COOPER BUSSMANN®

BU-245U-E-A

OK
RX
TX/LINK
RS-232
LAN
RS-485
DIO

COOPER **Bussmann®**

WIRELESS ETHERNET

Cooper Bussmann
BU-245U-E Wireless Ethernet & Device Server
User Manual
Version 1.7

COOPER Bussmann

Cooper Bussmann Application Engineering

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Thank you for your selection of the BU-245U-E Wireless Ethernet Modem. We trust it will give you many years of valuable service.

ATTENTION!

Incorrect termination of supply wires may cause internal damage and will void warranty.

To ensure your BU-245U-E enjoys a long life.

Double check ALL your connections with the user manual before turning the power on.

CAUTION

To comply with FCC RF Exposure requirements in section 1.1310 of the FCC Rules, antennas used with this device must be installed to provide a separation distance of at least 20 cm from all persons to satisfy RF exposure compliance.

DO NOT:

- Operate the transmitter when someone is within 20cm of the antenna
- Operate the transmitter unless all RF connectors are secure and any open connectors are properly terminated.
- Operate the equipment near electrical blasting caps or in an explosive atmosphere

All equipment must be properly grounded for safe operations. All equipment should be serviced only by a qualified technician.

FCC NOTICE:

This device complies with Part 15.247 of the FCC Rules.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference and

2. This device must accept any interference received, including interference that may cause undesired operation.

This device must be operated as supplied by Cooper Bussmann. Any changes or modifications made to the device without the written consent of Cooper Bussmann may void the user's authority to operate the device.

End user products that have this device embedded must be installed by experienced radio and antenna personnel, or supplied with non-standard antenna connectors, and antennas available from vendors specified by Cooper Bussmann. Please contact Cooper Bussmann for end user antenna and connector recommendations.

NOTICES: SAFETY

Exposure to RF energy is an important safety consideration. The FCC has adopted a safety standard for human exposure to radio frequency electromagnetic energy emitted by FCC regulated equipment as a result of its actions in Docket 93-62 and OET Bulletin 65 Edition 97-01.

FCC NOTICE:

Part 15 – This device has been tested and found to comply with the limits for a Class B digital device, pursuant to Part15 of the FCC rules (Code of Federal Regulations 47CFR Part 15). Operation is subject to the condition that this device does not cause harmful interference.

Notice – Any changes or modifications not expressly approved by Cooper Bussmann could void the user's authority to operate this equipment.

THIS DEVICE SHOULD ONLY BE CONNECTED TO PCS THAT ARE COVERED BY EITHER FCC DOC OR ARE FCC CERTIFIED.

UL NOTICE:

1. The Wireless Ethernet module is to be installed by trained personnel / licensed electricians only and installation must be carried out in accordance with the instructions listed in the Installation Guide and applicable local regulatory codes.

2. The units are intended for Restricted Access Locations.

3. The Wireless Ethernet module is intended to be installed in a final enclosure, rated IP54, before use outdoors.

4. The Equipment shall be powered using an external Listed Power Supply with LPS outputs or a Class 2 Power Supply.

5. The Wireless Ethernet module must be properly grounded for surge protection before use.

6. If installed in a hazardous environment coaxial cable shall be installed in a metallic conduit

IMPORTANT NOTICE

Cooper Bussmann products are designed to be used in industrial environments, by experienced industrial engineering personnel with adequate knowledge of safety design considerations.

Cooper Bussmann radio products are used on unprotected license-free radio bands with radio noise and interference. The products are designed to operate in the presence of noise and interference, however in an extreme case, radio noise and interference could cause product operation delays or operation failure. Like all industrial electronic products, Cooper Bussmann products can fail in a variety of modes due to misuse, age, or malfunction. We recommend that users and designers design systems using design techniques intended to prevent personal injury or damage during product operation, and provide failure tolerant systems to prevent personal injury or damage in the event of product failure. Designers must warn users of the equipment or systems if adequate protection against failure has not been included in the system design. Designers must include this Important Notice in operating procedures and system manuals.

These products should not be used in non-industrial applications, or life-support systems, without consulting Cooper Bussmann first.

1. A radio license is not required in some countries, provided the module is installed using the aerial and equipment configuration described in the BU-245U-E Installation Guide. Check with your local distributor for further information on regulations.

2. Operation is authorized by the radio frequency regulatory authority in your country on a non-protection basis. Although all care is taken in the design of these units, there is no responsibility taken for sources of external interference. Systems should be designed to be tolerant of these operational delays.

3. To avoid the risk of electrocution, the aerial, aerial cable, serial cables and all terminals of the BU-245U-E module should be electrically protected. To provide maximum surge and lightning protection, the module should be connected to a suitable earth and the aerial, aerial cable, serial cables and the module should be installed as recommended in the Installation Guide.

4. To avoid accidents during maintenance or adjustment of remotely controlled equipment, all equipment should be first disconnected from the BU-245U-E module during these adjustments. Equipment should carry clear markings to indicate remote or automatic operation. E.g., "This equipment is remotely controlled and may start without warning. Isolate at the switchboard before attempting adjustments."

5. The BU-245U-E module is not suitable for use in explosive environments without additional protection.

6. The BU-245U-E Operates using the same Radio frequencies and communication protocols as commercially available off-the shelf equipment. If your system is not adequately secured, third parties may be able to gain access to your data or gain control of your equipment via the radio link. Before deploying a system make sure you have considered the security aspects of your installation carefully.

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Cooper Bussmann is using a part of Free Software code under the GNU General Public License in operating the "BU-245U-E" product. This General Public License applies to most of the Free Software Foundation's code and to any other program whose authors commit by using it. The Free Software is copyrighted by Free Software Foundation, Inc. and the program is licensed "As is" without warranty of any kind. Users are free to contact Cooper Bussmann at the following Email Address: fusetech@cooperindustries.com for instructions on how to obtain the source code used in the "BU-245U-E."

A copy of the license is included in the section entitled "GNU Free Documentation License."

www.cooperbussmann.com/BussmannWirelessResources

CONTENTS

CHAPTER 1 INTRODUCTION

The BU-245U-E Industrial 802.11 Wireless Ethernet module provide wireless connections between Ethernet devices and/or Ethernet wired networks (LAN's). They each comply with their relevant IEEE 802.11 standard.

The BU-245U-E is available in a range of different models with different RF power and frequency options suitable for your country's local radio regulations.

BU-245U-E-G	**802.11 b/g 400mW max power**
BU-245U-E-A	**802.11 a 400mW max power**

The above models have the same functionality but use a different radio to communicate. The different radios do not communicate with each other, e.g. a BU-245U-E-G will not communicate with a BU-245U-E-A. Only modules of the same type are able to communicate wirelessly to each other.

Throughout this manual, any reference to "BU-245U-E" refers to one of the above models.

The BU-245U-E-G model uses a 2.4GHz Direct Sequence Spread Spectrum (DSSS) wireless transceiver. Users pick a 20MHz channel with 5MHz channel spacing from the available 13 starting with the first channel centered on 2.412GHz. Some limitations depending on country see Appendix C for channel selections.

Note that regulations in North America permit 11 x 2.4GHz channels and Europe permits 13 x 2.4GHz channels.

The BU-245U-E-A uses a 5GHz Direct Sequence Spread Spectrum (DSSS) wireless transceiver and users must select appropriate channel, transmit power, etc allowable in that country.

> **Please check with your Cooper Bussmann representative for the permitted channel usage in your country. See Appendix C for channels selections.**

The BU-245U-E unit also provides two serial connections as well as the Ethernet connections. It is possible to use all three data connections concurrently, allowing the BU-245U-E to act as a Device Server. Wireless connections can be made between serial devices and Ethernet devices. The BU-245U-E provides connection functionality between serial "Modbus RTU" devices and Ethernet "Modbus TCP" devices. Appropriate driver applications will be required in the host devices to handle other protocols.

The BU-245U-E has a standard RJ45 Ethernet connection which will operate at up to 100Mbit/sec. The module will transmit the Ethernet messages on the wireless band at rates between 1 and 54 Mbit/sec & 6 and 54 Mbit/sec depending on model, band, encryption methods and radio paths.

1.1 Network Topology

The BU-245U-E is an Ethernet device, and must be configured as part of an Ethernet network. Each BU-245U-E must be configured as an:

• "Access Point" or "Sta", "Station", "Client"

• "Bridge" or "Router"

You can also connect to the BU-245U-E via a RS232 or RS485 serial port using serial server or PPP (point-to-point) protocol. PPP allows the BU-245U-E to connect serial communications into the Ethernet network.
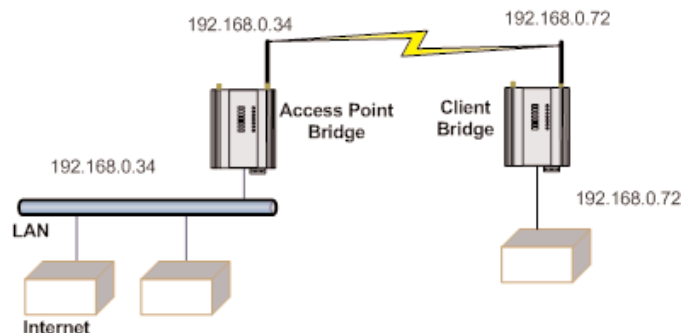
Access Point vs. Client

The Access Point unit acts as the "wireless master" unit. The Access Point accepts and authorizes links initiated by client units, and controls the wireless communications.

Clients (Stations) are slave units and when connected to the Access Point becomes transparent Ethernet link.

The first diagram shows a connection between two Ethernet devices using BU-245U-E Ethernet modems. In this example one BU-245U-E is configured as an Access Point and the other as a Client.
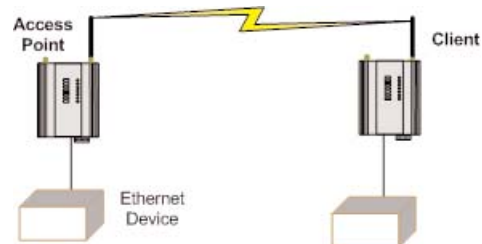
The second diagram shows an existing LAN being extended using BU-245U-Es. In this example, the Access Point should be configured at the LAN end - although the wireless link will still work if the Client is at the LAN end.
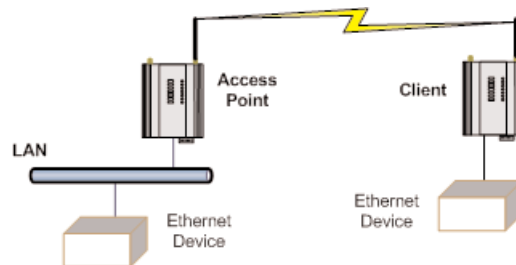
An Access Point can connect to multiple Clients. In this case, the Access Point should be the "central" unit.

An Access Point could be used as a "Repeater" unit to connect two BU-245U-E Clients, which do not have direct reliable radio paths.

There is no "Special" repeater module, any BU-245U-E can be a repeater and at the same time, can be connected to an Ethernet devices or on a LAN
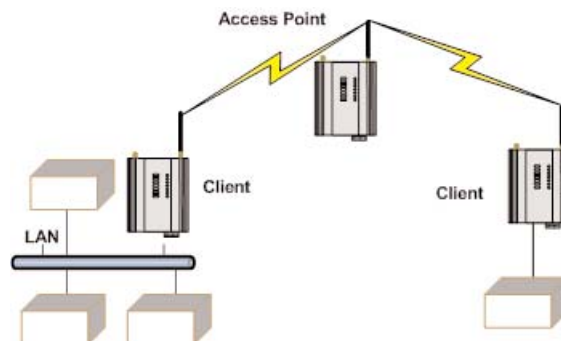
Multiple Access Points can be set-up in a "mesh" network to provide multiple repeaters.
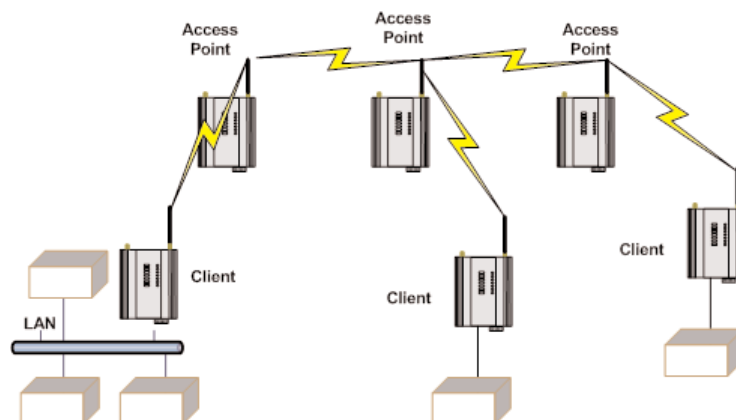
Bridge vs. Router

Each BU-245U-E is configured with an IP address for the Ethernet side, and another for the wireless side.

A **Bridge** connects devices within the same Ethernet network - for example, extending an existing Ethernet LAN. For a Bridge, the IP address for the wireless side is the same as the Ethernet side.
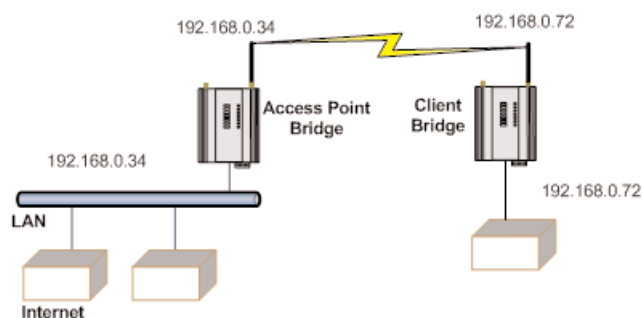
A **Router** connects devices on different LAN's.

The IP addresses for the Ethernet and wireless sides are different. In this example, the wireless link is part of LAN A, with the Client unit acting as a Router between LAN A and LAN B.
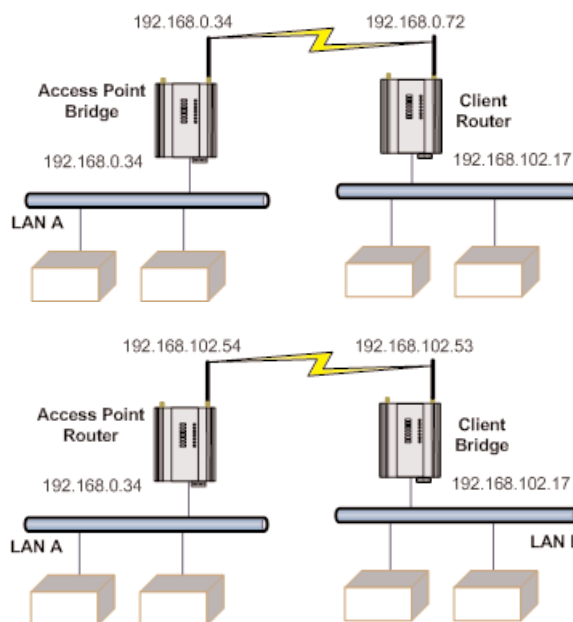
Alternately, the Access Point could be configured as a Router - the wireless link is then part of LAN B.

If more than two routers are required within the same radio network, then routing rules may need to be configured (refer section "3.13 Routing Rules" for further details). There is no limit to the number of Bridges in the same network - although there is a limit of 128 Client units linked to any one Access Point.
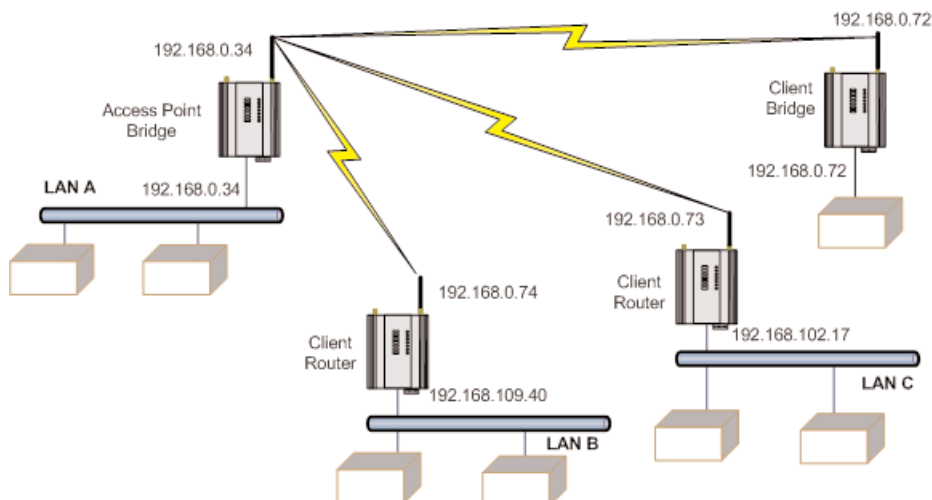
1.2 Getting Started Quickly

Most applications for the BU-245U-E require little configuration. The BU-245U-E has many sophisticated features, however if you don't require these features, this section will allow you to configure the units quickly.

First, read Chapter 2, "Installation." The BU-245U-E requires an antenna and a power supply.

• Power the BU-245U-E and make an Ethernet connection to your PC (for further information on how to do this, refer to section 3.2 " Configuring the Unit for the first time")

• Set the BU-245U-E address settings as per section 3.2 " Configuring the Unit for the first time"

• Save the configuration - the BU-245U-E is now ready to use.

Before installing the BU-245U-E, bench test the system. It is a lot easier to locate problems when the equipment is all together.

There are other configuration settings, which may or may not improve the operation of the system. For details on these settings, refer to section 3.0 "Start-up."

CHAPTER 2 INSTALLATION

2.0 General

The BU-245U-E modules are housed in a rugged aluminum case, suitable for DIN-rail mounting. Terminals will accept wires up to 2.5 mm^2 (12 gauge) in size.

> **All connections to the module must be SELV (Safety Extra Low Voltage). Normal 110-250V mains supply must not be connected to any terminal of the BU-245U-E module. Refer to Section 2.3 Power Supply.**

Before installing a new system, it is preferable to bench test the complete system. Configuration problems are easier to recognize when the system units are adjacent. Following installation, the most common problem is poor communications caused by incorrectly installed antennas, or radio interference on the same channel, or the radio path being inadequate. If the radio path is a problem (i.e., path too long, or obstructed), a higher performance antennas or a higher mounting point for the antenna may rectify the problem. Alternately, use an intermediate BU-245U-E Module as a repeater.

The BU-245U-E Installation Guide provides an installation drawing appropriate to most applications. Further information is detailed below.

Each BU-245U-E module should be effectively earthed via the "GND" terminal on the back of the module - this is to ensure that the surge protection circuits inside are effective.

2.1 Antenna Installation

The BU-245U-E module will operate reliably over large distances however the achievable distances will vary with the application, radio model, type and location of antennas, the degree of radio interference, and obstructions (such as buildings or trees) to the radio path.

The maximum range achievable depends on the radio model, the regulated RF power permitted in your country, and whether you use separate transmit and receive antennas.

If using a BU-245U-E-G (2.4GHz) with a single antenna, 10 km (6 miles) can be achieved in USA, Canada and Australia (4W EIRP) and 2km in Europe (100mW EIRP).

If using a BU-245U-E-A (5GHz) with a single antenna, 5 km (3 miles) can be achieved in USA, Canada and Australia (1W EIRP) and 3km in Europe (500mW EIRP) however more care is needed in selecting antennas, coax as well as radio paths need to be complete line of site (No obstruction what so ever).

To achieve the maximum transmission distance, the antennas should be raised above intermediate obstructions so the radio path is true "line of sight." The modules will operate reliably with some obstruction of the radio path, although the reliable distance will be reduced. Obstructions which are close to either antenna will have more of a blocking affect than obstructions in the middle of the radio path.

The BU-245U-E modules provide a diagnostic feature which displays the radio signal strength of transmissions (refer Chapter 4 "Diagnostics").

Line-of-sight paths are only necessary to obtain the maximum range. Obstructions will reduce the range, however may not prevent a reliable path. A larger amount of obstruction can be tolerated for shorter distances. For short distances, it is possible to mount the antennas inside buildings. An obstructed path requires testing to determine if the path will be reliable - refer the section 6 of this manual.

Where it is not possible to achieve reliable communications between two BU-245U-E modules, then a third BU-245U-E module may be used to receive the message and re-transmit it. This module is referred to as a repeater. This module may also have a host device connected to it.

The BU-245U-E unit has two antenna connections at the top of the module, allowing for two antennas to be fitted to the module. The left connector (looking at the front) labeled "RX" by default is connected only to the internal wireless receiver and the right connector labeled TX/RX is connected to both the transmitter and receiver (**Note).

> **NOTE: Each antenna port has the option to enable /disable the Receive and Transmit functionality by selecting Receive and Transmit Diversity on the radio page. When only one antenna is used, it must be connected to the TX/RX connector.**

Dual Antenna Installations

Most installations in industrial plants and factories use single omni-directional antennas. Installations can suffer from "

multi-path fading" effects where multiple reflected radio signals adversely affect the signal strength. This can be checked by moving the antenna a short distance (10 cm or 4 inches) - if the signal increases significantly then there are multi-path effects.

In a "static" installation, where the radio path is not changing, moving an antenna to the position of maximum signal solves this problem. However where the radio path changes because the BU-245U-E is mounted on moving equipment, or if there is moving equipment in the area, then the solution is to use two antennas. Because the two connectors are separated, the RF signal at each connector will be different in the presence of multi-path fading. The BU-245U-E unit will automatically select the higher RF signal provided RX diversity has been enabled on radio config page.

Note that directional antennas are not normally used in plant and factory installations.

Another reason for using dual antenna is to improve the receiver gain. All countries have a limit on the amount of transmitted power (from the module) and radiated power (from the antenna). In the US this is 1 Watt Transmit power and 4 watts EIRP (Effective Isotropic Radiated Power)

A general rule of thumb when working with dB and Power is to remember that doubling the Power is a 3dB gain.

Therefore if we add a 6dB gain antenna to the 1 Watt transmitter we can boost the EIRP to 4 Watts (1 watt

Line-of-Sight Installations

In longer line-of-sight installations, the range may be increased by using a high gain antenna on the TX/RX connector. However, the gain should not cause the effective radiated power (ERP) to exceed the permitted value. A second higher gain antenna can be connected to the RX connector without affecting ERP - this will increase the operating range provided any interference in the direction of the link is low.

Antennas

Antennas can be either connected directly to the module connectors or connected via 50 ohm coaxial cable (e.g. RG58 Cellfoil or RG213) terminated with a male SMA coaxial connector. The higher the antenna is mounted, the greater the transmission range will be, however as the length of coaxial cable increases so do cable losses.

The net gain of an antenna/cable configuration is the gain of the antenna (in dBi) less the loss in the coaxial cable (in dB). The maximum net gain of the antenna/cable configuration connected to the TX/RX connector is 0dB in Europe (100mW ERP). In USA, Canada and Australia (4W ERP), the maximum gain is 10dB for the BU-245U-E-400 or 16dB for the BU-245U-E-100.

There is no gain restriction for antennas connected to the RX connector.

(*) 20dB attenuator must be fitted if radio distance is less than 33ft (10m).

Antenna	BU-245U-E-G Gain (dBi)	BU-245U-E-A Gain (dBi)
Dipole	2 dBi	6 dBi
Collinear	5 or 10 dBi	10 dBi
Directional	18 dBi	10 – 20 dBi
Cable Loss	**dB per 30 m / 100 ft**	**dB per 30 m / 100 ft**
RG58 Cellfoil	-17 dB	-24.5 dB
RG213	-16.2 dB	-28.6 dB
LDF4-50	-3.6 dB	-5.5 dB

The net gain of the antenna/cable configuration is determined by adding the antenna gain and the cable loss.

For example, if using the BU-245U-E-G a 10dBi antenna (7.8dBd) with 10 meters of Cellfoil (-5.6dB) has a net gain of 2.2dB (7.8dB – 5.6dB).

Installation tips

Connections between the antenna and coaxial cable should be carefully taped to prevent ingress of moisture. Moisture ingress in the coaxial cable is a common cause for problems with radio systems, as it greatly increases the radio losses. We recommend that the connection be taped, firstly with a layer of PVC Tape, then with a vulcanizing tape such as "3M 23 tape", and finally with another layer of PVC UV Stabilized insulating tape. The first layer of tape allows the joint to be easily inspected when trouble shooting as the vulcanizing seal can be easily removed.

Where antennas are mounted on elevated masts, the masts should be effectively earthed to avoid lightning surges. For high lightning risk areas, surge suppression devices between the module and the antenna are recommended. If the antenna is not already shielded from lightning strike by an adjacent earthed structure, a lightning rod may be installed above the antenna to provide shielding.

Stretch to elongate sealant tape while wrapping over the connection

For proper UV protection Electrical Tape should then be wrapped over the Vulcanising Tape
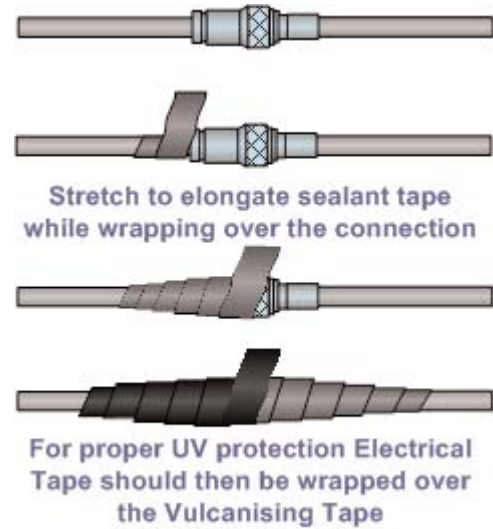
Omni-directional Antennas

An omni-directional antenna transmits the same amount of radio power in all directions - as such that are easy to install and use. The dipole antenna with integral 15 ft (5m) cable does not require any additional coaxial cable; however a cable must be used with the collinear antennas.

Omni-directional antennas should be mounted vertically, preferably 1 wavelength away (see drawing below for distances) from a wall or mast and at least 3ft (1m) from the radio module to obtain maximum range.

Wavelengths
900 MHz = 33 cm
2.4 GHz = 13 cm
5 GHz = 6 cm

1 wavelength

Omni Antenna

WEATHERPROOF CONNECTORS WITH "3M 23" TAPE

SURGE ARRESTOR (OPTIONAL)

COAXIAL CABLE

STRESS RELIEF LOOP

MAST

MODEM

PROVIDE GOOD GROUND CONNECTION TO MAST, MODULE AND SURGE ARRESTOR

GND

IF GROUND CONDITIONS ARE POOR, INSTALL MORE THAN ONE STAKE
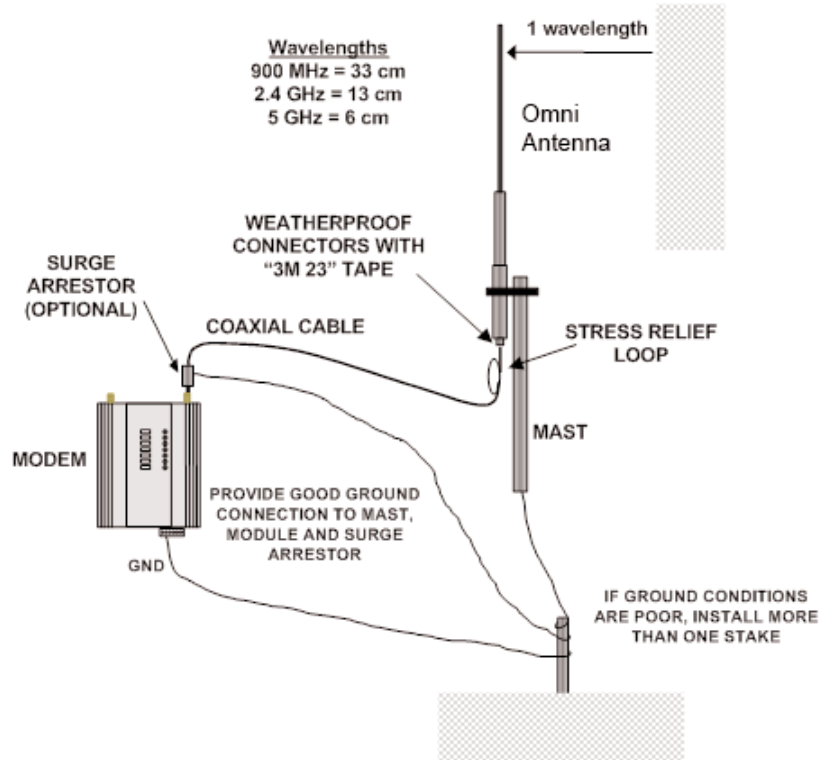
Directional Antennas.

Directional antennas can be a:

• Yagi antenna with a main beam and orthogonal elements, or

• Directional radome, which is cylindrical in shape, or

• Parabolic antenna.

A directional antenna provides high gain in the forward direction, but lower gain in other directions. This may be used to compensate for coaxial cable loss for installations with marginal radio path.

Yagi antennas should be installed with the main beam horizontal, pointing in the forward direction. If the Yagi is transmitting to a vertically mounted omni-directional antenna, then the Yagi elements should be vertical. If the Yagi is transmitting to another Yagi, then the elements at each end of the wireless link need to in the same plane (horizontal or vertical).

Directional radomes should be installed with the central beam horizontal and must be pointed exactly in the direction of transmission to benefit from the gain of the antenna. Parabolic antennas should be mounted as per the manufacturer's instructions, with the parabolic grid at the "back" and the radiating element pointing in the direction of the transmission.

Ensure that the antenna mounting bracket is well connected to "ground/earth."
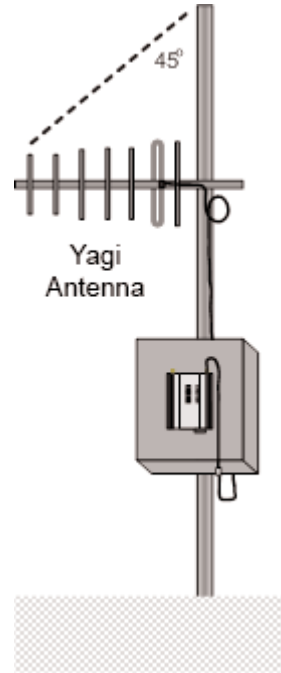
2.2 Power Supply

The BU-245U-E module can be powered from a 9 - 30Vdc power supply. The power supply should be rated at 1 Amp. The positive side of the supply must not be connected to earth. The supply negative is connected to the unit case internally. The DC supply may be a floating supply or negatively grounded.

The power requirements of the BU-245U-E unit are shown in the following table.
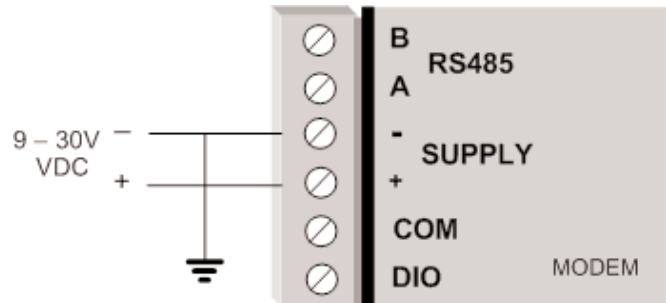
	BU-245U-E-G		BU-245U-E-A	
	12Vdc	24Vdc	12Vdc	24Vdc
Quiescent	290mA	150mA	300mA	160mA
TX @100mW	310mA	170mA	370mA	190mA
TX @ 400mW	340mA	180mA	410mA	210mA

A Ground Terminal is provided on the back of the module. This Terminal should be connected to the Main Ground point of the installation in order to provide efficient surge protection for the module (refer to the Installation Diagram).

2.3 Serial Connections

RS232 Serial Port

The serial port is a 9 pin DB9 female and provides for connection to a host device as well as a PC terminal for configuration, field testing and for factory testing. Communication is via standard RS232 signals. The BU-245U-E is configured as DCE equipment with the pinouts detailed below.

Hardware handshaking using the CTS/RTS lines is provided. The CTS/RTS lines may be used to reflect the status of the local unit's input buffer. The BU-245U-E does not support XON/XOFF.

Example cable drawings for connection to a DTE host (a PC) or another DCE hosts (or modem) are detailed above.
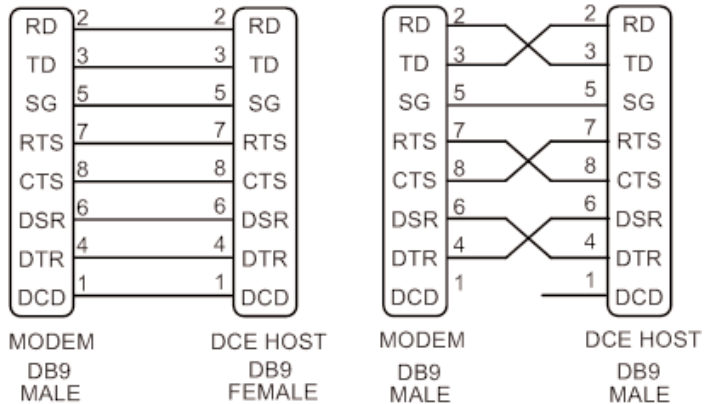
DB9 Connector Pinouts

Pin	Name	Direction	Function
1	DCD	Out	Data carrier detect
2	RD	Out	Transmit Data – Serial Data Output (from DCE to DTE)
3	TD	In	Receive Data – Serial Data Input (from DTE to DCE)
4	DTR	In	Data Terminal Ready
5	SG	- -	Signal Ground
6	DSR	Out	Data Set Ready - always high when unit is powered on.
7	RTS	In	Request to Send
8	CTS	Out	Clear to send
9	RI	- -	Ring indicator

RS485 Serial Port

The RS485 port provides for communication between the BU-245U-E unit and its host device using a multi-drop cable. Up to 32 devices may be connected in each multi-drop network.

As the RS485 communication medium is shared, only one of the units on the RS485 cable may send data at any one time. Thus, communication protocols based on the RS-485 standard require some type of arbitration.

RS485 is a balanced, differential standard but it is recommended that shielded, twisted pair cable be used to interconnect modules to reduce potential RFI. It is important to maintain the polarity of the two RS485 wires. An RS485 network should be wired as indicated in the diagram below and terminated at each end of the network with a 120-ohm resistor. On-board 120-ohm resistors are provided and may be engaged by operating the single DIP switch in the end plate next to the RS485 terminals. The DIP switch should be in the "1" or "ON" position to connect the resistor. If the module is not at one end of the RS485 cable, the switch should be OFF.
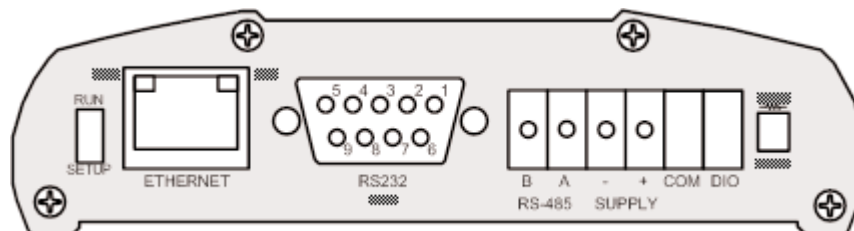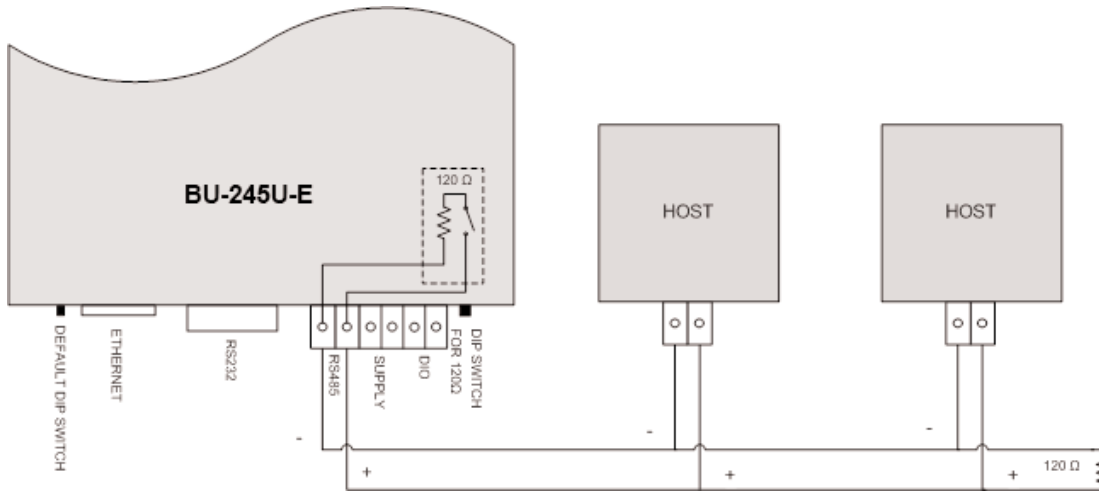
Shorter runs of 485 cable may not require the termination resistors to be enabled.

2.4 Discrete (Digital) Input/Output

The BU-245U-E has one on-board discrete/digital I/O channel. This channel can act as either a discrete input or discrete output. It can be monitored, or set remotely, or alternatively used to output a communications alarm status.

If used as an "input", the I/O channel is suitable for voltage free contacts (such as mechanical switches) or NPN transistor devices (such as electronic proximity switches). PNP transistor devices are not suitable. Contact wetting current of approximately 5mA is provided to maintain reliable operation of driving relays.

The digital input is connected between the "DIO" terminal and common "COM." The I/O circuit includes a LED indicator which is lit GREEN when the digital input is active, that is, when the input circuit is closed. Provided the resistance of the switching device is less than 200 ohms, the device will be able to activate the digital input.

The I/O channel may also be used as a discrete output. The digital outputs are transistor switched DC signals, FET output to common rated at 30Vdc 500mA.

The output circuit is connected to the "DIO" terminal. The digital output circuit includes a LED indicator which is lit RED when the digital output is active.
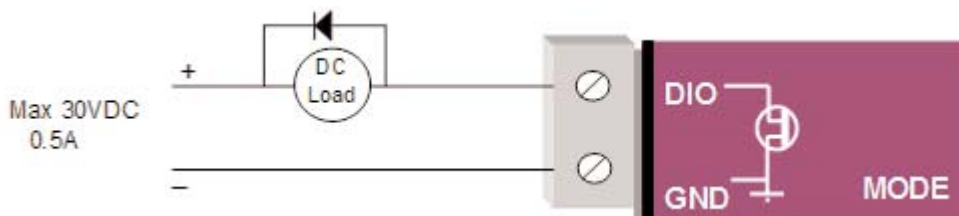
CHAPTER 3 OPERATION

3.0 Start-up

"Access Point" Start-up (BU-245U-E-G)

When an Access Point (AP) unit starts up it checks to see if the Channel selection is set to "Auto" and if so will scan all available channels, pick the quietest then begin transmitting periodic messages, called beacons, if it is configured with a fixed channel it will immediately begins sending beacons, on the configured channel.

Beacons include information that a Client may examine in order to identify if the Access Point is suitable for link establishment. Clients will only attempt to establish a link with an Access Point whose beacon indicates a matching SSID. Access Points do not initiate link establishment.

"Access Point" Start-up (BU-245U-E-A)

If the modem is configured to use "DFS" then it will behave slightly different, as it needs to comply with DFS regulations.

When an Access Point starts up it will scan all available channels from the selected groups and then select the quietest similar to the BU-245U-E-G. It will then go into a scan mode for 60 seconds where it listens for any Radar signals.

If a radar signal is detected it will flag the channel as being unavailable (Channel will stay unavailable for 30 minutes) and then pick another random channel and go through the same scanning process until a radar free channel be comes available.

"Client" Start-up

When a Client powers up, it scans for beacons from Access Points. While a link is not established, the Client cyclically scans all available channels for a suitable Access Point. The Client will attempt to establish a link with an Access Point only if it has matching SSID, Encryption method, etc. and other compatible capabilities as indicated by the beacon. If more than one suitable Access Point is discovered, the client will attempt to establish a link with the Access Point that has the strongest radio signal.

Link Establishment

Once a Client identifies a suitable Access Point for link establishment it attempts to establish a link using a two step process – "Authentication" and "Association." During Authentication the Client and Access Point check if their configurations permit them to establish a link. Once the Client has been authenticated, it will then request an Association to establish a link.

Status of the wireless link is indicated via the TX/LINK LED. For an Access Point, the TX/LINK LED will be OFF while no links have been established. Once one or more links have been established, the TX/LINK LED is on GREEN. For a Client, the Link LED will reflect the connection status to an Access Point. Link status is also displayed on the "Connectivity" page of the web interface.

After the link is established, data may be transferred in both directions. The Access Point will act as a master-unit and will control the flow of data to the Clients linked to it. Clients can only transmit data to the AP to which they are connected. When a Client transfers data to another Client, it first transmits the data to the AP, which then forwards the data to the destined Client.

Presence of a "link" does not mean that the connected unit is authorized to communicate over radio. If the encryption keys are incorrect between units in the same system, or a dissimilar encryption scheme is configured, the LINK led will light, however data cannot be passed over the wireless network.

A maximum of 127 Clients may be linked to an Access Point.

How a Link Connection is Lost

The Access Point refreshes the link status with a Client every time a message is received from that Client. If nothing is received from a Client for a period of 120 seconds, the Access Point sends a "link-check" message. If there is no response to the link-check a De-authenticate message is sent and the link is dropped.

A Client monitors beacon messages from an Access Point to determine whether the link is still present. If the Client can no longer receive beacons from the Access Point it assumes the AP is out-of-range and the link is dropped. Whenever a Client is not connected to an AP, it will cyclically scan all available channels for a suitable AP.

Roaming Clients

Clients can roam within a system however if the link to the Access Point fails or the radio signal level becomes too weak it will scan for beacons and connect to an Access Point (provided the SSID and any Encryption methods, keys, etc are compatible). If there are multiple Access Points it will select the connection with the best signal level. This functionality permits a client to have mobility whilst maintaining a link with the most suitable AP.

LED Indication

The following table details the status of the indicating LEDs on the front panel under normal operating conditions.

LED Indicator	Condition	Meaning
OK	GREEN	Normal Operation
OK	Flashing RED / GREEN	Module Boot Sequence
Radio RX	GREEN flash	Radio receiving data (Good Signal Strength)
Radio RX	RED flash	Radio receiving data (Low Signal strength)
TX/LINK	GREEN	Radio Connection Established
TX/LINK	RED Flash	Radio Transmitting
RS-232	GREEN flash	Data sent from RS-232 Serial Port
RS-232	RED flash	Data received to RS-232 Serial Port
LAN	ON	Link Established on Ethernet port
LAN	Flash	Activity on Ethernet port
RS-485	GREEN flash	Data sent from RS-485 Serial Port
RS-485	RED flash	Data received to RS-485 Serial Port
DIO	GREEN	Digital Input is grounded
DIO	RED	Digital Output is active
DIO	Off	Digital Output OFF and Input is open circuit

The Ethernet RJ45 port incorporates two indication LEDs. The LINK LED comes on when there is a connection on the Ethernet port, and will blink off briefly when activity is detected on the Ethernet Port. The 100MB LED indicates that the connection is at 100 MBit/Sec. The 100MB LED will be off for 10MB/Sec connection.

Other conditions indicating a fault are described in Chapter Four - DIAGNOSTICS.

3.1 Selecting a Channel

802.11b/g (2.4GHz)

The BU-245U-E-G conforms to the IEEE 802.11b/g Wireless LAN specification. The BU-245U-E-G supports 13 x 20MHz, 12 x 10MHz and 13 x 5MHz radio channels in the 2412MHz to 2482MHz frequency range. Channels are country or region specific. Please check your local regulatory body for compliance and channel selection.

You can see from the diagram below there are a limited number of channels available in the 2.4GHz frequency range. Care must be taken when selecting an operating channel as some of the channels overlap.

The 20M channels have a separation of 5MHz which means there is some overlap into the next channel, i.e., channel 1 will overlap into channel 2, 3 and 4; channel 6 will overlap into channels 3, 4, 5, 7, 8 and 9. If complete separation is required then you can use channels 1, 6 and 11 without any interference between the channels.
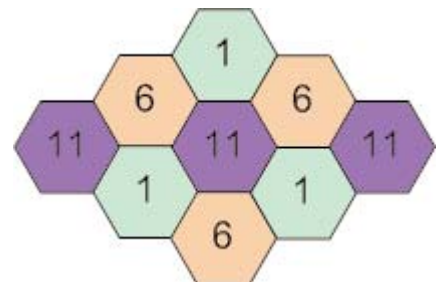
The 10M channels are also separated by 5MHz and overlap the adjacent channels by 5MHz forward and backward, i.e., Channel 41 will overlap with channel 42; channel 46 will overlap with channel 45 and 47.

Lastly the 5MHz channels are separated by 5MHz and do not overlap at all so you can operate all 13 channels at the same time with minimal interference with the adjacent channel.

Only one of these channels is used at a time and is configured at the Access Point, The Access Point then uses this channel to send out beacon transmissions and connections.

Clients scan all channels for a suitable Access Point and then adopt the same channel as the AP when a connection is established.

The following diagram shows the RF energy distribution for the 802.11b/g transmission:
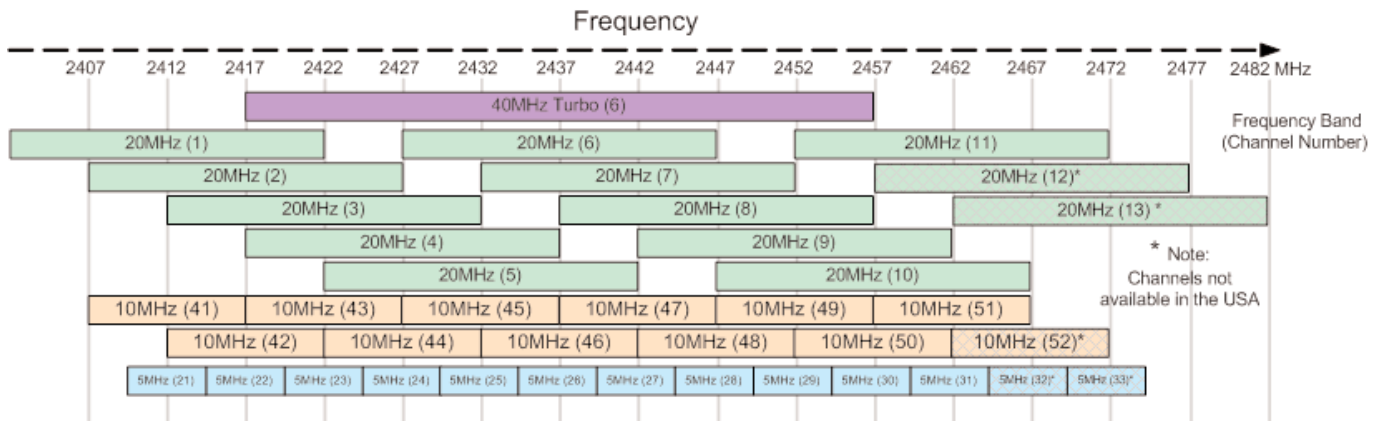
On the 20MHz channel (Green) most of the energy is transmitted within the channel however some of the energy is transmitted on the channels either side therefore causing interference on the these channels. The 10MHz channels (Orange) are similar with half of the energy overlapping into the next channel however you can configure up to 6 x non interfering channel at the one time. Lastly the 5MHz channels (Blue) do not overlap and so all 13 channels can be used at the same time.

There is also a single 40MHz Channel (Purple) which takes up over half of the full 2.4GHz band and so it much more susceptible to interference from other channels.

If there is more than one 802.11 AP within the same wireless range, then it is important that the APs are on channels as far apart as possible.

If there are two 20MHz channel APs, then set them to channel 1 and 11. If there are three, set them to 1, 6, and 11.
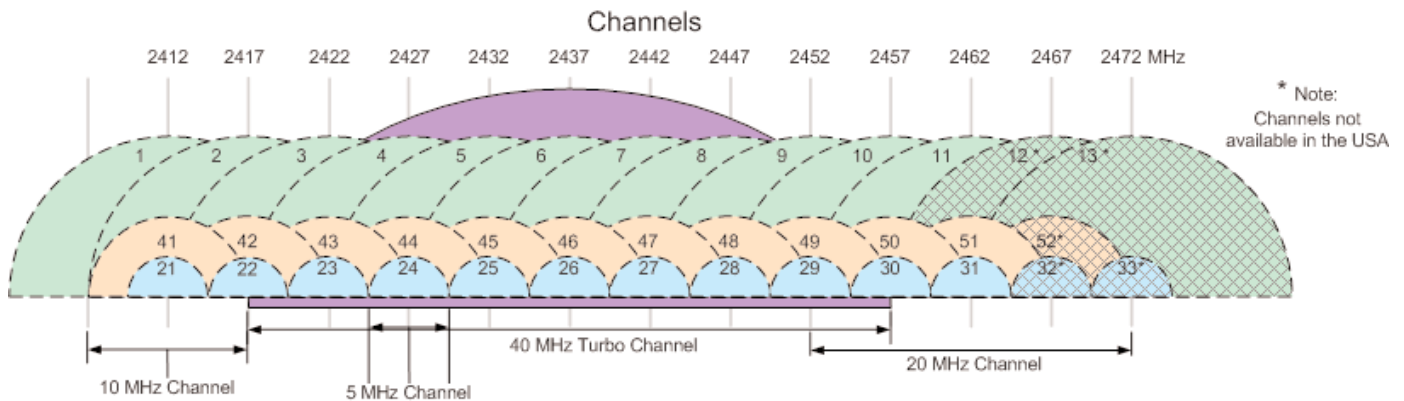
802.11a (5GHz)

The BU-245U-E-A utilizes frequency bands within the range of 5.15GHz and 5.825GHz. This is broken into 4 distinct U-NII bands and each region (EU, US, AUS, NZ, etc) have their own power and operational constraints, see Appendix C for more details.

The example below shows the US power and operational constraints

"Group 1":	5.15-5.25GHz	@ 50mW
"Group 2":	5.25-5.35GHz	@ 250mW to 1 Watt
"Group 3":	5.47-5.725GHz	@ 250mW to 1 Watt
"Group 4":	5.725-5.825GHz	@ 1Watt

Each frequency band has certain limitations on the amount of radiated power that it can output as well as whether the band uses what is called "Dynamic Frequency Selection" (DFS), explained below.
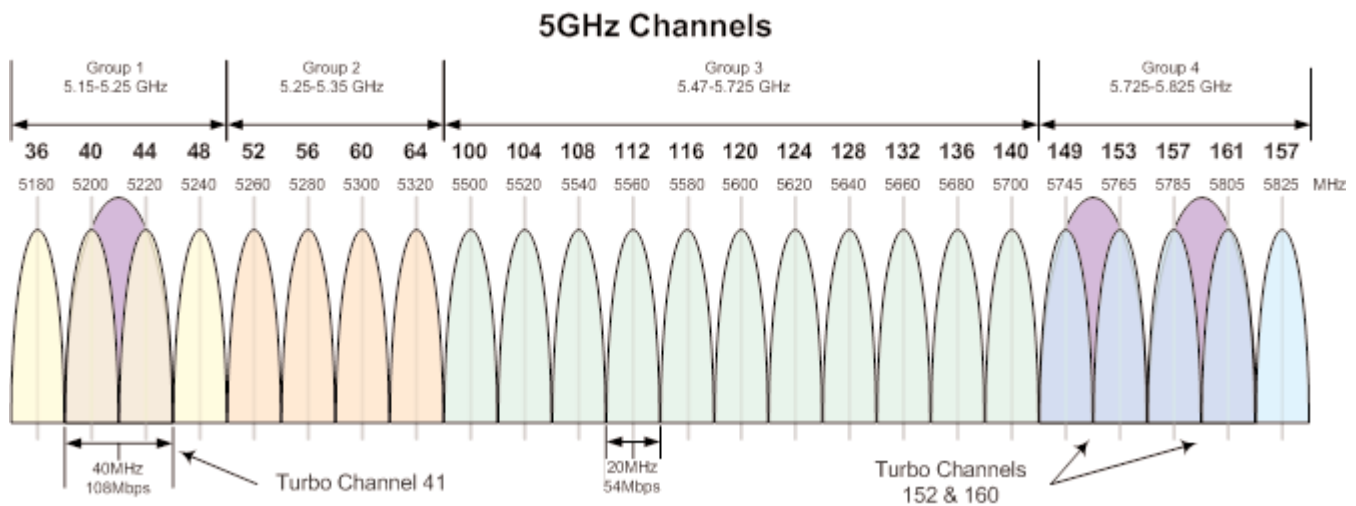
Dynamic Frequency Selection (DFS)

Because of the push within the 802.11a market to open up new spectrum for unlicensed radio a mechanism called "Dynamic Frequency Selection" needed to be developed so that the 802.11 Wi-Fi could coexist with existing military and telecommunication radar systems.

Access points with 5GHz radios comply with regulations that require radio devices to use Dynamic Frequency Selection (DFS), which can detect radar signals and avoid interfering with them by automatically scanning and then selecting another channel or band.

When DFS is enabled, the Access Point (master device) goes through the following steps:

1. The master device that initiates communications selects a channel and monitors that channel for potential radar interference for a minimum listening time of 60sec (channel availability check time). No transmissions can occur during this period.

2. If interference is detected then the system has to go and select another channel and repeat the channel availability check on the new channel (the original channel is added to a list of channels with radar).

3. Once a channel has been selected and passes the channel availability check the network starts to use that channel.

4. While using the channel the network's master device continuously monitors for potential interference from a radar source (this is referred to as "in-service monitoring"). If interference is detected then the network master device issues commands to all other in-network devices to cease transmissions. The channel is added to the list of channels with radar.

5. The master device then selects a new channel (one that is not on the radar list).

6. A channel that has been flagged as containing a radar signal, either by a channel availability check or by in-service monitoring, is subject to a 30 min non-occupancy period where it cannot be used by the device in order to protect scanning radars. The channel on the radar list will be purged once the non-occupancy period has elapsed for that channel.

3.2 Configuring the Unit for the First Time

The BU-245U-E has a built-in web server, containing web pages for analyzing and modifying the module's configuration. The configuration can be accessed using Microsoft® Internet Explorer version 7 or greater. This program is shipped with Microsoft Windows or may be obtained freely via the Microsoft® website. If using other browsers they must be fully compliant with IE7 SSL security.

> **NOTE: Microsoft Internet Explorer Version 6 will not load web pages due to a compatibility issue between IE6 and SSL-security web sites.**

Default Configuration

The default factory configuration of the BU-245U-E is:

• Client/Bridge/

• IP address192.168.0.1XX, where XX is the last two digits of the serial number (the default IP address is shown on the printed label on the back of the module)

• netmask 255.255.255.0

• Username is "user" and the default password is "user"

The BU-245U-E will temporarily load some factory-default settings if powered up with the Factory Default switch (on the end-plate of the module) in SETUP position. When in SETUP mode, wireless operation is disabled. The previous configuration remains stored in non-volatile memory and will only change if a configuration parameter is modified and the change saved.

> **Do not forget to set the switch back to the RUN position and cycle power at the conclusion of configuration for resumption of normal operation.**

Accessing Configuration for the First Time

Because the Default IP address is in the range 192.168.0.XXX it may not connect to you network or PC so there are two methods for accessing the configuration for the first time.

Method 1 - Change your computer settings so that the configuring PC is on the same network as the BU-245U-E with factory default settings. **This is the preferred method** and is much less complicated than the second method. You will need a "straight-through" Ethernet cable between the PC Ethernet port and the BU-245U-E. The factory default Ethernet address for the BU-245U-E is 192.168.0.1XX where XX are the last two digits of the serial number (check the label on the back of the module).

Method 2 - Requires temporarily changing the IP address in the BU-245U-E via an RS232 connection such that it is accessible on your network without having to change your PC network settings. When connected you can change the modem network settings to match that of your network.

Method 1 - Set PC to same network as BU-245U-E

Connect the Ethernet cable between unit and the PC configuring the module.

- Set the Factory Default Switch to the SETUP position. This will always start the BU-245U-E with Ethernet IP address 192.168.0.1XX, subnet mask 255.255.255.0, gateway IP 192.168.0.1 and the radio disabled. Do not forget to set the switch back to the RUN position and restart the module at the conclusion of configuration for resumption of normal operation.

- Power up the BU-245U-E module.

- Open "Network Settings" on your PC under Control Panel. The following description is for Windows XP - earlier Windows operating systems have similar settings.

- Open "Properties" of Local Area Connection.

- Select Internet Protocol (TCP/IP) and click on Properties.

- On the General tab enter IP address 192.168.0.1, Subnet mask 255.255.255.0 and press "OK"

- Open Internet Explorer and ensure that settings will allow you to connect to the IP address selected. If the PC uses a proxy server, ensure that Internet Explorer will bypass the Proxy Server for local addresses.

- This option may be modified by opening Tools -> Internet Options -> Connections Tab -> LAN Settings->Proxy Server -> bypass proxy for local addresses.

- Enter the default IP address for the BU-245U-E https://192.168.0.1XX where XX is the last two digits of the serial number.

Enter the username "user" and default password "user."

Figure 1 – Welcome Webpage

To resume normal configured operation when Configuration is complete, switch Factory Default dip-switch on the BU-245U-E to RUN and cycle power.

Note: Security Certificates. Configuration of the BU-245U-E uses an encrypted link (https). The security certificate used by the BU-245U-E is issued by Cooper Bussmann and matches the IP address 192.168.0.100.

When you first connect to the BU-245U-E, your web browser will issue a warning that Cooper Bussmann is not a trusted authority. Ignore this warning and proceed to the configuration web page. To avoid seeing this warning in future, you can install the certificate into your browser.

Internet Explorer 7 has an additional address check on security certificates. Unless the BU-245U-E has the address 192.168.0.100, when you first connect to the BU-245U-E, Internet Explorer 7 will issue a warning about mismatched security certificate address. You can turn off this behavior in IE7 by selecting

"Tools > Internet Options > Advanced > Security > Warn about certificate address mismatch*"

Method 2 - Set BU-245U-E Network address to match the local network

For this method you will need to determine what IP address, Gateway address, and netmask to assign to the BU-245U-E so that it appears on your network. Ask your system administrator if you don't know the correct settings for your network. E.g.

The default IP address of the BU-245U-E modem is 192.168.0.1 and the network you wish to connect to is on 10.10.0.X (PC is on 10.10.0.5)

Once you have determined the correct settings for your network, you need to connect to the modem's RS-232 serial port using a straight through serial cable and a terminal package such as HyperTerminal set to 115,200 baud. 8 data bits, 1 stop bit, no Parity.

- Open HyperTerminal and monitor communications
- Set the SETUP/RUN switch to the SETUP position, and connect power to the modem.
- Observe HyperTerminal and when you see the Dragon screen (see below) press <Enter> to get the following prompt "#"
- Type the following "ifconfig" and it will show the configuration of the Ethernet port and from this you will be able to see what the IP address is, e.g.,

> eth0 Link encap:Ethernet HWaddr 00:12:AF:FF:FF:FF
>
> inet addr:192.168.0.1 Bcast:192.168.0.255 Mask:255.255.255.0
>
> UP BROADCAST RUNNING MULTICAST MTU: 1500 Metric: 1
>
> RX packets:8 errors:0 dropped:0 overruns:0 frame:0
>
> TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
>
> collisions:0 txqueuelen:256

- Temporarily change the IP address to something that will enable connection to your local network. E.g type "ifconfig eth0 10.10.0.6 netmask 255.255.255.0" only add the netmask if the netmask is anything other than the standard 255.255.255.0
- IP address should now be changed and you can check by typing "ifconfig" again. Note these changes are only temporary and if the module is reset they will go back to the normal default (192.168.0.XXX).

- Open Internet Explorer and ensure that settings will allow you to connect to the IP address selected. If the PC uses a proxy server, ensure that Internet Explorer will bypass the Proxy Server for local addresses. This option may be modified by opening Tools -> Internet Options -> Connections Tab -> LAN Settings->Proxy Server -> bypass proxy for local addresses.

- Enter the IP address for the BU-245U-E into the Internet Explorer Address bar e.g. http://10.10.0.6 which is the IP address you temporarily configured with the ifconfig command.

- Enter the username "user" and default password "user."

- You should now be connected to the main index page on the modem as per figure 1 above.

- From here connect to the Network page and change the Ethernet Interface and Wireless Interface IP addresses to 10.10.0.6. Switch the RUN/SETUP switch back to RUN and press "Save Changes and Reset" button.

Note: As the modem can be setup numerous ways, e.g. Bridge, Router, etc this setup will allow the modem to appear on the 10.10.0.X network. Any other configuration changes can be done after this initial connection (see the following sections on configuration)

3.3 Quick Start Configuration

The BU-245U-E has a Quick Start Configuration option, which will cover most important parameters that are needed to get an initial connection. This is the first stage of the module configuration. For most applications, no further configuration is required. For more advanced applications, the other parameters can be changed via the normal configuration pages after the Quick Start configuration has been saved.

Select "Quick Start" from the Main Menu and then you need to select the following parameters:

Quick Start Configuration

Reset is required to activate settings.

Device Mode:

Operating Mode	Client (Station)
Default Gateway	192.168.0.1
IP Address	192.168.0.106
Subnet Mask	255.255.255.0
System Address (ESSID)	BU_245U-E_TEST
Radio Encryption	None
WPA Passphrase	passphrase

Notes:
- Radio Data Rate and Channel will be set to Auto.
- Radio Transmit Power will be set to maximum.
- Any previous configuration of unrelated parameters will not be modified, and will still apply.

[Save Changes] [Save Changes and Reset]

Quick Start Configuration

Operating Mode	Access Point or Client. Bridge operation is assumed - for Router selection, go to the Network page after Quick Start
Default Gateway	This is the address that the device will use to forward messages to remote hosts that are not connected to any of the local bridged network (Ethernet or Wireless)
IP Address / Subnet Mask	IP Address and Subnet Mask for your application.
System Address (ESSID)	The system address is a text string 1 to 31 characters in length used to identifies your system
Radio Encryption	Radio encryption selection - None, WPA-PSK (TKIP), WPA-PSK (AES) or WPA2 – refer to section 3.5 "Security Menu" if WEP or Enterprise encryption is required.
WPA Passphrase	128bit Encryption keys are internally generated based on the Passphrase and System Address (ESSID). The Passphrase must be between 8 and 63 characters in length, and must be the same for all BU-245U-E units in the same system.

The default settings will be shown. If your system is connecting individual devices which are not connected to an existing Ethernet LAN, then you can use the factory default IP values. If you are connecting to an existing LAN, then you need to change the IP addresses to match your LAN addresses.

After configuring, select "Save to Flash and Reset."

Radio Data Rate and Channel will be set to Auto, Radio Transmit Power will be set to maximum and any previous configuration of unrelated parameters will not be modified, and will still apply.

3.4 Network Configuration

You can view or modify Ethernet network parameters by selecting the "Network" menu. When prompted for username and password, enter "user" as the username, and "user" as the password in the password field (This is the factory default – See section 3.21 "Module Information Configuration" to change). If you have forgotten the IP address or password, the Factory Default switch may be used to access the existing configuration. Refer to previous section above for this procedure.

The Network Configuration page allows configuration of parameters related to the wired and wireless Ethernet interfaces. In general, IP address selection will be dependent upon the connected wired Ethernet device(s) – before connecting to an existing LAN consult the network administrator.

A system of BU-245U-Es must have at least one Access Point configured as a master with one or more Clients. All BU-245U-Es should be given the same System Address (ESSID) and Radio Encryption settings. For further information and examples on wireless network topologies refer section 1.1 "Network Topology" above.

The BU-245U-E supports several different radio encryption schemes. If utilizing any form of encryption, all modules in the system that communicate with each other will need the same encryption method and encryption keys.

WEP (Wired Equivalent Privacy) encryption is the weakest encryption method, defined by the original IEEE802.11 standard and uses a 40bit or 104bit key with a 24bit initialization vector to give a 64bit and 128bit WEP encryption level. WEP is not considered an effective security scheme, and should only be used if it is necessary to interoperate with other equipment which does not support more modern encryption methods.

WPA (Wi-Fi Protected Access) is a subset of the IEEE802.11i Security Enhancements specification.

The BU-245U-E supports WPA-1 TKIP and WPA-2 AES using a Pre-Shared Key (PSK).

- TKIP (Temporal Key Integrity Protocol) enhances WEP by using 128-bit encryption plus separate 64bit Tx and Rx MIC (Message Integrity Check) keys.
- AES (Advanced Encryption Standard), the most secure encryption method, is also based on 128-bit encryption key and is the recommended encryption method in most applications.

WPA-Enterprise (802.1x) removes the need to manage the Pre-shared Key (PSK) by using an external server to provide client authentication. Clients that are not authorized will be prevented from accessing the network. Once a client has provided the correct authentication credentials, access is permitted and data encryption keys are established, similar to WPA-PSK. Fine-grain (user level) access control can be achieved using this method.

An 802.1x capable RADIUS server may already be deployed in a large scale network environment. The BU-245U-E can make use of this server reducing replication of user authentication information.

In a typical WPA-enterprise setup, the BU-245U-E Access point acts as Authenticator, controlling access to the network. Wireless clients (BU-245U-Es, Laptops or other devices) act as Supplicants, requesting access to the network. The Authenticator communicates with an authentication (RADIUS) server on the Ethernet network to verify Supplicant identity. When a Supplicant requests access, it sends an access request to the Authenticator, which passes an authentication request to the external authentication server. When the user credentials of the Supplicant are verified, the Authenticator enables network access for the Supplicant, data encryption keys are established and network traffic can pass.

Configuration of WPA-Enterprise differs when the unit is configured as an Access point (Authenticator) or Client (Supplicant). If WDS interfaces are used, it is possible for one BU-245U-E to act as both an Authenticator and a Supplicant, however in this situation, only one set of user credentials can be entered for all Supplicants.

After changes are made to Network Configuration, it is important to save the configuration by selecting "Save Changes" or by selecting "Save Changes and Reset."

Network Settings Webpage Fields

Operating Mode	Used to select Access Point (Infrastructure), Client (Infrastructure). By default this is set to Client.
Device Mode	Used to select Bridge or Router mode. By default this is set to Bridge.
Bridge STP	Checking this box enables Spanning Tree protocol in bridged networks. See to section 3.11 "Spanning Tree Algorithm"" for more details
Bridge Priority	This is the priority associated with the Spanning tree protocol. Use lower numbers to move this station towards the root of the Spanning Tree, and use higher number here to move the station towards the leaves of the tree.
Default Gateway	This is the address that the device will use to forward messages to remote hosts that are not connected to any of the local bridged network (Ethernet or Wireless). This is only required if the wired LAN has a Gateway unit which connects to devices beyond the LAN - for example, Internet access. If there is no Gateway on the LAN, set to the same address as the Access Point - that is, the "Ethernet IP Address" below. Refer to section 3.15 "Routing Rules" for more information.
Obtain IP Address Automatically	Checking this item enables DHCP client on the BU-245U-E. A DHCP client requests its IP address from a DHCP server which assigns the IP Address automatically. For more information, refer to section 3.9 "DHCP Server Configuration", Default is unchecked.
MAC Address	This is the unique hardware address of the BU-245U-E and is assigned in the Factory. The BU-245U-E has two MAC addresses, one for each interface (Ethernet and Wireless). The Ethernet MAC is the primary MAC Address.
IP Address	The IP address of the BU-245U-E on its wired (Ethernet Interface) port and wireless (Wireless Interface) port. This should be set to the IP address you require. If the device mode is set to bridge, then the wired and wireless ports will have the same IP address.
IP Subnet Mask	The IP network mask of the BU-245U-E on its wired (Ethernet Interface) port and wireless (Wireless Interface) port. This should be set to appropriate subnet mask for your system (Typically 255.255.255.0).
System Address (ESSID)	A BU-245U-E wireless network comprises modules with the same "system address." Only modules with the same system address will communicate with each other. The system address is a text string 1 to 31 characters in length. Select a text string which identifies your system.
Desired BSSID	To force a client/station to always connect to the same Access Point enter the MAC address of that Access Point in the Desired BSSID field (Note that the ESSID of the Access Point must also match the configured ESSID of the client).
Radio Encryption	Select the desired radio Encryption level. Encryption key, passphrase, etc is entered on the "Security Menu" (See section below for details)
Save Changes	Save changes to non-volatile memory. The module will need to be restarted before the changes take effect.
Save Changes and Reset.	Save settings to non-volatile memory, and reboot BU-245U-E. Once the module has completed the reboot sequence, all changes are in effect.

3.5 Security Menu

Select the Radio Encryption level from the drop down menu on the Main index page and then press the "Save Changes" button.

Available encryption levels are - "None", "WEP (64-bit)", "WEP (128-bit)", "WPA PSK (TKIP)", "WPA PSK (AES)", "WPA2 PSK (AES)", "WPA PSK/ WPA2 PSK" & WPA-Enterprise. The default setting is "None."

IP Address	192.168.0.106
IP Subnet Mask	255.255.255.0
System Address (ESSID)	BU-245U-E_TEST
Desired BSSID	00:00:00:00:00:00
Radio Encryption	WPA-PSK(AES) ∨ Configure Encryption Settings on Security Page

[Save Changes] [Save Changes and Reset]

You will now need to go to the "Security Menu" and enter in the encryption keys (WEP), passphrase (WPA), etc.

Encryption Keys 1 to 4

These are the keys used to encrypt radio data to protect data from unwanted eavesdroppers when WEP Encryption is selected. These keys should be the same for all BU-245U-E units in the same system.

Authentication Mode =Open/Shared

One of the four keys may be selected as the default key, and is used to encrypt transmitted messages from the configured unit. A BU-245U-E can receive and decrypt a message from a module that has a different default key index as long as each module has the same key configured at the same index.
WEP keys must be entered as pairs of hexadecimal digits separated by colons. Hexadecimal digits are in the range 0...9 and A...F.

WEP Configuration

Authentication Mode	Open ∨
Default WEP Key	2 ∨
WEP Key 1	01:0D:12:1E:23:01:0D:12:1E:23:01:02:03
WEP Key 2	02:0E:13:1F:24:02:0E:13:1F:24:01:02:03
WEP Key 3	03:0F:14:19:25:03:0F:14:19:25:01:02:03
WEP Key 4	04:09:15:1A:26:04:09:15:1A:26:01:02:03

[Save Changes] [Save Changes and Reset]

64bit WEP requires 10 Hexadecimal digits, and 128bit WEP requires 26 Hexadecimal digits. For example, 12:AB:EF:00:56. for 64bit encryption, and 12:AB:EF:00:56:15:6B:E4:30:C8:05:F0:8D for 128bit encryption Encryption keys must not be all zeros, i.e., 00:00:00:00:00
WEP Open Authentication Mode

• Station sends an authentication request to the Access Point
• Access Point then authenticates the Station
• Station then associates with the Access Point and joins the network.

WEP Shares Authentication Mode

• Station sends an authentication request to the Access Point
• Access Point then sends a text based message to the Station
• Station uses its own WEP key to encrypt the text based message and sends it back to the Access Point.
• Access Point then decrypts the message using its on WEP key and if it matches authenticates the Station.
• Station then associates with the Access Point and joins the network.

When WPA Encryption is selected, 128bit Encryption keys are internally generated based on the Passphrase and System Address (ESSID). The Passphrase must be between 8 and 63 characters in length, and the Passphrase must be the same for all BU-245U-E units in the same system.

For optimal security a passphrase consisting of a combination of letters and numbers (i.e., not just a simple word or phrase) as well as upper and lower case. E.g. "WiReLeSs TeChNoLoGy 2010"

WPA Enterprise - Supplicant Configuration

Username / Password: User credentials that match a valid user on the RADIUS server.

Enable Debug: Must only be used during commissioning and only if requested by Cooper Bussmann Support. This must be disabled for normal operation.

Trusted CA Certificate Upload: Upload the certificate of the issuer of the RADIUS server's certificate. This enables the Supplicant to verify the identity of the RADIUS server during the authentication process.

Certificate Verification Result: Once a certificate has been loaded, this text box will contain validation information for the certificate. If this text is blank or contains errors, the certificate is invalid.

Trusted CA Certificate Contents: - Displays the contents of the loaded certificate.

WPA Enterprise - Authenticator Configuration

RADIUS Server IP Address/Port/Shared Secret: Connection information for the RADIUS Authentication Server.

Supplicant Re-authenticate Period: Sets the maximum time at which the Supplicant must re-authenticate. This parameter determines maximum time a client will still have access to the network after its user credentials have been revoked.

Enable Debug: Must only be used during commissioning and only if requested by Cooper Bussmann Support. This must be disabled for normal operation.

WPA Preshared Key Configuration

WPA Passphrase — passphrase

[Save Changes] [Save Changes and Reset]

WPA Enterprise - Supplicant Configuration

Username — Username
Password — Password
Enable Debug — ☐

[Save Changes] [Save Changes and Reset]

Trusted CA certificate upload

This certificate belongs to the issuer of the certificate for the 802.1x/R

[ ] [Browse...]

[Send] [Cancel]

WPA Enterprise - Authenticator Configuration

RADIUS Server IP Address — 192.168.0.75
RADIUS Server Port — 1812
RADIUS Server Shared Secret — secret
Supplicant Reauthenticate Period — 3600 seconds
Enable Debug — ☐

[Save Changes] [Save Changes and Reset]

3.6 Normal Operation

After addresses are configured, the units are ready for operation.

Refer to section 1 for an explanation on the operation of a Bridge and Router.

Transparent Bridge Operation

A bridge connects several Ethernet networks together, and makes them appear as a single Ethernet network to higher protocol layers.

By default, the BU-245U-E is configured as a transparent bridge. When a transparent bridge is started, it learns the location of other devices by monitoring the source address of all incoming traffic. Initially it forwards all traffic between the wired Ethernet port and the wireless port, however by keeping a list of devices heard on each port, the transparent bridge can decide which traffic must be forwarded between ports - it will only transfer a message from the wired port to the wireless port if it is required.

A bridge will forward all Broadcast traffic between the wired and wireless ports. If the wired network is busy with broadcast traffic, the radio network on the BU-245U-E can be unnecessarily overburdened. Use filtering to reduce broadcast traffic sent over the radio.
Refer Section 3.15 "Wireless Message Filtering" for how to configure a filter.

By default, a transparent bridge does not handle loops within the network. There must be a single path to each device on the network. Loops in the network will cause the same data to be continually passed around that loop. Redundant wireless links may be set up by enabling the bridge Spanning Tree Protocol (see section 3.11 "Spanning Tree Algorithm" for more details).

Router Operation

A router joins separate IP sub-networks together. The router has different IP addresses on its wired and wireless ports, reflecting the different IP addresses of the separate Ethernet networks. All of the devices in these separate networks identify the router by IP address as their gateway to the other network. When devices on one network wish to communicate with devices on the other network, they direct their packets at the router for forwarding.

As the router has an IP address on each of the networks it joins, it inherently knows the packet identity. If the traffic directed at the router cannot be identified for any of the networks to which it is connected, the router must consult its routing rules as to where to direct the traffic to. For details on configuring routing rules, see section 3.14 "Routing Rules."

3.7 Radio Configuration

The BU-245U-E can be configured for different radio transmission rates. A reduction in rate increases the reliable range (transmission distance). The factory-default data rate settings are suitable for the majority of applications and should only be modified by experienced users.

Note: This rate is for Transmit messages only as radio can receive on all data rates.

The BU-245U-E allows for a configurable fixed rate or an Auto radio transmission rate. When a fixed rate is configured the radio transmission rate is never altered, even under extremely poor conditions. The Auto rate will automatically change the radio data rate to give the best throughput. When a radio transmission is unsuccessful the BU-245U-E will automatically drop to the next lowest data rate and if subsequent transmissions are successful at the lower rate, the BU-245U-E will attempt to increase to the next highest rate. When a station connects to an access point the two devices negotiate a data rate based which is within configured range of radio data rates for both devices.

Select the "Radio" Menu to change the following configuration parameters. If a change is made, you need to select "Save Changes" to retain the changes. Changes will not take effect until the unit is reset.

Radio Mode	BU-245U-E -G support 802.11b and 802.11g radio standards and to limit operation to one or the other, select the desired standard. Normally selecting "auto" allows the modem to make the best choice.
	BU-245U-E -A only supports 802.11a radio standard.
Transmit Power Level	This allows adjustment of the radio power. Do not set the radio power above the allowed setting for your country You can reduce the power for short range applications, or to allow the use of high gain transmitter antennas while still complying with the emission requirements of your country.
	See "Appendix D" for dBm to mW conversion
Channel (AP Only)	BU-245U-E-G Radio Channels 1 to 13 (depending on country) may be configured at the Access Point. Refer Section 3.1.
	BU-245U-E -A Radio channels can be individually set (AP only – Client ignores the selection) or left in Auto (default) and then select the appropriate U-NII groups 1,2,3,4 each one having its own group of channels, Maximum Power and DFS selection.
	The default radio channel for both A & G models is Auto, meaning on startup it will scan all available and selected channel groups (Country dependent) and pick the quietest channel.
Channel Width (STA and Auto Channel Only)	BU-245U-E-G Stations only. When configured as a Station the module will periodically scan the channels looking for an Access Point. This option is used to speed up the Access Point scanning process of the Client radio by only scanning certain channel bands (5M, 10M, and 20M) or automatically scan all channels. Default is auto.
Turbo Mode (Only for fixed Channels – No Auto)	Selecting Turbo Mode doubles the transmit data rate offered on a Single channel. Maximum data rate up to 108Mbps.
	Only usable with other Cooper Bussmann BU-245U-E-A&G modules configured with the same Turbo Channel. If using the Turbo Mode feature all modem in the system will need to be configured with Turbo mode and the correct channel to communicate.
Transmit Data Rate	The radio baud rate in Mega (million) bits per second (Mbps) for point to point radio transmissions. The default value is Auto. Select a fixed rate to force the radio to use the selected rate.
	Note: Increasing the Transmit Data rate will decrease the Transmit power level. E.g., selecting 54 Mbps fixed data rate will reduce the transmit power from 400mW down to 125mW. This is to comply with 802.11 regulations.
Beacon Interval (AP only)	This interval is the period between beacon transmissions sent by an Access Point. The default value is 100 milliseconds, and it may be adjusted from 50 to 4095 milliseconds.
Disable SSID broadcast. (AP only)	This should be used to prevent unwanted eavesdroppers from detecting the radio network System Address (SSID) by passively listening to beacon transmissions from the Access Point. When disabled, Access Points will not transmit the System Address openly in Beacon messages. This is particularly useful in unencrypted radio networks.
Max Distance	Configure the maximum distance the radio signal is expected to travel. This allows the modem to compensate for the flight time of messages as they pass from the transmitter to the receiver, and as the acknowledgement messages are returned. Setting this value larger will cause a small reduction in throughput. Setting this value too small will cause communications problems over longer distances. Default distance is 5km
Save Changes	Save changes to non-volatile memory. Changes will not take effect until module is reset.
Save Changes and Reset	Save changes to non-volatile memory and reset module

Channel Selection

BU-245U-E-G modem (2.4GHz 802.11b/g) channel selection is done by selecting one of 13 channels from the drop down "Channel" list. (Country Dependent)

BU-245U-E-A modem (5GHz 802.11a) channel selection is shown below.

Channel (AP Only)   Auto   Select the channel group(s) to use for Auto selection below:
    Channel Group 1: 5.150-5.250GHz ☐ (Channels 36,40,44,48)
    Channel Group 2: 5.250-5.350GHz ☐ (Channels 52,56,60,64) [DFS]
    Channel Group 3: 5.470-5.725GHz ☐ (Channels 100,104,108,112,116,120,124,128,132,136,140) [DFS]
    Channel Group 4: 5.725-5.825GHz ☑ (Channels 149,153,157,161,165)
Transmit Data Rate   Auto   (max is 54 Mbps)

You can select an individual channel from the list keeping in mind that the channel will have some transmit and/or DFS constraints as indicated in Section 3.1 "Selecting a Channel" and Appendix C.

If using the Auto mode you will need to select the appropriate groups that you wish to use and the modem will automatically select an available channel from within the selected groups.

> **Note some of the Groups use DFS (Dynamic Frequency Selections) and if using these DFS channels you need to be aware that there will be a minimum 60 seconds scan/monitor time that the radio must perform to check there are no Military or Commercial Radars using the same frequency. If a Radar is detected the radio must select another random channel and again go through the 60 second scan/monitor time.**

Radio Throughput

Below is a table showing the maximum data throughput based on channel selection and receiver signal level.

Throughput is based on TCP/IP and there are three channel Bandwidths 20M, 10M, & 5M. These throughput estimations are based on perfect radio conditions, i.e., little to no outside radio interference present while data is being passed.

BU-245U-E Radio Data Throughput

2400Mhz Signal Strength	Data Rate in Mbps 20MHz	10MHz	5MHz
-74dBm	22	11	5.5
-77dBm	20	10	5
-83dBm	17	8.5	4.3
-86dBm	11	5.5	2.8
-90dBm	9	4.5	2.3
-91dBm	6	3	1.5
-93dBm	4.5	2.3	1.1
-94dBm	3	1.5	0.75

Throughput and Repeaters

It should also be noted that if using repeaters to extend the range there will be a reduction in throughput for each repeater hop.

The following table shows the drop in throughput for each hop and for each of the channel widths.

Data Throughput based on Repeater Hops

Signal	20MHz Channel				10MHz Channel				5MHz Channel			
Rep Hops	1	2	3	4	1	2	3	4	1	2	3	4
-74dBm	22	11.0	5.5	2.8	11.0	5.5	2.8	1.4	5.5	2.8	1.4	0.7
-77dBm	20	10.0	5.0	2.5	10.0	5.0	2.5	1.3	5.0	2.5	1.3	0.6
-83dBm	17	8.5	4.3	2.1	8.5	4.3	2.1	1.1	4.3	2.1	1.1	0.5
-86dBm	11	5.5	2.8	1.4	5.5	2.8	1.4	0.7	2.8	1.4	0.7	0.3
-90dBm	9	4.5	2.3	1.1	4.5	2.3	1.1	0.6	2.3	1.1	0.6	0.3
-91dBm	6	3.0	1.5	0.8	3.0	1.5	0.8	0.4	1.5	0.8	0.4	0.2
-93dBm	4.5	2.3	1.1	0.6	2.3	1.1	0.6	0.3	1.1	0.6	0.3	0.1
-94dBm	3	1.5	0.8	0.4	1.5	0.8	0.4	0.2	0.8	0.4	0.2	0.1

3.8 Advanced Radio Configuration

Some of the more advanced radio settings have been moved from the normal Radio configuration page so as to simplify the configuration process.

Care should be taken when making changes to parameters on this page.

TX Antenna	Select which antenna port the module will transmit from. Selections are Main Port Only, Both (Diversity) or Auxiliary Port Only. Module does not transmit from both ports at the same time. If needed, i.e., broadcast messages the radio will toggle transmissions between the antenna ports.
RX Antenna	Same as for TX antenna above but for the Receiver
DTIM Period (AP only)	DTIM sets which beacon frames incorporate extra information for low power sleeping client devices. Normally set this to 1.
RTS Threshold "Ready To Send"	RTS frames can be used to help avoid radio collisions between two stations that cannot directly hear each other. Any frame larger than RTS Threshold bytes will be preceded by an RTS message. The default value of RTS Threshold is 2346, which effectively disables RTS signaling, as this value is larger than the maximum frame size (Fragmentation Threshold).
Fragmentation Threshold	(Client Stations only). The maximum transmission unit (MTU) of data over the radio. If more than this number of bytes is input into the module, it will be transmitted in more than one message (or fragmented).
Interference Mitigation (AP only)	Interference Mitigation should only be turn ON (Default is OFF) if using Demo Whip antennas or if there is a high level of background interference.
	By enabling this option the radio will dynamically adjust radio parameters to help mitigate interference based on any background interference. It will reduce the receiver sensitivity and so should only be enabled on paths with a high fade Margin and good signal quality, etc.
Bursting	Selecting this option can increase the data throughput by reducing the overheads associated with wireless transmissions. If communicating with a device that does not support bursting the modem will drop back to non-bursting mode.
Passive Scanning (STA only)	Selecting this item stops a Client device from sending "probe request" messages when it is searching for an access point to connect to. Instead, the client waits for a beacon transmission from the access point.
Background Scanning (STA only)	Enabling this option will allow a modem to periodically rescan for Access Points so keep the connectivity page up to date with current system information. Default is off.
Enable Iperf Server	Enable Iperf Server function in the modem. Iperf is used for performing Radio surveys or radio path testing. See section 3.24 "TCP Throughput Test"
Fixed Noise Floor	Allows the Radio Receiver sensitivity Noise Floor to be moved above any interference. What this will do is essentially stop the radio communicating with devices with lower signal strength. For use in areas where there is a greater amount of interference

3.9 DHCP Client Configuration

DHCP (Dynamic Host Configuration Protocol) allows DHCP Clients to automatically obtain their IP Address at start-up. This simplifies network administration, as there is no need to manually configure each device with a separate IP Address. The BU-245U-E is able to act as a DHCP client. To set the BU-245U-E to acquire its IP address from a DHCP Server, check the box "Obtain IP Address Automatically" on the Network Configuration page.

When configured as a DHCP Client the "Device Name" on the Module Information page will be the module identifier (as the IP address will be unknown) and so should be given a unique name.

3.10 DHCP Server Configuration

The BU-245U-E is able to act as a DHCP server, supplying IP addresses automatically to other DHCP Client devices.

Note that the BU-245U-E units need to act in conjunction with their connected devices. If a connected device is a DHCP server, the local and remote BU-245U-E units can be configured as DHCP Clients and receive IP addresses from the server device. Similarly, if a BU-245U-E is configured as a DHCP server, it can provide IP addresses to DHCP Clients, both BU-245U-E units as well as other connected devices. Configuration items for the DHCP Server are listed below.

Enabled	Tick this box to enable the DHCP Server
IP Range Minimum / Maximum	The DHCP Server will assign IP addresses to DHCP Clients from within this range of addresses.
Gateway / Primary DNS / Secondary DNS	These Settings are common to all of the DHCP Clients, and refer to the gateway address, and Domain Name Service (DNS) Configuration.
Lease Time	This is the number of seconds the client is granted the assigned IP address. The client should renew its lease within this time.

3.11 DNS Server Configuration

DNS (Domain Name Service) allows devices to be given human-readable names in additions to their IP address. This makes identification of devices (hosts) simpler, and makes it possible to identify devices which have been automatically assigned their IP address by a DHCP server (See section 3.9 "DHCP Server Configuration"). DNS is the system which translates internet names (such as www.cooperbussmann.com) to IP Addresses. The Cooper Bussmann BU-245U-E can act as a DNS Server for a local network. Name to IP address mapping are automatically updated by the built in DHCP server when it issues an IP address to a client unit.

For the DNS Server configuration to be effective, Each DNS Client must be configured with the address of this DNS server, as either the primary or secondary DNS (secondary DNS is only used if there is no response from the primary DNS). Normally, this is done by setting the primary DNS field of the DHCP server configuration to the wireless IP address. This address is then provided to client units to use as their primary DNS server address when the DHCP server issues an IP address. The DNS Server is configured using the following settings.

Enabled	Tick this box to enable the DNS Server
Domain Name	This is a common suffix applied to the name of each device in the network. If your network is part of a larger network, this would be assigned to you by the relevant naming authority. If your network is stand-alone, this field is set to an arbitrary name of your choice.
Device Name (Host Name)	This is the DNS name of the local device. (Commonly referred to as the host name or computer name). This setting is duplicated on the main Module Information configuration page. This is the name which is used to refer to this device. (Refer Section 3.21 "Module Information Configuration.")

3.12 Spanning Tree Algorithm

The bridge "Spanning Tree Protocol" function was introduced to handle network loops and provide redundant paths in networks. To enable tick the STP box on any "WDS Connections" you have configured on the "Repeaters" configuration page.

For example, consider this network with a redundant wireless link. If the bridge Spanning Tree Protocol is enabled, one of the two wireless links will be disabled - that is, all wireless data will be transferred by one link only. If the active link fails, the other link will automatically start transferring the wireless data.
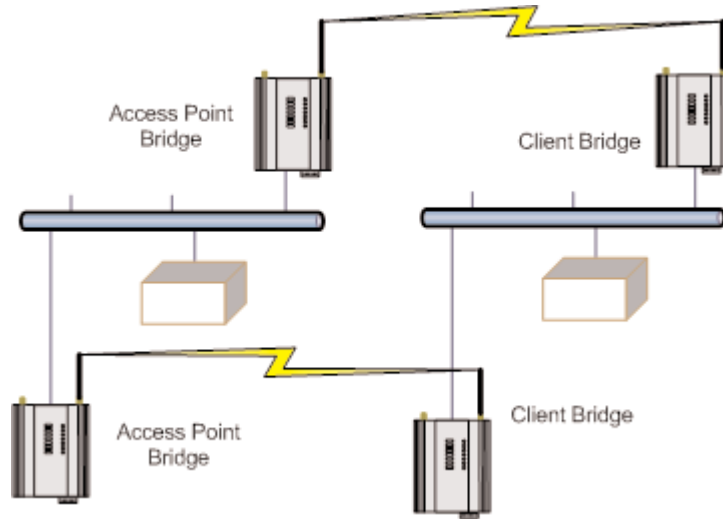
The Spanning Tree Protocol implemented is IEEE 802.1d compatible. The algorithm forms a loop-free network by blocking traffic between redundant links in the network. These blocked links are placed in a standby condition, and may be automatically enabled to repair the network if another link is lost. The Spanning Tree Algorithm maintains a single path between all nodes in a network, by forming a tree-like structure. The Bridge Priority determines where the node sits in the tree. A Bridge configured with the lowest priority (0) will become the root node in the network, and will direct traffic between each of its branches. The root node is typically the unit that handles the majority of traffic in the network. The BU-245U-E is configured with a Bridge Priority of 32768 by default. The intention is to reduce traffic that the BU-245U-E must handle, by placing it at the branch level in the network tree. As a branch, the BU-245U-E needs only pass traffic to devices that are its "leaves."

There is some overhead in maintaining a network utilizing the Spanning Tree Algorithm. Users wishing to increase their throughput, at the expense of redundancy should disable Spanning Tree. The Spanning Tree Protocol can be configured on the Repeaters configuration page.

3.13 Compatibility

3 Address (Layer 3 Bridge) & 4 Address Mode

What Addresses are in a wireless Ethernet data frame?

There are two different Wi-Fi communication "modes", 3 Address and 4 Address Modes. Each mode has a slightly different way that it addresses the data frames to other devices on the network.

In 3 Address Mode the addressing is made up of a Destination Address (DA), a Source Address (SA), and a BSSID (MAC Address of the Access Point)

In 4 Address Mode the addressing is made of a Destination Address (DA), a Source Address (SA), a Radio Transmit Address (RTA), and a Radio Receive Address (RRA).

Packets between AP and Client

Communications between Access Points and Client is generally done using 3 Address Mode because there are only 3 addresses within the communication path as indicated in the path from the Laptop to Station #1 in the diagram below.

If the Laptop wishes to communicate to Station #1 the DA will be Station #1, the SA will be the Laptop and the BSSID will be the APs MAC Address hence the 3 Address Mode.

The example shows the Laptop may need to communicate to the Ethernet Device connected to Station #2.

You can see that there is now a fourth address that cannot be addressed using the 3 Address Mode of communications.

i.e., Laptop, AP, Station #2 and Ethernet Device.

The example shows the Access Point and the Station as both being BU-245U-E modules which will happily communicate as both support 4 Address Mode.

However, there are some instances where a third Party Access Point may not be able to communicate using 4 Address Mode to a Client (Sta).

There are only a couple of ways around this sort of situation.

- Changing Station #2 to a Router, however this may mean that Station #2 and the Ethernet Device will use a different network address scheme which may be inconvenient and will require more setup.

- Configure the Access Point to communicate 4 Address Mode

If choosing the later this will only be possible if the Station and the AP support 4 Address Mode, some third Party APs do not.
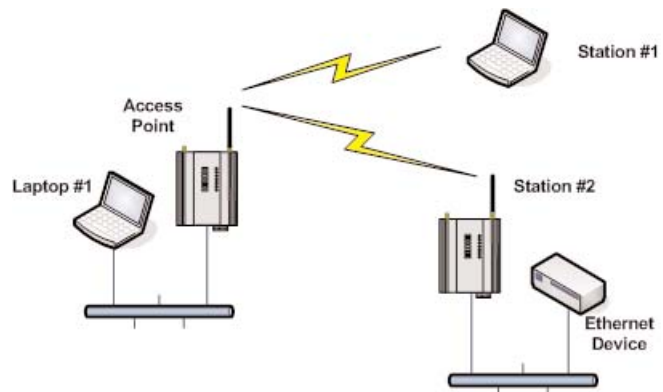
240U-E Compatibility

BU-245U-E-G modules can communicate with Cooper Bussmann 240U-E Ethernet modems however only in certain modes. The following table shows compatible configurations.

If communicating with Cooper Bussmann 240U-E Ethernet modems the 240U-Es need to be configured with WDS (4 address mode), not the default "3-address mode" and the 240U-E APs cannot be auto connect to any WDS AP.

	BU-245U-E-G AP	BU-245U-E-G Sta
BU-245U-E-G AP	Y	Y
BU-245U-E-G Sta	Y	Y

Notes:

1. Connection only if the BU-245U-E-G is configured with a virtual Station (Client) which in turn connects to the 240U-E Access Point.

2. Connection indication in the "connectivity" pages however it is not a true connection (see "3 Address & 4 Address Modes" above).

3.14 Multiple AP Repeater Mesh Network
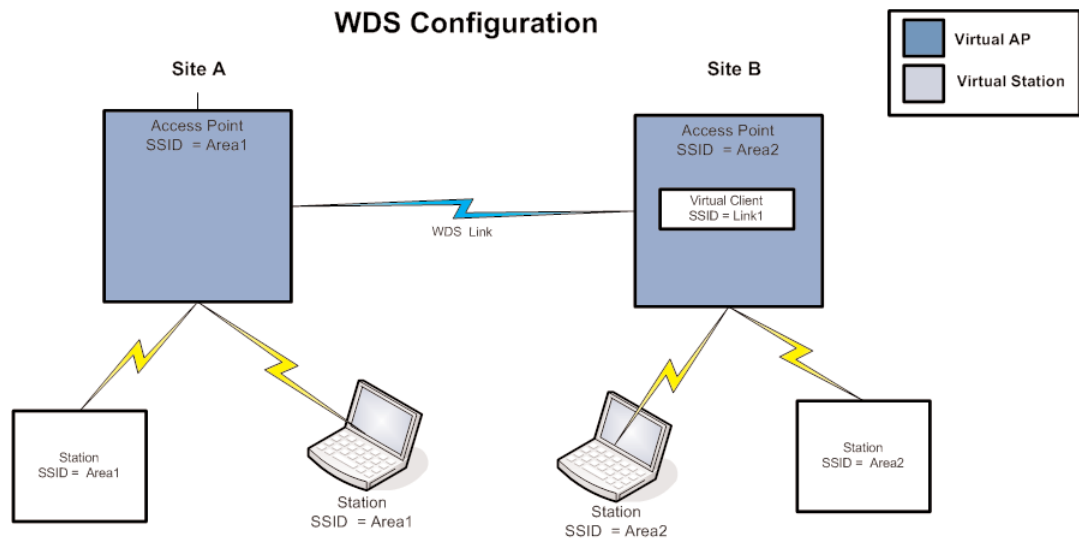
The range of a wireless network can be extended by allowing Access Points to behave as repeaters and forward traffic to other Access Points. Access Point to Access Point communications is also known as Wireless Distribution System (WDS). The BU-245U-E offers very powerful WDS configuration, allowing for a mesh network with self-healing functionality. Alternatively, fixed AP to AP links can be configured for optimized throughput.

Each BU-245U-E Access Point supports up to 10 separate interfaces for WDS links to other devices.

Each WDS interface can be either a bridge or router interface (refer section 1.1 "Network Topology" for more information on bridge vs router). If you need a simple repeater network, use a bridge interface.

A WDS bridge interface allows traffic to be bridged to another Access Point on the same IP network. WDS bridge interfaces do not require additional IP Address configuration, as they are bridged with the standard wireless interface that is used for connections to associated clients. All of the WDS interfaces on the one Access Point may be bridged if required.

WDS bridge interfaces have the advantage that redundant paths are permitted when using the bridge Spanning Tree Protocol (see section 3.11 "Spanning Tree Algorithm"), thus behaving as a self-healing mesh network. Bridged networks are also not as configuration intensive as routed networks. Since WDS bridge interfaces generally do not require IP address configuration (they inherit the IP address of the standard wireless interface).

A WDS router interface allows traffic to be routed to an Access Point on a different network, and therefore requires configuration of an IP address to reflect the network address of the destination network. WDS router interfaces cannot provide the redundancy of bridge interfaces, but can be used to reduce radio bandwidth requirements because the router can determine the destination based on IP address, whereas the bridge must go through a learning phase where all broadcast traffic must be retransmitted on each interface. Routed networks may also be used in some cases to avoid the overhead introduced by the bridge Spanning Tree Protocol when network loops exist.

Each WDS interface may also be configured with a different encryption algorithm; however each side of a single WDS link must specify the same encryption algorithm and keys.

Specify SSID for AP/STA modes or MAC Address for Point to point mode.

Router IP and Subnet should be left blank unless that WDS interface is to be on a different subnet. Leaving these fields blank will mean that the WDS interface will be bridged with the default wireless interface.

When adding WDS router interfaces, you may also need to add a Routing Rule on the Routing configuration page.

Spanning Tree Protocol (STP) column only applies when two or more interfaces are bridged.

A maximum of 10 WDS Connections can be configured. (A combined maximum of 5 AP and STA virtual modules applies.)

WDS Connections are made by adding one or more "Virtual Modules" to an Access Point (as illustrated in the diagram at the start of the section). Each virtual module can be configured with one of the standard wifi operating modes (Access Point or Station) or a non-standard Point to Point mode.

- Access Point and Station virtual modules allow for the possibility of dynamically created connections (based on SSID) and support WPA Encryption. A combined maximum of 5 AP and STA virtual modules can be configured per unit.

- Point to point mode virtual modules provide static connections (based on MAC addresses), and cannot support WPA Encryption. Point to point virtual modules should only be used for establishing WDS connections with third party Access Points that do not support standard WDS operation.

    All Access Points must be configured on the same fixed radio channel. Auto Channel selection must not be selected (See "Radio" page for details on configuring the channel.)

There are many different ways to setup wireless networks; often it depends on the devices you wish to connect and the existing network topology.

The following pages show some examples of how to connect devices into different types of systems.

Example – Extending Range Using WDS
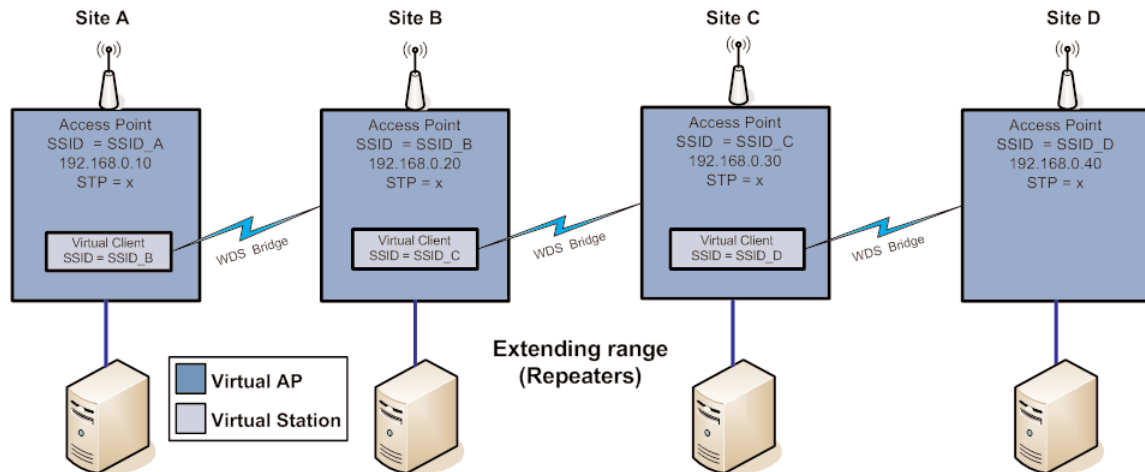
One of the most common uses for WDS is to extend the range of the wireless network using repeaters. The diagram above illustrates a simple example where the four Access Points are all at fixed locations (each of the Access Points could, of course, have one or more client/stations connected). Since the locations are fixed, we can avoid the overhead of using the Bridge Spanning Tree protocol here by configuring fixed WDS links to ensure that each Access Point will only connect to the next Access Point in the chain. Any number of additional intermediate repeaters could be added to the chain in a similar way.

Site B WDS Configuration 1

The WDS configuration for unit B is shown above (this page is accessible via the Repeaters link from the configuration web pages). Site B is acting as an Access point for Site A, and is a client to Site C, likewise Site C is acting as an Access Point for Site B, and a Client for Site D. Since this example is a bridged network i.e., all devices on the same IP network and each link is using a different SSID, there is no possibility of loops (i.e., multiple paths to the same location) therefore we do not need to incur the overhead of enabling STP (bridge spanning tree protocol).

We specify the devices at the other end of the WDS links by SSID only –MAC addresses can be used to specify point-to-point links to third party devices which do not support meshing via SSID.

In this example each Virtual connection is using the same Encryption method (WPA-PSK (AES) with a key of "Pass Phrase", however as in example #1 the Encryption method and key can be different for each virtual link or even disabled (no encryption). Also the Spanning Tree Protocol is disabled as there is no possibility of network loops.

Example - Roaming with WDS Access Points
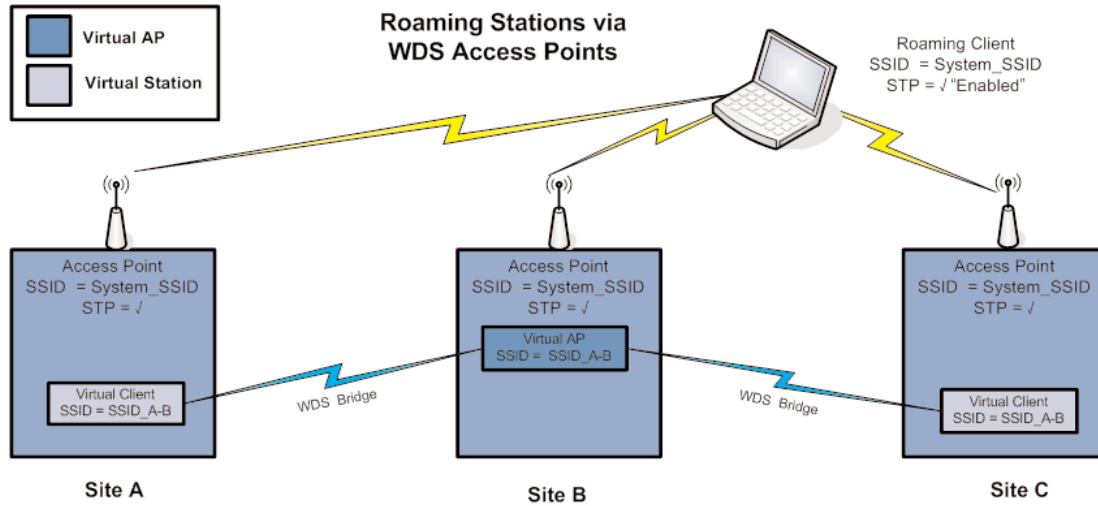
Another common use for WDS is extending the range across a large wireless network but allowing roaming connections between access points or being able to switch to the next Access Point when out of range of the previous Access Point.

The diagram above shows a bridging network with a number of Access Points all with the same SSID, network structure, etc (so as the Stations can freely roam between Access Points)

Each Access Point then needs a separate connection to the next Access Point, which is done using the WDS Virtual Access Points or Stations

Site B is acting as a Virtual AP for Site A & C, which in turn are acting as Virtual Stations.

This setup can be replicated to extend the range and will allow any Roaming Stations full connectivity across a network.

WDS Connections:

Add Entry   Delete Entry

#	Connection Mode	SSID / MAC Address	Encryption	Encryption Key	Router IP	Router Subnet	STP
1	AP (Downlink)	SSID_A-B	WPA2-PSK(AES)	PassPhrase			☑

Site B WDS Configuration 2

Example – Adding Redundancy

In the example below, 4 x Access Points (A, B, C, & D) form a mesh network using only WDS bridge interfaces. Each of the Access Points may also have its own clients associated. Each Access Point is configured with a different SSID, meaning the clients associated with each Access Point are fixed.
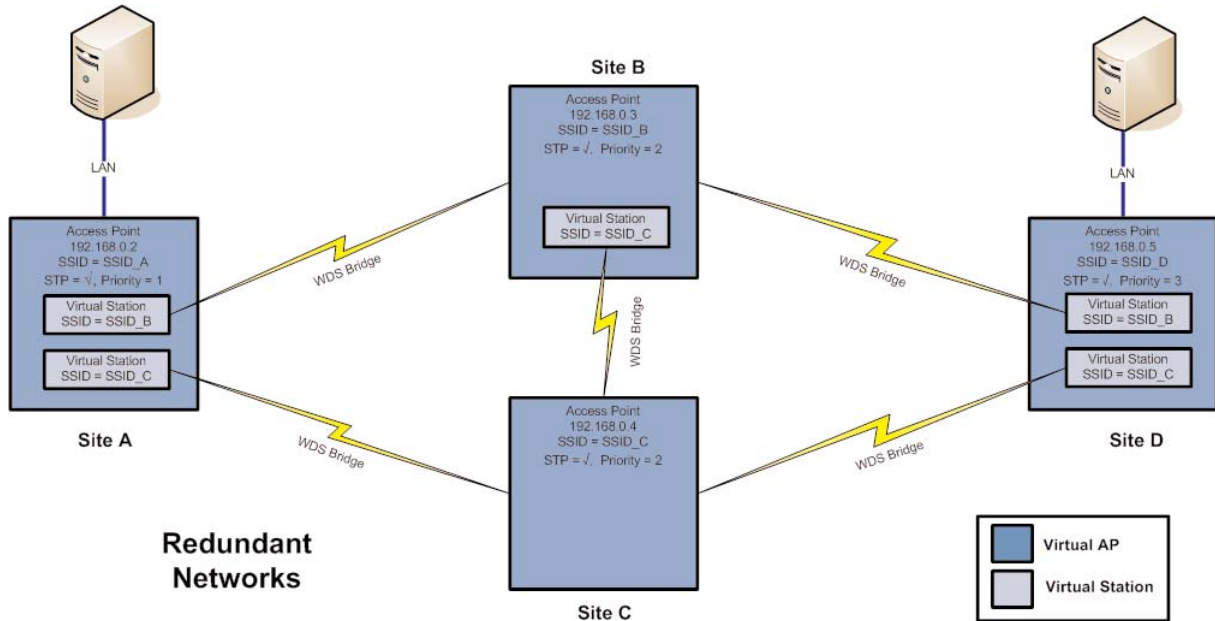
Sites A, B, C, and D can all exchange data with each other (as can all of their Stations) as if they were all on the same wired segment. It can be seen that there are redundant paths and therefore the possibility for loops to occur, so the bridge Spanning Tree Protocol should be enabled and depending on the size of the mesh possibly configuring a Bridge Priority.

Bridge Priority is used to determine the connection priority when selecting an interface to put into the forwarding state. You can assign higher priority values to interfaces that you want spanning tree to select first and lower priority values to interfaces that you want spanning tree to select last. If all interfaces have the same priority value, the MAC address is used to work out the priority.

To illustrate the redundancy, consider that if Site A needs to send data to Site D it has redundant paths through both B and C. However, due to the spanning tree protocol only one of B or C will relay the data, with the other taking over in the event of a failure.

The configuration for Site A and B are shown below. In this example, Site B uses its primary access point to act as an access point for Virtual Stations on Site A and D, and uses a Virtual Station to act as a client to Site C. Site A uses two Virtual Stations to act as clients to Site B and to Site C.

Device Mode:

Operating Mode	Access Point
Device Mode	Bridge
Bridge STP	☑
System Address (ESSID)	BU-245U-E_TEST

Site B configuration – Network Page configured as Primary Access Point

WDS Connections:

Add Entry | Delete Entry

#	Connection Mode	SSID / MAC Address	Encryption	Encryption Key	Router IP	Router Subnet	STP
1	Sta (Uplink)	SSID_C	WPA2-PSK(AES)	PassPhrase			☑

Site B WDS configuration - Repeaters Page configured with Virtual Station to Site C

WDS Connections:

Add Entry | Delete Entry

#	Connection Mode	SSID / MAC Address	Encryption	Encryption Key	Router IP	Router Subnet	STP
1	Sta (Uplink)	SSID_B	WEP(64 bit)	01:0D:12:1E:23			☑
2	Sta (Uplink)	SSID_C	WPA2-PSK(AES)	PassPhrase			☑

Site A&D WDS configuration - Repeaters Page configured with two Virtual Clients to Sites B & C.

Encryption levels and key above are shows as being different however they can be the same as in some of the earlier examples. One reason why the Encryption level and key would be different is because the Access Point may have clients that communicate using a different Encryption method e.g. 128 bit WEP and may not support the same Encryption method.
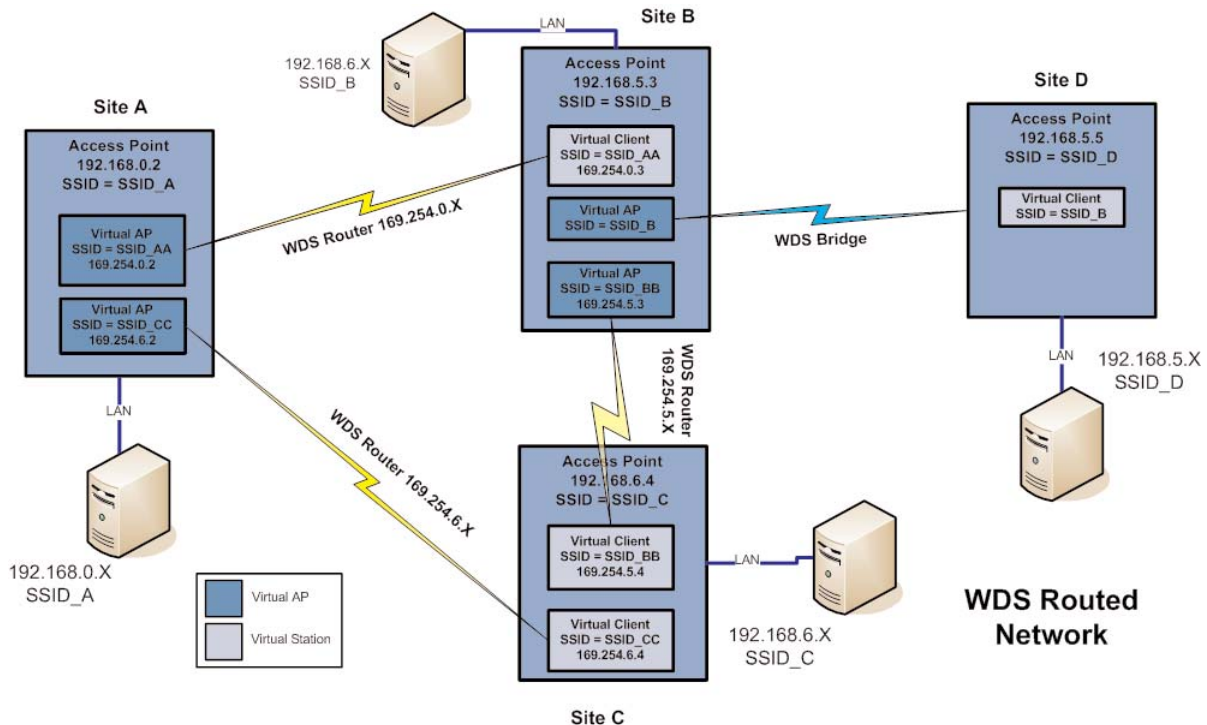
Example – WDS Routed Network

An example of using WDS router interfaces to achieve a similar physical topology to the WDS bridge example discussed earlier is illustrated below.

In both examples, there are four WDS Access points each with the possibility of having their own client/stations associated. In both examples A, B, C, and D can all exchange data with each other. The bridged example has the advantage of redundancy but at the expense of extra overhead. The routed example below cannot provide the redundancy of the bridged example, and requires more configuration effort, but does not have the overhead of using the bridge Spanning Tree Protocol, so is suited to fixed installations that do not require redundancy.

As mentioned previously, configuration of the WDS router example is more complex than the bridged example given earlier. Each Modem and each link have a different SSID. This is done to limit broadcast traffic and to route data only were it needs to go.

Site B in the WDS router example above has three WDS links – to Site A, C, and D; we show Site B's configuration below. It can be seen that there are 3 entries in the WDS Connections list.

WDS Connections:

#	Connection Mode	SSID / MAC Address	Encryption	Encryption Key	Router IP	Router Subnet	STP
1	Sta (Uplink)	SSID_AA	None		169.254.0.3	255.255.255.0	☑
2	AP (Downlink)	SSID_BB	None		169.254.5.3	255.255.255.0	☑
3	AP (Downlink)	SSID_B	None				☐

- The first entry specifies a connection from Site B to the virtual AP at Site A whose SSID is "SSID_AA", and has a separate Router IP address of 169.254.0.3 (this is the address that Site B adopts for the link to Site A). Note that this IP Address specifies a different network than that of the default interface for Site A or B (i.e., default interfaces 192.168.0.X and 192.168.X respectively). It is a requirement that the virtual interfaces at each end-point of a WDS link have the same network structure; this ensures that the WDS links at either end point are not bridged with their default interface.

- The second WDS entry above specifies a WDS link from Site B to the virtual Client at Site C whose SSID is "SSID_BB" and like the WDS link to Site A uses a different Router IP address (169.254.5.X) than the default interface. Note that this network address is also different to that used for the WDS link to Site A, so that these separate WDS interfaces are not internally bridged. In addition to adding these WDS link to Site A & C routing rules are required to direct traffic destined for the network address of these units, i.e., 192.168.0.X & 169.254.6.X. See below for examples routing rules.

- The third WDS entry specifies the WDS link to Site D. In the example, Site D is part of the same network structure as Site B; therefore does not require any entries in the Router IP and Subnet fields as the BU-245U-E automatically bridges this interface with the default wireless interface.

A consequence of using a different network address for the WDS link between Sites B & A and Site B & C, is that we now need to configure routing rules at Sites A, B and C so that the BU-245U-Es can determine where to send traffic destined for the other networks.

For example, if Site B receives traffic destined for network 192.168.0.x (i.e., somewhere on Site A's network), the routing rule specifies that the traffic must be forwarded to the end point of the WDS link to Site A. The routing rules for Site B are shown below (for more information on routing rules, refer to the section 3.14 "Routing Rules").

Routing Rules:

#	Name	Destination	Netmask	Gateway	Enabled
1	Route to Site A	192.168.0.0	255.255.255.0	169.254.0.2	☑
2	Route to Site C	192.168.6.0	255.255.255.0	169.254.5.4	☑

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So, in this example, Site B has a total of three IP addresses: 192.168.5.3 for the default interface; 169.254.0.3 for the WDS link to Site A; and 169.254.5.3 for the WDS link to Site C. Note: We choose to always use the same host address of 3 for unit B on all of its interfaces regardless of the network address.

• The first routing rule specifies 192.168.0.0 as the destination address (the network address of Site A) – because the last byte is zero, this refers to a route to the network (192.168.0.1 – 192.168.0.254 as opposed to a route to an individual host IP). The same rule specifies the address 169.254.0.2 as the gateway address (this is the WDS Router IP address that Site A has been configured with for its WDS link to Site B). So, this routing rule effectively tells the BU-245U-E that any traffic destined for the network 192.168.0.X should be forwarded to Site A via WDS link address 169.254.0.2.

• The second routing rule will be similar except the Destinations IP address will be 192.168.6.0 with a Netmask of 255.255.255.0, indicating all traffic for the 192.168.6.X network will be routed through the WDS link address 169.254.5.4. This is the WDS Router IP address that Site C has been configured with for its WDS link to Site B).

Units A and C would also require similar pairs of routing rules to direct traffic to the network addresses at the end points of their respective WDS links. Refer to section 3.14 "Routing Rules" for further information on routing rules.

The WDS Configuration page (as seen above) is accessible from the "Repeaters" link on any of the configuration web pages. The configurable WDS parameters are summarized below.

Add Entry Button	Add an entry to the WDS Connections table. This adds a virtual station to the device.
Delete Entry Button	Delete the currently selected entry in the WDS Connections table. To select a row, click anywhere in the row with the mouse, to highlight the entire row.

WDS Connections:

Connection Mode	Specify the connection mode for this link. AP (Downlink) configures the connection as a virtual access point. Sta (Uplink) configures the connection as a virtual client. Point-to-point configures the connection as a fixed link.
SSID / MAC Address	AP Mode: Specify the SSID that this virtual access point will use. Stations connecting to this virtual access point use this SSID.
	Sta Mode: Specify the SSID that this virtual station will use when connecting to other access points.
	Point-to-Point Mode: Specify the MAC address of an Access Point to establish a Fixed link with. Usually only required for third-party devices.
Encryption	Select the required Encryption (if any) for this WDS link.
Encryption Key	Enter the Encryption key (for WEP encryption) or the passphrase (for WPA encryption). For WEP encryption, the encryption key is set as WEP Key 1. For Sta Mode, this must match WEP Key 1 on the Access point this virtual client will connect to. For AP mode, clients must configure their WEP Key 1 to the same value as this key and select the Default WEP Key to be WEP Key 1.
Router IP	Leave this field blank if this WDS interface is to be bridged with the default wireless interface. Otherwise enter the IP address for this connection that specifies the IP network to which messages are routed.
Router Subnet	Leave this field blank if this WDS interface is to be bridged with the default wireless interface. Otherwise enter the subnet mask of the network to which messages are routed.
STP	Applicable to WDS bridged connections only. Select the STP option if you wish to enable the bridge Spanning Tree Protocol on this connection.

3.15 Routing Rules

When a BU-245U-E receives an IP frame that is destined for an IP address on a different network, it checks if the network address matches the network address of one of its own interfaces (i.e., hard-wired Ethernet, or wireless Ethernet, or WDS) and forwards the frame appropriately. However, if the IP network address does not match the network address of any of its interfaces, the BU-245U-E will forward the frame to its default gateway. In this case it is assumed that the default gateway has a valid route to the destination.

In some cases, it is not practical to have just one default gateway (i.e., routed wireless networks with more than two BU-245U-E routers; and in some cases when WDS router interfaces are used). If more than one "next-hop router" is required, the BU-245U-E allows for up to 30 routing rules to be configured. A routing rule specifies a destination network (or host) IP address and the corresponding next-hop router that messages for the specified destination will be forwarded to. It is assumed that the next-hop router (or gateway) will then deliver the data to the required destination (or forward it on to another router that will).
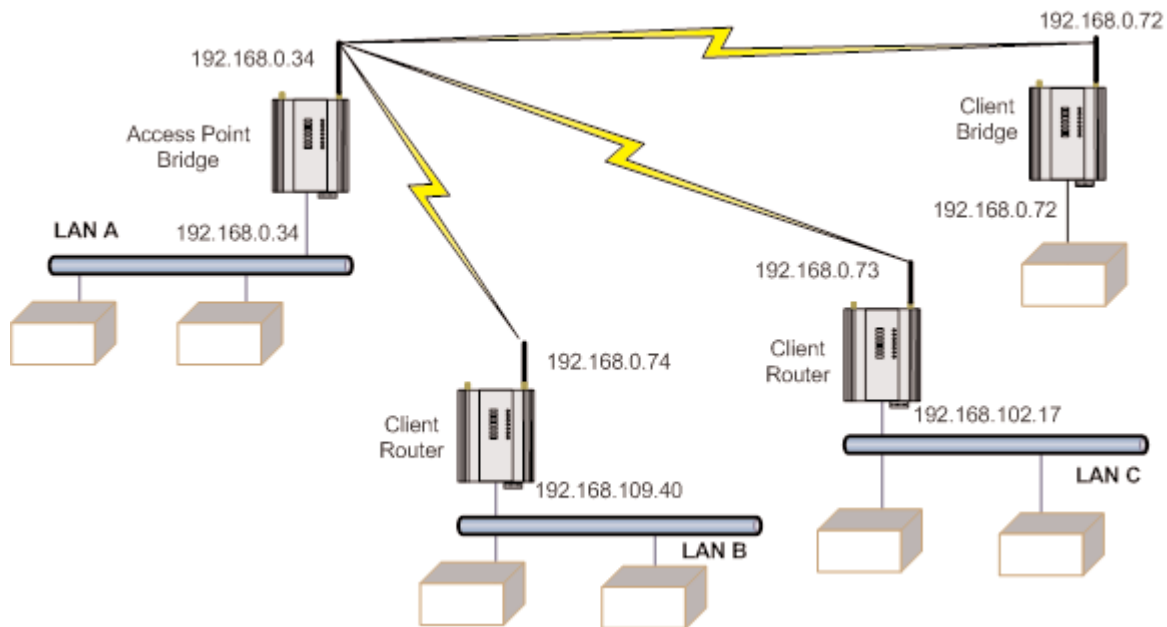
The above network diagram illustrates a situation where routing rules may need to be configured. In this example, the BU-245U-E clients need only specify the Access Point as their default gateway (i.e., they require no routing rules be configured). However, for the Access Point to be able to deliver traffic to LAN B and LAN C it needs to have routing rules configured that specify the respective BU-245U-E client/routers as next-hop routers (i.e., gateways) to networks B and C. Note that devices on LAN A should specify the BU-245U-E Access Point as their default gateway. An alternative to adding routing rules to the BU-245U-E in this example would be for each device on LAN A that needs to communicate with LANs B and C to have independent routing rules specifying the BU-245U-E clients at B and C as gateways to those networks.

The routing rules for the Access Point in the above example are shown below. The first entry shows the route to LAN B. The gateway for the route to LAN B is configured as the wireless IP address of the BU-245U-E client connected to LAN B. The destination for the route is configured as the network address of LAN B. Because the host id of the destination IP address is 0, it specifies a network address. Consequently, any traffic received at the Access Point with destination IP address 169.254.109.x (where x is any host id) will be forwarded to the BU-245U-E at LAN B.

Devices on LAN B & LAN C that needs to send messages back to LAN A will need to have their Gateway addresses directed to the BU-245U-E on their respected networks. i.e., a LAN B device needs to send data back to LAN A. The Gateway address will need to be configured as 169.254.109.40 as this is the IP address of the wired side of the LAN B BU-245U-E. Any message coming in with a 192.168.0.X IP address will be directed across the wireless interface to LAN A.

The Routing Rules configuration page can be accessed by selecting the "Routing" link on any of the configuration web pages. Up to 30 routing rules may be added to each BU-245U-E. The table below summarizes the configurable parameters of a routing rule.

Routing Rules:

#	Name	Destination	Netmask	Gateway	Enabled
1	Route to LAN B	169.254.109.0	255.255.255.0	192.168.0.74	☑
2	Route to LAN C	169.254.102.0	255.255.255.0	192.168.0.73	☑

Name	A name to describe the routing rule (Max 32 characters).
Destination	The destination network (or host) IP address (to specify a network address set the host address to 0. I.e., for an IP address 192.168.0.0 with Netmask 255.255.255.0 would specify a destination network, while 192.168.0.16 specifies a destination host).
Subnet Mask	The subnet mask for the destination network.
Gateway	The IP address of the next-hop router for the specified destination.
Enabled	Check this box to enable the rule. You can Uncheck the box to disable a routing rule without needing to re-enter the information at a later time.

Note: Entering dedicated Ethernet Routes can also be added to the wired Ethernet LAN in place of generating / adding routing rules into the modems.

3.16 Wireless Message Filtering

When configured as a Bridge, the BU-245U-E will transmit all broadcast messages appearing at its wired Ethernet port. When the BU-245U-E is configured as a Router, this does not occur.

In many cases, the intended recipient of the broadcast traffic does not lie at the opposite end of a proposed radio link. Reducing unnecessary broadcast traffic sent over the radio link, will increase available bandwidth for data. The BU-245U-E has a filtering feature to help reduce unnecessary wireless transmissions and enhance security.

The BU-245U-E may be configured to reject or accept messages to and from certain Addresses. To accept wireless messages from particular devices a "Whitelist" of Addresses must be made. Alternatively to reject messages from particular devices, a "Blacklist" of Addresses must be made. Filtering applies only to messages appearing at the wired Ethernet port of the configured BU-245U-E.

The Filter comprises of three lists: MAC Addresses, IP Address/Protocol/Port and ARP Filters. Each list may be set as either a Blacklist (to block traffic for listed devices and protocols), or as a Whitelist (to allow traffic for listed devices and protocols). The Filter operates on four rules listed below.

• The MAC Address filter is always checked before the IP Address filter.

• If a message matches a MAC filter entry, it will not be subsequently processed by the IP filter. If the MAC filter list is a Whitelist, the message will be accepted. If the MAC filter list is a Blacklist, the message will be dropped.

• The MAC address list checks the Source address of the message only.

- The IP Address filter checks both the source address and the destination address of the message. If either address match, then the rule is activated.

- ARP filtering applies only to ARP request packets (typically these are broadcast packets) which are sourced from the Ethernet interface and destined for the wireless interface. (ARP requests from devices on the wireless network will always be passed to the Ethernet interface. ARP response packets will always be passed).

When configuring a Whitelist it is important to add the Addresses of all devices connected to the BU-245U-E wired Ethernet port, that communicate over the wireless link. It is particularly important to add the Address of the configuration PC to the Whitelist. Failure to add this address will prevent the configuration PC from making any further changes to configuration. Design of the filter may be simplified by monitoring network traffic and forming a profile of traffic on the wired network. Network Analysis software, such as the freely available "Wireshark" program, will list broadcast traffic sent on the network.

For example, in the example, Device B needs to communicate with Device E via modems C & D. The Filtering requires that at Modem C has Device B in its Whitelist and Modem D has Device E in its Whitelist. With this filtering Device A will be not be able to access Device E, as Device A is not present in the Whitelist in Modem C.

If radio links are chained together to form a radio backbone, it is also important to consider the operation of the Layer 3 Transparent Bridge (Refer Section 3.5). A BU-245U-E Client will act as a MAC Address translator, as it acts as a MAC address proxy on behalf of devices connected to its wired Ethernet port. Addition of BU-245U-E Client MAC addresses into intermediate BU-245U-E units' Whitelist filters may be required for correct operation.
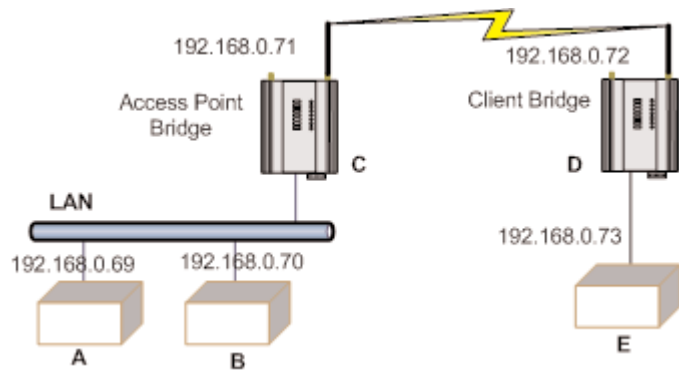
If an erroneous configuration has prevented all access to the module, SETUP mode can be used to restore operation.

MAC Address Filter Configuration:

MAC addresses are uniquely assigned to each device and so can be used to permit or deny network access to specific devices through the use of Blacklists and Whitelists.

In theory, MAC filtering allows a administrators to permit or deny network access to hosts associated with the MAC address, though in practice there are methods to circumvent this form of access control through address modification

The MAC filter entry will match only the source MAC address in the packet.

Note: It is important to add the MAC Address of the configuration PC when creating a Whitelist. If the configuration PC is not on the Whitelist, it will be unable to communicate with the module for further configuration.

Select "Blacklist" or "Whitelist"	Blacklist will prevent all listed devices from accessing the module and using the radio link.
	Whitelist will allow devices with the MAC addresses listed to communicate with the module and utilize the radio link. All other devices are blocked.
Add Entry	Add a row to the table of Mac Address filter rules
Delete Entry	Delete the currently selected MAC address filter rule.
Enable	Check to enable the rule.
MAC Address	Enter the desired source MAC Address
Save Changes	Save changes to non-volatile memory (Reset is required to activate)
Save Changes and Reset	Save to non-volatile memory And restart to activate changes

IP Address Filter Configuration:

The IP filter allows can be used to permit or deny network access to specific devices through the use of Blacklists (blocking of traffic that matches a rule) and Whitelists (allow traffic that matches a rule).

The IP filter entry will match either source or destination address in the packet. That is, if either the source or destination IP address falls within the address range specified in the rule, the packet is matched and will be discarded (Blacklist) or allowed (Whitelist).

If the protocol is specified, the protocol of the packet must also match. If the protocol is TCP or UDP the source or destination TCP/UDP can also be inspected. If the IP address and protocol matches and the source or destination port number falls within the range specified, the packet is matched.

Note: Configuration pages use TCP protocol on ports 80 and 443. Create Whitelist rules specifying the configuration PC's IP address, with TCP protocol, ports 80 and 443.

Select "Blacklist" or "Whitelist"	Blacklist will prevent all listed devices from accessing the module and using the radio link.
	Whitelist will allow devices with the IP addresses listed to communicate with the module and utilize the radio link. All other devices are blocked.
Add Entry	Add a row to the table of IP Address filter rules
Delete Entry	Delete the currently selected IP address filter rule.
Enable	Check this box to enable the rule
IP Address Min, IP Address Max	These set the range of IP addresses. All addresses within the specified range are affected by the rule.
Port Min, Port Max	When the protocol is set to TCP or to UDP, this is the range of port addresses to which the rule applies. When protocol is set to All or to ICMP, these settings have no effect.
Protocol	This chooses the protocol to which the rule applies. The rule can apply to Any protocol (All), or to only one of TCP, UDP, or ICMP (Ping).
Save Changes	Save changes to non-volatile memory (Reset is required to activate)
Save Changes and Reset	Save to non-volatile memory and restart to activate changes

ARP Filter Configuration

ARP (Address Resolution Protocol) is a broadcast message and is primarily used for finding a MAC address when only its IP or some other Network Layer address is known.

On large networks, you generally tend to get a high proportion of broadcast messages. Using ARP filters is useful for reducing broadcast traffic on the wireless network by only allowing ARP requests for known units to pass, or blocking ARP requests for high use addresses.

Select "Blacklist" or "Whitelist"	A Blacklist will block ARP requests that match the entry. A Whitelist will allow only ARP Requests that match the entry. All other devices are blocked.
Add Entry	Add a row to the table of ARP Address filter rules.
Delete Entry	Delete the currently selected ARP address filter rule.
Enable	Check this box to enable the rule.
IP Address	This sets the IP address that you wish to filter.
IP Netmask	Sets the IP Netmask.
Save Changes	Save changes to non-volatile memory (Reset is required to activate).
Save Changes and Reset	Save to non-volatile memory and restart to activate changes.

3.17 Serial Port Configuration

The BU-245U-E has an RS-232, and an RS-485 port for serial communications. These ports may be used for different purposes. The BU-245U-E offers three different serial functions, which are PPP server; Serial Gateway; and Modbus TCP to RTU Gateway.

RS-232 PPP Server

The BU-245U-E can be used as a PPP (Point-to-Point Protocol) Server to connect the wireless system to serial devices via the RS232 or RS485 serial ports.

PPP Server enables a network connection to the BU-245U-E over a serial cable. This is much like dial up internet. The maximum serial data rate is 115,200bps. Hardware or Software flow control may be selected.

With minimal configuration on the PC, you may use Dial up networking in Windows XP to connect to the network via the serial port.

For the BU-245U-E, users must configure the local IP address for the BU-245U-E and the remote device IP address. Some care must be taken in selecting these IP addresses.

• If you wish to use routing over this serial network connection, then the IP addresses selected must not lie on Wireless or Wired Ethernet networks already configured into the device. You must ensure they set routing rules appropriately for devices either side of the network.

• If you want the serial device visible as present on the Wireless or Wired network, then the local IP address must be the same as the IP address set for the desired port. A process called "Proxy ARP" is used to make the device visible on the network. In this process, the BU-245U-E pretends that it holds the IP address on the network, and responds on behalf of the remote device.

The result of this is similar to bridging for a single device, with some exceptions. One of these exceptions is the inability to handle name server searches of the network via this serial link. For example, you would encounter difficulty if you were to use Windows Explorer over the serial link to find a PC on the wired network. For this to operate correctly you must explicitly map computer names to IP addresses in the "LMHOSTS" file on your PC.

To configure Windows XP to establish a PPP connection to a BU-245U-E in SETUP mode, follow these steps:

1. On Network Connections in Windows XP, select Create a new connection.

2. On the New Connection Wizard, click Next.

3. Set up an advanced connection.

4. Connect directly to another computer.

5. Set PC as guest.

6. Set Connection Name.

7. Select a COM port.

8. Select availability.

9. Click Finish.

10. Select properties of this new connection by right clicking on connection.

11. General Tab click on Configure button.

12. Ensure maximum speed is 115200bps, click OK.

13. Select Networking Tab - click on Internet Protocol (TCP/IP) in list box and then click Properties button.

14. On Properties form click Advanced button.

15. On Advanced TCP/IP Settings form- General Tab, uncheck field in PPP link stating "Use IP header compression."

16. Configuration is now complete. Click on this newly created link to establish a connection to BU-245U-E.

17. Ensure both the username and the password are entered exactly as configured in BU-245U-E.
    (When booted in SETUP mode, the PPP server has username "user" and password "user.")

Serial Gateway (Server/Client/Multicast)

Serial Gateway functionality is available for both RS-232 and RS-485 ports independently, and enables serial data to be routed via the wired or wireless network connection. Serial Gateway functionality is similar to radio modem functionality, allowing point-to-point and multipoint serial data transfer.

The Serial Gateway can be configured as either as Server, Client, Multicast Group, or Modbus.

When configured as "Server", the module will wait for a TCP connection to be initiated by a remote client.

When configured as "Client", the module will automatically attempt to connect to a specified remote server using TCP. When configured as "Multicast Group", the module will broadcast data to all members of the same Multicast Group using UDP.

With the Serial Gateway Server, Client and Multicast functions it is possible for serial data from a 945U-E to be transferred to any other 945U-E serial ports including the corresponding port on the same 945U-E.

Serial Gateway (Modbus - Modbus RTU to TCP)

When configured as "Modbus", will allow a serial Modbus Client (Master) to connect with a single Ethernet Modbus TCP Server (Slave)

With the Modbus Function the serial data is encapsulated within a TCP/IP data frame and made available on the Ethernet network.

Both 945U-E serial ports and the hard wired Ethernet port can be configured to communicate completely separate data streams which can all be communicating at the same time.

Some of the possible Serial Gateway topologies are illustrated below.
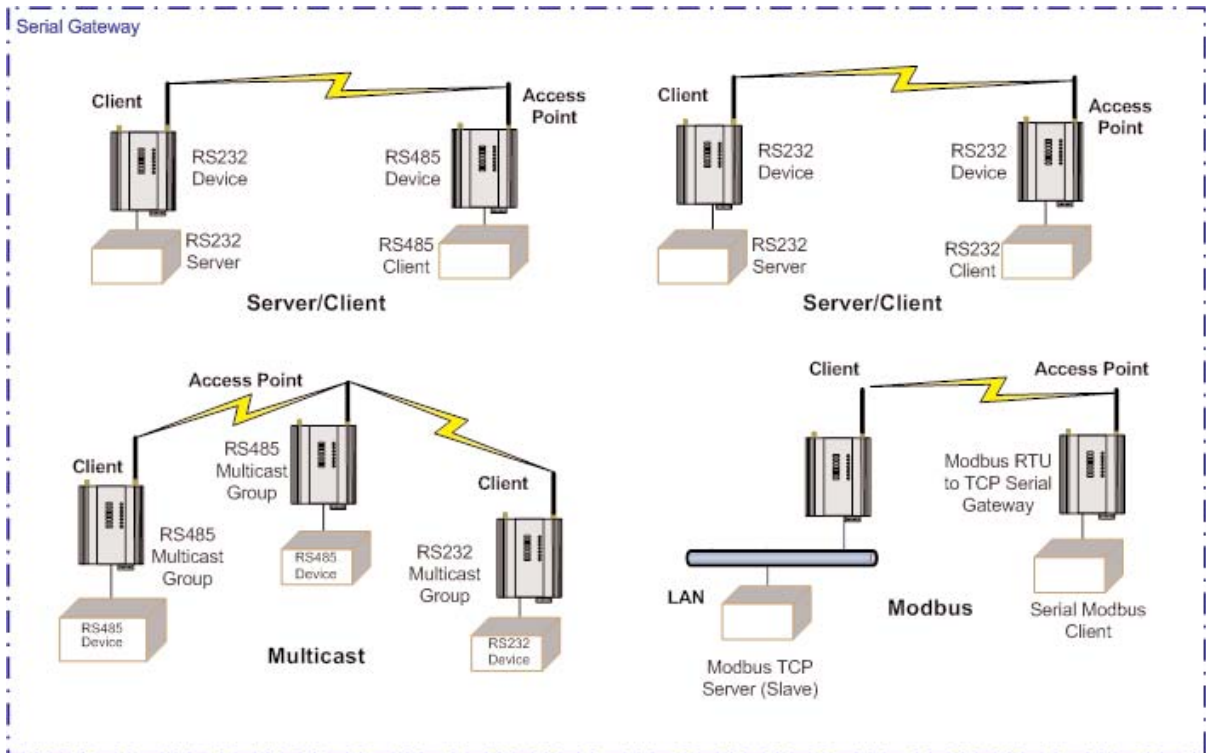
There are software packages available (i.e., SerialIP Redirector by Tactical Software) that can create a virtual serial port on a PC. This virtual serial port can be configured to connect to a BU-245U-E serial port. Standard programs can then be used to access this serial port as if it were actually connected to the PC. Alternatively HyperTerminal may be used to connect to a serial port on the BU-245U-E. When creating the HyperTerminal connection, select "Connect Using: TCP IP (Winsock)", enter the IP address of the BU-245U-E, and the port selected in the "Network port" field.

Modbus TCP to RTU Gateway

The Modbus TCP to RTU Gateway allows an Ethernet Modbus/TCP Client (Master) to communicate with a serial Modbus RTU Slave. The BU-245U-E makes this possible by internally performing the necessary protocol conversion. The conversion is always performed by the BU-245U-E which is directly connected to the Modbus serial device (i.e., only this module needs to have Modbus TCP to RTU Gateway enabled).
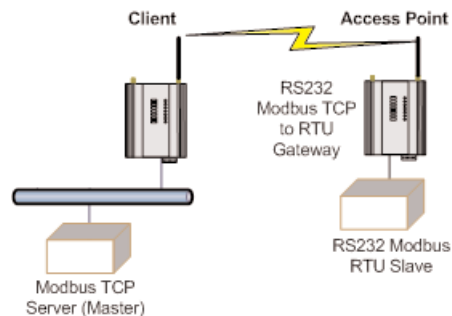
The above example demonstrates how a Modbus/TCP Client (Master) can connect to one or more Modbus RTU (i.e serial) Slaves. In this example the BU-245U-E Access Point is configured with the "RS232 Modbus/TCP to RTU Gateway" enabled. Once enabled, the gateway converts the Modbus/TCP queries received from the Master into Modbus RTU queries and forwards these over the RS232 port to the Slave. When the serial response to the query arrives from the Slave, it is converted to a Modbus/TCP response and forwarded via the network to the Modbus/TCP Master. If no response was received serially by the BU-245U-E within the configured Response Timeout, the BU-245U-E will initiate a number of retries specified by the configured Maximum Request Retries.

The Modbus TCP to RTU Gateway may be configured to operate on either the RS 232 or RS 485 port.

3.18 Serial Menu

RS232 / RS485 Serial Port Configuration

RS232 Port	Select the desired functionality. Select either PPP, Serial Gateway or Modbus TCP to RTU
Data Rate	The serial data rate desired. Serial data rates available range from 110bps to a maximum of 115,200bps.
Data Format	The data format desired. All the standard data formats are supported.
Flow Control	Selects CTS/RTS or None

RS232 PPP Server (Only RS232)

Username	User name to enter to access RS-232 PPP Server.
Password	Password to access RS-232 PPP Server.
Local IP Address	Select the IP address of the PPP server. The remote device may be made visible on the Ethernet or Wireless networks by either utilizing proxy-arp or routing. The proxy-arp feature may be enabled by setting the Local IP address the same as the Ethernet IP Address or the Wireless IP Address. The module will respond on behalf of the remote device, making it seem like the device is present on the configured network. Alternatively, if the IP address selected is not the same as the Ethernet or Wireless IP address, routing is used to pass data to the Ethernet and Wireless ports.
Remote Device IP Address	Select the IP address of the remote device. Ensure this address is not the same as any other device on the Ethernet or Wireless networks.

RS232 / RS485 Modbus TCP / RTU Converter

Modbus Server TCP Port	Port number used for the Modbus TCP – Standard port is 502.
Pauses Between Requests	Enter the delay between serial request retries in milliseconds
Response Timeout	Enter the serial response timeout in milliseconds – a serial retry will be sent if a response is not received within this timeout.
Connection Timeout	Enter the TCP connection timeout in seconds – if no Modbus/TCP data is received within this timeout then the TCP connection will be dropped. Set this field to zero for no timeout.
Maximum Request Retries	Enter the maximum number of request retries performed serially.
Maximum Connections	Enter the maximum number of simultaneous TCP connections to the server allowed.

RS232 / RS485 Serial Gateway

Serial Gateway Mode	Server - Module will wait for a connection to be initiated by a remote Client.
	Client - Module will automatically attempt to connect to the specified remote server.
	Multicast - Allows point to multi-point serial transfer. All members of the group will receive serial transmissions made by any other member of the Multicast group.
	Modbus - Allows a serial Modbus Client (Master) to connect with a single Ethernet Modbus TCP Server (Slave)
Character Timeout	Enter the maximum delay (in msec) between received serial characters before packet is sent via network.
Packet Size	The number of received bytes that will be buffered before a packet is sent via the network.
Listen Port (Server)	Server Only. Enter the TCP port number on which the server must listen for incoming connections. The standard TELNET port is 23.
Remote Device Port (Client)	Client only. Enter the TCP port number of the remote server (i.e., the remote port to automatically connect to).
Remote Device IP Address (Client)	Client only. Enter the IP Address of the remote server (i.e., the remote IP Address to Automatically connect to).
Multicast Group Port	Enter the UDP port number that all members of the group will use (i.e., all group members should use the same port number).
Multicast Group IP	Enter a valid Multicast IP Address identifying the group (i.e., all group members should use the same Multicast Group IP Address). Valid Multicast IP Addresses are in the range 224.0.1.0 to 238.255.255.255.
Modbus Server Port	Enter the TCP port number of the remote server (i.e., the remote port to automatically connect to).
Modbus Server IP Address	Enter the IP Address of the remote server (i.e., the remote IP Address to automatically connect to).

3.19 Multicast Pipe Manager

Previously it has been difficult to connect a single TCP device, i.e., a Scada / DCS system to multiple remote multicast serial devices.

Multicast Pipe allows this type of connection.

An example would be a Scada system that needs to communicate with multiple remote serial devices. A modem can be placed at each remote location and connected serially to each device. A multicast pipe is configured to communicate with all devices using a multicast address and port, i.e., 224.0.1.1:5000.

The Scada then communicates with the remotes via the IP address of the Multicast Manager and the port selected in the configuration, i.e., 5001.
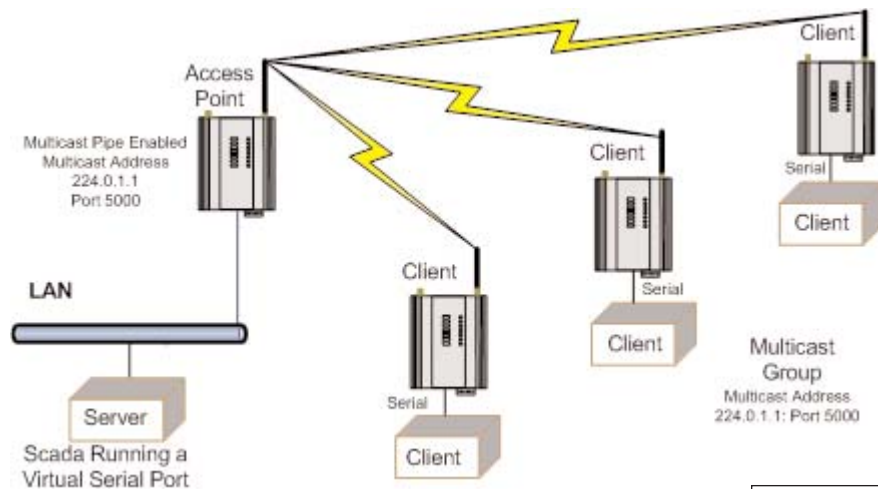
Multicast Pipe Manager

Enabled	Enables or disables the Multicast Pipe manager.
Server Port	Server port used by the Multicast Pipe Manager. Will need to be configured the same as the Port on the Client, i.e., Scada, DCS, etc
Multicast Group IP Address	Broadcast Address used when communicating to all other Multicast devices. This address will need to be the same on all communicating Multicast devices.
Multicast Group Port	Multicast Port used when communicating to all other Multicast devices. Will need to be the same on all communicating Multicast devices.

3.20 Digital Input/Output

The functionality of the shared Digital Input/Output pin may be configured via the "I/O Transfer" webpage. As this pin is shared, the Digital Input status will be ON when the Digital Output is set ON.

Shared Digital I/O Status:

Digital Input is: OFF

Digital Output is: OFF

[Switch Digital Output ON]

Communications Failure:

Digital output action on wifi link failure is [No Action ▼]

The Digital I/O channel can be transferred to/from another device using Modbus (see section "3.15 Modbus I/O Transfer") or it can be configured to provide status of the module communications. If the BU-245U-E disassociates from another unit (that is, there is no wireless link), you can configure the digital output to turn ON (set) or OFF (drop).

3.21 Modbus I/O Transfer

The BU-245U-E provides Modbus TCP Client and Modbus TCP Server functionality for I/O transfer. 5000 x 16bit general purpose registers are provided for Modbus (including the onboard Digital Input/Output) and are shared for both Client and Server. Modbus TCP Client (Master) and Modbus TCP Server (Slave) are both supported simultaneously, and when combined with the built in Modbus TCP to RTU Gateway the BU-245U-E can transfer I/O to/from almost any combination of Modbus TCP or RTU devices.

The layout of the BU-245U-E I/O Registers is summarized in the table below. Each register is internally saved as a 16 bit unsigned integer value. A Modbus transaction may access the entire 16 bit value of any register, or alternatively the most significant bit of a register may be accessed as a discrete value. The main use for the general purpose I/O registers is for intermediate storage, i.e., when transferring I/O from one Modbus Slave device to another. Also provided is the status of the onboard digital I/O, as well as the status of the wireless link. The 16 bit status register contains the value FFFF (hex) for ON and 0000(hex) for OFF. Inverted status registers are also provided where the registers contain 0000(hex) for ON and FFFF (hex) for OFF.

Registers	Purpose
1 – 4299	General purpose I/O registers (read/write)
4300	On-board Digital Input value (read only)
4301	Link Status (read only)
4320	On-board Digital Output value (read/write)
4370	On-board Digital Input inverted value (read only)
4371	Link Status inverted (read only)
4372-4999	Reserved for future use

Modbus TCP Client (Master) enables the BU-245U-E to connect to one or more Modbus TCP Servers (Slaves).

All Modbus Master messages are directed to/from the onboard I/O registers depending on configuration (described below).

The Modbus TCP Client may also poll Modbus RTU (i.e., serial) devices connected to either the local serial port or a remote BU-245U-E serial port by enabling the Modbus TCP to RTU gateway at the corresponding serial port (see section 3.16 "Serial Port Configuration").

Modbus TCP Client functionality allows connections to a maximum of 25 different Modbus TCP Servers.
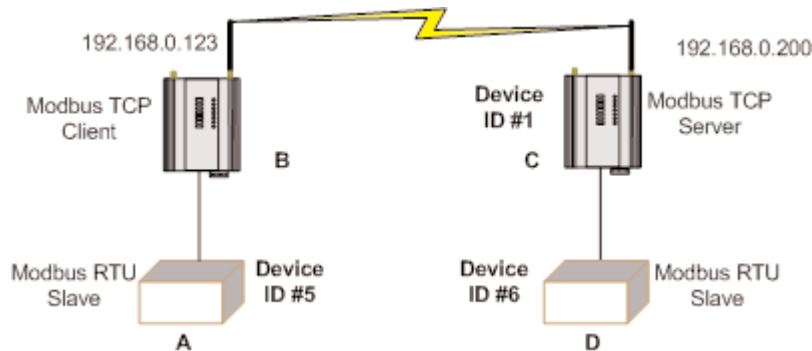
Modbus TCP Server (Slave) enables the BU-245U-E to accept connections from one or more Modbus TCP Clients (Masters).

All Modbus transactions routed to the onboard Modbus TCP Server are directed to/from the onboard general purpose I/O registers. The Modbus TCP Server is shared with the Modbus TCP to RTU Gateway, so that the Modbus "Device ID" is used to determine if a Modbus transaction is to be routed to the onboard Modbus TCP Server or to a Modbus RTU device connected to the serial port. Care should therefore be taken that all serially connected Modbus devices use a different Modbus Device ID (i.e., Modbus Slave Address) to the onboard Modbus TCP Server. Up to 32 separate connections to the Modbus TCP Server are supported.

Modbus TCP Configuration:

Enable Modbus TCP Server (Slave)	☐
Modbus Server Device Id	1
Enable Modbus TCP Client (Master)	☐
Modbus Client Scan Rate (msec)	1000
Reset Registers on Comms Fail	☐
Comms Fail Timeout (sec)	10
Enable Modbus Statistics	☐
Log Background Noise	☑

Modbus RTU (serial) Master functionality is achieved by combining the Modbus TCP Client (Master) and Modbus TCP to RTU Gateway. Simply specify a Modbus TCP Client (Master) connection to a Modbus TCP Server where the server is the address of any BU-245U-E with Modbus TCP to RTU Gateway enabled. Care should be taken to ensure that the Device ID (i.e., Modbus Address) of the serial device is different to the Device ID of the onboard Modbus TCP Server of the BU-245U-E that the serial device is connected to.

The BU-245U-E provides a configurable option to automatically reset the value of the onboard I/O registers to zero in the event of a communications failure. If a valid Modbus transaction directed to/from a given register has not been completed for longer than a configurable timeout, then the value of that register will be reset to zero.

An example of the Modbus functionality of the BU-245U-E is illustrated below. In this example the status of the onboard digital input at C will be reflected at the onboard digital output at B. Also, 8 single bit registers from Modbus serial device D will be transferred to A.

Modbus TCP Client Mappings:

Add Entry   Delete Entry

#	Local Register	IO Count	Function Code	Destination Register	Device Id	Server IP Address	Response Timeout (ms)	Comm Fail Register
1	4300	1	15: Write Coils	4320	1	192.168.0.200	1000	0
2	1	8	02: Read Discretes	1	6	192.168.0.123	1000	0
3	1	8	15: Write Coils	1	5	192.168.0.200	1000	0

Unit B is configured with Modbus TCP Server enabled and Device ID = 1, Unit C is configured as shown above.

- The first will write the register 4300 (Local Digital Input) to server IP address 192.168.0.200 (Unit B), Device ID #1, register 4320 (Local Digital output).

- The second mapping shows a Modbus read command of 8 Discretes starting at register 1 (Destination Reg) on Device ID #6 connected to IP address 192.168.0.123 (it self) and store the values at register #1 locally.

- The third mapping shows the Modbus write command (Write Coils) which is writing the local 8 I/O's starting at register 1 across to Server IP address 192.168.0.200, Device ID #5, destination reg #1.

The configuration of unit B is shown below (accessible via the "I/O Transfer" configuration page). It can be seen that Modbus TCP Client has been enabled with a 500msec scan rate, meaning that there will be a 500msec delay between each of the mappings directed at any server. The "Reset Registers on Comms Fail" option is enabled with a timeout of 60 seconds, indicating that any of the registers at unit B will be reset if a successful Modbus transaction involving that register has not been executed in the last 60 seconds. The Modbus TCP to RTU Gateway at B must also be enabled (see section "3.13.3 Modbus TCP to RTU Gateway") to allow Modbus communications with the serial device A.

Three "Modbus TCP Client Mappings" are also configured at B in order to perform the required I/O transfer. The first mapping transfers the status of the onboard digital input at C to the onboard digital output at B. Local Register 4320 specifies the register for the onboard digital output at B (since B is the local unit at which the mapping is configured). I/O Count 1 specifies that only one I/O point is being transferred (i.e., the single digital I/O). Function Code 02: Read Discretes specifies the standard Modbus function code to read discrete (i.e., digital) inputs. Destination Register 4300 specifies the register for the onboard digital input at unit C (since C is the destination unit for this mapping). Device ID 1is the ID of the onboard Modbus TCP Server at C. Server IP Address 192.168.0.200 is the IP address of unit C – which is the Modbus TCP Server we are reading from. Response Timeout 1000 ms specifies that unit C must respond to this message within 1000ms. Comm Fail Register 0 specifies the local register where the communications status for this mapping will be stored.

The second mapping reads 8 registers from serial unit D into onboard registers in unit B. Note that in this case the specified Device ID 6 is the Modbus Address of the serial device D, while the Server IP Address 192.168.0.200 is the IP Address of unit C since the Modbus TCP to RTU Gateway at unit C converts the Modbus TCP message to Modbus RTU and routes it out the serial port to unit D.

The third mapping takes the 8 registers read by the second mapping and writes them to the serial unit A. The specified Device ID 5 is the Modbus Address of the serial device A, and the Server IP Address 192.168.0.196 is the IP Address of the local unit B since the local Modbus TCP to RTU Gateway is to route the message out the serial port to unit A.

Since the BU-245U-E supports Modbus TCP Client and Server simultaneously, the Modbus TCP Server for unit B above could also be enabled. This would allow one (or more) external Modbus TCP Clients anywhere on the extended wired or wireless network to connect to unit B and monitor the status of the I/O registers – including the I/O at units A, C, and D. This is a very powerful and flexible feature which could, for example, be exploited by a central monitoring facility or SCADA.

Modbus TCP Configuration on I/O Transfer Menu:

Enable Modbus TCP Server (Slave)	Check this box to enable the onboard Modbus TCP Server. All Modbus TCP connections to the module IP Address and specified Modbus Server Device ID will be routed to the onboard I/O registers.
Modbus Server Device ID	Specify the Modbus Device ID for the onboard Modbus TCP Server. Allowed values are 0 to 255.
Enable Modbus TCP Client (Master)	Check this box to enable the onboard Modbus TCP Client. I/O to be transferred via the Modbus TCP client is specified with Modbus TCP Client Mappings.
Modbus Client Scan Rate	Enter the delay (in milliseconds) between execution of consecutive Modbus TCP Client Mappings to the same Server.
Reset Registers on Comm's Fail	When Enabled the value in any onboard I/O register will be reset to zero if a valid Modbus transaction directed to/from the given register has not been completed for longer than the Comms Fail Timeout.
Comms Fail Timeout	The period of time after which onboard I/O registers will be reset if a valid Modbus transaction directed at that register has not completed.
Enable Modbus Statistics	Enables the Modbus Diagnostic registers as shown in Section 4.5 "Internal Diagnostics Modbus Registers" Disabling this option will free up the registers and also slightly increase processing resources.
Log background Noise	RSSI & BGND on Rx messages are made available in the diagnostic registers (Section 4.5 "Internal Diagnostics Modbus Registers" for details. For a Hex value of 5F5D the 5D byte = RSSI and the 5F byte = BGND (Convert value from hex to dec and add a "-"e.g. 5F = -95dB). Enabling this option removes the RSSI byte from these registers and so only the Background Noise value is made available.

Modbus TCP Client Mappings on I/O Transfer Menu:

Local Register	Enter the starting onboard I/O register number that the specified Modbus Master transaction will transfer I/O to/from.
I/O Count	Specify the number of consecutive I/O register to be transferred for the specified transaction.
Function Code	Specify the Modbus Function Code for the transaction.
Destination Register	Enter the starting I/O register number in the destination device that the specified Modbus Master transaction will transfer I/O to/from.
Device ID	Enter the Modbus Device ID of the destination Modbus device
Server IP Address	Specify the IP Address of the destination Modbus TCP Server for the specified transaction.
Response Timeout	Enter the timeout (in milliseconds) to wait for a response to the specified transaction.
Comm Fail Register	Enter the onboard I/O Register number to store the communication status of the specified transaction. The Specified register will be set to 0 if communications is successful, 0xFFFF if there is no connection to the specified server, or 0xFFxx where xx is the Modbus Exception Code

3.22 Module Information Configuration

Module Information Webpage Fields

This configuration page is primarily for information purposes. With the exception of the password, the information entered here is displayed on the home configuration webpage of the BU-245U-E.

Username	Configuration of Username. This is the username used to access the configuration on the BU-245U-E. Take care to remember this username if you change it as it will be needed to access the BU-245U-E in future.
Password	Configuration of Password. This is the password used to access the configuration on the BU-245U-E. Take care to remember this password if you change it as it will be needed to access the module in future.
Device Name	A text field if you wish to label the particular BU-245U-E. This is also the DNS name (hostname) of the device if you are using DNS.
Owner	A text field for owner name.
Contact	A text field for owner phone number, email address etc.
Description	A text field used for a description of the purpose of the unit.
Location	A text field used to describe the location of the BU-245U-E.

3.23 System Tools

The System Tools Page has a number of tools that help maintain the module firmware and configuration.

TCP Throughput Test	Performs a Throughput Test. See section 3.23 "TCP Throughput Test" below for details
Configuration Summary	This option is used to save all the different configuration pages onto one page, for easy viewing. Page can also be saved (using the File/Save As function on the drop File Menu) for future reference and emailing module configuration details to Technical Support in the event of any configuration problems.
System Log File	Shows an event log of the modules operation, used for diagnosing problems. Page can be saved and emailed to Cooper Bussmann if requested. "Clear System Log" will clear out the log file and start fresh.
Read Configuration File	This option will show the module configuration in XML format. This file can be saved for future reference.
Write Configuration File	Any configuration XML files saved using the "Read Configuration" above can be loaded back into the module
Firmware Upgrade	This option is used for firmware upgrades. Load the file using the "Browse" button and when found press "Send" which will load the file into the module. When completed press "Reset" Firmware upgrade can be done locally or remotely via the radio.
Reset	Resets the module
Factory Default Configuration	Loads the Factory default configuration and resets. CAUTION – Doing this will overwrite any current configuration

3.24 TCP Throughput Test

The performance of a wireless link is best measured in terms of the maximum throughput that can be achieved. The recommended method of measuring throughput is with the "iperf" utility. Iperf has client and server functionality, where the server waits for a client connection. For wireless links, it is recommended that iperf throughput testing is performed on point to point links while the remainder of the wireless network is inactive (i.e., not sending any data).

Iperf is built into the modems for convenience, and allows measurement of TCP throughput with default iperf parameters. For access to all iperf features and a slightly more accurate result due to module processor overheads etc, it is recommended that iperf be run externally on a PC or laptop, see Appendix E "External Iperf Test."

Internal Throughput Test

Before testing ensure that the end node of the Wi-Fi Link that you wish to test has the Iperf Server enabled under the Advanced Radio Settings page and Saved to Flash and the module has been reset. See Figure 3

Figure 2.

Connect to the web page of the module that will be performing the Iperf test, select "System Tools" link on the right hand side of the webpage and then select "TCP Throughput Test" and you will see the Screen as shown below.

TCP Throughput Test

The performance of a wireless link is best measured in terms of the maximum throughput that can be achieved. The recommended method of measuring throughput is with the "iperf" utility. Iperf has a client and server functionality, where the server waits for a client connection. For wireless links, it is recommended that iperf throughput testing is performed on point to point links while the remainder of the wireless network is inactive (i.e. not sending any data).

Iperf is built into the modems for convenience, and allows measurement of TCP throughput with default iperf parameters. For access to all iperf features it is recommended to run iperf externally on a PC or laptop.

Iperf Client functionality is activated below. The specified IP address must be a device running iperf in Server mode (if a remote modem is to be the iperf server then ensure that it is enabled on the advanced radio configuration page). Each run of the onboard iperf client will perform a TCP throughput test of 10 second duration.

Remote Device IP Address: 192.168.0.118   [Measure Throughput]

Note: TCP Throughput test must be run using Microsoft Internet Explorer 8 or later.

Remote Device IP Address: 192.168.0.118   [Measure Throughput]

Enter the IP address of the remote device that you wish to test and press the "Measure Throughput" button.

The specified IP address must be running Iperf in Server mode (if the remote modem does not have the Iperf server running then you will get the following Error message on the web page, "Iperf error, check connectivity to server." Ensure that it has been enabled and the module has been reset. Each press of the "Measure Throughput" button will perform a TCP throughput test of 10 second duration.

You will see the message "Performing Iperf Test" text and and if you look at the modules you will see the TX/Link & RX Led's flashing very fast as it performs the test. Approximately 10 seconds later a graph showing the actual throughput over the 10 second period and a calculated average will be displayed.

The graph below shows the data throughput range between 8 and 14.5Mbits per second with an overall average of 10.9Mbits per second.

It is recommended to perform this throughput test a number of times to get better sample of the overall throughput.

Iperf throughput for 10 second interval:
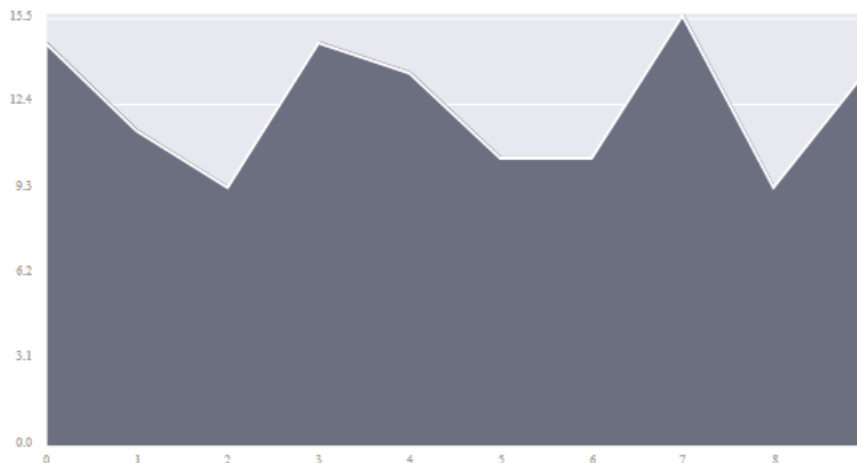
Average throughput = 12.20 Mbits/sec.

3.25 Remote Configuration

Because a module configuration is viewed and changed in a web format (which uses TCP/IP protocol), you can view or change the configuration of a remote module via the wireless link, provided the remote module already have a wireless link established to the local BU-245U-E.

To perform remote configuration, connect a PC to the local module, run Internet Explorer and enter the IP address of the remote unit (or device name if using DNS) - the configuration page of the remote module will be shown and changes can be made.

Care must be taken if modifying the configuration of a module remotely. If the Radio Configuration is changed, some changes made may cause loss of the radio link, and therefore the network connection.

It is advisable to determine the path of the links to the modules you wish to modify, and draw a tree diagram if necessary. Modify the modules at the "leaves" of your tree diagram. These will be the furthest away from your connection point in terms of the number of radio or Ethernet links.

In a simple system, this usually means modifying the Client modules first and the Access Point last.
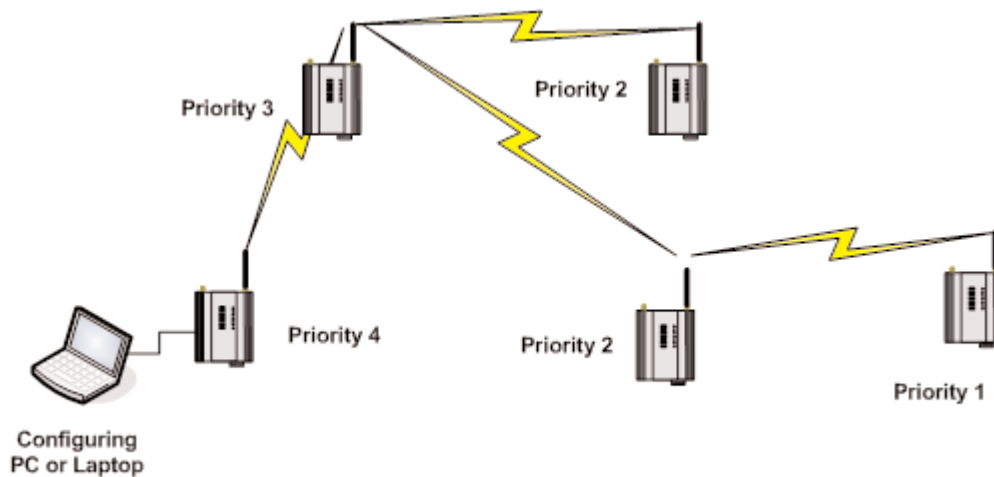
Remote Configuration Priority

3.26 Configuration Examples

Setting a BU-245U-E to Factory Default Settings

Access configuration webpage on the BU-245U-E. Refer section"3.2."

- Click on "System Tools" Menu Item

- Click on Factory Default Configuration Reset, and wait for unit to reset. While the module executes the reset sequence the OK LED will flash. The OK LED will turn green when the reset sequence is complete.

Extending a Wired Network

Access Point Configuration

Connect straight through Ethernet cable between PC and BU-245U-E.

Ensure configuration PC and BU-245U-E are setup to communicate on the same network

Set dipswitch to SETUP mode.

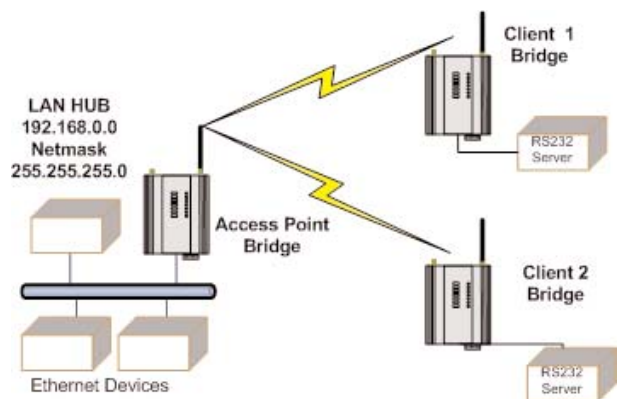Power up unit, and wait for the OK LED to cease flashing.

Adjust PC network settings

Set Configuration PC network card with network setting of IP address 192.168.0.1, netmask 255.255.255.0

Open configuration webpage with Internet Explorer at address https://192.168.0.1XX/ where XX is the last two digits of the module's serial number

When prompted for password, enter default username "user" and password "user"

Click "Network", and select Operating Mode as Access Point.

Select Device Mode as Bridge.

Change the Gateway IP Address to 192.168.0.1

Change the Ethernet and Wireless IP addresses to 192.168.0.200

Change Ethernet and Wireless Subnet masks to 255.255.255.0

Enter a System Address (ESSID) string

Select the Radio Encryption required.

Set dipswitch to RUN

Save the changes and unit will restart with new settings.

Client 1 Configuration

Perform the same configuration steps as the Access Point configuration with the following differences:

Set the Ethernet and Wireless IP addresses of BU-245U-E to 192.168.0.201

Set the Operating Mode to Client.

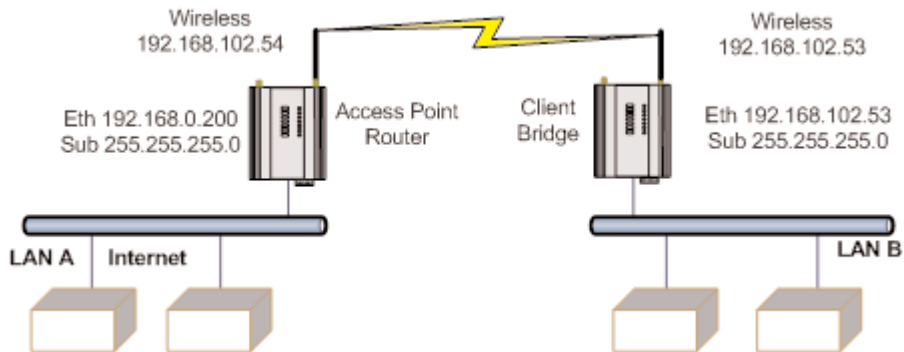Ensure the ESSID and Radio Encryption method match the Access Point.

If encryption is used, ensure the encryption keys or passphrase match the Access Point.

Client 2 Configuration

As above, however set the Ethernet and Wireless IP addresses as 192.168.0.202

Connecting two Separate Networks Together

LAN A Configuration

In this example, LAN A is connected to the internet via a router at IP address 192.168.0.1.

Devices on LAN A that only require access to devices on LAN A and B, should have their gateway IP address set to the BU-245U-E Access Point as 192.168.0.200.

Devices on LAN A, that must interact with devices on LAN A and B and the internet should set the internet router 192.168.0.1 as their gateway, and must have a routing rule established for devices on LAN B. On PCs, this may be achieved with the MS-DOS command ROUTE.
For this example use: ROUTE ADD 169.254.102.0 MASK 255.255.255.0 192.168.0.200

LAN B Configuration

All devices on LAN B should be configured so their gateway IP address is that of the BU-245U-E Access Point as 169.254.102.54

Access Point Configuration

- Connect straight through Ethernet cable between PC and BU-245U-E.

- Ensure configuration PC and BU-245U-E are setup to communicate on the same network

- Set dipswitch to SETUP

- Power up unit, and wait for LINK led to cease flashing.

- Adjust PC network settings

Set Configuration PC network card with network setting of IP address 192.168.0.1, netmask 255.255.255.0

- Open configuration webpage with Internet Explorer at address https://192.168.0.1XX/

When prompted for password, enter default username "user" and password "user"

Enter "Network", and select Operating Mode as Access Point.

Device Mode should be set to Router.

Set the Gateway IP address to 192.168.0.1

Set the Ethernet IP address to 192.168.0.200, network mask 255.255.255.0

Set the Wireless IP address to 169.254.102.54, network mask 255.255.255.0

Select the Radio Encryption required, and enter encryption keys or passphrase if necessary.

Set dipswitch to RUN.

Click on button Save to Flash and Reset. Webpage will display that message indicating details are being written to flash. Wait for BU-245U-E to reboot before removing power. Enter a System Generator String.

Client Configuration

Perform the same configuration steps as the Access Point configuration with the following differences:

Enter "Network", and select Operating Mode as Client.

Device Mode should be set to Bridge.

Set the Gateway IP address to 169.254.102.54

Set the Ethernet IP address to 169.254.102.53, network mask 255.255.255.0

Set the Wireless IP address to 169.254.102.53, network mask 255.255.255.0

Click on button Save to Flash and Reset. Webpage will display that message indicating details are being written to flash. Wait for BU-245U-E to reboot before removing power.

Extending Range of a Network with a Repeater Hop

Configure units as described in Section "Extending a wired network." Place the Access Point at the remote intermediate repeater location. Additional repeaters can be added using Wireless Distribution System (WDS) – refer 3.13 "Multiple AP Repeater Mesh Network for further details.
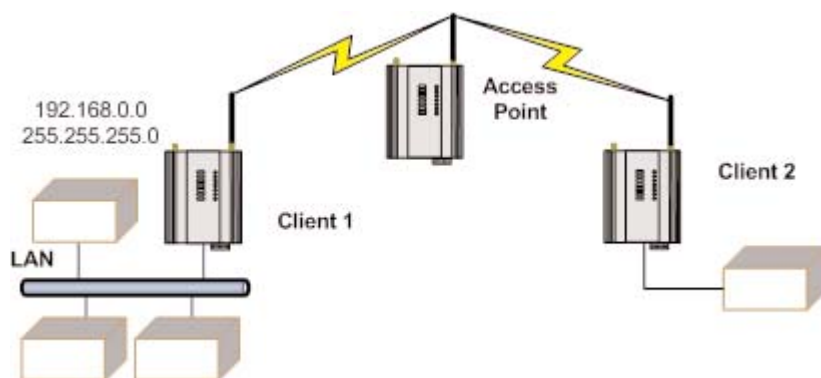
CHAPTER 4 DIAGNOSTICS

4.0 Diagnostics Chart

LED Indicator	Condition	Meaning
OK	GREEN	Normal Operation
OK	RED Continuously	Supply voltage too low. OR Internal Module Fault
OK	RED At Power ON	Boot Loader delay at start-up
OK	Fast Flash RED / GREEN	Module Boot Sequence
OK	Slow Flash RED / GREEN	Module Boot Sequence
Radio RX	GREEN flash	Radio receiving data
Radio RX	RED flash	Radio receiving data (Low Signal strength)
TX/LINK	GREEN	Connection Established to remote device
TX/LINK	RED Flash	Radio Transmitting
RS-232	GREEN flash	Data sent from RS-232 Serial Port
RS-232	RED flash	Data received to RS-232 Serial Port
LAN	ON	Link Established on Ethernet port
LAN	Flash	Activity on Ethernet port.
RS-485	GREEN flash	Data sent from RS-485 Serial Port
RS-485	RED flash	Data received to RS-485 Serial Port
DIO	GREEN	Digital Input is grounded.
DIO	RED	Digital Output is active
DIO	OFF	Digital Output OFF and Input is open circuit.

The green OK LED on the front panel indicates correct operation of the unit. This LED turns red on failure as described above. When the OK LED turns red shutdown state is indicated. On processor failure, or on failure during start-up diagnostics, the unit shuts down, and remains in shutdown until the fault is rectified. During Module, boot-up the OK LED flashes RED-GREEN until the boot sequence is complete.

Boot Status LED Indication During Start-up

The OK LED indicates the status of the module during the boot up process. At power on, the OK LED comes on RED. During kernel boot the OK LED flashes Red-Green at a 1Hz rate (½ second red, ½ second green). During module initialization, the OK LED flashes Red-Green at 0.5Hz rate (1-second red, 1-second green). When initialization is complete, the OK LED switches to green continuously.

If the OK LED remains red at power on, this could indicate either low supply voltage (The module will not attempt to boot until supply voltage is within range); Module fault; or a long boot delay. To check if the boot delay is the problem, plug a terminal into the RS-232 serial port and configure for 115,200 baud, 8 data, no parity.

4.1 Diagnostic Information Available

Connectivity

The Connectivity webpage displays connections and available networks. The "Connected Devices" section displays the radio channel, received signal strength, and radio data rate for each Client or Access Point by their MAC Address. The readings shown are based upon the last received data message from the Access Point or Client. Client stations also display a list of detected Access points (Site Survey), including network name (SSID), channel and maximum data rate.

Note that when updating the Connectivity webpage, it is necessary to hold down the <ctrl> key while pressing the refresh button. Otherwise, the information will not be updated.

Connected Devices:

```
wi0:
=====
ADDR              AID CHAN   RATE RSSI BGND CAPS
06:12:af:00:90:ce   1    3  11.00M  -91  -98 ESs
```

Connectivity Parameters

AID	Association ID: Every Client gets a unique temporary ID from the AP
CHAN	Channel: What radio channel is being used.
RATE	Radio Data Rate:
RSSI	Radio Signal Strength Index (Amount of received signal strength).
BGND	Background interference level in dBms: The amount of internal noise the radio is able to hear. This level does not indicate external radio interference noise level
CAPS	Capabilities (Ref 802.11 Standard)

Site Survey

Site Survey is a one off snapshot showing what Access Points are available for connection.

This list is only available on Clients and only available at start-up of the module or by selecting Background Scanning on the radio page.

Site Survey:

```
SSID          BSSID           CHAN   RATE  S:N     INT CAPS
ELPRO_TEST0   00:02:6f:45:4d:1e   1  11.00M -81:-96 100 EP
BAGNET        06:12:af:00:34:92   2  54.00M -89:-96 100 EPSs WPA WME ATH
              06:12:af:00:93:32   4  54.00M -93:-96 100 EPSs RSN WME ATH
ELPRO_TEST_|... 00:12:af:00:16:d5 11  54.00M -89:-96 100 ESs  WME ATH
BU-245_Test   06:12:af:00:90:ce   3  54.00M -97:-98 100 ESs  WME ATH
```

Site Survey

SSID	The Service Set Identifier or Network Name used to identify a particular network.
BSSID	BSSID is the MAC (Medium Access Control) address of the AP (Access Point)
CHAN	Channel: What radio channel is being used.
RATE	Maximum Radio Data Rate
S:N	Signal to Noise Ratio
INT	Beacon Interval
CAPS	Capabilities (Ref 802.11 Standard)

4.2 Channel Survey

The Cooper bussmann 802.11 Ethernet modem utilizes a half duplex radio channel for communications. At any given time, an Access Point and its associated clients occupy a radio channel. These radio channels, or frequencies, are license free and may contain interference from any number of other radio transmitters. When installing or diagnosing a 945/245 modem, the potential capacity of a given radio channel will be reduced by the existence of these other RF signals on the same channel.

The 245/945 modems allow us to see how much RF activity is on a given channel as a percentage of the total channel utilization. A channel that is very busy will have high channel utilization (usually 50% or greater). Conversely a channel that is quiet will have low channel utilization.

Channel Survey and Custom Survey can therefore be valuable tools to use when performing site surveys in order to determine the best RF channel to use. It is also a valuable diagnostics tool for identifying the spare capacity on a given channel, as well as possible sources of interference.

Channel Survey screen displays a graph showing the percentage of time that a channel is unavailable, or busy, due to three possible causes:

1) The connected modem is transmitting.

2) The connected modem is receiving valid data from another modem.

3) The connected modem has detected RF noise or interference.

Channel Survey shows the Channel utilization and Noise Floor Graph with 1 second, 1 minute and 1 hour periods.

Bar Graph of Percent Channel Utilization with 1 Second Intervals:

Average Channel Utilization for past 60 seconds = 10%
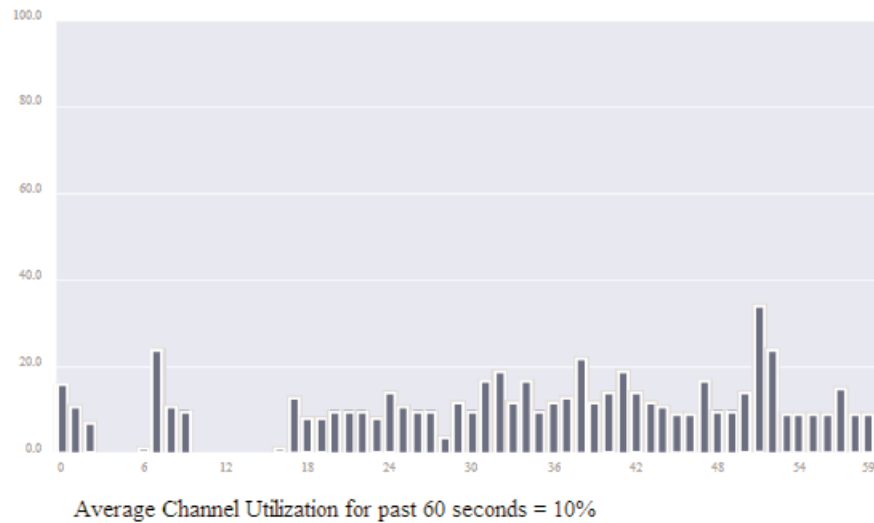
The first screen shows a percent of the overall radio traffic on the channel that is currently being used.

Bar Graph of Noise Floor (dBm) with 1 second intervals:

Average Noise Floor for past 60 seconds = -92dBm
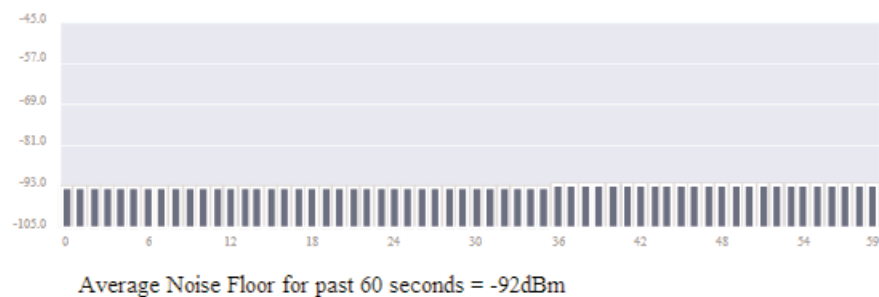
The next screen shot shows the radio receive noise floor for the last 60 seconds.

Bar Graph of Percent Channel Utilization with 1 minute intervals:

Average Channel Utilization for past 14 minutes = 0%

The third screen shot shows the average Channel utilization for each minute up to one hour. It will also give a running average for the total number of minutes up to 59 minutes.

Bar Graph of Noise Floor (dBm) with 1 minute intervals:

Average Noise Floor for past 14 minutes = -92dBm
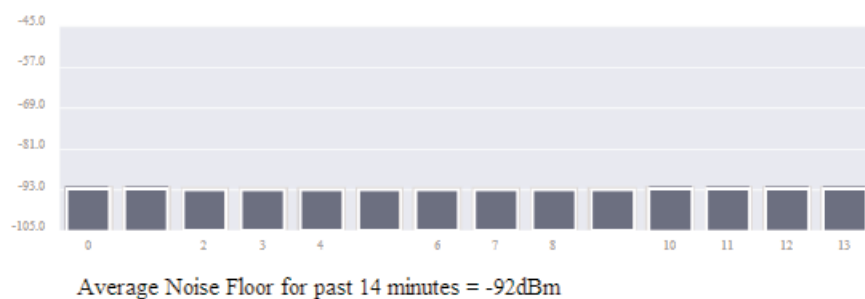
The next screen shot shows the running radio receive noise floor average for each minute up to 59 minutes.

The Channel Survey page also shows two other screen shots (not shown here) which indicate the Percent Channel utilization and Noise Floor in one hour intervals. The screens will only show the last 24 hour period.

4.3 Custom Survey

Custom Survey is essentially the same as the Channel Survey (explained in the previous section) except the three channel utilizations can be turned on or off thus showing the different amount of traffic related data.

Percent Radio TX – Any transmitted messages from the radio to other devices.

Percent Radio RX – Any DSSS or OFDM messages received by the radio (basically any Standard Wi-Fi data packets from either Cooper Bussmann or competitor radios).

Percent Busy (CCA or Noise) – Clear Channel Assessment is the detection of any ongoing transmissions or noise, i.e., Microwaves, 2.4Mhz FHSS, Cordless Phones, RC devices, etc.

By configuring the different chart options we can get a clear idea of the amount of data being transmitted, received and the amount of other noise that can be heard at the radio.

Configure what is to be logged on each chart, select a time interval and save changes and the charts will then be displayed below the settings. Click the button again to manually redraw the graphs.

Each graph will display a Percent Channel utilization using the selected criteria and time interval (Seconds, Minutes or Hours).

Example One

Chart one shows the amount of data that is being transmitted over a Wi-Fi link and chart two shows the amount of data being received from all sources (Wi-Fi and other noise). We can see from this that there is very little outgoing data but you can see a constant stream of data being received.
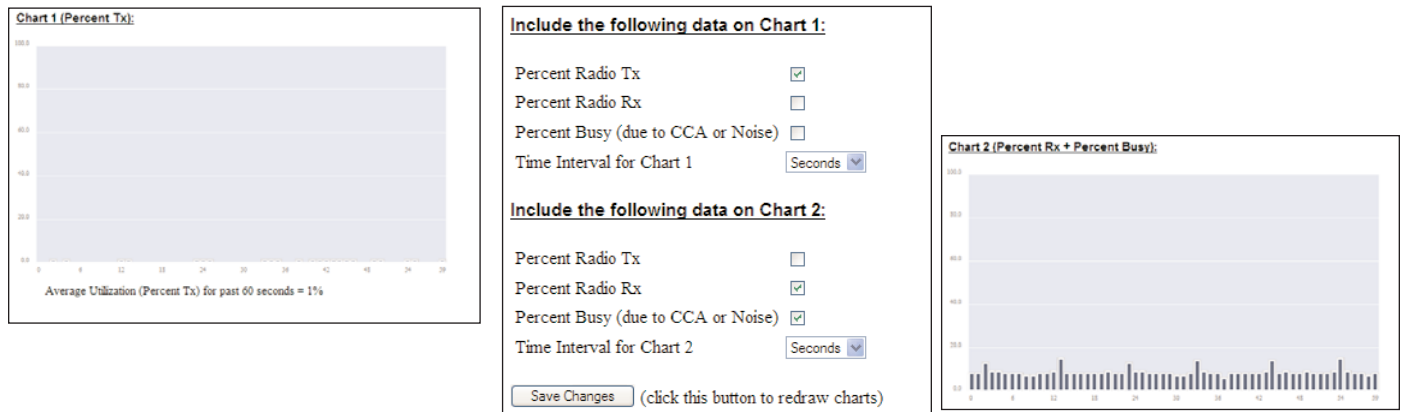
Example Two

In the second example we can see that chart one shows the amount of Data being received from Wi-Fi devices and chart two shows the amount of other noise that is being received. From this you can see that in the last 60 second period there was a 20 second interval with around 60-80 % channel Utilization in this case from a 2.4MHz FHSS telemetry device.
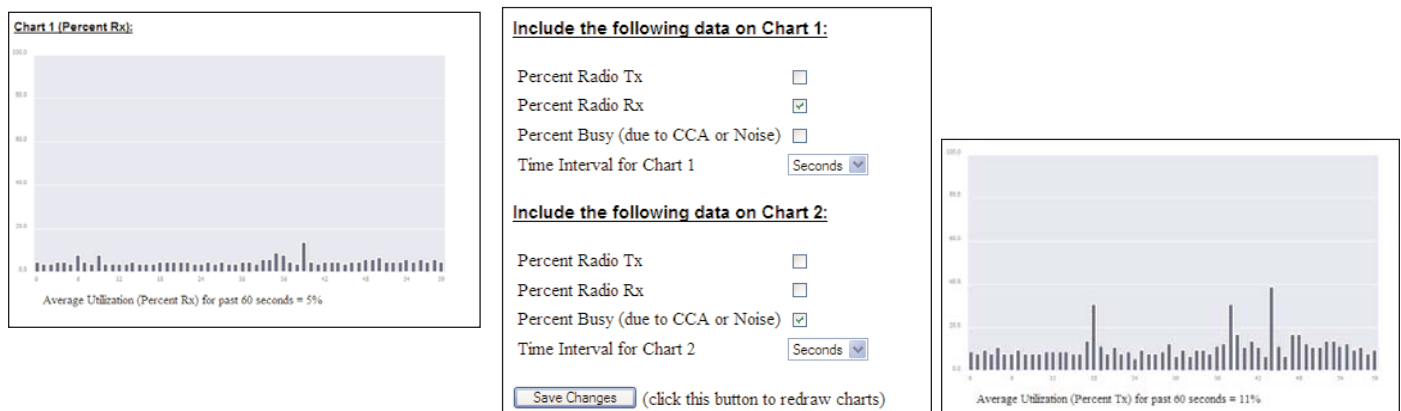
With this sort of outside interference it is recommended to perform the same test but over a longer period so as to get a clearer indication of channel utilization.

Chart 1 (Percent Tx + Percent Rx):

Average Utilization (Percent Tx + Percent Rx) for past 60 seconds = 16%

4.4 Statistics

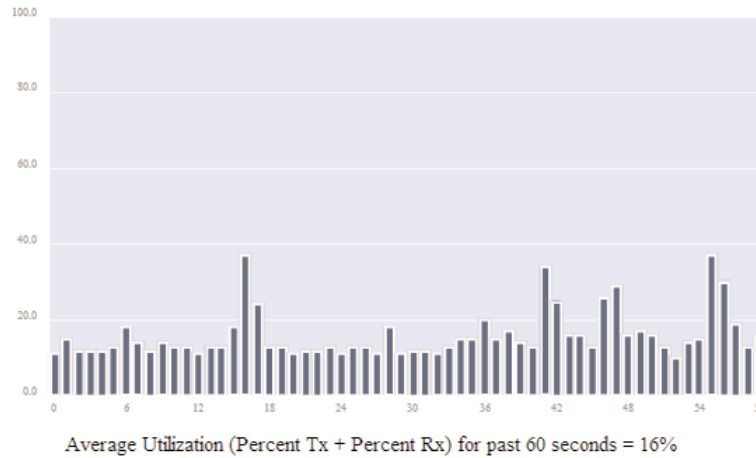The Statistics webpage is used for advanced debugging of BU-245U-E. This webpage details the state of the BU-245U-E and performance information. This page is typically useful to Cooper Bussmann technical support personnel in diagnosing problems with the module.

Note that when updating the Statistics webpage, it is necessary to hold down the <ctrl> key while pressing the refresh button. Otherwise, the information will not be updated.

Network Traffic Analysis

There are many devices and PC programs that will analyze performance of an Ethernet network. Freely available programs such as Ethereal provide a simple cost effective means for more advanced analysis. By monitoring traffic on the wired Ethernet, a better idea of regular traffic can be discovered.

Network Analysis programs make configuration of a filter for the BU-245U-E a simple task.

Statistics

Time:

```
Uptime
=========================================
 01:31:27 up  1:27, load average: 1.34, 1.57, 1.56

Date and Time Recorded
=========================================
Thu Jan  1 01:31:27 UTC 1970
```

System Log:

```
<46>Jan  1 00:00:40 syslogd started: BusyBox v1.00
<13>Jan  1 00:00:40 root: config_main:****  System Boot   ****
<13>Jan  1 00:00:40 root: config_main:Restoring Configuration with Factory Test
<13>Jan  1 00:00:40 root: config_main:IP Address set to 192.168.0.122
<13>Jan  1 00:00:40 root: config_main:Restoring Generic Brand File
<13>Jan  1 00:00:40 root: config_main:Restoring Generic product File
<13>Jan  1 00:00:40 root: config_main:Restoring Generic radio_locale File
<13>Jan  1 00:00:40 root: config_main:Starting Configuration Server Database
<13>Jan  1 00:00:41 root: config_main:adjusting priority of config-server to -10
<6>Jan  1 00:00:41 config-server: Start Config
<13>Jan  1 00:00:41 root: config_main:adjusting priority of config-server pid=23
<7>Jan  1 00:00:41 config-server: Socket fds Created
```

4.5 Internal Diagnostics Modbus Registers

There are a number of internal diagnostic registers that can be accessed via Modbus TCP/RTU that will help with analyzing and diagnosing the radio network. To access these register the Modbus Server will need to be enabled and a Modbus Server address will need to be configured (See 3.20 "Modbus I/O Transfer" for details on how this is done).

After enabling the Modbus Client you can then access the following information by reading the corresponding Modbus Address at the Server ID address.

Connection Information

Register	Module	Description
5000	Both	Total number Associated Stations
5001	Both	Current Radio Channel. See section 3.6 "Radio Configuration" for channel details
5002	Both	Number Wireless Interfaces configured, includes Virtual Interfaces – wi1-wi10
5010	Both	Wireless Adapter (wi0) - Link Status
5011	Both	Wireless Adapter (wi0) - Link Status Inverted
5012	Both	Wireless Adapter (wi0) - Number Associated Stations for this interface
5013	AP Only	Wireless Adapter (wi0) - Points to the starting register of the APs Station List. First interface (wi0) will always start at 5200 and dynamically enter data depending on the number of STA's. Remaining interfaces (wi1-wi10) will be entered after wi0 data. Register 5023, 5033, etc will indicate starting location for each interface.
5014	STA Only	Wireless Adapter (wi0) – RSSI & BGND of Rx message from AP e.g. Hex 5F5D = 5F for RSSI and 5D for BGND (Convert value from hex to dec and add a "-" e.g. 5F = -95dB)
5015	STA Only	Wireless Adapter (wi0) - Transmit Data Rate from the Access Point
5016	STA Only	Wireless Adapter (wi0) - MAC Address of the Access Point
5020-5026	As per 5010-5016	As per registers 5010-5016 but for the next Wireless Adapter (wi1)
5030-5036	As per 5010-5016	As per registers 5010-5016 but for the next Wireless Adapter (wi2)
5040-5046	As per 5010-5016	As per registers 5010-5016 but for the next Wireless Adapter (wi3)
...etc.	As per 5010-5016	As per registers 5010-5016 but for the next Wireless Adapter (wi10)
5200	AP Only	RSSI of the Client (STA)
5201	AP Only	Transmit Data Rate to Client (STA)
5202	AP Only	MAC address of Client (STA)
...etc.	AP Only	Dynamic list of STA's Refer to register 5023, 5033, etc for starting register of each wi interface
9999	Both	Reset module (enter FFFF to reset module)

Statistic Register	Module	Description
4500	Both	Total data packets received on the interface
4502	Both	Received frames with antenna 1 (TX/RX)
4504	Both	Received frames with antenna 2 (RX)
4506	Both	Receiver / default antenna switches
4508	Both	Receive message failed due to bad CRC
4510	Both	Receive message failed due to decryption
4512	Both	Receive message failed due to MIC failure
4514	Both	Receive message failed due to FIFO overrun
4516	Both	Beacon missed interrupts
4518	Both	Total data packet sent on the interface
4520	Both	Transmit frames with antenna 1 (TX/RX)
4522	Both	Transmit frames with antenna 2 (RX)
4524	Both	Transmitter antenna switches
4526	Both	Transmitter on-chip retries
4528	Both	Transmit message failed due to too many retries
4530	Both	Transmit frames with alternate rate
4532	Both	Transmit frames with no ack marked (i.e., broadcast, multicast)
4534	Both	Management frames transmitted
4536	Both	Transmit frames with rts enabled
4538	Both	Transmit frames with cts enabled
4540	Both	Beacons transmitted
4542	Both	Beacon missed count
4544	Both	Beacon miss reset count
4546	Both	Transmit message failed due to no tx buffer (data)
4548	Both	Fatal hardware error interrupts
4550	Both	Receiver PHY error summary count
4552	Both	Transmitter queue stopped because it's full

4.6 Testing Radio Paths

Connection and Signal Strength

The general procedure for radio range testing a link is fairly simple. Configure two units to form a link using automatic radio rates. Install the Access Point at a fixed location. Take a laptop computer and the Client to each of the remote locations, and analyze the link using the Connectivity webpage. If a beacon is heard from the Access Point, the Client will update its Connectivity webpage with the received signal strength of beacon messages from the Access Point.

If the signal is strong enough, a link may be established, and the Connectivity webpage of the Access Point may be opened. If the link is weak, the LINK led will go out, and the remote Connectivity webpage of the Access Point will fail to load. Using this procedure, the signal strengths of units at both locations may be analyzed, and traffic is sent between the units whilst remote Webpages are opened.

Throughput Test

A more thorough test is to perform a throughput test which will check the amount of data that can be reliably achieved via the Wireless link. There are a number of software tools that we can use to check the data throughput, i.e., FTP - file transfer protocol, Iperf, Qcheck, etc.

The preferred application is "Iperf" which has been configured in each modem and can be enabled to perform this test. It can also be run externally using Laptops at either end of the radio link.

All of the above applications measure the raw data throughput and from this we can determine the amount of interference from the measured and calculated data throughput levels.

The way "iPerf" works is a Server is enabled at one end of the link and a Client at the other. The "iPerf" Client will then will pass data over the link and calculate and display the throughput accordingly.

"iPerf" server can be run internally on the modem by enabling this feature on the Advanced Radio page of one of the modems, see section 3.24 "TCP Throughput Test." It can also be run externally on a PC or laptop connected at each end of the radio link. See Appendix E "External Iperf Test" for a detailed procedure on how to use Iperf to externally check radio data throughput.

The internal "iPerf" is a basic cut down version of the standard "iPerf" and should be used as a guide only. For a more comprehensive test "iPerf" should be run externally using Laptops or PCs at each end of the Wi-Fi link.
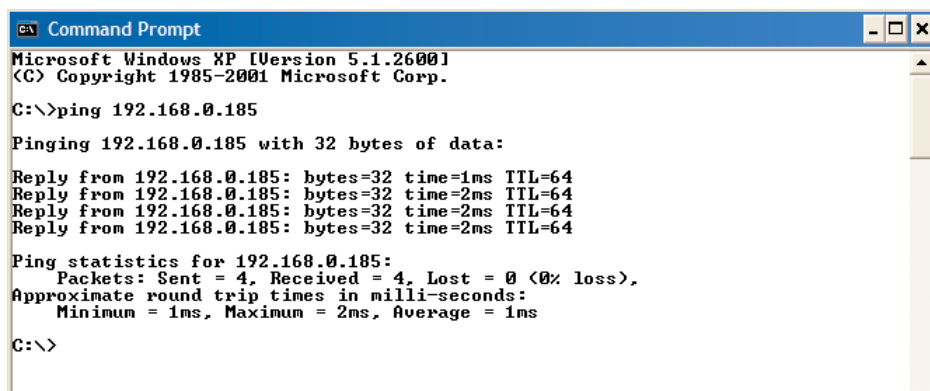
4.7 Utilities

"Ping"

Ping is a basic Internet program that lets you verify that a particular IP address exists and can accept requests. Ping is used diagnostically to ensure that a host computer or device you are trying to reach is actually operating. If, for example, a user can't ping a host, then the user will be unable to send files to that host. Ping operates by sending a packet of data to a designated address and waiting for a response. The basic operation of Ping can be performed by following these steps in any Windows operating system.

Click on the Start Menu and select Run. Type in "cmd" and enter, you should then see the command screen come up. There will be a certain directory specified (unique to your own PC) with a flashing cursor at the end. At the cursor type the word "ping" leaving a space and the default IP address for the BU-245U-E at first start-up.

This command would be written as "ping 192.168.0.118" then <enter> to send the ping command. The PC will reply with an acknowledgement of your command and if your BU-245U-E is correctly configured your reply will look something like this.

The screen shot below shows the response of the "ping –t 192.168.0.118" command.

This –t command is used to repeatedly ping the specified node in the network, to cancel use "Ctrl – C"

A good test for the network once it is first set up is to use "ping" repeatedly from one PC's IP address to the other PC's IP address. This gives a good indication of the network's reliability and how responsive it is from point to point. When you enter "Ctrl-C" the program reports a packet sent-received-lost percentage.

"Ipconfig"

"ipconfig" can be used to show your current TCP/IP information, including your address, DNS server addresses, adapter type and so on.

```
Command Prompt                                              _ □ ×
Microsoft Windows XP [Version 5.1.2600]
<C> Copyright 1985-2001 Microsoft Corp.

C:\>ipconfig

Windows IP Configuration

Ethernet adapter Test LAN:

        Connection-specific DNS Suffix  . : TestPC
        IP Address. . . . . . . . . . . : 192.168.0.17
        Subnet Mask . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . :

C:\>
```

In the above example ipconfig was entered in the command prompt. The reply back shows the PC's IP address, Subnet mask and the gateway it is connected to.

Other ipconfig commands will return back more information. The hardware or MAC address of the computer may be discovered using the command ipconfig /all.
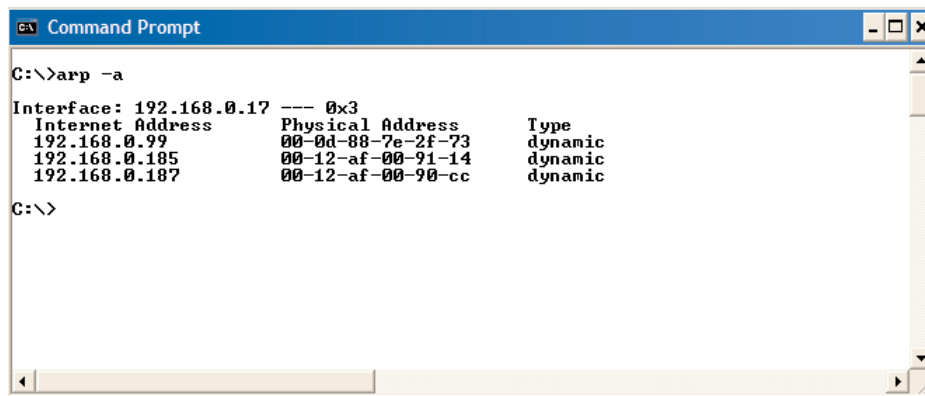
Ipconfig /? lists all of the commands and their usages available for use.

"Arp"

Displays and modifies the IP-to-Physical address translation tables used by Address Resolution Protocol (ARP).

Once a remote computer has been pinged, this can be used to see the IP address & MAC address of the remote computer. It will also show any other devices on the network that it may be connected to.

Command used for above screen shot is "arp –a." It shows the PC's direct IP address of 192.168.0.17 as also shown before with ipconfig command. The other IP address shown with its associated MAC address is another device with a connection to the PC. In this example it is the IP address of a PLC connected to the PC also.

```
Command Prompt                                              _ □ ×
C:\>arp -a

Interface: 192.168.0.17 --- 0x3
  Internet Address       Physical Address       Type
  192.168.0.99           00-0d-88-7e-2f-73      dynamic
  192.168.0.185          00-12-af-00-91-14      dynamic
  192.168.0.187          00-12-af-00-90-cc      dynamic

C:\>
```

"Route"

Route is used for the Router function. This is where you are joining 2 different networks together via the BU-245U-E refer to Section 1.1

Normally the BU-245U-E will only accept one routing rule, by using the Default Gateway IP Address on the Main Network Page. If more than one routing rule is needed then a Routing Table is required, e.g. Multiple networks each with a different IP range.

In the example below a routing rule needs to be entered into the Network A's PC which will allow access between Network A and Network B. This is can be entered at the command prompt as per instruction below.

Route PRINT will show all active routes on PC,

Route ADD will add a routing table to network,

route DELETE <destination netmask gateway interface> will delete the unwanted routing table

route CHANGE modifies an existing route.
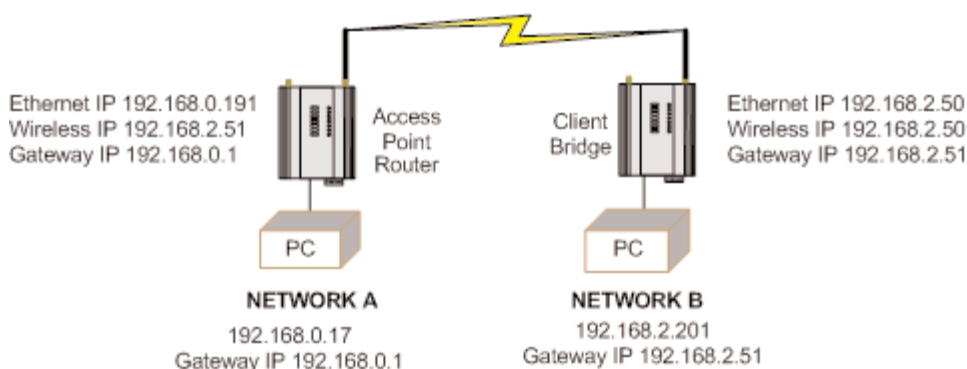
An example of a routing table is shown for the configuration below.

Access Point Router Settings	Client Bridge Settings
Gateway IP 192.168.0.1	Gateway IP 192.168.2.51
Ethernet IP 192.168.0.191	Ethernet IP 192.168.2.50
Subnet Mask 255.255.255.0	Subnet Mask 255.255.255.0
Wireless IP 192.168.2.051	Wireless IP 192.168.2.50
Subnet Mask 255.255.255.0	Subnet Mask 255.255.255.0

In the Network A PC a routing rule is to be set.

This will allow Network A & B to have access to each other. This is entered under cmd prompt.

Network A Settings	Network B Settings
IP Address 192.168.0.17	IP Address 192.168.2.201
Subnet Mask 255.255.255.0	Subnet Mask 255.255.255.0
Gateway IP 192.168.0.1	Gateway IP 192.168.2.51

Route ADD 192.168.2.0 MASK 255.255.255.0 192.168.0.191

This says access everything on network B (192.168.2.0) with the Mask of 255.255.255.0 on Network A via the Ethernet IP Interface 192.168.0.191

IP Address 192.168.2.0 will allow everything on this network to be shared by the router. When adding a routing table you will need to enter this in. Once entered in the Router will determine whether to pass information over the router if it is addressed to do so or not. For added security MAC address filtering could be added as mentioned earlier in Section 3.

CHAPTER 5 SPECIFICATIONS

General

EMC specification	EN 300 683	FCC Part 90
Radio specification	EN 300 328	FCC Part 15.247, RSS 210
Housing	114 x 140 x 30mm, 4.5 x 5.5 x 1.2 inch	Powder-coated, extruded aluminum, DIN rail mount
Terminal blocks	Removable	Suitable for 12 gauge (2.5mm^2) conductors
LED indication	Module Status, Serial RX and TX, Radio RX and TX, Radio Link, Ethernet Activity / Link	
Operating Temperature	-40 to +60°C, -40 to +140°F	0 – 99% RH non-condensing

Power Supply

Nominal supply	9 to 30Vdc	Overvoltage and reverse voltage protected
Average current drain	BU-245U-E-G = 290mA @ 12V BU-245U-E-A = 300mA @ 12V BU-245U-E-G = 150mA @ 24Vdc BU-245U-E-A = 160mA @ 24Vdc	
Current drain when transmitting (400mW)	BU-245U-E-G = 340mA @ 12V BU-245U-E-A = 410mA @ 12V BU-245U-E-G = 180mA @ 24Vdc BU-245U-E-A = 210mA @ 24Vdc	
Ethernet Port	10/100 BaseT	RJ45
Standard	IEEE 802.3 compliant	Bridge/router, Access point/ client functionality

Radio Transceiver

Transmit power (Power may be limited by country specific configuration)	Model BU-245U-E-G	Maximum Power 1-24 Mb/s: 400mW (+26 dBm) 36 Mb/s: 250mW(+24 dBm) 48 Mb/s: 160mW(+22 dBm) 54 Mb/s: 125mW(+21 dBm)
	BU-245U-E-A	6-24 Mb/s: 400mW (+26 dBm) 36 Mb/s: 250mW(+24 dBm) 48 Mb/s: 160mW(+22 dBm) 54 Mb/s: 125mW(+21 dBm)
Channels 2.4GHz	13 x 5MHz Spacing	First channel centre at 2.412GHz
Channels 5GHz	12 fixed channels (3 Turbo Mode) or Auto Channel/Group selection	Auto Channel/Group selection utilizes DFS depending on Group selection
Receiver sensitivity (8% FER)	Model	Receiver Sensitivity
	BU-245U-E-G	-97dBm @ 1Mb/s, -94dBm @ 6Mb/s, -90dBm @ 18Mb/s, -74dBm @ 54Mb/s
	BU-245U-E-A	-94dBm @ 6Mb/s, -90dBm @ 18Mb/s, -74dBm @ 54Mb/s
Antenna Connector	2 x Female SMA coaxial	Two connectors for signal diversity or High gain receive antenna.
Wireless data rate – configurable	1 to 54Mb/s (BU-245U-E-G), Turbo – 108Mb/s 6 to 54Mb/s BU-245U-E-A), Turbo – 108Mb/s	"Auto" function determines fastest rate possible

Serial Ports

RS232 Port	DB9 female DCE	RTS/CTS/DTR/DCD hardware signals provided
RS485 Port	2 pin terminal block	Max distance 4000' / 1.2 km
Data rate (bit/sec) - configurable	1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 76800, 115200	7 or 8 data bits, Stop/start/parity bits configurable

System Parameters

System address (ESSID)	1 to 31 character text string
Wireless data encryption	WEP (64bit and 128bit), WPA PSK (TKIP), WPA PSK (AES), WPA2-PSK(AES), WPA PSK/WPA2-PSK, WPA Enterprise
User Configuration	Via embedded web page via RS232 commands
Diagnostics LED's	Power / OK, Ethernet Link, Activity, 100mb/s, Radio Link, RX, Rx Weak Signal, TX, Serial RX/TX, Digital I/O Input / Output status
Other	RSSI measurement in dBm
	Connectivity Information
	System Log file

Appendix A FIRMWARE UPGRADE

Determine which firmware version is present in the module to be upgraded by viewing the index webpage of the module.

Firmware versions 1.0.3 and later may be upgraded via the configuration web pages. This upgrade can be done locally with a PC connected directly to the module, or remotely over a working radio link. For remote upgrade, it is advisable to reduce radio traffic over the link from other devices, as much as possible. If necessary, create a temporary separate radio network to perform the upgrade to remote modules. Please refer to the "Web based Upgrade" section for the upgrade procedure.

Web Based Upgrade

Web based firmware upgrade is available from the System tools page by selecting "firmware upgrade." Firmware upgrade is performed by uploading a "patch" file which is specific to the currently installed firmware version. If the device firmware version has fallen multiple versions behind the desired version, it may be necessary to upload multiple "patch" files. Once the patch files are uploaded, reset the module to perform the firmware upgrade. You will receive more detailed instructions if it is necessary to upgrade the module firmware.

Firmware Upgrade

Firmware upgrade may be performed using this page. Firmware upgrades may be made using the radio network. Note that the unit must be reset before the new firmware is applied.

DO NOT DISCONNECT POWER UNTIL FIRMWARE UPGRADE IS COMPLETE.

If programming fails, a manual firmware upgrade may have to be performed locally to restore normal operation.

Upgrade will take approximately 1 minute if connected directly via wired ethernet. It may take longer if programmed remotely using the radio network depending on the current radio baud rate. Performing an upgrade via a poor radio path is not recommended.

[_____] [Browse...]

[Send] [Cancel]

[Reset]

APPENDIX B GLOSSARY

ACK
Acknowledgment.

Access Point
An access point connects wireless network stations (or clients) to other stations within the wireless network and also can serve as the point of interconnection between the wireless network and a wired network. Each access point can serve multiple users within a defined network area. Also known as a base station.

Antenna Gain
Antennae don't increase the transmission power, but focus the signal more. So instead of transmitting in every direction (including the sky and ground) antenna focus the signal usually either more horizontally or in one particular direction. This gain is measured in decibels

Bandwidth
The maximum data transfer speed available to a user through a "network."

Bridge
A bridge is used to connect two local area networks together. Bridges are typically used to connect wireless networks to wired networks. Typically, bridges will transfer messages between networks only when the message destination is on the other network. Messages that are destined for the same network as they originated on are not passed to the other network, therefore reducing traffic on the entire network.

Collision Avoidance
A network node procedure for proactively detecting that it can transmit a signal without risking a collision with transmissions from other network nodes.

Client / Sta / Station
A device on a network that gains access to data, information, and other devices through a Server (Access Point).

Crossover Cable
A special cable used for networking two computers without the use of a hub. Crossover cables may also be required for connecting a cable or DSL modem to a wireless gateway or access point. The cable is wired so that the signals "crossover", connecting transmit signal on one side to receiver signals on the other.

CSMA/CA
Carrier Sense Multiple Access/Collision Avoidance is a "listen before talk" method of minimizing (but not eliminating) collisions caused by simultaneous transmission by multiple radios. IEEE 802.11 states collision avoidance method rather than collision detection must be used, because the standard employs half duplex radios—radios capable of transmission or reception—but not both simultaneously. Unlike conventional wired Ethernet nodes, a WLAN station cannot detect a collision while transmitting. If a collision occurs, the transmitting station will not receive an ACKnowledge packet from the intended receive station. For this reason, ACK packets have a higher priority than all other network traffic. After completion of a data transmission, the receive station will begin transmission of the ACK packet before any other node can begin transmitting a new data packet. All other stations must wait a longer pseudo randomized period of time before transmitting. If an ACK packet is not received, the transmitting station will wait for a subsequent opportunity to retry transmission.

CSMA/CD
Carrier Sense Multiple Access/Collision Detection is the access method used on an Ethernet network. A network device transmits data after detecting that a channel is available. However, if two devices transmit data simultaneously, the sending devices detect a collision and retransmit after a random time delay.

DHCP
Dynamic Host Configuration Protocol A utility that enables a server to dynamically assign IP addresses from a predefined list and limit their time of use so that they can be reassigned. Without DHCP, an IT Manager would have to manually enter in all the IP addresses of all the computers on the network. When DHCP is used, whenever a computer logs onto the network, it automatically gets an IP address assigned to it.

Dial-Up
A communication connection via the standard telephone network, or Plain Old Telephone Service (POTS).

DNS
Domain Name Service A program that translates URLs to IP addresses by accessing a database maintained on a collection of Internet servers. The program works behind the scenes to facilitate surfing the Web with alpha versus numeric addresses. A DNS server converts a name like mywebsite.com to a series of numbers like 107.22.55.26. Every website has its own specific IP address on the Internet.

DSL
Digital Subscriber Line Various technology protocols for high-speed data, voice and video transmission over ordinary twisted-pair copper POTS (Plain Old Telephone Service) telephone wires.

Encryption Key

An alphanumeric (letters and/or numbers) series that enables data to be encrypted and then decrypted so it can be safely shared among members of a network. WEP uses an encryption key that automatically encrypts outgoing wireless data. On the receiving side, the same encryption key enables the computer to automatically decrypt the information so it can be read. Encryption keys should be kept secret

Firewall

A device or computer program that keeps unauthorized users out of a private network. Everything entering or leaving a system's internal network passes through the firewall and must meet the system's security standards in order to be transmitted. Often used to keep unauthorized people from using systems connected to the Internet.

Hub

A multiport device used to connect PCs to a network via Ethernet cabling or via 802.11. Wired hubs can have numerous ports and can transmit data at speeds ranging from 10 Mbps to multi-Gigabyte speeds per second. A hub transmits packets it receives to all the connected ports. A small wired hub may only connect 4 computers; a large hub can connect 48 or more.

Hz

Hertz. The international unit for measuring frequency, equivalent to the older unit of cycles per second. One megahertz (MHz) is one million hertz. One gigahertz (GHz) is one billion hertz. The standard US electrical power frequency is 60 Hz, the AM broadcast radio fequency band is 535—1605 kHz, the FM broadcast radio frequency band is 88—108MHz, and wireless 802.11b/g LANs operate at 2.4GHz.

IEEE

Institute of Electrical and Electronics Engineers, New York, www.ieee.org. A membership organization that includes engineers, scientists and students in electronics and allied fields. It has more than 300,000 members and is involved with setting standards for computers and communications.

Infrastructure Mode

An 802.11 setting providing connectivity to an AP. As compared to Ad-Hoc mode, whereby 802.11 devices communicate directly with each other, clients set in Infrastructure Mode all pass data through a central AP. The AP not only mediates wireless network traffic in the immediate neighborhood, but also provides communication with the wired network. See Ad-Hoc and AP.

I/O

Input / Output. The term used to describe any operation, program or device that transfers data to or from a computer.

Internet Appliance

A computer that is intended primarily for Internet access is simple to set up and usually does not support installation of third-party software. These computers generally offer customized web browsing, touch-screen navigation, e-mail services, entertainment and personal information management applications.

IP

Internet Protocol. A set of rules used to send and receive messages across local networks and the Internet.

IP telephony

Technology that supports voice, data and video transmission via IP-based LANs, WANs, and the Internet. This includes VoIP (Voice over IP).

IP Address

A 32-bit number that identifies each sender or receiver of information that is sent across the Internet. An IP address has two parts: an identifier of a particular network on the Internet and an identifier of the particular device (which can be a server or a workstation) within that network.

IPX-SPX

Internetwork Packet Exchange, a networking protocol used by the Novell NetWare operating systems. Like UDP/IP, IPX is a datagram protocol used for connectionless communications. Higher-level protocols, such as SPX and NCP, are used for additional error recovery services. Sequenced Packet Exchange, SPX, a transport layer protocol (layer 4 of the OSI Model) used in Novell Netware networks. The SPX layer sits on top of the IPX layer (layer 3) and provides connection-oriented services between two nodes on the network. SPX is used primarily by client/server applications.

ISDN

A type of broadband Internet connection that provides digital service from the customer's premises to the dial-up telephone network. ISDN uses standard POTS copper wiring to deliver voice, data or video.

ISO Network Model

A network model developed by the International Standards Organization (ISO) that consists of seven different levels, or layers. By standardizing these layers, and the interfaces in between, different portions of a given protocol can be modified or changed as technologies advance or systems requirements are altered. The seven layers are: Physical , Data Link, Network, Transport, Session, Presentation, Application.

LAN

Local Area Network. A system of connecting PCs and other devices within the same physical proximity for sharing resources such as an Internet connections, printers, files and drives.

Receive Sensitivity

The minimum signal strength required to pick up a signal. Higher bandwidth connections usually have less receive sensitivity than lower bandwidth connections.

Router

A device that forwards data from one WLAN or wired local area network to another.

SNR

Signal to Noise Ratio. The number of decibels difference between the signal strength and background noise.

Transmit Power

The power usually expressed in mW or dBm that the wireless device transmits at.

MAC Address

Media Access Control address. A unique code assigned to most forms of networking hardware. The address is permanently assigned to the hardware, so limiting a wireless network's access to hardware - such as wireless cards - is a security feature employed by closed wireless networks. But an experienced hacker - armed with the proper tools - can still figure out an authorized MAC address, masquerade as a legitimate address and access a closed network.

Every wireless 802.11 device has its own specific MAC address hard-coded into it. This unique identifier can be used to provide security for wireless networks. When a network uses a MAC table, only the 802.11 radios that have had their MAC addresses added to that network's MAC table will be able to get onto the network.

NAT

Network Address Translation: A network capability that enables a number of computers to dynamically share a single incoming IP address from a dial-up, cable or xDSL connection. NAT takes the single incoming IP address and creates new IP address for each client computer on the network.

NIC

Network Interface Card. A type of PC adapter card that either works without wires (Wi-Fi) or attaches to a network cable to provide two-way communication between the computer and network devices such as a hub or switch. Most office wired NICs operate at 10 Mbps (Ethernet), 100 Mbps (Fast Ethernet) or 10/100 Mbps dual speed. High-speed Gigabit and 10 Gigabit NIC cards are also available. See PC Card.

Proxy Server

Used in larger companies and organizations to improve network operations and security, a proxy server is able to prevent direct communication between two or more networks. The proxy server forwards allowable data requests to remote servers and/or responds to data requests directly from stored remote server data.

RJ-45

Standard connectors used in Ethernet networks. RJ-45 connectors are similar to standard RJ-11 telephone connectors, but RJ-45 connectors can have up to eight wires, whereas telephone connectors have four.

Server

A computer that provides its resources to other computers and devices on a network. These include print servers, Internet servers and data servers. A server can also be combined with a hub or router.

Site survey

The process whereby a wireless network installer inspects a location prior to installing a wireless network. Site surveys are used to identify the radio- and client-use properties of a facility so that access points can be optimally placed.

SSL

Secure Sockets Layer. A commonly used encryption scheme used by many online retail and banking sites to protect the financial integrity of transactions. When an SSL session begins, the server sends its public key to the browser. The browser then sends a randomly generated secret key back to the server in order to have a secret key exchange for that session

Sub network or Subnet

Found in larger networks, these smaller networks are used to simplify addressing between numerous computers. Subnets connect together through a router.

Switch

A type of hub that efficiently controls the way multiple devices use the same network so that each can operate at optimal performance. A switch acts as a networks traffic cop: rather than transmitting all the packets it receives to all ports as a hub does, a switch transmits packets to only the receiving port.

TCP

Transmission Control Protocol. A protocol used along with the Internet Protocol (IP) to send data in the form of individual units (called packets) between computers over the Internet. While IP takes care of handling the actual delivery of the data, TCP takes care of keeping track of the packets that a message is divided into for efficient routing through the Internet. For example, when a web page is downloaded from a web server, the TCP program layer in that server divides the file into packets, numbers the packets, and then forwards them individually to the IP program layer. Although each packet has the same destination IP address, it may get routed differently through the network. At the other end, TCP reassembles the individual packets and waits until they have all arrived to forward them as single message.

TCP/IP
The underlying technology behind the Internet and communications between computers in a network. The first part, TCP, is the transport part, which matches the size of the messages on either end and guarantees that the correct message has been received. The IP part is the user's computer address on a network. Every computer in a TCP/IP network has its own IP address that is either dynamically assigned at startup or permanently assigned. All TCP/IP messages contain the address of the destination network as well as the address of the destination station. This enables TCP/IP messages to be transmitted to multiple networks (subnets) within an organization or worldwide.

VoIP
Voice Over Internet Protocol. Voice transmission using Internet Protocol to create digital packets distributed over the Internet. VoIP can be less expensive than voice transmission using standard analog packets over POTS (Plain Old Telephone Service).

VPN
Virtual Private Network. A type of technology designed to increase the security of information transferred over the Internet. VPN can work with either wired or wireless networks, as well as with dial-up connections over POTS. VPN creates a private encrypted tunnel from the end user's computer, through the local wireless network, through the Internet, all the way to the corporate servers and database.

WAN
Wide Area Network. A communication system of connecting PCs and other computing devices across a large local, regional, national or international geographic area. Also used to distinguish between phone-based data networks and Wi-Fi. Phone networks are considered WANs and Wi-Fi networks are considered Wireless Local Area Networks (WLANs).

WEP
Wired Equivalent Privacy. Basic wireless security provided by Wi-Fi. In some instances, WEP may be all a home or small-business user needs to protect wireless data. WEP is available in 40-bit (also called 64-bit), or in 108-bit (also called 128-bit) encryption modes.
As 108-bit encryption provides a longer algorithm that takes longer to decode, it can provide better security than basic 40-bit (64-bit) encryption.

Wi-Fi
Wireless Fidelity: An interoperability certification for wireless local area network (LAN) products based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard.

APPENDIX C CHANNELS

802.11b/g

Channel	Frequency (MHz)	North America	Europe	Australia	Japan	Most of world
1	2412	Yes	Yes	Yes	Yes	Yes
2	2417	Yes	Yes	Yes	Yes	Yes
3	2422	Yes	Yes	Yes	Yes	Yes
4	2427	Yes	Yes	Yes	Yes	Yes
5	2432	Yes	Yes	Yes	Yes	Yes
6	2437	Yes	Yes	Yes	Yes	Yes
7	2442	Yes	Yes	Yes	Yes	Yes
8	2447	Yes	Yes	Yes	Yes	Yes
9	2452	Yes	Yes	Yes	Yes	Yes
10	2457	Yes	Yes	Yes	Yes	Yes
11	2462	Yes	Yes	Yes	Yes	Yes
12	2467	No	Yes	Yes	Yes	Yes
13	2472	No	Yes	Yes	Yes	Yes
14	2484	No	No	No	.11b only	No

802.11b/g Turbo

Channel	Frequency (MHz)	North America	Europe	Australia	Japan	Most of world
6	2437	Yes	Yes	Yes	Yes	Yes

802.11a – Maximum Radio Transmitter Power

Channel	Frequency (MHz)	Europe max TX Power (Master)	Europe max TX Power (Slave)	Australia max TX Power	NZ max TX Power	USA max TX Power
36	5180	23 dBm	23 dBm	23 dBm	23 dBm	17 dBm
40	5200	23 dBm	23 dBm	23 dBm	23 dBm	17 dBm
44	5220	23 dBm	23 dBm	23 dBm	23 dBm	17 dBm
48	5240	23 dBm	23 dBm	23 dBm	23 dBm	17 dBm
52	5260	20 dBm	20 dBm	20 dBm	20 dBm	24 dBm
56	5280	20 dBm	20 dBm	20 dBm	20 dBm	24 dBm
60	5300	20 dBm	20 dBm	20 dBm	20 dBm	24 dBm
64	5320	20 dBm	20 dBm	20 dBm	20 dBm	24 dBm
100	5500	26 dBm	20 dBm	20 dBm	20 dBm	24 dBm
104	5520	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
108	5540	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
112	5560	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
116	5580	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
120	5600	26 dBm	20 dBm	n/a	20 dBm	24 dBm
124	5620	26 dBm	20 dBm	n/a	20 dBm	24 dBm
128	5640	26 dBm	20 dBm	n/a	20 dBm	24 dBm
132	5660	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
136	5680	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
140	5700	26 dBm	20 dBm	24 dBm	20 dBm	24 dBm
149	5745	n/a	n/a	26 dBm	26 dBm	26 dBm
153	5765	n/a	n/a	26 dBm	26 dBm	26 dBm
157	5785	n/a	n/a	26 dBm	26 dBm	26 dBm
161	5805	n/a	n/a	26 dBm	26 dBm	26 dBm
165	5825	n/a	n/a	26 dBm	26 dBm	26 dBm

802.11a Turbo - Maximum Radio Transmitter Power

Channel	Frequency (MHz)	Europe max (Master)	Europe max (Slave)	Australia max	NZ max	USA max
42	5210	23 dBm	23 dBm	23 dBm	23 dBm	17 dBm
152	5755	n/a	n/a	26 dBm	26 dBm	26 dBm
160	5795	n/a	n/a	26 dBm	26 dBm	26 dBm

APPENDIX D 802.11A & TX POWER

U-NII Band	Frequency (MHz)	EU & South Africa		USA		Australia		New Zealand	
		No DFS	DFS	No DFS	DFS	No DFS	DFS	No DFS	DFS
1	5150-5250	200mW	–	50mW	–	200mW	–	200mW	–
2	5250-5350	–	100mW	–	500mW	–	100mW	–	100mW
3	5470-5725	–	500mW	–	500mW	–	250mW	–	500mW
4	5725-5825	–	–	4 W	–	4 W	–	4 W	–

All Power levels are shown as EIRP (Effective Isotropic Radiated Power)

dB to mWatt Conversion

Watts	dBm	Watts	dBm
10mW	10 dB	200mW	23 dB
13mW	11 dB	316mW	25 dB
16mW	12 dB	398mW	26 dB
20mW	13 dB	500mW	27 dB
25mW	14 dB	630mW	28 dB
32mW	15 dB	800mW	29 dB
40mW	16 dB	1.0 W	30 dB
50mW	17 dB	1.3 W	31 dB
63mW	18 dB	1.6 W	32 dB
79mW	19 dB	2.0 W	33 dB
100mW	20 dB	2.5 W	34 dB
126mW	21 dB	3.2 W	35 dB
158mW	22 dB	4.0 W	36 dB

Appendix E External Iperf Test

This Appendix shows how to set up and use the Iperf application to test the throughput of Ethernet Modems.

Iperf is a tool used to measure the throughput and quality of a network link. Jperf is used in conjunction with Iperf and displays the Iperf data results graphically. This instruction covers both Iperf and Jperf, it does not cover the setup and configuration of the modems. Details of this can be found in previous sections.

Materials

- 2 x Ethernet Modems configured as a bridge
- 2 x PC Computers with Ethernet Ports
- Suitable Power Supplies for the Ethernet Modems
- Straight through Ethernet cables
- Iperf / Jperf Application

Installation

The Application can be downloaded from the following link http://sourceforge.net/projects/iperf/, download and save to a location on your PC.

Extract to zip file to the ROOT directory on your PC, i.e., C:\. This folder contains the main Iperf application as well as the Jperf graphical interface.
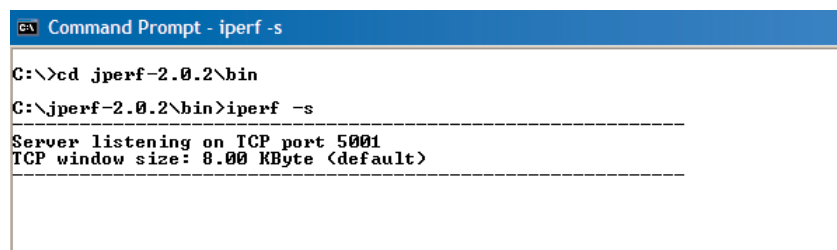
Copy this folder to the 2nd PC or download to the second PC and extract as per above instructions.

Iperf Applications

The Iperf /Jperf application needs to be run on the PC or laptop at each end of the wireless link that is to be tested.

At the Server PC open a Command prompt by selecting Windows Start/run and enter "CMD."

When command prompt appears we need to set the directory to where the Iperf application resides, i.e., where it was saved above, and from here run the Iperf server command "iperf – s." See Figure 1

Figure 1

Note: If you get a security pop up on PC select Unblock for the application to run.

Iperf server application is now running and waiting for a Client connection.

On the Client PC open up a CMD prompt and change the directory to jperf-2.0.2\bin as performed above for the server.

This time enter the Iperf command to start the client communication to the server. "Iperf –c <IP address of Server PC> -w 65535. See Figure 2

Figure 2

This will run a test over the Wi-Fi Link to the Server PC and report back results as seen in Figure 3.

These results show the Bandwidth (Throughput) of the test as 16.2Mbits/sec.

Figure 3

Using the Theoretical throughput calculations in Table 1 you can compare the results with the measured to give an indication of the difference between expected and measured. Remembering that the theoretical calculations are best case possible results.

	BU-245U-E-G	BU-245U-E-A	BU-945U-E (20Mhz)
54Mbps	27Mbps	27Mbps	27Mbps
11Mbps	5Mbps	5Mbps	5Mbps
1Mbps	500Kbps	500Kbps	500Kbps

Table 1

In the command line for the Client mapping we established the Server IP address followed by the –w 65535, -w is the window size and the maximum TCPIP window size is 65535bytes.

Another entry that can be added is –t <seconds> to run the test for a specific time period. Example of this is in figure 5 where the same test is run for 30 seconds.

JPerf Application

Jperf is a graphical interface that runs over the top of Iperf. It will display a graph result from the Iperf test.

To run Jperf open a CMD prompt and change to the "jperf-2.0.2: directory and run the "Jperf" application as shown in Figure 4. The CMD screen will disappear and the Jperf Screen will appear as seen in Figure 5.
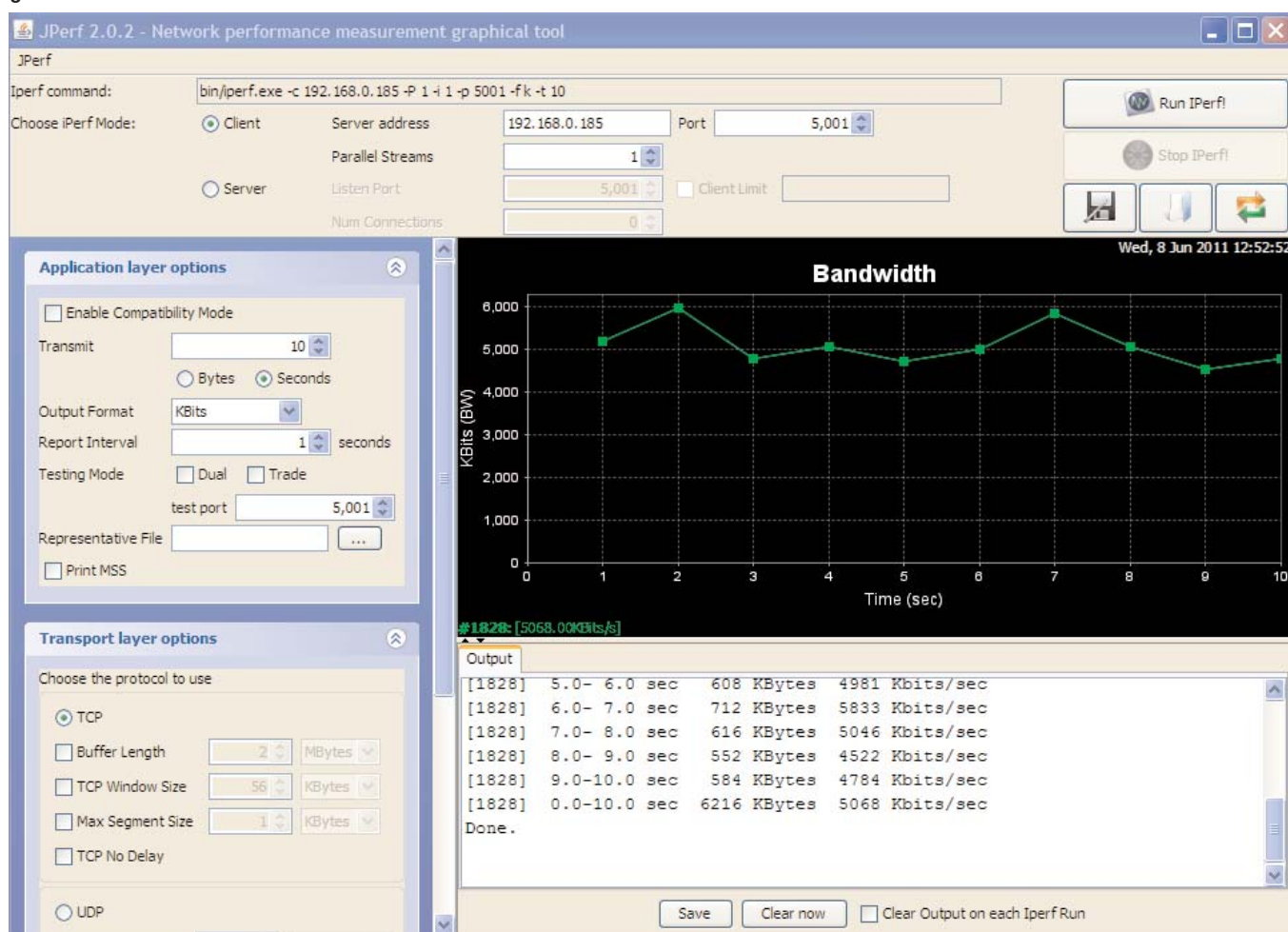

Figure 4

Figure 5

When Jperf screen appears select Client Mode, enter in IP address of the Server PC; leave Port as default and press Run Iperf button. The test will run again and the Bandwidth (Throughput) display will show results of the test.

Note: Jperf runs using Java technology and depending on PC setup further installation of Java software may be required.

APPENDIX F GNU FREE DOC LICENSE

Version 2, June 1991

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- Live Chat: www.cooperbussmann.com

Online Resources

Visit www.cooperbussmann.com for the following resources:

- Product search & cross-reference
- Product & technical materials
- Solutions centers for information on topical issues including arc-flash, selective coordination & short-circuit current rating
- Technical tools, like our arc-flash calculator
- Where to purchase Cooper Bussmann product

Services

Cooper Bussmann Services team provides engineering expertise in electrical system reviews, electrical safety training & component testing for Agency compliance. Contact:

- Phone: 636-207-3294
- E-mail: services@cooperindustries.com

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