Operating Manual

Pico Series P2400

Miniature 2.4 GHz Wireless Mode (OEM & Enclosed Models)

Document: Pico Series P2400 Operating Manual.v1.0.5
Firmware: v1.014

Important User Information

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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 simplify or enhance device usage.

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

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Important User Information (continued)

P2400 Regulatory Requirements

⚠️ *WARNING:*

To satisfy FCC/IC RF exposure requirements for mobile transmitting devices, a separation distance of 25 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

⚠️ *WARNING:*

Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

⚠️ *WARNING:*

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 UFL to Reverse Polarity SMA connectors with the antennas listed in Appendix A When integrated in OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the tables must be tested to comply with FCC Section 15.203 (unique antenna connectors) and Section 15.247 (emissions).

⚠️ *WARNING:*

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

⚠️ *WARNING:*

EQUIPMENT LABELING
The FCC and IC numbers depend on the model of the radio module. Do NOT use the Marketing Name of the product but the Model to distinguish the Certifications Numbers. 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.

⚠️ *WARNING:*

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:
(1) This device may not cause interference; and (2) This device must accept any interference, including interference that may cause undesired operation of the device.

SAMPLE LABEL REQUIREMENT for Model: p2400:   Japan MIC p2400:

Ⓡ **210-114971**

> **Contains:**
> **FCCID: NS9P2400   IC: 3143A-14P2400**

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.

Important User Information (continued)

⚠️ *WARNING:*

Pour satisfaire aux exigences de la FCC/IC d'exposition RF pour la base et mobiles sur une distance de séparation de 25 cm ou plus doit être maintenue entre l'antenne de cet appareil et des personnes lors de fonctionnement du dispositif. Pour assurer la conformité des opérations au plus près que cette distance n'est pas recommandée. L'antenne utilisée pour ce transmetteur ne doit pas être co-localisés en conjonction avec toute autre antenne ou transmetteur.

⚠️ *WARNING:*

Son fonctionnement est soumis aux deux conditions suivantes : (1) ce dispositif ne doit pas causer d'interférences nuisibles et (2) cet appareil doit accepter toute interférence reçue, incluant les interférences qui peuvent provoquer un fonctionnement indésirable .

⚠️ *WARNING:*

Les changements ou modifications non expressément approuvés par Microhard Systems Inc. pourraient annuler l'autorité de l'utilisateur à utiliser l'équipement . Ce dispositif a été testé avec MCX et connecteurs SMA à polarité inverse sur les antennes répertoriées à l'annexe A Lorsqu'il est intégré dans les produits OEM , antennes fixes nécessitent une installation empêchant les utilisateurs finaux de les remplacer par des antennes non approuvées . Antennes ne figurant pas dans les tableaux doivent être testés pour se conformer à la Section 15.203 (connecteurs d'antenne uniques) et à la Section 15.247 (émissions) .

⚠️ *WARNING:*

MAXIMUM PIRE
Règlement FCC permettent jusqu'à 36 dBm puissance isotrope rayonnée équivalente (PIRE) . Par conséquent, la somme de la puissance émise (en dBm), la perte de câblage et le gain d'antenne ne peut pas dépasser 36 dBm.

⚠️ *WARNING:*

ÉQUIPEMENT DE MARQUAGE
Les numéros FCC et IC dépendent du modèle du module radio . Ne pas utiliser le nom marketing du produit, mais le modèle de distinguer les numéros Certifications . Ce dispositif a été approuvé de façon modulaire . Le fabricant , nom du produit, et les identificateurs de la FCC et d'Industrie Canada de ce produit doivent figurer sur l'étiquette à l'extérieur de l'équipement de l'utilisateur final .

⚠️ *WARNING:*

Cet appareil est conforme aux CNR exempts de licence d'Industrie Canada . Son fonctionnement est soumis aux deux conditions suivantes : (1) Ce dispositif ne peut causer des interférences ; et (2) Ce dispositif doit accepter toute interférence , y compris les interférences qui peuvent causer un mauvais fonctionnement de l'appareil.

L'EXEMPLE D'ÉTIQUETTE: **Japan MIC p2400:**

Contains:
FCCID: NS9P2400   IC: 3143A-P2400

Cet appareil est conforme à la partie 15 des règles de la FCC. Son fonctionnement est soumis aux deux conditions suivantes : (1) ce dispositif ne doit pas causer d'interférences nuisibles et (2) cet appareil doit accepter toute interférence reçue, incluant les interférences qui peuvent provoquer un fonctionnement indésirable .

®210-114971

Revision History

Revision	Description	Initials	Date
1.0	First Release	PEH	December 2016
1.0.1	Added notes to RS485 setup on P2400-ENC	PEH	June 2017
1.0.2	Added Japan MIC Certification Number	PEH	March 2018
1.0.3	Updated antenna list	PEH	Aug 2019
1.0.4	Removed Cavity Filter	PEH	Sept 2019
1.0.5	Added solder stencil thickness (0.15mm)	PEH	Sept 2020

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Appendices

1.0 Overview

The Pico Series P2400 is capable of delivering high-performance, robust and secure wireless serial communications in Point to Point or Point to Multipoint topologies.

The Pico Series is available as a tightly integrated OEM module, for the ultimate in design integration. When properly configured and installed, long range communications at very high speeds can be achieved.

Pico P2400 Series modules are a 2.4 GHz Frequency Hopping modem, providing flexible wireless data transfer between most equipment types which employ a serial interface. The modem type of the module is software selectable using AT commands.

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

1.1 Performance Features

• SCADA	• remote monitoring	• robotics
• remote telemetry	• fleet management	• display signs
• traffic control	• GPS	• railway signaling
• industrial controls	• metering	

Key performance features of the Pico Series P2400 include:

- 2.4 GHz ISM[1] Band Frequency Hopping Operation

- up to 1W of output power (adjustable)

- transparent, low latency link rates up to 345 kbps

- communicates with virtually all serial based devices

- wide temperature specification

- 32 bits of CRC, selectable retransmission and forward error correction

- separate diagnostics port - remote diagnostics and online network control

- ease of installation and configuration - the P2400 utilizes a subset of standard AT-style commands, similar to those used by traditional telephone line modems

- 3.3V logic level compatibility

[1]2.400-2.4835 GHz, which is license-free within North America; may need to be factory-configured differently for some countries, contact Microhard Systems Inc. for details.

1.0 Overview

1.2 Pico Series P2400 Specifications

Electrical/General

Supported Frequency:	2.400 - 2.4835 GHz
Spreading Method:	Frequency Hopping, DTS
Error Detection:	32 bits of CRC, ARQ
Data Encryption: (Optional)	128-bit AES Encryption (Requires export permit outside US and Canada.)
Forward Error Correction:	Hamming, BCH, Golay, Reed-Solomon, Viterbi
Range:	Up to 30 miles (50km)
Output Power:	Up to 1W (20-30dBm, adjustable)
Sensitivity:	See Table 1-1
Link Rate:	19.2 to 345 kbps
Serial Baud Rate:	300 to 230.4 kbps
Core Voltage:	OEM: 3.6VDC is required for 1W ENC: 7-30 VDC
Power Consumption: (3.3VDC)	Sleep: < 1mA (Future) Idle: 20mA Rx: 45mA to 98mA Tx Peak: 2A
Rejection:	Adjacent Channel @ 2400 MHz: 57dB Alternate Channel @ 2400 MHz: 65dB

⚠️

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

Environmental

Operation Temperature:	-40°F(-40°C) to 185°F(85°C)
Humidity:	5% to 95% non-condensing

Mechanical

Dimensions:	OEM: 26.5mm X 33mm X 3.5mm ENC: 57mm X 95mm X 38mm	
Weight:	OEM: 5 grams ENC: 120 grams	
Connectors:	Antenna:	OEM: UFL ENC: RP-SMA
	Data:	OEM: 80 Pin/Pad SMT ENC: DB9

1.0 Overview

1.2 Pico Series P2400 Specifications

Rate (kbps)	Power	Sensitivity (dBm)	Bandwidth (kHz)	Regulatory
19.2	1W	-116	25	FCC/IC
56	1W	-113	60	FCC/IC
115.2	1W	-109	150	FCC/IC
172.8	1W	-108	180	FCC/IC
230.4	1W	-106	230	FCC/IC
276.4	1W	-105	400	FCC/IC
345	1W	-103	400	FCC/IC
19.2	100mW	-115	25	FCC/IC/CE
56	100mW	-110	60	FCC/IC/CE
115.2	100mW	-109	150	FCC/IC/CE
172.8	100mW	-108	180	FCC/IC/CE
230.4	100mW	-106	230	FCC/IC/CE
276.4	100mW	-105	400	FCC/IC/CE
345	100mW	-103	400	FCC/IC/CE

Table 1-1: P2400 Specifications

2.0 Hardware Description

The Pico Series P2400 Modems are available as OEM modules. This 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 Microhard development board can provide a convenient evaluation platform to test and design with the module. (Contact Microhard Systems for details)

Any P2400 Series module may be configured as a Master, Repeater or Remote in a PTP or PMP Topology. 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.

Image 2-1: Pico P2400 Top View
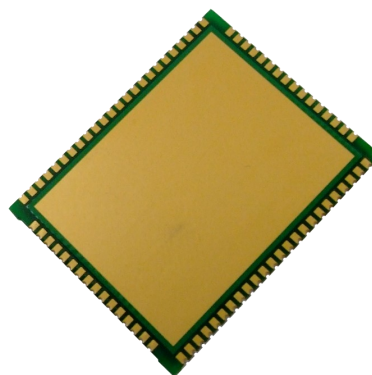
Image 2-2: Pico P2400 Bottom View

2.0 Hardware Description

2.1 Mechanical Drawings

The P2400 OEM Modules have an extremely small form factor as seen in *Drawing 3-3 below*.
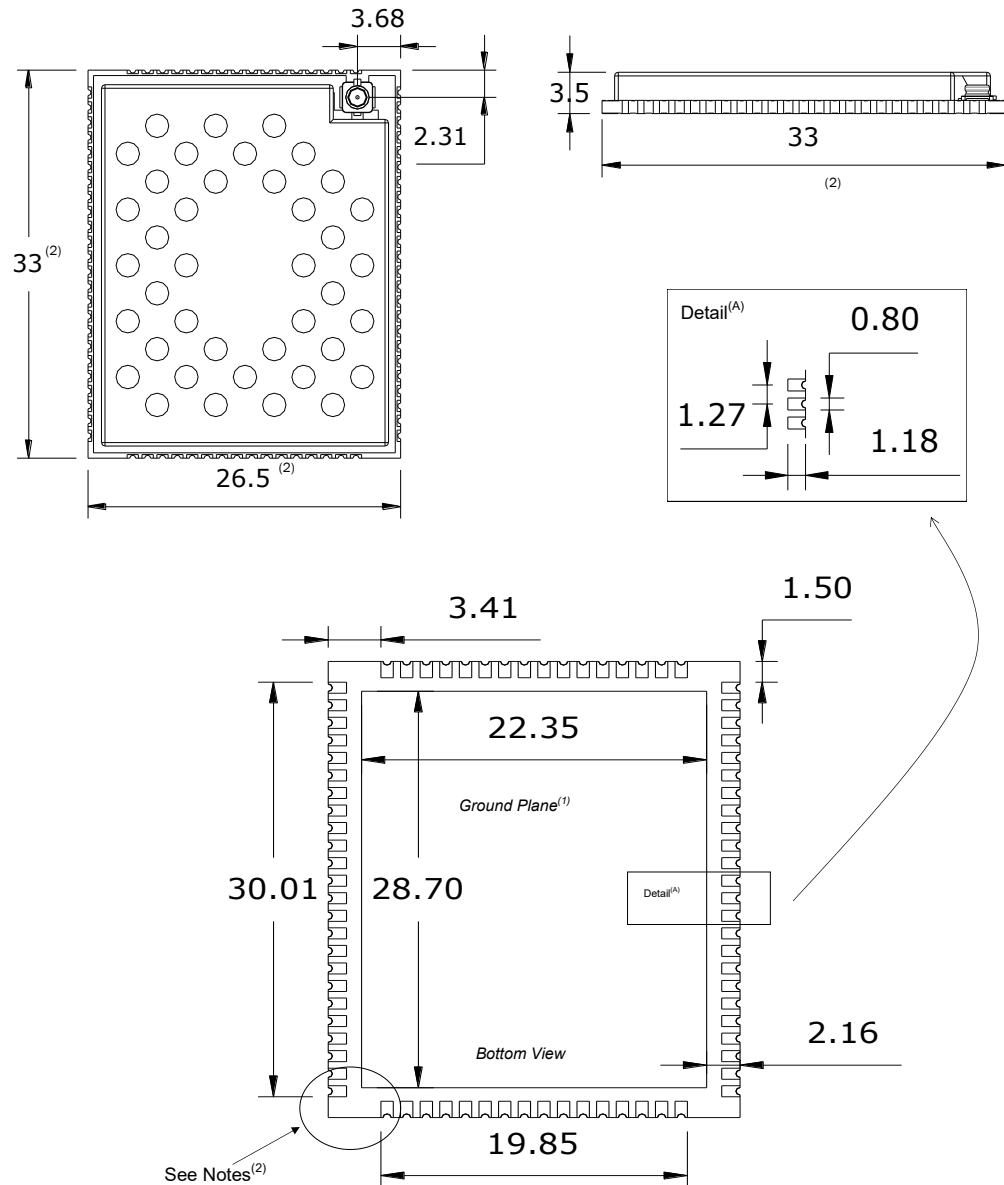
Units: millimeters

1. Ground plane must be connected to GND for required heat dissipation.
2. Due to manufacturing methods additional PCB material may be present on the corners that cannot be removed. Designs should allow for a small tolerance of this additional material, ± 0.25mm

Drawing 2-1: P2400 OEM Mechanical

2.0 Hardware Description

2.1.1 Recommended Solder Mask (Pad Landing)

Units: millimeters

Detail(B)

0.81

1.27

1.83
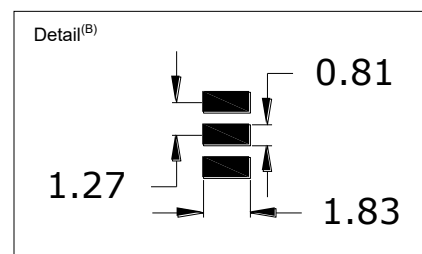
Drawing 2-2: P2400 Recommended Solder Mask

2.0 Hardware Description

2.1.2 Recommended Solder Paste Pattern

Units: millimeters
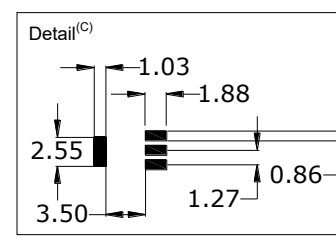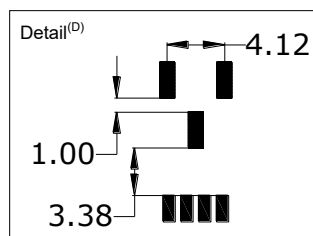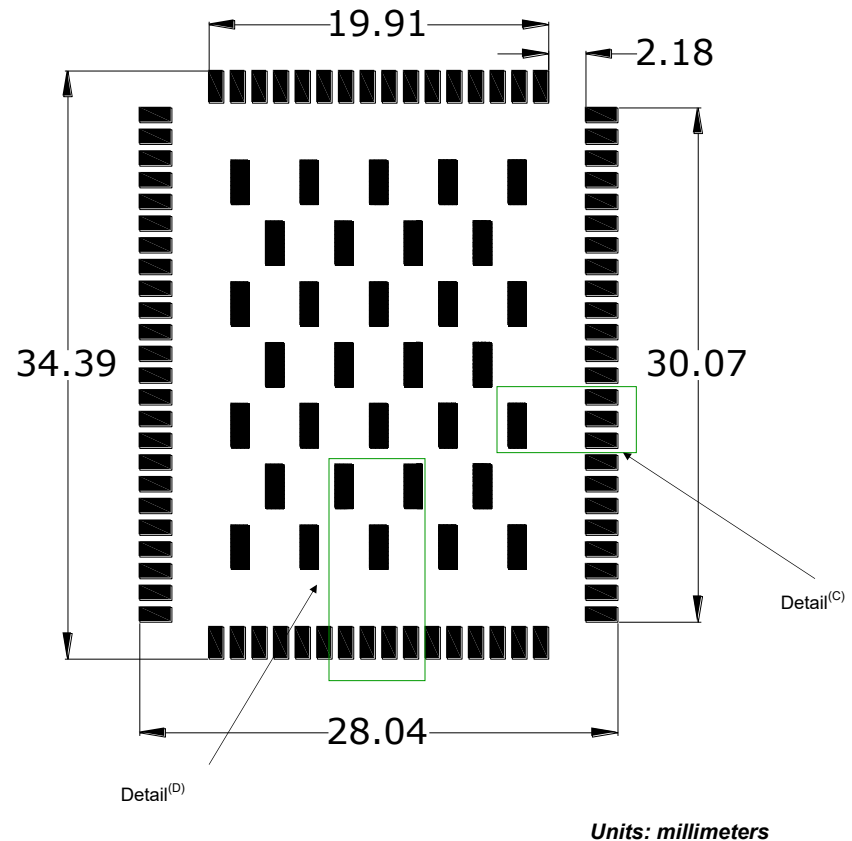
Drawing 2-3: P2400 Recommended Solder Paste (Stencil thickness is 0.15mm)

2.1.3 OEM Connectors

Antenna
All P2400 OEM Modules use an UFL connector for the antenna connection.

Data
The interface to the P2400 OEM module is a tight integration using 80 pad SMT connections.

2.0 Hardware Description

2.1.4 SMT Temperature Profile
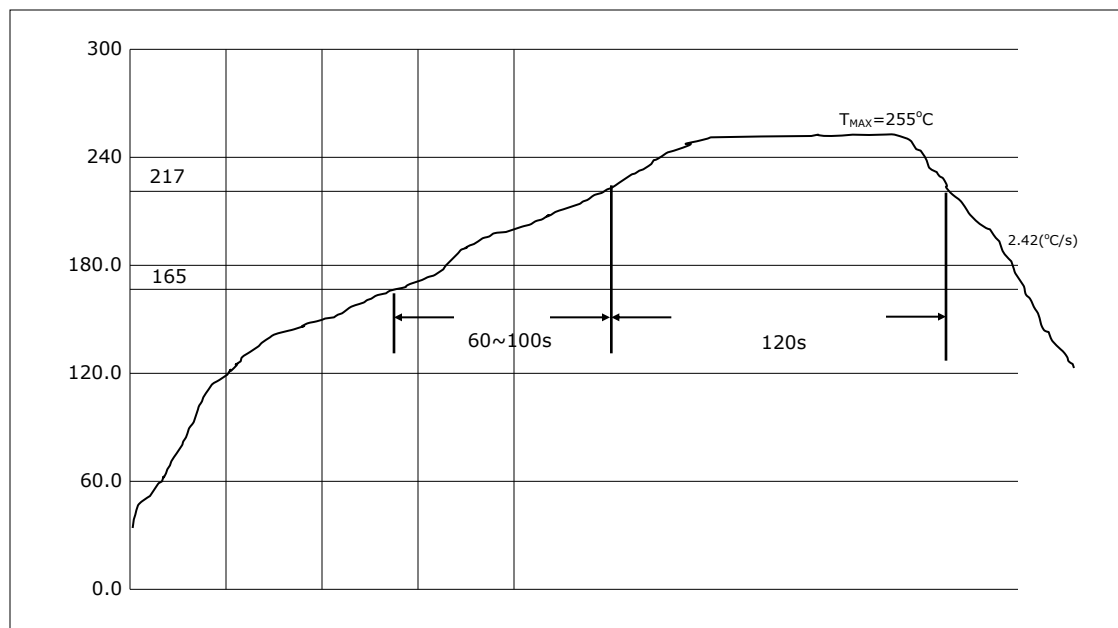
Drawing 2-4: Reflow Profile

Temperature Zone	Time	Parameter
Preheat zone: (40°C - 165°C)	-	Heating rate: 0.5^{o}C/s-2°C/s
Soak Zone: (165°C - 217°C)	60 - 100s	-
Reflow zone: (>217°C)	120s	Peak reflow: 255°C
Cooling zone	Cooling rate: 2°C/s ≤ Slope ≤ 5°C/s	

Table 2-1: Reflow Parameters

Zone	Temperature (^{o}C)
1	120
2	140
3	160
4	180
5	215
6	255
7	255
8	255
9	250
10	130
Chain Speed: 60cm/min	

Table 2-2: Oven Temperature Profile

2.1.5 SMT Baking Instructions (MSL)

The P2400 OEM modules must be baked before mounting, the following baking instruction should be followed for the best results:

   a)   Minimum of 8 to 12 hours at 125°C +/- 5°C for high-temperature device containers.
   b)   Unused modules should be stored at ≤ 10% RH

2.0 Hardware Description

2.2 Pico OEM Pin Descriptions

Top edge (left to right): GND, GND, GND, GND, GND, GND, DNC, DNC, DNC, DNC, DNC, Reserved, Reserved, GND, GND, GND

Pins 67, 66, 65 labeled at top right.

Left side (pins 1-24):
Pin	Name
1	GND
2	DNC
3	DNC
4	DNC
5	DNC
6	DNC
7	USR1 - GPS/1PPS
8	USR2 - Alarm
9	USR3
10	I/O1
11	I/O2
12	I/O3
13	I/O4
14	USR AO0
15	USR AN0
16	USR AN1
17	GND
18	USBDP
19	USBDM
20	RSSI LED1
21	RSSI LED2
22	RSSI LED3
23	LED RX
24	LED TX

Center label: Pico Series P2400 (Top View)

Right side (pins 41-64):
Pin	Name
64	Vcc
63	Vcc
62	Vdd
61	Reserved
60	Reserved
59	Reserved
58	Reserved
57	Reserved
56	Reserved
55	Reserved
54	Reserved
53	Reserved
52	Reserved
51	CANRX
50	CANTX
49	Reserved
48	Reserved
47	!Wakeup_usr
46	!CONFIG
45	!RESET
44	RSMode
43	Reserved
42	Vbat
41	GND

Bottom edge (pins 25-40, left to right): GND, GND, Serial RING, Serial RxD, Serial TxD, Serial DSR, Serial CTS, Serial DTR, Serial DCD, Serial RTS, USR SCK, Reserved, Control RxD, Control TxD, GND, GND

Drawing 2-4: Pico P2400 80-pin OEM Connection Info

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

The above drawing depicts a top view of the P2400-OEM Module. The corner pads numbers (1, 25, 41, and 65) are printed directly on the bottom of the PCB for easy identification.

A full description of the connections and function of each pin is provided on the pages that follow.

2.0 Hardware Description

Pin Name	No.	Description	Dir
GND	*1,17,25-26,39-41,65-67,75-80*	Ground reference for logic, radio, and I/O pins.	
DNC	2,3,4,5,6	Reserved for factory use only.	
USR1 – GPS/1PPS	7	*Currently Not Supported. For Future Expansion*	I
USR2 - Alarm	8	*Reserved for future use.*	O
USR3	9	*Reserved for future use.*	O
I/O1-4	10,11,12,13	Digital Input/output Pins. -0.3 to +3.6 V input, 3.3 V Output @ 3mA maximum. *Future Use.*	I/O
USR_ANO0	14	*Currently Not Supported. For Future Expansion*	O
USR_AN0 USR_AN1	15 16	Analog Inputs. 0 to 3V input, 12 bit *Future Use.*	I
USBDP	18	*Currently Not Supported. For Future Expansion*	
USBDM	19	*Currently Not Supported. For Future Expansion*	
LED_1 (RSSI1)	20	Receive Signal Strength Indicator 1. Active high, cannot drive LED directly. Requires current limiting resistor. 8mA maximum.	O
LED_2 (RSSI2)	21	Receive Signal Strength Indicator 2. Active high, cannot drive LED directly. Requires current limiting resistor. 8mA maximum.	O
LED_3 (RSSI3)	*22*	Receive Signal Strength Indicator 3. Active high, cannot drive LED directly. Requires current limiting resistor. 8mA maximum.	*O*
LED_RX	23	Active high output indicates receive and synchronization status. Active high, cannot drive LED directly. Requires current limiting resistor. 8mA maximum.	O
LED_TX	24	Active high output indicates module is transmitting data over the RF channel. Active high, cannot drive LED directly. Requires current limiting resistor. 8mA maximum.	O
Serial RING	27	Internally connected to GND through a 22kΩ resistor. *Reserved for future use.*	O
Serial RxD	28	Receive Data. Logic level input into the modem. It is recommended to wire this pin out through a zero ohm resister to a header and jumper block for external access to the serial port for modem recovery procedures.	I
Serial TxD	29	Transmit Data. Logic level Output from the modem. It is recommended to wire this pin out through a zero ohm resister to a header and jumper block for external access to the serial port for modem recovery procedures.	O
Serial DSR	30	Data Set Ready. Active low output. *The DSR line may be used to enable the transmitter of the RS485 driver chip.*	O
Serial CTS	31	Clear To Send. Active low output. *The CTS line may be used to enable the transmitter of the RS485 driver chip. (P2400 Enclosed)*	O
Serial DTR	32	Data Terminal Ready. Active low input.	I
Serial DCD	33	Data Carrier Detect. Active low output.	O
Serial RTS	34	Request To Send. Active low input.	I
USR SCK	35	*Currently Not Supported. For Future Expansion*	I

Table 2-1: Pico Series Pin Description

Caution: During power up or reset, output pins from the Pico are in an unknown state. It is advised to use pull up or pull down resisters as appropriate.

2.0 Hardware Description

Caution: During power up or reset, output pins from the Pico are in an unknown state. It is advised to use pull up or pull down resisters as appropriate.

Pin Name	No.	Description	Dir
Reserved	36	*Reserved for future use.*	
Control RxD	37	Diagnostics receive data. Logic level input from a PC to the module. *Used for Diagnostics Protocol, contact Microhard Systems for documentation.*	I
Control TxD	38	Diagnostics transmit data. Logic level output from module to a PC. *Used for Diagnostics Protocol, contact Microhard Systems for documentation.*	O
Vbat	42	Input voltage sensing analog input line, up to 60VDC maximum. Used to measure the main supply voltage. User design must add a 10kΩ 1% 1/16W resistor in series.	I
Reserved	43	*Reserved for future use.*	
RSMode	44	*Internally connected to GND through a 10kΩ resistor. *Reserved for future use.**	O
!RESET	45	Active low input will reset the module.	I
!CONFIG	46	Active low input signal to put module into default serial interface (RS232) and default baud rate (9600/8/N/1) during power up. Pull high or leave floating.	I
!Wakeup_usr	47	*Currently Not Supported. For Future Expansion*	I
Reserved	48	*Reserved for future use.*	
Reserved	49	*Reserved for future use.*	
CANTX	50	*Currently Not Supported. For Future Expansion*	
CANRX	51	*Currently Not Supported. For Future Expansion*	
Reserved	52-61	*Reserved for future use.*	
Vdd	62	Positive voltage supply voltage for the digital section of the module (3.3V).	I
Vcc	63,64	Positive voltage supply voltage for the radio module (3.3V). The Vcc lines are internally connected together. Vcc of 3.6V is required for 1W Tx power.	I
Reserved	68,69	*Reserved for future use.*	
DNC	70-74	Reserved for factory use only.	

Table 2-1: Pico Series Pin 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.

2.0 Hardware Description

2.3 Minimum Connection Requirements
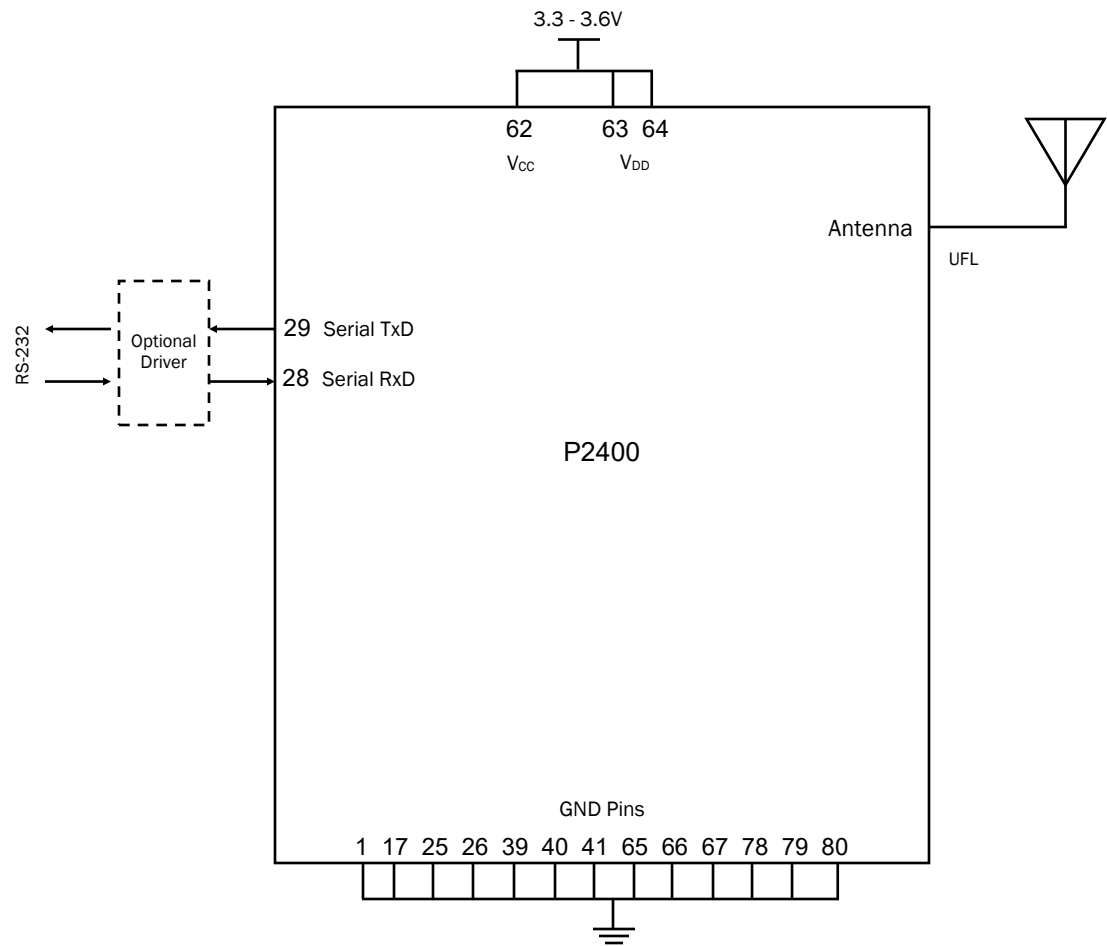
Drawing 2-5: P2400 Minimum Connection Block Diagram

2.0 Hardware Description

2.4 Electrical Characteristics

2.4.1   Test Conditions

Unless otherwise specified, all voltages are referenced to V_{ss}(GND).

2.4.1 Minimum and Maximum Values

Unless otherwise specified the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies.

Data based on characterization results, design simulation and/or technology characteristics are indicated in the table footnotes and are not tested in production. Based on characterization, the minimum and maximum values refer to sample tests and represent the mean value plus or minus three times the standard deviation (mean±3Σ).

2.4.1.2 Typical Values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = 3.3 V. They are given only as design guidelines and are not tested.

Typical ADC accuracy values are determined by characterization of a batch of samples from a standard diffusion lot over the full temperature range, where 95% of the devices have an error less than or equal to the value indicated (mean±2Σ).

2.4.1.3 Loading Capacitor

The loading conditions used for pin parameter measurement are shown in **Figure 2-1**.

2.4.1.4 Pin Input Voltage

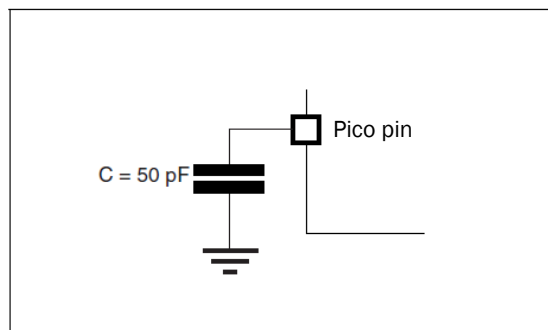The input voltage measurement on a pin of the Pico is described in **Figure 2-2**.

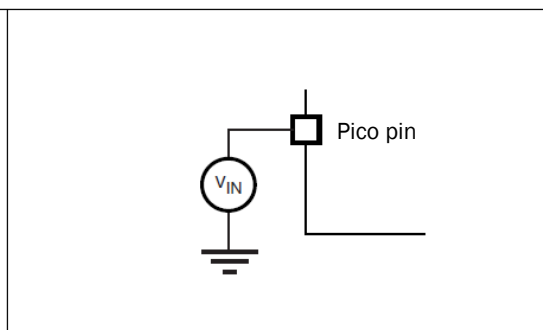Figure 2-1 Pin Loading Conditions   Figure 2-2 Pin Input Voltage

2.0 Hardware Description

2.4.2 Absolute Maximum Ratings

Stresses above the absolute maximum ratings listed in **Table 2-2: Voltage Characteristics** and **Table 2-3: Current Characteristics** may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

2.4.3 Operating Conditions

Symbol	Ratings	Min	Max	Unit
V_{CC}/V_{DD}	External main supply voltage.	0	3.8	V
V_{IN}	Input voltage on any pin.	-0.3	V_{DD}+0.3	

Table 2-2 Voltage Characteristics

Symbol	Ratings	Max	Unit
I_{VDD}	Total current into Pico Series (source).	70	mA
I_{VSS}	Total current out of Pico Series (sink).	70	
I_{IO}	Output current sunk by any I/O and control pin.	20	
	Output Current sourced by any I/O and control pin.	-8	

Table 2-3 Current Characteristics

2.4.3.1 Operating Conditions at Power-up / Power-down

The parameters given in *Table 2-4: Operating Conditions at Power-up/ Power-down* are derived from tests performed under the ambient temperature ratings of the Pico Series.

Symbol	Parameter	Min	Max	Unit
t_{VDD}	V_{DD} rise time rate.	0	∞	µs/V
	V_{DD} fall time rate.	20	∞	

Table 2-4 Operating Conditions at Power-up/Power-down

2.4.3.2 Operating Conditions Voltage Characteristics

The parameters given in *Table 2-5: Operating Conditions Voltage Characteristics* are derived from tests performed under the ambient temperature ratings of the Pico Series.

Symbol	Ratings	Min	Max	Unit
V_{CC}	External radio supply voltage.	3.3[1]	3.6	V
V_{DD}	External digital supply voltage.	3.0	3.6	

Table 2-5 Operating Conditions Voltage Characteristics

1.   The modem will not be able to transit at full power if V_{CC} is less than 3.6VDC.

2.0 Hardware Description

2.4.3.3 Operating Conditions Current Characteristics

The parameters given in *Table 2-6: Operating Conditions Current Characteristics* are derived from tests performed under the ambient temperature ratings of the Pico Series. Test conditions measured total P2400 current (Icc+Idd) while Vcc=Vdd=3.6V, Frequency = 2440 MHz and ambient temperature of 25°C.

Symbol	Ratings	Min	Typ	Max	Unit
I_{TX100}	Radio current 100% TX @ 100mW		618		
I_{TX250}	Radio current 100% TX @ 250mW		746		
I_{TX500}	Radio current 100% TX @ 500mW		885		
I_{TX1000}	Radio current 100% TX @ 1000mW		1312	1500	
I_{RX}	Radio current 100% RX		266		mA
$I_{RX-RUN-Srch}$	Radio RX running in Search state		266		
$I_{RX-RUN-Sync}$	Radio RX running in Synchronized state		186		
I_{IDLE}	Radio IDLE current IDLE		73		

Table 2-6 Operating Conditions Current Characteristics

2.4.3.4 I/O Port Characteristics

General Input / Output Characteristics

The parameters given in *Table 2-7: I/O Static Characteristics* are derived from tests performed under the ambient temperature ratings of the Pico Series. All I/Os are CMOS and TTL compliant. I/O's refer to all input and outputs of the Pico Series.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Input low level voltage	TTL ports	-0.5		0.8	V
V_{IH}	Input high level voltage		2		V_{DD}+0.5	
V_{IL}	Input low level voltage	CMOS ports	-0.5		0.35 V_{DD}	V
V_{IH}	Input high level voltage		0.65 V_{DD}		V_{DD}+0.5	
V_{hys}	IO Schmitt trigger voltage hysteresis[1]		200			mV
I_{lkg}	Input leakage current	$V_{SS} \leq V_{IN} \leq V_{DD}$			±1	μA
R_{PU}	Weak pull-up equivalent resistor[2]	$V_{IN} = V_{SS}$	30	40	50	kΩ
R_{PD}	Weak pull-down equivalent resistor[2]	$V_{IN} = V_{DD}$	30	40	50	
C_{IO}	I/O pin capacitance			8		pF

1. Hysteresis voltage between Schmitt trigger switching levels. Based on characterization, not tested in production.
2. Pull-up and pull-down resistors can be used on input/output pins.

Table 2-7 I/O Static Characteristics

2.0 Hardware Description

Output Driving Current

The GPIOs (general purpose input/outputs) can sink or source up to +/-8 mA, and sink +20 mA (with a relaxed V_{OL}).

In the user application, the number of I/O pins which can drive current must be limited to respect the absolute maximum rating specified in **Section 2.1.4.2**:

- The sum of the currents sourced by all the I/Os on VDD cannot exceed the absolute maximum rating I_{VDD} (see **Table 2-3**).
- The sum of the currents sunk by all the I/Os on VSS cannot exceed the absolute maximum rating I_{VSS} (see **Table 2-3**).

Output Voltage Levels

Unless otherwise specified, the parameters given in **Table 2-8** are derived from tests performed under ambient temperature and V_{DD} supply voltage ratings of the Pico Series. All I/Os are CMOS and TTL compliant.

Input / Output AC Characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OL}[1]	Output low level voltage for an I/O pin when 8 pins are sunk at same time	TTL port I_{IO} = +8mA		0.4	V
V_{OH}[2]	Output high level voltage for an I/O pin when 8 pins are sourced at same time		V_{DD}-0.4		
V_{OL}[1]	Output low level voltage for an I/O pin when 8 pins are sunk at same time	CMOS port I_{IO} = +8mA		0.4	V
V_{OH}[2]	Output high level voltage for an I/O pin when 8 pins are sourced at same time		2.4		
V_{OL}[1][3]	Output low level voltage for an I/O pin when 8 pins are sunk at same time	I_{IO} = +20mA		1.3	V
V_{OH}[2][3]	Output high level voltage for an I/O pin when 8 pins are sourced at same time		V_{DD}-1.3		

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in **Table 2-3** and the sum of IIO (I/O ports and control pins) must not exceed I_{VSS}.
2. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in **Table 2-3** and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD}.
3. Based on characterization data, not tested in production.

Table 2-8 Output Voltage Characteristics

The values of input/output AC characteristics are given in Table 2-9.

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{f(IO)out}$	Output high to low fall time	CL = 50 pF		125	ns
$t_{r(IO)out}$	Output low to high level rise time			125	
t_{EXTIpw}	Pulse width of external signals used as interrupts.		1		ms

Table 2-9 Input / Output AC Characteristics

2.0 Hardware Description

NRST Pin Characteristics

The NRST pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor, RPU (see **Table 2-7**).

2.4.3.5 12-bit ADC Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IL(NRST)}$	NRST Input low level voltage		-0.5		0.7	V
$V_{IH(NRST)}$	NRST Input high level voltage		2		V_{DD}+0.5	
$V_{hys(NRST)}$	NRST Schmitt trigger voltage hysteresis			200		mV
R_{PU}	Weak pull-up equivalent resistor	V_{IN}=V_{SS}	30	40	50	kΩ
V_{NF}	NRST Input pulse		300			ns

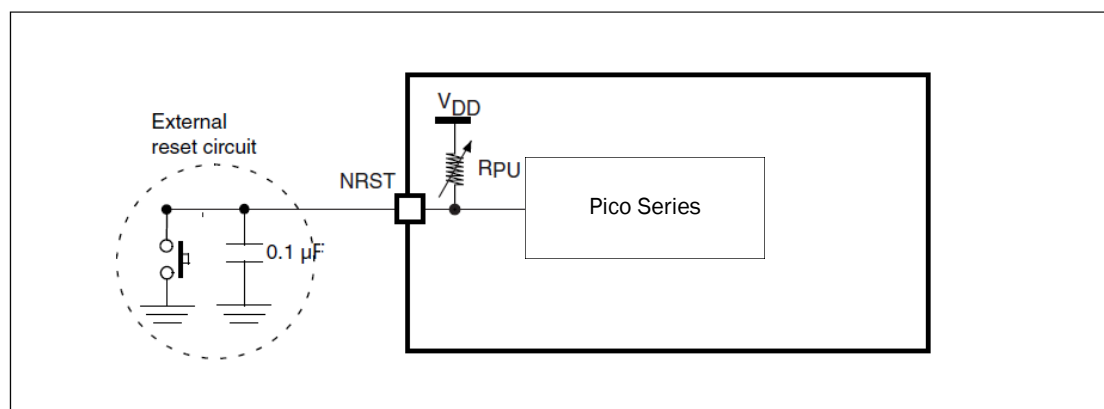Table 2-10 NRST Pin Characteristics

Figure 2-3 Recommended NRST Pin Protection

The parameters given in **Table 2-11: ADC Characteristics** are derived from tests performed under the ambient temperature and supply voltage ratings of the Pico Series.

Symbol	Parameter	Min	Max	Unit
V_{AIN}	Conversion voltage range	0	3.0	V
R_{AIN}	External input impedance	0	1.2	kΩ

Table 2-11 12-bit ADC Characteristics

Symbol	Parameter	Test Conditions	Typ	Max	Unit
ET	Total unadjusted error		1.3	2	
EO	Offset error		1	1.5	
EG	Gain error	T_A = 25°C	0.5	1.5	LSB
ED	Differential linearity error		0.7	1	
EL	Integral linearity error		0.8	1.5	

Table 2-12 ADC Accuracy

2.0 Hardware Description

ADC Accuracy Characteristics
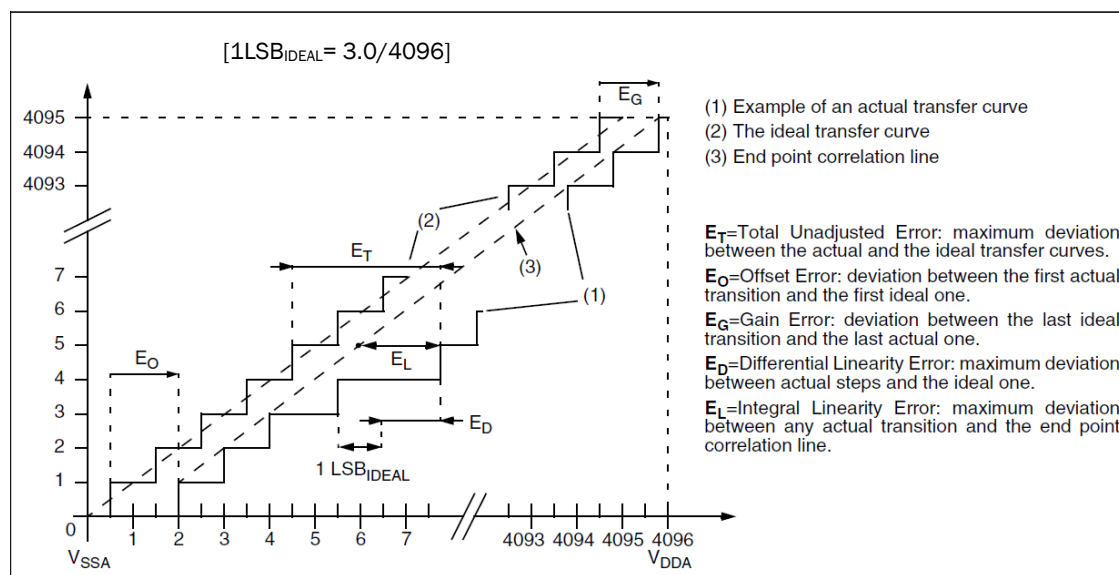

Figure 2-4 ADC Accuracy Characteristics

2.0 Hardware Description

2.5 P2400 to Nano n2420 Pin-Outs

The following table shows a pin-out comparison between the P2400 and the n2420. This table may be useful for customers who current have the n2420 who wish to migrate to the P2400 platform.

For detailed pin descriptions refer to Section 2.3 Pin Description.

Pin Name	P2400 Pin No.	n2420 Pin No.	Description
USR1	7	35	*Currently Not Supported. For Future Expansion*
USR2	8	37	*Reserved for future use.*
USR3	9	39	*Reserved for future use.*
USR_AN0	15	9	Analog Input 0. *Future Use.*
USBDP	18	25	*Currently Not Supported. For Future Expansion*
USBDM	19	21	*Currently Not Supported. For Future Expansion*
LED_1 (RSSI1)	20	30	Receive Signal Strength Indicator 1.
LED_2 (RSSI2)	21	28	Receive Signal Strength Indicator 2.
LED_3 (RSSI3)	22	26	Receive Signal Strength Indicator 3.
LED_RX	23	22	Active high output indicates receive and synchronization status.
LED_TX	24	24	Active high output indicates module is transmitting RF data.
Serial RING	27	38	*Reserved for future use.*
Serial RxD	28	42	Receive Data. Logic level input into the modem.
Serial TxD	29	44	Transmit Data. Logic level Output from the modem.
Serial DSR	30	36	Data Set Ready. Active low output.
Serial CTS	31	32	Clear To Send. Active low output.
Serial DTR	32	40	Data Terminal Ready. Active low input.
Serial DCD	33	46	Data Carrier Detect. Active low output.
Serial RTS	34	34	Request To Send. Active low input.
USR SCK	35	50	*Currently Not Supported. For Future Expansion*
Control RxD	37	20	Diagnostics receive data.
Control TxD	38	18	Diagnostics transmit data.
Vbat	42	17	Battery Voltage sensing analog input line.
RSMode	44	19	*Reserved for future use.*
!RESET	45	15	Active low input will reset the module.
!CONFIG	46	13	Active low input signal to put module into default serial mode.
!Wakeup_usr	47	11	*Currently Not Supported. For Future Expansion*
!Bootpgm_mode	48	7	*Reserved for future use.*
CANTX	50	12	*Currently Not Supported. For Future Expansion*
CANRX	51	10	*Currently Not Supported. For Future Expansion*
Vdd	62	51,53,55,57,59	Positive voltage supply voltage for the digital section of the module (3.3V).
Vcc	63,64		Positive voltage supply voltage for the radio module (3.3V).
Vcc2	75,76,77	N/A	*Reserved for future use.*

Table 2-13: P2400 to Nano n2420 Pin Description

2.0 Hardware Description

2.6 P2400 Enclosed

The Pico Enclosed provides a standalone P2400 with standard interfaces for Data, Power and Antennas. The P2400 Enclosed is ideal for base stations or applications where complicated integration of the OEM module is not required, but a modem with a small footprint is still required. The P2400 Enclosed can also be used to quickly evaluate the features and performance of the P2400 modems.

The P2400 Enclosed provides quick access to several of the interfaces of the P2400, such as:

- Input Power (7-30VDC)
- Power LED (Blue)
- RS232/RS485 Data Interface
- RSSI LED Indicators (Green)
- TX/RX LED Indicators (Red/Green)
- CONFIG Button
- Antenna
- USB Port (Internal Serial to USB (Diagnostics Port))
- I/O pins (Future Development)

Image 2-4: P2400 Enclosed

2.0 Hardware Description

2.6.1 P2400 Enclosed Dimensional Drawings
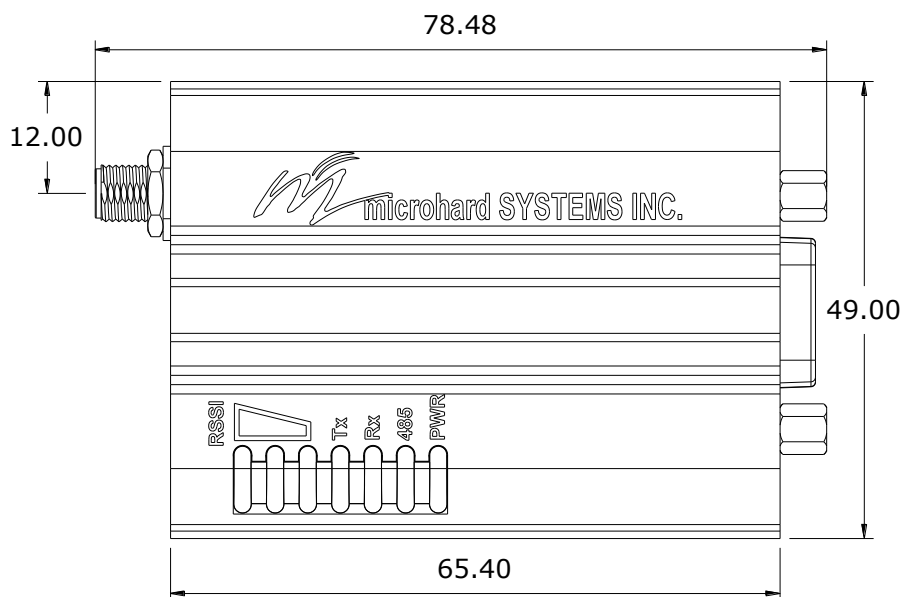
Drawing 2-6: P2400 Top View
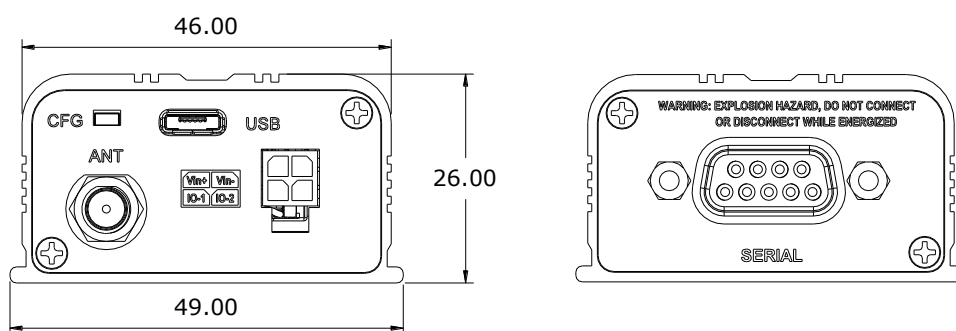
Drawing 2-7: P2400 Enclosed End Views

Drawing 2-8: P2400 Enclosed Side View

Notes: The dimension unit is mm.
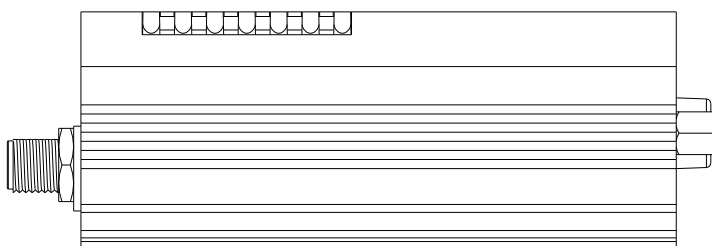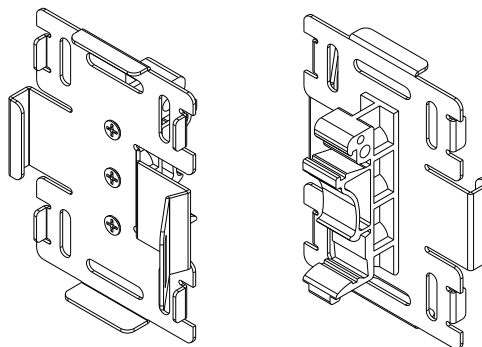
2.0 Hardware Description

2.6.2 P2400 Enclosed Mounting Bracket (Order Option)

Drawing 2-6: P2400 –ENC Mounting Bracket Front/Rear (Shown optional TS35 DIN Rail Mount)

Notes: The dimension unit is mm.

2.0 Hardware Description

2.6.3   P2400 Enclosed Connectors & LED Indicators
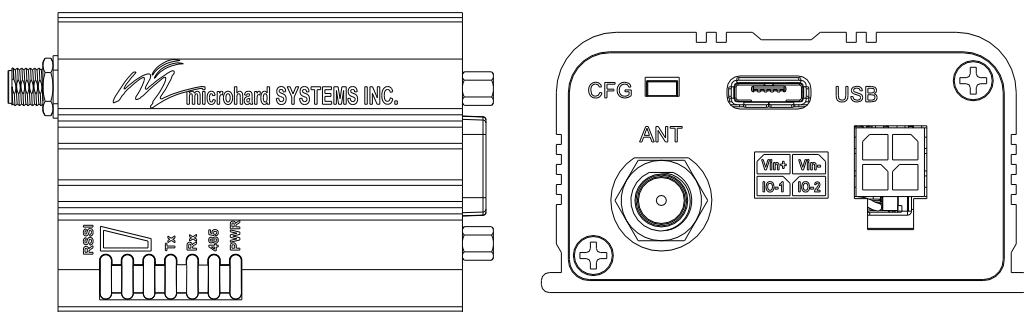
Drawing 2-9: Connectors & LED's (Top & End)

PWR (Blue)
This LED will illuminate when the P2400 Enclosed is connected to a power source (9-30 VDC)

485 (Blue)
This LED will illuminate when the P2400 Enclosed Data port is configured as a RS485 port. (Register S142 Serial Channel Mode set to RS485 <u>and</u> Handshaking set to &K1)

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

RX LED (Green)
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. The value of RSSI is reported in S123.

MODE	Unit Type	LED STATUS		
		RX/SYNC	**TX**	**RSSI 1,2,3**
COMMAND	All	OFF	OFF	OFF
DATA	Master Repeater	ON while receiving valid data	ON while Transmitting data	1-3 ON in proportion to signal strength received from remotes.
DATA - during sync. acquisition	Remote	OFF	OFF	Cycling with 300ms ON time
DATA - when synchronized	Remote	ON while synced	ON when transmitting	1-3 ON in proportion to signal strength received from Master/ Repeater

Table 2-14: LED Operation

2.0 Hardware Description
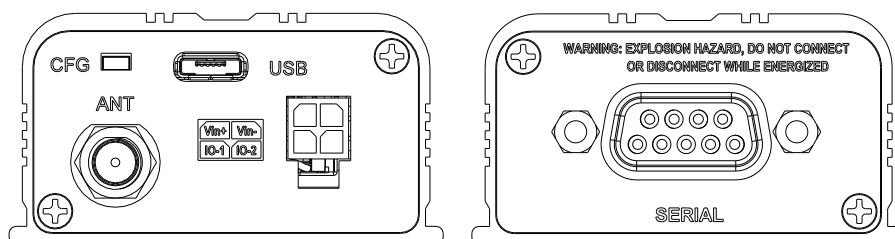
Drawing 2-10: Connectors & LED's (Front & Back)

CFG Button
Holding this button while powering-up the modem will boot the unit into COMMAND mode: the default serial interface will be active and temporarily set to operate at its default serial settings of RS232 and 9600/8/N/1.

USB
Micro-AB USB Port. Internal USB to Serial Converter. Provides access to the Serial Diagnostics Port.

The **SERIAL** (RS232/485 Port (DCE)) on the Enclosed model is for:

- RS232/485 Serial data when in **DATA MODE**, or

- for configuring the modem when in **COMMAND MODE**.

Refer to registers **S102**, **S103** and **AT&K** for additional serial port options.

Pin No.	RS232	RS485 Full-Dup	RS485* Half-Dup
1	DCD		
2	RXD	TX-	Data-
3	TXD	RX+	
4	DTR		
5	Ground		
6	DSR		
7	RTS	RX-	
8	CTS	TX+	Data+
9	N/C		

Table 2-15: Data DB9 Pin Assignments

Caution: Using a power supply that does not provide proper voltage may damage the modem.
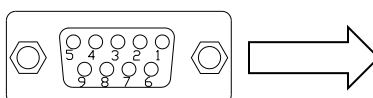
Vin+/Vin– is used to power the unit. The input Voltage range is 9-30 Vdc.

IO-1 / IO-2
Programmable I/O. Not currently supported in firmware. Future Development.

ANT
RP-SMA Female Bulkhead Antenna connector.
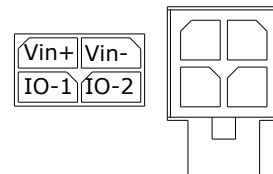
* For RS485 2-Wire mode TX+ and RX+ must be tied together, and TX– and RX– must be tied together.

3.0 Configuration

To begin configuration, the P2400 must be mounted into a either a Microhard supplied development board (with factory attached interface card), or be mounted into a customer designed platform. The P2400 is configured using AT commands through the *Data* port, or using special diagnostic commands through the *Diagnostic* Port. Refer to **Section 2: Hardware Description** for information related to interfacing to, or powering the module.

To issue AT commands through the **Data** port, the P2400 must first be set into **Command Mode** as described below.

3.1 Configuration/Unit Modes

3.1.1 Command Mode

- the P2400 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 blue power LED.
- the P2400's configuration options (registers) may be viewed and modified using AT commands.

Two methods are typically used to place the Pico Series into Command Mode.

1. Force to Command Mode

- Power down off the Development Board assembly.
- Connect a 9-pin straight-through serial cable from the PC serial port to the rear RS-232 port (DATA) of the modem.
- Launch a terminal communications program (e.g. HyperTerminal) and configure for 9600bps, 8 data bits, No parity, 1 stop bit (8N1), no flow control
- press and hold the CONFIG button
- continue to press the CONFIG button and apply power to the modem
- release the CONFIG button
- On power up the terminal session window should show "NO CARRIER OK" as seen below:
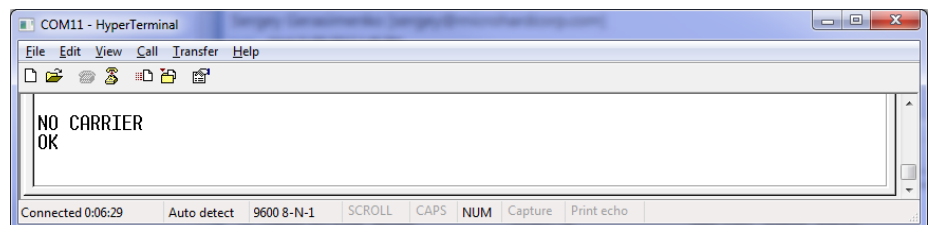
Image 3-1: Command Mode

- the P2400 is now in command mode, and AT commands can be used to configure or query the settings. AT&V will display the current configuration, and the registers can be queried using the ATSXXX=? Command where XXX = the register number. Help is available using the ATSXXX /? Command.
- Any and all changes must be written to NVRAM using the AT&W command.

3.0 Configuration

2.   Escape from Data Mode

- With the P2400 powered up and 'online', connect a 9-pin straight-through serial cable from the PC serial port to the RS-232 DATA port on the dev board.
- Launch a terminal program (e.g. HyperTerminal) and configure for the P2400's established serial baud rate parameters (PC & modem must match).
- Pause 1 second, type '**+++**' , pause 1 second: the monitor should show the module response of 'NO CARRIER   OK'
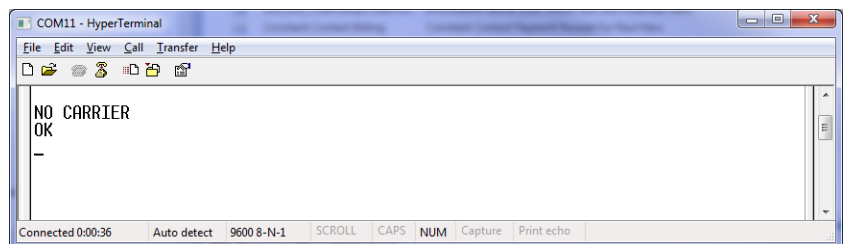
Image 3-2: Command Mode

- The P2400 is now in command mode, and AT commands can be used to configure or query the settings.
- Entering the AT&V command as shown will show the current configuration as seen below: (The data displayed varies based on network and unit type.)
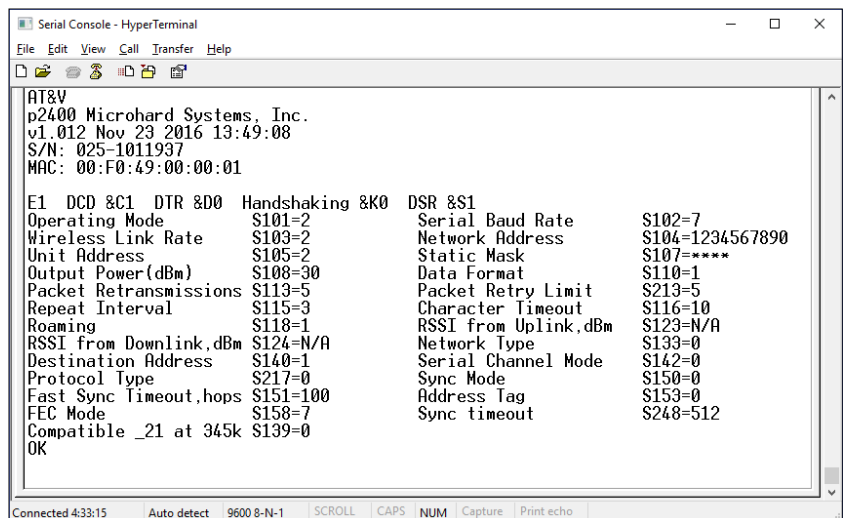
Image 3-3: Command Mode - AT&V Display

3.1.2 Data Mode

Data Mode is the normal operational state of all deployed P2400 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]***

3.0 Configuration

3.1.3 Network Type (S133)

When configuring the P2400 the Network Type must be decided and planned for a successful deployment. The P2400 currently supports Point to Point, Point to Multipoint network topologies.

To change the network type the register S133 (Network Type) is used as seen below:

Network Type **S133**   = **0 - Point to Multipoint**
= 1 - Point to Point
= 2 - Peer to Peer
= (Additional Modes may be available)

Ensure the correct network type is set before proceeding. It is recommended to start with the factory default settings to aid in initial configuration (discussed later), and then changing registers as required.

3.1.4 Frequency Hopping - Channel Spacing

Registers can be changed by entering the AT command as seen below:

Example:
ATS133=1 <enter>

Any registers that are changed must be written to flash using the **AT&W** command>

FCC requires that FHSS systems hop on 76 different channels within the 2.4 GHz ISM Band. The maximum time spent on any one channel must not exceed 400ms.

To calculate the center frequency represented by each channel only the starting frequency and the size of each channel (Channel Bandwidth) need to be known. For the 2.4 GHz ISM Band, the starting frequency is 2.401600 GHz, and the Channel Bandwidth is dependent on the current link rate.

Freq channel n =   2401.600+ ($(n-1)$ x BW)MHz.

Example: Channel 75 @ 172 kbps =   2401.600 +((75-1) x 0.280) MHz
2401.600 + (74 x 0.280) MHz
2401.600 + 20.72 MHz
2422.32 MHz or 2.42232 GHz

Link Rate (kbps)	Channel Bandwidth (kHz)
19.2	50
24.7	50
57.6	100
115.2	280
172.8	280
230.4	280
276.4	400
345.6	400

Table 3-1: Link Rate & BW

3.0 Configuration

3.2 Point to Point Network

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. Point to Point is enabled by setting register S133 to 1 (*ATS133=1, Network Type*).

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 when required to communicate with a specific Slave.
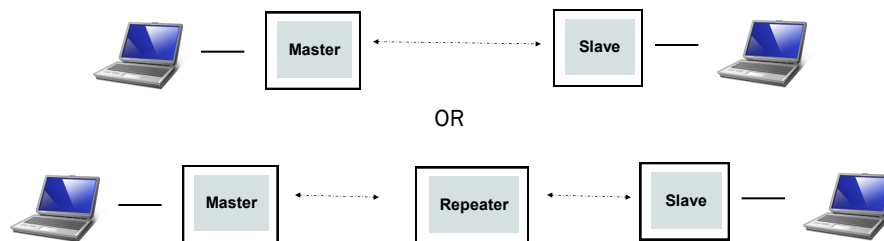
Drawing 3-1: Point to Point Network Topology

3.2.1 Operating Modes / Unit Types

In a Microhard Point to Point Network, three unit types or operating modes are available: the Master, Repeater, and the Remote. The **Masters** role is to provide network synchronization for the system, which ensures all units are active and able to communicate as required. The Master controls the flow of data through the system; all data passes through it. The diagram below shows a unit configured as a Master.
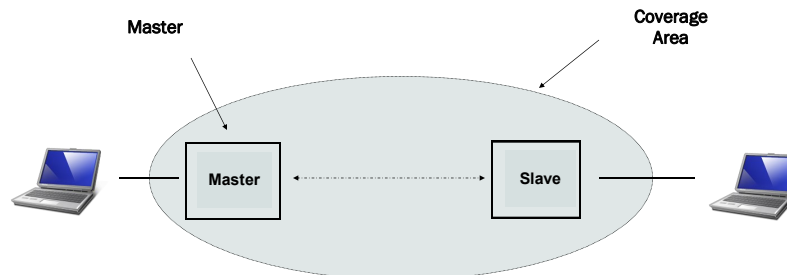
Drawing 3-2: Point to Point Master

3.0 Configuration

Repeaters can be used to extend the coverage of the Master. Required only if necessary to establish a radio path between a Master and Slave(s); stores and forwards 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 cut the overall throughput of the network in ***half***; 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, a work around is to place 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 a 'null modem' cable. Each modem would require its own antenna; careful consideration should be given with respect to antenna placement and modem configuration.

Drawing 3-3: Point to Point Repeater

A ***Slave (Remote)*** is an endpoint/node within a network to which a local device is attached. Communicates with Master either directly or through one or more Repeaters.

Units can be configured   to   perform   the   various
roles discussed by setting reg-   ister S101   as follows:
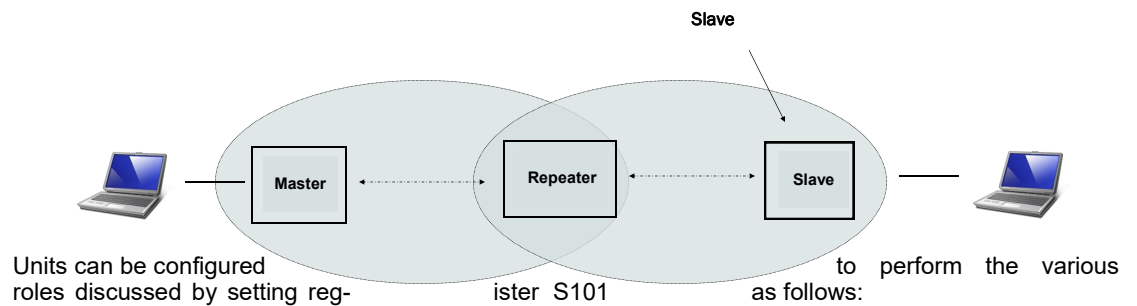
Drawing 3-4: Point to Point Slave

        ATS101 = 0   -   Master
        ATS101 = 1   -   Repeater
        ATS101 = 2   -   Slave (Remote)

3.0 Configuration

3.2.2 Configuration Using Factory Defaults

Factory default setting commands can be used to aid in the configuration and deployment of the P2400 modules, providing a known starting point in the configuration process for each unit type. Using the factory default commands sets all applicable registers to factory recommended settings and allows for initial connectivity between units. Configuring modems using the factor default settings have the following benefits:

- hastens the configuration process - l*oad default settings 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 factory default setting and any improper adjustments will be overwritten and a 'fresh start' can be made with known-to-work settings*

For many networks, the factory default commands may be all that is necessary to configure and deploy a simple Point to Point Network. Other applications may require additional registers to be configured. Regardless of the complexity of the configuration, the factory default settings provide a starting point for all configurations. All unit types have a factory default setting command.

AT&F6	-	Point to Point Master (Fast - 172kbps)
AT&F7	-	Point to Point Slave (Fast)
AT&F8	-	Point to Point Master (Slow - 19.2kbps)
AT&F9	-	Point to Point Slave (Slow)

The screen shots for each unit type highlight the key registers that are automatically changed to create a Point to Point configuration. There may also be additional registers such as the Network ID that are recommended to be changed.

Each PTP Network must have a unique network ID. This can be changed using register S104: Network Address.

```
Serial Console - HyperTerminal                                    —    □    ×
File  Edit  View  Call  Transfer  Help

AT&F /?
 Frequency Hopping (FH) modems
&F1 -  FH Master Fast PMP
&F2 -  FH Slave Fast PMP
&F3 -  FH Repeater Fast PMP
&F4 -  FH Master Slow PMP
&F5 -  FH Slave Slow PMP
&F6 -  FH Master Fast PP
&F7 -  FH Slave Fast PP
&F8 -  FH Master Slow PP
&F9 -  FH Slave Slow PP
&F10 - FH Master Fast PMP no Time ACK
&F11 - FH Master Fast P2P no Time ACK
&F12 - FH Master Fast PP no Time ACK
&F15 - FH Master WL
&F16 - FH Slave WL
&F18 - FH Master Fast TDMA
&F19 - FH Slave Fast TDMA

&F100 - Reset Hopping Modes

Connected 6:17:19   Auto detect   9600 8-N-1   SCROLL   CAPS   NUM   Capture   Print echo
```

Image 3-5: Frequency Hopping Factory Defaults

3.0 Configuration

AT&F6 Point to Point Master (Fast)

```
Serial Console - HyperTerminal                                    ─  □  ✕
File  Edit  View  Call  Transfer  Help

AT&F6  Ⓐ

OK
AT&W  Ⓑ
OK
AT&V  Ⓒ
p2400 Microhard Systems, Inc.
v1.012 Nov 23 2016 13:49:08
S/N: 025-1011937
MAC: 00:F0:49:00:00:01

E1  DCD &C1  DTR &D0  Handshaking &K0  DSR &S1
Operating Mode          S101=0  Ⓕ    Serial Baud Rate     Ⓘ  S102=7
Wireless Link Rate      S103=2  Ⓖ    Network Address      Ⓙ  S104=1234567890
Unit Address          Ⓓ S105=1        Static Mask             S107=****
Output Power(dBm)       S108=30        Data Format             S110=1
Packet Retransmissions  S113=5         Packet Retry Limit      S213=5
Character Timeout       S116=10        RSSI from Uplink,dBm    S123=N/A
RSSI from Downlink,dBm S124=N/A        Network Type            S133=1  Ⓗ
Destination Address   Ⓔ S140=2        Repeaters Y/N        Ⓚ  S141=0
Serial Channel Mode     S142=0         Protocol Type           S217=0
Sync Mode               S150=0         Fast Sync Timeout,hops S151=100
Address Tag             S153=0         Multimaster Mode        S154=0
FEC Mode                S158=6         Compatible _21 at 345k S139=0
OK

Connected 5:00:00   Auto detect   9600 8-N-1   SCROLL  CAPS  NUM  Capture  Print echo
```
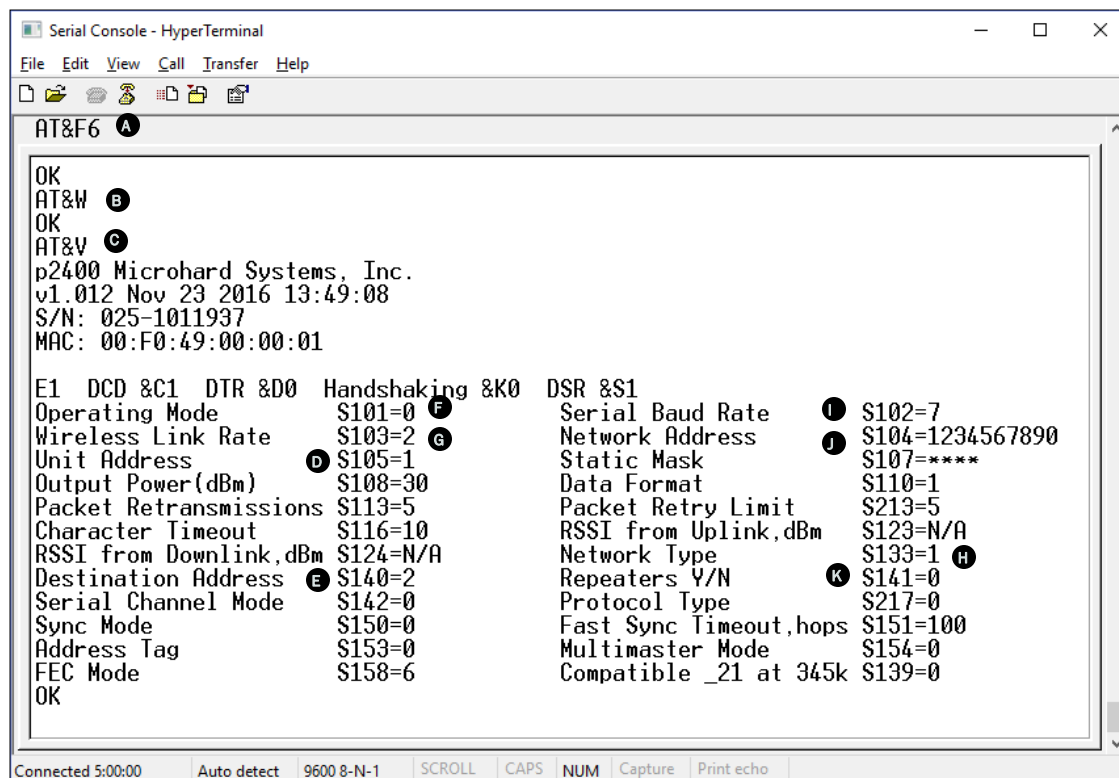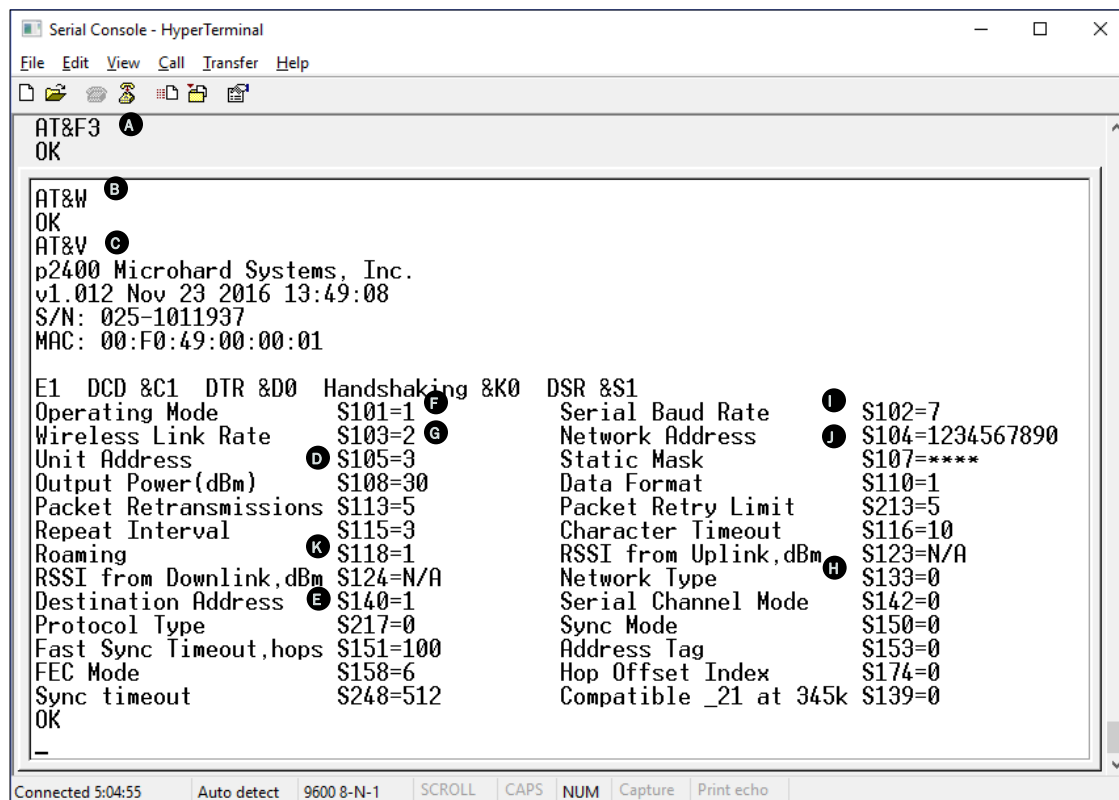
Image 3-6: Factory Defaults AT&F6 - Point to Point Master

A) AT&F6 - Sets the factory defaults for a Point to Point Master.
B) AT&W   - Writes the changes to NVRAM.
C) AT&V   - Displays the configuration as seen above.
D) S105   - Every unit in a Point to Point Network must have a unique unit address. The Master is automatically set to 1, and should not be changed.
E) S140   - The destination address is unit address of the final destination, which all data is to be sent. The address entered would generally be the unit address of the Slave.
F) S101   - The operating mode defines the unit type and is set to 0, which is a Master.
G) S103   - Wireless Link Rate must be set to the same value of each unit in the system. Higher link rates may result in higher throughput, but lower link rates usually provide better sensitivity and overall robustness.
H) S133   - The network type must be set to 1 for Point to Point operation. The content displayed by the AT&V command will vary with the network type.
I) S102   - The serial baud rate (and data format S110) must match that of the connected device.
J) S104   - Each unit in a Network must have the same Network Address. It is strongly recommended to never use the default setting of 1234567890. To change the Network Address, the ATS104=XXXXXXX command can be used.
K) S141   - This register informs the master if 1 or more repeaters are present in the system. This applies only to the master radio.

Remember, when registers are changed the values must be written to NVRAM using the AT&W command. To switch from command mode to data mode (online mode), the ATA command can be issued.

3.0 Configuration

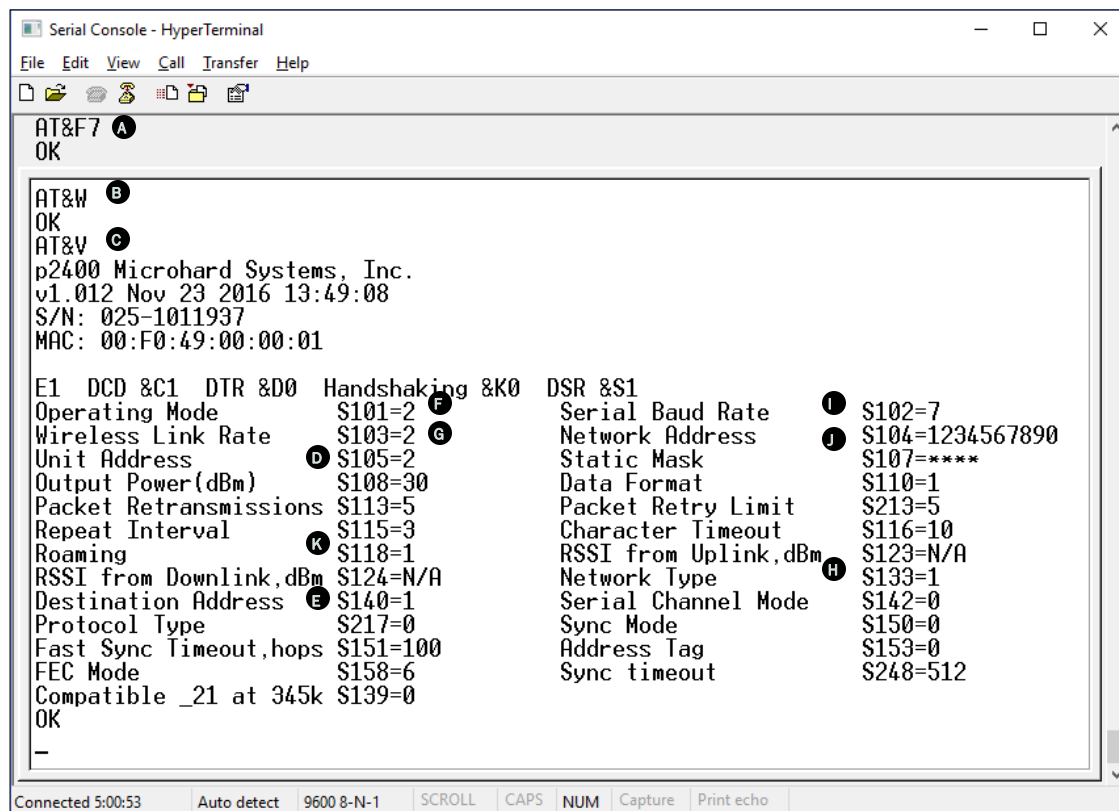### *AT&F7 Point to Point Slave (Fast)*

Image 3-7: Factory Defaults AT&F7 - Point to Point Slave

A) AT&F7 - Sets the factory defaults for a Point to Point Slave.
B) AT&W - Writes the changes to NVRAM.
C) AT&V - Displays the configuration as seen above.
D) S105 - Every unit in a Point to Point Network must have a unique unit address. The address of the slave (remote) is automatically set to 2. *This can be changed, but ensure that the destination address on the master is also changed!*
E) S140 - The destination address is unit address of the final destination to which all data is to be sent. In a Point to Point Network this address is set to 1, the unit address of the master, and should not be changed.
F) S101 - The operating mode defines the unit type and is set to 2, which is a Slave (Remote).
G) S103 - Wireless Link Rate must be set to the same value of each unit in the system.
H) S133 - The network type must be set to 1 for Point to Point operation. The content displayed by the AT&V command varies with the network type.
I) S102 - The serial baud rate (and data format S110) must match that of the connected device.
J) S104 - Each unit in a Network must have the same Network Address. To change the Network Address, the ATS104=XXXXXXX command can be used.
K) S118 - If the slave is to connect through a repeater, enter the unit address of the repeater here.

3.0 Configuration

Point to Point Repeater

There is no Factory default mode for a PTP Repeater, the procedure below outlines the steps required to add a repeater to a PTP system.

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.

3.2.3 Retransmissions

Packet Retransmissions can be used to ensure data reaches its intended destination by resending the same packet over and over. In Point to Point system all data is acknowledged by the destination, resulting in retransmissions only being used if no acknowledgement is received. The overall impact on system performance, while not as significant as it is in Mesh and Point to Multipoint networks, should still be considered. The more times a modem retransmits data, the more the overall throughput of the system is reduced. To adjust the retransmission rate, use register S113, the default value is 5 (+ the initial transmission).

> S113 = 5   -   Packet Retransmissions (0-254)

Retransmissions are typically used in noisy environments to combat interference and low signal strength, ensuring data is received at the intended destination.

3.2.4 Network Synchronization

Network Synchronization is what allows all units to hop from frequency to frequency at the same time. For units to synchronize with the network, each unit must have the same:

> - Network ID (S104)
> - Network Type (S133)

Sync Timeout

Once synchronized to the network the unit does not need to receive sync data often to keep track of where the system is supposed to be (in time and frequency). The sync Timeout defines the number of hops where no sync data is received from a Master and/or Repeater before losing sync. In other words, how long a unit will remain synchronized with the network without receiving any sync packets before it gives up and loses sync.

> S248 = 512   Sync Timeout (4-65534)

Setting a value too low will cause the unit to lose sync easily and time will be wasted trying to re-sync to the network. Several hops can go by without receiving a sync packet, and this is completely normal. If this value is set too high, the unit will assume for a long time that the network is still out there, when especially in mobile applications, it may not be.

3.0 Configuration

3.3 Point to Multipoint Network

In a Point to Multipoint Network, a path is created to transfer data between the Master modem and nu-
merous remote modems. The remote modems may simply be Slaves with which the Master communi-
cates 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'. Point to Multipoint is
enabled by setting register S133 to 0 (*ATS133=0, Network Type*).
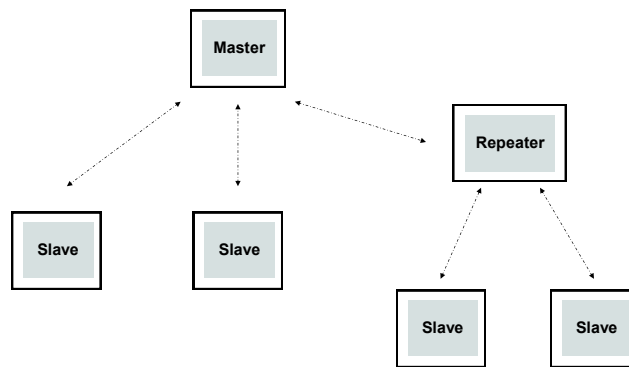
Drawing 3-1: Point to Multipoint Network Topology

3.3.1   Operating
Modes / Unit Types

In a Microhard Point to Multipoint Network, three unit types or operating modes are available: the Mas-
ter, the Repeater, and the Remote. The *Master* modems role is to provide network synchronization for
the system, which ensures all units are active and able to communicate as required. The Master con-
trols the flow of data through the system; all data passes through it. The diagram below shows a unit
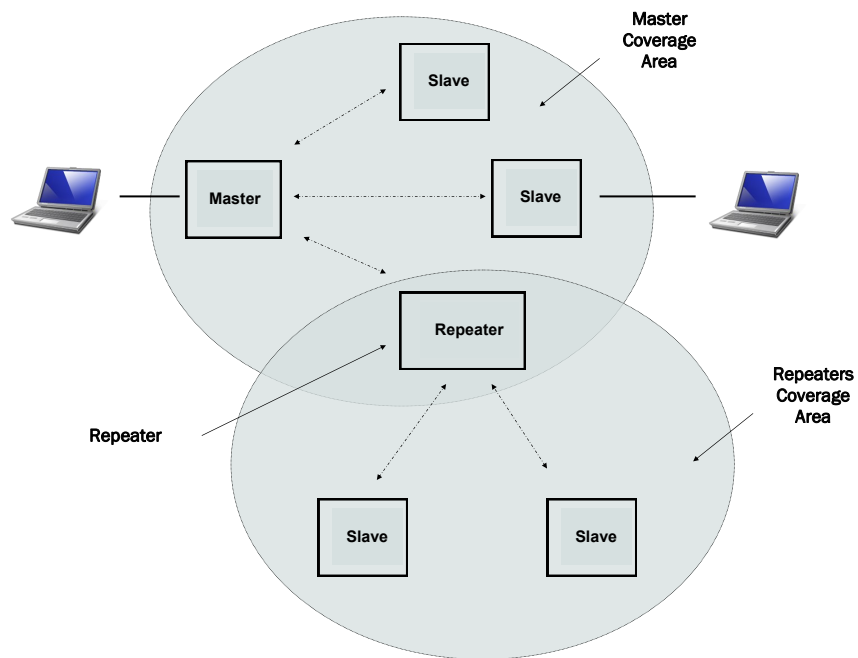configured as a Master.
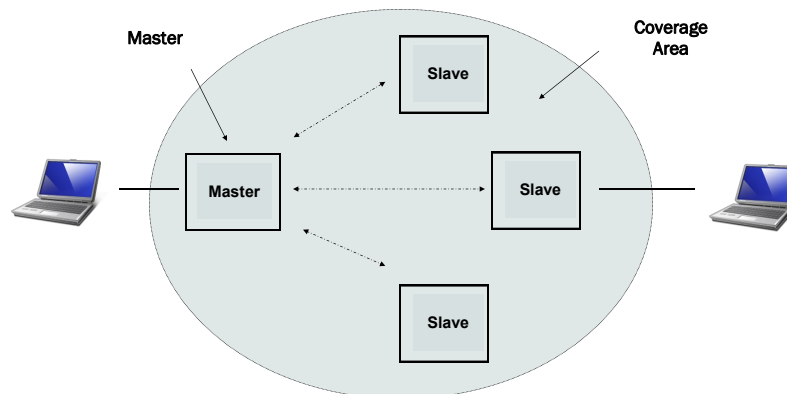
Drawing 3-2: Point to Multipoint Master

3.0 Configuration

Repeaters can be used to extend the coverage of the Master. Required only if necessary to establish a radio path between a Master and Slave(s); stores and forwards 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 cut the overall throughput of the network in **_half_**; 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, a work around is to place 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 a 'null modem' cable. Each modem would require its own antenna; careful consideration should be given with respect to antenna placement and modem configuration.

Drawing 3-3: Point to Multipoint Repeater

3.0 Configuration

A *Slave (Remote)* is a endpoint or node within a network to which a local serial device is attached. Communicates with Master either directly or through one or more Repeaters.
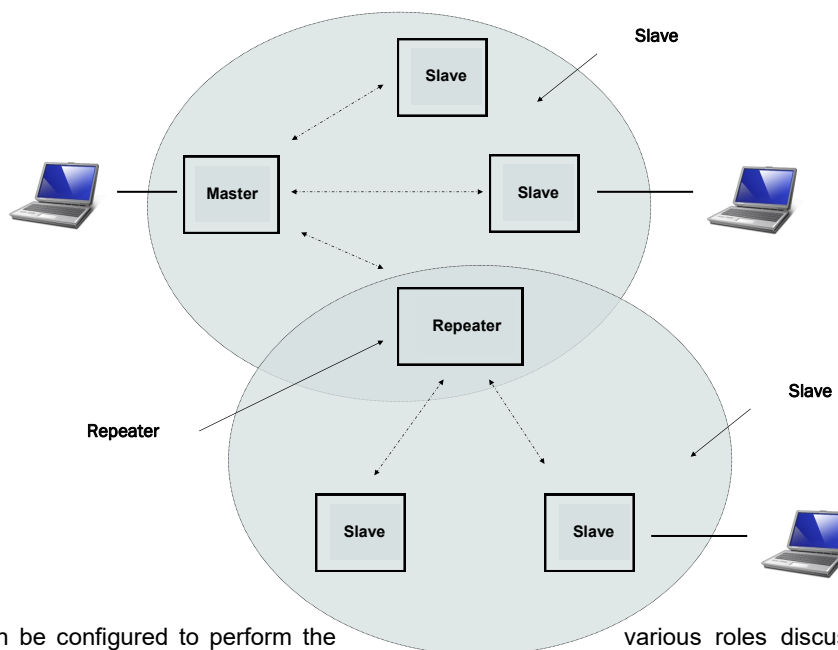
Units can be configured to perform the various roles discussed by setting register S101 as follows:

Drawing 3-4: Point to Multipoint Slave

ATS101 = 0	-	Master
ATS101 = 1	-	Repeater
ATS101 = 2	-	Slave (Remote)

The next section discussed using Factory Default commands to configure the various types of units that are available in a Point to Multipoint network, simplifying the configuration process.

3.0 Configuration

3.3.2 Configuration Using Factory Defaults

Factory default setting commands can be used to aid in the configuration and deployment of the Pico series modules, providing a known starting point in the configuration process for each unit type. Using the factory default commands sets all applicable registers to factory recommended settings and allows initial connectivity between units. Configuring modems using the factor default settings have the following benefits:

- hastens the configuration process - l*oad default settings and, if necessary, apply only minor settings / adjustments*

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

For many networks, the factory default commands may be all that is necessary to configure and deploy a simple Point to Multipoint Network. Other applications may require additional registers to be configured. Regardless of the complexity of the configuration, the factory default settings provide a starting point for all configurations. All PMP unit types have a factory default setting command.

AT&F1	-	Point to Multipoint Master (Fast - 172kbps)
AT&F2	-	Point to Multipoint Slave
AT&F3	-	Point to Multipoint Repeater
AT&F4	-	Point to Multipoint Master (Slow Mode - 19.2kbps)
AT&F5	-	Point to Multipoint Slave

The screen shots for each unit type will highlight the key registers that are automatically changed to create a Point to Multipoint configuration. There may also be additional registers such as the Network ID that are recommended to be changed.

Each PMP Network must have a unique network ID. This can be changed using register S104: Network Address.
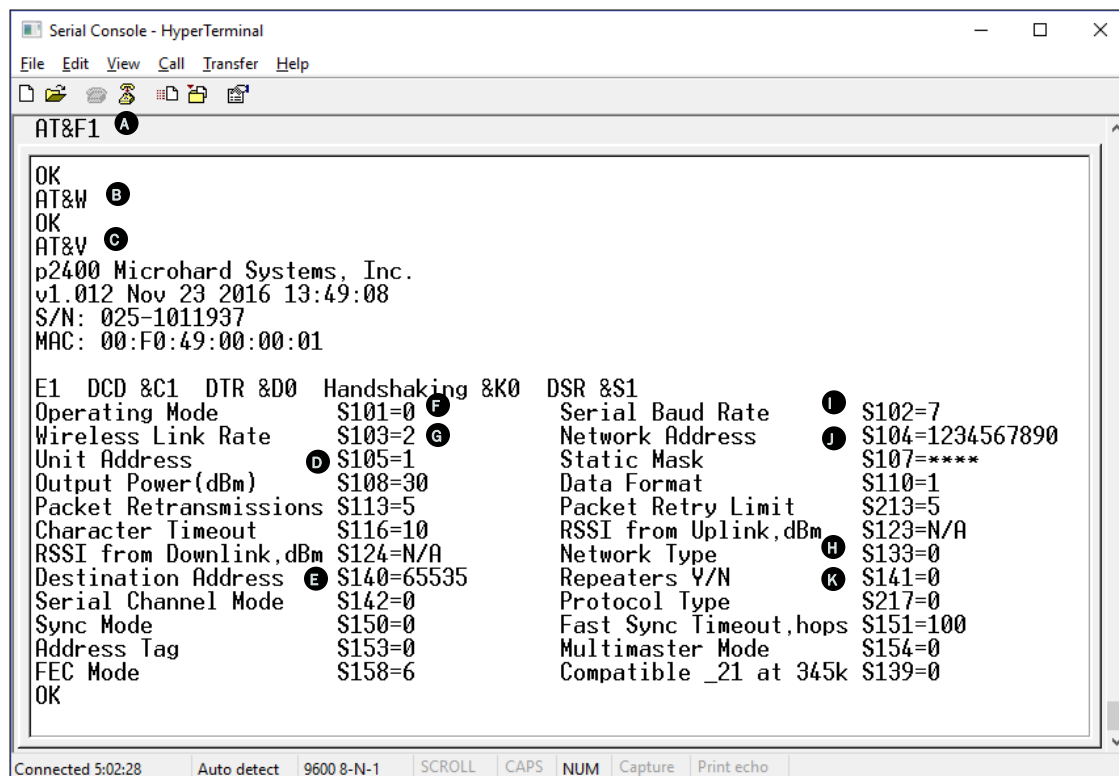
```
AT&F /?
 Frequency Hopping (FH) modems
&F1 -   FH Master Fast PMP
&F2 -   FH Slave Fast PMP
&F3 -   FH Repeater Fast PMP
&F4 -   FH Master Slow PMP
&F5 -   FH Slave Slow PMP
&F6 -   FH Master Fast PP
&F7 -   FH Slave Fast PP
&F8 -   FH Master Slow PP
&F9 -   FH Slave Slow PP
&F10 -  FH Master Fast PMP no Time ACK
&F11 -  FH Master Fast P2P no Time ACK
&F12 -  FH Master Fast PP no Time ACK
&F15 -  FH Master WL
&F16 -  FH Slave WL
&F18 -  FH Master Fast TDMA
&F19 -  FH Slave Fast TDMA

&F100 - Reset Hopping Modes
```

Image 3-4: Frequency Hopping Factory Defaults

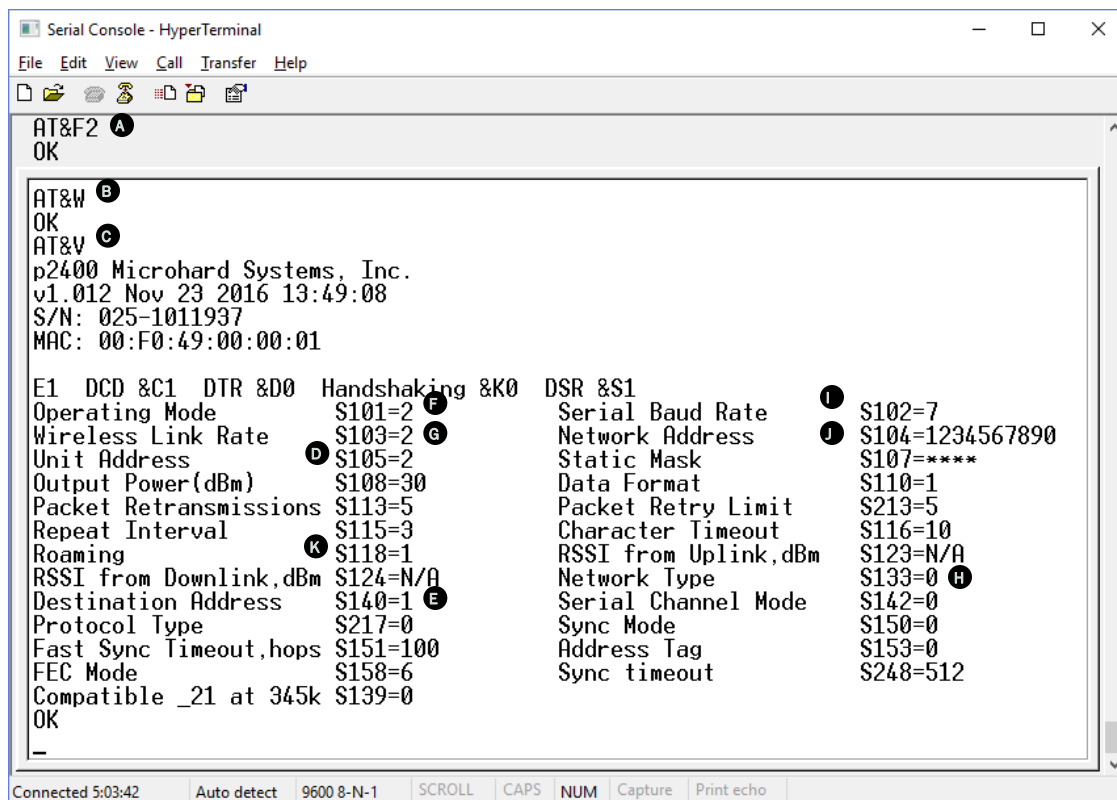# 3.0 Configuration

AT&F1 Point to Multipoint Master (Fast)

Image 3-5: Factory Defaults AT&F1 - Point to Multipoint Master

A) AT&F1 - Sets the factory defaults for a Point to Multipoint Master.
B) AT&W - Writes the changes to NVRAM.
C) AT&V - Displays the configuration as seen above.
D) S105 - Every unit in a Point to Multipoint Network must have a unique unit address. The Master is automatically set to 1, and should not be changed.
E) S140 - The destination address for a PMP Network, by default is 65535, which means data is broadcast from the Master to all other units.
F) S101 - The operating mode defines the unit type and is set to 0, which is a Master.
G) S103 - Wireless Link Rate must be set to the same value of each unit in the system. Higher link rates may result in higher throughput, but lower link rates usually provide better sensitivity and overall robustness.
H) S133 - The network type must be set to 0 for Point to Multipoint operation. The content displayed by the AT&V command will vary with the network type.
I) S102 - The serial baud rate (and data format S110) must match that of the connected device.
J) S104 - Each unit in a Network must have the same Network Address. It is strongly recommended to never use the default setting of 1234567890. To change the Network Address, the ATS104=XXXXXXX command can be used.
K) S141 - This register informs the master if 1 or more repeaters are present in the system. This applies only to the master radio.

Remember, anytime registers are changed the values must be written to NVRAM using the AT&W command. To switch from command mode to data mode (online mode), the ATA command can be issued.

3.0 Configuration

AT&F2 Point to Multipoint Slave (Fast)

Image 3-6: Factory Defaults AT&F2 - Point to Multipoint Slave

A) AT&F2 - Sets the factory defaults for a Point to Multipoint Slave.
B) AT&W - Writes the changes to NVRAM.
C) AT&V - Displays the configuration as seen above.
D) S105 - Every unit in a Point to Multipoint Network must have a unique unit address. The ad dress of the slave (remote) is automatically set to 2. If adding more than 1 Slave, this will need to be modified for each unit added.
E) S140 - The destination address is the final destination to which all data is to be sent. In a Point to Multipoint Network this address is set to 1, the unit address of the Master, and should not be changed.
F) S101 - The operating mode defines the unit type and is set to 2, which is a Slave (Remote).
G) S103 - Wireless Link Rate must be set to the same value of each unit in the system.
H) S133 - The network type must be set to 0 for Point to Multipoint operation.
I) S102 - The serial baud rate (and data format S110) must match that of the connected device.
J) S104 - Each unit in a Network must have the same Network Address. To change the Network Address, the ATS104=XXXXXXX command can be used.
K) S118 - If the slave is to connect through a repeater, enter the unit address of the repeater here.

3.0 Configuration

AT&F3 Point to Multipoint Repeater (Fast)

Image 3-7: AT&F3 Point to Multipoint Repeater

A) AT&F3 - Sets the factory defaults for a Point to Multipoint Repeater.

B) AT&W - Writes the changes to NVRAM.

C) AT&V - Displays the configuration as seen above.

D) S105 - Every unit in a Point to Multipoint Network must have a unique unit address. The address of the Repeater is automatically set to 3.

E) S140 - The destination address is the final destination to which all data is to be sent. In a Point to Multipoint Network this address is set to 1, the unit address of the Master, and should not be changed.

F) S101 - The operating mode defines the unit type and is set to 1, which is a Repeater.

G) S103 - Wireless Link Rate must be set to the same value of each unit in the system.

H) S133 - The network type must be set to 0 for Point to Multipoint operation.

I) S102 - The serial baud rate (and data format S110) must match that of the connected device.

J) S104 - Each unit in a Network must have the same Network Address. To change the Network Address, the ATS104=XXXXXXX command can be used.

K) S118 - If the repeater is to connect through another repeater, enter the unit address of the repeater here.

3.0 Configuration

3.3.3 Unit Addressing

In a Point to Multipoint Network each unit must have a unique unit address, which can be configured using register S105. Duplicate addresses may result in unpredictable problems in the network. In a PMP Network data flow is such that data from the Master is sent to all units by setting the destination address (S140) to 65535, meaning data is broadcast to all units.

3.3.4 Retransmissions

Packet Retransmissions can be used to ensure data reaches its intended destination by resending the same packet over and over. In Point to Multipoint system data is not acknowledged by the destination, meaning data will be transmitted, an additional number of times specified by S113, resulting in a significant impact on system performance. The more times a modem retransmits data, the more the overall throughput of the system is reduced. To adjust the retransmission rate, use register S113, the default value is 5 (+ the initial transmission). Although, this number should be as low as possible to keep as much bandwidth in the system as possible.

> S113 = 5   -   Packet Retransmissions (0-254)

Retransmissions are typically used in noisy environments to combat interference and low signal strength, ensuring data is received at the intended destination.

3.3.5 Network Synchronization

Network Synchronization is what allows all units to hop from frequency to frequency at the same time.

For units to synchronize with the network, each unit must have the same:

> - Network ID (S104)
> - Network Type (S133)

Sync Timeout

Once synchronized to the network the unit does not need to receive sync data often to keep track of where the system is supposed to be (in time and frequency). The sync Timeout defines the number of hops where no sync data is received from a Master and/or Repeater before losing sync. In other words, how long a unit will remain synchronized with the network without receiving any sync packets before it gives up and loses sync.

> S248 = 100   Sync Timeout (4-65534)

Setting a value too low will cause the unit to lose sync easily and time will be wasted trying to re-sync to the network. Several hops can go by without receiving a sync packet, and this is completely normal. If this value is set too high, the unit will assume for a long time that the network is still out there, when especially in mobile applications, it may not be.

3.0 Configuration

3.3.6 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 4.3 are applicable, with the exception that the following registers 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.

3.0 Configuration

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.

3.0 Configuration

3.3.7 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.

3.0 Configuration

3.3.8 Everyone-to-Everyone (E2E)

E2E mode is used for communications between all remote modems,

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

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

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

To establish a basic E2E network:

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.

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

4.0 Register/Command Reference

4.1 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]**.

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).

g, G	**Spectrum Analyzer**

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.

This is a very useful feature of the P2400. 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 P2400 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 P2400 Channel 1 is at 2401.6 MHz, with subsequent channels in increments dependent on the link rate. Therefore, to calculate the frequency of channel *n*: (BW = Channel Bandwidth in MHz)

Freq channel n = 2401.6+ ((n-1) x BW) MHz.

I*n*	**Identification**

The I command returns information about the P2400.

1	Product Code
3	Product Identification (Firmware Version)
4	Firmware Date
5	Firmware Copyright
6	Firmware Time
255	Factory-Configured Options listing

4.0 Register/Command Reference

ATlogin	Login

AT Login can be used to enable a password prior to accessing command mode and changing any configuration parameters. The modem must be restarted before settings will be enabled.

```
Serial Console - HyperTerminal                    —    □    ×
File  Edit  View  Call  Transfer  Help

atlogin
New Password (32 chars max) : ****
OK


Connected 5:43:29    Auto detect   9600 8-N-1    SCROLL   CAPS   NUM   Capture   Print echo
```
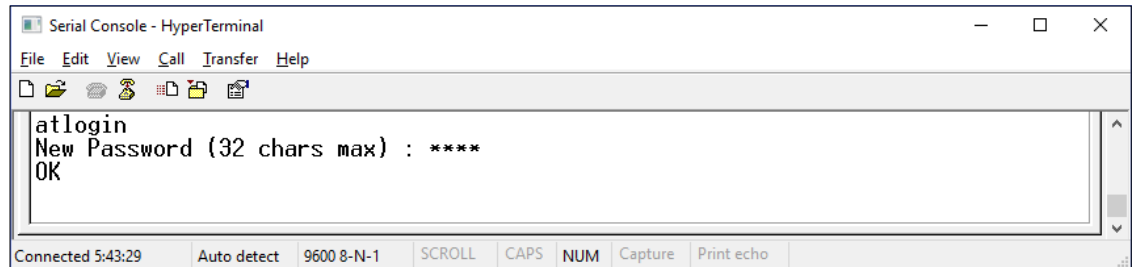
Image 6-1: AT login

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 P2400 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

$$\textbf{ATN } \textbf{F}_{start} \textbf{ F}_{stop} \textbf{ S D}\textit{[Enter]}$$

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 2402.250 2420.250 25 100

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

4.0 Register/Command Reference

&F*n*	Load Factory Default Configuration

Loading Factory Default settings allow for quick configuration of systems by setting a known starting point with factory recommended settings for each type of unit. The Factory settings change all settings required to initiate default communication with other unit types.

Values
Frequency Hopping (FH) modems &F1   FH Master Fast PMP &F2   FH Slave Fast PMP &F3   FH Repeater Fast PMP &F4   FH Master Slow PMP &F5   FH Slave Slow PMP &F6   FH Master Fast PP &F7   FH Slave Fast PP &F8   FH Master Slow PP &F9   FH Slave Slow PP &F10 FH Master Fast PMP no Time ACK &F11 FH Master Fast P2P no Time ACK &F12 FH Master Fast PP no Time ACK &F15 FH Master WL &F16 FH Slave WL &F18 FH Master Fast TDMA &F19 FH Slave Fast TDMA &F100 - Reset Hopping Modes

4.0 Register/Command Reference

&H0	Frequency Restriction

By default, the P2400 will hop on frequencies across the entire 2.4 GHz ISM band. For some applications or within certain operating environments, it may be desired to prohibit the modem from operating on specific frequencies or range(s) of frequencies. The modem will not allow 'too many' frequencies to be restricted; it requires a certain amount of bandwidth within which to operate to comply with regulations.

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

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

Following is an example of entering Frequency Restrictions. First, the AT&H0 command is invoked:
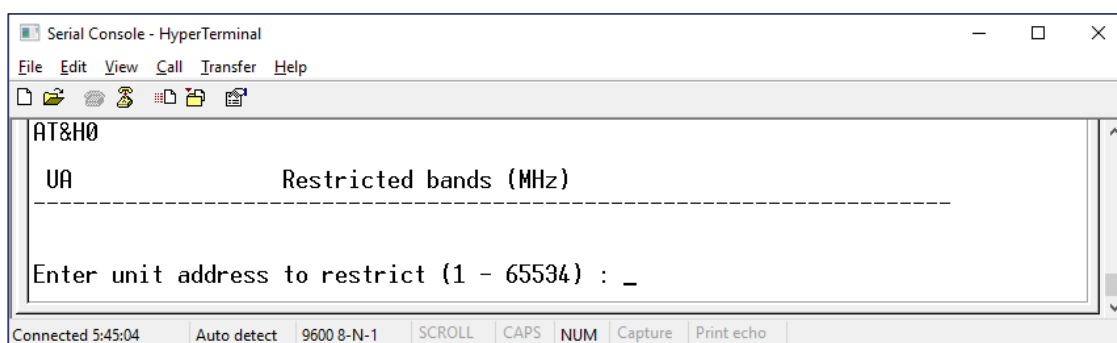
Image 4-1: Frequency Restriction

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.) Having entered '1', the modem prompts for the first restricted frequency to be entered.
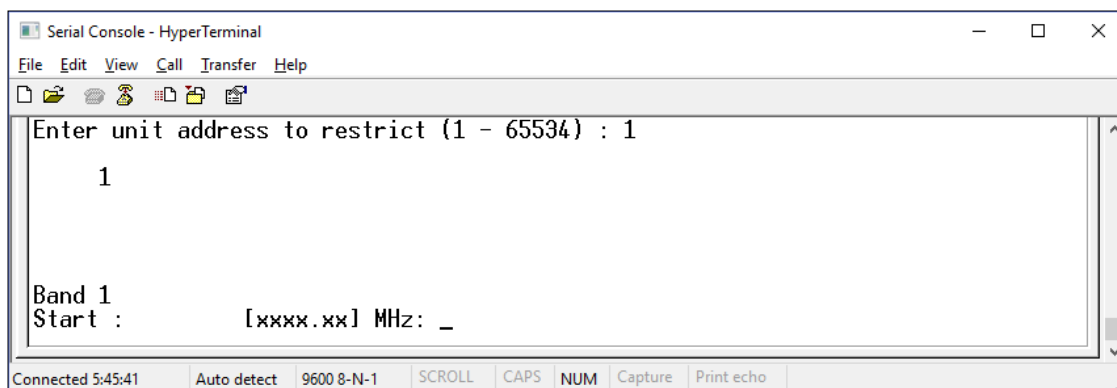
Image 4-2: Unit Address

4.0 Register/Command Reference

&H0	Frequency Restriction (continued)
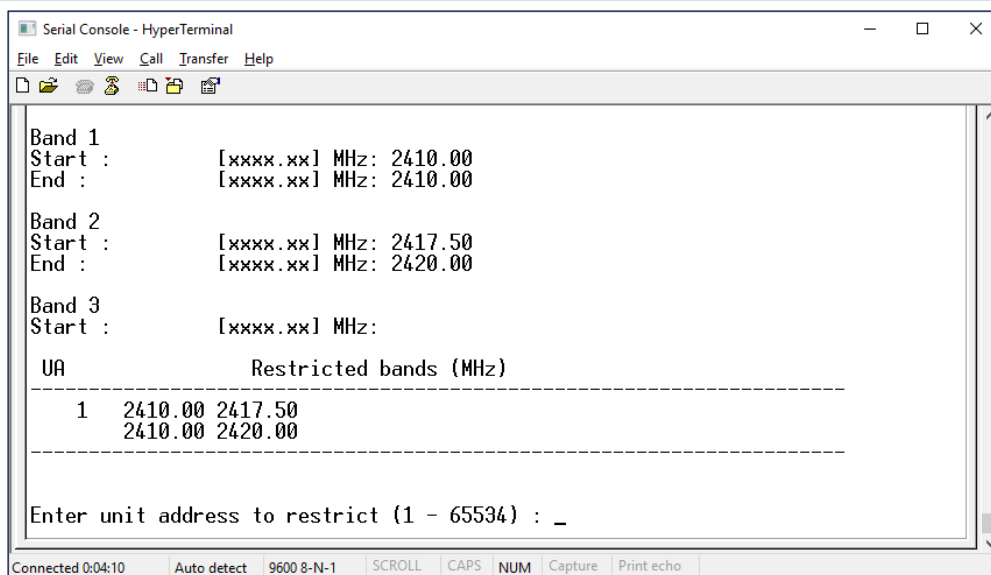
Image 4-3: Restricted Bands

2410.00 was entered as the 'start' and 'end' of Band 1; this will restrict the frequency of 2410.00MHz. The range of 2417.50 to 2420.00 MHz 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.

&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. Any changes made to the Pico Series must be written to NVRAM using the AT&W command (AT&WA will write the changes & set unit in online mode)

4.0 Register/Command Reference

4.2 Settings (S) Registers

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

The previous sections provide configuration detail related to different operating modes and network to-pologies; this section examines each S register in detail for reference or advanced/custom networks. 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]**
Help format:	**ATS<S register #><space>/? [Enter]**

The P2400 is a multi-Frequency Modem that can operate in several different modes as discussed in previous sections. The registers applicable for each mode, and network/protocol type may vary. Where possible, it has been noted in the title box if the register is only used in specific modes.

NB = Narrowband, Licensed Modes (400 MHz)
FH = Frequency Hopping Modes (400 MHz and/or 900 MHz)

y <command	command name> *x*

S0	**Power-up Mode**

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**

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)**

4.0 Register/Command Reference

| **S101** | **Operating Mode** |

The Operating mode defines the role in the network a unit plays. A P2400 modem may be configured for any role required within a radio network.

Master: Only one per network. In PP/PMP 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 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.

Slave: Interfaces with remote devices and communicates with Master either directly or via Repeater(s).

Values (selection)

0 - Master
1 - Repeater
2 - Slave (Remote)

| **S102** | **Serial Baud Rate** |

The serial baud rate is the rate at which the modem is to communicate with the attached local asynchronous device. This value must match the PC or serial device that is connected to data port on the P2400.

When forcing a module to Command Mode the data port will temporarily communicate at the default value. When the P2400 is retuned to Data Mode, the serial port settings are returned to those specified in S102 and S110.

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**		

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

| **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)

Frequency Hopping modems:
0 - 19200
1 - 115200
2 - 172800
3 - 230000
4 - 276000
5 - 340000
6 - 24700
8 - 57600

| **S104** | **Network Address (ID)** |

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

Change the default value for the Network ID 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.

4.0 Register/Command Reference

Change S107 to something unique for your network.

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. Refer to the specific modem type for more information in regards to unit addressing.

Values (1-65535 or 1-255)
1

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.

For NB modems it is used by Pacific Crest protocol for security purposes. Default: Empty String

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**	**(1W)**
25	(320)		

4.0 Register/Command Reference

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)	S109	time (ms)	S109	time (ms)
0	1.498	16	89.997	32	11.997	48	21.998
1	2.001	17	99.998	33	12.500	49	22.999
2	2.498	18	125.000	34	12.998	50	24.000
3	3.002	19	150.001	35	13.501	51	25.001
4	3.997	20	4.500	36	13.998	52	26.001
5	4.997	21	5.501	37	14.502	53	27.002
6	6.999	22	5.998	38	15.502	54	27.997
7	10.001	23	6.501	39	16.000	55	28.998
8	14.999	24	7.502	40	16.497	56	8.335
9	19.997	25	8.000	41	17.001	57	199.997
10	29.999	26	8.497	42	17.498	58	250.000
11	40.000	27	9.000	43	18.001	59	300.002
12	50.002	28	9.498	44	18.499	60	349.998
13	59.998	29	10.499	45	19.002	61	378.997
14	69.999	30	11.002	46	19.499		
15	80.001	31	11.499	47	20.998		

Table 4-1: Hope Interval (S109)

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. The value must match the PC or Serial Based device that is connected to the data port.

When forcing a module to Command Mode the data port will temporarily communicate at the default value. When the P2400 is retuned to Data Mode, the serial port settings are returned to those specified in S102 and S110.

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

4.0 Register/Command Reference

S111	Packet Min Size

This is the minimum number of collected bytes in one buffer before the buffer can be closed by the character timeout timer controlled by S116. Typically should not be modified.

Values (1 - 255)

1

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 in frequency hopping modems.

Values (1 - 255)

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 number of times that a packet will be retransmitted (in addition to the initial transmission). Retransmissions can be used to provide system robustness and to ensure data delivery due to noisy environments or weak signal levels. Retransmissions should not be used as the only means to correct for data collisions. Retransmissions create additional traffic and can have a significant impact on overall throughput of a system.

See register S213 for Repeaters.

Values (0 - 254)

5

S115	Repeat Interval

In **PP/PMP** S115 determines the number of slots which are available within a window of opportunity for Remote units to submit channel requests to the Master modem. For a large number of remotes, the value of S115 should be set relatively high:

Values (0 - 255)

3

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.

4.0 Register/Command Reference

S116 **Character Timeout**

Character Timeout in 1/4 of character time (0-255). Default = 10 (2.5 character time). 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. If the timer detects a gap in the data exceeding the Character Timeout value, the modem will transmit the data.

Values (0 - 254)

10

The Pico 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:

S118=65535: 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.

Values

65535 full roaming

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

1

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.

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.

S119 **Quick Enter to Command Mode**

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

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

Values

0   disabled
1   enabled

4.0 Register/Command Reference

S123	RSSI from Uplink (dBm)

This register displays the average signal strength received over the previous 8 hop intervals from a Master/Repeater. The value in this register is also reflected in status lines RSSI1, 2, and 3, which connect to the modem's RSSI LEDs.

Values (dBm)

-120 to –20dBm (max reading)

The 'ATS123 /?' command will show the RSSI statistics (min, max, average, channel, frequency).

S124	RSSI from Downlink (dBm)

This register displays the average signal strength received over the previous 8 hop intervals from a Slave/Repeater. The value in this register is also reflected in status lines RSSI1, 2, and 3.

Values (dBm)

-120 to –20dBm (max reading)

The 'ATS124 /?' command will show the RSSI statistics (min, max, average, channel, frequency).

S130	No Sync Intake

Defines if the modem will accept data when/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 - **Disabled**
1 - Enabled

S133	Network Type

This register defines the type of network being deployed. This register must be set to the same value on every unit in the system.

Point to Multipoint - The Master broadcasts data to all units, and all remote units send data back to the Master.
Point to Point - Point to point traffic between 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-2-Everyone - E2E).

Values

0 - Point to Multipoint (PMP)
1 - Point to Point (PP)
2 - Peer to Peer or Everyone to Everyone.
3 - Reserved
4 - PMP with acks

S139	Compatible_21 at 345

If this register is set the P2400 will be compatible with the MHX2421 operating at a link rate of 345kbps.

Values

0 - Disabled
1 - Enabled

4.0 Register/Command Reference

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.

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.

In **PMP** and **PP** modes - the range is 1 to 65535, where 65535 is broadcast:

PMP	- Master S140=65535, Remote S140=1
PTP	- Master S140=UA of Remote, Remote S140=1 (Master)
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

Varies by network and unit type

S141 — Repeaters Y/N

This register informs, and only applies to the Master, as to the presence of any Repeater(s) in the network. With one or more Repeaters in the system, a networks throughput is divided in half.

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.

-ATS142=2 RS485 interface, Full duplex (4-wire), Tx driver is on only when data are being sent. This mode could be used for multi-drop systems.
-ATS142=3 RS485 interface, Full duplex (4-wire), Tx driver is on always. This mode has reduced Tx driver switching noise.

Values

0 - RS-232 interface
1 - Half-duplex RS-485
2 - Full-duplex RS-485 (Tx switch)
3 - Full-duplex RS-485 (Tx on)

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.

4.0 Register/Command Reference

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

S158	FEC (Forward Error Correction) Mode

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

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

FEC consumes significant 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.

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)**

Types of FEC available within the P2400 (FH Modems):

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

4.0 Register/Command Reference

S163	CRC Check on Diag Port

Enables CRC checking of received data on local diagnostic port
Default - 1 (enable), 0 - disable. Note that even if disabled,
the incoming data must have two dummy bytes transmitted in place of
CRC bytes. See the P2400 Diagnostic Channel Protocol Manual for
more information.

Values

0 - Disable
1 - Enable

S167	Tx Enable

Tx Enable 0 - Disabled, 1- Enabled (default)
Enables RF emission.

Modem will never transmit data if disabled, it will be in a listen only
mode.

Values

0 - Disable
1 - Enable

S213	Packet Retry Limit

Packet Retry Limit(0 - 254). Valid only for repeater's uplink (from child
to parent)

Values (0 - 254)

5

S214	Diagnostics Packet Retransmission

Enables the retransmission of Diagnostic Packets. Diagnostics Packet
Retransmission(0 - 254). 0 - (default)

See the P2400 Diagnostics Manual for more information.

Values (0 - 254)

0

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

S238	Hopping Mode

Hopping mode register (S238) is preset by manufacturer. It is a read-
only register for the end user. S238 controls the modem either hopping
on pattern or on frequency table.

Values

0 - Hopping on pattern
1 - Hopping on frequency table
2 - Hopping on channel
3 - Hopping on frequency

4.0 Register/Command Reference

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 previous sections. 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)

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**)** 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

4.0 Register/Command Reference

4.3 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

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)

&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 synchronized (FH), when channel is idle (NB)** 4 - DCD on when synchronized (FH), when channel is busy (NB)

&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 - DTR disconnects and switches to command mode

&K*n*	**Handshaking**
Enables or disables hardware handshaking. - AT&K0 hardware handshaking disabled, used only for RS232 interface (S142=0). - AT&K1 must be selected when RS485 interface is used (S142=1, 2 or 3). - AT&K3 hardware handshaking enabled, used only for RS232 interface (S142=0).	**Values** **0 Handshaking disabled** 1 CTS Control Transmitter of RS485 driver chip. 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 - DSR = 0 in data mode, 1 command mode

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

5.0 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
The P2400 currently operates in the 2.4 GHz ISM FHSS Band and supports various Point-to-Point and Point-to-Multipoint topologies.

Throughput
The P2400 is capable of up to 345 kbps asynchronous baud rate. 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.   When contemplating antenna types, keep in mind the directivity (omnidirectional or directional) of the antennas being used.

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 P2400 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 Pico Series features the maximum available transmit power combined with exceptional receive sensitivity - two 'numbers' which will produce the most favorable path calculation results.

5.0 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 Pico 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 frequency ranges supported 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 Pico 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 minimizing power consumption are available with the P2400 such the ability to operate at lower transmit power given the receive sensitivity of the distant modem.

Interference

The frequency hopping spread spectrum (FHSS) operation of the Pico Series most often allows it to work well in an environment within which there may be sources of in-band interference. Frequency Restriction (Hopping Zones) 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.

5.0 Installation

5.1 Path Calculation

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.

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.

5.0 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 5-1: Path Loss (2.4 GHz)

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

5.2 Installation of Antenna System Components

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

5.2.1 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.

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.

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.

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

5.0 Installation

Direct human contact with the antenna is potentially unhealthy when a P2400 is generating RF energy. Always ensure that the P2400 equipment is powered down (off) during installation.

5.2.2 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.

5.2.3 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.

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.

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 online/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
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.

&F*n*
Load Factory Default Configuration
Frequency Hopping Modems
&F1 - FH Master Fast PMP
&F2 - FH Slave Fast PMP
&F3 - FH Repeater Fast PMP
&F4 - FH Master Slow PMP
&F5 - FH Slave Slow PMP
&F6 - FH Master Fast PP
&F7 - FH Slave Fast PP
&F8 - FH Master Slow PP
&F9 - FH Slave Slow PP
&F10 - FH Master Fast PMP no Time ACK
&F11 - FH Master Fast P2P no Time ACK
&F12 - FH Master Fast PP no Time ACK
&F15 - FH Master WL
&F16 - FH Slave WL
&F18 - FH Master Fast TDMA
&F19 - FH Slave Fast TDMA

&F100 - Reset Hopping Modes

&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*

&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)

&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

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

S*xxx* /?
Display S Register Help Text
-where xxx is the S register's number, this command will result in displaying the available settings of that register. Not all registers have help text.

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

S101
Operating Mode
For FH modems
0 - Master
1 - Repeater
2 - Remote

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)
Frequency Hopping modems:
0 - 19200
1 - 115200
2 - 172800
3 - 230000
4 - 247000
5 - 340000
6 - 24700
8 - 57600

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

S105
Unit Address
1-65534

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

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

S113 - Packet Retransmissions
0-255
5*

S115 - Repeat Interval
0-255
1*

S123
RSSI Value (dBm, read only)

S133
Network Type
0 - Point to Multipoint
1 - Point to Point
2 - Peer to Peer
3 - Reserved
4 - PMP with acks

S140
Destination Address
1-65535, where 65535 = Broadcast

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)*

S244
Channel Access Mode
0 - Channel request (default),
1 - TDMA,
2 - Fast TDMA
3 - On GPS index,
4 - Adaptive TDMA

Appendix C: AT Utility Firmware Upgrade Procedure

To update the firmware, it is recommended to use the Microhard Utility called **AT Firmware Upgrade**. This utility is available for download from the Microhard Support Site below:

http://support.microhardcorp.com

To access the downloads section of the support site, you must first register, if you have not already done so.

1. Power up the Modem and Connect a straight through serial cable to the DATA Port of the module. (If installed in development board).

2. Run the firmware utility downloaded from the Microhard Support site.

    "ATFirmwareUpgrade.exe"

3. Select the COM port on your PC that is connected to the Module.

4. Browse to the firmware file supplied by Microhard Systems. (.img) to be uploaded to the module.

5. Click the "Load" button. *If a password was setup using the ATlogin command, you will be prompted for this password before you can update the firmware.*

6. The utility will establish a connection to the module and load the firmware. Once complete, a message will be display at the bottom of the utility window indicating that the process succeeded.
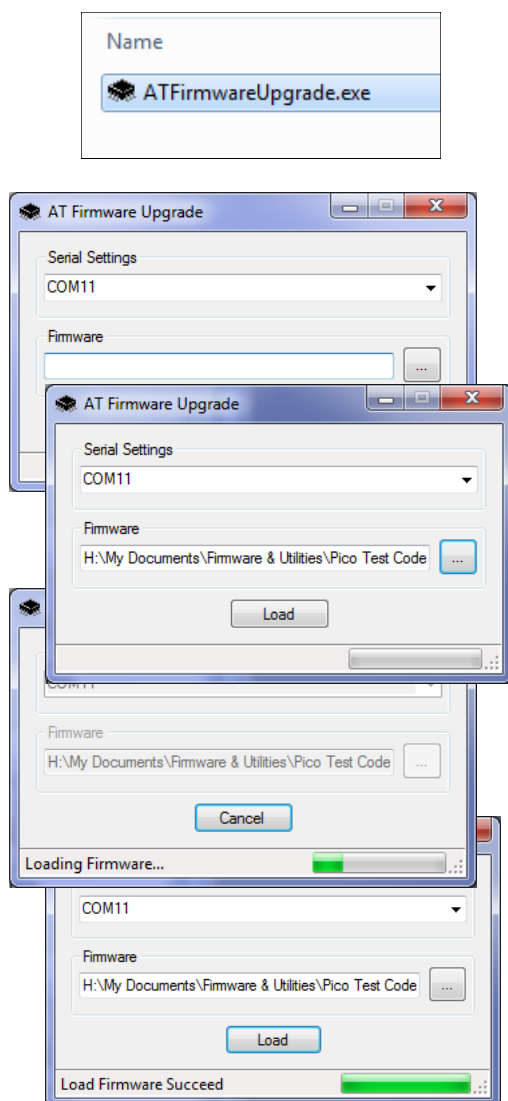
Image C-1: Firmware Upgrade

Appendix D: AT Command Firmware Upgrade Procedure

To update the firmware on the Pico Series Radio, it is recommended to use the Microhard Utility called **AT Firmware Upgrade**, discussed on the previous page. If it is not possible to use the utility, the following procedure can be used to load firmware using AT commands. The file type used for this procedure is not the same as when using the utility.

AT Command Upgrade Procedure

1. Enter Command Mode.

2. Select the baud rate 115200 bps (ATS102=1) for the modem to minimize the firmware upgrade time. Connect Microhard modem through a COM port as the setting with serial port terminal software:

    Baud Rate: 115200
    Parity bit: None
    Data bits: 8
    Stop bits: 1
    Flow Control: None

3. Run Microhard AT command to do the flash upgrade in the following sequence:

    3.1 Run "at&u0<CR>" at command terminal

    Initialize the modem into flash image upgrade mode

    3.2 Run "at&u1<CR>" at command terminal

    Load the flash image into the modem. After this command is entered, don't do anything except send the firmware file provided by Microhard (.img). The Modem doesn't send ACK packets after receiving every data block; it sends "OK" response only when modem receives the last data block. It sends an "ERROR" response if the file was not received.

    3.3 Run "at&u2<CR>" at command terminal

    Pre-arm the image flashing. You have 20s to trigger the writing procedure of the firmware image from RAM to Flash memory. If you missed that window of opportunity, you need to pre-arm modem again.

    3.4 Run "at&u3<CR>" at command terminal

    Flash the loaded image. After this command has been issued, any action and power changes could damage the modem. Modem returns the "ERROR" response when the 20s time-out is expired. The approximate duration on this step is 30s.

    After the flash upgrade finishes, the modem reboots and it is ready to work.

Appendix E: 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 P2400 Serial Interface on the Development Board 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:

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

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.

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 F: Pico Development Board Schematic

Appendix G: Pico-MHX Adapter Card (Page 1 of 2)

Pico-MHX Adapter Card

The Pico-MHX Adapter card is available to users of the MHX platform who wish to transition and/or evaluate the Pico platform without a complete redesign.

Pico-MHX Adapter Board

Pico-MHX Adapter Pin-outs

The following shows the pins available on the Pico-MHX Adapter. For more information, refer to the detailed pin description in this manual, or in the respective MHX manual. This is provided as a quick reference. The drawing depicts a top view of the Adapter. The corner pins (1,20,21,40) are printed directly on the PCB for reference.

Signal	Pin		Pin	Signal
Vcc	1		40	NC
Vcc	2		39	NC
3.3V or 5V Select	3		38	NC
VClock	4		37	NC
!Shutdown	5		36	NC
!Bootpgm_Mode	6		35	Diag TxD
USR_AN0	7		34	Diag RxD
!WAKEUP_usr	8	MHX	33	Rx/SYNC_LED
!Config	9	Pin-Out	32	TxMODE_LED
!Reset	10	(Top View)	31	RSSI3_LED
VBat	11		30	RSSI2_LED
Sleep_Mode	12		29	RSSI1_LED
GND	13		28	CTS
GND	14		27	RTS
GND	15		26	DSR
GND	16		25	RING
GND	17		24	DTR
USR_1	18		23	TxD
USR_2	19		22	RxD
USR_3	20		21	DCD

MHX Series Pin-Out (Top View)

Appendix G: Pico-MHX Adapter Card (Page 2 of 2)
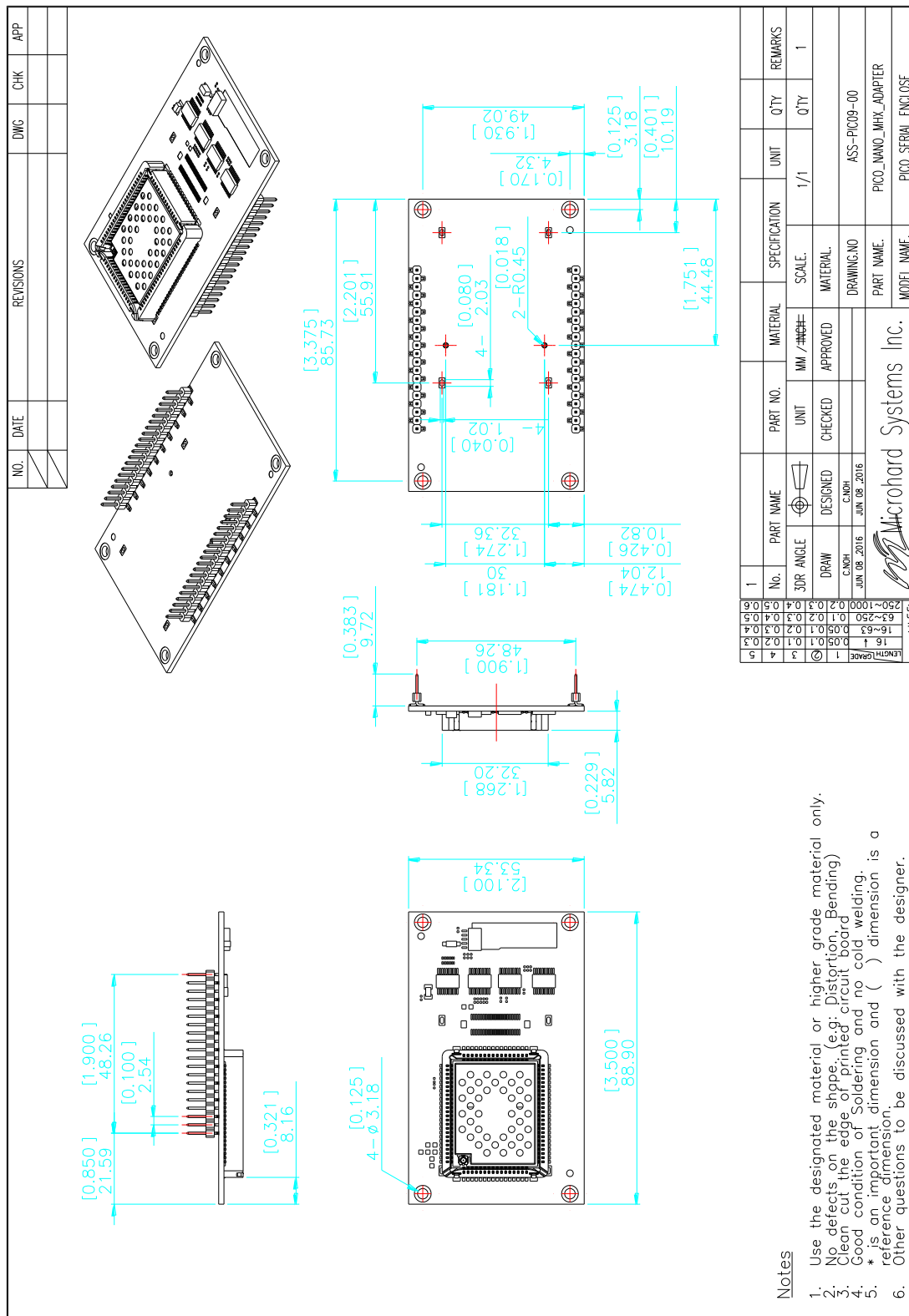
Appendix H: Approved Antennas

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
	NW001	2.5dBi, Shenzhen Norminson Technology CO.LTD. - 2.4GHz Rubber Ducky Antenna Reverse SMA Straight
	WCP2400-MMCX4	2.5dBi, Laird Technologies - 2.4GHz Rubber Ducky MMCX
	GW.59.3153	2.5dBi, Taoglas - 2.4 GHz Rubber Ducky Reverse SMA Straight
Yagi Antennas		
	MHS034100	9 dBi, 2.4GHz Yagi Directional Antenna RPTNC Pigtail
	MHS034000	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 UFL connectors with the antennas listed in Appendix A When integrated in OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the tables must be tested to comply with FCC Section 15.203 (unique antenna connectors) and Section 15.247 (emissions). Please Contact Microhard Systems Inc. if you need more information.

Industry Canada: This device has been designed to operate with the antennas listed above, and having a maximum gain of 15 dBi. Antennas not included in this list or having a gain greater than 15 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication. This Class B digital apparatus complies with Canadian ICES-003.

Industrie Canada: Cet appareil a été conçu pour fonctionner avec les antennes énumérées ci-dessus, et ayant un gain maximal de 15 dBi. Antennes pas inclus dans cette liste ou présentant un gain supérieur à 15 dBi sont strictement interdits pour une utilisation avec cet appareil. L'impédance d'antenne requise est de 50 ohms. Pour réduire les interférences radio potentielles pour les autres utilisateurs, le type d'antenne et son gain doivent être choisis afin que la puissance isotrope équivalente (PIRE) ne soit pas supérieure à celle requise pour une communication réussie rayonnée. Cet appareil numérique de classe B est conforme à la norme ICES -003 du Canada.

150 Country Hills Landing NW
Calgary, Alberta
Canada T3K 5P3

Phone: (403) 248-0028
Fax: (403) 248-2762
www.microhardcorp.com