Operating Manual

MHX 2420
2.4GHz Spread Spectrum OEM Module
Development Board
High Voltage (HV) Option
Firmware Version 3.1092A
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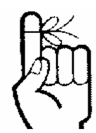
Important User Information (continued)

About This Manual

It is assumed that users of the products described herein have either system integration or design experience, as well as an understanding of the fundamentals of radio communications.

Throughout this manual you will encounter not only illustrations (that further elaborate on the accompanying text), but also several symbols which you should be attentive to:

Caution or **Warning**
Usually advises against some action which could result in undesired or detrimental consequences.



Point to Remember
Highlights a key feature, point, or step which is noteworthy. Keeping these in mind will simply or enhance device usage.

Tip
An idea or suggestion to improve efficiency or enhance usefulness.

Important User Information (continued)

MHX 2420 Regulatory Requirements

PLEASE READ THIS SECTION CAREFULLY

WARNING:

To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 23 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

WARNING:

Changes or modifications not expressly approved by Microhard Systems Inc. could void the user's authority to operate the equipment. This device has been tested with MCX and Reverse Polarity SMA connectors with the antennas listed in Appendix A When integrated in OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the tables must be tested to comply with FCC Section 15.203 (unique antenna connectors) and Section 15.247 (emissions).

WARNING:

MAXIMUM EIRP

FCC Regulations allow up to 36 dBm equivalent isotropically radiated power (EIRP). Therefore, the sum of the transmitted power (in dBm), the cabling loss and the antenna gain cannot exceed 36 dBm.

This is not FCC approved. It is for demonstration purposes only, not for sale. This equipment is subject to FCC rules and the equipment will comply with the appropriate rules before delivery to the buyer.

Revision History

Revision 2.0	June 01, 2007

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6.0 Configuration (continued)

Table of Contents (continued)

1.0 Overview

The MHX 2420 OEM module is capable of delivering high-performance wireless serial communications in a variety of network topologies.

When properly configured and installed, long range communications at very high speeds can be achieved.

MHX 2420 modules operate within the 2.4000-2.4835GHz ISM frequency band, using frequency hopping spread spectrum (FHSS) technology. They provide reliable wireless asynchronous data transfer between most equipment types which employ an RS232, RS422, or RS485 interface.

The small size and superior performance of the MHX 2420 makes it ideal for many applications. Some typical uses for this modem:

- SCADA
- remote telemetry
- traffic control
- industrial controls
- remote monitoring
- fleet management
- GPS
- wireless video
- robotics
- display signs
- railway signaling

1.1 Performance Features

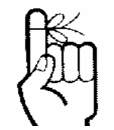
Key performance features of the MHX 2420 include:

- transmission within a public, license-exempt band of the radio spectrum[1] - this means that the modems may be used without access fees or recurring charges (such as those incurred by cellular airtime)
- transparent, low latency link providing up to 230kbps continuous throughput
- communicates with virtually all PLCs, RTUs, and serial devices through either an RS232, RS422, or RS485 interface
- industrial temperature specifications
- supports point-to-point, point-to-multipoint, TDMA, peer-to-peer, store and forward repeater, ad hoc
- maximum allowable transmit power (1 Watt)

[1] 2.4000-2.4835GHz, which is license-free within North America; may need to be factory-configured differently for some countries: contact Microhard Systems Inc.

1.0 Overview

- low power consumption in Sleep Mode (real-time clock wakeup)
- 32 bits of CRC, selectable retransmission and forward error correction
- separate diagnostics port - transparent remote diagnostics and online network control
- ease of installation and use - the MHX 2420 utilizes a subset of standard AT-style commands, similar to those used by traditional telephone line modems
- 3.3V or 5V logic level compatibility
- Footprint backwards compatible with MHX 2400



The MHX 2400 is not forward compatible with the MHX 2420.

While the typical application of MHX 2420 module is to provide short– to mid-range wireless communications between DTEs, they can be adapted to almost any situation where an asynchronous serial interface is used and data intercommunications is required.

Hardware options for the MHX 2420 module include the Development Board (a very convenient and robust interface assembly which will enable prompt evaluation and testing of the module) and the High Voltage (HV) Option. This manual includes information regarding both of these options.

1.0 Overview

1.2 MHX 2420 Specifications

Refer to the Specifications Sheet supplied to you for your particular model.

1.0 Overview

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2.0 QUICK START

This QUICK START guide will enable you to promptly establish basic connectivity between a pair of MHX 2420 modems in a point-to-point (ref. 5.1) configuration.

2.1 Required Materials

- 2 MHX 2420 modules
- 2 Development Boards, each with Power Adapter and Rubber Ducky Antenna
- 2 PCs with HyperTerminal (or equivalent) and 1 COM port each, or
  1 PC with HyperTerminal and 2 COM ports
- 2 straight-through serial cables (9-pin M to 9-pin F)

2.2 Set-Up Procedure

- Install MHX 2420 modules into Development Boards
- Connect straight-through cable from each Development Board (rear 'RS-232' port) to COM port of PC (see section 3.2.1.2).
- Open a HyperTerminal session for each Development Board connection, and configure it as 9600, 8 data bits, no parity, 1 stop bit, and no handshaking - then open the 'connection' (at bottom left of HyperTerminal window, the word 'Connected' should appear).
- Plug power adapter (8-30VDC) into wall outlet and, while depressing the CFG button on the Development Board, attach the 'green' connector of the wall adapter cable to the rear of the Development Board; repeat with other Development Board (see section 3.2.1).
- When the above step is performed, the HyperTerminal window should show the response 'NO CARRIER OK'.

continued...

2.0 Quick Start

...continued

- At this point, both MHX 2420 modules are in COMMAND MODE. For one module (to be the MASTER), type AT&F6 [Enter], then type AT&WA [Enter]. This module's Development Board TX LED (red) should now be illuminated. For the other module (to be the SLAVE), type AT&F7 [Enter], then type AT&WA [Enter]. This module's Development Board RX and 3 RSSI LED's should illuminate.

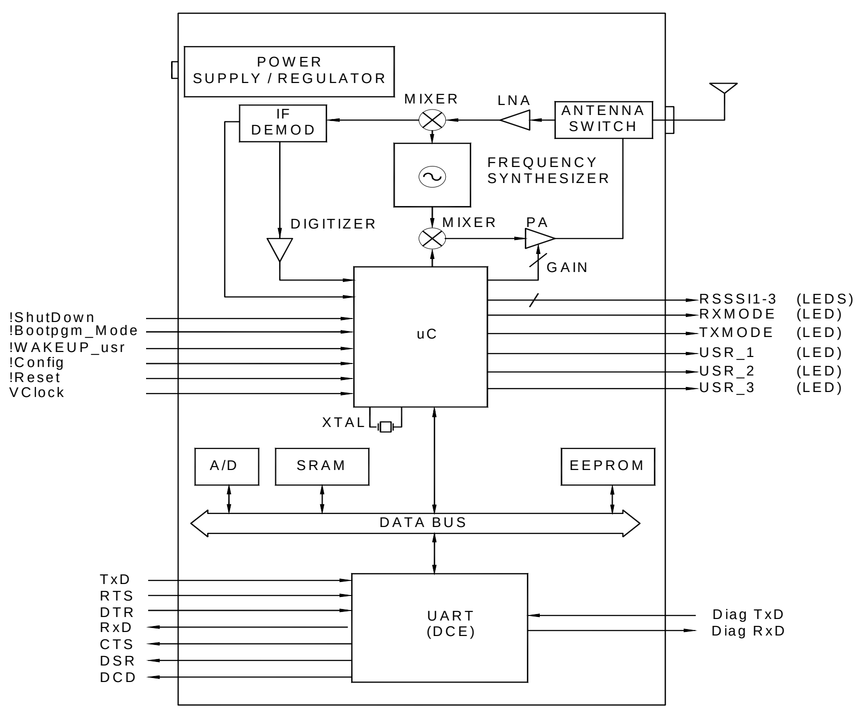
- We now have 'radio' connectivity. If text is entered in one PC's HyperTerminal window, it should appear in the other's; and vice versa.

3.0 Hardware Features

The MHX 2420 module is typically complemented by interface circuitry (e.g. power, data interface) for most applications.

Any MHX 2420 module may be configured as a Master, Repeater (or Repeater/Slave), or Slave.

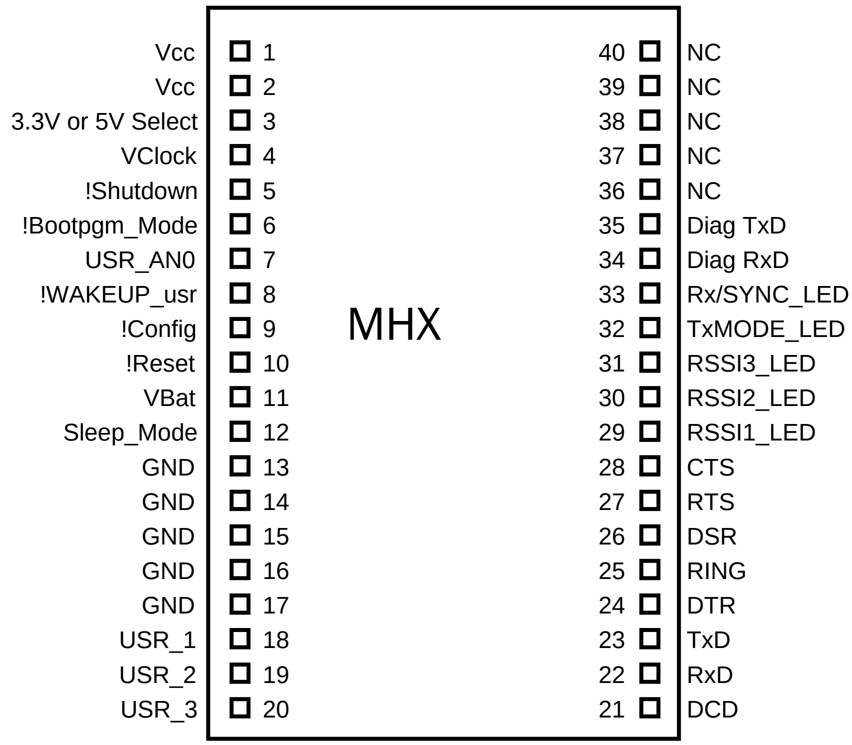
This versatility is very convenient from a 'sparing' perspective, as well for convenience in becoming very familiar and proficient with using the module: if you are familiar with one unit, you will be familiar with all units.



Drawing 1: MHX 2420 Functional Block Diagram

3.0 Hardware Features

3.1 MHX 2420 Pin-Out Description



Drawing 2: MHX 2420 Pin-out

Pins 36, 37, 38, 39, and 40 are reserved for factory use. Do not use these pins for any other purpose.

Inputs and outputs are TTL level unless otherwise specified.

The above drawing depicts a top view of the MHX 2420 module. The corner pins (1, 20, 21, and 40) are printed directly upon it for convenient reference.

Not shown in the drawing above is the MCX (F) RF connector. It is located near the 'Pin 20' corner of the module.

A full description of the various pin connections and functions is provided on the pages that follow.

3.0 Hardware Features

Pin Name	No.	Description	In/ Out
Vcc	1, 2	Positive voltage supply input for the module.	I
3.3V or 5.5V Select	3	Output voltage level selector. When connected to 3.3VDC, the module will output 3.3V on its output pins; when connected to 5VDC, 5VDC will be presented as TTL high on the module's output pins.	I
VClock	4	Real time clock to wake-up the module from sleep mode. Internally pulled-up, this pin may be left floating.	I
!Shutdown	5	Active low input signal applied to this pin will manually shutdown the module. Pull high or leave unterminated if not being used.	I
!Bootpgm_Mode	6	Active low input signal to download firmware into the module. Pull high or leave unterminated if not being used.	I
USR_AN0	7	Analog input. *Reserved for future use.*	I
!Wakeup_usr	8	Active low input signal to wake-up the module from sleep mode. Internally pulled-up, this pin may be left floating.	I
!Config	9	Active low input signal to put the module into default serial interface (RS-232) and default baud rate (9600,8/N/1, no flow control) during power-up. Pull high or leave unterminated if not being used.	I
!Reset	10	Active low input will reset module.	I
Vbat	11	Battery voltage sensing analog input line, up to 60VDC. A 10k-ohm resistor is required inline from the power source. Reading will be 0 if connected to GND (ground).	I
Sleep_Mode	12	Sleep mode indication output. Active high.	O

Table 1: MHX 2420 Pin-Out Description

3.0 Hardware Features

Pin Name	No.	Description	In/ Out
GND	13-17	Ground reference for logic, radio, and I/O pins.	
USR_1	18	System status indicator.	O
USR_2	19	Not used. Leave disconnected.	O
USR_3	20	*Reserved for future use.*	O
DCD	21	Data Carrier Detect. Active low output.	O
RxD	22	Receive Data. Logic level output.	O
TxD	23	Transmit Data. Logic level input.	I
DTR	24	Data Terminal Ready. Active low input.	I
RING	25	Ring indicator for RS-232. Active low output. This signal/pin could be used to drive Receive Enable on RS-485 driver.	O
DSR	26	Data Set Ready. Active low output. Could be used to drive Transmitter Enable on RS-485 driver.	O
RTS	27	Request To Send. Active low input.	I
CTS	28	Clear To Send. Active low output.	O
RSSI1_LED	29	Receive Signal Strength Indicator 1. Active high, can drive LED directly. Refer to Section 3.2.2 for additional information about LED operation.	O
RSSI2_LED	30	Receive Signal Strength Indicator 2. Active high, can drive LED directly. Refer to Section 3.2.2 for additional information about LED operation.	O
RSSI3_LED	31	Receive Signal Strength Indicator 3. Active high, can drive LED directly. Refer to Section 3.2.2 for additional information about LED operation.	O

Table 1: MHX 2420 Pin-Out Description (continued)

3.0 Hardware Features

Pin Name	No.	Description	In/ Out
TXMODE_LED	32	Active high output indicates module is transmitting data over the RF channel. Can drive LED directly. Refer to Section 3.2.2 for additional information about LED operation.	O
RX/SYNC LED	33	Active high output indicates receive and synchronization status. Can drive LED directly. Refer to Section 3.2.2 for additional information about LED operation.	O
Diag RxD	34	Diagnostics receive data. Logic level input.	I
Diag TxD	35	Diagnostics transmit data. Logic level output.	O
N/C	36-40	Reserved for factory use only.	

Table 1: MHX 2420 Pin-Out Description (continued)

All input/output logic circuits employ CMOS technology and are therefore subject to CMOS threshold levels.

All inputs incorporate Schmitt triggers with hysteresis. Output pins 29, 30, and 31 are conventional logic level outputs.

All serial communications signals are logic level (0 and 3.3 or 5VDC). DO NOT connect RS-232 level (+12, -12VDC) signals to these lines without shifting the signals to logic levels.

RxD is the data received by the radio through the wireless link and output via the serial port; TxD data received into module from serial port and transmitted over the wireless link.

The MHX 2420 is designed to be footprint backwards compatible with the MHX 910 and MHX 910A. If the customer interface was designed appropriately, the MHX 2420 module may be installed in place of the MHX 910 or MHX 910A module.

3.0 Hardware Features

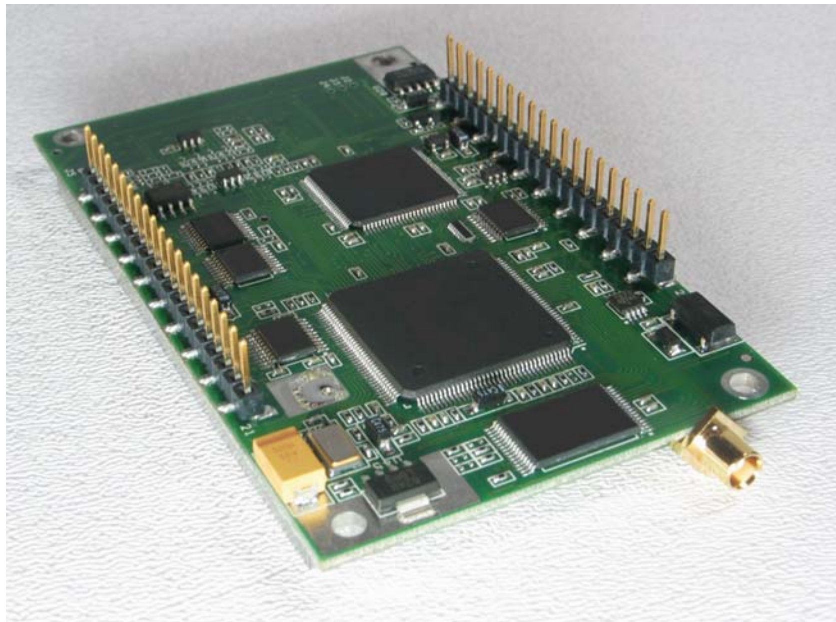


Image 1: View of MHX 2420

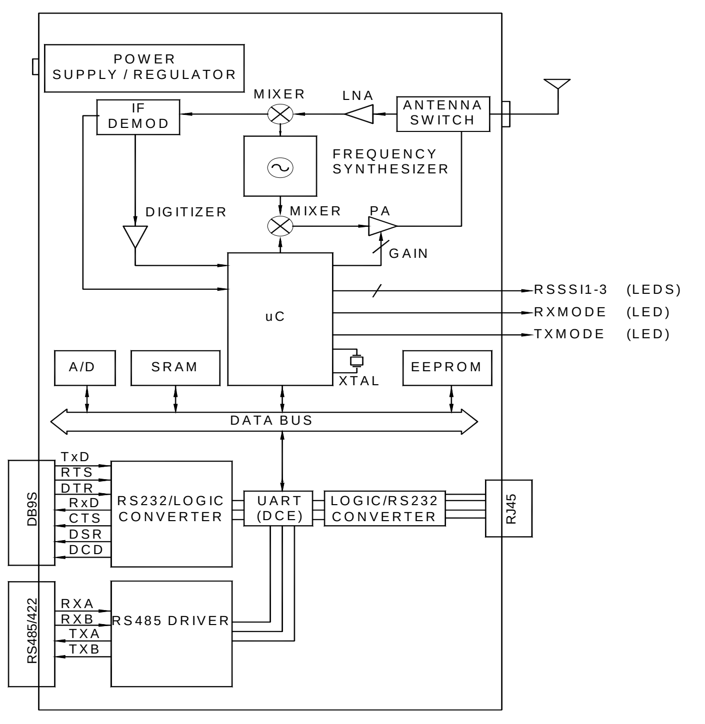
3.0 Hardware Features

3.2 Development Board

The Development Board provides a number of convenient interfaces for the MHX 2420 module:

- power
- data interfaces
- indicators
- antenna connection

It also serves as a robust platform for evaluating the performance of the MHX 2420 module.



Drawing 3: Functional Block Diagram: MHX 2420 Module in Development Board

Comparing the above drawing with Drawing 1, the interfaces added by the Development Board (described above) can be seen.

3.0 Hardware Features

3.2.1 Connections

3.2.1.1 Front

On the front of the Development Board is the SERIAL DIAGNOSTICS port. The connector is of type RJ45; signal levels are RS232. Note also the small CFG (configuration) pushbutton.

The SERIAL DIAG port is NOT an Ethernet port.

The SERIAL DIAG port does not support AT commands.

The **SERIAL DIAG** port is used for two purposes:

- online diagnostics and configuration at 115.2kbps (using MHS-supplied BLACK RJ45-DE9 cable (P/N MHS044000) and MHS software)
- firmware upgrade (using MHS-supplied BLUE RJ45-DE9 cable (P/N MHS044010))

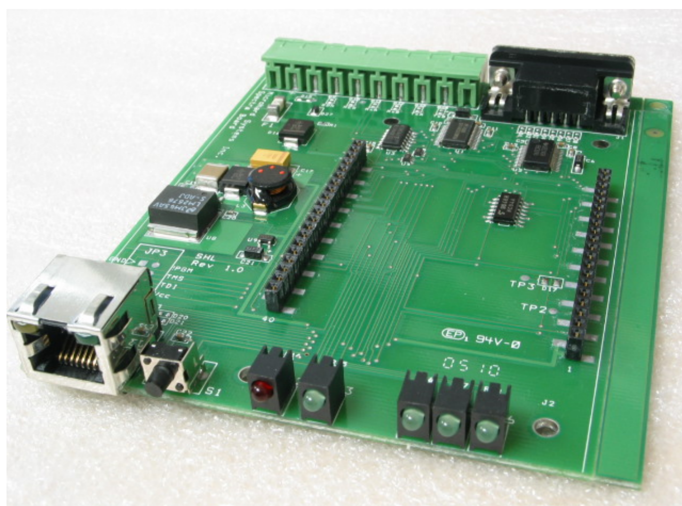
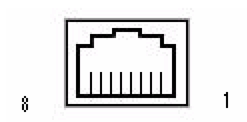


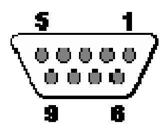
Image 2: Front View of MHX 2420 Development Board

CFG Button (S1)

Holding this button depressed while powering-up the modem will boot the unit into configuration mode: the default serial interface (rear DE9, RS232) will be active and set to operate at its default serial baud rate of 9600bps.

3.0 Hardware Features





RJ45 Pin No.	Name	MHS044000 DE9 Pin No.	MHS0044010 DE9 Pin No.
1			4
2	Diag RXD	2	
3	Diag TXD	3	
4			3
5	SG	5	5
6			2
7	RESET*		
8			7

* active high

Table 2: SERIAL DIAG Port Cable Pin-outs

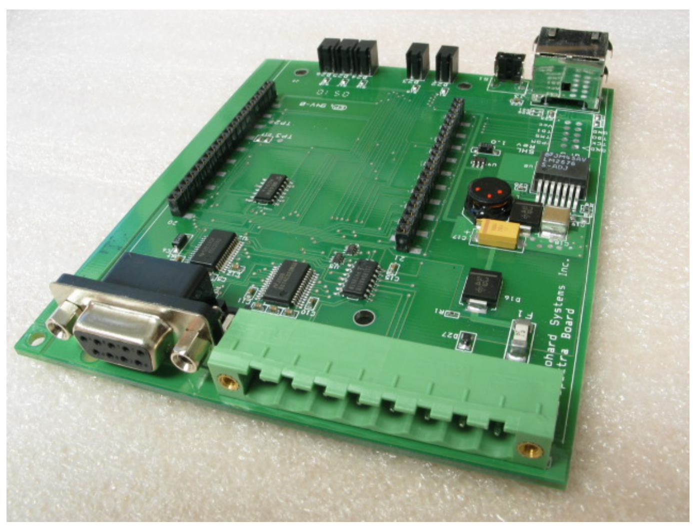


Image 3: Rear View of MHX 2420 Development Board

3.2.1.2 Rear

RS232 Port (DCE) on the rear of the circuit board is used for

- RS232 serial data (300-230,400bps) when in DATA MODE, or
- for configuring the modem when in COMMAND MODE.

RS422/485 Port used to interface the MHX 2420 Development Board to a DTE with the same interface type.

Either the RS232 or RS422/485 interface is used for data traffic.

3.0 Hardware Features

DE9S Pin No.	Name	Input or Output
1	DCD	O
2	RXD	O
3	TXD	I
4	DTR	I
5	SG	
6	DSR	O
7	RTS	I
8	CTS	O
9	Not Used	

Table 3: RS232 Pin Assignment

Caution: Using a power supply that does not provide proper voltage may damage the modem.

Green Conn. Pin No.	Name	Input or Output
1	TxB (D+)	O
2	TxA (D-)	O
3	RxB (R+)	I
4	RxA (R-)	I
5	Not Used	
6	SHDN	I
7	Vin -	
8	Vin +	I

Table 4: Phoenix-type Connector Pin Assignment

Grounding the SHDN pin shuts down the modem.

Antenna Connector

The MHX 2420 module uses an MCX connector for the RF signal. Contact Microhard Systems Inc. regarding available 'pigtail' and coaxial cabling options.

3.0 Hardware Features

3.2.2 Indicators

Referring to Section 3.1.1 Image 1 and Table 4, it can be seen that a number of indicators are available which conveniently show the status of the modem's RF and serial data communications.

- **System Status LED (Green)**

Location: top right of the front panel RJ45 jack.

This LED is illuminated when the system is powered-up and core status is okay. This is the only LED that is illuminated when the modem is in COMMAND MODE.

- **RX/SYNC LED (Green)**

When lit, this LED indicates that the modem is synchronized and has received valid packets.

- **TX LED (Red)**

When illuminated, this LED is indicating that the modem is transmitting data over the air.

- **Receive Signal Strength Indicator (RSSI) (3x Green)**

As the received signal strength increases, starting with the furthest left, the number of active RSSI LEDs increases.

Signal strength is calculated based on the last four valid received packets with correct CRC.

RSSI is also reported in S123.

3.0 Hardware Features

			LED STATUS	
MODE	**M/R/S**	**RX/SYNC**	**TX**	**RSSI 1,2,3**
COMMAND	All	OFF	OFF	OFF
DATA	Master	ON while receiving valid data packets from Slaves and Repeaters in the network	ON	1-3 ON in proportion to signal strength received from Slaves and Repeaters in the network
Fast Sync	Master	OFF	ON	Cycling with 300ms ON time
DATA - during sync. acquisition	Repeater	OFF	OFF	Cycling with 300ms ON time
DATA - when synchronized	Repeater	ON for first portion of hop interval	ON for second portion of hop interval	1-2 ON in proportion to signal strength received from Slaves; if Slaves silent for >2s, Repeater will indicate RSSI based on signal strength received from Master
DATA - during sync. acquisition	Slave	OFF	OFF	Cycling with 300ms ON time
DATA - when synchronized	Slave	ON	ON when transmitting a packet	1-3 ON in proportion to signal strength received from Repeater or Master with which Slave communicates

Table 5: LED Operation

3.0 Hardware Features

3.3 High Voltage (HV) Option

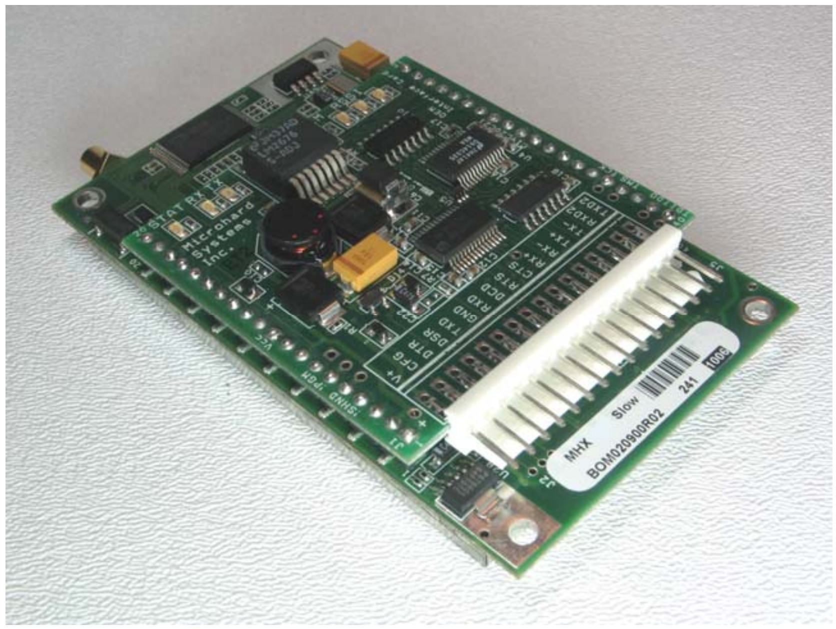


Image 4: MHX 2420 with HV Option

‘High Voltage’ is a relative term.

The HV Option’s input voltage range is +9 to +30VDC, and the module can output RS-232-level signals.

These voltages are ‘high’ relative to the TTL levels (input voltage and signal) at which the MHX 2420 module itself operates.

When a combination of small size and functionality are required, the MHX 2420 with HV Option is a very convenient solution.

This device incorporates the electrical interface circuitry to readily accommodate standard power and signal voltage levels.

The mechanical interface for the electrical signals is a 16-pin connector (see image above). A mating connector is supplied with each module.

Being ready to deploy, the MHX 2420 with HV Option minimizes the development cycle time associated with building-out from the MHX 2420 module alone.

3.0 Hardware Features

3.31 Pin-Outs

Pin Name	No.	Description	In/ Out
V+	1	Positive supply voltage.	I
!CONFIG	2	Force to Command Mode if grounded.	I
DTR	3	RS-232 Data Terminal Ready.	I
DSR	4	RS-232 Data Set Ready.	O
TXD	5	RS-232 Transmit Data.	O
GND	6	Power and signal ground.	
RXD	7	RS-232 Receive Data.	I
DCD	8	RS-232 Data Carrier Detect.	O
RTS	9	RS-232 Request to Send.	I
CTS	10	RS-232 Clear to Send.	O
TX+	11	RS-485 Non-inverting driver output.	O
TX-	12	RS-485 Inverting driver output.	0
RX-	13	RS-485 Inverting receiver input.	I
RX+	14	RS-485 Non-inverting receiver input.	I
TXD2	15	Diagnostic transmit data.	O
RXD2	16	Diagnostic receive data.	I

Table 6: MHX 2420 HV Option Pin-Out Description

3.0 Hardware Features

HV Card (DCE)			DTE (DE9)	
Pin No.	Name	< Direction >	Pin No.	Name
8	DCD	>	1	DCD
5	TXD	>	2	RXD
7	RXD	<	3	TXD
3	DTR	<	4	DTR
6	GND		5	GND
4	DSR	>	6	DSR
9	RTS	<	7	RTS
10	CTS	>	8	CTS

Table 7: RS-232 Interface

The above table provides information about the MHX 2420 HV Option's RS-232 serial interface.

Refer also to Appendix F for a more detailed explanation of the various signals.

See Appendix G for RS-485 (2– and 4-wire) wiring information.

4.0 Operating Modes

4.1 Command Mode

In this mode:

- the MHX 2420 module is offline (data is not passing through the unit via it's local data lines or RF communications)
- if installed in a Development Board, the only LED illuminated will be the small green LED at the top right of the front panel SERIAL DIAG (RJ45) port (this LED is connected to the MHX 2420 module's Pin 19: USR_1 System Status Indicator output.
- the MHX 920's configuration options (registers) may be viewed and modified

4.1.1 How to Enter Command Mode

Two methods are typically used to place the MHX 2420 - installed in a Development Board - into command mode:

1. Force to Command Mode

- power off the Development Board assembly
- connect a 9-pin straight-through serial cable from PC COM port to the Development Board's rear RS-232 port
- launch a terminal communications program (e.g. HyperTerminal) and configure for 9600bps, 8 data bits, No parity, 1 stop bit (8N1)
- press and hold the Development Board's CFG button (S1 on front of unit)
- continue to press the CFG button and apply power to the modem
- release the CFG button
- observe the front of the Development Board: only the small green LED should be illuminated, indicating that the MHX 2420 is in Command Mode.

2. Escape from Data Mode

- with MHX 2420 'online', connect a 9-pin straight-through serial cable from PC COM port to the Development Board's rear RS-232 port
- launch a terminal communications program (e.g. HyperTerminal) and configure for the MHX 2420's established serial baud rate parameters (PC & modem must match)
- pause 1 second, type '+++' (see Section 6.2, S1), pause 1 second: the monitor should show the module response of 'NO CARRIER OK'
- the MHX 2420 is now in Command Mode (observe Development Board's front panel: only the small green LED should be illuminated)

4.0 Operating Modes

4.2 Data Mode

The normal operational state of all deployed MHX 2420 modules. In this mode the module is prepared to exchange data as per its configuration settings. Available LED indications can provide an indication of the data exchange (TX and RX LEDs).

To enter DATA mode from COMMAND mode, enter the command: *ATA [Enter]*

The following three modes are the ‘radio network’ roles (see Section 6.2, S101):

4.3 Master

One per network, the source of synchronization for the system. The Master controls the flow of data through the system; all data passes to or through it.

4.4 Repeater

Required only if necessary to establish a radio path between a Master and Slave(s); stores and forwards the data sent to it. Synchronizes to Master and provides synchronization to ‘downstream’ units.

If a local device is attached to a Repeater’s serial data port, the Repeater will also behave as a Slave (aka Repeater/ Slave).

Adding one or more Repeaters within a network will HALVE the throughput; the throughput is halved only once, i.e. it does not decrease with the addition of more Repeaters.

If there is a ‘path’ requirement to provide Repeater functionality, but throughput is critical, this may be accomplished by placing two modems at the Repeater site in a ‘back-to-back’ configuration. One modem would be configured as a Slave in the ‘upstream’ network; the other a Master (or Slave) in the ‘downstream’ network. Local connection between the modems would be accomplished with a ‘null modem’ cable. Each modem would require its own antenna; careful consideration should be given with respect to antenna placement and modem configuration.

4.5 Slave

Endpoint/node within a network to which a local device is attached. Communicates with Master either directly or through one or more Repeaters. See Sections 5.3 and 5.4 for information regarding ‘Slave-to-Slave’ communications.

5.0 Network Topologies

The MHX 2420 may be configured to operate in a number of different operating modes and participate in various network topologies.

Note: This section describes network topologies and also contains details regarding related factory default settings to enable the reader to readily see the correlation between various registers. Refer to section 6 for further detailed information regarding configuration options and details.

- hastens the configuration process

l*oad default and, if necessary, apply only minor settings adjustments*

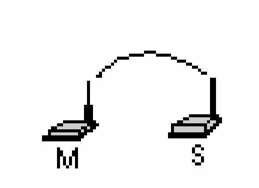
- aids in troubleshooting

if settings have been adjusted and basic communications cannot be established, simply revert to the applicable factory default setting and any improper adjustments will be overwritten and a 'fresh start' can be made - with known-to-work settings

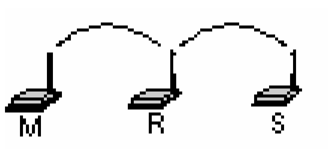
For convenience, a number of factory default configurations related both to operating modes and network topologies are available. Configuring modems using factory default settings has the following benefits:

Settings (S) register S133 configures the modem for the 'Network Type' within which it will be participating.

5.1 Point-to-Point (PTP)



In a point-to-point network, a path is created to transfer data between Point A and Point B, where Point A may be considered the Master modem and Point B a Slave. Such a PTP network may also involve one or more Repeaters (in a store-and-forward capacity) should the radio signal path dictate such a requirement.



A PTP configuration may also be used in a more dynamic sense: there may be many Slaves (and Repeaters) within such a network, however the Master may have its 'Destination Address' (S140) changed as and when required to communicate with a specific Slave.

PTP factory default settings:	**Master**	**&F6**
	Slave	**&F7**
slow mode (optional) :	Master	&F8
	Slave	&F9

5.0 Network Topologies

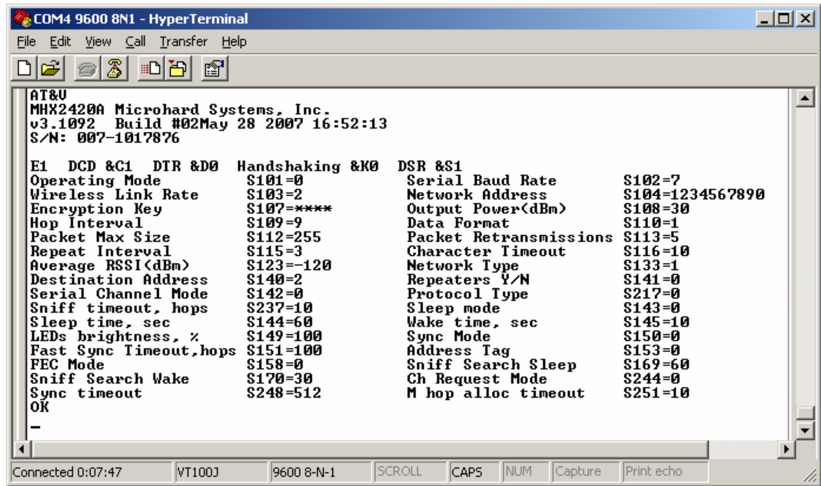


Image 5: &F6 PTP Master Configuration View

The screen captures on this page clearly show that most of the registers in both the Master and the Slave have the same values.

(S105 is not visible in the Master view: its value is, and must be, 1.)

The differences are S101 (Operating Mode), S105 (Unit Address), and S140 (Destination Address).

The nature of PTP is clear: The Master's destination (S140) is 2 (the Unit Address (S105) of the Slave); the Slave's destination is the Master.

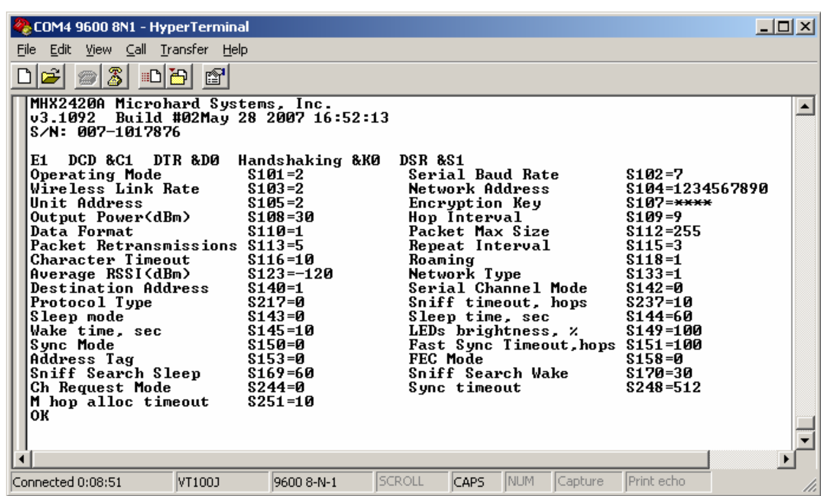
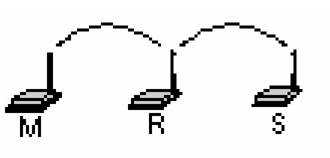


Image 6: &F7 PTP Slave Configuration View

5.0 Network Topologies



'Network Type' (S133) is set to 1 for PTP operation.

Note that the Master has a register 'S141 - Repeaters Y/N' and the Slave does not. This register informs the Master of there being one or more Repeaters in this network. The factory defaults assume 'no' and assign a value of 0. If a Repeater is to be installed, and all the Master and Slave defaults will be maintained, following is a procedure on how to configure a Repeater into this fixed (non-mobile) PTP network:

Master

- enter into Command Mode
- change S141 (Repeaters Y/N) to 1 (which means 'Yes')
- save the change using the AT&W command
- go online with the ATA command

Repeater

- enter into Command Mode
- load a third modem with &F7 (PTP Slave factory default settings)
- change the Operating Mode (S101) from 2 (Slave) to 1 (Repeater)
- change the Unit Address (UA) (S105) from 2 to 3
- save the changes using the AT&W command
- go online with the ATA command

Slave

- enter into Command Mode
- change S118 from 1 (the UA of the Master) to 3 (the UA of the Repeater)
- save the change using the AT&W command
- go online with the ATA command

This system may be tested by sending text at 9600bps, 8N1 through the RS-232 serial port of one modem and observing that it appears at the RS-232 serial port of the other modem. The Slave is synchronized to the Repeater, which in turn is synchronized to the Master. If the Repeater is taken offline, in a matter of moments the Slave's RSSI LEDs will indicate that it is 'scanning' for its immediate upstream unit; place the Repeater online and the Slave will quickly acquire it. If the Master is taken offline, both the Repeater and Slave will begin to scan.

5.0 Network Topologies

5.2 Point-to-Multipoint (PMP)

In a point-to-multipoint network, a path is created to transfer data between the Master modem and numerous remote modems. The remote modems may simply be Slaves with which the Master communicates directly, and/or Slaves which communicate via Repeaters. Some or all of the Repeaters may also act as Slaves in this type of Network, i.e. the Repeaters are not only storing and forwarding data, but are also acting as Slaves. Such Repeaters may be referred to as 'Repeater/Slaves'.

PMP factory default settings:	**Master**	**&F1**
	Slave	**&F2**
	Repeater	**&F3**
slow mode (optional) :	Master	&F4
	Slave	&F5

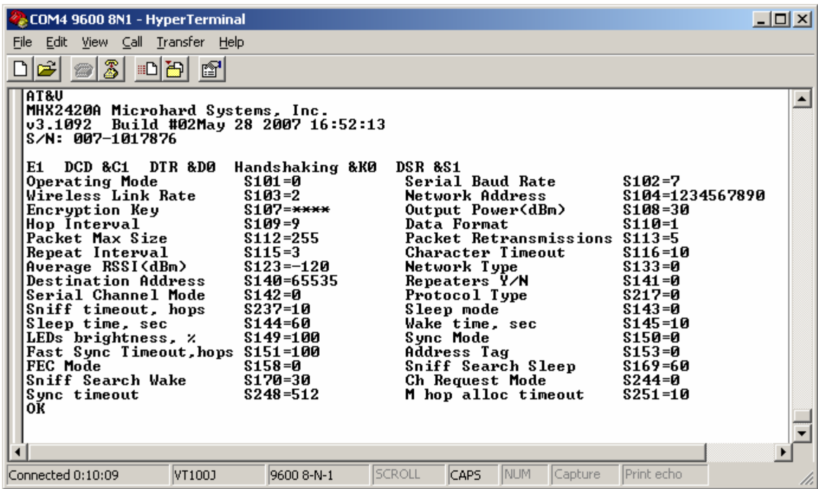


Image 7: &F1 PMP Master Configuration View

The factory default PMP Master configuration reveals the following differences with respect to the PTP factory default Master: S133=0 (PMP network) and S140=65535 (the broadcast address, indicating that this Master (*point*) will send its data to all modems - *multipoint*). On a **PMP Master**, **set S113=0** and increase only if required.

5.0 Network Topologies

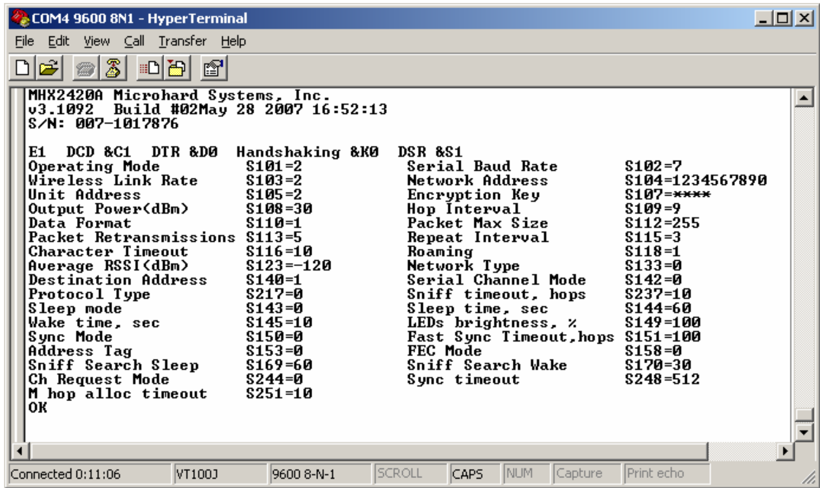
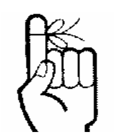


Image 8: &F2 PMP Slave Configuration View

Each modem in any network must have a unique Unit Address.



When bench testing PMP and using the factory default settings for the Master, Repeater, and Slave:

Master S141 must be changed from 0 to 1, and Slave S118 must be modified to be the UA of the Repeater (3), otherwise the Slave will synchronize directly to the Master, bypassing the Repeater.

Insofar as the factory defaults are concerned, the difference between the PMP Master and PMP Slave (above) are simply the Operating Mode (S101), Unit Address (S105), and the Destination Address (S140).

With the exception of the Master modem, all modems in a PMP network have a Destination Address of 1 - the UA of Master modem - to which all data is destined.

The settings for a factory default PMP Repeater are unique only with respect to S101 (1) and S105 (3).

5.0 Network Topologies

5.2.1 Point-to-Multipoint TDMA

Time Division Multiple Access (TDMA) is available as a special form of the PMP network topology.

In TDMA mode, the Master modem will sequence through the Remotes in the network allowing each one, in turn, to transmit its data. The maximum number of Remotes which can communicate with a Master in this configuration is sixteen (16).

To configure a TDMA network, the default settings described in 5.2 are applicable, with the exception that the following registers (ref. Section 6.2) on the Master must be modified as required:

- S244 Channel Request Mode
- S251 Master Hop Allocation Timeout

For TDMA, set S244=1.

The default for S251 is 10 (hop intervals). If the system is to be deployed in a 'clean' RF environment, this number should perhaps be reduced to 2 or 3 to provide enough time for the Slave to initiate its response but to not potentially waste a significant number of hop intervals waiting for an unresponsive Slave to send data.

In addition, the following AT commands (ref. Section 6.1) are applicable to TDMA mode:

- T? view entire (maximum 16 item) Registered Slaves List
- T*n*=*UA* enter a Slave's Unit Address (UA) into the Registered Slave's List item number *n*, where *n*=0-15, and *UA* = 0-65534 (selecting a UA value of 0 terminates the list)
- T*n*? view Registered Slaves List entry number *n*, where *n*=0-15. Response is UA of List entry number

The default Registered Slaves list consists of 16 entries (0-15), populated with Unit Addresses of 2 thru 17 respectively.

On the following page is an example to illustrate basic TDMA operation. For an actual deployment, application-specific parameters must be considered and other various modem configuration options optimized accordingly.

5.0 Network Topologies

Example:

5 Slaves, configured with PMP defaults (&F2). Unit Addresses: 3, 7, 10, 15, and 21.

UA 3 has some data, 7 has no data, 10 has data, 15 is powered-off, and 21 has data but its RF connection is very intermittent due to an intermittent outdoor antenna connection.

Master has been configured as PMP default Master (&F1). Clean RF environment.

Changes to be made to the Master:

S244=1

S251=3

ATT0=3

ATT1=7

ATT2=10

ATT3=15

ATT4=21

ATT5=0 (this terminates the list)

The Master will 'poll' (give the opportunity to transmit) the Slave with UA 3. This Slave will transmit its data (up to maximum amount of hops allowed) and then inform the Master of same.

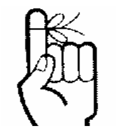
On the next hop, the Master will sequence to the next modem, UA 7. Slave 7 will inform the Master it has no data and on the next hop, the Master will sequence to UA 10.

Slave 10 will transmit its data (up to maximum amount of hops allowed) and inform the Master when complete.

The Master then polls unit 15, no response. On the next hop interval, the Master will poll unit 15 again: no response. It will poll one more time on the following hop interval and, with no response, will move on to poll UA 21 which has data and sends it to the Master—but due to the faulty outdoor antenna connection, the Master does not receive the message from the Slave indicating that it has sent all of its data, so the Master will wait for the value of S251 (3 hops) for such a message from the Slave before moving on to begin the cycle again at UA 3.

5.0 Network Topologies

5.3 Peer-to-Peer (P2P)



A P2P network requires a Master modem.

The data being transmitted from one Slave to another in P2P mode is transferred via the Master.

P2P mode is used for communications between pairings of Remote modems,

> e.g. Slave 12 can exchange data with (only) Slave 14, Slave 6 can exchange data with (only) Slave 7, etc.

There are no specific factory default settings for P2P modems.

To establish a basic P2P network:

<u>Master</u>

- enter into Command Mode
- load the &F1 factory default settings
- change the Network Type (S133) to 2
- change Packet Retransmissions (S113) from 5 to 0 (increase from 0 if required)
- save the change using the AT&W command
- go online with the ATA command

<u>Slave 1</u>

- enter into Command Mode
- load the &F2 factory default settings
- change the Network Type (S133) to 2
- change the Destination Address to 3 (to be the UA of Slave 2)
- save the change using the AT&W command
- go online with the ATA command

<u>Slave 2</u>

- enter into Command Mode
- load the &F2 factory default settings
- change the Network Type (S133) to 2
- change the Unit Address (S105) to 3
- change the Destination Address to 2 (the UA of Slave 1)
- save the change using the AT&W command
- go online with the ATA command

The Master will broadcast (actually 're-broadcast') the data incoming to it from both Slaves to all (2) Slaves; one Slave's data has a destination being the other Slave and vice versa.

5.0 Network Topologies

5.4 Everyone-to-Everyone (E2E)

E2E mode is used for communications between all remote modems,

i.e. data from every modem is broadcast to every other modem in the network.

Considering the amount of data re-broadcasting (via the Master), it is a very bandwidth-intensive network topology.

There are no specific factory default settings to configure modems for E2E operation.

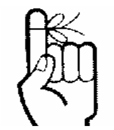
To establish a basic E2E network:

<u>Master</u>

- enter into Command Mode
- load the &F1 factory default settings
- change the Network Type (S133) to 2
- change Packet Retransmissions (S113) from 5 to 0 (increase from 0 if required)
- save the change using the AT&W command
- go online with the ATA command

<u>Slaves</u>

- enter into Command Mode
- load the &F2 factory default settings
- change the Network Type (S133) to 2
- change the Unit Address (S105) to a unique number (range: 2-65534)
- change the Destination Address to 65535 (the broadcast address)
- save the change using the AT&W command
- go online with the ATA command



An E2E network requires a Master modem.

The data being transmitted from remote units in an E2E network travels to the Master and is then re-broadcast to all other remotes.

6.0 Configuration

In following factors must be considered when preparing to configure the modems:

- the application
- network topology
- physical distribution of the network

Components involved in the configuration process of the MHX 2420:

- Interfacing with the module, and
- Inputting the desired values into a variety of registers

Interfacing to the MHX 2420 for the purpose of configuring it may be accomplished in a number of ways:

If mounted in a Development Board:

- Rear RS-232 connector, 9-pin straight-through cable, and PC running communications program, or
- Front SERIAL DIAG RJ45 port, MHS configuration cable, and PC running MHS System Diagnostics software.

With HV Option:

- Properly connect PC running communications program to pins 5 (TXD), 6 (GND), and 7 (RXD) of HV Option's 16-pin connector, or
- Connect using the System Diagnostics software (running on a PC) to the 16-pin connectors pins 15 (TXD2), 6 (GND), and 16 (RXD2).

Once connected and in Command Mode, changes to the MHX 2420's configuration are made using convenient AT commands, the majority of which involve Settings (S) Registers.

As discussed in Section 5, there are several factory default settings which can make configuration of the modules quite simple. There are no DIP switches to set; switches which may subsequently become inadvertently misadjusted or intermittent.

6.0 Configuration

6.1 AT Commands

Appendix B is a quick reference for the available AT commands; in this sub-section are details regarding the most commonly used.

To invoke an AT command, enter Command Mode, then type **AT *<command>* [Enter]**.

If changes were made to the modem's configuration and it is intended that those changes be saved to non-volatile memory, do so with the AT command '&W' prior to placing the modem online.

y < command	command name > ***x***

A	**Answer**

Upon completion of tasks being done with the modem in Command Mode, invoking this command will place the modem back 'online' (into Data Mode).

D*xxxxx*, DT*xxxxx*, DP*xxxxx*	**Dial**

Identical commands which change the modem's unit address to *xxxxx* and then put the modem into Data Mode.

6.0 Configuration

g, G **Spectrum Analyzer**

This is a very useful feature of the MHX 2420. ATg or ATG will provide a display of signal levels received within the operating environment and frequency range of the modem under test. ATg averages 256 samples, ATG 16,000.

Invoking the ATg command causes the MHX 2420 to sweep the operating band and provide a display of both the mean and peak signal levels, in dBm, found on each channel.

The 'graphical' display is limited from –110dBm to –53dBm, and is in 1dB increments. Ignore the leftmost asterisk in calculations (as below).

How to interpret the display (example):

```
...
ch 78  -137dBm  *          No signal was measured on channel 78.
ch 80  -105dBm  ******...  Mean signal level: -(110-5 (asterisks)) = -105dBm
...                        Peak signal level: -(110-5 (asterisks) -3 (dots)) = -102dBm
```

Channel 1 is at 2.4016GHz, with subsequent channels in 400kHz increments up to Channel 202 at 2.4820GHz. Therefore, to calculate the frequency of channel *n*: Freq channel *n* = 2401.6 + ((*n-1*) x 0.400)MHz.

6.0 Configuration

I*n* Identification

The I command returns information about the MHX 2420.

1	Product Code (MHX 2420)
2	Issue ROM Check (OK or ERROR)
3	Product Identification (Firmware Version)
4	Firmware Date
5	Firmware Copyright
6	Firmware Time
7	Serial Number
255	Factory-Configured Options listing

6.0 Configuration

N Advanced Spectrum Analyzer

The Advanced Spectrum Analyzer feature provides for a very detailed analysis of a particular area of the radio frequency spectrum within which the MHX 2420 operates.

The specific start (of scan) and stop frequencies, along with step (increment) size and dwell (on frequency) time are user-definable.

Following is the format for the ATN command:

In Command Mode

ATN F_{start} F_{stop} S D*[Enter]*

where

F_{start} = start frequency in MHz (including 0-6 decimal places)
F_{stop} = stop frequency in MHz (including 0-6 decimal places)
S = step increment in kHz (from 1-1000)
D = dwell time in ms (from 1-1000)

Example:

ATN 2410.250 2420.500750 25 100

Note: Be sure to enter spaces as shown in the format detailed above.

O Online Mode

Upon completion of tasks being done with the modem in Command Mode, invoking this command will place the modem back 'online' (into Data Mode).

6.0 Configuration

&F*n* Load Factory Default Configuration

See Section 5.0 for detailed information on the various factory default options.

Slow Mode is an option for the MHX 2420.

If the module being configured does not support Slow Mode, do not load a Slow Mode factory default configuration.

Values

1 PMP Master
2 PMP Slave
3 PMP Repeater
4 Slow Mode PMP Master
5 Slow Mode PMP Slave
6 PTP Master
7 PTP Slave
8 Slow Mode PTP Master
9 Slow Mode PTP Slave

6.0 Configuration

&H0 Frequency Restriction

By default, the MHX 2420 will hop on frequencies across the entire 2.4000-2.4835GHz ISM band. For some applications or within certain operating environments, it may be desired to prohibit the modem from operating on specific frequencies or range(s) of frequencies. The modem will not allow ‘too many’ frequencies to be restricted; it requires a certain amount of bandwidth within which to operate to comply with regulations.

Following is an example of entering Frequency Restrictions on a MHX 2420 modem. First, the AT&H0 command is invoked:

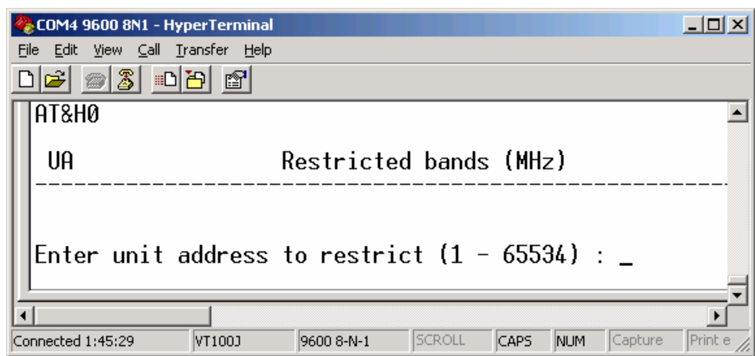


Image 9

The modem responds with a prompt for the Unit Address.

(Enter the Unit Address for the Master (1) and all Repeaters in the network into each modem in the network.)

All modems in the network must have the same frequency restriction configured within them.

Use the ATg or ATG feature to help identify the frequency/ range of possible interfering signals within the 2.4000-2.4835GHz ISM band, and then use the AT&H0 feature to configure the modem to avoid them.

6.0 Configuration

&H0 Frequency Restriction (continued)

Having entered ‘1’, the modem prompts for the first restricted frequency to be entered.

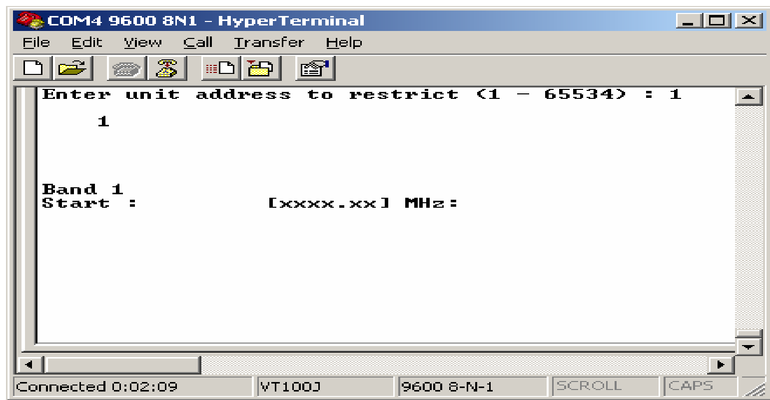


Image 10

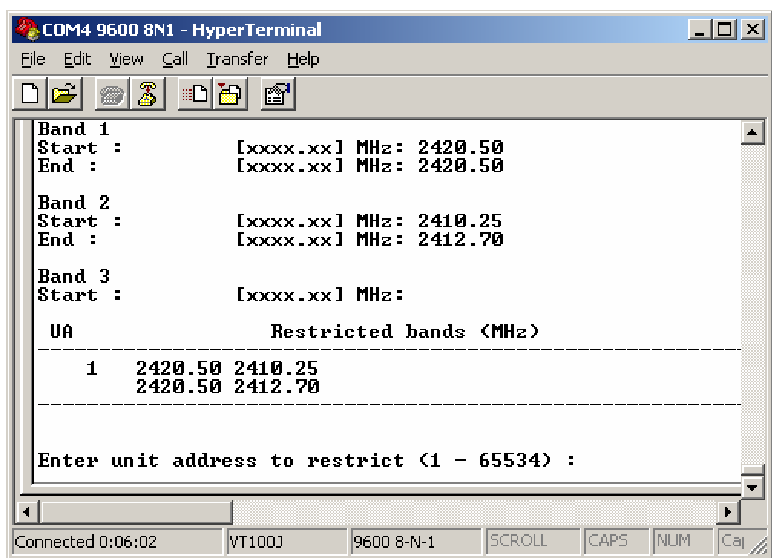


Image 11

To modify an existing restriction, simply overwrite it.

To remove a restriction, overwrite it with 0000.00.

2420.50 was entered as the ‘start’ and ‘end’ of Band 1; this will restrict the frequency of 2420.50MHz. The range of 2410.25 to 2412.70MHz was defined as the second (Band 2) restriction.
When prompted to enter Band 3, the [Esc] key was entered to escape the entry process and the summary at left/bottom was displayed.
Pressing [Esc] again saves and exits the process.

6.0 Configuration

&H1 Repeater Registration

When more than one Repeater exists in a network, the Unit Address of each Repeater should be registered within **every modem** in the network. The reason for doing this is to enable the modems to create hopping patterns which will be orthogonal to each other, thereby minimizing possible interference between network segments.

Upon entering the AT&H1 command, the modem prompts as follows:

- **A** to add a Repeater (this is done by entering the Unit Address of the Repeater)
- **R** to remove a Repeater
- **C** to clear all registered Repeaters.

Pressing the [Esc] key saves and exits the process.

&V View Configuration

Displays S Register names and current values.

&W Write Configuration to Memory

Stores active configuration into the modem's non-volatile memory.

6.0 Configuration

6.2 Settings (S) Registers

The majority of modem configuration is done via the Settings (S) Registers.

Section 5.0 provides information on the available factory default settings as related to operating modes and network topologies; this section examines each S register in detail. Appendix C is a quick reference for the S register options.

In the following descriptions, default settings (where applicable) are in **boldface**. In Command Mode,

query format: **ATS<*S register* #>*?* [Enter]**

change format : **ATS<S register #>=<value> [Enter]**

If the command referenced by ***y*** (above) is found to be italicized in the following register descriptions, it indicates that the particular command will not appear in the AT&V (view configuration) display.

y <command command name> ***x***

S0 Auto Answer

This register determines in which mode the modem will be upon power-up.
If selected to power-up in Command Mode, the modem will be offline from the wireless network, and ready to be configured upon power-up.
The typical mode of operation is for the modem to power-up in Data mode: ready to participate in data transfer over the wireless network.

Values

0 up in Command Mode
1 up in Data Mode

Modification of S1 may be required when operating the MHX 2420 module via a telephone modem connection interface.

S1 Escape Code

Escape character. If >127, escape feature is disabled. Changes to S1 cannot be saved to non-volatile memory.
Modification of this register may be necessary when connecting the modem to a telephone modem where the +++ character string may result in undesired consequences.

Values

any ASCII value
+ (decimal 43)

6.0 Configuration

Note re nomenclature:

A 'Remote' (non-Master) modem is either a Repeater or a Slave.

If a Repeater is not being used as a Repeater/Slave (i.e. there is no device attached to its local data port), leave its handshaking OFF (&K0) and set the serial baud rate (S102) to 115200bps.

S101 Operating Mode

The operating mode defines the role of a modem. A MHX 2420 modem may be configured for any role required within a radio network. This is convenient for reasons of familiarity with any/all units, as well as for hardware sparing purposes.

The default operating mode is dependent on which factory default option is selected.

MASTER: Only one per network. In all network types (see S133) data either originates at, is destined to, or 'passes through' the Master.

REPEATER: May act simply as a 'Repeater' to store and forward data to/from an upstream unit to/from a downstream unit (e.g. when there is a long distance between the latter units), or, may act as a Repeater/Slave in which case the above function is performed AND the unit may also exchange data as a Slave within the network.
If 1 or more repeaters are to be in a network: see Section 6.2, S141.
If 2 or more repeaters are to be in a network: see Section 6.1, AT command &H1.

SLAVE: Interfaces with remote devices and communicates with Master either directly or via Repeater(s). Communications between 2 or more Slaves is possible - through the Master - see S133 and Section 5.3, 5.4.

Values

0 Master
1 Repeater
2 Slave

6.0 Configuration

102 Serial Baud Rate

The serial baud rate is the rate at which the modem is to communicate with the attached local asynchronous device.

Note: Most PC's do not readily support serial communications greater than 115200bps.

Values

bits per second (bps)

0	230400	8	7200
1	115200	9	4800
2	57600	10	3600
3	38400	11	2400
4	28800	12	1200
5	19200	13	600
6	14400	14	300
7	**9600**		

S103 Wireless Link Rate

This register determines the rate at which RF communications will occur over a given network.
All modems within a particular network must be configured with the same wireless link rate.
Faster link rates result in greater throughput, however, for each 'step' increase in link rate, there is an approximately 1dB reduction in sensitivity.

Values

bits per second (bps)

0	19200*
1	115200
2	**172800**
3	230400
4	270000**
5	340000**

* 'slow mode' (optional)
** 'high-speed mode' (optional)

6.0 Configuration

S104 Network Address

All modems in a given network must have the same Network Address. This unique network address is not only a security feature for a particular network, but also allows other networks - with their own unique network address - to operate in the same area without the possibility of undesired data exchange between networks.

Change the default value for the Network Address to something unique for your network. Do this for an added measure of security and to differentiate your network from others which may be operating nearby.

Values

0-4,000,000,000

1234567890

S105 Unit Address

The unit address is, and must be, a unique identifier of each modem in a network. The address value is 16-bits in length.

The Master has by default, and must retain, a unit address of 1; 65535 is the broadcast address.

Values

2-65534

6.0 Configuration

Change S107 to something unique for your network.

S107 Static Mask

This mask is applied to the transmitted data, and removed from the received data. It is an added form of security for a network.

If you require Strong Encryption, 128-bit AES Encryption contact Microhard Systems for Part Numbers and Export Restrictions.

Values

up to 32 characters

6.0 Configuration

FCC regulations allow for up to 36dBi effective isotropic radiated power (EIRP). The sum (in dBm) of the transmitted power, the cabling loss, and the antenna gain cannot exceed 36dBi.

S108 Output Power

This setting establishes the transmit power level which will be presented to the antenna connector at the rear of the modem.

Unless required S108 should be set not for maximum, but rather for the minimum value required to maintain an adequate system fade margin.

Values

dBm (mW equivalent)

20 (100)
21 (125)
22 (160)
23 (200)
24 (250)
25 (320)
26 (400)
27 (500)
28 (630)
29 (800)
30 (1000)

6.0 Configuration

S109	Hop Interval

This register is effective only on the Master and is responsible for establishing the rate at which all modems within a particular network change frequency (hop - from frequency to frequency).

Long hop intervals typically result in the greatest data throughput, however shorter hop intervals may decrease latency, particularly of smaller packets of data.

The default setting of 20ms is satisfactory for most applications. If adjustment of S109 is being considered, also consider the serial baud rate, wireless link rate, and maximum packet size (S102, S103, and S112).

Values

milliseconds (ms)

0	1.5	10	30
1	2.0	11	40
2	2.5	12	50
3	3.0	13	60
4	4.0	14	70
5	5.0	15	80
6	7.0	16	90
7	10	17	100
8	15	18	125
9	**20**	19	150

6.0 Configuration

S110 Data Format

This register determines the format of the data on the serial port. The default is 8 data bits, No parity, and 1 Stop bit.

Values

1	**8N1**	6	7N2
2	8N2	7	7E1
3	8E1	8	7O1
4	8O1	9	7E2
5	7N1	10	7O2

S112 Packet Max Size

Determines that maximum number of bytes from the connected device that should be encapsulated into a packet.
Large packet sizes may produce the best data throughput; however, a smaller packet is less likely to become corrupted and, if it does, is retransmitted with a lesser impact on network traffic.
The default setting of 255 bytes is suited to most applications. If adjustment of S112 is being contemplated, take into consideration such factors as data rate, wireless link rate, and the hop interval (S102, S103, S109).

Values

bytes

0-255

255

S113 Packet Retransmissions

This register determines the maximum amount of times that a packet will be retransmitted (in addition to the initial transmission), noting the following specific behaviours in various network topologies:

PMP: Master will retransmit each data packet the exact number of times specified in its S113; Slave will retransmit only if necessary, and then only until a given packet is acknowledged or the value of the Slave's S113 is reached (after which it will discard the packet if retransmission not successful).

PTP: Modem will retransmit to its counterpart only if necessary, and to a maximum number of the value in S113. Packet is discarded if retransmissions are not successful.

Recipients of packets will discard any duplicates.

In a PMP system, set S113 to the minimum value required as, effectively, the data throughput from Master to Remote is divided by 1 plus the number stored in S113.

Values

0-255
5

6.0 Configuration

S115 Repeat Interval

S115 determines the number of slots which are available within a window of opportunity for Remote units to submit channel requests to the Master modem.

For a large number of remotes, particularly if there may be concurrent demand for Remotes to desire to send information to the Master, the value of S115 should be set relatively high: Remotes will randomly contend for the ability to access the channel request slots.

For a small number of Remotes, particularly if their need to transmit data to the Master is quite random, it is advisable to keep S115 closer to the default value so as to not 'waste bandwidth' by maintaining a relatively large window housing a greater-than-necessary number of channel reservation request slots.

In a TDMA-type system, S115 may be set to 1 as the Remotes are not able to request a transmission channel: the Master polls each Remote for data.

Values

hop intervals
1-255

3

6.0 Configuration

S116 Character Timeout

This ‘timer’ looks for gaps in the data being received from the local attached device. The timer is activated after the Minimum Packet Size (S111, default 1 Byte) has been accumulated in the modem, after which, if the timer detects a gap in the data exceeding the Character Timeout value, the modem will transmit the data.

The MHX 2420 will accumulate data in its buffers until either (a) Maximum Packet size (S116) has been accumulated, or (b) Minimum Packet Size (S111) has been accumulated AND the Character timeout has expired—whichever occurs first.

If S116 is set to 0ms, the modem will buffer exactly the Minimum Packet size and then transmit that data.

Values

ms
0-254

10

6.0 Configuration

S118 — Roaming

This feature allows a Remote unit to synchronize with a specified 'upstream' unit (either Master or Repeater). The options are as follows:

S118=65535: With this value in its S118 register, a Remote will synchronize with an upstream unit which has the same network address (S104) and static mask (S107) as the Remote. Should that upstream unit fail, this Remote will attempt to synchronize with another 'upstream' unit within the same network. This ability is particularly well-suited to mobile applications.

S118=1-254: In most static (fixed) networks, where there are no Repeaters, the default value of 1 is maintained: All Slaves synchronize to the Master (whose unit address is 1).
In networks where Repeaters are present, the value of a Remote's S118 corresponds to the particular upstream modem with which a particular Remote is intended to communicate, e.g. Slave UA (S105)=3 may have an S118=2, where the modem with UA 2 is a Repeater between the Slave and the Master; the Repeater will have an S118=1.

S118 dictates which modem (by Unit Address (UA)) a Remote unit will 'look' or 'attach to' for its upstream signal path.

When bench testing 3 modems for a Master-Repeater-Slave link, be sure to set the Slave's S118 to the UA of the Repeater, and the Repeater's S118 to the UA (1) of the Master.

This will ensure that data is routed from the Slave through the Repeater to the Master; otherwise, if the Slave's S118 is left at the default value of 1, the Slave will communicate directly with the Master, bypassing the Repeater altogether.

Values

65535 full roaming

1-254 specific (fixed) unit address (Master or Repeater) with which to associate

1

6.0 Configuration

S119	Quick Enter to Command Mode

If this register is set to 1, a delay of 5 seconds is introduced at power-up before the modem will go into Data Mode. If, during these 5 seconds, the user enters 'mhx' the modem will instead go into Command Mode and reply with 'OK'. The terminal baud rate must be set to 9600bps. If an incorrect character is entered, the modem will immediately go into Data mode.

The default setting is 0: The modem will promptly go into Data Mode upon power-up.

Values

0 disabled
1 enabled

6.0 Configuration

S123 Average RSSI

This register displays (it is not a 'setting') the average signal strength received over the previous 4 hop intervals. The value in this register is also reflected in status lines RSSI1, 2, and 3, which connect to the modem's front panel RSSI LEDs.

A Master modem's RSSI LEDs will not illuminate to any degree until such time as it has received valid packets from a 'downstream' unit. Also, should the downstream unit(s) fail, a Master will maintain the last RSSI reading display.

Values

dBm

-110 to –55dBm (maximum reading)

S133 Network Type

Defines the type of network (see Section 5.0 for a detailed description of network topologies).

In a point-to-multipoint (PMP) network, the Master broadcasts data to all units, and all remote units send their data (ultimately) to the Master.

A point-to-point (PTP) network involves a Master and a Slave (with 0 or more Repeaters inbetween).

Peer-to-Peer involves either communication between 2 (typically remote) units (P2P) or between all units (everyone-to-everyone - E2E).

ALL modems in a network must have the SAME value for Network Type.

Values

0 Point-to-Multipoint
1 Point-to-Point
2 Peer-to-Peer or Everyone-to-Everyone

6.0 Configuration

S140 Destination Address

As the name implies, this register specifies the ultimate destination for a modem's data.

Different network topologies dictate the configuration of S140:

PMP : Master S140=65535, Remote S140=1

PTP : Master S140=UA of Remote, Remote S140=1

P2P : Master S140=65535, S140 of each (of 2 / pair) Remote modem is the UA of the other

E2E : S140 of all modems=65535 (broadcast)

Values

1-65535

With one or more Repeaters in the system, a network's throughput is divided in half. Exercising the option of back-to-back 'Repeaters' - which requires 2 modems at a 'Repeater' site - eliminates the division of bandwidth.

If there is more than one Repeater in a network, the Repeaters should be 'registered'. See Section 6.1 AT&H1 Repeater Registration for how to accomplish this.

S141 Repeaters Y/N

This register informs - and applies only to - the Master as to the presence of any Repeater(s) in the network.

Values

0 no repeater
1 1 or more repeaters

6.0 Configuration

S142 Serial Channel Mode

This register defines the physical serial interface which will be used for data communications.

Note: When placed into Command Mode, the module will communicate via the RS-232 interface at 9600bps, 8N1.

Values

0 RS-232 interface
1 half-duplex RS-485
2 full-duplex RS-485

6.0 Configuration

S143 Sleep Mode

This register applies only to Remote (i.e. not Master) modems, and determines if the Remote should remain active continuously (S143=0, default), or enter a timer-based sleep mode.

Sleep Mode 1

To awaken module:

1. Apply TTL high logic level to WAKEUP! input of MHX2420 module.

2. Modem fully awakens when there is incoming data on local data port; stays awake (active) when there is data on local data port or incoming via the RF link.

Sleep Mode 2

To awaken module:

Same as above, except the module will not stay awake on data incoming via RF link; unit will go back to sleep when Wake Time (S143) expires.

Sniff Mode 1

Remote in this mode awakens when data on local data port. Modem will try to find an upstream unit (Master or Repeater) for a brief period of time defined by S237. If upstream unit is found, modem stays awake for Wake Time (S145), if upstream unit not found, modem will go to sleep for Sleep Time (S144). Sniffing cycle is very brief; unit stays awake only when there is data on local data port or until such time as all data to be transmitted is transmitted.

Sniff Mode 2

Same as Sniff Mode 1 except modem will remain awake only when there is data on local data port (i.e. over-the-air data will not keep unit awake).

6.0 Configuration

S143 Sleep Mode (continued)

Sniff Mode 3

Same as Sniff Mode 1 except data will be discarded if modem cannot find upstream unit.

Values

0 active (no sleep)
1 sleep mode 1
2 sleep mode 2
3 sniff mode 1
4 sniff mode 2
5 sniff mode 3

6.0 Configuration

S144	Sleep Time

This register applies only to Remote modems and is only effective when S143>0.
Defines sleep duration for up to approximately 18 hours.

Two conditions will awaken a Remote: 1. sleep duration time has expired, or 2. incoming data on local data port.

When a sniff mode is selected (S143), the modem will start its sniff cycle when the Sleep Time expires or will wake up completely when there is data on its local data port.

Values
seconds
0-65535
60

6.0 Configuration

The most effective way to put an entire network into sleep/ sniff mode is by turning off, or putting into command mode, the Master modem.

S145 Wake Time

Applies only to Remote modems and effective only when S143>0. This register determines how long a modem will stay awake after the local data port and radio links become idle.

When the modem is idle for the amount of time specified in S145, it will go to sleep; it will go to sleep immediately if ‘upstream’ unit is offline or goes into sleep/sniff mode.

Values

seconds

0-65535

10

S149 LED Brightness

This is a power saving feature which controls the current available to LEDs such that they operate with from 0% (off) to 100% available brightness.

It is recommend to set S149 to 100 for testing in a shop environment, and then reduce the value as required when deploying in the field where power consumption may be of concern.

Values

percent (%)

0-100

100

6.0 Configuration

S150 Sync Mode

This setting applies only to the Master modem.
S150 dictates which sync mode the Master will use when it initially goes online.
Quick sync mode results in the Master hopping very quickly, which will enable a downstream unit to become synchronized faster.

A setting of 1 applies only in a point-to-point (PTP) configuration: the Master will stay in quick sync mode until such time as it receives an acknowledgement from its associated Slave, it will then remain hopping quickly for the number of hop intervals (8-255) defined by S152 (Fast Sync Hold on Ack), after which time it will go into normal sync mode.

A value of 2 results in the Master going into quick sync mode when it initially comes online and then remaining in that mode for the duration specified in S151 (fast sync timeout) and then return to normal sync mode.

Values

0 normal sync
1 quick sync mode, wait for acknowledgement
2 quick sync mode, wait for timeout

S151 Fast Sync Timeout

This register settings applies only to a Master modem.
Effective only when S150=2.

Defines how long, in milliseconds, a Master modem will stay in fast sync mode after it initially goes online.

Values

milliseconds (ms)

100-65000

200

6.0 Configuration

S153	Address Tag

If enabled, the modem prepends 4 extra bytes to the data: first byte = 0x00, second = 0xFF, third = source unit address (high byte), fourth = source unit address (low byte).

Value

0 disable
1 enable

6.0 Configuration

If throughput is not of primary concern and there is an emphasis on providing the most robust data communications, FEC should be considered.

S158 FEC (Forward Error Correction) Mode

A number of FEC schemes are available with different coding rates.

FEC consumes some bandwidth: depending on which coding rate is chosen, a number of coding bits are transmitted along with the 'data' bits.

In 'noisy' or long-range communications environments, FEC may effectively increase throughput by decreasing the amount of packet retransmissions which would otherwise be required.

Communications range may also be extended with the use of FEC: at a certain distance where data would otherwise be unacceptably corrupted, employing FEC may be all that is required to maintain the integrity of that data at that distance.

Types of FEC available within the MHX 2420:

Hamming (7,4)	:	Information rate 0.5, corrects 1 out of 7 bits
Hamming (15,11)	:	Information rate 0.66, corrects 1 out of 15 bits
Hamming (31,24)	:	Information rate 0.75, corrects 1 out of 31 bits
Binary BCH (47,36)	:	Information rate 0.75, corrects 2 bits
Golay (23, 12, 7)	:	Information rate 0.75, corrects 3 bits
Reed-Solomon (15,11)	:	Information rate 0.687, corrects 2 nibbles

Values

0 No FEC
1 Hamming (7,4)
2 Hamming (15,11)
3 Hamming (31,24)
5 Binary BCH (47,36)
6 Golay (23,12,7)
7 Reed-Solomon (15,11)

6.0 Configuration

S217 Protocol Type

For most applications, the default value of 0 - resulting in transparent operation - will be maintained in this register.

Setting this register to a value of 1 specifies MODBUS operation, in which the modem will frame the output data and comply with MODBUS specifications.

S217=2 configures the modem for DF1 filtering. In this mode, the PLC's address must match the Unit Address of the modem. Data not intended for a specific PLC/Modem pairing will be blocked from passing through the modem to the attached PLC.

Values

0 transparent
1 MODBUS RTU
2 DF1 protocol, full-duplex, with address filtering

6.0 Configuration

The longer the Sniff Timeout (duration), the more assured it is that the Remote modem will ‘find’ an upstream unit when it is desired to wake up the system, however more power will be consumed.

S237 Sniff Timeout

This register applies only to Remote modems.
Defines how many hops the unit will sniff for upon expiry of the Sleep Time (S144).

The Sniff Timeout (sniff duration) in milliseconds is calculated as follows:
Sniff Timeout=S237 (hops) x hop interval (per S109)

Example: S237=20, S109=9 (=20ms)
Sniff Timeout = 20 (hops) x 20ms per hop = 400ms

Values

hops

1-255

10

6.0 Configuration

S244 Channel Request Mode

Channel Request Mode 'on' (default), allows a Remote modem which has data to send to request from the Master permission to do so. When granted, the Remote will be allowed to transmit all of its data (no other Remotes may transmit during this period), upon completion of which it will release the channel. This feature eliminates collisions which would otherwise occur if a number of Remotes were all trying to transmit at the same time (e.g. if S244=2).

TDMA mode is discussed in detail in Section 5.2.1. It relates to Channel Requests in that, in TDMA mode, the Master does not allow such requests from Remotes; the Master sequences through a list of Remotes, giving each one in turn an opportunity to transmit.

Values

0 Channel Request
1 TDMA Mode
2 No Channel Request

6.0 Configuration

S251 Master Hop Allocation Timeout

In TDMA mode (see S244 and Section 5.2.1) this register determines how long, in hop intervals, the Master will wait for a Remote to either (a) begin to send data or (b) indicate that it has completed sending all of its data, prior to the Master sequencing to the next Remote to be given permission to transmit.

In a 'clean' RF environment, it may be of benefit to reduce S251 to 2 or 3 as, should a Remote be unable to communicate for some reason, the 'wait' time for the Master to proceed to poll the next Slave would be reduced.

Values

hops
1-254
10

6.0 Configuration

6.3 Serial Interface Commands

A number of register settings are specifically related to the serial data interface. Some, which have been discussed previously, include:

S102 Serial Baud Rate	determines the rate of communications between the modem and the local device
S110 Data Format	defines the data, stop, and parity bit count
S142 Serial Channel Mode	selects the actual serial interface to be used
S217 Protocol Type	defines the nature of the incoming data and what, if any, special action should be taken by the modem upon the data

Also, there are AT commands which effect the configuration of the module, specifically with respect to the handling of data at the RS-232 interface:

&C Data Carrier Detect (DCD)
&D Data Terminal Ready (DTR)
&K Handshaking
&S Data Set Ready (DSR)

The above four items are discussed further in this section.

6.0 Configuration

&C*n* Data Carrier Detect (DCD)

Controls the module's DCD output signal to the attached device. Determines when the DCD line is active.

Values

0 DCD always on
1 DCD on when modems synchronized*
2 DCD used for output data framing and Modbus mode
3 On Slave units, DCD will pulse for 2ms each time valid sync packet received from Master which sends 1 sync packet per hop

*DCD always on when module configured as a Master

6.0 Configuration

&D*n* — Data Terminal Ready (DTR)

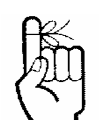
Controls the action that the module will perform when the DTR input line's state is modified.

Values

0 **DTR ignored**
2 deassert DTR to force module into Command mode (at serial baud rate set by S102); DTR must be reasserted before putting module back into data mode (normally done using ATA command)

&K*n* — Handshaking

Enables or disables hardware handshaking.



Software flow control (XON/XOFF) is not supported.

Values

0 **handshaking disabled**
3 RTS/CTS handshaking enabled

6.0 Configuration

&Sn Data Set Ready (DSR)

Controls the module's DSR line and determines when it is active.

Values

0 DSR always on
1 ON in Data mode, OFF in Command mode
2 DTR/DSR signaling: Remotes output state of Master's DTR on their local DSR line in PMP network. Master only outputs state of Slave's DTR on its local DSR line in PTP. Not supported in P2P or E2E network.

7.0 Installation

The installation, removal, or maintenance of any antenna system components must be undertaken only by qualified and experienced personnel.

The are a number of factors to consider when preparing to deploy a radio network, several of which have been touched-upon or detailed elsewhere within this manual. Following is a listing of a number of factors, in no particular order:

Network Topology

Section 5.0 detailed the various network topologies which the MHX 2420 will support. Determine which topology is suited to your specific requirements.

Throughput

The MHX 2420 is capable of 230.4kbps asynchronous serial data throughput. The network topology has an effect on how this available throughput is 'shared' between all nodes on the network.

Distance

The physical distance between the modems dictates such things as required antenna performance and heights, and whether or not a Repeater(s) is required. When contemplating antenna types and Repeater sites, keep in mind the directivity (omnidirectional or directional) of the antennas being used, and also recall the effect of a Repeater on throughput (see Section 4.4).

Terrain

Along with distance, the terrain is a very important consideration with respect to antenna height requirements. The term 'line-of-sight' (LOS) refers to being able to 'see' one location from another - a minimum requirement for a radio signal path. In addition to LOS, adequate clearance must also be provided to satisfy 'Fresnel Zone' requirements - an obstruction-free area much greater than the physical LOS, i.e. LOS is not enough to completely satisfy RF path requirements for a robust communications link.

Transmit Power

Having read thus far through the factors to be considered, it should be clear that they are all interrelated. Transmit power should be set for the minimum required to establish a reliable communications path

7.0 Installation

with adequate fade margin. Required transmit power is dictated primarily by distance, antenna type (specifically the 'gain' of the antennas being used), and the receive sensitivity of the distant modem. Cable and connector losses (the physical path from the modem's 'antenna connector' to the antenna's connector) must also be taken into account.

Receive Sensitivity

The MHX 2420 has exceptional receive sensitivity, which can produce a number of benefits, such as: added fade margin for a given link, being able to use less expensive coaxial cable or antenna types, being able to operate at greater distances for a given distant transmitter power (perhaps negating the requirement for a Repeater site!). Distance, antenna gain, transmit power, and receive sensitivity are critical 'numbers' for radio path calculations. Fortunately, the MHX 2420 features the maximum available transmit power combined with exceptional receive sensitivity - two 'numbers' which will produce the most favorable path calculation results.

Fade Margin

When all radio path numbers are being considered and hardware assumptions are being made, another factor to consider is the 'fade margin' of the overall system. the fade margin is the difference between the anticipated receive signal level and the minimum acceptable receive level (receive sensitivity). Being that the MHX 2420 performs to exacting specifications, the overall deployment should be such that the modems may be utilized to their full potential to provide a reliable and robust communications link. A typical desired fade margin is in the order of 20dB, however oftentimes a 10dB fade margin is acceptable.

Frequency

The 2.4GHz frequency range is effected by rain to some degree. Path calculations provide results which specify 'required' antenna heights. For cost savings, sometimes the height requirements are not adhered to: this may result in unreliable communications.

7.0 Installation

Power Requirements

The MHX 2420 may be integrated into a system (Development Board, HV Option, or custom) which accepts a range of DC input voltages (supply current requirements must also be met). In some deployments, power consumption is critical. A number of features related to minimize power consumption are available with the MHX 2420: sleep/sniff modes, LED dimming, and the ability to operate at less transmit power given the receive sensitivity of the distant modem.

Interference

The frequency hopping spread spectrum (FHSS) operation of the MHX 2420 most often allows it to work well in an environment within which there may be sources of in-band interference. Frequency Restriction is a built-in feature which may be utilized to avoid specific frequencies or ranges of frequencies; the Spectrum Analyzer function may be used to identify areas of potential interference.

7.0 Installation

FCC regulations allow for up to 36dBi effective isotropic radiated power (EIRP). The sum (in dBm) of the transmitted power, the cabling loss, and the antenna gain cannot exceed 36dBi.

7.1 Path Calculation

Assuming adequate antenna heights, a basic formula to determine if an adequate radio signal path exists (i.e. there is a reasonable fade margin to ensure reliability) is:

Fade Margin = System Gain - Path Loss

where all values are expressed in dB.

As discussed on the previous page, a desired fade margin is 20dB.

System gain is calculated as follows:

System Gain = Transmitter Power + (Transmitter Antenna Gain - Transmitter Cable and Connector Losses) + (Receiver Antenna Gain - Receiver Cable and Connector Losses) + | Receiver Sensitivity |.

where all values are expressed in dB, dBi, or dBm, as applicable.

Example:

Tx power = 30dBm
Tx antenna gain = 6dBi
Tx cable/connector loss = 2dB
Rx antenna gain = 6dBi
Rx cable/connector loss = 2dB
Rx sensitivity = -106dBm

System Gain = [30+(6-2)+(6-2)+106]dB
= [30+4+4+106] dB
= 144dB.

Assuming a path loss of 113dB for this example, the fade margin = 144-113 = 31dB.
31dB exceeds the desired fade margin of 20dB, therefore this radio communications link would be very reliable and robust.

On the following page are examples of actual path loss measurements taken in an open rural environment; the path loss numbers do not apply to urban or non-LOS environments.

7.0 Installation

To satisfy FCC radio frequency (RF) exposure requirements for mobile transmitting devices, a separation distance of 20cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operation at less than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

Never work on an antenna system when there is lightning in the area.

Distance (km)	Master Height (m)	Remote Height (m)	Path Loss (dB)
5	15	2.5	121.5
5	30	2.5	115.9
8	15	2.5	129.1
8	15	5	122.7
8	15	10	110.0
16	15	2.5	140.3
16	15	5	133.9
16	15	10	121.2
16	30	10	114.6
16	30	5	127.4
16	30	2.5	133.8

Table 5: Path Loss

Once the equipment is deployed, average receive signal strength may be determined by accessing S Register 123.

7.2 Installation of Antenna System Components

The installation, removal, or maintenance of any antenna system components must be undertaken only by qualified and experienced personnel.

7.0 Installation

7.2.1 Antennas

The two most common types of antenna are the omnidirectional ('omni') and directional (Yagi).

An **omni** typically has 3-6dBi gain and spreads its energy in all directions (hence the name 'omnidirectional'). The 'pattern' of the energy field is in the shape of a donut, with the antenna mounted vertically at the centre. This vertical-mounted antenna produces a signal which is vertically 'polarized'.

A **Yagi** has a more focused antenna pattern, which results in greater gain: commonly, 6-12dBi. The pattern of a Yagi is in the shape of a large raindrop in the direction in which the antenna is pointed. If the elements of the Yagi are perpendicular to the ground (most common orientation) the radiated signal will be vertically polarized; if parallel to the ground, the polarization is horizontal.

Direct human contact with the antenna is potentially unhealthy when a MHX 2420 is generating RF energy. Always ensure that the MHX 2420 equipment is powered down (off) during installation.

The network topology, application, and path calculation are all taken into consideration when selecting the various antenna types to be used in a radio network deployment.

In a long-range PTP network, Yagi antennas should be considered. There antennas will provide for the most focused 'RF connection' between the two sites.

In a PMP network where Remotes are located in all directions from the Master, the Master site will have an omni so that it can communicate with all Remotes; the Remotes, however, may all employ Yagi antennas 'pointed at' the Master.

Typically a Repeater site will employ an omni such that it can readily receive an RF transmission from one direction and be able to readily transmit it in another.

If an application involves Remotes which are not stationary (e.g. mobile application), all sites would likely use omni antennas so that wherever the units may be, there should be antenna pattern coverage.

7.0 Installation

The path calculation (see Section 7.1) will determine the antenna gain requirements. Refer to the beginning of this section to review the various factors which must be considering when deploying a network. Do not discount the importance of the REQUIRED HEIGHT for the antennas within your network.

To comply with FCC regulations, the maximum EIRP must not exceed 36dBm.

7.2.2 Coaxial Cable

The following types of coaxial cable are recommended and suitable for most applications (followed by loss at 2.4GHz, in dB, per 100 feet):

- LMR 195 (19)
- LMR 400 (6.8)
- LMR 600 (4.4)

For a typical application, LMR 400 may be suitable. Where a long cable run is required - and in particular within networks where there is not a lot of margin available - a cable with lower loss should be considered.

When installing cable, care must be taken to not physically damage it (be particularly careful with respect to not kinking it at any time) and to secure it properly. Care must also be taken to affix the connectors properly - using the proper crimping tools - and to weatherproof them.

7.0 Installation

All installation, maintenance, and removal work must be done in accordance with applicable codes.

7.2.3 Surge Arrestors

The most effective protection against lightning-induced damage is to install two lightning surge arrestors: one at the antenna, the other at the interface with the equipment. The surge arrestor grounding system should be fully interconnected with the transmission tower and power grounding systems to form a single, fully integrated ground circuit.
Typically, both ports on surge arrestors are N-type female.

Appendix B: AT Command Quick Reference

The following commands may be used when the modem is in COMMAND MODE; all are to be preceded with "AT" and followed with [Enter]. An asterisk (*) indicates a default setting, where applicable.

A
Answer
-this command puts the modem into data mode

D*xxxxx*, DT*xxxxx*, DP*xxxxx*
Dial
-identical commands which change the unit address to *xxxxx* and put the modem into data mode

g, G
Spectrum Analyzer
Used to help determine if interfering RF signals are present.

I*n*
Identification
-follow ATI with either of the following '*n*':
1-product code
2-ROM check (OK or ERROR)
3-firmware version
4-firmware date
5-firmware copyright
6-firmware time
7-serial number
255-factory-configured options listing

N
Advanced Spectrum Analyzer
Advanced spectrum analyzer provides for a more detailed scrutiny of the RF environment.

O
Online Mode
-this command puts the modem into data mode

T*x*
Registered Slave List (TDMA)
? -view list
T*n=UA* -set list number *n* equal to Remote's Unit Address
T*n*? -view list item *n*

&F*n*
Load Factory Default Configuration
-follow AT&F with either of the following '*n*':
1-MASTER Point-to-Multipoint, use with &F2/&F3 modems
2-SLAVE Point-to-Multipoint, works with &F1
3-REPEATER Point-to-Multipoint, works with &F1/&F2
4-SLOW MODE* MASTER Point-to-Multipoint
5-SLOW MODE* SLAVE Point-to-Multipoint
6-MASTER Point-to-Point, works with &F7
7-SLAVE Point-to-Point, works with &F6
8-SLOW MODE* MASTER Point-to-Point
9-SLOW MODE* SLAVE Point-to-Point
**SLOW MODE is optional*

&C*n*
DCD (Data Carrier Detect)
-controls modem's DCD output signal
0-DCD always on
1-*DCD on when modem's sync'ed, always on if Master
2-DCD used for output data framing and Modbus mode
3-Slave: DCD pulses for 2ms when modem receives valid sync pulse from Master (which sends sync pulse once per hop)

&D*n*
DTR (Data Terminal Ready)
-controls the action the modem performs when the DTR input line is toggled
-follow ATD with either of the following '*n*':
0-*DTR line ignored
2-deassert DTR to force modem from data mode into command mode at S102 serial baud rate; DTR must be asserted before putting modem back into data mode (normally done using 'ATA' command)

&H0
Frequency Restriction
Follow onscreen prompts to input undesired frequencies.

&H1
Repeater Registration
When more than 1 repeater exists in a network, the repeaters should be 'registered' using this command to ensure that frequencies used are orthogonal to each other (thereby minimizing potential interference).

&K*n*
Handshaking
-determines handshaking between modem and host device
0-*disable handshaking
3-enable hardware (RTS/CTS) handshaking

&S*n*
DSR (Data Set Ready)
-controls modem's DSR line and determines when it is active
0-DSR always on
1-*DSR ON in data mode, OFF in command mode
2-DTR/DSR signaling: slaves and repeaters output state of master's DTR on their local DSR line in PMP mode, master only outputs state of slave's DTR on its local DSR line in PTP network, not supported in P2P or E2E network.

Appendix B: AT Command Quick Reference

AT&V
View Configuration
-displays all visible S registers and their current values

&W
Write Configuration to Memory
-stores active configuration into modem's non-volatile memory

S*xxx*?
Read S Register Value
-where xxx is the S register's number, this command will result in displaying the current setting of that register

S*xxx*=*yyy*
Set S Register Value
-where xxx is the S register's number, this command will place value yyy in that register

Appendix C: Settings (S) Register Quick Reference

The registers described in this Appendix are ones which are normally 'visible' to the user. The values stored in these registers effect the operation of the modem. An asterisk * represents default value (if applicable).

Query format : **ATS***xxx***? [Enter]** where *xxx* is S register *number* detailed below
Change format : **ATS***xxx*=*y* **[Enter]** where *xxx* is S register number and *y* is desired value

S0
Auto Answer
0-modem will power-up in command mode
1-*modem will power-up in data mode

S2
Escape Code
-contains ASCII value of escape character
-*'43' is default value, which represents the ASCII character '+'
-values greater than 127 disable the escape feature and prevent user from returning to command mode
-changes cannot be stored to non-volatile memory

S101
Operating Mode
0-Master
1-Repeater
2-Slave

S102
Serial Port Baud Rate (bps)

- 0-230400
- 1-115200
- 2-57600
- 3-38400
- 4-28800
- 5-19200
- 6-14400
- 7-*9600
- 8-7200
- 9-4800
- 10-3600
- 11-2400
- 12-1200
- 13-600
- 14-300

S103
Wireless Link Rate (bps)
1-115200
2-*172800
3-230400

S104
Network Address
0-4,000,000,000
*1234567890

S105
Unit Address
2-65534 (master is 1, broadcast is 65535)

S107
Static Mask
-up to 16 characters
*default

S108
Output Power Level
20-30dBm
*30 (1W)

S109
Hop Interval (ms)

- 0-1.5
- 1-2.0
- 2-2.5
- 33.0
- 4-4.0
- 5-5.0
- 6-7.0
- 7-10
- 8-15
- *9-20
- 10-30
- 11-40
- 12-50
- 13-60
- 14-70
- 15-80
- 16-90
- 17-100
- 18-125
- 19-150

S110
Data Format (of Asynchronous serial input to modem)

- 1-*8N1
- 2-8N2
- 3-8E1
- 4-8O1
- 5-7N1
- 6-7N2
- 7-7E1
- 8-7O1
- 9-7E2
- 10-7O2

S112
Packet Max Size (bytes)
0-255
*255

S113
Packet Retransmissions
0-65535
*5

S115
Repeat Interval
1-255
*3

Appendix C: Settings (S) Register Quick Reference

S118
Roaming
65535-roaming enabled
1-254-fixed upstream unit
*1

S119
Quick Enter to Command Mode
0-*disabled
1-enabled

S123
RSSI Value (dBm, read only)

S133
Network Type
0-Point-to-Multipoint (PMP)
1-Point-to-Point (PP)
2-Peer-to-Peer (P2P)

S140
Destination Address
1-65535

S141
Repeater Existence
0-*no repeater
1-1 or more repeaters exist

S142
Serial Channel Mode
0-*RS-232 interface
1-half-duplex RS-485
2-full-duplex RS-485

S143
Sleep Mode
0-*active (no sleep)
1-sleep mode 1, stays awake on local and air data
2-sleep mode 2, stays awake only on local data
3-sniff mode 1, stays awake on local and air data
4-sniff mode 2, stays awake only on local data
5-sniff mode 3, same as sniff mode 1 but will discard data if cannot find upstream unit

S144
Sleep Duration (seconds)
0-65535
*60

S145
Awake Timeout (seconds)
0-65535
*10

S149
LED Brightness (%)
0-100
*100

S150
Quick Sync Mode
0-*normal sync
1-quick sync mode, wait for acknowledgement
2-quick sync mode, wait for timeout

S151
Quick Sync Timeout (ms)
100-65534
*200

S153
Address Tag
0-*disable
1-enable

S158
FEC Mode
0 *No FEC
1 Hamming (7,4)
2 Hamming (15,11)
3 Hamming (31,24)
5 Binary BCH (47,36)
6 Golay (23,12,7)
7 Reed-Solomon (15,11)

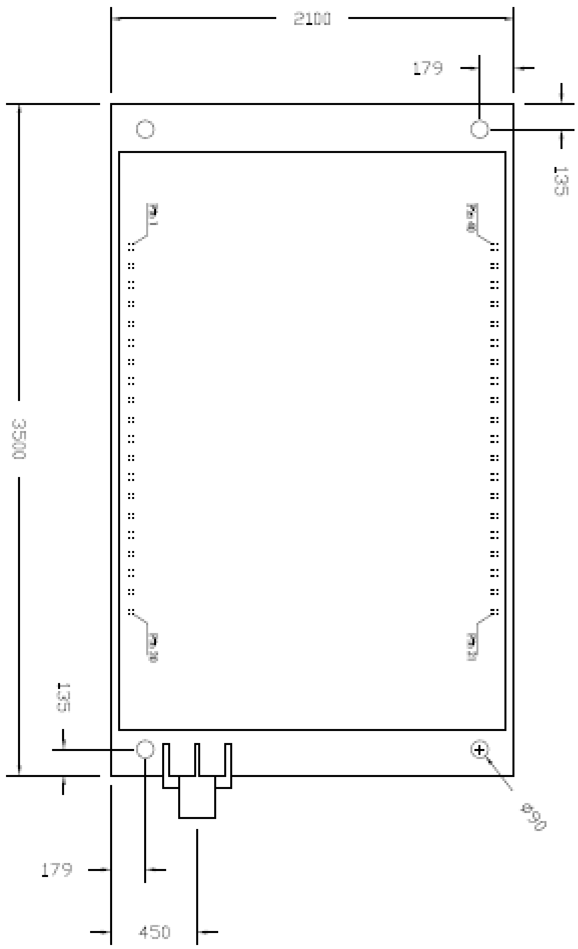
S217
Protocol Type
0-*transparent
1-MODBUS RTU
2-DF1 protocol, address filtering

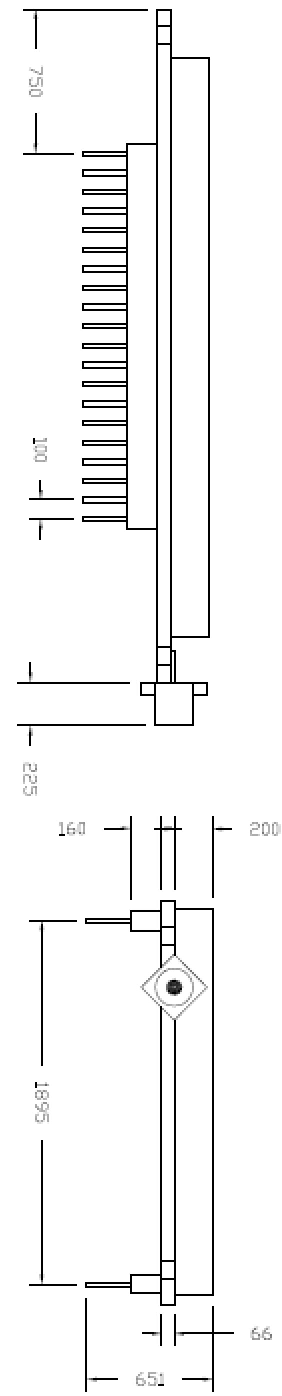
S237
Sniff Duration (hops)
1-255
*10

S244
Channel Request Mode
0-*channel request
1-TDMA mode
2-no channel request

S251
Master Hop Allocation Timeout (hops)
1-254
*10

Appendix E: MHX 2420 Mechanical Drawing





Notes:

1. This document contains proprietary information and may not be reproduced or disclosed, in whole or in part, except with the written permission of Microhard Systems Inc.

2. The dimension unit is mil (1/1000th of an inch).

Appendix F: Development Board Serial Interface

Module (DCE)		Signal		Host Microprocessor (DTE)
1		DCD	→	IN
2		RX	→	IN
3	←	TX		OUT
4	←	DTR		OUT
5		SG		
6		DSR	→	IN
7	←	RTS		OUT
8		CTS	→	IN

Table F1

Arrows denote the direction that signals are asserted (e.g., DCD originates at the DCE and tells the DTE that a carrier is present).

The MHX 2420 module uses 8 pins on the header connector for asynchronous serial I/O. The interface conforms to standard RS-232 signals without level shifting, so direct connection to a host microprocessor is possible.

The signals in the asynchronous serial interface are described below:

DCD *Data Carrier Detect* - Output from Module - When asserted (TTL low), DCD informs the DTE that a communications link has been established with another MHX 2420.

RX *Receive Data* - Output from Module - Signals transferred from the MHX 2420 are received by the DTE via RX.

TX *Transmit Data* - Input to Module - Signals are transmitted from the DTE via TX to the MHX 2420.

DTR *Data Terminal Ready* - Input to Module - Asserted (TTL low) by the DTE to inform the module that it is alive and ready for communications.

continued...

Appendix F: Development Board Serial Interface

...continued

SG *Signal Ground* - Provides a ground reference for all signals transmitted by both DTE and DCE.

DSR *Data Set Ready* - Output from Module - Asserted (TTL low) by the DCE to inform the DTE that it is alive and ready for communications. DSR is the module's equivalent of the DTR signal.

RTS *Request to Send* - Input to Module - A "handshaking" signal which is asserted by the DTE (TTL low) when it is ready. When hardware handshaking is used, the RTS signal indicates to the DCE that the host can receive data.

CTS *Clear to Send* - Output from Module - A "handshaking" signal which is asserted by the DCE (TTL low) when it has enabled communications and transmission from the DTE can commence. When hardware handshaking is used, the CTS signal indicates to the host that the DCE can receive data.

Notes:

It is typical to refer to RX and TX from the perspective of the DTE. This should be kept in mind when looking at signals relative to the module (DCE); the module transmits data on the RX line, and receives on TX.

"DCE" and "module" are often synonymous since a module is typically a DCE device.

"DTE" is, in most applications, a device such as a host microprocessor.

Appendix G: RS-485 Wiring

The MHX 2420 can be connected into a 2-wire or 4-wire RS-485 network. Transmission line termination should be placed only at the extreme ends of the data line if the RS-485 network runs at high data rates and has a long wiring run.

2-wire RS-485

Figure G1 shows a typical two-wire configuration for an RS-485 connection to a MHX 2420. Two wires are shared by transmitting and receiving in a 2-wire configuration, so it is very important for the modem to seize the line at the right time when it transmits. Note again that a transmission line termination is required if the system has high data rates and long wiring runs.

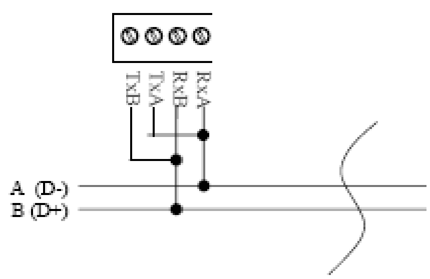


Figure G1: 2-wire RS-485 Configuration

4-wire RS-485

A MHX 2420 can also be connected into a RS-485 network in a four-wire fashion as shown in Figure G2. In a four-wire network it is necessary that one node be a master node and all others be slaves. The network is connected so that the master node communicates to all slave nodes. All slave nodes communicate only with the master node. Since the slave nodes never listen to another slave response to the master, a slave node cannot reply incorrectly to another slave node.

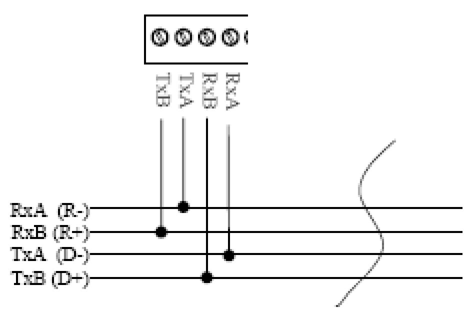


Figure G2: 4-wire RS-485 Configuration

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