AN1192

MRF24J40 Basic Driver

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INTRODUCTION

The basic driver for the MRF24J40 is the firmware that helps RF engineers or test engineers to test and verify the functionality of the MRF24J40.

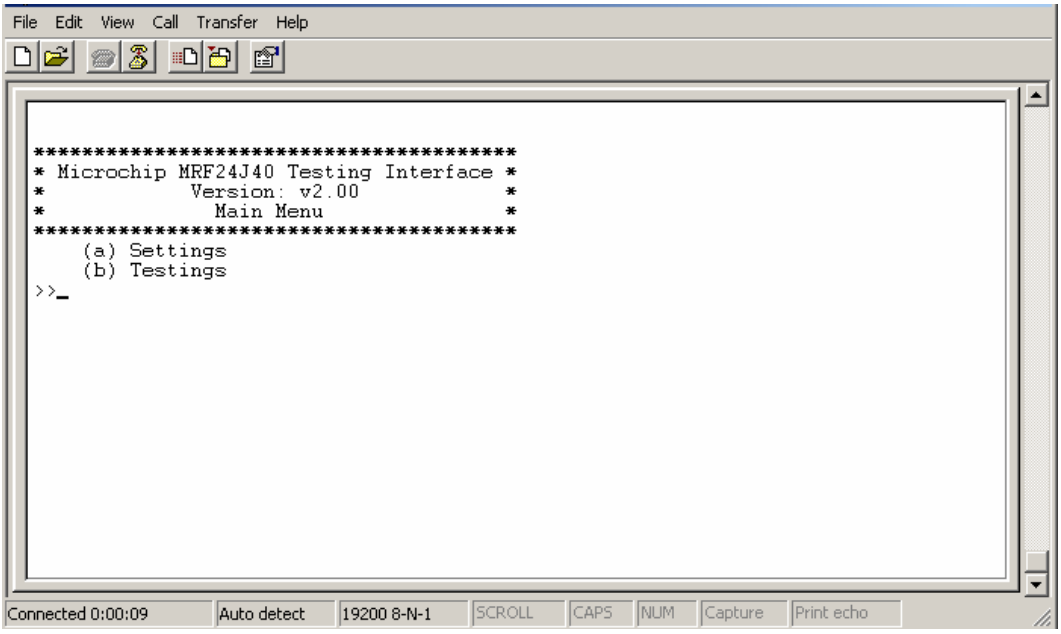
The basic driver runs on the PICDEM™ Z Demonstration Board and is already programmed. The demo board will be connected to the HyperTerminal that is running on a computer through a serial port. The basic driver can acquire commands from the HyperTerminal and output the results on the HyperTerminal. A menu system will be provided on the HyperTerminal for the user to access different functionalities.

The main idea was to create an easy to use and simple UI to allow the user to interact with the RF module.

The basic driver source code and hex file are available in the application note zip file.

Launching the program through the HyperTerminal will prompt us with the following menu:

FIGURE 1: PROGRAM LAUNCHED THROUGH HyperTerminal MENU WINDOW



There are two items under the main menu: **Settings** and **Testings**. The **Settings** menu will configure the firmware as well as the radio. The **Testings** menu will trigger the radio to perform certain tasks.

Please note at the bottom of the window, the settings for the HyperTerminal connection: 19200-8-N-1. Figure 2 displays information on creating a HyperTerminal connection

FIGURE 2: CREATING A HyperTerminal CONNECTION DISPLAY

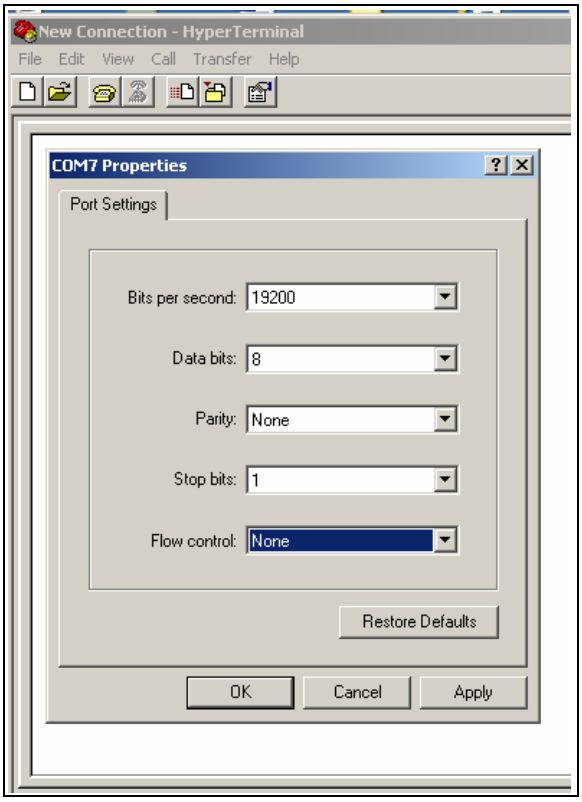
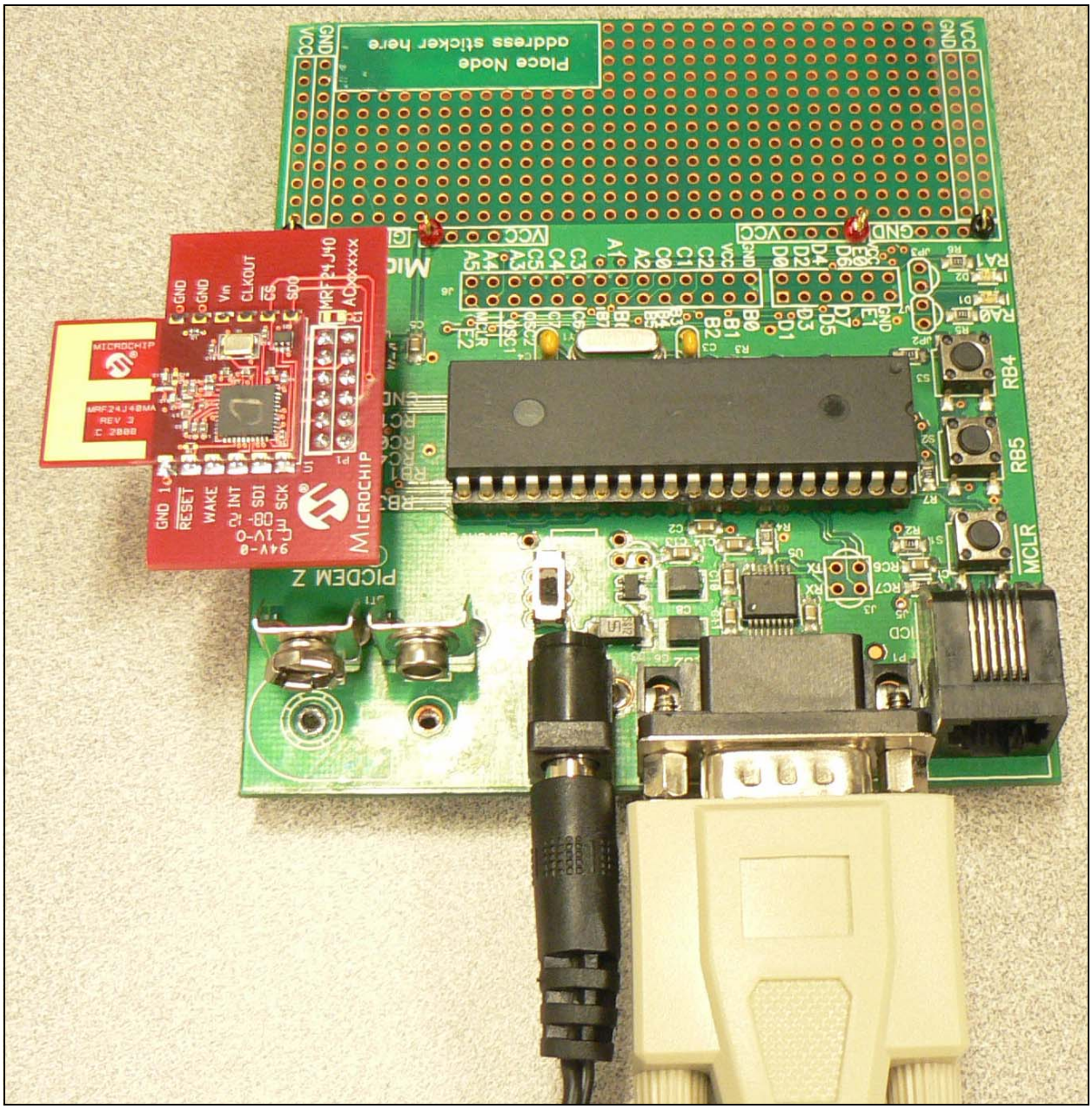


FIGURE 3: PICDEM™ Z EVALUATION BOARD

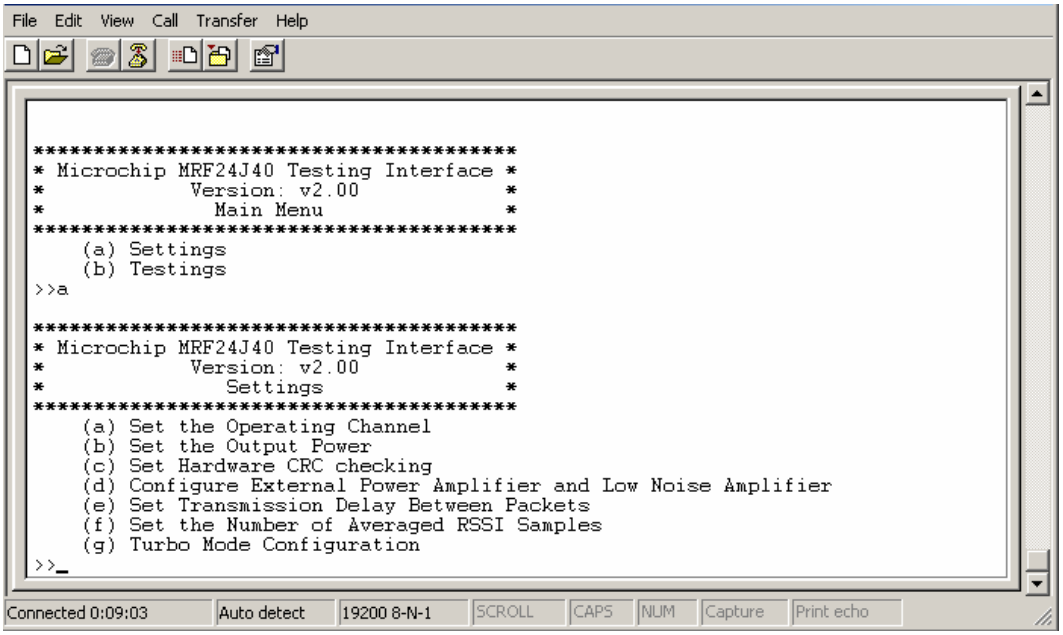


THE SETTINGS

Let's investigate the **Settings** by simply typing "a" which results in the following prompt appearing, as shown in Figure 4.

Note:	Simply hitting the "~" key will bring us back to the main menu of **Settings** and **Testings**.

FIGURE 4: SETTINGS MENU

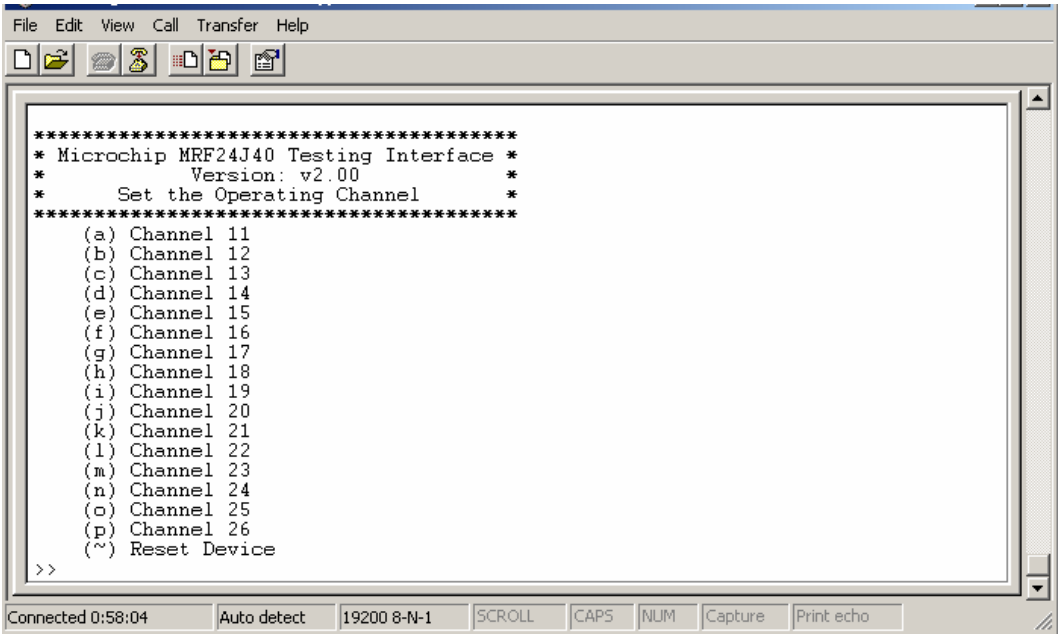


The following is a description of all these options:

(a) Set the Operating Channel

This simply gives us the option of selecting the working channel. The user may select one of the following 16 channels as shown in Figure 5.

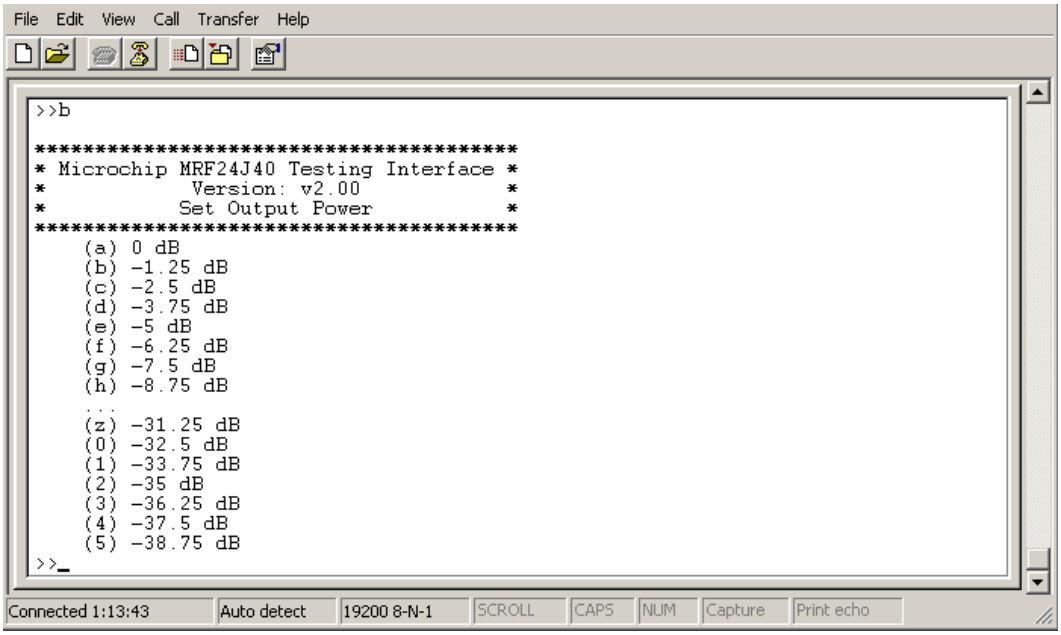
FIGURE 5: OPERATING CHANNEL SELECTION MENU



(b) Set the Output Power

This gives us the option to configure the RF power of the output transmitted signal. The transceiver has the option of adjusting the output power from a minimum of -38.75 dBm up to a maximum of 0 dBm in steps of 1.25 dB. The new menu will look like that shown in Figure 6.

FIGURE 6: SET OUTPUT POWER MENU

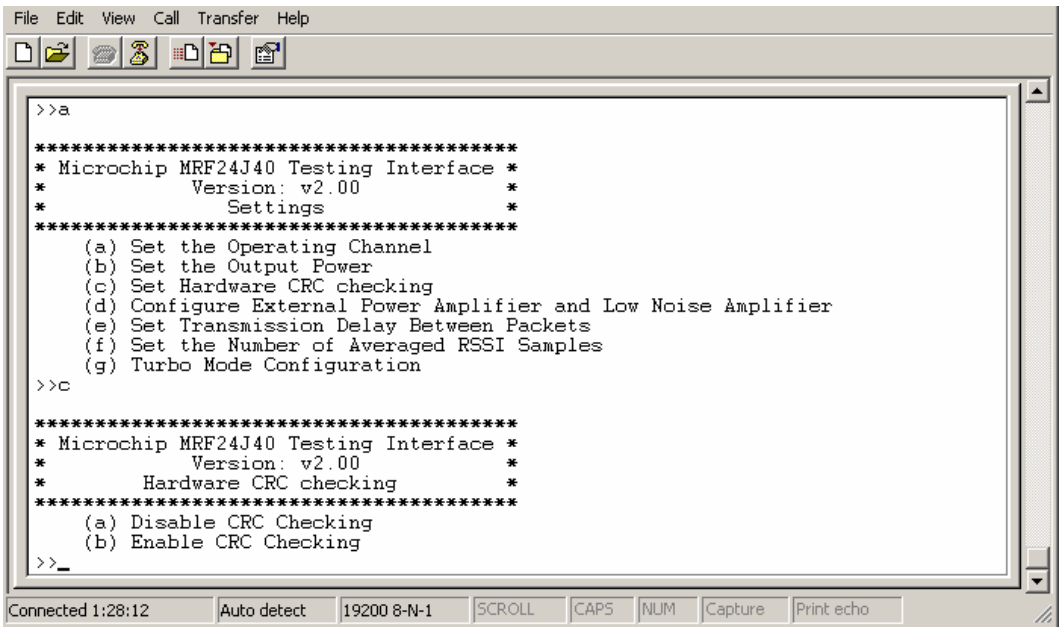


(c) Set Hardware CRC Checking

Simply put, this will enable or disable the Cyclic Redundancy Check (CRC), also called the Frame Checksum (FCS). Basically, the receiver will be set to do or not to do a CRC checking.

The menu will look like that shown in Figure 7.

FIGURE 7: HARDWARE CRC CHECKING MENU



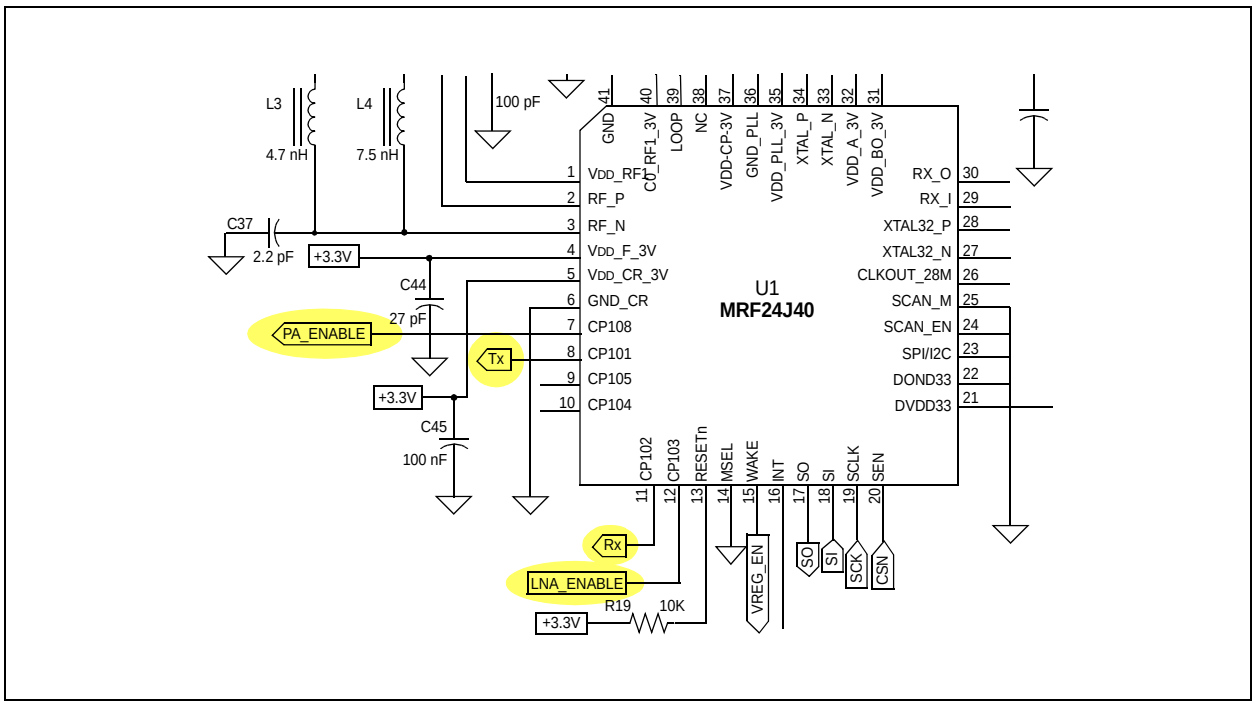
(d) Configure External Power Amplifier and Low Noise Amplifier

For some applications, an external RF power amplifier and also an external Low Noise Amplifier (LNA) might be required in order to keep a reliable link between two devices. In that case, before initiating a Transmitting mode, the power amplifier has to be activated. The same option will be required if the device has an external LNA. That means before entering a Receive mode, the user needs to activate the LNA.

The transceiver will provide 3.3V at specific ports in order to activate specific external circuits: a power amplifier for Tx mode or an LNA for Rx mode.

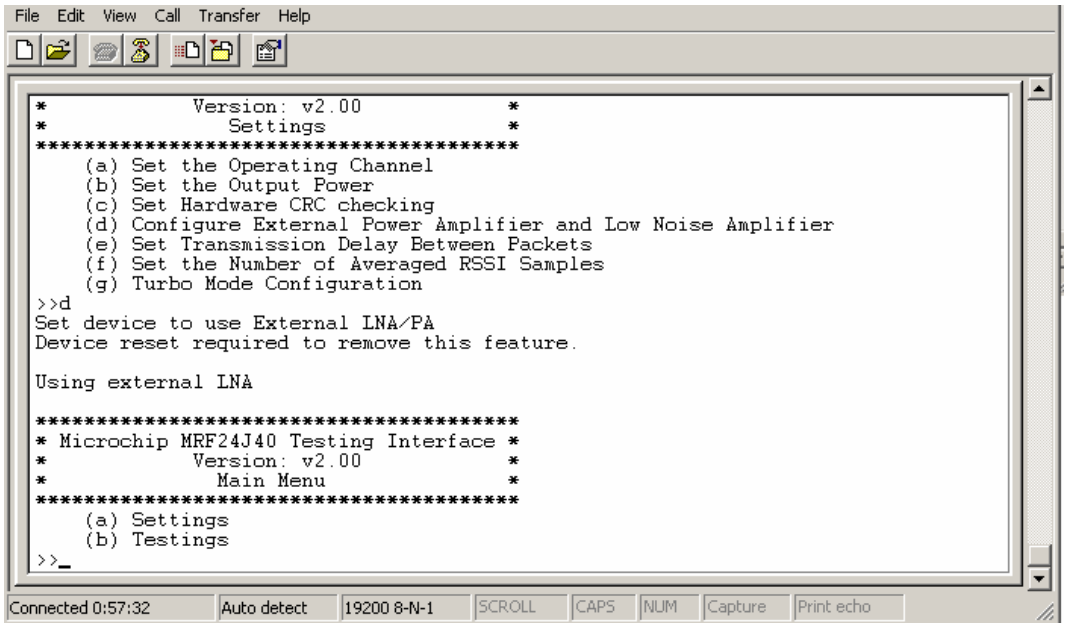
Figure 8 displays an excerpt from a schematic diagram showing these ports highlighted.

FIGURE 8: SCHEMATIC SHOWING HIGHLIGHTED PORTS



The menu will look like that shown in Figure 9.

FIGURE 9: CONFIGURE EXTERNAL POWER AMPLIFIER AND LOW NOISE AMPLIFIER MENU

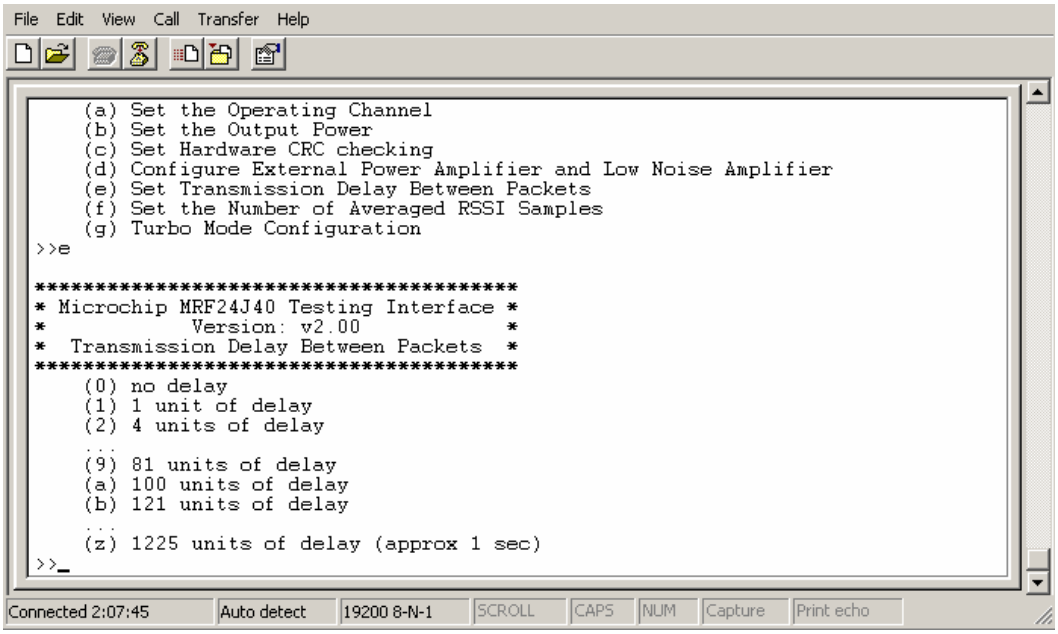


(e) Set Transmission Delay Between Packets

This is a useful option in case we want to track the transmitted signal using the ZENA™ software. This option will allow us to send packets with a time delay between them and it will be useful for the FCC certification process, too, where a specific duty cycle will be required.

The default is a 1-unit delay. The menu will look like that shown in Figure 10.

FIGURE 10: SET TRANSMISSION DELAY BETWEEN PACKETS MENU

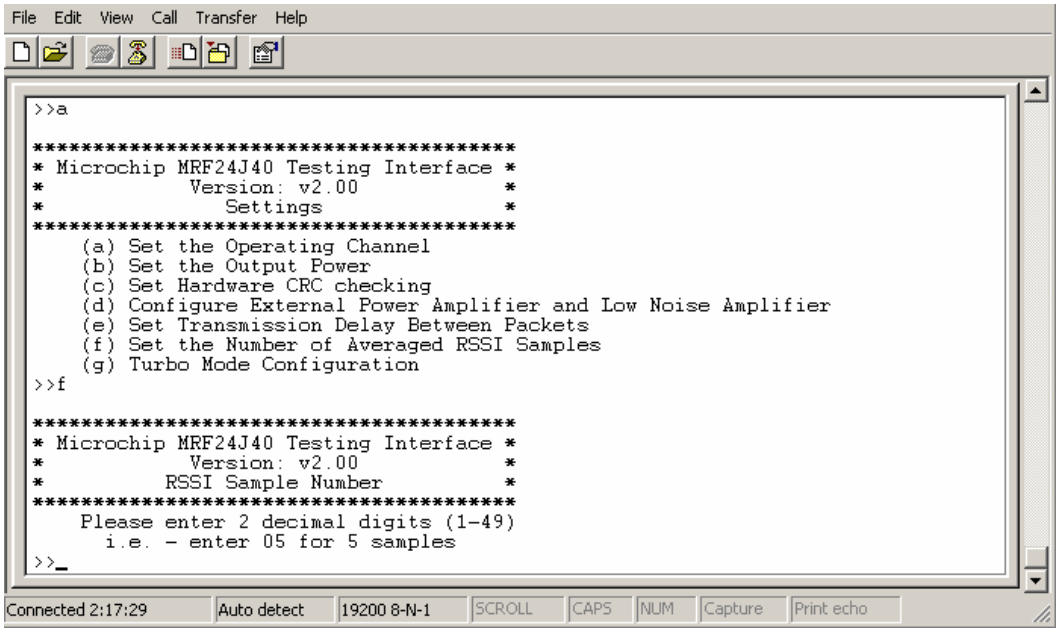


(f) Set the Number of Averaged RSSI Samples

RSSI stands for Received Signal Strength Indicator for the received packet.

In Receive mode, the transceiver will provide the RSSI automatically; however, it is up to us to choose between displaying it instantly (no average), or averaged. The menu will look like that shown in Figure 11.

FIGURE 11: SET THE NUMBER OF AVERAGED RSSI SAMPLES MENU



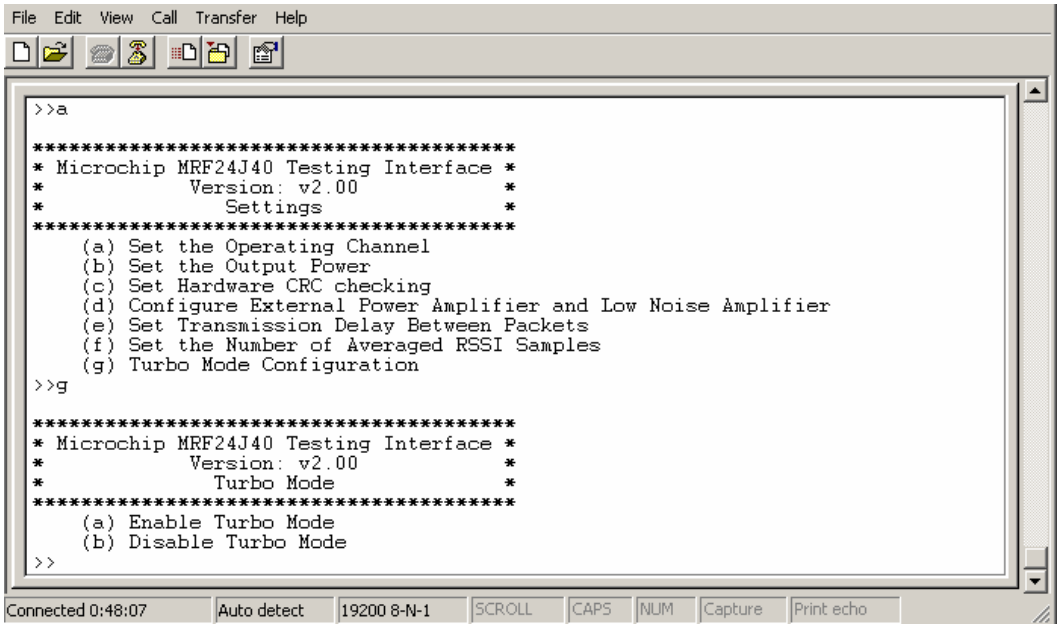
(g) Turbo Mode Configuration

The MRF24J40 provides a Turbo mode to transmit and receive data at a higher rate of 625 kbps, which is 2.5 times faster than the 250 kbps specified by IEEE 802.15.4™.

The menu will look like that shown in Figure 12.

Note:	If the user is using the ZENA software to track the packets, the Turbo mode will not be able to be tracked on the ZENA software.

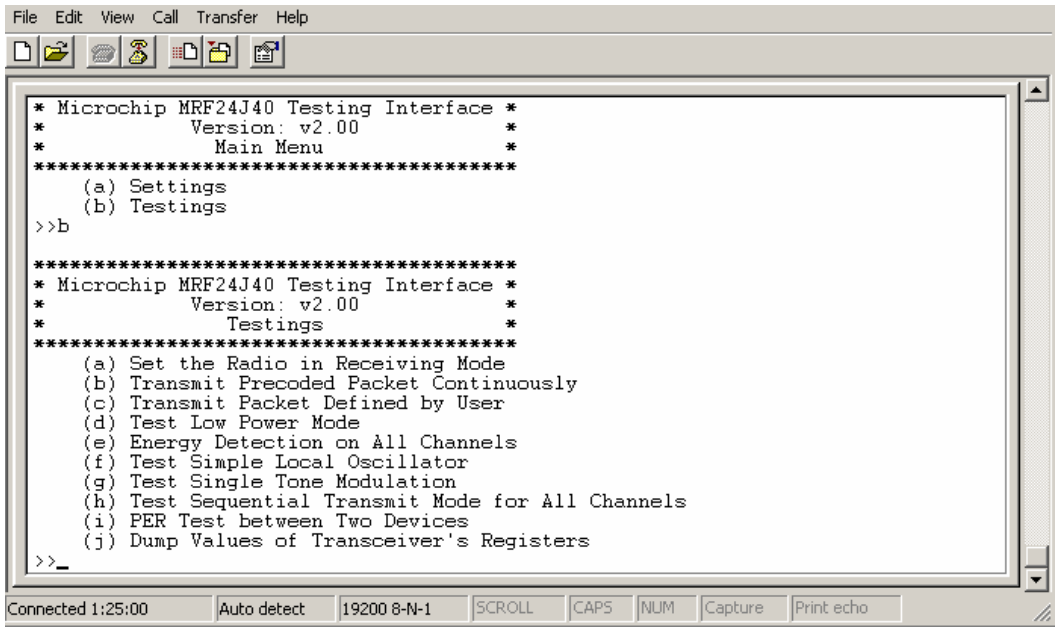
FIGURE 12: TURBO MODE CONFIGURATION MENU



THE TESTINGS

Now, let's investigate the **Testings** by simply typing "b" which results in the following prompt appearing:

FIGURE 13: TESTINGS MENU



(a) Set the Radio in Receiving Mode

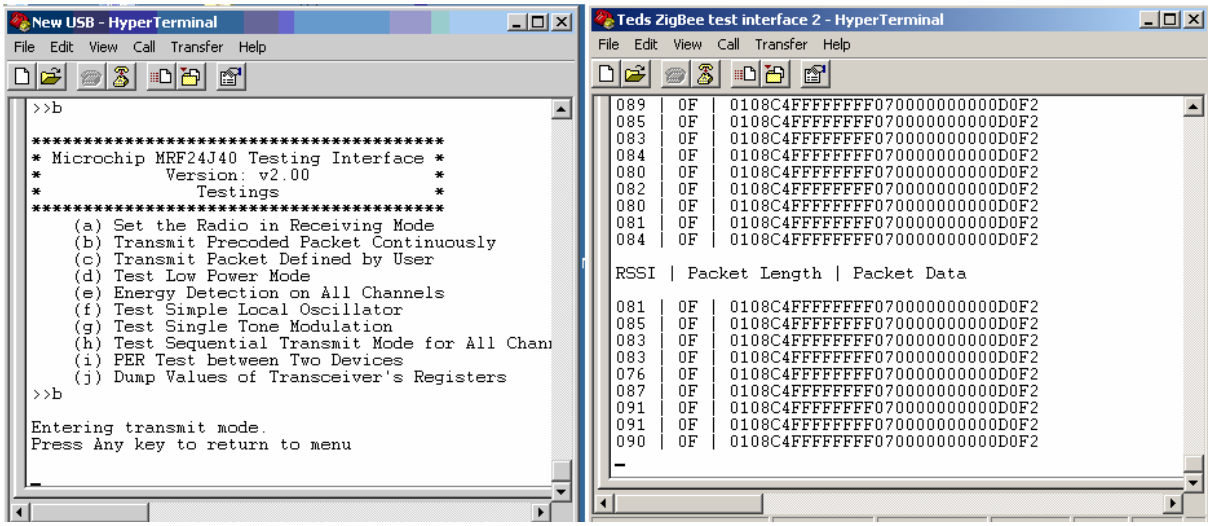
To begin, we need to have a first module in Transmitting mode on a specific channel – for example, it will be channel 18. Then, we will set a second module on the same working channel (18).

Using option (a) from **Testings** will set this second module in Receive mode and a menu will come up and print in real time the RSSI values of the received packets, the packets' length and the content of the received packets.

Note:	It is a good rule of thumb to set the transmitter with some delay between the packets.

In the end, we will have something like this on our computer display: the left window showing the transmitter status and the right window showing the receiver activity.

FIGURE 14: TRANSMITTER STATUS/RECEIVER ACTIVITY DISPLAY



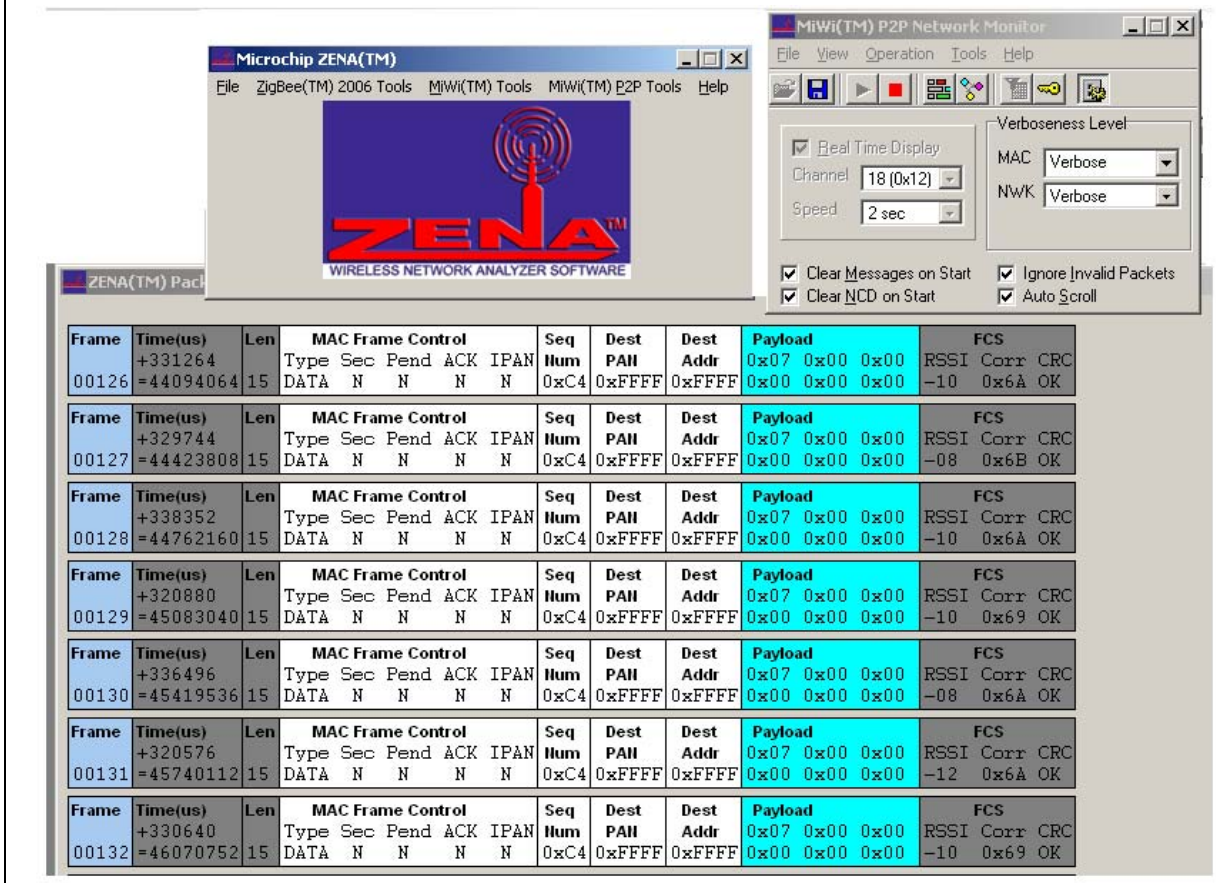
(b) Transmit Precoded Packet Continuously

Assuming we already have chosen the working channel, and optionally, the delay between transmitted packets, then this new option will set the transceiver in Transmitting mode.

Note:	In case the user will use an external PA, please make sure the supply current is big enough to sustain the PA demand of current (between 150 mA and 500 mA depending on the application).

Using the ZENA software, we will be able to see something like Figure 15 on our computer display:

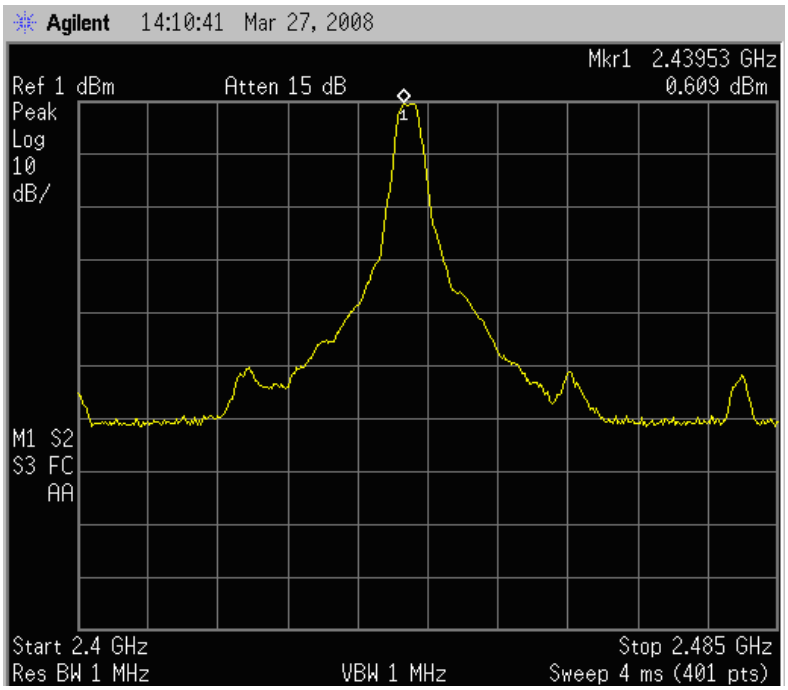
FIGURE 15: TRANSMITTING MODE USING THE ZENA™ SOFTWARE DISPLAY



However, if we are able to solder a coaxial semirigid cable to the output of the transceiver (after disconnecting the antenna by cutting the trace) and connect it to the spectrum analyzer, we will be able to see the shape shown in Figure 16.

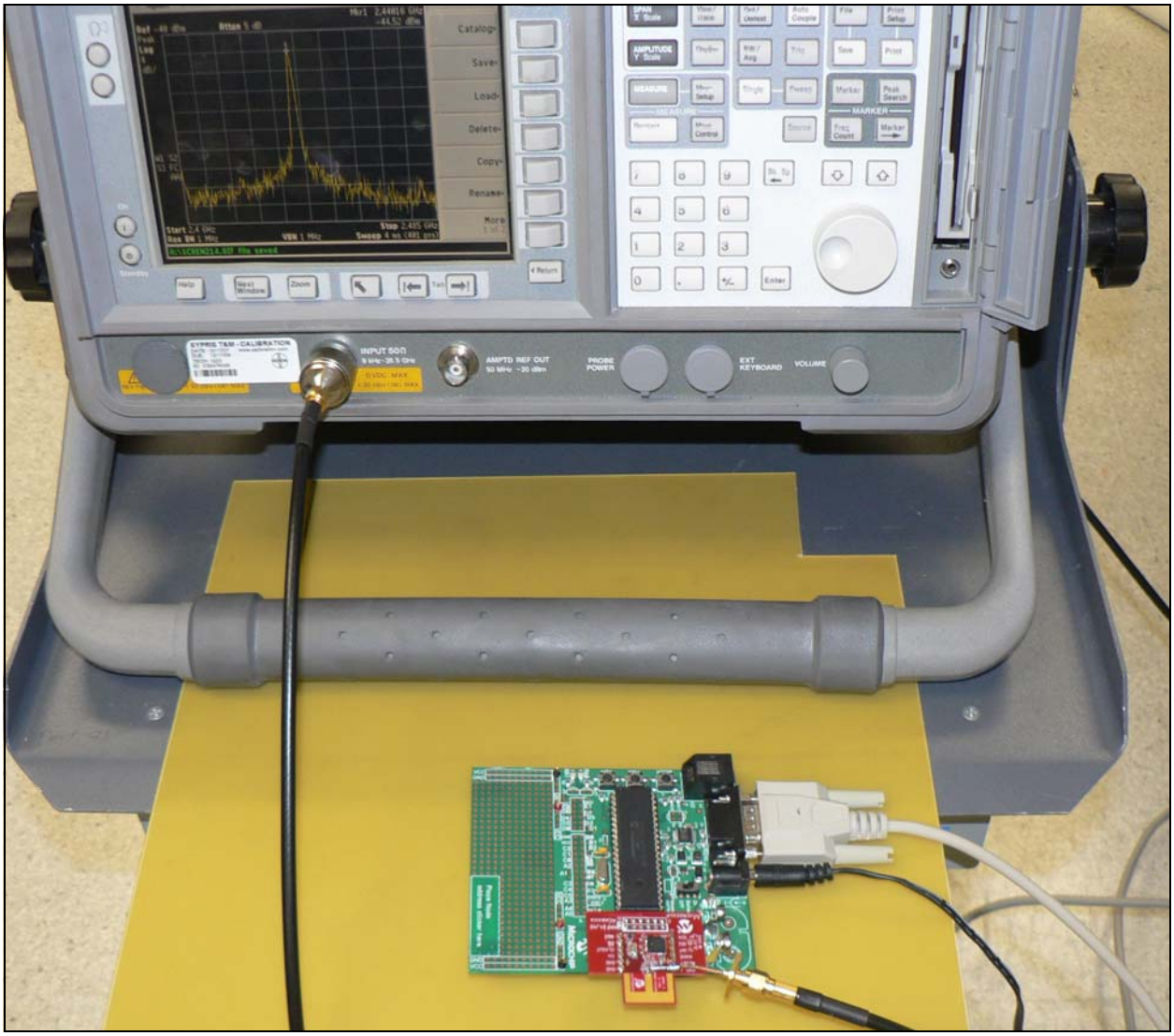
Note: The spectrum analyzer needs to be on "Max and Hold".

FIGURE 16: THE SPECTRUM OF A ZigBee™ PROTOCOL (IEEE 802.15.4™) SIGNAL



Note: Some boards are provided with an SMA connector option. For these boards, the connection to the spectrum analyzer will be easy and there is no need to solder a small coaxial semirigid to the board.

FIGURE 17: THE SETUP FOR MEASUREMENTS USING A SPECTRUM ANALYZER

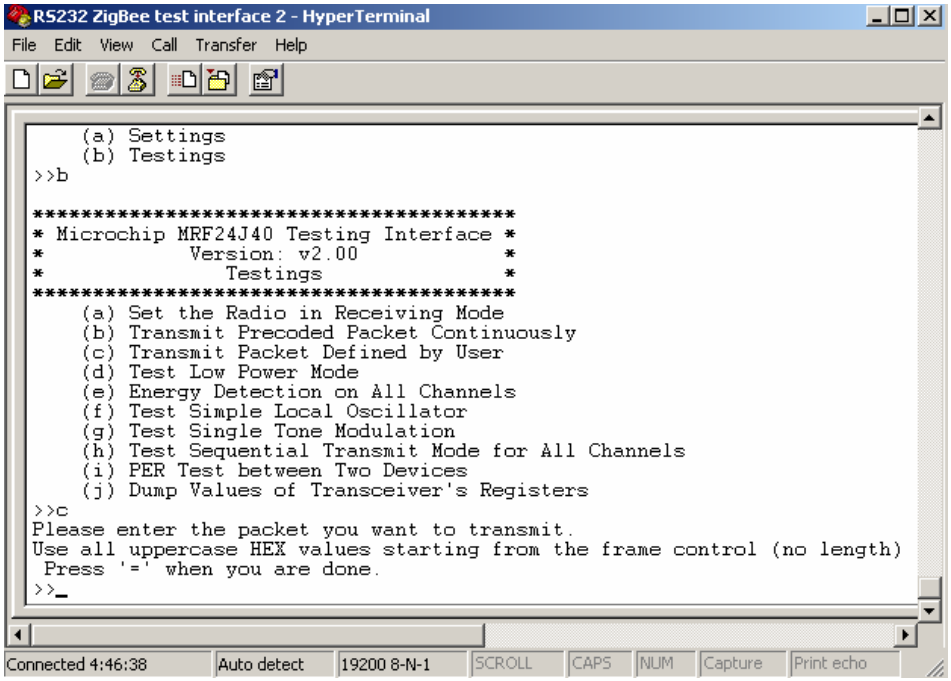


(c) Transmit Packet Defined by User

This option is self-explanatory. Once the working channel is set, the user will be prompted with the following menu after hitting the “c” key.

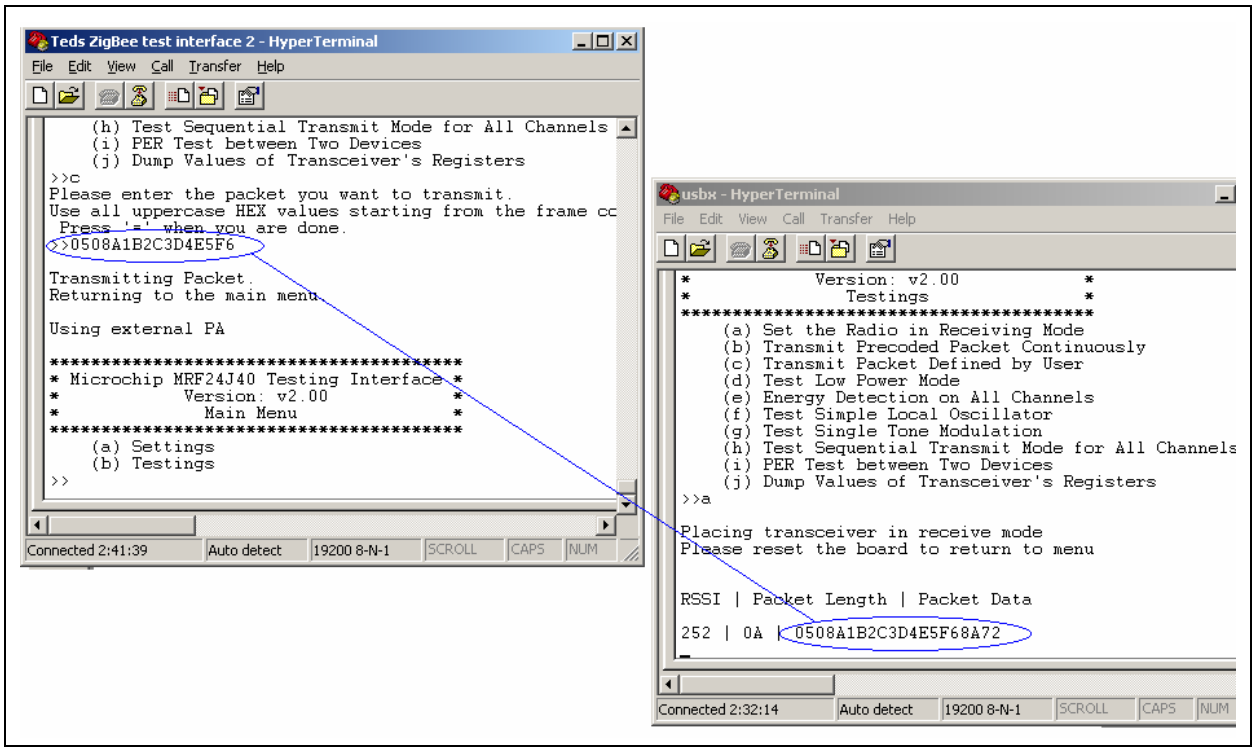
Note: Please be sure the format of data will follow the IEEE 802.15.4 specifications: “7.2 MAC Frame Formats paragraph”.

FIGURE 18: TRANSMIT PACKET DEFINED BY USER MENU



Assuming the user will have a second module set on Receiving mode, the display may look like the one shown in Figure 19.

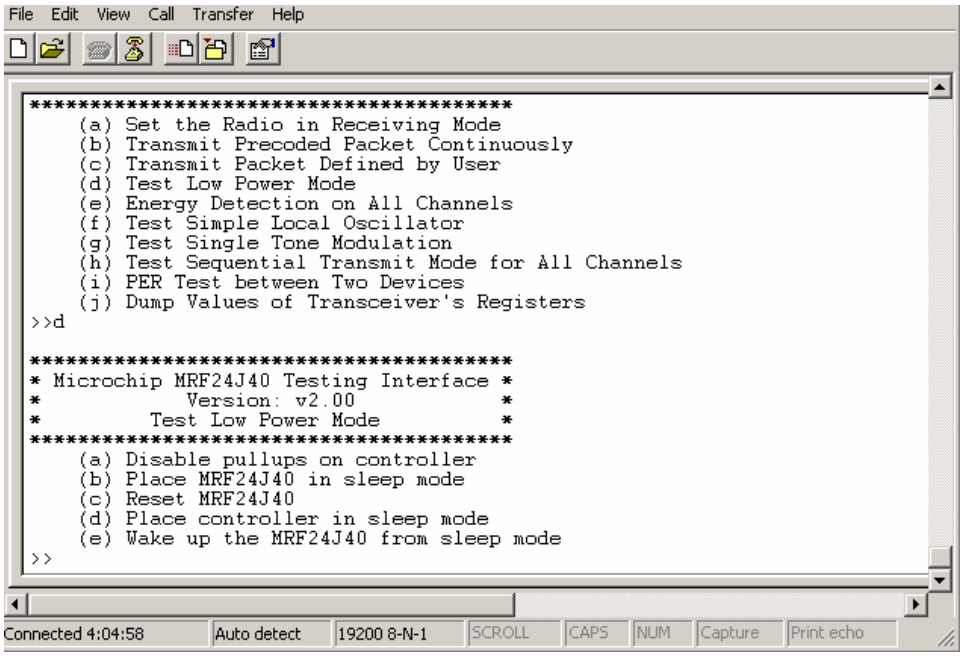
FIGURE 19: SECOND MODULE ON RECEIVING MODE DISPLAY



(d) Test Low-Power Mode

This option is useful for people trying to measure the current consumption of the entire RF board or the entire PICDEM Z application in Sleep mode. The menu will look like Figure 20 and is self-explanatory.

FIGURE 20: TEST LOW-POWER MODE MENU



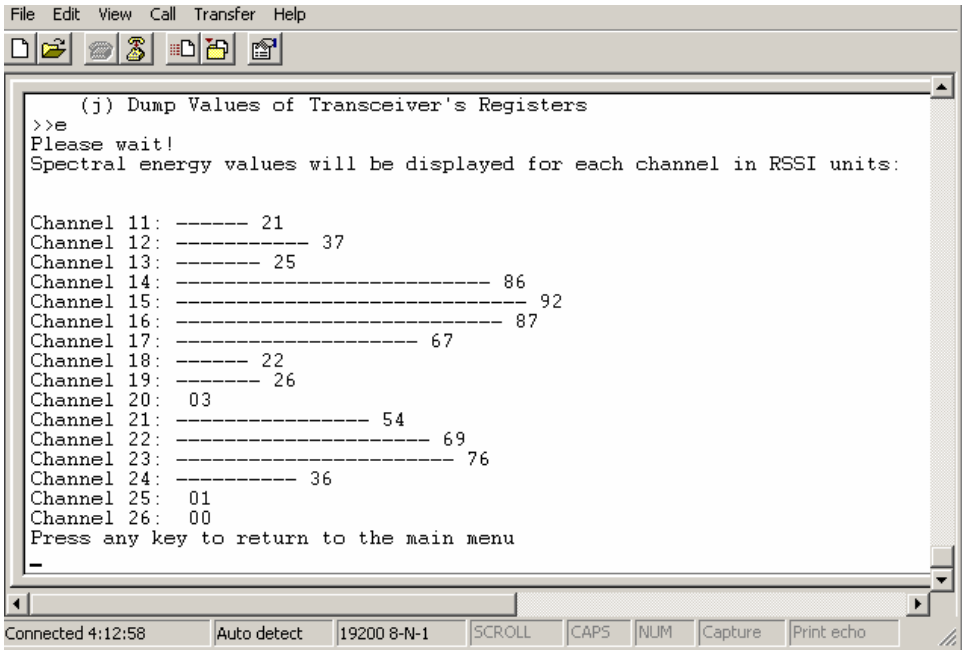
(e) Energy Detection on All Channels

This option will scan the entire Industrial Scientific and Medical (ISM) band and print out the level of RF spectral energy on each ZigBee protocol channel. This option is useful for the user, because it is providing a picture of channel occupancy regardless of if the transmitter is a ZigBee protocol device (IEEE 802.1.5.4), WLAN device (IEEE 802.11) or any other transmitter on a 2.4 GHz ISM band.

Knowing the ISM band occupancy, the user will be able to choose a channel which is less occupied while testing his RF module. The magnitude of RF spectral energy is displayed in RSSI hex values.

Note:	In case your module has an LNA, please be sure you enable it before starting energy detection.

FIGURE 21: ENERGY DETECTION ON ALL CHANNELS MENU

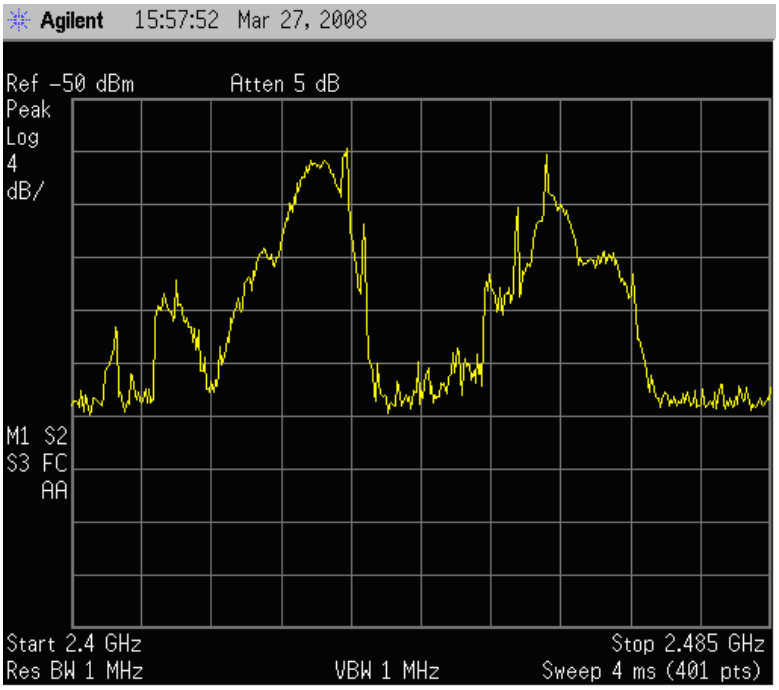


The accuracy of Figure 21 is quite good. We did the same survey on the ISM band (in the same location) using a spectrum analyzer and a good antenna (having at least 2 dBi gain) and compared the two pictures.

Figure 22 (saved from the spectrum analyzer) is a good replica and correlates very well with what we saw in Figure 21, displayed from the MRF24J40 Basic Driver.

Note:	In case the user has an RF board with PA/ LNA, please make sure to first select option (d) in settings to configure the board for power amplifier and low noise amplifier before going in **Testings** – option (e).

FIGURE 22: THE ISM BAND OCCUPANCY



(f) Test Simple Local Oscillator

This option is very useful for people interested in seeing the frequency of the local oscillator for a specific channel. Using the same setup as the one used in option **"(b) Transmit Precoded Packet Continuously"** – we will be able to see the magnitude and frequency of the local oscillator on a spectrum analyzer.

Please be sure to first select the working channel and then use this option.

The menu and the saved picture from the spectrum analyzer are displayed in Figure 23.

Note:	This is a controlled programmed leakage of the local oscillator allowed to be at the output of the transceiver.

FIGURE 23: TEST SIMPLE LOCAL OSCILLATOR MENU

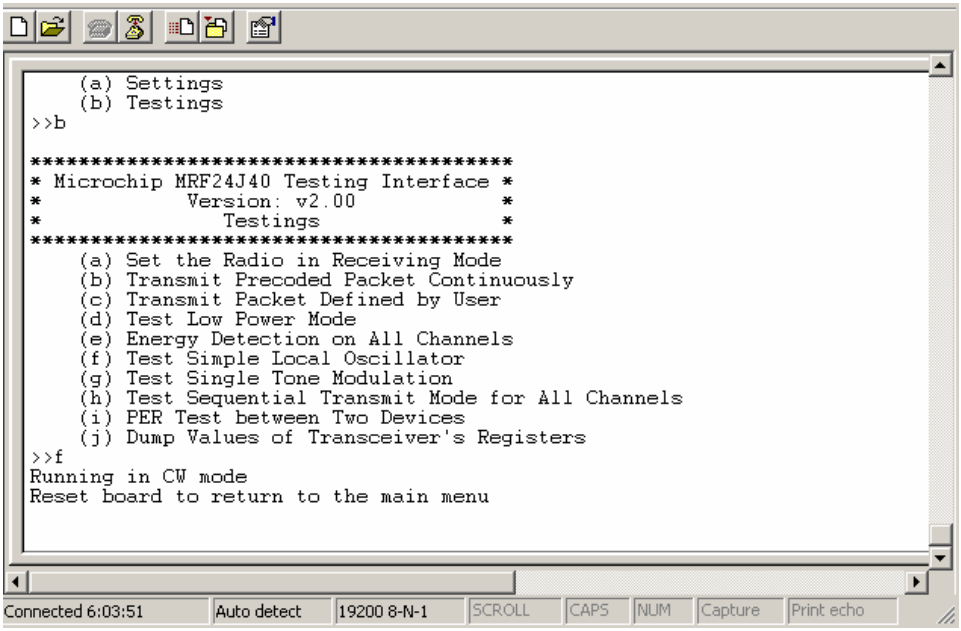
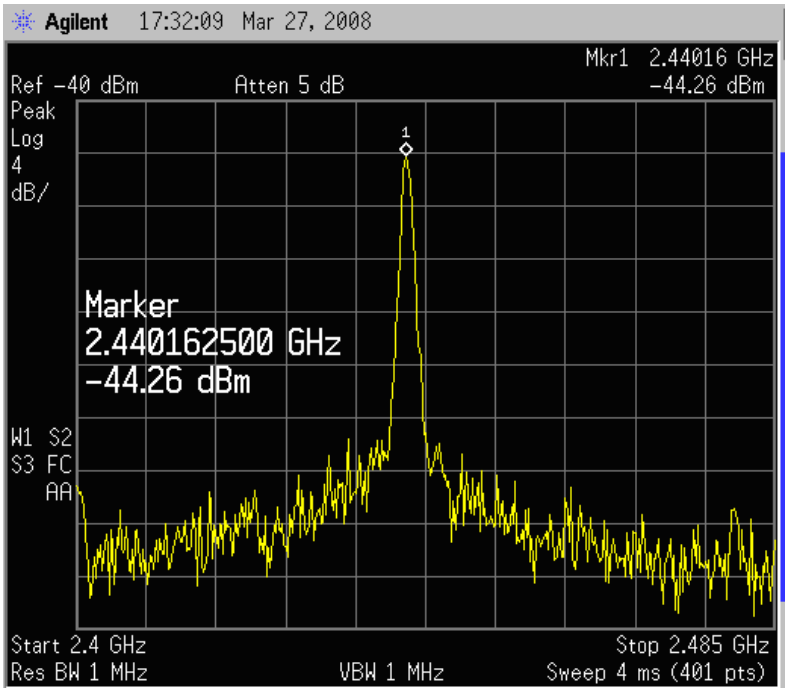


Figure 24 displays a picture of measured LO on channel 18 saved from the spectrum analyzer.

FIGURE 24: LOCAL OSCILLATOR LEAKAGE



(g) Test Single Tone Modulation

This option might be quite useful for people trying to tune some RF circuits or are interested in visualizing a Continuous Wave (CW) signal at the output of the transceiver.

The fixture used in this measurement is identical to the one used in describing the option **"(b) Transmit Pre-coded Packet Continuously"** and the menu which will trigger this function is shown in Figure 25.

It is quite easy to see that the menu has two options:

- Visualize the single tone signal for one specific channel.
- Visualize the single tone for all channels from the ISM band in the Sweeping mode.

The pictures below the menu will display "screen captures" from the spectrum analyzer for both cases: single channel and Sweeping mode on the ISM band.

Note:	The Single Tone Sweeping mode seems to be quite useful when the user wants to characterize the antenna gain on the entire ISM band. In that case, a device will be set in Tx Sweeping mode and a good omni-directional antenna will be connected to a spectrum analyzer to display the spectrum of received signals. Please be sure the test is done free of RF interferences and reflections (OATS – Open Area Test Site).

FIGURE 25: TEST SINGLE TONE MODULATION MENU

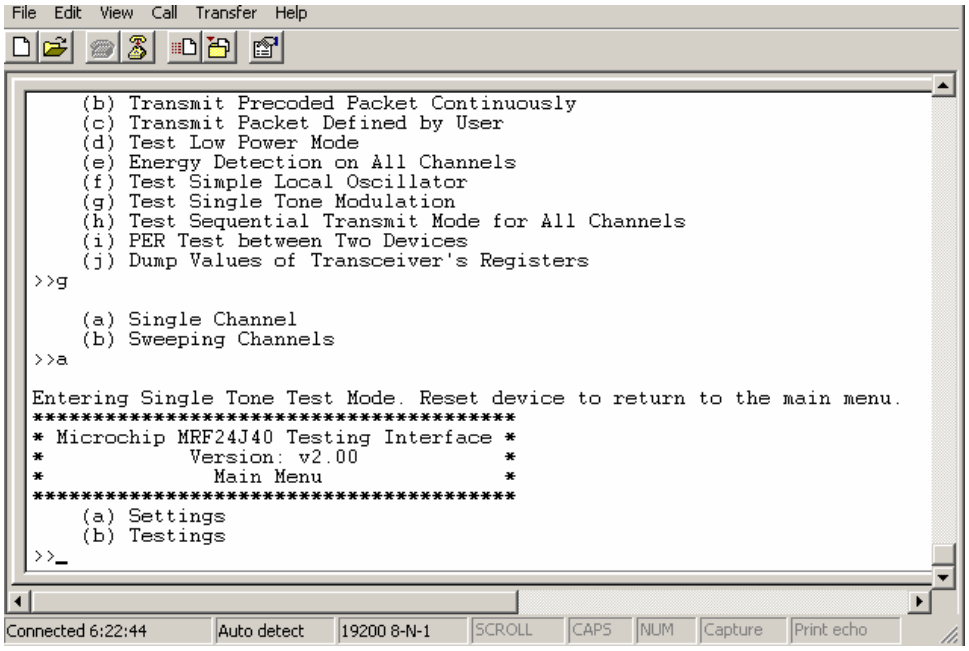
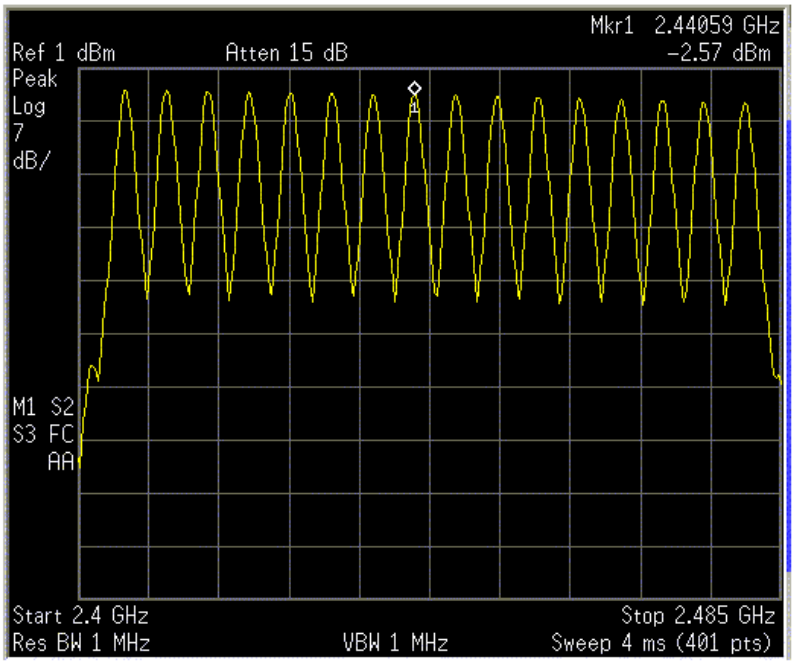
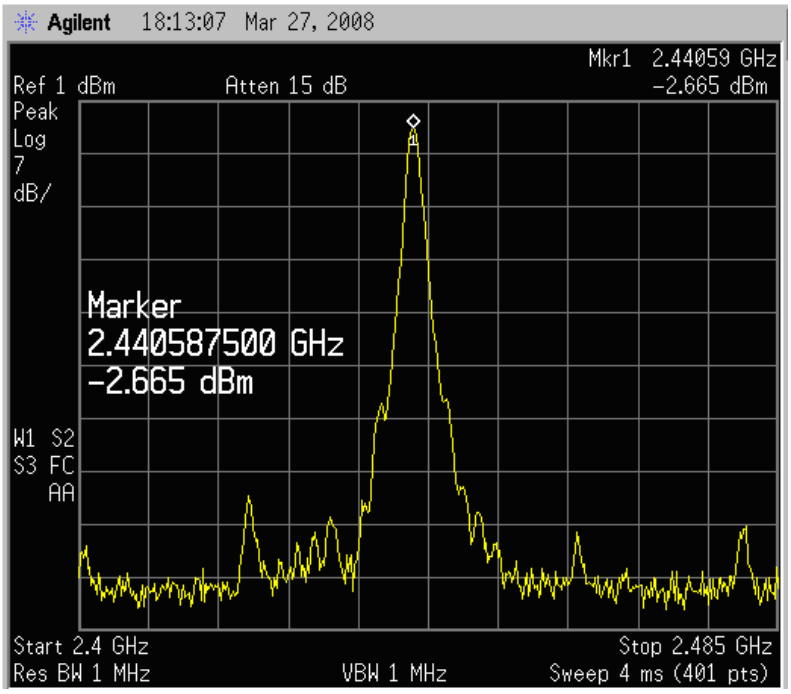


FIGURE 26: SWEEPING ISM BAND IN Tx SINGLE TONE MODE



Note: The spectrum analyzer must be set on “Max and Hold mode” in order to have this screen capture.

FIGURE 27: SINGLE TONE CHANNEL 18



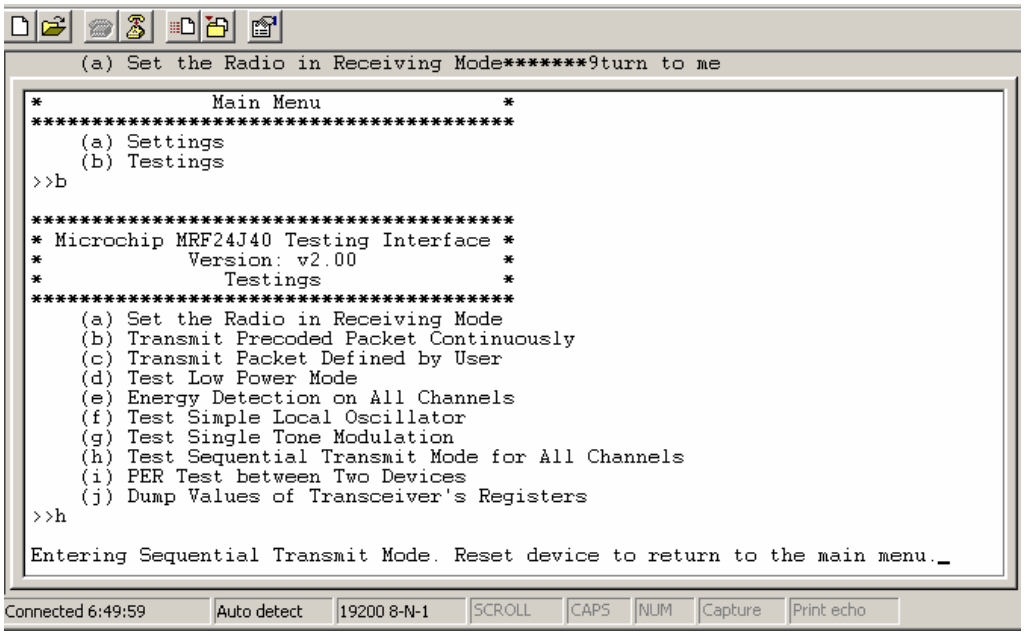
Note: The spectrum analyzer must be set on “Max and Hold mode” in order to have this screen capture.

(h) Test Sequential Transmit Mode for All Channels

This is probably one of the quickest and most interesting test of all. It starts transmitting in ZigBee mode (actually IEEE 802.15.4 mode to be more accurate) from channel 11 and ends up on channel 18.

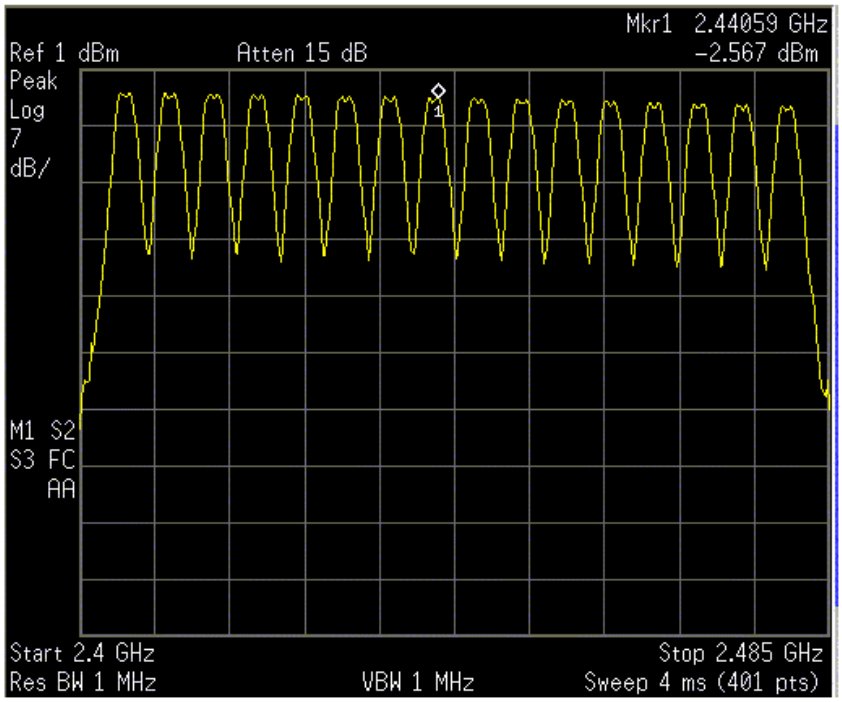
The menu will look like the one in Figure 28:

FIGURE 28: TEST SEQUENTIAL TRANSMIT MODE FOR ALL CHANNELS MENU



The screen capture from a spectrum analyzer will look like the one in Figure 29:

FIGURE 29: SWEEPING ISM BAND IN Tx ZigBee™ MODE



(i) PER Test Between Two Devices

This test was developed for the purpose of testing the indoor and outdoor coverage between two devices.

IEEE 802.15.4 specifies that a reliable link between two ZigBee protocol devices is defined as the one where the PER (Packet Error Rate) is below or equal to 1% for 1000 packets transmitted/received.

The idea is simple:

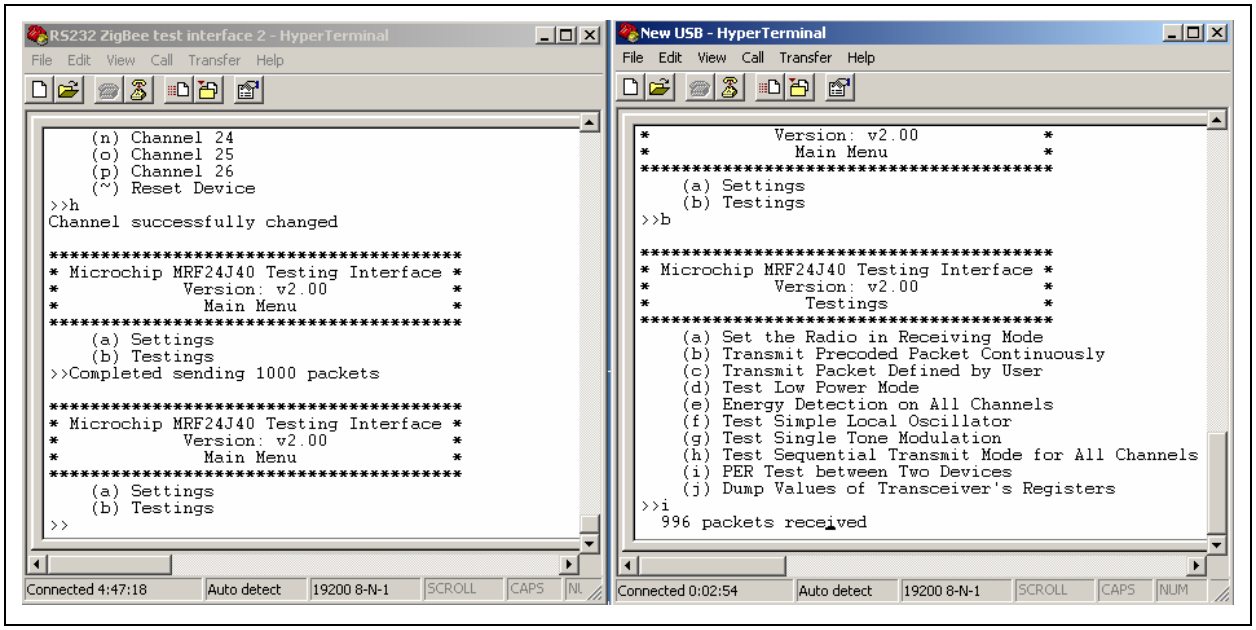
- A first PICDEM Z kit is placed on a stand (plastic pole, 7 foot tall) after being set for a specific working channel.

  By default, it will enter itself in Receiving mode – no need for further action.
- A second PICDEM Z kit will be placed on a second stand (plastic pole, 7 foot tall) and set for the same working channel. Then, hitting the key, “i”, will trigger the following sequence for this second module:
  - It will send a message/request to the first module asking it to start sending 1000 packets and immediately it will place itself in Receive mode to be able to handle all of these 1000 incoming packets.

FIGURE 30: THE STAND WITH THE PICDEM™ Z DEVICE ON IT

The menus will look like the ones in Figure 31:

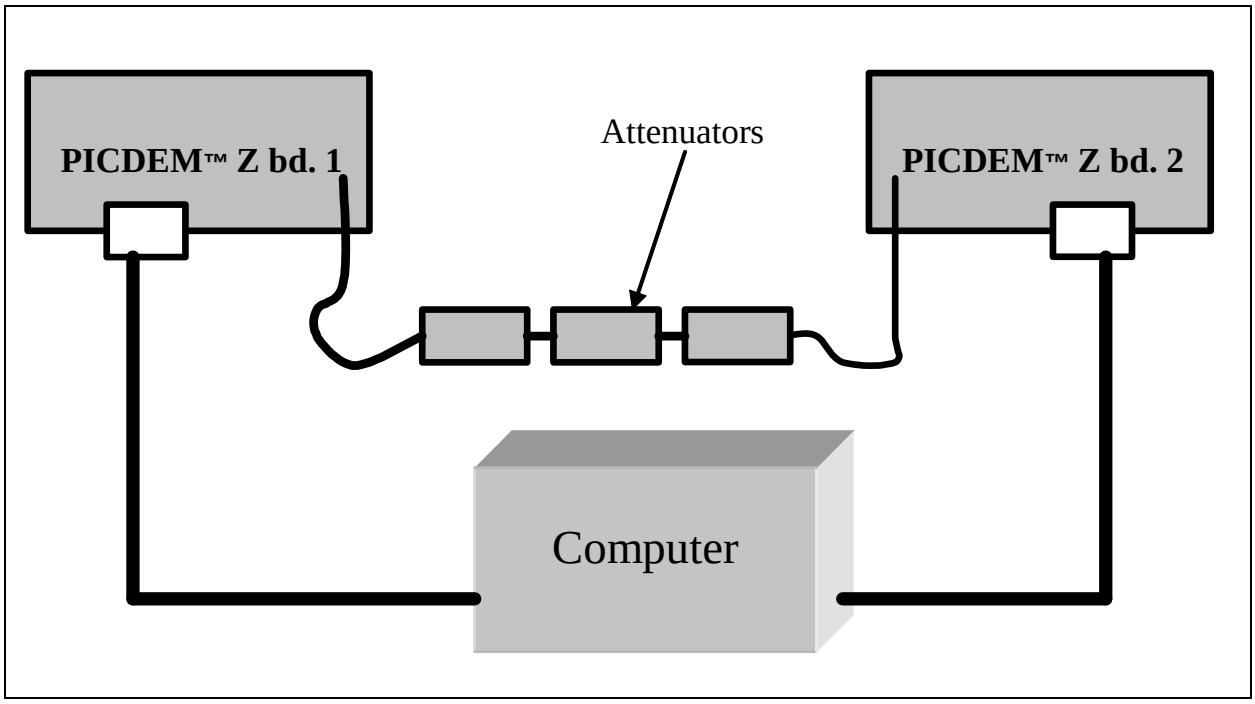
FIGURE 31: THE TRANSMITTER/THE RECEIVER



This test will give the user the freedom to increase the distance between the two modules and see how far the communication will keep a PER below 1%.

This test might also be used to find the sensitivity of the RF device, but the user needs to precisely measure the magnitude of the input signal.

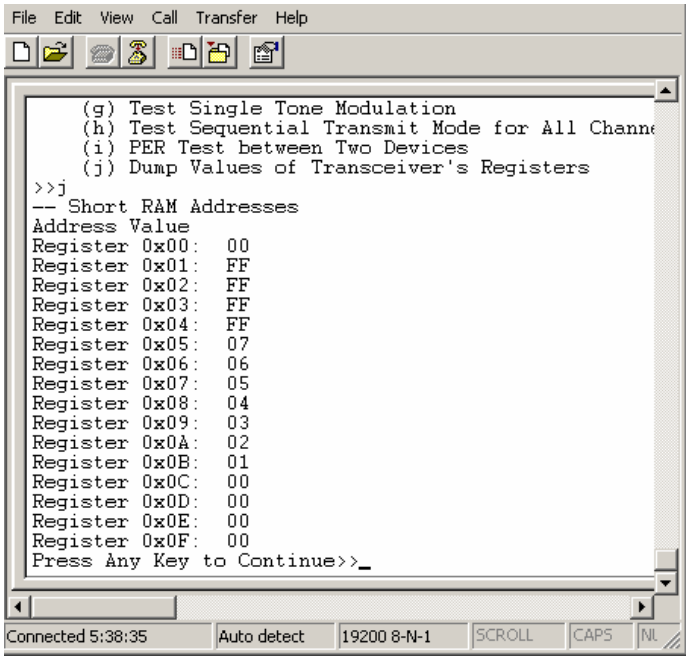
FIGURE 32: INCREASING DISTANCE AND KEEPING PER BELOW 1%



(j) Dump Values of Transceiver's Registers

For users interested in finding the content of the internal registers of the MRF24J40 transceiver, we implemented this test which displays them in an easy to follow Scrolling mode. After hitting the key, "j", the display will look like that shown in Figure 33.

FIGURE 33: DUMP VALUES OF TRANSCEIVER'S REGISTERS MENU



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.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
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