UC WIRELESS
WI-LAN TECHNOLOGIES INC

VIP 110-24

Operator's Manual

Rev: Preliminary

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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 UC Wireless Inc. may void the user's authority to operate this equipment. UC Wireless 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.

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UC WIRELESS 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 UC WIRELESS's packing slip or other transportation receipt.

UC WIRELESS'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 PURCHASER has promptly reported same to UC WIRELESS in writing. All replaced Products or parts shall become UC WIRELESS's property.

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

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TABLE OF CONTENTS

1 INTRODUCTION

The *VIP 110-24* is the building block of the UC Wireless proprietary "VINE" Network topology. This unique network topology can be used to provide broadband internet access by a Service Provider or to interconnect multiple nodes in a private network.

The VINE technology allows a complete wireless network to start with as little as two radios, and gradually grow, a node at a time, into a very large and complex wireless network. New nodes can be added at any time with the sole requirement that they must have line of sight connectivity to another node already on the VINE. The new node, once attached, becomes a potential attaching point for other nodes.

VINE uses time, frequency, and directional diversity to coordinate the Medium Access for all the nodes. This well choreographed diversity allows multiple nodes to transmit without collisions in the same geographical area. This results in a very high air time utilization which translates into superior throughput performance.

VINE is designed to specifically address the following requirements:

- Gradual deployment and expansion
- Long distance between nodes
- Support of multi-hop transmissions. Not all nodes need to be in line of sight
- Highly efficient air time utilization
- Efficient delivery of broadcast traffic (necessary for network management)
- Fair network availability under heavy loads (a few nodes with heavy load must not "choke" the network availability to all other nodes)
- Node by node Quality Of Service Options: Minimum and maximum user data rate settings separate for inbound and outbound traffic ***[NOTE: This feature not implemented in version 3.00 software.]***
- Automatic RF data rate selection on each individual link
- Self configuring allowing new nodes to be added with minimal configuration
- Support for a small number of mobile nodes that can roam throughout the fixed underlying network. ***[NOTE: This feature not implemented in version 3.00 software.]***

The *VIP 110-24* is a Spread Spectrum transceiver that implements the VINE protocol. The radio includes a 10-Base T Ethernet port for connection to the Local Area Network (LAN). The radios can be set to operate in either Bridge mode or Router mode. ***[NOTE: The router feature is not implemented in version 3.00 software.]*** In bridge mode, any station connected to the LAN can see any other station connected to all the other LANs at the remote sites. No special configuration of the user stations is necessary, as each of them believes that there is just one Ethernet.

The *VIP 110-24* is a Spread Spectrum radio operating in the "Industrial Scientific and Medical" (ISM) band from 2.400GHz to 2.4835 GHz. Spread Spectrum technology allows operation without a license with an output power of up to 23 dBm at speeds up to 11 Mbps (mega-bits per second).

With exception of the indoor power inserter, all of the *VIP 110-24* electronics are included in a watertight outdoor unit enclosure. A single CAT 5 cable carries the Ethernet data and DC power to the outdoor enclosure. This architecture allows the radio to be mounted outdoors, in close proximity to the antennas, resulting in the following benefits:

- The radio Low Noise Amplifier (LNA) is as close to the antenna as possible. The cable run between the antenna and the outdoor unit is usually short and therefore cable losses at 2.4 GHz are negligible. This improves the overall link margin.
- The unit Power Amplifier is also in close proximity to the antenna. All the power is delivered to the antenna with minimal losses in the cable.

The *VIP 110-24* also includes a number of unique features that make the unit easy to install and operate:

- Spectrum analysis capability with a graphical display of the energy in the RF band
- Accurate measurement of the Receive Signal Strength (RSS)
- Antenna Alignment Aid output, at the outdoor unit, with an audio pitch proportional to the RSS ***[NOTE: This feature not implemented in version 3.00 software.]***
- Automatic adjustment of RF speed to adapt to the RF link margins
- Automatic adjustment of the RF transmit power to manage frequency reuse
- Multitude of frequency channels allow operation anywhere in the band
- Dual antenna port to support store and forward operation in the unique VINE network topology

Refer to section 5.1 for a "Quick Start" guide to set up the radios.

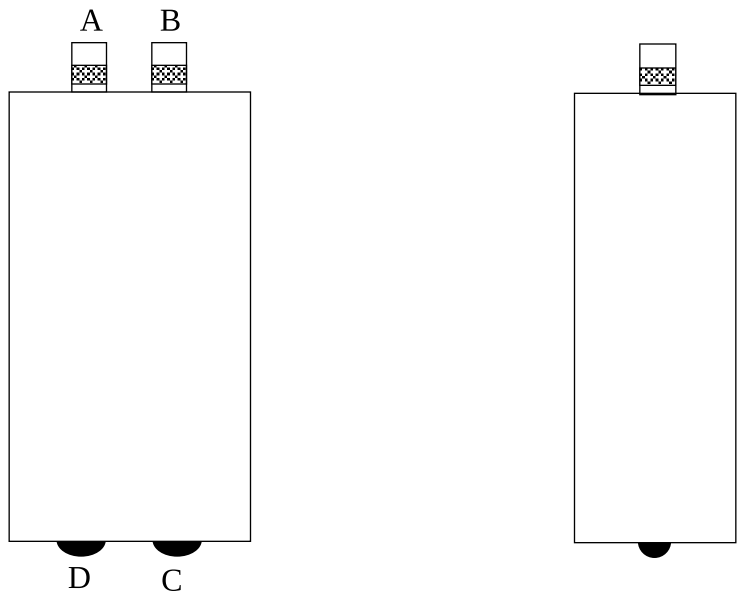
2 SPECIFICATIONS

RF Specifications	
RF Frequency Band	2.410GHz to 2.470 GHz
RF Signal Bandwidth (-20 dBc)	18 MHz
RF Channels	31 (4 non-overlapping)
Transmitter Output Power	0 to 23 dBm (programmable)
Modulation Type	direct sequence spread spectrum
RF Data Rates (one way)	1, 2, 5.5, 11 Mbps
Receiver Sensitivity (10^{-6} BER)	-89 dBm (@ 1 Mpbs) –86 dBm (@ 2 Mbps) -84 dBm (@ 5.5 Mbps) -81 dBm (@ 11 Mbps)
Data Interfaces	
Auxiliary Port	RS-232
Ethernet Port	10 BaseT
Power Requirements	
Input Voltage	+12 to +24 Volts DC
Power Consumption	less than 5 Watts
Environment	
Temperature	-35 to +65 Degrees C
Max. Humidity	90% non-condensing
Mechanical:	
Dimensions	3.14" wide x 2.24" high x 4.92" deep (79mm W x 56 H x 125 D)
Weight	2.4 lbs. (1.1 Kg).

3 HARDWARE

3.1 Enclosure and Connectors

Figure 3.1 shows the *VIP 110-24* enclosure. 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 data and the user interface.



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

Table 3.1 – VIP 110-24 Connectors

CONNECTOR	TYPE	Function
A	N-FEMALE	2.4 GHz RF connector to the upstream (directional) antenna
B	N-FEMALE	2.4 GHz RF connector to the downstream (omni or sector) antenna
C	Switchcraft	Test connector (3 pin) used as an antenna alignment aid(1) and for RS-232 console port.
D	Switchcraft	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.

An eight conductor CAT 5 cable must be connected between the *VIP 110-24* and the Power Inserter Unit. The wiring for this cable is shown in figure 3.2.

The table 3.2 shows the pin assignment of the three pin, auxiliary port cable. The unit is shipped with a plug in this connector. The connector can be used during installation as a console port and also as a audio antenna alignment aid[(1)]

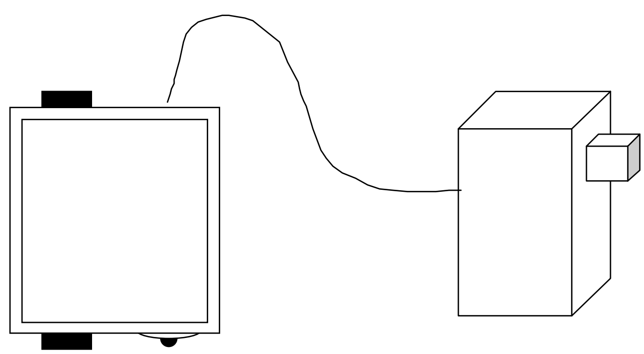
Table 3.2 - Auxiliary Port Connector Pin Assignments

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

[(1)] ***[NOTE: This feature not implemented in version 3.00 software.]***

3.2 Power Inserter Unit

The Power Inserter Unit includes a wall mount power supply wired to a small plastic enclosure with two RJ45 connectors and a bi-color LED. The two RJ-45 connectors are labeled "To LAN" and "To radio".



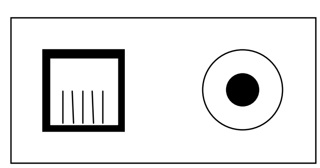


Table 3.3 – Power Inserter Unit

Connector/LED	Type	Function
To LAN	RJ-45	10/100 Base-T to be connected to the Local Area Network. Use a straight through cable to connect to a hub and a cross over cable to connect directly to a computer. See table 3.4 for pin assignments
To radio	RJ-45	Carries the DC power and Ethernet signals to the *VIP 110-24*. See table 3.5 for pin assignments
LED	Amber	**Amber**: Indicates that the power inserter unit has DC power from the wall supply but no power is being drawn by the *VIP 110-24*.
	Green	**Green**: Indicates that the *VIP 110-24* is drawing power.

Table 3.4 – "To LAN" Ethernet Connector Pin Assignments

Signal Name	Abbr.	Pin	Direction
Ethernet Tx	Tx (+)	1	Radio to Ethernet
Ethernet Tx	Tx (-)	2	Radio to Ethernet
Ethernet Rx	Rx (+)	3	Ethernet to Radio
(not connected)		4	
(not connected)		5	
Ethernet Rx	Rx (-)	6	Ethernet to radio
(not connected)		7	
(not connected)		8	

Table 3.5 – "To radio" Ethernet Connector Pin Assignments

Signal Name	Abbr.	Pin	Direction
Ethernet Tx	Tx (+)	1	radio to Ethernet
Ethernet Tx	Tx (-)	2	radio to Ethernet
Ethernet Rx	Rx (+)	3	Ethernet to radio
+24 VDC	24v (+)	4	Inserter to Radio
+24 VDC	24v (+)	5	Inserter to Radio
Ethernet Rx	Rx (-)	6	Ethernet to radio
24 VDC ground	24v (-)	7	Inserter to Radio
24 VDC ground	24v (-)	8	Inserter to Radio

3.3 Outdoor Interconnect Cable

The interconnect cable between the Power Inserter Unit and the *VIP 110-24* carries the following signals

1. DC voltage to supply power to the *VIP 110-24*.
2. 10 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 70 meters. Figure 3.2 shows interconnect diagram for this cable and connector types. Table 3.6 lists a few part numbers and sources of appropriate CAT 5 cable for this application. UC Wireless carries several pre-made cables of different lengths.

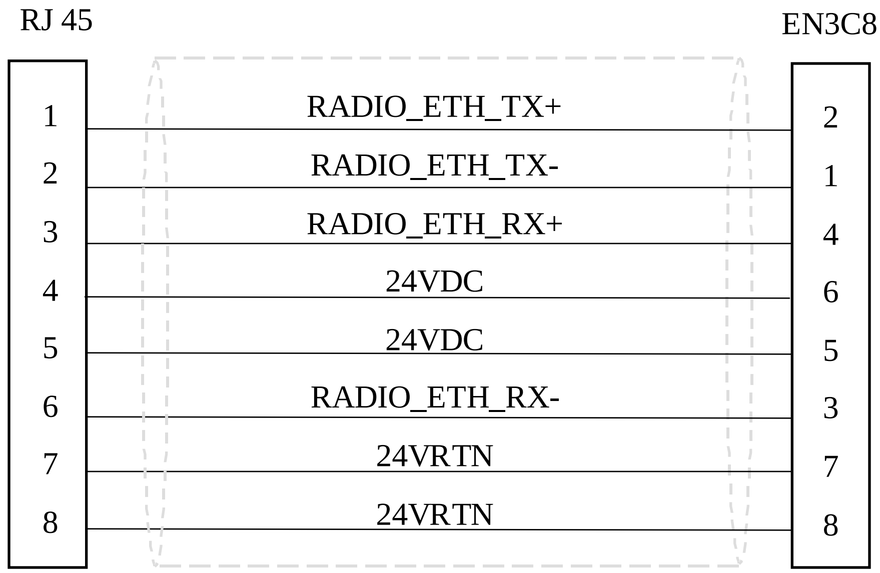


Fig 3.2

Table 3.6 – Indoor/Outdoor Unit CAT 5 cable

Part number	**Manufacturer**	**Description**
04-0010-34	Superior Essex	Industrial shielded, weatherproof cable for direct burial, aerial and other severe environments
18-241-31(gray) 18-241-11 (beige)	Superior Essex	Unshielded outdoor rated cable
2137113 (ivory) 2137114 (gray)	General Cable	Unshielded outdoor rated cable
BC1002	Belden	Unshielded outdoor rated cable

4 ANTENNAS, SITE SELECTION, PATH ANALYSIS

4.1 Introduction

NOTE

Basic instructions for connecting the antenna to the radio are given in section 5. If the system is to be used at short to moderate ranges and there are no major obstructions between antennas, the more detailed information in this section may not be necessary.

Because *VIP 110-24* 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.

4.2 Selecting Antenna Type

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 *VIP 110-24*, the three antenna types listed below will fulfill most installation requirements.

Antenna Type	**Gain**	**UCW Model Number**
Omnidirectional	9 dBi	OA2.4-9
Sector	12 dBi	2405H-90
Semi-Parabolic	24 dBi	DA2.4-24

4.2.1 Directionality

An antenna may be designed to receive and transmit in all directions. Such antennas are omnidirectional. An example of an omnidirectional receiving antenna would be a television antenna in a metropolitan area where each television station transmits its signal from a different location relative to the receiver. Similarly, a centrally located television transmitter would use an omnidirectional transmitting antenna.

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 horizontal omnidirectional antenna redirects its power and sensitivity from these directions, increasing performance in the horizontal plane.

An omnidirectional antenna is used with a *VIP 110-24* unit for typical VINE networks where a given radio must communicate with a variety of "downstream radios in various directions.

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 onmidirectional 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.

4.2.2 Gain

"Gain" specifies the receive and transmit performance of any antenna compared to a standard omnidirectional antenna ("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," which describes the standard spherical radiation pattern.

One type of directional antenna available from UC Wireless 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 standard omnidirectional antenna.

For omnidirectional coverage from fixed locations, UC Wireless provides collinear antennas. The collinear design achieves gain by increased focus in comparison with the dipole design. The standard collinear antenna used with the *VIP 110-24* provides 9 dBi gain, representing an eight-fold power and sensitivity increase.

4.2.3 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 elements horizontal provides horizontal polarization, while mounting the antenna with the elements vertical provides vertical polarization. Similarly, the orientation of the radiating element of the parabolic antenna determines polarization.

In setting up the *VIP 110-24* 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.

4.3 Site Selection

At the high operating frequencies of the *VIP 110-24* 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 in the radio network 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. Therefore, the distance between the antenna and the radio is limited to a cable length that does not exceed the maximum attenuation tolerated by the system. Since various cable types offer different attenuation levels, maximum length depends on cable type. Generally speaking, because the *VIP 110-24* is an outdoor unit with the output port connected directly to the antenna, cable losses are negligible and the radio will compensate, but there are limits to this compensation. See table 4-2 for sample cables and their respective attenuation values.

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

4.3.1 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.

4.3.2 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 transmitting antenna, receiving antenna, or both 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 4-1. (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.

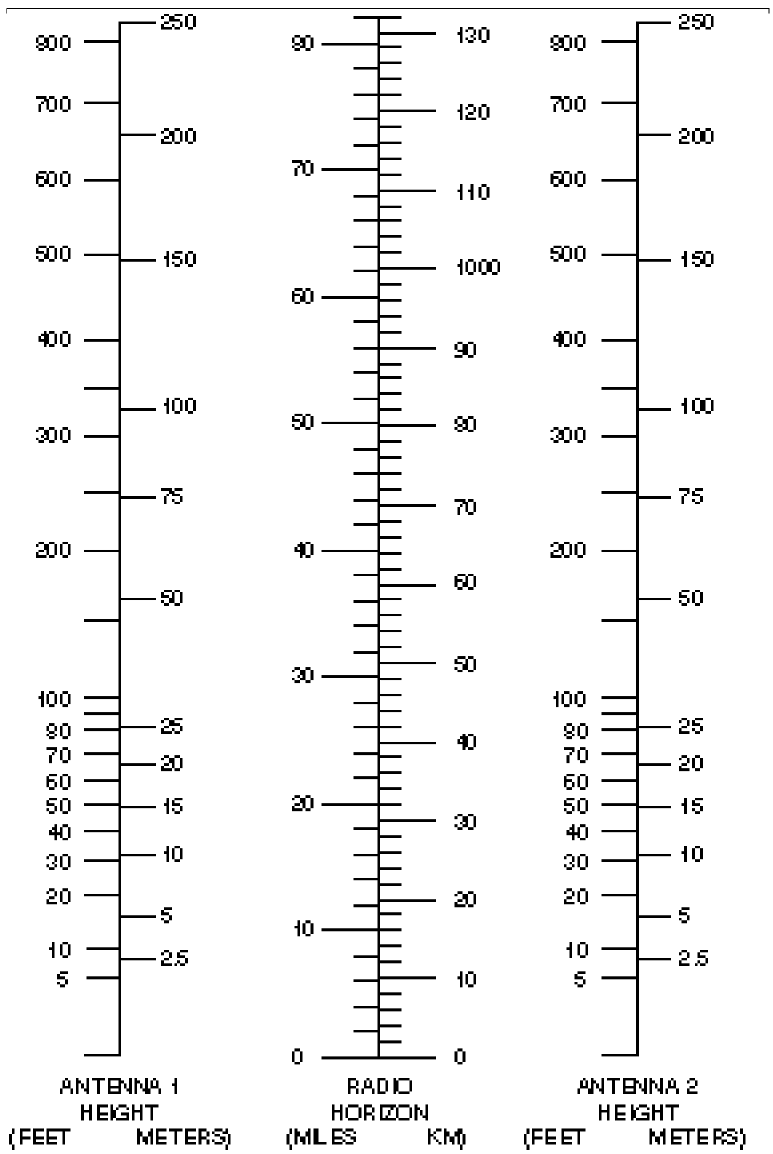


Figure 4-1. Antenna Height and Radio Horizon Graph

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.

4.3.3 Point-to-Point Path Analysis

A full point to point analysis should consist of at a minimum, a background noise evaluation of all locations where radios are to be installed, a determination of the minimum antenna height required to obtain a "line-of-sight", and a calculation of the expected 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. 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 and primary purpose to calculate the theoretical RSS level at the receive radio 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 to this, the RSS level allows the operator to do a quick check on the integrity of the system installation by verifying that the received RSS level is close to the calculated value.

A background scan is easily accomplished using the built in Spectrum Analysis tool of the *VIP 110-24*. This should be done before any installation of any equipment is completed.

Although the graph of figure 4-1 provides a useful guide to antenna height requirements, a more accurate determination of those requirements can be obtained by means of the following analysis, described in the following steps.

NOTE

> Computer programs available from many vendors can perform portions of this procedure.

Requirements for this procedure are:

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

Procedure:

1. On the topographic map, lot 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.

An additional increment must be added to the height of each obstruction because of the earth's curvature. For each obstruction calculate this increment 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.

Another increment must be added to the height of each obstruction because of the Fresnel zone (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	=	259 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.

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.

The following section will show how to calculate the RSS level expected at the radio and to determine the theoretical link margin at the sight.

Determine free-space path loss, using either table 4-1, the graph of figure 4-2, or the formula following figure 4-2.

Table 4-1. Free-Space Path Loss at 2.4 GHz

Distance (miles)	Path Loss @ 2.4 GHz (dB)
1	-104
2	-110
3	-114
4	-116
5	-118
6	-120
7	-121
8	-122
9	-123
10	-124
11	-125
12	-126
13	-126
14	-127
15	-128
20	-130
25	-132
30	-134
35	-135
40	-136
45	-137
50	-138

Distance (km)	Path Loss @ 2.4 GHz (dB)
1	-100
2	-106
3	-110
4	-112
5	-114
6	-116
7	-117
8	-118
9	-119
10	-120
15	-124
20	-126
25	-128
30	-130
35	-131
40	-132
45	-133
50	-134
55	-135
60	-136
70	-137
80	-138

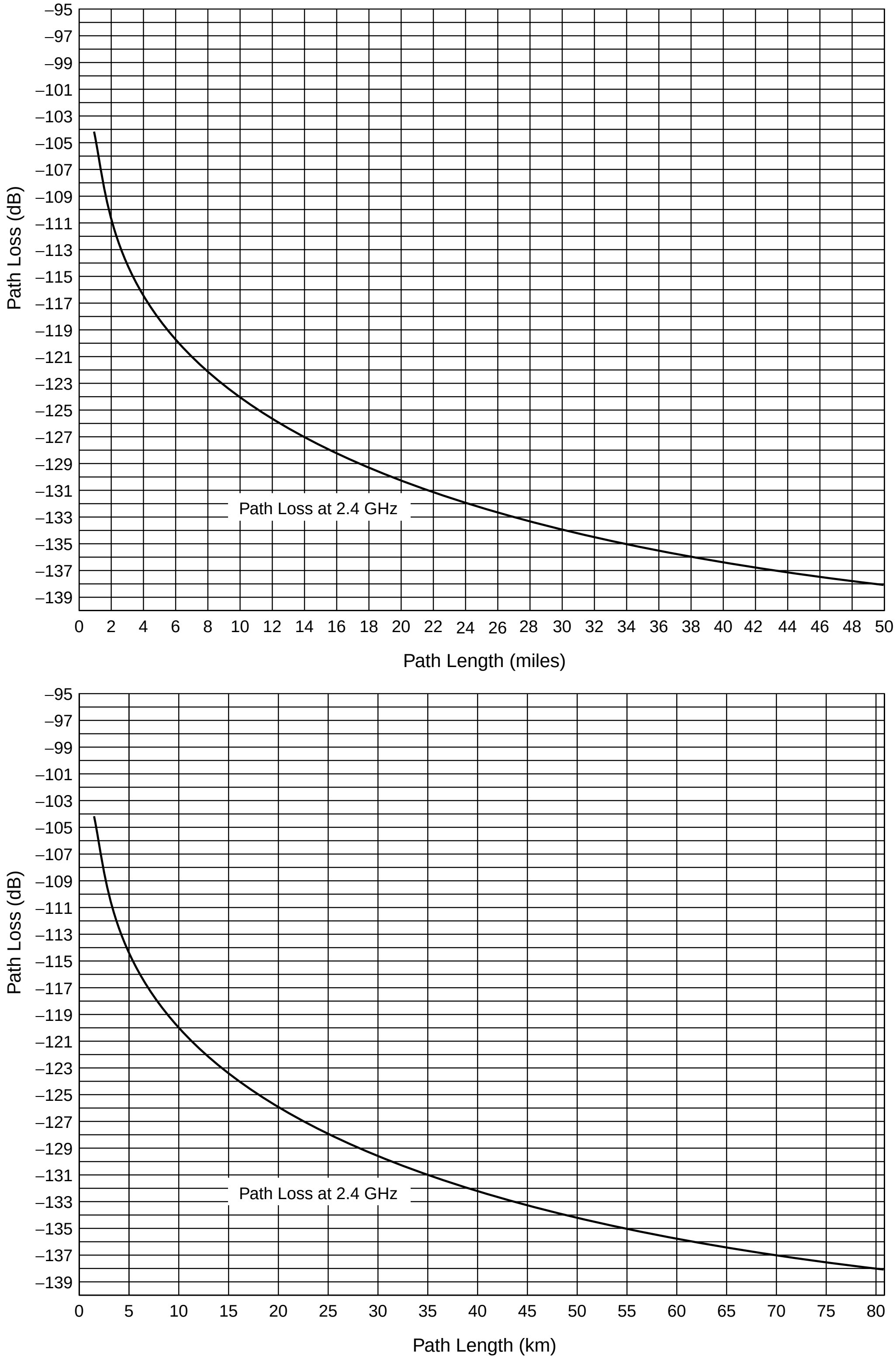


Figure 4-2. Free-Space Path Loss at 2.4 GHz

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

Where:

(for US units)

-L	=	loss in dB
C	=	6.6 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

$$-L = 36.6 + 20(1) + 20(3.38)$$

$$-L = -124\ \mathrm{dB}$$

Calculate effective radiated power (ERP) at the transmit antenna. Since the VIP 110-24 is housed in an outdoor enclosure, there is usually no transmission line loss as the antenna is generally connected directly to the radio connector. However, if an additional cable is used between the radio and the antenna cable, the cable loss (attenuation) must be included in order to calculate the correct RSS level.

WR 2411 output power	=	+ 23 dBm
Cable attenuation	=	- 2 dB
Transmit antenna gain	=	+ 17 dB
Effective Output Power	=	+ 38 dBm

NOTE: Table 4.2 lists attenuation values for various cables.

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

RSS = Pt - Lp + Gr

Where:

Pt	=	Output power from the transmit antenna
Lp	=	path loss
Gr	=	Gain of the receive antenna

For example, for the above system at a distance of 10 miles, with transmit output power of 38 dBm, and a receive antenna gain of 24 dB, the equation would be:

RSS = 38 dBm - 124 dB + 24 dB
= -62 dBm

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

Calculated RSS level at receiver	=	-62 dBm
Sensitivity of 2411 at 11 Mbps	=	-81 dB
link margin	=	+19 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 general rule of thumb it is recommended that all systems have a link margin of better than 20 dB.

4.3.4 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. Of those antennas in section 4.2 for *VIP 110-24* systems, the directional antennas can be mounted for horizontal or vertical polarization, while the omnidirectional antennas use only vertical polarization. Horizontally polarized omnidirectional antennas are available as a special purchase.

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 *VIP 110-24* has a built in feature that allows the operator to use both an audio tone and a voltage measurement to assist in aligning the antenna. Refer to chapter 5 on the use of this built-in antenna alignment aid feature. ***[NOTE: This feature not implemented in version 3.00 software.]***

4.3.5 Cable Loss (Attenuation)

The VIP 110-24 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 4.2 shows loss per 100 feet (30 meters) at 2.4 GHz for typical antenna cable types.

Table 4-2. Loss at 2.4 GHz for Standard Coaxial Cable Types

Cable Type	Loss per 100 ft. (30 m)@ 2.4 GHz
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:

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

4.3.6 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 antenna and ODU.

4.3.7 Other Considerations – Antenna Grounding

WARNING

VERY IMPORTANT INFORMATION!!!

As an elevated metal object with a wire connection below, an antenna is an excellent lightning attractor, and an effective ground must be provided to deflect lightning strikes to ground. An additional advantage of effective system grounding is the minimizing of electrical noise and interference, which can significantly degrade system performance.

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

- The antenna should be mounted on a mast or tower that is well grounded to earth.
- All antenna lead connectors should be correctly installed to provide a good, solid connection to the cable shield.
- Threaded couplings mating antenna lead connectors should be clean and tight; bayonet type connectors should not be used.
- Weatherproof connectors must be used for outdoor connections to prevent corrosion, which will interfere with grounding.
- All power and antenna grounds should be made common at a single point such as an equipment rack, cabinet enclosure chassis, or antenna tower. This single-point ground should have a solid ground connection to earth.
- A surge arrestor or lightning protector should be installed at the point where the antenna cable enters the building or cabinet. The lightning protector should be properly grounded at the single-point chassis ground. Carefully follow the installation instructions provided by the manufacturer of the protection device. An appropriate lightning protector is available from UC Wireless.

5 INSTALLATION AND SETUP (*Quick Start*)

The *VIP 110-24* units are shipped pre-configured to operate as "repeaters". It is recommended that an initial check be performed on the bench before a field installation. For this bench check out you need two *VIP 110-24* units.

5.1 Bench Check Out

For initial check-out, perform the following steps using two *VIP 110-24* radios. One of the radios will be configured as the "root" of the network and the other as a "repeater".

1. Connect the *VIP 110-24* Auxiliary 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 *VIP 110-24* using a CAT 5 cable as defined in section 3.

3. At the root radio connect the radio Antenna B port (N type connector) to an appropriate 2.4 GHz band antenna using an RF coaxial cable.

4. At the repeater radio connect the radio Antenna A port to an appropriate 2.4 GHz band antenna using an RF coaxial cable.

5. Connect the two Power Inserter Units to a power outlet. Make sure that the power supplies are rated for the appropriate voltage (110 or 220 Vac).

6. The radios will perform power up calibration and diagnostic tests. Verify that radios identify themselves with the correct serial number. At the end of the tests, the radios output the command prompt:

   ucw-nnnnn #>

   where nnnnn are the last five digits of the radio serial number.

7. Set the "repeater" *VIP 110-24* to its factory default configuration by typing the command:

   > load factory
   > save-configuration

8. Configure the second radio (defined as the "root") by typing the commands:

   > load factory
   > **node type=root**
   > save-configuration

9. At the terminal connected to the repeater radio enter the command:

   > **show radio-node**

   Verify that the root node is listed with the correct serial number. The output also displays the transmit RF power and Receive Signal Strength (RSSI) in both link directions.

10. At the terminal connected to the repeater radio enter the command:

    > **show ethernet**

    Verify that the ethernet station connected to the root LAN is visible at the repeater radio.

11. The terminal connected to each radio can be used to further modify the radio's operating parameters. Section 6 describes the command language used to perform those functions.

5.2 Applications

5.2.1 VINE Network Topology and Operation

The *VIP 110-24* is the building block of the VINE wireless network. In order to deploy and configure a complete wireless network successfully, some knowledge of the VINE protocol and operation is helpful.

The VINE network topology is a tree. The different node types in the tree are: "root", "repeater", "leaf" and "mobile" ***[NOTE: The mobile feature not implemented in version 3.00 software.]***. Figure 5.1 below illustrates a possible network. Figure 5.2 shows a graph representation of the same network.

Each *VIP 110-24* in a VINE network operates in a half duplex mode, i.e., it may either transmit or receive at any given time. Transmissions consist of variable length packets. "Outbound" packets flow "downstream" or away from the root node. "Inbound" packets flow "upstream" or towards the root.

The outdoor unit of the *VIP 110-24* is equipped with two antenna ports. Antenna port A is assigned for communications with that node's "parent". Note that each node in the VINE has one and only one parent node. The antenna connected to port A must always be a high gain directional antenna pointing to this upstream node. The root node is the only radio without a parent node.

Antenna port B is assigned for communications with the node's "children". This antenna must provide coverage to all of the node's children. Depending on the geographic location of those children the antenna connected to port B could be an omni, sector, or directional antenna. Leaf nodes do not have children, so no antenna is connected to port B.

Outbound and inbound transmissions must always be assigned to two non-overlapping channel frequencies (this is done automatically by the VINE software but if the default "channel plan" is overridden, this needs to be taken into account).

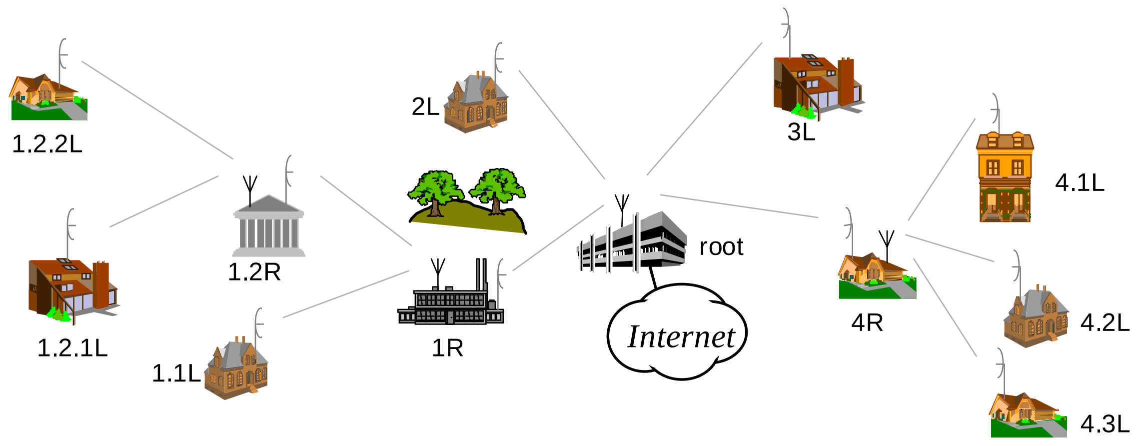


Figure 5.1 – VINE network topology

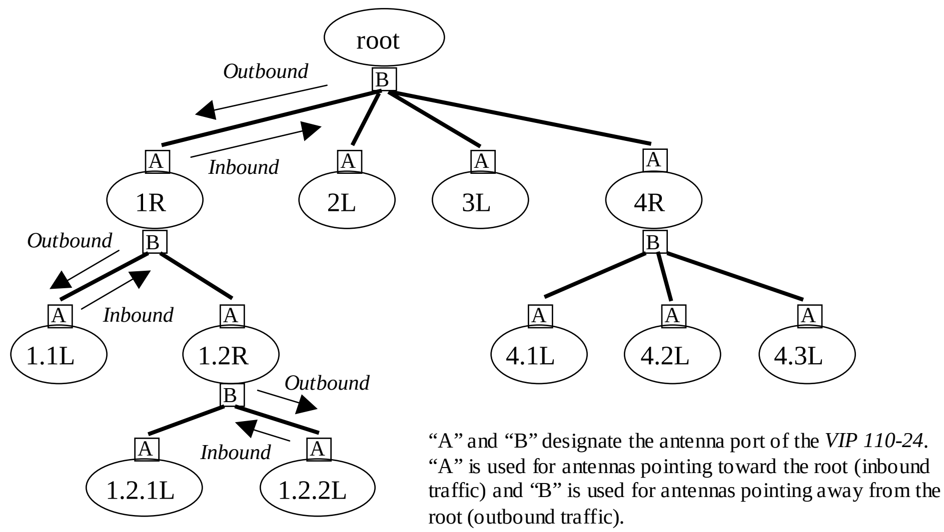


Figure 5.2 - VINE graph representation

Node naming convention for figure 5.2

1. Designate the root node as "root".
2. Number all nodes one-hop away from the root (referred to as its "children") sequentially starting at 1.
3. Name all the children of each repeater by giving them the parent number and appending a sequential number starting at 1 (use a '.' to separate the parent designator from the child number).
4. Repeat step 3 until all nodes are named. Add an R or an L to the end of the designator to indicate whether the radio is a repeater or a leaf.

With this topology, a transmission within any given "branch" (defined as a parent radio together with its one-hop children) will not interfere with simultaneous transmissions in any other branches. Any two simultaneous outbound transmissions in different branches will be received by the intended nodes due to the high gain antenna attached to the receivers. Similarly, any two simultaneous inbound transmissions in different branches will be received by the intended upstream nodes due to the high gain antenna attached to the transmitters. This scheme is further optimized by having all radios control their output power to achieve no more than the adequate link margin for that particular transmission.

The network in figure 5.1 shows why the inbound and outbound transmissions need to be on different channels. For example, repeater "4R" may perform an outbound transmission, through an omni antenna, at the same time as leaf "3L" performs an inbound transmission to the root. If the inbound and outbound were on the same frequency, there would be a collision at the root.

There may be specific situations where the diversity achieved through the dual frequency operation and antenna directivity would not work. For example, if radios 1R, 1.2R, and 1.2.2L were in a straight line, inbound transmissions from 1.2.2L could reach 1R and interfere with a simultaneous inbound transmission from 1.1L. Those specific cases can be addressed with one or more of the following techniques:

1. Power management: reduce the transmit power from 1.2.2L so that the signal at 1R is significantly below the signal from 1.1L
2. Additional channels: Use the "primary" frequency channels between 1R and its children and the "secondary" channels between 1.2R and its children (see section 5.3)
3. Antenna polarization: use horizontal antenna polarization between 1.2R and its children, and vertical polarization between 1R and its children.

The capability of having multiple simultaneous transmissions in the same geographic area is key to achieve a high network throughput. Within one branch, each parent services all its children by polling each one in turn. The poll/response time is very fast due to the radios fast turnaround and acquisition times. This way, the demand on network resources by children that are not generating or receiving traffic becomes negligible.

Even though repeaters run asynchronously from each other, the complete VINE has an underlying synchronization mechanism that allows repeaters to switch between being a "parent" and a "child" at the appropriate times. Packets can flow up or down the tree, with each radio forwarding the packet through the appropriate Ethernet or RF ports.

The VINE protocol is ideal for bursty traffic that is typical in data communications. The available bandwidth is allocated on demand to the nodes that are "active". If the network gets congested, there are different Quality of Service parameters that allow the network manager to give priority to certain nodes. Nodes with a "committed information rate" (CIR) will always have access to the committed bandwidth. When those nodes are not using their committed bandwidth, it becomes available to be shared among all nodes. The unique VINE flow control mechanism adaptively shares this excess bandwidth equally among all active nodes without a CIR. ***[NOTE: The flow control feature not implemented in version 3.00 software.]***

The root and repeater nodes are always searching for new child nodes. This allows any node to be added to the network by simply pointing the antenna A at the appropriate repeater, and turning the power ON. Within a few seconds the new node establishes contact with the repeater. The network will first authenticate the new node by validating the "Network ID" supplied by the new node. Once authenticated, the new node will be able to transmit and receive traffic in the network.

In an Internet Access application, one of the nodes is connected to the wired Internet. In a VINE network this node is designated as the "anchor", and it is where a large majority of the traffic will originate and converge. For these applications it is typically desirable to make the root node the anchor.

5.2.2 Ethernet Bridging

Currently the *VIP 110-24* operates as an Ethernet bridge. Future upgrades will add an IP Router option.

As a bridge, the *VIP 110-24* runs 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).

Each *VIP 110-24* in the VINE periodically transmits the information about the local Ethernet addresses to all other radios. Therefore every *VIP 110-24* holds an Ethernet table that includes one entry for every Ethernet address connected to any of the LANs (this table can be examined with the "show ethernet" command).

With this information on hand, each *WIN Router* 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 connected to a remote radio, queue that packet to be forwarded through the appropriate RF port.
3. If the destination address is unknown, "flood" the packet into the VINE network. The packet will show up at every LAN connected to any radio in the VINE.

Each *VIP 110-24* 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. The user 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.

Bridging has two major advantages over routing:

1. There is absolutely no configuration required. The *VIP 110-24* learns about all stations automatically and routes the packets appropriately.

2. All layer 3 protocols (IP, IPX or others) can be bridged.

5.3 Field Installation

NOTICE

The antennas for the *VIP 110-24* must be professionally installed on permanent structures for outdoor operations. The installer is responsible for ensuring that the limits imposed by the Federal Communications Commission (FCC) Regulations 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.

5.3.1 Antenna Selection and Alignment

The *VIP 110-24* 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 *VIP 110-24*, UC Wireless provides the three antenna types listed below:

Antenna Type	Gain	UCW Model Number
Omnidirectional	9 dBi	OA2.4-9
Yagi	17 dBi	DA2.4-17
Dish Reflector	24 dBi	DA2.4-24

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. Horizontally polarized omnidirectional antennas are available upon special request.

[NOTE: The antenna alignment feature not implemented in version 3.00 software.]

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. The three pin "Auxiliary port" connector in the *VIP 110-24* can be programmed to output a signal that is proportional to the receive signal strength. This signal can be a voltage, to be read in a DC voltmeter, or an audio pitch that can be heard with a pair of headphones. After performing a rough alignment, if the link is operational, issue the following command:

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

and then adjust the antenna for the highest pitch or dc voltage out of the test connector.

Once the antenna is aligned type the command:
>aaa off

5.3.2 Spectrum Analysis and channel selection

Radio operation in unlicensed bands has the potential of suffering from interference from other equipment operating in the same band. The use of directive antennas (used for the upstream connection), greatly reduces the potential for interference. In addition, the *VIP 110-24* includes several features, described below, to identify and overcome sources of interference.

The *VIP 110-24* 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 for the specific link.

With regard to the spectrum analysis output, keep in mind that the *VIP 110-24* receiver RF bandwidth is approximately 18 MHz, but the channels are only 2 MHz apart. In essence, any channel in the spectrum output that shows a low "noise" level is a good candidate for operation.

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.

The inbound and outbound channels must be non-overlapping. By default the *VIP 110-24* comes configured with two choices (primary and secondary) for each inbound and outbound links. This "channel plan" can be examined with the command:

>**display-configuration**

The factory default channel plan is shown below:

	Outbound	**Inbound**
Primary:	5	25
Secondary:	35	15

At a repeater or leaf nodes, select the appropriate Outbound channel by first performing a spectrum analysis on antenna A (pointed in the direction of its upstream node). If the spectrum analysis show strong noise in the primary outbound channel (channel 5), then select the secondary outbound channel (channel 35) by typing the command:

>**rf-receive outbound=secondary**
>save

At the root and repeater nodes, select the appropriate Inbound channel by first performing a spectrum analysis on antenna B. If the spectrum analysis show strong noise in the primary inbound channel (channel 25), then select the secondary inbound channel by typing the command:

>**rf-receive inbound=secondary**
>save

If the primary and secondary choices happen to both have interference, the default channel plan itself may be modified. However this must be done with care to avoid overlapping inbound and outbound channels with other units that may be within line of sight.

These commands change the respective receive channels only. The transmit channels from the radio at the opposite end of each link will be automatically set to the appropriate value when the nodes get attached to the network.

The monitor-environment command is used to evaluate the RSS level of *VIP 110-24*'s operating in the deployment area and can be used to select the best access point for a new node that is being installed. This differs from the spectrum analysis function in that the monitor-environment command scans only the selected channels and for a longer period. The display shows the address of the radio(s) seen, the channel at which the radio receives an RF signal, the RSS level, a flag indication (new node poll or good/bad), the time, and the number of good/bad packets.

The display-environment command does not interrupt normal operation of the radio, but shows the same information as the monitor-environment command. At startup, or after losing its parent, the radio will perform an abbreviated version of the environment scan, looking ONLY at the primary-outbound channel (or the selected outbound channel for VINE 3.xx)

5.3.3 Output Power

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 into the different antennas must be limited to avoid spilling over into the FCC protected band from 2.4835 GHz to 2.500 GHz. The table below takes all these considerations into account and shows the maximum allowed output power.

Maximum Output Power (dBm)

Channel	Frequency (MHz)	Antenna Gain 9 dBi	17 dBi	24 dBi
5	2410.0	23	22	21
6	2412.0	23	23	22
7	2414.0	23	23	22
8	2416.0	23	23	22
9	2418.0	23	23	22
10 to 29		23	23	23
30	2360.0	23	23	23
31	2462.0	23	22.4	22.2
32	2464.0	23	20	19.3
33	2466.0	20.5	17.7	16.9
34	2468.0	19.8	16.8	16.4
35	2470.0	19.6	16.7	15

5.3.4 Maximum Permissible Exposure (MPE) Limitations

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

Antenna installations must be engineered so that MPE is limited to 1 mW/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**	**17**	**24**
Max. Output Power	23	23	23
MPE safe distance (cm)	11*	28	63

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

5.4 Upgrading the Firmware.

Occasionally, software upgrades become available from the factory. Software for the *VIP 110-24* product line is distributed in the form of text files with the extension "`.dwn`" (for "download"). The easiest way to apply these software files to the radio is by using the UPGRADE.EXE utility, available on UC Wireless's website:

http://www.ucwireless.com/software/ vip11024.shtml

Instructions for this utility can be found in Application note XXX, found at UC Wireless's website:

http://www.ucwireless.com/appnotes/

Follow the procedure in Application note XXX to install the new software.

6 COMMANDS

6.1 Configuration techniques

There are two 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 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

When the unit is mounted on a tower, it is generally difficult to get access to the RS-232 port at the bottom of the radio. Because of this, the radio can also be configured via ethernet. In order to use this method, the access program "Econsole" must be installed on a computer with an ethernet interface. This computer must then be connected via its ethernet interface to the LAN port of the power inserter. Configuration commands can then be sent and received via the ethernet interface of the radio. Refer to Appendix C for instructions on the use of Econsole.

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

ucw-nnnnn #>

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". Appendix A lists all the commands available.

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 <Carriage Return> key.

6.2 Command syntax

The command interpreter in the *VIP 110-24* 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 *VIP 110-24* 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:
  >**show-tables table=radio-nodes**
  can be shortened to any of the following:
  >**show-tables radio-nodes**
  >**show radio**
  >**show rn**

- 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.

The following sections describe the various commands in detail. A summary list of all commands and default values are contained in Appendix A.

6.3 Configuration Management Commands

A "radio configuration" consists of a set of programmable parameters that define the radio operation with regard to a variety of operating modes. The radio holds four configurations at all times, identified as "current", "main", alternate", and "factory".

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 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.

WARNING

The *VIP 110-24* 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.

The configuration management commands are listed below:

load-configuration

source=main or ***alternate*** 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**

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**

display-configuration

source= current or ***main*** or ***alternate*** or ***factory***

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

Examples:

> **display-configuration source=current**
> **display**

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 *VIP 110-24* is shipped with no password that 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.

Examples:

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

WARNING

The *VIP 110-24* 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.

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.

unlock

enable-configuration="ASCII string"

This command, with the correct password, unlocks the access to the commands that allow the radio configuration to be altered.

Examples:

> **unlock enable-configuration= bh7g8**

6.4 Major Configuration Parameters

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

node

network-id=0…4,294,967,295

The network ID is a network wide value that needs to be the same for all the nodes in the network. When a new node attempts to attach to the network, it transmits the network ID. The parent radio checks if this network ID matches its own network ID. If this check fails the new node is not admitted into the network.

Examples:

> **node network-id=67903**

name="ASCII string"

Gives the node a meaningful name for further reference. The name can be up to 12 characters. This name will be used as the command prompt. It is also used to identify the node in a variety of commands and displays.

Examples:

> **node name=bank_of_england**

type=root or ***repeater*** or ***leaf*** or ***mobile***

The node type defines the operation of the radio within the VINE network (see section 5.2). The type can be set to one of four values:

root: The root radio is the logical hub of the network and controls the network timing. There must be only one root in a VINE network.

repeater: The repeater nodes are subsidiary to the root or other repeaters. A repeater node acts as a slave to its parent and as a master to its children. Repeaters also keep searching for new child nodes by performing "new node polls".

leaf: A leaf node is just like a repeater except that it does not perform new node polls. This results in a slight optimization of network timing.

mobile: A mobile node is similar to a leaf node but it is allowed to have an omni antenna connected to its antenna A port. It will use a different set of frequencies than the other nodes. (*mobile nodes are not yet supported*)

Examples:

> **node type=leaf**

antenna=single or ***dual***

Typically the root and leaf nodes operate with a single antenna while a repeater operates with a dual antenna. This command allows the user to specify a dual antenna mode for root or leaf nodes. Repeater nodes always operate in dual antenna mode.

A root node in "dual" antenna mode uses the two antenna ports for downstream communications. This can be used to reach a far away node using a directional antenna connected to port A, while still using an omni connected to port B.

A leaf node in "dual" antenna mode may have two directional antennas pointing at two distinct upstream repeaters. If the connection to the network through antenna A fails, the leaf node attempts to connect using antenna B.

(root and leaves in dual antenna mode are not supported at this time)

Examples:

> **node antenna=single**

anchor=yes or ***no***

Some network applications have the characteristic that the traffic to all radios is originated at a single node in the network. That same node is also the destination of all traffic transmitted by all other radios. This is the case for an Internet Access application for example. For these applications this special node should be designated as the "anchor" (only one node in the network should be the anchor). The anchor node enforces the receive flow rates (specified with the "min-flow-rate" and "max-flow-rate" commands) for each radio.

It is generally more efficient to make the anchor node the same as the root node although it is not necessary to do so.

Examples:

> **node anchor=yes**

min-flow-rate

transmit-kbps=1…1000

Specifies the minimum data rate that the radio will accept from the Ethernet port to be offered into the VINE network, even during congested periods. This is equivalent to the "Committed Information Rate (CIR)" in a frame relay environment.

receive-kbps=1…1000

Specifies the minimum data rate that the anchor radio will accept from its Ethernet, addressed to this specific node, even during congested periods. This is equivalent to the "Committed Information Rate (CIR)" in a frame relay environment.

Examples:

> **min-flow-rate transmit-kbps=500**

max-flow-rate

transmit-kbps=1…10000

Specifies the maximum data rate that the radio will accept from its Ethernet port to be offered into the VINE network, even during idle periods.

receive-kbps=1…10000

Specifies the maximum data rate that the anchor radio will accept from its Ethernet, addressed to this specific node, even during idle periods.

Examples:

> **max-flow-rate receive-kbps=1024**

rf-receive-channel

outbound= primary or ***secondary***

Selects the channel to be used for receiving outbound packets transmitted by this radio's parent. The mapping into actual channel numbers are specified in the "channel plan". The "primary" channel should be the first choice. The secondary channel is provided in case there is interference in the primary choice.

inbound= primary or ***secondary***

Selects the channel to be used for receiving inbound packets transmitted by this radio's children. The mapping into actual channel numbers are specified in the "channel plan". The "primary" channel should be the first choice. The secondary channel is provided in case there is interference in the primary choice.

mobile= primary or ***secondary***

Selects the channel to be used for communications with mobile nodes (inbound or outbound). The mapping into actual channel numbers are specified in the "channel plan". The "primary" channel should be the first choice. The secondary channel is provided in case there is interference in the primary choice.

Examples:

> **rf-receive-channel inbound=primary**

(Secondary rf-receive-channels are not supported at this time. Use the "channel plan" command and change the primary channels in order to operate at channels different than the defaults)

rf-channel-plan

inbound-primary=5..35

inbound-secondary=5..35

outbound-primary=5..35

outbound-secondary=5..35

The channel plan sets the receive channel choices available to this node for outbound, inbound, or mobile communications. The factory default channel plan is shown below:

	Outbound	**Inbound**
Primary:	5	25
Secondary:	35	15

Normally this would not be modified. However, if both primary and secondary choices are not suitable, each entry in the channel plan can be modified with this command. When modifying the channel plan, several guidelines need to be considered:

1. The outbound channel number corresponding to the channel selected by the rf-receive command must match one of the outbound channel numbers on this node's parent channel plan.

2. All channels must be non-overlapping (see appendix A for a list of non-overlapping channels). If the network is not intended to support mobile radios, those two entries can be ignored and those channels reused.

Examples:

> **rf-channel-plan inbound-primary=10**

rf-nnp-tx-power-dbm

power-dbm=0..23

This parameter sets the output power of the new node poll from a root or repeater. This affects only the port B output. the output power of the new node poll reply from a repeater or leaf are set via the "rf-to-parent" command.

Examples:

> **rf-nnp-tx-power-dbm power-dbm=15**

(automatic mode is not supported at this time)

rf-to-parent

mode=automatic or ***manual***

The RF link from the radio to its parent can be set to automatically adjust to obtain the optimum RF data rate and power for any selected link margin. The RF data rate and power can also be adjusted manually if desired.

margin-db=0..40

The margin is defined by the user to determine the threshold at which the local radio will start to adjust the RF data rate and power. The local radio will switch the power and RF data rate until the selected margin is obtained at the parent radio.

speed-mbps= 1, 2, 5.5, 11

When set to automatic mode, the receive RF speed is usually set automatically by the local radio when it attaches to the network based on the RF signal strength. This command allows overriding this automatic selection. The specified speed will be used for the RF link to the parent radio.

(automatic mode is not supported at this time)

power-dbm=0..23

When set to automatic mode, the transmit power is usually set automatically by the local radio when it attaches to the network based on the RF signal strength. This command allows overriding this automatic selection. The specified power will be used for the RF link to the parent radio.

Examples:

> **rf-to-parent margin-db=20**

rf-from-parent

mode=automatic or ***manual***

The RF link from the parent to radio can be set to automatically adjust to obtain the optimum RF data rate and power for any selected link margin. The RF data rate and power can also be adjusted manually if desired.

margin-db=0..40

The margin is defined by the user to determine the threshold at which the parent radio will start to adjust the RF data rate and power. The radio will switch the power and RF data rate until the selected margin is obtained at the local.

speed-mbps= 1, 2, 5.5, 11

When set to automatic mode, the receive RF speed is usually set automatically by the parent radio when it attaches to the network based on the RF signal strength. This command allows overriding this automatic selection. The specified speed will be used for the RF link from the parent radio.

(automatic mode is not supported at this time)

power-dbm=0..23

When set to automatic mode, the transmit power is usually set automatically by the parent radio when it attaches to the network based on the RF signal strength. This command allows overriding this automatic selection. The specified power will be used for the RF link from the parent radio.

Examples:

> **rf-from-parent speed-mbps=2**

orphan-reset

timeout-sec=30..3600

After power up, a non-root radio attempts to get attached to a parent radio by responding to a "new node poll" transmitted periodically by the root and all repeater radios. If a radio fails to get attached (or drops an existing attachment), it will perform a complete reset after the timeout specified in this command.

This feature is useful if a command is issued to a remote radio changing its parameters in such a way that breaks the link to its parent. In that case the remote radio will drop its attachment to the network, wait for the "orphan-reset-timeout" and then perform a reset. As a result the radio reverts to the saved configuration allowing it to get reattached to the network.

Examples:

> **orphan-reset timeout-sec=200**

6.5 Bridge Management Commands

Bridge management commands set the specific operating characteristics relating to the operation of the radios as a network. These commands allow access to remote radios and give the user information relating to the interface between radios.

ethernet

timeout-sec=5..1800

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

multi-cast-timeout-sec=5..3600

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

Examples:

> **ethernet multi-cast-timeout-sec=3000**

show-tables

table=radio-nodes or ***ethernet-stations*** or ***counters*** or ***flow-control*** or ***link-speeds*** or ***parents*** or ***all***

fomat=normal or ***basic*** or ***times***

Displays information about the overall VINE network. The "show-tables table=ethernet-stations" command can be a two part command with an option of "format".

The "radio-node" table displays the system start time, current radio configuration, and information about all radios currently in the network.

The "ethernet-stations" table contains information about all the known ethernet stations in the network.

The "counters" table contains various statistics.

The "flow-control" shows the flow control settings.

The "link-speed" shows the link speeds in the individual RF links.

Under the "show-tables table=ethernet-stations" command, the "normal" format contains a detailed output of the ethernet stations including the number of packets coming to and going from the local radio and the number of packets being forwarded to and from the local radio, packets lost, and data rate. (*Not yet impemented*)

Under the "show-tables table=ethernet-stations" command, the "basic" format lists the number of packets coming to and going from the local radio and the number of packets being forwarded to and from the local radio.

Under the "show-tables table=ethernet-stations" command, the "times" format shows the multicast status, when each radio was added, and the idle status.

Example:

>show-tables table=radio-nodes
>show-tables table=ethernet format=basic

6.6 Installation and Link Monitoring Commands

antenna-alignment-aid

tone=on or ***off***

This command turns ON or OFF a tone into the Test connector of the outdoor unit. This tone is proportional to the signal strength being received by the radio. This output tone also contains a DC component. For antenna alignment, connect the Test connector to a pair of headphones or a DC voltmeter, then orient the antenna for the highest pitch or voltage level.

Not implemented in version 3.XX

spectrum-analysis

input=a-antenna or ***b-antenna***

display=graph or ***table***

dwell-time-ms=0..1000

This command performs a scan of **<u>all</u>** the channels in the band, 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").

During the test the RF input into the radio can be selected between one of the two antennas or a test oscillator that is included with every outdoor unit. Running the spectrum analysis with the test oscillator as an input is useful to check the health of the local radio.

Example:

>spectrum-analysis input=b-antenna
>spectrum-analysis input=a-antenna display=table dwell-time=500

monitor-flow

This command continuously displays the data flow rate of the network.

monitor-link

node= node-name or ***#node-number***

clear=on or ***off***

This command continuously displays link statistics with any of this radio's direct neighbors. The neighbor radio is identified either by the node name or by the node number (as displayed with the "show" command) preceded by the # character. The "clear=on" parameter clears the current statistics.

Examples:

>monitor-link node=bank_of_england
>monitor-link clear=on

test-rf-link

command= status or ***start*** or ***stop***

node=node-name or ***#node-number***

This command can be used to perform an RF link test between this radio and a radio specified by the "node" parameter. . The node is identified either by the node name or by the node number (as displayed with the "show" command) preceded by the # character . Once the test is started the radio continuously generates and transmits test packets addressed to the specified node. The remote node echoes those packets back. The status of the test (number of packets transmitted and received) can be viewed by issuing the command "test-rf-link status".

Examples:

>test-rf-link command=start node=bank_of _england
>test-rf-link command=status

monitor-environment

channel=5..35

The "monitor-environment" command continuously displays the RSS level measured at the selected channels. The radio will then select the best channel to establish a link based on these measurements. The user can select up to six channels for monitoring.

Examples:

>monitor-environment channel=15

display-environment

The "display-environment" command does a single "snapshot" of the information shown in the "monitor-environment" command while looking at only the primary outbound channel.

6.7 Event Logging Commands

The *VIP 110-24* 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).

display-log

region=end or ***beginning*** or ***all***

length=1..500

id=0..150

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 20). 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 will allow the user to display only the events with the specified category range.

Examples:

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

clear-log

Clears the contents of the system event log, including the first 100 events.

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 terminal as they occur.

Examples:

>max-event print=6

6.8 Miscellaneous commands

date

The *VIP 110-24* 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

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**

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 rf-channel-plan

history

Displays the previous commands entered.

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.

version

Displays the radio model and software version.

APPENDIX A – Command Summary Tables

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.

If a parameters that is NOT part of the radio configuration is omitted, it defaults to the value displayed in bold.

Configuration Management Commands

Command	Parameters	Values	Factory Configuration
load-configuration	source	main alternate factory	main
save-configuration	destination	main alternate	main
display-configuration	source	current main alternate factory	current
change-password	enable-configuration	<string>	
lock			
unlock	enable-configuration	<string>	

Major Configuration Parameters

Command	Parameters	Values	Factory Configuration
node	network-id	0..4,294,967,295	0
	name	ASCII string	ucw-serial no.
	type	root repeater leaf mobile	repeater
	antenna	single dual	single
	anchor	yes no	no
min-flow-rate	transmit-kbps	1..1000	10
	receive-kbps	1..1000	10
max-flow-rate	transmit-kbps	1..10000	10000
	receive-kbps	1..10000	10000
rf-channel-plan	inbound-primary	5..35	25
	inbound-secondary	5..35	15
	outbound-primary	5..35	5
	outbound-secondary	5..35	35
	mobile-primary	5..35	15
	mobile-secondary	5..35	35
rf-receive-channel	outbound	primary secondary	primary
	inbound	primary secondary	primary
	mobile	primary secondary	primary

Command	Parameters	Values	Factory Configuration
rf-speed	mbps	auto, 1, 2, 5.5, 11	11
rf-power	dbm	0..23	23
orphan-reset	timeout-sec	30..3600	600

Bridge Management Commands

Command	Parameters	Values	Factory Configuration
ethernet	timeout-sec	5..1800	30
	multi-cast-timeout-sec	5..3600	600
remote (two part command, part A and part B)	node (A)	node-name or #node-number	
	command (B)	"command"	
show-tables (ethernet-stations two part command, part A and part B)	table	radio-nodes ethernet-stations (A) counters all	radio-nodes
	format (B)	normal basic times	basic

Installation and Link Monitoring Commands

Command	Parameters	Values	Factory Configuration
antenna-alignment-aid	tone	off on	off
spectrum-analysis	input	a-antenna b-antenna test-oscillator	a-antenna
	display	graph table	graph
	dwell-time-ms	1…1000	20
time-analysis	channel	5..50	5..50
	input	a-antenna b-antenna test-oscillator	a-antenna
	display	graph table	graph
	dwell-time-ms	1, 2, 5, 10, 20, 50, 100, 200, 500	20
monitor-link	node	node-name or #node-number	
	clear	no yes	no
test-rf-link	command	status start stop	status
	node	node-name or #node-number	
monitor-environment	channel	5..35	5, 41
display environment			

Event Logging Commands

Command	Parameters	Values	Factory Configuration
display-log	region	end beginning all	end
	length	1…500	20
	id	0…150	0
	min-level	0…7	0
	max-level	0…7	7
clear-log			
max-event	save	0..7	5
	print	0..7	3
clear-alarm			

Miscellaneous Commands

Command	Parameters	Values	Factory Configuration
date	date	dd-mmm-yyyy	
	time	hh:mm:ss	
	zone	offset or code	GMT
time	time	hh:mm:ss	
	date	dd-mmm-yyyy	
	zone	offset or code	GMT
help	command		
history			
reboot			
version			

APPENDIX B – Channel Frequency Assignment

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

Number of Non-Overlapping Channels	Suggested Channel Allocation	Frequency Separation (MHz)
3	5, 20, 35	30.0
4	5, 15, 25, 35	20.0