Chapter 2 System Description

This Chapter describes the following:

System Overview

The PTM 1000 broadband wireless system consists of two primary elements: a hub (indoor unit and outdoor unit) and multiple remotes (indoor and outdoor units), as shown in Figure 2.

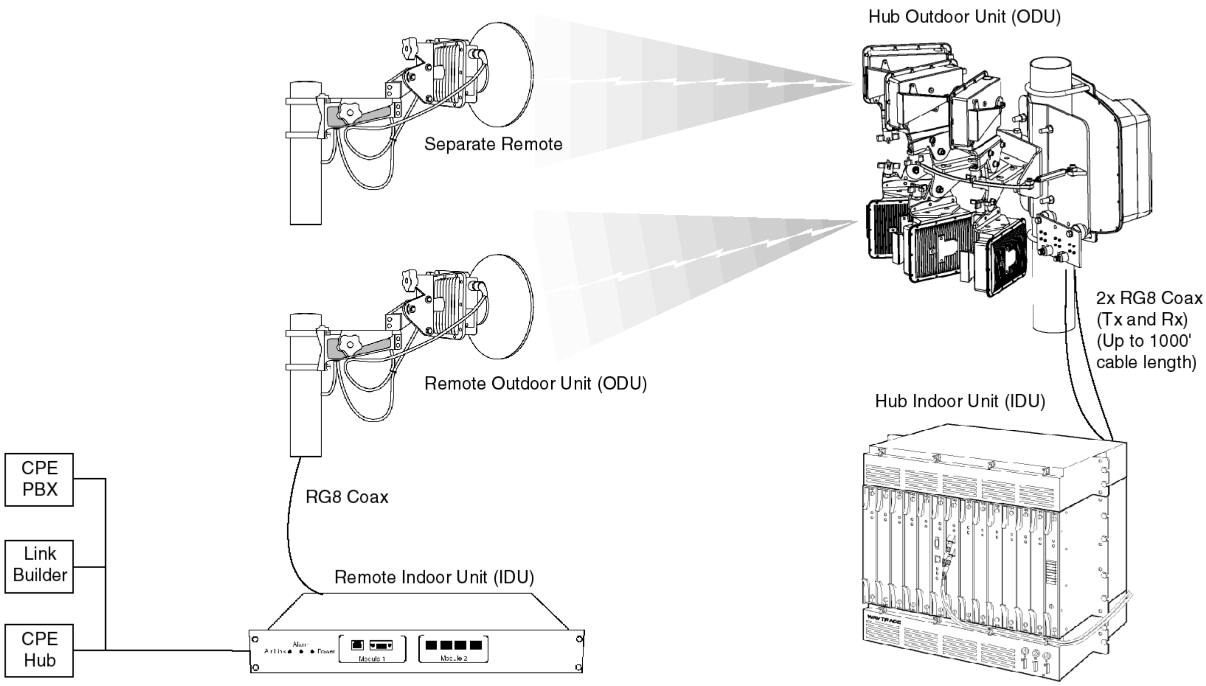

Figure 2 *PTM 1000 Broadband Wireless System*

The hub is equivalent to a base station in cellular terminology. The hub is composed of an indoor unit (IDU) and an outdoor unit (ODU). The hub IDU, which consists of electronic equipment housed in a stand-alone cabinet or in a free-standing rack, is placed within an office building or other structure.

The hub ODU is placed on top of the structure where the IDU is housed, and can be as much as 1000 feet away from the IDU. It consists of multiple horn or dish antennas with their associated interface electronics and mounting frames.

The remote is composed of an indoor unit (IDU) and an outdoor unit (ODU). The remote IDU is placed within an office building or other interior structure. The remote IDU is composed of electronic equipment housed in a standalone cabinet or in a free-standing rack.

The remote ODU is placed on top of the office building or other external structure, up to 1000 feet. The remote ODU can also be placed indoors. The remote ODU consists of a single parabolic antenna, its associated interface electronics and mounting frame.

Hub – Remote Comparison

The remote IDU is similar to the hub IDU. The following paragraphs compare their capabilities:

- The remote is a single antenna/single airlink device. The remote performs the same types of functions as the hub, using a single airlink time slot. The hub has multiple time slots, one slot per remote.
- The remote antenna is a high gain parabolic device, which has a narrow beam. In comparison, the hub can also use antennas that are designed to cover a wider area. The remote uses the same RF transceiver electronics as the hub. Each remote is composed of a single transceiver and antenna. The hub can support as many as four remotes, with each containing a single transceiver and antenna.
- The remote ODU does not require an outdoor distribution box (ODB), as does the hub. For the remote, the functions of the hub ODB are incorporated into the remote IDU.
- The remote IDU is connected to the remote ODU via one coaxial cable, which transports IF frequencies between the IDU and the ODU. The coaxial cable is also used to deliver power from the IDU to the ODU.

- The PTM 1000 System requires "line of sight" between the hub antenna and remote antenna. For indoor mounting, the remote TRA must be placed near a window that maintains a line of sight to the hub.
- Because the remote uses only one TRA for each remote IDU, the remote requires only one modem control function. Further, there is no need to frequency multiplex multiple IF signals onto the coaxial cable (there are no multiple IFs to multiplex). Unlike the hub, the remote does not require a separate IFD PCA.
- Critical IFD PCA functions are carried over to the remote. The coax control channel from the hub IFD PCA is required to permit the remote to configure the TRA. The remote uses the same FM modem as the one used in the IFD PCA. The remote also uses the RSSI and cable compensation.
- The remote IDU interfaces directly to the end customer equipment.

System Connections

Hub Connections

One hub IDU can support up to four outdoor frames (ODFs), with each ODF servicing a 90-degree quadrant. A pair of RG-8 coaxial cables run between the intermediate frequency distribution (IFD) printed circuit assemblies (PCAs) in the hub IDU and the outdoor distribution box (ODB) in the hub ODU, connecting the hub indoor unit to the outdoor unit.

The two RG-8 coaxial cables provide an interface between the hub IDU and ODU. These cables transport intermediate frequencies (I/F) from the hub IDU to the ODU (forward), and from the hub ODU to the IDU (reverse). Power from the hub IDU is delivered to the ODU on both the forward link and reverse link cables.

Note Transport from the hub to the remote is considered a *forward* transmission because the remote downloads in this direction. Transport from the remote to the hub is a *reverse* transmission because the remote uploads in this direction.

The hub interconnects and switches between two types of communication interfaces:

- High speed wireless airlinks to multiple remotes
- OC-3 links to wireline broadband networks

Each remote unit interfaces to the hub through a single high speed airlink and provides one or more customer premise data ports for DS1 or Ethernet connection.

Remote Connection

The remote network connection uses much less bandwidth than the hub's OC3 interface. The remote may have a maximum of 11 DS1 ports at this time. The hub is the distribution point and there are multiple remotes for each hub, but traffic flow is referenced to the remote.

The PTM 1000 System references the forward link as the RF path from the Service Provider's network connection through the hub to the remote. The reverse link is data flow from the remote to the hub and to the Service Provider's network.

Note Transport from the hub to the remote is considered a forward link because the remote downloads in this direction. Transport from the remote to the hub is an reverse link because the remote uploads in this direction.

Hub Indoor Unit (IDU)

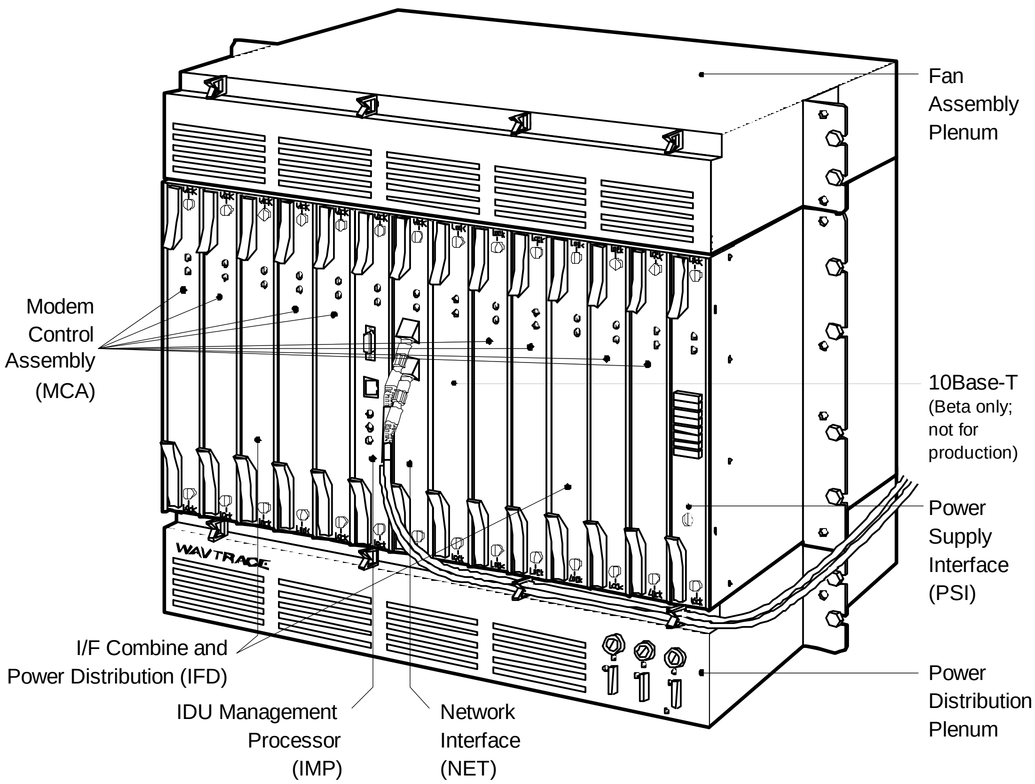

Figure 3 *hub Indoor Unit (IDU)*

Note The hub IDU is shipped with printed circuit assemblies (PCAs) installed. The PCAs are tested as a customer-configured system.

IDU Card Cage and Backplane

The hub IDU consists of a shelf of electronics housed in either a standalone cabinet or a free-standing rack (see Figure 3). The PCAs are arranged on the shelves such that a small market entry system can be configured on one shelf, which can be added to at a later date. The control shelf contains the system modules, which are shared by all of the remotes serviced by the system. These modules include:

- Indoor management processor (IMP)
- Power supply interface (PSI)
- Network interface (NET)

The common control shelf contains up to eight modem control assemblies (MCAs) and two IFD PCAs.

The MCA and IFD PCAs service a group of transmitter-receiver assemblies (TRAs) on a common ODF. The MCA and IFD PCAs combine to form two MCA groups. Each MCA group interfaces to a forward TDM bus and a reverse TDM bus, which carry data in a parallel, synchronous format between the network interfaces and the MCA groups. The two TDM buses are controlled by the NET PCA, which interfaces the TDM buses to the network interface.

The IDU is powered with –48Vdc. Each PCA in the IDU converts the –48Vdc power feed to the voltages required for on-board use.

Printed Circuit Assemblies (PCAs)

Circuit boards in the hub IDU, except for the PSI PCA, may be installed and uninstalled with power applied to the card cage. The IMP software maintains the system configuration and restores the system to its original configuration when a PCA is replaced. The MCA board can function as a master or slave, depending on which slot it is inserted. A slave MCA board can be replaced without affecting the operation of another MCA board that is installed in the same card cage. Hot-swapping a master MCA will affect the airlink associated with that MCA. Although the IMP can be hot-swapped, removing and reinserting the IMP causes a system reset.

Caution The system may be damaged if the PSI is plugged in while the hub has power applied. Power to the hub must be removed before removing or adding a PSI.

All PCAs are upgradable and replaceable.

Indoor Management Processor (IMP)

The IMP PCA provides primary management of the PTM system, including the hub (IDU, ODU) and the remote (IDU, ODU). The IMP PCA maintains configuration and alarm information for the entire system.

Note Software upgrades are downloaded to the IMP PCA.

The IMP PCA performs the following functions:

- It provides the interface to OAM and P management and craft maintenance workstations.
- It performs system clock generation and timing distribution within the system.
- It configures and monitors the subassemblies of the PTM 1000 System and establishes and releases remote communication channels.

To carry out these functions, the IMP PCA communicates with the NET, MCA and IFD PCAs primarily via an HDLC bus. Messages destined for the hub ODU or the remote units are forwarded via the coaxial control channel. In the case of remote units, messages are forwarded via the airlink control channel.

Power Supply Interface (PSI)

The PSI PCA accepts a –48 Vdc input and distributes the voltage to the hub back plane and N connectors, which carry DC power to the hub ODU. The PSI provides fuse protection for each of the N connectors using indicating fuses. The PSI also detects loss of current flow for each of the N connectors and provides an alarm indication to the IMP.

The PSI has fuses on the front, along with caution notes.

Caution ⚠ For continued protection against risk of fire, replace blown fuses only with same type and rating of fuse. Refer to *Electrical Specifications* in *Appendix A* of this guide.

Network Interface (NET)

The NET PCA provides:

- Interface between the airlink and the SONET communication network
- Pathway for remote-to-remote switching

The OC-3 NET module is the interface between the OC-3 SONET optical input/outputs and the switching matrix on the NET PCA. The module is a self-contained OC-3 interface.

Note The plug-in module used on the PCA is not hot-swappable.

The NET PCA provides remote-to-remote switching via the STS-3 port. The NET PCA can support two TDM buses (TDM bus 1 and TDM bus 2) to transfer data to and from the NET PCA to the MCA PCAs.

The NET PCA provides:

- Performance monitoring. Gathers statistics for Errored Seconds, Severely Errored Seconds, and Unavailable Seconds in 15 minute intervals and stores them for 48 hours.
- Cross-connect switching. Provides complete SONET and TDM time slot routing capability for OC-3 trunks and loopback between MCA groups. This functionality is directly available to the connection manager. remote-to-remote routing is achieved using the STS-3 loopback interface; the incoming path of an airlink (a TDM time slot) is switched to a virtual tributary of the outgoing loopback, and the corresponding virtual tributary of the incoming loopback is switched to the outgoing TDM time slot of the airlink.

Important The NET PCA contains a laser that meets Class 1 Laser Safety Requirements of IEC 825-2: 1993 and U.S. Department of Health Services 21 CFR 1040.10 and 1040.11 (1990) when operated within the specified temperature, power supply, and duty
cycle ranges.

Modem Control Assembly (MCA)

The MCA performs time division duplex (TDD) and time division multiple access (TDMA) acquisition and control of intermediate frequency (I/F) carriers, which form the wireless airlink. A hub IDU supports up to eight MCAs.

The MCA performs the modulation of the digital baseband signal to and from an intermediate frequency (I/F) using a quadrature amplitude modulated (QAM) method. The MCA employs a dual down-conversion receive architecture. A common local oscillator is used for the first receive down-conversion and transmit up-conversion. The same local oscillator is frequency-divided by two and used as a reference for the AFC direct digital synthesizer (DDS). The AFC DDS is programmed in both phase and frequency to provide accurate frequency control to the QAM receiver block.

Power input to the MCA is nominally –48Vdc. Separate power conditioning is provided for the digital, analog and RF electronics on the MCA. A combination of linear regulation and passive filtration is implemented on each power form for noise reduction and power form isolation.

I/F Combine and Power Distribution (IFD)

The IFD PCA is the interface between the MCA and the coaxial cables to the ODB. One IFD PCA can support a maximum of four MCAs.

A typical frequency-multiplexed interface combines four modem signals from the MCAs for transmission over two coaxial cables to one ODB. I/F signals at 480 MHz from four MCAs are combined in the forward link path by converting each signal to four different I/Fs. The reverse link signals are received from the cable and mixed to 480 MHz, selected and transmitted over the backplane to individual MCAs.

Another set of two-way signals are multiplexed onto the cables control channel for controlling and monitoring four TRAs.

Fan Assembly Plenum

The Fan Assembly Plenum mounts directly above the IDU shelf assembly. It contains three –48Vdc-powered fans, which provide airflow for the hub IDU card cage. The rotation of each fan is monitored and an alarm indication is provided to the IMP in the case of a fan rotation failure.

Power Distribution Plenum

The PTM 1000 requires customer supplied –48Vdc power capable of delivering that voltage at 10A per shelf. A connector in the back of the Power Distribution Plenum receives power from the power supply and distributes it throughout the system. All power circuits into the system have 10A fuses and an LED for each fuse per fan assembly. A green LED indicates that there is power to the Power Distribution Plenum. Each PCA in the IDU receives –48 power from the backplane connector, then converts the power to its desired operating voltage.

LEDs and Alarms

Each PCA in the hub IDU has one red and one green LED. In all cases, the green LED indicates that there is power to the circuit board. The red LED indicates that the circuit board has detected a fault or alarm condition.

Alarm indicators for failure detection and fault isolation are sent to the IMP for reporting to the Network Operating Center. Each alarm is categorized as critical, major or minor to provide an indication of the severity of an alarm. Fault conditions can be verified using diagnostics and cleared by replacing the affected PCA. In some cases, a condition external to the PTM 1000 System may trigger an alarm, which may only be cleared by removing the offending external condition.

Hub Outdoor Unit (ODU)

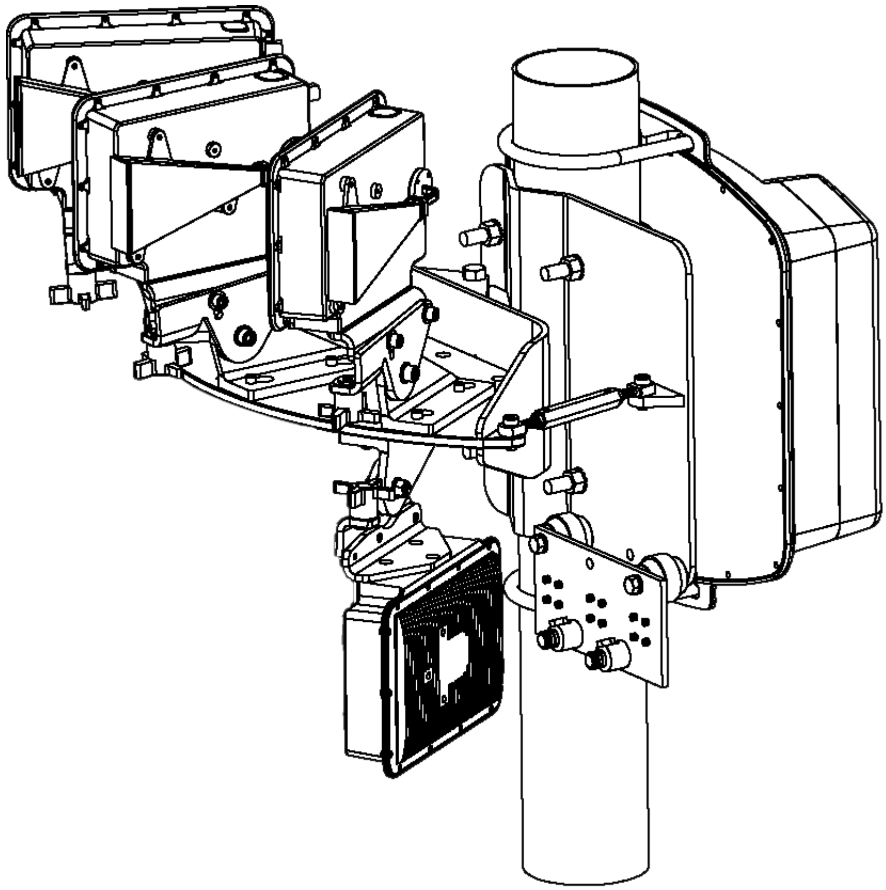

Figure 4 *hub Outdoor Unit (ODU)*

The hub ODU comprises multiple horn antennas with their associated interface electronics and mounting frames (see Figure 4).

Two tiers of TRAs consisting of up to three antennas per tier can be mounted on an outdoor frame (ODF). Typically, four ODFs are used to service a 360-degree area surrounding a building.

Up to four TRAs connect to an ODB, which interfaces the IF signals from the TRAs to the two coax cables connecting the IDU and ODUs. Up to two ODBs, providing coax interfaces for 12 TRAs, can be mounted on an ODF. An ODU can have up to four ODFs to provide RF coverage of a 360-degree area surrounding a building. Typically, the ODU, including the TRAs and ODBs, is located on the roof of an office building and is subjected to environmental extremes without the aid of fans or cooling systems.

Transmitter-Receiver Assembly (TRA)

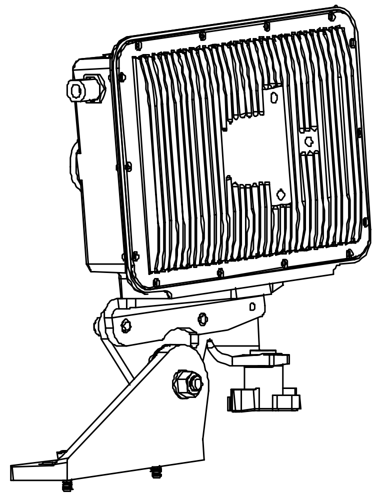

Figure 5 *Transmitter-Receiver Assembly (TRA)*

Each antenna uses interface electronics provided by the transmitter PCA. The term "transmitter-receiver assembly" refers to the antenna, the transmitter PCA, the millimeter-wave front end, and the mechanical housing. The TRA forms a single digital interface, providing all of the processing of the RF signals to and from the antenna.

Outdoor Distribution Box (ODB)

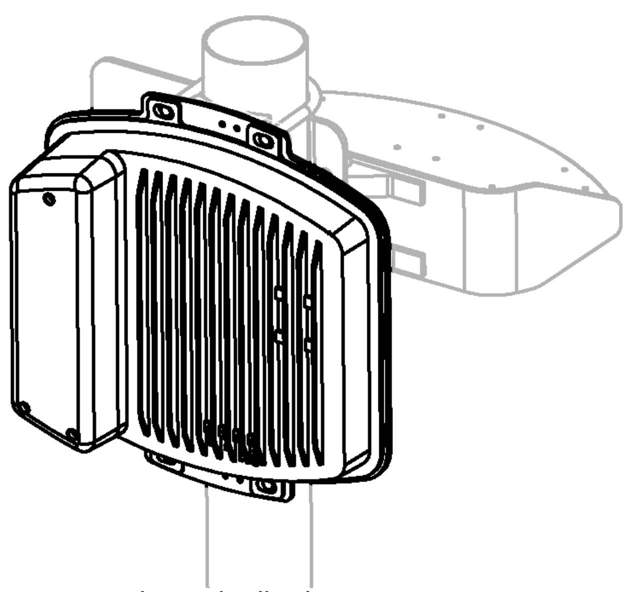

Figure 6 *Outdoor Distribution Box*

The ODB manages the frequency multiplexing of reverse and forward IF signals between the IDU and ODU. There is one reverse cable and one forward cable for each ODB. Each cable carries signals for four point-to-multipoint TRAs and a coax control channel.

The ODB receives the –48 Vdc generated in the IDU from both the reverse and forward coaxial cables and distributes the –48 Vdc to the four TRAs for dc-to-dc conversion to provide the voltages required by the transmitters and front ends.

Hub Outdoor Frame (ODF)

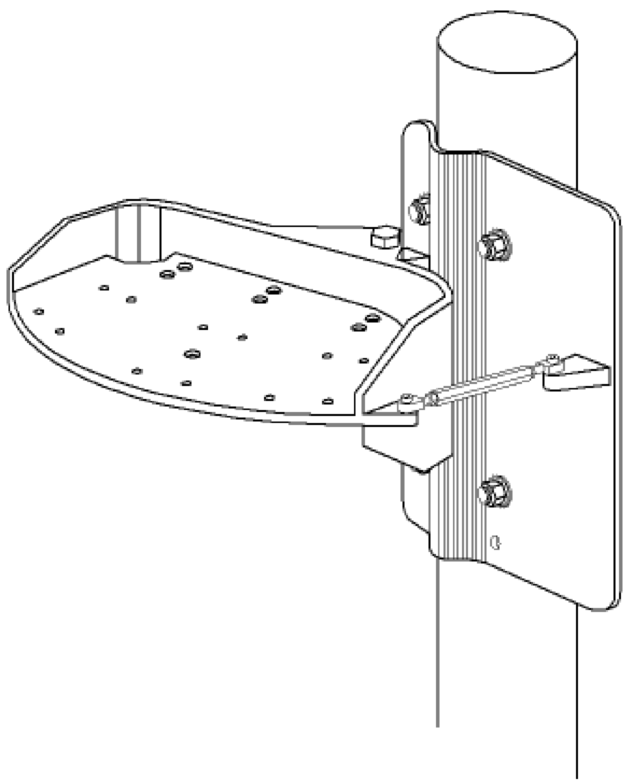

Figure 7 *Outdoor Frame*

The hub ODF is installed on a buyer-furnished or Wavtrace-provided tower. The hub ODF fits towers that meet specific design requirements. Tower requirements and specifications are provided to the customer during the site survey.

Remote Indoor Unit (IDU)

Note The remote IDU is shipped with individual printed circuit assemblies (PCAs) installed. The PCAs are tested as a customer-configured system.

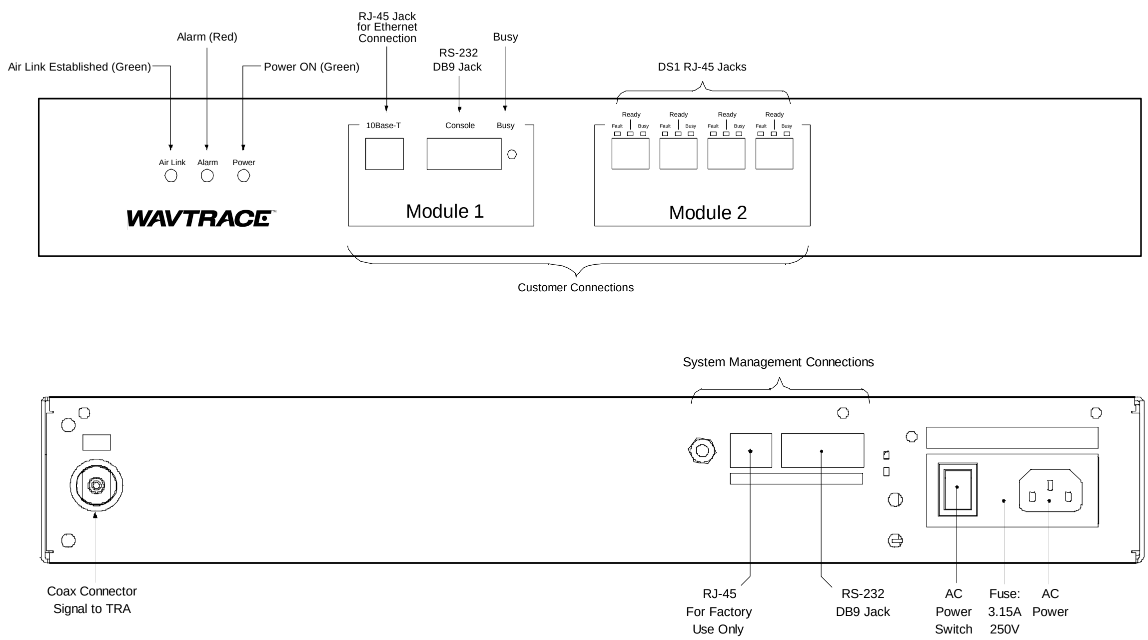

Figure 8 *remote IDU*

IDU shelf and backplane

The remote IDU consists of a set of electronics housed in either a stand-alone cabinet or a free-standing rack. The remote IDU contains at least four PCAs:

- remote MCA
- Motherboard
- Backplane
- At least one I/O module. There are two types of I/O modules, the Quad DS1 and the 10Base-T Ethernet interface.

The remote IDU uses forced air cooling and has air slots on both sides of the enclosures.

The remote MCA and motherboard PCAs are powered via the –48 Vdc backplane. The remote IDU has an internal universal AC power supply. The output of this power supply is –48 Vdc.. Each PCA in the IDU converts the –48 Vdc power feed to the voltages required for on-board use.

The Motherboard converts the –48 Vdc power to the voltages it requires and the I/O modules use.

Printed Circuit Assemblies (PCAs)

The circuit boards (PCAs) for the remote IDU are pre-assembled and tested as a single unit. The remote IDU is replaced as a single field replaceable unit in the field; individual PCA replacements are not required.

Remote Modem Control Assembly (RMCA)

The remote MCA handles the time division duplex (TDD) and time division multiple access (TDMA) control. It performs the modulation of the digital baseband signal to and from an intermediate frequency (I/F) using the quadrature amplitude modulate (QAM) method.

Motherboard

The motherboard has space for three I/O modules. The Motherboard contains RF circuitry equivalent to the hub’s IFD PCA, the timing generation from the IMP, and the coax command channel from the IFD and I/O module interface.

IFD Contribution

The remote IDU uses three functions from the hub's IFD PCA: the coax command channel (CCCH), the 15Mhz reference signa,l and the DC power couple and sense for the TRA. In the hub, the IFD PCA frequency multiplexes multiple MCA signals on to one coaxial cable. Since there is only one TRA on the remote, there is no need for the multiple IFs.

The IFD also provides adjustable gain to the IF signals and the CCCH. This gain adjust is necessary to compensate for different length coaxial cables (to the TRA).

IMP contribution CPU/Clock

The CPU design for the remote Motherboard came primarily from the hub's IMP PCA. Some of the clock generation functions are from the IMP. In addition, the remote Motherboard uses similar phase locking methods as those used on the hubs IMP PCAs.

The remote provides the DC power and 15Mhz reference clock coupling in addition to the RF signals via a single coaxial cable. The TRA has only one coaxial connector. The reverse link, forward link, power, and reference clock all pass through the single coaxial connection.

Switching Power Supply

The remote IDU is powered from 110Vac. The remote IDU has a built-in AC/DC power converter, which accepts 90-260 Vac, 50-60 Hz. The power unit is UL/CSA safety certified and uses a standard IEC power input connector. A fully loaded remote requires approximately 210W power.

LEDs and Alarms

The remote IDU has three LEDs – one red and two green. One of the green LEDs indicates that the remote unit is powered and has passed its power-on self test. The red LED indicates that a failure has been detected or that there is an alarm condition. The other green LED indicates that the airlink is active.

Each IO Module has additional LEDs specific to that module or IO port.

The DS1 connection uses LEDs to reflect port status and alarms. Each of the four ports on a DS1 module has its own set of LEDs. The Ethernet module has LEDs that are similar to those found on a router or bridge.

Remote Outdoor Unit (ODU)

The remote ODU consists of a single parabolic antenna with its associated interface electronics and mounting frame. The antenna assembly forms a single digital airlink interface.

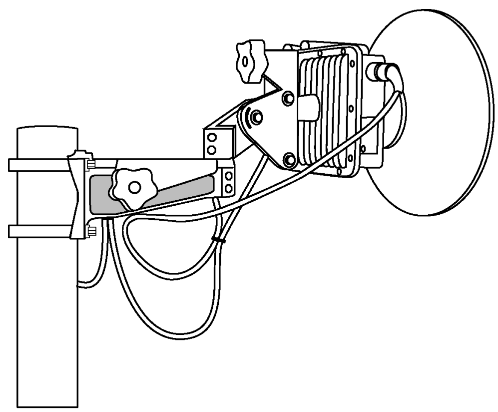

Figure 9 *Remote ODU*

Transmit and Receive Assembly (TRA)

The antenna electronics are contained in the Transmit and Receive PCA (TRX) and a millimeter-wave front end. Together, the antenna, TRX PCA, millimeter-wave front end, and the mechanical housing – which contains the electronics – are referred as the Transmit and Receive Antenna Assembly (TRA).

The TRX PCA and its associated millimeter wave Front End provide all of the processing of the RF signals to and from the antenna. The millimeter wave Front End detects the receive signal while the TRX PCA conditions the signal to be passed on to the remote IDU. The TRX PCA processes the transmit signal. The TRX PCA has an on-board processor to control its functions as follows:

- The on-board processor interfaces with the MCA processor via the coax control channel (CCCH) for alarm notification, configuration management, transceiver performance monitoring, and fault management.

- The on-board processor interfaces with the on-board phase lock loop ICs for initialization, control and monitoring, and also interfaces to on-board A/D and D/A converters for control and monitoring of variable filters, RF output power, and temperature sensing.
- The TRA has a Receive Signal Strength Indicator (RSSI) to help align the antenna during installation. The TRA also has a connector to attach a multimeter for measuring a dc voltage which corresponds to a peak RSSI.

The TRA has two connections – one DB9 connector for a serial port, and a coaxial cable connection for the RF interface and power. During normal operation, only the coaxial connection is required. Power, RF intermediate frequencies and an embedded command channel are all provided using the coaxial line.

Chapter 3 Grounding

This Chapter describes the following:

General Requirements

EMP Surge Protectors

The EMP surge protectors must be installed in the correct orientation. For the surge protectors installed outdoors next to the transmit/receive antenna, the protected side is the side leading to the antenna/transceiver or ODB connection. For the surge protectors installed indoors next to the hub indoor electronic equipment, the protected sider is the side leading to the hub indoor electronics. Verify that components are working properly by checking the functionality of these components once a year. For surge protectors that use gas capsules, the gas capsules should be replaced when capability is reduced, or routinely every three years maximum. Check the electrical bond to ground whenever performing maintenance.

Grounding

All ground cabling (from the ODU ground bus bar to a single point ground) should be #6AWG stranded, tinned copper wire, sheathed in green jacketing with a THNN or similar rating for outdoor use. Braided cables are not acceptable. All cable end lug connectors should be two-hole, tinned copper lugs, ideally with two holes for two ¼-inch diameter bolts. Lugs should be crimped and protected with heat shrink, preferably adhesive-lined and installed per manufacturer’s instructions. All bolts should have thread-locking features such as lock washers or electrically conductive thread locking compounds. Bolts should be corrosion protected or stainless steel and torqued to 30-45 inch-lbs. Do not use aluminum wiring.

Connections

Clean all mating surfaces to provide adequate electrical connections. Protect all outdoor connections with electrically conductive anti-corrosion compounds and verify the electrical bond. All connection to pipes or curved surfaces should be connected via a corrosion resistant (stainless steel, bronze, brass) clamp or device suitable for that purpose.

Building Ground

All ground bars need to have a direct connection to building or earth ground via a single ground cable and bonded per NEC Sec. 250-G. In addition, verify that the building's electrical ground is also bonded to the building ground system. If using the building structural elements as the path to ground, first verify that the structural elements are connected to the building electrical ground (in some earthquake prone areas, the individual floor structural elements are separated by rubber pads). Do not use sprinkler systems, drainpipes or HVAC ducts,as they are not reliable grounding elements. If there is no building ground, then construct an earth ground using two eight-foot, 5/8" diameter ground rods 8 to 15 feet apart. Use copper clad ground rods. All connections to ground rods should use copper hardware, nuts, bolts, etc. All connections below ground should be joined via an exothermic process, *Cadweld* or equivalent.

Equipment Grounding

Ground all equipment. Connect all equipment cabinets, racks, enclosures, telephone circuit surge protectors and signal lines to a single point ground. A Daisy chain method of grounding is not permitted. All elements should have their own individual conductors to the single point ground.

Wire Routing

All ground cable should use the shortest path to the next connection, however there should not be any sharp bends in the wire routing. Minimize the number of bends, and ensure that runs are as straight and as long as possible. A minimum bend radius of 8 inches is preferable since the cabling is also a path for EMP, which will not travel around sharp bends. All bends, curves, and spliced conductors should be towards the ground location (grounded end) of the conductor. At all ground connections, leave enough cable for drip loops. Secure all cables to preventing chafing or any excessive movement. Separate all ground cables from the signal or power cables by a minimum of 2 inches.

Hub Grounding

The following paragraphs describe outdoor and indoor grounding for the hub. Use the following schematic in Figure 10 as a guide during installation and grounding.

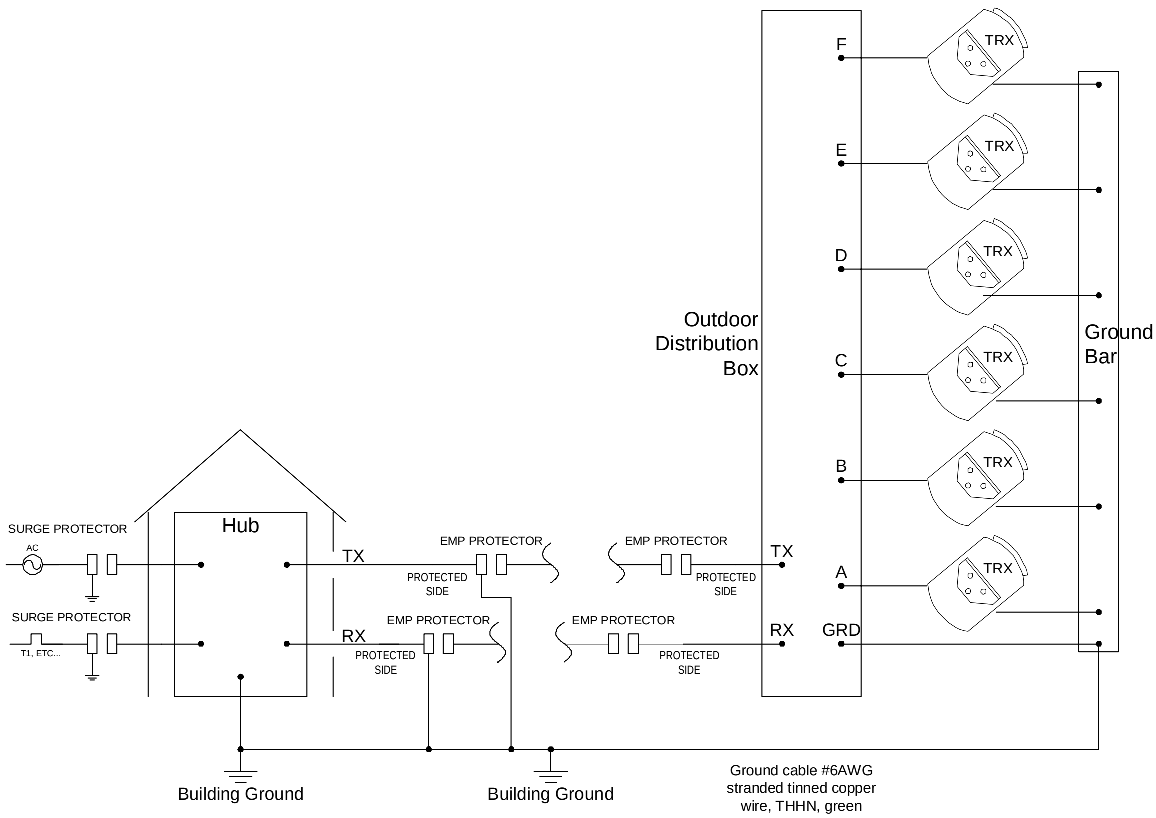

Figure 10 *Hub Schematic*

Hub Outdoor Grounding Requirements

After installing the ground bar at the hub antenna frame location (see Figure 11), bond the ground bar to building ground. If the ground cable to building ground is terminated prior to running it back to the indoor installation location, a separate ground cable must be installed parallel to ground the signal cable every 100 feet and at all 90-degree (or more) bends. This cable must also be terminated at the ground bar and at the building ground. Secure both ground and signal cable every 4 to 8 feet. Also, all elements of the installation (tower, enclosures, and gratings, etc.) must be grounded using appropriate hardware. Verify all bonded connections.

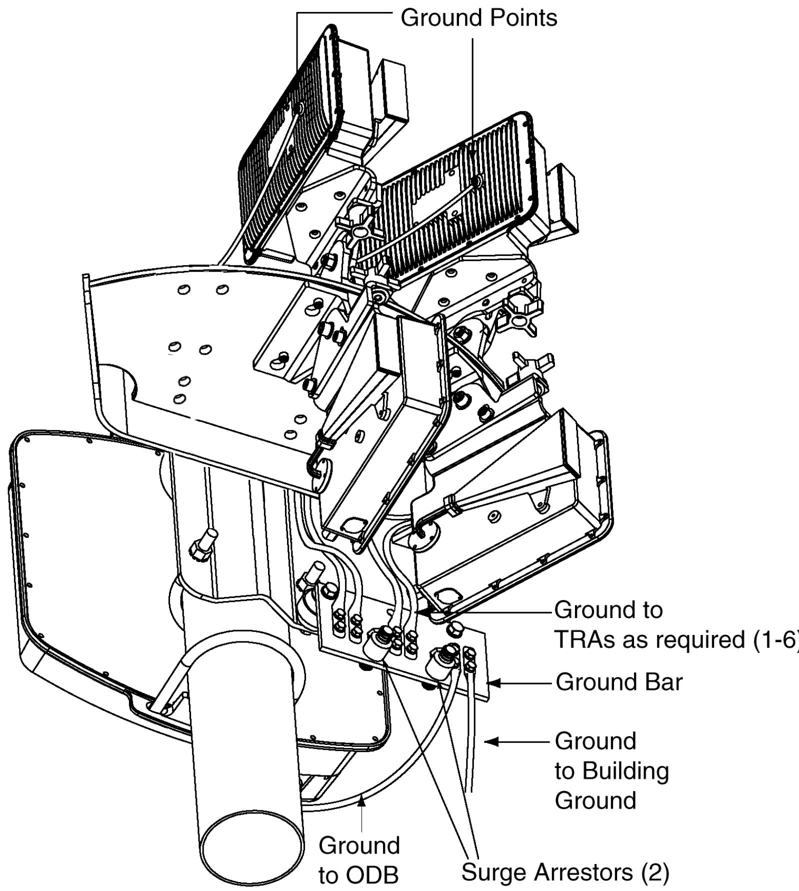

Figure 11 *Hub Pole Ground Installation*

Hub Indoor Grounding Requirements

After installing the ODU ground bar at the hub indoor electronics location (see Figure 12), bond the ground bar to building ground. The wall-mounted channels for the building ground must withstand a 50lb downward load. Locate the IDU ground bar installation point as near as possible to the signal cable entry point. The signal cable coming from the indoor electronics must be connected to the protected side of the surge protector. The signal cable coming from the outdoor antenna must be connected to the surge side of the surge protector.

All elements of the installation (racks, halos, routing windows, tower, enclosures, and gratings, etc.) must grounded to the ground bar using appropriate hardware. All ground connections should be electrically bonded and should have anti-oxidation grease. Verify all bonded connections.

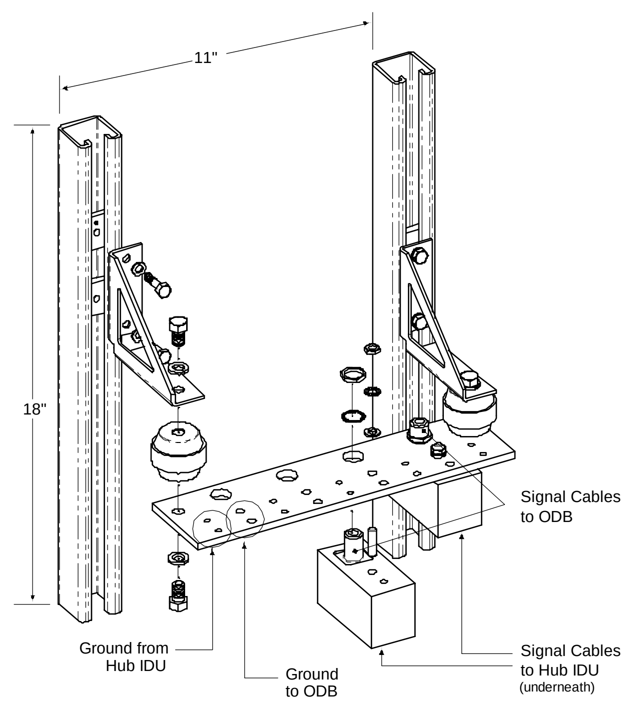

Figure 12 *Hub Ground Bar Installation*

Remote Grounding

The following paragraphs describe outdoor and indoor grounding for the remote. Use the following schematic in Figure 10 as a guide during installation and grounding.

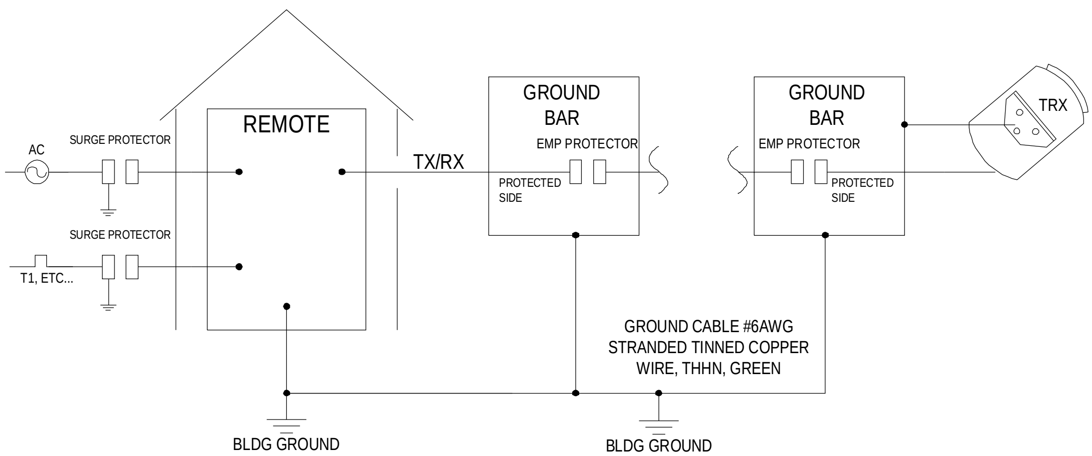

Figure 13 *Remote Grounding Schematic*

Remote Outdoor Grounding Requirements

After installing the ground bar at the remote antenna location (see Figure 14), bond the ground bar to the building ground. If the ground cable to the building ground is terminated prior to running it back to the indoor installation location, a separate ground cable must be installed parallel to ground the signal cable every 100 feet and at all 90-degree (or more) bends. Terminate this cable at the ground bar and at the building ground. Secure both ground and signal cable every 4 to 8 feet. Also, all elements of the installation (tower, enclosures, and gratings, etc.) must be grounded, using appropriate hardware. Verify all bonded connections.

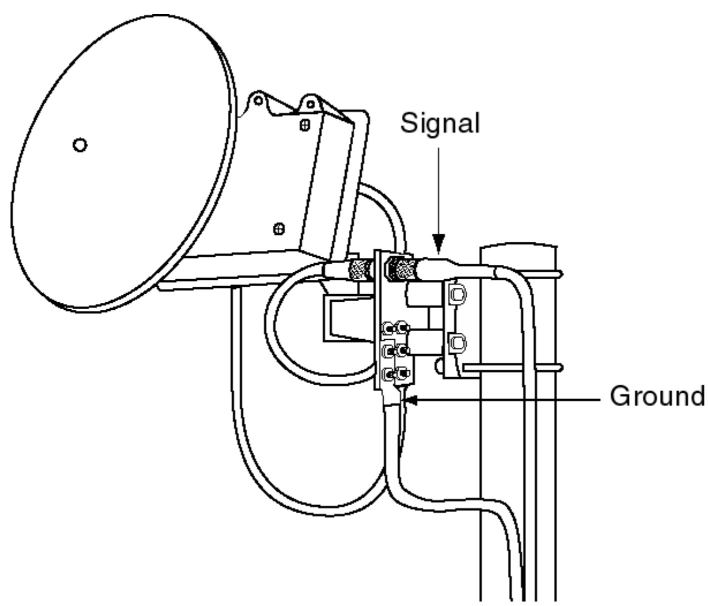

Figure 14 *Remote Ground Installation*

Remote Indoor Grounding Requirements

After installing the ground bar at the remote indoor electronics location (see Figure 15), bond the ground bar to the building ground. The wall-mounted channels for the building ground must withstand a 50lb downward load. Locate the ground bar installation point as near as possible to the signal cable entry point. The signal cable coming from the indoor electronics must be connected to the protected side of the surge protector. The signal cable coming from the outdoor antenna must be connected to the surge side of the surge protector.

All elements of the installation (racks, halos, routing windows, tower, enclosures, and gratings, etc.) must grounded to the ground bar using appropriate hardware. All ground connections should be electrically bonded and should have anti-oxidation grease applied. Verify all bonded connections.

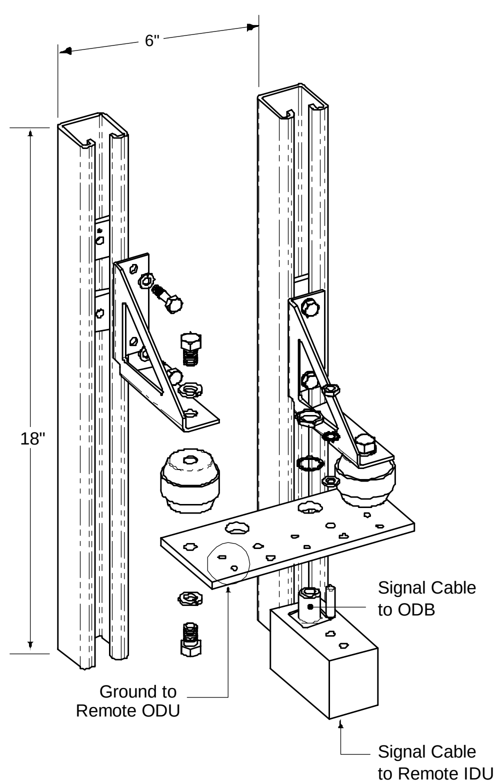

Figure 15 *Remote Ground Bar Installation*