

About This Manual

This document provides the user with details in setting up and using the Matrix evaluation kits [Part#: MTX10-KIT1 (10mW) and MTX12-KIT1 (100mW)]. The document also provides information and references for software developers to write applications for use with the Matrix modules [Part#: MTX10 (10mW) and MTX12 (100mW)].

This document contains the following chapters:

Chapter 1 – Evaluation Kit Overview

Chapter 2 – Quick Start

Chapter 3 – Interface Module Description

Chapter 4 – Matrix Evaluation Software

Chapter 5 – Matrix/Zigbee Ready Module Input/Output

Chapter 6 – Matrix Application Guide

Appendix A – Open Field Range Test Results

Appendix B – Agency Statements

Related Documents

- Host Protocol
- EICD

Index

CHAPTER 1	4
MATRIX EVALUATION KIT OVERVIEW	4
CHAPTER 2	5
QUICK START	5
CHAPTER 3	9
MATRIX INTERFACE MODULE	9
CHAPTER 4	15
SOFTWARE OVERVIEW	15
CHAPTER 5	33
MATRIX/ZIGBEE READY MODULE INPUT/OUTPUT	33
CHAPTER 6	35
MATRIX APPLICATION GUIDE.....	35
APPENDIX A	47
RANGE TEST RESULTS	47
APPENDIX B	48
AGENCY STATEMENTS	48

CHAPTER 1

Matrix Evaluation Kit Overview

1.1 Description

The evaluation kit provides the end user the ability to quickly become familiar with the Matrix module. Included in the kit are two Matrix modules and a quick start guide to demonstrate the communication link between the two modules. Also included is a GUI interface referred to as the Matrix Evaluation Test Tool (TT) to quickly communicate with the RF modules.

The Evaluation software demonstration is presented in Chapter 4. The important features provided by the evaluation software are:

- Short and Long Addressing
- Configurable Digital and Analog I/O
- Demonstrating a Wireless Link
- Packet Error Rate Statistics.

1.2 Contents

The Matrix Evaluation Kit Contains:

- Two RF Modules with Firmware Loaded and Soldered to the Interface Modules
- Two Interface Modules
- Two RS-232 Interface Cables
- 4 AA Batteries
- 1 CD (includes User's Guide, Host Protocol Document, EICD, and Matrix Evaluation Tool "Setup.exe" file)

CHAPTER 2

Quick Start

2.1 Board Description

The Matrix module is a 2.4GHz 802.15.4 data transceiver module based on the Chipcon CC2430 Low Power 8051/Transceiver device. It provides enhanced range performance with either a 10mW or 100mW* power amplifier. The module also contains an integrated PCB trace antenna. Power is supplied by the host device through the interface connection in accordance to the operating voltage requirements with a nominal operating voltage of +3.3V. Exact details on the interface connections and messaging are available in the Matrix Electrical Interface Control Drawing.

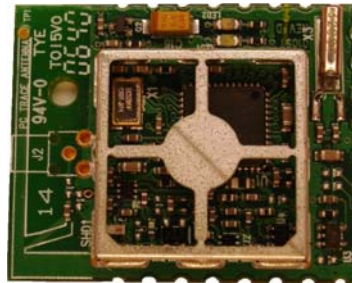


Figure 2-1. Top-Side of RF Matrix Module

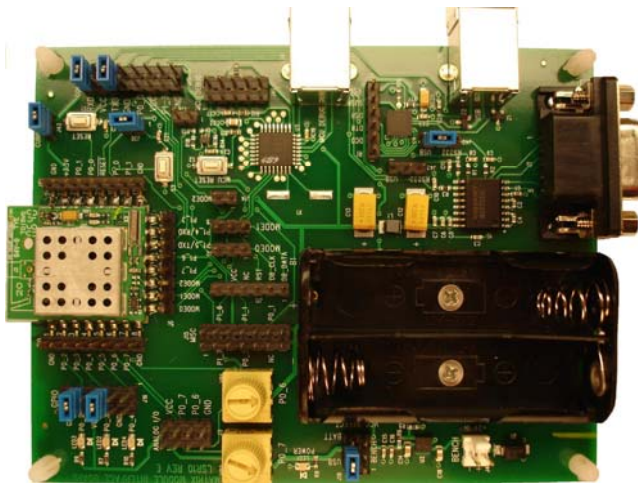


Figure 2-2. Top Side of Matrix Interface Board

* Operation is Limited to 10mW Maximum for European Union Compliance

2.2 Operational Overview

The quick start demonstration presented in this chapter is referred to as the ping pong test. The ping pong test allows an end user to easily verify communication between two transceivers and get a feel for the quality of the link via feedback of the flashing LEDs.

Operation involves two boards, with one designated as a master device and the other as a slave device. The master periodically transmits packets to the slave. If the slave receives and verifies the packet, it will flash its LEDs and transmit an acknowledgement to the master. If the master receives and verifies the acknowledgement, it will flash its LEDs.

In normal ping pong mode, LEDs indicate signal strength (two LEDs on indicate high signal strength, one LED indicates low signal strength). If the LEDs do not light, the packet or acknowledgement was not received.

2.2.1 *Power Up*

Insert batteries into interface boards and verify that battery supply is selected using the jumper as shown in Figure 2-3 below (J43 1-2, J18 4-6, J16 5-6, J16 9-10, and J36 1-2).

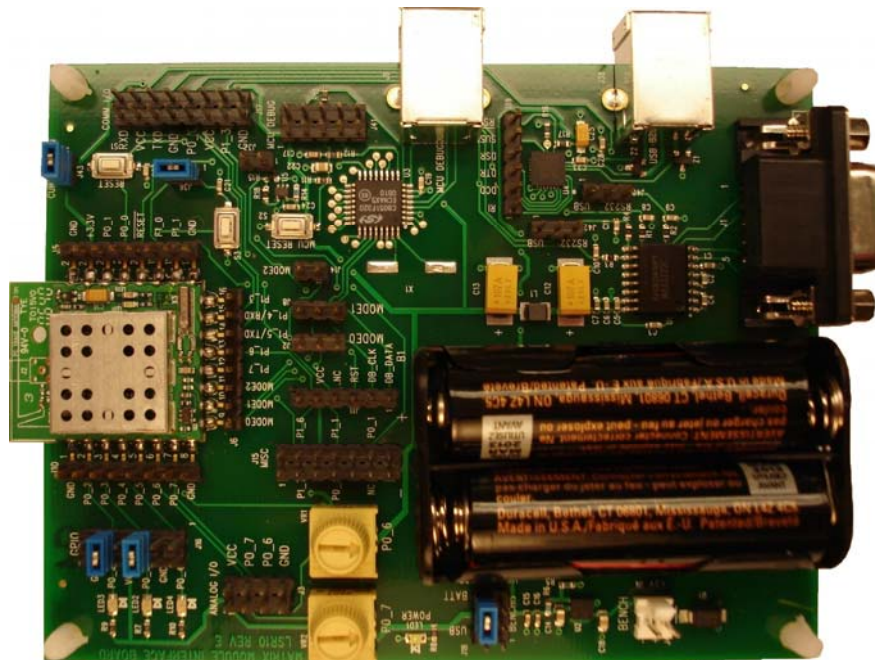


Figure 2-3. RF Matrix Module and Interface Board

2.2.2 Master/Slave Selection

Master device setup:

1. Press reset button (S1), see Figure 3-1 location 5, and user button (S3), see Figure 3-1 location 6, on Interface Board simultaneously.
2. Release reset button (S1) on Interface Module.
3. Wait until yellow LED (LED2) is lit, then release reset button (S1).

Slave device setup:

1. Press reset button (S1) and user button (S3) on Interface Board simultaneously.
2. Release reset button (S1) on Interface Module.
3. Quickly release the user button (S3) (Release within 1.5 seconds of performing step 2 above).

2.2.3 Association Mode

In association mode, the red LED (LED3) will flash rapidly on each board until it has linked with the other device. At this point, the red LED (LED3) will go out and the yellow LED (LED2) will begin to flash rapidly for approximately two seconds. Association mode lasts up to thirty seconds after power up, so the master and slave pair should be powered up at relatively the same time. If the transceivers link, they will enter the ping pong mode after association mode times out. However, if they do not link, they will not communicate and the sequence must be repeated from the point of master/slave selection at power up.

2.2.4 Ping Pong Mode

In ping pong mode, the master and slave boards will flash one or two LEDs with each packet (slave) or acknowledge (master) received, based on message signal strength. Refer to Table 2-1 below for a description of the LEDs versus signal strength. In case there is a lot of traffic on the default channel, it is possible to change the channel.

Red LED	Yellow LED	Signal Strength
Off	Off	None
Off	On	Marginal
On	Off	Good
On	On	Excellent

Table 2-1. LED Signal Strength Definitions

2.2.5 Channel Changing (can only be performed if boards have been associated)

While in the ping pong mode, the current channel can be changed to one of four other unique channels (four channels total). This is accomplished by holding the push button for approximately two seconds, at which point the yellow LED (LED2) will be lit steady. Once the push button is released, the current channel option number (one through four) is displayed by a series of flashes on the red LED (LED3). Each short push button press will increment the channel option number and display it with a given number of flashes on the red LED (LED3). To accept the last selected channel, hold the push button until the yellow LED (LED2) goes out (approximately two seconds). After again releasing the button, the device will return to the ping pong mode.

Note that both the master and slave devices must be set to the same channel option number for the pair to communicate, and each board must be individually set to that given channel option number.

CHAPTER 3

Matrix Interface Module

3.1 Interface Module Overview (See Figure 3 – 1 for Photo)

The interface module provides the user the ability to quickly assess the functions of the Matrix module such as I/O and the mobility to verify operation of a wireless link in any environment of the user's choosing.

This chapter describes in detail the functions of the Matrix interface board that can be verified using the Matrix evaluation software provided in this kit.

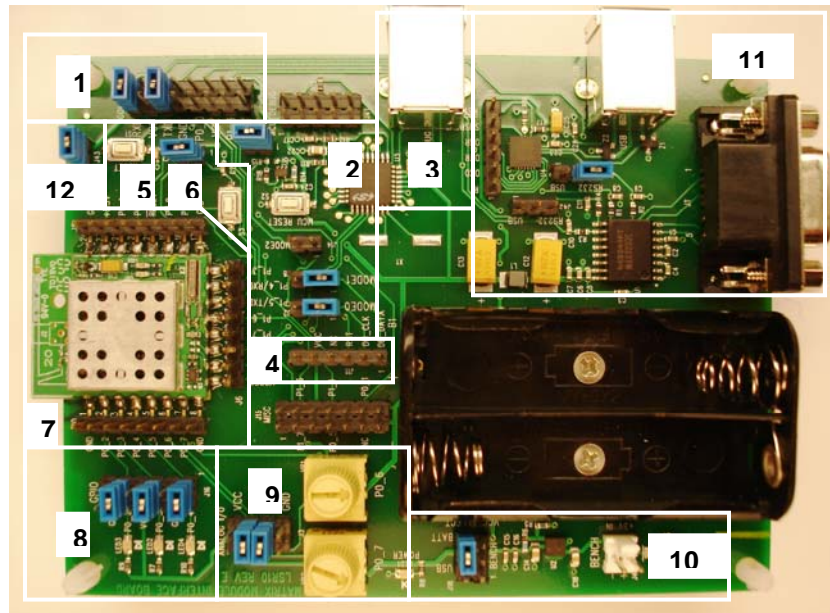


Figure 3 -1 Interface Module with Matrix Module Inserted in Socket

3.1.1 *Interface Board Description for Each Location Shown in Figure 3-1*

Serial Communications Header (location 1)

- Header that allows the user to monitor the serial TX (MODTXD) and RX (MODTXD) data lines from section 9 as shown in Figure 3-1 above. The header also provides quick access to Port C pins 0 and 1 on the microprocessor.

Mode Select and Programmer/Debugger Jumpers (location 2)

- Leave jumpers uninstalled for normal operation. Jumpers J2 1-2 and J8 1-2 should be installed in order to program or debug the CC2430 with the USB Programming/Debugging Port.

Programming/Debugging PC Connector (location 3)

- Location 3 refers to the programming/debugging PC connector. Via this USB connector it is possible to either program the Matrix Module or debug when developing custom firmware for the module.
- For programming the Matrix Module with custom firmware, the suggested programming software tool is the “Chipcon SmartRF04 Flash Programmer”. This tool is available from TI/Chipcon. In addition to the software tool a USB A-B cable is also required for connection between the interface board and a PC.
- For debugging firmware that is developed using the IAR Embedded Workbench for 8051, this USB connector can also be used. Again a USB A-B cable is required. Additionally the jumpers J2 1-2, J8 1-2, and J37 1-2, shown in location 2 of Figure 3-1 need to be installed.

Off Board Programming Header (location 4)

- Location 4 refers to the off board programming header. Via this header it is possible to connect to an off board Matrix Module and program it while in-circuit.
- A custom cable needs to be built that will allow the off board Matrix Module to be connected to the interface board. Signals that are provided on header J11 include “DEBUG_DATA”, “DEBUG_CLK”, “RST”, “GND”, AND “VCC”.
- Refer to the “Programming/Debugging PC Connector” section above for information on programming the Matrix Module.

Reset Button (location 5)

- Location 5 indicates the white button that provides ability to reset the microprocessor on the Matrix module.

User Button (location 6)

- Location 6 indicates the white user button. Its main purpose is for use with the ping pong range test (described in Section 2.2 above). In order to use this button jumper J36 1-2 needs to be installed.

Headers for Access to All I/O Pins (location 7)

- Header to provide quick access to all of the I/O pins on the Matrix Module.

LED Enable/Disable Header (location 8)

- To utilize LED's the jumpers must be connected as shown in Figure 3-1. The jumpers may be removed to externally access pins P0_2, P0_3, and P0_4 for input or output operation.

Analog Input Select Header (location 9)

- Location 9 shows 2 yellow variable analog potentiometers. With the jumpers installed as shown in location 9 (at locations J3 3-4 and J3 5-6) on the ANALOG I/O header, the onboard potentiometers may be utilized to demonstrate the analog capabilities of the Matrix Module.
- Remove the two jumpers to utilize external analog or digital peripherals on pins P0_6 and P0_7.

Power Supply Circuitry (location 10)

- Location 10 encompasses the power supply circuitry.
- As shown in Figure 3-2 below, the jumper is set for bench power supply (3.5 – 5VDC). Bench power supply may be connected to the white header (note positive and negative terminals).
- To use battery power, place the jumper as shown in Figure 3-3 below and insert 2 AA batteries in power pack onboard the interface board.
- To use USB power, place the jumper as shown in Figure 3-4 below. USB power comes from the USB Communication Port (location 10 in Figure 3-1) when used with the Evaluation Test Tool. Note that USB power cannot be used with the USB Programming/Debugging Port (location 3 in Figure 3-1).

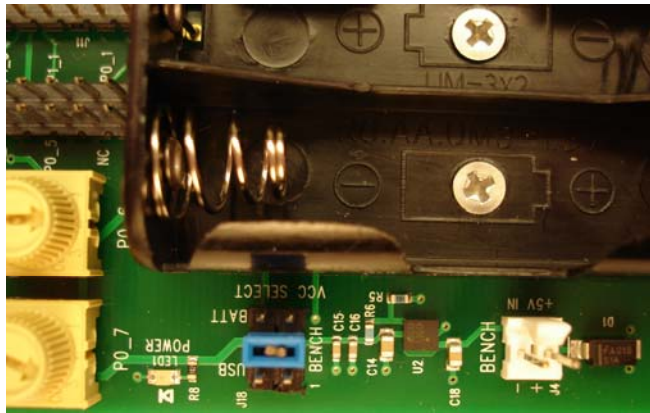


Figure 3-2. Jumper Set For Bench Supply

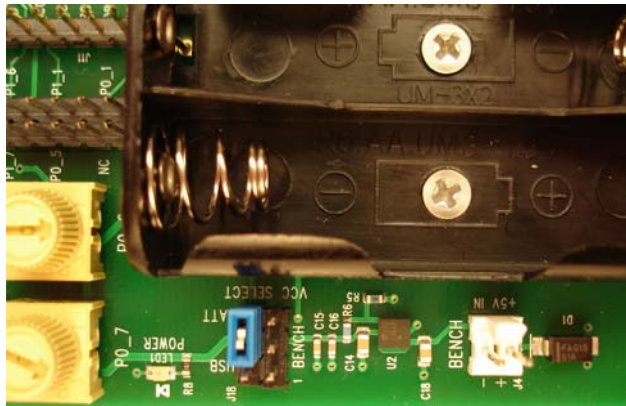


Figure 3-3. Jumper Set For Battery Supply

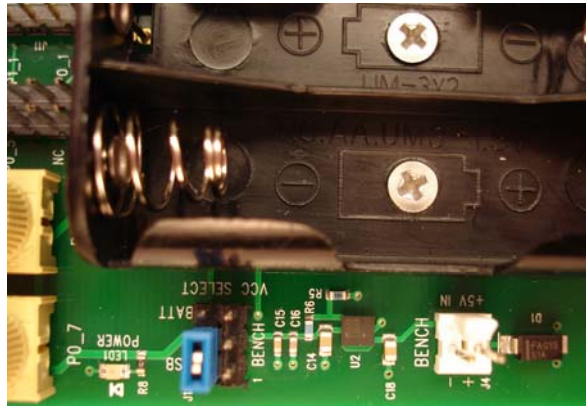


Figure 3-4. Jumper Set For USB Supply

RS-232 Communication and USB Communication Circuitry (location 11)

- Location 11 encompasses the circuitry for communicating with the module via either RS-232 serial or USB. Only one of the interfaces (RS-232 or USB) can be used at a time. Either of these interfaces allows communications with the supplied evaluation test tool software.
- To use the RS-232 serial interface with the test tool, jumper J40 2-3 should be installed as shown in Figure 3-5 below.
- To use the USB interface with the test tool, jumper J40 1-2 should be installed as shown in Figure 3-6 below.



Figure 3-5. Jumper Set For RS-232 Serial Communications

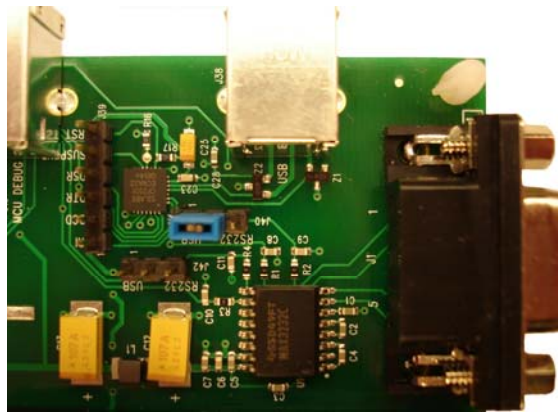


Figure 3-6. Jumper Set For USB Communications

Current Monitor Header (location 12)

- Provides user quick access to monitor current supplied to the RF Module. Useful in determining current used by device when in normal or sleep mode.
- To utilize this feature the user must remove the jumper and attach current monitor between the two header pins.

CHAPTER 4

Software Overview

4.1 Software Description

The Matrix evaluation software was designed to give the developer an ability to quickly test the features built into the Matrix module. The evaluation software is described in the following sections. A screen shot of the evaluation software is shown in Figure 4-1. Developers please refer to Chapter 5 for information on building custom applications for use on the Matrix module.

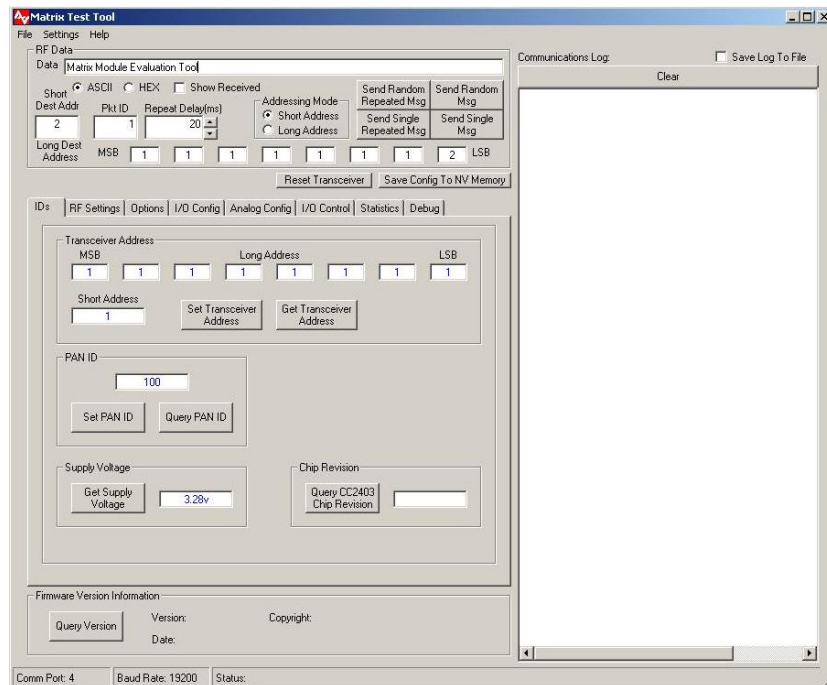


Figure 4-1. Evaluation Software - Main Screen

4.2 Software Setup

Prior to installing the test tool, power the Matrix module and connect up either the RS-232 serial communications or USB communications cable. Refer to Section 3 above for the correct jumper settings for each the power supply connection and communications connection that will be used (Jumpers J17 11-12 and J17 15-16 should be installed, jumper J40 1-2 is for USB or J40 2-3 is for RS-232, and jumper J18 3-4 is for bench supply, J18 2-4 is for USB communications supply, or J18 4-6 is for battery supply).

Note that when using the USB communications connector and cable that a virtual serial COM port is created that should show up in the “Communications Settings” dialog shown in Figure 4-2 below.

Install the Evaluation test tool using the self extracting setup program and execute the MatrixTT.exe to start the program.

If the bottom status bar as shown in Figure 4-1 shows a COM port number and a baudrate, then connection with the module has been successful and you can skip to Section 4.2.1.

If the bottom status bar shows “Comm Port: None”, then the test tool was not able to find a Matrix module on any of the available PC COM ports.

Pull down the “Settings” menu and click the “Communications” entry. The screen shown in Figure 4-2 will appear.

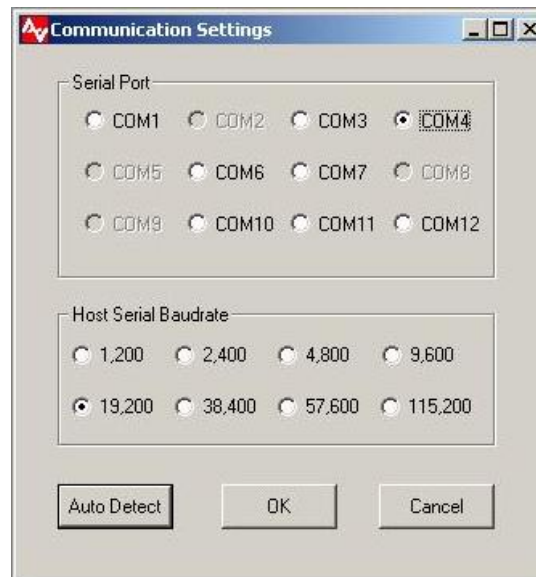


Figure 4-2. Communication Setup Screen under “Settings” Pull Down Menu

The default baudrate is set to 19,200 baud, so leave that setting alone. Determine serial port in use and select “OK”. Next click the “Get Version” button on the bottom of the test tool to verify communication with the device. If the version does not appear, verify correct COM port and select “OK” and verify communication successful. Another option if the COM port in use is not known is to select “Auto Detect”. If “Auto Detect” is successful the status bar should show a comm port number and a baudrate.

If communication is still unsuccessful with the Matrix module, verify all jumper settings, restart test tool, and perform steps outlined above.

4.2.1 Main Section of Test Tool (Upper left portion of the Test Tool as shown in Figure 4-1)

RF Data

- Data - Text box to allow user to transmit desired messages to other modules or view messages from another module.
- Ascii/Hex (Radio Buttons) – Gives user ability to view or enter messages in Hex or Ascii format
- Show Received (Check Box) – If checked the RF Data text box displays received data in selected format.
- Addressing Mode – Selects whether messages are sent to a long (64 bit) or short (16 bit) address.
- Repeat Delay – Allows user to adjust time between sending repeated messages.

Reset Transceiver (command button)

- Performs a software reset of the microcontroller.

Save Config to NV Memory (command button)

- Permanently saves configuration settings from IDs, RF Settings, and Debug tabs to non-volatile memory. This feature allows users to cycle power or reset the module without losing previously saved settings.

4.2.2 Setting Device Identification (See Figure 4-1)

Transceiver Address

- Short Address – Device defaults to using short address unless this field is set to 65,534. If using short address protocol only use values from 0 to 65,533.
- Long Address – Eight byte address used for communication between devices if short address is set to 65,534.
- Set Transceiver Address – Sets Long and Short Address*
- Get Transceiver Address – Gets Long and Short Address*

PAN ID (Personal Area Network Identification)

- Set PAN ID – Range 0 to 16383 (14 bit Value)
- Get PAN ID – Returns current PAN ID

4.2.3 Getting Supply Voltage (See Figure 4-1)

Supply Voltage

- Get Supply Voltage – Gets the voltage that is applied to the Matrix module.
- The value returned is a single byte. To determine the voltage from the reading that is returned use the following formula. Supply Voltage = (Reading / 255) x 3.75

4.2.4 Getting CC2430 Chip Revision (See Figure 4-1)

Chip Revision

- Query CC2430 Chip Revision – Gets the revision number of the CC2430 RF transceiver. Rev A will be 0x00, Rev B will be 0x01, Rev C will be 0x02, etc.

4.2.5 RF Settings (See Figure 4-3)

The RF Settings page can be accessed by selecting the *RF Settings* tab in the software and is shown in Figure 4-3. The following features are provided in the RF settings page.

- Acknowledgement Settings* – If enabled the destination device will transmit an acknowledgement to the originating device. If disabled the destination device will not send an acknowledgement back to the originating device. Query Acknowledgement settings displays current setting in text box.
- Receive All Messages Setting* - If enabled all messages will be received from devices with same PAN ID and RF Channel and will inhibit device from transmitting. This feature is only to be used for diagnostic purposes (Feature Currently Not Available)
- Set or Query RF Channel* - channels 11 (2405MHz) – 26 (2480MHz) may be used
- Set or Query Transmitter Power Level* - Ranges from 0 – 31 (31 is max level). Refer to Table 4-1 for information on power setting versus conducted output power level.
- Set RF Module Power Mode for Sleep, Idle, or Wakeup.
- Set/Get All Programmable Settings (PAN ID, Txcvr Long Address, Txcvr Short Address, RF Channel, Receive All Setting (Feature Not Available), RF Acks/Retries, RF Power Level).

* To permanently save select the “Save Config to NV Memory” command button.

RF Power Level Setting	Module Output Power Without PA	Module Output Power With 10mW PA	Module Output Power With 100mW PA
0-6	-25dBm	-14.5dBm	1.5dBm
7-16	-15dBm	-5dBm	11dBm
17-21	-10dBm	0dBm	15dBm
22-24	-7dBm	3dBm	17dBm
25-26	-5dBm	5.5dBm	18dBm
27-28	-3dBm	7.5dBm	18.5dBm
29-30	-1dBm	9dBm	19dBm
31	0dBm	10dBm	20dBm

Table 4-1. RF Power Level

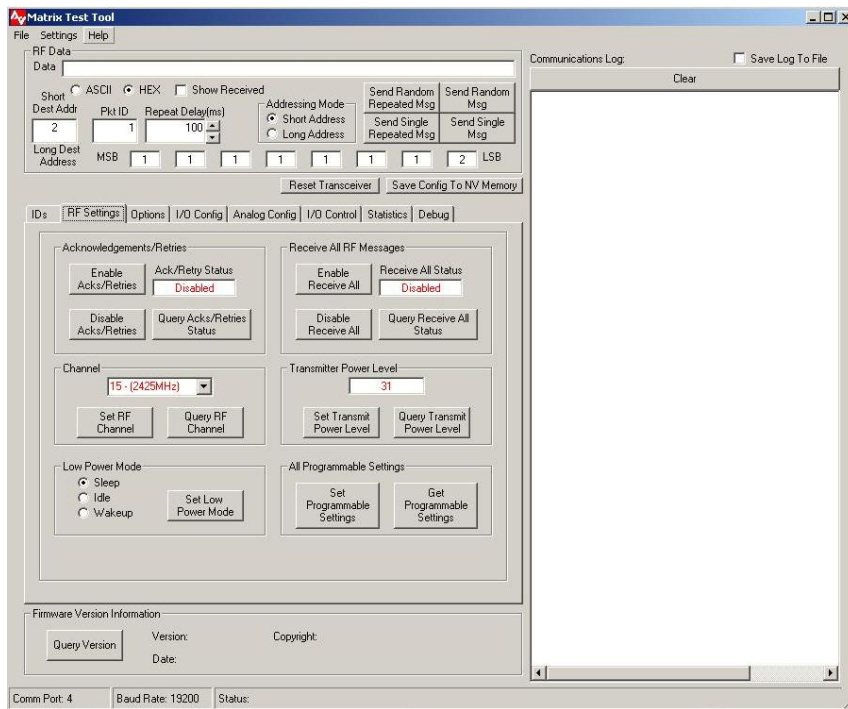


Figure 4-3. RF Settings

4.2.6 Options (See Figure 4-4)

The Options page can be accessed by selecting the *Options* tab in the software, and is shown in Figure 4-4. The following features are provided in the Options page.

Host Serial Baudrate

- Allows the user to change the serial baudrate to be either 1.2k, 2.4k, 4.8k, 9.6k, 19.2k, 38.4k, 57.6k, or 115.2k.
- After clicking on “Set Interface Parameters” the module will send back a host acknowledgement, save the new baudrate setting to non-volatile memory, and perform a software reset.
- After changing the host serial baudrate it will be necessary to change the baudrate that the test tool uses to communicate with the module as described in Section 4-2.
- Set Interface Parameters – Sets Host Serial Baudrate.
- Get Interface Parameters – Gets Host Serial Baudrate.

Radio Features and Options

- PA Mode – Enables or disable the external 10mW or 100mW power amplifier (depending on version of the module). Select 1mW to disable the external power amplifier and 10mW/100mW to enable the external power amplifier.
- Set Radio Features and Options* – Sets the PA Mode.
- Get Radio Features and Options – Gets the PA Mode.

* To permanently save select the “Save Config to NV Memory” command button.

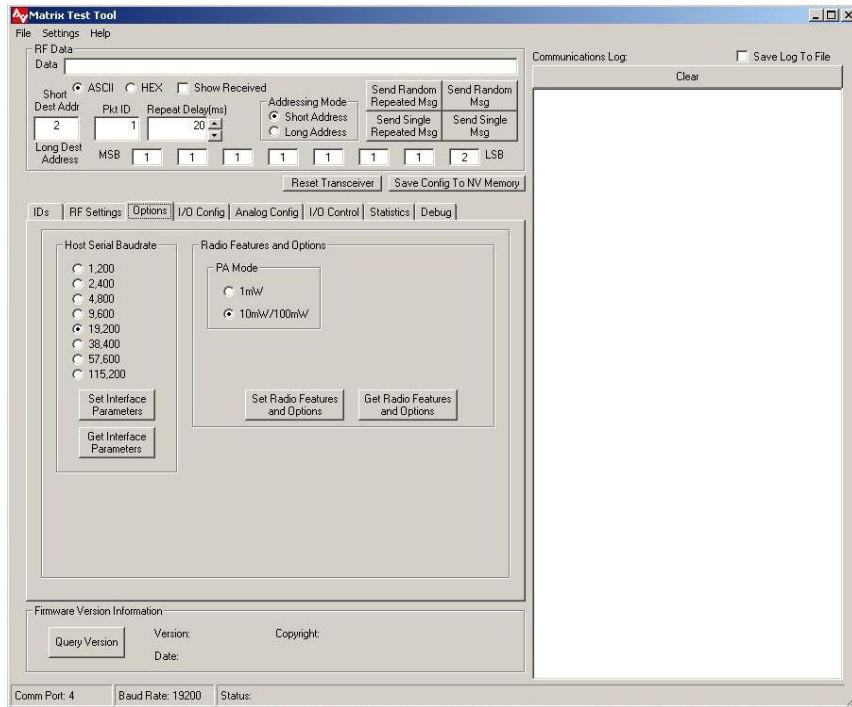


Figure 4-4. Options

4.2.7 I/O Configuration (See Figure 4-5)

The I/O Configuration page can be accessed by clicking the *I/O Config* tab in the software, and is shown in Figure 4-5. The I/O Configuration page can be used to configure select I/O pins for digital or analog operation. Refer to Table 4-2 for information on the I/O pin capabilities.

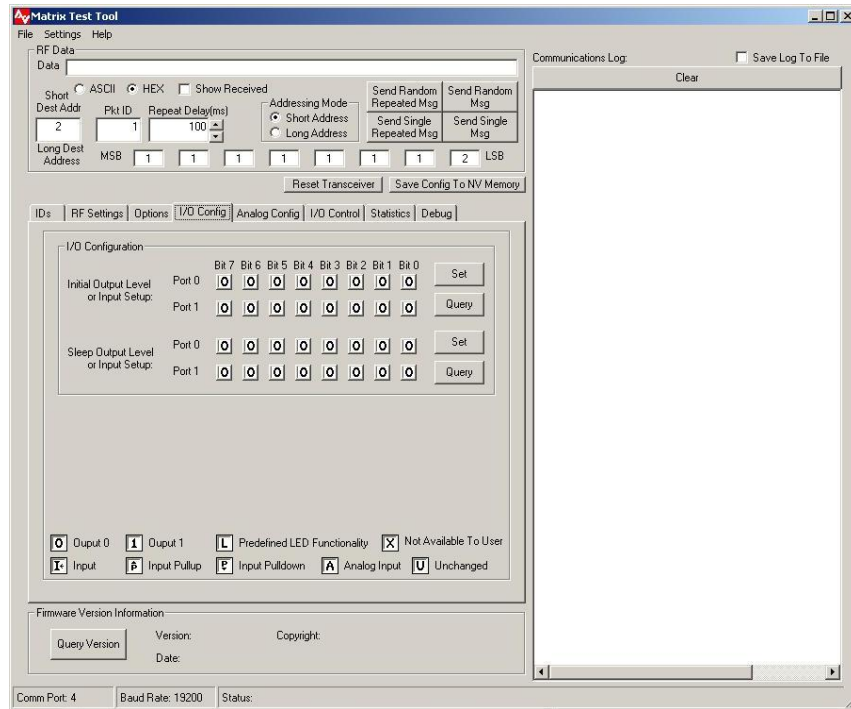


Figure 4-5. Digital I/O Configuration

I/O Configuration

- Initial Output Level or Input Setup – Gives user the ability to set selective port pins for Output (0 or 1 Initial Value), Predefined LED Functionality (L), Analog Input (A), or Input with or without internal pull-up or pull-down resistor enabled.
- Sleep Output Level or Input Setup - Gives user the ability to configure I/O pin states as desired for sleep operation. If Unchanged (U) is selected then the particular pin(s) retain their state when sleep operation is selected.

Pin	Available To User	Analog Input	LED Function	Output	Input	Pull-up Pull-down	Notes
P0_0	X	X	X	X	X	X	If LED functionality is enabled on this pin, then the functionality is automatically disabled from pin P0_2 and P0_3.
P0_1	X	X	X	X	X	X	If LED functionality is enabled on this pin, then the functionality is automatically disabled from pin P0_2 and P0_3.
P0_2	X	X	X	X	X	X	If LED functionality is enabled on this pin, then the functionality is automatically disabled from pin P0_0 and P0_1.
P0_3	X	X	X	X	X	X	If LED functionality is enabled on this pin, then the functionality is automatically disabled from pin P0_0 and P0_1.
P0_4	X	X		X	X	X	
P0_5	X	X		X	X	X	
P0_6	X	X		X	X	X	
P0_7	X	X		X	X	X	
P1_0	X			X	X		
P1_1	X			X	X		
P1_2				X	X	X	Used internally to enable/disable external power amplifier (output).
P1_3				X	X	X	Host interface Clear-To-Send (CTS) serial handshake signal (output).
P1_4				X	X	X	Host interface serial receive data signal (input).
P1_5				X	X	X	Host interface serial transmit data signal (output).
P1_6	X			X	X	X	
P1_7	X			X	X	X	

Table 4-2. I/O Pin Capabilities

4.2.8 Analog Configuration (See Figure 4-6)

The Analog Configuration page can be accessed by clicking the *Analog Config* tab in the software, and is shown in Figure 4-6. The Analog Configuration page can be used to configure the pins set as analog inputs (Refer to Section 4.2.7) for their analog-to-digital converter settings.

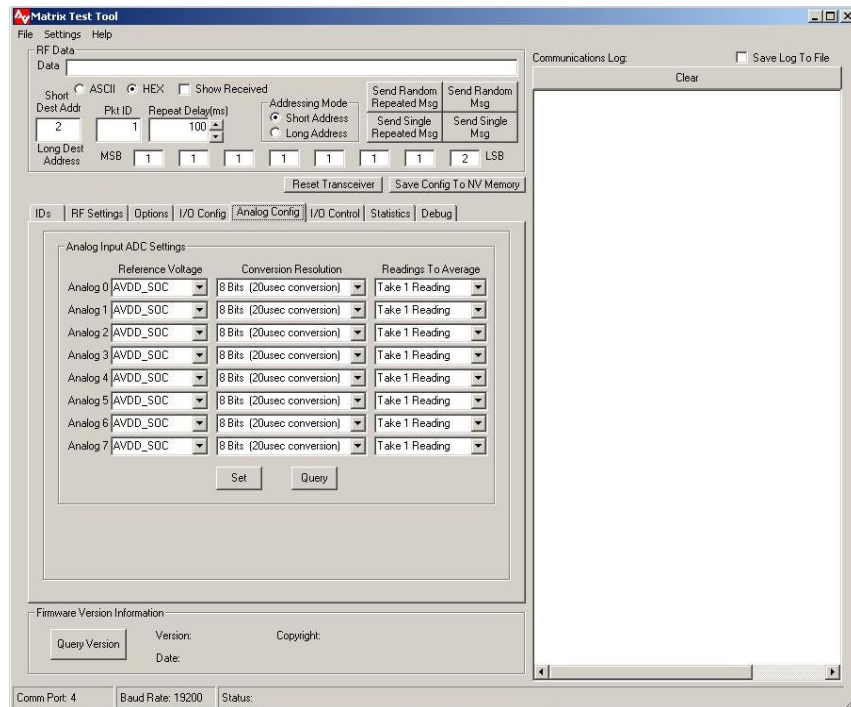


Figure 4-6. Analog Input Configuration

Analog Input ADC Settings

- Reference Voltage – Gives user the ability to select the voltage reference that will be used for the conversion. Options consist of the AVDD_SOC supply voltage, the internal 1.25v reference, a voltage applied to analog input pin 7 (P0_7), or the differential voltage applied between analog input pins 6 and 7 (P0_6 and P0_7).
- Conversion Resolution - Gives user the ability to select the resolution of the conversion. Options consist of 8, 10, 12 or 14 bits of resolution, and the conversion takes longer as the resolution of the conversion increases.
- Readings To Average – Gives user the ability to select the number of ADC converter readings to average before returning a result. Options consist of 1, 2, or 4 readings to average.

4.2.9 I/O Control (See Figure 4-7)

The I/O Control page can be accessed by clicking the *I/O Control* tab in the software, and is shown in Figure 4-7. The I/O Control page can be used to read analog and digital inputs and set digital outputs.

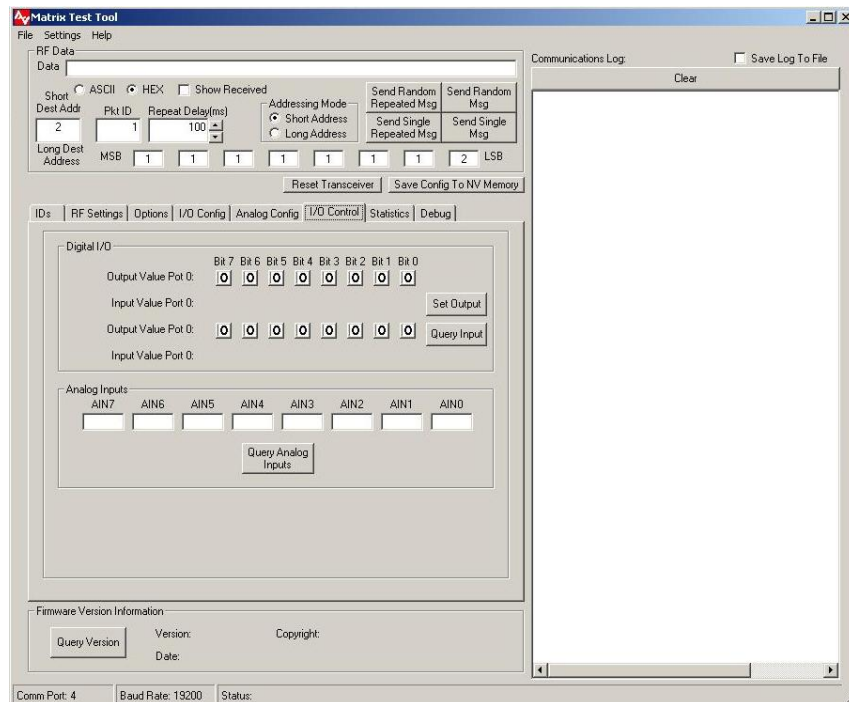


Figure 4-7. I/O Control

Digital I/O

- Set Output – Sets pins configured as digital outputs to the selected level (0 or 1).
- Query Input – Gets the input level (0 or 1) for pins configured as digital inputs.

Analog Inputs

- Readings – Displays analog input values read by the microcontroller for pins configured as analog inputs. The analog readings are taken using the settings in the Analog Config tab (Section 4.2.8).

4.2.10 Statistics (See Figure 4-8)

The Statistics page can be accessed by clicking the *Statistics* tab in the software, and is shown in Figure 4-8. The Statistics page can be used to evaluate the wireless link for packet error rates and throughput.

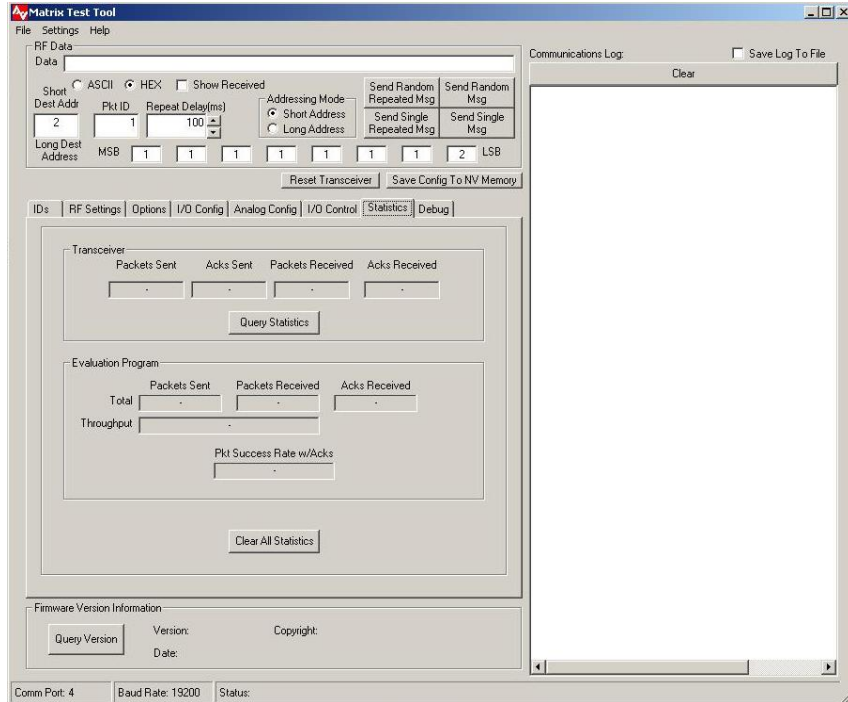


Figure 4-8. Statistics Screen

“Transceiver” Statistics

- Packets Sent - Number of packets transmitted.
- Acknowledgements (Acks) Sent – Number of acknowledgements sent by receiver.
- Packets Received – Number of packets received.
- Acks Received – Number of acknowledgements received by the transmitter.

“Evaluation Program” Statistics

The window toward the bottom the page labeled “Evaluation Program” contains information about the integrity of the link between the host computer and the radio board.

4.2.11 Debug Settings (See Figure 4-9)

The Debug Settings page can be accessed by clicking the *Debug* tab in the software, and is shown in Figure 4-9. The Debug page can be used to enable debug signals and internal LED functionality.

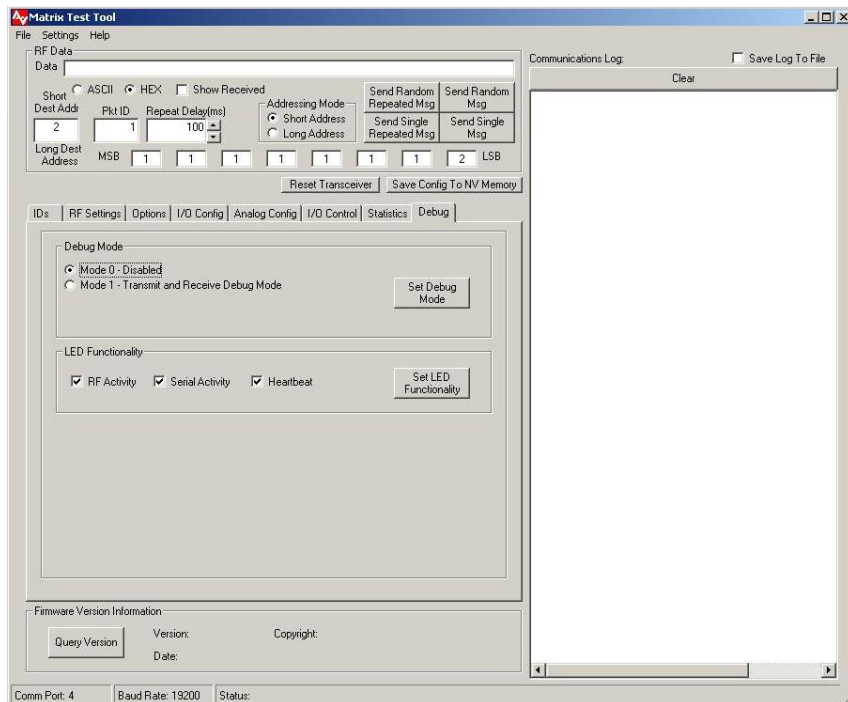


Figure 4-9. Debug Settings Screen

Debug Mode

- Mode 0 – No debug pulses on pins.
- Mode 1 – Refer to Host Protocol Document for Information.

LED Functionality (Refer to Host Protocol Document for Information)

- Depending on the I/O Configuration for the pins that can have LED outputs enabled (refer to Section 4.2.7), and whether or not the specific LED functionality is enabled, the LEDs will momentarily flash when serial activity, RF activity, or heartbeat activity occurs.
- Refer to Table 4.3 below for information on which output pin, and corresponding LED if populated on the module or interface board, will pulse based on the activity.
- RF Activity – LED flashes when transmitting or receiving a RF message.
- Serial Activity – LED flashes when communicating through the serial port. Received RF messages will flash the transmit LED if the message is transmitted out the host serial port.
- Heartbeat – LED flashes every two seconds to visually verify to user that device is operating.

Pins Configured For LED Functionality	RF Rx	RF Tx	Serial Rx	Serial Tx	Heartbeat
Onboard LEDs P0_0 - Green P0_1 - Red	Red (P0_1)	Green (P0_0)	Red (P0_1)	Green (P0_0)	Green (P0_0)
Interface Board LEDs P0_2 - Red P0_3 - Yellow	Red (P0_2)	Yellow (P0_3)	Red (P0_2)	Yellow (P0_3)	Yellow (P0_3)

Table 4-3. LED Functionality

4.3 Setting Up and testing a Wireless Link

Operational testing of the Matrix RF module requires at least 2 units in order to establish a link. One unit will be the initiator and the other will be the responder. In order for a link to be established it is necessary to setup the transceiver's RF Channel, long or short address, and PAN ID.

Link testing may be performed in either a single ended or a round trip fashion. This can help to differentiate between real world packet error performance and raw radio performance. If Acknowledgement settings are not used then it is a single-ended test, if Acknowledgements are enabled then it is a round trip test.

4.3.1 Single-ended Test

Single ended performance will require 2 computers, since it will be necessary to read the statistics from each radio. An example setup is outlined below.

Device 1 (Refer to Figures 4-10 and 4-12)

1. Set PAN ID to 100 (IDs Page).
2. Set Short Address to 1 (IDs Page). Note to use long addressing set short address to 65,535.
3. Disable Acknowledgements/Retries (RF Settings Page).
4. Disable Receive All RF Messages (RF Settings Page).
5. Set to RF Channel 23 (RF Settings Page).
6. Set transmitter power setting to 31 (RF Settings Page).
7. Set Short Destination address to 2 (Located Upper left corner of TT).
8. Select Short Address Radio Button (Upper Section of TT).
*Long may be selected if sending to a long address device.
9. Select "Save Config To NV Memory" Command Button (Upper Section of TT).
10. Check the Show Received box (Upper Section of Test Tool).

Device 2 (Refer to Figures 4-11 and 4-12)

1. Set PAN ID to 100 (IDs Page).
2. Set short address to 2 (IDs Page). Note to use long addressing set short address to 65,535.
3. Disable Acknowledgements/Retries (RF Settings Page).
4. Disable Receive All RF Messages (RF Settings Page).
5. Set to RF Channel 23 (RF Settings Page).
6. Set transmitter power setting to 31 (RF Settings Page).
7. Set Short Destination address to 1 (Located Upper left corner of TT).
8. Select Short Address Radio Button (Upper Section of TT).
*Long may be selected if sending to a long address device.
9. Select "Save Config To NV Memory" Command Button (Upper section of TT).
10. Check the Show Received box (Upper Section of Test Tool).

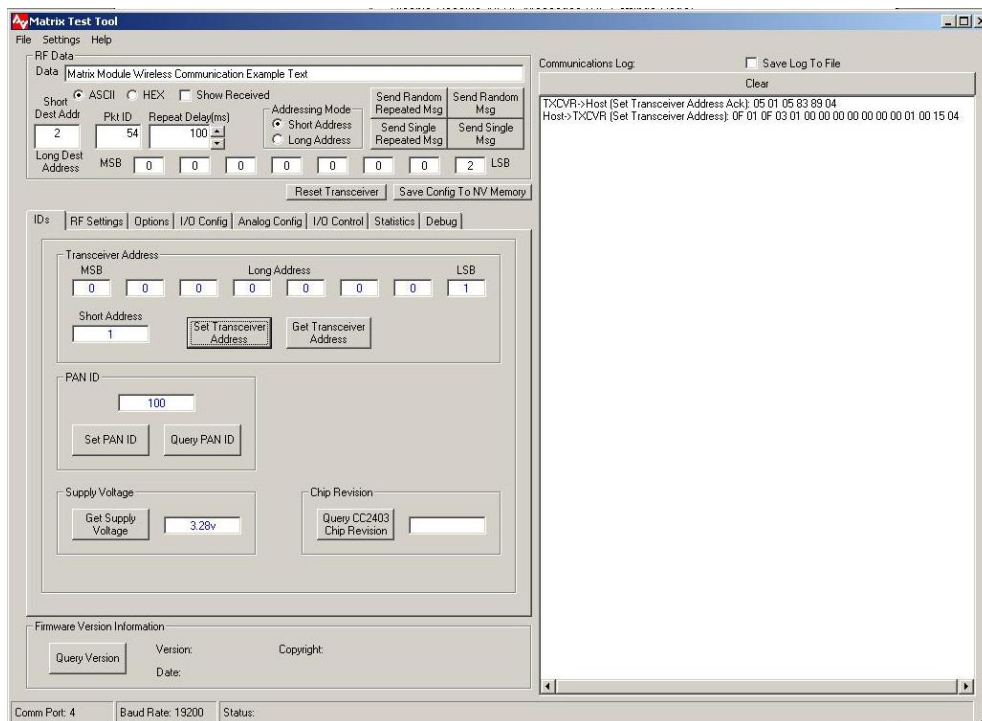


Figure 4-10. ID Settings for Device 1

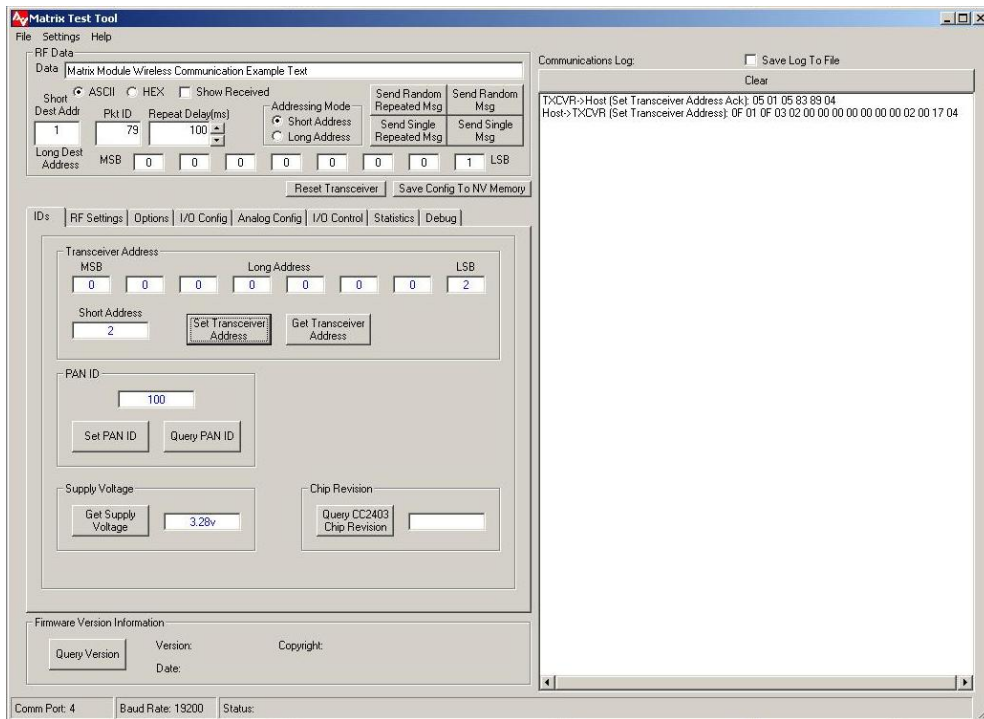


Figure 4-11. ID Settings for Device 2.

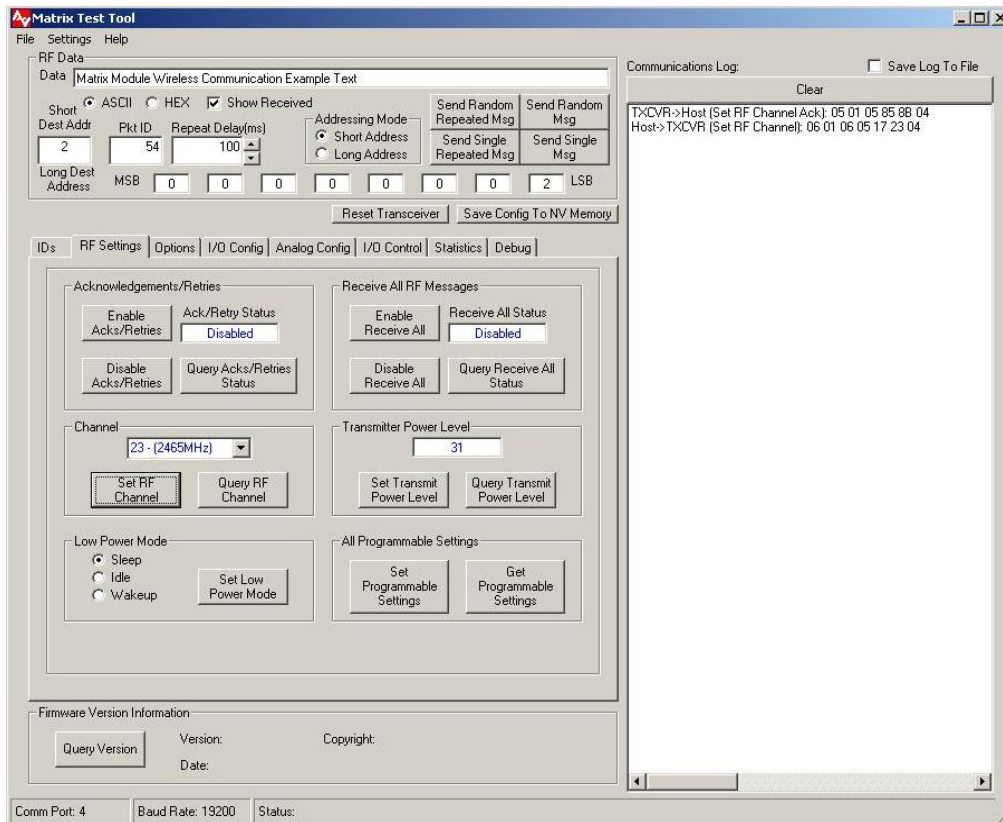


Figure 4-12. RF Settings for Initiating and Receiving Device

Operational Description

Place the 2 units in physically separate locations and apply power to them. The statistics will clear when power is cycled, but they will need to be cleared manually after each test if power is not cycled.

Connect each individual PC serial port to each of the units and verify the correct destination address is typed in the address field on the top of the test tool. Type a short message into the “*RF Data*” window of the initiating device. The message can be any text or numbers. If no message is entered it will not be possible to transmit.

Set the “Repeat Delay” to 100 msec if it isn’t already set. Click the “Send Single *Repeated Msg*” button to start transmission. The radio will send messages repeatedly with 100mSec in between messages until the “*Stop Repeat*” button is clicked.

Allow the test to run for some convenient amount of time and then stop transmission. Go to the “*Statistics*” screen of the initiating device and select the “Query Statistics” command button and record the packets sent in the Transceiver section of the test tool. Next select “Query Statistics” on the receive device and record packets received in the Transceiver section of the Statistics page. Link success is simply the ratio of the “Packets Received” to the “Packets Sent”.

This test will give the raw performance of the link in one direction without retries. It is a good indicator of the RF environment in which the radios are being used. High levels of noise or other products operating in the 2.4 GHz band can cause lower packet success rates.

4.3.2 Round Trip Test

To test the ability of the system to retry messages in a noisy environment, it is necessary to use a round trip test where the remote end can acknowledge receipt of packets. Use the setup screen as shown in Figure 4-10 thru 4-12 for each respective device, but **enable** acknowledgements on both devices (Refer to RF Settings Page).

Perform the test in the same manner as the single ended test. Run enough transmissions to get a statistically valid sampling of the radio environment over a reasonable period of time.

Look at the “*Statistics*” screen on the initiating radio to find the total number of packets sent. Link quality is displayed in the Pkt Success Rate w/Acks text box. Total link success is the ratio of “*Acks Received*” to “*Packets Sent*”.

CHAPTER 5

Matrix/Zigbee Ready Module Input/Output

5.1 Overview

There are a total of 12 user input/output pins on the Matrix module, all of which can be configured as digital inputs or outputs. Of the 12 configurable digital I/O pins, 8 of them can also be configured as analog inputs.

5.2 Digital Inputs/Outputs

There are 12 configurable digital input/output pins that can be programmed to be either inputs or outputs. In addition, if the pins are inputs, all except for two (P1_0 and P1_1) of them can be enabled for either an internal pull-up or pull-down resistor. Refer to Table 4-2 for the specific I/O pin capabilities.

Using the digital input output pins consists of the following:

Configuring the pins

Select direction (digital input or digital output), enable or disable pull-up or pull-down resistors for pins configured as digital inputs, and set the initial output value for pins configured as digital outputs (0 or 1). These parameters define the configuration of the pins when a reset occurs. Also the direction and pull-up/pull-down parameters are used to set the state of the pins after exiting sleep mode. Note that if the internal pull-up or pull-down resistors are used that all pins within the same port have to either be pull-ups or pull-downs.

Configuring the sleep state of the pins

Select direction (input or output), enable or disable pull-up or pull-down resistors for pins configured as digital inputs, and set the output value for pins configured as digital outputs. Although these parameters are the same as those shown in the “Configuring the pins” item shown above, they are independent and are the state of the pins when the Matrix module is put into Sleep Mode.

Reading the state of the pins configured as inputs

Read the digital value (0 or 1) of the signal applied to the pins configured as inputs.

Setting the state of the pins configured as outputs

Set the digital value (0 or 1) for the pins configured as outputs.

5.3 Analog Inputs

There are 8 pins that can be configured as analog inputs. Refer to Table 4-2 for the specific I/O pin capabilities.

Using the analog input pins consists of the following:

Configuring the pins

Select direction as analog input. Select the analog-to-digital converter settings for each specific pin configured as an analog input (refer to Section 4.2.7).

Configuring the sleep state of the pins

Select direction (input or output), enable or disable pull-up or pull-down resistors for pins configured as digital inputs, and set the output value for pins configured as digital outputs. Note that pins configured as analog inputs under normal operating mode can be set as anything when the Matrix module is put into Sleep Mode.

Reading the state of the pins configured as analog inputs

Read the analog digital value (0 or 1) of the signal applied to the pins configured as inputs.

Matrix Application Guide

6.1 Overview

This Chapter describes the essentials for using the host protocol to configure and use a Matrix module in an application. Please refer to Host Protocol Document for Further Details on messaging.

6.1.1 Host Protocol

The host protocol that is used to communicate with a Matrix module is a simple binary based protocol. Every message in the protocol consists of a header, a trailer, and potentially some payload information, which is consistent with other LSR module data packet structures. With the Matrix module it is possible to configure the baudrate from 1.2k up to 115.2, and as such it uses a DMA peripheral in conjunction with the UART so that reliable data transfers are possible at the higher data rate. In order to simplify operation of the DMA peripheral when used with the UART, all messages sent to and received from the Matrix module should additionally have the “Length” byte repeated as the first byte in a packet (prior to the header).

The header is made up of a start byte (0x01), a length byte that is the length of the entire message including header and trailer, and a message type that identifies the intention of the message.

The payload varies from message to message but in general includes things such as data to be sent or received, or configuration information.

The trailer is made up of a checksum, which is the sum of all of the bytes in the message, starting at the start byte (0x01) and up through the payload, and an end byte (0x04). Note that the checksum computation does not include the additional “Length” byte that precedes the start byte.

Every message that the host device sends to the Matrix module has a complimentary acknowledgement message that will get sent back upon successful decoding and processing by the Matrix module.

6.1.2 Configuration

After power-up or after receiving a “Reset Request” (type 0x18) message, the Matrix module will read the configurable parameters from the on-board microcontroller’s non-volatile FLASH memory, and store them in RAM to be used from that point on. Changing a parameter by sending the module a new message does not automatically result in the module saving the parameter to non-volatile memory, but rather just changes the value stored in RAM. This allows a particular host application to change the configurable parameters dynamically without unnecessarily writing to, and shortening the lifetime of, the non-volatile memory. All of the Matrix module’s configurable parameters that are stored in RAM can be saved to non-volatile memory by sending a “Save Configuration Values to Non-Volatile Memory” (type 0x11) message.

Communication Parameters

There are six configuration parameters used to setup the Matrix module for communications, which are outline below.

1. Set PAN ID – The Personal Area Network (PAN) ID is used to establish networks of transceivers. Only devices with the same PAN ID will communicate with one another.
2. Set Transceiver Address – The Transceiver Address is used to differentiate transceivers within a network. Each transceiver should be configured with a different address. The Transceiver Address consists of both a short two byte and a long eight byte address. Setting the short address to 65,534 (0xFFFE) will cause the Matrix module to use its long address. To use the short address, the short address should be set to between 0-65,533.
3. Set RF Channel – The RF channel is used to select the channel in the 2.4GHz band that the transceiver will operate on. Communication between transceivers is only possible if the devices are both using the same RF channel. Valid RF channels are from 11 (2405MHz) to 26 (2480MHz).
4. Enable/Disable Receive All RF Messages (Feature Currently Not Available) – Enabling receive all RF messages allows all messages on the configured PAN ID to be received by the Matrix module. This intended use of receive all messages is for diagnostics tools so that it is possible to see all messages on a network. Note that when this mode is enabled that it is not possible to transmit RF messages.
5. Enable/Disable RF Acknowledgements and Retries – When RF Acknowledgements and Retries are enabled, the destination transceiver will respond to the received RF message with an RF acknowledgement. If the source transceiver does not receive an RF acknowledgement, it will attempt to re-send the message to the destination transceiver up to 3 more times (3 retries). By using acknowledgments and retries, the likelihood of successfully getting a message from one transceiver to another increases.
6. Set Transmit Power Level – This setting allows for adjusting the transmit power, which affects the overall range. The range varies from 0 to 31.

Input/Output Parameters

There are three configuration messages used to setup parameters for controlling the user input and output pins, which are outlined below.

1. Set I/O Configuration – This message is used to configure the direction (input or output), whether or not the internal pull-up or pull-down resistors are enabled for pins configured as inputs, and the initial output value for pins configured as outputs. The initial output value is the default state that output pins will be assigned after power-up or a “Reset Request” command is issued to the module.

2. Set I/O Sleep State – This message defines the state that the I/O pins will be put into when the low power sleep mode of operation is requested for the module. Similar to the “Set I/O Configuration” message, the direction of the pin, whether or not the pull-up or pull-down resistors are enabled for input pins, and the output value for output pins can be configured. Upon exiting sleep mode the pins will be configured back to the state they were in prior to entering sleep mode.
3. Set Analog Input ADC Settings – This message is used to set up how the ADC conversion will be done for pins configured as analog inputs. The settings include the reference voltage that the conversion is based on, the resolution of the ADC conversion, and the number of samples to average when a reading is taken. Note that the higher the ADC conversion resolution the longer it takes to do a conversion.

Diagnostics and Feedback Parameters

There are two configuration parameters used to setup diagnostics and user LED feedback which are outlined below.

1. **Set Debug Mode** – Setting the debug mode allows the host application to configure what debug information gets displayed on the three mode pins when the mode pins are in their default state. The default state for the mode pins is that none of the pins are externally pulled-down. The intent of the debug signals is to allow for monitoring on an oscilloscope how the device is operating.
2. **Set LED Functionality** – This message is used to configure if any LED feedback information is enabled or not, and if it is enabled what it represents. For modules that are embedded in an enclosure, the LED functionality can altogether be disabled to further reduce power consumption. Several examples of the types of functionality that can be displayed on the LEDs are a heartbeat LED flash to indicate the microcontroller is running or flashes when an RF or serial message is either transmitted or received. Multiple functions can be enabled simultaneously. The LED functionality can be enabled on pins P0_0 and P0_1 or on P0_2 and P0_3, or it can be disabled altogether and then the pins can be used as user I/O. If LED functionality is enabled for use on P0_0 and P0_1, either LEDs can be populated on the Matrix modules itself, or off board LEDs can be utilized. When LED functionality is enabled for use on P0_2 and P0_2, then it is required that off board LEDs be used.

Example configuration

The following example will show details of what host protocol messages a host device would send to a Matrix module to configure all of its programmable settings. After all of the settings have been sent to the transceiver, save configuration parameters message is issued to save the settings to non-volatile memory.

Settings

PAN ID:	100
Transceiver Address:	Long Address = 500 (short address needs to be 65,535)
RF Channel:	18
Receive All:	Disabled
Acknowledgements and Retries:	Enabled
Transmit Power Level:	31 (maximum)
I/O Pin Configuration:	All inputs with pull-up resistors enabled
I/O Pin Sleep State:	All inputs with pull-up resistors enabled (unchanged)
Debug Mode:	Disabled
LED Functionality:	Heartbeat and flash on RF activity, LED activity on pins P0_0 and P0_1

Host Messages

1. Set PAN ID
< 0x07 0x01 0x07 0x01 0x64 0x00 0x6D 0x04 >
2. Set Transceiver Address
< 0x0F 0x01 0x0F 0x03 0xF4 0x01 0x00 0x00 0x00 0x00 0x00 0x00
0xFF 0xFF 0x06 0x04 >
3. Set RF Channel
< 0x06 0x01 0x06 0x05 0x12 0x1E 0x04 >
4. Disable Receive All RF Messages
< 0x06 0x01 0x06 0x07 0x00 0x0E 0x04 >
5. Enable Acknowledgements and Retries
< 0x06 0x01 0x06 0x09 0x01 0x11 0x04 >
6. Set Transmit Power Level
< 0x06 0x01 0x06 0x0F 0x1F 0x35 0x04 >
7. Set I/O Pin Configuration
< 0x0F 0x01 0x0F 0x01E 0x00 0xFC 0x00 0x00 0x00 0x03 0x00
0xFC 0x00 0x00 0x29 0x04 >
8. Set I/O Pin Sleep State
< 0x10 0x01 0x10 0x23 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x34 0x04 >
9. Disable Debug Mode
< 0x06 0x01 0x06 0x27 0x00 0x2E 0x04 >
10. Enable Heartbeat and Flash On RF Activity LED Functionality
< 0x06 0x01 0x06 0x28 0x05 0x34 0x04 >
11. Save Configuration Parameters To Non-Volatile Memory
< 0x05 0x01 0x05 0x11 0x17 0x04 >

For all of the messages shown above that would get sent from the host application to the Matrix module, a host level acknowledgement will be sent back when it has been successfully processed. It is recommended that the host application send a message to the module and then wait for an acknowledgement response prior to sending the next message. This will take care of flow control and prevent the host application from overflowing the module.

6.1.3 RF Messaging

Overview

The Matrix module provides a versatile command set for communications between modules. Depending on the application's requirements, either short or long address modes can be used. Short addressing mode uses a two byte transceiver address, while long addressing mode uses eight byte transceiver addresses. It is also possible to communicate between transceivers using mixed addressing modes, hence a message can be sent from a transceiver with a short address to another transceiver with a long address or vice versa.

There is a single host message that is used to send data from one transceiver to another and two host messages that are generated when a message is received. When in receive all (Feature Not Available) mode of operation and a message is received by a transceiver, host message type 0xA9 is generated and sent out the serial port to the host. In the default mode of operation (receive all mode disabled) host message type 0x95 is generated and sent out the serial port to the host.

RF host messages consist of a standard header (start, length and type), RF message header, payload, and a standard trailer (checksum and stop). The RF message header contains a Packet ID, a Target/Sender identifier, an Address Mode byte, and the Transceiver Addresses. The Packet ID is used to identify each message and should be incremented for each new packet when sending a message. The Target/Sender byte indicates where the message originated from and is being sent to. Messages either are originated from or sent to either the host or the application. The application is the user application code that is running on the Matrix module (currently not supported). The host is the host application. The Address Mode byte describes the type of addressing for the particular message. The upper nibble indicates the addressing mode used for the destination of the message, while the lower nibble indicates the mode for the source of the message. A 0 is used to represent a short address, while a 1 represents a long address. Following the Addressing Mode is the destination address and then the source address (for received messages only – types 0x95 and 0xA9).

Short Addressing

In order to use short addressing it is required that the transceiver address be set between 0 and 65,533 (0xFFFFD). Setting the short address to 65,534 (0xFFFFE) causes the transceiver module to use the eight byte long address.

Long Addressing

Long addressing mode is configured by setting the short address to 65,534 and then selecting a long address in the range of 0 to 18,446,744,073,709,551,614 (0xFFFFFFFFFFFFFFFE).

Broadcasts

It is possible to broadcast a message to all transceivers configured to the same RF channel and PAN ID. Messages are broadcast by sending the message to the short destination transceiver address 65,535 (0xFFFF).

Receive All (Feature Currently Not Available)

Receive all mode is used as a diagnostic mode in which a transceiver can listen to and receive all of the messages from any device that is communicating on the same PAN ID and RF channel. Messages with long and short addressing types will be received, and when a message is received it is sent out the host serial port with a message type of 0xA9. In receive all mode it is not possible to transmit messages to other transceivers.

Addressing Modes Summary

The Table 6-1 below gives an overview of the addressing modes that are available in the Matrix module. The table shows a summary of what happens when messages are sent between two modules (Transceiver A and Transceiver B) using the various addressing modes (short and long), and also broadcasts.

The first column “Host Send Mode” lists what type of message the host would send to the Matrix module into transceiver A. The “Addressing Mode” columns show what type of address (short or long) each transceiver is configured to use. Upon transceiver A receiving the message from the host device, transceiver A would then send a message over the RF link to transceiver B using the type of address shown in the first column. If transceiver B successfully receives the RF message from transceiver A, then a host message is generated that will be sent from transceiver B to the host connected to transceiver B. The messages that get generated will have the source and destination addresses contained in it which are shown in the table under the “Host Receive Mode” columns. A dash (-) denotes that a message was not received by the transceiver because the destination address for transceiver B was not the same type (short or long) as the destination address type to which the message was sent (shown in the first column). It is assumed that the destination address to whom the message is being sent is the same as that address for which the receiving transceiver is configured to use.

Host Send Mode (Host -> Txcvr A)	Addressing Mode (Txcvr A -> Txcvr B)		Host Receive Mode (Txcvr B -> Host)		Broadcast
	Txcvr A	Txcvr B	Source	Destination	
Short	Short	Short	Short	Short	Ok
Short	Short	Long	- (Note 1)	- (Note 1)	Ok
Short	Long	Short	Long	Short	Ok
Short	Long	Long	- (Note 1)	- (Note 1)	Ok
Long	Short	Short	- (Note 2)	- (Note 2)	-
Long	Short	Long	Short	Long	-
Long	Long	Short	- (Note 2)	- (Note 2)	-
Long	Long	Long	Long	Long	-

Table 6-1. Addressing Overview

Note 1: Since a transceiver is setup with both a long and a short address, if long addressing is being used (short address = 65,534) and a message is being sent to the transceiver with a short address of 65,534, a RF acknowledgement will be sent by the MAC.

Note 2: Since a transceiver is setup with both a long and a short address, if short addressing is being used (short address not equal to 65,534) and a message is being sent to the transceiver with a long address that matches the transceiver's long address, a RF acknowledgement will be sent by the MAC.

6.1.4 Example Messaging

For all of the following examples it is assumed that the PAN ID and RF channel are set to be the same on both Matrix modules. Also the messages will originate in the host connected to transceiver A and they will be sent to transceiver B. The data contained in the message will be 0x01, 0x02, 0x03. All received messages have a Link Quality Indication (LQI) of 200 (0xC8).

Short To Short Addressing

The following example will show details of communications between two Matrix modules both configured to use short addressing.

Settings

Transceiver A Address: Short Address = 1
Long Address = Don't care

Transceiver B Address: Short Address = 2
Long Address = Don't care

Packet ID: 10
Target/Sender: Host

Host -> Transceiver A – (Send n RF Data Bytes To Destination Transceiver ID)
< 0x0D 0x01 0x0D 0x14 0x0A 0x11 0x00 0x02 0x00 0x01 0x02 0x03 0x45 0x04 >

Assuming that Transceiver B receives the message from Transceiver A, then it would send a host message out of its serial port.

Transceiver B -> Host – (Received n RF Data Bytes From Transceiver ID)
< 0x10 0x01 0x10 0x95 0x0A 0x11 0xC8 0x00 0x02 0x00 0x01 0x00 0x01 0x02 0x03 0x92 0x04 >

Short To Long Addressing

The following example will show details of communications between two Matrix modules with transceiver A configured to use short addressing and transceiver B configured to use long addressing.

Settings

Transceiver A Address: Short Address = 1
Long Address = Don't care

Transceiver B Address: Short Address = 65,534 (use long address)
Long Address = 2 (0x0000000000000002)

Packet ID: 10

Target/Sender: Host

Host -> Transceiver A – (Send n RF Data Bytes To Destination Transceiver ID)
< 0x13 0x01 0x13 0x14 0x0A 0x11 0x10 0x02 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x01 0x02 0x03 0x5B 0x04 >

Assuming that Transceiver B receives the message from Transceiver A, then it would send a host message out of its serial port.

Transceiver B -> Host – (Received n RF Data Bytes From Transceiver ID)
< 0x16 0x01 0x16 0x95 0x0A 0x11 0xC8 0x10 0x02 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x01 0x00 0x01 0x02 0x03 0xA8 0x04>

Long To Short Addressing

The following example will show details of communications between two Matrix modules with transceiver A configured to use long addressing and transceiver B configured to use short addressing.

Settings

Transceiver A Address: Short Address = 65,534 (use long address)
Long Address = 1 (0x0000000000000001)

Transceiver B Address: Short Address = 2
Long Address = Don't care

Packet ID: 10

Target/Sender: Host

Host -> Transceiver A – (Send n RF Data Bytes To Destination Transceiver ID)
< 0x0D 0x01 0x0D 0x14 0x0A 0x11 0x00 0x02 0x00 0x01 0x02 0x03 0x45 0x04 >

Assuming that Transceiver B receives the message from Transceiver A, then it would send a host message out of its serial port.

Transceiver B -> Host – (Received n RF Data Bytes From Transceiver ID)
< 0x16 0x01 0x16 0x95 0x0A 0x11 0xC8 0x01 0x02 0x00 0x01 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x01 0x02 0x03 0x99 0x04>

configured as digital inputs contain any meaningful information. A zero indicates a low signal is applied to the input, while a one indicates a high signal is applied.

Example:

Digital Inputs = P0_6, P0_5, P1_7, and P1_1.
Digital Input P0_6 = 0
Digital Input P0_5 = 1
Digital Input P1_7 = 0
Digital Input P1_1 = 1

Host -> Matrix Module – (Query Digital Pin Input State – Type 0x21)
< 0x05 0x01 0x05 0x21 0x27 0x04 >

Matrix Module -> Host – (Respond With Digital Pin Input State – Type 0xA1)
< 0x07 0x01 0x07 0xA1 0x40 0x02 0xEB 0x04 >

3. Query Analog Pin Values – This message is used to read the values of the analog input signals. The result is returned in a host message that gets sent back from the Matrix module containing a two byte value (LSB to MSB), for each of the eight potential analog inputs, with the 8, 10, 12, or 14 (depending on ADC conversion resolution) least significant bits representing the voltage applied to the inputs. Prior to reading the analog inputs the ADC conversion settings need to be set as described in Section 4.2.7. Note that the most significant bit of the conversion result is the sign bit.

Example:

ADC Settings: 1.25v Reference
10 Bit Resolution
Average 1 Reading

Analog Input P0_7 = 0.42v (10 bit value => 172 = 0x00AC)
Analog Input P0_6 = 1.07v (10 bit value => 438 = 0x01B6)

Host -> Matrix Module – (Query Analog Pin Values – Type 0x22)
< 0x05 0x01 0x05 0x22 0x28 0x04 >

Matrix Module -> Host – (Respond With Analog Pin Values – Type 0xA2)
< 0x15 0x01 0x15 0xA2 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0xB6 0x01 0xAC 0x00 0x1B 0x04 >

Appendix A

Range Test Results

*A.1.1 Matrix with Inverted F (Trace) Antenna Open Field Range Results TBD**

** TBD*

Appendix B

Agency Statements

Compliance Statement (Part 15.19)

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Warning (Part 15.21)

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement (Part 15.105 (b))

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

RF Exposure (OET Bulletin 65)

To comply with FCC RF exposure requirements for mobile transmitting devices, this transmitter should only be used or installed at locations where there is at least 20cm separation distance between the antenna and all persons.

To comply with FCC's RF exposure limits for general population/uncontrolled exposure, the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

OEM Responsibility to the FCC Rules and Regulations

The **Matrix 10mW** Module has been certified per FCC Part 15 rules for integration into products without further testing or certification. To fulfill the FCC certification requirements the OEM of the **Matrix 10mW** Module must ensure that the information provided on the **Matrix 10mW Module** label is placed on the outside of the final product.

The **Matrix 10mW** Module is labeled with its own FCC ID Number. If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following:

“Contains Transmitter Module FCC ID: TFB-MATRIXL”

or

“Contains FCC ID: TFB-MATRIXL”

The OEM of the **Matrix 10mW** Module must only use the approved antenna, which has been certified with this module.

The OEM of the **Matrix 10mW** Module must test their final product configuration to comply with Unintentional Radiator Limits before declaring FCC compliance per Part 15 of the FCC rules.

Industry Canada Statement per Section 4.0 of RSP-100

The term "IC:" before the certification / registration number only signifies that the Industry Canada technical specifications were met.

Section 7.1.5 of RSS-GEN

Operation is subject to the following two conditions:

- 1) this device may not cause harmful interference, and
- 2) this device must accept any interference received, including interference that may cause undesired operation.

Section 7.1.4 of RSS-GEN

This device has been designed to operate with an antenna having a maximum gain of **3.8** dB. Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is **50** ohms."

Section 7.1.5 of RSS-GEN

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication.

Section 2.6 of RSS-102

This portable transmitter with its antenna complies with Industry Canada RF Exposure Limits for General Population/Uncontrolled Exposure.