CHAPTER

5

Remote Unit

In This Chapter:

This chapter provides descriptions of the BRU-100 and BRU-150 Remote Unit (RU).

Overview

BeamPlex remote units operate cost-effectively in non-line-of-sight environments and provide high speed, near-symmetric connections to broadband customers.

Two models of the remote unit are available:
BRU-100 – Outdoor, service provider installation. Includes the outdoor unit (ODU), power supply, power injector, associated cabling and software. A RIT Interface Box is optional. The ODU typically attaches to an exterior wall or roof.
BRU-150 – Indoor, subscriber self-installation. Includes the transceiver (indoor unit), window-mount antenna, power supply, and software.

Both models use the same electronics and function in the same manner.

The remote unit provides the wireless termination point for the BeamPlex system at the subscriber's location. It connects to the subscriber's terminal equipment (computer) across a LAN, or directly by Ethernet 10/100 BaseT.

The airlink serves as the connection between the subscriber's computer and the base station. It utilizes the BeamReach-developed *Adaptive MultiBeam OFDM* technology. Depending on the airlink signal strength, different data rates are possible.

See Appendix B "Remote Unit Specifications" for reference.

BRU-100

A BRU-100 remote unit consists of the following major components:

Outdoor Unit – RF assembly; digital assembly with ASICs and microprocessors; DC/DC power supply; 16-element array antenna with 20° beamwidth and 18 dBi gain

Power Adapter – 110/220 VAC input; 48 VDC output for the RF and digital circuitry in the outdoor unit

Power Injector – 8-lead Ethernet from computer plus power and return from Power Adapter; 6-lead output to outdoor unit

RIT Interface Box (RIB) – Optional device; mounts to outside wall; 10-pin RJ-45 for connecting to outdoor unit

RU Installation Tool (RIT) – Software application in handheld PC to facilitate the installation process

BRU-150

A BRU-150 remote unit consists of the following major components:

Transceiver – This indoor unit has the same electronics as the BRU-100's outdoor unit, except that it does not have an integrated antenna.

Antenna – A window-mount, directional antenna with approximately 90° beamwidth housed in a transparent enclosure.

Power supply – Connects to standard 120 VAC and outputs 48 VDC to the transceiver.

Future versions of the remote unit are planned to include the following models and added capabilities:

BRU-450 – High capacity business model
HPNA – Home Phone Network Alliance support (in Version 1.0)
VoIP – Voice over IP support

BRU-100 Features and Benefits

The BRU-100 is a fully integrated remote unit suitable for professional installation in outdoor environments. Using a high gain antenna, the BRU-100 maximizes cell coverage and range in challenging propagation environments. The outdoor unit provides for simple, fast, low cost installations and high operational reliability. Ethernet connectivity makes it compatible with all types of subscriber LAN equipment.

Features

- Fully integrated outdoor unit
- Single drop cable for power and subscriber interface
- Non-line-of-sight operation (NLOS)
- Sustained throughput up to 1.5 Mbps (downlink) and 1.2 Mbps (uplink)
- Multi-level QoS and SLA support
- Ethernet user interface
- PPP/Bridged Ethernet networking model
- Automatic link quality measurements
- Remote configuration and management
- 2.3 GHz (WCS) band operationand 2.5–2.7 GHz (MMDS/ITFS)

Benefits

- Reduced installation time and cost
  - NLOS, below the roof line
  - One piece outdoor unit, simple cabling
- Reduced operational costs
  - Over the air service management and configuration
  - Over the air software upgrades
- Flexible service offerings
  - Variable service rates – 64 kbps to 1.5 Mbps downlink, up to 1.2 Mbps uplink
  - Multi level QoS via DiffServ, service provider defined SLAs
  - Service transparency using bridged Ethernet model
- High quality voice services, file swapping and streaming media
- Increased cell coverage in comparison to the BRU-150
- Subscriber equipment compatibility
  - Standard Ethernet LAN interface
  - Compatible with standard NICs, hubs, routers, firewalls and 802.11 WLANs

BRU-150 Features and Benefits

The BRU-150 is a fully integrated remote unit designed for subscriber selfinstallation. The high gain, wide beamwidth antenna minimizes the need for pointing to establish an airlink with a base station. The installation process is automated, requiring minimal user actions.

Features

- Fully integrated transceiver packaged in an aesthetic housing for indoor use
- Simple wiring and automated process for ease of installation
- Diagnostic software on subscriber's computer to assist customer support calls
- Non-line-of-sight operation (NLOS)
- Sustained throughput up to 1.5 Mbps (downlink) and 1.2 Mbps (uplink)
- Ethernet user interface
- PPP/Bridged Ethernet networking model
- Remote configuration and management
- 2.3 GHz (WCS)

Benefits

- Subscriber self-installation, no truck roll required
- Reduced operational costs
  - Over the air service management and configuration
  - Over the air software upgrades
- Flexible service offerings
  - Variable service rates – 64 Kbps to 1.5 Mbps downlink, up to 1.2 Mbps uplink
  - Multi level QoS via DiffServ, service provider defined SLAs
  - Service transparency using bridged Ethernet model
- High quality voice services, file swapping and streaming media
- Subscriber equipment compatibility
  - Standard Ethernet LAN interface
  - Compatible with standard NICs, hubs, routers, firewalls and 802.11 WLANs

Remote Unit Interfaces

For both models of the RU there are two basic interfaces:

The airlink to the base station.

The Ethernet data interface to the Customer Premise Equipment (CPE).

All CPE connects to the RU through an Ethernet data interface. Network equipment can be used to connect multiple CPE to the RU.
Future versions of the BRU-100 will use an Integrated Access Device (IAD) for phone and fax equipment.

The airlink interface connects an RU to its associated base station. As part of the RU provisioning process, each RU is assigned a primary base station for its communications.

Architecture

Both models of the RU utilize the same electronics, but their physical architectures differ.

BRU-100

The BRU-100 consists of an outdoor unit (ODU), power injector, power adapter and associated cabling and software. The ODU is mounted outdoors, attached to either a side of the facility (home or business building) or to the roof. The ODU contains the antenna element, digital electronics, RF electronics, a power supply and subscriber interface circuits in a self-contained unit. The BRU-100 uses a directional antenna and one or more carrier frequencies (identical to the base station frequencies) to transmit information to its associated base station. This requires that the antenna be positioned and secured in the direction of a stable RF path in order to maintain a reliable link over time.

BRU-150

A BRU-150 consists of a transceiver, antenna, power adapter, and associated cabling. The transceiver contains all the electronic components and software, and is designed to reside inside the subscriber's building. The BRU-150 has a directional antenna with a 90° beamwidth so precise pointing is not necessary. The antenna mounts to a window using two feet with adhesive patches.

SLA information for each subscriber is programmed over-the-air onto the RU by the BeamPlex Element Management System via the base station. For upstream traffic from the subscriber, the RU will set DiffServ Code Points based on the hardware data port and the appropriate SLA, and apply the associated traffic conditioning functions and rules to that traffic.

The RU implements DiffServ for QoS provisioning. It can read DiffServ Code Points (DSCPs) in IP packets sent downstream from the base station, and set DSCPs in IP packets that are sent upstream to the base station. The RU uses DSCPs in conditioning traffic before sending it upstream to the base station.

DSCPs can be mapped to subsets of the traffic conditioning functions (marking, metering, shaping and policing), which determine the QoS for the traffic flow. An RU will learn from its corresponding base station the DSCPs to be used, and levels of QoS and associated traffic conditioning functions to apply to the traffic.

Remote Unit Components

This section provides details of the components that comprise the BRU-100 and BRU-150 remote units.

BRU-100 Components

The BRU-100 remote unit consists of the components described in this section.

Outdoor Unit

The BRU-100 outdoor unit (ODU) contains the digital electronics, RF electronics, antenna, and power supply (regulating) circuits in a self-contained, weatherized unit.
The ODU dimensions are 15" x 15" x 2.5" and its weight is 10.5 pounds excluding the mounting bracket and hardware.
The ODU is weatherized and complies with IEC 529, Class IP45 environmental classification and can withstand driven rain and water projected in jets.

Digital Section

To reduce the overall cost of the ODU and provide maximum performance levels, the digital section utilizes a highly integrated single ASIC architecture. The ASIC integrates BeamPlex-specific functions for a reliable, compact design on a single printed circuit board.
Generally, the integrated ODU digital hardware provides these main functions:
• **Control Processor** – Handles DSP (traffic processing, AGC etc.) functions and software control (MAC layer and above processing). The DSP filtering lowers SAW filter costs, increasing the cost effectiveness of this design.
• **Digital Processing Hardware** – ASIC that provides the digital hardware required for communication on the airlink.
• **CPE Interface** – Provides the physical and MAC layer interface to the CPE (customer premise equipment). This interface consists of two 10/100BaseT interfaces or one Ethernet and one HomePNA interface (in Version 1.0), which share a single multi-pair cable into the customer's home.
• **RF Interface** – Provides the data and control interface to the RF hardware electronics from the digital hardware and software.

RF Section

RF hardware is incorporated into a single printed circuit assembly in the ODU and provides these functions:
• A receive mode that performs down-conversion, filtering, and digitizing of the airlink waveform.

• A transmit mode that performs analog signal generation from digital data, upconversion,
and filtering to produce the airlink waveform.
• A stable, tunable frequency reference that can be tuned by the digital hardware, to lock all Linear Oscillators and clocks to this frequency reference.
• Gain control in both the Rx and Tx modes to accommodate the defined range of path losses and component tolerances necessary to maintain a stable airlink.
• Power consumption minimized by switching high power components synchronous with TDD transmit and receive mode time slots.
• Pre-selector filtering to reject out-of-band energy in the Rx mode and to filter potential spurious emissions in the Tx mode.

Antenna
The antenna is a low cost planar array antenna utilizing a 16 element diamond shaped configuration. The antenna has been designed by BeamReach Networks to utilize the latest manufacturing techniques, which achieves the lowest cost and highest performance. The antenna provides a 3 db beam width of 18 degrees and has a gain of 18 dBi.

Power Injector and Power Adapter

Power is supplied to the ODU by an indoor AC Power Adapter connected to the Power Injector. The AC Power Adapter converts the 100-240 volt AC power to a 48-volt DC source. This 48-volt DC source is then transferred by a single pair of conductors in the remote unit cable to the ODU. The output rating of the AC Power Adapter is 48 volts DC at 750 mA, and the unit is UL approved.
The Power Injector is a small component that adds the DC power onto the cable running to the ODU. The Power Injector also provides the Ethernet data interface to the end user.

The current version provides a single Ethernet connection to the ODU using a 4-pair, CAT 5 cable. Future versions will provide a second, Efficient Forward (priority) Ethernet conductor in a 5-pair, CAT 5 cable.

Cabling and Protection

The cabling from the ODU to the power injector is outdoor rated, UL approved, with four twisted pair conductors. This outdoor cable is limited to 90 meters (295 feet) in length.

A RIT Interface Box (RIB) may be affixed to the outside wall. This device has punch down blocks to terminate the ODU wiring and the indoor wiring. The RJ-45 is used for the RIT during installation or if troubleshooting is needed.

In addition to the ODU cable, a 10-gauge wire for grounding is required to run from the ODU to an approved grounding location at the installation facility.

For optional protection, an Antenna Discharge Unit (ADU) can be used in addition to the 10-gauge ground wire. An ADU provides the highest level of protection against transient voltages such as lightning or fallen power lines. The ADU incorporates gas discharge tubes on each pair of data connections. The tubes will

open during a power surge and then reconnect after the surge has been dissipated to ground. An ADU also requires a connection to an approved ground location.

RU Installation Tool (RIT)

The RIT is a portable computer that runs a BeamReach Networks' application that is used to install and commission the BRU-100 Remote Unit. The RIT connects to the ODU and communicates over an Ethernet connection. It also synchronizes with a PC to exchange files, where the PC connects to the file servers in the BeamPlex Element Management System. The RIT can also connect to a GPS receiver or magnetic compass if these devices are used during installation.

Platform

The RIT software utility is designed to run on a handheld or ruggedized PDA type computer, which is not supplied with the BRU-100. The unit has to be portable to for use during the installation operation. The sizes are limited to palm, handheld and very small laptop type computers. Windows CE™ is the selected operating system for its Microsoft® Windows™ compatibilities and the variety of hardware platforms available.

These hardware features are recommended for the portable computer:

A touch screen for visual interface from the RIT and for simple acknowledgements of program questions.

A keypad for program interface operation

32 MB of RAM

Ethernet adapter (RJ-45) and RS 232 serial port (DB-9)

Internal battery supply with AC and DC recharge capability

RIT Architecture

The RIT consists of the following communications components:

Ethernet interface for communication with the ODU during installation

Serial interface for synchronization with a PC

Serial interface to allow communication to other devices:

— Synchronization with a PC

— GPS receiver

— Electronic Compass

The ODU maintains secure access by requiring a password and login through the RIT.

Functions

The RIT performs numerous useful functions supporting the installation and commissioning of RUs.

• Storage of Operating Information

The RIT receives and stores files containing pre-installation records, wireless network parameters and post-installation records. These files typically contain the following information: Pre-Installation Records File

– Service/Sales Order

– Order Status

– End User Name/Address/ Phone number

– GPS Latitude/Longitude

– Building structure information - type, stories, material, etc.

– Configuration and location information on three base stations
Wireless Network Parameters File
– Frequency Band – WCS, MMDS or 3.5GHz
– Current ODU software release
– Signal thresholds for three different service levels
– Base station availability
Post-Installation Records File
– Service Order Information
– RU electronic serial number
– Actual GPS location
– Antenna installation information

• Antenna Alignment Assistance
Directional bearings for antenna pointing are calculated from GPS readings, based on the location of the base station and the installation site. The installation site location can be derived from a GPS reading, from a map, or from an Internet/web-based program.
The RIT displays indicators to assist the technician in aligning the ODU antenna towards its serving base station. Visual displays of signal-to-noise ratio and signal strength provide guidance for antenna alignment.
A Process completed successfully message will be displayed on the RIT when the ODU has been properly aligned with the appropriate base station.

• Software, Testing and Configuration of the RU
The RIT is capable of sending operational software to an ODU if the latest version is not installed. The RIT is also able to retrieve software and record configuration details of the RU installation as needed.
The RIT can read the ODU's internal configuration data and display it to the operator. The RIT is also capable of reading and displaying the same configuration data available to the BeamPlex Element Management System.
The RIT can direct the RU to run internal diagnostics (built-in test) and display the results. This testing provides assurance to the installer that a reliable airlink has been established and that the ODU is properly functioning.

BRU-150 Components

The BRU-150 remote unit consists of the components described in this section.

Transceiver

The BRU-150 transceiver contains the digital and RF electronics, and the power supply. The front panel has three **Signal Strength** LEDs that illuminate in a progressive pattern to indicate the quality of the signal being received. The **Sync** LED illuminates amber when power is applied to the unit, flashing amber while it is searching for a base station, and solid green when it synchronizes with a base station. The **Air Link** LED illuminates green when the RU—base connection completes and the unit is ready to use. It flickers to indicate data traffic is being passed.

The back panel contains the connectors for the antenna, power adapter and Ethernet (RJ-45).
The transceiver's dimensions are 9" x 4" x 9" and weighs 3 pounds.
The technical description of the electronic components of the ODU in the section Outdoor Unit is an applicable description of the transceiver also. The exception being that the BRU-150 uses an external antenna rather than the integrated antenna of the BRU-100.

Antenna

The antenna is a four element, micro-strip patch array in a transparent acrylic housing. The dimensions are 15" x 2" x 0.5".
The antenna has a 90° horizontal beamwidth and a gain of 11 dBi.
The antenna mounts in a widow by two feet that attach at the top and bottom of the antenna. The feet affix to the window with adhesive strips. The antenna can rotate ±35° horizontally when mounted.
The connector for the cable is an MCX jack located inside the bottom post where the foot attaches.

Power Adapter

The power adapter is the same unit as for the BRU-100. Input power in 110 to 240 VAC, output is +48 VDC at 750 mA

Installation Procedure

The remote unit installation and provisioning process can be divided into four major steps. The RIT, as described in the preceding section, is instrumental in the installation process. The RU is intended to be professionally installed in a fixed position with its antenna oriented towards the serving base station. Standard portable power and hand tools are needed for the installation, in addition to the RIT.

The complete installation process from when the installer arrives at the customer's premises to connection to the customer's computer is estimated to be 90 minutes. Thirty minutes are consumed in mounting and positioning the outdoor antenna components. Another thirty minutes are used for installation of wiring to the end user's computer. An additional 30 minutes are budgeted for ancillary operations: greeting the customer; unpacking and packing tools and equipment; completion of any on-site paperwork etc. While this product requires professional installation, future remote unit versions will be user installable.

ODU Installation

The outdoor unit (ODU) is designed to be mounted at a height of 3 to 10 meters. ODU installation height depends on several factors, including local restrictions (building codes and homeowner rules and regulations), location of subscriber's computer, and signal strength from selected base station. A practical minimum height is approximately first-floor ceiling height (3 meters).
Upon arrival at the installation site, the installer selects a potential location for the ODU. The ODU is mounted onto a telescoping tripod at this location and the RIT is connected to the unit. The ODU is elevated to a height of what will be the permanent installation. Pointing the ODU at the primary base station, the installer verifies that an acceptable signal level can be received. This signal assessment also determines to which base station (of the three available) the ODU should be pointed. After a functional airlink is established, the physical mounting to the end user's structure can be achieved with a high probability of a successful connection.

At this point, the internal self-test is initialized by the RIT and run within the ODU. Any updated software is then loaded into the ODU if required.
While the RIT is connected, over-the-air communications can be initiated with the base station. Using software on the RIT, optimal pointing of the ODU is achieved using measurements of RF signal strength.

Synchronization/Ranging/Authentication

After the airlink is established, the RIT initiates an information exchange between the remote unit and the base station that results in a functioning communication channel. That process is described in the sub-sections below.

Synchronization

Synchronization is the process by which the remote unit acquires frequency and time synchronization with the target base station. For frequency synchronization, the remote unit searches for the FLS signal from the target base station, as each

base station transmits a unique FLS signal. For time synchronization, the remote unit adjusts its receive gate and aligns its frame with the base station to compensate for propagation delay. There is also a time-of-day synchronization at the MAC layer where the remote unit obtains the global time-slot count from the base, which is important for MAC management functions.

Ranging

Ranging is the process by which the remote unit adjusts its transmission gate and power levels so that its signals arrive at the base station with the proper timing to align with the base station's receive gate, and with an appropriate power level for the base station to demodulate the initial data. During subsequent data transfers, the base station continuously measures timing and power errors, then commands the remote unit to make fine adjustments.

Registration/Authentication

During registration, the base station assigns a unique RUID code to the remote unit. This code allows the base station to uniquely identify each remote unit. Authentication is where the remote unit identifies itself as a legitimate network element to the base station and the BMS.
This is the information that was downloaded from the BeamPlex Element Management System.At this point the remote unit is assigned to the appropriate base station.

Note: Any change of base station assignment will require the installer to reinstall and authenticate to the new base station utilizing the RIT.
Once assigned, the customer order information from the RIT and the Electronic Serial Number (ESN) from the ODU are sent to the base station. The base station uses the ESN to obtain the Key String (KS) from the Key Management System (KMS). The base station uses the sales order information to obtain the RU configuration file, including the Service Level Agreement (SLA), from the Configuration Server. The base station catalogs this information along with any SLA parameters, and sends a KS and the SLA parameters to the RU.

Cabling and Connections

Next, the RU wiring into the building with the subscriber's computer is completed. The ODU is grounded with a 10-gauge wire. Depending on the local building requirements, the ODU wiring is penetrated into the customer structure in one of thee ways:

- The standard and simplest method is to run the cable straight through the wall and terminate it with a connector for the Power Injector.
- If a network demarcation is required at the building entrance, an RU Interface Box (RIB) can be installed. The RIB is described in the section Cabling and Protection.
- In areas where additional electrical protection is required an Antenna Discharge Unit (ADU) can be installed to protect the ODU. The ADU is also described in the section Cabling and Protection.

Once the ODU cabling is inside the structure, the line is terminated with an RJ-45 connector, which mates with the corresponding jack in the Power Injector. The Power Adapter is then plugged into the AC outlet, and its other wire is connected

to the Power Injector to supply power to the ODU. The subscriber's PC or LAN device may now be connected to the Power Injector with an Ethernet cable.

Subscriber Provisioning

ISP software can now be loaded onto the subscriber's computer to complete the service order process. Management functions are established with the Subscriber Management System, and the subscriber sets up his or her account with the ISP. See the section Service Provisioning and Management for details on the service provisioning process.

Subscriber LAN Architectures

The BeamPlex system uses the concept of a *service flow* to support multiple grades of service. A service flow contains a set of traffic profiles and QoS parameters. Service providers can set and use these parameters as they see fit. A base station takes into account the requirements of all service flows when allocating bandwidth to an RU. During the RU installation process the RIT sends appropriate SLA parameters to the remote unit.

There are a number of options for Subscriber LAN configuration. The simplest LAN consists of direct connections between a subscriber's host equipment and the RU. Other devices can be inserted between these hosts and the RU, such as an Ethernet hub, bridge, switch or an IP router. In future versions, POTS-like voice will be supported allowing the connection of standard analog telephones and fax machines.

IP Addresses

In the RU, there is one host (data) port, thus limiting the number of direct connections to one. If an Ethernet hub, bridge or switch is added to the subscriber's LAN, the number of connections can be increased. In this configuration, the number of hosts that can be connected is limited by the number of Ethernet addresses supported by the RU. In Version 1.0, a fully-configured RU will support eight Ethernet addresses (based on caching space in the RU).

With an IP router in the subscriber LAN, there is no limitation on the number of host Ethernet addresses. This is due to the router terminating the Ethernet connections between the hosts and the RU. Thus, the RU will receive only the Ethernet address of the router. The limitation on the number of hosts is now based on the IP addressing plan that is used on the subscriber LAN, or on any physical limitations of the router.

IP address space that a subscriber uses on the LAN can be part of the SP's address space (the SP sells or rents a block of IP address space to the subscriber), or it can be part of a private IP address space (for example, 10.0.0.0) using NAT.

Forwarding Behavior

BeamPlex network devices, base stations and remote units accept and forward traffic in a manner referred to as *enhanced bridging*. Bridging is forwarding traffic based on a layer 2 (link-layer) address. The scope of bridging is the set of layer 2 addresses that are bound by layer 3 (such as IP) addressing rules. Enhanced bridging refers to the ability of BeamPlex devices to monitor and act upon layer 3 information, without forwarding traffic at layer 3 (routing). This is layer 2 bridging of Ethernet frames, where IP header fields are observed and modified as each Ethernet frame is processed. Since no IP information is used in the forwarding process (in Version 1.0), it is still considered bridging.
Part of the processing of Ethernet frames is to classify them based on their Quality of Service (QoS) requirements. This results in modifying the IP header to add a DiffServ Code Point (DSCP), which is used to condition traffic through the base station. Thus, enhanced bridging allows IP QoS to be provisioned in base stations and RUs, and to be used to optimize traffic flows and network performance to subscribers, while maintaining layer 2 bridged behavior.

IP QoS

The bridging model used by the BeamPlex system is enhanced through the addition of traffic conditioning based on IP QoS information. For Version 1.0, IP QoS uses IETF-standard Differentiated Services (DiffServ, or DS) process to *get*, *set*, and *modify* QoS information in IP headers.

Classification and Marking

IP packets arriving at the RU are classified according to their service type. For Version 1.0 there are two types of service: Best Effort (BE) and Expedited Forwarding (EF) [DS Field]. Best Effort service is unpredictable and unreliable, suitable to applications that are capable of operating under variable delay and capacity conditions. Traffic flows that use TCP as their transport mechanism can generally use BE service, as can be seen in Internet traffic studies. However, applications that generate traffic flows which are sensitive to variable delay and/or capacity conditions require better support in the network. Expedited Forwarding indicates the need for better support, particularly in terms of delay performance.
For Version 1.0, EF service is intended for VoIP traffic flows. IP packets marked with a DSCP for EF (101110) will be given preferential treatment by the traffic conditioning functions described above, as well as preferred scheduling at the upstream outbound interface (the airlink at the RU, or the backhaul interface at the base station).