

New Radio Utility Driver Program for Microchip MRF89XA Sub-GHz Wireless Transceiver

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INTRODUCTION

The New Radio Utility Driver Program for Microchip MRF89XA Transceiver provides design engineers and wireless application developers a development and testing platform for the MRF89XA RF transceiver. Microchip's MRF89XA Sub-GHz RF transceiver supports FSK, OOK modulations, and Frequency Hopping Spread Spectrum (FHSS) in 863-870 MHz, 902-928 MHz, and 950-960 MHz frequency bands. The MRF89XA transceiver conforms to Part 15.247 and Part 15.249 of the FCC regulatory standards. The MRF89XA Radio Utility Driver Program can be used to test the Transmit (TX), Receive (RX), and Sleep mode capabilities of the transceiver using different modulation schemes and spreading mechanisms.

The New Radio Utility Driver Program for Microchip MRF89XA Transceiver can run on either the PIC18 Explorer Development Board or the Explorer 16 Development Board, to which the MRF89XA module is interfaced via its PICtail™/PICtail Plus board. The development board is connected to the PC's serial port, and a simple terminal emulator (such as Tera Term)

program can be used as a user interface. For more information on setting up, refer to the **Section "Hardware Test Setup"**.

The New Radio Utility Driver Program for Microchip MRF89XA Transceiver application note is supported by relevant source code and corresponding hex files for evaluation and testing. The source code is supported on PIC18 (8-bit MCU) and PIC24 (16-bit MCU) platforms through the MPLAB® X IDE and the XC8 and XC16 compilers. For more details on the source code (firmware), see **Appendix A: "Source Code"**.

The New Radio Utility Driver Program for Microchip MRF89XA Transceiver supports features listed in [Table 1](#).

This application note provides users with the following functionalities:

- Test framework to check the functionalities of the MRF89XA transceiver
- Demonstration of MRF89XA and MCU-based wireless node
- MRF89XA radio and 8-bit/16-bit MCU connection interface
- Reference source code to initialize, configure, and manage MRF89XA radio and related functions
- Demo application and techniques to handle data transfers between two MRF89XA-based wireless nodes

TABLE 1: MRF89XA RADIO UTILITY DRIVER PROGRAM FEATURES

Feature	Functionality
Packet Analysis	Functions as a sniffer or packet analyzer, when the transceiver is programmed in Receive mode.
IEEE 802.15.4™ Specification Compliance	Transmits and receives packets compliant with the IEEE 802.15.4 specification.
All-Channel Energy Detection	Performs energy-detect scans on all channels.
Low-Power Testing	Enables testing of the MRF89XA RF transceiver in Sleep mode.
End-to-End Testing	Provides Packet Error Rate (PER) and Ping Pong testing between two transceivers.
Data Transfer Method	Packet, Buffered, and Continuous modes

HARDWARE TEST SETUP

The hardware interface of the Microchip Sub-GHz transceiver modules with any of the PIC® microcontrollers, generally known as Wireless Node, is illustrated in [Figure 1](#).

The wireless nodes can be realized using a combination of the PIC MCU development board and the MRF89XA PICtail/PICtail Plus Daughter Board.

The range and performance experiments require at least two wireless nodes for testing. The measurement setup is done using any of the two development boards with two identical Sub-GHz modules on each of them (for simplicity purpose). In this application note, the measurements are done using two identical RF nodes.

Note: Use MRF89XAM8A for all 800 MHz bands and MRF89XAM9A for 900 MHz bands.

Hardware Setup Requirements

The following hardware are used for the range and performance parameter tests with the Sub-GHz MRF89XA transceiver modules:

- Two MRF89XAM8A/MRF89XAM9A PICtail™/PICtail Plus Daughter Boards
- Any of the following Microchip hardware development platforms:
 - Two Explorer 16 Development Boards (Part number: DM240001)
 - Two PIC 18 Explorer Development Boards (Part number: DM183032)
- One of the following Microchip development tools for programming/debugging:
 - MPLAB® REAL ICE™ In-Circuit Emulator/ MPLAB® ICD 3/PICkit™ 3
 - ZENA™ Wireless Adapter: 868 MHz MRF89XA (AC182015-2) and 915 MHz MRF89XA (AC182015-3)
- Power supply: 9V/0.75A or equivalent battery pack

Note 1: Explorer 8 Development Board (part number: DM160228) can also be used in place of PIC18 Explorer Development Board.

2: Explorer 16/32 Development Board (part number: DM240001-2) can also be used in place of Explorer 16 Development Board.

Software/Utility Setup Requirements

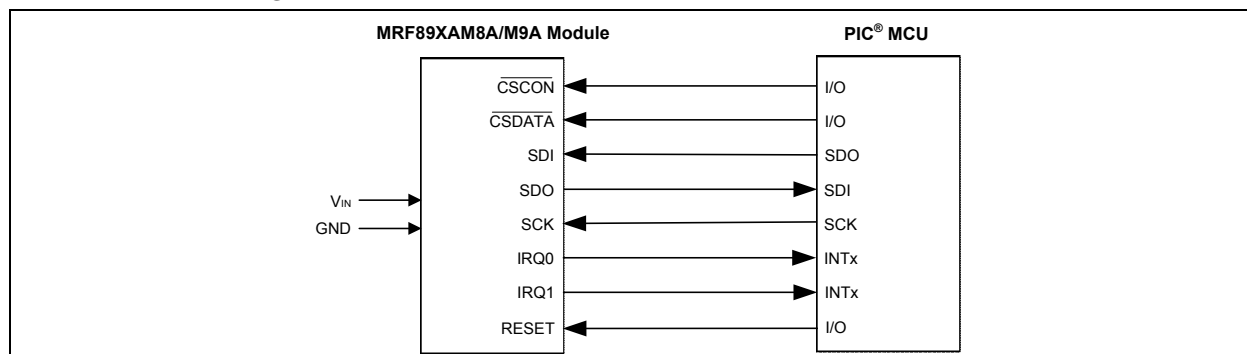
The basic utility driver firmware is used for testing, measuring, and verifying the performance and functionality of the MRF89XA transceiver. The driver utility program runs on any of the Microchip development boards. The New Radio Utility Driver Program for Microchip MRF89XA Transceiver source code is available and compiled using the MPLAB® IDE and XC18/XC16 compilers.

The software and utility tools requirement to run the driver program application are as follows:

- Microchip 8-bit MCU compiler - XC8, v1.38 and above
- Microchip 16-bit MCU compiler - XC16, v1.26 and above
- Microchip MPLAB X IDE v3.45 and above
- New Radio Utility Driver Program for Microchip MRF89XA Transceiver source code Ver1.0 available as part of AN2583.zip from the AN2583 application note web page www.microchip.com/mrf89XA
- Tera Term v4.94

PC tools like the Windows® terminal emulator programs (for example, Tera Term) are mainly used to run all the basic transceiver driver functions. The functions require commands from the terminal emulator program and output the results on the terminal emulator program. The demo boards used for testing functionalities and performance measurements are connected to the terminal emulator program on the PC through a serial port with required settings. For details, see **Section “Connecting to the Host PC”**.

FIGURE 1: MICROCONTROLLER TO MRF89XA MODULE INTERFACE - WIRELESS/RF NODE DIAGRAM



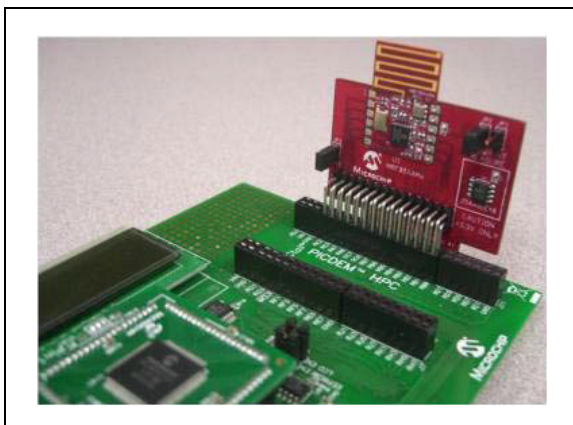
Other Microchip wireless tools like the Wireless Development Studio (WDS), along with ZENA wireless adapter, are also conveniently used for control and monitoring. For information on WDS Help and Software and on ZENA™ analyzer, visit the Microchip web site (www.microchip.com).

PIC18 Explorer Development Board and MRF89XA PICtail™/PICtail Plus Board Connections

The 28-pin connector (P2) of the MRF89XA PICtail/PICtail Plus daughter board can be plugged into the PIC18 Explorer Development Board PICtail connector (J3) slot. The connection details between the PIC MCU on the PIC18 Explorer Development Board and the MRF89XA module is illustrated in Figure 2. This connection supports the four-wire SPI, Reset, interrupts, and other MRF89XA handshake signals between the PIC18F87J11 and the MRF89XA daughter board. The PIC18 Explorer Development Board is supported by the PIC18F87J11 through its Processor In Module (PIM). For more information on the PIC18 Explorer Development Board usage and programming with MRF89XA modules, refer to the “MRF89XAMxA PICtail™/PICtail Plus Daughter Board User’s Guide”.

Note: For newer designs or advanced feature requirements for the PIC18 platform development boards, use the Explorer 8 Development Board. The board offers compatibility for application code or firmware developed using the PIC18 Explorer Development Board and related PICtail/PICtail Plus boards. For more details, refer to www.microchip.com/explorer8.

FIGURE 2: MRF89XAM8A/M9A PICtail™/PICtail PLUS DAUGHTER BOARD PLUGGED INTO THE PIC18 EXPLORER DEVELOPMENT BOARD



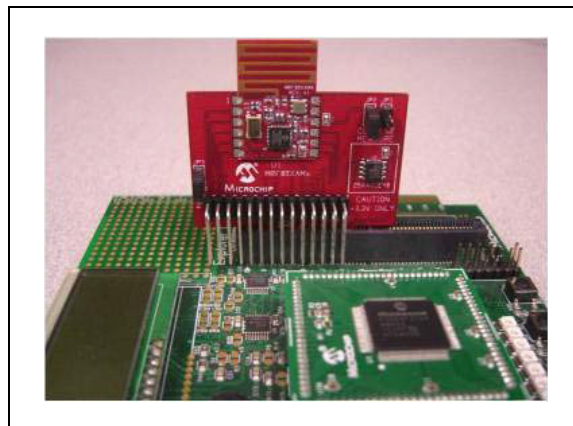
Explorer 16 Development Board and Sub-GHz Module Connections

The 30-pin card edge connector (J3) of the MRF89XAMxA PICtail/PICtail Plus Daughter Board is plugged into the PICtail Plus connector on the Explorer 16 Development Board. This connection supports the four-wire SPI, Reset, interrupts, and other MRF89XA handshake signals between the PIC MCU and the MRF89XA daughter board. The connection setup between the Explorer 16 Development Board and the Sub-GHz daughter boards is illustrated in Figure 3.

For more information on the Explorer 16 Development Board usage and programming with Sub-GHz modules, refer to the “MRF89XAMxA PICtail™/PICtail Plus Daughter Board User’s Guide”.

Note: For newer designs or advanced feature requirements for the PIC24 platform development boards, use the Explorer 16/32 Development Board. The board offers compatibility for application code or firmware developed using the Explorer 16 Development Board and related PICtail/PICtail Plus boards. For more details, refer to www.microchip.com/explorer16.

FIGURE 3: MRF89XAM8A/M9A PICtail™/PICtail PLUS DAUGHTER BOARD PLUGGED INTO THE EXPLORER 16 DEVELOPMENT BOARD



GETTING STARTED

To set up the MRF89XA RF transceiver-based wireless node, perform the following steps:

1. Insert the MRF89XA RF transceiver daughter card into any of the development boards.
For the PIC18 Explorer Development Board, refer to the **Section “PIC18 Explorer Development Board and MRF89XA PICTail™/PICTail Plus Board Connections”**.
For the Explorer 16 Development Board, refer to the **Section “Explorer 16 Development Board and Sub-GHz Module Connections”**.
2. Plug in the power cord for the development board.
3. Connect the development board with the PC that will display the MRF89XA Radio Utility Driver Program interface with an RS-232 serial cable.
4. Program the PIC18/PIC24 MCU with the `MRF89XA_Radio_Utility_Driver.X.production.hex` file using the available Microchip programmer or debugger.
5. Open the Tera Term and run through the driver utility program using the configurations listed in [Table 1](#). For more information on the serial port setup, refer to **Section “Connecting to the Host PC”**.

Note: For first time users, refer to the User's Guide of the respective programmer or debugger.

Note: The LEDs toggle for most of the operations while running the Radio Utility Driver demo application.

Connecting to the Host PC

The MRF89XA Radio Utility Driver Program's user interface can be accessed by connecting the development board and the PC with an RS-232 serial cable. PCs with operating systems such as Windows® XP (or later) can use any of the serial communication terminal emulator programs (like Tera Term) as a user interface setup to command wireless nodes over UART and monitor the status.

[Table 2](#) lists the configuration settings for the serial port communication.

TABLE 2: SERIAL PORT SETTINGS

Parameter	Setting
Bits per Second	19200
Data bits	8
Parity	Even
Stop bits	1
Flow Control	None

USING THE MRF89XA RADIO UTILITY DRIVER FIRMWARE

The New Radio Utility Driver Program for Microchip MRF89XA Transceiver can be operated through the user interface that is displayed on the host computer. After powering the PIC18 Explorer or the Explorer 16 Development Boards with the MRF89XA daughter card, the user must configure the default mode of operation by following the setup procedure explained in **Section "Setup Menu"**.

The following shortcut keys can be used on Tera Term to navigate through the menus as shown in [Table 3](#).

TABLE 3: SHORTCUT KEYS

Shortcut Key	Functionality
<Ctrl> + <z>	Exits and returns to the Main Menu. It can be used to stop or exit from any step.
<Ctrl> + <x>	Resets the transceiver. Stops the current process and programs the transceiver with default values (listed in Table 4).
<Ctrl> + <s>	Displays the current system status and configuration values. It can be used at any step in the program.

Setup Menu

- Select the default mode of modulation type from one of the following options:
 - Frequency-Shift Keying (FSK)
 - On-Off Keying (OOK)

[Figure 4](#) shows the Setup Menu screen for the configuration and setup using the Tera Term. The user can modify the modulation type using "Configure MRF89XA --> Select modulation type" from the Main Menu. Refer to the sections on [Figure 5](#) for details.

- Select the frequency of operation from one of the following options:
 - Frequency Band: 902-915 MHz
 - Frequency Band: 915-928 MHz
 - Frequency Band: 950-960 MHz
 - Frequency Band: 863-870 MHz

The user can modify the frequency band and center frequency using "Configure MRF89XA --> Select Operating Frequency".

- Select the data rate.

Data rate setting is determined by the type of modulation selected in the first step. The maximum value supported by FSK modulation is 200 kbps and 32 kbps in OOK modulation. The bandwidth and the frequency deviation values listed, along with each data rate, are the optimal settings for that data rate.

The users can modify the data rate, bandwidth, and frequency deviation of operation using the "Configure MRF89XA" menu options from the Main Menu. [Figure 5](#) shows the Main Menu and a sample status command output.

FIGURE 4: SETUP MENU

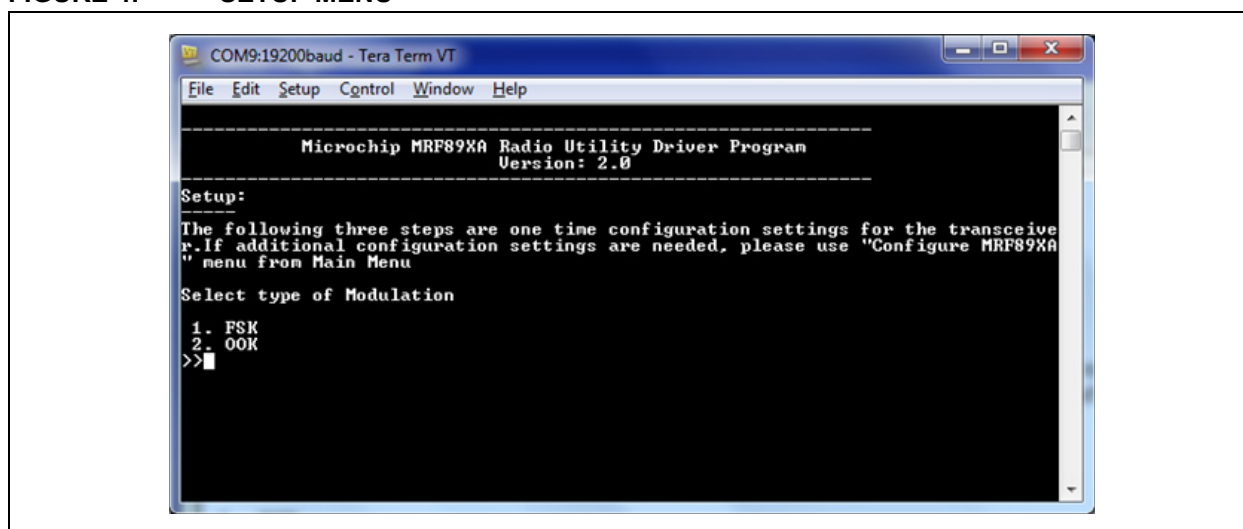
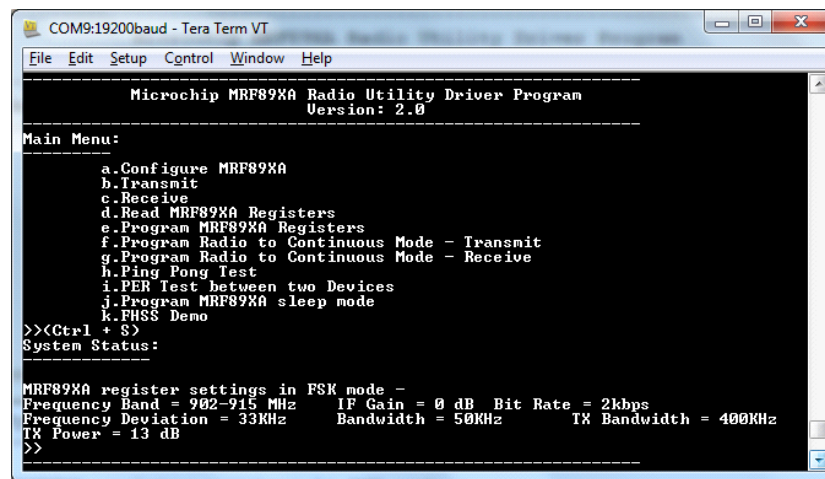


FIGURE 5: MAIN MENU WITH SAMPLE STATUS COMMAND OUTPUT



```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help

Microchip MRF89XA Radio Utility Driver Program
Version: 2.0

Main Menu:
a. Configure MRF89XA
b. Transmit
c. Receive
d. Read MRF89XA Registers
e. Program MRF89XA Registers
f. Program Radio to Continuous Mode - Transmit
g. Program Radio to Continuous Mode - Receive
h. Ping Pong Test
i. PER Test between two Devices
j. Program MRF89XA sleep mode
k. FHSS Demo
>><Ctrl + S>
System Status:
-----
MRF89XA register settings in FSK mode -
Frequency Band = 902-915 MHz   IF Gain = 0 dB   Bit Rate = 2kbps
Frequency Deviation = 33KHz    Bandwidth = 50KHz   TX Bandwidth = 400KHz
TX Power = 13 dB
>>
  
```

Main Menu And Configure Menu

There are two menus as shown in [Figure 6](#):

- **Main Menu:** Contains the test function commands.
- **Configure Menu:** Configures the transceiver and can be accessed from the Main Menu.

FIGURE 6: MENUS

Main Menu:

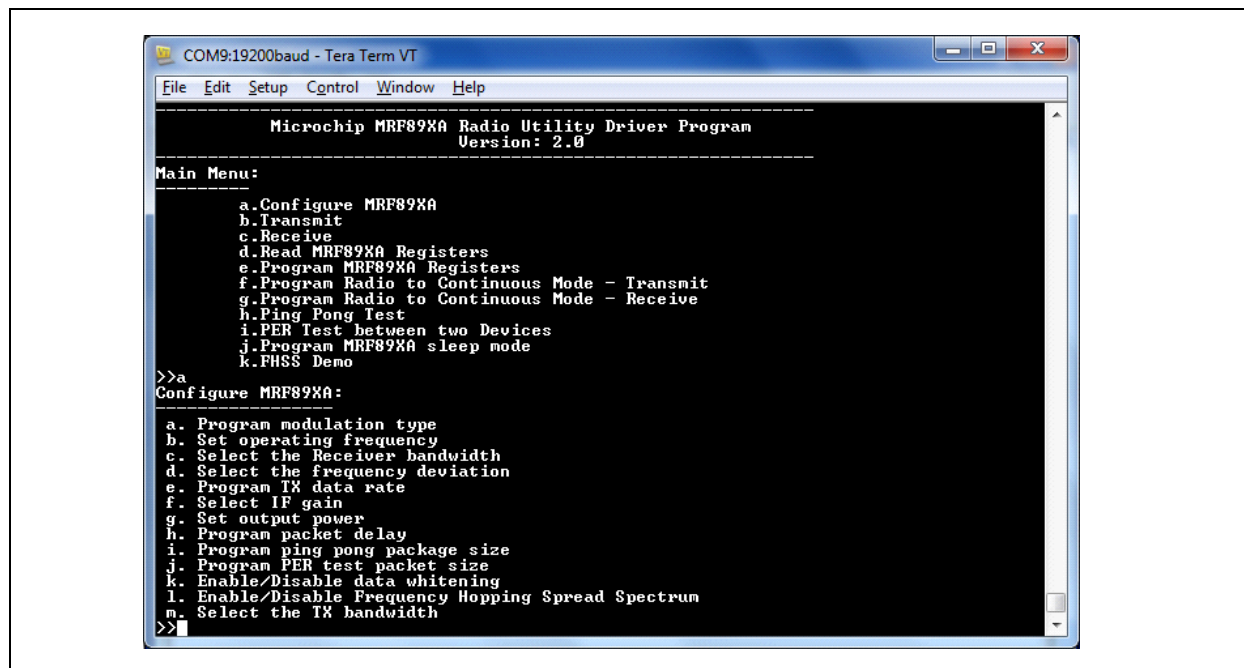
- Configure MRF89XA
- Transmit
- Receive
- Read MRF89XA Registers
- Program MRF89XA Registers
- Program Radio to Continuous Mode – Transmit
- Program Radio to Continuous Mode – Receive
- Ping Pong Test
- PER Test between two Devices
- Program MRF89XA to sleep mode

Configure Menu:

- Program modulation type
- Set operating frequency
- Select the bandwidth
- Select the frequency deviation
- Program TX data rate
- Select IF Gain
- Set output power
- Program packet delay
- Program ping pong package size
- Program PER test packet size
- Enable/Disable data whitening
- Enable/Disable Frequency Hopping Spread Spectrum

Figure 7 shows the Main Menu and Configure Menu on the Tera Term display.

FIGURE 7: THE MAIN AND CONFIGURE MENU



EXECUTING FIRMWARE COMMANDS

This section describes the commands executed by the Main Menu and Configure Menu. The following are the subsections of the Main Menu and Configure Menu commands:

- **Configuration Commands:** The Main Menu command for accessing the Configure Menu and Configure Menu commands
- **Test function commands:** The test and functional commands on the Main Menu

Configuration Commands

The MRF89XA RF transceiver can operate using the MRF89XA Radio Utility Driver Program's default values. These values are listed in Table 4.

TABLE 4: DEFAULT CONFIGURATION SETTINGS

Attribute	Setting
Modulation	Value chosen during setup procedure
Frequency Band	Value chosen during setup procedure
Center Frequency	Value chosen during setup procedure

TABLE 4: DEFAULT CONFIGURATION SETTINGS (CONTINUED)

Attribute	Setting
Data Rate	Value chosen during setup procedure
Bandwidth	Value chosen during setup procedure
Frequency Deviation	Value chosen during setup procedure
IF Gain	Maximal Gain (0 dB)
TX Output Power	13 dBm
Receiver Sensitivity for FSK	-107 dBm at 25 kbps
Receiver Sensitivity for OOK	-113 dBm at 2 kbps
Packet Delay	1 Unit (1 Unit for Explorer 16 = 5 ms; 1 Unit for PIC18 Explorer = 4 ms)
Ping pong package size	100 packets
PER test packet size	16 bytes
Data whitening mode	Disabled
Frequency Hopping mode	Disabled

Note 1: Resetting the MRF89XA RF transceiver sets the parameters to these default values.

- 2:** The power level at the antenna is different from the configured power level. The transmitted power level is lower because of the insertion losses in matching network due to SAW filter.

Configuring MRF89XA

This Main Menu command displays the Configure MRF89XA Menu as shown in [Figure 8](#).

The user can reconfigure the values through the Configure MRF89XA menu as shown in [Figure 8](#).

PROGRAM MODULATION TYPE

This menu option, as shown in [Figure 9](#), enables the user to set the MRF89XA transceiver to either FSK or OOK modulation. The default value for this parameter is the value chosen during the setup procedure. The user must program the appropriate data rate, bandwidth, and frequency deviation settings. The RF transceiver returns the settings to these default values.

FIGURE 8: CONFIGURE MRF89XA MENU

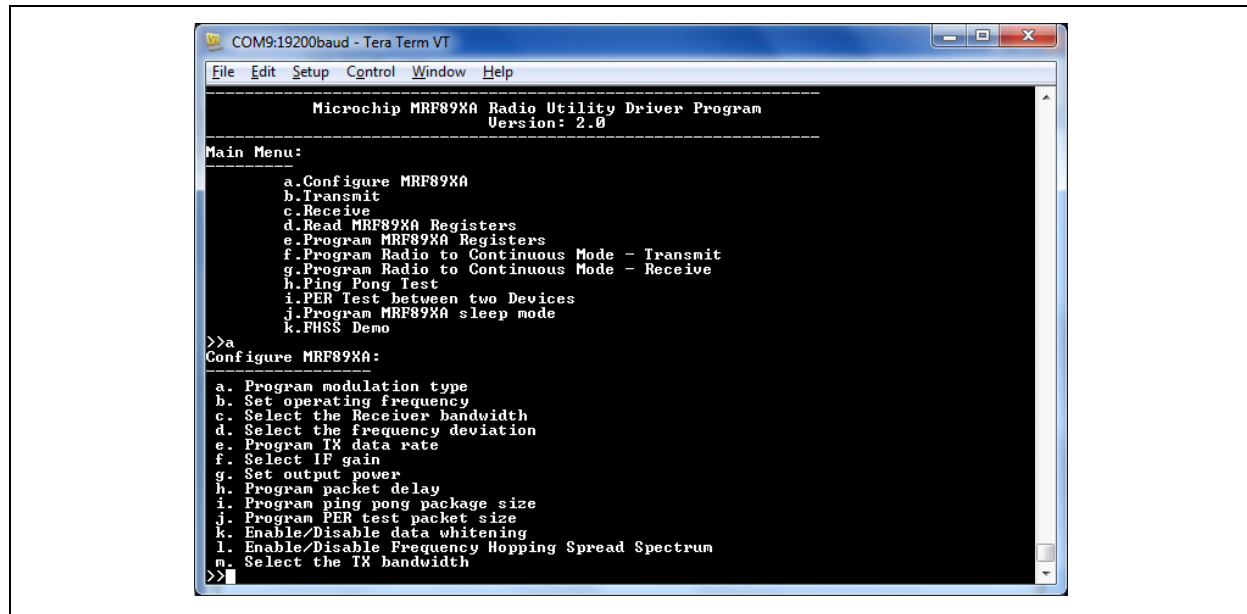
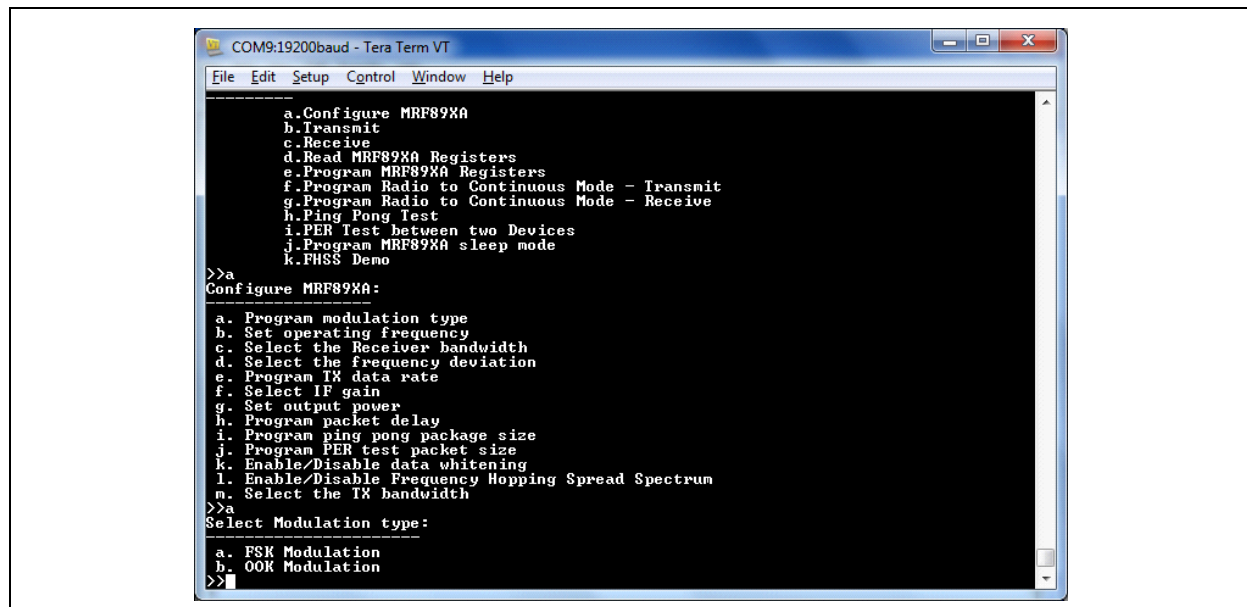


FIGURE 9: PROGRAM MODULATION TYPE



SET OPERATING FREQUENCY

This menu option, as shown in [Figure 10](#), enables the user to select the frequency band and program the center frequency for the operation of the MRF89XA transceiver.

The user can operate at one of the following frequency bands: 902-915 MHz, 915-928 MHz, 950-960 MHz, or 863-870 MHz, and then proceed to program the center frequency.

To program the required center frequency, the user must first program RiREG, PiREG, and SiREG. The Ri corresponds to R1/R2, similarly to Pi and Si.

The center frequency can be calculated using [Equation 1](#) and [Equation 2](#). For more details, refer to the “MRF89XA Data Sheet”.

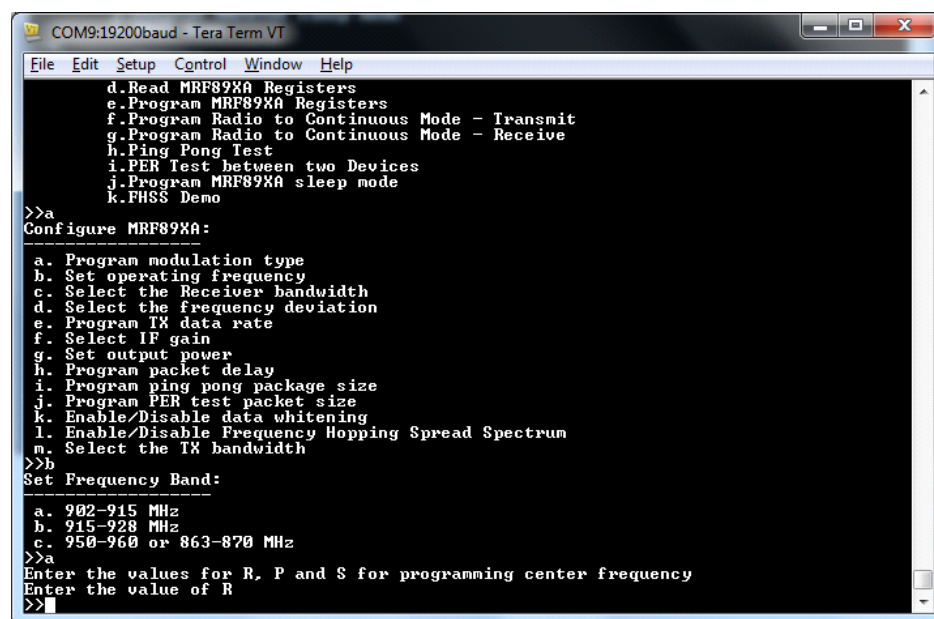
EQUATION 1:

$$\text{Center Frequency (FSK)} = (9 * F_{\text{xtal}} * [75 (P_{\text{iREG}} + 1) + S_{\text{iREG}}]) / (8 * R_{\text{iREG}} + 1)$$

EQUATION 2:

$$\text{Center Frequency (OOK)} = (9 * F_{\text{xtal}} * [75 (P_{\text{iREG}} + 1) + S_{\text{iREG}}]) / (8 * R_{\text{iREG}} + 1) - F_{\text{DEV}}$$

FIGURE 10: SET OPERATING FREQUENCY



SELECT THE BANDWIDTH

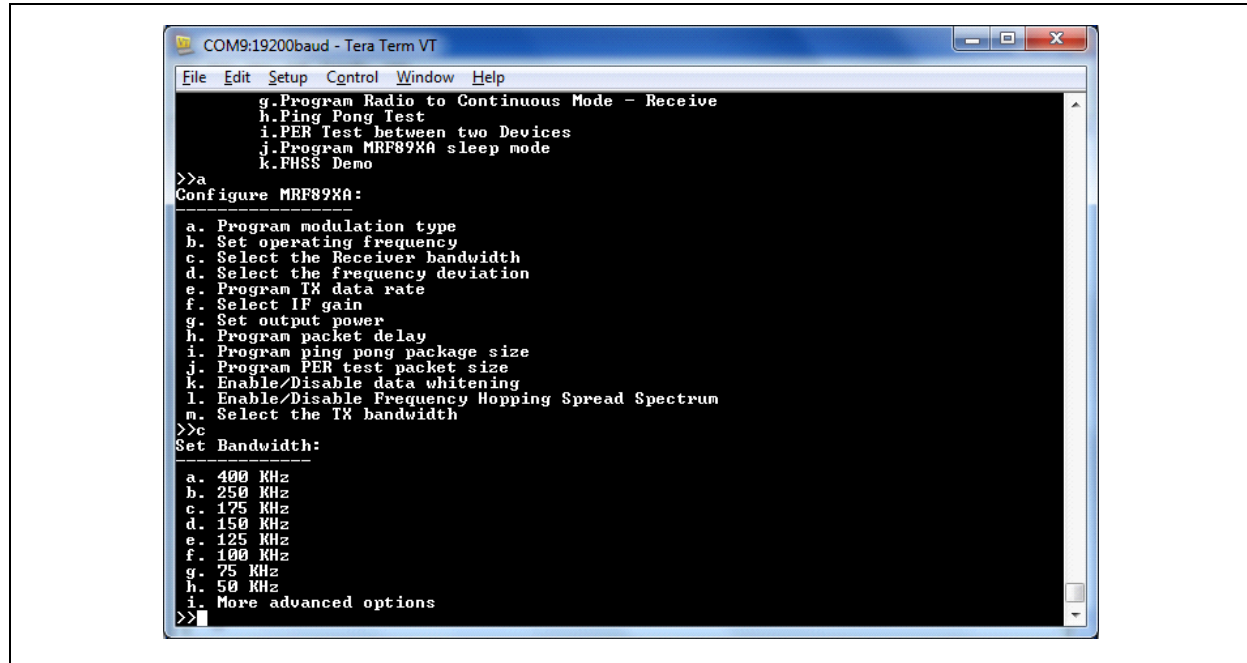
The menu option, as shown in [Figure 11](#), enables the user to program the receiver bandwidth.

The MRF89XA transceiver supports 400-KHz, 250-KHz, 175-KHz, 150-KHz, 125-KHz, 100-KHz, 75-KHz, and 50-KHz bandwidth operations. The user must program the appropriate bandwidth based on the selected data rate information. The default value for the bandwidth is the value chosen during the setup procedure.

The MRF89XA transceiver allows the programming of the bandwidth between 25 KHz–400 KHz. For more advanced options, the user must select “i” from the Set Bandwidth Menu and then select the appropriate bandwidth.

For programming the bandwidth, the user must select “Program MRF89XA registers” from the Main Menu and program the register “FILCREG”. For more information on MRF89XA registers, refer to the “*MRF89XA Data Sheet*”.

FIGURE 11: SELECTING THE RECEIVER BANDWIDTH



SELECT THE FREQUENCY DEVIATION

The menu option, as shown in [Figure 12](#), enables frequency deviation programming.

The frequency deviation can be set as 200 KHz, 133 KHz, 100 KHz, 80 KHz, 67 KHz, 50 KHz, 40 KHz, and 33 KHz. The default value for frequency deviation is the value selected during the setup procedure. For more advanced options, select “i” from the Select Frequency Deviation menu and then set the frequency deviation according to [Equation 3](#).

EQUATION 3:

$$FDEV = (FXTAL / (32 * (FDVAL + 1)))$$

where, $0 \leq FDVAL \leq 255$

For programming the frequency deviation, the user must select “Program MRF89XA registers” from the Main Menu and program the register “FDEVREG”. For more information on MRF89XA register, refer to the “*MRF89XA Data Sheet*”.

PROGRAM TX DATA RATE

The menu option, as shown in [Figure 13](#), enables programming the desired TX data rate.

The MRF89XA Radio Utility Driver Program enables the user to select from the standard data rates: 1.56 kbps, 2 kbps, 2.41 kbps, 4.76 kbps, 5 kbps, 8 kbps, 9.52 kbps, 10 kbps, 12.5 kbps, 16.67 kbps, 20 kbps, 40 kbps, 50 kbps, 100 kbps, and 200 kbps. The maximum value that can be programmed in OOK modulation is 32 kbps and 200 kbps for FSK modulation. The default value is the value selected during the setup procedure.

For programming the MRF89XA daughter board to advanced options, chose the option “i” from the Data Rate menu and program the BRVAL<6:0> as shown in [Equation 4](#).

EQUATION 4:

$$Bit\ Rate = (FXTAL / (64 * (BRVAL + 1)))$$

where, $0 \leq BRVAL \leq 127$

For programming the data rate, the user must choose “Program MRF89XA registers” from the Main Menu and then program the register “BRSREG”. For more information on MRF89XA registers, refer to the “MRF89XA Data Sheet”.

FIGURE 12: SETTING UP THE FREQUENCY DEVIATION

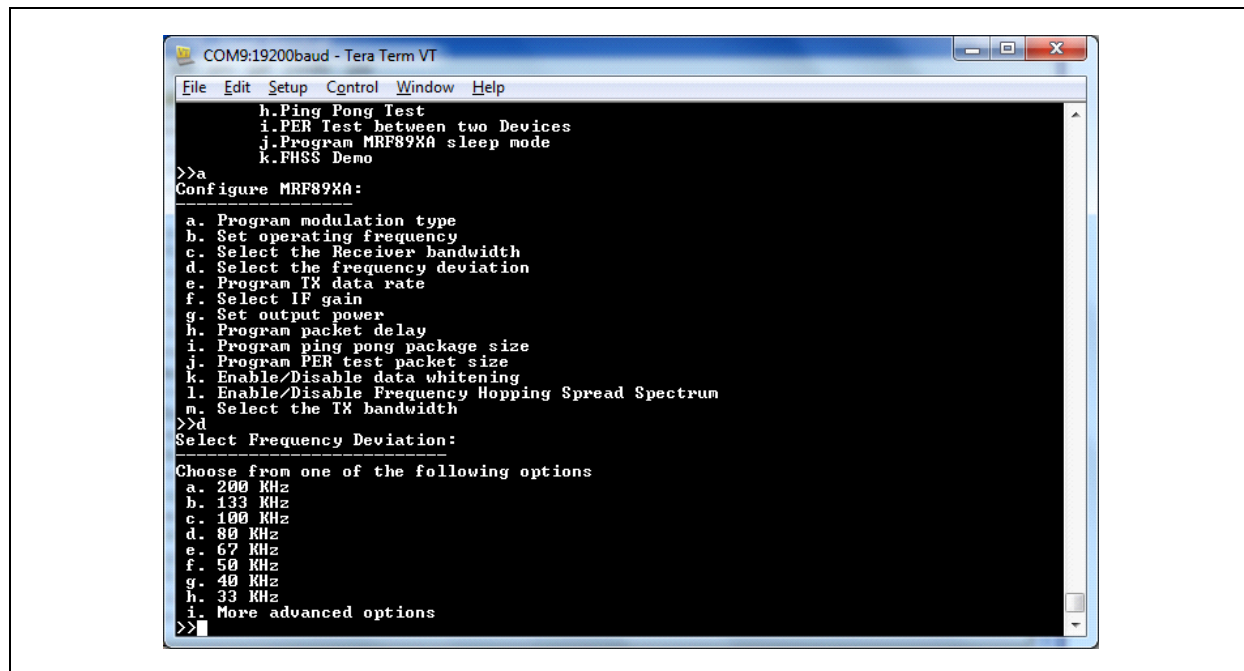
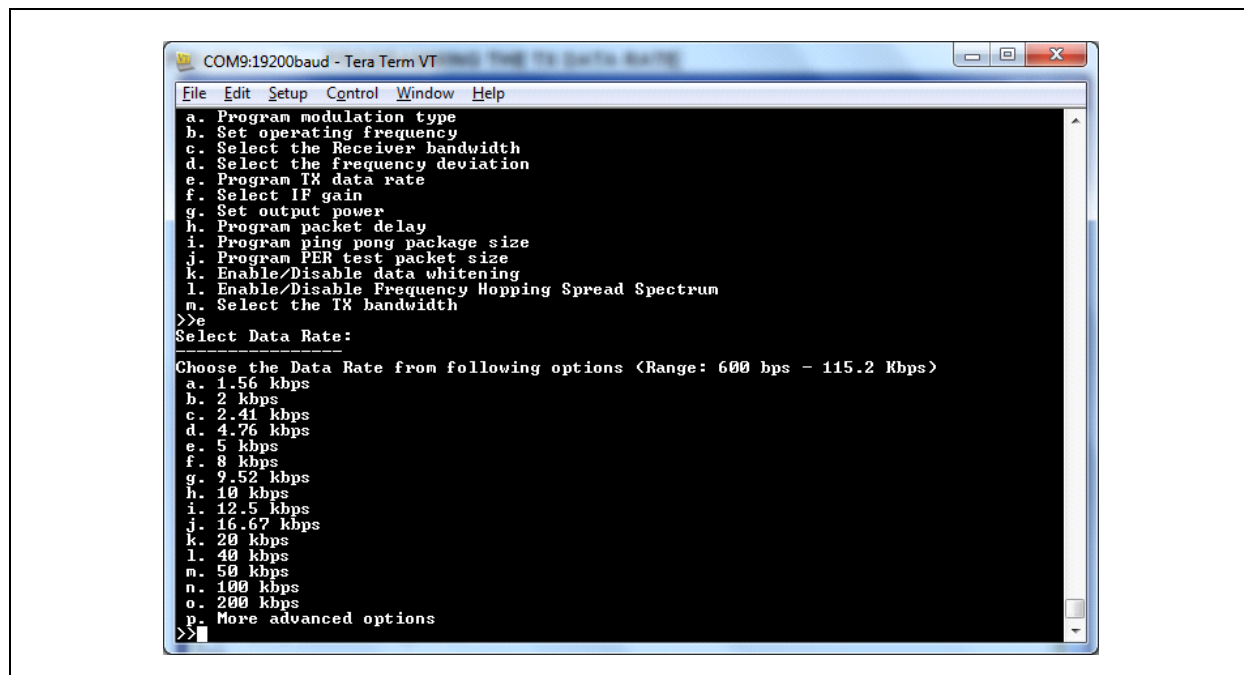


FIGURE 13: PROGRAMMING THE TX DATA RATE



SELECT IF GAIN

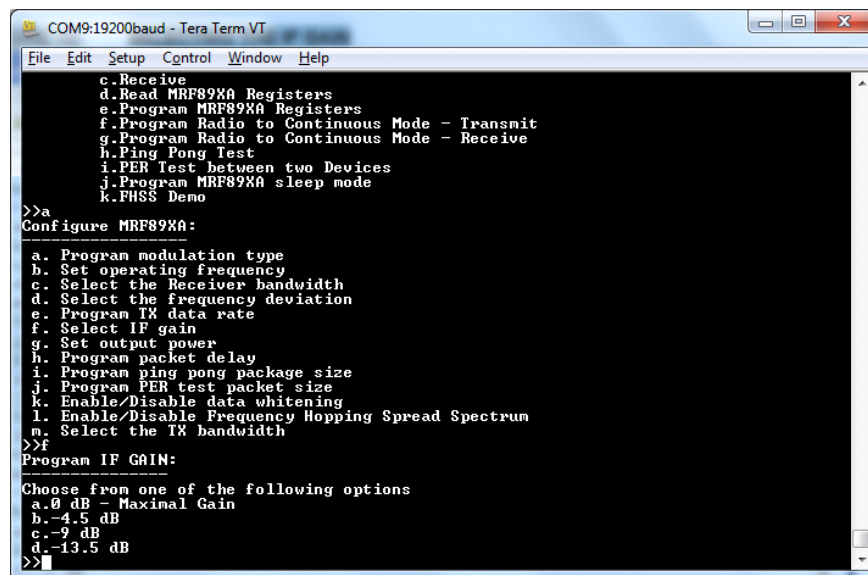
The menu option, as shown in [Figure 14](#), enables programming the IF gain. The IF gain can be programmed to different attenuation: -0 dB, -4.5 dB, -9 dB, or -13.5 dB. The default value for this parameter is 0 dB.

Note: The power level at the antenna is different from the configured power level. The transmitted power level is lower because of the insertion losses in matching network due to SAW filter.

SET TX OUTPUT POWER

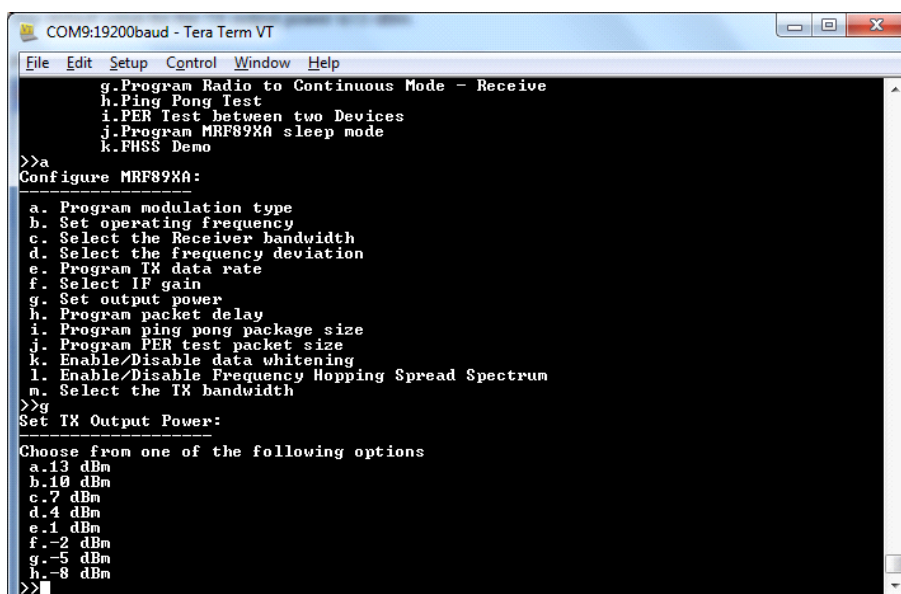
The menu option, as shown in [Figure 15](#), enables programming the TX output power. The TX output power can be set to different levels: 13 dBm, 10 dBm, 7 dBm, 4 dBm, 1 dBm, -2 dBm, -5 dBm, -8 dBm. The default value for the TX output power is 13 dBm.

FIGURE 14: SELECTING THE IF GAIN



```
COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
c.Receive
d.Read MRF89XA Registers
e.Program MRF89XA Registers
f.Program Radio to Continuous Mode - Transmit
g.Program Radio to Continuous Mode - Receive
h.Ping Pong Test
i.PER Test between two Devices
j.Program MRF89XA sleep mode
k.FHSS Demo
>>a
Configure MRF89XA:
a. Program modulation type
b. Set operating frequency
c. Select the Receiver bandwidth
d. Select the frequency deviation
e. Program TX data rate
f. Select IF gain
g. Set output power
h. Program packet delay
i. Program ping pong package size
j. Program PER test packet size
k. Enable/Disable data whitening
l. Enable/Disable Frequency Hopping Spread Spectrum
m. Select the TX bandwidth
>>f
Program IF GAIN:
Choose from one of the following options
a. 0 dB - Maximal Gain
b. -4.5 dB
c. -9 dB
d. -13.5 dB
>>
```

FIGURE 15: SETTING THE TX OUTPUT POWER



```
COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
g.Program Radio to Continuous Mode - Receive
h.Ping Pong Test
i.PER Test between two Devices
j.Program MRF89XA sleep mode
k.FHSS Demo
>>a
Configure MRF89XA:
a. Program modulation type
b. Set operating frequency
c. Select the Receiver bandwidth
d. Select the frequency deviation
e. Program TX data rate
f. Select IF gain
g. Set output power
h. Program packet delay
i. Program ping pong package size
j. Program PER test packet size
k. Enable/Disable data whitening
l. Enable/Disable Frequency Hopping Spread Spectrum
m. Select the TX bandwidth
>>g
Set TX Output Power:
Choose from one of the following options
a. 13 dBm
b. 10 dBm
c. 7 dBm
d. 4 dBm
e. 1 dBm
f. -2 dBm
g. -5 dBm
h. -8 dBm
>>
```

PROGRAM PACKET DELAY

The menu option, as shown in Figure 16, determines the size of inter-packet delay between a continuous stream of packets (during transmit/Ping Pong test/PER test).

This feature enables the user to select the interval between the packets transmitted on air.

The size of packet delay can be set to 1, 10, or 100 units, where one unit corresponds to 5 ms on Explorer 16, and 4 ms on PIC18 Explorer Development Board.

PROGRAM PING PONG PACKAGE SIZE

The menu option, as shown in Figure 17, sets the number of Ping Pong test packets to be exchanged between transmitting and receiving transmitters.

The Ping Pong test package size can be set to 10, 100, or 250 packets. (For more information on Ping Pong test, refer to the Section “Program Radio to Continuous Mode – Receive”).

FIGURE 16: PROGRAMMING THE PACKET DELAY

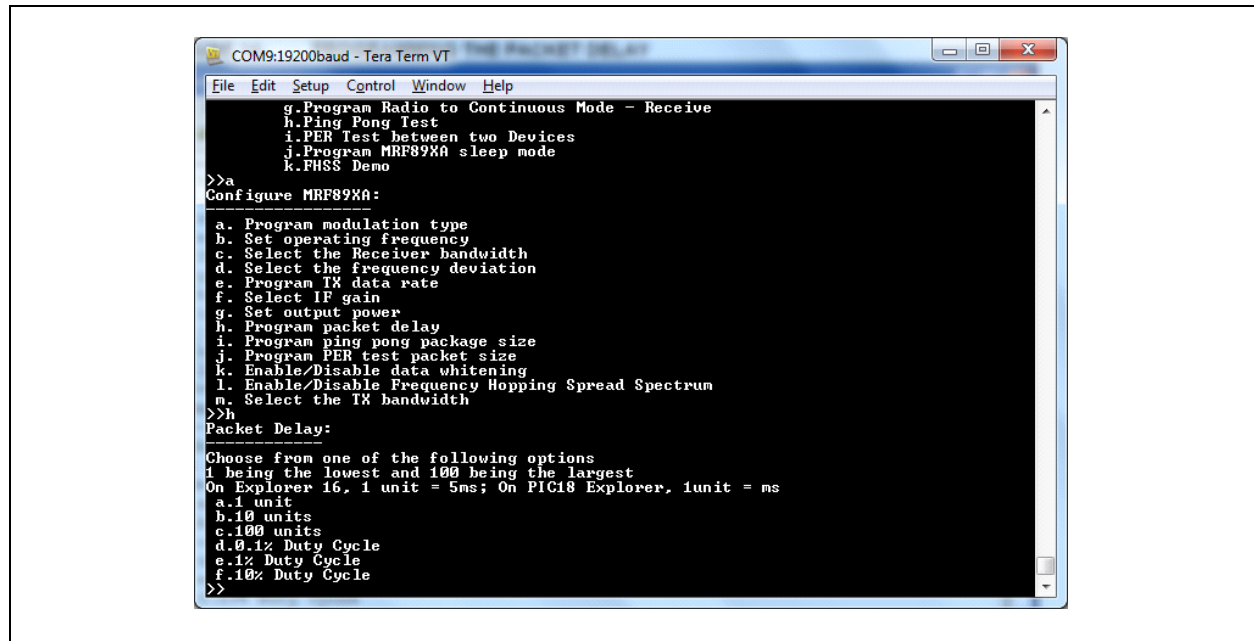
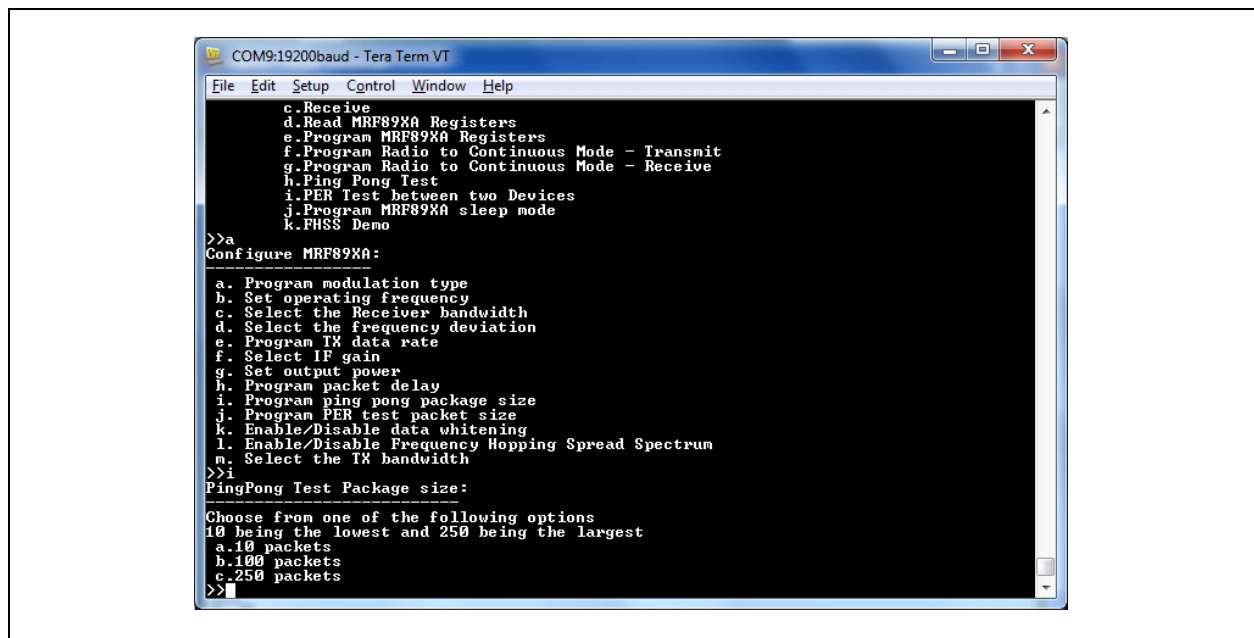


FIGURE 17: PROGRAMMING THE PING-PONG PACKAGE SIZE



PROGRAM PER TEST PACKET SIZE

The menu option, as shown in [Figure 18](#), sets the length of the packet that is used for performing PER test between transceivers. Using the PER test packet size, the user can find out the PER percentage for different packet lengths.

The PER test packet size can be set to 16, 32, or 64 bytes. The PER percentage for large packet lengths is expected to be more than the PER percentage for small packet lengths. Therefore, the user is given an option to test the PER at different packet lengths.

ENABLE/DISABLE DATA WHITENING

Data whitening or data scrambling is widely used to randomize the user data before it is transmitted on the air. This technique can be used to meet Power Spectral Density Requirements for Part 15.247.

The menu option, as shown in [Figure 19](#), enables or disables data whitening. For more information, refer to the “*MRF89XA Data Sheet*”.

FIGURE 18: PROGRAMMING PER TEST PACKET SIZE

```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
c.Receive
d.Read MRF89XA Registers
e.Program MRF89XA Registers
f.Program Radio to Continuous Mode - Transmit
g.Program Radio to Continuous Mode - Receive
h.Ping Pong Test
i.PER Test between two Devices
j.Program MRF89XA sleep mode
k.FHSS Demo
>>a
Configure MRF89XA:
a. Program modulation type
b. Set operating frequency
c. Select the Receiver bandwidth
d. Select the frequency deviation
e. Program TX data rate
f. Select IF gain
g. Set output power
h. Program packet delay
i. Program ping pong package size
j. Program PER test packet size
k. Enable/Disable data whitening
l. Enable/Disable Frequency Hopping Spread Spectrum
m. Select the TX bandwidth
>>j
PER Test Packet size:
Choose from one of the following options
16 being the lowest and 128 being the largest
a. 16 bytes
b. 32 bytes
c. 64 bytes
>>
  
```

FIGURE 19: DATA WHITENING MODE MENU

```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
a.Configure MRF89XA
b.Transmit
c.Receive
d.Read MRF89XA Registers
e.Program MRF89XA Registers
f.Program Radio to Continuous Mode - Transmit
g.Program Radio to Continuous Mode - Receive
h.Ping Pong Test
i.PER Test between two Devices
j.Program MRF89XA sleep mode
k.FHSS Demo
>>a
Configure MRF89XA:
a. Program modulation type
b. Set operating frequency
c. Select the Receiver bandwidth
d. Select the frequency deviation
e. Program TX data rate
f. Select IF gain
g. Set output power
h. Program packet delay
i. Program ping pong package size
j. Program PER test packet size
k. Enable/Disable data whitening
l. Enable/Disable Frequency Hopping Spread Spectrum
m. Select the TX bandwidth
>>k
Data Whitening:
a. Enable
b. Disable
>>
  
```


ENABLE/DISABLE FREQUENCY HOPPING SPREAD SPECTRUM (FHSS)

The MRF89XA RF transceiver has a frequency hopping scheme that conforms to part 15.247 of the FCC regulatory standards. Using FHSS, the user can perform TX, RX, PER, and Ping Pong tests. The FHSS hopping algorithm is a Master-Slave architecture.

The menu option, as shown in [Figure 20](#), enables or disables FHSS.

Test function commands

Test activation and other functional commands are issued through the Main Menu. Using the test function command, the user can perform TX, RX, Sleep mode, and range testing. To display Main Menu from anywhere in the program interface, press <Ctrl> + <z>.

TRANSMIT

This menu option, shown in [Figure 21](#) and [Figure 22](#), enables the user to set MRF89XA in transmit mode. The packet structure can be either a user-defined structure (as shown in [Figure 23](#) and [Figure 24](#)) or a predefined structure (as shown in [Figure 21](#) and [Figure 22](#)). Using this mode, the user can verify the TX and RX of the device.

The predefined packet structure is:

```
01 08 C4 FF FF FF FF 07 01 00 01 00
```

The maximum length of the packet to transmit user-defined packet continuously is 64 bytes. For more information, refer to the “MRF89XA Data Sheet”.

FIGURE 20: FHSS MENU

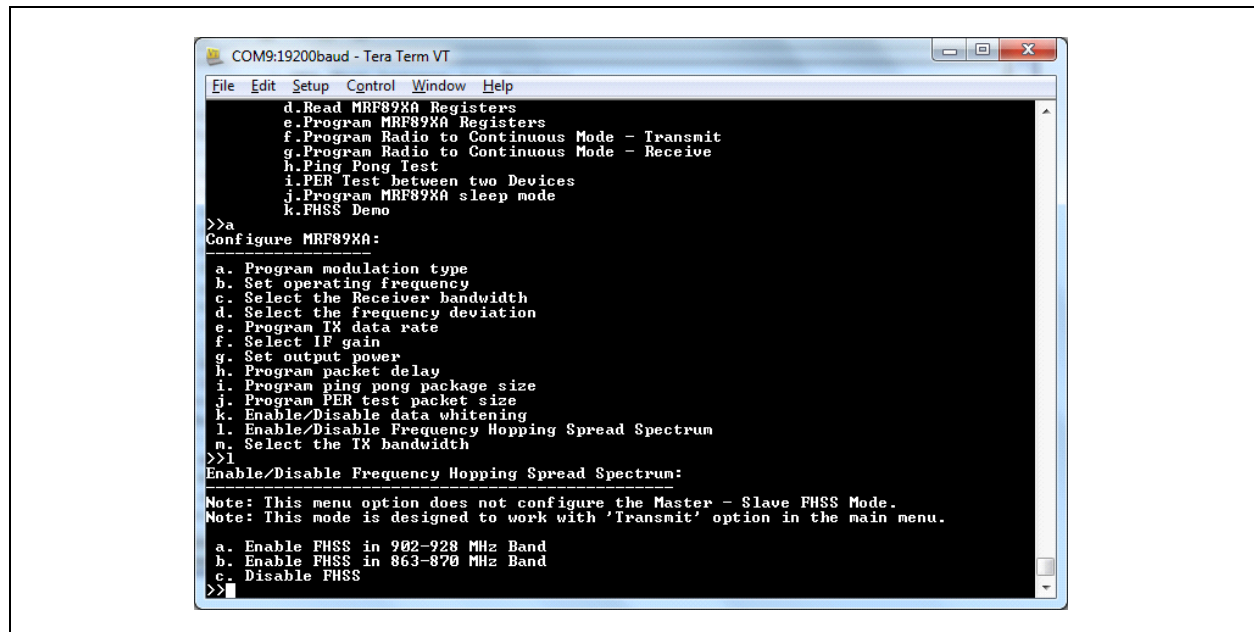


FIGURE 21: TRANSMIT PREDEFINED PACKET MENU

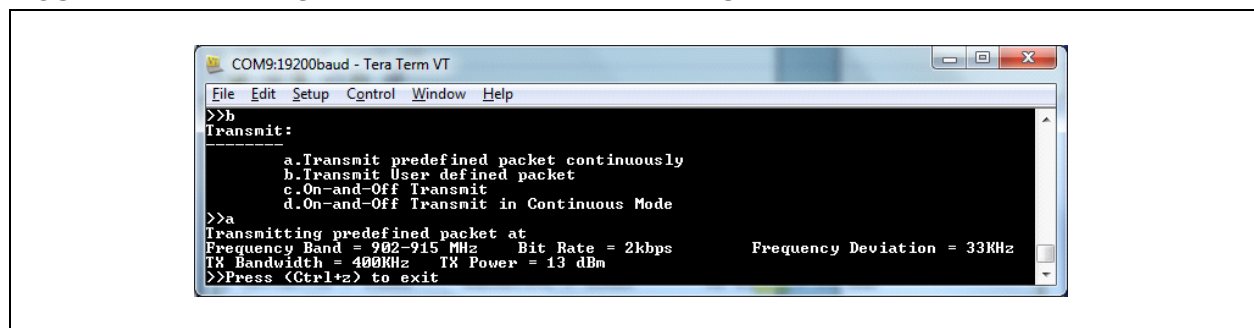


FIGURE 22: VERIFICATION OF TRANSMIT - PREDEFINED PACKET

```

COM8:19200baud - Tera Term VT
File Edit Setup Control Window Help
Receive:
a.Verbose mode
b.Summary mode
c.Packet Count mode
>>a
MRF89XA in Verbose Receive Mode at
Frequency Band = 902-915 MHz IF Gain = 0 dB Bit Rate = 2kbps Frequency
y Deviation = 33KHz Receiver Bandwidth = 50KHz
>>Press Ctrl+z to exit
Number : Length : Packet Data : RSSI (<n dB)
1 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
2 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
3 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
4 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
5 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
6 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
7 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69
8 : 10 : 01 08 C4 FF FF FF FF 07 01 00 01 00 04 00 00 00 : 69

```

FIGURE 23: USER-DEFINED PACKET TRANSMISSION

```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
k.FHSS Demo
>>b
Transmit:
a.Transmit predefined packet continuously
b.Transmit User defined packet
c.On-and-Off Transmitt
d.On-and-Off Transmitt in Continuous Mode
>>b
Please Enter the packet you want to transmit
Use hex values and press '=' when you are done
>>2015099=
Transmitting User-defined packet at
Frequency Band = 902-915 MHz Bit Rate = 2kbps Frequency Deviation = 33KHz
TX Bandwidth = 400KHz TX Power = 13 dBm
>>Press <Ctrl+z> to exit

```

FIGURE 24: VERIFICATION OF TRANSMIT – USER-DEFINED PACKET

```

COM8:19200baud - Tera Term VT
File Edit Setup Control Window Help
Receive:
a.Verbose mode
b.Summary mode
c.Packet Count mode
>>a
MRF89XA in Verbose Receive Mode at
Frequency Band = 902-915 MHz IF Gain = 0 dB Bit Rate = 2kbps Frequency
y Deviation = 33KHz Receiver Bandwidth = 50KHz
>>Press Ctrl+z to exit
Number : Length : Packet Data : RSSI (<n dB)
1 : 03 : 20 15 09 : 69
2 : 03 : 20 15 09 : 69
3 : 03 : 20 15 09 : 69
4 : 03 : 20 15 09 : 69
5 : 03 : 20 15 09 : 69
6 : 03 : 20 15 09 : 69
7 : 03 : 20 15 09 : 69
8 : 03 : 20 15 09 : 69

```

The inter-packet delay between the continuous streams of packets can be defined using the “Program Packet Delay” option in the Configure MRF89XA menu. To verify the transmission, the user must set up a device (receiver operating at the same frequency and same data rate). The detailed steps for setting up a device are as follows:

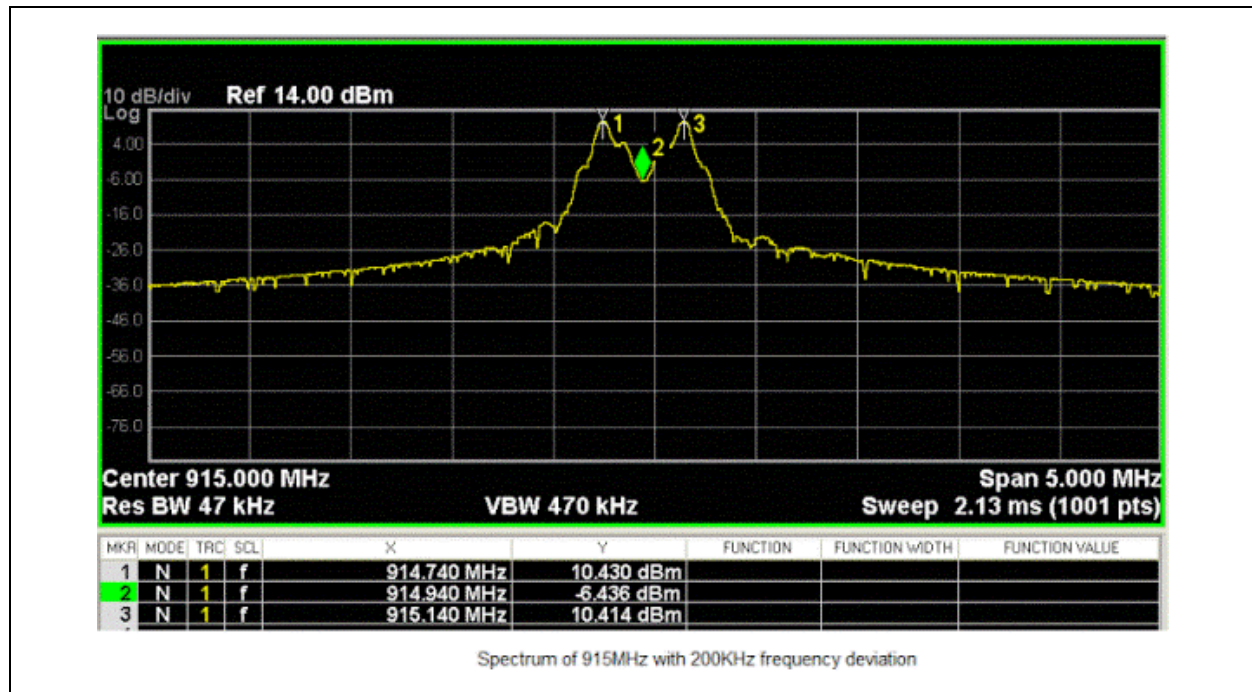
1. Review the transmitter and receiver configuration values (center frequency, bit rate,

frequency deviation, bandwidth, data whitening, FHSS, and so on). Press <Ctrl> + <s> to display the values. The default configuration values are listed in [Table 4](#).

2. To modify the configuration settings:
 - a. Press <Ctrl> + <z> to go to the Main Menu, and then select “a. Configure MRF89XA”. For more information about menu settings, refer to **Section “Program modulation**

- type”.
- Edit the desired parameters.
 - Return to the Main Menu using <Ctrl> + <z>.
- The receiver can be configured either in “Verbose mode,” “Summary mode,” or “Packet Count mode”. For more information, refer to the **Section “Receive”**.
 - Refer to the **Section “Program packet delay”** to modify the inter-packet delay.
 - Choose the Transmit mode, either predefined packet or user-defined packet. To transmit a user-defined packet, enter the hexadecimal values to be transmitted and press the equals “=” key after entering the entire packet contents. This process is shown in [Figure 21](#).
 - Transmission starts immediately.
 - To stop transmission, press <Ctrl> + <z>.
- The transmitted signal can be observed on an RF Spectrum Analyzer as shown in [Figure 25](#).

FIGURE 25: CAPTURING THE TRANSMISSION ON SPECTRUM ANALYZER



RECEIVE

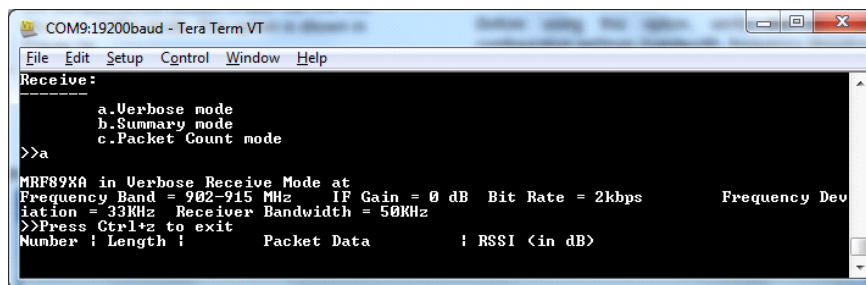
This menu option enable users to set the MRF89XA transceiver to Receive mode, and to capture and display the received packets on the screen. The following three display modes are available:

- **Verbose mode:** The entire contents of the packet are dumped on the screen. A user can use this mode as Sniffer mode. This option is shown in [Figure 26](#).
- **Summary mode:** Only the packet count received for each second is displayed. A user can introduce an interferer and observe the packet drop. This option is shown in [Figure 28](#).
- **Packet Count mode:** The total packet count is retained until the user exits from this mode. This mode can be used along with the signal generator to verify the received packet count versus the transmitted packet count. This option is shown in [Figure 29](#).

Before using this option, verify the receiver's configuration settings (bandwidth, frequency deviation, and center frequency) against that of the transmitter. Setting up the transmitter is shown in [Figure 27](#).

To exit the Receive mode, press <Ctrl> + <z>.

FIGURE 26: VERBOSE RECEIVE MODE

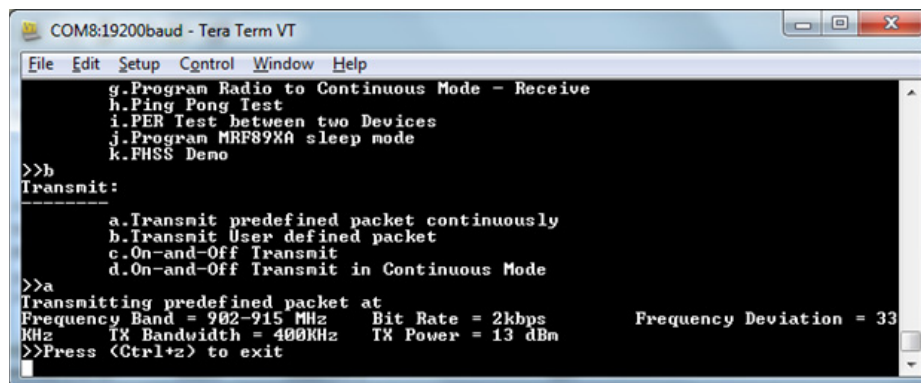


```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
Receive:
a.Verbose mode
b.Summary mode
c.Packet Count mode
>>a
MRF89XA in Verbose Receive Mode at
Frequency Band = 902-915 MHz IF Gain = 0 dB Bit Rate = 2kbps Frequency Dev
iation = 33KHz Receiver Bandwidth = 50KHz
>>Press Ctrl+z to exit
Number Length Packet Data RSSI (in dB)

```

FIGURE 27: SETTING UP TRANSMITTER

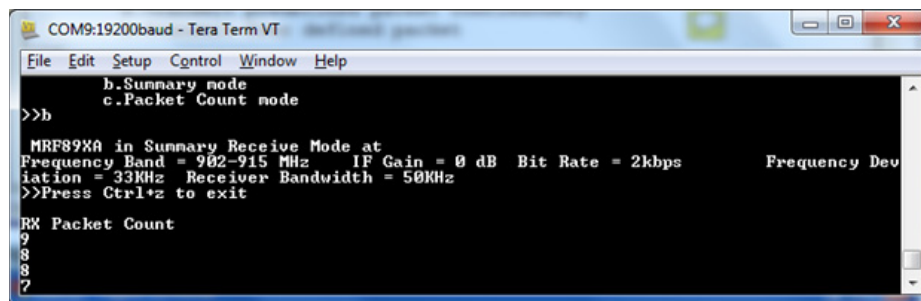


```

COM8:19200baud - Tera Term VT
File Edit Setup Control Window Help
g.Program Radio to Continuous Mode - Receive
h.Ping Pong Test
i.PER Test between two Devices
j.Program MRF89XA sleep mode
k.FHSS Demo
>>b
Transmit:
a.Transmit predefined packet continuously
b.Transmit User defined packet
c.On-and-Off Transmit
d.On-and-Off Transmit in Continuous Mode
>>a
Transmitting predefined packet at
Frequency Band = 902-915 MHz Bit Rate = 2kbps Frequency Deviation = 33
KHz TX Bandwidth = 400KHz TX Power = 13 dBm
>>Press Ctrl+z to exit

```

FIGURE 28: SUMMARY MODE

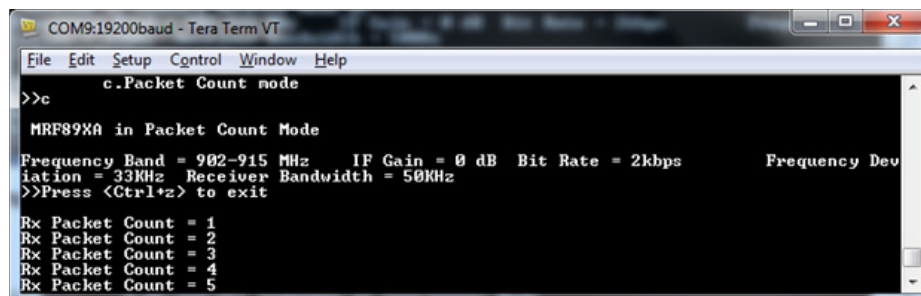


```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
b.Summary mode
c.Packet Count mode
>>b
MRF89XA in Summary Receive Mode at
Frequency Band = 902-915 MHz IF Gain = 0 dB Bit Rate = 2kbps Frequency Dev
iation = 33KHz Receiver Bandwidth = 50KHz
>>Press Ctrl+z to exit
RX Packet Count
Number Length Count
9
8
8
7

```

FIGURE 29: PACKET COUNT MODE



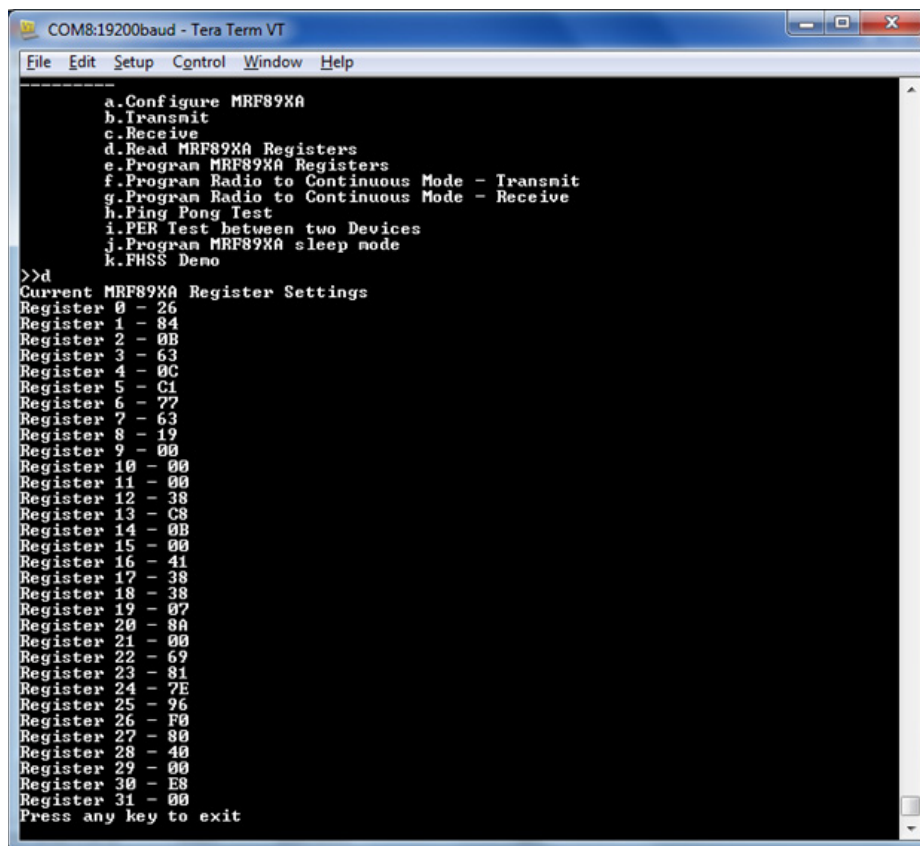
```

COM9:19200baud - Tera Term VT
File Edit Setup Control Window Help
c.Packet Count mode
>>c
MRF89XA in Packet Count Mode
Frequency Band = 902-915 MHz IF Gain = 0 dB Bit Rate = 2kbps Frequency Dev
iation = 33KHz Receiver Bandwidth = 50KHz
>>Press Ctrl+z to exit
RX Packet Count = 1
RX Packet Count = 2
RX Packet Count = 3
RX Packet Count = 4
RX Packet Count = 5

```

READ MRF89XA REGISTERS

This menu option, shown in [Figure 30](#), enables users to read the MRF89XA register values. To modify the register value, select “Program MRF89XA Registers” from the Main Menu.

FIGURE 30: MRF89XA REGISTER READ BACK

The screenshot shows a Tera Term VT window titled "COM8:19200baud - Tera Term VT". The window contains a menu with the following options:

- a.Configure MRF89XA
- b.Transmit
- c.Receive
- d.Read MRF89XA Registers
- e.Program MRF89XA Registers
- f.Program Radio to Continuous Mode - Transmit
- g.Program Radio to Continuous Mode - Receive
- h.Ping Pong Test
- i.PER Test between two Devices
- j.Program MRF89XA sleep mode
- k.FHSS Demo

The user has selected option 'd', and the screen displays the "Current MRF89XA Register Settings" for registers 0 through 31. The values are as follows:

Register	Value
Register 0	26
Register 1	84
Register 2	0B
Register 3	63
Register 4	0C
Register 5	C1
Register 6	77
Register 7	63
Register 8	19
Register 9	00
Register 10	00
Register 11	00
Register 12	38
Register 13	C8
Register 14	0B
Register 15	00
Register 16	41
Register 17	38
Register 18	38
Register 19	07
Register 20	8A
Register 21	00
Register 22	69
Register 23	81
Register 24	7E
Register 25	96
Register 26	F0
Register 27	80
Register 28	40
Register 29	00
Register 30	E8
Register 31	00

Press any key to exit

PROGRAM MRF89XA REGISTERS

This menu option, shown in [Figure 31](#), enables the user to modify the MRF89XA internal register values.

PROGRAM RADIO TO CONTINUOUS MODE – TRANSMIT

This menu option, shown in [Figure 32](#), enables the user to verify the frequency and the oscillator signal output. This command enables the local oscillator to start running without any modulation being used.

FIGURE 31: PROGRAM MRF89XA REGISTERS

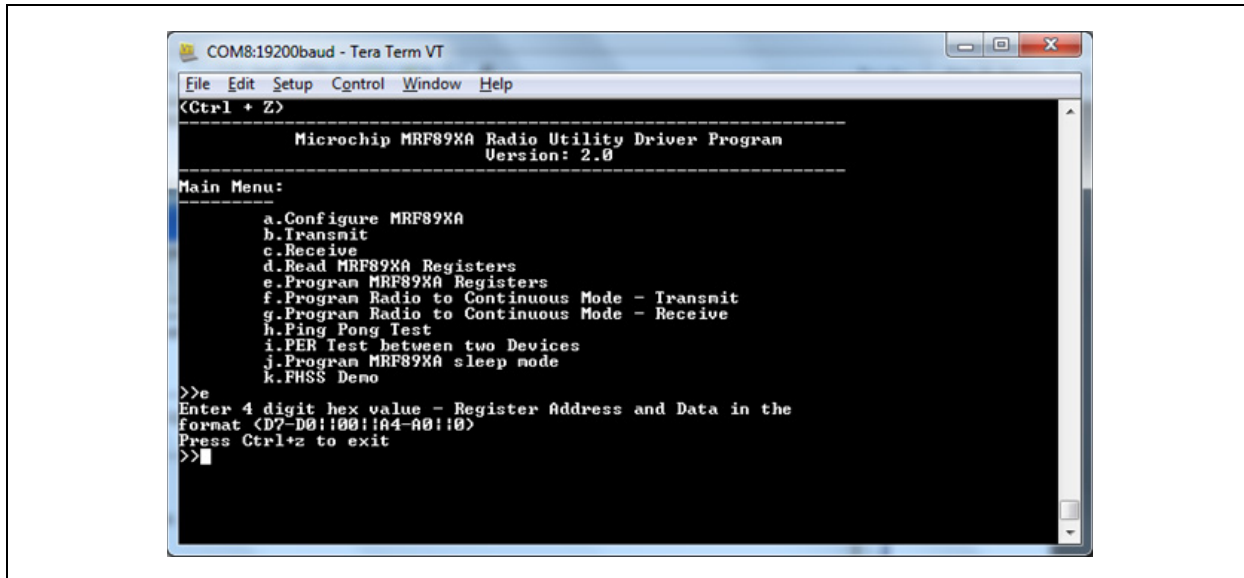
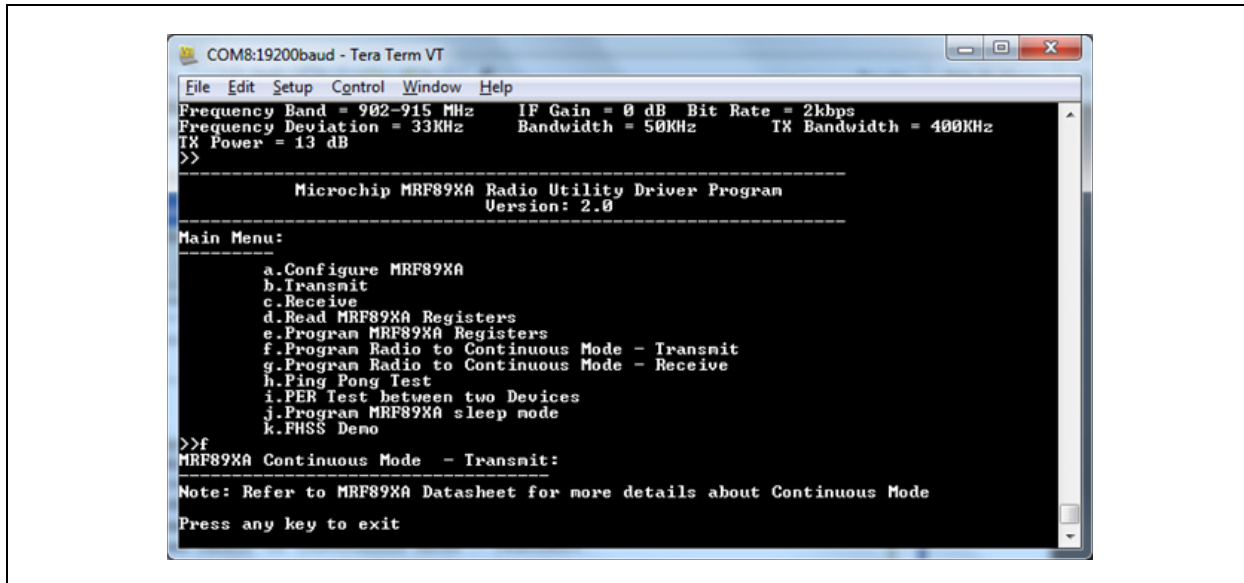


FIGURE 32: CONTINUOUS MODE – TRANSMIT



PROGRAM RADIO TO CONTINUOUS MODE – RECEIVE

This menu option configures the MRF89XA device in Continuous mode with the receiver enabled. The received data is available on the DATA pin. For more information about Continuous mode, refer to the “MRF89XA Data Sheet”.

PING PONG TEST

This menu option, shown in [Figure 34](#) and [Figure 35](#), can be used to test the compliance with a European standard for blocking and desensitization. It measures the capability of a device to receive a signal without degradation because of unwanted signals at other frequencies.

The required signal's degradation of its Packet Error Rate (PER) must be less than 1%, or the Bit Error Rate (BER) must be less than 0.1%.

FIGURE 33: CONTINUOUS MODE – RECEIVE

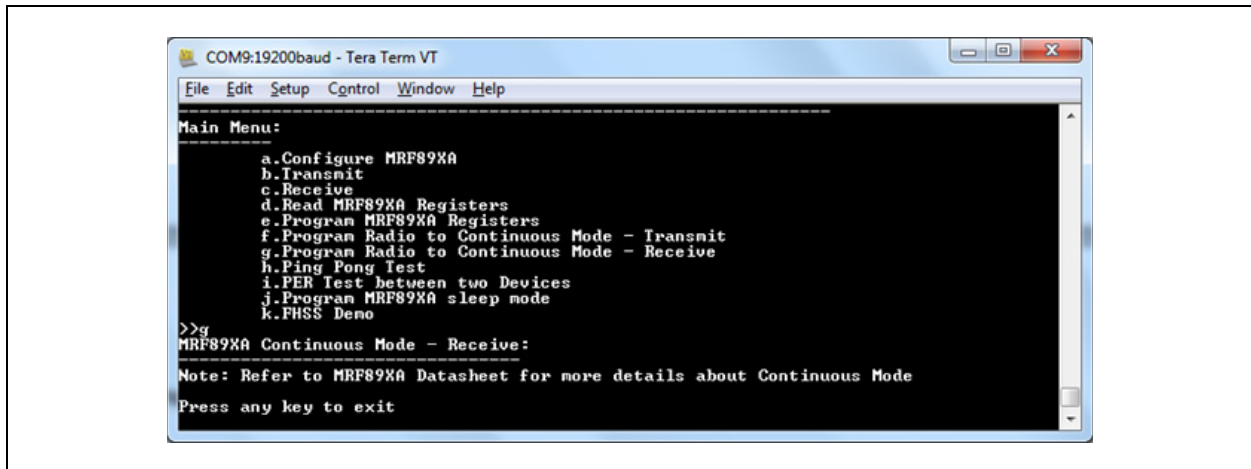


FIGURE 34: PING PONG TEST – TRANSMIT

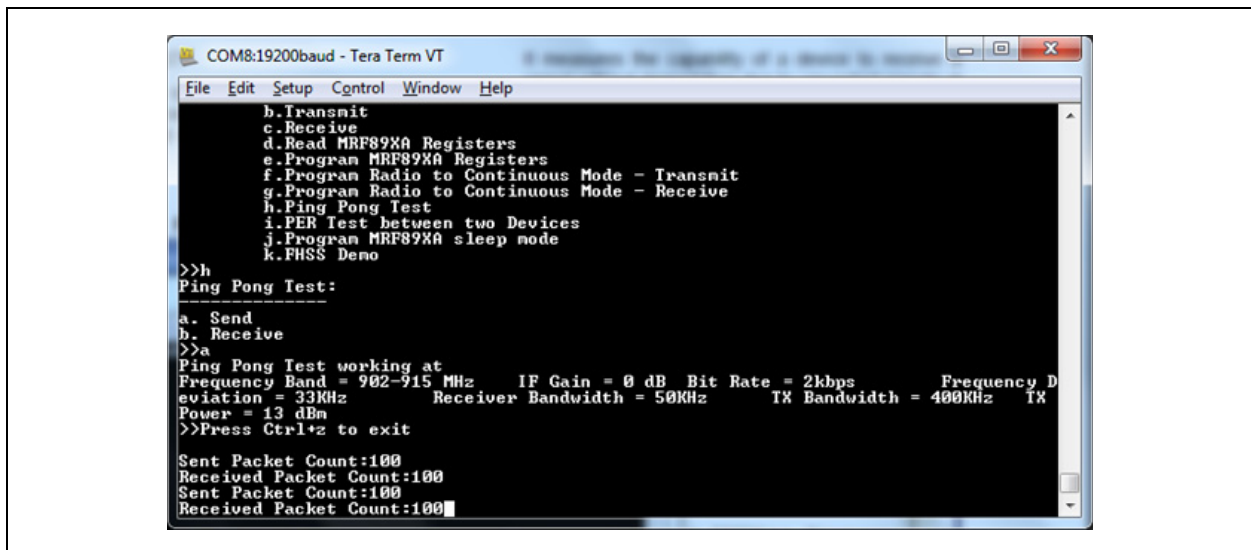
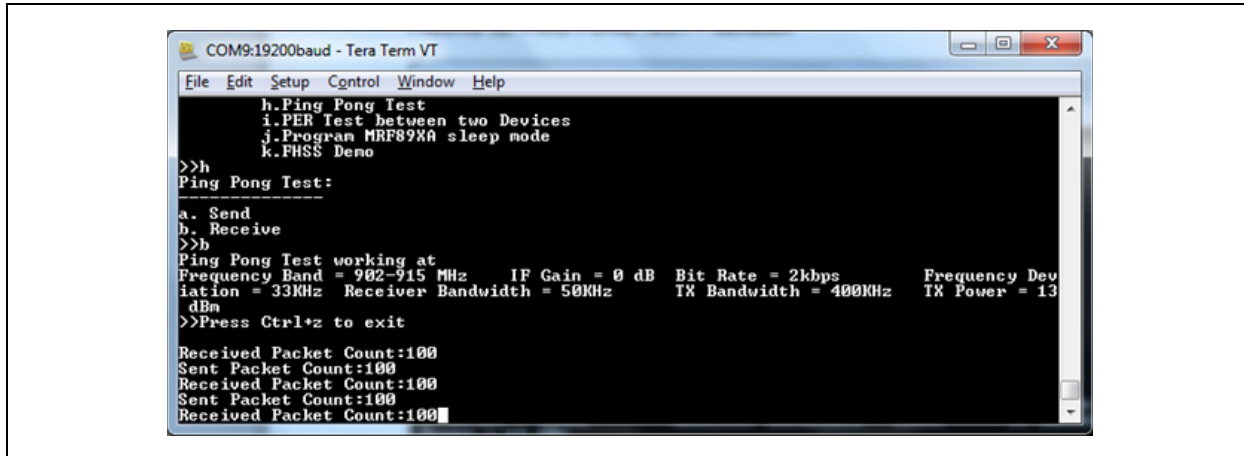


FIGURE 35: PING PONG TEST – RECEIVE



This test is used to perform a range testing. The test requires two MRF89XA transceivers; each one is running the MRF89XA utility program. Prior to initiating the test, both transceivers must be configured for the same operating frequency, data rate, and Ping Pong test package size. To perform a desensitization test, a signal generator is required.

To perform a desensitization test:

1. Program the Ping Pong package size.
2. On Test Node 1, select the Main Menu option "Ping- Pong Test" and then select "Receive".
3. On Test Node 2, select the Main Menu option "Ping Pong Test" and then select "Send".

Test Node 2 transmits the designated number of packets to Test Node 1; Test Node 1 (Figure 34) reports the number of received packets and transmits the number of specified packets to Test Node 2.

This process continues until it is stopped. To stop this process, press <Ctrl> + <z>.

4. While the packets are exchanged, activate a signal generator. Perform also a sweep in frequency that is large enough to create interference signals for the two transceivers.
5. Watch two dialog boxes and record the number of lost packets. Based on the number of lost packets and the package size, the user can calculate the "Packet Error Rate".

EQUATION 5: PACKET ERROR RATE

$$\text{Packet Error Rate\%} = (\text{Number of Lost Packets} / \text{Ping-Pong package size}) * 100$$

Note: To perform the range testing, the user can hold one device and move further until PER is not greater than 1%.

PER TEST BETWEEN TWO DEVICES

This menu option, shown in [Figure 36](#) and [Figure 37](#), performs a Packet Error Rate (PER) test between two transceivers. The length of the packet can be selected using the “PER test packet size” option in configuration commands. For more information, refer to the [Section “Configuration Commands”](#).

The PER test option can be used when testing the PER observed at the receiver when the other transceiver is configured as a sender. This PER test was designed to be used for range testing purposes.

The PER test requires two MRF89XA RF transceivers; each is running the MRF89XA utility program and set to the same frequency, bandwidth, and data rate. The PER test has the following steps:

1. Select “Receive” under the PER test menu to configure one of the wireless nodes (Node 1) as the receiver.
2. Select “Send” under the PER test menu to configure another wireless node (Node 2) as the sender. (Node 2 sends 100 packets.)
3. Node 1 reports the number of packet received and the PER percentage.
4. Node 2 continues to send 100 packets at a time continuously, and Node 1 reports the observed PER rate. To exit PER test mode, press <Ctrl> + <z>.

FIGURE 36: PER TEST – TRANSMIT

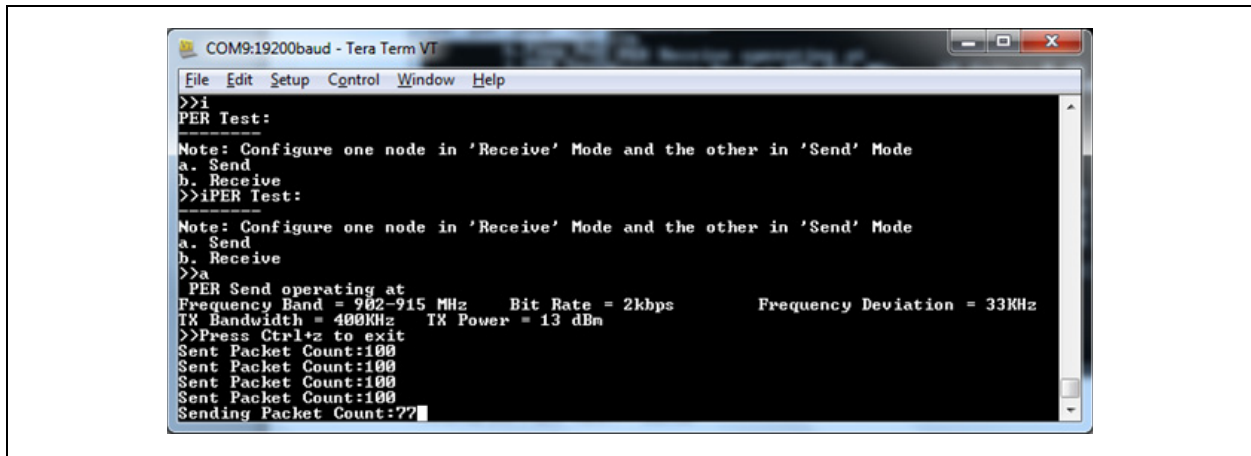
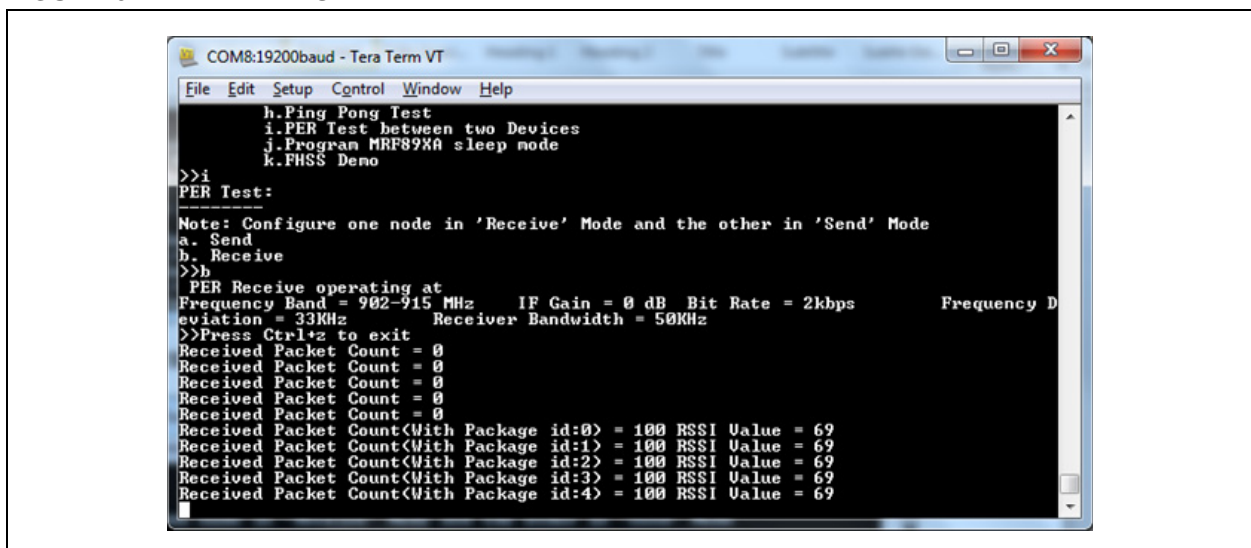


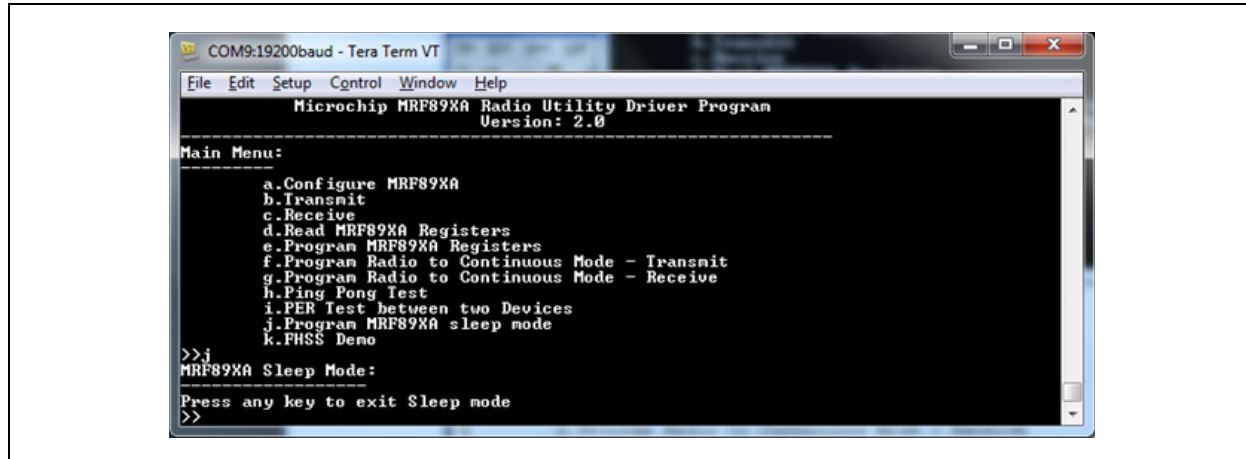
FIGURE 37: PER TEST – RECEIVE



PROGRAM MRF89XA TO SLEEP MODE

This menu option, as shown in [Figure 38](#), enables the user to set the MRF89XA transceiver to Sleep mode. In this mode, the MRF89XA sleep current can be measured.

FIGURE 38: MRF89XA SLEEP MODE



CONCLUSION

The Microchip MRF89XA Transceiver Utility Driver Program is developed to show the flexibility of using Microchip RF transceiver. For developers looking for a short-range, low data rate, wireless solution, the choices are plenty across multiple frequency bands, at different data rates and other features.

The Microchip MRF89XA Utility Driver Program provides a low-cost and low-complexity test platform for application developers to understand the features offered by the Microchip MRF89XA transceiver. It enables RF transceivers, supported by Microchip, to be hooked up and be tested in simple ways.

REFERENCES

- “MRF89XA Data Sheet” (DS70622), Microchip Technology Inc.
- “MRF89XAM8A Data Sheet” (DS70651), Microchip Technology Inc.
- “MRF89XAM9A Data Sheet” (DS75017), Microchip Technology Inc.
- “MRF89XAMxA PICtail™/PICtail Plus Daughter Board User’s Guide” (DS70653), Microchip Technology Inc.
- “MPLAB® ICD 3 In-Circuit Debugger User’s Guide” (DS51766), Microchip Technology Inc.
- “PICDEM™ PIC18 Explorer Demonstration Board User’s Guide” (DS51721), Microchip Technology Inc.
- “Explorer 16 Development Board User’s Guide” (DS51589), Microchip Technology Inc.
- “ZENA™ Wireless Adapter User’s Guide” (DS70664), Microchip Technology Inc.
- IEEE Std 802.15.4™-2003, Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (WPANs). New York: IEEE, 2003.
- IEEE Std 802.15.4™-2006, (Revision of IEEE Std 802.15.4-2003). New York: IEEE, 2006.
- “AN1204, Microchip MiWi™ P2P Wireless Protocol” (DS01204), Yifeng Yang, Pradeep Shamanna, Derrick Lattibeaudiere, and Vivek Anchalia, Microchip Technology Inc., 2008-2017.
- “AN1340, Microchip MRF89XA Radio Utility Driver Program” (DS01340), Sushma Myneni, Microchip Technology Inc., 2010.
- “AN1631, Simple Link Budget Estimation and Performance Measurements of Microchip Sub-GHz Radio Modules” (DS00001631), Pradeep Shamanna, Microchip Technology Inc., 2013.

REVISION HISTORY

Revision A (November 2017)

This is the initial release of the document.

APPENDIX A: SOURCE CODE

SOURCE CODE FOR THE RADIO UTILITY DRIVER PROGRAM FOR MICROCHIP MRF89XA

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All software covered in this application note are available as a single WinZip archive file. This archive file can be downloaded from the Microchip corporate web site at: www.microchip.com.

A.1 Source code file list

Table 5 provides the list of files that are used as part of the Application Note source code project file named as MRF89XA_Radio_Utility_Driver. The New Radio Utility Driver Program for Microchip MRF89XA Transceiver source code Ver1.0 is available as part of AN2583.zip from the AN2583 application note web page or www.microchip.com/mrf89XA. Users should program the PIC18/PIC24 MCU with the MRF89XA_Radio_Utility_Driver.X.production.hex file using the available Microchip programmer or debugger.

TABLE 5: MRF89XA UTILITY DRIVER CODE FILE LIST FOR PIC18/PIC24 MCUs

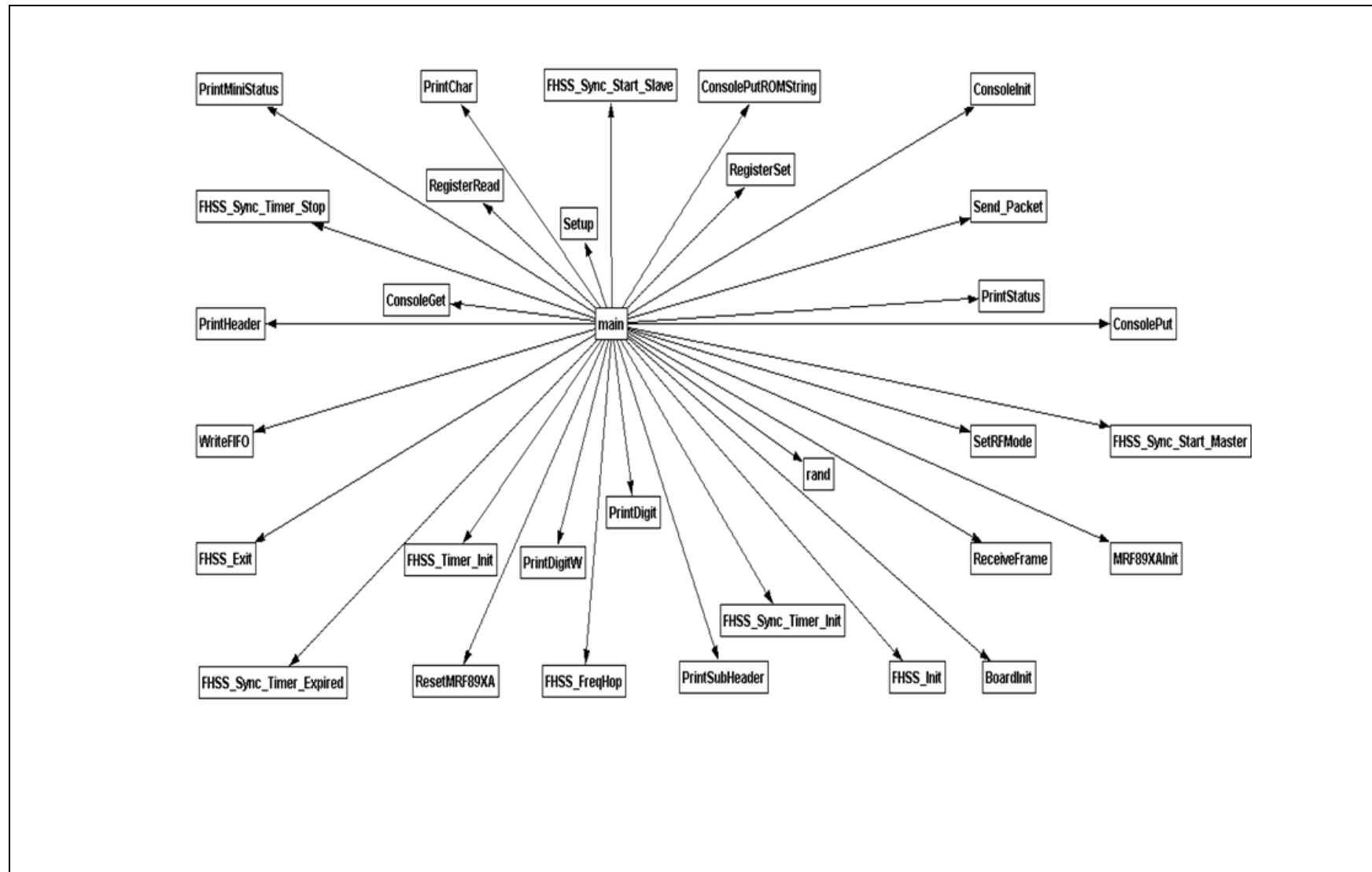
File name	File type	Description
main	.c	Initializes the state machine which is used to demonstrate the Demo Application. This file is also responsible for timer initialization.
EUI_config	.h	Flash MAC address of radio transceiver
driver_mrf_89xa	.c and .h	Initializes radio transceiver and register declaration. Supports function definitions to operate radio register using SPI.
FHSS	.c and .h	Initializes the FHSS related functions, registers, and parameters.
console	.c and .h	Initializes the console. Declares and defines function for console display.
spi	.c and .h	Initializes SPI. Declares and defines function for SPI operation.
system	.c and .h	Initializes the system and declares structures used for data operation.
system_config	.h	Initializes the pin configuration for microcontroller connections with MRF89XA radio transceiver. Also initializes pin configuration for LEDs.

Note: In system_config.h file, pin configuration for the 8-bit platform is for the PIC18F87J11 microcontroller and the pin configuration for the 16-bit platform is for the PIC24FJ128GA010 microcontroller.

A.2 Source Code Call Graph

Figure 39 shows the source code call graph.

FIGURE 39: SOURCE CODE CALL GRAPH



NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
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ISBN: 978-1-5224-2335-5

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