BreezeNET PRO.11 Series

User's Guide

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Trade Names

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Statement of Conditions

The information contained in this manual is subject to change without notice. BreezeCOM Ltd. shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this manual or equipment supplied with it.

Warranty

In the following warranty text, “the Company” shall mean:
- BreezeCOM Inc., for products located in the USA.
- BreezeCOM Ltd., for products located outside the USA.

This BreezeNET product is warranted against defects in material and workmanship for a period of one year. During this warranty period the Company will, at its option, either repair or replace products that prove to be defective.

For warranty service or repair, the product must be returned to a service facility designated by the Company. Authorization to return products must be obtained prior to shipment. The buyer shall pay all shipping charges to the Company and the Company shall pay shipping charges to return the product to the buyer.

The Company warrants that the firmware designed by it for use with the unit will execute its programming instructions when properly installed on the unit. The Company does not warrant that the operation of the unit or firmware will be uninterrupted or error-free.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the buyer, buyer supplied interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance. No other warranty is expressed or implied. The Company specifically disclaims the implied warranties of merchantability and fitness for any particular purpose.

Electronic Emission Notices

This device complies with Part 15 of the FCC rules, ETSI 300-328, UL, UL/C, TUV/GS, and CE.

Operation is subject to the following two conditions:
1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

FCC Radio Frequency Interference Statement

This equipment has been tested and found to comply with the limits for a class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Information to User

Any changes or modifications of equipment not expressly approved by the manufacturer could void the user’s authority to operate the equipment and the company’s warranty.

CONTACTING BREEZECOM TECHNICAL SUPPORT

Should you need assistance beyond the scope of this guide, please contact your local BreezeCOM reseller or distributor. If they cannot solve your problem, feel free to contact the BreezeCOM Technical Support Depatrment. The support representatives can assist you in solving any problems that cannot be solved by your reseller.

When requesting support, please have the following items available:

- Configuration of the system, including models of the BreezeCOM equipment used.
- Antenna type and cable lengths.
- Site information such as possible radio path problems (like trees, machines, and buildings).
- Distance between devices.
- Configuration, statistic counters, and error messages as seen on the monitor.
- Description of problems encountered.

To contact BreezeCOM Technical Support, refer to the Technical Support page of the BreezeCOM website: www.breezecom.com

TABLE OF CONTENTS

1. INTRODUCTION TO THE BREEZENET PRO.11 SERIES

This chapter explains how to use this guide, presents the members of the ***BreezeNET PRO.11 Series***, describes the benefits of ***BreezeNET PRO.11*** Wireless LANs, and lists the product specifications.

1.1. How to Use This Guide

This User's Guide contains instructions for overall planning and setting up your wireless LAN, and provides details of how to install each unit, and how to install antennas and accessories.

This guide contains the following chapters:

- **Chapter 1 Introduction –** Explains how to use this guide and presents the members of the ***BreezeNET PRO.11 Series***.
- **Chapter 2 Basic Installation –** Details how to install most ***BreezeNET PRO.11 Series*** units.
- **Chapter 3 Device Setup and Management –** Describes how to use the local terminal to setup, configure, and manage ***BreezeNET PRO.11 Series*** units.
- **Chapter 4 SA-PCR PRO.11 PC Card Installation, Setup, and Management –** Describes how to install the SA-PCR Card, and how to setup and manage the Card using the *SA-PCR Configuration* and *SA-PCR Site Survey* Windows applications.
- **Chapter 5 Planning and Installing Wireless LANs –** Provides guidelines and restrictions regarding antenna selection and installation, and includes outdoor antenna range tables.
- **Chapter 6 Accessory Installation –** Introduces some of the accessories available for specific installations, and describes how to install them.
- **Chapter 7 Upgrade Procedure –** Explains how to perform future upgrades for ***BreezeNET PRO.11 Series*** units using a TFTP application.

- **Chapter 8 System Troubleshooting –** Contains a troubleshooting guide that provides answers to some of the more common problems which may occur when installing and using ***BreezeNET PRO.11 Series*** products.
- **Chapter 9 Appendix –** This appendix lists MIBs and traps supported by ***BreezeNET PRO.11 Series*** products, lists product and attachment specifications, provides an overview of the concepts related to wireless LANs, discusses the concepts and applications of radio signal propagation relevant to wireless LANs, and introduces the new 802.11 standard.

1.2. BreezeNET PRO.11 Series Features

Following is a partial list of the features in the ***BreezeNET PRO.11 Series***:

- **IEEE 802.11 Compliant** – All ***BreezeNET PRO.11 Series*** units are fully compliant with the final IEEE 802.11 specification for wireless LANs, and thus support interoperability with other 802.11 compliant vendors.
- **Fully integrated product family –** One high-performance Access Point for all products in the series.
- **Increased Throughput –** Up to 2 Mbps data throughput; the best figure in the market!
- **Translation Bridging –** Support for both translation and transparent bridging as defined in the IEEE 802.1.h and RFC 1042 standards.
- **Seamless Roaming –** Network connection is maintained while roaming between overlapping coverage areas. Transmission and reception can be continued while moving at high speeds with no data packet loss or duplication.
- **Load Sharing** – Traffic is equally distributed among all Access Points in the area.
- **Redundancy** – In co-located cell environments, upon failure of an Access Point, stations will switch to other available Access Points.
- **LED Display –** Power, Network Activity, and WLAN Load or Signal Quality LEDs indicate the current status of the unit.
- **Upgrading –** Simple, quick, and free software upgrades via TFTP.

- **Future-proof Investment** – All "infrastructure" items in the PRO.11 Series line offer Flash updates.

- **SA-PCR Card** – The SA-PCR PRO.11 PC Card is extremely compact and does not extend beyond your PC. It comes with two retractable antennas, or two connectors to which antennas may be connected. Multi-rate support for 1, 2, and 3 Mbps guarantees efficient use of the medium. Throughput is up to 2 Mbps – the highest rate on the market!

  - **Configuration Application** – This user-friendly application helps you quickly setup stations containing SA-PCR Card. You can save the configuration to a file and import the file to other stations for fast installation.

  - **Site Survey Application –** This user-friendly application records the signal strength received by the SA-PCR Card at different locations, giving a clear image of existing coverage. The gathered data indicates whether to add, remove, or move Access Points.

1.3. BreezeNET PRO.11 Series Product Line

The ***BreezeNET PRO.11 Series*** product line consists of:

Product Name	**Available Types**	**Antenna Type**
Access Point	AP-10 PRO.11 AP-10D PRO.11	Internal External
Single Station Adapter	SA-10 PRO.11 SA-10D PRO.11	Internal External
Four Port Station Adapter	SA-40 PRO.11 SA-40D PRO.11	Internal External
Workgroup Bridge	WB-10 PRO.11 WB-10D PRO.11	Internal External
PCMCIA PC Card *Station Adapter Card*	SA-PCR PRO.11 SA-PCD PRO.11	Internal External
Extended Range Access Point	AP-10DE PRO.Plus	External
Extended Range Bridge	WB-10DE PRO.Plus	External

Note: *1. The WB-10DE and AP-10DE are not compatible with the BreezeNET PRO.11 series.*

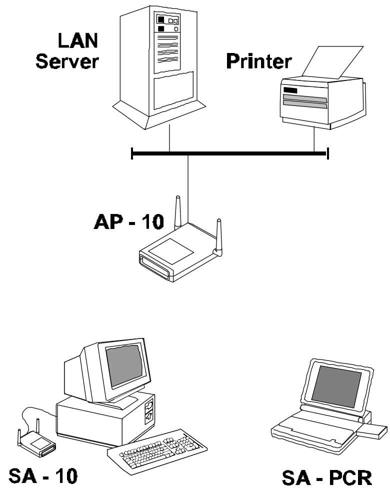
2. Units in the BreezeNET PRO.11 series are not compatible with units in the BreezeNET PRO series.

1.3.1. Access Point

The Access Point is fully compliant with the IEEE 802.11 wireless LAN standard.

The ***BreezeNET*** Access Point is a wireless hub that provides access for wireless workstations into wired Ethernet LANs. It also contains the wireless coordinating function that enables workstations equipped with a Station Adapter (Station Adapter, Bridge, and SA-PCR) to communicate with one another inside the cell coverage area (even if they are not in direct line of sight) via the Access Point. Any two wireless stations in two different cells can communicate through their Access Points.

Figure 1.1: AP-10 PRO.11 with Two Built-In Omni-Directional Antennas



Mobile workstations, such as laptops and hand-held devices, can *roam* between Access Points that belong to the same Extended Service Set (ESS). In an Extended Service Set, all Access Points have the same ESSID. When the access points are set up so that their coverage areas overlap, users can roam seamlessly from cell to cell. This means that there is no interruption of network connection when moving from one coverage area to the other through the overlap and is completely transparent to the user and the applications. The Station Adapters decide when a mobile user becomes disassociated from one access point and associated with another. This process is fully transparent, requires no user intervention and involves no loss of data packets.

Position multiple access points in locations where heavy network traffic is expected to create a multicell and increase the aggregate throughput capacity in areas where it is needed most. The system implements a Load

Balancing algorithm to divide the stations equally between the available co-located Access Points.

The ***BreezeNET*** Access Point contains an embedded SNMP agent enabling effective management by BreezeVIEW or any standard SNMP management station. Software upgrades can be downloaded by TFTP protocol via the wired LAN or wireless LAN.

The Access Point is available in two models:

- AP-10 PRO.11 with two integrated omni-directional antennas.
- AP-10D PRO.11 for use with external high-gain antenna(s).

1.3.2. Single Station Adapter

The ***BreezeNET*** Single Station Adapter is a wireless LAN station adapter that converts any device equipped with an Ethernet interface into a wireless LAN station. The Single Station Adapter is transparent to the device's hardware, software, and network operating system. This enables plug-and-play installation.

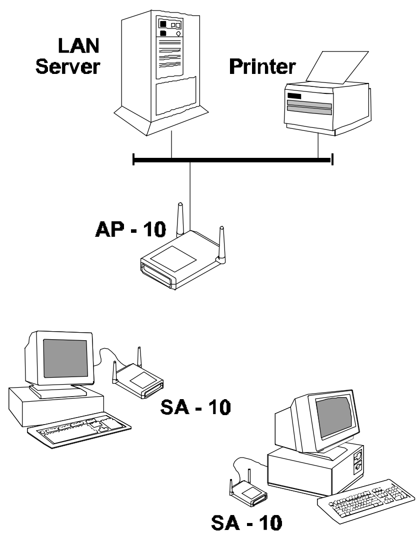


Figure 1.2: SA-10 PRO.11 with Two Integrated Omni-Directional Antennas

The Single Station Adapter enables its workstation to communicate with any other wireless stations in the same cell coverage area, and to access all network resources such as file servers, wired stations, printers and shared databases via the ***BreezeNET*** Access Point. Any two wireless stations in two different cells can communicate through their Access Points.

Workstations that can be connected to the wireless LAN include PCs, X-Terminals, Digital, SUN, HP, IBM, and Apple computers, and any other device that supports Ethernet. The unit is transparent to the workgroup devices' hardware, software, and network operating system.

The Single Station Adapter contains an embedded SNMP agent enabling effective management. Software upgrades are downloaded by TFTP via the Ethernet port or via the Wireless LAN and Access Point.

Network connection is maintained while roaming between overlapping coverage areas. Transmission and reception can be continued while moving at high speed with no data packet loss or duplication.

The Single Station Adapter is available in two models:

- SA-10 PRO.11 with two integrated 2dbi omni-directional antennas.
- SA-10D PRO.11 for use with external antenna(s).

1.3.3. Four Port Station Adapter

The ***BreezeNET*** Four-Port Workgroup Adapter is a wireless LAN adapter that connects a workgroup of up to four Ethernet-equipped workstations to the wireless LAN. The Four Port Station Adapter is transparent to the workgroup devices' hardware and software, allowing plug-and-play installation.

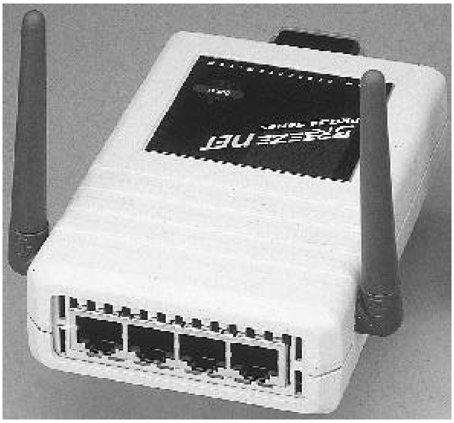
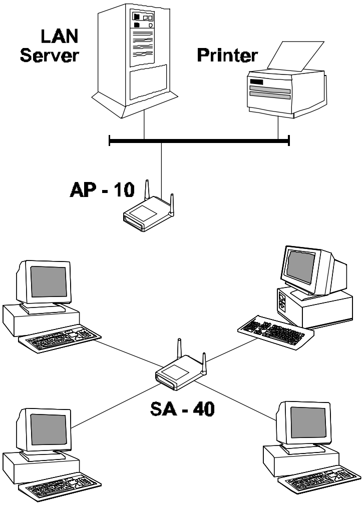


Figure 1.3: SA-40 PRO.11 with Two Integrated Omni-Directional Antennas



The Four Port Station Adapter enables connected workstations to communicate with other wireless stations in the same cell coverage area, and to access all network resources such as file servers, wired stations, printers and shared databases via the ***BreezeNET*** Access Point. The Four Port Station Adapter also allows highly efficient and fast wired communication among the four connected workstations.

Workstations that can be connected to the wireless LAN include PCs, X-Terminals, Digital, SUN, HP, IBM, and Apple computers, and any other device that supports Ethernet. The unit is transparent to the workgroup devices' hardware, software, and network operating system.

The ***BreezeNET*** Four Port Station Adapter contains an embedded SNMP agent and software downloading capabilities which allow it to be effectively managed. Software upgrades are downloaded by TFTP protocol via the Ethernet ports or via the Wireless LAN and Access Point.

Network connection is maintained while roaming between overlapping coverage areas. Transmission and reception can be continued while moving at high speed with no data packet loss or duplication.

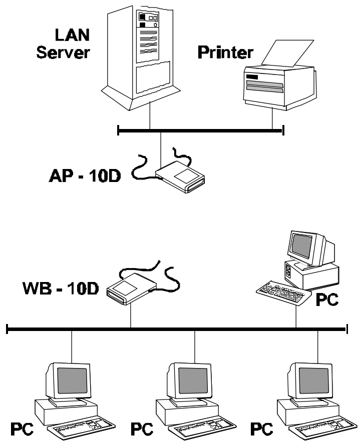
The Four Port Station Adapter is available in two models:

- SA-40 PRO.11 with two integrated omni-directional antennas.
- SA-40D PRO.11 for use with external antenna(s).

1.3.4. Workgroup Bridge

The ***BreezeNET*** Workgroup Bridge is a high-speed, wide-range wireless LAN bridge that provides connectivity to remote Ethernet networks.

Figure 1.4: WB-10D PRO.11 with Two External Antenna Connector Ports



The Workgroup Bridge communicates with the ***BreezeNET*** Access Points of the remote LANs effectively creating an extended wireless network spanning sites situated up to 6 miles apart (in Europe this range is limited by ETSI regulations to 2.5 Km.). In this way a central Ethernet LAN may be connected with one or more branch office LANs.

In addition, an *island* consisting of a Workgroup Bridge together with an Access Point can work as a relay. Transmissions from the central LAN and from the remote LAN are relayed via the island located between them. This configuration effectively doubles bridge range.

Workstations that can be connected to the wireless LAN include PCs, X-Terminals, Digital, SUN, HP, IBM, and Apple computers, and any other device that supports Ethernet. The unit is transparent to the workgroup devices' hardware, software, and network operating system.

The ***BreezeNET*** Workgroup Bridge contains an embedded SNMP agent and software downloading capabilities enabling effective management. Software upgrades are downloaded using TFTP protocol via the Ethernet ports or via the wireless LAN and Access Point.

The Workgroup Bridge is available in two models:

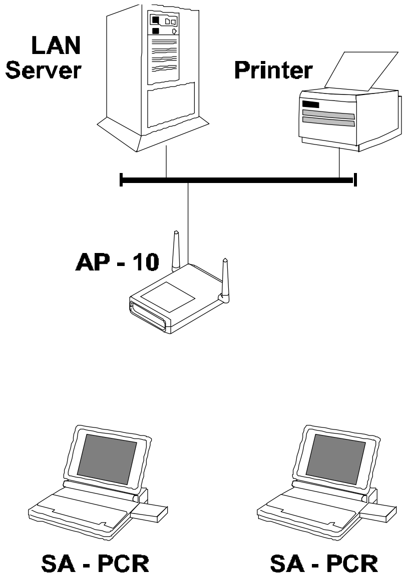
- WB-10 PRO.11 with two integrated 2dbi omni-directional antennas.
- WB-10D PRO.11 with two external antenna connector ports.

1.3.5. PC Card

The PC Card gives the portable computer user continuous connectivity and complete mobility, allowing seamless roaming throughout the wireless LAN campus.

Figure 1.5: The SA-PCR PRO.11 PC Card

The ***BreezeNET*** PC Card converts any portable computer (notebook, lap-top, pen-based, hand-held etc.) containing a PCMCIA Release 2.1 Type II slot into a wireless LAN workstation.



The PC Card can communicate with any other wireless station in its cell coverage area, and can access all network resources such as file servers, other wired stations, printers and shared databases via the ***BreezeNET*** Access Point.

Network connection is maintained while roaming between overlapping cell coverage areas.

Transmission and reception can be continued while moving at high speed with no data packet loss or duplication.

The PC Card is available in two models:

- SA-PCR PRO.11 with two integrated omni-directional retractable antennas.
- SA-PCD PRO.11 with two external antenna connector ports.

1.3.6. Extended Range Access Point and Bridge

Note: *This product complies with European ETSI 300-328 and should only be used in countries which implement this standard.*

The BreezeNET WB-10DE is a high-speed, wide-range wireless LAN bridge that provides connectivity to remote Ethernet networks.

The WB-10DE communicates with the BreezeNET AP-10DE Access Points of the remote LANs effectively creating an extended wireless network spanning sites situated up to 5 Km apart. In this way a central Ethernet LAN may be connected with one or more branch office LANs.

The WB-10DE and AP-10DE products comply with European ETSI standard 300-328. They should not be used in countries where FCC standards are applicable.

The WB-10DE and AP-10DE can be used as a point-to-point as well as a point-to-multipoint solution.

Note: *The WB-10DE and AP-10DE are not compatible with the BreezeNET PRO.11 Series. The SA-10 PRO.11, SA-PCR PRO.11, SA-40 PRO.11, AP-10 PRO.11 and WB-10 PRO.11 units cannot communicate with the AP-10DE or the WB-10DE.*

The BreezeNET AP-10DE and WB-10 DE contain an embedded SNMP agent and software downloading capabilities enabling effective management. Software upgrades are downloaded using TFTP protocol via the Ethernet ports or via the wireless LAN and Access Point.

The BreezeNET DE Access Point and Bridge are available for use with external antenna connector ports as seen in Figure 1.4.

1.4. BreezeNET PRO.11 Functional Description

BreezeNET PRO.11 units add wireless functionality to existing Ethernet LANs.

1.4.1. Quick Review of Ethernet

Standard Ethernet LAN stations are wired to a common bus. When one of the stations sends a message, it assigns a destination address to the message and sends the message on the bus. All stations on the bus “hear” the message, but only the station with the proper address processes the message.

1.4.2. Startup Procedure

When wireless units (other than AP-10) start up, they scan the frequencies for an AP-10. If an active AP-10 is in range, the units synchronize with it. The addresses associated with the units are registered in the AP-10 (the registration process is different for each unit type). From then on, the units can send and receive messages to and from the wired LAN.

1.4.3. AP-10 Access Point

The AP-10 Access Point is connected to a wired Ethernet LAN, and it keeps a list of known stations on its wireless side. When an AP-10 “hears” a message that is destined for a wireless station, the AP-10 forwards the message wirelessly to the station. If the message has a destination address that the AP-10 does not recognize, the AP-10 ignores the message.

The AP-10 is constantly “listening” for wireless messages as well. When the AP-10 “hears” a wireless message destined for another wireless unit, it relays the message directly to the wireless unit without forwarding the message to the wired LAN. When the AP-10 “hears” a wireless message whose destination it does not recognize (since it does not keep a list of known stations on its wired side), it forwards the message to the wired LAN. Messages cannot be sent directly between wireless stations without an AP-10 to relay the message.

1.4.4. SA-10 Station Adapter

The SA-10 station adapter is connected to a station’s network card. When the station sends a message, the SA-10 wirelessly forwards it to the AP-10.

And when the AP-10 receives a message destined for the station, it wirelessly forwards the message to the SA-10.

The first time the station sends a message, the station's address is registered in the AP-10. The AP-10 keeps only the first address for each SA-10, so the SA-10 will not work properly if connected to more than one station.

1.4.5. SA-40 Station Adapter

The SA-40 station adapter has four connectors for up to four stations and works just like the SA-10. As each station connected to the SA-40 sends its first message, each address is registered in the AP-10. The AP-10 keeps only up to four addresses for each SA-40, so the SA-40 will not work properly if connected to more than four stations.

1.4.6. WB-10 Wireless Bridge

As opposed to the SA-10 and SA-40 that connect directly to stations, the WB-10 wireless bridge connects to a wired Ethernet LAN (Hub). When a station on the WB-10's LAN sends a message that is not destined for a local station, the WB-10 wirelessly forwards the message to the AP-10. And when the AP-10 receives a message destined for a station on the WB-10s LAN, the AP-10 wirelessly forwards it to the WB-10. In this way, the WB-10 and AP-10 work together like a standard network bridge.

The first time each station on the WB-10's LAN sends a message, the station's address is registered in the WB-10 and the AP-10. The WB-10 and AP-10 can hold all the addresses necessary to support an entire LAN connected to a WB-10.

1.4.7. SA-PCR Station Adapter

The SA-PCR station adapter is inserted into the station's PCMCIA slot and works just like the SA-10. As opposed to the SA-10 and SA-40 station adapters that connect to the station's network card, the SA-PCR *is* the station's network card. The SA-10 and SA-40 can be used with stations of any operating system as long as the station sends legal Ethernet messages, but the SA-PCR requires a driver that is compatible with the station's operating system.

2. BASIC INSTALLATION

This chapter describes how to physically install most ***BreezeNET PRO.11 Series*** units. Installation for the SA-PCR PRO.11 PC Card Adapter is described in Chapter 4.

The ***BreezeNET PRO.11 Series*** is a plug-and-play solution, and the units begin to function when the following basic installation is complete. However, you can adapt the system to your particular needs using the local terminal (see Chapter 3).

For a description of various overall system configurations, refer to Chapter 5.

2.1. Basic Installation Checklist

Standard installation involves the following steps:

- Check the Package List.
- Position the unit and the antenna in the best location.
- Connect the power supply to the unit.
- Connect the Ethernet port to the unit.
- Check unit functionality using the LED indicators.

2.2. Check the Package List

When you first open the package, verify that the unit is complete with the following components:

- The unit, complete with two omni-directional antennas or RF connectors for use with external antennas (“D” models).
- Quick Installation Guide/Card.
- 5V DC power supply transformer.
- Mounting bracket for wall or ceiling installations and torque key for antenna connectors (supplied with "D" models).

The AP-10 PRO.11 and AP-10DE Access Points come with the following additional components:

- The ***BreezeNET PRO.11 Series*** User's Guide.
- A monitor connector cable for connecting the units to a monitor in order to perform Local Terminal Management functions (see section 3.1).
- Proprietary MIB disk for performing remote unit configuration and monitoring via SNMP (see section 9.1.1).

Open the packaging carefully and make sure that none of the items listed above are missing. Do not discard packaging materials. If, for any reason, the unit is returned, it must be shipped in its original package.

2.3. Position the Unit

BreezeNET PRO.11 wireless LAN products are robust, trouble-free units, designed to operate efficiently under a wide range of conditions. The following guidelines are provided to help you position the units to ensure optimum coverage and operation of the wireless LAN.

Metal Furniture

Position the units clear of metal furniture and away from moving objects such as metal fans or doors.

Microwave Ovens

For best performance, position the units clear of radiation sources that emit in the 2.4 GHz frequency band, such as microwave ovens.

Antennas

For models with integrated antennas, make sure the antennas are extended upward vertically in relation to the floor. For models with external antennas, connect the external antennas and RF cable. For information about external antenna installation, refer to section 5.3 *Outdoor Installation Considerations*.

Heat Sources

Keep the units well away from sources of heat, such as radiators, air-conditioners, etc.

2.3.1. Additional Considerations When Positioning the Access Point

When positioning the AP-10 PRO.11 and AP-10DE Access Points, take into account the following additional considerations.

Height

Install the Access Point at least 1.5m above the floor, clear of any high office partitions or tall pieces of furniture in the coverage area. The Access Point can be placed on a high shelf, or can be attached to the ceiling or a wall using a mounting bracket.

Central Location

Install the Access Point in a central location in the intended coverage area. Good positions are:

- In the center of a large room.
- In the center of a corridor.
- At the intersection of two corridors.

Many modern buildings have partitions constructed of metal or containing metal components. We recommend that you install the Access Points on the corridor ceilings. The radio waves propagated by the ***BreezeNET PRO.11*** LAN are reflected along the metal partitions and enter the offices through the doors or glass sections.

2.4. Connect the Unit to the Power Supply

The unit operates on a power input of 5V DC, (1200mA , 1500mA peak) supplied by the power transformer included with the unit.

- Plug the output jack of the power transformer into the DC input socket on the unit. This socket may be located on the rear or side panel of the unit.
- Connect the supplied power transformer to a power outlet - 110/ 220VAC.

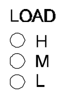
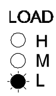
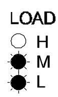
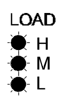
2.5. Connect the Unit to the Ethernet Port

- Connect one end of a an Ethernet 10BaseT cable (not supplied) to the RJ-45 port on the rear panel of the unit (marked UTP).
- Connect the other end of the connector cable to the Ethernet outlet:
    - When connecting an SA-10 or SA-40 to a PC, use a *straight* cable.
    - When connecting an AP-10 or WB-10 to a LAN, use a *straight* cable.
    - When connecting an AP-10 or WB-10 to a PC, use a *crossed* cable.
    - When connecting an AP-10 to a WB-10, use a *crossed* cable.

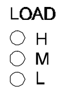
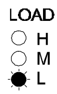
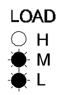
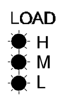
2.6. Check Unit Functionality using LED indicators

Check the unit functionality by using the LEDs on the front panel. The following tables describe the front panel LEDs for Stations (SA-10, SA-40) and Bridges (WB-10), and for Access Points.

2.6.1. Station (SA-10, SA-40) and Bridge (WB-10) LEDs

Name	Description	Functionality
PWR	power supply	On – After successful power up Off – Power off
WLNK	WLAN Link	On – Unit is synchronized or associated with an AP Off – Unit is not synchronized or associated with an AP
ETHR	Ethernet activity	On – Reception on Ethernet port Off – No reception on Ethernet port
QLT	Quality of reception	 very low quality reception or not synchronized with Access Point less than -81 dBm  low quality reception (usually enabling 1 Mbps traffic) from -81 to -77 dBm  medium quality reception (usually enabling 2 Mbps traffic) from -77 to -65 dBm  high quality reception (usually enabling 3 Mbps traffic) greater than -65 dBm

2.6.2. Access Point LEDs

Name	Description	Functionality
PWR	power supply	On – After successful power up Off – Power off
INFR	radio interference	Off – No interference Blinking – Interference Present
ETHR	Ethernet activity	On – Reception of data from Ethernet LAN that is forwarded to WLAN (in reject unknown mode) Off – No reception of data from Ethernet LAN that is forwarded to WLAN
LOAD	WLAN load Number of associated stations	 no stations  1-8 stations  9-16 stations  17 or more stations

2.6.3. Verifying the Ethernet Connection

Once you have connected the unit to an Ethernet outlet, verify that the ETHR LED on the front panel is blinking. The ETHR LED should blink whenever the unit receives LAN traffic.

At the other end of the Ethernet link, verify that the LINK indicator is ON. For APs the LINK indicator is located on the attached hub port, and for Station Adapters the LINK indicator is located on the NIC.

3. DEVICE SETUP AND MANAGEMENT

This chapter explains how to access the local terminal program, and how to use the terminal program to setup, configure, and manage most ***BreezeNET PRO.11 Series*** units. Setup, configuration and management for the SA-PCR PRO.11 PC Card Adapter is described in Chapter 4.

The ***BreezeNET PRO.11 Series*** is a plug-and-play solution and operates immediately after physical installation without any user intervention. However, you can adapt the system to your particular needs using the local terminal. In addition, all products in the series contain an SNMP agent and are configurable remotely via the network.

Note: *Reset the unit after making configuration changes so that the changes will take effect.*

3.1. Accessing and Using Local Terminal Management

Þ ***To access Local Terminal Management:***

1. Use the Monitor cable (supplied with the Access Point) to connect the MON jack on the rear panel of the unit to the COM port of your ASCII ANSI terminal or PC.
2. Run a terminal emulation program (such as HyperTerminal™).
3. Set up communication parameters to the following:
   - Baud Rate: 9600
   - Data Bits: 8
   - Stop Bits: 1
   - Parity: None
   - Flow Control: XON/XOFF
   - Connector: Connected COM port.
4. Press Enter. The main menu appears.

Þ ***To use Local Terminal Management:***

1. Press an option number to open/activate the option. You may need to press Enter in some cases.
2. Press Esc to exit a menu or option.
3. Reset the unit after making configuration changes.

3.2. Configuration Screens

Listed below are the menus, sub-menus, and parameters/options in the terminal program that the **Installer** can edit. Default values are listed where applicable.

Numbers in the table below indicate how to reach each option. For example, to reach the *1.2.1 IP Address* option, start at the main menu and press 1, then 2, and then 1.

Menu	Sub-Menu	Parameter/Option	Default Values
1. System Config-uration	1.1 Station Status	• Unit Mode • Unit H/W Address • Unit WLAN Addr *(SA-10/40, WB-10 Only)* • Station Status *(SA-10 Only)* • AP Address *(SA-10/40 Only)* • Current Number of Associations *(AP Only)* • Number of Associations Since Last Reset • Cur. Number of Authentications *(AP Only)* • Max Number Authentications *(AP Only)*	
	1.2 IP and SNMP Parameters	1.2.1 IP Address 1.2.2 Subnet Mask 1.2.3 Default Gateway Address 1.2.4 SNMP Traps 1.2.5 Display Current Values	 Enabled
	1.3 Wireless LAN (WLAN) Parameters	1.3.1 Hopping Sequence *(AP Only)* 1.3.2 Hopping Set *(AP Only)* 1.3.3 ESSID 1.3.4 Maximum Data Rate 1.3.5 Transmit Diversity 1.3.6 Mobility 1.3.7 Load Sharing 1.3.8 Long Range 1.3.9 Preferred AP *(SA-10/40, WB-10 Only)* 1.3.A Display Current Values	1 (FCC standard) 2 (FCC standard) ESSID1 3Mbps Use 2 Antennas* Stationary Disabled** Disabled Not Set
	1.4 Bridging	1.4.1 LAN-WLAN Bridge Mode *(AP Only)* 1.4.2 Intelligent Bridging Period *(AP Only)* 1.4.3 IP Filtering 1.4.4 Tunneling 1.4.5 Broadcast Relaying 1.4.6 Unicast Relaying	Reject Unknown 15 sec Disabled Both Enabled Enabled

	1.5 Station Control	1.5.1 Reset Unit 1.5.2 Set Factory Defaults	
2. Advanced Settings	2.3 Performance	2.3.1 Dwell Time *(AP Only)*	128 msec
	2.4 Radio	2.4.4 Auto Calibration	Enabled
3. Site Survey	3.1 System Counters	3.1.1 Display Counters 3.1.2 Reset Counters	
	3.2 Survey Software	3.2.1 Operation Mode 3.2.2 Data Type 3.3.3 Data Rate 3.3.4 Antenna 3.3.5 Power Level 3.3.6 Number of Packets to Tx 3.3.7 Time Between Packets 3.3.8 Packet Length 3.3.9 Display Rx Packets per Frequency 3.3.D Display Actual Configuration 3.3.L Load Default Configuration 3.3.S Start Statistics 3.3.Q Stop Statistics 3.3.N Neighboring AP's	
4. Access Control		4.1 Change Access Rights 4.2 Change Installer Password 4.3 Show Current Access Right	

* Option *1.3.5 Transmit Diversity* has the default value *Use #2* for the SA-40 unit only.
** Option *1.3.7 Load Sharing* has the default value *Enabled* for the AP-10 unit only.

3.3. Main Menu

PRO.11 Series   *Unit Model (SA-10, SA-40, WB-10, AP-10)*

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
BreezeNET Monitor
 =================
1 – System Configuration
2 – Advanced Settings
3 - Site Survey
4 - Access Control

Select option >
```

Software Version

Figure 3.1: Main Menu

3.4. System Configuration Menu

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
System Configuration menu
=========================
1 - Station Status
2 - IP and SNMP Parameters
3 - Wireless LAN Parameters
4 – Security
5 - Bridging
6 - Station Control

Select option >
```

Figure 3.2: System Configuration Menu

3.4.1. Station Status

Station Status is a read-only sub-menu that displays the current values of the following parameters:

- **Unit Mode –** Identifies the unit’s function. For example, if the unit is an Access Point, “AP” appears in this field. If the unit is a Station Adapter (SA-10, SA-40) or a QB-10, "SA" appears in this field.
- **Unit H/W Address –** Displays the unit’s unique IEEE MAC address.
- **Unit WLAN Address (SA or WB) –** The address by which the unit associates. For the SA-10, this is the address of the PC. For the SA-40 and WB-10, this is the address of the hardware. This field does not appear when the unit is an AP.
- **Station Status (SA or WB) –** Current status of the station. There are three options:
  - *Scanning* - The station is searching for an AP with which to associate.
  - *Sync Waiting for Address* - The station is synchronized with an AP but has not yet learned its WLAN MAC address (this option is

relevant only to the SA-10). The AP does not forward packets to the station when it is in this mode.

- *Associated* - The station is associated with an AP and has adopted the attached PC MAC address (for SA-10) or uses the unit's H/W address (SA-40 and WB-10), and is receiving packets from the LAN.

- **AP Address (Station Only)** – Address of the AP with which the unit is currently associated.
- **Current Number of Associations (AP Only)** – Total number of stations currently associated with this AP.
- **Number of Associations Since Last Reset** – For stations, this indicates the total number of associations and disassociations with various APs. This is usually an indication of roaming. When the unit is an AP, this field indicates how many station are currently associated with this particular AP.
- **Current Number of Authentications (AP Only)** – Total number of stations currently authenticated with this AP. A station may be concurrently authenticated with several APs, but is associated with only one AP at a time.
- **Maximum Number of Authentications (AP Only) –** Maximum number of stations that were authenticated with this AP at one time.

3.4.2. IP and SNMP Parameters

All BreezeNET PRO.11 units contain IP Host software. This software is used for testing the unit for SNMP management functions and for downloading software upgrades using the TFTP protocol.

- **IP Address –** IP address of the unit.
- **Subnet Mask –** Subnet mask of the unit.
- **Default Gateway Address –** Gateway address of the unit.
- **SNMP Traps –** Whether this unit sends SNMP traps. If enabled, when an event occurs, a trap is sent to the defined host address (see section 9.1.2 for a list of traps). You can configure the host address to which the traps are sent through SNMP management.

- **Display Current Values –** Displays information concerning the current status of all IP-related items.

3.4.3. Wireless LAN (WLAN) Parameters

The WLAN Parameters Menu contains the following options:

- **Hopping Sequence (AP Only)** – Hopping sequence of the unit.

  A hopping sequence is a pre-defined series of channels (frequencies) that are used in a specific, pseudo-random order as defined in the sequence. The unit "hops" from frequency to frequency according to the selected sequence. When more than one AP is co-located in the same area (even if they are not part of the same network) it is recommended to assign a different hopping sequence to each AP.

  Hopping sequences are grouped in three hopping sets. The hopping set selected in the Hopping Set screen (see next parameter) determines which hopping sequences are available in this screen. When setting up multiple APs in the same site, always choose hopping sequences from the same hopping set. This reduces the possibility of collisions on the WLAN.

  This parameter is set only in AP-10 PRO.11 Access Point. It is not accessible from any other ***BreezeNET PRO.11*** unit. All other stations learn it from the Access Point during the association process. Different co-located WLAN segments should use different hopping sequences.

- **Hopping Set (AP Only) –** Hopping set (between 1 and 3) of the unit. Hopping sequences are grouped in several hopping sets. The hopping set selected in this screen determines which hopping sequences are available in the Hopping Sequence screen (see previous parameter). Always use the same hopping set per site.

  Following is the list of hopping sequences and sets for each country.

  The default value for all countries except Japan is: Hopping Sequence=1, Hopping Set=2.

  For Japan, the default value is Hopping Sequence=6, Hopping Set=1.

Australia
set 1 = 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57
set 2 = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37, 40, 43, 46, 49, 52, 55, 58
set 3 = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47, 50, 53, 56, 59

Canada
set 1 = 0, 3, 6, 9, 12, 15, 18, 21, 24, 27
set 2 = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28
set 3 = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29

EthAirNet (1.144)
set 1 = 0, 3, 6, 9, 12, 15, 18, 21
set 2 = 1, 4, 7, 10, 13, 16, 19, 22
set 3 = 2, 5, 8, 11, 14, 17, 20

Europe DD
set 1 = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
set 2 = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
set 3 = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Europe ETSI
set 1 = 0, 3, 6, 9, 12, 15, 18, 21
set 2 = 1, 4, 7, 10, 13, 16, 19, 22
set 3 = 2, 5, 8, 11, 14, 17, 20

France
set 1 = 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
set 2 = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31
set 3 = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32

Israel
set 1 = 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
set 2 = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31
set 3 = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32

Japan
set 1 = 6, 9,12,15
set 2 = 7,10,13,16
set 3 = 8,11,14,17

Korea
set 1 = 6, 9,12,15
set 2 = 7,10,13,16
set 3 = 8,11,14,17

Netherlands
set 1 = 0, 3, 6, 9, 12
set 2 = 1, 4, 7, 10, 13
set 3 = 2, 5, 8, 11, 14

Spain
set 1 = 0, 3, 6, 9, 12, 15, 18, 21, 24
set 2 = 1, 4, 7, 10, 13, 16, 19, 22, 25
set 3 = 2, 5, 8, 11, 14, 17, 20, 23, 26

US FCC and Europe ETSI
set 1 = 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57, 60, 63, 66, 69, 72, 75
set 2 = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37, 40, 43, 46, 49, 52, 55, 58, 61, 64, 67, 70, 73, 76
set 3 = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47, 50, 53, 56, 59, 62, 65, 68, 71, 74, 77

Site Proprietary
set 1 = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22
set 2 = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22
set 3 = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22

- **ESSID –** ESSID of the unit (up to 32 printable ASCII characters). The ESSID is a string used to identify a WLAN. This ID prevents the unintentional merging of two co-located WLANs. A station can only associate with an AP that has the same ESSID. Use different ESSIDs to segment the WLAN network and add security.

Note: *The ESSID is case-sensitive.*

- **Maximum Data Rate –** Maximum data rate of the unit. ***BreezeNET PRO.11*** units operate at 1 Mbps, 2 Mbps or 3 Mbps. The unit adaptively selects the highest possible rate for transmission. Under certain conditions (compatibility reasons or for range/speed trade-off) you may decide to limit the use of higher rates.

- **Transmit Diversity –** Which antennas are used for transmission. During reception, a ***BreezeNET PRO.11*** unit dynamically selects the antenna where reception is optimal. In contrast, *before* transmission the unit selects the antenna from which it will transmit. It usually uses the antenna last used for successful transmission. In models with external antennas, sometimes only a single antenna is used. In this case, Transmit Diversity should be configured to transmit only from that single antenna. Similarly, models using a booster or an LNA use only a single antenna for transmission.

- **Mobility** – ***BreezeNET PRO.11*** stations optimize their roaming algorithms according to the mobility mode parameter. For example, a stationary station is more tolerant of bad propagation conditions. It assumes that this is a temporary situation and is not caused by the station changing position. Initiating a roaming procedure in such a case would be counter-productive. In general, Wireless stations can be used in one of three mobility modes:

  - *Mobile* – High Mobility. For stations that may move at speeds of over 30 km per hour.

  - *Portable* – Medium Mobility. For stations that may move at speeds of over 10 km per hour, but not over 30 km per hour.

  - *Stationary* – Low Mobility. For stations that will not move at speeds of over 10 km per hour. *Stationary* is the default value, and in almost all cases this is the best choice.

- **Load Sharing –** Whether load sharing is enabled for the unit. When installing a Wireless LAN network in a high-traffic environment, you can increase the aggregate throughput by installing multiple APs to create co-located cells. When load sharing is enabled, the wireless stations distribute themselves evenly among the APs to best divide the traffic between the APs.

- **Long Range** – Whether long range communication is enabled for the unit. Enable long range only when units are more than 20 km apart. When long range is enabled, a unit that has transmitted will allow more time for an ACK to be received from the other unit. It is not recommended to enable long range for links under 20 km. Achieving long range communication depends on RF conditions and configuration. Enabling the *Long Range* parameter has no effect on the achievable range.
- **Preferred AP** – AP MAC (Ethernet) address of the preferred AP. You can configure a station to prefer a specific AP unit. When the station powers up, it will associate with the preferred AP even if the signal from that AP is lower than the signal from other APs. The station will roam to another AP only if it stops receiving beacons from the preferred AP.
- **Display Current Values** – This read-only status screen displays current WLAN parameters. Press any key to return to the WLAN Parameters Menu.

3.4.4. Bridging

The Bridging Menu contains the following options:

- **LAN to WLAN Bridging Mode (AP Only)** – The options are:
  - *Reject Unknown* – Type 0 to allow transmission of packets only to stations that the AP knows to exist in the Wireless LAN (behind the Wireless Bridge).
  - *Forward Unknown* – Type 1 to allow transmission of all packets except those sent to stations that the AP recognizes as being on its wired Ethernet side. When connecting very large networks, it is recommended to set this parameter to *forward unknown*.
- **Intelligent Bridging Period (AP Only)** – Intelligent bridging enables smooth roaming of WB-10 units. When intelligent bridging is enabled, the AP goes into a special bridging mode for a fixed amount of time whenever a wireless bridge (WB) roams into its area. This mode causes the AP to forward packets destined for the stations behind the WB-10 even though they are known or were learned from the wired side (except that no learning of the wired LAN will take place). Afterwards, the AP

will switch back to *Reject Unknown* bridging mode. This procedure prevents packets destined for stations behind the bridge from getting lost. The value of this parameter is the length of time in seconds that the AP will remain in special mode.

- **IP Filtering** – Whether IP filtering is enabled for the unit. Enable IP Filtering to filter out any other protocol (such as IPX) if you want that only IP traffic will pass through the WLAN.
- **Tunneling** – Whether the unit performs tunneling. Enable Appletalk tunneling if the network contains a mix of Ethertalk1 (ET1) and Ethertalk2 (ET2) stations to ensure smooth communications. Enable IPX tunneling if IPX protocol is running over your network. Be sure to set all units to the same tunneling setting.
- **Broadcast Relaying (AP Only)** – Whether the unit performs broadcast relaying. When Broadcast Relaying is enabled, Broadcast packets originating in WLAN devices are transmitted by the AP back to the WLAN devices, as well as to the LAN. If it is disabled, these packets are sent only to the local wired LAN and are not sent back to the WLAN. Disable Broadcast Relaying only if you know that all Broadcast messages from the WLAN will be destined to the wired LAN.
- **Unicast Relaying** – Whether the unit performs Unicast relaying. When Unicast Relaying is enabled, Unicast packets originating in WLAN devices can be transmitted back to the WLAN devices. If this parameter is disabled, these packets are not sent to the WLAN even if they are intended for devices on the WLAN. Disable Unicast Relaying only if you know that all Unicast messages from the WLAN will be destined to the local wired LAN.

3.4.5. Station Control

The Station Control Menu contains the following options:

- **Reset Unit** – Resets the BreezeNET PRO.11 unit and applies any changes made to the system parameters.
- **Set Factory Defaults** –When this option is implemented, system parameters revert back to the original factory default settings. There are two options:
    - *Full* – All parameters revert to defaults except for Japan Call Sign (if applicable).

- *Partial* – All parameters revert except for Japan Call Sign (if applicable), IP Address, Subnet Mask, Default Gateway, Hopping Sequence, Hopping Set, ESSID, Transmit Diversity, Long Range, Preferred AP, IP Filtering, Hopping Standard, Power Level, Auto Calibration.

3.5. Advanced Settings Menu

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
Advanced menu
================
1 - Compatibility
2 - Roaming
3 - Performance
4 - Radio
5 - Rate
6 - AP Redundancy Support
7 - Maintenance

Select option >
```

Figure 3.3: Advanced Settings Menu

Modification of most of the parameters that can be accessed from this menu is limited to Certified ***BreezeCOM*** Engineers only. The Installer has access to modify the following parameter of the **Performance** menu:

- **Dwell Time (AP Only) –** The time spent on a radio channel before hopping to the next channel in the sequence.

The Installer also has access to modify the following parameter of the **Radio** menu:

- **Auto Calibration –** When the unit is started, it performs an internal self-test. Part of this test is automatic calibration of the DC Offset and deviation pattern. Auto Calibration is not supported in the “DE” models, and it therefore must be disabled for “DE” units.

The following sections describe the important parameters and relevant information in the Advanced Settings menu that can be viewed, but not modified, the the Installer.

3.5.1. Performance

The Performance menu contains parameters regarding unit performance:

- **RTS Threshold –** Minimum packet size to require an RTS. For packets smaller than this threshold, an RTS is not sent and the packet is transmitted directly to the WLAN.

3.5.2. Radio

The Radio menu contains the following major parameters:

- **Hopping Standard –** The *Hopping Standard* is a set of rules regarding the radio transmission standard allowed in each country. Units will work together only if set to the same hopping standard. Use this parameter to set the unit's hopping standard to that of the relevant country.

- **Power level –** Output power level at which the unit is transmitting. There are two possibilities, Low (4dBm) or High (17 dBm) at the antenna connector.

3.5.3. Rate

The Rate menu contains the following relevant counters:

- **Rate Counters –** The number of frames transmitted in each data-rate since the last time the unit was reset. The *Reset Counters* option will reset these counters also. In APs, the counters for all associated stations are displayed, indicated by their MAC address. In stations, only the stations' rate counters are displayed with no indication of address. The rate counters show the rate the packet was transmitted for the first time, not including retransmissions. The **Ret** counter shows the number of frames that had to be retransmitted, and does not count the number of retransmissions that actually accrued.

  Checking rate counters is the best way to determine which data rate is optimal for the unit. It is recommended to restrict the *Maximum Data Rate* (refer to section 3.4.3) for each unit according to these counters.

3.5.4. Maintenance

The Maintenance menu contains the following major parameters and information:

- **Display Alarm Log –** The last four error messages that the unit displayed since the last *Factory Defaults* reset. The Alarm log stores events in four levels of error notifications: *MSG (Message)*, *WRN (Warning)*, *ERR (Error)*, and *FTL (Fatal)*.

  You can control message severity as follows: in the main menu, press Y-*Testing*, press 2-*System Info and System Parameters*, and press 4-*Events Storage*. Use the 1-*Event Storage Policy runtime value* option to set the policy until the next reset. Use the 2-*Event Storage Policy Nv ram value* option to set the constant policy for the Alarm Log.

- **Japan Call Sign –** The Japan Call Sign is part of the Japanese standard, defined according to local regulations. The Japanese Ministry of Communications supplies an activation code for the units; this code is set in the factory for each unit.

3.6. Site Survey Menu

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
Site Survey menu
================
1 - System Counters
2 - Survey Software

Select option >
```

Figure 3.4: Site Survey Menu

The Site Survey Menu gives access to the sub-menus necessary to perform a *Site Survey* that helps you position your units and align their antennas, as well as perform troubleshooting.

The following sections first describe the sub-menus in the Site Survey menu, and then explain step-by-step how to perform a Site Survey. The Site Survey menu contains two sub-menus:

- System Counters
- Survey Software

3.6.1. System Counters

The System counters are a simple yet very efficient tool to monitor, interpret and analyze the Wireless LAN performance. The counters contain statistics concerning Wireless and Ethernet frames. The submenu contains the following options:

- **Display Counters –** Choose this option to display the current value of the Ethernet and Wireless counters.
- **Reset Counters** - Choose this option to reset all the counters. After choosing this option you will be requested to type 1 for confirmation or 0 to cancel the reset.

Ethernet Counters

Ethernet counters display statistics about the unit's Ethernet port activity.

The unit receives Ethernet frames from its UTP port and forwards them to its internal bridge, which decides whether or not to transmit them to the Wireless LAN. The units have a smart hardware filter mechanism which filters most of the frames on the LAN, and hardware filtered frames are not counted.

On the other side, frames which where received from the wireless LAN and some frames generated by the unit (answers to SNMP queries and pings which reached to the unit via the UTP port), will be transmitted to the UTP port.

Available Counters:

- **Total Received frames –** The total number of frames received from the UTP port. This counter includes both bad and good frames.
- **Received Bad Frames –** The number of frames with errors received from the UTP port. High values (more than just a few) indicate a problem in the UTP connection such as a bad UTP cable or hub port.

- **Received good frames –** The number of good frames (i.e. frames with no errors) received from the UTP port.
- **Forwarded to the bridge –** The number of received frames that were forwarded to the unit's internal bridge. This counter should be equal to the number of good frames unless the internal bridge is overloaded.
- **Missed Frames –** Frames that the unit recognized but failed to read due to internal bridge overload. This counter should equal zero unless the internal bridge is overloaded.
- **Transmitted to Ethernet –** The number of frames transmitted by the unit to the UTP port. These mainly include frames that have been received from the Wireless side, but also includes frames generated by the unit itself.

Wireless LAN Counters

Wireless counters display statistics about the unit's Wireless LAN activity.

Transmission to the wireless media includes data frames received from the UTP ports, as well as self generated control and management frames. When a data frame is transmitted, the unit will wait for an *acknowledge* from the receiving side. If an *acknowledge* is not received, the unit will retransmit the frame until it gets an acknowledge (there are no retransmissions for control frames). If the unit has retransmitted a frame for the maximum number of retransmissions (refer to section 3.5.1) it will stop re-transmitting the frame and drop this frame.

Available Counters:

- **Total Transmitted Frames –** The number of frames transmitted to the wireless media. The count includes the first transmission of data frames (without retransmissions), and also the number of control and management frames.

  Notice that an AP continuously transmits a control frame called *beacon* in every frequency to which it hops, in order to publish its existence and keep its associated stations synchronized. Thus, the total transmitted frames counter will get high values even if the AP-10 is not connected to an active LAN.
- **Total Transmitted Frames (Bridge)** - The total number of data frames transmitted to the wireless media (i.e. frames that were received form the

UTP port and forwarded to the internal bridge which decided to transmit them to the wireless media).

- **Total Transmitted Data Frames –** This counter is similar to the above but counts only data frames. In most ***BreezeNET PRO.11*** units, the number of total transmitted frames and total transmitted frames (bridge) are identical. In the case of the AP, due to the inclusion of beacon frames, this number will be higher than that for Total transmitted frames.
- **Frames Dropped (too many retries) –** The number of frames which were dropped since they were retransmitted for the maximum number of allowed retransmissions and weren't acknowledged.
- **Total Transmitted Fragments –** The total number of transmitted frames. The count includes data, control and management frames and also the number of retransmissions of data frames (for example, if the same data frame is retransmitted ten times, the count will increase ten times).
- **Total Retransmitted Fragments –** The total number of retransmissions of data frames (for example, if the same data frame is retransmitted ten times then the count will increase ten times). In a point-to-point application, this counter should relatively correspond to the number of bad fragments received on the other side.
- **Total Tx Errors –** The number of transmit errors that have occurred. Currently this counter also includes normal situations where a fragment has not been transmitted because the dwell time has elapsed.
- **Internally Discarded –** The number of frames that the AP discarded due to a buffer overflow. Frame discard will occur mainly when the wireless conditions are bad and the unit is busy re-transmitting frames and doesn't have time for handling new frames.
- **Power Saving Aged –** The AP buffers frames for stations in a power saving sleep mode. This counter counts the number of frames dropped by the AP because a station did not wake up for a long time.
- **Power Saving Free Entries –** Number of free buffers (one frame each) available for power save management. These buffers hold messages for stations that only periodically make contact with the AP due to power considerations.

- **Total Received Frames -** The number of frames received from the wireless media. The count includes data and control frames (including beacons received from AP's).
- **Total Received Data Frames –** The number of data frames received from the wireless media.
- **Total Received Fragments** – The total number of frames received, including data, control and duplicate data frames (see *duplicates and dwell timeouts* parameter below).
- **Bad Fragments Received** – The number of frames received from the WLAN with errors. In a point-to-point application, this counter should relatively correspond to the number of retransmitted fragments on the other side.
- **Duplicates and Dwell timeouts –** When a unit receives a frame it sends an *acknowledge* for it. If the acknowledge is lost, than it receives a second copy of the same frame, since the other side thinks this frame was not received. Although duplicate frames are counted, only the first copy of the frame is forwarded to the UTP port.

3.6.2. Survey Software

The Survey Software sub-menu enables you to align antennas and to assess the radio signal quality of a point-to-point link. The sub-menu includes the following options:

- **Operation Mode –** When running a Site Survey, set the units on either side of the link to either receive (option 1) or transmit (option 2) packets (one unit should be set to transmit and the other to receive). Option 0 (Idle mode) is not active at present.
- **Data Type** – Data is transmitted in the form of pseudo-random data. This is the default. Option 1 (Null Packets) is for use with SA-PCR Cards and is a future option. Do not change this setting.
- **Data Rate –** Rate at which the unit is transmitting. Do not make any changes to this setting.
- **Antenna –** State of the antennas as configured in Transmit Diversity (see section 3.4.3). Do not make any changes to this setting.

- **Power Level** – Level of power at which the unit is operating. There are two possibilities, Low or High. In this case, the unit is operating at a high power level. Do not make any changes to this setting.
- **Number of Packets to Tx** – Number of data packets transmitted. Do not make any changes to this setting.
- **Time Between Packets** – Time between data packets measured in 100 millisecond units. Do not make any changes to this setting.
- **Packet Length** – Length of each data packet measured in bytes. Do not make any changes to this setting.
- **Display Rx Packets per Frequency** – Histogram of the number of frames received on each channel. This graph is explained fully in section 3.6.4 *Using the Rx Packets per Frequency Histogram*.
- **Display Actual Configuration** – Default parameters to be used in the Site Survey procedure.
- **Load Default Configuration** – If any changes were made for any reason to any of the previous parameters, select this option to cancel these changes and return to the original default parameters.
- **Start Statistics** – Press **S** and then press any digit to start Site Survey.
- **Stop Statistics** – Press **Q** and then press any key to stop update of Site Survey statistics.

3.6.3. Using the Site Survey Software

Þ ***To use the Site Survey Software:***

1. Roughly align the antennas on either side of the link before starting the Site Survey procedure.
2. Verify that the Ethernet cables are disconnected from both units.
3. Press **1** to go to the Operation mode screen. Set the units on either side of the link to either receive (option 1) or transmit (option 2) packets (one unit should be set to transmit and the other to receive). Option 0 (Idle mode) is not active at present.
4. Make no changes in the following sub-menus:

- Data Type
- Data Rate
- Antenna
- Power Level
- Number of Packets to Transmit
- Time Between Packets
- Packet Length
- Frequency Hopping menu

These sub-menus reflect the defaults already set in the unit and need not be changed in order to carry out the survey.

5. Start the survey by selecting option (S) in the Survey Software menu in both units. When performing a site survey from a station to an AP (transmitting from the station to the AP), always begin with the station (select option (S) on the station).

6. On the transmit side, a screen appears displaying a table with the number of packets and the frequency at which each packet was transmitted (refer to Figure 3.5). This list is updated continuously. Select option (Q) to stop sending packets.

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
# Tx Packets Channel
                 0      37
                 1      10
                 2       7
                 3      30
                 4      28
                 5      44
                 6      35
                 7      12
                 8      48
                 9      76
                10      42

Hit any key to return >
```

Figure 3.5: Transmit Statistics

7. On the receive side of the link, the screen displays a table showing the packet number received, the frequency at which each packet was transmitted, the Received Signal Strength Indicator (RSSI) for each antenna and the antenna that was selected for reception (refer to Figure 3.6). Use only the RSSI reading from the selected antenna.

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
# Pack Len_Ant Idle_q Brker_q Data_q RSSI1 RSSI2 Bit_Err BER(M) Frq
60 400     1      5    16392    45     155   138    0      0     74
61 400     1     14    16392    39     155   139    0      0     64
62 400     2     14    16392    34     153   154    0      0     32
63 400     1     55    16392    48     154   153    0      0     25
64 400     2     95    16392    44     154   155    0      0     29
65 400     1      8    16392    52     155   151    0      0     34
66 400     1      7    16392    50     154   152    0      0     21

Hit any key to return >
```

Figure 3.6: Receive Statistics

8. The RSSI is given in arbitrary units. Use the following graph (Figure 3.7) to correlate RSSI to dBm.

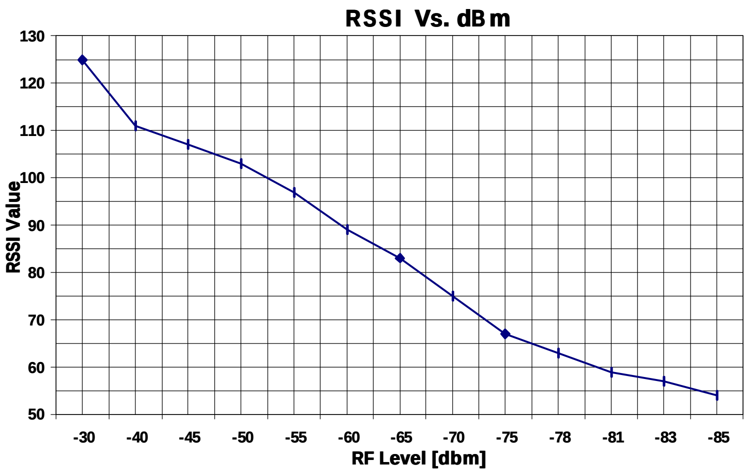


Figure 3.7: RSSI to dBm Graph

9. Re-align the antennas until the maximum received signal strength is attained. As you align the antennas, you will see that the RSSI (received signal strength indicator) continually increases until it

reaches a certain level after which the RSSI begins to decrease. This is the maximum attainable RSSI level indicating optimum receive antenna alignment.

10. Switch the functions of either side of the link (set the transmit unit to receive and the receive unit to transmit) and repeat the procedure to check the link from the opposite direction.

3.6.4. Using the Rx Packets per Frequency Histogram

Use the *Display Rx Packets per Frequency* option to see a histogram of the number of frames received on each channel.

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24

Max = 187
Min = 112
                                                                           #
     #                      #            #   #                             #
 #   #              ####    ###          # # #  #   # ##  #  ## # #  ##    #
 #   ## ##  #   ## ######## ######   # ######## # ### ##  #  ## # #  ## # ##
####### ## ######################################################### ########
#############################################################################
^         ^         ^         ^         ^         ^         ^         ^
2       +10       +20       +30       +40       +50       +60       +70

Hit any key to return >
```

Figure 3.8: Display Rx Packets per Frequency

Each point of the histogram line corresponds to a frequency. The base frequency appears at the far left, and gradations are marked in steps of ten along the line. A hash represents each packet received on a given frequency (#). The Max and Min values indicate the highest and lowest number of frames received across all frequencies. This graph is very useful for tracking interference. Frequencies with low numbers of packets received probably have more interference than other frequencies.

3.7. Access Control Menu

Access Control functions enable the System Administrator or Installer to limit access to Local Terminal Maintenance setup and configuration menus.

```
BreezeNET PRO.11 Series (SA-10)
Version:  4.211
Date: 25 Jun 1998 15:46:24
Access Control menu
===================
1 - Change Access Rights
2 - Change Installer Password
S - Show Current Access Right

Select option > 1
```

Figure 3.9: Access Control Menu

The Access Control menu includes the following options:

- **Change Access Rights** – This screen determines the level of access rights to the ***BreezeNET PRO.11*** unit's setup and configuration menus. When the unit is first installed, the default setting is option (1), Installer and the default password is "user":
  - *User* – The Local Terminal Management menus are read-only for a user who does not possess the correct password. The ESSID and security parameters are hidden by asterisks (*) at this level.
  - *Installer* – The installer has access to configure all required parameters in the system configuration menu, as well as some of the advanced settings. Access is password-protected. After configuration, the installer should change access rights to option (0), User. The installer can also change the installer password (see next parameter).
  - *Technician* – Only an Certified BreezeCOM Engineer possessing the correct password can select this option to configure all the parameters and settings.
- **Change Installer Password** – Type in the new password according to the directions on screen. This screen changes the installer password to prevent unauthorized persons from making any changes in system

configuration and setup. The password is limited to eight printable ASCII characters. This option is not available at User level.

- **Show Current Access Right –** This read-only screen presents the current access right configuration.

Important**: If you change the Installer password* ***do not forget it*, or you will be unable to change the unit's access rights.*

4. SA-PCR PRO.11 PC CARD INSTALLATION, SETUP, AND MANAGEMENT

The SA-PCR Card brings wireless connectivity to laptops and hand-held devices. The latest version of the Card looks and functions very differently from the previous version.

This chapter describes how to install the SA-PCR Card, and how to setup and manage the Card using the *SA-PCR Configuration* and *SA-PCR Site Survey* Windows applications.

4.1. Installing the SA-PCR Driver, and Applications

The following sections describe in detail:

- Checking the SA-PCR Package Contents.
- What to do before you install the SA-PCR.
- Installation Troubleshooting.
- Using the LED indicators to verify proper operation.
- Installing the SA-PCR applications.
- Uninstalling the SA-PCR drivers and applications.

4.1.1. Check Package Contents

The SA-PCR PRO.11 package should contain:

- SA-PCR PRO.11 PC Card.
- Drivers diskette and applications diskette.
- Quick Installation and Operation Guide.

4.1.2. Before You Begin

Before installing, do the following:

- Verify that the AP unit with which the SA-PCR unit will work is an AP-10 PRO.11. The SA-PCR PRO.11 will work only with an AP-10 PRO.11 unit.
- It is advisable to turn on the AP before installing the SA-PCR, thereby enabling you to use the SA-PCR LEDs to check the status of the SA-PCR when installation is complete. See section 4.1.4 for explanation of the LEDs.
- Uninstall any previous versions of the drivers or applications (refer to section 4.1.8). You can check the version of the current installation by viewing the *Maintenance* tab of the Configuration application.
- When installing on Windows 95/98, verify that you have the Windows CD with you, or that the Windows CAB files are installed on your local hard disk in a directory whose name does not exceed 8 letters. When the CAB files are on the disk, they are usually found in `C:\Windows\Options\Cabs`.
- When installing on Windows NT, verify that you have the Windows NT CD with you, or that the Windows NT distribution files are installed on your local hard disk. During installation, enter the path of the distribution files whenever a message appears asking for them.

4.1.3. Installing SA-PCR Drivers

The procedure for installing the SA-PCR drivers depends on your operating system:

- For Windows 95, refer to section 4.1.3.1.
- For Windows 98, refer to section 4.1.3.2.
- For Windows NT, refer to section 4.1.3.3.

4.1.3.1 Installation for Windows 95

- Check which version of Windows 95 is running on your machine as follows:

  1. Go to the Windows 95 desktop, right-click the *My Computer* icon, and select *Properties*. The *System Properties* window opens.

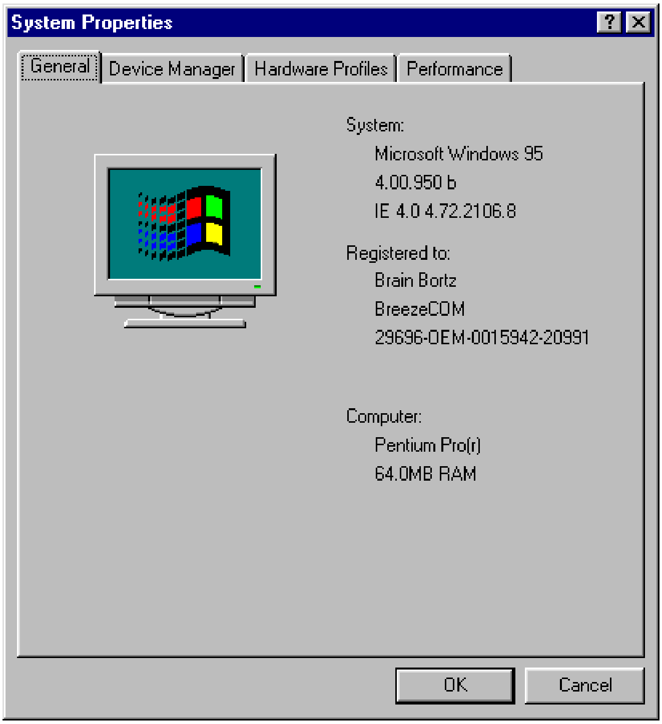


Figure 4.1: System Properties Window – Windows 95B

  2. Go to the *General* tab and look under the *System* heading. If the phrase 4.00.950**b** appears, then you are using Windows 95B, otherwise it is Windows 95A.

  3. In case of Windows 95A, continue with section 4.1.3.1.1. In case of Windows 95B, continue with section 4.1.3.1.2.

4.1.3.1.1 Installation for Windows 95A

Þ ***To install on Windows 95A, do the following:***

1. Insert the SA-PCR slot in the PCMCIA slot on your computer. Windows 95 detects the unit and displays the *New Hardware Found* window.

Figure 4.2: New Hardware Found Window

2. Select the *Driver from disk provided by hardware manufacturer* option and press **OK**.

3. When prompted for the location of the driver, insert the *BreezeCOM drivers diskette* and type **`A:\`** and press **OK**. The necessary files are copied from the diskette.

4. When the *Please insert disk labeled Windows 95 CD-ROM* appears, insert the Windows 95 CD and press **OK**. If the Windows 95 CAB files are located on your local hard disk, you can point to that location (usually found at `\Windows\Options\Cabs`).

5. If this is the first time a network card has been installed on this machine, a network setup window may appear. It is not necessary to fill out this window for the purposes of this installation.

6. Restart the computer.

7. Continue with section 4.1.4.

4.1.3.1.2 Installation for Windows 95B

Þ ***To install on Windows 95B, do the following:***

1. Insert the SA-PCR slot in the PCMCIA slot on your computer. Windows 95 detects the unit, briefly displays the *New Hardware Found* window, and then displays the *Update Device Driver Wizard* window.
2. Insert the *BreezeCOM drivers diskette* and press **Next**. When Windows 95 notifies it has found the driver, press **Finish**.
3. If the Windows 95 CAB files are not found automatically, the message *Please insert disk labeled Windows 95 CD-ROM* appears. Press **OK**.
4. If the file BRZCOM.VXD is not found, direct the window to `A:\` and press **OK**.
5. If no other windows appear, the installation is complete. If the *Please insert disk labeled Windows 95 CD-ROM* appears, press **OK**, enter the path of the Windows 95 CAB files, and press OK. Installation is now complete.
6. Restart the computer.
7. Continue with section 4.1.4.

4.1.3.2 Installation for Windows 98

⇒ ***To install on Windows 98, do the following:***

1. Insert the SA-PCR slot in the PCMCIA slot on your computer. Windows detects the unit and displays the *New Hardware Found* window.
2. When the *Add New Hardware Wizard* window appears, press **Next**.
3. Select the *Search for best driver* option and press **Next**.
4. Insert the *BreezeCOM drivers diskette*, select the *Floppy disk drives* option, and press **Next**.
5. The installation wizard notifies you that the driver for the BreezeCOM PCMCIA Wireless LAN Adapter has been located. Press **Next**.
6. A window appears notifying you that the driver for the BreezeCOM Wireless LAN Adapter has been installed. Press **Finish**.
7. Restart the computer.
8. Continue with section 4.1.4.

4.1.3.3 Installation for Windows NT

Þ ***To install on Windows NT, do the following:***

1. Press the Windows **Start** button, select *Settings*, and then select *Control Panel*. Double-click on the *Network* icon.

2. If the message *The Windows NT Networking is not installed. Do you want to install it now?*, continue with step 2a. If this message does not appear, continue with step 2b.

   a. Press **Yes** and choose *Wired to the network*. When a list of supported network adapters appears, press **Have Disk**.

   b. Go to the *Adapters* tab, press **Add**, and then press **Have Disk**.

3. Insert the *BreezeCOM drivers diskette*, enter the location of the diskette (such as *a:*\) and press **OK**.

4. From the list choose *BreezeNET Wireless LAN PC Card* and press **OK**. The *SA-PCR LAN Adapter Properties* window appears.

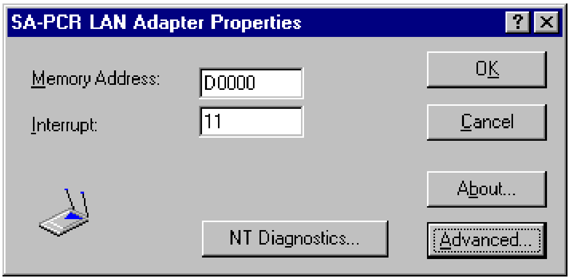


Figure 4.3: SA-PCR LAN Adapter Properties Window

5. The default settings are memory range D0000h to D3FFFh, IRQ 11. In the following steps we will verify that these default settings are acceptable for your machine.

Note: *If the SA-PCR Configuration application is already installed, you can access it directly by pressing* ***Advanced****.*

6. Press the Windows **Start** button and select *Run*. Type *WINMSD* and press **OK**. The *Windows NT Diagnostics* window appears.

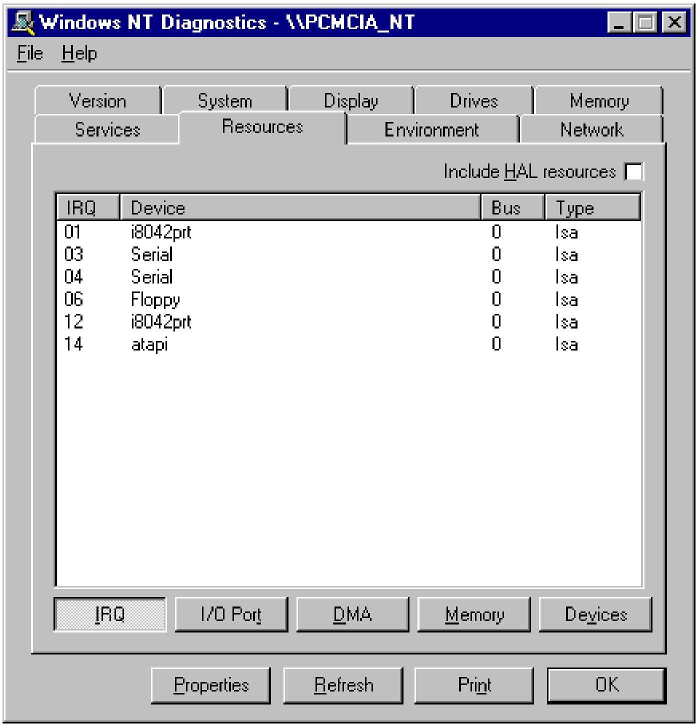


Figure 4.4: Windows NT Diagnostics Window

7. Press **IRQ** and verify that IRQ 11 is not taken. If it is, find an IRQ that is not taken. For example, in the illustration IRQ 2 is not taken.

8. Press **Memory** and verify that memory from D0000h to D3FFFh is not taken. If it is, find another free memory location, such as E0000h.

9. Return to the *SA-PCR LAN Adapter Properties* window (refer to Figure 4.3). If the default values for *Memory Address* and *Interrupt* are acceptable, press **OK**. Otherwise, enter new values and press **OK**.

10. Press **Close** to close each installation window.

11. If configuration windows for other network components (such as *Protocol*) appear, fill them in according to the instructions of your network administrator.

12. Restart Windows NT.

13. Continue with section 4.1.4.

4.1.4. Checking the LED Indicators

Verify proper operation of the SA-PCR using the LED indicators:

Color	Description	Meaning
Yellow	Link Status	Blink – Scanning Solid –Associated
Green	Data Traffic	Blink – According to traffic

The LED indicators are useful only if there is an activated AP in the area.

4.1.5. Installing the Applications

If the SA-PCR applications have been previously installed, uninstall them before reinstalling (refer to section 4.1.8).

⇒ ***To install the SA-PCR applications:***

1. Insert the BreezeCOM application diskette.
2. Press the Windows **Start** button and select *Run*. Type A:\setup and press **OK**.
3. In the *Choose the Destination Location* window, choose a location for the installation, and press **Next**.
4. When the *Setup Complete* window appears, press **Finish**. Icons for the applications are added to the *Windows Programs* menu, and a SA-PCR Configuration icon is added in the Control Panel.

4.1.6. Initial Configuration

If your wireless network uses a non-default ESSID, enter the proper ESSID as follows:

1. **Start the *SA-PCR Configuration* application.**
   Press the Windows *Start* button, select *Program*, select *BreezeCOM*, and then select *Configuration*.
2. **Edit the ESSID parameter.**
   Go to the *WLAN Paramters* tab and enter the ESSID that matches the AP unit.
3. **Restart the computer.**

4.1.7. Troubleshooting Tips

This section provides hints regarding troubleshooting installation:

- **Check for conflicting resources** – Press the Windows *Start* button, select *Settings*, and then select *Control Panel*. Double-click on the *Network* icon and go to the *Adapters* tab. An exclamation point next to the WLAN card indicates a conflict with another driver or device.

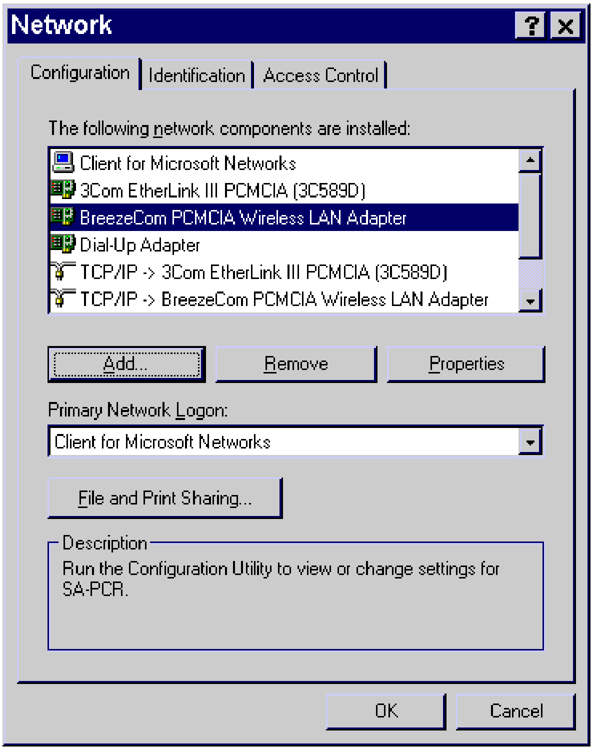


Figure 4.5: Network Window

- **Check `autoexec.bat` and `config.sys`** – Look for device drivers or lines containing device or call commands in the `autoexec.bat` or the `config.sys` files.

- **Try to resolve resource conflicts by editing Windows parameters** – Go to the Windows desktop, right-click the *My Computer* icon, and select *Properties*. Go to the *Device Manager* tab, select *Network Adapters*, press *Properties*, and go to the *Resources* tab. Edit the *Memory Range* and *Interrupt* parameters.

- **Reinstall** – After disabling conflicting resources, reinstall the SA-PCR.

4.1.8. Uninstalling SA-PCR Drivers and Applications

This section describes how to uninstall the SA-PCR drivers, and the SA-PCR applications.

Þ ***To uninstall SA-PCR drivers:***

If your operating system is Windows 95, you must first do the following:

1. Press the Windows **Start** button, select *Settings*, and then Select *Control Panel*. Double click on the *PC Card icon*, select *BreezeCOM Wireless LAN PC Card* and press **Stop**. Close all active applications. Continue below.

If your operating system is Windows 98 or NT, start here.

1. Press the Windows *Start* button, select *Settings*, and then select *Control Panel*. Double click on the *Network* icon, go to the *Configuration* tab, select *BreezeCOM Wireless LAN Adapter*, and press **Remove**.
2. When asked to restart the computer, press **No**.
3. Insert the *BreezeCOM Drivers diskette*. Press the Windows *Start* button, select *Run*, and type **`a:\DrvClean`**.
4. When notified that the SA-PCR driver has been deleted, press **Setup**.
5. Restart the computer.

Þ ***To uninstall SA-PCR applications:***

1. Press the Windows *Start* button, select *Settings*, and then select *Control Panel*. Double click on the *Add/Remove Programs* icon, select *BreezeCOM PCMCIA Applications* and press **Add/Remove**.

4.2. Using the SA-PCR Configuration Application

This section describes how to use the SA-PCR Configuration application to configure and manage your SA-PCR Card.

4.2.1. Accessing the Application

Open the SA-PCR Configuration application as follows:

- Press the *Start* button, select *Programs*, select the *BreezeCOM Application* program group and choose *Configuration*.

The SA-PCR Configuration main window opens.

4.2.2. Main Window

The SA-PCR Configuration main window contains four tabs described in the following sections. In addition, the main window contains the following buttons:

- **OK –** Implements any changes you made and closes the window.
- **Undo** – Causes the window to display currently active values. This is useful if you started changing values and you want to start again from the current values.
- **Cancel** – Closes the window without implementing any changes you made.
- **Apply** – Implements any changes you made but leaves the window open.

4.2.3. Resetting the PC Card

Þ ***To reset the Card, close the Configuration and Site Survey applications and then do one of the following:***

- Restart the computer, or
- Stop the PC card then eject and reinsert the Card, or

- Stop and refresh the driver as follows:
  - Right-click the *My Computer* icon on the desktop, choose *Properties*, and go to the *Device Manager* tab.
  - Select *Network Adapters*, select *BreezeCOM WLAN Adapter*, and press *Refresh*.

4.2.4. Station Status Tab

The Station Status tab of the SA-PCR Configuration application displays basic information about the Card and its drivers and shows current Card status.

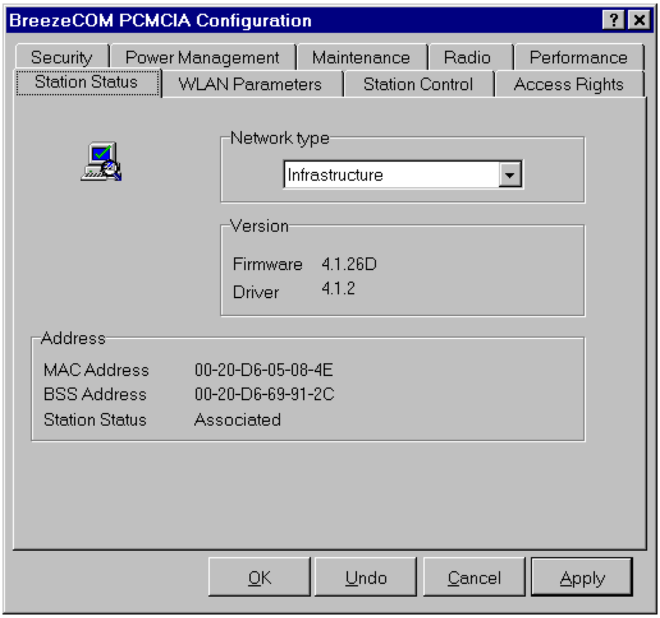


Figure 4.6: Station Status Tab

The Station Status tab contains the following parameters:

- **Firmware Version –** Displays the version of unit's current firmware (internally installed software). The first two numbers of the firmware and driver versions should be identical. The remaining numbers (if any) indicate the minor version. The final letter indicates the hardware version.
- **Driver Version –** Displays the version of unit's current driver.

- **MAC Address** – Displays the unit's unique IEEE MAC address.
- **AP Address –** The MAC address of the AP with which the unit is currently associated.
- **Station Status –** Current status of the unit. There are three options:
    - *Scanning* - The unit is searching for an AP with which to associate.
    - *Associated* – The unit is associated with an AP and has adopted the attached PC MAC address.
- **Network Type –** This value of this parameter should be *infrastructure*.

Note: *Parameter changes take effect only after reset (refer to section 4.2.3, Resetting the PC Card).*

4.2.5. WLAN Parameters Tab

The WLAN Parameters tab of the SA-PCR Configuration application lets you view and edit basic Wireless LAN parameters of the Card.

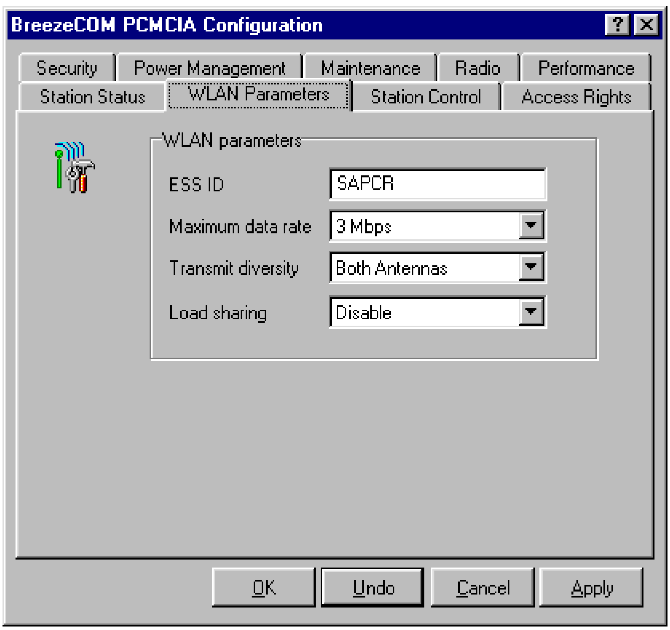


Figure 4.7: WLAN Parameters Tab

The WLAN Parameters tab contains the following parameters:

- **ESSID –** An ASCII string of up to 32 characters used to identify a WLAN that prevents the unintentional merging of two co-located WLANs. It is essential that the ESSID is set to the same value in all stations and Access Points in the extended WLAN.

Note: *The ESSID is case-sensitive.*

- **Maximum Data Rate –** By default, the unit adaptively selects the highest possible rate for transmission. Under certain conditions (for range/speed trade-off) you may decide not to use the higher rates. Possible values are 1, 2, or 3 Mbps.
- **Transmit Diversity –** By default, the unit dynamically selects the antenna where reception and transmission is optimal. If your model has an external antenna and uses only a single antenna, set Transmit Diversity to transmit only from that single antenna. Antenna number one is the antenna nearest the yellow LED.
- **Load Sharing –** When installing a Wireless LAN network in a high-traffic environment, you can increase the aggregate throughput by installing multiple APs to create co-located cells. Enable Load Sharing to cause your stations to equally divide their traffic between the available APs.

Note: *Parameter changes take effect only after reset (refer to section 4.2.3, Resetting the PC Card).*

4.2.6. Station Control Tab

The Station Control tab of the SA-PCR Configuration application allows you to return the Card to default configuration values, and export/import configuration files.

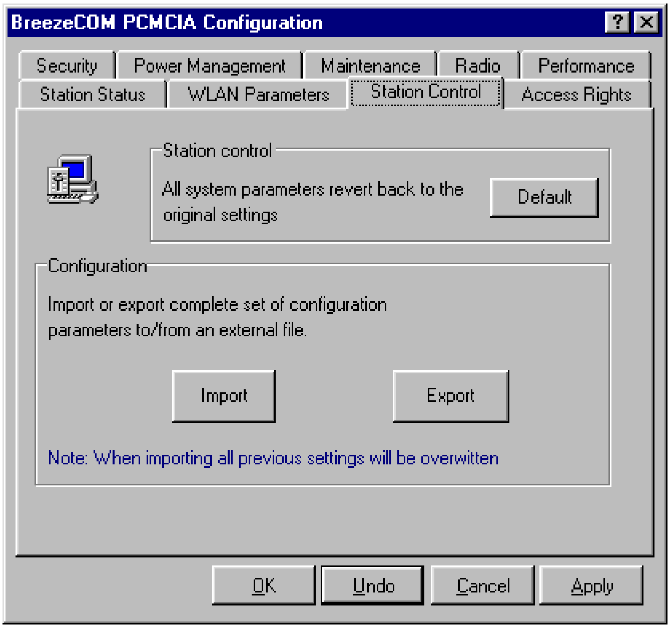


Figure 4.8: Station Control Tab

The Station Control tab contains the **Default** button which returns all parameters to factory default values.

To ease configuration of several units, you can configure one unit and then save the configuration as a file (with a .BRZ extension). You can later import the configuration file to other units.

- **Import –** Imports a configuration file to this unit, and overwrites all previous settings.
- **Export –** Exports the current configuration of this unit to a file.

Note: *Parameter changes take effect only after reset (refer to section 4.2.3, Resetting the PC Card).*

4.2.7. Access Rights Tab

The Access Rights tab of the SA-PCR Configuration application lets you login to the Card as User, Installer, or Technician, and lets you change the password.

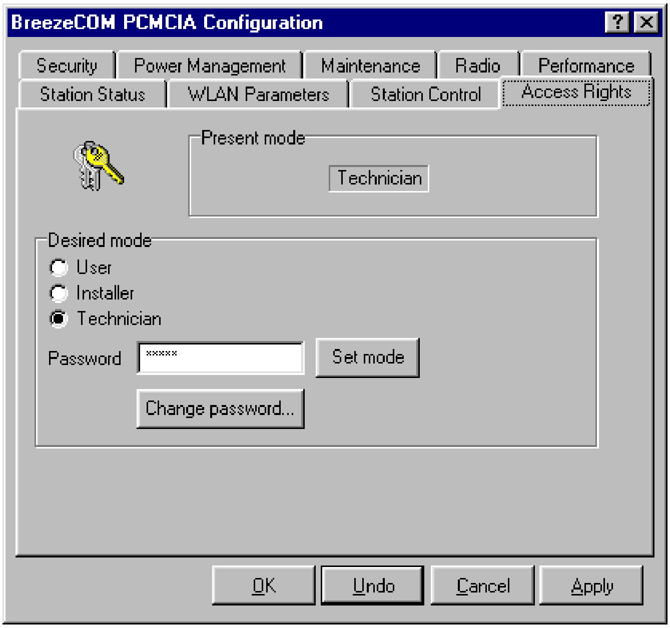


Figure 4.9: Access Rights Tab

The Access Rights tab displays the current mode (User, Installer, or Technician) in the **Present Mode** box. This mode determines the extent of access to system parameters. Users can view some of the window tabs, but cannot modify parameters. Installers can view all of the tabs and can modify some of the values. Technician access rights are reserved for Certified BreezeCOM Technicians.

When the Configuration application opens, it will begin at the same mode that was active when it closed. If security is an issue, change the access mode to User before you close the application. The first time the application is opened, it is set to Installer access mode.

The default password for Installer mode is *User*. If security is an issue, change the Installer password.

Þ ***To change the Access Rights mode:***

1. Select the radio button next to the desired mode.
2. Type in the password. No password is necessary to lower the access right level.
3. Press **Set mode**. The name of the new mode appears in the Present Mode box.

Þ ***To change the password for Installer Access Rights mode:***

1. Look at the Present Mode box to verify that you are in Installer mode.
2. Press **Change Password**.
3. In the Change Password dialog box, type in the new password twice and press OK.

   The password has changed.

***Important**: If you change the Installer password **do not forget it**, or you will be unable to change the unit's access rights.*

4.2.8. Power Management Tab

***Note**: The Power Management tab is not yet implemented.*

The Power Management tab of the SA-PCR Configuration application allows you to enable/disable power management mode, and to fine tune the power management mode parameters.

This tab is not visible when in *User* login mode. When in *Installer* login mode, you can see the parameters. When in *Technician* login mode, can edit the parameters.

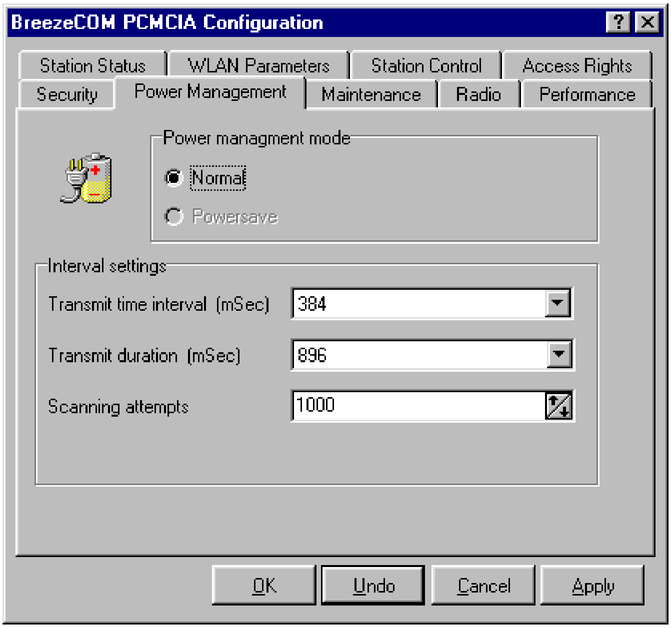


Figure 4.10: Power Management Tab

The Power Management tab contains the following parameters:

- **Power Management Mode** – *Powersave* mode enables WLAN units (such as laptops or hand-held devices) to conserve battery power. To enable this feature you must also enable power saving for the AP.

When power management mode is enabled, the unit “sleeps” most of the time, and “wakes up” occasionally to transmit to the AP. The *Interval Settings* parameters affect the power management algorithm:

- **Transmit Time Interval (msec) –** At what intervals the unit "wakes up".
- **Transmit Duration (msec)** – How long the unit remains "awake".
- **Scanning Attempts –** How many times the "awake" unit cycles through the frequencies, before "going back to sleep".

4.2.9. Maintenance Tab

The Maintenance tab of the SA-PCR Configuration application allows you to cause the unit to verify firmware/driver compatibility, and set how the unit handles 802.3 packets.

This tab is not visible when in *User* login mode. When in *Installer* login mode, you can see the parameters. When in *Technician* login mode, can edit the parameters.

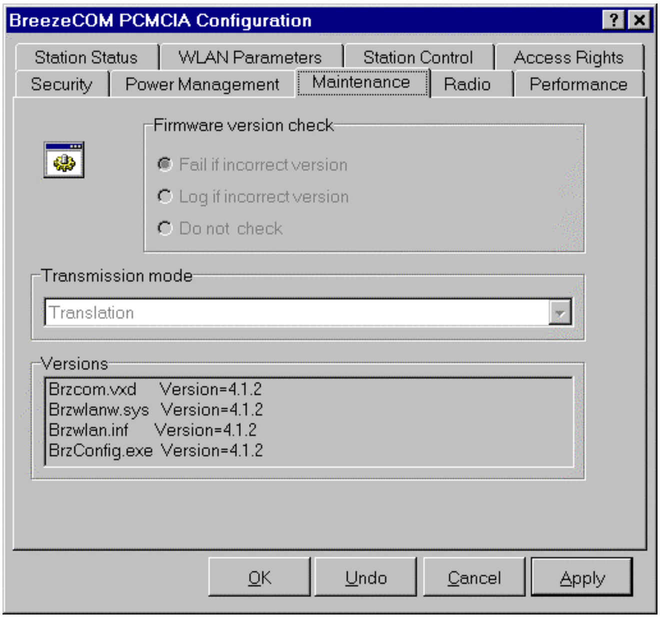


Figure 4.11: Maintenance Tab

The Maintenance tab contains the following parameters:

- **Firmware Version Check –** Whether the unit checks compatibility of current firmware version to current drivers, and what to do if they are incompatible. Detailed information about the versions appears at the bottom of the window.

- **Transmission Mode –** This parameter cannot be modified by the Installer.
- **Versions –** Windows drivers are divided into three files: Brzcom.vxd, Brzwlanw.sys, and Brzwlan.inf. The version number of all these files must be identical. control information of these files is displayed.

  The Configuration application file is called BrzConfig.exe. The first two numbers of the application version must match the first two numbers of the drivers.

4.2.10. Radio Tab

The Radio tab of the SA-PCR Configuration application allows you to set the power level of the unit and choose a hopping standard.

This tab is not visible when in *User* login mode. When in *Installer* login mode, you can see the parameters. When in *Technician* login mode, can edit the parameters.

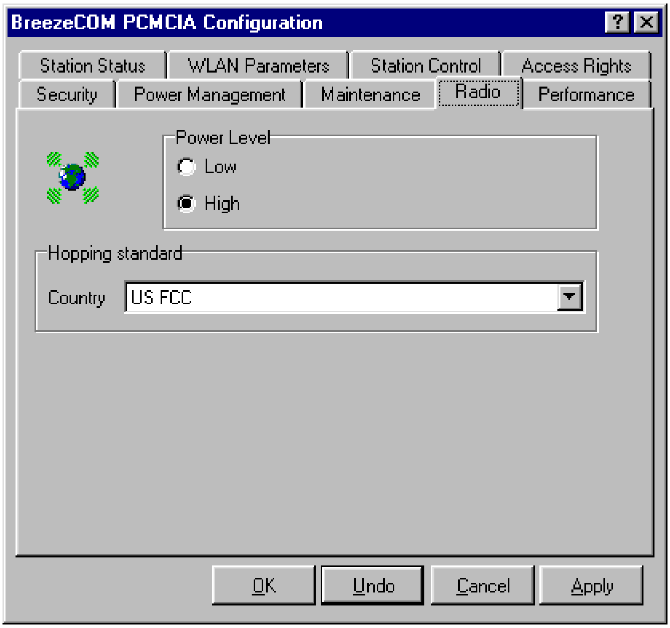


Figure 4.12: Radio Tab

The Radio tab contains the following parameters:

- **Power Level –** Level of power at which the unit is operating. There are two possibilities, Low or High.

- **Hopping Standard –** The *Hopping Standard* is a set of rules regarding the radio transmission standard allowed in each country. Units will work together only if set to the same hopping standard. Use this parameter to set the unit's hopping standard to that of the relevant country.

4.2.11. Performance Tab

The Performance tab of the SA-PCR Configuration application allows you to fine-tune performance and roaming parameters.

This tab is not visible when in *User* login mode. When in *Installer* login mode, you can see the parameters. When in *Technician* login mode, can edit the parameters. Only major parameters are described below.

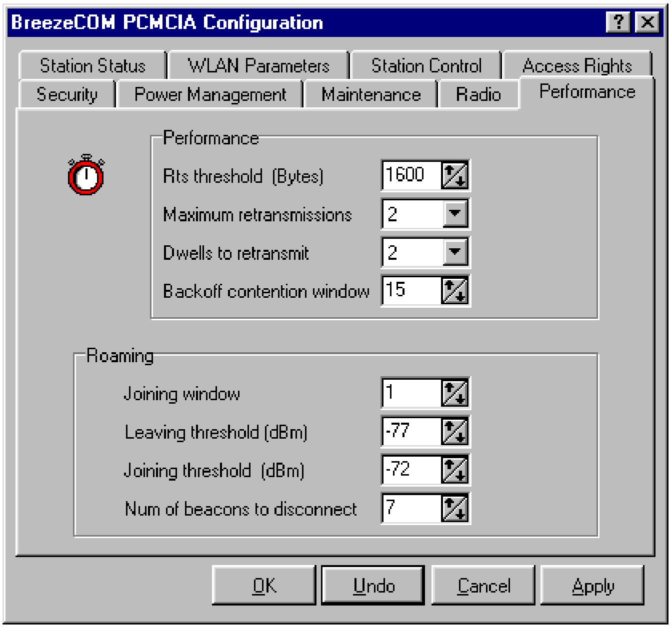


Figure 4.13: Performance Tab

The Performance tab contains the following important parameter:

- **Rts threshold (bytes) –** Minimum packet size to require an RTS (Request To Send). For packets smaller than this threshold, an RTS is not sent and the packet is transmitted directly to the WLAN. If your wireless network has more than 7 stations (all SA-PCRs, or a mix of SA-PCRs and SA-10/40s), set the RTS Threshold to 1600.

4.3. Using the SA-PCR Site Survey Application

This section describes how to use the SA-PCR Site Survey application to manage your SA-PCR Card. The Site Survey application keeps you informed of the signal strength your unit is receiving.

You can run a Site Survey to compare reception at various locations. This is extremely useful when first setting up the wireless LAN, since you can easily determine where reception is good or bad, and where many Access Points overlap.

The following sections describe how to access the Site Survey application, how to read the main Site Survey window, and how to perform a site survey.

4.3.1. Accessing the SA-PCR Site Survey Application

Open the SA-PCR Site Survey application as follows:

- Press the *Start* button, select *Programs*, select the *BreezeCOM Application* program group and choose *Site Survey*.

The SA-PCR Configuration main window opens.

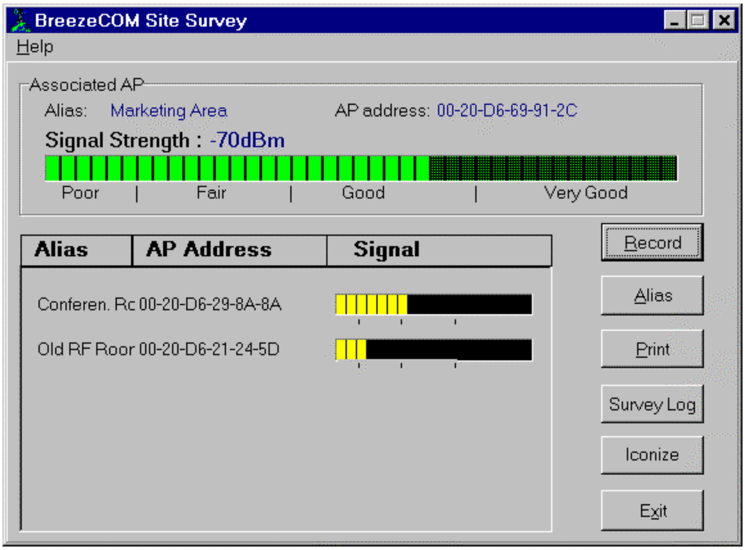


Figure 4.14: SA-PCR Site Survey

4.3.2. SA-PCR Site Survey Main Window

The Site Survey main window contains the following sections:

- **Associated AP** – This section, located at the top of the window, displays various parameters regarding the Access Point with which the unit is currently associated.
    - *Alias* – The alias you have assigned to the AP that the SA-PCR is currently associated with. To assign aliases to AP units, press the Alias button. If no alias has been assigned to the AP, this field displays “no alias”.
    - *AP Address* – The IEEE MAC address of the AP.

- *Signal Strength* – The strength of the signal from the AP in dBm. The table below maps the signal strength indicators to dBm ranges:

Signal	*Poor*	*Fair*	*Good*	*Very Good*
dBm	less than -74	-74 to -69	-68 to -61	greater than -61

- *Signal Bar* – The signal bar is a graphical representation of the signal strength. The longer the bar, the stronger the signal. As signal strength drops, the bar changes from green, to yellow, to red

- **Neighbor APs** – This section, located at the bottom of the window, displays nearby APs (up to 4)from which the station is receiving a signal. For each AP, the following parameters are displayed:
  - *Alias* – The alias you have assigned to the AP. To assign aliases to AP units, press the Alias button. If no alias has been assigned to the AP, this field displays “no alias”.
  - *AP Address* – The IEEE MAC address of the AP.
  - *Signal* – A miniature signal bar indicating the current signal strength from the AP. When you hold the cursor over the line, the exact value appears.

- **Buttons** – The following buttons appear on the right side of the Site Survey window. Several of the buttons are used in the course of performing a Site Survey as described in section 4.3.3:
  - *Record* – Records the signal strength of the current location in the Survey Log, as well as all neighboring APs. In the Record window, you can add the name of the location and a remark. You can view the Survey Log by pressing **Survey Log**.
  - *Alias* – Lets you assign alias names to APs. In the Alias window, enter the AP address and the desired alias. For convenience, you can drag and drop the address of the associated AP from the main window into the Alias window. For neighbor APs, you should use Ctrl-C to copy the AP Address from the main window.
  - *Print* – Opens a Site Survey report showing the information in the Survey Log, including neighbor APs. You can print the file by pressing the Printer button, or save the file by pressing the Diskette button. You can save the file as text, or as a QRP file viewable using this application.

- *Survey Log* – Opens the Survey Log at the bottom of the main window. The Survey Log displays the information recorded using the **Record** button. Press **Clear Log** to clear the Survey Log. Press **Delete Last** to delete the last recorded reading.

Survey Location	Associated AP	Signal	Remark
Here	AP#13	112	With Anteenas
There	AP#13	203	With Anteenas
Near by	AP#13	85	without antennas

Figure 4.15: Survey Log

- *Iconize* – Closes the Site Survey window and opens the *Connection Quality Graph* that indicates current signal strength of the associated AP at a glance. The Graph can be moved anywhere on the screen, and will always appear on top of other applications. Hold the cursor over the **X** to see the signal strength in units. Press the **X** to close the Graph and open the Site Survey window.

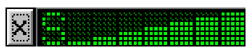


Figure 4.16: Connection Quality Graph

4.3.3. Performing a Site Survey with the SA-PCR

You can run a Site Survey to compare reception at various locations. This is extremely useful when first setting up the wireless LAN, since you can easily determine where reception is good or bad, and where many Access Points overlap.

Þ ***To run a Site Survey:***

1. Open the Site Survey application.
2. Press **Survey Log** to expand the bottom of the Site Survey window.
3. Bring the station to a new location.
4. Press **Record**. Type in the name of the location and a remark, and press OK. The signal details of the current location appear in the Survey Log at the bottom of the window.
5. Repeat steps 2 and 3 with other locations. The recorded readings should give you a good idea of where reception is good or bad, and where many APs overlap unnecessarily.
6. When you are done recording, press **Print**. A site survey report appears containing information about each recorded location including signal strength of associated AP and of neighbor APs. You can print the file by pressing the Print button, or save the file by pressing the Diskette button. You can save the file as text, or as a QRP file viewable using this application only.

5. PLANNING AND INSTALLING WIRELESS LANS

All products in the ***BreezeNET PRO.11 Series*** are available in several models: standard, “D”, and “DE”. The standard model is equipped with two integrated 2 dBi omni-directional antennas and is suitable for indoor, short-to-medium range installations. The “D” and “DE” models are equipped with two customized female connectors for use with a range of external antennas.

This chapter describes various possible system configurations, lists points to consider when performing indoor and outdoor installations, presents guidelines and restrictions regarding external antenna installation, and also describes some antennas that work well with ***BreezeNET PRO.11*** units.

5.1. System Configurations

This chapter describes various wireless LAN configurations, and how to set them up:

- **Single Cell Configuration** – The wireless LAN consists of an Access Point and the wireless workstations associated with it.
- **Overlapping Cell Configuration –** The wireless LAN consists of two or more adjacent Access Points whose coverage slightly overlaps.
- **Multicell Configuration** – The wireless LAN consists of several Access Points installed in the same location. This creates a common coverage area that increases aggregate throughput.
- **Multi-Hop Configuration –** The wireless LAN contains AP-WB pairs that extend the range of the wireless LAN.

Many wireless LANs contain several of these configurations at different points in system. The Single Cell configurations is the most basic, and the other configurations build upon it.

5.1.1. Single Cell Configuration

A basic ***BreezeNET*** *cell* consists of an Access Point and the wireless workstations associated with it. You can convert most workstations (PCs, X-Terminals, Apple, Digital, SUN, HP, IBM and others) that are equipped with an Ethernet network interface card (NIC) to wireless workstations simply by connecting a ***BreezeNET*** SA-10 PRO.11 Station Adapter. You can convert most laptop computers with a PCMCIA slot into a wireless mobile station by using the SA-PCR PRO.11 PCMCIA Card.

There are three types of Single Cell Configuration:

- Point-to-Point
- Point-to-Multipoint
- Mobile Applications

Each type is explained in the following sections.

5.1.1.1 Point-to-Point

Point-to-Point installations (refer to Figure 5.1) require directional antennas at either end of the link. To select the best antenna for a specific application, consider the following factors:

- Distance between sites
- Required throughput
- Clearance between sites
- Cable length.

Refer to the range tables (section 5.3.7) to determine the best combination of antennas for your application.

5.1.1.2 Point-to-Multipoint

Point-to-Multipoint applications consist of one or more APs at the central site and several remote stations and bridges (SA-10, SA-40, WB-10). In this case, use an Omni-6 antenna with the Access Point because of its 360° radiation pattern. In the United States, the Omni-7.2 antenna (which also has a 360° radiation pattern but has a wider range) can also be used. The

Omni-7.2 antenna comes with a 20ft. low loss cable and a mast mount bracket for rooftop installations.

The remote units should use directional antennas aimed in the direction of the AP's antenna(s).

5.1.1.3 Mobile Applications

In mobile applications, station orientation changes continuously. In order to maintain connectivity throughout the entire coverage area, most mobile applications require omni-directional antennas for both Access Points and wireless stations. In a motor vehicle, for example, you can install an SA-10 in the cabin, and mount the antennas (in most cases an Omni-6) on the roof.

5.1.1.4 Extending the LAN with WLAN Bridging

The figures below demonstrate how the WB-10 can be used to extend a regular network with a wireless link.

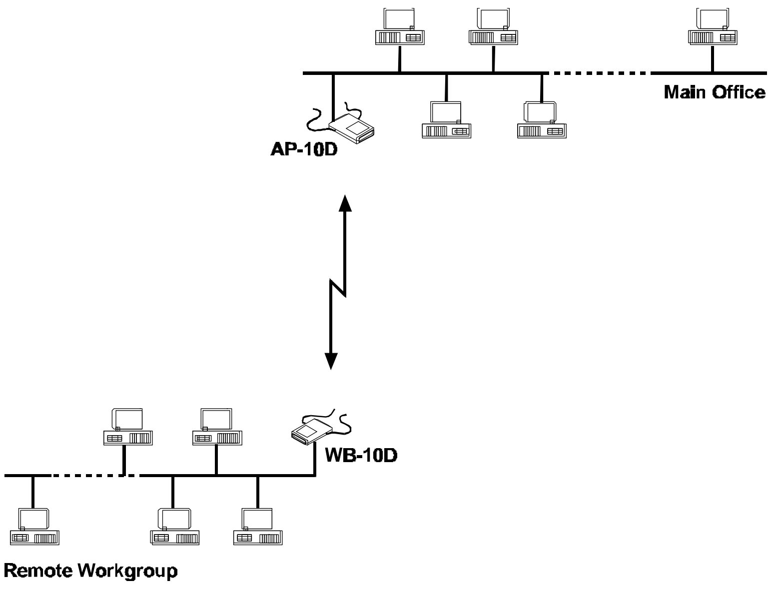


Figure 5.1: Connecting Remote Offices to Main Office Network

The WB-10 PRO.11 also enables connectivity between a wireless LAN and individual workstations or workgroups located outside the LAN. The WB-10 PRO.11 enables these wireless stations in its coverage area to communicate with the wireless LAN and gain access to all of the network resources such as file servers, printers and shared databases.

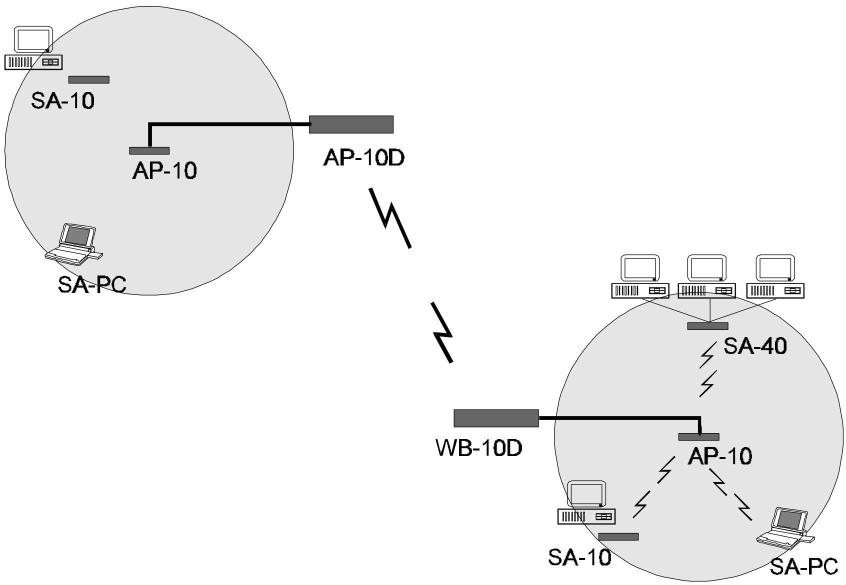


Figure 5.2:   Wireless Bridging Between Two or More Wireless LAN Segments

5.1.1.5 Setting Up a Single BreezeNET Cell

Þ ***To set up a single BreezeNET cell:***

1. Install the Access Point (refer to section 2, *Basic Installation*). Be sure to position the Access Point as high as possible.

Note: *It is not necessary at this point to connect the Access Point to an Ethernet backbone, since Access Points continuously transmit signals (beacon frames) whether they are connected to an Ethernet backbone or not.*

2. Install a Station Adapter or SA-PCR Card (refer to section 2, *Basic Installation*).

3. Check the LED indicators of the front panel of the Station Adapter, or the Site Survey application of the SA-PCR Card to check signal strength.

4. Make any necessary adjustments, for example:

- Adjust the antennas
- Adjust the location of the Station Adapter
- Adjust the location of the Access Point

5. Proceed to setup the other workstations.

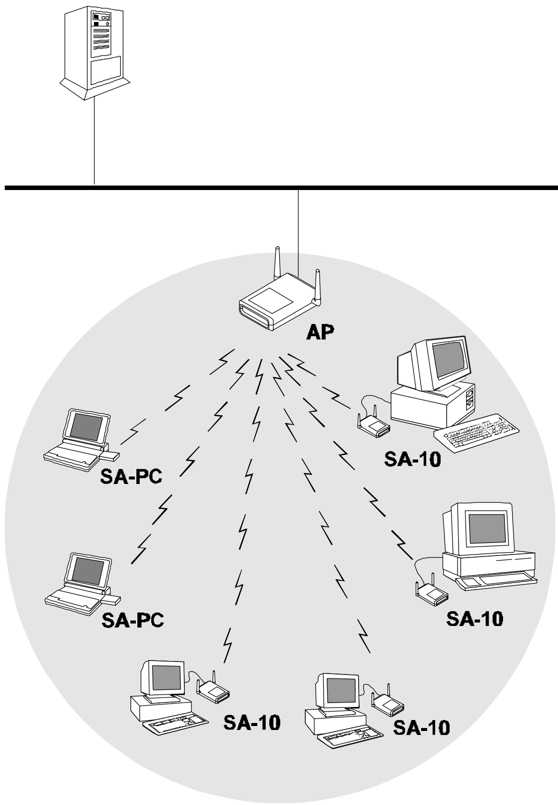


Figure 5.3: Single Cell Configuration

5.1.2. Overlapping Cell Configuration

When two adjacent Access Points are positioned close enough to each other, a part of the coverage area of Access Point #1 overlaps that of Access Point #2. This overlapping area has two very important attributes:

- Any workstation situated in the overlapping area can associate and communicate with either Access Point #1 or Access Point #2.
- Any workstation can move seamlessly through the overlapping coverage areas without losing its network connection. This attribute is called *Seamless Roaming*.

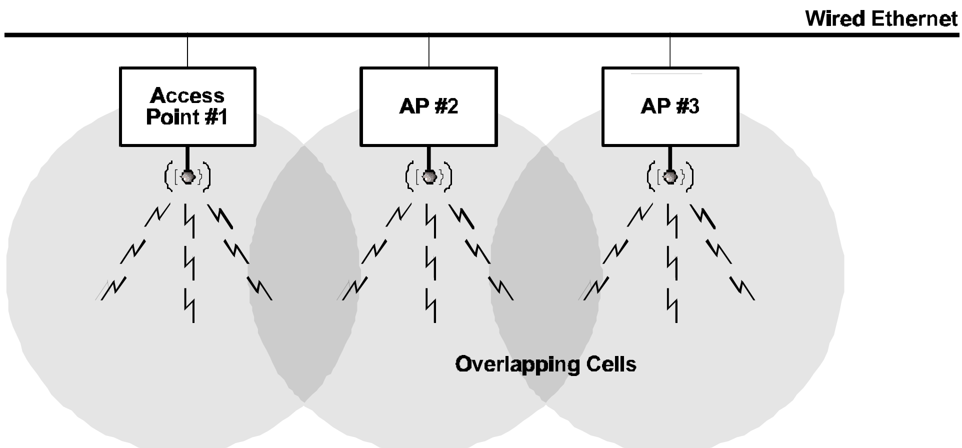


Figure 5.4: Three Overlapping Cells

Þ ***To set up overlapping BreezeNET cells:***

1. Install an Access Point (refer to section 2, *Basic Installation*). Be sure to position the Access Point as high as possible.
2. Install the second Access Point so that the two are positioned closer together than the prescribed distance (refer to section 5.2.4).
3. To allow roaming, configure all Access Points and stations adapters to the same ESSID.
4. To improve collocation and performance, configure all Access Points to different hopping sequences of the same hopping set.
5. Install a Station Adapter or SA-PCR Card on a workstation.

6. Position the wireless workstation approximately the same distance from the two Access Points.

7. Temporarily disconnect the **first** Access Point from the power supply. Verify radio signal reception from the first Access Point. View the LED indicators of the front panel of the Station Adapter, or the Site Survey application of the SA-PCR Card, to check signal strength of the first Access Point.

8. Disconnect the **second** Access Point from the power supply and re-connect the first Access Point. View the LED indicators of the front panel of the Station Adapter, or the Site Survey application of the SA-PCR Card, to check signal strength of the second Access Point.

7. If necessary, adjust the distance between the Access Points so the coverage areas overlap.

8. Continue setting up overlapping cells until the required area is covered.

Note: *It is not necessary at this point to connect the Access Points to an Ethernet backbone, since Access Points continuously transmit signals (beacon frames) whether they are connected to an Ethernet backbone or not.*

5.1.3. Multicell Configuration

Areas congested by many users and a heavy traffic load may require a multicell structure. In a multicell structure, several Access Points are installed in the same location. Each Access Point has the same coverage area, thereby creating a common coverage area that increases aggregate throughput. Any workstation in the overlapping area can associate and communicate with any Access Point covering that area.

Þ ***To set up a BreezeNET multicell:***

1. Calculate the number of Access Points needed as follows: Multiply the number of active users by the required throughput per user, and divide the result by 1.5Mbps (net throughput supported by collocated Access Points). Consider the example of 5 active stations, each requiring 0.5 Mbps throughput. The calculation is (5*.5)/1.5=1.6. Two Access Points should be used. This method is accurate only for the first few Access Points.

   The aggregate throughput of the common coverage area is equal to the number of co-located Access Points multiplied by the throughput of each individual Access Point, minus a certain amount of degradation caused by the interference among the different Access Points.

2. Install several Access Points in the same location a few meters from each other so they cover the same area. Be sure to position the Access Points as high as possible.

3. To allow roaming and redundancy, configure all Access Points and stations adapters to the same ESSID.

4. To improve collocation and performance, configure all Access Points to different hopping sequences of the same hopping set.

5. Install Station Adapters or SA-PCR Cards on workstations.

6. Make sure that the *Load Sharing* option is activated. Stations will automatically associate with an Access Point that is less loaded and provides better signal quality.

Note: *It is not necessary at this point to connect the Access Points to an Ethernet backbone, since Access Points continuously transmit signals (beacon frames) whether they are connected to an Ethernet backbone or not.*

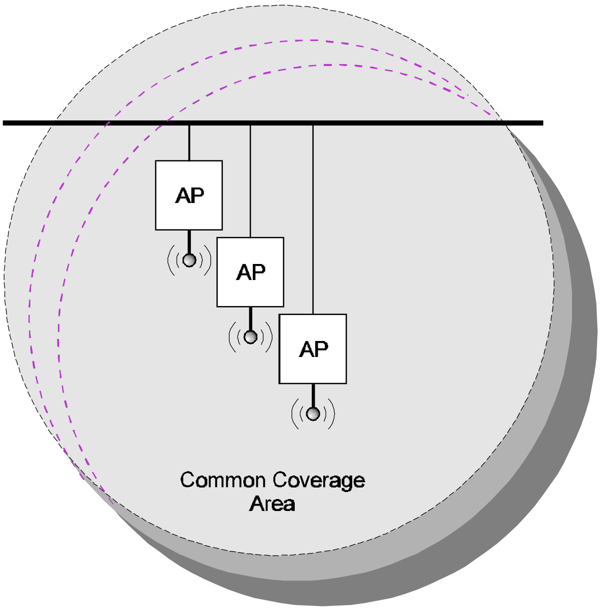


Figure 5.5: Multicell Configuration

5.1.4. Multi-hop Configuration (Relay)

When you want to connect two sites between which a line-of-sight does not exist, an AP-WB pair can be positioned at a third location where line-of-sight exists with each of the original locations. This third location then acts as a relay point.

In areas where a wired LAN backbone is not available, another AP can be added to the AP-WB relay to distribute a wireless backbone. In this way, the range of a wireless system can be extended.

System configuration is as follows:

Þ ***To set up a BreezeNET multi-hop cell:***

1. Install an AP at the main office (refer to section 2, *Basic Installation*).

2. Install a WB at the remote site (refer to section 2, *Basic Installation*).

3. Install an AP-WB pair in a high location that has a clear line of sight to both the main office and the remote site. Many AP-WB pairs can form a chain.

4. When an AP and WB communicate over the wireless LAN, set them both to the same ESSID. For example, set the AP of the main office and the WB of the first AP-WB relay pair to the same ESSID. Also, set the AP of the last AP-WB relay and the WB of the remote site to the same ESSID; this ESSID should be different from the first ESSID.

   Another option is to use one ESSID, and to set the *Preferred AP* parameter of each WB to its paired AP (refer to section 3.4.3). This option allows stations to roam between the sites.

5. As usual, make sure that the *hopping sequence* of the Access Points are different.

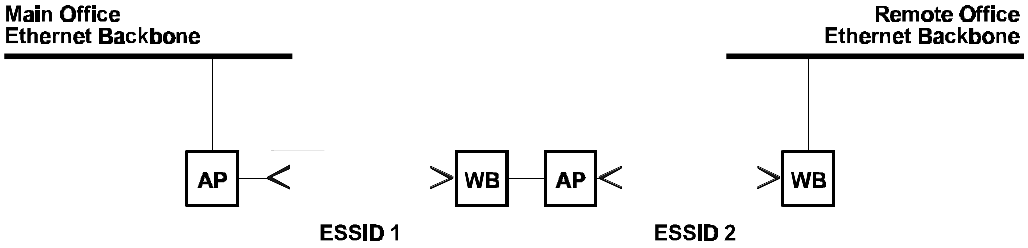


Figure 5.6: Multihop Configuration

6. If desired, an additional AP may be added at the main office and remote site, and between each AP-WB pair to provide wireless LANs at those points (see illustration).

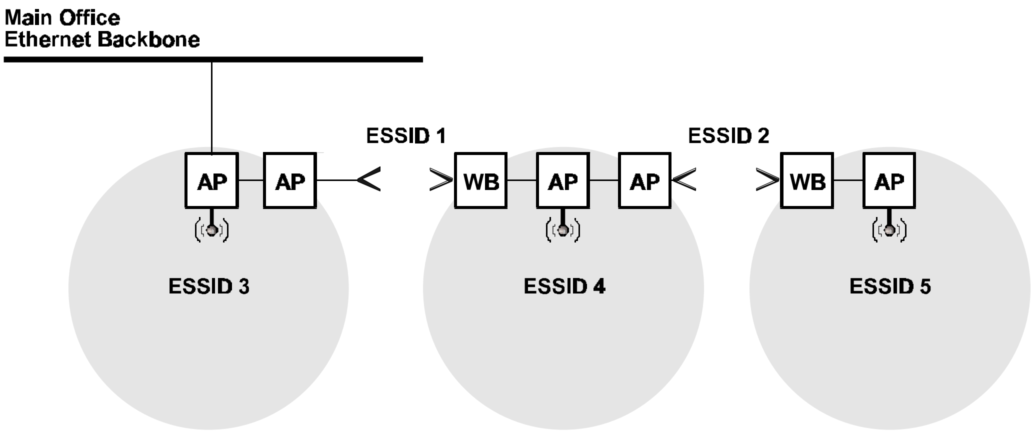


Figure 5.7: Advanced Multihop Configuration

7. Install Station Adapters or SA-PCR Cards on workstations (refer to section 2, *Basic Installation*).

5.2. Indoor Installation considerations

This chapter describes various considerations to take into account when planning an indoor installation including site selection, antenna diversity, antenna polarization, construction materials, and cell size.

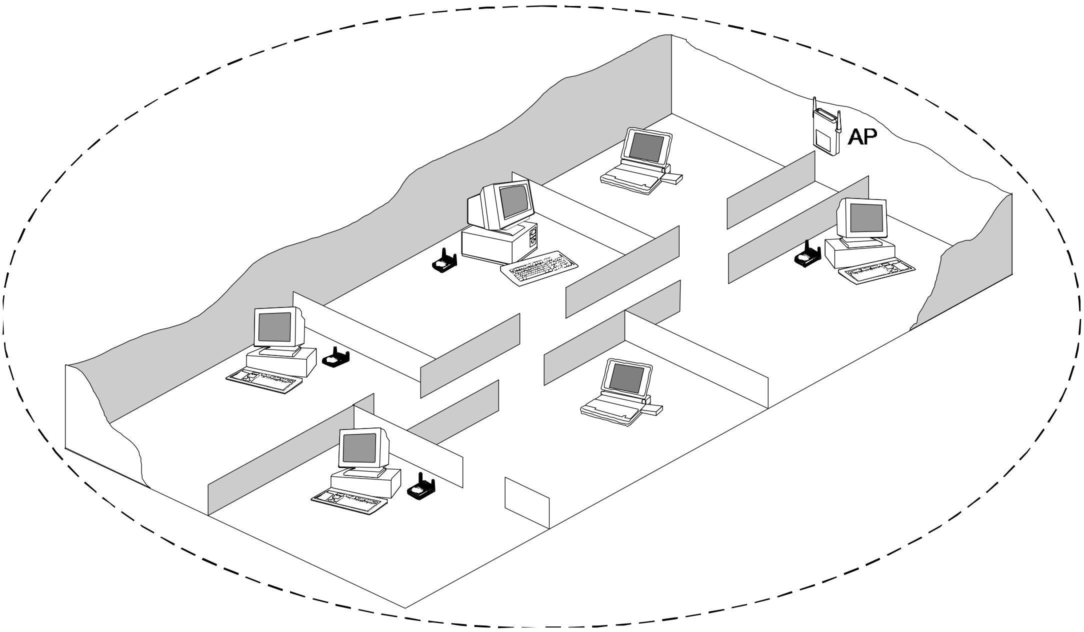


Figure 5.8: BreezeNET LAN in a typical office environment

5.2.1. Site Selection Factors

BreezeNET PRO.11 wireless LAN products are robust, trouble-free units, designed to operate efficiently under a wide range of conditions. The following guidelines are provided to help you position the units to ensure optimum coverage and operation of the wireless LAN.

Metal Furniture

Position the units clear of metal furniture and away from moving objects such as metal fans or doors.

Microwave Ovens

For best performance, position the units clear of radiation sources that emit in the 2.4 GHz frequency band, such as microwave ovens.

Antennas

Make sure the antennas are extended upward vertically in relation to the floor. For models with external antennas, connect the external antennas and RF cable.

Heat Sources

Keep the units well away from sources of heat, such as radiators, air-conditioners, etc.

5.2.1.1 Site Selection for Access Points

When positioning Access Points, take into account the following additional considerations.

Height

Install the Access Point at least 1.5m above the floor, clear of any high office partitions or tall pieces of furniture in the coverage area. The Access Point can be placed on a high shelf, or can be attached to the ceiling or a wall using a mounting bracket.

Central Location

Install the Access Point in a central location in the intended coverage area. Good positions are:

- In the center of a large room.
- In the center of a corridor.
- At the intersection of two corridors.

Many modern buildings have partitions constructed of metal or containing metal components. We recommend that you install the Access Points on the corridor ceilings. The radio waves propagated by the ***BreezeNET PRO.11*** LAN are reflected along the metal partitions and enter the offices through the doors or glass sections.

5.2.2. Antennas for Indoor applications

For most indoor applications, the best choice is the standard unit equipped with its integrated 2dBi antennas. The units are small, easy to install and cover a large area.

In some installations, it is required to install the unit and antenna separately. In such instances, use the AP-10D with the omni-6 antenna kit (6dbi omni-directional antenna with 3 meter RG-58 cable). In the USA (FCC regulated) and in non-regulated countries, the omni-6 comes with a shorter antenna cable, extending the coverage area.

The Uni-8.5 is also useful in indoor applications. It is very small and easily wall-mounted, but its radiation pattern is limited (75°).

BreezeCOM recommends that, for indoor applications, you use two antennas per unit to utilize the diversity gain of the system.

5.2.2.1 Antenna Diversity

In applications where no multipath propagation is expected, a single antenna is sufficient to ensure good performance levels. However, in cases where multipath propagation exists, BreezeCOM recommends that two antennas be used. This takes advantage of space diversity capabilities. By using two antennas per unit, the system can select the best antenna on a per-packet basis (every several milliseconds).

Multipath propagation is to be expected when there are potential reflectors between the main and remote sites. These reflectors may be buildings or moving objects such as airplanes and motor vehicles. If this is the case, the radio signal does not travel in a straight line, but is reflected or deflected off of the object, creating multiple propagation paths.

When installing a single antenna, modify the *transmit diversity* option to either antenna 1 or antenna 2, according to the antenna being used (refer to section 3.4.3).

5.2.2.2 Antenna Polarization

Antenna polarization must be the same at either end of the link. In most applications, the preferred orientation is vertical polarization. Above-ground propagation of the signal is better when it is polarized vertically. To verify antenna polarization, refer to the assembly instructions supplied with the antenna set.

5.2.3. Construction Materials

A cell's coverage area is affected by the construction materials of the walls, partitions, ceilings, floors and the furnishings of the cell. Due to their intrinsic nature, these materials may cause radio signal loss:

- Metal objects reflect radio signals. They do not let the signals pass through.
- Wood, glass, plastic and brick reflect part of the radio signals and allow part of the radio signals to pass through.
- Water and objects with a high moisture content absorb a large part of the radio signals.

Use the following table as a guidline to predict the effects of different materials.

Table 5.1: Signal Loss Chart

Obstruction	**Additional Loss (dB)**	**Effective Range**	Approx. Range
Open Space	0dB	100%	1000ft. (300m)
Window (non-metallic tint)	3dB	70%	700ft. (215m)
Window (metallic tint)	5-8dB	50%	500ft. (150m)
Light Wall (dry wall)	5-8dB	50%	500ft. (150m)
Medium Wall (wood)	10dB	30%	300ft. (100m)
Heavy Wall (solid core 6")	15-20dB	15%	150ft. (50m)
Very Heavy Wall (solid core 12")	20-25dB	10%	100ft. (30m)
Floor/Ceiling (solid core)	15-20dB	15%	150ft. (50m)
Floor/Ceiling (heavy solid core)	20-25dB	10%	100ft. (30m)

Note: *Take stairwells and elevator shafts into consideration when positioning Access Points. There is no way to quantify the loss associated with these obstructions, however they do have an effect on the signal.*

5.2.4. Cell Size

Cell size is determined by the maximum possible distance between the Access Point and the Station Adapter. This distance varies according to the building floor plan and the nature of that environment. There are several general categories:

Open Indoor Areas

Open office areas with no partitioning and no obstacles between the Access Point and the BreezeNET workstation.

The suggested maximum distance between Access Point and workstation:

Standard AP-10 PRO.11: .... 200m (600 ft.)

Semi-Open Indoor Areas

Open-plan offices partitioned into individual workspaces, factory floor areas, warehouses, etc.

The suggested maximum distance between Access Point and workstation:

Standard AP-10 PRO.11 .... 100m (300 ft.)

Closed Indoor Areas

A floor divided into individual offices by concrete, masonry or sheet-rock walls. A house is also a closed indoor area.

The suggested maximum distance between Access Point and workstation:

Standard AP-10 PRO.11 .... 50m (150 ft.)

5.3. Outdoor Installation Considerations

This chapter describes various considerations to take into account when planning an outdoor installation including site selection, antenna alignment, antenna diversity, antenna polarization, antenna seal, and cell size.

5.3.1. Site Selection Factors

When selecting a location for external antennas, remember to take into consideration the following guidelines:

- Minimum distance between sites
- Maximum height above the ground
- Maximum line of sight clearance
- Maximum separation between antennas (diversity option)

Path of Clearest Propagation

A propagation path is the path that signals traverse between the antennas of any two bridges. The “line” between two antenna sites is an imaginary straight line which may be drawn between the two antennas. Any obstacles in the path of the “line” degrade the propagation path. The best propagation path is, therefore, a clear line of sight with good clearance between the “line” and any physical obstacle.

Physical Obstacles

Any physical object in the path between two bridges can cause signal attenuation. Common obstructions are buildings and trees. If a bridge’s antenna is installed indoors, the walls and/or windows between the two sites are physical obstructions. If the antenna is positioned outdoors, any buildings or other physical structure such as trees, mountains or other natural geographic features higher than the antenna and situated in the path between the two sites can constitute obstructions.

Install indoor antennas as close as possible to a window (or wall if a window is not accessible) facing the required direction. Avoid metal obstacles such as metal window frames or metal film anti-glare windows in the transmission path. Install outdoor antennas high enough to avoid any obstacles which may block the signal.

Minimal Path Loss

Path loss is determined mainly by several factors:

- Distance between sites
  Path loss is lower and system performance better when distances between sites are shorter.

- Clearance
  Path loss is minimized when there exists a clear line of sight. The number, location, size, and makeup of obstacles determine their contribution to path loss.

- Antenna height
  Path loss is lower when antennas are positioned higher. Antenna height is the distance from the imaginary line connecting the antennas at the two sites to “ground” level. “Ground” level in an open area is the actual ground. In dense urban areas, “ground” level is the average height of the buildings between the antenna sites.

5.3.2. Rooftop Installation

Warning: *Rooftop antenna installations are extremely dangerous! Incorrect installation may result in death, serious injury and/or damage. Such installations should be performed by professional antenna installers only!*

Rooftop installations offer several advantages:

- Increased antenna range.
- Less obstacles in path.
- Improved performance due to greater height.
- Reduced multipath problems.

5.3.3. Antennas for Outdoor Applications

The ***BreezeNET PRO.11 Series*** can be used in point-to-point or point-to-multipoint configurations.

5.3.3.1 Point-to-Point

A point-to-point link is based on the use of one Access Point with external antennas (AP-10D or AP-10DE) and one adapter (SA-10/40D, WB-10D or WB-10DE). The AP and the WB must be equipped with one or two directional antennas. The necessary antenna gain depends on the required range and performance.

5.3.3.2 Point-to-Multipoint

Setting up a point-to-multipoint link requires the use of an AP-10D equipped with omni-directional antennas and a remote WB-10D (or SA-10/40D) equipped with high-gain directional antennas.

5.3.3.3 Antenna Alignment

Low gain antennas do not require alignment due to their very wide radiation pattern. High gain antennas have a narrow beamwidth necessitating an alignment procedure in order to optimize the link.

Check antenna alignment by using the LED indicators on the front panel of whichever adapter is used in the link (WB-10D or SA-10/40D). These LED indicators provide indication of reception quality.

Þ ***To perform antenna alignment:***

1. Assemble antennas according to the assembly instructions included with the antenna set.
2. Mount the antennas as high as possible.
3. Connect the coaxial cable to the AP at the main site.
4. Connect the coaxial cable to the WB (or SA) at the remote site.
5. Power on the AP and the WB (or SA).
6. Synchronize the units by aligning the antennas manually until the WLNK indicator LED on the front panel of the wireless Bridge and/or Station Adapter illuminates.
7. Align antennas at the main and remote sites until maximum signal quality is obtained. (Check QLT LEDs on the front panel of the Station Adapter and the wireless Bridge.)

If the received signal quality is lower than expected for this antenna/range combination, change antenna height and verify RF cables connections.

5.3.3.4 Antenna Diversity

In applications where no multipath propagation is expected, a single antenna is sufficient to ensure good performance levels. However, in cases where multipath propagation exists, BreezeCOM recommends that two antennas be used. This takes advantage of space diversity capabilities. By using two antennas per unit, the system can select the best antenna on a per-packet basis (every several milliseconds).

Multipath propagation is to be expected when there are potential reflectors between the main and remote sites. These reflectors may be buildings or moving objects such as airplanes and motor vehicles. If this is the case, the radio signal does not travel in a straight line, but is reflected or deflected off of the object, creating multiple propagation paths.

When installing a single antenna, modify the *transmit diversity* option to either antenna 1 or antenna 2, according to the antenna being used (refer to section 3.4.3).

5.3.3.5 Antenna Polarization

Antenna polarization must be the same at either end of the link. In most applications, the preferred orientation is vertical polarization. Above-ground propagation of the signal is better when it is polarized vertically. To verify antenna polarization, refer to the assembly instructions supplied with the antenna set.

5.3.4. Antenna Seal

When using outdoor antennas, you must seal the antenna connectors against rain. Otherwise the antennas are not suitable for use in outdoor installations.

5.3.5. Cell Size

Cell size is determined by the maximum possible distance between the Access Point and the Station Adapter, usually related to point-to-multipoint installations using external antennas. For open outdoor areas with an unobstructed line of sight between the Access Point and the BreezeNET PRO.11 workstation, the suggested maximum distance between Access Point and workstation is:

Standard AP-10 PRO.11 ....700m (2000 ft.)

5.3.6. Link Distance

Link distance is the maximum distance between the AP and the station adapter, usually related to point-to-point installations using external antennas. For open outdoor areas with an unobstructed line of sight between the Access Point and the wireless bridge, the suggested maximum distance is:

AP-10D PRO.11 with external antennas....... up to 10Km (7 miles) in the USA
up to 2.5Km in Europe

AP-10DE PRO.11 with external antennas..... up to 5Km in Europe

Note: *The maximum distance of 10Km/7 miles is achieved using 24 dBi antennas. The maximum distance of 2.5Km is achieved using 18 dBi antennas.*

For range tables, refer to section 5.3.7, *Using Outdoor Range* Tables.

5.3.7. Using Outdoor Range Tables

Outdoor installations must have a clear line-of-sight. Solid obstacles such as buildings or hills prevent the establishment of a link. Partial obstacles such as trees or traffic can reduce range. Extending coaxial cables can cause an increase in assembly signal loss and a reduction in range.

The ranges in the following tables are attained under good propagating conditions when using the standard cables supplied in the antenna set. Actual ranges may vary due to specific multipath and interference conditions.

For specific range guidelines and information about extending cables, consult your local dealer or BreezeCOM central offices.

Ranges are subject to change without notice.

5.3.8. FCC Outdoor Range Tables (USA)

The following tables are compliant with FCC regulations.

Table 5.2: BreezeNET USA/FCC Range Table - 1 Mbps

Ant. type		**Omni2**	**Omni-6**	**Omni-7**	**Uni-8.5**	**Uni-11**	**Uni-13**	**Uni-16**	**Uni-18**	**Uni-24**
	Asmb gain	2 dBi	5 dBi	6 dBi	6.5 dBi	9 dBi	11 dBi	14 dBi	15 dBi	19 dBi
Omni-2	**2 dBi**	2500 ft	3800 ft	3900 ft	4000 ft	1.0 mi	1.2 mi	1.4 mi	1.5 mi	1.9 mi
Omni-6	**5 dBi**	3800 ft	4300 ft	4600 ft	4800 ft	1.2 mi	1.5 mi	1.7 mi	1.8 mi	2.2 mi
Omni-7	**6 dBi**	3900 ft	4600 ft	4800 ft	1.0 mi	1.3 mi	1.6 mi	1.8 mi	1.9 mi	2.3 mi
Uni-8.5	**6.5 dBi**	4000 ft	4800 ft	1.0 mi	1.1 mi	1.4 mi	1.7 mi	1.9 mi	2.0 mi	2.4 mi
Uni-11	**9 dBi**	1.0 mi	1.2 mi	1.3 mi	1.4 mi	1.7 mi	2.0 mi	2.3 mi	2.5 mi	2.9 mi
Uni-13	**11 dBi**	1.2 mi	1.5 mi	1.6 mi	1.7 mi	2.0 mi	2.2 mi	2.6 mi	2.8 mi	3.2 mi
Uni-16	**14 dBi**	1.4 mi	1.7 mi	1.8 mi	1.9 mi	2.3 mi	2.6 mi	3.1 mi	3.4 mi	3.7 mi
Uni-18	**15 dBi**	1.5 mi	1.8 mi	1.9 mi	2.0 mi	2.5 mi	2.8 mi	3.4 mi	3.5 mi	4.0 mi
Uni-24	**19 dBi**	1.9 mi	2.2 mi	2.3 mi	2.4 mi	2.9 mi	3.2 mi	3.7 mi	4.0 mi	6.0 mi

Table 5.3: BreezeNET USA/FCC Range Table - 2 Mbps

Ant. type		**Omni-2**	**Omni-6**	**Omni-7**	**Uni-8.5**	**Uni-11**	**Uni-13**	**Uni-16**	**Uni-18**	**Uni-24**
	Asmb gain	2 dBi	5 dBi	6 dBi	6.5 dBi	9 dBi	11 dBi	14 dBi	15 dBi	19 dBi
Omni-2	**2 dBi**	1500 ft	2000 ft	2300 ft	2500 ft	0.6 mi	0.7 mi	0.8 mi	0.9 mi	1.1 mi
Omni-6	**5 dBi**	2000 ft	2400 ft	2600 ft	2800 ft	0.7 mi	0.9 mi	1.0 mi	1.1 mi	1.3 mi
Omni-7	**6 dBi**	2300 ft	2600 ft	2900 ft	3000 ft	0.8 mi	1.0 mi	1.2 mi	1.3 mi	1.4 mi
Uni-8.5	**6.5 dBi**	2500 ft	2800 ft	3000 ft	0.6 mi	0.8 mi	1.0 mi	1.3 mi	1.3 mi	1.5 mi
Uni-11	**9 dBi**	0.6 mi	0.7 mi	0.8 mi	0.8 mi	0.9 mi	1.1 mi	1.4 mi	1.5 mi	1.7 mi
Uni-13	**11 dBi**	0.7 mi	0.9 mi	1.0 mi	1.0 mi	1.1 mi	1.2 mi	1.5 mi	1.7 mi	2.0 mi
Uni-16	**14 dBi**	0.8 mi	1.0 mi	1.2 mi	1.3 mi	1.4 mi	1.5 mi	1.8 mi	2.0 mi	2.6 mi
Uni-18	**15 dBi**	0.9 mi	1.1 mi	1.3 mi	1.3 mi	1.5 mi	1.7 mi	2.0 mi	2.2 mi	2.8 mi
Uni-24	**19 dBi**	1.1 mi	1.3 mi	1.4 mi	1.5 mi	1.7 mi	2.0 mi	2.6 mi	2.8 mi	3.5 mi

Table 5.4: BreezeNET USA/FCC Range Table - 3 Mbps

Ant. type		Omni-2	Omni-6	Omni-7	Uni-8.5	Uni-11	Uni-13	Uni-16	Uni-18	Uni-24
	Asmb gain	2 dBi	5 dBi	6 dBi	6.5 dBi	9 dBi	11 dBi	14 dBi	15 dBi	19 dBi
Omni-2	**2 dBi**	500 ft	750 ft	800 ft	850 ft	1200 ft	1600 ft	0.4 mi	0.5 mi	0.6 mi
Omni-6	**5 dBi**	750 ft	900 ft	1000 ft	1100 ft	1600 ft	2000 ft	0.5 mi	0.6 mi	0.7 mi
Omni-7	**6 dBi**	800 ft	1000 ft	1000 ft	1200 ft	1700 ft	2100 ft	0.6 mi	0.7 mi	0.8 mi
Uni-8.5	**6.5 dBi**	850 ft	1100 ft	1200 ft	1400 ft	2200 ft	0.5 mi	0.7 mi	0.7 mi	0.9 mi
Uni-11	**9 dBi**	1200 ft	1600 ft	1700 ft	2200 ft	0.5 mi	0.6 mi	0.8 mi	0.9 mi	1.0 mi
Uni-13	**11 dBi**	1600 ft	2000 ft	2100 ft	0.5 mi	0.6 mi	0.7 mi	0.9 mi	1.0 mi	1.2 mi
Uni-16	**14 dBi**	0.4 mi	0.5 mi	0.6 mi	0.7 mi	0.8 mi	0.9 mi	1 mi	1.1 mi	1.4 mi
Uni-18	**15 dBi**	0.5 mi	0.6 mi	0.7 mi	0.7 mi	0.9 mi	1.0 mi	1.1 mi	1.2 mi	1.5 mi
Uni-24	**19 dBi**	0.6 mi	0.7 mi	0.8 mi	0.9 mi	1.0 mi	1.2 mi	1.4 mi	1.5 mi	2 mi

Note: *The use of an LNA can improve the range by 30%-40%. To achieve this it is necessary to install an LNA on both sides of the link (in each site). An LNA will NOT enlarge the link if it is installed only on one side of the link. When using an LNA you must use two antennas - one for TX and one for RX.*

5.3.9. ETSI Outdoor Range Tables (Europe and Rest-of-World) – D Models

In order to comply with ETSI regulations, 20dBm (100mW) EIRP units using antenna kits indicated as *low* must be configured to the low power setting (4 dBm).

Using an 18dbi antenna and lowering the output power of the unit complies with ETSI regulations and improves reception. Installing this antenna at both ends of the link increases the total range. Installing this antenna at one end of the link does not increase the range, but it does increase the throughput of traffic received at the end with the 18 dbi antenna.

The following tables are compliant with ETSI regulations.

Table 5.5: BreezeNET Europe and ROW Range Table – D Models
Data Rate = 1Mbps, Sen=-81dBm

Antenna Kit	Omni-2	Omni-6	Uni-8.5	Uni-18/20 (Low)	Uni-18/15 (Low)	Uni-18/10 (Low)
Omni-2	710m	790m	750m	670m	730m	790m
Omni-6	790m	890m	840m	750m	820m	890m
Uni-8.5	750m	840m	790m	710m	770m	840m
Uni-18/20	670m	750m	710m	1,910m	2,020m	2,130m
Uni-18/15	730m	820m	770m	2,020m	2,130m	2,250m
Uni-18/10	790m	890m	840m	2,130m	2,250m	2,370m

Table 5.6: BreezeNET Europe and ROW Range Table – D Models
Data Rate = 2Mbps, Sen=-75dBm

Antenna Kit	Omni-2	Omni-6	Uni-8.5	Uni-18/20 (Low)	Uni-18/15 (Low)	Uni-18/10 (Low)
Omni-2	350m	400m	380m	330m	370m	400m
Omni-6	400m	450m	420m	380m	410m	450m
Uni-8.5	380m	420m	400m	350m	390m	420m
Uni-18/20	330m	380m	350m	1,240m	1,310m	1,380m
Uni-18/15	370m	410m	390m	1,310m	1,380m	1,460m
Uni-18/10	400m	450m	420m	1,380m	1,460m	1,540m

Table 5.7: BreezeNET Europe and ROW Range Table – D Models
Data Rate = 3Mbps, Sen=-67dBm

Antenna Kit	Omni-2	Omni-6	Uni-8.5	Uni-18/20 (Low)	Uni-18/15 (Low)	Uni-18/10 (Low)
Omni-2	140m	160m	150m	130m	150m	160m
Omni-6	160m	180m	170m	150m	160m	180m
Uni-8.5	150m	170m	160m	140m	150m	170m
Uni-18/20	130m	150m	140m	560m	610m	670m
Uni-18/15	150m	160m	150m	610m	670m	730m
Uni-18/10	160m	180m	170m	670m	730m	790m

Note: *All antennas above 8.5 (i.e. 12, 18, and 24), require a filter to be ETSI-compliant.*

5.3.10. ETSI Outdoor Range Tables (Europe and Rest-of-World) – DE Models

The following tables are compliant with ETSI regulations.

Table 5.8: BreezeNET Europe and ROW Range Table – DE Models
Data Rate = 1Mbps, Sen=-85dBm

Antenna Kit	Uni-24/20	Uni-24/15	Uni-24/10
Uni-24/20	3,920m	4,140m	4,370m
Uni-24/15	4,140m	4,370m	4,610m
Uni-24/10	4,370m	4,610m	4,870m

Table 5.9: BreezeNET Europe and ROW Range Table – DE Models
Data Rate = 2Mbps, Sen=-79dBm

Antenna Kit	Uni-24/20	Uni-24/15	Uni-24/10
Uni-24/20	2,550m	2,690m	2,840m
Uni-24/15	2,690m	2,840m	3,000m
Uni-24/10	2,840m	3,000m	3,160m

Table 5.10: BreezeNET Europe and ROW Range Table – DE Models
Data Rate = 3Mbps, Sen=-71dBm

Antenna Kit	Uni-24/20	Uni-24/15	Uni-24/10
Uni-24/20	1,430m	1,510m	1,600m
Uni-24/15	1,510m	1,600m	1,680m
Uni-24/10	1,600m	1,680m	1,780m

***Note**: All antennas above 8.5 (i.e. 12, 18, and 24), require a filter to be ETSI-compliant.*

***Note:** The use of an LNA can improve the range by 30%-40%. To achieve this it is necessary to install an LNA on both sides of the link (in each site). An LNA will NOT enlarge the link if it is installed only on one side of the link. When using an LNA you must use two antennas - one for TX and one for RX.*

5.3.11. Non-Regulated Outdoor Range Tables – D Models

Table 5.11: BreezeNET Non-Regulation Range Table – D Models
Data Rate = 1Mbps, Sen=-81dBm

Antenna Kits	Omni-2	Omni-6	Uni-8.5	Uni-18/20	Uni-18/15	Uni-18/10	Uni-24/20	Uni-24/15	Uni-24/10
Omni-2	710m	790m	750m	1,980m	2,090m	2,210m	3,050m	3,220m	3,400m
Omni-6	790m	890m	840m	2,130m	2,250m	2,370m	3,280m	3,460m	3,650m
Uni-8.5	750m	840m	790m	2,050m	2,170m	2,290m	3,160m	3,340m	3,520m
Uni-18/20	1,980m	2,130m	2,050m	4,870m	5,140m	5,420m	7,500m	7,910m	8,350m
Uni-18/15	2,090m	2,250m	2,170m	5,140m	5,420m	5,730m	7,910m	8,350m	8,820m
Uni-18/10	2,210m	2,370m	2,290m	5,420m	5,730m	6,040m	8,350m	8,820m	9,310m
Uni-24/20	3,050m	3,280m	3,160m	7,500m	7,910m	8,350m	11,550m	12,190m	12,860m
Uni-24/15	3,220m	3,460m	3,340m	7,910m	8,350m	8,820m	12,190m	12,860m	13,580m
Uni-24/10	3,400m	3,650m	3,520m	8,350m	8,820m	9,310m	12,860m	13,580m	14,330m

Table 5.12: BreezeNET Non-Regulation Range Table – D Models
Data Rate = 2Mbps, Sen=-75dBm

Antenna Kits	Omni-2	Omni-6	Uni-8.5	Uni-18/20	Uni-18/15	Uni-18/10	Uni-24/20	Uni-24/15	Uni-24/10
Omni-2	350m	400m	380m	1,290m	1,360m	1,430m	1,980m	2,090m	2,210m
Omni-6	400m	450m	420m	1,380m	1,460m	1,540m	2,130m	2,250m	2,370m
Uni-8.5	380m	420m	400m	1,330m	1,410m	1,490m	2,050m	2,170m	2,290m
Uni-18/20	1,290m	1,380m	1,330m	3,160m	3,340m	3,520m	4,870m	5,140m	5,420m
Uni-18/15	1,360m	1,460m	1,410m	3,340m	3,520m	3,720m	5,140m	5,420m	5,730m
Uni-18/10	1,430m	1,540m	1,490m	3,520m	3,720m	3,920m	5,420m	5,730m	6,040m
Uni-24/20	1,980m	2,130m	2,050m	4,870m	5,140m	5,420m	7,500m	7,910m	8,350m
Uni-24/15	2,090m	2,250m	2,170m	5,140m	5,420m	5,730m	7,910m	8,350m	8,820m
Uni-24/10	2,210m	2,370m	2,290m	5,420m	5,730m	6,040m	8,350m	8,820m	9,310m

Table 5.13: BreezeNET Non-Regulation Range Table – D Models
Data Rate = 3Mbps, Sen=-67dBm

Antenna Kits	Omni-2	Omni-6	Uni-8.5	Uni-18/20	Uni-18/15	Uni-18/10	Uni-24/20	Uni-24/15	Uni-24/10
Omni-2	140m	160m	150m	600m	650m	710m	1,110m	1,180m	1,240m
Omni-6	160m	180m	170m	670m	730m	790m	1,200m	1,260m	1,330m
Uni-8.5	150m	170m	160m	630m	690m	750m	1,150m	1,220m	1,290m
Uni-18/20	600m	670m	630m	1,780m	1,880m	1,980m	2,740m	2,890m	3,050m
Uni-18/15	650m	730m	690m	1,880m	1,980m	2,090m	2,890m	3,050m	3,220m
Uni-18/10	710m	790m	750m	1,980m	2,090m	2,210m	3,050m	3,220m	3,400m
Uni-24/20	1,110m	1,200m	1,150m	2,740m	2,890m	3,050m	4,220m	4,450m	4,700m
Uni-24/15	1,180m	1,260m	1,220m	2,890m	3,050m	3,220m	4,450m	4,700m	4,960m
Uni-24/10	1,240m	1,330m	1,290m	3,050m	3,220m	3,400m	4,700m	4,960m	5,230m

5.3.12. Extending the range using the TPA-24 and LNA-10

The following tables show examples of how outdoor ranges of D-model units can be extended using the TPA-24 and LNA-10 devices.

In the range tables below, the note ***LNA*** means that the LNA 10 Low Noise Receive Amplifier is used (see section 6.2). The note ***TPA*** means that the TPA 24 Transmit Power Amplifier is used (see section 6.1). When the LNA or TPA are used, one of the unit's antennas should be permanently set to transmit and the other to receive. In this case, Antenna Diversity is not applicable. The use of an LNA or a Booster (TPA 24) will only enlarge the range if they are installed on both sides of the link.

The identification of "TX kit" and "RX kit" is for reference purposes only. They do not have any other meaning than for arranging the table to show the effects of the LNA and Booster (TPA 24).

For ranges over 30 km, it is recommended to consult BreezeCOM technical support or your local dealer.

Important: In the following tables, "Omni-6/10" refers to an Omni 6dbi antenna with a 10 Meter Heliax cable.

Table 5.14: TPA-24 and LNA-10 Extension Range Table. Data Rate = 1Mbps, Sen=-81dBm

Transmit and Receive Antenna Kits for Side A / **Transmit and Receive Antenna Kits for Side B**			**TX kit**		Omni-6/10	Omni-6/10	Omni-6 (TPA)	Omni-6 (TPA)	Uni-18/10	Uni-18/10	Uni-18/10 (TPA)	Uni-18/10 (TPA)	Uni-24/10	Uni-24/10	Uni-24/10 (TPA)	Uni-24/10 (TPA)
			TX EIRP		21	21	30	30	33	33	42	42	39	39	48	48
			RX kit		Omni-6/10	Omni-6 (LNA 10)	Omni-6/10	Omni-6 (LNA)	Uni-18/10	Uni-18/10 (LNA)	Uni-18/10	Uni-18/10 (LNA)	Uni-24/10	Uni-24/10 (LNA)	Uni-24/10	Uni-24/10 (LNA)
			RX Gain		4	8.35	4	8.35	16	20.35	16	20.35	22	26.35	22	26.35
TX kit	**EIRP**	**RX kit**	**RX Gain**													
Omni-6/10	21	Omni-6/10	4		1,070m	1,070m	1,070m	1,470m	2,550m	2,550m	2,550m	3,480m	3,920m	3,920m	3,920m	5,370m
Omni-6/10	21	Omni-6 (LNA)	8.35		1,070m	1,470m	1,070m	1,470m	2,550m	3,480m	2,550m	3,480m	3,920m	5,370m	3,920m	5,370m
Omni-6 (TPA)	30	Omni-6/10	4		1,070m	1,070m	2,050m	2,050m	2,550m	2,550m	4,870m	4,870m	3,920m	3,920m	7,500m	7,500m
Omni-6 (TPA)	30	Omni-6 (LNA)	8.35		1,470m	1,470m	2,050m	2,810m	3,480m	3,480m	4,870m	6,660m	5,370m	5,370m	7,500m	10,260m
Uni-18/10	33	Uni-18/10	16		2,550m	2,550m	2,550m	3,480m	6,040m	6,040m	6,040m	8,260m	9,310m	9,310m	9,310m	12,730m
Uni-18/10	33	Uni-18/10 (LNA)	20.35		2,550m	3,480m	2,550m	3,480m	6,040m	8,260m	6,040m	8,260m	9,310m	12,730m	9,310m	12,730m
Uni-18/10 (TPA)	42	Uni-18/10	16		2,550m	2,550m	4,870m	4,870m	6,040m	6,040m	11,550m	11,550m	9,310m	9,310m	17,780m	17,780m
Uni-18/10 (TPA)	42	Uni-18/10 (LNA)	20.35		3,480m	3,480m	4,870m	6,660m	8,260m	8,260m	11,550m	15,790m	12,730m	12,730m	17,780m	24,320m
Uni-24/10	39	Uni-24/10	22		3,920m	3,920m	3,920m	5,370m	9,310m	9,310m	9,310m	12,730m	14,330m	14,330m	14,330m	19,600m
Uni-24/10	39	Uni-24/10 (LNA)	26.35		3,920m	5,370m	3,920m	5,370m	9,310m	12,730m	9,310m	12,730m	14,330m	19,600m	14,330m	19,600m
Uni-24/10 (TPA)	48	Uni-24/10	22		3,920m	3,920m	7,500m	7,500m	9,310m	9,310m	17,780m	17,780m	14,330m	14,330m	27,380m	27,380m
Uni-24/10 (TPA)	48	Uni-24/10 (LNA)	26.35		5,370m	5,370m	7,500m	10,260	12,730m	12,730m	17,780m	24,320m	19,600m	19,600m	27,380m	37,450m

Table 5.15: TPA-24 and LNA-10 Extension Range Table. Data Rate = 2Mbps, Sen=-75dBm

Transmit and Receive Antenna Kits for Side A / Transmit and Receive Antenna Kits for Side B																
			TX kit		Omni-6/10	Omni-6/10	Omni-6 (TPA)	Omni-6 (TPA)	Uni-18/10	Uni-18/10	Uni-18/10 (TPA)	Uni-18/10 (TPA)	Uni-24/10	Uni-24/10	Uni-24/10 (TPA)	Uni-24/10 (TPA)
			TX EIRP		21	21	30	30	33	33	42	42	39	39	48	48
			RX kit		Omni-6/10	Omni-6 (LNA 10)	Omni-6/10	Omni-6 (LNA)	Uni-18/10	Uni-18/10 (LNA)	Uni-18/10	Uni-18/10 (LNA)	Uni-24/10	Uni-24/10 (LNA)	Uni-24/10	Uni-24/10 (LNA)
			RX Gain		4	8.35	4	8.35	16	20.35	16	20.35	22	26.35	22	26.35
TX kit	**EIRP**	**RX kit**	**RX Gain**													
Omni-6/10	21	Omni-6/10	4		560m	560m	560m	930m	1,650m	1,650m	1,650m	2,260m	2,550m	2,550m	2,550m	3,480m
Omni-6/10	21	Omni-6 (LNA)	8.35		560m	930m	560m	930m	1,650m	2,260m	1,650m	2,260m	2,550m	3,480m	2,550m	3,480m
Omni-6 (TPA)	30	Omni-6/10	4		560m	560m	1,330m	1,330m	1,650m	1,650m	3,160m	3,160m	2,550m	2,550m	4,870m	4,870m
Omni-6 (TPA)	30	Omni-6 (LNA)	8.35		930m	930m	1,330m	1,820m	2,260m	2,260m	3,160m	4,320m	3,480m	3,480m	4,870m	6,660m
Uni-18/10	33	Uni-18/10	16		1,650m	1,650m	1,650m	2,260m	3,920m	3,920m	3,920m	5,370m	6,040m	6,040m	6,040m	8,260m
Uni-18/10	33	Uni-18/10 (LNA)	20.35		1,650m	2,260m	1,650m	2,260m	3,920m	5,370m	3,920m	5,370m	6,040m	8,260m	6,040m	8,260m
Uni-18/10 (TPA)	42	Uni-18/10	16		1,650m	1,650m	3,160m	3,160m	3,920m	3,920m	7,500m	7,500m	6,040m	6,040m	11,550m	11,550m
Uni-18/10 (TPA)	42	Uni-18/10 (LNA)	20.35		2,260m	2,260m	3,160m	4,320m	5,370m	5,370m	7,500m	10,260m	8,260m	8,260m	11,550m	15,790m
Uni-24/10	39	Uni-24/10	22		2,550m	2,550m	2,550m	3,480m	6,040m	6,040m	6,040m	8,260m	9,310m	9,310m	9,310m	12,730m
Uni-24/10	39	Uni-24/10 (LNA)	26.35		2,550m	3,480m	2,550m	3,480m	6,040m	8,260m	6,040m	8,260m	9,310m	12,730m	9,310m	12,730m
Uni-24/10 (TPA)	48	Uni-24/10	22		2,550m	2,550m	4,870m	4,870m	6,040m	6,040m	11,550m	11,550m	9,310m	9,310m	17,780m	17,780m
Uni-24/10 (TPA)	48	Uni-24/10 (LNA)	26.35		3,480m	3,480m	4,870m	6,660m	8,260m	8,260m	11,550m	15,790m	12,730m	12,730m	17,780m	24,320m

Table 5.16: TPA-24 and LNA-10 Extension Range Table. Data Rate = 3Mbps, Sen=-67dBm

Transmit and Receive Antenna Kits for Side A			**TX kit**		Omni-6/10	Omni-6/10	Omni-6 (TPA)	Omni-6 (TPA)	Uni-18/10	Uni-18/10	Uni-18/10 (TPA)	Uni-18/10 (TPA)	Uni-24/10	Uni-24/10	Uni-24/10 (TPA)	Uni-24/10 (TPA)
			TX EIRP		21	21	30	30	33	33	42	42	39	39	48	48
Transmit and Receive Antenna Kits for Side B			**RX kit**		Omni-6/10	Omni-6 (LNA 10)	Omni-6/10	Omni-6 (LNA)	Uni-18/10	Uni-18/10 (LNA)	Uni-18/10	Uni-18/10 (LNA)	Uni-24/10	Uni-24/10 (LNA)	Uni-24/10	Uni-24/10 (LNA)
			RX Gain		4	8.35	4	8.35	16	20.35	16	20.35	22	26.35	22	26.35
TX kit	**EIRP**	**RX kit**	**RX Gain**													
Omni-6/10	21	Omni-6/10	4		220m	220m	220m	370m	890m	890m	890m	1,270m	1,430m	1,430m	1,430m	1,960m
Omni-6/10	21	Omni-6 (LNA)	8.35		220m	370m	220m	370m	890m	1,270m	890m	1,270m	1,430m	1,960m	1,430m	1,960m
Omni-6 (TPA)	30	Omni-6/10	4		220m	220m	630m	630m	890m	890m	1,780m	1,780m	1,430m	1,430m	2,740m	2,740m
Omni-6 (TPA)	30	Omni-6 (LNA)	8.35		370m	370m	630m	1,030m	1,270m	1,270m	1,780m	2,430m	1,960m	1,960m	2,740m	3,740m
Uni-18/10	33	Uni-18/10	16		890m	890m	890m	1,270m	2,210m	2,210m	2,210m	3,020m	3,400m	3,400m	3,400m	4,650m
Uni-18/10	33	Uni-18/10 (LNA)	20.35		890m	1,270m	890m	1,270m	2,210m	3,020m	2,210m	3,020m	3,400m	4,650m	3,400m	4,650m
Uni-18/10 (TPA)	42	Uni-18/10	16		890m	890m	1,780m	1,780m	2,210m	2,210m	4,220m	4,220m	3,400m	3,400m	6,490m	6,490m
Uni-18/10 (TPA)	42	Uni-18/10 (LNA)	20.35		1,270m	1,270m	1,780m	2,430m	3,020m	3,020m	4,220m	5,770m	4,650m	4,650m	6,490m	8,880m
Uni-24/10	39	Uni-24/10	22		1,430m	1,430m	1,430m	1,960m	3,400m	3,400m	3,400m	4,650m	5,230m	5,230m	5,230m	7,160m
Uni-24/10	39	Uni-24/10 (LNA)	26.35		1,430m	1,960m	1,430m	1,960m	3,400m	4,650m	3,400m	4,650m	5,230m	7,160m	5,230m	7,160m
Uni-24/10 (TPA)	48	Uni-24/10	22		1,430m	1,430m	2,740m	2,740m	3,400m	3,400m	6,490m	6,490m	5,230m	5,230m	10,000m	10,000m
Uni-24/10 (TPA)	48	Uni-24/10 (LNA)	26.35		1,960m	1,960m	2,740m	3,740m	4,650m	4,650m	6,490m	8,880m	7,160m	7,160m	10,000m	13,680m

5.4. Available Antennas and Antenna Kits

This following table describes several transmit/receive antennas that work well with ***BreezeNET PRO.11*** units.

Table 5.17: FCC Available Antennas (USA)

Model	Ant. Gain	Cable Len	Kit Contains:	Ideal for:	Disper-sion.	Dimensions H x W x D
OMNI-2	2 dBi	N/A	2 OMNI-2 Antennas Proprietary SMA	Converting “D” Models for use indoors	360°H/ 60° V	3"x.5" Tubular
OMNI-6	6 dBi	4-ft	OMNI-6 Antenna Mounting Hardware 4-ft Cable Assembly	Extending indoor range of access points and station adapters	360°H/ 26° V	13"x0.75" Tubular
OMNI-7.2	7.2 dBi	20-ft	OMNI-7.2 Antenna Mounting Hardware 20-ft Cable Assembly	Establishing 360° coverage for outdoor multipoint links	360°H/ 22° V	16"x0.75" Tubular
UNI-8.5	8.5 dBi	8-ft	UNI-8.5 Antenna Mounting Hardware 8-ft Cable	Extending indoor range of access points and/or station adapters	75°H/ 60° V	4"x3.7"x1.2"
UNI-8.5Ext	8.5 dBi	8-ft	UNI-8.5 Antenna Mounting Hardware 8-ft Cable Assembly	Short range outdoor multipoint links	75°H/ 60° V	4"x3.7"x1.2"
UNI-11P-75	11 dBi	30-ft	UNI-11P-75 Antenna Mounting Hardware 30-ft Cable Assembly	ISPs, school districts, and campus area networks requiring wide dispersion patterns	75°H/ 28° V	11"x7.5"x3.5"
UNI-13P	13 dBi	20-ft	UNI-13P Antenna Mounting Hardware 20-ft Cable Assembly	Medium range outdoor multipoint links	46°H/ 28° V	11"x7.5"x3.5"
UNI-16P	16 dBi	30-ft	UNI-16P Antenna Mounting Hardware 30-ft Cable Assembly	Medium to long range outdoor multipoint links requiring compact form factors	28°H/ 28° V	11"x11"x3.5"
UNI-18	18 dBi	30-ft	UNI-18 Antenna Mounting Hardware 30-ft Cable Assembly	Long range outdoor point-to-point and multipoint links	12°H/ 14° V	16"x20"X15"
UNI-24	24 dBi	50-ft	UNI-24 Antenna Mounting Hardware 50-ft Cable Assembly	Long range outdoor point-to-point links	6°H/ 10° V	24"x36"x15"

Table 5.18: ETSI Available Antennas (Europe and Rest-of-World)

Model	Ant. Gain	Cable Len	Kit Contains:	Ideal for:	Disper-sion.	Dimensions H x W x D
OMNI-2	2 dBi	N/A	2 OMNI-2 Antennas Proprietary SMA	Converting "D" Models for use indoors	360°H/ 60° V	3"x.5" Tubular
OMNI-6	6 dBi	3m	OMNI-6 Antenna 90° Mount Bracket 3m RG-58 Cable	Extending indoor range of access points and station adapters	360°H/ 26° V	13"x0.75" Tubular
UNI-8.5	8.5 dBi	6m	UNI-8.5 Antenna Wall Mounting HW 6m RG-58 Cable	Extending indoor range of access points and/or station adapters	75°H/ 60° V	4"x3.7"x1.2"
UNI-18/10 UNI-18/15 UNI-18/20	18 dBi	10m 15m 20m	UNI-18 Antenna U-bolt for pole Heliax Cable	Long range outdoor point-to-point and multipoint links	12°H/ 14° V	16"x20"X15"
UNI-24/10 UNI-24/15 UNI-24 /20	24 dBi	10m 15m 20m	UNI-24 Antenna U-bolt for pole Heliax Cable	Long range outdoor point-to-point links	6°H/ 10° V	24"x36"x15"

5.5. Precautions

5.5.1. Professional Installers Only

Caution: *Detached antennas, whether installed indoors or out, should be installed ONLY by experienced antenna installation professionals who are familiar with local building and safety codes and, wherever applicable, are licensed by the appropriate government regulatory authorities.*

Failure to do so may void the BreezeNET Product Warranty and may expose the end user to legal and financial liabilities. BreezeCOM and its resellers or distributors are not liable for injury, damage or violation of government regulations associated with the installation of detached antennas.

5.5.2. Transmit Antenna Gain

Regulations regarding maximum antenna gains vary from country to country. It is the responsibility of the end user to operate within the limits of these regulations and to ensure that the professional installer is aware of these regulations, as well. The FCC in the United States and ETSI in Europe limit effective transit power to 36dBm (USA) and 20dBm (Europe). The maximum total assembly gain of antennas and cables in this case equals 19dBi (USA) and 3dBi (Europe).

Violation of government regulations exposes the end user to legal and financial liabilities. BreezeCOM and its resellers and distributors shall not be liable for expense or damage incurred as a result of installations which exceed local transmit gain limitations.

5.5.3. Spurious Radio Frequency Emissions

The regulations referred to in the previous section also specify maximum “out-of-band” radio frequency emissions. Install a filter as close as possible to the BreezeNET PRO.11 “D” model unit connector.

5.5.4. Lightning Protection

Lightning protection is designed to protect people, property and equipment by providing a path to ground for the lightning’s energy. The lightning arrestor diverts the strike energy to ground through a deliberate and controlled path instead of allowing it to choose a random path. Lightning protection for a building is more forgiving than protection of electronic devices. A building can withstand up to 100,000 volts, but electronic equipment may be damaged by just a few volts.

Lightning protection entails connecting an antenna discharge unit (also called an arrestor) to each cable as close as possible to the point where it enters the building. It also entails proper grounding of the arrestors and of the antenna mast (if the antenna is connected to one).

The lightning arrestor should be installed and grounded at the point where the cable enters the building. The arrestor is connected to the unit at one end and to the antenna at the other end.

The professional installer you choose must be knowledgeable about lightning protection. The installer must install the lightning protector in a way that maximizes lightning protection. BreezeCOM offers the following high-quality lightning arrestor assembly:

BreezeNET AL 1 Lightning Arrestor - Part No. 872905 5 ft (1.5m), “N” Male to “N” Female.

5.5.5. Rain Proofing

12, 18, and 24 dBi antennas must be sealed against rain at the point the cable enters the pole before they are suitable for external use.

6. ACCESSORY INSTALLATION

This chapter introduces some of the accessories available for specific installations, and describes how to install them.

6.1. TPA 24 Transmit Power Amplifier (Booster)

The TPA 24 transmit power amplifier is used to amplify the transmit power to a fixed output of 24 dBm (250 mW). The TPA 24 is especially useful when long RF cable runs are required. In addition, the TPA 24 simplifies antenna alignment by enabling the use of wider dispersion transmit antennas (12 dBi maximum). The TPA 24 is internally protected against lightning and voltage surge protection.

There are two models:

- The TPA 24 NL receives input power in the range of -10dBm to 0dBm.
- The TPA 24 NH receives an input power of 0dBm to +10dBm. Both models then amplify the input power to a fixed output level of 24dBm (250mW).

The TPA is powered by 12VDC carried from the power inserter by the RF cable.

***Note**: The TPA 24 is not available in the USA due to FCC regulations.*

When used in compliance with ETSI regulations, the TPA 24 can be connected to cables and antennas resulting in a total transmitted power of 20dBm (100 mW) EIRP.

For technical specifications, refer to section 9.2.2 *Specifications for TPA 24 Transmit Power Amplifier*.

6.1.1. Installing the TPA 24

Þ ***To install the TPA 24:***

1. Choose one of the TPA 24 models according to the power level at the input of the booster. In general the NH model is used. For installations with long cables (high attenuations), the NL model should be used.

2. Choose one of the antenna connectors to be used for transmission. This connector is called the *transmit antenna* of the unit.

3. Configure the ***BreezeNET PRO.11*** unit via the Monitor to transmit through the transmit antenna using the Transmit Diversity parameter (see section 3.4.3).

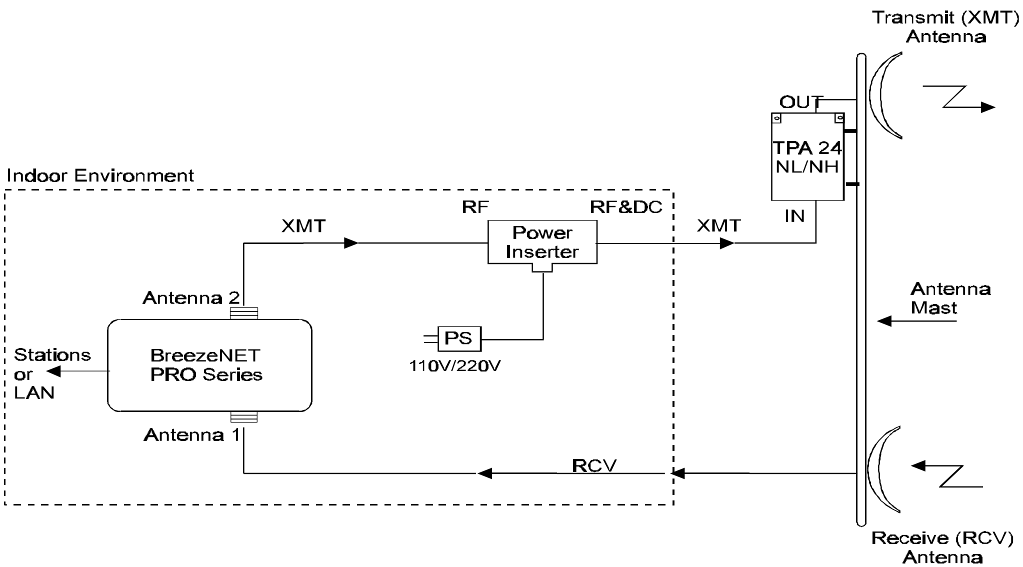


Figure 6.1: TPA 24 Installation

4. Connect the TPA 24 RF output directly to the transmit antenna.

5. Attach the TPA 24 RF input to the Power Inserter with the RF cable. The Power Inserter must be installed indoors.

6. Connect the RF cable leading from the Power Inserter to the transmit antenna on the ***BreezeNET PRO.11*** unit.

7. Plug the power cable leading from the Power Inserter into any available 110/220V outlet. The power supply must be installed indoors.

Note: *Installations exceeding regulations set by local authorities expose the installer and the user to potential legal and financial liabilities.*

8. For reception, use a separate antenna connected to the other antenna connector of the BreezeNET unit.

6.2. LNA 10 Low Noise Receive Amplifier

The LNA 10 is a high-performance, low-noise preamplifier designed to enhance fringe area reception and provide additional gain on the receive antenna. Its exceptionally small size and light weight enables it to be directly mounted on the antenna by means of the female RF IN connector. Power is obtained through an RG-59 coaxial cable connected to the power supply. The LNA 10 is internally protected against lightning and voltage surge protection.

The Power Supply (PS) and Power Inserter are supplied with the LNA 10. The RG-59 coaxial cable with F-type connector is not supplied and must be purchased separately.

For technical specifications, refer to *Specifications for LNA 10 Low Noise Receive Amplifier* in the appendices.

6.2.1. Installing the LNA 10

Before installing the LNA 10, the following steps must be taken:

1. Choose one of the antenna connectors to be used for reception. This connector is called the *receive antenna* of the unit. The other connector is called the transmit antenna of the unit.

2. Configure the ***BreezeNET PRO.11*** unit via the Monitor to transmit through the transmit antenna only using the Transmit Diversity parameter (see section 3.4.3). This prevents transmission from going through the LNA 10.

3. Connect the LNA 10 RF input directly to the receive antenna, as close as possible.

4. Attach the LNA 10 RF output directly to the RF cable going down to the receive antenna connector on the ***BreezeNET PRO.11*** unit.

5. Connect the RG-59 coaxial cable which leads down to the Power Inserter to the “Signal and Power out” connector on the LNA 10.

6. Connect the Power Inserter to the power supply (both are indoor units).

7. For transmission, use a separate antenna connected to the other antenna connector (transmit antenna) of the BreezeNET unit.

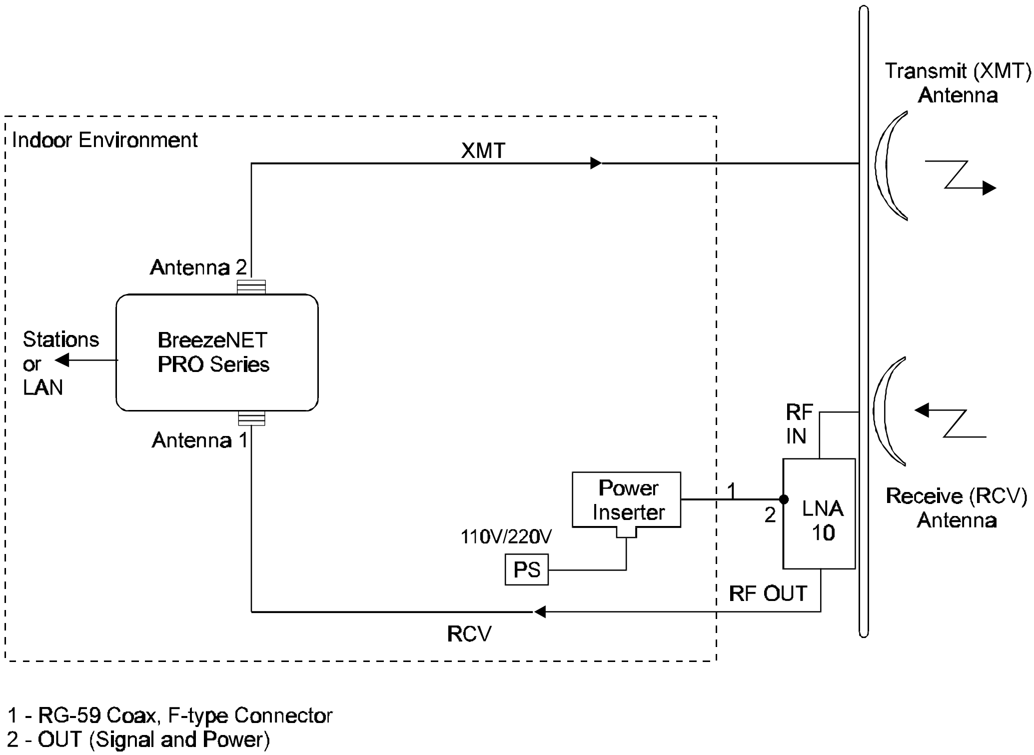


Figure 6.2: LNA 10 Connections Diagram

6.3. RFS 122 Radio Frequency Splitter

The RFS 122 Radio Frequency Splitter is used to split the RF signal generated by a transmitter into two signals. These signals are then sent to two different and independent antennas. The RFS 122 enables radio transmission using two directional antennas connected to the same port of the ***BreezeNET PRO.11*** unit. Similarly, the splitter is used to combine two receiving antennas to one antenna connector.

Before installing the RFS 122, configure the ***BreezeNET PRO.11*** unit via the Monitor to transmit through Antenna 2 only using the Transmit Diversity parameter (see section 3.4.3), and connect the RFS 122 to antenna connector 2.

For technical specifications, refer to section 9.2.4, *Specifications for RFS 122 Radio Frequency Splitter*.

6.3.1. Installing the RFS 122

The following diagram illustrates RFS-122 installation.

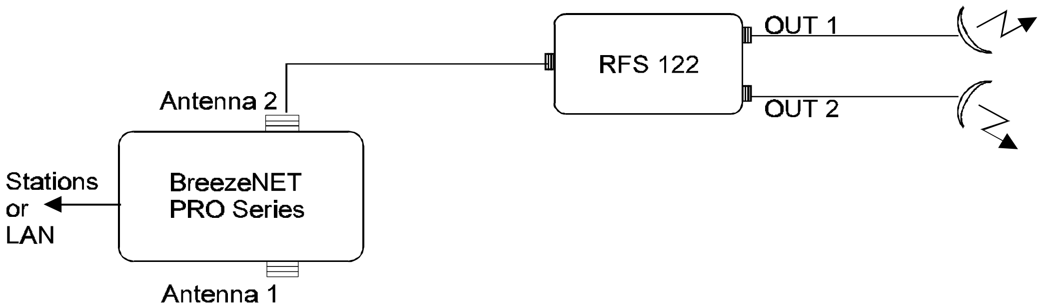


Figure 6.3: RFS-122 Connection Diagram

6.4. AL 1 Lightning Arrestor

The AL 1 Lightning Arrestor is used to protect transmitters and receivers from transients originating from lightning or EMP.

The AL 1 is gas tube-based and is not radioactive. The gas discharge tube can sustain several transients if the time period between transients is sufficient to allow the tube to cool down.

For technical specifications, refer to section 9.2.5, *Specifications for AL 1 Lightning Arrestor*.

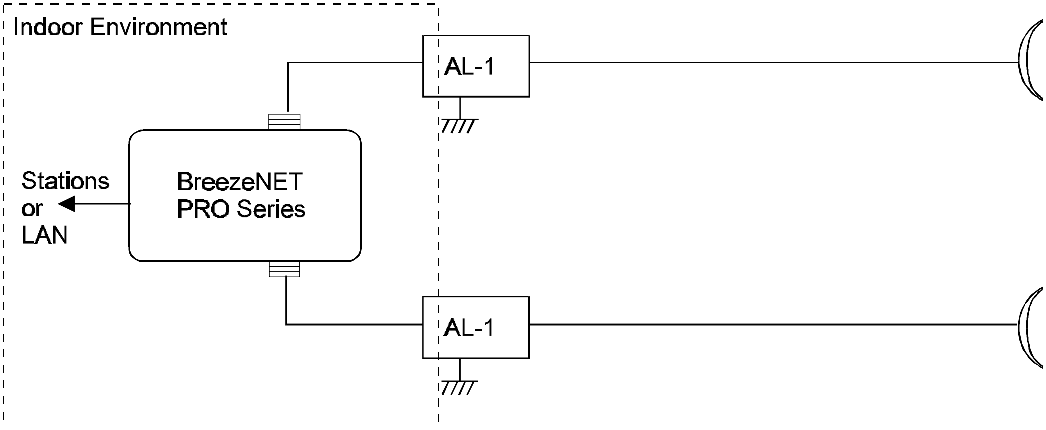


Figure 6.4: AL-1 Connection Block Diagram

One of the female-type N connectors is mounted directly through a hole in the shelter wall and held in place with a lockwasher and nut.

7. UPGRADE PROCEDURE

Firmware upgrades to the unit's flash memory is done by a simple download procedure using a TFTP application. Before beginning an upgrade, *be sure you have the correct files and latest instructions*. Upgrade packages can be obtained at the BreezeCOM web site: **www.breezecom.com**.

In general terms, upgrading includes the following steps:

1. Set up an IP connection to the device. You can verify working connection using the Ping command.

2. Run TFTP software and connect to the device.

3. Use TFTP to download the erase file to the device Use the tables below to determine the specific file to use, according to the unit's current version. This causes the flash memory to be cleared. ***Do not* reset the device now.**

4. Use TFTP to download the software file to the device. Use the tables below to determine the specific file to use, according to the unit's current version.

5. The unit resets itself and comes up with the new upgraded version.

Table 7.1: Upgrade Files

Current Version of Unit	Flash Erase File Name	Software Download File Name	
		AP-10	SA-10, SA-40, WB-10
3.2, 3.38, 3.42, 3.50	download	eanaf	eansf
3.52, 4.204	erase	eanafb	eansfb
3.62, 4.210, 4.211	fw-erase	ap_fw	sawb_fw

The *current* version and type of the unit determine the files used for upgrade. For example, when upgrading an AP-10 from version 3.52 to version 4.211, use the *erase* and *eanafb* files. When upgrading a SA-10 from version 3.62 to version 4.211, use the *fw-erase* and *sawb_fw* files.

8. SYSTEM TROUBLESHOOTING

The following troubleshooting guide provides answers to some of the more common problems which may occur when installing and using ***BreezeNET PRO.11 Series*** products. If problems not mentioned in this guide should arise, checking the Ethernet and WLAN counters may help (see section 8.2). If the problem persists, please feel free to contact your local distributor or the BreezeCOM Technical Support Department.

8.1. Troubleshooting Guide

Problem and Indication	Possible Cause	Corrective Action
No Power to Unit. PWR LED is off.	1. Power cord is not properly connected. 2. Power supply is defective.	1. Verify power cord is properly connected to the BreezeNET unit and to the power outlet. 2. If this is not the cause, replace the power supply.
Failure to establish wireless link. WLNK LED is off and unit resets every few minutes.	1. Power supply to units may be faulty 2. The units may not have the same ESSID as the AP-10.	1. Verify power to units (AP and SA/ WB). 2. Verify that all units in the network have the same ESSID as the AP (ESSID must be identical in all units in the network): 3. Verify wireless link: • Set AP and unit (SA or WB) side by side. • Power on each unit and see if a wireless link is established (even “D” models without their external antennas should establish a link if placed side by side with the AP). • If the units fail to associate, reset units to factory default values reset unit (see section 3.4.5). The units should now establish a wireless link.
Failure to establish wireless link (“D” models/external antennas)	1. Power supply to units may be faulty. 2. Cables may be improperly connected 3. There may be some problem with antenna installation.	1. Verify power to units. 2. Verify that all cables are connected securely. 3. Refer to previous section and verify wireless link between the units. 4. Verify that the antenna(s) are properly installed (see relevant section in this manual): • Check antenna alignment. • Verify that antenna polarization is the same at both ends. • Verify that the range matches specifications. • Verify line-of-sight/antenna alignment/antenna height.
Wireless link established, but there is no Ethernet activity (AP and WB units).	1. Ethernet hub port or UTP cable is faulty. 2. Ethernet port in unit is faulty.	1. Check that the LINK LED is on and solid at the hub port. If this is not the case, the port is inactive. Try another port on the hub or another UTP cable. 2. Verify that Ethernet port in unit is working. Ping unit to verify Ethernet connection. 3. Verify that you are using a cross-over UTP cable (pins 1

Problem and Indication	Possible Cause	Corrective Action
		& 3, 2 & 6) if connected directly to workstation, or a straight-through cable if connected to a hub. 4. Check ETHR LED indicator in unit and Ethernet counters in Monitor to verify Ethernet activity (see section 3.6.1).
Wireless link established, but there is no Ethernet activity (SA-10 and SA-40 units).	1. Ethernet port on Network Interface card is faulty. 2. Ethernet port of unit is faulty. 3. UTP cable is faulty.	1. Verify that the LINK LED is lit and solid at the NIC port. If this is not the case, the port is inactive. Try using another UTP cable or another workstation. 2. Ping the unit to check the Ethernet port. If you cannot ping the unit, this may indicate failure of cable, Ethernet port of unit or Ethernet port of workstation's NIC. Change UTP cable and retry. If you still cannot ping the unit, exchange units and try to ping the new unit using the same NIC and cable.
No network detected at Station Adapter (SA-10, SA-40) workstation.	1. Workstation networking is improperly configured. 2. UTP cable connection is faulty. 3. Failure to pass Ethernet packets.	1. Reset both Access Point and Station Adapter. • Re-establish network connection. • Verify proper workstation network configuration. 2. Try to ping the remote network. Failure to detect the network may indicate a failure to pass Ethernet packets. 3. Verify UTP cable connection. Solid LINK LED in workstation NIC indicates proper Ethernet connection. 4. Check monitor messages for errors or other indications of problems. 5. Check station counters to verify increase in Ethernet counters which indicates Ethernet activity (see section 3.6.1).
High quality signal but throughput is poor.	1. Too much interference or multipath propagation. 2. Ethernet port of the unit may be faulty.	1. Move the unit or the antennas out of the range of interference. • Check counters to see if more than 10% of total transmitted frames are retransmitted fragments (see section 3.6.1). • Check if more than 10% of total received data frames are bad fragments (see section 3.6.1). 2. Verify Ethernet port activity by checking Ethernet counters (see section 3.6.1).
Link signal quality low or not as good as expected (indoor installation).	1. Possible multipath or structural interference.	Reposition the unit outside range of possible interference. • Check for heavy metal structures (e.g. elevators, racks, file cabinets) near unit. • Check counters for excessive retransmissions or received bad fragments. • Site may require higher gain antennas. • site may require a multicell structure (multiple AP units) due to multipath/structural interference.
Link signal quality low or not as good as expected (outdoor installation).	There may be a problem with certain aspects of outdoor installation considerations (see relevant section in *this manual*).	Refer to section 5.3, *Outdoor Installation Considerations*: • Verify that there is a clear line-of-site. • Verify antenna height. • Verify antenna polarization. • Verify antenna alignment. • Check length of cable between antenna and unit (an

Problem and Indication	Possible Cause	Corrective Action
		overly long extension cable may adversely affect performance).
Unit associates with the wrong Access Point.	In a multicell structure with overlapping cells, the units may not associate with the closest Access Point.	For a unit to associate with a specific Access Point, assign a unique ESSID to the Access Point and to all the units you want to include in that wireless network.
Reduced performance in a multi-AP configuration.	The APs in the same coverage area have not been assigned unique hopping sequences.	Assign a unique hopping sequence to each AP in the coverage area. Each AP must have a unique hopping sequence regardless of ESSID.
Rx / Tx calibration error messages.	Auto Calibration is enabled for a “DE” unit.	Disable Auto Calibration for the unit (refer to section 3.5).

8.2. Checking Counters

Checking counters is also a good way to pinpoint any problems that may occur in the ***BreezeNET*** wireless LAN. Counters can be checked from the monitor. See section 3.6.1.

8.2.1. WLAN Counters

When checking WLAN counters, total retransmitted fragments should be below 10% of total transmitted (bridge) frames. If total retransmitted fragments are above 10%, this indicates errors in data transmission. Too many retransmissions may be an indication of interference between the transmitting and receiving units. Also, the ratio between Frames Dropped (too many retries) and Total Transmitted Frames (Bridge) should not exceed 1:40 (2.5%)

Received bad fragments should be no more than 10% of the total received data frames. If more than 10% of the total received data frames are bad fragments, this may indicate that there is a problem with the wireless link.

Refer to the Troubleshooting guide (section 8) above for possible corrective action.

8.2.2. Ethernet Counters

When checking the Ethernet counters, received bad frames should be zero (0). If this is not the case, this may indicate a problem with the Ethernet connection. Verify Ethernet port link at hub, workstation, and unit. Assign a unique IP address to the unit and ping.

9. APPENDIX

This appendix includes the following sections:

- **Supported MIBs and Traps –** Lists MIBs and traps supported by ***BreezeNET PRO.11 Series*** products.
- **Technical Specifications –** Lists product and attachment specifications.
- **Wireless LAN Concepts –** Provides an overview of the concepts related to wireless LANs.
- **Radio Signal Propagation –** Discusses the concepts and applications of radio signal propagation relevant to wireless LANs.
- **IEEE 802.11 Technical Tutorial –** Introduces the new 802.11 standard.

9.1. Supported MIBs and Traps

This chapter lists MIBs and traps supported by ***BreezeNET PRO.11 Series*** products.

9.1.1. Supported MIBs

All products in the ***BreezeNET PRO.11 Series*** as well as the Extended Range Access Point (AP-10 DE) and Workgroup Bridge (WB-10 DE) contain an embedded SNMP (Simple Network Management Protocol) agent. All functions can be accessed from the Management Information Base (MIB) using an SNMP application.

BreezeNET PRO.11 Series agents support the following MIBs:

- MIB-II (RFC1213)
- BRIDGE-MIB (RFC1286)
- BreezeCOM Private MIB

The BreezeCOM Private MIB can be viewed by opening the MIB file on the provided diskette.

9.1.2. Supported Traps

The following traps are implemented by BreezeNET PRO.11 units. All BreezeNET PRO.11 units with enabled Trap Sending will send traps to the network's designated managers. The traps can be viewed and filtered using SNMPc.

To enable/disable Trap Sending for a device, use the *IP and SNMP Parameters* menu (see section 3.4.2).

The following table lists the traps implemented by BreezeCOM PRO.11 units:

Trap	Variables	Description
brzAProamingIn	brzTrapSTAMacAddr	A station has roamed into this AP coverage area. The trap contains the MAC address of the associated station.
brzAPassociated	brzTrapSTAMacAddr	A new station is associated with this AP. The trap contains the MAC address of the associated station.
brzAPdisassociated	brzTrapSTAMacAddr	A station has disassociated itself from this AP. The trap contains the MAC address of the associated station.
brzAPaging	brzTrapSTAMacAddr	A station association was aged out and removed from this AP. The trap contains the MAC address of the aged-out station.
brzAProamedout	brzTrapSTAMacAddr	A station has roamed out of this AP's range. The trap contains the MAC address of the station that roamed out.
brzSTAassociated	brzLastAPMacAddr brzTrapAPMac brzTrapLastRssiQuality brzTrapRssiQuality	A station has become associated with, or roamed to, a new AP. The trap contains the MAC address and average RSSI level of the new AP (*TrapAPMac* and *TrapRssiQuality* variables). If the station has been roaming, the MAC address of the old AP and the RSSI level prior to roaming are also provided (*LastAPMacAddr* and *LastRssiQuality* variables). For an association, the second address appears as all zeros.
brzWlanStatus	brzTrapToggle brzTrapMacAddress	The wireless media condition has changed. An ON value is sent when the wireless LAN quality for a station or AP drops below the WLAN trap threshold. An OFF value is sent if the quality improves beyond the threshold. The current value of wireless LAN quality is also sent.
brzWlanStatusOfStation	brzTrapToggle brzTrapMacAddress	The quality of the wireless connection to the AP has changed. An ON value is sent when the connection goes lower than the predetermined threshold. An OFF value is sent when the quality improves above the threshold. The brzTrapMacAddress variable contains the MAC address of the applicable station.
brzGeneral	brzTrapIndex brzTrapText	For future use.

9.2. Technical Specifications

9.2.1. Specifications for BreezeNET PRO.11 Units

The following table provides the technical specifications for all products in the ***BreezeNET PRO.11 Series***.

Technical Specifications	AP-10 PRO.11, SA-10/40 PRO.11, WB-10 PRO.11	SA-PCR PRO.11 SA-PCD PRO.11
Wired LAN interface		
Compliant with	Ethernet / IEEE 802.3 CSMA/CD standard	N/A
Physical Interface	10BaseT	PC Card type II / PCMCIA 2.1
Network Operating Systems supported	All	Windows 95, 98, NT4
Network protocols supported	All	NDIS
Wireless LAN interface		
Compliant with	IEEE 802.11 CSMA / CA Wireless LAN standard	
Physical interface – two antennas	Integrated or External	
Radio Specifications		
Type	Frequency Hopping Spread Spectrum (FHSS)	
Frequency range	2.4 GHz – 2.4835 GHz (ISM band) (different ranges available for countries using other bands)	
Dwell time	32, 64, 128 ms	
Transmitted power: - integrated antennas	Up to 100 mW (20dBm) EIRP	
Transmitted power: - external antennas	D models: - High Power (at the connector): 17dBm (50mW) - Low Power (at the connector): 4dBm (25 mW)	
	DE models: At the connector: 0.01mW (-2dBm)	N/A
Sensitivity - @ 1 Mbps - @ 2 Mbps - @ 3 Mbps	- 81 dBm - 75 dBm - 67 dBm	
Modulation	Multilevel GFSK	
Demodulation Technology	DSP-based with adaptive equalization	
Antenna Diversity	Two antennas, selected for use on a packet basis	
Frequency Accuracy	+/- 10 PPM	
Approvals of Compliance	FCC part 15, ETS 300-328, UL, UL/C, TUV/GS, CE	

Technical Specifications	Access Points AP-10 PRO.11	Station Adapters SA-10/40 PRO.11	Ethernet Bridges WB-10 PRO.11	SA-PCR/ SA-PCD Adapters SA-PC PRO.11
Configuration and Management				
Configuration and Setup	Via Local Monitor port (serial RS-232)			Via Application
SNMP management - SNMP agents - Access via	 MIB II, Bridge MIB, WLAN MIB, and private MIB Wired LAN, Wireless LAN			N/A
Site Survey	Via Local Monitor port (serial RS-232) Via SNMP			Via Application
Front Panel Display LED indicators	- Power on - Wired LAN activity - Wireless LAN synchronization - Wireless LAN signal quality/Load			- Link Status - Data Traffic
S/W upgradeable	Through TFTP download			via PC
System Considerations				
Range (Access Point to Station)	Depends on rate and antenna cable length/quality. (Accurate values must be calculated for specific installations.) Refer to section 5.3.7, *Using Outdoor* Range Tables.			
- Range - unobstructed with integrated antennas	2000 ft. (600m)			1500 ft. (450m)
- Range - unobstructed with external antennas (models D and DE)	USA FCC - up to 6 miles Europe ETSI - up to 2.5 km Europe ETSI (DE model only) - up to 5 km Non-Regulated - 30 km and above			N/A
- Range - Office Environment	Up to 500 ft. (150m)			
Maximum no. of APs per wired LAN	Unlimited			
Maximum no. of co-located (overlapping) cells (Access Points)	15			
Data Rate - over the air - nominal net - aggregate	1, 2, or 3 Mbps Up to 2 Mbps Over 5 Mbps with overlapped cells			
High Speed roaming	up to 60 mph (90 kph)			
Load sharing support	yes (with WIX™)			
Dynamic rate selection based on radio medium quality	Yes			

Technical Specifications	Access Points AP-10 PRO.11	Station Adapters SA-10/40 PRO.11	Ethernet Bridges WB-10 PRO.11	SA-PCR/ SA-PCD Adapters SA-PC PRO.11
Electrical				
External Power Supply	100V - 250V, 50-60Hz, 0.5A			via network PC
Input Voltage	5Vdc			5Vdc
Power Consumption	1.5A (peak) 1.2A (average)			- XMT 365mA (peak) - RCV 280mA (peak)
Dimensions (without antennas and power supply)	5.1” x 3.4” x 1.35” (13cm x 8.6cm x 3cm)			standard PCMCIA Type II
Weight (without antennas and power supply)	0.9 lb. (0.4 kg.)			1.1 oz (32 gr.)
Environmental				
Operating Temperature	32° F - 105° F (0° C - 40° C)			
Operating Humidity	5% - 95% non-condensing			

Note: *All specifications are subject to change without notice.*

9.2.2. Specifications for TPA 24 Transmit Power Amplifier

Models used with the BreezeNET PRO.11 Series	• TPA 24 NL • TPA 24 NH
Input Power	• TPA 24 NL: -10dBm - 0dBm (Low input) • TPA 24 NH: 0dBm - +10dBm (High input)
Output Power	24 dBm (250mW) (fixed output level)
Input Impedance	50Ω
Output Impedance	50Ω (DC short)
Operating Temperature	-20° to 50°C
Power Requirements	12V; 420 mA (Power Supply and Power Inserter are supplied with models TPA-24 NL and TPA-24 NH)
Connectors	• TPA 24: IN - N-type Male OUT - N-type Female • Power Inserter: RF - N-type Male RF&DC - N-type Female
Dimensions	70mm x 150mm x 25mm (2.8”x 6”x 1”)
Operating Environment	• TPA 24 - For outdoor/indoor use • Power Supply - For indoor use • Power Inserter - For indoor use

Note: *All specifications are subject to change without notice.*

9.2.3. Specifications for LNA 10 Low Noise Receive Amplifier

Gain	10dB
Noise Figure	1.5dB Typ, 2dB Max.
Response Flatness	± 1.5dB
Max. RF Input Level	-15dBm
Input Impedance	50Ω
Output Impedance	50Ω
Connectors	• LNA-10: RF IN: N-type, female RF OUT: N-type, male Signal and Power IN: not in use Signal and Power OUT: F-type, female • Power Inserter: To CONV - F-type, female To TV - F-type, female
Power Supply: **Required Voltage** **Required Current**	 +12V to +28Vdc 20mA
Operating Temperature	-20° C to +50° C
Dimensions	60mm x 35mm x 25mm (2.3"x 1.3"x 1")
Operating Environment	LNA 10 - outdoor/indoor Power Supply - indoor Power inserter - indoor

Note: *All specifications are subject to change without notice.*

9.2.4. Specifications for RFS 122 Radio Frequency Splitter

Insertion Loss	3.8dB max.
Isolation	19dB min.
Power Rating	10 W max.
Internal Load Dissipation	125 mW max.
Input Impedance	50Ω
Output Impedance	50Ω
Connectors	• SUM: N-type, Male • PORTS: N-type, Female (on each port)
Operating Temperature	-20° C to +85° C
Dimensions	51mm x 51mm x 19mm (2” x 2” x 0.75”)
Operating Environment	Outdoor/Indoor

Note: *All specifications are subject to change without notice.*

9.2.5. Specifications for AL 1 Lightning Arrestor

Turn on voltage	75V
Insertion loss	0.3dB typical
DC path from input to output	existing
Operating Temperature	-55° C to +70° C
Dimensions	67.5mm x 25mm x 25mm (2.7” x 1” x 1”)
Connectors	• Antenna Port: N-type, Female • Equipment Port: N-type, Female
Operating Environment	Indoor/Outdoor
Grounding	One of the female-type N connectors is mounted directly through a hole in the shelter wall and held in place with a lockwasher and nut.

Note: *All specifications are subject to change without notice.*

9.3. Wireless LAN Concepts

Wireless LAN technology is becoming increasingly popular for a wide variety of applications. After evaluating the technology, users are convinced of its reliability, more than satisfied with its performance, and are ready to use it for large-scale and complex wireless networks.

Originally designed for indoor office applications, today's wireless LANs can be used for both indoor client-server and peer-to-peer networks as well as for outdoor point-to-point and point-to-multipoint remote bridging applications.

Wireless LANs are designed to be modular and very flexible. They can also be optimized for different environments. For example, point-to-point outdoor links are less susceptible to interference and can have higher performance if designers increase the "dwell time" and disable the "collision avoidance" and "fragmentation" mechanisms described later in this section.

Topology

Wired LAN Topology

Traditional LANs (Local Area Networks) link PCs and other computers to one another and to file servers, printers and other network equipment using cables or optic fibers as the transmission medium.

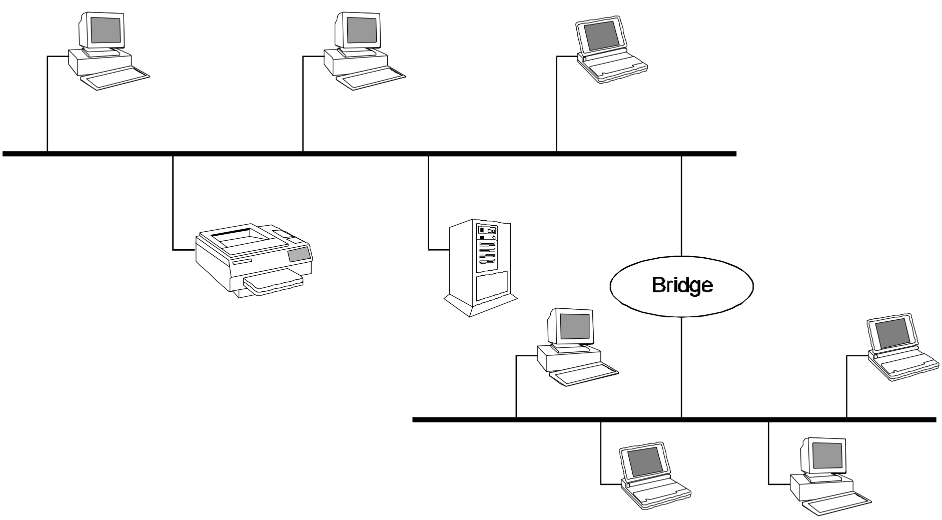


Figure 9.1: Wired LAN Topology

Wireless LAN Topology

Wireless LANs allow workstations to communicate and to access the network using radio propagation as the transmission medium. Wireless LANs can be connected to existing wired LANs as an extension, or can form the basis of a new network. While adaptable to both indoor and outdoor environments, wireless LANs are especially suited to indoor locations such as office buildings, manufacturing floors, hospitals and universities.

The basic building block of the wireless LAN is the Cell. This is the area in which wireless communication takes place. The coverage area of a cell depends on the strength of the propagated radio signal and the type and construction of walls, partitions and other physical characteristics of the indoor environment. PC-based workstations, notebook and pen-based computers can move freely in the cell.

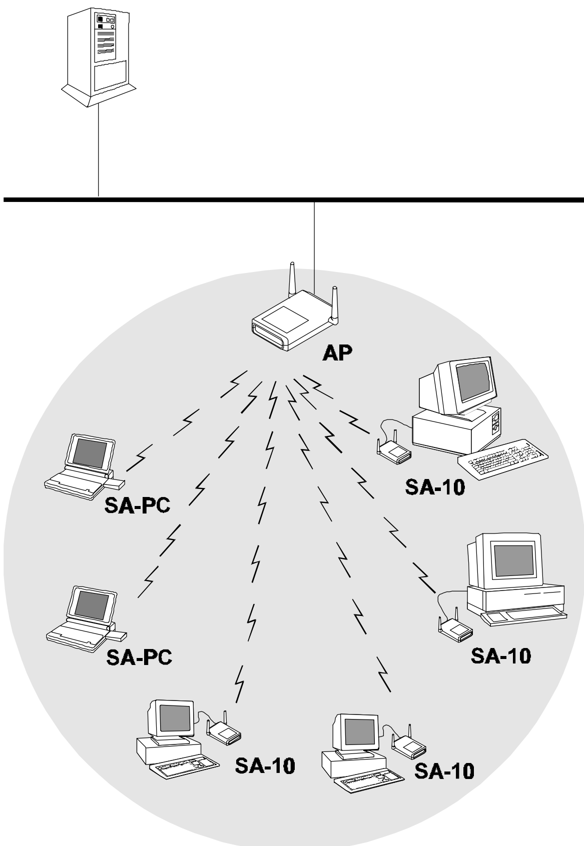


Figure 9.2: The Basic Wireless LAN Cell

Each wireless LAN cell requires some communications and traffic management. This is coordinated by an Access Point (AP) which communicates with each wireless station in its coverage area. Stations also communicate with each other via the AP, so communicating stations can be hidden from one another. In this way, the AP functions as a relay, extending the range of the system.

The AP also functions as a bridge between the wireless stations and the wired network and the other wireless cells. Connecting the AP to the backbone or other wireless cells can be done by wire or by a separate wireless link, using wireless bridges. The range of the system can be extended by cascading several wireless links, one after the other.

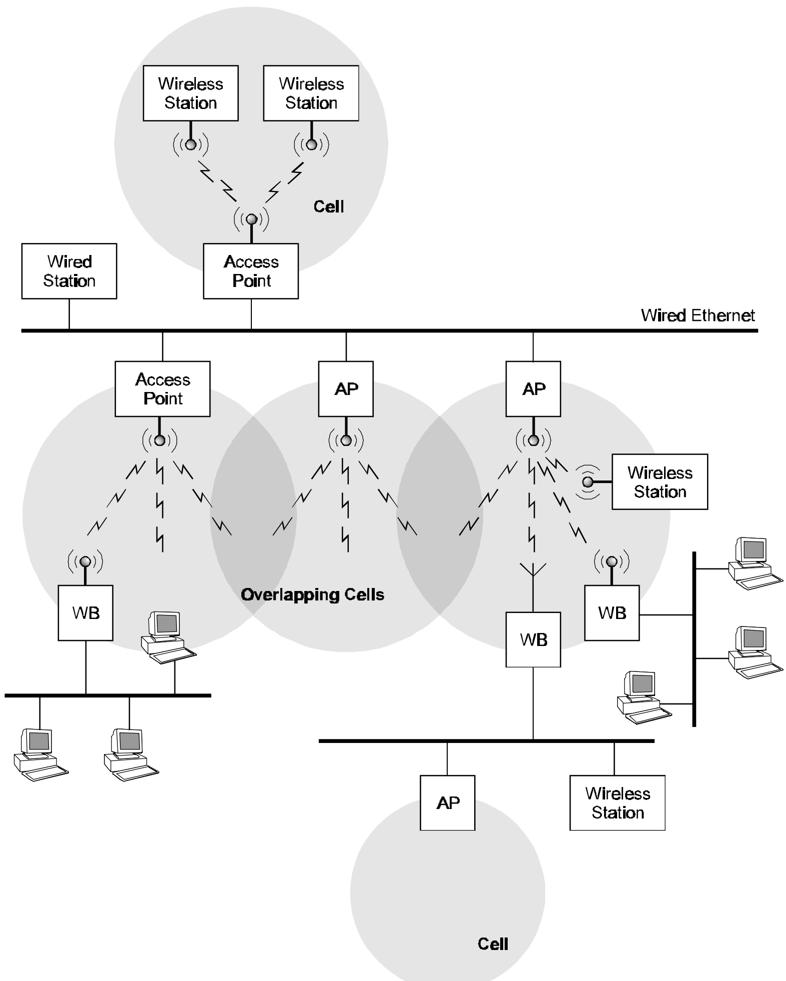


Figure 9.3: Wireless LAN Connectivity

Roaming

When any area in the building is within reception range of more than one Access Point, the cells' coverage is said to overlap. Each wireless station automatically establishes the best possible connection with one of the Access Points. Overlapping coverage areas are an important attribute of the wireless LAN setup, because this enables seamless roaming between overlapping cells.

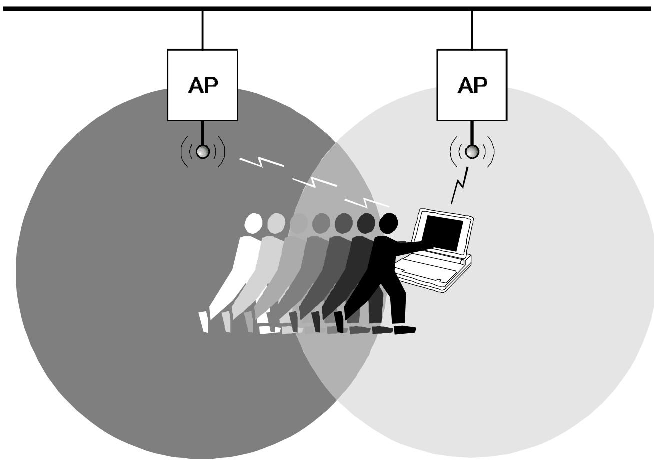


Figure 9.4: Roaming Through Overlapping Cells

Roaming allows mobile users with portable stations to move freely between overlapping cells, constantly maintaining their network connection. Roaming is seamless: a work session can be maintained while moving from one cell to another. Multiple Access Points can provide wireless coverage for an entire building or campus. When the coverage area of two or more APs overlap, the stations in the overlapping area can establish the best possible connection with one of the APs, continuously searching for the best AP. In order to minimize packet loss during switchover, the "old" and "new" APs communicate to coordinate the process.

Load Balancing

Congested areas with many users and heavy traffic load per unit may require a multi-cell structure. In a multi-cell structure, several co-located APs "illuminate" the same area creating a common coverage area which increases aggregate throughput. Stations inside the common coverage area automatically associate with the AP that is less loaded and provides the best signal quality. The stations are equally divided between the APs in order to equally share the load between all APs. Efficiency is maximized because all APs are working at the same low level load. Load balancing is also known as load sharing.

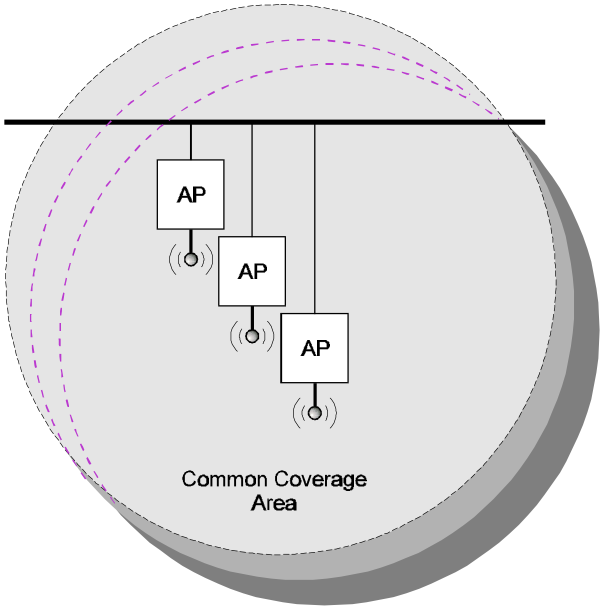


Figure 9.5: The Common Coverage Area of a Multi-cell Structure

Dynamic Rate Switching

The data rate of each station is automatically adjusted according to the received signal quality. Performance (throughput) is maximized by increasing the data rate and decreasing re-transmissions. This is very important for mobile applications where the signal quality fluctuates rapidly, but less important for fixed outdoor installations where signal quality is stable.

Media Access

When many users are located in the same area, performance becomes an issue. To address this issue, wireless LANs use the Carrier Sense Multiple Access (CSMA) algorithm with a Collision Avoidance (CA) mechanism in which each unit senses the medium before it starts to transmit.

If the medium is free for several microseconds, the unit can transmit for a limited time. If the medium is busy, the unit will back off for a random time before it senses again. Since transmitting units compete for air time, the protocol should ensure equal fairness between the stations.

Fragmentation

Fragmentation of packets into shorter fragments adds protocol overhead and reduces protocol efficiency when no errors are expected, but reduces the time spent on re-transmissions if errors are likely to occur. No fragmentation or longer fragment length adds overhead and reduces efficiency in case of errors and re-transmissions (multi-path).

Collision Avoidance

To avoid collisions with other incoming calls, each station transmits a short RTS (Request To Send) frame before the data frame. The Access Point sends back a CTS (Clear To Send) frame with permission to start the data transmission. This frame includes the time that this station is going to transmit. This frame is received by all the stations in the cell, notifying them that another unit will transmit during the following Xmsec, so they can not transmit even if the medium seems to be free (the transmitting unit is out of range).

Channelization

Using Frequency Hopping Spread Spectrum (FHSS), different hopping sequences are assigned to different co-located cells. Hopping sequences are designed so different cells can work simultaneously using different channels.

Since hopping sequences and hopping timing of different cells cannot be synchronized (according to FCC regulations), different cells might try to use the same channel occasionally. Then, one cell uses the channel while the other cell backs off and waits for the next hop. In the case of a very noisy environment (multiples and interference), the system must hop quickly. If the link is quiet and clean, it is better to hop slowly, reducing overhead and increasing efficiency.

9.4. Radio Signal Propagation

9.4.1. Introduction

This section explains and simplifies many of the terms relating to antennas and RF (Radio Frequency) used when dealing with an RF installation system.

The following diagram depicts a typical radio system:

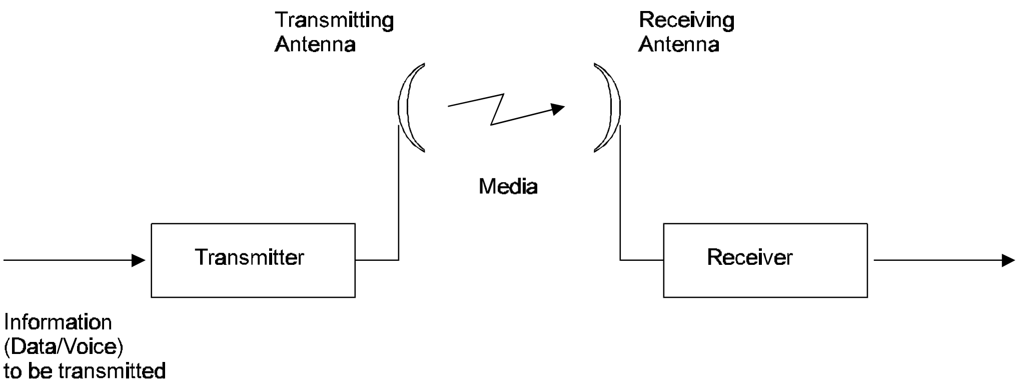


Figure 9.6: A Typical Radio System

A radio system transmits information to the transmitter. The information is transmitted through an antenna which converts the RF signal into an electromagnetic wave. The transmission medium for electromagnetic wave propagation is free space.

The electromagnetic wave is intercepted by the receiving antenna which converts it back to an RF signal. Ideally, this RF signal is the same as that originally generated by the transmitter. The original information is then demodulated back to its original form.

9.4.2. RF Terms and Definitions

dB

The dB convention is an abbreviation for decibels. It is a mathematical expression showing the relationship between two values.

RF Power Level

RF power level at either the transmitter output or the receiver input is expressed in Watts. It can also be expressed in dBm. The relation between dBm and Watts can be expressed as follows:

$P_{dBm} = 10 \text{ x Log } P_{mw}$

For example: 1 Watt = 1000 mW; $P_{dBm} = 10 \text{ x Log } 1000 = 30$ dBm
100 mW; $P_{dBm} = 10 \text{ x Log } 100 = 20$ dBm

For link budget calculations, the dBm convention is more convenient than the Watts convention.

Attenuation

Attenuation (fading) of an RF signal is defined as follows:

Figure 9.7: Attenuation of an RF signal

P_{in} is the incident power level at the attenuator input
P_{out} is the output power level at the attenuator output

Attenuation is expressed in dB as follows:

$P_{dB} = -10 \text{ x Log } (P_{out}/P_{in})$

For example: If, due to attenuation, half the power is lost ($P_{out}/P_{in} = 1/2$), attenuation in dB is $-10 \text{ x Log } (1/2) = 3_{dB}$

Path Loss

Loss of power of an RF signal travelling (propagating) through space. It is expressed in dB. Path loss depends on:

- The distance between transmitting and receiving antennas
- Line of sight clearance between the receiving and transmitting antennas
- Antenna height

Free Space Loss

Attenuation of the electromagnetic wave while propagating through space. This attenuation is calculated using the following formula:

Free space loss = 32.4 + 20xLog(F_{Mhz}) + 20xLog(R_{Km})

F is the RF frequency expressed in Mhz.
R is the distance between the transmitting and receiving antennas.
At 2.4 Ghz, this formula is: 100+20xLog(R_{Km})

Antenna Characteristics

Isotropic Antenna

A hypothetical, lossless antenna having equal radiation intensity in all directions. Used as a zero dB gain reference in directivity calculation (gain).

Antenna Gain

A measure of directivity. It is defined as the ratio of the radiation intensity in a given direction to the radiation intensity that would be obtained if the power accepted by the antenna was radiated equally in all directions (isotropically). Antenna gain is expressed in dBi.

Radiation Pattern

A graphical representation in either polar or rectangular coordinates of the spatial energy distribution of an antenna.

Side Lobes

The radiation lobes in any direction other than that of the main lobe.

Omni-directional Antenna

Radiates and receives equally in all directions in azimuth. The following diagram shows the radiation pattern of an omnidirectional antenna with its side lobes in polar form.

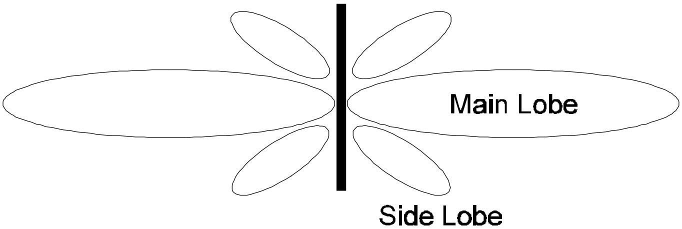


Figure 9.8: Side View

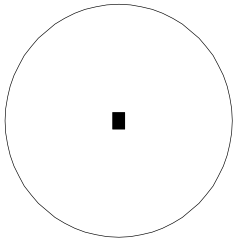


Figure 9.9: Top View

Directional Antenna

Radiates and receives most of the signal power in one direction. The following diagram shows the radiation pattern of a directional antenna with its side lobes in polar form:

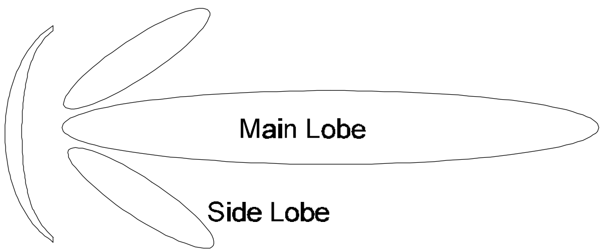


Figure 9.10: Radiation Pattern of Directional Antenna

Antenna Beamwidth

The directiveness of a directional antenna. Defined as the angle between two half-power (-3 dB) points on either side of the main lobe of radiation.

System Characteristics

Receiver Sensitivity

The minimum RF signal power level required at the input of a receiver for certain performance (e.g. BER).

EIRP (Effective Isotropic Radiated Power)

The antenna transmitted power. Equal to the transmitted output power minus cable loss plus the transmitting antenna gain.

P_{out}	Output power of transmitted in dBm
Ct	Transmitter cable attenuation in dB
Gt	Transmitting antenna gain in dBi
Gr	Receiving antenna gain in dBi
Pl	Path loss in dB
Cr	Receiver cable attenuation is dB
Si	Received power level at receiver input in dBm
Ps	Receiver sensitivity is dBm

$Si = P_{out} - Ct + Gt - Pl + Gr - Cr$

$EIRP = P_{out} - Ct + Gt$

Example:

Link Parameters:

Frequency: 2.4 Ghz
P_{out} = 4 dBm (2.5 mW)
Tx and Rx cable length (Ct and Cr) = 10 m. cable type RG214 (0.6 dB/meter)
Tx and Rx antenna gain (Gt and Gr) = 18 dBi
Distance between sites = 3 Km
Receiver sensitivity (Ps) = -84 dBm

Link Budget Calculation

$EIRP = P_{out} - Ct + Gt = 16$ dBm
$Pl = 32.4 + 20xLog(FMhz) + 20xLog(RKm) \cong 110$ dB
$Si = EIRP - Pl + Gr - Cr = -82$ dBm

In conclusion, the received signal power is above the sensitivity threshold, so the link should work. The problem is that there is only a 2 dB difference between received signal power and sensitivity. Normally, a higher margin is desirable due to fluctuation in received power as a result of signal fading.

Signal Fading

Fading of the RF signal is caused by several factors:

- Multipath

The transmitted signal arrives at the receiver from different directions, with different path lengths, attenuation and delays. The summed signal at the receiver may result in an attenuated signal.

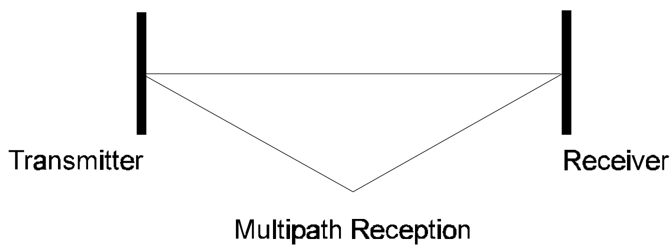


Figure 9.11: Multipath Reception

- Bad Line of Sight

  An optical line of sight exists if an imaginary straight line can connect the antennas on either side of the link.

  Radio wave clear line of sight exists if a certain area around the optical line of sight (Fresnel zone) is clear of obstacles. A bad line of sight exists if the first Fresnel zone is obscured.

- Link Budget Calculations
- Weather conditions (Rain, wind, etc.)

At high rain intensity (150 mm/hr), the fading of an RF signal at 2.4 GHz may reach a maximum of 0.02 dB/Km

Wind may cause fading due to antenna motion

- Interference

Interference may be caused by another system on the same frequency range, external noise, or some other co-located system.

The Line of Sight Concept

An optical line of sight exists if an imaginary straight line can be drawn connecting the antennas on either side of the link.

Clear Line of Sight

A clear line of sight exists when no physical objects obstruct viewing one antenna from the location of the other antenna.

A radio wave clear line of sight exists if a defined area around the optical line of sight (Fresnel Zone) is clear of obstacles.

Fresnel Zone

The Fresnel zone is the area of a circle around the line of sight.
The Fresnel Zone is defined as follows:

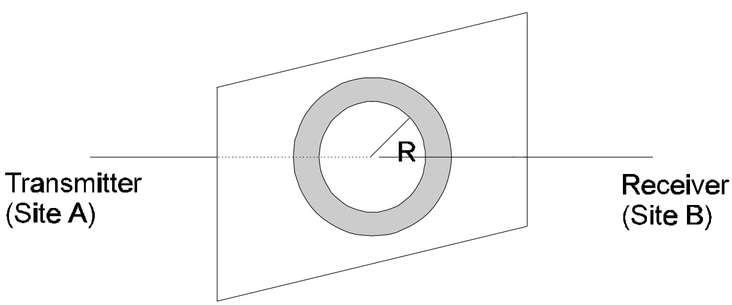


Figure 9.12: Fresnel Zone

$R = \frac{1}{2} \sqrt{(\lambda x D)}$

R: radius of the first Fresnel zone

λ: wavelength

D: distance between sites

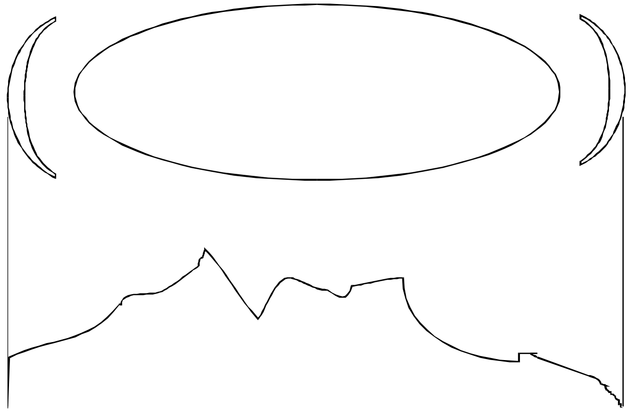


Figure 9.13: Fresnel Zone Clear of Obstacles

When at least 80% of the first Fresnel Zone is clear of obstacles, propagation loss is equivalent to that of free space.

9.5. IEEE 802.11 Technical Tutorial

The purpose of this chapter is to give technical readers a basic overview of the new IEEE 802.11 Standard, enabling them to understand the basic concepts, principles of operation, and the reasons behind some of the features and/or components of the Standard.

The document does not cover the entire Standard and does not provide enough information for the reader to implement an 802.11-compliant device (for this purpose the reader should refer to the Standard itself).

9.5.1. Architecture Components

An 802.11 LAN is based on a cellular architecture where the system is subdivided into cells. Each cell (called **Basic Service Set,** or **BSS**, in the 802.11 nomenclature) is controlled by a Base Station (called **Access Point** or, in short, **AP**).

Although a wireless LAN may be formed by a single cell, with a single Access Point, (and as will be described later, it can also work without an Access Point), most installations will be formed by several cells, where the

Access Points are connected through some kind of backbone (called **Distribution System** or **DS**). This backbone is typically Ethernet but, in some cases, might be wireless itself.

The whole interconnected wireless LAN, including the different cells, their respective Access Points and the Distribution System, is seen as a single 802 network to the upper layers of the OSI model and is known in the Standard as the **Extended Service Set** (**ESS**).

The following diagram shows a typical 802.11 LAN including the components described above:

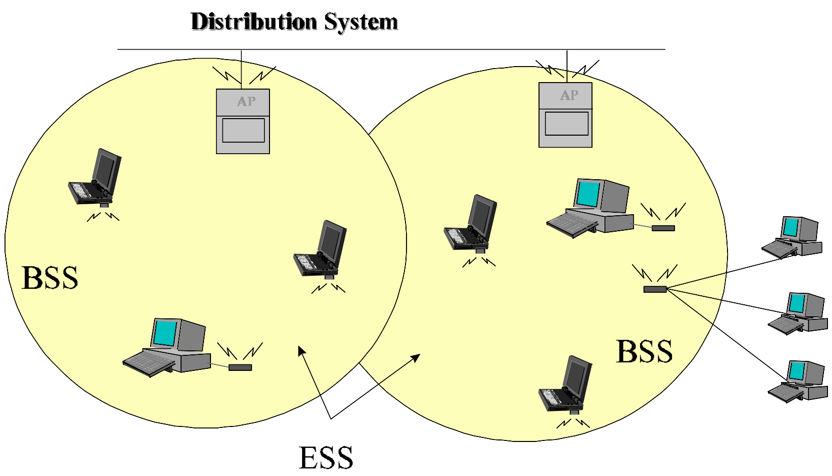


Figure 9.14: Typical 802.11 LAN

The standard also defines the concept of a **Portal**. A portal is a device that interconnects between an 802.11 and another 802 LAN. This concept is an abstract description of part of the functionality of a "translation bridge".

Even though the standard does not necessarily require it, typical installations will have the AP and the Portal on a single physical entity. This is also the case with BreezeCOM's AP which provides both functions.

9.5.2. IEEE 802.11 Layers Description

As in any 802.x protocol, the 802.11 protocol covers the Media Access Control Layer (MAC) and Physical Layer (PHY). The Standard currently defines a single MAC which interacts with three PHYs (all of them running at 1 or 2 Mbit/s) as follows:

- Frequency Hopping Spread Spectrum (FHSS) in the 2.4 GHz Band
- Direct Sequence Spread Spectrum (DSSS) in the 2.4 GHz Band, and
- InfraRed

802.2			Data Link Layer
802.11 MAC			
FH	DS	IR	PHY Layer

Beyond the standard functionality usually performed by MAC Layers, the 802.11 MAC performs other functions that are typically related to upper layer protocols, such as Fragmentation, Packet Retransmissions, and Acknowledges.

9.5.3. The MAC Layer

The MAC Layer defines two different access methods, the Distributed Coordination Function and the Point Coordination Function:

9.5.3.1 The Basic Access Method: CSMA/CA

The basic access mechanism, called the **Distributed Coordination Function**, is basically a Carrier Sense Multiple Access with Collision Avoidance mechanism (known as **CSMA/CA**). CSMA protocols are well-known in the industry, the most popular being Ethernet, which is a CSMA/CD protocol (CD standing for Collision Detection).

A CSMA protocol works as follows: A station desiring to transmit senses the medium. If the medium is busy (i.e. some other station is transmitting) then the station defers its transmission to a later time. If the medium seems free then the station is allowed to transmit.

These kinds of protocols are very effective when the medium is not heavily loaded since it allows stations to transmit with minimum delay. But there is always a chance of two or more stations simultaneously sensing the medium as being free and transmitting at the same time, causing a collision.

These collision situations must be identified so the MAC layer can retransmit the packet itself, not by the upper layers, to avoid significant delay. In the Ethernet case, a collision is recognized by the transmitting stations which listen while transmitting and go into a retransmission phase based on an **exponential random backoff** algorithm.

While these Collision Detection Mechanisms are a good idea on a wired LAN, they cannot be used on a wireless LAN environment for two main reasons:

1. Implementing a Collision Detection Mechanism would require the implementation of a Full-Duplex radio capable of transmitting and receiving at the same time, an approach that would increase the price significantly.
2. In a wireless environment we cannot assume that all stations can hear each other (a basic assumption of the Collision Detection scheme), and the fact that a station wants to transmit and senses the medium as free doesn't necessarily mean that the medium is free around the receiver's area.

In order to overcome these problems, 802.11 uses a Collision Avoidance (CA) mechanism together with a Positive Acknowledge scheme, as follows:

1. A station wanting to transmit senses the medium. If the medium is busy then it delays. If the medium is free for a specified time (called Distributed Inter Frame Space (DIFS) in the standard), then the station is allowed to transmit.
2. The receiving station checks the CRC of the received packet and sends an acknowledgment packet (ACK). Receipt of the acknowledgment indicates to the transmitter that no collision occurred. If the sender does not receive the acknowledgment, then it retransmits the fragment until it either receives acknowledgment or is thrown away after a given number of retransmissions.

9.5.3.2 Virtual Carrier Sense

In order to reduce the probability of two stations colliding because they cannot hear each other, the standard defines a Virtual Carrier Sense mechanism:

A station wanting to transmit a packet first transmits a short control packet called **RTS** (Request To Send), which includes the source, destination, and the duration of the following transaction (i.e. the packet and the respective **ACK**), the destination station responds (if the medium is free) with a response control Packet called **CTS** (Clear to Send), which includes the same duration information.

All stations receiving either the RTS or the CTS, set their **Virtual Carrier Sense** indicator (called **NAV**, for **Network Allocation Vector**), for the given duration, and use this information together with the Physical Carrier Sense when sensing the medium.

This mechanism reduces the probability of a collision on the receiver area by a station that is “hidden” from the transmitter to the short duration of the RTS transmission because the station hears the CTS and “reserves” the medium as busy until the end of the transmission. The duration information on the RTS also protects the transmitter area from collisions during the ACK (from stations that are out of range of the acknowledging station).

It should also be noted that, due to the fact that the RTS and CTS are short frames, the mechanism also reduces the overhead of collisions, since these are recognized faster than if the whole packet was to be transmitted. (This is true if the packet is significantly bigger than the RTS, so the standard allows for short packets to be transmitted without the RTS/CTS transmission. This is controlled per station by a parameter called **RTS Threshold**).

The following diagrams show an exchange between stations A and B, and the NAV setting of their neighbors:

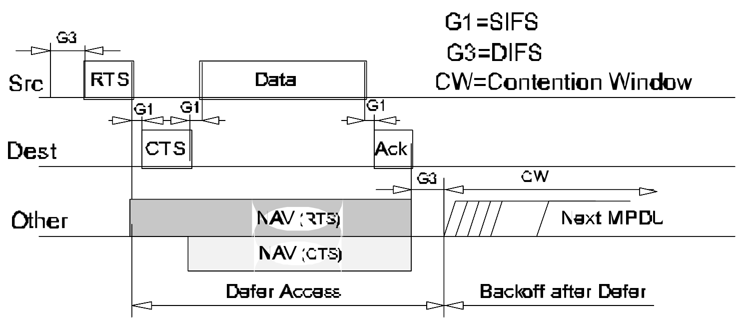


Figure 9.15: Transaction Between Stations A and B

The NAV State is combined with the physical carrier sense to indicate the busy state of the medium.

9.5.3.3 MAC Level Acknowledgments

As mentioned earlier in this document, the MAC layer performs Collision Detection by expecting the reception of an acknowledge to any transmitted fragment (Packets that have more than one destination, such as Multicasts, are not acknowledged.)

9.5.3.4 Fragmentation and Reassembly

Typical LAN protocols use packets several hundred bytes long (the longest Ethernet packet could be up to 1518 bytes long).

There are several reasons why it is preferable to use smaller packets in a wireless LAN environment:

- Due to the higher Bit Error Rate of a radio link, the probability of a packet getting corrupted increases with the packet size.
- In case of packet corruption (either due to collision or noise), the smaller the packet, the less overhead it causes to retransmit it.
- On a Frequency Hopping system, the medium is interrupted periodically for hopping (in our case every 20 milliseconds), so, the smaller the packet, the smaller the chance that the transmission will be postponed after dwell time.

However, it doesn't make sense to introduce a new LAN protocol that cannot deal with packets 1518 bytes long which are used on Ethernet, so the committee decided to solve the problem by adding a simple fragmentation/ reassembly mechanism at the MAC Layer.

The mechanism is a simple Send-and-Wait algorithm, where the transmitting station is not allowed to transmit a new fragment until one of the following happens:

1. Receives an ACK for the said fragment, or
2. Decides that the fragment was retransmitted too many times and drops the whole frame.

It should be noted that the standard does allow the station to transmit to a different address between retransmissions of a given fragment. This is particularly useful when an AP has several outstanding packets to different destinations and one of them does not respond.

The following diagram shows a frame (MSDU) being divided to several fragments (MPDUs):

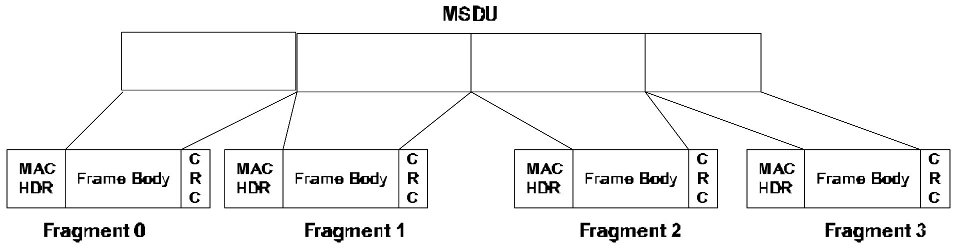


Figure 9.16: Frame Fragmentation

9.5.3.5 Inter Frame Spaces

The Standard defines 4 types of Inter Frame Spaces, which are use to provide different priorities:

- **SIFS - Short Inter Frame Space**, separates transmissions belonging to a single dialog (e.g. Fragment-Ack), and is the minimum Inter Frame Space. There is always at most one single station to transmit at any given time, therefore giving it priority over all other stations.
  This value is a fixed value per PHY and is calculated in such a way that the transmitting station will be able to switch back to receive mode and be capable of decoding the incoming packet. On the 802.11 FH PHY this value is set to 28 microseconds

- **PIFS - Point Coordination IFS**, is used by the Access Point (or Point Coordinator, as called in this case), to gain access to the medium before any other station. This value is SIFS plus a Slot Time (defined in the following paragraph), i.e. 78 microseconds.

- **DIFS - Distributed IFS**, is the Inter Frame Space used for a station willing to start a new transmission, which is calculated as PIFS plus one slot time, i.e. 128 microseconds.

- **EIFS - Extended IFS**, which is a longer IFS used by a station that has received a packet that it could not understand. This is needed to prevent the station (which could not understand the duration information for the Virtual Carrier Sense) from colliding with a future packet belonging to the current dialog.

9.5.3.6 Exponential Backoff Algorithm

Backoff is a well known method used to resolve contention between different stations wanting to access the medium. The method requires each station to choose a Random Number (n) between 0 and a given number, and wait for this number of Slots before accessing the medium, always checking if a different station has accessed the medium before.

The **Slot Time** is defined in such a way that a station will always be capable of determining if another station has accessed the medium at the beginning of the previous slot. This reduces collision probability by half.

Exponential Backoff means that each time the station chooses a slot and happens to collide, it will increase the maximum number for the random selection exponentially.

The 802.11 standard defines an **Exponential Backoff Algorithm**, that must be executed in the following cases:

- When the station senses the medium before the first transmission of a packet, and the medium is busy
- After each retransmission, and
- After a successful transmission

The only case when this mechanism is not used is when the station decides to transmit a new packet and the medium has been free for more than DIFS.

The following figure shows a schematic of the access mechanism:

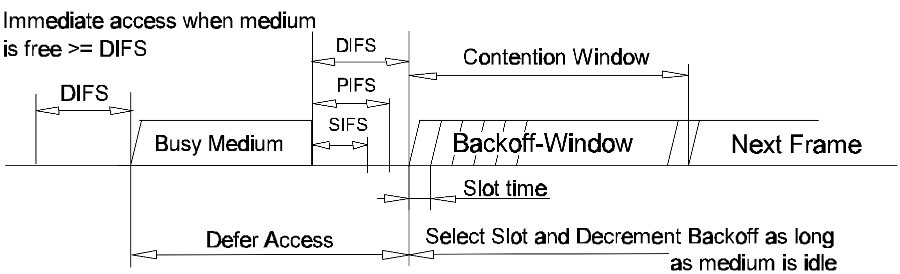


Figure 9.17: Access Mechanism

9.5.4. How Does a Station Join an Existing Cell (BSS)?

When a station wants to access an existing BSS (either after power-up, sleep mode, or just entering the BSS area), the station needs to get synchronization information from the Access Point (or from the other stations when in ad-hoc mode, which will be discussed later).

The station can get this information by one of two means:

1. **Passive Scanning**: In this case the station just waits to receive a Beacon Frame from the AP, (the beacon frame is a frame sent out periodically by the AP containing synchronization information), or
2. **Active Scanning:** In this case the station tries to locate an Access Point by transmitting Probe Request Frames, and waits for Probe Response from the AP.

Both methods are valid. A method is chosen according to the power consumption/performance trade-off.

9.5.4.1 The Authentication Process

Once the station has located an Access Point, and decides to join its BSS, it goes through the **Authentication Process**. This is the interchange of information between the AP and the station, where each side proves the knowledge of a given password.

9.5.4.2 The Association Process

Once the station is authenticated, it then starts the **Association Process**, which is the exchange of information about the station and BSS capabilities, and which allows the DSS (the set of APs) to know about the current position of the station). A station is capable of transmitting and receiving data frames only after the association process is completed.

9.5.5. Roaming

Roaming is the process of moving from one cell (or BSS) to another without losing connection. This function is similar to the cellular phones' handover, with two main differences:

1. On a packet-based LAN system, the transition from cell to cell may be performed between packet transmissions, as opposed to telephony where the transition may occur during a phone conversation, this makes the LAN roaming a little easier, but

2. On a voice system, a temporary disconnection may not affect the conversation, while in a packet-based environment it significantly reduces performance because retransmission is then performed by the upper layer protocols.

The 802.11 standard does not define how roaming should be performed, but defines the basic tools. These include active/passive scanning, and a re-association process, where a station which is roaming from one Access Point to another becomes associated with the new one[1].

9.5.6. Keeping Synchronization

Stations need to keep synchronization, which is necessary for keeping hopping synchronized, and other functions like Power Saving. On an infrastructure BSS, this is achieved by all the stations updating their clocks according to the AP's clock, using the following mechanism:

The AP periodically transmits frames called Beacon Frames. These frames contain the value of the AP's clock at the moment of transmission (note that this is the moment when transmission actually occurs, and not when it is put in the queue for transmission. Since the Beacon Frame is transmitted using CSMA rules, transmission may be delayed significantly).

The receiving stations check the value of their clocks at the moment the signal is received, and correct it to keep in synchronization with the AP's clock. This prevents clock drifting which could cause loss of synch after a few hours of operation.

9.5.7. Security

Security is one of the first concerns that people have when deploying a wireless LAN. The 802.11 committee has addressed the issue by providing what is called WEP (Wired Equivalent Privacy).

Users are primarily concerned that an intruder should not be able to:

- Access the Network resources by using similar wireless LAN equipment
- Capture wireless LAN traffic (eavesdropping)

[1] The BreezeNET product line provides a patented enhanced roaming mechanism which allows stations to roam at speeds of 60 Km/h without losing or duplicating packets.

9.5.7.1 Preventing Access to Network Resources

This is done by the use of an Authentication mechanism where a station needs to prove knowledge of the current key. This is very similar to Wired LAN privacy, in the sense that an intruder needs to enter the premises (by using a physical key) in order to connect his workstation to the wired LAN.

9.5.7.2 Eavesdropping

Eavesdropping is prevented by using the WEP algorithm which is a Pseudo Random Number Generator initialized by a shared secret key. This PRNG outputs a key sequence of pseudo-random bits equal in length to the largest possible packet which is combined with the outgoing/incoming packet producing the packet transmitted in the air.

The WEP is a simple algorithm based on RSA's RC4 which has the following properties:

- **Reasonably strong:**
  Brute-force attack to this algorithm is difficult because every frame is sent with an Initialization Vector which restarts the PRNG for each frame.

- **Self Synchronizing:**
  The algorithm re-synchronizes for each message. This is necessary in order to work in a connection-less environment, where packets may get lost (as any LAN).

9.5.8. Power Saving

Wireless LANs are typically related to mobile applications. In this type of application, battery power is a scare resource. This is the reason why the 802.11 standard directly addresses the issue of Power Saving and defines an entire mechanism which enables stations to go into sleep mode for long periods of time without losing information.

The main idea behind the Power Saving Mechanism is that the AP maintains a continually updated record of the stations currently working in Power Saving mode, and buffers the packets addressed to these stations until either the stations specifically request the packets by sending a polling request, or until they change their operation mode.

As part of its Beacon Frames, the AP also periodically transmits information about which Power Saving Stations have frames buffered at the AP, so these stations wake up in order to receive the Beacon Frame. If there is an indication that there is a frame stored at the AP waiting for delivery, then the station stays awake and sends a Polling message to the AP to get these frames.

Multicasts and Broadcasts are stored by the AP, and transmitted at a pre-known time (each DTIM), when all Power Saving stations who wish to receive this kind of frames are awake.

9.5.9. Frame Types

There are three main types of frames:

- Data Frames: which are used for data transmission
- Control Frames: which are used to control access to the medium (e.g. RTS, CTS, and ACK), and
- Management Frames: which are frames that are transmitted in the same manner as data frames to exchange management information, but are not forwarded to upper layers (e.g. beacon frames).

Each frame type is subdivided into different Subtypes, according to its specific function.

9.5.10. Frame Formats

All 802.11 frames are composed of the following components:

Preamble	PLCP Header	MAC Data	CRC

9.5.10.1 Preamble

This is PHY dependent, and includes:

- **Synch:** An 80-bit sequence of alternating zeros and ones, which is used by the PHY circuitry to select the appropriate antenna (if diversity is used), and to reach steady-state frequency offset correction and synchronization with the received packet timing.
- **SFD:** A Start Frame delimiter which consists of the 16-bit binary pattern 0000 1100 1011 1101, which is used to define frame timing.

9.5.10.2 PLCP Header

The PLCP Header is always transmitted at 1 Mbit/s and contains Logical information used by the PHY Layer to decode the frame. It consists of:

- **PLCP_PDU Length Word:** which represents the number of bytes contained in the packet. This is useful for the PHY to correctly detect the end of packet.
- **PLCP Signaling Field:** which currently contains only the rate information, encoded in 0.5 Mbps increments from 1 Mbit/s to 4.5 Mbit/s.
- **Header Error Check Field:** Which is a 16 Bit CRC error detection field.

9.5.10.3 MAC Data

The following figure shows the general MAC Frame Format. Part of the fields are only present in part of the frames as described later.

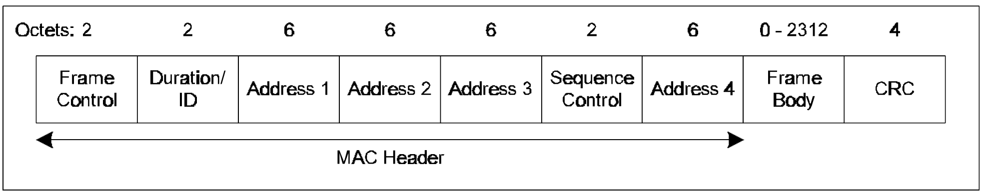


Figure 9.18: MAC Frame Format

Frame Control Field

The Frame Control field contains the following information:

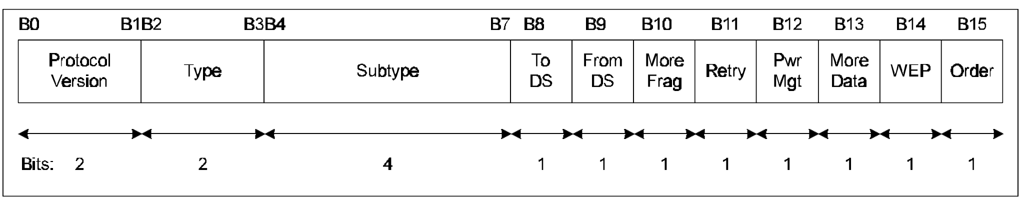


Figure 9.19: Frame Control Field

Protocol Version

This field consists of 2 bits which are invariant in size and placement across following versions of the 802.11 Standard, and will be used to recognize possible future versions. In the current version of the standard the value is fixed as 0.

Type and Subtype

These 6 bits define the Type and SubType of the frame as indicated in the following table:

Type Value b3 b2	Type Description	Subtype Value b7 b6 b5 b4	Subtype Description
00	Management	0000	Association Request
00	Management	0001	Association Response
00	Management	0010	Association Request
00	Management	0011	Reassociation Response
00	Management	0100	Probe Request
00	Management	0101	Probe Response
00	Management	0110-0111	Reserved
00	Management	1000	Beacon
00	Management	1001	ATIM
00	Management	1010	Disassociation
00	Management	1011	Authentication
00	Management	1100	Deauthentication
00	Management	1101-1111	Reserved
01	Control	0000-0001	Reserved
01	Control	1010	PS-Poll
01	Control	1011	RTS
01	Control	1100	CTS
01	Control	1101	ACK
01	Control	1110	CF End
01	Control	1111	CF End + CF-ACK
10	Data	0000	Data
10	Data	0001	Data + CF-Ack
10	Data	0010	Data + CF-Poll
10	Data	0011	Data + CF-ACK + CF-Poll
10	Data	0100	Null Function (no data)
10	Data	0101	CF-Ack (no data)
10	Data	0110	CF-Poll (no data)
10	Data	0111	CF-Ack + CF-Poll (no data)
10	Data	1000-1111	Reserved
10	Data	0000-1111	Reserved

ToDS

This bit is set to 1 when the frame is addressed to the AP for forwarding to the Distribution System (including the case where the destination station is in the same BSS, and the AP is to relay the frame).

The Bit is set to 0 in all other frames.

FromDS

This bit is set to 1 when the frame is received from the Distribution System.

More Fragments

This bit is set to 1 when there are more fragments belonging to the same frame following the current fragment.

Retry

This bit indicates that this fragment is a retransmission of a previously transmitted fragment. This is used by the receiver station to recognize duplicate transmissions of frames that may occur when an Acknowledgment packet is lost.

Power Management

This bit indicates the Power Management mode that the station will be in after the transmission of this frame. This is used by stations which are changing state either from Power Save to Active or vice versa.

More Data

This bit is used for Power Management as well as by the AP to indicate that there are more frames buffered for this station. The station may decide to use this information to continue polling or even changing to Active mode.

WEP

This bit indicates that the frame body is encrypted according to the WEP algorithm

Order

This bit indicates that this frame is being sent using the Strictly-Ordered service class.2

[2] The Strictly-Ordered Service Class is defined for users that cannot accept change of ordering between Unicast Frames and Multicast Frames (ordering of Unicast frames to a specific address is always maintained).

Duration/ID

This field has two meanings depending on the frame type:

- In Power-Save Poll messages this is the Station ID
- In all other frames this is the duration value used for the NAV Calculation.

Address Fields

A frame may contain up to 4 Addresses depending on the ToDS and FromDS bits defined in the Control Field, as follows:

- **Address-1** is always the Recipient Address (i.e. the BSS station that is the immediate recipient of the packet). If ToDS is set, this is the AP Address; if ToDS is not set, then this is the address of the end-station.
- **Address-2** is always the Transmitter Address (i.e. the station which is physically transmitting the packet). If FromDS is set, this is the AP address; if it is not set, then it is the Station address.
- **Address-3** is in most cases the remaining, missing address. On a frame with FromDS set to 1, Address-3 is the original Source Address; if the frame has the ToDS set, then Address 3 is the destination Address.
- **Address-4** is used in special cases where a Wireless Distribution System is used, and the frame is being transmitted from one Access Point to another. In such cases, both the ToDS and FromDS bits are set, so both the original Destination and the original Source Addresses are missing.

The following Table summarizes the usage of the different Addresses according to ToDS and FromDS bits setting:

To DS	From DS	Address 1	Address 2	Address 3	Address 4
0	0	DA	SA	BSSID	N/A
0	1	DA	BSSID	SA	N/A
1	0	BSSID	SA	DA	N/A
1	1	RA	TA	DA	SA

The only known protocol that would need this service class is DEC's LAT.

Sequence Control

The Sequence Control Field is used to represent the order of different fragments belonging to the same frame, and to recognize packet duplications. It consists of two subfields, Fragment Number and Sequence Number, which define the frame and the number of the fragment in the frame.

CRC

The CRC is a 32-bit field containing a 32-bit Cyclic Redundancy Check (CRC)

9.5.11. Most Common Frame Formats

9.5.11.1 RTS Frame Format

The RTS frame looks as follows:

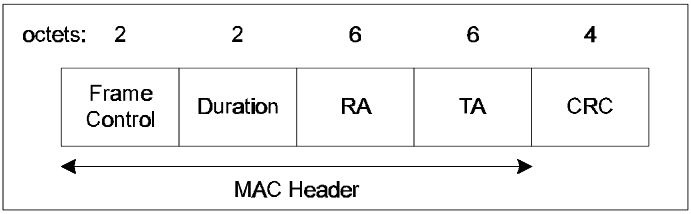


Figure 9.20: RTS Frame Format

The RA of the RTS frame is the address of the STA on the wireless medium that is the intended immediate recipient of the next Data or Management frame.

The TA is the address of the STA transmitting the RTS frame.

The Duration value is the time, in microseconds, required to transmit the next Data or Management frame, plus one CTS frame, plus one ACK frame, plus three SIFS intervals.

9.5.11.2 CTS Frame Format

The CTS frame looks as follows:

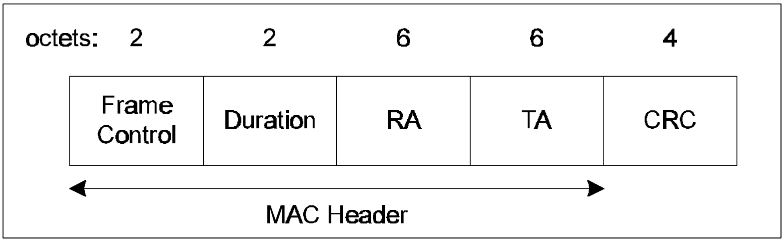


Figure 9.21: CTS Frame

The Receiver Address (RA) of the CTS frame is copied from the Transmitter Address (TA) field of the immediately previous RTS frame to which the CTS is a response.

The Duration value is the value obtained from the Duration field of the immediately previous RTS frame, minus the time, in microseconds, required to transmit the CTS frame and its SIFS interval.

9.5.11.3 ACK Frame Format

The ACK frame looks as follows:

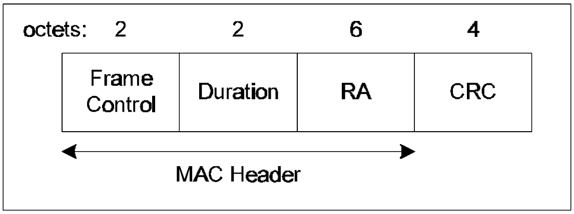


Figure 9.22: ACK Frame Format

The Receiver Address of the ACK frame is copied from the Address 2 field of the immediately previous frame.

If the More Fragment bit was set to 0 in the Frame Control field of the previous frame, the Duration value is set to 0, otherwise the Duration value is obtained from the Duration field of the previous frame, minus the time, in microseconds, required to transmit the ACK frame and its SIFS interval.

9.5.12. Point Coordination Function (PCF)

Beyond the basic Distributed Coordination Function, there is an optional Point Coordination Function, which may be used to implement time-bounded services, like voice or video transmission. This Point Coordination Function makes use of the higher priority that the Access Point may gain by the use of a smaller Inter Frame Space (PIFS).

By using this higher priority access, the Access Point issues polling requests to the stations for data transmission, hence controlling medium access. To still enable regular stations to access the medium, there is a provision that the Access Point must leave enough time for Distributed Access in between the PCF.

9.5.13. Ad-hoc Networks

In certain circumstances, the users may wish to build up wireless LAN networks without an infrastructure (more specifically without an Access Point). This may include file transfer between two notebook users, co-workers meeting outside the office, etc.

The 802.11 Standard addresses this need by the definition of an “ad-hoc” mode of operation. In this case, there is no Access Point and part of its functionality is performed by the end-user stations (such as Beacon Generation, synchronization, etc.). Other AP functions are not supported (such as frame-relaying between two stations not in range, or Power Saving).