



INSTALLATION & OPERATION

A53325-01 and A53325-04 ETHERNET SPREAD SPECTRUM RADIO (Point-to-Point, Point-to-Multi-Point, MESH Tree, and Linear Network)

DECEMBER 2005, REVISED MAY 2014

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VERSION C.1

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- 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.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC rules.



RF EXPOSURE WARNING



All antenna installation and servicing is to be performed by qualified technical personnel only. When servicing or working at distances closer than 7 feet (2 meters), ensure the transmitter has been disabled. Depending upon the application and the gain of the antenna, the total composite power could exceed 100 watts EIRP. The antenna location should be such that only qualified technical personnel can access it, and under normal operating conditions no other person can come in contact or approach within 7 feet (2 meters) of the antenna.

DOCUMENT HISTORY

| Version | Release Date | Details of Change |
|---------|---------------|--|
| A | | Initial release |
| B | December 2005 | <ul style="list-style-type: none"> • Updated Proprietary Information on page ii. • Added non-vital product warning on page 1-1. • Added information throughout document for Point-to-Multi-Point operation. • Added DHCP information to Glossary, Paragraphs 6.4, and 8.5.1 that DHCP protocol only works in conjunction with Safetran's Wayside Access Gateway (WAG). • Corrected Table 1-2 <i>A53325 Included Components</i>. • Added DC Power Inserter caution note on page 1-5 that input voltage must not exceed the power specification of the radio or damage to the radio could result. • Added notes on pages 1-5 and 1-7 that Power Inserter is required when cable lengths exceed 100 feet. • Added cautions to paragraph 1.6 and Specifications page B-1 that reversed polarity of the input power to the radio will damage the radio. • Inserted new Table 1-9 for <i>Available Radio Accessories</i>. • Corrected software versions in Table 2-1, and on page 7-1. • Updated Tables 4-1 and 10-1 <i>Antenna Types</i> to include Omni Mount, Yagi, and Yagi mount. • Added paragraph 4.2 for Safetran Antenna Kit general information. • Added step in paragraphs 5.1 and 6.1 <i>Bench Checkout</i> to perform <code>directory</code> command and select software prior to the <code>load factory</code> command. • Corrected steps in paragraph 7.2 for installing new firmware through Ethernet port for LNW with non-compatible firmware. • Corrected DHCP command in paragraph 8.5.1 IP-Configuration. (For LNW mode only) Was: <code>dhcp-client=off</code> or <code>on</code>. Is: <code>ip dhcp=yes</code> or <code>no</code>. • Updated Appendix A Table A-2 <i>Major Configuration Parameters</i>, Table A-3 <i>Internet Protocol (IP) Management Commands</i>, and Table A-4 <i>Installation and Link Monitoring Commands</i>. • Added Point-to-Multi-Point Quick Setup Example to Appendix E. • Added steps to Appendix E for Point-to-Point and Linear Network Quick Setup Examples to perform <code>directory</code>, <code>set-default-program</code> and <code>reboot</code> commands prior to the <code>load factory</code> command. |

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| B.1 | May 2007 | <ul style="list-style-type: none"> • Section 8 , paragraphs 8.4.5 & 8.4.6 – deleted speed command, as it is not available in LNW mode. |
| C | April 2010 | <ul style="list-style-type: none"> • Rewrite of all sections to reflect the new firmware changes. • Incorporated Mesh Tree topology. |
| C.1 | May 2014 | <ul style="list-style-type: none"> • Rebrand for Siemens |
| | | |

NOTES, CAUTIONS, AND WARNINGS

Throughout this manual, notes, cautions, and warnings are frequently used to direct the reader's attention to specific information. Use of the three terms is defined as follows:

WARNING

INDICATES A POTENTIALLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY. WARNINGS ALWAYS TAKE PRECEDENCE OVER NOTES, CAUTIONS, AND ALL OTHER INFORMATION.

CAUTION

REFERS TO PROPER PROCEDURES OR PRACTICES WHICH IF NOT STRICTLY OBSERVED, COULD RESULT IN A POTENTIALLY HAZARDOUS SITUATION AND/OR POSSIBLE DAMAGE TO EQUIPMENT. CAUTIONS TAKE PRECEDENCE OVER NOTES AND ALL OTHER INFORMATION, EXCEPT WARNINGS.

NOTE

Generally used to highlight certain information relating to the topic under discussion.

If there are any questions, contact Siemens Industry Inc., Rail Automation Application Engineering.

ELECTROSTATIC DISCHARGE (ESD) PRECAUTIONS

Static electricity can damage electronic circuitry, particularly low voltage components such as the integrated circuits commonly used throughout the electronics industry. Therefore, procedures have been adopted industry-wide which make it possible to avoid the sometimes invisible damage caused by electrostatic discharge (ESD) during the handling, shipping, and storage of electronic modules and components. Siemens Industry, Inc., Rail Automation has instituted these practices at its manufacturing facility and encourages its customers to adopt them as well to lessen the likelihood of equipment damage in the field due to ESD. Some of the basic protective practices include the following:

- Ground yourself before touching card cages, assemblies, modules, or components.
- Remove power from card cages and assemblies before removing or installing modules.
- Remove circuit boards (modules) from card cages by the ejector lever only. If an ejector lever is not provided, grasp the edge of the circuit board but avoid touching circuit traces or components.
- Handle circuit boards by the edges only.
- Never physically touch circuit board or connector contact fingers or allow these fingers to come in contact with an insulator (e.g., plastic, rubber, etc.).
- When not in use, place circuit boards in approved static-shielding bags, contact fingers first. Remove circuit boards from static-shielding bags by grasping the ejector lever or the edge of the board only. Each bag should include a caution label on the outside indicating static-sensitive contents.
- Cover workbench surfaces used for repair of electronic equipment with static dissipative workbench matting.
- Use integrated circuit extractor/insertion tools designed to remove and install electrostatic-sensitive integrated circuit devices such as PROM's (OK Industries, Inc., Model EX-2 Extractor and Model MOS-40 Insertion (or equivalent) are highly recommended).
- Utilize only anti-static cushioning material in equipment shipping and storage containers.

For information concerning ESD material applications, please contact the Technical Support Staff at 1-800-793-7233. ESD Awareness Classes and additional ESD product information are also available through the Technical Support Staff.

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GLOSSARY

- ATCS:** Advanced Train Control System - A set of standards compiled by the AAR for controlling all aspects of train operation.
- DHCP:** Dynamic Host Configuration Protocol – An Internet protocol for automating the configuration of computers that use TCP/IP. DHCP can be used to automatically assign IP addresses, to deliver TCP/IP stack configuration parameters such as the subnet mask and default router, and to provide other configuration information. **Note:** DHCP on this radio only works in conjunction with Safetran's Wayside Access Gateway (WAG).
- Echelon®:** The company that created the LonTalk™ LAN used by Siemens Rail Automation. Term often used to refer to the twisted pair network.
- Ethernet:** An IEEE 802.3 standard for contention networks. Ethernet uses a bus or star topology and relies on the form of access known as Carrier Sense Multiple Access with Collision Detection (CSMA/CD) to regulate communication line traffic. Data is transmitted in variable-length frames containing delivery and control information and up to 1500 bytes of data. The Ethernet standard provides for baseband transmission at 10 or 100 megabits per second.
- IETF** The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.
- IP:** See TCP/IP.
- LAN:** Local Area Network – A collection of devices, usually PCs or workstations, that are interconnected for the purpose of sharing data, typically on an Ethernet communications platform.
- LNW:** Linear Network topology.
- PtP / PmP:** Point to Point / Point to Multi-Point topology.
- PTC:** Positive Train Control - A system of monitoring and controlling train movements to provide increased safety

- SNMP:** Simple Network Management Protocol – A simple, transaction-based (command/response) protocol, which allows a variety of third-party software products to query network devices and collect data. SNMP is a specification for the interaction between the **SNMP agent** embedded in a network device, and the **SNMP manager** software running on another machine in the network. SNMP data travels in IP packets, using the UDP port 161 for the agent. To use SNMP, the device must have an IP address.
- SSR:** Spread Spectrum Radio – A Spread Spectrum radio operates in the “Industrial Scientific and Medical” (ISM) band from 2.400GHz to 2.4835 GHz. It is designed to provide a robust link under adverse conditions, often encountered in this unlicensed band.
- TCP/IP:** Transmission Control Protocol / Internet Protocol - The Internet protocol used to connect a world-wide internetwork of universities, research laboratories, military installations, organizations, and corporations. The TCP/IP includes standards for how computers communicate and conventions for connecting network and routing traffic.
- TDD:** Radios setup in Point to Point or Point to Multi-Point configuration operate in Time Division Duplex (TDD) mode using a configurable size time slot.
- Telnet:** A protocol that enables an Internet user to log on to and enter commands on a remote computer or device linked to the Internet, as if the user were using a text-based terminal directly attached to that computer or device. Telnet is part of the TCP/IP suite of protocols. Also, a client program that implements the Telnet protocol.
- UDP:** User Datagram Protocol - A transport protocol used primarily for the transmission of network management information. Not as reliable as TCP.
- WAG:** Wayside Access Gateway – Safetran assembly A53457 converts Echelon messages to Ethernet messages allowing Safetran equipment to use Ethernet Spread Spectrum radios for communications. WAG assembly A53457 also converts Echelon received messages to RS232 messages allowing the system to use modems for communication between Safetran equipment.

SECTION 1

PRODUCT DESCRIPTION

1.0 PRODUCT DESCRIPTION

1.1 Radio Overview

The A53325 2.4 GHz Ethernet Spread Spectrum Radio is a license free radio that can be used to bridge Ethernet LAN's (Local Area Networks) across distances ranging from a few hundred feet to 30 miles (48 Km) and beyond. It can be deployed in point-to-point, point-to-multipoint, and a generic mesh/tree configuration, where any node can be used as an access point to nodes further downstream. Mobile applications can be configured to enable nodes to autonomously roam between multiple access points, keeping mobile nodes connected to the network at all times. In a standalone configuration the radio provides an Ethernet interface to the user.

WARNING

THE A53325 ESSR IS A NON-VITAL PRODUCT. CAUTION MUST BE TAKEN WHEN INTERFACING THE A53325 ESSR TO ANY VITAL SIGNAL OR CROSSING EQUIPMENT AS THE A53325 ESSR CAN NOT BE USED TO PERFORM, EITHER DIRECTLY OR INDIRECTLY, ANY VITAL FUNCTIONS. ENSURE THE A53325 ESSR IS INSTALLED PER MANUFACTURER'S INSTRUCTIONS, AND/OR ALL EQUIPMENT INTERCONNECTIONS ARE IN COMPLIANCE WITH RAILROAD PROCEDURES AND SPECIFICATIONS.



Outdoor Pole Mount



Indoor Wall Mount

Figure 1-1 53325 ESSR Pole and Wall Mount Installations

The A53325 is a Spread Spectrum radio operating in the “Industrial Scientific and Medical” (ISM) band from 2.400GHz to 2.4835 GHz. It is designed to provide a robust link under adverse conditions, often encountered in this unlicensed band. This includes the following features:

1. All the electronics are housed in an environmentally sealed enclosure rated for outdoor installation. You can mount the unit in close proximity to the antenna, which increases system performance by avoiding RF cable losses or expensive rigid coax cables. The radio receives power over the CAT5 Ethernet cable.
2. The radio RF bandwidth is much narrower than other unlicensed devices in the 2.4 GHz band. This has several advantages, namely (i) the radio sensitivity is greatly improved allowing longer ranges, (ii) there are a much larger number of non-overlapping channels to choose from, and (iii) it is much easier to find an unused gap in a crowded spectrum.
3. For long range links in a crowded spectrum the most desirable receive frequencies at each end of the link are often different. In the A53325 transmit and receive frequencies can be selected independently of each other.

4. The radio incorporates spectrum analysis and timing analysis tools, which allow the operator to quickly perform a survey of the RF environment without the need for spectrum analyzers.
5. Unique antenna alignment aid provides audio feedback proportional to the RSSI, freeing the installer’s hands to adjust and tighten the antenna without having to hold or look at other instrumentation. (Requires auxiliary port audio adapter cable P/N: Z706-00259-0000).

The radio implements a transparent bridge algorithm, where each unit automatically learns the addresses of all stations in the network and forwards over RF only the traffic that needs to be delivered to the remote units. This reduces the RF throughput required by the radio. If the radio is used standalone, an indoor “power inserter” unit combines the power and Ethernet data into a single CAT5 cable connected to the radio. Radio power can also be provided via connection to Safetran’s A53457 Wayside Access Gateway (WAG) unit for installation requiring DC isolation or media conversion.

The A53325 can be configured over a local serial interface using HyperTerminal, or over the Ethernet using the “Ethernet console” program (Econ) provided on CD. Once a unit is configured with an IP address you can also configure and monitor the unit using Telnet or SNMP. The radio firmware, in non-volatile memory, can also be updated remotely.

1.2 Ordering Information

1.2.1 Hardware Information

The following is the ordering information for the A53325 Ethernet Spread Spectrum Radio.

9000-53325-0X

| | |
|---|--------------------------|
| 1 | 0 - 28 VDC FCC Certified |
| 4 | 0 - 28 VDC CE Certified |

1.2.2 Firmware Information

The following is the Firmware included with the 2.4 GHz ESSR Radio. Firmware is subject to change pending upgrades.

- 9VA21-A01X - RF Test Mode
- 9VA03-A01X - Mesh Tree
- 9V879-A01X - Linear Network
- 9V867-A01X - Point-to-Point
- 9V881-A01X - Point-to-Multi-Point

1.3 Included Radio Components

Table 1-1 shows the components that are typically shipped with each A53325 radio.

Table 1-1 A53325 Included Components

| DESCRIPTION | P/N |
|--|------------------|
| Radio unit (outdoor type). | A53325 -01 / -04 |
| Mounting Bracket Kit for securing the A53325 unit to an outdoor mast. | Z916-00056-0000 |
| CD with this Operator's Manual, Econsole installer program, firmware files, and RF Link Budget Calculator. | 9V880-A01 |

1.4 Pole Mounting Bracket Installation

The radio is shipped with mounting hardware designed to easily mount the unit onto a pole outdoors. You can secure the radio to poles of up to 2.5 inches (6.3 cm) in diameter.

Before taking the radio into the field, assemble the mounting hardware as follows:

1. Using the two screws provided, secure the flat aluminum plate into the recessed channel on the back of the unit.
2. Thread the L shape bolt into the hole of the V shape bracket. The non-threaded segment of the bolt should be outside of the V bracket.

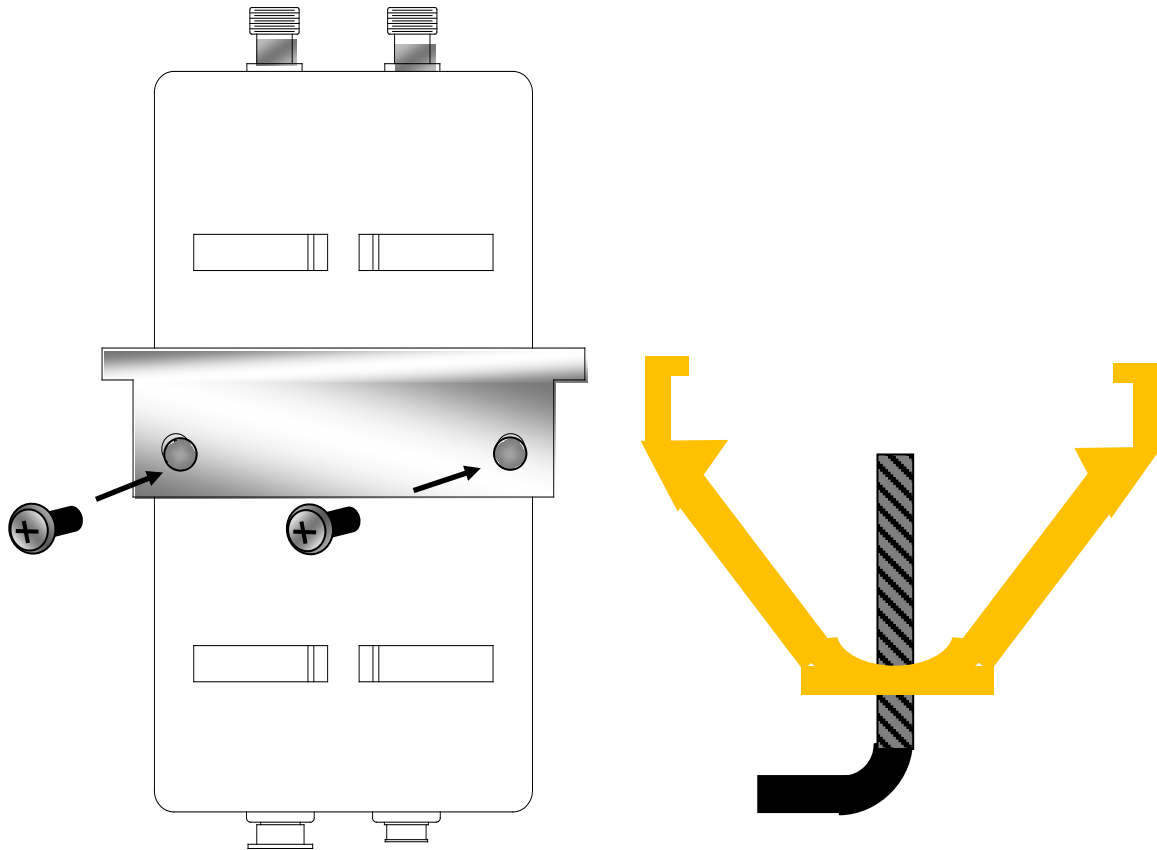
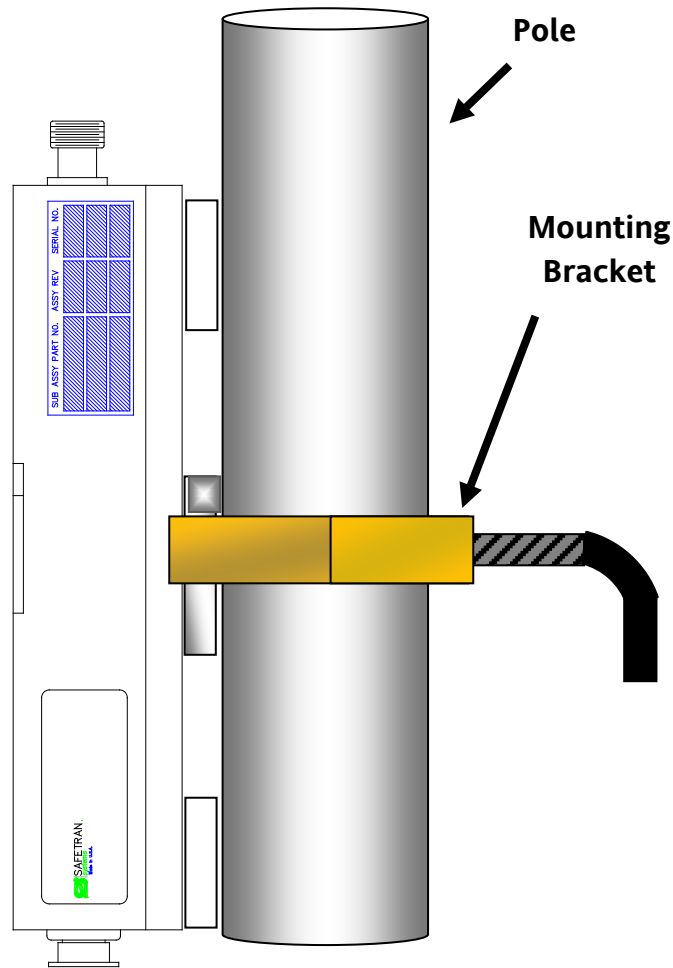


Figure 1-2 Pole Mounting Bracket Installation

In order to secure the radio outdoors place the radio against a pole with the RF connectors facing up (see Figure 1-3) the back of the radio enclosure has four guiding feet that prevent it from sliding from side to side.

1. Place the V bracket around the pole, sliding its two grooves up into the aluminum plate on the back of the radio.
2. Once the grooves reach the stops, manually tighten the L shaped bolt so that it “bites” into the pole.



POLE MOUNT

Figure 1-3 Pole Mounting

1.5 Wall Mount Bracket (Optional)

An optional Wall Mount Bracket is available for indoor installation of the A53325 ESSR. To install the wall bracket follow the procedure below:

1. Mark hole locations using the bracket as a template.
2. Mount the screws into the wall allowing enough gap to slide on the bracket.
3. Slide the bracket on to the screws and secure.
4. Mount the A53325 ESSR on to the bracket with the RF connectors facing up.

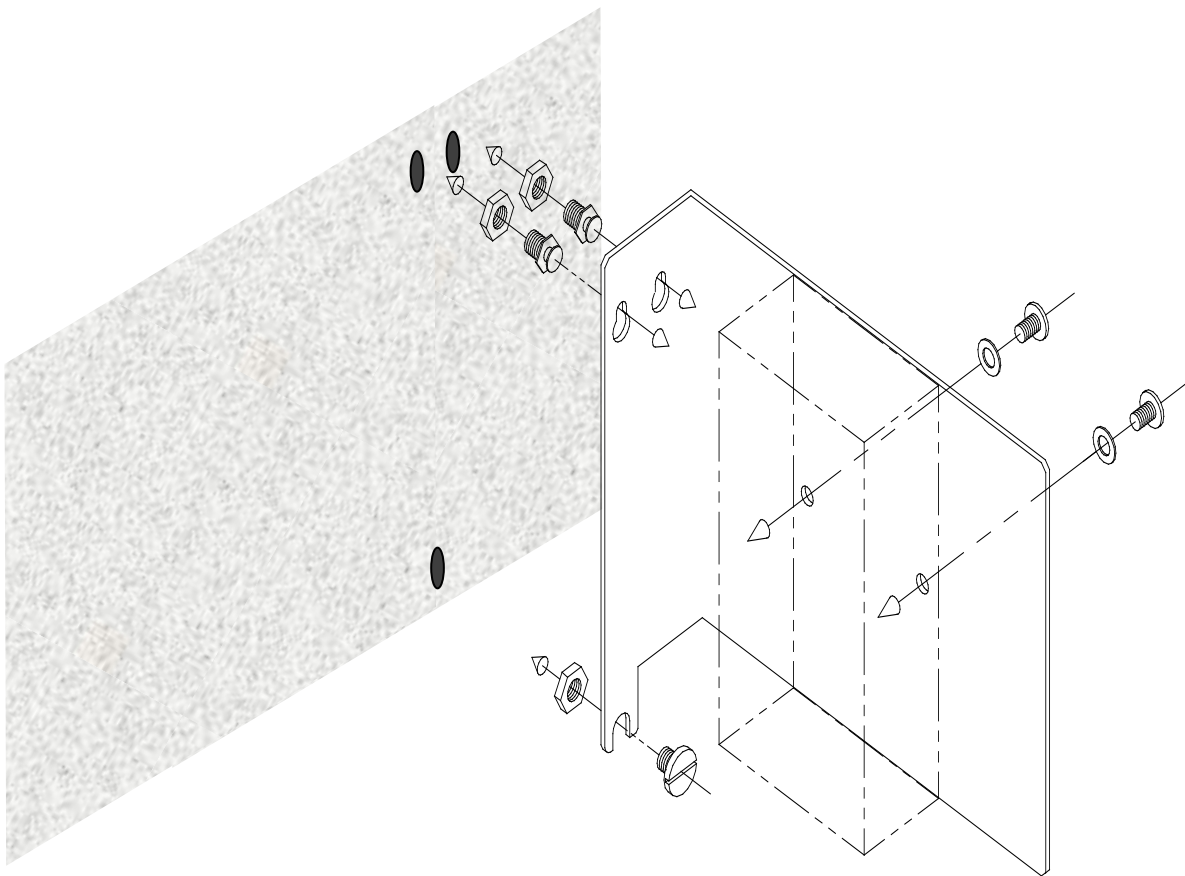


Figure 1-4 Wall Mounting

1.6 Radio Connectors

Figure 1-5 shows the A53325 construction. The radio is housed in a rectangular enclosure with two N-female connectors at the top for connection to RF antennas, and two special purpose connectors at the bottom for DC power, serial interface, Ethernet data and control.

The function of each connector is described in Table 1-2.

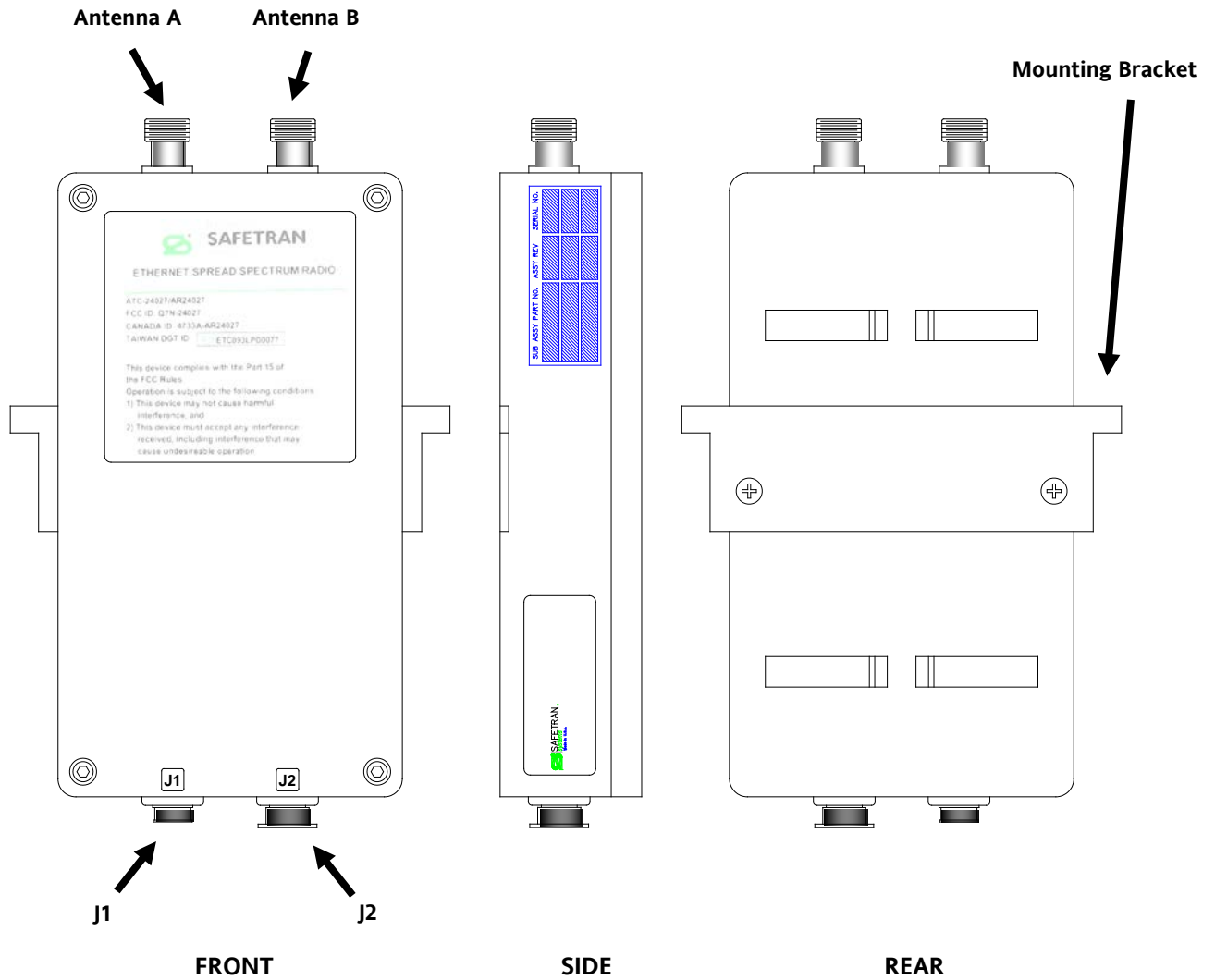


Figure 1-5 A53325 Construction and Connector Locations

Table 1-2 A53325 Connectors

| CONNECTOR | TYPE | FUNCTION |
|-----------|--------------------|---|
| A | N-Female | 2.4 GHz RF connector to antenna A. (Pointing at “Left” neighbor in a Linear Network). |
| B | N-Female | 2.4 GHz RF connector to antenna B. (Pointing at “Right” neighbor in a Linear Network). |
| J1 | Lumberg 8-pin male | 10/100 Base-T data interface and DC power input (8 pin). Must be connected to a “Power Inserter Unit” or Safetran Wayside Access Gateway (WAG) unit with a CAT 5 cable. |
| J2 | Lumberg 3-pin male | Auxiliary port (3 pin) used as an antenna alignment aid and for RS-232 console port. |

An eight conductor CAT 5 cable must be connected between the A53325 radio and a Power Inserter or WAG Unit. The wiring for this cable is shown in Figure 1-7 and APPENDIX E.

Table 1-3 shows the pin assignment of J2, the three-pin auxiliary port connector. The unit is shipped with a cover on this connector. The connector can be used during installation as a console port and also as an audio antenna alignment aid. Two cables are available to convert from this non-standard 3-pin connector to either a DB-9 connector (for RS-232 console) or to a standard audio jack (for connection to a headphone). See Table 1-9 for Siemens Rail Automation part numbers and APPENDIX E for cable diagrams.

Table 1-3 J2 Pin Assignments - 3-Pin Auxiliary Port Connector

| PIN | SIGNAL NAME | ABBR. | DIRECTION |
|-----|---------------|-------|--------------|
| 1 | Receive Data | RD | Radio Output |
| 2 | Transmit Data | TD | Radio Input |
| 3 | Ground | GND | |

1.6.1 VHLC Serial Cable

This is an optional serial DB-25 to DB-25 cable used with the Wayside Access Gateway. Table 1-4 lists the order numbers for the VHLC serial cables.

Table 1-4 VHLC Serial Cables

| DESCRIPTION | P/N |
|---|-----------------|
| 5 foot DB-25 - DB-25 VHLC serial cable | 9000-47715-0001 |
| 10 foot DB-25 - DB-25 VHLC serial cable | 9000-47715-0002 |
| 15 foot DB-25 - DB-25 VHLC serial cable | 9000-47715-0003 |
| 20 foot DB-25 - DB-25 VHLC serial cable | 9000-47715-0004 |
| 25 foot DB-25 - DB-25 VHLC serial cable | 9000-47715-0005 |
| 30 foot DB-25 - DB-25 VHLC serial cable | 9000-47715-0006 |

Figure 1-6 shows the schematic diagram for the VHLC serial cable.

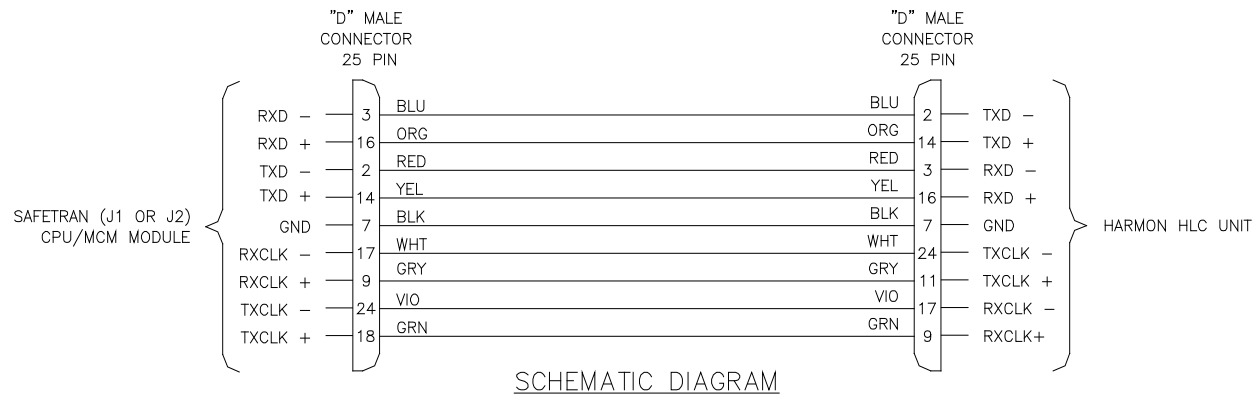


Figure 1-6 VHLC Cable

1.7 Power Inserter Unit

The Power Inserter Unit is available in two models: one for AC input, and one for DC input. The AC model includes a 24 VDC regulated power supply for connection to an AC outlet, whereas the DC model is strictly a DC power pass-through.

CAUTION

ENSURE THE INPUT VOLTAGE APPLIED TO THE **DC POWER INSERTER** DOES NOT EXCEED THE POWER INPUT SPECIFICATIONS OF THE A53325 RADIO, AS DAMAGE TO THE RADIO COULD RESULT.

NOTE

A Power Inserter is not required in applications where a WAG is supplying power to the radio, unless the cable length exceeds 100 feet.

Each Power Inserter has two RJ45 connectors and a bi-color LED. The two RJ-45 connectors are labeled “To LAN” and “To radio”. See following tables for details.

Table 1-5 Power Inserter Description (AC or DC Input)

| CONNECTOR / LED | TYPE | FUNCTION |
|-----------------|-----------------|---|
| To LAN | RJ-45 | 10/100 Base-T to be connected to the Local Area Network. Use a straight through cable to connect to a hub and a crossover cable to connect directly to a computer. See Table 1-6 for pin assignments. |
| To Radio | RJ-45 | Carries the DC power and Ethernet signals to the A53325. See Table 1-7 for pin assignments. |
| LED | Amber/ Green | Amber: Indicates that the power inserter unit has power input, but no power is being drawn by the A53325 radio. Green: Indicates the A53325 radio is drawing power. |

WARNING

THE POWER INSERTER CONNECTOR LABELED “TO RADIO” INCLUDES DC VOLTAGE ON TWO OF THE PINS. IT MUST NOT BE CONNECTED TO A LAN AS THIS VOLTAGE MAY DAMAGE SOME LAN CARDS.

Table 1-6 “To LAN” Ethernet Connector Pin Assignments

| PIN | SIGNAL NAME | ABBR. | DIRECTION |
|-----|-----------------|--------|-------------------|
| 1 | Ethernet Tx | Tx (+) | Radio to Ethernet |
| 2 | Ethernet Tx | Tx (-) | Radio to Ethernet |
| 3 | Ethernet Rx | Rx (+) | Ethernet to Radio |
| 4 | (not connected) | | |
| 5 | (not connected) | | |
| 6 | Ethernet Rx | Rx (-) | Ethernet to radio |
| 7 | (not connected) | | |
| 8 | (not connected) | | |

Table 1-7 “To Radio” Ethernet Connector Pin Assignments

| PIN | SIGNAL NAME | ABBR. | DIRECTION |
|-----|-------------|---------|-------------------------|
| 1 | Ethernet Tx | Tx (+) | Radio to Ethernet |
| 2 | Ethernet Tx | Tx (-) | Radio to Ethernet |
| 3 | Ethernet Rx | Rx (+) | Ethernet to Radio |
| 4 | VDC | DCV (+) | Power Inserter to Radio |
| 5 | VDC | DCV(+) | Power Inserter to Radio |
| 6 | Ethernet Rx | Rx (-) | Ethernet to Radio |
| 7 | ground | GND(-) | Power Inserter to Radio |
| 8 | ground | GND(-) | Power Inserter to Radio |

1.8 Outdoor Interconnect Power / Data Cable (J1)

The interconnect cable between the Power Inserter or Wayside Access Gateway (WAG), and A53325-J1 carries the following signals:

- DC voltage to supply power to the A53325.
- 10/100 Base-T Ethernet data.

CAUTION

REVERSED POLARITY OF THE INPUT POWER TO THE RADIO WILL DAMAGE THE RADIO.

Both of these signals are carried in a single CAT 5 cable. The system is designed to allow cable lengths up to 100 meters (300 feet).

NOTE

For applications using a WAG, a Power Inserter is required when the cable length exceeds 100 feet.

Table 1-8 lists some of the available hardware components to build this cable.

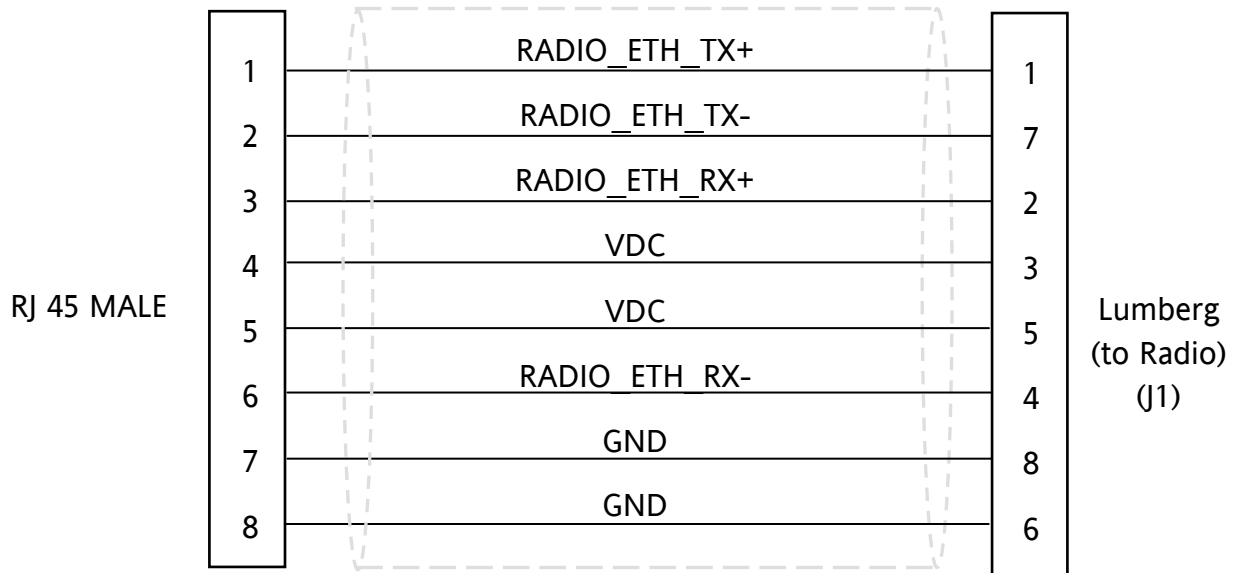


Figure 1-7 CAT 5 Outdoor Interconnect Power/Data Cable Diagram

Table 1-8 lists a few part numbers and sources of appropriate CAT 5 cable components for this application. See APPENDIX E for connector diagrams and assembly instructions.

Table 1-8 Indoor/Outdoor CAT 5 Cable Components

| PART NUMBER | MANUFACTURER | DESCRIPTION |
|--------------------------------------|----------------|--|
| 7919A | Belden | Shielded outdoor rated cable |
| 18-241-31(gray) 18-241-11 (beige) | Superior Essex | Unshielded outdoor rated cable |
| 5EXH04P24-BK-R-CMS-PV | CommScope | Unshielded outdoor rated cable |
| 2137113 (ivory) 2137114 (gray) | General Cable | Unshielded outdoor rated cable |
| BC1002 | Belden | Unshielded outdoor rated cable |
| 0321-03 | Lumberg | 3-pin weatherproof connector, female, unshielded |
| 0322-03 | Lumberg | 3-pin weatherproof connector, female, shielded |
| 0321-08 | Lumberg | 8-pin weatherproof connector, female, unshielded |
| 0322-08 | Lumberg | 8-pin weatherproof connector, female, shielded |

1.9 Radio Accessories

Table 1-9 shows the accessories available for the A53325 radio and their Siemens Rail Automation part numbers.

Table 1-9 A53325 Radio Accessories

| DESCRIPTION | P/N |
|--|------------------------------|
| AC Power Inserter Module. (110 VAC input to 24 VDC output) | Z932-00184-0000 |
| DC Power Inserter Module. (24 VDC battery passthrough) | Z932-00186-0000 |
| Auxiliary port 3-pin Console Cable for RS-232 connection. | Z706-00235-0000 |
| Auxiliary port 3-pin Audio Adapter Cable with audio jack. (Used for antenna alignment aid) | Z706-00259-0000 |
| CAT 5 Power / Data Cable for connection between A53325 radio and a Power Inserter Module or Safetran Wayside Access Gateway (WAG). | See Table 1-10 or Table 1-12 |
| Lightning Arrester / Surge Protector – NF to NM 2.4 GHz | Z803-00131-0000 |
| Lightning Arrester / Surge Protector – NF to NF 2.4 GHz | Z803-00132-0000 |

1.9.1 Pre-configured Power / Data Cables

For ease of installation, several pre-configured power/data CAT-5 cables of various lengths are available from Siemens Rail Automation. These cables provide the proper wiring with a standard RJ-45 male connector on one end, and a Lumberg 8-pin female connector on the other. Table 1-10 shows a list of available cables and their corresponding Siemens Rail Automation part numbers.

Table 1-10 Pre-configured CAT-5 Power / Data Cables for A53325 Radio

| DESCRIPTION | P/N |
|--|-----------------|
| 20 inch weatherproof CAT-5 power/data cable | Z706-00253-0000 |
| 5 foot weatherproof CAT-5 power/data cable | Z706-00236-0000 |
| 10 foot weatherproof CAT-5 power/data cable | Z706-00247-0000 |
| 20 foot weatherproof CAT-5 power/data cable | Z706-00254-0000 |
| 30 foot weatherproof CAT-5 power/data cable | Z706-00255-0000 |
| 50 foot weatherproof CAT-5 power/data cable | Z706-00237-0000 |
| 100 foot weatherproof CAT-5 power/data cable | Z706-00238-0000 |
| * 200 foot weatherproof CAT-5 power/data cable | Z706-00248-0000 |
| * 300 foot weatherproof CAT-5 power/data cable | Z706-00249-0000 |

* Power Inserter required

Table 1-11 shows a list of available tilt-over tower and house cables and their corresponding Siemens Rail Automation part numbers.

Table 1-11 Pre-configured CAT-5 Power/Data Tilt-Over Tower and House Cables

| DESCRIPTION | P/N |
|---|-----------------|
| 20 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0020 |
| 30 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0030 |
| 50 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0050 |
| 75 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0075 |
| 100 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0100 |
| *200 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0200 |
| *300 foot weatherproof CAT-5 power/data tower cable | Z706-00283-0300 |
| 50 foot weatherproof CAT-5 power/data house cable | Z706-00284-0050 |
| 75 foot weatherproof CAT-5 power/data house cable | Z706-00284-0075 |
| 100 foot weatherproof CAT-5 power/data house cable | Z706-00284-0100 |

* Power Inserter required

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SECTION 2

NETWORK TOPOLOGIES AND APPLICATIONS

2.0 NETWORK TOPOLOGIES AND APPLICATIONS

2.1 Network Topologies

The A53325 2.4 GHz Ethernet Spread Spectrum Radio can be deployed in a variety of topologies from a simple point-to-point link to complex networks with multiple hops, redundant nodes, and mobile nodes. In all applications the A53325 will act as bridges connecting the LANs from all sites together. From any LAN the A53325 will be able to access stations at all other sites, even when they are several hops away. The radios will perform all the packet switching, sending packets in the appropriate direction so that they reach their destination with the minimum number of hops.

The following table lists the various topologies that are possible and gives a brief description for each. Subsequent sections explain these topologies in more detail.

Table 2-1 Topologies

| Topology | Description |
|---------------------|---|
| Point-to-point | Single link between two points. For fixed sites use directional antennas to reach distances exceeding 30 miles (48 km). |
| Point-to-Multipoint | Central site with a single hub radio with links with up to 32 remote sites. The hub radio autonomously allocates bandwidth “on-demand” to each remote radio. You can co-locate multiple hub radios to increase total capacity or maximum number of remotes. |
| Tree topology | One root node with direct links to up to 32 remotes (like in point-to-multipoint). Any of the remotes can be promoted to a branch. A branch node operates as an access point for up to 32 additional remote nodes downstream (which can themselves be promoted to branch nodes). Radios come with two antenna ports, to deploy a branch node with one directional antenna pointing at the parent, and a second omni antenna to serve as an access point. |

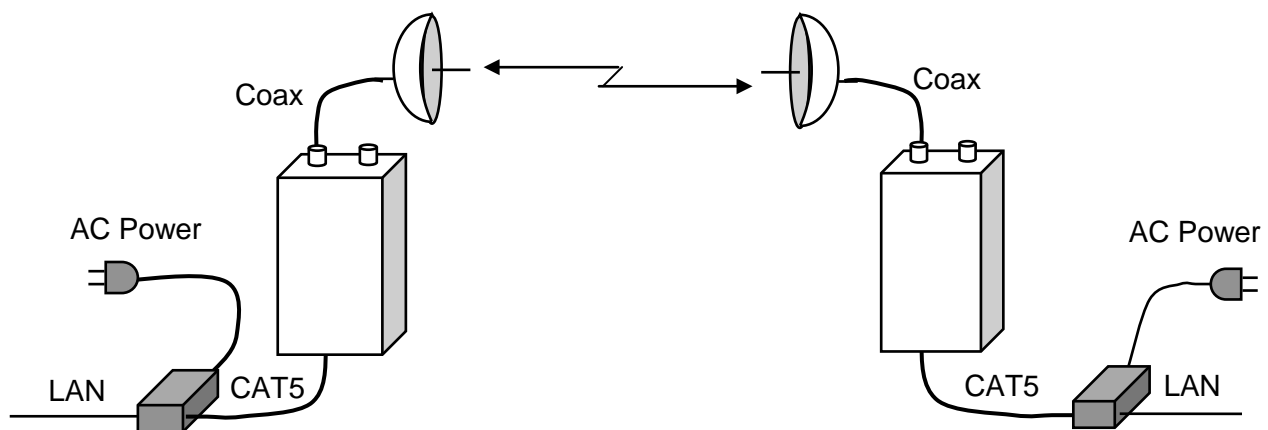
Table 2-1 Topologies (Continued)

| Topology | Description |
|----------------|---|
| Linear Network | Used for long networks with multiple stations along a railway, pipeline or roadside. Each node has at most two neighbors. Use the radio dual antenna port to deploy each radio with two directional antennas pointing at each neighbor. |
| Roaming | Used with mobile nodes that move around an area with multiple fixed access points. The mobile radios change the access point automatically to keep you connected to the fixed network. |

2.1.1 Point to point

In a point-to-point topology, when the two sites are fixed we recommend using directional antennas at both ends, pointing at each other. This increases the signal strength in the desired direction and shields the radios against unwanted interference from other sources. When you use directional antennas make sure you install both antennas with the same polarization (vertical or horizontal). Most often interfering sources are vertically polarized so you may want to install your link with horizontal polarization to get some additional isolation against those interference sources.

The point-to-point topology operates like a point-to-multipoint network where the hub has a single remote. You still need to configure one of the two radios to be the **hub** but configure it with the max number of children set to one. This optimizes the radio performance for point-to-point operation. See the **node** command in section 6.

**Figure 2-1 Point to Point Topology**

2.1.2 Point to Multipoint

In a Point to Multipoint topology one radio is designated as the **hub** and all other radios are designated as **remotes**. You can have up to 32 remote nodes. You typically deploy the hub radio with an omni-directional or sectorial antenna so that it can cover all the remotes. If the remote sites are fixed deploy them with directional antennas pointing at the hub. If the remotes are mobile, use omni-directional antennas everywhere.

Remote radios connect to the network automatically without need to change the configuration of the hub radio. All you need is to point an antenna at the hub and ensure that the following parameters are configured correctly:

1. The RF receive channel of the remote must match the transmit channel of the hub (see **rf-1-setup**).
2. The **network-id** parameter of the remote must match the network-id of the hub (see **node** command).
3. The **max-children** parameter at the hub must be large enough to give access to all the planned remotes (see **node** command).

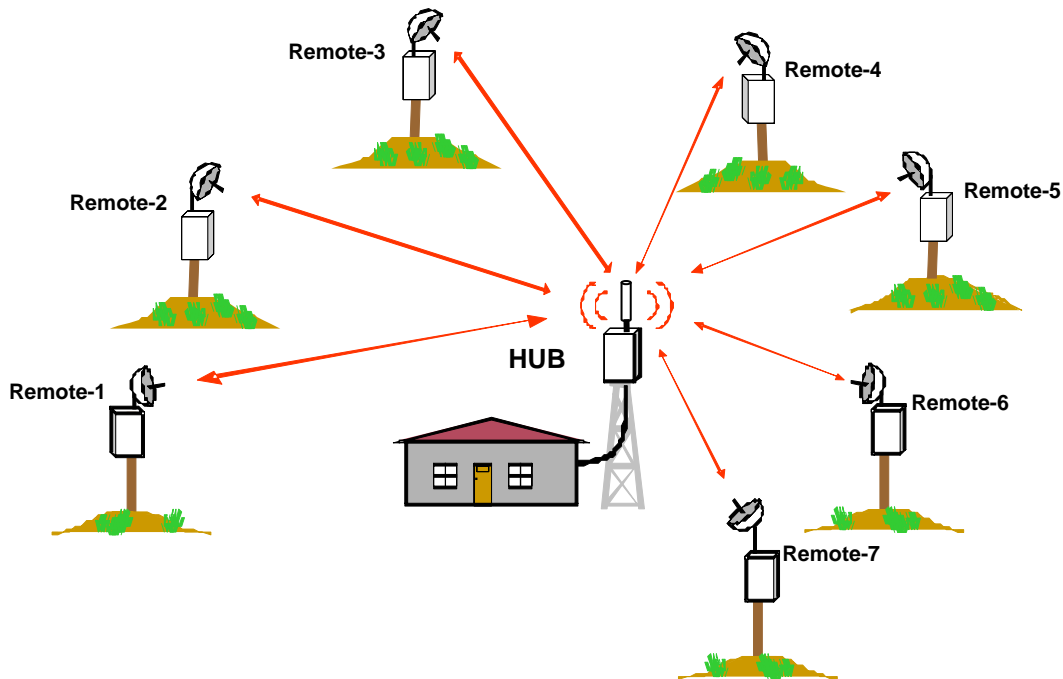


Figure 2-2 Point-to-Multipoint Topology

2.1.3 Tree Topology

In a Tree Topology There are three node types: one **root** node and multiple **branch** and **leaf** nodes (use the **node** command to configure the node type).

The **root** node performs a similar function to the hub in a point-to-multipoint topology and can have up to 32 direct links to remote sites. The radios at the remote sites can be configured as either **leaf** or **branch** nodes. A leaf node is similar to the remote in a point-multipoint topology. But a branch node, besides having a link to a **parent** (root or another branch), also operates as an access point for up to 32 additional remote nodes (**children**). Each of those nodes can again be configured as either a **leaf** or a **branch**. There is no limit to the number of levels in the tree.

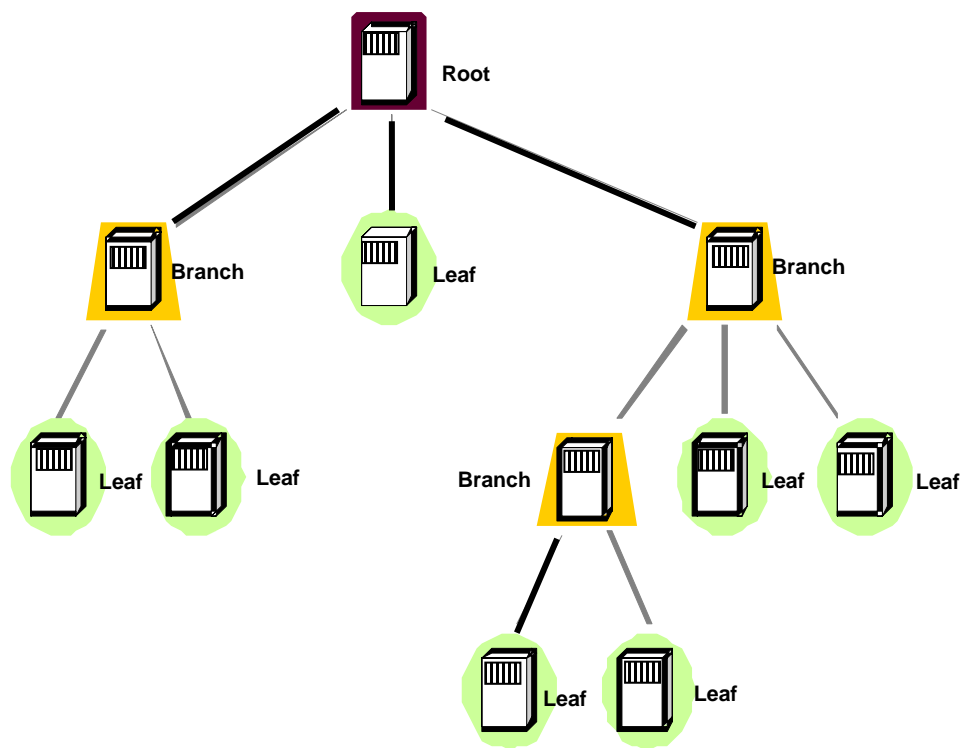


Figure 2-3 Tree Topology Network

A branch node has two independent RF configurations, one for the link with the parent, the other for the links with its children. Typically you set the link with the parent to use antenna A, and the link with the children to use antenna B. This allows you to deploy a directional antenna pointing at the parent node, while using an omni-directional or sectorial antenna for the links with the multiple children. This is not mandatory as it is possible to configure a branch radio to use a single antenna.

With a large network with many branch nodes it is necessary to pay special attention to the channel assignments. One simple approach is to allocate non-overlapping channels to each “cell” (a cell consists of a parent with all of its direct children). At the parent set both transmit and receive channels to the channel that are assigned to that cell. At the children set them to receive from the parent in that same channel (see commands **rf-1-setup** and **rf-2-setup**). Once enough distance separates cells it is permissible to start re-using overlapping channels.

The tree topology has the following features:

- There is no limit in the number of levels on the tree.
- Automatic association of new remote radios: just configure a new remote to receive on the transmit channel of the desired parent, and it will automatically associate to the network (use the “network-id” of the **node** command to prevent unauthorized radios from attaching).
- Self-learning bridging algorithm: the radios automatically learn the addresses of the equipment attached on any of the LANs and route the packets using the minimal number of hops to reach their destination.
- Self-healing network: If a parent node goes down a branch continues to operate and pass data between its children. Once the parent recovers the branch automatically reattaches to the rest of the network.

2.1.3.1 Dual antenna root mode

There is the option of running the root with two antennas. This may be useful if the remotes are grouped geographically such that the use two directional or sectorial antennas will cover each group. To run in this mode set the node type to **root-2** and use **rf-1-setup** and **rf-2-setup** to configure the RF parameters for each antenna.

2.1.3.2 Network throughput

A branch radio allocates half of the time to communicate with its parent and the other half with its children. A root radio does not have a parent, so it divides its children into two groups communicating with one group during the first half cycle, and with the second group during the second half. Each of these two groups gets half of the total network capacity. Therefore in the tree topology the maximum throughput available at one specific node in the tree is half of the total network capacity. This is irrespective of the level in the tree, i.e., there is no further drop in throughput as you go down the various levels.

2.1.3.3 Tree Topology PTC Application

Figure 2-4 displays a PTC application using A53325 ESSRs in a Tree Topology to enable multiple wayside sites to utilize a single 220 MHz PTC Radio location.

Multiple VIU Locations Sending Messages to a Single PTC Radio Location

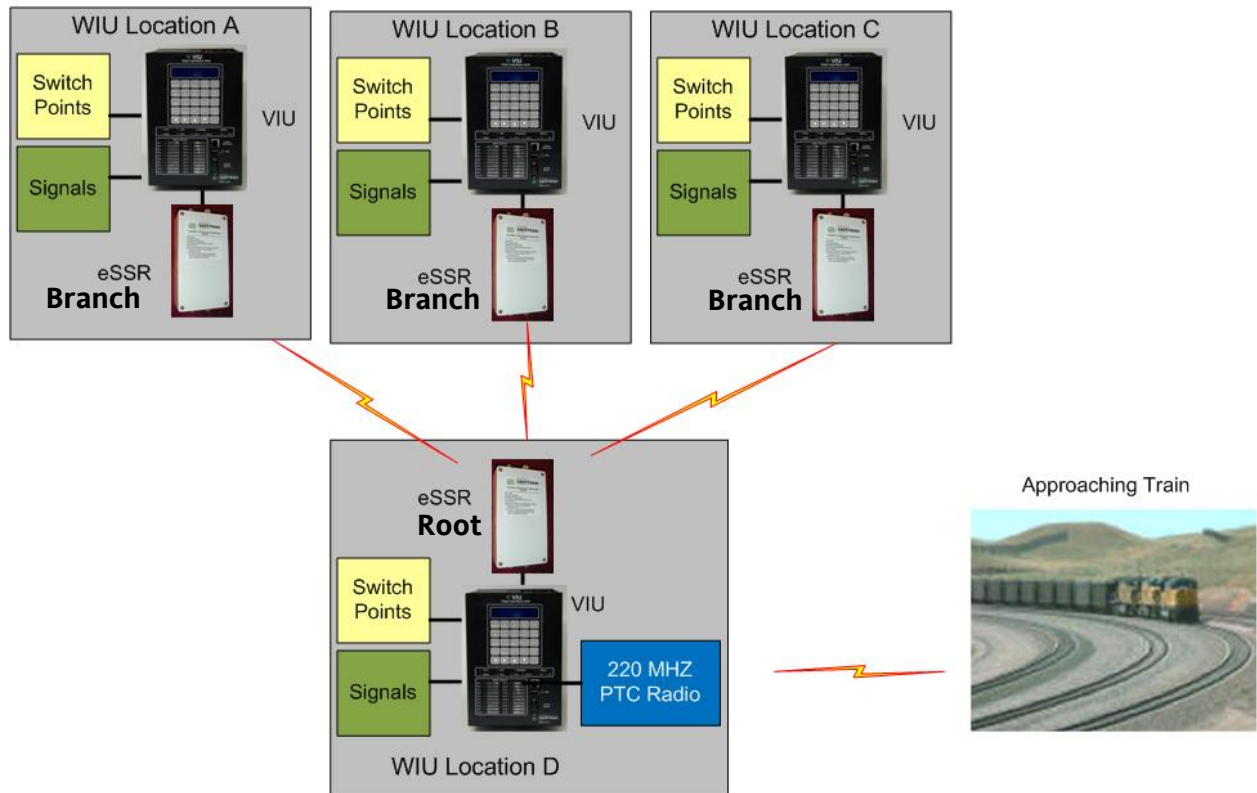


Figure 2-4 PTC Application

2.1.4 Linear Network

A Linear Network topology is ideal for providing communications in systems that naturally require stations deployed along a line. Some of the applications are:

- Railway wayside communications
- Pipeline communications
- Highway roadside communications
- Long links that requires multiple repeaters between the end points

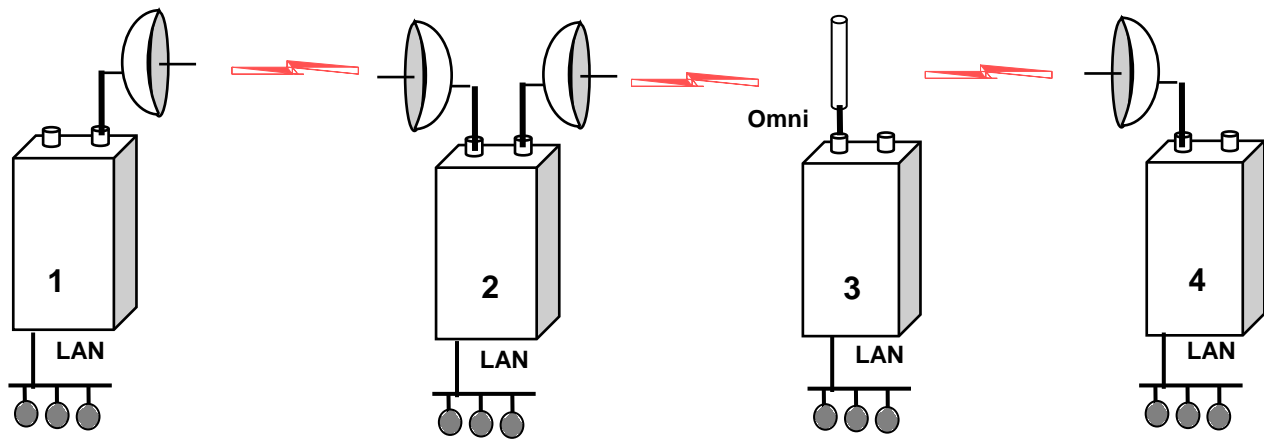


Figure 2-5 Linear Network

It is easy to implement a Linear Network as a subset of the Tree topology: configure the leftmost radio as a root and all the radios in the network as a branch. Install each radio with two directional antennas pointing at their two neighbors. For further details refer to Appendix E.

2.1.5 Roaming

With the roaming option, a remote or leaf radio can be configured with up to six different receive channels (see command **rf-1-setup**). With this capability you can deploy **multiple access points** in a region where a group of mobile radios will move around. Mobile radios attach to the network through any of the access points and automatically switch to a new one whenever the need arises.

This capability is ideal for communications between a control center and vehicles, where the vehicles must move beyond the range of a single hub radio.

All the access points are typically connected, through a backbone network, back to a central site. This backbone network can be wired or wireless. You can use the tree topology and have each branch and root serve both as access points and backbone nodes to bring the traffic back to the central site (see figure).

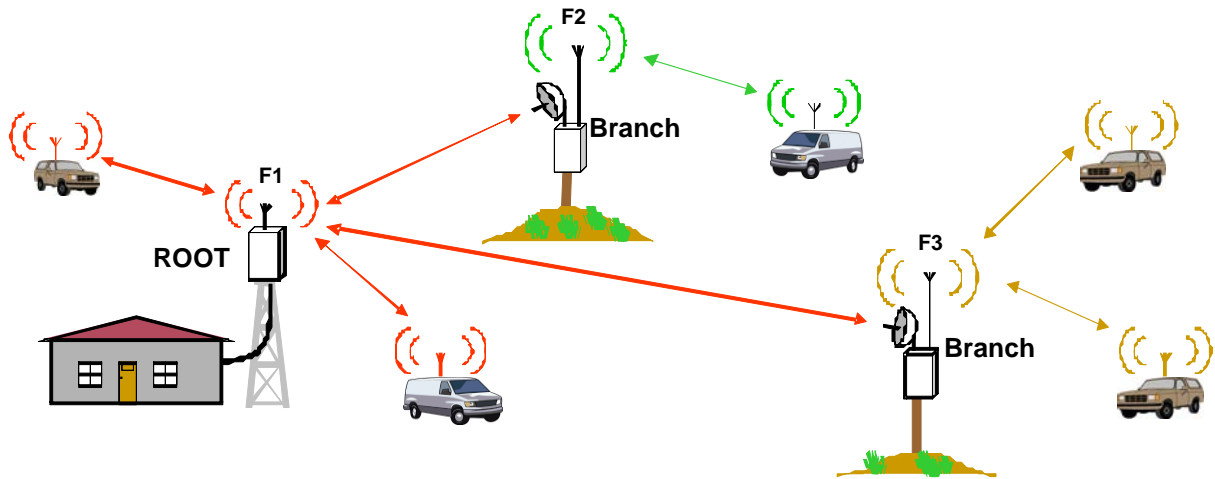


Figure 2-6 Roaming Vehicles Attaching To Any Of Three Access Points

The overall system supports the following features:

1. Mobile nodes automatically attach to the strongest access point.
2. As a mobile unit moves and the link to its parent fades, the mobile radio changes autonomously to attach to a stronger parent.
3. Connectivity to a central site, through a backbone network, is maintained when a mobile changes parent. Packet routing is switched over autonomously throughout the network so that packets are correctly routed immediately after the mobile radio changes the access point.
4. Using the Tree topology you can use the fixed nodes in the tree (root and branches) to provide the backbone network. Those same radios can also be the access points to the mobile leaf nodes. This approach depicted in Figure 2-6.

2.1.6 Time Division Duplex

The A53325 2.4 GHz Ethernet Spread Spectrum Radio operates in Time Division Duplex (TDD), mode meaning that the radio switches between transmit and receive over RF. In a point-to-multipoint topology this **cycle** consists of one phase used for **outbound** transmissions (from parent to children) and a separate phase for **inbound** transmissions (from the children to the parent). In the tree topology the cycle includes four phases: a branch node first communicates with its children (transmit and then receive) and then with its parent (receive and then transmit).

2.1.6.1 Fixed and Variable Cycle Split

The radio provides two parameters that let you configure the TDD operation to best suit your application. You can select the total **cycle period** between 20 and 40 ms and you can control the **cycle split** to favor either outbound or inbound traffic. You only need to set these two parameters at the hub or root node: all the children will pick up these TDD values from their parents.

A cycle period of 20 ms (default) results in lower latencies throughout the network. However there will be more transitions between transmit and receive resulting in somewhat lower throughput capacity for the network. A cycle period of 40 ms has the opposite effect.

For small networks a cycle period of 20 ms is usually preferred. If you have a network with many nodes that are simultaneously active the 40 ms cycle will give you better performance.

The cycle split controls the percentage of time allocated for outbound traffic (from parent to children) versus inbound traffic (from children to parent). The default is an automatic mode where the parent radio allocates the split of each cycle dynamically based on the amount of traffic queued up in each direction. In a tree network each parent decides this split independent of the other parents, based on the local traffic conditions. In most deployment this setting gives you the best performance.

You can also specify a **fixed cycle split**. You have the choice of 9 different values in 10% nominal increments from 10/90 (outbound/inbound) all the way to 90/10. You need to use the fixed TDD split when you co-locate multiple radios and want to avoid self-generated interference. Refer to section 2.1.8 for details about synchronizing co-located radios. The fixed split may also be appropriate in applications where the data traffic is constant and with pre-determined throughput.

2.1.6.2 On Demand Bandwidth Allocation

The complete TDD cycle is divided into slots of approximately 1 ms each. In automatic cycle split mode, the parent radio examines the total traffic queued up for outbound and inbound, and selects an appropriate cycle split. With fixed cycle split this step is omitted.

For the outbound traffic, the parent radio allocates the bandwidth on demand to each remote. If there is no traffic to a specific remote, the parent does not transmit any packets to that remote. When the parent has packets to multiple children, it distributes the available bandwidth evenly so that all children get equal throughput.

The parent starts every outbound transmission with a broadcast packet that includes the current cycle split as well as the slot allocation for the inbound phase. All children decode this packet and only transmit if they have been assigned one or more slots during the inbound phase.

When the children radios transmit they include a bandwidth request parameter informing the parent of how much inbound traffic they have queued up. The parent allocates slots to the children based on this information. On a given cycle, each child may be allocated zero, one, or several contiguous slots to transmit. If the aggregate requested bandwidth exceeds the network throughput the parent divides the available bandwidth fairly among the active children.

Once in a while the parent allocates a single slot to children that have remained idle to check if they now have inbound traffic. This check only takes a single inbound slot and this slot is allocated dynamically depending on current traffic load, available slots, and traffic history.

2.1.7 Radio Co-location and Interference

Installation of radios in close proximity may cause interference if not properly installed. Antenna location and type and operating frequencies are factors that must be considered when setting up a network.

2.1.7.1 Radio Co-location

As a network grows it often becomes necessary to deploy multiple radios at the same site. The reasons to co-locate radios include the following:

1. In a Tree network you want to achieve 360-degree coverage around a central site, but would like to use sector antennas rather than one omni. Sector antennas have higher gain than the omni and provide shielding from interfering signals originating at different sectors. In this situation deployment of a central site with six root radios for example, each one feeding a sector antenna covering 60-degree sectors.

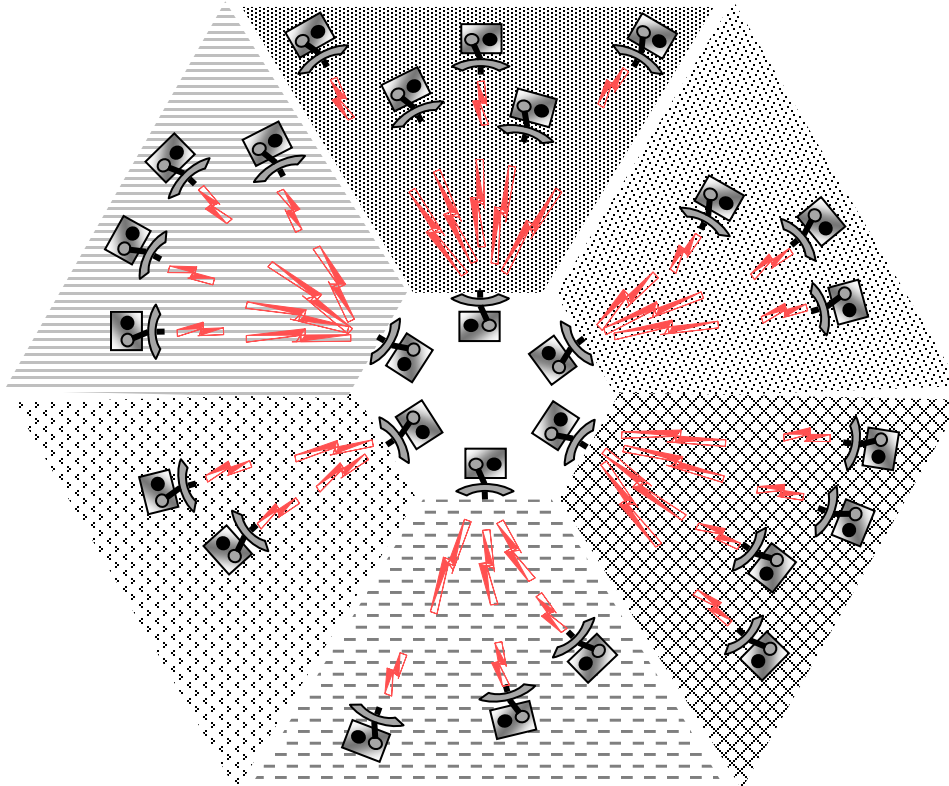


Figure 2-7 360 Degree Coverage with Sector Antennas

2. The number of leaf radios serviced by a single branch has grown to a point where the shared bandwidth is no longer adequate. You may then add a second branch radio operating on a different channel and split the leaf radios between two or more branch radios.
 3. It is desired to deploy two root radios to provide redundancy at the central site.
 4. It is desired to deploy a repeater site with two “back to back” radios.
- The problem is that when you co-locate two or more radios they can become the source of self-interference, *even if they are set to non-overlapping channels*. The reason for this is explained in the following section.

2.1.7.2 Co-located Radio Self-interference

The self-interference situation is illustrated in Figure 2-8, that shows radio A transmitting on channel f_1 while a co-located radio is trying to receive on channel f_2 . Because the antennas are in close proximity antenna B will pick up a significant portion of the signal transmitted by radio A.

Figure 2-8 also shows a block diagram of the radio front end circuitry. It includes an RF filter to reject out-of-band signals, followed by a Low Noise Amplifier (LNA), a second RF filter, Mixer and finally the Intermediate Frequency (IF) filter. Channel selection occurs at the Intermediate Frequency (IF), where the narrow band IF filter blocks out the other channels. This means that if the interferer (radio A) is in close proximity, and is transmitting while radio B is trying to receive, it may saturate the LNA or the Mixer of radio B. This results in radio B making errors even when it is set to a different channel than radio A.

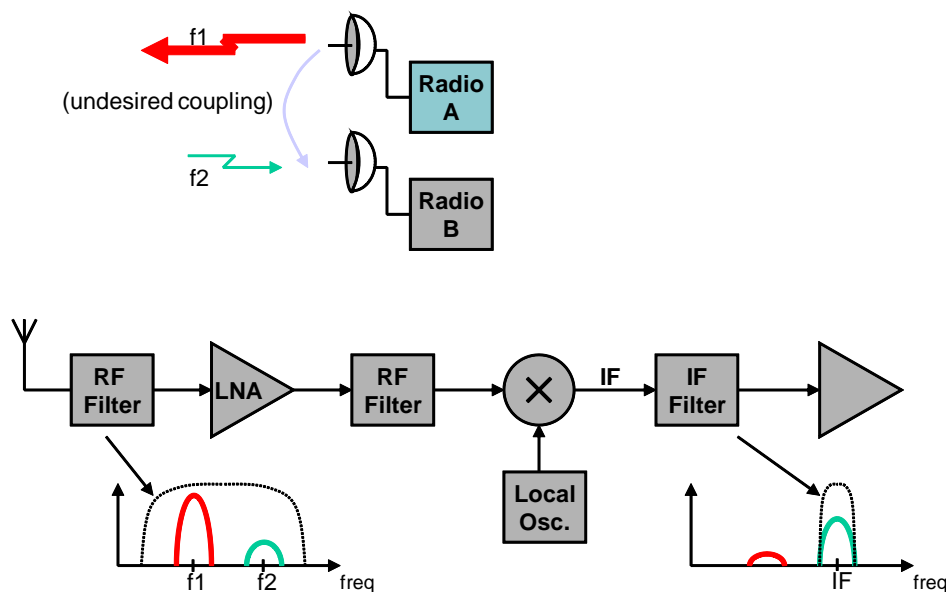


Figure 2-8 Co-located Radio Interference

The traditional approaches to reduce this self-interference include:

- Separate the antennas of the two radios further apart.
- Use different antenna polarization.
- Lower the transmit power of the interfering radio.

These approaches are limited and, at most, may allow you to co-locate three of four radios. The Afar SPAN technology implements a synchronization scheme that completely eliminates this self-interference allowing you to co-locate a much larger number of radios. This is explained in the following sections.

2.1.8 SPAN Network Synchronization

The A53325 Wireless Ethernet Bridge can be operated in a **fixed TDD** mode, where the complete cycle is divided into fixed length outbound and inbound phases. You can specify this cycle split to be 50/50 or asymmetric.

When you co-locate multiple devices you must choose a fixed split and it must be the same for all the co-located radios. The radios will then synchronize their cycle periods so that all co-located radios transmit at the same time and then receive at the same time. This avoids the situation depicted in Figure 2-8 altogether. With a synchronized site you can then deploy upwards of 24 radios at the same location.

The key to the synchronized SPAN network is the generation and distribution of the synchronization information or **heartbeat**. At any site where there is more than one co-located radio, the various radios detect each other, and automatically negotiate which should become the source of the heartbeat. If that device later is turned off or fails, another device will take its place without user intervention.

Figure 2-6 shows an example of a mixed network with multiple topologies. When the whole network is synchronized each radio runs its TDD in one of two timings, A or B, as shown in the figure. All radios at a single site run on the same cycle.

The following are guidelines you need to follow to achieve a successful synchronization in a complex network:

1. At any site with multiple radios ensure that all radios are connected to the same LAN. The LAN connection between radios must be FULL DUPLEX. Use the “>ether” command to check that the radio Ethernet port is in full duplex (see also section 2.1.10 for synchronizing a site where the radios are paired with NetCrossing Gateways).
2. You need to use a fixed TDD cycle split throughout the network. If you are co-locating multiple hubs or roots in a point-to-multipoint or tree configurations, choose any split appropriate for the traffic in your network. You must use the same value in all co-located radios.
3. When you co-locate all hubs or all roots, you may use a cycle period of either 20 or 40 ms, but it must be the same in all co-located devices. You can mix hub and root radios at the same site, but in that case you must set the hubs cycle periods to 20 ms and the roots to 40 ms.
4. You can also co-locate a remote (or a leaf or branch) with other radios. However children nodes have their cycles synchronized to their parents. So at one given site there can only

be one child node, which will become the source of the heartbeat. The other radios at that site must be hubs or roots. In this situation choose an even cycle split of 50/50.

5. Make sure that all radios have the **tdd sync-mode** set to **auto** (default).

If you follow these guidelines the radios will spread the synchronization across the network and completely avoid self-interference. Use the “>show” command to find which radio is the source for the heartbeat at that site and also whether there are any conflicts in the configuration.

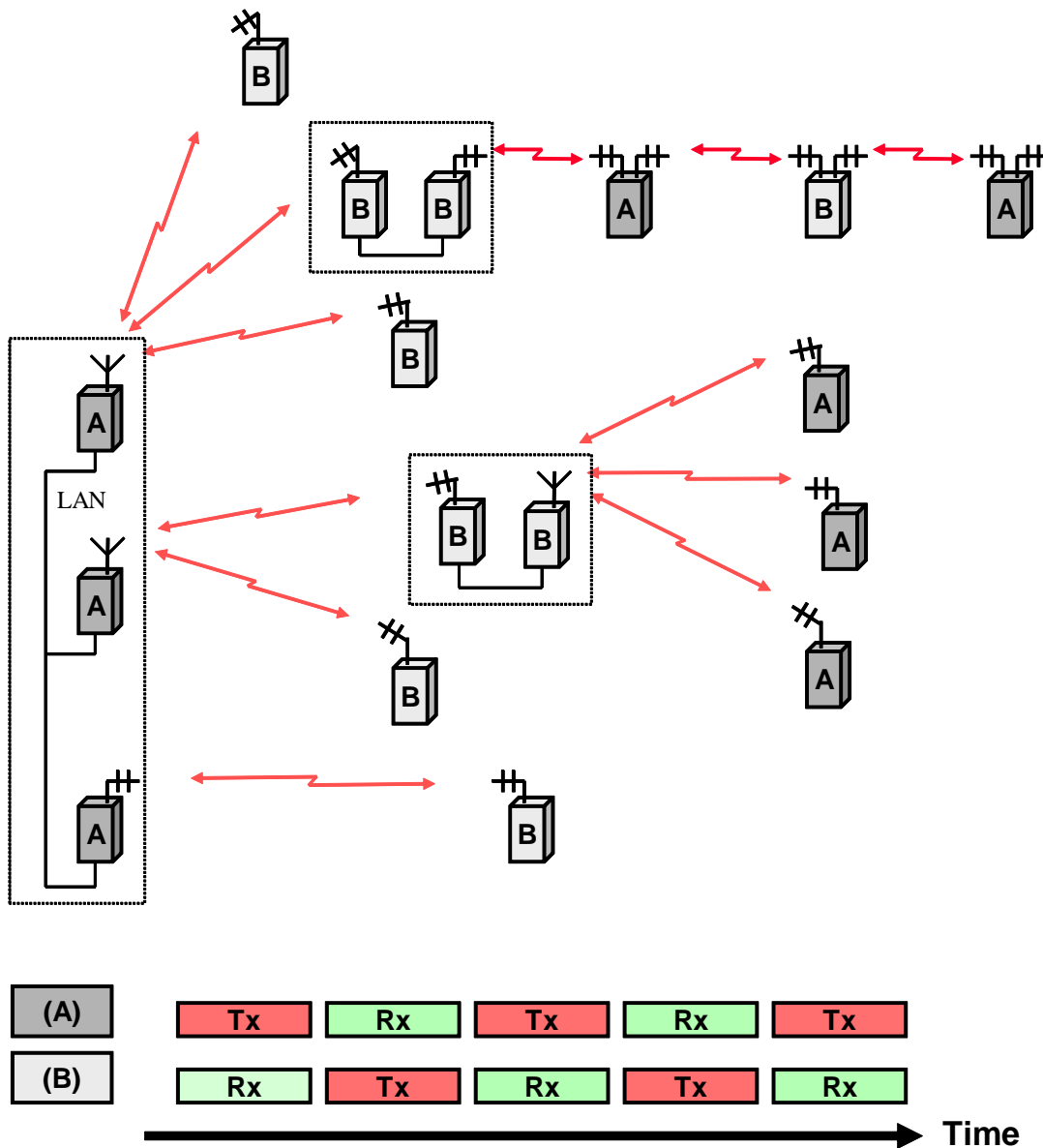


Figure 2-9 Multiple Topology Network

2.1.9 Heartbeat Suppression

There are situations when the multicast of heartbeat packets may not be necessary, and would put an unnecessary burden on the Ethernet. The radios detect these situations automatically and suppress the multicast of the heartbeat packets when there is no co-located device to receive them.

You may need to co-locate radios and do not wish them to try and synchronize to each other. For example, if the connection between LAN ports of the radios goes through bridges that insert variable delays on the Ethernet packets, the synchronization protocol may not work properly. In these cases you can turn off the radio participating in the synchronization protocol by setting the **tdd sync-mode** to **off**. This is also the appropriate setting if multiple co-located radios get synchronization over RF and therefore cannot accept a heartbeat over the Ethernet.. In these cases you need to avoid self-interference with the more traditional methods of increasing the separation between antennas, and/or reducing transmit power

2.1.10 Ethernet Bridging

The A53325 2.4 GHz Ethernet Spread Spectrum Radio uses self-learning and packet priority methods to direct messages over the network. The following further describes these methods.

2.1.11 Self-learning Bridging

The radio operates the Ethernet port in a self-learning bridge mode. It configures the port in promiscuous mode, i.e., it examines all the Ethernet packets that are flowing in the local LAN. Since these Ethernet packets contain a **source** and **destination** address, the radio quickly learns the addresses of all the **local** stations connected to the LAN (all the source addresses of packets flowing in the LAN are local).

As a radio receives packets over RF it also learns the addresses of stations that can be reached across that RF link. For a hub radio in a PmP topology, the radio keeps track of which addresses are associated with each remote.

With this information on hand, each radio examines the destination address of every Ethernet packet in the local LAN and makes one of the following decisions:

1. If the destination address is for a local station, discard the packet.
2. If the destination address is associated with a remote radio, queue that packet to be forwarded to that remote radio. Note that for a PmP topology, the hub radio keeps multiple output queues, one per remote radio.
3. If the station address is unknown or is a broadcast send the packet to all the remote radios.

Each device has capacity to store 500 entries in its Ethernet table. Entries are erased after a certain amount of time to allow for stations to be moved between LANs and not show up in two distinct LANs. You can control this time-out with the “ethernet” command. If the table ever gets full, entries that have been least used are erased to make room for new entries.

You can examine the table of ethernet addresses and their respective nodes with the command:

```
>show ethernet
```

2.1.12 Packet Priorities

As packets arrive into a radio from any port, the bridging algorithm determines if the packets need to be transmitted over RF. If so the radio queues the packets into one of several priority queues. Starting with the highest priority the packets are classified as follows:

- Vital packets: These are UDP packets with a specific destination UDP port number. This port number is part of the field programmable radio configuration (see command **>udp**).
- NetCrossing Gateways Serial packets: These are SNAP encapsulated packets containing synchronous serial data generated by the Afar NetCrossing Gateway devices.
- High-Priority: These includes network management packets for “ECON” command sessions, and also IP packets with a value in the “Type-Of-Service” indicating high priority. The radio interprets the IP TOS field per the IETF *differentiated services (DS)* definition as shown below:

| | | | | | | | |
|-----------|---|---|---|---|---|--------|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Codepoint | | | | | | Unused | |

When the codepoint field has the value **xxx000**, the three most significant bits are interpreted as **precedence** bits. The radio gives high priority to packets with a precedence field of 6 or 7. In hexadecimal notation this translates into TOS values of E0 and C0.

- Low-priority: All other packets

When the time to transmit over RF arrives, the software always takes packets from the higher priority queues first.

SECTION 3

ANTENNA INSTALLATION AND ALIGNMENT

3.0 ANTENNA INSTALLATION AND ALIGNMENT

3.1 Antenna Installation

NOTE

The antennas for the A53325 must be professionally installed on permanent structures for outdoor operations. The installer is responsible for ensuring that the limits imposed by the applicable regulatory agency (Federal Communications Commission, FCC, or CE) with regard to Maximum Effective Isotropic Radiated Power (EIRP) and Maximum Permissible Exposure (MPE) are not violated. These limits are described in the following sections.

The A53325 is typically attached to a pole (with the clamp provided) with the antenna connectors facing up. For optimum performance the radio must be mounted in close proximity to the antenna with a cable run typically under 7 feet (\approx 2 meters). For the A53325, three antenna types are available, as listed in Table 3-1.

Table 3-1 Antenna Types

| ANTENNA TYPE | GAIN | P/N |
|------------------|--------|-----------------|
| Omni directional | 12 dBi | Z913-00025-0000 |
| Omni Mount | | Z912-00070-0000 |
| Grid Parabolic | 17 dBi | Z913-00037-0000 |
| Grid Parabolic | 24 dBi | Z913-00023-0000 |
| Yagi | 15 dBi | Z913-00038-0000 |
| Yagi Mount | | Z912-00084-0000 |

For the linear network it is recommended the use of the 24 dBi gain antennas. Antennas at the end of each link must be mounted such that they have the same polarization, and directional antennas must be carefully oriented towards each other. The choice of polarization (horizontal vs. vertical) is, in many cases, arbitrary. However, many potentially interfering signals are polarized vertically and an excellent means of reducing their effect is to mount the system antennas for horizontal polarization.

Of those antennas listed above, the Parabolic and Yagi antennas can be mounted for horizontal or vertical polarization, while the Omni directional antenna can only be mounted for vertical polarization.

Proper grounding of the antenna is important for lightning protection as well as to prevent electrical noise interference from other sources. The antenna should be mounted to a mast or tower that is well grounded to Earth. Use threaded connectors to mate to the antenna lead connectors and check that all connectors are clean and tight. Use weatherproof connectors in all outdoor couplings. We recommend using Scotch® 2228 Rubber Mastic Tape from 3M (or equivalent) to further weatherproof outdoor connections.

In locations where it is warranted, install lightning protectors at the N type connectors leading to the antennas. You may also want to install a surge arrester/lightning protection on the Ethernet cable where it connects to the equipment rack. The lightning protectors should be properly grounded. Carefully follow the installation instructions provided by the manufacturer of the lightning protection device used.

3.2 Siemens Rail Automation Antenna Kits

Siemens Rail Automation offers a wide variety of antenna kits to fit your needs. Each kit contains all the hardware required to install the selected antenna type on a tilt-tower, wood pole, or in a bungalow. Contact Siemens Industry, Inc., Rail Automation Customer Service for details.

3.3 Antenna Alignment

When mounting the high gain antenna (24 dBi), the proper antenna alignment is extremely important since the beam-width of the antenna is very narrow. Once you perform a rough alignment and the link is in operation, you can use the “monitor-link” and “antenna-alignment-aid” commands. Type:

```
> monitor-link
```

in order to update, every half second, the link statistics including the RSSI level (this will be in association with two neighbors if in LNW mode). The antennas can then be aligned so that the respective RSSI is maximized. In the PmP topology, the hub antenna is typically an omni and does not need to be carefully aligned. But if you need to align a hub radio antenna for maximum signal from a particular remote, use the command:

```
> monitor-link node=N
```

where **N** identifies the remote per the table displayed with the **show** command.

NOTE

Since in many applications the antenna is on a tower where it is not practical to have a terminal nearby, the A53325 has an additional “antenna alignment aid” available on the outdoor unit. This feature uses the three pin “Auxiliary port” connector to output an audio signal with a pitch proportional to the receive signal strength. A special cable adapter is available that converts the three-pin connector into a standard female audio jack. This cable may be used to connect the three-pin connector to a pair of standard headphones while aligning the antenna. For more information on this cable and adapter contact Siemens Industry, Inc., Rail Automation and refer to part number Z706-00259-0000.

To enable the audible antenna alignment aid – at a terminal session issue the command:

```
> aaa audio or > aaa mode=a-antenna | b-antenna (for LNW mode)
```

(**aaa** is an abbreviation for “antenna-alignment-aid”)

then align the antenna until you hear the highest audio pitch. Once the antenna is aligned type the command:

```
> aaa off
```

to turn off the audio signal and revert the auxiliary port connector to console mode.

3.4 Spectrum Analysis and channel selection

Radio operation in unlicensed bands has the potential of suffering from interference from other equipment operating in the same band. The use of directive antennas greatly reduces the potential for interference. In addition, the A53325 includes several features, described below, to identify and overcome sources of interference.

The A53325 can be commanded to perform a spectrum analysis of the ISM band and report the results in either a graphical or tabular form. The command:

```
> spectrum-analysis input=a-antenna dwell=xx
```

instructs the radio to scan the entire band, dwelling on each channel for a programmable amount of time, and record the highest signal level in that channel. This feature can be used to perform a site survey and identify a selection of available “quiet” channels.

Note that even though the A53325 channels are spaced 2 MHz apart, the receiver RF bandwidth is approximately 5 MHz. Therefore the RSSI value reported for each channel represents the total energy in a 5 MHz band centered around that channel. For this reason, a narrow band transmitter will show up in the spectrum analysis report as a lobe with 5 MHz bandwidth. Conversely, you do not need to find a quiet 5 MHz wide region in the spectrum analysis report to select a quiet channel, i.e., any single channel sample that shows a low “noise” level, is a good candidate to select as an operating channel.

Once a potential operating channel has been identified using the spectrum analysis tool, a “timing analysis” may also be used to confirm that the selected channel is indeed clear. The command:

```
> time-analysis channel=xx input=a-antenna dwell=xx
```

Instructs the radio to dwell on the specified channel for the specified amount of time. After taking several samples the radio displays the signal level detected in that channel over time.

3.5 Output Power Limits (FCC)

The Federal Communications Commission (FCC) regulations limit the maximum Effective Isotropic Radiated Power (EIRP) for spread spectrum systems operating in the 2.4 GHz band. Close to the band edges, the output power must be limited to avoid spilling over into the FCC protected band from 2.4835 GHz to 2.500 GHz. Table 3-2 takes these considerations into account and shows the maximum allowed output power for the various antennas:

Table 3-2 Maximum Output Power (dBm)

| CHANNEL | FREQUENCY (MHz) | ANTENNA GAIN | | |
|----------|--------------------|--------------|--------|--------|
| | | 9 dBi | 18 dBi | 24 dBi |
| 3 to 19 | | 23 | 23 | 23 |
| 20 | 2440.0 | 21 | 23 | 21 |
| 21 to 33 | | 23 | 23 | 23 |
| 34 | 2468.0 | 23 | 23 | 22 |
| 35 | 2470.0 | 23 | 22 | 21 |
| 36 | 2472.0 | 23 | 21 | 20 |
| 37 | 2474.0 | 22 | 19 | 10 |

3.6 Output Power Limits (CE)

The European Telecommunications Standards Institute (ETSI) regulations impose a limit of 20 dBm as the maximum Effective Isotropic Radiated Power (EIRP) for direct sequence spread spectrum systems operating in the 2.4 GHz band. In addition, the maximum spectral power density is limited to 10 dBm per MHz maximum EIRP. Of these two limits the power density is the most restrictive for this radio. The installer must reduce the output power of the A53325 so that the EIRP of the radio does not exceed 10 dBm. The antenna gain, cable and connector losses must be taken into account when computing the maximum output power.

3.7 Maximum Permissible Exposure (MPE) Limitations

The installer must mount all transmit antennas so as to comply with the limits for human exposure to radio frequency (RF) fields per paragraph 1.1307 of the FCC Regulations. The FCC requirements incorporate limits for Maximum Permissible Exposure (MPE) in terms of electric field strength, magnetic field strength, and power density.

Antenna installations must be engineered so that MPE is limited to 1 mW/cm^2 , the more stringent limit for "uncontrolled environments". Table 3-3 specifies the minimum distance that must be maintained between the antenna and any areas where persons may have access, including rooftop walkways, sidewalks, as well as through windows and other RF-transparent areas behind which persons may be located.

Table 3-3 Minimum Distance Calculation to Avoid Antenna Radiation Hazard (exposure of 1 mW/cm^2)

| | | |
|-----------------------------------|----------|-----------|
| Antenna Gain (dBi): | 5 | 15 |
| Max. Output Power | 27 dBm | 19 dBm |
| MPE safe distance (inches) | 7.9* | 7* |

*** NOTE**

For fixed location transmitters, the minimum safe separation distance is 7 feet ($\approx 2\text{m}$), even if calculations indicate a lower MPE distance.

SECTION 4

INSTALLATION AND SETUP

4.0 INSTALLATION AND SETUP

It is recommended that an initial check be performed on the bench before a field installation.

For this bench checkout you need two A53325 units. Radio 1 will be configured as the hub and radio 2 will be configured as a remote. The first approach described below uses the “Ethernet Console Program” to emulate the terminal across an Ethernet connection. The second approach uses two terminals connected to the auxiliary port of the radios.

4.1 Bench Checkout (using radio Ethernet connection)

In order to use the Ethernet connection you need the “Ethernet Console Program” (Econsole) provided on the CD. See Appendix D for installation instructions for Econsole. Once Econsole is installed, perform the following steps.

1. Connect the PC Ethernet port to the “To LAN” connector of the Power Inserter Unit of radio 2.
 2. Use an Ethernet crossover cable if connecting the PC directly to the Power Inserter Unit, or use a straight cable if connecting through a hub.
2. Connect each Power Inserter Unit to the respective A53325 using a CAT 5 cable as defined in Section 1.
3. Antenna A of radio 1 needs to have RF connectivity to Antenna A of radio 2. You may establish this connection using actual 2.4 GHz antennas. Alternatively you may connect the two antenna ports using coaxial cables **through an RF attenuator**.

CAUTION

YOU MUST ALWAYS USE AN RF ATTENUATOR OF 30 DB OR HIGHER WHEN CONNECTING TWO ANTENNA PORTS BY CABLE; OTHERWISE YOU MAY DAMAGE THE UNIT RF RECEIVER.

4. Connect the two Power Inserter Units to a power outlet of the appropriate voltage.

5. On the PC open a DOS window and invoke the Econsole program by typing:

> **econ**

If only one radio is connected to the LAN, ECON will establish a connection with that radio. If more than one radio is in the same LAN, ECON provides a list of all radios found (see Appendix D for more detailed instructions on the use of Econsole). Once a connection to the radio is established, the radio outputs a prompt with the following format:

rmt-nnnnn #>

where nnnnn are the last five digits of the radio serial number. The first three letters may read **hub** or **rmt**. If the radio had previously been configured the prompt will be the radio **name**.

6. Set radio 2 to its factory default configuration by typing the commands:

> **load factory**

> **save-configuration**

7. Move the Ethernet cable from the radio 2 power inserter to the power inserter connected to radio 1. At the DOS window invoke once again the Econsole program. Configure radio 1 by typing the commands:

> **load factory**

> **node type=hub**

> **save-configuration**

8. Once radio 1 is configured as the hub it will establish a RF communication with radio 2. To verify this connection type:

> **show**

Check that the radio status shows “MASTER IN SYNC”, and that the number of remotes is 1. You may also type **>show radios** to see various statistics of the link with radio 2.

9. Once the link is established, Econsole can be used to configure the local or the remote radio. In order to switch the Econsole connection, logout of the current connection and re-invoke Econsole:

> **logout**

> **econ**

Econsole will list the two radios and give a choice to connect to either. The Commands section describes the command language used to further modify the radio’s operating parameters.

4.2 Bench Checkout (using radio auxiliary ports)

1. Connect each A53325 Console Port to a terminal, or a PC running a terminal emulation program. Configure the terminal settings as follows:
 - Baud rate: 9600
 - Word length: 8 bits
 - Parity: none
 - Stop bits: 1
2. Connect each Power Inserter Unit to the respective A53325 using a CAT 5 cable as defined in section 1.
3. Connect each radio Antenna A port (N type connector) to an appropriate 2.4 GHz band antenna using an RF coaxial cable. You may establish this connection using actual 2.4 GHz antennas. Alternatively you may connect the two antenna ports using coaxial cables **through an RF attenuator.**

CAUTION

ALWAYS USE AN RF ATTENUATOR OF 30 DB OR HIGHER WHEN CONNECTING TWO ANTENNA PORTS BY CABLE; OTHERWISE YOU MAY DAMAGE THE UNIT RF RECEIVER.

4. Connect the two Power Inserter Units to a power outlet of the appropriate voltage.
5. The radios output a banner identifying the software and hardware versions and serial number, followed by the command prompt with the following format:

```
rmt-nnnnn #>
```

where nnnnn are the last five digits of the radio serial number. The first three letters may read **hub** or **rmt**. If the radio had previously been configured the prompt will be the radio **name**.

6. Set radio 2 to its factory default configuration by typing the command:

```
> load factory
> save-configuration
```

7. Configure radio 1 by typing the commands:

```
> load factory
> node type=hub
> save-configuration
```

8. Once radio 1 is configured as the hub it will establish a RF communication with radio 2. To verify this connection type:

> show

Check that the radio status shows “MASTER IN SYNC”, and that the number of remotes is 1. You may also type **>show radios** to see various statistics of the link with radio 2.

9. The terminal connected to each radio can be used to further modify the radio’s operating parameters. The *Commands* Section describes the command language used to perform those functions.

4.3 Field Installation

4.3.1 Configuration

The A53325 units are shipped pre-configured with a factory default configuration. If the unit configuration has been altered, you can always reload it with the command:

> load factory

In order to deploy an RF network between two or more radios you need choose one radio to be the “hub” and configure it with the command:

> node type=hub

All other radios may be left configured with the factory configuration. As you turn them on with antennas pointing at the hub they will automatically join the network. Use the **>show** command to see the status of the radio, or the **>show radios** command at the hub for a complete list of all the radios in the network.

In most installations you may want to change several other parameters. The table below shows the most common ones and the associated commands to change them. Refer to the Commands section for a complete description of each command.

Table 4-1. Common Configuration Parameters

| Parameter | Description | Command |
|-------------------|---|---------------------------|
| RF channel | You may need to change the RF channels if there is interference on the default channel (20). You can configure the RF transmit channel independently from the RF receive channel. Refer to section 4.3.2 for the procedure for choosing new channels. | rf-receive rf-transmit |
| RF transmit power | The factory default is 18 dBm. You can configure this parameter in 1 dB increments from 0 to 23 dBm. Take care not to exceed the maximum power limits as described in sections 4.3.3 or 4.3.4. | rf-transmit |
| Network ID | The default value is 0. Change this value in all radios to a unique number to avoid unauthorized radios from joining the network | node |

4.3.2 Spectrum Analysis and channel selection

Radio operation in unlicensed bands has the potential of suffering from interference from other equipment operating in the same band. The use of directive antennas greatly reduces the potential for interference. In addition, the A53325 includes several features, described below, to identify and overcome sources of interference.

The A53325 can be commanded to perform a spectrum analysis of the ISM band and report the results in either a graphical or tabular form. The command:

>spectrum-analysis input=a-antenna dwell=xx

instructs the radio to scan the entire band, dwelling on each channel for a programmable amount of time, and record the highest signal level in that channel. This feature can be used to perform a site survey and identify the best receive channel.

Note that even though the A53325 channels are spaced 2 MHz apart, the receiver RF bandwidth is approximately 5 MHz. Therefore the RSSI value reported for each channel represents the total energy in a 5 MHz band centered around that channel. For this reason, a narrow band transmitter will show up in the spectrum analysis report as a lobe with 5 MHz bandwidth. Conversely, you do not need to find a quiet 5 MHz wide region in the spectrum analysis report to select a quiet channel, i.e., any single channel sample that shows a low “noise” level, is a good candidate to select as a receive channel.

Once a potential receive channel has been identified using the spectrum analysis tool, a “timing analysis” may also be used to confirm that the selected channel is indeed clear. The command:

>time-analysis channel=xx input=a-antenna dwell=xx

instructs the radio to dwell on the specified channel for the specified amount of time. After taking several samples the radio displays the signal level detected in that channel over time.

4.3.3 Output Power Limits (FCC)

The Federal Communications Commission (FCC) regulations limit the maximum Effective Isotropic Radiated Power (EIRP) for spread spectrum systems operating in the 2.4 GHz band. The table below takes these considerations into account and shows the maximum allowed output power for the various antennas

Table 4-2. Maximum Output Power (dBm)

| Frequency (MHz) | Antenna Gain | |
|--------------------|--------------|--------|
| | 5 dBi | 15 dBi |
| 1200 - 1284 | 27 dBm | 19 dBm |

4.3.4 Maximum Permissible Exposure (MPE) Limitations

The installer must mount all transmit antennas so as to comply with the limits for human exposure to radio frequency (RF) fields per paragraph 1.1307 of the FCC Regulations . The FCC requirements incorporate limits for Maximum Permissible Exposure (MPE) in terms of electric field strength, magnetic field strength, and power density.

Antenna installations must be engineered so that MPE is limited to 1 mW/cm², the more stringent limit for "uncontrolled environments". The table below specifies the minimum distance that must be maintained between the antenna and any areas where persons may have access, including rooftop walkways, sidewalks, as well as through windows and other RF-transparent areas behind which persons may be located.

**Table 4-3. Minimum Distance Calculation to Avoid Antenna Radiation Hazard
(Exposure of 1 mW/cm²)**

| Antenna Gain (dBi): | 5 | 15 |
|----------------------------|--------|--------|
| Max. Output Power | 27 dBm | 19 dBm |
| MPE safe distance (inches) | 7.9* | 7.9* |

*** NOTE**

For fixed location transmitters, the minimum safe separation distance is 7 feet (≈2m), even if calculations indicate a lower MPE distance.

SECTION 5

UPGRADING FIRMWARE

5.0 UPGRADING FIRMWARE

5.1 Description

The operational firmware for the A53325 is stored in Flash PROM and can be easily updated. The Flash PROM can hold multiple versions and types of firmware simultaneously.

Table 5-1 lists some of the “File Utility” commands used to download and manage the various files stored in Flash PROM. A more detailed explanation for each command can be found in the *Commands* section.

Table 5-1. File Utility Command Summary

| COMMAND | DESCRIPTION |
|---|---|
| <code>directory</code> | Lists all files stored in Flash PROM. |
| <code>delete-file filename</code> | Deletes the specified file from the directory. |
| <code>download-file path\filename</code> | Downloads the specified file from the PC path\filename into the Flash PROM. |
| <code>set-default-program filename</code> | Sets the indicated filename as the default program to run after power up. |
| <code>run-file filename</code> | Loads the indicated program into RAM and executes it. |

The firmware files (**for point-to-multipoint**) are named:

`pmp0x_xx.bze` (binary zipped file for downloads through the Ethernet port)

`pmp0x_xx.dw` (ascii file for download through the serial port, or via Telnet)

The firmware files (**for linear network**) are named:

`lnw0x_xx.bze` (binary zipped file for downloads through the Ethernet port)

`lnw0x_xx.dw` (ascii file for download through the serial port, or via Telnet)

where 0x_xx is the firmware version number. Instructions are included for transferring the files to a PC.

A new file can be downloaded into the radios in one of three ways:

1. Using the Econsole program running on a PC connected to the same physical LAN as one of the radios. This is the fastest method and allows you to download to multiple radios from the same PC.
2. Using a Telnet session from anywhere on the Internet. This requires the radio to have been pre-configured with an IP address.
3. Using a terminal emulator program (e.g. HyperTerminal) running on a PC connected through the serial port to the radio's RS-232 auxiliary port. This method only allows you to download to that specific radio.

The next three sections explain in detail how to download a new file using each method.

5.2 Installing New Firmware Through The Ethernet Port

This procedure assumes that the new firmware needs to be installed in all radios of a working network. The upgrade is performed from a single PC connected via Ethernet to one of the radios (PtP/ PmP), or one of the nodes anywhere in the linear network (LNW). Note that new firmware does not need to be compatible with the firmware currently running on the radios. You can still download new (incompatible) firmware and restart the network from a single location. **After downloading new firmware into a radio, the radio will continue to run the old firmware from its RAM memory until the radio is rebooted to activate the new firmware.**

1. If you have not done so, install the utility program "Econ" on the PC. This utility program is distributed on a CD with the radio. Please refer to Appendix D for instructions on how to install this utility.
2. Ensure the file with the new firmware (file `pmp0x_xx.bze`) is available on the PC.
3. Start the Econsole utility by typing "econ" from a DOS window command line. Econ will send a "discovery" message and display all the radios that it can see. Verify that all radios in the network are listed. Then select one of the radios in the list that you wish to upgrade.
4. Issue the command:

```
> directory
```

to view a list of files stored in Flash PROM as well as the available free space. Verify that the free space in flash PROM is larger than the size of the `pmp0x_xx.bze` file on the PC. If there is not enough space in Flash PROM delete one of the program files to make up space (use the command `delete filename`).

- If the radio configuration has been password protected, you must first unlock the protection with the command:

```
> unlock enable-configuration=password
```

(When the configuration is unlocked, the radio prompt displays the characters “#>”. In locked mode the prompt does not include the “#” character).

- Issue the command:

```
> download path\pmp0x_xx.bze
```

where *path* is the directory on the PC where the **pmp0x_xx.bze** file is stored. The *path* extension is not required if the file is in the same directory as the Econ program. As the download proceeds Econ displays a line showing the current percentage complete.

- Once the download is complete, issue the command:

```
> set-default-program pmp0x_xx
```

in order to make the new file the default program to run after a reset.

- Issue the command:

```
> single-node-reboot-timeout=60
```

in order to speed up the network recovery after rebooting the hub radio in the step below (this step is not necessary if the new firmware is known to be compatible with the old firmware, but it does not hurt in either case).

- Press the “F4” key to log-off the session with the current radio. Econ displays the list of all radios from the initial discovery phase. Select another radio in the network and repeat steps 4 through 8 above for each of the radios in the list.

For configurations with NON-COMPATIBLE FIRMWARE skip to Step 14

- Once **all** radios in the network have been loaded with the new firmware, log onto the hub radio (using Econsole) and issue the command:

```
> reboot
```

to cause the hub/master radio to restart using the new firmware.

If the new firmware running on the hub radio is **not compatible** with the old version running on a remote radio, the links to the remote will not be reestablished. In this case, after 60 seconds, the remote radio will “time out”, reboot, load, and activate the new firmware. The remote will then reestablish the links with the updated hub radio.

If the new firmware on the hub radio is **compatible** with the old version running on a remote radio, the links to the remote will be reestablished in a short time (with the hub radio running the new version, and the remote radio continuing to run the old version from its RAM). In this case it will be necessary to selectively reboot each remote radio running the old (compatible) version, in order to activate the new version.

Proceed as follows.

11. Wait at least sixty seconds from the moment you entered the reboot command to the hub radio to allow any remote radios running incompatible firmware a chance to reboot and initialize the new version, then press <CR>. Econsole automatically attempts to reconnect to the same radio. Once a new session with the hub radio is reopened issue the command:

```
> version
```

and check that the radio is indeed executing the new version.

12. Press the “**F4**” key to log-off the session with the hub radio. “Econ” displays the list of all radios from the initial discovery phase. Select a different radio from the list and issue the command:

```
> version
```

and check if this radio is running the new or old firmware version. If the radio is running the new version log-off and repeat this step with the next radio. If the radio is not running the new firmware version, perform the next step.

13. If the radio is running the **old** firmware version issue the command:

```
> reboot
```

Wait at least ten seconds for the radio to perform its start up code and re-establish the link. Then press <CR>. Econsole automatically attempts to reconnect to the same radio again. Once a new session with that radio is reopened issue the command:

```
> version
```

and check that this radio is now executing the new version. Repeat steps 12 and 13 until all radios are running the new firmware version.

This completes the process for radios with compatible firmware.

14. **For configurations with non-compatible firmware**, do **not** reboot the local radio first. If you do, you will lose all the links to the rest of the network radios. Log on to the radio furthest away from the local radio and issue the reboot command. Then log on to the next furthest radio and issue the reboot command. Continue with each radio working toward the local radio, but **DO NOT INCLUDE** the local radio. Skip the local radio and start the reboot process again with the furthest radio at the opposite end of the network. After all other radios have been rebooted, reboot the local radio. After the local radio reboots, the entire network should be reestablished. Select each radio in turn and issue the version command to verify the correct software is running on each radio.

5.3 Installing New Firmware Using Telnet

Telnet is a protocol that allows you to conduct a remote radio command session from a local host. The radio must have been pre-configured with an IP address and be reachable, over the network, from the local host. Refer to the *Network Management* section for details on how to configure a radio IP address and initiate a Telnet session. The Telnet terminal emulation must have the capability of sending an ASCII file to the remote machine. The following description assumes you are using HyperTerminal as the local Telnet terminal emulation.

1. Verify that the new software is available on the local machine. The download software for upgrade via Telnet must have a “.dwn” extension, e.g., `pmp03_2.dwn`.
2. Initiate a Telnet session with the radio as described in the *Network Management* section.
3. If the radio configuration has been password protected, you must first unlock the protection with the command:

```
> unlock enable-configuration=password
```

(When the configuration is unlocked, the radio prompt displays the characters “#>”. In locked mode the prompt does not include the “#” character).

4. Issue the command:

```
> directory
```

to view a list of files stored in Flash PROM as well as the available free space. Verify that there is enough free space in flash PROM for the new file. The space required will be the size of the `pmp0x_xx.dwn` file divided by 2.5. If there is not enough space in Flash PROM delete one of the program files to make up space (use the command `> delete filename`).

5. Start the download process by typing:

```
> download-file destination=pmp0x_xx method=inline
```

where 0x_xx file is new version of software being installed.

6. The radio will return with the following:

```
"Send the file ... if incomplete, end with a line with just a
period"
```

When you get this prompt, go to "Transfer-Send Text file..." in HyperTerminal and select the file to be installed. The file must have a ".dwn" extension.

7. After the file is successfully installed, issue the command:

```
> directory
```

to ensure that the file has been loaded into memory.

8. Issue the command:

```
> set-default-program pmp0x_xx
```

where 0x_xx file is new version of software being installed.

9. Issue the command:

```
> reboot
```

to restart the radio with the new software. Close the Telnet session, wait a few seconds and open a new session with the same radio.

10. Issue the command:

```
> version
```

to ensure the radio is running the latest version.

5.4 Installing New Firmware Using The RS-232 Serial Port

On occasion, it may be necessary to install new firmware using the RS-232 port. This is generally a less desirable method as the download time is much longer and you can only update the radio that is directly connected to the PC, i.e., remote updates are not possible.

The serial upgrade uses a PC with a terminal emulator. Any emulator can be used however it must have the facility to download a text file on demand. In the example below, the emulator used is Windows HyperTerminal.

1. Connect the A53325 Auxiliary Port (3-pin circular connector) to a terminal, or a PC running a terminal emulation program using the special adapter cable (Siemens Rail Automation P/N: Z706-00235-0000) supplied with the radio. Configure the terminal settings as follows:

Baud rate: 9600
 Word length: 8 bits
 Parity: none
 Stop bits: 1

2. Verify that the new software is available on the PC. The download software for the serial upgrade must have a “.dwn” extension, e.g., `pmp03_25.dwn`.
3. To have the shortest download time possible, set the radio to use the highest RS-232 speed allowable on the PC. In this example, a download speed of 57600 baud will be used. Set the console speed of the radio to 57600 baud by issuing the command:

```
> console-speed-bps 57600
```

4. Change the baud rate of the PC to match the radio. Remember that with HyperTerminal, you must disconnect the session and re-connect before the changes will take effect. Verify the PC communicates with the radio again.
5. If the radio configuration has been password protected, you must first unlock the protection with the command:

```
> unlock enable-configuration=password
```

(when the configuration is unlocked, the radio prompt ends with the characters “#>”. In locked mode the prompt does not include the “#” character).

6. Issue the command:

```
> directory
```

to view a list of files stored in Flash PROM as well as the available free space. Verify that there is enough free space in flash PROM for the new file. The space required will be the size of the `pmp0x_xx.dwn` file divided by 2.5. If there is not enough space in Flash PROM, delete one of the program files to make up space (use the command `> delete filename`).

7. Start the download process by typing:

```
> download-file destination= pmp0x_xx method=inline
```

where `0x_xx` file is new version of software being installed.

8. The radio will return with the following:

```
"Send the file ... if incomplete, end with a line with just a period"
```

When you get this prompt, go to "Transfer-Send Text file..." in HyperTerminal and select the file to be installed. The file must have a ".dwn" extension.

9. After the file is successfully installed issue the command:

```
> directory
```

to ensure that the file has been loaded into memory.

10. Issue the command:

```
> set-default-program pmp0x_xx
```

where 0x_xx file is new version of software being installed.

11. Issue the command:

```
> reboot
```

to restart the radio with the new software. Remember to change the PC HyperTerminal settings back to 9600 baud and disconnect/re-connect the session.

12. Issue the command:

```
> version
```

to ensure the radio is running the latest version.

5.5 Feature upgrades

The A53325 has the ability to turn ON or OFF optional features and capabilities. This is done via the use of the "license" command. This command requires a "key" that is specific to a particular radio serial number and capability. To obtain a feature key, you must supply the specific model number, the serial number, and the feature desired. Please contact Siemens Industry, Inc., Rail Automation for a list of optional features available for your radio.

SECTION 6

COMMANDS

6.0 COMMANDS

6.1 Configuration Techniques

There are four ways to configure the radio:

Serial Console: One configuration uses the auxiliary port at the bottom of the unit and consists of an asynchronous RS-232 link used for issuing configuration commands and monitoring the local radio status and performance (a DB-9 adapter cable is available from Siemens Rail Automation - P/N: Z706-00235-0000). This port defaults to operate with the following parameters at power up:

Baud rate: 9600
Word length: 8 bits
Parity: none
Stop bits: 1

This console port allows configuring and monitoring only the local radio, i.e. you cannot monitor and configure any of the remote radios reachable through RF.

Econsole/Ethernet: A second configuration method uses the Ethernet connection to the radio to perform the configuration. This approach has the advantage that any radio reachable across the Ethernet, or the RF link, can be configured from a single PC. Additionally the Ethernet connection is more readily available indoors than the console port.

In order to use the Ethernet connection to configure the radios the “Ethernet Console Program” (Econsole) needs to be installed on a PC. This PC must be connected to the LAN where one or more A53350 radios are connected. From this PC it is then possible to configure not only the radios directly connected to the LAN, but also any other radios reachable through one or more RF hops. Refer to Appendix D for instructions on the installation of Econsole.

Telnet: The third configuration method is using Telnet from a remote location. Telnet is explained in more detail in the *Network Management* section.

UDP/IP Interface: This is intended to allow a host computer to issue all the same text commands available through the other interfaces. Refer to the **udp-configuration** command (paragraph 6.5.4) for details.

After power-up the radio performs several diagnostic and calibration tests. At the end of these tests it outputs a command prompt. The default command prompts are:

```
rmt-nnnnn #>
```

where *nnnnn* is the last five digits of the radio serial number. If a node “name” has been assigned to the node, the prompt may be the node name.

The “**help**” command provides a list of all the commands available. For more detailed help on a specific command, type “**help** *command-name*”.

The radio keeps a history of several of the previously issued commands. Those commands can be viewed by pressing the up-arrow and down-arrow keys on the keyboard. Any of those previously issued commands can then be edited and reentered by pressing the <Enter> key.

6.2 Command Syntax

The command interpreter in the A53325 is designed to accommodate both a novice as well as an expert operator. All commands and parameters have descriptive names so that they are easily remembered and their meaning is clear. In order to be descriptive however, those commands are sometimes long. As the operator becomes familiar with the command language, typing the complete words could become cumbersome. The A53325 command interpreter recognizes any abbreviations to commands and parameter names, as long as they are unambiguous. If an ambiguous command is entered, the radio will output all possible choices.

Commands have the following generic form:

```
command parameter=value parameter=value
```

Following is a brief list of syntax rules:

- Words (for commands, parameters, or values) can be abbreviated to a point where they are unambiguous.
- Some commands or parameters consist of compound words separated by a hyphen. With compound words, the hyphen is optional. Additionally each word in a compound word can be abbreviated separately. For example, the following are all valid abbreviations for the command “save-configuration”: “save”, “savec”, “s-c”, “sc”.
- The parameter and value lists are context sensitive, i.e., in order to solve ambiguities the command interpreter only considers parameters valid for current command, or values valid for the current parameter.
- The arguments “parameter=value” must be entered with no blank spaces on either side of the ‘=’ sign. Those arguments (parameter/value pairs) can be listed in any order.

- Even though parameters can be listed in any order, there is a “natural” order known by the command interpreter. This allows the user to specify parameter values without having to type the parameter names. For example the command:

```
> spectrum-analysis input=a-antenna display=table
```

can be entered as (using abbreviation rules as well): `> spa a t`

- Using the preceding rule, for commands that have a single argument, the “parameter name” part of the argument is always optional, i.e., you can enter:

```
> command value
```

For example the command:

```
> save-configuration destination=main
```

can be shortened to any of the following:

```
> save-configuration main
```

```
> save main
```

```
> save
```

- Not all parameters associated with a command need to be specified. Depending on the command, when a parameter is omitted it either assumes a default value or keeps the last value assigned to that parameter.
- For all parameters that accept a numeric value the number can be entered in decimal, hexadecimal, or octal notation. To enter a number in hexadecimal precede it with a 0x or 0X. To enter a number in octal notation precede it with a 0 (zero). All other numeric values are interpreted as decimal. Example:

```
> rf-receive ch=0x1a      (hexadecimal)
```

```
> rf-receive ch=014      (octal)
```

The following sections describe the various commands grouped according to their functionality. A summary list of all commands is contained in Appendix A.

6.3 Configuration Management Commands

A **radio configuration** consists of a set of programmable parameters that define the radio operation with regard to a variety of operating modes. There are five different configurations identified as **current**, **main**, **alternate**, **factory** and **basic**.

The **main** and **alternate** configurations are both stored in non-volatile memory. They can be loaded into the **current** configuration with the **load** command. On power up the radio loads the **main** configuration from non-volatile memory into the current configuration.

The **current** configuration is the set of parameters currently being used and can be modified by the operator through several commands. This configuration is volatile. If the current configuration has been modified it should be saved using the **save** command. Otherwise the modifications will be lost if power is removed.

The **factory** configuration cannot be modified by the operator and is used to return the radio to the factory default condition. It is useful as a starting point to create a customized configuration.

The **basic** configuration is similar to the factory configuration with the exception that a few parameters are left unchanged when you issue the **load basic** command. The parameters left unchanged are the RF and the IP configuration. This is useful when you are logged on to a remote unit and need to start from a known configuration. If you were to issue the **load factory** command you might lose contact with the remote unit if, for example, it changes the antenna of the remote radio.

The access to change the radio configuration can be password protected. This password is set by the user with the **change-password** command. Once a password is set, issue the **lock** command to prevent any unauthorized changes to the configuration. Once locked, the configuration can only be modified by issuing the **unlock** command with the correct password.

When the configuration is unlocked, the radio prompt ends with the characters “#>” to remind the user that the configuration is unlocked. In locked mode the prompt does not include the “#” character. Once a password is set, the radio will automatically lock the configuration after 10 minutes without any commands being issued.

The configuration management commands are listed in the following paragraphs:

6.3.1 Change-Password

`enable-configuration="ASCII string"`

This command allows the user to set or change a password used to “lock” and “unlock” access to the commands that change the radio configuration. The A53325 is shipped with no password which allows access to all commands. Once a password is set and the configuration is locked, the password is needed to unlock the access to those commands. After changing the password you should also issue the “`save-configuration`” command to save the new password in non-volatile memory.

Example:

```
> change-password enable-configuration=bh7g8
```

NOTE

The A53325 is shipped without a password. If the “change-password” command is issued, be sure you do not forget the password. Once locked, without the password, the radio must be returned to the factory to be unlocked.

6.3.2 Display-Configuration

`source=current` or `main` or `alternate` or `basic` or `factory`

Displays all the parameter values for the specified configuration. If the source is not specified it defaults to “current”.

Examples:

```
> display-configuration factory
```

```
> discon
```

6.3.3 Load-Configuration

`source=main` or `alternate` or `basic` or `factory`

Loads the specified configuration into the current set of parameters controlling the radio operation. If no source is specified it defaults to the “main” configuration.

Examples:

```
> load-configuration source=factory
```

```
> load
```

6.3.4 Lock

This command locks the access to all the commands that can alter the radio configuration. Once locked you must use the “unlock” command to regain access to those commands. Note that a password must be set prior to the “lock” command being issued (the radios are shipped with no password), otherwise the lock command has no effect. If a password is set, the radio automatically “locks” the configuration at the end of 10 minutes with no command activity.

6.3.5 Save-Configuration

destination=main or **alternate**

Saves the current set of radio operating parameters into one of the two non-volatile configurations. If the destination is not specified it defaults to “main”.

Examples:

```
> save-configuration destination=alternate
> save
```

6.3.6 Unlock

debug-mode="ASCII string"

enable-configuration="ASCII string"

This command unlocks the access to various commands. The **enable-configuration** password (set with the change-password command) unlocks the various commands listed in this manual that alter the radio configuration. The **debug-mode** is a factory mode used for troubleshooting by customer support.

Example:

```
> unlock enable-configuration=bh7g8
```

6.4 Major Configuration Parameters

These commands change several operating parameters of the radio that are part of the radio configuration. When entering commands with multiple parameters, if a parameter is not included, that parameter keeps its current value.

6.4.1 Distance-Max

`maximum=10..255 (km), 10..158 (miles)`

`units=km or miles`

Sets the limit for the maximum distance of any RF link in this network. You only need to set this maximum distance at the hub node. All other nodes will automatically configure the maximum distance to that of the parent node.

In general you should leave the maximum distance set to the default value of 50 km (30 miles). But if you are deploying a network where one or more links exceed this distance you must change this parameter to a value that is equal to or greater than the maximum link distance.

Increasing the maximum distance results in a slight decrease of the network capacity.

Examples:

```
> distance 100 km
> distance units=miles
```

6.4.2 Ethernet

`speed=auto-10 or 10hdx or 10fdx or 100hdx or 100fdx or auto`

Sets the Ethernet port speed to a combination of 10 or 100 Mbps, half or full duplex, or auto negotiate.

In installations requiring a very long outdoor CAT5 cable, operation at 100 Mbps may become unreliable. For this reason the **auto-10** setting forces the speed to 10 Mbps but negotiates the half or full duplex. The **auto** setting negotiates both the speed and duplex to the fastest configuration supported by the other devices on the Ethernet.

`timeout-sec=5..10000`

Sets the time the radio will retain, in its internal table, Ethernet addresses obtained from the network.

`multi-cast-timeout-sec=5..10000`

Sets the time the radio will retain, in its internal table, Ethernet multi-cast addresses obtained from the network. This can not be set to a value below the station-timeout.

Example:

```
> ethernet speed=10fdx timeout=100
```

6.4.3 Node

`type=hub or remote or root-1 or root-2 or branch or leaf`

For point-to-point network configure one of the two radios as **hub** and the other as the **remote**. At the hub also set the **max-children** parameter to 1, which optimizes the network for point-to-point.

For a point-to-multipoint network configure the central radio as the **hub** and all other radios as **remote**. In a fixed installation you would typically deploy the remote radios with directional antennas pointing at the hub radio.

In a tree network configure the central radio as the **root**. Use **root-1** if a single antenna is used at the root. Use **root-2** for a root with two antennas on ports A and B.

In a tree network all other nodes must be configured as either **branch** or **leaf**. A branch node will attempt to connect to a parent (which can be the root or another branch) using the rf-1 configuration. It will also be acting as a parent and serve as an access point using rf-2 configuration.

A **leaf** node will attach to the parent (root or branch) using the rf-1 configuration.

Configuring a node to be a branch or a root the radio may indicate that it is not authorized to operate in that mode. Contact Siemens Rail Automation Customer Service for help.

`max-children=1..32`

In the cluster-hub network, configure all hubs with node type set to **hub** and all other radios set to **remote**. When you have multiple hub radios the cluster will automatically select one as the master-hub. Use the `>show radios` command at any of the hubs to find which one is the current master (index zero in the cluster hub table).

`max-remotes=1..29`

At the hub, root or branch nodes this value specifies the maximum number of children that will be allowed to join the network through this access point. Once the radio has the maximum children specified it stops allocating a slot for new nodes to join the network. This improves the inbound throughput slightly, especially if the number of children is small. It also prevents an unauthorized radio to join the network. In a point-to-point link make sure this parameter is set to 1.

`name="ASCII string"`

Gives the node a meaningful name for further reference. This name will be used as the command prompt. It is also used to identify the node in a variety of commands and displays. The name field can be up to 23 characters with no spaces. If spaces are desired, you may include the whole name in quotation marks.

network-id=0..65,535

For a link to get established, the network-id value of the radios involved must match. Setting unique network ids on each network prevents a radio from connecting to the wrong hub or peer if it happens to be within RF range, and on the same channel.

The value of the network-id is only displayed if the configuration is unlocked.

location="ASCII string"

Optional parameter to define the location of the node. This field is displayed in the "Display-configuration" output and also reported through SNMP. This field is used for information only. The location string can be up to 25 characters with no spaces. If spaces are desired, you may include the whole string in quotation marks.

contact="ASCII string"

Optional parameter to define the contact for maintenance purposes. This field is displayed in the "Display-configuration" output and also reported through SNMP. This field is used for information only. The contact string can be up to 25 characters with no spaces. If spaces are desired, you may include the whole string in quotation marks.

Example:

```
> node name=bank location="wall street" contact=964-5848
```

6.4.4 RF-1 RF-2 Setup

```
antenna=a, b
receive-channel=nn,nn,nn.....
transmit-channel=nn
power-dbm=nn
speed-mbps=nn
```

There are two RF configurations, 1 and 2, which take the same parameters. All node types use RF configuration 1. Node types root-2 or branch also use the RF configuration 2 for links with their children. The table below shows how the radios use the two RF configurations depending on the node type. Once the node type is set issue the ">display-configuration" command to display this information.

Table 6-1 RF Configurations

| Topology | Node type | rf-1 | rf-2 |
|---------------------|------------------|--------------------|--------------------|
| Point-to-Multipoint | hub | Link with children | Not used |
| | remote | Link with parent | Not used |
| Tree | root-1 | Link with children | Not used |
| | root-2 | Link with children | Link with children |
| | branch | Link with parent | Link with children |
| | leaf | Link with parent | Not used |

Antenna: In most topologies use antenna A for the RF configuration 1, and antenna B for the RF configuration 2. This is not mandatory, there are situations when you may want to override this default.

Receive-channel: For the link with the parent this value must match the transmit channel of the desired parent. If you have the roaming option enabled you can specify up to six receive channels for the rf-1 configuration (separate values with commas but no spaces). These channels should match the transmit channels of separate access points in the area (hub, root or branch). The radio will then attach to the parent with the strongest signal and change parent automatically when the signal becomes too weak.

Transmit-channel: This is only applicable at the parent nodes for the links with their children. At the child nodes, the transmit channel is configured automatically when the node attaches to the parent (it will be set to match the receive channel of the parent).

Power-dbm: This is the transmit power fed into the antenna. The default value is 18 dBm which is adequate in most situations. If you do not have enough link margin or there is interference in your channel you may want to increase the power up to the maximum value supported by your model. If your links are very short and you have plenty of signal you can reduce the transmit power in order to re-use the same channel in other links in the area.

Speed-mbps: This is only applicable at the parent nodes for the links with their children. At the child nodes the speed is set automatically to match that of the parent. The default value is always the highest speed supported by your specific model. The lower speeds may be appropriate for very long links where the receive signal strength is too weak and you need a little more link margin. We suggest that in those cases you first increase the transmit power and only then start reducing the speed.

Example:

```
> rf1 ant=a rec=15 tra=15 po=23 sp=0.5

> rf1 rec=6,13,18,24
```

6.4.5 Single-Node-Reboot

```
> timeout-sec=15..20000
```

After power up, radios attempts to get an RF link up with one or more radios. If a radio fails to get a link up (or drops all existing links), it will perform a complete reset after the timeout specified in this command.

This feature is useful if issuing a command to a distant radio (over an existing RF link) and the link drops as a consequence of the command. If that radio now has no other links up it waits for the "single-node-reboot" and then performs a reset. As a result, the radio reverts to the saved configuration, allowing it to reestablish the original link.

Example:

```
> snr 60
```

6.4.6 Time-Division-Duplex

```
> sync-mode=off or auto
```

This parameter selects whether this radio participates in the negotiation of the heartbeat synchronization to select a single source for the heartbeat. The default **auto** mode is recommended for most applications.

The **off** mode may be useful in situations where there is a variable and significant delay in the local Ethernet connecting the several co-located radios. In that case the radios may not be able to establish synchronization and you may get better results turning off the heartbeat protocol.

```
> cycle-period-ms= 20 or 40
```

A cycle period of 20 ms (default) results in lower latencies throughout the network. However there will be more transitions between transmit and receive resulting in somewhat lower throughput capacity for the network. A cycle period of 40 ms has the opposite effect.

For small networks a cycle period of 20 ms is usually preferred. If you have a network with many nodes that are simultaneously active the 40 ms cycle will give you better performance.

The cycle period only needs to be set at the hub radios. All the remotes will pick up the cycle period from the hubs.

```
> split-outbound-percent=auto or 10 or 20 or 30 or 40 or 50 or 60
    or 70 or 80 or 90
```

This parameter is relevant at the hub nodes only. It specifies the percentage of the total cycle period dedicated to RF transmissions. The remaining time is dedicated to receiving from the remotes. You do not need to specify this parameter at the remotes; as they join the network they will set their cycles to the complement of this value.

In **auto** mode the master hub radio dynamically assigns a split based on the current traffic load in each direction. This split may be different from cycle to cycle. This is the recommended setting.

Example:

```
> tdd sync=off cycle=40 split=70
```

6.5 Internet Protocol (IP) Management Commands

The IP Management commands configure the radio IP protocol parameters which allow the radio to be monitored and configured through Telnet and SNMP. Refer to the “*Network Management*” section for a more detailed explanation on those two applications.

6.5.1 IP-Configuration

```
address=<ip address>
netmask=<string>
gateway=<ip address>
dhcp-client=yes or no
```

This command configures the radio IP address, netmask and gateway. The IP configuration is optional and the radios are shipped with these parameters left blank. Once the IP configuration has been initialized, the radios will reply to “ping” packets. The IP configuration is also required in order to use the “ping”, “snmp” and “Telnet” features.

Alternatively you can enable the **dhcp-client** function. In that case the radio will attempt to configure its IP address parameters from a DHCP server in the network.

Since the two radios in a link are bridged together they are in the same “internet network”.

Example:

```
> ipconfig add=207.154.90.81 netmask=255.255.255.0 gateway=207.154.90.2
```

Note: To clear these values, enter all zeros.

6.5.2 Ping

destination=<string>

count=0..500

size-bytes=32..1400

This command causes the radio to “ping” the destination address and display the results. The “ping” packet consists of an ICMP packet with a length specified by the “size-bytes” parameter. The destination is any valid IP address. When the destination host receives the packet it generates a reply of the same size. Upon receiving the reply the radio displays the round trip delay. This process is repeated until the number of replies reaches the value specified by the “count” parameter (default to 4). A count of zero leaves ping running indefinitely until stopped by the user.

Example:

```
> ping 207.154.90.81 count=10 size=100
```

6.5.3 SNMP

The radio runs an SNMP agent which allows up to four IP addresses to be specified as valid SNMP managers. This command configures those IP addresses and the type of access allowed. You can issue the command up to four times to specify each separate IP address manager. The radios are shipped with all entries blank. While no entries are specified, the unit accepts SNMP “get” requests from any IP address within the “public” community. Once one or more entries are specified, the radio only responds to requests from the specific IP addresses listed. This list of authorized managers is also used for validating Telnet requests.

Refer to the “*Network Management*” section for an overview of Network Management using SNMP and Telnet.

manager=<ip address>

Specifies one valid IP address where the SNMP manager or Telnet session will run.

community=<string>

Any string of up to 9 characters. For SNMP requests the “community” field in the request packet from this IP address must match this parameter. For a Telnet session the username entered when initiating the session from this IP address must match this string. If this parameter is not specified it defaults to “public”. Note that you must always enter the “manager” IP address in the same command line that sets the “community” value.

`access=g` or `gs` or `gst` or `gt`

SNMP access type authorized for this IP manager. Specify as any combination of three letters: g (get), s (set) and t (trap). If this parameter is not specified it defaults to “get”. Note that you must always enter the “manager” IP address in the same command line that sets the “access” value.

`authentication-traps=0` or `1`

Specifies whether an “authentication trap” should be generated if a SNMP request is received that cannot be honored (due to invalid IP address, community or access fields). When enabled, all IP managers that have “trap” access will receive this trap.

`delete=1..4`

Allows deleting one entry in the SNMP table. The number 1..4 refers to the entry number as listed in the “display configuration” report.

Example:

```
> snmp manager=207.154.90.81 com=support access=gst
```

6.5.4 UDP-Configuration

`console=on` or `off`

`vital-port-1=1..0xFFFF`

`vital-port-2=1..0xFFFF`

`command-port=1..0xFFFF`

`max-response-bytes=500..1466`

`socket-mode=1` or `2`

`peer-address=<ip address>`

`peer-command-port=1..0xFFFF`

The **console** parameter turns **on** or **off** the radio UDP interface. The factory default is off. You may turn it on for either of the following purposes:

1. To send and receive “**vital packets**” which the radio classifies as the highest priority.
2. Send radio configuration text commands encapsulated in UDP/IP packets. This is useful when you want to configure the radio from a program running on an external computer

The **vital-port-1** and **vital-port-2** specify two different UDP port numbers. The radio examines the “source” and “destination” ports of any UDP encapsulated packets that the radio receives and queues for transmission over RF. If any of those two values match the vital-port-1 or vital-port-2, the packet is classified as “**vital priority**” and is transmitted ahead of all other packets.

All the remaining parameters are used for the purposes of issuing radio commands using UDP encapsulated packets. The formats of these UDP packets and radio replies are described in detail in section 7.3.2.

The **command-port** parameter is the UDP port number used by the radio to receive commands.

The **max-response-bytes** parameter allows extending the length of the UDP packets generated by the radio beyond the default 500.

The **socket-mode=1** (default) is intended for applications where the controlling program allocates a single socket for packets in both directions, while **socket-mode=2** is used when the program must create separate sockets for sending to the radio and receiving from the radio.

In both modes the radio listens for UDP packets addressed to the specified **command-port** number. In **socket-mode 1**, if you do not specify a **peer-address** and a **peer-command-port** the radio accepts packets from any IP address and port and sends the responses to the same IP address and port from which the command was received. If you specify a **peer-address** and/or a **peer-command-port** the incoming packets must match these parameters, otherwise the packets will be ignored.

In **socket-mode 2**, the radio sends the UDP command replies to the IP address specified by the **peer-address** parameter and sets the destination UDP port to the value specified by the **peer-command-port** parameter. Additionally the IP address on incoming packets must match the **peer-address** parameter.

6.6 Internet Protocol (IP) Management Commands

These commands are useful as installation aids and also for monitoring link statistics after the link is established.

6.6.1 Antenna-Alignment-Aid

mode=off or **a-antenna** or **b-antenna**

With the mode other than **off**, the radio outputs, through the auxiliary port, an audio signal with a pitch proportional to the Receive Signal Strength (RSS) level of packets received on the specified antenna. A special cable adapter is provided (Siemens Rail Automation P/N: Z706-00254-0000) that converts the three-pin auxiliary port connector into a standard female audio jack. Use this cable to connect the auxiliary port to a pair of standard headphones while aligning the antenna.

While the antenna alignment is **on**, the RS-232 console output is not available. When the antenna alignment output is set to **off** the auxiliary port output reverts to RS-232 console.

The antenna alignment output setting can also be saved as part of the radio configuration. This is useful to take a pre-configured radio to an installation site with no need to turn the antenna alignment ON (through a terminal) after power up.

Examples:

```
> aaa a-antenna
> aaa off
```

6.6.2 Monitor-Flow

At the master-hub this command shows the current data flow to and from each remote and updates this information once per second. At a remote unit this command shows the data flow statistics to the hub. Press the [space bar] to terminate the command.

6.6.3 Monitor-Link

```
node=1, 4..N
clear=0 or 1
```

This command continuously displays link statistics including the RSSI at both ends of the link, link distance, percent of packets lost, and the elapsed time since this link has been up. You must specify a valid **node** number from the list displayed by the **show links** command (if this radio is involved in only one link you do not need to enter the node number). Press the [space bar] to terminate the command.

The “clear=1” parameter clears the percent of dropped packets statistic. You can also clear that statistic by pressing the “zero” key while the command is running.

Example:

```
> monitor-link node=4 clear=1
```

6.6.4 Monitor-Roaming

If a radio is configured to roam between multiple hubs, this command shows which hubs are currently within range, and the Receive Signal Strength (RSSI) from each hub. The report also identifies the current hub that this radio is attached to. This information is refreshed once per second. Press the [space bar] to terminate the command.

6.6.5 Show-Table

```
table=status or radios or ethernet or econsole or ip-stack
format=counts or times
```

This command displays various tables in different formats as described below:

6.6.6 Status Table

This contains miscellaneous information including system start and run times, unit temperature, input DC voltage, and RF link status. The “format” parameter is not applicable for this table.

6.6.7 Ethernet-Stations Table

This table can be displayed in two formats, “counts” (default) and “times”.

```
> show ethernet (counts)
```

| # | MAC address | IP address | Radio | --Discard-- | | --Forward-- | |
|----|-------------------|----------------|-------|-------------|----|-------------|--------|
| | | | | from | to | from | to |
| 0 | ff-ff-ff-ff-ff-ff | | Local | 0 | 0 | 0 | 919 |
| 1 | 00-0d-94-00-3a-9d | | me | 0 | 0 | 388 | 361 |
| 2- | 01-0d-94-00-00-01 | | me | 0 | 0 | 0 | 0 |
| 3 | 00-a0-cc-66-70-8e | 207.154.90.161 | 4 | 0 | 0 | 197246 | 99568 |
| 4 | 00-a0-cc-d7-06-76 | 207.154.90.173 | Hub | 0 | 0 | 99578 | 197133 |
| 5 | 00-a0-cc-d6-fd-50 | | 6 | 0 | 0 | 122 | 148 |
| 6 | 00-a0-cc-d7-0b-0d | 207.154.90.204 | 5 | 0 | 0 | 180 | 0 |
| 7 | 00-a0-cc-d7-0b-14 | | Hub | 0 | 0 | 118 | 0 |
| 8 | 00-0d-94-00-42-69 | | 4 | 0 | 0 | 1 | 0 |

```
> show ethernet times
```

| # | MAC address | IP address | Radio | MC | Time added | Idle | VLAN |
|----|-------------------|----------------|-------|----|-----------------|---------|------|
| 0 | ff-ff-ff-ff-ff-ff | | Local | | 11-Jan 22:57:57 | | N/A |
| 1 | 00-0d-94-00-3a-9d | | me | X | 11-Jan 22:57:57 | | N/A |
| 2- | 01-0d-94-00-00-01 | | me | | 11-Jan 22:57:57 | 5490.86 | N/A |
| 3 | 00-a0-cc-66-70-8e | 207.154.90.161 | 4 | | 11-Jan 23:30:48 | | N/A |
| 4 | 00-a0-cc-d7-06-76 | 207.154.90.173 | Hub | | 11-Jan 23:32:32 | | N/A |
| 5 | 00-a0-cc-d6-fd-50 | | 6 | | 12-Jan 00:28:22 | | N/A |
| 6 | 00-a0-cc-d7-0b-0d | 207.154.90.204 | 5 | | 11-Jan 23:30:56 | 20.23 | N/A |
| 7 | 00-a0-cc-d7-0b-14 | | Hub | | 11-Jan 23:31:14 | 14.96 | N/A |
| 8 | 00-0d-94-00-42-69 | | 4 | | 12-Jan 00:29:06 | 21.64 | N/A |

Both formats list all the Ethernet stations attached to either this radio or other radios that have a direct link to this one. The tables list the MAC (Ethernet) address of the station, and, if known, the IP address.

The first row in the table tracks broadcast traffic while the second entry is always the address of the radio itself. The Radio column shows the radio where that station is physically attached. It may have a number 3 through N which identify one of the children radios as shown in the **show links** table. Or it may say: **“Local”** to indicate stations connected to the local Ethernet, **“me”** to identify this radio, **“Hub”** for the parent radio, and **“Bcast”** for addresses that are in an unknown segment (this radio broadcasts packets to these addresses through all ports).

The “counts” format shows the cumulative number of Ethernet packets that have been seen with that MAC addresses in the source (“from”) or the destination (“to”) fields. The radios operate the Ethernet port in promiscuous mode and therefore look at all the packets in the Local Area Network. The radios discard the packets that are known to be local, but forward all other packets to remote radios. These are accounted separately in the report.

The “times” format indicates whether that entry is for a “multicast” (MC) address, shows the time when the station was added to the table, and how long since that address has been seen. When the “idle” time exceeds the time specified by the “ethernet” command, that entry is deleted from the table.

6.6.8 Links Table

This table displays various statistics for all the RF links with adjacent radios. For a leaf or remote radio there is only one entry which is the link to the parent. For a parent radio there may be multiple entries. The entry with an ID of 1 is always the link to the parent. The table shows the link distance in either miles or km. You can use the “distance” command to change the units.

If this radio is enabled for roaming and is set to receive in more than one channel, then this report also includes the “Roaming Table”. This table includes a line for each receive channel, the Hub Serial Number of a hub transmitting in that channel, the RSSI and the time elapsed (in seconds) since that RSSI was measured.

```

ROAMING TABLE:
      Rx      Hub      Time
      chan    Ser.N    RSSI    elapsed
      ----    -
          12    16322    -73     1.0
          25    16300    -65     0.4
current chan -> 32    15005    -53     0.0
                  37

DIRECT LINKS:
# Ant  Name      Ser.N  Rmt  Rmt  My  % Dropped
-----  -----  -----  ---  ---  ---  ---
 1 A bra-15005 15005  -61   0   18  -53    0  0.0  000:58:40
  
```

6.6.9 Tree Table

In response to this command the radio broadcasts a discovery packet to obtain information from all the radios in the network including radios that may be several hops away. It then displays

various statistics for all the links. The first column indicates in an indented fashion the “level” of each radio in the tree, which corresponds to the number of hops away from the root (or hub). For each radio that is a parent the report displays the entries of all its children before moving to another node at the same level. You can find the parent of any node by going up the table to the first entry with one level lower.

COMPLETE TREE NETWORK:

| Level | Type | # | Name | IP address | /----- Parent | Link -----\ |
|-------|------|---|-----------|----------------|---------------|-------------|
| | | | | | km RSSI % | Uptime |
| 0 | RT1 | 0 | rt1-16322 | 207.154.90.108 | | |
| 1 | bra | 4 | bra-16300 | 207.154.90.161 | 0 -71 0 | 000:56:33 |
| 2 | lf | 4 | rmt-16323 | | 0 -71 0 | 001:05:25 |
| * 1 | bra | 6 | bra-15005 | 207.154.90.163 | 0 -76 0 | 000:58:20 |
| 2 | lf | 4 | lf-17001 | | 0 -53 0 | 000:56:33 |

6.6.10 Radios Table

This command displays both the **links table** and the **tree table** described above.

6.6.11 Econsole Table

The unit broadcasts an e-console discovery packet on both its ports: Ethernet and RF, and then reports all the replies. These include both gateways and radios that can be reached on either port.

6.6.12 Spectrum-Analysis

```
input=a-antenna or b-antenna
display=graph or table
dwell-time-ms=1..1000
```

This command switches the receiver to the specified antenna (defaults to A) and then performs a scan of **all** the channels from 2.400 to 2.500 MHz, dwelling on each channel for the specified amount of time (defaults to 20 milliseconds). While on each channel it measures the RSSI for that channel and stores its peak value. It then displays the data collected in a graphical or table formats (defaults to “graph”).

Note that even though the A53325 channels are spaced 2 MHz apart, the receiver RF bandwidth is approximately 5 MHz. Therefore the RSSI value reported for each channel represents the total energy in a 5 MHz band centered around that channel. For this reason, a narrow band transmitter will show up in the spectrum analysis report as a lobe with 5 MHz bandwidth. Conversely, you do not need to find a quiet 5 MHz wide region in the spectrum analysis report to select a quiet channel, i.e., any single channel sample that shows a low “noise” level, is a good candidate to select as a receive channel.

Examples:

```
> spectrum-analysis input=b-antenna
> spa dwell=500
```

6.6.13 Time-Analysis

```
channel=0..50
input=a-antenna or b-antenna
display=graph or table
dwell-time-ms=1, 2, 5, 10, 20, 50, 100, 200, 500
```

This command switches the receiver to the specified antenna (defaults to A) and then measures the RSSI for a **single** channel over a period of time. Each “sample” consists of the maximum RSSI measured during the dwell time specified (defaults to 20 milliseconds). After collecting 60 samples the RSSI values are displayed graphically or numerically (defaults to “graph”).

Examples:

```
> time-analysis input=b-antenna
> tia in=a dis=t dwell=500
```

6.7 File Utilities

The A53350 maintains a file system that allows multiple programs to be stored in either non-volatile flash PROM or volatile RAM. New programs can be downloaded into the A53350 memory through the auxiliary port, through the Ethernet port, or to a remote radio across the RF link.

One of the programs in flash PROM is designated as the default program to run after reboot. On power up that program is copied from PROM into RAM and the code runs out of RAM.

Both sections of memory (non-volatile flash PROM and volatile RAM) are segregated into two “directories”. The non-volatile flash PROM is called “flash” signifying the flash PROM and the volatile RAM is called “tmp” signifying the temporary status of the program. Use the “directory” command to view the programs loaded and whether they are in non-volatile or volatile memory.

Any program can be invoked with the command “run” without making it the default file. This is useful when upgrading the software over an RF link as a way to ensure that the new code is working correctly before making it the default.

6.7.1 Console-Speed-Bps

```
baud-rate-bps=9600 or 19200 or 38400 or 57600 or 115200
```

Sets the Auxiliary port of the radio to the specified baud rate. This setting is not saved in the radio configuration, the auxiliary port always reverts to 9600 baud on power up.

This command is useful to speed up the download process over the auxiliary port. Before issuing the download command, use this command to change the radio console speed to the highest baud rate supported by the PC. Then change the terminal settings to match the radio speed. Issue the download command described below and initiate the transfer at the terminal.

Example:

```
> console-speed-bps baud-rate-bps=115200
```

6.7.2 Copy-File

```
source=filename
```

```
destination=filename
```

Copies the input-file into the output-file. If the memory location is not defined (flash or tmp), the command assumes the flash directory.

Example:

```
> copy-file tmp\pmp01_22 pmp01_22
```

6.7.3 Delete-File

```
filename=filename
```

Deletes the specified file from RAM or Flash PROM. If the memory location is not defined (flash or tmp), the command assumes the flash directory.

Example:

```
> delete pmp01_22
```

6.7.4 Directory

```
format=short or full
```

Lists all the files currently stored in flash PROM and RAM, their size, the sectors occupied and the MD5 checksum (full version). It also indicates which of the files is the default program. Files stored in flash PROM have the `flash\` prefix. Files stored in RAM have the `tmp\` prefix.

Example:

```
> dir
```

6.7.5 Download-File

```

source=path\filename
destination=filename
method=inline or binary

```

Downloads a program file from a PC to the Radio.

To download a file through the Ethernet port or across RF links you need to be running the Econsole program on a PC attached to a radio through the Ethernet port. In this case the program file must be in binary zipped format (with extension **.bz**). The *path* in the source parameter is the PC directory where the file resides. The program file is transferred to the radio and is stored in memory under the name specified by the destination parameter. If the destination parameter is omitted, the file will be stored in Flash PROM with the same name as the source. Note that the “.bz” extension is required in the command. The download “method” must be “binary” (which is the default).

Example:

```
> download C:\load\pmp03_12.bz
```

Downloads the file *pmp03_12.bz* from the PC directory *C:\load*, into the unit file *flash\pmp03_12*.

If the download is executed from a terminal connected to the Auxiliary port, the file is in ASCII format and has the extension **.dwn**. The download method must be “inline”. The source parameter is not needed since, after issuing the command, you must initiate the transfer of the file from the terminal.

Example:

```
> download destination=pmp03_12 method=inline
```

After issuing the command initiate the file transfer using the terminal facilities.

6.7.6 Run-File

```
filename=filename
```

Executes the specified file. The file is first copied into RAM and then the program is executed out of RAM. If the radio is rebooted or power cycled, the radio reverts back to the program defined as the default program. If the memory location is not defined (*flash* or *tmp*), the command assumes the flash directory.

Example:

```
> run pmp03_04
```

6.7.7 Set-Default-Program

`filename=filename`

Sets the specified file as the default program to be loaded upon reboot or power cycle. Since the default program must reside in flash memory, the “flash\” prefix is assumed and is not required for the command.

Example:

```
> sdp pmp03_04
```

6.8 Event Logging Commands

The A53350 keeps track of various significant events in an “event log”. This event log holds up to 500 events. The first 100 entries in the log are filled sequentially after power up and are not overwritten. The remaining 400 entries consist of the last 400 events recorded. All events are time-tagged with system time.

Events are classified in different categories from level 0 (catastrophic error) to 7 (information).

6.8.1 Clear-Log

`region= all-events or reboot-reasons`

This command clears the contents of the system event log from the specified “region”. After a code upgrade it is recommended to clear the reboot reasons since the pointer in non-volatile memory pointing to the reason message may no longer be valid.

6.8.2 Display-Log

`region=end or tail or beginning or all-events or reboot-reasons`

`length=1..500`

`id=0..200`

`min-level=0..7`

`max-level=0..7`

This command outputs to the terminal the specified **region** of the event log. The **length** parameter specifies the number of events to output (defaults to 10). The remaining parameters provide filters to leave out specific events. If the **id** parameter is specified, only the event identified by that id will be displayed. The **min-level** and **max-level** settings allow the user to display only the events with the specified category range.

When the region is specified as **tail**, the command displays the last 10 events followed by a blank line, then waits for more events and displays them as they occur. You can press the space bar to exit this mode.

The **reboot-reasons** region of the event log consists of the last four events that caused the gateway to reboot. These events are stored in non-volatile memory. The time tag in these events is the time the gateway was up since it was rebooted, not the time of day.

Examples:

```
> display-log region=all
> display-log region=all length=300 min-level=2 max-level=6
```

6.8.3 Max-Event

Sets the event severity level that should be saved or displayed. These two parameters are saved as part of the configuration

save=0..7

Only events of the specified level or below will be saved in the event log.

print=0..7

Events of the specified level or below will be output to the console port as they occur.

Example:

```
> max-event print=6
```

6.9 Miscellaneous Commands

6.9.1 Date

The A53350 will set the internal radio date and time automatically by decoding Network Time Protocol (NTP) packets in the Ethernet LAN. The “zone” parameter specified with the “date” or “time” command will then be used to display the date/time in local time. The “zone” value is saved as part of the radio configuration.

If NTP packets are not available, the user can initialize the radio date and time with either the “date” or “time” commands. The parameters for both commands are identical, but the parameter order is different. The date command can be entered as:

```
> date 16-may-2000 10:32:06
```

date=day-month-year

Sets the date used by the radio. The day / month / year parameter may be separated by any valid separator ('-' '/' etc.)

time=hh:mm:ss

Sets the radio time in hours, minutes and seconds. Use colons to separate the three fields.

zone=zone-code or offset

Sets the time zone to be used by the radio to translate the NTP time to local time. It can be specified by an offset from GMT (-0800 or +0200 for example), or as a "zone-code". The valid "zone-codes" and the respective offsets are shown in .

Table 6-2. Zone Codes and Offsets

| ZONE | ZONE CODE | OFFSET |
|------------------------|-----------|--------|
| Pacific Standard Time | PST | -0800 |
| Pacific Daylight Time | PDT | -0700 |
| Mountain Standard Time | MST | -0700 |
| Mountain Daylight Time | MDT | -0600 |
| Central Standard Time | CST | -0600 |
| Central Daylight Time | CDT | -0500 |
| Eastern Standard Time | EST | -0500 |
| Eastern Daylight Time | EDT | -0400 |
| Greenwich Mean Time | GMT | 0000 |

6.9.2 Help [Command-Name]

If no command is specified, displays the complete list of commands. If a command is specified it displays the valid parameter and corresponding values for that specific command.

Example:

```
> help monitor-link
```

6.9.3 History

Displays the previous commands entered.

6.9.4 License

key=*"ASCII string"*

The “license” command is used to turn ON or OFF a set of optional features or capabilities. The key is a 35-character string combination of ASCII letters, numbers, and hyphens. The key must be input with the syntax as shown in the example below, including hyphens, for the radio to accept it. The characters can be input as upper or lower case.

After entering the key you must reboot the radio for the feature, enabled by the key, to take effect. Each key is unique for a particular radio serial number and capability, i.e. a key generated to turn ON a capability on one serial number will not work on another radio.

Example:

```
> license key=02EL1-ZGZ42-G0000-00C54-81WAJ-C9BEK
```

6.9.5 Logout

Closes the current Econsole session.

6.9.6 Reboot

Resets the radio, causing the software to perform a complete startup sequence. This is equivalent to power cycling the radio off and on.

NOTE

Any unsaved configuration parameters will be lost.
The Routing Table will also be cleared.

6.9.7 Time

time=**hh:mm:ss**

date=**day-month-year**

zone=**zone-code** or **offset**

This command is identical to the “date” command explained above, except for the order of the parameters. It allows the time and date to be entered as:

```
> time 10:32:06 16-may-2000
```

6.9.8 Version

Displays the radio model and software version.

SECTION 7

NETWORK MANAGEMENT

7.0 NETWORK MANAGEMENT

The radios operate as part of a network environment with many devices. Whether operated by an Internet Service Provider (ISP) or the Information Technology (IT) department of a business, there is often a need to supervise and manage the network from a central Network Operations Center (NOC). This chapter describes the features of the A53325 that are useful for this purpose.

7.1 Telnet

7.1.1 General

Telnet, which stands for Telecommunications Network, is a protocol that allows an operator to connect to a remote machine giving it commands interactively. Once a Telnet session is in progress, the local machine becomes transparent to the user, it simply simulates a terminal as if there was a direct connection to the remote machine. Commands typed by the user are transmitted to the remote machine and the responses from the remote machine are displayed in the Telnet simulated terminal.

7.1.2 Starting a Telnet Session

In order to start a Telnet session with a radio you first need to configure the radio with a unique valid IP address. This is done with the ***ip-configuration*** command described in the *Commands* section. This initial configuration must be done using either the RS-232 console port or the ECON program.

Once the radio has an IP address, you must start the Telnet application at the local machine and establish a connection with the IP address of the radio. If the local machine is a PC running Windows, you can start Telnet through HyperTerminal as follows:

1. Start the HyperTerminal application (in a typical Windows installation HyperTerminal can be found from the **Start** button under Programs/Accessories/Communications...)
2. From the **File** menu choose **New Connection**.
3. In the **Name** field enter any name you wish and press the OK button. This will open the "Connect To" window.
4. In the last field, titled "**Connect using:**", select **TCP/IP (Winsock)**. The fields above will change to **Host Address:** and **Port Number:**.

5. In the **Host Address** field, type the IP address of the radio, then press the OK button.
6. TCP will now attempt to connect to the specified device. If successful, the radio will request a login name with the prompt **login**:
7. Type `public` followed by the Enter key

The radio will now display its prompt command and you may type any commands as described in the *Commands* section.

If, after entering the `public` login name, the terminal displays the message “Login Failed”, this may be due to the radio being configured to be managed from only some specific IP addresses. This is explained in the following section.

7.1.3 Telnet Security

The remote management capability through Telnet opens the possibility for an unauthorized user to login to any radio accessible through the Internet. The radio configuration can be password protected with the use of the **lock** and **unlock** commands. If further security is desired you can specify up to four *source IP addresses* that are authorized to initiate Telnet sessions with the radio. When configured in this way, the radio will reject Telnet requests from all IP addresses that are not in the authorized list.

The authorized source IP addresses for Telnet are the same addresses that are authorized to perform SNMP management. They are entered using the *snmp* command described in the *Commands* section and can be viewed with the *display-configuration* command. When this list is empty, you can initiate a Telnet session from any IP address with the login name *public*. When this list is not empty, Telnet sessions can only be initiated from the listed hosts. Additionally, for each host, the login name must match the string listed for the *community* field.

If you wish to use this security feature you need to know the IP address of the local machine. On a PC running Windows, one way to find its IP address is to open a DOS window and issue the command:

```
> ipconfig
```


7.2 SNMP

7.2.1 Command Line Interface Versus SNMP

Configuration settings on the A53325 are displayed and modified using a command line interface, it can be accessed using the RS-232 console port, the Econsole program, or via a Telnet session.

In a Network Operation Center (NOC) environment, there is a need for an automated monitoring system to collect on an ongoing basis information from devices in the network for three purposes:

1. To build an inventory of all the devices of the network.
2. To keep track of all devices on the network and raise alarms when any device becomes unreachable (device failed, link down, etc).
3. To maintain statistics on traffic levels in order to implement usage-based charging, or to determine where congestion exists in the network, so that the network can be expanded to accommodate growth.

Command line interfaces are not very suitable for these purposes, and the A53325 supports the Simple Network Management Protocol (SNMP) to assist in these tasks. SNMP is a simple, transaction-based (command/response) protocol, which allows a variety of third-party software products to query network devices and collect data for these purposes.

For a generic introduction to the SNMP protocol, we recommend the book "The Simple Book - An Introduction to Internet Management" by Marshall T Rose (P T R Prentice-Hall, 1994).

7.2.2 SNMP Description

The SNMP protocol is described in the following documents:

- RFC1157 - Simple Network Management Protocol (SNMP) - <ftp://ftp.isi.edu/in-notes/rfc1157.txt>
- RFC1155 - Structure and identification of management information for TCP/IP-based internets - <ftp://ftp.isi.edu/in-notes/rfc1155.txt>
- RFC1213 - Management Information Base for Network Management of TCP/IP-based internets: MIB-II - <ftp://ftp.isi.edu/in-notes/rfc1213.txt>

SNMP is a specification for the interaction (*protocol*) between the **SNMP agent** embedded in a network device, and the **SNMP manager** software running on another machine in the network.

The data provided by the SNMP agent in a network device is described by a document called the MIB (Management Information Base). **MIB-II** describes the basic information provided by all devices, and additional documents describe optional extensions for components that may not exist in most devices.

Devices may also provide non-standard MIB groups. In order for a network management system to make use of these extended features, the MIB description must be obtained from the device manufacturer and loaded into the management station.

SNMP data travels in IP packets, using the UDP port 161 for the agent, so in order to use SNMP, the device must have an IP address.

7.2.3 Security Considerations in SNMP

SNMP was designed before the Internet grew commercial, and the original design was not secure. Later versions intended to provide security, but grew cumbersome and complex. As a result, most devices provide secure operation in a non-standard way.

The original SNMP design as embedded in the protocol, assigns network devices to named communities. Any transactions exchanged between the agent and the manager include the name of the community to which they both belong. The agent has a list of which access rights (set, get, trap) it will grant for each community of which it is a member.

In the A53325, this has been re-interpreted: The radio has a list of up to 4 management stations from which it will accept requests, and for each one - identified by its IP address - it is indicated what access rights it is granted, and which community string it must use. Requests from all other sources are ignored. Refer to the *snmp* command in the *Commands* section for details on how to configure the radio for management using SNMP..

If no management stations are listed, *get*-requests with the community *public* will be accepted and responded to from any IP address.

7.2.4 Examples of Network Management Systems

Some of the most common network management systems are listed below. All of them provide many similar features, including network status displays showing key devices on a map, where the devices change color if they have alarms, and with provisions for activating a remote paging device if there is a problem.

WhatsUp Gold (Ipswitch Inc)

<http://www.ipswitch.com/>
USD 800 (approx)

SNMPc (Castle Rock Computing, Inc)

<http://www.castlerock.com/>
USD 900 to USD 2700 (approx, depending on options)

OpenView (Hewlett-Packard)

<http://www.openview.hp.com/>

USD 3,000 to USD 10,000

The OpenView product line has been revamped; HP is now positioning it not as a turnkey software product, but as a custom adapted application to be bought through a value-added implementation partner.

Multi-Router Traffic Graphing

<http://www.mrtg.org/>

A free, open-source software, capacity planning tool.

7.2.5 A53325 Management Information Base (MIB)

The A53325 implements only the core MIB-II. A management station will see three interfaces in the **interfaces group**:

- 1 - Bridge
- 2 - Ethernet
- 3 - Radio

The first of these represents the attachment of the SNMP agent to the bridged network. Only IP traffic seen by the embedded host is counted.

The Ethernet device (**ifIndex=2**) represents the traffic passing through the radio's Ethernet port. This is what should be tracked by MRTG.

The third device represents the wireless transceiver. It will appear as **down** if the radio does not have a working link to its peer. This is useful for confirming the loss of a link. The traffic counts show all packets to and from the radio, including handshaking between the two radios.

7.3 UDP Command and Data Interface

7.3.1 Purpose

The A53325 firmware includes an optional command/data interface based on the UDP/IP protocol. This interface can be used for two purposes:

1. As a command interface allowing radio text commands and replies to be encapsulated in UDP/IP packets. This is useful when you want to configure the radio from a program running on an external computer
2. To send and receive **vital packets** which the radio classifies as the highest priority.

With the UDP Command Interface a host computer can issue all the same text commands available through the other interfaces and described in the radio Operator's Manual. The command text, in ASCII, must be encapsulated in an UDP/IP packet addressed to the radio. The radio replies to every command with text also encapsulated in an UDP/IP packet. This reply packet can be addressed to a pre-configured IP address or to the device that generated the command. See the `udp-configuration` command in section 4 for the options to configure this udp interface.

7.3.2 UDP Command Packet formats

Table 7-1 below shows the structure of the UDP command and reply packets. The host computer always initiates the command, and the radios reply to every command. The command sequence number field, in the reply, "echoes" the contents of the sequence number field in the command.

If the `socket-mode` is set to 2, the radio issues an "unsolicited reply" message on power up to the configured peer-address. This can be used to alert a host that the radio just rebooted. The command sequence number in this power up unsolicited reply is always zero.

The command and reply text is in ASCII. Refer to the *Commands* section for a complete list of all valid commands. Prior to using the UDP interface you must initialize the radio IP and the UDP configuration (using commands `ip-configuration` and `udp-configuration`) through either the RS-232 console or the Ethernet Econsole ports.

Table 7-1. UDP Command / Reply Packet Format

| Bytes | Host to Radio (Command) | Radio to Host (reply) | |
|-------|-------------------------------|-------------------------------|--------------------------------|
| 0-5 | Dest MAC address | Dest MAC address | Ethernet Encapsulation |
| 6-11 | Src MAC address | Src MAC address | |
| 12-13 | 0x0800 | 0x0800 | |
| 14-33 | IP header | IP header | UDP/IP encapsulation |
| 34-35 | Src port (any) | Src port: radio UDP cmd port | |
| 36-37 | Dest port: radio UDP cmd port | Dest port: UDP peer cmd port | |
| 38-39 | Length of UDP payload (6-500) | Length of UDP payload (6-500) | RFC-768 (UDP) RFC-760 (IP). |
| 40-41 | Checksum | Checksum | |
| 42-45 | Command Sequence number | Command Sequence number | Payload |
| 46-47 | Pad (all zeroes) | Reply code | |
| 48- | Command text | Reply text | |

The values of the “reply code” field are shown in the following table.

Table 7-2. Reply Code Field

| Code | Mnemonic | Description |
|------|-------------------|--|
| 0 | CMD_SUCCESS | Command executed successfully |
| 1 | CMD_RESTART | Unsolicited reply at startup. A start command must be given. |
| 2 | CMD_TRUNCATED | Response text overflow (truncated if over the value specified by max-response-bytes) |
| 3 | CMD_NOT_FOUND | Unknown Command |
| 4 | CMD_AMBIGUOUS | Ambiguous abbreviation |
| 5 | CMD_BAD_ARG_NAME | Illegal or ambiguous argument name |
| 6 | CMD_BAD_ARG_VALUE | Argument value out of range |
| 7 | CMD_ARG_MISSING | Required argument missing |
| 8 | CMD_FAILED | Command failed |
| 9 | CMD_DISABLED | A start command must be given |

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SECTION 8

RF LINK DESIGN

8.0 RF LINK DESIGN

8.1 Antenna Selection

The A53350 radio comes equipped with two antenna ports to connect to external antennas. It is very important to select the correct antennas based on the application. This section provides an overview of the major antenna parameters to help you select the correct antenna.

8.1.1 Antenna Types

There are a vast number of antenna types designed for various general and special purposes, but despite the huge variety, all designs essentially address two concerns, directionality and gain. These selection criteria are discussed in the following paragraphs, along with a third criterion, polarization.

For the A53325, the antenna types listed in will fulfill most installation requirements.

Table 8-1. Antenna Types Available From Siemens Rail Automation

| ANTENNA TYPE | GAIN | P/N |
|-----------------|--------|-----------------|
| Omnidirectional | 12 dBi | Z913-00025-0000 |
| Omni Mount | | Z912-00070-0000 |
| Grid Parabolic | 17 dBi | Z913-00037-0000 |
| Grid Parabolic | 24 dBi | Z913-00023-0000 |
| Yagi | 15 dBi | Z913-00038-0000 |
| Yagi Mount | | Z912-00084-0000 |

8.1.2 Antenna Mounting

Because A53325 radios communicate with each other by means of radio waves, all aspects of antenna installation affect their performance significantly, Consideration must be given to the following aspects:

- Antenna type used.
- Clear line-of-sight path between antennas.
- Antenna orientation.
- Antenna placement.
- Antenna-to-antenna distance between radios.
- Distance between the radio and its antenna (antenna cable length).

Therefore antenna installation is a vital part of system installation. Improper installation may greatly reduce system performance, possibly rendering the system inoperable.

8.1.3 Directionality

An antenna may be designed to receive and transmit in all directions. Such antennas are omnidirectional. The sensitivity and power of an omnidirectional antenna are unfocused; that is, they are spread through a wide volume of space, so the advantage of being able to communicate in all directions is traded off for limited sensitivity and power.

If it is determined that all signals of interest are coming from a definable direction, the omnidirectional antenna can be replaced by a directional or sectoral antenna, which increases sensitivity and power by focusing the beam in the desired direction.

In practice, even omnidirectional antennas take advantage of directionality by focusing their sensitivity and power in the horizontal plane. Rather than waste performance by sending signals into space or into the ground, the omnidirectional antenna redirects its power and sensitivity from these directions, increasing performance in the horizontal plane.

In Point-to-Point applications, where the direction of communication is known and fixed, a highly focused directional antenna can be used to provide maximum sensitivity and power. In addition, because of its decreased sensitivity in all directions but the desired one, the directional antenna improves performance by rejecting signals not coming from the desired direction. This provides an effective increase in signal-to-noise performance.

A sector antenna has a wider “spread” than a directional (generally between 60 to 120 degrees) which makes it a cross between an omnidirectional and a directional. This is useful in a point to multipoint configuration where multiple sites are grouped in the same general area. The installer can then make use of the higher sensitivity and power but also take advantage of the wider beam pattern and improved front to back ratio.

8.1.4 Gain

“Gain” specifies the receive and transmit performance of any antenna compared to a theoretical “isotropic” antenna or “spherical radiator”. The objective of a directional antenna design is to achieve gain, improving sensitivity and effective radiating power to increase range or data rate.

Gain is measured and stated in decibels, abbreviated dB. The decibel is a unit used to indicate the relative difference in power between two signals. For example, a signal 3 dB greater than another signal has twice as much power. The decibel is a logarithmic unit so each doubling of decibels represents a fourfold increase in power. Since 3 dB represents a doubling of power, 6 dB represents a fourfold power increase, 12 dB represents a 16-fold increase, etc. For antenna performance, the unit used is dBi, “i” standing for “isotropic”.

One type of directional antenna is called a “semi parabolic”. This antenna has a gain of 24 dBi, representing power and sensitivity levels 256 times greater than those of a isotropic antenna.

Collinear antennas are available for omnidirectional coverage from fixed locations. The collinear design achieves gain by increased focus in comparison with the dipole design. The standard collinear antenna used with the A53325 provides 12 dBi gain representing more than an eight-fold power and sensitivity increase.

8.1.5 Polarization

Another important concept for antenna performance is polarization. An antenna radiates radio waves that vibrate in a specific plane, normally horizontal or vertical. Polarization refers to the restriction of wave vibration to a single plane.

NOTE

Do not confuse polarization with directionality. The plane of wave vibration has nothing to do with the direction of wave propagation. For example, an antenna that focuses its energy in the horizontal plane may be vertically or horizontally polarized.

Designs such as the semi parabolic offer a choice of polarization. Mounting a semi parabolic antenna with the radiating element horizontal provides horizontal polarization, while mounting the antenna with the radiating elements vertical provides vertical polarization.

In setting up the A53325 system, either vertical or horizontal polarization can be used, as long as polarization is the same at both ends of each link. For any given pair of line-of-sight antennas, it is essential that they both have the same polarization. Differences in polarization among antennas – called “cross-polarization” – can reduce signal considerably.

8.1.6 Antenna Orientation

Directional antennas must be carefully oriented towards each other. Orientation of directional antennas is critical because their sensitivity is greatly reduced outside a fairly narrow angle. Performance of the system can be seriously degraded by misaligned directional antennas. The A53350 has a built in feature that allows you to use an audio signal to assist in aligning the antenna. Refer to the *Antenna Installation and Alignment* section for details.

8.2 RF Path Analysis

At the high operating frequencies of the A53325 system, radio waves travel in a nearly straight line-of-sight path. This is in contrast to the lower-frequency radio waves used for AM broadcasting. These waves bounce between the ionosphere and the earth's surface to travel long distances and operate over and around obstructions. Higher-frequency radio waves do not behave in this manner and are greatly weakened by substantial obstructions or the absence of a direct path. Simply put, all antennas communicating with each other must be able to physically "see" each other.

For this reason, a proper antenna site must meet the following criteria:

1. For optimum performance at maximum range, there must be a clear line-of-sight path among all antennas that communicate directly with each other. At shorter ranges, some degree of obstruction may be tolerated, but performance in the presence of obstruction is difficult to predict.
2. Elevating one or more of the antennas in the system increases maximum line-of-sight range, called the radio horizon. If antennas are located at a greater range than the ground-level radio horizon, a means must be available for elevating the antennas.
3. All antennas must be properly oriented, and a directional antenna must be carefully aimed at its target antenna to ensure communication at maximum range.
4. All antenna cables attenuate (reduce) signal strength in proportion to their length. Since various cable types offer different attenuation levels, maximum length depends on cable type. Since the A53325 is designed for outdoor installation, it can be installed in close proximity to the antenna, reducing or eliminating cable losses.

Each of these criteria is discussed at greater length in the following paragraphs.

8.2.1 Line-of-sight Requirements

At the high operating frequencies of the A53325 (2.4 GHz), radio waves travel in a nearly straight-line path. These frequencies are greatly weakened by substantial obstructions or the absence of a direct path. Simply put, all antennas communicating with each other must be able to physically “see” each other.

For shorter ranges, a degree of obstruction may be acceptable. For example, at less than maximum ranges the radio has some ability to “penetrate” trees and other foliage. On the other hand, geographical features (hills) and large buildings are likely to interfere with communications, and antennas must be elevated to see each other above such objects.

For links covering very long distances (exceeding 5 miles or 8 km) you also need to take into account the following factors:

- The curvature of the earth.
- Fresnel Zone clearance.
- Atmospheric refraction.

Figure 8-1 illustrates these concepts with an exaggerated representation of a long link. The following sections describe these effects. You can use the “Fresnel Zone Calculator”, shown in Figure 8-2, to make all the computations for the RF path analysis and determine if you have adequate antenna height for your links. The calculator runs on a PC and is available on CD.

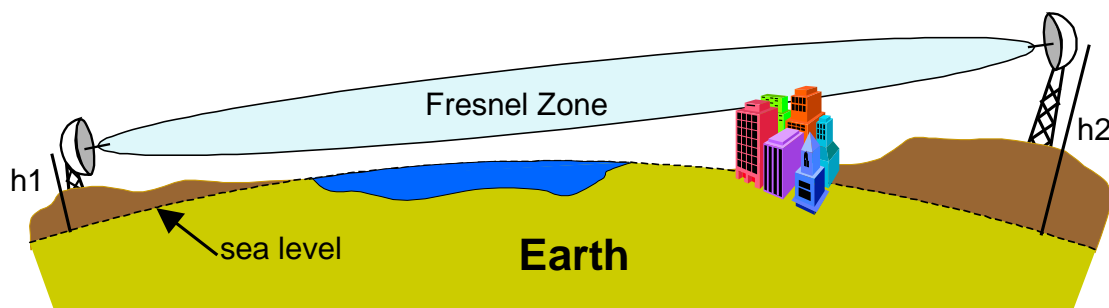


Figure 8-1 Earth Curvature, Fresnel Zone And Antenna Heights

| Fresnel Zone Clearance and Antenna Height Calculator | |
|---|---|
| Units: <input type="radio"/> miles, feet <input checked="" type="radio"/> km, metres | |
| Input Frequency: <input type="text" value="920"/> MHz Atmospheric Refraction: k factor: <input type="text" value="1.33"/> (typical 1.33) Percent of 1st FZ: <input type="text" value="60"/> % (typical 60%) Link Distance: <input type="text" value="75"/> km Antenna Heights: Site 1: <input type="text" value="73"/> m Site 2: <input type="text" value="181"/> m At an Arbitrary Point P: Distance from site 1: <input type="text" value="13"/> km Distance from site 2: <input type="text" value="62"/> km Height of obstruction: <input type="text" value="0"/> m | Output Equivalent Earth radius: 8472 km Equal Antenna Height Solution: Radius of 60% 1st FZ at mid point: 46.9 m Height of both antennas for FZ clearance: 129.8 m Minimum Clearance Point: Distance from site 1: 28.1 km Clearance between Earth and FZ: -10 m Clearance at Point P: Radius of 60% 1st FZ: 35.5 m Clearance between obstruction and FZ: 9 m |

Figure 8-2. Fresnel Zone Calculator

8.2.2 Earth Curvature

With long links the earth curvature can prevent the two antennas from seeing each other. This is illustrated in Table 8-2 and Table 8-3, which show the minimum antenna heights required, at both ends of the link, to simply clear the earth surface at various distances. As the distance grows the effect worsens requiring you to have access to high elevation points to deploy such links. The values in the table used a typical atmospheric refraction factor of 4/3 (see below).

8.2.3 Fresnel Zone

The Fresnel zone is a long ellipsoid that stretches between the two antennas. The **first** Fresnel zone is such that the difference between the direct path (AB) and an indirect path that touches a single point on the border of the Fresnel zone (ACB) is half the wavelength (see Figure 8-3).

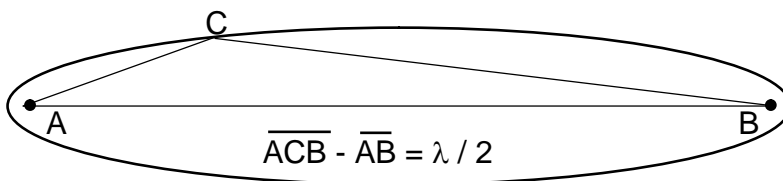


Figure 8-3. Fresnel Zone Definition

If a significant portion of the Fresnel Zone is obstructed the receive-signal-strength at the receiving antenna can be significantly attenuated. A rule of thumb is that you need at least 60% of the first Fresnel Zone clear of any obstructions in order for the radio wave propagation to behave as if it is in “free space”.

Even though at 2.4 GHz half of the wavelength is only 2.36 inches (6 cm), at long distances the radius of this ellipsoid can be quite large. This is illustrated in Table 8-2 and Table 8-3, which show the radius of this (60%) ellipsoid at the mid-point for various distances.

Table 8-2. Antenna Heights (Meters) To Clear The Earth And 60% Of The Fresnel Zone

| | | | | | | | | |
|--|-----|-----|----|----|----|----|----|-----|
| Distance (km): | 5 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
| Antenna height to clear earth (meters): | 0.4 | 1.5 | 6 | 13 | 24 | 37 | 53 | 72 |
| 60% Fresnel Zone radius at mid-point (meters): | 7.5 | 10 | 15 | 18 | 21 | 23 | 26 | 28 |
| Total antenna height required (meters): | 7.9 | 12 | 21 | 31 | 45 | 60 | 79 | 100 |

Table 8-3. Antenna Heights (Feet) To Clear The Earth And 60% Of The Fresnel Zone

| | | | | | | |
|---|----|----|-----|-----|-----|-----|
| Distance (miles) | 5 | 10 | 20 | 30 | 40 | 50 |
| Antenna height to clear earth (ft) | 3 | 12 | 50 | 113 | 200 | 313 |
| 60% Fresnel Zone radius at mid-point (ft) | 31 | 44 | 62 | 76 | 87 | 98 |
| Total antenna height required (ft) | 34 | 56 | 112 | 189 | 287 | 412 |

8.2.4 Atmospheric Refraction

Under normal atmospheric conditions radio waves do not propagate in a straight line, they actually bend slightly downward. This is due to "refraction" in the atmosphere that affects radio waves propagating horizontally. To take this downward bending into account, we perform all the RF path calculations using a larger value for the earth radius, such that we can then consider the radio waves as propagating in a straight line.

In the Fresnel Zone calculator you can change the earth radius multiplying factor (the "k factor") to take into account different atmospheric conditions. Under normal conditions the "k factor" is 4/3. However unusual weather conditions can cause significant changes to the refraction profile. For a high reliability link you may want to use a lower value for the k factor.

8.2.5 Clearing Obstructions

The calculator allows you to quickly determine whether you have enough clearance above a particular obstruction in the RF path, or alternatively, how high you need to elevate your antennas to clear the obstruction.

For each potential obstruction in the path you need to know its distance from one of your end points and the height of the obstruction. Drawing the path in "Google Earth" is a quick way of identifying buildings or structures that lay in the direct path and finding their distance from the end points. You may need to use a topographic map, draw the line between the end points, and create an accurate terrain profile. If there are buildings or trees in the path you need to determine or estimate their height and add it to the terrain elevation at those points.

For each of these potential obstruction points, enter its distance from site 1 in the bottom left input "spinner" of the calculator. On the right hand side the calculator displays the vertical separation between the bottom of the Fresnel Zone and the Earth sea level ("Clearance between Earth and FZ"). This value needs to be larger than the height of your obstruction. If it is not use the antenna height spinners to increase the height of one or both antennas until that clearance exceeds the height of your obstruction.

8.3 RF Link Budget Calculations

If you have radio-line-of-sight for your link (as explained in the previous section), then it is easy to compute the receive-signal-strength at the receiving radio and from there determine if you have an adequate “fade margin”.

You can use the “RF Link Budget Calculator”, shown in Figure 8-4, to make all the required computations and evaluate the trade-off between antenna gains, cable losses etc. The calculator runs on a PC and is available on CD.

Figure 8-4 - RF Link Budget Calculator

Even though your link is bi-directional, in the calculator Site 1 is viewed as the transmitter and Site 2 as the receiver. If you configure both radios with the same transmit power the results for both directions are identical. If you configure the transmit power of the two radios to different values you should compute the link budget in each direction separately.

The RF link budget calculations are made a lot easier by using “decibel” units (dB). The decibel is a logarithmic scale that compares a parameter value against a specific reference. The advantage of working in dB is that you can simply add all the parameters that boost your signal and subtract the ones that attenuate it.

The following paragraphs follow an RF signal from the transmit radio to the receive radio, explaining the various parameters and how they apply to the A53325 radio

8.3.1 Transmit Power

The RF signal starts at the output of the radio at Site 1 with a specific transmit power. In *the* A53325 you can configure that power from 0 to 23 dBm (the “m” in the dBm unit indicates that this power is measured relative to 1 milliwatt).

8.3.2 Cable Losses

The radio is connected to the antenna through an RF coaxial cable. As the signal propagates through this cable it is attenuated. The total attenuation (loss) depends on the frequency, cable type, cable length and number of connectors. You can use the “Cable Loss Calculator” (at the bottom of the RF Link Budget calculator), which includes the characteristics for several RF cable types. If your cable is not listed you can also enter its “loss per 100 ft” (or loss per meter) at 2.4 GHz and the calculator computes the total loss. Note that each connector along the way introduces additional attenuation, typically around 0.25 dB per connection.

The A53325 is housed in a watertight enclosure so that you can mount it in very close proximity to the antenna. That way you can keep the RF coaxial cable very short and therefore reduce these losses.

8.3.3 Antenna Gain

The transmit signal is radiated through the antenna at Site 1. The antenna focuses the radiated energy in a specific direction or plane, boosting your signal strength in that specific direction. That boost is measured by the “antenna gain” in dBi (the “i” in the dBi unit indicates that the antenna gain is measured in relation to an isotropic radiating element).

8.3.4 Distance and Free Space Loss

Once the signal is in the air it propagates towards the receiver but suffers attenuation as it radiates away from the transmitter. If there are no obstructions the total attenuation is called the Free-Space-Loss (FSL). This loss is a function of the frequency, f , and the distance, d . It can be computed, in dB, from the following expressions:

$$\text{FSL} = 32.4 + 20 \log f + 20 \log d \quad (\text{with } f \text{ in MHz and } d \text{ in km})$$

or

$$\text{FSL} = 36.6 + 20 \log f + 20 \log d \quad (\text{with } f \text{ in MHz and } d \text{ in miles})$$

The calculator computes this loss for you and displays it in the output panel. An easy rule to remember is that the free space loss increases by 6 dB every time you double the distance.

8.3.5 Receive Signal Strength

The signal is much weakened when it reaches the receiving antenna. That antenna will give it a boost, measured by the antenna gain in dBi. The signal is then attenuated as it propagates down the RF coaxial cable that connects that antenna to the radio. The Receive Signal Strength (RSS) parameter refers to the strength of the signal that finally arrives at the RF connector of the receiving radio at site 2. With all the gains and losses measured in dB, this receive signal strength is computed with the following expression:

$$\text{RSS} = \text{TxPower} - \text{CableLoss1} + \text{AntGain1} - \text{FSL} + \text{AntGain2} - \text{CableLoss2}$$

The RF Link Budget calculator always computes and displays this value in the output panel.

8.3.6 Receive Sensitivity

The radio Receiver Sensitivity is the receive-signal-strength at the input of the radio at which point its "Bit Error Rate (BER)" is at a specified value. Most manufacturers, including Siemens Rail Automation, use a BER of 1×10^{-6} (1 bit error in one million bits) to specify the radio receiver sensitivity. However make sure you check the specifications when comparing the sensitivity in radios from different manufacturers.

You can configure the A53325 radio to operate at four different RF speeds. Lower speeds give you a better receiver sensitivity. Use the appropriate value from the table below:

Table 8-4. RF Speed/Receiver Sensitivity

| | | | | |
|-----------------------------|------|-------|-------|-------|
| RF Speed (Mbps): | 2.75 | 1.375 | 0.500 | 0.250 |
| Receiver Sensitivity (dBm): | -90 | -93 | -95 | -98 |

8.3.7 Fade Margin

The Fade Margin is the difference between the Received Signal Strength and the radio Receiver Sensitivity. When you deploy a link you want to have a Receive Signal Strength that is sufficiently above the radio Receiver Sensitivity in order to survive signal fading due to a variety of factors. These factors might include slight misalignment of the antennas, losses due to fog and rain, etc. As a rule of thumb you should try to get at least 15 dB of fade margin in your links.

With the calculator you can select whether to compute the Distance, the Fade Margin or the Transmit Power. All these parameters are inter-related as described above. When you select one parameter to compute, its value in the input panel is disabled.

All the input values are controlled with “spinners”. As you change any input the calculator instantly updates the output values. By seeing the results immediately you can quickly evaluate trade-offs between different parameters.

8.3.8 Cable Loss (Attenuation)

The A53325 is housed in a watertight enclosure so that it may be mounted in very close proximity to the antenna. Using short cables to connect the radio to the antenna reduces signal losses. Table 8-5 shows loss per 100 feet (30 meters) at 2.4 GHz for typical antenna cable types.

Table 8-5. Loss at 2.4 GHz for Standard Coaxial Cable Types

| CABLE TYPE | LOSS PER 100 FT. (30 M) |
|-------------|-------------------------|
| RG-8 A/U | 14.4 dB |
| Belden 9913 | 8.0 dB |
| LMR 195 | 19 dB |
| LMR 400 | 6.7 dB |

To determine total cable loss for your installation, perform the following calculation:

For US units, multiply length in feet by the loss figure and divide by 100.

For metric units, multiply length in meters by the loss figure and divide by 30.

For example, for a 75-foot length of Belden 9913, the loss is:

$$\frac{75 \times 8.0}{100} = 6.0 \text{ dB}$$

8.3.9 Connector Loss

Loss is introduced with each pair of cable connectors. Attenuation losses of some standard cable types are shown in Table 8-6.

Table 8-6. Attenuation Loss per Cable Type

| CONNECTOR TYPE | LOSS PER CONNECTOR |
|----------------|--------------------|
| N-Type | 0.25 dB |
| SMA-Type | 0.25 dB |

The loss of each pair of connectors on all cables must be included to determine the total signal loss (attenuation) between the radio and the antenna.

8.4 Antenna Grounding and Protection

WARNING

AS AN ELEVATED METAL OBJECT WITH A WIRE CONNECTION BELOW, AN ANTENNA IS AN EXCELLENT LIGHTNING ATTRACTOR, AND AN EFFECTIVE GROUND MUST BE PROVIDED TO DEFLECT LIGHTNING STRIKES TO GROUND. AN ADDITIONAL ADVANTAGE OF EFFECTIVE SYSTEM GROUNDING IS THE MINIMIZING OF ELECTRICAL NOISE AND INTERFERENCE, WHICH CAN SIGNIFICANTLY DEGRADE SYSTEM PERFORMANCE.

Grounding involves providing a good, very low resistance connection from the antenna and radio to earth ground to provide a better path for lightning and electrical noise than that through the equipment. The following points should be taken into account in setting up system grounding:

- The antenna should be mounted on a mast or tower that is well grounded to earth.
- All antenna lead connectors should be correctly installed to provide a good, solid connection to the cable shield.
- Threaded couplings mating antenna lead connectors should be clean and tight; bayonet type connectors should *not* be used.
- Weatherproof connectors must be used for outdoor connections to prevent corrosion, which will interfere with grounding.

- All power and antenna grounds should be made common at a single point such as an equipment rack, cabinet enclosure chassis, or antenna tower. This single-point ground should have a solid ground connection to earth.
- If the unit is installed indoors, a surge arrester or lightning protector should be installed at the point where the antenna cable enters the building or cabinet. The lightning protector should be properly grounded at the single-point chassis ground. Carefully follow the installation instructions provided by the manufacturer of the protection device. Appropriate lightning protectors are available from Siemens Rail Automation as shown in Table 8-7 below.

Table 8-7. Lightning Arresters / Surge Protectors

| ARRESTER TYPE | P/N |
|------------------|-----------------|
| NF to NM 2.4 GHz | Z803-00131-0000 |
| NF to NF 2.4 GHz | Z803-00132-0000 |

APPENDIX A – COMMAND SUMMARY

This appendix lists all commands organized in the respective functional groups. Parameters that are part of the radio configuration are identified by having an entry under the “Factory Configuration” heading. When entering a command, if a parameter that is part of the radio configuration is omitted, the value for that parameter is not modified.

For commands that are not part of the radio configuration, if a parameter is omitted, the value for that parameter defaults to the value indicated in bold.

Table A-1. Configuration Management Commands

| COMMAND | PARAMETERS | VALUES |
|------------------------------|----------------------|---|
| change-password | enable-configuration | <string> |
| display-configuration | source | current main alternate basic factory |
| load-configuration | source | main alternate basic factory |
| lock | | |
| save-configuration | destination | main alternate |
| unlock | enable-configuration | <string> |

Table A-2. Major Configuration Parameters

| COMMAND | PARAMETERS | VALUES | FACTORY CONFIGURATION |
|-----------------------------|------------------------|--|-----------------------|
| distance-max | maximum | 10..160 | 80 |
| | units | km or miles | km |
| ethernet | speed | auto-10, 10hdx, 10fdx, 100hdx, 100fdx, auto, off | auto |
| | timeout-sec | 5..10000 | 30 |
| | multi-cast-timeout-sec | 5..10000 | 30 |
| node | type | hub, remote | remote |
| | max-remotes | 1..29 | 29 |
| | redundancy | 1..4 | 2 |
| | name | (23 character string) | rmt-nnnnn |
| | network-id | 0..65535 | 0 |
| | location | (25 character string) | |
| | contact | (25 character string) | |
| rf-1-setup | antenna | a, b | rf-1:a, rf-2:b |
| | receive channel | min...max | rf-1:12 rf-2:25 |
| | transmit channel | min...max | rf-1:12 rf-2:25 |
| | speed-mbps | [speeds] | max |
| | power-dBm | 0...max_power | 18 |
| rf-2-setup | antenna | a, b | rf-1:a, rf-2:b |
| | receive channel | min...max | rf-1:12 rf-2:25 |
| | transmit channel | min...max | rf-1:12 rf-2:25 |
| | speed-mbps | [speeds] | max |
| | power-dBm | 0...max_power | 18 |
| single-node-reboot | timeout-sec | 15..20000 | 900 |
| time-division-duplex | sync-mode | off, auto | auto |
| | cycle-period-ms | 20, 40 | 40 |
| | transmit-percent | auto, 10, 20, 30, 40, 50, 60, 70, 80, 90 | auto |

Table A-3. Internet Protocol (IP) Management Commands

| COMMAND | PARAMETERS | VALUES | FACTORY CONFIGURATION |
|--------------------------|----------------------|----------------------|-----------------------|
| ip-configuration | address | ip address | |
| | netmask | ip address | |
| | gateway | ip address | |
| | dhcp-client | 0, 1 | off |
| ping | destination | ip address | |
| | count | 0..500 (def 4) | |
| | size-bytes | 32..1400 | |
| snmp | manager | ip address | |
| | community | ASCII string (9 max) | |
| | access | g, gs, gt, gst | |
| | authentication-traps | 0, 1 | |
| | delete | 1..4 | |
| udp-configuration | console | on, off | off |
| | vital-port-1t | 1..0xFFFF | 0 |
| | vital-port-2t | 1..0xFFFF | 0 |
| | command-port | 1..0xFFFF | 422 |
| | max-response-bytes | 500..1466 | 512 |
| | socket-mode | 1, 2 | 1 |
| | peer-address | ip address | |
| | peer-command-port | 1..0xFFFF | 0 |

Table A-4. Installation and Link Monitoring Commands

| COMMAND | PARAMETERS | VALUES | FACTORY CONFIGURATION |
|------------------------------|--------------|--|-----------------------|
| antenna-alignment-aid | mode | off a-antenna b-antenna | off |
| monitor-flow | | | |
| monitor-link | node | 1 , 4, 5, 6... | |
| | clear | 0 , 1 | |
| | header | 0 , 1 | |
| | line-feed | 0 , 1 | |
| show-tables | table | status radios links ethernet econsole ip-stack | |
| | format | count times | |
| spectrum-analysis | input | a-antenna b-antenna | |
| | display | graph table | |
| | dwel-time-ms | 1...1000 (def: 20) | |
| time-analysis | channel | 0..50 | |
| | input | a-antenna b-antenna | |
| | display | graph table | |
| | dwel-time-ms | 1, 2, 5, 10, 20 , 50, 100, 200, 500 | |

Table A-5. File Utilities

| COMMAND | PARAMETERS | VALUES |
|----------------------------|-------------------|-------------------------------------|
| console-speed-bps | baud-rate-bps | 9600, 19200, 38400 57600, 115200 |
| copy-file | source | filename |
| | destination | filename |
| delete-file | filename | filename |
| directory | format | short full |
| download-file | source | path\filename |
| | destination | path\filename |
| | method | binary inline |
| run-file | filename | filename |
| set-default-program | filename | filename |

Table A-6. Event Logging Commands

| COMMAND | PARAMETERS | VALUES | FACTORY CONFIGURATION |
|--------------------|------------|---|-----------------------|
| clear-log | region | all-events reboot-reasons | |
| display-log | region | end tail beginning all-events reboot-reasons | |
| | length | 1..500 (def 10) | |
| | id | 0..200 | |
| | min-level | 0..7 (def: 0) | |
| | max-level | 0..7 (def: 7) | |
| max-event | save | 0..7 | 5 |
| | print | 0..7 | 3 |

Table A-7. Miscellaneous Commands

| COMMAND | PARAMETERS | VALUES | FACTORY CONFIGURATION |
|----------------|------------|-----------------------|-----------------------|
| date | date | dd-mmm-yyyy | |
| | time | hh:mm:ss | |
| | zone | offset or code | GMT |
| help | command | | |
| history | | | |
| license | key | <35 character string> | |
| logout | | | |
| reboot | | | |
| time | time | hh:mm:ss | |
| | date | dd-mmm-yyyy | |
| | zone | offset or code | GMT |
| version | | | |

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APPENDIX B – SPECIFICATIONS

Table B-1. Unit Specifications

| | |
|--|--|
| RF SPECIFICATIONS | |
| RF Frequency Band | 2400 MHz to 2483 MHz |
| RF Signal Bandwidth (-20 dBc) | 4.6 MHz |
| RF Channels | 11 (non-overlapping) |
| Transmitter Output Power | 0 to 27 dBm |
| Modulation Type | direct sequence spread spectrum |
| Receiver Sensitivity (10 ⁻⁶ BER) and Data Rates | -99 dBm (@ 250 kbps) -95 dBm (@ 500 kbps) -93 dBm (@ 1375 kbps) -90 dBm (@ 2750 kbps) |
| Maximum Receive Signal | -30 dBm (to stay in receiver linear region) +20 dBm (to avoid damage) |
| Modulation Type | Direct sequence spread spectrum |
| ETHERNET PORT | |
| Speed | 10/100 BaseT, full, half duplex (auto-negotiate) |
| Connector | 8 pin circular (Lumberg 0321-08) |
| NETWORKED OPERATION | |
| Network Topologies | Point-to-point, Point-to-multipoint, Mesh Tree, Linear Network, Roaming |
| Management | Telnet, SNMP (MIB2), or Econsole reach any node over wireless |
| Security | Optional 3-DES or AES encryption, 32 bit network ID/Password |
| CONSOLE/DIAGNOSTIC PORT | |
| Interface | RS-232/V24, asynchronous 9600 to 115 kbaud |
| Connector | 3 pin circular (Lumberg 0321-03) |
| POWER REQUIREMENTS | |
| Input Voltage (Outdoor Unit) | +9.5 to +58 Volts DC |
| Input Voltage (AC) | 110 VAC or 220 VAC (with external power supply) |
| Power Consumption | less than 5 Watts |
| Transient Max. Peak Power | 1500 W (with 10/1000 us waveform) |
| Transient Max. Peak Current | 35A (with 10/1000 us waveform as defined by R.E.A.) |
| ENVIRONMENT | |
| Temperature | -40 to +70 Degrees C |
| Max. Humidity | 95% non-condensing |
| MECHANICAL | |
| Dimensions | 4.72" wide x 8.66" high x 2.20" deep (120mm W x 220 H x 56 D) |
| Weight | 3.4 lbs. (1.5 Kg). |

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APPENDIX C – CHANNEL FREQUENCY ASSIGNMENT

The center frequency of each channel can be determined by the following expression:

$$\text{Freq(MHz)} = 2400 + 2 \times \text{Channel_number}$$

Table C-1 shows the frequencies for all channels that fall in the ISM band. Table C-2 shows the suggested channel allocation.

Table C-1. Channel Frequencies in the ISM Band

| Chan | Freq (GHz) | Chan | Freq (GHz) | Chan | Freq (GHz) | Chan | Freq (GHz) |
|------|------------|------|------------|------|------------|------|------------|
| 1 | 2.402 | 11 | 2.422 | 21 | 2.442 | 31 | 2.462 |
| 2 | 2.404 | 12 | 2.424 | 22 | 2.444 | 32 | 2.464 |
| 3 | 2.406 | 13 | 2.426 | 23 | 2.446 | 33 | 2.466 |
| 4 | 2.408 | 14 | 2.428 | 24 | 2.448 | 34 | 2.468 |
| 5 | 2.410 | 15 | 2.430 | 25 | 2.450 | 35 | 2.470 |
| 6 | 2.412 | 16 | 2.432 | 26 | 2.452 | 36 | 2.472 |
| 7 | 2.414 | 17 | 2.434 | 27 | 2.454 | 37 | 2.474 |
| 8 | 2.416 | 18 | 2.436 | 28 | 2.456 | 38 | 2.476 |
| 9 | 2.418 | 19 | 2.438 | 29 | 2.458 | 39 | 2.478 |
| 10 | 2.420 | 20 | 2.440 | 30 | 2.460 | 40 | 2.480 |

Table C-2. Suggested Channel Allocation

| NUMBER OF NON-OVERLAPPING CHANNELS | SUGGESTED CHANNEL ALLOCATION | FREQUENCY SEPARATION (MHZ) |
|------------------------------------|---|----------------------------|
| 12 | 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36 | 6.0 |
| 9 | 4, 8, 12, 16, 20, 24, 28, 32, 36 | 8.0 |
| 7 | 5, 10, 15, 20, 25, 30, 35 | 10.0 |

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APPENDIX D – ETHERNET CONSOLE PROGRAM

Short description

The Ethernet console program was developed in order to accommodate the remote configuration of a radio, i.e. the configuration in cases where the physical access to the radio is not feasible, or it is cumbersome. The software consists of two parts: the client and the server. The client runs on the administrator's PC, while the server runs on the radio.

The communication is done via a TCP-like protocol. There is an acknowledgment for every packet that is sent, as well as a retransmission mechanism when a packet gets lost.

Each radio allows multiple sessions, i.e. more than one client can be connected concurrently to the same server (radio). Nevertheless, for performance reasons, it is not recommended to have more concurrent sessions than they are really needed, and definitely not more than the maximum number which currently is 4.

System requirements

- MS Windows™ versions: Win95, Win98, Windows ME, WinNT, Win2000, WinXP
- NetBIOS installed
- WinPCap installed

Note: With regard to the Windows NT platform, the code has been tested with versions 4.0, and later.

Installation for Windows

In order to install the WinPCap library, if not already installed, just click on WinPCap.exe. Support and updates for this library can be found at <http://netgroup-serv.polito.it/winpcap/>. It is strongly suggested to uninstall older versions of the library and reboot the machine before installing the new one.

NetBIOS is a software component that comes by default with all Windows systems, so you don't have to install it. To start Econsole, simply open an MS-DOS window and type *econ*. For available command line arguments, please read the following "*Input arguments*" section.

Included files

- *win_readme.doc*
- *econ.exe* - The EConsole client
- *WinPCap* - The Windows installer for the WinPCap library
- *input_script.txt* - A sample input script file, that contains a list of radio commands.

Input arguments

You can provide the following arguments in the command line, even though none of them is required.

Input file

There are two sources for the input commands: the keyboard, or a text file. The second option is useful when you are running the same set of commands periodically, so you want to avoid retyping them every time you want to execute them. If there is an input file in the command line, then the keyboard will be deactivated and only the function keys will be available. If the specified file cannot be found, the application will be terminated.

Example:

```
C: > econ -i input.txt
```

Sample input file:

```
help
# this is a comment - note that the character # must appear as the
first character
time
date
# the following is a local command specifying a delay in seconds
. delay 10
time
. delay 1.5
version
logout
```

As you probably noticed from the above file, all the lines are interpreted as radio command, unless:

- a) They start with the character “#” which implies a comment.
- b) They start with the character “.” which implies a local command. Currently there is only one local command, namely the `delay <time in secs>`

NOTE

All the input scripts should end with the `logout` command. Since all the commands are terminated with the new line character, there must be one command per line and after the final `logout` command you must have an extra blank line.

Output file

When you want to capture the output of a session into a text file, you can pass the filename as an argument. If the file does not exist it will be created, otherwise it will be overwritten.

Example:

```
> econ -o output.txt
```

Radio MAC address

If you are interested in a specific radio, you can pass its MAC address and let the client ignore any response from other radios. That's very handy when you are always getting connected to the same radio and you want to avoid the manual selection of a preferred one. Very useful also in case you are using scripts for fully automated procedures.

Example:

```
> econ -r 00:78:24:22:BA:4F
```

Radio Serial Number

The same functionality as above (see Radio MAC address) can be achieved by providing the radio serial number, instead of the radio physical address. Note that you should not include the initial UC characters of the serial number (i.e. type `11078` instead of `UC11078`)

Example:

```
> econ -r 11787
```

Local Physical Address

Even though econsole identifies the PC local physical address automatically, there are some cases in which the user wants to specify the local address on his/her own. These cases usually arise when there are multiple NIC cards with the same names under WinNT operating system. In such case, the econ might pick up the wrong MAC address, and therefore the user should supply manually the physical address as a command line argument.

Example:

```
> econ -m 00:78:24:22:BA:4F
```

Inverse Screen Colors

You can change the default settings (white texture on black background) by providing the `-b` option, which will change the settings to black characters on white background.

Example:

```
> econ -b
```

Change the console window size

Currently you can specify two values, either 25 or 50. These values indicate the number of lines of the MS-DOS window.

Example:

```
> econ -l 50
```

Help

Function keys, including F1, are activated after you get connected to a radio. If you want to get help from the command line, you can use the `-h` argument.

Example:

```
> econ -h
```

Syntax:

```
econ <argument list>
argument list = argument list | argument | {}
argument = -o outputfile | -i inputfile | -r MAC address
```

Examples:

Let's say you want to read a list of commands from the text file called `in.txt`, and capture the output to a text file called `out.txt`. You are also interested only in a specific radio with MAC address equal to `00:78:24:22:BA:4F`. In that case, you will start the EConsole with the following arguments (the arguments order is irrelevant):

```
> econ -i in.txt -o out.txt -r 00:78:24:22:BA:4F
or...
```

If you are reading from the keyboard, and you are simply interested in capturing the output of the session, use the following syntax:

```
> econ -o out.txt
```

Since no input file was specified, it is assumed that the keyboard will be used for input, and ALL radios will participate in the discovery process.

Function Keys

Currently there are 6 different function keys.

- F1** - Online help - gives a short description of the other function keys and the input arguments.
- F2** - Active/deactivate diagnostic messages. Initially diagnostic messages are not shown, therefore if you want to see them you should press F2. Diagnostic messages include warnings, and retransmission info in order to get an idea of the connection's speed/integrity. Error messages are always shown.
- F3** - Terminates the current session and closes the application.
- F4** - Close the session with the current radio and display the results of the initial discovery phase to allow the user to connect to a new radio.
- F5** - Reverse/Restore screen settings. Initially the screen displays white letters on black background, but you can reverse it to black letters on a white background.
- F6** - Increases the console window buffer. This introduces a side bar which enables the user to scroll up and down. Available in Windows NT Only.

Troubleshooting & Updates

Common problems

1. Failed to open adapter.

This usually happens when you haven't installed properly the WinPCap library, or you have an older version of it. You should also make sure that your Ethernet adapters are working properly.

2. Cannot find radio(s) even though they are running properly.

Make sure that:

- The Ethernet cables are OK
- You are getting connected to the right network segment (i.e. try all Ethernet adapters)
- You are using the right MAC address. The system tries to identify the adapter physical address through some NetBIOS calls in the Win9X case, or some NDIS queries in the WinNT/Win2000 case. If NetBIOS is not installed, the econ will probably use the wrong local host MAC address. Also, if there is more than one Ethernet adapter installed with the same name, this might cause a problem in the WinNT case.

Resolution: Use the command line argument to specify the correct physical local address. You can see all the local physical address by executing the *ipconfig -all* command.

Example:

```
> econ -m 00:78:24:22:BA:4F
```

3. Find a radio but not getting connected.

Check if the maximum number of sessions has been reached. The maximum number of sessions on the server side is limited to four, therefore you should NOT connect to the same radio multiple times if not absolutely necessary. When the number of sessions reaches the limit the radio will ignore any new discovery messages.

Another reason might be a unreliable RF link causing a high packet loss. Since during the discovery phase there isn't any retransmission mechanism, it is quite possible that you managed to "see" the radio, but you weren't able to connect to it, because the connection request packet was lost. In such case, try to connect again.

4. High drop rate - screen freezes momentarily - connection times out.

There are two possible causes:

- a) The link between the client (PC) and the server (radio) is very weak. If the packet drop rate is more than 20%, then the connection is problematic.
- b) There are multiple sessions opened on the same server. With many concurrent sessions the server response may be noticeably slower. Always close the session gracefully by executing the *logout* radio command, and not by closing the MS-DOS console. If the *logout* command is not issued the session at the server will remain open for an additional 15 minutes. Use the *list long* command to find out the number of open sessions.

If a client is inactive for 30 minutes, and attempts are made to type a new command, the client may receive an “Unable to transfer packet” message, or a "Session timeout - application will be closed" message.

An open session times-out after 15 minutes of inactivity on the server side, or 30 minutes on the client side.

Acknowledgments

The WinPCap library was obtained from “Politecnico di Torino” and the code is distributed in binary form as part of the Econsole. The following copyright notice applies to that library.

```

/*
* Copyright (c) 1999, 2000
* Politecnico di Torino. All rights reserved.
*
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that: (1) source code distributions
* retain the above copyright notice and this paragraph in its entirety, (2)
* distributions including binary code include the above copyright notice and
* this paragraph in its entirety in the documentation or other materials
* provided with the distribution, and (3) all advertising materials mentioning
* features or use of this software display the following acknowledgement:
* “This product includes software developed by the Politecnico
* di Torino, and its contributors.” Neither the name of
* the University nor the names of its contributors may be used to endorse
* or promote products derived from this software without specific prior
* written permission.
* THIS SOFTWARE IS PROVIDED “AS IS” AND WITHOUT ANY EXPRESS OR IMPLIED
* WARRANTIES, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF
* MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.
*/

```

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APPENDIX E – CABLE DIAGRAMS

This Appendix contains the following diagrams:

Figure E-1 shows the assembly drawing for the Power/Data cable (CAT5) used to connect the Radio to a Power Inserter Unit.

Figure E-2 shows the assembly drawing for a Console cable for connection to a standard computer terminal used for radio configuration and monitoring.

Figure E-3 shows the assembly drawing for a 3-pin Audio Adapter cable for connection to the radio auxiliary port, and used with a pair of standard headphones as an antenna alignment aid.

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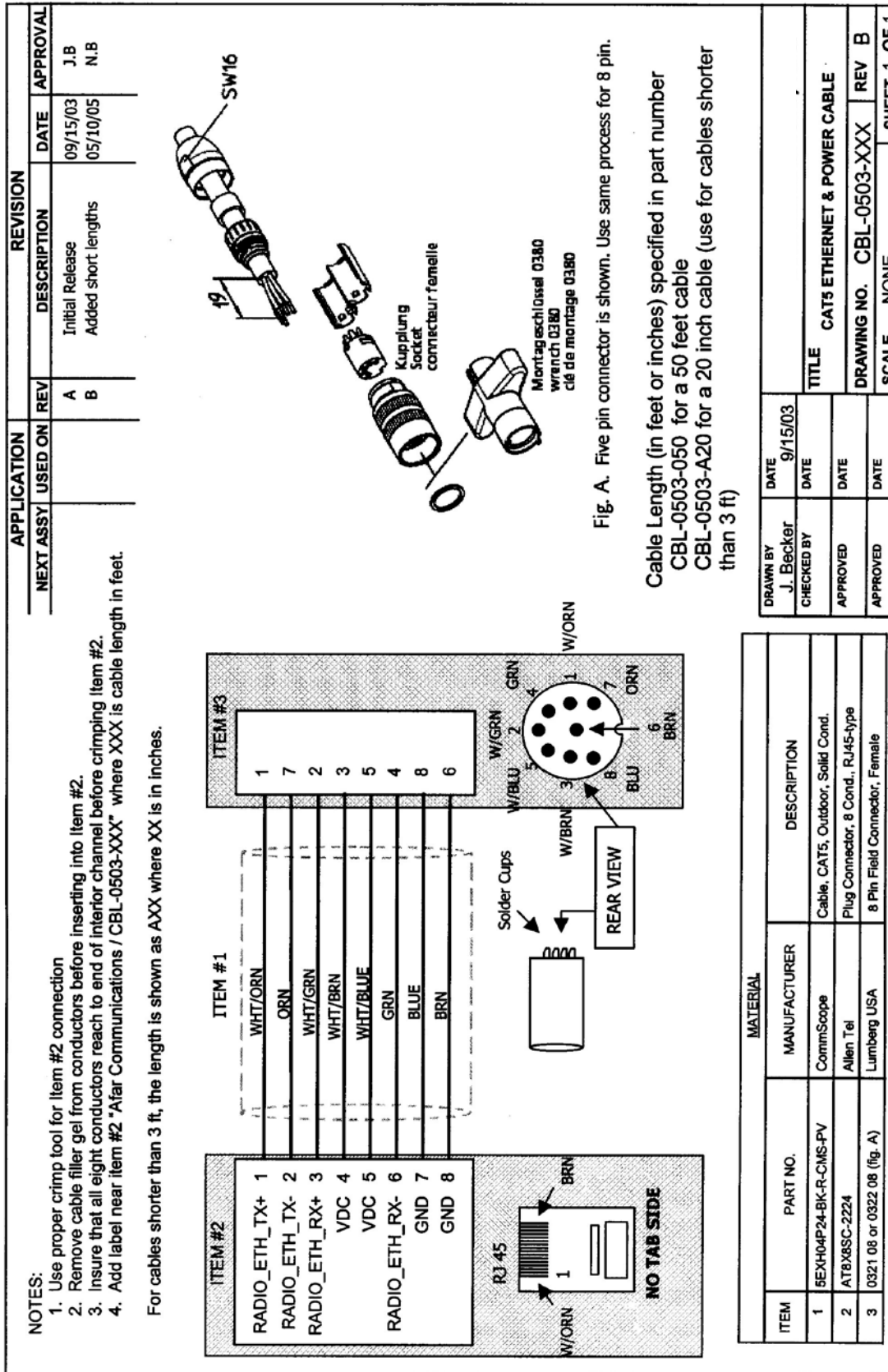


Figure E-1. CAT 5 Ethernet & Power Cable

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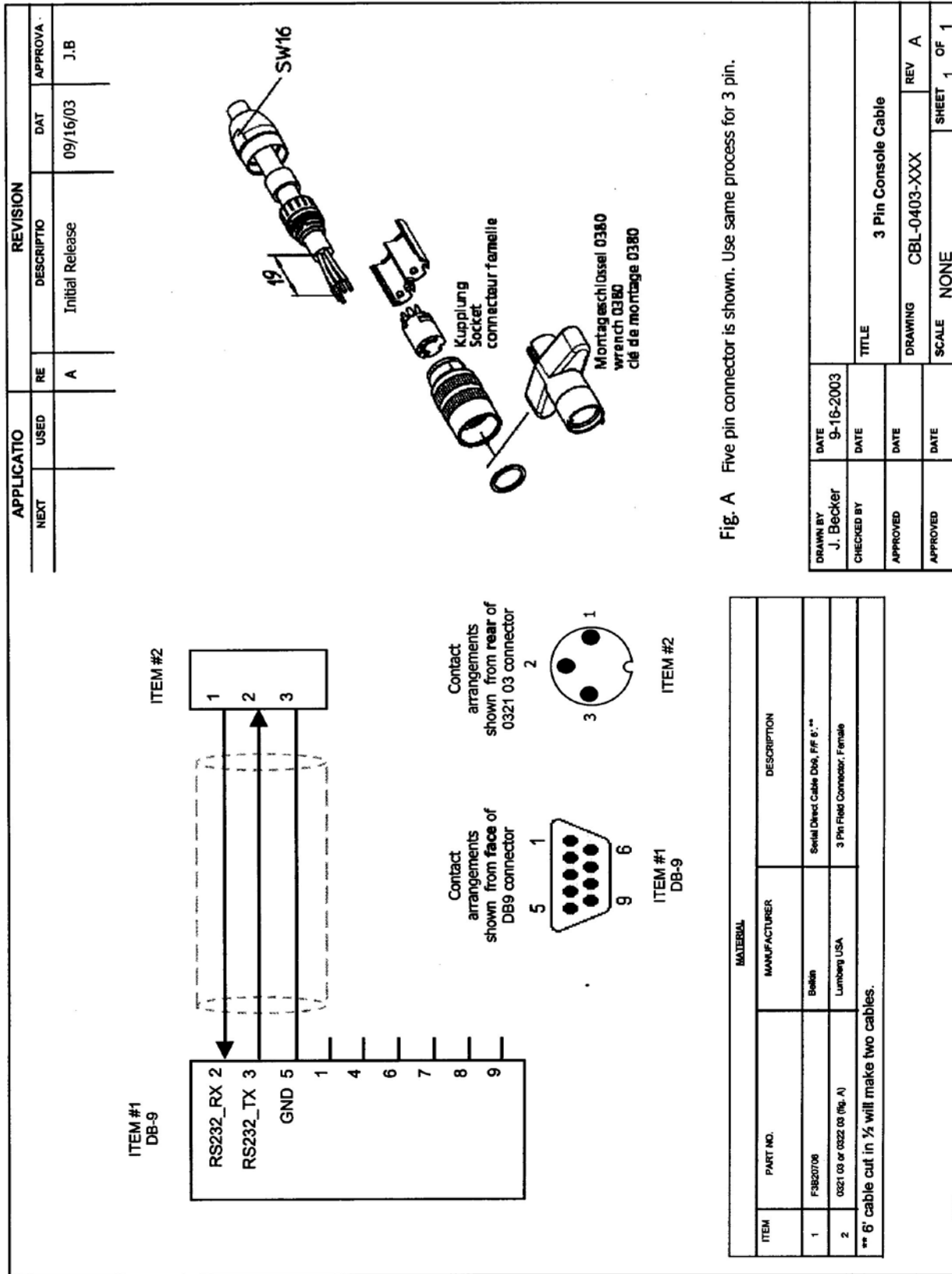


Figure E-2. 3-Pin Console Cable

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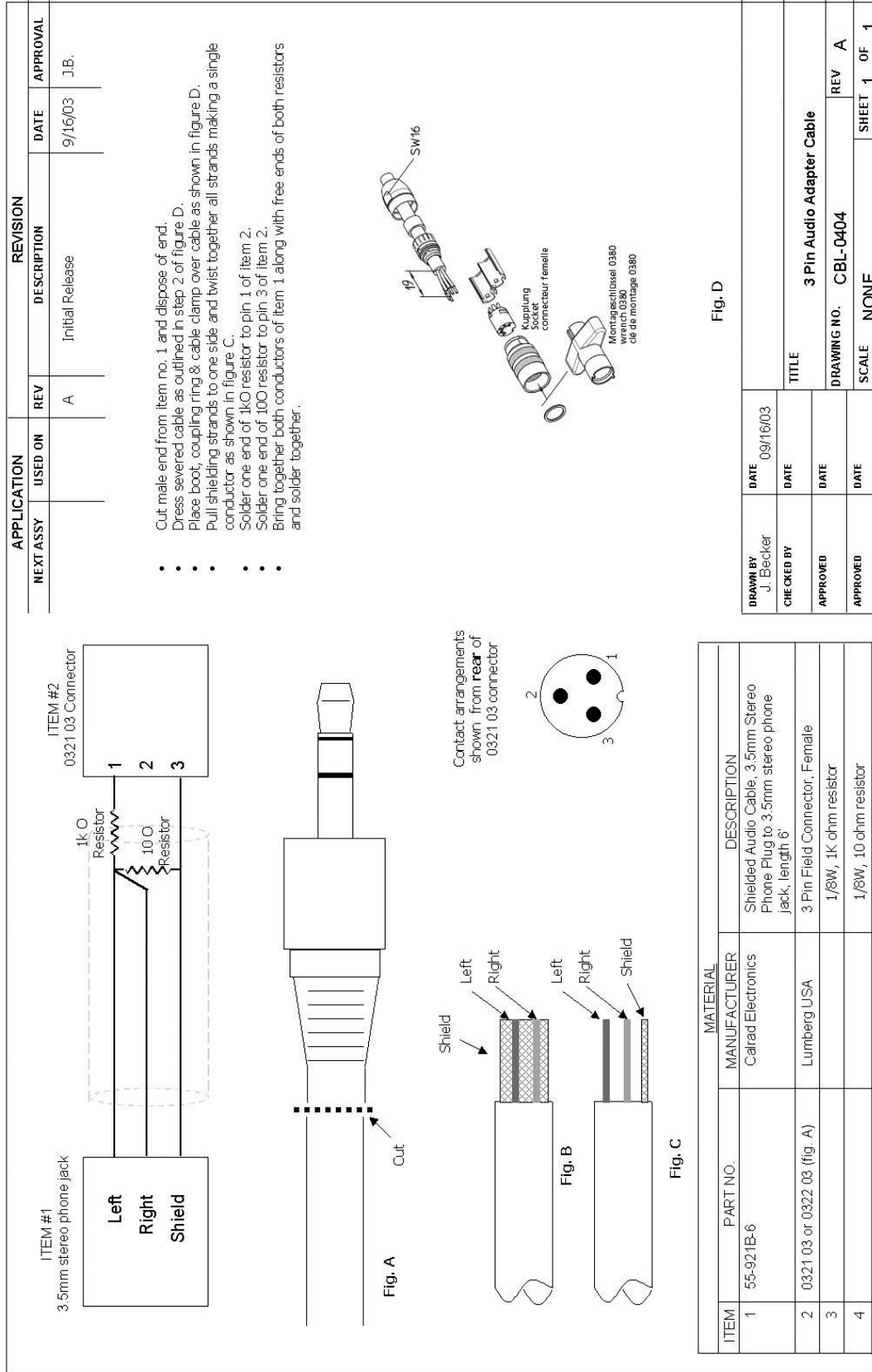


Figure E-3. 3-Pin Audio Adapter Cable

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APPENDIX F - QUICK SETUP

This Appendix contains the following quick setup examples:

Figure F-1 shows an A53325 wireless radio Point to Point quick setup example.

Figure F-2 shows an A53325 wireless radio Point to Multi-Point quick setup example.

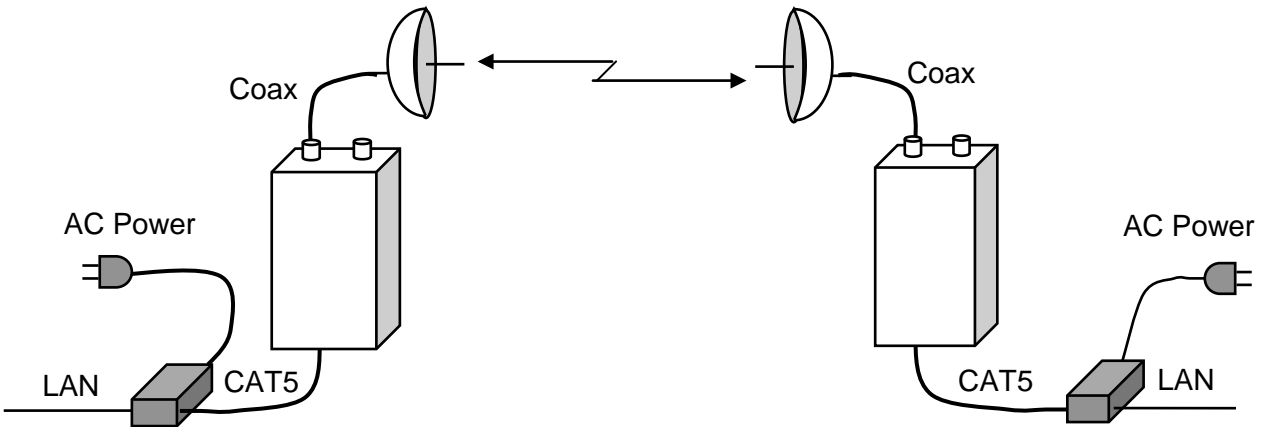
Figure F-3 shows an A53325 wireless radio Linear Network quick setup example.

Figure F-4 shows an A53325 wireless radio Tree Network quick setup Example.

Figure F-5 shows an A53325 wireless radio Tree Network and Roaming quick setup Example

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A53325 Wireless Point to Point Bridge Quick Setup Example

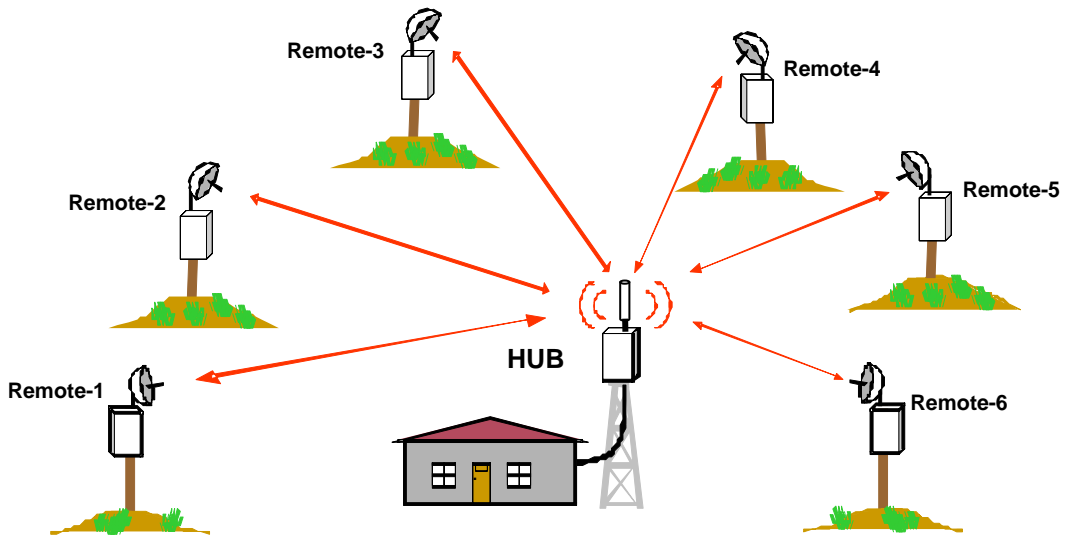


| | | |
|---|--|---|
| <pre>>load factory >node hub >node max-children=1 >save</pre> | Minimal Configuration | <pre>>load factory >save</pre> |
| <pre>>rf1 rec=18 tr=18</pre> | Changing RF Channels (optional) | <pre>>rf1rec=18</pre> |
| <pre>>rf1 power=23</pre> | Changing Tx Power (optional) | <pre>>rf1 power=23</pre> |
| <pre>>show radios >monitor-link</pre> | Checking Link Operation | <pre>>show radios >monitor-link</pre> |

Figure F-1 PmP Bridge Quick Setup Example

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A53325 Wireless Point to Multi-Point Bridge Quick Setup Example

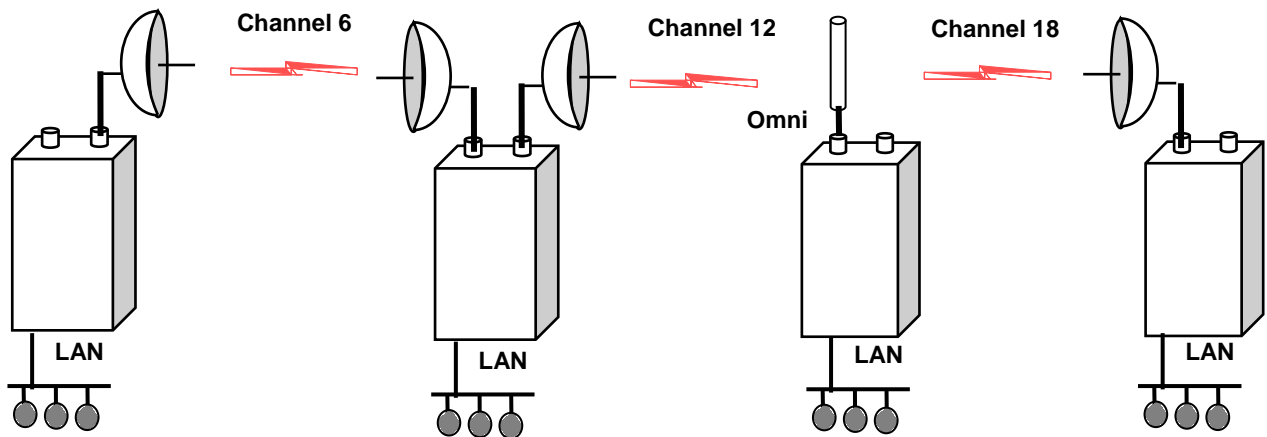


| | | |
|---|--|--------------------------------------|
| <pre>>load factory >node hub >save</pre> | Minimal Configuration | <pre>>load factory >save</pre> |
| <pre>>rf1 rec=18 tr=18</pre> | Changing RF Channels (optional) | <pre>>rf1 rec=18</pre> |
| <pre>>rf1 power=23</pre> | Changing Tx Power (optional) | <pre>>rf1 power=23</pre> |
| <pre>>show radios</pre> | Verifying Network Operation | |

Figure F-2 PmP Bridge Quick Setup Example

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A53325 Wireless Linear Network Quick Setup Example (firmware version 6.xx)

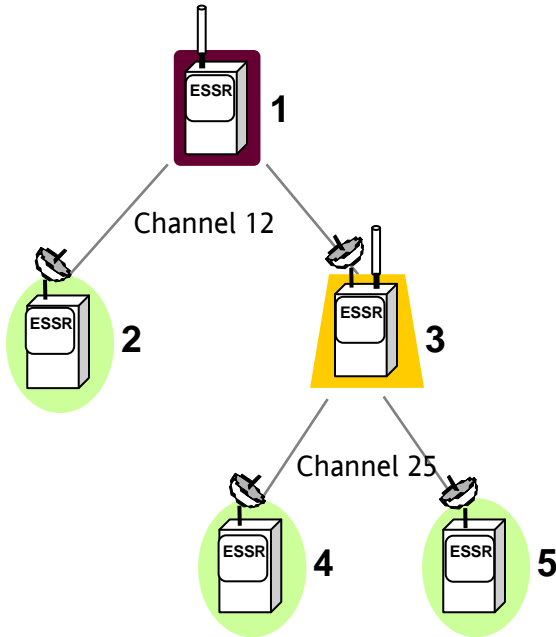


| Leftmost | Middle (2 Antennas) | Middle (single antenna) | Rightmost |
|---|--|---|--|
| <pre>>load factory >node type=root-1 >node max-children=1 >rf1 ant=b tr=6 rec=6 >save</pre> | <pre>>load factory >node type=branch >node max-children=1 >rf1 ant=a rec=6 >rf-2 ant=b tr=12 rec=12 >save</pre> | <pre>>load factory >node type=branch >node max-children=1 >rf1 ant=a rec=12 >rf-2 ant=a tr=18 rec=18 >save</pre> | <pre>>load factory >node type=leaf >rf1 ant=a rec=18 >save</pre> |

Figure F-3 Linear Network Quick Setup Example

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Wireless Tree Network Quick Setup Example (firmware version 6.xx)



| Antennas | | |
|-------------------|-----------------------------|----------|
| | A | B |
| 1 – root | Omni | not used |
| 2 – leaf | Directional (point to 1) | not used |
| 3 – branch | Directional (point to 1) | Omni |
| 4 – leaf | Directional (point to 3) | not used |
| 5 – leaf | Directional (point to 3) | not used |

Minimum Configuration

| 1 | 2 | 3 | 4 and 5 |
|---|---|---|--|
| <pre>>load factory >node type=root-1 >rf1 tr=12 rec=12 ⁽¹⁾ >save</pre> | <pre>>load factory >node type=leaf >rf1 rec=12 ⁽¹⁾ >save</pre> | <pre>>load factory >node type=branch >rf1 rec=12 ⁽¹⁾ >rf2 tr=25 rec=25 ⁽¹⁾ >save</pre> | <pre>>load factory >node type=leaf >rf1 rec=25 >save</pre> |

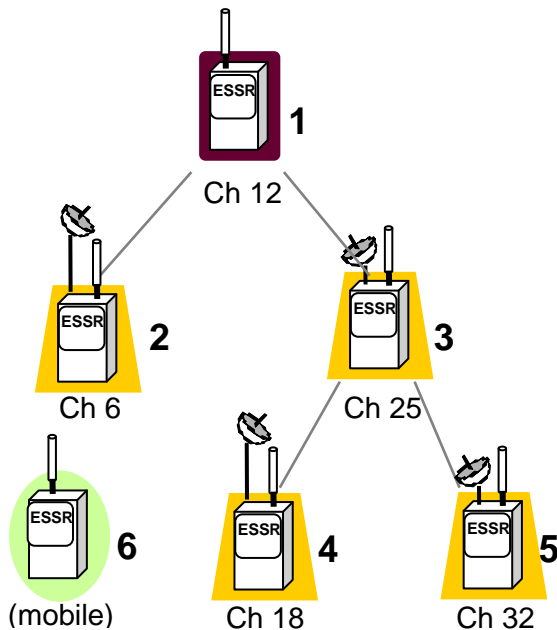
Note 1: Channel 12 and 25 are the defaults for rf1 and rf2 configurations. These commands are not necessary if you plan to use those defaults.

At any node use command “>show tree” to view the complete network and key statistics for each link

Figure F-4 Wireless Tree Network Quick Setup Example

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PulsAR-24027 Wireless Tree Network and Roaming Quick Setup Example (firmware version 6.xx)



| | Antennas | |
|------------|-----------------------------|----------|
| | A | B |
| 1 – root | Omni | not used |
| 2 – branch | Directional (point to 1) | Omni |
| 3 – branch | Directional (point to 1) | Omni |
| 4 – branch | Directional (point to 3) | Omni |
| 5 – branch | Directional (point to 3) | Omni |
| 6 – leaf | Omni | not used |

MINIMUM CONFIGURATION

| 1 | 2 | 3 | 4 | 5 | 6 |
|-------------------------------------|----------------------------|-------------------------------------|----------------------|----------------------|----------------------------|
| >load factory | >load factory | >load factory | >load factory | >load factory | >load factory |
| >node type=root-1 | >node type=branch | >node type=branch | >node type=branch | >node type=branch | >node type=leaf |
| >rf1 tr=12 rec=12 ⁽¹⁾ | >rf1 rec=12 ⁽¹⁾ | >rf1 rec=12 ⁽¹⁾ | >rf1 rec=25 | >rf1 rec=25 | >rf1 rec=6,12, 18,25,32 |
| | >rf2 tr=6 rec=6 | >rf2 tr=25 rec=25 ⁽¹⁾ | >rf2 tr=18 rec=18 | >rf2 tr=32 rec=32 | |
| >save | >save | >save | >save | >save | >save |

Note 1: Channel 12 and 25 are the defaults for rf1 and rf2 configurations. These commands are not necessary if you plan to use those defaults.

At any node, use the command “>show tree” to view the complete network and key statistics for each link. At the mobile use the command “>monitor-roam” to see the signal strengths and verify the roaming operation as the signal strengths vary.

Figure F-5 Wireless Tree Network and Roaming Quick Setup Example

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APPENDIX G - THEORY OF OPERATION LINEAR NETWORKS

This Appendix contains the following quick contents:

CONTENTS

- G1** Overview
- G2** Operation
 - G2.1** Cycle Timing
 - G2.2** RF Channel Plan
 - G2.3** Data Throughput
 - G2.4** Latency
 - G2.5** Bridging Algorithm
 - G2.6** Priority Queues

FIGURES

- Figure G1** Linear Network Topology
- Figure G2** Expanded Network Topology Example

TABLES

- Table G1** Time Slotted Operation Of A Synchronized Linear Network
- Table G2** Frequency Allocation

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G1 Overview

shows the general topology of a Wireless Linear Network. RF frequency assignments are such that each node in the network has at most two neighbors with which it can communicate directly. These neighbors are referred to as the **left** and **right** neighbors. Following are some characteristics of the Linear Network:

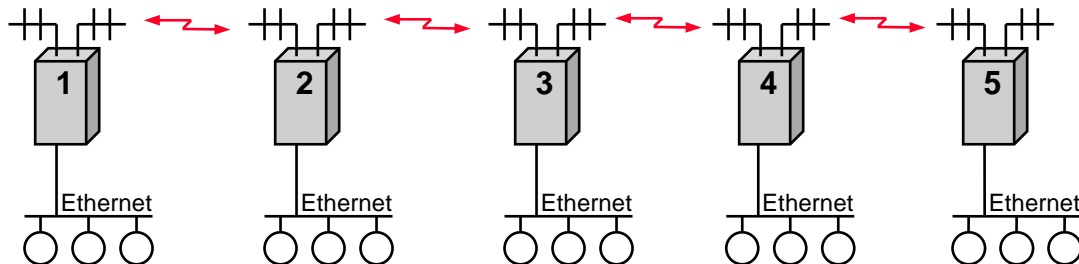


Figure G1 Linear Network Topology

1. Each node consists of a single radio with two RF ports. Typically a node is deployed with two directional antennas pointing at each of the node's neighbors.
2. Each node has an Ethernet port for connection to a LAN, or directly to the user equipment. When a device is added to the Ethernet Table of a node radio, that information is broadcast to the left and right neighbors.
3. A packet can enter the linear network at any node, through the Ethernet port. If the packet is addressed to a station at a remote LAN, the radio transmits the packet to its right or left neighbor as necessary. The packet may then go through multiple hops in one direction until it exits the linear network at its destination.
4. When a packet goes through multiple hops, the packet does not show up at the local LANs of the intermediate nodes.
5. The network supports broadcast packets, which are transmitted, left and right, until they show up at every local LAN.
6. The behavior described in the above paragraphs is self-learned. No user configuration is required.
7. In the Linear Network all radios are peers, there is no master radio providing synchronization, and therefore no single point failure.
8. If a node fails, the two segments of the original linear network continue to operate as two separate linear networks. Once the failed node is reactivated, the two networks automatically merge into one.

9. The radios sort all messages to be transmitted over the air into four priority levels and always transmit the higher priority messages ahead of lower priority.
10. The basic Linear Network topology can be expanded and combined with other A53325 topologies, including Point-to-Point and Point-to-Multi-Point. shows an example of these combinations.

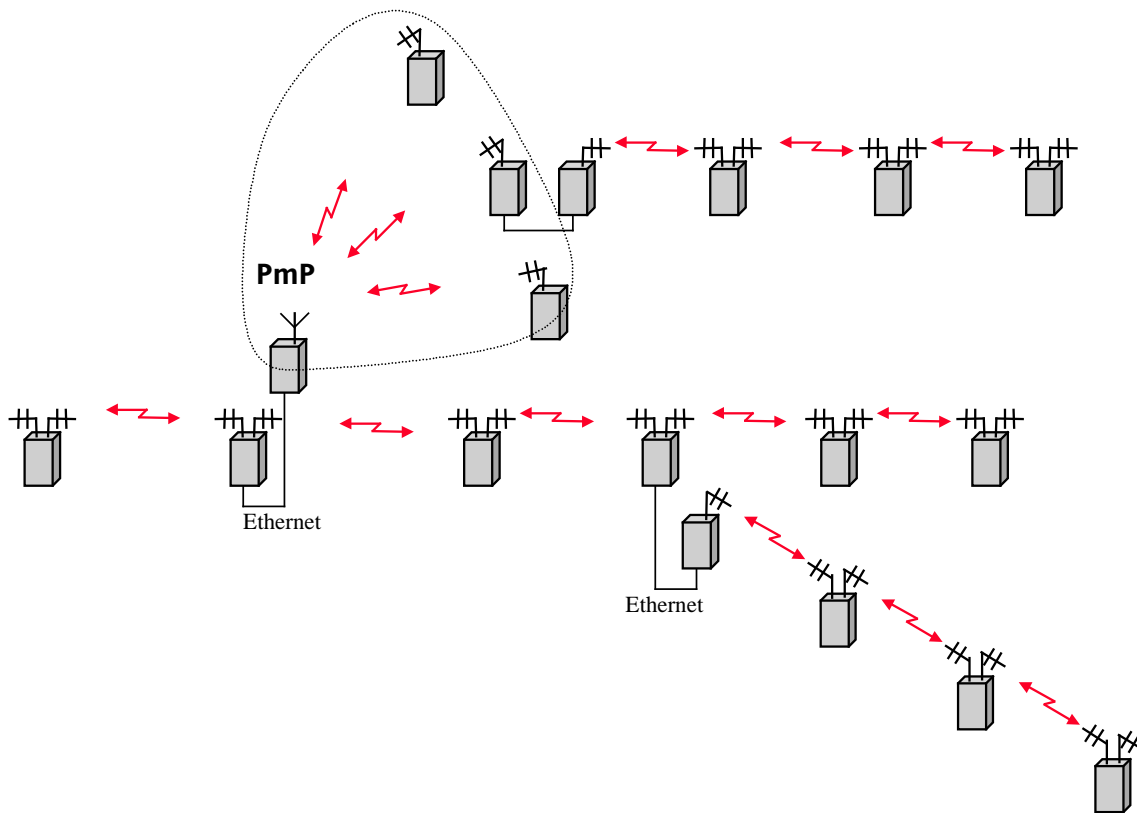


Figure G2 Expanded Network Topology Example

G2 Operation

G2.1 Cycle Timing

The radios have two RF ports. The RF front end of the radio can be switched, under software control, to either of the two antennas. The radios are half duplex, i.e. they can either transmit or receive. Therefore, at any given time, a radio can be doing one of four actions, as described below.

Each of the four actions occurs in fixed time slots. All radios execute the same four phase cycle, consisting of the following phases in order:

1. Transmit to the Left (TL)
2. Transmit to the Right (TR)
3. Receive from the Right (RR)
4. Receive from the Left (RL)

The total cycle time is 20 ms, with each phase lasting approximately 5 ms.

Once synchronized, adjacent radios have their respective cycles offset by exactly two slots.

shows how a synchronized network operates over time.

Table G1 Time Slotted Operation Of A Synchronized Linear Network

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|----|--------|-----------|-----------|-----------|-----------|-----------|-----------|
| TL | | RR ← f1 ← | TL | RR ← f2 ← | TL | RR ← f1 ← | TL |
| TR | → f1 → | RL | TR → f2 → | RL | TR → f1 → | RL | TR → f2 → |
| RR | ← f1 ← | TL | RR ← f2 ← | TL | RR ← f1 ← | TL | RR ← f2 ← |
| RL | | TR → f1 → | RL | TR → f2 → | RL | TR → f1 → | RL |
| TL | | RR ← f1 ← | TL | RR ← f2 ← | TL | RR ← f1 ← | TL |
| TR | → f1 → | RL | TR → f2 → | RL | TR → f1 → | RL | TR → f2 → |
| RR | ← f1 ← | TL | RR ← f2 ← | TL | RR ← f1 ← | TL | RR ← f2 ← |
| RL | | TR → f1 → | RL | TR → f2 → | RL | TR → f1 → | RL |
| TL | | RR ← f1 ← | TL | RR ← f2 ← | TL | RR ← f1 ← | TL |
| TR | → f1 → | RL | TR → f2 → | RL | TR → f1 → | RL | TR → f2 → |

(time)

G2.2 RF Channel Plan

The radio configuration is field programmable with respect to the various frequencies, used to communicate with the left and right neighbors. A complete linear network can be deployed using only two non-overlapping frequencies as shown in . This frequency plan assumes that the signal level at a radio five hops away will always be significantly below the signal from a neighboring radio (example: node 6 in slot 1 is exposed to the signal from node 5 but also from node 1 on the same frequency).

A different frequency plan, using more non-overlapping frequencies, can be used when the assumption above is invalid. The A53325 has 12 non-overlapping channels. below shows a different approach using more non-overlapping channels:

Table G2 Frequency Allocation

| | | | | | | | | | | | | |
|----------|---|-----|-----|------|------|------|------|------|------|-----|-----|------|
| Node: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| Channel: | | ←5→ | ←6→ | ←15→ | ←16→ | ←25→ | ←26→ | ←35→ | ←36→ | ←5→ | ←6→ | ←15→ |

The use of overlapping channel in adjacent links is not a problem since in the Linear Network only every other link is active at one given time. However you should avoid using the exact same channel in adjacent links. This prevents the possibility of the wrong link getting established inadvertently (for example, if you had used channel 5 between nodes 2 and 3 above, a link could get established between nodes 1 and 3 if node 2 was powered down).

In this approach the first time we repeat a channel is after 8 hops. If this was a problem you could use channels 7,8 instead of 5,6 between nodes 9, 10 and 11.

G2.3 Data Throughput

The throughput across a single hop in the linear network is about half of what you would get in a Point-to-Point link. The reason is that each node divides its time, half to communicate with a left neighbor and the other half with the right neighbor. With the RF speed set to the maximum value of 2.75 Mbps (half duplex), the effective throughput between any two nodes is about 550 Kbps full duplex. Note that you could have communications between nodes 1 and 2 and, at the same time, between 2 and 5 (for example) without affecting each other, i.e., both could be running at ~550 Kbps simultaneously. In this example node 2 would be offering a total throughput of 2.2 Mbps (550 Kbps full duplex in each direction).

The end nodes of a linear network (furthest to the left and furthest to the right) are always looking for new neighbors to expand the linear network. In order to make sure that a new neighbor is always found, irrespective of cycle offset, the end nodes of a network "steal" one cycle every 20 to look for a new neighbor. This approach degrades the throughput capacity of

the end nodes by about 5%. You can avoid this degradation by configuring a known end nodes as a **left** node and/or a **right** node (see the command `>node type=xxx`).

G2.4 Latency

When a packet enters a node in the linear network it will take anywhere between 0 and 20 milliseconds for it to be forwarded in the correct direction (see Table G1). After the first transmission the message performs one hop every 10 ms. Therefore to cross N hops, the average and maximum delay experienced by a packet will be:

Average delay across N hops = $10 \times N$

Maximum delay across N hops = $10 \times (N+1)$

This assumes that the linear network is not congested. If the packet encounters a congested area it may be delayed further according to the packet priority.

G2.5 Bridging Algorithm

From a packet switching point of view, the radios operate as a three port switch, switching packets at layer 2 of the OSI model. They implement a self-learning bridge algorithm that allows them to switch the packets appropriately with no user configuration. This is briefly described below.

The radios operate the Ethernet port in “promiscuous” mode, thereby accepting every packet traveling in the local LAN. All Ethernet packets contain a source and destination address that identifies the physical addresses of the sending and receiving device. A radio collects all the source addresses into its “Ethernet address table”, and tags those addresses as **local** (i.e. these devices are reachable through the Ethernet port).

The radios perform a similar algorithm when they receive a data packet over RF (left or right). In this case, the radio examines the Ethernet source address of the packet (the complete Ethernet packet is encapsulated in an RF frame). It enters that address into its address table tagged as being on the radio left or right side as appropriate.

The address table also includes a time tag of when the address entry was last updated. Once in a while the radios scan the address table and delete any entries that have not been updated for a specified timeout. This allows the network to adapt to situations where a device is moved from one LAN to another. The station timeout is configurable from as low as 5 seconds to as high as 24 hours. Large timeouts are appropriate if some devices generate packets very sporadically but need to receive them frequently.

With this mechanism, each radio in the linear network builds an address table that contains the addresses of most stations across the entire linear network, and whether they are local or can be reached through the right or left RF ports. With this table on hand, when a radio receives an

Ethernet packet, on any port, it checks if the destination address is in the table, and if so, transmits the packet on the port indicated in the table (but if the packet arrived at the port that is supposed to go out on, the radio discards the packet instead).

If the destination address is not in its address table, or is the broadcast address, the radio transmits the packet on the other two ports.

With this self-learning algorithm, when the linear network is first powered up, there is a large amount of broadcast traffic since the address tables are empty. However this broadcast traffic causes all the tables to be populated and it will soon subside.

G2.6 Priority Queues

As packets arrive into a radio from any port, the bridging algorithm determines if the packets need to be transmitted over RF. If so the radio queues the packets into one of several priority queues. Starting with the highest priority. Packets are classified as follows:

- Vital packets: These are UDP packets with a specific destination UDP port number. This port number is part of the field programmable radio configuration (see command `udp`).
- High-Priority: These include network management packets for “ECON” command sessions, and also IP packets with a value in the “Type-Of-Service” indicating high priority. The radio interprets the IP TOS field per the IETF *differentiated services (DS)* definition as shown below:

| | | | | | | | |
|-----------|---|---|---|---|---|--------|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Codepoint | | | | | | Unused | |

When the codepoint field has the value **xxx000**, the three most significant bits are interpreted as **precedence** bits. The radio gives high priority to packets with a precedence field of 6 or 7.

- Low-priority: All other packets.

When the time to transmit over RF arrives, the software always takes packets from the higher priority queues first.