APPENDIX E: MANUAL

Please refer to the following pages for the installation manual.

Installation Manual

MM102365V1

Rev. B, Jul-04

OpenSky®

SkyLink® ISM Radio Network

ISM Radio and Backhaul Router

tyco Electronics

MACOM

MANUAL REVISION HISTORY

REV	DATE	REASON FOR CHANGE
R1A	Feb. 2004	Original Release
B	Jul. 2004	Updated Table 6-1: ISM Antennas and added antenna installation caution.

M/A-COM Technical Publications would particularly appreciate feedback on any errors found in this document and suggestions on how the document could be improved. Submit your comments and suggestions to:

Wireless Systems Business Unit
M/A-COM, Inc.
Technical Publications
221 Jefferson Ridge Parkway
Lynchburg VA, 24501
fax your comments to: (434) 455-6851
e-mail us at: techpubs@tycoelectronics.com

This manual and the hardware and software it describes are copyright © 2004 M/A-COM, Inc. All rights are reserved under the copyright laws of the United States and Canada and other laws. Without limiting the rights under copyright, no part of this document may be reproduced, stored in or introduced into a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), or for any purpose, without the express written permission of M/A-COM, Inc.

The contents of this manual are not intended to and do not constitute a warranty of any sort. M/A-COM, Inc and Tyco Electronics specifically disclaim any implied warranties of merchantability or fitness for any particular purpose resulting from this manual.

Information in this document is subject to change without notice. M/A-COM, Inc. reserves the right to revise and make changes to this manual (and to the product and software) from time to time without obligation to notify any person of, or to provide any person with, such revisions or changes.

M/A-COM, Inc. and/or Tyco Electronics may have patents, patent applications, trademarks, copyrights, or other intellectual property rights covering subject matter in this document. Except as expressly provided in any written license agreement from M/A-COM, the furnishing of this document does not give any license to these patents, trademarks, copyrights, or other intellectual property.

Windows and Windows95 are registered trademarks of Microsoft Corporation.

All other brand and product names are trademarks, registered trademarks, or service marks of their respective holders.

Notice of Copyright
Copyright ©2004 M/A-COM, Incorporated.
All rights reserved.

Notice of Trademark
The name M/A-COM, the OpenSky and SkyLink product names, and the M/A-COM and OpenSky logos are all trademarks of M/A-COM, Inc.

M/A-COM, Inc.
1011 Pawtucket Blvd.
Lowell, MA 01853
Phone: 978.442.4000

Printed in the United States of America.

TABLE OF CONTENTS

Page

1. REGULATORY AND SAFETY INFORMATION 8

1.1 REGULATORY INFORMATION 8

1.2 SAFETY DURING INSTALLATION AND SERVICE 9

1.3 SAFETY SYMBOLS 10

2. SPECIFICATIONS 11

2.1 ISM TOWER TOP RADIO 11
2.1.1 Transmit 11
2.1.2 Receive 11
2.1.3 Physical 12
2.1.4 Environmental 12
2.1.5 Power 12

2.2 BACKHAUL ROUTER 12
2.2.1 Interfaces 12
2.2.2 Fiber Optic Interface 12
2.2.3 Physical 13
2.2.4 Environmental 13
2.2.5 Power 13

3. INTRODUCTION 14

3.1 PRODUCT DESCRIPTION 14

3.2 COMPONENTS 14
3.2.1 ISM Radio 14
3.2.2 Backhaul Router 14

3.3 SUB-SYSTEM COMMUNICATION LINKS 15

3.4 RADIO OPERATING MODES: MASTER AND SLAVE 15
3.4.1 Master 15
3.4.2 Slave 15

3.5 ISM NETWORK CONFIGURATION 15
3.5.1 Networked Master/Slave 16
3.5.2 Packet Path To The Tower Site 16
3.5.3 Packet Path to the Backhaul Router 16
3.5.4 Packet Path to the Cell Site ISM Radios 16

3.6 OPENSKY APPLICATIONS 17
3.6.1 Standalone Repeater Operation 17
3.6.2 Cell-Drop-and-Repeat Operation 17

3.7 TECHNICAL ASSISTANCE 18

4. UNPACKING AND CHECKING EQUIPMENT 19

4.1 UNPACKING EQUIPMENT 19

4.2 INSPECTING AND INVENTORYING EQUIPMENT 19

5. PRE-INSTALLATION CONSIDERATIONS 20

5.1 CHECKLIST 20

TABLE OF CONTENTS

Page

5.2 BACKHAUL ROUTER INSTALLATION CHECKLIST 20
5.3 PREPARATION FOR FIELD INSTALLATION 21
5.4 SAFETY RECOMMENDATIONS 21
5.5 HAZARD WARNINGS 21
5.6 ELECTROSTATIC DISCHARGE 22
5.7 CABLING CONSIDERATIONS 22
5.7.1 Ethernet Connections 22
5.7.2 ISM Radio Power/Fiber Optic Connections 22
5.7.3 Maintenance Port Connection 22

6. INSTALLATION 24

6.1 TOWER TOP ISM RADIO ENCLOSURE INSTALLATION 24
6.1.1 Power and Grounding Requirements 24
6.1.2 Lightning Protection 24
6.1.3 ISM Radio Co-Located with the Backhaul Router 25
6.1.4 Connect Radio to Another ISM Device 26
6.2 ANTENNA SYSTEM INSTALLATION 26
6.2.1 Antenna Installation 26
6.2.2 Antenna RF Cable Installation 27
6.2.3 Antenna System Testing 27
6.3 POWER/FIBER OPTIC CABLE INSTALLATION 28
6.3.1 Installing the Power/Fiber Optic Cable Assembly 29
6.4 BACKHAUL ROUTER INSTALLATION 31
6.4.1 Front Panel Features 31
6.4.2 Rear Panel Features 32
6.4.3 Mounting the Backhaul Router 33
6.4.4 Power Cable Installation 33
6.4.5 Ethernet Connection 34
6.4.6 Fiber Optic Connection 34
6.5 MAINTENANCE AND TEST CONNECTIONS 35
6.5.1 Connecting an ISM Radio to a PC or Terminal 35
6.5.2 Connecting Backhaul Router to a PC or Terminal 35
6.5.3 Maintenance Port Settings 37

7. NETWORK CONFIGURATION 38

7.1 INTRODUCTION 38
7.2 ROUTING TABLES 38
7.3 CONFIGURING THE BACKHAUL ROUTER 39
7.3.1 Step 1 – Configure Backhaul ISM and IP Network Addresses 39
7.3.2 Step 2 – Setup Backhaul Routing Table 39
7.4 CONFIGURING THE TOWER TOP RADIO 40
7.4.1 Step 1 – Configure the Tower Top Radio Topology 40
7.4.2 Step 2 – Configure the Tower Top Radio Routing Table 40
7.4.3 Step 3 – Configure the Tower Top Radio RF Table 41
7.4.4 Step 4 – Configure the Tower Top Radio Frequency List Table 41
7.4.5 Step 5 – Verification Configuration 41

TABLE OF CONTENTS

Page

7.5 CONFIGURING THE CELL SITE ISM RADIO 42
7.5.1 Step 1 – Configure Cell Site Radio Topology 42
7.5.2 Step 2 – Configure Cell Site Radio Routing Table 42
7.5.3 Step 3 – Configure Cell Site Radio RF Table 42
7.5.4 Step 4 – Configure Cell Site Radio Frequency List Table 43
7.5.5 Step 5 – Connect Test Antenna 43
7.5.6 Step 6 – Verify Configuration 43

8. SAMPLE ISM NETWORK CONFIGURATION 44

8.1 CONFIGURATION PROCEDURE. 45
8.1.1 Configure Backhaul Router 46
8.1.2 Configure Tower Radio 47
8.1.3 Verification Commands 48
8.1.4 Configure Cell Site Radio 3 48
8.1.5 Configure Cell Site Radio 4 49
8.1.6 Configure Cell Site Radio 5 50
8.1.7 Verification Commands 50

9. AT COMMAND SET 51

9.1 USING HELP COMMAND 51
9.1.1 Accessing the Function Displays 51
9.1.2 Accessing Verbose Information 54
9.1.3 Displaying Configuration Information 55

9.2 SETTING DEVICE PARAMETERS 55
9.2.1 Network Administration 55
9.2.2 Changing the ISM Address 55
9.2.3 Changing the IP Address 56
9.2.4 Displaying Backhaul MAC Address 56
9.2.5 Changing the UDP Port Address 56
9.2.6 Changing Default ISM Destination 57
9.2.7 Changing RF Slot Interval Timer 57
9.2.8 Changing RF Packets per Interval 57
9.2.9 Changing RF Transmit Delay 58
9.2.10 Changing Mode of Operation 58
9.2.11 Changing Network Port Assignment 59
9.2.12 Enabling +15 VDC on Port A or B 59

9.3 MANAGING THE ROUTING TABLE 60
9.3.1 Saving the Routing Table 60
9.3.2 Routing Table Entries 60
9.3.3 Adding a Routing Table Entry 61
9.3.4 Removing a Routing Table Entry 62
9.3.5 Displaying Routing Table Entries 62
9.3.6 NMS Trap Target Entries 63

9.4 MANAGING THE RF CONFIGURATION TABLE 65
9.4.1 Saving the RF Configuration Table 65
9.4.2 RF Configuration Table Entries 65
9.4.3 Adding an RF Configuration Entry 67
9.4.4 Displaying RF Configuration Table Entries 67
9.4.5 Removing an RF Configuration Table Entry 68

TABLE OF CONTENTS

Page

9.5 MANAGING THE FREQUENCY LIST TABLE 69
9.5.1 Saving the Frequency List Table 69
9.5.2 Adding a Frequency List Entry 69
9.5.3 Displaying a Frequency List Table 70
9.5.4 Removing Frequency List Entry 70

9.6 SAVING CONFIGURATION AND PARAMETER CHANGES 71
9.6.1 Saving Configuration Changes 71
9.6.2 Saving Parameters Permanently 71

10. TROUBLESHOOTING 73

10.1 OVERVIEW 73

10.2 EQUIPMENT REQUIRED 73

10.3 REMOTE TROUBLESHOOTING 73

10.4 ON SITE TROUBLESHOOTING 74

11. INSTALLATION CHECKSHEETS 78

12. DIAGRAMS 81

12.1 APPLICATION DIAGRAMS 81
TYPICAL CELL SITE ANTENNA SYSTEM WITH GROUNDING 81
TYPICAL CELL SITE ANTENNA ASSEMBLY 82
TYPICAL ISM MASTER ANTENNA ASSEMBLY 83

12.2 ASSEMBLY DIAGRAMS 84
ISM RADIO IN MINI-CELL ENCLOSURE 84
ISM RADIO IN TTR ENCLOSURE 85
AC POWERED BACKHAUL ROUTER 86
DC POWERED BACKHAUL ROUTER 87

12.3 INTERCONNECT DIAGRAMS 88
ISM RADIO IN MINI_CELL ENCLOSURE 88
ISM RADIO IN RTT ENCLOSURE 89

12.4 CABLE DIAGRAMS 90
POWER/FIBER OPTIC CABLE 90
POWER/FIBER OPTIC CABLE 91

TABLE OF FIGURES

Page

FIGURE 3-1: TOWER AND CELL SITE ISM RADIOS 16
FIGURE 3-2: ISM REPEATER CELL-CONFIGURATION SETUPS 17
FIGURE 6-1: ISM TOWER TOP RADIO ENCLOSURE 25
FIGURE 6-2: FIBER CABLE MOUNTED IN TOWER TOP RADIO ENCLOSURE 29
FIGURE 6-3: WIRING THE POWER/FIBER OPTIC CABLE ASSEMBLY 30
FIGURE 6-4: BACKHAUL ROUTER – FRONT PANEL 31
FIGURE 6-5: BACKHAUL ROUTER – REAR PANEL (DC) 32
FIGURE 6-6: BACKHAUL ROUTER – OUTPUT CONNECTIONS 34
FIGURE 6-7: RS-232 CABLE FOR CONNECTING PC TO ISM RADIO 35
FIGURE 6-8: MAINTENANCE PORT (TEST) SERIAL I/O 36
FIGURE 6-9: ISM RADIO I/O CONNECTORS 36

TABLE OF TABLES

Page

TABLE 5-1: EIA/TIA-232 BAUD FOR DISTANCE RATES 23
TABLE 6-1: ISM ANTENNAS 26
TABLE 6-2: ANTENNA RF CABLES 27
TABLE 6-3: POWER/FIBER OPTIC CABLE ASSEMBLY LENGTHS 28
TABLE 6-4: BACKHAUL ROUTER FRONT PANEL INDICATORS 31
TABLE 6-5: RJ-45 TO DB-9 CONNECTIONS 36
TABLE 7-1: ISM AND IP NETWORK ADDRESSES 39
TABLE 7-2: BACKHAUL ROUTING TABLE 39
TABLE 7-3: TOWER TOP RADIO CONFIGURATION 40
TABLE 7-4: TOWER TOP RADIO ROUTING TABLE CONFIGURATION 40
TABLE 7-5: TOWER TOP RADIO RF ENTRIES 41
TABLE 7-6: TOWER RADIO FREQUENCY LIST CONFIGURATION 41
TABLE 7-7: VERIFY CONFIGURATION 41
TABLE 7-8: CELL SITE RADIO CONFIGURATION 42
TABLE 7-9: CELL SITE RADIO ROUTING TABLE CONFIGURATION 42
TABLE 7-10: CELL SITE RADIO RF TABLE CONFIGURATION 42
TABLE 7-11: CELL SITE RADIO FREQUENCY LIST CONFIGURATION 43
TABLE 7-12: VERIFY CONFIGURATION 43
TABLE 9-1: COMMAND STRINGS AND RADIO/BACKHAUL ROUTER FUNCTIONS 52

1. REGULATORY AND SAFETY INFORMATION

1.1 REGULATORY INFORMATION

These devices generate RF electromagnetic energy during transmit mode. They are designed for and classified as "Occupational Use Only" meaning they must be used only during the course of employment by individuals aware of the hazards and the ways to minimize such hazards. These devices are NOT intended for use by the "General Population" in an uncontrolled environment.

- This device complies with Part 15 of the **F**ederal **C**ommunications **C**ommission (**FCC**) Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference; and (2) this device must accept any interference received, including interference that may cause undesired operation.

- The FCC does not require the user to obtain a station license for this radio equipment before operating it.

- This is a professionally installed device with a fixed power level. Only antennas listed on the grant must be used. Shorter cable lengths or cable types with less gain must not be substituted as a replacement other than those tested and listed in this manual.

The antenna(s) used for this transmitter must be installed by a professional to provide a separation distance of at least 32 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

- The operator is responsible at all times for the proper operation and maintenance of the equipment.

- No FCC license is required for personnel maintaining the equipment.

- FCC regulations state that the frequency, deviation, and power of a radio transmitter must be maintained within specified limits. It is therefore recommended that the power level be checked before the station is placed in service.

Use of this radio as described below will result in user exposure substantially below the FCC recommended limits for human exposure to Radio Frequency Electromagnetic energy.

Before operating this radio:

- Do not operate this radio if any of the RF connectors are not secure or if open connections are not properly terminated.

- Do not operate this radio near electrical blasting caps or in an explosive atmosphere.

NOTE

Changes or modifications not expressly approved could void the user's authority to operate this equipment.

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 installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment 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.

1.2 SAFETY DURING INSTALLATION AND SERVICE

The radio and antennas must be installed by experienced installation professionals. During the installation of directional antennas, the installer must not point the main beam of the antenna at locations occupied by persons and must warn others to maintain a minimum distance of 4 meters from the antenna. Failure to follow these instructions will void the product warranty and may expose the end user and others to excessive Radio Frequency hazards. All antennas are intended to be installed outdoors and at distances from personnel well beyond the minimum allowable distance.

Proper grounding is necessary, not only for correct functionality and maximum performance, but to minimize damage that may occur from lightning strikes. The ISM radio includes lightning-protection devices, but they are only effective if the connections are made as the design intended. Follow the installation instructions to ensure a properly grounded unit.

The radio must be serviced and installed by qualified technicians only. Be sure that the radio is properly grounded according to the installation instructions.

This equipment generates or uses radio frequency energy. Changes or modifications may cause harmful interference unless the modifications are expressly approved in the instruction manual. The user could lose the authority to operate this equipment if an unauthorized change or modification is made.

1.3 SAFETY SYMBOLS

The following conventions are used throughout this manual to alert the user to general safety precautions that must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. M/A-COM, Inc. assumes no liability for the customer's failure to comply with these standards.

The **WARNING** symbol calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING symbol until the conditions identified are fully understood or met.

The **CAUTION** symbol calls attention to an operating procedure, practice, or the like, which, if not performed correctly or adhered to, could result in damage to the equipment or severely degrade the equipment performance.

The **NOTE** symbol calls attention to supplemental information, which may improve system performance or clarify a process or procedure.

The **ESD** symbol calls attention to procedures, practices, or the like, which could expose equipment to the effects of **E**lectro-**S**tatic **D**ischarge. Proper precautions must be taken to prevent ESD when handling circuit modules.

2. SPECIFICATIONS [1]

2.1 ISM TOWER TOP RADIO

2.1.1 Transmit

Frequency Range	2400-2480 MHz
First Transmit Frequency	2412 MHz
Last Transmit Frequency	2468 MHz
Modulation	DBPSK
Spreading Modulation	Direct Sequence Spread Spectrum
Sequence Length	11-15 chips, Software Configurable
Tuning Step Size	1.0 MHz
Frequency Control	PLL Synthesizer
RF output Impedance	50 Ohms
Power Output	-4 dBm to 28 dBm (630 mw) in 1 dB steps
Transmitter Duty Cycle	50%
Spurious & Harmonic Emissions	Meets FCC requirements CFR47 Part 15

2.1.2 Receive

Frequency Range	2400-2480 MHz
First Receive Frequency	2412 MHz
Last Receive Frequency	2468 MHz
Tuning Step Size	1.0 MHz
Frequency Control	PLL Synthesizer
Sensitivity	-90 dBm for 10^{-5} Bit Error Rate AWGN
Adjacent Channel Rejection	25 dB
Intermodulation	42 dB

[1] These specifications are intended primarily for the use by the service technician. Refer to the appropriate Specifications Sheet for the complete specifications.

2.1.3 Physical

Height x Width x Depth	16 x 12 x 8 in. (40.5 x 30.5 x 20.5 cm)
Weight	17 lbs (including environmental enclosure)

2.1.4 Environmental

Operating	-30°C to 60°C to 15,000 ft Altitude
Non-operating	-40°C to 70°C to 30,000 ft Altitude
Humidity	5% to 95% Relative Humidity at 50°C

2.1.5 Power

DC Power	+12 to +16 VDC
Power Dissipation	12 Watts max
FCC ID	BV8MTT-A025

2.2 BACKHAUL ROUTER

2.2.1 Interfaces

Ethernet Interface	IEEE 802.3 10Base-T (10 Mbit/s)
RS-422 Interface	9-pin D-type Connector
Maintenance Port	EIA/TIA-232asynchronous Serial Interface at 19.2K baud. Uses RJ-45 Connector

2.2.2 Fiber Optic Interface

Connector	Type ST
Wavelength	820 nm Nominal
Fiber Type	62.5/125 μm Multimode
Transmit Power Level	-15 dBm peak @ 25° C, with 1 meter cable length
Receiver Sensitivity	-26dBm @ 25° C with 1 meter cable length
Bit Rate	1.25 Mbit/s
Coding	Manchester

2.2.3 Physical

Height (2 rack units)	3.50 in. (8.9 cm)
Width	Standard 19 in. rack (48.3 cm)
Depth	14 in. (35.6 cm)
Weight	13 lbs

2.2.4 Environmental

Operating	0 °C to 60 °C to 15,000 ft altitude
Non-operating	-20 °C to 70 °C to 30,000 ft altitude
Humidity	5% to 90% relative humidity non-condensing

2.2.5 Power

Voltage (DC)	Nominal -48 VDC
Voltage (AC)	Nominal 110 VAC (optional)
Power	50 Watts maximum

3. INTRODUCTION

This manual describes how to install an ISM Radio Network consisting of the ISM Tower Top Radio and the optional Backhaul Router. Because each installation is unique, this manual is designed only as a guide for installing these products.

3.1 PRODUCT DESCRIPTION

The ISM Radio System extends the reach and signal strength of the overall OpenSky® network and provides essential connectivity to ISM devices.

The ISM Network provides:

- Extended reach without high profile towers.
- Point-to-multipoint connectivity to extend the coverage area.
- Low-latency links with minimal impact on OpenSky network performance.
- **S**erial **L**ine **I**nternet **P**rotocol (**SLIP**) and **I**nternet **P**rotocol (**IP**) packet processing.

Data and voice network controllers for the OpenSky network are located at the Operation Center. From the Operation Center, voice and data packets are routed:

- Locally to other ISM devices.
- To another Operation Center.
- Through Interoperability Gateways to non-OpenSky networks.

Each tower site can be equipped with an ISM radio for one-hop communication directly to cell sites. In addition, to enable the radio to function as a repeater where a link between a cell site and a tower site cannot be made with a single hop, an additional ISM radio can be connected via fiber to an existing link. For additionally supported configurations, refer to the ISM Radio Network Design Guide.

Cell sites are an extension of a tower site's network of OpenSky Base Stations.

3.2 COMPONENTS

3.2.1 ISM Radio

The Tower Top ISM radio communicates with an ISM radio operating at each cell site. The Cell Site ISM radio provides an interface to the OpenSky Base Station co-located at the cell site.

3.2.2 Backhaul Router

The Backhaul Router performs the protocol processing and enables an ISM radio to communicate to an industry standard Network Access Router using an Ethernet 10base-T connection.

The Network Access Router connection (a T1 Point-to-Point microwave link) terminates at the Operation Center.

3.3 SUB-SYSTEM COMMUNICATION LINKS

The ISM radio is a **D**irect **S**equence **S**pread **S**pectrum (**DSSS**) radio compliant with the FCC Part 15.247 regulations. It operates in the unlicensed ISM frequency band available for public use, between 2.400-2.4835 GHz.

The radio operates as a subsystem within the OpenSky network to provide point-to-multipoint communication links between tower sites and cell sites.

The ISM link extends a tower site's coverage area beyond the devices it can reach directly. Areas poorly served by high profile tower sites due to budgetary constraints, remote location or topographical challenges can be affordably and reliably served from a cell site with optional ISM repeater site(s) in an ISM subsystem.

3.4 RADIO OPERATING MODES: MASTER AND SLAVE

The ISM radio can be configured to operate in either of two modes: Master or Slave.

3.4.1 Master

A radio in Master mode controls the RF communications path of up to six radios configured in Slave mode. A Master operating in **T**ime **D**ivision **M**ultiplexed (**TDM**) order initiates all RF communications. In short, the Master radio addresses all associated Slave radios in round-robin fashion, giving each in turn the opportunity to transmit or receive ISM addressed voice and data packets.

3.4.2 Slave

A radio in Slave mode transmits and receives segmented IP packets encapsulated with ISM headers only when addressed by its associated ISM Master radio. The Slave radio buffers data received from its SLIP (or fiber optic) interface until granted the time slot to transmit to its respective Master. A Slave radio has a maximum amount of data that is transmitted in any given time slot provided by the Master.

NOTE

It should be noted that an ISM Master radio is also capable of communicating with another ISM Master radio depending on the system design.

3.5 ISM NETWORK CONFIGURATION

Figure 3-1 shows an ISM Tower Top radio supporting six cell site ISM radios. In this configuration, the tower site is equipped with several DCX Base Station Units and a Backhaul Router with a single Master ISM radio acting as a hub.

3.5.1 Networked Master/Slave

The Master radio communicates with up to six Cell Site (or repeater, or Slave) radios. Each operates at 2.4 GHz and burst transfers the data using a 1 Mbps half duplex air link. The Master radio manages a **T**ime **D**ivision **D**uplex (**TDD**) protocol to service each Slave.

3.5.2 Packet Path To The Tower Site

The tower site functions as a relay. IP packets destined for a cell site OpenSky Base Station are routed to the appropriate tower site using the T1 Point-to-Point Microwave link in a manner identical to packets destined for OpenSky DCX Base Stations at that tower site.

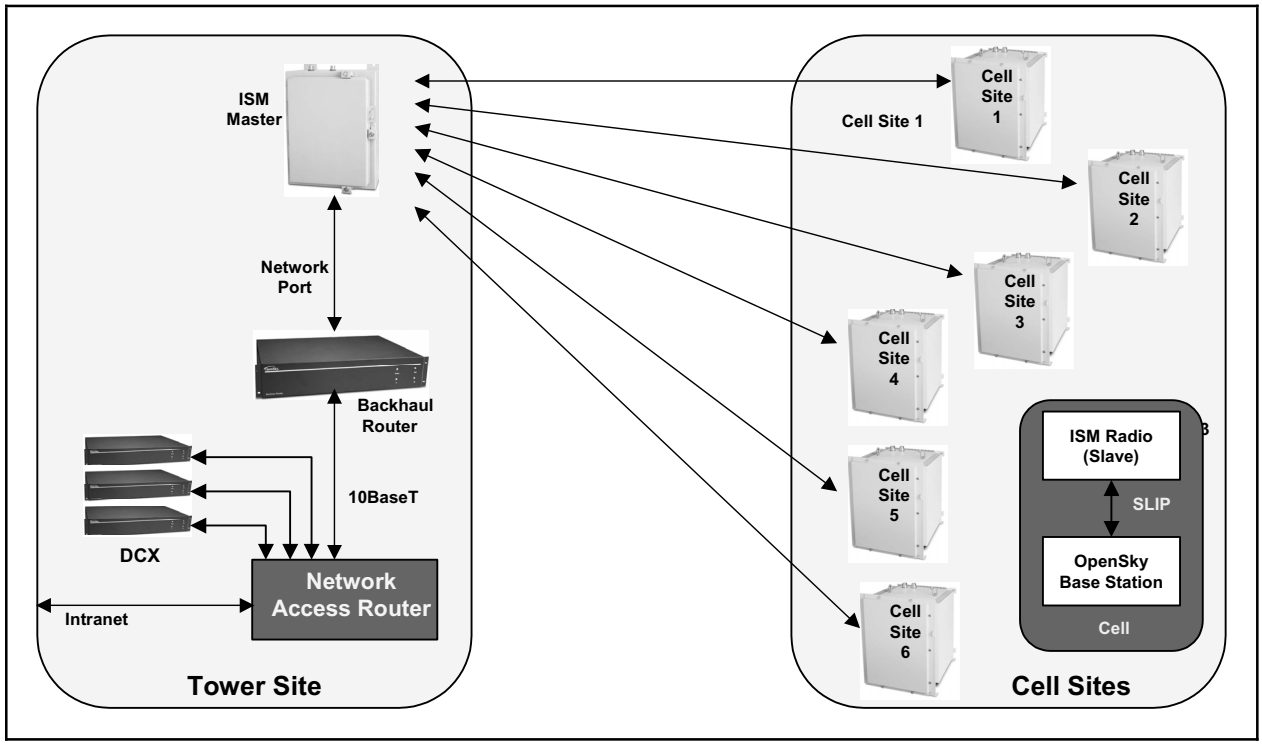


Figure 3-1: Tower and Cell Site ISM Radios

3.5.3 Packet Path to the Backhaul Router

The Network Access Router at the tower site routes ISM IP streams to the Backhaul Router for protocol conversion and forwarding to the Master radio via the ISM network interface port.

NOTE

The Network Access Router is a component that includes a Cisco 3600 or other Ethernet 10Base-T Router.

3.5.4 Packet Path to the Cell Site ISM Radios

The Master radio, in turn, routes the IP packets to the appropriate Slave radio. The Slave radio then passes the IP stream to the associated OpenSky Base Station unit co-located at the cell site via an EIA-232 SLIP interface.

The TDM system has the capacity to deliver bi-directional SLIP data at 38.4 Kbps to each Slave radio.

3.6 OPENSKY APPLICATIONS

Depending on network configuration requirements, ISM radios can operate as Standalone Repeaters or as part of a Cell-Drop-and-Repeat setup.

3.6.1 Standalone Repeater Operation

- Two radios are used in a Repeater configuration, whether in Repeater or Cell-Drop-and-Repeat.
- Regardless of the setup, radios are always configured in Master/Slave combinations.
- A Master radio (whether at a primary tower site, repeater site or Cell-Drop-and-Repeat) can always be configured as a multipoint radio.

3.6.2 Cell-Drop-and-Repeat Operation

In a Cell-Drop-and-Repeat setup, one radio operates as a standard Slave in communication with the primary tower site. A second radio at a repeater site or Cell-Drop-and-Repeat site is configured as a Master radio similar to a tower site.

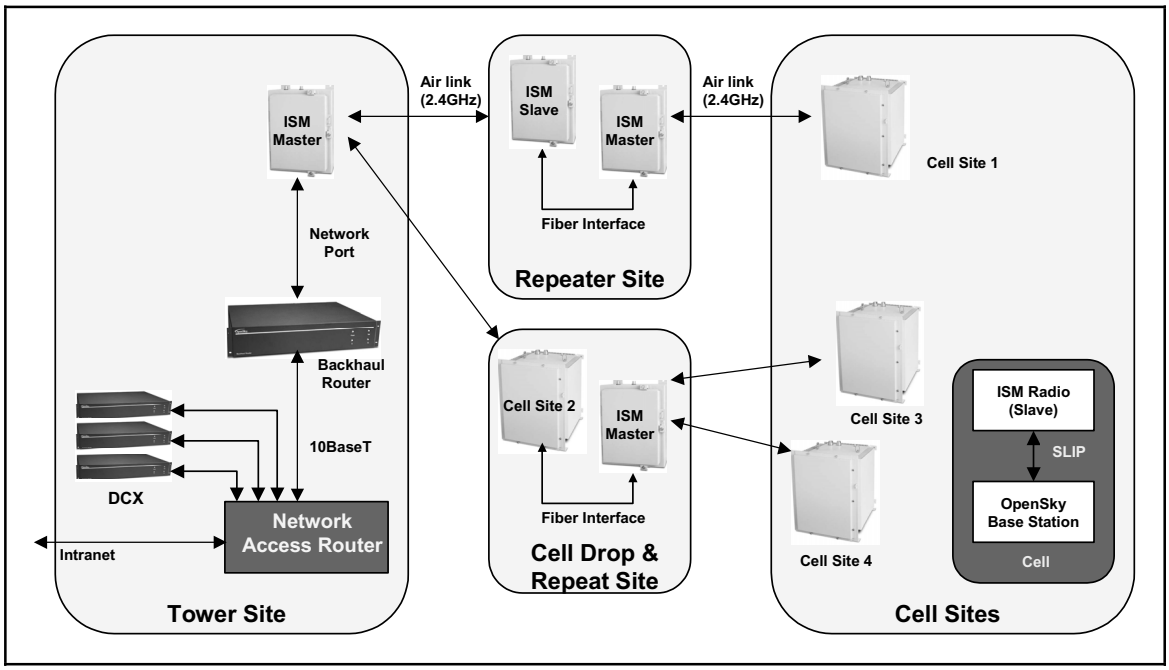


Figure 3-2: ISM Repeater Cell-Configuration Setups

The interface between the repeater radios uses the fiber optic network port for data communications.

3.7 TECHNICAL ASSISTANCE

The Technical Assistance Center's (TAC) resources are available to help with overall system operation, maintenance, upgrades and product support. TAC is the point of contact when answers are needed to technical questions.

Product specialists, with detailed knowledge of product operation, maintenance and repair provide technical support via a toll-free (in North American) telephone number. Support is also available through mail, fax and e-mail.

For more information about technical assistance services, contact your sales representative, or call the Technical Assistance Center directly at:

North America:	800-528-7711
International:	434-385-2400
FAX:	434-455-6712
e-mail:	tac@tycoelectronics.com

4. UNPACKING AND CHECKING EQUIPMENT

Before unpacking, installing or operating the ISM Network equipment, read this section of the manual thoroughly. It contains details pertinent to unpacking and handling instructions, and safety precautions to protect users and equipment.

4.1 UNPACKING EQUIPMENT

The ISM radio and Backhaul Router are each shipped in separate transit packages. The associated cabling and accessories for each unit, if any, are shipped in separate containers.

When unpacking the equipment, check the contents against the packing list. Contact your M/A-COM OpenSky representative and the carrier if any discrepancies are noted.

NOTE

Save the shipping cartons and packing materials in case the equipment needs to be shipped back to the M/A-COM for service.

The radio contains ESD sensitive components. Only qualified personnel should open the chassis door.

4.2 INSPECTING AND INVENTORYING EQUIPMENT

Carefully unpack the equipment and examine each item. If there is any damage to the equipment, contact the carrier immediately and have their representative verify the damage. If you fail to report the shipping damages immediately, you may forfeit any claim against the carrier.

CAUTION

After removal from the carton, examine the radio and backhaul router for broken, damaged, loose or missing parts. Examine the RF connector(s), circular power connector and ground lug for cracks, bent or damaged threads, or damage to any paint or seals. If any are noted, contact OpenSky Customer Service immediately to discuss and arrange the return of the equipment to M/A-COM for replacement. Any unauthorized attempts to repair or modify this equipment will void the warranty and could create a safety hazard.

5. PRE-INSTALLATION CONSIDERATIONS

Do not proceed with installation until earlier sections of this manual have been studied and safety precautions and hazard warnings read and understood.

Failure to follow installation guidelines could pose physical danger along with the risk of permanently disabling equipment.

Qualified professional technicians must install this equipment.

5.1 CHECKLIST

Prior to installation, ensure the following are at hand:

- Backhaul Router with latest software
- ISM radio to be configured as a Tower Top radio with latest software
- ISM radios to be configured as Cell Site radios with latest software
- Power/Fiber Optic Cables
- Antenna System for the Tower Top Radio
- Antenna System (one for each slave site)

See Section 6.2.1or the ISM Network Design Guide for antenna recommendations.

5.2 BACKHAUL ROUTER INSTALLATION CHECKLIST

The Backhaul Router Installation Checklist (shown in Section **Error! Reference source not found.**) documents each router's pertinent data and lists the procedures for initial hardware installation of a new Backhaul Router.

- Photocopy this checklist prior to installation.
- Annotate the checklist as each action is completed.
- If a Site Log is kept, include a copy of this checklist for each Backhaul Router at the site.

5.3 PREPARATION FOR FIELD INSTALLATION

Prior to actual field installation, installers should be provided an outline of the ISM network design. The ISM and IP address of each ISM device and the IP address of the Base Station/DCX at each cell site should also be obtained. This information should be recorded on the ISM Network Design forms found in Section **Error! Reference source not found.**.

- Photocopy the ISM Network Design form prior to installation.
- Enter the data for each radio or cell site on the form.
- Once data is collected, it is possible to set up the ISM network in a test lab, prior to field deployment.

5.4 SAFETY RECOMMENDATIONS

The guidelines should be studied prior to working on the Backhaul Router or any equipment powered by electricity.

- Locate the emergency power-off switch. In the event of an electrical accident, it is necessary to turn off the power quickly.
- Power should be turned off and cord unplugged to eliminate all chance of an electrical accident before installing or removing a chassis or working near the power supplies.
- Installers should not work alone if potentially hazardous conditions exist.

Jewelry must be removed (including rings, necklaces, and watches) before working on equipment connected to power lines. Metal objects will heat up when connected to power and ground and can cause serious burns or weld the metal object to the terminals.

5.5 HAZARD WARNINGS

Dangerous Voltages. The Backhaul Router uses –48 VDC or 110 VAC power. These voltages are dangerous and can cause severe electrical shock. The following precautions must be observed when operating or maintaining this equipment.

- Never alter or disconnect the ground connection on the unit or the power cord.
- Never connect an AC source if connected to –48 VDC.
- Never operate this equipment with the covers removed.

An electrical shock hazard exists if this device is connected to 230 VAC mains where both sides of the AC line are floating above ground. The circuit breaker protects only one side of the AC input line. Even if the circuit breaker opens because of high current, the other side of the line in a floating system is still energized.

5.6 ELECTROSTATIC DISCHARGE

Electro**S**tatic **D**ischarge (**ESD**) can damage equipment and impair electrical circuitry. It occurs when electronic components are handled without adequate precautions or proper earth grounding and can result in complete or intermittent failures.

ESD-prevention procedures must be followed when removing and replacing components.

- Ensure that the chassis is electrically connected to earth ground.
- Installers must wear an ESD-preventive wrist strap and ensure it makes good skin contact. To properly guard against ESD damage and shocks, the wrist strap and cord must operate effectively.
- The clip must be connected to an unpainted surface of the chassis frame to safely channel unwanted ESD voltages to ground.
- If no wrist strap is available, grounding can be achieved by touching the metal part of the chassis.

5.7 CABLING CONSIDERATIONS

When planning the installation of the Backhaul Router to a Network Access Router, it is necessary to consider distance limitations and potential **E**lectro**M**agnetic **I**nterference (**EMI**) as defined by the **E**lectronic **I**ndustries **A**ssociation (**EIA**).

Each installation connection must be planned to accommodate the following unique distance limitations.

5.7.1 Ethernet Connections

The distance limitations for Ethernet 10Base-T indicate a maximum segment distance of 328 feet (100 m).

5.7.2 ISM Radio Power/Fiber Optic Connections

The distance limitations for the ISM radio power and fiber optic cable indicate a maximum cable length of 600 feet (183 m). The distance is limited primarily to the voltage drop due to current resistance loss in the power cable.

5.7.3 Maintenance Port Connection

The maintenance port interface is the EIA/TIA-232 (RS-232C). Travel distance for EIA/TIA-232 signals is determined by bit rate. Generally, the slower the data rate, the greater the distance a signal can travel.

Table 5-1 shows the standard relationship between baud rate and maximum distance.

Table 5-1: EIA/TIA-232 Baud for Distance Rates

DATA RATE (BAUD)	DISTANCE (FEET)	DISTANCE (METERS)
2,400	200	60
4,800	100	30
9,600	50	15
19,200	50	15
38,400	50	15
NOTE: The baud rate for the maintenance port is fixed at 19,200 baud, so the maximum cable limit shall not exceed 50 feet or 15 meters.		

6. INSTALLATION

6.1 TOWER TOP ISM RADIO ENCLOSURE INSTALLATION

The Tower Top ISM Radio Enclosure is designed for mounting outdoors on rooftops and poles, building sides and the sides of telecommunications towers. It must be properly mounted, cabled, dressed and tied off, and all grounding cables and interconnections must follow the instructions provided.

Do not proceed with installation until earlier sections of this manual have been studied and safety precautions and hazard warnings read and understood.

Failure to follow installation guidelines could pose physical danger along with the risk of permanently disabling equipment.

Qualified professional technicians should install this equipment only.

Cable clamps, mounting brackets, ground clamps and cables for both the radio and Backhaul Router must follow the specifications set out in this manual as regards the following:

- Chassis ground cables for Tower Top ISM Radio Enclosure, #6 AWG or larger, 7 strands or larger.
- Grounding of outer conductor on RF cable, clamps to use, grounding cable to use.
- Rack grounding cable Backhaul Router.
- Lightning protection device on DC power grounding specifications.
- Fiber Optic cable clamps: what to use, where to tie off and how many feet apart.
- Brackets, bolts etc for mounting radio.
- Termination of antenna port if not used.

6.1.1 Power and Grounding Requirements

The radio operates using +12 VDC to +16 VDC input voltage. Its maximum power requirement is 12 Watts. DC Power is provided via the Fiber Optic Cable assembly (MAIROS0002-XXXXX).

The Enclosure has a grounding lug on the bottom of the chassis. This grounding lug must be connected to a ground reference using #6 AWG stranded wire or heavier gauge.

6.1.2 Lightning Protection

The Tower Top ISM Radio Enclosure contains integral lightning protection. For tower top installations, or any installation in which the radio is not co-located with a Backhaul Router, no additional precautions should be required to protect against lightning.

Figure 6-1: ISM Tower Top Radio Enclosure

6.1.3 ISM Radio Co-Located with the Backhaul Router

The ISM radio requires DC power in the range of +12 VDC to +16 VDC. The Backhaul Router provides +15 VDC on its rear panel. When the Backhaul Router is present, it is the preferred power source for the ISM radio.

Because it is often co-located with a Backhaul Router in a ground-level enclosure, special care must be taken to protect the Backhaul Router and other co-located equipment from lightning surges and spikes.

A lightning suppressor should be well grounded and mounted at the egress point to the building (or enclosure) that houses the Backhaul Router.

A Polyphasor (part number IS-17 VDC-30A-FG) or comparable component may be used to provide lightning protection on the +15 VDC power lines.

6.1.4 Connect Radio to Another ISM Device

The devices that constitute the ISM network are ISM Master radios, ISM Slave radios, and Backhaul Routers. An ISM radio can be connected to another ISM device via the RF link, the Network Port, or the SLIP port. Additionally, the radio uses its SLIP port to connect to an OpenSky Base Station Refer to the Assembly Diagram in Section 12.2.

NOTE

Where two ISM Cell radios reside at the same site, only the first radio requires an RF link to the master. The second radio links to the first via the fiber optic connection.

A Master radio is typically located in a tower, physically connected to a co-located Backhaul Router via the fiber optic port.

6.2 ANTENNA SYSTEM INSTALLATION

This section covers installing the antenna system, including RF cables from the antennas to the ISM radio enclosure.

Crews trained and equipped for working on antenna towers generally install antenna systems. As a result, this manual assumes these skilled personnel will be working on the towers and installing the antenna cables and the Antenna Systems.

6.2.1 Antenna Installation

Factors to consider when choosing the appropriate antenna(s) for your installation include distances to be covered, number of cells the radio will support, desired link margin, wind load and terrain.

Table 6-1 is a list of antennas that have been tested and approved for use with the ISM radio.

Table 6-1: ISM Antennas

PART NUMBER	MANUFACTURER	ANTENNA TYPE	GAIN	SIZE	WEIGHT
SSB-2424GD	SSB ELECTRONIC	Directional	24 dBi	23.5 x 39.25 x 15 in.	5.4 lbs
ANAD-159W-A-10-SM	M/A-COM	Directional	16 dBi	12 x 12 in.	1.8 lbs
MFB24006	MAXRAD	Omni	6 dBi	11.5 in.	0.38 lbs
MFB24008	MAXRAD	Omni	8 dBi	20 in.	0.5 lbs
MFB24010	MAXRAD	Omni	10 dBi	36 in.	0.65 lbs
SP2-2.4NS	RADIO WAVES, INC.	Directional	21.3 dBi	24 in.	22 lbs
G3-2.4NF	RADIO WAVES, INC.	Directional	24.5 dBi	28.8 in.	25 lbs
WRO2400-135H	WINNCOM TECHNOLOGIES CORP	Omni	13.5 dBi	29.2 in.	2.5 lbs

NOTE

Follow the Antenna manufacturers assembly instructions when assembling the antennas.
Care should be taken that the reflector is installed in the proper direction with the reflector matching the polarity of the system.

6.2.2 Antenna RF Cable Installation

Depending on the length of cable required for your installation, cable loss, the associated antenna, budgetary restraints and other factors, either of the cables in Table 6-2 may be used with a 2.4 GHz ISM Radio System.

Table 6-2: Antenna RF Cables

CABLE PART NUMBER	MANUFACTURER	DESCRIPTION	LOSS DB/100' @ 2.484GHZ
LDF4.5	ANDREW	5/8 in. RF cable	2.65
LDF5	ANDREW	7/8 in. RF Cable	2.02

When installing RF cables, always adhere to the minimum bending requirements provided by the manufacturer. For Andrew Products, the values are:

CABLE SIZE	BENDING RADIUS
5/8-inch	8-inch (200 mm)
7/8-inch	10-inches (250 mm)

Install hoisting grips and cable hangers as required by the System Installation Diagrams provided by the System Engineer.

Ensure antenna system is properly grounded in accordance with all local and state codes. The Application Diagrams in Section 12.1 illustrate typical grounding methods.

6.2.3 Antenna System Testing

Upon completion of the antenna system installation, the antenna lines should be tested with a **F**requency **D**omain **R**eflectometer (**FDR**) similar to the Anritsu Site Master model S332C.

1. Disconnect the antenna cable "N" connector from the top of the ISM Radio enclosure.
2. Connect the FDR to the antenna cable "N" connector.
3. Setup the FDR to make sweeps over the band from 2.400 to 2.485 GHz.
4. The output of the sweeps should be archived and left with the customer, installer and project documentation for future reference when troubleshooting the system.

6.3 POWER/FIBER OPTIC CABLE INSTALLATION

This section covers installing the Power/Fiber Optic cable assembly between the ISM Tower Top Radio enclosure and the shelter demarcation point.

In addition to providing data communication, the Power/Fiber Optic cable assembly also supplies power to the ISM Tower Top Radio from the Backhaul Router.

Fiber Optic Cable Assembly:

The cable assembly is made with non-conducting materials that can withstand a maximum crush resistance of 50 lbs.

End pieces and connectors: These components are easily damaged. The bend radius should be not less than 1.5 in. for this section of the cable assembly.

Weather resistant section: The bend radius should be not less than 6 in. for this section of the cable assembly.

The assembly must be supported to provide strain relief for the light and fragile ends of the cable that mount onto the ST connectors on the rear of the Backhaul Router. It must also have strain relief to support its weight. The cable is not plenum rated. It supports a maximum hang weight of 200 lb. Maximum hoist length is 1000 ft.

The Power/Fiber Optic cable assembly is available in a number of different lengths. Select the appropriate length, from Table 6-3, that meets the installation requirements.

Table 6-3: Power/Fiber Optic Cable Assembly Lengths

PART NUMBER	LENGTH (FEET)
MAIR0S0002-00006	6
MAIR0S0002-00010	10
MAIR0S0002-00025	25
MAIR0S0002-00050	50
MAIR0S0002-00100	100
MAIR0S0002-00140	140
MAIR0S0002-00200	200
MAIR0S0002-00250	250
MAIR0S0002-00300	300
MAIR0S0002-00350	350
MAIR0S0002-00400	400
MAIR0S0002-00450	450

6.3.1 Installing the Power/Fiber Optic Cable Assembly

1. Secure the fiber optic cable to the Tower Top Enclosure as shown in Figure 6-2.

CAUTION

Handle the fiber optical cable assembly with care. It can break easily.

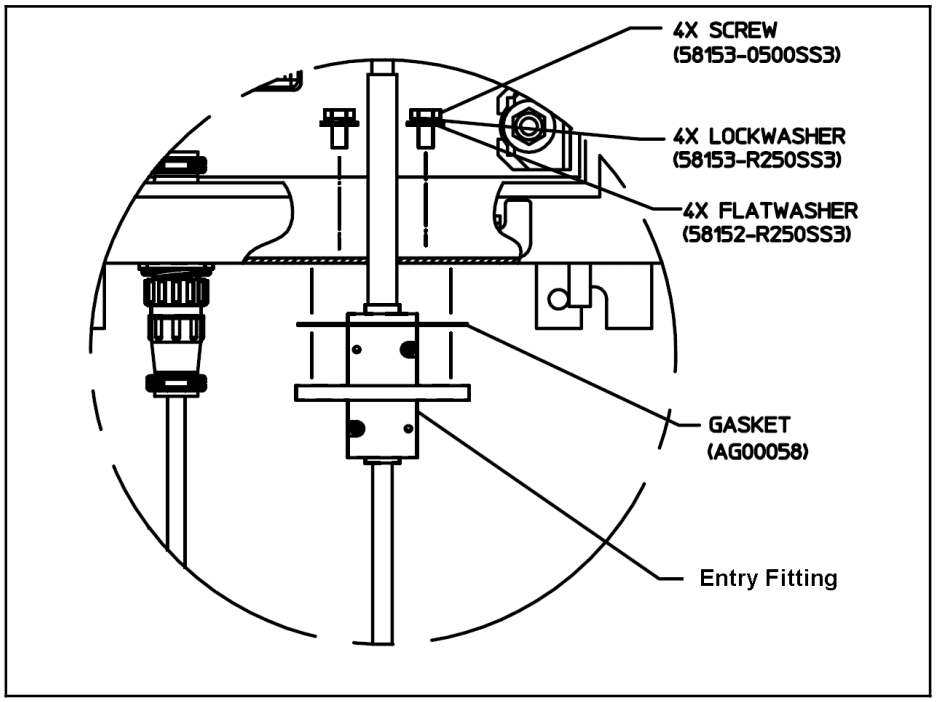


Figure 6-2: Fiber Cable Mounted in Tower Top Radio Enclosure

2. Connect the blue and brown power wires to the surge (input) side of the surge protector as shown in Figure 6-3.

NOTE

Remove and secure any previously installed wires from the surge protector input before installing the power lines from the Power/Fiber Optic cable assembly.

3. Connect the green ground wire to the ground stud.
4. Connect RX fiber optic line (1) to the RX port on the ISM radio.
5. Connect the TX fiber optic line (2) to the TX port on the ISM radio.
6. Secure the remaining fiber optic cables and install a tie wrap to secure the cable assembly to the bracket next to the surge protector.

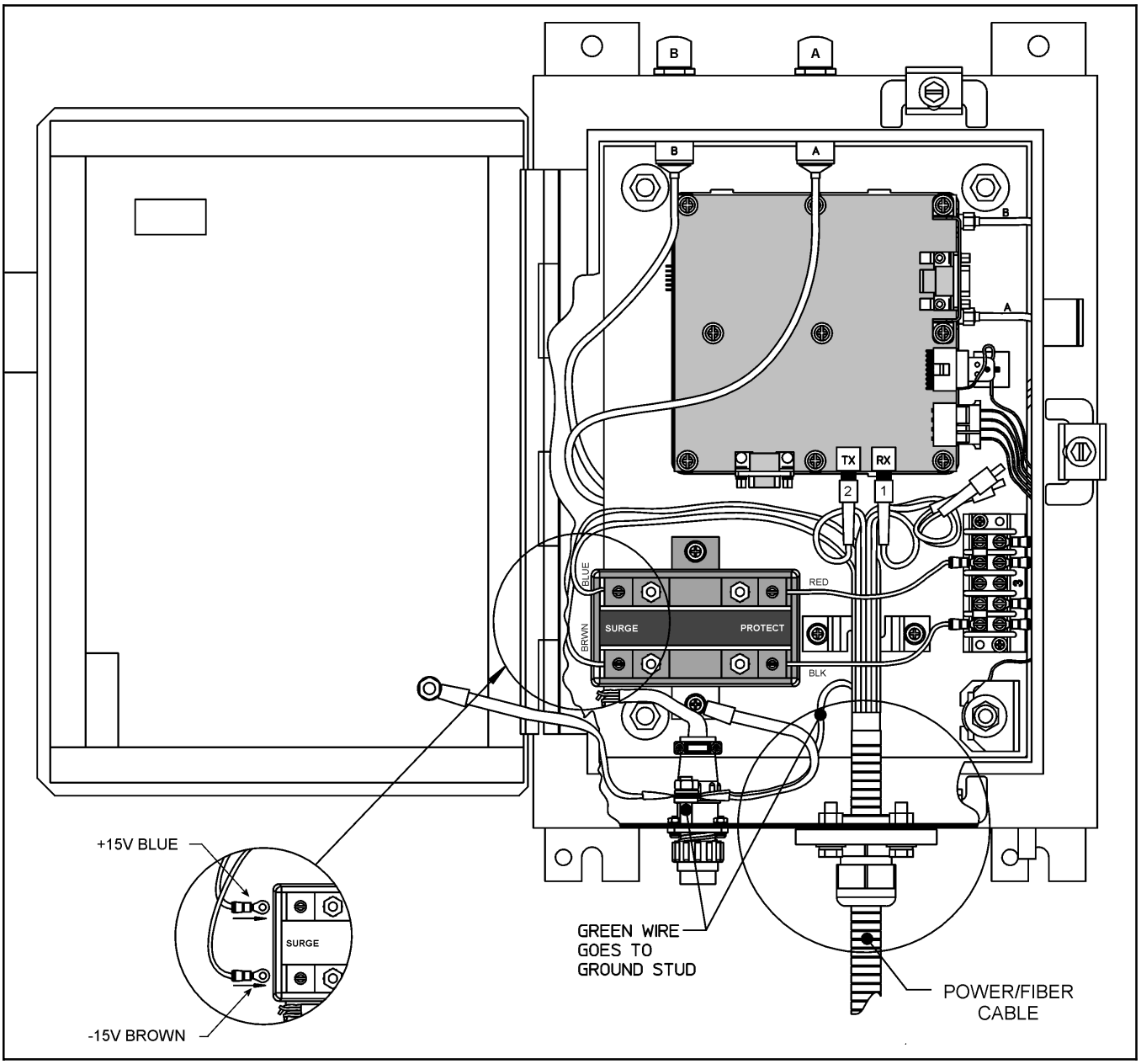


Figure 6-3: Wiring the Power/Fiber Optic Cable Assembly

7. Secure the cable assembly to the tower as required.

NOTE

Secure the Power/Fiber Optic cable assembly to the tower using the same process as that used to secure the antenna RF cable. The cable assembly should also be grounded to the tower at the same intervals as the RF cables.

When possible, do not bring the excess cable into the shelter. Excess cable should be coiled and fastened to the underside of the ice bridge.

8. Run the cable assembly through the demarcation point and into the shelter.
9. Connect the fiber optic connectors to the Fiber Optic Coupler.
10. Connect the ground wire to the Main Ground Bus.

11. Connect the DC power wires the DC Polyphaser.

6.4 BACKHAUL ROUTER INSTALLATION

This section provides information for installing the backhaul Router. The Backhaul Router is available as an AC powered unit or as a DC powered unit.

6.4.1 Front Panel Features

The Backhaul Router front panel has four LED indicators:

- Power LED
- Test LED
- Port A RX/TX LED
- Port B RX/TX LED

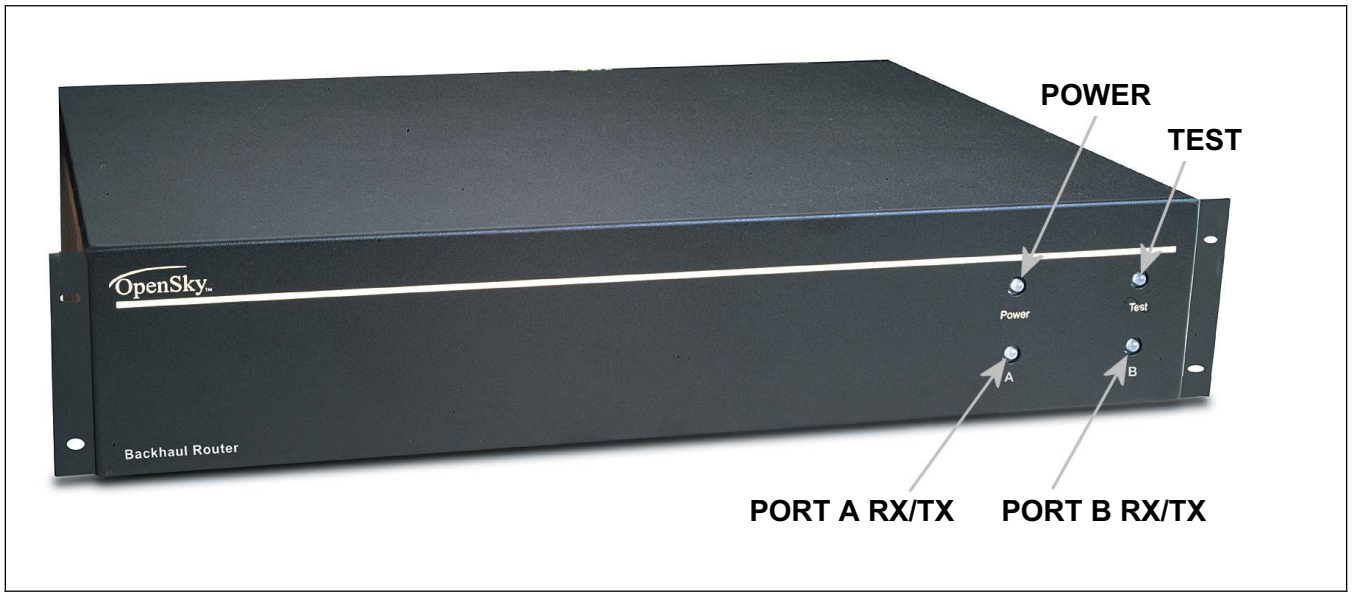


Figure 6-4: Backhaul Router – Front Panel

Table 6-4: Backhaul Router Front Panel Indicators

LED INDICATOR	FUNCTION
Power	Solid green whenever power is applied to the Router.
Test	Dedicated for system test and maintenance.
Port A RX/TX	Flashing indicates packets are being sent or received through the Port A interface.
Port B RX/TX	Flashing indicates packets are being sent or received through the Port B interface.

6.4.2 Rear Panel Features

The Backhaul Router rear panel contains the connectors for interfacing with the Tower Top ISM radio and the Internet router. These connectors include the following:

- Port A +15 VDC (output)
- Port A RS-485
- Port A Fiber TX / Port A Fiber Rx
- 10Base-T LAN Port
- Test or Maintenance Port
- Port B +15 VDC (output)
- Port B RS-485
- Port B Fiber Tx / Port B Fiber Rx
- –48 VDC (input)
- Ground Tab

NOTE

100BaseT-X connector is not used.

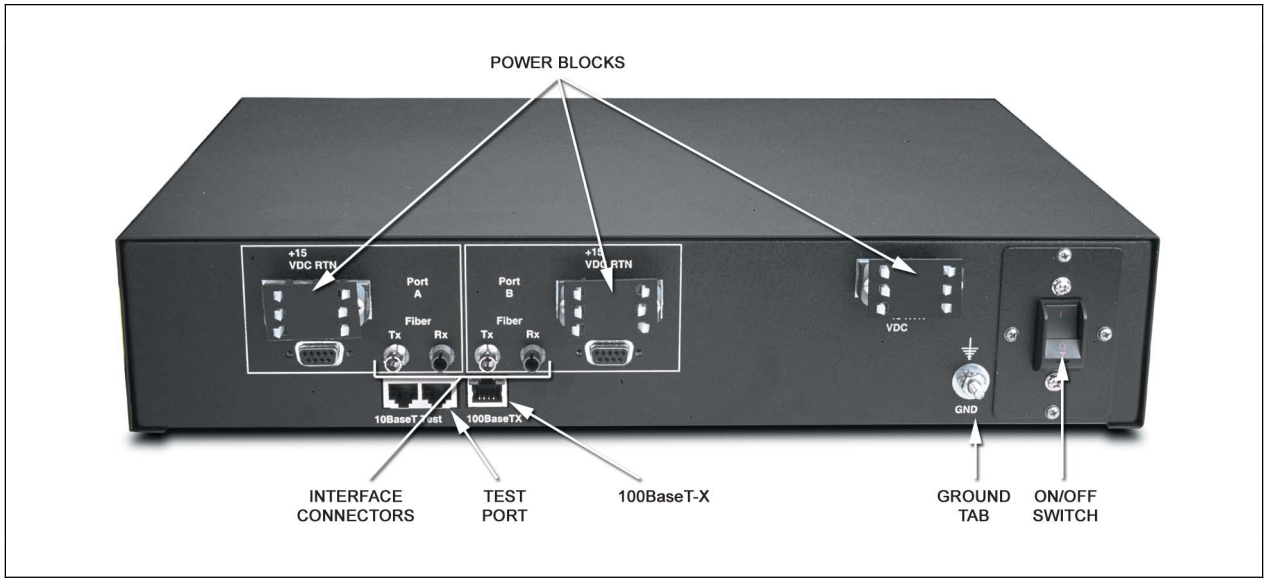


Figure 6-5: Backhaul Router – Rear Panel (DC)

NOTE

Backhaul Router AC Version: The DC terminal block is not present and a cover plate is installed in its place. AC power is provided via a power connector with built in the circuit breaker.

6.4.3 Mounting the Backhaul Router

The Backhaul Router is designed for mounting into a standard 19-inch rack in a 2 RU (Rack Unit) space. It occupies 3.5 inches of vertical rack space and extends approximately 22 in into the rack.

Secure the router in the cabinet using four screws through the router mounting brackets. This is the preferred method for supporting of the unit when installed in the rack.

Airflow moves through the left and right sides of the chassis. Blocking the sides of the chassis can impede airflow, leading to dangerous overheating.

Avoid using slide brackets or any other obstruction that restricts airflow.

Make sure grounding strap is tied to the Backhaul Router Ground Tab.

6.4.4 Power Cable Installation

Dangerous Voltages. The backhaul Router uses –48 VDC or 110 VAC power. These voltages are dangerous and can cause **severe electrical shock**.

The following precautions must be observed when operation or maintaining this equipment.

- **Never alter or disconnect the ground connection** on the unit or the power cord.
- **Never operate this equipment with the covers removed**.
- **Always disconnect the power cord from the power source** when removing or installing covers, internal components, and wiring.

6.4.4.1 AC Powered Backhaul Router

1. Ensure the Power switch is in the off position.
2. Connect the AC power cord to the rear panel AC power connector.
3. Connect the other end to a circuit breaker protected AC source.

6.4.4.2 DC Powered Backhaul Router

1. Ensure the Power switch is in the off position.
2. Connect the DC power cable to the rear panel -48 VDC power connector.
3. Connect the other end to a power source capable of providing the –48 VDC required.

6.4.5 Ethernet Connection

The Ethernet port is labeled 10Base-T (see Figure 6-6). It is used to connect the Backhaul Router through a Hub to a Cisco (or similar) Network Access Router.

Connect an Ethernet cable between the Backhaul Router 10BaseT (RJ-45) connector and the 10/100BaseT connector on the Network Access Router.

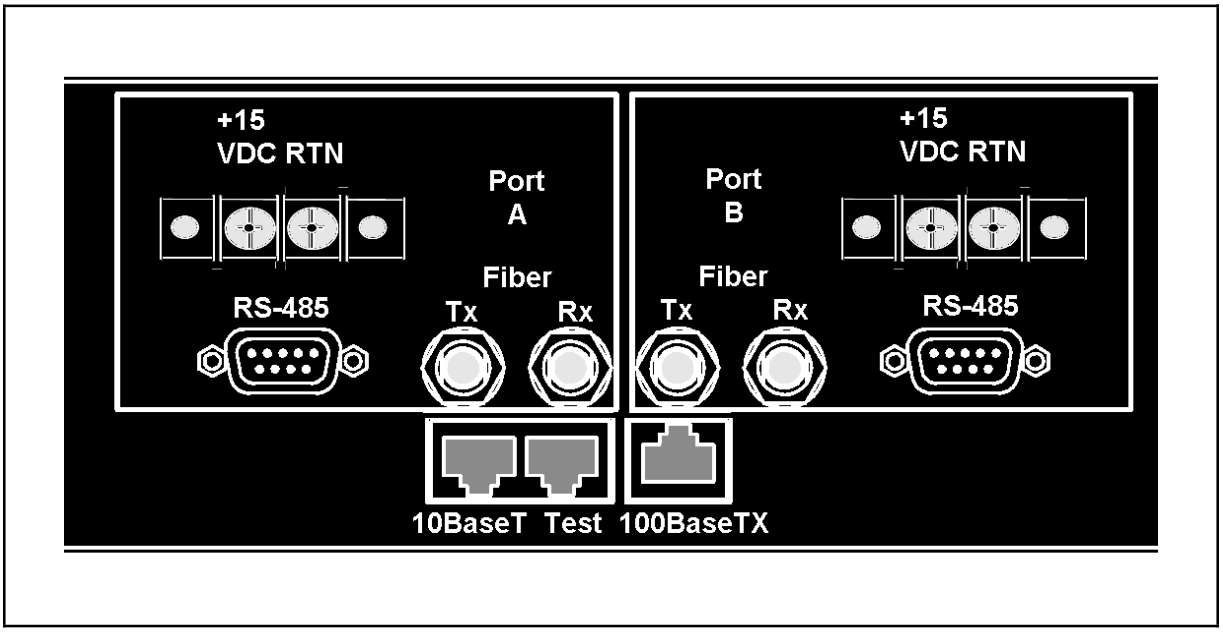


Figure 6-6: Backhaul Router – Output Connections

6.4.6 Fiber Optic Connection

The fiber optic cables provide the data communication path to the ISM Tower Top Radio.

CAUTION

Handle the fiber optical cable assembly with care. It can break easily.

There are two ports available: Fiber Optic Port A and Fiber Optic Port B.

The fiber optic cables are often color-coded or numbered. This feature is used as a guide for connecting the Transmit and Receive lines between the Backhaul Router and the fiber optic coupler or the Tower Top Radio. The color identifies the same fiber on both ends of the cable.

1. Select a Port. If the router is to be connected to only one ISM Tower Top Radio, use Port A.
2. Connect the fiber optic cables onto the ST connectors on the rear of the Backhaul Router (see Figure 6-6).
3. Connect the Transmit (TX) output on the rear of the Backhaul Router to the Receive (RX) input in the Tower Top Radio

4. Connect the Receive (RX) input on the rear of the Backhaul Router to the Transmit (TX) output in the Tower Top Radio.

6.5 MAINTENANCE AND TEST CONNECTIONS

This section provides information for connecting a **P**ersonal **C**omputer (PC) to the ISM radio or the Backhaul Router for maintenance or testing.

To connect the Backhaul Router to a computer or terminal you must have the proper interface cable. Most computers and terminals are **D**ata **T**erminal **R**eady (**DTE**) devices. Since the ISM Radio is also a DTE device, you must use a DTE-DTE interface cable. These cables are also called null-modem, modem eliminator, or cross over cables.

NOTE

If the terminal is other than a DTE model, an appropriate cable must be used for this connection.

6.5.1 Connecting an ISM Radio to a PC or Terminal

The PC to ISM Radio maintenance port interface cable must have the proper connector on each end, and the internal wiring must be correct.

The ISM radio uses a DB-9 *female* connector for the maintenance port and the PC usually requires a DB-9 *male* connector on its COM port. A *female* connector has holes inside the connector housing, and the *male* connector has pins inside the connector housing. Figure 6-7shows the type needed to connect the ISM radio to most computers and terminals.

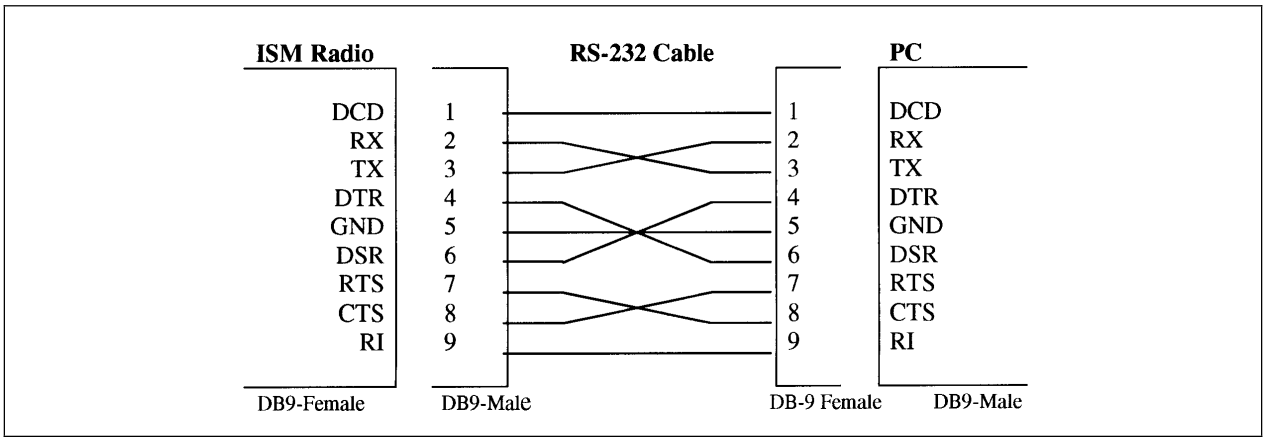


Figure 6-7: RS-232 Cable for Connecting PC to ISM Radio

6.5.2 Connecting Backhaul Router to a PC or Terminal

An RJ-45-to-DB-9 adapter is required to connect the Backhaul Router (TEST) to the PC (see Figure 6-6). The cable shown in Figure 6-8 can be used to connect the Backhaul Router to most computers and terminals. Refer to Table 6-5 for connector pin outs.

Table 6-5: RJ-45 to DB-9 Connections

RJ45	DB-9
4	5
5	3
6	2

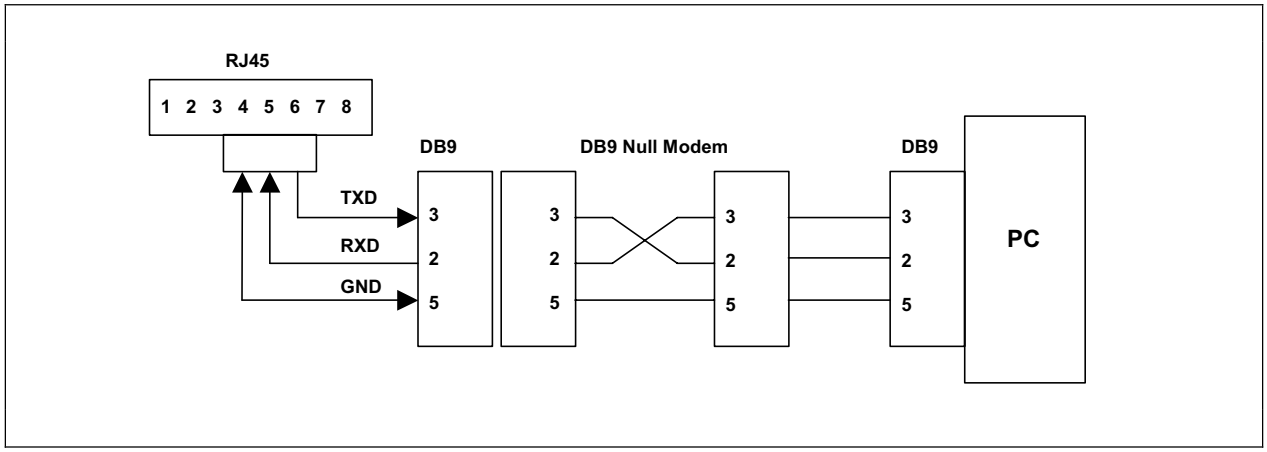


Figure 6-8: Maintenance Port (TEST) Serial I/O

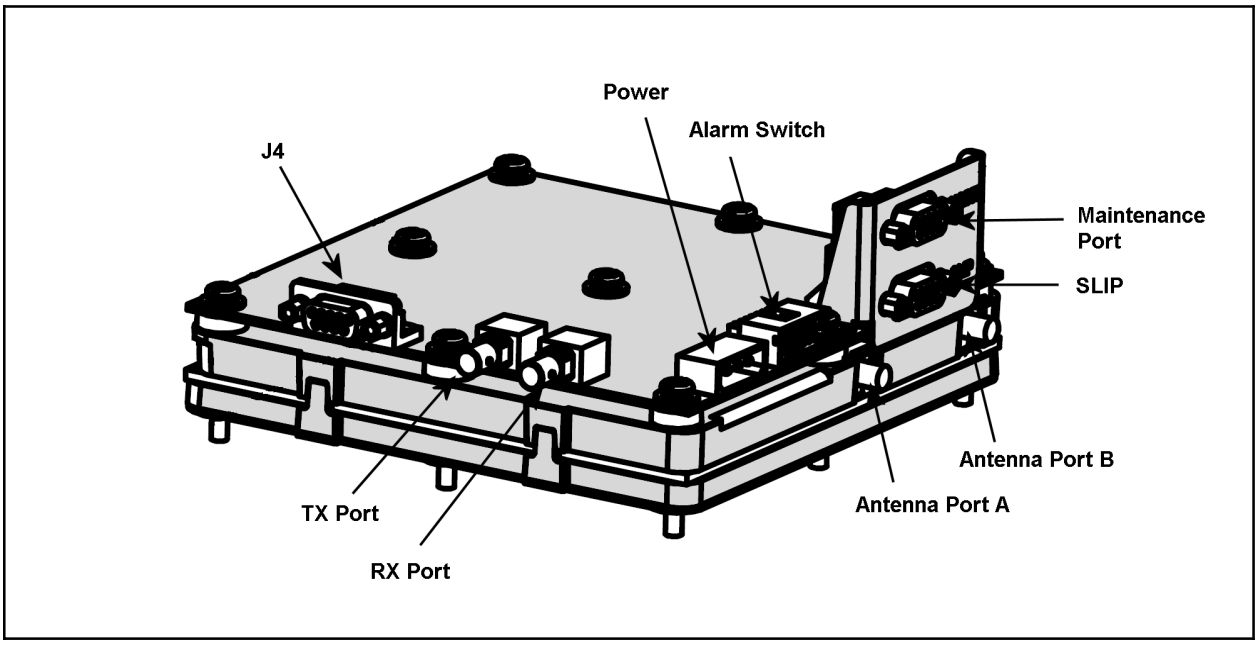


Figure 6-9: ISM Radio I/O Connectors

6.5.3 Maintenance Port Settings

Use the DB-9 to DB-9 RS-232 cable to connect the radio to a computer or terminal. Connect the male end through the radio's top connector, also referred to as the maintenance port. See Figure 6-9.

Below are the communication settings for a radio-to-PC or terminal connection.

- Baud Rate: 19200 bits/sec
- Parity: None
- Data Bits: 8 data bits
- Stop Bits: 1
- Flow Control: None

7. NETWORK CONFIGURATION

7.1 INTRODUCTION

Prior to placing the equipment into operation, it must be properly configured as a system. The following sections provide instructions for configuring the individual components of the system and setting the system up as a functioning network.

NOTE

Remote configuration involves the use of the **at@send** command. It can also be used to verify the link connectivity among ISM Devices.

All configuration commands are entered from either:

- A 10Base-T Ethernet port through the Network Access Router, or
- A Maintenance port, directly on-site, or other configuration using the maintenance port.

This is typically performed using a PC that has terminal emulation software. The commands can be hand entered or loaded from a configuration file set up ahead of time.

A list of ***at**** commands and their syntax is available in Section 9. Additionally, Section 8 provides an example of an ISM network configuration.

7.2 ROUTING TABLES

Logical connections and network topology previously defined as part of the network design are stored in the routing table.

Typical connections are entered in the routing table through the maintenance port or remotely through another radio, provided there is a link address for the target radio in the remote radio's routing table.

NOTE

Instructions containing **<Enter>** indicates the installer should press the keyboard Enter key.

7.3 CONFIGURING THE BACKHAUL ROUTER

The Backhaul Router can be remotely configured by using the at@send command from a local or remote ISM radio maintenance port.

If remote changes are made to the Backhaul Router that impact link or route data, remote configuration will no longer be available. A site visit to manually connect to the device may be necessary to restore the link.

The at@send command is used to verify link connectivity among devices connected in the ISM network.

7.3.1 Step 1 – Configure Backhaul ISM and IP Network Addresses

Configure the Backhaul Router with its own ISM address and IP network address.

Table 7-1: ISM and IP Network Addresses

COMMAND SYNTAX	DESCRIPTION
at*addr <ism>	Assign Backhaul Router's ISM address.
at*ip <ip>	Assign Backhaul Router's IP address.
at&w	Save configuration table.

7.3.2 Step 2 – Setup Backhaul Routing Table

Add the ISM radio devices that are present in the network to the Backhaul Router routing table. This includes the base stations that are attached to the Cell Site radios.

Table 7-2: Backhaul Routing Table

COMMAND SYNTAX	DESCRIPTION
at*rtrem *	Clear the Backhaul Router routing table entries.
at*rte <ip,type,ism,port>	Add entries to the Backhaul Router routing table for each ISM radio device present in the network, including Cell Base Stations.
at*pwra*[1 | 0]	Enables/Disable 15 VDC output at Port A.
at*pwrb*[1 | 0]	Enable/Disable 15 VDC output at Port B.
at*mssave	Save routing table.
atz	Reboot.

7.4 CONFIGURING THE TOWER TOP RADIO

7.4.1 Step 1 – Configure the Tower Top Radio Topology

Configure the Tower Top radio with its own ISM address, IP network address, radio type, RF slot interval and Packets Per Interval. Also configure the default destination address so it points to the Backhaul Router's ISM address.

Table 7-3: Tower Top Radio Configuration

COMMAND SYNTAX	DESCRIPTION
at*addr <ism>	Assign Tower Top Radio ISM address.
at*ip <ip>	Assign Tower Top Radio IP address.
at*type 5	Make this ISM a Tower Top Radio.
at*intv 10	RF slot interval.
at*ppi 4	Number Packets per slot Interval.
at*defdest <ism>	Default Destination ISM device.
at&w	Save configuration table.

7.4.2 Step 2 – Configure the Tower Top Radio Routing Table

Configure the Tower Top radio's routing table so it contains an entry for itself, the Backhaul Router and each Cell Site radio it is connected to.

Table 7-4: Tower Top Radio Routing Table Configuration

COMMAND SYNTAX	DESCRIPTION
at*rtrem *	Clear Tower Top radio routing table entries
at*rte <ism,ip,type,port,RF index>	Add entries to Tower Top radio routing table. There should be an entry for the Tower Top radio itself, an entry for the Backhaul Router and entries for each ISM Radio logically attached to the Tower Top Radio.
at*mssave	Save routing table.
atz	Reboot system.

7.4.3 Step 3 – Configure the Tower Top Radio RF Table

Configure the Tower Top radio's RF table so that it contains an entry for each Cell Site radio in its network.

Table 7-5: Tower Top Radio RF Entries

COMMAND SYNTAX	DESCRIPTION
at*rfrem *	Clear the Tower Top radio RF table entries.
at*rfe <index,antenna,chip,sequence,attennuation,ism>	Add an entry to device RF table, for each RF path to the Tower Top radio.
at*mssave	Save RF configuration table.

7.4.4 Step 4 – Configure the Tower Top Radio Frequency List Table

Configure the Tower Top radio's frequency list table. This table defines the frequencies the Tower Top radio uses when linking with a Cell Site radio.

Table 7-6: Tower Radio Frequency List Configuration

COMMAND SYNTAX	DESCRIPTION
at*flrem *	Clear Tower Top radio frequency list table entries.
at*fle <frequency>	Add an entry to device frequency list for each frequency desired.
at*mssave	Save frequency list table.
atz	Reboot system.

7.4.5 Step 5 – Verification Configuration

Attach PC to the Backhaul Router's Maintenance port and type the following commands. If the equipment is operating properly, the requested information is displayed on the PC terminal.

Table 7-7: Verify Configuration

COMMAND SYNTAX	DESCRIPTION
at@send3 at&v	Displays parameter stores.
at@send3 at*rfdisp	Displays RF table.
at@send3 at*rtdisp	Displays route statement.
at@send3 at*fldisp	Displays frequency list.
Note: send3 indicates Device # 3	

7.5 CONFIGURING THE CELL SITE ISM RADIO

7.5.1 Step 1 – Configure Cell Site Radio Topology

Configure each individual Cell Site radio with its own ISM address, IP network address, radio type and default destination ISM device. The default destination ISM should be the Backhaul Router's ISM address.

Table 7-8: Cell Site Radio Configuration

COMMAND SYNTAX	DESCRIPTION
at*addr <ism>	Assign Cell Site radio ISM address.
at*ip <ip>	Assign Cell Site radio IP address.
at*type 3	Make this ISM a Cell Site radio.
at*defdest <ism>	Default Destination ISM device.
at&w	Save configuration table.

7.5.2 Step 2 – Configure Cell Site Radio Routing Table

Configure the Cell Site radio's routing table so it contains an entry for the Backhaul Router, the Tower Top radio and the Base Station to which it is attached. All devices in a spoke from the Tower Top radio are included in the cell routing table.

A cell routing table does not include other cells unless they are in the same RF daisy chain string created by a cell drop and repeat configuration

Table 7-9: Cell Site Radio Routing Table Configuration

COMMAND SYNTAX	DESCRIPTION
at*rtrem *	Clear Cell Site radio routing table entries.
at*rte <ism,ip,type,port,RF index>	Add entry to Cell Site radio routing table.
at*mssave	Save routing table.

7.5.3 Step 3 – Configure Cell Site Radio RF Table

Configure the Cell Site radio's RF table so that it contains an entry that points to the Tower Top radio to which it is attached.

Table 7-10: Cell Site Radio RF Table Configuration

COMMAND SYNTAX	DESCRIPTION
at*rfrem *	Clear Cell Site radio RF table entries.
at*rfe <index,antenna,chip,sequence,attennuation,ism>	Add entry to Cell Site radio RF table.
at*mssave	Save RF configuration table.

7.5.4 Step 4 – Configure Cell Site Radio Frequency List Table

Configure the Cell Site radio's frequency list table.

Table 7-11: Cell Site Radio Frequency List Configuration

COMMAND SYNTAX	DESCRIPTION
at*flrem *	Clear Cell Site radio frequency list entries.
at*fle <frequency>	Add entry to Cell Site radio frequency list, for each frequency to be linked with the master (Tower Top) radio.
at*mssave	Save frequency list table.
atz	Reboot system.

7.5.5 Step 5 – Connect Test Antenna

Attach test antennas to the Tower Top radio and to the Cell Site radios antenna ports.

7.5.6 Step 6 – Verify Configuration

Attach PC to the Backhaul Router's Maintenance port and type the following commands. If the equipment is operating properly, the requested information is displayed on the PC terminal.

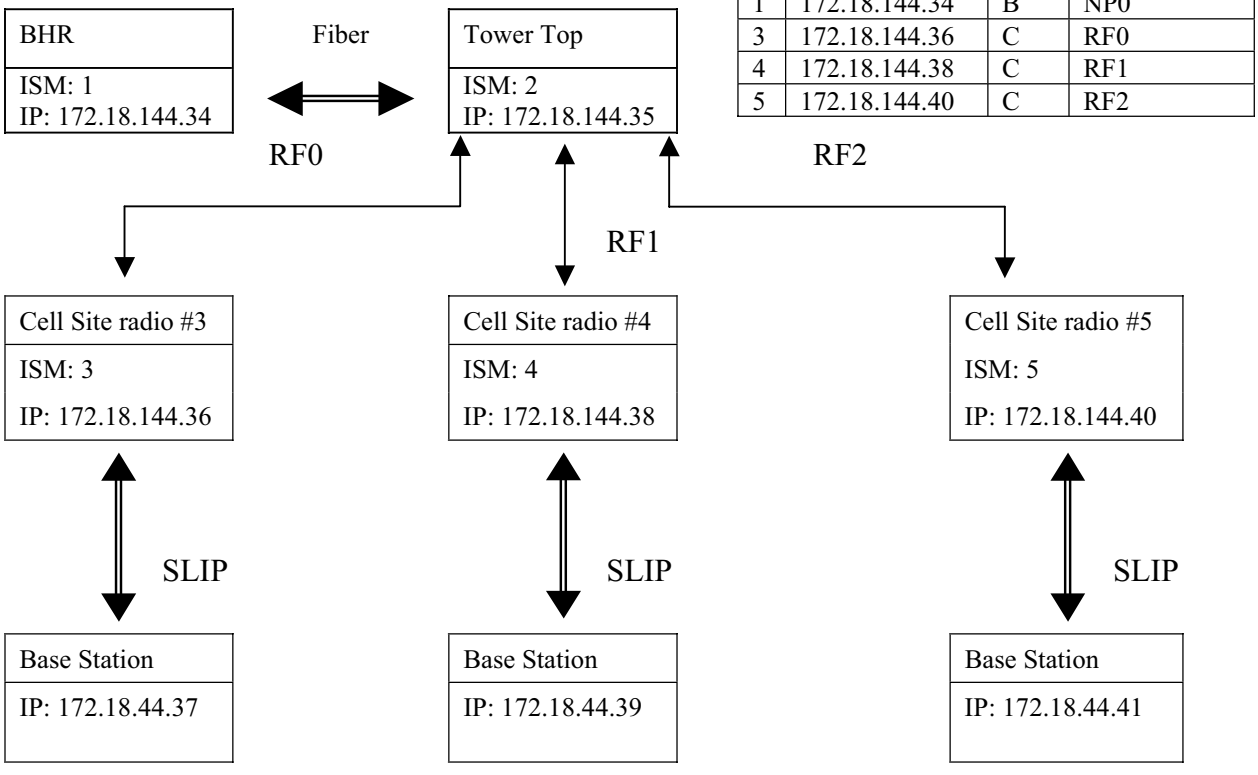
Table 7-12: Verify Configuration

COMMAND SYNTAX	DESCRIPTION
at@send3 at&v	Displays parameter stores.
at@send3 at*rfdisp	Displays RF table.
at@send3 at*rtdisp	Displays route statement.
at@send3 at*fldisp	Displays frequency list.
Note: send3 indicates Device # 3	

8. SAMPLE ISM NETWORK CONFIGURATION

This section contains a sample configuration for an ISM network containing a **B**ackhaul Router, a **T**ower Top radio (master), three **C**ell Site radios (slaves), and three **S**lip Destinations (Base Stations) in a point to multi-point configuration.

BACKHAUL ROUTER ROUTING			
IP ADDRESS	**TYPE (See Section 9.3.2)**	**ISM ADDRESS**	**PORT**
172.18.144.34	B	1	This Device
172.18.144.35	T	2	NA
172.18.144.36	C	3	NA
172.18.144.37	S	3	NA
172.18.144.38	C	4	NA
172.18.144.39	S	4	NA
172.18.144.40	C	5	NA
172.18.144.41	S	5	NA



Tower Top Routing Table			
2	172.18.144.35	T	This Device
1	172.18.144.34	B	NP0
3	172.18.144.36	C	RF0
4	172.18.144.38	C	RF1
5	172.18.144.40	C	RF2

Cell Site radio 3 Routing Table			
1	172.18.144.34	B	RF0
2	172.18.144.35	T	RF0
3	172.18.144.37	S	Slip

Cell Site radio 4 Routing Table			
1	172.18.144.34	B	RF1
2	172.18.144.35	T	RF1
4	172.18.144.39	S	Slip

Cell Site radio 5 Routing Table			
1	172.18.144.34	B	RF2
2	172.18.144.35	T	RF2
5	172.18.144.41	S	Slip

8.1 CONFIGURATION PROCEDURE.

Complete the following tables:

ISM NETWORK IP/ISM DESIGN TABLE			
DEVICE	**ISM ADDRESS**	**IP ADDRESS**	**COMMENTS**
Backhaul Router	1	172.18.144.34	
ISM Tower Radio	2	172.18.144.35	
ISM Cell Site radio	3	172.18.144.36	
ISM Cell Site radio	4	172.18.144.38	
ISM Cell Site radio	5	172.18.144.40	
Base Station Cell	3	172.18.144.37	ISM address used is the same as cell ISM radio address
Base Station Cell	4	172.18.144.39	ISM address used is the same as cell ISM radio address
Base Station Cell	5	172.18.144.41	ISM address used is the same as cell ISM radio address

ISM Network RF Table						
Device	**ISM Address**	**RF Port**	**Antenna**	**Attenuation***	**Chip Size**	**Spread Sequence**
ISM Cell Site radio	3	0	A	0	11	0x5B8
ISM Cell Site radio	4	1	A	0	11	0x5B8
ISM Cell Site radio	5	2	A	0	11	0x5B8

* If using a 24dBi gain antenna (PMANT25-HD-PF1), a minimum attention of 8dB should be programmed in.

NOTE

Care should be taken that ISM networks in the same area or that could potentially expose each other to RF be allocated unique addresses. A convention whereby a figure of ten is added to each network address that has the potential to cause interference would be a reasonable convention to employ. For example, network one would be allocated an address of 1-8, with network two having an address of 11-18 and network three, 21-28.

8.1.1 Configure Backhaul Router

CONFIGURATION TABLE COMMANDS	
at*addr 1	My ISM address
at*ip 172.18.144.34	My IP address
at&w	Save configuration table
ROUTING TABLE COMMANDS	
at*rtrem *	Remove any prior entries from table
at*rte 172.18.144.34,b,1,me	My entry into the routing table
at*rte 172.18.144.35,t,2,na	Tower Radio connected to network Port A
at*rte 172.18.144.36,c,3,na	Cell Site radio 3 entry
at*rte 172.18.144.38,c,4,na	Cell Site radio 4 entry
at*rte 172.18.144.40,c,5,na	Cell Site radio 5 entry
at*rte 172.18.144.37,s,3,na	Base station attached to Cell Site radio 3
at*rte 172.18.144.39,s,4,na	Base station attached to Cell Site radio 4
at*rte 172.18.144.41,s,5,na	Base station attached to Cell Site radio 5
at*udp6425	Sets the UDP port for AT processing
at*np0	Radio set to use fiber optic interface
at*pwra1	Enables 15 VDC output at Port A
at*pwrb0	Disables 15 VDC output at Port B
at*nms_target 0,10.137.0.31,14100,FF,-1	
at*nms_target 1,10.128.1.32,14100,FF,-1	
at*nms_port6104	
at*nms_enable1	
NMC REPORTING COMMANDS	
at*nms_target0,10.134.0.31,14000,FF,2	Allows cell alarms and link status to be remotely monitored via the NMC
at*nms_port6103	
at*nms_enable1	

8.1.2 Configure Tower Radio

CONFIGURATION TABLE COMMANDS	
at*addr 2	ISM address
at*ip 172.18.144.35	IP address
at*type 3	Radio type – Tower Radio
at*intv 10	RF interval
at*ppi 4	RF packets per interval
at&w	Save configuration table
at*defdest1	Sets the default destination address for this device
at*udp6425	Sets the UDP port for AT processing
at*np0	Radio set to use fiber optic interface
ROUTING TABLE COMMANDS	
at*rtrem *	Remove any prior entries from table
at*rte 2,172.18.144.35,t,m,0	Routing entry
at*rte 1,172.18.144.34,b,n,0	Backhaul Router entry
at*rte 3,172.18.144.34,c,r,0	Cell Radio 3 entry
at*rte 4,172.18.144.38,c,r,1	Cell Radio 4 entry
at*rte 5,172.18.144.40,c,r,2	Cell Radio 5 entry
at*nms_target 0,10.137.0.31,14000,FF,1	
at*nms_target 1,10.128.1.32,14000,FF,1	
at*nms_port6103	
at*nms_enable1	
at*mssave	Save routing table
atz	Reboot Backhaul
RF TABLE COMMANDS	
at*rfrem *	Remove all entries from the RF table
at*rfe 0,an,11,5b8,0,3	RF entry for Cell radio 3
at*rfe 1,an,11,5b8,0,4	RF entry for Cell radio 4
at*rfe 2,an,11,5b8,0,5	RF entry for Cell radio 5
FREQUENCY LIST COMMANDS	
at*fle 2412	
at*fle 2426	
at*fle 2440	
at*fle 2454	
at*fle 2467	

8.1.3 Verification Commands

Connect the fiber optic cable between the Tower Top radio and the Backhaul Router. Attach PC to the Backhaul Router's Maintenance port and type the following commands. If the equipment is operating properly, the requested information is displayed on the PC terminal.

VERIFICATION TABLE COMMANDS	
at@send3 at&v	Displays parameter stores
at@send3 at*rfdisp	Displays RF table
at@send3 at*rtdisp	Displays route statement
at@send3 at*fldisp	Displays frequency list
Note: send3 indicates Device # 3	

8.1.4 Configure Cell Site Radio 3

CONFIGURATION TABLE COMMANDS	
at*addr 3	My ISM address
at*ip 172.18.144.36	My IP address
at*type 5	My radio type – Cell Site radio
at*intv 10	RF interval
at*ppi 4	RF packets per interval
at&w	Save configuration table
ROUTING TABLE COMMANDS	
at*rtrem *	Remove any prior entries from table
at*rte 1,172.18.144.34,b,r,0	Backhaul Router's entry
at*rte 2,172.18.144.35,t,r,0	Tower Radio's entry
at*rte 3,172.18.144.37,s,s,0	Base station's entry
at*mssave	Save routing table
atz	Reboot Backhaul
RF TABLE COMMANDS	
at*rfrem *	Remove all entries from the RF table
at*rfe 0,an,11,5b8,0,2	RF entry for the Tower Radio
FREQUENCY LIST COMMANDS	
at*fle 2412	
at*fle 2426	
at*fle 2440	
at*fle 2454	
at*fle 2467	

8.1.5 Configure Cell Site Radio 4

CONFIGURATION TABLE COMMANDS	
at*addr 4	My ISM address
at*ip 172.18.144.38	My IP address
at*type 5	My radio type – Cell Site radio
at*intv 10	RF interval
at*ppi 4	RF packets per interval
at&w	Save configuration table
ROUTING TABLE COMMANDS	
at*rtrem *	Remove any prior entries from table
at*rte 1,172.18.144.34,b,r,1	Backhaul Router's entry
at*rte 2,172.18.144.35,t,r,1	Tower Radio's entry
at*rte 4,172.18.144.39,s,s,0	Base station's entry
at*mssave	Save routing table
atz	Reboot Backhaul
RF TABLE COMMANDS	
at*rfrem *	Remove all entries from the RF table
at*rfe 0,an,11,5b8,0,2	RF entry for the Tower Radio
FREQUENCY LIST COMMANDS	
at*fle 2412	
at*fle 2426	
at*fle 2440	
at*fle 2454	
at*fle 2467	

8.1.6 Configure Cell Site Radio 5

CONFIGURATION TABLE COMMANDS	
at*addr 5	My ISM address
at*ip 172.18.144.39	My IP address
at*type 5	My radio type – Cell Site radio
at*intv 10	RF interval
at*ppi 4	RF packets per interval
at&w	Save configuration table
ROUTING TABLE COMMANDS	
at*rtrem *	Remove any prior entries from table
at*rte 1,172.18.144.34,b,r,2	Backhaul Router's entry
at*rte 2,172.18.144.35,t,r,2	Tower Radio's entry
at*rte 5,172.18.144.41,s,s,0	Base station's entry
at*mssave	Save routing table
atz	Reboot Backhaul
RF TABLE COMMANDS	
at*rfrem *	Remove all entries from the RF table
at*rfe 0,an,11,5b8,0,2	RF entry for the Tower Radio
FREQUENCY LIST COMMANDS	
at*fle 2412	
at*fle 2426	
at*fle 2440	
at*fle 2454	
at*fle 2467	

8.1.7 Verification Commands

Connect the fiber optic cable between the Tower Top radio and the Backhaul Router. Attach PC to the Backhaul Router's Maintenance port and type the following commands. If the equipment is operating properly, the requested information is displayed on the PC terminal.

VERIFICATION TABLE COMMANDS	
at@send3 at&v	Displays parameter stores
at@send3 at*rfdisp	Displays RF table
at@send3 at*rtdisp	Displays route statement
at@send3 at*fldisp	Displays frequency list
Note: send3 indicates Device # 3	

9. AT COMMAND SET

9.1 USING HELP COMMAND

The Help command is available to remind users or administrators what commands the ISM Radio supports, and how to access these commands through the maintenance port.

In addition, for any command string, Help can display the associated function.

Finally, Help can also display the range of allowed values that will complete certain text-entry maintenance and configuration functions.

9.1.1 Accessing the Function Displays

Depending on your familiarity with the ISM Radio functions and the keyboard entries used to launch them, you can choose to display a complete table or an abbreviated list of command strings only.

9.1.1.1 Display Command String List Only

Type **at? <Enter>** or simply **? <Enter>** to display the full list of commands the ISM Radio supports.

Example:

1. Type **at? <Enter>** or **? <Enter>** to display the Command Strings list.
2. This phrases the Help question: *What Command Strings launch which radio functions*?
3. In response, the console will display just a list of Command Strings, but not their associated functions.

9.1.1.2 Display Command String List and Associated Functions

Type **at?? <Enter>** to display the full list of commands the ISM Radio supports and the Command strings that launch them.

Example:

1. Type **at?? <Enter>** to access the full Help menu.
2. This phrases the Help question: *Which Command strings launch which radio functions*?
3. The console will display a list of Command strings alongside the radio functions they launch.

Table 9-1: Command Strings and Radio/Backhaul Router Functions

COMMAND STRINGS	ISM RADIO FUNCTIONS	BACKHAUL ROUTER FUNCTIONS
ati	Displays Radio Info	Displays Backhaul router info
at*addr	My ISMR Address	My ISMR Address
at*udp	UDP PORT for AT Services	UDP PORT for AT Services
at*type	My Radio Type	My Radio Type
at*intv	RF Slot Interval	
at*ppi	Number of packets to send every RF interval	
at*rftto	Milliseconds to wait after RX for next TX	
at*ip	Set Radio IP address	Set device IP address
at*defdest	Default ISM number for unknown IP addresses	
at*mac		Show Ethernet address (hex)
at*np	Network Port Type	Network Port Type
at*pwra		Power Supply A
at*pwrb		Power Supply B
at*rtrem	Remove RTE Entry	Remove RTE Entry
at*rtdisp	Display RTE Table	Display RTE Table
at*rte	Modify RTE Table	Modify RTE Table
at*rfrem	Remove RF_CONFIG Entry	
at*rfdisp	Display RF_CONFIG Table	
at*rfe	RF_CONFIG Table	
at*flrem	Remove Frequency List Entry	
at*fldisp	Display Frequency List	
at*fle	Frequency List	
at*mssave	Save Master/Slave Config Settings	Save Master/Slave Config Settings
ate	Enable/Disable Echo	Enable/Disable Echo
atv	Enable/Disable Verbose mode	Enable/Disable Verbose mode
atz	Boot into Application mode	Boot into Application mode
at&f	Restores Non-vol Parameters and Reboots	Restores Non-vol Parameters and Reboots
at&r	Restores Non-vol Parameters without Rebooting (manual reboot required)	Restores Non-vol Parameters without Rebooting (manual reboot required)

COMMAND STRINGS	ISM RADIO FUNCTIONS	BACKHAUL ROUTER FUNCTIONS
at&w	Saves Non-vol Parameters	Saves Non-vol Parameters
at@send	Sends String Elsewhere	Sends String Elsewhere
at**dbg	Debug Flag	
at**rfmdisp	Display RF Management Info	
at**holdmon	Force to Monitor and Hold Mode	
at**cfreq	Changes Current Freq	
at**surv	Survey a Freq	
at**srt	Spread Random test	
at**ttt	Two Tone test	
at*rssi	Display RSSI value	
at*temp	Display Temperature value	
at*batt	Display Battery value	
at&v	Displays All Values	Displays All Values
at	Ack Only (at? Displays Command List)	Ack Only (at? Displays Command List)
?	Displays Command List	Displays Command List
OK		

9.1.1.3 Display the Current Value of a Command or Parameter

Typing any command string from the Keyboard Entry list, plus a question mark, will reveal the current setting of the management command or parameter.

For example, entering the command **at*addr?** returns the current value of the ISM address.

Example:

1. Type **at*addr? <Enter>**on the network management console.
2. This phrases the Help question: *What is the current setting of **at*addr** (My ISMR Address)?*
3. In response, the console will display the current setting of the ISM Address (for example, **2**).

9.1.1.4 Display The Range of Allowed Values for Command Functions

Typing any command string from the Keyboard Entry list, plus two question marks, reveals the range of values for command parameter.

For example, entering **at*addr??** returns the current value of the ISMR Address.

Example:

1. Type **at*addr?? <Enter>** on the network management console.
2. This phrases the Help question: *What are the allowed values for **at*addr** (My ISMR Address)?*

3. In response, the console displays the full range of values that can be selected to describe, in this example, an ISMR Address (**1-99**).

9.1.2 Accessing Verbose Information

Rather than displaying the current settings for each command or configuration one at a time, consider displaying the full range of current settings in one step.

Example:

1. Type **at&v <Enter>**at the maintenance port.
2. This phrases the Help question: What are all the current settings for this Radio (Backhaul Router)?
3. In response, the console displays the full list of current settings.

   For example (ISM radio):

```
MY ISMR ADDR:     56
UDP PORT for AT Services:     6425
MY RADIO TYPE:    5

RF SLOT INTERVAL:       40
PACKETS PER INTERVAL:   4
RF transmit timeout:    0

RADIO IP:   192.168.105.4
DEFAULT DEST DEV#:      1
NETWORK PORT TYPE:      0

RTE TABLE: Use at*rtdisp to display details.
RF_CONFIG TABLE: Use at*rfdisp to display details.
FREQ_LIST: Use at*fldisp to display details

ECHO:  1
VERBOSITY:   1
APP MODE:    2
DEBUG FLAG:  8192

OK
```

   For example (Backhaul Router):

```
MY ISMR ADDR: 2
UDP PORT for AT Services: 6425
MY DEVICE TYPE: 2
DEVICE IP: 192.168.105.4
DEVICE ETHERNET ADDRESS (MAC): 0:10:ec:0:19:b9

NETWORK PORT TYPE: 0
Radio A Power: 0
Radio B Power: 0
RTE TABLE: Use at*rtdisp to display details.
ECHO: 1
VERBOSITY: 1
APP MODE: 1
DEBUG FLAG: 0


OK
```

9.1.3 Displaying Configuration Information

Two more Help functions allow users/administrators to display the current software version number and the unique identifier for the equipment.

9.1.3.1 How to Display Serial Number

1. Type **ati0 <Enter>** at the maintenance port.
2. This phrases the Help question: *What is the unique equipment identifier (serial number) for this ISM Radio (Backhaul Roiuter)?*
3. In response, the console will display the serial number.

9.1.3.2 How to Display Installed Software

1. Type **ati4 <Enter>**at the maintenance port.
2. This phrases the Help question: *What is the revision number of the software currently loaded on this equipment?*
3. In response, the console will display current software data.

   For example:

```
>>>>> ISM Version ISMR001.07 Jan 12, 2001 13:46:22
OK
```

9.2 SETTING DEVICE PARAMETERS

Logical connections and network topology previously defined as part of the network design is stored in the routing table.

Connections are typically entered in the Routing Table through the maintenance port or remotely through another radio. This process of making and saving logic and topography details is known as configuration.

9.2.1 Network Administration

IP Addresses, ISM Addresses, UDP Port Addresses, RF Slot Interval Timing and other Backhaul or radio functions detailed in the several sections that follow are the responsibility of the network administrator and are established or changed at the maintenance port or remotely through the 10Base-T Ethernet port.

9.2.2 Changing the ISM Address

ISM devices in the OpenSky Network use ISM Addresses to communicate with each other. Each device in the ISM sub-network is identified by a unique ISM address (a one- or two-digit number from 1-99).

Example:

1. Type **at*addr** *num* at the maintenance port or remotely, where *num* is the new address of the ISM device you're configuring (a unique one-or two-digit number 1-99). Example: **at*addr 33**
2. Press the **Enter** key.
3. This sequence states the command: *Change the ISM address of this device to 33.*
4. The console confirms your change: **OK**

9.2.3 Changing the IP Address

In addition to the ISM addresses that ISM devices use to communicate with each other within the ISM Sub-network, every ISM device also uses a unique IP Address to facilitate end-to-end communication across the entire OpenSky network.

Example:

1. Type **at*ip** ***num.num.num.num*** at the maintenance port or remotely, where the *num* sequence is the new IP address, in the familiar dotted decimal format of IP addresses worldwide (four numbers between 1-255, without leading zeroes, separated by dots). Example: **at*ip 192.168.174.2**
2. Press the **Enter** key.
3. This sequence states the command: *Change the IP address of this device to 192.168.174.2*
4. The console confirms your change: **OK**

9.2.4 Displaying Backhaul MAC Address

The Backhaul Router uses a MAC (**M**edia **A**ccess **C**ontrol) address to translate an OpenSky device IP address into an Ethernet physical address.

The 10Base-T is an Ethernet port used to connect the Backhaul Router through a Hub to a Cisco (or similar) Network Access Router. Also, the Ethernet protocol enables remote configuration and maintenance functions.

Example:

1. Type **at*mac** on the local or remote console.
2. Press the **Enter** key.
3. This sequence states the command: *Display the Backhaul Router's Ethernet physical address to 0:10:ec:0:19:b9*.
4. The console **displays the Mac Ethernet Address in hexadecimal format**.
   Example: **0:10:ec:0:19:b9**

9.2.5 Changing the UDP Port Address

The Backhaul Router or ISM radio uses UDP (**U**ser **D**atagram **P**rotocol) to provide services. Service multiplexing/demultiplexing is achieved at the protocol level with software ports. The AT command processing uses UDP port 6425 for its service.

Example:

1. Type **at*udp** *port* at the maintenance port or remotely, where *port* sequence is the new specific service setting for the UDP port. Example: **at*upd** ***6425***
2. Press the **Enter** key.
3. This sequence states the command: Change the service setting of the UDP port to 6425 for AT command processing.
4. The console confirms your change: **OK**

9.2.6 Changing Default ISM Destination

The Backhaul Router or ISM radio uses a default ISM destination address to route packets with unknown IP addresses.

The function makes it possible to share information among ISM devices without accessing the end-to-end IP addressing system of the OpenSky network.

Example:

1. Type **at*defdest** *addr* at the maintenance port or remotely, where *addr* is the new default ISM destination address. Example: **at*defdest** ***14***
2. Press the **Enter** key.
3. This sequence states the command: *Change the default ISM destination address for this device to 14.*
4. The console confirms your change: **OK**

9.2.7 Changing RF Slot Interval Timer

The Master Radio initiates all RF communications in TDM (Time Division Multiplexed) order.

In round-robin fashion, the Master ISM addresses all associated Slave radios in turn, giving each the opportunity to transmit or receive ISM addressed voice and data packets for an amount of time specified in the RF Slot Interval Timer.

Each Slave device timer can be set for any duration from 1 to 5000 milliseconds.

Example:

1. Type **at*intv** *num* at the maintenance port or remotely, where *addr* is the new RF Slot Interval setting. Example: **at*intv** ***10***
2. Press the **Enter** key.
3. This sequence states the command: *Change the RF Slot Interval Timer for this device to 10 milliseconds.*
4. The console confirms your change: **OK**

9.2.8 Changing RF Packets per Interval

The ISM radio can be configured to send a maximum number of packets over the RF link per RF slot interval.

While Slave devices in an ISM subsystem can be configured with nonidentical RF Slot Interval Timers, all Packets Per Interval settings must be identical; either no maximums are set or all radios are set to the same maximum number of packets.

Example:

1. Type **at*ppi** *num* at the maintenance port or remotely, where *num* is the maximum number of packets to be sent over the RF link during an RF Slot Interval. Example: **at*ppi** ***4***
2. Press the **Enter** key.

3. This sequence states the command: *Set or change the maximum number of Packets Per Interval for this ISM Subsystem to 4.*
4. The console confirms your change: **OK**

9.2.9 Changing RF Transmit Delay

An ISM Master Radio can be configured to wait a specified number of milliseconds before transmitting a packet. However, this is not recommended.

The default setting of zero (0) milliseconds is the preferred and recommended setting for this parameter. Other settings, because they limit data throughput, may degrade system performance.

NOTE

This is a Master Radio function only. Slave devices may accept an entry in this configuration field, but will ignore any setting you make

Example:

1. Type **at*rftto** *delay* at the maintenance port or remotely, where *delay* is the number of milliseconds a Master device will wait before transmitting data packets. Example: **at*rftto *10***
2. Press the **Enter** key.
3. This sequence states the command: *Set or change the number of milliseconds this device will wait before sending a packet to 10.*
4. The console confirms your change: **OK**

9.2.10 Changing Mode of Operation

When it comes out of the carton, the ISM Radio is neither Master nor Slave. Its hardware supports both. How it performs depends on choices you make during configuration and setup.

Even after an ISM device has been configured for Master or Slave operation, its Mode of Operation can be changed remotely through a Routing Table update or at a terminal connected to the maintenance port.

A single-digit code determines whether the device operates as Master or Slave:

Code Number	Mode of Operation
3	Radio operates as Master
5	Radio operates as Slave

Example:

1. Type **at*type** *mode* at the maintenance port or remotely, where *mode* is the code number indicating Master or Slave mode. Example: **at*type *3***
2. Press the **Enter** key.
3. This sequence states the command: *Set or change this radio to operate as a Master device.*
4. The console confirms your change: **OK**

9.2.11 Changing Network Port Assignment

The Backhaul Router and ISM radio contain two network hardware interface ports: a fiber optic interface and an RS-422 port. Software configuration determines which interface port is used for subsystem communications. The fiber optic interface is the default port.

NOTE

Slave devices may accept an entry in this configuration field, but it will be ignored.

A single-digit code determines whether the device uses the default fiber optic interface or connects to the network via the RS-422 port.

Code Number	Assigned Port
0	Radio uses the fiber optic interface
1	Radio uses the RS-422 interface

Example:

1. Type **at*np** *type* at the maintenance port or remotely, where *type* is the code number indicating fiber optic or RS-422 port. Example: **at*np *0***
2. Press the **Enter** key.
3. This sequence states the command: *Assign the fiber optic port to network use for this device.*
4. The console confirms your change: **OK**

9.2.12 Enabling +15 VDC on Port A or B

The Backhaul Router has output power blocks on Ports A and B that can be used to supply +15 VDC to ISM radios attached to them.

Use small variations in the procedure below to enable or disable 15 Volts of Direct Current to the power blocks for either port.

The choice is the responsibility of the network administrator and is established or changed at the local or remote console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

1. Type **at*pwra *mode*** on the local or remote console, where **pwra** identifies Port A as the target (pwrb identifies Port B) and *mode* identifies your intention to **disable** (mode **0**) or **enable** (mode **1**) the flow of current to the power block. Example: **at*pwra *1***
2. Press the **Enter** key.
3. This sequence states the command: *Enable+15 VDC to the power block on Port A*.
4. The console confirms your change: **OK**
5. To save the change to non-volatile memory, type **at&w <Enter>**.

9.3 MANAGING THE ROUTING TABLE

The Routing Table determines where the ISM Radio forwards its packet.

The Network Administrator is responsible for the Routing Table. The table can be generated or changed at the Network Management Console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

9.3.1 Saving the Routing Table

Entries in the Routing Table are stored in non-volatile memory and copied into volatile memory after power is applied to the radio. Changes made only in volatile memory will not survive Power Down.

NOTE

Remember to save changes to Non-Volatile Memory.

The Routing Table like other entries in the configuration table is stored in non-volatile memory and copied into volatile memory at Power Up. To survive Power Down, changes must be saved in non-volatile memory. To save changes: type **at*mssave Enter**.

Remember - Volatile Memory does not survive Power Down. Only changes saved into Non-Volatile Memory will survive Power Down.

When making permanent changes to the routing table, save them to non-volatile memory so you won't lose your changes when the radio is turned-off.

To save the changes, type: **at*mssave** then press the **Enter** key.

9.3.2 Routing Table Entries

A single command line made up of several components separated by commas, comprises a Routing Table entry for an ISM device.

Entry Format:

Routing Table entries take the form: **at*rte** *ism addr, ip addr, type, port, RF link*

Where:

COMMAND	PURPOSE
at*rte	rte adds a Routing Table Entry (rte) to the configuration for this ISM device.
ism addr	A one- or two-digit number between 1-99 that specifies the device's unique ISM address within the sub-network.
ip addr	IP Address in familiar dotted decimal notation associates the IP address of an ISM device to its ISM link address.

Continued…

COMMAND	PURPOSE
type	Describes the type of the source device, according to the following: C Cell radio/slave T Tower radio/master B Backhaul Router S Slip Destination I IP Source
port	Describes which Backhaul Router interface will make the connection path to the ISM at this address, according to the following: M This device N Network port R RF port S SLIP port
RF link	A number between 0 to 5 that describes RF link associated with this entry. The RF links are described in the RF configuration table. This value is ignored unless the *port* (identified in the parameter field above) is an RF port.

Example:

In the sample Routing Table entry: **at*rte 14,192.168.105.3,C,N,0**

at*rte	is the command line
14	is the device's ISM address and
192.168.105.3	is the IP address
C	designates the device as a cell radio/slave
N	indicates the device connects the Network Port
0	describes the RF Link (ignored unless the device connects through the RF link)

9.3.3 Adding a Routing Table Entry

1. Type a routing table command string at the network management console or maintenance port. For example: **at*rte 14,192.168.105.3,C,N,0.** (See *Sample Entry* above for a breakdown of the parameters of a routing table entry.)
2. Press the **Enter** key.
3. This sequence states the command: *Add a routing table entry for ISM address 14, IP address 192.168.105.3, a Slave cell radio connected through Network Port.*
4. The console confirms the change:

```
>14,IP(192.168.105.3),c,n
>OK
```

5. To save the change to non-volatile memory, type **at*mssave <Enter>**.

NOTE

Remember to save changes to Non-Volatile Memory.

9.3.4 Removing a Routing Table Entry

The Routing table determines where the ISM Radio forwards its packet. Use the procedure below to remove a link address from the routing table.

Configuration and changes to the routing table are the responsibility of the network administrator. Entries are established or changed at the network management console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

1. Type the routing table deletion string **at*rtrem** *addr* at the network management console or maintenance port where *addr* is the ISM address of the ISM device whose entry you wish to delete. For example: **at*rtrem *13***
2. Press the **Enter** key.
3. This sequence states the command: *Remove the routing table entry for ISM device 13*
4. The console confirms the change:

```
>Device 13 deleted from RTE table
>OK
```

5. To save the change to non-volatile memory, type **at*mssave Enter**

NOTE

Remember to save changes to Non-Volatile Memory.

9.3.5 Displaying Routing Table Entries

To display the complete contents of the Routing Table for an ISM device, use the procedure below.

The Routing Table is the responsibility of the network administrator and can be verified at the network management console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

1. Type a routing table display string at the terminal attached to the maintenance port:
   at*rtdisp <Enter>

2. The console displays a table of routing entries for all networked devices. The table below is entirely hypothetical; your display will be specific to your particular network setup:

```
13      192.168.105.2   Backhaul Router    This Device   0

14      192.168.105.3   Tower radio        RF Port       0

15      192.168.105.4   Cell Radio         RF Port       1

OK
```

9.3.6 NMS Trap Target Entries

This command sets up NMS targets, which will receive the OpenSky NMS traps specified by the mask.

Entry Format:

Routing Table entries take the form: **at*nms_target** id, ip_address, port, mask, ism id

Where:

PARAMETERS	DESCRIPTION
id	Target ID (0 or 1)
ip_address	IP address of NMS trap server
port	Port number for OpenSky NMS trap communications (1–32767)
mask	The bit mask defining which traps are sent to the NMC Bit — Description 0 — 0 - Disable status trap, 1 - Enable status trap 1 — 0 - Disable fault trap, 1 - Enable fault trap 2 — 0 - Disable performance trap, 1 - Enable performance trap
ism id	This is the device ISM address (0-99). It is applicable to all devices, including secondary Backhaul Routers, reporting trap data to the NMC through the primary Backhaul Router (usually device #1). For Primary Backhaul Routers, this is an exit interface specifier rather than an ism id. Enter "**-1**" to correspond to the Ethernet port.

Example:

In the sample Routing Table entry: **at*nms_target 0, 101.202.33.45, 14000, FF, 1**

at*nms_target	is the command line
0	is the target ID
101.202.33.45	is the NMC IP address
14000	designates the port number
FF	is the bit mask
1	is the device ISM address

9.4 MANAGING THE RF CONFIGURATION TABLE

The RF Configuration Table contains the parameters that control the antenna selection, the attributes of the PN sequence generator and the power level for the RF transmitter section. Each entry in the table corresponds to an RF link with another ISM radio. There is a maximum of six entries in this table.

The RF Configuration Table is the responsibility of the network administrator and is established or changed at the Network Management Console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

9.4.1 Saving the RF Configuration Table

The RF Configuration Table is stored in non-volatile memory and copied into volatile memory when power is applied to the radio. Changes are made only in volatile memory and will not survive Power Down.

When making permanent changes to the RF Configuration Table, save them to non-volatile memory so you won't lose your changes when the radio is turned-off.

To save the changes, type: **at*mssave** then press the **Enter** key.

NOTE

Remember to save changes to Non-Volatile Memory.

The RF Configuration Table is stored in non-volatile memory and copied into volatile memory at Power Up. To survive Power Down, changes must be saved in non-volatile memory. To save changes: type **at*mssave <Enter>**.

Remember- Volatile Memory does not survive Power Down. Only changes saved into Non-Volatile Memory will survive Power Down.

9.4.2 RF Configuration Table Entries

A single command line made up of several components separated by commas, comprises an RF Configuration Table entry for an ISM device.

The parameters of an RF Configuration Table entry are:

- the Table Index, specified by *index*
- the Transmit and Receive Antenna: *antenna*
- the Spread Chip size: *chip size*
- the Spreading Sequence: *sequence*
- the Transmit Attenuation: *atten*
- the ISM Link Address: *link addr*

Entry Format:

RF Configuration Table entries take the form: **at*rfe** *index, antenna, chip size, sequence,atten, addr*

Where:

PARAMETER	PURPOSE
at*rfe	rfe adds an RF Configuration entry (rfe) to the configuration for the ISM device identified by the index parameter.
index	A number from 0 to 5 (for a total of 6 entries per table) uniquely identifying this link. This parameter (described as the *RF Link* in the Figure describing Routing Table Entries) is the number referenced by the Routing Table entries for a particular ISM device.
antenna	A 2-letter code for the following antenna setups: Antenna / Transmitter / Receiver AN / RF Port A / RF Port A AD / RF Port A / Diversity mode BN / RF Port B / RF Port B BD / RF Port B / Diversity mode DD / Diversity mode / Diversity mode
chip size	The number of bits to be used by the PN sequence generator. Legal entries for this field are 11, 13, 15 and 16 bits.
sequence	The sequence used by the PN sequence generator.
atten	Sets the amount of attenuation to be used in the transmit path. The radio outputs 30dBm minus the amount of attenuation set in this field. If using a 24dBi gain antenna (PMANT25-HD-PF1), a minimum attention of 8 dB should be programmed in.
addr	A number between 1-99 that specifies the ISM address of the radio at the other end of this RF link.

Example:

In the following sample RF Configuration Table entry:

at*rfe 0,AN,11,0x54B,4,14

at*rfe is the command line

0 is the unique index indicator for an ISM device

AN is the antenna identifier

11 is the number of bits in a PN sequence

0x54B is the PN sequence used

4 is the amount of attenuation in the transmit path

14 is an ISM address

9.4.3 Adding an RF Configuration Entry

1. Type an RF Configuration Entry string at the network management console or maintenance port. For example: **at*rfe 0,AN,11,0x54B,4,14**
2. Press the **Enter** key.
3. This sequence states the command: *Add an RF Configuration Table entry for ISM device 0, with a Port A to Port A antenna setup with no diversity on the receive side, a chip size set to 11 bits, following the PN chip size sequence of 54B (hexadecimal), with 4 dBm attenuation in the transmitter power level, at ISM Address 14.*
4. The console confirms your entry: **OK**
5. To save the change to non-volatile memory, type **at*mssave <Enter>**.

NOTE

Remember to save changes to Non-Volatile Memory.

9.4.4 Displaying RF Configuration Table Entries

To display the complete contents of the RF Configuration Table for an ISM Master radio and its associated Slave devices, use the procedure below.

The RF Configuration Table is the responsibility of the network administrator and can be verified at the network management console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

1. Type an RF Configuration Table display command at the terminal attached to the maintenance port: **at*rfdisp <Enter>**
2. The console displays RF entries for all devices associated with the ISM Master device. The table below is entirely hypothetical; your display will be specific to your particular network setup:

INDEX	LINK IN USE	ANTENNA / DIVERSITY	CHIP SIZE	SPREAD SEQUENCE	ATTENUATION	ISM ADDRESS
0:	1	A without Div	11	0x5b8	10dB	14
1:	1	B without Div	11	0x5b8	10dB	15
2:	0	B without Div	11	0x5b8	10dB	3
3:	0	B without Div	11	0x5b8	10dB	3
4:	0	B without Div	11	0x5b8	10dB	3
5:	0	B without Div	11	0x5b8	10dB	3

9.4.5 Removing an RF Configuration Table Entry

Each entry in the RF Configuration Table corresponds to an RF link with another ISM radio. Use the procedure below to remove a link address from the RF Configuration table.

The table is the responsibility of the Network Administrator. Entries are established or changed at the Network Management Console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

1. Type the RF table deletion string **at*rfrem** *index* at the network management console or maintenance port where *index* is the RF link identifier of the ISM device whose entry you wish to delete (a number from 0 to 5). For example: **at*rfrem *0***
2. Press the **Enter** key.
3. This sequence states the command: *Remove the RF Configuration table entry for the ISM device at RF Link 0.*
4. The console confirms your change: ***OK***
5. To save the change to non-volatile memory, type **at*mssave <Enter>.**

NOTE

Remember to save changes to Non-Volatile Memory.

9.5 MANAGING THE FREQUENCY LIST TABLE

The ISM radio uses the Frequency List Table to establish a communication link with other radios in the ISM network.

Each entry in the table corresponds to an allowed frequency to be used for linking with other radios. Allowed frequencies will fall within the range from 2412-2468 MHz.

The Frequency List is the responsibility of the Network Administrator and is established or changed through a terminal attached to the maintenance port or remotely through the 10Base-T Ethernet port.

9.5.1 Saving the Frequency List Table

The Frequency List Table is stored in non-volatile memory and copied into volatile memory when power is applied to the radio. Changes are made only in volatile memory and will not survive Power Down.

When making permanent changes to the Frequency List Table, save them to non-volatile memory so you won't lose your changes when the radio is turned-off.

To save the changes, type: **at*mssave** then press the **Enter** key.

NOTE

Remember to save changes to Non-Volatile Memory.

The Frequency List Table is stored in non-volatile memory and copied into volatile memory at Power Up. To survive Power Down, changes must be saved in non-volatile memory. To save changes: type **at*mssave <Enter>**.

Remember- Volatile Memory does not survive Power Down. Only changes saved into Non-Volatile Memory will survive Power Down.

9.5.2 Adding a Frequency List Entry

1. Type the Frequency List Entry command at the Network Management Console.
   For example: **at*fle *2440***
2. Press the **Enter** key.
3. This sequence states the command: *Add Frequency 2440 MHz to the list of allowable frequencies for linking other radios to this ISM device.*
4. The console confirms your entry:
   2440
   OK.
5. To save the change to non-volatile memory, type **at*mssave <Enter>**.

NOTE

Remember to save changes to Non-Volatile Memory.

9.5.3 Displaying a Frequency List Table

The ISM radio uses the Frequency List Table to establish communication link with other radios in the ISM network. Only frequencies listed in the table are available for linking to other ISM devices.

To display the frequency list table, use the command below.

Example:

1. Type the Display Frequency List command at the terminal attached to the maintenance port: **at*fldisp <Enter>.**
2. The console displays all available frequencies and their current status. Of course, the table below is entirely hypothetical; your display will be specific to your particular network setup:

```
Frequency List

2412 MHz —Status: Unknown

2440 MHz —Status: Unknown
2467 MHz —Status: Unknown

OK
```

9.5.4 Removing Frequency List Entry

The ISM radio uses the Frequency List Table to establish communication link with other radios in the ISM network. Only frequencies listed in the table are available for linking to other ISM devices.

Use the command below to remove a frequency from the list of frequencies available for ISM links.

Example:

1. Type the Frequency List Entry deletion command **at*flrem** *freq* at the network management console or maintenance port where *freq* is the RF frequency you wish to delete from the list of frequencies available for RF Links to ISM devices. For example: **at*flrem *2440***
2. Press the **Enter** key.
3. This sequence states the command: *Remove the frequency 2440MHz from the Frequency List Table.*
4. The console confirms your change:

```
Frequency 2440 deleted from FREQ_LIST
OK
```

5. To save the change to non-volatile memory, type **at*mssave <Enter>**.

NOTE

Remember to save changes to Non-Volatile Memory.

9.6 SAVING CONFIGURATION AND PARAMETER CHANGES

This manual makes repeated reference to the importance of saving configuration changes to non-volatile memory to make your changes permanent.

The ISM Radio uses both volatile (temporary) and non-volatile (permanent) memory to handle configuration details. At Power Up, configuration data is copied into non-volatile memory.

9.6.1 Saving Configuration Changes

Changes made to the Routing Table, the RF Configuration Table and the Radio Frequency List need to made permanent so they can be preserved when power to the radio is turned off

9.6.1.1 Temporary Configuration Changes

Changes you make on an ad-hoc basis to address a temporary situation will remain active in volatile memory until you power the radio down, but will not survive Power Down.

9.6.1.2 Permanent Configuration Changes

When making changes you wish to make permanent, take the extra step of saving them to non-volatile so you will not lose the changes when the radio is powered down.

To save the changes, type: **at*mssave** then press the **Enter** key.

Changes can be saved at the network management console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

1. To save changes you make to the Routing Table, the RF Configuration Table and the Radio Frequency List, type the Non-Volatile Save command **at*mssave** at the network management console.
2. Press the **Enter** key.
3. The console confirms your change: **OK**

9.6.2 Saving Parameters Permanently

The ISM Radio uses both volatile (temporary) and non-volatile (permanent) memory to handle configuration details. At Power Up, configuration data and Radio Parameters are copied into non-volatile memory. Any changes made during a radio session but not saved to non-volatile memory will be lost at Power Down.

9.6.2.1 Temporary Parameter Changes

Changes you make on an ad-hoc basis to address a temporary situation will remain active in volatile memory only until you power the radio down.

9.6.2.2 Permanent Parameter Changes

When making changes to radio parameters you wish to make permanent, take the extra step of saving them to non-volatile memory so you will not lose the changes when the radio is powered down.

To save the changes, type: **at&w** then press the **Enter** key.

Changes can be saved at the network management console, a terminal attached to the maintenance port, or remotely through the 10Base-T Ethernet port.

Example:

To save radio parameters:

1. Type the Non-Volatile Save command **at&w** at the Network Management Console.
2. Press the **Enter** key.
3. The console confirms you change: **OK**

10. TROUBLESHOOTING

10.1 OVERVIEW

This document is intended to present some techniques used for determining problems with an ISM link. The document is not intended to be comprehensive. In many cases not all of the steps will need to be followed. In other cases an engineer will be needed to go beyond the items offered in this guide. This guide assumes some familiarity with the product and system such that the ability to connect to the radio locally and remotely is known.

In general most issues typically fall into three general categories. Most intermittent issues or link reliability issues will fall into the first two categories. In many cases the issue will turn out to be a combination of A and B, when the link has been degraded to the point where by the interference level is now impacting the link.

- RF path or antenna system issues: This can be path obstructions (Trees that have grown, buildings that have been constructed), antenna failure, alignment changes or water intrusion in the antenna system.
- Interference issues: Since the 2.4Ghz band is unlicensed interferes can change on a daily basis.
- Other issues: The normal hardware failures of the equipment such as power supply.

In general troubleshooting should be done in a methodical approach and troubleshooting findings should be documented thoroughly. Use the diagram at the end of the section to go through the link one component at a time from end to end.

10.2 EQUIPMENT REQUIRED

Listed below are some tools that can be used to aid in troubleshooting:

- For antenna sweep: FDR, Anritsu Site Master S332C or equivalent.
- For interference & alignment: 2.4 GHz Spectrum Analyzer, Anritsu Site Master S332C or Berkely Varitronics Yellow Jacket Plus.
- Laptop computer with terminal program (Windows HyperTerminal is fine) and straight through DB9 female to male interface cable. For connection to ISM radio.

10.3 REMOTE TROUBLESHOOTING

A tremendous amount of troubleshooting can be done remotely. Further before going on site you need to be familiar with the system design.

From the NMC:

1. Check the fault browser in the NMC to determine if there are any faults.
2. Check the history browser in the NMC to determine a history of the issues that are occurring on the link.
3. Are there patterns of outages in clumps or are they evenly spread out? Randomly spread out issues is an indication of an RF system or interference issue.

4. Are there specific times of the day that outages occur? This could be an indication of inversion or a particular interferer that only comes on at specific times of a day.

Remote login to ISM via Urat or equivalent means:

5. Review and check general configurations; **at&v**[2].
6. Review RF configuration; **at*rfdisp**[2].
7. Review frequency list; **at*fldisp**[2].
8. Review routing table; **at*rtdisp**[2].
9. Review current RF state table; **at**rfmdisp**.

   The key items you are looking for is the **cfrq** field which displays the current frequency and the **ena** field which shows the state of the link (1 = up; 0 = down).

   The address under column 0 is the address of the device on the other end of the link for the row in the table.

   If the current frequency is not the first one in the list, then at one point in time the frequencies prior to the current frequency in the list (#7 above) has had interference. The radio always starts at the beginning of the list if it has a problem with the current frequency. If you look at this periodically over time it will give you a better understanding of what frequencies may be better than others.

10. Review the link Statistics; **at*nms_stat**; **at*nms_clear** to clear stats.

    Links with issues will show large values in lost connections and packets in error. For good links these values are very small or zero. Key fields are:

    - **link state** – Should equal 2 when connected in normal operation.
    - **current frequency** – is the RF frequency in MHz that the logical channel number is using.
    - **lost connections** – is a counter that increments every time that a logical channel number loses connection with its peer (master/slave).

    Under receive status group sub fields:

    - **packets in error** – the number of packets that were rejected due to checksum errors, buffer overflows.
    - **dropped** – the number of packets that have been discarded due to buffer overflow.

10.4 ON SITE TROUBLESHOOTING

Before going on site understand the design:

1. What height and orientation should the antennas be installed at? Verify this against the as-built drawings.
2. What is the design margin in reference to the signal strength that should be seen at the ISM receiver?
3. What does the path profile look like?
4. Are there potential path obstructions?

[2] When debugging an existing link the configuration should be matched to the configuration as installed. Typically if the configuration is the same then you need to look elsewhere for your problem. With exception to the frequency list you would not expect your configuration to require to be changed over time.

5. Are there other of our ISM links in the area?

   If so, the configurations of these links should be checked. ISM links that can potentially see each other should have unique device addresses. With unique address the links can co-exist even if on the same frequency. If the links do not have unique address the signal strength must be approximately 15 dB better at the capturing receiver.

6. ***Before intrusive troubleshooting or changes are made to the link, the quality of the link needs to be documented via the statistics and or a ping test. This will allow a baseline to compare with once work is done on the link to verify improvement.***

Don't overlook the simple stuff:

7. Does the radio have power?
8. Is the directional antenna pointed in the right direction?
9. Is the antenna feed straight on directional antennas?
10. Is the antenna feed installed with the same polarity as the grid (If grid antenna is used)?
11. Has a porcupine eaten your cell box?
12. Is there exposed connection or areas of possible water intrusion?
13. Are there any obvious sources of potential interference near by?

Once you get through the simple stuff:

NOTE

For debugging, all RF test connections should be connected as close to the radio as possible. Specifically, unhooking the SMA connection at the radio and hooking the test set to the semi-ridged cable inside the enclosure is the best location. Be careful not to damage the semi-ridged cable.

14. Sweep Antenna lines using the FDR. Match the results to the original site sweeps performed during installation. [3]

    If original sweeps are not available look for anything out of the normal. If you see any significant change in the plots, the antenna system should be debugged.

    Spare antennas and feed horns should be kept on hand along with the normal antenna system parts like connectors, feed line and vapor wrap.

15. Turn off both Master and Slave ISM radios.

    The master can be powered down remotely from the Backhaul Router.

16. Hook up spectrum analyzer to the antenna system. Set analyzer to look at the entire band (2.400 to 2.485 GHz). Set on peak hold and look for interferers. Look for interferes for at least five minutes. The more data the better as some interferes may only be present sporadically. [3]

17. With the measuring end radio off, put the remote end in SRT (Spread Random Test) mode for two to five minutes; **at**srt on/off cfreq atten ant sec**;

    For example: **at**srt 1 2412 0 A 300** would put in test mode on freq 2412 on antenna port A for 5 minutes.

[3] Items 14 & 16 can be done with a test antenna and test feed line to verify interferers and signal strength at RX radio if antenna system is suspected to be bad.

18. Measure RX signal strength and compare it to the expected design signal strength. The measured and designed to signal strength should be within a couple of dB, if not, you have some sort of RF issue. If the antenna system checks out, the difference could be due to an obstruction in the path.[4]

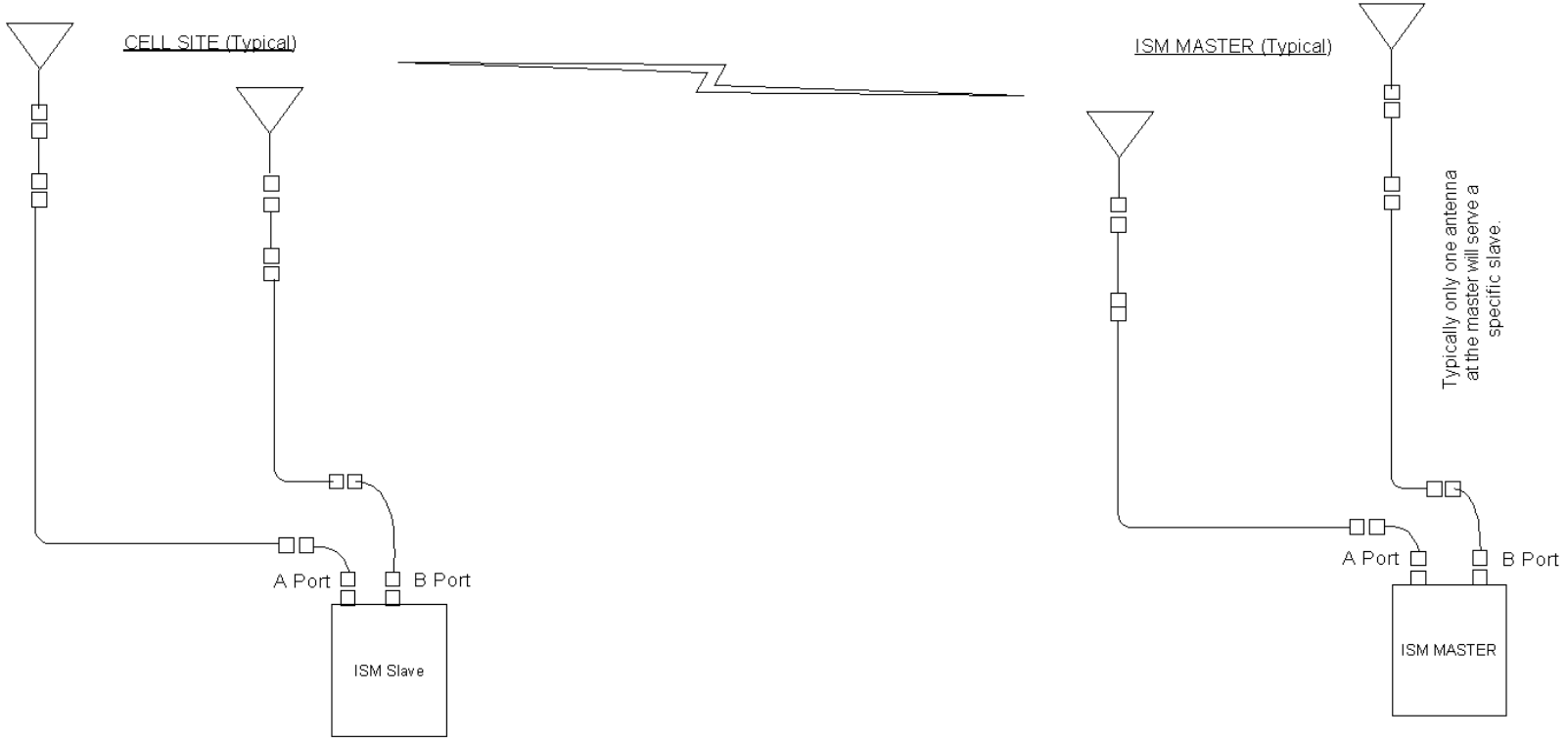
    Repeat this test on each port to verify the ports on both ends (if so equipped) and to test out each RF path.

19. Interference avoidance. If the proper signal strength is seen and the antennas check out and you have some interference on the band in step 14. That is, if interferers are within 10 – 15 dB of the receive signal, then the link will most likely be impacted.

    Try removing frequencies that look congested or bad in step 14 from the frequency list. Any signal within approximately 6 MHz on either side of the center frequency can impact the link.

20. If your RX signal strength is as expected you may want to verify the forward and reflected power of the radio. The proper TX power of the radio is ~ 23 to 25 dBm average power and ~ 26-28 dBm peak.

[4] Item 18 can be done with a test antenna and test feed line to verify interferers and signal strength at RX radio if antenna system is suspected to be bad.



Use this diagram to troubleshoot the system. Mark on the drawing at the point of measurement the actual configuration and measurements taken. Also Fill in tables below as you progress through the troubleshooting procedure.

Slave Frequency List:
Slave Current Frequency:
Statistics Before testing:
Statistics After testing:
Designed to RSSI at radio port:
Potential Interferance (list freqs)?:
Antenna Sweep A side O.K.?
Antenna Sweep B side O.K.?

Ping Test Results Before Troubleshooting:
Ping Test Results After Troubleshooting:
Are there potential obstructions in the path?:

Master Frequency List:
Master Current Frequency:
Statistics Before testing:
Statistics After testing:
Designed to RSSI at radio port:
Potential Interferance (list freqs)?:
Antenna Sweep A side O.K.?
Antenna Sweep B side O.K.?

Figure 10-1: Troubleshooting Diagram

11. INSTALLATION CHECKSHEETS

BACKHAUL ROUTER INSTALLATION CHECKLIST			
SITE NAME			
BACKHAUL ROUTER SERIAL NUMBER			
INSTALLER NAME			
SOFTWARE REVISION			
Task	**Check When Done**	**Verified By**	**Date**
SITE POWER VOLTAGES VERIFIED			
CABLING CORRECT			
REQUIRED TOOLS AVAILABLE			
ADDITIONAL EQUIPMENT AVAILABLE			
STARTUP SEQUENCE COMPLETED			
INITIAL SYSTEM OPERATION VERIFIED			
SOFTWARE REVISION			
ROUTING CONFIGURATION SET-UP			
CHASSIS GROUNDED			
LIGHTNING PROTECTION FOR ISM RADIO POWER LINES			

ISM NETWORK INSTALLATION CHECKLIST

ISM Network IP/ISM Design

Device	ISM Address	IP Address	Comments
BACKHAUL ROUTER			
TOWER TOP ISM RADIO			
CELL SITE ISM RADIO			
CELL SITE ISM RADIO			
CELL SITE ISM RADIO			
CELL SITE ISM RADIO			
BASE STATION CELL			
BASE STATION CELL			
BASE STATION CELL			
BASE STATION CELL			

ISM Network RF Design

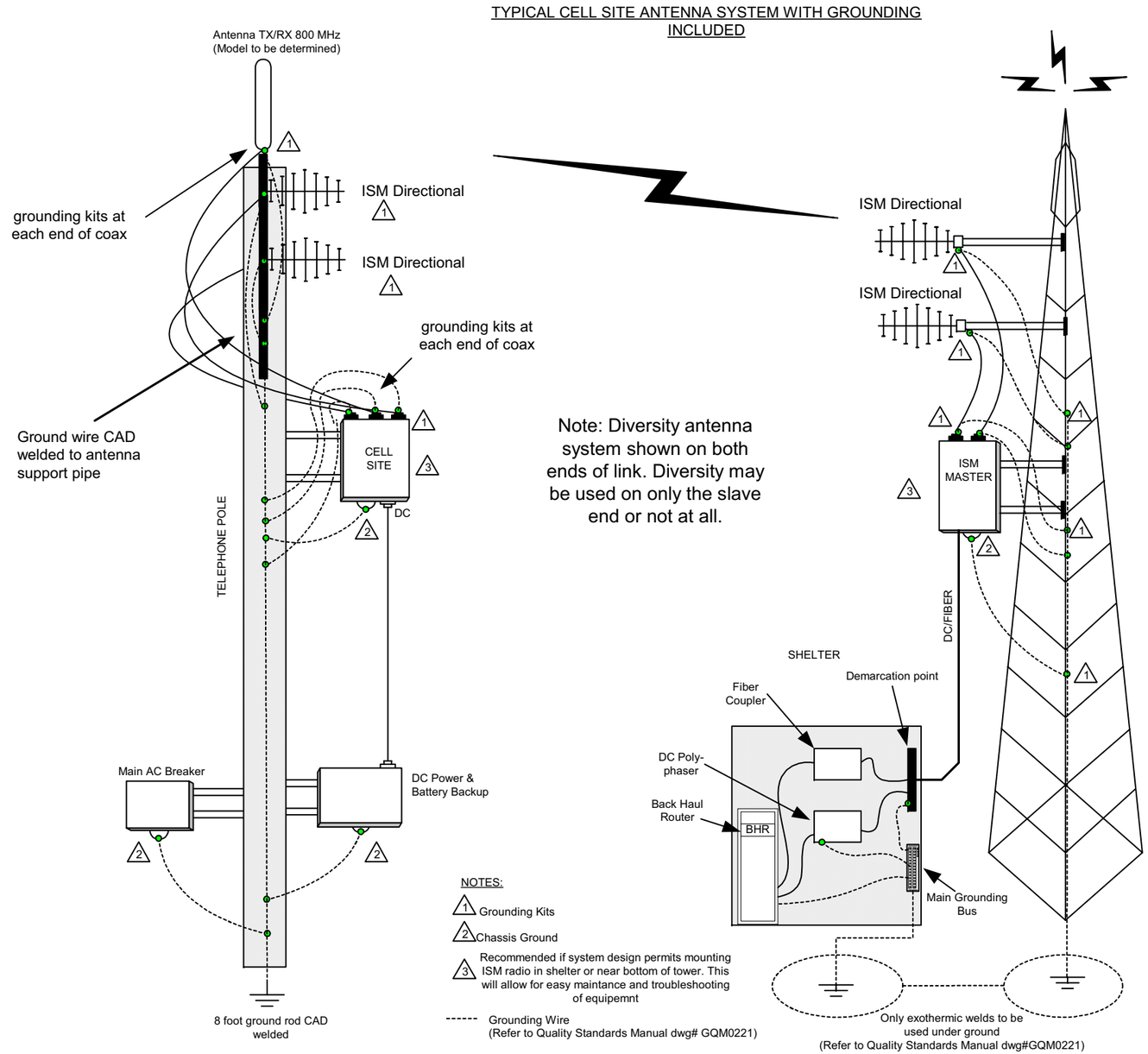
Device	ISM Address	RF Port	Antenna	Attenuation*	Chip Size	Spread Sequence
ISM CELL SITE RADIO						
ISM CELL SITE RADIO						
ISM CELL SITE RADIO						
ISM CELL SITE RADIO						

* If using a 24dBi gain antenna (PMANT25-HD-PF1), a minimum attention of 8dB should be programmed in.

This page intentionally left blank

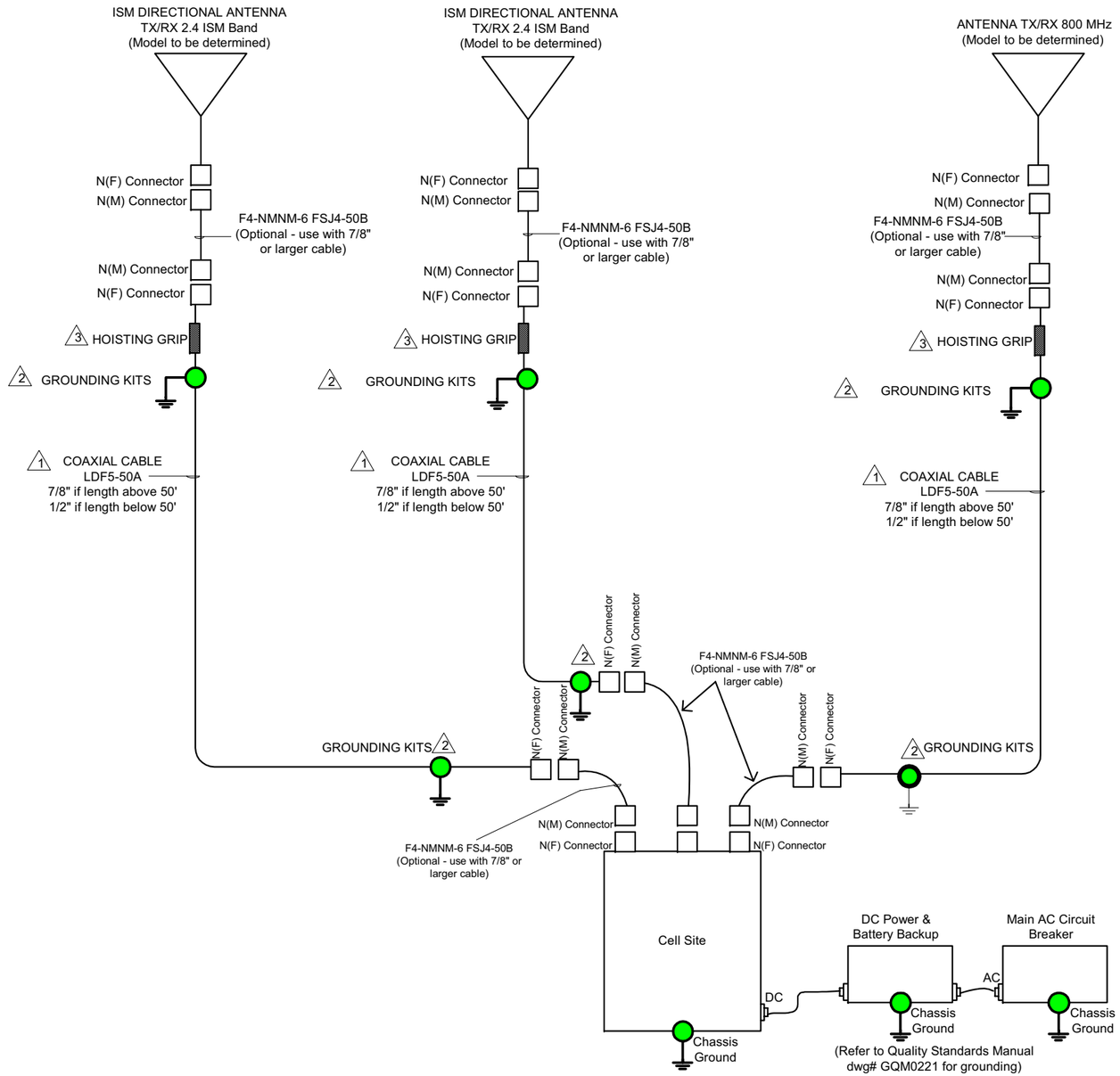
12. DIAGRAMS

12.1 APPLICATION DIAGRAMS



TYPICAL CELL SITE ANTENNA SYSTEM WITH GROUNDING
(ISM Typ Inst Dwg, Sh. 1, Rev. 101403)

CELL SITE ANTENNA ASSEMBLY



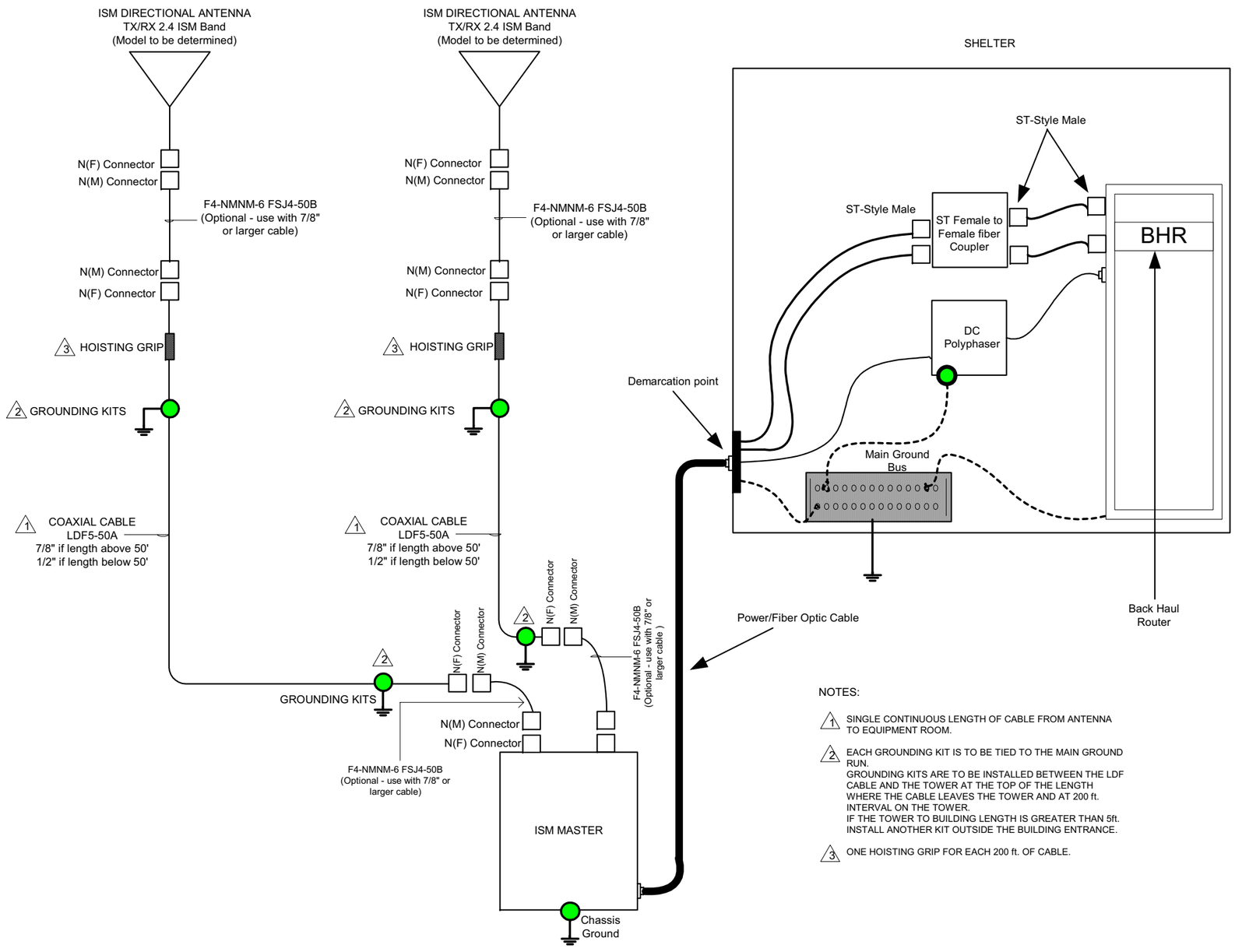
Note: Diversity antenna system shown. If not setup as diversity system only one ISM antenna would be used. The antenna system shown only as an example. The design engineer or other responsible party will define the actual build to specifications for your system.

NOTES:

1. SINGLE CONTINUOUS LENGTH OF CABLE FROM ANTENNA TO EQUIPMENT ROOM.
2. EACH GROUNDING KIT IS TO BE TIED TO THE MAIN GROUND RUN.
   GROUNDING KITS ARE TO BE INSTALLED BETWEEN THE LDF CABLE AND THE TOWER AT THE TOP OF THE LENGTH WHERE THE CABLE LEAVES THE TOWER AND AT 200 ft. INTERVAL ON THE TOWER.
   IF THE TOWER TO BUILDING LENGTH IS GREATER THAN 5ft. INSTALL ANOTHER KIT OUTSIDE THE BUILDING ENTRANCE.
3. ONE HOISTING GRIP FOR EACH 200 ft. OF CABLE.

TYPICAL CELL SITE ANTENNA ASSEMBLY
(ISM Typ Inst Dwg, Sh. 2, Rev. 101403)

ISM MASTER ANTENNA ASSEMBLY

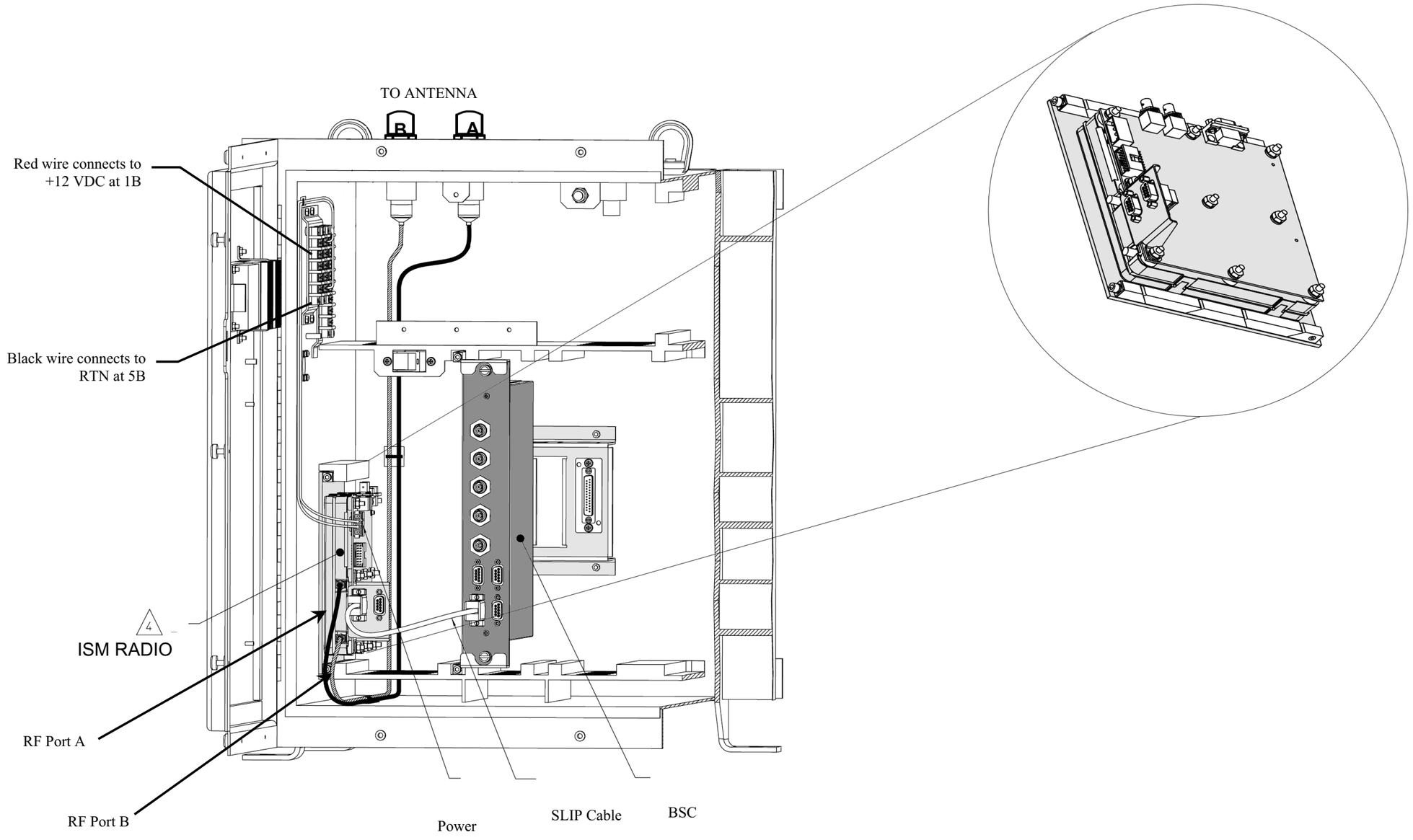


NOTES:

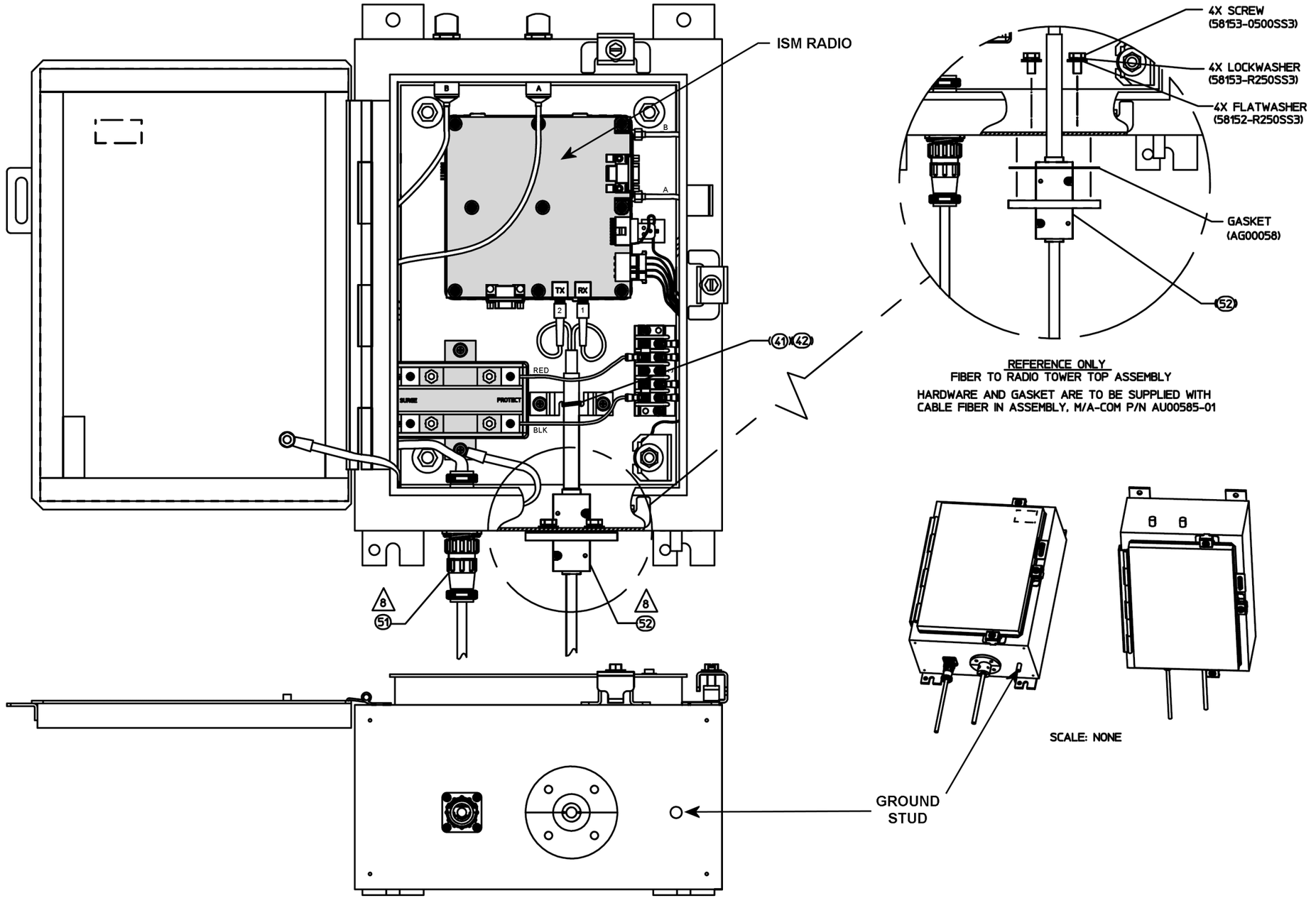
1. SINGLE CONTINUOUS LENGTH OF CABLE FROM ANTENNA TO EQUIPMENT ROOM.
2. EACH GROUNDING KIT IS TO BE TIED TO THE MAIN GROUND RUN.
   GROUNDING KITS ARE TO BE INSTALLED BETWEEN THE LDF CABLE AND THE TOWER AT THE TOP OF THE LENGTH WHERE THE CABLE LEAVES THE TOWER AND AT 200 ft. INTERVAL ON THE TOWER.
   IF THE TOWER TO BUILDING LENGTH IS GREATER THAN 5ft. INSTALL ANOTHER KIT OUTSIDE THE BUILDING ENTRANCE.
3. ONE HOISTING GRIP FOR EACH 200 ft. OF CABLE.

TYPICAL ISM MASTER ANTENNA ASSEMBLY
(ISM Typ Inst Dwg, Sh. 3, Rev. 101403)

12.2 ASSEMBLY DIAGRAMS

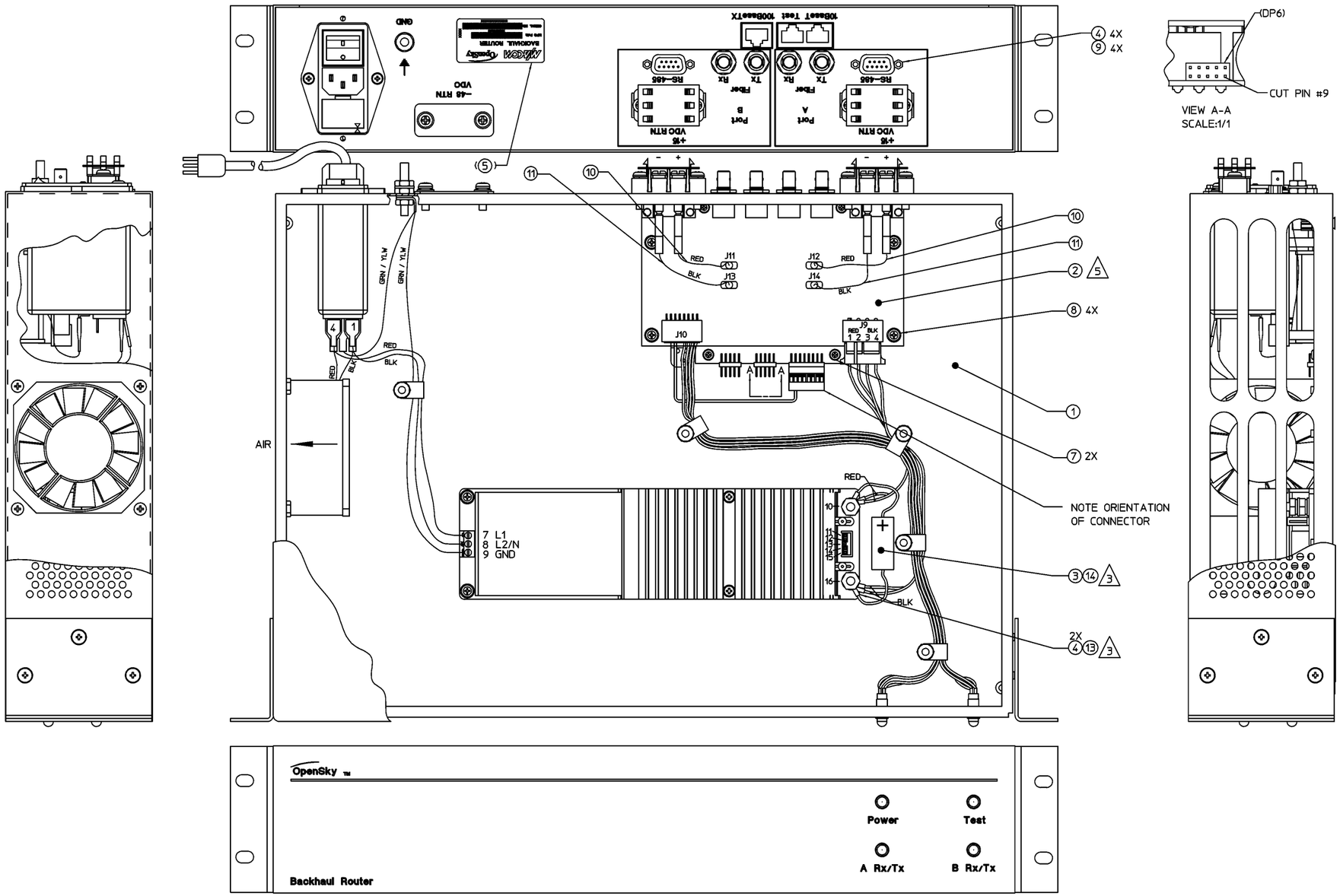


ISM RADIO IN MINI-CELL ENCLOSURE
(Made from BG01214-XX, Sh.8, Rev. D and AU004944, Sh.1, Rev. C)



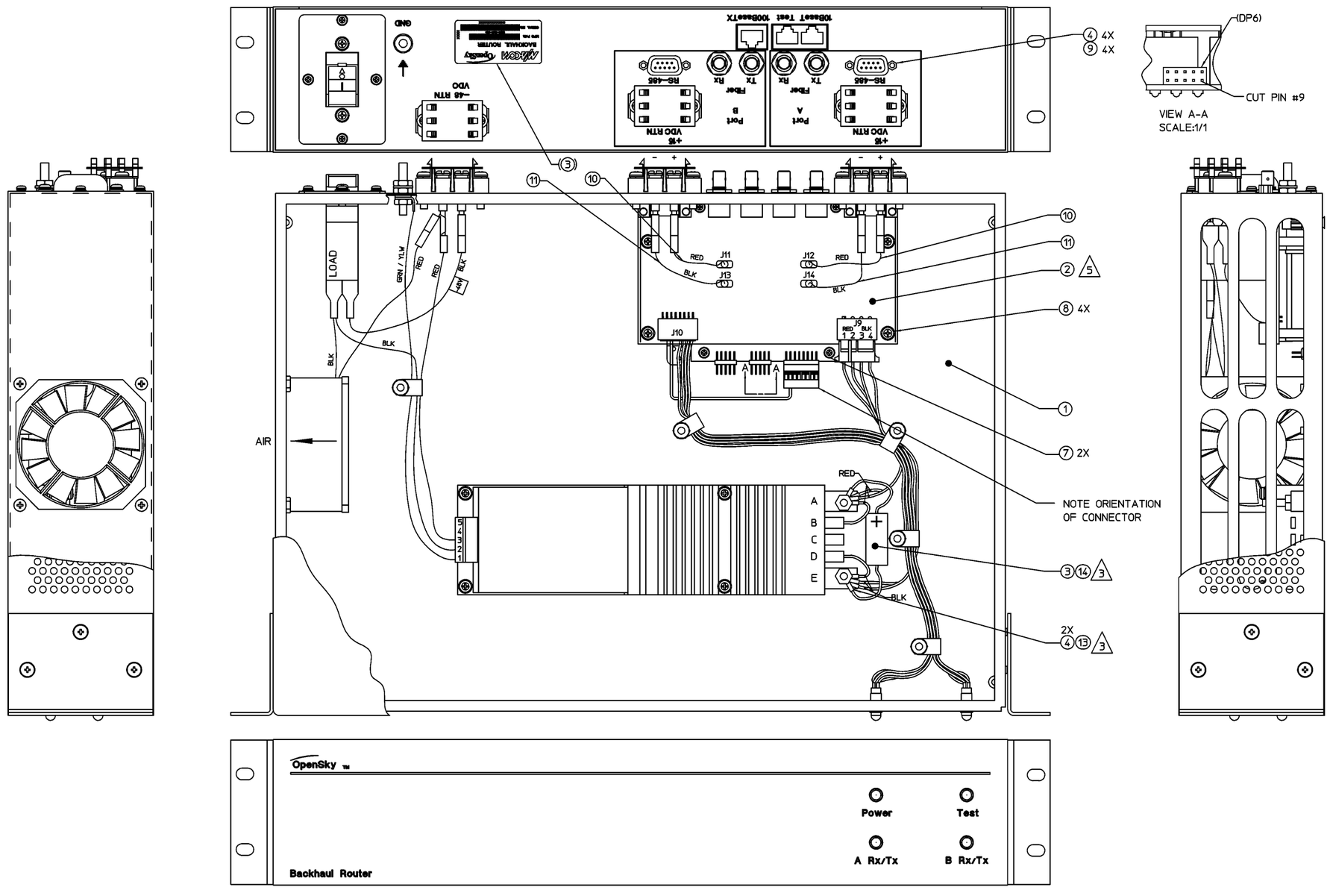
ISM RADIO IN TTR ENCLOSURE

(Made from 1000002545, Sh. 3, Rev. E)



AC POWERED BACKHAUL ROUTER

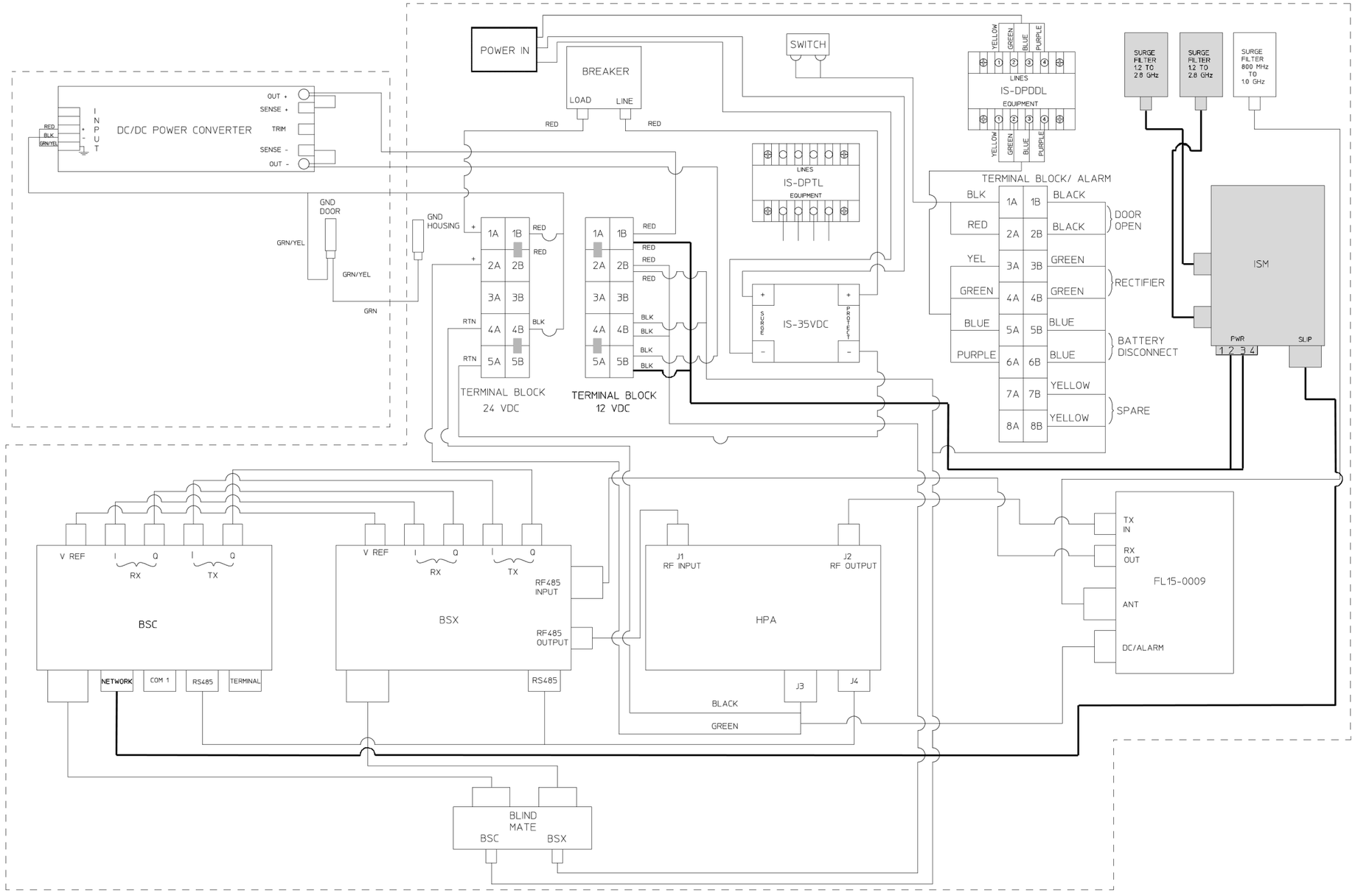
(Made from 1000003826, Sh. 2, Rev. A)



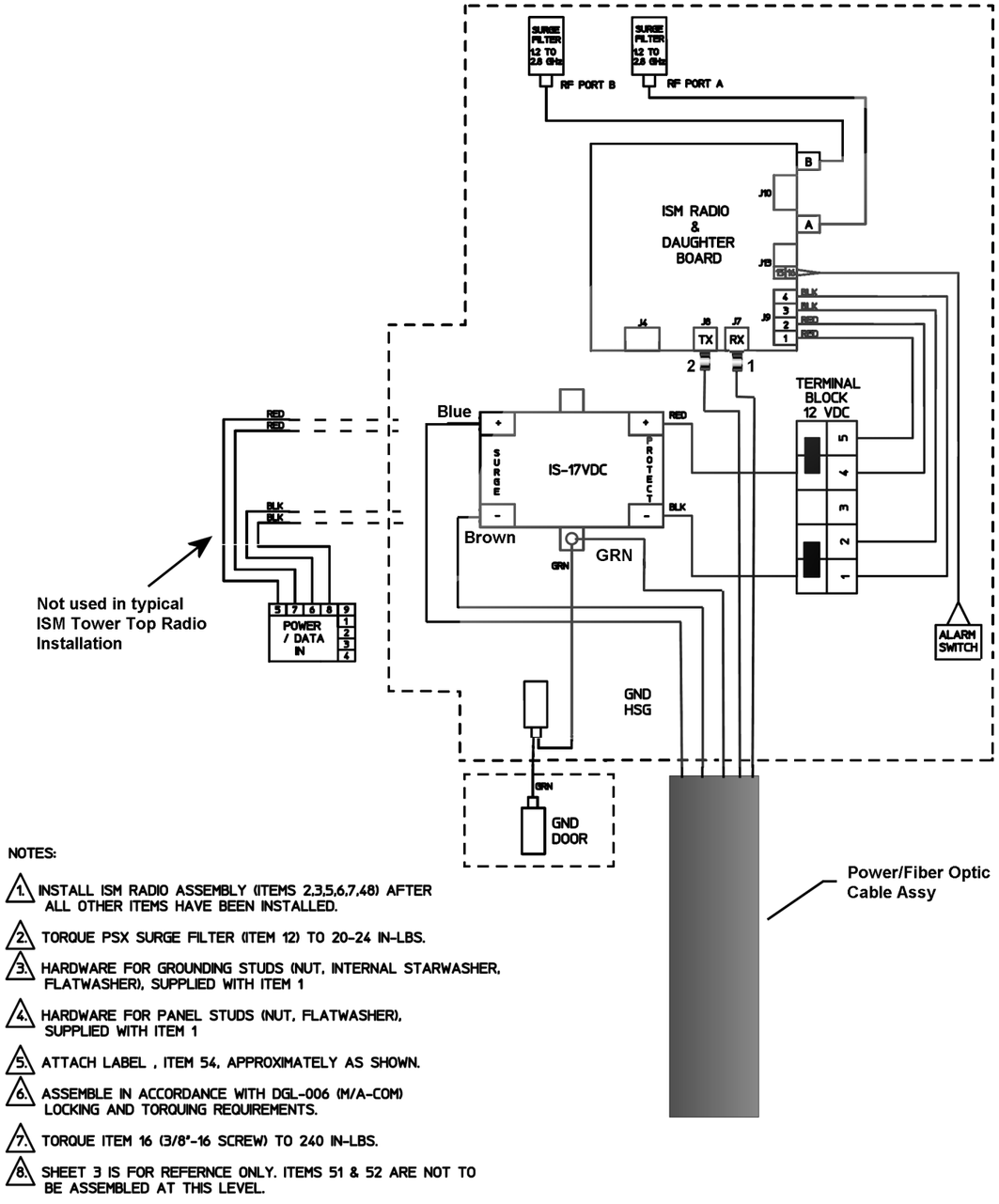
DC POWERED BACKHAUL ROUTER

(Made from 1000003823, Sh. 2, Rev. A)

12.3 INTERCONNECT DIAGRAMS



ISM RADIO IN MINI_CELL ENCLOSURE
(Made from BG001214-XX, Sh. 14, Rev. D)



NOTES:

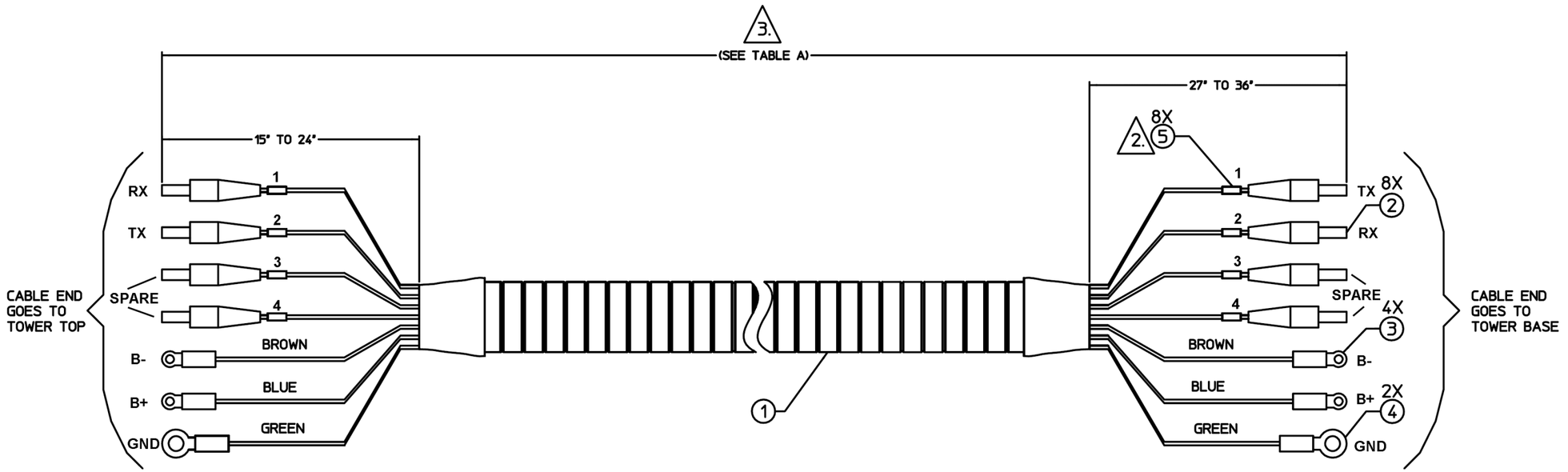
1. INSTALL ISM RADIO ASSEMBLY (ITEMS 2,3,5,6,7,48) AFTER ALL OTHER ITEMS HAVE BEEN INSTALLED.
2. TORQUE PSX SURGE FILTER (ITEM 12) TO 20-24 IN-LBS.
3. HARDWARE FOR GROUNDING STUDS (NUT, INTERNAL STARWASHER, FLATWASHER), SUPPLIED WITH ITEM 1
4. HARDWARE FOR PANEL STUDS (NUT, FLATWASHER), SUPPLIED WITH ITEM 1
5. ATTACH LABEL , ITEM 54, APPROXIMATELY AS SHOWN.
6. ASSEMBLE IN ACCORDANCE WITH DGL-006 (M/A-COM) LOCKING AND TORQUING REQUIREMENTS.
7. TORQUE ITEM 16 (3/8"-16 SCREW) TO 240 IN-LBS.
8. SHEET 3 IS FOR REFERNCE ONLY. ITEMS 51 & 52 ARE NOT TO BE ASSEMBLED AT THIS LEVEL.

	QTY REQ'D	ITEM NO	PART/IDENTIFYING NUMBER	NOMENCLATURE/DESCRIPTION
-0002	-0001			PARTS LIST
	2	54	1000012194-0001	LABEL, ISM TOWER TOP (M/A-COM)
	1	53	1000000858	GASKET, DOOR SWITCH (M/A-COM)
	REF	52	BR01-0002-XXX	BACKHAUL TO RADIO CABLE (FIBER) (M/A-COM)
	REF	51	IS01-0006-XXX	ISM POWER CABLE (M/A-COM)
	1	50	AJ03040	BRACKET, FIBER CABLE, RTT ASSY (M/A-COM)
		49		DELETED
	1	48	AJ02841	SUPPORT BRACKET FOR CONNECTOR 750586 (M/A-COM)
	REF	47	2098-0275-54	MINI-TORQUE WRENCH, TYPE A, 8 IN-LBS (M/A-COM)
	6	46	205818-3	SCREWLOCK, FEMALE, 4-40 (AMP)
	2	45	VC-625-8-RED	RUBBER HOLE PLUG (CAPLUGS)
		44		DELETED
	1	43	AG00057	GASKET, POWER CONNECTOR (M/A-COM)
	REF	42	GS2B TENSION	HAND TOOL FOR CABLE TIES PLT1M (PANDUIT)
	4	41	PLT1M	CABLE TIES (PANDUIT)
	3	40	TC5345A	BACKMOUNT ADHESIVE (THOMAS & BETTS)
	1	39	AU00602-02	CABLE, GROUND, RTT ASSY (M/A-COM)
	1	38	AU00602-01	CABLE, GROUND, RTT ASSY (M/A-COM)
		37		DELETED
		36		DELETED
		35		DELETED
		34		DELETED
		33		DELETED
		32		DELETED
		31		DELETED
	1	30	AU00584-01	CABLE: 16 PIN CONN TO ALARM SWITCH (M/A-COM)
	1	29	AU00582-01	CABLE: POWER CONN TO TERM BLOCK, RTT ASSY (M/A-COM)
	1	28	AU00581-01	CABLE: IS-17VDC TO TERM BLOCK, RTT ASSY (M/A-COM)
	4	27	501-040800-00	KEPNUT, #4-40 (ELECTRONIC-FASTNERS)
	4	26	63B04074540XBF	SCREW, #4-40 UNC-2A X .438 LG PAN SEMS (SHAKEPROOF)
	1	25	AU00580-01	CABLE: POWER / DATA IN, RTT ASSY (M/A-COM)
	2	24	PE3448-24	CABLE: SMA MALE TO N MALE (PASTERNACK)
	2	23	NAS620C-8	FLATWASHER, #8 REDUCED DIAMETER (NAS)
	2	22	58074-0750SS3	SCREW, #8-32 UNC-2A X .750 LG PAN HD SS (M/A-COM)
	1	21	MS601-XP-05-01A	MARKER STRIP FOR TERMINAL BLOCK (KULKA ELECTRIC)
	2	20	601J	JUMPER (KULKA ELECTRIC)
	1	19	601-GP-05	TERMINAL BLOCK, DUAL 5 POS. (KULKA ELECTRIC)
	1	18	92141A031	FLATWASHER, 3/8", SS (MCMASTER-CARR)
	4	17	92146A031	LOCKWASHER, 3/8", SS (MCMASTER-CARR)
	1	16	92240A622	SCREW, 3/8"-16 X .75 LG SS HEX HD CAP (MCMASTER-CARR)
	1	15	AN960-816	FLATWASHER, 1/2", SS (ANS)
	1	14	90264A212	COUPLING NUT, 3/8"-16 X 4" (MCMASTER-CARR)
	1	13	AJ02842	SUPPORT BRACKET FOR ALARM SWITCH, RTT ASSY (M/A-COM)
	2	12	PSX	IN LINE EMP SURGE FILTER, 1.2 - 2.8 GHz (POLYPHASER)
		11		DELETED
		10		DELETED
	4	9	63B10064590XBF	SCREW, #10-32 UNC-2A X .375 LG PAN SEMS (SHAKEPROOF)
	1	8	IS-17VDC-30A-FG	17 VDC LIGHTNING PROTECTOR (POLYPHASER)
	9	7	58152-R164SS3	FLATWASHER, #8 SS (M/A-COM)
	11	6	58153-R164SS3	LOCKWASHER, #8 SS (M/A-COM)
	9	5	58074-1500SS3	SCREW, #8-32 UNC-2A X 1.5 LG PAN HD SS (M/A-COM)
	A/R	4	40140	LOCTITE 401 (LOCTITE)
	1	3	BG01168	ISM RADIO DAUGHTER BOARD ASSY (M/A-COM)
	1	2	BG01259-01	ISM RADIO (M/A-COM)
	1	1	AU00567-01	RTT ENCLOSURE SUB-ASSY (M/A-COM)

ISM RADIO IN RTT ENCLOSURE

(Made from 1000002545, Sh. 1, Rev. E)

12.4 CABLE DIAGRAMS



NOTES:

1. ASSEMBLE PER IPC-610 CLASS 2.
2. FIBER CONNECTORS SHOULD BE CLEARLY LABELED USING EITHER COLORS OR NUMBERS.
3. TOLERANCE FOR TOTAL CABLE LENGTH SHALL BE ± 2%. FOR CABLE LENGTHS 50 FT OR LESS, A TOLERANCE OF ± 5% IS ACCEPTABLE.
4. ITEMS 6 THRU 14 SHALL BE APPLIED ONLY TO THE CABLE END THAT GOES TO THE TOWER TOP. WHEN PACKAGED THIS END SHOULD BE ON TOP SO THAT IT MAY BE UNCOILED FIRST.
5. ON BOTH ENDS OF THE CABLE, ITEMS 15 & 16 SHALL BE USED TO KEEP ALL LINES TOGETHER IN THE CUTBACK SECTION.
6. THE PART NUMBER (MAIR0S0002-XXXXX) SHALL BE WRITTEN ON A LABEL AND LOCATED AS SHOWN. -XXXXX INDICATES THE LENGTH OF THE CABLE BEING MADE. IE: FOR A 200 FT CABLE, THE PART NUMBER SHOWN SHALL BE MAIR0S0002-00200.
7. IDENTIFICATION OF THE SUGGESTED SOURCE(S) OF SUPPLY HEREON IS NOT TO BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTINUED AVAILABILITY AS A SOURCE OF SUPPLY FOR THE ITEM DESCRIBED IN THE DRAWING.

TABLE A

DASH NO.	LENGTH
-00006	6 FT
-00010	10 FT
-00025	25 FT
-00050	50 FT
-00100	100 FT
-00140	140 FT
-00200	200 FT
-00250	250 FT
-00300	300 FT
-00350	350 FT
-00400	400 FT
-00450	450 FT

7.

SUGGESTED SOURCE OF SUPPLY:	
VENDOR	PART NO.
ANDREW CORPORATION 10504 W. 153RD STREET ORLAND PARK, IL 60462	** AMR-MA-S30403-XXX

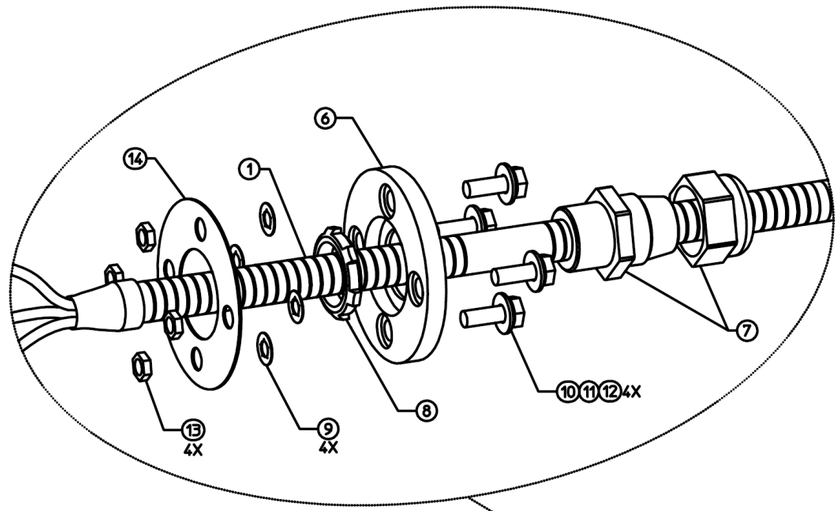
** -XXX REFERS TO TOTAL CABLE LENGTH
IE. AMR-MA-S30403-200 IS A 200 FT CABLE

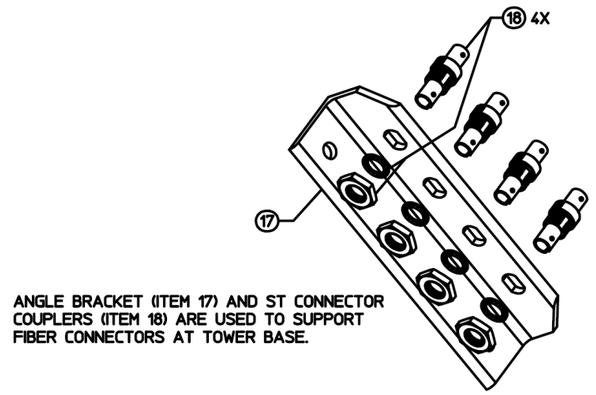
5. NOT SHOWN

4.

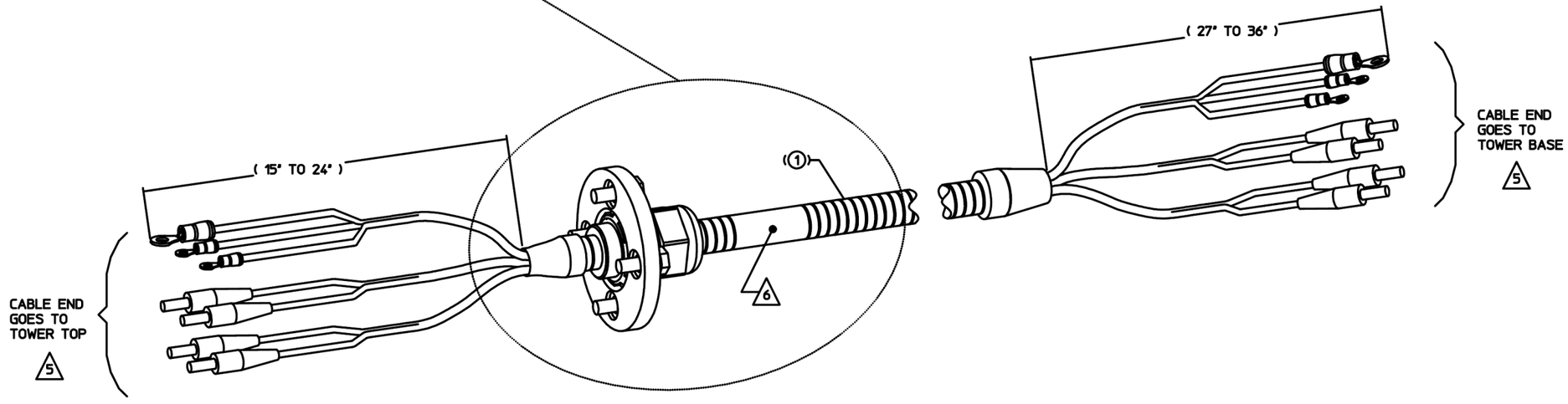
QTY REQ'D	ITEM NO	PART/IDENTIFYING NUMBER	NOMENCLATURE/DESCRIPTION	
-XXXXX			PARTS LIST	
4	18	504021	ST CONNECTOR COUPLING RECEPTACLE, 2.5MM BAYONET	(AMP)
1	17	AMR-AB	ANGLE BRACKET PLUS HARDWARE	(ANDREW)
A/R	16	243171-1-01	CABLE TIE	(ANDREW)
A/R	15	243170-1-04	BRAIDED SLEEVING	(ANDREW)
1	14	248819	GASKET	(ANDREW)
4	13	9999-57	NUT, 1/4"-20 UNC, SS	(ANDREW)
4	12	9974-143	LOCKWASHER, 1/4", SS	(ANDREW)
4	11	9997-131	FLATWASHER, 1/4", SS	(ANDREW)
4	10	9963-416	SCREW, 1/4"-20 UNC X 1.00" LG SS HEX HD CAP	(ANDREW)
4	9	248810	PUSH RETAINER	(ANDREW)
1	8	247321	SEALING NUT	(ANDREW)
1	7	245499	ENTRY FITTING	(ANDREW)
1	6	248802	PLATE	(ANDREW)
8	5		FIBER INDENTIFICATION LABELS	(ANDREW)
2	4	35273	WIRE TERMINAL, PIDG-RING TONGUE, .25 STUD, 10-12 AWG	(AMP)
4	3	320634	WIRE TERMINAL, PIDG-RING TONGUE, #6 STUD, 10-12 AWG	(AMP)
8	2	492458-3	ST CONNECTOR, 2.5MM BAYONET MULTIMODE CERAMIC	(AMP)
A/R	1	AMR-S304	AMARRA CABLE WITH COPPER ARMOR SHIELD	(ANDREW)

POWER/FIBER OPTIC CABLE
(MAIR0S0002, Sh. 1 Rev. 0)





ANGLE BRACKET (ITEM 17) AND ST CONNECTOR COUPLERS (ITEM 18) ARE USED TO SUPPORT FIBER CONNECTORS AT TOWER BASE.



POWER/FIBER OPTIC CABLE
(MAIR0S0002, Sh. 2, Rev. 0)

M/A-COM Inc.
1011 Pawtucket Blvd.
Lowell, MA 01853
Phone: 978.442.4000
www.macom-wireless.com

Printed in U.S.A.