microhard SYSTEMS INC.

Operating Manual

Nano Series

900MHz/2.4GHz Spread Spectrum OEM Module
Nano Interface Card
Nano Motherboard Board
Nano Enclosed

Document: Nano Series Operating Manual.v2.9

February 2012

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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)

Regulatory Requirements

WARNING

To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 23cm 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 being used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

WARNING

This device can only be used with Antennas listed in Appendix C/D. Please contact Microhard Systems Inc. if you need more information or would like to order an antenna.

MAXIMUM EIRP
FCC Regulations allow up to 36dBm Effective Isotropic Radiated Power (EIRP). Therefore, the sum of the transmitted power (in dBm), the cabling loss and the antenna gain cannot exceed 36dBm.

WARNING

EQUIPMENT LABELING
This device has been modularly approved. The manufacturer, product name, and FCC and Industry Canada identifiers of this product must appear on the outside label of the end-user equipment.

SAMPLE LABEL REQUIREMENT:

For n920S and n920F Nano Series OEM

FCCID: NS908P24
IC: 3143A-08P24

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

For n920T Nano Series OEM

FCCID: NS908P25
IC: 3143A-08P25

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

For n2420

FCCID: NS911P31
IC: 3143A-11P31

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

Please Note: These are only sample labels; different products contain different identifiers. The actual identifiers should be seen on your devices if applicable.

Revision History

Revision 2.90	Updated Section 3.2 High Speed Interface	February 2012
Revision 2.85	Updated High Speed Interface Drawing 3-8	February 2012
	Updated Pictures for new enclosure.	
Revision 2.84	Removed option 3 from AT&C command	December 2011
Revision 2.82	Added table 1-2 Nano Enclosed Current Consumption	September 2011
	Corrected S244 parameters on page 74.	
Revision 2.81	n2420 Updates	August 2011
Revision 2.8	Updated mechanical drawings for n2420/n920	August 2011
Revision 2.7	Added information about S159 (AES), S177, Sleep etc.	April 2011
Revision 2.61	Additional S109 (Hop Interval) Values, Misc Updates	January 2011
Revision 2.6	Added additional TDMA modes	December 2010
Revision 2.5	Updated Address	June 2010
Revision 2.4	Added n2420, misc formatting	May 2010
Revision 2.3	Misc updates	August 2009
Revision 2.2	Misc updates	June 2009
Revision 2.1	Misc updates	January 2009
Revision 2.0	Added Nano Enclosed / MHX Drawings	September 2008
	Reformatting	
Revision 1.9	Added Interface Card Dimensional Drawing	August 2008
	Corrected Appendix J RS485 Drawings	
Revision 1.8	Misc updates	July 15, 2008
Revision 1.7	Added Nano Development Board	July 7, 2008
Revision 1.6	Corrected connector part number	June 23, 2008
Revision 1.5	Updated TDMA specifications	June 17, 2008
Revision 1.4	Updated FCC/IC Approvals, Added footprint drawing	May 23, 2008
Revision 1.3	Added Pin-Out Drawing	April 29, 2008
Revision 1.2	Updated FCC/IC Approvals	April 21, 2008
Revision 1.1	Corrected Mechanical Drawings—Appendix E	April 8, 2008
Revision 1.0	Preliminary Release	March 25, 2008

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1.0 Overview

The Nano Series Nano Series is capable of delivering high-performance wireless serial communications in a variety of network topologies.

The Nano series is available as an OEM modem, as part of a development /interface kit or as a Enclosed modem. When properly configured and installed, long range communications at very high speeds can be achieved.

Nano Series modules operate within the 902-928MHz or 2.4000-2.4835GHz ISM frequency bands, 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 Nano Series 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 Nano Series 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 1.2 Mbps continuous throughput
- communicates with virtually all PLCs, RTUs, and serial devices through either an RS232, RS422, or RS485 interface
- supports point-to-point, point-to-multipoint, store and forward repeater, TDMA
- wide temperature specification
- maximum allowable transmit power (1 Watt)
- 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 configuration - the Nano Series utilizes a subset of standard AT-style commands, similar to those used by traditional telephone line modems
- 3.3V logic level compatibility (Nano OEM models)

[1]902-928MHz or 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

1.2 Nano Series Specifications

Electrical/General

Frequency: n920: 902 - 928 MHz
n2420: 2.4000 - 2.4835GHz

Spreading Method: Frequency Hopping /DTS

Band Segments: Selectable via Freq. Restriction

Error Detection: 32 bits of CRC, ARQ

Data Encryption: (Optional) 128-bit or 256-bit AES Encryption (Requires export permit outside US and Canada.)

Range: n920: 60+ miles (100km)
n2420: 30+ miles (50km)

Output Power: 100mW to 1W (20-30dBm)

Sensitivity: (n920) -116 dBm - Slow
-108 dBm - Fast
-100 dBm - Turbo

Sensitivity: (n2420) -107 dBm - Fast
-99 dBm - Turbo

Serial Baud Rate: Up to 230.4 kbps - Slow/Fast
Up to 3.2 Mbps - Turbo (* Synchronous)

Link Rate: 19.2 kbps to 1.3824 Mbps

Core Voltage: 3.3VDC Nominal (+/- 0.3V)

Current Consumption:

Characteristics (3.3V)	Min.	Typical	Max.	Units
Full time Rx*	140	240	280	mA
Max Continuous Tx Current	1000	1300	1500	mA
Typical Tx and Rx Average		450		mA
Sleep Current Draw		2		mA

* Dependant on speed and mode.

Table 1-1: n920 OEM Current Consumption

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

Tip: Future enhancements of the Nano Series products may require higher current requirements than listed. It is good design practice to over spec power supplies to allow for future design options.

1.0 Overview

1.2 Nano Series Specifications (Continued)

@12V	RX	TX@1W (AVG)	TX@1W (PEAK)
n2420BF-ENC	70mA to 90mA	230mA	450mA
n920F-ENC	80mA to 110mA	400mA	540mA
@24V	**RX**	**TX@1W (AVG)**	**TX@1W (PEAK)**
n2420BF-ENC	36mA to 45mA	120mA	240mA
n920F-ENC	40mA	210mA	270mA

Table 1-2: Nano Enclosed Series Current Consumption

Environmental

Operation Temperature: -40^{o}F(-40^{o}C) to 185^{o}F(85^{o}C)

Humidity: 5% to 95% non-condensing

Mechanical

Dimensions:

Nano Series OEM: 1.25” (32mm) X 2.0” (51mm) X 0.25”(6.35mm)
Nano Enclosed: 2.25” (57mm) X 3.75” (95mm) X 1.75” (45mm)

Weight:

Nano OEM: 0.7oz. (19 grams)
Nano Enclosed: 0.6 lb. (270 grams)

Connectors:

Antenna: MMCX

Data, etc: AVX-Kyocera 5046 Series 60 pin board to board connectors.

Nano n920 OEM module: 14-5046-060-630-829+
Nano n2420 OEM module: 14-5046-060-645-829+

Interface Card: 24-5046-060-600-829+ (Nano mating connector used for both n920 and n2420)

Microhard Systems Inc Part Number: MHS030510 (Strips of 100)

2.0 Quick Start

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

2.1 Required Materials

- 2 Nano Series modules
- 2 Nano Series Interface Cards + 2 MHX Development Boards OR 2 Nano Motherboards, with power adapters and Rubber Ducky Antennas
- 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 Nano Series modules into the Nano Series Interface Cards and then into the MHX Development Boards, or directly into the Nano Motherboard.
- Connect straight-through cable from each Nano/MHX Development Board (rear 'RS-232' port, the "DATA" port) to the COM port of PC (see section 3.4.1.2 for MHX Dev Board pin-outs or Section 3.5.2 for Nano Dev Board pin-outs). *This setup procedure uses the DATA port on the Nano, not the Diagnostics port. Ensure you are connected to the correct port.*
- 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/CONFIG button on the front of the Nano Motherboard/MHX Development Board, attach the 'green' connector of the wall adapter cable to the rear connector; repeat with other MHX Development Board or Nano Motherboard.
- When the above step is performed, the HyperTerminal window should show the response 'NO CARRIER OK'.
- At this point, both Nano Series modules are in COMMAND MODE. For one module (to be the MASTER), type AT&F6 [Enter], then type AT&WA [Enter]. This module's 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 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 Description

3.1 Nano Series OEM Module

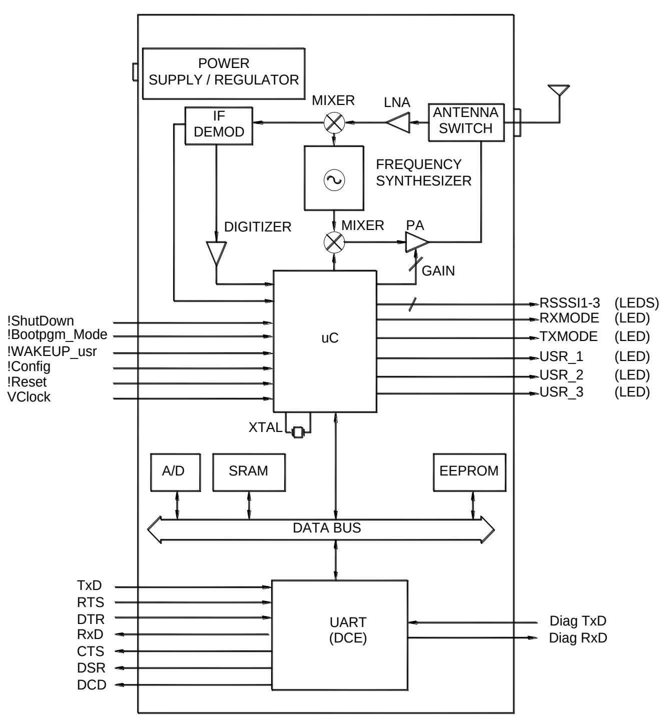
The Nano Series Modems are available in both OEM and Enclosed packages. The OEM version supplies all the required raw signals to allow the unit to be tightly integrated into applications to efficiently maximize space and power requirements. The Enclosed version of the Nano Series modem allows for a fully operational table top or mountable solution. The various interface cards and development boards can provide a convenient evaluation platform or an in between end solution.

The Nano Series OEM module is typically complemented by interface circuitry (e.g. power, data interface) for most applications. The Nano Interface Card, MHX Development Board (used with Nano Interface Card) and Nano Motherboard provide much of this interface circuitry to aid in the integration or evaluation of the Nano Series module.

The Nano Enclosed Modem supplies all required interface circuitry and all that is required are general user interfaces (RS232, antenna, power).

Any Nano Series 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 familiar and proficient with using the module: if you are familiar with one unit, you will be familiar with all units.



Drawing 3-1: Nano Series Functional Block Diagram

Image 3-1: Nano n920 OEM Bottom View

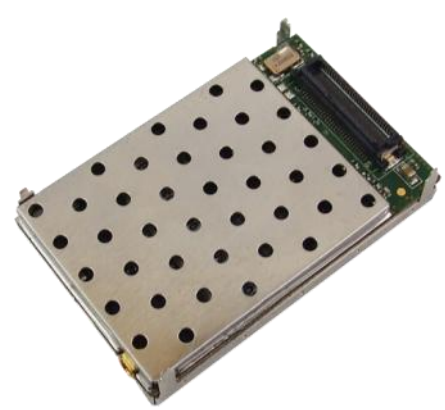
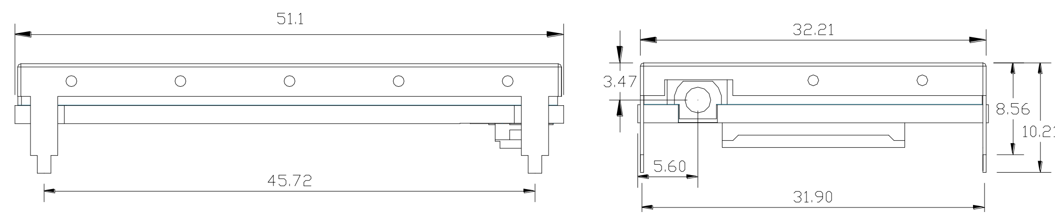


Image 3-2: Nano n2420 OEM Bottom View

3.0 Hardware Description

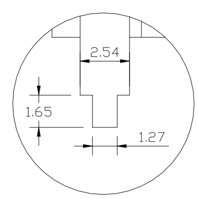
3.1.1 Nano OEM Mechanical Drawing

The Nano Series OEM Modules have an extremely small form factor as see in *Drawing 3-3* and *Drawing 3-4* below.

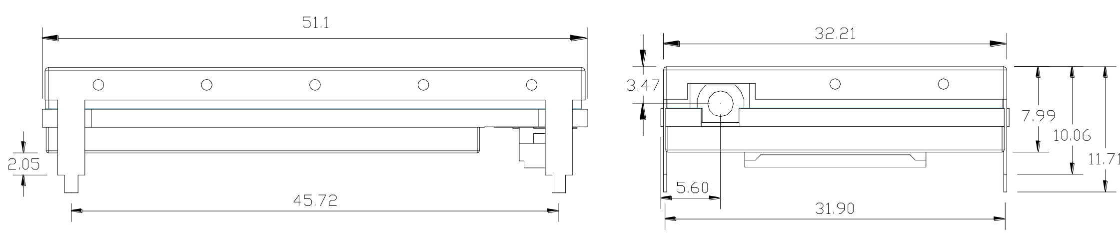


Drawing 3-3: Nano n920 OEM Mechanical

Units: millimeters



Leg Detail



Drawing 3-4: Nano n2420 OEM Mechanical

3.1.2 Nano OEM Connectors

Antenna
All Nano OEM Modules use an MMCX connector for the antenna connection.

Data
The Data connector uses a AVX-Kyocera 5046 Series 60 pin board to board connector. The manufacturers part numbers are listed below, or the mating connector is available directly from Microhard Systems.

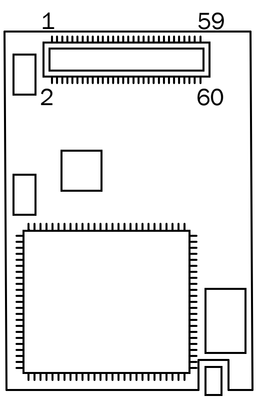
AVX-Kyocera Part Number: 24-5046-060-600-829+
Microhard Systems Inc Part Number: MHS030510 (Strips of 100)

The above part numbers are for the mating connector required to interface to the Nano Series Modems. (The mating connector is the same for both the n920 and the n2420)

To assist in the layout or circuits required to interface with the Nano Series Modems, see *Appendix E*. Also an Orcad Library file is available from Microhard Systems.

3.0 Hardware Description

3.1.3 Nano OEM Pin-Out Description



Nano Series Bottom

Pins 2, 4, 6, and 8 are reserved for factory use. Do not use these pins for any other purpose.

Inputs and outputs are 3.3V nominal (3.0V min — 3.6V max) unless otherwise specified.

NC	2	1	*Ethernet LED0 (Future)*
NC	4	3	*Ethernet LED1 (Future)*
NC	6	5	Vclock
NC	8	7	!Bootpgm_mode
CAN+/CAT6 (Future)	10	9	USR_AN0
CAN-/CAT3 (Future)	12	11	!WAKEUP_usr
CAT2 (Future)	14	13	!CONFIG
CAT1 (Future)	16	15	!RESET
Control RxD	18	17	Vbat
Control TxD	20	19	RSMode
LED_RX	22	21	*USB_DDM (Future)*
LED_TX	24	23	*USB_CNX (Future)*
RSSI3_LED	26	25	*USB_DDP(Future)*
RSSI2_LED	28	27	Reserved
RSSI1_LED	30	29	Reserved
Serial CTS	32	31	Reserved
Serial RTS	34	33	Reserved
Serial DSR	36	35	USR_1/ 1PPS
Serial RING	38	37	USR_2
Serial DTR	40	39	USR_3
Serial TxD	42	41	Mode Line(Future)
Serial RxD	44	43	5V/8V (Future)
Serial DCD	46	45	5V/8V (Future)
Reserved	48	47	5V/8V (Future)
USR_SCK	50	49	5V/8V (Future)
GND	52	51	Vcc (3.3V)
GND	54	53	Vcc (3.3V)
GND	56	55	Vcc (3.3V)
GND	58	57	Vcc (3.3V)
GND	60	59	Vcc (3.3V)

Nano Series

Drawing 3-5: Nano Series 60-pin OEM Connector Pin-out

The above drawing depicts a bottom view of the Nano Series connector. The corner pins (1, 2, 59, and 60) are printed directly upon it for convenient reference.

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

See *Appendix E* for an example schematic for interfacing to the Nano OEM module.

3.0 Hardware Description

Pin Name	No.	Description	In/ Out
Ethernet LED0,1	*1,3*	**Reserved for future Ethernet LED use.**	
NC	2,4,6,8	Reserved for factory use only.	
Vclock	5	Real time clock to wake-up the module from sleep mode. Internally pulled-up, this pin may be left floating.	I
!Bootpgm_Mode	7	Active low input signal to download firmware into the module. Pull high or leave unterminated if not being used.	I
USR_AN0	9	Analog input. *Reserved for future use.*	I
Ethernet	*10,12,14,16*	**Reserved for future Ethernet use.**	
!WAKEUP_usr	11	Active low input signal to wake-up the module from sleep mode. Internally pulled-up, this pin may be left floating.	I
!CONFIG	13	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	I
!RESET	15	Active low input will reset module	I
Vbat	17	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
RSMode	19	Sleep mode indication output. Active high.	O
Control RxD	18	Diagnostics receive data. Logic level output from Nano Series to a PC.	O
Control TxD	20	Diagnostics transmit data. Logic level input from a PC into the Nano Series.	I
USB_DDM	*21*	**Reserved for future USB**	
USB_CNX	*23*	**Reserved for future USB**	
USB_DPP	*25*	**Reserved for future USB**	
Reserved	25,29,31,33	Reserved for future use.	
LED_RX	22	Active high output indicates receive and synchronization status. Can drive LED directly. Refer to section 3.4.2 for additional information about LED operation.	O
LED_TX	24	Active high output indicates module is transmitting data over the RF channel. Can drive LED directly. Refer to section 3.4.2 for additional information about LED operation.	O
RSSI3_LED	26	Receive Signal Strength Indicator 3. Active high, can drive LED directly. Refer to *Section 3.4.2.1 Table 3-6: LED Operation* for additional information about LED operation.	O
RSSI2_LED	28	Receive Signal Strength Indicator 2. Active high, can drive LED directly. Refer to *Section 3.4.2.1 Table 3-6: LED Operation* for additional information about LED operation.	O
RSSI1_LED	30	Receive Signal Strength Indicator 1. Active high, can drive LED directly. Refer to *Section 3.4.2.1 Table 3-6: LED Operation* for additional information about LED operation.	O

Table 3-1: Nano Series Pin-Out Description

3.0 Hardware Description

Pin Name	No.	Description	In/ Out
RSSI2_LED	28	Receive Signal Strength Indicator 2. Active high, can drive LED directly. Refer to Section 3.4.2 for additional information about LED operation.	O
RSSI1_LED	30	Receive Signal Strength Indicator 1. Active high, can drive LED directly. Refer to Section 3.4.2 for additional information about LED operation.	O
Serial CTS	32	Clear To Send. Active low output.	O
Serial RTS	34	Request To Send. Active low input.	I
Serial DSR	36	Data Set Ready. Active low output. Could be used to drive Transmitter Enable on RS-485 driver.	O
Serial RING	38	Ring indicator for RS-232. Active low output. This signal/pin could be used to drive Receive Enable on RS-485 driver.	O
Serial DTR	40	Data Terminal Ready. Active low input.	I
Serial TxD	42	Transmit Data. Logic level input into the modem.	I
Serial RxD	44	Receive Data. Logic level output from the modem.	O
Serial DCD	46	Data Carrier Detect. Active low output.	O
USR_1/PPS	35	System status indicator.	O
USR_2	37	*Reserved for future use.*	O
USR_3	39	*Reserved for future use.*	O
Mode Line	41	*Reserved for future use.*	
5V/8V	43,45,47, 49	*Reserved for future use.*	
Reserved	48	*Reserved for future use.*	
USR_SCK	50	User Synchronization Clock. Required for high speed data transfer in the Nano Turbo.	I
Vcc	51,53,55, 57,59	Positive voltage supply voltage for the module (3.3V).	I
GND	52,54,56, 58,60	Ground reference for logic, radio, and I/O pins.	

Table 3-1: Nano Series Pin-Out Description (continued)

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

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

3.0 Hardware Description

3.2 High Speed Interface

The special high speed interface is used for the communication between the user device and the Turbo version of the Nano Series. This interface is a high speed clocked synchronous channel that supports serial data to and from a modem. The Nano acts as a slave and the user's device acts as the master, meaning the user's device **must** supply the clock signal. The important feature of this interface is the use of hardware handshaking.

User's device **must** supply the clock signal while RING is low.

Pin Name	No.	Description	In/ Out
Serial RxD	44	Serial data from modem to user device	O
Serial TxD	42	Serial data to modem from user device	I
USR_SCK	50	Clock signal from user device to modem	I
CTS	32	Clear To Send. Used for handshaking purposes.	O
RING	38	Signal used for the initiation of data transfer from modem to user device.	O

Table 3-2: Nano Turbo High Speed Interface Signals

Technical Specifications	
Type of serial channel	Clocked synchronous
Modem's serial mode	Slave
Type of data communication	Packets
Maximum data packet size	1558 bytes
Maximum serial link rate	Up to 3.2 Mbps*
Delay from bit transition to the rising edge of clock	Less than 1/2 clock period

Table 3-3: Nano Turbo High Speed Interface Technical Specifications

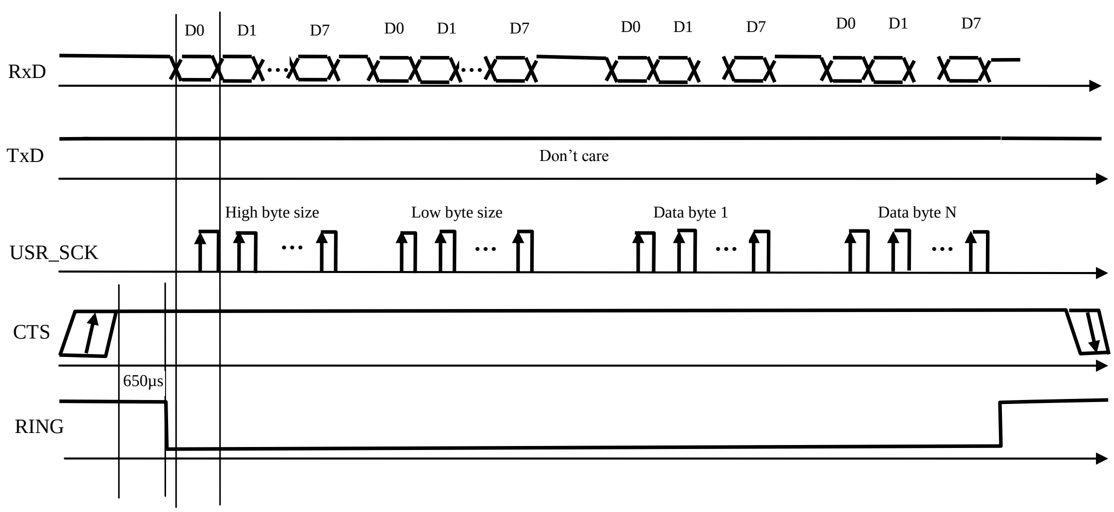
On the following pages, timing diagrams show examples of the flow of data between a users device and the Nano Series.

3.0 Hardware Description

3.2.1 Data Transfer — Modem to User Device

When the modem has data to transmit to the user it makes CTS high (if it was low), then transitions RING low and waits for the clock. It is possible that while CTS is low the user may have just started sending the clock signal to the modem and the modem didn't have time to detect it. Due to this potential conflict when we make CTS high, about 650 µs is required to detect if there was transmission in progress. If, after waiting 650 µs the modem doesn't report any bytes received the modem is reconfigured in transmit mode, loads the message and transitions RING low. The user is required to start sending clock but there is no requirement on a delay between RING going low and the clock. When the modem gets enough clocks to output all data we make RING go high, free the buffer, switch to receive mode and once ready, make CTS low for the new cycle. Once RING is high, the user must stop sending the clock within 100 µs.

The modem sends a data packet, where the first two bytes represent a packet size: the first byte is a high byte; the next byte is a low byte. The packet size can't be zero and can't exceed 1558.



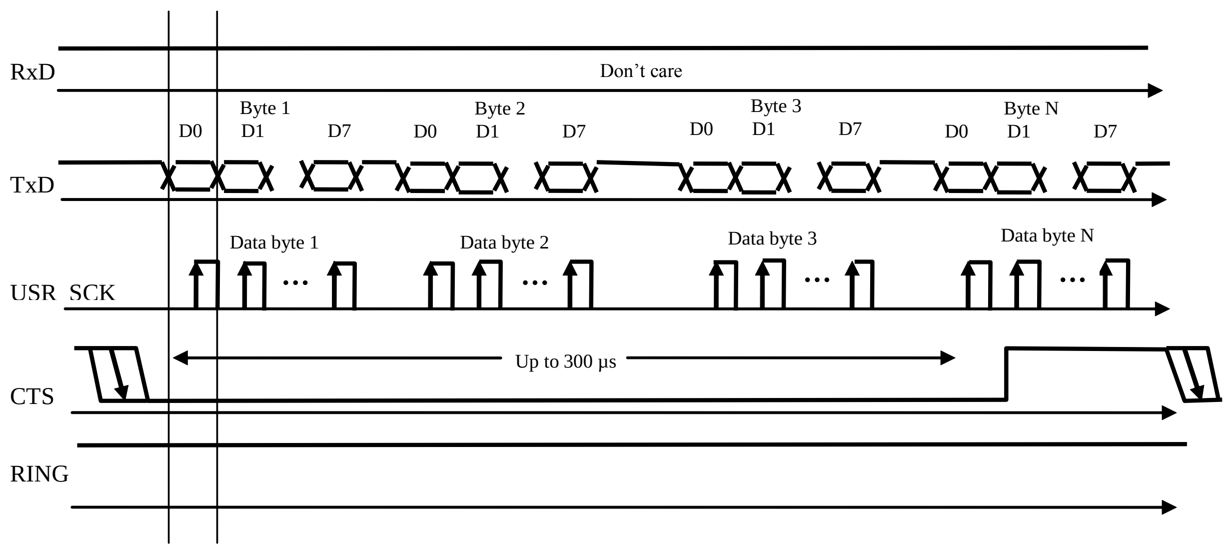
Drawing 3-6: Data transfer from Nano Series to user device

3.0 Hardware Description

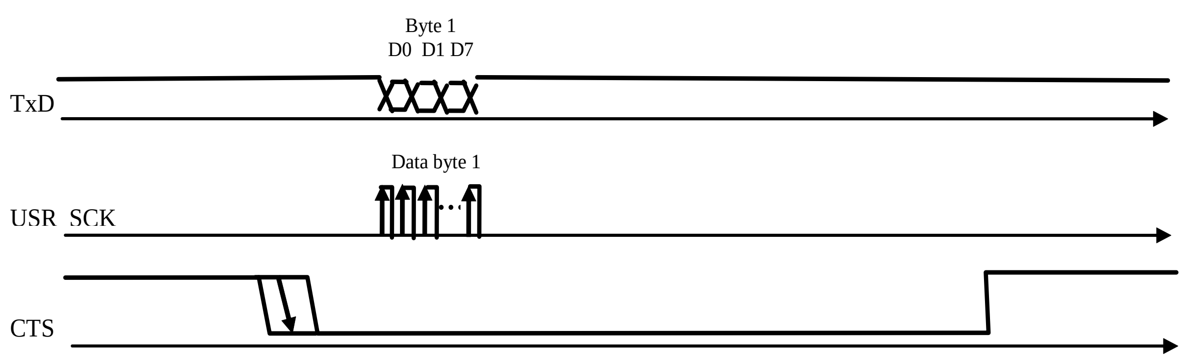
3.2.2 Data Transfer — User Device to modem

When the user has data to send to a modem it must have sensed the falling edge of the CTS line, and the CTS line must currently be low. At this point the modem is configured in receive mode and waits for the user to start the clock signal and begin data transfer from the user device to the Modem. The modem will set the CTS signal high up to 300µs after the start of data transmission.

User's device must supply the clock signal (USR_SCK) to the modem, the bit transition should be done on the falling edge of clock and modem latched data on rising edge of clock. The size of data packet must not exceed 1558 bytes. User's device can start sending the next data packet only when the falling edge of CTS is detected and CTS is low.

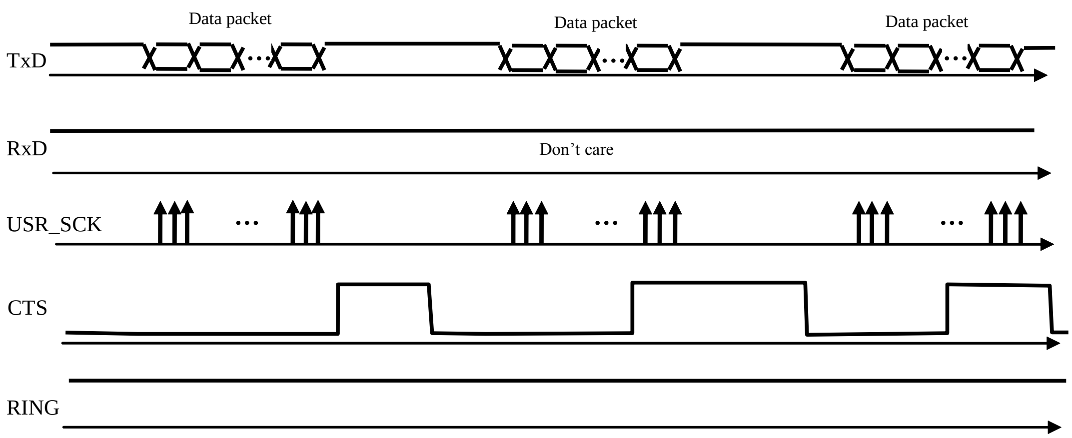


Drawing 3-7: Data transfer from user device to modem (Long Packet)

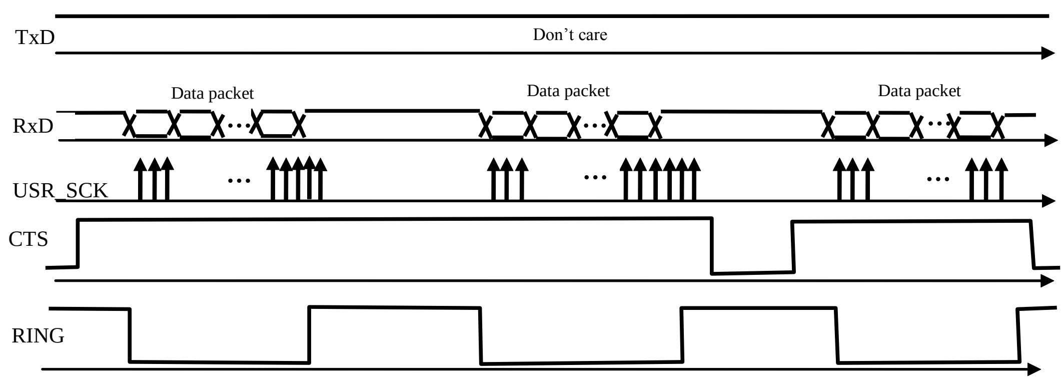


Drawing 3-8: Data transfer from user device to modem (1 Byte Packet)

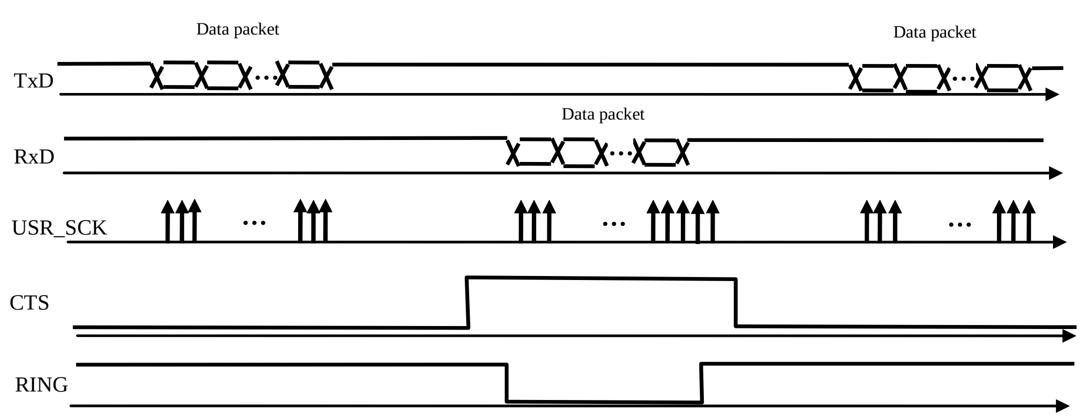
3.0 Hardware Description



a) Sequence of "User to Modem" Communication



b) Sequence of "Modem to User" Communication



c) Combined Sequence

Drawing 3-9: Data transfer between user device and Nano Series

3.0 Hardware Description

3.3 Nano Interface Card

Image 3-3: Nano Interface Card

Image 3-4: Nano Interface Card with n920 Installed

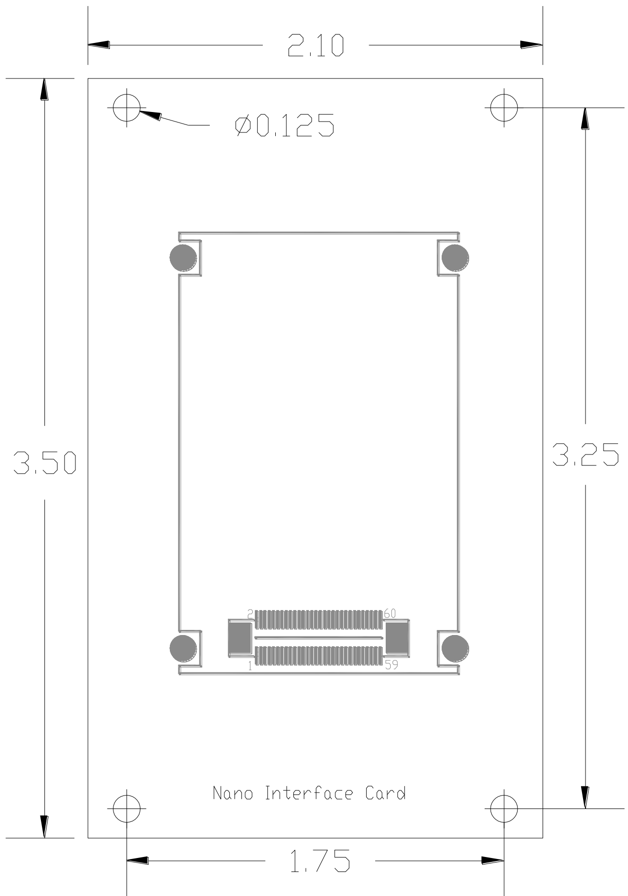
The Nano Interface Card provides a convenient adapter to work with existing MHX development boards and MHX based designs. Using the Interface Card user's can quickly condition existing MHX interface signals to work with the Nano Series. The Interface card converts 5V logic to 3.3V logic and routes the signals to MHX pin-out designations.

The Interface Card can also be used to retrofit Nano Series Modems into existing designs, as well as provide a mounting mechanism for new designs. The mechanical interface for the electrical signals is a 40-pin connector (see image above).

Being ready to deploy, the Nano Series with Interface card can minimize the development cycle time associated with building-out from the Nano OEM module alone.

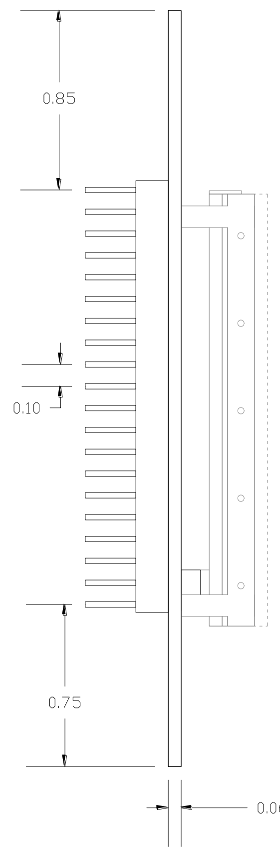
3.0 Hardware Description

3.3.1 Nano Interface Card Mechanical Drawing



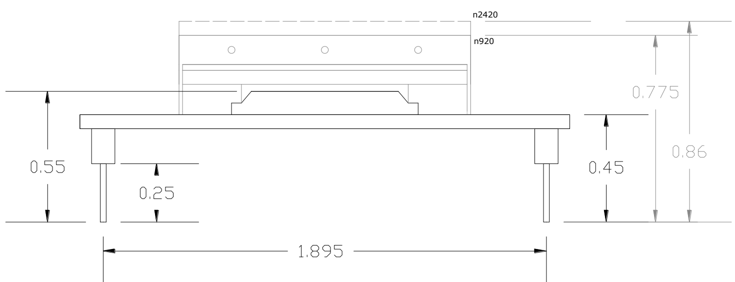
Top View

Drawing 3-10: Nano Interface Card Top View



Side View

Drawing 3-11: Nano Interface Card Side View



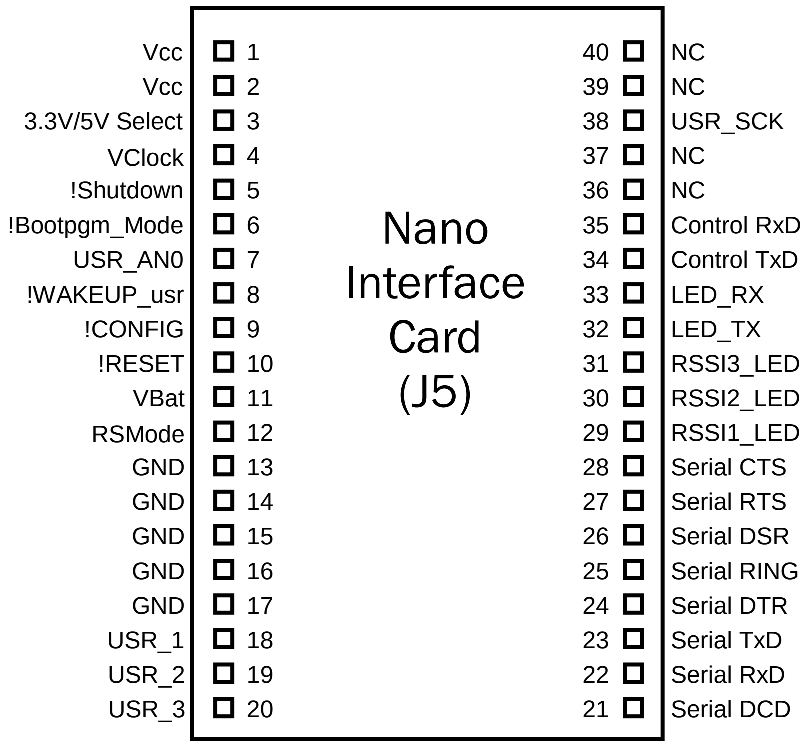
End View

Drawing 3-12: Nano Interface Card End View

Notes: The dimension unit is inches.

3.0 Hardware Description

3.3.2 Nano Interface Card Pin-Outs



Drawing 3-13: J-5 Nano Interface Card Pin-Out Description

The above drawing shows the pin-out of the 40-pin connector on the Nano interface card. It depicts a top view of the card. For easy reference the corner pins (1,20,21,40) are printed on the card.

A brief description of the various pin connections and functions is provided on the pages that follow. For additional information about the connections and functions of the various pins, refer to *Section 3.1.3: Nano Series Pin-Out Description.*

3.0 Hardware Description

Caution: For detailed pin functions see *Section 3.1.3 Nano Series Pin-Out Description*.

Pin Name	No.	Description	In/ Out
Vcc	1, 2	Positive supply voltage.	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.	I
!Shutdown	5	Input to manually shutdown the module.	I
!Bootpgm_Mode	6	Input to download firmware.	I
USR_AN0	7	Analog input. *Reserved for future use.*	I
!WAKEUP_usr	8	Input to wake-up the module from sleep mode.	I
!CONFIG	9	Input to put the module into default serial interface during power-up.	I
!RESET	10	Active low input will reset module.	I
Vbat	11	Battery voltage sensing analog input line,.	I
RSMode	12	Sleep mode indication output. Active high.	O
GND	13-17	Ground reference for logic, radio, and I/O pins.	
USR_1	18	System status indicator.	O
USR_2	19	*Reserved for future use.*	O
USR_3	20	*Reserved for future use.*	O
Serial DCD	21	Data Carrier Detect. Active low output.	O
Serial RxD	22	Receive Data. Logic level output.	O
Serial TxD	23	Transmit Data. Logic level input.	I
Serial DTR	24	Data Terminal Ready. Active low input.	I
Serial RING	25	Ring indicator for RS-232.	O
Serial DSR	26	Data Set Ready.	O
Serial RTS	27	Request To Send. Active low input.	I
Serial CTS	28	Clear To Send. Active low output.	O
RSSI1_LED	29	Receive Signal Strength Indicator 1.	O
RSSI2_LED	30	Receive Signal Strength Indicator 2.	O
RSSI3_LED	31	Receive Signal Strength Indicator 3.	O
LED_TX	32	Output indicates module is transmitting data over the RF channel.	O
LED_RX	33	Output indicates receive and synchronization status.	O
Control TxD	34	Diagnostics Tx data. Logic level Input from a PC or terminal to Nano.	I
Control RxD	35	Diagnostics Rx data. Logic level output from Nano to a PC or terminal.	O
USR_SCK	38	User Synchronization Clock. Required for high speed data transfer in the Nano Turbo.	I
N/C	36,37, 39,40	Reserved for factory use only.	

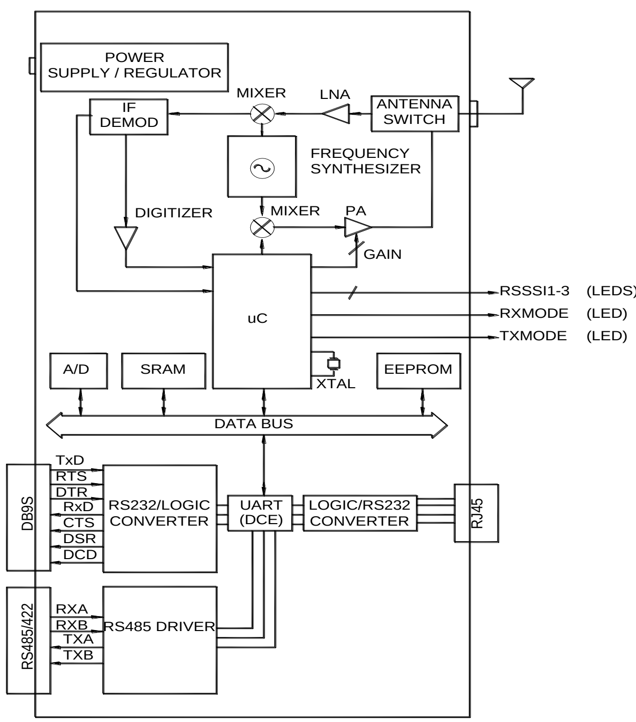
Table 3-4: Nano Interface Card Pin-Out Description

3.0 Hardware Description

3.4 MHX Development Board

The MHX Development Board can be used to evaluate the Nano Series using the Nano Interface Card as an adapter. The MHX development board can then provide a number of convenient interfaces for the Nano module:

- power
- data interfaces
- indicators
- antenna connection



Drawing 3-14: Functional Block Diagram: Nano in Development Board

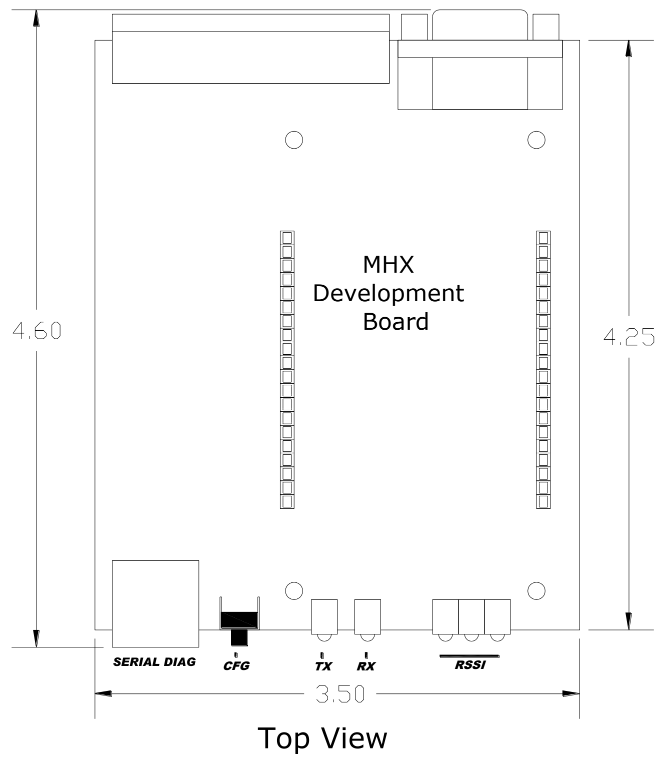
Image 3-5: MHX Development Board Front View

Image 3-6: MHX Development Rear View

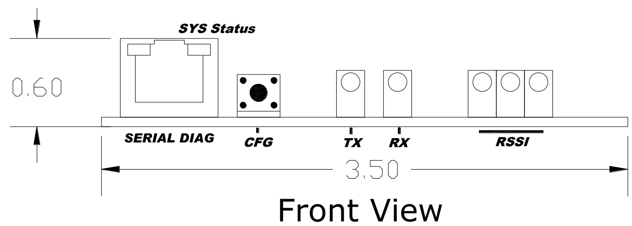
Comparing the above drawing with Drawing 3-1, the interfaces added by the MHX Development Board (described above) can be seen.

3.0 Hardware Description

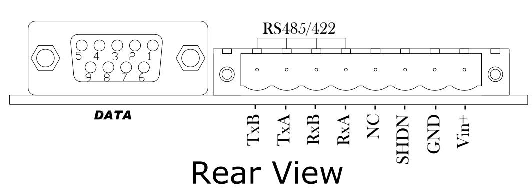
3.4.1 MHX Development Board Mechanical Drawings



Drawing 3-15: MHX Development Board Top View



Drawing 3-16: MHX Development Board Front View



Drawing 3-17: MHX Development Board Rear View

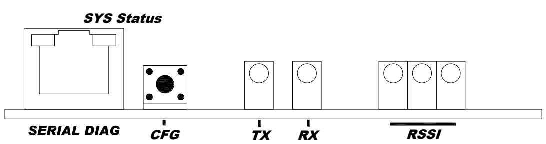
Notes: The dimension unit is inches.

3.0 Hardware Description

3.4.2 MHX Development Board Connectors & Indicators

3.4.2.1 Front

On the front of the MHX Development Board is the SERIAL DIAGNOSTICS port, CFG Button, and the SYS Status, TX, RX, RSSI LED's.



Drawing 3-18: MHX Development Board Indicators

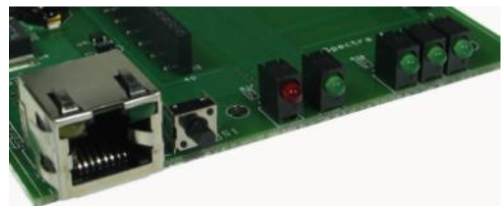


Image 3-7: MHX Development Board Indicators

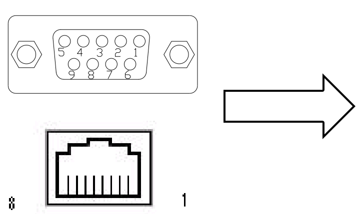
The **SERIAL DIAG (RS232)** port is used for two purposes:

- 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))

The SERIAL DIAG port is **NOT** an Ethernet port.

The SERIAL DIAG port does not support AT commands.

Caution: Nano Series "LC" versions do not support the Diagnostics Port



RJ45 Pin #	Name	MHS044000 DE9 Pin #	MHS0044010 DE9 Pin #
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 3-5: SERIAL DIAG Port Cable Pin-outs

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 Description

3.4.2 MHX Development Board Connectors & Indicators

3.4.2.1 Front (Continued)

System Status LED (Green)
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.

TX LED (Red)
When illuminated, this LED is indicating that the modem is transmitting data over the air.

RX/SYNC LED (Green)
When illuminated, this LED indicates that the modem is synchronized and has received valid packets.

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.

MODE	M/R/S	LED STATUS		
		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

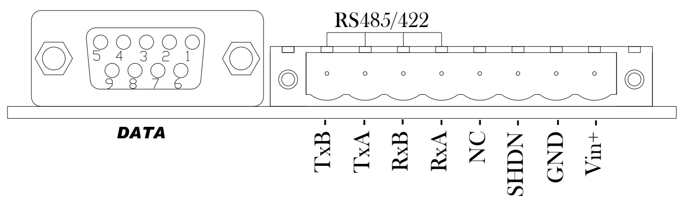
Table 3-6: LED Operation

3.0 Hardware Description

3.4.2 MHX Development Board Connectors & Indicators

3.4.2.2 Rear

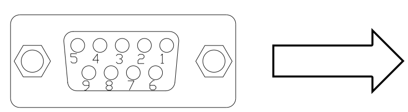
On the back of the MHX Development Board is the Data port, RS485/422 interface, as well as the power connections.



Drawing 3-19: MHX Development Board Rear View

The **DATA (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**.

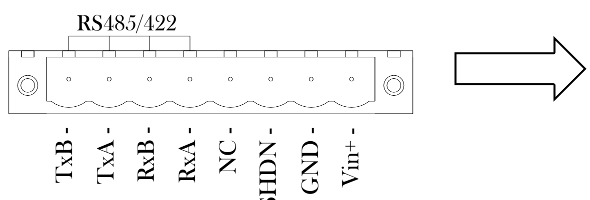


DE9S Pin #	Name	Input or Output
1	DCD	O
2	RXD	O
3	TXD	I
4	DTR	I
5	SG	
6	DSR	O
7	RTS	I
8	CTS	O
9	Not Used	

Table 3-7: RS232 Pin Assignment

The **RS422/485 Port** used to interface the MHX Development Board to a DTE with the same interface type. Either the RS232 or RS422/485 interface is used for data traffic.

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



Green Conn. Pin #	Name	Input or Output
8	TxB (D+)	O
7	TxA (D-)	O
6	RxB (R+)	I
5	RxA (R-)	I
4	Not Used	
3	SHDN*	I
2	Vin -	
1	Vin +	I

Table 3-8: Phoenix-type Connector Pin Assignment

**Grounding the SHDN pin shuts down the modem.*

3.0 Hardware Description

3.5 Nano Motherboard & Enclosed

The Nano Motherboard and Nano Enclosed share the same signals, indicators, connections and operate identically so they will be described in the same section.

The Nano Motherboard can be used to quickly evaluate the features and performance of the Nano Series Modems, or it can be integrated entirely into applications as a quick and robust interface to the Nano Modems. The Nano Motherboard operates directly with the Nano, and does not require use of the Interface Card.

The Nano Enclosed provides a fully enclosed, stand alone modem, requiring only cabled connections. The Nano Enclosed can be used on a table top like surface, or using the mounting holes provided can be mounted anywhere for a permanent solution.

- Power
- Data Interfaces
- Indicators
- Antenna

Nano Motherboard

Image 3-8: Nano Motherboard Front View

Image 3-9: Nano Motherboard Rear View

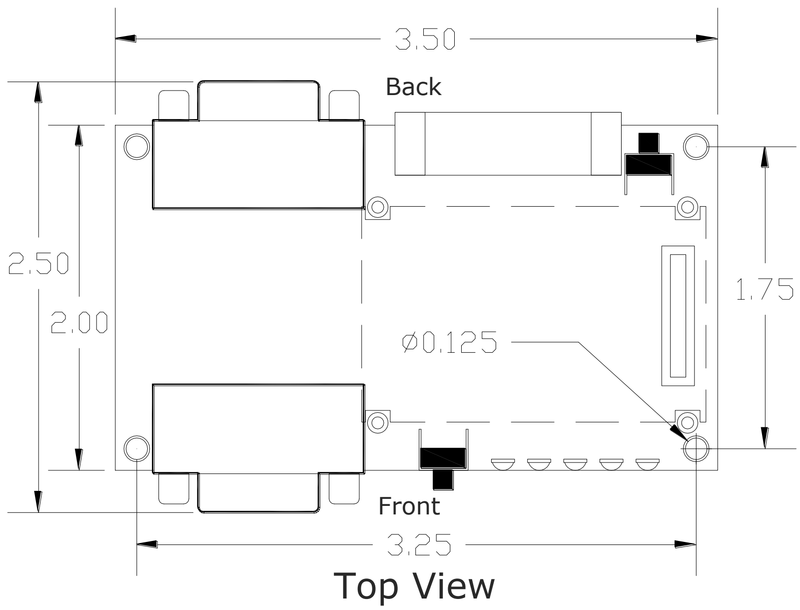
Nano Enclosed

Image 3-10: Nano Enclosed Front View

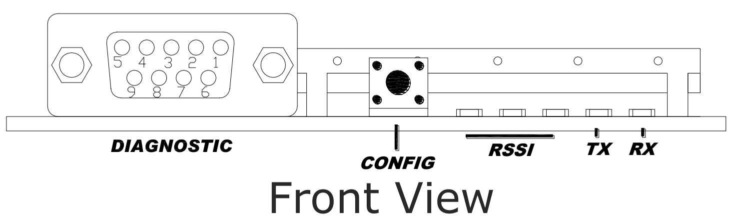
Image 3-11: Nano Enclosed Rear View

3.0 Hardware Description

3.5.1 Nano Motherboard Dimensional Drawings



Drawing 3-20: Nano Motherboard Top View



Drawing 3-21: Nano Motherboard Front View

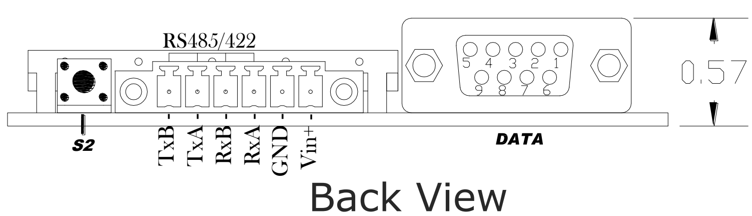
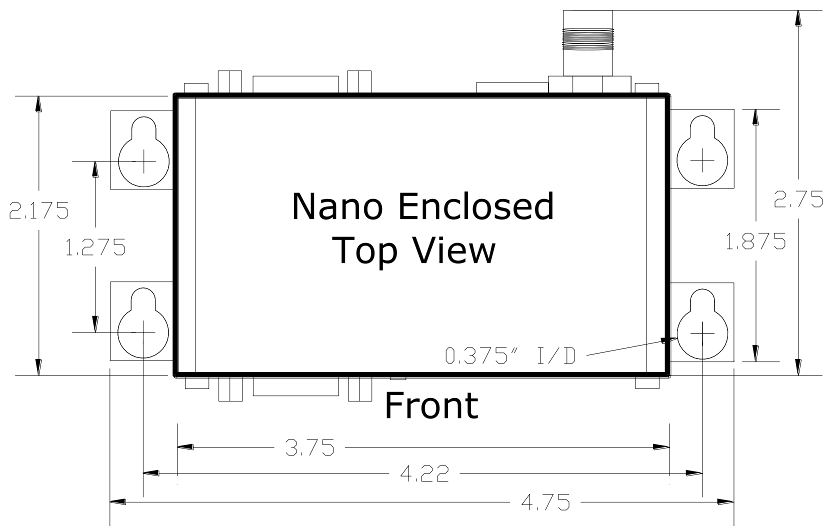


Image 3-22: Nano Motherboard Back View

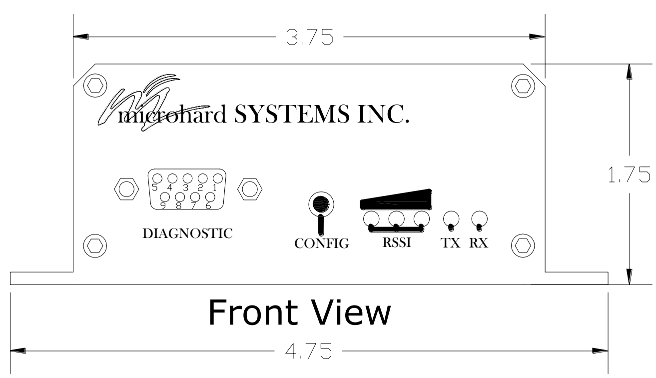
Notes: The dimension unit is inches.

3.0 Hardware Description

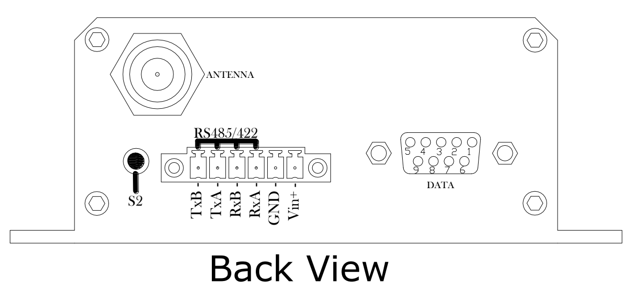
3.5.2 Nano Enclosed Dimensional Drawings



Drawing 3-23: Nano Enclosed Top View



Drawing 3-24: Nano Enclosed Front View



Drawing 3-25: Nano Enclosed Back View

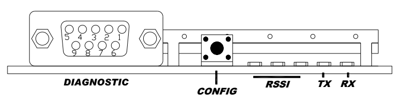
Notes: The dimension unit is inches.

3.0 Hardware Description

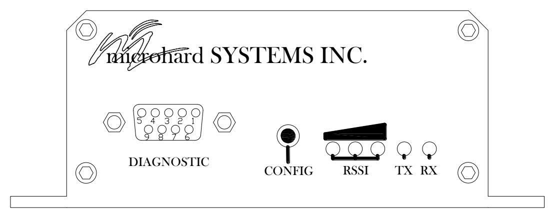
3.5.3 Connectors and Indicators

3.5.3.1 Front

On the front of the Development Board is the DIAGNOSTIC port, CONFIG Button, and the RSSI, TX and RX LED's.



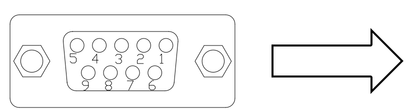
Drawing 3-26: Nano Motherboard Front View



Drawing 3-27: Nano Enclosed Front View

The **Diagnostic** port (RS232) is used for two purposes:

- online diagnostics and configuration at 115.2kbps.
- firmware upgrades



Signal Name	PIN #	Input or Output
DCD		
RXD	2	O
TXD	3	I
DTR		
SG	5	
DSR		
RTS		
CTS		

Table 3-9: Diagnostic Port RS232 Pin Assignment

Refer to *Section 3.4.2.1 Table 3-6: LED Operation* for more information on LED behavior.

CONFIG Button
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.

TX LED (Red)
When illuminated, this LED indicates that the modem is transmitting data over the air.

RX/SYNC LED (Green)
When illuminated, this LED indicates that the modem is synchronized and has received valid packets.

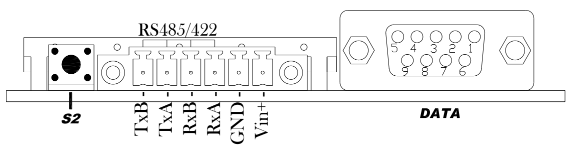
Receive Signal Strength Indicator (RSSI) (3x Green)
As the received signal strength increases, starting with the furthest left, the number of active RSSI LEDs increases. Signal strength is calculated based on the last four valid received packets with correct CRC. RSSI is also reported in S123.

3.0 Hardware Description

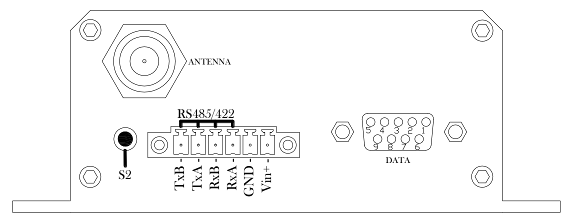
3.5.3 Connectors and Indicators

3.5.3.2 Rear

On the back of the Development Board is the Data port, RS485/422 interface, as well as the power connections.



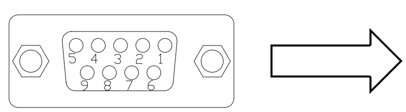
Drawing 3-28: Nano Motherboard Rear View



Drawing 3-29: Nano Enclosed Rear View

The **DATA (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**.



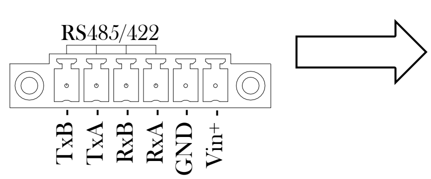
Name	Data Port	Input or Output
DCD	1	O
RXD	2	O
TXD	3	I
DTR	4	I
SG	5	
DSR	6	O
RTS	7	I
CTS	8	O
RING	9	O

Table 3-10: Data RS232 Pin Assignment

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

The **RS422/485 Port** is used to interface the Nano Development Board to a DTE with the same interface type. Either the RS232 or RS422/485 interface is used for data traffic.

Vin+/Vin– is used to power the unit. The input Voltage range is 9-30 Vdc.



Green Conn. Pin No.	Name	Input or Output
6	TxB (D+)	O
5	TxA (D-)	O
4	RxB (R+)	I
3	RxA (R-)	I
2	Vin -	
1	Vin +	I

Table 3-10: Data RS422/485 / Vin Pin Assignment

4.0 Operating Modes

4.1 Command Mode

In this mode:

- the Nano 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 Nano Interface Card's Pin 18: USR_1 System Status Indicator output. The Nano Motherboard is not equipped with this LED.
- the Nano'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 Nano - installed in a Development Board or in a Nano Motherboard - into command mode:

1. Force to Command Mode

- power off the Development Board or Motherboard assembly
- connect a 9-pin straight-through serial cable from PC COM port to the 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 CFG/CONFIG button (S1 on front of unit)
- continue to press the CFG/CONFIG button and apply power to the modem
- release the CFG/CONFIG button
- observe the front of the Development Board: only the small green LED should be illuminated, indicating that the Nano is in Command Mode.

2. Escape from Data Mode

- with the Nano 'online', connect a 9-pin straight-through serial cable from PC COM port to the rear RS-232 port
- launch a terminal communications program (e.g. HyperTerminal) and configure for the Nano'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 Nano 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 Nano 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 Nano 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.

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:

- 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

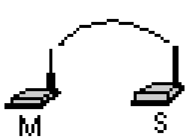
Settings (S) register S133 configures the modem for the 'Network Type' within which it will be participating.

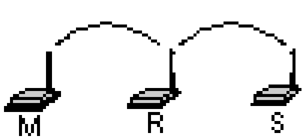
5.1 Point-to-Point (PTP)

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

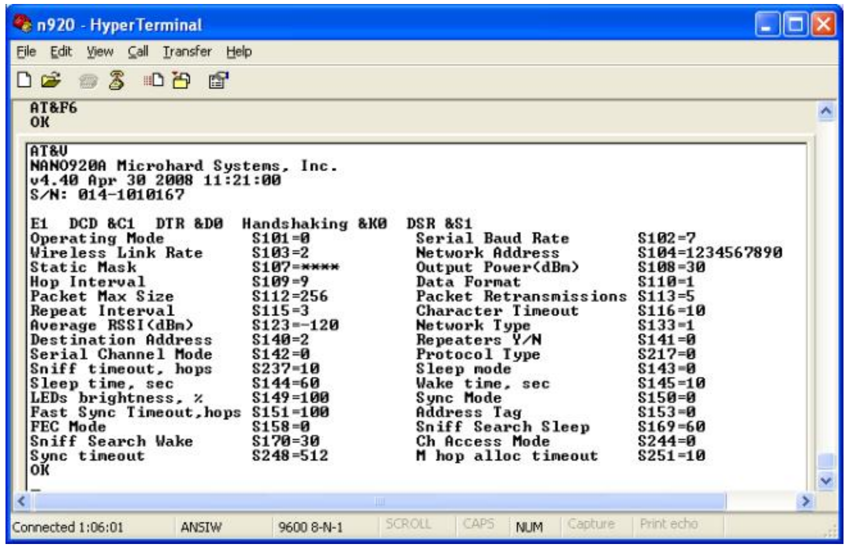


Image 5-1: &F6 PTP Master Configuration View

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.

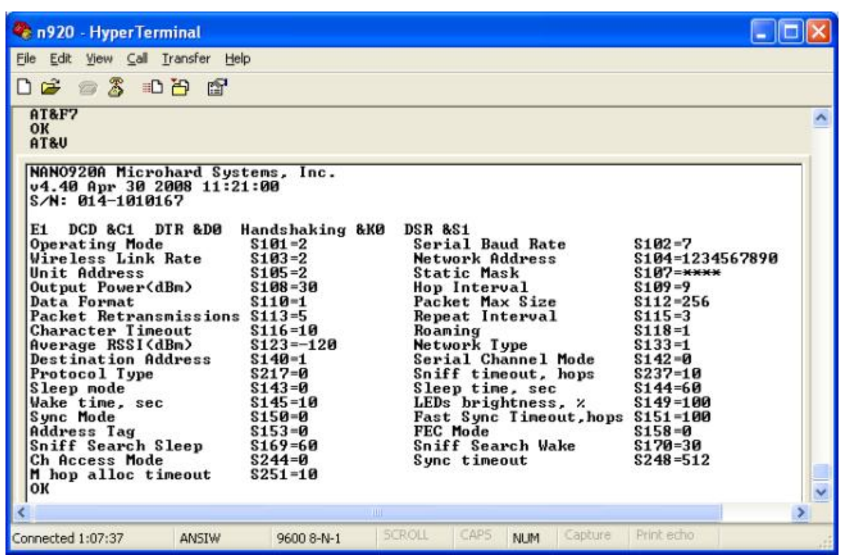
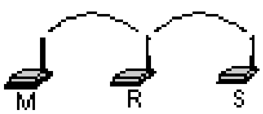


Image 5-2: &F7 PTP Slave Configuration View

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

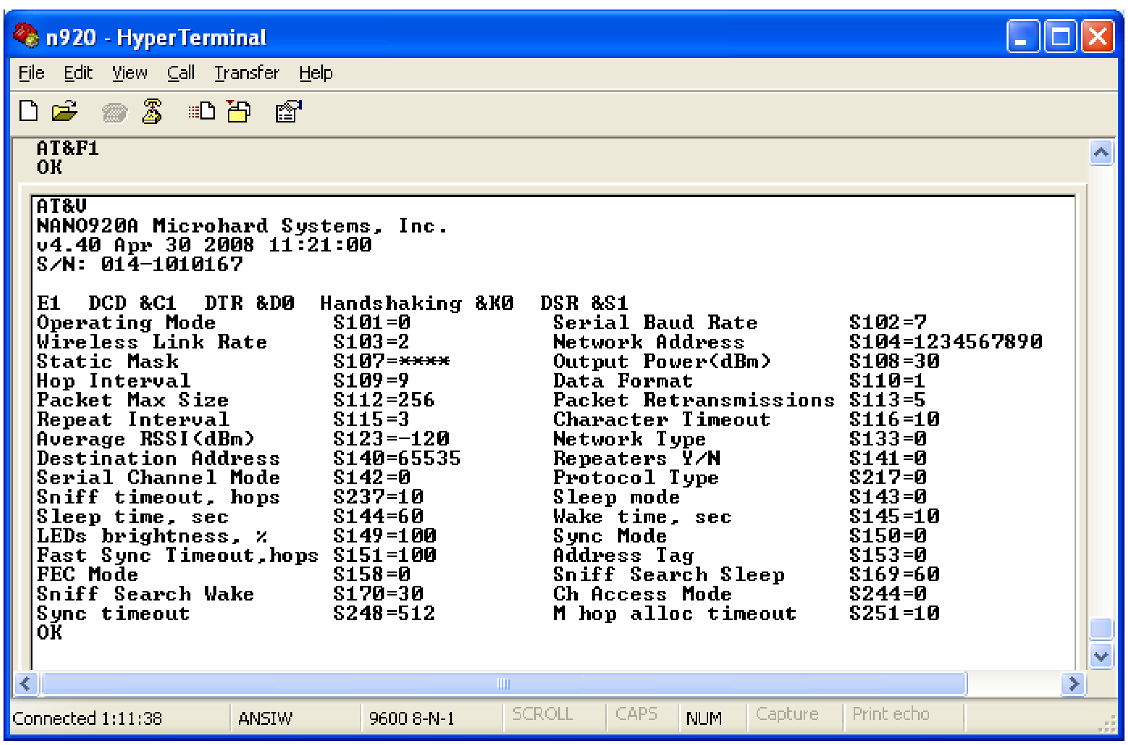


Image 5-3: &F1 PMP Master Configuration View

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

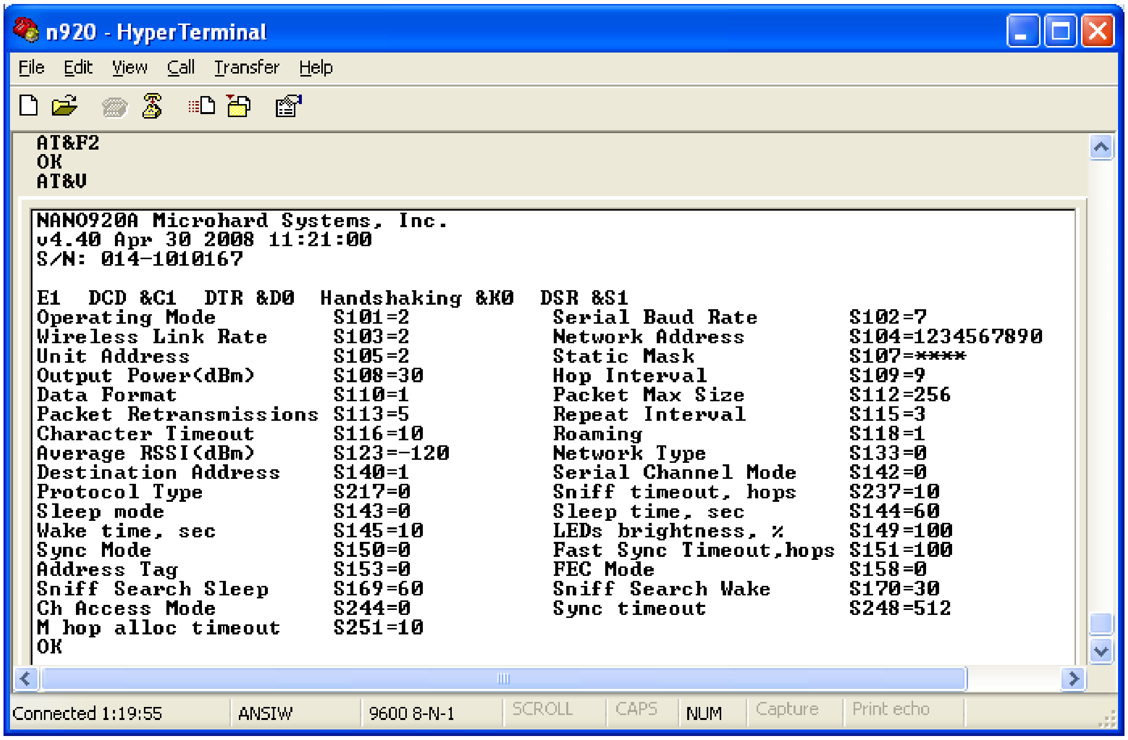


Image 5-4: &F2 PMP Slave Configuration View

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 (Standard TDMA)

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

In Standard TDMA mode, a list of remote units is configured in the Master modem, the Master unit then cycles through the list and indicates to the remote when it is able to transmit its data. The remote unit would then begin sending data, if it had data to send, and then release the channel when no longer needed. This would indicate to the master unit to queue the next unit and so on.

In this mode each slave unit has the channel or right to broadcast, for varying lengths of time, and if a remote did not respond, the Master would need to time out before moving on to the next unit in the list. The maximum number of Remotes which can communicate with a Master in this configuration is 2^{13} (8192).

To configure a Standard 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. (Must be set on Master and all Slaves)

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 used to populate, view and change the Registered Slaves List:

- T? view entire Registered Slaves List
- T*n*=*UA* enter a Slave's Unit Address (UA) into the Registered Slave's List item number *n,* where *n*=0-8191, and *UA* = 0-65534 (selecting a UA value of 0 terminates the list)
- T*n*? view Registered Slaves List entry number *n,* where *n*=0-8191. Response is UA of List entry

The default Registered Slaves list consists of 8192 entries (0-8191), populated with Unit Addresses of 2 thru 8193 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 all of its data 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 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

5.2.2 Adaptive TDMA

Adaptive TDMA allows for the list of slaves to be populated and changed automatically and is ideal for systems that are changing constantly (i.e mobile applications). In Adaptive TDMA the user does not create or enter the TDMA list, when the system is first initialized the master will accept channel requests from slaves and begin to create a TDMA slave list.

As in Standard TDMA mode, the Master modem will sequence through a list of remotes allowing each one, in turn, to transmit its data. If a slave is not in the list, or misses its turn to send it data it will send a channel request to the Master at the end of the current TDMA cycle, where the master will accept requests for a specified number of hops. Once the Master radio hears the request, the unit is added to the list for the next TDMA cycle. On the other hand, if a slave is assigned a channel and it does not respond it begins to age and unless it begins to respond it will be removed from the TDMA list.

To configure an Adaptive 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
- S234 Master Channel Request Timeout (1-254)
- S235 Routing Time to Live (1-255)

For Adaptive TDMA, set S244=4. (Must be set on the Master and all Slaves).

The Master Channel Request Timeout register S234 determines how many hop intervals the Master waits for channel requests at the end of each TDMA cycle and allows slaves to submit channel requests. A large value for S234 adds overhead to the end of each TDMA cycle, so ideally this should be kept fairly short, however, in very large systems, a too short of a time will mean making populating the initial TDMA list take many TDMA cycles.

Register S235 defines the aging process of slave units (i.e going out of range, turned off etc) and removal from the TDMA list. S235 is an index from 1-65535. If set for 65535, the unit will never be removed from the list. Otherwise the index begins a countdown that is decremented by the Master at regular intervals when a slave is not responsive. Once data, any data, is received by the Master, this index is reset. If the Index reaches 0, the slave unit will be removed from the TDMA list. If the slave comes back to life (i.e. comes back into range), it can request a channel at the end of the TDMA frame and be added to the list once again.

The AT&R1 command can be issued on the Master to view the current TDMA table. The Master unit is always present in the TDMA list as unit address 1.

5.0 Network Topologies

5.2.3 GPS Indexed TDMA (ADHOC)

For GPS applications, GPS TDMA may be an ideal operating mode for some customers. Unlike other types of TDMA, GPS TDMA doesn't use master units to synchronize and maintain timing of the network. In a traditional system if there was a problem with the Master the entire system would be inoperable, so by not using a master, system survivability is increased. Data can be broadcast to all units within range, or to specific units defined by the destination address of each unit.

In GPS TDMA all units are connected to an external GPS unit that provides a 1PPS timing signal to radio (Contact Microhard Systems for specifications of GPS signal and input into radio). The entire TDMA frame is then exactly 1 second. The 1 second frame is then divided into time slots and units are addressed in such a way that the unit address equals the time slot in which they can transmit data. The number of slaves supported is defined by the hop interval (register S109) as follows:

Hop Interval (S109)	# of Time Slots	# of Slaves
200ms	5	5
100ms	10	10
50ms	20	20
25ms	40	40
20ms	50	50
10ms	100	100
5ms	200	200

Table 5-1: GPS Indexed TDMA Time Slots

The valid address range for units is defined by the total number of supported unit as seen in the table above. In the case where the hop interval is configured as 20ms, 50 units can be supported, the address range is from 1 to 50. The unit address determines which time slot the unit is assigned. For example, unit 7, is assigned time slot 7. The unit can then determine when after the 1PPS from the GPS unit it can begin to send data, and for how long (20ms).

To configure an GPS Indexed TDMA, the default settings described in 5.2 are applicable, with the exception that the following registers (ref. Section 6.2) on all units must be modified as required:

- S244 Channel Request Mode

For GPS TDMA, set S244=3.

5.0 Network Topologies

5.2.4 Fast TDMA

A special version of TDMA, 'Fast TDMA' has been designed to minimize the TDMA cycle for systems with large numbers of remote units, while maintaining the opportunity for each unit to be able to transit its data. Fast TDMA is intended to sequence as many slaves as possible in the shortest amount of time possible. It is based on the following diagram:

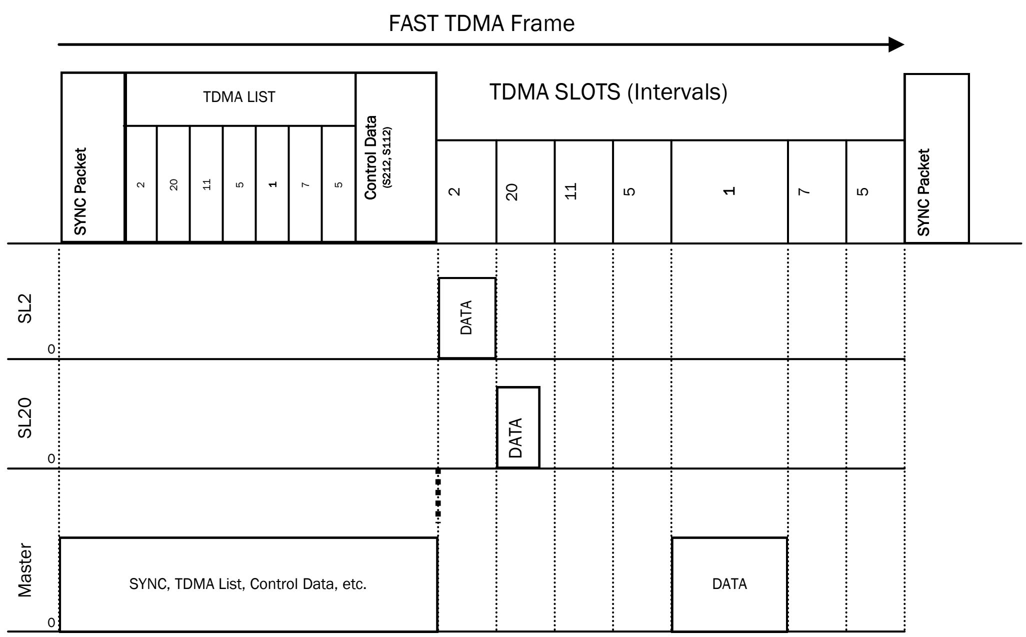


Figure 1: Fast TDMA Operation & Timing

At the start of a Fast TDMA Frame, the Master unit sends information to all the units in the TDMA network. Included in this information is:

1) ***SYNC Packet*** - used for system synchronization.

2) ***TDMA Table/List*** - This is the list of all the addresses of all the remote units in the network, as well as the order, and frequency in which they are to transmit data. Unit addresses can be listed in any order, and can be listed multiple times to reduce latency. The Master unit can be included in the table as unit address 1 if data is required to be transmitted from the master to the remote units.

   The TDMA Cycle/period depends on the size of the TDMA table. The current TDMA table used for Fast TDMA operation is limited to 2048 entries. (128 entries are saved in non-volatile memory and the rest of the entries must be re-entered every time on power up)

3) ***Control Data*** - Various control data such as the value of the Master units S212 register (Max Expected Packet Size), and the Masters S112 register (Max Packet Size).

5.0 Network Topologies

Sending this data to the remote units is important for the operation and timing of Fast TDMA as it uses this information to determine the slot duration, and identifies to each unit when, and for how long it will be allowed to transmit data. Unlike traditional TDMA, the master unit only sends synchronization data at the very beginning of the TDMA frame. Other user data can be sent by the master unit, by assigning it a slot in the TDMA table, but at this point it acts as a remote unit, rather than a master unit.

Register 212 is used to set the expected packet size of the data received by the master, from the remote units. This register is only set in the Master unit, and defines the maximum duration, in bytes, of how long each remote unit is allowed to transmit data. The slot sizes for each remote unit is identical, and defined by the S212 register.

The slot size for the user data of the Master, is defined by the Master units S112 register, it does not have to match the slot size of the remote units (S212). As seen in Figure 1, the time slot for the Master unit (In a PMP network, the Master always has a unit address of 1), is different than the time slots for the other units.

The S112 register on the remote units is the Max Packet Size of the data transmitted to the master, it has to be equal to or less than the S212 register of the Master, as the master expects the data to only be this size, or smaller. Essentially if S112 of the remote units is larger than S212, the data will not fit into the allotted slot, and the data will be lost.

The maximum buffer size is 1580 bytes, which would limit the values of registers S112 and S212 to 1580 bytes.

The remote units (and the Master) can then use the data above to calculate, when it will be allowed to transmit data. By knowing which unit in the list, and how long the remote and master TDMA slots are, each unit in a Fast TDMA network will know precisely when to transmit its data.

If a remote misses a Master's SYNC packet the remote unit will not transmit until a new SYNC packet is received, if the remote keeps missing the sync packet for a duration longer than that defined by register S248 - Sync Timeout (in seconds), the remote will go into search mode and start looking for a master. This duration of search time can be significant as the master only sends SYNC/TDMA packets at the very start of a TDMA Frame (time depends on size of TDMA table).

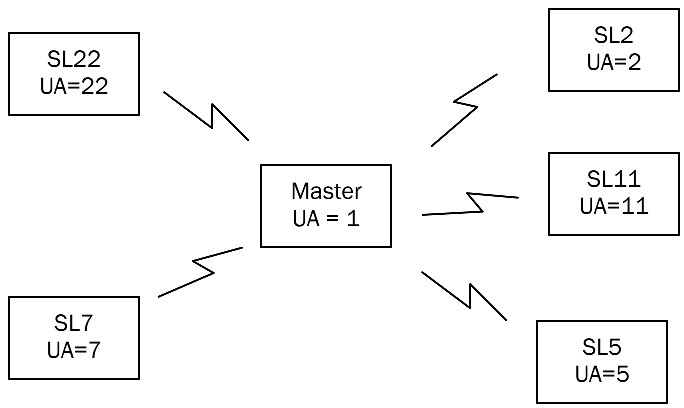
Fast TDMA assumes single packets are sent during assigned time slots, if multiple packets of varying lengths are required, it is best to assign multiple slots to ensure data overhead is taken into consideration. Contact Microhard for more information if required. Retransmissions, ACK and packet fragmentation are not used in this mode.

5.0 Network Topologies

To calculate the duration of the entire Fast TDMA Frame:

For the link rate 172kbps:
T_tdma_table(N_entries) = 2.3076 + 0.0684 * N_entries;
T_data_packet(N_bytes) = 1.9327 + 0.0673 * N_bytes;
T_total = T_tdma_table + T_data_packet_Master* N_Masters +
T_data_packet_Slave* N_Slaves, where N_Masters + N_Slaves = N_entries

For Example: You have a system with 5 remotes and 1 master as seen below:



The Master collects data from Remote 2, 11, 5, 7, and 22. Remote 5 contains GPS data, you want this data updated more frequently than the data from the other units. You also need to send correction data three times per frame to ensure accurate readings. Your TDMA table may look something like:

TDMA Table

UA,	*// Position*
1,	// 1
5,	// 2
2,	// 3
11,	// 4
1,	// 5
5,	// 6
7,	// 7
22,	// 8
1,	// 9
5,	// 10

The Max packet size of the remotes, S212 on master = 100 bytes

The Max Packet size of the Masters data to the remotes, S112 on master = 200 bytes

Using the formula given above:

T_tdma_table(10) = 2.3076 + (0.0684 * 10) = 2.9916
T_data_packet_Master(200) = 1.9327 + (0.0673 * 200) = 15.3927
T_data_packet_Slave(100) = 1.9327 + (0.0673 * 100) = 8.6627
T_total = 2.9916 + 15.3927*3 + 8.6627*7
T_total = 2.9916 + 46.1781 + 60.6389
T_total = 109.8086

We find that the entire TDMA frame will take just under 110 ms

5.0 Network Topologies

In addition to the settings required to configure a PMP network, additional registers must be set to define the Fast TDMA parameters of operation:

S244 ***Channel Request Mode*** = 2 Selects fast TDMA mode. Must be set on master and remotes.

S112 ***Packet Max Size*** - Determines the maximum data packet size of the user data from the Master, so the duration of the master data slot. It can be different for master and slaves.

S212 ***Max Expected Packet Size*** - (Set only on Master). S212 is the maximum packet size the remote units can send to the master, therefore defining the duration of the data slot for the remote units. The remote S112 register must be equal to or less than the value of the masters S212 register.

S168 ***Sniffer Mode*** - (Filter mode). This option can be used to set up Fast TDMA mode so that remotes can receive data from other remotes, not only from the master. This information could be used in systems where units could benefit from information collected by others.

Entering the TDMA Table:

ATT? View the entire registered TDMA table
ATTn=UA enter a Slave's Unit Address (UA) into the TDMA table. Where n = position in the table. Use 0 to terminate the list.
ATTn? View a specific entry on the TDMA table.

Limitations:

a) Remote diagnostics is not supported due to varying packets sizes. Contact Microhard Systems for more information on remote diagnostics. Only local diagnostics is supported in this mode.
b) Repeaters are not supported.

Factory default settings AT&F18 (Master) and AT&F19(Slaves)

AT&F18 and AT&F19 provide default settings for the Master (AT&F18) and a default slave (AT&F19). These default settings can be overwritten if needed. The values set by using these commands are as follows. Additionally, a default TDMA table is populated as listed.

Master Fast TDMA (AT&F18)

```
ATS244=2        //  Fast TDMA mode
ATS112=235      //  Master's maximum packet size.
ATS212=130      //  Maximum packet size
ATS184=150      //  Data time to live in 10ms, e.g. 1.5s
ATS232=10 //    Incoming user data limit, e.g. 10 buffers
```

5.0 Network Topologies

Slave Fast TDMA (AT&F19)

```
ATS244=2        //  Fast TDMA mode
ATS112=130      //  Slaves' maximum packet size
ATS184=150      //  Data time to live in 10ms, e.g. 1s
ATS232=10       //  Incoming user data limit, e.g. 10 buffers
ATS248=10       //  Synchronization time-out in seconds, e.g. 10s
```

If register S168 is 1 or 2 (default 0), slave receives data from everyone in the network (sniffer).

Default TDMA table for 1s polling time:

```
1, // 0
2001, // 1
2002,    // 2
2003,    // 3
2004,    // 4
2005,    // 5
2006,    // 6
2007,    // 7
2008,    // 8
2009,    // 9
2010,    // 10
2011,    // 11
2012,    // 12
2013,    // 13
2014,    // 14
2015,    // 15
2016,    // 16
2017,    // 17
2018,    // 18
2019,    // 19
1,       // 20
2020,    // 21
2021,    // 22
2022,    // 23
2023,    // 24
2024,    // 25
2025,    // 26
2026,    // 27
2027,    // 28
2028,    // 29
2029,    // 30
2030,    // 31
2031,    // 32
2032,    // 33
2033,    // 34
2034,    // 35
2035,    // 36
2036,    // 37
2037,    // 38
2038,    // 39
1,       // 40
2039,    // 41
2040,    // 42
2041,    // 43
2042,    // 44
2043,    // 45
2044,    // 46
2045,    // 47
2046,    // 48
2047,    // 49
2048,    // 50
2049,    // 51
2050,    // 52
2051,    // 53
2052,    // 54
2053,    // 55
2054,    // 56
2055,    // 57
2056,    // 58
2057,    // 59
1,       // 60
2058,    // 61
2059,    // 62
2060,    // 63
2061,    // 64
2062,    // 65
2063,    // 66
2064,    // 67
2065,    // 68
2066,    // 69
2067,    // 70
2068,    // 71
2069,    // 72
2070,    // 73
2071,    // 74
2072,    // 75
2073,    // 76
2074,    // 77
2075,    // 78
2076,    // 79
1,       // 80
2077,    // 81
2078,    // 82
2079,    // 83
2080,    // 84
2081,    // 85
2082,    // 86
2083,    // 87
2084,    // 88
2085,    // 89
2086,    // 90
2087,    // 91
2088,    // 92
2089,    // 93
2090,    // 94
0,       // 95
```

5.0 Network Topologies

5.3 Peer-to-Peer (P2P)

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:

A P2P network requires a Master modem.

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

Master

- 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

Slave 1

- 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

Slave 2

- 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)

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.

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:

Master

- 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

Slaves

- 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

6.0 Configuration

The 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 Nano:

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

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

If mounted in a MHX Development Board/Nano Interface Card combination:

- 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 (RadioNetwork).

If mounted in a Nano Motherboard:

- Rear RS-232 connector, 9-pin straight-through cable, and PC running communications program, or
- Front RS-232 connector, 9-pin straight-through cable, and PC running MHS System Diagnostics software (RadioNetwork).

Once connected and in Command Mode, changes to the Nano'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.

g, G — Spectrum Analyzer

This is a very useful feature of the Nano. 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 Nano 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
```

For the n920 Channel 1 is at 902.4MHz, with subsequent channels in 280kHz increments. Therefore, to calculate the frequency of channel *n*: Freq channel *n* = 902.4+ ((*n-1*) x 0.280)MHz. For the n2420, channel 1 is at 2401.6 MHz.

Also displayed is the average received signal strength for 5 channels above the ISM bands. This area of the spectrum is used by paging networks.

6.0 Configuration

I*n* Identification

The I command returns information about the Nano.

1 Product Code
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

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 Nano 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 905.250 908.500750 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 Nano.

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

&H0 — Frequency Restriction

By default, the Nano will hop on frequencies across the entire 900MHz and 2.4GHz ISM bands. 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.

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 902-928MHz ISM band, and then use the AT&H0 feature to configure the modem to avoid them.

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

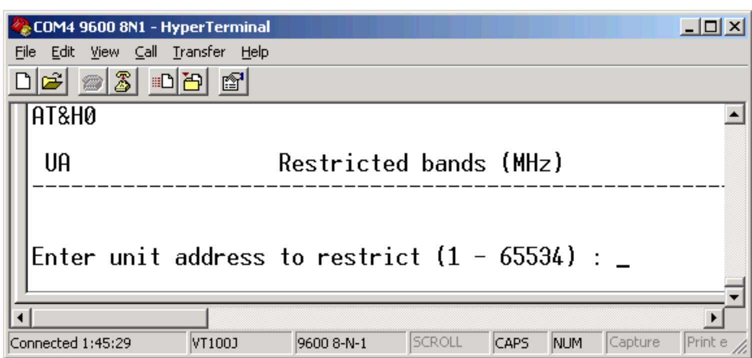


Image 6-1: Frequency Restriction

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.)

6.0 Configuration

&H0 Frequency Restriction (continued)

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

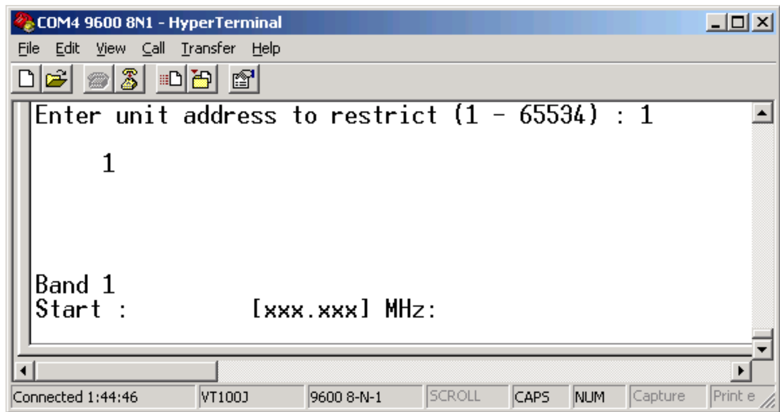


Image 6-2: Unit Address

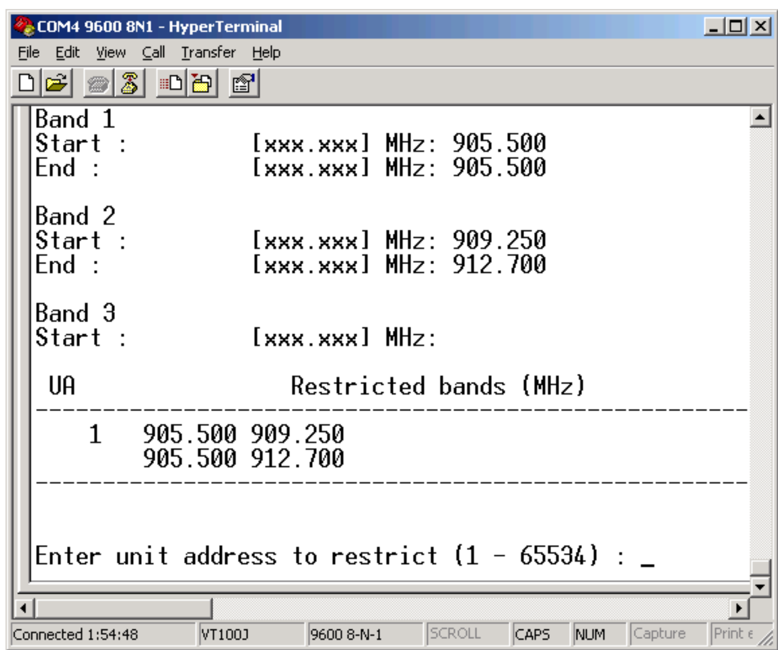


Image 6-3: Restricted Bands

905.500 was entered as the ‘start’ and ‘end’ of Band 1; this will restrict the frequency of 905.500MHz. The range of 909.250 to 912.700MHz 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. To modify an existing restriction, simply overwrite it. To remove a restriction, overwrite it with 000.000.

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

S2 Escape Code

Modification of S2 may be required when operating the Nano module via a telephone modem connection interface.

Escape character. If >127, escape feature is disabled. 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 Nano Series 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

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

S102 — Serial Baud Rate

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

Values (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**		

6.0 Configuration

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 (bps)

0 19200*
1 115200** n920LC*^
2 172800**
3 230400**
8 1.2 Mbps***

* n920 (Slow)
** n920/2420F (Fast)
*** n920/2420T (Turbo)

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.

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.

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

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.

Values (up to 16 char)

default (the word itself)

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))

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

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).

Hop Interval S109 should only be changed if recommended by Microhard Support and/or for specific applications!

S109	time (ms)	S109	time (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

Table 6-1: Hope Interval (S109) Standard Values

Values shown in Table 6-2 may not be available in all versions. Contact Microhard for more information.

S109	time (ms)	S109	time (ms)	S109	time (ms)
20	4.5	32	12	44	18.5
21	5.5	33	12.5	45	19
22	6.0	34	13	46	19.5
23	6.5	35	13.5	47	21
24	7.5	36	14	48	22
25	8.0	37	14.5	49	23
26	8.5	38	15.5	50	24
27	9.0	39	16	51	25
28	9.5	40	16.5	52	26
29	10.5	41	17	53	27
30	11	42	17.5	54	28
31	11.5	43	18	55	29

Table 6-2: Hope Interval (S109) Extended Values

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

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).

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.

Values (bytes)

1-256
255

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.

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 behaviors in various network topologies:

Values

0-255
5

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.

PTP: Modem will retransmit to its counterpart only if necessary, and to a maximum number of the value in S113.

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.

Values (Hop Intervals)

1-255
3

For a large number of remotes, 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, 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.

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, if the timer detects a gap in the data exceeding the Character Timeout value, the modem will transmit the data.

Values

1/4 Characters
0-254
10

The Nano will accumulate data in its buffers until either (a) Maximum Packet size (S112) 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 0, the modem will buffer exactly the Minimum Packet size and then transmit that data.

S118 Roaming

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

Values

65535 full roaming

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

1

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.

6.0 Configuration

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.

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

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.

Values

0 disabled
1 enabled

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

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.

Values (dBm)

-110 to –55dBm (max reading)

S130 — No Sync Intake

Defines if the modem will accept data if the remote has become unsynchronized from the Master. If set to 0, this function will be disabled and any data received will be ignored. If set to 1, the modem will accept data and buffer it until the unit is synchronized.

Values

0
1

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.

Values

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

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

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

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

S142 Serial Channel Mode

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

Values

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

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

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

When status register S143 is set to a value of 1, the unit will use the registers S144 and S145 to determine how long a unit will remain awake when idle, or if the unit has gone to sleep, how long it will sleep for.

In this mode, data will be monitored on the ***serial port*** and the ***RF link***. If no data is being transmitted or received after an amount of time specified by S145 (Wake Time), the unit will begin to sleep for the amount of time determined by register S144 (Sleep Time).

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.

If data is detected on the local serial port, the unit will immediately wake up.

For OEM models, the *!WAKEUP_usr* input (pin #8) can be used wake the unit at any time. Sleeps for S144 seconds or until the falling edge of the !WAKEUP line. The unit will stay awake for at least S145 seconds. After that the unit will go to sleep if the ! WAKEUP line is high and all data is sent.

Sleep Mode 2

This mode is similar to Sleep mode 1, except , data will be monitored ***only on the serial port***. If no data is being transmitted or received after an amount of time specified by S145 (Wake Time), the unit will begin to sleep for the amount of time determined by register S144 (Sleep Time).

Sniff Mode 1

When status register S143 is set to a value of 3, the unit will monitor all data from the ***serial*** and ***RF link***. Upon wake up, the unit will begin to try to find a master or repeater to synchronize to. The amount of time the unit tries to find a master is determined by the number of hops, rather than time. (Time can be calculated by multiplying the number of hops in S237 and the hop interval specified in register S109).

If a master is found, the unit will stay awake for at least the time specified by register S145 (Wake Time). If there is data to transmit, the unit will stay awake until all data has been transmitted. If a master or repeater is not found, the unit will go to sleep for S144 (Sleep Time) seconds. The sniffing cycle is very brief.

If data is detected on the local serial port, the unit will immediately wake up.

6.0 Configuration

S143 (Continued) — Sleep Mode

Sniff Mode 2

When status register S143 is set to a value of 4, the unit works the same way as sniff mode 1, except, the unit will monitor all data from only the ***serial port***.

Sniff Mode 3

When status register S143 is set to a value of 5, the unit works the same way as sniff mode 1 and will monitor all data from both the ***serial*** and ***RF link***. The difference is, if no master is found, all data will be discarded.

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

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
2-65535
60

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

Values

seconds
0-65535
10

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.

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

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.

Values

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

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.

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

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

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 Nano:

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 0.5, corrects 3 bits
Reed-Solomon (15,11)	:	Information rate 0.687, corrects 2 nibbles

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

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

S159 Encryption Mode (AES)

AES encryption is only available in models delivered as –AES. This is a factory configured option that can only be loaded and enabled at the factory at time of assembly. The use of AES encryption, and export laws governing AES, vary from country to country, contact Microhard Systems Inc. for more information.

AES (Advanced Encryption Standard) provides an extremely strong level of encryption for data for security of wireless data communication. The use of AES may cause slight degradation of system performance due to the processing requirements of the encoding/decoding process.

Up to three levels of AES are available, 128 bit, 192 bit and 256 bit. Only the specific options enabled by the factory will be available Once a level of AES is chosen using register S159, the encryption key must be entered. The same AES setting and encryption key must be entered on every modem in the network.

The size of the key is dependant of the level of AES:

128bit AES:	16 Byte Encryption Key
192bit AES:	24 Byte Encryption Key
256bit AES:	32 Byte Encryption Key

The encryption key can be entered in registers S107 or S177 as they share the same key array for encryption. S107 (Static Mask) is used to enter in up to 32 printable characters (ASCII). If using 128 or 192 bit AES, any character entered after 16 or 24 bytes respectively will be ignored. If less than the required number of characters is entered, 0's will be appended to fill the encryption key array.

To improve the strength of the key, S177 can be used to enter 16-32 bytes (dependant of the AES type) of binary non-printable characters. This register requires the appropriate number bytes to be entered. In other words, if you are using AES256, S177 requires 32 bytes of data to be entered. A binary file can be transferred to the modem using a terminal program after a ATS177= command has been invoked.

Values

0 No encryption
1 AES 128 bit
2 AES 192 bit
3 AES 256 bit

S177 Binary Encryption Key

When using AES encryption, S177 can be used to define the encryption key in binary. The type of AES used defines the minimum number of binary bytes that need to be entered. See S159 for more information.

Values (Binary Bytes)

16 - 32 Bytes (AES type dependant)

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.

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

S232 Maximum Buffer in Storage

This register defines the maximum number of packets sent on the user serial port that can be stored in the buffer.

Values

1-255
200

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.

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 (Standard)
2 Fast TDMA
3 GPS Indexed TDMA
4 Adaptive TDMA

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.

S248 Sync Timeout

This register defines how many hop intervals where the slave does not receive a synchronization packet from the master, before it will become unsynchronized and begins to search for a master.

Values

1-65534
512

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.

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.

&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

*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

&S*n* — 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 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:

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

Network Topology

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

Throughput

The n920/2420F 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 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 Nano Series 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 Nano Series features the maximum available transmit power combined with exceptional receive sensitivity - two 'numbers' which will produce the most favorable path calculation results.

7.0 Installation

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 Nano Series 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 900MHz and 2.4GHz frequency ranges are not effected by rain to any significant degree, and is also able to penetrate through foliage and ‘around obstacles’ to a certain degree. This being the case, some may choose to scrimp on the physical deployment, particularly when it comes to antenna (tower) heights. Path calculations provide results which specify ‘required’ antenna heights. For cost savings and in taking advantage of the characteristics of the frequency range, sometimes the height requirements are not adhered to: this may result in unreliable communications.

Power Requirements

The Nano Series may be integrated into a system (Development Board, 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 Nano Series: 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 Nano Series 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. Cavity filters are also available if required: contact Microhard Systems Inc. for further information.

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.

Assuming a path loss of 113dB for this example, the fade margin = 143-113 = 30dB.
30dB 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.

Example:

Tx power = 30dBm
Tx antenna gain = 6dBi
Tx cable/connector loss = 2dB
Rx antenna gain = 3dBi
Rx cable/connector loss = 2dB
Rx sensitivity = -108dBm

System Gain = [30+(6-2)+(3-2)+108]dB
= [30+4+1+108]dB
= 143dB.

7.0 Installation

Distance (km)	Master Height (m)	Remote Height (m)	Path Loss (dB)
5	15	2.5	116.5
5	30	2.5	110.9
8	15	2.5	124.1
8	15	5	117.7
8	15	10	105
16	15	2.5	135.3
16	15	5	128.9
16	15	10	116.2
16	30	10	109.6
16	30	5	122.4
16	30	2.5	128.8

Table 7-1: Path Loss

To satisfy FCC radio frequency (RF) exposure requirements for mobile transmitting devices, a separation distance of 23cm 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.

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.

7.2.1 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.

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

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.

7.0 Installation

Direct human contact with the antenna is potentially unhealthy when a n920 is generating RF energy. Always ensure that the n920 equipment is powered down (off) during installation.

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

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

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.

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.

7.2.2 Coaxial Cable

The following types of coaxial cable are recommended and suitable for most applications (followed by loss at 900MHz, in dB, per 100 feet):

- LMR 195 (10.7)
- LMR 400 (3.9)
- LMR 600 (2.5)

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.

7.2.3 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.

7.2.4 External Filter

Although the Nano Series is capable of filtering-out RF noise in most environments, there are circumstances that require external filtering. Paging towers and cellular base stations in close proximity to the Nano's antenna can desensitize the receiver. Microhard Systems Inc.'s external cavity filter eliminates this problem. The filter has two N-female connectors and should be connected inline at the interface to the RF equipment.

Appendix A: 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 A: 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 B: 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

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)
0-19200 (n920S)
1-115200 (n920/2420F) (n920LC)
2-*172800 (n920/2420F)
3-230400 (n920/2420F)
8-1.2Mbps (n920/2420T)

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)
1-256
*255

S113
Packet Retransmissions
0-255
*5

S115
Repeat Interval
1-255
*3

Appendix B: 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

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

Appendix C: n920 Approved Antennas

Group	Part Number	Description
Quarter Wave		
	MHS031010	<1.5dBi, 900MHz 1/4 Wave Antenna Reverse SMA Right Angle
	MHS031020	<1.5dBi, 900MHz 1/4 Wave Antenna Reverse SMA Straight
	MHS031030	<1.5dBi, 900MHz 1/4 Wave Antenna Reverse SMA Right Angle MHS
	MHS031040	<1.5dBi, 900MHz 1/4 Wave Antenna Reverse SMA Straight MHS
	MHS031050	<1.5dBi, 900MHz 1/4 Wave Antenna MCX Right Angle MHS
	MHS031060	<1.5dBi, 900MHz 1/4 Wave Antenna Reverse SMA Straight
Rubber Ducky		
	MHS031000	2dBi, 900MHz Rubber Ducky Antenna RPTNC Swivel
	MHS031070	2dBi, 900MHz Rubber Ducky Antenna Reverse SMA Swivel
	MHS031080	2dBi, 900MHz Rubber Ducky Antenna Reverse SMA Straight
Transit Antennas		
	MHS031210	3dBd, 900 MHz Transit Antenna with Ground Plane
	MHS031220	3dBd, 900MHz Transit Antenna No Ground Plane
	MHS031230	3dBd, 900MHz Transit Antenna Permanent Mount GP
	MHS031240	3dBd, 900MHz Transit Antenna Permanent Mount NGP
		Mounts for Transit Antennas have a RPTNC Pigtail
Yagi Antennas		
	MHS031311	6dBd, 900MHz Yagi Directional Antenna Antenex, RPTNC Pigtail
	MHS031431	6.5dBd, 900MHz Yagi Directional Antenna Bluewave, RPTNC Pigtail
	MHS031501	9dBd, 900MHz Yagi Directional Antenna Antenex, RPTNC Pigtail
	MHS031441	10dBd, 900 MHz Yagi Directional Antenna Bluewave, RPTNC Pigtail
	MHS031451	11dBd, 900 MHz Yagi Directional Antenna Bluewave, RPTNC Pigtail
	MHS031401	12dBd, 900MHz Yagi Directional Antenna Antenex, RPTNC Pigtail
	MHS031411	12dBd, 900MHz Yagi Directional Antenna Bluewave, RPTNC Pigtail
Patch Antennas		
	MHS031440	8dBi, 900 MHz, Patch Antenna, RPTNC Pigtail
	MHS031430	12.5dBi, 900 MHz Patch Antenna, RPTNC Pigtail
Omni Directional		
	MHS031251	3dBd, 900MHz Omni Directional Antenna Antenex, RPTNC Pigtail
	MHS031461	3dBd, 900 MHz Omni Directional Antenna Bluewave, RPTNC Pigtail
	MHS031321	6dBd, 900MHz Omni Directional Antenna Antenex, RPTNC Pigtail
	MHS031471	6dBd, 900 MHz Omni Directional Antenna Bluewave, RPTNC Pigtail

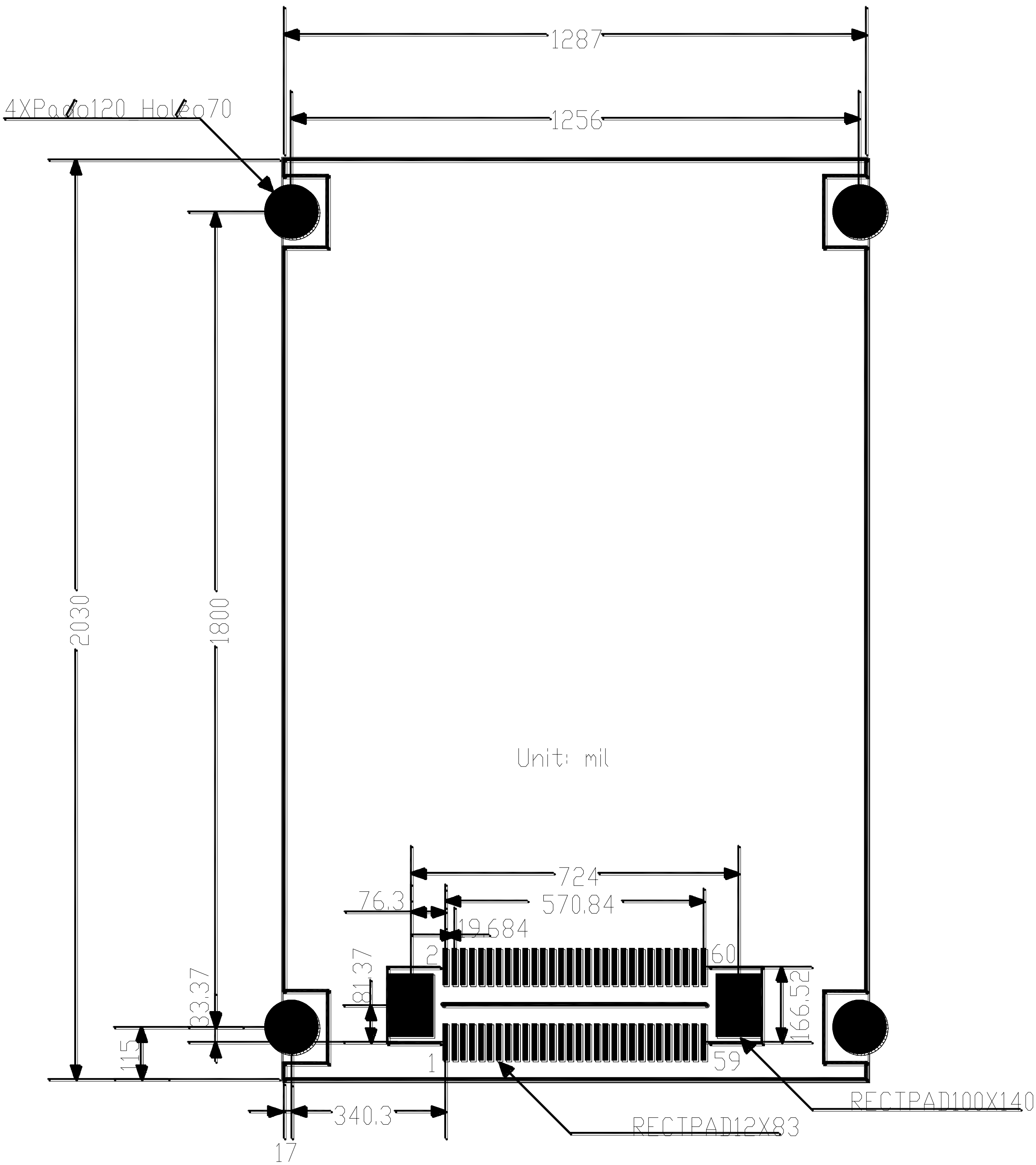
WARNING: ***Changes or modifications not expressly approved by Microhard Systems Inc. could void the user's authority to operate the equipment. This device has been tested with MCX and Reverse Polarity SMA connectors with the antennas listed in Appendix C. When integrated in OEM products, fixed antennas 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). Please Contact Microhard Systems Inc. if you need more information.***

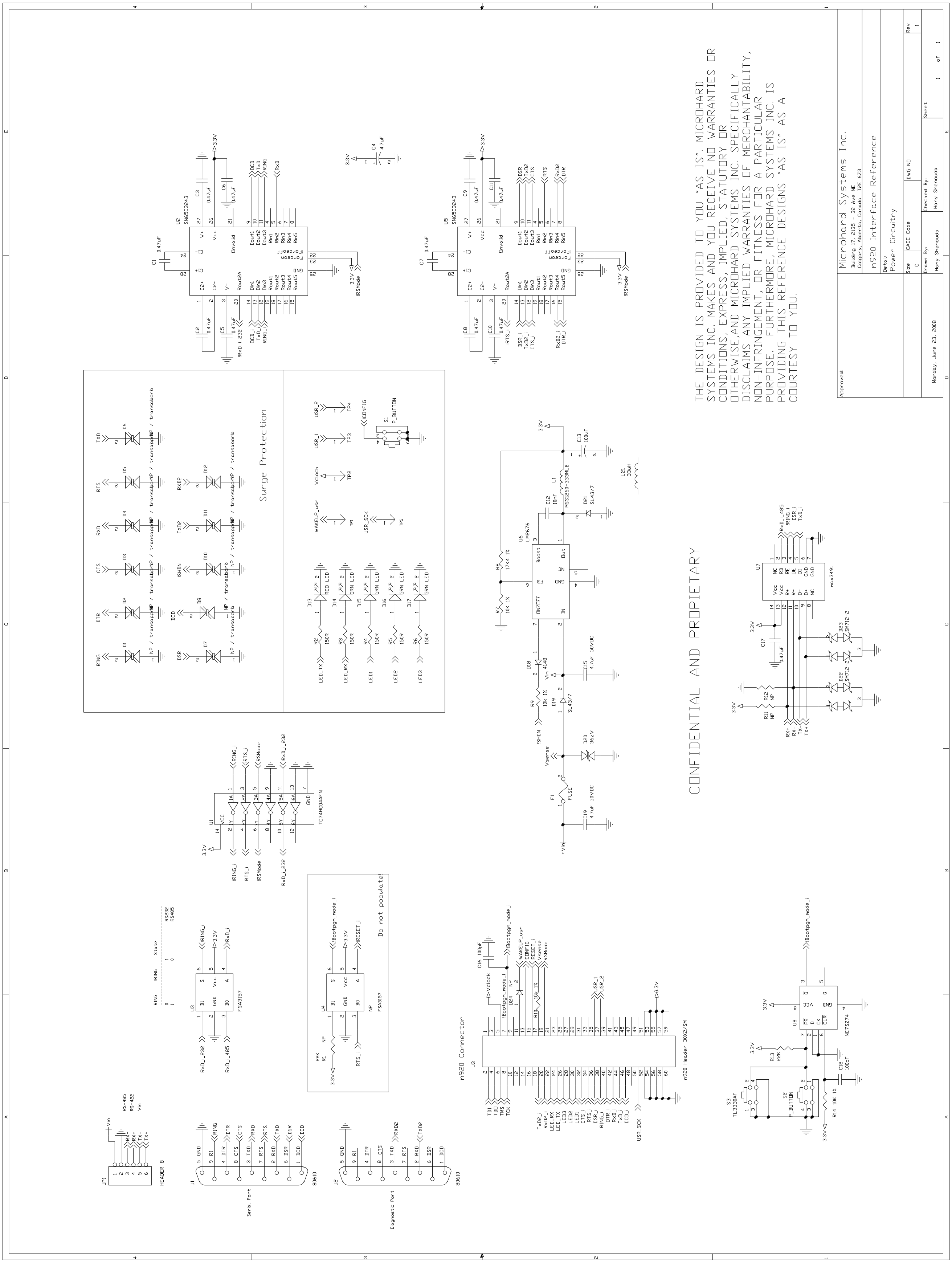
Appendix D: n2420 Approved Antennas

Group	Part Number	Description
Rubber Ducky		
	MHS031100	2dBi, 2.4GHz Rubber Ducky Antenna RPTNC Swivel
	MHS031110	2dBi, 2.4GHz Rubber Ducky Antenna Reverse SMA Swivel
	MHS031120	2dBi, 2.4GHz Rubber Ducky Antenna Reverse SMA Straight
Yagi Antennas		
	MHS034100	9 dBi, 2.4GHz Yagi Directional Antenna RPTNC Pigtail
	MHS034110	12 dBi, 2.4GHz Yagi Directional Antenna RPTNC Pigtail
	MHS034120	14 dBi, 2.4GHz Yagi Directional Antenna RPTNC Pigtail
	MHS034150	14.5 dBi, 2.4GHz Yagi Directional Antenna RPTNC Pigtail
Patch Antennas		
	MHS034200	8 dBi, 2.4GHz Mini Flat Patch Directional Antenna RPTNC Pigtail
	MHS034210	14 dBi, 2.4GHz Flat Patch Directional Antenna RPTNC Pigtail
Omni Directional		
	MHS031260	5 dBi, Omni Directional Antenna RPTNC Pigtail
	MHS034000	6 dBi, 2.4GHz Omni Directional Antenna RPTNC Pigtail
	MHS031340	8 dBi, Omni Directional Antenna RPTNC Pigtail
	MHS034020	10.5 dBi, 2.4GHz Omni Directional Antenna RPTNC Pigtail
	MHS034030	12 dBi, 2.4GHz Omni Directional Antenna RPTNC Pigtail
	MHS034040	15 dBi, 2.4GHz Omni Directional Antenna RPTNC Pigtail

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 D. 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). Please Contact Microhard Systems Inc. if you need more information.***

Appendix E: n920/n2420 Layout Footprint

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CONFIDENTIAL AND PROPIETARY
Surge Protection
n920 Connector
Serial Port
Diagnostic Port
Do not populate
Microhard Systems Inc.
n920 Interface Reference
Power Circuitry
Monday, June 23, 2008

Appendix G: Development Board Serial Interface

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 n920 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 n920.

RX *Receive Data* - Output from Module - Signals transferred from the n920 are received by the DTE via RX.

TX *Transmit Data* - Input to Module - Signals are transmitted from the DTE via TX to the n920.

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.

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.

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

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 H: RS-485 Wiring

The n920 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.

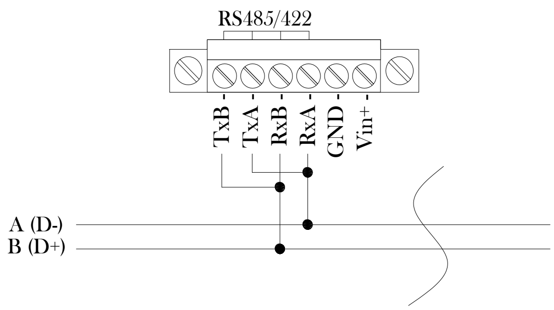

Figure J1: 2-wire RS-485 Configuration

2-wire RS-485

Figure J1 shows a typical two-wire configuration for an RS-485 connection to a n920. 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.

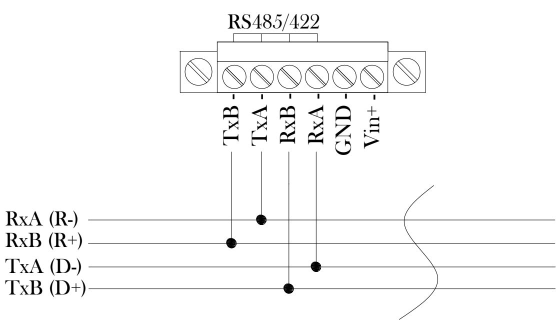

Figure J2: 4-wire RS-485 Configuration

4-wire RS-485

A n920 can also be connected into a RS-485 network in a four-wire fashion as shown in Figure J2. 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.

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