

It is possible to add a delay with the instruction *Wait*:

```
Wait (3000)
```

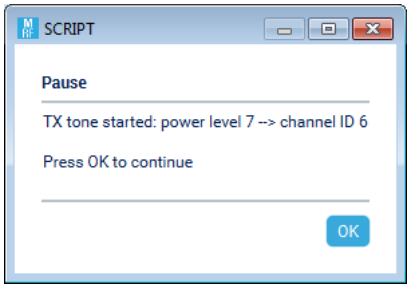
This instruction delays the script execution for three seconds. Time is given in milliseconds.

In the ACI panel screen, a pause is inserted in the script with the *Add pause in script* button.

### Pause command in the script

The *Pause* command adds a pause during the proceeding of the script. This command opens a pop-up window customized with the user's comment.

**Figure 53. Script pause**




The *OK* button allows the user to continue the script.

Command: Pause (*user comment*)

The user text must be enclosed between quote marks (“).

**Figure 54. Example**

```
# Pause demo script


# Start tone
Send(ACI_HAL_TONE_START; 0x04)


# Pause command
Pause("TX tone started")


# Send stop tone
Send (ACI_HAL_TONE_STOP)
```

## Loop command in the script

A loop can be used in the script to repeat some actions automatically.

### Loop usage

To repeat a part of a script, the commands must be enclosed between two instructions:

- *Loop (count, 0, 5)*: This instruction indicates the beginning of the repeated section. The *count* variable is the name given to the counter. The first value is the start value and the second one is the end value. In this example, the counter *count* is increased from 0 to 5. There are six iterations.
- *EndLoop* indicates the end of the loop. If the counter reaches the end value, execution continues to the next line. If the counter does not reach the end value, it is updated, and execution goes back to the *Loop* instruction.

**Figure 55. Loop simple example**

```
Loop (count; 1; 3)
Pause ("test the loop")
EndLoop
```

This script, given as an example in *Figure 55*, displays three times: *test the loop*.

**Using the counter value**

It is possible to use the counter value in other lines of the script to change the parameter values during script execution. When the counter name is embedded inside square brackets, the tool inserts the counter value.

**Figure 56. Loop second simple example**

```
Loop (count; 1; 3)
Pause ("The loop counter is [count]")
EndLoop
```

The script in *Figure 56* displays *The loop counter is 1*, then *The loop counter is 2*, and finally, *The loop counter is 3*.

Some parameters require hexadecimal values. In this case, add an ampersand (&) after the first bracket. The tool replaces the counter name with the hexadecimal value.

If count = 10, *0xA* replaces [&count].

**Special count option**

The counter value can increase or decrease. If the start value is bigger than the end value, the counter is decremented.

**Figure 57. Loop decrement**

```
Loop (mycount; 3; 1)
```

In the countdown example (*Figure 57*), *mycount* takes the values 3, 2, and 1.

The counter can have a specific increment value when a third value is added to the loop instruction, as shown in *Figure 58*:

**Figure 58. Loop specific increment**

```
Loop (mycount; 1; 6; 2)
```

This example counts with a step of 2. Successive values are 1, 3, and 5. The loop stops at 5 because 7 is higher than 6.

The loop can include another loop. It is mandatory to use a different counter name.

**Figure 59. Nested loop**

```
Loop (row;4;5)
  Loop (column;3;2)
    Pause ("coord: [row] [column]")
  EndLoop
EndLoop
```

The script provided as a nested loop example in *Figure 59* displays: *coord: 4 3*, *coord: 4 2*, *coord: 5 3*, and *coord 5 2*.

### Loop script verdict

The loop generates some special lines in the verdict file. The added lines help the user follow the execution.

The script shown in *Figure 60* generates the verdict shown in *Figure 61*.

**Figure 60. Example of loop script verdict**

```
Loop (FREQ, 13, 15)

EndLoop
```

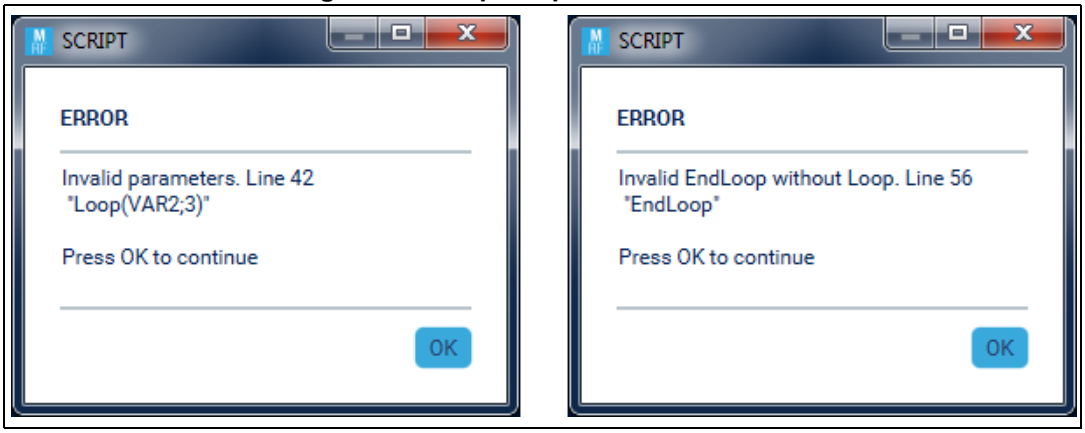
**Figure 61. Display of loop script verdict**

```
-- Loop Start (FREQ=13) --                    | --      |             |
-- Loop (FREQ=14) --                          | --      |             |
-- Loop (FREQ=15) --                          | --      |             |
-- Loop End (FREQ) --                         | --      |             |
```

The beginning and end of the loop are indicated, and the counter value is also inserted in decimal for each iteration.

In the case of an error in an instruction, a pop-up warns the user when the script is executed and the line is skipped. If a Loop instruction is missing or invalid, the EndLoop generates the *Invalid EndLoop without Loop* warning message.

**Figure 62. Script loop error**




## 3.6 Command-line interface (CLI)

### 3.6.1 Installation

No specific installation is required because the command-line interface is included with the STM32CubeMonitor-RF graphical user interface tool.

### 3.6.2 Getting started

To access the CLI, open a terminal and launch the tool with an argument from the installation directory. When no argument is used, the GUI launches.

By default, the installation directory is:

- macOS®: */Applications/STM32CubeMonitor-RF.app/Contents/MacOS*
- Linux®: */local/home/<user>/STMicroelectronics/STM32CubeMonitor-RF*
- Windows®: *C:\Program Files\STMicroelectronics\STM32CubeMonitor-RF*

To list all available CLI commands, execute:

```
./STM32CubeMonitor-RF --help
```

### 3.6.3 Arguments for CLI commands

#### Optional arguments

| | |
|---|---|
| `-a, --aciLog=<aciLogFile>` | Name of the file to save the ACI log.<br>To get the ACI log as described in *Section 3.3.5: Log functionalities*, this argument must be defined with a filename to allow the recording in this file. The file is in csv format. It can be opened using a spreadsheet tool to improve data viewing. |
| `-v, --verbose` | Verbose mode that displays the raw details concerning the board identification on connection. |
| `-b, --baudrate=<baudRate>` | Define the UART baud rate (the default value is 115200 bauds). Refer to *Section 2.3: Opening COM* if the default baud rate is not relevant. |

#### Required arguments

| | |
|---|---|
| `-p, --port=<COMxx>` | Define the COM port to use. If the COM ports are unknown, first use the list command to identify them. |

### 3.6.4 Basic commands

#### list

```
./STM32CubeMonitor-RF list          [-a=<aciLogFile>]
```

This command lists all available COM ports, including those not connected to an STM32 Bluetooth® LE board.

#### getInfo

```
./STM32CubeMonitor-RF getInfo       -p=<COMxx>
                                    [-b=<baudRate>]
                                    [-v]
                                    [-a=<aciLogFile>]
```

This command gets the version information of the STM32 Bluetooth® LE board connected to the COM port set as a required argument (refer to *Section 3.6.3: Arguments for CLI commands* for details).

### 3.6.5 Informative commands

#### getCommands

```
./STM32CubeMonitor-RF getCommands    -p=<COMxx>
                                     [-v]
                                     [-a=<aciLogFile>]
                                     [-b=<baudRate>]
```

This command provides all the available ACI commands for the STM32 Bluetooth® LE board connected to the COM port set as a required argument (refer to *Section 3.6.3: Arguments for CLI commands* for details).

#### getParameters

```
./STM32CubeMonitor-RF getParameters  -p=<COMxx>
                                     -n=<ACICommandName>
                                     [-v]
                                     [-a=<aciLogFile>]
                                     [-b=<baudRate>]
```

This command provides all the available ACI commands for the STM32 Bluetooth® LE board connected to the COM port set as a mandatory argument (refer to *Section 3.6.3: Arguments for CLI commands* for details).

Specific required argument:

`-n, --name=<ACICommandName>` Name of the ACI command (use the getCommands command to retrieve this name).

Refer to *Section 3.6.3: Arguments for CLI commands* for details about the other possible arguments for this command.

### 3.6.6 Execution commands

#### SendCommand

```
./STM32CubeMonitor-RF sendCommand    -p=<COMxx>
                                     -c=<ACICommand>
                                     [-v]
                                     [-a=<aciLogFile>]
                                     [-b=<baudRate>]
```

Use this command to execute a unitary ACI command on the target connected to the COM port set as a mandatory argument (refer to *Section 3.6.3: Arguments for CLI commands* for details).

Specific required argument:

`-c, --command=<ACICommand>` ACI command to execute. The command format is the same as the one used in the script format (refer to *Section 3.5.5: List of script commands*).

Format example:

"Send(ACI_HAL_WRITE_CONFIG_DATA;0x00;0x06;0x222233445570)"

The first parameter is the ACI command name. The next parameters are the values of the ACI command arguments.

#### script

```
./STM32CubeMonitor-RF script        -p=<COMxx>
                                    -s=<scriptFile>
                                    [-r=<verdictFile>]
                                    [-v]
                                    [-a=<aciLogFile>]
                                    [-b=<baudRate>]
```

Use this command to execute a script file on the target connected to the COM port set as a mandatory argument (refer to *Section 3.6.3: Arguments for CLI commands* for details).

Specific required argument:

| | | |
|---|---|---|
| `-s,` | `--script=<scriptFile>` | Script file to execute. Refer to *Section 3.5: Scripts* for guidelines and examples. |

Specific optional argument:

| | | |
|---|---|---|
| `-r,` | `--result=<verdictFile>` | Name of the file to register the verdict result. |

### 3.6.7 Examples

#### list

Command:

```
$ ./STM32CubeMonitor-RF list
```

Output:

```
COM5;COM4;COM44;COM3;COM7
```

Comment:

This command lists all available COM ports, including those not connected to an STM32 Bluetooth® LE board.

#### getInfo

Command:

```
$ ./STM32CubeMonitor-RF getInfo -p COM7
```

Output:

```
CM0 FUS version             :1.2.0
CM0 Safeboot version        :0.0.0
CM0 version                 :1.18.0.3
```

```
CM4 version                :0.0.1
Device                     :stm32wbxx
Device Id                  :0x495
Device Revision            :8193
Device package type        :a
Hardware version           :2.1.0
Manufacturer               :STMicroelectronics
Stack info                 :Full stack
Tag Number                 :119
```

### getCommands

Command:

```
$ ./STM32CubeMonitor-RF getCommands -p COM7
```

Output:

```
HCI_DISCONNECT
HCI_READ_REMOTE_VERSION_INFORMATION
HCI_SET_EVENT_MASK
HCI_RESET
HCI_READ_CONNECTION_ACCEPT_TIMEOUT
HCI_WRITE_CONNECTION_ACCEPT_TIMEOUT
HCI_READ_TRANSMIT_POWER_LEVEL
HCI_SET_CONTROLLER_TO_HOST_FLOW_CONTROL
HCI_HOST_BUFFER_SIZE
HCI_HOST_NUMBER_OF_COMPLETED_PACKETS
HCI_READ_AFH_CHANNEL_ASSESSMENT_MODE
HCI_WRITE_AFH_CHANNEL_ASSESSMENT_MODE
HCI_SET_EVENT_MASK_PAGE_2
HCI_READ_AUTHENTICATED_PAYLOAD_TIMEOUT
HCI_WRITE_AUTHENTICATED_PAYLOAD_TIMEOUT
HCI_SET_ECOSYSTEM_BASE_INTERVAL
HCI_CONFIGURE_DATA_PATH
[...]
ACI_L2CAP_COC_DISCONNECT
ACI_L2CAP_COC_FLOW_CONTROL
ACI_L2CAP_COC_TX_DATA
VS_HCI_C1_WRITE_REGISTER
VS_HCI_C1_READ_REGISTER
```

Comment:

This command lists all available Bluetooth® LE ACI commands on the board connected.

### getParameters

Command:

```
$ ./STM32CubeMonitor-RF getParameters -p COM7 -n
ACI_GATT_WRITE_CHAR_VALUE
```

Output:

```
[PARAMETER]=(hci_packet_indicator) [VALUE]=(0x01) [LITERAL]=(HCI
Command Packet) [IS_ENUMERABLE]=(false) [IS_EDITABLE]=(false)
[NEED_CHECK]=(false)

[PARAMETER]=(op_code) [VALUE]=(0xFD1C)
[LITERAL]=(ACI_GATT_WRITE_CHAR_VALUE) [IS_ENUMERABLE]=(false)
[IS_EDITABLE]=(false) [NEED_CHECK]=(false)

[PARAMETER]=(parameter_total_length) [VALUE]=(0x06)
[IS_ENUMERABLE]=(false) [IS_EDITABLE]=(false) [NEED_CHECK]=(false)

[PARAMETER]=(connection_handle) [VALUE]=(0x0000)
[MIN_VALUE]=(0x0000) [MAX_VALUE]=(0xEA3F) [DEFAULT_VALUE]=(0x0000)
[IS_ENUMERABLE]=(false) [IS_EDITABLE]=(true) [NEED_CHECK]=(false)

[PARAMETER]=(attr_handle) [VALUE]=(0x0000) [IS_ENUMERABLE]=(false)
[IS_EDITABLE]=(true) [NEED_CHECK]=(false)

[PARAMETER]=(attribute_val_length) [VALUE]=(0x01)
[DEFAULT_VALUE]=(0x01) [IS_ENUMERABLE]=(false) [IS_EDITABLE]=(true)
[NEED_CHECK]=(true)

[PARAMETER]=(attribute_val) [VALUE]=(0x00) [IS_ENUMERABLE]=(false)
[IS_EDITABLE]=(true) [NEED_CHECK]=(false)
```

Comment:

This command retrieves the characteristics of each parameter to be used with the ACI command set as one of its mandatory arguments.

getParameters is used to obtain the name of the parameters, their formats through their default values, and their orders to help the creation of the execution commands.

### sendCommand

Command:

```
$ ./STM32CubeMonitor-RF senCommand -p COM7 -c "Send(HCI_RESET)" -a
~/myAciLog.txt
```

The *myAciLog.txt* file lists the ACI command sent together with its result as displayed in the AciLog screen of the GUI. The commands used to connect the board before the launch of the ACI command requested are also listed.

*~/myAciLog.txt*:

```
Nb, Time, Port Com, Type, Parameter, Value, Literal, Information
0,18:04:49:580,COM7,HCI_READ_LOCAL_VERSION_INFORMATION,hci_packet_i
ndicator,0x01,HCI Command Packet,
0,18:04:49:580,COM7,HCI_READ_LOCAL_VERSION_INFORMATION,op_code,0x10
01,HCI_READ_LOCAL_VERSION_INFORMATION,
0,18:04:49:580,COM7,HCI_READ_LOCAL_VERSION_INFORMATION,parameter_to
tal_length,0x00,
[...]
4,18:04:49:706,COM7,HCI_RESET,hci_packet_indicator,0x01,HCI Command
Packet,
4,18:04:49:706,COM7,HCI_RESET,op_code,0x0C03,HCI_RESET,
4,18:04:49:706,COM7,HCI_RESET,parameter_total_length,0x00,
```

```
4,18:04:49:706,COM7,HCI_RESET,Raw,[0x01:0x03:0x0C:0x00]
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,hci_packet_indicator
,0x04,HCI Event packet,
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,event_code,0x0E,HCI_
COMMAND_COMPLETE_EVENT,
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,parameter_total_leng
th,0x04,
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,num_hci_command_pack
ets,0x01,The Number of HCI command packets which are allowed to be
sent to the Controller from the Host.
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,command_opcode,0x0C0
3,HCI_RESET,Opcode of the command which caused this event.
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,status,0x00,Success,
Status error code.
5,18:04:49:708,COM7,HCI_COMMAND_COMPLETE_EVENT,Raw,[0x04:0x0E:0x04:
0x01:0x03:0x0C:0x00]
```

For improved data viewing, open the csv-formatted *myAciLog.txt* file in a spreadsheet tool as shown in *Figure 63*.

**Figure 63. Contents of *myAciLog.txt* displayed in a spreadsheet tool (sendCommand)**

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Nb | Time | Port Com | Type | Parameter | Value | Literal | Information | | |
| 2 | 0 | 18:04:49:580 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | hci_packet_indicator | 0x01 | HCI Command Packet | | | |
| 3 | 0 | 18:04:49:580 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | op_code | 0x1001 | HCI_READ_LOCAL_VERSION_INFORMATION | | | |
| 4 | 0 | 18:04:49:580 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | parameter_total_length | 0x00 | | | | |
| 5 | 0 | 18:04:49:580 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | Raw | [0x01:0x01:0x10:0x00] | | | | |
| 6 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_packet_indicator | 0x04 | HCI Event packet | | | |
| 7 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | event_code | 0x0E | HCI_COMMAND_COMPLETE_EVENT | | | |
| 8 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | parameter_total_length | 0x0C | | | | |
| 9 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | num_hci_command_packets | 0x01 | | The number of HCI command pacl | | |
| 10 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | command_opcode | 0x1001 | HCI_READ_LO | Opcode of this command which c | | |
| 11 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code | | |
| 12 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_version | 0x0D | | Version of the HCI Specification s | | |
| 13 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_subversion | 0x0077 | | Revision of the HCI implementati | | |
| 14 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | lmp_version | 0x0D | | Version of the Current LMP suppo | | |
| 15 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | company_identifier | 0x0030 | | Company identifier for the manuf | | |
| 16 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | lmp_subversion | 0x2177 | | Subversion of the Current LMP in t | | |
| 17 | 1 | 18:04:49:586 | COM7 | HCI_COMMAND_COMPLETE_EVENT | Raw | [0x04:0x0E:0x0C:0x01:0x01:0x10:0x00:0x0D:0x77:0x00:0x0D:0x30:0x00:0x77:0x21] | | | | |
| 18 | 2 | 18:04:49:595 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | hci_packet_indicator | 0x20 | Local Command Packet | | | |
| 19 | 2 | 18:04:49:595 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | op_code | 0xFD62 | VS_HCI_C1_DEVICE_INFORMATION | | | |
| 20 | 2 | 18:04:49:595 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | parameter_total_length | 0x00 | | | | |
| 21 | 2 | 18:04:49:595 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | Raw | [0x20:0x62:0xFD:0x00] | | | | |
| 22 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_packet_indicator | 0x21 | Local Event Packet | | | |
| 23 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | event_code | 0x0E | HCI_COMMAND_COMPLETE_EVENT | | | |
| 24 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | parameter_total_length | 0x42 | | | | |
| 25 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | num_hci_command_packets | 0x01 | | The number of HCI command pacl | | |
| 26 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | command_opcode | 0xFD62 | VS_HCI_C1_D | Opcode of this command which c | | |
| 27 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code | | |
| 28 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | revision id | 0x2001 | | Revision Id (from DBGMCU_IDCO | | |
| 29 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | device code id | 0x0495 | | Device Code Id (from DBGMCU_II | | |
| 30 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | package type | 0x0A | | Package Type (from package data | | |
| 31 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | device type id | 0x26 | | Device Type Id (from FLASH UID64 | | |
| 32 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | st company id | 0x000080E1 | | ST Company Id (from FLASH UID64 | | |
| 33 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | uid64 | 0x00129B82 | | UID64 (from FLASH UID64) | | |
| 34 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | uid96 | 0x20343743594D50130047003A | | UID96 from Unique Device ID regi | | |
| 35 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | safe boot information | 0x00000000 | | Safe Boot Information (Not Applic | | |
| 36 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | rss information | 0x00000000100000601020000 | | Rss Information (Not Applicable f | | |
| 37 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw version | 0x01120003 | | CM0+ Wireless FW Information (N | | |
| 38 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw memory size | 0x161E002F | | CM0+ Wireless FW Information (N | | |
| 39 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw stackinfo | 0x00000006 | | CM0+ Wireless FW Information (N | | |
| 40 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw reserved | 0x00000000 | | CM0+ Wireless FW Information (N | | |
| 41 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | local fw information | 0x00000100 | | Local FW Information (Hard code | | |
| 42 | 3 | 18:04:49:597 | COM7 | HCI_COMMAND_COMPLETE_EVENT | Raw | [0x21:0x0E:0x42:0x01:0x62:0xFD:0x00:0x01:0x20:0x95:0x04:0x0A:0x26:0xE1:0x80:0x( | | | | |
| 43 | 4 | 18:04:49:706 | COM7 | HCI_RESET | hci_packet_indicator | 0x01 | HCI Command Packet | | | |

### script

Command:

```
$ ./STM32CubeMonitor-RF script -p COM7 -a ~/myAciLog.txt -r
~/myResult.txt -s ~/myScript_AdvertisingScan_GAP_Extended.txt
```

*myScript_AdverstisingScan_AP_Extended.txt* is the filename of the script file in this example. The file content is as follows:

```
# Address Initialisation
Send(ACI_HAL_WRITE_CONFIG_DATA;0x00;0x06;0x222233445570)
#Send(ACI_HAL_SET_TX_POWER_LEVEL;0x00;0x11)
# GATT Initialisation
Send(ACI_GATT_INIT)
# GAP Initialisation with all roles with 7 bytes reserved for the
name
Send(ACI_GAP_INIT;0x0F;0x00;0x07)
# Set the name
Send(ACI_GATT_UPDATE_CHAR_VALUE;0x0005;0x0006;0x00;0x07;0x434150595
24F44)
Send(ACI_GAP_SET_IO_CAPABILITY;0x01)
Send(ACI_GAP_SET_AUTHENTICATION_REQUIREMENT;0x01;0x01;0x02;0x00;0x0
7;0x10;0x01;0x00013A57;0x00)
# ----- Extended advertising -------------
Send(ACI_GAP_ADV_SET_CONFIGURATION;0x00;0x00;0x0013;0x000007D0;0x00
0007D0;0x07;0x00;0x00;0x112233445566;0x00;0x01;0x00;0x01;0x00;0x00)
Send(ACI_GAP_ADV_SET_ADV_DATA;0x00;0x03;0x00;0x08;0x320102434150090
4)
Send(ACI_GAP_ADV_SET_ENABLE;0x01;0x01;0x00;0x0000;0x00)
#------- Scan ---------------------------
Send(ACI_GAP_START_GENERAL_DISCOVERY_PROC;0x07D0;0x07D0;0x00;0x01)
Wait(4000)
Send(ACI_GAP_ADV_SET_ENABLE;0x00;0x01;0x00;0x0000;0x00)
```

Output:

```
Execution status : ok
```

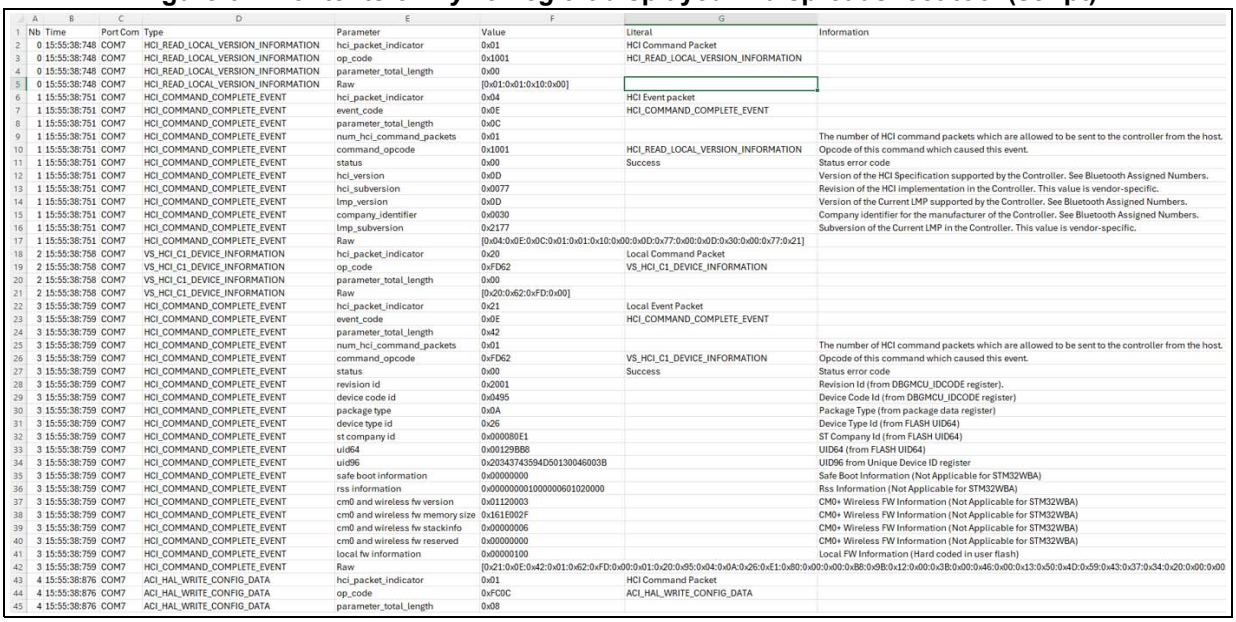
In this example, the verdict result is set in the file *myResult.txt* as follows:

```
SCRIPT REPORT

Script name : myScript_AdvertisingScan_GAP_Extended.txt
Test date : 18/03/2025 09:58:41

Verdict : SUCCESS    No error detected

Command                                | Sent | ACI status |
ACI raw result

ACI_HAL_WRITE_CONFIG_DATA              | OK   | 0x00       |
[0x04,0x0E,0x04,0x01,0x0C,0xFC,0x00]
ACI_GATT_INIT                          | OK   | 0x00       |
[0x04,0x0E,0x04,0x01,0x01,0xFD,0x00]
ACI_GAP_INIT                           | OK   | 0x00       |
[0x04,0x0E,0x0A,0x01,0x8A,0xFC,0x00,0x05,0x00,0x06,0x00,0x08,0x00]
ACI_GATT_UPDATE_CHAR_VALUE             | OK   | 0x00       |
```

```
[0x04,0x0E,0x04,0x01,0x06,0xFD,0x00]
ACI_GAP_SET_IO_CAPABILITY                | OK    | 0x00        |
[0x04,0x0E,0x04,0x01,0x85,0xFC,0x00]
ACI_GAP_SET_AUTHENTICATION_REQUIREMENT   | OK    | 0x00        |
[0x04,0x0E,0x04,0x01,0x86,0xFC,0x00]
ACI_GAP_ADV_SET_CONFIGURATION            | OK    | 0x00        |
[0x04,0x0E,0x04,0x01,0xC0,0xFC,0x00]
ACI_GAP_ADV_SET_ADV_DATA                 | OK    | 0x00        |
[0x04,0x0E,0x04,0x01,0xC2,0xFC,0x00]
ACI_GAP_ADV_SET_ENABLE                   | OK    | 0x00        |
[0x04,0x0E,0x04,0x01,0xC1,0xFC,0x00]
ACI_GAP_START_GENERAL_DISCOVERY_PROC     | OK    | 0x00        |
[0x04,0x0F,0x04,0x00,0x01,0x97,0xFC]
ACI_GAP_ADV_SET_ENABLE                   | OK    | 0x00        |
[0x04,0x0E,0x04,0x01,0xC1,0xFC,0x00]

END of report
```

In this example, the ACI log is registered in the *myAciLog.txt* file. For improved data viewing, open it in a spreadsheet tool as shown in *Figure 64*.

**Figure 64. Contents of *myAciLog.txt* displayed in a spreadsheet tool (script)**



| Nb | Time | Port Com | Type | Parameter | Value | Literal | Information |
|---|---|---|---|---|---|---|---|
| 0 | 15:55:38:748 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | hci_packet_indicator | 0x01 | HCI Command Packet | |
| 0 | 15:55:38:748 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | op_code | 0x1001 | HCI_READ_LOCAL_VERSION_INFORMATION | |
| 0 | 15:55:38:748 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | parameter_total_length | 0x00 | | |
| 0 | 15:55:38:748 | COM7 | HCI_READ_LOCAL_VERSION_INFORMATION | Raw | [0x01:0x01:0x10:0x00] | | |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_packet_indicator | 0x04 | HCI Event packet | |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | event_code | 0x0E | HCI_COMMAND_COMPLETE_EVENT | |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | parameter_total_length | 0x0C | | |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | num_hci_command_packets | 0x01 | | The number of HCI command packets which are allowed to be sent to the controller from the host. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | command_opcode | 0x1001 | HCI_READ_LOCAL_VERSION_INFORMATION | Opcode of this command which caused this event. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_version | 0x0D | | Version of the HCI Specification supported by the Controller. See Bluetooth Assigned Numbers. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_subversion | 0x0077 | | Revision of the HCI implementation in the Controller. This value is vendor-specific. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | lmp_version | 0x0D | | Version of the Current LMP supported by the Controller. See Bluetooth Assigned Numbers. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | company_identifier | 0x0030 | | Company identifier for the manufacturer of the Controller. See Bluetooth Assigned Numbers. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | lmp_subversion | 0x2177 | | Subversion of the Current LMP in the Controller. This value is vendor-specific. |
| 1 | 15:55:38:751 | COM7 | HCI_COMMAND_COMPLETE_EVENT | Raw | [0x04:0x0E:0x0C:0x01:0x01:0x10:0x00:0x0D:0x77:0x00:0x0D:0x30:0x00:0x77:0x21] | | |
| 2 | 15:55:38:758 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | hci_packet_indicator | 0x20 | Local Command Packet | |
| 2 | 15:55:38:758 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | op_code | 0xFD62 | VS_HCI_C1_DEVICE_INFORMATION | |
| 2 | 15:55:38:758 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | parameter_total_length | 0x00 | | |
| 2 | 15:55:38:758 | COM7 | VS_HCI_C1_DEVICE_INFORMATION | Raw | [0x20:0x62:0xFD:0x00] | | |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_packet_indicator | 0x21 | Local Event Packet | |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | event_code | 0x0E | HCI_COMMAND_COMPLETE_EVENT | |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | parameter_total_length | 0x42 | | |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | num_hci_command_packets | 0x01 | | The number of HCI command packets which are allowed to be sent to the controller from the host. |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | command_opcode | 0xFD62 | VS_HCI_C1_DEVICE_INFORMATION | Opcode of this command which caused this event. |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | revision id | 0x2001 | | Revision Id (from DBGMCU_IDCODE register). |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | device code id | 0x0495 | | Device Code Id (from DBGMCU_IDCODE register) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | package type | 0x0A | | Package Type (from package data register) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | device type id | 0x26 | | Device Type Id (from FLASH UID64) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | st company id | 0x000080E1 | | ST Company Id (from FLASH UID64) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | uid64 | 0x00129B88 | | UID64 (from FLASH UID64) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | uid96 | 0x20343743594D50130046003B | | UID96 from Unique Device ID register |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | safe boot information | 0x00000000 | | Safe Boot Information (Not Applicable for STM32WBA) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | rss information | 0x0000000010000000601020000 | | Rss Information (Not Applicable for STM32WBA) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw version | 0x01120003 | | CM0+ Wireless FW Information (Not Applicable for STM32WBA) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw memory size | 0x161E002F | | CM0+ Wireless FW Information (Not Applicable for STM32WBA) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw stackinfo | 0x00000006 | | CM0+ Wireless FW Information (Not Applicable for STM32WBA) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | cm0 and wireless fw reserved | 0x00000000 | | CM0+ Wireless FW Information (Not Applicable for STM32WBA) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | local fw information | 0x00000100 | | Local FW Information (Hard coded in user flash) |
| 3 | 15:55:38:759 | COM7 | HCI_COMMAND_COMPLETE_EVENT | Raw | [0x21:0x0E:0x42:0x01:0x62:0xFD:0x00:0x01:0x20:0x95:0x04:0x0A:0x26:0xE1:0x80:0x00:0x00:0xB8:0x9B:0x12:0x00:0x3B:0x00:0x46:0x00:0x13:0x50:0x4D:0x59:0x43:0x37:0x34:0x20:0x00:0x00 | | |
| 4 | 15:55:38:876 | COM7 | ACI_HAL_WRITE_CONFIG_DATA | hci_packet_indicator | 0x01 | HCI Command Packet | |
| 4 | 15:55:38:876 | COM7 | ACI_HAL_WRITE_CONFIG_DATA | op_code | 0xFC0C | ACI_HAL_WRITE_CONFIG_DATA | |
| 4 | 15:55:38:876 | COM7 | ACI_HAL_WRITE_CONFIG_DATA | parameter_total_length | 0x08 | | |

### How to investigate in the case of a script error

Command:

```
$ ./STM32CubeMonitor-RF script -p COM7 -a ~/myAciLog.txt -r
~/myResult.txt -s ~/myScript_AdvertisingScan_GAP_Extended.txt
```

Output:

```
Execution status : failed, see verdict result for details if option
activated
```

Use a spreadsheet tool to check the *myAciLog.txt* file and search the error in the status as shown *Figure 65* in and *Figure 66*.

**Figure 65. Contents of *myAciLog.txt* displayed in a spreadsheet tool (error investigation 1 of 2)**

| | A | B | C | D | E | F | G | |
|---|---|---|---|---|---|---|---|---|
| 1 | N | Time | Port Co | Type | Parameter | Value | Literal | Information |
| 11 | 1 | 17:15:58:899 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code |
| 27 | 3 | 17:15:58:909 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code |
| 55 | 5 | 17:15:59:035 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 66 | 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x62 | Invalid operation | Status error code. |
| 80 | 9 | 17:15:59:043 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x0C | Command Disallowed | Status error code. |
| 99 | 11 | 17:15:59:047 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 111 | 13 | 17:15:59:050 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 131 | 15 | 17:15:59:156 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 157 | 17 | 17:15:59:161 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 173 | 19 | 17:15:59:265 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 189 | 21 | 17:15:59:269 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |
| 202 | 23 | 17:15:59:272 | COM7 | HCI_COMMAND_STATUS_EVENT | status | 0x00 | Success | Status error code. |
| 619 | 46 | 17:16:03:275 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x00 | Success | Status error code. |

**Figure 66. Contents of *myAciLog.txt* displayed in a spreadsheet tool (error investigation 2 of 2)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | 17:15:59:038 | COM7 | ACI_GATT_INIT | hci_packet_indicator | 0x01 | HCI Command Packet | |
| 6 | 17:15:59:038 | COM7 | ACI_GATT_INIT | op_code | 0xFD01 | ACI_GATT_INIT | |
| 6 | 17:15:59:038 | COM7 | ACI_GATT_INIT | parameter_total_length | 0x00 | | |
| 6 | 17:15:59:038 | COM7 | ACI_GATT_INIT | Raw | [0x01:0x01:0xFD:0x00] | | |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | hci_packet_indicator | 0x04 | HCI Event packet | |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | event_code | 0x0E | HCI_COMMAND_COMPLETE_EVENT | |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | parameter_total_length | 0x04 | | |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | num_hci_command_packets | 0x01 | | The Number of HCI command packets which are allowed to be sent to the Controller from the Host. |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | command_opcode | 0xFD01 | ACI_GATT_INIT | Opcode of the command which caused this event. |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | status | 0x62 | Invalid operation | Status error code. |
| 7 | 17:15:59:039 | COM7 | HCI_COMMAND_COMPLETE_EVENT | Raw | [0x04:0x0E:0x04:0x01:0x01:0xFD:0x62] | | |

In this example, the ACI_GATT_INIT has been already done, resulting in an error.

# 3.7 OTA transfer

## 3.7.1 OTA presentation

Over-the-air (OTA) transfer executes the transfer of data from a device to a remote device without a cable. Data are applicative data, like user configuration, pictures, music, or firmware. STM32CubeMonitor-RF provides a transfer function from the computer to the remote device over Bluetooth® LE.

In this section, the computer or device sending the data is named the *Source device*.

The source device transfers the data and the OTA loader to the address requested by the user.

The implementation example does not include security in the transfer process. The users are expected to change their loader or application to perform the security verification based on their requirements.

The OTA process is described in the application note *Over-the-air application and wireless firmware update for STM32WB series microcontrollers* (AN5247), available on www.st.com. Read these documents for the details of device configuration and OTA procedure. In this user manual, there is only a summary of the procedure, to explain how to use the tool. Read the application note to get detailed information about the target software and the Bluetooth low Bluetooth® LE services used.

### OTA loader

The OTA loader is the first application that starts at boot or reboot. The OTA loader checks the boot conditions, and if the flash memory is empty.

When the bootloader starts in OTA mode, the loader creates an OTA service and some characteristics required to perform the OTA transfer. These attributes are used to perform the transfer.

The loader fits in the first six sectors of the flash memory. So, the block at the address *0x6000* is free and used to upload user data.

**Table 1. OTA loader address table**

| Flash memory address | Flash memorycontent |
|---|---|
| *+0x0000* | OTA bootloader |
| *+0x1000* | OTA bootloader |
| *+0x…* | OTA bootloader... |
| *+0x6000* | Free for user data |
| *+0x7000* | User application |
| *+0x8000* | User application |
| *+0x….* | User application... |

- In the STM32WB sample code, the binary is stored at the *0x7000* address.
- In the STM32WBA sample code, the binary is stored at the *0x7C00* address. The bootloader starts at this address after upload.

### 3.7.2 OTA procedure

The OTA procedure occurs between one source device and the target device. The process is based on operations:

1. Activate the OTA mode on the target device.
2. Connect in OTA mode and transfer data.

#### Activation of the OTA mode

The computer sends an indication to the target device to reboot in OTA mode, with the download information. The target restarts in OTA mode and erases the flash memory area required for the transfer.

#### Connection in OTA mode and data transfer

The source device first connects to the OTA loader and discovers the details of the service and characteristics to be able to transfer the data. Then the sequence is:

1. Configure the target device to send an indication to the source device.
2. Write in the target device the command to initiate the procedure, with the exact storage address.
3. Write each block of data. Depending on the optimized or not MTU size, the blocks are 20- or 248-byte long, and the binary must be transferred in many blocks.
4. At the end of the last block, write the confirmation that all blocks have been sent.
5. The source device waits for the reboot confirmation from the target.

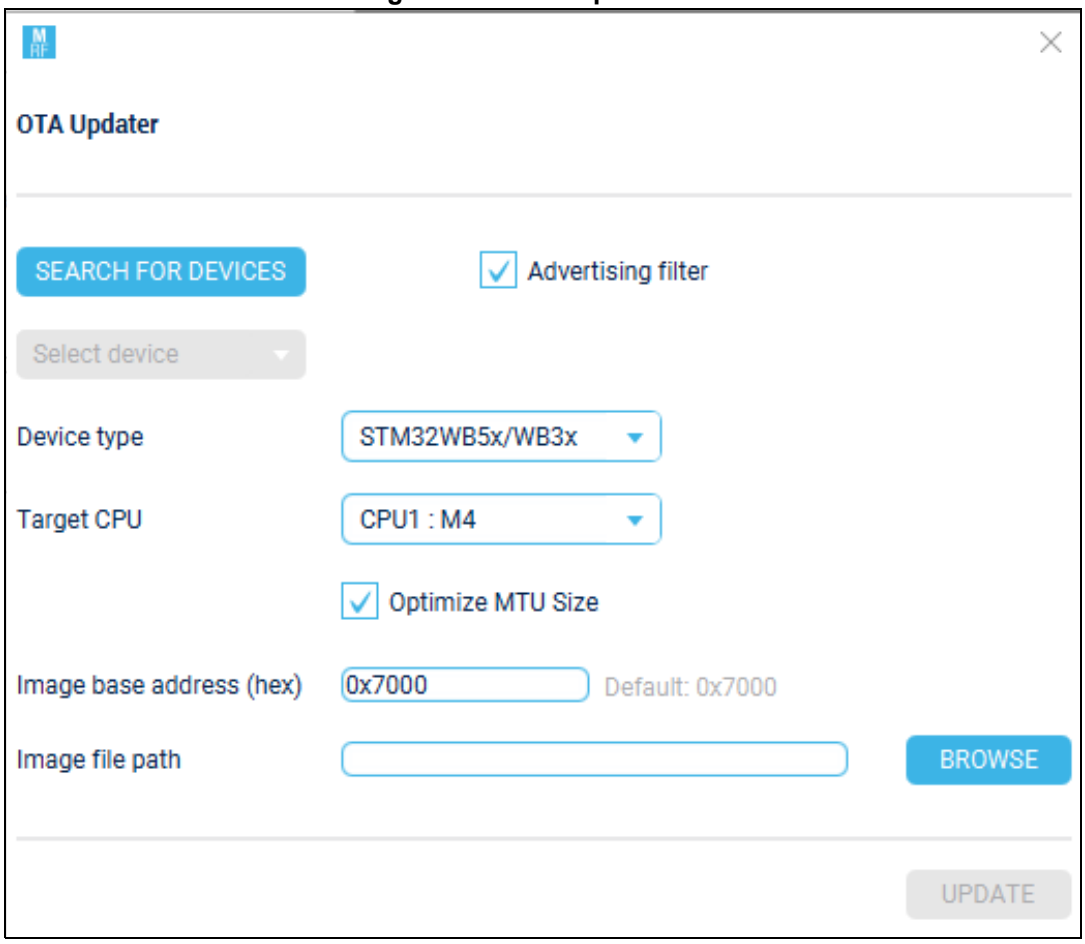
### 3.7.3 Use the tool to perform an OTA update

The OTA function is available in the device menu in the menu bar. Click on the device and then click on OTA updater.

#### Search procedure

The first operation is to find the target device. The tool needs to perform a scan of Bluetooth® LE devices and list all the devices with OTA capabilities.

**Figure 67. Search procedure**



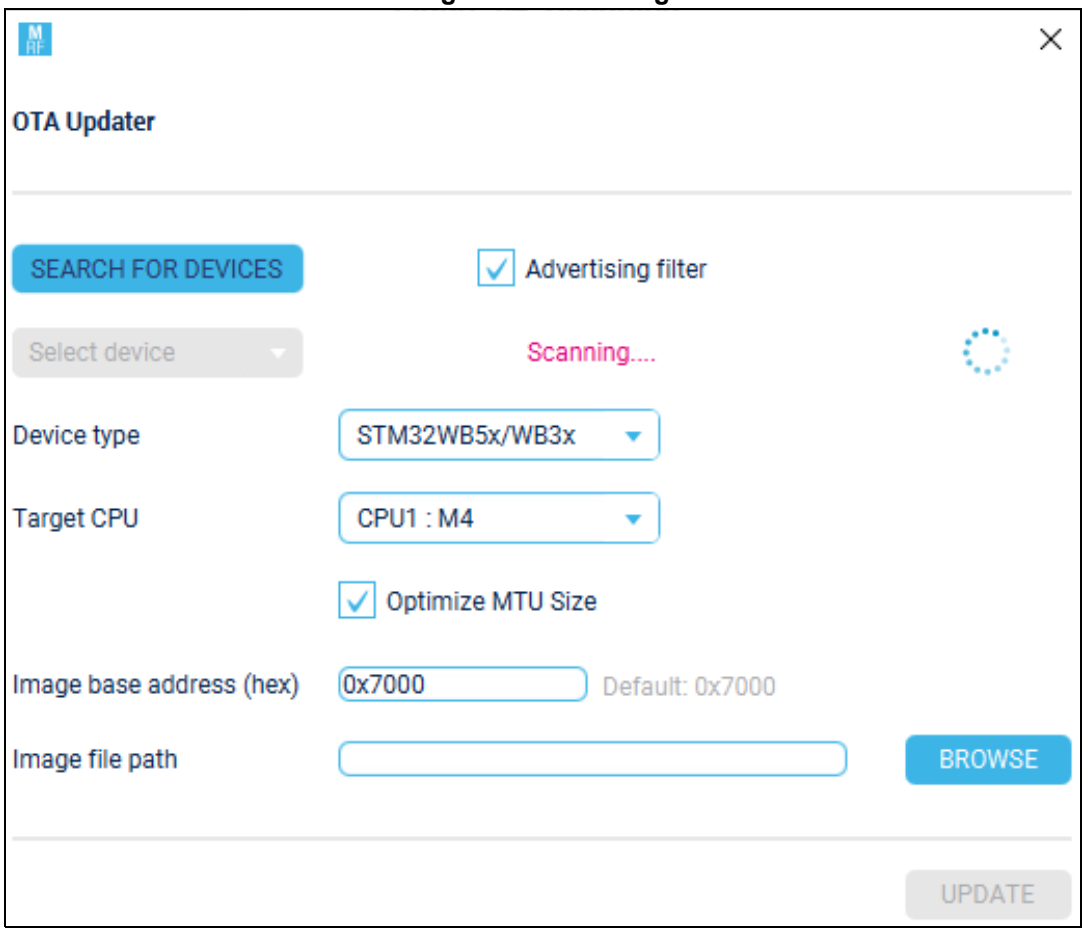

The tool provides an advertising filter to refine the search procedure with an advertising message.

**Table 2. Search filtering**

| Filter | Search method | Comment |
|---|---|---|
| No filter | Scans all Bluetooth® LE devices and provides the list. | Some devices listed are not compatible with OTA. |
| Advertising filter | Scans all Bluetooth® LE devices and provides a list of devices with ST OTA information. | Gives only the list of compatible devices. |

To start the search, click on the *SEARCH FOR DEVICES* button.

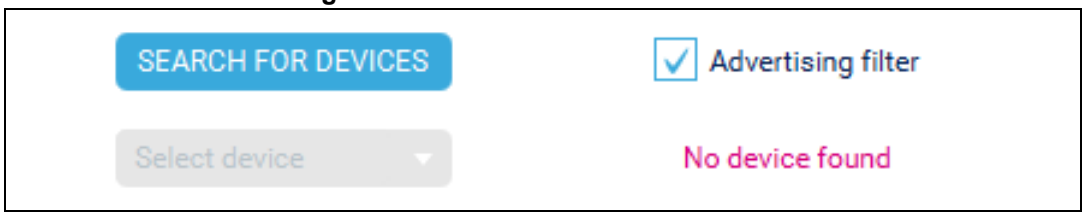
**Figure 68. Scanning**




The search procedure starts.

If no target device is found, the tool indicates *No device found*.

**Figure 69. No device found**



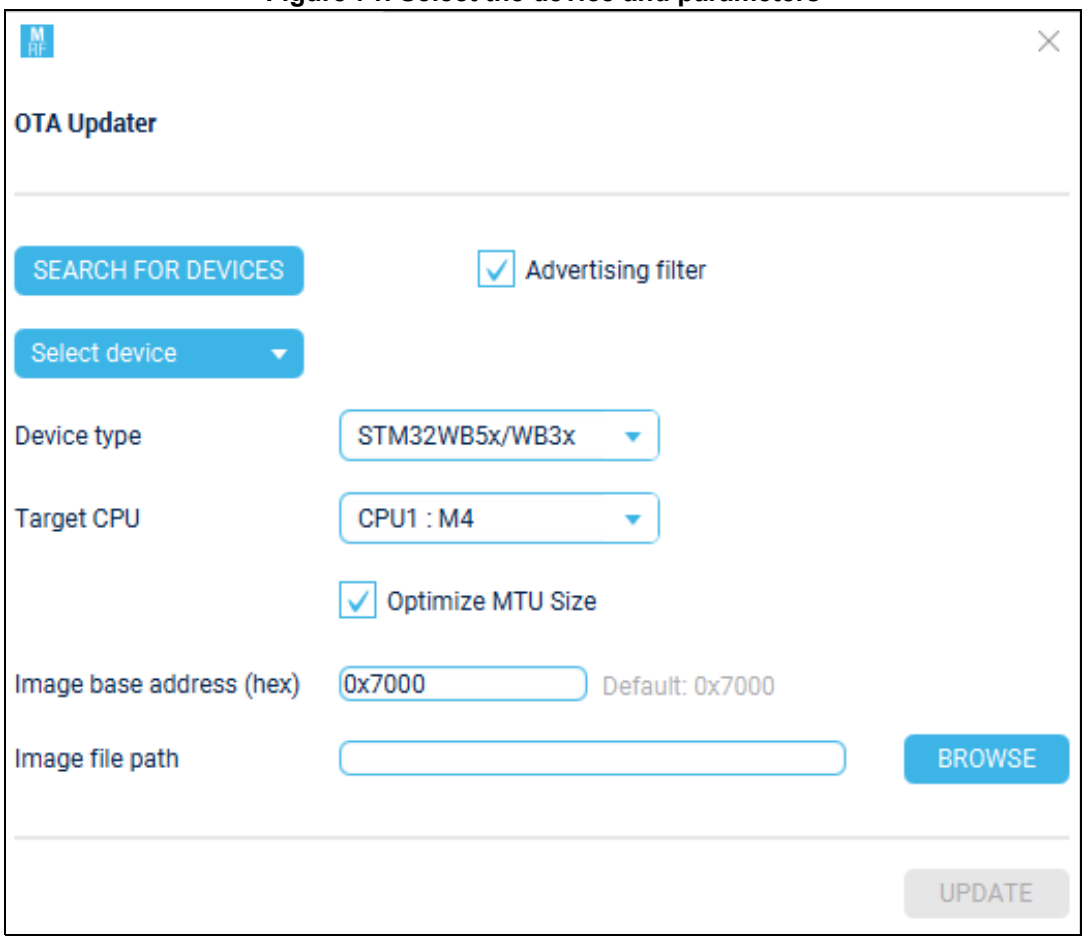

If a candidate device is found, the select device box changes to blue.

**Figure 70. Device found**

### Device and parameters selection

After the search procedure, if one or more devices are found, the user selects the device with the picklist *Select device*.

**Figure 71. Select the device and parameters**




The picklist displays the list of boards found:

- For a device with Bluetooth® LE characteristics:
  Bluetooth® LE address - Device name - OTA enabled
- For a device already in OTA mode:
  Bluetooth® LE address - Device name - OTA loader

Select the firmware target:

- For user data or user application firmware, select the *CPU1: M4*
- For the wireless stack, select the *CPU2: M0+*

Select the device type:

- STM32WB5x/WB3x product lines
- STM32WB1x product line. Note that for this device type, only *Target CPU1: M4* can be updated.
- STM32WBAxx product line. Note that for this device type, only *Target CPU1* can be updated

The *Optimize MTU size* option allows the user to increase the ATT maximum transmission unit (MTU) from 20 to 248 bytes.

The image base address is the place where the binary file must be stored on the target device. It is a hexadecimal value and must be a multiple of *0x800* for STM32WB5x/WB3x/WB0x, *0x1000* for STM32WB1x, or *0x2000* for STM32WBAxx to match with the flash memory sector. For the wireless stack, the address is the temporary location in the CPU1 user part area. The default address value is given aside.

The image file path is the binary file to load. Enter the path in the box, or use the BROWSE button to select the file to download.

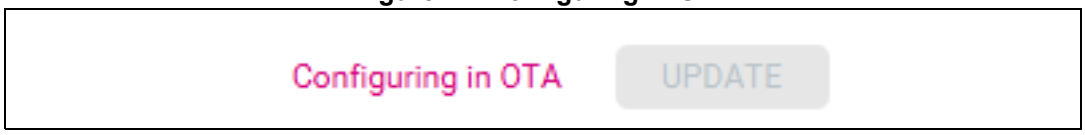
The configuration is finished and the software is ready to start the update procedure.

### Flashing the remote device

Press the *UPDATE* button to start flashing the target device.

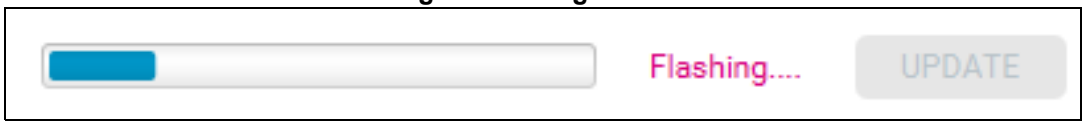
1. First step: if the selected device has an OTA characteristic, the tool first restarts the device in OTA bootloader mode. The indication *Configuring in OTA* is displayed.

**Figure 72. Configuring in OTA**




2. Second step: the transfer process to the OTA bootloader is performed. The data are transferred in blocks of 20 bytes. To avoid the overload of log windows, the log information related to block transfer is not displayed. Only the flow control event and the errors are shown.
3. A progress bar monitors the memory load.

**Figure 73. Progress bar**




At the end of the update process,

4. The target device reboots.
5. The user closes the OTA panel or starts a new search to flash another device.

## 3.8 Beacon

### 3.8.1 Beacon presentation

A beacon is an active device discoverable by other devices.

The beacon device only sends information by advertisement and does not receive any data.

The data shared by the beacon are very small. A connected device receives them and the application on the device is notified of a beacon presence. The application uses the cloud to get more information and act accordingly.

**Figure 74. Beacon presentation**


When an application is informed of beacon proximity, it uses the beacon identification to request the web server more information about the beacon. The application gets information related to the geographical position of the beacon or the action to perform, like displaying commercial ads or starting an interactive application.

**Figure 75. Beacon usage**

Many organizations have created beacons. The specifications from Apple® and Google® are frequently used:

- iBeacon: This is the Apple format. The beacon broadcasts fixed content, to identify the beacon easily.
- Eddystone UID: Google defines it. The beacon transmits fixed content (UID), the box that is a unique ID, referenced in the Google database to interact with applications.
- Eddystone URL: Another Google format. It provides a short URL to use for the *Physical web*.
- Eddystone TLM: An additional beacon advertising information providing beacon information (battery status, temperature).
- Eddystone EID: Like UID, but broadcasts encrypted data to provide better security.

### 3.8.2 Beacon configuration methods:

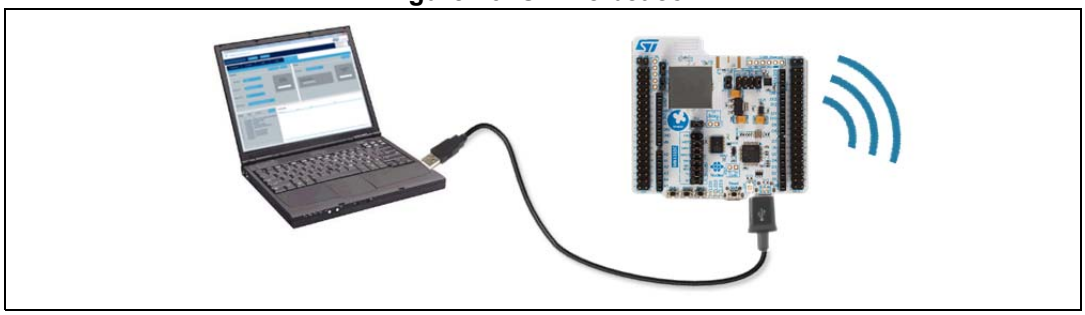
STM32CubeMonitor-RF is used to generate and configure beacons. Different methods have been defined to accommodate the user's needs. This chapter describes the different methods supported.

#### Online beacon

In online mode, the tool is directly configuring the main device in a beacon. The tool sends ACI commands to configure the boards in the Advertising mode and configure the content of the advertising packet. The main device acts as a beacon until turned off.

The main advantage of this method is to configure a beacon with a board in Transparent mode quickly. The drawback is that the configuration is lost when the board is reset or powered off.

**Figure 76. Online beacon**

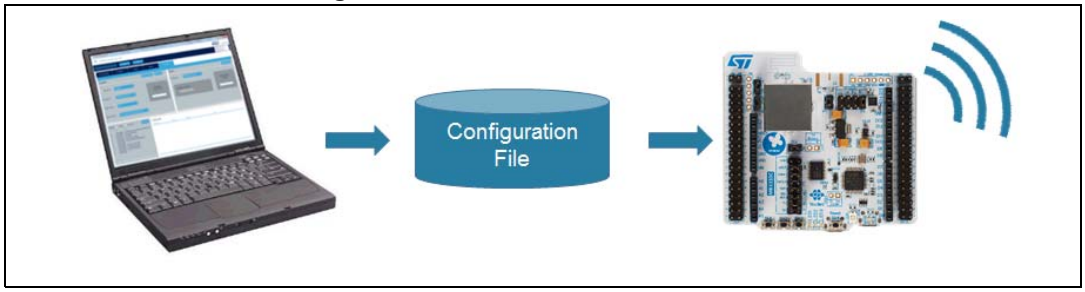


#### Offline beacon

The Offline beacon mode is used to prepare the configuration of a board not directly connected to the STM32CubeRF-Monitor. The parameters to configure the beacon are stored in a data file. The file is used to configure a target board running the beacon example firmware. The file must be stored in the target flash memory at the *0x6000* address. The beacon firmware reads the data and configures the advertising block accordingly. Details of the configuration file are described in *Table 4*.

The interest of the method is to have an independent beacon, which is useful if the user needs many beacon boards at the same time. It is possible to keep many configuration files to change the configuration quickly. The drawback is that the configuration file must be transferred manually to the target device so it is less flexible than the Online mode.

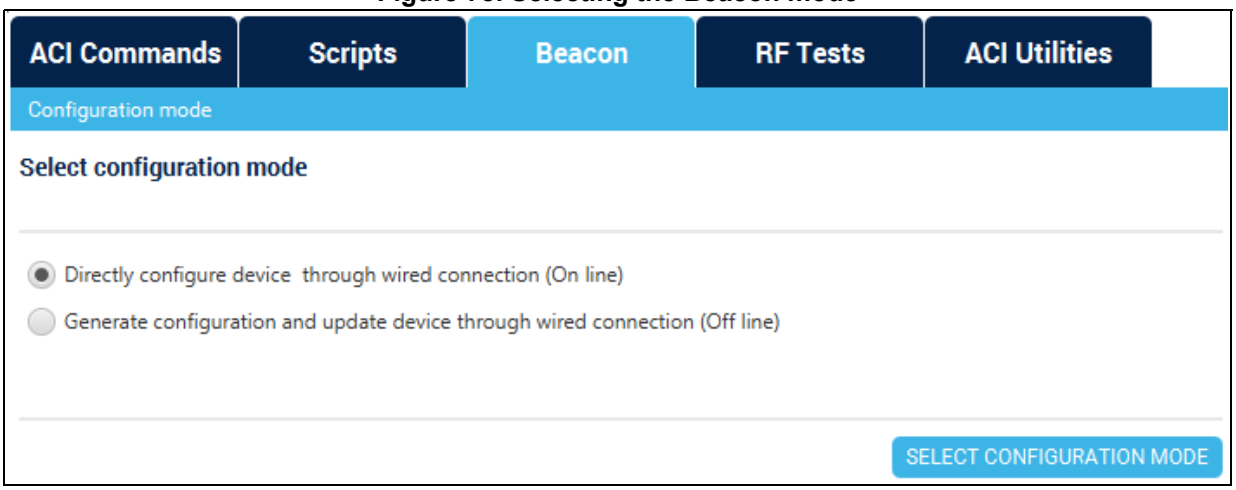
**Figure 77. Offline beacon**



### Selecting the Beacon mode

The selection of the configuration mode is the first action to prepare the beacon. The user must choose the mode when selecting the beacon tab.

**Figure 78. Selecting the Beacon mode**




Select one of the two bullets and click on *SELECT CONFIGURATION MODE*.

## 3.8.3 Configuration of the beacon with STM32CubeMonitor-RF

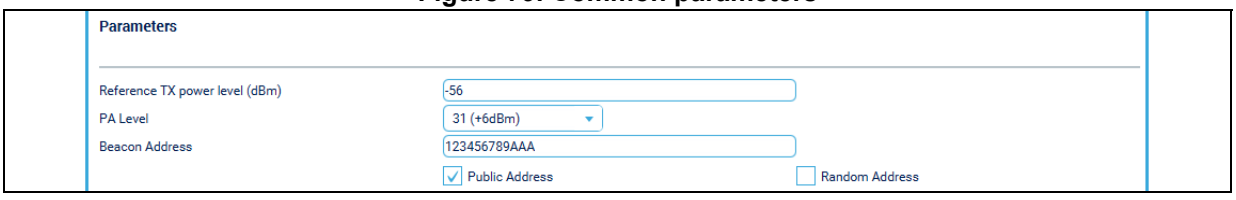
To configure the beacon,

1. Select the configuration method.
2. Fill in the beacon parameters, some are common for all beacons, and others are specific for the beacon type.
3. Generate/transfer the configuration. Additional information might be required according to the configuration method.

### Common parameters

Some beacon parameters are common for all kinds of beacons. The common parameters are at the top of the beacon panel:

**Figure 79. Common parameters**




The first parameter is the *Reference TX power level*, and the second parameter is the real *TX power level*.

To save batteries, the power level of the beacon might be lowered, reducing consumption and visibility. Using high power extends the range of visibility but drains more power. The user needs to define the power level based on the power source and beacon purpose.

The device detecting the beacon needs to estimate if the beacon is close or far. Unfortunately, the received power level is not enough to estimate the real distance:

- Some beacons might transmit with high power, while others are using low power.
- The design of the beacon antenna might be efficient.

The reference power information is added to help determine the distance. This is the power level received at one meter from the beacon. The application uses this value and the received strength to estimate the distance, independently of the real TX power used and the beacon characteristics.

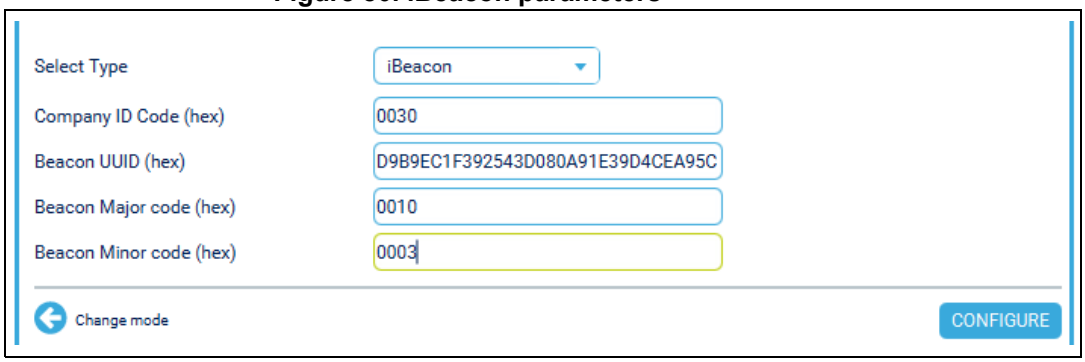
The easiest solution to fill this parameter is to configure a beacon with the required Tx level, and then measure the received level at one meter. Then the beacon is reconfigured with the value measured at one meter in the *Reference TX power level* field.

The second set of parameters is the beacon address. There are three possibilities:

- Set the address in the box and tick the *public address* to use the entered address.
- Tick the *random address* checkbox. A random address is used.
- If nothing is selected, the default public address of the board is used.

### iBeacon parameters

**Figure 80. iBeacon parameters**




First, select the type: iBeacon (default choice)

The users must check the Apple website for information about the iBeacon structure and the conditions to use iBeacon for their project: https://developer.apple.com/ibeacon/

More information is also available at https://en.wikipedia.org/wiki/IBeacon.ttps://en.wikipedia.org/wiki/IBeacon.

The company code is a value based on the Bluetooth® LE SIG group-assigned values. For iBeacon, the Apple value is used: *0x004C*. The assigned values are available on the SIG website: https://www.bluetooth.com/specifications/assigned-numbers/company-identifiers

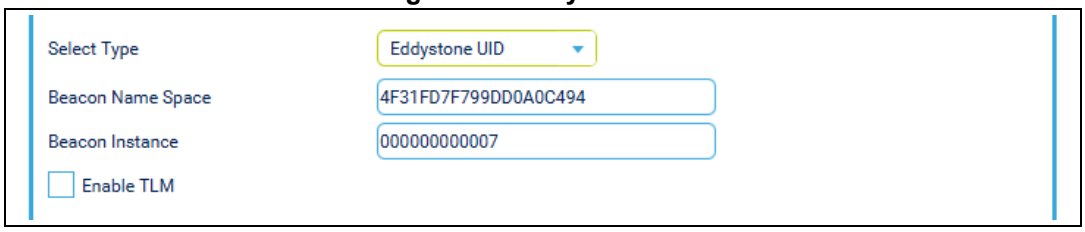
The beacon UUID is the unique identifier for a group of beacons. Apple explains how to define the identifier in the document *Getting started with iBeacon* available at https://developer.apple.com/ibeacon/Getting-Started-with-iBeacon.pdf.

The user defines the major and minor codes to identify logically different beacons sharing the same UUID.

When all parameters are updated, click on *CONFIGURE*. The data are ready for transfer (refer to *Configuration transfer*).

### Eddystone UID parameters

**Figure 81. Eddystone UID**




The Eddystone UID parameters are the beacon UID, a 16-byte identifier, formed by:

- The *Name Space*, 10 bytes used to group some beacons in a logical pool. Google describes the way to generate the value. Refer to https://github.com/google/eddystone/tree/master/eddystone-uid.
- The *Beacon Instance*, 6 bytes gives a unique ID inside the pool.

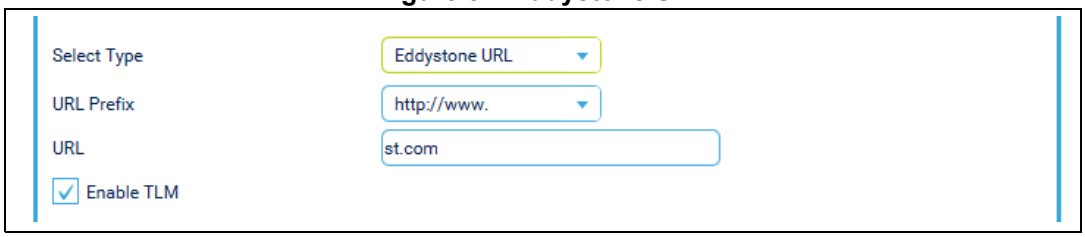
When a beacon is discovered on a smartphone, the UID value is not directly usable by the phone application. Google offers a cloud service to associate one or more data with a beacon. The smartphone application retrieves this information to perform the required actions.

The last option is the *Enable TLM tick* box. When TLM is used, the beacon interleaves some status information inside the normal beacon advertisement. The TLM frame has information about battery level, temperature, the time the beacon is on, and the number of frames transmitted. The TLM information is not known by the tool. So, the firmware must manage directly by itself. Consequently:

- The TLM option is not used for the Online configuration mode.
- For Offline and OTA modes, a bit is set in the configuration file (refer to *Appendix A*).

### Eddystone URL parameters

**Figure 82. Eddystone URL**




The Eddystone URL format is just sending a URL in the advertising message. To optimize space, the start and end of the URL might be compressed.

1. Select the URL prefix: the prefix is encoded in 1 byte in the advertising.
2. Fill in the rest of the URL in the URL box, without a prefix. The URL is analyzed, and if the end of the URL is encodable, the tool encodes it. A long URL does not work, so ST recommends using the URL short service to obtain a short URL.

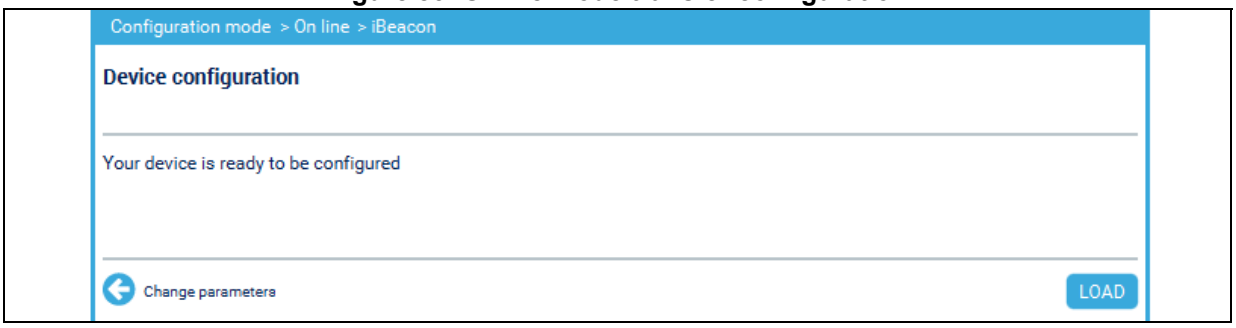
The TLM option is the same as the UID beacon.

### Configuration transfer

The transfer depends on the selected configuration mode.

1. Online mode transfer configuration

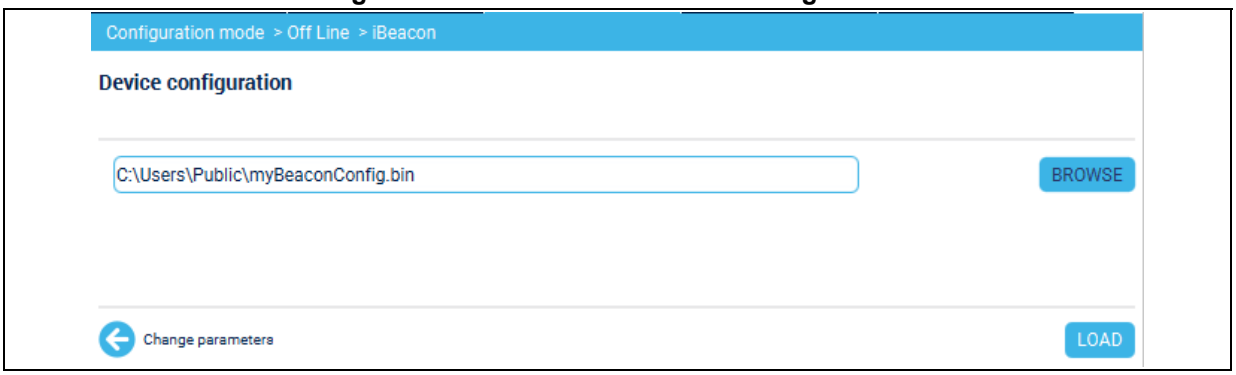
**Figure 83. Online mode transfer configuration**




No extra parameters are required: just click on *LOAD* and the main device is initialized and configured in the beacon.

2. Offline mode transfer configuration

**Figure 84. Offline mode transfer configuration**

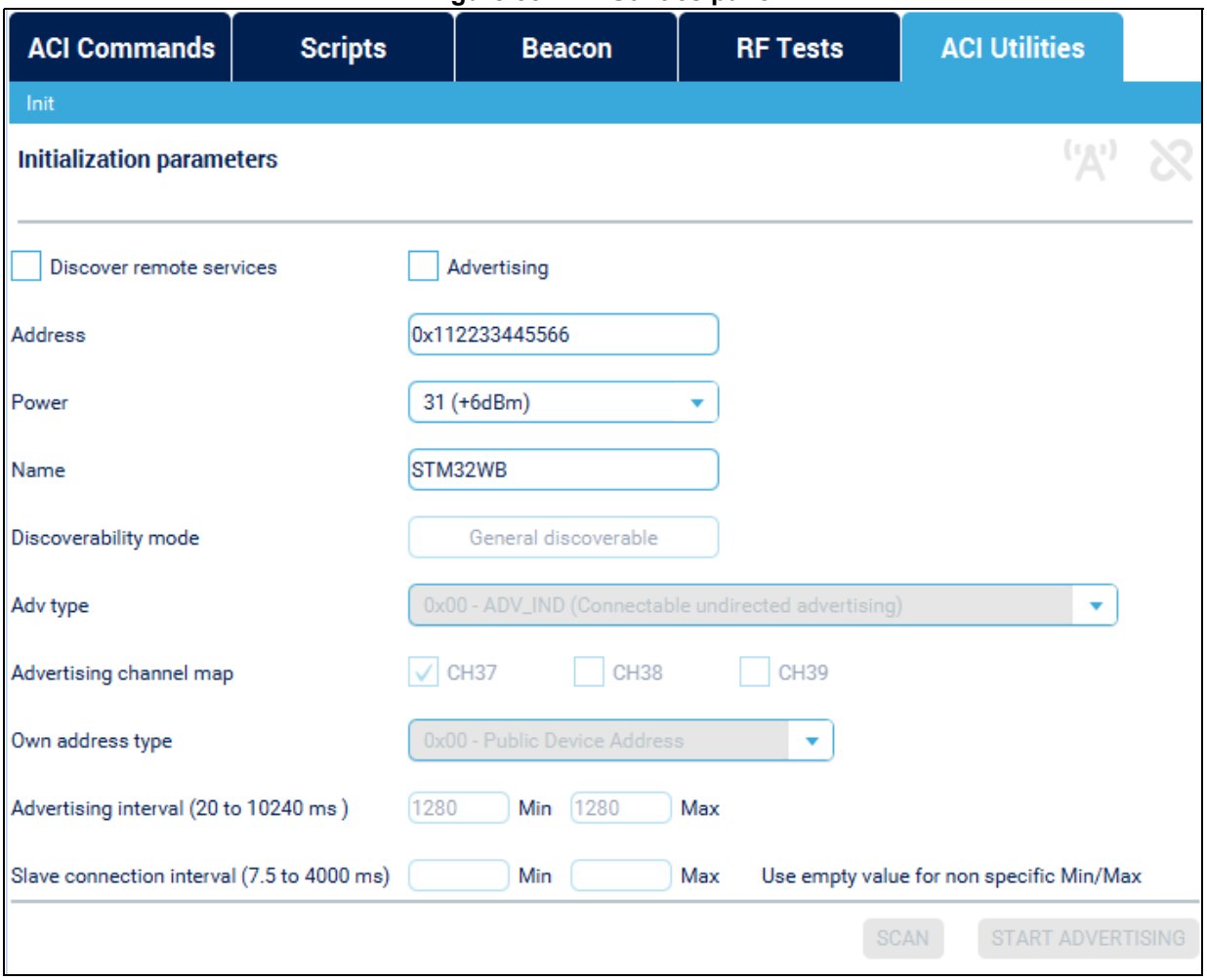



Use the *BROWSE* button to select the path and file to create. Copy the file to the target device using a flash memory programmer or another tool.

## 3.9 ACI Utilities

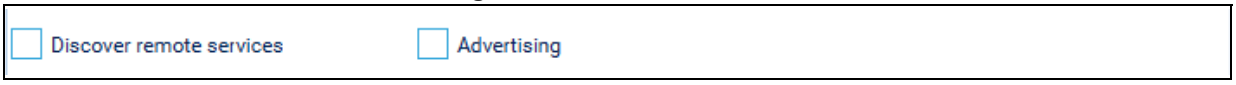
The *ACI Utilities* panel is used to configure the device to perform either the advertising signal or to discover remote devices and explore their services and characteristics.

**Figure 85. ACI Utilities panel**




The first action is to select to discover remote services, manage to advertise, or both, by clicking the appropriate checkbox.

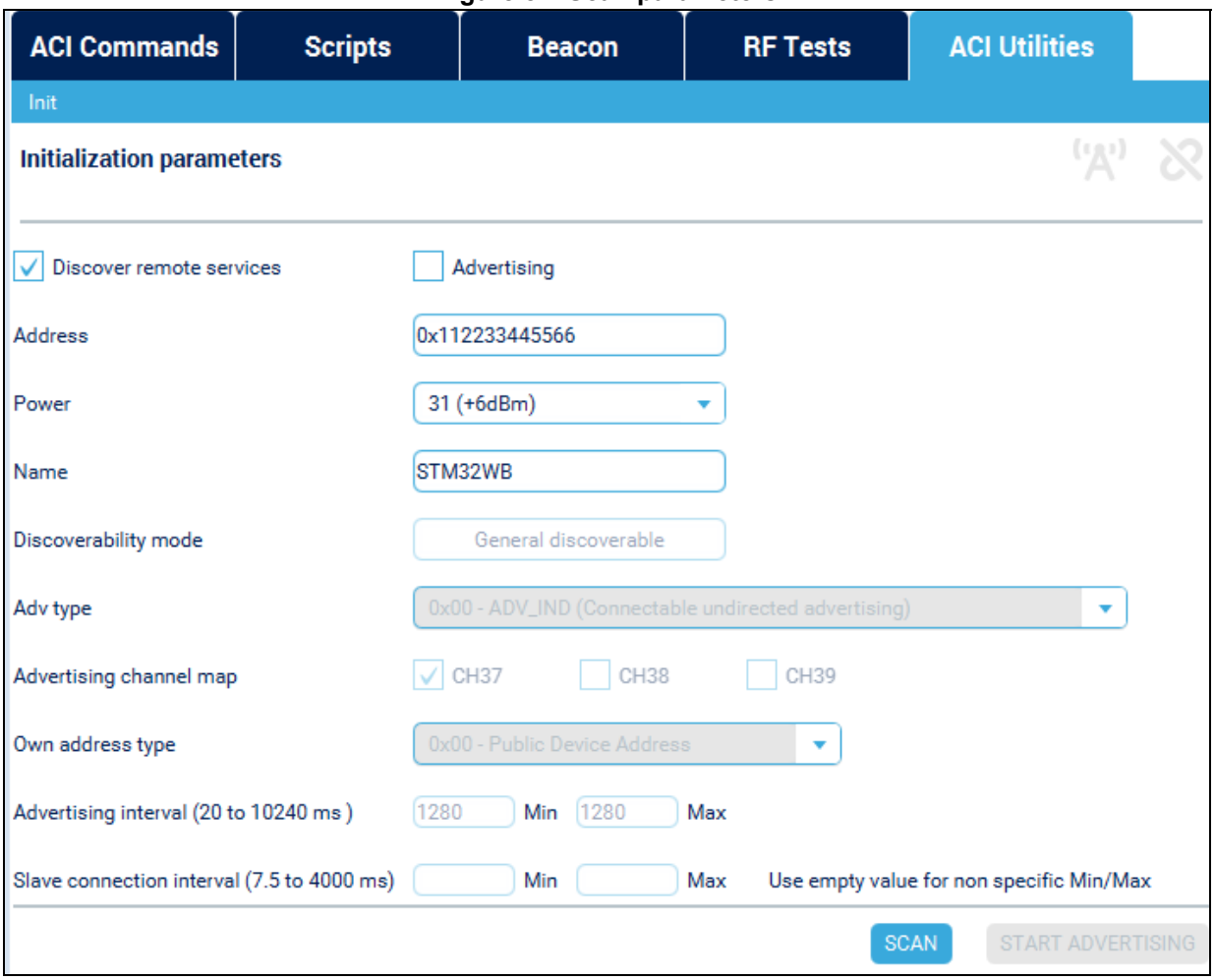
**Figure 86. Select checkbox**



### 3.9.1 Remote services discovering

The remote service discovery performs a scan of the remote devices in the area.

**Figure 87. Scan parameters**

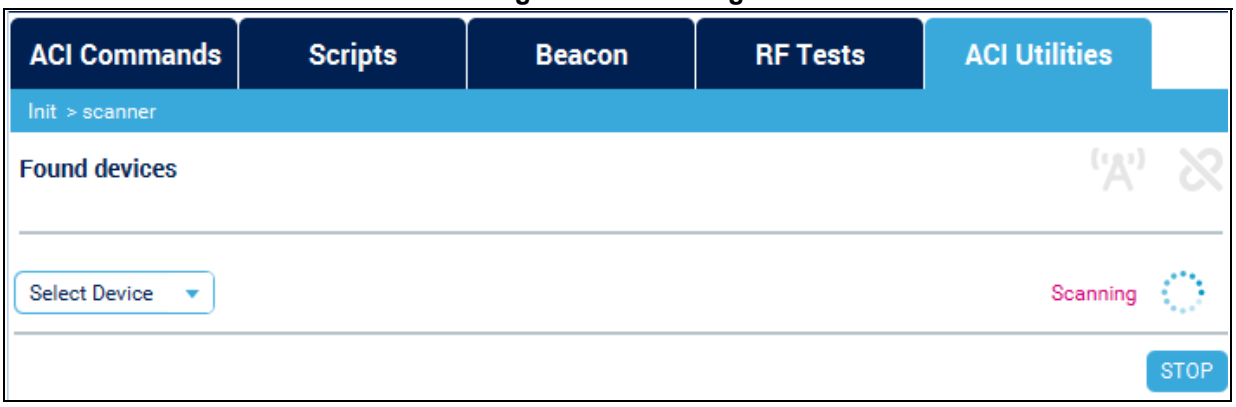



To perform a scan of the available devices:

1. Enter the device address.
2. Select the power level with the picklist.
3. Enter the device name.
4. Click on the *SCAN* button to start the discovery.

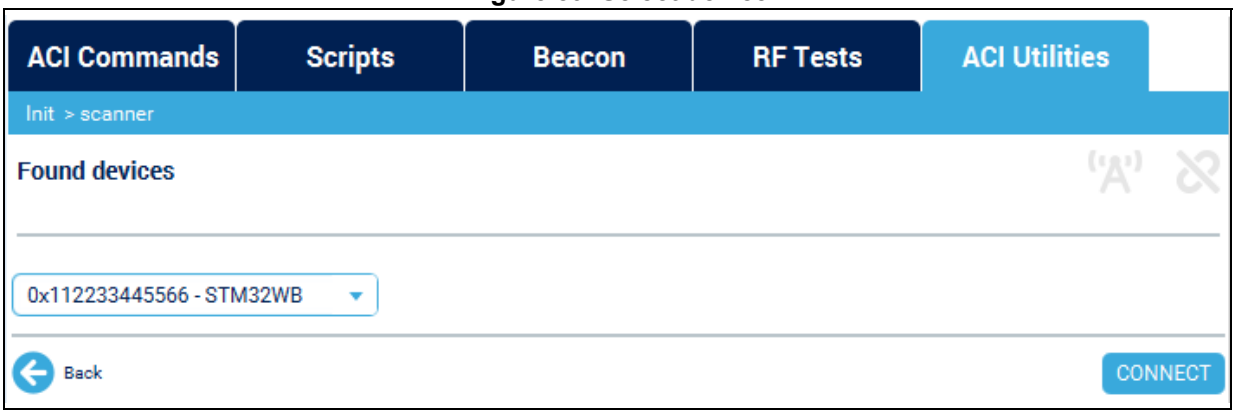
The search procedure starts, and it is possible to stop it using the *STOP* button.

Figure 88. Scanning




If no remote device is found, the tool indicates *No device found*. Otherwise, the user chooses one of the devices found in the *Select Device* box.

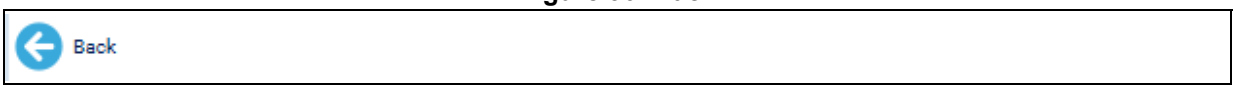
Figure 89. Select device




At this stage, the user performs another scan procedure upon request.

- Click on the back button

Figure 90. Back

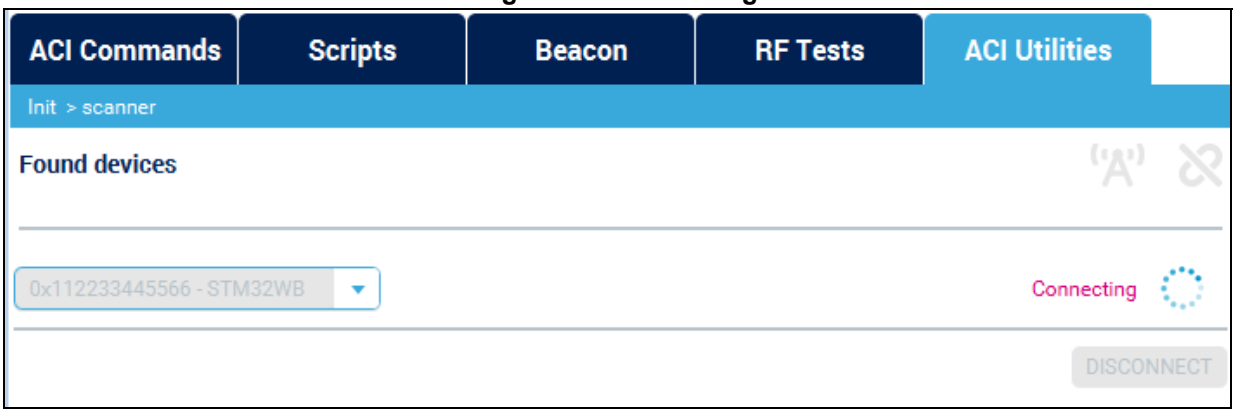



- Click on the *Init* in the top bar

Figure 91. Init

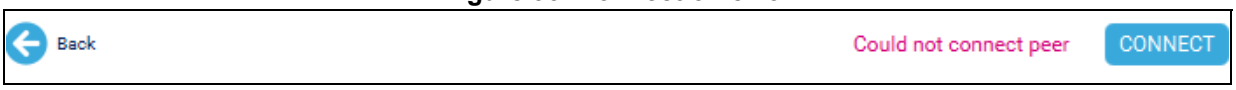

Or connect to the selected remote device, by clicking on the *CONNECT* button.

Figure 92. Connecting




If the connection fails, an error is displayed.

Figure 93. Connection error




Once connected, the connect icon appears in blue and the list of available services is proposed.

Figure 94. Connected icon

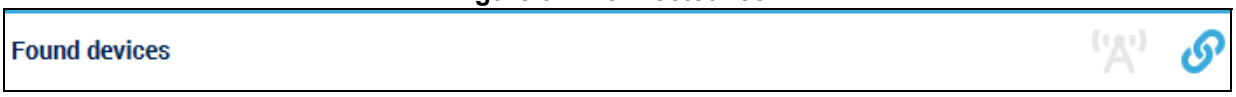
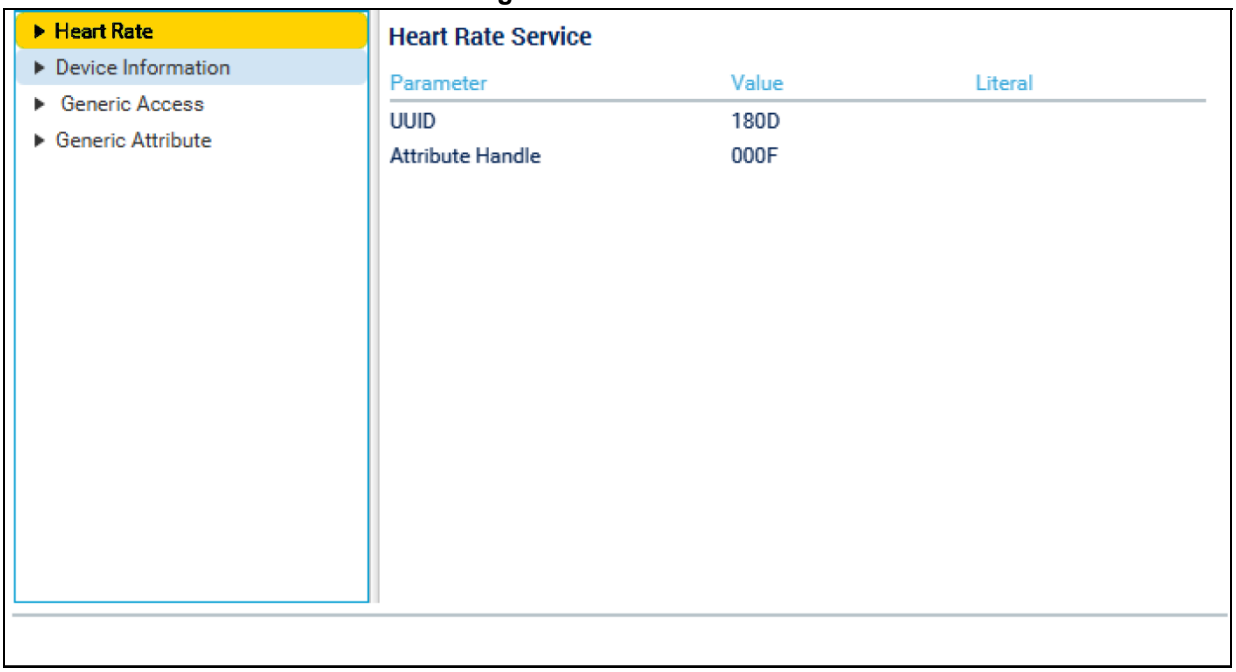
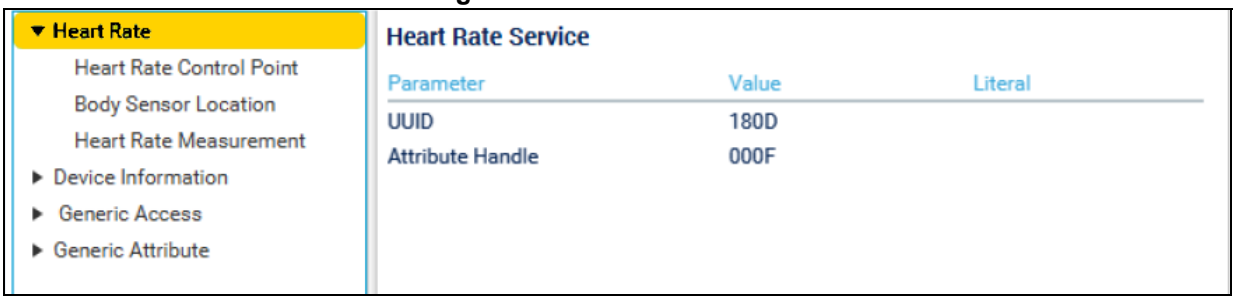



Figure 95. Services list




When the user selects a service, its details are displayed. Clicking on the arrow displays the characteristics linked to the above service.

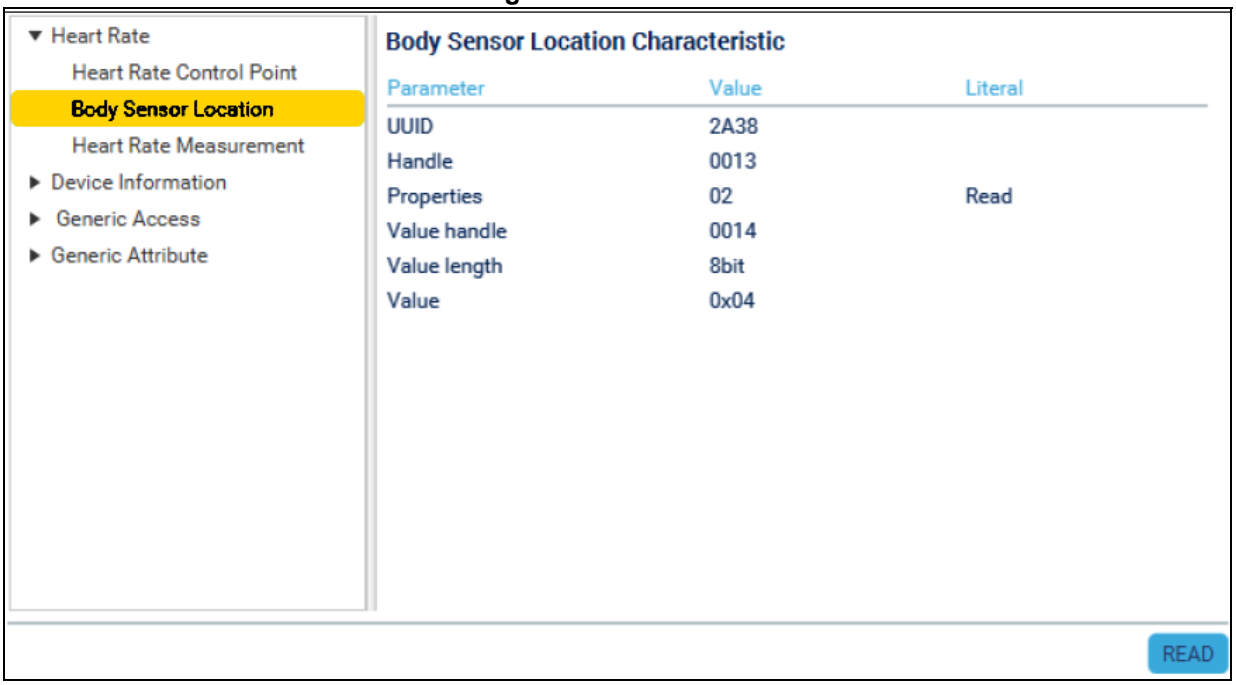
**Figure 96. Characteristics list**




The user can select a parameter and, depending on it, read, or write a value and be notified of the value change. Note that read and write long characteristics are not supported, or authenticated signed write.

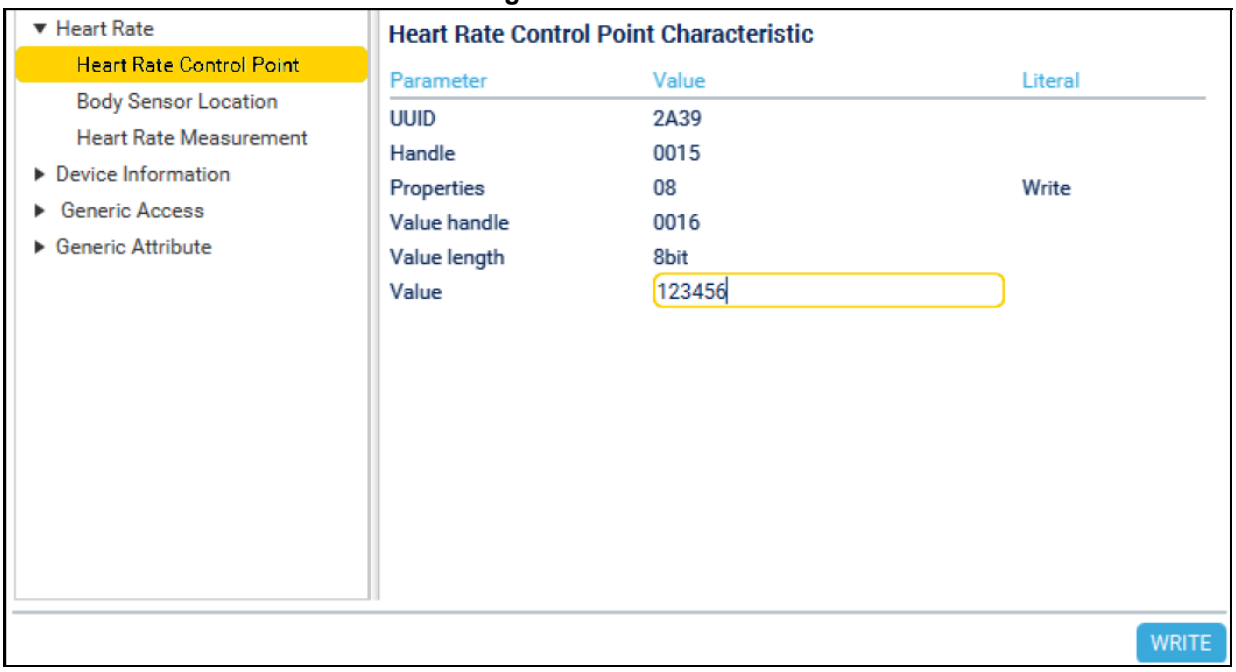
To read a value, the user clicks on the *READ* button.

**Figure 97. Read value**




To write a value, the user enters the new value and clicks on the *WRITE* button.

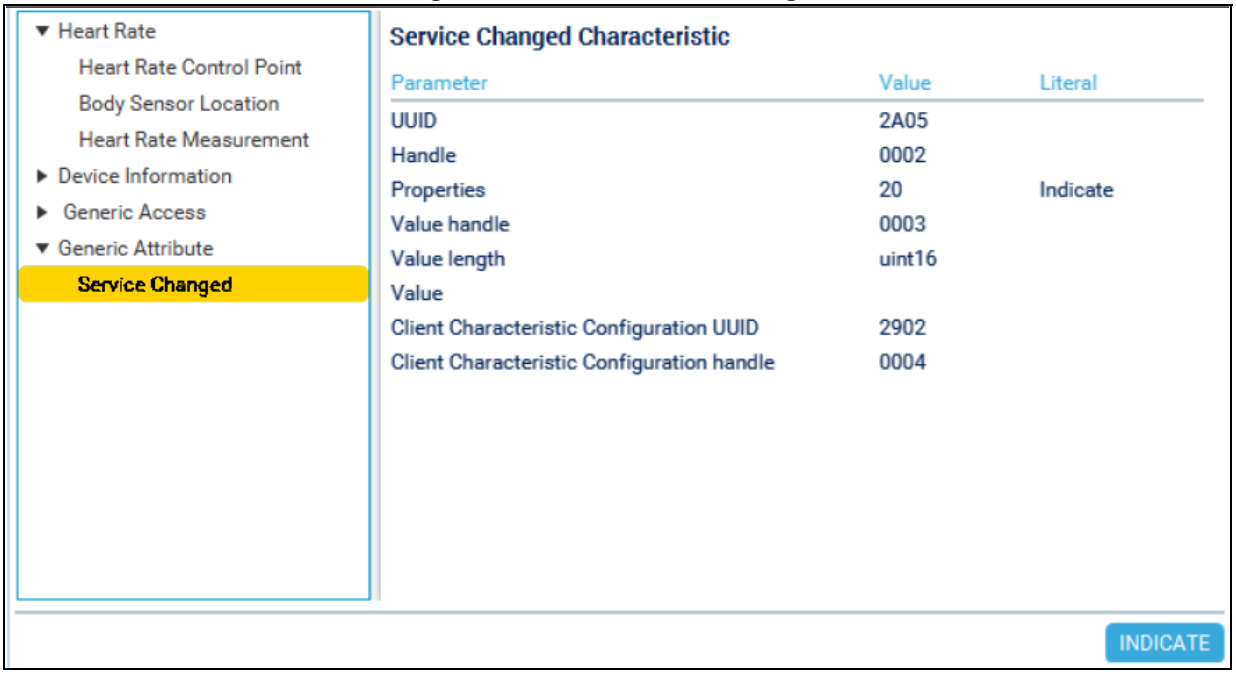
**Figure 98. Write value**




There are two ways to be informed of a value change: either via the indicated method or a notification, depending on the method property supported by the remote device.

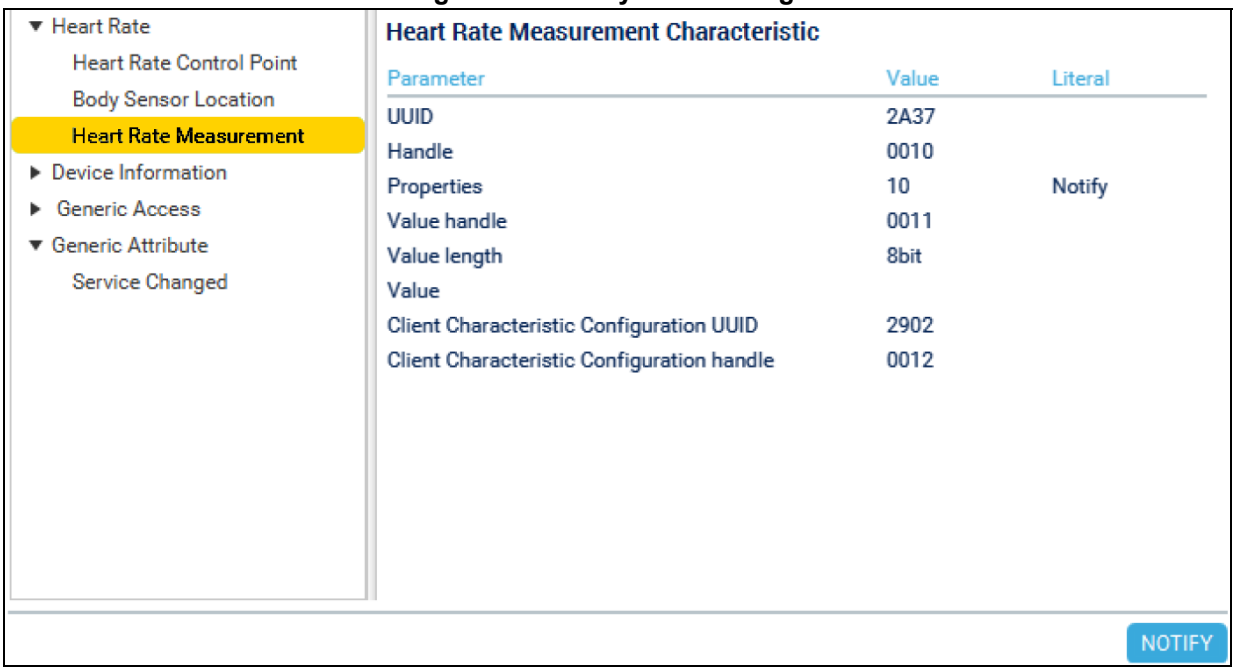
To receive an indication of value change, the user can click on the *INDICATE* button.

**Figure 99. Indicate value changed**




To receive a notification upon value change, the user can click on the *NOTIFY* button.

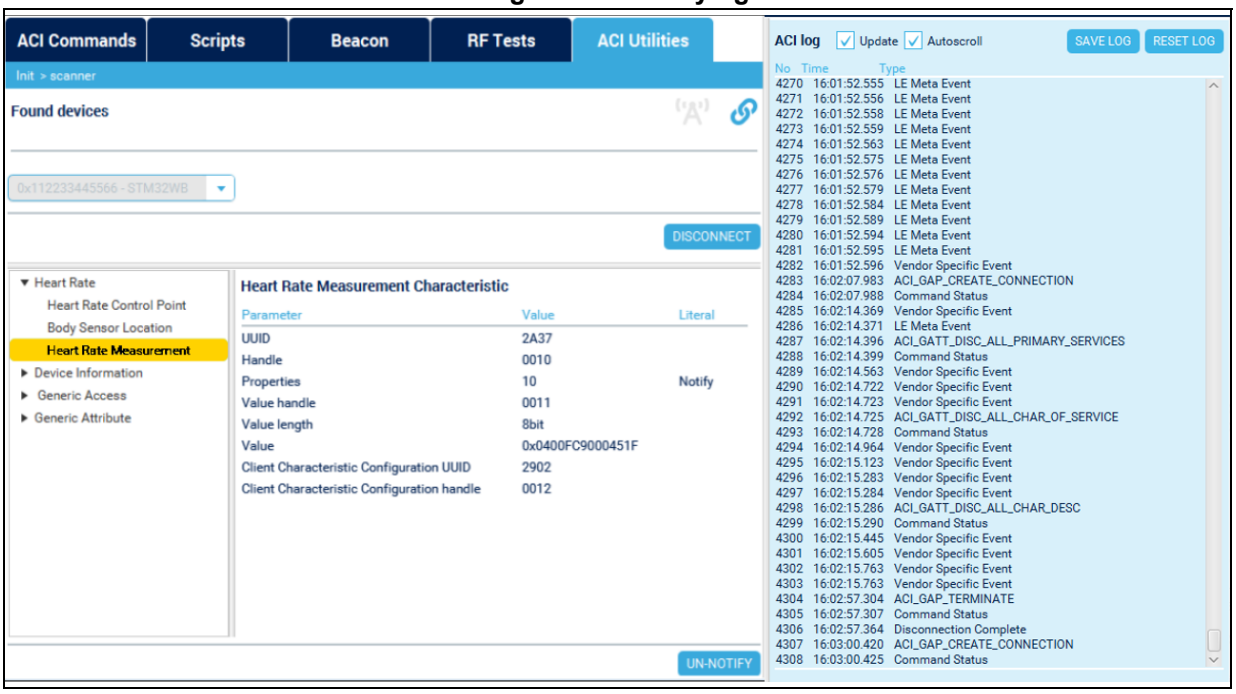
**Figure 100. Notify value changed**




Upon each change, a notification (resp. indication) is received and the new value is displayed. The user can be informed of multiple characteristic value changes at the same time. To stop the notification (resp. indication), the user can click on the *UN-NOTIFY* button (resp. *UN-INDICATE*).

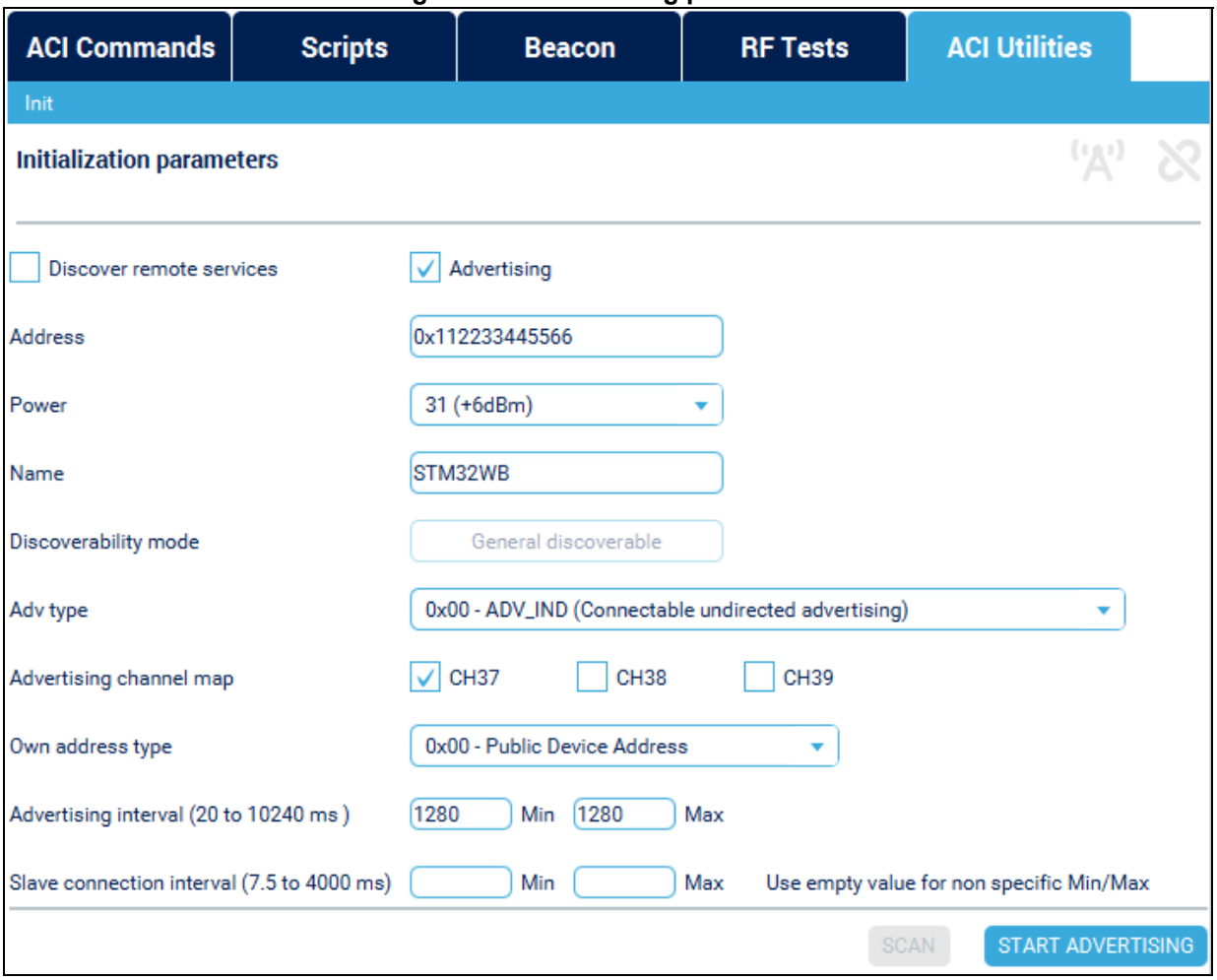
On disconnection, all registered notifications are removed.

**Figure 101. Notifying**



### 3.9.2 Advertising

**Figure 102. Advertising parameters**

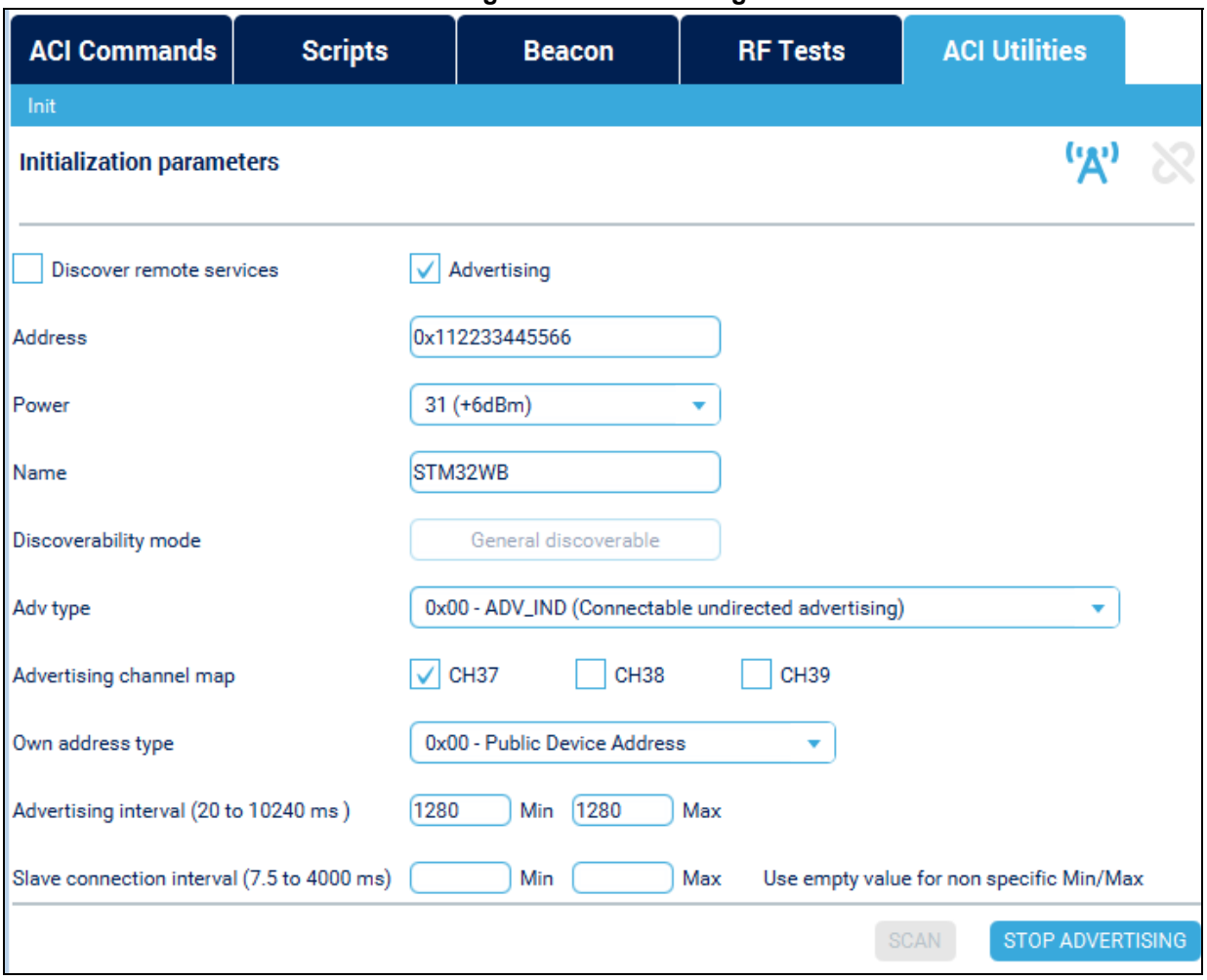



To activate the Advertising mode:

1. Enter the device address.
2. Select the power level with the picklist.
3. Enter the device name.
4. Select the advertising type with the picklist.
5. Select at least one channel from 37, 38, and 39.
6. Enter the advertising interval.
7. Enter an optional target connection interval.
8. Click on the *START ADVERTISING* button to start the procedure.

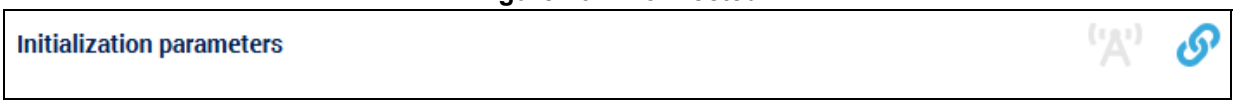
The search procedure starts, and the advertising icon appears in blue. It is possible to stop it using the *STOP ADVERTISING* button.

**Figure 103. Advertising**




The connect icon might appear in blue if a remote device connects. In that case, advertising stops.

**Figure 104. Connected**



# 4 OpenThread mode

## 4.1 Presentation

### 4.1.1 Panel

The OpenThread main panel is organized with three tabs, *Commands*, *Scripts*, and *Network Explorer*.

**Figure 105. OpenThread - Command tab**

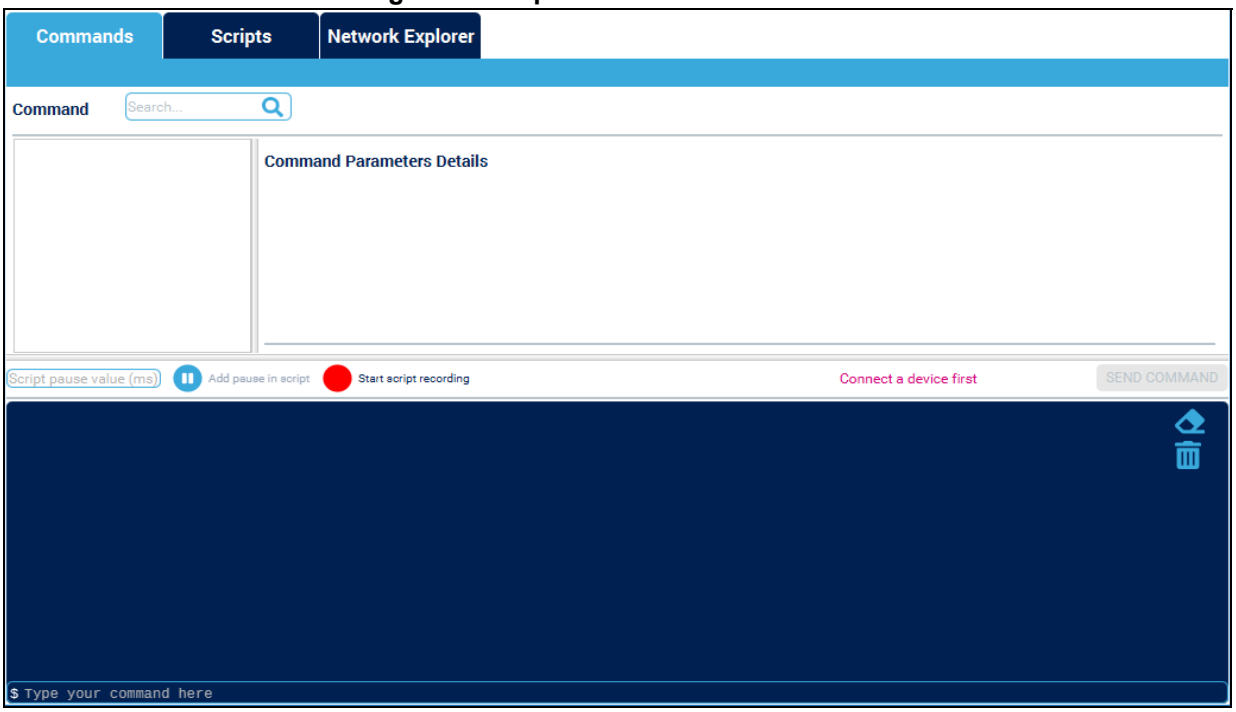
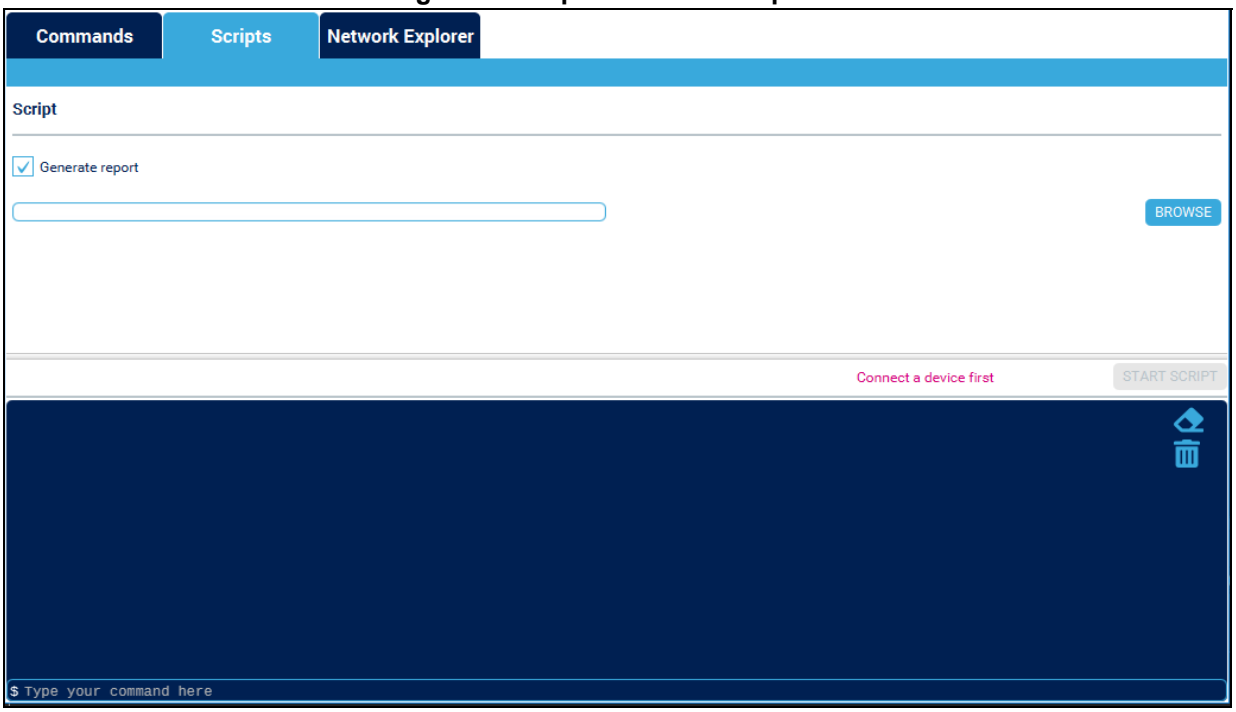


Figure 106. OpenThread - Script tab




The first two tabs have one common bottom area, the terminal area.

Figure 107. OpenThread - Network Explorer tab

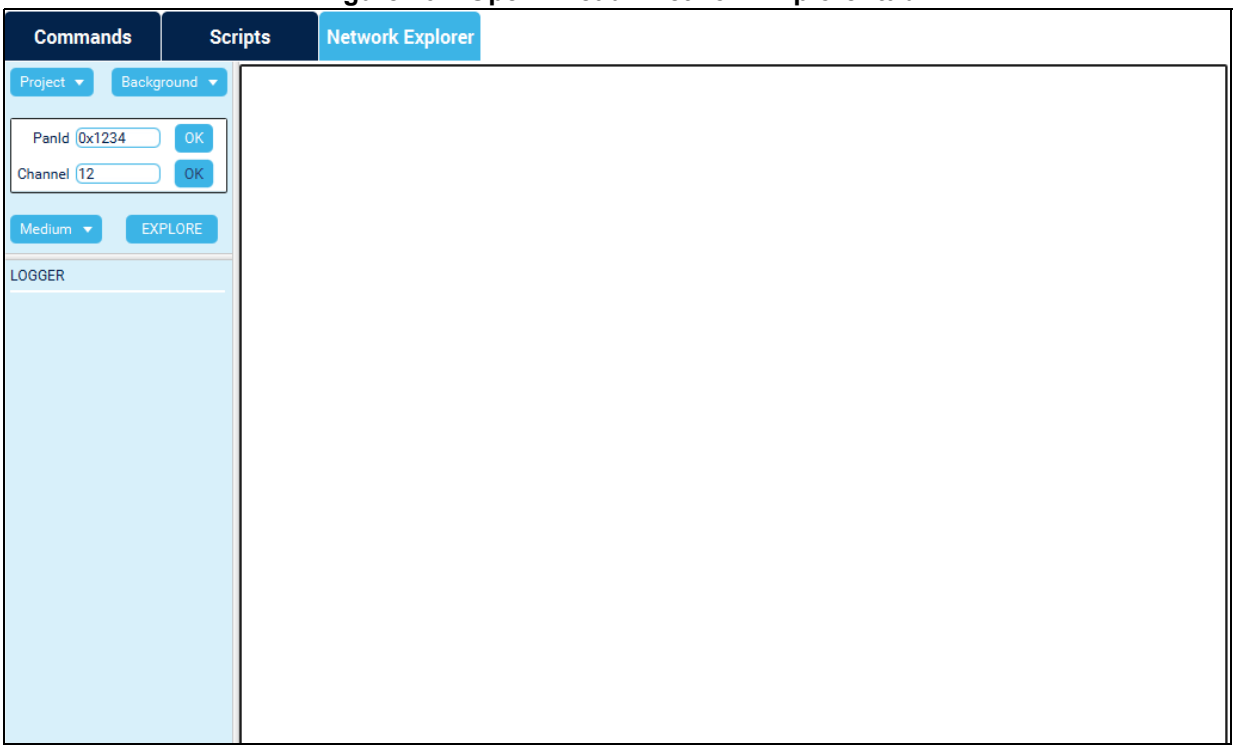


**Figure 108. OpenThread common bottom area**


The terminal area is used to show the messages exchanged between the application and the target. The commands sent to the target can be seen and the responses received from the target. Those messages can be cleared with the rubber icon.

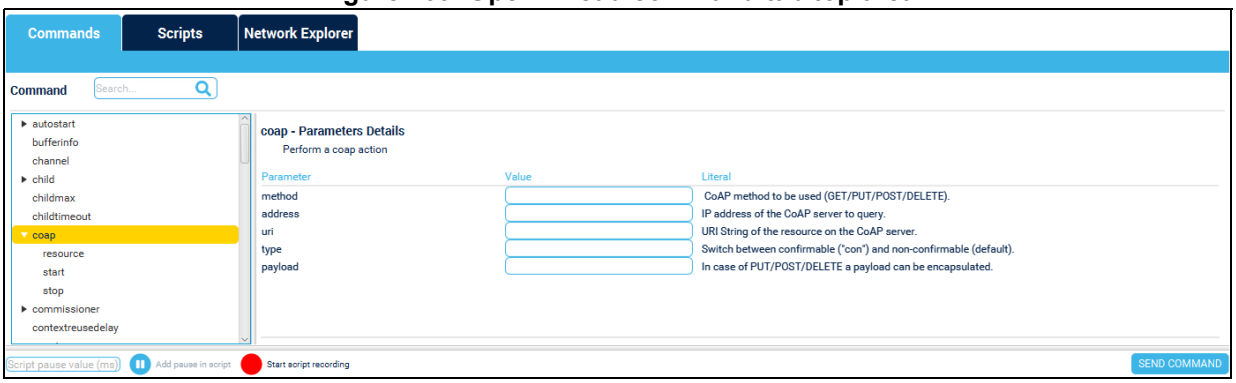
The bottom line with a $ character is a command line. The user types the command with the parameters and presses <Enter> to send the command. The commands sent with this line are recorded in the history file and can be recalled with up and down arrows. This history can be deleted with the trash icon.

One other way is using the commands list and parameter area to fill the line, then the user can modify the line and send a command with the entering key. The commands list and parameters area are described in the chapter Commands tab.

## 4.2 Commands tab

This tab is dedicated to the OpenThread commands and parameters. The top area gives access to the commands list and parameters. Some commands can be used to read and send values, others are only commands sent to the OpenThread stack.

**Figure 109. OpenThread command tab top area**



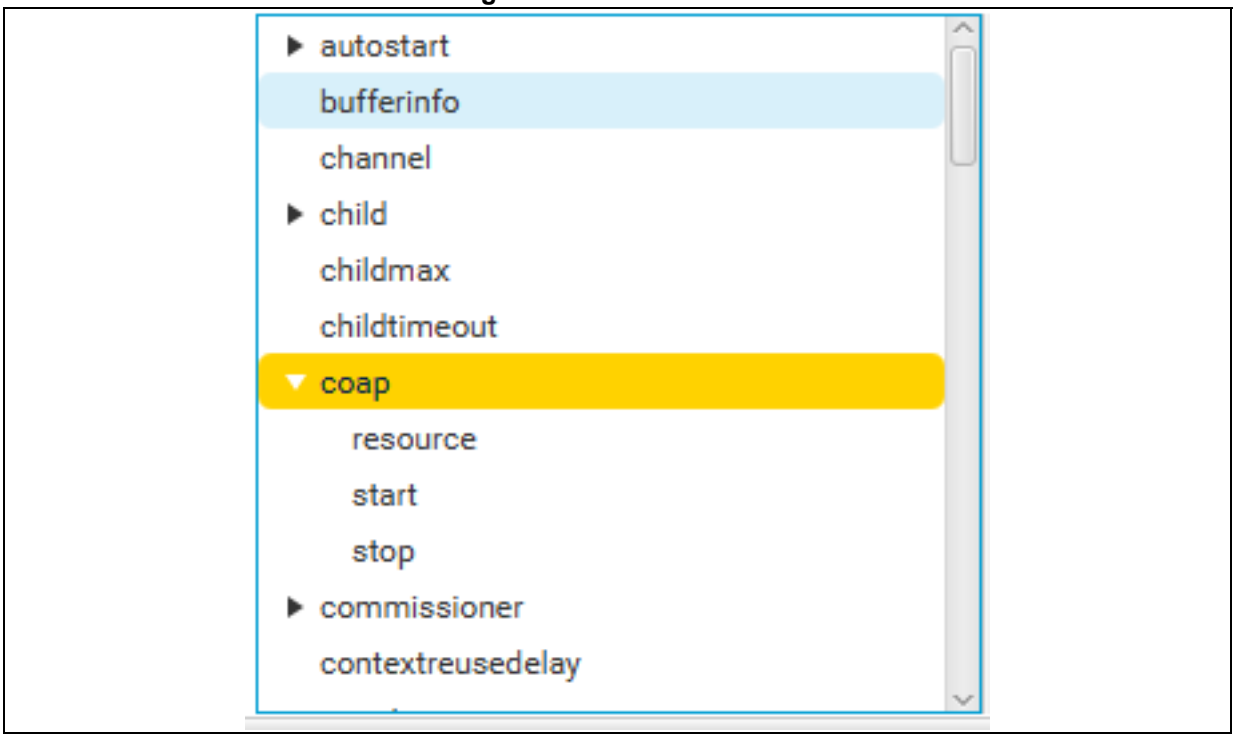

For commands used to send data, the *SEND COMMAND* button sends the command with parameters to the target.

For commands able to read information, two buttons are available: *READ* and *SEND COMMAND*. The *READ* button sends the command without parameters to read the value. The *SEND COMMAND* button sends the command with parameters to the target.

**Figure 110. Script buttons**

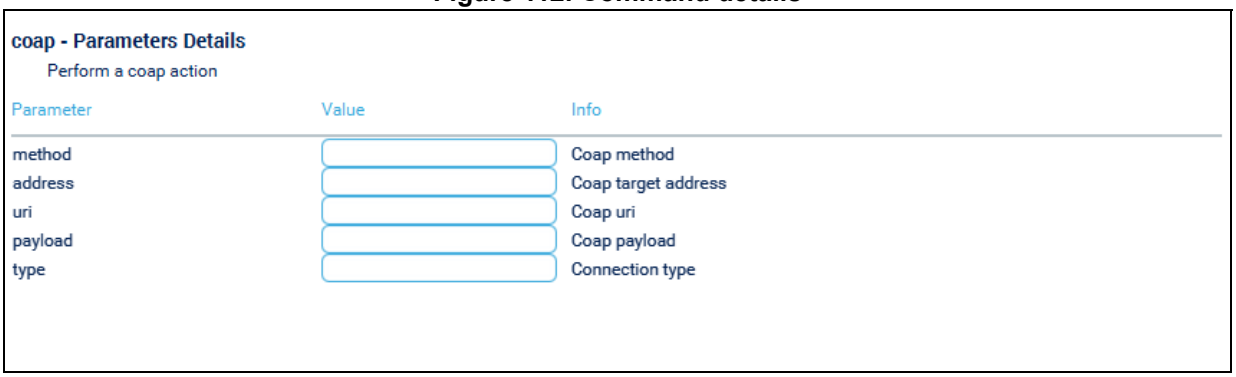

The *Start script recording* and *Add pause in script* buttons allow saving a script. This part is described in *Section 4.3: OpenThread scripts tab*.

**Figure 111. Command list**




The command list is arranged in alphabetical order, and accessible from the tree, for example below the *coap* command, there are *coap resource*, *coap start*, and *coap stop* commands.

**Figure 112. Command details**



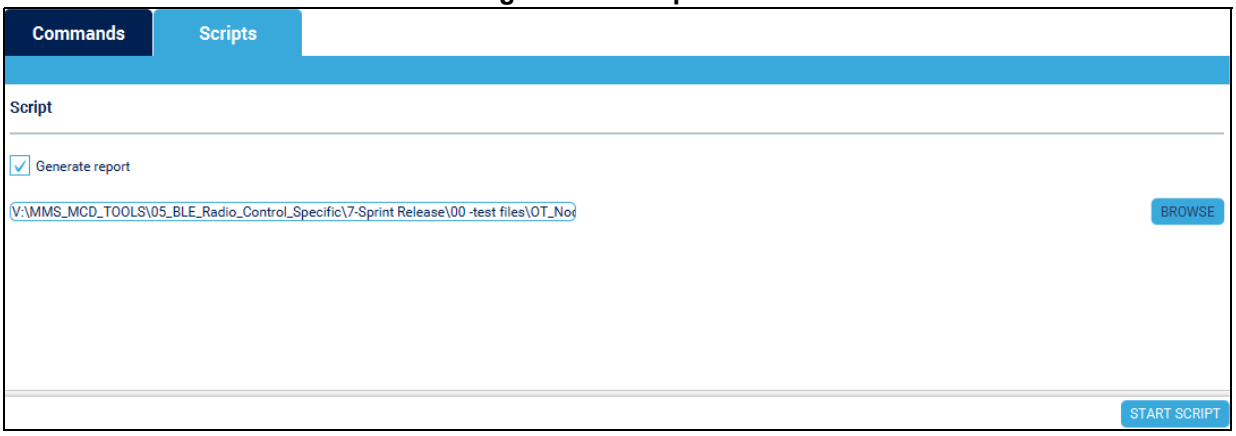

The command name and the definition are in the upper part of the command details area. Below is one table of parameters with the parameter name, there is one writable field to define the value and information concerning this parameter.

Note that when sending a reset command on an STM32WB USB dongle, the VCP device is reset and disconnects. A new connection procedure is needed to perform further tests.

## 4.3 OpenThread scripts tab

The OpenThread scripts tab is used to launch the script stored in a text file.

**Figure 113. Scripts tab**




The scripts use the same syntax as the Bluetooth® LE scripts. The OpenThread specificities are described in this chapter. Consult the Bluetooth® LE script description in *Section 3.5* for general information.

### 4.3.1 OpenThread script example

**Figure 114. Sample script**

```
#STM32CubeMonitor-RF sample script
# OpenThread ping node script

#Pause command
Pause ("Ready to start the test")

#Send reset command:
Send (reset)

#Set channel
Send (channel 11)

#Set the PAN ID:
Send (panid 0x1234)

#Bring up the IPv6 interface:
Send (ifconfig up)

#Start Thread protocol operation:
Send (thread start)

#Wait for a few seconds and verify that the device has become a
Thread leader:
wait (5000)

#Check state
Send (state)

#Ipaddr
Send (ipaddr)
```

### 4.3.2 List of script commands

The OpenThread scripts use the same commands as Bluetooth® LE, but the *Send* command is modified to send Thread commands.

The OpenThread commands are sent with the *Send* instruction:

```
Send (OPENTHREAD_CMD_NAME Parameter1Value Parameter2Value).
```

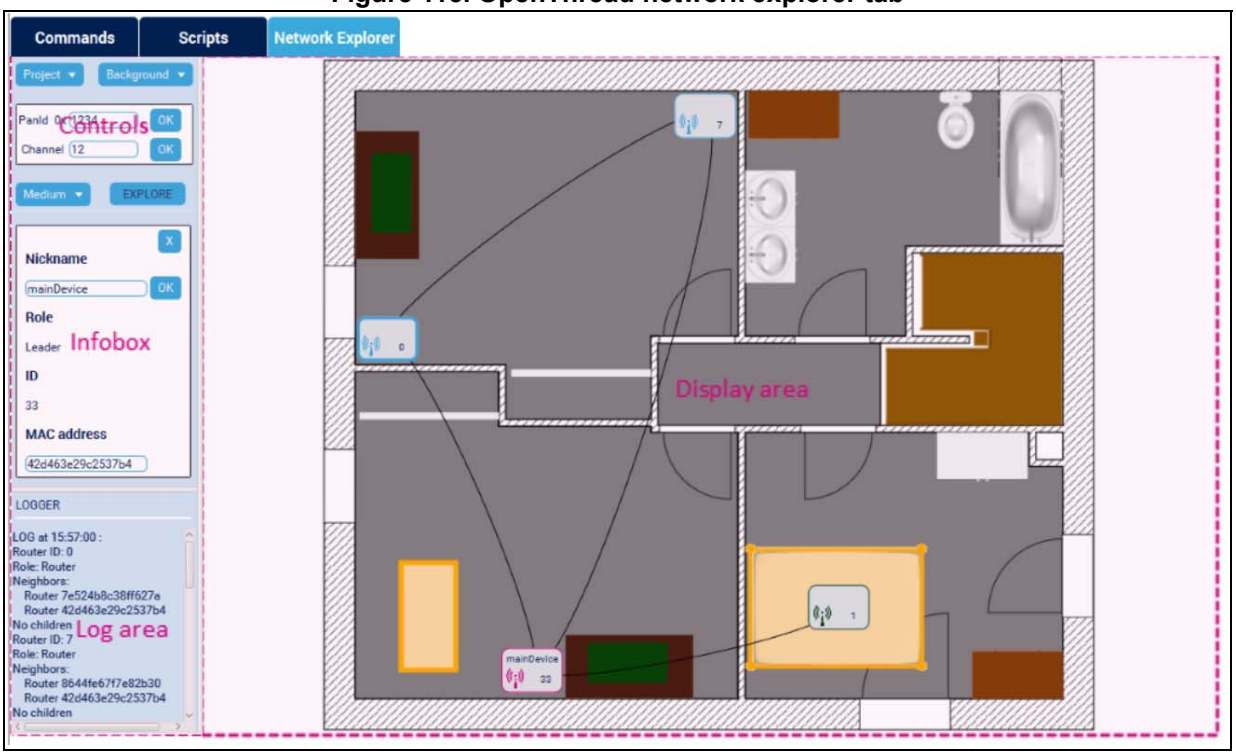
The part inside the brackets is the command line to send.

## 4.4 Network Explorer tab

This feature can only be used if the DUT has the *Thread_Cli_cmd* firmware to be able to copy data from the UART to the OpenThread command-line interpreter. Refer to *Section 2.2.1* for further information about firmware.

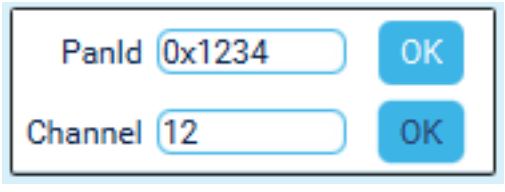
This tab is dedicated to the exploration and display of the network to which the DUT device is attached. The representation of the network is displayed in the central area. There are some basic control functions in the up-left corner of the pane. Just below, there is information on the selected node in an infobox plus logs of the exploration.

**Figure 115. OpenThread network explorer tab**




### 4.4.1 Controls

**Figure 116. Auto connection functions**



The network explorer tab easily configures the panId and channel of the DUT device.

The panId is entered in hexadecimal format, with no need to specify *0x*. The value must be contained between *0x0000* and *0xfffe*. The value *0xffff* corresponds to an unconfigured panId.

The channel is defined in decimal format and must be contained in [11;26]. The panId must be configured before configuring the channel. As from the STM32WB V1.14 version, the network key is initialized to a random value, so this parameter is set to *00112233445566778899aabbccddeeff*. It is the default controller key used by the previous firmware.

For both parameters, if the filled value is in the wrong format, nothing is changed, and the actual value of the device remains displayed. Moreover, if a network exploration is ongoing neither parameter can be changed.

At the first DUT connection or when switching to the network explorer tab, the tool checks the current values of both parameters and displays them in the fields as information.

**Figure 117. Project and background management**


The two menu buttons on the top of the control area give control to the project itself and the background image.

The *Project* menu proposes three choices:

1. *New choice* cleans the current session by resetting the display area and stopping the ongoing exploration if there is one.
2. *Open choice* opens a file explorer to choose a backup of a project to use in the session. When a project is loaded from the *Open choice* box, there is a two-step process:
   – The saved image is first restored as the background of the right area.
   – When a scan is started, if a saved project device is detected, it is instantly displayed in its last place with its former nickname. This association is based on the unique MAC addresses of the devices.
3. *Save choices* saves the current project. In this backup, there is the background image, the location of the icons on that image, and the nicknames of the devices.

The *Background* menu allows either to:

- Remove the background image.
- Open a file explorer to put an image in the display area as a background.

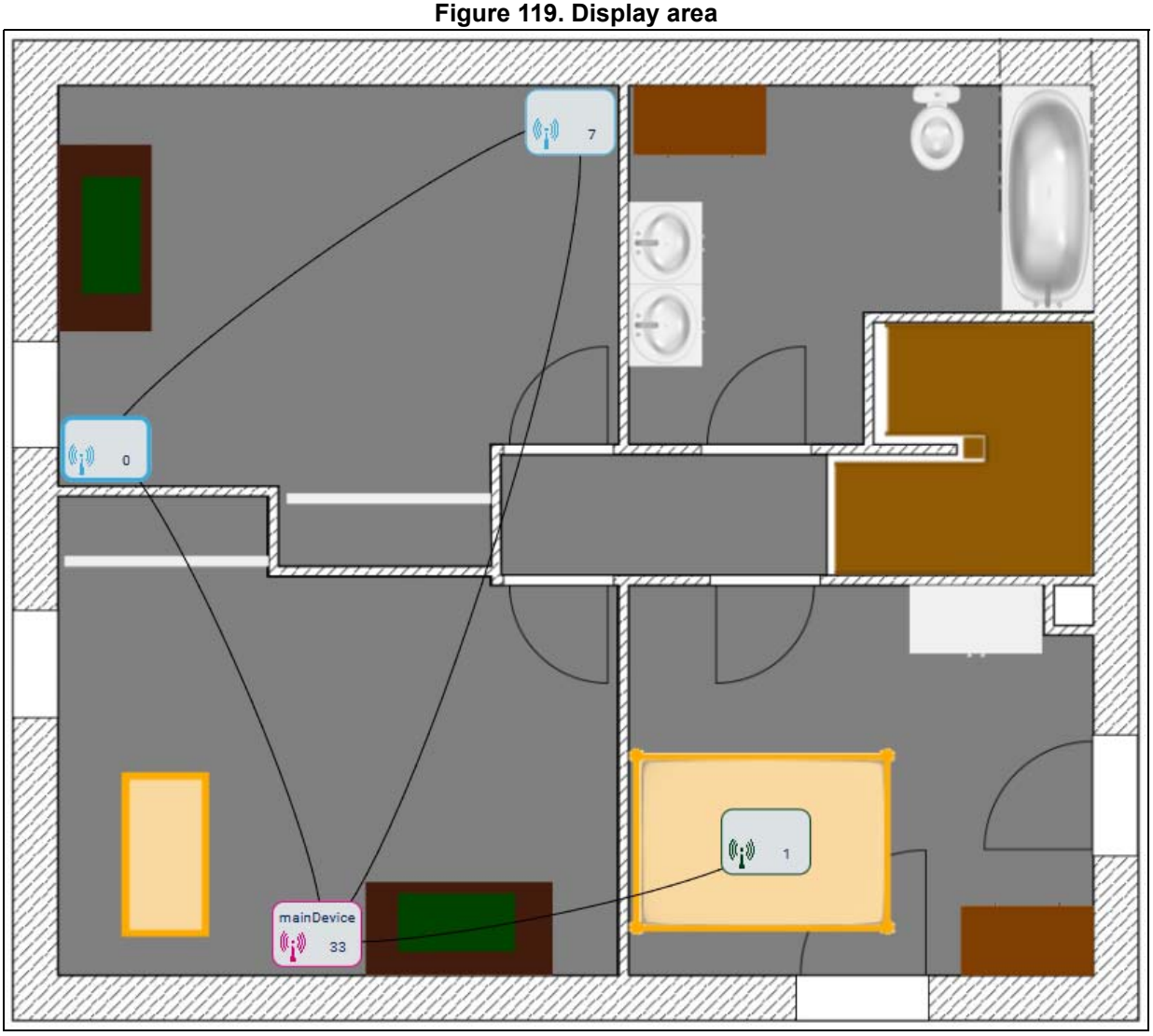
**Figure 118. Explore and size choice controls**


Once the DUT device is connected to a Thread network, the EXPLORE button starts the network exploration sequences. It turns to *STOP* when the exploration is ongoing.

The *Choice box* at the left of the EXPLORE button chooses the size of the icon between three standard sizes: *Small*, *Medium*, and *Large*. It can be changed at any time. The size of the icons is adapted according to the dimensions of the background image.

### 4.4.2 Display area

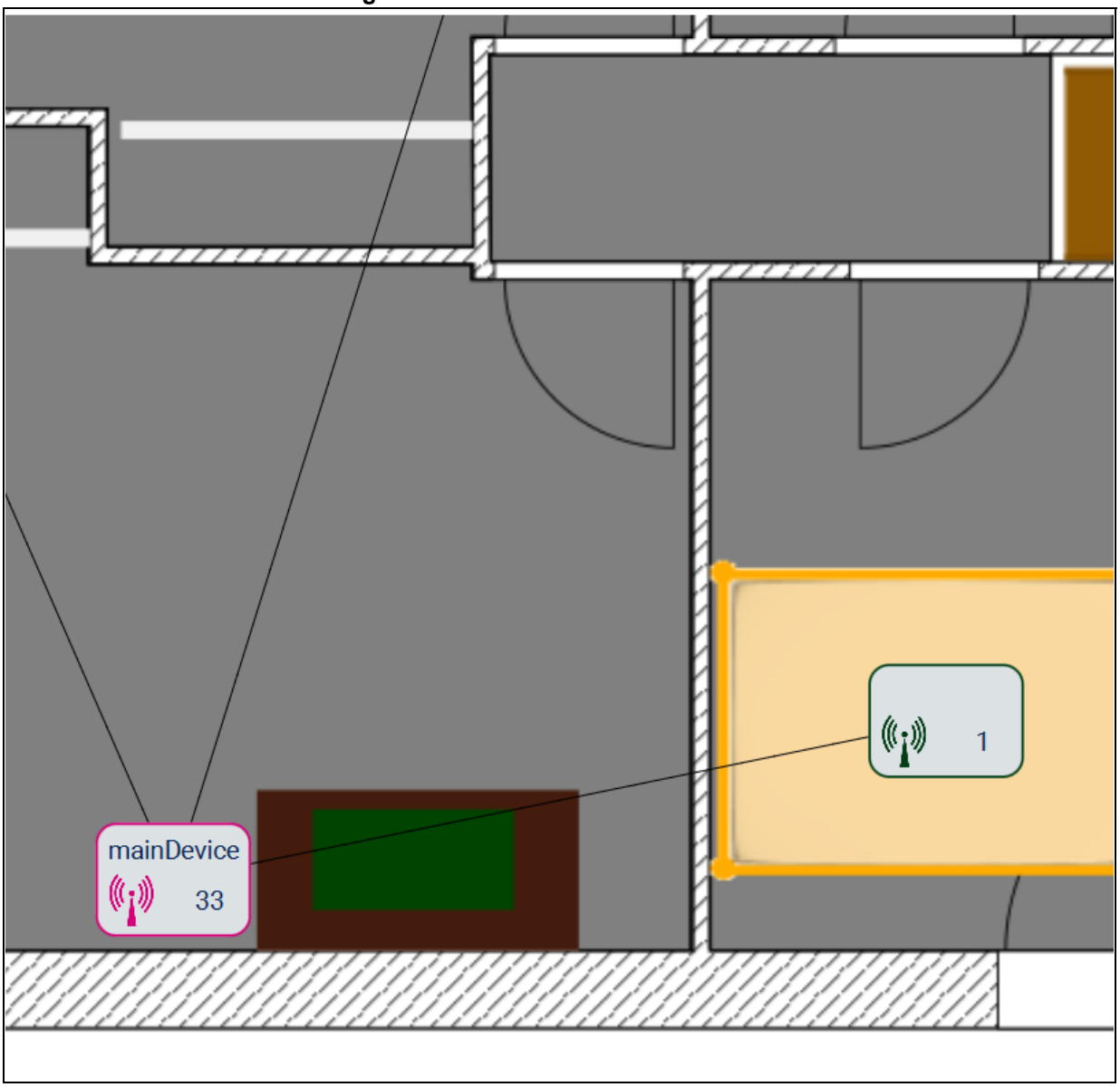
**Figure 119. Display area**




The result of the network exploration is displayed with icons representing the devices of the network and their links. Each icon gives three types of information:

1. The color of the borders and the logo (pink for a *Leader*, cyan for a *Router*, and green for a *Child*) gives the role.
2. The number on the right side of the logo gives the ID.
3. The eventual nickname is written above the logo.

**Figure 120. Zoom and motion controls**

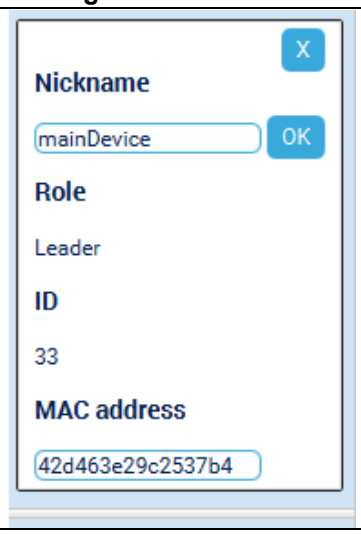



In the display area, it is possible to make several kinds of movement:

- Holding the left click of the mouse can move an icon everywhere inside the right area. If dragged on another icon, it turns gray and is automatically replaced if dropped on another icon to avoid overlays.
- Zoom in or out is done with the mouse wheel. The motion is centered on the mouse pointer.
- The whole content of the right area can be moved by holding the right click of the mouse. However, this movement is subject to constraints, as the zone background (imported image or default blank background) cannot leave the zone completely.
- A double-click (left) anywhere on the area centers the background and restores the zoom x1.

### 4.4.3 Infobox

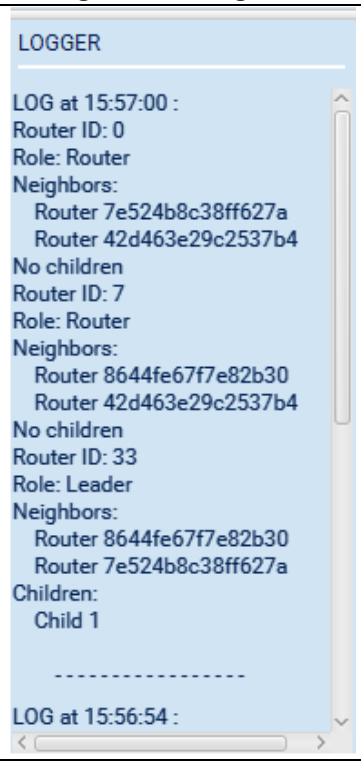
**Figure 121. Infobox**




An infobox can be instantiated just below the control area by clicking on the concerned icon. It allows modification of the node nickname and indicates its role, ID, and MAC address.

### 4.4.4 Log area

**Figure 122. Log area**




The log area is in the bottom-left part of the tab. It prints the last two exploration results of the network in written form. This area is updated after each new exploration.

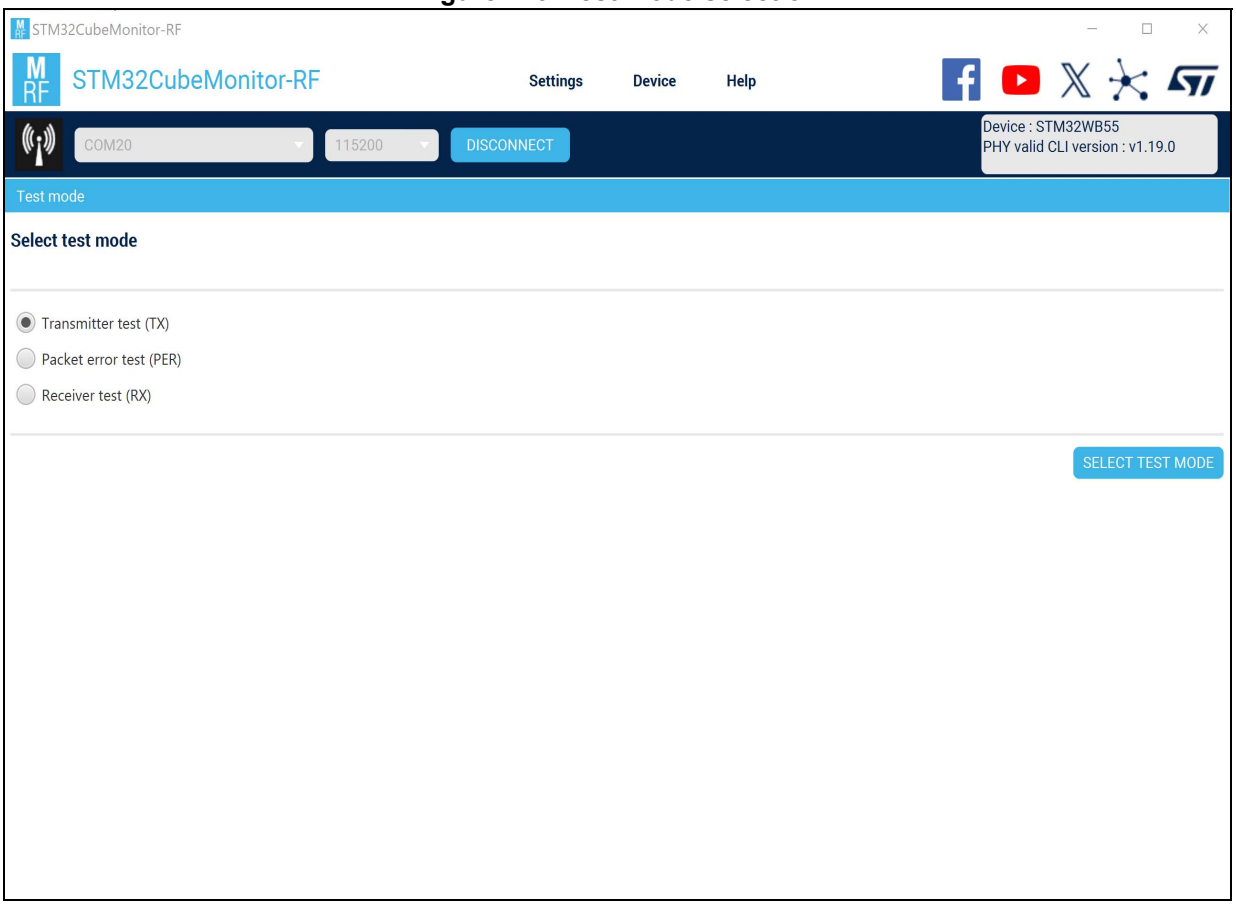
# 5 802.15.4 RF test mode

## 5.1 Presentation

The RF test panel performs the 802.15.4 radio frequency tests on the main device. Three test modes are available: Transmitter (TX), Receiver (RX), and Packet error rate (PER):

- The TX test sets the device in emission (TX continuous).
- The RX test sets the device in reception.
- The PER test sets the device in reception and one additional device is used as a packet generator.

**Figure 123. Test mode selection**



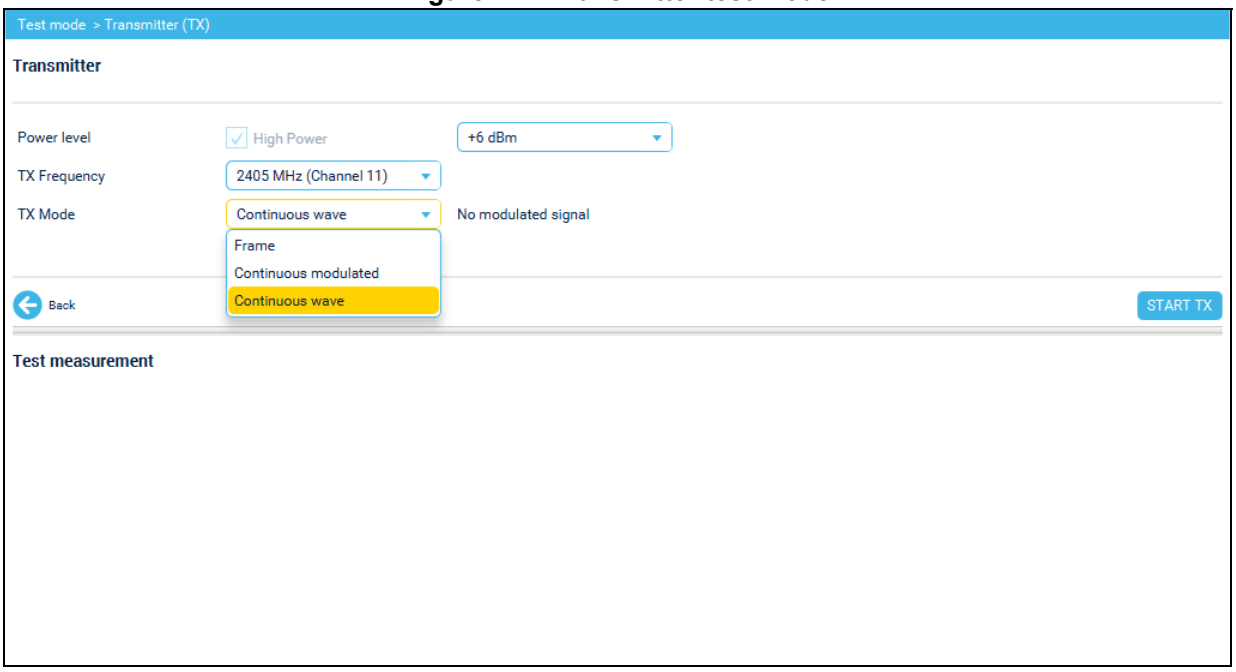

The user selects the mode by checking the radio button and pressing the *SELECT TEST MODE* key to switch on the new panel.

To change the mode, it is necessary to come back to this panel. There is a *Back* key and a breadcrumb link in each test panel to come back to this *Test mode selection* panel.

## 5.2 Transmitter test mode (TX)

This test mode configures the 802.15.4 device in emission. Two TX modes are available, Frame and Continuous modulated modes.

**Figure 124. Transmitter test mode**



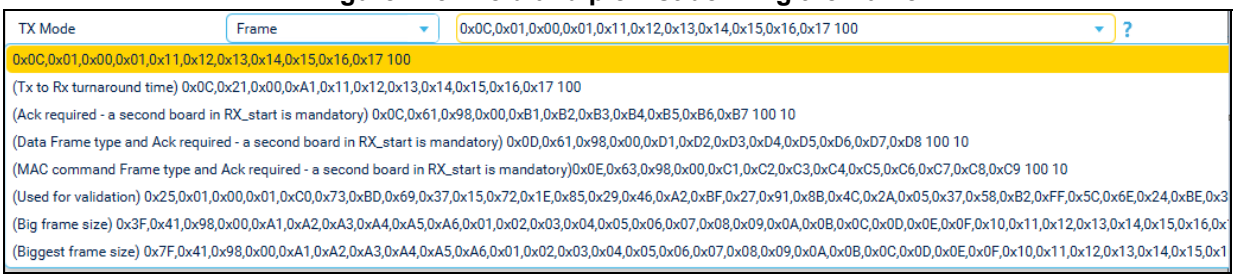

The user must:

- For the STM32WBA devices, check or uncheck the *High Power* box according to high-power support.
- Select the power level:
  - For the STM32WB MCUs, select the range from +6 to -21 dBm.
  - For the STM32WBA MCUs, the supported range depends on high-power support:
    - Select from +3 to -20 dBm in Low-power mode
    - Select from+10 to -20 dBm in High-power mode
- Select the TX frequency (Channel 11 - 2405 MHz to Channel 26 - 2480 MHz).
- Select the TX mode, Frame, Continuous modulated, or Continuous wave.

### 5.2.1 Frame mode

This mode allows the user to send a MAC frame. Either the user selects one frame available in the picklist or it fills the field.

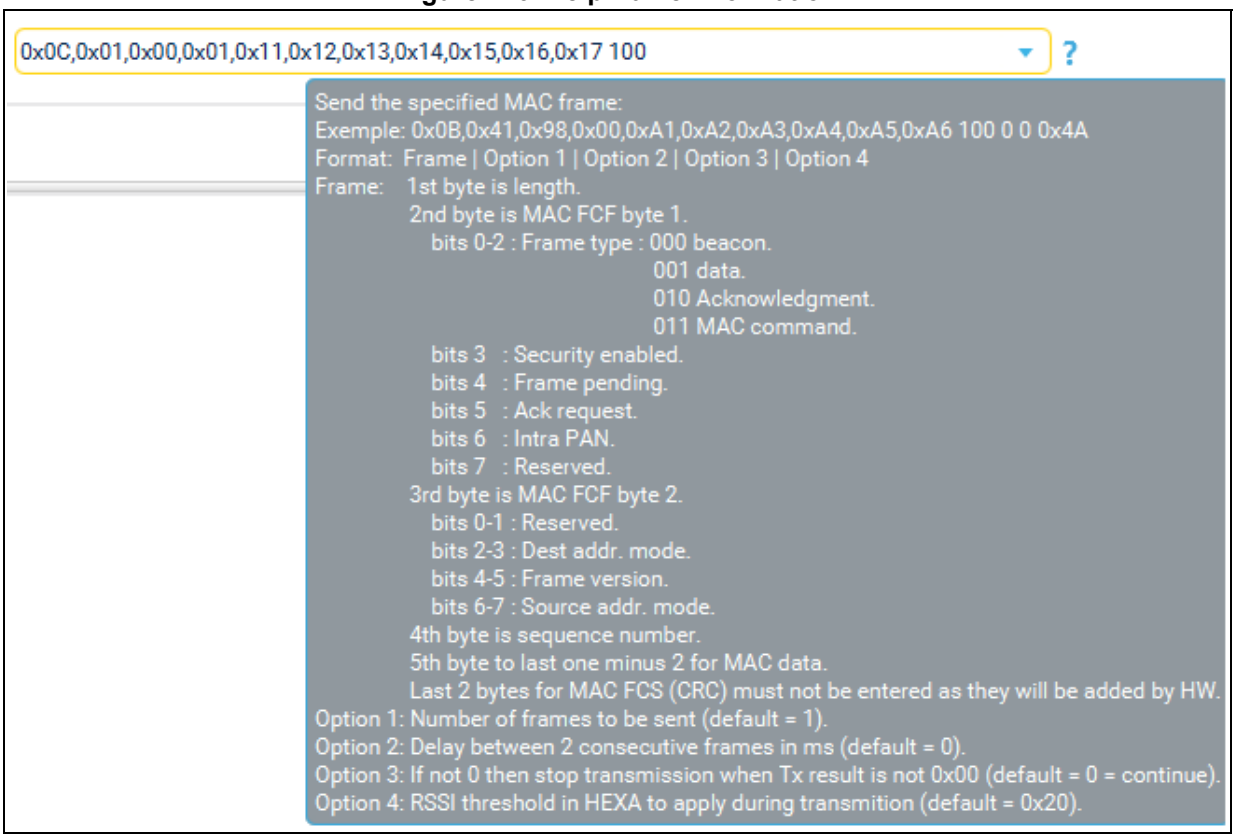
**Figure 125. Field and picklist defining the frame**




*Note: In the picklist, there is the frame required for the certification test of TX to RX turnaround time.*

The help information is visible with a mouse over the question mark, on the right side of the field.

**Figure 126. Help frame information**



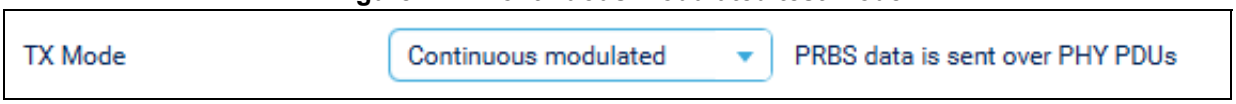

The *START TX* button is enabled when the frame in the field is valid. Press the start button to launch the transmission, the button is disabled until the frame is transmitted.

### 5.2.2 Continuous modulated mode

This mode transmits a continuous signal where pseudo-random binary sequence (PRBS) data is sent over PHY PDU.

Press the *START TX* button to launch the transmission. The label of the button is switched to *STOP TX* and allows the user to stop the transmission.

**Figure 127. Continuous modulated test mode**




### 5.2.3 Continuous wave mode

This mode transmits a continuous signal with no modulation.

Press the *START TX* button to launch the transmission. The label of the button is switched to *STOP TX* and allows the user to stop the transmission.

## 5.3 Receiver test (RX) mode

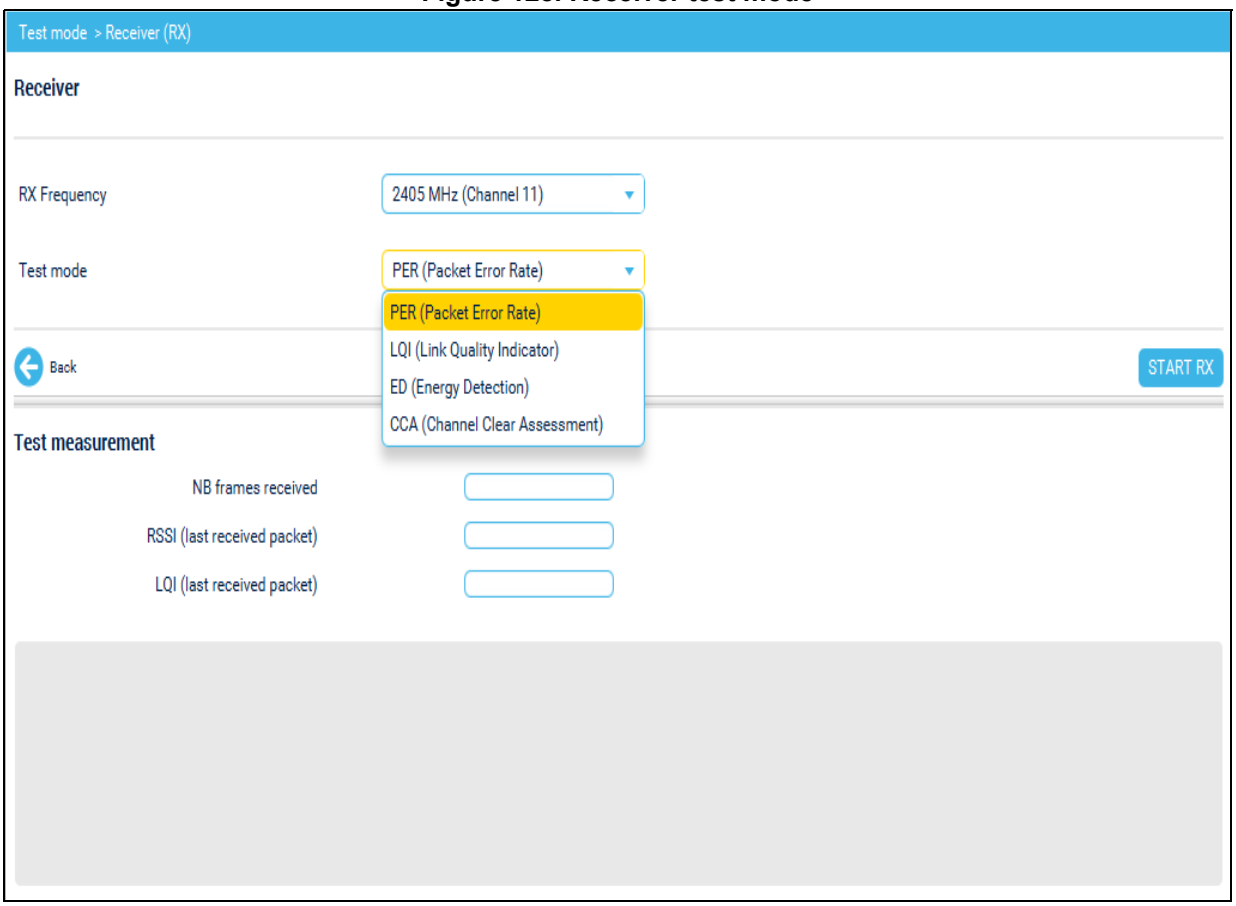
This test mode configures the device in reception and requires an external generator.

Four tests are available:

1. PER (packet error rate) requires an external frame generator.
2. LQI (link quality indicator) requires an external frame generator.
3. ED (energy detection) requires an external continuous wave generator.
4. CCA (channel clear assessment) requires an external frame generator.

*Note: LQI, ED, and CCA tests are available with PHY valid CLI version v1.8.1 and upper.*

**Figure 128. Receiver test mode**

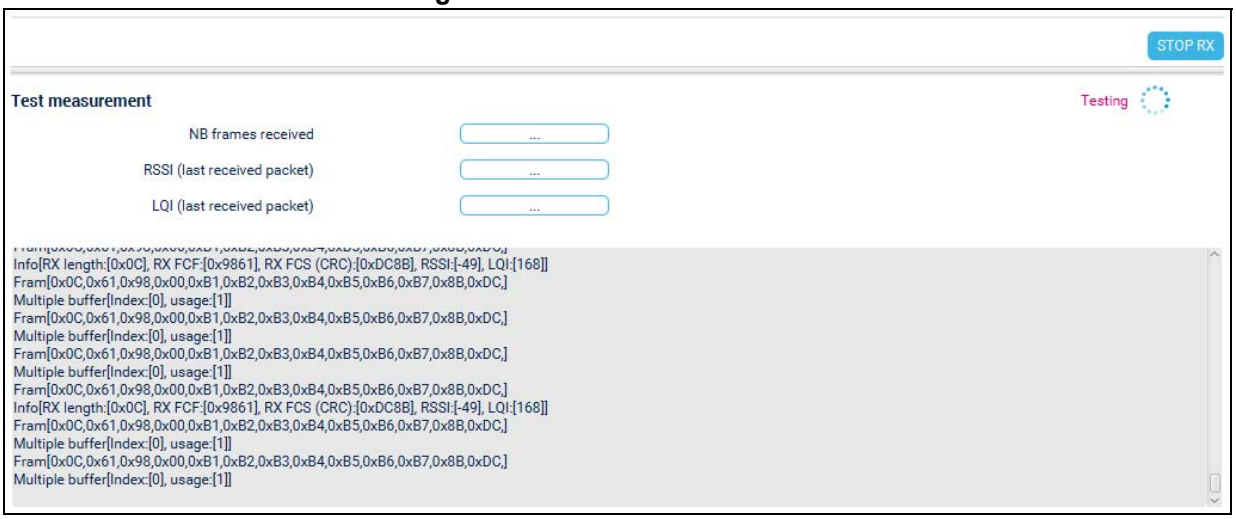


### 5.3.1 Packet error rate (PER) test

This test requests to use an external frame generator and follow the procedure below:

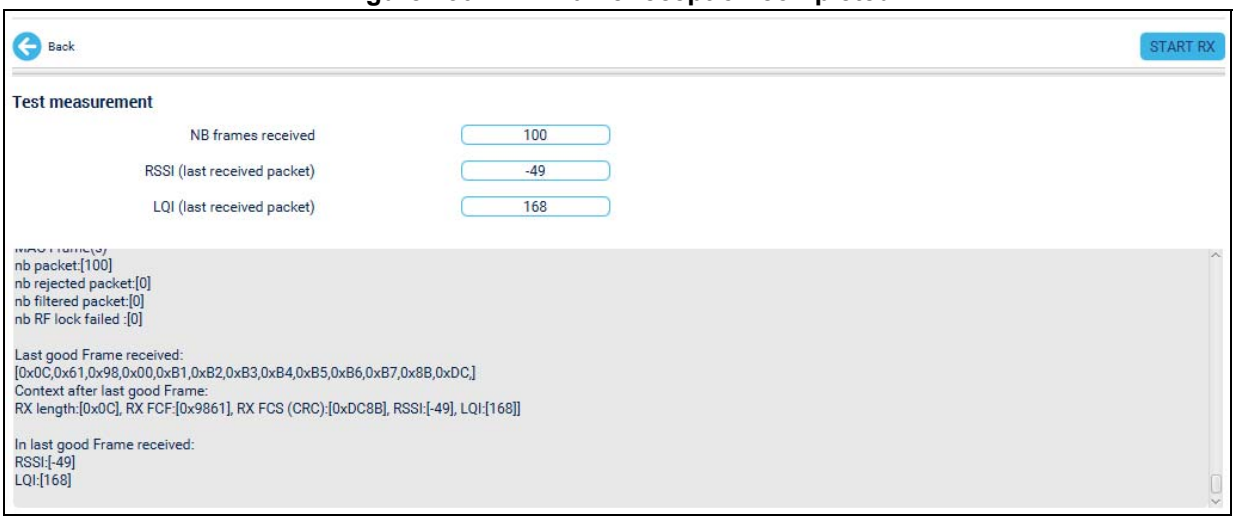
- Select the channel to be tested.
- Press the *START RX* button; the device enters *Receiver mode* and the button switches to *STOP RX*.
- With one external generator, send the frames to test in the frequency selected above.
- On the application side, the frames received appear in a gray part. This part is available from PHY valid CLI version v1.8.0 and upper.

**Figure 129. PER frames received**




- Once the frames are completely sent, press the *STOP RX* button. The three fields NB frames, RSSI, and LQI are filed. The button switches to *START RX*.

**Figure 130. PER frame reception completed**




- Depending on the number of frames sent, the PER can be calculated using the value in the *NB frames received field*.

### 5.3.2 Link quality assessment (LQI) test

This test requests to use an external frame generator and follow the procedure below:

- Select the channel to be tested.
- Either the measurement is done in continuous (default mode) or step-by-step checking the *Single measurement* item.
- With one external generator, send the RF signal to test in the frequency selected above.
- Press the *START RX* button to launch the LQI measurement.
- The instantaneous measurement appears on the right side and is also reported in the chart.

**Figure 131. LQI measurement**

### 5.3.3 Energy detection (ED) test

This test requests to use an external frame generator and follow the procedure below:

- Select the channel to be tested.
- Either the measurement is done in continuous (default mode) or step-by-step checking the *Single measurement* item.
- With one external generator, send the RF CW signal in the frequency selected above.
- Press the *START RX* button to launch the ED measurement.

The instantaneous measurement appears on the right side and is also reported in the chart.

**Figure 132. ED measurement**

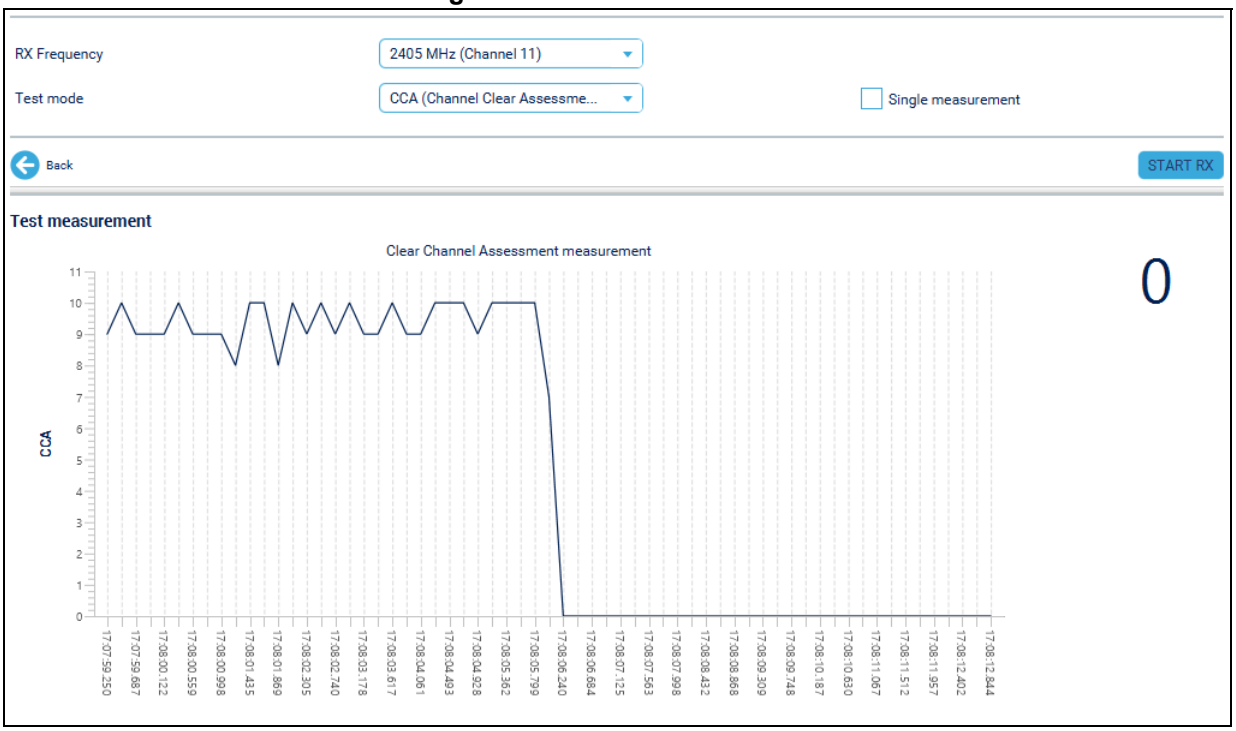

### 5.3.4 Channel clear assessment (CCA) test

This test requests to use an external frame generator and follow the procedure below:

- Select the channel to be tested.
- Either the measurement is done continuously (default mode) or step by step when checking the *Single measurement* item.
- With one external generator, send the RF signal to test in the frequency selected above.
- Press the *START RX* button to launch the CCA measurement.

The instantaneous measurement appears on the right side and is also reported in the chart.

Figure 133. CCA measurement




## 5.4 Packet error rate (PER) mode

This mode configures the device in reception and one other device to play the role of the generator.

The tool makes three measurements:

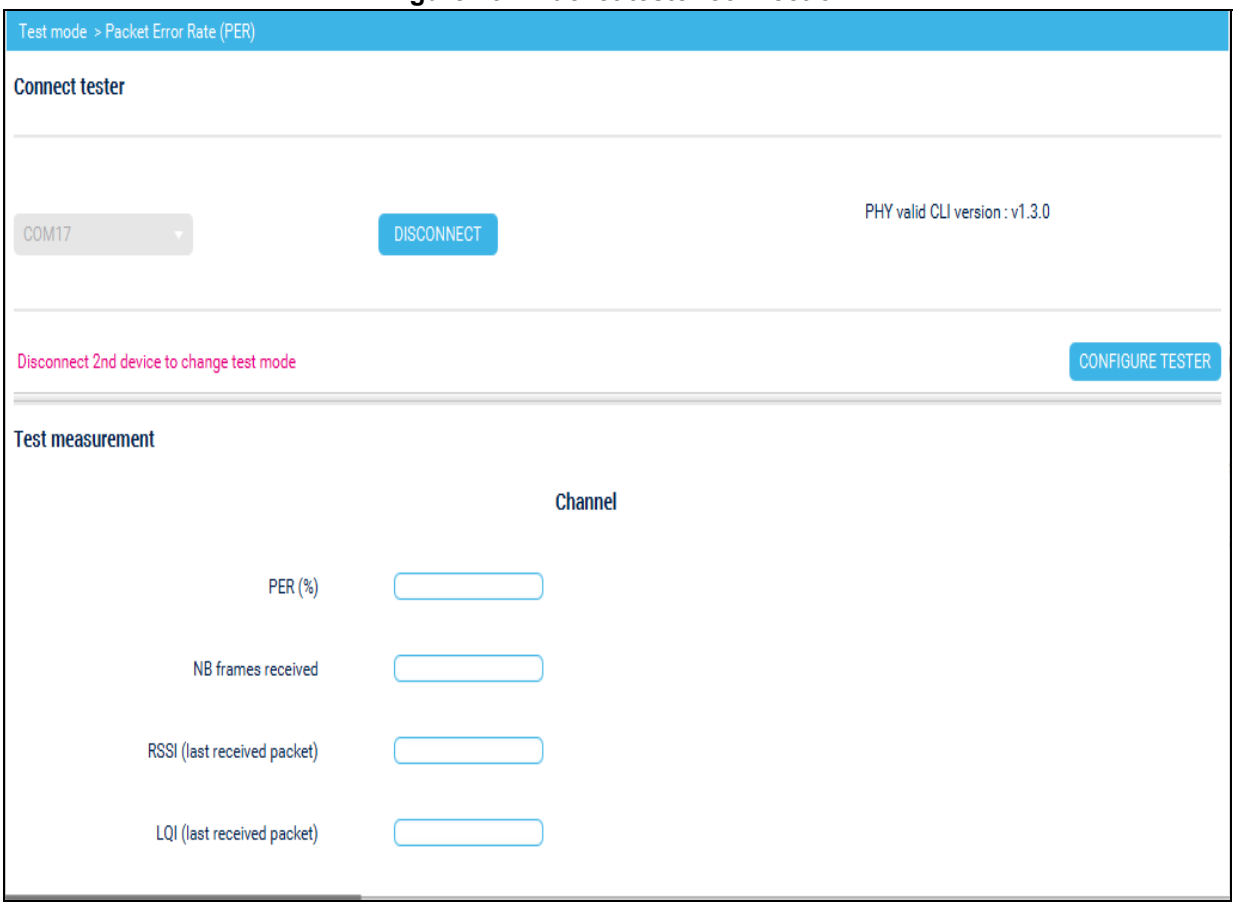
- RSSI: Received signal strength indication
- LQI: Link quality indicator
- PER: Packet error rate - computed with the number of frames received and the number of frames sent
  100 x (Number of frames sent - number of frames received) / Number of frames sent

Four steps are necessary:

- Connect the additional device to play the role of a packet generator (tester).
- Configure the parameters of the tester.
- Configure the parameters of the device under test (DUT).
- Configure the measurement.

### 5.4.1 Connecting the additional device to play the role of a packet generator (tester)

**Figure 134. Packet tester connection**



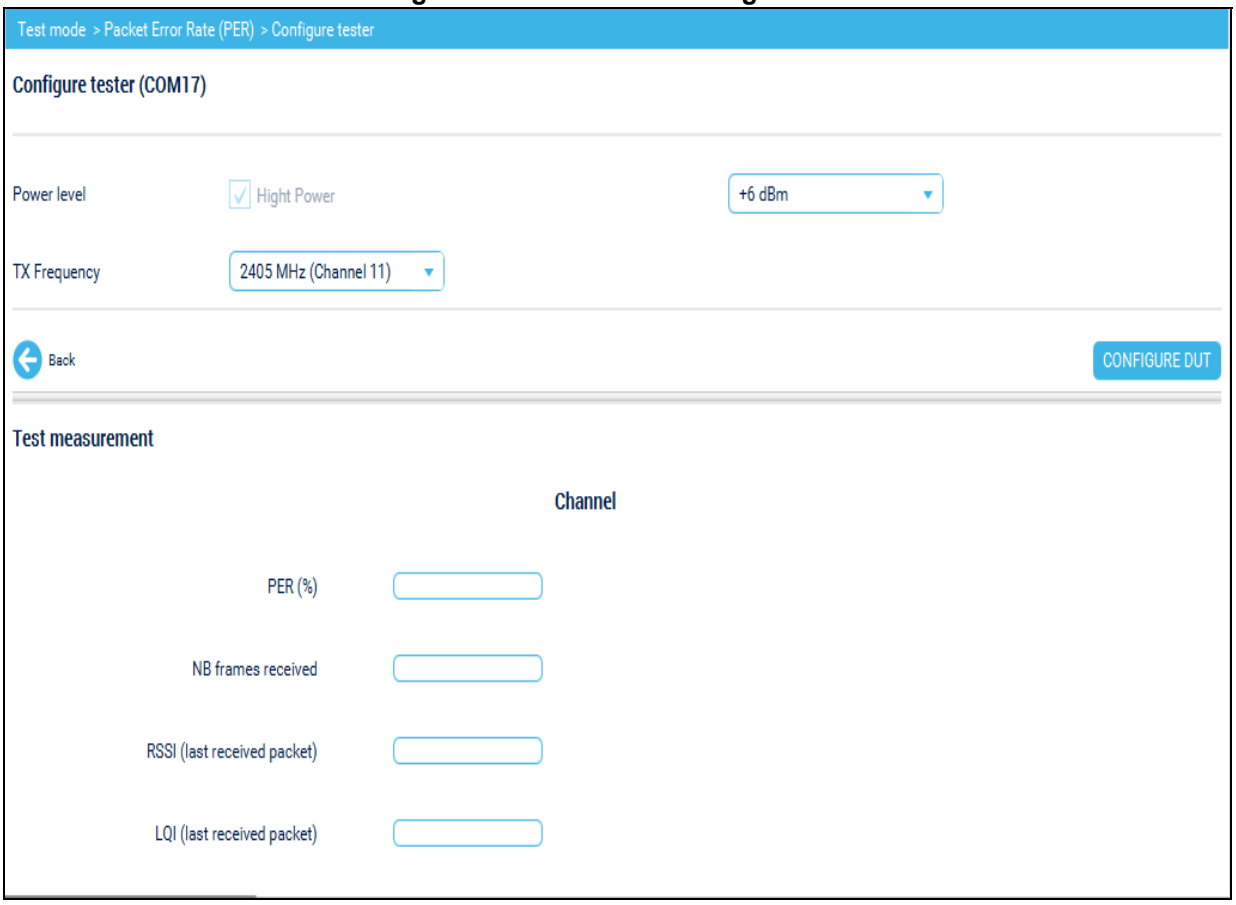

- Plug one additional device into the computer (the same requirements as the first device, refer to *Section 2.2*).
- Select the serial port to use in the picklist.
- Click on the *CONNECT* key, the device information must appear on the right side of the *connect* key.

When the second device is connected, it is not possible to change the mode. First, the user needs to disconnect the device and then press the *back* button.

Click on *CONFIGURE TESTER* to set the tester parameters.

### 5.4.2 Configure the parameters of the tester

**Figure 135. PER tester configuration**



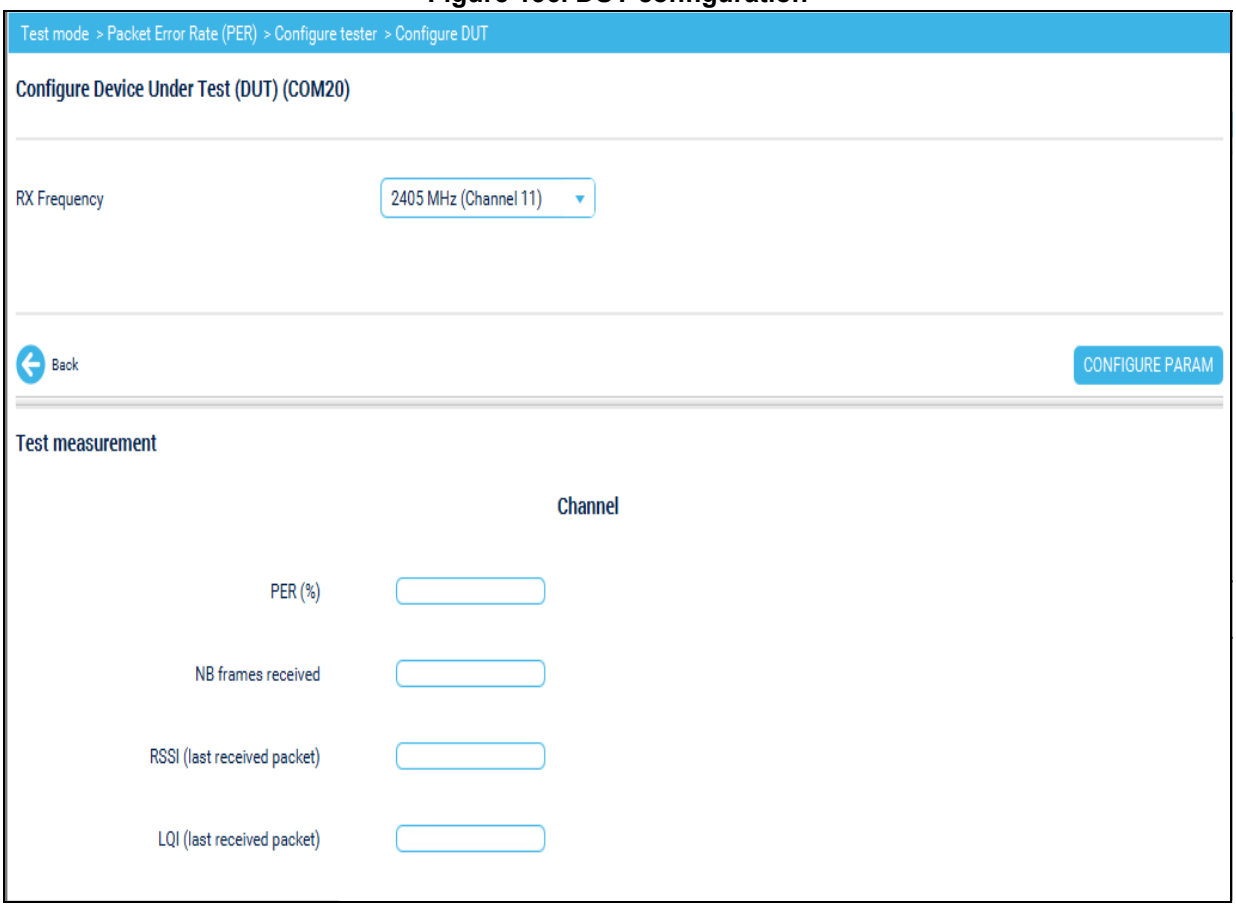

The user must:

- For the STM32WBA devices, check or uncheck the High Power box according to high-power support.
- Select the power level in the *Power Level* picklist.
- Select the frequency in the *TX frequency* picklist. This parameter is used only for the Single measurement mode. It is not used for Continuous or Multiple-channel modes. It is applied to the tester device.

Click on *CONFIGURE DUT* to set the Device Under Test configuration.

### 5.4.3 Configure the parameters of the device under test (DUT)

**Figure 136. DUT configuration**



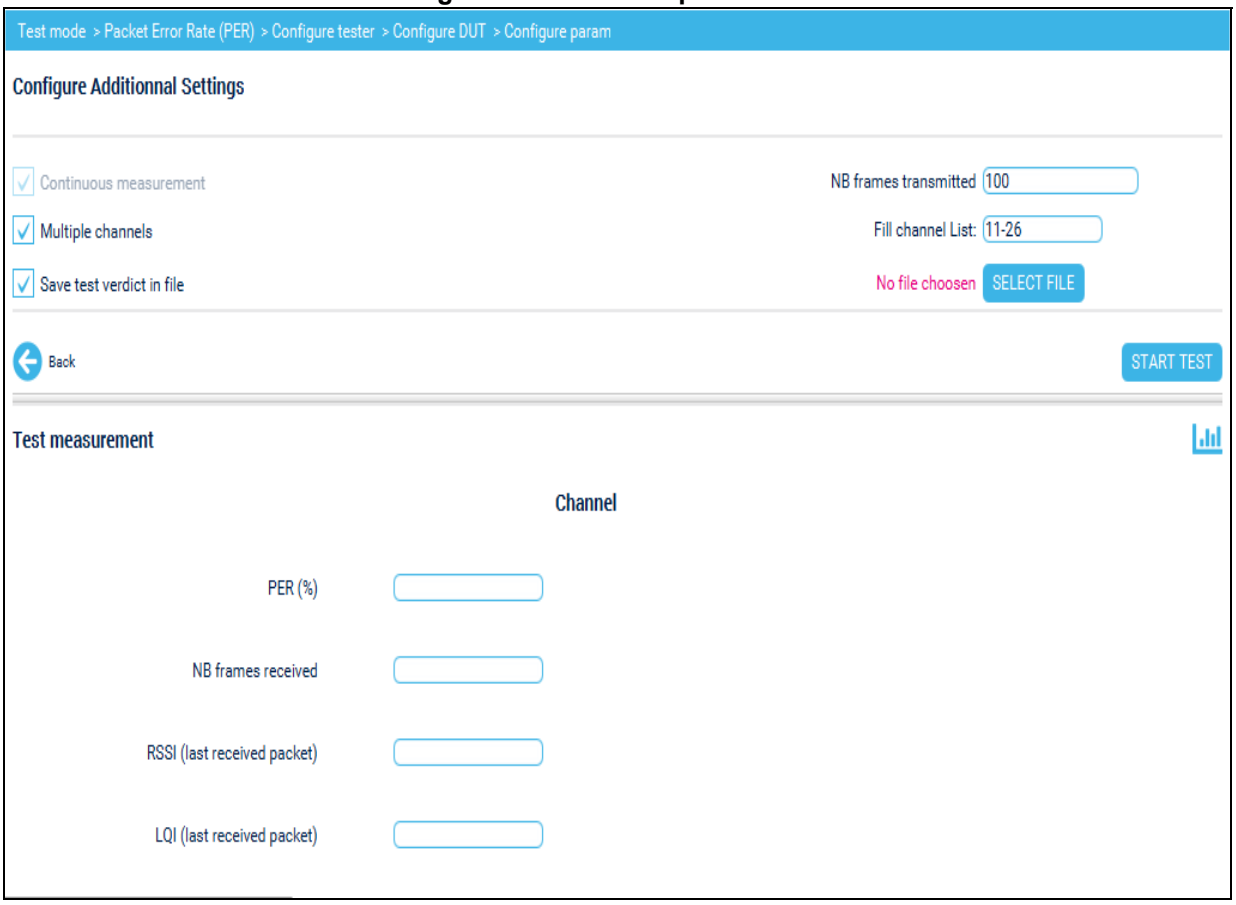

The user must:

- Select the frequency in the *RX frequency* picklist. It is the frequency of the DUT.

Click on *CONFIGURE PARAM* to set the test configuration:

### 5.4.4 Configure the measurement

**Figure 137. PER test parameters**




Three measurement modes are available:

- **Single measurement** measures once the frame number is defined. The frequency of the tester is the one defined in the *PER tester configuration* panel (TX frequency). The frequencies of DUT are as defined in the *DUT configuration* panel.
- **Continuous measurement** repeats the measurement on frame number until the user presses the *Stop Test* key. The DUT and tester frequencies are identical. They are defined once in the *DUT configuration* panel.
- **Multiple channels** measure the frequency defined in the *Fill channel list* field. The default values are *11-26*, which means that all channels are in the range of 11 to 26. It is possible to use a comma to define channel by channel: *12,15,24* or mix both: *11,14-20,25,26*. The user can interrupt the test with the *Stop Test* key.

The results of continuous and multiple-channel measurements can be saved in a csv file. The user must check the *Save test verdict in file* checkbox and define the file name by the *SELECT FILE* key before starting the test.

**Table 3. Measurement setting**

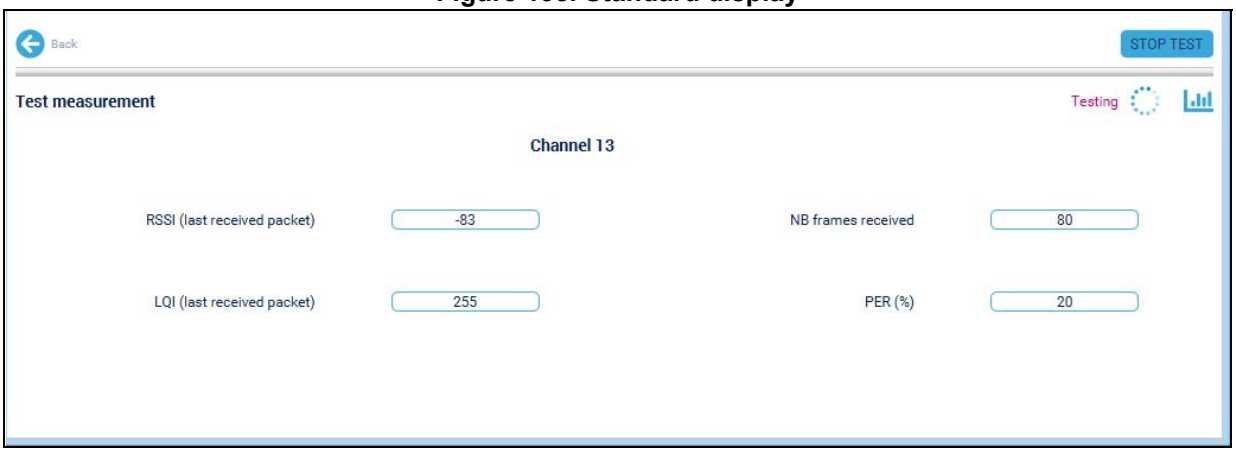
| Measurements | Single | Continuous | Multiple channels |
|---|---|---|---|
| **Continuous measurement checkbox** | Unchecked | Checked | Checked |
| **Multiple-channel checkbox** | Unchecked | Unchecked | Checked |
| **Save test verdict in file checkbox** | Not available | Available | Available |

Three display modes are available:

1. Standard display

There are the PER and RSSI values and LQI for one channel.

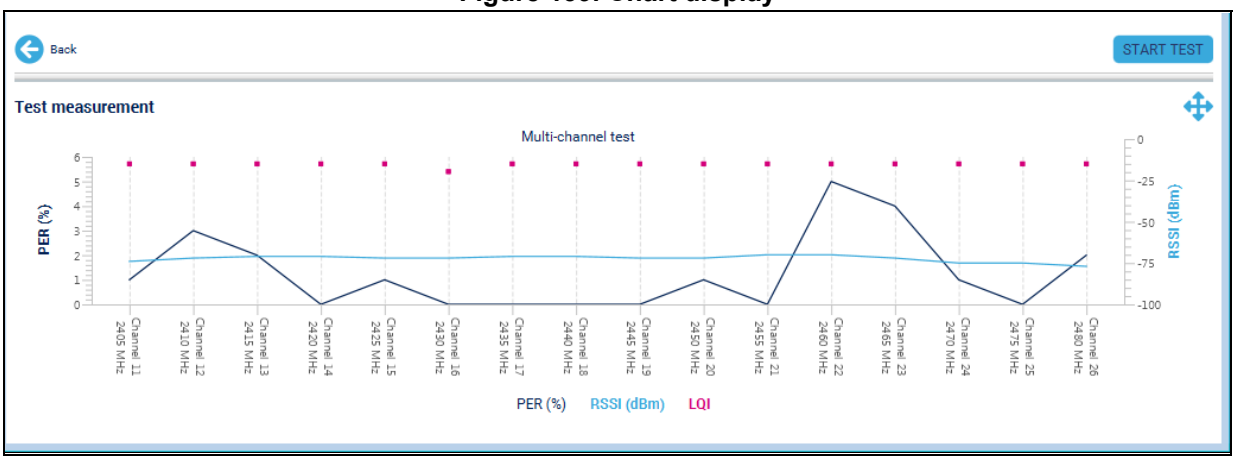
**Figure 138. Standard display**




2. Chart display

In the same chart, there are the PER and RSSI values and LQI for channels that the user defines.

**Figure 139. Chart display**



3. Large display

The user can switch between a PER display and RSSI and LQI using the arrow icons on the left and right.

**Figure 140. Large PER display**

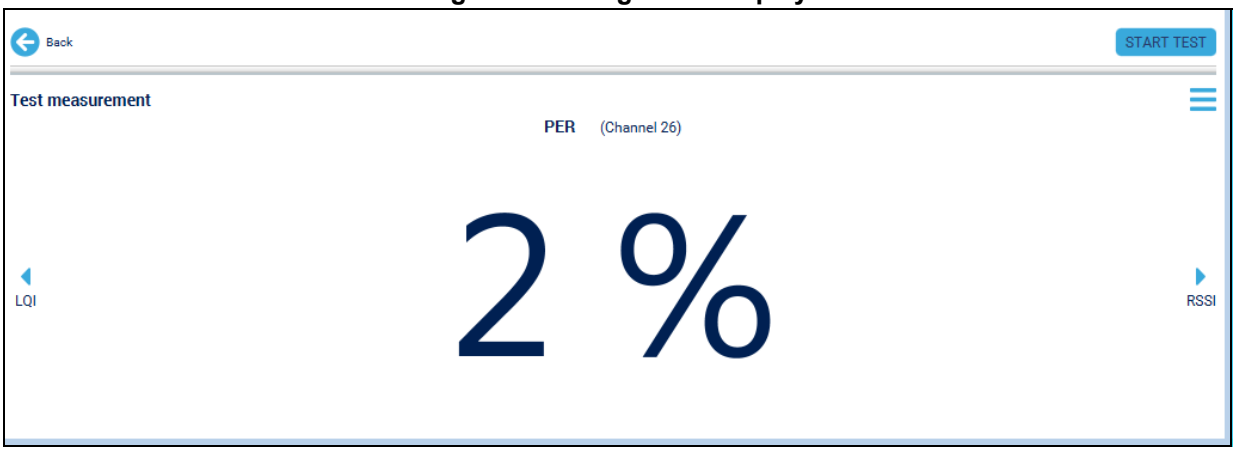
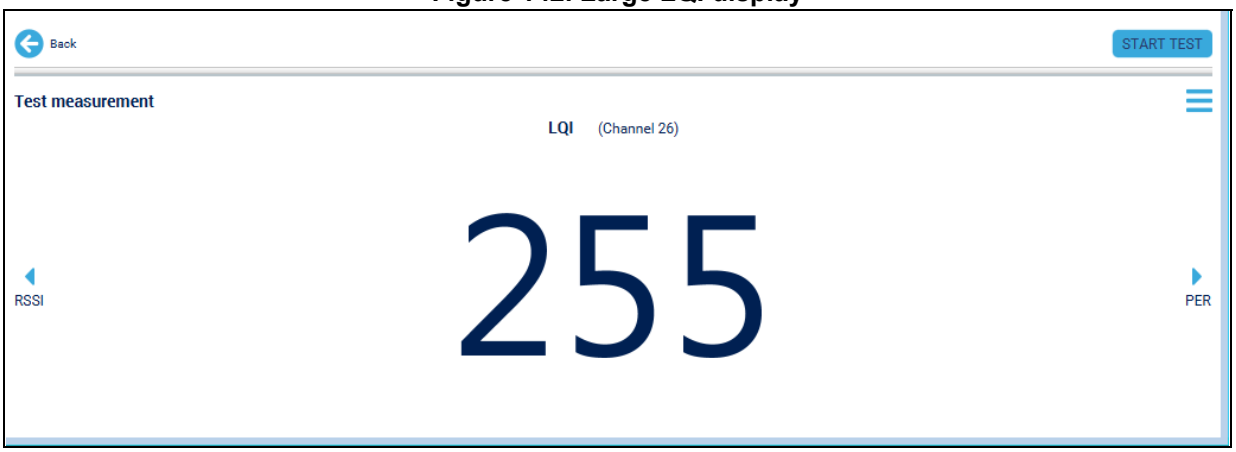



**Figure 141. Large RSSI display**


**Figure 142. Large LQI display**



# 6 802.15.4 sniffer

## 6.1 Presentation

The 802.15.4 sniffer allows the user to detect and log 802.15.4 packets between the devices communicating in the neighborhood of the sniffer device. Packets captured by the device are logged and formatted in a readable format, thanks to Wireshark, an external free software tool.

## 6.2 Prerequisite

### 6.2.1 Sniffer device

To configure the device as a sniffer, refer to *Section 2.2.3*. Once done, connect the STM32WBx5 Nucleo board to the host computer using the USB_USER connector.

Make sure that the 5 V source jumper connector is plugged into the USB MCU.

### 6.2.2 Wireshark

Install Wireshark v2.4.6 or later, available from http://www.wireshark.org, and add the installation path to the path environment variable if it is not already done.

Once done, the user must copy the Python™ sniffer script stm32cubeMonRf_sniffer.py and the associated stm32cubeMonRf_sniffer.bat file in the Wireshark *extcap* directory. Files are available in the sniffer directory where the tool is installed, by default for Windows: *\Program Files (x86)\STMicroelectronics\STM32CubeMonitor-RF\sniffer*.

The Wireshark *extcap* path is available in the Help/About Wireshark menu under the *Folders* tab.

Under macOS and Linux, the *stm32cubeMonRf_sniffer.py* file must have execute permission.

### 6.2.3 Python™

Install Python™ v2.7.x or later available from https://www.python.org/downloads. Then add the installation path to the path environment variable if it is not already done.

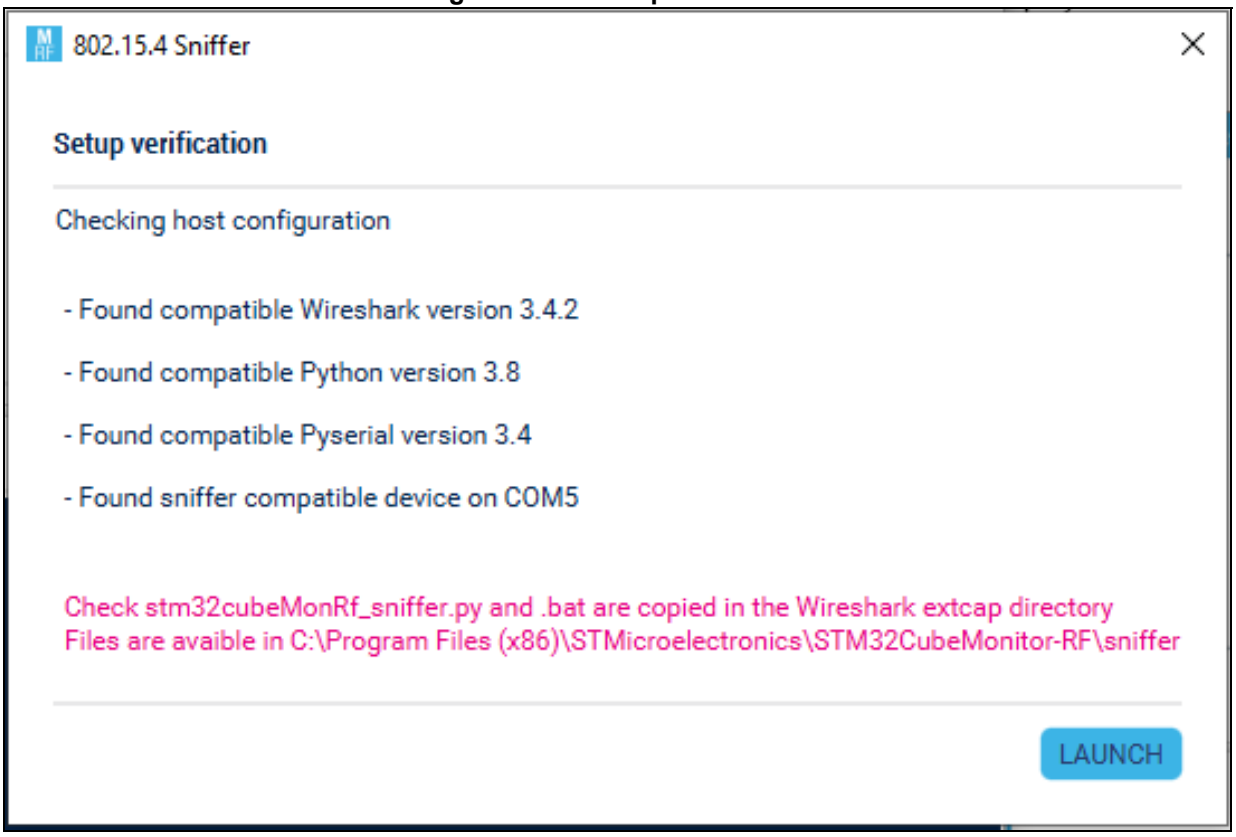
The user also needs to install the Python™ serial port extension, *pyserial*, available from https://pypi.org/project/pyserial.

## 6.3 Setup verification

The 802.15.4 sniffer, available as a button on the home screen or in the Settings/mode menu on the menu bar, can invoke the sniffer. In both cases, the tool checks that the prerequisites are fulfilled.

If this is not the case, the user is asked to correct it. Otherwise, the following pop-up window is displayed. To launch the sniffer, click on the LAUNCH button.

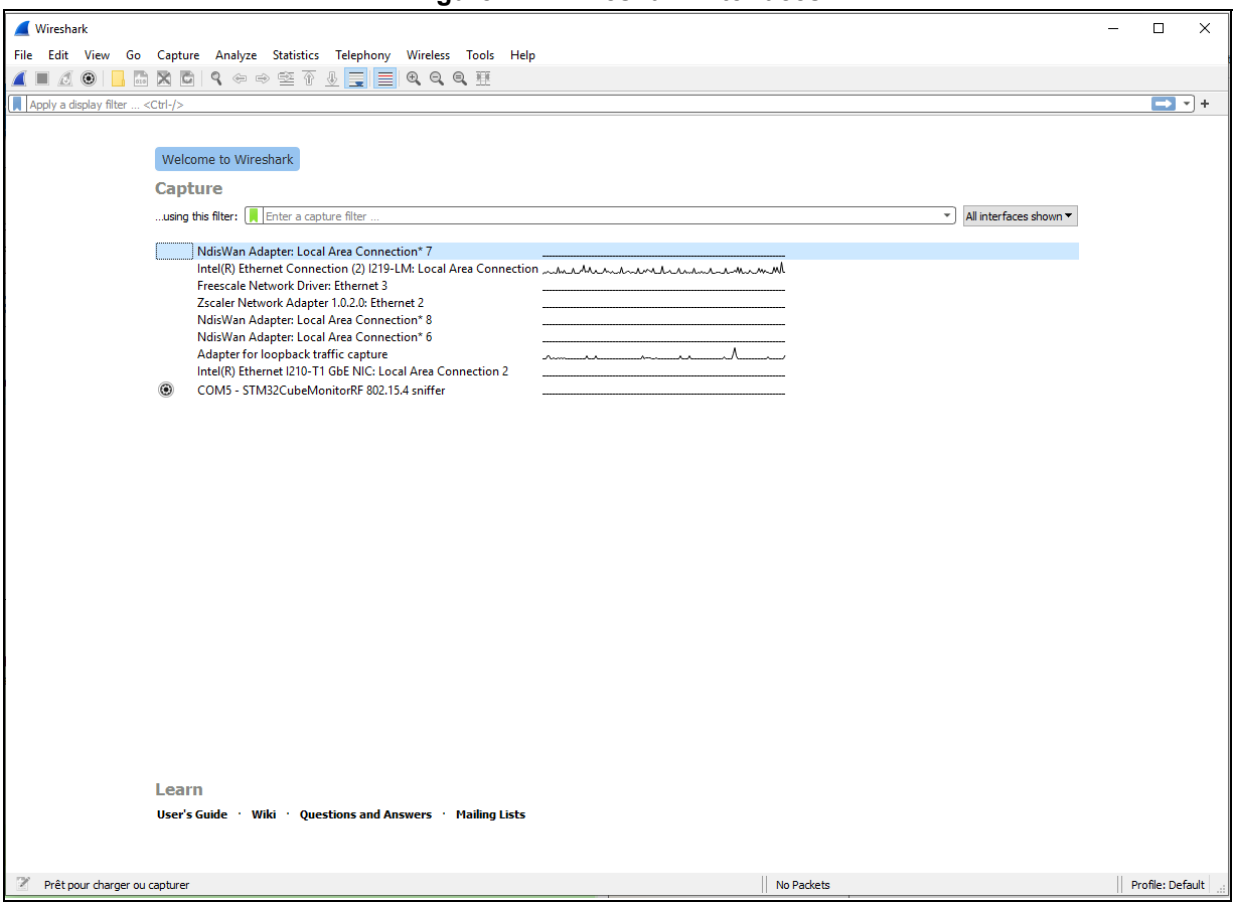
**Figure 143. Prerequisite check**



### 6.3.1 Sniffer launch

Once Wireshark is launched, the user is proposed to choose the interface to sniff.

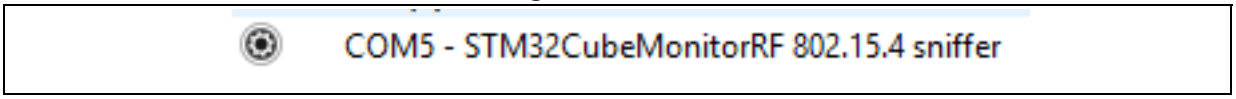
**Figure 144. Wireshark interfaces**




### 6.3.2 Select interface

Choose the interface corresponding to the device configured for sniffing by clicking on the wheel.

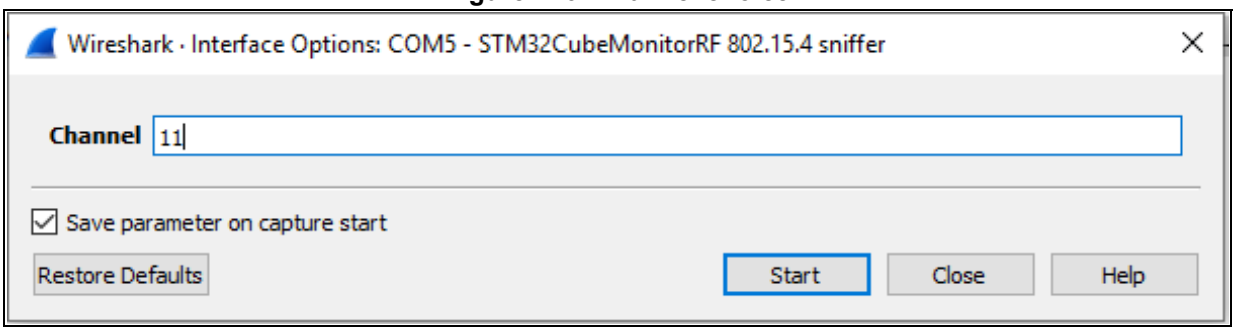
**Figure 145. Wheel**



### 6.3.3 Channel configuration

The user is asked to choose the channel to be sniffed.

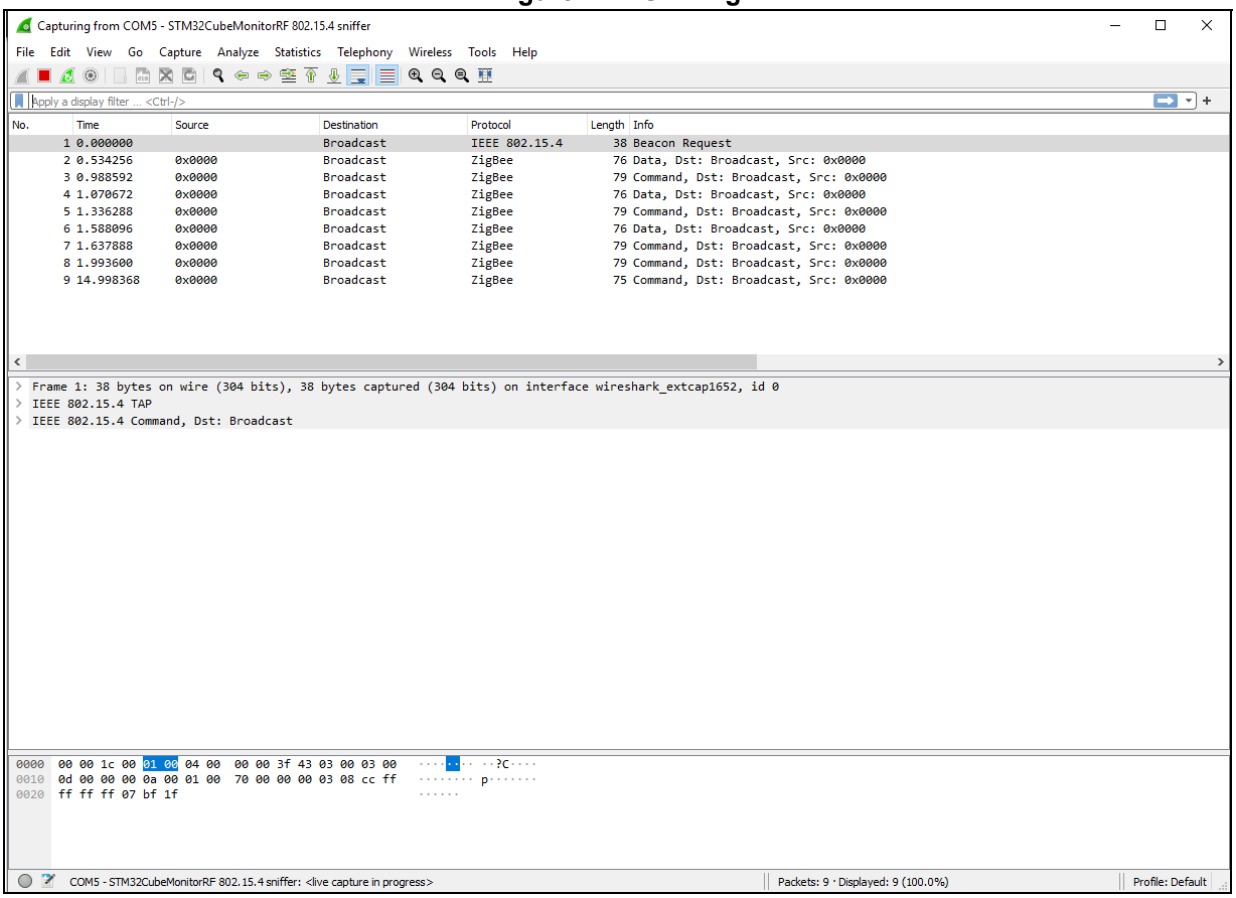
**Figure 146. Channel choice**




### 6.3.4 Sniffing start

Once the channel is selected, click on start. The list of sniffed packets appears at the top with details of the selected packet in the middle and the packet byte at the bottom.

**Figure 147. Sniffing**



# Appendix A Beacon configuration format

The beacon configuration file is binary. Its content is explained in *Table 4*.

**Table 4. Beacon configuration format**

| Byte # | Name | Value | Description |
|---|---|---|---|
| 0 | Address type | 0,1,2 | Address type:<br>0 = board default address<br>1 = random address<br>2 = static address provided in the block |
| 1 - 6 | Address | address | Static address for the beacon. Valid only if the address type is 2. |
| 7 | Tx power | *0x00-0x1F* | Tx power to be used for the beacon.<br>Value *PA_Level* of command ACI_HAL_SET_TX_POWER_LEVEL: 0 to 31 |
| 8 | Beacon additional feature | 0 or 1 | 0: No additional feature<br>1: TLM activated<br>Other values reserved |
| 9 | Advertising payload length | 13-32 | Length of payload data |
| 10 - 41 | Advertising payload | - | Beacon advertisement payload, to be inserted in the advertisement |

# Revision history

Table 5. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 27-Nov-2017 | 1 | Initial version |
| 25-Jan-2018 | 2 | Updated:<br>– *Introduction*<br>– *Section 3.3.2: Test mode receiver (RX)*<br>Added:<br>– Two tables: *Table 2: Specific AD encoding for code example* and *Table 3: Search filtering*<br>– Twelve new figures<br>– *Section 3.2.1: How to send an ACI command*<br>– *Section 3.2.2: Search function*<br>– *Section 3.4.4: Script report*<br>– *Section: Pause command in the script*<br>– *Section 3.5.3: Advertising change for OTA in ST example* |
| 23-Aug-2018 | 3 | Complete content reorganized to explain tool support to the original *Bluetooth® Low Energy mode* in *Section 3* and the new *OpenThread mode* in *Section 4*. |
| 13-Feb-2019 | 4 | Updated:<br>– *Section 4: OpenThread mode* and most of the figures with the new version tool<br>Added:<br>– *Section 5: 802.15.4 RF test mode* |
| 12-Jul-2019 | 5 | Updated:<br>– Tool version 2.4.0<br>– *Section 3.5: OTA transfer* simplified. Details are reported in the application note. |
| 30-Mar-2020 | 6 | Added:<br>– STM32WB35 support with updated paths<br>– *Section 4.4* on Thread® network exploration feature |
| 12-Nov-2020 | 7 | Updated:<br>– Tool version 2.6.0<br>Added:<br>Six new sections:<br>– *Section 5.2.1: Frame mode*<br>– *Section 5.2.2: Continuous modulated mode*<br>– *Section 5.3.1: Packet error rate (PER) test*<br>– *Section 5.3.2: Link quality assessment (LQI) test*<br>– *Section 5.3.3: Energy detection (ED) test*<br>– *Section 5.3.4: Channel clear assessment (CCA) test*<br>dealing with all the applicable tests in the *Transmitter test mode (TX)* and *Receiver test mode (RX)* |

**Table 5. Document revision history (continued)**

| Date | Revision | Changes |
|---|---|---|
| 08-Feb-2021 | 8 | All modifications linked to the new feature 802.15.4 sniffer<br>Updated:<br>– *Introduction*<br>– *Section 1.2: Welcome screen* with *Figure 1*<br>– *Section 2.2.3: VCP device*<br>– *Figure 61*, *Figure 62*, *Figure 65*, *Figure 105*, and *Figure 114*<br>Added:<br>– *Section 6: 802.15.4 sniffer* with *Figure 141* to *Figure 145* |
| 22-Jul-2021 | 9 | All modifications linked to the new tool version 2.8.0<br>Updated:<br>– *Section 2.2: VCOM/UART connection*<br>– *Section 3.3.3: PER*<br>– *Section 3.4.3: Scripts modification*<br>– *Section 3.5.3: Use the tool to perform an OTA update*<br>– *Section 3.6.3: Configuration of the beacon with STM32CubeMonitor-RF*<br>– *Figure 61*, *Figure 62*, *Figure 65*, and *Figure 80* to *Figure 82* |
| 07-Jul-2022 | 10 | Updated:<br>– *Section 4.4: Network Explorer tab* with the default master key of the former firmware<br>– *Section 2.2.1: VCOM connection* to *Section 2.2.3: VCP device* linked to the added section below<br>Added:<br>– *Section 3.2: Bluetooth® Low Energy stack* |
| 29-Nov-2022 | 11 | All modifications linked to the new tool version 2.10.0<br>Added:<br>– *Section 2.3: Opening COM* regarding connection error in the wrong mode<br>Updated:<br>– *Section 3.2: Bluetooth® Low Energy stack* with *Table 1*<br>– *Section 3.5.1: Launching scripts* path<br>– *Figure 72: Selecting the Beacon mode*<br>Removed:<br>– Beacon OTA configuration including former *Figure 72*<br>– *Configuration transfer* OTA mode scan transfer including former *Figure 80* to *Figure 82* |
| 06-Mar-2023 | 12 | All modifications linked to the new tool version 2.11.0<br>Added:<br>– Support to STM32XWBAxx microcontrollers<br>– *Save log* in *Section 3.3.5: Log functionalities* with new *Figure 28* and *Figure 29*<br>– *Section 5.2.3: Continuous wave mode*<br>Updated:<br>– *Figure 2*, *Figure 6*, *Figure 23*, *Figure 97*, and *Figure 120* |

**Table 5. Document revision history (continued)**

| Date | Revision | Changes |
|---|---|---|
| 04-Jul-2023 | 13 | All modifications linked to the new tool version 2.12.0<br>Removed *Table 1 Bluetooth® Low Energy stack and STM32CubeMonitor-RF feature compatibility* |
| 23-Nov-2023 | 14 | All modifications linked to the new tool version 2.13.0<br>Updated:<br>– Applicable tool version quoted in *Introduction*<br>– *Figure 2*, *Figure 3*, *Figure 63*, *Figure 64*, and *Figure 67*<br>– Source code paths in *Section 2.2.1: VCOM connection* |
| 14-Mar-2024 | 15 | All modifications linked to the new tool version 2.14.0<br>Updated:<br>– Applicable tool version quoted in *Introduction*<br>– *Figure 119*, *Figure 120*, *Figure 124*, and *Figure 130* to *Figure 133* |
| 02-Jul-2024 | 16 | All modifications linked to the new tool version 2.15.0<br>Updated:<br>– Applicable tool version quoted in *Introduction*<br>– Support of STM32WB0xx microcontrollers as mentioned in *Getting started* |
| 22-Nov-2024 | 17 | Modifications linked to the new tool version 2.16.0<br>Updated:<br>– Applicable tool version quoted in *Introduction*<br>– Support of STM32WB06x microcontrollers as mentioned in *Getting started*<br>– *Figure 63*, *Figure 64*, and *Figure 67* |
| 18-Feb-2025 | 18 | Modifications linked to the new tool version 2.17.0.<br>Updated *Getting started* to add support of STM32WBA6x devices.<br>Updated *Section 2.2.1: VCOM connection*.<br>Minor text edits across the whole document. |
| 30-Jun-2025 | 19 | Modifications linked to the new tool version 2.18.0:<br>– Updated *Section 2.2.1: VCOM connection* with Transparent Mode firmware loading for the STM32WB05xN network coprocessor<br>– Updated the connection issue to Linux® in *Section 2.3: Opening COM*<br>– Updated *Figure 84: Offline mode transfer configuration* in *Section 3.8.3: Configuration of the beacon with STM32CubeMonitor-RF*<br>– Added *Section 3.6: Command-line interface (CLI)*<br>Changed Bluetooth® Low Energy to Bluetooth® LE and applied minor text edits throughout the document. |