AN2575

New Radio Utility Driver Program for Microchip MRF24J40 2.4 GHz Wireless Transceiver

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INTRODUCTION

The New Radio Utility Driver Program for Microchip MRF24J40 Transceiver provides design engineers and wireless application developers a development and testing platform for the MRF24J40 IEEE 802.15.4™ 2.4 GHz RF transceiver and related modules. The program configures and runs tests of basic transceiver functionalities such as transmission, reception, and Sleep and Turbo modes, using a command-line and menu-driven user interface.

The New Radio Utility Driver Program for Microchip MRF24J40 Transceiver can run on either the PIC18 Explorer Development Board or the Explorer 16 Development Board, to which the MRF24J40 module is interfaced via its PICtail™/PICtail Plus board. The development board is connected to a PC's serial port and operated from a terminal emulator (such as Tera Term). For more details on the setup, see **Section "Hardware Test Setup"**.

The New Radio Utility Driver Program for Microchip MRF24J40 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 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 MRF24J40 Transceiver supports features as listed in Table 1.

This application note provides users with the following functionalities:

- Test framework to check functionalities of MRF24J40 transceiver
- Demonstration of MRF24J40 and MCU-based wireless node
- MRF24J40 radio and 8-bit/16-bit MCU connection interface
- Reference source code to initialize, configure, and manage MRF24J40 radio and related functions
- Demo application and techniques to handle data transfers between two MRF24J40-based wireless nodes

TABLE 1: MRF24J40 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 MRF24J40 RF transceiver in Sleep mode.
End-to-End Testing	Provides Packet Error Rate (PER) and Ping Pong testing between two transceivers.
Data Modes	Normal (IEEE 802.15.4) and Turbo modes.

HARDWARE TEST SETUP

The hardware interface of the MRF24J40 transceiver module with any of the PIC® MCUs, generally known as Wireless Node, is illustrated in Figure 1. The same wireless nodes can be realized using a combination of the PIC MCU development board and the MRF24J40 PICtail/PICtail Plus Daughter Board.

The characterization 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 MRF24J40 modules on each of them (for simplicity purposes).

In this application note, the tests are done using two identical MRF24J40 modules as RF (wireless) nodes.

Note:	The new module part replacement for MRF24J40MB and MRF24J40MC are MRF24J40MD and MRF24J40ME, respectively. Refer to the new module parts whenever MRF24J40MB and MRF24J40MC are mentioned in this document.

Hardware Setup Requirements

The following hardware are used for the range and performance parameter tests with the MRF24J40 transceiver modules:

- Two MRF24J40MA/MB/MC/MD/ME PICtail™/ PICtail Plus Daughter Boards
- Portable 2 dBi/5 dBi Aristotle P/N RFA-02-5-F7H1-70B-15 with type whip/dipole, if the MRF24J40MC/ME modules are used
- 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™/MPLAB® ICD 3/ PICkit™ 3
  - ZENA™ Wireless Adapter - 2.4 GHz (AC182015-1)
- 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 MRF24J40 transceivers. The driver utility program runs on any of the Microchip development boards. The New Radio Utility Driver Program for Microchip MRF24J40 Transceiver source code is available and compiled using the MPLAB® IDE and XC18/XC16 compilers.

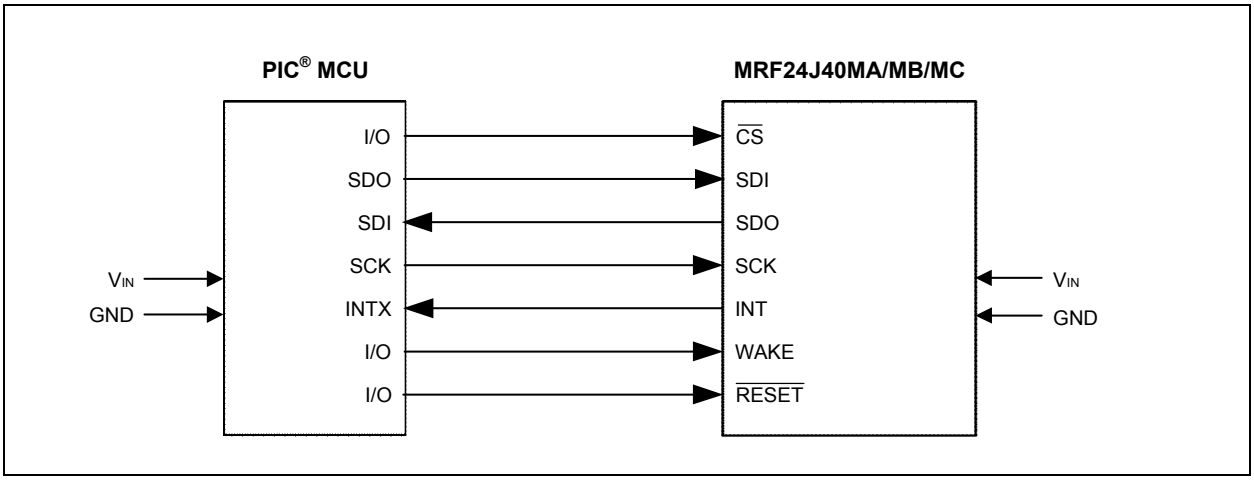
The software and utility tools requirement to run the driver program application are as follows:

- 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 MRF24J40 Transceiver source code Ver1.0 available as part of `AN2575.zip` from the AN2575 application note web page www.microchip.com/mrf24j40
- TeraTerm 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"**.

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).

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



PIC18 Explorer Development Board and MRF24J40 PICtail™/PICtail Plus Board Connections

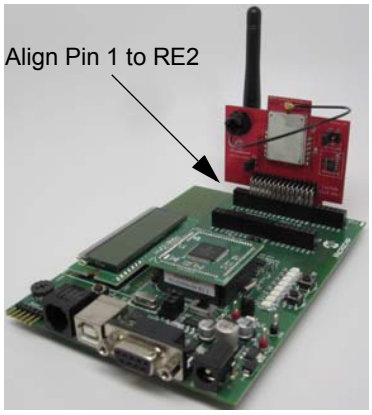
The 28-pin connector (P2) of the MRF24J40 module PICtail board is used to connect the PIC18 Explorer Development Board on the PICtail connector (J3) slot. This connection supplies 3.3V power, four-wire Serial Peripheral Interface (SPI), reset, wake, and interrupt connections to the MRF24J40 RF transceiver.

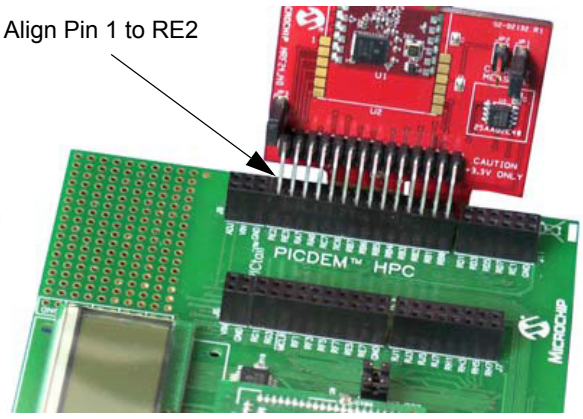
Figure 2 illustrates the MRF24J40 module connections with the PIC18 Explorer Development Board. The PIC18 Explorer Development Board is supported by the PIC18F87J11 through its Processor In Module (PIM).

For more information on the use and programming of PIC18 Explorer Development Board, refer to the *"MRF24J40MA/MB PICtail™/PICtail Plus Daughter Board User's Guide"*.

Note:	For newer designs or advanced feature requirements for the PIC18 platform development boards, use 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, see www.microchip.com/explorer8.

FIGURE 2: MRF24J40MA/MB/MC PICtail™/PICtail PLUS DAUGHTER BOARD PLUGGED INTO THE PIC18 EXPLORER DEVELOPMENT BOARD





Explorer 16 Development Board and MRF24J40 PICtail™/PICtail Plus Board Connections

The 30-pin PCB-edge connector (J3) of the MRF24J40 RF transceiver daughter card is used to connect the Explorer 16 Development Board's PICtail plus connector. This connection supplies 3.3V power, four-wire SPI, reset, wake, and interrupt connections to the MRF24J40 RF transceiver.

Figure 3 illustrates the plugging arrangement between the Explorer 16 Development Board and the MRF24J40 modules.

For more information on the use and programming of the Explorer 16 Development Board with 2.4 GHz modules, refer to the *"MRF24J40MA/MB PICtail™/ PICtail Plus Daughter Board User's Guide"*.

Note:	For newer designs or advanced feature requirements for the PIC24 platform development boards, use 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, see www.microchip.com/explorer16.

GETTING STARTED

To set up the MRF24J40 RF transceiver based wireless node, perform the following steps:

1. Insert the MRF24J40 RF transceiver daughter card into the development board.
   For the PIC18 Explorer Development Board, refer to the **Section "PIC18 Explorer Development Board and MRF24J40 PICtail™/PICtail Plus Board Connections"**.
   For the Explorer 16 Development Board, refer to the **Section "Explorer 16 Development Board and MRF24J40 PICtail™/PICtail Plus Board Connections"**.
2. Plug in the power cord for the development board that will hold the MRF24J40 RF transceiver.
3. Connect an RS-232-to-USB serial cable between the development board and the computer that will display the PIC microcontroller utility driver user interface.
4. Program the PIC18/PIC24 MCU with the `MRF24J40_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 by 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.

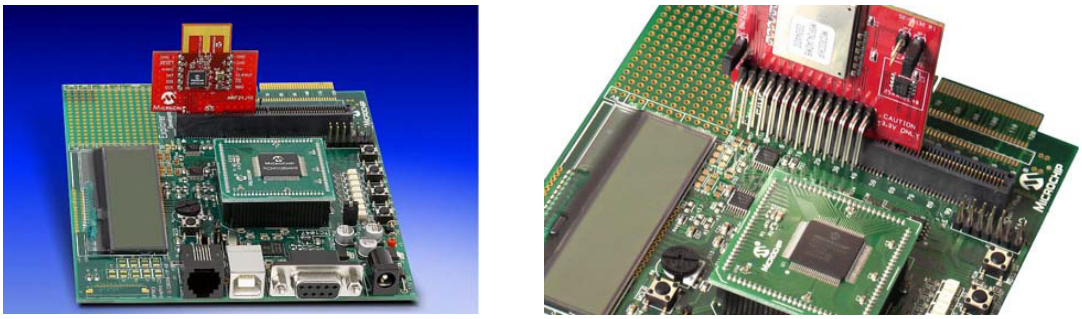
Connecting to the Host PC

The PC displaying the PIC microcontroller utility driver user interface connects to the development board through the PC's serial port. PCs with Windows® XP (or later) operating system can use any of the serial communication terminal emulator programs (like Tera Term) as user interface setup to command wireless nodes over UART and monitor the status. The required configuration settings for the serial port communication program are shown in Table 2.

TABLE 2: SERIAL PORT SETTINGS

Parameter	Setting
Bits per second	19200
Data bits	8
Parity	Even
Stop bits	1
Flow control	None

FIGURE 3: MRF24J40MA/MB/MC PICtail™/PICtail PLUS DAUGHTER BOARD PLUGGED INTO THE EXPLORER 16 DEVELOPMENT BOARD

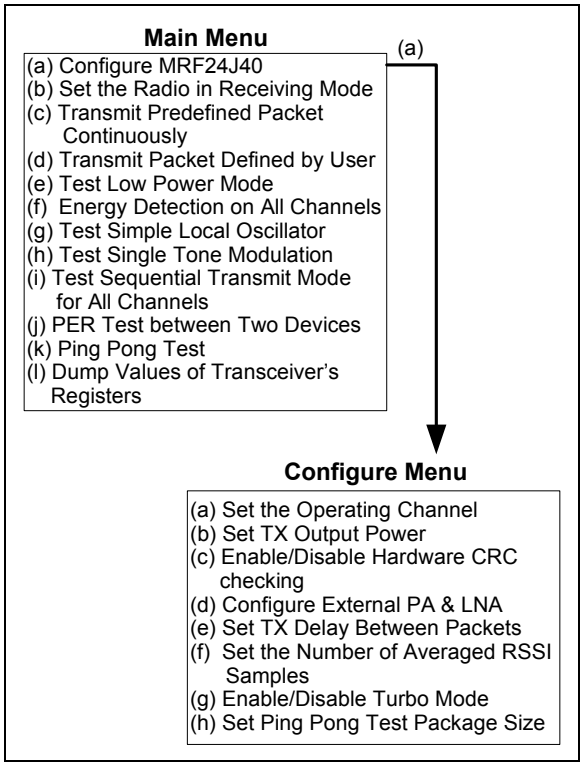


USING THE MRF24J40 RADIO UTILITY DRIVER FIRMWARE

Firmware Overview

The PIC microcontroller is operated through a menu displayed on the host computer, using a serial port communication application. There are two major menus as shown in Figure 4.

FIGURE 4: PRIMARY MENUS



- **Main Menu** – contains the test function commands
- **Configure Menu** – accessed from the Main Menu and contains commands for configuring the transceiver

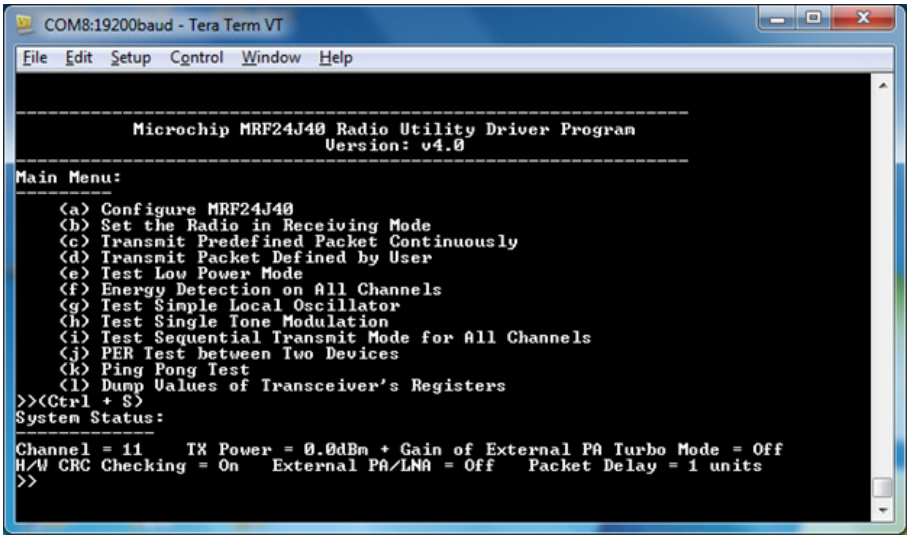
Hot keys can be used to navigate through the menus. See Table 3.

TABLE 3: KEYBOARD HOT KEY COMMANDS

Hot Key	Functionality
<Ctrl> + <z>	Exits and returns to the Main Menu. This hot key is used to stop or exit from any step.
<Ctrl> + <x>	Resets the transceiver and reverts configuration settings to their default values. This hot key can be used at any step.
<Ctrl> + <s>	Displays the current system status and configuration values. This hot key can be used at any step in the program.
<Ctrl> + <t>	Continuously transmits predefined packets. This hot key can only be used from the Main Menu.
<Ctrl> + <r>	Sets the radio in Receive mode (verbose). This hot key can only be used from the Main Menu.

Figure 5 displays the **Main Menu,** the **System Status**, and the configuration values displayed using the hot keys <Ctrl> + <s>.

FIGURE 5: MAIN MENU AND STATUS LINE



Process Overview

Section "Configuration Commands" and **Section "Test Function Commands"** provide the details of the PIC microcontroller driver commands. This section provides an overview of the sequence in which the commands are used.

TABLE 4: FUNCTIONAL OVERVIEW

Task (Optional Task)	Command
Transmitting	
Set operating channel	Configure Menu (a)
Configure External PA/LNA	Configure Menu (d)
Program TX Output power	Configure Menu (b)
(Enable Turbo mode)	Configure Menu (g)
(*If continuous transmission*: Set inter-packet delay)	Configure Menu (e)
Set type of transmission: • Continuous • Single packet • (See "End-to-End Testing")	Main Menu (c) Main Menu (d)
Receiving	
Set operating channel	Configure Menu (a)
Configure External PA/LNA	Configure Menu (d)
(Enable CRC checking)	Configure Menu (c)
Program RSSI samples	Configure Menu (f)
(Enable Turbo mode)	Configure Menu (g)
Enable receiving	Main Menu (b)
End-to-End Testing	
Set operating channel	Configure Menu (a)
Configure External PA/LNA	Configure Menu (d)
Program TX output power	Configure Menu (b)
(Enable Turbo mode)	Configure Menu (g)
(Enable CRC checking)	Configure Menu (c)
Initiate test: • Ping Pong test • PER test	Main Menu (k) Main Menu (j)
Other Tests	
Sleep Mode: Enable, Wake-up	Main Menu (e)
Perform energy scan on all channels	Main Menu (f)
Test local oscillator	Main Menu (g)
Test single-tone modulation	Main Menu (h)
Sequential transmit on all channels	Main Menu (i)
Read transceiver's registers	Main Menu (l)

EXECUTING FIRMWARE COMMANDS

This section provides details of the commands that can be used from the Main Menu and Configure Menu, through the following subsections:

- **Configuration Commands** – the Main Menu command for accessing the Configure Menu and the Configure Menu commands
- **Test Function Commands** – the test and functional commands on the Main Menu

Configuration Commands

The MRF24J40 RF transceiver is ready to operate using the PIC microcontroller's default values. The default values are shown in Table 5.

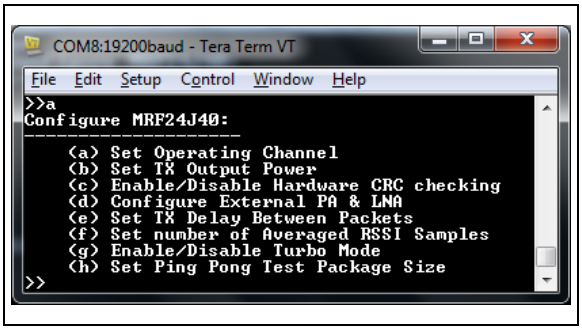
TABLE 5: DEFAULT CONFIGURATION SETTINGS

Attribute	Setting
Channel	11
TX Output Power	0 dBm
Receiver Sensitivity	-95 dBm
Hardware CRC Checking	On
External PA and LNA	Off
TX Delay between Packets	1 unit
Number of averaged RSSI samples	1
Turbo Mode	Off
Ping Pong Test Package Size	100

Note: Resetting the MRF24J40 RF transceiver sets the parameters to these default values.

Optionally, the values can be reconfigured through the secondary, Configure Menu, displayed in Figure 6.

FIGURE 6: CONFIGURE MENU



CONFIGURE MRF24J40

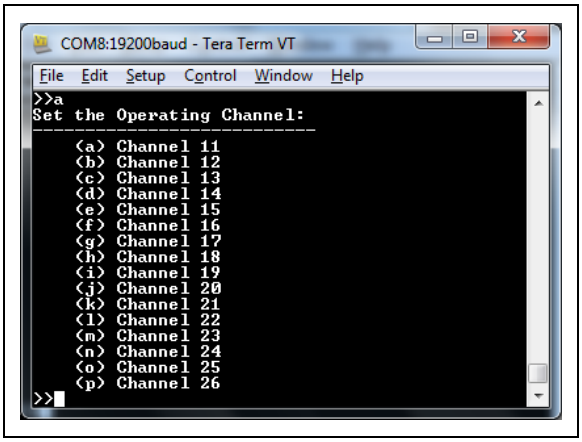
This Main Menu command displays the MRF24J40 Configure Menu as shown in Figure 6.

Set Operating Channel

The menu option, shown in Figure 7, enables the selection of one of the 16 operating channels available in the 2.4 GHz range. The default operating channel is 11.

When a channel is selected, the current system status displays at the bottom of the screen. Check the `Channel` = value to confirm the setting.

FIGURE 7: OPERATING CHANNEL MENU



Note: For details on finding the channel with the least noise, see **Section "Energy Detection on All Channels"**.

Set TX Output Power

The menu option, shown in Figure 8, sets the transceiver's output power. The default transmitting output power is 0 dBm.

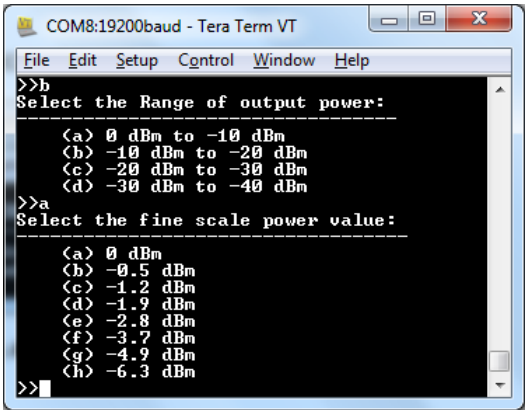
This parameter is configured with a two-tier menu (see Table 6):

- The first menu *designates the range* from which the output power value will be chosen.
- The second menu *specifies* the output power value by indicating *the value to be added to the initial or starting value of the previous menu's range*.

TABLE 6: TX OUTPUT POWER MENUS – OUTPUT COMPUTATION

	Option from Range Menu	Option from Fine-Scale Menu	Output
Process	**x dBm to *y* dBm**	***z* dBm**	*x* + *z* dBm
Example	**(b)-10 to -20 dBm**	**(b)-0.5 dBm**	-10.5 dBm

FIGURE 8: OUTPUT POWER RANGE AND SELECTION MENUS



The two-tier menus enable the values shown in Table 7.

TABLE 7: OUTPUT POWER VALUES

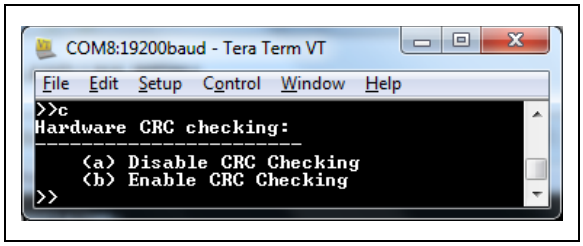
Range in dBm	Values in dBm			
0 to -10	0	-0.5	-1.2	-1.9
	-2.8	-3.7	-4.9	-6.3
-10 to -20	-10	-10.5	-11.2	-11.9
	-12.8	-13.7	-14.9	-16.3
-20 to -30	-20	-20.5	-21.2	-21.9
	-22.8	-23.7	-24.9	-26.3
-30 to -40	-30	-30.5	-31.2	-31.9
	-32.8	-33.7	-34.9	-36.3

When the TX output power value is programmed, the current system status displays on the screen. Check the `TX Power` = value to confirm the setting.

Enable/Disable Hardware CRC checking

The menu option, as shown in Figure 9, enables or disables a Cyclic Redundancy Check (CRC) of incoming packets. If CRC checking is enabled, the Medium Access Layer (MAC) discards incoming packets with incorrect CRC. If CRC checking is disabled, incoming packets with incorrect CRC are passed to the host layer.

FIGURE 9: CRC CHECKING MENU



By default, this feature is enabled.

When this parameter is set, the current system status displays at the bottom of the screen. Check the status line's `H/W CRC Checking` value to confirm the change.

CONFIGURE EXTERNAL PA AND LNA

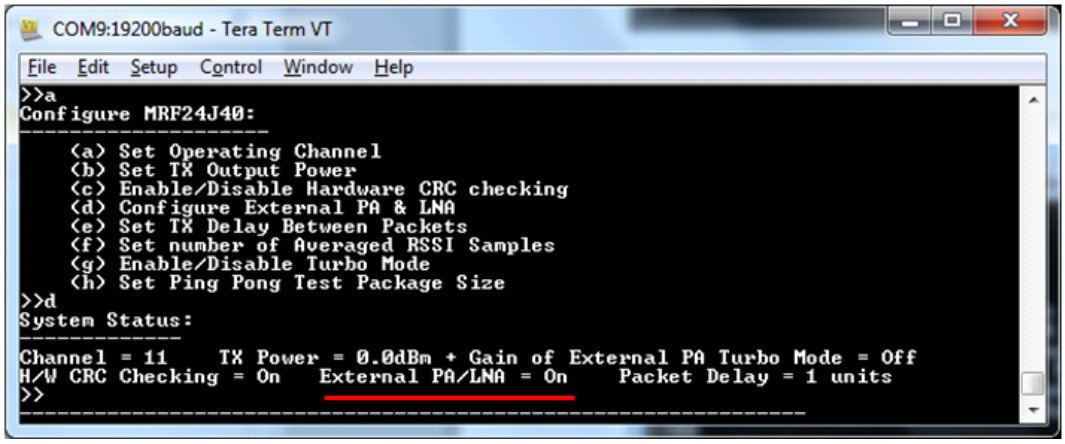
This menu option enables or disables an external Power Amplifier (PA) and a Low Noise Amplifier (LNA). The configuration of those amplifiers is done through the General Purpose digital I/O (GPIOx) pins of the MRF24J40 RF transceiver. For more information, see section "External PA/LNA Control" of the *MRF24J40 Data Sheet*.

The external PA and LNA option is disabled by default. When the External PA and LNA option is enabled, the current system status displays on the screen, as shown in Figure 10. Check the `External PA/LNA` value to confirm the setting.

Note:	Make sure that the PA or LNA is disabled when the MRF24J40MA module is used, because the GPIO pins of the module are grounded.

The external PA and LNA can subsequently be disabled by resetting the MRF24J40 RF transceiver, which returns the configuration to its default values. To do so, press the hot key <Ctrl> + <x>.

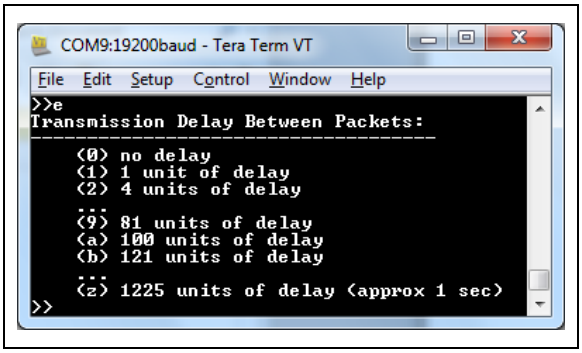
FIGURE 10: PA AND LNA MENU



SET TX DELAY BETWEEN PACKETS

The menu option, shown in Figure 11, determines the size of the inter-packet delay between continuously transmitted TX packets. (To enable the transmitting MRF24J40 RF transceiver send these packets, select the Main Menu option **(c) Transmit Predefined Packet Continuously**.)

FIGURE 11: TX PACKETS DELAY MENU



The size of the delay can be set with the PC's number or letter keys: numbers to configure from no delay to 81 units of delay, and letters to set a delay of 100 using 1,225 units of delay. Refer to Table 8.

TABLE 8: TX PACKET DELAY MENU – DELAY CONFIGURATION

Key Type	Delay Input Value	Delay Applied Value
Number	*n*	n^2
Letter	*a* = 10 *b* = 11 • • • *z* = 35	*a* = 100 *b* = 121 • • • *z* = 1,225

By default, the delay is one unit, the equivalent being:

- PIC18 Explorer Development Board – 2 ms
- Explorer 16 Development Board – 4 ms

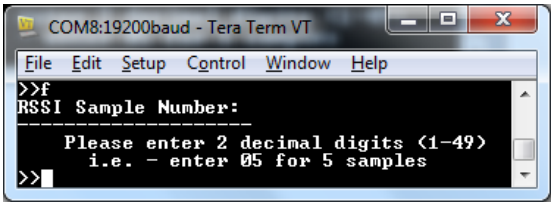
When the packet delay value is configured, the current system status displays on the screen. Check the `Packet Delay` value to confirm the setting.

SET NUMBER OF AVERAGED RSSI SAMPLES

The Received Signal Strength Indicator (RSSI) measures the signal quality of a received packet. Using an RSSI measurement that is averaged over multiple readings provides a more accurate value than a single-reading RSSI.

The menu option, shown in Figure 12, sets the number of RSSI samples to be averaged. The resulting measurements are displayed on the screen by using the Main Menu option **(a) Set the Radio in Receiving Mode**. For more details, refer to **Section "Set the Radio in Receiving Mode"**.

FIGURE 12: RSSI SAMPLE MENU



By default, the sample size is one.

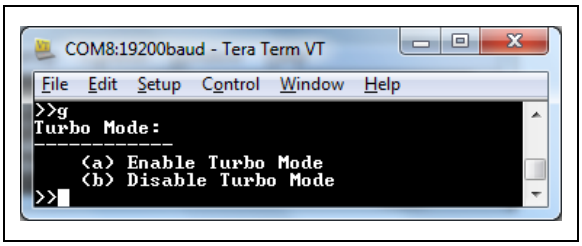
ENABLE/DISABLE TURBO MODE

The MRF24J40 RF transceiver has a Turbo mode that transmits and receives data at 625 kbps, that is, two and a half times the normal rate for proprietary protocols.

The menu option, shown in Figure 13, enables or disables the Turbo mode.

Note:	The ZENA analyzer cannot capture packets transmitted in Turbo mode.

FIGURE 13: TURBO MODE MENU

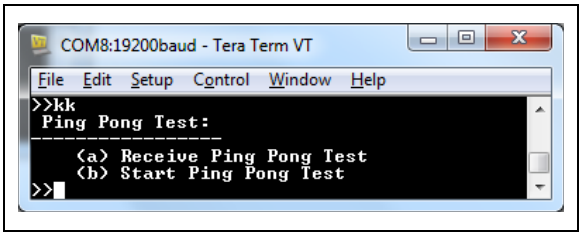


By default, the Turbo mode is disabled. When the mode is enabled or disabled, the current system status displays on the screen. Check the `Turbo Mode` value to confirm the setting.

SET PING PONG TEST PACKAGE SIZE

The menu option, shown in Figure 14, sets the number of ping pong packets exchanged between the transmitting and receiving transceivers. For more details about ping pong tests, see **Section "Ping Pong Test"**.

FIGURE 14: PING PONG MENU



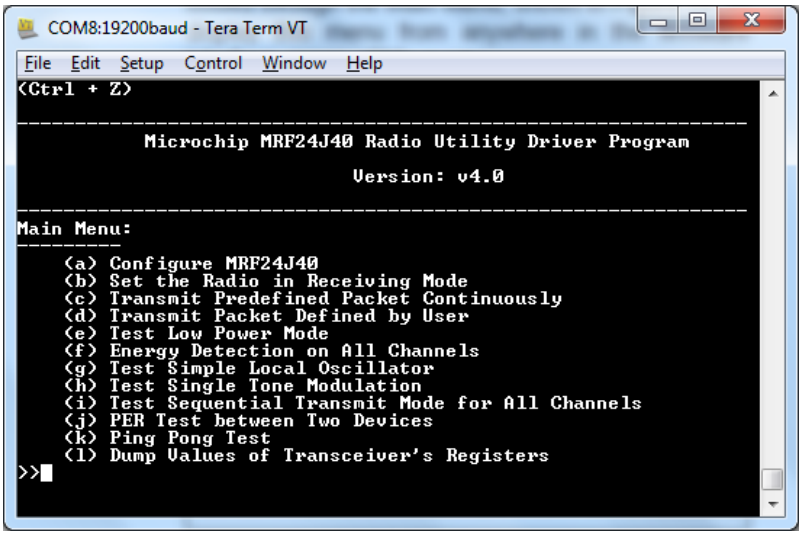
Type one to three digits and press <Enter>.

The default value of this parameter is 100.

Test Function Commands

Test activation and other functional commands are issued through the Main Menu as shown in Figure 15. To display this menu from anywhere in the firmware interface, press the hot key <Ctrl> + <z>.

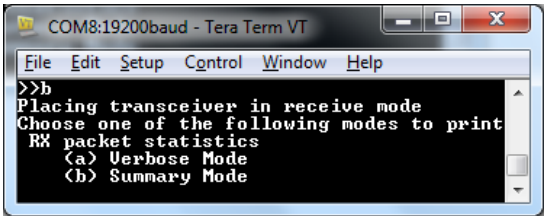
FIGURE 15: MAIN MENU



SET THE RADIO IN RECEIVING MODE

This menu option displays a received packet's statistics on the screen. Two display modes are available as shown in Figure 16:

FIGURE 16: SET RADIO TO RECEIVE



- Verbose Mode – displays all of the packet data (see Figure 17)
- Summary Mode – displays the statistics accumulated and printed for every second (see Figure 18)

When one of the options is selected, the received data is displayed. To take the transceiver out of Receiving mode, press the hot key <Ctrl> + <z>.

Before executing the command on the receiving transceiver, ensure to run the "transmit packet" commands on the transmitting transceiver.

FIGURE 17: RADIO IN RECEIVING MENU – VERBOSE MODE

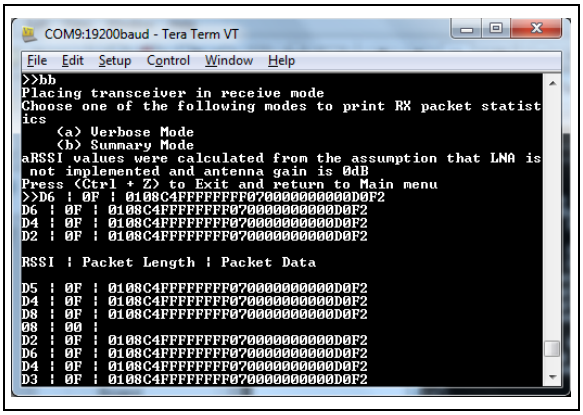
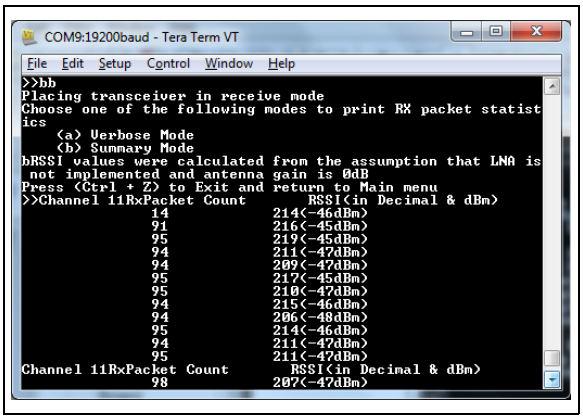


FIGURE 18: RADIO IN RECEIVING MENU – SUMMARY MODE



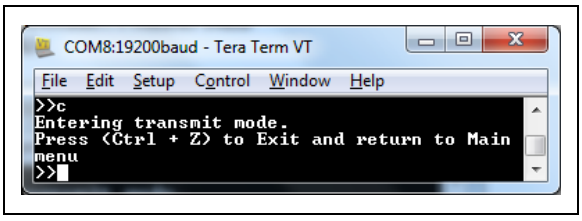
TRANSMIT PREDEFINED PACKET CONTINUOUSLY

The menu option, shown in Figure 19, continuously transmits a predefined packet until the hot key <Ctrl> + <z> is pressed.

The predefined packet is:

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

FIGURE 19: TRANSMIT PREDEFINED PACKET MENU



Before executing the <Ctrl> + <z> command:

1. Review the configuration values of the transmitting transceiver. (Pressing the hot key <Ctrl> + <s> displays most of the values.)

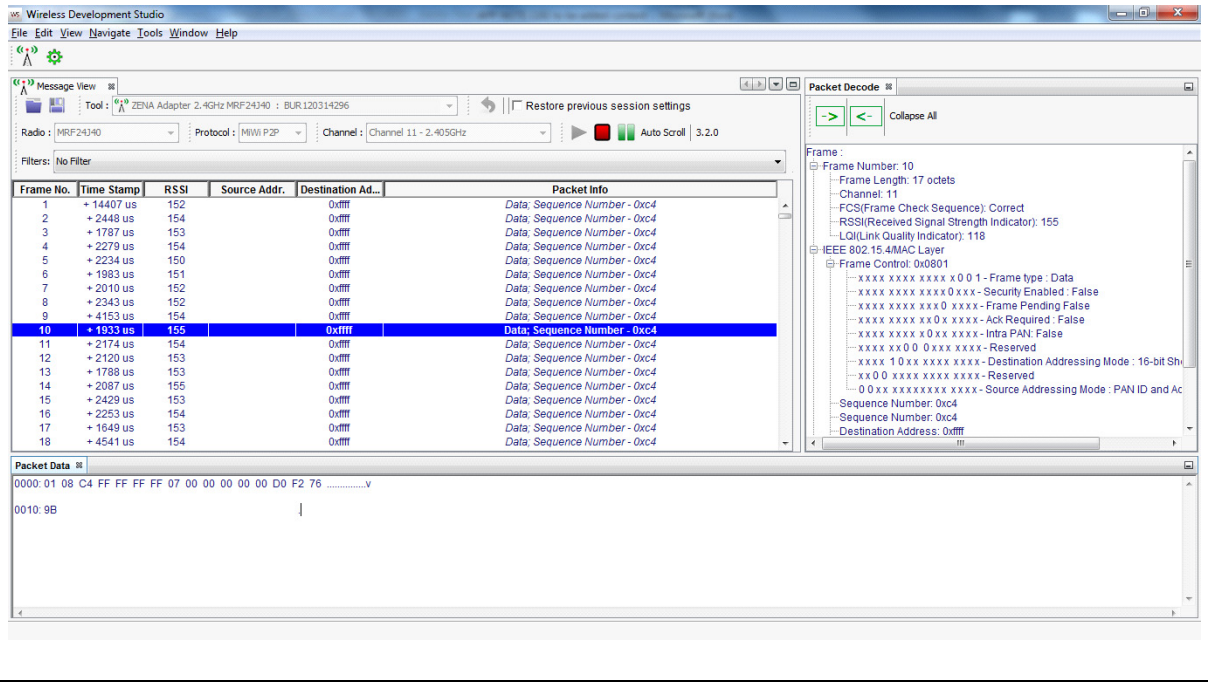
   The default configuration values are shown in **Section "Configuration Commands"**.

2. If some parameters need to be changed:
   a. Display the Main Menu (by pressing the hot key <Ctrl> + <z>) and select **(a) Configure MRF24J40**. The Configure Menu, shown in Figure 6, appears.
   b. Edit the desired parameters.
   c. Return to the Main Menu (<Ctrl> + <z>).

The configuration for the delay between each packet (inter-packet delay) may need to be changed from its default value (1 unit) in accordance with the time delays as required by the receiver or sniffer. The receiving (second) transceiver, at times, may not be able to display the continuously received packets on the Tera Term based on the differences in the Transmit and Receive packet delays. This particularly can be the case with sniffers as well, such as the ZENA analyzer.

Figure 20 shows a second transceiver using the ZENA analyzer to monitor a message sent with this command. If a second transceiver is using the PIC microcontroller as a sniffer or analyzer, see **Section "Set the Radio in Receiving Mode"**.

FIGURE 20: TRANSMITTING MODE USING THE ZENA™ SOFTWARE DISPLAY



TRANSMIT PACKET DEFINED BY USER

The menu option, shown in Figure 21, enables the transmission of a user-defined packet that conforms to IEEE 802.15.4™ specifications.

After the menu appears:

1. Type the *hexadecimal* values to be transmitted, capitalizing all letters.
2. Press the equals key (**=**) to send the entered data.

   The PIC microcontroller automatically checks if the packet conforms to the IEEE 802.15.4 format.

   - If the format is correct:
     - The message is sent.
     - The following message appears: `Packet Transmission – Success.`
     - The Main Menu reappears.
   - If the format is incorrect, an error message is displayed.
3. If an error message appears:
   a. Double check the message and retype it.
   b. Repeat steps 1 and 2.

The user-defined packet is transmitted only once. To transmit the same packet multiple times, re-execute the **(d) Transmit Packet Defined by User** option as many times as desired.

Figure 21 shows the user-defined packet sent from a transmit node, where the PIC microcontroller sets the MRF24J40 in the transmit mode. Figure 22 shows the same packet in the received format on another node, where the PIC microcontroller sets the MRF24J40 in the receive mode.

FIGURE 21: TRANSMIT USER-DEFINED PACKET MENU

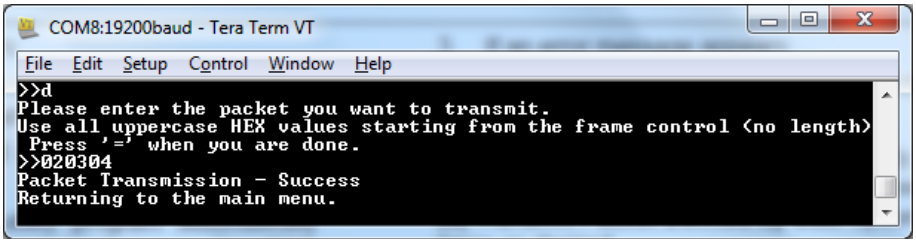
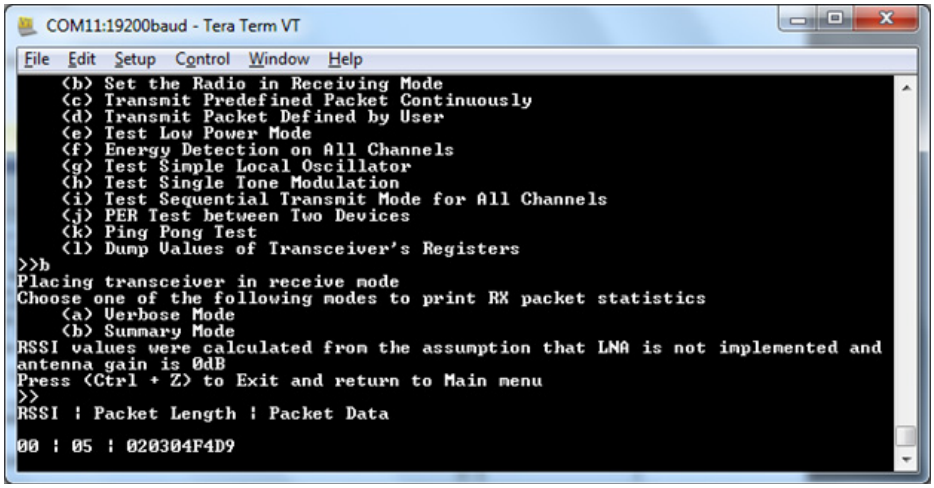


FIGURE 22: RECEIVED BACK USER-DEFINED PACKET



TEST LOW-POWER MODE

This menu option can:

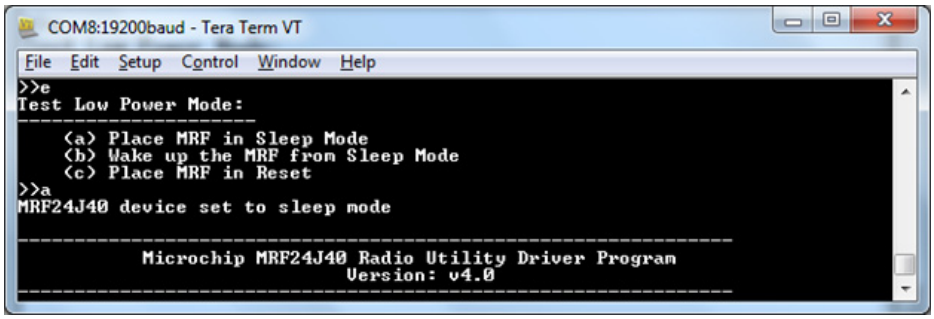
- Put the MRF24J40 RF transceiver in Sleep mode
- Wake the transceiver from Sleep mode
- Reset the transceiver

The Sleep mode enables designers to measure the MRF24J40 RF transceiver's Sleep current.

Figure 23 shows the option menu and the text display that appears when the transceiver is put into Sleep mode.

To bring the transceiver out of Sleep mode, use the **(b) Wake up the MRF from Sleep Mode** option or reset the transceiver. Resetting the transceiver reverts all configuration settings to their default values.

FIGURE 23: TEST LOW-POWER MODE MENU



ENERGY DETECTION ON ALL CHANNELS

The menu option, shown in Figure 24, scans the energy levels on all the 2.4 GHz IEEE 802.15.4 channels. For more accuracy, the RSSI reading from the MRF24J40 RF transceiver is averaged over 200 samples.

Before selecting the operating channel, use this option to find the least-occupied channel. This is particularly helpful with tests like the Packet Error Rate (PER) test between two devices.

This test is comparable with that done by a spectrum analyzer. See Figure 25.

To correlate Figure 24 and Figure 25:

- Equivalent antennas must be used, and the comparison must incorporate cable loss.

  (For Figure 25, the whip antenna has 1 dBi gain and 0.3 dB cable loss.)
- The sweeping time of ISM bands must be the same.
- The spectrum analyzer must have the appropriate resolution bandwidth.
- If the board has a high-gain LNA, the values in Figure 24 must be adjusted accordingly.

FIGURE 24: ENERGY DETECTION MENU

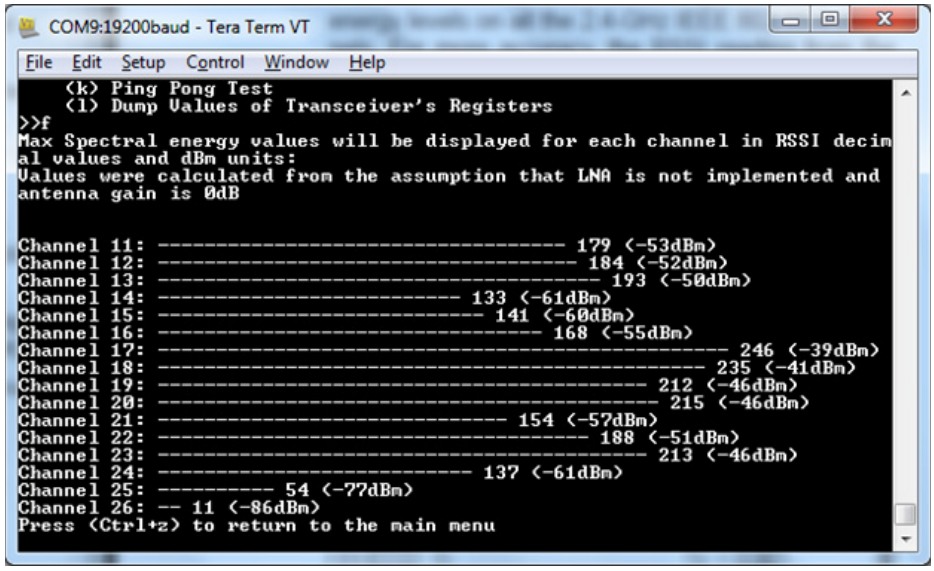
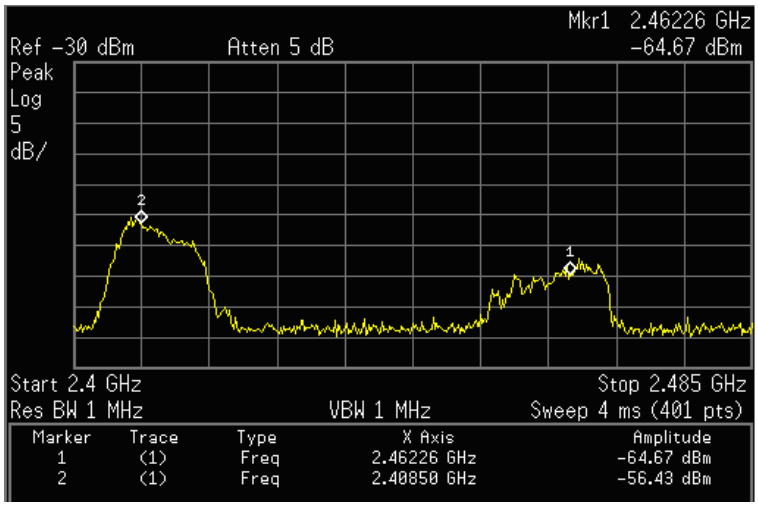


FIGURE 25: ENERGY DETECTION TEST ON A SPECTRUM ANALYZER



TEST SIMPLE LOCAL OSCILLATOR

The menu option, shown in Figure 26, can be used to check the frequency and output level of a local oscillator for a specific channel.

This command enables the local oscillator to start running without any modulation.

To end the test and return to the Main Menu, press the hot key <Ctrl> + <z>.

Before executing this test, select the required channel.

Figure 27 shows a comparable test by a spectrum analyzer.

FIGURE 26: TEST LOCAL OSCILLATOR MENU

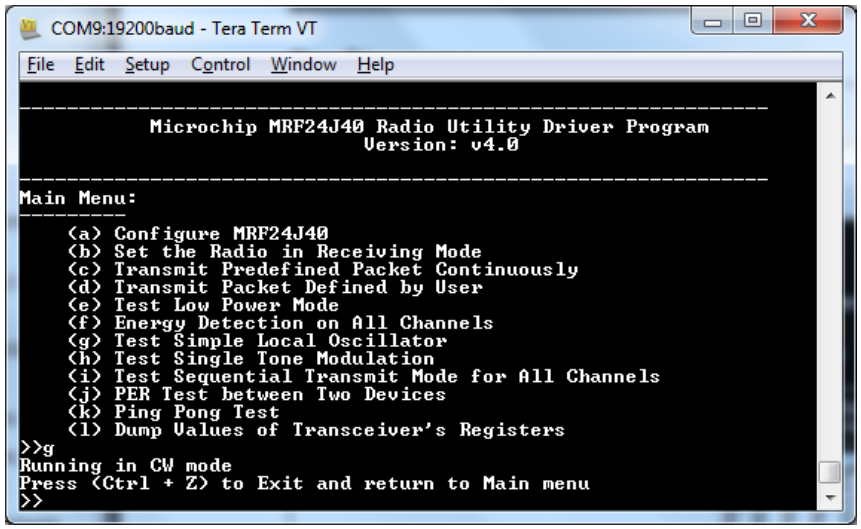
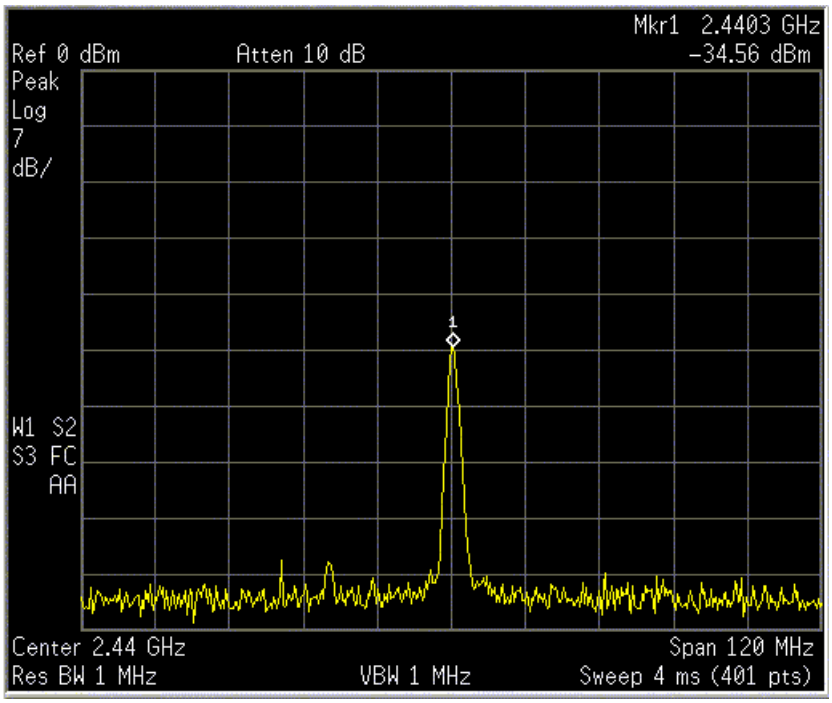


FIGURE 27: OSCILLATOR LEAKAGE TEST ON A SPECTRUM ANALYZER



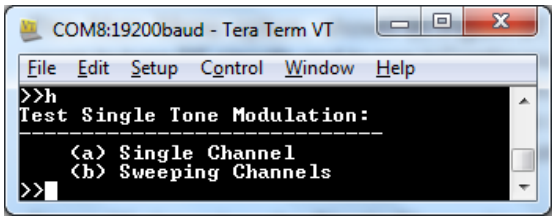
TEST SINGLE TONE MODULATION

The menu option, shown in Figure 28, allows users to tune RF circuits and to see a Continuous Wave (CW) signal as the transceiver's output. This single-tone modulation test can be done for a single channel (the first option) or for all the channels, one after another.

Figure 29 shows how the **Single Channel** test appears on a spectrum analyzer. Figure 30 shows how the **Sweeping Channels** test appears on an analyzer.

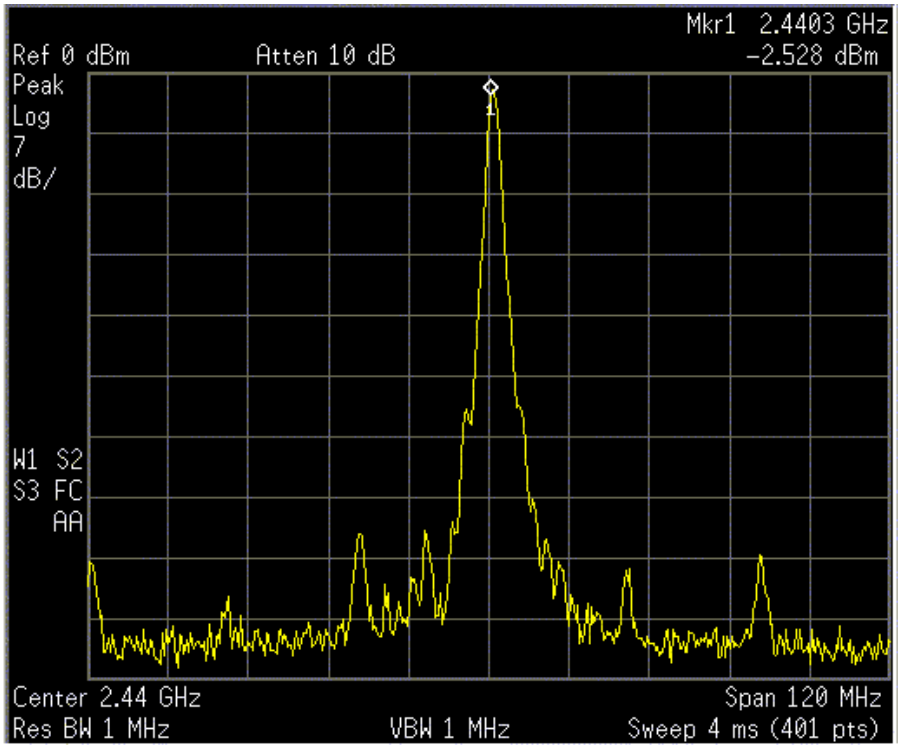
To end the test and return to the Main Menu, press the hot key <Ctrl> + <z>.

FIGURE 28: SINGLE-TONE TEST MODULATION MENU



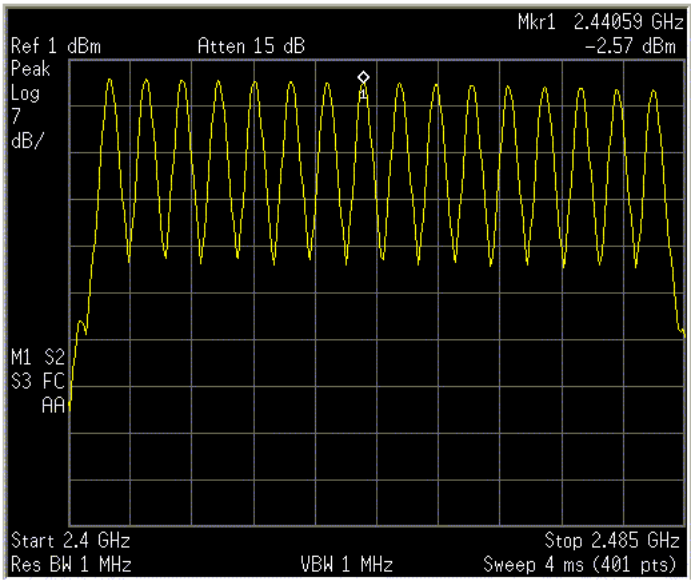
This **Sweeping Channels** option of this function can also be used to characterize the antenna gain on all the channels. To do this, a good omni-directional antenna should be connected to the spectrum analyzer.

FIGURE 29: SINGLE-CHANNEL TONE TEST ON A SPECTRUM ANALYZER



Note: The actual level is 1 dB higher than the level displayed in this figure. That difference is because of the loss in the coaxial cable used to measure the signal. This rule should be applied to all spectrum analyzer measurements presented in the application note.

FIGURE 30: SWEEPING-CHANNELS TONE TEST ON A SPECTRUM ANALYZER



TEST SEQUENTIAL TRANSMIT MODE FOR ALL CHANNELS

The menu option, shown in Figure 31, is equivalent to using the **Transmit Predefined Packet Continuously** option's test, except that the continuous transmission sweeps from channel 11 through 26.

To end the test and return to the Main Menu, press the hot key <Ctrl> + <z>.

Figure 32 shows how this test looks on a spectrum analyzer.

FIGURE 31: TEST SEQUENTIAL TRANSMIT, ALL CHANNELS MENU

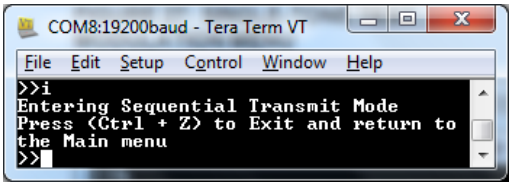
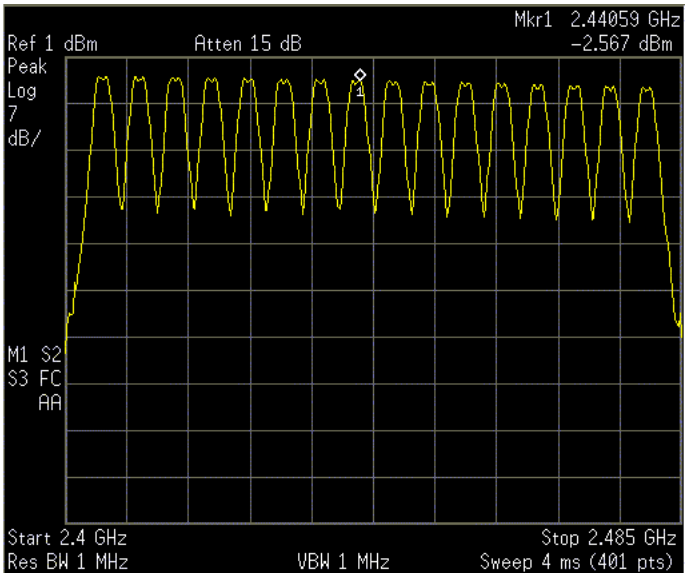


FIGURE 32: SEQUENTIAL TRANSMIT TEST ON A SPECTRUM ANALYZER



PER TEST BETWEEN TWO DEVICES

This menu option performs a test of the Packet-Error Rate (PER) between two devices. This is a one-iteration test with a predetermined number of packets.

The IEEE 802.15.4 specification defines a reliable link as having a PER less than 1%.

This test requires two MRF24J40 RF transceivers, each one running the PIC microcontroller and set to the same operating channel. After the command is executed from Node 1:

1. Node 1 sends a message to Node 2 for it to transmit 1,000 packets and, as shown by the underlined prompt line in Figure 33, reports that the test has commenced.
2. Node 2 sends the packets and, as shown by the underlined prompt line in Figure 34, reports that the packets have been sent.
3. As shown in Figure 33, Node 1 reports how many packets were received.

This test can be repeated with the units at different distances to determine the devices' coverage.

FIGURE 33: PER TEST – NODE 1

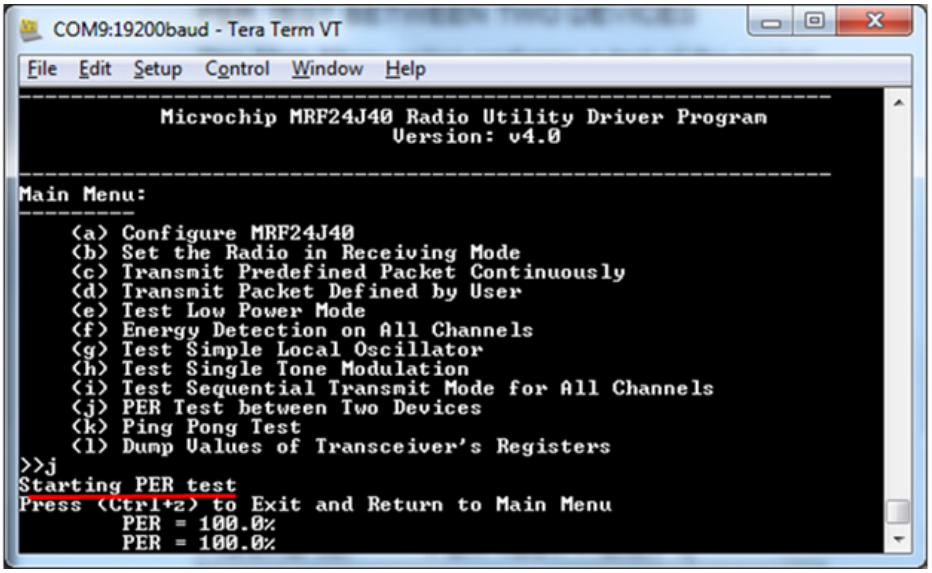
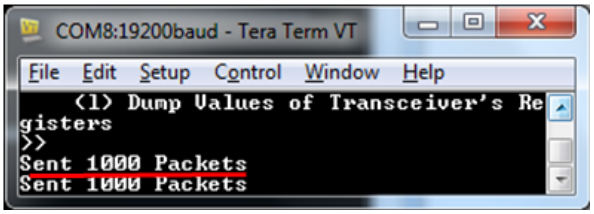


FIGURE 34: PER TEST – NODE 2



PING PONG TEST

This menu option tests for compliance to the 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 wanted 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%.

The test requires two MRF24J40 RF transceivers, each one running the PIC microcontroller. Prior to initiating the test, both transceivers must be configured for the same operating channel (for more details, refer to **Section "Set Operating Channel"**) and the same test-package size (see **Section "Set Ping Pong Test Package Size"**).

A signal generator also is needed. The generator's antenna should have at least 0 db gain.

To run the test perform the following steps:

1. On Node 1, select the Main Menu option **(k) Ping Pong Test** and select the option **(a) Receive Ping Pong Test**.
2. On Node 2, activate the command and select the option **(b) Start Ping Pong Test**.

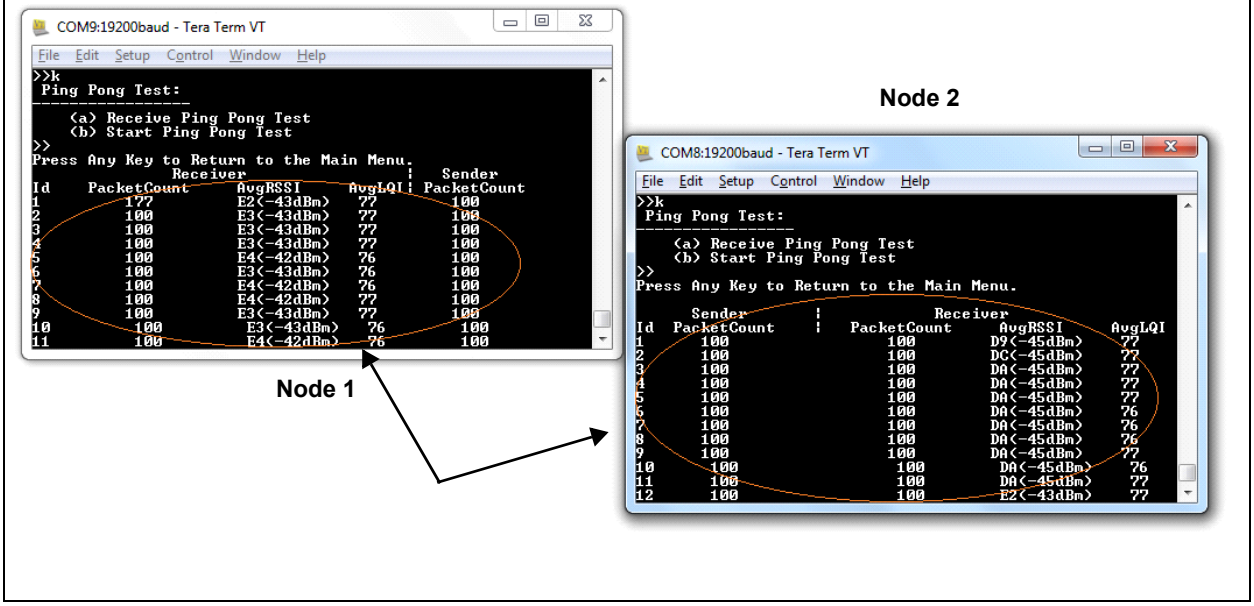
   Node 2 transmits the designated number of packets to Node 1. Node 1 reports the number of received packets and transmits the specified number of packets to Node 2. Refer to Figure 35 for Ping Pong Test Node 1 and Node 2 screens.

   The process continues until stopped.
3. While the packets are being exchanged, activate a signal generator and modify its frequency setting.

   Use the signal generator to sweep a bandwidth large enough to create interference signals for the two transceivers.
4. Watch the two dialog boxes and record the number of lost packets.
5. To end the test and return to the Main Menu, press the hot key <Ctrl> + <z>.

If required, this test can be repeated with the units at different distances to determine the coverage of devices.

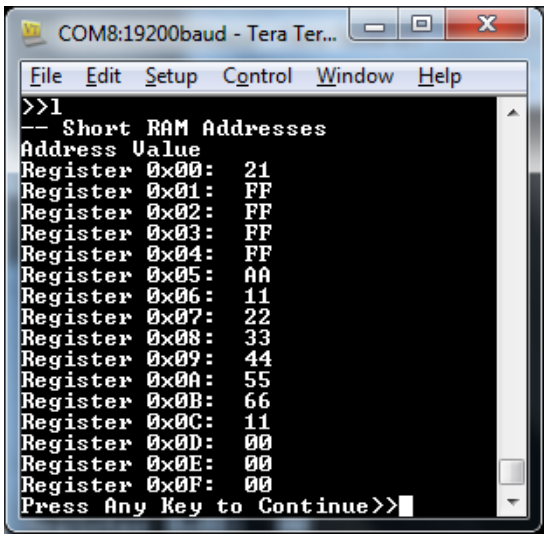
FIGURE 35: PING PONG TEST



DUMP VALUES OF TRANSCEIVER'S REGISTERS

The menu option, shown in Figure 36, reads the transceiver's 8-bit register values that are used for setting the MAC and baseband modes. For more information on register details, see *MRF24J40 Data Sheet*.

FIGURE 36: DUMP REGISTERS



After the command is executed, the first screen of registers appears. To view the next screen of register values, press any key. After the last screen of registers appears, the Main Menu displays automatically.

CONCLUSION

The Microchip MRF24J40 Transceiver Utility Driver Program is developed to show the flexibility of using Microchip RF transceivers. 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 MRF24J40 Utility Driver Program provides a low-cost and low-complexity test platform for application developers to understand the features offered by the Microchip MRF24J40 transceiver. It enables RF transceivers, which are supported by Microchip, to be hooked up and be tested in simple ways.

REFERENCES

- *"MRF24J40 Data Sheet"* (DS39776), Microchip Technology Inc.
- *"MRF24J40MA 2.4 GHz IEEE Std. 802.15.4™ RF Transceiver Module"* (DS70329), Microchip Technology Inc.
- *"MRF24J40MD/ME 2.4 GHz IEEE Std. 802.15.4™ RF Transceiver Module with PA/LNA" (DS70005173), Microchip Technology Inc.*
- *"MRF24J40MA/MB PICtail™/PICtail Plus Daughter Board User's Guide*" (DS51867), 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.
- *"MPLAB® ICD 3 In-Circuit Debugger User's Guide"* (DS51766), 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.
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- *"AN1204, Microchip MiWi™ P2P Wireless Protocol"* (DS01204), Yifeng Yang, Pradeep Shamanna, Derrick Lattibeaudiere, and Vivek Anchalia, Microchip Technology Inc., 2008-2017.
- *"AN1192, Microchip MRF24J40 Radio Utility Driver Program*" (DS01192), Sushma Myneni and Teodor Manolescu, Microchip Technology Inc., 2008-2009.
- *"AN1629, Simple Link Budget Estimation and Performance Measurements of Microchip 2.4 GHz Radio Modules"* (DS00001629), 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 MRF24J40

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 9 provides the list of files that are used as part of the Application Note source code project file named as `MRF24J40_Radio_Utility_Driver`. The New Radio Utility Driver Program for Microchip MRF24J40 Transceiver source code Ver1.0 is available as part of `AN2575.zip` from the AN2575 application note web page or www.microchip.com/mrf24j40. Users should program the PIC18/PIC24 MCU with the `MRF24J40_Radio_Utility_Driver.X.production.hex` file using the available Microchip programmer or debugger.

TABLE 9: MRF24J40 UTILITY DIVER CODE FILE LIST FOR PIC18/PIC24 MCUs

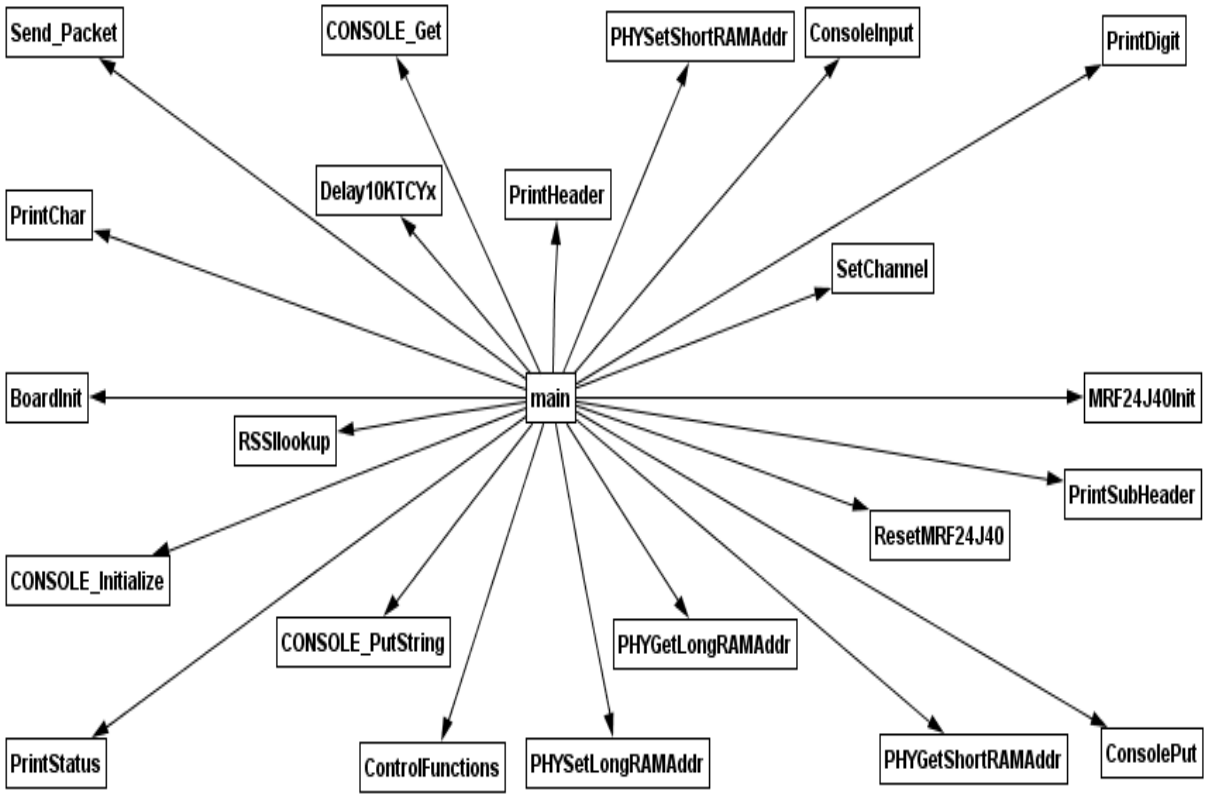
File name	File type	Description
main	`.c`	Initializes the state machine that is used to demonstrate the Demo Application. This file is also responsible for timer initialization.
EUI_config	`.h`	Flash MAC address of radio transceiver.
driver_mrf_24j40	`.c` and `.h`	Initializes the radio transceiver and register declaration. Supports function definitions to operate radio register using SPI.
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 MRF24J40 radio transceiver. Also initializes the pin configuration for LEDs.

Note: In `system_config.h` file, the 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 37 shows the source code call graph.

FIGURE 37: 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.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
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