

Industrial 900-MHz Wireless Modem

User Manual

Standard and Rated C1D2 versions are available.



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This equipment generates, uses, and can radiate radio-frequency energy, and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio communication. It has been tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart B of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when the equipment is operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user at his own expense will be required to take whatever measures may be necessary to correct the interference.

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

This digital apparatus does not exceed the Class A limits for radio noise emission from digital apparatus set out in the Radio Interference Regulation of Industry Canada.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de la classe A prescrites dans le Règlement sur le brouillage radioélectrique publié par Industrie Canada.

Regulatory Requirements

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

MAXIMUM EIRP

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

Who Can Use This Manual

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

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Instrucciones de Seguridad (Normas Oficiales Mexicanas Electrical Safety Statement)

1. Todas las instrucciones de seguridad y operación deberán ser leídas antes de que el aparato eléctrico sea operado.
2. Las instrucciones de seguridad y operación deberán ser guardadas para referencia futura.
3. Todas las advertencias en el aparato eléctrico y en sus instrucciones de operación deben ser respetadas.
4. Todas las instrucciones de operación y uso deben ser seguidas.
5. El aparato eléctrico no deberá ser usado cerca del agua—por ejemplo, cerca de la tina de baño, lavabo, sótano mojado o cerca de una alberca, etc.
6. El aparato eléctrico debe ser usado únicamente con carritos o pedestales que sean recomendados por el fabricante.
7. El aparato eléctrico debe ser montado a la pared o al techo sólo como sea recomendado por el fabricante.
8. Servicio—El usuario no debe intentar dar servicio al equipo eléctrico más allá de lo descrito en las instrucciones de operación. Todo otro servicio deberá ser referido a personal de servicio calificado.
9. El aparato eléctrico debe ser situado de tal manera que su posición no interfiera su uso. La colocación del aparato eléctrico sobre una cama, sofá, alfombra o superficie similar puede bloquea la ventilación, no se debe colocar en libreros o gabinetes que impidan el flujo de aire por los orificios de ventilación.
10. El equipo eléctrico debe ser situado fuera del alcance de fuentes de calor como radiadores, registros de calor, estufas u otros aparatos (incluyendo amplificadores) que producen calor.
11. El aparato eléctrico deberá ser conectado a una fuente de poder sólo del tipo descrito en el instructivo de operación, o como se indique en el aparato.
12. Precaución debe ser tomada de tal manera que la tierra física y la polarización del equipo no sea eliminada.
13. Los cables de la fuente de poder deben ser guiados de tal manera que no sean pisados ni pellizcados por objetos colocados sobre o contra ellos, poniendo particular atención a los contactos y receptáculos donde salen del aparato.
14. El equipo eléctrico debe ser limpiado únicamente de acuerdo a las recomendaciones del fabricante.
15. En caso de existir, una antena externa deberá ser localizada lejos de las líneas de energía.
16. El cable de corriente deberá ser desconectado del cuando el equipo no sea usado por un largo periodo de tiempo.
17. Cuidado debe ser tomado de tal manera que objetos líquidos no sean derramados sobre la cubierta u orificios de ventilación.
18. Servicio por personal calificado deberá ser provisto cuando:
 - A: El cable de poder o el contacto ha sido dañado; u
 - B: Objetos han caído o líquido ha sido derramado dentro del aparato; o
 - C: El aparato ha sido expuesto a la lluvia; o
 - D: El aparato parece no operar normalmente o muestra un cambio en su desempeño; o
 - E: El aparato ha sido tirado o su cubierta ha sido dañada.

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Quick Start Guide

This Quick Start guide will enable you to promptly establish basic connectivity between a pair of MDR100A-R5 or MDR112A-R5 modems in a point-to-point configuration.

What's Included

- (2) MDR100A-R5 or MDR112A-R5 Radios with power adapters and Rubber Ducky Antennas

Additional Items You Will Need

- (2) PCs with HyperTerminal (or equivalent) and (1) COM port each, or
- (1) PC with HyperTerminal and (2) COM ports.
- (2) straight-through serial cables (9-pin M to 9-pin F).

Setup Procedure

Open HyperTerminal and configure it as 9600, 8 data bits, no parity, 1 stop bit, and no handshaking, then open the "connection" (at bottom left of HyperTerminal window, the word "Connected" should appear).

Plug the included power adapter (8-30-VDC) into a wall outlet and press the CFG/CONFIG button on the front of the MDR100A-R5 or MDR112A-R5.

The HyperTerminal window should show the response "NO CARRIER OK."

At this point, both MDR100A-R5 or MDR112A-R5 radios are in COMMAND MODE. To configure one module as the Master, type AT&F6 [Enter], then type AT&WA [Enter]. This module's TX LED (red) should light. To configure the other module as the Slave, type AT&F7 [Enter], then type AT&WA [Enter]. This module's RX and 3 RSSI LEDs will light.

The radio is now connected. If you enter text in one PC's HyperTerminal window, it will appear in the other's window and vice versa.

1. Specifications

Electrical/General	
Frequency	902–928 MHz
Spreading Method	Frequency-Hopping/DTS
Band Segments	Selectable via Frequency Restriction
Error Detection	32 bits of CRC, ARQ
Data Encryption (Optional)	128-bit or 256-bit AES Encryption (requires an export permit outside U.S. and Canada)
Range	60+ miles (100 km)
Speed	
Serial Baud Rate	Up to 230.4 kbps (slow/fast); Up to 3.2 Mbps (turbo, synchronous)
Link Rate	19.2 kbps to 1.3824 Mbps
Power	
Output Power	100 mW to 1 W (20–30 dBm)
Sensitivity	-116 dBm (slow), -108 dBm (fast), -100 dBm turbo
Core Voltage	3.3 VDC nominal (±0.3 V)
Current Consumption	See Table 1-1 below.
Environmental	
Operating Temperature	-40 to +185° F (-40 to +85° C)
Humidity	5 to 95% noncondensing
Mechanical	
Connectors	(1) enclosed RP-SMA female bulkhead antenna
Dimensions	1.75"H x 3.75"W x 2.25"D (4.5 x 9.5 x 5.7 cm)
Weight	0.6 lb. (0.27 kg)

Table 1-1. Current Consumption (mA).			
Current Consumption	MIn.	Typical	Max.
Full-time RX*	140	240	280
Max. continuous TX current	1000	1300	1500
Typical TX and RX average	—	450	—
Sleep Current Draw	—	2	—
Current Consumption	RX	TX @1W (average)	TX @ 1 W (peak)
@12 V	80 mA to 110 mA	400 mA	540 mA
@24 V	40 mA	210 mA	270 mA

* Depends on speed and mode.

Dimensional Diagrams

Dimensions for the modem are shown in Figures 1-1 through 1-3.

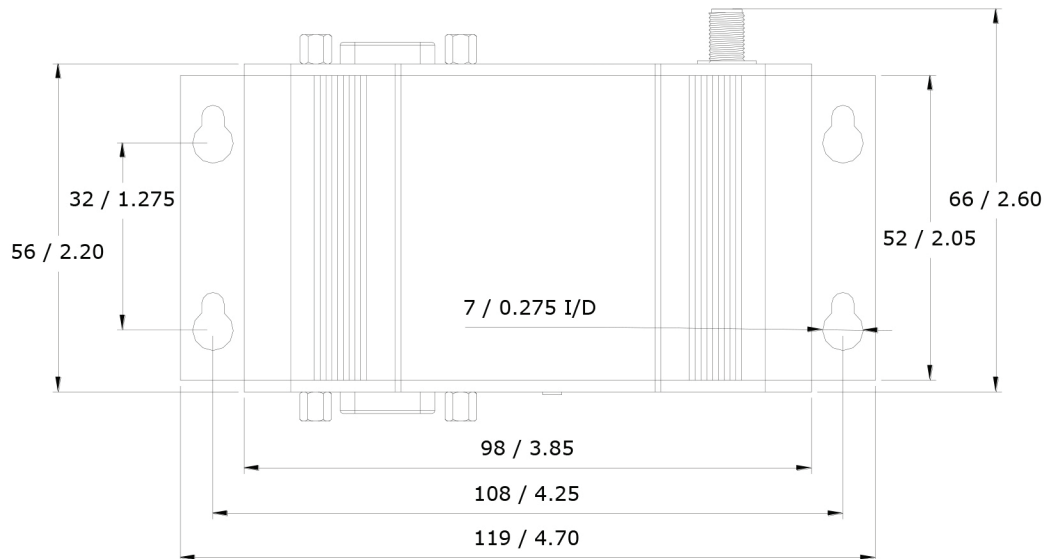


Figure 1-1. MDR100A-R5 top view.

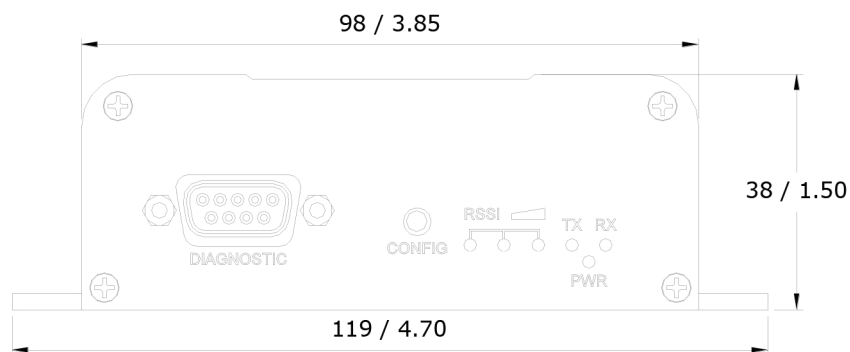


Figure 1-2. MDR100A-R5 front view.

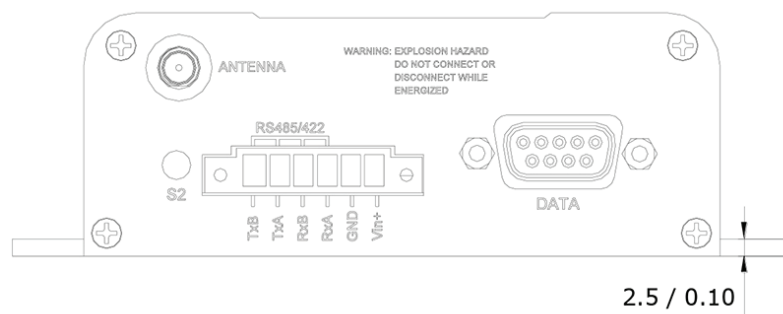


Figure 1-3. MDR100A-R5 back view.

2. Overview

2.1 Introduction

The MDR100A-R5 or MDR112A-R5 delivers high-performance wireless serial communications in a variety of network topologies.

The MDR100A-R5 or MDR112A-R5 operates within the 902–928 MHz ISM frequency bands, using frequency-hopping spread-spectrum (FHSS) technology. It provides reliable wireless asynchronous data transfer between most equipment types that use an RS-232, RS-422, or RS-485 interface.

The small size and superior performance of the MDR100A-R5 or MDR112A-R5 makes it ideal for many applications. Some typical uses for this modem include:

- SCADA
- Remote telemetry
- Traffic control
- Industrial controls
- Remote monitoring
- Fleet management
- GPS
- Wireless video
- Robotics
- Display signs
- Railway signaling

2.2 Features

Key performance features of the MDR100A-R5 or MDR112A-R5 include:

- Transmission within a public, license-exempt band of the radio spectrum¹—this means that the modems may be used without access fees or recurring charges (such as those incurred by cellular airtime).
- Transparent, low-latency link providing up to 1.2 Mbps continuous throughput.
- Communicates with virtually all PLCs, RTUs, and serial devices through either an RS-232, RS-422, or RS-485 interface.
- Supports point-to-point, point-to-multipoint, store-and-forward repeater, TDMA.
- Wide temperature specification.
- Maximum allowable transmit power (1 Watt).
- Low power consumption in Sleep Mode (real-time clock wakeup).
- 32 bits of CRC, selectable re-transmission and forward error correction.
- Separate diagnostics port—transparent remote diagnostics and online network control.
- Easy to install and configure—the MDR100A-R5 or MDR112A-R5 uses a subset of standard AT-style commands, similar to those used by traditional telephone-line modems.

2.3 What's Included

- (2) MDR100A-R5 or MDR112A-R5 Radios with power adapters and Rubber Ducky Antennas

To download this user manual from our Web site:

- 1. Go to www.blackbox.com
- 2. Enter the part number (MDR100A-R5 or MDR112A-R5) in the search box:
- 3. Click on the “Resources” tab on the product page, and select the document you wish to download.

If you have any trouble accessing the Black Box site to download the manual, you can contact our Technical Support at 724-746-5500 or info@blackbox.com.

2.4 Hardware Description

The MDR100A-R5 or MDR112A-R5 provides a fully enclosed, standalone modem, requiring only cabled connections. The MDR100A-R5 or MDR112A-R5 can be used on a table top surface or mounted on a flat surface or a wall using the mounting holes.

A pair of the Industrial 900-MHz Wireless Modems are shown in Figure 2-1. On the front of the unit is the DIAGNOSTIC port, CONFIG Button, and the RSSI, TX and RX LEDs. The RX and RSSI LEDs on the unit on the right are lit green to indicate that the unit is receiving data. The components are described in Table 2-1. The TX LED on the unit on the left is lit red to indicate that it is transmitting data.



Figure 2-1. Front panel.

Table 2-1. Modem components.		
Number in Figure 2-1	Component.	Description
1	DB9 connector	The diagnostic port (RS-232) is used for two purposes: <ul style="list-style-type: none">• Online diagnostics and configuration at 115.2 kbps.• Firmware upgrades.
2	CONFIG Button	Press and hold this button while powering-up the modem to boot the unit into configuration mode: the default serial interface (rear DB9, RS-232) will be active and set to operate at its default serial baud rate of 9600 bps.
3	(3) Receive Signal Strength Indicator (RSSI) (3x Green)	As the received signal strength increases, starting with the furthest left, the number of active RSSI LEDs increases. Signal strength is calculated based on the last four valid received packets with correct CRC. RSSI is also reported in S123.
4	TX LED (Red)	When lit, this LED indicates that the modem is transmitting data over the air.
5	RX/SYNC LED (Green)	When lit, this LED indicates that the modem is synchronized and has received valid packets. <i>NOTE: There is also a Power LED below the TX and RX LEDs.</i>

Table 2-2. RS-232 diagnostic port pinout.

Signal Name	Pin Number	Input or Output
DCD	—	
RXD	2	O
TXD	3	I
DTR	—	
SG	5	
DSR	—	
RTS	—	
CTS	—	

Data Port (RS-232 Port DCE)

The DATA (RS-232 Port (DCE) on the rear of the circuit board is used for:

- RS-232 serial data (300-230, 400 bps) when in DATA MODE, or
- for configuring the modem when in COMMAND MODE.

Table 2-3. RS-232 data port pinout.

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

RS-422/485 Port

The RS-422/485 Port is used to interface the MDR100A-R5 or MDR112A-R5 to a DTE with the same interface type. Either the RS-232 or RS-422/485 interface is used for data traffic.

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

Table 2-4. RS-422/485 port pinout.

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

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

3. Operating Modes

3.1 Command Mode

In this mode:

- The MDR100A-R5 or MDR112A-R5 module is offline (data is not passing through the unit via its local data lines or RF communications).
- The MDR100A-R5 or MDR112A-R5's configuration options (registers) may be viewed and modified.

How to Enter Command Mode

Two methods are typically used to place the MDR100A-R5 or MDR112A-R5 into command mode:

1. Force to Command Mode:

- Power off the MDR100A-R5 or MDR112A-R5.
- Connect a 9-pin straight-through serial cable from PC COM port to the rear RS-232 port.
- Launch a terminal communications program (e.g. HyperTerminal) and configure for 9600 bps, 8 data bits, No parity, 1 stop bit (8N1).
- Press and hold the CFG/CONFIG button (S1 on front of unit).
- Continue to press the CFG/CONFIG button and apply power to the modem.
- Release the CFG/CONFIG button.
- Observe the front panel—only the small green LED should be lit, indicating that the MDR100A-R5 or MDR112A-R5 is in Command Mode.

2. Escape from Data Mode:

- With the MDR100A-R5 or MDR112A-R5 “online,” connect a 9-pin straight-through serial cable from the PC COM port to the rear RS-232 port.
- Launch a terminal communications program (e.g. HyperTerminal) and configure for the MDR100A-R5 or MDR112A-R5's established serial baud rate parameters (PC and modem must match).
- Pause 1 second, type “+++” (see Section 5.2, S1), pause 1 second: the monitor should show the module response of “NO CARRIER OK.”
- The MDR100A-R5 or MDR112A-R5 is now in Command Mode (observe the front panel: only the small green LED should be lit).

3.2 Data Mode

Data Mode is the normal operational state of all deployed MDR100A-R5 or MDR112A-R5 radios. In this mode, the module is prepared to exchange data as per its configuration settings. Available LED indications can provide an indication of the data exchange (TX and RX LEDs).

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

The following three modes are the “radio network” roles (see Section 5.2, S101).

3.3 Master

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

3.4 Repeater

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

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

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

If there is a "path" requirement to provide Repeater functionality, but throughput is critical, 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 uses a "null modem" cable. Each modem would require its own antenna; carefully consider antenna placement and modem configuration.

3.5 Slave

Endpoint/node within a network to which a local device is attached. Communicates with the Master either directly or through one or more Repeaters. See Sections 4.3 and 4.4 for information regarding "Slave-to-Slave" communications.

4. Network Topologies

The MDR100A-R5 or MDR112A-R5 may be configured to operate in a number of different operating modes and participate in various network topologies.

NOTE: This section describes network topologies and also contains details about related factory default settings to enable the reader to readily see the correlation between various registers. Refer to Chapter 5 for detailed information about configuration options and details.

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

- Hastens the configuration process.
Load default and if necessary, apply only minor settings adjustments.
- Aids in troubleshooting.
if settings have been adjusted and basic communications cannot be established, simply revert to the applicable factory default setting and any improper adjustments will be overwritten and a “fresh start” can be made with known-to-work settings.

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

4.1 Point-to-Point (PTP)

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

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

PTP factory default settings:

Master &F6
Slave &F7

slow mode (optional) :

Master &F8
Slave &F9

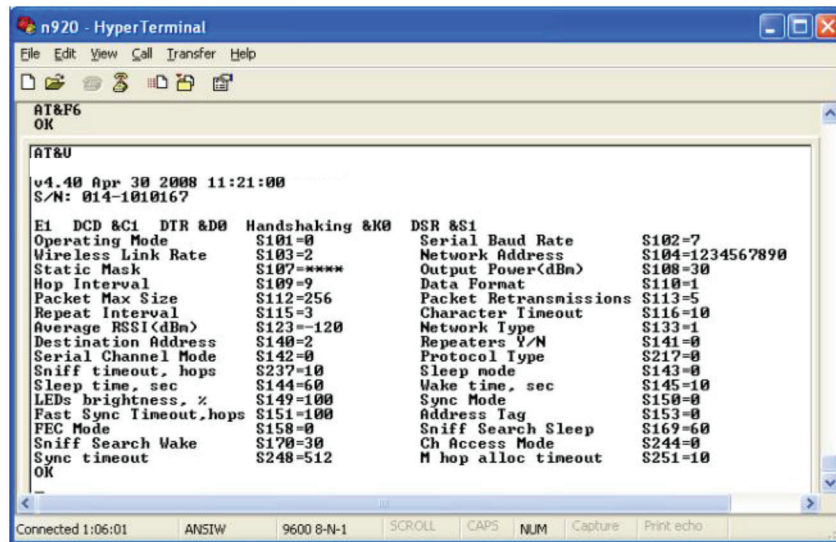


Figure 4-1. &F6 Master Configuration View.

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

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

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

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

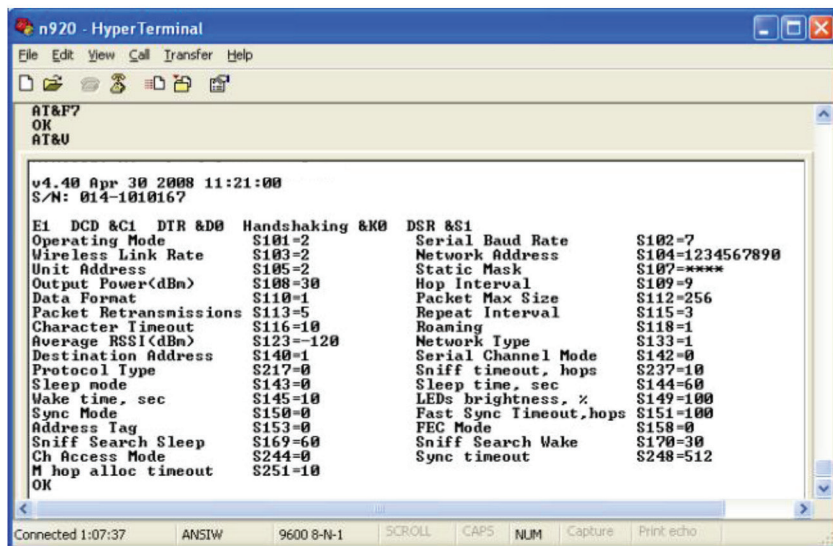


Figure 4-2. &F7 Slave Configuration View.

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

NOTE: The Master has a register "S141 - Repeaters Y/N" and the Slave does not. This register informs the Master that there are one or more Repeaters in this network. The factory defaults assume "no" and assign a value of 0. If you plan to install a Repeater, and maintain all the Master and Slave defaults, follow the procedure on the next page for how to configure a Repeater into this fixed (non-mobile) PTP network.

Chapter 4: Network Topologies

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.

You can test this system by sending text at 9600 bps, 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.

4.2 Point-to-Multipoint (PMP)

In a point-to-multipoint network, a path is created to transfer data between the Master modem and numerous remote modems. The remote modems may simply be Slaves with which the Master communicates directly, and/or Slaves that 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.”

Factory default settings:

Master	&F1
Slave	&F2
Repeater	&F3

slow mode (optional):

Master	&F4
Slave	&F5

```

n920 - HyperTerminal
File Edit View Call Transfer Help

AT&F1
OK

AT&U

v4.40 Apr 30 2008 11:21:00
S/N: 014-1010167

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
Static Mask S107=**** Output Power(dBm) S108=30
Hop Interval S109=9 Data Format S110=1
Packet Max Size S112=256 Packet Retransmissions S113=5
Repeat Interval S115=3 Character Timeout S116=10
Average RSSI(dBm) S123=-120 Network Type S133=0
Destination Address S140=65535 Repeaters Y/N S141=0
Serial Channel Mode S142=0 Protocol Type S217=0
Sniff timeout, hops S237=10 Sleep mode S143=0
Sleep time, sec S144=60 Wake time, sec S145=10
LEDs brightness, % S149=100 Sync Mode S150=0
Fast Sync Timeout,hops S151=100 Address Tag S153=0
FEC Mode S158=0 Sniff Search Sleep S169=60
Sniff Search Wake S170=30 Ch Access Mode S244=0
Sync timeout S248=512 M hop alloc timeout S251=10
OK

```

Connected 1:11:38 ANSIW 9600 8-N-1 SCROLL CAPS NUM Capture Print echo

Figure 4-3. &F1 Master Configuration View.

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

```

n920 - HyperTerminal
File Edit View Call Transfer Help

AT&F2
OK
AT&U

v4.40 Apr 30 2008 11:21:00
S/N: 014-1010167

E1 DCD &C1 DTR &D0 Handshaking &K0 DSR &S1
Operating Mode S101=2 Serial Baud Rate S102=7
Wireless Link Rate S103=2 Network Address S104=1234567890
Unit Address S105=2 Static Mask S107=****
Output Power(dBm) S108=30 Hop Interval S109=9
Data Format S110=1 Packet Max Size S112=256
Packet Retransmissions S113=5 Repeat Interval S115=3
Character Timeout S116=10 Roaming S118=1
Average RSSI(dBm) S123=-120 Network Type S133=0
Destination Address S140=1 Serial Channel Mode S142=0
Protocol Type S217=0 Sniff timeout, hops S237=10
Sleep mode S143=0 Sleep time, sec S144=60
Wake time, sec S145=10 LEDs brightness, % S149=100
Sync Mode S150=0 Fast Sync Timeout,hops S151=100
Address Tag S153=0 FEC Mode S158=0
Sniff Search Sleep S169=60 Sniff Search Wake S170=30
Ch Access Mode S244=0 Sync timeout S248=512
M hop alloc timeout S251=10
OK

```

Connected 1:19:55 ANSIW 9600 8-N-1 SCROLL CAPS NUM Capture Print echo

Figure 4-4. PMP Slave Configuration View.

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In Figures 4-3 and 4-4, the difference between the factory default for the PMP Master and PMP Slave are simply the Operating Mode (S101), Unit Address (S105), and the Destination Address (S140).

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

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

NOTES:

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

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

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

4.2.1 Point-to-Multipoint TDMA (Standard TDMA)

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

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

In this mode, each slave unit has the channel or right to broadcast, for varying lengths of time, and if a remote did not respond, the Master would need to time out before moving on to the next unit in the list. The maximum number of Remotes that can communicate with a Master in this configuration is 213 (8192).

To configure a Standard TDMA network, the default settings described in 4.2 apply, with the exception that the following registers (ref. Section 5.2) on the Master must be modified as required:

- S244 Channel Request Mode.
- S251 Master Hop Allocation Timeout.

For TDMA, set S244=1. (Must be set on Master and all Slaves.)

The default for S251 is 10 (hop intervals). If the system is to be deployed in a “clean” RF environment, this number should 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 (see Section 5.1) are used to populate, view and change the Registered Slaves List:

- T?: View entire Registered Slaves List
- Tn= 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).
- Tn?: 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.

Below 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.

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 the same.

On the next hop, the Master will sequence to the next modem, UA 7. Slave 7 will inform the Master that 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. Because of 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 this message from the Slave before moving on to begin the cycle again at UA 3.

4.2.2 Adaptive TDMA

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

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

To configure an Adaptive TDMA network, the default settings described in 4.2 are applicable, with the exception that the following registers (see Section 5.2) on the Master must be modified as required.

- S244 Channel Request Mode.
- S234 Master Channel Request Timeout (1–254).
- S235 Routing Time to Live (1–255).

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

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

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

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To view the current TDMA table, issue the AT&R1 command on the Master. The Master unit is always present in the TDMA list as unit address 1.

4.2.3 GPS Indexed TDMA (ADHOC)

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

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

Table 4-1. GPS Indexed TDMA Time Slots.		
Hop Interval (S109)	# of Slaves	# of Time Slots
200 ms	5	5
100 ms	10	10
50 ms	20	20
25 ms	40	40
20 ms	50	50
10 ms	100	100
5 ms	200	200

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

To configure a GPS Indexed TDMA, the default settings described in 4.2 apply, with the exception that the following registers (see Section 5.2) on all units must be modified as required:

- S244 Channel Request Mode.

For GPS TDMA, set S244 = 3.

4.2.4 Fast TDMA

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

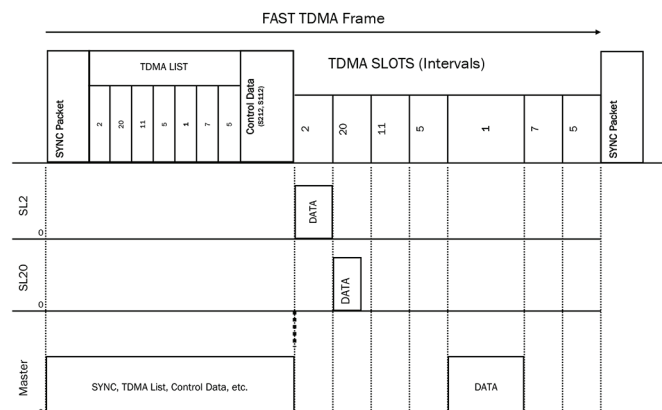


Figure 4-5. Fast TDMA operation and timing.

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

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

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

3. Control Data—Includes various control data, such as the value of the Master units S212 register (Max Expected Packet Size), and the Master unit's S112 register (Max Packet Size).

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

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

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

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

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

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

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

Fast TDMA assumes single packets are sent during assigned time slots. If multiple packets of varying lengths are required, assign multiple slots to ensure data overhead is considered. Retransmissions, ACK, and packet fragmentation are not used in this mode.

To calculate the duration of the entire Fast TDMA Frame:

For the link rate 172kbps:

$T_{\text{tdma_table}}(N_{\text{entries}}) = 2.3076 + 0.0684 * N_{\text{entries}};$

$T_{\text{data_packet}}(N_{\text{bytes}}) = 1.9327 + 0.0673 * N_{\text{bytes}};$

$T_{\text{total}} = T_{\text{tdma_table}} + T_{\text{data_packet_Master}} * N_{\text{Masters}} + T_{\text{data_packet_Slave}} * N_{\text{Slaves}},$ where $N_{\text{Masters}} + N_{\text{Slaves}} = N_{\text{entries}}$

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

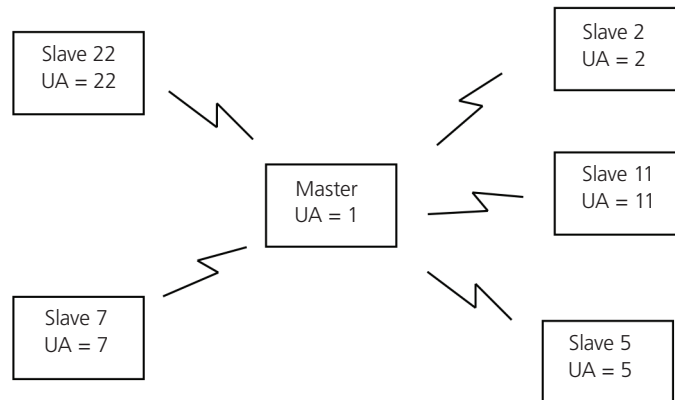


Figure 4-6. Sample system configuration.

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

TDMA Table

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

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

The Max. Packet size of the Master's data to the remotes, S112 on master = 200 bytes.

Using the formula given above:

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

The entire TDMA frame will take just under 110 ms.

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

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

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

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

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

Entering the TDMA Table:

ATT? View the entire registered TDMA table.

ATTn=UA Enter a Slave's Unit Address (UA) into the TDMA table. n = the position in the table. Use 0 to terminate the list.

ATTn? View a specific entry in the TDMA table.

Limitations:

- a. Remote diagnostics is not supported because packets sizes vary. Only local diagnostics is supported in this mode.
- b. Repeaters are not supported.

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

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

Master Fast TDMA (AT&F18)

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

Slave Fast TDMA (AT&F19)

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

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

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Default TDMA table for 1s polling time:

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

4.3 Peer-to-Peer (P2P)

P2P mode is used for communications between pairings of Remote modems, e.g. Slave 12 can exchange data with (only) Slave 14, Slave 6 can exchange data with (only) Slave 7, etc.

There are no specific factory default settings for P2P modems.

To establish a basic P2P network:

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 incoming data from both Slaves to both Slaves; one Slave’s data has a destination will be the other Slave and vice versa.

NOTES:

A P2P network requires a Master modem.

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

4.4 Everyone-to-Everyone (E2E)

E2E mode is used for communications between all remote modems, i.e., Data from every modem is broadcast to every other modem in the network.

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

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

To establish a basic E2E network:

Master

- Enter into Command Mode.
- Load the &F1 factory default settings.
- Change the Network Type (S133) to 2.
- Change Packet Retransmissions (S113) from 5 to 0 (increase from 0 if required).
- Save the change using the AT&W command.
- Go online with the ATA command.

Slaves

- Enter into Command Mode.
- Load the &F2 factory default settings.
- Change the Network Type (S133) to 2.
- Change the Unit Address (S105) to a unique number (range: 2–65534).
- Change the Destination Address to 65535 (the broadcast address).
- Save the change using the AT&W command.
- Go online with the ATA command.

NOTES:

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.

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

- The application.
- Network topology.
- Physical distribution of the network.

Components involved in the configuration process of the MDR100A-R5 or MDR112A-R5:

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

Interfacing to the MDR100A-R5 or MDR112A-R5 to configure it may be done in a number of ways:

If mounted in a MDR100A-R5 or MDR112A-R5 Interface Card combination:

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

If mounted in a MDR100A-R5 or MDR112A-R5:

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

Once connected and in Command Mode, changes to the MDR100A-R5 or MDR112A-R5's configuration are made using convenient AT commands, the majority of which involve Settings (S) Registers.

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

5. Configuration

5.1 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].

Table 5-1. AT commands.		
y < command	command name > x	Description
A	Answer	When tasks are done with the modem in Command Mode, invoking this command will place the modem back “online” (into Data Mode).
Dxxxxx, DTxxxxx, DPxxxxx	Dial	Identical commands that change the modem’s unit address to xxxxx and then put the modem into Data Mode.
g, G	Spectrum Analyzer	<p>This is a very useful feature of the MDR100A-R5 or MDR112A-R5. 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.</p> <p>Invoking the ATg command causes the MDR100A-R5 or MDR112A-R5 to sweep the operating band and provide a display of both the mean and peak signal levels, in dBm, found on each channel.</p> <p>The “graphical” display is limited from –110dBm to –53dBm, and is in 1-dB increments. Ignore the leftmost asterisk in calculations (as below).</p> <p>How to interpret the display (example):</p> <p>...</p> <p>ch 78 -137dBm * No signal was measured on channel 78.</p> <p>ch 80 -105dBm *****... Mean signal level: -(110-5 (asterisks)) = -105 dBm</p> <p>... Peak signal level: -(110-5 (asterisks) -3 (dots)) = -102 dBm</p> <p>For the MDR100A-R5 or MDR112A-R5, Channel 1 is at 902.4 MHz, with subsequent channels in 280 kHz increments. To calculate the frequency of channel n: Freq channel n = 902.4+ ([n-1] x 0.280) MHz.</p> <p>Also displayed is the average received signal strength for 5 channels above the ISM bands. This area of the spectrum is used by paging networks.</p>
In	Identification	<p>The I command returns information about the MDR100A-R5 or MDR112A-R5.</p> <p>1 Product Code</p> <p>2 Issue ROM Check (OK or ERROR)</p> <p>3 Product Identification (Firmware Version)</p> <p>4 Firmware Date</p> <p>5 Firmware Copyright</p> <p>6 Firmware Time</p> <p>7 Serial Number</p> <p>255 Factory-Configured Options listing</p>

NOTE: If you changed the modem’s configuration and you want to save those changes to non-volatile memory, use the AT command “&W” before placing the modem online.

Table 5-1 (continued). AT commands.

y < command	command name > x	Description
N	Advanced Spectrum Analyzer	<p>The Advanced Spectrum Analyzer feature provides for a very detailed analysis of a particular area of the radio frequency spectrum within which the MDR100A-R5 or MDR112A-R5 operates.</p> <p>The specific start (of scan) and stop frequencies, along with step (increment) size and dwell (on frequency) time are user-definable.</p> <p>Following is the format for the ATN command:</p> <p>In Command Mode</p> <p>ATN F_{start} F_{stop} S D[Enter]</p> <p>where</p> <p>F_{start} = start frequency in MHz (including 0–6 decimal places)</p> <p>F_{stop} = stop frequency in MHz (including 0–6 decimal places)</p> <p>S = step increment in kHz (from 1–1000)</p> <p>D = dwell time in ms (from 1–1000)</p> <p>Example:</p> <p>ATN 905.250 908.500750 25 100</p> <p><i>NOTE: Be sure to enter spaces as shown in the format detailed above.</i></p>
O	Online Mode	When the modem completes tasks in Command Mode, invoking this command will place the modem back “online” (into Data Mode).
&Fn	Load Factory Default Configuration	<p>See Chapter 4 for detailed information on the various factory default options.</p> <p>Values</p> <ul style="list-style-type: none"> 1 PMP Master 2 PMP Slave 3 PMP Repeater 4 Slow Mode PMP Master 5 Slow Mode PMP Slave 6 PTP Master 7 PTP Slave 8 Slow Mode PTP Master 9 Slow Mode PTP Slave

NOTES:

Slow Mode is an option for the MDR100A-R5 or MDR112A-R5.

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

Table 5-1 (continued). AT commands.

y < command	command name > x	Description
&H0	Frequency Restriction	By default, the MDR100A-R5 or MDR112A-R5 will hop on frequencies across the entire 900-MHz ISM bands. For some applications or within certain operating environments, You might want to prohibit the modem from operating on specific frequencies or range(s) of frequencies. The modem will not allow "too many" frequencies to be restricted; it requires a certain amount of bandwidth within which to operate to comply with regulations. Following is an example of entering Frequency Restrictions on a MDR100A-R5 or MDR112A-R5 modem. First, the AT&H0 command is invoked:

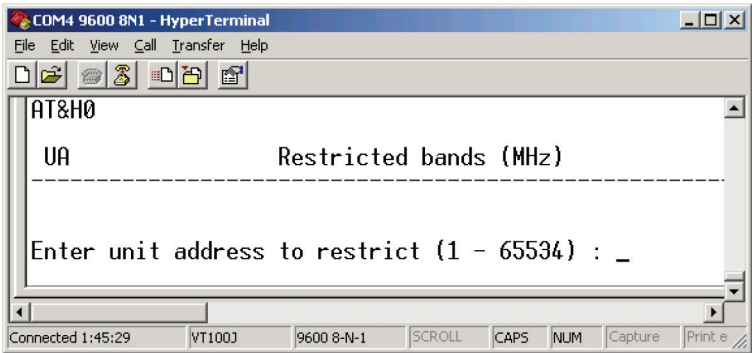


Figure 5-1. Frequency Restriction.

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.)

NOTES:

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

Use the ATg or ATG feature to help identify the frequency/range of possible interfering signals within the 902–928MHz ISM band, and then use the AT&H0 feature to configure the modem to avoid them.

After you enter "1," the modem prompts you to enter the first restricted frequency.

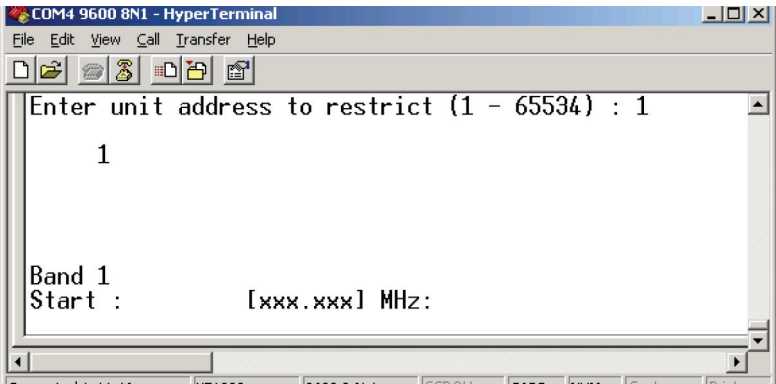


Figure 5-2. Unit Address.

Table 5-1 (continued). AT commands.

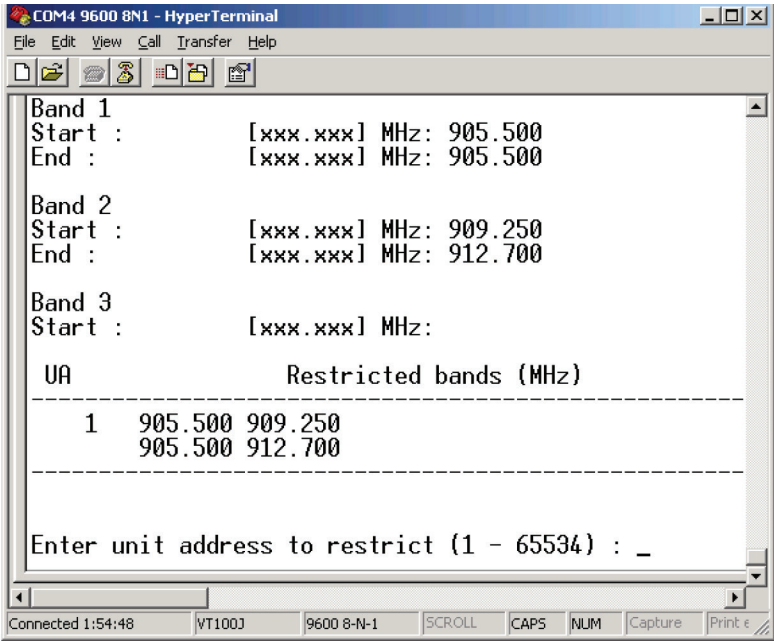
y < command	command name > x	Description
&H0 (continued)	&H0 Frequency Restriction (continued)	<div></div>
&H1	Repeater Registration	<p>When more than one Repeater exists in a network, the Unit Address of each Repeater should be registered within every modem in the network. The reason for doing this is to enable the modems to create hopping patterns that are orthogonal to each other, thereby minimizing possible interference between network segments.</p> <p>Upon entering the AT&H1 command, the modem prompts as follows:</p> <ul style="list-style-type: none">• 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. <p>Press the [Esc] key to save and exit the process.</p>
&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.

Figure 5-3. Restricted Bands.

905.500 was entered as the “start” and “end” of Band 1; this will restrict the frequency of 905.500 MHz. The range of 909.250 to 912.700 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.

5.2 Settings (S) Registers

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

Chapter 4 provides information on the available factory default settings as related to operating modes and network topologies; this section examines each S register in detail. Appendix C is a quick reference for the S register options.

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

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

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

Table 5-2. S Register settings.

y < command	command name > x	Description
S0	Auto Answer	<p>This register determines the mode the modem will be in 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.</p> <p>Values: 0 up in Command Mode 1 up in Data Mode</p> <p><i>NOTE: If the command referenced by y (above) italicized in the following register descriptions, the particular command will not appear in the AT&V (view configuration) display.</i></p>
S2	Escape Code	<p>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.</p> <p>Values: any ASCII value + (decimal 43)</p> <p><i>NOTE: Modification of S2 may be required when operating the MDR100A-R5 or MDR112A-R5 module via a telephone modem connection interface.</i></p>
S101	Operating Mode	<p>The operating mode defines the role of a modem. A MDR100A-R5 or MDR112A-R5 modem may be configured for any role required within a radio network.</p> <p>The default operating mode depends on which factory default option is selected.</p> <p>MASTER: Only one per network. In all network types (see S133) data either originates at, is destined to, or “passes through” the Master.</p> <p>REPEATER: May act simply as a “Repeater” to store and forward data to/from an upstream unit to/from a downstream unit (e.g. when there is a long distance between the latter units), or, may act as a Repeater/Slave in which case the above function is performed AND the unit may also exchange data as a Slave within the network.</p> <p>If 1 or more repeaters are to be in a network: see Section 6.2, S141. If 2 or more repeaters are to be in a network: see Section 6.1, AT command &H1.</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description																																
S101 (continued)	Operating Mode (continued)	<p>SLAVE: Interfaces with remote devices and communicates with Master either directly or via Repeater(s). Communication between 2 or more Slaves is possible—through the Master—see S133 and Sections 5.3 and 5.4.</p> <p>Values:</p> <p>0 Master</p> <p>1 Repeater</p> <p>2 Slave</p> <p>NOTES:</p> <p><i>A “Remote” (non-Master) modem is either a Repeater or a Slave.</i></p> <p><i>If a Repeater is not being used as a Repeater/Slave (i.e. there is no device attached to its local data port), leave its handshaking OFF (&K0) and set the serial baud rate (S102) to 115200 bps.</i></p>																																
S102	Serial Baud Rate	<p>The serial baud rate is the rate at which the modem will communicate with the attached local asynchronous device.</p> <p>Values (bps):</p> <table><tr><td>0</td><td>230400</td><td>8</td><td>7200</td></tr><tr><td>1</td><td>115200</td><td>9</td><td>4800</td></tr><tr><td>2</td><td>57600</td><td>10</td><td>3600</td></tr><tr><td>3</td><td>38400</td><td>11</td><td>2400</td></tr><tr><td>4</td><td>28800</td><td>12</td><td>1200</td></tr><tr><td>5</td><td>19200</td><td>13</td><td>600</td></tr><tr><td>6</td><td>14400</td><td>14</td><td>300</td></tr><tr><td>7</td><td>9600</td><td></td><td></td></tr></table> <p>NOTE: Most PCs do not readily support serial communications greater than 115200 bps.</p>	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		
0	230400	8	7200																															
1	115200	9	4800																															
2	57600	10	3600																															
3	38400	11	2400																															
4	28800	12	1200																															
5	19200	13	600																															
6	14400	14	300																															
7	9600																																	
S103	Wireless Link Rate	<p>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 1 dB reduction in sensitivity.</p> <p>Values:</p> <p>0 19200*</p> <p>1 115200** MDR100A-R5 or MDR112A-R5**</p> <p>2 172800**</p> <p>3 230400**</p> <p>8 1.2 Mbps***</p> <p>* MDR100A-R5 or MDR112A-R5 (Slow)</p> <p>** MDR100A-R5 or MDR112A-R5(Fast)</p> <p>*** MDR100A-R5 or MDR112A-R5/T (Turbo)</p> <p>NOTE: Change the default value for the Network Address to something unique for your network. Do this for an added measure of security and to differentiate your network from others that may be operating nearby.</p>																																

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description												
S104	Network Address	<p>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.</p> <p>Values (0–4,000,000,000): 1234567890</p> <p>Change the default value for the Network Address to something unique for your network. Do this for added security and to differentiate your network from others that may be operating nearby.</p>												
S105	Unit Address	<p>The unit address is, and must be, a unique identifier of each modem in a network. The address value is 16 bits in length.</p> <p>The Master has by default, and must retain, a unit address of 1; 65535 is the broadcast address.</p> <p>Values: 2–65534</p>												
S107	Static Mask	<p>This mask is applied to the transmitted data, and removed from the received data. It is an added form of security for a network.</p> <p>Values: default (the word itself)</p> <p><i>NOTE: Change S107 to something unique for your network.</i></p>												
S108	Output Power	<p>This setting establishes the transmit power level that will be presented to the antenna connector at the rear of the modem.</p> <p>Unless required, S108 should be set not for maximum, but rather for the minimum value required to maintain an adequate system fade margin.</p> <p>Values (dBm [mw]):</p> <table><tr><td>20 (100)</td><td>26 (400)</td></tr><tr><td>21 (125)</td><td>27 (500)</td></tr><tr><td>22 (160)</td><td>28 (630)</td></tr><tr><td>23 (200)</td><td>29 (800)</td></tr><tr><td>24 (250)</td><td>30 (1000)</td></tr><tr><td>25 (320)</td><td></td></tr></table> <p><i>NOTE: FCC regulations allow for up to 36 dBi effective isotropic radiated power (EIRP). The sum (in dBm) of the transmitted power, the cabling loss, and the antenna gain cannot exceed 36 dBi.</i></p>	20 (100)	26 (400)	21 (125)	27 (500)	22 (160)	28 (630)	23 (200)	29 (800)	24 (250)	30 (1000)	25 (320)	
20 (100)	26 (400)													
21 (125)	27 (500)													
22 (160)	28 (630)													
23 (200)	29 (800)													
24 (250)	30 (1000)													
25 (320)														

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S109	Hop Interval	<p>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).</p> <p>Long hop intervals typically result in the greatest data throughput; however, shorter hop intervals may decrease latency, particularly of smaller packets of data.</p> <p>The default setting of 20 ms is satisfactory for most applications. If you plan to adjust S109, also consider the serial baud rate, wireless link rate, and maximum packet size (S102, S103, and S112).</p> <p><i>NOTE: Hop Interval S109 should only be changed if recommended by Technical Support and/or for specific applications.</i></p>

Hop Interval (S109) Standard Values.

S109	time (ms)	S109	time (ms)
0	1.5	10	30
1	2.0	11	40
2	2.5	12	50
3	3.0	13	60
4	4.0	14	70
5	5.0	15	80
6	7.0	16	90
7	10	17	100
8	15	18	125
9	20	19	150

Hop Interval (S109) Extended Values.

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

NOTE: Values shown in Tables may not be available in all versions.

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description										
S110	Data Format	<p>This register determines the format of the data on the serial port.</p> <p>The default is 8 data bits, No parity, and 1 Stop bit.</p> <p>Values:</p> <table><tr><td>1 8N1</td><td>6 7N2</td></tr><tr><td>2 8N2</td><td>7 7E1</td></tr><tr><td>3 8E1</td><td>8 7O1</td></tr><tr><td>4 8O1</td><td>9 7E2</td></tr><tr><td>5 7N1</td><td>10 7O2</td></tr></table>	1 8N1	6 7N2	2 8N2	7 7E1	3 8E1	8 7O1	4 8O1	9 7E2	5 7N1	10 7O2
1 8N1	6 7N2											
2 8N2	7 7E1											
3 8E1	8 7O1											
4 8O1	9 7E2											
5 7N1	10 7O2											
S112	Packet Max Size	<p>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.</p> <p>Values (bytes):</p> <p>1–256</p> <p>255</p> <p><i>NOTE: If you plan to adjust S112, consider data rate, wireless link rate, and the hop interval (S102, S103, S109).</i></p>										
S113	Packet Retransmissions	<p>This register determines the maximum amount of times that a packet will be retransmitted (in addition to the initial transmission), noting the following specific behaviors in various network topologies:</p> <p>PMP: Master will retransmit each data packet the exact number of times specified in its S113; Slave will retransmit only if necessary, and then only until a given packet is acknowledged or the value of the Slave’s S113 is reached.</p> <p>PTP: Modem will retransmit to its counterpart only if necessary.</p> <p>Values:</p> <p>0–255</p> <p>5</p> <p><i>NOTE: 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.</i></p>										
S115	Repeat Interval	<p>S115 determines the number of slots that are available within a window of opportunity for Remote units to submit channel requests to the Master modem.</p> <p>For a large number of remotes, the value of S115 should be set relatively high: Remotes will randomly contend for the ability to access the channel request slots.</p> <p>For a small number of Remotes, 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.</p> <p>In a TDMA-type system, S115 may be set to 1, because the Remotes are not able to request a transmission channel, the Master polls each Remote for data.</p> <p>Values (Hop Intervals)</p> <p>1–255:</p> <p>3</p>										

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S116	Character Timeout	<p>This “timer” looks for gaps in the data 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.</p> <p>The MDR100A-R5 or MDR112A-R5 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.</p> <p>If S116 is set to 0, the modem will buffer exactly the Minimum Packet size and then transmit that data.</p> <p>Values: 1/4 Characters 0–254 10</p>
S118	Roaming	<p>This feature allows a Remote unit to synchronize with a specified “upstream” unit (either Master or Repeater). The options are as follows:</p> <p>S118=65535: With this value in its S118 register, a Remote will synchronize with an upstream unit that has the same network address (S104) and static mask (S107) as the Remote. If that upstream unit fails, this Remote will attempt to synchronize with another “upstream” unit within the same network. This ability is helpful in mobile applications.</p> <p>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).</p> <p>In networks where Repeaters are present, the value of a Remote’s S118 corresponds to the particular upstream modem with which a particular Remote will 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.</p> <p>S118 dictates which modem (by Unit Address (UA)) a Remote unit will “look” or “attach to” for its upstream signal path.</p> <p>Values: 65535 full roaming 1–254 specific (fixed) unit address with which to associate 1</p> <p><i>NOTES: When bench testing 3 modems for a Master-Repeater-Slave link, be sure to set the Slave’s S118 to the UA of the Repeater, and the Repeater’s S118 to the UA (1) of the Master.</i></p> <p>This will ensure that data is routed from the Slave through the Repeater to the Master; otherwise, if the Slave’s S118 is left at the default value of 1, the Slave will communicate directly with the Master, bypassing the Repeater altogether.</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S119	Quick Enter to Command Mode	<p>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 9600 bps. If you enter an incorrect character, the modem will immediately go into Data mode.</p> <p>The default setting is 0: The modem will promptly go into Data Mode upon power-up.</p> <p>Values: 0 disabled 1 enabled</p>
S123	Average RSSI	<p>This register displays (it is not a “setting”) the average signal strength received over the previous 4 hop intervals. The value in this register is also reflected in status lines RSSI1, 2, and 3, which connect to the modem’s front panel RSSI LEDs.</p> <p>Values: -110 to -55dBm (max. reading)</p> <p><i>NOTE: A Master modem’s RSSI LEDs will not light until such time as it receives valid packets from a “downstream” unit. Also, if the downstream unit(s) fail(s), a Master will maintain the last RSSI reading display.</i></p>
S130	No Sync Intake	<p>Defines if the modem will accept data if the remote has become unsynchronized from the Master. If set to 0, this function will be disabled and any data received will be ignored. If set to 1, the modem will accept data and buffer it until the unit is synchronized.</p> <p>Values: 0 1</p>
S133	Network Type	<p>Defines the type of network (see Section 5.0 for a detailed description of network topologies).</p> <p>In a point-to-multipoint (PMP) network, the Master broadcasts data to all units, and all remote units send their data (ultimately) to the Master.</p> <p>A point-to-point (PTP) network involves a Master and a Slave (with 0 or more Repeaters in-between).</p> <p>Peer-to-Peer involves either communication between 2 (typically remote) units (P2P) or between all units (everyone-to-everyone —E2E).</p> <p>Values: 0 Point-to-Multipoint 1 Point-to-Point 2 Peer-to-Peer or Everyone-to-Everyone</p> <p><i>NOTE: ALL modems in a network must have the SAME value for Network Type.</i></p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S140	Destination Address	<p>As the name implies, this register specifies the ultimate destination for a modem's data.</p> <p>Different network topologies dictate the configuration of S140: PMP: Master S140=65535, Remote S140=1 PTP: Master S140=UA of Remote, Remote S140=1 P2P: Master S140=65535, S140 of each (of 2/pair) remote modems is the UA of the other.</p> <p>E2E : S140 of all modems=65535 (broadcast)</p> <p>Values: 1-65535</p>
S141	Repeaters Y/N	<p>This register informs—and applies only to—the Master if any Repeater(s) are present in the network.</p> <p>Values: 0 no repeater 1 one or more repeaters</p> <p><i>NOTES:</i></p> <p><i>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.</i></p> <p><i>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.</i></p>
S142	Serial Channel Mode	<p>This register defines the physical serial interface that will be used for data communications.</p> <p>Values: 0 RS-232 interface 1 half-duplex RS-485 2 full-duplex RS-485</p> <p><i>NOTE: When placed into Command Mode, the module will communicate via the RS-232 interface at 9600 bps, 8N1.</i></p>
S143	Sleep Mode	<p>This register applies only to Remote (i.e. not Master) modems, and determines if the Remote should remain active continuously (S143=0, default), or enter a timer-based sleep mode.</p> <p>Sleep Mode 1: When status register S143 is set to a value of 1, the unit will use the registers S144 and S145 to determine how long a unit will remain awake when idle, or if the unit has gone to sleep, how long it will sleep.</p> <p>In this mode, data will be monitored on the serial port and the RF link. If no data is being transmitted or received after an amount of time specified by S145 (Wake Time), the unit will sleep for the amount of time determined by register S144 (Sleep Time).</p> <p>If data is detected on the local serial port, the unit will immediately wake up.</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S143 (continued)	Sleep Mode (continued)	<p>This register applies only to Remote (i.e. not Master) modems, and determines if the Remote should remain active continuously (S143=0, default), or enter a timer-based sleep mode.</p> <p>Sleep Mode 1 (continued): For OEM models, the !WAKEUP_usr input (pin #8) can be used to wake the unit at any time. The unit sleeps for S144 seconds or until the falling edge of the !WAKEUP line. The unit will stay awake for at least S145 seconds. After that, the unit will go to sleep if the !WAKEUP line is high and all data is sent.</p> <p>Sleep Mode 2: This mode is similar to Sleep mode 1, except that data will be monitored only on the serial port. If no data is being transmitted or received after an amount of time specified by S145 (Wake Time), the unit will sleep for the amount of time determined by register S144 (Sleep Time).</p> <p>Sniff Mode 1: When status register S143 is set to a value of 3, the unit will monitor all data from the serial and RF link. Upon wake up, the unit will begin to try to find a master or repeater to synchronize to. The amount of time the unit tries to find a master is determined by the number of hops, rather than time. (Time can be calculated by multiplying the number of hops in S237 by the hop interval specified in register S109).</p> <p>If a master is found, the unit will stay awake for at least the time specified by register S145 (Wake Time). If there is data to transmit, the unit will stay awake until all data has been transmitted. If a master or repeater is not found, the unit will sleep for S144 (Sleep Time) seconds. The sniffing cycle is very brief.</p> <p>If data is detected on the local serial port, the unit will immediately wake up.</p> <p><i>NOTE: The most effective way to put an entire network into sleep/sniff mode is by turning off, or putting into command mode, the Master modem.</i></p> <p>Sniff Mode 2: When status register S143 is set to a value of 4, the unit works the same way as sniff mode 1, except that the unit will monitor all data from only the serial port.</p> <p>Sniff Mode 3: When status register S143 is set to a value of 5, the unit works the same way as sniff mode 1 and will monitor all data from both the serial and RF link. The difference is that if no master is found, all data will be discarded.</p> <p>Values: 0 active (no sleep) 1 sleep mode 1 2 sleep mode 2 3 sniff mode 1 4 sniff mode 2 5 sniff mode 3</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S144	Sleep Time	<p>This register applies only to Remote modems and is only effective when S143>0. Defines sleep duration for up to approximately 18 hours.</p> <p>Two conditions will awaken a Remote:</p> <ol style="list-style-type: none"> 1. Sleep duration time has expired, or 2. Incoming data on local data port. <p>When a sniff mode is selected (S143), the modem will start its sniff cycle when the Sleep Time expires or will wake up completely when there is data on its local data port.</p> <p>Values: seconds 2–65535 60</p>
S145	Wake Time	<p>Applies only to Remote modems and effective only when S143>0.</p> <p>This register determines how long a modem will stay awake after the local data port and radio links become idle.</p> <p>When the modem is idle for the amount of time specified in S145, it will go to sleep; it will go to sleep immediately if the “upstream” unit is offline or goes into sleep/sniff mode.</p> <p>Values: seconds 0–65535 10</p> <p><i>NOTE: The most effective way to put an entire network into sleep/sniff mode is by turning off, or putting into command mode, the Master modem.</i></p>
S149	LED Brightness	<p>This is a power saving feature that controls the current available to LEDs so they operate with 0% (off) to 100% available brightness.</p> <p>We recommend setting S149 to 100 for testing in a shop environment, and then reducing the value as required when deploying in the field where power consumption is a factor.</p> <p>Values: percent (%) 0–100 100</p>
S150	Sync Mode	<p>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.</p> <p>Values: 0 normal sync 1 quick sync mode, wait for acknowledgement 2 quick sync mode, wait for timeout</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S150 (continued)	Sync Mode (continued)	<p>A setting of 1 applies only in a point-to-point (PTP) configuration: the Master will stay in quick sync mode until 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), then it will go into normal sync mode.</p> <p>A value of 2 results in the Master going into quick sync mode when it initially comes online and then remains in that mode for the time specified in S151 (fast sync timeout) and then returns to normal sync mode.</p>
S151	Fast Sync Timeout	<p>This register settings apply only to a Master modem. Effective only when S150=2.</p> <p>Defines how long, in milliseconds, a Master modem will stay in fast sync mode after it initially goes online.</p> <p>Values: milliseconds (ms) 100-65000 200</p>
S153	Address Tag	<p>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).</p> <p>Value: 0 disable 1 enable</p>
S158	FEC (Forward Error Correction) Mode	<p>A number of FEC schemes are available with different coding rates.</p> <p>FEC consumes some bandwidth: depending on which coding rate is chosen, a number of coding bits are transmitted along with the "data" bits.</p> <p>In "noisy" or long-range communications environments, FEC may effectively increase throughput by decreasing the amount of packet retransmissions that would otherwise be required.</p> <p>Communications range may also be extended via FEC: at a certain distance where data would otherwise be unacceptably corrupted, using FEC may be all that is required to maintain the integrity of that data at that distance.</p> <p>Types of FEC available within the MDR100A-R5 or MDR112A-R5: 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</p> <p>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)</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S150 (continued)	Sync Mode (continued)	<i>NOTE: If throughput is not of primary concern and you want to provide the most robust data communications, consider FEC.</i>
S159	Encryption Mode (AES)*	<p>*AES encryption is a factory configured option that can only be loaded and enabled at the factory when the product is assembled. Using AES encryption, and export laws governing AES, vary from country to country. The AES option is only available by special order. Contact Black Box Technical Support at 724-746-5500 or info@blackbox.com.</p> <p>AES (Advanced Encryption Standard) provides an extremely strong level of encryption for data for security of wireless data communication. The use of AES may cause slight degradation of system performance because of the processing requirements of the encoding/decoding process.</p> <p>Up to three levels of AES are available: 128 bit, 192 bit and 256 bit. Only the specific options enabled by the factory will be available. Once you choose a level of AES using register S159, enter the encryption key. Enter the same AES setting and encryption key on every modem in the network.</p> <p>The size of the key is depends on the level of AES: 128-bit AES: 16 Byte Encryption Key 192-bit AES: 24 Byte Encryption Key 256-bit AES: 32 Byte Encryption Key</p> <p>Enter the encryption key in registers S107 or S177, because they share the same key array for encryption. S107 (Static Mask) is used to enter in up to 32 printable characters (ASCII). If using 128 or 192 bit AES, any character entered after 16 or 24 bytes respectively will be ignored. If you enter less than the required number of characters, 0's will be appended to fill the encryption key array.</p> <p>To improve the strength of the key, use S177 to enter 16–32 bytes (depending on the AES type) of binary non-printable characters. This register requires the appropriate number bytes to be entered. In other words, if you are using AES256, S177 requires 32 bytes of data to be entered. A binary file can be transferred to the modem using a terminal program after a ATS177= command has been invoked.</p> <p>Values: 0 No encryption 1 AES 128 bit 2 AES 192 bit 3 AES 256 bit</p>
S177	Binary Encryption Key	<p>When using AES encryption, S177 can be used to define the encryption key in binary. The type of AES used defines the minimum number of binary bytes that need to be entered. See S159 for more information.</p> <p>Values (Binary Bytes): 16–32 Bytes (AES type dependent)</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S217	Protocol Type	<p>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.</p> <p>Values: 0 transparent 1 MODBUS RTU 2 DF1 protocol, full-duplex, with address filtering</p>
S232	Maximum Buffer in Storage	<p>This register defines the maximum number of packets sent on the user serial port that can be stored in the buffer.</p> <p>Values: 1–255 200</p>
S237	Sniff Timeout	<p>This register applies only to Remote modems.</p> <p>Defines how many hops the unit will sniff for when the Sleep Time (S144) expires.</p> <p>Calculate the Sniff Timeout (sniff duration) in milliseconds as follows: Sniff Timeout=S237 (hops) x hop interval (per S109)</p> <p>Values: hops 1–255 10</p> <p>Example: S237=20, S109=9 (=20 ms)</p> <p>Sniff Timeout = 20 (hops) x 20ms per hop = 400 ms</p> <p><i>NOTE: The longer the Sniff Timeout (duration), the likely the Remote modem will “find” an upstream unit when you want to wake up the system; however, more power will be consumed.</i></p>
S244	Channel Request Mode	<p>Channel Request Mode “on” (default), allows a Remote modem that has data to send to request permission from the Master. When granted, the Remote will be allowed to transmit all of its data (no other Remotes may transmit during this period), then it will release the channel. This feature eliminates collisions that would otherwise occur if a number of Remotes were all trying to transmit at the same time.</p> <p>TDMA mode is discussed in detail in Section 5.2.1. In TDMA mode, the Master does not allow Channel Requests from Remotes; the Master sequences through a list of Remotes, giving each one in turn an opportunity to transmit.</p> <p>Values: 0 Channel Request 1 TDMA Mode (Standard) 2 Fast TDMA 3 GPS Indexed TDMA 4 Adaptive TDMA</p>

Table 5-2 (continued). S Register settings.

y < command	command name > x	Description
S248	Sync Timeout	<p>This register defines how many hop intervals elapse before the slave will become unsynchronized and begins to search for a master.</p> <p>Values: 1–65534 512</p> <p><i>NOTE: In a “clean” RF environment, reduce S251 to 2 or 3. If a Remote is unable to communicate for some reason, the “wait” time for the Master to proceed to poll the next Slave will be reduced.</i></p>
S251	Master Hop Allocation Timeout	<p>In TDMA mode (see S244 and Section 5.2.1) this register determines how long, in hop intervals, the Master will wait for a Remote to either (a) begin to send data or (b) indicate that it has completed sending all of its data, before the Master sequences to the next Remote to be given permission to transmit.</p> <p>Values: hops 1–254 10</p>

5.3 Serial Interface Commands

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

S102: Serial Baud Rate determines the rate of communications between the modem and the local device.

S110: Data Format defines the data, stop, and parity bit count.

S142: Serial Channel Mode selects the actual serial interface to be used.

S217: Protocol Type defines the nature of the incoming data and what, if any, special action should be taken by the modem.

Also, there are AT commands that affect the configuration of the module, specifically the handling of data at the RS-232 interface:

&C: Data Carrier Detect (DCD)

&D: Data Terminal Ready (DTR)

&K: Handshaking

&S: Data Set Ready (DSR)

The above four items are discussed in Table 5-3.

Table 5-3. Serial Interface Commands.

Command	Command Name	Description
&Cn	Data Carrier Detect (DCD)	Controls the module's DCD output signal to the attached device. Determines when the DCD line is active. Values: 0 DCD always on 1 DCD on when modems synchronized* 2 DCD used for output data framing and Modbus mode *DCD always on when module configured as a Master
&Dn	Data Terminal Ready (DTR)	Controls the action that the module will perform when the DTR input line's state is modified. Values: 0 DTR ignored 2 deassert DTR to force module into Command mode (at serial baud rate set by S102); DTR must be reasserted before putting module back into data mode (normally done using the ATA command).
&Kn	Handshaking	Enables or disables hardware handshaking. Values: 0 handshaking disabled 3 RTS/CTS handshaking enabled <i>NOTE: Software flow control (XON/XOFF) is not supported.</i>
&Sn	Data Set Ready (DSR)	Controls the module's DSR line and determines when it is active. Values: 0 DSR always on 1 ON in Data mode, OFF in Command mode 2 DTR/DSR signaling: Remotes output state of Master's DTR on their local DSR line in PMP network. Master only outputs state of Slave's DTR on its local DSR line in PTP. Not supported in P2P or E2E network.

6. Installation

Consider the following when preparing to deploy a radio network:

Network Topology

Section 5.0 detailed the various network topologies that the MDR100A-R5 or MDR112A-R5 will support. Determine which topology meets your specific requirements.

Throughput

The MDR100A-R5 or MDR112A-R5 is capable of 230.4 kbps asynchronous serial data throughput. The network topology has an effect on how this available throughput is “shared” between all nodes on the network.

Distance

The physical distance between the modems determines the required antenna performance and heights, and whether or not a Repeater(s) is required. When contemplating antenna types and Repeater sites, keep in mind the directivity (omnidirectional or directional) of the antennas being used, and also recall the affect of a Repeater on throughput (see Section 3.4).

Terrain

Along with distance, consider the terrain 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

Set transmit power to 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. Also consider the cable and connector losses (the physical path from the modem’s “antenna connector” to the antenna’s connector).

Receive Sensitivity

The MDR100A-R5 or MDR112A-R5 has exceptional receive sensitivity. This can provide benefits, including: added fade margin for a given link, ability to use less expensive coaxial cable or antenna types, ability to operate at greater distances for a given distant transmitter power (possibly negating the requirement for a Repeater site!). Distance, antenna gain, transmit power, and receive sensitivity are critical “numbers” for radio path calculations. Fortunately, the MDR100A-R5 or MDR112A-R5 features the maximum available transmit power combined with exceptional receive sensitivity—two “numbers” that will produce the most favorable path calculation results. Only qualified and experienced personnel should install, remove, or maintain the antenna system.

Fade Margin

When all radio path numbers are considered and hardware assumptions are 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). The MDR100A-R5 or MDR112A-R5 performs to exacting specifications, so the overall deployment should use the modems may be utilized to their full potential to provide a reliable and robust communications link. A typical desired fade margin is about 0 dB, but often a 10 dB fade margin is acceptable.

Chapter 6: Installation

Frequency

The 900-MHz frequency ranges are not significantly affected by rain and can penetrate through foliage and “around obstacles” to a certain degree. Path calculations provide results that 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 MDR100A-R5 or MDR112A-R5 may be integrated into a system that accepts a range of DC input voltages (supply current requirements must also be met). In some deployments, power consumption is critical. A number of features related to minimize power consumption are available with the MDR100A-R5 or MDR112A-R5 Series: sleep/sniff modes, LED dimming, and the ability to operate at less transmit power given the receive sensitivity of the distant modem.

Interference

The frequency hopping spread spectrum (FHSS) operation of the MDR100A-R5 or MDR112A-R5 most often allows it to work well in an environment within which there may be sources of in-band interference. Frequency Restriction is a built-in feature that may be used 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.

6.1 Path Calculation

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

$$\text{Fade Margin} = \text{System Gain} - \text{Path Loss}$$

where all values are expressed in dB.

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

System gain is calculated as follows:

$$\text{System Gain} = \text{Transmitter Power} + (\text{Transmitter Antenna Gain} - \text{Transmitter Cable and Connector Losses}) + (\text{Receiver Antenna Gain} - \text{Receiver Cable and Connector Losses}) + |\text{Receiver Sensitivity}|$$

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

Assuming a path loss of 113 dB for this example, the fade margin = $143 - 113 = 30$ dB. 30 dB exceeds the desired fade margin of 20 dB, 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.

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

Example:

Tx power = 30 dBm

Tx antenna gain = 6 dBi

Tx cable/connector loss = 2 dB

Rx antenna gain = 3 dBi

Rx cable/connector loss = 2 dB

Rx sensitivity = -108 dBm

$$\text{System Gain} = [30 + (6 - 2) + (3 - 2) + 108] \text{dB}$$

$$= [30 + 4 + 1 + 108] \text{dB}$$

$$= 143 \text{dB}.$$

Table 6-1. Distance.

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
161	15	2.5	135.3
16	15	5	128.9
16	30	10	116.2
16	30	10	109.6
16	30	5	122.4
16	30	2.5	128.8

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

6.2 Installation of Antenna System Components

Only qualified and experienced personnel should install, remove, or maintain any antenna system components.

6.2.1 Antennas

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

An omni typically has 3–6 dBi 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 center. This vertical-mounted antenna produces a signal that is vertically “polarized.”

A Yagi has a more focused antenna pattern, which results in greater gain: commonly, 6–12 dBi. 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.

CAUTION: To satisfy FCC radio frequency (RF) exposure requirements for mobile transmitting devices, maintain a separation distance of 23 cm or more 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 with any other antenna or transmitter.

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

WARNING: Direct human contact with the antenna is potentially unhealthy when a MDR100A-R5 or MDR112A-R5 is generating RF energy. Always ensure that the equipment is powered down (off) during installation.

In a long-range PTP network, consider using Yagi antennas. These antennas will provide for the most focused “RF connection” between the two sites.

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

Chapter 6: Installation

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

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

The path calculation (see Section 6.1) will determine the antenna gain requirements. Refer to the beginning of this section to review the various factors which must be considering when deploying a network. Do not discount the importance of the REQUIRED HEIGHT for the antennas within your network.

6.2.2 Coaxial Cable

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

- ThinNet Cable, RG-58, 10BASE2, PVC (NEC CL2), 5-ft. (1.5-m), product code LCN300-0005
- ThinNet Cable, RG-58, 10BASE2, PVC (NEC CL2), 10-ft. (3.0-m), product code LCN300-0010
- ThinNet Cable, RG-58, 10BASE2, PVC (NEC CL2), 60-ft. (18.2-m), product code LCB300-0060

For a typical application, LCN300 cable may be suitable. Where a long cable run is required and within networks where there is not a lot of margin available, consider using a cable with lower loss.

When installing cable, do not damage it (be particularly careful with respect to not kinking it at any time) and to secure it properly. Also be sure to affix the connectors properly—using the proper crimping tools—and to weatherproof them.

6.2.3 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.

6.2.4 External Filter

Although the MDR100A-R5 or MDR112A-R5 is capable of filtering-out RF noise in most environments, there are circumstances that require external filtering. Paging towers and cellular base stations near the MDR100A-R5 or MDR112A-R5's antenna can desensitize the receiver. The MDR100A-R5 or MDR112A-R5's external cavity filter eliminates this problem. The filter has two N-female connectors and should be connected inline at the interface to the RF equipment.

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

Table A-1. AT Command Quick Reference.

Command	Command Name	Description
A	Answer	This command puts the modem into data mode.
Dxxxxx, DTxxxxx, DPxxxxx	Dial	Identical commands that change the unit address to xxxxx and put the modem into data mode.
g, G	Spectrum Analyzer	Used to help determine if interfering RF signals are present.
In	Identification	Follow ATi with either of the following “n”: 1-product code 2-ROM check (OK or ERROR) 3-firmware version 4-firmware date 5-firmware copyright 6-firmware time 7-serial number 255-factory-configured options listing
N	Advanced Spectrum Analyzer	Advanced spectrum analyzer provides for a more detailed scrutiny of the RF environment.
O	Online Mode	This command puts the modem into data mode.
Tx	Registered Slave List (TDMA)	? -view list Tn=UA -set list number n equal to Remote’s Unit Address. Tn? -view list item n
&Fn	Load Factory Default Configuration	Follow AT&F with either of the following “n”: 1-MASTER Point-to-Multipoint, use with &F2/&F3 modems 2-SLAVE Point-to-Multipoint, works with &F1 3-REPEATER Point-to-Multipoint, works with &F1/&F2 4-SLOW MODE* MASTER Point-to-Multipoint 5-SLOW MODE* SLAVE Point-to-Multipoint 6-MASTER Point-to-Point, works with &F7 7-SLAVE Point-to-Point, works with &F6 8-SLOW MODE* MASTER Point-to-Point 9-SLOW MODE* SLAVE Point-to-Point *SLOW MODE is optional
&Cn	DCD (Data Carrier Detect)	Controls modem’s DCD output signal. 0-DCD always on 1-*DCD on when modem’s sync’ed, always on if Master 2-DCD used for output data framing and Modbus mode 3-Slave: DCD pulses for 2 ms when modem receives valid sync pulse from Master (which sends sync pulse once per hop)
&Dn	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)

Appendix A: AT Command Quick Reference

Table A-1 (continued). AT Command Quick Reference.

Command	Command Name	Description
&H0	Frequency Restriction	Follow onscreen prompts to input undesired frequencies.
&H1	Repeater Registration	When more than one repeater exists in a network, the repeaters should be "registered" using this command to ensure that frequencies used are orthogonal to each other (thereby minimizing potential interference).
&Kn	Handshaking	Determines handshaking between modem and host device. 0-*disable handshaking 3-enable hardware (RTS/CTS) handshaking
&Sn	DSR (Data Set Ready)	Controls modem's DSR line and determines when it is active. 0-DSR always on 1-*DSR ON in data mode, OFF in command mode 2-DTR/DSR signaling: slaves and repeaters output state of master's DTR on their local DSR line in PMP mode, master only outputs state of slave's DTR on its local DSR line in PTP network, not supported in P2P or E2E network.
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.
Sxxx?	Read S Register Value	Where xxx is the S register's number, this command will result in displaying the current setting of that register.
Sxxx=yyy	Set S Register Value	Where xxx is the S register's number, this command will place value yyy in that register.

Appendix B: Settings (S) Register Quick Reference

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

Query format: AT\$xxx? [Enter] where xxx is S register number detailed below

Change format: AT\$xxx=y [Enter] where xxx is S register number and y is desired value

Table B-1. S-Register Quick Reference.

Command	Command Name	Description
S0	Auto Answer	0-modem will power-up in command mode 1-*modem will power-up in data mode
S2	Escape Code	Contains ASCII value of escape character. *“43” is the default value, which represents the ASCII character ‘+’ Values greater than 127 disable the escape feature and prevent the user from returning to command mode.
S101	Operating Mode	0-Master 1-Repeater 2-Slave
S102	Serial Port Baud Rate (bps)	<ul style="list-style-type: none"> • 0–230400 • 1–115200 • 2–57600 • 3–38400 • 4–28800 • 5–19200 • 6–14400 • 7–*9600 • 8–7200 • 9–4800 • 10–3600 • 11–2400 • 12–1200 • 13–600 • 14–300
S103	Wireless Link Rate (bps)	0–19200 1–115200 2–*172800 3–230400 8–1.2Mbps
S104	Network Address	0–4,000,000,000 *1234567890
S105	Unit Address	2–65534 (master is 1, broadcast is 65535)
S107	Static Mask	up to 16 characters *default
S108	Output Power Level	20–30 dBm *30 (1 W)

Appendix B: Settings (S) Register Quick Reference

Table B-1 (continued). S-Register Quick Reference.

Command	Command Name	Description
S109	Hop Interval (ms)	<ul style="list-style-type: none"> • 0–230400 • 1–115200 • 2–57600 • 3–38400 • 4–28800 • 5–19200 • 6–14400 • 7–*9600 • 8–15 • *9–20 • 10–30 • 11–40 • 12–50 • 13–60 • 14–70 • 15–80 • 16–90 • 17–100 • 18–125 • 19–150
S110	Data Format (of Asynchronous serial input to modem)	<ul style="list-style-type: none"> • 1-*8N1 • 2-8N2 • 3-8E1 • 4-8O1 • 5-7N1 • 6-7N2 • 7-7E1 • 8-7O1 • 9-7E2 • 10-7O2
S112	Packet Max Size (bytes)	1–256 *255
S113	Packet Retransmissions	0–255 *5
S115	Repeat Interval	1–255 *3
S118	Roaming	65535–roaming enabled 1–254–fixed upstream unit *1
S119	Quick Enter to Command Mode	0-*disabled 1-enabled
S123	RSSI Value (dBm, read only)	—
S133	Network Type	0-Point-to-Multipoint (PMP) 1-Point-to-Point (PP) 2-Peer-to-Peer (P2P)
S140	Destination Address	1–65535
S141	Repeater Existence	0-*no repeater 1-1 or more repeaters exist
S142	Serial Channel Mode	0-*RS-232 interface 1-half-duplex RS-485 2-full-duplex RS-485
S143	Sleep Mode	0-*active (no sleep) 1-sleep mode 1, stays awake on local and air data 2-sleep mode 2, stays awake only on local data 3-sniff mode 1, stays awake on local and air data 4-sniff mode 2, stays awake only on local data 5-sniff mode 3, same as sniff mode 1 but will discard data if cannot find upstream unit

Appendix B: Settings (S) Register Quick Reference

Table B-1 (continued). S-Register Quick Reference.

Command	Command Name	Description
S144	Sleep Duration (seconds)	0–65535 *60
S145	Awake Timeout (seconds)	0–65535 *10
S149	LED Brightness (%)	0–100 *100
S150	Quick Sync Mode	0-*normal sync 1-quick sync mode, wait for acknowledgement 2-quick sync mode, wait for timeout
S151	Quick Sync Timeout (ms)	100–65534 *200
S153	Address Tag	0-*disable 1-enable
S158	FEC Mode	0 *No FEC 1 Hamming (7,4) 2 Hamming (15,11) 3 Hamming (31,24) 5 Binary BCH (47,36) 6 Golay (23,12,7) 7 Reed-Solomon (15,11)
S217	Protocol Type	0-*transparent 1-MODBUS RTU 2-DF1 protocol, address filtering
S237	Sniff Duration (hops)	1–255 *10
S244	Channel Request Mode	0-*channel request 1-TDMA mode
S251	Master Hop Allocation Timeout (hops)	1-254 *10

Appendix C: RS-485 Wiring

The MDR100A-R5 or MDR112A-R5 can be connected into a 2-wire or 4-wire RS-485 network. Terminate the transmission line only at the extreme ends of the data line if the RS-485 network runs at high data rates and has a long wiring run.

2-wire RS-485

Figure C-1 shows a typical two-wire configuration for an RS-485 connection to a MDR100A-R5 or MDR112A-R5. Two wires are shared for transmitting and receiving in a 2-wire configuration, so the modem must seize the line at the right time when it transmits. Note again that a transmission line termination is required if the system has high data rates and long wiring runs.

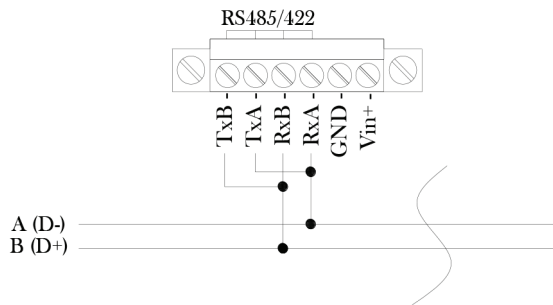


Figure C-1. 2-wire RS-485 Configuration.

4-wire RS-485

A MDR100A-R5 or MDR112A-R5 can also be connected into a RS-485 network in a four-wire configuration as shown in Figure C-2. In a four-wire network, one node must be a master node and all others must be slaves. The network is connected so that the master node communicates to all slave nodes. All slave nodes communicate only with the master node. Since the slave nodes never listen to another slave response to the master, a slave node cannot reply incorrectly to another slave node.

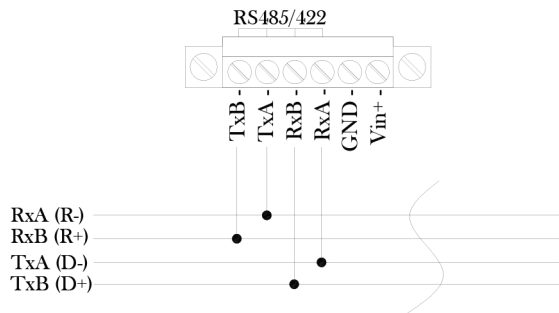


Figure C-2. 2-wire RS-45 Configuration.

Appendix D: Troubleshooting

D.1 Contacting Black Box

If you determine that your Industrial 900-MHz Wireless Modem is malfunctioning, do not attempt to alter or repair the unit. It contains no user-serviceable parts. Contact Black Box Technical Support at 724-746-5500 or info@blackbox.com. Before you do, make a record of the history of the problem. We will be able to provide more efficient and accurate assistance if you have a complete description, including:

- the nature and duration of the problem.
- when the problem occurs.
- the components involved in the problem.
- any particular application that, when used, appears to create the problem or make it worse.
- Host computer make and model.
- Type of operating system installed (e.g. Windows 8, Mac OS X, etc.).
- Make and model of the USB 3.0 device attached to the product.
- Description of the installation.
- Description of the problem.

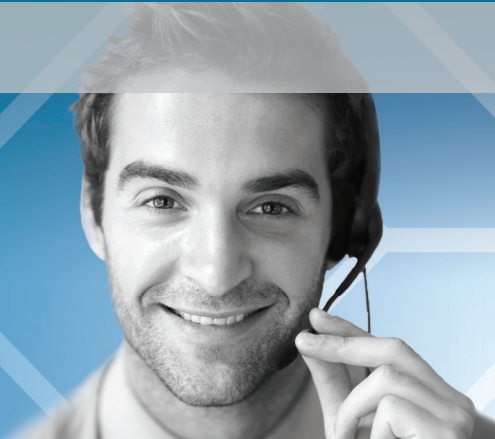
D.2 Shipping and Packaging

If you need to transport or ship your Industrial 900-MHz Wireless Modem:

- Package it carefully. We recommend that you use the original container.
- If you are returning the unit, make sure you include everything you received with it. Before you ship for return or repair, contact Black Box to get a Return Authorization (RA) number.

Black Box Tech Support: FREE! Live. 24/7.

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About Black Box

Black Box provides an extensive range of networking and infrastructure products. You'll find everything from cabinets and racks and power and surge protection products to media converters and Ethernet switches all supported by free, live 24/7 Tech support available in 60 seconds or less.

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