Radio Evaluation Demo for EZRadioPRO®

1. Introduction

The Radio Evaluation demo provides an easy way to evaluate the performances of the EZRadioPRO® devices. The demo can be used in the laboratory to measure the basic RF parameters of the radio (output power, sensitivity, etc.); however, it is mainly designed to evaluate radio performance through range testing.

A self explanatory, on-screen menu system walks the user through the radio configuration; so, the demo can be used in stand-alone mode without any PC.

2. Hardware Configuration

The demo is designed for the Si4030-B1, Si4031-B1, Si4032-B1, Si4330-B1, Si4430-B1, Si4431-B1, Si4432-B1, Si4330-A1, Si4430-A1, Si4431-A1, Si4432-V2, Si100x-B1, Si100x-B2, Si101x-B1, Si101x-B2, Si102x-B2, and Si103x-B2 devices and runs on the UDP platform. More devices will be supported in later versions of the demo.

2.1. Test Card and Pico Board Options

Test cards are provided for Si4x3x, Si100x, and Si101x devices. Pico boards are also provided for the Si102x and Si103x. The Si10xx family includes an MCU and a radio device.

The power amplifier and the LNA are not connected inside the Si4x3x and Si10xx devices. Several different test cards and Pico boards are introduced to provide examples for main connection schemes.

On test cards or Pico boards using direct-tie connection, the TX and RX pins are directly connected externally, eliminating the need for an RF switch.

On test cards or Pico boards using an RF switch, separate transmit and receive pins on the RFIC are connected to an antenna via an SPDT RF switch for single antenna operation. The radio device assists with control of the RF switch. By routing the RX State and TX State signals to any two GPIOs, the radio can automatically control the RF switch. The GPIOs disable the RF switch if the radio is not in active mode.

On test cards using split connection, the TX and RX pins are routed to different antenna connectors.

The actual antenna configuration of the test cards or Pico boards is stored in the EEPROM of each card. The demo automatically recognizes the antenna connections and sets the boards up accordingly. The user does not need to make these settings.

Note: The transmit output of Si4x3x and Si10xx devices must be terminated properly before output power is enabled. This is accomplished by using a proper antenna or connecting the power amplifier to an RF instrument that provides 50 Ω termination to ensure proper operation and protect the device from damage.

2.2. UDP Platform

The example source codes run on the Universal Development Platform (UDP). The UDP consists of several boards. Both the MCU card and the test card are plugged into the UDP Motherboard (UP-BACKPLANE-01EK). It provides the power supply and USB connectivity for the development system. The MCU card (UPMP-F960-EMIF-EK) has several peripherals for simple software development (e.g. LEDs, Push Buttons, etc.), and it has a socket for various MCU selections. The UPPI-F960-EK MCU Pico board is used for software development and has a C8051F960 MCU on it. It controls the radio on the test card using the SPI bus. The test card is connected to the 40-pin connector (J3) on the UDP Motherboard where the following signals are used (UDP_MB refers to UDP Motherboard, and MCU refers to the MCU of the UPMP-F960-EMIF card). Pico boards, such as the UPPI-1020GM-915TR, include the MCU and the radio. Its function is equal to the MCU card and the radio test card. For more information on the UDP platform, refer to the “UDP Motherboard User's Guide”.

Table 1. Pin Configuration of Si4x3x

Si4x3x			UDP Platform
Pin Number	**Pin Name**	**Pin Function**	**Pin Name**
Exposed pad	GND	Ground	Ground
1,12	VDD	Supply input	PWR_RADIO through UDP_MB-J21
17	NIRQ	Interrupt output, active low	MCU/P1.6
20	SDN	Shutdown input, active high	MCU/P1.7
16	NSEL	SPI select input	MCU/P2.3
15	SCLK	SPI clock input	MCU/P2.0
14	SDI	SPI data input	MCU/P2.2
13	SDO	SPI data output	MCU/P2.1

Table 2. Pin Configuration of Si102x

Si102x			UDP Platform
Pin Number	**Pin Name**	**Pin Function**	**Pin Name**
D2, D6, B16, B17, A32, B28	GND	Ground	Ground
A17, A25	VDD	Supply input	PWR_RADIO through UDP_MB-J21
B11	NIRQ	Interrupt output, active low	MCU/P1.6
A15	SDN	Shutdown input, active high	MCU/P1.7
/	NSEL	SPI select input	MCU/P2.3
/	SCLK	SPI clock input	MCU/P2.0
/	SDI	SPI data input	MCU/P2.2
/	SDO	SPI data output	MCU/P2.1

2.2.1. Setting up the Development Board

Before running the demo, the UDP platform must be configured according to the following instructions:

If the test card is used:

1. Connect the Si4x3x Test card to the 40-pin (J3) connector.
2. Connect the antenna(s) to the SMA connector(s) of the test card.
3. Set S5 to OFF to disable the 6.5 V voltage on Pin 36 of the test card connector.
4. Short the JP19 and JP21 jumpers as shown in Figure 1 to provide VDD for the radio (the current consumption of the radio can be measured through these jumpers).
5. Short P12(P0.4 and P0.5) on the UPMP-F960-EMIF card.

Figure 1. Jumper Positions (JP19, JP21)

If the Pico board is used:

1. Plug the Pico board into the socket of the UPMP-F960-EMIF card.
2. Connect the antenna(s) to the SMA connector(s) of the Pico board.
3. Short P12(P0.4 and P0.5) on the UPMP-F960-EMIF card.

2.2.2. Downloading and Running the Demo

If the setup is programmed with a different firmware, perform the following steps to set up the board for running the demo:

1. Connect the USB debug adapter to the 10-pin J13 connector of the MCU card (see Figure 2).
2. To power the board, connect a 9 V dc power supply to J20 (UDP_MB), or connect the development board to a PC over USB cable (J16 on UDP_MB).
3. Turn on S3 on UDP_MB (Power switch).
4. Start Silicon Labs IDE on your computer.
5. Connect the IDE to the C8051F960 MCU (if test card is used) or Si102x, Si103x (if Pico boards is used) of the development board by pressing the Connect button on the toolbar or by invoking the menu Debug → Connect menu item.
6. Erase the flash of the C8051F960 MCU or Si10xx in the Debug. Download object code → Erase all code space menu item.
7. Download the desired example HEX file either by hitting the Download code (Alt+D) toolbar button or from the Debug → Download object code menu item.
8. Hit the Disconnect toolbar button or invoke the Debug → Disconnect menu item to release the device from halt and let it run.

Figure 2. J13 Connector of the MCU Card

3. Demo

After running the demo, the first screen is the Welcome Screen, which shows the version number of the firmware. The Welcome Screen is shown for up to three seconds or as long as any of the push buttons is pressed.

Figure 3. Welcome Screen

3.1. Menu System

The on-screen menu system is designed for easy configuration. The user can select between laboratory and range test mode. For accurate range testing, the demo measures the actual packet error rate (PER) of the radio link. The RF settings of the radio can be configured based on predefined data rate, modulation, and frequency settings. It is also possible to change the packet configuration and the output power of the radio.

Four push buttons are used to navigate in the menu system, and soft labels help the user understand the current function of the given buttons. In general, push button 1 (PB1) is used to select an item; push buttons 2 (PB2) and 3 (PB3) are used to scroll between the menu options, and push button 4 (PB4) is used to go to the next menu page. A small arrow (→) points to the actual setting.

The demo can be configured through four menu pages. The first page is used to select the functionality of the demo (packet error rate test or laboratory modes). The range test can be performed for single-way (Transmit or Receive mode) or bidirectional (Transceiver mode) radio communication.

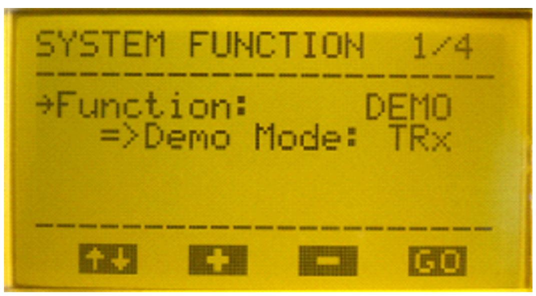

Figure 4. Range Test Demo Mode

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In laboratory mode, the following tests are available:

- Unmodulated carrier (CW) mode is used to measure the output power of the radio.
- Random modulated (PN9) mode is used to verify the modulated output power.
- Bite Error Rate (BER) mode is used to measure the sensitivity of the radio with a continuous PN9 modulated data stream.
- Packet Error Rate (PER) mode is used to measure the sensitivity of the radio based on packet reception.
- In Direct Receive (RAW RX) mode, the received continuous data stream is provided on one of the GPIOs of the radio.

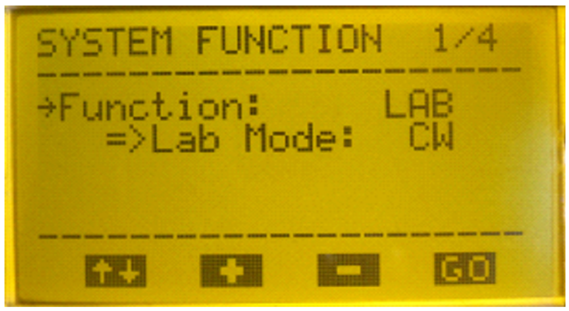

Figure 5. Laboratory Mode

The basic RF parameters (data rate, modulation, and frequency) can be selected from a predefined list on Menu Page 2. Most of the test cards or Pico boards are designed for a certain frequency band. There is an EEPROM on each test card or Pico board that contains this information. The demo offers only the available frequencies for which the test card or Pico board is designed.

The available RF settings vary for different frequency bands.

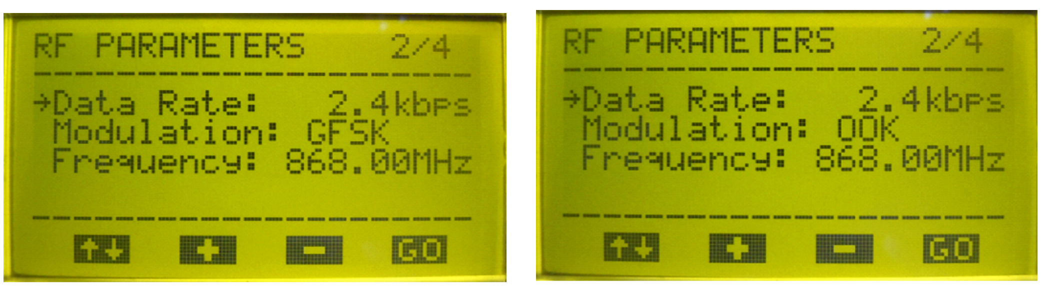

Figure 6. RF Parameters Settings for GFSK and OOK Mode

The menu page shown in Figure 7 is used to adjust the output power of the radio.

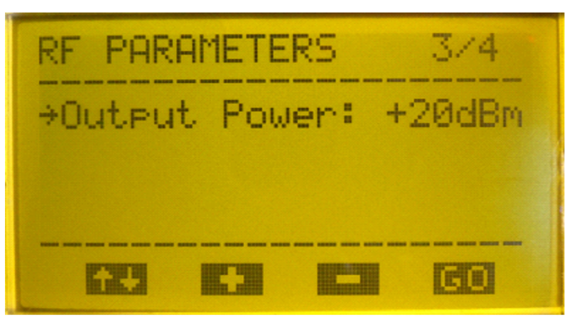

Figure 7. Output Power Setting

Menu Page 4 is used to configure the packet configuration of the Packet Error Rate demo. The Self ID field is filled automatically based on the serial number of the given test card or Pico board. It is important to set up the destination ID accurately or the link will not work. The destination ID has to be the self ID of the other device.

The default packet configuration of the demo is as follows:

1. Destination ID is the same as the Self ID.
2. Packet payload length is 5 bytes.
3. Max. packets is 1000 packets.

However, the length of the packet can be adjusted with the Packet Length option if the user wants to test the Packet Error Rate with a longer packet.

The “Max. Packets” option defines the number of packets to be sent during the test.

The Packet Length and the Max. Packet options must be configured only on the Transmit (initiator) side of the link and apply on the receive side automatically.

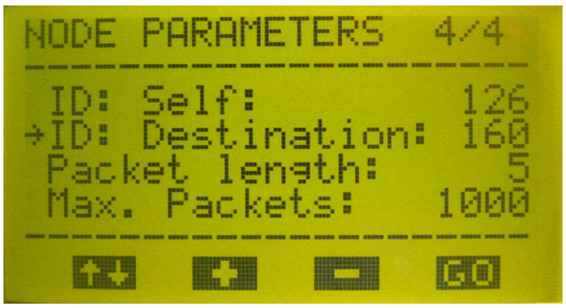

Figure 8. Packet Configuration

If RAW mode of Laboratory mode is selected, there are only two pages for the user to configure the chip. For information on the sections on Menu Pages 2 (Figure 9) and 3 (Figures 10 and 11), refer to “AN463: Raw Data Mode with EZRadioPRO”.

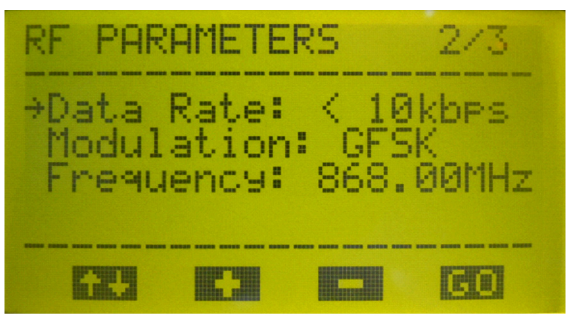

Figure 9. RF Parameters Setting

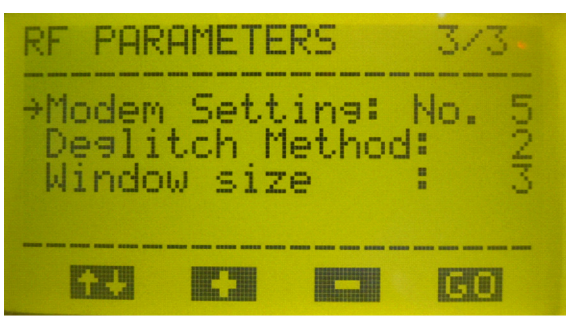

Figure 10. Software Algorithms Setting when Deglitch Method is 2

Figure 11. Software Algorithms Setting when Deglitch Method is 1

3.2. Bidirectional Range Test

After the demo is fully configured, it enters into the demo page, where the range test can be started.

The screen is divided into three sections. At the top of the page, soft labels show the functions of the LEDs. LED1 blinks when a packet is transmitted; LED2 blinks if a packet is successfully received (with valid CRC and packet content matching the expected value), and LED3 shows the actual Receive Signal Strength Level (RSSI) of the received packet on a bar graph.

The middle section of the screen, shown in Figure 12, summarizes the RF settings and the source/destination addresses.

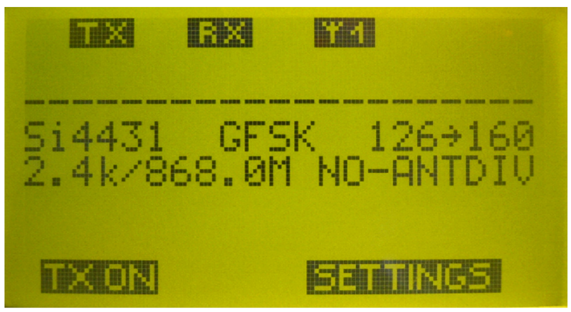

Figure 12. Demo Page

At the bottom of the screen, the soft labels show the actual functionality of the push buttons. PB3 and PB4 are used to go back to the configuration menu.

After entering Demo mode, both ends of the link are in receive mode. The test starts if one end of the link starts to transmit ping packets; it can be initiated by pressing PB1. After that, the originator transmits a ping packet for the second board. If it receives the packet correctly, it transmits an acknowledgement packet. Each ping packet has a serial number (increased by the originator after every packet transmission) that is transmitted back by the acknowledgement packet. If the originator receives the acknowledgement within a predefined timeout, then it considers the link to be working; otherwise, it increases the number of missed packets by one. The originator also stores the number of transmitted PING packets, so the demo can calculate the Packet Error Rate based on this information. These are updated on the sixth line of the LCD after each packet transmission (number of received ACK / number of sent packets, actual packet error rate in percent).

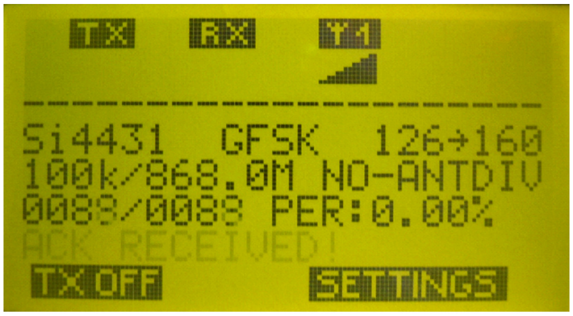

Figure 13. Running PER Test

The demo runs as long as the number of transmitted packets has reached the predefined number or until it is interrupted by PB1.

3.3. One-Way Range Test

The range test can also be performed with one-way radio communication. In this case, one end of the link needs to be set up as the transmitter (this will be the originator as described in the bidirectional link); the other end of the link needs to be the receiver.

The test needs start at the transmit side by pressing PB1. The test runs as long as the number of transmitted packets reaching the predefined number or the demo is interrupted by PB1. The user can follow the number of transmitted packets on the LCD.

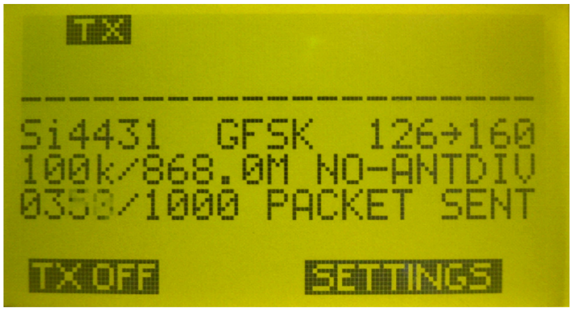

Figure 14. Transmit Node

The demo works the same as the bidirectional one; however, the number of lost packets and the packet error rate are defined only at the receive side based on the difference between the previously- and last-received packet IDs.

Figure 15. Receive Node

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3.4. Laboratory Modes

These modes can be used to fully evaluate the receiving and transmitting performances of the radio. Note that all the lab modes require RF test equipment, such as a spectrum analyzer and RF signal generator.

3.4.1. CW Mode

CW mode is used to test the output power of the test card and obverse the unmodulated carrier spectrum. In this mode, only the frequency and the output power are configurable parameters.

A spectrum analyzer is used to measure the transmit performances of the radio and must be connected through a proper RF cable to the TX SMA connector of the test card or Pico board.

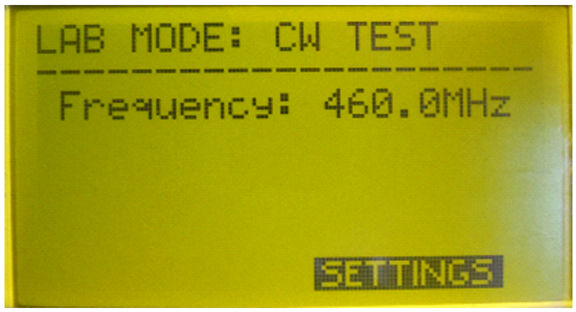


Figure 16. LCD Screen During CW Mode

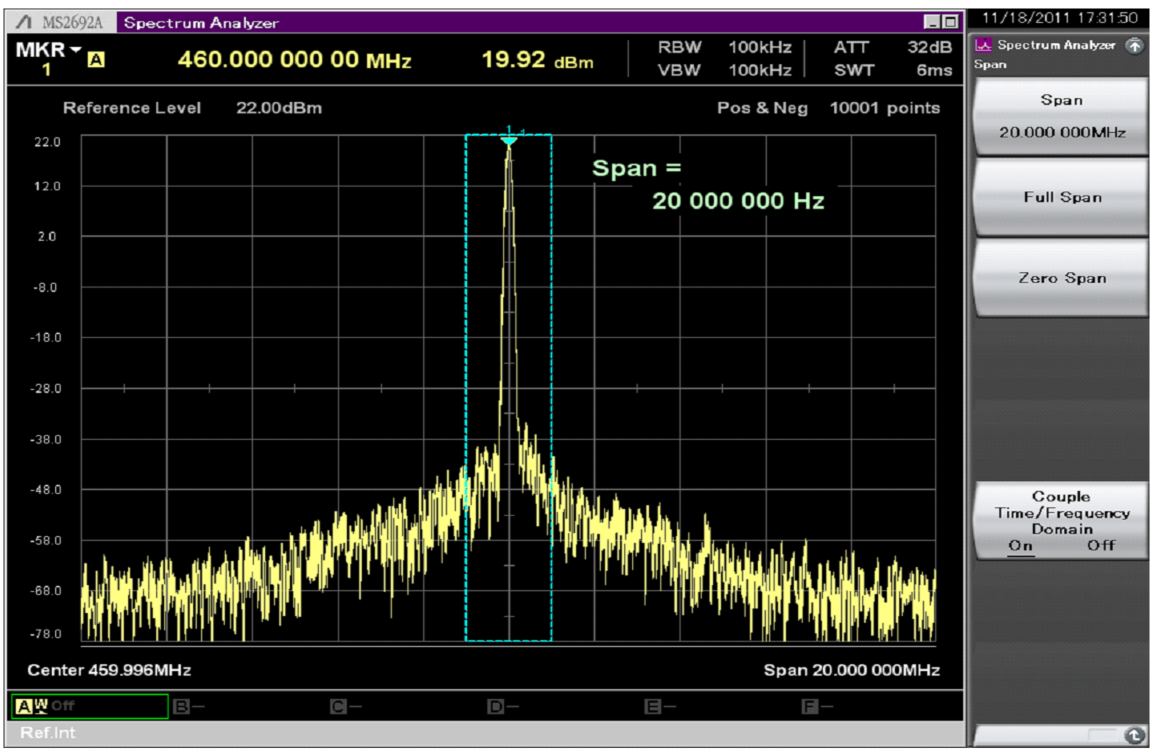


Figure 17. Unmodulated CW Signal Measured with Spectrum Analyzer

3.4.2. PN9 Mode

In this mode, the power amplifier of the radio is generated internally using a pseudo-random (PN9 sequence) bit generator. The primary purpose of this mode is to observe the modulated spectrum without having to provide data for the radio.

Figure 18 shows the last page of the PN9 mode, and Figure 18 shows the spectrum when the test card works in PN9 mode. The data rate is 256 kbps; the deviation is 128 kHz, and the modulation type is GFSK.

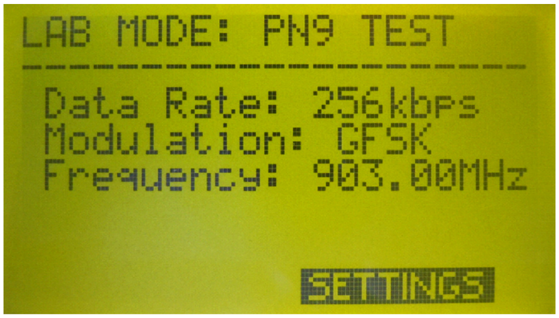


Figure 18. LCD Screen during PN9 Mode

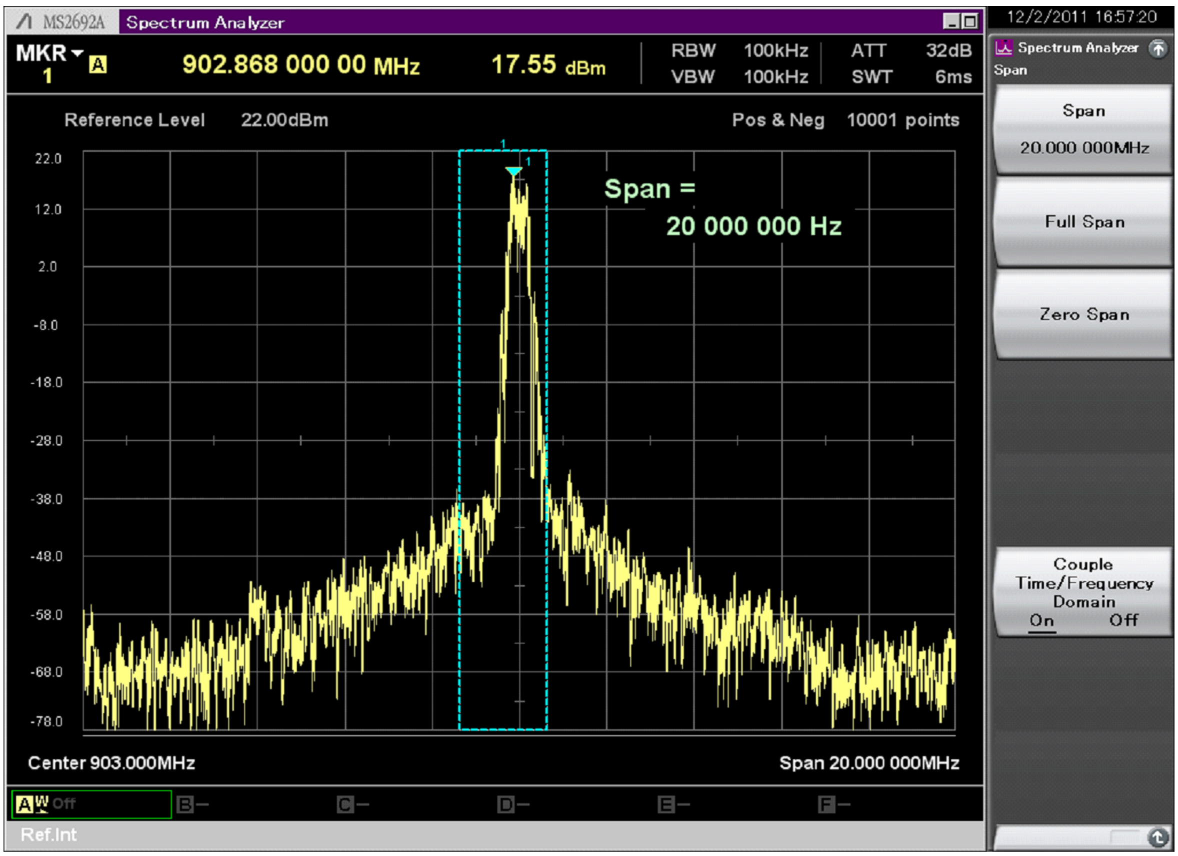


Figure 19. PN9 Modulated Signal (GFSK, 256 kbps Data Rate, ±128 kHz Deviation)

3.4.3. BER Mode

The sensitivity of the radio can be measured with a random continuous data stream (PN9). This mode is called bit error rate. The radio is set into continuous receive mode. The RF data needs to be fed to the RX SMA of the test card or Pico board, and the radio provides the received data and clock on its GPIOs. GPIO0 outputs the received data. The received data must be fed back to the RF signal generator, which can then compare the transmitted and received data bits and calculate the bit error rate. By adjusting the output power of the signal generator, the sensitivity of the radio can be measured (it is typically measured for 10–3 BER). The suggested hardware configuration is shown in Figure 20.

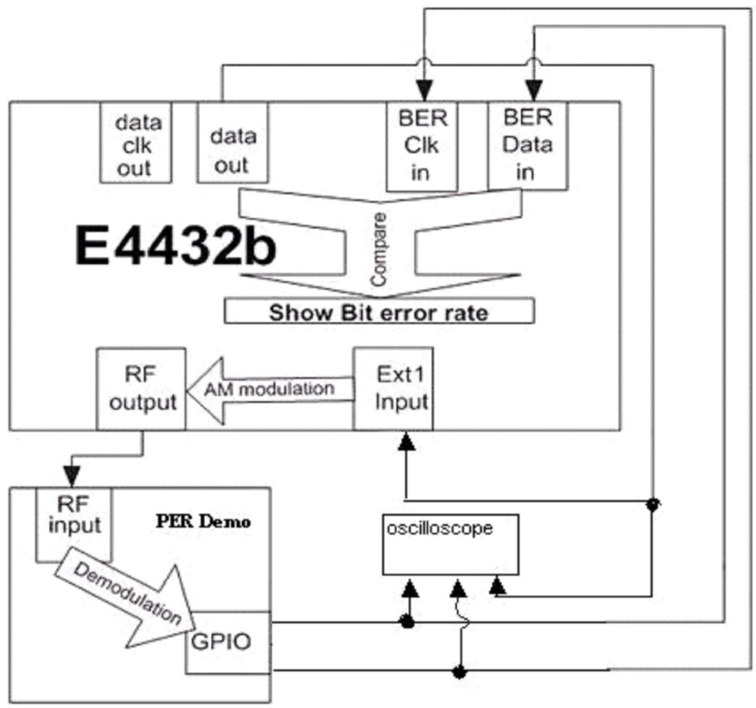


Figure 20. BER Measurement Setup

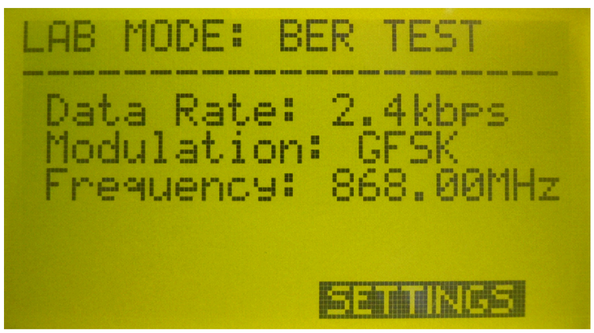


Figure 21. LCD Screen During BER Mode

3.4.4. PER Mode

The sensitivity of the radio can be measured by receiving packets. This test also involves an RF signal generator, which can transmit predefined packets after a trigger signal. In this mode, the radio is set to receive; then, the demo generates a trigger (falling edge on LED1). Upon receiving the trigger, the generator must send a packet. If the radio does not receive the packet within timeout, it increases the number of the missed packet counter and updates the PER information and the actual RSSI on the LCD screen. By adjusting the output power of the generator, the sensitivity of the radio can be determined. It is usually defined for a 1% or 20% packet error rate.

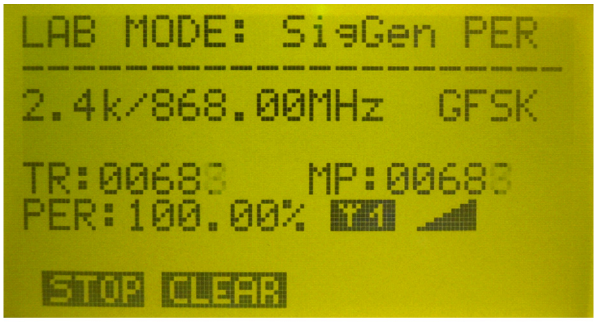


Figure 22. PER Test with Signal Generator

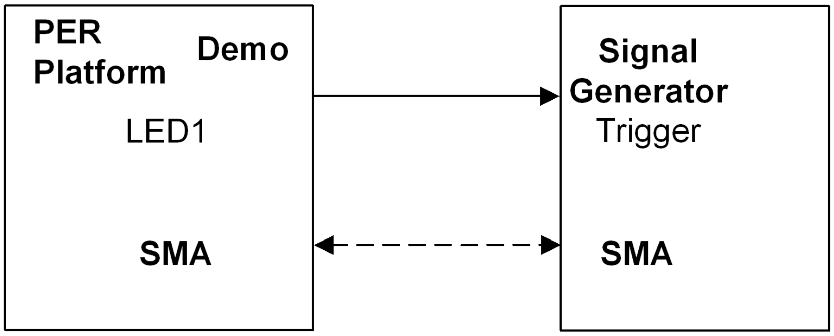


Figure 23. Packet Error Rate Measurement Setup

3.4.5. RX RAW Mode

The radio can be used to receive a continuous bit stream and provide this information on one of the GPIOs. The Si443x allows for the reception of any packet structure without the need to follow the recommended packet structure in the data sheet. Refer to “AN463: Raw Data Mode with EZRadioPRO” for more details. The RAW data mode is implemented here as one of the laboratory modes. During this mode, the demo is in continuous Receive mode and provides the received data bits on GPIO1 and the data clock on GPIO2. After the software algorithm filter, the glitch of the received data is removed, and the clear received data is provided on the PIEZO speaker, which is located on the right top of the LCD card.

Notes:

1. Because we provide received data on GPIO1 and data clock on GPIO2, the test cards or Pico boards using an RF switch cannot work in this mode.
2. R10, R11, R12, R15, R16, and R19 on the UPMP-F960-EMIF card should be configured correctly. R11, R15, and R19 should be connected, and R10, R12, and R16 should be disconnected.

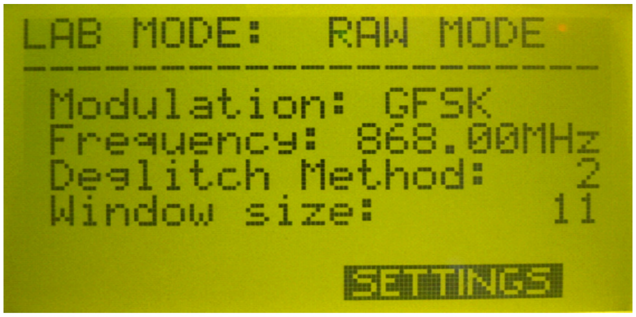
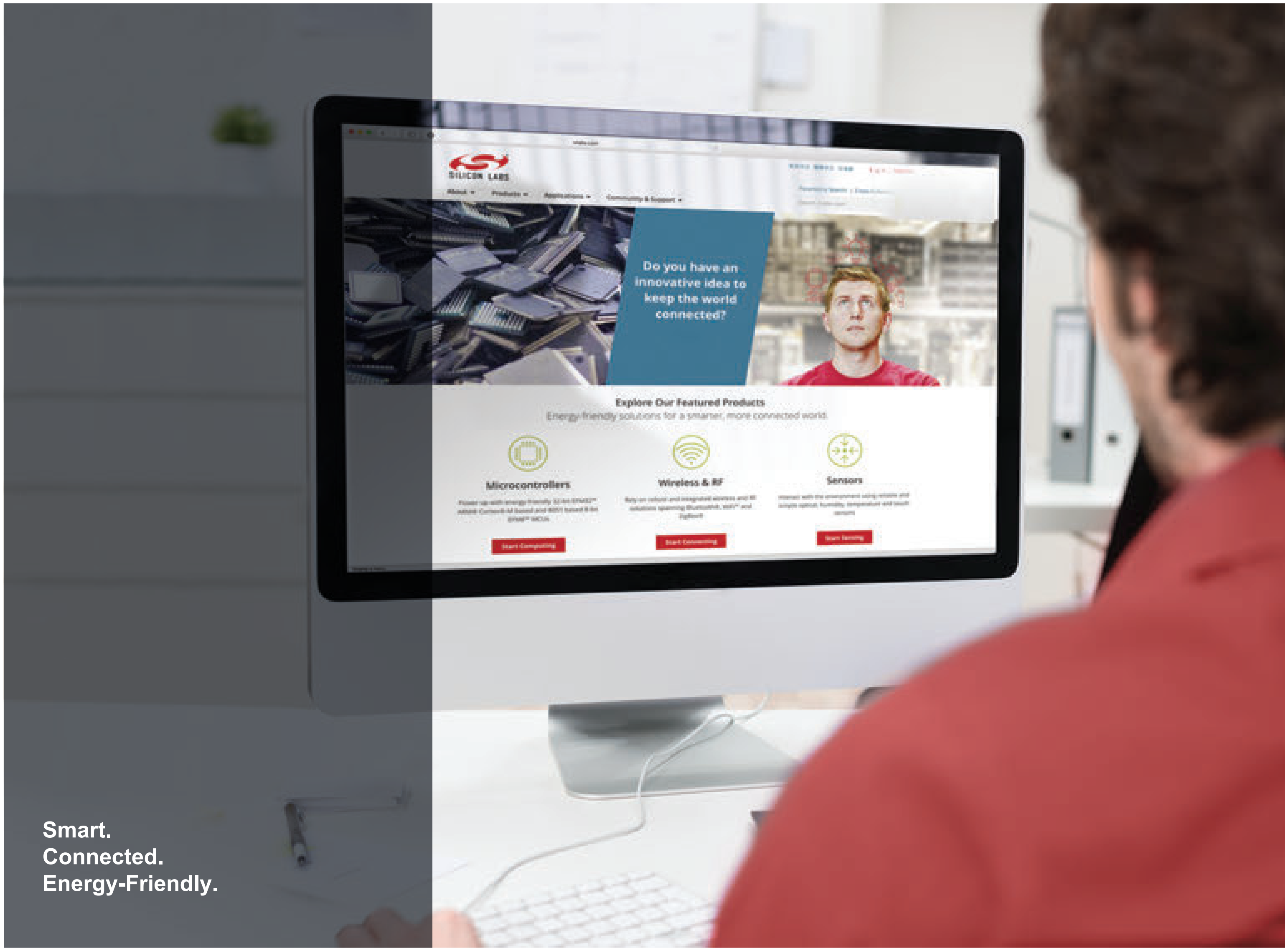


Figure 24. RX RAW Mode



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