Wireless Configuration:

Channel: specifies the operating channel of the system, within the 100 MHz available in the 5.8GHz UNII band. The table below specifies the center frequencies of each permitted channel.

Channel	Frequency
1	5735 MHz
1A	5745 MHz
2	5755 MHz
2A	5765 MHz
3	5775 MHz
3A	5785 MHz
4	5795 MHz
4A	5805 MHz
5	5815 MHz

To avoid interference, two PTP links operating in the same physical location (co-located) or within close proximity (e.g. across the street) must be separated by at least one channel, i.e. the gap between channels should be 20 MHz or more (e.g. channels 1 and 3). Refer to Section 8.5 for further information regarding deployment rules.

Tx Power: this parameter specifies the power level of the system, which is preset at the factory and should not be altered. In the event that this parameter needs to be changed, please contact the Redline support team at support@redlinecommunications.com.

Adaptive rate: checking this box sets the system to operate in adaptive modulation mode. It is recommended to keep the AN-50 in this mode so that the system can automatically adjust the modulation level to the highest possible data rate based on measured RF performance. The user can define the minimum desired modulation level by setting the ***Main rate*** parameter (see next item). If the system meets this data rate, then the "***Signal"*** LED on the front panel will light continuously green. If packet errors exceed one out of a million, then the system will automatically lower the modulation level to maintain the link. In this case, the LED will flash green. If errors continue when the system reaches the lowest modulation level, then the LED will flash red to indicate a failed RF link.

The user can also disable the dynamic modulation mode by unchecking the ***Adaptive rate*** box. In this mode, the user is required to set the ***Main rate*** and the ***Rate diff*** (see below). Refer to Table 1 to determine which modulation level can be used based on the measured signal to noise ratio.

It is recommended not to operate the system in manual mode, as this mode is intended primarily for field support.

Note the "***Signal"*** LED will light solid green when the packet error rate is less than 1 out of a million. When the errors exceed this limit, the LED will not illuminate, indicating the RF link has failed.

Main rate [Mb/s]: Defines the desired net data rate for the link.

Rate dif.: applies when the ***Adaptive rate*** is disabled. ***Rate dif*** specifies how many levels the system must drop in modulation before beginning re-transmission to address packet errors. The ***Rate diff*** value can be set from 1-7, with 2 being the typical value.

Master: Sets the AN-50 system to serve as the Master system, while the other AN-50 assumes a slave role.

Version: Specifies the current version of the system software. Note, software can be remotely downloaded into the AN-50. The system comprises sufficient memory to hold two independent software loads – the operator can specify which load to download into the system.

Peak Transmitted Power per channel and modulation

The maximum conducted power is limited by the software / firmware to limit the maximum power for each channel. According to the rating showed in the following table based on direct measurements the maximum power for each channel isn't user modifiable:

PEAK TRANSMIT POWER (Measured a Peak Power Meter) **(dBm)**					
Transmitted Channel	**Frequency (MHz)**	**64QAM (54 Mb/s)**	**16QAM (36 Mb/s)**	**QPSK (18 Mb/s)**	**BPSK (9 Mb/s)**
1	5.735	-7.4	-7.4	-7.4	-7.4
1A	5.745	16.6	16.6	16.6	16.6
2	5.755	17.3	17.3	17.3	17.3
2A	5.765	20.0	20.0	20.0	20.0
3	5.775	20.5	20.5	20.5	20.5
3A	5.785	20.0	20.0	20.0	20.0
4	5.795	17.3	17.3	17.3	17.3
4A	5.805	16.6	16.6	16.6	16.6
5	5.815	-7.4	-7.4	-7.4	-7.4

6.4. Upgrade

The upgrade screen, shown in Figure 16, is used to upgrade the existing software load of the AN-50 unit with new software stored in a binary file on the server or host computer. The system uses the Trivial File Transfer Protocol (TFTP) to execute the process. Two input fields have to be filled in by the operator: ***TFTP Server IP Address*** and ***File name***. The ***TFTP Server IP Address*** is the IP address of the host computer or server that contains the upgraded software in binary format, while ***File name*** is the name of the actual binary file.

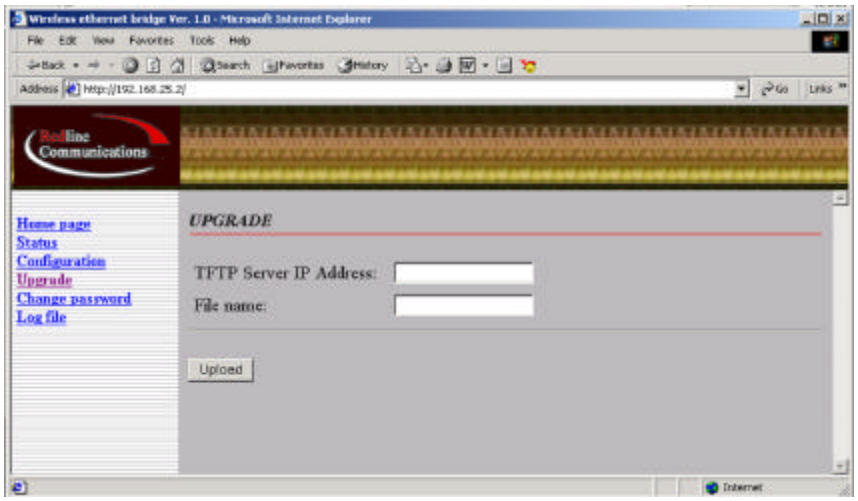


Figure 16 Upgrade screen.

After typing the ***TFTP Server IP Address*** and ***File name,*** press ***Upload*** to begin the file transfer. A status screen (see Figure 17) will immediately follow, which displays, in real-time, the number of bytes being transferred from the host computer/server to the AN-50 unit. The upgrade file size is approximately 1 Megabyte, and can take approximately 1-2 minutes to download from the server to the AN-50 memory.

Note the AN-50 contains two memory pages for storing the software/firmware binary code images. One memory location holds the current software, while the second memory area is used to store the new software load. Upon successful transfer of the upgrade file, the AN-50 will verify the integrity of the new software load before transitioning its system to the new binary image. If errors were introduced during the transfer process, as a result of say link degradation, then the AN-50 will reject the new software load, and provide a warning that the upgrade was unsuccessful. In this case, the operator will need to repeat the upgrade process. As mentioned previously, the upgrade process can be achieved remotely, using HTTP over the Internet.

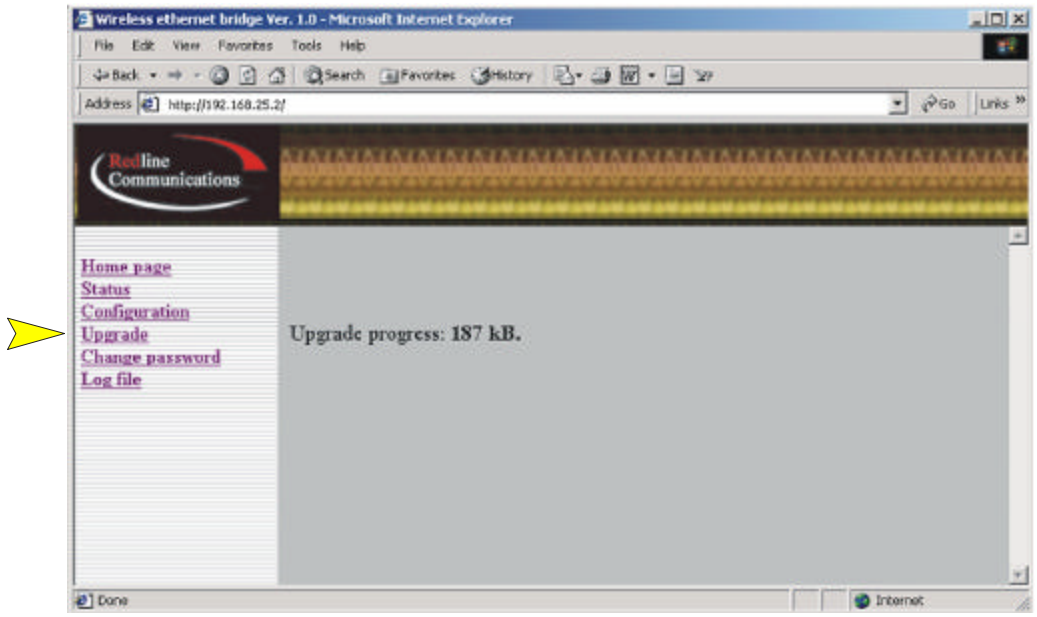


Figure 17 Status of upgrade file transfer.

6.5. Change Password

The default password for the system, set from the factory, is '***admin'***. To change the password, click on ***Change password*** from the main menu and apply a new value in the ***Password*** field (see Figure 18) using any alphanumeric combination. Note the field is case sensitive and should be up to 16 characters length.

A ***Long Reset*** – depressing the 'reset' button for more that five (5) seconds - will restore the password to ***admin'***.

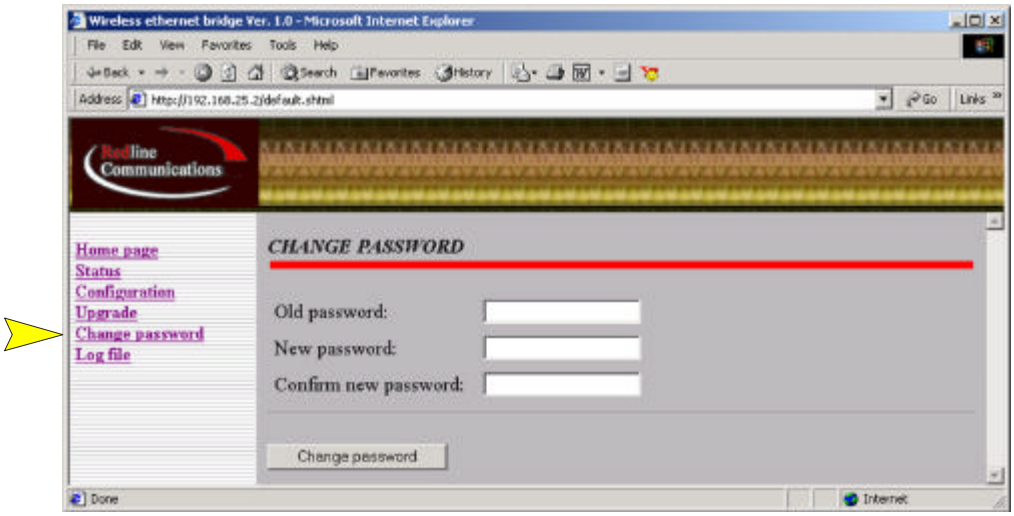


Figure 18 Change Password Screen.

6.6. Log File

The ***Log File*** screen, shown in Figure 19, provides a display of the last ten (10) messages recorded by the AN-50 describing either system activity or errors that have occurred.

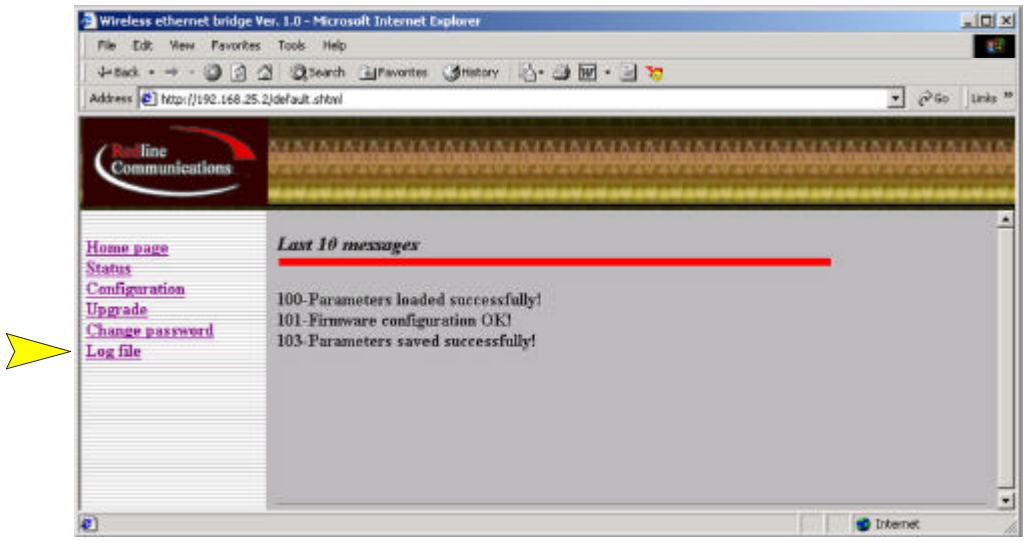


Figure 19 Log File Screen.

The Log File will also indicate if the following transactions were successfully completed:

- ***Save Configuration*** **–** Under the 'Configuration' screen.
- ***Upload*** **–** Under the 'Upgrade' screen.
- ***Change Password*** **–** Under the 'Change Password' screen.

The following provides a brief description of the key messages recorded onto the Log File by the system:

Log File Message	Description
100-Parameters loaded successfully!	All system parameters have been successfully downloaded.
101-Firmware configuration OK!	The onboard firmware configuration have been properly setup
102-Ethernet switch configured!	The Ethernet port has been properly configured and is operational.
103-Parameters saved successfully!	The latest configuration parameters have been successfully saved into the system memory.
104-Upgrade OK!	The software upgrade process completed successfully
105-Password change successful!	The new password entered in the system was

	successfully changed.
201-EEPROM corrupted. Def. param. loaded!	The memory area containing the system configuration has been corrupted. Default parameters loaded.
202-Error while saving parameters!	The latest configuration parameters have not been successfully saved. In this case, repeat the save configuration process to try to resolve the problem.
203-Another upgrade in progress!	The system is already in the upgrade mode, in the event the operator inadvertently invoked multiple simultaneous upgrades.
204-Invalid upgrade parameters!	The parameter entered is in error. If this message appears, check for typing errors.
205-Upgrade failed!	The software upgrade process completed unsuccessfully.
206-Password change unsuccessful!	The new password entered into the system was not successful. In this case, repeat the process.
207-Timeout on reading data packet!	The system has time-out looking for packets from the host computer or server. Check for obvious problems such as disconnected or faulty cable.
209-TFTP error received!	The Trivial File Transfer Protocol (TFTP) routine used to download the software to the AN-50 during the Upgrade process failed. Likely cause is disconnected or faulty cable.
210-Error: TFTP unknown message!	The TFTP client received an unknown message. In this case, repeat the upgrade process.
211-Error: while writing flash!	While writing the parameters into AN-50 flash memory an unexpected error occur. Try to repeat the process and if the error persist contact Red Line Communications support team.
212-Error firmware configuration!	While writing the firmware into AN-50 system memory an unexpected error occur. Try to repeat the process and if the error persist contact Red Line Communications support team.

7. Diagnostics and Troubleshooting

This section provides basic diagnostic and troubleshooting steps to help you solve problems that may have occurred with the AN-50. If, after reading this section, you are unable to get the system operating properly, please contact the support team at Redline at support@redlinecommunications.com. Include the model name and serial number of the system (located at the bottom of the unit) in your communication with Redline.

Troubleshooting can be performed using the front panel LEDs and the host computer/server connected locally or remotely to the AN-50.

7.1. Diagnostics via the front panel

The front panel of the AN-50 comprises key status LEDs, grouped under the headings System, Wireless and Ethernet, to help with first level diagnoses of problems encountered with the unit.

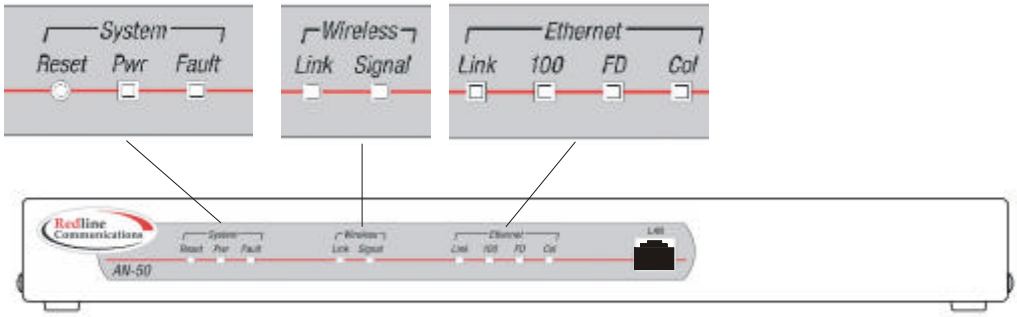
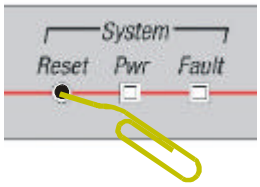


Figure 20 Front panel status LEDs.



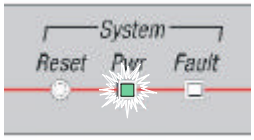
Throughout this section, reference is made to the '***Reset***' button, which is a micro-switch recessed in the front panel in the ***System*** block. Use a small narrow object, such as a paper clip, to depress the button. Depressing the button for less than five (5) seconds is known as a 'quick reset', and is equivalent to turning on and off the unit. A quick reset essentially reloads the current configuration software into the system's processor from the flash memory (long term memory) and restarts the unit.

Depressing the 'reset' button for more than five (5) seconds executes what is known as a 'long reset'. A long reset reloads the previously saved operating software load (which may be the manufacturer's original software load) and restarts the system. Note, the software version that existed in the system before the long reset will have to be reloaded, either locally or remotely. An example of where a reset will help, is in the event that your password or IP address if

forgotten. The reset function will simply restore the system back to its original settings.

The remainder of this section lists possible problems that may occur and the corresponding remedies.

7.1.1. System Power

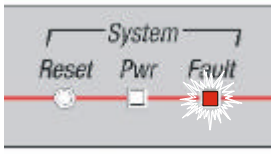


Check to see if the ***Pwr*** LED is solid and green. If no, then power is not getting to the unit. The most probable causes are:

Table 1 System Power Diagnostics.

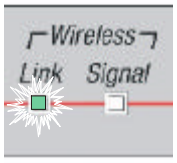
Symptom	Possible Problem	Solution
No power (Pwr LED does not illuminate)	On/Off switch in Off position	Turn on switch.
	Fuse blown	Replace fuse.
	Power cord disconnected	Securely connect cord to terminal and outlet.

7.1.2. System Fault



If the ***Fault*** LED illuminates solid red, then it is an indication that there is a serious problem with the system software or hardware. A ***long reset*** may remedy the problem. If not, then contact the Redline support team.

7.1.3. Wireless Link



The Wireless ***Link*** LED illuminates solid green when the system is properly communicating with the remote terminal. The LED will flash green when the system is operating below the desired modulation level, but at low packet errors (i.e. less than 1 packet lossed out of 1 million packets). When the LED does not illuminate, it is an indication that there is a problem either in the terminal, radio, host computers/servers, or with the actual propagation path itself. The table below lists some of the potential problems:

Table 2 Wireless Link Diagnostics.

Symptom	Possible Problem	Solution
No wireless link (Link LED does not illuminate)	Remote terminal is not on or is mal-functioning.	Verify operation of remote terminal.
	The propagation path is blocked.	Clear path or re-locate antennas

Symptom	Possible Problem	Solution
	The transceiver is mal-functioning.	Repair or replace transceiver.
	Antenna has moved and is no longer boresight with remote terminal.	Re-align antenna
	Cable between transceiver and antenna or between transceiver and terminal not properly connected.	Properly secure cables.
	Power not getting to the transceiver from the terminal.	Repair or replace terminal.

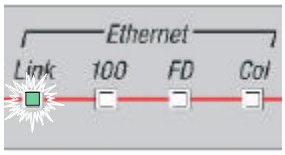
7.1.4. Wireless Signal

The Wireless ***Signal*** will flash in amber when RF signals (frames) are not being properly received by the transceiver. This may not be a serious problem if the LED only flashes intermittently, however, if it flashes constantly, then the table below summarizes some of the problems that may be occurring.

Table 3 Wireless Signal Diagnostics.

Symptom	Possible Problem	Solution
Poor RF Link (***Signal*** LED flashes)	Obstructions in the propagation path causing signal degradation.	Try to remove obstacles or re-locate antenna.
	Antenna moved, due to high winds.	Re-align antenna.
	Poor cable connection between transceiver and antenna	Repair or replace cable.

7.1.5. Ethernet Link



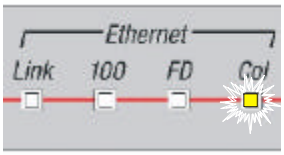
The Ethernet ***Link*** LED will illuminate green and solid when the LAN connection to the host computer/server or switch/router is properly functioning. If this LED is not on, then the following possible problems may exist:

Table 4 Ethernet Link Diagnostics.

Symptom	Possible Problem	Solution

Symptom	Possible Problem	Solution
Poor Ehternet Link (***Link*** LED off)	Poor cable connection between terminal and computer/server or between terminal and switch/router.	Carefully check all cable connections.
	Wrong type of Ethernet cable between terminal LAN port and host computer/server or switch/router.	If the terminal LAN port is connected to a host computer or server directly, then ensure a straight-through cable is used. Otherwise, to connect the terminal to a switch or router, ensure a crossover cable is used.
	The auxiliary Network equipment including switch/router, host computer/server, may be malfunctioning.	Repair or replace faulty units.
	System processor hang-up	Try quick reset or long reset.

7.1.6. Ethernet Collision



The ***Ethernet Col LED*** flashes amber when packet collisions occur over the LAN. Note, in any shared IP network, it is typical for packet collisions to occur intermittently. However, if the LED flashes constantly, then there is a serious problem somewhere in the LAN connection. Some possible causes are:

Table 5 Ethernet Collision Diagnostics.

Symptom	Possible Problem	Solution
Poor Collision Link connection. (***Col*** LED flashes)	Poor cable connection between terminal and computer/server or between terminal and switch/router.	Carefully check all cable connections.

7.2. Troubleshooting via the screen menu

The section assumes that the LEDs on the front panel of the AN-50 are indicating normal functionality, i.e. **Ethernet - Link** is illuminated green and solid.

7.2.1. Home page does not appear

If, after trying to log onto the AN-50 terminal(using HTTP commands) the Home Page does not appear on the screen, then several possibilities exist. The first test

is to ping the terminal from the host computer by typing in the following text from the command line:

>Ping 192.168.25.2

Note the IP address used in this example is the default address supplied by the factory. If the IP address has been changed since then, it is important to use the current address.

If the ping test was successful (i.e. the computer was able to send and receive packets with the terminal) then the problem may be with the text that was entered into the HTTP navigator or with the HTTP program itself. Retype the text or re-boot the host computer to try to resolve the problem.

If the ping was unsuccessful, then there may be problems with the IP address that you are using. Try retyping the address. If this fails, and it appears you have forgotten the IP address of the terminal, then perform a ***Long Reset*** to restore the terminal to the default value.

Table 6 Home Page Diagnostics.

Symptom	Possible Problem	Solution
Home Page does not appear	Incorrect IP address	Perform a ping test from the host computer command line. If the ping test is unsuccessful, then problem is with the IP address. Perform long reset to apply default address.
	Problems with HTTP or host computer.	If Ping is successful, then the problem is most likely with the HTTP program or host computer.

8. Fixed Wireless Access Primer

8.1. Introduction

This section provides an overview of the design and benefits of a Fixed Wireless Access (FWA) network architecture based on the Redline AN-50 system. There are several advantages of an FWA system over traditional wireline alternatives such as PSTN, ISDN, T1, DSL, cable and Fiber, including:

- Greater availability
- Lower cost of ownership per link
- Higher throughput (with the exception of fiber)
- Greater distances
- Quicker time to market
- Greater portability

The Redline AN-50 can be configured as a point-to-point (PTP) or switched PTP (S-PTP) system (Rev 0.7) to provide both backhaul and access distribution services under one infrastructure and management system. The Revision 0.7 product will be a software upgrade to the current version, which can be accomplished remotely.

The system functions logically as a transparent bridge, hence, providing all the benefits of a converged IP network, i.e. 'IP everywhere'. A converged network allows operators to reduce network buildout costs significantly by employing standard IP appliances everywhere, from backbone to end-user.

8.2. Who can benefit from the AN-50?

The AN-50 is an ideal solution for:

- Carriers
- Internet Service Providers (ISPs)
- Enterprises
- Education and Campuses

A) Carriers

The AN-50 will provide benefit to both Incumbent and Competitive Local Exchange Carriers (ILECs and CLECs, respectively). Although ILECs own and provide services over wireline infrastructures within a specific geographical area, they are faced with challenges of reaching outlining regions suffering from poor to no services. The ILEC is usually compelled to provide an expensive solution using a series of PTP radio links, with low throughput (e.g. T1) and costly license fees and network interfaces including T1 multiplexers. The AN-50 provides a cost

effective alternative, by connecting a remote site from the local CO, as shown in see Figure 21.

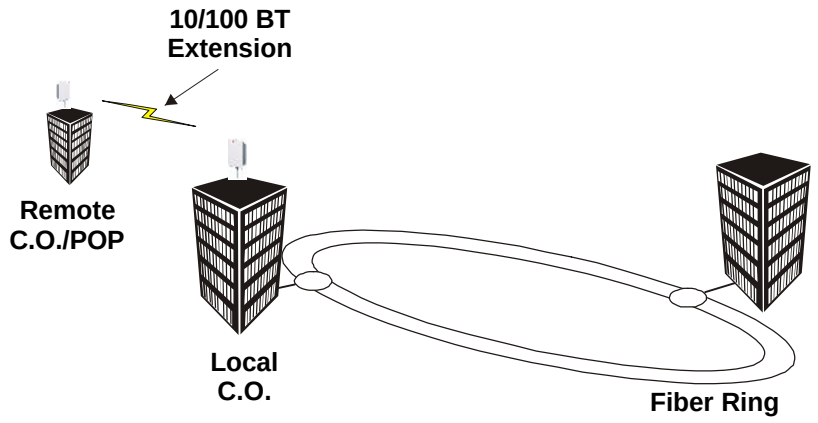


Figure 21 Wireless Extension for Carriers.

The same challenges are faced by the CLECs, who will use the AN-50 to quickly;

- Extend their existing fiber network, and
- Establish a remote Point of Presence (POP).

B) Internet Service Providers

The AN-50 is perfect for ISPs looking to provide cost effective broadband solutions to demanding business customers including Small Office Home Office (SOHO) and Small to Medium sized Enterprises (SME) located just outside of the downtown core, where there is a lack of infrastructure. High speed leased lines are expensive and hard to obtain, especially from local telephone companies. Wireless access provides a reliable quality of service, over longer distances while avoiding giving away access dollars to the Telco.

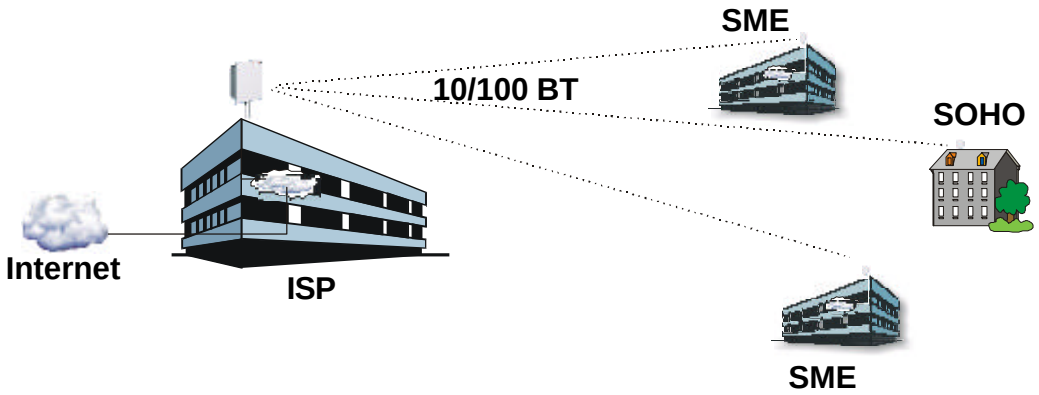


Figure 22 Wireless Solution for ISPs

C) Enterprise

Enterprises are particularly frustrated by the lack of broadband connectivity to their branch offices, factories, or warehouses located just outside of the urban core. Establishing a LAN solution over several remote locations presents a significant inter-network challenge using conventional wireline solutions. The AN-50 is well suited for addressing the LAN extension requirement, offering superior data rates quickly and efficiently, and in a secure format using Data Encryption Standard (DES) to protect sensitive information.

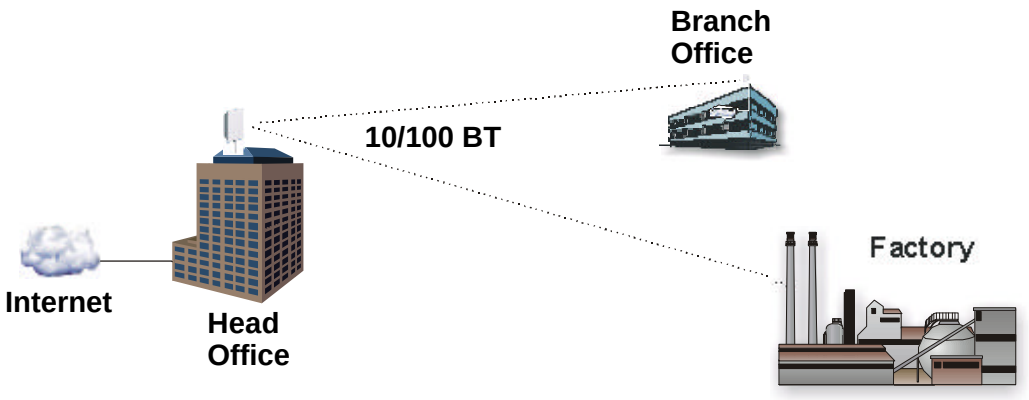


Figure 23. Wireless Solution for Enterprise.

D) Education and Campuses

The World Wide Web (WWW) represents a key element of the education system today, with FWA systems serving as an important enabler in bringing Internet content to the student body. Fixed wireless systems such as the AN-50 provide a cost effective means of creating a backbone for connecting existing and new campus buildings to the educational infrastructure to support distant learning, and two way interactive training.

8.3. The UNII band advantage

Wireless systems provide an effective means of achieving broadband connectivity quickly and over large distances. The AN-50 currently operates in the Unlicensed National Information Infrastructure (UNII) band, which is the license exempt (LE) portion of the spectrum. LE bands allow any operator to freely set up a wireless network without requiring formal consent from the regulatory agent. While this provides great advantages in terms of cost effectiveness (e.g. no license fees) and time to market (no regulatory process to follow), the ease of access to the spectrum opens the door for potential interference arising from other operators attempting to exploit the ‘free’ band. The Redline product includes several key features to mitigate the effects of interference arising from other systems

operating co-channel in the vicinity, as well as to cope with propagation anomalies such as multipath. These features include:

Adaptive Modulation

The AN-50 automatically selects modulation level, in both the up and downstream direction (an Industry first), to maximize spectral efficiency based on the measured signal to noise (S/N) level. The modulation levels supported are:

- Binary Phase Shift Keying (BPSK)
- Quadrature Phase Shift Keying (QPSK)
- 16 Qaudrature-Carrier Amplitude Modulation (QAM)
- 64 QAM

Refer to Table 7 for a summary of data rates for each modulation level.

Advanced Error Correction

In addition to conventional forward error correction techniques, the AN-50 uses an Acknowledge/Request (ARQ) scheme to dramatically reduce errors from interference and multipath

Orthogonal Frequency Division Multiplex (OFDM) processing

The Redline OFDM technique offers tremendous robustness in the presence of harsh multipath interference.

Narrow Beamwidth

Narrow antenna beams reduce considerably the probability of interference entering the system.

Adaptive Frequency Tuning

In the event the interference is too great, the system will switch over to an alternate 'clean' channel.

In addition to the anti-interference features described above, the AN-50 also holds several advantages other competitive advantages:

- High Data Rates (54)
- High Bandwidth Efficiency
- Long Reach and Wide Coverage
- Higher Power Efficiency
- 'Over the air' Security

8.4. Wireless Facts

Wireless technology has been around for many years, proving to be a reliable communication medium, primarily for long haul point to point applications, supporting critical links across the country for telephony and broadcast services. With the recent surge of two-way Internet use and the corresponding need for tremendous broadband to end users, fixed wireless systems are playing an even more important role in supporting network infrastructures.

The AN-50 has been designed to operate in the UNII band, which occupies the license exempt portion of the spectrum. License exempt allows any operator to freely set up a wireless network without requiring formal consent from the regulatory agent. While this provides great advantages in terms of cost and time to market, the ease of access to the spectrum can produce undesirable effects, such as potential interference arising from other users exploiting the 'free' band. By following some simple deployment guidelines, issues of this nature can be avoided. Note there exist professional engineering firms that specialize in deploying fixed wireless access systems, if you do not wish to do it alone.

The following provides a checklist of steps to be taken in deploying your AN-50 link:

- Conduct Site Survey
- Install the antenna
- Run the IF cable
- Install the terminal.

Refer to section 5, page 12, for a description of each deployment step listed above. This section provides additional background material to Section 5, to include a description of the Link Budget tool, Fresnel zone considerations, height calculations and radar horizon issues, interference issues with other systems, etc.

8.4.1. Link Budget

Redline has developed a link budget to help characterize the range performance of the AN-50 for both LOS and NLOS conditions using different system parameters. This link budget can be obtained by contacting us at sales@redlinecommunications.com. Note the tool provides a first order approximation, and does not consider the details of any specific terrain profile, which may impact performance. Rather, a generalized terrain is used in the calculations, based on empirical formulas approved by governing bodies such as the IEEE and ITU. The tool also assumes the terminal heights are 100 ft and 15 ft above the mean terrain level. Higher installs will improve the link performance, while lower heights on either end will reduce range performance.

The link budget tool estimates the distance over which the system can operate for a desired error rate to achieve robust communication. A link is considered robust if the average error rate is less than 1 bit out of every 1000 million bits, expressed as 10^{-9}, for an availability of 99.99%. Availability is described in more detail below.

The table below describes the net data rate (after coding overhead) that can be obtained for each modulation type in an ideal propagation situation.

Table 7 Modulation and Data Rate Table.

Modulation Level	S/N_{min} (dB)	Coding Rate	Symbol Rate (Mbps)	Raw Data Rate (Mbps)	Net Data Rate (Mbps)
BPSK	7	½	3	8	6
BPSK	8	¾	4.5	12	9
QPSK	11	½	6	16	12
QPSK	13	¾	9	24	18
16 QAM	16	½	12	32	24
16 QAM	20	¾	18	48	36
64 QAM	23	?	24	64	48
64 QAM	25	¾	27	72	54

As given in the table, higher order modulation levels require greater S/N to maintain the same BER performance. The noise in this case is defined as the noise floor of the receiver, i.e. it assumes no interference from other sources (interference from other sources are addressed below). The main path calculation for determining range performance is given as:

$$RSL = Ptx + Gtx – FSL + Grx$$

Where:

Ptx is the transmit power level in dBm
Gtx is the transmit antenna gain in dB
FSL is the free space loss attenuation in dB, and
Grx is the receive antenna gain in dB

The FSL value is dependent on the range between the two terminals, the type of terrain over which the link is deployed, and whether or not the link is operating line of sight (LOS) or non-LOS (NLOS). The LOS FSL calculation is well understood and easy to calculate, and relies on the fact that there is absolutely no obstacle near the direct path. The precise method for determining the amount of clearance required in claiming LOS is to make use of a factor called the Fresnel zone. A Fresnel zone is defined as the path difference of ?/2 away from the direct

path, as shown in Figure 24. A 'cleared LOS' link assumes there are no obstacles within 60% of the first Fresnel zone of the direct path.

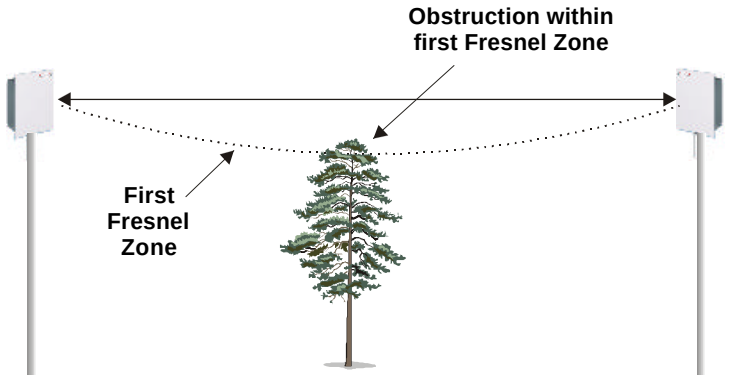


Figure 24 Fresnel Zone obstruction.

The formula for calculating the radius of the first Fresnel zone, as depicted in Figure 25, is given as:

$$R = 72.1\sqrt{\frac{D1 * D2}{f * (D1 + D2)}} \text{ (ft)}$$

where,

- D1 and D2 are the distances from the terminals to the point of interest (in miles), and
- F is the frequency (in GHz)

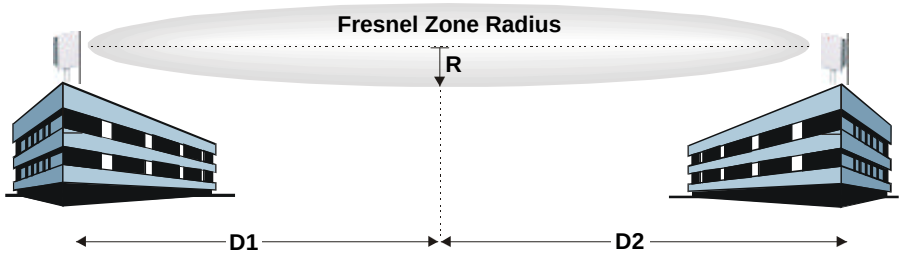


Figure 25 Fresnel zone radius calculation.

Specific FSL formulas are required to deal with this NLOS phenomenon. There are many NLOS calculations available from established institutions including the Institute of Electrical and Electronics Engineers (IEEE) and International

Telecommunications Union (ITU), who are chartered with developing standardized calculations. The Redline link budget tool is built upon these formulas, however, it is important to bear in mind that the calculations are an estimate only, with relatively large standard deviations (5-15 dB) depending on the exact deployment scenario and obstacle characteristics.

The last element to consider in the path calculation is the signal to noise (S/N) ratio, which is defined as:

$$S/N = RSL - Smin$$

where,

Smin is the receiver sensitivity expressed in dBm.

The Smin is determined by the thermal noise generated by the amplifier as well as the bandwidth of the filter used in the receiver front-end. It defines the power level at which the receiver is sensitive enough to properly detect the signal. For the AN-50 operating in a channel spacing of 20 MHz, the Smin is approximately –96 dBm. Therefore, to operate the link at the specified BER, the received signal must exceed Smin by the S/N_{min} specified for each modulation level in Table 7.

To ensure the link is sufficiently robust to deal with unexpected attenuation effects and seasonal fades, the S/N must be set higher than the S/N_{min} specified in Table 7. The difference between these two levels is called the **Fade Margin (FM).** FM is similar to a 'power reserve' in which extra power is designed into the link budget to deal with additional fades arising from such factors as climatic conditions (seasonal), multipath dispersions, and shadowing effects from natural (foliage) and man-made obstacles (buildings). The FM is determined by the availability one desires. Availability is defined as the amount of time (expressed in % per year) that a link properly detects the signal. "Properly" in this case is a BER that is less than 10^{-9}. The table below describes the outage period per year that corresponds to the different availability values.

Table 8 Availability versus outage time.

Availability (%)	Outage Period per year
99.9	8.8 hours
99.99	**53 minutes**
99.999	5.3 minutes
99.9999	32 seconds

The link should be designed for an availability greater than 99.99%. Based on this value, the FM for different ranges is given below:

Table 9 Fade margin versus distance for 99.99% availability

Distance (km)	Fade Margin (dB)
10	5
20	14
30	18
40	23
50	25

The table assumes an average terrain with some roughness and normal inland temperature climate (i.e. non-coastal and non-artic).

A key advantage of the Redline product is that it features a transmission correction scheme called Acknowledge/ReQuest (ARQ). The ARQ algorithm essentially detects when a packet(s) has been lost, due to fading, and makes a request to the remote system to re-transmit the lost packet(s). This feature provides an equivalent link budget gain of over 5 dB, which translates directly to an improved margin.

Another key advantage of the Redline product is that it features dynamic adaptive modulation, i.e., the system adjusts the modulation level automatically, on a burst-by-burst basis, based on the measured S/N response. In this manner, the network is constantly balanced for the optimum spectral efficiency, no matter what propagation conditions prevail. Higher modulation levels (e.g. 64 QAM) are typically deployed at reduced ranges while lower modulation levels (e.g. BPSK) are implemented at far ranges.
A sample link budget is shown in Figure 26 for the AN-50 operating in 16 QAM, 3/4 code rating, providing a net data rate of 36 Megabits per second (Mbps). The tool calculation is performed for LOS, however the graphs below cover the NLOS conditions as well.

Redline Link Budget

		Point to Point		
Transmitter		**Down**	**Up**	
Frequency	5.8	5.8	5.8	GHz
Average Power Into Antenna	Max Power	19	19	dBm
Tx Ant Gain (Dn/Up)	4.5 deg pencil beam / 4.5 deg pencil beam	27	27	dBi
	EIRP	**46**	**46**	dBm
Propagation				
Range		25.0	25.0	km
Path loss	Line of Sight (LOS)	**135.63**	**135.63**	dB
Signal Profile				
Channel BW	20	20.00	20.00	MHz
Modulation/Coding Rate	16 QAM 3/4			
Alpha Factor		0.75	0.75	
Guard Interval	Rls 1	0.80	0.80	
	Net Data Throughput	**36.00**	**36.00**	Mb/s
	Total Spectral Efficiency	**1.80**	**1.80**	bits/s/Hz
Receiver				
Receiver Antenna Gain		27.00	27.00	dB
	Rx Signal Level	**-62.63**	**-62.63**	dBm
RX Noise Figure		5.00	5.00	dB
Rx Implementation Loss		0.50	0.50	dB
	RX Noise level	**-96.74**	**-96.74**	dBm
	Req'd min SNR	**20.00**	**20.00**	dB
	Fade Margin at 25 Km	**14.11**	**14.11**	**dB**

Note: Graphs are based on upstream link.

Figure 26 Link Budget for 16 QAM ¾ code rate, 36 Mbps

The fade margin graph for this link budget is given in Figure 27 for three conditions, LOS (top blue line), NLOS with outdoor antenna (middle red line), and NLOS for indoor antenna (bottom green line). The middle scenario, NLOS outdoor install, assumes the Fresnel zone is completely obstructed, with near optical LOS or partially obstructed LOS resulting from limited tree blockages.

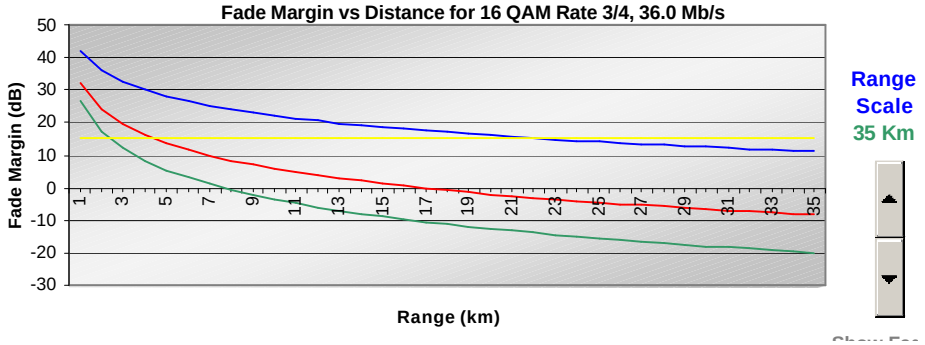


Figure 27 Fade margin graphs for LOS and NLOS.

The LOS profile in the graph shows that a range of ~25 Km can be obtained with a fade margin of 15 dB. With ARQ, the range can be extended to ~35 km for the same BER performance and availability.

The graph assumes a fade margin of 15 dB, as discussed earlier. The effects of rain at UNII bands are negligible, hence are not included in the link budget.

It is important to note the link calculation assumes that the Earth's curvature is not blocking the propagation path. The equation for determining the distance at which the Earth will cause blockage is called the Radar Horizon, and is given as follows:

$$R_h = 4.1(\sqrt{h_1} + \sqrt{h_2}) \quad \text{(Km)}$$

where,

h_1 is the height of terminal 1 (m)
h_2 is the height of terminal 2 (m)

The table below specifies the horizon distance (Km) that can be achieved for different terminal heights ranging from 10 to 70 m above mean terrain level.

Table 10 Radar horizon ranges for different terminal heights (H_1 and H_2).

		H_2						
		10	20	30	40	50	60	70
H_1	10	25.9	31.3	35.4	38.9	42.0	44.7	47.3
	20	31.3	36.7	40.8	44.3	47.3	50.1	52.6
	30	35.4	40.8	44.9	48.4	51.4	54.2	56.8
	40	38.9	44.3	48.4	51.9	54.9	57.7	60.2
	50	42.0	47.3	51.4	54.9	58.0	60.7	63.3
	60	44.7	50.1	54.2	57.7	60.7	63.5	66.1
	70	47.3	52.6	56.8	60.2	63.3	66.1	68.6

8.5. Deployment Scenarios

This section examines two types of deployment scenarios: co-located (same roof top) and adjacent area.

The current version of the AN-50 is a high-speed point-to-point (PTP) system, supporting a single link (two terminals communicating with each other only). A subsequent software release of the AN-50 will upgrade the system to a Switched-PTP (S-PTP) system. This upgrade will be achieved remotely (i.e. through the internet using the HTTP command set). Hence, it is prudent to design your access network with the knowledge that the system will be upgradeable to a S-PTP unit, to support multiple links from a single node, as shown in Figure 29.

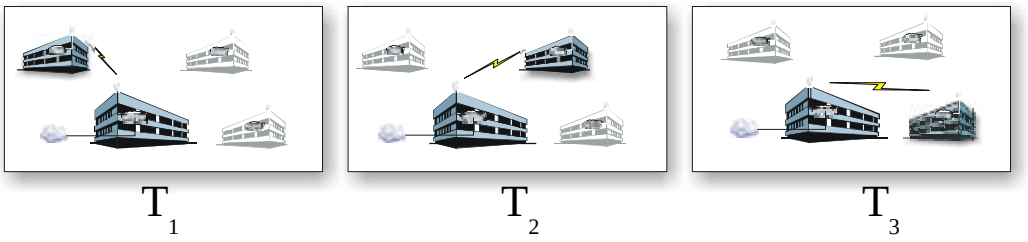


Figure 29 Switched PTP configuration.

8.5.1. Co-located deployments.

It is possible to deploy more than one AN-50 from the same roof-top to support multiple links, however, it is important to consider issues that may arise from co-channel and adjacent channel interference.

Co-channel interference results when two systems operate simultaneously in the same channel. This must be avoided by programming different channels from the AN-50 ***Configuration*** screen. Adjacent channels are acceptable, however, it is important that the adjacent channel does not exceed the acceptable channel to interference (C/I) ratio for the system, as shown in Figure 30 (C is the desired channel, while I is the interferer).

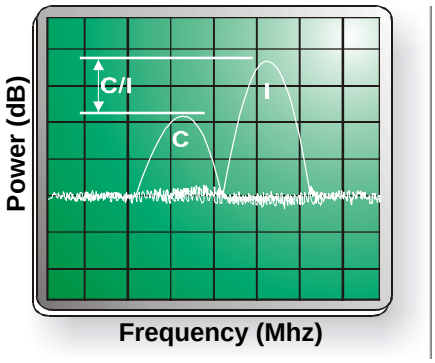


Figure 30 Adjacent channel interference.

8.5.2. Adjacent area deployments.

It is important during the installation process to ensure there is no potential for interference from other systems deployed in adjacent areas. Figure 31 presents a simple deployment configuration to illustrate the potential interference that may arise from adjacent area sources (Users 1-4 in the figure). The desired communication link is between Terminals 1 and 2. The link between Users 1 and 2 must operate in an adjacent channel to avoid interference with the desired link. Users 3 and 4, on the other hand, can operate co-channel, since they are outside

the narrow beamwidth of both terminals. Narrow beamwidths are one feature of the AN-50 to help address potential interference.

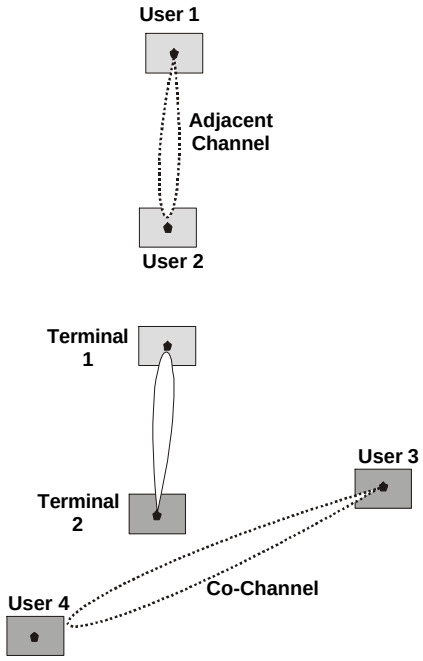


Figure 31 Deployment Scenarios.

GLOSSARY OF TERMS

A/D	Analog to Digital
AC	Alternating Current
AN-50	Access Node 50
ARQ	Acknowledge Request
BER	Bit Error Rate
Bin	Binary
BPSK	Binary Phase Shift Keying
Col	Collision
DB	Decibels
DBm	Decibels above a milliwatt
DHCP	Dynamic Host Configuration Protocol
FD	Dull Duplex
FWA	Fixed Wireless Access
GHz	GigaHertz
GHz	Gigahertz
GUI	Graphical User Interface
HTTP	Hyper Text Transfer Protocol
IF	Intermediate Frequency
IP	Internet Protocol
KB	Kilobyte
LAN	Local Area Network
LED	Light Emitting Diode
LOS	Line of Sight
MAC	Medium Access Control
MB	Megabyte
MHz	MegaHertz
MHz	Megahertz
NLOS	Non LOS
OFDM	Orthogonal Frequency Division Multiplex
PHY	Physical

PTP	Point to Point
QAM	Quadrature-Carrier Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
Rx	Receiver
S/N	Signal to Noise ratio
S-PTP	Switched Point to Point
TFTP	Trivial File Transfer Protocol
Tx	Transmitter
UNII	Unlicensed National Information Infrastructure
VAC	Voltage AC

9. AN-50 Specifications

AN-5 System Characteristics	
System Capability	Non Line of Sight operations PTP and Switched PTP configurations (Rls 0.7)
Services Supported	High speed IP data
RF Band	5.8 GHz (UNII)
Channel Size	20 MHz
RF dynamic range	> 50 dB
Data Rate (Mbps) in 20 MHz channel	Up to 54 Mbps
Network Attributes	• DHCP client/server/passthrough • VLAN
Modulation	Adaptive modulation automatically selects: • BPSK • QPSK • 16 QAM • 64 QAM
Coding rates	½, ¾, and ?
QoS	• Peak information rate (PIR) (Rls 2) • Committed information rate (CIR) (Rls 2)
MAC	• Point to multipoint • Dynamic bandwidth allocation (Best Effort), and QoS • Polling based scheduler • Acknowledge/Request (ARQ) error correction • Concatenation • Fragmentation
Range	Up to 50 Km, dependent on deployment conditions.
Total number of remote terminals node	>32 active users
Network Services Supported	High speed data, IP Layer 3 services
Duplex Technique	Time division duplex
OFDM carrier profile	64 point FFT
Backhaul Connection	100 BT Ethernet
Physical Configuration	• Terminal, radio, and antenna • 3rd party hub/switch
Configuration & Management	• DHCP client/server/passthrough • SNMP relay agent