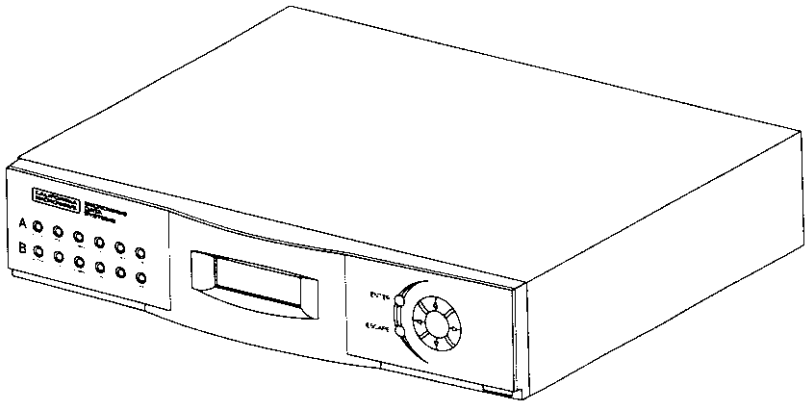
Exhibit C
Installation & Operation
Manual

MDS 4790



400 MHz
Multiple Address System
Master Station Radio

MDS 05-3438A01, REV. 01
SEPTEMBER 1998

MICROWAVE
DATA
SYSTEMS

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1.0 INTRODUCTION

This guide presents installation and operating instructions for the MDS 4790 master station radio. It begins with an overall description of the radio's features and is followed by the steps required to install the radio and place it into normal operation.

Additionally, the guide contains troubleshooting tips for resolving system difficulties that may be encountered. After installation, we suggest keeping this guide near the radio for future reference.

2.0 PRODUCT DESCRIPTION

The MDS 4790 (Figure 1) is a full-duplex data telemetry radio suitable for use as a master in a Multiple Address System (MAS) and Supervisory Control and Data Acquisition (SCADA) applications. The MDS 4790 uses microprocessor control and Digital Signal Processing (DSP) technology to provide highly reliable communications even under adverse conditions.

The MDS 4790 operates between 350 MHz and 512 MHz and is intended to be used in systems with MDS 4710 remote radios. The radio is available in either a redundant configuration or a non-redundant configuration. Refer to *Section 2.1, Redundant versus Non-redundant* for further description.

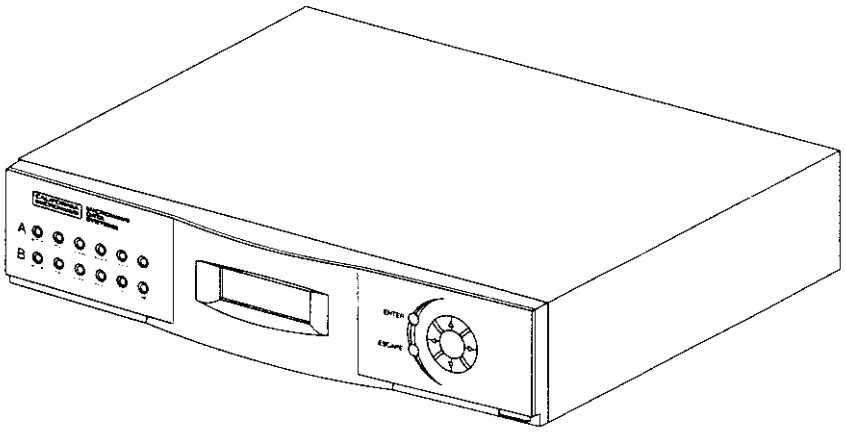


Figure 1. MDS 4790 master station

All radio assemblies, including the duplexer and power supply are contained in the radio's compact (2RU high) enclosure. The radio's compact size allows it to fit into most existing systems, in either tabletop or rack-mounting arrangements. Connectors are provided on the rear panel for easy connection of power, antenna, data, alarm and diagnostic functions.

2.1 Redundant versus Non-redundant

A redundant configuration means that the master station has two complete transceiver systems installed in the enclosure. In the event of a primary transceiver system failure, the controlling logic causes a switch-over to the standby transceiver system. The redundant transceiver configuration has a standby transceiver that is constantly operating and its operational readiness is monitored. However, the transmitter power amplifier in the standby transceiver is not operating when it is in standby mode.

The non-redundant configuration is where there is only one transceiver system installed in the enclosure and no back-up transceiver operation is possible.

2.2 Applications

The MDS 4790 is designed for point-to-multipoint data transmission in oil & gas pipeline communications, lottery systems and telecommunications systems. 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.

Basic MAS Master Station Operation

Figure 2 shows a typical point-to-multipoint system using an MDS 4790 radio.

The most basic system consists of a central master station and several associated remote units as shown in Figure 2.

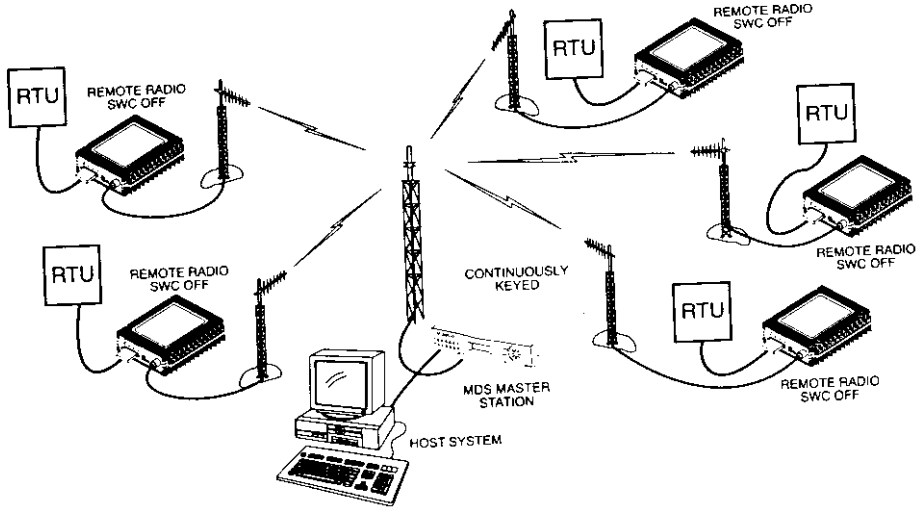


Figure 2. Typical MAS network

Repeater and Polling Remote Operation

A MAS system using repeater and polling-remote radios is shown in Figure 3. Notice that the polling remote radio is operating at half-duplex and the repeater is operating full-duplex.

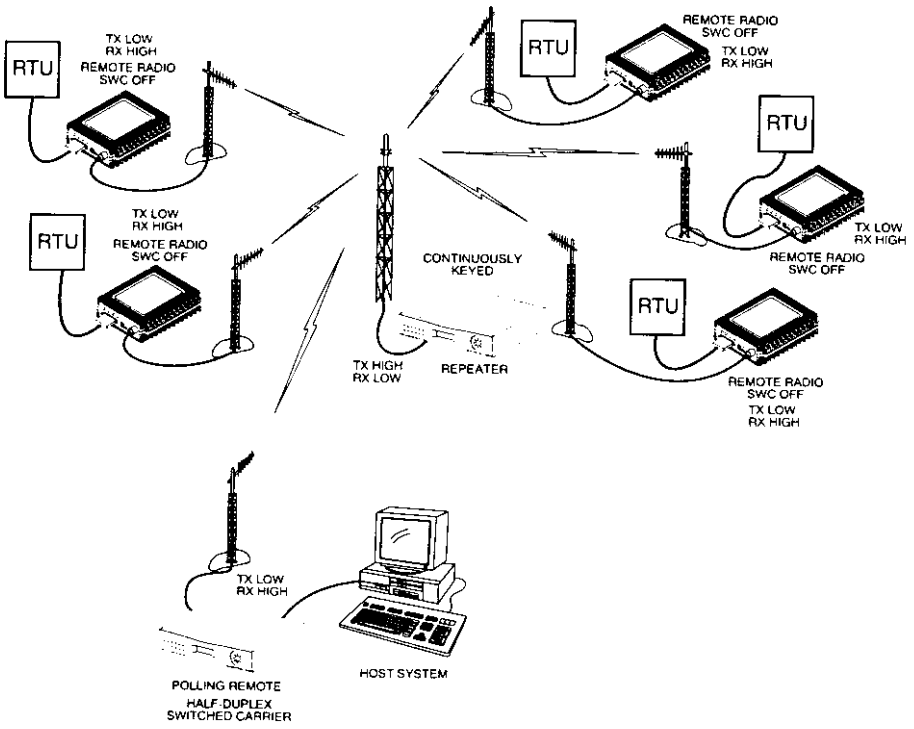


Figure 3. Typical repeater and polling-remote network

2.3 Features

Reliability is a hallmark of the MDS 4790 design. The radio employs a one-piece transceiver board which minimizes RF losses and eliminates the need for inter-board cabling. This also allows easy plug-in replacement should servicing become necessary.

In addition, the optional redundant version of the radio includes redundant transceiver boards and power supply modules that automatically become active in the event of a failure in either of the transceivers or power supplies. This ensures continued operation in the event of most radio failures.

The following list highlights many of the radio's key features. For a full listing of specifications, see *Section 7.0, TECHNICAL REFERENCE.*

- Operation from 24, 48 Vdc or 110 to 240 Vac mains
- Built-in diagnostics (local and remote)
- Front panel configuration of all operating parameters
- Time stamping of alarms and major events
- Software available for PC diagnostics & control (including firmware upgrade capability)
- Flexible mounting with connectors on front or rear

2.4 Accessories

The radio can be used with one or more of the accessories listed in Table 1. Contact Microwave Data Systems for ordering information.

Table 1. Transceiver Accessories

Option	Description	MDS P/N
Diagnostics & Control Software	Computer software that allows PC control of the radio for diagnostics, control and software upgrades.	Contact MDS
Diagnostic & Control Interface Cable	Allows connection of a PC for diagnostics and control of the radio (DB-9 to DB-9).	97-1971A04
Auxiliary Front Panel Mounting Bracket	Allows rack mounting of the detachable front panel.	82-3189A01

Simplex and Switched Carrier Operation

System-wide simplex operation is achieved by switching the master carrier on to transmit then off to receive. The same frequency is used for both transmit and receive.

Switched carrier, half-duplex mode is achieved by switching the master carrier on to transmit then off to receive. Different frequencies are used for transmit and receive.

2.5 Model Number Codes

The radio model number is printed on the serial number label, which is affixed to the radio chassis. Figure 4 shows the significance of the characters in the model number string for standard models. Contact MDS for specific information on optional configurations of the radio.

THIS INFORMATION IS SUBJECT TO CHANGE. DO NOT USE THIS INFORMATION FOR PRODUCT ORDERING.

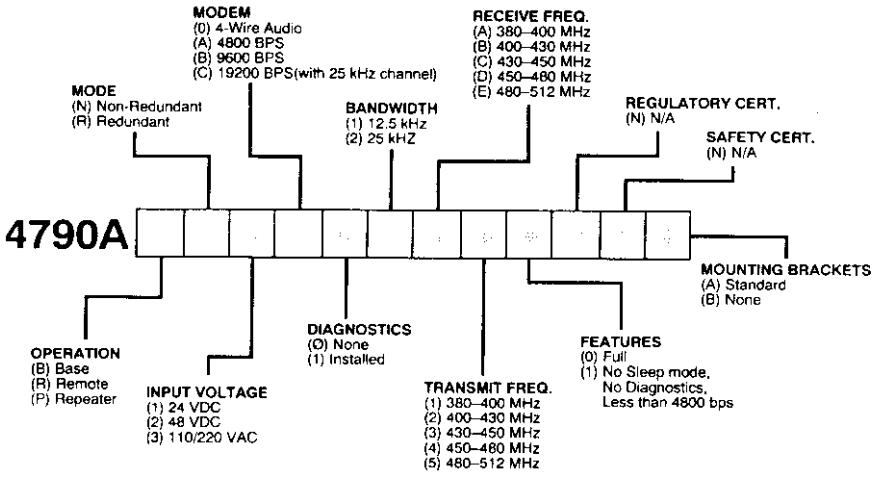


Figure 4. Model Number Codes

2.6 Terms & Abbreviations

If you are new to digital radio systems, some of the terms used in this guide may be unfamiliar. The glossary below defines many of these terms and will prove helpful in understanding the operation of the transceiver.

BERT—Bit-error rate test. The results of a BERT are normally expressed as a ratio (power of 10) of the number of bits received in error compared to the total number received.

BER—Bit-error rate. See also BERT.

Bit—Binary digit. The smallest unit of digital data, often represented by a one or a zero. Eight bits usually comprise a byte.

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

Byte—A digital "word" usually made up of eight bits.

dBi—Decibels of gain relative to an isotropic radiator. (A hypothetical antenna which radiates equally in all directions.) Used to express antenna gain.

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

DCE— Data (circuit terminating) Communications Equipment. In data communications terminology, this is the "modem" side of a computer-to-modem connection. The transceiver is a DCE device which is designed to connect to a DTE device.

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

DSP—Digital Signal Processing. Advanced circuit technique to increase radio performance, primarily in modulation and demodulation.

DTE—Data Terminal Equipment. In data communications terminology, this is the computer side of a computer-to-modem connection. (Connects to the DCE device.)

Fade Margin—The maximum tolerable reduction in received signal strength which still provides an acceptable signal quality. This compensates for reduced signal strength due to multipath, slight antenna movement or changing atmospheric losses. Expressed in decibels.

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.

Fresnel Zone—A point of maximum width or girth of the transmitted radio signal. Obstructions in this region (the "first Fresnel zone") can have a detrimental effect on reception quality. As a general rule, 60 percent of the first Fresnel zone should be free of obstructions in a well designed system. (Additional considerations are also required when planning a microwave path. A detailed discussion of the subject is presented in *Section 7.1, RF Propagation Planning.*)

Half-Power Beamwidth—The customary way of measuring the width of a directional antenna's radiation pattern. This beamwidth is measured in degrees between the half-power points (the point at which the power is reduced 3 dB with respect to the main beam).

kbps—Kilobits-per-second.

Multipath Fading—Signals arriving at the receiver out of phase which have a tendency to cancel each other. It is caused by reflections of the transmitted wave and results in distortion at the receiver or weak received signal strength.

RSSI—Received signal strength indication. Expressed in dBm.

SNR—Signal-to-noise ratio. Expressed in decibels (dB).

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).

3.0 INSTALLATION PLANNING

The installation of the transceiver 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 antennas and feedlines, and minimizing the chance of interference. This material should be reviewed before beginning equipment installation.

3.1 General Requirements

There are three main requirements for installing the transceiver—adequate and stable primary power, a good antenna system, and the correct interface between the transceiver and the data device. Figure 5 shows a typical station arrangement.

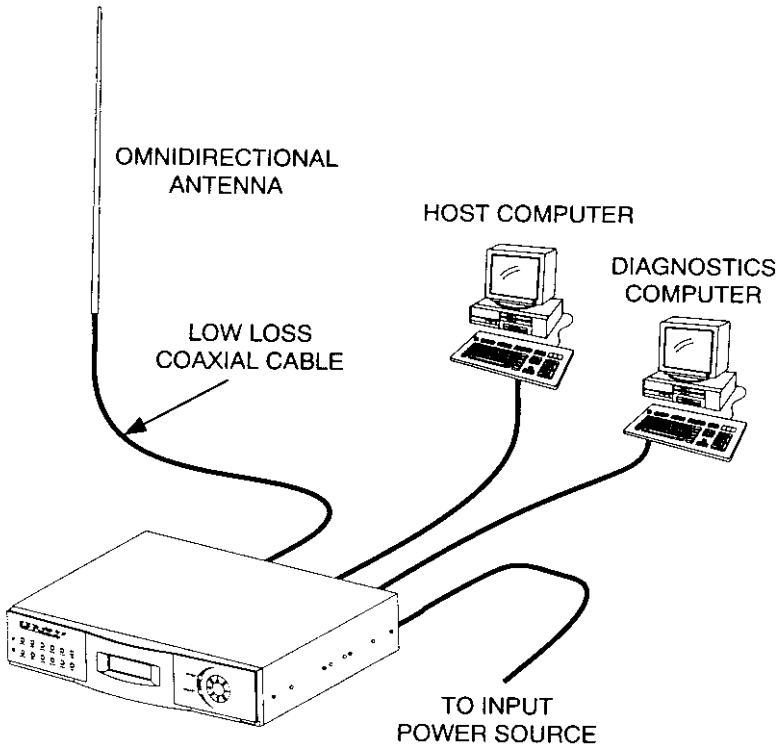


Figure 5. Typical Station Arrangement

Site Selection

For a successful installation, careful thought must be given to selecting the site for the master station and the remote radios. Suitable sites should offer:

- An antenna location that provides an unobstructed path to all the remote radios in the system.
- A source of adequate and stable primary power
- Suitable entrances for antenna, interface or other required cabling

These requirements can be quickly determined in most cases. A possible exception is the first item—verifying that an unobstructed transmission path exists. Microwave 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 following discussion will provide helpful background.

Terrain and Signal Strength

A line-of-sight path between stations is highly desirable and provides the most reliable communications link in all cases. A line-of-sight path can often be achieved by mounting each station antenna on a tower or other elevated structure that raises it to a level sufficient to clear surrounding terrain and other obstructions.

The requirement for a clear transmission path depends upon the distance to be covered by the system. If the system is to cover only a limited distance, say 5 km (3.1 miles), then some obstructions in the transmission path may be tolerable. For longer range systems, any obstruction could compromise the performance of the system, or block transmission entirely.

The signal strength at the receiver must exceed the receiver sensitivity by an amount known as the fade margin to provide reliable operation under various conditions.

Section 7.1, RF Propagation Planning includes a detailed discussion on path planning and should be reviewed before beginning an installation. Computer software is also available for this purpose that can greatly simplify the steps involved in planning a path.

On-the-Air Test

If you've analyzed the proposed transmission path and feel that it is acceptable, an on-the-air test of the equipment and path should be conducted. This not only verifies the path study results, but allows you to see firsthand the factors involved at each installation site.

The test can be performed by installing a radio at each end of the proposed link and checking the RSSI value reported at the front panel LCD screen of the radio. 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 for one or both stations.

To prepare the equipment for an on-the-air test, follow the general installation and operation procedures given in this guide and become familiar with the operating instructions given in Section 5.0.

A Word About Interference

Interference is possible in any radio system. However, since the MDS 4790 is designed for use in a licensed system, interference is less likely because frequency allocations are normally coordinated with consideration to geographic location and existing operating frequencies.

The risk of interference can be further reduced through prudent system design and configuration. Allow adequate separation between frequencies and radio systems.

Keep the following points in mind when setting up your radio system:

1. Systems installed in lightly populated areas are least likely to encounter interference; those in urban and suburban environments are more likely to be affected by other devices operating in the 400 MHz frequency band and adjacent services.

2. Directional antennas should be used at the remote end of the link. They confine the transmission and reception pattern to a comparatively narrow beam, which minimizes interference to and from stations located outside the pattern.

3. If interference is suspected from another system, it may be helpful to use antenna polarization that is opposite to the interfering system's antennas. An additional 20 dB (or more) of attenuation to interference can be achieved by using opposite antenna polarization.

3.2 Antenna & Feedline Selection

Antenna System

The antenna system is perhaps the most crucial part of the system design. An antenna system that uses poor quality feedline, or is improperly aligned with the companion site will result in poor performance, or no communication at all.

Generally speaking, an omni-directional antenna is used at the master station site and the remote radios use directional antennas.

Microwave Data Systems can also furnish antennas for use with the transceiver. Consult your MDS representative for details.

Feedline Selection

For maximum performance, a good quality feedline must be used to connect the radio to the antenna. For short range transmission, or where very short lengths of cable are used (up to 8 Meters [26 feet]), an inexpensive type coax such as Type RG-213 may be acceptable.

For example, 100 feet (30 meters) of RG-58A/U cable (commonly used for frequencies below 100 MHz) has an insertion loss of 5 dB at 450 MHz. A 500 milliwatt transmitter operating into such a feedline would produce only 160 milliwatts at the antenna; a similar loss in receiver sensitivity would result and no amount of gain within the receiver can recover the signal lost in the feedline.

On the other hand, a 100 foot (30 meters) length of 1⅝ inch cable has a loss of 0.52 dB at the same frequency, but its cost is many times greater than RG-58A/U.

For systems covering short distances, feedline loss is relatively unimportant, and 6 dB or more of loss may be completely acceptable. For systems designed for maximum range however, each dB of loss directly affects signal-to-noise ratio at the receiver. It is good practice to keep feedline losses as low as possible and certainly under 3 dB. Remember that for each 3 dB of feedline loss, half the transmitter power is lost, and twice the receive signal power is needed to produce the same signal-to-noise ratio.

RG-8A/U is a widely available and inexpensive feedline that is suitable for systems with short ranges or those with short feedlines. For longer feedlines and lower losses, Andrew HELIAX™ semi-rigid coaxial cable or similar products are a good choice. Table 2 shows the length of various types of cable and the resulting degradation in signal strength.

Mount the antenna and feedline securely to the supporting structure to avoid damage due to wind and ice loading. Refer to the instructions provided by the antenna and feedline manufacturers to ensure a safe and reliable installation.

Table 2. Feedline loss chart (450 MHz)

Cable Type	3.05 Meters (10 Feet)	15.24 Meters (50 Feet)	30.48 Meters (100 Feet)	152.4 Meters (500 Feet)
RG-8A/U	0.51 dB	2.53 dB	5.07 dB	25.35 dB
½ in. HELIAX	0.12 dB	0.76 dB	1.51 dB	7.55 dB
⅞ in. HELIAX	0.08 dB	0.42 dB	0.83 dB	4.15 dB
1¼ in. HELIAX	0.06 dB	0.31 dB	0.62 dB	3.10 dB
1⅝ in. HELIAX	0.05 dB	0.26 dB	0.52 dB	2.60 dB

4.0 INSTALLATION PROCEDURES

This section presents the steps necessary for installing the radio and connecting it to associated equipment. After completing these steps, the radio will be ready for in-service operation.

4.1 Unpacking and Inspection

Figure 6 shows a typical transceiver shipment. 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. Save all packing materials for possible re-shipment.

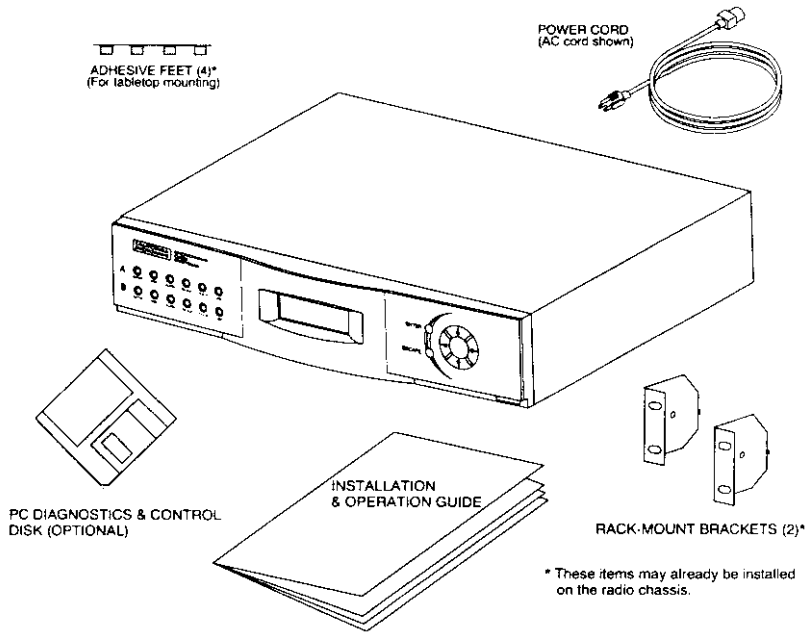


Figure 6. Typical Shipment

4.2 Mounting the Radio

The radio should be located in a relatively clean, dust free environment that allows easy access to the rear panel connectors as well as front panel controls and indicators. Air must be allowed to pass freely over the heat-sink on the rear panel.

Figure 7 shows the mounting dimensions of the radio. Most commonly, it is installed in a 2U 3.5 inch (88.90 mm) rack-mount configuration, but it can also be installed in a simple tabletop arrangement if desired.

Rack Mounting

To rack mount the radio, use the supplied mounting brackets (MDS P/N 82-3184A01) to secure the chassis to the rack cabinet. The brackets can be attached at any of four points on the sides of the enclosure— front, back, middle facing front, and middle facing back (see Figure 7). This provides flexibility to accommodate most rack mounting arrangements.

Tabletop Mounting

As an alternative to rack mounting, the radio can be placed on any sturdy shelf or tabletop that will support the weight of the unit. Adhesive backed rubber feet are provided with the radio for use in tabletop installations. These should be placed near each corner of the chassis underside to prevent scratching of the mounting surface.

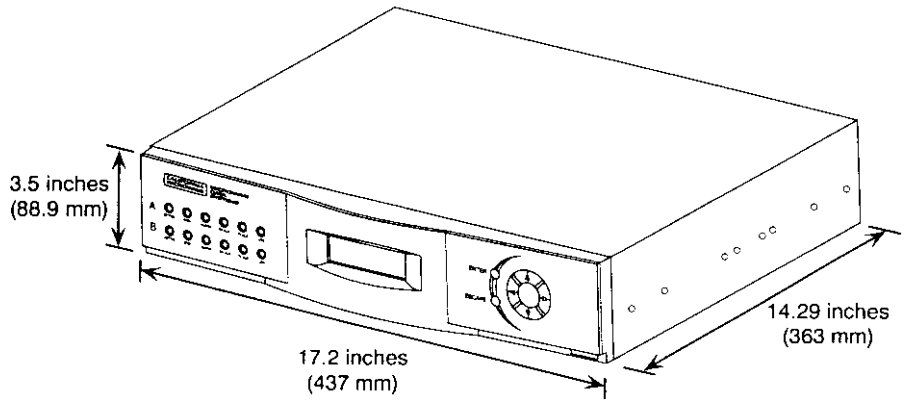


Figure 7. Mounting Dimensions & Bracket Details

Remote Front Panel Mounting—*Optional Configuration*

If desired, the front panel can be detached from the radio and mounted separately to the rack cabinet. This option is needed in rack-mount installations where all connections and control will be performed from one side of the unit. An Auxiliary Mounting Plate (P/N 82-3189A01) is available for this type of mounting.

To remove the front panel from the radio and re-mount it to the Auxiliary plate, follow these steps:

1. Detach the panel from the radio by grasping it firmly along its bottom edge and pulling away from the radio chassis (Figure 8).

2. Release the modular connector and cable from the back of the panel. Plug it into an inline splice connector (MDS P/N 73-1155A09). Snap the splice connector into the front of the chassis at the square cutout.

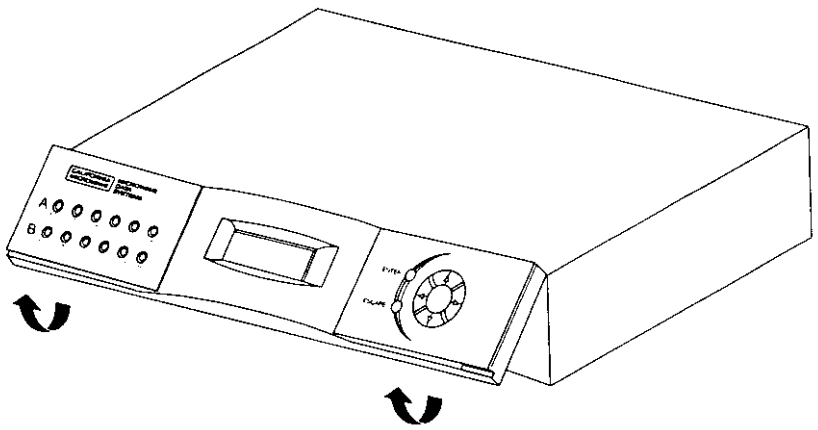


Figure 8. Front Panel Removal

3. Snap the front panel onto the Auxiliary Mounting Plate in the same manner it was attached to the main radio chassis.

4. Mount the auxiliary plate to the rack cabinet just above (or below) the radio chassis.

5. Attach the extension cable (MDS P/N 03-2198A04) between the front panel modular connector and the inline splice connector on the radio chassis.

4.3 Primary Power

CAUTION
POSSIBLE EQUIPMENT DAMAGE

Before connecting primary power to the radio, verify that power source matches the power supply operating range and type of service (AC or DC). Improper voltages may damage the equipment. The radio has either a nominal 24 volt DC, 48 volt DC, or a 110/220 Vac power supply module. (Refer to specifications for voltage ranges). The input voltage is marked on the module at the rear of the radio.

AC-Powered Units

AC-powered radios are designed to operate from 100 to 240 Vac (50/60 Hz) primary power. No special configuration is required to operate the radio anywhere within the input voltage range. An AC power cord is supplied with these units. If the radio is equipped with the 110–240 Vac power supply option, the unit can be powered from a DC source between 120 Vdc to 370 Vdc as well.

DC-Powered Units

Figure 9 shows a rear view of the DC power supply. Connection to the DC power supply is made with a three conductor plug-in terminal strip. The radio can be operated in either a positive or negative ground configuration. The center pin of the connector is not connected in the radio.

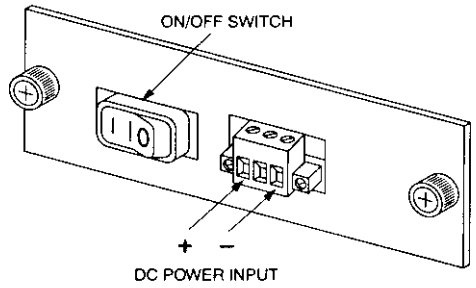


Figure 9. Rear View of DC Power Supply

4.4 Antenna System

Antenna Installation

The antenna manufacturer's installation instructions should be followed for proper operation of the antenna. Using the proper mounting hardware and bracket ensures a secure mounting arrangement with no pattern distortion or detuning of the antenna. The following reminders apply to all antenna installations:

- Mount the antenna in the clear, as far away as possible from obstructions such as buildings, metal objects and dense foliage. Choose a location that provides a clear path in the direction of the associated station.

NOTE: Strong fields near the antenna can interfere with the operation of low level circuits and change the values of the data being received. For this reason, the antenna should be mounted at least 3 meters (10 feet) from the radio and other electronic equipment.

Feedline Installation

A low loss feedline is recommended for use with the radio. *Section 3.2, Antenna & Feedline Selection* provides suggestions on choosing the correct feedline for your installation. Whatever cable is used, it should be kept as short as possible to keep signal losses to a minimum.

When installing the feedline, take care to prevent damage due to kinking, twisting or excessive stretching of the cable. After installation, fasten the cable securely to the antenna tower or other supporting structure.

A Type-N connector is required to connect the feedline to the radio. The feedline connectors must be installed in accordance with the manufacturer's instructions. Follow the manufacturer's recommendations for weatherproofing connectors that will be installed outdoors.

If large diameter semi-rigid coaxial cable is used for the feedline, insert a short length of ¼ inch Superflex™ Cable (MDS P/N 97-1677A28) or other low-loss flexible cable between the radio and the feedline. This flexible interface eliminates tight bends in the feedline and reduces stresses on the feedline and connectors. The flexible section also allows the radio to be mounted on slides and pulled out without placing undue stress on the transmission line.

4.5 Interface Wiring Connections

All connections to the radio are made at the rear panel (Figure 10). In addition to the power and antenna connections already discussed, there are three interface connectors; J1–Diagnostics, J2–Alarm, and J3–E1 Data.

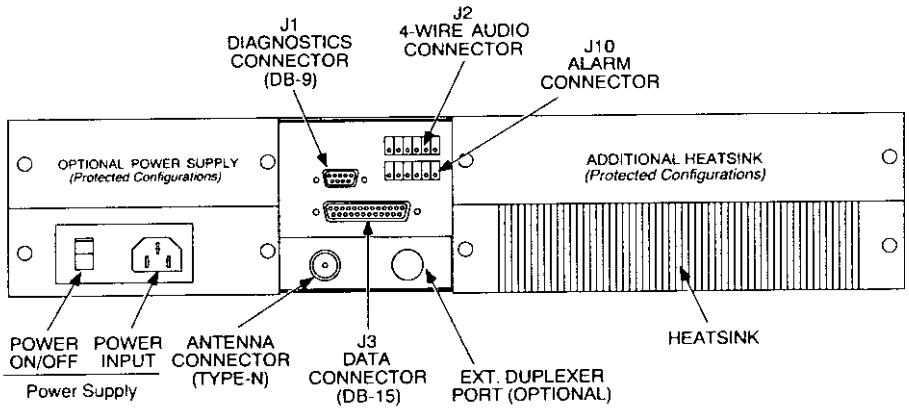


Figure 10. Rear Panel of MDS 4790

Data Interface Connector

The data interface connector (available on the rear of the radio) is the main system data interface and typically connects to the host computer.

Refer to Figure 11 and Table 3.

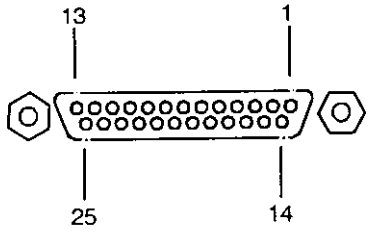


Figure 11. Data interface connector

Table 3. Data interface pinouts

Pin Number	Input/ Output	Pin Description
1	--	**Protective Ground.** Connects to ground (negative supply potential) on the radio's PC board.
2	IN	**TXD—Transmitted Data.** Accepts TX data from the connected device.
3	OUT	**RXD—Received Data.** Outputs received data to the connected device.
4	IN	**RTS—Request-to-Send Input.** Keys the transmitter when RTS asserted.
5	OUT	**CTS—Clear-to-Send Output.** Is active after the programmed CTS delay time has elapsed.
6	OUT	**DSR—Data Set Ready.** Provides a +6 Vdc DSR signal through a 2.5 kΩ resistor.
7	--	**Signal Ground.** Connects to ground (negative supply potential) at radio's PC board.
8	OUT	**DCD—Data Carrier Detect.** Goes active when the radio detects an on-frequency signal.
9	IN	**No Connection**
10	OUT	**No Connection**
11	OUT	**Receive Audio Output.** Connects to the audio input of an external (AFSK) modem. The output impedance is 600 Ω, and the level is factory set to suit most installations. Use Pin 7 for the modem's return lead.
12	IN	**No Connection**
13	--	**No Connection**
14	--	**No Connection**
15	OUT	Do not connect—Reserved for future use.
16	--	**No Connection**
17	--	Do not connect—Reserved for future use.
18	IN/OUT	**No Connection**
19	OUT	**14.0 Vdc Output.** Provides a source of regulated voltage at 1.5 amperes for low power accessories.
20	--	**No Connection**
21	OUT	**No Connection**

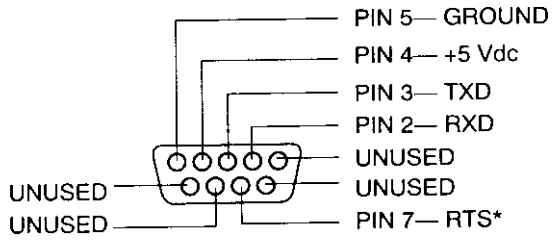
Table 3. Data interface pinouts *(Continued)*

Pin Number	Input/ Output	Pin Description
22	--	**No Connection**
23	IN	**No Connection**
24	--	Do not connect—Reserved for future use.
25	OUT	**No Connection**

Diagnostics

There is a 9-pin D-type connector on the rear panel of the radio that provides radio system diagnostics information. The diagnostics connector allows the user to perform control and diagnostics functions on the radio system from the connected computer. The communication speed between the computer and radio is 9600 bps.

Figure 12 shows the EIA-574 (9-pin EIA-232) pin functions of the DIAGNOSTICS connector as viewed from the rear panel of the radio. Connection to J1 can be made with a DB-9 male connector available from many electronics distributors.



* Used when reprogramming the radio firmware with a PC.

Figure 12. J1 Pin Connections

Alarm Contacts and Battery Back-up Connections

J10 is a plug-in terminal strip that provides connections for optional alarm circuits. Figure 13 shows the function of each terminal as viewed from the rear panel.

Terminals 1 and 2 provide relay contacts that close when a minor alarm is encountered. Terminals 3 and 4 provide relay contacts that close when a major alarm is encountered.

The contacts are rated for 1 ampere at 60 Volts AC or DC.

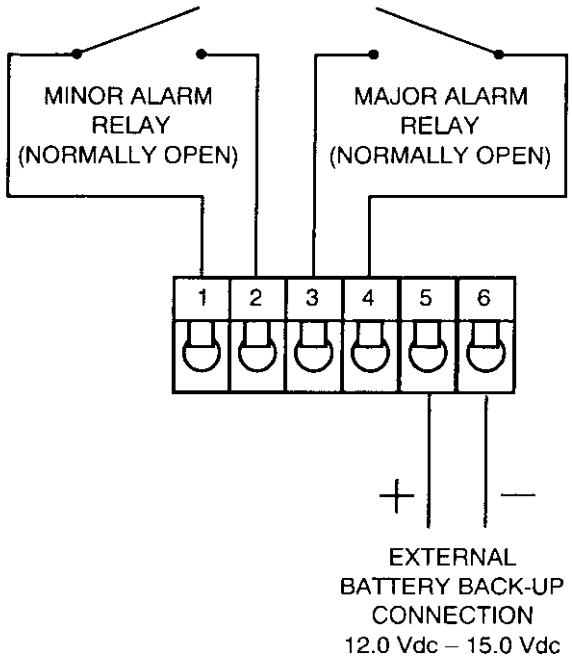


Figure 13. Alarm Relay Connections

4-Wire Audio Connector

J2 is a plug-in terminal strip that provides connections for 4-wire audio circuits. Figure 13 shows the function of each terminal as viewed from the rear panel.

Terminals 1 and 2 are for transmit audio input with a nominal 600 ohm impedance. Terminals 3 and 4 provide a receive audio output with a nominal 600 ohm impedance. Pins 5 and 6 provide a source for an external keying source. Connecting pins 5 and 6 together keys the radio.

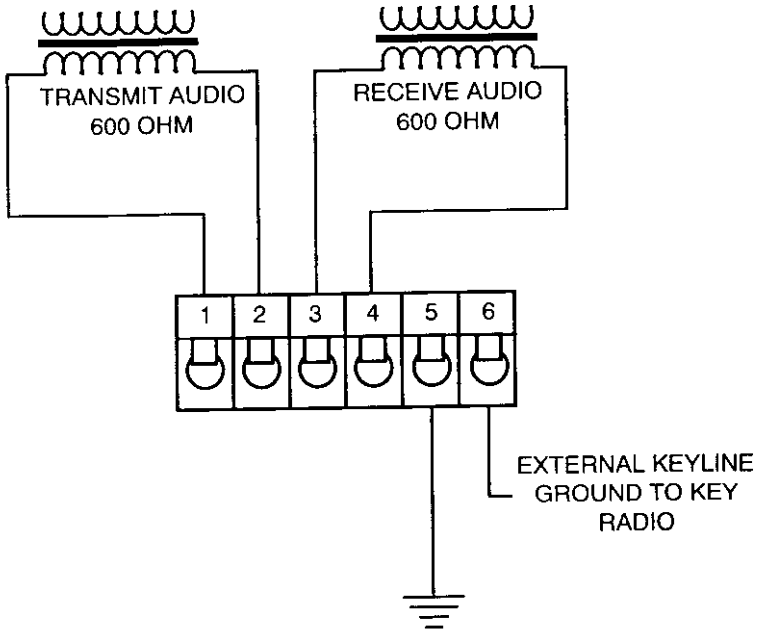


Figure 14. 4-wire audio connections

4.6 Post Installation Checks

Before applying power to the radio, verify that:

- All connections are properly wired and secure
- Input voltage matches that of the installed power supply
- Antenna heading is preset in the direction of the associated station

This completes the installation of the radio. *Section 5.0, OPERATION* explains the unit's controls and indicators and gives initial startup procedures.

5.0 OPERATION

The transceiver is designed for continuous, unattended operation. Under normal conditions, the only time operator intervention is required is to power the unit up or down, or to change an operating parameter. This section explains the use of the radio's controls and indicators and provides steps for initial startup of the equipment.

5.1 Controls & Indicators

Refer to Figure 15 and the following text for an explanation of the front panel controls and indicators. In all radios shipped from the factory, Transceiver B is installed in the chassis. On a redundant radio (spare transceiver & power supply installed), the references given here apply equally to Transceiver A and B.

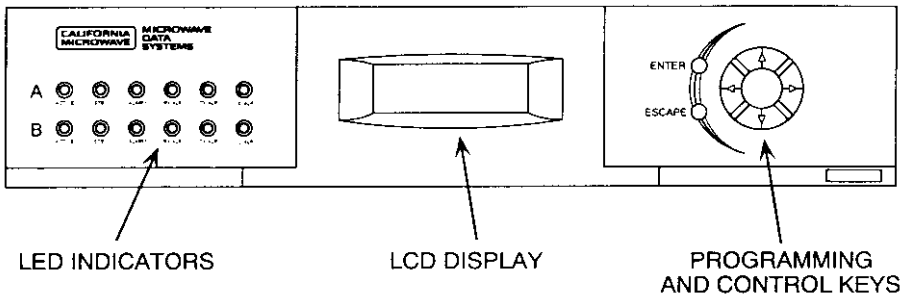


Figure 15. Front Panel Controls & Indicators

LED Indicators

The basic operation of the transceiver can be checked by viewing the LED Indicator panel. In normal operation, only the green ACTIVE LED (and one of the yellow STBY LEDs in protected radios) should be lit. All other LEDs are red in color, and when lit, indicate a potential problem in the radio system.

Refer to Figure 16 and the text that follows for a detailed explanation of the LED indicators.

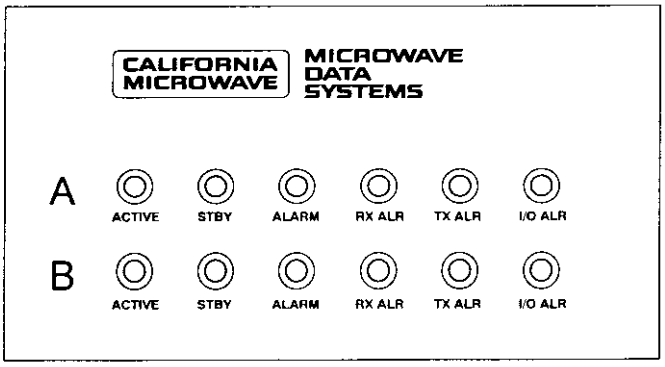


Figure 16. LED Indicators

Table 4. Explanation of Front Panel LEDs

LED Name	Color	Meaning When Lit
ACTIVE	Green	Transceiver board (A or B) is the selected unit.
STBY	Yellow	Transceiver board (A or B) is currently in standby mode. (Functional on Protected version only.)
ALARM	Red	General fault not covered by the alarm categories below (RX ALR, TX ALR, I/O ALR)
RX ALR	Red	Difficulty receiving—may be due to an antenna problem, receiver fault, or other condition causing no or a weak received signal level.
TX ALR	Red	Fault with the transmit circuitry, or the transmitter is unkeyed.
I/O ALR	Red	The data rate or format of data at the data interface connector is incompatible with the radio settings.

LCD Display

The LCD display is used in conjunction with the front panel controls to view (or change) the radio's operating parameters, or to perform diagnostic functions to evaluate radio system operation.

At initial power up (or after any extended period with no keypad activity), the LCD display shows the Startup screen (Figure 17). The startup screen displays the owner's name and message. Typically shown is the system name and site name.

The startup screen is one of many screens that can be displayed by the radio. A detailed description of each screen is provided in later in this guide. (See *Section 5.3, Configuration & Programming.*)

Figure 17. Startup Screen (Typical)

Programming & Control Buttons

The programming and control buttons are located at the far right side of the front panel. Figure 18 shows a detailed view of these controls. Their functions are explained in the following text.

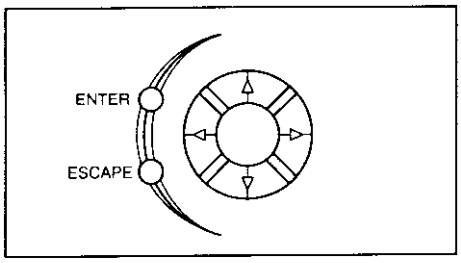


Figure 18. Programming & Control Buttons

- **ENTER**—Used to initiate a parameter change. For example, suppose you were viewing the Backlight Intensity screen, and wanted to change the intensity of the lighting. You would press the ENTER button and the message **change pending** would appear at the bottom of the screen. This indicates that a change can now be made using the arrow keys (described below). After the change has been made, the ENTER key is pressed again to set the change. The message **done** is displayed to indicate successful completion of the operation.
- **ESCAPE**—Returns you to the previously selected screen. It is a good way of cancelling a pending change. Also, by pressing the ESCAPE button three times, you can return to the Startup Screen (Figure 17) at any time.
- **Arrow keys** (△ ▽ ◁ ▷)—Used to navigate through the various screens and menus and to make changes to displayed settings. Their use is covered in greater detail in *Section 5.3, Configuration & Programming*

5.2 Initial Startup

Operation of the radio can be started by simply connecting primary power to the unit and setting the rear panel POWER switch to ON.

NOTE: It is important to realize that the MDS 4790 is normally continuously keyed and the radio will transmit when the power is switched on. Ensure there is a suitable load on the antenna connector before switching the power on.

Normal Indications

When power is first applied, the following events occur in a normally working unit:

- All indicators light briefly and a beep is emitted
- The radio displays the Startup screen similar to Figure 17
- The ACTIVE LED for the selected transceiver lights. (In a protected version, the STBY LED also lights for the standby unit.)

Maximizing RSSI

Since the master station almost always uses an omni-directional antenna, maximizing signal strength is done at the remote sites where directional antennas are typically used.

5.3 Configuration & Programming

In most cases, the radio is shipped from the factory ready for immediate operation. There are, however, several user-selectable parameters that may be adjusted if desired. In addition, there are several status and diagnostic screens that can be used to evaluate the performance of the radio.

All configuration and programming is performed using the radio's front panel push-button and LCD display. This section describes the use of the radio's internal menu system, and shows typical examples of each LCD screen that can be accessed.

Software Navigation

Figure 19 shows an overview of the radio's menu screens. Within a few seconds of applying power, the startup screen appears on the LCD screen. This is the starting point for all radio operations.

The up/down and left/right arrow keys are used to move between the various screens and menus. To move from the startup screen to the Menu Directory, press the ENTER button once. At any menu, pressing the ESCAPE button three times (maximum) will return the user to the startup screen.

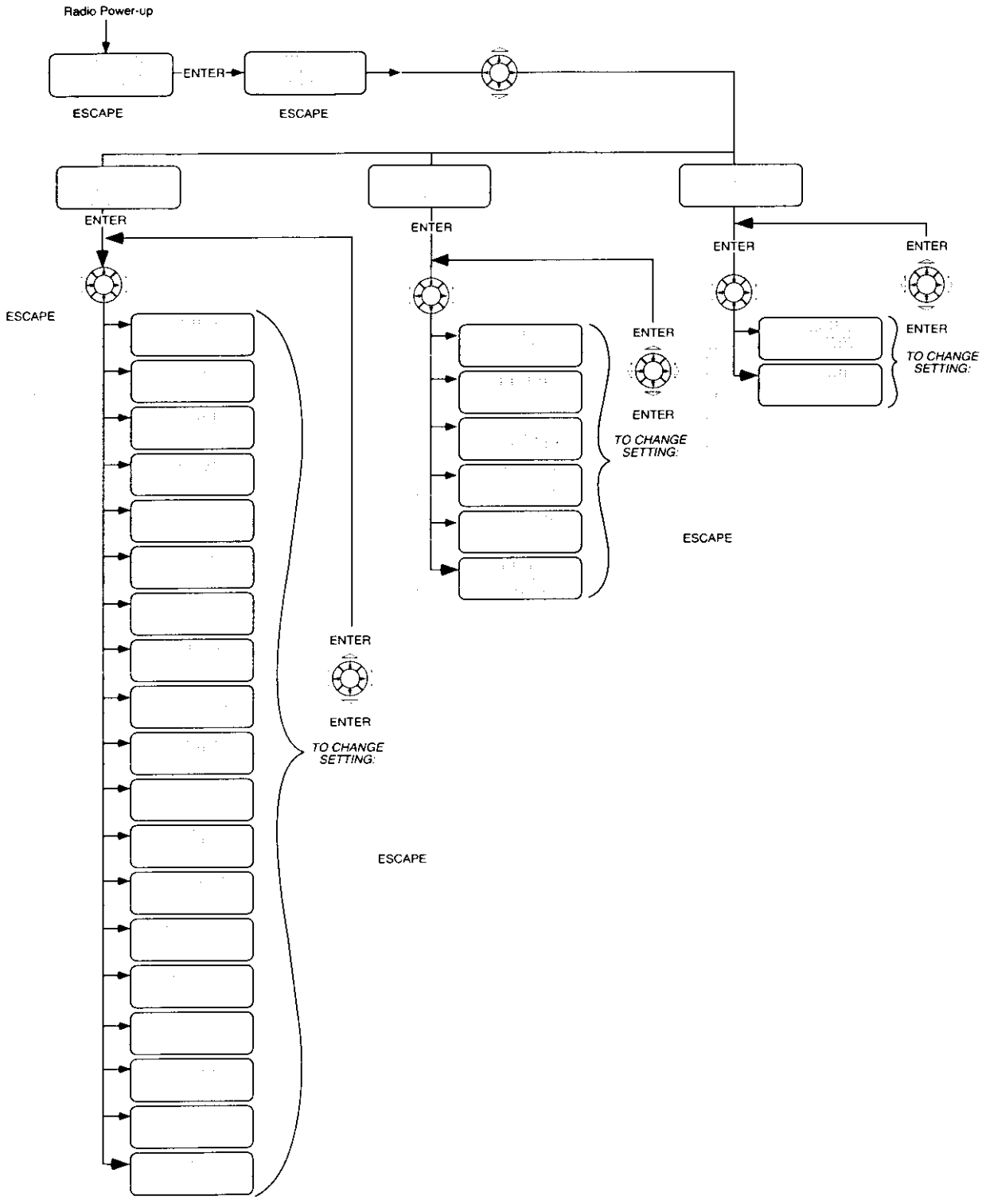


Figure 19. Front panel menu flowchart

The Menu Directory Screen (Figure 20) shows the three available menus—**Configuration, Diagnostics**, and **Event Log**. The up/down arrow keys can be used to select any one of these menus.

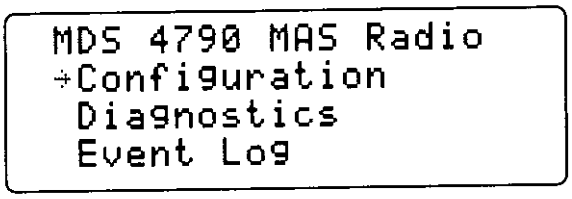


Figure 20. Menu Directory Screen

To enter a selected menu, press the right arrow key. This displays the first item in that menu. Successive key presses advance to display additional items. At the end of the list, the display returns to the Menu Directory. You can also return to the Menu Directory Screen at any time by pressing the ESCAPE button).

IMPORTANT!
ACCESS LEVEL MUST BE SET TO MAKE CHANGES

Access Level

To make changes to radio settings (other than backlight intensity or display contrast) the access level must be set to **USER**.

This is explained in the Access Level screen description starting on page 27.

5.4 Screen-by-Screen Descriptions

This section describes each of the LCD screens shown by the transceiver. These screens are presented in four major groups as follows:

Group 1—Startup Screen & Menu Directory (details page 27)

These screens are starting points for all programming and viewing activities.

Group 2—Configuration Screens (details page 27)

The Configuration screens are used to view or define the transceiver's operating parameters. They include:

- Access Level
- Transmit & Receive Frequency
- Output Power
- Modem
- Baudrate and Parity of Data Port
- Emphasis On or Off
- Clear to Send (CTS) Delay
- Push to Talk (PTT) Delay
- Soft Carrier Dekey
- Transmit & Receive Timeout Timers
- Continuous Keying
- Key on Data
- Data Buffering
- Transmit & Receive Audio Level
- Transmit & Receive Gain
- Major & Minor Alarm Masks
- Backlight Intensity & Contrast
- Set Owner Name & Message
- Set Time & Date

Group 3—Diagnostic Screens (details page 31)

The Diagnostic screens allow you to view important status information for the local and remote radio, as well as run several tests useful in locating system problems. The Diagnostic screens include:

- Receive Signal Strength
- S/N Ratio
- A or B Radio Control
- Key/Dekey
- Show Temperature and Internal Voltages
- Model Number
- Serial Number
- Software Revision

Group 4—Event Logs (details page 32)

The event logs show information concerning the 800 most recent operating changes. These events include system problems, *as well as normal operator actions such as turning the power on or off.* There are three screens in this group; Show Event Logs, IAct Event Logs and Clear Event Logs.

GROUP 1—MAIN SCREENS

Startup Screen

```
MDS 4790 MAS Radio

   OWNERS NAME
 OWNERS MESSAGE
```

At initial power up (or after any extended period with no keypad activity), the LCD display shows the Startup Screen. The startup screen displays the product model number as well as the owner's name and message.

Typically, the system name and site name are displayed as the owner's name and message. For information on how to set what is displayed on this screen see *Set Owner's Name on page 30* and *Set Owner's Message on page 30.*

Press ENTER to change to the Menu Directory screen.

Menu Directory

```
MDS 4790 MAS Radio
→Configuration
 Diagnostics
 Event Log
```

This screen shows the three available menus; **Configuration, Diagnostics,** and **Event Log**. The item opposite the right-pointing arrow denotes the currently selected menu.

Press the up/down arrow keys to select the desired menu, and then press the right/left arrow keys to traverse that menu.

•THINT: To return here from any point in the program, press ESCAPE three times.

GROUP 2—CONFIGURATION

Access Level

```
Set Access Level
      User
```

This screen shows the access level setting for the radio's operating software. There are four levels as follows:

None—This is the default setting upon power up. It allows viewing many items, but prohibits access to critical configuration settings.

User—Allows access to most common parameters such as frequency, transmit power, CTS delay, etc.

```
Set Access Level
      User

(change pending)
```

Factory—Reserved for MDS factory use. A 4-digit key entry is required.

Engineering—Reserved for MDS factory use. A 4-digit key entry is required.

To change the access level, press ENTER and use the up/down arrow keys to view the desired level. Press ENTER to select that level. You will be prompted for a 4-digit key for any access level other than Locked.

Note: The radio automatically returns to Access Level "NONE" when the power is turned off.

```
Set Access Level
      User
     (Done)
```

Transmit Frequency

```
Transmit Frequency
   400.00000
```

This menu displays the current transmitter frequency and allows the frequency to be changed in increments as set in the Reference Frequency setting.

If the transmit frequency is changed more than 1 MHz, the duplexer must be replaced or retuned. Refer to *Duplexer and Helical Filter Retuning on page 44* for information on retuning the duplexer and helical filters.

Receive Frequency

```
Receive Frequency
   400.00000
```

This menu displays the current receive frequency and allows the frequency to be changed in increments as set in the Reference Frequency setting.

If the receive frequency is changed more than 1 MHz, the duplexer must be replaced or retuned. If the receive frequency is changed more than 5 MHz, helical filter adjustments must be made. Refer to *Duplexer and Helical Filter Retuning on page 44* for information on retuning the duplexer and helical filters.

Reference Frequency

```
Reference Frequency
    6.250 KHz
```

This menu displays the current step size of the transmit and receive frequency and allows the frequency step size to be changed.

The reference frequency is the increment that the frequency can be changed by when setting the transmit and recieve frequency.

Output Power Setting

```
Output Power Setting
      30 dBm
```

This menu displays the current transmit power output setting in dBm. The transmit output power is adjustable between +37 dBm and +20 dBm. Refer to Table 5 to convert dBm to watts if necessary.

Table 5. dBm versus watts

dBm	Watts
+37 dBm	5.0 watts
+35 dBm	3.2 watts
+33 dBm	2.0 watts
+31 dBm	1.25 watts
+29 dBm	800 milliwatts
+27 dBm	500 milliwatts
+25 dBm	320 milliwatts
+23 dBm	200 milliwatts
+20 dBm	100 milliwatts

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Radio Mode

```
Radio Mode
  Master
```

This menu displays the currently set mode the radio is in. The two choices are Master and Remote.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Clear To Send Delay

```
Clear to Send Delay
0 milliseconds
```

This menu displays the currently set Clear-to-Send Delay. This is the delay between when RTS is asserted by the host computer on the data port and when the CTS line on the data port is asserted.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Push to Talk Delay

```
Push to Talk Delay
0 milliseconds
```

This menu displays the currently set Push-to Talk Delay. This is a delay between when RTS is asserted by the host computer and when the radio is keyed and begins to transmit.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Soft Carrier Dekey

```
Soft Carrier Dekey
0 milliseconds
```

This menu displays the currently set Soft-carrier Dekey delay.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Keying Timer Duration

```
Keying Timer
30 seconds
```

This menu displays the status of the Keying Timer Duration. The Keying timer is a timer that will disable the transmitter after a set period of time to prevent unnecessary use of the frequency. If the radio is set to continuous keying, the Keying timer is disabled. The keying timer is also sometimes referred to as a Time-out Timer.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Keying Timer

```
Keying Timer
30 seconds
enabled
```

This menu displays the duration of the Keying Timer. The Keying timer is a timer that will disable the transmitter after a set period of time to prevent unnecessary use of the frequency. If the radio is set to continuous keying, the Keying timer is disabled. The keying timer is also sometimes referred to as a Time-out Timer.

To change the selection, press ENTER and then use the up/down, left/right arrow keys to view the desired selection. Press ENTER again to set the change.

Continuous Keying

```
Continuous Keying
enabled
```

This menu displays whether or not the radio is continuously keyed. Typically, a master station is set for Continuously Keying.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

Data Buffering

```
Data Buffering
enabled
```

This menu displays whether or not the radio data buffer is enabled or disabled.

If the data buffer is enabled, the radio operates in seamless mode, where the data is sent over the air as quickly as possible. However, the receiver will buffer (hold) the data until enough bytes have arrived to cover worst case gaps in transmission. This mode of operation is required for protocols such as MODBUS™ that do not allow gaps in their data transmission.

If the data buffer is disabled, the radio operates with the lowest possible data latency (average). Data bytes are sent out the data 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.

To change the selection, press ENTER and then use the up/down arrow keys to view the desired selection. Press ENTER again to set the change.

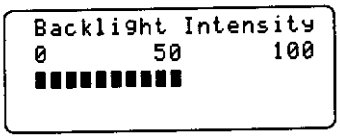
Display Contrast

This menu displays the contrast setting of the LCD display. Changing the contrast setting may aid the clarity of the LCD display if viewed from an angle.

The bar display indicates the relative setting of the contrast.

To change the selection, press ENTER and then use the left/right arrow keys to move the bar display to the desired setting. Press ENTER again to set the change.

Backlight Intensity

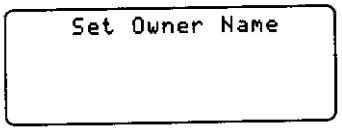


This menu displays the brightness or backlight level setting of the LCD display. Changing the backlight setting may aid the clarity of the LCD display when viewed under different light conditions.

The bar display indicates the relative setting of the backlight level.

To change the selection, press ENTER and then use the left/right arrow keys to move the bar display to the desired setting. Press ENTER again to set the change.

Set Owner's Name



This menu displays the Owner's Name that can be set to any text less than 20 characters. The owner's name is displayed on the main screen when the radio is idle or when the radio is first powered-up.

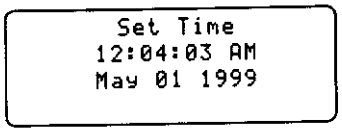
To change the name, press ENTER and then use the left/right to access particular letters. Then use the left/right arrow keys to view the desired selection. Press ENTER again to set the change.

Set Owner's Message

This menu displays the Owner's Message that can be set to any text less than 20 characters. The owner's message is displayed on the main screen when the radio is idle or when the radio is first powered-up.

To change the message, press ENTER and then use the up/down, left/right arrow keys to view the desired selection. Press ENTER again to set the change.

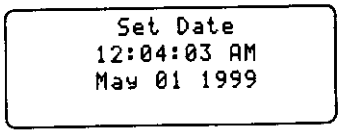
Set Time



This menu displays the date and time set in the radio. The accuracy of the date and time are important because event codes are date and time "stamped."

To change the time, press ENTER and then use the up/down, left/right arrow keys to view the desired selection. Press ENTER again to set the change.

Set Date



This menu displays the date and time set in the radio. The accuracy of the date and time are important because event codes are date and time "stamped."

To change the date, press ENTER and then use the up/down, left/right arrow keys to view the desired selection. Press ENTER again to set the change.

GROUP 3—DIAGNOSTICS

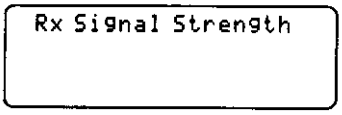
Transmitter Control

This menu displays the state of the transmitter. Keyed indicates the transmitter is set to transmit and dekeyed indicates the transmitter has been set not to transmit.

This setting is used when working on the radio and the radio must be keyed to evaluate transmitter output power.

To change the date, press ENTER and then use the up/down, left/right arrow keys to view the desired selection. Press ENTER again to set the change.

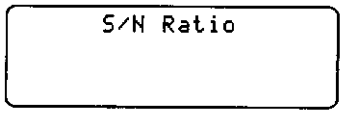
Receive Signal Strength



This menu displays the current received signal strength in dBm.

In a typical master station configuration, the received signal strength is read from each of the remote transceivers transmit to the master station in turn.

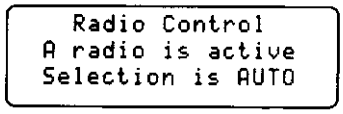
S/N Ratio



This menu displays the current Signal to Noise Ratio in dBm.

In a typical master station configuration, the received signal strength is read from each of the remote transceivers transmit to the master station in turn.

Radio Control



This menu displays the currently active transceiver system inside the MDS 4790.

In addition, the selection of a transceiver system is made from this menu.

When **Selection is:**

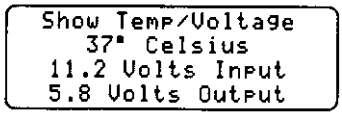
Set to **AUTO**, switchover to the inactive transceiver system will occur if a fault condition occurs on the active transceiver system.

Set to **A** , transceiver A is set as the active transceiver system and no switchover will occur if an error condition is detected in the radio.

Set to **B**, transceiver B is set as the active transceiver system and no switchover will occur if an error condition is detected in the radio.

To change which transceiver system is active or automatic switchover, press ENTER and then use the up/down or left/right arrow keys to view the desired selection. Press ENTER again to set the change.

Show Temperature and Voltages



This menu displays the current internal temperature of the radio, and internal voltages.

The input voltage is the voltage that connects to the transceiver board and is unregulated. This voltage is essentially the output from the power supply assembly.

The output voltage is read after a 5.6 Vdc regulator on the transceiver board.

Serial Number

```
Serial Number
00755959
```

This menu displays the serial number of the active transceiver *board*. This number will not match the serial number on the serial number label on the radio.

Software Revision

```
Software Revision

06-3321A02
0.0.0     5Aug1998
```

This menu displays the current internal software part number and revision information.

GROUP 4—EVENT LOG

View Event Log

```
Log    1 of    1
5/ 1/1998 12:00:00
   System Boot
```

This screen shows the event loged on the *active* transceiver board. The event log number, date and time of the event, and a description of the event are shown.

This screen shows the most recent log when first entered. Use the up/down arrow keys to scroll through the stored history of events.

6.0 TROUBLESHOOTING

This section discusses the many troubleshooting tools built into the transceiver. In many cases these tools will allow you to diagnose a system problem and restore operation as quickly as possible.

MDS does not recommend component level repair of the transceiver in the field. However, the major assemblies of the transceiver may be replaced without the need for tools or test equipment. *Section 6.3, Replacing Assemblies* covers this in detail.

If you are unable to solve a system problem with the information provided here, technical assistance is also available from Microwave Data Systems. Refer to the inside back cover of this guide for contact information.

NOTE: Before starting any detailed troubleshooting, check the basic requirements at both ends of the link: primary power, secure cable connections and proper antenna heading. In many cases, one of these things may be at fault and cause poor operation or a complete loss of link service.

6.1 Troubleshooting with LED Indicators

The first indication of a problem is usually an illuminated Alarm LED on the front panel. In normal operation, only the green (ACTIVE) LED should be lit (and one of the yellow STBY LEDs in a protected radio).

Refer to Figure 21 and the text that follows for an explanation of the LED indicators.

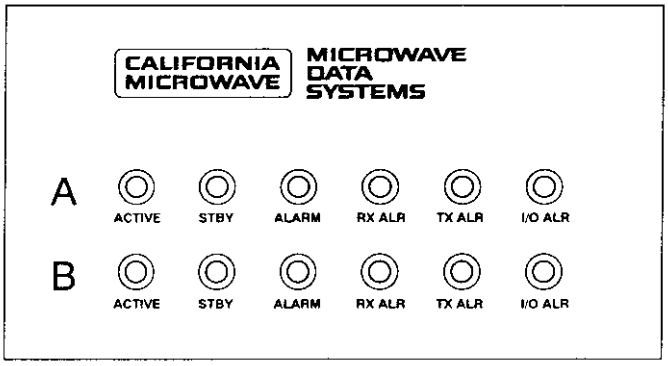


Figure 21. LED Indicators

Table 6. Explanation of Front Panel LEDs

LED Name	Color	Meaning When Lit
ACTIVE	Green	Transceiver board (A or B) is the selected unit.
STBY	Yellow	Transceiver board (A or B) is currently in standby mode. (Functional on Protected version only.)
ALARM	Red	General fault not covered by the alarm categories below (RX ALR, TX ALR, I/O ALR)
RX ALR	Red	Difficulty receiving—may be due to an antenna problem, receiver fault, or other condition causing no or a weak received signal level.
TX ALR	Red	Fault with the transmit circuitry, or the transmitter is unkeyed.
I/O ALR	Red	The data rate or format of data at the data interface connector is incompatible with the radio settings.

6.2 Troubleshooting with the LCD Display

Diagnostic Tests

The radio includes several useful tools in the **Diagnostics** menu that can be used to identify system problems. These include local and remote status screens, loopback configurations, and other internal tests. Brief descriptions of these tools are given below. Refer to *Section 5.4, Screen-by-Screen Descriptions* for detailed information.

Local and Remote Status Screens

The local and remote status screens can be used to gather important information about both ends of the radio link, including signal strength, BER, Signal-to-Noise Ratio and power output.

Loopback Configurations

The radio supports several types of loopback tests that can be performed with external equipment. These tests are very helpful in evaluating the overall RF and data performance of the system. A detailed description of the loopback tests is covered in *Section 5.4, Screen-by-Screen Descriptions.*

Other Tests

The **Run Tests** screen in the **Diagnostics** menu can be used to perform eight sequential tests on the transceiver's internal circuitry.

Event Codes

Event codes are another helpful way of identifying system problems. The radio stores recent events in a log that can be reviewed using the **Event Log** screen (see full description in *Section 5.4, Screen-by-Screen Descriptions*). In addition to on-site troubleshooting, the event log messages are also helpful when calling MDS for technical assistance.

Not all events are considered to be problems. For example, an intentional action such as turning the primary power on will be recorded as an event even though it is not a true error condition. In many cases however, the events leading up to a failure can be reviewed to help determine the cause of a problem.

- Major alarms generally indicate a hardware failure, or other abnormal condition that will prevent (or hamper) further operation of the radio link. Generally speaking, major alarms cause the internal transceiver assemblies to switch-over operation on a protected model.
  Connections to a relay that is actuated by these alarms are provided on the rear panel ALARM connector. (See Figure 13 on page 18.)

- Minor alarms generally will not prevent operation of the radio link, but may impair performance. This includes out-of-tolerance conditions, low signal-to-noise ratios, etc. The cause of a minor alarm should be investigated and corrected to prevent an eventual system failure.
  Connections to a relay that is actuated by these alarms are provided on the rear panel ALARM connector. (See Figure 13 on page 18.)

6.3 Replacing Assemblies

Component level repair of the transceiver in the field is *not* recommended due to the complex nature of the circuitry and the use of surface mount technology throughout the radio. Malfunctioning assemblies should be returned to the factory (or authorized service center) for repair or replacement.

One approach to field-level servicing is to have spare modules available for the three easily replaced assemblies of the transceiver—the Main Transceiver Board, Power Supply, and Front Panel. In this way, a defective assembly can be quickly removed and replaced with a working unit. The following instructions describe the removal and installation of these assemblies.

CAUTION
POSSIBLE EQUIPMENT DAMAGE

The primary power to the radio must be disconnected before removing or installing transceiver or power supply assemblies.

Transceiver Board & Power Supply Assemblies

To remove either of these assemblies, loosen the two captive thumbscrews at each side of the module, and slide the unit straight out as shown in Figure 22. (There are no cables to disconnect, as the modules are fitted with in-line connectors.)

To re-install these modules, make sure that the slides are properly aligned with the guide slots on the chassis, and push straight in. Tighten the thumbscrews to secure the assembly.

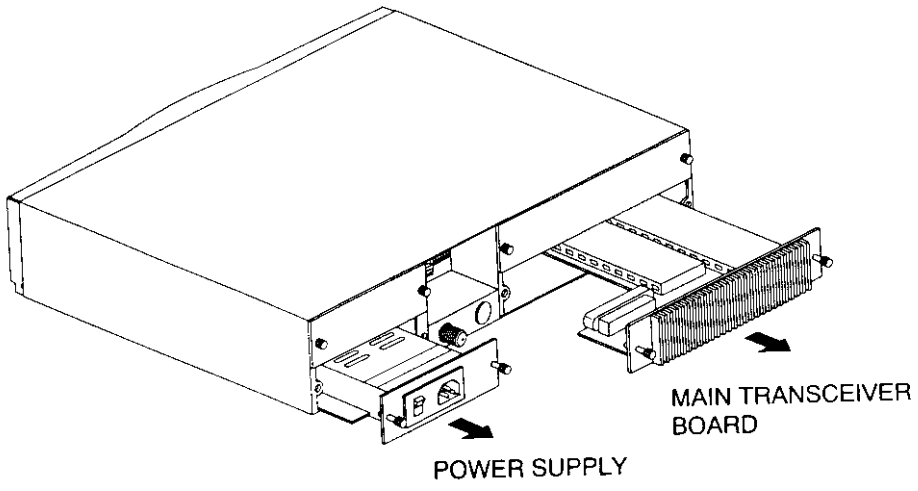


Figure 22. Main Transceiver & Power Supply Removal

Front Panel

The front panel is secured to the chassis with spring-loaded latches. To remove the panel, simply pull out at the bottom edge until it is free from the chassis (Figure 23). You will also need to disconnect the modular cable from the back of the panel. Reverse these steps to re-install the front panel on the chassis.

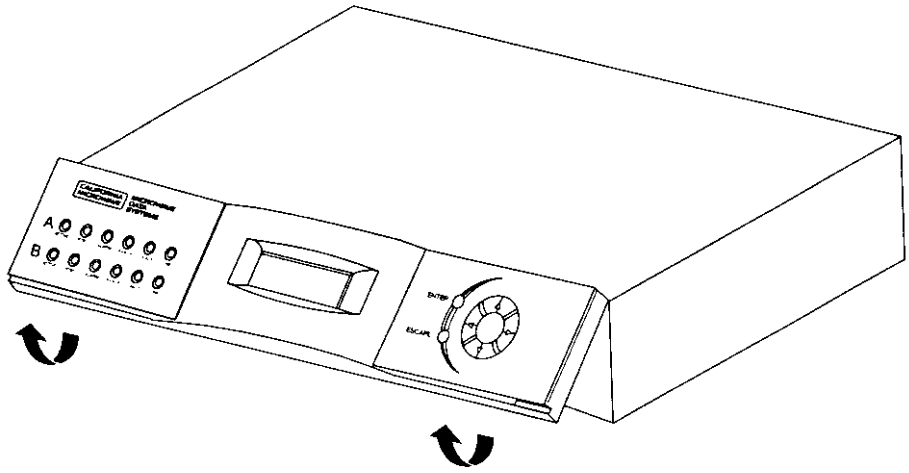


Figure 23. Front Panel Removal/Replacement

7.0 TECHNICAL REFERENCE

GENERAL	
Size:	2RU (88.90 mm/3.5 inch) high 363 mm (14.3 in) deep 437 mm (17.2 in) wide —includes duplexer and power supply
Weight:	9 kg (19.8 lbs.)
Frequency Range:	330–512 MHz Front panel programmable, duplexer, and helical filters may require retuning. *(Refer to Figure 4 on page 5 for hardware band limits)*
T/R Separation:	
RF Occupied Bandwidth:	
Antenna Impedance:	50 Ohms
Data Rates:	300, 1200, 2400, 4800, 9600, 19200, 384 00 bps asynchronous
Data Interface:	EIA-232
Modulation Type:	
Temperature Range:	0 to 50 degrees C guaranteed operation
Humidity:	95% Non-Condensing

Environmental:	Designed for ETS 300 019, Class 3.1 and 3.2
EMC:	Designed for ETS 300 385
System Gain:	110 dB
Voltage Ranges:	
24 Vdc Power Supply	19.4 to 37 Vdc
48 Vdc Power Supply	36 to 75 Vdc
110/220 Vac Power Supply	
Power Consumption:	30 Watts
Data Latency:	7 ms maximum at 9600 bps
DIAGNOSTIC FUNCTIONS	
Local Indicators:	Active, Standby, General Alarm, TX Fault, RX Fault, I/O Fault
Remote Indicators:	Minor and major alarm relay contacts (Available on rear panel)
Measurements:	RSSI, Power, S/N, BER, Alarms
Remote Readings:	Remote RSSI, S/N, BER & alarms via embedded diagnostic data stream. (RS-232-type port at rear panel)
Loopback:	Local digital loopback, Local RF loopback, Remote digital loopback
RECEIVER	
Sensitivity:	–89 dBm for 1×10^{-6} BER –92 dBm for 1×10^{-3} BER
Residual BER:	1×10^{-10}
Dynamic Range:	From sensitivity to –30 dBm better than 1×10^{-6} BER
TRANSMITTER	
Power Output:	+27 dBm (500 mW) out of duplexer (approx. +28.5 dBm out of transmitter)
Frequency Stability:	1.5 ppm
Spurious Outputs:	Less than –60 dBm
Duty Cycle:	Continuous/100%

7.1 RF Propagation Planning

Establishing a reliable point-to-point radio link requires system planning and design. It is helpful to have an understanding of the physical parameters affecting propagation. The following material discusses these factors and will assist you in designing a dependable transmission path for your radio link.

NOTE: This section is intended for use as a guideline when planning transmission paths. It does not consider all of the local conditions that may be present, nor does it guarantee that adequate signal strength will be obtained in a given system. There is no substitute for an on-the-air test to verify the predicted path results, and to check the overall operation of the radio system.

To assure a highly reliable path, a line of sight between both ends of the link is desirable. For short paths (up to 5 kilometers [3.1 miles]) some obstructions may be acceptable, but the performance of a blocked path is always less predictable than a clear path.

Fresnel Zone Clearance

As the distance spanned by a link gets longer, it is necessary to have more than just a grazing path between the two ends; the path must clear the ground or other obstacles by some percentage of a Fresnel zone.

The Fresnel zone corresponds to the width or girth of the radio signal. There are first, second, and third Fresnel zones but the first zone is the only one that has substantial effects on signal strength.

The first Fresnel zone can be visualized as an oval shaped volume between two station antennas (Figure 24). As the width of the radio wave front gets blocked by obstructions, less of the signal can get to the receiver antenna.

In addition to blocking the signal, obstructions in the first Fresnel zone may also cause multipath interference due to reflective and refractive signal paths. The reflected or refracted signal may arrive at the receiver out of phase with the desired signal and cause a cancelling effect.

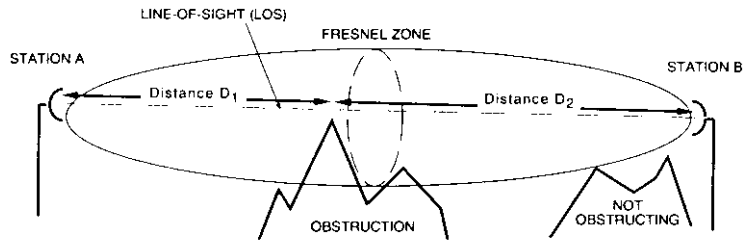


Figure 24. Fresnel Zone Obstructions

As a matter of practice, 60 percent of the first Fresnel zone must be clear of obstructions (0.6 x F) to allow a clear, unobstructed microwave path.

Remember, the first Fresnel zone calculation is only one parameter determining path quality.

Earth Curvature

As the distance of a communication link increases, the clearance problem is compounded by the earth's curvature. Radio waves traveling through typical atmospheric conditions bend slightly, which is represented by treating the earth as though it were slightly flatter than it actually is. Experience has shown that if we consider the earth's radius to be ⅓rds of its actual size we get good agreement between theory and measured propagation results.

Figure 25 shows a representation of the ⅓ earth "radio horizon." This figure shows that under normal radio propagation conditions, a station with its antenna 15 meters above flat terrain will have a radio horizon approximately 15 kilometers away, well beyond the visual horizon.

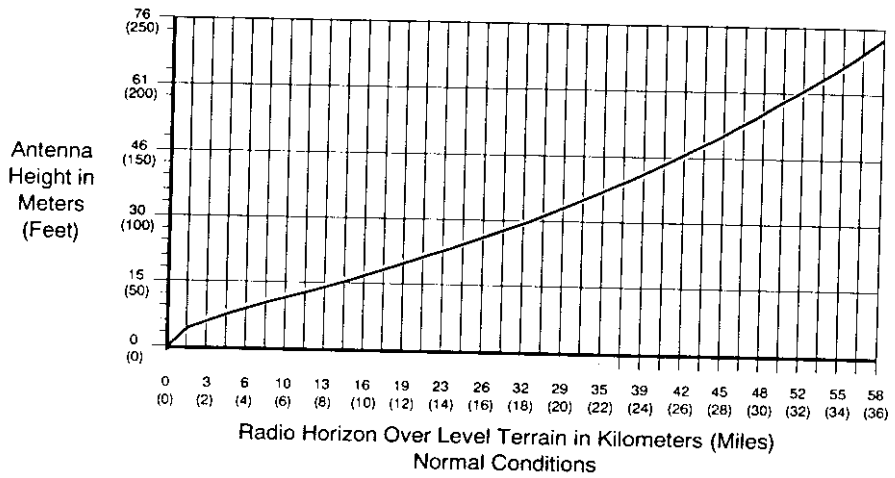


Figure 25. Antenna Height vs. Theoretical Radio Horizon

Fade Margins

Variations in the temperature and humidity of the atmosphere with elevation cause the signals to bend more or less, resulting in fading at the receiver. The longer the path is, the more likely that deep fades will occur, hence the greater the fade margin required.

Different parts of the world have differing propagation which can be categorized as favorable, average, or adverse. In general, mountainous areas have favorable propagation conditions while tropical areas and those near large bodies of water have adverse conditions.

Calculating Path Loss

Assuming that we have satisfied the Line-of-Sight and first Fresnel zone clearance requirements, we can calculate the path loss. At 450 MHz the loss between two isotropic radiators (0 dBi antennas) that are 1 km apart is 86 dB. For every doubling of distance, the loss increases by an additional 6 dB. Knowing this, the output power (+25 dBm), and the receiver sensitivity (–90 dBm), we can calculate antenna size and tower height requirements to cover any desired distance.

7.2 Formulas for System Planning

The following standard formulas are provided for assistance in determining system installation parameters.

Free Space Path Loss

$$\alpha_{fs} = 92.4 + 20\log_{10} f + 20\log_{10} d$$

Where:

α_{fs} = free space loss in dB
d = path distance in kilometers
f = frequency in GHz

Parabolic Antenna Gain

$$G = (20)\log_{10}(7.4Df)$$

Where:

G = antenna gain in dBi
D = dish diameter in meters
f = frequency in GHz

This formula assumes a typical 50 percent antenna illumination efficiency and is representative of a full parabolic antenna.

Fresnel Zone Boundary

$$F_n = 17.3\sqrt{\frac{nd_1 \cdot d_2}{fD}}$$

Where:

F_n = Fresnel zone boundary in meters

d_1 = distance from one end of the path to the Fresnel zone boundary (in kilometers)

d_2 = distance from the other end of the path to the Fresnel zone boundary (in kilometers)

D = total path distance (d_1+d_2) in kilometers

f = frequency in GHz

n = Fresnel zone, 1 (for 1st) is used here

Parabolic Antenna Beamwidth

$$\phi = \frac{21.3}{fD}$$

Where:

ϕ = beamwidth in degrees (between –3 dB points)

f = frequency in GHz

D = dish diameter in meters

This formula is representative of a full parabolic antenna.

Theoretical Signal Strength

$$RSSI = EIRP - \alpha_{fs} + G_{ra} - L_{rfl}$$

Where:

RSSI = signal strength at the receiver in dBm

EIRP = RF Power Output in dBm + G_{ta} –L_{tfl}

α_{fs} = free-space path loss in dB

G_{ra} = receive antenna gain in dBi

L_{rfl} = receive feedline loss in dB

L_{tfl} = transmit feedline loss in dB

G_{ta} = transmit antenna gain in dBi

Probability of System Fading

$$FProb = a \times b \times 6.0 \times 10^{-7} \times f \times d^3 \times 10^{(-F)/10}$$

Where:

$FProb$ = probability of fading more than F

a = terrain factor

- 4 is used for very smooth terrain such as over water
- 1 is used for average terrain, with moderate roughness
- 0.25 is used for mountainous, or very rough terrain

b = climate factor

- 0.5 is used for a hot, humid climate
- 0.25 is used for temperate or northern areas
- 0.125 is used for a very dry climate

f = frequency in GHz

d = path length in km

F = fade margin, in dB

7.3 Bench Testing Setup

Figure 26 shows a sample test setup that can be used to verify the basic operation of MDS 4790 radio. This test can be performed with any number of remote radios by using a power divider with the appropriate 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. 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 connected to the DIAGNOSTICS port on the master station.

CAUTION
POSSIBLE EQUIPMENT DAMAGE

It is very important to use attenuation between all units in the test setup. The amount of attenuation required depends 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 radio in the test setup.

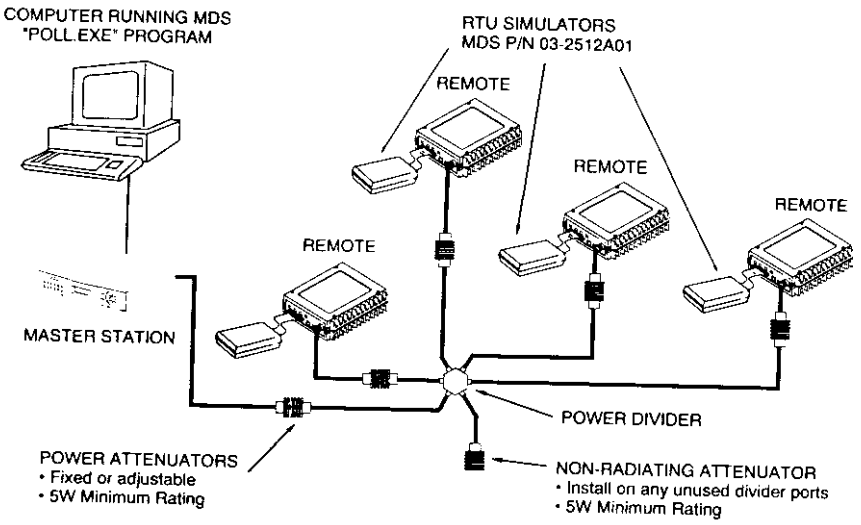


Figure 26. Bench test setup

7.4 PC Diagnostics & Control

As an alternative to using the radio's front panel, a personal computer and a terminal program such as ProComm Plus can be used to control and configure the radio. (See Figure 27.)

Connecting the Computer

To connect a PC to the radio:

1. Connect a DB-9 to DB-9 cable (Figure 28) between the PC and the radio's rear panel DIAGNOSTICS connector.

2. Install the diagnostics and control software onto the computer, and follow the online prompts and instructions.

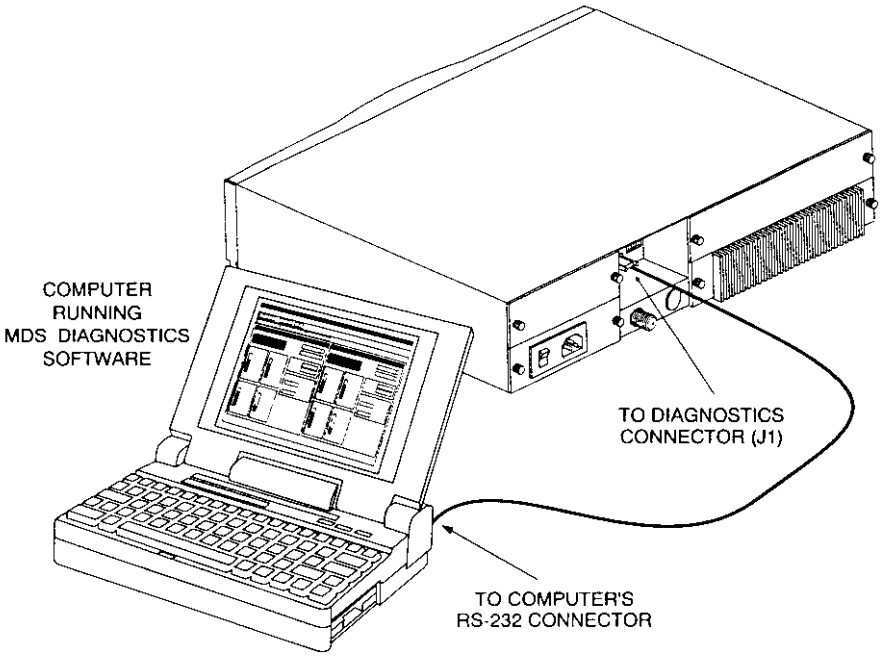


Figure 27. PC Connected to the Master Station

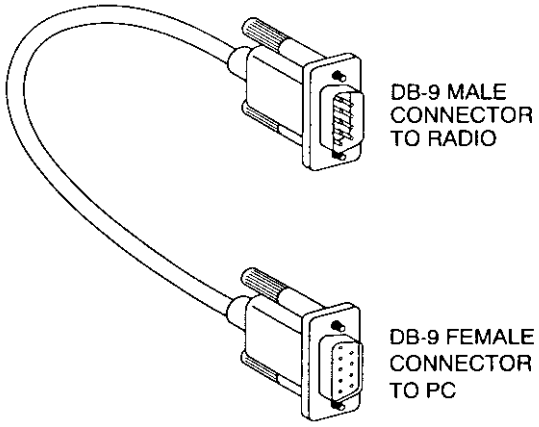


Figure 28. PC Diagnostics Cable (DB-9 to DB-9)
Required for PC Control & Diagnostics

7.5 Duplexer and Helical Filter Retuning

To be supplied.

7.6 dBm-Watts-Volts Conversion Chart

Table 7 is provided as a convenience for determining the equivalent voltage or wattage of an RF power expressed in dBm.

Table 7. dBm-Volts-Watts Conversion Chart

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	V	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

NOTES

QUICK START GUIDE

1. Install and connect the antenna system to the radio. (Page 14)

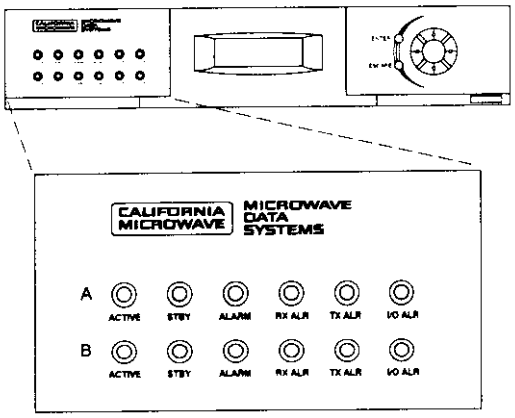
- Use a directional antenna aimed at the associated station.
- Use low loss feedline suited for 400 MHz. Keep the feedline as short as possible.

2. Connect the host computer to the rear panel DATA connector.

3. Verify proper mains voltage level, connect mains to the radio and set the power switch to ON.

4. Measure Received Signal Strength

5. Observe Front Panel Indicators for proper operation.



ACTIVE (green)—This transceiver board (A or B) is the selected unit.

STBY (yellow)—This transceiver board (A or B) is the standby unit (Protected version only).

ALARM (red)—General fault not covered by the other alarm categories (RX ALR, TX ALR, I/O ALR).

RX ALR (red)—Difficulty receiving. May be due to an antenna problem, receiver fault, or other condition causing a low received signal level.

TX ALR (red)—Fault with the transmit circuitry, or the transmitter is unkeyed.

I/O ALR (red)—The data rate or format of data at the data interface connector is incompatible with the radio settings.

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 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.