UG147: Flex SDK v2.x Range Test Demo User's Guide

This user's guide provides an easy way to evaluate the link budget of the Wireless Gecko EFR32 devices using Silicon Labs' Radio Abstraction Interface Layer (RAIL) by performing a range test between two nodes. Range Test is a standalone test application that creates a radio link between two evaluation kits and sends predefined amount of packets from the transmitter side to the receiver. The range test demo implements packet error rate (PER) measurement. PER is a commonly-used technique for measuring the quality of RF links in wireless systems under particular conditions.

Proprietary is supported on all EFR32FG devices. For others, check the device's data sheet under Ordering Information > Protocol Stack to see if Proprietary is supported. In Proprietary SDK version 2.7.n, Connect is not supported on EFR32xG22.

KEY POINTS

- Evaluate the link budget of the Wireless Gecko EFR32 devices.
- Range Test is a standalone test application that creates a radio link between two evaluation kits.
- PER is a commonly-used technique for measuring the quality of RF links.

1. Running Simplicity Studio

For more information on Simplicity Studio, please refer to *QSG138: Getting Started with the Silicon Labs Flex Software Development Kit for the Wireless Gecko (EFR32™) Portfolio*.

Before running the RAILtest, the WSTK base board must be configured according to the following instructions:

To start, you need to set up two EFR32 development kits (radio boards with mainboards). See figure below. Once you have installed all the required software you can connect your EFR32 development kit hardware to your PC using a mini USB cable. Make sure the 3-way power switch in the bottom left is set to AEM.

If you want to connect to your WSTK over Ethernet, you should plug in an Ethernet cable at this time. The IP address will be printed to the LCD screen during startup of the WSTK but may be lost when the app starts. To see this again, reboot the WSTK and press the reset button for several seconds to prevent the EFR32 from loading its application.

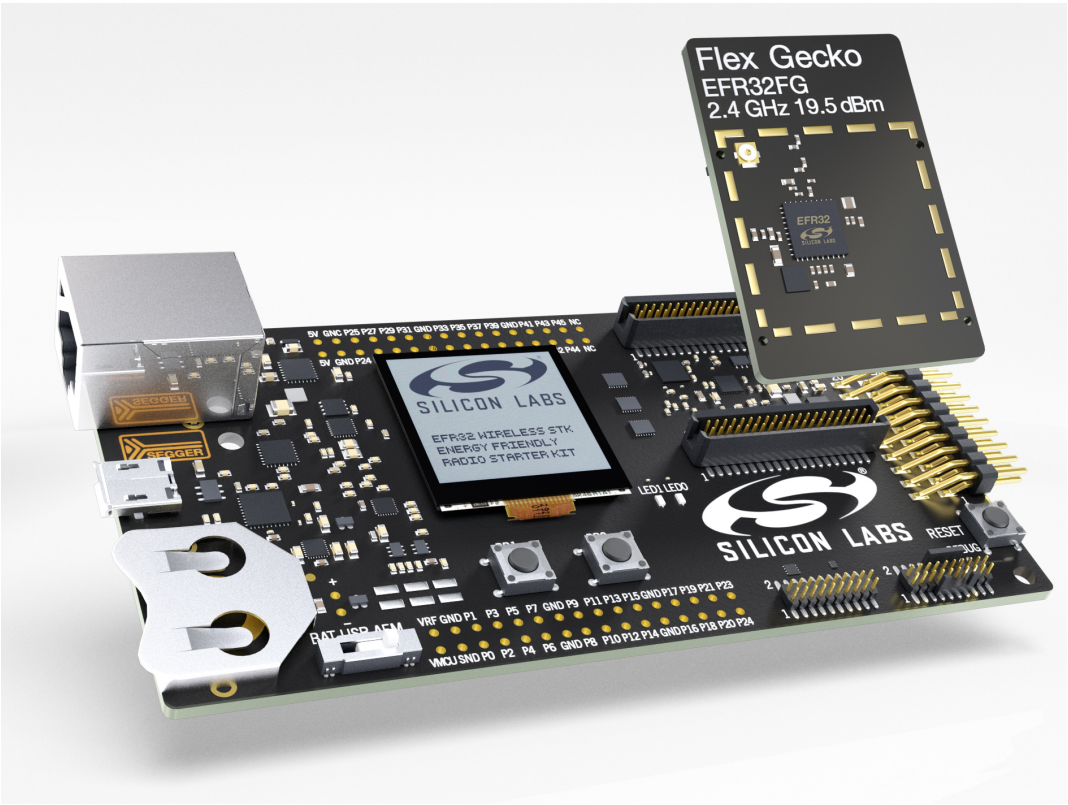

Figure 1.1. EFR32FG Radio Board with Main Board

1.1 Select Range Test Application

1. Once Simplicity Studio is running, under the Device tab select the USB serial number of your J-Link device. There should be only one if you have connected only one EFR32 development kit. (After connecting the WSTK to the PC, the first screen on the LCD of the mainboard is the Start Screen, which shows the serial number of your device.)
2. In the Launcher (default) window, click on the green [**New Project**] button.

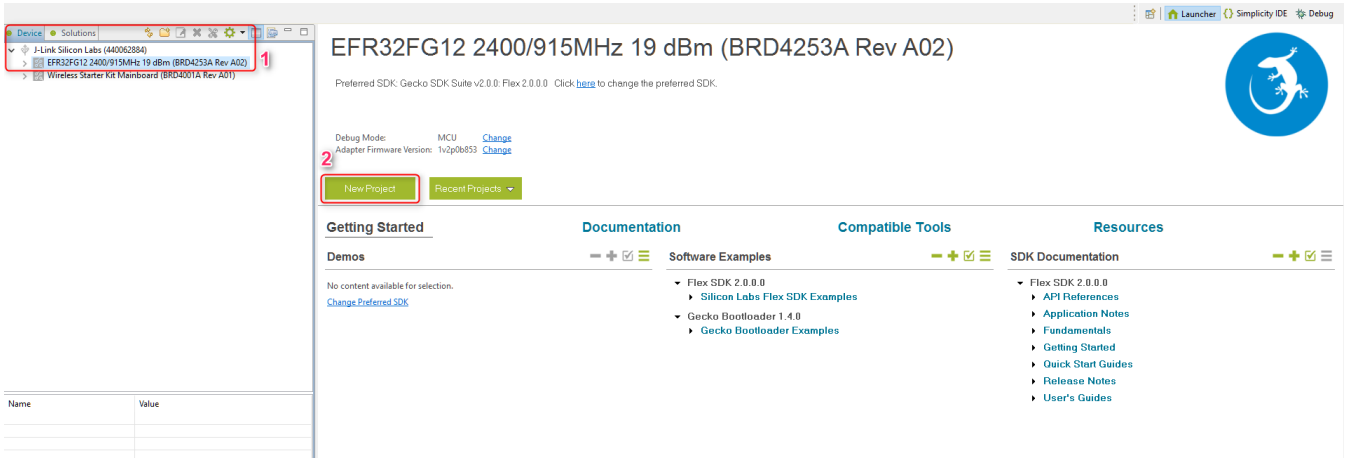

Figure 1.2. Simplicity Studio's Launcher [Default] Perspective

3. In the New Project Setup dialog, first select the [**Silicon Labs Flex SDK**] and click next.

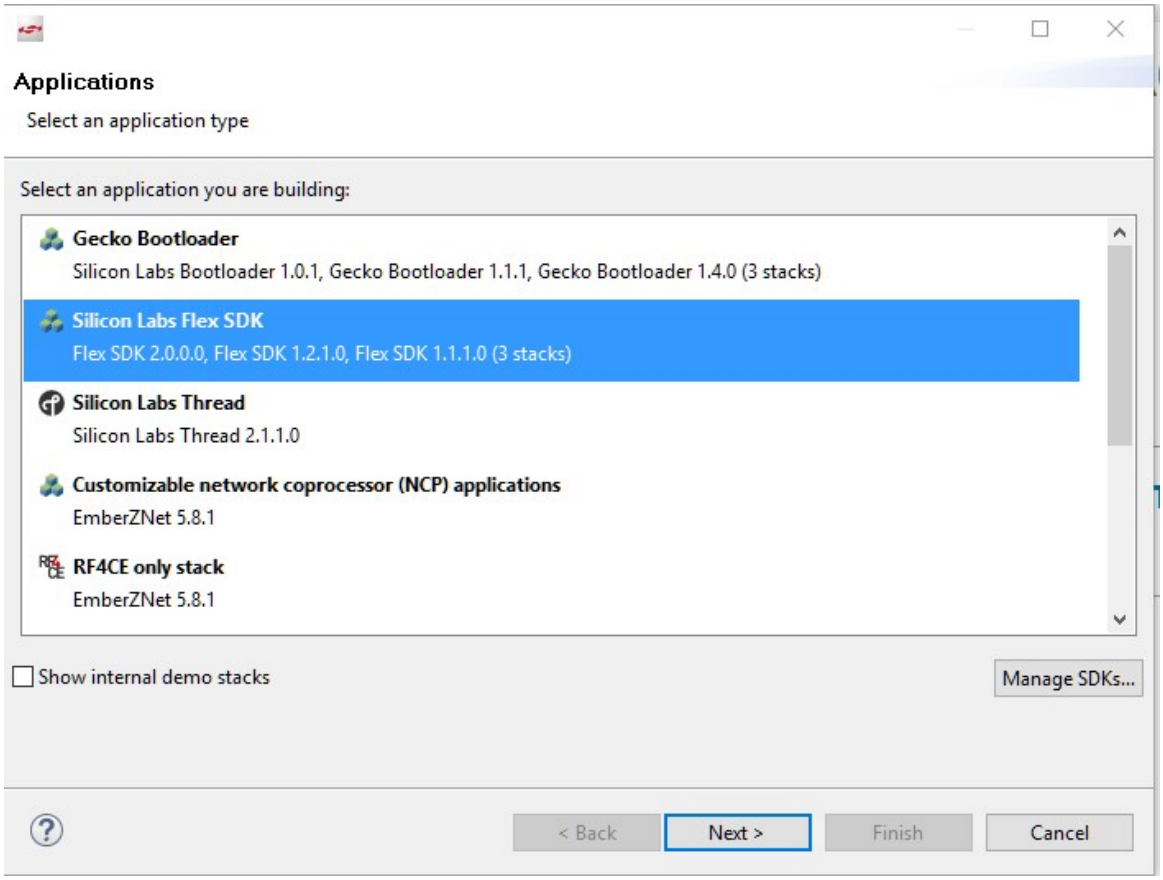

Figure 1.3. New Silicon Labs Example Project Window

4. Select the preferred SDK version and click [**Next**] .

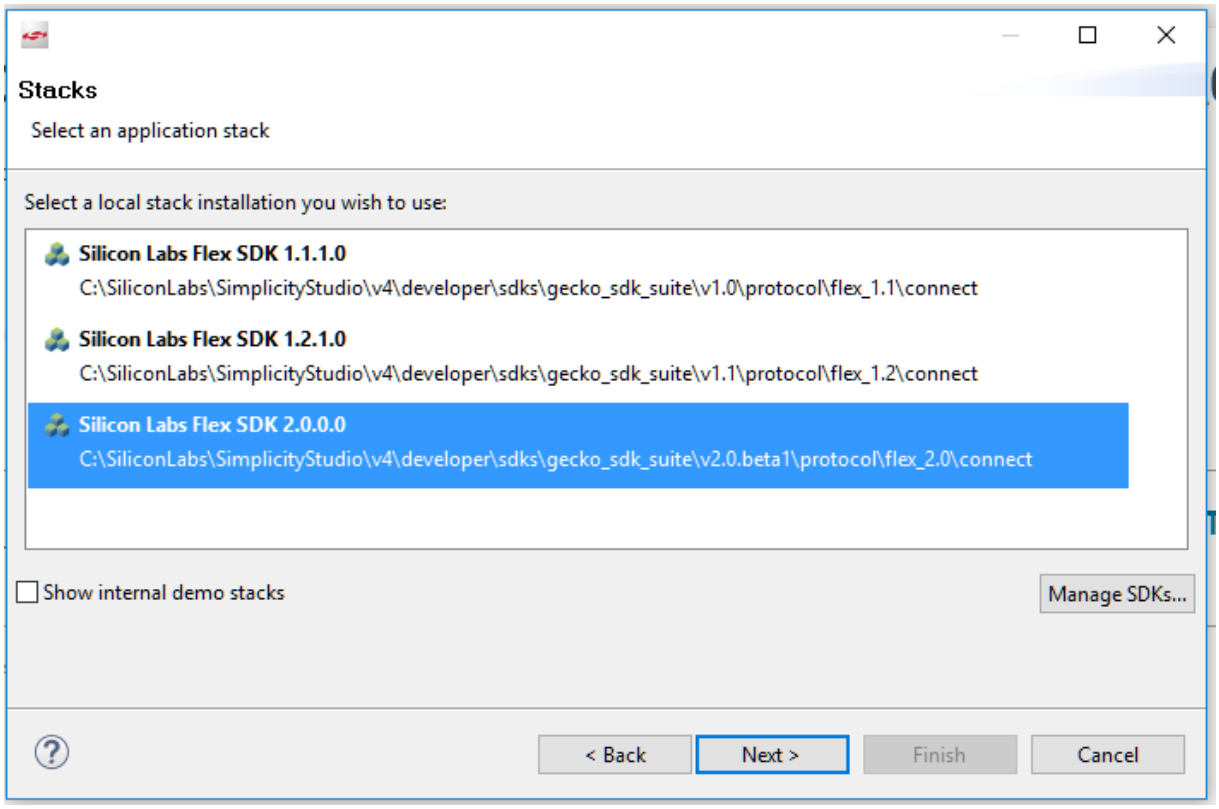

Figure 1.4. Select Stack

5. From the list of sample applications available in the selected SDK, select the [**RAIL: Range Test Sample Application**] and click [**Next**].

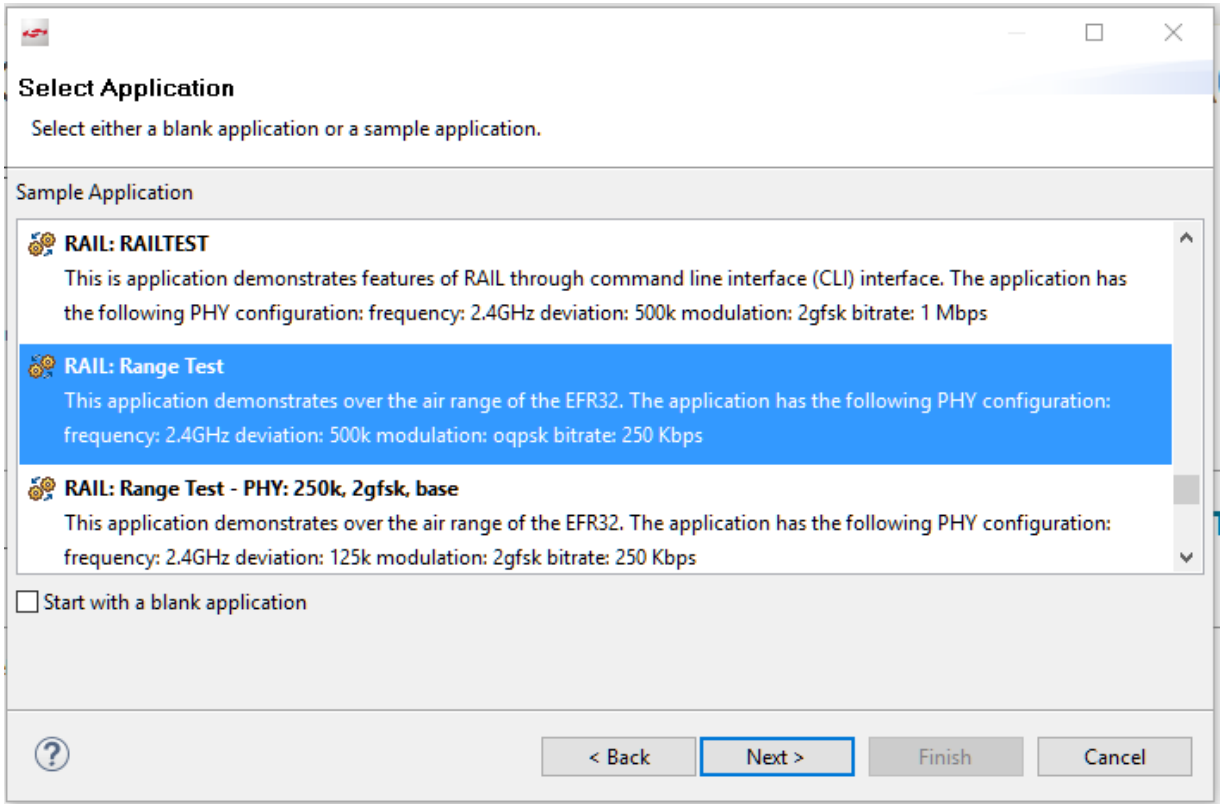

Figure 1.5. Select Application

6. Enter a name and location for your project and click [**Next**] .

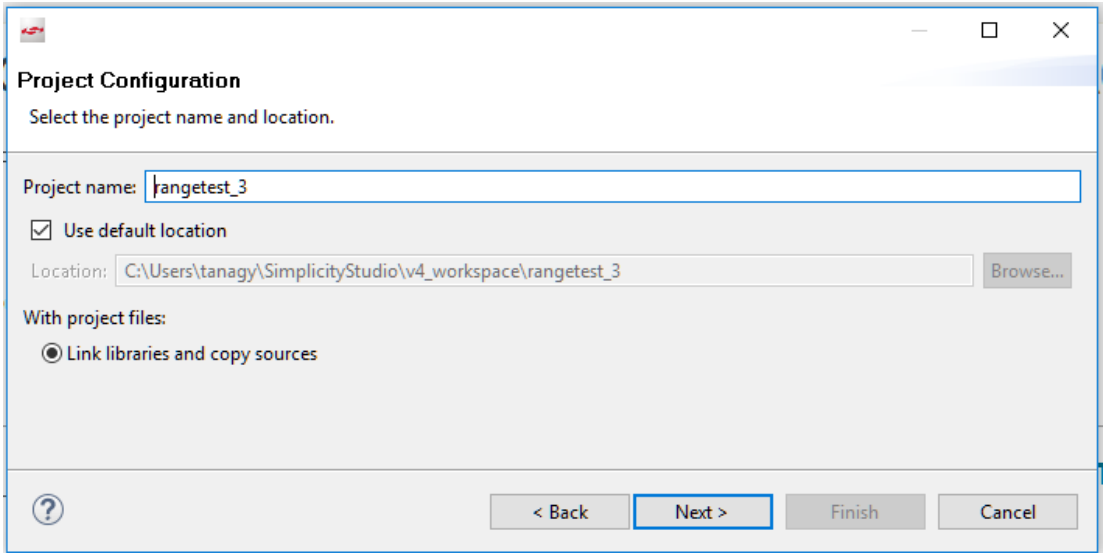

Figure 1.6. Project Configuration

7. Select the board, part, and toolchain configuration and click [**Finish**]. By default, Simplicity Studio populates the Board and the Part number fields with your connected starter kit. If these fields are not correct, you must change them manually.

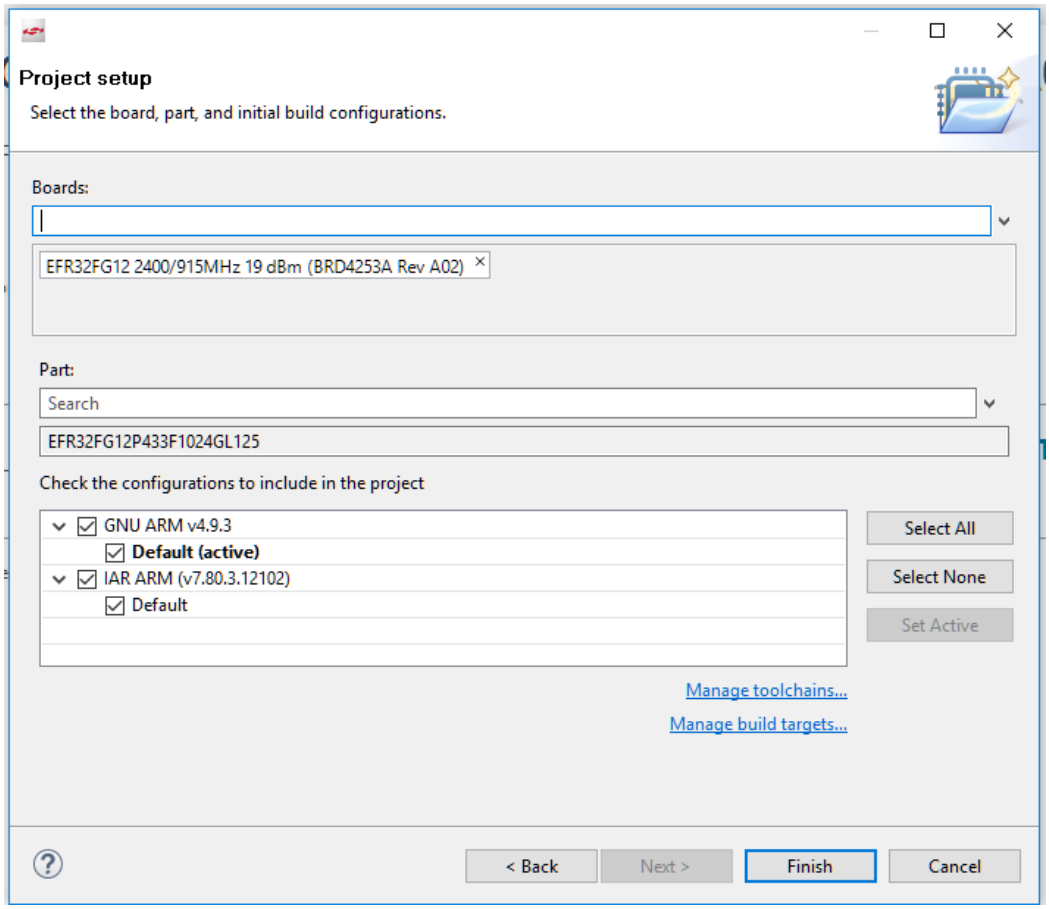

Figure 1.7. Project Setup

Note: You must have a Toolchain and Build target selected and configured for the [**Finish**] button to enable. If you do not see the [**Finish**] button enabled, check your Toolchains and Build targets by clicking on the links at the bottom of the dialog.

1.2 Generate the Application

1. When you finish creating your sample application, an Application Builder General tab opens. In the General Tab, if the architecture parameters shown for MCU and Radio and Board Type are not correct for your target device, change them by clicking on the [**Edit Architecture**] button and then selecting from its list. In general, the initial configuration settings for sample applications should be correct.

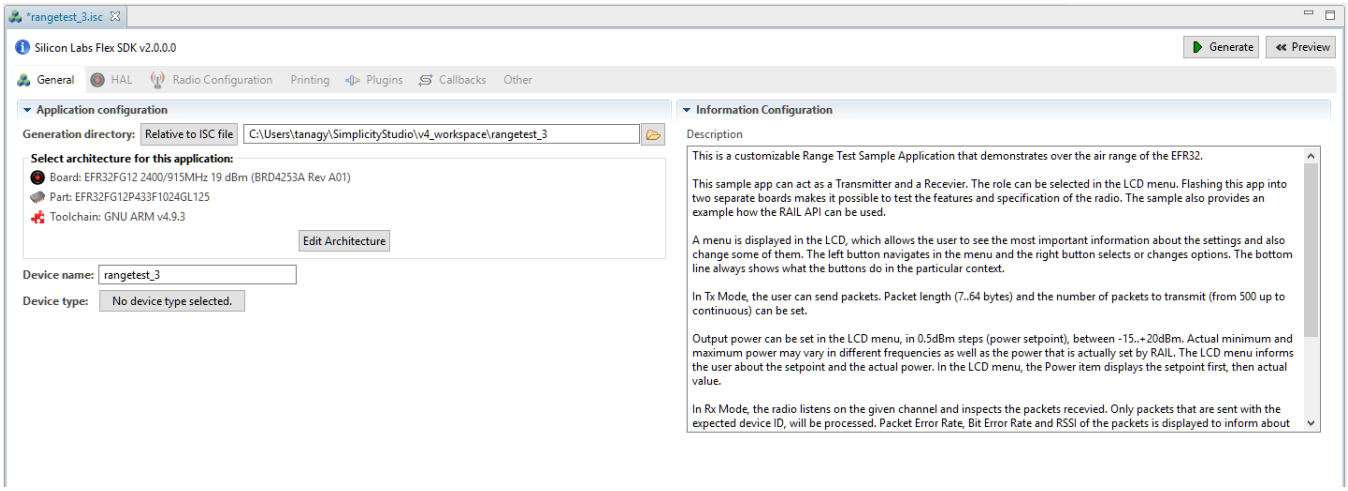

Figure 1.8. Application Builder General Tab

2. The RAIL application framework allows you to modify the PHY configuration for the application. Choose the [**Radio Configuration**] tab to modify the PHY configuration for your application. Click [**Generate**] in the upper right corner of the Application Builder window. For more information on how to set the modem parameters, refer to *AN971: EFR32 Radio Configurator User's Guide*.

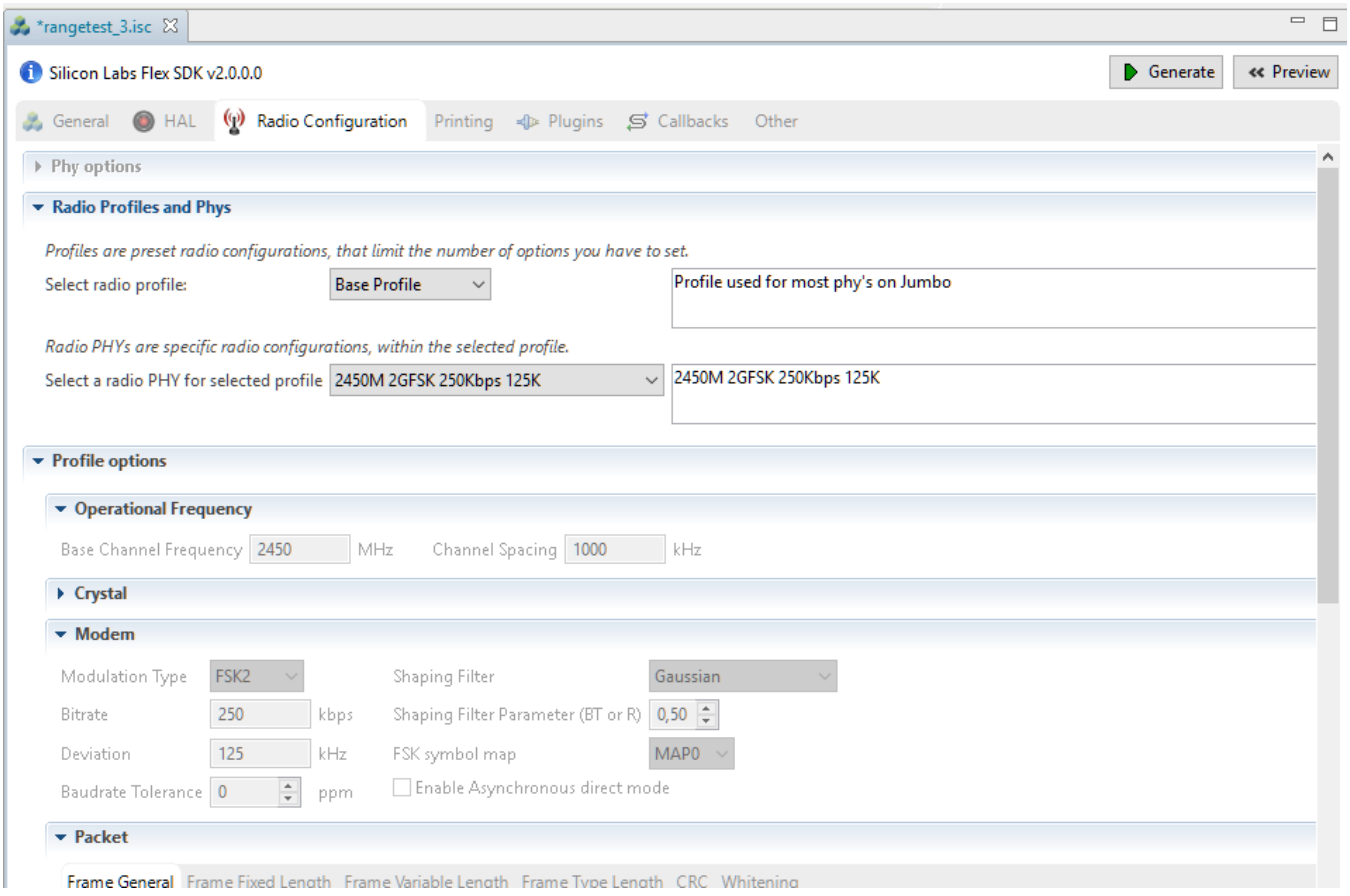

Figure 1.9. Application Builder Radio Configurator Tab

Note: Whenever the application configuration has been changed, you must click [**Generate**] again.

3. When generation is complete a dialog shows the generated files, one of which has the extension .eww. Click [**OK**].

1.3 Build the Application

Click Build in the top tool bar.

Your sample application will compile based on its build configuration. You can change the build configuration at any time in the Project Explorer View by right clicking on the project and going to Build Configurations > Set Active.

1.4 Load the Binary onto your Device/Flash Programming

In case a full erase is not necessary, press the Debug button in the Developer Perspective.

This will flash the project into the board if it was successfully built. This will only update the program memory.

Once the project is flashed, the board can be started with the Resume button .

An alternative way to the above described process:

1. In the Simplicity Studio Launcher window, select your target device.
2. With the device selected, select the [**Flash Programmer**] tile on the right-hand side.

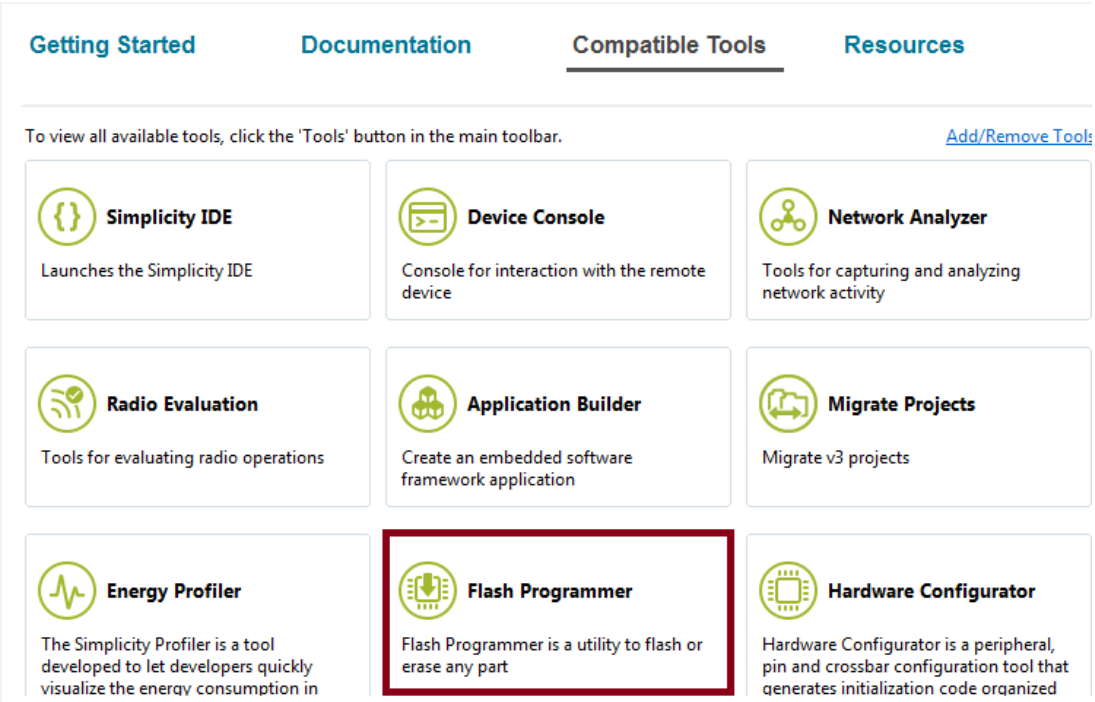

Figure 1.12. Flash Programmer Tile

3. The Flash Programmer opens. In this perspective, you can choose your file type and browse your file.

4. Select your file type.

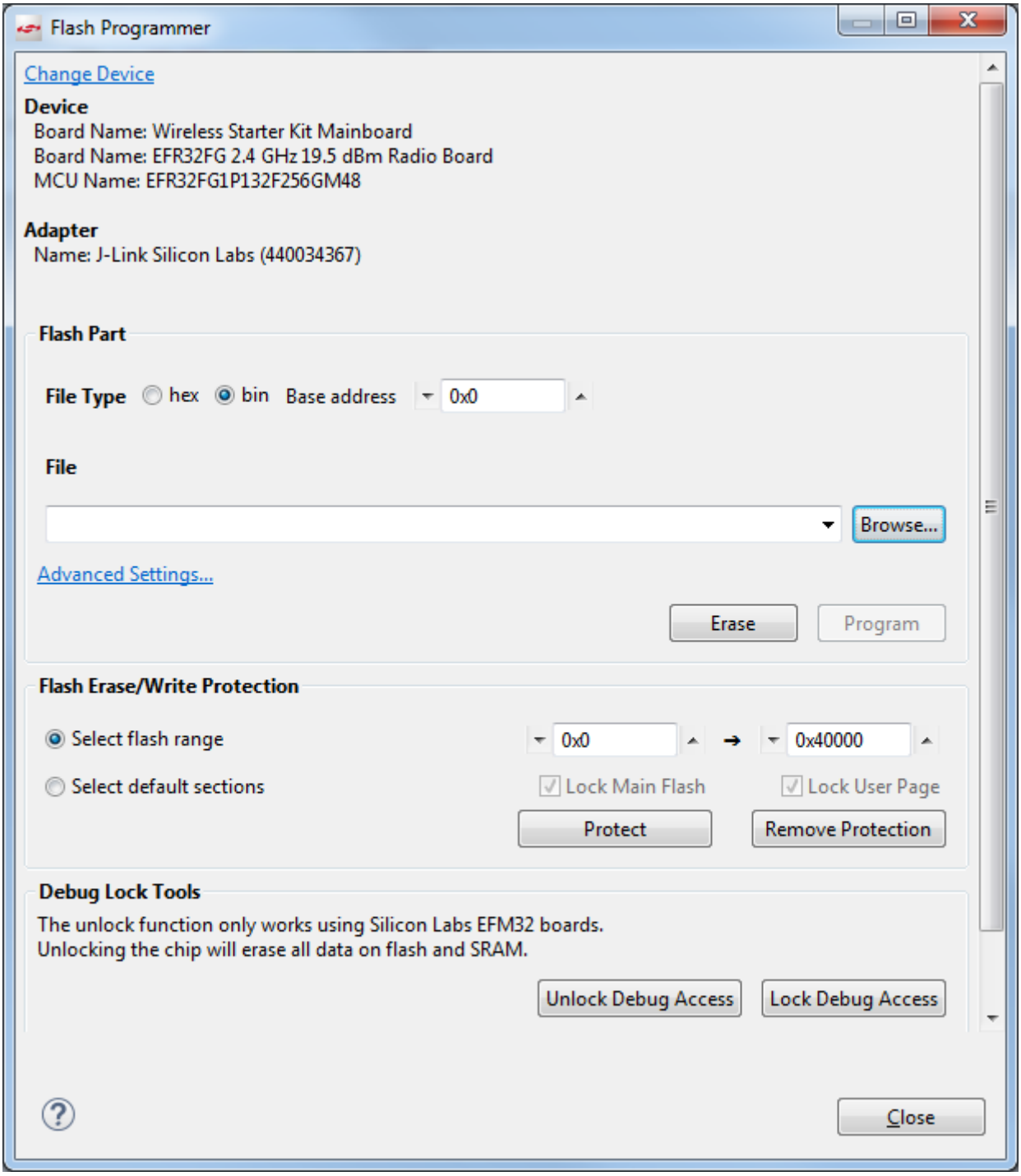

Figure 1.13. Uploading .bin or .hex Images

5. Navigate to the .bin or .hex image you wish to upload.
6. Check [**Erase**], to make sure that any previous bootloader or other non-volatile data is erased before your new image is uploaded.
7. Click [**Program**] to program the flash.
8. You will be notified once the upload is complete.

After starting the demo, the first screen is the Welcome Screen, which shows the set operational frequency and RF power level.

The Welcome Screen is shown for up to three seconds or as long as any of the push buttons is pressed.

2. Basics of the Range Test Application

Range Test creates a radio link between two evaluation kits and sends predefined amount of packets from the transmitter side to the receiver. The Application can be configured through the onscreen menu system of the board and does not require a PC connection. The receiver calculates packet error rate (PER). It also displays the current RSSI level in dBm units and draws a chart of the RSSI historical data. For long tests the transmitter can be set up to transmit continuously. It is not necessary to start both sides synchronously.

2.1 Basics of the Packet Error Rate

The range test demo provides measurement results regarding the quality of the RF link. The demo uses two RF nodes. One node is used as the “transmitter” (TX) and the other as the “receiver” (RX). The transmitter sends packets to the receiver repeatedly. The packet includes the address of the transmitter and number of the sent packet. The packet number increments from packet to packet. The receiver receives the packet and checks its address. If their addresses match, the packet number is stored.

Packet error rate is calculated according to the following equation:

$$Packet\ Error\ Rate(PER)[\%] = \frac{(P_{Tx} - P_{Rx})}{P_{Tx}} * 100$$

Where P_{TX} is the number of sent packets and P_{RX} is the number of received packets.

3. Menu System

After starting the demo, the first screen is the Welcome Screen, which shows Silicon Laboratories logo, the carrier frequency and the RF power level. The Welcome Screen is shown for up to three seconds or as long as any of the push buttons is held pressed.

Figure 3.1. Radio Board Welcome Screen

The next screen displayed in the LCD is a menu, which allows the user to see the most important information about the settings and also change some of them. The on-screen menu system is designed for easy configuration. For accurate range testing, the demo measures the actual packet error rate (PER) of the radio link. The desired channel, packet count, payload length and the moving average window size are configurable parameters. It is also possible to change the self- and remote-IDs of the participants. Some of the RF settings of the radio, such as frequency and output power, are listed in the menu.

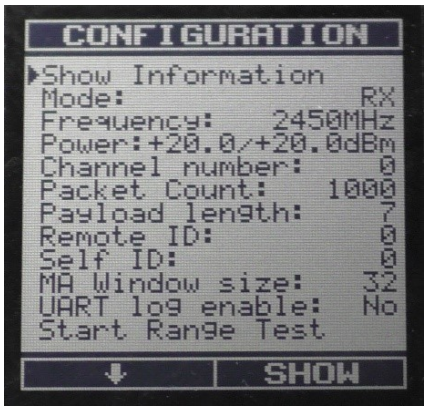

Figure 3.2. Configuration Menu

The demo can be configured through several menu items. Two push buttons are used to navigate the menu system; soft labels describe the current function of the buttons. In general, push button 1 is used to navigate down through the menu items. Push button 0 is used to configure the menu item selected by the pointer. Those items can be configured where a + label can be seen on the right bottom corner. In Tx Mode, the user can send packets. Packet length (7–64 bytes) and the number of packets to transmit (from 500 up to continuous) can be set. Output power can be set in the LCD menu, in 0.5 dBm steps (power setpoint), between -15 and +20 dBm. Actual minimum and maximum power may vary in different frequencies as well as the power that is actually set by RAIL. The LCD menu informs the user about the setpoint and the actual power. In the LCD menu, the Power item displays the setpoint first, then actual value. In Rx Mode, the radio listens on the given channel and inspects the packets recevied. Only packets that are sent with the expected device ID, will be processed.After the menu items are configured, the range test can be started. During the test, all of the measured information can be observed on the LCD screen.

In case the UART mode is turned on, status message can be observed on the UART TX line for each radio packet. These information are formatted in a human readable parsable format.

Example:

```
Receiver side: Rcvd, OK:246, CRC:0, Sent:16800, Payld:7, MASize:32, PER:98.5, MA:96.9, RSSI:-46.5, IdS:0, IdR:0
Transmitter side: Sent, Actual:626, Max:1000, IdS:0, IdR:0
```

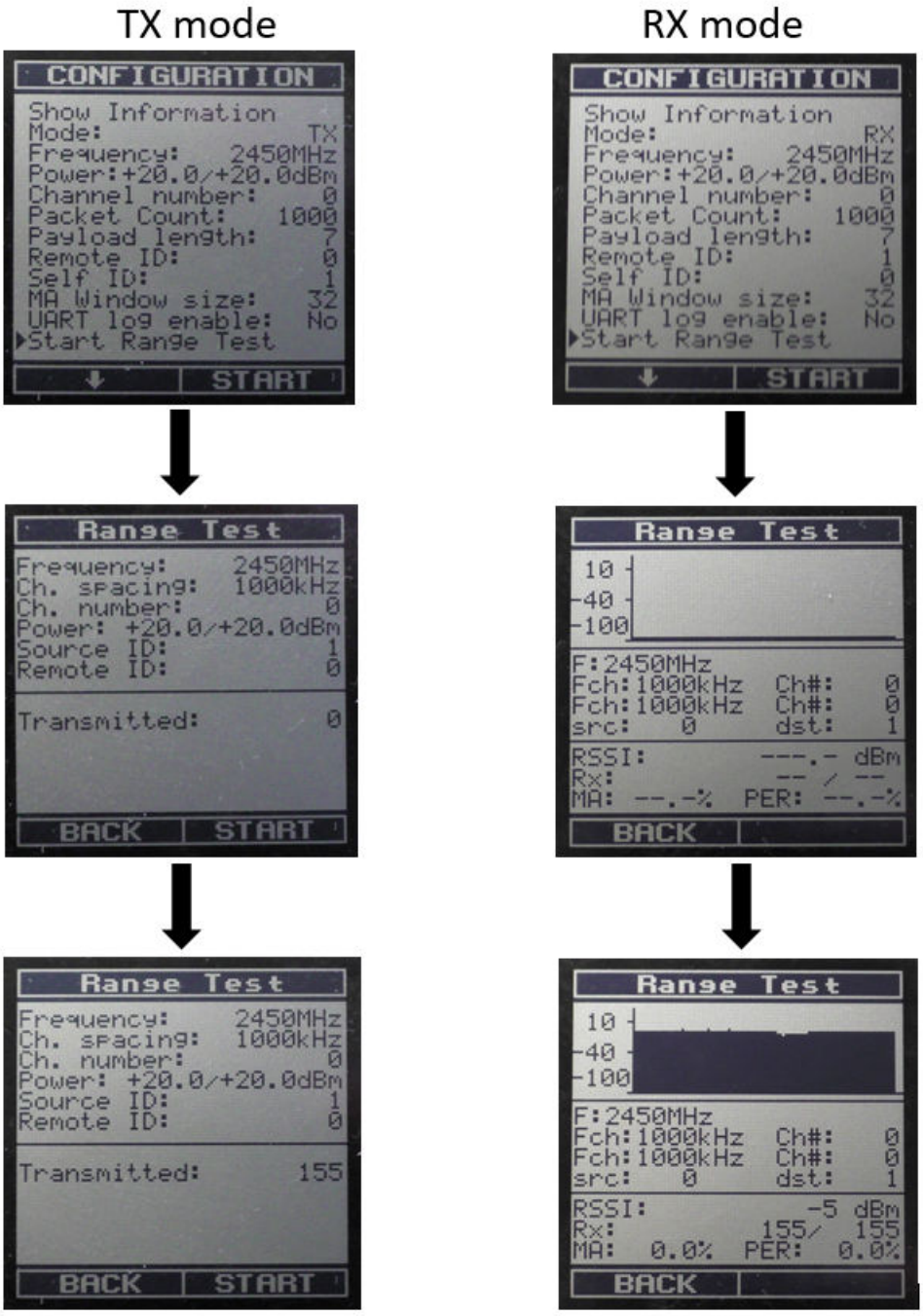

Figure 3.3. Configure and Operate the Range Test

The test runs as long as the number of transmitted packets reaches the predefined number or until the test is interrupted by Button 0. The user can follow the number of transmitted packets on the LCD screen only on the transmit side. The number of lost packets and the packet error rate are defined only at the receive side and are based on the first and last received packet numbers.

The signal strength of the incoming packet is measured during packet reception, and the actual RSSI value is shown on the LCD display. The RSSI values are also presented as a graph on the screen, the dynamic change in RSSI value can be observed accurately by configuring the moving average window size.

The actual RSSI value is measured when the sync word of the packet is received. The RSSI is typically used to qualify the link: greater level shows a better link quality. Please note that a systematic offset (see figure below) will appear in the RSSI value returned by RAIL test command due to matching network, radio configuration, etc. The users need to profile their board and account for the offset when using the returned value.

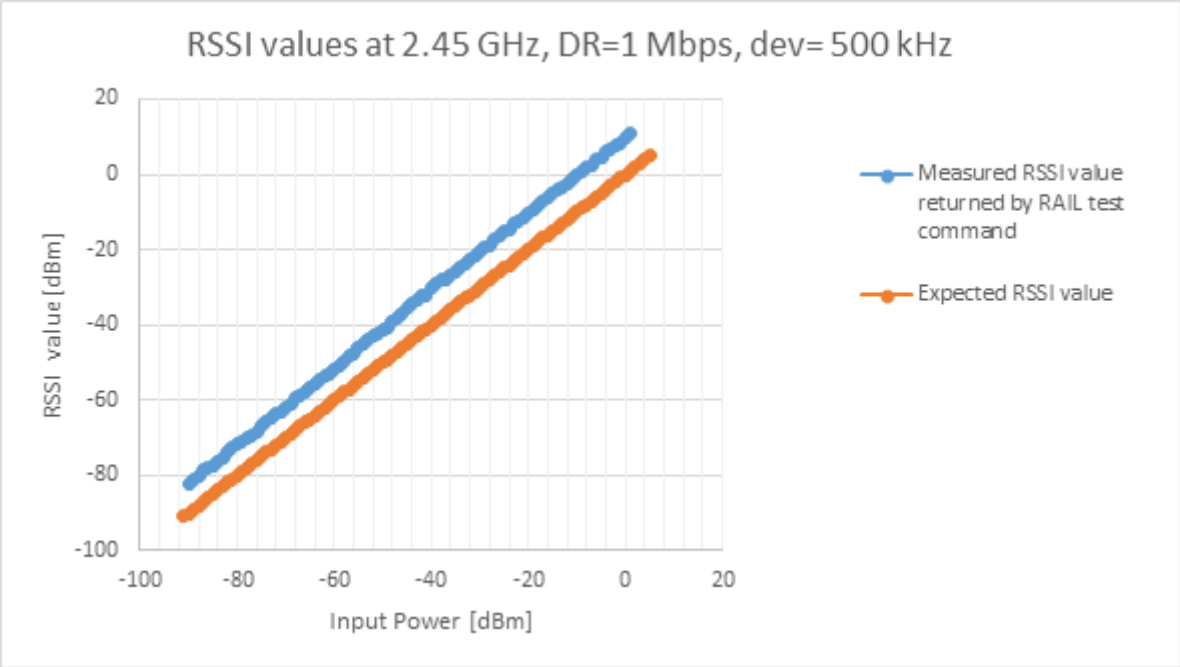

Figure 3.4. RSSI Curve

4. Range Test

The range test can be performed inside a building if indoor propagation is tested. However, it is advised to perform the test outside the building, line-of-sight, to get the best possible range result, as well as the best comparable results to different settings. It is also recommended that the antennas be located at least 1.5 m above the ground. If you are going to use the WSTK as a mobile device to run the range test, it is recommended to connect an external AA battery pack or a USB power bank to the WSTK board. The coin cell battery will not have enough power to do long-term testing. If the development kit is powered from a battery, the 3 position switch needs to be changed from AEM to VBAT.

Perform the following steps to conduct the range test:

1. Connect the radio boards to the two WSTK base boards.
2. Connect the two WSTK base boards to the Simplicity Studio, select the [**Range Test Sample Application**] project and configure your custom settings through the [**Radio Config → Profile Options**] tab. Build your project and flash your device. (For more details on this step, please refer to Running Simplicity Studio.)
3. In case the UART communication is not used, unplug the devices from the PC, put batteries into the WSTKs and switch them on.
4. The range test is performed as a one-way radio communication. Configure the devices so that one is in RX and the other is in TX mode by selecting [**TX**] and [**RX**] in the [**MODE**] menu item.
5. Configure the range test through the menu items. It is important to set the self- and remote-IDs of the participants correctly. Then start the test in the [**Start Range Test**] menu item on both devices. (See Figure 3.3 Configure and Operate the Range Test on page 12.)
6. The actual packet transmission can be started at the transmit side by pressing [**START**] again.
7. Follow the progress of the test on the LCDs.
8. If PER<1%, reset the PER on the boards and try to walk further in the area. Propagation conditions usually improve if the user distances himself from a possibly faded area.

Configuration	Tx Power	Rx Sensitivity	PCB Antenna Gain	Range in Dry Weather Condition	Range in Wet Weather Condition	Link Budget
169 MHz 2GFSK 2.4 kbps 1.2 kHz	19.5 dBm	-124 dBm	-12.5 dB	3000 m	480 m	118.5 dB
169 MHz 2GFSK 38.4 kbps 20 kHz	19.5 dBm	-112 dBm	-12.5 dB	1200 m	240 m	106.5 dB
169 MHz 2GFSK 500 kbps 125 kHz	19.5 dBm	-97 dBm	-12.5 dB	380 m	100 m	91.5 dB
433 MHz 2GFSK 2.4 kbps 1.2 kHz	10 dBm	-122.5 dBm	-0.5 dB	4400 m	640 m	131.5 dB
433 MHz 2GFSK 50 kbps 25 kHz	10 dBm	-110 dBm	-0.5 dB	1600 m	310 m	119 dB
433 MHz 2GFSK 100 kbps 50 kHz	10 dBm	-107.5 dBm	-0.5 dB	1300 m	270 m	116.5 dB
490 MHz 2GFSK 2.4 kbps 1.2 kHz	19.5 dBm	-123 dBm	0 dB	9400 m	1100 m	142.5 dB
490 MHz 2GFSK 10 kbps 5 kHz	19.5 dBm	-118 dBm	0 dB	6400 m	850 m	137.5 dB
490 MHz 2GFSK 38.4 kbps 20 kHz	19.5 dBm	-111.6 dBm	0 dB	3900 m	590 m	131.1 dB
490 MHz 2GFSK 100 kbps 50 kHz	19.5 dBm	-107.8 dBm	0 dB	2900 m	470 m	127.3 dB
868 MHz 2GFSK 2.4 kbps 1.2 kHz	13 dBm	-118.2 dBm	0 dB	2700 m	440 m	131.2 dB
868 MHz 2GFSK 38.4 kbps 20 kHz	13 dBm	-109.1 dBm	0 dB	1300 m	260 m	122.1 dB
868 MHz 2GFSK 500 kbps 125 kHz	13 dBm	-100 dBm	0 dB	670 m	150 m	113 dB
915 MHz 2GFSK 0.6 kbps 0.3 kHz	19.5 dBm	-125 dBm	0.5 dB	7800 m	990 m	145.5 dB
915 MHz 2GFSK 50 kbps 25 kHz	19.5 dBm	-107.9 dBm	0.5 dB	2100 m	370 m	128.4 dB
915 MHz 2GFSK 100 kbps 50 kHz	19.5 dBm	-105.5 dBm	0.5 dB	1700 m	300 m	126 dB
915 MHz 2GFSK 500 kbps 175 kHz	19.5 dBm	-98 dBm	0.5 dB	980 m	200 m	118.5 dB
2.4 GHz 2GFSK 250 kbps	19.5 dBm	-99 dBm	1-3dB	280 m	105 m	122.5 dB
2.4 GHz 2GFSK 1 Mbps	19.5 dBm	-93.1 dBm	1-3 dB	180 m	75 m	116.5 dB

Simplicity Studio

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