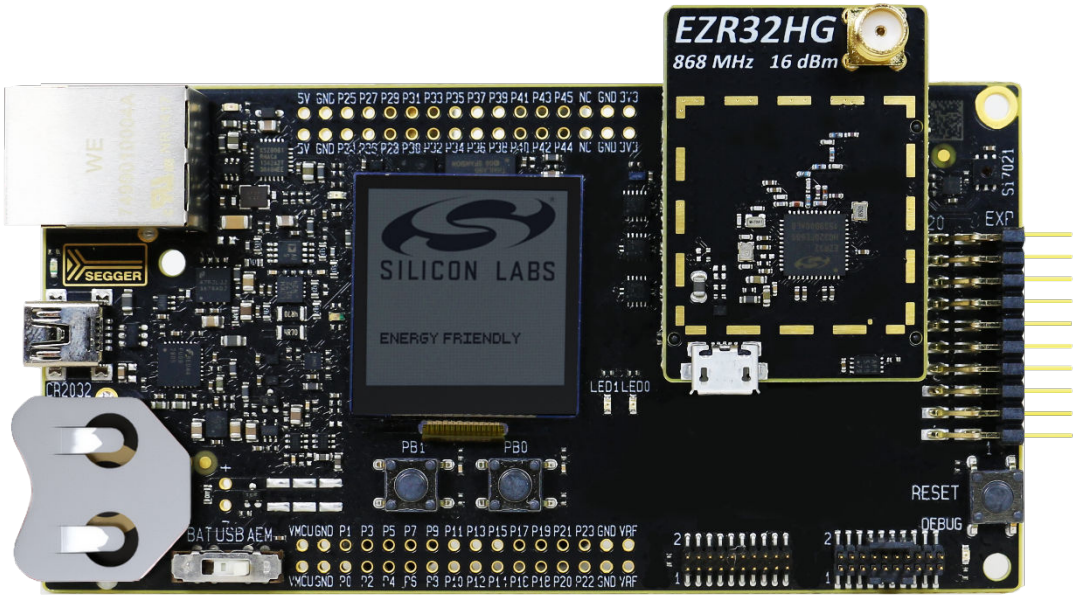
AN1004: RF Evaluation with EZR32

This document describes using the EZR32 sample codes for RF evaluation tests on EZR32 kits and on custom hardware equipped with EZR32.

KIT FEATURES

- Transmit tests with unmodulated carrier
- Transmit test with PN9 pseudorandom modulated signal
- BER measurement
- PER measurement



1. Using an Example

1.1 Opening an Example

All of the RF evaluation measurements start with opening an application.

Start Simplicity Studio™ and connect your board. You should see it under “Detected hardware”. Click on the Software Examples tile:

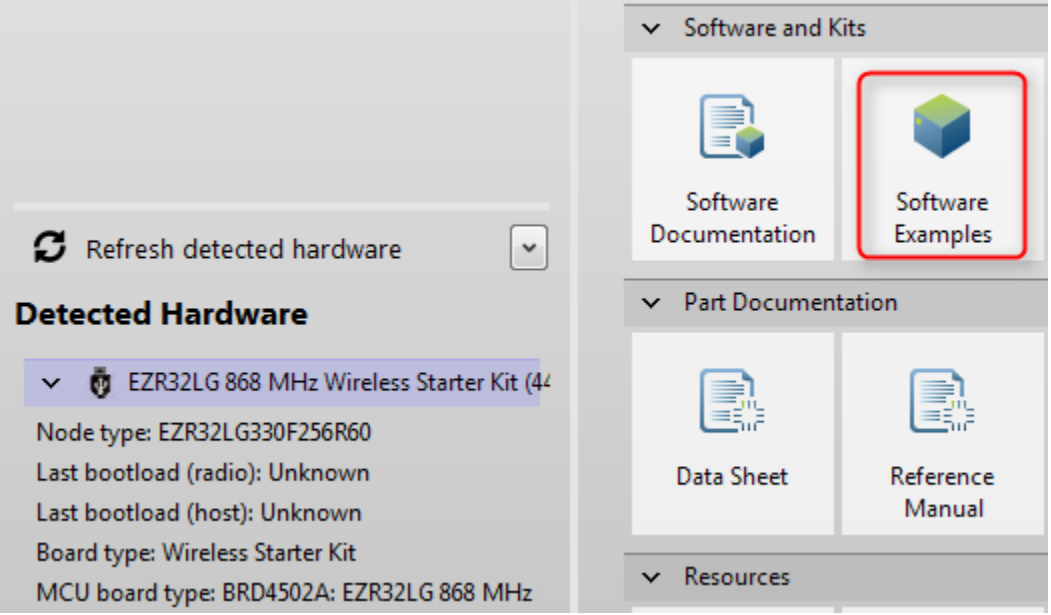


Figure 1.1. Software Examples

On the next screen, you can modify your kit, your MCU type, and the SDK, which should always be EFM32 SDK. If you detected your kit, it should automatically fill in the "Kit" and the "Part" parameters. If you want to test a custom hardware, see chapter 5. Testing with Custom Board.

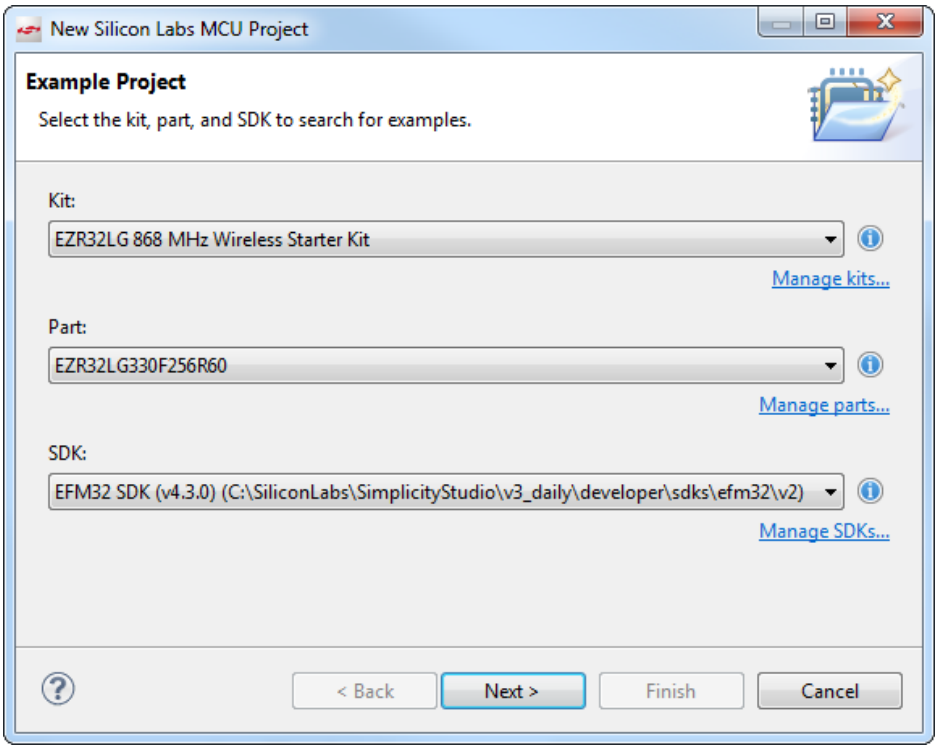


Figure 1.2. Example Project Hardware Configuration

On the next screen, you will see the available examples.

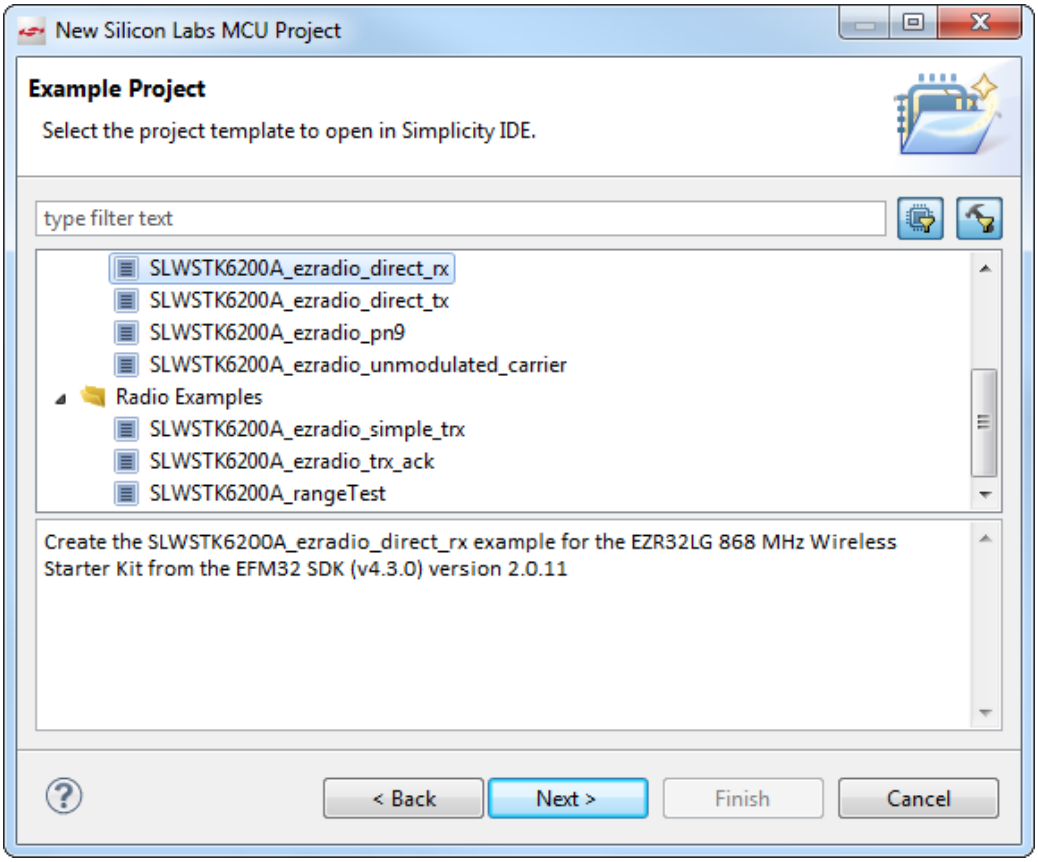


Figure 1.3. Example List

The important examples for RF performance measurement are:

- Direct RX, which is the base of BER measurement
- PN9, which implements a PN9 modulated transmission
- Unmodulated carrier, which transmits unmodulated carrier
- RangeTest, which is usable for PER measurements

Select any of these examples and click next. In the next windows, you can select the application name and the compiler toolchain. Generally, you don't have to modify anything there.

After Simplicity Studio generates the project, it switches to the Development perspective and opens the main.c automatically.

1.2 Modifying the Radio Configuration

All EZR32 projects provide a GUI-based radio configuration option, where you can set up the radio. The radio configurator is located in the RadioConfig folder and is called "radio-configurator_SLWSTK62xxA.isc".

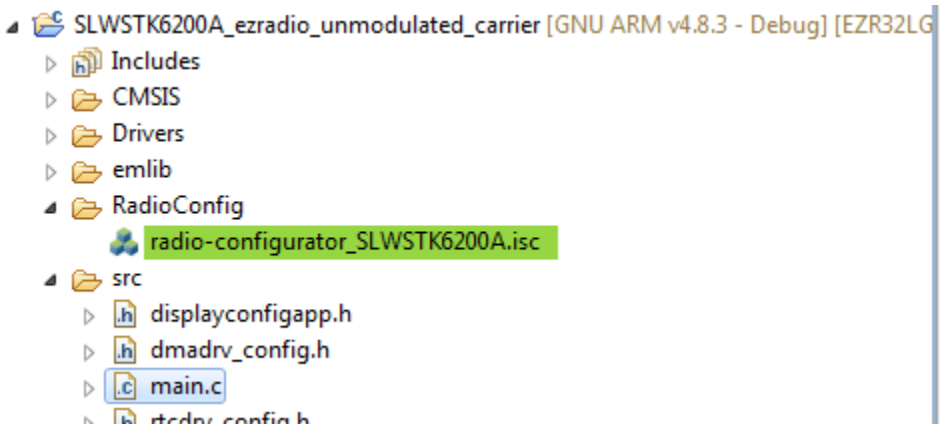


Figure 1.4. Radio Configurator ISC

The radio configurator is built up from sections. Some of the important sections for RF evaluation are:

- Frequency: The carrier frequency can be modified here
- Crystal: You can set the crystal parameters and the load capacitance here
- RF parameters: The modulation parameters can be modified here (PN9, DirectRX, and RangeTest only)
- Packet configuration: You can set the packet configuration and the per-field modulation settings here (RangeTest only)
- GPIOs: You can set the behavior of the radio's four GPIOs

After you set up the configuration, click the Generate button in the upper right corner to modify the project.

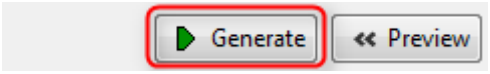


Figure 1.5. Generate Button

It will show a notification window with the generated files (if this is not the first time you generate headers, it will ask permission to overwrite files).

The most important generated file is **radio-config-wds-gen.h**, which holds the actual configuration for the radio.

1.3 Uploading the project

The easiest way to upload your application is to start debugging it. To do so, click on the Debug button. This will also build your application if it is not built yet.

Figure 1.6. Debug Button

After successfully uploading your application, Studio will automatically switch to the Debug perspective, suspended before the first line of the main function. To start the program, click on the Resume button.

Figure 1.7. Resume Button

To exit from debug mode, click on the Disconnect button.

Figure 1.8. Disconnect Button

2. Transmit Tests

An unmodulated carrier can be used to measure output power, phase noise, and spurious emission (harmonics). PN9 is useful for measuring spectrum emission.

On the software side, these tests are pretty similar.

Open the Unmodulated carrier or PN9 sample application and open its radio configurator.

You probably want to configure the carrier frequency and the crystal parameters under the "Frequency" and "Crystal" sections, respectively:

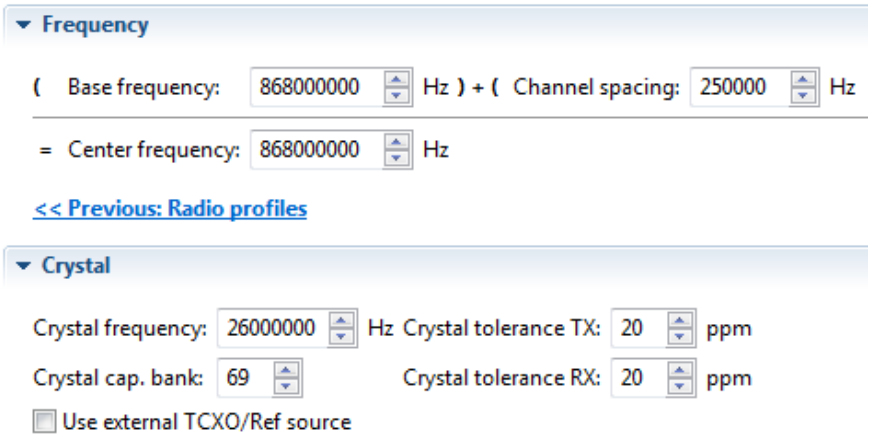


Figure 2.1. Frequency and Crystal Configuration

Set up the PA level and mode under the "Power amplifier (PA)" section:

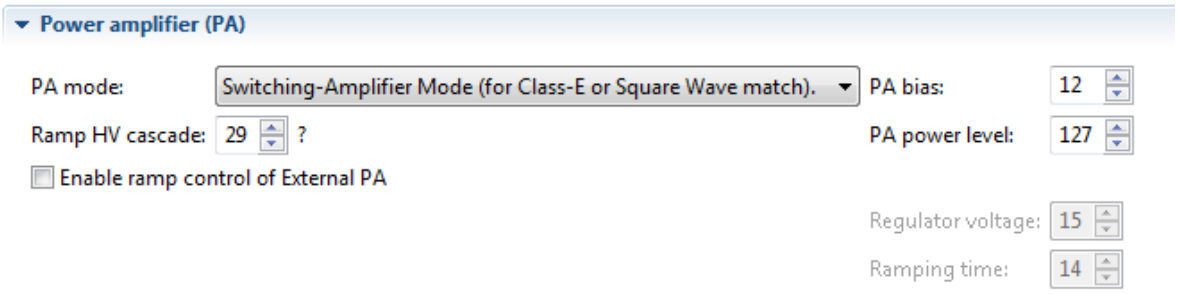


Figure 2.2. Power Amplifier Configuration

For a PN9 sequence, set up the modulation type, data rate, and deviation under the "RF parameters" section.

Figure 2.3. Modulation Configuration

Once you set up everything, generate the configuration and upload the project (see the previous chapter for details).

You should see the following on the WSTK:

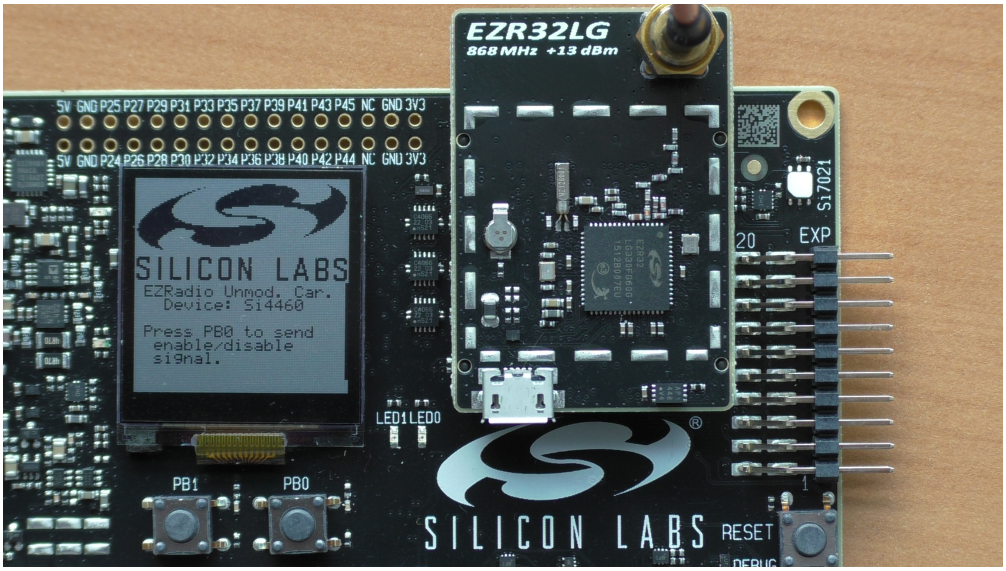


Figure 2.4. Unmodulated Carrier Example Running on a WSTK

As it says on the display, press PB0 to enable/disable the signal. When the signal is enabled, you should see “CW/PN9 signal: ON” on the bottom of the display.

3. BER Measurement with DirectRX

3.1 Set up the Configuration

The BER test can be used to establish baseline sensitivity, selectivity, and blocking performance of the receiver.

Note: Frequency offset and DR offset parameters cannot be measured in BER test mode; for those parameters, run PER tests.

Open the DirectRX example, and open its radio configurator. Set up the RF parameters for the frequency and crystal configurations as described in the previous chapter. Make sure to check “Enable BER mode”. This mode creates a configuration for testing BER performance on a PN9 test sequence.

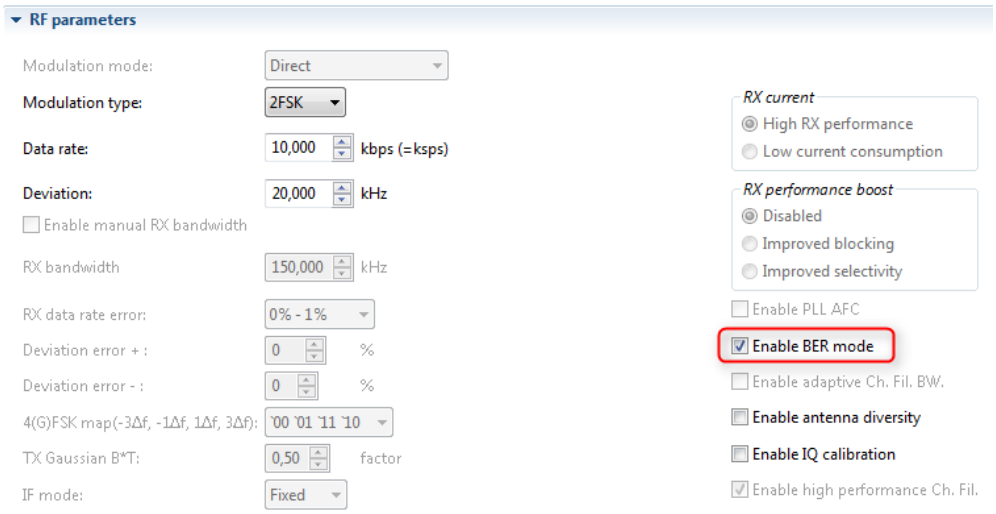


Figure 3.1. BER Mode Setting

For BER testing, you want to wire out the demodulated signal to a pin. This can be done under the "GPIOs" section:

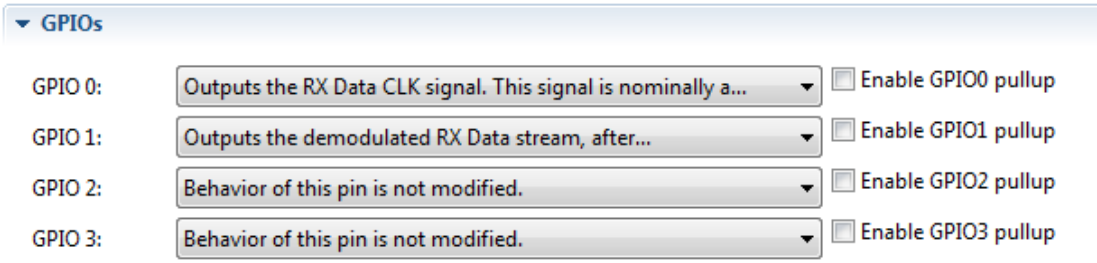


Figure 3.2. GPIO Configuration for BER Measurement

Note that you cannot use GPIO on **all** of the boards. On boards with switched matching, GPIO2 and GPIO3 are used to control the RF switch.

GPIO0 and GPIO1 are not directly connected to a pin on the EZR32LG and EZR32WG parts. Using these pins is possible, but it will require a small code modification described in chapter 3.2 Using GPIO0 and GPIO1 on EZR32LG or EZR32WG.

After you set up everything, generate the configuration.

3.2 Using GPIO0 and GPIO1 on EZR32LG or EZR32WG

On EZR32LG and EZR32WG, GPIO0 and GPIO1 are not wired directly to the pin. To use them with an instrument, you will have to set up PRS channels in the EZRadio driver. To enable it, add the following code to the end of the function `GpioSetup` in main.c:

```
/* Setup PRS for PTI pins */
CMU_ClockEnable(cmuClock_PRS, true);

/* Configure RF_GPIO0 and RF_GPIO1 to inputs. */
GPIO_PinModeSet((GPIO_Port_TypeDef)RF_GPIO0_PORT, RF_GPIO0_PIN, gpioModeInput, 0);
GPIO_PinModeSet((GPIO_Port_TypeDef)RF_GPIO1_PORT, RF_GPIO1_PIN, gpioModeInput, 0);

/* Pin PA0 and PA1 output the GPIO0 and GPIO1 via PRS to PTI */
GPIO_PinModeSet(gpioPortA, 0, gpioModePushPull, 0);
GPIO_PinModeSet(gpioPortA, 1, gpioModePushPull, 0);

/* Disable INT for PRS channels */
GPIO_IntConfig((GPIO_Port_TypeDef)RF_GPIO0_PORT, RF_GPIO0_PIN, false, false, false);
GPIO_IntConfig((GPIO_Port_TypeDef)RF_GPIO1_PORT, RF_GPIO1_PIN, false, false, false);

/* Setup PRS for RF GPIO pins */
PRS_SourceAsyncSignalSet(0, PRS_CH_CTRL_SOURCESEL_GPIOH, PRS_CH_CTRL_SIGSEL_GPIOPIN15);
PRS_SourceAsyncSignalSet(1, PRS_CH_CTRL_SOURCESEL_GPIOH, PRS_CH_CTRL_SIGSEL_GPIOPIN14);
PRS->ROUTE = (PRS_ROUTE_CH0PEN | PRS_ROUTE_CH1PEN);

/* Make sure PRS sensing is enabled (should be by default) */
GPIO_InputSenseSet(GPIO_INSENSE_PRS, GPIO_INSENSE_PRS);
```

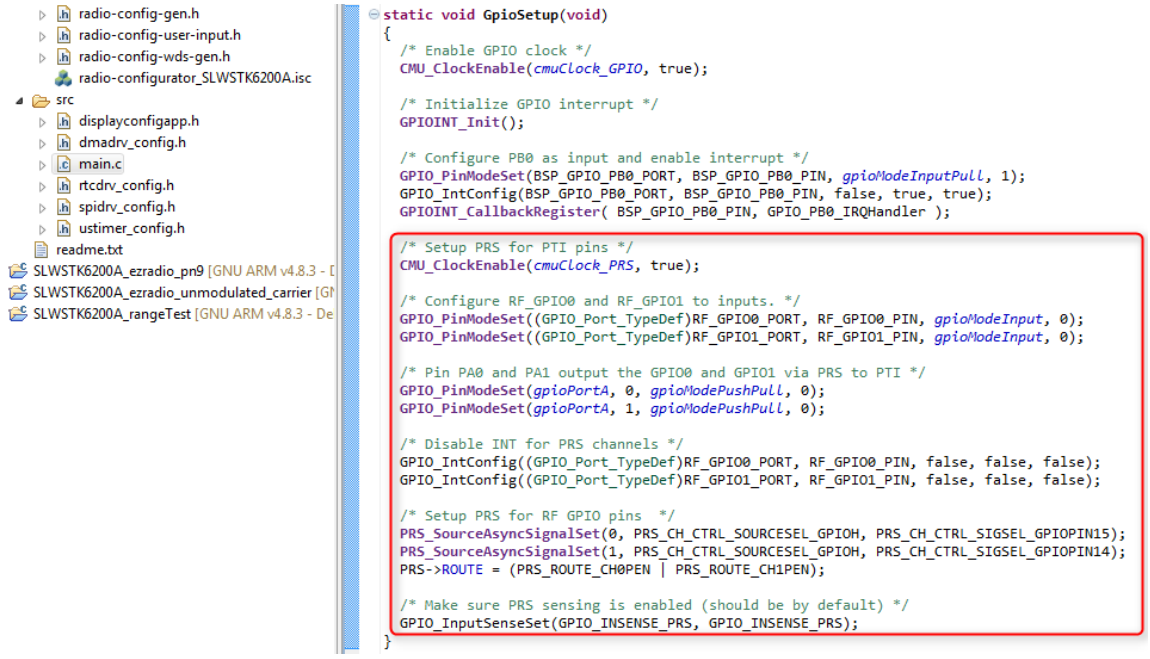


Figure 3.3. Enabling PRS Channels

3.3 Using the Sample Application for Measurements

Once you set up everything, upload the configured sample application. Use the following table to locate the GPIOs where you can access the demodulated data stream:

Table 3.1. Radio GPIO Locations

Radio GPIO	MCU pin EZR32WG/EZR32LG	MCU pin EZR32HG	WSTK pin
GPIO0	PA0/pin10 (through PRS)	GPIO0/pin25	P30
GPIO1	PA1/pin11 (through PRS)	GPIO1/pin26	P31
GPIO2	GPIO2/pin63	GPIO2/pin15	P32
GPIO3	GPIO3/pin64	GPIO3/pin16	P33

After you have uploaded the application, you should see something like this:

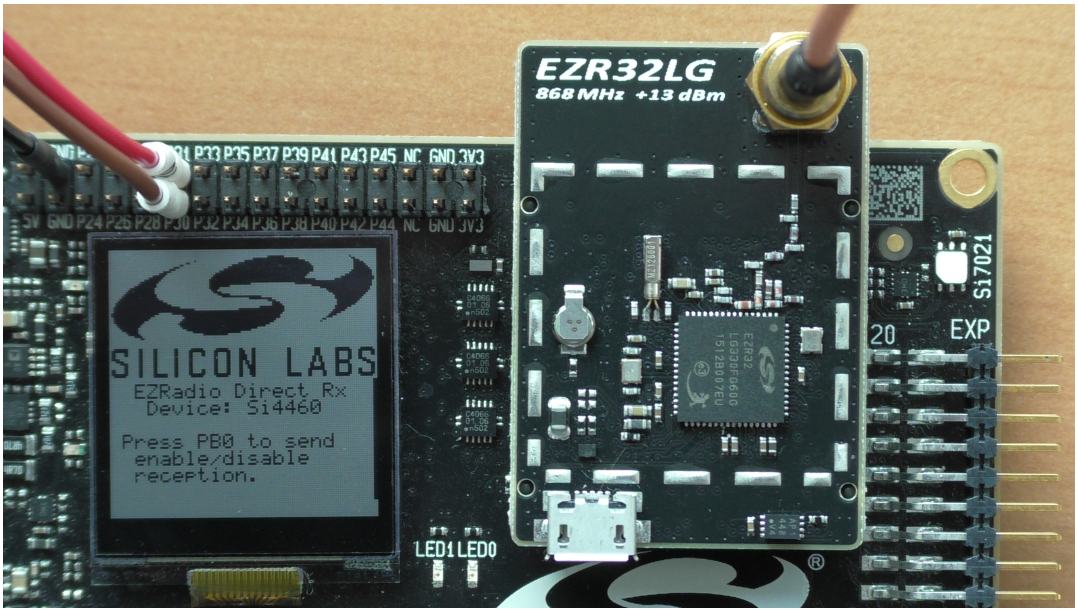


Figure 3.4. DirectRX Example Running on a WSTK

As it says on the display, press PB0 to enable/disable reception. When reception is enabled, you should see “Direct receive is ON” on the bottom of the display.

4. Using RangeTest for PER Measurement

The PER (packet error rate) measurement is useful for determining the RF performance in an application.

Note: RangeTest is not yet available for parts equipped with Si4467 or Si4468 radios.

Open the RangeTest example, and then open its radio configurator. Set up the frequency and crystal configurations similarly to the PN9 test. When setting up the RF parameters, note that you have many more options than you had in DirectRX mode, since this is a packet-based configuration.

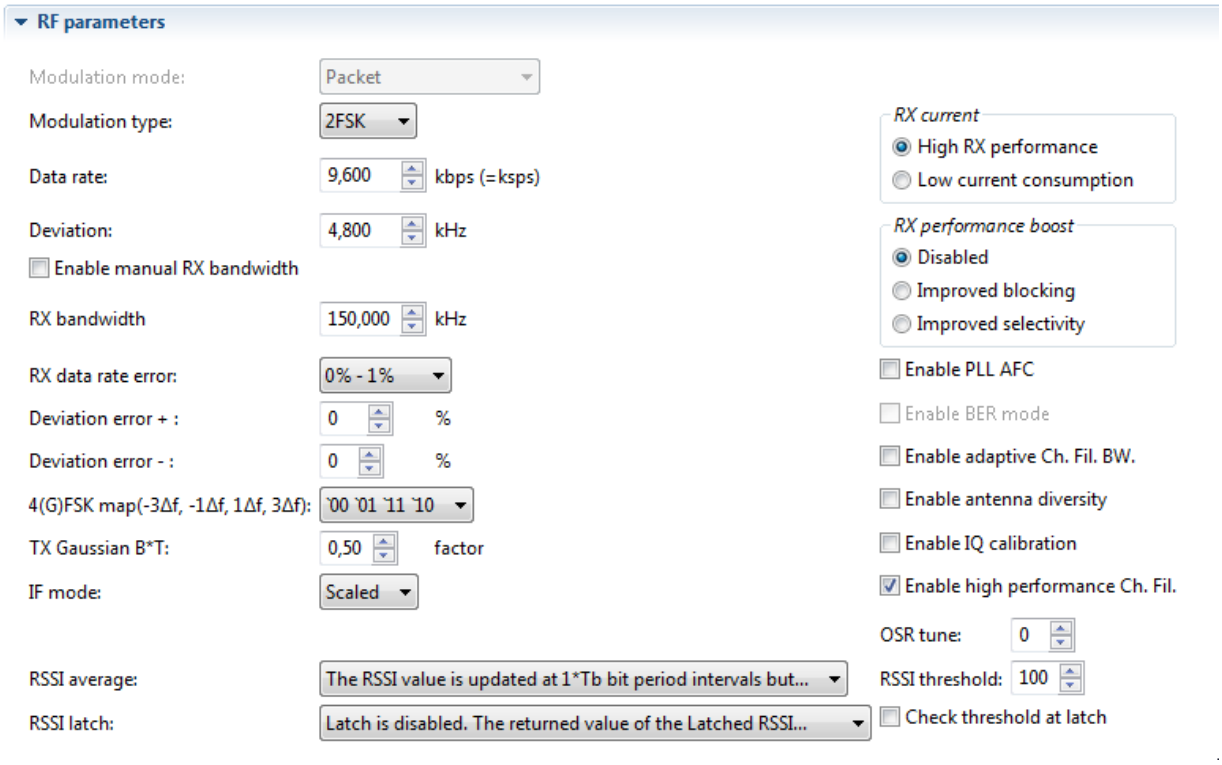


Figure 4.1. RF Configuration

Next, set up the packet configuration, according to your requirements:

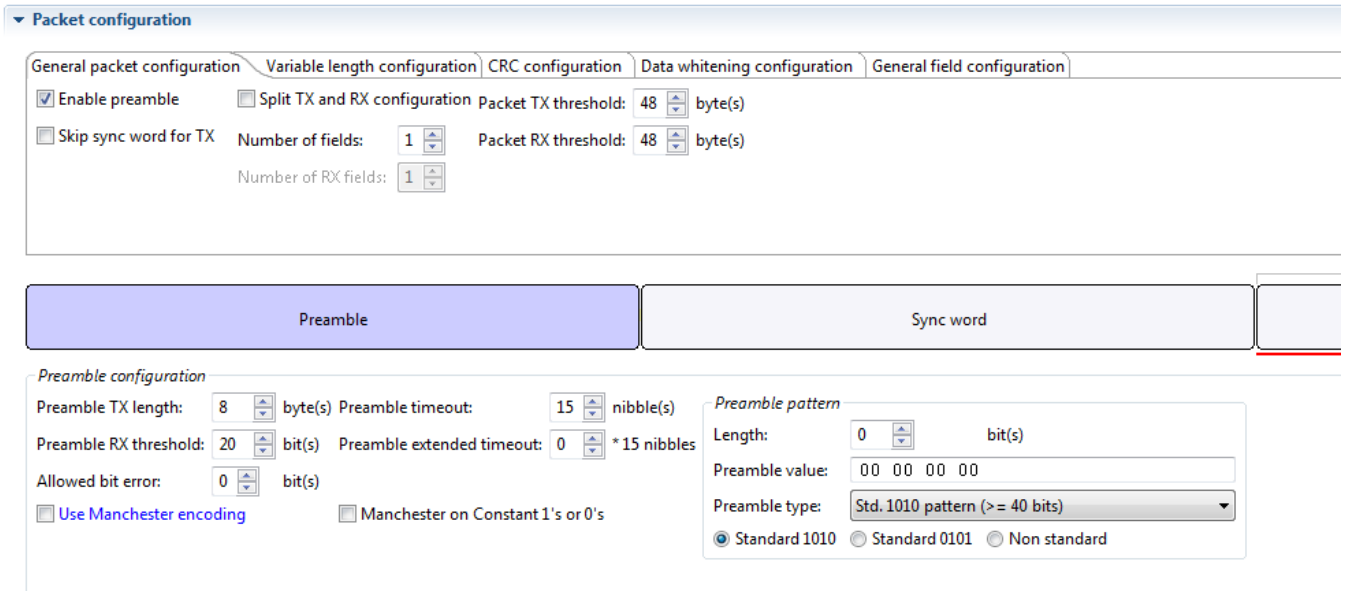


Figure 4.2. Packet Configuration

Then generate the configuration and upload the sample application to your board.

On the usage of the RangeTest application, refer to chapters 2, 3 and 4 of the user guide, "UG147: Flex Gecko 2.4 GHz, 20 dBm Range Test Demo User's Guide". Thiat application is basically the same as the one described here, but on a different platform.

5. Testing with Custom Board

These tests are usable on any board, but you will have to remove the WSTK user interface to use them.

5.1 Starting with the Right Sample

These examples do not use any board specific features, so the only important thing is to select the example for your MCU type (EZR32HG, EZR32LG or EZR32WG). Note that all MCUs have two main types: EZR32xx3yy with USB and EZR32xx2yy without USB. All kits have the USB enabled parts. Since these examples do not use the USB, you can use them on any EZR32xx2yy part. Studio will give you a warning before uploading, but you can safely ignore it.

5.2 Radio Configuration

When you have opened the project and the radio configurator, select the part you have under the section "Application configuration":

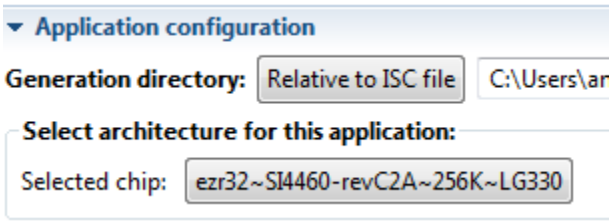


Figure 5.1. Part Selection in Radio Configurator

Otherwise, the radio configuration is exactly the same as the radio configuration with the kits.

5.3 Unmodulated Carrier

Replace the contents of the provided main.c with the following:

```
#include "em_chip.h"
#include "ezradio_cmd.h"
#include "ezradio_plugin_manager.h"
#include "em_cmu.h"

int main(void)
{
  EZRADIODRV_HandleData_t appRadioInitData = EZRADIODRV_INIT_DEFAULT;
  EZRADIODRV_Handle_t appRadioHandle = &appRadioInitData;
  CHIP_Init();
  CMU_ClockEnable(cmuClock_GPIO, true);
  ezradioInit( appRadioHandle );
  ezradioStartUnmodulatedCarrier( appRadioHandle );
}
```

5.4 PN9

Replace the contents of the provided main.c with the following:

```
#include "em_chip.h"
#include "ezradio_cmd.h"
#include "ezradio_plugin_manager.h"

int main(void)
{
 EZRADIODRV_HandleData_t appRadioInitData = EZRADIODRV_INIT_DEFAULT;
 EZRADIODRV_Handle_t appRadioHandle = &appRadioInitData;
 CHIP_Init();
 ezradioInit( appRadioHandle );
 ezradioStartPN9( appRadioHandle );
}
```

5.5 DirectRX (BER)

Replace the contents of the provided main.c with the following:

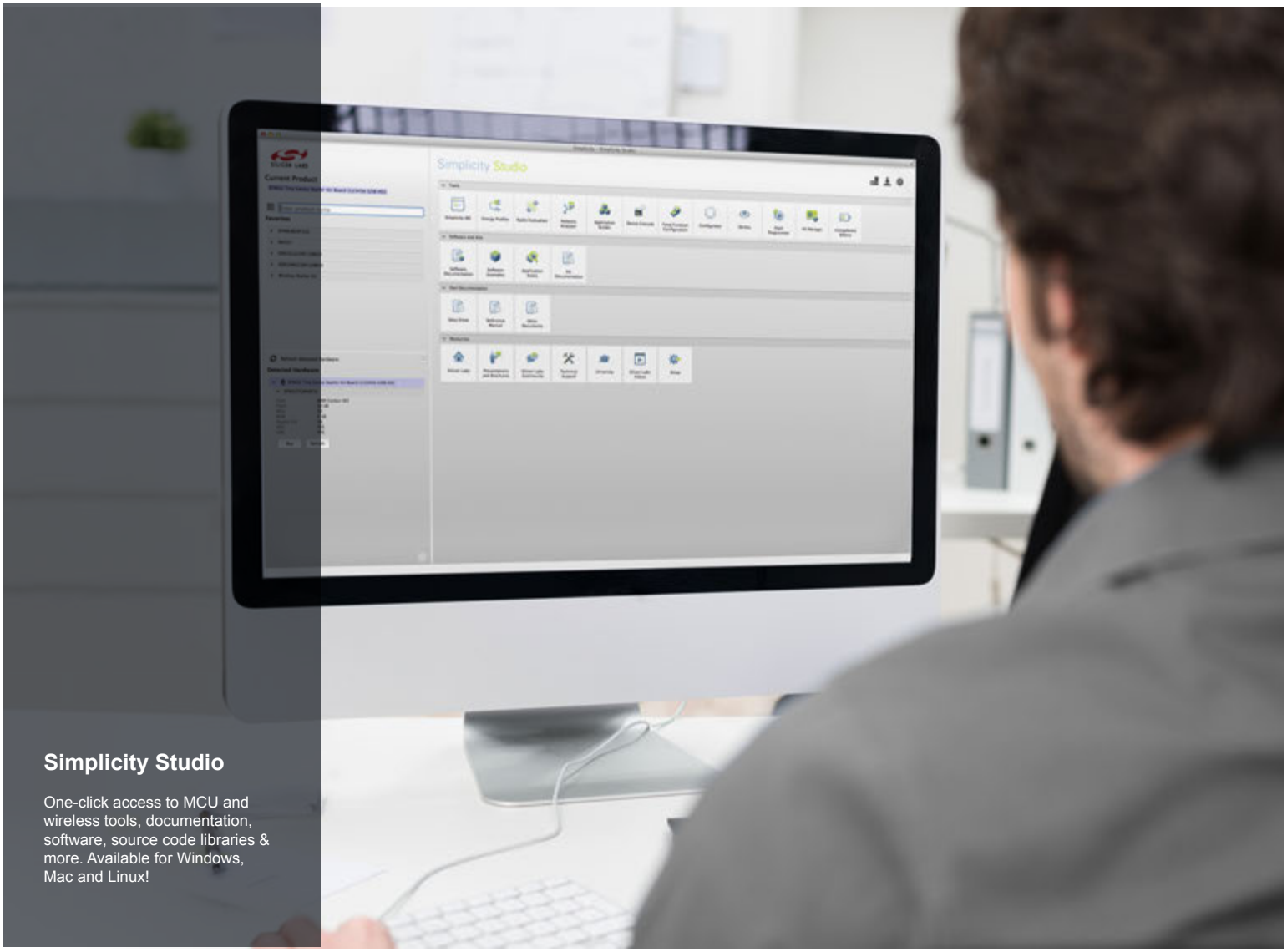
```
#include "em_chip.h"
#include "em_cmu.h"
#include "ezradio_cmd.h"
#include "ezradio_plugin_manager.h"

int main(void)
{
 EZRADIODRV_HandleData_t appRadioInitData = EZRADIODRV_INIT_DEFAULT;
 EZRADIODRV_Handle_t appRadioHandle = &appRadioInitData;
 CHIP_Init();
 CMU_ClockEnable(cmuClock_GPIO, true);
 ezradioInit( appRadioHandle );
 ezradioStartDirectReceive( appRadioHandle );
}
```

For the EZR32LG and EZR32WG, it is recommended that you enable the PRS channels for GPIO0 and 1:

```
#include "em_chip.h"
#include "ezradio_cmd.h"
#include "ezradio_plugin_manager.h"
#include "em_gpio.h"
#include "em_prs.h"
#include "em_cmu.h"

int main(void)
{
EZRADIODRV_HandleData_t appRadioInitData = EZRADIODRV_INIT_DEFAULT;
EZRADIODRV_Handle_t appRadioHandle = &appRadioInitData;
CHIP_Init();
CMU_ClockEnable(cmuClock_GPIO, true);

/* Setup PRS for PTI pins */
CMU_ClockEnable(cmuClock_PRS, true);

 /* Configure RF_GPIO0 and RF_GPIO1 to inputs. */
 GPIO_PinModeSet((GPIO_Port_TypeDef)RF_GPIO0_PORT, RF_GPIO0_PIN, gpioModeInput, 0);
 GPIO_PinModeSet((GPIO_Port_TypeDef)RF_GPIO1_PORT, RF_GPIO1_PIN, gpioModeInput, 0);

 /* Pin PA0 and PA1 output the GPIO0 and GPIO1 via PRS to PTI */
 GPIO_PinModeSet(gpioPortA, 0, gpioModePushPull, 0);
 GPIO_PinModeSet(gpioPortA, 1, gpioModePushPull, 0);

 /* Disable INT for PRS channels */
 GPIO_IntConfig((GPIO_Port_TypeDef)RF_GPIO0_PORT, RF_GPIO0_PIN, false, false, false);
 GPIO_IntConfig((GPIO_Port_TypeDef)RF_GPIO1_PORT, RF_GPIO1_PIN, false, false, false);

 /* Setup PRS for RF GPIO pins */
 PRS_SourceAsyncSignalSet(0, PRS_CH_CTRL_SOURCESEL_GPIOH, PRS_CH_CTRL_SIGSEL_GPIOPIN15);
 PRS_SourceAsyncSignalSet(1, PRS_CH_CTRL_SOURCESEL_GPIOH, PRS_CH_CTRL_SIGSEL_GPIOPIN14);
 PRS->ROUTE = (PRS_ROUTE_CH0PEN | PRS_ROUTE_CH1PEN);

 /* Make sure PRS sensing is enabled (should be by default) */
 GPIO_InputSenseSet(GPIO_INSENSE_PRS, GPIO_INSENSE_PRS);

 ezradioInit( appRadioHandle );
 ezradioStartDirectReceive( appRadioHandle );
}
```

5.6 RangeTest (PER)

Currently it is not possible to use RangeTest without the WSTK peripherals.



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