AN1340

MRF89XA Radio Utility Driver Program

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INTRODUCTION

The MRF89XA Radio Utility Driver Program provides design engineers 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 band. 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 MRF89XA Radio Utility Driver Program can run on either the PIC18 Explorer (PIC18F87J11) or the Explorer 16 (PIC24F128GA010) development boards, to which the MRF89XA RF transceiver daughter board is attached. The development board is connected to the PC's serial port and a simple hyper-terminal program can be used as user interface. For more information on setting up, refer to the **Section "Getting Started".**

The MRF89XA Radio Utility Driver Program source code and hex files are in the applications note's compressed file. For additional reference materials, see **Section "References"**.

GETTING STARTED

The following procedure helps you to setup the MRF89XA Radio Utility Driver Program on the development or testing platform:

1. Insert the MRF89XA RF transceiver daughter card into the development board.
   If you are using the PIC18 Explorer development board, refer to the **Section "Using the PIC18 Explorer Development Board"**.
   If you are using Explorer 16 development board, refer to the **Section "Using the Explorer 16 Development Board".**
2. Plug in the power cord for the development board.
3. Connect an RS-232 serial cable between the development board and PC that will display the MRF89XA Radio Utility Driver Program interface.
4. Program the development board with the appropriate hex file.

Note:	The hex files for PIC18 Explorer and Explorer 16 development boards are different.

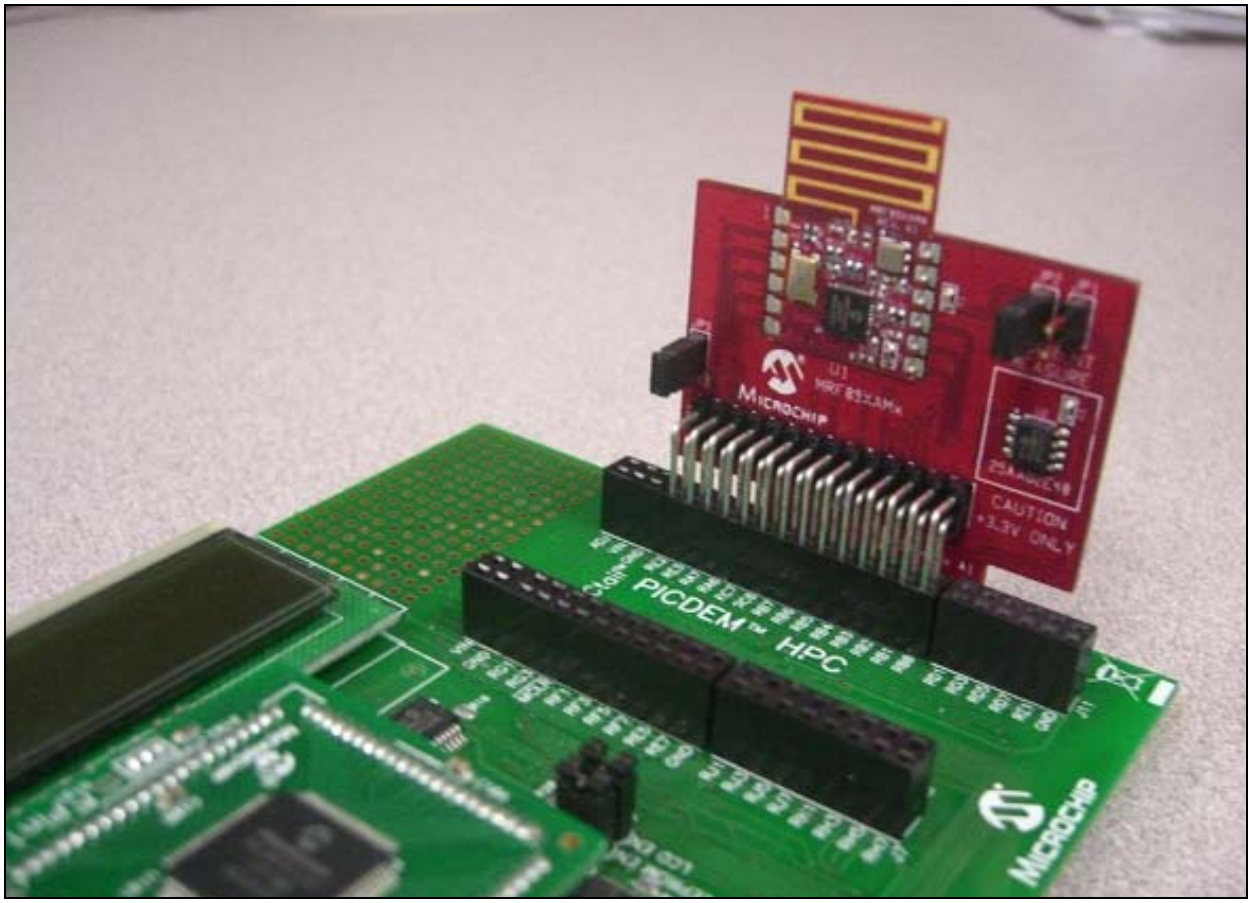
If you are using of MPLAB® ICD 3 for the first time, refer to "*MPLAB® ICD 3 User's Guide"* (DS51766A), *Section 4.3.2, "Loading a hex File*".

5. Open the HyperTerminal program from the Windows and configure, details are listed in Table 1. For more information on the setup, refer to the **Section "Connecting to the Host PC"**.

Using the PIC18 Explorer Development Board

The MRF89XA daughter board can be connected to the PICtail™ connector J3 on the PIC18 Explorer board. This connection supports 4-wire SPI, interrupts and other MRF89XA handshake signals between the PIC© microcontroller and the MRF89XA daughter board. Figure 1 illustrates this setup (using the PIC18 Explorer board).

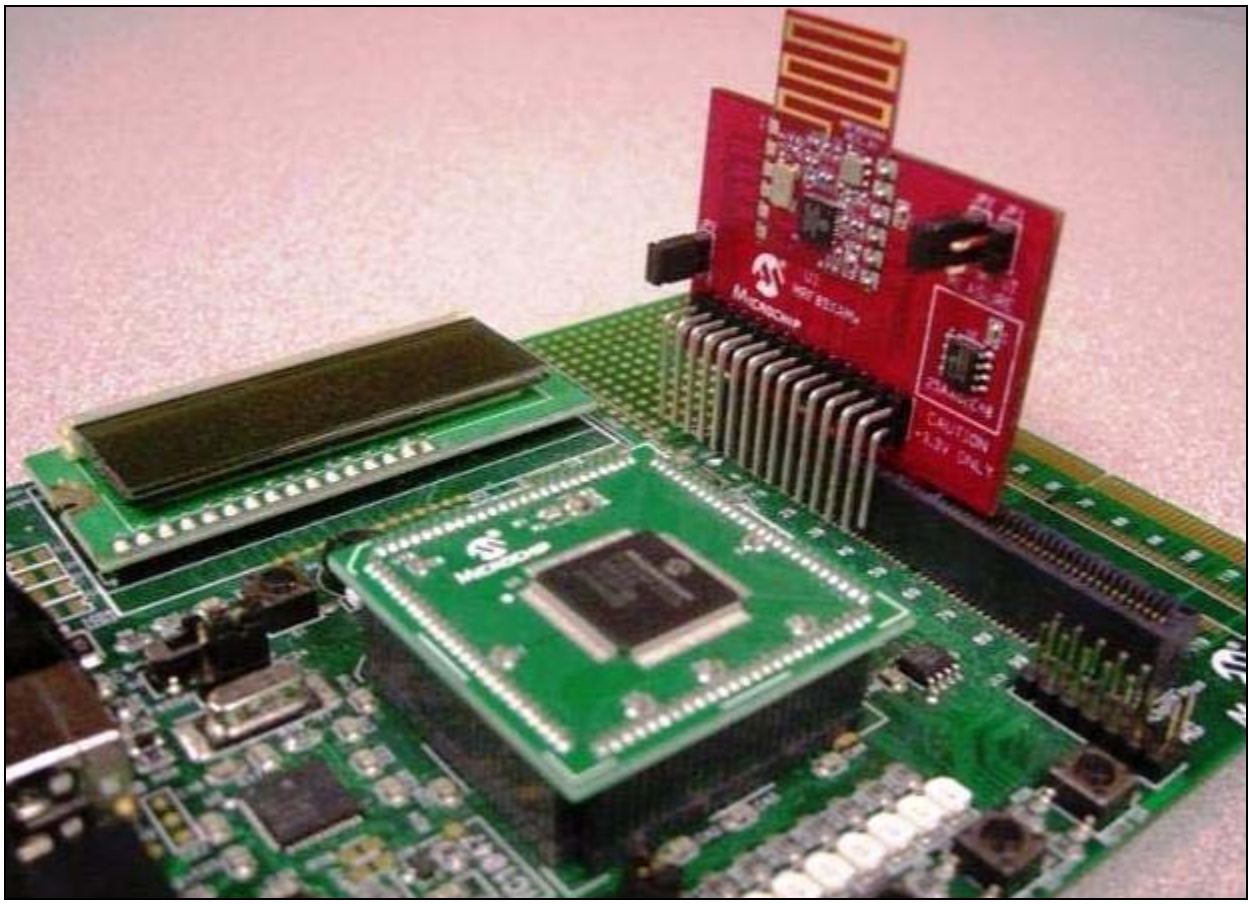
FIGURE 1: CONNECTING THE MRF89XA DAUGHTER BOARD TO THE PICTAIL™ CONNECTOR J3 ON THE PIC18 EXPLORER BOARD



Using the Explorer 16 Development Board

The MRF89XA daughter board's PCB-edge connector can be used to connect to the Explorer 16 development board's PICtail™ Plus connector. This connection supports 4-wire SPI, interrupts and other MRF89XA handshake signals between the PIC microcontroller and the MRF89XA daughter board. The setup between the Explorer 16 Development Board and the MRF89XA daughter board is displayed in Figure 2.

FIGURE 2: CONNECTING THE MRF89XA DAUGHTER BOARD TO THE PICTAIL™ CONNECTOR J3 ON THE PIC18 EXPLORER BOARD



Connecting to the Host PC

The MRF89XA Radio Utility Driver Program's user interface can be accessed by connecting an RS-232 serial cable between the development board and the PC. PCs with operating systems such as Windows® XP or Windows® NT can use the HyperTerminal Program. Other serial port communication utilities or application programs can also be used based on your familiarity and availability.

Table 1 lists the configuration settings for the serial port communication.

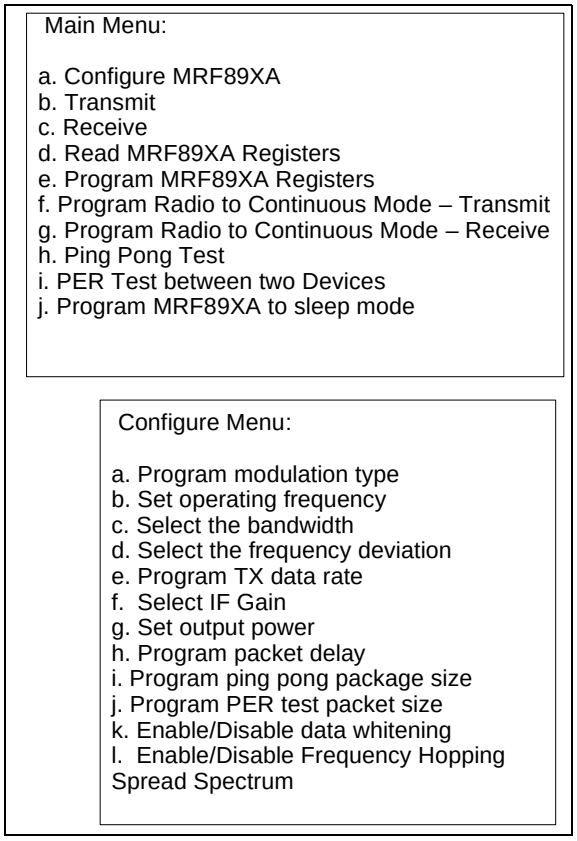
TABLE 1: SERIAL PORT SETTINGS

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

USING THE MRF89XA RADIO UTILITY DRIVER PROGRAM

The MRF89XA Radio Utility Driver Program can be operated through the user interface that is displayed on the host computer. There are two menus as shown in Figure 3.

FIGURE 3: MENUS



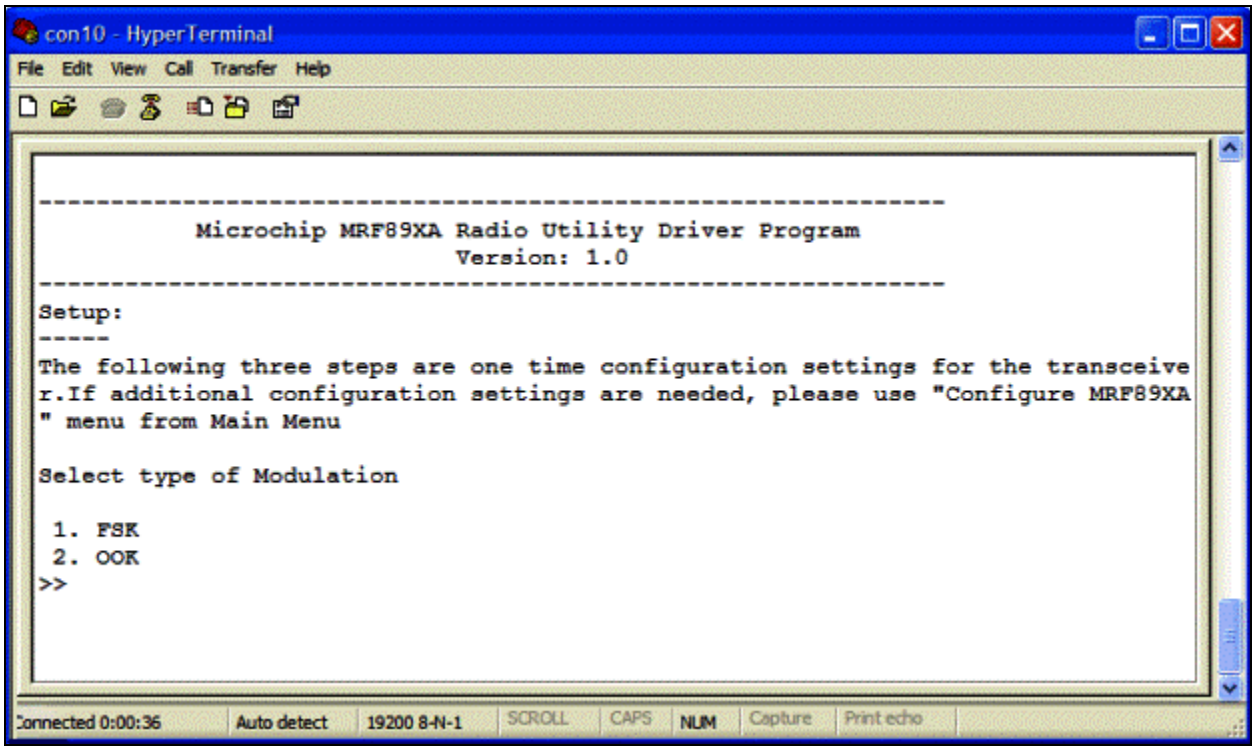
- **Main Menu**: Contains the test function commands.
- **Configure Menu**: Configures the transceiver and it can be accessed from the Main Menu.

The following shortcut keys can be used to navigate through the menus.

TABLE 2: SHORTCUT KEYS

Shortcut Key	Functionality
<Ctrl> + <z>	Exit and return to Main Menu. It can be used to stop or exit from any step.
<Ctrl> + <x>	Reset the transceiver. Stops the current process and programs the transceiver with default values (listed in Table 3).
<Ctrl> + <s>	Display the current system status and configuration values. It can be used at any step in the program.

FIGURE 4: SETUP PROCEDURE



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 these setup procedure.

1. Select the default mode of modulation type from one of the following options:
   a) FSK
   b) OOK

The user can modify the modulation type using “Configure MRF89XA => Select modulation type” from the Main Menu.

2. Select the frequency of operation from one of the following options:
   a) Frequency Band: 902-915 MHz
   b) Frequency Band: 915-928 MHz
   c) Frequency Band: 950-960 MHz
   d) Frequency Band: 863-870 MHz

The user can modify the frequency band and center frequency using “Configure MRF89XA => Select Operating Frequency”.

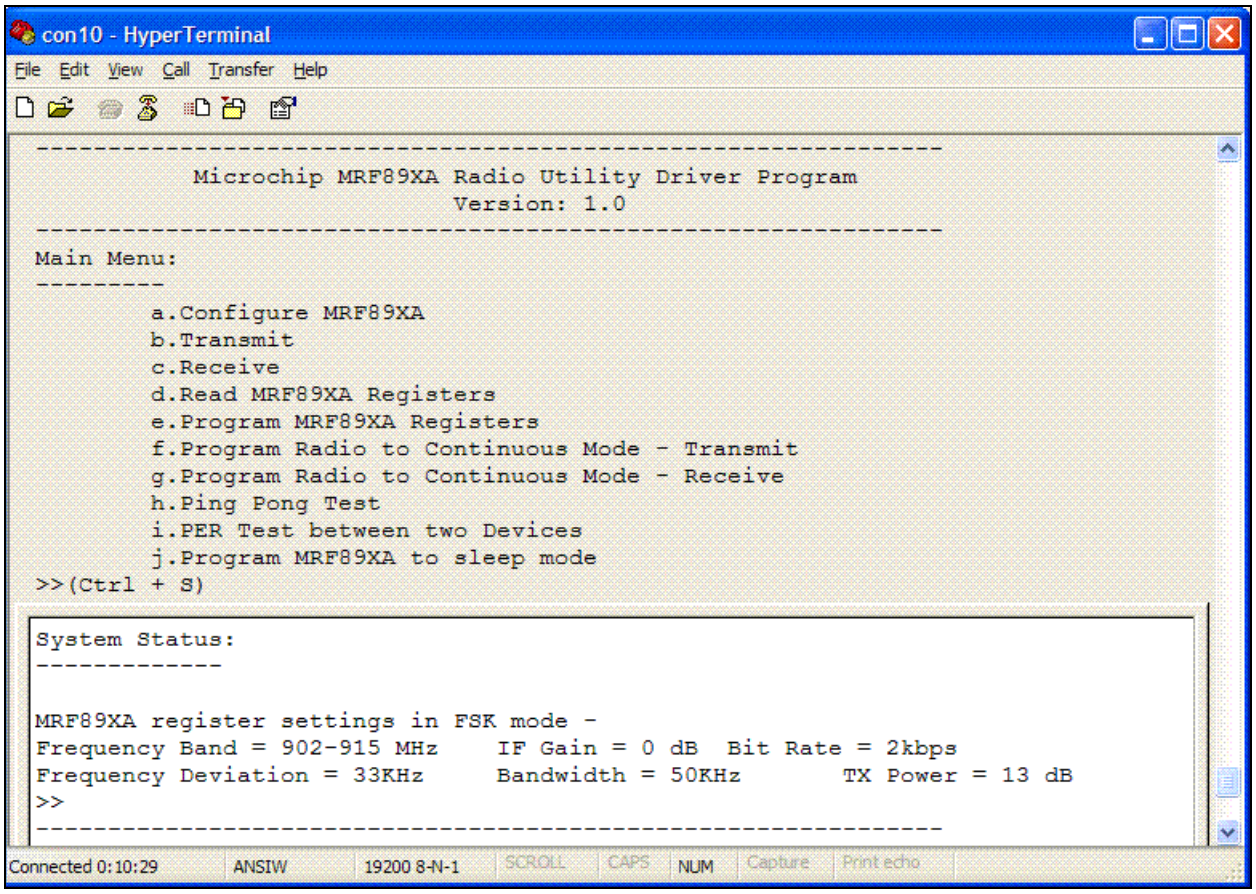
3. Select the data rate.

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 by using the “Configure MRF89XA” menu options from the Main Menu.

Figure 5 shows the Main Menu and a sample status command output.

FIGURE 5: THE MAIN MENU



EXECUTING FIRMWARE COMMANDS

This section describes the commands executed by the Main Menu and Configure Menu. The following are 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 3.

TABLE 3: DEFAULT CONFIGURATION SETTINGS

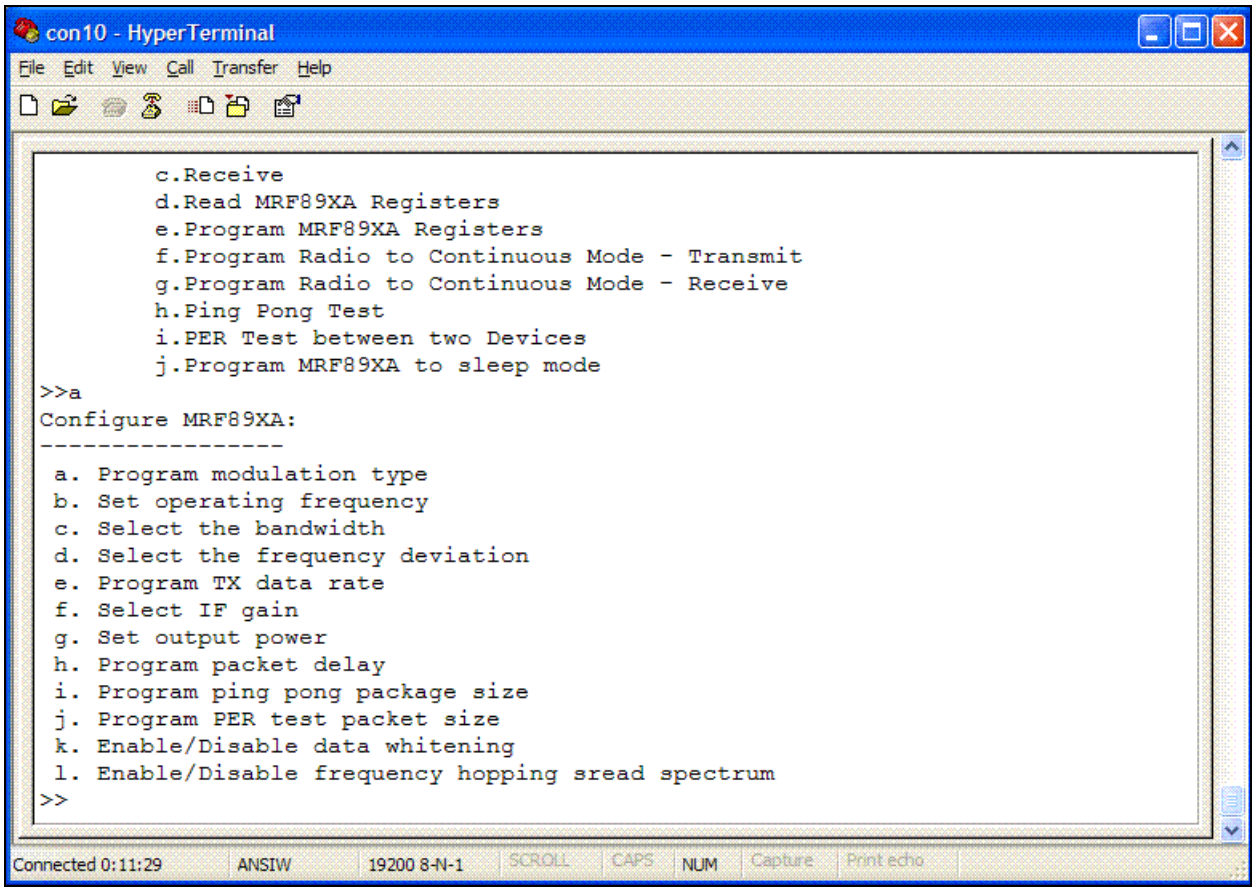
Attribute	Setting
Modulation	Value chosen during setup procedure
Frequency Band	Value chosen during setup procedure
Center Frequency	Value chosen during setup procedure
Data Rate	Value chosen during setup procedure
Bandwidth	Value chosen during setup procedure
Frequency Deviation	Value chosen during setup procedure
IF Gain	Maximal Gain (0 dB)
TX Output Power	13dBm
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 returns the settings 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.

The user can reconfigure the values through the Configuration Menu as shown in Figure 6.

FIGURE 6: CONFIGURATION MENU



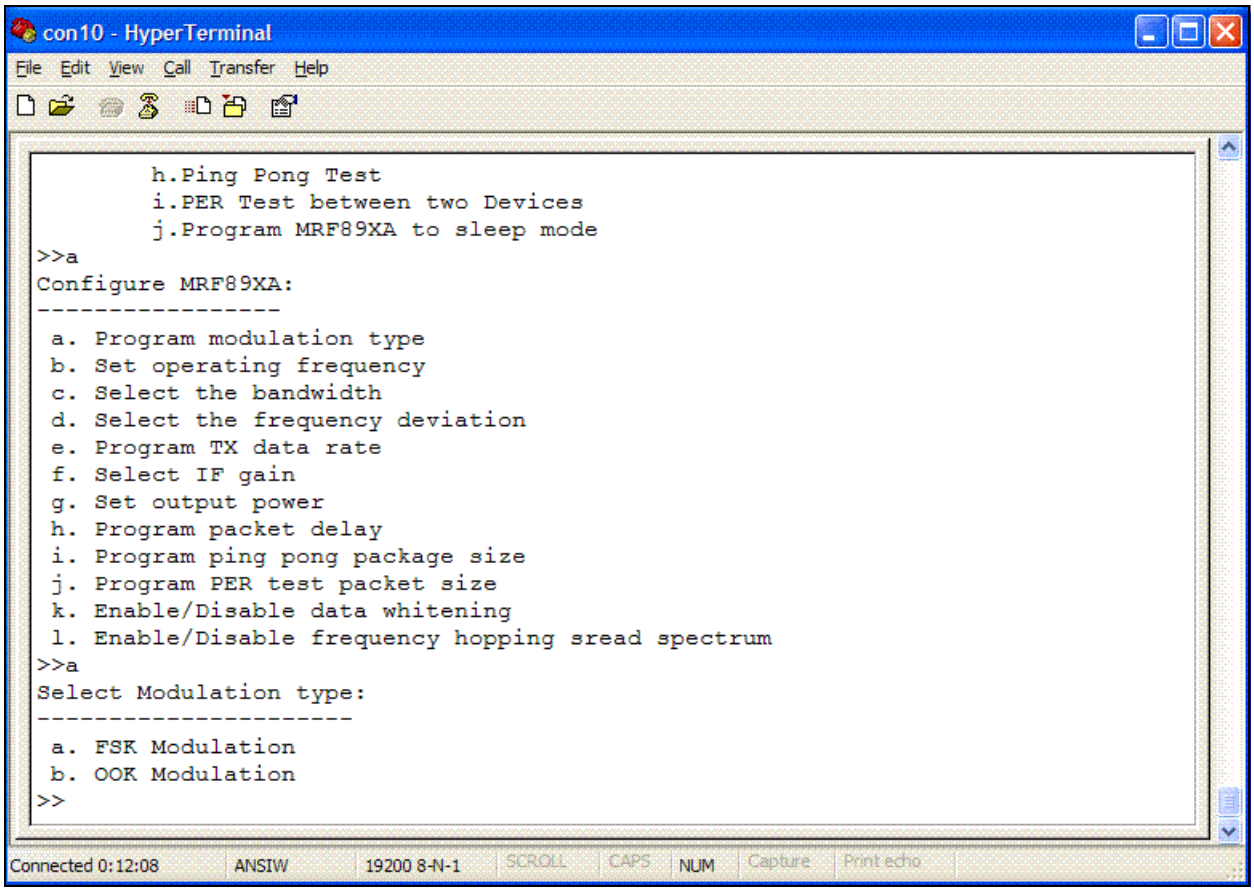
Configure MRF89XA

This Main Menu command displays the Configuration Menu as shown in Figure 6.

PROGRAM MODULATION TYPE

This menu option, as shown in Figure 7, 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.

FIGURE 7: PROGRAM MODULATION TYPE



SET OPERATING FREQUENCY

This menu option, as shown in Figure 8, 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 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 program RiREG, PiREG and SiREG.

The center frequency can be calculated using the Equation 1 and Equation 2:

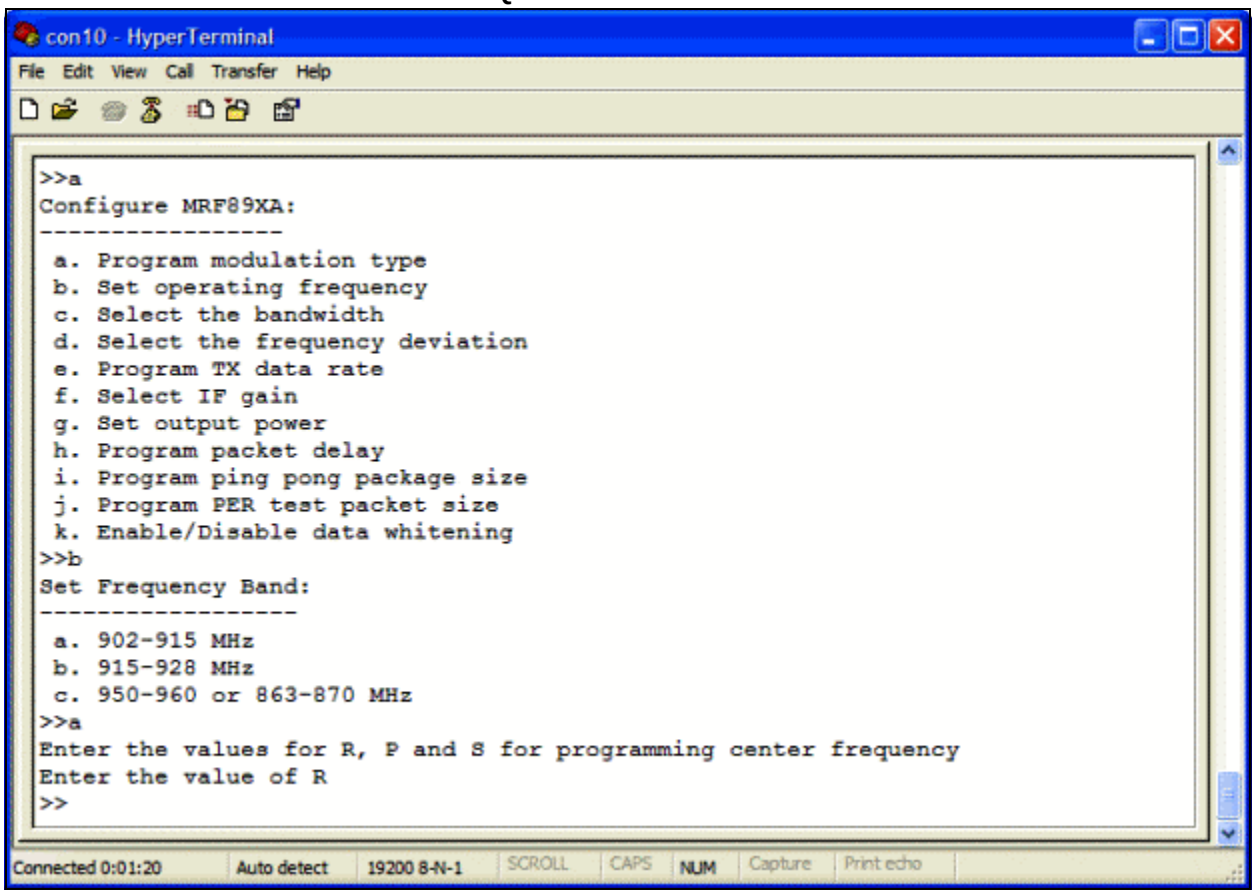
EQUATION 1:

*Center Frequency (FSK) = (9 * Fxtal *[75 (PiREG + 1) + SiREG])/(8*RiREG + 1)*

EQUATION 2:

*Center Frequency (OOK) = (9 * Fxtal *[75 (PiREG + 1) + SiREG])/(8*RiREG + 1) - FDEV*

FIGURE 8: SET OPERATING FREQUENCY



SELECT THE BANDWIDTH

This Configuration Menu option, as shown in Figure 9, 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 operation. The user must program the appropriate bandwidth based on the selected data rate information.

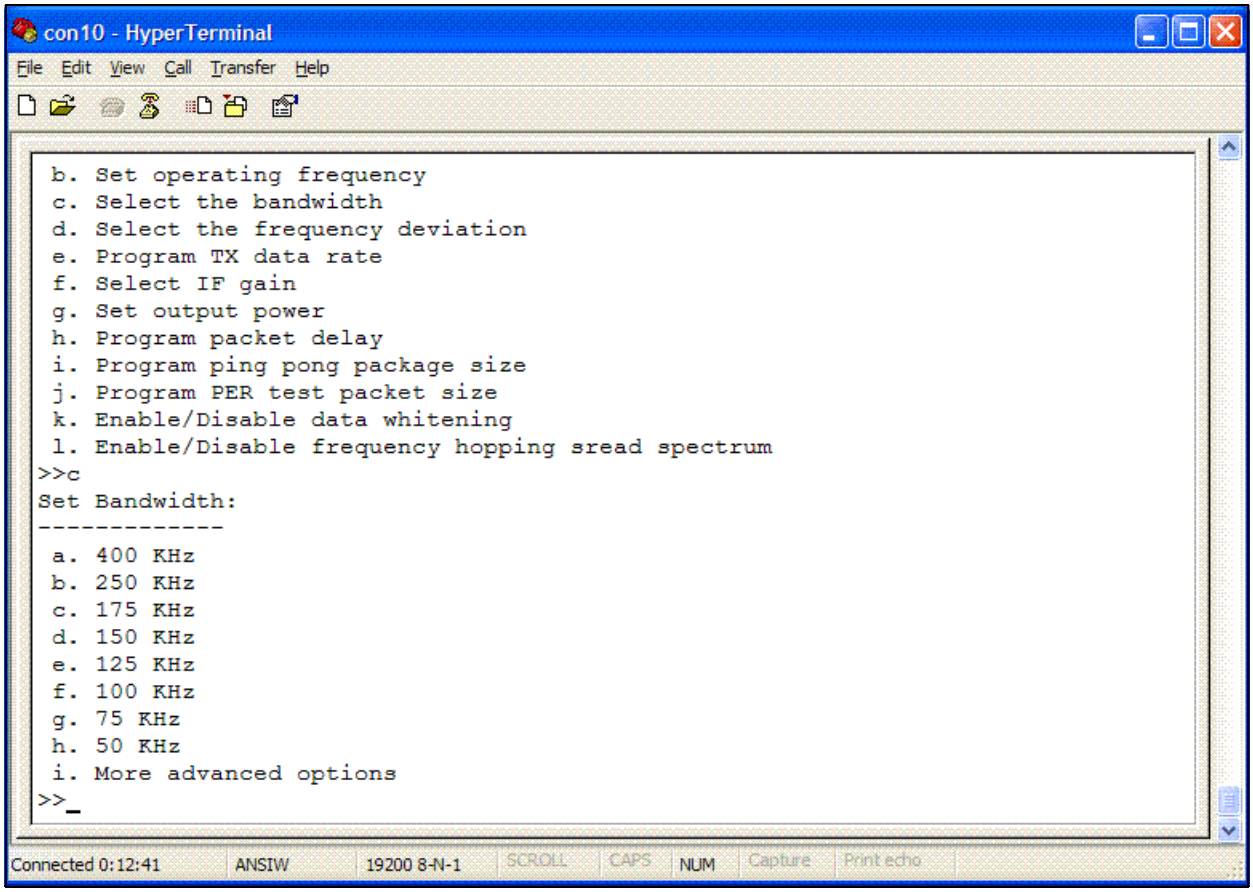
The default value for the bandwidth is the value chosen during the setup procedure.

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 register, refer to the "*MRF89XA Data Sheet*" (DS70622B).

FIGURE 9: SELECTING THE BANDWIDTH



SELECT THE FREQUENCY DEVIATION

This Configuration Menu option, shown in Figure 10, 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 the Equation 3.

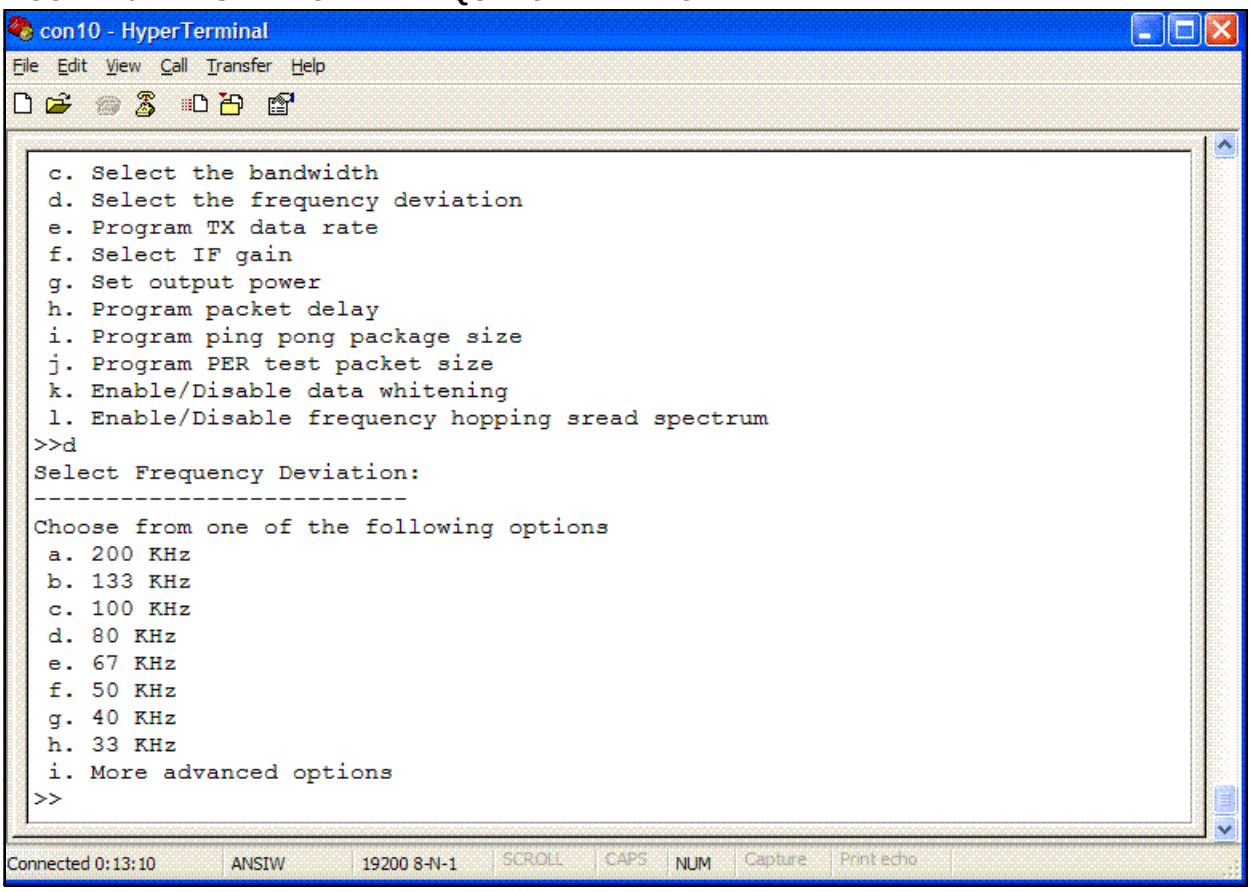
EQUATION 3:

$$FDEV = (FXTAL /(32 * (FDVAL + 1)))$$
$$\text{where } 0 \leq FDVAL \leq 255$$

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*" (DS70622B).

FIGURE 10: SETTING THE FREQUENCY DEVIATION



PROGRAM TX DATA RATE

This Configuration Menu option, shown in Figure 11, enables programming the desired TX data rate.

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.

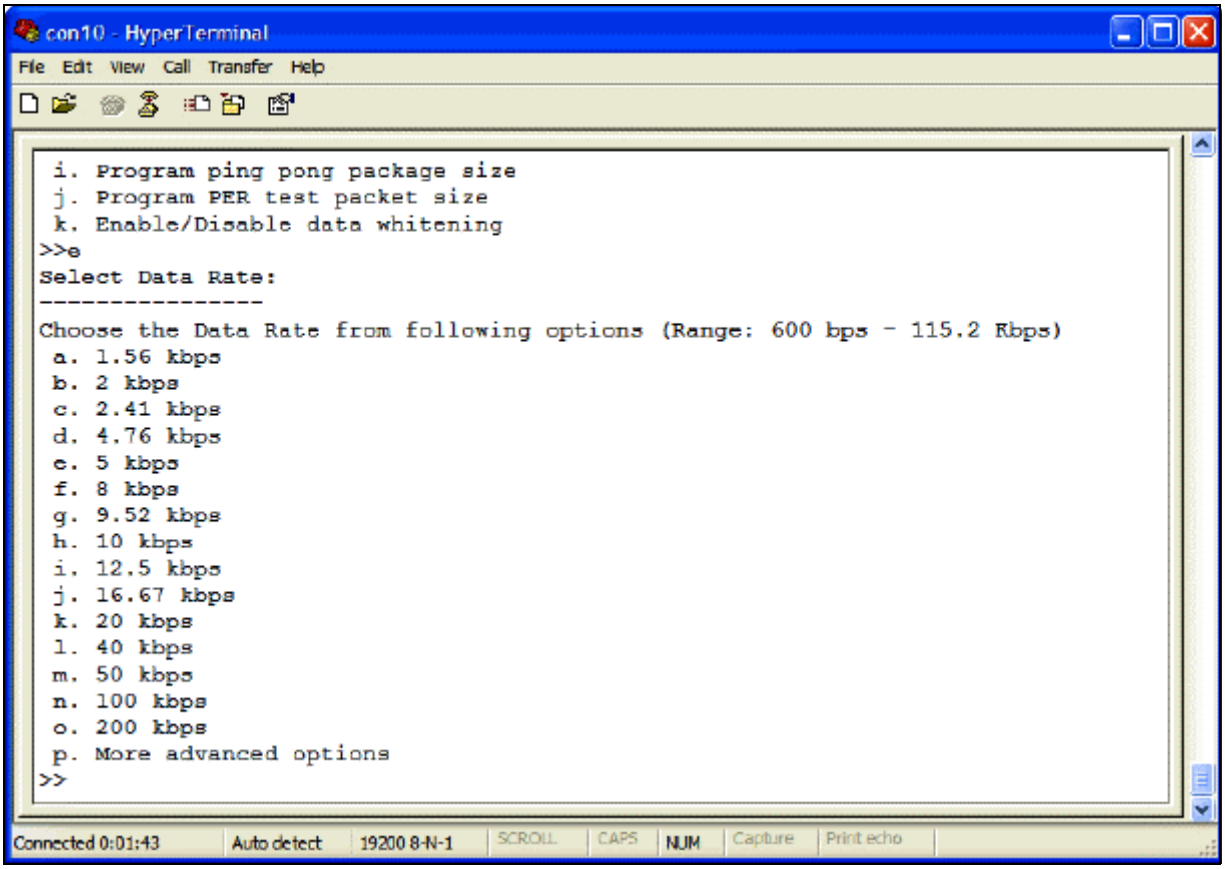
For programming the MRF89XA daughter board to advanced options, chose the option “i” from the Data Rate menu and program the BRVAL<6:0> as shown in Equation 4.

EQUATION 4:

*Bit Rate = (FXTAL / (64 * (BRVAL+1))) where 0 ≤ BRVAL ≤ 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*” (DS70622B).

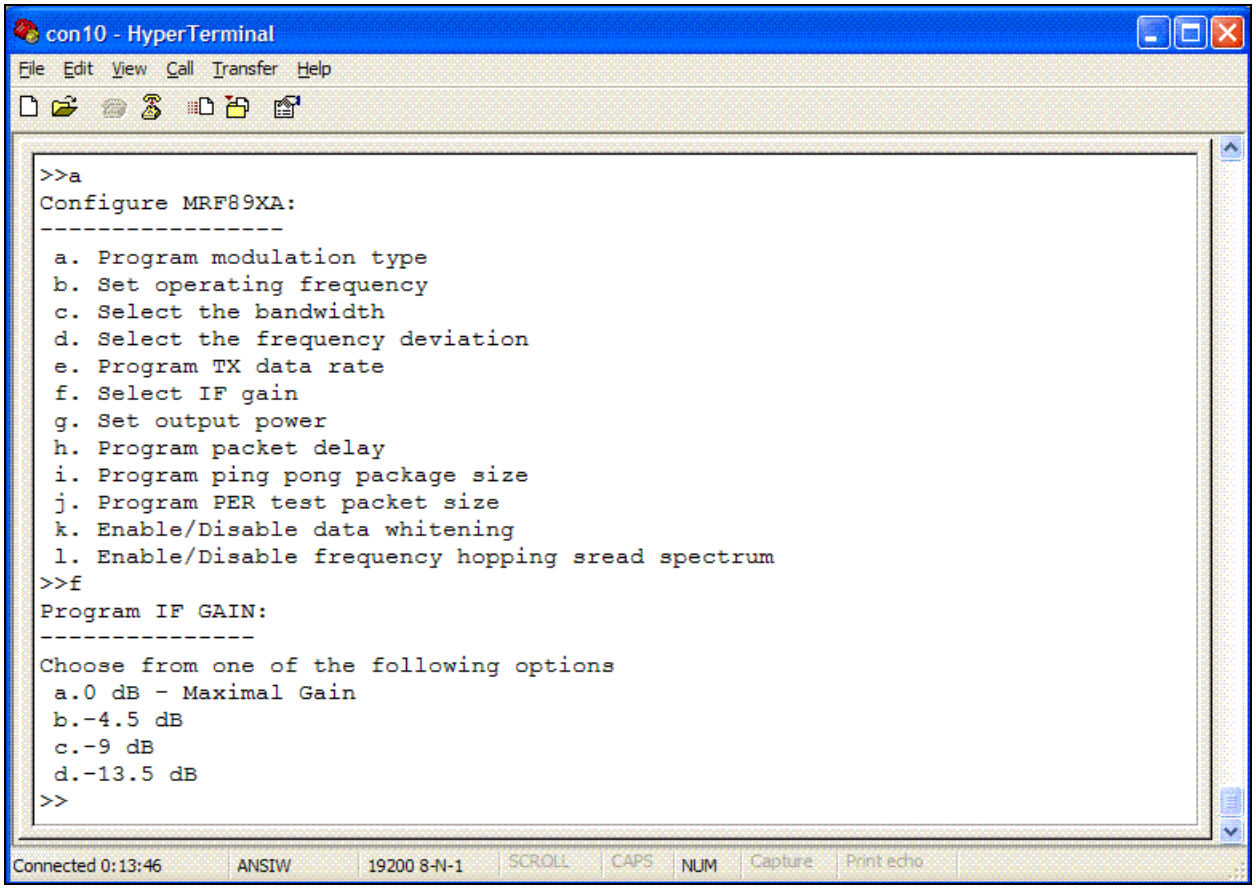
FIGURE 11: PROGRAMMING THE TX DATA RATE



SELECT IF GAIN

This Configuration Menu option, shown in Figure 12, 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.

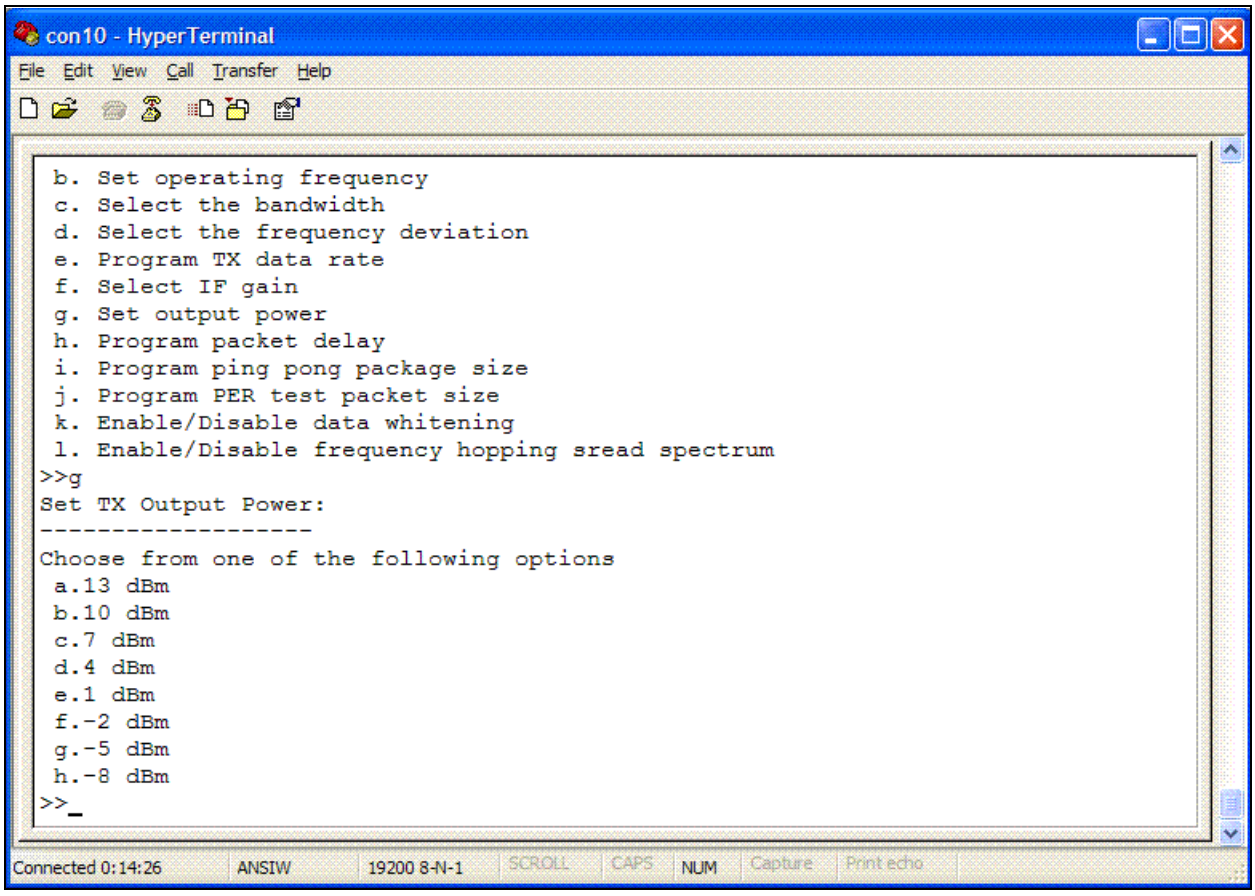
FIGURE 12: SELECTING THE IF GAIN



SET OUTPUT POWER

This Configuration Menu option, shown in Figure 13, 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 is13 dBm.

FIGURE 13: SETTING THE TX OUTPUT POWER



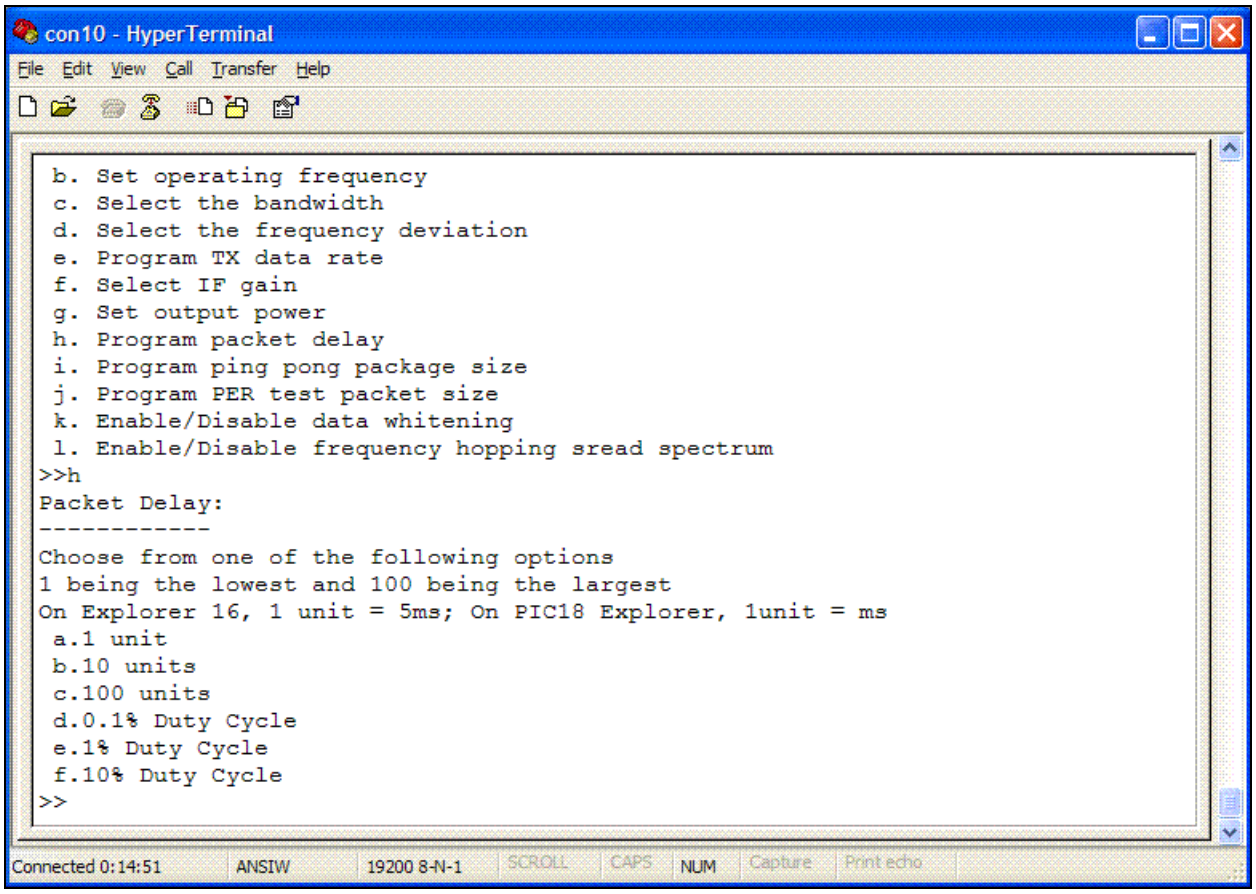
Note:	The power level at the antenna is different from the configured power level. The transmitted power level is lower because of the insertion losses in matching network due to SAW filter

PROGRAM PACKET DELAY

This Configuration Menu option, shown in Figure 14, 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 or 10 or 100 units. Where 1 unit corresponds to 5 ms on Explorer 16 and 4 ms on PIC18 Explorer.

FIGURE 14: PROGRAMMING THE PACKET DELAY

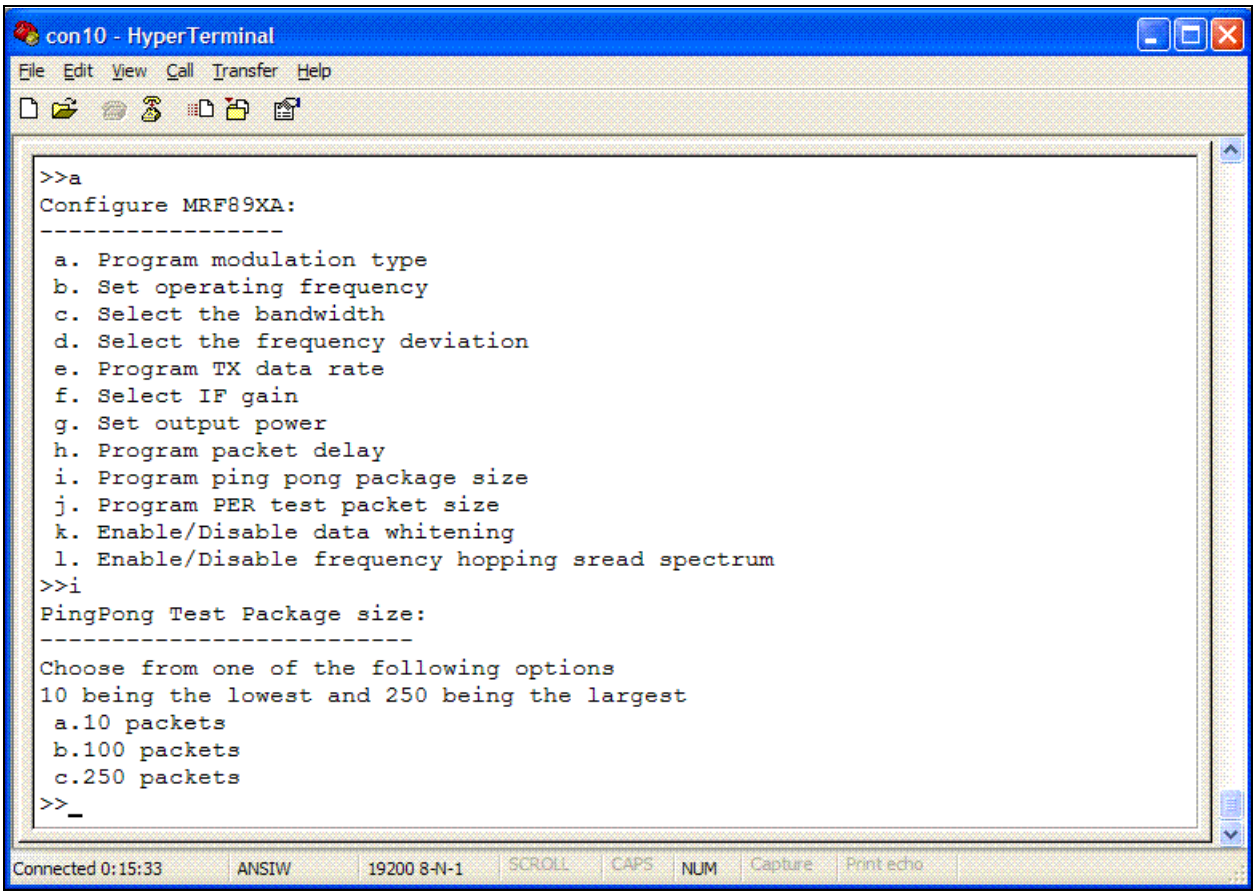


PROGRAM PING PONG PACKAGE SIZE

This Configuration Menu option, shown in Figure 15, 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 or 100 or 250 packets. (For more information on Ping Pong test, refer to the **Section "Program Radio to Continuous Mode – Receive"**).

FIGURE 15: PROGRAMMING THE PING-PONG PACKAGE SIZE

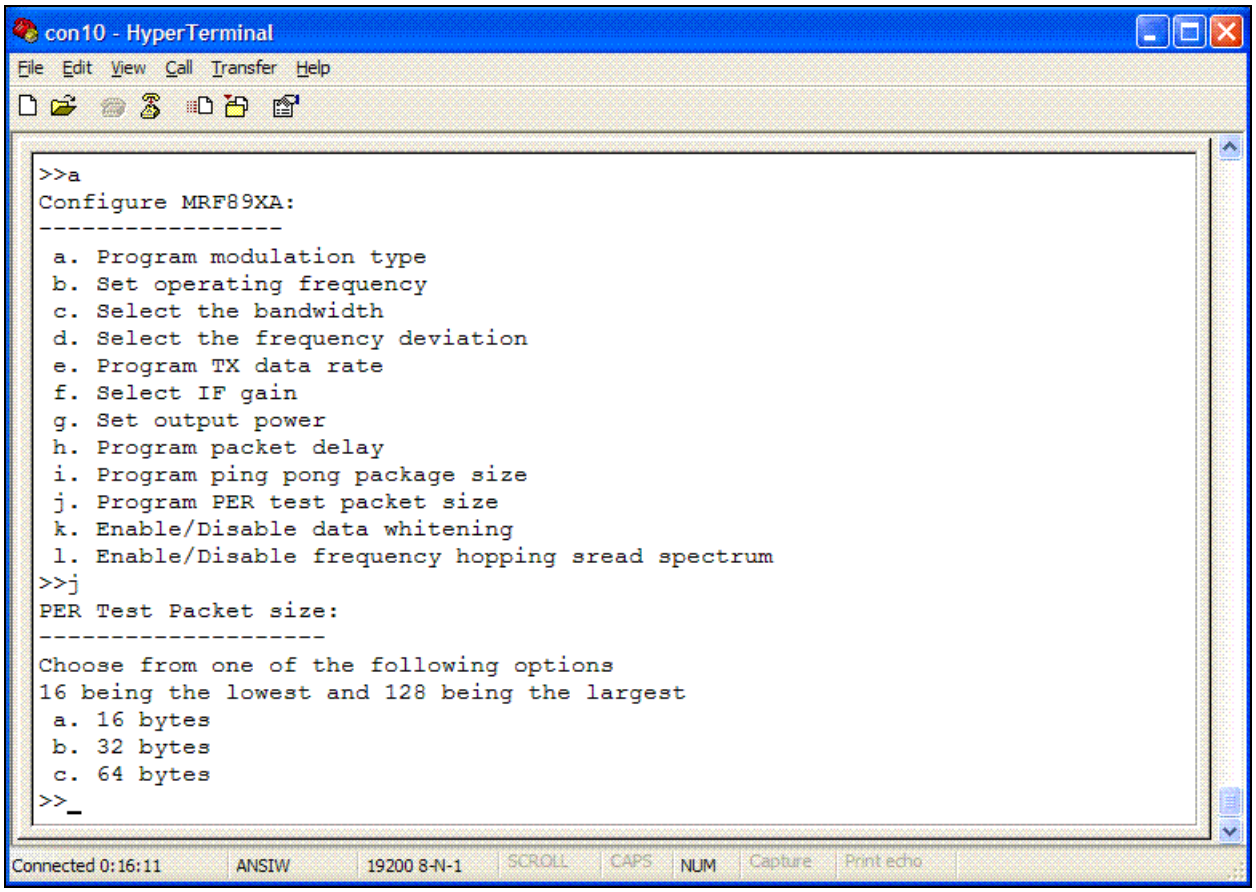


PROGRAM PER TEST PACKET SIZE

This Configuration Menu option, shown in Figure 16, set the length of the packet that is used for performing PER test between transceivers. Using the PER test packet size, user can find out the PER percentage for different packet lengths.

The PER test packet size can be set to 16 or 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 has given an option to test the PER at different packet lengths.

FIGURE 16: PROGRAMMING PER TEST PACKET SIZE

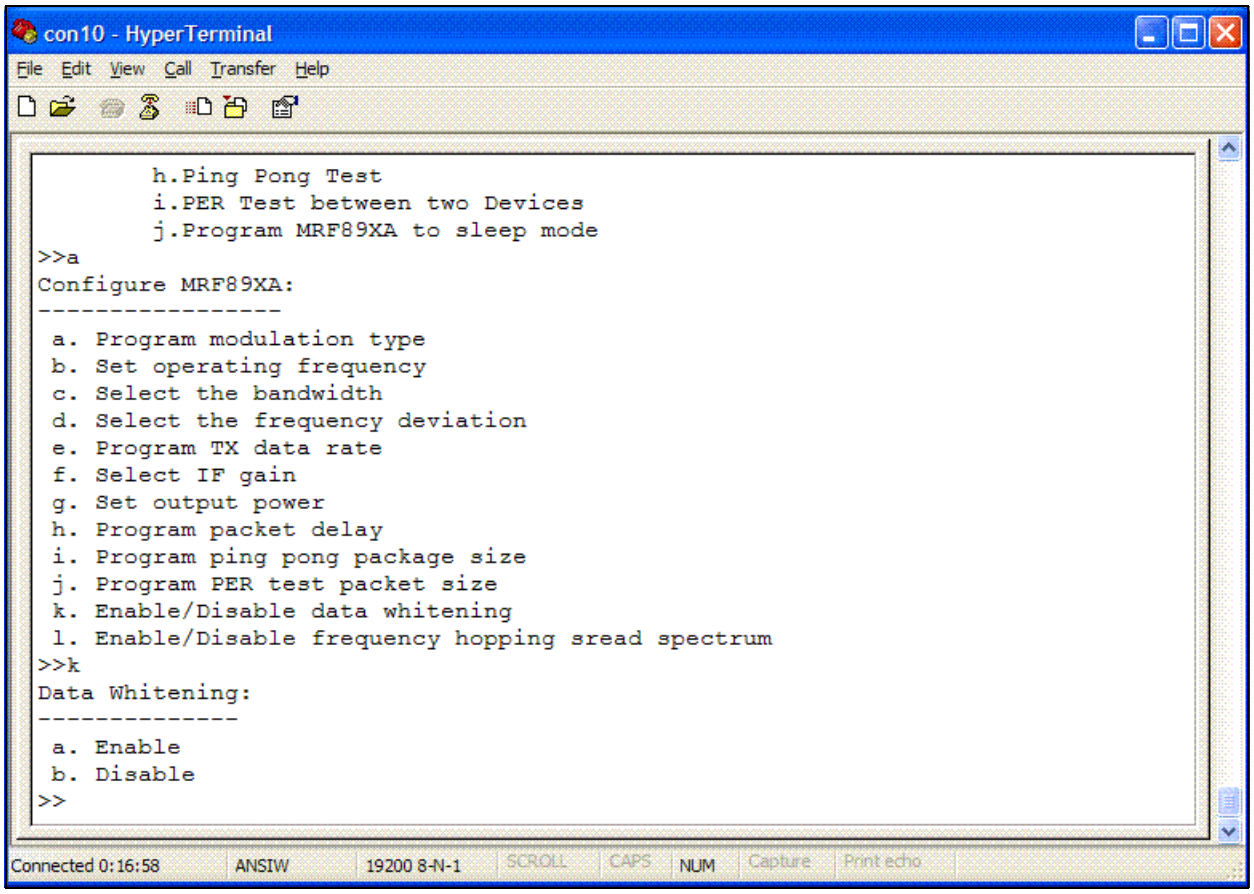


ENABLE/DISABLE DATA WHITENING

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.

This Configuration Menu option, shown in Figure 17, enables or disables data whitening. For more information, refer to the "*MRF89XA Data Sheet*" (DS70622B).

FIGURE 17: DATA WHITENING MODE MENU

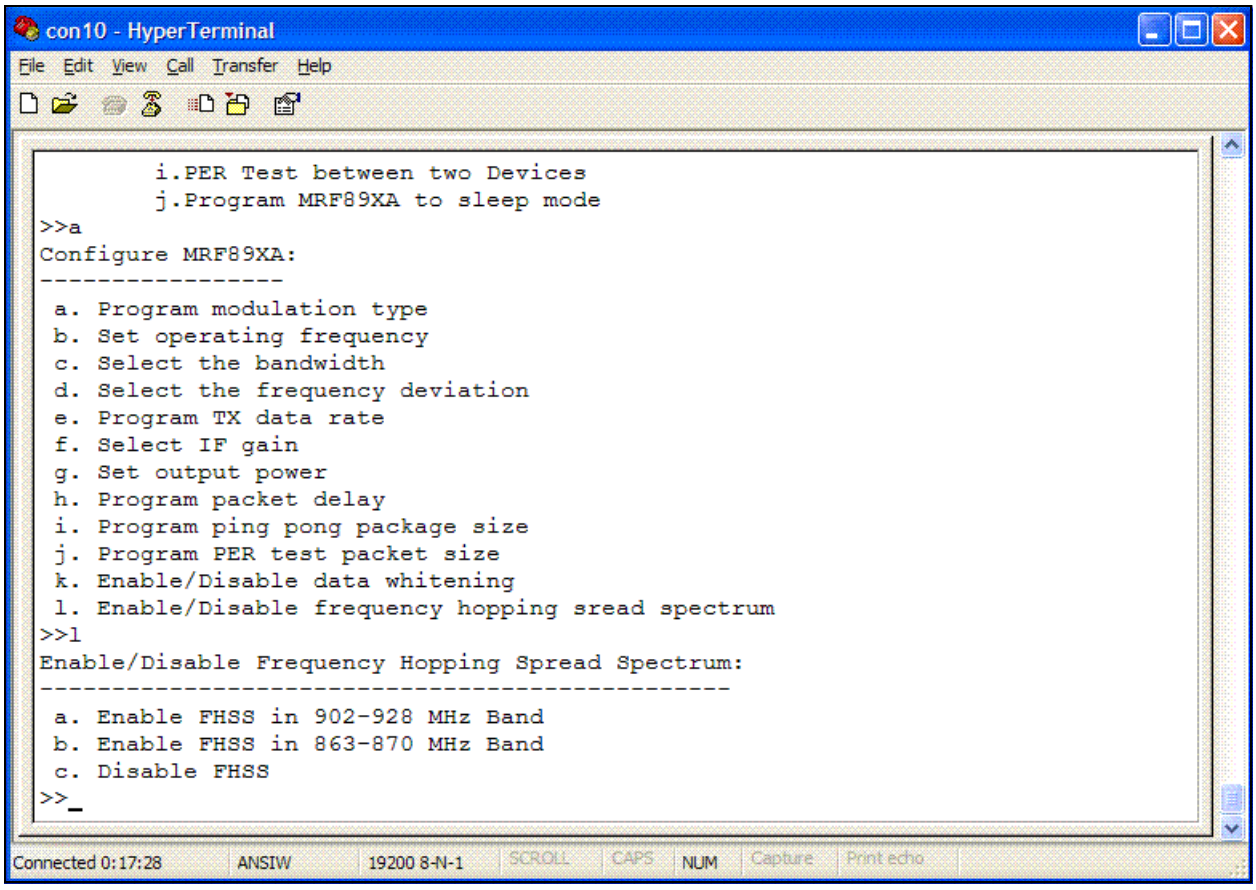


ENABLE/DISABLE FREQUENCY HOPPING SPREAD SPECTRUM (FHSS)

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

This Configuration Menu option, shown in Figure 18, enables or disables FHSS.

FIGURE 18: FHSS MENU



Test function commands

Test activation and other functional commands are issued through the Main Menu. Using test function command, 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 Main Menu option, shown in Figure 19 and Figure 20, enables the user to set MRF89XA in transmit mode. The packet structure can be either user-defined structure as shown in Figure 21 and Figure 22 or a pre-defined structure as shown in Figure 19 and Figure 20. Using this mode, 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*" (DS70622B).

FIGURE 19: TRANSMIT PREDEFINED PACKET MENU

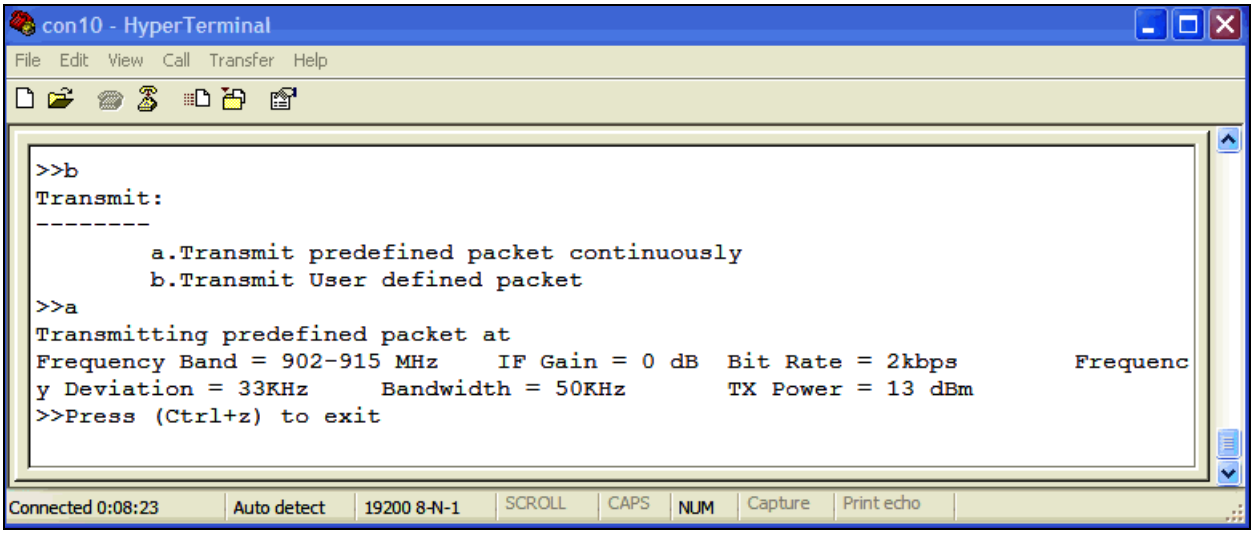


FIGURE 20: VERIFICATION OF TRANSMIT - PREDEFINED PACKET

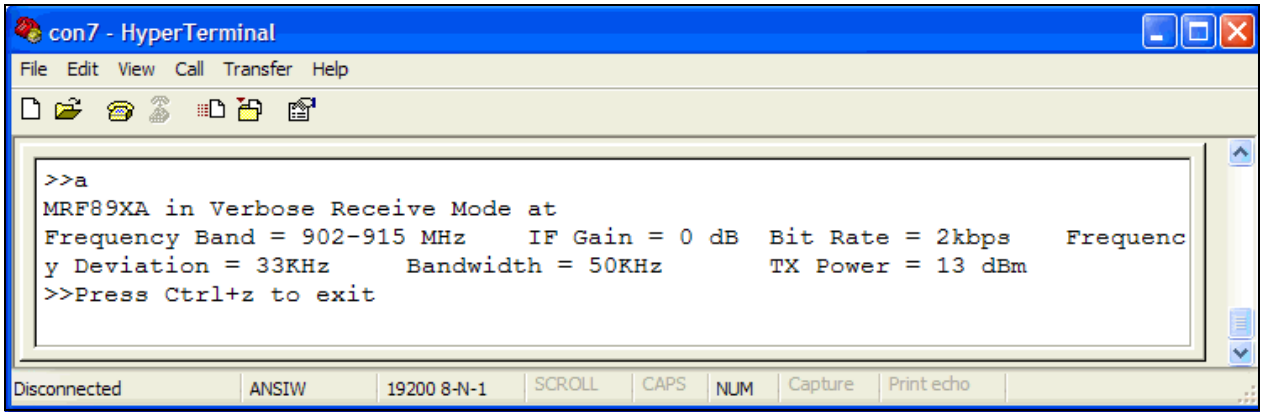


FIGURE 21: USER DEFINED PACKET TRANSMISSION

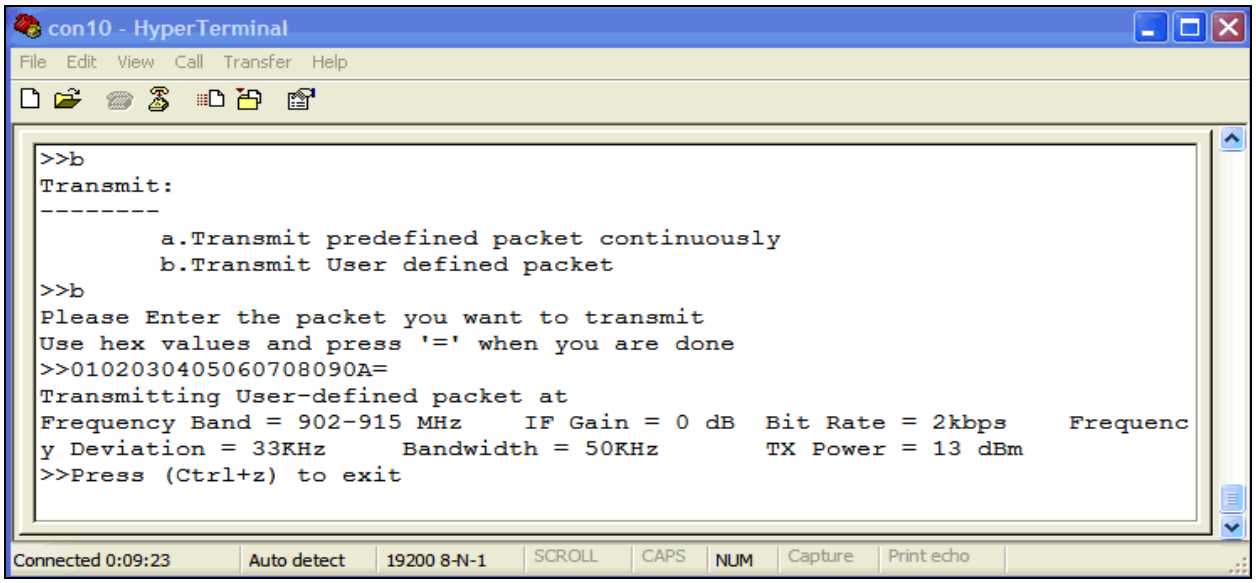
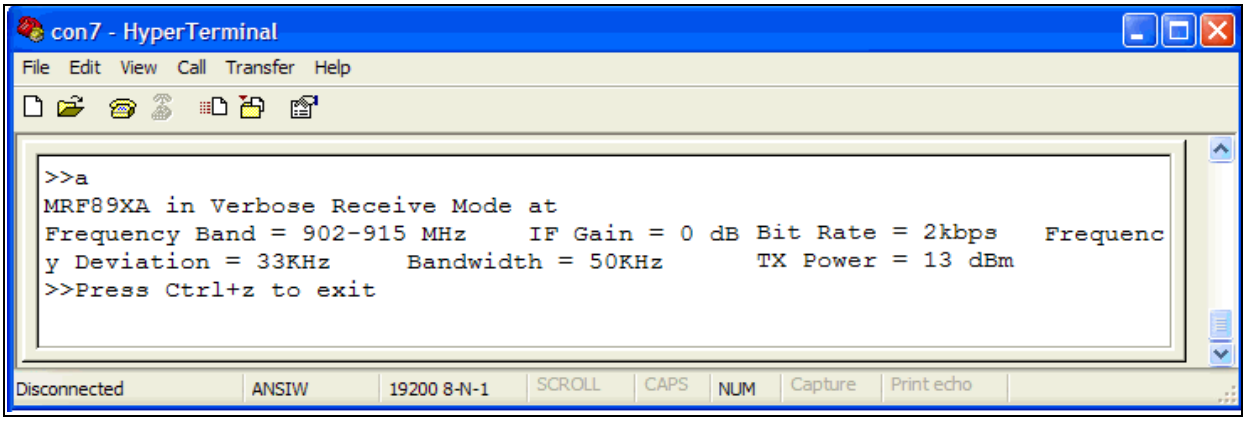


FIGURE 22: VERIFICATION OF TRANSMIT – USER DEFINED PACKET



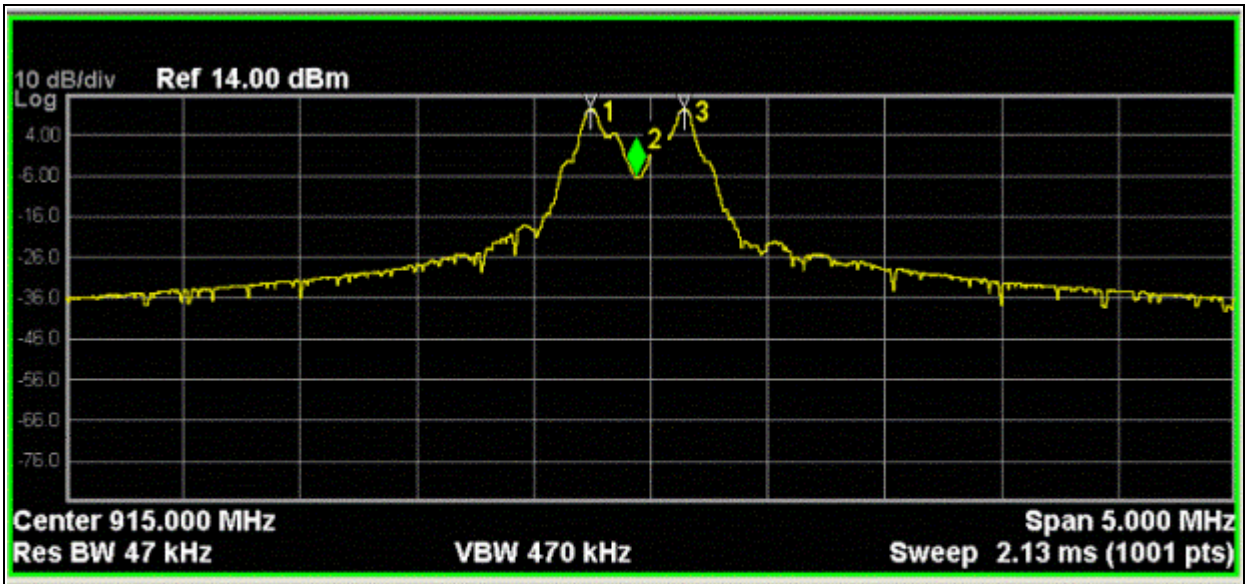
The inter-packet delay between the continuous streams of packets can be defined using the “Program Packet Delay” option in the Configuration Menu commands. To verify the transmission, user must setup a device (receiver operating at the same frequency and same data rate). The detailed steps for setting 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 3.
2. To modify the configuration settings:

   Go to the Main Menu (by pressing <Ctrl> + <z>) and then select “(a) Configure MRF89XA” (Configuration Menu). For more information about configuration menu settings, refer to the **Section “Configure MRF89XA”**.
   - Edit the desired parameters
   - Return to the Main Menu <Ctrl> + <z>.
3. The receiver can be configured either in “Verbose Mode” or “Summary mode” or “Packet Count mode”. For more information, refer to the **Section “Receive”**.
4. Refer to the **Section “Program packet delay”** to modify the inter-packet delay.
5. Choose the Transmit mode, either pre-defined packet or user-defined packet. If you want to transmit a user-defined packet, enter the hexadecimal values to be transmitted and press <=> “equals” key after entering the entire packet contents. This process is shown in Figure 19.
6. Transmission starts immediately.
7. To stop transmission, press <Ctrl> + <z>.

The transmitted signal can be observed on a RF Spectrum Analyzer as shown in Figure 23.

FIGURE 23: CAPTURING THE TRANSMISSION ON SPECTRUM ANALYZER



Spectrum of 915MHz with 200KHz frequency deviation

RECEIVE

This Main Menu option enable users to set MRF89XA transceiver to Receive mode, and 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 24.
- Summary mode: Only the packet count received for each second will be displayed. A user can introduce an interferer and observe the packet drop. This option is shown in Figure 26.
- 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 27.

Before using this option, verify the receiver's configuration settings (bandwidth, frequency deviation, center frequency) against that of transmitter. Setting up the transmitter is shown in Figure 25.

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

FIGURE 24: VERBOSE RECEIVE MODE

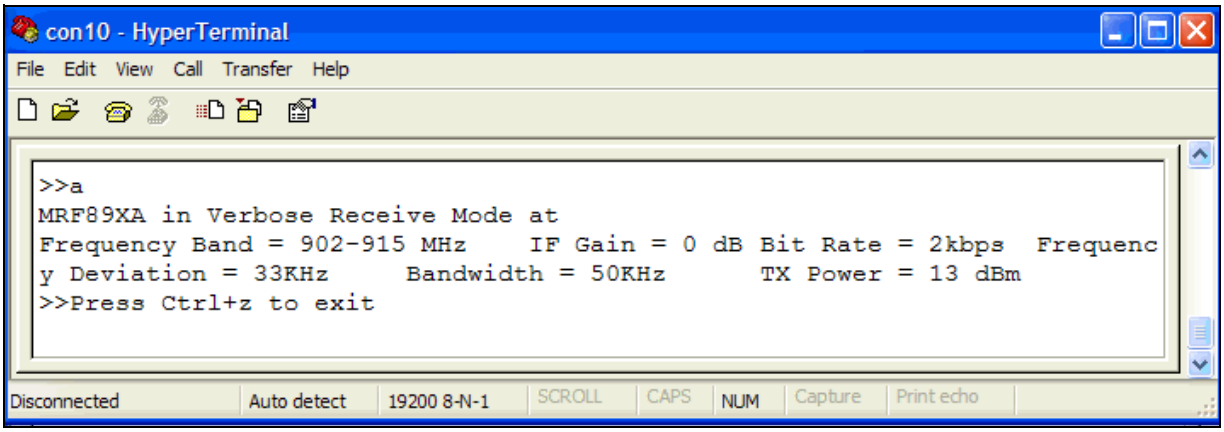


FIGURE 25: SETTING UP TRANSMITTER

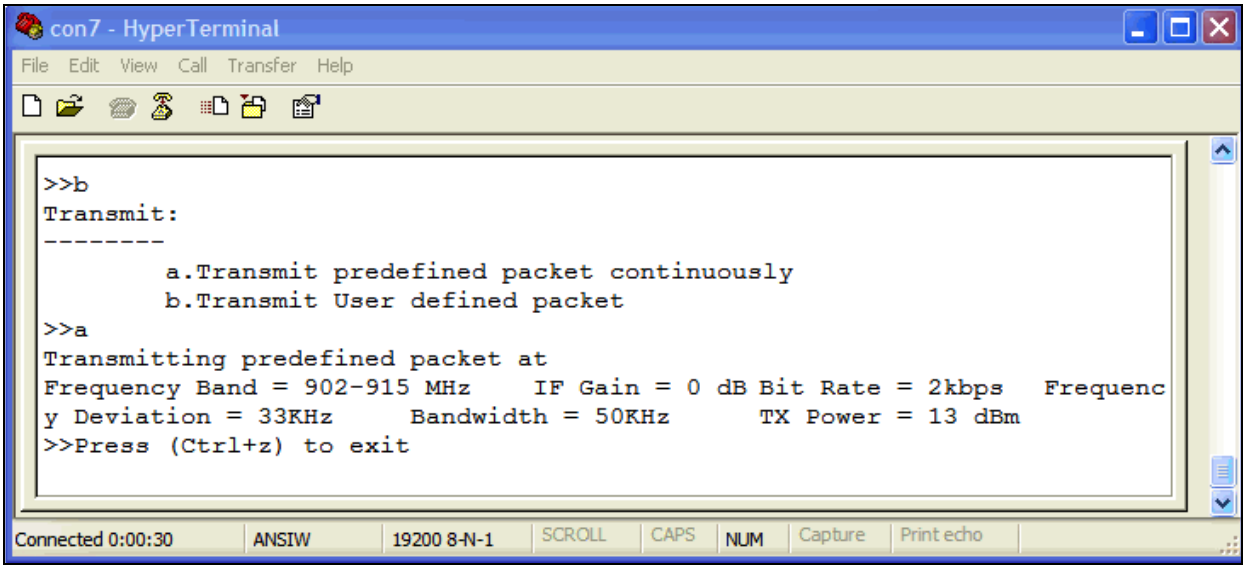


FIGURE 26: SUMMARY MODE

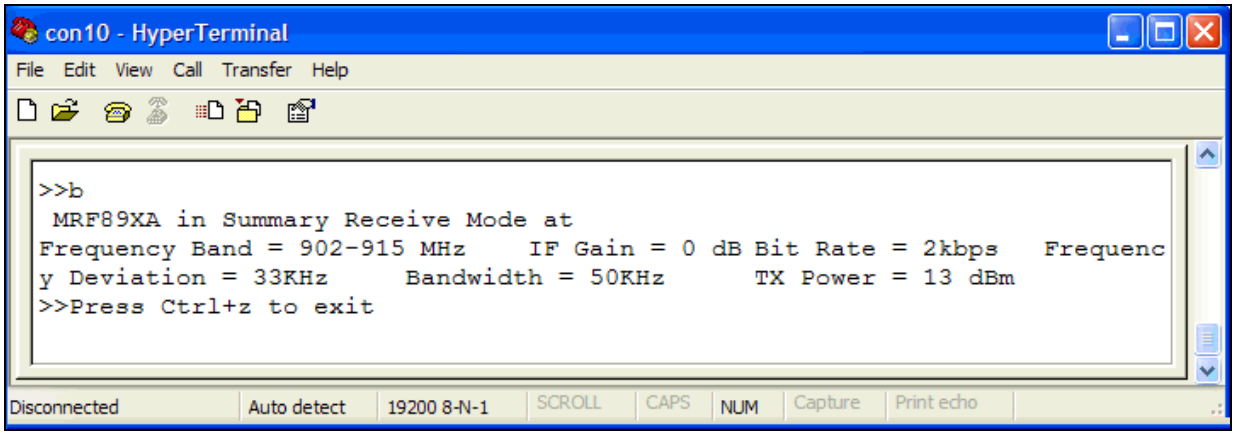
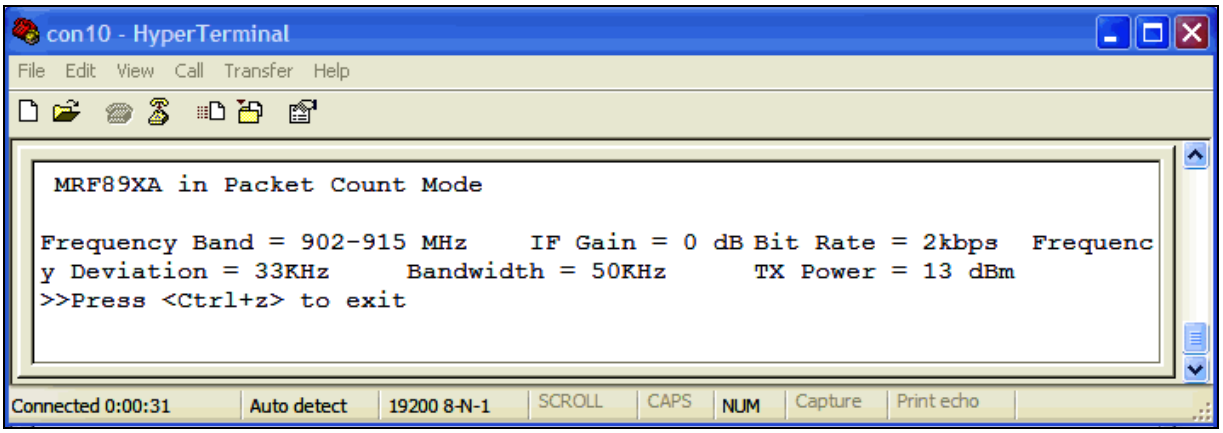


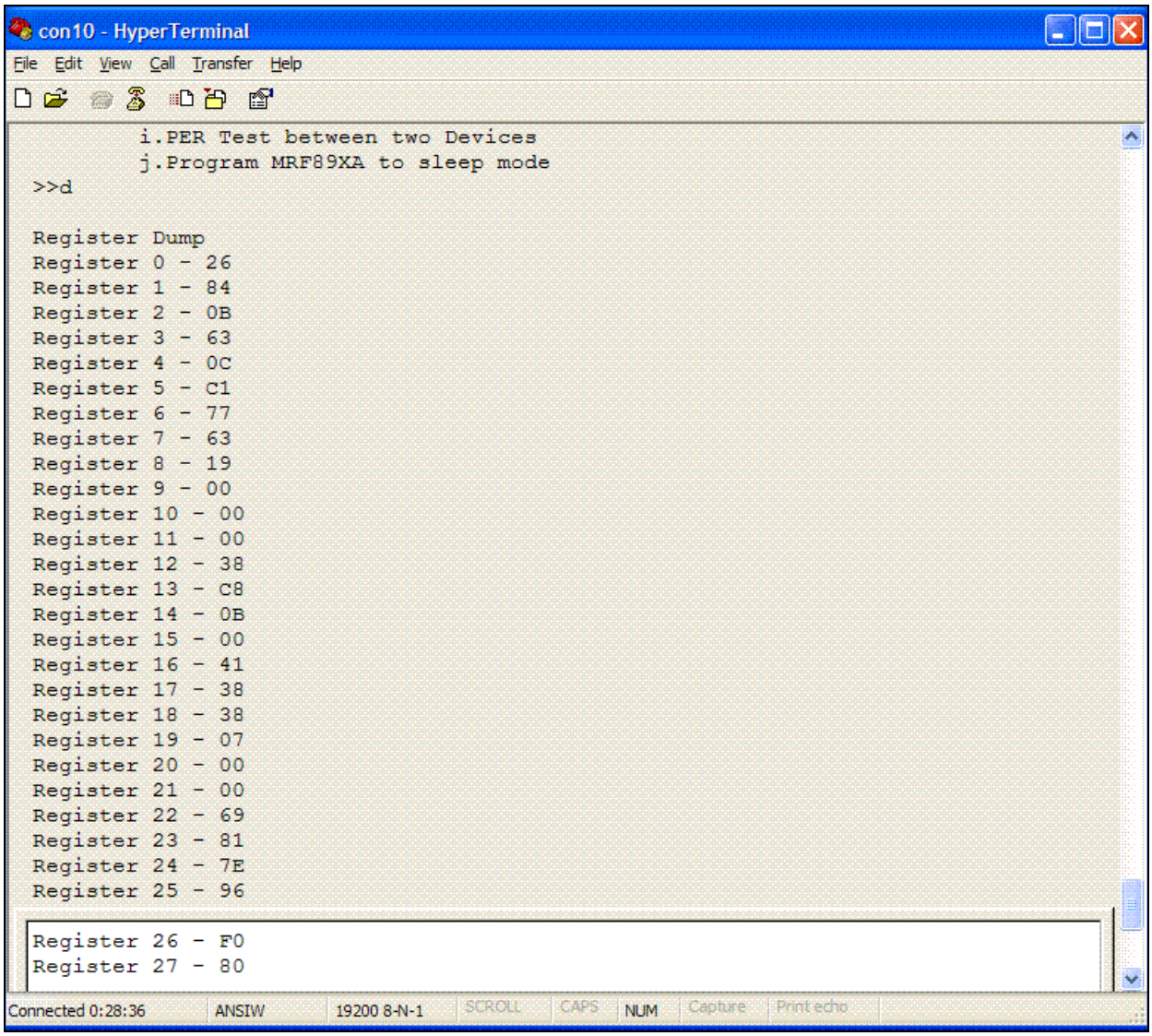
FIGURE 27: PACKET COUNT MODE



READ MRF89XA REGISTERS

This Main Menu option, shown in Figure 28, enables users to read the MRF89XA register values. To modify the register value, select “Program MRF89XA Registers” from the Main Menu.

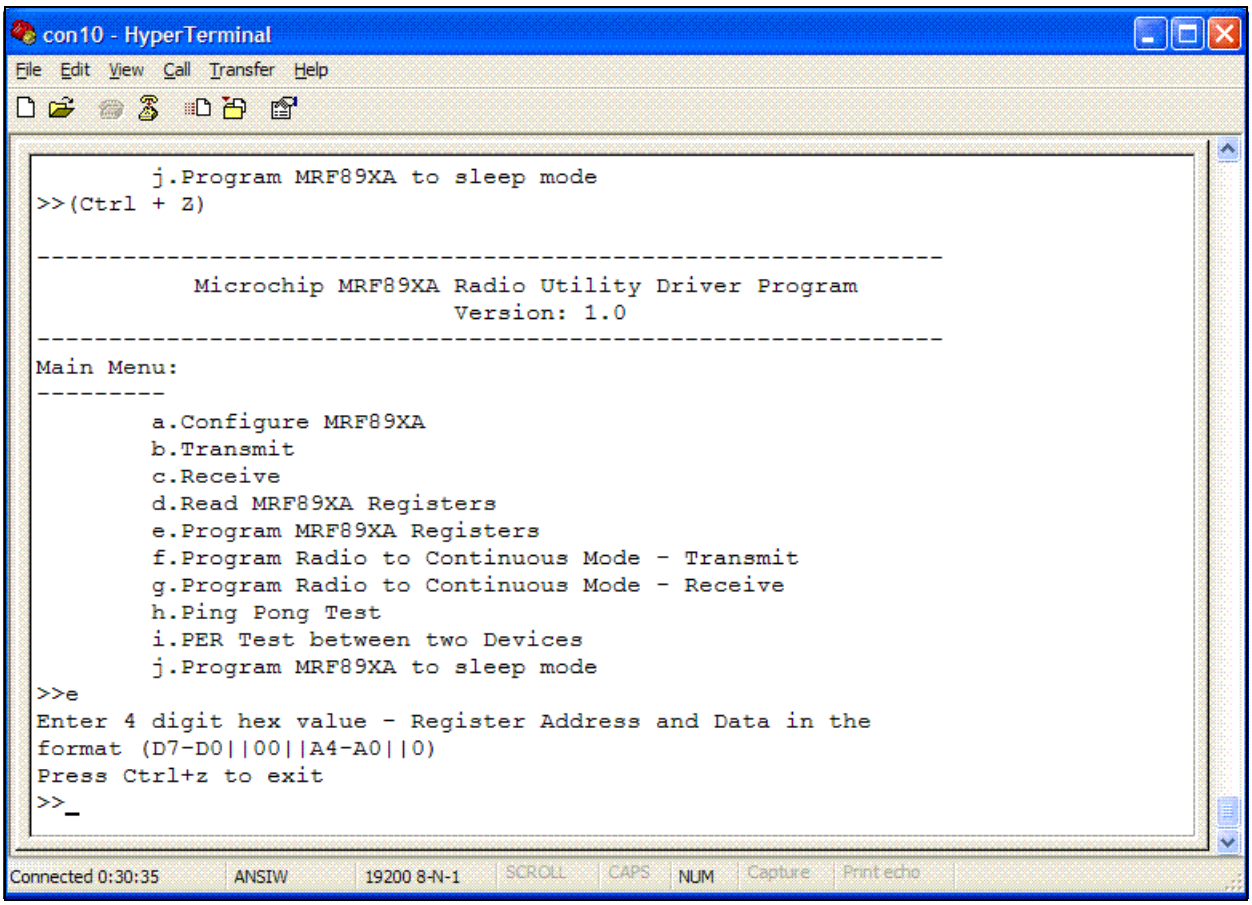
FIGURE 28: MRF89XA REGISTER READ BACK



PROGRAM MRF89XA REGISTERS

This Main Menu option, shown in Figure 29, enables the user to modify the MRF89XA internal register values.

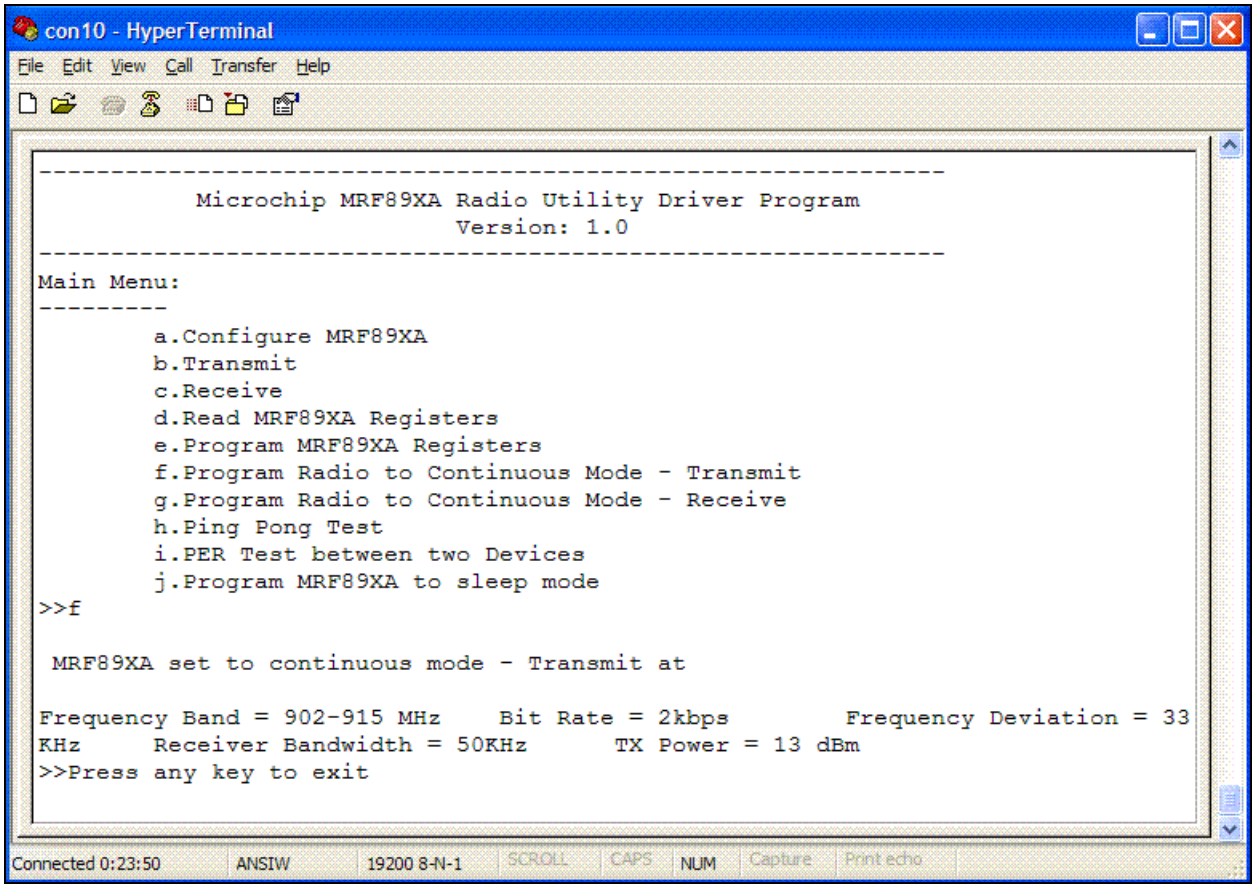
FIGURE 29: PROGRAM MRF89XA REGISTERS



PROGRAM RADIO TO CONTINUOUS MODE – TRANSMIT

This Main Menu option, shown in Figure 30, 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.

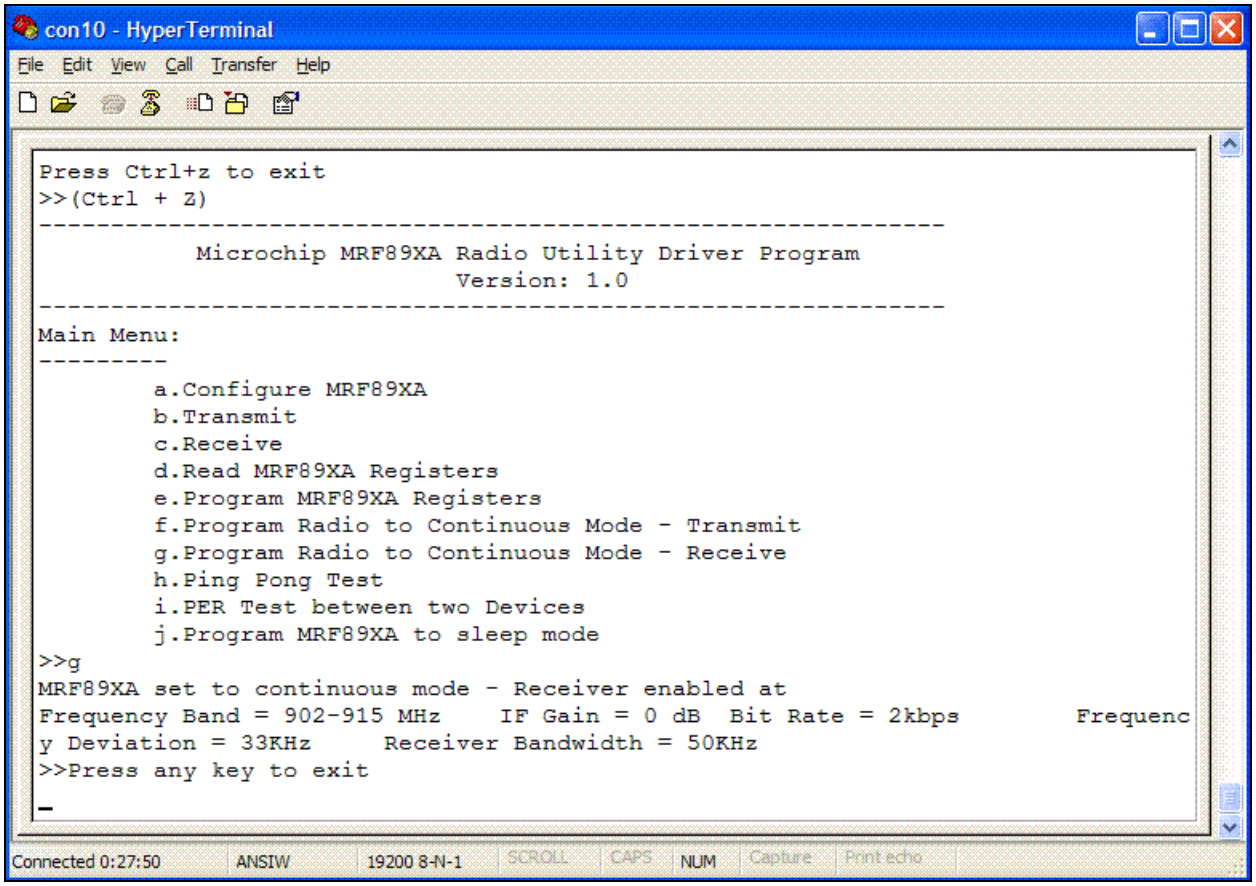
FIGURE 30: CONTINUOUS MODE – TRANSMIT



PROGRAM RADIO TO CONTINUOUS MODE – RECEIVE

This Main Menu option configures the MRF89XA device in Continuous Mode with the receiver enabled. The received data will be available on the DATA pin. For more information about Continuous mode, refer to the *MRF89XA Data Sheet* (DS70622B).

FIGURE 31: CONTINUOUS MODE – RECEIVE



PING PONG TEST

This Main Menu option, shown in Figure 32 and Figure 33, 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 due to 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) less than 0.1%.

FIGURE 32: PING PONG TEST – SENDER

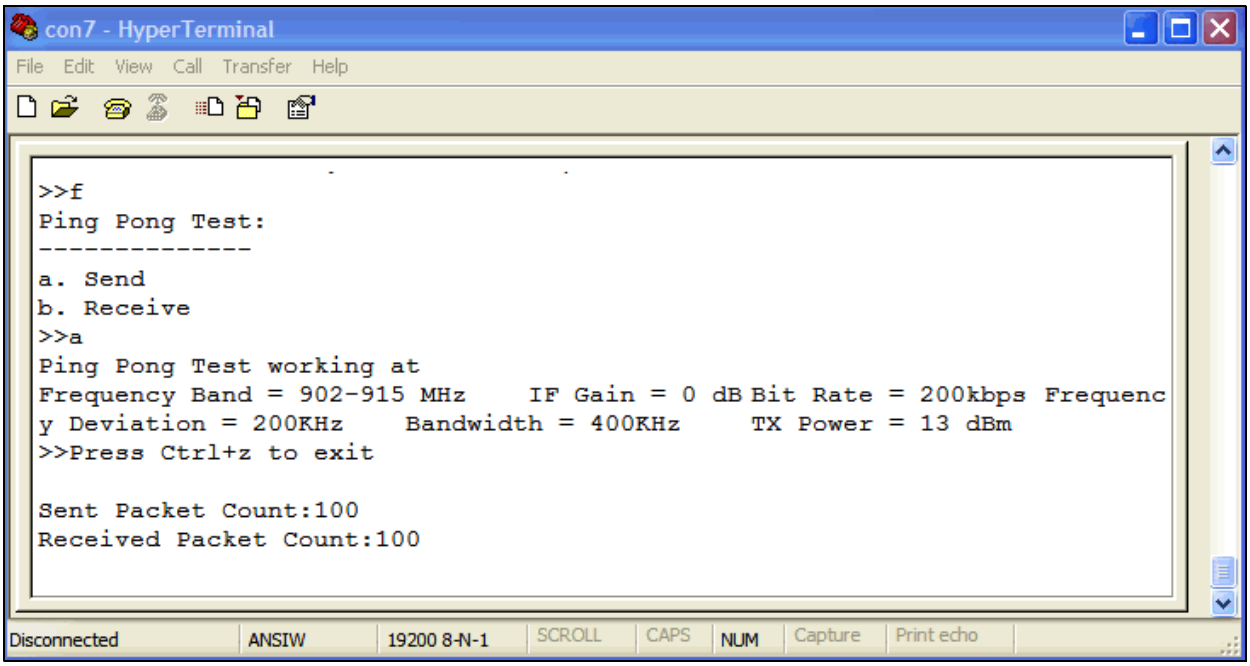
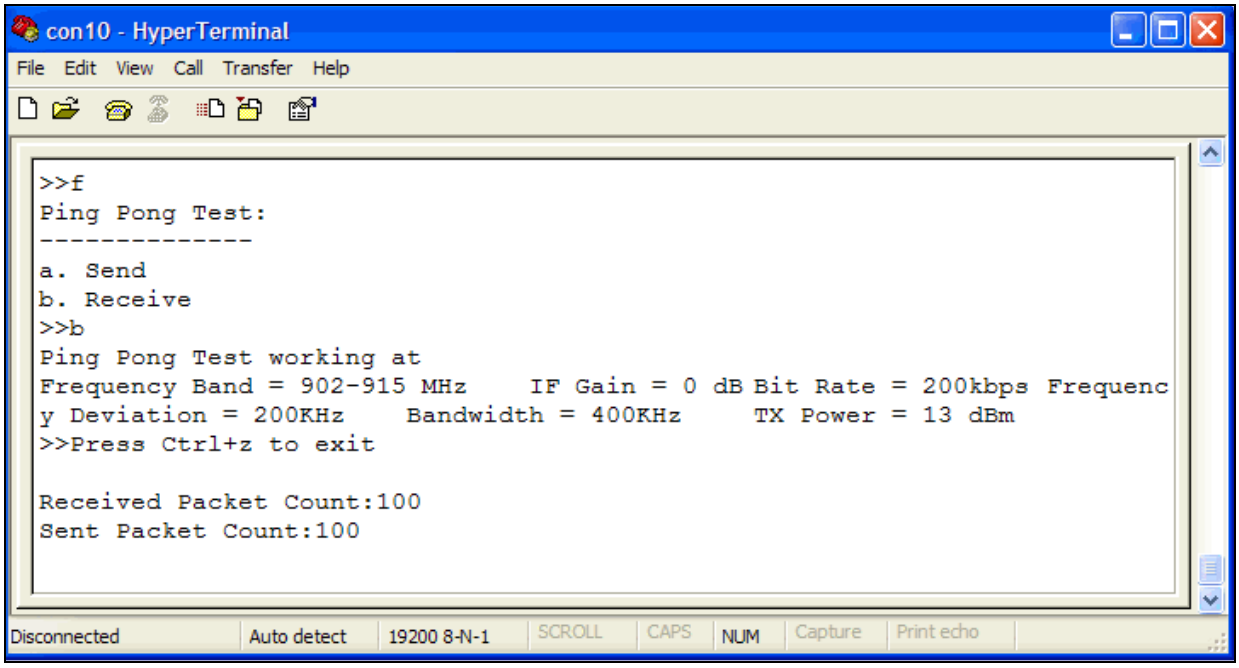


FIGURE 33: PING PONG TEST – RECEIVER



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. If you want to perform a desensitization test, a signal generator is required.

To perform a desensitization test:

1. Program Ping Pong package size.
2. On Unit 1, select the Main Menu option “Ping-Pong Test” and then select “Receive”.
3. On Unit 2, select the Main Menu option “Ping Pong Test” and then select “Send”.
4. Unit 2 transmits the designated number of packets to Unit 1, Unit 1(Figure 32) reports the number of received packets and transmits the number of specified packets to Unit 2.

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

5. While the packets are exchanged, activate a signal generator. Also perform a sweep in frequency that is large enough to create interference signals for the two transceivers.
6. 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

*Packet Error Rate% = (Number of Lost Packets/ Ping-Pong package size) * 100*

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

PER TEST BETWEEN TWO DEVICES

This Main Menu option, shown in Figure 34 and Figure 35, performs a Packet Error Rate (PER) test between two transceivers. The length of the packet can be selected using the option “PER test packet size” in configuration commands. For more information, refer to the **Section “Configuration Commands”.**

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.

FIGURE 34: PER TEST – SEND

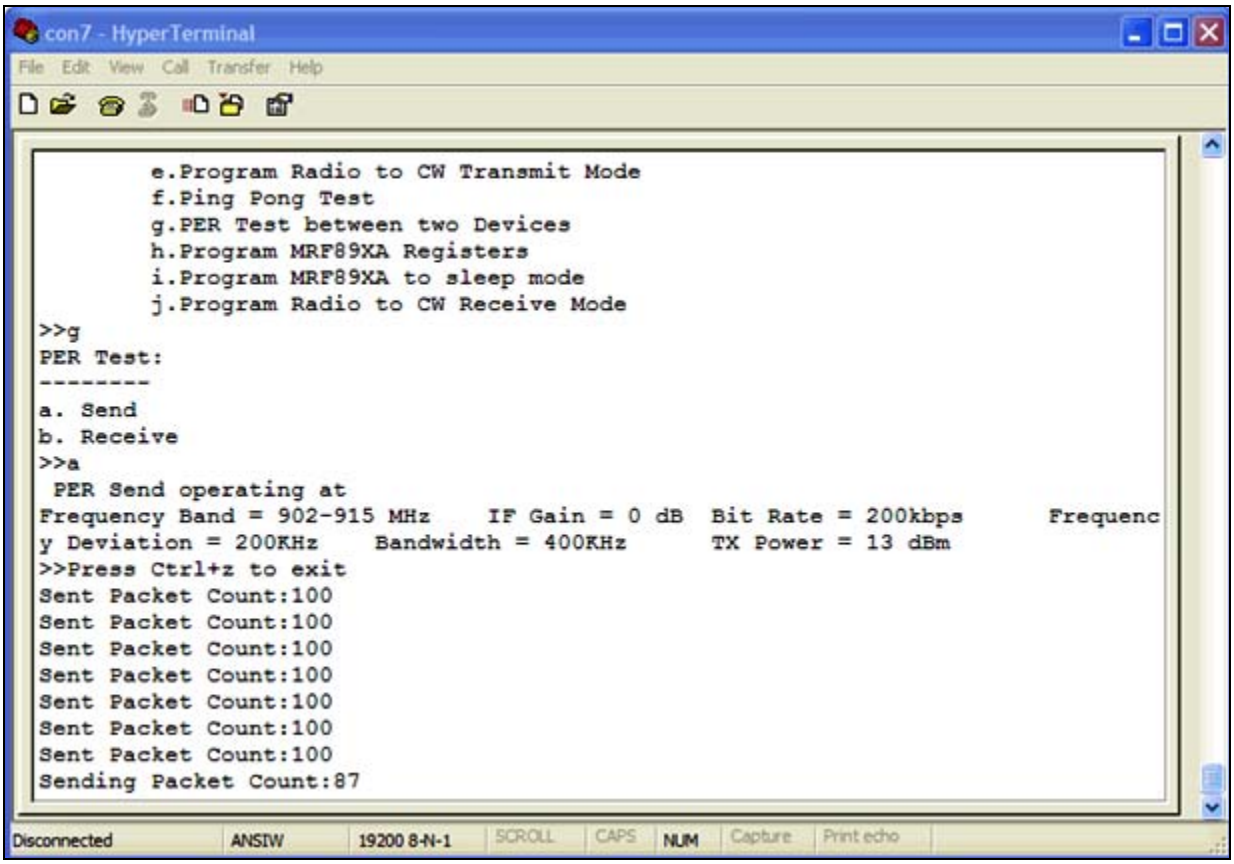
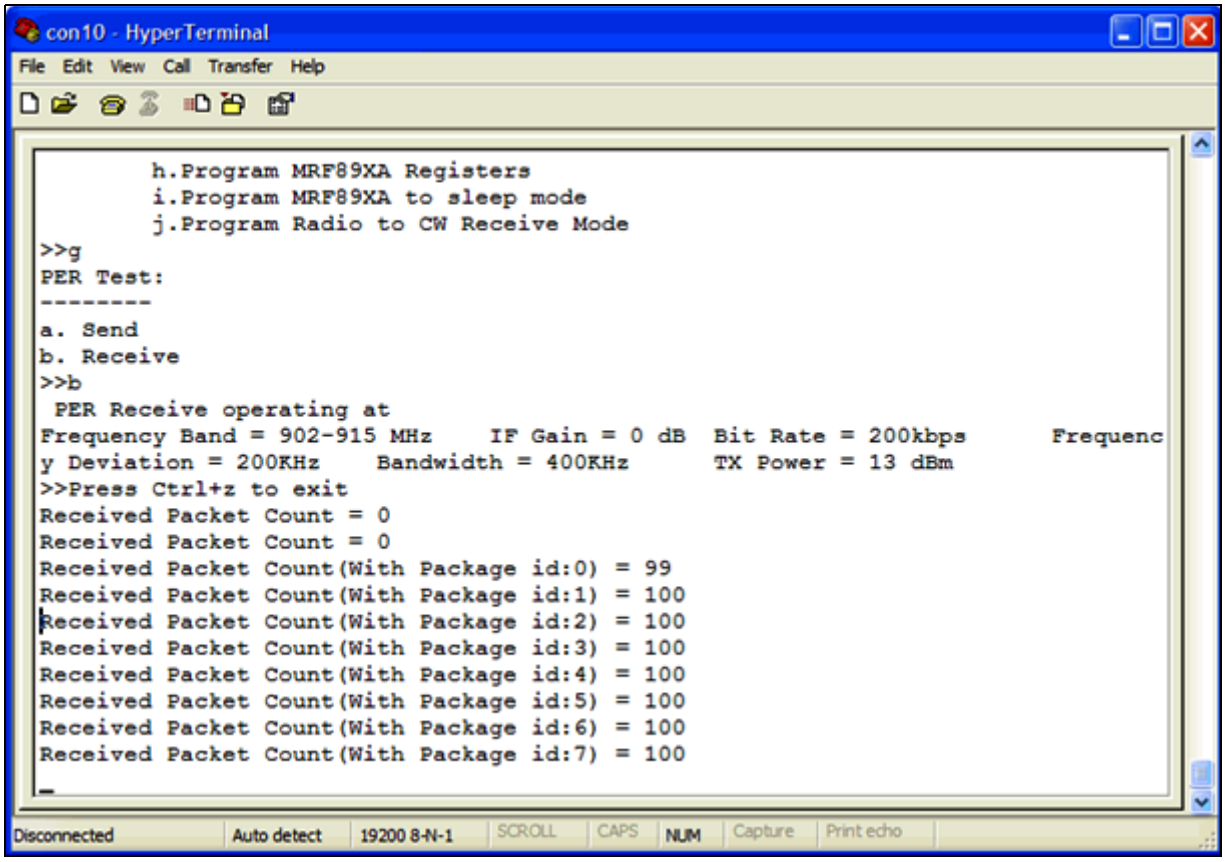


FIGURE 35: PER TEST – RECEIVE



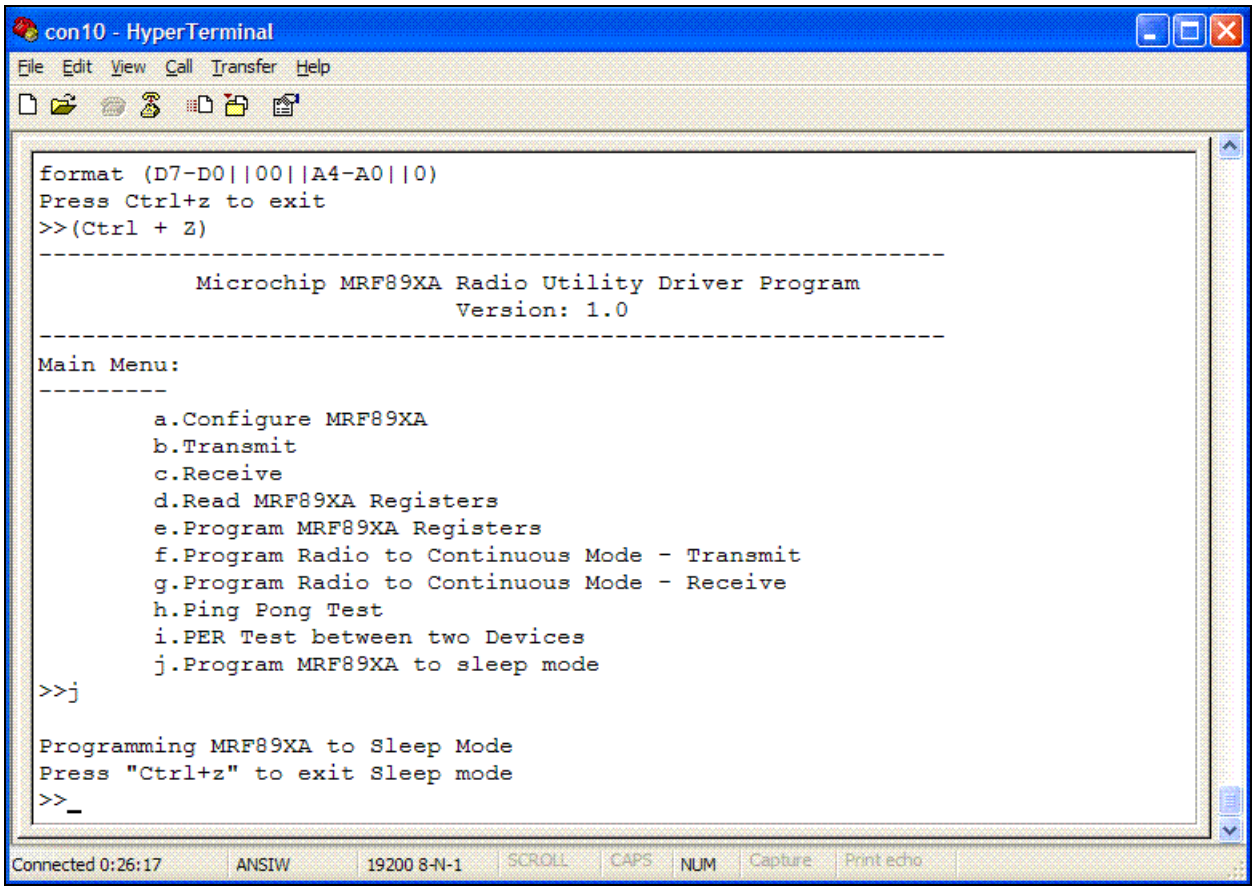
The PER test requires two MRF89XA RF transceivers: each is running the MRF89XA utility program and set to the same frequency, bandwidth and data rate. The PER test has the following steps:

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

PROGRAM MRF89XA TO SLEEP MODE

This Main Menu option, as shown in Figure 36, enables the user to set the MRF89XA transceiver to Sleep mode. In this mode, the MRF89XA sleep current can be measured.

FIGURE 36: MRF89XA SLEEP MODE



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"MPLAB® ICD 3 User's Guide" (DS51766A), Microchip Technology Inc.

"MRF89XA Data Sheet" (DS70622B), Microchip Technology Inc.

"PICDEM PIC18 Explorer Demonstration Board User's Guide" (DS51721B), Microchip Technology Inc.

REVISION HISTORY

Revision A (July 2010)

This is the initial release of the document.

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