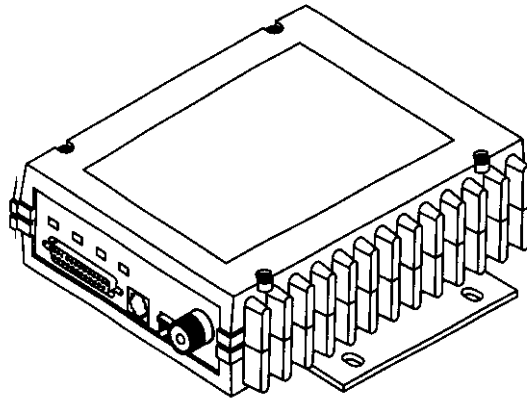**Attachment 1**
Installation & Operation
Manual

MDS 9810/24810

900 MHz/2.4 GHz Spread Spectrum Data Transceivers

MDS 05-3301A01, Rev. A
FEBRUARY 1999

Installation and Operation Guide

ADAPTIVE BROADBAND™

On April 29, 1999, California Microwave Corporation became
Adaptive Broadband Corporation. Any references in this
manual to California Microwave Corporation or Microwave
Data Systems have been assumed by the Adaptive Broadband
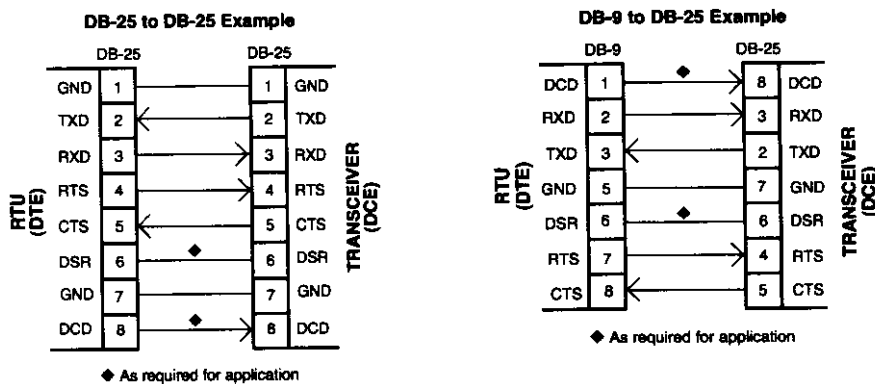Corporation.

QUICK START GUIDE

Below are the basic steps for installing the transceiver. Detailed instructions are given in "INSTALLA-TION" on page 22 of this guide.

1. Install and connect the antenna system to the radio

- Use good quality, low-loss coaxial cable. Keep the feedline as short as possible.
- Preset directional antennas in the direction of desired transmission.

2. Connect the data equipment to the radio's INTERFACE connector

- Connection to the radio must be made with a DB-25 Male connector. Connections for typical systems are shown below.
- Connect only the required pins. Do not use a straight-through RS-232 cable with all pins wired.
- Verify the data equipment is configured as DTE. (By default, the radio is configured as DCE.)

DB-25 to DB-25 Example

RTU (DTE)				TRANSCEIVER (DCE)
GND	1	1	GND	
TXD	2	2	TXD	
RXD	3	3	RXD	
RTS	4	4	RTS	
CTS	5	5	CTS	
DSR	6	6	DSR	
GND	7	7	GND	
DCD	8	8	DCD	

◆ As required for application

DB-9 to DB-25 Example

RTU (DTE)				TRANSCEIVER (DCE)
DCD	1	8	DCD	
RXD	2	3	RXD	
TXD	3	2	TXD	
GND	5	7	GND	
DSR	6	6	DSR	
RTS	7	4	RTS	
CTS	8	5	CTS	

◆ As required for application

3. Apply DC power to the radio

- Observe proper polarity. The red wire is the positive lead; the black is negative.

4. Set the radio's basic configuration with a Hand-Held Terminal (HHT)

- Set the baud rate/data interface parameters as follows. Use the **BAUD xxxxx abc** command, where **xxxxx** equals the data speed and **abc** equals the communication parameters as follows:
  a = Data bits (7 or 8)
  b = Parity (N for None, O for Odd, E for Even
  c = Stop bits (1 or 2)
  (Example: **BAUD 9600 8N1**)

  NOTE: 7N1, 8E2 and 8O2 are invalid parameters and are not supported by the transceiver.

5. Verify proper operation by observing the LED display

- Refer to Table 7 on page 32 for a description of the status LEDs.
- Refine directional antenna headings for maximum receive signal strength using the **RSSI** command.

TABLE OF CONTENTS

Copyright Notice

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are protected by **copyright: 1999 Microwave Data Systems**, a division
of California Microwave, Inc. All rights reserved.

Microwave Data Systems reserves its right to correct any errors and
omissions.

Operational Safety Notices

RF Exposure The radio equipment described in this guide uses radio frequency trans-
mitters. Although the power level is low, the concentrated energy from
a directional antenna may pose a health hazard. Do not allow people to
come in close proximity to the front of the antenna when the transmitter
is operating.

This manual is intended to guide a professional installer to install,
operate and perform basic system maintenance on the described radio.

ISO 9001 Registration

Microwave Data Systems' adherence to this internationally accepted quality system standard provides one of the strongest assurances of product and service quality available.

MDS Quality Policy Statement

We, the employees of Microwave Data Systems, are committed to achieving total customer satisfaction in everything we do.

Total Customer Satisfaction in:

- Conception, design, manufacture and marketing of our products.

- Services and support we provide to our internal and external customers.

Total Customer Satisfaction Achieved Through:

- Processes that are well documented and minimize variations.

- Partnering with suppliers who are committed to providing quality and service.

- Measuring our performance against customer expectations and industry leaders.

- Commitment to continuous improvement and employee involvement.

FM/UL/CSA Notice
MDS 9810 & MDS 24810 When Approved

This product is available for use in Class I, Division 2, Groups A, B, C & D Hazardous Locations. Such locations are defined in Article 500 of the National Fire Protection Association (NFPA) publication NFPA 70, otherwise known as the National Electrical Code.

The transceiver has been recognized for use in these hazardous locations by three independent agencies — Underwriters Laboratories (UL), Factory Mutual Research Corporation (FMRC) and the Canadian Standards Association (CSA). The UL certification for the transceiver is as a Recognized Component for use in these hazardous locations, in accordance with UL Standard 1604. The FMRC Approval is in accordance with FMRC Standard 3611. The CSA Certification is in accordance with CSA STD C22.2 No. 213-M1987.

FM/UL/CSA Conditions of Approval:

The transceiver is not acceptable as a stand-alone unit for use in the hazardous locations described above. It must either be mounted within another piece of equipment which is certified for hazardous locations, or installed within guidelines, or conditions of approval, as set forth by the approving agencies. These conditions of approval are as follows:

1. The transceiver must be mounted within a separate enclosure which is suitable for the intended application.

2. The antenna feedline, DC power cable and interface cable must be routed through conduit in accordance with the National Electrical Code.

3. Installation, operation and maintenance of the transceiver should be in accordance with the transceiver's installation manual, and the National Electrical Code.

4. Tampering or replacement with non-factory components may adversely affect the safe use of the transceiver in hazardous locations, and may void the approval.

5. When installed in a Class I, Div. 2, Groups A, B, C or D hazardous location, observe the following:
   WARNING —EXPLOSION HAZARD— Do not disconnect equipment unless power has been switched off or the area is know to be non-hazardous.

Refer to Articles 500 through 502 of the National Electrical Code (NFPA 70) for further information on hazardous locations and approved Division 2 wiring methods.

FCC Notice, U.S.A.
MDS 9810 & MDS 24810 When Approved

The MDS 9810/24810 transceivers comply with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This device is specifically designed to be used under Section 15.247 of the FCC Rules and Regulations. Any unauthorized modification or changes to this device without the express approval of Microwave Data Systems may void the user's authority to operate this device.

Furthermore, this device is indented to be used only when installed in accordance with the instructions outlined in this manual. Failure to comply with these instructions may also void the user's authority to operate this device.

Notice

While every reasonable effort has been made to ensure the accuracy of this manual, product improvements may result in minor differences between the manual and the product shipped to you. If you have additional questions or need an exacts specification for a product, please contact our Customer Service Team using the information at the back of this guide. In addition, manual updates can often be found on the MDS Web site at www.microwavedata.com.

1.0   ABOUT THIS MANUAL

This guide presents installation and operating instructions for the MDS 9810 and 24810 transceivers. Following installation, we suggest keeping this guide near the equipment for future reference.

2.0   PRODUCT DESCRIPTION

The transceivers, shown in Figure 1, are spread spectrum radios designed for license-free operation in the 900 MHz (9810) or 2.4 GHz (24810) frequency band. Employing microprocessor control and Digital Signal Processing (DSP) technology, they are highly reliable for long-distance communications, even in the presence of weak signals or interference.

DSP technology also makes it possible to obtain information about radio operation and troubleshoot problems, without going to the remote radio. By simply connecting to the master station, diagnostic data can be obtained on any DSP radio in the system, even while payload data is being transmitted. (See "Performing Network-Wide Remote Diagnostics" on page 57.)

The transceiver is housed in a compact and rugged die-cast aluminum case that need only be protected from direct exposure to the weather. It contains a single printed circuit board with all necessary components for radio operation. No jumper settings or adjustments are required to configure the radio for operation.
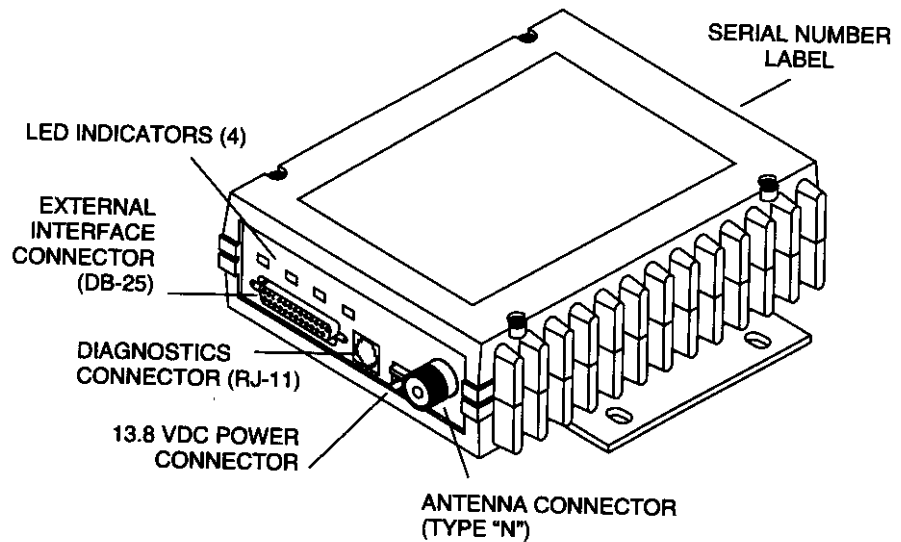
Figure 1. MDS 9810/24810 Transceiver

Transceiver Features

Listed below are several key features of the MDS 9810/24810 transceivers. These are designed to ease the installation and configuration of the radio, while retaining the ability to make changes in the future.

- 1,019 frequencies over 902–928 MHz (9810) or 2.4–2.4835 GHz (24810), subdivided into eight frequency zones
- Configurable operating zones to omit frequencies with constant interference
- 65,000 available network addresses
- Network-wide configuration from the master station; eliminates most trips to remote sites
- Data transparency–ensures compatibility with virtually all asynchronous SCADA system RTUs
- Peak-hold RSSI, averaged over eight hop cycles
- Operation at up to 19200 bps continuous data flow; 38400 bps non-continuous
- Same hardware for all supported data rates: 1200, 2400, 4800, 9600, 19200, 38400 bps asynchronous
- Same hardware for master or remote configuration
- Data latency typically less than 10 ms
- Supports EIA-232 (formerly called RS-232) user interface
- Low current consumption–30 mA or less average draw in "sleep" mode.

Model Configuration Codes

The radio model number is printed on the end of the radio enclosure, and provides key information about how the radio was configured when it was shipped from the factory. See Figure 3 and Figure 3 for an explanation of the model number characters.

THIS INFORMATION IS SUBJECT TO CHANGE.

DO NOT USE FOR PRODUCT ORDERING.

Figure 2. MDS 24810 transceiver model configuration codes

THIS INFORMATION IS SUBJECT TO CHANGE.

DO NOT USE FOR PRODUCT ORDERING.
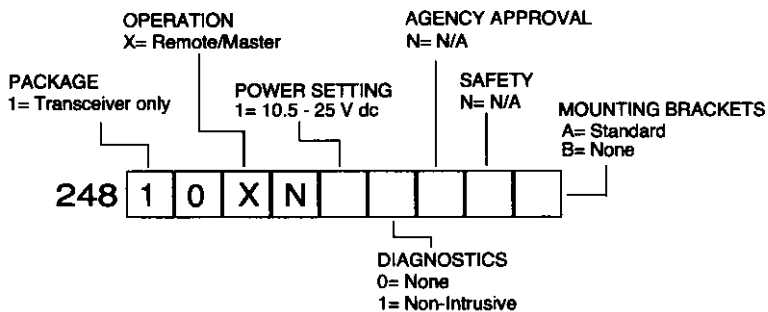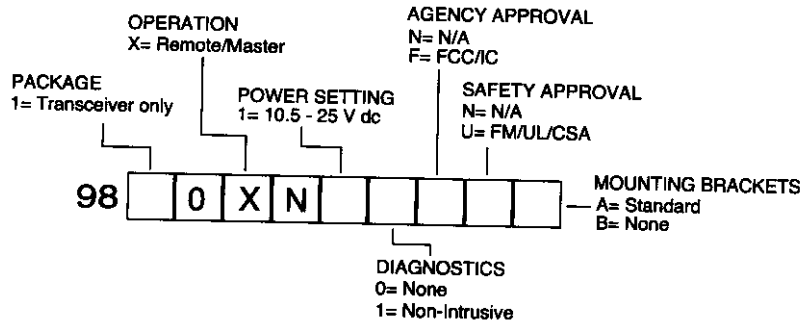
```
              OPERATION                    AGENCY APPROVAL
              X= Remote/Master             N= N/A
                                           F= FCC/IC
    PACKAGE
    1= Transceiver only    POWER SETTING      SAFETY APPROVAL
                           1= 10.5 - 25 V dc   N= N/A
                                               U= FM/UL/CSA

                                                      MOUNTING BRACKETS
     98    0  X  N                                  — A= Standard
                                                      B= None

                              DIAGNOSTICS
                              0= None
                              1= Non-Intrusive
```

Figure 3. MDS 9810 transceiver model configuration codes

2.1 Spread Spectrum Radios—How Are They Different?

The main difference between a traditional (licensed) radio system and the MDS 9810/24810 transceivers is that these units "hop" from channel to channel many times per second using a specific hop pattern applied to all radios in the network. A distinct hopping pattern is provided for each of the 65,000 available network addresses, thereby minimizing the chance of interference with other spread spectrum systems. In the USA, and certain other countries, no license is required to install and operate this type of radio system.

2.2 Typical Applications

Multiple Address Systems (MAS)

This is the most common application of the MDS 9810/24810 transceivers. It consists of a central control station (master) and two or more associated remote units, as shown in Figure 4. An MAS network provides communications between a central host computer and remote terminal units (RTUs) or other data collection devices. The operation of the radio system is transparent to the computer equipment. When used in this application, the transceiver provides an excellent alternative to traditional (licensed) MAS radio systems.
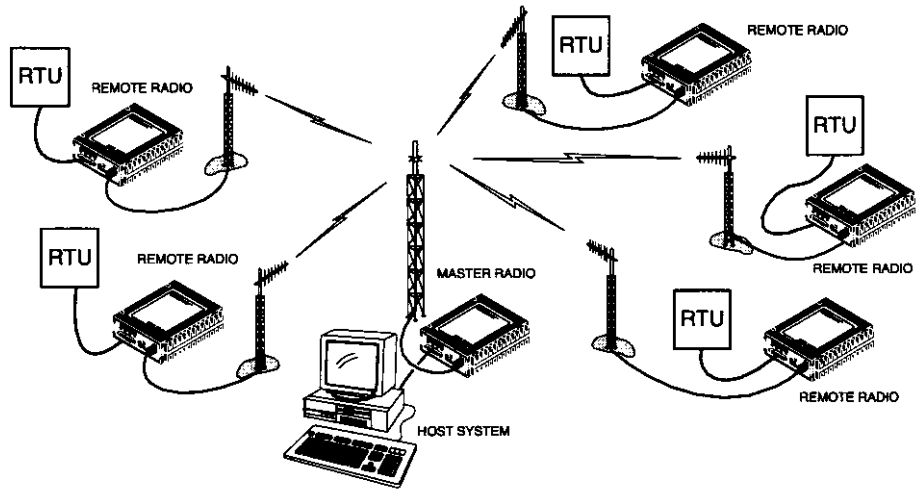
Figure 4. Typical MAS network

Simplex "Peer-to-Peer"

Peer-to-peer communication is possible using the transceiver's simplex mode. With this arrangement (Figure 5), two or more remote units can share information by direct communication with each other in addition to communicating with a central master radio. This is possible because the transmit and receive frequencies for each hop channel are the same at each radio when simplex mode is enabled. If adequate transmission paths exist, each radio can communicate with all other units in the network. Additional details for peer-to-peer systems are provided in Section 5.2 (page 26).
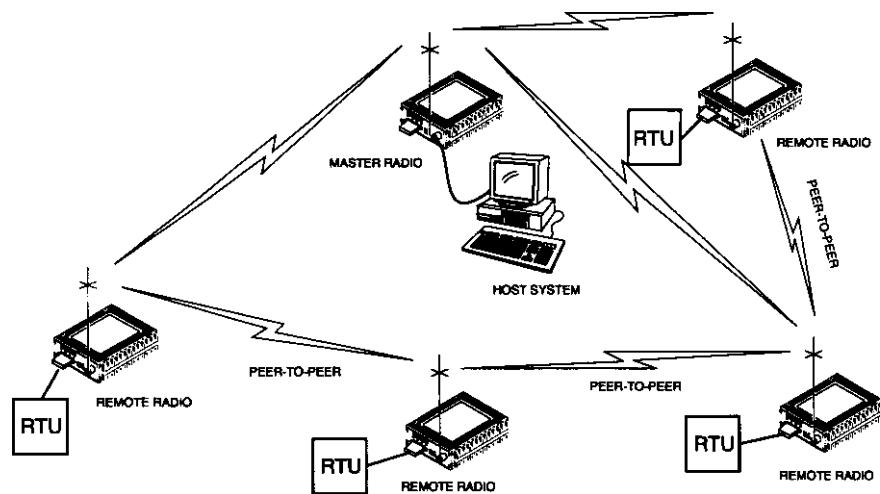
Figure 5. Typical simplex "peer-to-peer" network

Peer-to-Peer with Repeater Assistance

Peer-to-peer communication is also possible using this alternate arrangement (see Figure 6). It overcomes the range limitations of a simplex peer-to-peer system by using a repeater to re-transmit the signals of all stations in the network. The repeater consists of two radios — one programmed in the remote-master mode, and the other programmed as a conventional master. Additional details for peer-to-peer systems are given in Section 5.2 (page 26).

Figure 6. Typical peer-to-peer network with repeater assistance

Point-to-Point System

A point-to-point configuration (Figure 7) is a simple arrangement consisting of just two radios — a master and a remote. This provides a simplex or half-duplex communications link for the transfer of data between two locations.
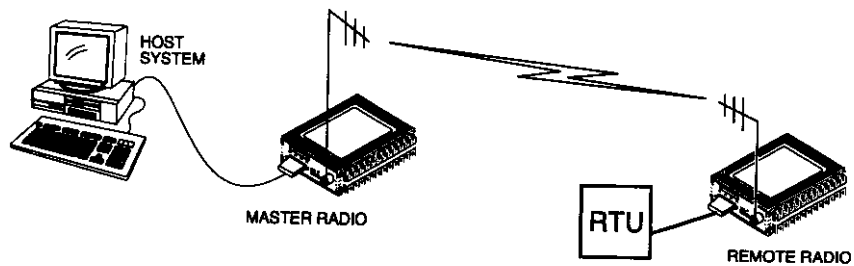
Figure 7. Typical point-to-point link

Tail-End Link ("MAS Extension")

A tail-end link can be used to extend the range of a traditional (licensed) MAS system. This might be required if an outlying site is blocked from the MAS master station by a natural o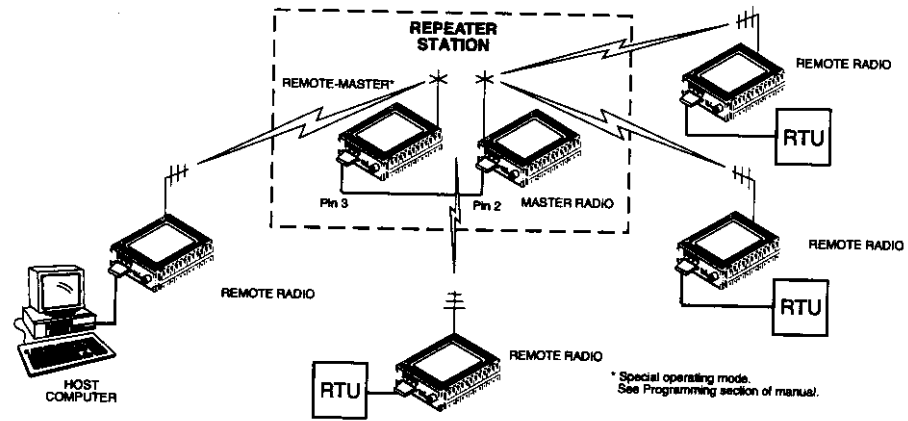r man-made obstruction. In this arrangement, an MDS 9810/24810 radio links the outlying remote site into the rest of a licensed MAS system by sending data from that site to a companion MDS 9810/24810 installed at one of the licensed remote sites. (See Figure 8).

As the data from the outlying site is received at the licensed remote site, it is transferred to the licensed radio (via a local cable connection) and is then transmitted to the MAS master station in the usual manner. Additional details for tail-end links are given in Section 5.3 (page 29).

Figure 8. Typical tail-end link arrangement

Repeater Arrangement

Although the range between MDS 9810 radios is typically 10 to 15 and 6 to 10 miles for MDS 24810 radios (over average terrain), it is possible to extend the range by connecting two units together in a "back-to-back" fashion to form a repeater, as shown in Figure 9. Additional details for repeater systems are given in Section 5.3 (page 29).
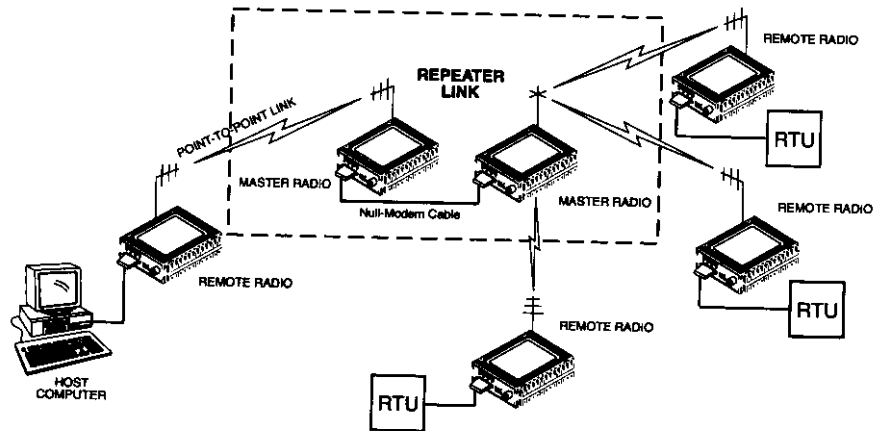
Figure 9. Typical repeater system configuration

2.3 Accessories

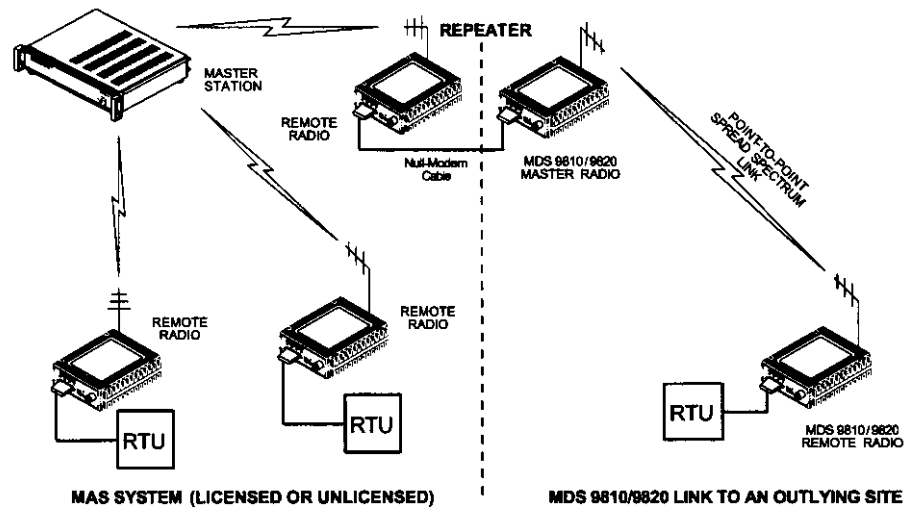The MDS 9810/24810 transceivers can be used with one or more of the accessories listed in Table 1. Contact MDS for ordering information.

Table 1. Accessories

Accessory	Description	MDS P/N
Hand-Held Terminal Kit (HHT)	Terminal that plugs into the radio's RJ-11 DIAG(NOSTICS) connector. Allows radio programming, diagnostics & control. Includes carrying case, cable set and manual.	02-1501A01
RTU Simulator	Test unit that simulates data from a remote terminal unit. Comes with polling software that runs on a PC. Useful for testing radio operation.	03-2512A01
Radio Configuration Software	Windows-based software that allows radio programming and control using a PC. Includes on-line instructions. (See Section 9.5 (page 66) for PC connection details.)	03-3156A01
EIA-232 to EIA-422 Converter	External adapter that converts the radio's DATA INTERFACE connector to EIA-422 compatible signaling. May be required for long cable runs (over 50 feet/15 meters). DB-25 female EIA-422 connector.	03-2358A01
TTL Converter	External adapter used to convert the radio's DATA INTERFACE connector to TTL compatible signaling. DB-25 female TTL connector.	03-2223A01

3.0 GLOSSARY OF TERMS

If you are new to spread spectrum radio, some of the terms used in this guide may be unfamiliar. The following glossary explains many of these terms and will prove helpful in understanding the operation of the transceiver.

Antenna System Gain—A figure, normally expressed in dB, representing the power increase resulting from the use of a gain-type antenna. System losses (from the feedline and coaxial connectors, for example) are subtracted from this figure to calculate the total antenna system gain.

Bit—The smallest unit of digital data, often represented by a one or a zero. Eight bits (plus start, stop, and parity bits) usually comprise a byte.

Bits-per-second—See *BPS*.

BPS—Bits-per-second. A measure of the information transfer rate of digital data across a communication channel.

Byte—A string of digital data usually made up of eight data bits and start, stop and parity bits.

Decibel (dB)—A measure of the ratio between two signal levels. Frequently used to express the gain (or loss) of a system.

Data Circuit-terminating Equipment—See *DCE*.

Data Communications Equipment—See *DCE*.

Data Terminal Equipment—See *DTE*.

dBi—Decibels referenced to an "ideal" isotropic radiator in free space. Frequently used to express antenna gain.

dBm—Decibels referenced to one milliwatt. An absolute unit used to measure signal power, as in transmitter power output, or received signal strength.

DCE—Data Circuit-terminating Equipment (or Data Communications Equipment). In data communications terminology, this is the "modem" side of a computer-to-modem connection. The MDS 9810/24810 transceivers are DCE devices.

Digital Signal Processing—See *DSP*.

DSP—Digital Signal Processing. In the MDS 9810/24810 transceivers, the DSP circuitry is responsible for the most critical real-time tasks; primarily modulation, demodulation, and servicing of the data port.

DTE — Data Terminal Equipment. A device that provides data in the form of digital signals at its output. Connects to the DCE device.

Equalization — The process of reducing the effects of amplitude, frequency or phase distortion with compensating networks.

Fade Margin — The greatest tolerable reduction in average received signal strength that will be anticipated under most conditions. Provides an allowance for reduced signal strength due to multipath, slight antenna movement or changing atmospheric losses. A fade margin of 20 to 30 dB is usually sufficient in most systems.

Frame — A segment of data that adheres to a specific data protocol and contains definite start and end points. It provides a method of synchronizing transmissions.

Frequency Hopping — The spread spectrum technique used by the MDS 9810/24810 transceivers, where two or more associated radios change their operating frequencies several times per second using a set pattern. Since the pattern appears to jump around, it is said to "hop" from one frequency to another.

Frequency Zone — The transceivers use up to 1,019 discrete channels in the 902 to 928 MHz (9810) or 2.4 to 2.4835 GHz (24810) spectrums. A group of 128 channels is referred to as a zone. The transceivers use eight frequency zones. (Five channels are reserved for network control purposes.)

Hardware Flow Control — A transceiver feature used to prevent data buffer overruns when handling high-speed data from the RTU or PLC. When the buffer approaches overflow, the radio drops the clear-to-send (CTS) line, which instructs the RTU or PLC to delay further transmission until CTS again returns to the high state.

Host Computer — The computer installed at the master station site, which controls the collection of data from one or more remote sites.

Latency — The delay (usually expressed in milliseconds) between when data is applied to TXD (Pin 2) at one radio, until it appears at RXD (Pin 3) at the other radio.

MAS — Multiple Address System. A radio system where a central master station communicates with several remote stations for the purpose of gathering telemetry data. Figure 4 on page 4 shows an example of an MAS system.

Master (Station)—The one radio transceiver in a spread spectrum network that automatically provides synchronization information to one or more associated remote transceivers. A radio may be programmed for either master or remote mode using software commands. See Section 7.0, *PROGRAMMING* (beginning on page 35).

MCU—Microcontroller Unit. This is the processor responsible for controlling system start-up, synthesizer loading, hop timing, and key-up control.

Microcontroller Unit—See *MCU*.

Mode—This refers to the programmed function of an MDS spread spectrum radio—master or remote. (See also *Remote Station* and *Master Station*.)

Multiple Address System (MAS)—See *Point-Multipoint System*.

Network Address—User-selectable number between 1 and 65000 that is used to identify a group of transceivers that form a communications network. The master and all remotes within a given system *must* have the same network address.

Network-Wide Diagnostics—An advanced method of controlling and interrogating MDS radios in a radio network.

Point-Multipoint System—A radio communications network or system designed with a central control station that exchanges data with a number of remote locations equipped with terminal equipment.

Poll—A request for data issued from the host computer (or master PLC) to a remote radio.

PLC—Programmable Logic Controller. A dedicated microprocessor configured for a specific application with discrete inputs and outputs. It can serve as a host or as an RTU.

Programmable Logic Controller—See *PLC*.

Remote Radio—A radio in a spread spectrum network that communicates with an associated master station. A radio may be programmed for either master or remote mode using software commands. See Section 7.0, *PROGRAMMING* (beginning on page 35).

Remote Terminal Unit—See *RTU*.

RTU—Remote Terminal Unit. A data collection device installed at a remote radio site.

SCADA—Supervisory Control And Data Acquisition. An overall term for the functions commonly provided through an MAS radio system.

Standing Wave Ratio—See *SWR*.

Supervisory Control And Data Acquisition—See *SCADA*.

SWR—Standing Wave Ratio. A parameter related to the ratio between forward transmitter power and the reflected power from the antenna system. As a general guideline, reflected power should not exceed 10% of the forward power (~ 2:1 SWR).

Zone—See *Frequency Zone*.

4.0 INSTALLATION PLANNING

The installation of the radio is not difficult, but it does require some planning to ensure station reliability and efficiency. This section provides tips for selecting an appropriate site, choosing an antenna system, and reducing the chance of harmful interference.

4.1 General Requirements

There are three main requirements for installing the radio—adequate and stable primary power, a good antenna system, and the correct interface between the transceiver and the data device.

Figure 10 shows a typical remote station arrangement. At a remote station, a directional antenna is normally used, and a Remote Terminal Unit (RTU) or other telemetry equipment replaces the host computer normally used in a master station.
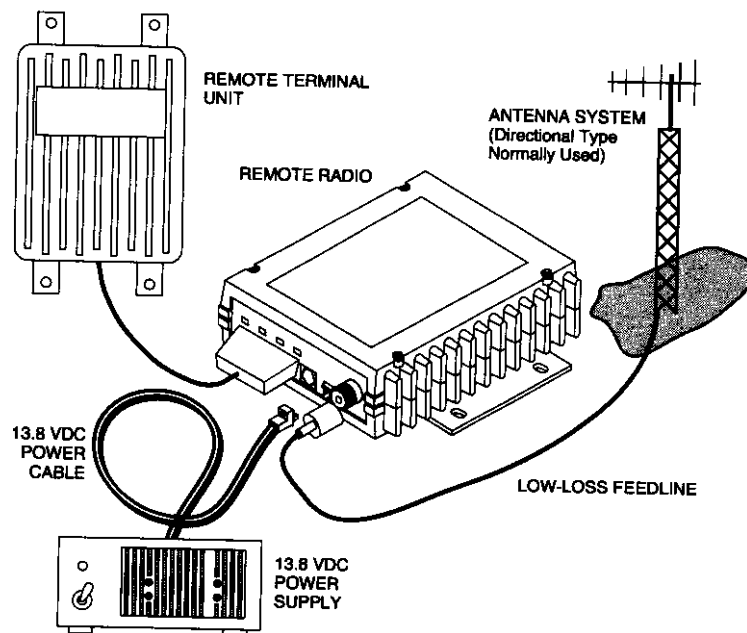

REMOTE TERMINAL UNIT

ANTENNA SYSTEM (Directional Type Normally Used)

REMOTE RADIO

13.8 VDC POWER CABLE

LOW-LOSS FEEDLINE

13.8 VDC POWER SUPPLY

Figure 10. Typical remote station arrangement

4.2 Site Selection

For a successful installation, careful thought must be given to selecting proper sites for the master and remote stations. Suitable sites should provide:

- Protection from direct weather exposure
- A source of adequate and stable primary power
- Suitable entrances for antenna, interface or other required cabling
- Antenna location that provides an unobstructed transmission path in the direction of the associated station(s)

These requirements can be quickly determined in most cases. A possible exception is the last item—verifying that an unobstructed transmission path exists. Radio signals travel primarily by line-of-sight, and obstructions between the sending and receiving stations will affect system performance. If you are not familiar with the effects of terrain and other obstructions on radio transmission, the discussion below will provide helpful background.

Terrain and Signal Strength

While the 900 MHz and 2.4 GHz bands offers many advantages over VHF and UHF frequencies for data transmission, they are also more prone to signal attenuation from obstructions such as terrain, foliage, buildings, and other things in the transmission path.

A line-of-sight transmission path between the master station and its associated remote site(s) is highly desirable and provides the most reliable communications link. A line-of-sight path can often be achieved by mounting the station antenna on a tower or other elevated structure that raises it to a level sufficient to clear surrounding terrain and other obstructions.

The importance of a clear transmission path relates closely to the distance to be covered by the system. If the system is to cover only a limited geographic area, say up to 3 miles (4.8 km) for the 9810, or 1 mile (1.6 km) for the 24810, then some obstructions in the transmission path can usually be tolerated with minimal impact. For longer range systems, any substantial obstruction in the transmission path could compromise the performance of the system, or block transmission entirely.

Much depends on the minimum signal strength that can be tolerated in a given system. Although the exact figure will differ from one system to another, a Received Signal Strength Indication (RSSI) of –90 dBm or stronger will provide acceptable performance in many systems. While the equipment will work at lower signal strengths, this provides a "fade

margin" to account for variations in signal strength which may occur from time-to-time. RSSI can be measured with a Hand-Held Terminal connected to the remote radio's DIAG(NOSTICS) connector. (See Section 7.0, beginning on page 35.)

Conducting a Site Survey

If you are in doubt about the suitability of the radio sites in your system, it is best to evaluate them before a permanent installation is begun. This can be done with an on-the-air test (preferred method); or indirectly, using path-study software.

An on-the-air test is preferred because it allows you to see firsthand the factors involved at an installation site and to directly observe the quality of system operation. Even if a computer path study was conducted earlier, this test should be done to verify the predicted results.

The test can be performed by first installing a radio and antenna at the proposed master station site and then visiting each remote site with a transceiver and a hand-held antenna. (An RTU simulator—MDS Part No. 03-2512A01—can be connected to each radio in the network to simulate data during this test.)

With the hand-held antenna positioned near the proposed mounting spot, a technician can check for synchronization with the master station (shown by a lit SYNC lamp on the front panel) and measure the reported RSSI value. If adequate signal strength cannot be obtained, it may be necessary to mount the station antennas higher, use higher gain antennas, or select a different site. To prepare the equipment for an on-the-air test, follow the general installation procedures given in this guide and become familiar with the operating instructions given in Section 6.0, beginning on page 32.

If time is short, and a site survey is impractical, a computer path study is a good alternative. Factors such as terrain, distance, transmitter power, receiver sensitivity, and other conditions are taken into account to predict the performance of a proposed system. Contact MDS for more information on path study services.

4.3 A Word About Radio Interference

The MDS 9810/24810 transceivers share frequency spectrums with other services and other Part 15 (unlicensed) devices in the US. As such, near 100% error free communications may not be achieved in a given location, and some level of interference should be expected. However, the radio's flexible design and hopping techniques should allow adequate performance as long as care is taken in choosing station location, configuration of radio parameters and software/protocol techniques.

In general, keep the following points in mind when setting up your communications network:

1. Systems installed in rural areas are least likely to encounter interference; those in suburban and urban environments are more likely to be affected by other devices operating in the license-free frequency band and by adjacent licensed services.

2. If possible, use a directional antenna at remote sites. Although these antennas may be more costly than omnidirectional types, they confine the transmission and reception pattern to a comparatively narrow lobe, which minimizes interference to (and from) stations located outside the pattern. (The use of a directional antenna may not be possible in a simplex peer-to-peer network, where all remotes are designed to communicate with one another.)

3. If interference is suspected from a nearby licensed system (such as a paging transmitter, in the case of the 9810), it may be helpful to use horizontal polarization of all antennas in the network. Because most other services use vertical polarization in this band, an additional 20 dB of attenuation to interference can be achieved by using horizontal polarization.

4. Multiple MDS 9810/24810 systems can co-exist in proximity to each other with only very minor interference *as long as they are each assigned a unique network address.* Each network address has a different hop pattern.

5. If constant interference is present in a particular frequency zone, it may be necessary to "lock out" that zone from the radio's hopping pattern. The radio includes built-in software to help users identify and remove blocked frequency zones from its hopping pattern. Refer to the discussion of ZONE DATA (page 52) and SKIP (page 50) commands for more information.

6. If interference problems persist even after removing blocked zones, try reducing the length of data streams. Groups of short data streams have a better chance of getting through in the presence of interference than do long streams.

7. The power output of all radios in a system should be set for the lowest level necessary for reliable communications. This lessens the chance of causing unnecessary interference to nearby systems.

4.4 Antenna & Feedline Selection

Antennas

The equipment can be used with a number of antennas. The exact style used depends on the physical size and layout of a system. Contact your MDS representative for specific recommendations on antenna types and hardware sources.

In general, an omnidirectional antenna (Figure 12) is used at the master station site in an MAS system. This provides equal coverage to all of the remote sites.

NOTE: Antenna polarization is important. If the wrong polarization is used, a signal reduction of 20 dB or more will result. Most systems using a gain-type omnidirectional antenna at the master station employ vertical polarization of the signal; therefore, the remote antenna(s) must also be vertically polarized (elements oriented perpendicular to the horizon).

When required, horizontally polarized omnidirectional antennas are also available. Contact your MDS representative for details.
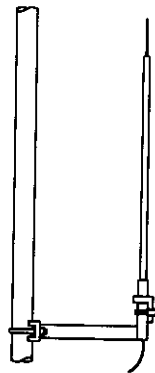

Figure 11. Omnidirectional antenna for MDS 9810 transceiver
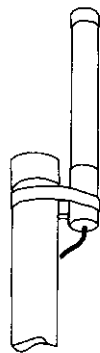
**Figure 12. Omnidirectional antenna for
MDS 24810 transceiver (mounted to mast)**

At remote sites and point-to-point systems, a directional Yagi
(Figure 13), radome-protected Yagi (for the MDS 24810) (Figure 14) or
dish-type (for the MDS 24810) (Figure 15) antenna is generally recom-
mended to minimize interference to and from other users. Antennas are
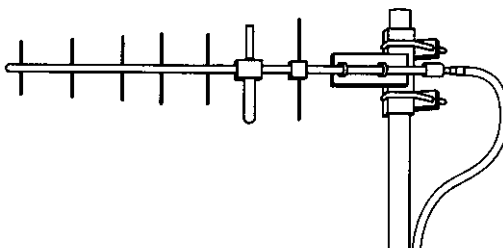available from a number of manufacturers.

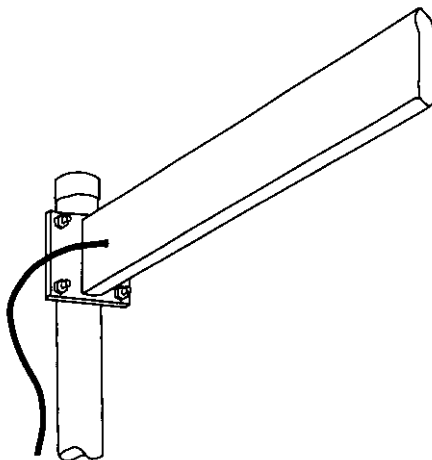**Figure 13. Typical Yagi antenna (mounted to mast)**

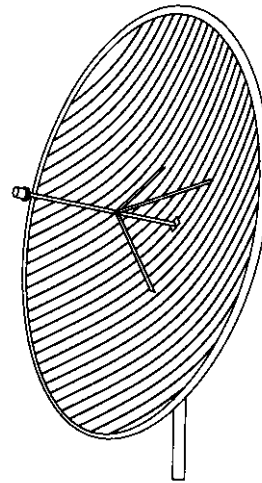**Figure 14. Radome-protected Yagi antenna for MDS 24810**

Figure 15. Typical dish antenna for MDS 24810 transceiver

Feedlines

The choice of feedline used with the antenna should be carefully considered. Poor-quality coaxial cables should be avoided, as they will degrade system performance for both transmission and reception.

MDS 24810 transceiver

Since the radio operates at a nominal 2.4 GHz, the choice of feedline is important to maintain a balance of cost and performance. It is recommended that only low-loss feedlines which have a foam dielectric and a full shield are used.

MDS 9810 transceiver

For cable runs of less than 20 feet (6 meters), or for short range transmission, an inexpensive type such as Type RG8A/U may be acceptable. Otherwise, we recommend using a low-loss cable type suitable for 900 MHz, such as Heliax®. Regardless of the cable used, it should be kept as short as possible to minimize signal loss.

Table 2 and Table 3 list several types of feedlines and indicates the signal losses (in dB) that result when using various lengths of each cable at 900 MHz and 2.4 GHz. The choice of cable will depend on the required length, cost considerations, and the amount of signal loss that can be tolerated.

Table 2. Length vs. loss in coaxial cables at 900 MHz

Cable Type	10 Feet (3.05 Meters)	50 Feet (15.24 Meters)	100 Feet (30.48 Meters)	500 Feet (152.4 Meters)
RG-8A/U	0.85 dB	4.27 dB	8.54 dB	42.70 dB
1/2 inch HELIAX	0.23 dB	1.15 dB	2.29 dB	11.45 dB
7/8 inch HELIAX	0.13 dB	0.64 dB	1.28 dB	6.40 dB
1 1/4 inch HELIAX	0.10 dB	0.48 dB	0.95 dB	4.75 dB
1 5/8 inch HELIAX	0.08 dB	0.40 dB	0.80 dB	4.00 dB

Table 3. Flexible hardline losses at 2 GHz

Cable Type	10 Feet (3.05 Meters)	50 Feet (15.24 Meters)	100 Feet (30.48 Meters)	500 Feet (152.4 Meters)
3/8 Inch HELIAX	0.51 dB	2.55 dB	5.10 dB	25.5 dB
1/2 Inch HELIAX	0.35 dB	1.73 dB	3.46 dB	17.3 dB
7/8 inch HELIAX	0.20 dB	0.99 dB	1.97 dB	9.85 dB
1 1/4 inch HELIAX	0.15 dB	0.73 dB	1.45 dB	7.50 dB
1 5/8 inch HELIAX	0.13 dB	0.63 dB	1.25 dB	6.25 dB

4.5 How Much Power Can I Run?

For non-point-to-multipoint and point-to-point systems, the transceiver is supplied from the factory set for a +30 dBm (1 Watt) RF power output setting; this is the maximum transmitter output power allowed under FCC rules. The power must be *decreased* from this level if the antenna system gain exceeds 6 dBi. The allowable level is dependent on the antenna gain, feedline loss, and the transmitter output power setting. Power considerations for point-to-multipoint and point-to-point systems using the MDS 9810 and MDS 24810 transceivers are discussed in the next sections.

For All MDS 9810 Systems

To determine the maximum allowable power setting of the radio, proceed as follows:

1. Determine the antenna system gain by subtracting the feedline loss (in dB) from the antenna gain (in dBi). For example, if the antenna gain is 9.5 dBi, and the feedline loss is 1.5 dB, the antenna system gain would be 8 dB. (If the antenna system gain is 6 dB or less, no power adjustment is required.)

2. Subtract the antenna system gain from 36 dBm (the maximum allowable EIRP). The result indicates the maximum transmitter power (in dBm) allowed under the rules. In the example above, this is 28 dBm.

3. If the maximum transmitter power allowed is less than 30 dBm, use the **PWR** command (described on page 48) to set the power accordingly.

For convenience, Table 4 lists several antenna system gains and shows the maximum allowable power setting of the radio. Note that a gain of 6 dB or less entitles you to operate the radio at full power output—30 dBm (1 watt).

Table 4. Antenna system gain vs. power output setting

Antenna System Gain (Antenna Gain in dBi* minus Feedline Loss in dB†)	Maximum Power Setting (in dBm)	EIRP (in dBm)
6 (or less)	30	36
8	28	36
10	26	36
12	24	36
14	22	36
16	20	36

* Most antenna manufacturers rate antenna gain in dBd in their literature. To convert to dBi, add 2.15 dB.

† Feedline loss varies by cable type and length. To determine the loss for common lengths of feedline, see Table 3 on page 18 for the MDS 24810 transceiver and Table 2 on page 18 for the MDS 9810 transceiver.

For MAS Point-to-Multipoint Systems (MDS 24810)

For point-to-multipoint systems, the FCC limits the EIRP (Effective Isotropic Radiated Power) to +36 dBm. Accordingly, if an antenna is used with a 8 dBi gain rating, the transmitter power needs to be set no higher than +28 dBm (640 milliwatts).

Generally, it is better to reduce the transmit power and use larger, higher-gain dish antennas (Figure 15). Using higher-gain antennas instead of increasing transmitter power gives a higher system gain and reduces the susceptibility to interference due to the narrower beam width of the higher gain antenna.

Table 5 lists several antenna system gains and shows the maximum allowable power setting of the radio.

Table 5. Antenna system gain vs. power output setting in point-to-multipoint systems

Antenna System Gain (Antenna Gain in dBi* minus Feedline Loss in dB†)	Maximum Power Setting (in dBm)	EIRP (in dBm)
6 (or less)	30	36
8	28	36
10	26	36
12	24	36
14	22	36
16	20	36
18	18	36
20	16	36
22	14	36
24	12	36
26	10	36

* Most antenna manufacturers rate antenna gain in dBd in their literature. To convert to dBi, add 2.15 dB.

† Feedline loss varies by cable type and length. To determine the loss for common lengths of feedline, see Table 3 on page 18.

For Point-to-Point Systems (MDS 24810)

In point-to-point systems operating in the 2.4 GHz band, the FCC restricts the transmit power to +30 dBm (1 watt) with an antenna rated at 6 dBi gain. However, the FCC allows an increase in antenna gain with a trade-off of transmit power 3 to 1.

For example, an antenna rated for 12 dBi gain can be used with a transmit power of 28 dBm. In this case, +36 dBi EIRP is exceeded by 4 dB. Table 6 lists the allowable transmit power with allowable antenna gain.

Table 6. Antenna system gain vs. power output setting in point-to-point systems

Antenna System Gain (Antenna Gain in dBi* minus Feedline Loss in dB†)	Maximum Allowable Power Setting (in dBm)	EIRP (in dBm)
6 (or less)	30	Less than 36
8	28	36
10	29	39
12	28	40

Table 6. Antenna system gain vs. power output setting in point-to-point systems

Antenna System Gain (Antenna Gain in dBi* minus Feedline Loss in dB†)	Maximum Allowable Power Setting (in dBm)	EIRP (in dBm)
14	28	42
16	27	43
18	26	44
20	26	46
22	25	47
24	24	48
26	24	50
28	23	51
30	22	52
32	22	54
34	21	55
36	20	56
38	20	58
40	19	59
42	18	60
44	18	62
46	17	63
48	16	64
50	16	66

5.0 INSTALLATION

Figure 16 shows a typical transceiver product shipment, along with an optional Hand-Held Terminal (HHT). Check the contents against the packing list secured to the outside of the shipping box. Accessories and spare parts kits, if any, are wrapped separately. Inspect all items for signs of damage and save all packing materials for possible re-shipment.
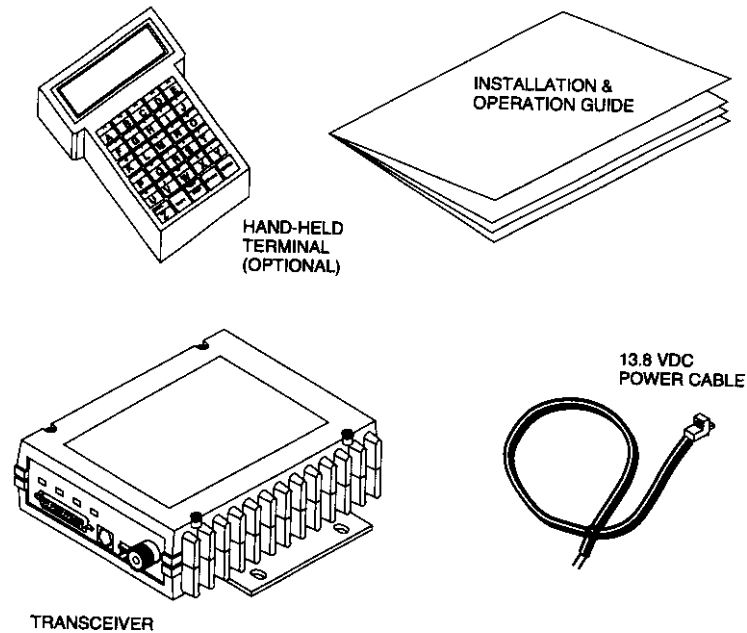

HAND-HELD
TERMINAL
(OPTIONAL)

INSTALLATION &
OPERATION GUIDE

13.8 VDC
POWER CABLE

TRANSCEIVER

Figure 16. Typical Transceiver shipment

Below are the basic steps for installing the MDS 9810/24810 transceivers. In most cases, these steps alone will be sufficient to complete the installation. Should further information be required, contact Microwave Data Systems at the number given on the inside back cover of this manual.

If you are installing a peer-to-peer, tail-end link or repeater system, you should also review Sections 5.2 (page 26) and 5.3 (page 29) for important details on antennas, cabling and software settings.

NOTE: It is recommended that the master station be installed *first*. In this way, it will be possible to quickly check the operation of each associated remote station as it is placed on the air.

5.1 Transceiver Installation

1. Mount the transceiver to a stable surface using the brackets supplied with the radio. (Fasteners/anchors are not supplied.)

   Figure 17 shows the dimensions of the transceiver case and its mounting bracket. If possible, choose a mounting location that provides easy access to the connectors on the end of the radio and an unobstructed view of the LED status indicators.

NOTE: The screws holding the brackets to the radio are 5/16 inch (8 mm) long so as not to damage the radio's PC board when tightened. If, for any reason, these screws are replaced, the new screws must not exceed this length.
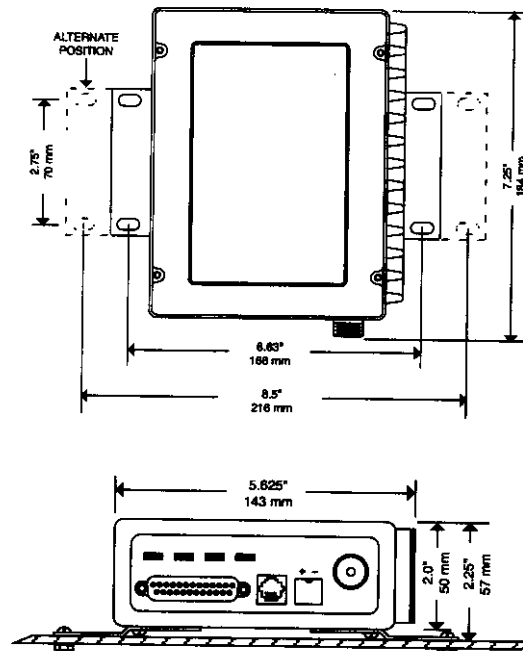

Figure 17. Transceiver mounting dimensions

2. Install the antenna and antenna feedline for the station. Antennas should be mounted in the clear and in accordance with the manufacturer's instructions.

   Additional information on antennas and feedlines is contained in Section 4.4 (page 15).

NOTE: Strong fields near the antenna can interfere with the operation of the low level RTU circuits and change the reported values of the data being monitored. For this reason, the antenna should be mounted at least 10 feet (>3 meters) from the radio, RTU, sensors and other components of the system.

3. Connect the data equipment to the transceiver's DATA INTERFACE connector. Use only the required pins for the application—Do *not* use a fully pinned (25 conductor) cable. Typical applications require the use of Pin 2 (transmit data—TXD), Pin 3 (received data—RXD) and Pin 7 (signal ground). Figure 18 shows a detailed view of the DATA INTERFACE connector.

If hardware flow control is desired, Pin 4 (request to send—RTS) and Pin 5 (Clear-to-Send—CTS) are also required. A complete list of pin functions is provided in Table 16 on page 64.
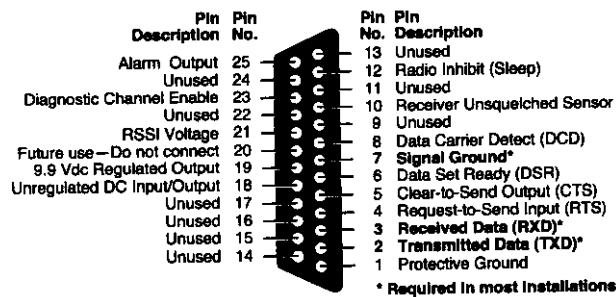

Pin Description	Pin No.		Pin No.	Pin Description
			13	Unused
Alarm Output	25		12	Radio Inhibit (Sleep)
Unused	24		11	Unused
Diagnostic Channel Enable	23		10	Receiver Unsquelched Sensor
Unused	22		9	Unused
RSSI Voltage	21		8	Data Carrier Detect (DCD)
Future use—Do not connect	20		7	Signal Ground*
9.9 Vdc Regulated Output	19		6	Data Set Ready (DSR)
Unregulated DC Input/Output	18		5	Clear-to-Send Output (CTS)
Unused	17		4	Request-to-Send Input (RTS)
Unused	16		3	Received Data (RXD)*
Unused	15		2	Transmitted Data (TXD)*
Unused	14		1	Protective Ground

* Required in most installations

Figure 18. Transceiver interface connector pins
As viewed from outside the radio

NOTE: The data cabling between the transceiver and the connected device should be kept as short as possible. Cable runs over 50 feet (15 meters) may require the use of EIA-422 signaling. Consult MDS for details.

4. Measure and install the primary power for the transceiver. It must be within 10.5–25 V dc and be capable of furnishing up to 500 (MDS 9810) or 750 (MDS 24810) milliamperes. Be sure to observe proper polarity. The red wire on the power cable is the positive lead; the black is negative.

NOTE: The radio is designed for use only in negative ground systems.

The power supply used with the transceiver should be equipped with overload protection (NEC Class 2 rating), to protect against a short circuit between its output terminals and the transceiver power connector.

5. Set the radio's configuration using a Hand-Held Terminal (HHT). Review Section 7.0, *PROGRAMMING* (beginning on page 35), if you are unfamiliar with connecting and using the HHT.

The three essential settings for MDS 9810/24810 transceivers are:

Mode—Master or Remote

Network Address—a unique number from 1–65000

Data Interface Parameters—bps, data bits, parity, stop bits

a. Connect an HHT to the DIAG(NOSTICS) connector (see Figure 19). After the HHT beeps, press ENTER to display the ready ">" prompt.

b. Set the Mode—Determine whether the transceiver will be used as a master or remote, and program it accordingly using the **MODE_M** or **MODE_R** command (page 47). (**MODE_M** = Master, **MODE_R** = Remote.) Press ENTER. The HHT will display **PROGRAMMED OK**.

NOTE: All transceivers are normally shipped from the factory pre-configured as remotes.
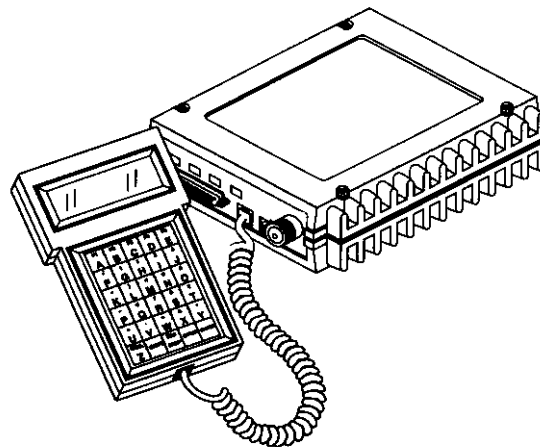
Figure 19. HHT connected to transceiver

c. Program the network address—Type **ADDR** (page 41) followed by SPACE, SHIFT, and then the desired address number (1–65000). Press ENTER. *All radios in a given system must be programmed with the same network address.* After programming the address, **PROGRAMMED OK** will be displayed.

> **NOTE:** It is strongly recommended that the last four digits of the master radio's serial number be used as the network address. In this way, it is unlikely that two systems will have the same address.

d. Set the data interface parameters to match the connected data device—The default setting is 4800 baud, 8 data bits, no parity, 1 stop bit. If your data equipment requires a different setting, use the **BAUD xxxxx abc** command (page 42), where **xxxxx** equals the baud rate (1200, 2400, 4800, 9600, 19200, or 38400 bps) and **abc** indicates the control bits as follows:

 a = Data bits (7 or 8)
 b = Parity (N for None, O for Odd, E for Even)
 c = Stop bits (1 or 2)

Using this scheme, a sample entry for the **BAUD xxxxx abc** command would look like this: **BAUD 4800 8N1** (A similar example using a five-character baud rate would appear as follows: **BAUD 19200 8N1**)

Press ENTER. After setting the data parameters, **PROGRAMMED OK** will be displayed.

> **NOTE:** 7N1, 8O2, and 8E2 are invalid communication settings and are not supported by the transceiver.

e. Record the Mode, Network Address, and Baud Rate settings on a label and affix it to the transceiver cover.

6. Repeat the above steps for each transceiver in the network.

This completes the basic installation of the MDS 9810/24810 transceiver. Section 6.1, *Initial Start-up* (beginning on page 32), contains steps for evaluating radio performance.

5.2 Peer-to-Peer Systems

Peer-to-peer systems allow remote radios to communicate with each other as well as with the central master station. The paragraphs below describe two types of peer-to-peer systems—simplex and repeater assisted.

Simplex Peer-to-Peer

A simplex peer-to-peer system is one in which all radios use the same transmit and receive frequencies. This is sometimes known as single-frequency operation. A simplex arrangement is the simplest configuration for peer-to-peer systems, although it usually has limited transmission range because of the need for all stations to use omnidirectional antennas. (If range is a concern, see "Peer-to-Peer with Repeater Assistance" on page 27.)

With a simplex peer-to-peer system, there are three key items to remember:

Programming

To program a system for simplex operation, the master radio must be set to **SIMPLEX ON** (page 50). This setting is automatically applied to all remote radios as soon as they become synchronized with the master radio.

Antennas

Omnidirectional antennas are normally required at all stations in a simplex system. The transmission range may be significantly reduced as compared with stations using directional antennas, so it is especially important that sites be chosen to allow sufficient signal strength between all units. A discussion of site selection is provided in Section 4.2.

Collision Avoidance

One problem with peer-to-peer systems is the risk of data "collisions" that can occur through self-interference. This problem can be alleviated with data protocols (such as Harris DNP3) which use Carrier Sense Multiple Access (CSMA) to detect a busy channel. In these systems, Pin 10 (Receiver Unsquelched-RUS) on the transceiver should be connected to the RTU's Data Carrier Detect (DCD) pin.

Peer-to-Peer with Repeater Assistance

A shortcoming of a simplex peer-to-peer network is that communication range is often reduced because of the need for all stations to use omnidirectional antennas. An alternative peer-to-peer network can be established using a repeater station to re-transmit the signals of all stations in the network. (See Figure 20.) Because directional antennas (aimed at the repeater site) can be used at all remote sites, the communication range of the system is greatly increased. Like a simplex peer-to-peer system, each remote station can "hear" the transmissions of the others so that data collisions can be avoided.
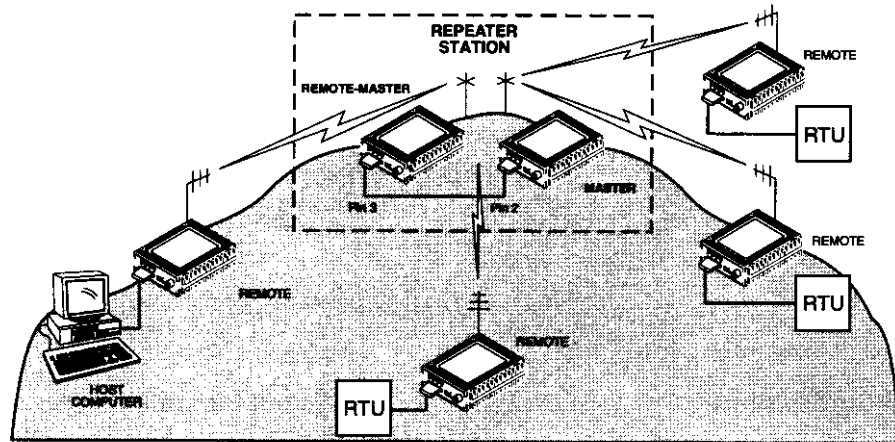
Figure 20. Peer-to-peer network with repeater assistance

Here are some specific requirements for peer-to-peer systems with repeater assistance:

Repeater Setup

The repeater station in a peer-to peer network consists of two co-located transceivers—one programmed as a remote using master frequencies (**MODE R-M** command, page 47), and the other programmed as a master (**MODE M** command).

Interface Wiring

Pin 2 (TXD) of the master radio must be connected to Pin 3 (RXD) of the other radio (the one programmed as **MODE R-M**) using a local interface cable. This allows the signals received by the **MODE R-M** radio to be re-transmitted by the master. The signal ground leads (Pin 7) must also be connected to each other.
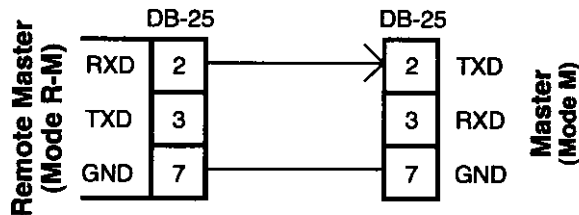
**Figure 21. Data interface cable wiring
for peer-to-peer systems with repeater assistance**

Antennas

Two omnidirectional antennas are required at peer-to-peer repeater stations—one for each radio. It is important to minimize coupling between these antennas. The necessary isolation can be achieved by **vertical separation**. In this arrangement, one antenna is mounted *directly* over the other, separated by at least 4 feet (1.22 Meters). This takes advantage of the minimal radiation exhibited by vertically polarized antennas directly above and below one another.

Full-Duplex Configuration

The paragraphs above discuss the requirements for a basic Repeater Assisted Peer-to-Peer system. If a full-duplex system is required (with the SCADA host computer located at the repeater), additional considerations apply. If you are constructing this type of system, contact Microwave Data Systems and request a copy of Application Bulletin 97002. Bulletins are also available on our BBS line at (716) 242-8426. The parameters of operation are 8 data bits, no parity and 1 stop bit (8-N-1). The BBS supports modem speeds from 300 to 14.4 kbps. The MDS World Wide Web site, www.microwavedata.com, also contains this information.

5.3 Tail-End Links

A tail-end link is established by connecting an MDS 9810/24810 radio "back-to-back" with another radio such as a licensed MDS 2300/4300 series transceiver. This can be used to link an outlying remote site into the rest of an MAS network. Here are some specific requirements for tail-end link systems:

Interface Wiring

The connection between the two radios in a tail-end link system must be made as shown in Figure 22.
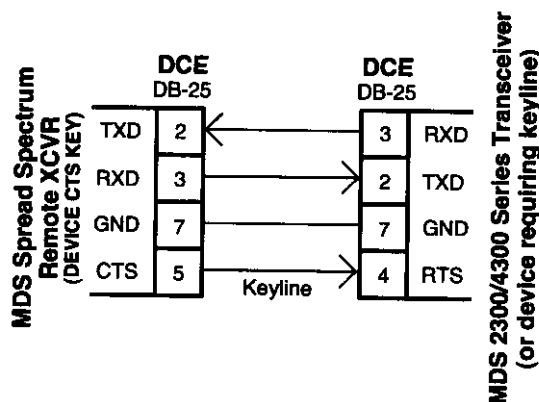
Figure 22. Data interface cable wiring for tail-end links

Programming

In a tail-end link system, the radio's device behavior must be set to DEVICE CTS KEY (page 44) using the HHT. This allows one radio to control the keying of another. Also, the CTS delay time must be set (using the CTS xxx command, page 43) to the time required for the other transceiver to key up. This time is typically 10 ms for MDS 2300/4300 series transceivers.

5.4 Repeaters

Two MDS 9810/24810 radios (or another MDS spread spectrum radio) may be connected "back-to-back" using a null-modem cable to form a repeater station. This is sometimes required in a network that includes a distant remote station that would otherwise be unable to communicate with the master station due to distance or terrain.

A repeater works by re-transmitting data from the outlying remote site to the master station and vice versa. It introduces a small amount of end-to-end transmission delay, but this is not a problem in most systems.

The geographic location of a repeater station is especially important. A site must be chosen that allows good communication with *both* the master and the outlying remote site. This is often on top of a hill, or other elevated terrain from which both sites can be "seen" by the repeater station antennas. A detailed discussion on the effects of terrain is given in Section 4.2, *Site Selection* (beginning on page 12).

Here are some specific requirements for repeater systems:

Antennas

Two antennas are required at repeater stations—one for each radio. Measures must be taken to minimize the chance of interference between these antennas. One effective technique for limiting interference is to employ **vertical separation**. In this arrangement, one antenna is mounted *directly* over the other, separated by at least 4 feet (1.22 Meters). This takes advantage of the minimal radiation exhibited by most antennas directly above and below their driven elements.

Another interference reduction technique is to cross-polarize the repeater antennas. If one antenna is mounted in the vertical plane, and the other in the horizontal plane, an additional 20 dB of attenuation can be achieved. (Remember that the corresponding stations must use the same antenna orientation when cross-polarization is used.)

System Addresses

The two radios that are wired together at the repeater site must have different system addresses. To set or view the system address, see "ADDR [1...65000]" on page 41.

Interface Wiring

A null-modem cable (Figure 23) is required between the DATA INTERFACE connectors of the two radios forming a repeater station. This allows them to freely exchange data even though they are both configured as DCE devices.
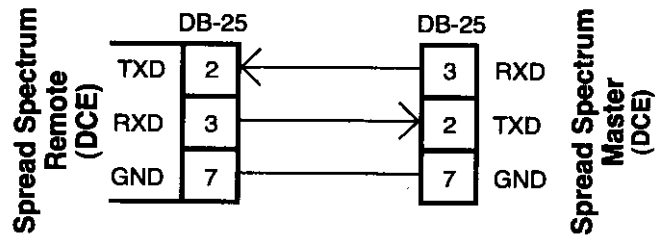
Spread Spectrum Remote (DCE)

DB-25   DB-25

TXD 2 → 3 RXD
RXD 3 → 2 TXD
GND 7 — 7 GND

Spread Spectrum Master (DCE)

Figure 23. Data interface cable wiring for null-modem cable
(used for repeater)

5.5 Using the Radio's Sleep Mode

In some installations, such as at solar-powered sites, it may be necessary to keep the transceiver's power consumption to an absolute minimum. This can be accomplished using Sleep Mode. In this mode, power consumption is reduced to less than 30 milliamperes.

Sleep Mode can be enabled under RTU control by asserting a ground (or EIA-232 low) on Pin 12 of the radio's DATA INTERFACE connector. The radio stays in Sleep Mode until the low is removed, and all normal functions are suspended. As a status indication, the radio's PWR LED flashes once every four seconds to indicate that it is in Sleep Mode.

The radio can be "woken up" by your RTU every minute or so to verify synchronization with the master station. When Pin 12 is opened (or an EIA-232 high is asserted), the radio will be ready to receive data within 75 milliseconds.

It is important to note that power consumption will increase significantly as communication from the master station degrades. This is because the radio will spend a greater period of time "awake," looking for synchronization messages from the master radio.

System Example

This example describes Sleep Mode implementation in a typical system. Using this information, you should be able to configure a system that will meet your own particular needs.

Suppose you need communications to each remote site only once per hour. Program the RTU to raise an EIA-232 line once each hour (DTR for example) and wait for a poll and response before lowering it again. Connect this line to Pin 12 of the radio's DATA INTERFACE connector. This will allow each RTU to be polled once per hour, with a significant savings in power consumption.

6.0 OPERATION

6.1 Initial Start-up

In-service operation of the MDS 9810/24810 transceiver is completely automatic. Once the unit has been properly installed and configured, operator actions are limited to observing the LED status indicators for proper operation.

If all parameters are correctly set, operation of the radio can be started by following these steps:

1. Apply primary power to the radio.

2. Observe the transceiver LED status panel (Figure 24) for the proper indications. Table 7 provides a complete explanation of the LED functions.

   In a normally operating system, the following LED indications will be seen within 16 seconds of start-up:

   - PWR lamp lit continuously
   - SYNC lamp lit continuously
   - Remote radio(s) transmitting data (TXD) and receiving data (RXD) with the master station

PWR   SYNC   TXD   RXD
■   ■   ■   ■
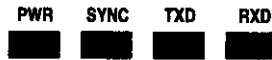
Figure 24. LED status indicators

Table 7. LED status indicators

LED Name	Description
PWR	• Continuous—Power is applied to the radio; no problems detected. • Flashing 5 times per second—Fault indication. See Section 8.0, TROUBLESHOOTING (beginning on page 54). • Flashing once every 4 seconds—radio is in Sleep mode.
SYNC	Lights continuously to indicate the radio is receiving/sending synchronization frames. Within 16 seconds of power-up, this LED should be lit continuously.
TXD	Indicates EIA-232 space (logic high) signal input to the DB-25 connector.
RXD	Indicates EIA-232 space (logic high) signal output from the DB-25 connector.

6.2 Performance Optimization

After the basic operation of the radio has been checked, you may wish to optimize its performance using some of the suggestions given here. The effectiveness of these techniques will vary with the design of your system and the format of the data being sent.

Complete instructions for using the software commands referenced herein are provided in Section 7.0, *PROGRAMMING* (beginning on page 35).

Antenna Aiming

For optimum performance of directional antennas, they must be accurately aimed in the direction of desired transmission. The easiest way to do this is to point the antenna in the approximate direction, then use the remote radio's built-in Received Signal Strength Indication (RSSI) feature to further refine the heading for maximum received signal strength.

RSSI can be read by connecting an HHT to the remote radio's RJ-11 DIAG(NOSTICS) jack and entering the **RSSI** command. Instructions on connecting and using an HHT are given in Section 7.0, *PROGRAM-MING* (beginning on page 35).

In an MAS system, RSSI readings are only meaningful when initiated from a remote station. This is because the master station typically receives signals from several remote sites, and the RSSI would be continually changing as the master receives from each remote in turn.

Antenna SWR Check

It is necessary to briefly key the transmitter for this check by placing the radio in the **SETUP** mode (page 49) and using the **KEY** command on the HHT. (To unkey the radio, enter **DKEY**; to disable the setup mode and return the radio to normal operation, enter **Q** or **QUIT**.)

MDS 9810 transceiver

The SWR of the antenna system should be checked before the radio is put into regular service. For accurate readings, a wattmeter suited for 1000 MHz is required. One unit meeting this criteria is the Bird Model 43™ directional wattmeter with an 800-1 element installed.

The reflected power should be less than 10% of the forward power (~2:1 SWR). Higher readings usually indicate problems with the antenna, feedline or coaxial connectors.

MDS 24810 transceiver

The antenna system should be checked before the radio is placed into regular service. Ensure the feedline and its connectors are in good condition and are correctly installed to a suitable 2.4 to 2.5 GHz band antenna. Ensure the polarization of the antenna matches the polarization of the antenna at the other end of the link. For a more accurate determination of the antenna system condition, an

accurate in-line wattmeter installed between the feedline and the antenna can be used to check forward and reflected power. A Bird type 43 wattmeter equipped with a 431-20 (1 watt) slug is suitable for this purpose.

The forward power measured at the antenna with the in-line watt-meter should read the difference between the MDS 24810 power setting (**PWR**, page 48) and the feedline loss. The reflected power measured determines the amount of antenna/feedline mismatch at this point. If excessive reflected power is measured at this point, check the antenna and its connections. If the measured forward power is much less than expected, check the feedline, its connectors, and the output power setting of the MDS 24810.

Data Buffer Setting

The default setting for the data buffer is ON to accommodate virtually any data format. However, if the system can operate satisfactorily with the buffer OFF, we recommend doing so using the **BUFF OFF** command (page 42). This allows the radio to operate with the lowest possible latency and improves channel efficiency.

Hoptime Setting

The default hop time setting is **HOPTIME NORMAL**. If message sizes typi-cally exceed 256 bytes, channel efficiency can be improved by setting this parameter to **HOPTIME LONG**.

A detailed explanation of the **HOPTIME** command, and a table listing the available selections and the channel efficiency associated with each, can be found on page 45.

Baud Rate Setting

The default baud rate setting is 4800 bps to accommodate most systems. If your system will support a higher data rate, you should increase the radio's transmission speed using the **BAUD xxxxx abc** command (page 42). It should be set to the highest speed that can be sent by the data equipment in the system. (The transceiver supports speeds from 1200 to 38400 bps)

Radio Interference Checks

The **ZONE DATA** command (page 52) can be used to check for interference in the radio's eight frequency zones. If interference is found in one or more of these zones, the **SKIP** command (page 50) can be used to omit them from the hop pattern. You should also review Section 4.3, *A Word About Radio Interference* (beginning on page 13), when dealing with interference problems.

7.0 PROGRAMMING

There are no manual controls or adjustments on the MDS 9810/24810 radio. Programming and control is performed remotely, using InSite 5 Radio System Management Software (MDS P/N 03-3475A01), or on site, using an MDS Hand-Held Terminal (MDS P/N 02-1501A01). Contact MDS for ordering information.

7.1 Hand-Held Terminal Connection & Start-up

This section gives basic information for connecting and using the MDS Hand-Held Terminal for control of the radio. For more information about the terminal, see the instructions supplied with each HHT kit.

The steps below assume that the HHT has been configured for use with the MDS 9810/24810 Transceiver (80 character screen display). If the HHT was previously used with a different model transceiver, or if its default settings have been changed, refer to Section 7.2 for setup details.

Follow these steps to connect the HHT:

1. Connect the HHT's coiled cord to the DIAG(NOSTICS) (RJ-11) jack on the radio as shown in Figure 25. This automatically places the radio into the control and programming mode.

   As an alternative, the DATA INTERFACE (DB-25) connector may be used for programming instead of the DIAG(NOSTICS) jack. With this arrangement, Pin 23 of the HHT cable must be grounded to enable the diagnostic channel. (See Table 16 on page 64.)
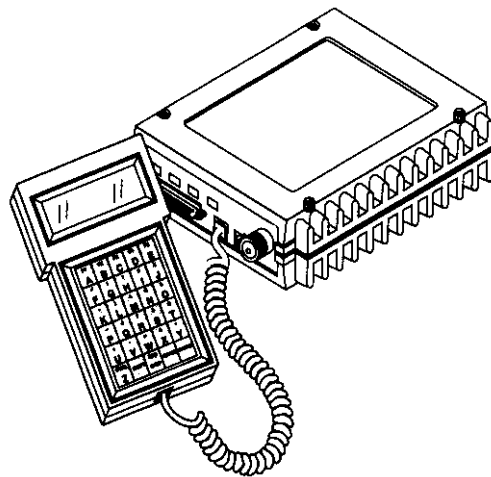
Figure 25. Hand-Held Terminal connected to the MDS 9810/24810

2. When the HHT is connected, it runs through a brief self-check, ending with a beep. After the beep, press [ENTER] to receive the ready ">" prompt.

7.2 Hand-Held Terminal Setup

The following is a set of instructions for re-initializing an HHT for use with the MDS 9810/24810. These steps may be required if the HHT was previously used with a different radio, or if the HHT default settings have been inadvertently altered.

1. Plug the HHT into the DIAG(NOSTICS) connector. Enable the setup mode by pressing the [SHIFT], [CTRL] and [SPACE] keys in sequence. The display shown in Figure 26 will appear.
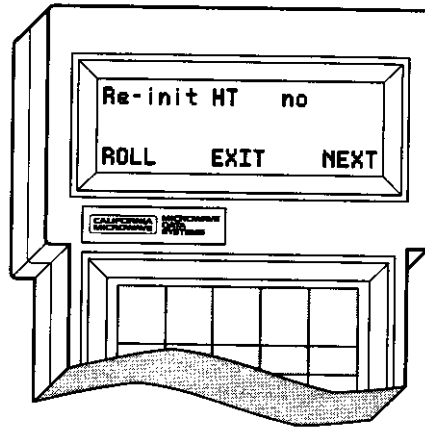
Figure 26. HHT setup display

2. The first of 15 menu items will be displayed. Settings can be reviewed by pressing the NEXT function ([E] key). Parameter settings can be changed by pressing the ROLL function ([A] key).

3. Set up the HHT as listed in Table 8.

Table 8. HHT Operational settings

Parameter	Setting	Parameter	Setting
Re-init HT	NO	Scroll On	33rd
Baud Rate=	1200	Cursor	ON
Comm bits=	8,1,n	CRLF for CR	OFF
Parity Error	OFF	Self Test	SLOW
Key Repeat	OFF	Key Beep	ON
Echo	OFF	Screen Size	80
Shift Keys	YES	Menu Mode	LONG
Ctl Chars	PROCS		

4. Exit the HHT setup mode by pressing Ⓒ for Exit, or by pressing the Ⓐ (Roll) key after the final menu item has been reviewed.

7.3 Keyboard Commands

Table 9 is a reference chart of software commands for the transceiver. See Section 7.4 for detailed command descriptions.

Entering Commands

The proper procedure for entering commands is to type the command, followed by an ENTER keystroke. For programming commands, the command is followed by SPACE and the appropriate information or values, then ENTER .

Here are some additional points to remember when using the HHT:

- Use the SHIFT key to access numbers; press again to return letters.
- Flashing square cursor (∎) = letter mode.
- Flashing superscript rectangular cursor (▫) = number mode.
- Use ESC/BKSP key to edit information or commands being typed in.

Error Messages

Below are some common HHT error messages you may encounter:

- **UNKNOWN COMMAND**—Command was not recognized.
- **INCORRECT ENTRY**—Command format or its arguments invalid.
- **COMMAND FAILED**—Command was unable to complete successfully. Possible software problem.
- **NOT PROGRAMMED**—Software was unable to program the EEPROM or the requested display item was not programmed.
- **TEXT TOO LONG**—Response to **OWN** or **OWM** command when too many characters have been entered.
- **NOT AVAILABLE**—The entered command or parameter was valid, but it referred to a currently unavailable choice.
- **PASSWORD INVALID**—The entered password was invalid, and was not accepted.
- **ACCESS DENIED**—Command is invalid for current password level.
- **EEPROM FAILURE**—The **INIT** command cannot write to EEPROM.

Table 9. Command summary

	COMMAND	DESCRIPTION
NETWORK CONFIGURATION These programming commands can only be used at the master radio.	**BUFF [ON, OFF]** Details Page 42	ON = Seamless data, OFF = Fast byte throughput.
	HOPTIME [XSHORT, SHORT, NORMAL, LONG] Details Page 45	Select hop time—XSHORT, SHORT, NORMAL, LONG
	SIMPLEX [ON, OFF] Details Page 50	Program simplex/half-duplex selection. ON = simplex, OFF = half-duplex
	SKIP [NONE, 1...8] Details Page 50	Select combination of frequency operating zones to avoid.
NETWORK-WIDE DIAGNOSTICS CONFIGURATION	**DLINK [xxxxx]** Details Page 44	Set baud rate of diagnostics link
	DTYPE [NODE/ROOT/GATE/PEER] Details Page 45	Set radio's operational characteristics for net-work-wide diagnostics

Table 9. Command summary (Continued)

SET/PROGRAM COMMANDS

COMMAND	DESCRIPTION
ADDR [1...65000] Details Page 41	Program network address
AMASK [0000 0000–FFFF FFFF] Details Page 41	Sets alarm response. Default is FFFF FFFF.
ASENSE [HI/LO] Details Page 42	Changes the sense of the alarm output. Default is HI.
BAUD [xxxxx abc] Details Page 42	Set data communication parameters
CTS [0–255] Details Page 43	Program CTS delay in milliseconds. (A value of 0 returns CTS immediately)
CTSHOLD [0-6000] Details Page 43	Set/display "hold time" that CTS remains present following last character transmission from DD-25 port.
DEVICE [DCE, CTS KEY] Details Page 44	Set device behavior; DCE (normal) or CTS Key (Repeater)
INIT Details Page 46	Initialize parameters to default values
MODE [M, R, R-M] Details Page 47	Program operating mode, where M = Master, R = Remote, R-M = Remote-Master (Remote radio programmed to operate on Master frequencies)
OWM [xxxxx] Details Page 47	Program owner's message (30 characters maximum)
OWN [xxxxx] Details Page 47	Program owner's name (30 characters maximum)
PWR [xx–30] Details Page 48	Program forward power output in dBm.
RTU [ON/OFF/0-80] Details Page 48	Re-enables or disables the radio's internal RTU simulator and sets the RTU address.
RXTOT [NONE, 0–1440] Details Page 49	Specifies max. duration to wait before issuing a time-out alarm. Default is OFF.
UNIT [1000–65000] Details Page 52	Program unit address (For future applications)
ZONE DATA Details Page 52	Show zone data statistics. Press "Q" to quit
ZONE CLEAR Details Page 53	Reset zone data statistics

Table 9. Command summary (Continued)

COMMAND	DESCRIPTION
ADDR [1...65000] Details Page 41	Network address (1-65000)
ALARM	Obsolete command—see STAT
AMASK [0000 0000–FFFF FFFF] Details Page 41	Sets alarm response. Default is FFFF FFFF.
ASENSE [HI/LO] Details Page 42	Changes the sense of the alarm output. Default is HI.
BAUD [xxxxx abc] Details Page 42	Display data communication parameters
BUFF [ON, OFF] Details Page 42	Data buffering mode: ON = seamless data OFF = fast byte throughput
CTS [0–255] Details Page 43	CTS delay in ms (0-255 ms)
DUMP	Show all programmable settings. Intended for use with a PC and MDS Radio Configuration software (P/N 03-3156A01).
DEVICE [DCE, CTS KEY] Details Page 44	Device behavior (DCE, or CTS KEY)
HOPTIME [XSHORT, SHORT, NORMAL, LONG] Details Page 45	Show hop time
HREV	Hardware revision level
MODE [M, R, R-M] Details Page 47	Show operating mode: M = Master, R = Remote, M-R = Remote-Master
OWM	Owner's message or site name
OWN	Owner's name or system name
PWR [xx–30] Details Page 48	Forward power output setting in dBm
RSSI Details Page 48	Received signal strength in dBm (continuously updated). Not available at master radio until SETUP is enabled. Accurate readings are not provided for signal strengths greater than –50 dBm.
RXTOT [NONE, 0–1440] Details Page 49	Specifies amount of time to wait before issuing a time-out alarm. Default is NONE.
SER	Serial number of radio
SHOW [PORT, DC, PWR] Details Page 50	Show active port, DC voltage, or measured RF power (dBm)
SIMPLEX [ON, OFF] Details Page 50	Simplex/half-duplex selection ON = Simplex, OFF = half-duplex
SKIP [NONE, 1...8] Details Page 50	Skip a frequency operating zone
SNR Details Page 51	Signal-to-noise ratio
SREV	Display transceiver firmware revision level
STAT Details Page 51	Current alarm status
TEMP Details Page 52	Transceiver's internal temperature (°C)
UNIT [1000–65000] Details Page 52	Show programmed unit address (1000-65000)
ZONE DATA Details Page 52	Show zone data statistics. Press "Q" to quit.

Sidebar (vertical): DISPLAY OPERATING STATUS

Table 9. Command summary (Continued)

	COMMAND	DESCRIPTION
DIAGNOSTIC/TEST	**KEY**	Enables the transmitter. (Radio must be in Setup mode.)
	DKEY	Disables the transmitter. (Radio must be in Setup mode.)
	DMGAP [xx] Details Page 44	(diagnostics) Sets the amount of time to wait after the receipt of a character before interpreting the next received character as the start of a new message.
	TX [xxxx] Details Page 52	Set/display transmit frequency. (Radio must be in Setup mode.)
	RX [xxxx] Details Page 49	Set/display Setup mode receive frequency. (Radio must be in Setup mode.)
	SETUP Details Page 49	Enables Setup mode. Times out after 15 minutes. Press "Q" to quit.

7.4 Detailed Command Descriptions

The only essential commands for most applications are Network Address (**ADDR**), Mode, (**MODE**) and Baud Rate (**BAUD**). However, proper use of the additional commands allows you to tailor the transceiver for a specific use, or conduct basic diagnostics on the radio. This section gives more detailed information for many of the user commands listed in Table 9.

In many cases, the commands below can be used in two ways. First, you can type *only* the command name (for example, **ADDR**) to view the currently programmed data. Secondly, you can set or change the existing data by typing the command, followed by a space, and then the desired entry (for example, **ADDR 1234**). In the list below, allowable programming variables, if any, are shown in brackets [ ] following the command name.

ADDR [1...65000]

This command sets or displays the radio's network address. The network address can range from 1 to 65000.

Network address must be programmed at the time of installation and must be common across each radio in a given network. Radios are typically shipped with the network address unprogrammed. This causes the address to display as **NONE**. This leaves the system in an invalid state and prevents operation.

AMASK [0000 0000–FFFF FFFF]

This command sets the alarm bits that cause the alarm output signal to be triggered. The PWR LED will still flash for all alarms, but the alarm output signal will only be activated for those alarms that have the corresponding mask bit set. The hex value for the mask aligns directly with the hex value for the **ALARM** command. The default is **FFFF FFFF**.

Through proper use of the **AMASK** command, it is possible to tailor the alarm response of the radio. For more information on configuring the alarm response, contact Microwave Data Systems and request Application Bulletin 98-002.

ASENSE [HI/LO]

This command is used to set or display the sense of the alarm output at Pin 25 of the DATA INTERFACE connector. The default for transceivers is active **HI**.

BAUD [xxxxx abc]

This command sets or displays the communication attributes for the DATA INTERFACE port. The command has no effect on the RJ-11 DIAG(NOSTICS) port.

The first parameter (**xxxxx**) is baud rate. Baud rate is specified in bits-per-second and must be one of the following speeds: 1200, 2400, 4800, 9600, 19200, or 38400. In the worst case, the radio will always accept a minimum of 500 data bytes in a single continuous data transmission. At baud rates of 4800 bps or less, the radio can support unlimited continuous data transmission at any hop rate. If hop time is set to **NORMAL** or **LONG**, baud rates of up to 19200 bps with continuous unlimited data transmission are possible. (See **HOPTIME** command.)

The second parameter of the **BAUD** command (**abc**) is a 3-character block indicating how the data is encoded:

> **a** = Data bits (**7** or **8**)
> **b** = Parity (**N** for None, **O** for Odd, **E** for Even)
> **c** = Stop bits (**1** or **2**)

The factory default setting is 4800 baud, 8 data bits, no parity, 1 stop bit (Example: **4800 8N1**).

NOTE: 7N1, 8O2, and 8E2 are invalid communication settings and are not supported by the transceiver.

BUFF [ON, OFF]

This command sets or displays the received data handling mode of the radio. The command parameter is either **ON** or **OFF**. (The default is **ON**.) The setting of this parameter affects the timing of *received* data sent out the DATA INTERFACE connector. Data transmitted over the air by the radio is unaffected by the **BUFF** setting.

If data buffering is set to **OFF**, the radio will operate with the lowest possible average latency. Data bytes are sent out the DATA INTERFACE port as soon as an incoming RF data frame is disassembled. Average and typical latency will both be below 10 ms, but idle character gaps may be introduced into the outgoing data flow.

If data buffering is **ON**, the radio will operate in a seamless mode. That is, data bytes will be sent over the air as quickly as possible, but the receiver will buffer the data until enough bytes have arrived to cover worst case gaps in transmission. The delay introduced by data buffering may range from 25 to 50 ms, but the radio will not create any gaps in the output data stream. This mode of operation is required for protocols such as MODBUS™ that do not allow gaps in their data transmission.

Note that seamless mode (**BUFF ON**) is intended only for applications where the transmitter's baud rate is greater than or equal to the receiver's baud rate. Enforcement of this rule is left up to the user.

Changes to the **BUFF** setting may only be made at the *master radio*. This is because the master radio broadcasts the buffer setting for the entire network. At remote radios, the buffer setting may be read when the radio is in synchronization with the master, but it may not be changed.

CTS [0–255]

The **CTS** (clear-to-send) command sets or displays the timer value associated with the CTS line response. The command parameter ranges from 0 to 255 milliseconds.

For DCE operation, the timer specifies how long to wait after the RTS line goes high before asserting the CTS line. A timer value of zero means that the CTS line will always be asserted (unless the radio is attempting to throttle data as part of normal flow control operation).

For CTS Key operation (see the **DEVICE** command), the timer specifies how long to wait after asserting the CTS line before sending data out the DATA INTERFACE port. A timer value of zero means that data will be sent out the data port without imposing a key-up delay. (Other delays may be in effect from other radio operating parameters.)

CTSHOLD [0-6000]

Used in **DEVICE CTS KEY** mode, this command sets the amount of time in milliseconds that CTS remains present following transmission of the last character out of the DD-25 port. This "hold time" can be used to prevent squelch tail data corruption when interworking with other radios. If the command is entered when the radio is in **DEVICE DCE** mode, the response **CTSHOLD N/A** will be displayed.

DEVICE [DCE, CTS KEY]

The **DEVICE** command sets or displays the device behavior of the radio. The command parameter is either **DCE** or **CTS KEY**.

The default selection is **DCE**. In this mode, CTS will go high following RTS, subject to the CTS programmable delay time. Keying is stimulated by the input of characters at the data port. Hardware flow control is implemented by dropping the CTS line if data arrives faster than it can be transmitted.

If **CTS KEY** is selected, the radio is assumed to be controlling another radio, such as in a repeater system. The RTS line is ignored and the CTS line is used as a keyline control for the other radio. CTS is asserted immediately after the receipt of RF data, but data will not be sent out the **DATA INTERFACE** port until after the CTS programmable delay time has expired. (This gives the other radio time to key.)

Following transmission of the last byte of data, CTS will remain asserted for the duration specified by the **CTSHOLD** command. **CTSHOLD** should be set sufficiently high.

DLINK [xxxxx]

DLINK followed by the baud rate sets the baud rate (bps) of the diagnostics link. The following **DLINK** baud rates selections are allowed:

- 1200
- 2400
- 4800
- 9600
- 19200 (default setting)

Example: **DLINK 4800** sets the RJ-11 DIAG port to operate at 4800 bps. The default is **DLINK 19200** and **DLINK ON**.

NOTE: The same baud rate must be entered into the InSite Equipment List's **BAUD** field.

DMGAP [xx]

The **DMGAP** command sets the amount of time in milliseconds to wait after the receipt of a character before interpreting the next received character as the start of a new message. When data port baud rates are slow, the gap between characters within a poll may be so long that the radio interprets the next character as the start of a new poll. When diagnostics is being performed using passive messaging (see *Performing Network-Wide Remote Diagnostics* on page 57), this command may be used to change this behavior.

DTYPE [NODE/ROOT/GATE/PEER]

The **DTYPE** command specifies the radio's operational characteristics for network-wide diagnostics. There are four possible types of nodes in a network-wide diagnostics system.

The common types are:

- **ROOT**–Always one, and only one, per network. The root is the focal point of network-wide diagnostics information. Intrusive diagnostics can originate from any radio, including the root. However, the root is the only radio through which non-intrusive diagnostics can be conducted.

- **NODE**–The most common setting, and the default. This is the basic system radio device-type. Typically, the radio network is comprised of nodes and one root. Intrusive diagnostics can originate from any node. However, non-intrusive diagnostics can only be conducted from the root node.

The default radio device-type is **NODE**. Less used are:

- **GATE**
- **PEER**

These node types are needed for repeater sub-networks and simplex sub-networks where simplex frequencies are used. See the Network-Wide Diagnostics System Handbook for an explanation of these node types.

HOPTIME [XSHORT, SHORT, NORMAL, LONG]

The **HOPTIME** command sets or displays the hop time setting. The command is one of four keywords whose parameters and related efficiencies are shown in Table 10.

Although the default setting is **HOPTIME NORMAL**, transmission efficiency can usually be improved by using **HOPTIME LONG** when message sizes typically exceed 256 bytes. This is because there will be less frequent channel hops when using this setting, contributing to a smoother flow of transmitted data.

Table 10. Hop time parameters

Hop Time Keyword	Time per Hop	Max. Bytes per Hop	Channel Efficiency
XSHORT	10 ms	9	32.1%
SHORT	40 ms	72	64.3%
NORMAL	80 ms	162	72.0%
LONG	160 ms	336	74.5%

Except for special cases, the use of **HOPTIME SHORT** or **HOPTIME XSHORT** is *not* recommended because of reduced channel efficiency. The only time these selections should be considered is when the message size is very small and strong interference of a persistent nature is occurring on many frequencies. In this case, a shorter hop time may improve the chances of a message getting through—but at the cost of reduced channel efficiency.

Changes to the **HOPTIME** setting may only be made at the *master radio*. (This is because the master radio establishes the hop time setting for the entire network.) At remote radios, the hop time setting may be read when the radio is in synchronization with the master, but it may not be changed.

INIT

The **INIT** command is used to reset the radio's operating parameters to the factory defaults. This may be helpful when trying to resolve configuration problems that may have resulted from the entry of one or more improper command settings. If you are unsure of which command setting may have caused the problem, this command allows you to get back to a known working state.

Use of the **INIT** command causes the following changes to be applied:

Table 11. Factory default values produced by INIT command

	Default Setting	Corresponding Command
For all radios		
Device operation	DCE	**DEVICE DCE**
RF output power	30 dBm (1 watt)	**PWR 30**
CTS delay	0 (CTS is continuously asserted)	**CTS 0**
DATA INTERFACE port	4800 baud 8 data bits no parity 1 stop bit	**BAUD 4800 8N1**
Remote radios		
Transmitter test frequency	**MDS 9810** 927.975 MHz **MDS 24810** 2483.44 MHz	**TX xxx**
Receiver test frequency	**MDS 9810** 902.025 MHz **MDS 24810** 2400.08 MHz	**RX xxx**

Table 11. Factory default values
produced by INIT command (Continued)

	Default Setting	Corresponding Command
Master radio		
Transmitter test frequency	**MDS 9810** 902.025 MHz **MDS 24810** 2400.08 MHz	**TX xxx**
Receiver test frequency	**MDS 9810** 927.975 MHz **MDS 24810** 2483.44 MHz	**RX xxx**
Skipped frequencies	None (radio will hop across all 1019 frequencies)	**SKIP NONE**
Hop time	Normal (80 ms per hop)	**HOPTIME NORMAL**
Simplex/duplex operation	Half-duplex	**SIMPLEX OFF**
Buffer mode	Seamless data mode enabled	**BUFF ON**

MODE [M, R, R-M]

The **MODE** command sets or displays the operating mode of the radio. A master radio is designated by an **M**; a remote is designated by an **R**.

R-M indicates that the transceiver has been programmed to the special remote-master mode (used in repeater-assisted peer-to-peer systems; see Section 2.2, *Typical Applications* (beginning on page 3) for details). The **R-M** mode denotes a remote radio operating on master frequencies. In all other respects, a remote-master behaves just like a normal remote.

All units default to remotes; other modes must be specifically programmed with the **MODE** command.

OWM [xxxxx]

The **OWM** command sets or displays an optional owner's message, such as the system name. The entry can contain up to 30 characters.

OWN [xxxxx]

The **OWN** command sets or displays an optional owner's name, such as the site name. The entry can contain up to 30 characters.

PWR [xx–30]

This command displays or sets the desired RF forward output power setting of the radio. The **PWR** command parameter is specified in dBm and can range from 20 dBm (MDS 9810 transceiver) or 10 dBm (MDS 24810 transceiver) through 30 in 1 dBm steps. The default setting is 30 dBm (1 watt). To read the actual (measured) power output of the radio, use the **SHOW PWR** command.

In the USA, maximum allowable power is governed by FCC limits on Effective Isotropic Radiated Power output (EIRP). The EIRP limit of +36 dBm means that any user with a net antenna gain greater than 6 dBi must decrease the **PWR** setting accordingly. Section 4.5, *How Much Power Can I Run?* (beginning on page 18) contains a detailed discussion of this topic.

RSSI

This command displays the radio's Received Signal Strength Indication in dBm (decibels relative to 1 mW). The output can range from –50 dBm to –110 dBm. Command availability and results depend on the mode of operation (master or remote).

For a remote radio, under normal operation, RSSI is based on the average signal strength of the SYNC message received in each of the eight frequency zones. (RSSI is sampled each time a SYNC message is received—every 1.6 seconds.) When using the RSSI reading to align a directional antenna, it is important to make changes slowly so that the RSSI reading will provide meaningful results. It will take several seconds to indicate a change in signal level. The radio stays in RSSI mode until [ENTER] is pressed.

For a master radio, under normal operation, entering the RSSI command causes the response **NOT AVAILABLE** to be returned. This is because a master is normally receiving signals from several remote stations and an RSSI reading would be continually changing. The only exception is when the **SETUP** command has been enabled. This disables hopping and allows reading a "raw" RSSI signal level in real time from a master *or* remote radio.

RTU [ON/OFF/0-80]

This command re-enables or disables the radio's internal RTU simulator, which runs with MDS' proprietary polling programs (poll.exe and rsim.exe). The internal RTU simulator is available whenever a radio has diagnostics enabled. This command also sets the RTU address that the radio will respond to.

The internal RTU can be used for testing system payload data or pseudo bit error rate testing. It can be helpful in isolating a problem to either the external RTU or the radio.

RX [xxxx]

This command sets or displays the test receive frequency used in place of hopping whenever the radio is in Setup mode. The test receive frequency can be reprogrammed to any value between 927.975 MHz and 902.025 MHz (MDS 9810) or 2400.00 and 2483.44 MHz (MDS 24810), inclusive. The factory default settings are listed below and have been selected to be non-intrusive to normal operation.

	Default Receive Frequencies	
	Master	Remote
MDS 9810	927.975 MHz	902.025 MHz
MDS 24810	2483.44 MHz	2400.08 MHz

RXTOT [NONE, 0–1440]

This command sets or displays the amount of time (in minutes) to wait for the next received data packet before issuing a receiver time-out alarm. The default is **NONE**.

SETUP

This command sets up the transceiver for checking antenna SWR or transmitter power with external measuring equipment. *Do not use during normal operation.*

When the **SETUP** command is entered, the HHT prompt changes to **SETUP>**, and:

- Hopping is disabled.
- Synthesizer frequencies are reset to the test frequencies specified by the **TX** and **RX** commands.
- The radio can be keyed using the **KEY** command. **DKEY** is used to unkey the radio. (If the radio is left in a keyed state it is automatically unkeyed after several minutes.)
- The **RSSI** is sampled in a raw, continuous fashion regardless of whether the unit is a master or a remote.

Entering **Q** or **QUIT** returns the system to normal operation.

A timer keeps the Setup mode from accidentally leaving the system disabled. After 10 minutes the system behaves as if **Q** or **QUIT** had been entered, returning to normal operation.

SHOW [PORT, DC, PWR]

The **SHOW** command displays three types of information based on the command variables. These are:

- **PORT**—Displays which connector port (RJ-11 or DB-25) is *currently active* for diagnostics and control.
- **DC**—Displays DC input/output voltages.
- **PWR**—Displays the actual (measured) RF power output in dBm. Unlike the **PWR** command, this command shows the *actual* level being measured, not the programmed RF power setting.

SIMPLEX [ON, OFF]

The **SIMPLEX** command sets or displays the radio's mode of operation (simplex or half-duplex).

By default, the system operates in half-duplex mode (**SIMPLEX OFF**). In this mode, the transmit frequency of the master is the receive frequency of the remote (and vice-versa). The transceiver uses a transmit/receive frequency split of ±1.6 MHz (MDS 9810) or 5.12 (MDS 24810) MHz. The offset varies such that both frequencies will always fit within the same zone. (A zone is a 3.2 MHz (MDS 9810) or 10.24 MHz (MDS 24810) sub-band—see the **ZONE DATA** command.)

When simplex mode is selected (**SIMPLEX ON**), the master and remotes always transmit and receive on the same frequency. This setting is required for peer-to-peer simplex networks where remotes must be able to communicate with other remotes. A slight increase in end-to-end delay will occur when using this mode.

This command is "read-only" at remote radios. (Remotes must be synchronized with the master radio to read the simplex status.)

SKIP [NONE, 1...8]

This command sets or displays which, if any, of the eight 3.2 MHz (MDS 9810) or 10.24 MHz (MDS 24810) (128 frequency) zones will be skipped from the radio's hopping sequence. Skipping zones is one way of dealing with constant interference on one or more frequencies. See Section 4.3 (page 13) for more information on dealing with interference.

Figure 27 shows the frequency range covered by each zone. The command parameter is either the keyword **NONE** or an undelimited string of up to seven digits where each digit 1...8 represents a corresponding zone to skip. (For zone parameter input, the digits can appear in any order and can be optionally separated by a blank space.) The **SKIP** command is read-only at remote radios. (Remotes must be synchronized with the master radio to read the skip status.)

MDS 9810 TRANSCEIVER

ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8
902.200 to 905.375	905.400 to 908.575	908.600 to 911.775	911.800 to 914.975	915.000 to 918.175	918.200 to 921.375	921.400 to 924.575	924.600 to 927.775

MDS 24810 TRANSCEIVER

ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8
2400.640 to 2410.800	2410.880 to 2421.040	2421.120 to 2431.280	2431.360 to 2441.520	2441.600 to 2451.760	2451.840 to 2462.000	2462.080 to 2472.240	2472.320 to 2482.480

Figure 27. Frequency zones for MDS 9810 and 24810 transceivers

SNR

This command displays the signal-to-noise ratio of the received signal expressed in dB. As used in this guide, the definition of signal-to-noise is based upon the signal level following equalization, for valid frames only. (A valid frame is defined as containing no more than one bit error, and belonging to a frame addressed for the receiving radio.) SNR is updated and latched for each valid frame received. A filter in the DSP tempers the effect of any sudden changes in the value.

SNR output ranges from 10 dB to 33 dB. A value of 10 dB represents little or no signal. A value of 24 dB represents a very strong signal. For remote radios, a value of 0 is reserved to mean "no signal"; it is displayed whenever a remote is not in synchronization with the master station.

When the **SNR** command is used, it causes the DIAG(NOSTIC) port to enter an update mode, and it will provide an updated signal-to-noise ratio every 1.6 seconds. It stays in this mode until the ENTER key is pressed.

SREV

This command displays the software version currently loaded into the transceiver.

A display of **06-3111A02** is an example of the software version identifier.

STAT

This command is used to check alarm status. If no alarms exist, the message **NO ALARMS PRESENT** appears at the top of the HHT display.

If an alarm does exist, a two-digit event code (00–31) is displayed and the event is identified as a "major" or "minor" alarm. A brief description of the event is also given.

If more than one alarm exists, the word **MORE** appears at the bottom of the screen and additional alarms are viewed by pressing the ⌈ENTER⌋ key. Detailed descriptions of the alarm codes are provided in Table 13 on page 55.

TEMP

This command displays the internal temperature of the transceiver in Centigrade. (Note that the radio is specified to operate in an environment between –30 C° and +60 C°). This internal reading may be higher than the outside temperature by several degrees.

TX [xxxx]

This command sets or displays the test transmit frequency used in place of hopping whenever the radio is in Setup mode. The test transmit frequency can be reprogrammed to any value between 902.025 MHz and 927.975 MHz (MDS 9810) or 2400.00 and 2483.44 MHz (MDS 24810), inclusive. The factory default settings are listed below and have been selected to be non-intrusive to normal system operation.

	Default Transmit Frequencies	
	Master	**Remote**
MDS 9810	927.975 MHz	902.025 MHz
MDS 24810	2400.08 MHz	2483.44 MHz

UNIT [1000–65000]

The unit address is factory programmed to the last four digits of the serial number. If re-programmed in the field, the entry must consist of five digits. This command is reserved for future applications.

ZONE DATA

The transceiver divides its frequency operating spectrum into eight contiguous 3.2 MHz (MDS 9810) or 10.24 MHz (MDS 24810) zones. (These are the same zones referenced by the **SKIP** command described earlier.) Data frame statistics are maintained for each zone to indicate the transmission quality through the network. This information is useful for identifying zones where significant interference exists.

Zone quality information can be accessed using the **ZONE DATA** command on a connected HHT. For each zone (1–8), it shows you the number of data frames sent, the number received, and the number received with errors. If an excessive number of errors are seen in one or more frequency zones, it may indicate interference, and you should consider "skipping" those zones using the **SKIP** command.

The **ZONE DATA** command displays its information on four lines as shown in Figure 28. If the display seems to "roll off" the screen, verify that your HHT is set for an 80 character screen size. See Section 7.2, *Hand-Held Terminal Setup* (beginning on page 36).

ZONE #

DATA FRAME STATISTICS

1: TX TOTAL 00007579 — TOTAL SENT
1: RX TOTAL 00007579 — TOTAL RECEIVED
1: RX ERROR 00000015
NEXT ZONE?> — TOTAL REC'D WITH ERRORS
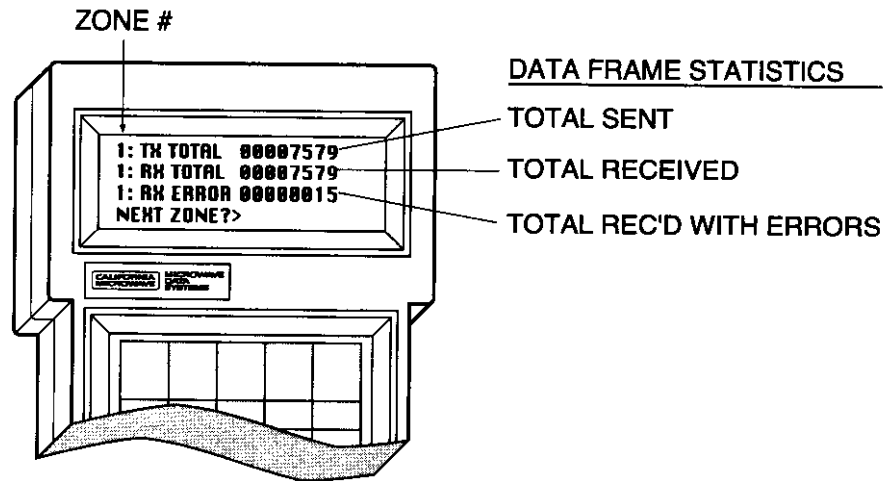
Figure 28. HHT display for ZONE DATA command

If **ZONE DATA** alone is entered, the information for Zone 1 is displayed first. Successive zones can be viewed by pressing the **ENTER** key, or by entering the zone number of your choice (1...8) at the **NEXT ZONE?>** prompt.

It is also possible to go directly to a specific zone by entering **ZONE DATA [1...8]**, where the number entered equals the desired zone. Data for the specified zone is displayed and then control returns to the command prompt.

Entering **Q** or **QUIT** causes the program to exit and return to the command prompt.

A variation on the **ZONE DATA** command is **ZONE DATA!** This causes data to be retrieved from *all* zones. Data is sequentially displayed for each of the 8 zones and then control returns to the command prompt.

(Note: If a frequency zone has been skipped, statistics will still be gathered for that zone when **ZONE DATA** is invoked at a remote site, but the numbers will accumulate very slowly since the only data being passed in a skipped zone is the radio's synchronization signal. When invoked at a master, no polls will be received from a skipped zone.)

ZONE CLEAR

The **ZONE CLEAR** command clears the zone data for *all* zones, resetting the count to 0. (Zone data is also cleared automatically upon reboot, or upon saturation of a zone data counter.)

8.0 TROUBLESHOOTING

Successful troubleshooting of an MDS transceiver system is not difficult, but requires a logical approach. It is best to begin troubleshooting at the master station, as the rest of the system depends on the master for polling instructions and synchronization data. If the master station has problems, the operation of the entire network will be affected.

When communication problems are found, it is good practice to begin by checking the simple things. All radios in the network must meet these basic requirements:

- Adequate and stable primary power
- An efficient and properly aligned antenna system
- Secure connections (RF, data & power)
- Proper programming of the radio's operating parameters, especially Mode selection (**MODE**), Network Address (**ADDR**), and interface Baud Rate (**BAUD**)
- The correct interface between the radio and the connected data equipment (proper cable wiring, data format and timing).

8.1 LED Indicators

The LED status indicators are an important troubleshooting tool and should be checked whenever a problem is suspected. Table 12 describes the function of each status LED.

PWR   SYNC   TXD   RXD

■ ■ ■ ■

Table 12. LED status indicators

LED Name	Description
PWR	• Continuous—Power is applied to the radio, no problems detected. • Flashing 5 times per second—Fault indication. See Section 8.0, TROUBLESHOOTING (beginning on page 54). • Flashing once every 4 seconds—Radio is in Sleep Mode.
SYNC	Lights continuously to indicate the radio is receiving/sending synchronization frames. Within 16 seconds of start-up, this LED should be lit continuously.
TXD	Indicates EIA-232 space signal (logic high) input to the DB-25 connector.
RXD	Indicates EIA-232 space signal (logic high) output from the DB-25 connector.

8.2 Alarm Codes

When an alarm condition exists, the transceiver creates an alarm code that can be read on an HHT connected to the radio's DIAG(NOSTICS) port. These codes can be very helpful in resolving many system difficulties.

Checking for Alarms—STAT command

To check for the presence of alarms, enter **STAT** on the HHT. If no alarms exist, the message **NO ALARMS PRESENT** appears at the top of the display.

If an alarm does exist, a two-digit alarm code (00–31) is displayed, and it is identified as a major or minor alarm. A brief description of the alarm is also given. Alarm codes and their meanings are listed in Table 13.

If more than one alarm exists, the word **MORE** appears at the bottom of the screen; additional alarms can be viewed by pressing ENTER.

Major Alarms vs. Minor Alarms

Major alarms report serious conditions that generally indicate a hardware failure, or other abnormal condition that will prevent (or seriously hamper) further operation of the transceiver.

With the exception of alarm code 00 (network address not programmed), major alarms generally indicate the need for factory repair. Contact MDS for further assistance.

Minor alarms report conditions which, under most circumstances, will not prevent transceiver operation. This includes out-of-tolerance conditions, baud rate mismatches, etc. The cause of these alarms should be investigated and corrected to prevent system failure.

Alarm Code Definitions

Table 13 contains a listing of all event codes that may be reported by the transceiver.

Table 13. Alarm codes

Alarm Code	Alarm Type	Description
00	Major	The network address is not programmed.
01	Major	Improper software detected for this radio model.
02, 03	--	Reserved for factory use.
04	Major	One or more of the programmable synthesizer loops is reporting an out-of-lock condition.
05	--	Reserved for factory use.
06	Major	A-to-D fault.

Table 13. Alarm codes (Continued)

Alarm Code	Alarm Type	Description
07	Major	One or more of the radio's internal voltage regulators is reporting a failure. The radio will not operate.
08	Major	The system is reporting that it has not been calibrated. Factory calibration is required for proper radio operation.
09	--	Reserved for factory use.
10	Major	The microcontroller unit (MCU) was unable to properly program the system to the appropriate defaults. A hardware problem may be indicated.
11	--	Reserved for factory use.
12	Major	Receiver time-out alarm.
13-15	--	Reserved for factory use.
16	Minor	The unit address is not programmed.
17	Minor	A data parity fault has been detected on the DATA INTERFACE connector. This usually indicates a parity setting mismatch between the radio and the RTU.
18	Minor	A data framing error has been detected on the DATA INTERFACE connector. This may indicate a baud rate mismatch between the radio and the RTU.
19–24	--	Reserved for factory use.
25	Minor	The 6.0 volt power regulator is out-of-tolerance. If the error is excessive, operation may fail.
26	Minor	The dc input voltage is out-of-tolerance. If the voltage is too far out-of-tolerance, operation may fail.
27, 28	--	Reserved for factory use.
29	Minor	RF output power fault detected. (Power differs by more than 2 dB from set level.) Often caused by high antenna system SWR. Check antenna, feedline and connectors.
30	Minor	The system is reporting an RSSI reading below –105 dBm. Bit errors are likely to be present in the data.
31	Minor	The transceiver's internal temperature is approaching an out-of-tolerance condition. If the temperature drifts outside of the recommended operating range, system operation may fail.

8.3 Performing Network-Wide Remote Diagnostics

Diagnostics data from a remote radio can be obtained by connecting a laptop or personal computer running MDS InSite diagnostics software to any radio in the network. Figure 33 shows an example of a setup for performing network-wide remote diagnostics.
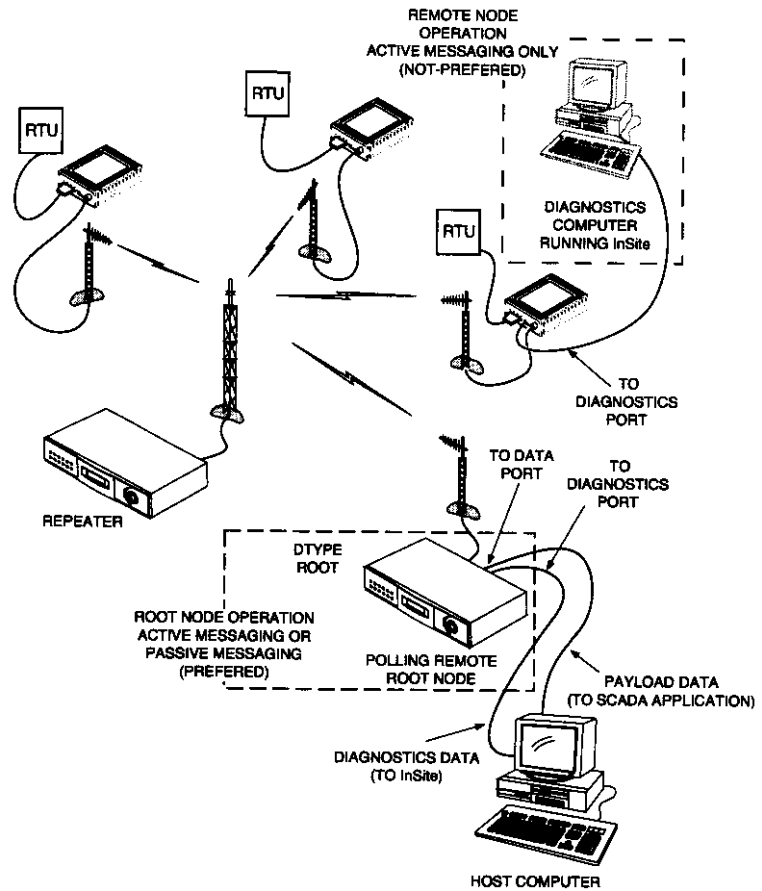
Figure 29. Network-Wide Remote Diagnostics Setup

If a PC is connected to any radio in the network, intrusive polling (polling which briefly interrupts payload data transmission) can be performed. To perform diagnostics without interrupting payload data transmission, connect the PC to a radio defined as the "root" radio. A radio is defined as a root radio using the **DTYPE ROOT** command locally, at the radio.

A complete explanation of remote diagnostics can be found in MDS'
Network-Wide Diagnostics System Handbook (MDS P/N
05-3467A01).

Table 14. Network-wide diagnostics radio setup commands

	COMMAND	DESCRIPTION
NETWORK-WIDE DIAGNOSTICS CONFIGURATION	DLINK [xxxxx] Details Page 59	Set baud rate of diagnostics link
	DTYPE [NODE/ROOT/GATE/PEER] Details Page 59	Set radio's operational characteristics for net-work-wide diagnostics

1. Program one radio in the network as the root radio by entering the
   DTYPE ROOT command at the radio.

2. At the root radio, use the **DLINK ON** and **DLINK [baud rate]** commands
   to configure the diagnostic link protocol on the RJ-11 port.

3. Program all other radios in the network as nodes by entering the
   DTYPE NODE command at each radio.

4. Use the **DLINK ON** and **DLINK [baud rate]** commands to configure the
   diagnostic link protocol on the RJ-11 port of each node radio.

5. Connect same-site radios using a null-modem cable at the radios'
   diagnostic ports.

6. Connect a PC on which MDS InSite software is installed to the root
   radio, or to one of the nodes, at the radio's diagnostic port. (This PC
   may be the PC being used to collect payload data, as shown in
   Figure 33.)

   To connect a PC to the radio's DIAG. port, an RJ-11 to DB-9 adapter
   (MDS P/N 03-3246A01) is required. If desired, an adapter cable
   may be constructed from scratch, using the information shown in
   Figure 34.
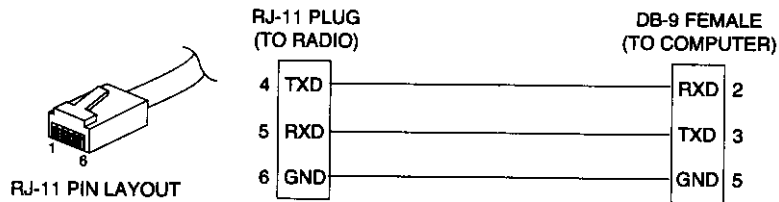
Figure 30. RJ-11 to DB-9 Adapter Cable

7. Launch the MDS InSite application at the PC. (See the MDS InSite 5 Radio System Management Software Installation Notes for instructions.)

DLINK [xxxxx]

DLINK followed by the baud rate sets the baud rate (bps) of the diagnostics link. The following **DLINK** baud rates selections are allowed:

- 1200
- 2400
- 4800
- 9600
- 19200 (default setting)

Example: **DLINK 4800** sets the RJ-11 **DIAG** port to operate at 4800 bps. The default is **DLINK 19200** and **DLINK ON**.

NOTE: The same baud rate must be entered into the InSite Equipment List's **BAUD** field.

DTYPE [NODE/ROOT/GATE/PEER]

The **DTYPE** command specifies the radio's operational characteristics for network-wide diagnostics. There are four possible types of nodes in a network-wide diagnostics system.

The common types are:

- **ROOT**–Always one, and only one, per network. The root is the focal point of network-wide diagnostics information. Intrusive diagnostics can originate from any radio, including the root. However, the root is the only radio enabling non-intrusive diagnostics.
- **NODE**–The most common setting, and the default. This is the basic system radio device-type. Typically, the radio network is comprised of nodes and one root. Intrusive diagnostics can originate from any node. However, non-intrusive diagnostics can not be facilitated through a node.

The default radio device-type is **NODE**. Less used are:

- **GATE**
- **PEER**

These node types are needed for repeater sub-networks and simplex sub-networks where simplex frequencies are used. See the Net-work-Wide Diagnostics System Handbook for an explanation of these node types.

8.4 Troubleshooting Chart

Table 15 provides suggestions for resolving some common system difficulties that may be experienced in the radio system. If problems persist, contact the factory for further assistance. Refer to the inside back cover of this guide for additional information.

Table 15. Troubleshooting chart

Difficulty	Recommended System Checks
Unit is inoperative.	a. Check for the proper supply voltage at the power connector.
	b. The transceiver's internal resettable fuse may have tripped. To reset it, momentarily remove and re-apply power to the radio.
Interference is suspected.	a. Verify that the system has a unique network address. Nearby systems with the same address will cause interference.
	b. Use the **ZONE DATA** command (page 52) to check for interference in specific zones. Lock out affected zone(s) using the **SKIP** command (page 50).
	c. If omnidirectional antennas are used on remote stations, consider changing to directional antennas. This will often limit interference to and from other stations.
No synchronization with master, or poor overall performance.	a. Check for secure interface connections at the radio and the connected device.
	b. Check the antenna, feedline and connectors. Reflected power should be less than 10% of the forward power reading (SWR ≈ 2:1 or lower).
	c. If the remote radio is in synchronization, but performance is poor, check the received signal strength using the **RSSI** command (page 48). If RSSI is low, it may indicate antenna problems, or misalignment of directional antenna headings.
	d. Verify proper programming of system parameters: mode, network address, data interface baud rate, transmitter power, CTS delay, etc. It may be helpful to use the **INIT** command (page 46), which resets all parameters to factory defaults.
	e. Check for alarms using the **STAT** command (page 51)

9.0 TECHNICAL REFERENCE

The following section contains material that is not essential to using the radio, but may prove helpful in diagnosing performance problems or in gaining a better understanding of the unit's operation.

9.1 Technical Specifications

GENERAL

Frequency Hopping Range:	Up to 1019 frequencies within:
	MDS 9810: 902–928 MHz, configurable in 3.2 MHz zones
	MDS 24810: 2400.00–2483.44 MHz, configurable in 10.24 MHz zones
Hop Pattern:	Based on network address
Frequency Stability:	±1.5 ppm
Simplex Operation:	User selectable
Half-Duplex Operation:	**MDS 9810**: ±1.6 MHz TX/RX split **MDS 24810**: 5.12 MHz TX/RX split
Network Addresses:	65,000
Temperature Range:	Transceiver: –30°C to +60°C
Humidity:	95% at +40°C; non-condensing
Primary Power:	Transceiver: 13.8 V dc (10.5–25 V dc range
Transceiver Supply Current (typical)::	
Transmit:	**MDS 9810**: 400 mA @ 13.8 V dc **MDS 24810**: 600 mA @ 13.8 V dc
Receive:	**MDS 9810**: 125 mA @ 13.8 V dc **MDS 24810**: 200 mA @ 13.8 V dc
Sleep Mode:	<30 mA @ 13.8 V dc
Size (excluding mtg. hardware):	2.0" x 5.62" x 7.25" 51 x 143 x 184 mm
Weight:	2.2 lb/1.0 kg
Case:	Die-cast aluminum
Approvals:	• FCC Part 15.247
	• Industry Canada RSS-210 and RSS-139
	• ETSI ETS 300 328
	• UL/FM Class 1, Div. 2; Groups A, B, C and D hazardous locations
	• UL Listed
	• CE Mark
	• Contact MDS for information on availability and governmental approvals in other countries

DATA CHARACTERISTICS

Data Interface:	EIA-232 signaling standard
Interface Connector:	DB-25 female
Data Rate:	1200, 2400, 4800, 9600, 19200, 38400 bps asynchronous
Data Latency:	<10 ms typical (buffer off)

Byte Length:	10 or 11 bits
Maximum Data Transmission:	Continuous up to 19200 bps; Non-continuous at 38400 bps

TRANSCEIVER RF CHARACTERISTICS

TRANSMITTER:
Power Output
(at antenna connector):   **MDS 9810**: 0.1 to 1.0 watt (+20 dBm to +30 dBm) ±1.0 dB, set by user
MDS 24810: 0.01 to 1.0 watt (+10 dBm to +30 dBm) ±1.5 dB, set by user

Duty Cycle:	Continuous
Modulation Type:	Binary CPFSK
Output Impedance:	50 Ohms
Spurious:	–60 dBc
Harmonics:	–80 dBc

RECEIVER
Type:	Double conversion superheterodyne
Bit-Error Rate:	**MDS 9810**: Less than 1×10^{-6} at –110 dBm **MDS 24810**: Less than 1×10^{-6} at –102 dBm
Intermodulation:	**MDS 9810**: 59 dB minimum (EIA) **MDS 24810**: 59 dB minimum (EIA)
Desensitization:	**MDS 9810**: 75 dB **MDS 24810**: 72 dB
Spurious:	70 dB minimum
Bandwidth:	**MDS 9810**: 25 kHz **MDS 24810**: 50 kHz

Interference Ratio
(BER degraded by 10^{-1}):

Co-channel:	–10 dB
Adjacent channel:	+30 dB
Two channels away:	+50 dB
Three channels away:	+60 dB

Time Required to Synchronize
with Master Radio: Less than 13 seconds (typical)

9.2 RSSI Checks with a Voltmeter

As an alternative to the HHT method of measuring RSSI (see *Antenna Aiming* on page 33), a dc voltmeter may be connected to Pin 21 of the transceiver's DATA INTERFACE connector.

Figure 31 shows the relationship between RSSI and the dc voltage at Pin 21.

NOTE: RSSI Readings are not accurate for incoming signal strengths over –50 dBm.)
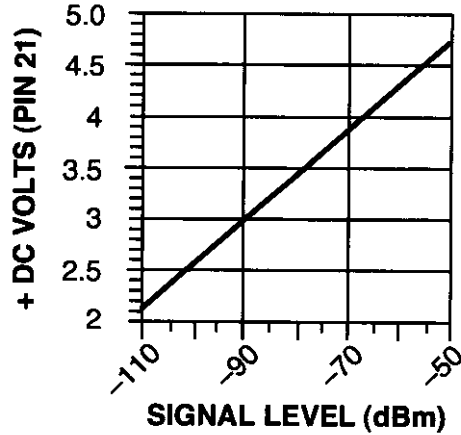
Figure 31. RSSI vs. V dc at Pin 21 of DATA INTERFACE connector

9.3 Data Interface Connections (DB-25)

The DATA INTERFACE connector is used to connect the radio to an external DTE data terminal that supports the EIA-232 format. The radio supports data rates of 1200, 2400, 4800, 9600, 19200 and 38400 bps (asynchronous data only).

The DATA INTERFACE connector mates with a standard DB-25 plug that is available from many electronics parts distributors. Table 16 lists each pin on the connector and describes its function. Figure 32 shows the DATA INTERFACE connector.

Pin Description	Pin No.		Pin No.	Pin Description
Alarm Output	25		13	Unused
Remote Switchover*	24		12	Radio Inhibit (Sleep)
Diagnostic Channel Enable	23		11	Unused
Unused	22		10	Receiver Unsquelched Sensor
RSSI Voltage	21		9	Unused
Future use—Do not connect	20		8	Data Carrier Detect (DCD)
9.9 Vdc Regulated Output	19		7	Signal Ground**
Unregulated DC Input/Output	18		6	Data Set Ready (DSR)
Unused	17		5	Clear-to-Send Output (CTS)
Unused	16		4	Request-to-Send Input (RTS)
Unused	15		3	Received Data (RXD)**
Unused	14		2	Transmitted Data (TXD)**
			1	Protective Ground

* Unused in transceivers
** Required in most installations

Figure 32. Data interface connector (DB-25) pins
As viewed from outside the radio

Table 16. Data interface connector (DB-25) pin descriptions

Pin Number	Input/ Output	Pin Description
1	--	**Protective Ground** Connects to ground (negative supply potential) on the radio's PC board and chassis.
2	IN	**TXD—Transmitted Data** Accepts TX data from the connected device.
3	OUT	**RXD—Received Data** Supplies received data to the connected device.
4	IN	**RTS—Request-to-Send Input**
5	OUT	**CTS—Clear-to-Send Output** Goes "high" after the programmed CTS delay time has elapsed (DCE), or keys an attached radio when RF data arrives (CTS KEY).
6	OUT	**DSR—Data Set Ready** Provides a +6 V dc DSR signal through a 2.5 kΩ resistor.
7	--	**Signal Ground** Connects to ground (negative supply potential) at the radio's PC board.
8	OUT	**DCD—Data Carrier Detect** A "high" indicates hopping synchronization.
9	--	Unused.
10	OUT	**RUS—Receiver Unsquelched Sensor** Provides +8 V dc through a 1 kΩ resistor whenever the receiver squelch is open, and drops to less than 1 V dc when the squelch is closed.
11	--	Unused.
12	IN	**Sleep Mode** A ground on this pin turns off most circuits in the radio, including transmit, receive, modem and diagnostic functions. This allows for greatly reduced power consumption, yet preserves the radio's ability to be quickly brought on line. See Section 5.5, Using the Radio's Sleep Mode (beginning on page 31) for details.
13	--	Unused.

Table 16. Data interface connector (DB-25) pin

Pin Number	Input/Output	Pin Description
14	--	Unused.
15	--	Do not connect—Factory test point.
16	--	Unused.
17	--	Do not connect—Factory test point.
18	IN/OUT	**Accessory Power** Unregulated input/output. Provides a source of power for low-current accessories. The supply voltage may be between 11.0 and 25 volts.
19	OUT	**9.9 V dc Regulated Output** Provides a source of regulated voltage at 100 mA for low-power accessories.
20	--	Do not connect—Reserved for future use.
21	OUT	**RSSI—Received Signal Strength Indication** A dc voltmeter may be connected to this pin to read the relative strength of the incoming signal. Figure 31 on page 63 compare RSSI to dc voltage.
22	--	Unused.
23	IN	**Diagnostic Channel Enable** A ground on this pin causes the radio's microcontroller to open the DB-25 DATA INTERFACE connector for diagnostics and control (in place of the more commonly used RJ-11 DIAG(NOSTICS) connector).
24	--	Unused.
25	OUT	**Alarm Output** A logic low (less than 0.5 volts) on this pin indicates normal operation. A logic high (greater than 4 volts) indicates that an alarm condition is present. This pin can be used as an alarm output, provided the internal series resistance of 1 kΩ is considered.

9.4 Bench Testing Setup

Figure 33 shows a sample test setup that can be used to verify the basic operation of MDS radios. This test can be performed with any number of remote radios by using a power divider with the required number of output connections.

The RTU simulator shown in the test setup (MDS Part No. 03-2512A01) is a microcontroller that emulates a remote terminal unit operating at 1200, 2400, 4800, or 9600 bps. Custom software is supplied with the RTU simulator that allows continuous polling of remote radios. The software reports the number of polls sent, polls received, and the number of errors detected. The software runs on an IBM-compatible personal computer.

NOTE: It is very important to use attenuation between all units in the test setup. The amount of attenuation required will depend on the number of units being tested and the desired signal strength (RSSI) at each transceiver during the test. In no case should a signal greater than –50 dBm be applied to any transceiver in the test setup.
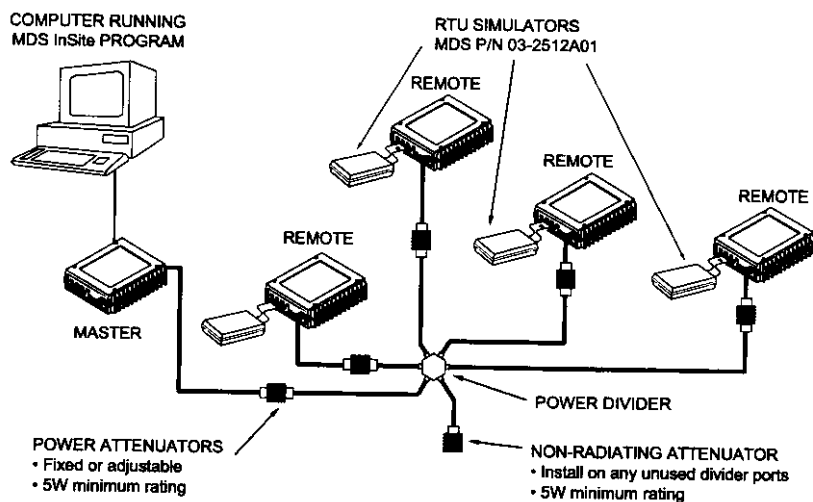
Figure 33. Typical setup for bench testing of radios

9.5 Using Radio Configuration Software

Windows-based Radio Configuration software (MDS P/N 03-3156A01) is used for upgrading the internal radio software when new features become available from Microwave Data Systems. The software includes on-line user instructions, and an installation booklet is provided with the software package. Contact MDS for ordering information.

Connecting a PC

To connect a PC to the radio's DIAG(NOSTICS) port, an RJ-11 to DB-9 adapter cable (MDS P/N 03-3246A01) is required. If desired, this cable may be constructed from scratch using the information shown in Figure 34.

Upgrading the Radio's Software

Using the Radio Configuration software, select **RADIO SOFTWARE UPGRADE** under the **SYSTEM** menu. Follow the prompts and on-line instructions to complete the upgrade procedure.

Software upgrades are distributed as ASCII files with a **.S28** extension. These files use the Motorola S-record format. When the download is activated, the radio's PWR LED will flash rapidly, confirming that a download is in process. The download takes about two minutes.

NOTE: If a download fails, the radio is left unprogrammed and inoperative. This is indicated by the PWR LED flashing slowly (1 second on/1 second off). This condition is only likely if there were a power failure to the computer or radio during the downloading process. The download can be attempted again when the fault has been corrected.
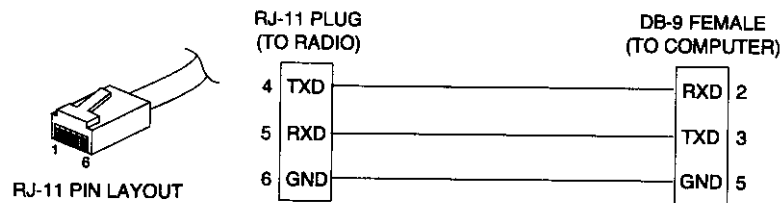
Figure 34. RJ-11 to DB-9 adapter cable
(for software upgrade using connected PC)

9.6 dBm-Watts-Volts Conversion Chart

Table 17 is provided as a convenience for determining the equivalent voltage or wattage of an RF power expressed in dBm.

Table 17. dBm-Watts-Volts conversion—for 50 ohm systems

dBm	V	Po
+53	100.0	200W
+50	70.7	100W
+49	64.0	80W
+48	58.0	64W
+47	50.0	50W
+46	44.5	40W
+45	40.0	32W
+44	32.5	25W
+43	32.0	20W
+42	28.0	16W
+41	26.2	12.5W
+40	22.5	10W
+39	20.0	8W
+38	18.0	6.4W
+37	16.0	5W
+36	14.1	4W
+35	12.5	3.2W
+34	11.5	2.5W
+33	10.0	2W
+32	9.0	1.6W
+31	8.0	1.25W
+30	7.10	1.0W
+29	6.40	800mW
+28	5.80	640mW
+27	5.00	500mW
+26	4.45	400mW
+25	4.00	320mW
+24	3.55	250mW
+23	3.20	200mW
+22	2.80	160mW
+21	2.52	125mW
+20	2.25	100mW
+19	2.00	80mW
+18	1.80	64mW
+17	1.60	50mW
+16	1.41	40mW
+15	1.25	32mW
+14	1.15	25mW
+13	1.00	20mW
+12	.90	16mW
+11	.80	12.5mW
+10	.71	10mW
+9	.64	8mW
+8	.58	6.4mW
+7	.500	5mW
+6	.445	4mW
+5	.400	3.2mW
+4	.355	2.5mW
+3	.320	2.0mW
+2	.280	1.6mW
+1	.252	1.25mW

dBm	V	Po
0	.225	1.0mW
-1	.200	.80mW
-2	.180	.64mW
-3	.160	.50mW
-4	.141	.40mW
-5	.125	.32mW
-6	.115	.25mW
-7	.100	.20mW
-8	.090	.16mW
-9	.080	.125mW
-10	.071	.10mW
-11	.064	
-12	.058	
-13	.050	
-14	.045	
-15	.040	
-16	.0355	

dBm	mV	Po
-17	31.5	
-18	28.5	
-19	25.1	
-20	22.5	.01mW
-21	20.0	
-22	17.9	
-23	15.9	
-24	14.1	
-25	12.8	
-26	11.5	
-27	10.0	
-28	8.9	
-29	8.0	
-30	7.1	.001mW
-31	6.25	
-32	5.8	
-33	5.0	
-34	4.5	
-35	4.0	
-36	3.5	
-37	3.2	
-38	2.85	
-39	2.5	
-40	2.25	.1µW
-41	2.0	
-42	1.8	
-43	1.6	
-44	1.4	
-45	1.25	
-46	1.18	
-47	1.00	
-48	0.90	

dBm	mV	Po
-49	0.80	
-50	0.71	.01µW
-51	0.64	
-52	0.57	
-53	0.50	
-54	0.45	
-55	0.40	
-56	0.351	
-57	0.32	
-58	0.286	
-59	0.251	
-60	0.225	.001µW
-61	0.200	
-62	0.180	
-63	0.160	
-64	0.141	

dBm	µV	Po
-65	128	
-66	115	
-67	100	
-68	90	
-69	80	
-70	71	.1nW
-71	65	
-72	58	
-73	50	
-74	45	
-75	40	
-76	35	
-77	32	
-78	29	
-79	25	
-80	22.5	.01nW
-81	20.0	
-82	18.0	
-83	16.0	
-84	11.1	
-85	12.9	
-86	11.5	
-87	10.0	
-88	9.0	
-89	8.0	
-90	7.1	.001nW
-91	6.1	
-92	5.75	
-93	5.0	
-94	4.5	
-95	4.0	
-96	3.51	
-97	3.2	

dBm	µV	Po
-98	2.9	
-99	2.51	
-100	2.25	.1pW
-101	2.0	
-102	1.8	
-103	1.6	
-104	1.41	
-105	1.27	
-106	1.18	

dBm	nV	Po
-107	1000	
-108	900	
-109	800	
-110	710	.01pW
-111	640	
-112	580	
-113	500	
-114	450	
-115	400	
-116	355	
-117	325	
-118	285	
-119	251	
-120	225	.001pW
-121	200	
-122	180	
-123	160	
-124	141	
-125	128	
-126	117	
-127	100	
-128	90	
-129	80	.1fW
-130	71	
-131	61	
-132	58	
-133	50	
-134	45	
-135	40	
-136	35	
-137	33	
-138	29	
-139	25	
-140	23	.01fW

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IN CASE OF DIFFICULTY...

MDS products are designed for long life and trouble-free operation. However, this equipment, as with all electronic equipment, may have an occasional component failure. The following information will assist you in the event that servicing becomes necessary.

FACTORY TECHNICAL ASSISTANCE

Technical assistance for MDS products is available from our Customer Support Team during business hours (8:00 A.M.–5:30 P.M. Eastern Time). When calling, please give the complete model number of the radio, along with a description of the trouble symptom(s) that you are experiencing. In many cases, problems can be resolved over the telephone, without the need for returning the unit to the factory.

Please use the following telephone numbers for product assistance:

> 716-242-9600 (Phone)
> 716-242-9620 (FAX)

FACTORY REPAIRS

Component level repair of radio equipment is *not* recommended in the field. Many components are installed using surface mount technology, which requires specialized training and equipment for proper servicing. For this reason, the equipment should be returned to the factory for any PC board repairs. The factory is best equipped to diagnose, repair and align your radio to its proper operating specifications.

If return of the equipment is necessary, you will be issued a Returned Material Authorization (RMA) number. The RMA number will help expedite the repair so that the equipment can be repaired and returned to you as quickly as possible. Please be sure to include the RMA number on the outside of the shipping box, and on any correspondence relating to the repair. *No equipment will be accepted for repair without an RMA number.*

A statement should accompany the radio describing, in detail, the trouble symptom(s), and a description of any associated equipment normally connected to the radio. It is also important to include the name and telephone number of a person in your organization who can be contacted if additional information is required.

The radio must be properly packed for return to the factory. The original shipping container and packaging materials should be used whenever possible. All factory returns should be addressed to:

> Microwave Data Systems
> Customer Service Department
> (RMA No. XXXX)
> 175 Science Parkway
> Rochester, NY 14620 USA

When repairs have been completed, the equipment will be returned to you by the same shipping method used to send it to the factory. Please specify if you wish to make different shipping arrangements.