SYSTEM III INTELLEGENT RADIO MODEM
REFERENCE MANUAL

11/98, III - 1

CAUTION

Risk of electric shock - do not open.

To reduce the risk of electric shock:

Do not remove the cover or back of the IRM unit.

There are no user-serviceable parts inside.

Refer servicing to qualified, factory Trained service personnel.

This equipment meets part 90 and part 94 of the FCC rules.

NOTICE

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus as set out in the radio interference regulations of the Canadian Department of Communications.

INFORMATION TO USER

Class B Digital Device or Peripheral

NOTE

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses, and can radiate radio frequency energy and, if not following measures:

- Relocate or change the orientation of the ment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/ TV technician for help.

WARNING

Changes or modifications not expressly approved by Aria Wireless systems could void the user's authority to operate the equipment.

To minimize the potential for RF interference, Aria :Wireless Systems recommends shielded interconnecting cables to data terminal equipment.

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SYSTEM III™

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SYSTEM III

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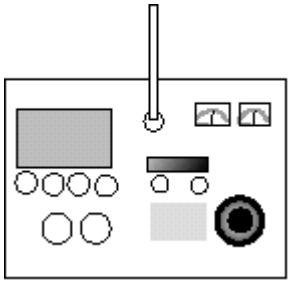

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Section 6 - Theory

1.1 - About this Manual

This is a Reference Guide for the System III Intelligent Radio Modem (IRM)

This book is the first in a series of four manuals designed to work together for Users, Installers and Service Technicians. The information contained in this reference guide covers:

How the IRM works
How to Install and configure your IRM unit
How to interface your equipment through the Network
IRM operations
Troubleshooting IRM unit malfunctions

It Does NOT Contain

Operational description of any of the component equipment - this information is contained in:

Book#	Name
2	System III - Repeater Reference Manual
3	System III - CEMA Software Reference Manual
4	System III - Network Manager Reference Manual

Notes, Warnings and Tables

NOTE
Text included in this box emphasizes information pertinent to a sequential order, or the possibility of damage to the IRM network system.

WARNING
Alerting you to possible bodily injury, the black boxes with white text contain safety warnings.

1.3 - IRM Features

Features

- 19.2 or 9.6 kbps data rate
- Accepts all common user protocols
- 50 km (30 mile) operating range
- Operates in 400, 800 and 900 MHz frequency bands
- Efficient CEMA network protocol
- Remote software load and configuration
- Compact package
- Simple set-up and operation

Description

The Intelligent Radio Modem

The System III Intelligent Radio Modem (IRM) provides high capacity wireless data transmission from data entry terminals or host computers over metropolitan area radio networks operating at speeds of 9600 or 19,200 bits per second. The unit may be configured either for transparent operation with the customer's host computer protocol or for use with the Collision Eliminating Multiple Access (CEMA) network protocol.

When interfacing terminals to the CEMA wireless network, the IRM fully emulates the host computer's terminal controller and transmits any terminal mode changes to the IRM attached to the host computer. Similarly in interfacing host computers to the network, the IRM emulates all terminal control functions including polling and allows only packets containing data to be transmitted. Virtual multi-drop capability allows the IRM to serve multiple terminal devices from a single RS-232 port. It can also drive port sharing devices, short haul modems or microcell servers.

Compatibility

The IRM is fully compatible with the System III SNMP Compliant Network Manager. This capability allows the network operator to remotely monitor IRM operating status, to reconfigure communications port parameters or protocol settings, and to download new firmware revisions. With these Network Manager features, the user can perform most IRM servicing without a site visit.

1.4 - IRM Specifications

The IRM System

The IRM incorporates an external power supply, RF transceiver, digital processor and firmware. World wide operation is supported via the external power supply, which accepts 110 to 230 volts A/C and supplies 12 volts DC power to the IRM enclosure. The digitally synthesized RF transceiver module ensures high quality error free data transmission over a wide range of frequencies and channel spacings. By using a proven Motorola 68000 microprocessor coupled with flash memory program storage, the digital processor module supports a large variety of firmware based protocols that are commonly used in interactive data terminals. Contained in the firmware are the network protocol functions and one or two customer equipment protocols plus extensive diagnostics and network management functions. To provide enhanced throughput and security, data compression and encryption functions may be added.

Specifications

1. Frequency Coverage and Data Rates

Coverage	Transmit Range	Receive Range
405-512 MHz	Ft ± 5.0 MHz	Fr ± 5.0 MHz
805-960 MHz	Ft ± 7.5 MHz	Fr ± 7.5 MHz

Transmitter and receiver center Frequencies (Ft & Fr) are to be specified at time of order. The operational frequencies can be programmed in the field within the above specified coverage limitations. Ft and Fr may be any value which lies between the lowest coverage frequency plus 5.0 MHz or 7.5 MHz and the highest coverage frequency minus 5.0 or 7.5 MHz as applicable.

Data Rate	Channel Spacing	Modulation
9,600 BPS	25.0 KHz	2 state FSK
9,600 BPS	12.5 KHz	4 state FSK
19,200 BPS	25.0 KHz	4 state FSK

1.4 - IRM Specifications

2. Transmitter Specifications

• **Maximum Power Output**:	5 Watts (+37 dBm)
• **Duty Cycle:**	100%
• **Turn-on Time:**	< 1 Millisecond
• **Frequency Stability:**	1.5 ppm
• **Frequency Sources:**	TCXO Controlled Direct Digital Synthesis
• **Reference Frequency:**	19.6608 MHz

3. Receiver Specifications

• **Type:**	Double conversion superheterodyne
• **Adjacent Channel Rejection:**	
	First Adjacent Channel 50 dB
	Second Adjacent channel 60 dB
• **Spurious Rejection**	70 dB
• **Image Rejection:**	60 dB
• **Intermodulation Rejection:**	60 dB
• **Saturation:**	-20dBm
• **Sensitivity:**	(10^{-6} Bit Error Rate)
	9600 BPS 25 kHz -100 dBm
	9600 BPS 12.5 kHz -90 dBm
	19,200 BPS 25 kHz -87 dBm

4. User Interface

• Front Panel Indicators

4 status LED's
1 Power LED

• Rear Panel

Antenna Connector:	TNC type female 50 ohms
Customer Device Connectors:	RS-232 DB-25 Female, configured as DCE
	Received Signal Strength Test Point
	12 Volt Power Jack

5. Regulatory Compliance

• **Safety approvals**:	UL, CSA, TUV
• **FCC Type Acceptance**:	Parts 22, 90 or 94 as applicable
• **Canada Compliance**:	RSS-119 or RSS-122 as applicable
• **Emissions**:	FCC Part 15, Sub-part B
• **FCC ID's**	
805-960 MHz:	JK2DM208000B
405-512 MHz:	JK2DM204000
• **Emission Designator**:	
12.5 KHz models	11K7F1D
25 KHz models	17K1F1D

1.4 - IRM Specifications

6. Electrical and Mechanical

•External Power supply

Input Power:	110/230 VAC, 50/60 Hz, Auto-sensing.
Power Consumption:	42 Watts Maximum
Output Power:	12 volts DC, 3.5 amperes maximum
Dimensions:	3.4"W x 5.9"L x 2.0"H (86 x 149 x 56 mm)
Weight:	18 oz. (510 grams)

•IRM Enclosure

Dimensions:	7"W x 9.5"D x 2.5"H (178 x 241 x 64 mm)
Weight:	5 pounds (2.3 Kg)
Temperature Range:	Operating: 0 to +50 Degrees C Storage: -40 to +80 Degrees C
Humidity:	5-95% non-condensing

7. Digital Module

•Microprocessor:	Motorola 68000, 14.7 MHz Clock
•Memory:	1024 KB Reprogrammable Flash Memory 256 or 512 KB Random Access Memory (RAM) 8 KB Electrically Erasable Read Only Memory (EEROM)
•Customer Equipment Ports:	1 or 2 RS-232 Serial Ports

1.4 - IRM Specifications

8. Firmware

•Network Capabilities	CEMA Network Version 2.0
•Customer Equipment Protocols	IBM SNA/SDLC IBM 3270 Bisynchronous Burroughs Poll Select Asynchronous Burroughs Poll Select Synchronous Asynchronous Terminal X.25 Level 2, LAPB Visa Types 1 and 2 Datapac 3201
•Operational Functions	CEMA network control Customer equipment interface Customer equipment protocol processing
•Network Management and Troubleshooting Functions	Interface via CEMA network to management workstation Remote configuration Radio status reporting Protocol process alerts Diagnostics
•Configuration Method	Remote or local configuration using PC based Network Manager Parameters stored in nonvolatile EEROM

All Stated specifications are subject to change without notice or obligation.

1.5 - IRM in a Network

The IRM is one component of the System III network. It can be used as a:

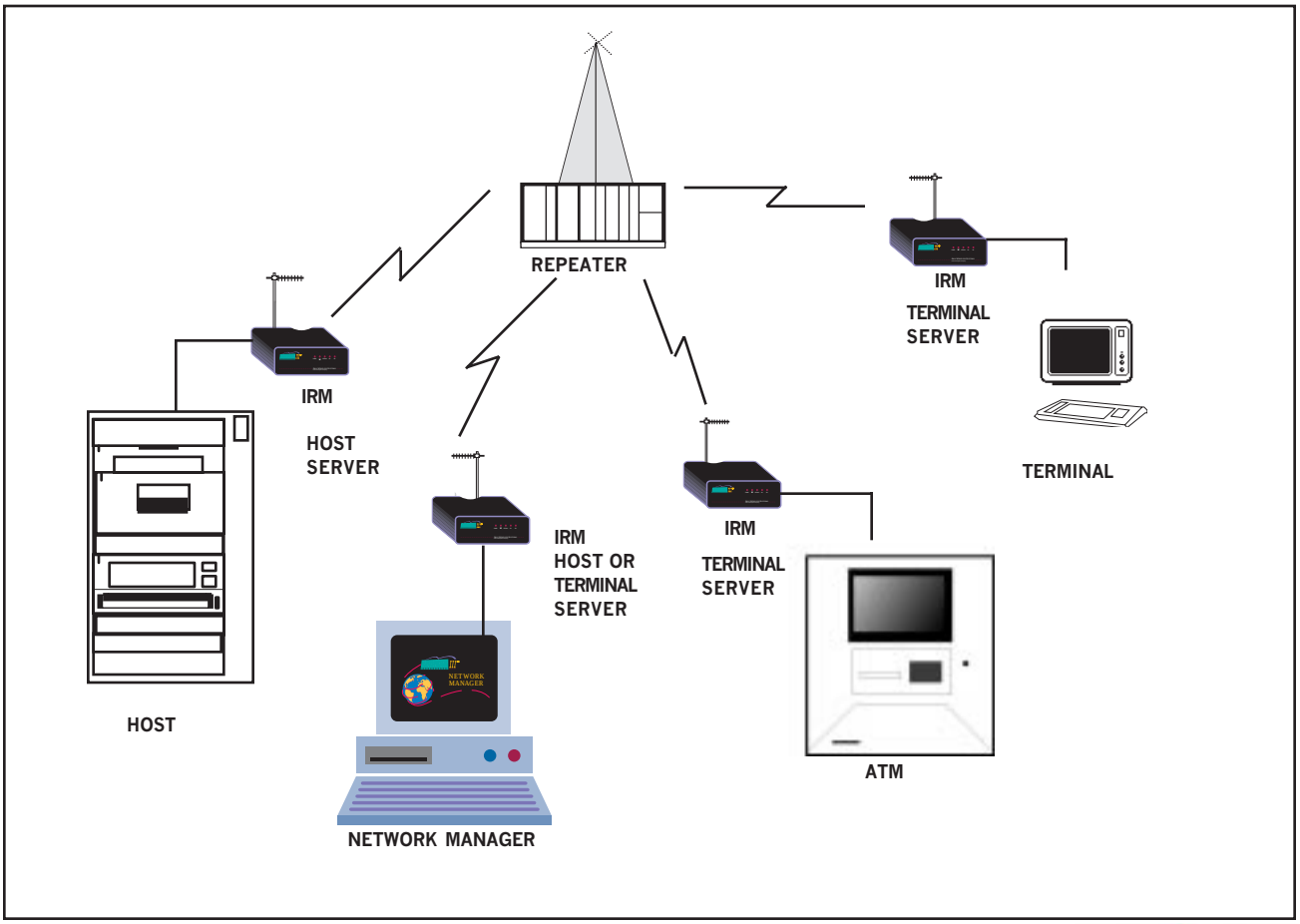
1.) Host Server, or

2.) Terminal Server

When connected to a mainframe, or host computer network, the IRM is configured as a Host Server.

As a terminal server, the IRM connects the terminal or series of terminals to the CEMA network.

Any host or terminal server IRM can be used for Network Manager access.

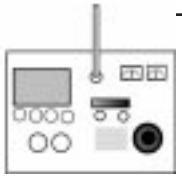


2.1 – Installation General

What to do for Installation Startup

The following chapter will cover these **steps** for installing the IRM unit and checking functionality:

1. Install the antenna
2. Install the data connection
3. Configure the network parameters



4. Perform a radio check-out
5. Go operational – turn the unit on and let it connect!

Warnings to Heed Before Installing your IRM unit

Safeguards

This section contains important safety instructions that apply to the installation, operation and servicing of the IRM.

Read the Instructions

All the safety and operating instructions should be read before the IRM is operated.

Retain the Instructions

The safety and operating instructions should be kept in an easily accessible place for future reference.

Heed All the Warnings

All warnings on the IRM and in the operating instructions should be followed.

NOTE
Warnings pertaining to bodily injury are contained in black boxes like this one.

Follow Instructions

Follow all instructions pertaining to the entire network contained in these manuals. This includes this manual as well as:

Book #	Name
2	System III Repeater Reference Manual
3	System III CEMA Reference Manual
4	System III Network Manager Reference Manual

2.1 – Installation General

Water and Moisture

The IRM should not be used near water. It is intended for indoor use only.

Placement andVentilation

The IRM should be situated so that its location or position does not interfere with its proper ventilation. Openings in the cabinet are provided for ventilation to ensure reliable operation and to protect it from overheating. These openings must not be blocked or covered. Do not place it in an enclosed environment, such as a bookcase or cabinet that may impede the flow of air through the ventilation openings.

Heat

The IRM should be situated away from heat sources such as radiators, heat registers, stoves or other equipment that produce heat.

Grounding or Polarization

The IRM is equipped with a grounded polarized AC line plug. This plug will fit into the power outlet in only one way. This is a safety feature. If the plug should fail to fit into the outlet, contact your electrician to replace your obsolete outlet. If you need an extension, use a grounded polarized cord.

Power-Cord Protection

Power-supply cords should be routed so that they are not likely to be walked on or pinched by items placed upon or against them, paying particular attention to cords at plugs, convenience receptacles, and the point where they exit from the IRM power module.

Cleaning

Unplug the IRM from the wall outlet before cleaning. Do not use liquid cleaners or aerosol cleaners. Use only a damp cloth for cleaning.

Power Lines

The IRM antenna should be located away from power lines.

Outdoor Antenna Grounding

If an outside antenna is connected to the IRM, be sure the antenna system is grounded so as to provide some protection against voltage surges and built-up static charges. In the U.S., Section 810 of the National Electrical Code, ANSI/NFPA, No. 70-1984, provides information with respect to proper grounding of the mast and supporting structure, grounding of the lead-in wire to an antenna discharge unit, size of grounding conductors, location of antenna discharge unit, connection to grounding electrodes, and requirements for the grounding electrode.

2.1 – Installation General

Non- use Periods

When left unused for a long period of time, the power cord of the IRM should be unplugged.

Object and Liquid Entry

Care should be taken so that objects do not fall, and liquids are not spilled, into the enclosure openings.

Damage Requiring Service

The IRM should be serviced by qualified service personal when:

- The power-supply cord or plug has been damaged
- Objects have fallen, or liquid has been spilled into the IRM
- The IRM has been exposed to rain
- The IRM does not appear to operate normally or exhibits a marked change in performance
- The IRM has been dropped, or the enclosure damaged

Servicing

The user should not attempt to service the IRM beyond what is described in the operating instructions. All other servicing should be referred to authorized service personnel.

Placement and Power

Place the IRM on a table or shelf. Insure that the ventilation holes are not obstructed in any way. The IRM should be installed in a clean dry area. Do not install it outside or in a place where it may be exposed to moisture or very high temperatures. The IRM may be operated from 110/120 VAC or 220/240 VAC, 50/60 Hz. The power module automatically adapts to whatever power is used. There is no selector switch.

2.2 – Antenna Installation

Step 1 – Install the Antenna

The IRM operates as a remote station in a multiple access half duplex system. A repeater receiver/transmitter, located at a central point in the network system, receives all remote messages and retransmits the messages to all remote stations. The IRM antenna should be located so that it points to the repeater.

Site Survey

When designing a Multiple Address System (MAS) network, several critical items must be considered:

- location of antenna
- length of cable run
- near field obstructions.

Some of the less obvious items to be considered are:

- radio sensitivity
- radio selectivity
- fade margin
- atmospherics with multipath fading

A Site Survey Form is provided on the following page.

2.2 – Antenna Installation

Site Survey Form

Project Name: _____

Site Name: _____

Address: _____

Contact: _____

Phone _____

SiteInformation:

Approximate Street Location (directions): _____

_____

Building Description (sketch here):

Height _____ Composition _____ Roof Type: _____

Antenna Mounting Structure:

☐ Pipe Mount ☐ Tower Tripod ☐ Chimney ☐ Other

Receive Frequency

RSL From ground: _____

From roof: _____

Antenna location in reference building: _____

Length of feed line required _____

Equipment location: _____

Radio type: _____

Peripheral equipment required: _____

Line extenders, modems, muxes, etc.: _____

Notes: _____

_____

2.2 – Antenna Installation

Antenna Location, Cable Length and Near Field Obstructions

It is important to document and maintain the precise location of the Receive Signal Level test. This will assure that the RSL reported allows a measurable fade margin for the individual location. This also allows the calculation of cable loss to be determined to the location of the radio. In that sense, it is very important to note an approximate distance between antenna and radio location. While taking the RSL, take into consideration near field obstructions such as: trees, buildings, water tanks, and other obstructions. Near field obstructions may sometimes cause multipath fading in different situations.

RSL in Reference to Radio Sensitivity, Radio Selectivity, and Multipath Fading

The usable RSL for an IRM is a signal level that is at least as strong as the receiver's specified sensitivity (-87dBm @ 19.2 K, -90 dBm @ 9600). This signal strength should be maintained at the antenna port of the radio in order to have a proper fade margin. It is also important to consider adjacent channel rejection of any near frequency transmissions in the area. An adjacent channel in combination with a low RSL could create saturation problems.

Fading

Power fading includes results of beam bending, which is affected by terrain clearance, beam angle of arrival, trapping, or deflection of the beam. Power fading due to loss or terrain clearance, also called diffraction fading, may be to depths of 20 to 30 dB. Atmospheric ducts and layers cause power fades up to 20 dB or more, which may persist for hours or days. Multipath fading includes phase-interference effects from ground-reflected and atmospheric paths. Interference may occur between the direct wave and the reflection from ground or water surfaces, as well as between the direct wave and partial reflections from atmospherics or elevated layers.

2.2 – Antenna Installation

Power Budget Calculation

Frequency of Operation = 950 MHz

Free Space Loss Attenuation (dB) = $96.6+20\text{Log}(D_{miles})+20\text{Log}(F_{GHz})$

Antenna gain is specified in decibels above an isotropic point source (dBi). Some antenna manufacturers specify their antenna gain in decibels referenced to a dipole (dBd). The relationship is dBi = dBd + 2.14.

Losses not in the power budget that should be considered in the fade margin:

• Multipath: the reinforcement or cancellation of the directly received signal by signals reflected from the terrain, buildings or other sources.

• Diffraction Loss: the scattering of the beam by buildings, terrain or other obstacles that are partially in the direct path.

• Foliage Loss: absorption of RF energy by trees in the direct path of the beam.

Systems operating in the frequencies of 400, 800 and 900 MHz suffer negligible losses due to atmospheric absorption, rain or snow.

Power Budget Calculation			
Transmit Power (5 watts)			+37.0 dBm
Connector & T-Line Loss (100' 7/8" LLF)			-2.0 dB
Duplexer Loss			-1.0 dB
Omnidirectional Antenna gain			+11.0 dBi
Repeater EIRP (Effective Isotropic Radiated Power)			+45.0 dBm
Free Space Loss (15 miles, 24 km) @ 950 MHz			-120.0 dB
7-element Yagi Antenna Gain			+13.0 dBi
Connector & T-Line Loss (250' 1/2" LLF)			-6.0 dB
Received Signal Strength at Connector			-68.0 dBm
Minimum Receiver Signal Strength, 10-6 BER	-100 dB	-90 dBm	-87 dBm
Fade Margin	32 dB	22 dB	19 dB
Radio Type	2.5 kHz	12.5 kHz	25 kHz
	9.6 bps	9.6 bps	19.2 Kbps

2.2 –Antenna Installation

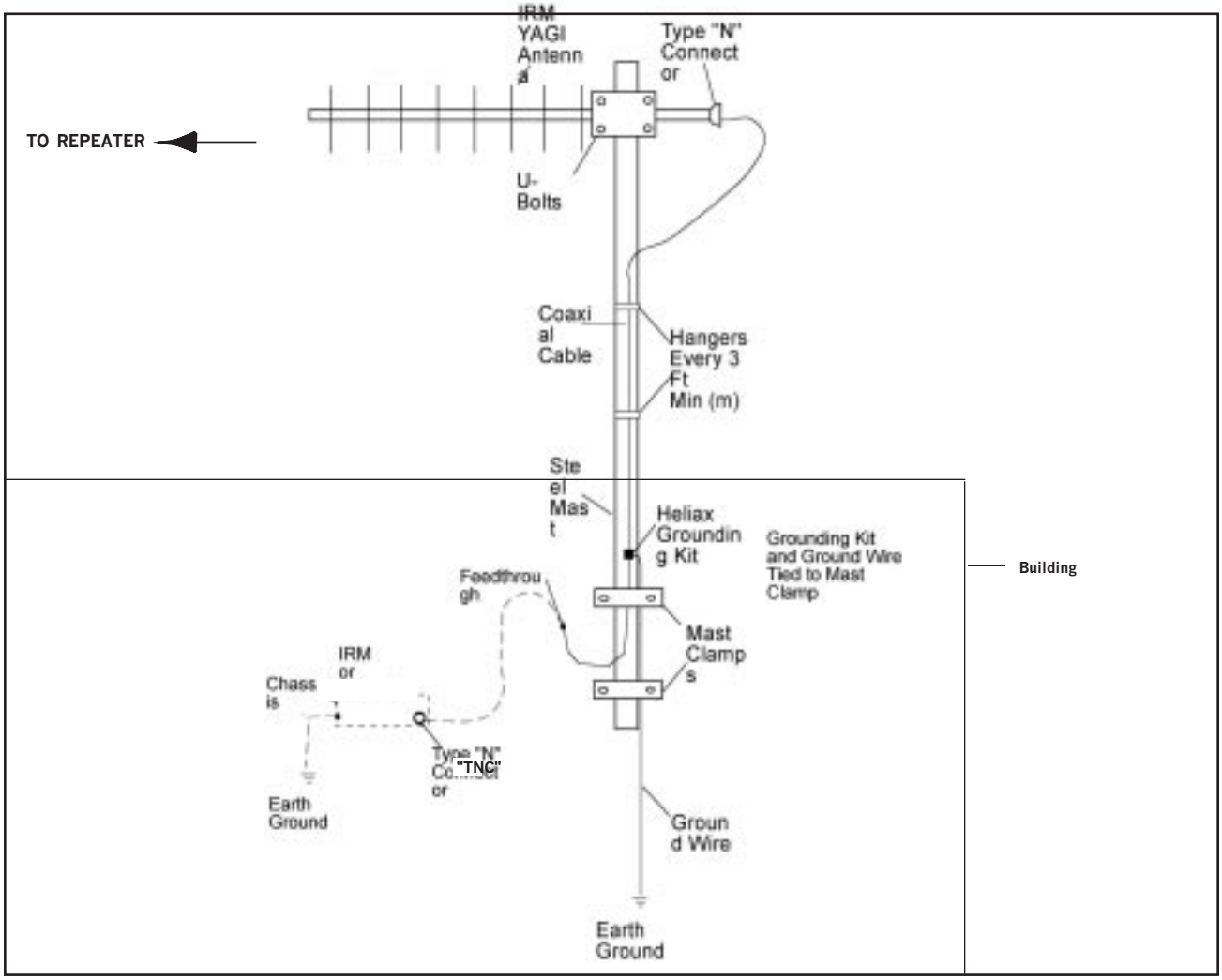
Icing

Along with multipath fading, severe icing affects antenna patterns and in turn the RSL. Yagi antenna performance can be degraded and their directivity even reversed due to severe icing. Icing reduces usable antenna bandwidth and distorts radiation patterns. Experiments have shown that as ice loading increases, impedance match and radiation pattern changes become progressively worse.

For a given thickness, deviation from performance values become worse as frequency goes up. The thicker the ice on the radiator, the more the fed dipole's resonant frequency is reduced. This effect makes it seem as if the directors were lengthened. Basically, as the amount of ice increases, the propagation characteristics of the antenna approaches zero, and the antenna is no longer directional but becomes a reflecting system.

Mounting

The IRM antenna must be mounted so that it has unobstructed line of sight to the repeater location. The antenna is usually mounted on a pipe mount or tower on top of a building or some structure that will provide the proper height.



2.2 – Antenna Installation

What Types of Antennas To Use

The antennas used by IRM remote stations are directional, meaning the radiated energy from the antenna is focused into a narrow beam and transmitted toward the repeater antenna. A typical antenna would be a broadband yagi antenna with a gain of 10 dB and impedance of 50 ohms. Directional antennas must be aimed at the repeater antenna quite accurately (± 10 degrees); otherwise the beam will miss the repeater and the repeater will receive a low signal level or no signal at all.

Typical 400 MHz Yagi Antennas

Model Number*	Frequency MHz	Gain (dBd)	Number of Elements
PLC-406	406-402	7.5	6
PLC-456	450-470	7.5	6
PLC-476	470-490	7.5	6
PLC-496	490-512	7.5	6
PLC-4010	406-402	11.5	10
PLC-4510	450-470	11.5	10
PLC-4710	470-490	11.5	10
PLC-4910	490-412	11.5	10

Wind survival, PLC models: 125 mph (200kph)
Max. mast mount, PLC models: 2 in (5cm)

*To order PLC antennas with an N-connector, add an N to the model number. For example, PLC-4510N.

Typical 900 MHz Yagi Antennas

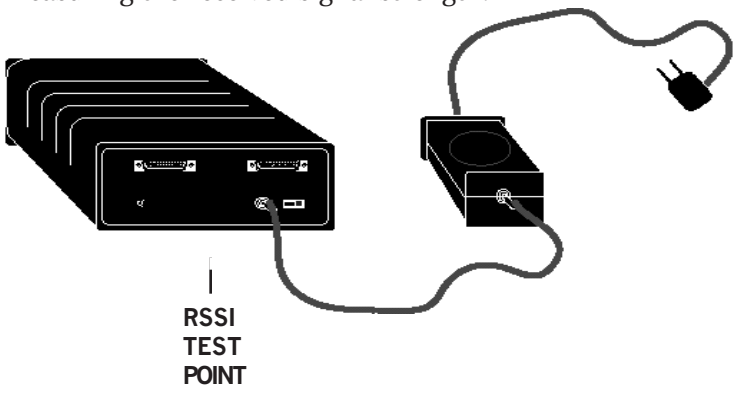
Manufacturer	Model	Type	Gain
Cushcraft	9010N	Yagi	10 dBd
Cushcraft	904N	Yagi	4 dBd
Sinclair	SRL-415	Yagi	10 dBd
Scala	TY-900	Yagi	10 dBd
Mark	CV9900	Omni	9 dBd
Cellwave RFS	(Variety)	Omni	(Variety)

2.2 – Antenna Installation

Aligning the Antenna

When mounting the antenna, make a coarse alignment. Use a compass to calculate azimuth and elevation positions and rotate the antenna to its approximate position. For fine antenna alignment, position the antenna while monitoring the RF signal strength received from the repeater. The antenna is aligned when the maximum signal strength is attained.

The test point at the rear of the IRM is for measuring the received signal strength.



Use a DC Volt meter to measure the Received Signal Strength Indicator (RSSI) voltage. Use one of the panel screws as a ground reference point. Refer to this table for Signal Strength Measurement:

Receive Signal Strength Indication

400/500 MHz		800/900 MHz	
dBm	**VDC**	**dBm**	**VDC**
>-30	5.0V	>-30	5.0V
-40	5.0V	-40	4.75V
-50	4.9V	-50	4.25V
-60	4.4V	-60	3.75V
-70	3.8V	-70	3.25V
-80	3.2V	-80	2.75V
-90	2.6V	-90	2.25V
-100	2.0V	-110	1.75V
-110	1.3V	-110	1.3V
<-120	1.1V	<-120	1.1V

2.2 – Antenna Installation

Coaxial Cable

The coaxial cable carries the RF signal between the antenna and the IRM. The type of cable used for any particular installation depends on the amount of loss of RF signal that can be tolerated. A number of cable types and sizes are available. The lowest signal loss is achieved by the larger and more costly cables. The loss may range from 0.8 dB to 8.9 dB per 100 ft. among different cable types.

These are some of the cables available for use at RF Frequencies. The table gives the loss per unit length at 950 MHz. Losses will be less at 400 MHz.

Typical Coaxial Cables

Cable Size and Type	Loss Per	Loss in dB Per 100 Ft.	Loss in dB Per 100 Meters
Andrew LDF7-50A	1 5/8 inch heliax	0.8	2.7
Andrew LDF5-50A	7/8 inch heliax	1.3	4.3
Andrew LDF4-50A	1/2 inch heliax	2.3	7.7
Andrew FSJH-50B	1/2 inch superflex heliax	3.6	11.7
Belden 9913	7/16 inch PVC jacketed	4.5	14.8
Belden 9914	7/16 inch RG8/U	6.0	19.7
RG-213/U	7/16 inch PVC jacketed	8.9	29.2

Run the cable from the antenna down the pole or mast into the building. Connect it to the IRM with a male type TNC connector. The coaxial cable must be firmly supported through its entire run so it will not move under severe weather conditions. If a cable is allowed to move, it will eventually fatigue mechanically and fail. A wide variety of hardware is available for mounting coaxial cables. Connect the antenna cable to the type TNC connector at the rear panel. Tighten the screw type connector by hand until it is tight.

2.2 – Antenna Installation

Recommendations

The following is a list of installation recommendations.

- When 2 or more IRMs are used at the same location, maintain at least 4 feet (1.3 meters) vertical spacing between yagi antennas for 400-500 MHz radios and at least 2 feet (.70 meters) vertical spacing between antennas for 900 MHz radios.
- Use RG 213/U coax up to 75 feet (25 meters), 1/2 inch hard-line over 75 feet, 7/8 inch hard-line over 150 feet (50 meters) for remotes.
- Use 7/8 inch coax or greater for repeater installations.
- Use only directional yagi antennas for all remote and host IRM installations.
- Maintain clear line of sight to the repeater at all remote and host IRM locations. Using multipath may work but is not recommended for maximum performance.
- Maintain an RSL (Receive Signal Level) at least as strong as the receiver's specified sensitivity at all locations (20 dB above noise floor or better is recommended) for best performance with adequate fade margin.
- Maintain a VSWR of 1.3:1 or better on all antennas.
- Do not exceed an RSL of -20 dBm at any receiver to reduce the possibility of distortion due to saturation.
- All remote, host and repeater antenna installations must be properly grounded. This includes grounding the feed line and radio housing to the building ground or grounded tower.
- All DTE cables should be shielded and as short as possible (under 50 feet for RS-232-C devices).
- Leave IRM AC line power on at all times to maintain stability and long term performance.
- Use 1.5 inch galvanized pipe for yagi antenna mast.

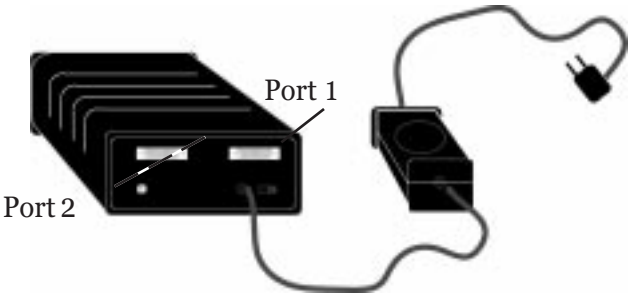
Summary

In order to increase signal strength several options can be considered. The cable run, connectors and antenna must be checked to make sure there is a proper antenna system. If the signal degradation is intermittent, the antenna height may need to be raised. However, the antenna gain may be increased by the use of a co-phased antenna. This is essentially two antennas aligned to obtain an additive signal. Usually this results in a 3 dB gain overall. The last option would be relocation of the antenna in order to avoid near field obstructions and possibly shorten an extra long cable run.

2.3 – Data Interface

STEP 2

Install the Data Connection



Connect the user DTE equipment to the user ports at the rear panel. These ports are RS-232C, DCE, 25 pin D-type female connectors. Up to two user ports are available, and are labeled Port 1 and Port 2. The use of shielded RS-232 cables between the IRM and user equipment is recommended to insure the IRM system complies with mandated emissions limits.

DCE User Port Interface Signals

DB-25 Pin	Signal
1	Frame Ground
2	Transmitted Data (TD), input
3	Received Data (RD), output
4	Request to Send (RTS), input
5	Clear to Send (CTS), output
6	Data Set Ready (DSR), output
7	Signal Ground
8	Carrier Detected (DCD), output
9	Test +12V, output
10	Test -12V, output
11	
12	
13	
14	
15	Transmission Clock, DCE Source, output
16	
17	Received Clock DCE Source, output
18	
19	
20	Data Terminal Ready (DTR), input
21	
22	Ring Indicator (RI), output
23	
24	External Transmitter Clock (ETC)
	DTE Source, input

2.3 - Data Interface

IRMs, Tail Circuits and Modems

In certain installations of IRMs, it will be necessary to use cross-over (tail circuit) cables, short-haul and dial-up modems to obtain connectivity of the RS-232 port to a distant device. The IRM's RS-232 ports are configured as DCE (Data Communications Equipment), either synchronous or asynchronous, depending on the configuration of the IRM. The physical port parameters follow the rules in EIA specification EIA-232-E, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

With a straightforward connection, such as an IRM (DCE) connected to a data terminal device (DTE), wiring is as simple as a straight-through DB-25 cable to connect the two devices. In an asynchronous application, the two devices will then require configuration to match port speeds.

In a synchronous application, speed will have to be set along with which device will source the clock, and the handshake configuration (RTS/CTS). In most installations, the DCE provides clock to the DTE, which is the default setting (internal clock) on the IRM.

When the IRM is to be connected to another DCE device such as a modem or multiplexer, special cables and timing settings are required to maintain synchronization between the devices. Typical examples of these types of circuits are illustrated on the following pages.

Tail Circuit

A tail circuit is a special cable that connects two DCE devices to each other. It transposes the receive/transmit data, clock and handshake lines to make each end "look" like a DTE.

2.3 - Data Interface

Example 1: Dial-Up Modem

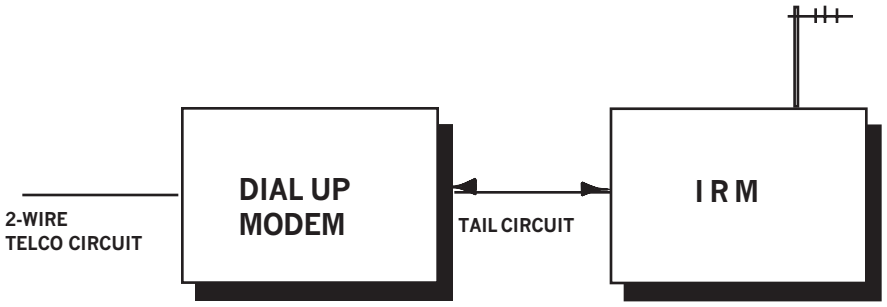
The connection of a dial-up modem to a Network Manager IRM for remote monitoring of a system is an asynchronous DCE to DCE connection that requires a tail circuit. The baud rates must be matched for both devices and the modem configured for auto-answer.

Modem configuration is left to the user, but certain S- register parameters must be programmed as follows. Programming the modem is detailed in the manufacturer's operation manual. The example given is for a 9600 bps, V.32 Modem such as Black Box Modem 4232.

Modem Settings:

S Register 0, 'Rings to answer": 1 or more, set to number of rings desired to answer the line.

S Register 21, "Terminal Bit-Mapped Operations": 96, DCD ON only with carrier present, DSR ON at initiation of connection.

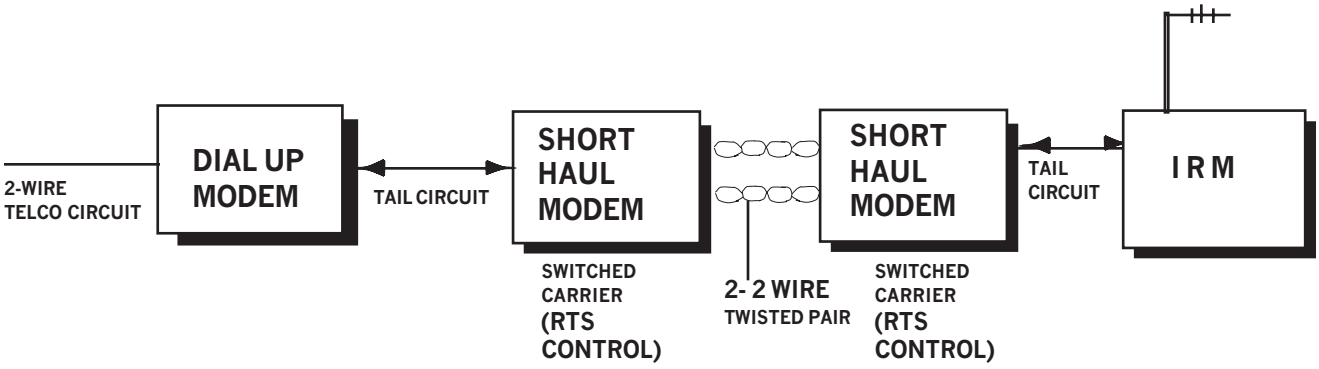


2.3 - Data Interface

Example 2: Asynchronous Short-Haul Connection

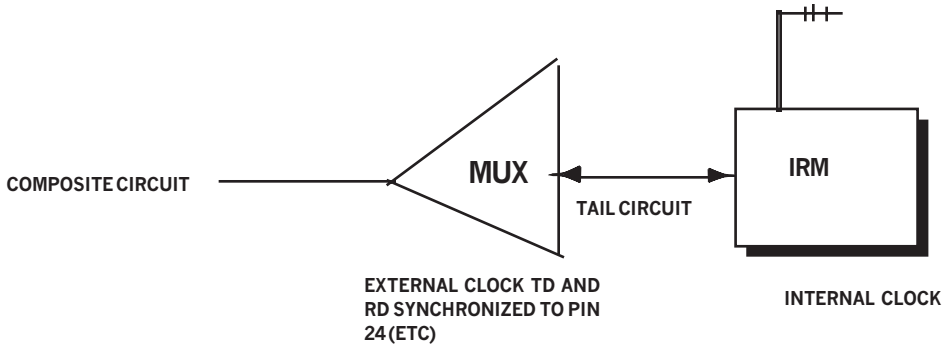
An example of this type of connection is the connectivity of the Network Manager node to a dial-up modem via short-haul modems.

The short-haul modems require switched-carrier operation under control of RS-232 signal RTS (Request To Send).



Example 3: Synchronous DCE - DCE Connection

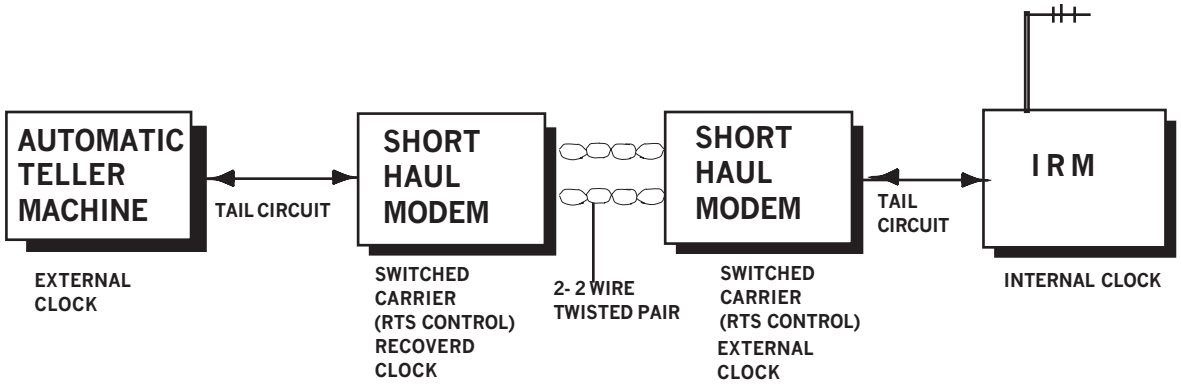
An example of a synchronous DCE - DCE circuit is a multiplexer (normally a DCE) connected to a host server IRM. This type of connection is used to provide the host line connection to the IRM from a remotely located mainframe computer or front-end processor.



Example 4: Synchronous Short-Haul Modem (SHM) Connection

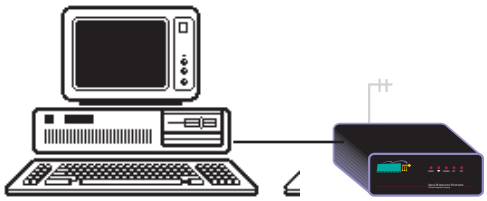
This circuit is used when the IRM is separated from the terminal device (an ATM, for example) by a long distance. The clock source will be the IRM (internal), with the SHM connected to it set for external, the SHM connected to the ATM set for recovered, and the ATM set for external.

This synchronizes all of the devices in the chain to the IRM clock. The SHM's must be configured for constant carrier mode with the RTS/CTS delay at the terminal end set greater than the RTS/CTS delay set in the IRM.



3.1 - Configuration

Step 3 - Configure the Network Parameters



There are several user settable parameters in the IRM that must be set prior to operation. These are set via the PC-based configuration menu of the Network Manager.

> NOTE
> The IRM is a Network device - it works in concert with many other units on a network. Many of its parameters (frequency, network address, etc.) depend on the network parameters. Refer to Book #4 (the Network Manager) for instructions on how to operate the configuration utility of the Network Manager.

There are two methods of configuration:

- Local - PC connects directly to the IRM
- Remote - modifications are made over the radio network

Local is recommended for initial installation or when a change is necessary and the CEMA network is not up.

Remote configuration is for minor modification on an operational unit. It has the advantage of eliminating a trip to the remote site.

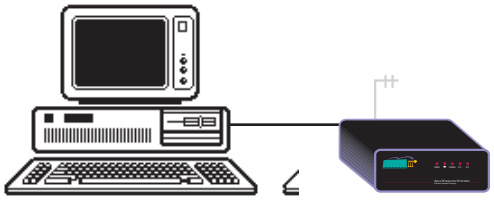
The following items ***must*** be configured before the unit is operational:

- Receive and Transmit Frequencies
- CEMA addressing
- Protocol Selection (each port)
- Protocol specific parameters

3.2 - Local Configuration

Local Configuration

1. Connect the equipment as shown below. The PC's COM serial port connects to the IRM's Port 1 with a standard RS232 straight through cable.



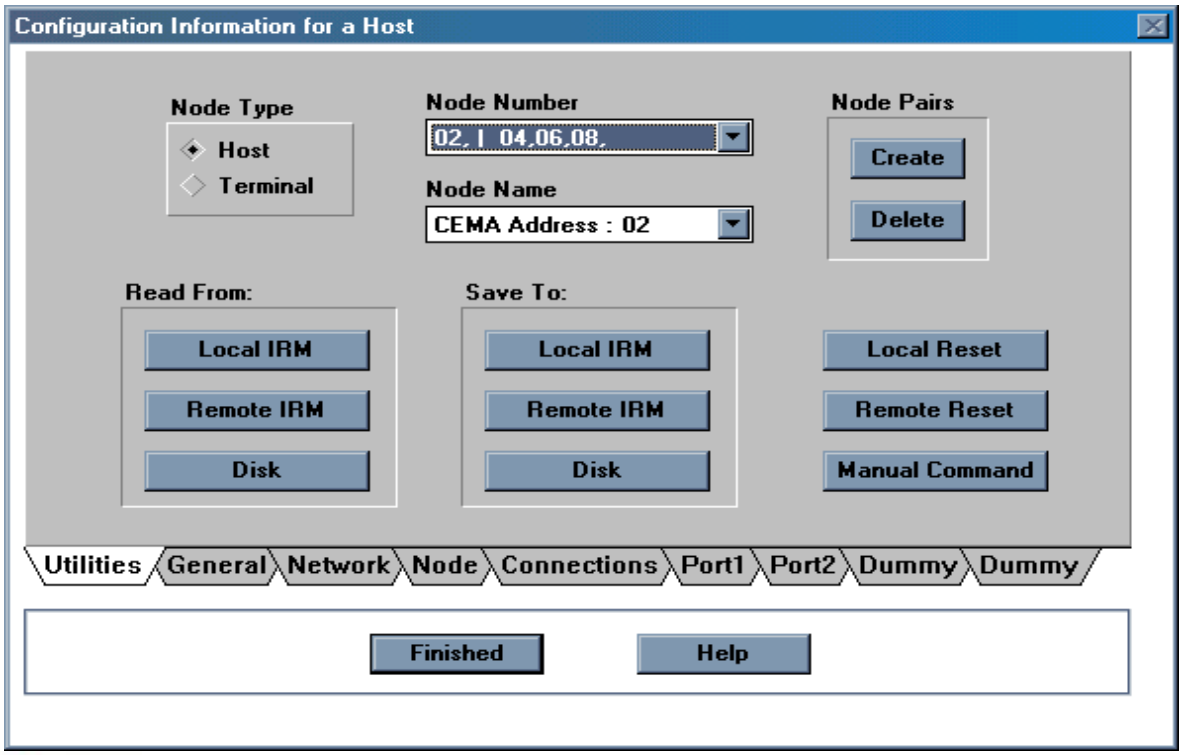
2. Start the Network Manager program, and call up the General Screen by pressing the Tab...(to be imported from Network Manger manual - Book#4).

3. Turn on the IRM. The IRM will enter the local configuration mode under any of the following conditions:

a. It recognizes Network Manager connection on Port 1 within the first several seconds of power up.

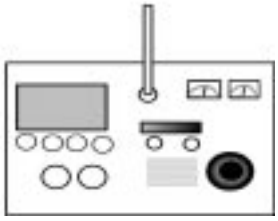
b. The IRM is in its default configuration: i.e., no protocols enabled, Port 1 as the Network Manager port, and Port 2 as the Diagnostic port. This is the usual configuration from the factory.

c. Internal switch forces Port 1 to the Network Manager interface. Use this if methods (a) and (b) above don't work (see SEC 4.2 mode switches).



3.3 - Radio Frequency Check

Step 4 - Radio Frequency Check



Once the IRM is installed and configured, the last step before going operational is checking the radio frequency with an RF Communication Test Set.

Equipment

RF Communications Test Set IFR model 1200S, (HP Model 8920A), or equivalent.

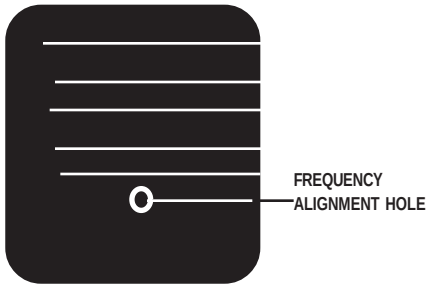
Procedure

1. Place the RF Communications Test Set in close proximity to the IRM, and set it to receive the IRM's transmit frequency. Place a small portable antenna on the IFR antenna port.

2. With a small portable antenna connected to the IRM's antenna port, turn ON the IRM. Its transmit oscillator will generate a small amount of RF.

> WARNING
> NEVER connect the IRM's RF port directly to the RF Comm Test Set antenna port. It will damage the RF Comm Test Set when the IRM transmits.

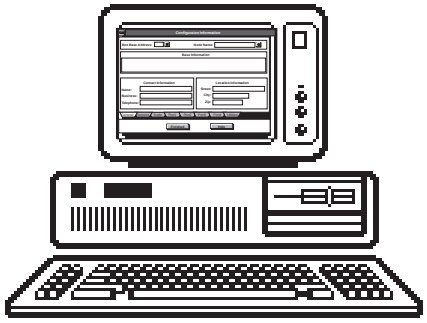
3. Measure the center frequency of the IRM's transmitter and adjust the frequency to within 0.00005% (e.g., at 928 MHz => +/- 450 Hz) with a non-metallic tuning tool. The adjustment screw is accessed from the bottom of the unit, through a hole in the bottom cover.



BOTTOM VIEW OF IRM

3.1 - Configuration

Step 3 - Configure the Network Parameters



There are several user settable parameters in the IRM that must be set prior to operation. These are set via the PC-based configuration menu of the Network Manager.

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Remote configuration is for minor modification on an operational unit. It has the advantage of eliminating a trip to the remote site.

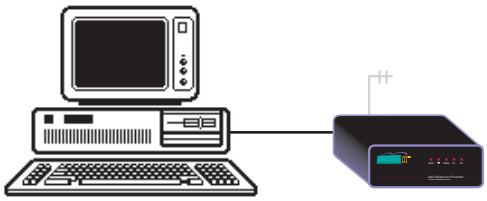
The following items ***must*** be configured before the unit is operational:

* Receive and Transmit Frequencies
* CEMA addressing
* Protocol Selection (each port)
* Protocol Specific parameters

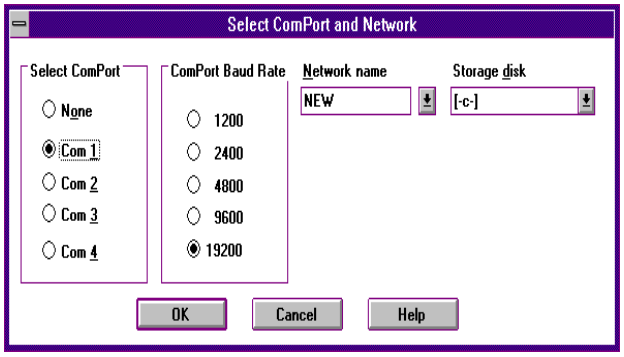
3.2 - Local Configuration

Set Up

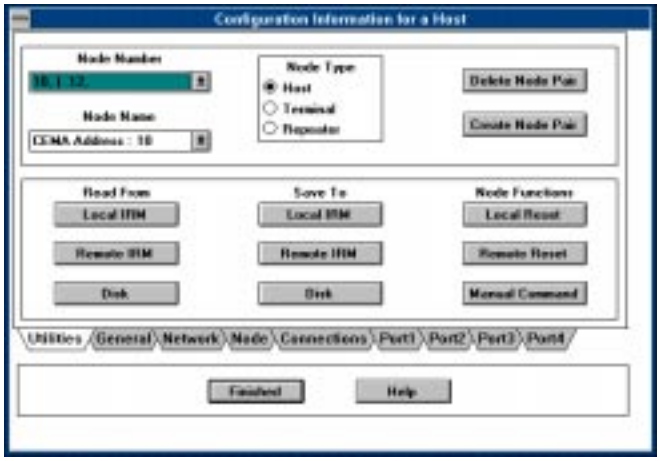
Connect the equipment as shown below. The PC's COM serial port connects to the IRM's Port 1 with a standard RS232 straight through cable. Note which COM port is being used on the PC for future reference. Turn on the IRM and verify functionality.



Detailed information pertaining to the Network Manager Program and its operation is covered in the Network Manager Manual (Book #4). Running under Windows, activate the Network Manager Program and select the Setup menu choice. Enter PC Com port, baud rate, and desired Network database selections.



Running in the Command and Config window, Select "Config" to access IRM Configuration Information window. You will see the following screen:



You will notice that when a "Node Type" is selected, the menu entries are filled in under the "Read From", "Save To" and "Function" sub-titles. This indicates that the Network Manager recognized the IRM and is prepared for further configuration activities.

3.2 - Local Configuration

If the Network Manager does not recognize the IRM, the Config Screen will look like this:

Reset the IRM and re-select the Node Type. Be sure to allow enough time for the IRM to power-up and run its self tests. Once the IRM has been recognized, information can be downloaded or uploaded locally by simply performing a local “Read” or “Save” from/to an IRM.

The default factory configuration for an IRM is no protocol enabled, Port 1 as a Network Manager Port, and Port 2 configured as a Diagnostic port. To configure an IRM with new information, simply configure each configuration menu tab with required information and perform a local “Save To” function. Refer to the Network Manager Manual (Book #4) for detailed configuration information.

3.3 - Remote Configuration

Remote configuration of an IRM requires the unit be an active participant on a network and previously configured (locally). Being an active participant, the unit is able to receive and acknowledge changes to its configuration over an operation network. Typically, the IRM and Network Manager used to monitor network performance is used re-configure remote units. Refer to the Network Manager Manual (Book #4) for detailed Remote configuration information.

NOTE: When remotely configuring an IRM, it is prudent that a Remote "Read From" be executed to acquire existing remote IRM configuration information. Typically, the remote configuration function is used to modify an existing port or network parameters, thus all other previously configured information is unchanged and configuration changes are achieved by simply editing the acquired configuration information.

Identify the IRM (Node Address) that is to be re-configured and note it for future reference.

Bring up the Network Manager and IRM that will be used to issue remote configuration commands using the same procedure local configuration. Verify that the unit is an active participant on the network by verifying the operational LED patterns discussed in Section 4.1 of this document.

To acquire existing remote configuration information, select the (Remote IRM) "Read From" function and enter the remote node address as instructed.

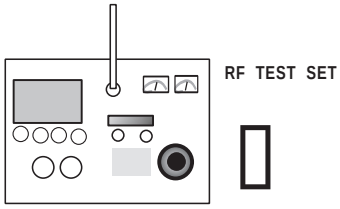
Upon entering the node address and issuing a "Read", you will notice status information being displayed in the lower left-hand corner of the display. This information is the actual configuration data of the remote IRM and can accessed by simply selecting/ displaying the various menu tabs contained within the Network Manager Config window. Upon receipt of a "Finished with Retrieve" status message, all configuration information will have been retrieved from the remote IRM.

Make any configuration changes by simply editing each Config window menu tab selection. Upon completion of the configuration changes, return to the Utilities menu and execute a (Remote IRM) "Save To" function.

Enter the remote node address as instructed and execute the "Write" function. Again, observe the lower left-hand portion of the display for status information.

Upon receipt of a finished, with port configuration, the remote configuration has taken place and the new configuration changes are in place.

3.4 - Radio Frequency Check



Once the **IRM** is installed and configured, the last step before going operational is checking the radio frequency with an RF Communication Test Set.

Equipment
RF Communications Test Set IFR model 1200S, (HP Model 8920A), or equivalent.

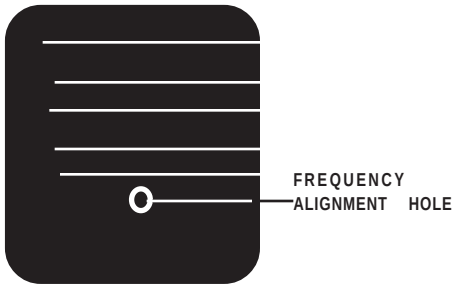
Procedure

1. Place the RF Communications Test Set in close proximity to the IRM, and set it to receive the IRM's transmit frequency. Place a small portable antenna on the IFR antenna port.

2. With a small portable antenna connected to the IRM's antenna port, turn ON the IRM. Its transmit oscillator will generate a small amount of RF.

> WARNING
> NEVER connect the IRM's RF port directly to the RF Comm Test Set antenna port. It will damage the RF Comm Test Set when the IRM transmits.

3. Measure the center frequency of the IRM's transmitter and adjust the frequency to within 0.00005% (e.g., at 928 MHz => +/- 450 Hz) with a non-metallic tuning tool. The adjustment screw is accessed from the bottom of the unit, through a hole in the bottom cover.



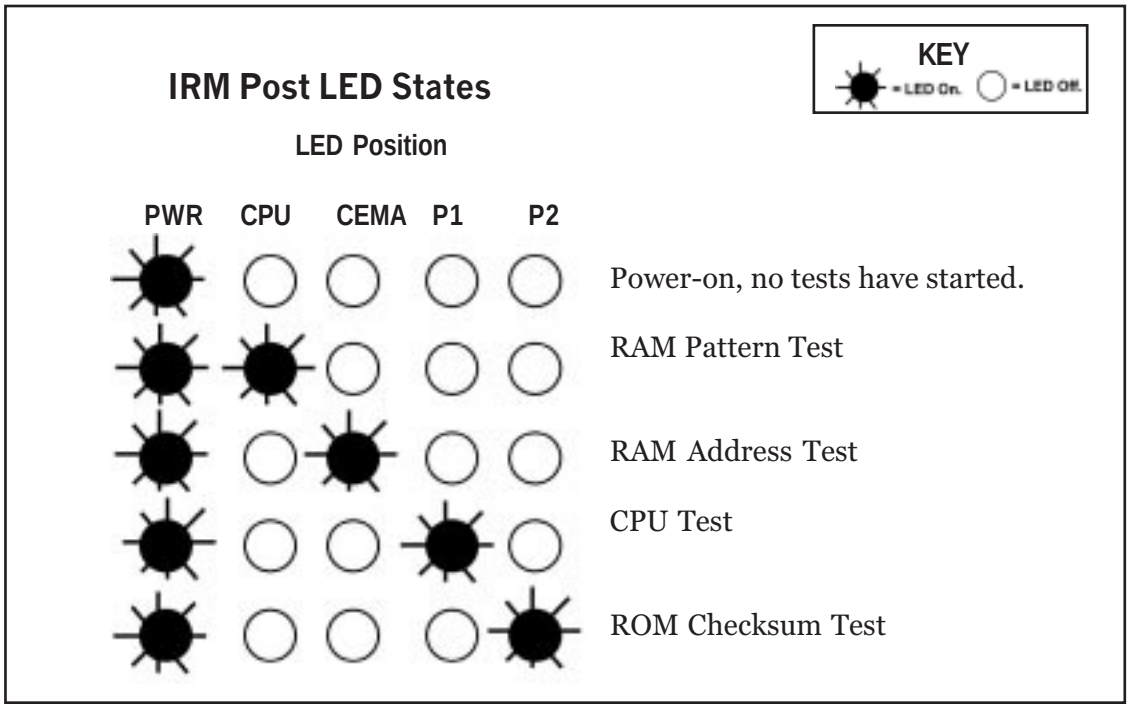
BOTTOM VIEW OF IRM

4.1- LED Display

Power On Self Test

Immediately after applying power to the IRM, the front panel LEDs will display the status of the Power On Self Test (POST).

Completion of POST is indicated by the right-hand four lamps displaying a motion pattern from right to left and back three times.



Radio Tuning

After POST is complete, the Radio tuning Process will take place. This is indicated by flashing the CEMA and P1 LEDs.

Operational Modes

At the completion of the Radio tuning process, one of the operating modes will be entered. Which mode is entered is dependent on the internal switch setting as described later in this section. For each operational mode, a unique front-panel LED pattern is displayed.

4.1- LED Display

Operational Mode LED Patterns

MODE	LED Pattern Description
Invalid Configuration Mode	All LEDs flash together at a 1/2 Hz rate.
Invalid ROM (Flash RAM) checksum	LED #2 (CEMA) flashes at a 2 Hz rate.
Radio Test Mode	One LED will continuously scan from left to right.
Bit Error Rate Test Mode	Two LEDs will continuously scan from left to right.
Burn-in Diagnostic Mode	One LED will scan back and forth
Normal Operational Mode	See the section that follows.

During normal operation, LEDs will display like this:

NORMAL LED DISPLAY

LED	DESCRIPTION
PWR	+5V Power Always On
1 CPU	Blink - Normal Operation Steady - IRM error condition
2 CEMA	Network Active ON - Network is active OFF - Network is not active
3 (P1)	Port 1 Protocol Status
4 (P2)	Port 2 Protocol Status

4.1- LED Display

The precise behavior of the protocol status LEDs differ depending on the protocol. Refer to the specific protocol section in the CEMA software manual for complete details. In general, the port status LEDs behave like this:

Port Protocol Status Display

LED Behavior	What it Means
Off:	Port has not established connection with it's remote partner.
Slow Blink: 1 second On, 1 second Off (Same rate as CPU LED)	Port has made connection with its remote partner, but there is no data activity or polling at the port.
Fast Blink: half-second On, half-second Off (Twice as fast as CPU LED)	a.) Host Server - recognizes polls but is not responding because the remote terminal is not responding. b.) Terminal Server - polls are being sent, but no response is received.
ON: Port is sending and receiving polls and responses.	Port is sending and receiving polls and responses.

4.1- LED Display

CEMA Diagnostic Display

Optionally, the LED display can be changed to a CEMA diagnostic display by changing the Port Status internal switch #5as described in the next chapter and shown by this symbol.

The CEMA Diagnostic display is described in the following chart:

CEMA DIAGNOSTIC DISPLAY

LED		DESCRIPTION
1	CPU	CPU LED Blink - Normal Operation Steady - IRM error condition
2	CEMA	Network Active ON - Network is active OFF - Network is not active
3 (P1)	CEMA	Transmit ON - IRM has data to send to the radio network OFF - IRM does not have data to send
4 (P2)	CEMA	Receive ON - IRM has sent data and is expecting an acknowledgment OFF - IRM has received the proper acknowledgment for all data sent

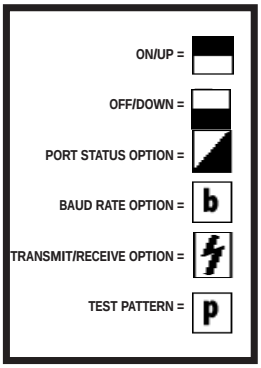
4.2 - Mode Switches

Internal Switches

Internal switches are used for special purpose diagnostics and testing to:

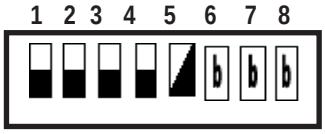
- Force configuration mode when other methods are unavailable, or when different baud rates must be used.
- Perform advanced diagnostics on CEMA
- Enter test pattern mode when testing the radios

Access the internal switches by removing the top cover (see section 5).



Switch Position Description

Normal Operational mode (attempt will be made to enter configuration mode before going operational)



bbb=baud rate option

= port status option

NOTE
Leave switches in NORMAL MODE unless you are performing diagnostics or testing.

Radio Test Mode

= Transmit/receive option

= Test Pattern

Baud Rate Option:

b b b	Meaning
	19200 baud
	9600 baud
	2400 baud
	1200 baud

Test Pattern Option:

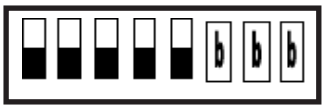
p p p	Meaning
x x x	Receive Mode (x = don't care)
	Transmit Pattern 00H (2-state FSK)
	Transmit Pattern 55H (4 state FSK)
	Transmit Pattern FFH

Port Status Option:

	Meaning
	Port Status LEDs show the port protocol status (normal)
	Port Status LEDs show the CEMA transmit /receive status (diagnostic)

4.2 - Mode Switches

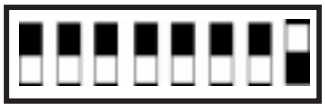
Non-configuration operational mode (system will not attempt to enter configuration mode, instead it will enter operational mode immediately)



Forced configuration mode (will not enter operational mode)

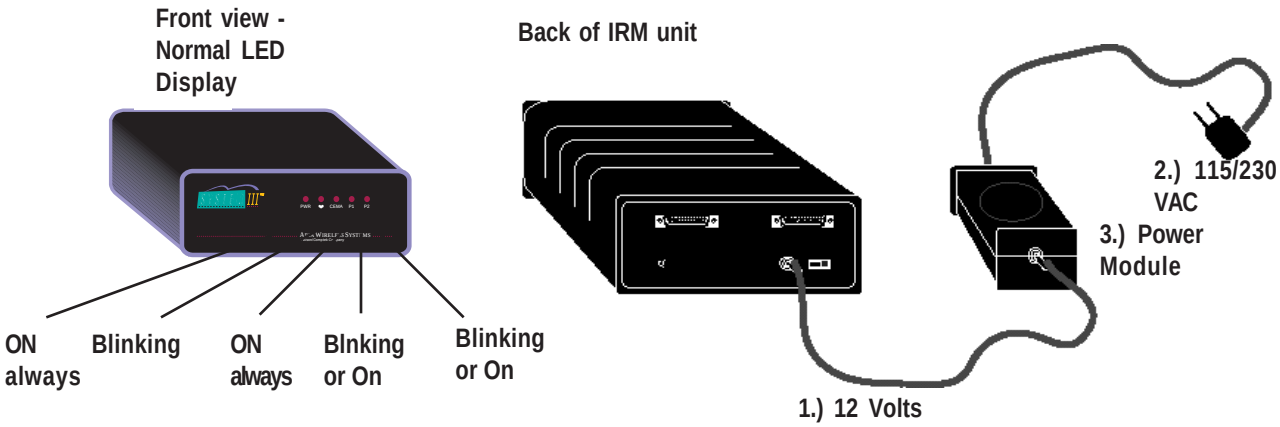
bbb=baud rate option

Diagnostic Mode is for factory use only.



Factory Burn-in Mode is for factory use only.

4.3 - Troubleshooting



The front panel LEDs are illuminated as above in normal operating conditions.

Front Panel LED illuminations only provide information for basic operational conditions.

LED	Indication	Problem	Solution
POWER	Not illuminating.	Not getting power to the IRM unit.	a.) Make sure Power Switch (1.) is ON. b.) Make sure the 12V Power Cable (2.) coming from the power module is connected to the IRM unit. c.) Make sure that the 115/230 VAC is plugged in to an outlet. d.) Measure 12V on DC cable for output with the DC voltmeter.
	No 12 Volts out of power module.	If all these have checked out and there is no voltage.	Replace the Power Module (3.).
POWER	LED still not illuminated.	IRM unit doesn't power up when supplied 12V DC.	Remove the rear panel, check interconnnecting cable. If 12 Volts (1.) is present at the CPU board, then replace CPU board. If not, replace Radio board.
CPU	Light is not blinking at a one-second rate.	CPU is not running correctly.	a.) Make sure that PWR LED is illuminated. b.) Make sure that the IRM is in Operation mode, not Configuration mode. Replace CPU board.

Troubleshooting guide is continued on next page...

4.3 - Troubleshooting

LED	Indication	Problem	Solution
CEMA	LED is not steady ON.	IRM does not recognize a valid CEMA network.	a.) Make sure that PWR LED is on, and CPU LED is blinking. b.) Check RF signal level, antenna cable connection and antenna alignment. c.) A possible radio problem exists. Either replace the radio board, or refer to Refer to the CEMA Manual for diagnosing a CEMA network.
Port 1/ Port 2	LED is not illuminating.	Port has not made connection with its remote partner.	a.) Make sure that PWR CPU and CEMA LEDs are illuminated. b.) Verify port addressing. c.) Refer to the CEMA reference manual for port addressing procedure.

NOTE
LEDs will behave differently, depending on protocol software. Refer to the CEMA manual for LED behavior.

Up to this point, you have been troubleshooting general operating problems. If communications are still not established and the radio link is known to be good, it may be an interfacing problem or network addressing problem. Refer to the CEMA Software Reference Manual for details on CEMA Addressing and interfacing to your specific protocol.

5.1 - Servicing

General Servicing

WARNING
Servicing should only be performed by qualified factory trained service personnel. Removing the cover of the IRM creates the risk of electrical shock.

Servicing by unauthorized personnel may void your IRM Warranty.

NOTE
Many hardware components are specified in metric. Be sure to use metric tools (nut drivers, wrenches, etc.) when appropriate.

WARNING
Always disconnect the AC Power Before Removing the IRM cover to avoid the risk of Electrical Shock.

NOTE
Remember that you are working with ELECTROSTATIC SENSITIVE devices.

Electrostatic Sensitive Device (ESD) Precautions

The digital logic board and the radio board contain electrostatic sensitive devices, and circuits may be damaged if proper precautions are not observed.

- Handle the boards only while wearing a grounded wrist strap and working at a static free workstation.
- Circuit boards should be stored in anti-static bags and in their original shipping packaging.
- If a wrist strap and static free workstation are not available and a board must be handled, use the following procedure to reduce the possibility of ESD damage.
- To discharge any static charge from your body, place one hand in contact with the chassis before touching a circuit board. Keep your hand in contact with the chassis while handling the board. Do not touch any of the ICs and pick up the board only at the edges.
- Do not set the board down on a work surface.
- Return boards to anti-static bags as soon as possible.

5.1 - Servicing

Servicing

Most problems with the IRM are due to improper configuration of the programmable parameters or mis-application or incompatibility with the interfacing software.

When a fault does occur, it is usually best to replace the entire unit at the remote site, then perform repairs at a repair shop.

There are three replaceable assemblies in the IRM. They are:

- Power Module
- CPU board
- Radio board

Test Equipment

To service your IRM unit, the following equipment, or its equivalent is recommended:

1. RF Communications Test Set

- IRF Model 1200S Communications Service Monitor **IFR, Inc, Wichita, KS**
- Hewlett Packard Model 8920A, RF Test Set, **Hewlett Packard, Cupertino, CA**

2. Data Line Monitor

- **Feline Parascope Data Monitor**, Frederick Engineering, frederick, MD.
- **Hewlett Packard 4952A Protocol Analyzer**, Hewlett Packard Corp., Cupertino, CA

5.2 - Internal Access

When to Open the Unit

You will need internal access to the IRM unit when:

- replacing the CPU board or radio board
- accessing the DIP switches to enter the various test modes

You do not need internal access to perform a routine frequency alignment.

To access any internal components, follow this procedure:

Removing the back panel

1. Disconnect the DC power, antenna cable and data cable(s) from the rear panel connectors.
2. Remove the screw at each of the four corners of the back panel.
3. Remove the two hex nuts from each 25-pin "D" data connector.

The rear panel and bezel will now remove freely from the case.

Removing the Top Cover

Slide the top cover off the bottom base by pulling it towards the rear of the unit. The front panel and bottom cover will remain attached to the unit's frame.

CPU Board Removal/Replacement

1. Remove the two Phillips screws at the front edge of the board (LED side), near the U27 power converter. Do not remove the power converter hex nut, only the two Phillips screws.
2. Remove the interconnecting cable strap between the CPU board and the Radio board.
3. Slide the board out toward the rear of the unit.

Reverse these steps when replacing the CPU board.

Radio Board Removal/Replacement

1. Remove the top cover and CPU board first.
2. From the top of the unit, (looking where the missing CPU board was) remove the two flat head screws. These are holding the radio board in from the other side.
3. Slide the radio board toward the rear of the unit.

Reverse these steps when replacing the radio board.

5.3 - Radio Checkout

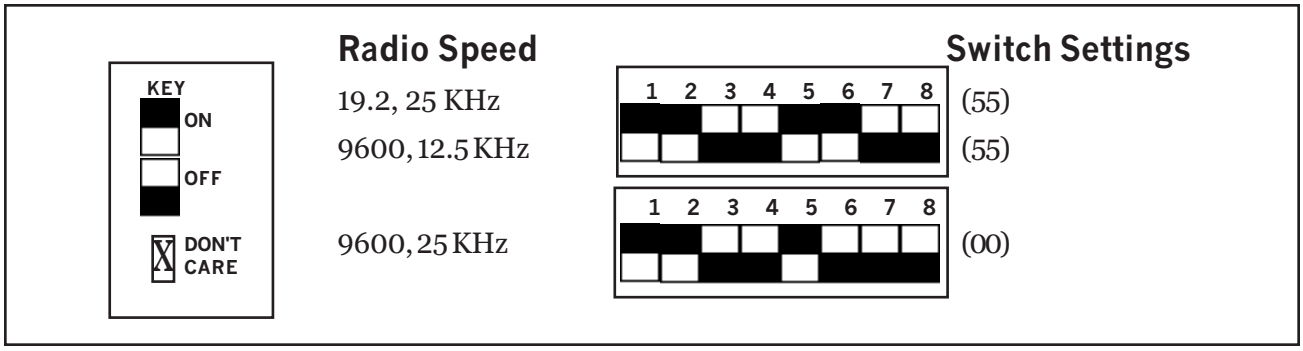
Radio Board Alignment and Checkout

The radio board is not repairable at the field level. Malfunctioned radio boards should be removed and replaced. The radio board requires periodic checks of frequency, output power and RF receive signal strength level. These checks will insure the system continues to operate as it did when installed and will also satisfy regulatory authority frequency and power regulations.

Frequency Check and Alignment

Connect the IRM RF antenna port to the RF Comm Test Set 50 ohm T/R port and set the RF Comm Test Set to measure the IRM's transmit frequency (e.g. 928.00000 MHz). Set the IRM to the Test Pattern Mode by using the internal DIP switches. For 4-state FSK radios (19.2 Kbps and 12.5 Khz 9600 bps models), generate the "55" pattern.

For 2-state FSK radios (25 KHz 9600 bps models), generate the "00" pattern.



Measure the transmit frequency and adjust, if necessary, the TCXO adjustment on the radio so that the frequency is within 0.00005% (e.g., 928.0000 MHz,+/-450 Hz).

NOTE

Allow a minimum of 10 minutes warm-up time for the TCXO before attempting to align. This TCXO adjustment is made through the hole in the bottom panel.

If the frequency does not adjust to within these specified limits, replace the Radio Board. This single oscillator provides the reference for both the transmitter and receiver, so no further checks on frequency are required.

NOTE

After the first three months of operation, the TCXO may drift in frequency due to crystal aging. The alignment should be checked after this period if there is any questionable performance. After this initial period, the frequency should be checked yearly.

5.3 - Radio Checkout

Output Power Check

With the equipment connected as described above, verify that the transmit power output of the IRM is 2.0 watts, minimum. If the power out is not at least this value, check the Radio Board.

NOTE
Radios may have power output of 4 watts or more. Be sure to check that the maximum power output is in compliance with your local regulations. If the power is too high, add attenuation in your transmission line or consult the factory for lower power options.

Deviation Check

A deviation check is not necessary for routine calibration. The deviation parameters are embedded in the radio's firmware, so there is no risk of configuring with the wrong value. A deviation check can still be used as a quick operational test, but many RF Comm test sets are not accurate enough to measure the performance for a 4 state FSK radio. The deviation should be as follows:

Radio Type		Deviation
19.2k	25 kHz	+/- 3.2 kHz
9600	25 kHz	+/- 3.2 kHz
9600	12.5 kHz	+/- 2.9 kHz

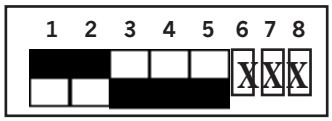
5.3 - Radio Checkout

Receiver Signal Level Check

The RF receive signal level check is a test of the RF path between the transmitter and the receiver. If the level is lower than it was when the system was installed it is an indication of a problem. There may be an obstruction in the RF path, a problem with the antenna or a damaged coaxial cable. The receive level will provide an early indication of a problem that may be corrected before it causes disruption of service. Refer to Radio Test Data Sheet that came with the IRM to convert the DC volt receiver signal strength indication to dBm, or use the table in Sec.2, pg. 10, as a guide.
If the signal strength has dropped by more than 5 dB, the problem should be investigated and corrected. The problem may be due to changes in the path (tree growth, new buildings, etc.), misaligned or faulty antenna and RF cables, or poor receiver performance. Use the RF Comm Test Set to check the receiver signal strength at the end of the antenna cable. If this signal strength has not degraded, then the receiver may have poor sensitivity.

Receiver Sensitivity Check

Measure the receiver sensitivity by connecting the IFR 1200S Test Set to the IRM as described in the Frequency Check and Alignment portion of this manual. Place the RF Comm Test Set in the Generate Mode, and set the IRM to Test Pattern Mode, Transmitter OFF setting by using the internal DIP switches.

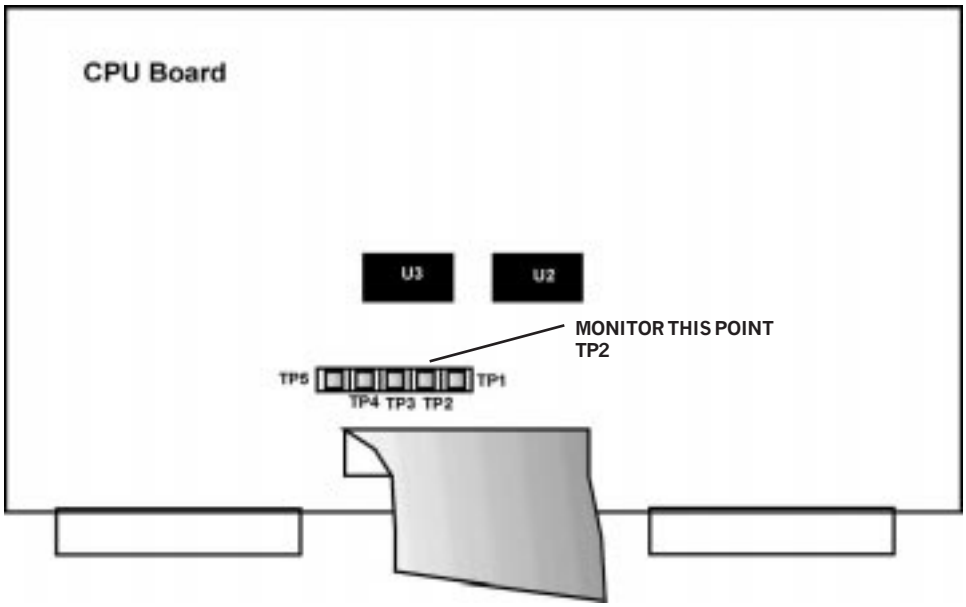


Set the RF Communication Test Set to generate a carrier at the IRM receive frequency modulated with a sinewave tone at the frequency and deviation shown in this table:

Radio Type	Deviation	Sinewave	Minimal Signal Level for Decoding
19.2 Kbps 25 KHz	3.2 KHz	4800 Hz	-87dBm
9600 bps 25KHz	3.2 KHz	4800 Hz	-100dBm
9600 bps 12.5 KHz	2.9 KHz	2400 Hz	-90dBm

5.3 - Radio Checkout

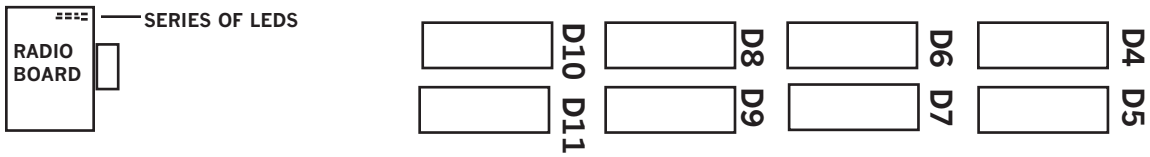
For example, for a 19.2 Kbps, 25 KHz radio, modulate with a 4800 Hz sine wave tone at 3.2 KHz deviation. Monitor TP2 on the Board. Decrease the power out of the RF Communication Test Set until the point where the received data begins to lose data bits. Proper data decoding should occur down to the level shown in the table.



5.4 - Radio LED Display

LEDs Location

On the top left corner of the radio board are eight indicator LEDs that display the radio's operation.



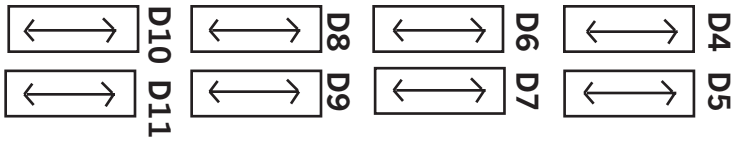
At power up, the LEDs go through a sequence of displays as described in the following paragraphs. At the end of this sequence, the radio is operational and the normal display is:

D4	Blinking at 2-3 second rate indicating microprocessor is running.
D6	Off in Receive On in Transmit
D8	Always On

All others are **Off**.

LED Test

This mode is indicated by two quick row-flashings, 1/4 second long.



Command Mode

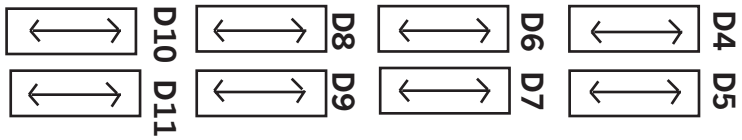
Waiting for frequency download from the IRM CPU board. All LEDs are On. If the frequency isn't received within 4 seconds *and* the EEROM frequency is not valid, the processor goes to Factory Setup Mode.

5.4 - Radio LED Display

Startup Tests

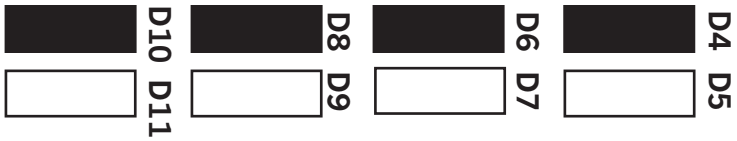
Startup tests consist of several flashes, lasting about 1 second. If a test fails, the processor halts, and the LEDs indicate a pattern telling which test failed. If no tests fail, we advance to tuning.

Rx Lo Tuning



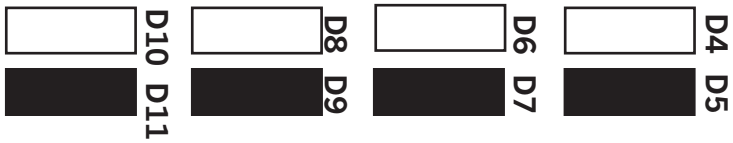
This mode lasts about 8 seconds, slewing the DDS from the highest to lowest valid frequency for the installed Rx VCO to cause the PLL to lock on, then moves the frequency smoothly to the downloaded LO frequency.

Tx Lo Tuning



This mode lasts about 8 seconds, same as Rx.

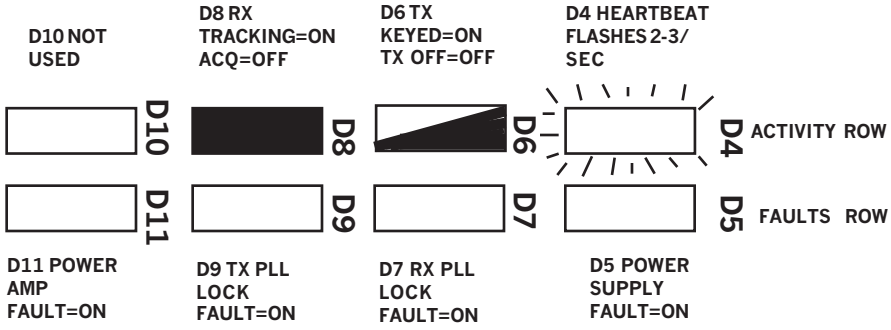
Operational Mode



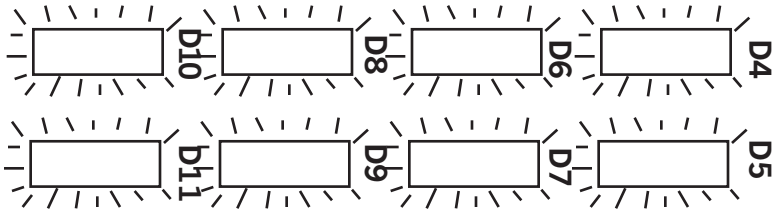
5.4 - Radio LED Display

Once the processor gets here, it stays in this mode forever.

Configuration Mode

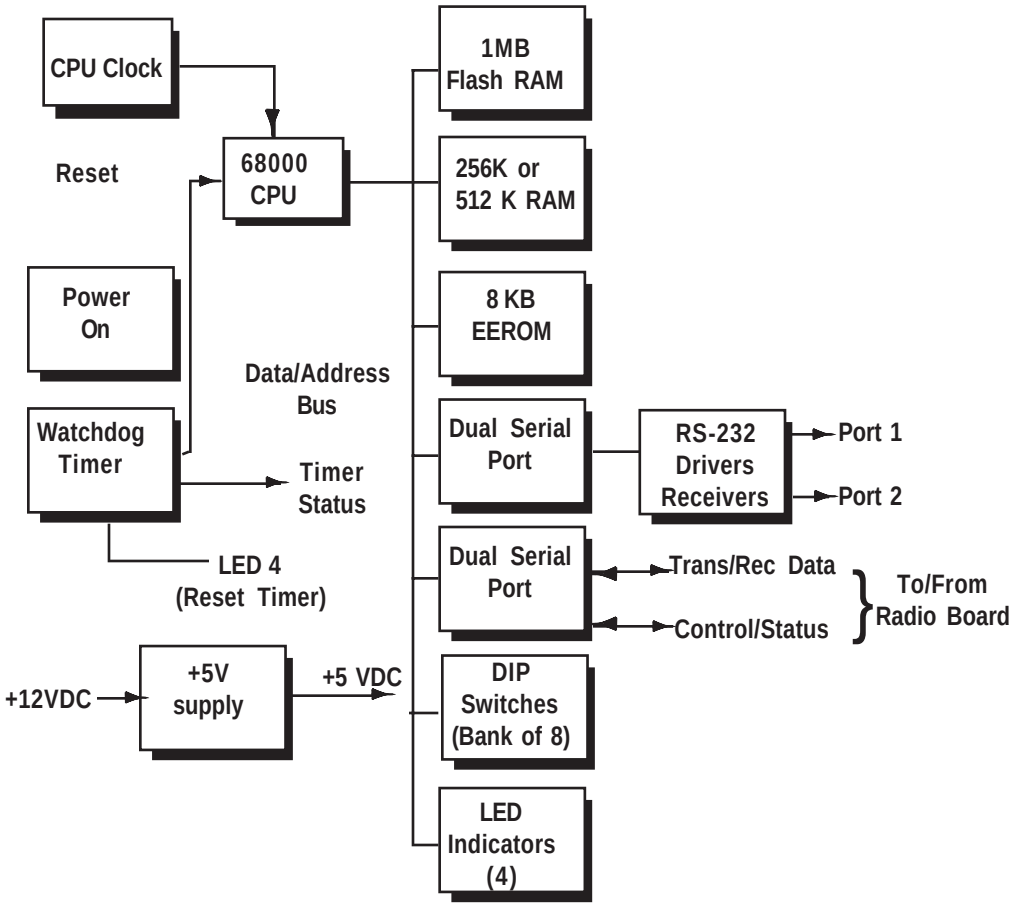


The LEDs will blink all together when in the configuration Mode. It is ready to accept programming commands from the asynchronous serial channel from the CPU Board, such as frequency or mode settings. It will enter this when commanded by the CPU or when its internal EEROM is not valid.



6.1 - CPU Board

The CPU board consists of a 68000 CPU operating at 14.7 MHz with no wait states, EPROM, RAM, EEROM two dual serial ports, DIP switch inputs and LED indicator outputs. The CPU RESET signal may be generated in two ways: power-up, or watchdog timer. Both occurrences of RESET appear identical to the CPU, however a status signal, generated by the watchdog timer logic, allows the CPU to identify a watchdog reset. The CPU services the watchdog timer periodically with a signal that, under normal system operation, alternately turns on and off the CPU LED indicator . Should the CPU operate improperly, and not service the watchdog timer, a RESET will be generated to restart the IRM.



6.2 - Radio Board

System Memory

The memory of the system is allocated as follows: 1 MB of Flash RAM provides for the IRM's operational firmware, protocol drivers and user server routines. 8 KB of EEROM contains user port protocol information, addressing and other configuration parameters. 256 KB or 512 KB RAM provides storage for program variable and buffers.

Communications Controllers

One Dual Universal Synchronous Communications Controller (DUSCC) and its associated RS-232 drivers and receivers allow for up to two user equipment ports. The DUSCCs support bit-oriented or character-oriented synchronous data link controls and asynchronous protocols. The operating mode and data format can be programmed independently for each channel. Each channel contains a transmitter, receiver, multi-function timer, parity/CRC generator/checker and associated control circuits. General purpose modem control inputs and outputs are programmed for other functions.

Another single DUSCC acts as the serial interface to the radio board. Data is sent to and is received from the radio board at 9600 bps or 19,200 bps synchronous. The other DUSCC channel is asynchronous and sends and receives control and status data. A TX KEY signal from the DUSCC is used to switch the radio board from transmit to receive mode.

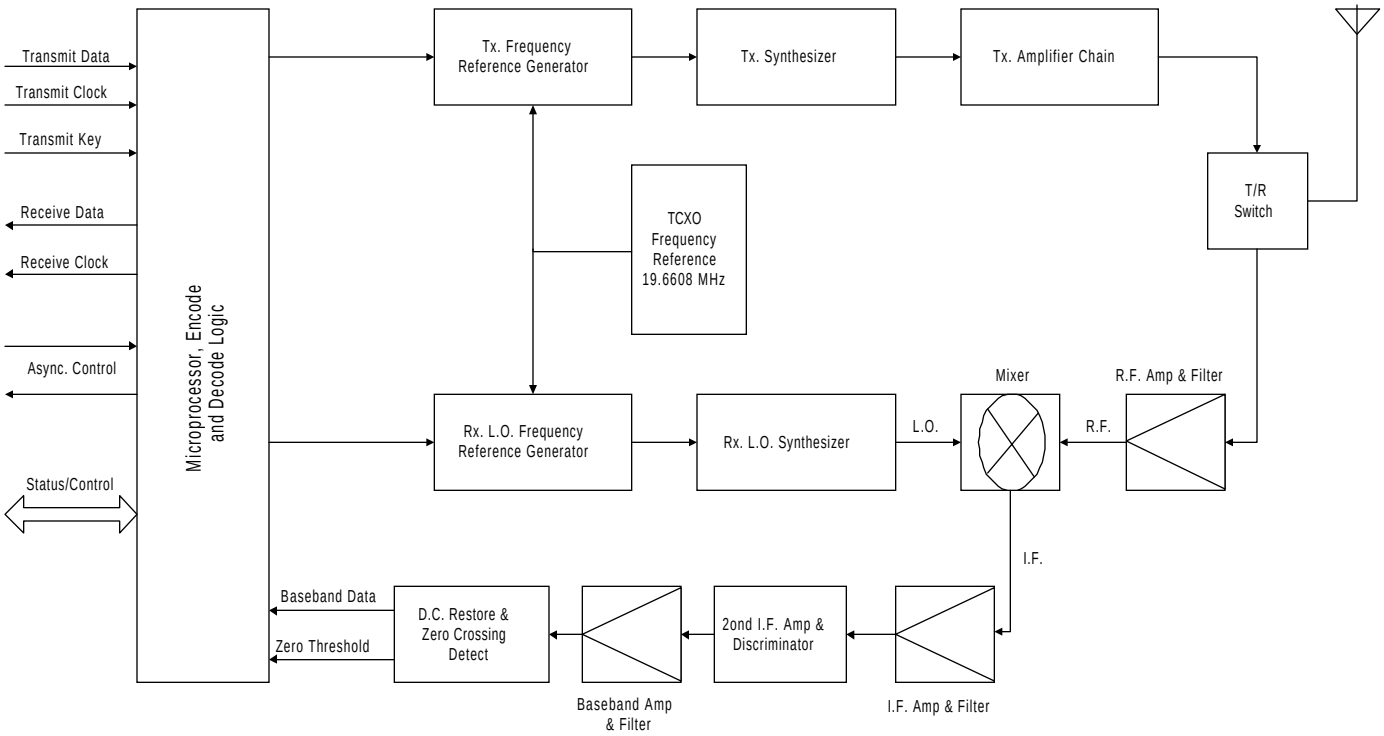
6.2 - Radio Board

Functional Description

Radio Board

The radio is a narrow band, multi-state Frequency Shift Keyed (FSK) half-duplex RF assembly designed to transmit and receive digital data at clock rates up to 19.2 Kbps. The radio will operate as either a 2 state or 4 state FSK radio, depending on the data rate and channel spacing.

For the 9600 bps, 25 KHz version, 2 state modulation is used. Each bit is encoded into one of two frequencies. For the 9600 bps, 12.5 KHz and 19.2 Kbps, 25 KHz versions, every 2 bits of the data stream are encoded into one of four distinct frequencies.



6.2 - Radio Board

A microcontroller — the 68HC11 — a microprocessor with on-chip memory and I/O, controls all of the radio's functions. At any one time, the radio operates in one of three modes: Startup, Transmit or Receive.

Startup

The radio performs a brief self-test, then waits for frequency commands from its connected CPU board. The downloaded receive and transmit frequencies are stored in the radio's non-volatile memory (EEROM) as default values. These frequencies, (or the defaults, if not downloaded within 5 seconds), are used to tune the receiver's Local Oscillator (LO) and transmitter's synthesizer. Depending on the frequency chosen, the tuning process will take 5-10 seconds for each side. After the tuning is finished, the radio enters receive or transmit operational mode.

Transmit

When the externally driven Transmit Key line goes high, the 68HC11 controller accepts data which is internally converted into frequency commands that are output to a transmitter reference generator which, in turn creates a frequency modulated reference signal at frequencies 1/N of the desired transmit frequency. This reference signal is applied to a frequency synthesizer, where it is multiplied by N, input to an amplifier chain and connected to the RF output connector via a Transmit/Receive (T/R) switch.

Transmit Frequency Deviation

	Deviation from Center Freq (Hz)	
Bit Pattern	25 KHz	12.5 KHz
00	-3120	-2875
01	-1040	-958
10	+1040	+958
11	+3120	+2875

The 68HC11 controller commands the reference generator, sometimes referred to as the Direct Digital Synthesizer (DDS) to smoothly transition between each of the four frequencies, shown in the above table. This smooth transition between steps reduces the transmitted signal's spectrum.

6.2 - Radio Board

Receive

When the Transmit Key line is low, the T/R switch connects the RF connector to the receiver front end, where the received signal is filtered, amplified, and applied to a mixer. The local oscillator signal is generated in the same fashion as the transmitter signal described above, providing an input to a synthesizer outputting an LO signal 45 MHz above the desired frequency. Thus, the mixer output is the desired signal mixed down to an Intermediate Frequency (IF) of 45 MHz. The IF signal is applied to an IF amplifier and discriminator, creating a baseband signal which is filtered and amplified.

DC Restore Circuit

Instead of an Automatic Frequency Control (AFC) typically used by most radios to compensate for errors due to frequency shifts, this radio uses a DC restore circuit. The baseband signal is AC coupled to the decoder through a high pass filter. This removes any DC offsets that may occur from RF frequency errors or other sources. The decoded data stream is then converted to an analog signal and applied to a low pass filter that is the complement of the high pass filter. This low pass filtered signal represents the original DC portion of the received signal (minus the offset errors) . The high and low pass signals are combined and form the DC restored signal for decoding.

The resulting baseband signal is applied to the 68HC11 controller's analog to digital (A/D) converter, and to a comparator whose output enables the 68HC11 to establish symbol clock timing, or to determine when to sample the received signal. The sampled signal is used to make "state" decisions, i.e., to decide the bit(s) to output for each symbol. The 68HC11 successively determines the received 2-bit pattern based on the A/D sampled value and the previous bit decision. These 2-bit symbols form a bit stream which, along with the bit clock, is outputted to the attached CPU board. The bit clock is two times the A/D sample clock.

Radio Board/CPU Interface

A digital interface provides data exchange with the logic board and software control and configuration of the radio board by the logic board. The interface consists of the following signals:

From the logic board:
- transmit data
- transmit clock
- transmit key

To the logic board:
- receive data
- receive clock

Frequencies used for receive local oscillator and the transmitted RF can be downloaded from the main CPU board of the IRM via an asynchronous serial channel. The receiver provides a DC voltage proportional to the received signal strength. The signal strength voltage is for installation and service use and can be measured on the test point at the rear panel of the IRM.

6.2 - Radio Board

Radio to CPU Interconnect Cable

Pin	Signal	Description	Direction
1	TX Data	Data transmitted over the network	CPU to radio
2	TX Clock	Data Clock.	CPU to radio
3	TX Key	Turn on the radio transmitter	CPU to radio
4	RX Data	Data received from the network	Radio to CPU
5	RX Clock	Data clock.	Radio to CPU
6	SCI RD	Serial Channel Interface	CPU to radio
7	SCI TD	Serial Channel Interface	Radio to CPU
15	Tx Disable	Tx Shutdown	CPU to radio
18	BIT	Built In Test Status	Radio to CPU
13	TX On	The radio transmitter is on.	Radio to CPU
8	Radio Reset	Resets radio board logic.	CPU to radio
19,21	+5V		CPU to radio
24,26	+12V		Radio to CPU
9,10,11, 12,14,16, 17,20,23,25	GND	Signal ground	

Revision D 12/10/97

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