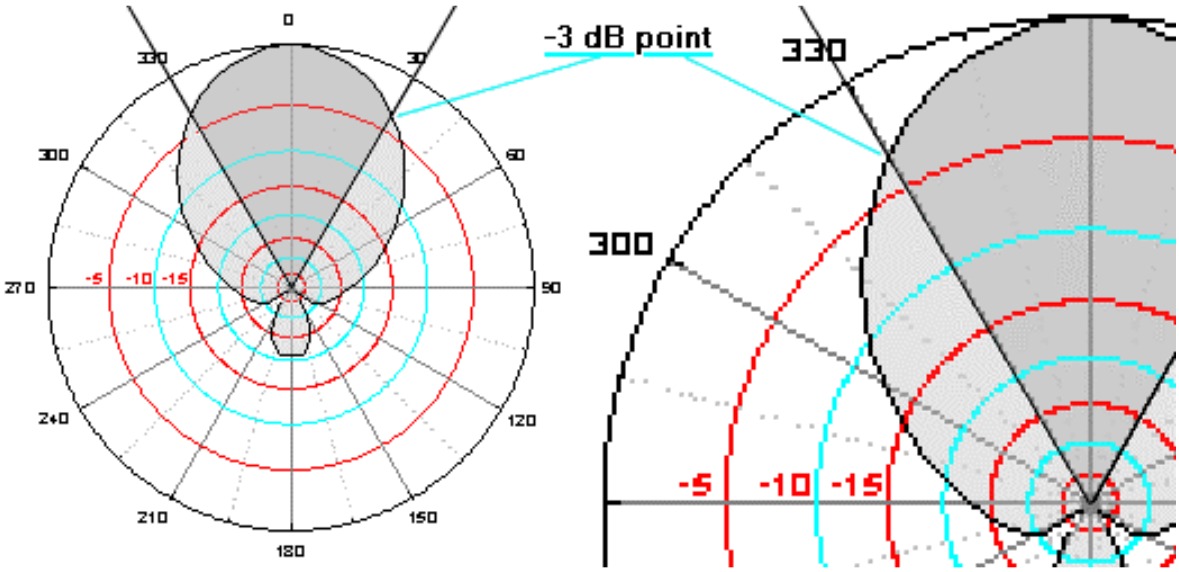
Modular Mining Systems M/LC Repeaters

302395 User's Guide and Repeater Network Design Guide



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1. Introduction

The Modular Mining Systems M/LC radio network provides high-quality, low-maintenance communications to all mine operating areas. (M/LC stands for “MasterLink® Cisco” and is based on an Ethernet Bridge from Cisco Systems.)

To keep the system working optimally, you can monitor performance reports and graphical displays. Furthermore, equipment operators will inform you of any system degradation.

This document discusses the following topics:

- how to design an M/LC Repeater Network (i.e. infrastructure). Network design includes hardware options, coverage issues, details on the 302395 Cisco electronics unit, and all FCC requirements
- how to select the appropriate antenna for each repeater location
- how to conduct a mobile access point relocation, and how to verify radio coverage at the new location
- how to configure the 302395 Cisco electronics unit using configuration software

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2. Design Principles of a M/LC Repeater Network

2.1 General Hardware Selection Guidelines

When selecting hardware components of a M/LC Repeater Network, there are several important issues that must be addressed.

2.1.1 M/LC Infrastructure Hardware

Because Cisco bridges and access point have their own proprietary routing algorithms that dictate how to make the "wireless" hops back to the hardline network, they can not be mixed with standard MasterLink (M/L) repeaters.

IMPORTANT: ALL repeaters used in a mine must either be M/L or M/LC, but not a combination of the two.

All of the *mobile equipment* in the mine should be standard M/L, and as such, will associate themselves with one of the M/LC repeaters. As these mobile *clients* travel through the mine, they may change associations often with the various M/LC repeaters.

M/LC Repeater Infrastructure includes the following:

- shovels
- base stations
- crusher bays
- mobile and fixed repeaters

Although it is possible for a shovel to be a M/L client instead of a M/LC repeater, it is highly recommended that they be established as a M/LC repeater. This enables them to provide coverage to surrounding haul trucks as the shovel digs itself into tights spots where coverage from a regular repeater site is difficult. Remember, if the part number doesn't contain an "M/LC" designation, it is not Cisco-based.

The GPS ground station need not be M/LC since its location is determined by other factors not related to vehicle coverage (such as satellite constellation view, proximity to power, security, or even hardwired Ethernet). A wireless M/L ground station needs only to associate itself with a M/LC repeater in order to get its correction data through.

2.1.2 Data Rates and Range

The M/LC repeater hardware is based on the 802.11b specification and as such supports data rates of 1.0 Mbps, 2.0 Mbps, 5.5 Mbps, and 11.0 Mbps. As the data rate increases, the range deceases. At ½ watt of output power, the expected ranges are as follows:

DATA RATE	ANTENNAS	EXPECTED RANGE
2.0 Mbps	Two 6 dBi Omnis	8 miles
11.0 Mbps	Two 6 dBi Omnis	3 miles

The M/LC Repeater network will always transmit at the highest data rate possible provided there is a good RF link between the two access points. Therefore, in practically all instances, intra-access point traffic will be at 11.0 Mbps. However, M/L hardware transmits at 2.0 Mbps, so communications between clients and the M/LC access points will be at 2.0 Mbps.

2.1.3 M/LC Point-to-Point Links

In a M/LC infrastructure, any point-to-point links must also be Cisco-based. Point-to-point links generally use the 24.0 dBi dish antennas at each end in order to provide a link for distances up to 24 miles. Although they could use the same channel as the rest of the mine, it is best if they are on a separate channel. However, it is even better if they operate completely out of the 2.4 GHz Frequency range in order to keep the 2.4 GHz 802.11b channels as traffic free as possible. 5.8 GHz point-to-point links are available from Modular Mining Systems. These Cisco 1400 Aironet links are compatible with a M/LC repeater infrastructure. They are listed on the MMS intranet site.

2.1.4 Temperature Related Decisions

M/LC mobile repeaters do not ship with batteries because in many instances batteries are obtained locally. However, if a mine site will be operating from 0 to –20 C for extended periods of time (several days), then SLA (Sealed Lead Acid) AGM (Absorbed Glass Matte) batteries must be used. These are available from Modular as part number 105900 and are 12V Size 27 108AH. Repeaters will ship with foam insulated battery boxes, and the foam must be placed over the vent in cold weather.

If temperatures will be below –20 C for extended periods of time, then NiCad batteries are recommended in order to avoid "blackout" periods. NiCads are relatively expensive and heavy. 20 NiCad cells provide 205AH at 1.2V each for a total of 448 lbs and 24V. With the battery box they weight over 600 lbs.

M/LC shovel and crusher systems are all LT (Low Temp) already since the mobile hubs used have the larger Vicor power supplies. All cables are now Xtra-guard 4. Therefore, with respect to a M/LC infrastructure, the battery configuration is the decision point. Also, see "Sizing a Solar Repeater" below.

2.1.5 Sizing a Solar Repeater

Modular provides a 150 W and a 300 W M/LC mobile solar repeater. The amount of sunlight during the worst month of the year is what dictates which one should be purchased. A solar analysis may be obtained by Emailing the city (or Lat / Long) mine location information to Modular. This analysis will estimate the performance of each system during each of the 12 months of the year, and will include the optimum angle of solar panel tilt. It is very important that the panels be tilted at this angle during installation and facing perfectly South (if in Northern Hemisphere) or perfectly North (if in Southern Hemisphere).

In the rare case of excellent sunlight but constant colder temperatures (0 to –20 C), such as at very high elevations, four SLA AGM batteries should be used in a 150 W mobile repeater. By design, usually only

two batteries are used with a 150 W repeater and four with a 300 W system, but you can always choose to install four batteries in a 150 W system. (The battery box holds four.)

2.1.6 Lightning Protection

All M/LC repeaters come with some lightning protection. There are Polyphasors on the GPS and RADIO RF inputs into the battery box. Also, power from the solar panels runs into a Delta lightning arrestor. All chassis ground wires connect to one of the bolts at the base of the mast. However, the repeater uses no lightning diverter at the top of the mast, nor does it use ground straps, or ground stake/rods.

If lightning is a concern at your installation, you can purchase the 302510 Lightning Protection Option Kit from Modular for each mobile repeater. This kit includes the diverter at the top of the mast, ground braids, copper straps, and a ground rod.

2.2 General Coverage Guidelines

Before designing a M/LC infrastructure, review the following general rules.

2.2.1 Locations, Repeater Quantities, and Antennas

Location	Description
PITS	It is always desirable to have triple coverage inside of deep pits. Three repeaters positioned around the edge at geographically different locations is recommended (roughly 120 degrees apart). However, they also must have a clear line-of-sight to other repeaters so there is a trade-off to be made between visibility to other repeaters, and view of the pit. The vertical beamwidth of the antenna must be enough to cover into the pit from the edge. Although a omni (or sector) antenna can be tilted downward up to 10 degrees into the pit to aid in this endeavor, the other line-of-sight repeaters must remain in the coverage pattern of the antenna (which would be tilted up off the backside).
HAUL ROADS	It is desirable to have right side and left side coverage although this is not always possible.
REPEATERS	Ideally, each repeater would provide coverage over a selected area of the mine while at the same time, having a view of at least two other "upstream" repeaters. "Upstream" repeaters are access points that must be used in order to reach a hard-wired bridge (or zero-hop) node. Minimizing the number of required "hops" is important in order to maximize bandwidth (i.e. maximize the amount of traffic). The more "zero-hop" (i.e. direct wired) repeaters that are available, the better the system throughput will be.
SHOVELS	Shovels are the most difficult area to cover. That is why M/LC shovel systems have been provided in order to provide the repeater function. A point-to-point link can be used to increase the number of effective zero-hop sites. This aids greatly in covering haul trucks near the shovel. When a 6 dBi omni is mounted on the shovel above the cab on the six-foot mast, a good view of other repeater site(s) should be obtained.
CRUSHERS, OTHER FIXED LOCATIONS	Fixed buildings are usually good locations for repeaters since they provide AC power so that a lower cost AC repeater may be used. Many times the top of the roof provides a good high coverage location. If Ethernet is available at the building, then a "wired" "zero-hop" is available.

2.2.2 Location Considerations and Antenna Selection

Section 3 in this manual provides details of the antenna patterns and gains. Each repeater location must have an appropriate antenna selected in order to fulfill the coverage goals of that location. Typically around the edges of the mine property, sectors are used in order to keep the RF energy on the mine property (which also maximizes the range at that location). Sector antennas are also used against large structures if an omni is not possible at the very top. Typically, omni antennas are used in the middle of the mine, on rooftops, on shovels, and other high points. Dishes are only used for point-to-point links. Always make sure that no solid reflective objects are close to an antenna and in its beam pattern. This will result in high energy reflections which will cause null (i.e. dead areas) in you desired coverage area.

2.2.3 Overall System Throughput Design Considerations

Even though intra-repeater (or intra-access point) traffic is at 11.0 Mbps, the “system” bandwidth or throughput is reduced in direct proportion to the number of wireless access points (or “hops”) that a message must be routed though in order to get to a bridge (an access point [AP] that is hardwired to the LAN). Therefore, it is desirable to have as many “zero-hop” or “hardwired” APs as possible. Therefore, always take advantage of all hardwired LAN locations as possible in order to install an AP. Good examples of this are crushers, truck shops, and dispatch buildings with are often hardwired to the LAN via fiber optics or even microwave links.

If a mine site is very large, and the hardwired Ethernet is only available at one location (which may not even be a good site for an access point), then a point-to-point link should be used in order to construct another “zero-hop” or “wired” equivalent access point. This is important to minimize bottlenecks and avoid excessive “message hopping” though a repeater network. Although one of the 802.11b channels may be used for this, often it is best to use a completely different frequency band in order to minimize 2.4 GHz traffic. The Cisco 1400 Aironet Bridges are highly recommended for this.

2.2.4 Channel Selection

802.11b LAN networks can use 11 channels of operation. These range from 1 (2412 MHz) to 11 (2462 MHz) and are separated by 5 MHz increments. However, because the occupied spectrum of each channel is approximately 20 MHz, only three of these channels should ever be used at one time. Due to the RF characteristics of the radio hardware, channel 1 almost always contains the most output power (and slightly better performance). Assuming 0.3 dB per channel reduction, typically, channel 11 has 1.5 dB less output power than channel 1. If good coverage and bandwidth can be achieved using only one channel it should be channel 1. If two channels are decided on then it should be channel 1 and channel 11 since frequency separation is far more important than output power in this case. If three channels are to be used, then channels 1, 6, and 11 would be used.

2.3 The 302395 Repeater Electronics Unit

The common element to all M/LC repeater infrastructure installations is the 302395 M/LC Electronics unit. This contains the Cisco BR350 Bridge, the ½ bi-directional power amp, the SKII GPS, and the MMS power and interface circuit board. When using this unit always following these guidelines:

- Keep the unit out of direct sunlight.
- Always provide lightning protection on the GPS and RADIO RF connectors.
- Always follow the "System Config" diagrams when setting up an installation.
- Use only approved antennas and power settings listed below.

2.3.1 Approved Antennas

Only five antennas are approved by the FCC. No other antennas may be used with this system. These antennas are the following:

MMS PN	ANTENNA DESCRIPTION	HORIZONTAL BEAMWIDTH	VERTICAL BEAMWIDTH	POWER SETTING
105831	Omni 2.5 dBi gain ½ wave stub	360 deg	60 deg	50 dBm
105342	Omni 6.0 dBi gain black foamed (hardened)	360 deg	25 deg	50 dBm
105920	Sector 10 dBi gain	90 deg	35 deg	50 dBm
105708	Sector 13 dBi gain	120 deg	16 deg	50 dBm
105735	Dish 24 dBi high gain	9 deg	9 deg	5.0 dBm

The patterns and usage of these antennas is covered in the next section.

2.4 FCC Statements

MANDATORY SAFETY INSTRUCTIONS TO INSTALLERS AND USERS

1. Use only antennas supplied by Modular Mining Systems or dealer.
2. Antenna Minimum Safe Distance: 20 cm.
3. Antenna Gain: Zero dBd referenced to a dipole.

The Federal Communications Commission has adopted a safety standard for human exposure to RF (radio frequency) energy which is below the OSHA (Occupational Safety and Health Act) limits.

Antenna Mounting

The antenna supplied by Modular Mining Systems or dealer must not be mounted at a location such that during radio transmission, any person or persons can come closer than the above minimum safe distance to the antenna, i.e. 20 cm.

To comply with current FCC RF exposure limits, the antenna must be installed at or exceeding the minimum safe distance shown above, and in accordance with the requirements of Modular Mining Systems.

Base Station Installation	The antenna should be fixed-mounted on an outdoor permanent structure. RF exposure compliance must be addressed at the time of installation.
Mobile Repeater Installation	The antenna must be mounted on a mast that is 12 feet or higher so that RF exposure compliance is satisfied.
Mine Vehicle Installation	The antenna should be fixed-mounted on the vehicle facing away from the vehicle such that a person is not able to move in front of the antenna. RF exposure compliance must be addressed at the time of installation.

Antenna Substitution

Do not substitute any antenna for the one supplied or recommended by Modular Mining Systems. You may be exposing person or persons to harmful radio frequency radiation. You may contact Modular Mining Systems for further instructions.

WARNING: Maintain a separation distance from the antenna to person(s) of at least 20 cm.

You, as the qualified end-user of this radio device, must control the exposure conditions of bystanders to ensure the minimum separation distance (above) is maintained between the antenna and nearby persons for satisfying RF Exposure compliance. The operation of this transmitter must satisfy the requirements of Occupational / Controlled Exposure Environment, for work-related use. Transmit only when person(s) are a least the minimum distance from the properly installed, externally mounted antenna.

Changes or Modifications

CAUTION: changes or modifications not expressly approved by Modular Mining Systems could void the user's authority to operate the equipment.

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3. Antenna Evaluation

As part of the initial system design, Modular Mining Systems commissions an RF propagation study to create a custom radio network for your mine. This design specifies

- the number and location of access points
- the type of antenna on each access point
- the azimuth, height, and elevation of each antenna

Antennas are selected and positioned to provide customized coverage so that every part of the active mine area is serviced by at least two access points.

5 Antenna Types

Omnidirectional 2.5 dBi | **Omnidirectional 6 dBi** | **Sector 10 dBi** | **Sector 13 dBi** | **Parabolic 24 dBi**

Figure 1 Antenna Types

3.1 Antenna Characteristics

Antennas have three main characteristics:

horizontal coverage pattern	(horizontal *beamwidth*)
vertical coverage pattern	(vertical *beamwidth*)
gain	(signal amplification power)

3.1.1 Antenna Coverage Patterns

Antennas transmit and receive signals in a specific pattern; each pattern has a horizontal and vertical component. (See Figure 2.)

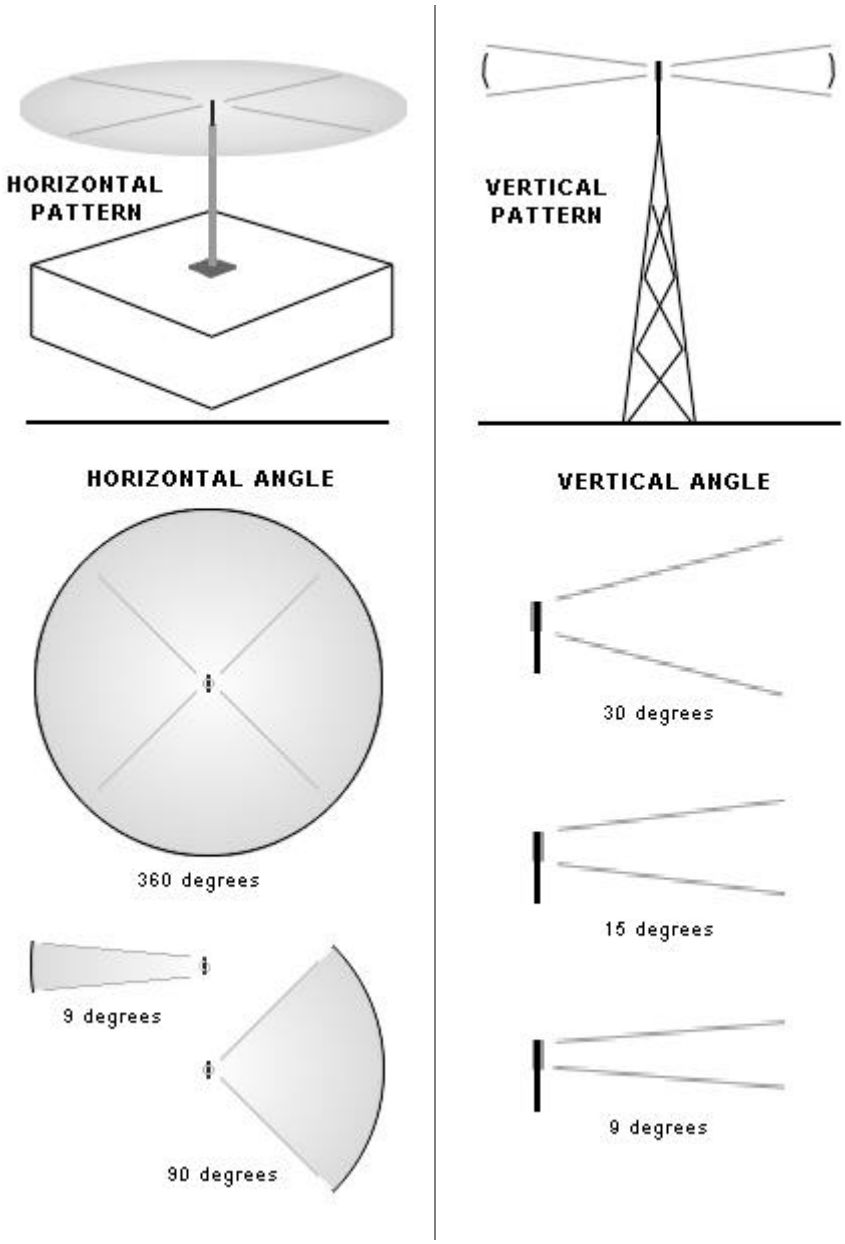


Figure 2 Antenna Patterns - Horizontal and Vertical Components

3.1.2 Antenna Gain

Gain is the ability of an antenna to amplify received and transmitted signals. Numerically, it is the comparison between an antenna's maximum signal strength and the signal strength of a laboratory standard.

3.1.2.1 dBi (Decibels Relative to Isotropic)

An antenna's gain specification normally appears as a decibel value. The decibel scale is a logarithmic scale used for representing comparative signal strengths; it is the ratio of one signal compared to a second signal.

When describing antenna gain, "decibel" is abbreviated as "dBi" (*decibels relative to isotropic*). "Relative" signifies that this measurement is a comparison between the antenna's signal and a second signal, and "isotropic" indicates that the second signal is the theoretical ideal laboratory standard.

For example, the network uses two different omni antennas having gains of 2.5 dBi and 6.0 dBi, and two different sector antennas with gains of 10 dBi and 13 dBi.

Note: You will also see "decibel" abbreviated as "dB" (without the "i"). "dB" signifies that a signal's strength is being compared to the strength of a second signal that is not the laboratory standard. For example, "dB" is used when describing the relative strengths of a signal in different parts of a signal pattern. (See section 3.3.2.1.)

3.2 Antenna Types

Antennas are also classified by their characteristic horizontal pattern. The system uses three classifications of antennas:

- omnidirectional (*"omni"*) antennas
- sector antennas
- parabolic antennas

Figure 3 shows general horizontal beamwidth patterns for these antenna types.

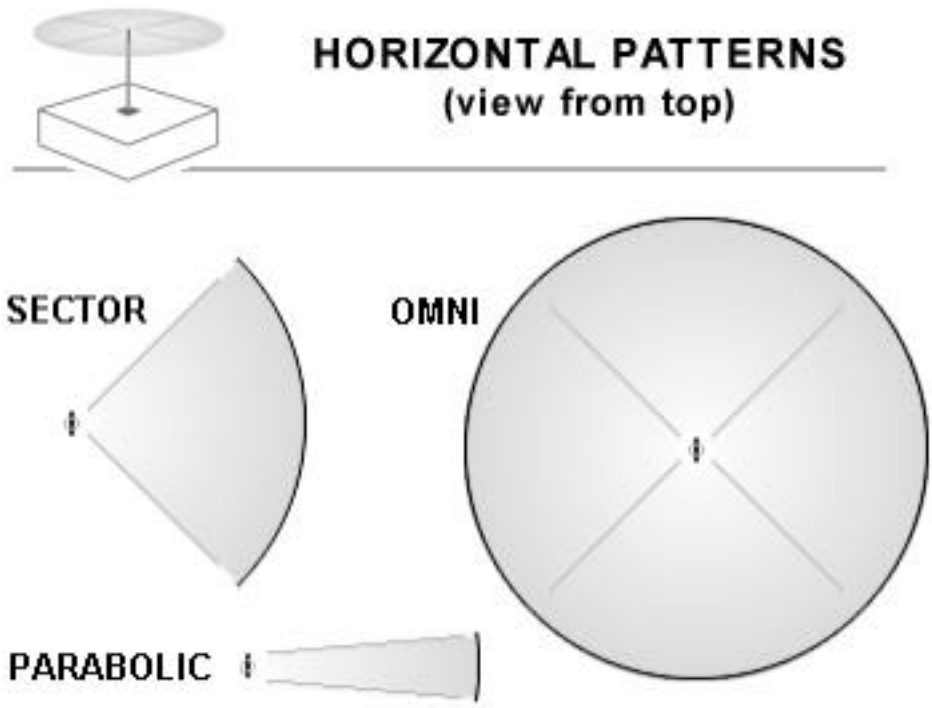


Figure 3 Typical Horizontal Patterns

Omnidirectional antennas transmit and receive signals equally well in all directions horizontally.

Sector antennas direct and receive most of their signals in one sector horizontally.

Parabolic antennas focus most of their transmission and reception signal in a small horizontal region.

You can visualize an antenna's pattern as being similar to light emitted from a light bulb:

Antenna Type	pattern similar to	pattern description
omnidirectional	bare light bulb	light shines in all directions
sector	floodlight	light floods an area
parabolic	spotlight	light focused into narrow beam

3.3 Antenna Patterns

Antenna patterns have three main components:

- lobes
- relative gain
- tilt angle

3.3.1 Lobes

Antennas do not radiate and receive signals equally well in all directions. When depicted graphically, this results in a pattern that has lobes in it.

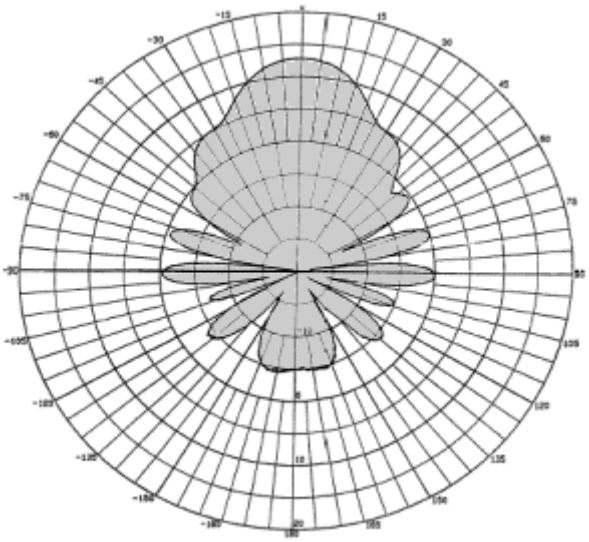


Figure 4 Lobes in Antenna Pattern

Figure 4 shows the top view, or horizontal component, of an antenna's radiation pattern. As you move around the antenna, the signal strength changes — the farther a lobe extends from the center of the circle, the stronger the signal is in that direction.

3.3.2 Relative Gain

As shown in Figure 4, the strength of an antenna's signal varies as you move around the antenna's signal pattern. You might measure a signal a certain distance from an antenna where the signal is at its peak power, and then measure the signal at another location the same distance from the antenna where the signal might be only half as powerful as at the first location.

This difference in signal strength, or gain, is measured in decibels.

3.3.2.1 dB (Decibels)

When comparing antenna gains where one of the signals is *not* a laboratory standard, "decibel" is abbreviated as "dB." (For use of the "dBi" abbreviation for an antenna's gain specification, see section 3.1.2.1.) Typically, when measuring signal strength in an antenna's pattern, you compare your readings to the antenna's peak signal rather than to a laboratory standard.

A graph of an antenna's pattern uses the decibel scale to indicate how an antenna's gain varies across the pattern.

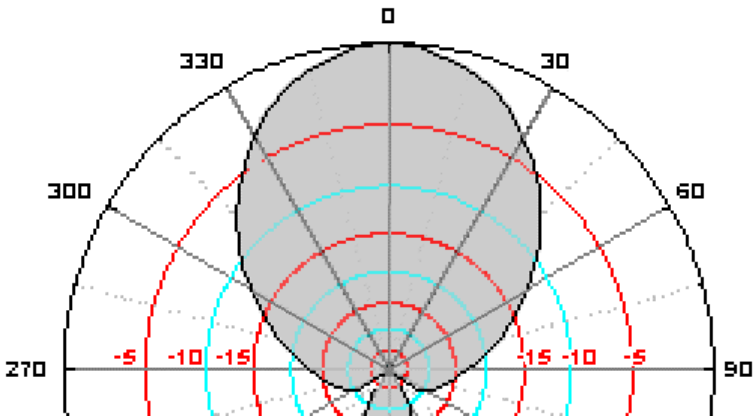


Figure 5 Antenna Pattern dB Scale

Figure 6 shows a horizontal antenna pattern. The outermost ring signifies 100 percent signal power, or 0 (zero) percent signal loss. The next outermost circle (labeled —*5*) shows the region where the signal strength has dropped 5 dB from the original 100 percent (0 dB) level. The next circles show where the signal has dropped off 10 dB and 15 dB from the 0 dB level.

Note: A negative (—) dB value indicates a reduction in signal power.

Full radio signal power is obtained at 0 degrees, where there is 0 dB signal drop off. As you move to either side of 0 degrees the signal power starts to drop off, and crosses the —5 dB point, the —10 dB point, the —15 dB point, and finally the —20 dB point.

3.3.2.2 Half Power Points (—3 dB Points)

The most important part of an antenna's signal pattern is that portion where the signal is at least at the 50 percent power level. This level is commonly referred to as the *half power point*, or the *—3 dB point*.

The antenna pattern in Figure 6 has its half power points (—3 dB points) at 330 degrees and 30 degrees, giving this antenna a usable horizontal pattern of 60 degrees.

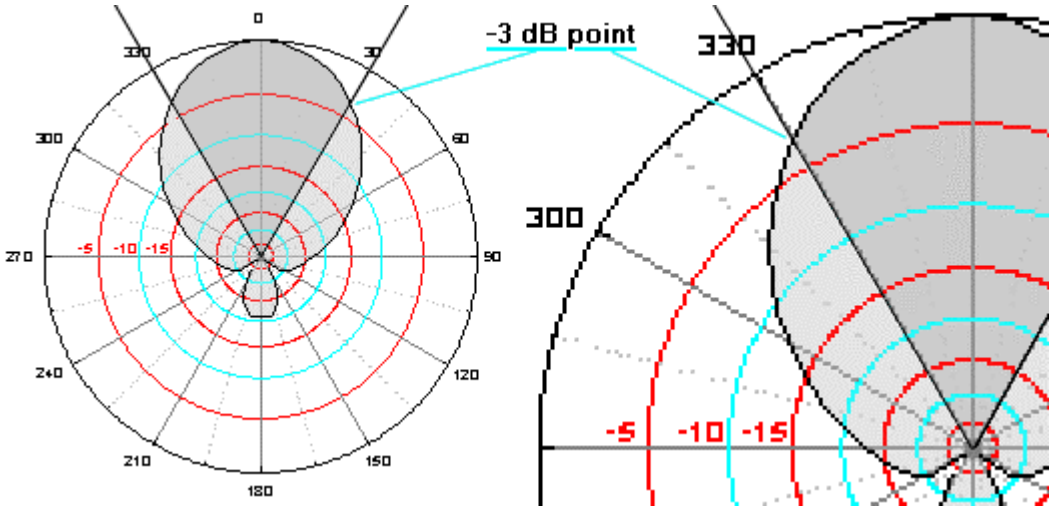


Figure 6 Half Power Points

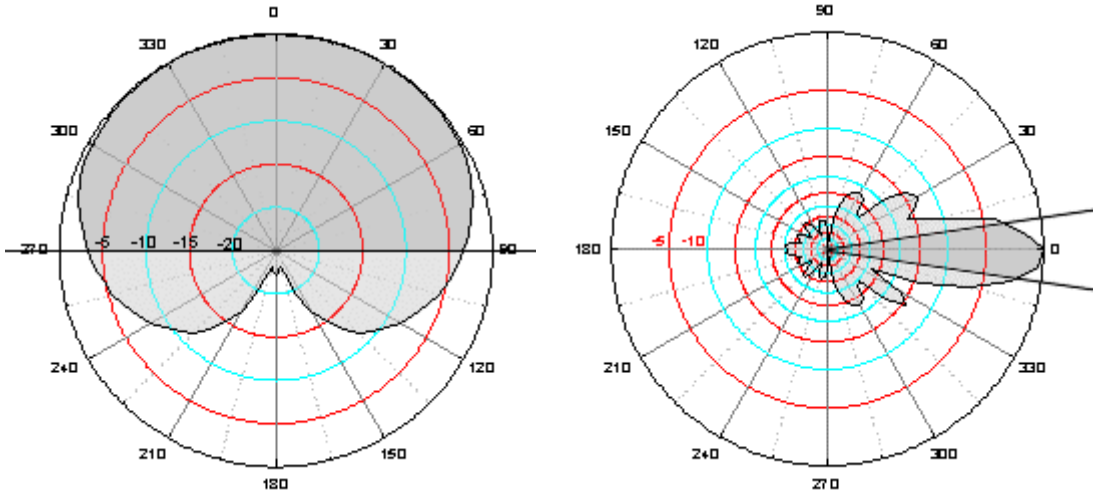
This angle between the two half power points is also commonly referred to as the antenna's *beamwidth*.

Figure 7 shows sample patterns for three antennas where the half power points are marked by dark lines extending from the center of the pattern, and the primary part of the pattern is shaded in dark gray.

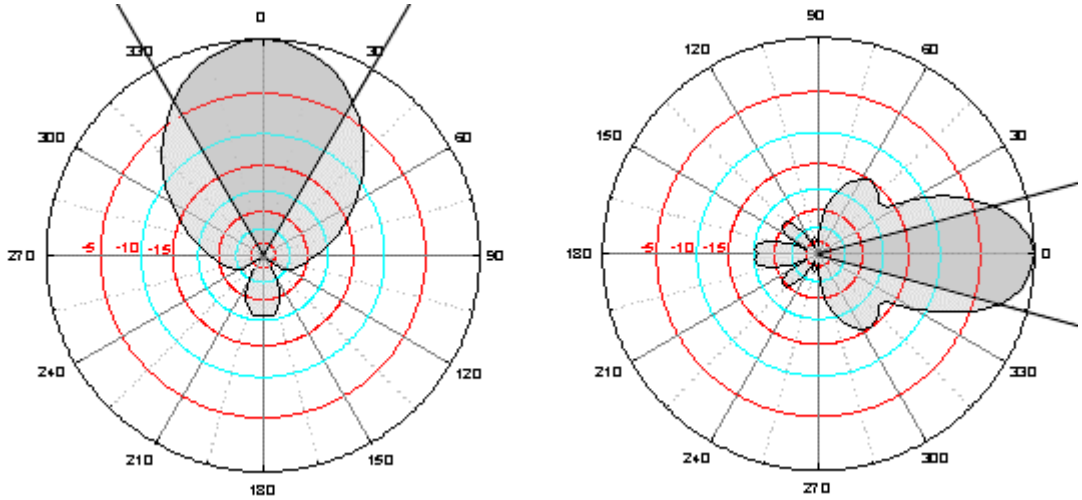
The antennas have the following horizontal and vertical components:

- Antenna A 180 degrees Horizontal 15 degrees Vertical
- Antenna B 60 degrees Horizontal 30 degrees Vertical
- Antenna C 30 degrees Horizontal 60 degrees Vertical

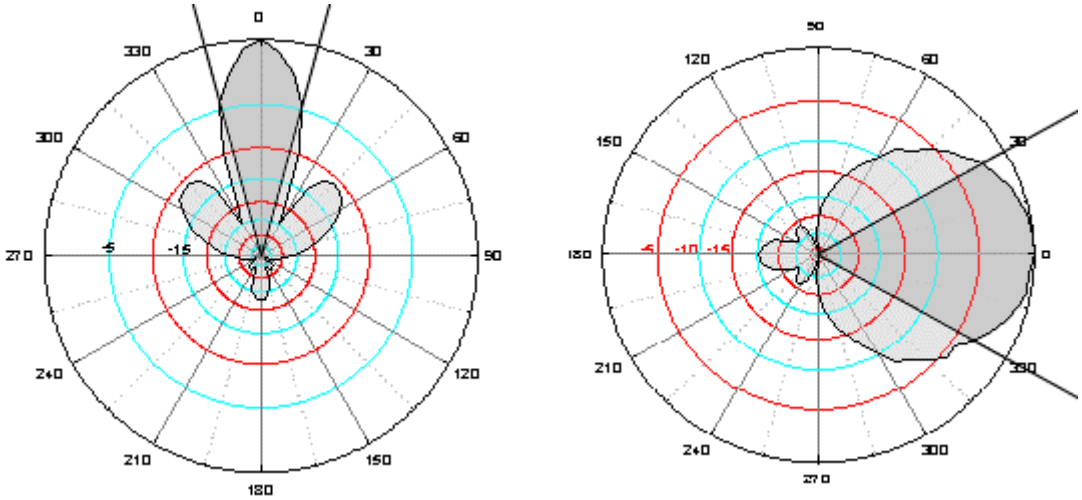
Note that as the horizontal component decreases, the vertical component increases. This relationship always exists as long as the antenna's signal amplification properties, or *gain*, remains the same.



180 degrees Horizontal ANTENNA A 15 degrees Vertical



60 degrees Horizontal ANTENNA B 30 degrees Vertical



30 degrees Horizontal ANTENNA C 60 degrees Vertical

Figure 7 Horizontal and Vertical Lobes

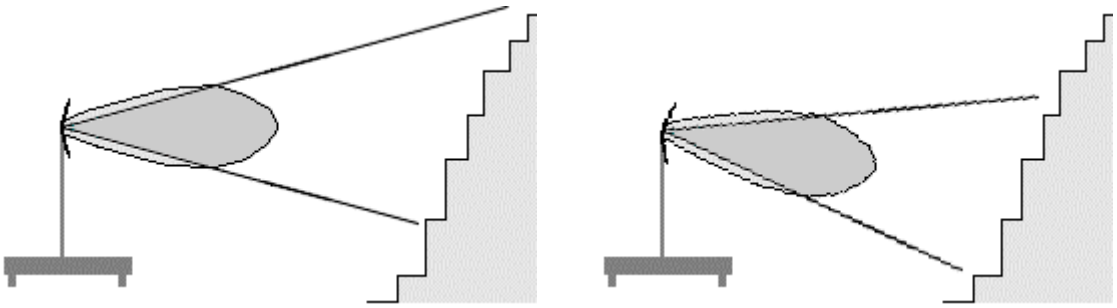
Basically, higher gain antennas concentrate more of the available RF energy into a smaller, more focused beam. The total amount of energy radiated from each antenna is therefore approximately the same (assuming that each is equally matched to 50 ohms).

3.3.3 Tilt Angle (Down Tilt)

Figure 7 shows an antenna with a narrow vertical pattern. Because of this pattern, when you use this type antenna in an open pit mine, you must verify that it provides radio coverage in all areas where you need it.

For example, the left side of Figure 8 shows an access point that is providing coverage to the upper portion of a pit. Any equipment traveling in that part of the pit can communicate with the access point, but vehicles near the bottom of the pit will not have reliable radio contact.

The access point on the right side of Figure 8 has its antenna tilted downward. Now equipment near the bottom of the pit will have an improved signal, but equipment in the upper portion of the pit will have poor coverage.



Level Antenna **Antenna with Down Tilt**

Figure 8 Antenna Tilt Angle (Down Tilt)

To change an antenna's tilt angle, adjust the antenna mounting hardware or alter the antenna's mounting position.

Note: For antennas mounted on mobile access points, you can change the tilt of the antenna by adjusting the vertical height of the outriggers on the trailer.

3.3.3.1 Vertical Coverage by Antenna Type

Certain antenna types are more suitable for covering areas with large vertical elevations.

Parabolic antennas	Parabolic antennas increase gain at the expense of beamwidth - they have a narrow horizontal pattern and a narrow vertical pattern. (may have limited usefulness in the situation shown in Figure 8)
Omnidirectional antennas	Omnidirectional antennas *("omnis")* have a 360 degree horizontal pattern, but some have a narrow vertical beamwidth. (may have limited usefulness in the situation shown in Figure 8)
Sector antennas	Sector antennas have a smaller horizontal coverage pattern than omnis but provide better vertical coverage and higher gain.

3.4 Signal Patterns and Gain Characteristics for Antenna Types

This section describes signal patterns and gain characteristics for antennas used in the radio network.

3.4.1 Omnidirectional Antennas

The network uses two omnidirectional antenna models.

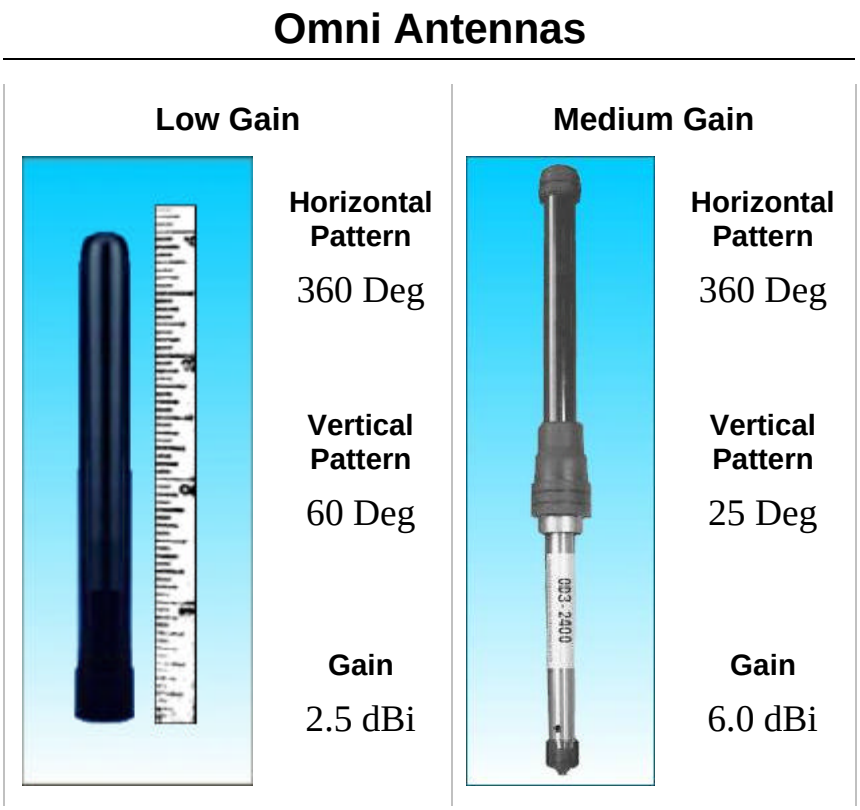


Figure 9 Omnidirectional Antennas

Characteristics of Omni Antennas

Horizontal Pattern	omni-directional antennas provide full 360 degree coverage
Vertical Pattern	taller higher-gain omni antennas have more narrowly focused vertical coverage
Gain	gain increases as vertical pattern becomes more focused

3.4.2 Sector Antennas

The network uses two sector antenna models.

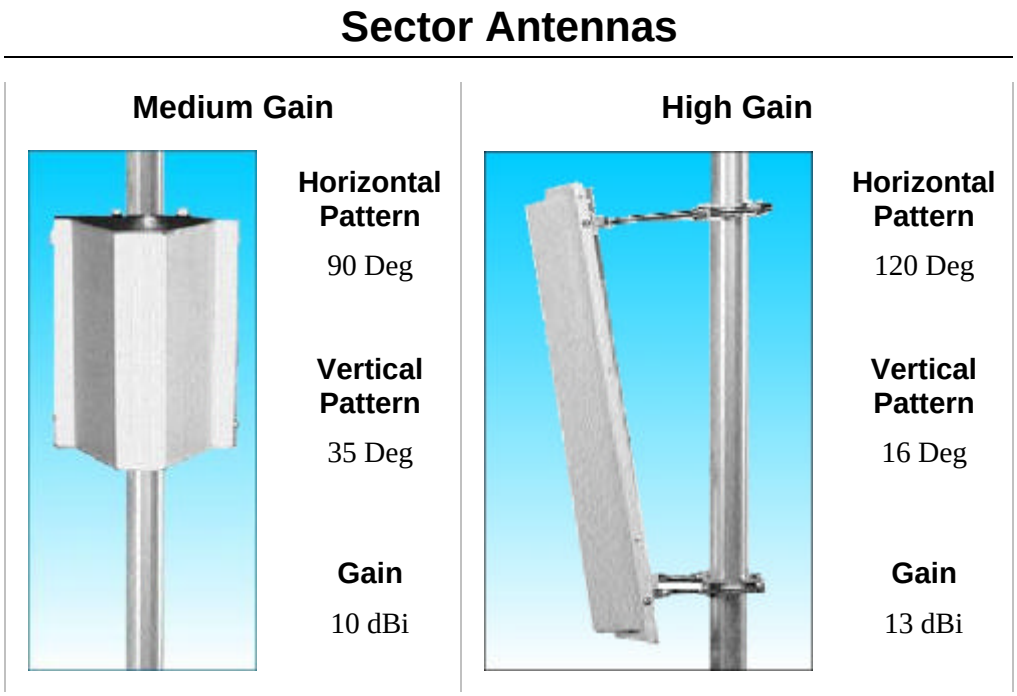


Figure 10 Sector Antennas

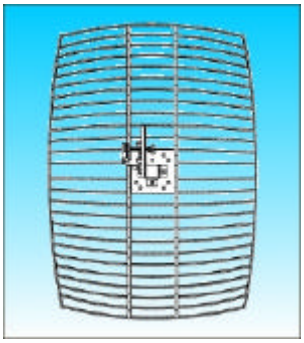
Characteristics of Sector Antennas

Medium Gain	tall vertical pattern covers deeper pits, but narrower horizontal pattern provides less horizontal coverage
High Gain	wider horizontal coverage and higher gain than medium gain antenna, but narrower vertical pattern requires antenna tilt for good vertical pit coverage

3.4.3 Parabolic Antenna

The network uses one parabolic antenna model.

Parabolic Antenna



Horizontal Pattern

9 Deg

Vertical Pattern

9 Deg

Gain

24 dBi

Figure 11 Parabolic Antenna

Characteristics of Parabolic Antennas

Horizontal / Vertical Pattern	narrow beams for focused transmission power and improved reception, with proper antenna aiming
Gain	high gain due to focused pattern
Ice / No Ice	ice model designed to withstand freeze/thaw cycles

3.5 Adjusting, Changing, or Relocating an Antenna

If you have determined that your communications problem is not caused by a hardware malfunction, then you can evaluate the following antenna options:

- redirecting or changing an antenna on an existing access point
- moving an access point
- adding a new access point

Prior to changing the network, however, you need to review the design of the existing network, and understand the placement of each access point and the use of each antenna on each access point.

3.5.1 Understanding the Requirements of Your Network

Before adjusting, changing, or relocating an antenna, you should gather the following information:

1. Review the characteristics of the present network.
   a. What is its intended coverage area?
   b. What are all the signal obstructions (buildings, terrain, etc.) that were considered in the original design?
   c. What is the intended coverage area for each antenna in the network?
2. What conditions have changed that now require an alteration to the original network?
   a. Has the original coverage area changed?
   b. Are there new signal obstructions (buildings, terrain, etc.)?
   c. Which antennas are affected by these changes?

3.5.2 Recording Antenna Characteristics

When you have isolated your network problem to a single access point, record the specifications for that access point's antenna.

What are the characteristics of the antenna on the mobile access point that you are evaluating?

Antenna Characteristics	
Antenna type:	☐ omnidirectional ☐ sector ☐ parabolic
Antenna gain:	_____ dBi
If a sector antenna, horizontal pattern:	☐ 90 degrees ☐ 120 degrees
Angle between antenna and no coverage area:*	_____ degrees
* *What is the angle between the areas of heavy no coverage clusters and the repeater antenna?*	

Refer to the RF Theory section of the *MasterLink Design Manual* for detailed information on antenna types, patterns, and ranges.

3.6 Obtaining Additional Guidance

Before contacting regional support for assistance you will want to collect all relevant information on the condition of your network.

When you discover a no coverage area in the mine, answer the following questions:

1. Is the no coverage area in a new mine operations area?
2. Has the mine recently altered the network? (For example, has a mobile access point been moved?)
3. Are the antennas that serve the no coverage area operating properly?
4. Does any structure or terrain block the signal?
5. Does the no coverage area fall within the primary horizontal and vertical signal lobes of the antenna serving the area?

Note: To measure antenna angles you will need to take simple field measurements with a protractor or bubble level device.

For major changes in mining operations, you may need to add additional access points. Contact your regional Modular Mining Systems support office if you think this is the case.

4. Moving an Access Point

Because a mine's layout is constantly changing, the radio network provides access points that can be moved when necessary.

4.1 Selecting a New Access Point Site

Mine operations may require that you move an access point a short distance, where the access point, in its new location, maintains line-of-sight contact with all its associated coverage areas.

Be aware of potential signal blockage problems at the new location. After moving the access point, verify good radio coverage at the new site. (See section 4.3, "Verifying Radio Coverage.")

If you must move an access point a long distance, and line-of-sight contact cannot be maintained to all previous coverage areas, have a radio engineer determine the new site location so that all serviced areas continue to receive proper coverage.

4.2 Relocation Procedures

Once you have selected a new access point site, refer to Appendix C of the *MasterLink Mobile Access Point Assembly Manual* for relocation procedures.

4.3 Verifying Radio Coverage

After you move the access point to its new site you verify proper radio coverage by performing a drive test in the coverage area.

5. Cisco Wireless Access Point Support

5.1 Cisco Initial Setup

5.1.1 Site First Steps

To configure the Cisco Aironet 350 Access Point to work at a customer site, you need to do the following:

1. Configure Ethernet Connected devices as Root Bridges
2. Configure static IP addresses.
3. Configure device names (mpr11, etc).
4. Configure customer specific WEP keys.

You can do all of these things by either connecting with each device via the serial port (see *Appendix A — 302395 Connection Diagram*), or by connecting them all to a network that has a DHCP server and using the Web browser based interface.

To use the DHCP/Web interface, connect all devices to the network and power them on. After they have been powered on for several minutes, you can use the command line query tool (FindWAPM) to report the IP addresses of all the Access Point parents on the network. The FindWAPM tool queries the network for the Wireless Access Point Monitors that are built into the repeater box, and reports back what devices it finds. Once you connect a device, you can use the steps in Appendix B to configure each one.

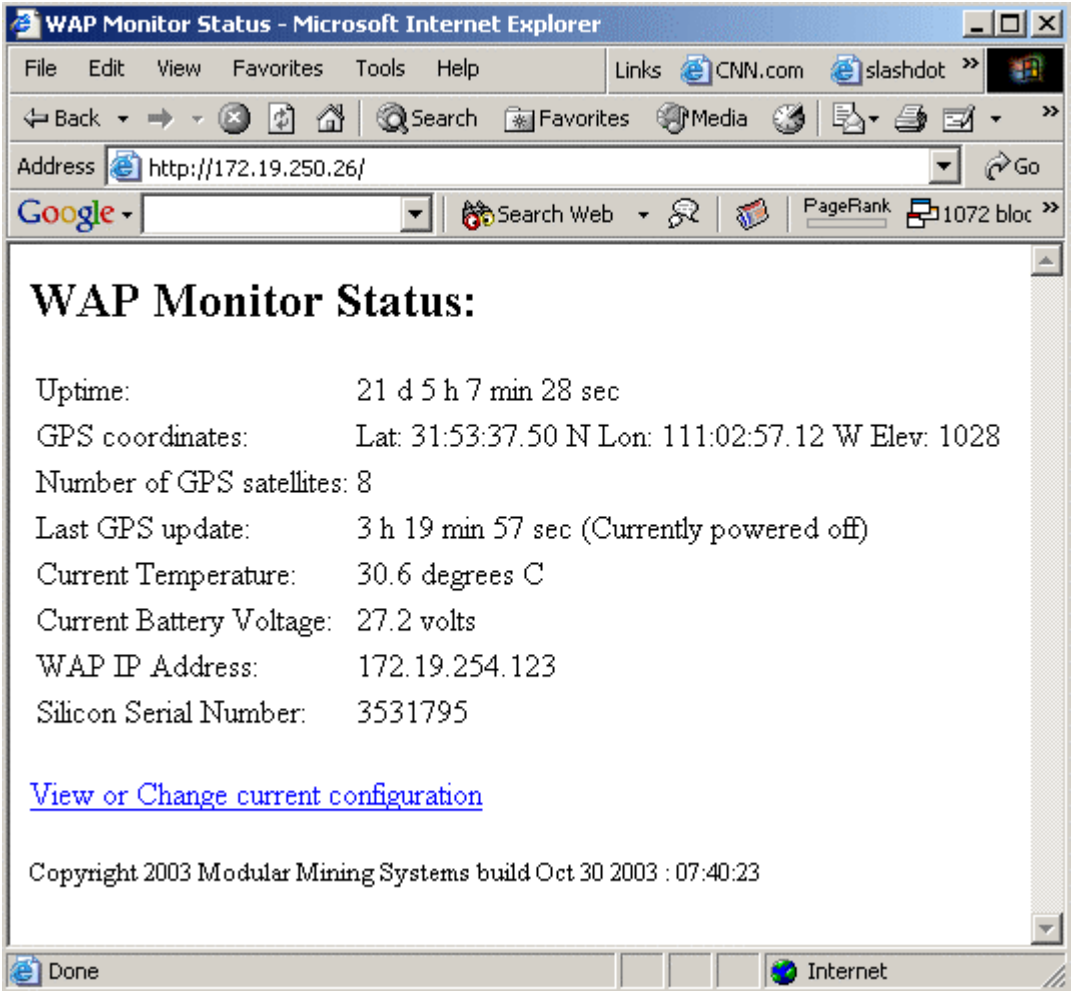
5.1.2 WAP Monitor

The WAP Monitor is a small computer attached to the Cisco via Ethernet. It has a SK2 GPS receiver as well as circuitry to monitor temperature and battery voltage. This device has its own MAC and IP addresses. The FindWAPM utility will find all of these devices and report back their information.

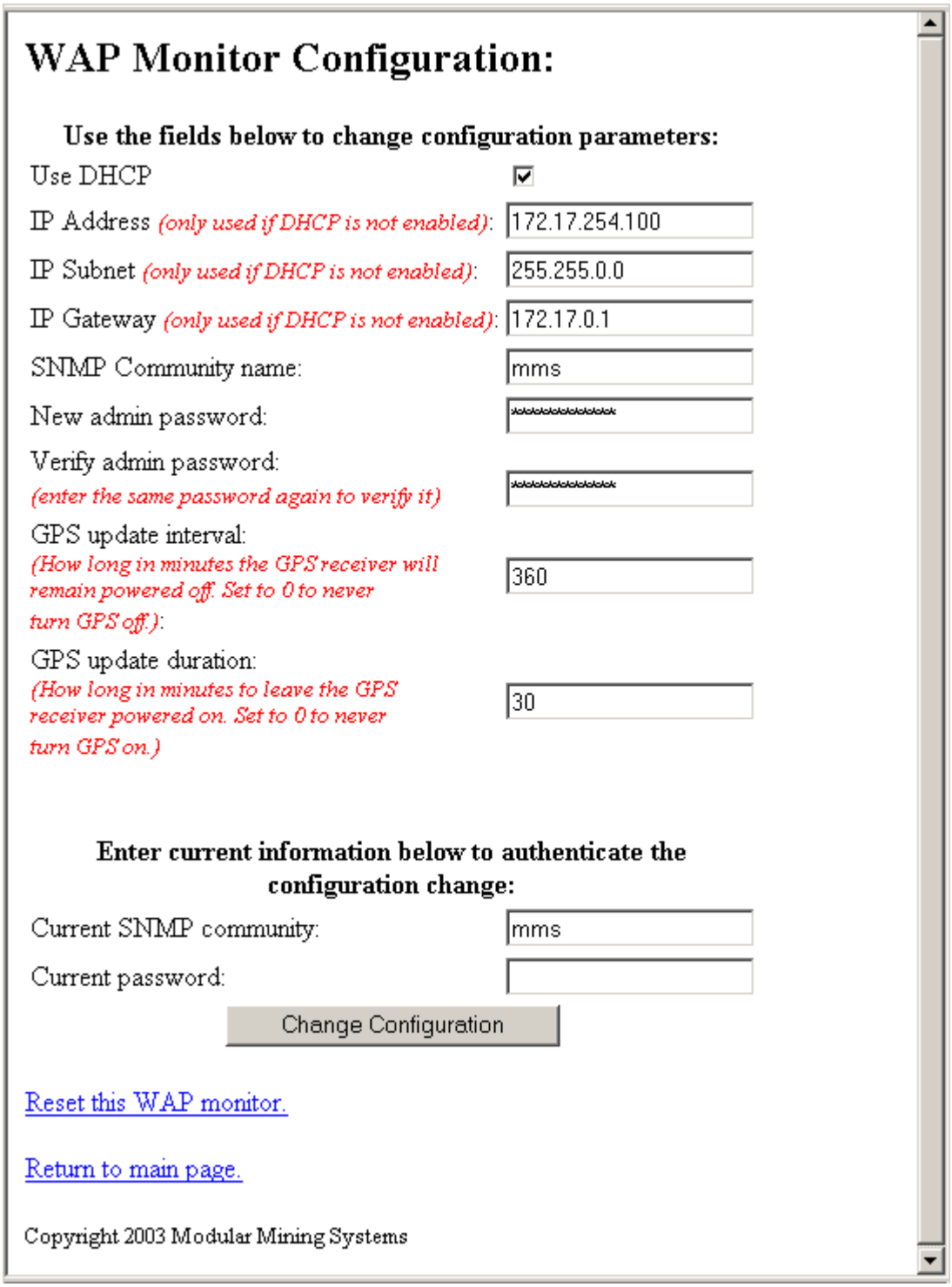
```
cnb4:src$ FindWAPM
Reply from 172.19.250.26:
        Lat: 114817500 Lon: 3895190176 Elev: 1028       Num Sats: 8 GPS Age: 11930
        Parent IP: 172.19.254.123
        Temp: 30.6 Voltage: 27.2
Reply from 172.19.250.29:
        Lat: 114838080 Lon: 3895227796 Elev: 1005       Num Sats: 8 GPS Age: 11895
        Parent IP: 172.19.254.117
        Temp: 28.0 Voltage: 27.2
Reply from 172.19.250.27:
```

```
        Lat: 114841260 Lon: 3895267816 Elev: 1000       Num Sats: 8 GPS Age: 19271
        Parent IP: 172.19.254.118
        Temp: 30.6 Voltage: 27.3
Reply from 172.19.250.25:
        Lat: 114827520 Lon: 3895306156 Elev: 1018       Num Sats: 8 GPS Age: 19807
        Parent IP: 172.19.254.124
        Temp: 28.0 Voltage: 28.2
```

The default configuration is to use DHCP to get an IP address for these devices. If you do not have a DHCP server, you must temporarily enable a server, then go to the DHCP assigned IP address of each device and configure it with a static IP address. You can do this through the HTTP interface by entering the IP address you find with the FindWAPM utility. In the above example of the FindWAPM output, going to the WAPM at 172.19.250.26 would display the following screen:



To change the IP address, click the “View or Change current configuration” link, which will take you to the following screen:



WAP Monitor Configuration:

Use the fields below to change configuration parameters:

Use DHCP ☑

IP Address *(only used if DHCP is not enabled)*: 172.17.254.100

IP Subnet *(only used if DHCP is not enabled)*: 255.255.0.0

IP Gateway *(only used if DHCP is not enabled)*: 172.17.0.1

SNMP Community name: mms

New admin password: ••••••••••••••

Verify admin password:
(enter the same password again to verify it) ••••••••••••••

GPS update interval:
(How long in minutes the GPS receiver will remain powered off. Set to 0 to never turn GPS off.): 360

GPS update duration:
(How long in minutes to leave the GPS receiver powered on. Set to 0 to never turn GPS on.) 30

Enter current information below to authenticate the configuration change:

Current SNMP community: mms

Current password:

Change Configuration

Reset this WAP monitor.

Return to main page.

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5.1.3 MasterLink/OMS/Dispatch Integration

The Network.hosts file should contain entries for all Cisco WAPs:

```
172.17.0.123     mpr123     cisco
172.17.0.120     mpr120     cisco
```

After adding these entries, reload OMSns with 'OMSns –r'

Modify /dsp/client/psw/OMSrun to contain a line that will start the CiscoDiags daemon:

```
CiscoDiags&
```

Verify that MasterLink mobile devices (trucks/shovels/etc.) are getting the network metric information by connecting via OMStip and typing 'wan0 status'. If they are getting the information, IP addresses for the Cisco APs will appear in the list. This metric information is sent to all mobile equipment through a broadcast message once every 20 seconds.

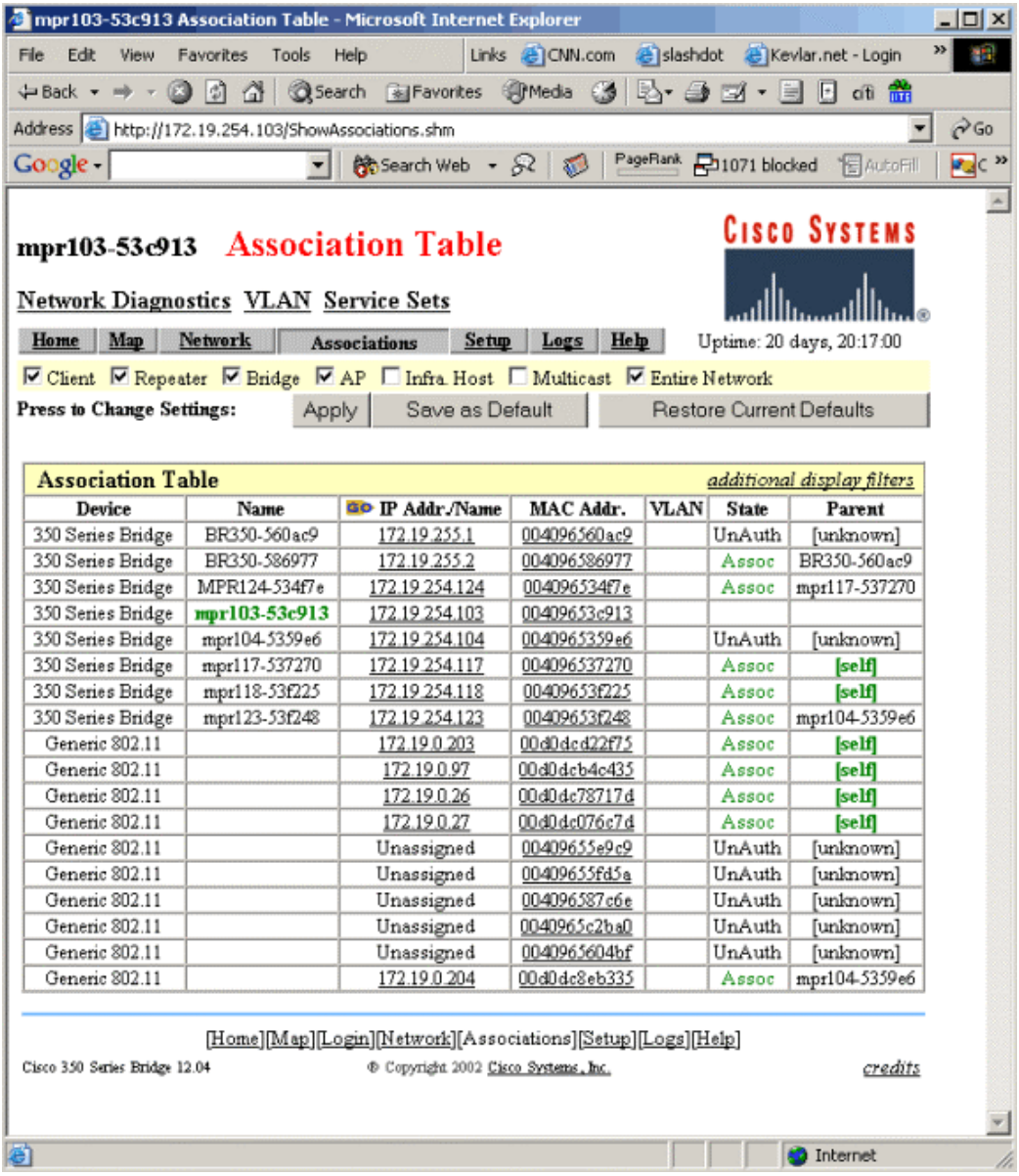
5.2 Troubleshooting

5.2.1 The System Log

Each WAP keeps a log in RAM of important events (if the device is powered down, the log is lost). Check this log if you are experiencing any problems.

5.2.2 Association Page

If you connect to any Cisco WAP in the network and view the Associations page, you can select the "Entire Network" checkbox and click the "Save as Default" button to see the entire network at a glance. From this screen, you can see what AP each device is associated with.



5.2.3 Link Test

The Cisco Link test is available from the association page. You can only perform a link test when two devices are associated. From the parent device, click the MAC address of the device you want to test with, and you should see a link test button. If you do not see this button, the device you are connected to isn't associated (either as a child or parent) with the station whose MAC address you clicked.

Below are the results of a normal good link test.

mpr117-537270 LinkTest Log mpr103-53c913 - Microsoft Internet Explorer

Pkts. Attempted	100	Pkts. Requested	100
Pkts. Successful	100	Payload Size	500
Avg. Delay	24.2 msec	[Min, Max] Delay	[19.2, 326.9] msec
Transmit Rates	100 at 11.0		

To the Station		From the Station	
Avg. Signal Strength	77%	Avg. Signal Strength	76%
[Min, Max] Strength	[77%, 78%]	[Min, Max] Strength	[74%, 79%]
Pkts. No Retries	100	Pkts. No Retries	98
Pkts. 1 Retry	0	Pkts. 1 Retry	2
Pkts. Mult. Retries	0	Pkts. Mult. Retries	0
Pkts. Max. Retries	0		
Pkts. Lost	0	Pkts. Lost	0
Duplicate Pkts.	0	Duplicate Pkts.	0
RTS Retries	0	RTS Retries	0
Data Retries	2	Data Retries	2

Test Again | Continuous Test

5.2.4 Ping test

You can use the broadcast ping (ping –b 172.17.255.255) if you are using Linux. All possible devices will respond, giving you a quick idea of the latency and reliability of the network. Below is an example of the command:

```
cnb4:mms$ ping -b 172.19.255.255
WARNING: pinging broadcast address
PING 172.19.255.255 (172.19.255.255) from 172.19.0.5 : 56(84) bytes of data.
64 bytes from 172.19.0.5: icmp_seq=1 ttl=255 time=0.036 ms
64 bytes from 172.19.255.5: icmp_seq=1 ttl=255 time=1.51 ms (DUP!)
64 bytes from 172.19.254.104: icmp_seq=1 ttl=64 time=1.73 ms (DUP!)
64 bytes from 172.19.254.103: icmp_seq=1 ttl=64 time=2.32 ms (DUP!)
64 bytes from 172.19.254.123: icmp_seq=1 ttl=64 time=9.95 ms (DUP!)
64 bytes from 172.19.254.117: icmp_seq=1 ttl=64 time=11.4 ms (DUP!)
64 bytes from 172.19.254.118: icmp_seq=1 ttl=64 time=16.1 ms (DUP!)
64 bytes from 172.19.254.124: icmp_seq=1 ttl=64 time=23.9 ms (DUP!)
64 bytes from 172.19.0.5: icmp_seq=2 ttl=255 time=0.019 ms
64 bytes from 172.19.255.5: icmp_seq=2 ttl=255 time=1.49 ms (DUP!)
64 bytes from 172.19.254.104: icmp_seq=2 ttl=64 time=1.73 ms (DUP!)
64 bytes from 172.19.254.103: icmp_seq=2 ttl=64 time=2.03 ms (DUP!)
64 bytes from 172.19.254.117: icmp_seq=2 ttl=64 time=5.65 ms (DUP!)
64 bytes from 172.19.254.118: icmp_seq=2 ttl=64 time=9.26 ms (DUP!)
64 bytes from 172.19.254.123: icmp_seq=2 ttl=64 time=11.8 ms (DUP!)
64 bytes from 172.19.254.124: icmp_seq=2 ttl=64 time=12.6 ms (DUP!)
64 bytes from 172.19.0.5: icmp_seq=3 ttl=255 time=0.015 ms
64 bytes from 172.19.255.5: icmp_seq=3 ttl=255 time=1.53 ms (DUP!)
64 bytes from 172.19.254.104: icmp_seq=3 ttl=64 time=1.63 ms (DUP!)
64 bytes from 172.19.254.103: icmp_seq=3 ttl=64 time=2.04 ms (DUP!)
64 bytes from 172.19.254.117: icmp_seq=3 ttl=64 time=6.71 ms (DUP!)
64 bytes from 172.19.254.118: icmp_seq=3 ttl=64 time=7.66 ms (DUP!)
64 bytes from 172.19.254.123: icmp_seq=3 ttl=64 time=10.2 ms (DUP!)
64 bytes from 172.19.254.124: icmp_seq=3 ttl=64 time=13.1 ms (DUP!)
--- 172.19.255.255 ping statistics ---
3 packets transmitted, 3 received, +21 duplicates, 0% loss, time 2017ms
rtt min/avg/max/mdev = 0.015/6.445/23.981/6.106 ms
```

5.3 Serial Port Configuration

5.3.1 Initial Configuration (Serial Port)

5.3.1.1 Connect PC to MasterLink/Cicso Repeater Hub

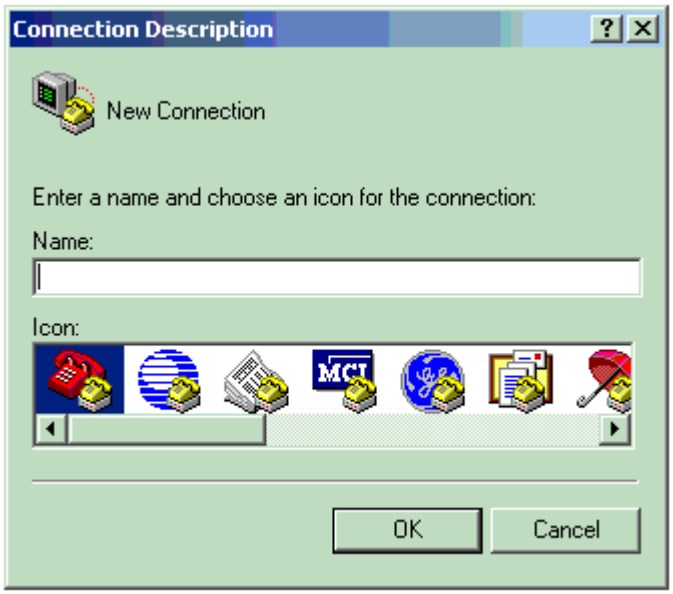
1. Using a standard SLIP cable, connect the COM1 serial port on the PC to the service serial port on the MasterLink/Cisco Repeater Hub.
2. Turn off power to the MasterLink/Cisco Repeater Hub.

5.3.1.2 Hyper Terminal Setup

Access the PC HyperTerminal connector or other terminal emulator software and configure it to talk to the MasterLink/Cisco Repeater Hub serial port by doing the following:

1. On the PC, select Start=>Programs=>Accessories=>Communications=>HyperTerminal.

   The Connection Description dialog box appears:



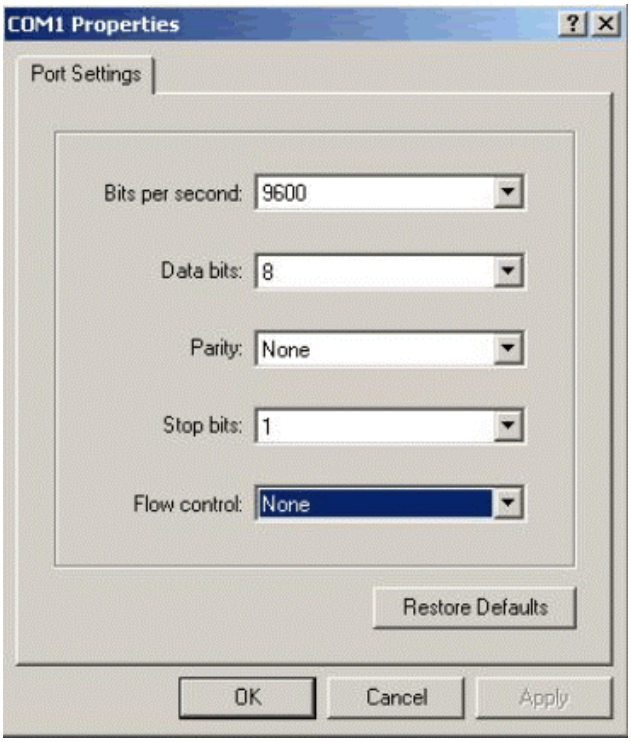
2. In the Name box, type a name for the connection session and click the OK button.

   The Connect To dialog box appears.

3. In the Connect using box, use the menu to enter COM1, as shown below, and then click the OK button.

The COM1 Properties dialog box appears.

4. Using the pull-down menus, in the Bits per second box, enter 9600; in the Data bits box, enter 8; in the Parity box, enter None; in the Stop bits box, enter 1; and in the Flow control box, enter None, as shown below.



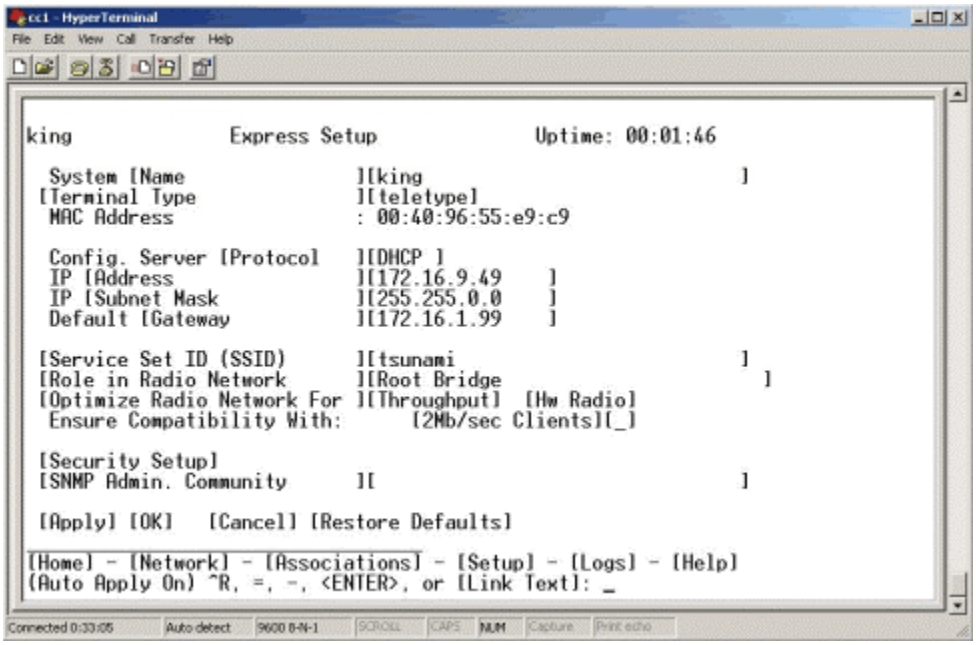
5. Click the OK button.
6. Power up the MasterLink/Cisco Repeater Hub.

   The HyperTerminal window appears and text scrolls as the Cisco 350 boots up.

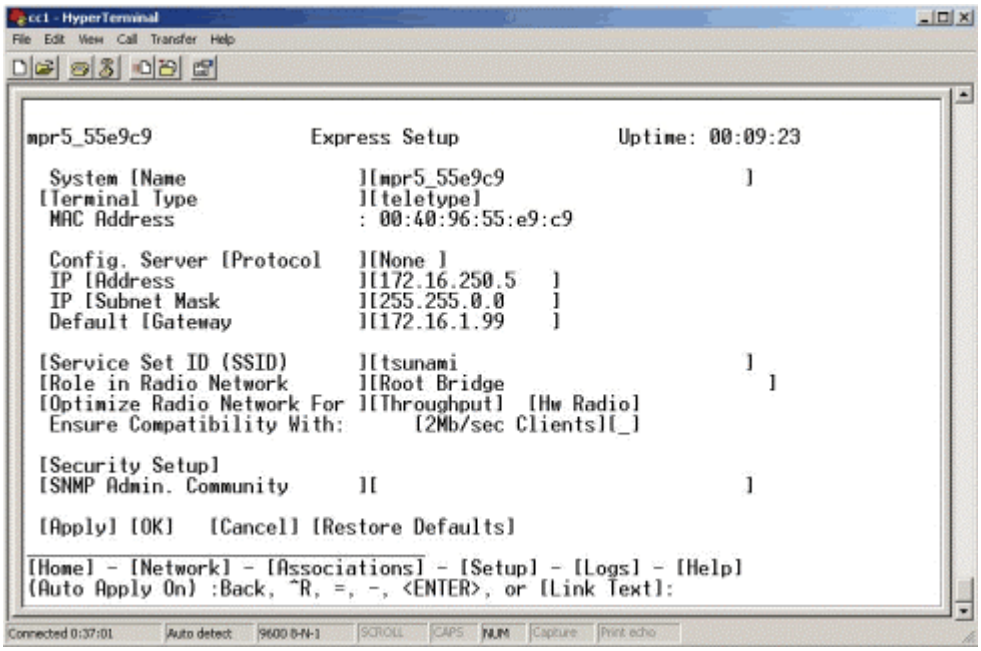
5.3.1.3 Express Setup

After the Cisco finishes booting, do the following to perform an express setup of the Cisco 350.

3. Type s in the HyperTerminal window to display the Setup screen.
4. Type ex to display the Express Setup screen, shown below.

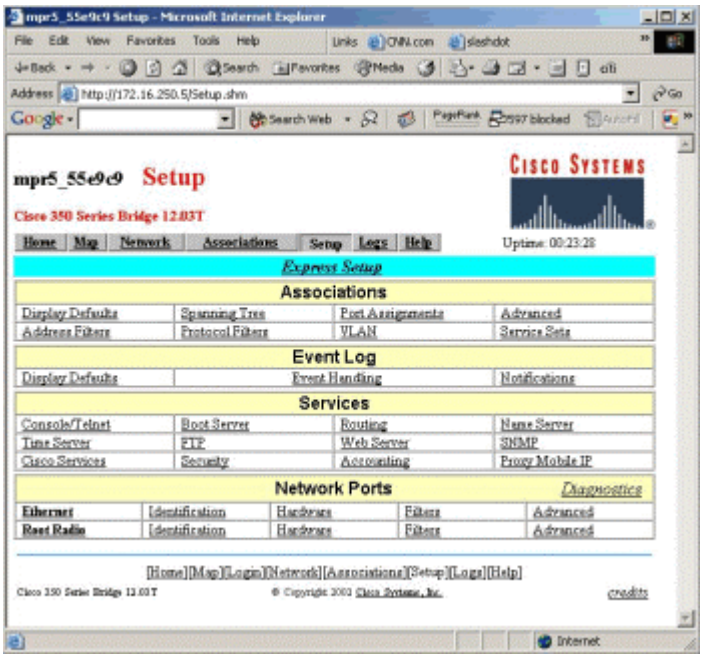


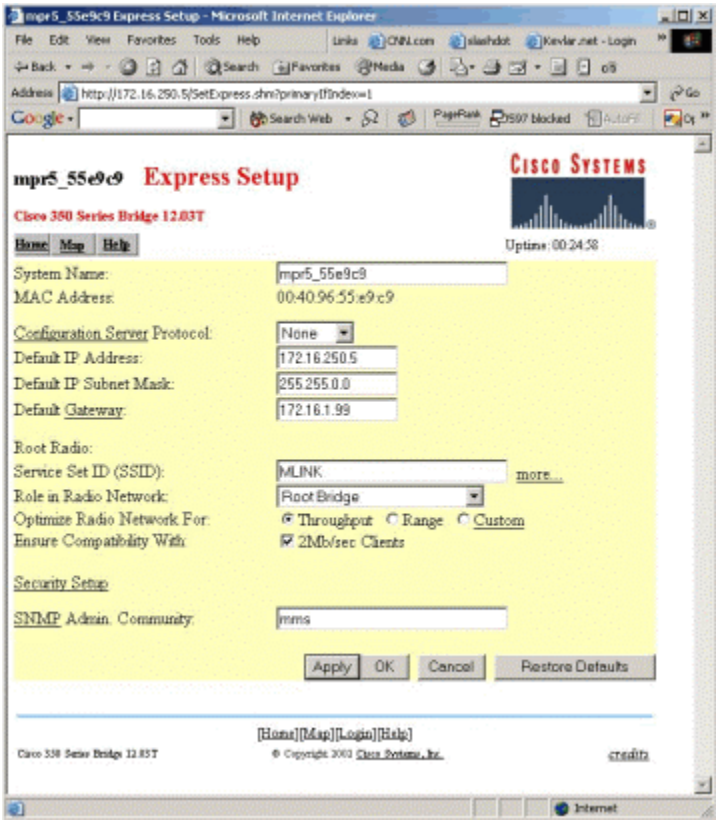
5. To change a field, start typing the name of the field that is shown in brackets. As soon as you have typed enough of the name for the device to know which field you want to edit, the field will auto complete the rest of the name. For instance, to set the "Config. Server Protocol", type "Pr" and you will see the word "Protocol" appear. Now hit enter to edit this field.
6. Setup and save IP/Mask/Gateway, and any other fields you wish to edit at this point.



5.4 Standard Configuration via HTTP

Now connect to the device through a web browser, using the IP address you specified in the setup.





5.4.1.1 Ethernet connected

Role: Root Bridge

5.4.1.2 Wireless

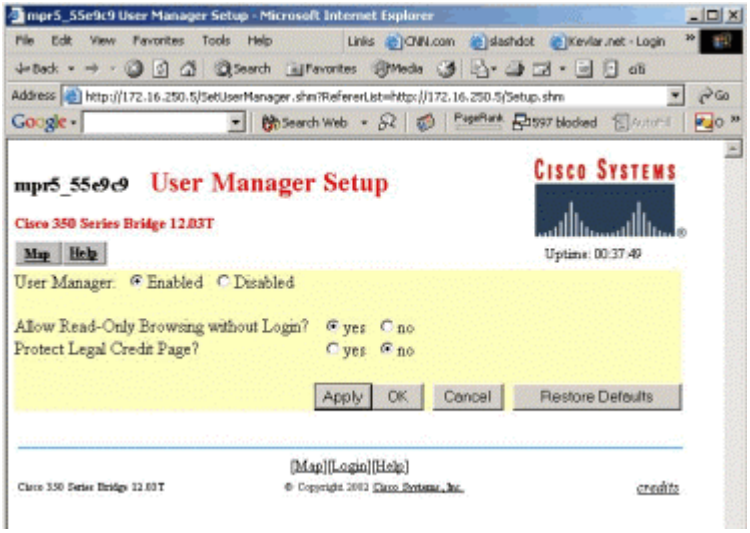
Role: Non-Root Bridge w/clients

Select the "Ensure Compatibility With: 2Mb/sec Clients" checkbox.

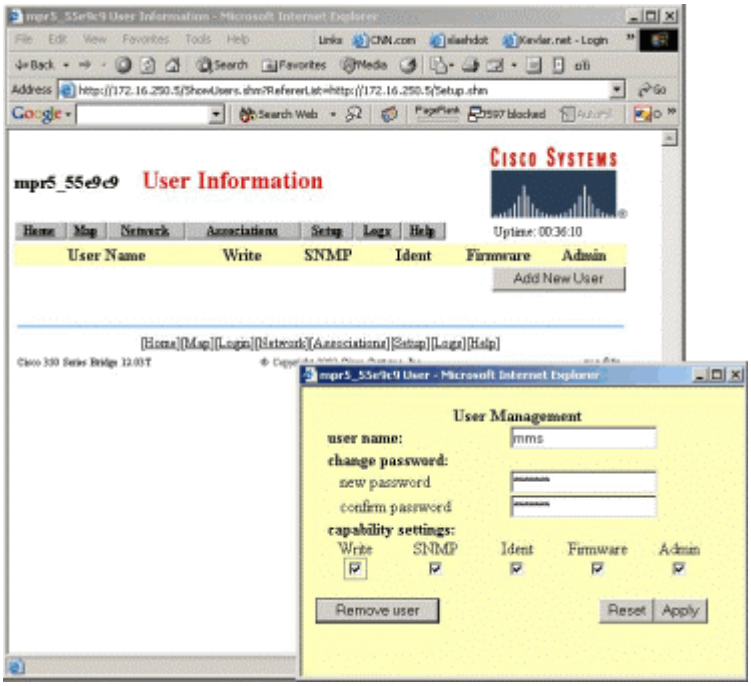
Set the following parameters:

- Set the system name as desired (mpr120, etc.) (from express setup page)
- Set the SNMP admin community to "mms". This is needed for the CiscoDiags application to get the network metric information to send to MasterLink devices (from express page)
- SSID (MLINK is the default for MasterLink) (from express setup page)
- Disable DNS (speeds boot-up time)
- Username/password (same for all WAPs to make upgrading firmware or configuration easier via the distribute firmware feature).

First, enable the user manager:

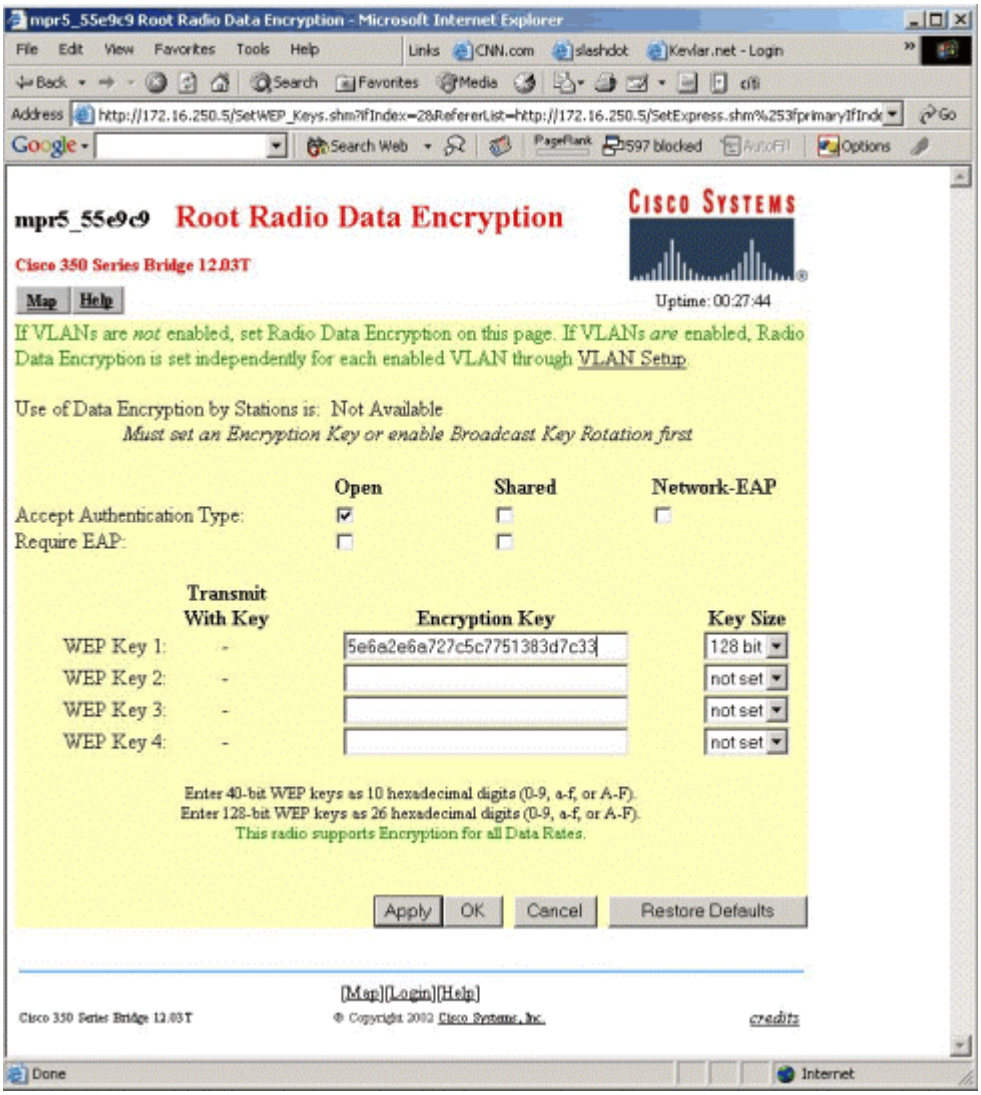


Now, add a user and set all the permissions:

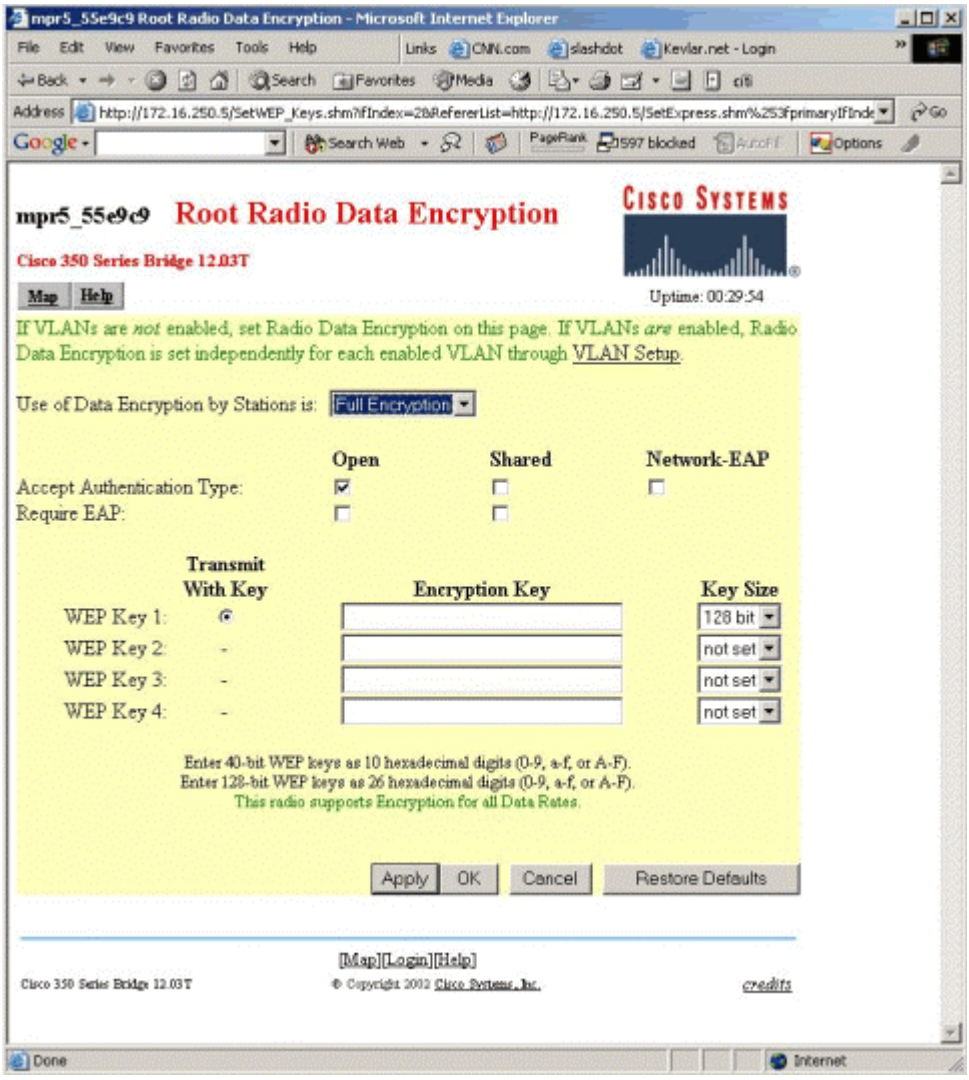


5.4.1.3 WEP

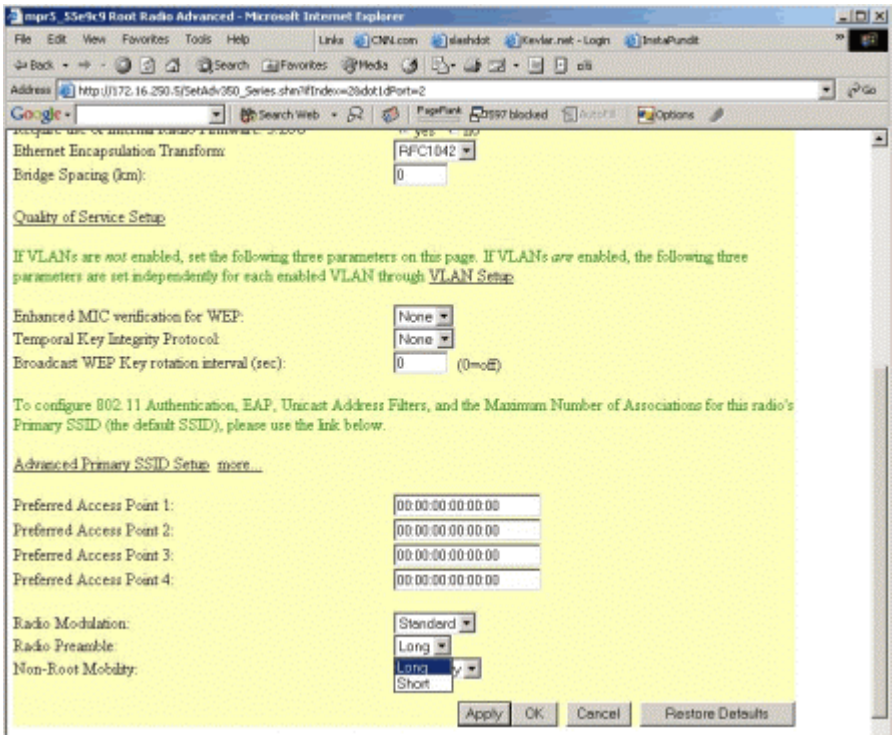
First, set the WEP key to whatever key you chose to use:



After clicking the OK button, return to this screen to enable encryption:



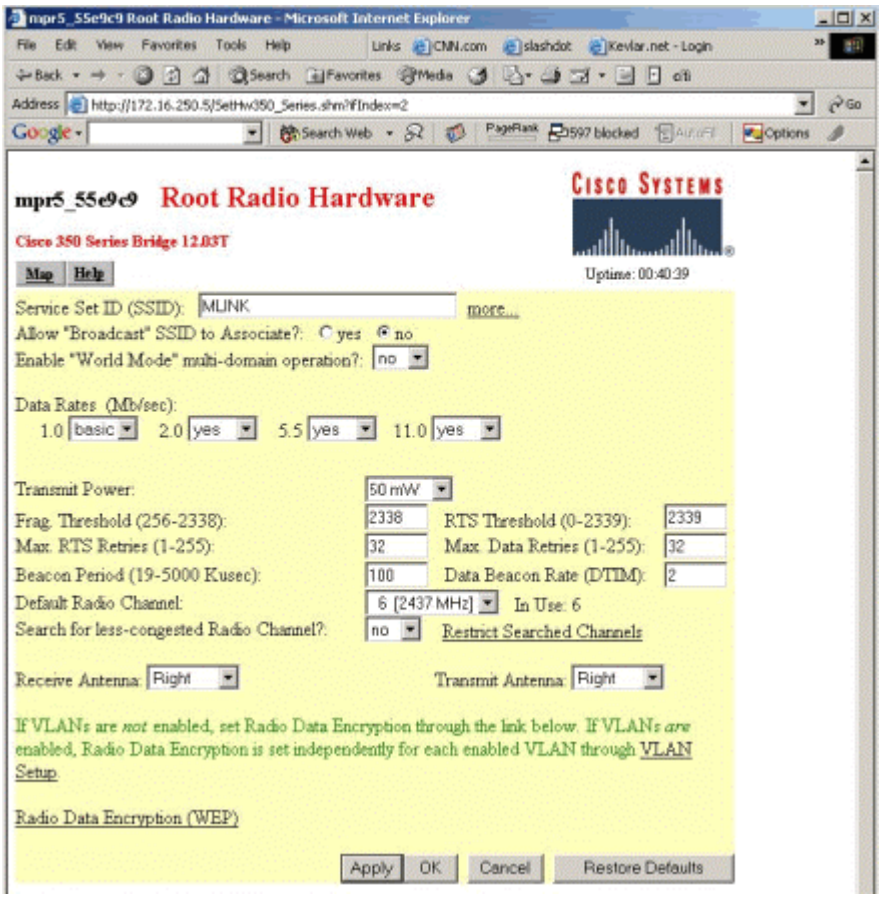
Set Long preambles (MasterLink requires long preambles to be set). Do this from the Root Radio: Advanced screen.



5.4.1.4 Setting the Channel

From the Root Radio: Hardware screen:

- Set both receive and transmit antenna to ‘Right’.
- Select the desired Channel, and set “Search for less-congested Radio Channel?” to “No”.



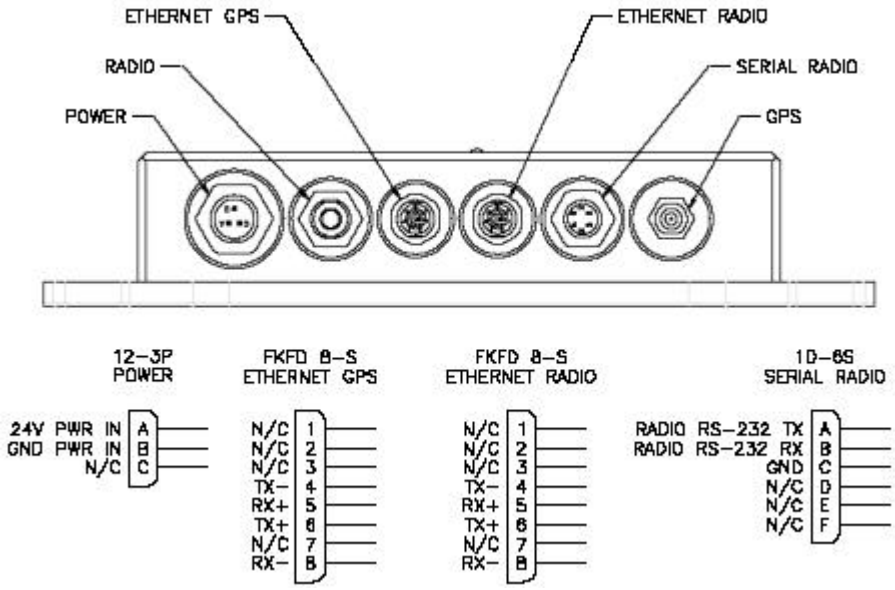
5.5 Password Recovery

If the password for the Cisco devices is lost, refer to the Cisco document: “Password Recovery Procedure for Cisco Aironet Equipment” located at http://www.cisco.com/en/US/products/hw/wireless/ps430/products_password_recovery09186a00800949d0.shtml.

The short description of how to reset the configuration, including all passwords, is to connect to the device via the serial cable, then reboot it. Within four minutes of rebooting, you can type ‘:resetall’ (without the quotes). If the device prompts you for a username/password, just press enter and type :resetall when it returns you to the prompt.

After this procedure is done, all configuration steps in this document will need to be performed again.

6. Appendix A — 302395 Connection Diagram



Revision History

Revision	Date	Comments
—	February 2002	First issue