Apollo

by Wireless Interactive

PRODUCT MANUAL

November 2006

Wireless Interactive
23112 Alcalde Drive, Suite C
Laguna Hills, CA 92653

Tel: +1 949 215 6277
Fax: +1 949 215 6278

Customer Service

Wireless Interactive provides customer service during normal U.S. Pacific Coast business hours and may be reached by voice, fax, or email as follows:

Tel: +1 949 215 6277
Fax: +1 949 215 6278
email: cs@wirelessinteractive.com

If you must return the equipment, please contact us for a Return Material Authorization (RMA) number. Equipment should be shipped to:

Wireless Interactive
23112 Alcalde Drive, Suite C
Laguna Hills, CA 92653
U.S.A.

STATEMENT OF WARRANTY

Wireless Interactive Comm.,Inc. (Collectively referred to as "WICI“) products, except as otherwise stated in an applicable price list, are warranted against defects in workmanship and material for a period of one (1) year from date of delivery as evidenced by WICI's packing slip or other transportation receipt.

WICI's sole responsibility under this warranty shall be to either repair or replace, at its option, any component which fails during the applicable warranty period because of a defect in workmanship and material, provided CUSTOMER has promptly reported same to WICI in writing. All replaced Products or parts shall become WICI's property.

WICI shall honor the warranty at WICI's facility in Laguna Hills, California. It is CUSTOMER's responsibility to return, at its expense, the allegedly defective Product to WICI. CUSTOMER must notify WICI and obtain shipping instructions prior to returning any Product. Transportation charges for the return of the Product to CUSTOMER shall be paid by WICI within the United States. For all other locations, the warranty excludes all costs of shipping, customs clearance and other related charges. If WICI determines that the Product is not defective within the terms of the warranty, CUSTOMER shall pay WICI all costs of handling, transportation and repairs at the prevailing repair rates.

All the above warranties are contingent upon proper use of the Product. These warranties will not apply (i) if adjustment, repair, or parts replacement is required because of accident, unusual physical, electrical or electromagnetic stress, negligence of CUSTOMER, misuse, failure of electric power environmental controls, transportation, not maintained in accordance with WICI specifications, or abuses other than ordinary use (ii) if the Product has been modified by CUSTOMER or has been repaired or altered outside WICI's factory, unless WICI specifically authorizes such repairs or alterations; (iii) where WICI serial numbers, warranty date or quality assurance decals have been removed or altered.

WICI also reserves the right to make product improvements without incurring any obligation or liability to make the same changes in Products previously manufactured or purchased. In no event shall WICI be liable for any breach of warranty in an amount exceeding the net selling price of any defective Product. No person, including any dealer, agent or representative of WICI is authorized to assume for WICI any other liability on its behalf except as set forth herein. Nonpayment of any invoice rendered within the stated payment terms automatically cancels any warranty or guarantee stated or implied. If any payment is due WICI for services performed hereunder, it shall be subject to the same payment terms as the original purchase.

WICI HEREBY DISCLAIMS ALL IMPLIED WARRANTIES OF PRODUCTS INCLUDING WITHOUT LIMITATION, ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The warranties expressly stated herein are the sole obligation or liability on the part of WICI arising out of or in connection with the sale or performance of the products.

Products Manufactured by Others - For the products not manufactured by WICI the original manufacturer's warranty shall be assigned to CUSTOMER to the extent permitted and is in lieu of any other warranty, express or implied. For warranty information on a specific product, a written request should be made to WICI.

IN NO EVENT WILL WICI BE LIABLE TO CUSTOMER FOR (i) FOR REPROCUREMENT COSTS; (ii) SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES; (iii) ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS ARISING OUT OF OR IN CONNECTION WITH THIS AGREEMENT, OR THE USE OF PERFORMANCE OF WICI PRODUCTS, REGARDLESS OF WHETHER THE CAUSE OF ACTION IS IN CONTRACT, TORT, INCLUDING NEGLIGENCE, OR ANY OTHER FORM.

No action, whether in contract or tort, including negligence, arising out of or in connection with this Agreement, may be brought by either party more than eighteen (18) months after the cause of action has accrued, except that an action for nonpayment may be brought within eighteen (18) months of the date of last payment.

FCC Notice

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved in writing by Wireless Interactive may void the user's authority to operate this equipment. Wireless Interactive can not accept any financial or other responsibilities that may be the result of your use of this information, including direct, indirect, special, or consequential damages. Refer to warranty documents for product warranty coverage and specifics.

TABLE OF CONTENTS

1 **1 ......PRODUCT DESCRIPTION 1-1**

1.1 RADIO OVERVIEW 1-1
1.2 RADIO COMPONENTS 1-2
1.3 RADIO CONNECTORS 1-3
1.4 POWER INSERTER UNITS 1-4
1.5 OUTDOOR INTERCONNECT CABLE 1-6

2 **2 ...... THEORY OF OPERATION 2-1**

2.1 NETWORK TOPOLOGIES 2-1
2.1.1 Firmware builds 2-1
2.1.2 Point to Multipoint topology 2-1
2.1.3 Point to point topology 2-2
2.2 TIME DIVISION DUPLEX 2-2
2.2.1 Fixed and varibale cycle split 2-2
2.2.2 On demand bandwidth allocation 2-2
2.2.3 Automatic Remote Association 2-3
2.3 BURST SYNC - OVERCOMING INTERFERENCE 2-3
2.3.1 Radio co-location 2-3
2.3.2 Co-located radios self-interference 2-4
2.3.3 Burst Sync 2-5
2.3.4 Heartbeat packet suppression 2-6
2.4 ETHERNET BRIDGING 2-7
2.4.1 Self-learning bridging 2-7
2.4.2 Packet priorities 2-7

3 **3 ...... INSTALLATION AND SETUP 3-1**

3.1 BENCH CHECK OUT 3-1
3.1.1 Using the radio Ethernet connection 3-1
3.1.2 Using the radio auxiliary port 3-2
3.2 FIELD INSTALLATION 3-3
3.2.1 Mounting Bracket installation 3-3
3.2.2 Earth Grounding 3-4
3.2.3 Power/Ethernet cable 3-5
3.2.4 Antenna Installation 3-6
3.2.5 Antenna Alignment 3-7
3.2.6 Radio Configuration 3-7
3.2.7 Spectrum Analysis and channel selection 3-8
3.2.8 Output Power Limits (FCC) 3-9
3.2.9 Output Power Limits (CE) 3-9
3.2.10 Maximum Permissible Exposure (MPE) Limitations 3-9
3.3 UPGRADING THE FIRMWARE. 3-10
3.3.1 Description 3-10
3.3.2 Installing new firmware through the Ethernet port 3-11
3.3.3 Installing new firmware using Telnet 3-13
3.3.4 Installing new firmware using the RS-232 serial port 3-14
3.3.5 Feature upgrades 3-15

4 **4 ...... COMMANDS 4-1**

4.1 CONFIGURATION TECHNIQUES 4-1

4.2 COMMAND SYNTAX 4-2
4.3 CONFIGURATION MANAGEMENT COMMANDS 4-3
4.4 MAJOR CONFIGURATION PARAMETERS 4-5
4.5 INTERNET PROTOCOL (IP) MANAGEMENT COMMANDS 4-9
4.6 INSTALLATION AND LINK MONITORING COMMANDS 4-10
4.7 FILE UTILITIES 4-13
4.8 EVENT LOGGING COMMANDS 4-16
4.9 MISCELLANEOUS COMMANDS 4-17

5 5 ..... NETWORK MANAGEMENT 5-1

5.1 TELNET 5-1
5.1.1 General 5-1
5.1.2 Starting a Telnet Session 5-1
5.1.3 Telnet Security 5-2
5.2 SNMP 5-2
5.2.1 Command Line Interface Versus SNMP 5-2
5.2.2 What is SNMP? 5-3
5.2.3 Security Considerations in SNMP 5-3
5.2.4 Examples of Network Management Systems 5-4
5.2.5 APOLLO-24 Management Information Base (MIB) 5-4

6 6 ..... ANTENNAS, SITE SELECTION & PATH ANALYSIS 6-1

6.1 LINK BUDGET CALCULATIONS 6-1
6.2 ANTENNA SELECTION 6-2
6.2.1 Antenna Types 6-2
6.2.2 Directionality 6-2
6.2.3 Gain 6-3
6.2.4 Polarization 6-3
6.3 SITE SELECTION 6-4
6.3.1 Line-of-Sight Path 6-4
6.3.2 Radio Horizon (Maximum Line-of-Sight Range) 6-5
6.3.3 Antenna Orientation 6-6
6.3.4 Cable Loss (Attenuation) 6-7
6.3.5 Connector Loss 6-7
6.4 POINT-TO-POINT RF PATH ANALYSIS 6-8
6.4.1 Antenna Height Analysis 6-8
6.4.2 Receive Signal Strength Calculation 6-10

7 APPENDIX A – COMMAND SUMMARY 1

8 APPENDIX B - SPECIFICATIONS 1

9 APPENDIX C – CHANNEL FREQUENCY ASSIGNMENT 1

10 APPENDIX D – ETHERNET CONSOLE PROGRAM 1

11 APPENDIX E – CABLE DIAGRAMS 1

1 PRODUCT DESCRIPTION

1.1 Radio Overview

The *APOLLO-24* Wireless Ethernet Bridge 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 50 miles (80 Km) and beyond. It can be deployed in point-to-point or point-to-multipoint configurations.

The *APOLLO-24* 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.

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 is 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 *APOLLO-24,* the 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.

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 unit. 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.

The *APOLLO-24* is Burst Sync capable. In Burst Sync mode all radios synchronize their transmissions such that any co-located radios all transmit and receive at the same time, thereby avoiding self-generated interference. This technique allows deploying large networks with sites where upwards of 24 radios are co-located without self-interference.

The *APOLLO-24* can be configured over a local serial interface or over the Ethernet using the Ethernet Console Utility. 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 Radio Components

Table 1.1 below shows the part numbers of various components and accessories that are available in connection to the *APOLLO-24* radio. Some of these components are optional and may be purchased separately.

Refer to section 3.2, Field Installation, for a description on how to assemble some of these components.

Table 1.1 - *APOLLO-24* Components and Accessories

Description	Part No.
APOLLO-24 outdoor unit.	APOLLO-24
Bracket hardware for securing the *APOLLO-24* unit to an outdoor mast.	WIKIT-060110
Ground Lug and washer for connection to Earth Ground	
AC Power Inserter Module with 110-240 VAC power supply	WIPWI-010310
DC Power Inserter Module with pigtail for external DC connection ([1])	WIPWI-010610
DC/DC converter for operation from –48 VDC ([1])	WIPWS-014810
CD with this Operator's Manual, Econsole program, and other application notes.	
CAT 5 cable for connection between *APOLLO-24* radio and power inserter module ([1])	WI7919A-0503-xxx
Auxiliary port cable for RS-232 connection ([1])	WICBL-040310
Auxiliary port cable with Audio jack for antenna alignment ([1])	WICBL-040410
2.4 GHz Lightning arrestor for the antenna ports ([1])	WIALLSXM-ME
Surge suppressor for the Ethernet and Power CAT5 cable ([1])	WICAT5PS-I

1 Not supplied with standard radio kit. Available from Wireless Interactive as optional equipment.

1.3 Radio Connectors

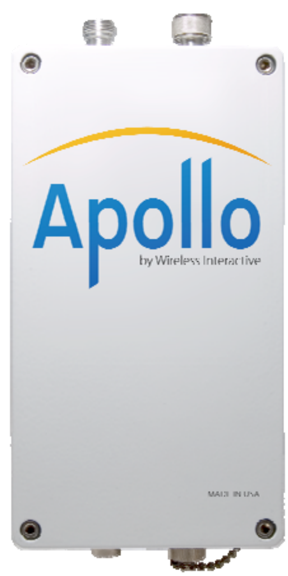
Figure 1.1 shows the *APOLLO-24* radio mounted on a mast. The radio is housed in a rectangular enclosure with two N-female connectors at the top for connection to RF antennas, and two special purpose connectors, at the bottom, for DC power, Ethernet data and control.

The function of each connector is described in the table below.

Table 1.2 – *APOLLO-24* Connectors

CONNECTOR	TYPE	Function
A	N-FEMALE	2.4 GHz RF connector to antenna A
B	N-FEMALE	2.4 GHz RF connector to antenna B
C	Lumberg 3 pin male	Auxiliary port (3 pin) used as an antenna alignment aid and for RS-232 console port.
D	Lumberg 8 pin male	10/100 Base-T data interface and DC power input (8 pin). Must be connected to the "Power Inserter Unit" with a CAT 5 cable.

Figure 1.1. Apollo Outdoor Unit



An eight conductor CAT 5 cable must be connected between the *APOLLO-24* and the Power Inserter Unit. The wiring for this cable is shown in Figure 1.3.

Table 1.3 shows the pin assignment of the three pin auxiliary port connector. The unit is shipped with a cover in this connector. The connector can be used during installation as a console port and also as an audio antenna alignment aid. Wireless Interactive has available two cables to convert from this non-standard 3-pin connector to either a DE-9 connector (for RS-232 console) or to a standard audio jack (for connection to a headphone). See Appendix E for cable diagrams.

Table 1.3 – Auxiliary Port Connector Pin Assignments

Pin	Signal Name	Abbr.	Direction
1	Receive Data	RD	Radio Output
2	Transmit Data	TD	Radio Input
3	Ground	GND	

1.4 Power Inserter Units

The Power Inserter Unit is a small indoor module that injects DC power into the unused lines of the Ethernet CAT5 cable. There are two models (figure 1.2), one for operation from an AC source (110-240 VAC), and the other for operation from a DC source (10 to 28 VDC). If your DC supply is –48 VDC Wireless Interactive also carries a DC/DC converter that you can use in conjunction with the DC Power inserter.

The Standard AC Power Inserter Unit includes a power supply for connection to an AC outlet (110-240 VAC), two RJ45 connectors and a bi-color LED. The two RJ-45 connectors are labeled "To LAN" and "To Radio".

The DC Power Inserter Unit has two RJ45 connectors labeled "Data In", "P+Data Out", a green LED, and a 10 ft pigtail cable for connection to your DC supply voltage or the DC/DC converter.

Figure 1.2 – Power Inserter Units and DC/DC Converter

Table 1.4 – Power Inserter Units

Connector/LED	Type	Function
To LAN DATA IN	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 cross over cable to connect directly to a computer. See table 1.5 for pin assignments.
To radio P+DATA OUT	RJ-45	Carries the DC power and Ethernet signals to the *APOLLO-24*. See table 1.6 for pin assignments.
LED (AC Power Inserter)	Amber/ Green	**Amber**: Indicates that the power inserter unit has power from the wall supply but no power is being drawn by the *APOLLO-24*. **Green**: Indicates that the *APOLLO-24* is drawing power.
LED (DC Power Inserter)	Green	Indicates that there is DC power in the pigtail input

WARNING

The Power Inserter connectors labeled "To radio" or "P+DATA OUT" includes DC voltage in two of the pins. It must **not** be connected to a LAN as this voltage may damage some LAN cards.

Table 1.5 – "To LAN" (DATA IN) 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 1.6 – "To radio" (P+DATA OUT) 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

1.5 Outdoor Interconnect Cable

The interconnect cable between the Power Inserter Unit and the *APOLLO-24* carries the following signals

1. DC voltage to supply power to the *APOLLO-24*.
2. 10/100 Base-T Ethernet data.

Both these signals are carried in a single CAT 5 cable. The system is designed to allow cable lengths up to 100 meters (300 feet). Figure 1.3 shows the interconnect diagram for this cable and connector types. Table 1.7 lists a few part numbers and sources of appropriate CAT 5 cable for this application. Wireless Interactive offers custom length cables. See Appendix E for connector diagrams, part numbers, and assembly instructions.

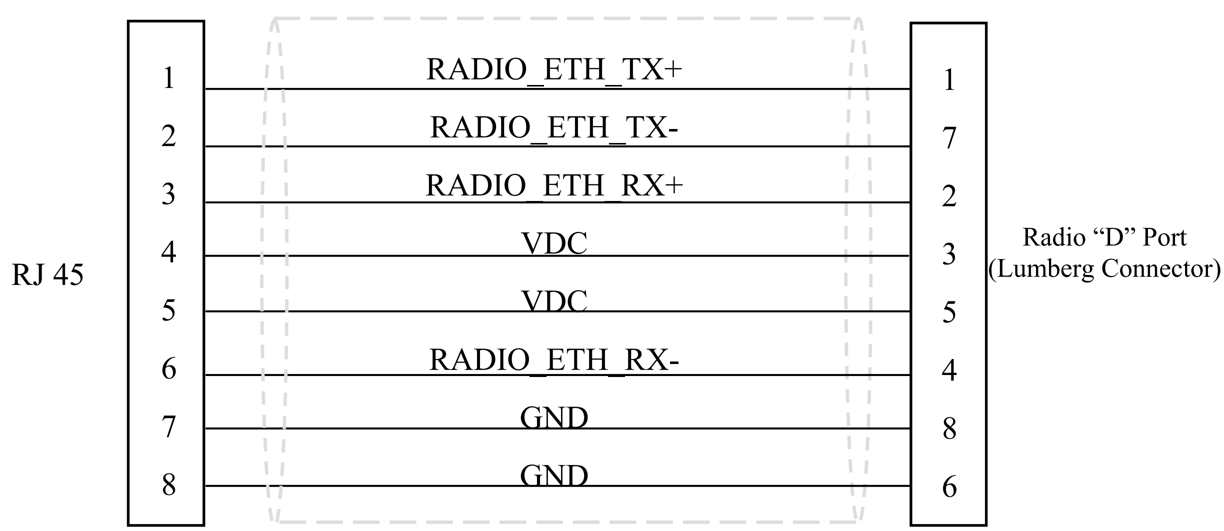


Figure 1.3 - CAT 5 Outdoor Interconnect cable diagram

Table 1.7 – Indoor/Outdoor Unit CAT 5 cable

Part number	Manufacturer	Description
WI7919A	Wireless Interactive	Shielded outdoor rated CAT5e cable, FTP
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

2 THEORY OF OPERATION

2.1 Network Topologies

2.1.1 Firmware builds

You may use the APOLLO-24 to deploy a wireless network in various topologies, including Point-to-Point (PtP), Point-to-Multi-Point (PTMP) and also a Linear Network topology. The radio non-volatile memory can hold various programs at any given time but only one program can be running at a time (use the **`>directory`** command to view all the files loaded into the radio memory). The different software programs are identified in the table below. The filename itself identifies the version of the software. The file PMP04_XX for example, is version 4.XX of the Point to Multipoint software (in the actual filename the XX is replaced with digits 0 through 9).

Topology	File Name
Point to Multi-Point	PMP04_XX
Linear Network	LNW04_XX

This manual covers the Point-to-Point and Point-to-Multi-Point operation. A separate Manual covers the Linear Network topology.

Prior to version 4.00 of the firmware there was a separate firmware built for deploying of a Point-to-Point link (P2P03_XX). With version 4.00 and later you deploy a point-to-point link using the PTMP firmware with the configuration optimized for point-to-point.

2.1.2 Point to Multipoint topology

In a Point to Multi-Point topology one radio is designated as the **`hub`** (or basestation), and all other radios are designated as **`remotes`**. The hub radio must communicate with all of the remotes, therefore it is typically deployed with an omnidirectional or a sectorial antenna. The remote radios only communicate with the hub radio, therefore they are typically deployed with a directional antenna pointing at the hub.

A hub radio can support up to 32 remote radios. If your network grows beyond that limit of Burst Sync, the radios allow you to easily add more hub radios that co-exist without generating self-interference.

There is no difference in the hardware between a hub and a remote device. However, you may need to obtain a key from the factory to enable a radio to operate in hub mode.

2.1.3 Point to point topology

In a point-to-point topology you only have two radios establishing a single link. When the end points 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.

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. Hub radios can be configured to accept a specific maximum number of remotes (see command "**`node`**"). By setting this parameter to one the link is optimized for operation in point-to-point.

2.2 Time Division Duplex

2.2.1 Fixed and varibale cycle split

The APOLLO-24 radio operates in Time Division Duplex (TDD) mode meaning that the radio operates in a **`cycle`** consisting of two phases: the first phase is used for **`outbound`** transmissions (from hub to remotes) and the second phase for **`inbound`** transmissions (from the remotes to the hub). Total cycle time is fixed at 20 ms. However the APOLLO-24 provides great flexibility in determining the "split" between the outbound and inbound phases.

At the hub radio you can configure the cycle split in the following ways:

Fixed cycle split: You can specify the cycle split in 10% nominal increments from 10/90 (outbound/inbound) all the way to 90/10. The advantage of a fixed TDD split is that it allows co-locating multiple radios and completely avoiding self-generated interference. This is achieved through Burst Sync explained in section 2.3. The fixed split may also be appropriate in applications where the data traffic is constant and with pre-determined throughput.

Automatic cycle split: in this mode the hub radio changes the cycle split dynamically based on the amount of traffic queued up in each direction. If you have a point-to-point link or a point-to-multipoint network with no co-located radios and bursty traffic, then the automatic cycle split will typically deliver the best performance.

2.2.2 On demand bandwidth allocation

The complete TDD cycle is divided into 20 slots of approximately just under 1 ms each. In automatic cycle split mode, the hub 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 hub radio allocates the bandwidth on demand to each remote. If there is no traffic to a specific remote, the hub does not transmit any packets to that remote. When the hub has packets to multiple remotes, it distributes the available bandwidth evenly so that all remotes get equal throughput.

The hub 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 remotes decode this packet and only transmit if they have been assigned one or more slots during the inbound phase.

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

Once in a while the hub allocates a single slot to remotes 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.

2.2.3 Automatic Remote Association

When a new remote radio is first powered up, it listens for transmissions from a hub radio. Since the hub radio starts the cycle with a broadcast packet (containing the inbound slot allocation), the remote radio receives these packets and synchronizes its TDD cycle to that of the hub.

Once in a while the hub radio allocates the first inbound slot for an invitation to new remote nodes to join the network. When the new remote detects this invitation, it transmits, on the first slot of the inbound phase, an **`attach request packet`**. The hub authenticates the remote, and replies, during the outbound phase, with an accept or reject packet. Once the remote receives the accept packet the association is complete and the units start passing data packets.

If multiple remotes transmit the **`attach request packet`** at the same time, there may be a collision preventing the hub from receiving either packet. When the remotes do not get an accept or reject packet in response to their attach request, they realize that there was a collision. The remotes will then perform a backoff collision avoidance algorithm that spreads their next attach request transmissions allowing all remotes to quickly join in.

You can specify the maximum number of remotes that a hub may acquire (use the **node** command). Once the hub acquires this maximum numbers of remotes it stops allocating the first slot to attach request packets, therefore increasing the inbound throughput slightly.

2.3 Burst Sync - Overcoming Interference

2.3.1 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 Point-to-Multipoint 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 you might deploy a central site with six hub radios for example, each one feeding a sector antenna covering 60 degree sectors.

2. The number of remote radios serviced by a single hub has grown to a point where the shared bandwidth is no longer adequate. You may then add a second hub radio operating on a different channel and split the remotes between two or more hubs.

3. You want 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.

2.3.2 Co-located radios self-interference

The self-interference situation is illustrated in Figure 2.1, that shows radio A transmitting on channel f1 while a co-located radio is trying to receive on channel f2. Because the antennas are in close proximity, antenna B will pick up a significant portion of the signal transmitted by radio A.

Figure 2.1also 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.

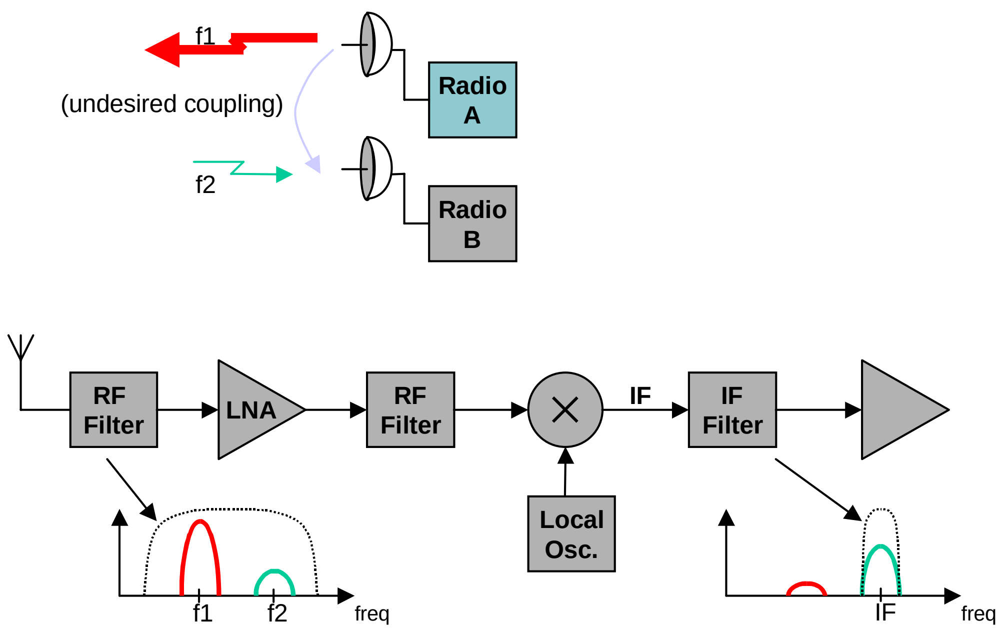


Figure 2.1– Co-located radio interference

The traditional approaches to reduce this self-interference include:

- Separate the antennas of the two radios further apart.
- Use different antenna polarizations.
- 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 Wireless Interactive Burst Sync technology implements a synchronization scheme that completely eliminates this self-interference allowing you to co-locate a much large number of radios. This is explained in the following sections.

2.3.3 Burst Sync

The APOLLO-24 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 2.1 altogether. With a synchronized site you can then deploy upwards of 24 radios at the same location.

The key to Burst Sync is the generation and distribution of the synchronization information or **heartbeat.** All the different software builds implement the same synchronization protocol, so you can build networks that mix different topologies (PTP, PTMP and Linear Networks) and yet keep all radios synchronized. At any site where there is more than one device co-located the devices 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 2.2 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.

2. In the Linear Network the TDD split is always 50/50. Therefore if the total network includes a section with one or more linear networks you must specify a 50/50 split in all networks.

3. The most typical situation where you would use an asymmetric split is when you have mutliple hubs in a point to multipoint application with asymmetric traffic. You must configure all the hubs with the same TDD split. All the remotes automatically set their TDD split to the complement of the hubs (if the hubs were set to transmit 70%, the remotes will automatically be set to transmit 30%). If you then co-locate a radio with any of those remotes, it needs to have its TDD split set to transmit 30%. This restriction makes the 50/50 split the most natural when the network starts growing in complexity.

4. A remote radio synchronizes its cycle to the hub. Therefore if it is co-located with another radio it must be the source of the heartbeat. Any other radio co-located with the remote can only be a hub or a leftmost node of a linear network.

5. The same applies to all radios in a linear network other than the leftmost radio. All those radios synchronize their cycles to the respective left radio. Therefore they must be the heartbeat source for that site.

Make sure that all radios have the **tdd sync-mode** set to **auto**. If you follow the above guidelines the radios will spread the synchronization across the network and completely avoid self-interference. At any device use the **">show**" command to find which radio is the source for the heartbeat at that site.

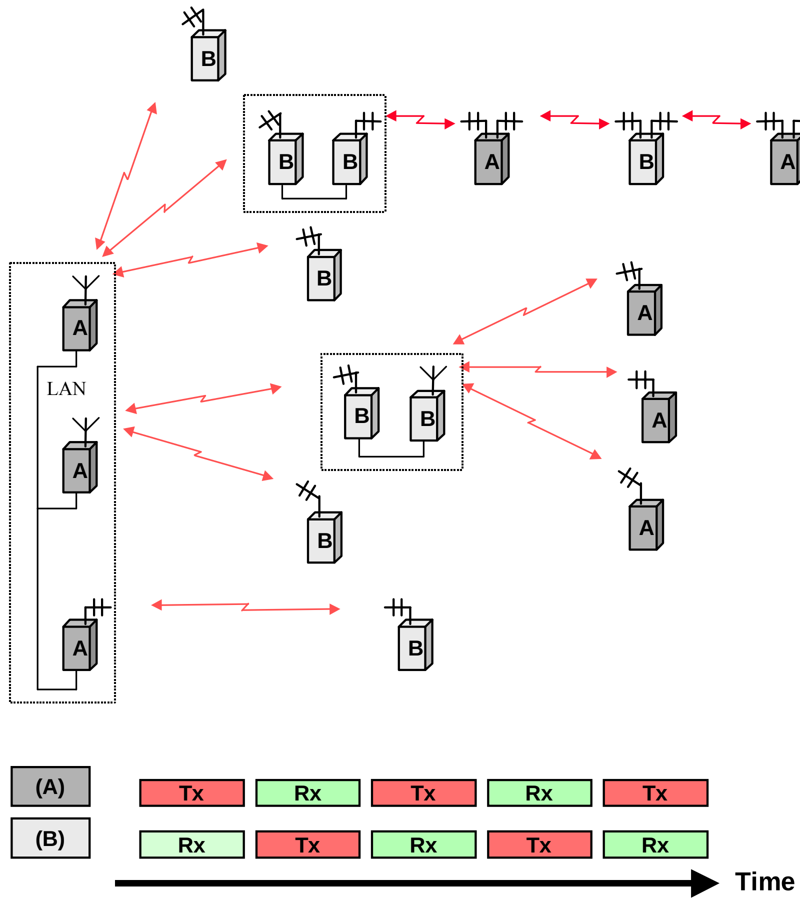


Figure 2.2– Mutliple Topology Network

2.3.4 Heartbeat packet 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 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.

2.4 Ethernet Bridging

2.4.1 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 PTMP 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 PTMP 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
```

2.4.2 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:

- 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.

3 INSTALLATION AND SETUP

> **NOTE**
>
> Appendix F contains a quick set up diagrams showing the minimum configuration and commands necessary to put up a point-to-point link and a point to multipoint network.

3.1 Bench Check Out

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

For this bench check out you need two *APOLLO-24* 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.

3.1.1 Using the radio Ethernet connection

In order to use the Ethernet connection you need the "Ethernet Console Program" (Econsole) provided in 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. 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 *APOLLO-24* 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.
4. Connect the two Power Inserter Units to a power outlet of the appropriate voltage.
5. At 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 are 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. Section 4 describes the command language used to further modify the radio's operating parameters.

3.1.2 Using the radio auxiliary port

1. Connect each *APOLLO-24* 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 *APOLLO-24* 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.

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. Section 4 describes the command language used to perform those functions.

3.2 Field Installation

3.2.1 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. Also install the provided ground lug for connection to the earth ground as described in step 3 of the section below.
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.

In order to secure the radio outdoors place the radio against a pole with the RF connectors facing up (see Figure 1.1). The back of the radio enclosure has four guiding feet that prevent it from sliding from side to side. Place the V bracket around the pole, sliding its two grooves up into the aluminum plate on the back of the radio. Once the grooves reach the stops, manually tighten the L shaped bolt so that it "bites" into the pole.

3.2.2 Earth Grounding

For an outdoor installation you must provide a solid ground connection between the APOLLO-24 metal enclosure and the Earth ground. This will minimize possible damage due to static buildup or nearby lightning.

In locations where it is warranted, you may also want to install a lightning arrestor device at the N type connector of the radio leading to the antenna (Wireless Interactive part no WIAL-LSXM-ME). This is particularly recommended if the coaxial cable between the radio and antenna is of considerable length (greater than 2 meters or 6 ft). If you install the lightning arrestor, follow these same directions but connect the grounding cable to the appropriate screw/lug of the arrestor rather than the radio.

Each radio is shipped with a small ground lug (part no. SLU-35), and a lock washer to facilitate the installation of the ground connection.

You will require some additional supplies that are easily found at a hardware store, namely:

- AWG #6 copper grounding cable (4.1 mm diameter).
- Grounding lug, nut, bolt, lock washer (as required) for attaching the cable to the metal tower or structure.
- Anti oxidizing paste
- Outdoor cable ties (as required)

The following steps describe a procedure for a proper Earth ground connection:

1. Select an adequate grounding point on the tower or structure near the radio. This point should be below the unit and must not be inside the building. If you must drill a hole make sure it is NOT in the tower supports or cross braces. If several outdoor units are installed in the same area you may use the same grounding point.

2. Apply a thin film of anti oxidizing paste to both sides of the supplied grounding lug blade, as well as the threads of the screw used to secure the lug.

3. Install this grounding lug onto the radio enclosure with one of the two screws used to secure the mounting plate. This screw must go through (i) the lock washer, (ii) the grounding lug blade, (iii) the radio mounting plate and finally into the enclosure, in that order. Insure that the cable connector of the grounding lug is pointing downward.

4. Prepare the grounding cable by stripping an adequate amount of insulation from both ends and apply anti oxidizing paste to the exposed copper.

5. Insert one end of the exposed cable into the radio ground lug and tighten the screw on the lug.

6. Use steel wool or sand paper to clean the grounding point on the metal tower or structure.

7. Apply a thin film of anti oxidizing paste to this grounding point surface.

8. Fasten the cable to the grounding point using a lug, bolt and nut as required.

9. If required secure the cable to the tower or structure with cable ties or clips. DO NOT bundle this grounding cable with any other cable used for data, power or RF.

<u>Cautions</u>

When using the anti oxidizing paste read and follow the instructions and warnings for the selected product. In addition you should note the following general guidelines:

- The paste will act as a lubricant, therefore always use lock washers.
- DO NOT apply the paste to RF and data cable connections: the anti-oxidizing paste is conductive and may degrade the performance or damage the equipment.
- DO NOT use electrical or other tape for sealing the grounding connections when using anti oxidizing paste
- DO NOT use thread-locking compound on the same screw with anti oxidizing paste.

Inspect the grounding connections on a regular basis as well as after a lightning strike. Look for cables that may have been damaged or connections that may have loosen up or oxidize over time. Replace any damaged cables or connectors and tighten any loose connections.

3.2.3 Power/Ethernet cable

Connect the outdoor cylindrical connector of the CAT5e cable to port D of the radio. The other end of this cable (with an RJ45 connector) plugs into the indoor Power Inserter Unit.

You can optionally install the Ethernet/Power Surge Suppressor module (WICAT5PS-I) at the point where the CAT5e cable enters the building. This protects your indoor equipment against surges induced by nearby lightning on the outdoor CAT5 cable. The surge suppressor has two RJ45 connectors and a ground wire, which you must connect to an earth ground.

If you use a DC source to power the radio, make sure you do not exceed the CAT5e cable length specified in the table below. At port D the radio requires 8 VDC. With the DC voltages shown (at the power inserter), the maximum cable length results in an input voltage at the radio of 8 VDC. The radio includes a voltage monitor which you can read with the >**show** command. This can be useful to determine the status of your battery for a battery-powered installation.

DC voltage (at power inserter)	Maximum CAT5e cable length (feet)	(meters)
9	51	16
10	103	31
11	155	47
12	206	63
13	258	79

3.2.4 Antenna Installation

NOTICE

The antennas for the *APOLLO-24* 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 *APOLLO-24* 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 2 meters (6 feet). For the *APOLLO-24*, Wireless Interactive provides the three antenna types listed below:

Antenna Type	Gain	Wireless Interactive Model Number
Omnidirectional	9 dBi	WIOD249
Panel	19 dBi	WIPA2419
Dish Reflector	24 dBi	WIDC24x

Antennas at each end of the 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 two directional antennas can be mounted for horizontal or vertical polarization, while the omnidirectional 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. Also use the "coax-seal tape" (included with the radio) to further weatherproof outdoor connections.

In locations where it is warranted, you may also want to install a lightning arrestor device at the N type connector of the radio leading to the antenna (Wireless Interactive part no WIAL-LSXM-ME). This is particularly recommended if the coaxial cable between the radio and antenna is of considerable length (greater than 2 meters or 6 ft).

3.2.5 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. The antenna can then be aligned so that the RSSI is maximized. In the PTMP topology, the hub antenna is typically an omni and dose 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

Since in many applications the antenna is on a tower where it is not practical to have a terminal nearby, the *APOLLO-24* has an additional "antenna alignment aid" available at 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. Wireless Interactive provides a special cable adapter that converts the three-pin connector into a standard female audio jack. Use this cable to connect the three-pin connector to a pair of standard headphones while aligning the antenna. At a terminal session issue the command:

>aaa audio (aaa is an abbreviation for "antenna-alignment-aid")

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

>aaa off

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

3.2.6 Radio Configuration

The *APOLLO-24* 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 section 4 for a complete description of each command.

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 3.2.7 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 3.2.8 or 3.2.9	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

3.2.7 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 *APOLLO-24* includes several features, described below, to identify and overcome sources of interference.

The *APOLLO-24* 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 *APOLLO-24* 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.

3.2.8 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. The table below takes these considerations into account and shows the maximum allowed output power for the various antennas

Maximum Output Power (dBm)

Channel	Frequency (MHz)	Antenna Gain 9 dBi	Antenna Gain 18 dBi	Antenna Gain 24 dBi
3 to 19		23	23	23
20	2440.0	23	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

3.2.9 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 *APOLLO-24* 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.

3.2.10 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". 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.

Minimum Distance calculation to avoid Antenna Radiation Hazard (exposure of 1 mW/cm^2)

Antenna Gain (dBi):	9	18	24
Max. Output Power	23	23	23
MPE safe distance (cm)	11*	28*	63*

*NOTE: For fixed location transmitters, the minimum separation distance is 2 m, even if calculations indicate a lower MPE distance.

3.3 Upgrading the Firmware.

3.3.1 Description

The operational firmware for the *APOLLO-24* is stored in Flash PROM and can be easily updated. The Flash PROM can hold multiple versions of the firmware simultaneously. The table below 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 section 4.

File Utility command summary

Command	Description
directory	Lists all files stored in Flash PROM
delete-file filename	Deletes the specified file from the directory
download-file path/filename	Downloads the specified file from the PC path/filename into the Flash PROM
set-default-program filename	Sets the indicated filename as the default program to run after power up
run-file filename	loads the indicated program into RAM and executes it.

New firmware versions are made available from time to time at the following page in our website:

http://www.wirelessinteractive.com/support/softwareUpdates.php

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

pmpNN_NN.bz (binary zipped file for downloads through the Ethernet port)
pmpNN_NN.dwn (ascii file for download through the serial port, or via Telnet)

where NN_NN is the firmware version number. The website contains instructions for transferring the files into your PC.

A new file can be downloaded into the radios in one of three ways: (1) Using the "econ" program running in 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 RS-232 auxiliary port. This method only allows you to download to that specific radio.

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

3.3.2 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. Note that new firmware does not need to be compatible with the firmware currently running. You can still download incompatible firmware and restart the network from a single location.

1. If you have not done so, install the utility program "econ" in the PC. This utility program is distributed with the radios and can also be downloaded from the website. Please refer to appendix D for instructions on how to install this utility.

2. Make sure the file with the new firmware (file pmpNN_NN.bz) is available in the PC.

3. Start the econsole utility by typing "econ" from a DOS window. Econ will send a "discovery" message and display all the radios that can be seen. 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 pmpNN_NN.bz file in the PC. If there is not enough space in Flash PROM delete one of the program files to make up space (use command >delete filename).

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:

   >download ***path/*****pmpNN_NN.bz**

   where *path/* is the directory in the PC where the pmpNN_NN.bz 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.

7. Once the download is complete, issue the command:

   >set-default-program pmpNN_NN

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

8. Issue the command:

   >single-node-reboot timeout=60

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

9. Depress 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 for each of the radios.

10. Once all radios in the network have the new program, log onto the hub radio (using econsole) and issue the command:

    >reboot

    to cause that radio to restart using the new firmware.

11. If the new firmware is compatible with the old one, the links will be reestablished in a short time (with the hub running the new version and the remotes running the old version).

    If the new firmware is incompatible with the old one, the links to the remotes will not be reestablished. In this case, after 60 seconds, the remote radio will reboot. They will then load the new firmware and be able to reestablish the links with the hub.

12. Wait at least ten seconds from the moment you entered the reboot command, then press <CR>. Econsole automatically attempts to reconnect to the same radio. Once a new session with that radio is reopened issue the command:

    >version

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

13. Depress 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 and issue the command:

    >version

    and check if that radio is running the new or old version. If the radio is already running the new version repeat this step with the next radio. Otherwise perform the next step.

14. If the radio is running the old 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 the radio is indeed executing the new version.

Note that the file downloads are executed with the link in full operation. The only downtime in the link occurs when the radios are rebooting. The radio configuration is kept intact when a new version is started. The downtime for the radio being restarted, is typically less than twenty seconds. When upgrading to an incompatible version, the downtime will be slightly over one minute.

3.3.3 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 section 5 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 in the local machine. The download software for upgrade via Telnet must have a ".dwn" extension, e.g., pmp03_25.dwn.

2. Initiate a Telnet session with the radio as described in section 5.

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 ends with 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 pmpNN_NN.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 command >delete filename).

5. Start the download process by typing:

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

   where NN_NN 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 insure that the file has been loaded into memory.

8. Issue the command:

   >set-default-program pmpNN_NN

   where NN_NN 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 insure the radio is running the latest version.

3.3.4 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 *APOLLO-24* Auxiliary Port (3 pin circular connector) to a terminal, or a PC running a terminal emulation program. A special adapter cable is supplied by Wireless Interactive. 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 in 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 pmpNN_NN.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 command >delete filename).

7. Start the download process by typing:

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

   where NN_NN 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 insure that the file has been loaded into memory.

10. Issue the command:

    ```
    >set-default-program  pmpNN_NN
    ```

    where NN_NN 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 insure the radio is running the latest version.

3.3.5 Feature upgrades

The *APOLLO-24* 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 your local distributor for a list of optional features available for your radio.

4 COMMANDS

4.1 Configuration techniques

There are three ways to configure the radio. One 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. This port is always set to operate with the following parameters:

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 can not monitor and configure any of the remote radios reachable through RF.

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 at a PC. This PC must be connected to the LAN where one or more *APOLLO-24* 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.

The third configuration method is using Telnet from a remote location. Telnet is explained in more detail in section 5.

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

`rmt-nnnnn #>` (for a remote radio in a PTMP topology)
`hub-nnnnn #>` (for the hub radio in a PTMP topology)

where nnnnn are the last five digits of the radio serial number. If a node "name" has been assigned to the node, the prompt will be that name.

The "help" command provides a list of all the commands available. To get more detailed help for 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.

4.2 Command syntax

The command interpreter in the *APOLLO-24* 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 *APOLLO-24* 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 an 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 notation 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 are contained in Appendices A and B.

4.3 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 can not 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 below:

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 *APOLLO-24* 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.

Examples:

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

WARNING

The *APOLLO-24* is shipped with no password. If the "change-password" command is issued make sure you do not forget the password. Once locked, without a password, the radio must be returned to the factory to be unlocked.

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
```

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
```

lock

This command locks the access to all the commands that can alter the radio configuration. Once locked 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.

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
```

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.

Examples:

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

4.4 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.

distance-max

kilo-meters=16..160
miles=10..100

Sets the limit for the maximum distance of the RF link. In general you should leave this parameter set to the default value of 80 Km (50 miles). But if you are deploying a link that exceeds this distance you must change this parameter to a value that is equal or greater than the link distance.

All nodes in the network must have this parameter set to the same value. For example, in a point to multipoint network where only one link exceeds the nominal 80 Km, you must still set all nodes in the network to the new value.

Increasing this parameter results in a slight decrease of throughput offered by the radios.

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 very long outdoors CAT5 cable, operation at 100 Mbps may become unreliable. For this reason the **auto-10**-setting forces the speed to 10Mbps 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.

Examples:

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

node

type=hub or ***remote***

In a point to multipoint network one radio must be configured as a **hub** while all other radios are configured as **remote**. Typically you would deploy the remote radios with a directional antenna pointing at the hub radio.

max-remotes=1..32 (for PTMP software only)

At the hub radio this value specifies the maximum number of remotes that will be allowed to join in. Once the hub radio has this many remotes it stops allocating a slot for new nodes to join the network. This increases the inbound throughput slightly, specially if the number of remotes is small. For a point-to-point link make sure you set this parameter 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.

Examples:

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

rf-receive-setup

channel=3..37
antenna=a, b

This command configures the channel, and antenna used in the RF reception.

Note that for a remote radio to join the network, the channel selected by this command must match the transmit channel selected for the hub radio.

Example:

```
>rfre ch=15
```

rf-transmit-setup

channel=3..37
antenna=a, b
power-dbm=0..23
speed-mbps= 0.25 or ***0.50*** or ***1.37*** or ***2.75***

This command configures the channel, antenna, transmit power and speed used in the RF transmissions.

You only need to configure the transmit channel of the hub radio. The remote radios will automatically set their transmit channels to match the receive channel of the hub.

Example:

```
>rftr ch=15 sp=2.7 po=18
```

single-node-reboot

timeout-sec=15..20000

After power up, a radio 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 a command is issued remotely to a 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 perform a reset. As a result, the radio reverts to the saved configuration, allowing it to reestablish the original link.

Examples:

```
>snr 60
```

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.

See Section 2.3 (Bust Sync – Overcoming Interference) for a detailed explanation of the synchronization between co-located radios.

cycle-period-ms= 10 or ***20*** or ***30*** or ***40*** (not yet available***)***

At this time this parameter is set at 20 ms and can not be modified.

The cycle period is the total TDD time consisting, at the hub, of the transmit interval followed by the receive interval. Use shorter cycle periods to reduce the latency in the link and larger values to increase the link capacity.

transmit-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 node 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 hub radio dynamically assigns a split based on the current traffic load in each direction. This split may be different from cycle to cycle.

At very low RF speeds (0.25 and 0.5 Mbps) the radio will not allow you to select some of the more asymmetric splits as they would result in packets that are too short to carry any meaningful data.

Select fixed splits if you wish to co-locate multiple radios and avoid self-interference. Select the **auto** mode in a single point to multipoint network without co-located radios. See section 2.2.1 for a more detailed explanation of fixed versus auto tdd splits.

Example:

```
>tdd sync=auto transmit=30
```

4.5 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 section 5 for a more detailed explanation on those two applications.

ip-configuration

address=<ip address>
netmask=<string>
gateway=<ip address>

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.

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
```

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
```

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 with 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 section 5 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 can not 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 refer to the entry number as listed in the "display configuration" report.

Example:

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

4.6 Installation and Link Monitoring Commands

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

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. Wireless Interactive provides a special cable adapter 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.

Example:

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

monitor-flow

At the 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.

monitor-link

node=3 `to` ***n*** `(for a hub in the PTMP software only)`
clear=0 or 1

This command continuously displays link statistics including link status, number of packets received, number of packets lost, and RSSI. At the hub of a PTMP network the node parameter specifies which link to monitor. The number specified must match one of the remote numbers as displayed by the **`show`** command.

The "clear=1" parameter clears the cumulative counts in the report.

Examples:

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

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:

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.

radios table

Only valid at the hub. It displays all the remote radios that are in the network including the RF link statistics (transmit power and RSSI) and link distances.

ethernet-stations table

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

>show ethernet

```
Ethernet Stations:
                                                  --Discard--       --Forward--
 #       MAC address   IP address    Radio   from        to      from        to
 0 ff-ff-ff-ff-ff-ff                   0        0         0         0       183
 1 00-d0-39-00-2d-cb                  -2        0         0       209       165
 2 00-a0-cc-66-8e-a6   207.154.90.171  3      136        54    139575       172
 3 00-d0-39-00-2d-c3                   0        0         0         0         0
```

>show ethernet times

```
Ethernet Stations:
 #       MAC address   IP address  Radio MC  Time added      Idle
 0 ff-ff-ff-ff-ff-ff                   0   29-Nov 16:17:08
 1 00-d0-39-00-2d-cb                  -2   29-Nov 16:17:08   0.01
 2 00-a0-cc-66-8e-a6   207.154.90.171  3   29-Nov 16:17:15   0.00
 3 00-d0-39-00-2d-c3                   0   29-Nov 16:23:41   9.18
```

Both formats list all the ethernet stations attached to any of the radios. The tables list the MAC (Ethernet) address of the station, and, if known, the IP address.

The first entry 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 with 2 representing the local radio and 3 through N the remote radios.

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. In bridge mode the radios are in "promiscuous" mode and look at all the ethernet packets in the Local Area Network. The radios "discard" the packets that are known to be local, but "forward" all other packets to the remote radio. 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.

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.

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 *APOLLO-24* 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
```

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").

Example:

```
>time-analysis input=b-antenna

>tia in=a dis=t dwell=500
```

4.7 File Utilities

The *APOLLO-24* 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 *APOLLO-24* 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.

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.

Examples:

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

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.

Examples:

```
>copy-file tmp/pmp03_25  pmp03_25
```

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.

Examples:

```
>delete pmp03_25
```

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.

Examples:

>dir

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

download 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.

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.

Examples:

```
>run pmp03_04
```

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.

Examples:

```
>sdp pmp03_04
```

4.8 Event Logging Commands

The *APOLLO-24* 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).

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.

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 then as they occur. You can press the space bar to exit this mode.

The **reboot-reasons** region of the event log consist of the last four events that 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
```

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.

Examples:

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

4.9 Miscellaneous commands

date

The *APOLLO-24* 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 below:

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

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.

Examples:

```
>help monitor-link
```

history

Displays the previous commands entered.

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
```

logout

Closes the current Econsole session.

reboot

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

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
```

version

Displays the radio model and software version.

5 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 *APOLLO-24* that are useful for this purpose.

5.1 Telnet

5.1.1 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.

5.1.2 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 section 4. 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 section 4.

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.

5.1.3 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 section 4 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
```

5.2 SNMP

5.2.1 Command Line Interface Versus SNMP

Configuration settings on the *APOLLO-24* are displayed and modified using a command line interface, which can be accessed using either the RS-232 console port, the ECONSOLE program, or via a TELNET session.

In a 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 *APOLLO-24* 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).

5.2.2 What is SNMP?

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.

5.2.3 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 *APOLLO-24*, 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 section 4 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.

5.2.4 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/
This is a free, open-source software, capacity planning tool.

5.2.5 *APOLLO-24* Management Information Base (MIB)

The *APOLLO-24* 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. If 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 radios.

.

6 ANTENNAS, SITE SELECTION & PATH ANALYSIS

6.1 Link Budget Calculations

Wireless Interactive supplies a Link Budget Calculator (Figure 6.1 below) that allows you to quickly perform some of the free space path analysis explained later in this section. You can use the calculator for the following computations:

- Determine the maximum range for a link.
- Find out what transmit power you should choose to obtain a desired fade margin.
- Find the expected Received Signal Strength and Fade Margin in a particular installation.

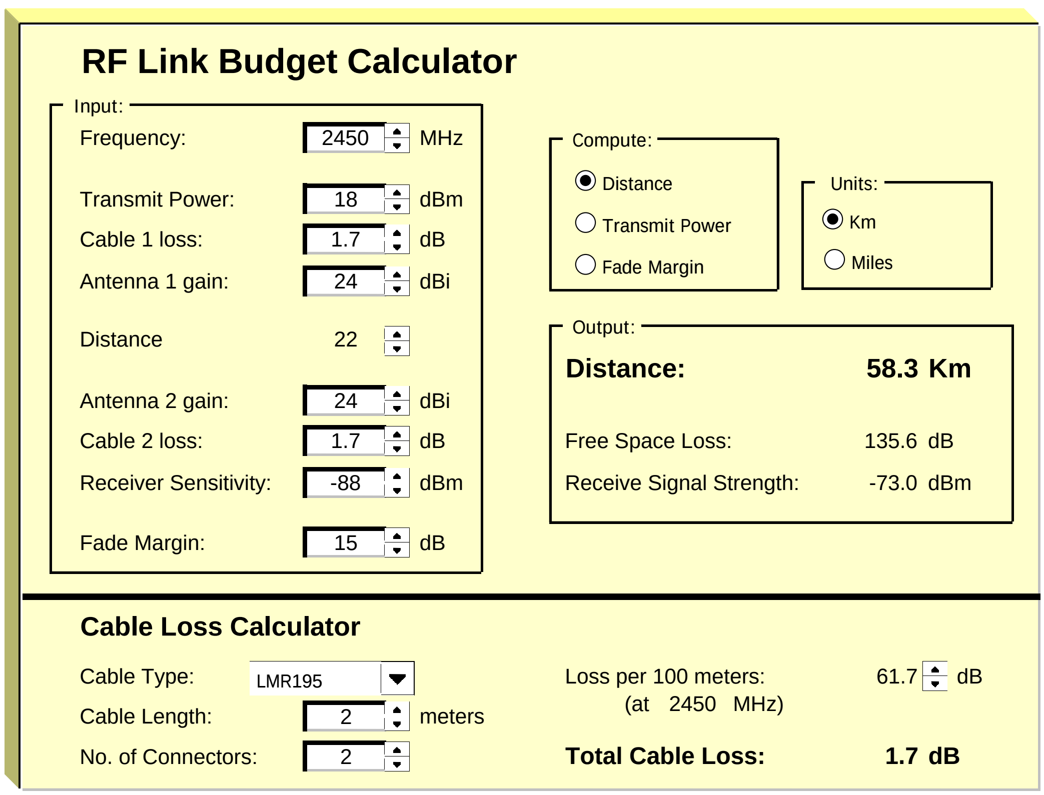


Figure 6.1. RF Link Budget Calculator

This calculator is in the CD provided with the radio and can also be downloaded from our website.

6.2 Antenna Selection

Because *APOLLO-24* radios communicate with each other by means of radio waves, all aspects of antenna installation affect their performance significantly, namely:

- 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.

This section discusses these issues and provides guidelines for selecting antenna type, selecting antenna location, and achieving an optimally functioning installation.

6.2.1 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 *APOLLO-24*, the three antenna types listed below will fulfill most installation requirements.

Antenna Type	Gain	Wireless Interactive Model Number
Omnidirectional	9 dBi	WIOD249
Panel	19 dBi	WIPA2419
Semi-Parabolic	24 dBi	WIDC24x

6.2.2 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.

6.2.3 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 available from Wireless Interactive 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.

For omnidirectional coverage from fixed locations, Wireless Interactive provides collinear antennas. The collinear design achieves gain by increased focus in comparison with the dipole design. The standard collinear antenna used with the *APOLLO-24* provides 9 dBi gain, representing an eight-fold power and sensitivity increase.

6.2.4 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 *APOLLO-24* 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.

6.3 Site Selection

At the high operating frequencies of the *APOLLO-24* 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 *APOLLO-24* 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.

6.3.1 Line-of-Sight Path

Because high-frequency radio waves are attenuated by obstructions, a clear line-of-sight path between antennas is required for optimum performance at maximum range. 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.

Because of the uncertainties of radio communication, it is difficult to predict the results in conditions where obstructions exist. The only valid advice is to try the proposed configuration and be prepared to move or elevate the antennas.

6.3.2 Radio Horizon (Maximum Line-of-Sight Range)

In visual terms, the horizon is the point in the distance where an object drops out of sight because it is blocked by the earth's curvature. If the observer or object is elevated, the visual horizon is extended, that is, the object can be seen at a greater distance before it drops out of view.

The same concept applies to radio signals: The radio horizon is the point in the distance where the path between two antennas is blocked by the curvature of the earth. Like the visual horizon, the radio horizon can be extended by elevating the antennas to extend communication range.

The radio horizon can also be extended or shortened by certain phenomena such as refraction due to atmospheric density and temperature inversions. Fog and rain, which reduce signal strength, can also shorten the radio horizon although in the ISM band, this loss is negligible.

A reasonable approximation of the radio horizon based on antenna height can be obtained from the graph in Figure 6.2 . (Note that this graph does not take atmospheric effects into account.) To use the graph, set a straight edge so that it crosses the height of one of the antennas in the column on the left and the height of the other antenna in the column on the right. The radio horizon in miles/km is shown where the straight edge crosses the center column.

If the radio horizon is well within maximum communication range of the system, this graph provides a reasonable guide for antenna height. However, as maximum range of the system is approached, results are less reliable because of atmospheric effects and other unpredictable phenomena. In such cases, the more thorough point-to-point path analysis described in the next section should provide more reliable results.

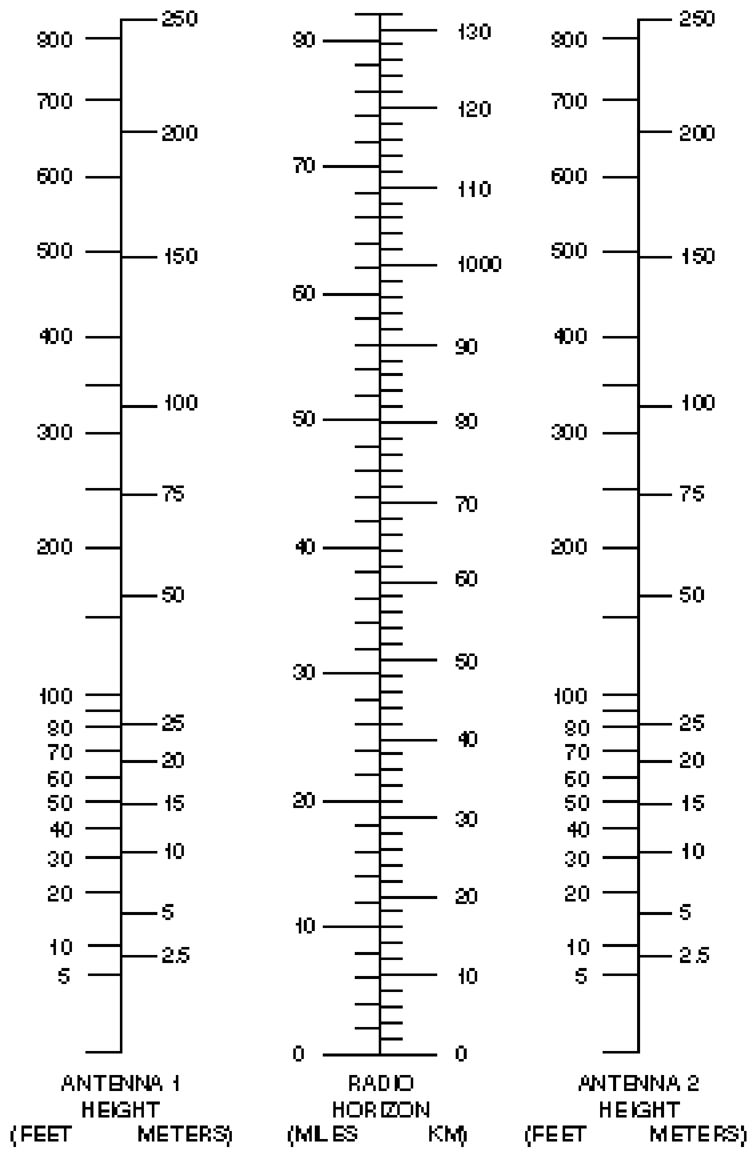


Figure 6.2 - Antenna Height and Radio Horizon Graph

6.3.3 Antenna Orientation

Antennas at each end of a communications link must be mounted similarly in terms of polarity, and directional antennas must be carefully oriented towards each other. The choice of polarization – horizontal vs. vertical – is in many cases arbitrary. However, interfering signals from such devices as cellular phones and pagers are generally polarized vertically, and an excellent means of reducing their effect is to mount system antennas for horizontal polarization.

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 mis-aligned directional antennas. The *APOLLO-24* has a built in feature that allows the operator to use an audio signal to assist in aligning the antenna. Refer to chapter 5 on the use of this built-in antenna alignment feature.

6.3.4 Cable Loss (Attenuation)

The *APOLLO-24* 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 3.2 shows loss per 100 feet (30 meters) at 2.4 GHz for typical antenna cable types.

Table 3-2. 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:

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

6.3.5 Connector Loss

Loss is introduced with each pair of cable connectors. Attenuation losses of some standard cable types are shown in the following table:

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.

6.4 Point-to-Point RF Path Analysis

A full point to point analysis should include:

- Background noise evaluation of all locations where radios are to be installed
- Determination of the minimum antenna height required to obtain "line-of-sight".
- Calculation of the expected Receive Signal Strength (RSS) level to be received at each of the locations.

The background noise measurement is critical as it gives the operator a preview of the potential performance variations and the feasibility of utilizing a particular radio at a location. For example, if the background noise is found to be at the same level as the radio sensitivity (when set to maximum speed), a tradeoff analysis can be conducted before installation to determine if lowering the data rate will allow the radio sufficient link margin to operate. The *APOLLO-24* includes a built-in spectrum analysis tool that can be used to perform this background scan.

A line-of-sight is required to insure the best performance from the radio. The calculations below will allow the operator to build towers and other mounting areas to the correct height before the antennas are installed.

The calculation of the RSS level is useful for two purposes. The first is to determine the link margin at the site. This information, when coupled with the background noise measurement, will tell the operator if a link can be established and give a reasonable "a priori" estimate of the performance of the system. In addition, the calculated RSS level allows the operator to do a quick check on the integrity of the system installation by verifying that the actual RSS level (reported by the radio) is close to the calculated value.

6.4.1 Antenna Height Analysis

Although the graph of Figure 6.2 provides a useful guide to antenna height requirements, a more accurate determination of those requirements can be obtained by means of the analysis described in the following steps. Note that computer programs, available from many vendors, can perform portions of this procedure.

Requirements for this procedure are:

- A topographical map of the installation site.
- Graph paper, ten divisions per inch or equivalent metric scale
- Straight edge
- Calculator

Procedure:

1. On the topographic map, plot the precise location of each antenna site.
2. Draw a line between the sites; this line is the radio path.
3. On the graph paper, establish a vertical axis for elevation and a horizontal axis for distance. It is usually easiest to make the vertical axis in feet or meters and the horizontal axis in miles or kilometers.

4. Following the radio path line on the map, identify all obstructions. Most topographical maps identify geographic information, such as hills and lakes, only. However, vegetation, buildings or other structures that will interfere with radio transmissions must also be included.
5. Plot each obstruction on the graph, marking its elevation and distance from the sites. For dense vegetation such as forests, add 40 to 60 feet (12 to 18 m) to the ground elevation.
6. Add the Earth's curvature to the height of each obstruction. For each obstruction calculate this increment by using the following formula:

$$d = \frac{d1 \times d2 \times C}{K}$$

Where:

(for US units:)

d	=	additional height increment in feet
d1	=	distance of the obstruction from the first site in miles
d2	=	distance of the obstruction from the second site in miles
C	=	.667 for US units
K	=	refractive index (use a value of 1.33).

(or for metric units:)

d	=	additional height increment in meters
d1	=	distance of the obstruction from the first site in km
d2	=	distance of the obstruction from the second site in km
C	=	.079 for metric units
K	=	refractive index (use a value of 1.33).

Add the "d" value to the height of each obstruction plotted on the graph.

7. Add the Fresnel Zone clearance to the height of each obstruction (the required increment is 60% of the first Fresnel zone radius). For each obstruction calculate the increment using the formula:

$$d = C\sqrt{\frac{d1 \times d2}{F \times D}}$$

Where:

(for US units:)

d	=	60% of the first Fresnel zone radius in feet
d1	=	distance of the obstruction from the first site in miles
d2	=	distance of the obstruction from the second site in miles
C	=	1368 for US units
F	=	2400 (frequency in MHz)
D	=	total path length in miles (d1 + d2).

(or for metric units:)

d	=	60% of the first Fresnel zone radius in meters
d1	=	distance of the obstruction from the first site in km
d2	=	distance of the obstruction from the second site in km
C	=	529 for metric units

F = 2400 (frequency in MHz)
D = total path length in km (d1 + d2).

Add the "d" value to the height of each obstruction plotted on the graph.

8. Determine ideal antenna height by drawing a line on the graph between the sites and across the top of the obstruction heights. Note the elevation at each antenna site.

6.4.2 Receive Signal Strength Calculation

This section shows how to calculate the RSS level expected at the radio and to determine the theoretical link margin. The Wireless Interactive "RF Link Budget Calculator", available in the CD or at the website, that performs all of these computations.

1. Determine free-space path loss, using either the following formula or the graph of Figure 6.3.

$$-L = C + 20\log(D) + 20\log(F)$$

Where:

(for US units)
-L = loss in dB
C = 36.6 for US units
D = path length in miles
F = 2400 (frequency in MHz)

(or for metric units)
-L = loss in dB
C = 32.5 for metric units
D = path length in km
F = 2400 (frequency in MHz)

For example, for a distance of 10 miles

$$-L = 36.6 + 20\log(10) + 20\log(2400)$$

$$-L = 124dB$$

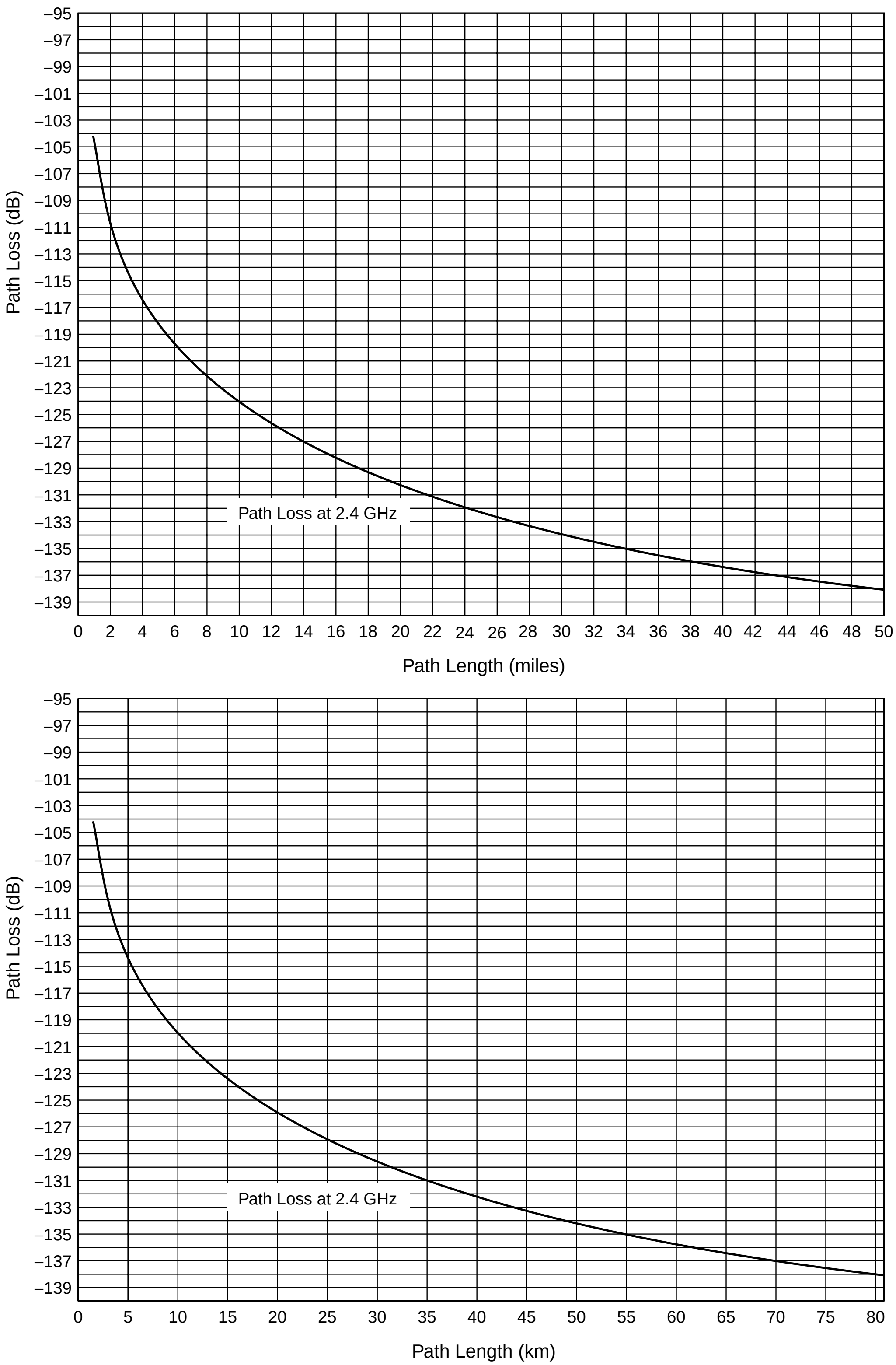


Figure 6.3 - Free-Space Path Loss at 2.4 GHz

2. Calculate effective radiated power (ERP) at the transmit antenna using the formula:

$$ERP = TxPower - CableLoss + AntennaGain$$

Since the *APOLLO-24* is housed in an outdoor enclosure, there is usually little or negligeable cable loss if the antenna is connected directly to the radio connector. However, if an additional cable is used between the radio and the antenna, the cable loss (attenuation) must be included.

Transmit output power	=	+ 23 dBm
Cable and connector loss	=	- 2 dB
Transmit antenna gain	=	+ 18 dB
Effective Radiated Power	=	+ 39 dBm

NOTE: Table 3.2 lists attenuation values for various cables.

3. Calculate the RSS level at the receive radio using the formula:

RSS = ERP - Lp + Gr - Cl

Where:

ERP	=	Effective Radiated Powerfrom the transmit antenna
Lp	=	Path loss
Gr	=	Gain of the receive antenna
Cl	=	Cable and connector losses between antenna and receive radio

For the above system, at a distance of 10 miles, Effective Radiated Power of 39 dBm, receive antenna gain of 24 dB, and cable loss of 2 dB, the equation would be:

RSS = 39 dBm - 124 dB + 24 dB – 2dB
= -63 dBm

4. Calculate link margin by subtracting radio sensitivity from the calculated RSS level.

Calculated RSS level at receiver	=	-63 dBm
Sensitivity of *APOLLO-24* at 2.7 Mbps	=	-90 dBm
link margin	=	+27 dB

This figure, link margin, is the amount of signal received by the radio that is above the minimum required for the radio to meet its performance characteristics. This value is important since it gives the operator an indication of how much signal fade the system can tolerate. Signal fading may be caused by multiple radio paths (reflections) atmospheric conditions such as rain, temperature inversions, fog, etc., and may last anywhere from a few moments to several hours and cause as much as 20 to 30 dB of signal strength loss. Although it is possible to operate a system with a link margin as low as 5 dB, as a general rule of thumb it is recommended that all systems have a link margin of better than 15 dB.

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.

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>

Major Configuration Parameters

Command	Parameters	Values	Factory Configuration
distance-max	kilo-meters	16..160	80
	miles	10..100	50
ethernet	speed	auto-10, 10hdx, 10fdx 100hdx, 100fdx, auto	auto
	timeout-sec	5..10000	30
	multi-cast-timeout-sec	5..10000	600
node	type	hub, remote	remote
	max-remotes	1..32	32
	name	(23 character string)	rmt-nnnnn (PTMP)
	network-id	0..65535	0
	location	(25 character string)	
	contact	(25 character string)	
rf-receive-setup	channel	3..37	20
	antenna	a, b	a
rf-transmit-setup	channel	3..37	20
	antenna	a, b	a
	speed-mbps	0.25, 0.50, 1.37, 2.75	2.75
	power-dbm	0..23	18
single-node-reboot	timeout-sec	15..20000	900
time-division-duplex	sync-mode	off, auto	auto
	cycle-period-ms	10, 20, 30, 40	20
	transmit-percent	auto, 10, 20, 30, 40, 50, 60, 70, 80, 90	auto

Internet Protocol (IP) Management Commands

Command	Parameters	Values
ip-configuration	address	ip address
	netmask	ip address
	gateway	ip address
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

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	**3**,4,5…	
	clear	**0**, 1	
show-tables	table	**status** ethernet econsole ip-stack	
	format	**count** times	
spectrum-analysis	input	**a-antenna** b-antenna	
	display	**graph** table	
	dwell-time-ms	1…1000 (def: **20**)	
time-analysis	channel	0..50	
	input	**a-antenna** b-antenna	
	display	**graph** table	
	dwell-time-ms	1, 2, 5, 10, **20**, 50, 100, 200, 500	

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

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

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			

APPENDIX B - Specifications

RF Specifications	
RF Frequency Band	2.406 GHz to 2.474 GHz (center frequencies)
RF Signal Bandwidth (-20 dBc)	4.6 MHz
RF Channels	35 (12 non-overlapping)
Transmitter Output Power	0 to 23 dBm (programmable)
Modulation Type	direct sequence spread spectrum
RF Data Rates (one way)	0.25, 0.50, 1.375, 2.75 Mbps
Receiver Sensitivity (10^{-6} BER)	-97 dBm (@ 0.250 Mbps) -94 dBm (@ 0.500 Mbps) -93 dBm (@ 1.375 Mbps) -90 dBm (@ 2.750 Mbps)
Data Interfaces	
Auxiliary Port	RS-232
Ethernet Port	10/100 BaseT (auto-negotiate)
Power Requirements	
Input Voltage (Outdoor Unit)	
Standard:	+8 to +28 Volts DC
High voltage model:	+12 to +32 Volts DC
Input Voltage (AC)	110 VAC or 220 VAC
Power Consumption	less than 5 Watts
Environment	
Temperature	-40 to +70 Degrees C
Max. Humidity	90% non-condensing
Mechanical:	
Dimensions	4.72" wide x 8.66" high x 2.20" deep (120mm W x 220 H x 56 D)
Weight	2.4 lbs. (1.1 Kg).

APPENDIX C – Channel Frequency Assignment

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

Freq(MHz) = 2400 + 2 x Channel_number

The table below shows the frequencies for all channels that fall in the ISM band.

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

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

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

- Win95, Win98, Windows ME, WinNT, Win2000, WinXP
- NetBIOS installed
- WinPCap installed

Note: With regard to Windows NT platform, the code has been tested with versions 4.0, or newer. There is also a Linux beta version

Installation for Windows

In order to install the WinPCap library, if not already installed, just click on the 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 system, so you don't have to install it. To start the Econsole, simply open a MS-DOS window and type *econ***.** For available command line arguments, please read the "*input arguments*" section.

Included files

- *win_readme.doc* The file that you are reading
- *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:

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

Sample input file:

help
 # this is a comment - note that the character # must appear as the fist 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>*

Important 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 empty 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 irrelevent):

>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 and older version of it. Please visit http://netgroup-serv.polito.it/winpcap/ to get the latest version. 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 are more than one Ethernet adapter installed with the same name, this might cause 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.

1. 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.
2. 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.

5. If I leave the client inactive for half an hour, and try to type a new command, I get an unable to transfer packet message or I get a "session timeout - application will be closed" message.

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

Report a Bug & Updates

Please visit http://www.wirelessinteractive.com for more info.

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.

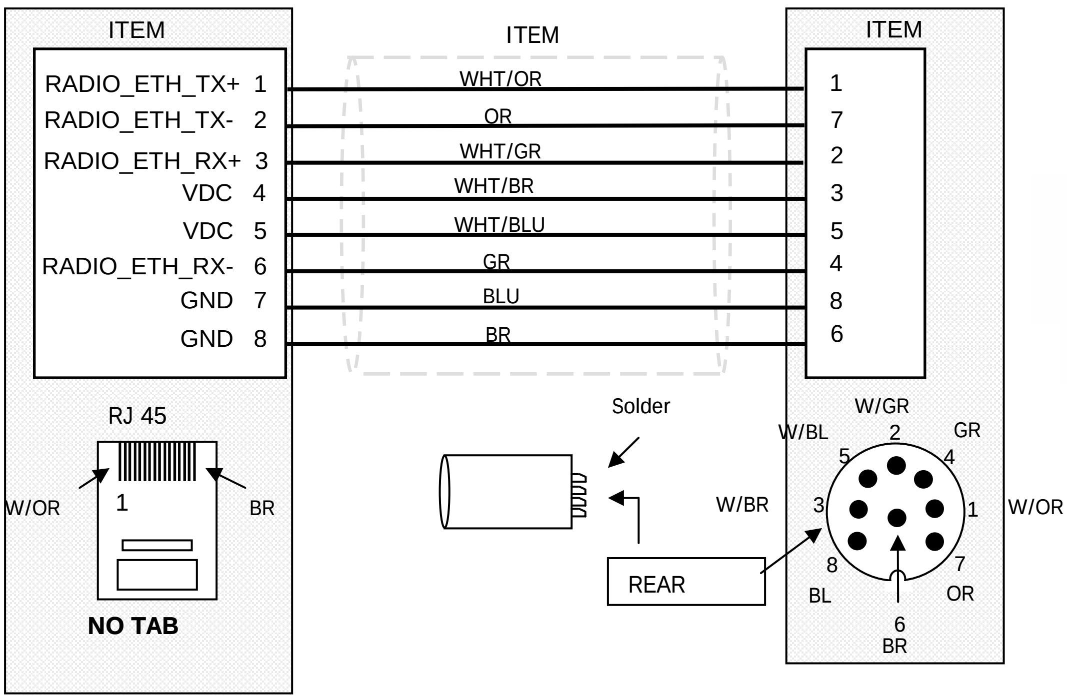
APPENDIX E – Cable Diagrams

The next two pages show the assembly drawings for the cables used to connect the Radio to a Power Inserter Unit (CAT5), and a Console cable for connection to a standard computer terminal used for Radio configuration and monitoring.

NOTES:

1. Use proper crimp tool for Item #2 connection
2. Remove cable filler gel from conductors before inserting into Item #2.
3. Insure that all eight conductors reach to end of interior channel before crimping Item #2.

APPLICATION		REVISION			
NEXT	USED		DESCRIPTION	DATE	APPR
			Initial Release	9/15/03	J.B



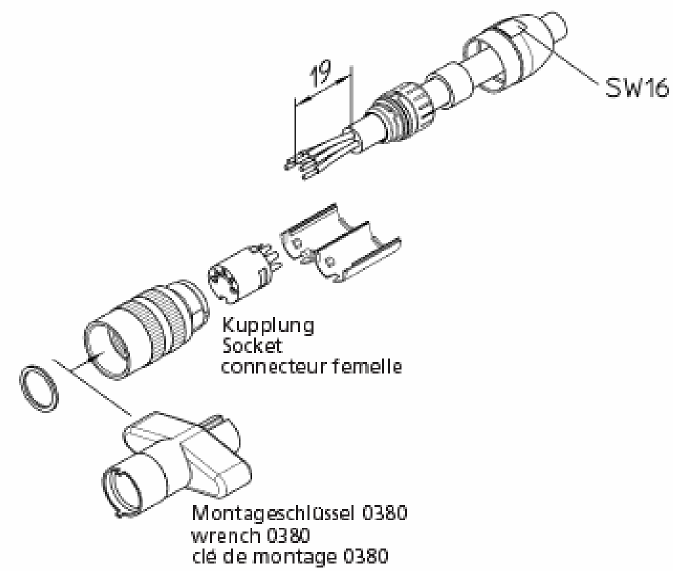


Fig. A Five pin connector is shown. Use same process for 8 pin.

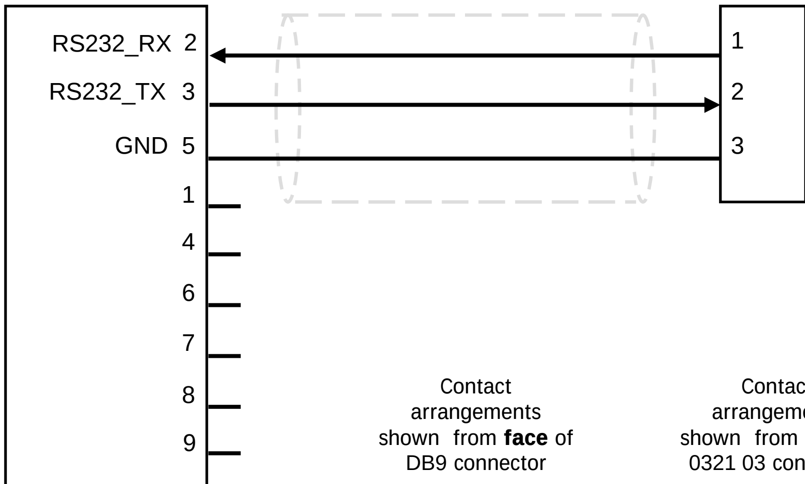
MATERIAL			
ITEM	PART NO.	MANUFACTURER	DESCRIPTION
1	WI7919A	Wireless Interactive	Cable, CAT5, Outdoor, Solid Cond.
2	AT8X8SC-2224	Allen Tel	Plug Connector, 8 Cond., RJ45-type
3	0321 08 or 0322 08 (fig. A)	Lumberg USA	8 Pin Field Connector, Female

DRAWN	DAT 9/15/03	**Wireless Interactive**
CHECKED	DAT	TITL CAT5 ETHERNET & POWER
APPROVE	DAT	REV A
APPROVE	DAT	SCALE NONE — SHEET 1

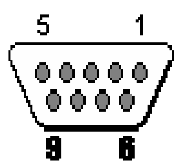
APPLICATIO		REVISION			
NEXT	USED	RE	DESCRIPTIO	DAT	APPROVA
		A	Initial Release	09/16/03	J.B

ITEM #1
DB-9

ITEM #2

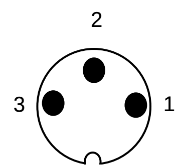


Contact arrangements shown from **face** of DB9 connector



ITEM #1
DB-9

Contact arrangements shown from **rear** of 0321 03 connector



ITEM #2

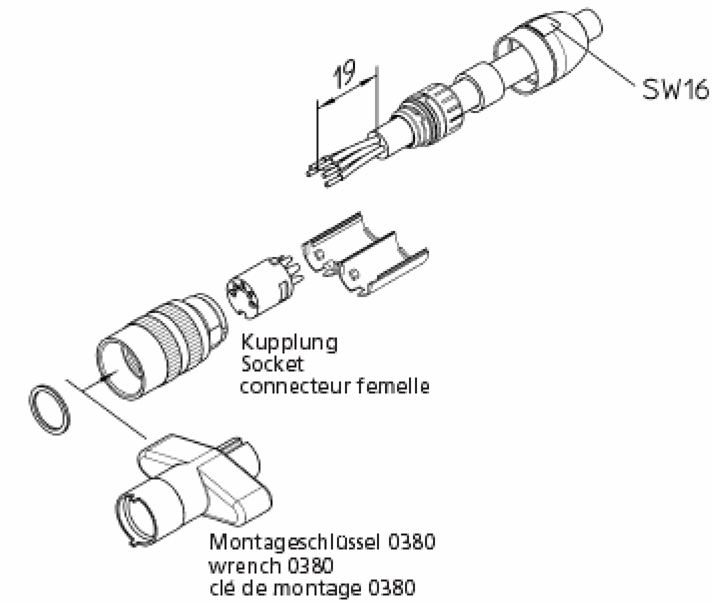


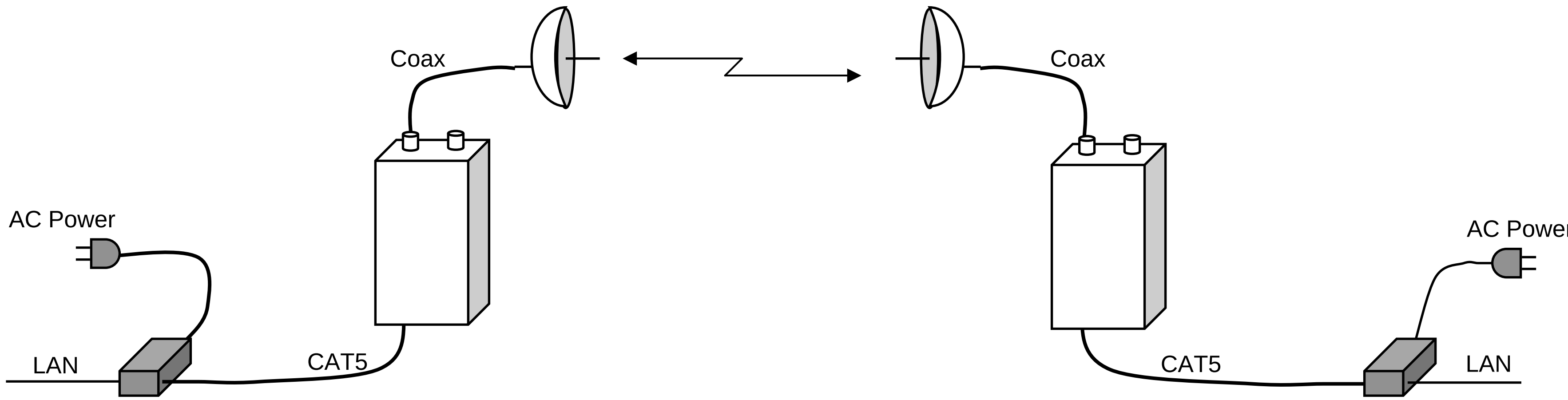
Fig. A Five pin connector is shown. Use same process for 3 pin.

MATERIAL			
ITEM	PART NO.	MANUFACTURER	DESCRIPTION
1	F3B20706	Belkin	Serial Direct Cable Db9, F/F 6'.**
2	0321 03 or 0322 03 (fig. A)	Lumberg USA	3 Pin Field Connector, Female

** 6' cable cut in ½ will make two cables.

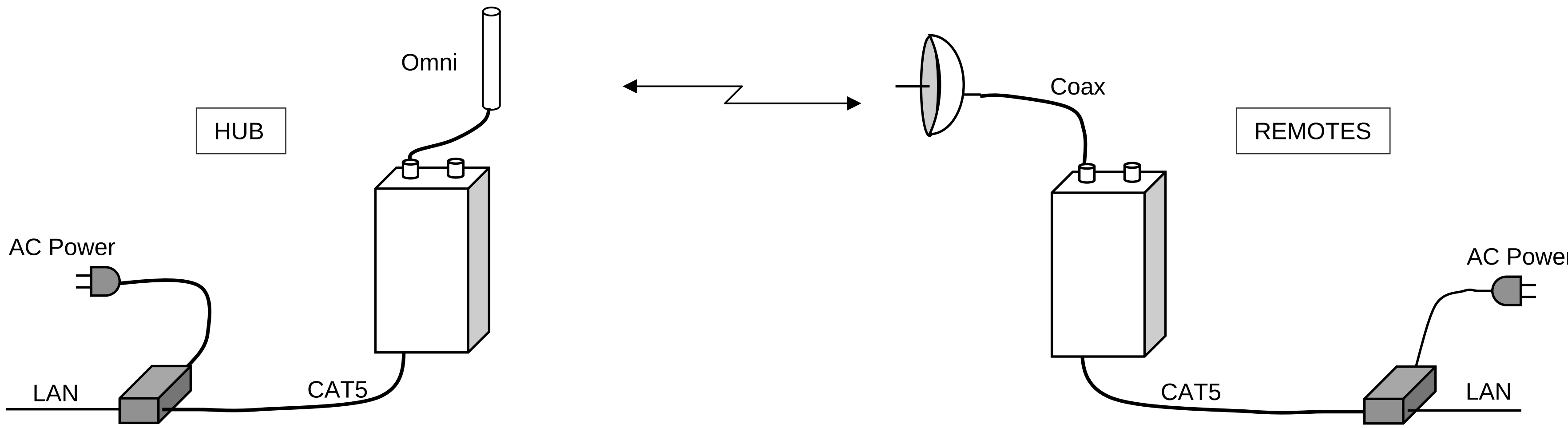
DRAWN	DAT	**Wireless Interactive**	
CHECKED BY	DAT	TITL **3 Pin Console Cable**	
APPROVE	DAT	DRAWING NO	RE A
APPROVE	DAT	SCALE NONE	SHEET 1

APOLLO-24 Wireless Point to Point Bridge
Quick Setup Example



	Minimal Configuration	
>load factory >node type=hub >node max-rem=1 >save		>load factory >save
	Changing RF Channels (optional)	
>rftr ch=30 >rfrec ch=14		>rfrec ch=30 >rftr ch=14
	Changing Tx Power (optional)	
>rftr power=23		rftr power=23
	Checking Link Operation	
>show radios		

APOLLO-24 Wireless Point to Multi-Point Bridge
Quick Setup Example



		Minimal Configuration			
	>load factory >node type=hub >save		>load factory >save		
		Changing RF Channels (optional)			
	>rf-tr ch=30 >rf-rec ch=14		>rf-rec ch=30 >rf-tr ch=14		
		Changing Tx Power (optional)			
	>rftr power=23		rftr power=23		
		Verifying Network Operation			
	>show radios				