arendi
Products

BLT2450
Applications and software tools

Release
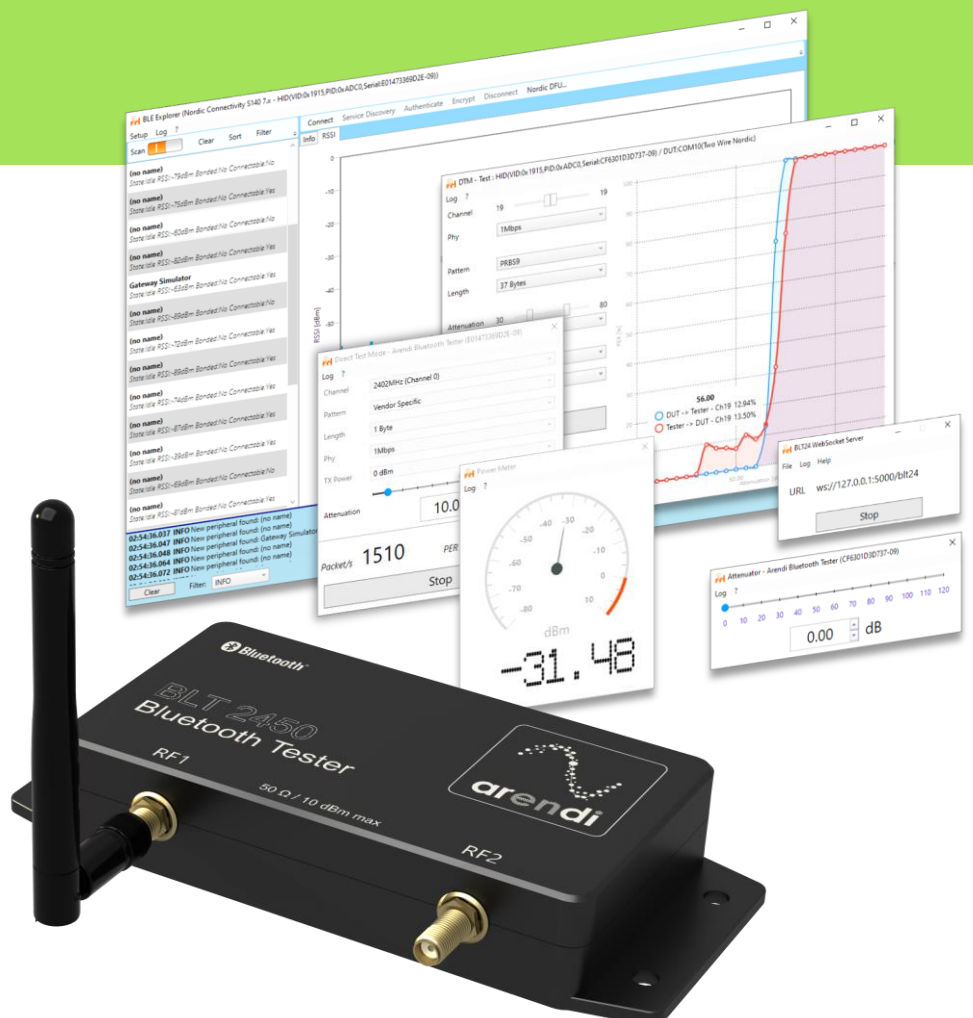11 May 2023

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History

Date	Author	Change
10.01.2022	TALRA	Initial
28.01.2021	TALRA	Review, clean up
11.05.2023	TALRA	Adding documentation for WebSocket Server application

Table of contents

1 PURPOSE

The BLT2450 tester is designed to simplify and improve development, testing and production of Bluetooth® capable products. This document gives an overview of the software tools available for controlling your BLT2450 tester and how to use them to optimize your product development.

2 TERMS AND DEFINITIONS

BLT Bluetooth Tester

DUT Device Under Test (customer device)

BLE Bluetooth Low Energy

DTM Direct Test Mode

PER Packet Error Rate in %

BER Bit Error Rate in %

dBm Power in decible, relative to 1mW

2.1 References

[1] DTM Specification: See Bluetooth Specification Version 5.2, Vol. 6, Part F
[2] WebSockets API: Find documentation on http://www.arendi.ch/blt2450
[3] WebSockets JavaScript / node.js client library:
    https://www.npmjs.com/package/@arendi/testing

3 OVERVIEW

Image 1 gives an overview of all available tools designed for the BLT2450 tester. Applications highlighted in green are packed within a single installer and provide basic functionalities for everyday use. Tools highlighted in gray are provided as libraries which you can use to build your own customized applications.

Are you missing a specific tool or functionality? We can provide customized solutions tailored to your requirements. Please contact our sales representative for further information.

Image 1   Overview of available tools

4 INSTALLATION

Download and run the latest installer available from our website https://www.arendi.ch/blt2450. This will install all available tools and libraries. All tools have been tested to run on Windows 10.

1 Download and run the installer. Click „next" to proceed
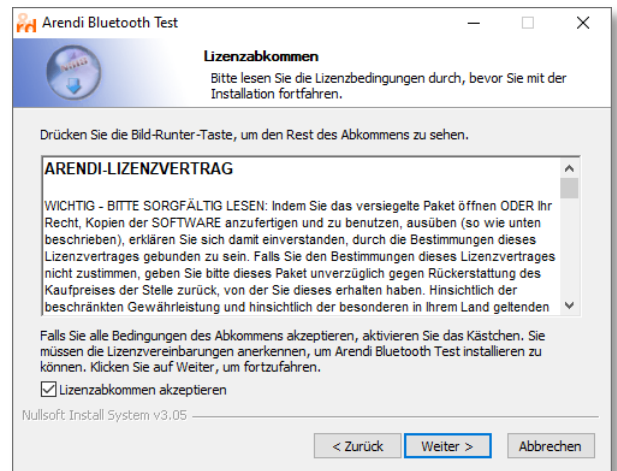
2 Accept the license agreement and click „next" to proceed
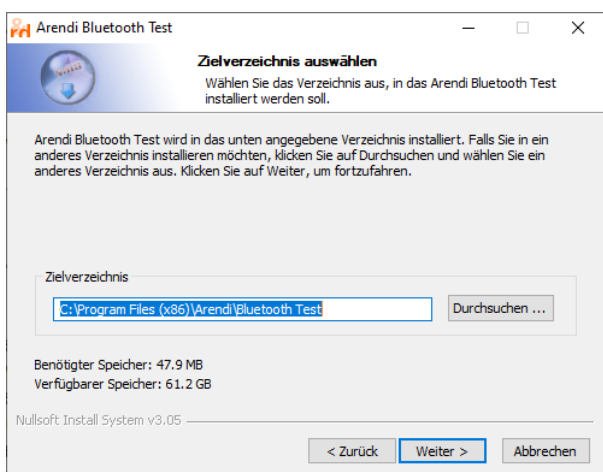
3 Change installation directory if required, click „next" to proceed
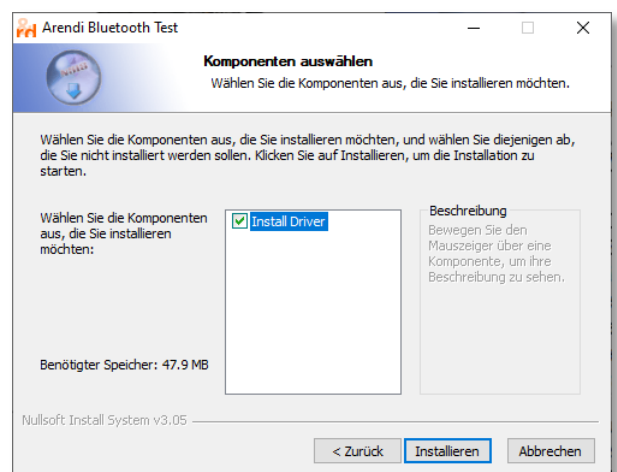
4 Check all components and complete installation by clicking on „install"

Image 2   Installing Arendi tools for BLT2450

4.1 Folder structure

After installation you find the tools in the specified directory. Per default the tools are installed to C:\Program Files (x86)\Arendi\Bluetooth Test\Software.
The installer creates shortcuts for all applications. Press the windows key and select an application from the start menu or navigate to the installation directory and start the application from the "Software" folder.

📁 **API**
Documentation of libraries

📁 **Documentation**
User manual for BLT2450

📁 **Driver**
USB Drivers for BLT2450

📁 **Examples**
Example code for .NET and LabVIEW applications

📁 **Software**
　📁　Attenuator
　📁　BleExplorer
　📁　DirectTestMode
　📁　LinkTest
　📁　PowerMeter
　📁　SensitivityTest
　📁　WebSocket

📄 **uninst.exe**
Uninstaller to remove installed tools

5 DIRECT TEST MODE

BLT2450   Custom Board   Development   Production   Compliance

The DTM Application is the most frequently used tool, it provides a simple user interface to execute standard DTM commands on the selected target. The DTM protocol uses simple commands to send and receive packets with a defined format [1]. Using the DTM Application is not limited to BL2450 testers, any custom boards connected to the PC through a (virtual) comport can be selected.

The DTM Application is most useful during development and compliance testing since it requires manual operation. For automated testing during production or for continuous integration consider building your own tool using the available libraries.

5.1 Typical setup

A typical DTM setup is illustrated in Image 3 below. A BLT2450 is used as a DTM tester communicating with a custom board using either a coax cable (conducted measurement) or antenna (radiated measurement). One instance of the DTM application is used to control the tester using the USB interface and a second instance can be used to control the custom board if it provides a suitable UART interface. If the custom board cannot be connected to the PC it must implement a stand-alone firmware that executes DTM commands. In any case, the custom board must provide a mechanism to trigger DTM commands.
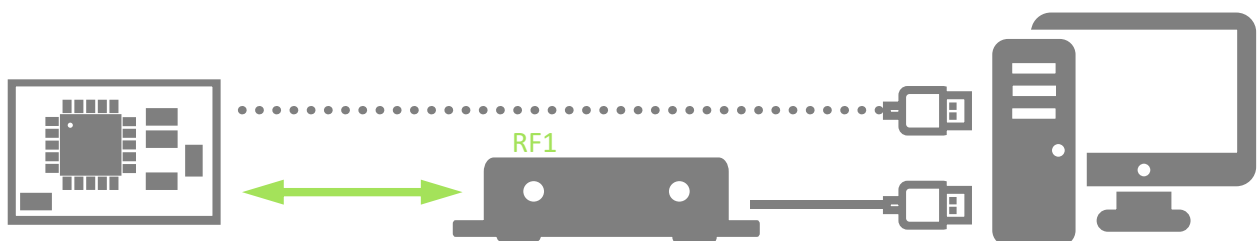
Image 3   Typical setup for DTM operation

5.2 Operation Manual

5.2.1 Start application and select target interface

After connecting the tester to your computer, start the program by selecting the DTM application from the Windows start menu or press the Windows start key and type "DTM (Direct Test Mode)".
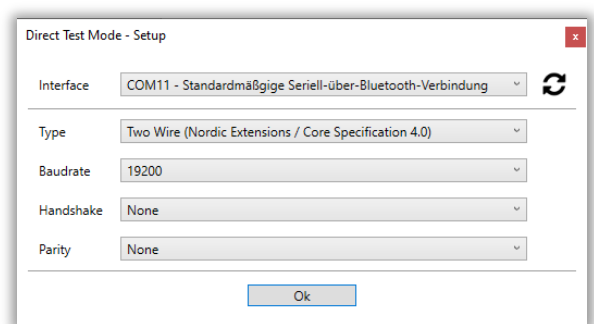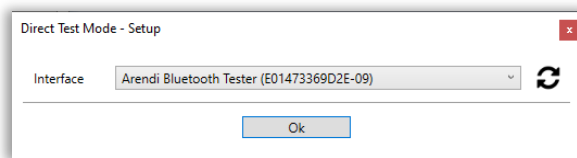
Image 4   Selecting DTM device

After startup, the dialog in Image 4 shows a list of all connected BLT tester and potential custom boards that can be selected. If your device is not listed, click on the refresh icon to reload all supported devices. Choosing a BLT2450 tester is simple and requires no further configuration. If instead the comport of a custom board is selected, you need to specify the following parameters:

Parameter	Description
Interface	Define the comport of your device. Use the windows device manager to find out what comport your device is using
Type	Select the interface type of your device, it is either Two Wire or HCI
Baudrate	Select the baudrate that is used by your board
Handshake	Choose the proper type of handshake your device is using
Parity	Choose the proper parity your device is using

Table 1   Interface settings

5.2.2 Usage

Initially, the DTM application is in IDLE mode where all RF related settings can be changed. Pressing the "RX" button puts the device into RX mode where received packets are continuously counted and used to calculate the Packet Error Rate (PER), whereas pressing the "TX" button puts the device into TX mode where packets are continuously transmitted. Pressing the "Stop" button puts the device back into IDLE mode.
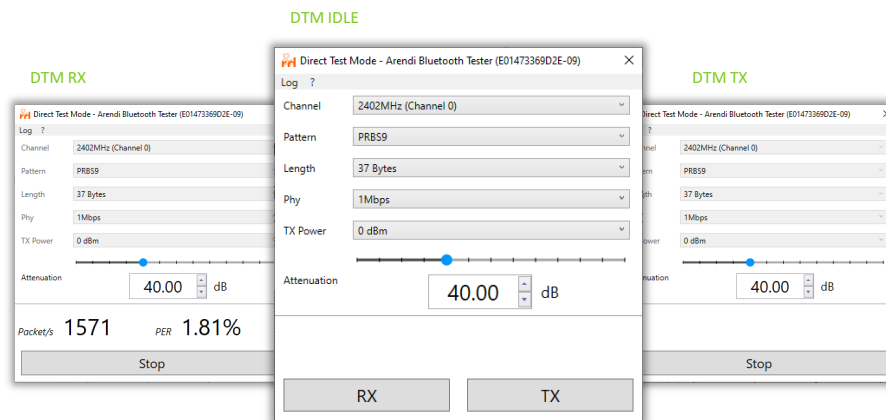
Image 5   Using DTM application

5.2.2.1 RF settings

Before starting the RX or TX tests, you need to specify the proper RF parameters. Make sure to use similar settings on both the tester and DUT.

Parameter	Description
Channel	Select the channel frequency of the device. The frequency range starts at 2'402MHz (channel 0) and increases in 2MHz steps up to 2'480MHz (channel 39). The most interesting frequencies for testing are 2'402MHz (lowest band) 2'440MHz (mid band) and 2'480MHz (highest band).
Pattern	Select a bit pattern that should be used for the payload. PRBS9 is used as a standard pattern for compliance testing
Length	Choose the number of bytes used for payload data, default for compliance testing is 37 bytes

Parameter	Description
Phy	Select the type of radio PHY
TX Power	Radio Tx power in dBm. Only available for BLT2450 tester or when choosing "Two Wire Nordic" mode at startup.
Attenuation	Set the attenuation to the signal being received or transmitted (only available for BLT2450 tester). Adding attenuation allows to simulate power loss that could be caused by increased communication distance and allows to find the sensitivity limit of a system.

Table 2   RF settings

5.2.2.2 RX Mode

In RX Mode the received packets are counted every second and then used to calculate the Packet Error Rate (PER). A PER of 0% means that no packets are lost, a PER of 100% means that no packets are received at all. The PER is dependent on several factors such as signal strength, receiver sensitivity or interference with other radio devices and as such is a good indicator of the performance of a test setup.
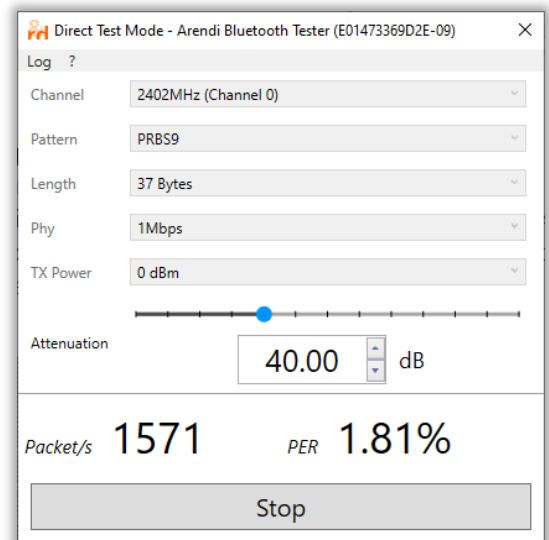
A PER of 30.8% (0.1% BER) is usually the limit, at which the sensitivity of a system is defined. Note that this is only valid when using PRBS9 with a packet length of 37 bytes.

5.2.2.3 TX Mode

In TX mode, the device is periodically sending DTM packets. The content and length of the packets are determined by the chosen settings.

To measure the output power of the transmitter it is useful to create an unmodulated carrier (CW). If your device runs the DTM firmware from Nordic Semiconductors, the following settings will activate CW mode:

Pattern: Vendor Specific, Length: 1 Byte

CW mode is not part of the DTM specification and no packets are transmitted.
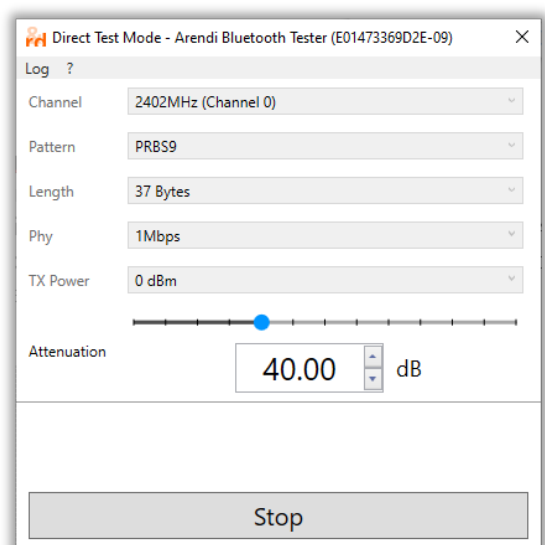
5.3 Use cases

5.3.1 BLT tester and DUT controlled by DTM application

This setup consists of a BLT tester and a DUT as shown in Image 6. The DUT is connected to the PC through a comport and receives DTM commands from the DTM application.
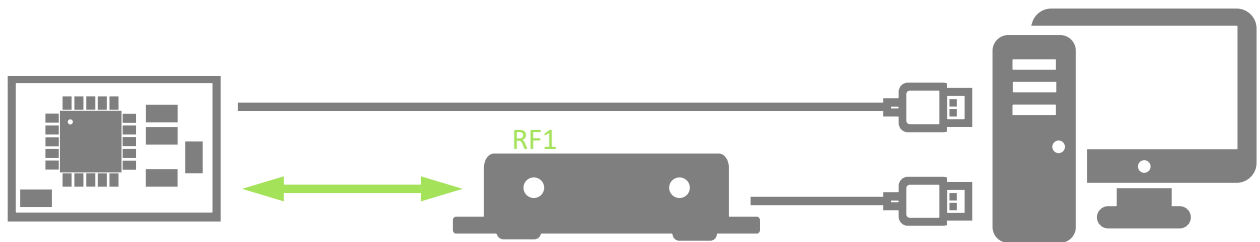
Image 6   Test setup with DUT connected to PC

To get started follow the steps described below:

1. Connect the BLT tester and DUT to the PC
2. Start the first DTM application instance and select the BLT tester
3. Start a second DTM application instance and select the comport of the DUT
4. Make sure the RF settings for the tester and DUT are consistent
5. Make sure that BLT tester and DUT are able to communicate using coax cable or antennas
6. Click the TX button on the tester instance and the RX button on the DUT instance
7. The DUT instance is now displaying the number of received packets and the calculated PER. Play with your setup and see how changing the attenuation, distance or position of the DUT influences the PER.

5.3.2 BLT tester with standalone DUT

This setup consists of a BLT tester and a DUT as shown in Image 7. The DUT has no connection to the PC and runs a standalone DTM firmware.
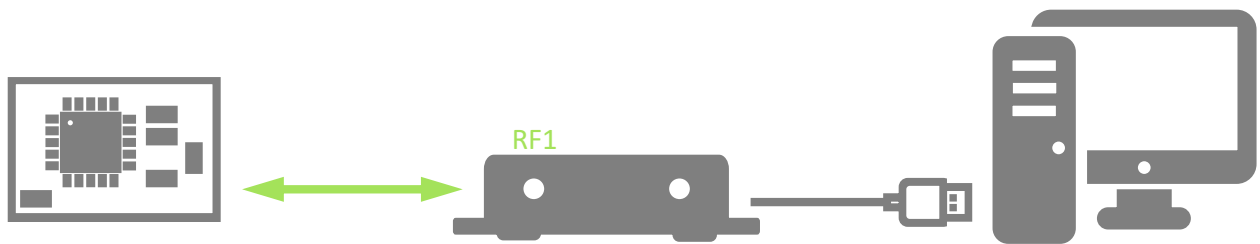
Image 7   Test setup with DUT not connected to PC

To get started follow the steps described below:

1. Connect the BLT tester to the PC
2. Start DTM application instance and select the BLT tester
3. Make sure the RF settings for the tester and DUT are consistent
4. Make sure that BLT tester and DUT can communicate using coax cable or antennas
5. Make sure that the DUT is permanently transmitting DTM packets
6. Click the RX button on the tester DTM application
7. The tester DTM application is now displaying the number of received packets and the calculated PER. Play with your setup and see how changing the attenuation, distance or position of the DUT influences the PER

If the DUT has the possibility to communicate or display a PER value, the direction can also be reversed: Make sure that the DUT is in DTM RX mode and put the BLT tester into DTM TX mode.

5.4 Common problems

5.4.1.1 BLT Tester not selectable

If your BLT tester does not show up in the device list, make sure it is properly connected to your computer and press the refresh button. Note that it takes 5 to 10 seconds until a newly connected BLT tester is detected by the OS.

5.4.2 DUT does not execute DTM commands properly

The communication between DUT and DTM application must work in both directions. If the DUT does not execute DTM commands properly this might be a problem with the UART interface. Proceed as follows:

Problem:
DUT is not properly executing DTM commands

↓

Check DUT is running valid DTM firmware
Check DUT is properly connected to PC
Check you use proper comport and settings

↓

Set DUT into RX mode. Do packet count and PER show valid numbers? — **no** → Communication with DUT is not working. Set DUT into TX mode and Tester into RX mode. Is Tester receiving any packets? — **no** → The DUT can neither receive DTM commands nor respond → check the UART RXD and TXD signals of the DUT!

↓ **yes**

Communication with DUT is ok. Check if RF components are properly assembled!

(from second box) ↓ **yes**

The DUT is able to receive and execute DTM commands but unable to respond → check the UART TXD signal of the DUT!

Image 8   Error handling with erroneous communication

5.4.3 PER is too high

If the communication between tester and DUT leads to high PER follow the steps below:

Problem:
PER between Tester and DUT is too high

↓

Reduce attenuation or distance between Tester and DUT and verify that there is a connection using either coax cable or antennas. Is PER equal to 100% ? — **no** → Some packets are exchanged but RF link is weak. Check DUT RF components are ok and no interference with other RF components exists (use coax cable or shielded box)!

↓ **yes**

No packets are exchanged
Check that Tester and DUT use equal RF settings.

Image 9   Error handling with too high PER

6 POWER METER

BLT2450	Custom Board	Development	Production	Compliance
✓	✗	✓	✗	✗

The Power Meter is a simple application to measure the total RF power applied to the BLT2450 tester. Note that the Power Meter displays the total power over the full frequency range only, it is not a spectrum analyzer!

The Power Meter is a useful tool to measure any RF signal within the supported frequency range independent of its frequency or protocol. To measure the output power of a DUT using a coax cable and unmodulated carrier (CW) is recommended. The Power Meter is most useful during development since it requires manual operation. For automated testing during production or for continuous integration consider building your own tool using the available libraries.

6.1 Typical setup

A typical Power Meter setup is illustrated in Image 10 below. A BLT2450 is used to measure the output power of a connected DUT and the application displays the total power.

RF1

Image 10 Typical setup for Power Meter operation

6.2 Operation Manual

6.2.1 Start application and select target interface

After connecting the tester to your computer, start the program by selecting the Power Meter application from the Windows start menu or press the Windows start key and type "Power Meter". If more than one BLT2450 tester are connected to the computer, the dialog in Image 11 appears. Choose the tester you want and click "OK" to start measuring.
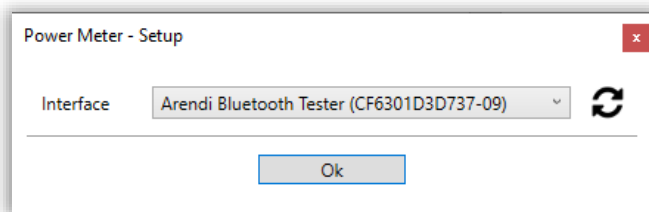

Image 11 Selecting BLT2450 tester

6.2.2 Usage

Using the Power Meter is very simple: Just read the displayed values from the application and your good. All values are measured in dBm.
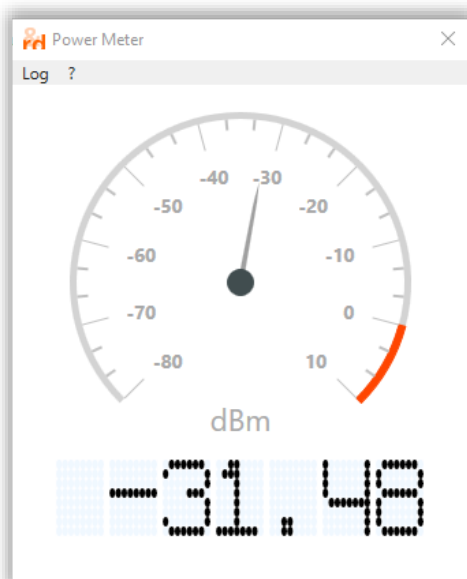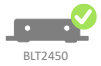

Image 12 Using Power Meter

7 ATTENUATOR

BLT2450	Custom Board	Development	Production	Compliance

The Attenuator applications turns the BLT2450 into a variable attenuator and allows to modify the attenuation between the two RF ports.

A variable attenuator is a very handy tool that allows any RF signal within the valid frequency range to be attenuated by the desired amount. As an example you can place the attenuator between two DUTs or between a DUT and its antenna to see how the system behaves with decreasing signal strength. Using the variable attenuator like this a very simple way to simulate increasing distance or losses caused by obstacles such as walls.

The Attenuator app is most useful during development since it requires manual operation. For automated testing during production or for continuous integration consider building your own tool using the available libraries.

7.1 Typical setup

A typical attenuator setup is illustrated in Image 13 below. A BLT2450 is used as a variable attenuator between two connected RF devices.

Image 13 Typical setup for Attenuator operation

7.2 Operation Manual

7.2.1 Start application and select target interface

After connecting the BLT2450 tester to your computer, start the program by selecting the attenuator application from the Windows start menu or press the Windows start key and type "Attenuator". If more than one BLT2450 tester are connected to the computer, the dialog in Image 14 appears. Choose the tester you want and click "OK" to proceed.
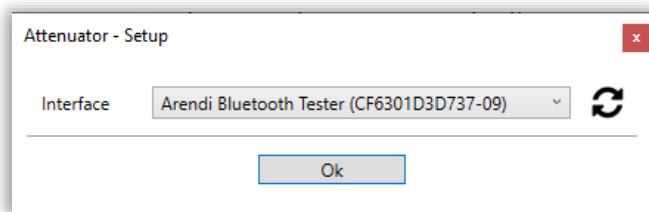
Image 14 Selecting BLT2450 tester

7.2.2 Usage

Set the attenuation by simply dragging the slider to the desired value or entering a valid number in the input field. The current attenuation can be increased and decreased by pressing the up and down arrow buttons.
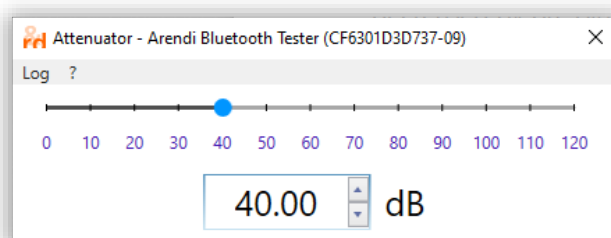
Image 15 Using Attenuator

8 SENSITIVITY TEST

BLT2450	Custom Board	Development	Production	Compliance
✓	✓	✓	✗	✗

The Sensitivity test is a very convenient application to automatically measure and plot the Packet Error Rate (PER) curve of a setup consisting of a BLT2450 tester and a DUT. The PER curve is a good indicator to calculate the RF sensitivity of a given device and to measure the effect of interferers. The DUT must be connected to the PC through a (virtual) comport and must be running a DTM firmware. Once the BLT2450 tester and DUT are selected, the application starts to measure the PER over the specified attenuation range with all selected frequencies and plots the result on a chart.

The Sensitivity Test application is most useful during development for quickly finding the sensitivity limit of a system. For automated measurements consider building your own application using the provided libraries.

8.1 Typical setup

A typical Sensitivity Test setup is illustrated in Image 16 below. A BLT2450 is used as a DTM tester communicating with the DUT using either a coax cable (conducted measurement) or antenna (radiated measurement). The DUT is connected to the PC through a (virtual) comport and runs a DTM firmware.
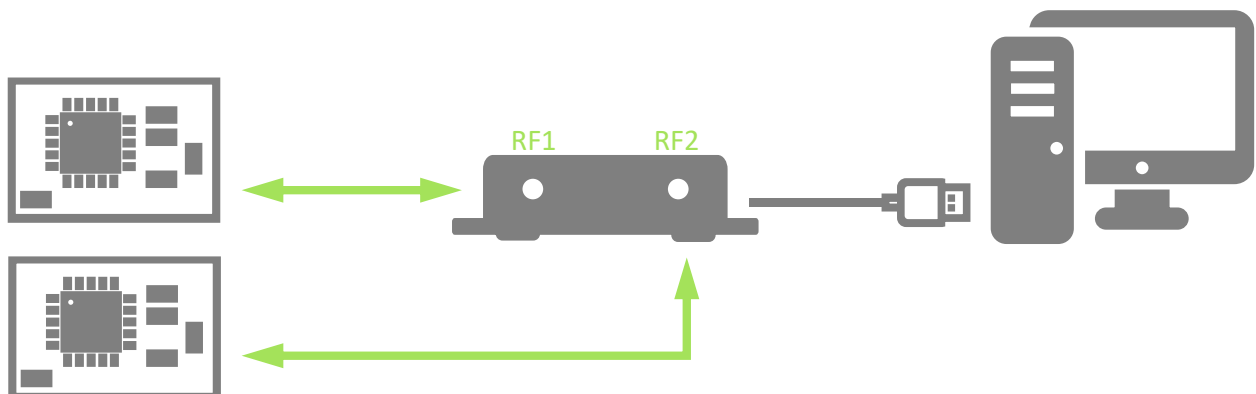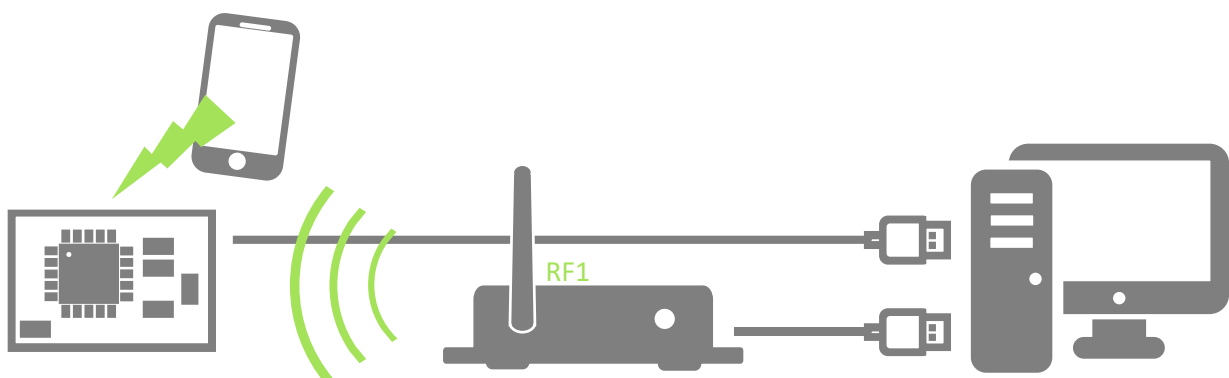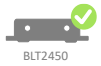

Image 16 Typical setup for Sensitivity Test operation

8.2 Operation Manual

8.2.1 Start application and select target interface

After connecting the BLT2450 Tester and DUT to your computer, start the program by selecting the Sensitivity Test application from the Windows start menu or press the Windows start key and type "Sensitivity Test".
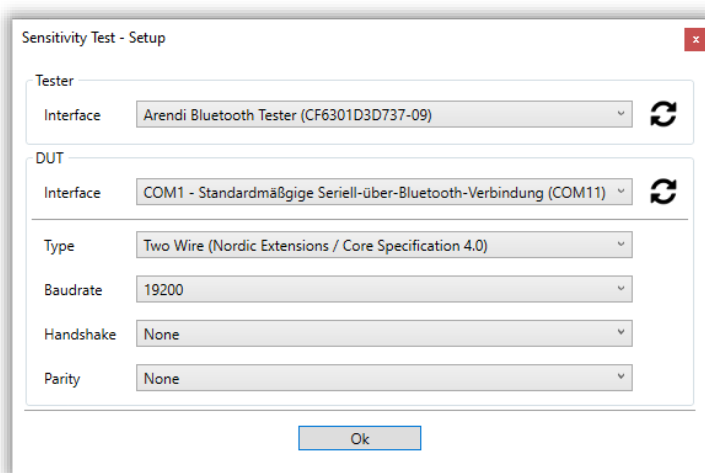
Image 17 Selecting DTM Tester and DUT

After startup, the dialog in Image 17 shows a list of all connected BLT2450 tester and potential DUTs that can be selected. Select the wanted BLT2450 tester and the comport of your DUT. For the DUT you need to specify the following parameters:

Parameter	Description
Interface	Define the comport of your device. Use the windows device manager to find out what comport your device is using
Type	Select the interface type of your device, it is either Two Wire or HCI
Baudrate	Select the baudrate that is used by your board
Handshake	Choose the proper type of handshake your device is using
Parity	Choose the proper parity your device is using

Table 3 Interface settings

8.2.2 Usage

Initially, the Sensitivity Test application is in IDLE mode where all RF related settings can be defined. Press the "Start" button to initiate the measurement process or "Stop" to quit any ongoing measurements and return to IDLE mode.

Note

Depending on the selected settings, a complete measurement can take quite a long time. It is recommended to do a quick scan with relaxed settings to find the area of interest before starting the actual measurement. A suitable configuration for a quick scan is as follows:

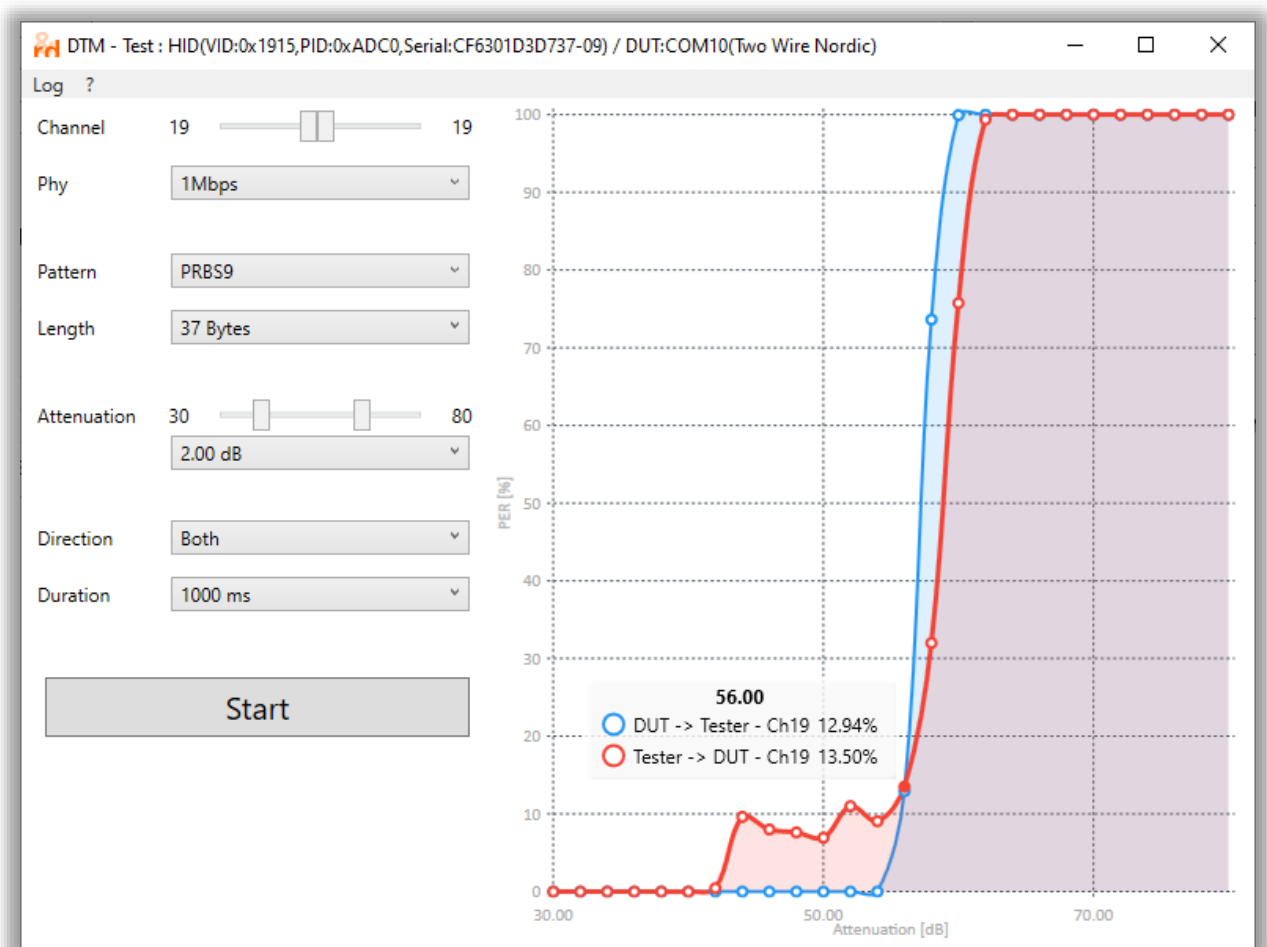Attenuation: Full range with step size 5dB, direction: Both, duration: 250ms

Image 18 Using DTM Test application

8.2.3 RF settings

Before starting the PER measurement, you need to specify the proper RF parameters as described below:

Parameter	Description
Channel	Select the frequency channels to be measured The frequency range starts at 2'402MHz (channel 0) and increases in 2MHz steps up to 2'480MHz (channel 39). The most interesting frequencies for testing are 2'402MHz (lowest band) 2'440MHz (mid band) and 2'480MHz (highest band). Using a larger range of channels increases the total measurement time considerably.
Phy	Select the type of radio PHY
Pattern	Select a bit pattern that should be used for the payload. PRBS9 is recommended for most cases (default setting)
Length	Choose the number of bytes used for payload data. 37 bytes is recommended for most cases (default setting)
Attenuation	Set the range of attenuation that should be used for the measurement and the step size. Using a larger range and smaller step size increases the total measurement time.
Direction	Select one of the following: • DUT to Tester Measures the PER of the DUT only • Tester to DUT Measures the PER of the Tester only • Both Measures the PER of both the DUT and Tester
Duration	The duration for every PER measurement. Larger values increase the total measurement time. 1000ms is recommended for most cases (default setting)

Table 4   RF settings

After a measurement has completed, the generated diagram can be used to quickly find the sensitivity of the system.

8.3 Use cases

8.3.1 Measure sensitivity

For measuring the sensitivity of your device, it is recommended to use a coax cable between the device and the BLT2450. Using a coax cable reduces interference with other RF devices and improves the sensitivity. If no coax cable connection is possible, consider performing the radiated measurement with the DUT and BLT2450 placed inside a shielded box instead.

Knowing the sensitivity of your device is useful to verify the design and test the influence of its components such as DCDC converters e.g.

A PER of 30.8% (0.1% BER) is usually the limit, at which the sensitivity of a system is defined. Note that this is only valid when using PRBS9 with a packet length of 37 bytes.

8.3.2 Measure immunity

Once you know the sensitivity of your system under optimum conditions, it is interesting to know how it behaves when other devices are causing interference as shown in Image 16. Compare the optimal sensitivity with measurements under "real" conditions and play with different frequencies.

8.3.3 Verify RF design

Verify the design of the RF components such as filters and antenna by comparing the sensitivity after modifications: If the sensitivity gets better, your modifications may be good. If for instance the sensitivity at lower frequencies is noticeably better than the sensitivity at higher frequencies this could be a hint that the antenna or antenna matching is detuned. Detuning can be caused by an nearby objects such as enclosure, batteries, body parts..

8.4 Common Problems

8.4.1 Very low sensitivity

If the sensitivity of your system is very low this might have several reasons. Some common issues are listed below:

- The antenna is detuned due to nearby objects
- The antenna is not properly matched
- Components on the DUT such as DCDC converters impact RF performance
- The crystal frequency is not within the required range
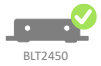
8.4.2 Tool is not responding

Check that the communication with the DUT works in both directions and that the DUT properly executes the received DTM commands. Use the DTM Application to test the communication with the DUT as described in chapter 5.4.2.

8.4.3 Non-symmetrical curves

The Sensitivity Test application can measure the PER curves in both directions: From tester to DUT and from DUT to tester. It's normal these two curves don't overlap but have qualitatively equally shapes. Curves with very different shapes can usually be seen when the DUT is not shielded and exposed to interferers.

For the BLT2450, received signal and interferers are attenuated equally well, thus yielding a constant signal to noise ratio (SNR). For an unshielded DUT, attenuation is applied to the signal only while the level of interference stays constant. This may lead to a very low SNR that causes low sensitivity. Repeat your measurement while the DUT is either shielded or placed inside a shielded box. Using coax cables rather than antennas also helps to reduce interference during measurement.

9 WEBSOCKET SERVER

| BLT2450 | Custom Board | Development | Production | Compliance | Integration |

The WebSocket Server is an application that runs in the background and provides access to all functionalities available on the BLT2450 and DUT through a simple WebSocket API [2]. Any WebSocket capable programming language or testing environment can be used to communicate with the WebSocket Server for executing commands or reading measurement results.

The WebSocket Server is most useful for automated testing such as production test or continuous integration. Using the API of the WebSocket Server, you can build your own application to control the BLT2450 and integrate it into your existing testing environment.

Note

The WebSocket Server and other BLT2450 tools cannot run simultanesously.

9.1 Typical setup

A typical setup for using the WebSocket Server is illustrated in the image below. The BLT2450 WebSocket Server must be running on the workstation, where the BLT2450 tester and DUT are connected to. Any WebSocket capable client can then access the BLT2450 WebSocket API.
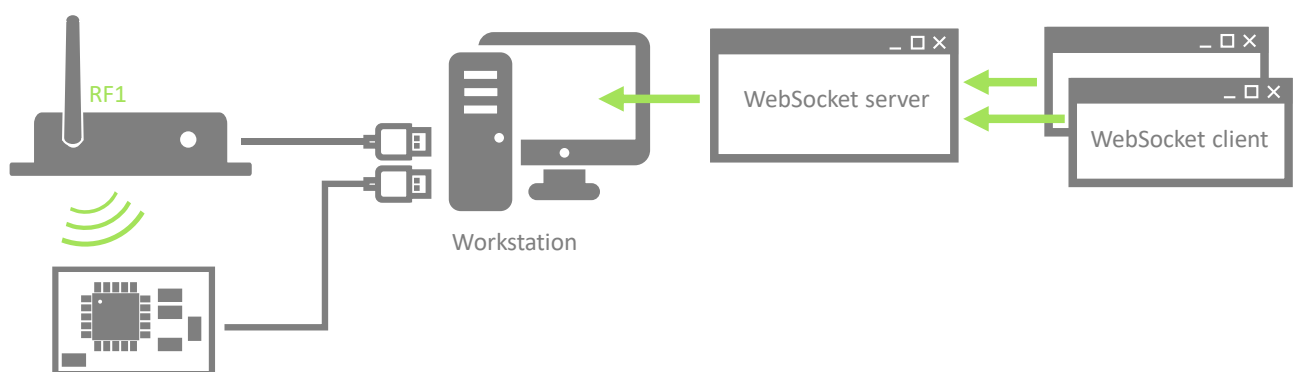

Image 19 Typical setup for WebSocket Server operation

9.2 Operation Manual

9.2.1 Start application and select target interface

Make sure to terminate any other BLT2450 tools before starting the WebSocket Server. Start the program by selecting the WebSocket Server application from the Windows start menu or press the Windows start key and type "BLT2450 Websocket Server". The WebSocket Server application is running in the background and can be accessed through its icon in the tray menu.

Image 20 Accessing BLT2450 WebSocket Server from tray menu

9.2.2 Usage

Click on the icon in the tray menu to open the WebSocket Server window. In the application window, Press the "Stop" button to stop the WebSocket Server, press the "Start" button to start the WebSocket Server.

Choose File/Exit to terminate the WebSocket Server or click on the close button ⊠ to minimize the application to the tray menu (WebSocket Server keeps running in the background).

Select File/Settings to change the port number of the WebSocket Server. Enter a valid number and press the "Save" button. After changing the settings, the WebSocket Server must be started as described before.
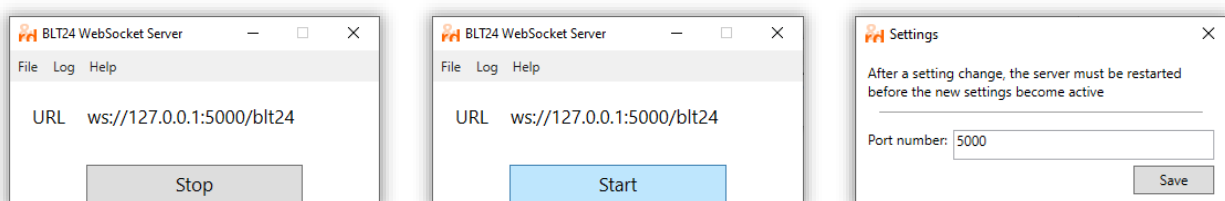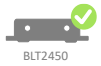

Image 21 Using WebSocket Server application

10 BLE EXPLORER

BLT2450   Custom Board   Development   Production   Compliance

With the BLE Explorer application, any BLT2450 tester can be used to scan for BLE devices and to connect and read attributes and display the current RSSI value.

10.1 Typical setup

A typical BLE Explorer setup is illustrated in Image 22 below. A BLT2450 tester is used as a BLE gateway that connects to multiple custom boards or smart devices. Usually an antenna is used for operation, but a coax cable can also be used in situations where a constant connection to only certain devices is desired.
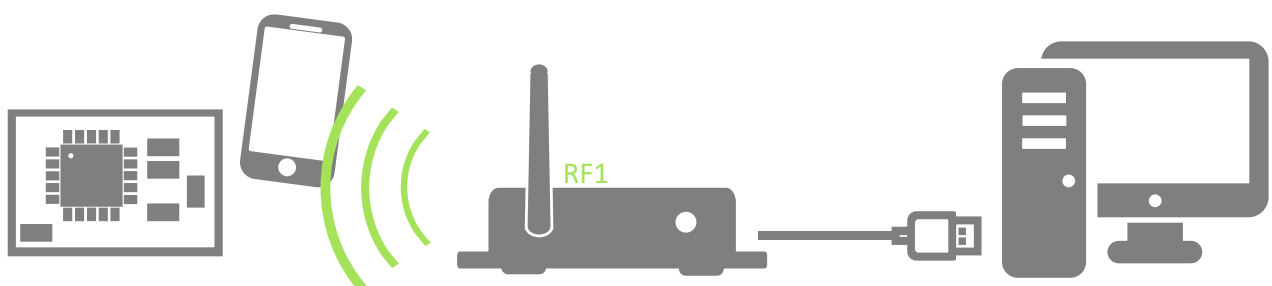
Image 22 Typical setup for BLE Explorer operation

10.2 Operation Manual

10.2.1 Start application and select target interface

After connecting the BLT2450 tester and DUT to your computer, start the program by selecting the BLE Explorer application from the Windows start menu or press the Windows start key and type "BLE Explorer".
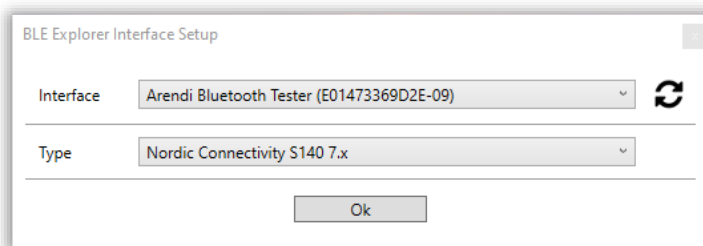

Image 23 Selecting BLT2450 tester

10.3 Usage

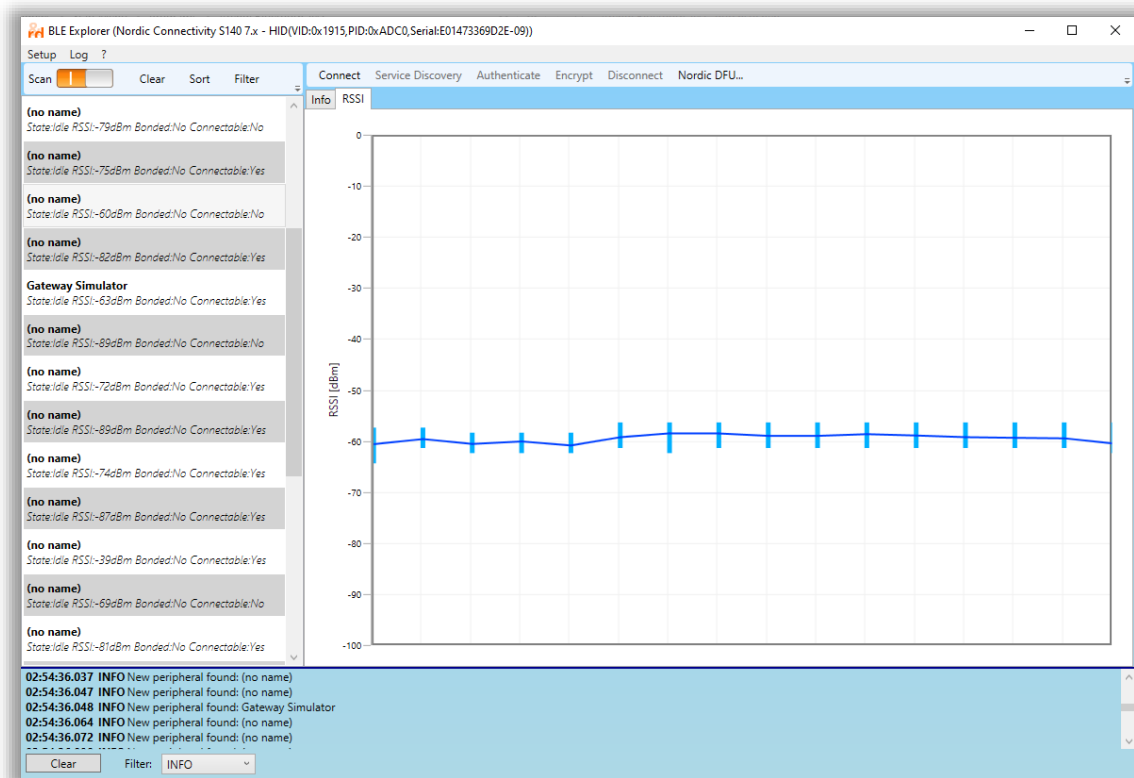Enable the "Scan" button to start scanning for BLE devices.

Image 24 Using BLE Explorer

The list on the left side of the application shows all visible BLE devices with their most relevant properties. Selecting a device from the list will show detailed information in the main panel. Select the RSSI panel to see a diagram containing the most recent RSSI values.

Press the "Clear" button to reset the device list and restart the scanning process. Press "Sort" to change the order of BLE devices in the list.

11 USER APPLICATION
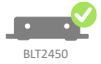
BLT2450	Custom Board	Development	Production	Compliance	Integration

Every product is different and every developer has different tool chains and requirements. Automated measurements during production or continuous integration need customized functionalities and a specific API. If you need an application that is tailored to your requirements, consider building your own application using the provided libraries. Building your own application has several advantages:

- Have full control of all available functions
- Build applications that integrate into your existing eco system or can be remote controlled using a standard interface (UART, TCP / IP sockets..)
- Building applications for production testing, continuous integration..

We provide different kinds of libraries:

- **WebSocket**
  Use our JavaScript / node.js client library [3] for communicating with the WebSocket Server application using the specified API [2].

- **.NET**
  Use the .NET libraries to build simple or complex .NET applications using a console interface or graphical user interface (GUI). Our .NET libraries are provided as .NET standard 2.0 libraries.

- **LabVIEW**
  Use the LabVIEW libraries to build applications that can be used inside your LabVIEW projects.

Please have a look at the provided examples to get started.

11.1 Use cases

There are unlimited possibilities for building your own application. Here are just a few examples:

- **Continuous integration**
  Improve the quality and reliability of your firmware using continuous integration. With continuous integration, firmware changes of your device can be tested and verified during the build process. A BLT2450 tester can be used to measure the signal strength of your product or connect to your BLE device and emulate user interaction..

- **Gateway**
  Build a gateway that collects data from your devices and makes them accessible to other applications

- **EMI verification**
  Create a BLE connection with your device to verify it operates properly during EMI testing. An interrupted connection is a strong indicator that the device encountered a reset or other software errors.

- **Production testing**
  Create applications to measure the performance of your device during production and for automated PASS / FAIL testing. Measure the PER or signal power of the device to detect problems like bad soldering of RF components or erroneous antennas, cables, matching..