Cambium
PMP/PTP 450i Series
User Guide

System Release 14.0

Cambium Networks™

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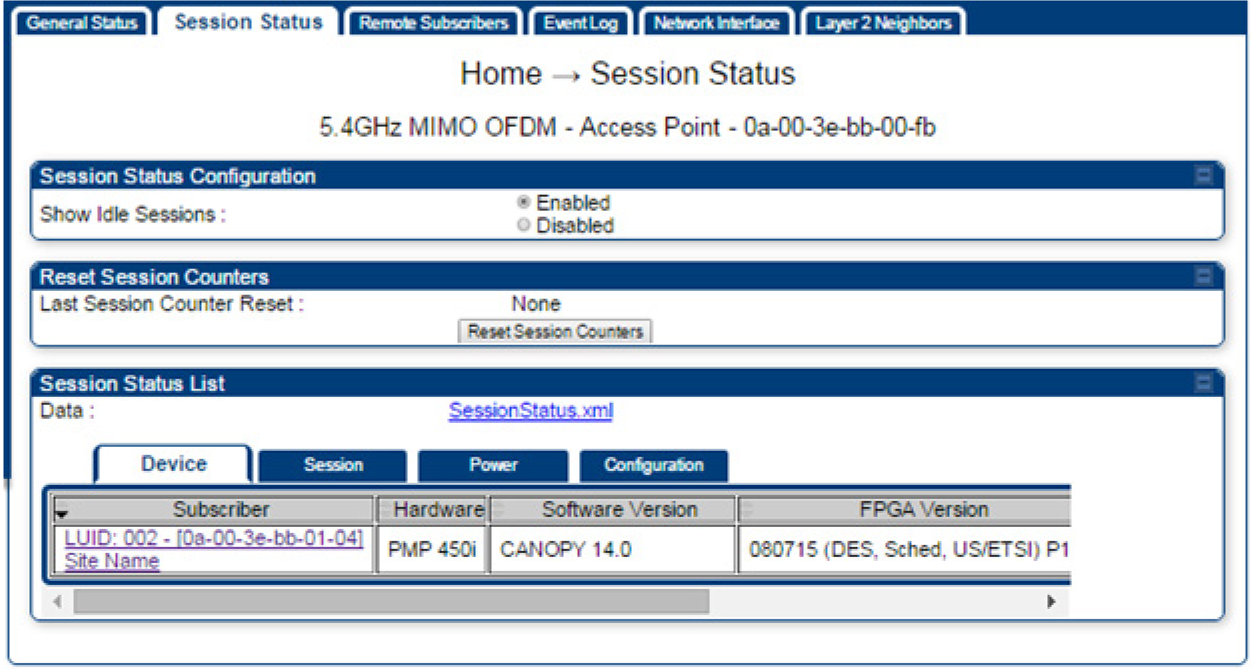

Home → Session Status

5.4GHz MIMO OFDM - Access Point - 0a-00-3e-bb-00-fb

Session Status Configuration

Show Idle Sessions : ● Enabled ○ Disabled

Reset Session Counters

Last Session Counter Reset : None

Session Status List

Data : SessionStatus.xml

Subscriber	Hardware	Software Version	FPGA Version
LUID: 002 - [0a-00-3e-bb-01-04] Site Name	PMP 450i	CANOPY 14.0	080715 (DES, Sched, US/ETSI) P1

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About This User Guide

This guide describes the planning, installation, configuration and operation of the Cambium PMP/PTP 450i Series of point-to-point wireless Ethernet bridges. It is intended for use by the system designer, system installer and system administrator.

For radio network design, refer to the following chapters:

- Chapter 1: Product description
- Chapter 2: System hardware
- Chapter 3: System planning
- Chapter 4: Legal and regulatory information
- Chapter 5: Preparing for installation
- Chapter 6: Installation

For system configuration, tools and troubleshooting, refer to the following chapters:

- Chapter 7: Configuration
- Chapter 8: Tools
- Chapter 9: Operation
- Chapter 10: Reference Information
- Chapter 11: Troubleshooting

Contacting Cambium Networks

Support website:	http://www.cambiumnetworks.com/support
Main website:	http://www.cambiumnetworks.com
Sales enquiries:	solutions@cambiumnetworks.com
Support enquiries:	support@cambiumnetworks.com
Repair enquiries:	rma@cambiumnetworks.com
Telephone number list:	http://www.cambiumnetworks.com/contact
Address:	Cambium Networks Limited, Global Headquarters, 3800 Golf Road, Suite 360, Rolling Meadows, IL 60008 USA

Purpose

Cambium Networks Point-to-Multi-Point (PMP)/Point-To-Point (PTP) 450i documents are intended to instruct and assist personnel in the operation, installation and maintenance of the Cambium PMP/PTP equipment and ancillary devices. It is recommended that all personnel engaged in such activities be properly trained.

Cambium disclaims all liability whatsoever, implied or express, for any risk of damage, loss or reduction in system performance arising directly or indirectly out of the failure of the customer, or anyone acting on the customer's behalf, to abide by the instructions, system parameters, or recommendations made in this document.

Cross references

References to external publications are shown in italics. Other cross references, emphasized in blue text in electronic versions, are active links to the references.

This document is divided into numbered chapters that are divided into sections. Sections are not numbered, but are individually named at the top of each page, and are listed in the table of contents.

Feedback

We appreciate feedback from the users of our documents. This includes feedback on the structure, content, accuracy, or completeness of our documents. Send feedback to support@cambiumnetworks.com.

Important regulatory information

The PMP/PTP 450i product is certified as an unlicensed device in frequency bands where it is not allowed to cause interference to licensed services (called primary users of the bands).

Application firmware

Download the latest PMP/PTP 450i Series firmware and install it in the Outdoor Units (ODUs) before deploying the PMP/PTP 450i equipment. Instructions for installing firmware are provided in Upgrading the software version and using CNUT on page 7-65.

USA specific information

Caution

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference, and
- This device must accept any interference received, including interference that may cause undesired operation

The USA Federal Communications Commission (FCC) requires manufacturers to implement special features to prevent interference to weather radar systems that operate in the band 5600 MHz to 5650 MHz. These features must be implemented in all products able to operate outdoors in the band 5470 MHz to 5725 MHz.

Manufacturers must ensure that such radio products cannot be configured to operate outside of FCC rules; specifically it must not be possible to disable or modify the radar protection functions that have been demonstrated to the FCC.

In order to comply with these FCC requirements, Cambium supplies variants of the PMP/PTP 450i for operation in the USA. These variants are only allowed to operate with license keys that comply with FCC rules.

To ensure compliance with FCC rules (KDB 443999: Interim Plans to Approve UNII Devices Operating in the 5470 - 5725 MHz Band with Radar Detection and DFS Capabilities), follow **Error! Reference source not found.** on page **Error! Bookmark not defined.**.

External antennas

When using a connectorized version of the product, the conducted transmit power may need to be reduced to ensure the regulatory limit on transmitter EIRP is not exceeded. The installer must have an understanding of how to compute the effective antenna gain from the actual antenna gain and the feeder cable losses.

The range of permissible values for maximum antenna gain and feeder cable losses are included in this user guide together with a sample calculation. The product GUI automatically applies the correct conducted power limit to ensure that it is not possible for the installation to exceed the EIRP limit, when the appropriate values for antenna gain and feeder cable losses are entered into the GUI.

Avoidance of weather radars (USA only)

To comply with FCC rules (KDB 443999: Interim Plans to Approve UNII Devices Operating in the 5470 - 5725 MHz Band with Radar Detection and DFS Capabilities), units which are installed within 35 km (22 miles) of a Terminal Doppler Weather Radar (TDWR) system (or have a line of sight propagation path to such a system) must be configured to avoid any frequency within +30 MHz or –30 MHz of the frequency of the TDWR device. This requirement applies even if the master is outside the 35 km (22 miles) radius but communicates with outdoor clients which may be within the 35 km (22 miles) radius of the TDWRs. If interference is not eliminated, a distance limitation based on line-of-sight from TDWR will need to be used. Devices with bandwidths greater than 20 MHz may require greater frequency separation.

When planning a link in the USA, visit http://spectrumbridge.com/udia/home.aspx, enter the location of the planned link and search for TDWR radars. If a TDWR system is located within 35 km (22 miles) or has line of sight propagation to the PTP device, perform the following tasks:

- Register the installation on http://spectrumbridge.com/udia/home.aspx.
- Make a list of channel center frequencies that must be barred, that is, those falling within +30 MHz or –30 MHz of the frequency of the TDWR radars.

The PMP/PTP 450i AP must be configured to not operate on the affected channels.

Canada specific information

Caution

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

(1) This device may not cause interference; and

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Industry Canada requires manufacturers to implement special features to prevent interference to weather radar systems that operate in the band 5600 MHz to 5650 MHz. These features must be implemented in all products able to operate outdoors in the band 5470 MHz to 5725 MHz.

Manufacturers must ensure that such radio products cannot be configured to operate outside of IC rules; specifically it must not be possible to disable or modify the radar protection functions that have been demonstrated to IC.

In order to comply with these IC requirements, Cambium supplies variants of the PMP/PTP 450i for operation in Canada. These variants are only allowed to operate with license keys that comply with IC rules. In particular, operation of radio channels overlapping the band 5600 MHz to 5650 MHz is not allowed and these channels are permanently barred.

In addition, other channels may also need to be barred when operating close to weather radar installations.

Other variants of the PMP/PTP 450i are available for use in the rest of the world, but these variants are not supplied to Canada except under strict controls, when they are needed for export and deployment outside Canada.

Renseignements specifiques au Canada

Attention

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Industry Canada (IC) a demandé aux fabricants de mettre en œuvre des mécanismes spécifiques pour éviter d’interférer avec des systèmes radar fonctionnant dans la bande 5600 MHz à 5650 MHz. Ces mécanismes doivent être mis en œuvre dans tous les produits capables de fonctionner à l'extérieur dans la bande 5470 MHz à 5725 MHz.

Les fabricants doivent s'assurer que les produits de radiocommunications ne peuvent pas être configurés pour fonctionner en dehors des règles IC, en particulier, il ne doit pas être possible de désactiver ou modifier les fonctions de protection des radars qui ont été démontrés à IC.

Afin de se conformer à ces exigences de IC, Cambium fournit des variantes du PMP/PTP 450i exclusivement pour le Canada. Ces variantes ne permettent pas à l’équipement de fonctionner en dehors des règles de IC. En particulier, le fonctionnement des canaux de radio qui chevauchent la bande 5600-5650 MHz est interdite et ces canaux sont définitivement exclus.

IC Approved Antennas

The list of antennas used to obtain IC approvals is provided in section Compliance with radio regulations, Industry Canada certification, Table 192 and Table 193.

Antennas externes

Lorsque vous utilisez une version du produit sans antenne intégrée, il peut être nécessaire de réduire la puissance d'émission pour garantir que la limite réglementaire de puissance isotrope rayonnée équivalente (PIRE) n'est pas dépassée. L'installateur doit avoir une bonne compréhension de la façon de calculer le gain de l'antenne réelle et les pertes dans les câbles de connections.

La plage de valeurs admissibles pour un gain maximal de l'antenne et des pertes de câbles de connections sont inclus dans ce guide d'utilisation avec un exemple de calcul. L'interface utilisateur du produit applique automatiquement la limite de puissance menée correct afin de s'assurer qu'il ne soit pas possible pour l'installation de dépasser la limite PIRE, lorsque les valeurs appropriées pour le gain d'antenne et les pertes de câbles d'alimentation sont entrées dans l'interface utilisateur.

Antennes approuvées par IC

La liste des antennas approveés pour l'operation au Canada est founie dans le chapitre Compliance with radio regulations, Industry Canada certification, tableaux Table 192 et Table 193.

EU Declaration of Conformity

Hereby, Cambium Networks declares that the Cambium PMP/PTP 450i Series Wireless Ethernet Bridge complies with the essential requirements and other relevant provisions of Directive 1999/5/EC. The declaration of conformity may be consulted at:

http://www.cambiumnetworks.com/support/ec-doc

Specific expertise and training for professional installers

To ensure that the PMP/PTP 450i is installed and configured in compliance with the requirements of Industry Canada and the FCC, installers must have the radio engineering skills and training described in this section.

The Cambium Networks technical training program details can be accessed from below link:

http://www.cambiumnetworks.com/training/category/technical-training/

Ethernet networking skills

The installer must have the ability to configure IP addressing on a PC and to set up and control products using a web browser interface.

Lightning protection

To protect outdoor radio installations from the impact of lightning strikes, the installer must be familiar with the normal procedures for site selection, bonding and grounding. Installation guidelines for the PMP/PTP 450i can be found in Chapter 2: System hardware and Chapter 3: System planning.

Training

The installer needs to have basic competence in radio and IP network installation. The specific requirements applicable to the PMP/PTP 450i should be gained by reading Chapter 5: Preparing for installation, Chapter 6: Installation, Chapter 7: Configuration, Chapter 8: Tools and Chapter 9: Operation; and by performing sample set ups at base workshop before live deployments.

The Cambium Networks technical training program details can be accessed from below link:

http://www.cambiumnetworks.com/training/category/technical-training/

Problems and warranty

Reporting problems

If any problems are encountered when installing or operating this equipment, follow this procedure to investigate and report:

1. Search this document and the software release notes of supported releases.
2. Visit the support website.
3. Ask for assistance from the Cambium product supplier.
4. Gather information from affected units, such as any available diagnostic downloads.
5. Escalate the problem by emailing or telephoning support.

Repair and service

If unit failure is suspected, obtain details of the Return Material Authorization (RMA) process from the support website (http://www.cambiumnetworks.com/support).

Hardware warranty

Cambium's standard hardware warranty is for one (1) year from date of shipment from Cambium Networks or a Cambium distributor. Cambium Networks warrants that hardware will conform to the relevant published specifications and will be free from material defects in material and workmanship under normal use and service. Cambium shall within this time, at its own option, either repair or replace the defective product within thirty (30) days of receipt of the defective product. Repaired or replaced product will be subject to the original warranty period but not less than thirty (30) days.

To register PMP and PTP products or activate warranties, visit the support website. For warranty assistance, contact the reseller or distributor. The removal of the tamper-evident seal will void the warranty.

⚠ **Caution**

Using non-Cambium parts for repair could damage the equipment or void warranty. Contact Cambium for service and repair instructions.

Portions of Cambium equipment may be damaged from exposure to electrostatic discharge. Use precautions to prevent damage.

Security advice

Cambium Networks systems and equipment provide security parameters that can be configured by the operator based on their particular operating environment. Cambium recommends setting and using these parameters following industry recognized security practices. Security aspects to be considered are protecting the confidentiality, integrity, and availability of information and assets. Assets include the ability to communicate, information about the nature of the communications, and information about the parties involved.

In certain instances Cambium makes specific recommendations regarding security practices, however the implementation of these recommendations and final responsibility for the security of the system lies with the operator of the system.

Warnings, cautions, and notes

The following describes how warnings and cautions are used in this document and in all documents of the Cambium Networks document set.

Warnings

Warnings precede instructions that contain potentially hazardous situations. Warnings are used to alert the reader to possible hazards that could cause loss of life or physical injury. A warning has the following format:

Warning

Warning text and consequence for not following the instructions in the warning.

Cautions

Cautions precede instructions and are used when there is a possibility of damage to systems, software, or individual items of equipment within a system. However, this damage presents no danger to personnel. A caution has the following format:

Caution

Caution text and consequence for not following the instructions in the caution.

Notes

A note means that there is a possibility of an undesirable situation or provides additional information to help the reader understand a topic or concept. A note has the following format:

Note

Note text.

Caring for the environment

The following information describes national or regional requirements for the disposal of Cambium Networks supplied equipment and for the approved disposal of surplus packaging.

In EU countries

The following information is provided to enable regulatory compliance with the European Union (EU) directives identified and any amendments made to these directives when using Cambium equipment in EU countries.

Disposal of Cambium equipment

European Union (EU) Directive 2002/96/EC Waste Electrical and Electronic Equipment (WEEE)

Do not dispose of Cambium equipment in landfill sites. For disposal instructions, refer to

http://www.cambiumnetworks.com/support/weee-compliance

Disposal of surplus packaging

Do not dispose of surplus packaging in landfill sites. In the EU, it is the individual recipient's responsibility to ensure that packaging materials are collected and recycled according to the requirements of EU environmental law.

In non-EU countries

In non-EU countries, dispose of Cambium equipment and all surplus packaging in accordance with national and regional regulations.

Chapter 1: Product description

This chapter provides a high level description of products in the PMP/PTP 450i series. It describes in general terms the function of the product, the main product variants and the main hardware components. The following topics are described in this chapter:

- Overview of the PMP/PTP 450i Series on page 1-2 introduces the key features, typical uses, product variants and components of the PMP/PTP 450i series.
- Wireless operation on page 1-8 describes how the PMP/PTP 450i wireless link is operated, including modulation modes and spectrum management.
- System management on page 1-12 introduces the PMP/PTP 450i management system, including the web interface, configuration, security, alerts and recovery.

Overview of the PMP/PTP 450i Series

This section introduces the key features, typical uses, product variants and components of the PMP/PTP 450i series.

Purpose

Cambium PMP/PTP 450i Series products are designed for Ethernet bridging over point-to-point and point-to-multipoint microwave links in unlicensed and lightly-licensed frequency bands between 4.9 GHz and 5.9 GHz. Users must ensure that the PMP/PTP 450i Series complies with local operating regulations.

The PMP/PTP 450i Series acts as a transparent bridge between two or more segments of the operator's network. In this sense, it can be treated as a virtual wired connection among points. The PMP/PTP 450i Series forwards 802.3 Ethernet frames destined for the other part of the network and filters frames it does not need to forward. The system is transparent to higher-level protocols such as VLANs.

Key features

The PMP/PTP 450i is a high performance wireless bridge for Ethernet traffic. It is capable of operating in line-of-sight (LOS), near-LOS and non-LOS propagation condition. Its maximum LOS range is 40 mi (or 64 km).

The PMP 450i Connectorized AP is to be used with an external antenna. The PMP 450i Integrated AP has an integrated sector antenna with 16 dBi gain.

The PMP 450i Integrated SM has an integrated directional antenna with 23 dBi gain.

The PMP 450i Connectorized SM is to be used with an external antenna.

The PTP 450i Integrated ODU has its own flat-panel antenna with 23 dBi gain for 4.9 to 5.9 GHz. The PTP 450i Connectorized ODU is designed for use with an external antenna.

The PMP/PTP 450i Series has extensive quality of service (QoS) classification capability.

The Cambium PMP/PTP 450i Series offers the following benefits:

- Cambium's highest performing point-to-multipoint solution, with up to 129 Mbps usable throughput for PMP and upto 132 Mbps usable throughput for PTP
- State-of-the-art MIMO (Multi-In Multi-Out) technology
- Better spectral efficiency than other MIMO alternatives
- Efficient GPS synchronized, scheduled TDD operation for easy AP/BHM site deployment and performance that is consistent regardless of SM/BHS loading
- A range of cost-effective subscriber device solutions to meet the business case of any network application
- MIMO Matrix B: This technique provides for the ability to double the throughput of a radio transmission under proper RF conditions. Different data streams are transmitted simultaneously on two different antennas.
- MIMO-A mode: This mode of operation has same modulation levels as the MIMO-B mode, namely: QPSK, 16-QAM, 64-QAM and 256-QAM.

Table 1 gives a summary of the main PMP/PTP 450i characteristics.

Table 1 Main characteristics of the PMP/PTP 450i Series

Characteristic	Value
Topology	PMP/PTP
Wireless link condition	LOS, near LOS or non-LOS
Range	PTP: Up to 40 mi (or 64 km) depending on configuration PMP: Up to 40 mi (or 64 km)
Duplexing	TDD (symmetric and asymmetric)
Connectivity	1000Base-T Ethernet Main port with PoE input
Operating frequencies	4.9 to 5.925 GHz
Tx Power	max 27 dBm
Channel bandwidth	5, 10 and 20 MHz
High spectral efficiency	Up to 6.5 bps/Hz
Data rate	Up to 129 Mbps (20 MHz channel BW) for PMP Up to 132 Mbps (20 MHz channel BW) for PTP

Frequency bands

The PMP/PTP 450i ODU can be configured by the user to operate in the following bands:

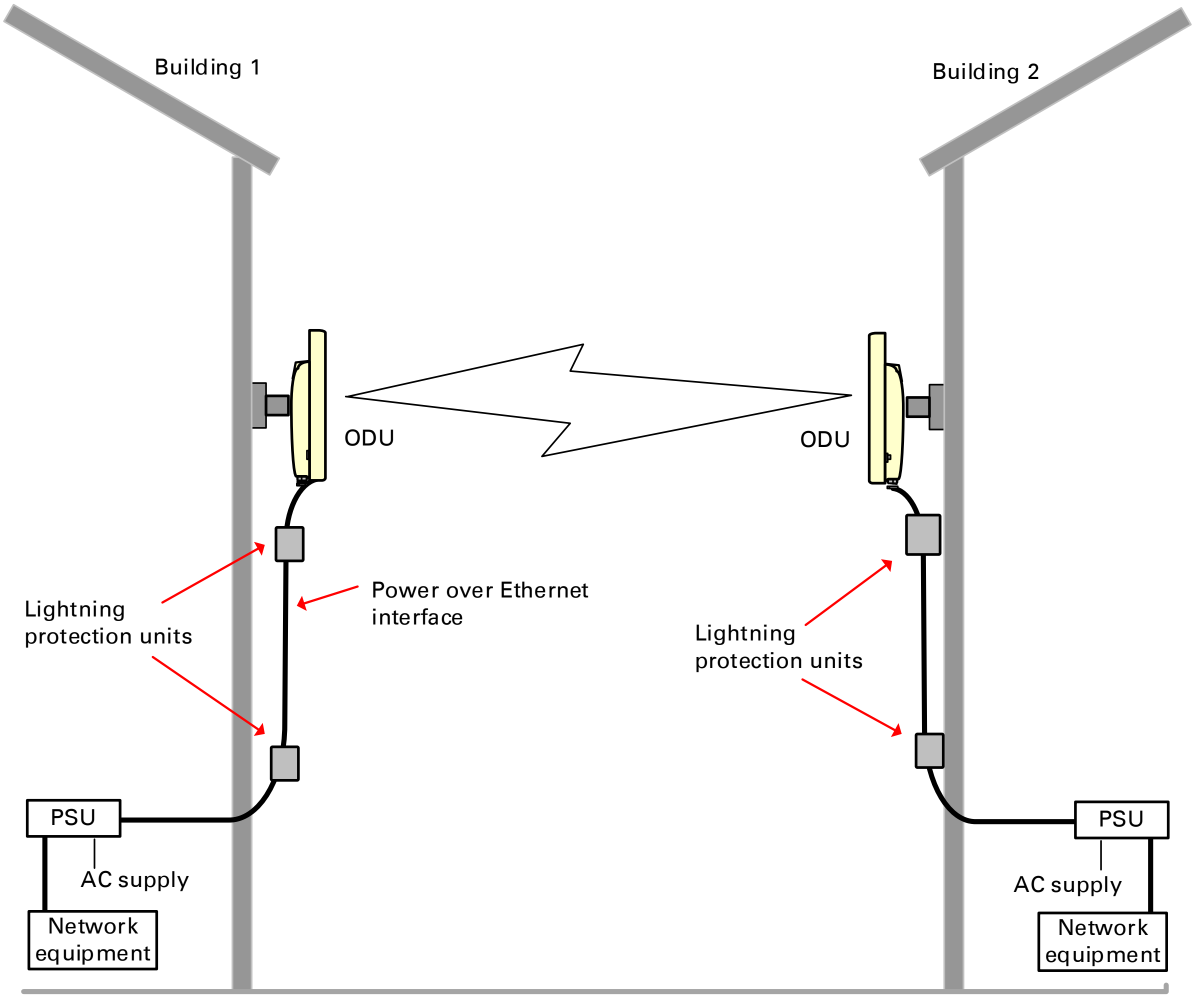
- 4.9 GHz band: 4900 to 5000 MHz
- 5.1 GHz band: 5150 to 5250 MHz
- 5.2 GHz band: 5250 to 5350 MHz
- 5.4 GHz band: 5470 to 5725 MHz
- 5.8 GHz band: 5725 to 5900 MHz

Typical deployment

The PMP/PTP 450i is an "all outdoor" solution consisting of a wireless bridge across sites. Each site installation consists of an Integrated or Connectorized outdoor unit (ODU) and a power supply (PSU) (see Figure 1). The ODU provides the following interfaces:

- Ethernet port: This provides proprietary power over Ethernet and connection to the management and/or data networks via 100BASE-TX or 1000BASE-T Ethernet.

Figure 1 PMP/PTP 450i typical bridge deployment



Point-to-Multipoint

The PMP 450i Series consists of Access Point (AP) and Subscriber Module (SM) ODU. The radio link operates on a single frequency channel in each direction using Time Division Duplex (TDD).

Applications for the PMP 450i Series include:

- High throughput enterprise applications
- nLOS video surveillance in metro areas
- Urban area network extension
- Network extension into areas with foliage

Point-to-Point (Backhaul)

The PTP 450i Series consists of two BH (Backhaul) ODUs. The customer can decide, via software configuration, if this unit is a BHM (Backhaul Master) or a BHS (Backhaul Slave). The radio link operates on a single frequency channel using Time Division Duplex (TDD).

Applications for the PTP 450i Series include:

- Enterprise Access

- nLOS video surveillance
- Leased line replacements and backup solutions
- Network extension

Hardware overview

The main hardware components of the PMP/PTP 450i are as follows:

- Outdoor unit (ODU): The ODU is a self-contained transceiver unit that houses both radio and networking electronics.

  The **PTP 450i** is supplied in the following configurations:

  - BH ODU:
    - Integrated : 23 dBi flat panel antenna - 4.9 GHz to 5.925 GHz
    - Connectorized option for use with an external antenna. The BH ODU can be configured as a BHM or a BHS

  The **PMP 450i** is supplied in the following configurations:

  - AP ODU:
    - Integrated: 16 dBi sector antenna - 4.9 GHz to 5.925 GHz
    - Connectorized option for use with an external antenna.
  - SM ODU:
    - Integrated 23 dBi flat panel antenna : 4.9 GHz to 5.925 GHz
    - Connectorized option for use with an external antenna.
- The ODU is supplied in the following regional variants:
  - FCC, intended for deployment in the USA
  - EU, intended for deployment in countries of the European Union or other countries following ETSI regulations
  - Rest of the World (RoW), intended for deployment in countries other than USA and EU countries.
  - IC, intended for deployment in Canada
- An indoor power supply module providing Power-over-Ethernet (PoE) supply to ODU (AP/SM/BH).
- Antennas and antenna cabling: Connectorized ODUs require external antennas connected using RF cable.
- Ethernet cabling: All configurations require a copper Ethernet Cat5e connection from the ODU (Ethernet port) to the PoE.
- Lightning protection unit (LPU): LPUs are installed in the ports copper drop cables to provide transient voltage surge suppression.
- Ground cables: ODU, LPUs and outdoor copper Ethernet cables are bonded to the site grounding system using ground cables.

For more information about these components, including interfaces, specifications and Cambium part numbers, refer to Chapter 2: System hardware.

Wireless operation

This section describes how the PMP/PTP 450i wireless link is operated, including modulation modes, power control and security.

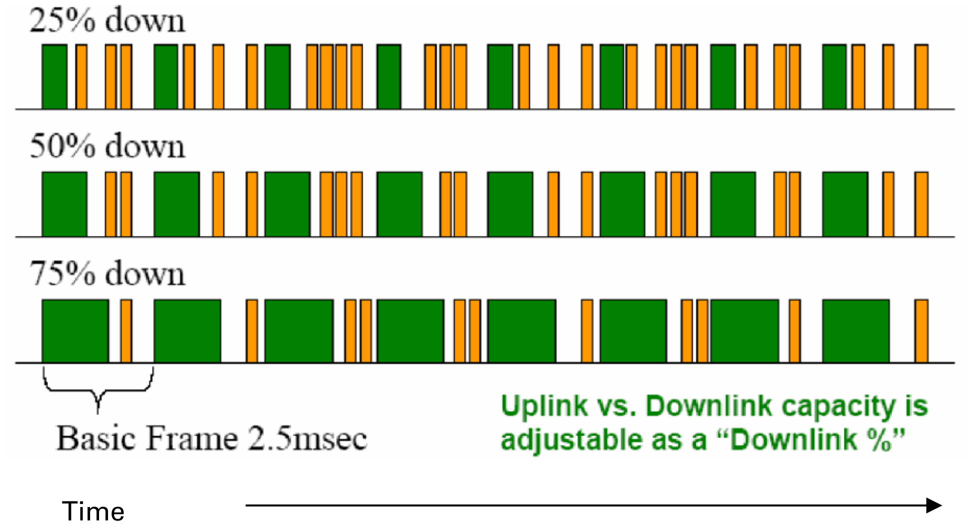
Time division duplexing

The system uses Time Division Duplexing (TDD) – one channel alternately transmits and receives rather than using one channel for transmitting and a second channel for receiving. To accomplish TDD, the AP/BHM must provide sync to its BHS. Furthermore, collocated APs/BHMs must be synced together – an unsynchronized AP/BHM that transmits during the receive cycle of a collocated AP/BHM can prevent a second AP/BHM from being able to decode the signals from its APs/BHSs. In addition, across a geographical area, APs/BHMs that can "hear" each other benefit from using a common sync to further reduce self-interference within the network.

Modules use TDD on a common frequency to divide frames for uplink (orange) and downlink (green) usage, as shown in the figure below.

For more information on synchronization configuration options, see GPS synchronization on page 2-23.

Figure 2 TDD frame division


25% down
50% down
75% down
Basic Frame 2.5msec
Uplink vs. Downlink capacity is adjustable as a "Downlink %"
Time

TDD frame parameters

The TDD burst duration varies depending on the following:

- OFDM and Channel bandwidth
- Cyclic Prefix
- Frame Period
- Frame configuration - Downlink Data
- Link operation – Dynamic Rate Adaptation

OFDM and channel bandwidth

The PMP/PTP 450i series transmits using Orthogonal Frequency Division Multiplexing (OFDM). This wideband signal consists of many equally spaced sub-carriers. Although each sub carrier is modulated at a low rate using conventional modulation schemes, the resultant data rate from the sub-carriers is high. OFDM works exceptionally over a Non-Line-of-Sight (NLoS) channel.

The channel bandwidth of the OFDM signal is configurable to one of the following values: 5, 10 and 20 MHz. Higher bandwidths provide greater link capacity at the expense of using more bandwidth. Systems configured for a narrower channel bandwidth provide better receiver sensitivity and can also be an appropriate choice in deployments where the amount of free spectrum is limited.

Note

The Channel Bandwidth must be configured to the same value at both ends of the link. Not all channel bandwidths are available in all regulatory bands.

Cyclic Prefix

OFDM technology uses a cyclic prefix, where a portion of the end of a symbol (slot) is repeated at the beginning of the symbol (slot) to allow multi-pathing to settle before receiving the desired data. A 1/16 cyclic prefix means that for every 16 bits of throughput data transmitted, an additional bit is used.

Frame Period

The time between the beginning of a frame and the end of that frame. The PMP/PTP 450i supports two frame period i.e. 2.5 ms and 5 ms.

The higher frame period configuration would provide higher throughput as it reduces frame overhead during transmission. At the same time, it will impact latency. With the 5ms frame, the latency will be double that of the 2.5 ms frame period.

Frame configuration - Downlink Data

The percentage of frame assigned to transport downlink data. The downlink data specifies the percentage of the aggregate throughput for the downlink (frames transmitted from the AP/BHM to the subscriber). The configurable range is 15 to 85 percentage.

Link operation – Dynamic Rate Adapt

PMP/PTP 450i Series products offer eight levels or speeds of operation – 2X MIMO-B and 1X MIMO-A (QPSK), 4X MIMO-B and 2X MIMO-A (16-QAM), 6x MIMO-B and 3X MIMO-A (64-QAM) and 8X MIMO-B and 4X MIMO-A (265-QAM). If received power is less due to distance between the AP/BHM and the SM/BHS or due to obstructions, or if interference affects the RF environment, the system automatically and dynamically adjusts the links to the best operation level.

The system chooses its modulation rate dynamically, based on an internal ARQ (Automatic Repeat reQuest) error control method. With ARQ, every data slot of every frame sent over the air (except downlink broadcast) is expected to be acknowledged by the receiver, and if acknowledgement is not received, the data is resent. The sending unit monitors these re-sends and adjusts the modulation rate accordingly. It is normal to have links that change levels of operation as the RF environment changes. Furthermore, the uplink or downlink portions of TDD duty cycle operate independently; normal operation can have a downlink running at 6x while the uplink RF environment only supports 2x.

The various modulation levels used by the PMP/PTP 450i are shown in Table 2.

Table 2 Modulation levels

Rate	MIMO-B	MIMO-A
QPSK	2X MIMO-B	1X MIMO-A
16-QAM	4X MIMO-B	2X MIMO-A
64-QAM	6X MIMO-B	3X MIMO-A
256-QAM	8X MIMO-B	4X MIMO-A

Note

MIMO-A achieves half the throughput of MIMO-B but adds a combining diversity (gain) which enhances the link budget or availability.

MIMO

Multiple-Input Multiple-Output (MIMO) techniques provide protection against fading and increase the probability that the receiver decodes a usable signal. When the effects of MIMO are combined with those of OFDM techniques and a high link budget, there is a high probability of a robust connection over a non-line-of-sight path.

The sub-features that comprises the MIMO techniques utilized in the PMP/PTP 450i product are:

- Matrix A: This technique enables the PMP/PTP 450i radio to use a scheme that optimizes coverage by transmitting the same data over both antennas. This redundancy improves the signal to noise ratio at the receiver making it more robust, at the cost of throughput.
- Matrix B: This technique provides for the ability to double the throughput of a radio transmission under proper RF conditions. Different data streams are transmitted simultaneously on two different antennas.

Encryption

The Cambium PMP/PTP 450i Series supports optional encryption for data transmitted over the wireless link. The PTP 450i Series supports the following forms of encryption for security of the wireless link:

- **DES (Data Encryption Standard)**: An over-the-air link encryption option that uses secret 56-bit keys and 8 parity bits. DES performs a series of bit permutations, substitutions, and recombination operations on blocks of data. DES encryption does not affect the performance or throughput of the system.
- **AES (Advanced Encryption Standard):** An over-the-air link encryption option that uses the Rijndael algorithm and 128-bit keys and 256-bit key size to establish a higher level of security than DES. AES products are certified as compliant with the Federal Information Processing Standards (FIPS 197) in the U.S.A.

System management

This section introduces the PMP/PTP 450i management system, including the web interface, installation, configuration, alerts and upgrades.

Management agent

PMP/PTP 450i equipment is managed through an embedded management agent.

Management workstations, network management systems or PCs can be connected to this agent using the module's Ethernet port or over-the air (SM/BHS)

The management agent supports the following interfaces:

- Hypertext transfer protocol (HTTP)
- Hypertext transfer protocol secure (HTTPS)
- RADIUS authentication
- Simple network management protocol (SNMP) – v2c and v3
- Network time protocol (NTP)
- System logging (Syslog)
- Wireless Manager (WM) software
- Canopy Network Updater Tool (CNUT) software

Web server

The PMP/PTP 450i management agent contains a web server. The web server supports access via the HTTP/HTTPs interface.

Web-based management offers a convenient way to manage the PMP/PTP 450i equipment from a locally connected computer or from a network management workstation connected through a management network, without requiring any special management software. The web and SNMP are the interfaces supported for installation of PMP/PTP 450i and for the majority of PMP/PTP 450i configuration management tasks.

Web pages

The web-based management interfaces provide comprehensive web-based fault, configuration, performance and security management functions organized into the following groups:

Access Point or Backhaul Master:

- Home
- Configuration
- Statistics
- Tools
- Logs
- Accounts
- Quick Start
- Copyright

Subscriber Module or Backhaul Slave

- Home
- Configuration
- Statistics
- Tools
- Logs
- Accounts
- PDA
- Copyright

Identity-based user accounts

- When identity-based user accounts are configured, a security officer can define from one to four user accounts, each of which may have one of the four possible roles:
- ADMINISTRATOR, who has full read and write permissions. This is the level of the root and admin users, as well as any other administrator accounts that one of them creates.
- INSTALLER, who has permissions identical to those of ADMINISTRATOR except that the installer cannot add or delete users or change the password of any other user.
- TECHNICIAN, who has permissions to modify basic radio parameters and view informational web pages
- GUEST, who has no write permissions and only a limited view of General Status tab
- Admin, Installer and Tech accounts can be configured as READ-ONLY. This will allow the account to only see the items.

See Managing module access by passwords for detailed information on account permissions.

Remote Authentication Dial-in User Service (RADIUS)

The PMP 450i system includes support for RADIUS (Remote Authentication Dial In User Service) protocol functionality including:

- Authentication: Allows only known SMs onto the network (blocking “rogue” SMs), and can be configured to ensure SMs are connecting to a known network (preventing SMs from connecting to “rogue” APs). RADIUS authentication is used for SMs, but not used for APs.
- SM Configuration: Configures authenticated SMs with MIR (Maximum Information Rate), High Priority, and VLAN (Virtual LAN) parameters from the RADIUS server when a SM registers to an AP.
- SM Accounting provides support for RADIUS accounting messages for usage-based billing. This accounting includes indications for subscriber session establishment, subscriber session disconnection, and bandwidth usage per session for each SM that connects to the AP.
- Centralized AP and SM user name and password management: Allows AP and SM usernames and access levels (Administrator, Installer, Technician and Read-Only) to be centrally administered in the RADIUS server instead of on each radio and tracks access events (logon/logoff) for each username on the RADIUS server. This accounting does not track and report specific configuration actions performed on radios or pull statistics such as bit counts from the radios. Such functions require an Element Management System (EMS) such as Cambium Wireless Manager. This accounting is not the ability to perform accounting functions on the subscriber/end user/customer account.
- Framed-IP-Address: Operators may use a RADIUS server to assign management IP addressing to SM modules.

SNMP

The management agent supports fault and performance management by means of an SNMP interface. The management agent is compatible with SNMP v2c and SNMP v3 using Management Information Base (MIB) files which are available for download from the Cambium Networks Support website:

https://support.cambiumnetworks.com/files/ptp450

https://support.cambiumnetworks.com/files/pmp450

Network Time Protocol (NTP)

The clock supplies accurate date and time information to the system. It can be set to run with or without a connection to a network time server (NTP). It can be configured to display local time by setting the time zone and daylight saving in the Time web page.

If an NTP server connection is available, the clock can be set to synchronize with the server time at regular intervals. PMP/PTP 450i devices may receive NTP data from a CMM4 module, an NTP server configured in the system's management network.

The Time Zone option is configurable on the AP's/BHM's Time Configuration page, and may be used to offset the received NTP time to match the operator's local time zone. When set on the AP/BHM, the offset is set for the entire sector (AP/BHSs is notified of the current Time Zone upon initial registration). If a Time Zone change is applied, the AP/BHSs are notified of the change in a best effort fashion, meaning some AP/BHSs may not pick up the change until the next re-registration. Time Zone changes are noted in the Event Log of the AP/BHM and SM/BHS.

An AP/BHM which is receiving NTP date and time information from an NTP server or from a GPS synchronization source may be used as an NTP server. Any client which has IP connectivity to the BHM may request NTP date and time information from the AP/BHM. No additional configuration (other than the AP/BHM receiving valid NTP data) is required to use the AP/BHM as an NTP server.

Wireless Manager (WM)

Cambium Networks Wireless Manager 4.0 is recommended for managing PMP/PTP 450i networks. You can achieve better uptime through better visibility of your network with the Cambium Wireless Manager. This network management software tool offers breakthrough map-based visualization capabilities using embedded Google maps, and combined with advanced configuration, provisioning, alerting and reporting features you can control your entire outdoor wireless network including Point-to-Multipoint and Point-to-Point solutions as well as other SNMP enabled devices. With its powerful user interface you can not only be able to control your network's access, distribution and backhaul layers, but can also have visibility to WLAN sites and be able to quickly launch indoor network management systems. Some key features of Wireless Manager are:

- **Template-Based Configuration**: With Wireless Manager's user-defined templates you can accelerate the process for the configuration of the devices you add to your network resulting in quicker and easier deployments. The template-based functionality provides an automated way to configure large numbers of network devices with just a few mouse clicks, and can be scheduled to occur at any time via Wireless Manager's Task Scheduler.
- **Ultralight Thin Client**: With the growing mobile workforce it is important to have access to the status of your network at any time. With Wireless Manager you can view the status and performance of your entire wireless network via a compact web interface accessible by your smart phone.
- **Map-Based Visualization**: Wireless Manager overlays sophisticated real-time information about your network elements onto building layouts and dynamic Google maps. Visuals can be scaled to view an entire city or building or a specific area, floor or link.
- **High Availability Architecture Support**: Wireless Manager offers a high availability option, providing a highly reliable and redundant network management solution that ensures you always have management access to your network.

- **High Scalability**: The enhanced Wireless Manager offers you server scalability with support for up to 10,000 nodes as well as support for distributed server architecture.

Cambium's Wireless Manager 4.0 available for download at:
http://www.cambiumnetworks.com/support/management-tools/wireless-manager/

Canopy Network Updater Tool (CNUT)

CNUT (Canopy Network Updater Tool) is the stand-alone software update tool for PMP/PTP 450i Series products. The CNUT 4.9.12 or greater should be used for 450i radios.

The Canopy Network Updater Tool has the following features:

- Automatically discovers all network elements
- HTTP and HTTPs
- Executes UDP command that initiates and terminates the Auto-update mode within APs/BHMs. This command is both secure and convenient:
  - For security, the AP/BHM accepts this command from only the IP address that specified in the Configuration page of ODU.
  - For convenience, Network Updater automatically sets this Configuration parameter in the AP/BHM to the IP address of the Network Updater server when the server performs any of the update commands.
- Allows you to choose among updating:
  - Entire network.
  - Only elements that you select.
  - Only network branches that you select.
- Provides a Script Engine that you can use with any script which:
  - The user can define.
  - Cambium supplies.

CNUT is available at:

http://www.cambiumnetworks.com/support/management-tools/cnut/

Radio recovery mode – Radio Recovery Console / Default Mode (fka Default Plug)

The PMP/PTP 450i recovery mode provides a means to recover from serious configuration errors including lost or forgotten passwords and unknown IP addresses.

Recovery mode also allows new main application software to be loaded even when the integrity of the existing main application software image has been compromised. The most likely cause of an integrity problem with the installed main application software is where the power supply has been interrupted during a software upgrade.

The recovery mode supports a single IPv4 interface, with IP address 169.254.1.1, and with default link settings.

Note

When Recovery has been entered through a power on/off/on cycle, the ODU will revert to normal operation if no web access has been made to the unit within 30 seconds. This prevents the unit remaining inadvertently in recovery following a power outage.

Recovery mode options

Options in recovery mode (IPv4 only) are as follows:

- Load a prevoius SW image
- Boot with default Canopy system software settings (similar to the hardware default plug on previous Canopy-based PMP platforms)

The last most recent software image loaded to the board is retained. The factory image is not retained.

Boot with default Canopy system software settings (similar to the hardware default plug on previous Canopy-based PMP platforms).

See Radio Recovery Console on page 9-58.

Chapter 2: System hardware

This chapter describes the hardware components of a PMP/PTP 450i link.

The following topics are described in this chapter:

- System Components on page 2-2 describes system components of PTP and PMP including its accessories.
- Cabling and lightning protection on page 2-16 describes various cable and lightning protection.
- Antennas and antenna cabling on page 2-21 describes supported antennas and its accessories.
- GPS synchronization on page 2-23 describes UGPS and CMM4.

System Components

Point-to-Multipoint (PMP)

The PMP radio is a transceiver device. It is a connectorized or radiated outdoor unit containing all the radio, networking, and surge suppression electronics. It can be purchased as:

- Access Point Module (AP)
- Subscriber Module (SM)

PMP 450i Integrated or Connectorized ODU

The PMP 450i is supplied in following configurations:

Access Point (AP):

- ODU with an integrated 16 dBi Sector antenna for 4.9 to 5.925 GHz
- Connectorized ODU to be used with a separately mounted external antenna.

Subscriber Module (SM):

- SM Integrated ODU with an integrated 23 dBi flat panel antenna for 4.9 to 5.925 GHz
- SM Connectorized ODU to be used with a separately mounted external antenna.

Product variants

Table 3 PMP 450i variants

Variant	Region	Antenna	Frequency Range	Channel Bandwidth	Max Tx Power	Notes
5 GHz PMP 450i AP	FCC	Connectorized	4900 – 5925 MHz	5, 10, 20 MHz	27 dBm	Transmit power limited based on regional setting
		Integrated 16 dBi 90 degree				
	RoW	Connectorized				
		Integrated 23 dBi				
	Canada	Connectorized				
		Integrated 23 dBi				
	RoW DES	Connectorized				
		Integrated 23 dBi				
5 GHz PMP 450i SM	FCC	Connectorized	4900 – 5925 MHz	5, 10, 20 MHz	27 dBm	Transmit power limited based on regional setting
		Integrated 23 dBi				
	RoW	Connectorized				
		Integrated 23 dBi				
	Canada	Connectorized				
		Integrated 23 dBi				
	RoW DES	Connectorized				
		Integrated 23 dBi				

Note

Not all variants may be available at the same time in some or all regions. Please contact your sales representative for details on availability.

Backhaul (PTP)

The Backhaul radio is a transceiver device. It is a connectorized or integrated outdoor unit containing all the radio, networking, and surge suppression electronics. It can be configured as:

- Backhaul Master (BHM)
- Backhaul Slave (BHS)

PTP 450i Integrated or Connectorized ODU

The PTP 450i Backhaul (BH) is supplied in the following configurations:

- PTP 450i Integrated ODU which has a 23 dBi flat panel antenna for 4.9 to 5.925 GHz
- PTP 450i Connectorized ODU requires a separately mounted external antenna. External antennas generally have higher gains than the integrated antennas, allowing the PTP 450i to cope with more difficult radio conditions.

Product variants

Table 4 PTP 450i variants

Variant	Region	Antenna	Frequency Range	Channel Bandwidth	Max Tx Power	Notes
5 GHz PTP 450i	FCC	Connectorized	4900 – 5925 MHz	5, 10, 20 MHz	27 dBm	Transmit power limited based on regional setting
		Integrated 23 dBi				
	RoW	Connectorized				
		Integrated 23 dBi				
	Canada	Connectorized				
		Integrated 23 dBi				
	RoW DES	Connectorized				
		Integrated 23 dBi				

Note

Not all variants may be available at the same time in some or all regions. Please contact your sales representative for details on availability.

AP/SM/BHM/BHS interfaces

The AP/SM/BHM/BHS interfaces are illustrated below.

Figure 5 AP/SM/BHM/BHS interfaces

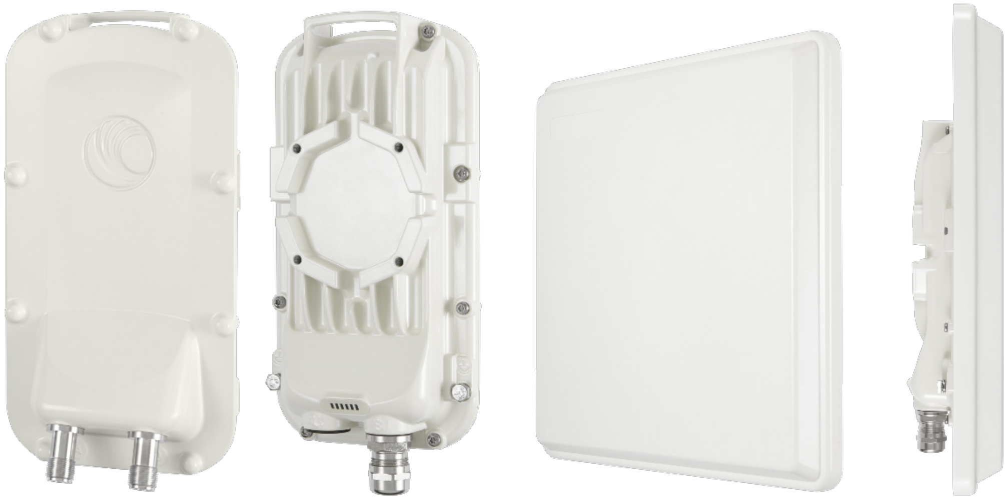


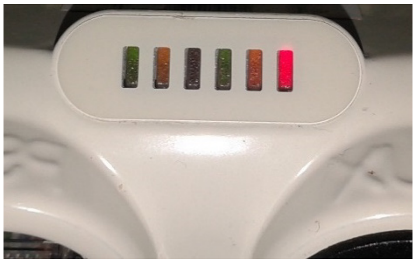
Table 5 AP/SM/BHM/BHS interface descriptions and cabling – 5 GHz

Interface	Function	Cabling
PSU/Ethernet	Power-over-Ethernet, Ethernet communications (management and data)	RJ45 Cable See Table 46 on page 5-11
Aux/Sync	Sync Audio tones	RJ 45 Cable See Table 47 on page 5-11
RF Port A	Vertical RF connection to antenna	50 ohm RF cable, N-type
RF Port B	Horizontal RF connection to antenna	50 ohm RF cable, N-type
Ground Lugs	For grounding the unit	10 AWG copper wire

Diagnostic LEDs

The diagnostic LEDs of PMP 450i are as shown in Figure 3.

Figure 3 Radio diagnostic LEDs, viewed from unit front

ODU LED Display	LED Labels					
	🟩	🟨	🟥	🟩	🟨	🟥
	LNK/5	ACT/4	GPS/3	SES/2	SYN/1	PWR

Note

The LED color helps distinguish the position of LED. The LED color does not indicate any status.

AP/BHM LEDs

The diagnostic LEDs report the information about the status of the BHM/AP.

Table 6 AP/BHM LED descriptions

LED	Color when active	Status information provided	Notes
PWR	Red	DC power	Always lit after 10-20 seconds of power on. **Note** The LED color helps you distinguish position of the LED. The LED color does not indicate any status.
SYN/1	Yellow	Presence of sync	
SES/2	Green	Unused	
GPS/3	Red	Pulse of sync	Lit when the AP/BHM is getting a sync pulse from a GPS source goes along with SYN/1
ACT/4	Yellow	Presence of data activity on the Ethernet link	Flashes during data transfer. Frequency of flash is not a diagnostic indication.
LNK/5	Red/ Green/ Orange (bi-colored for 10/100/1000)	Ethernet link	Continuously lit when link is present. 10Base-T : Red 100Base-T : Green 1000Base-T : Orange

SM/BHS LEDs

The SM/BHS LEDs provide different status of radio based on the operating modes. A SM/BHS in "operating" mode registers and passes traffic normally. A SM/BHS in "aiming" mode does not register or pass the traffic, but displays (via LED panel) the strength of received radio signals (based on radio channel selected via **Tools > Alignment**).

Table 7 SM/BHS LED descriptions

		Status information provided		
LED	**Color when active**	**SM / BHS in “Operating” Mode**	**SM / BHS in “Aiming” Mode**	**Notes**
PWR	Red	DC power		Always lit after 10-20 seconds of power on.
SYN/1	Yellow	Presence of sync	These five LEDs act as a bar graph to indicate the relative quality of alignment. As power level improves during alignment, more of these LEDs are lit.	Lit when SM/BHS is in sync with an AP/BHM.
SES/2	Green	Session Indicator		Lit when SM/BHS is in session.
GPS/3	Red	Unused		On - high interference. Blinking - medium interference. Off - low interference.
ACT/4	Yellow	Presence of data activity on the Ethernet link		Flashes during data transfer. Frequency of flash is not a diagnostic indication.
LNK/5	Red/ Green/ Orange (bi-colored for 10/100/1000)	Ethernet link		Continuously lit when link is present. 10Base-T : Red 100Base-T : Green 1000Base-T : Orange

Operating Mode

- Scanning: If the SM/BHS is not registered to AP/BHM, then these three LEDs cycle on and off from left to right (SYN/1, SES/2 and GPS/3).
- Ethernet Link: The LNK/5 LED lit continuously when link is present.
- Data Transfer: The ACT/4 LED lit on the presence of data activity on the Ethernet link.

Aiming Mode

The 5 LEDs (SYN/1, SES/2, GPS/3, ACT/4 and LNK/5) are turned into a 5-position bar graph. The more LEDs that are lit, the better the RSSI and Jitter values the module is seeing. The colors of the LEDS have no particular meaning other than to assist is distinguishing one position from the next.

Power Supply

The PSU is an indoor Power over Ethernet (POE) power injector. It is connected to the ODU and network terminating equipment using Cat5e cable with RJ45 connectors.

- Cambium Networks 60 W AC power injector
- Cambium Networks -48 V DC telecom power injector
- CMM4 with external 56 V power supply

PSU part numbers

Table 8 PSU part numbers

Cambium description	Cambium part number
Power supply, -48 V DC power injector	N000000L036A
AC+DC Enhanced Power Injector	C000065L002A
Power Suppy, 60 W, 56 V with Gbps support	N000065L001B

-48 V DC Power Injector

The DC Power Injector interfaces are shown in Figure 4 and described in Table 9.

Figure 4 -48 V DC Power Injector interfaces

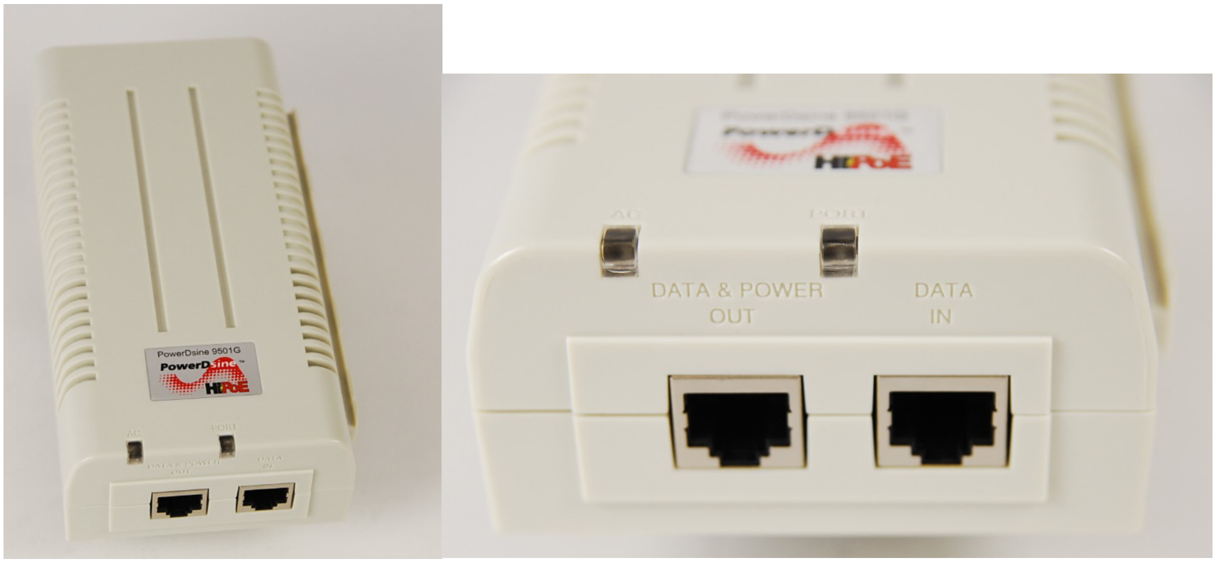


Table 9 -48V DC Power Injector interfaces

Interface	Function

DC input	36 to 60V, 2A
RJ 45 Sockets	Two (Data In and Data & Power Out)
LEDs	Two (AC and Port)

AC Power Injector

The AC Power Injector interfaces are shown in Figure 5 and described in Table 10.

Figure 5 AC Power Injector interfaces

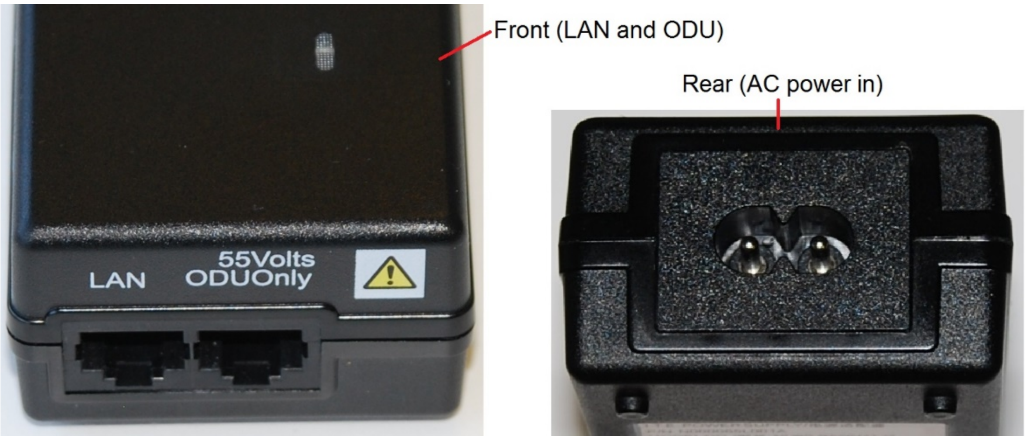


Table 10 AC Power Injector interface functions

Interface	Function
AC power in	AC power input (main supply)
ODU	RJ45 socket for connecting Cat5e cable to ODU
LAN	RJ45 socket for connecting Cat5e cable to network
Power (green) LED	Power supply detection

AC+DC Enhanced Power Injector

The AC+DC Enhanced Power Injector interfaces are shown in Figure 6 and described in Table 11.

Figure 6 AC+DC Enhanced Power Injector interfaces

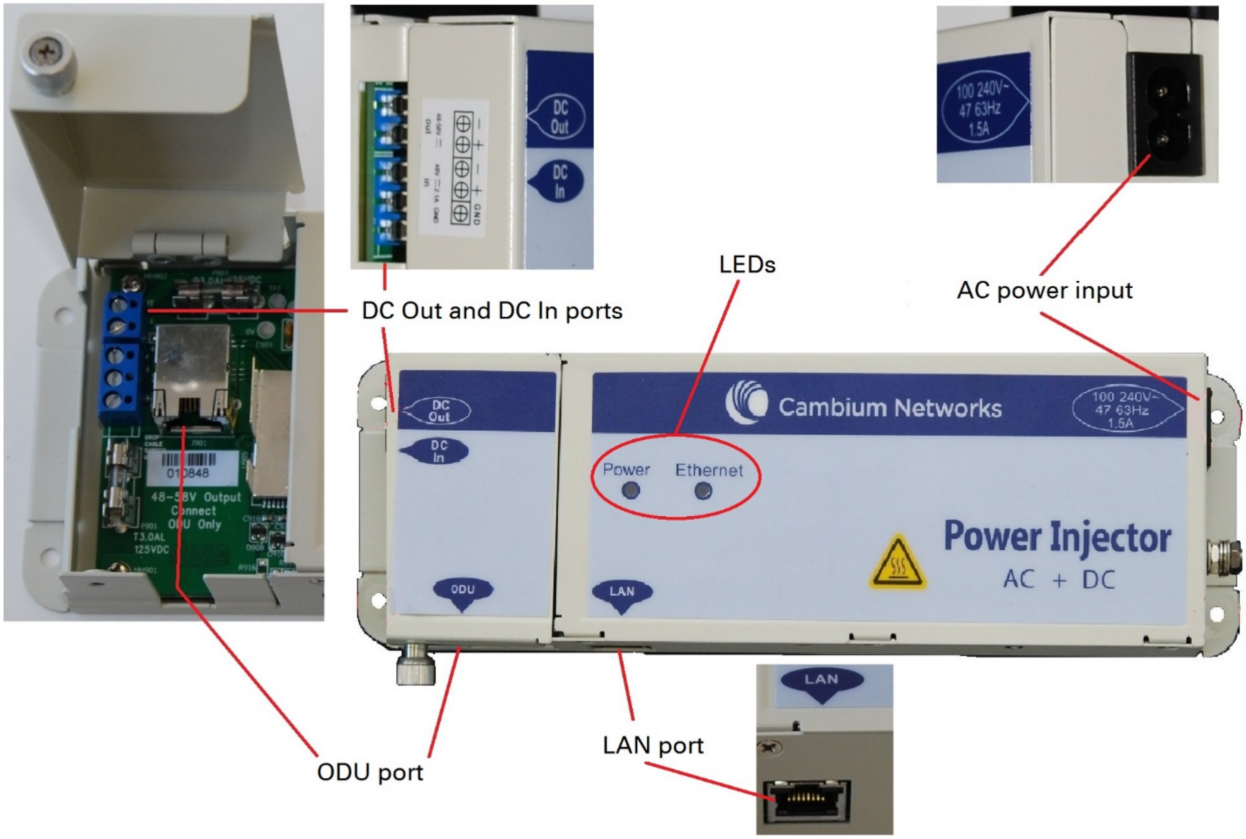


Table 11 AC+DC Enhanced Power Injector interface functions

Interface	Function
100-240V 47-63Hz 1.5A	AC power input (main supply)
DC In	Alternative DC power supply input
DC Out	DC power output to a second PSU (for power supply redundancy) or to a NIDU
ODU	RJ45 socket for connecting Cat5e cable to ODU
LAN	RJ45 socket for connecting Cat5e cable to network
Power (green) LED	Power supply detection
Ethernet (yellow) LED	Ethernet traffic detection

ODU part numbers

Order PMP/PTP 450i Integrated or Connectorized ODUs from Cambium Networks (Table 13). Each of the parts listed in Table 13 includes the following items:

- 23 dBi integrated ODU
- 16 dBi integrated ODU
- Connectorized ODU

Integrated ODUs, when sold individually, are supplied without mounting brackets.

PMP 450i

Table 12 PMP 450i ODU part numbers

Cambium description	Cambium part number
AP (Access Point)	
5 GHz PMP 450i Connectorized Access Point (RoW)	C050045A001A
5 GHz PMP 450i Connectorized Access Point (FCC)	C050045A002A
5 GHz PMP 450i Connectorized Access Point (EU)	C050045A003A
5 GHz PMP 450i Connectorized Access Point (DES Only)	C050045A004A
5 GHz PMP 450i Connectorized Access Point (IC)	C050045A015A
5 GHz PMP 450i AP, Integrated 90°sector antenna (RoW)	C050045A005A
5 GHz PMP 450i AP, Integrated 90°sector antenna (FCC)	C050045A006A
5 GHz PMP 450i Integrated Access Point, 90 degree (EU)	C050045A007A
5 GHz PMP 450i AP, Integrated 90°sector antenna (DES only)	C050045A008A
5 GHz PMP 450i AP, Integrated 90°sector antenna (IC)	C050045A016A
SM (Subscriber Module)	
5 GHz PMP 450i Connectorized Subscriber Module	C050045C001A
5 GHz PMP 450i SM, Integrated High Gain Antenna	C050045C002A

PTP 450i

Table 13 PTP 450i ODU part numbers

Cambium description	Cambium part number
5 GHz PTP 450i END, Connectorized (RoW)	C050045B001A
5 GHz PTP 450i END, Integrated High Gain Antenna (RoW)	C050045B002A
5 GHz PTP 450i END, Connectorized (FCC)	C050045B003A
5 GHz PTP 450i END, Connectorized (EU)	C050045B005A
5 GHz PTP 450i END, Connectorized (DES only)	C050045B007A
5 GHz PTP 450i END, Connectorized (IC)	C050045B015A
5 GHz PTP 450i END, Integrated High Gain Antenna (FCC)	C050045B004A
5 GHz PTP 450i END, Integrated High Gain Antenna (EU)	C050045B006A
5 GHz PTP 450i END, Integrated High Gain Antenna (DES only)	C050045B008A
5 GHz PTP 450i END, Integrated High Gain Antenna (IC)	C050045B016A
Ethernet cable adapter for CMM4	N000045L001A

ODU mounting brackets & Accessories

The list of supported brackets is provided in Table 14.

- The "Title bracket assembly" is the recommended bracket for the AP, SM or BH integrated units.
- The "Mounting Bracket (Connectorized)" can be used where a low profile and ease of assembly of Connectorized AP, SM or BH is required.
- The "Mounting Bracket (Integrated)" provide a wider range of adjustment for AP, SM and BH integrated devices.

Table 14 Accessories part numbers

Cambium description	Cambium part number
Mounting brackets	
Tilt Bracket Assembly	N000045L002A
Mounting Bracket (Integrated)	N000065L031A
Mounting Bracket (Connectorized)	N000065L032A
Miscellaneous	
Ethernet cable adapter for CMM4	N000045L001A

Lightning protection

The PMP/PTP 450i Series supports the lightning protection units listed in Table 15.

The LPU offers the higest level of protection and is the recommended device. Where low cost deployement are essential, for example for SM in residential application, the Gigabit Surge Suppressor may be used instead.

Table 15 Lighning protection part numbers

Cambium description	Cambium part number
LPU and Grounding Kit (1 kit per ODU)	C000065L007A
Gigabit Surge Suppressor (56V)	C000000L033A

ODU interfaces

The Ethernet and Sync/AUX ports are on the rear of the integrated and connectorized ODUs (Figure 7). These interfaces are described in Table 16.

Figure 7 ODU rear interfaces

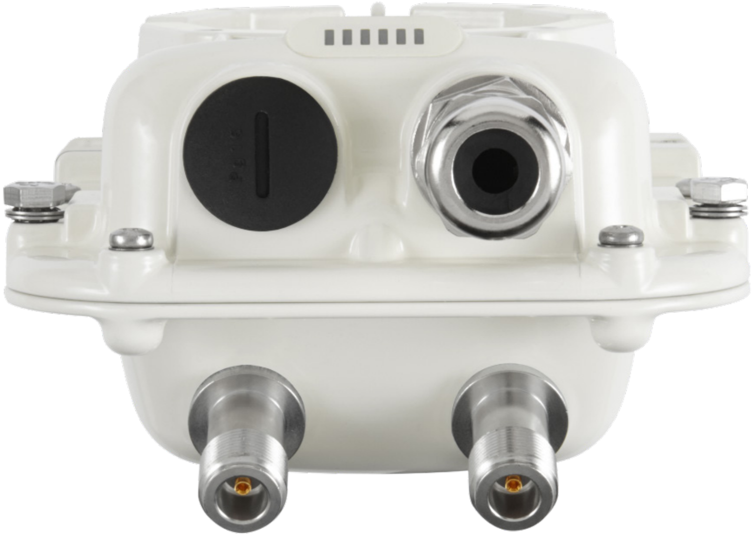


Table 16 ODU rear interfaces

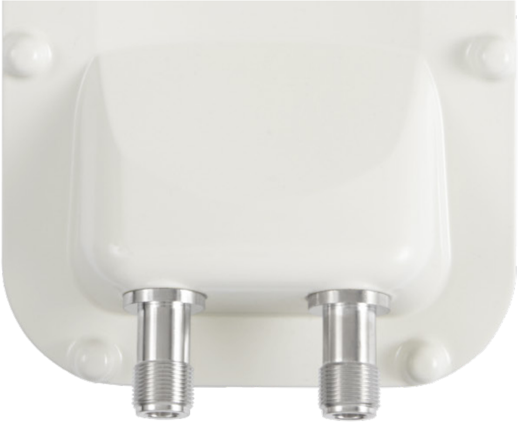
Port name	Connector	Interface	Description
Main PSU	RJ45	PoE input	Proprietary power over Ethernet (POE).
		10/100/1000BASE-T Ethernet	Data
Sync/AUX	RJ45	10/100/100BASE-T Ethernet (see Note below)	Data
		PoE output (see Note below)	Standard IEEE802.3at PoE.
		Sync input/output	Connection and powering of UGPS Sync input

Note

The Ethernet functionality and associated PoE output capability are not supported in this firmware release.

The front of the connectorized ODU (Figure 7) provides N type female connectors for RF cable interfaces to antennas with horizontal (H) and vertical (V) polarization.

Figure 8 Connectorized ODU antenna interfaces



Cabling and lightning protection

Ethernet standards and cable lengths

All configurations require a copper Ethernet connection from the ODU (Ethernet port) to the PoE.

Table 17 specifies, for each type of PSU and configuration, the maximum permitted PSU drop cable length.

Table 17 PSU drop cable length restrictions

System configuration		Maximum cable length (m/ft)	
Power supply	**PoE powered device on AUX/SYNC port (see Note below)**	**From power supply to ODU**	**From ODU to PoE device on AUX/SYNC port (see Note below)**
AC Power Injector (60W)	None	100 m	N/A
	IEEE 802.3at Type 2	100 m in total	
AC+DC enhanced Power Injector (90W)	None	100 m	N/A
	IEEE 802.3at Type 2	100 m in total	
-48 V DC power injector	None	100 m	N/A
	IEEE 802.3at Type 2	100 m in total	
CMM 4 with 56 V supply	None	100 m	N/A
	IEEE 802.3at Type 2	Not supported	
IEEE802.3at compliant supply	None	100 m	N/A
	IEEE 802.3at Type 2	Not supported	

Note

The Ethernet functionality and associated PoE output capability are not supported in this firmware release.

The Ethernet connectivity for CMM4 requires the part “Ethernet cable adapter for CMM4 – N000045L001A”.

Outdoor copper Cat5e Ethernet cable

Outdoor Cat5e cable is used for all connections that terminate outside the building. For example, connections between the ODU, surge suppressors (if installed), uGPS receivers (if installed) and the power supply injector. This is known as a "drop cable" (Figure 9).

The following practices are essential to the reliability and longevity of cabled connections:

- Use only shielded cables and connectors to resist interference and corrosion.
- For vertical runs, provide cable support and strain relief.
- Include a 2 ft (0.6 m) service loop on each end of the cable to allow for thermal expansion and contraction and to facilitate terminating the cable again when needed.
- Include a drip loop to shed water so that most of the water does not reach the connector at the device.
- Properly crimp all connectors.
- Use dielectric grease on all connectors to resist corrosion.

Order Superior Essex type BBDGe cable from Cambium Networks (Table 18). Other lengths of this cable are available from Superior Essex.

Figure 9 Outdoor drop cable

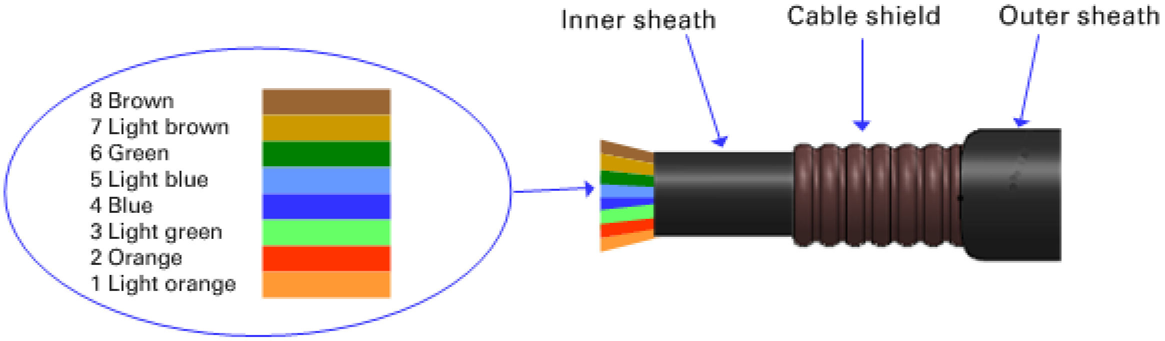


Table 18 Drop cable part numbers

Cambium description	Cambium part number
1000 ft Reel Outdoor Copper Clad CAT5E	WB3175
328 ft (100 m) Reel Outdoor Copper Clad CAT5E	WB3176

PoE cable for Main port

The PoE cable pinout diagram for Main port is given below.

Table 19 Main port PoE cable pinout

RJ45 pin	Interface	Ethernet description	PoE input description
1	1000 BaseT Ethernet with PoE In	+TxRx0	+Ve or -Ve
2		–TxRx0	
3		+TxRx1	+Ve or –Ve
6		–TxRx1	
5		–TxRx2	+Ve or –Ve
4		+TxRx2	
7		+TxRx3	+Ve or –Ve
8		–TxRx3	

Note

The PoE input on the Main port accepts any polarity as long as there is at least one pair at +Ve and at least one at –Ve.

Table 20 Aux port PoE cable pinout

RJ45 pin	Interface	Ethernet description	PoE output description
1	1000 BaseT Ethernet with PoE Out	+TxRx0	-Ve
2		–TxRx0	
3		+TxRx1	+Ve
6		–TxRx1	
5	GPS	GPS power out,Alignment tone out,GPS data out	N/A
4		GPS data in	
7		GPS 0v	
8		GPS Sync in	

Cable grounding kit

Copper drop cable shields must be bonded to the grounding system in order to prevent lightning-strike arcing (resulting in fire risk and damage to equipment).

One grounding kit (Figure 10) is required for each grounding point on the PSU. Order cable grounding kits from Cambium Networks (Table 21).

⚠ **Caution**

To provide adequate protection, all grounding cables must be a minimum size of 10 mm^2 csa (8AWG), preferably 16 mm^2 csa (6AWG), or 25 mm^2 csa (4AWG).

Figure 10 Cable grounding kit

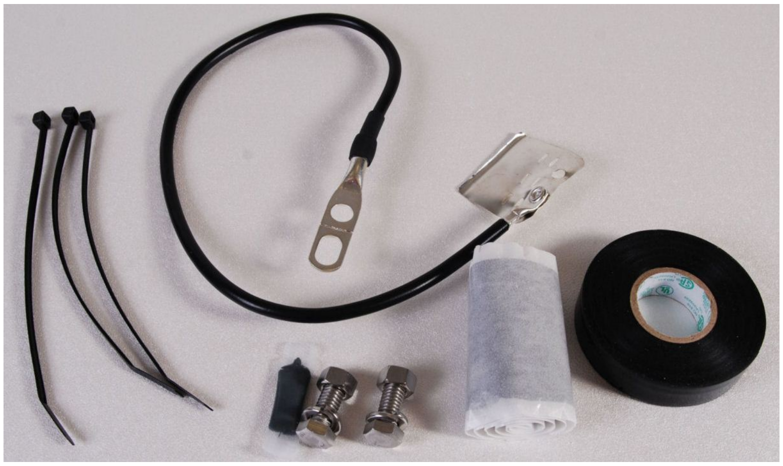


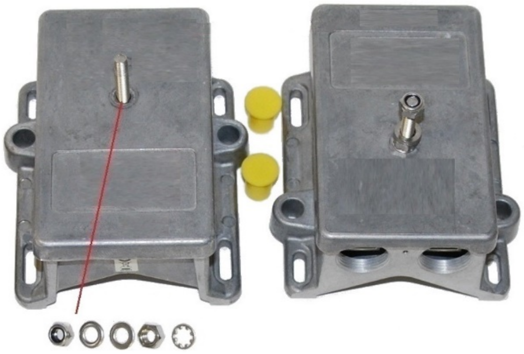
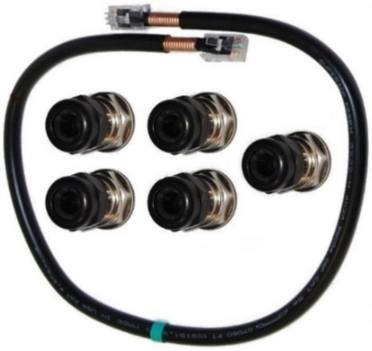
Table 21 Cable grounding kit part numbers

Cambium description	Cambium part number
Cable Grounding Kits For 1/4" And 3/8" Cable	01010419001

Lightning protection unit (LPU) and grounding kit

PMP/PTP 450i LPUs provide transient voltage surge suppression for ODU installations. Each PSU requires two LPUs, one near the ODU and the other near the linked device, usually at the building entry point (Table 22).

Table 22 LPU and grounding kit contents

Lightning protection units (LPUs) LPU grounding point nuts and washers 	ODU to top LPU drop cable (600 mm) EMC strain relief cable glands 
U-bolts, nuts and washers for mounting LPUs 	ODU to top LPU ground cable (M6-M6)
Bottom LPU ground cable (M6-M10) 	ODU to ground cable (M6-M10

One LPU and grounding kit (Table 22) is required for the PSU drop cable connection to the ODU. If the ODU is to be connected to an auxiliary device, one additional LPU and grounding kit is required for the Aux drop cable. Order the kits from Cambium Networks (Table 23).

Table 23 LPU and grounding kit part number

Cambium description	Cambium part number
PMP/PTP 450i LPU and Grounding Kit (One Kit Per End)	C000065L007

Antennas and antenna cabling

Antenna requirements

Each connectorized ODU requires one external antenna (normally dual-polar).

For connectorized units operating in the USA or Canada, choose external antennas which are recommended by Cambium Networks. Do not install any other antennas.

Supported AP external antennas

The recommend AP external antennas are listed in Table 24.

Table 24 List of AP external antennas

Cambium description	Cambium part number
5 GHz Horizontal and Vertical Polarization Antenna for 90 Degree Sector	85009324001
5 GHz Horizontal and Vertical Polarization Antenna for 60 Degree Sector	85009325001

Note

LINKPlanner, Cambium Networks planning tool, contains an up-to-date, exhaustive list of antennas that can be used with Cambium Products.

RF cable and connectors

RF cable of generic type LMR-400 is required for connecting the ODU to the antenna. N type male connectors are required for connecting the RF cables to the connectorized ODU. Two connectors are required per ODU. Use weatherproof connectors, preferably ones that are supplied with adhesive lined heat shrink sleeves that are fitted over the interface between the cable and connector. Order CNT-400 RF cable and N type male connectors from Cambium Networks (Table 25).

Table 25 RF cable and connector part numbers

Cambium description	Cambium part number
50 Ohm Braided Coaxial Cable - 75 meter	30010194001
50 Ohm Braided Coaxial Cable - 500 meter	30010195001
RF Connector, N, Male, Straight for CNT-400 Cable	09010091001

Antenna accessories

Connectorized ODUs require the following additional components:

- Cable grounding kits: Order one cable grounding kit for each grounding point on the antenna cables. Refer to Lightning protection unit (LPU) and grounding kit on 2-19
- Self-amalgamating and PVC tape: Order these items to weatherproof the RF connectors
- Lightning arrestors: When the connectorized ODU is mounted indoors, lightning arrestors (not LPUs) are required for protecting the antenna RF cables at building entry. One arrestor is required per antenna cable. One example of a compatible lightning arrestor is the Polyphaser LSXL-ME or LSXL (not supplied by Cambium Networks).

RJ45 connectors and spare glands

RJ45 connectors are required for plugging Cat5e cables into ODUs, LPUs, PoEs and other devices. Order RJ45 connectors and crimp tool from Cambium Networks (Table 26).

The ODU is supplied with one environmental sealing gland for the drop cable.

Figure 11 Cable gland

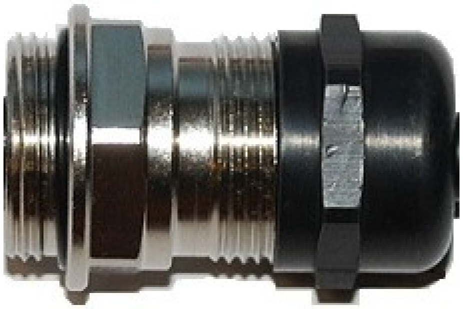


Table 26 RJ45 connector and spare gland part numbers

Cambium description	Cambium part number
Tyco/AMP, Mod Plug RJ45, 100 pack	WB3177
Tyco/AMP Crimp Tool	WB3211
RJ-45 Spare Grounding Gland - PG16 size (Qty. 10)	N000065L033

GPS synchronization

GPS synchronization description

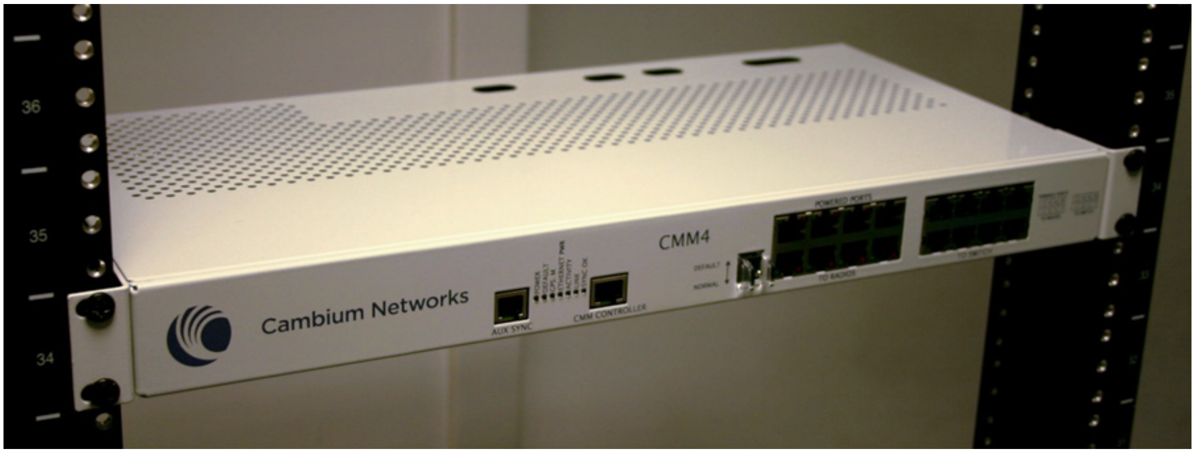
Cambium's PMP and PTP portfolio offers GPS synchronization to limit the network's own self-interference. The "Cluster Management CMM" provides Global Positioning System (GPS) synchronization to the AP/BHM and all associated SMs/BHS.

CMM4 (Rack Mount)

The Cluster Management Module (CMM) is the heart of the Cambium system's synchronization capability, which allows network operators to reuse frequencies and add capacity while ensuring consistency in the quality of service to customers.

For operators who prefer indoor CMM mounting, Cambium offers the Rack-Mounted Cluster Management Module 4. The unit is designed to be mounted onto a standard 19-inch telecommunications rack and to allow the Cambium CMM4 to be co-located with other telecommunications equipment.

Figure 12 CMM4 (Rack Mount)



The CMM4 has two DC power inputs, one 29 V and one 56V. It can be used to power and synchronized both 29V legacy products such as PMP 450 and 56V products such as PMP 450i simultaneously.

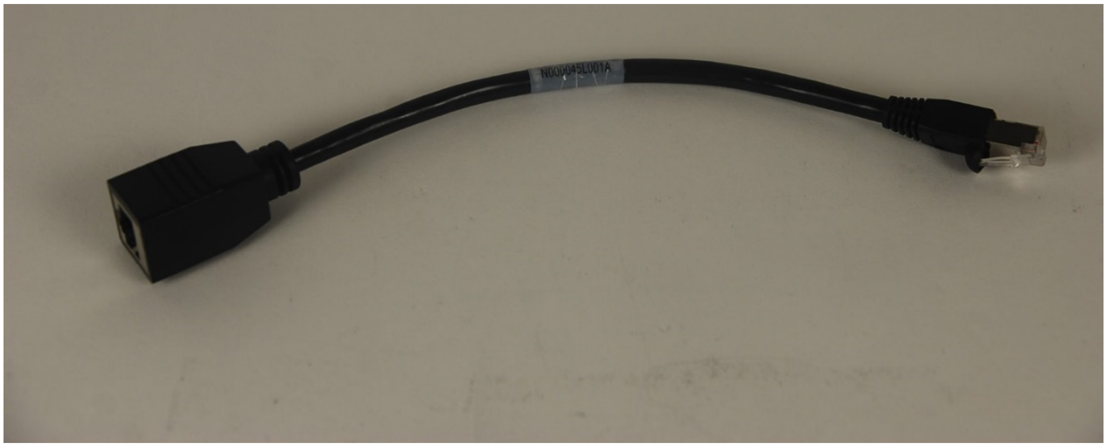
If the 29V legacy products are connected to the CMM4, a 29V power supply needs to be connected.

If PMP/PTP 450i are connected to a CMM4, it needs to be connected with an external 56V PSU".

Warning

PMP 450 and PMP 450i require different wiring of the drop cable between the CMM4 and device. If a PMP450 is replaced by a PMP450i and the existing drop cable needs to be re-used, the adapter "CMM4 56V power adapter, #N000045L001A" must be used between the CMM4 and the existing drop cable

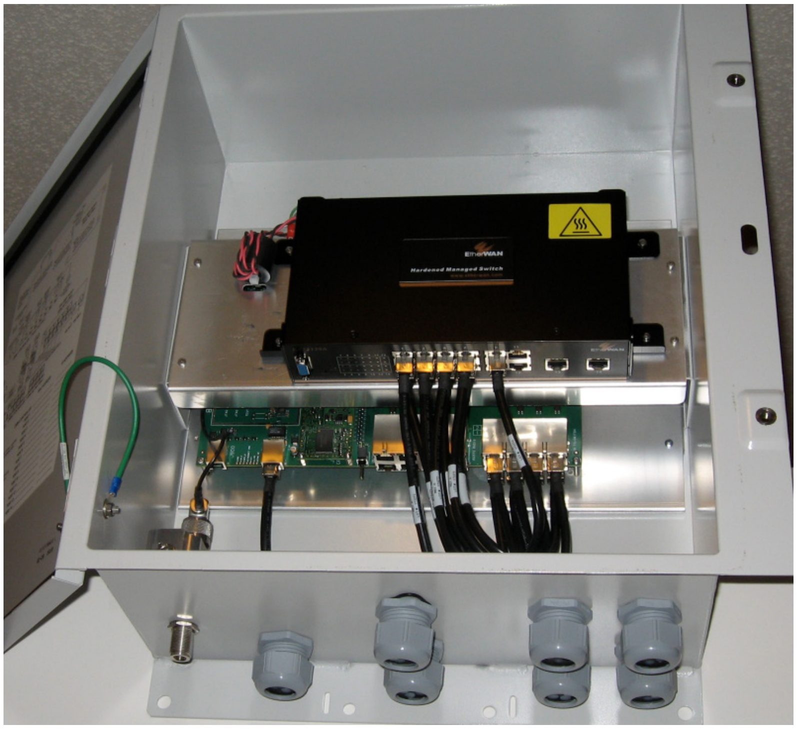
Figure 13 CMM4 56V power adapter



CMM4 (Cabinet with switch)

Designed to deliver consistent and reliable wireless broadband service, the PMP/PTP system gracefully scales to support large deployments. The cluster management module is the heart of the system's synchronization capability which allows network operators to re-use frequencies and add capacity while ensuring consistency in the quality of service to customers. As a result, subscribers can experience carrier-grade service even at the outer edge of the network.

Figure 14 CMM4 (Cabinet with switch)



CMM4 (Cabinet without switch)

This CMM includes all of the functionality listed above but there is no switch. This provides the network operator the flexibility to use the switch of their choice with the power and synchronization capabilities of the CMM4.

Ordering the components

This section describes how to select components for PMP/PTP 450i Greenfield network or PMP/PTP 450i network migration. It specifies Cambium part numbers for PMP/PTP 450i components.

PMP/PTP 450i component part numbers

Table 27 PMP/PTP 450i components

Cambium description	Cambium part number
5 GHz PMP 450i Connectorized Access Point (ROW)	C050045A001A
5 GHz PMP 450i Connectorized Access Point (FCC)	C050045A002A
5 GHz PMP 450i Connectorized Access Point (EU)	C050045A003A
5 GHz PMP 450i Connectorized Access Point (DES Only)	C050045A004A
5 GHz PMP 450i Connectorized Access Point (IC)	C050045A015A
5 GHz PMP 450i Integrated Access Point, 90 degree (ROW)	C050045A005A
5 GHz PMP 450i Integrated Access Point, 90 degree (FCC)	C050045A006A
5 GHz PMP 450i Integrated Access Point, 90 degree (EU)	C050045A007A
5 GHz PMP 450i Integrated Access Point, 90 degree (DES Only)	C050045A008A
5 GHz PMP 450i Integrated Access Point, 90°sector antenna (IC)	C050045A016A
5 GHz PMP 450i Connectorized Subscriber Module	C050045C001A
5 GHz PMP 450i SM, Integrated High Gain Antenna	C050045C002A
5 GHz PTP 450i END, Connectorized (ROW)	C050045B001A
5 GHz PTP 450i END, Integrated High Gain Antenna (ROW)	C050045B002A
5 GHz PTP 450i END, Connectorized (FCC)	C050045B003A
5 GHz PTP 450i END, Integrated High Gain Antenna (FCC)	C050045B004A
5 GHz PTP 450i END, Connectorized (EU)	C050045B005A
5 GHz PTP 450i END, Integrated High Gain Antenna (EU)	C050045B006A
5 GHz PTP 450i END, Connectorized (DES Only)	C050045B007A
5 GHz PTP 450i END, Integrated High Gain Antenna (DES only)	C050045B008A
5 GHz Horizontal and Vertical Polarization Antenna for 90 Degree Sector	85009324001
5 GHz Horizontal and Vertical Polarization Antenna for 60 Degree	85009325001

Sector	
50 Ohm Braided Coaxial Cable - 75 meter	30010194001
50 Ohm Braided Coaxial Cable - 500 meter	30010195001
RF Connector, N, Male, Straight for CNT-400 Cable	09010091001
AP Optional Equipment	
POWER SUPPLY, 30W, 56V – Gbps support	N000000L034A
AC Power Injector	N000065L001B
AC+DC Enhanced Power Injector	C000065L002B
Ethernet cable adapter for CMM4	N000045L001A
CMM4 to PMP/PTP donegg dongle	N000045L001A
Power over Ethernet midspan, 60 W, -48 VDC Input	N000000L036A
Gigabit Surge Suppressor (56V)	C000000L033A
Series Blanking Plug Pack (Qty 10)	N000065L036A
Mounting Bracket (Integrated)	N000065L031A
Tilt Bracket Assembly	N000045L002A
Extended Warranty	
PMP 450 AP Extended Warranty, 1 Additional Year	SG00TS4009A
PMP 450 AP Extended Warranty, 2 Additional Years	SG00TS4017A
PMP 450 AP Extended Warranty, 4 Additional Years	SG00TS4025A
PMP 450 SM Extended Warranty, 1 Additional Year	SG00TS4010A
PMP 450 SM Extended Warranty, 2 Additional Years	SG00TS4018A
PMP 450 SM Extended Warranty, 4 Additional Years	SG00TS4026A

Chapter 3: System planning

This chapter provides information to help the user to plan a PMP/PTP 450i link.

The following topics are described in this chapter:

- Typical deployment on page 3-2 contains diagrams illustrating typical PMP/PTP 450i site deployments.
- Site planning on page 3-7 describes factors to be considered when planning the proposed link end sites, including grounding, lightning protection and equipment location.
- Radio Frequency planning on page 3-14 describes how to plan PMP/PTP 450i links to conform to the regulatory restrictions that apply in the country of operation.
- Link planning on page 3-19 describes factors to be taken into account when planning links, such as range, path loss and throughput.
- Planning for connectorized units on page 3-22 describes factors to be taken into account when planning to use connectorized ODUs with external antennas in PMP/PTP 450i links.
- Data network planning on page 3-24 describes factors to be considered when planning PMP/PTP 450i data networks.
- Network management planning on page 3-32 describes how to plan for PMP/PTP 450i links to be managed remotely using SNMP.
- Security planning on page 3-33 describes how to plan for PMP/PTP 450i links to operate in secure mode.

Typical deployment

This section contains diagrams illustrating typical PMP/PTP 450i site deployments.

ODU with PoE interface to PSU

In the basic configuration, there is only one Ethernet interface, a copper Cat5e power over Ethernet (POE) from the PSU to the ODU (PSU port), as shown in the following diagrams: mast or tower installation (Figure 15), wall installation (Figure 16) and roof installation (Figure 17).

Figure 15 Mast or tower installation

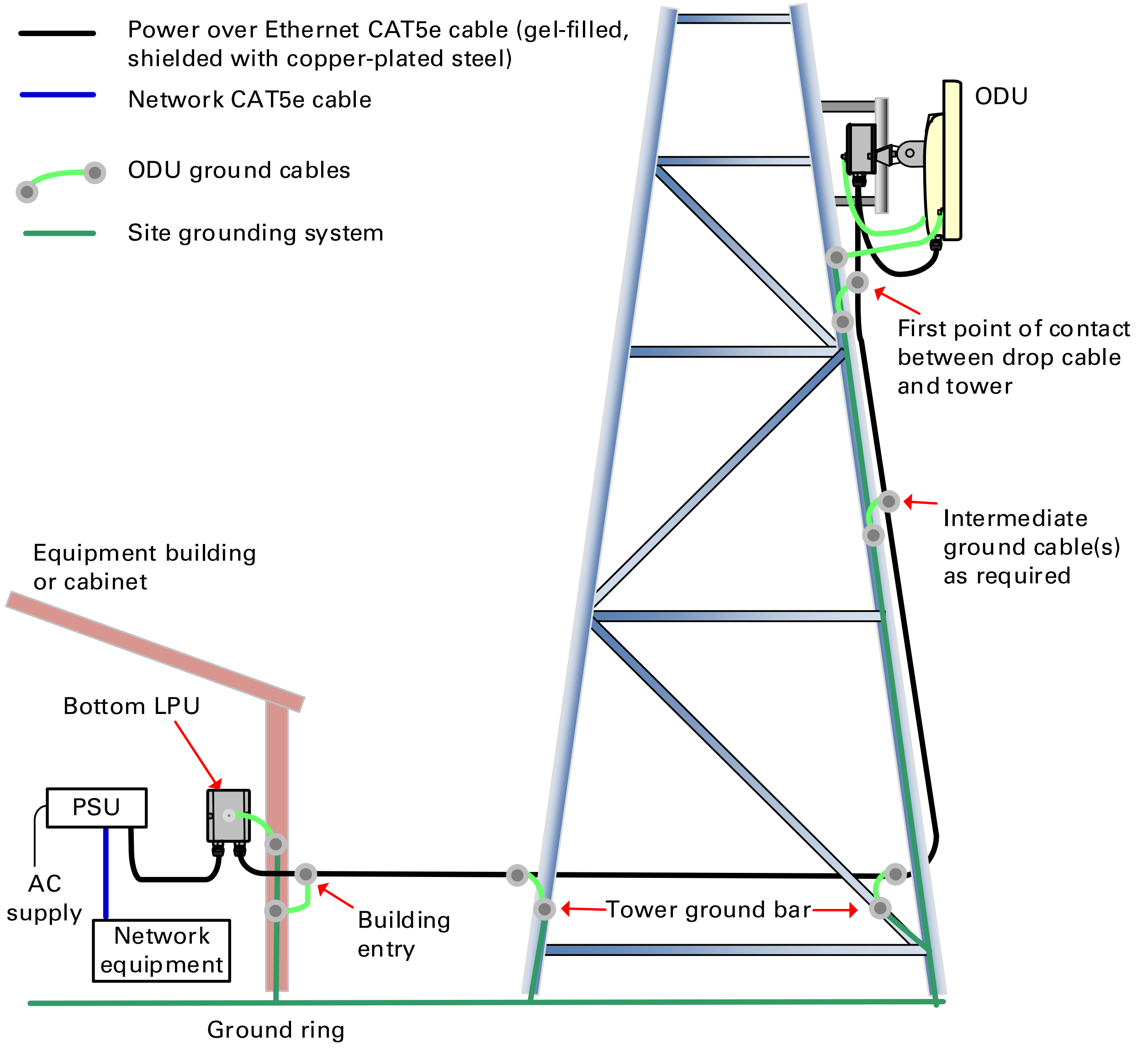

Power over Ethernet CAT5e cable (gel-filled, shielded with copper-plated steel)
Network CAT5e cable
ODU ground cables
Site grounding system
ODU
First point of contact between drop cable and tower
Intermediate ground cable(s) as required
Equipment building or cabinet
Bottom LPU
PSU
AC supply
Network equipment
Building entry
Tower ground bar
Ground ring

Figure 16 Wall installation

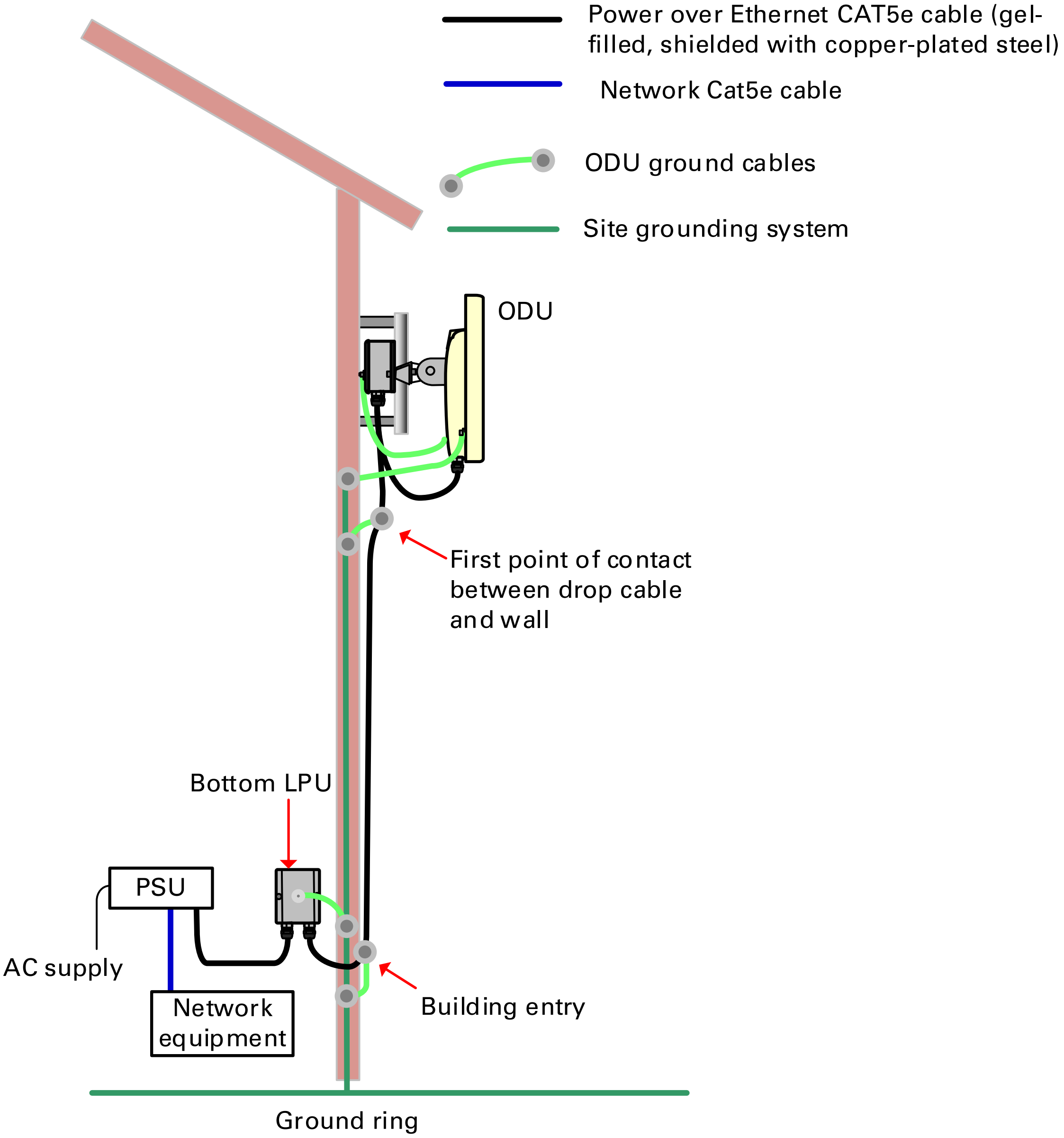

Power over Ethernet CAT5e cable (gel-filled, shielded with copper-plated steel)
Network Cat5e cable
ODU ground cables
Site grounding system
ODU
First point of contact between drop cable and wall
Bottom LPU
PSU
AC supply
Network equipment
Building entry
Ground ring

Figure 17 Roof installation

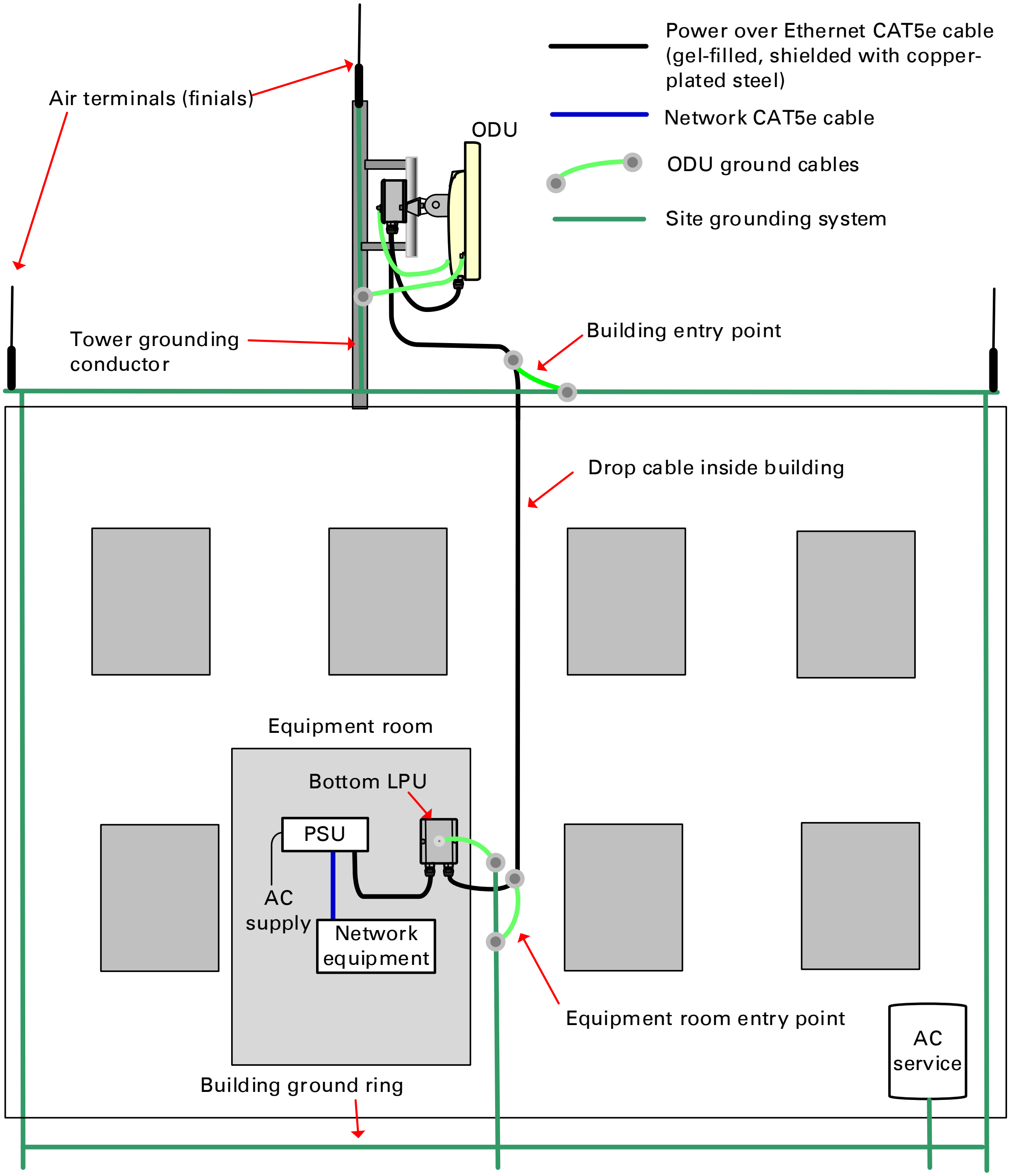


Figure 18 GPS receiver wall installation

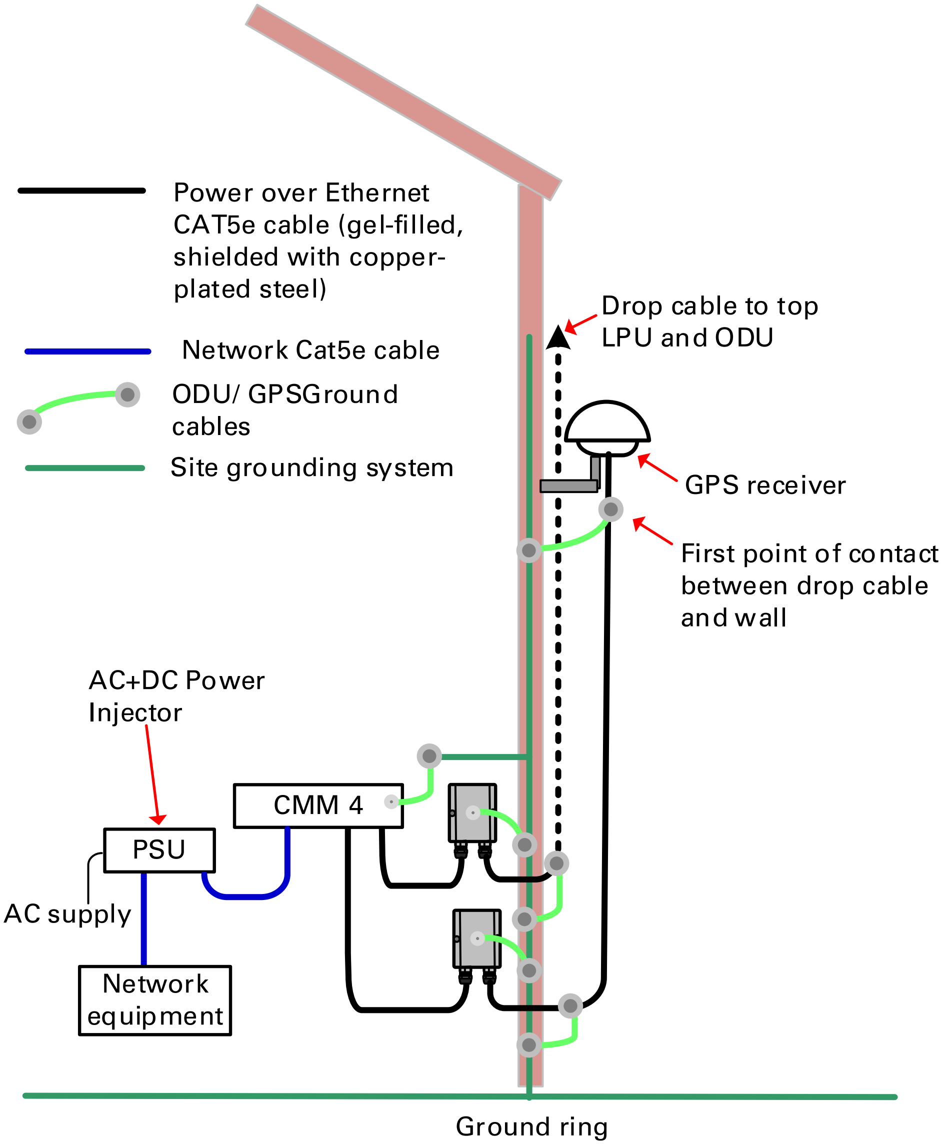
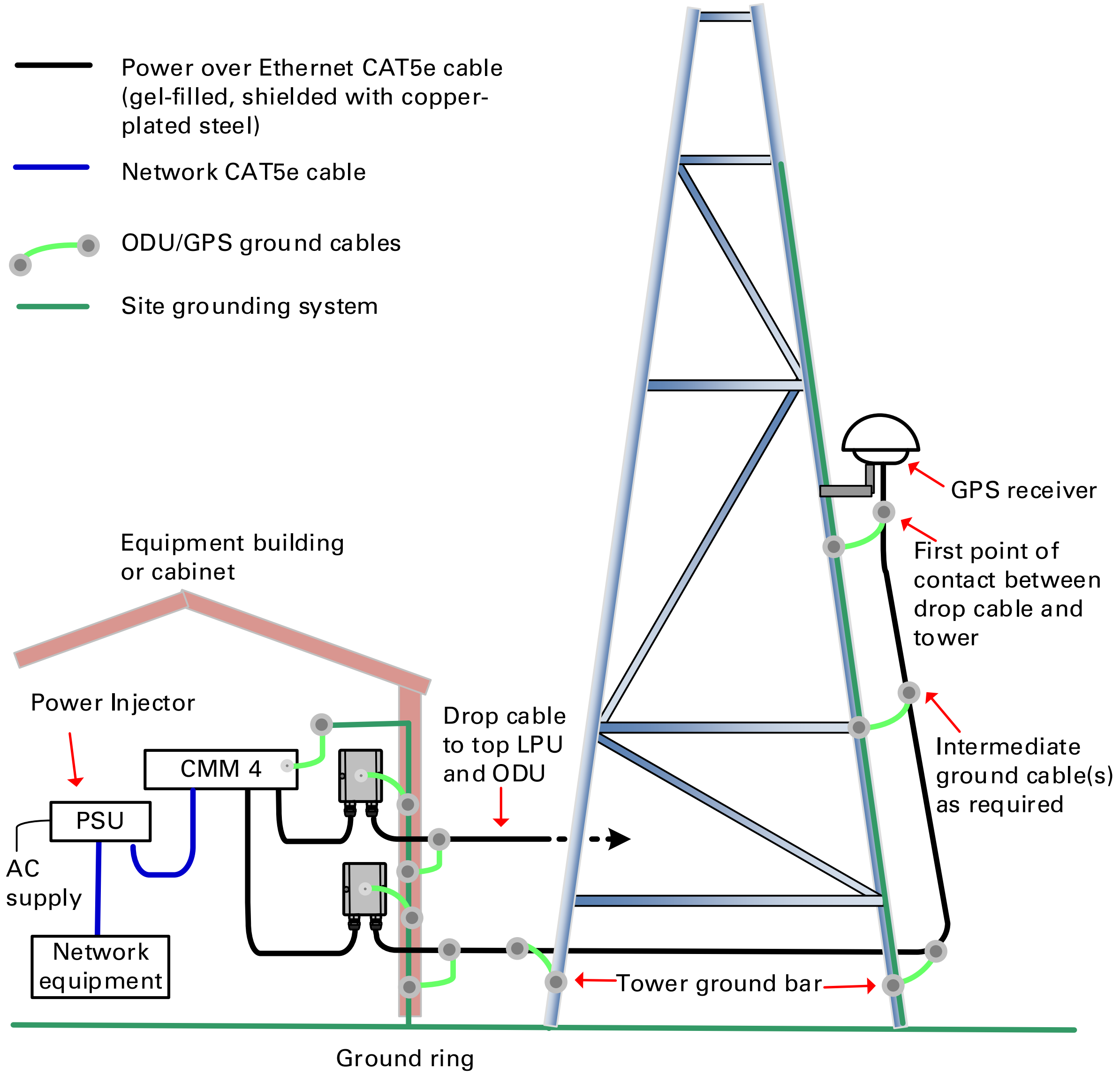

Power over Ethernet CAT5e cable (gel-filled, shielded with copper-plated steel)
Network Cat5e cable
ODU/ GPSGround cables
Site grounding system
Drop cable to top LPU and ODU
GPS receiver
First point of contact between drop cable and wall
AC+DC Power Injector
CMM 4
PSU
AC supply
Network equipment
Ground ring

Figure 19 GPS receiver tower or mast installation


Power over Ethernet CAT5e cable (gel-filled, shielded with copper-plated steel)
Network CAT5e cable
ODU/GPS ground cables
Site grounding system
Equipment building or cabinet
Power Injector
CMM 4
PSU
AC supply
Network equipment
Drop cable to top LPU and ODU
GPS receiver
First point of contact between drop cable and tower
Intermediate ground cable(s) as required
Tower ground bar
Ground ring

Site planning

This section describes factors to be considered when choosing sites for PMP or PTP radios, power supplies, CMM4 (if applicable) and UGPS (if applicable).

Site selection for PMP/PTP radios

When selecting a site for the ODU, consider the following factors:

- Height and location to ensure that people are kept away from the antenna; see Calculated distances and power compliance margins on page 4-24.
- Height and location to achieve the best radio path.
- Indoor location where power supply LED indicators accessible and cable length should not exceed maximum recommended length; see Power supply site selection
- Ability to meet the requirements specified in Grounding and lightning protection on page 3-8.
- Aesthetics and planning permission issues.
- Cable lengths; see Ethernet standards and cable lengths on page 2-16.
- The effect of strong winds on the installation; see ODU wind loading on page 3-11.

Calculated distances and power compliance margin

The calculated minimum separation distances, recommended distances and resulting margins for each frequency band and antenna combination. These are conservative distances that include compliance margins. At these and greater separation distances, the power density from the RF field is below generally accepted limits for the general population.

PMP/PTP 450i equipment adheres to all applicable EIRP limits for transmit power when operating in MIMO mode. Separation distances and compliance margins include compensation for both transmitters.

Power supply site selection

When selecting a site for the ODU power supply, consider the following factors:

- Indoor location with no possibility of condensation, flooding or rising damp.
- Availability of a mains electricity supply.
- Located in an environment where it is not likely to exceed its operational temperature rating, allowing for natural convection cooling.
- Accessibility for viewing status indicator LED and connecting Ethernet cables.
- Cable lengths; see Ethernet standards and cable lengths on page 2-16.

Maximum cable lengths

When installing PMP/PTP 450i Series ODU, the maximum permitted length of the shielded copper Ethernet interface cable is 330 feet (100m) from AP/BHM/SM/BHS to their associated power supplies or CMM4.

Grounding and lightning protection

Warning

Electro-magnetic discharge (lightning) damage is not covered under warranty. The recommendations in this guide, when followed correctly, give the user the best protection from the harmful effects of EMD. However 100% protection is neither implied nor possible.

Structures, equipment and people must be protected against power surges (typically caused by lightning) by conducting the surge current to ground via a separate preferential solid path. The actual degree of protection required depends on local conditions and applicable local regulations. To adequately protect a PMP/PTP 450i installation, both ground bonding and transient voltage surge suppression are required.

Full details of lightning protection methods and requirements can be found in the international standards IEC 61024-1 and IEC 61312-1, the U.S. National Electric Code ANSI/NFPA No. 70-1984 or section 54 of the Canadian Electric Code.

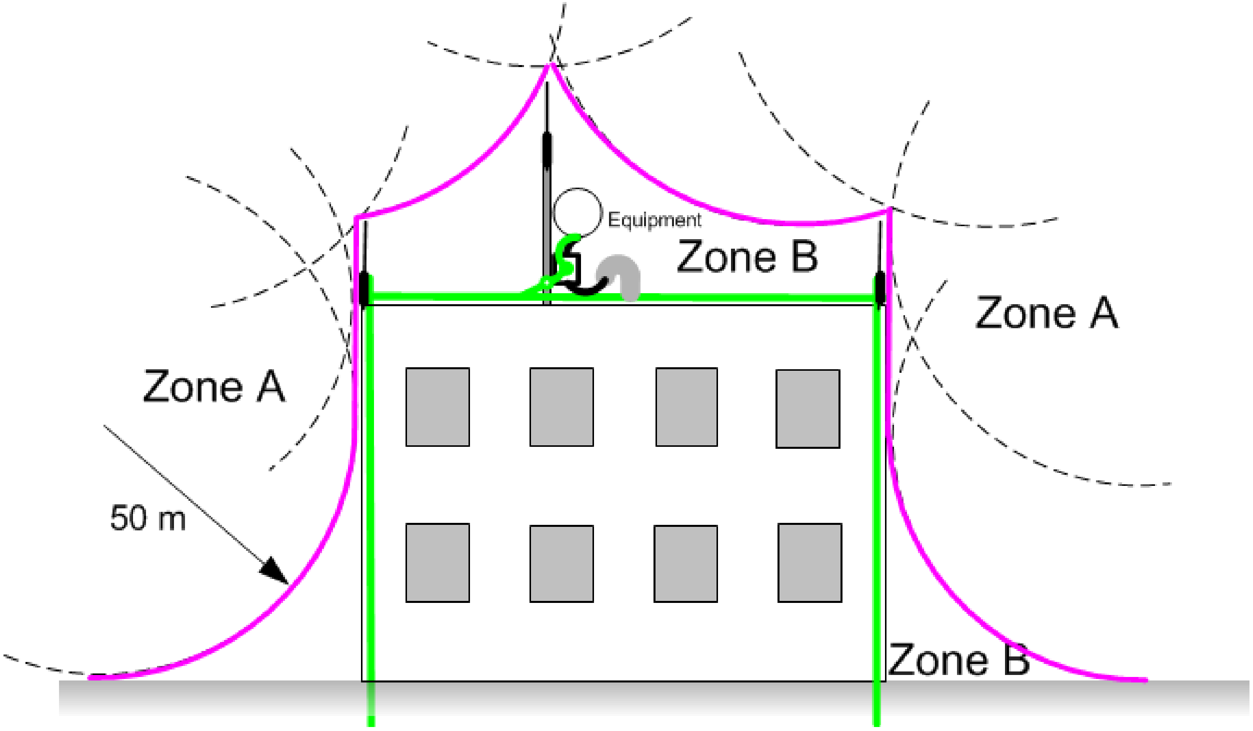
Note

International and national standards take precedence over the requirements in this guide.

Lightning protection zones

Use the rolling sphere method (Figure 20) to determine where it is safe to mount equipment. An imaginary sphere, typically 50 meters in radius, is rolled over the structure. Where the sphere rests against the ground and a strike termination device (such as a finial or ground bar), all the space under the sphere is considered to be in the zone of protection (Zone B). Similarly, where the sphere rests on two finials, the space under the sphere is considered to be in the zone of protection.

Figure 20 Rolling sphere method to determine the lightning protection zones



Zone A: In this zone a direct lightning strike is possible. Do not mount equipment in this zone.

Zone B: In this zone, direct EMD (lightning) effects are still possible, but mounting in this zone significantly reduces the possibility of a direct strike. Mount equipment in this zone.

Warning

Never mount equipment in Zone A. Mounting in Zone A may put equipment, structures and life at risk.

Site grounding system

Confirm that the site has a correctly installed grounding system on a common ground ring with access points for grounding PMP/PTP 450i equipment.

If the outdoor equipment is to be installed on the roof of a high building (Figure 17), confirm that the following additional requirements are met:

- A grounding conductor is installed around the roof perimeter to form the main roof perimeter lightning protection ring.
- Air terminals are installed along the length of the main roof perimeter lightning protection ring, typically every 6.1m (20ft).
- The main roof perimeter lightning protection ring contains at least two down conductors connected to the grounding electrode system. The down conductors should be physically separated from one another, as far as practical.

ODU and external antenna location

Find a location for the ODU (and external antenna for connectorized units) that meets the following requirements:

- The equipment is high enough to achieve the best radio path.
- People can be kept a safe distance away from the equipment when it is radiating. The safe separation distances are defined in Calculated distances and power compliance margins on page 4-24.
- The equipment is lower than the top of the supporting structure (tower, mast or building) or its lightning air terminal.
- If the ODU is connectorized, select a mounting position that gives it maximum protection from the elements, but still allows easy access for connecting and weatherproofing the cables. To minimize cable losses, select a position where the antenna cable lengths can be minimized. If diverse or two external antennas are being deployed, it is not necessary to mount the ODU at the midpoint of the antennas.

ODU ambient temperature limits

Select a location where the ODU can operate within safe ambient temperature limits. The following points need to be considered while selecting a location for the ODU:

- The ODU must be mounted in a Restricted Access Location (as defined in EN 60950-1) if the operating ambient temperature may exceed 40°C, including solar radiation.
- If the ambient temperature never exceeds 40°C, the temperature of the external metal case parts of the ODU will not exceed the touch temperature limit of 70°C.
- If the ambient temperature never exceeds 60°C, the temperature of the external metal case parts of the ODU will not exceed the touch temperature limit of 90°C.

Note

A restricted access location is defined (in EN 60950-1) as one where access may only be gained by use of a tool or lock and key, or other means of security, and access is controlled by the authority responsible for the location. Access must only be gained by persons who have been instructed about the reasons for the restrictions applied to the location and about any precautions that must be taken. Examples of permissible restricted access locations are a lockable equipment room or a lockable cabinet.

ODU wind loading

Ensure that the ODU and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed PMP/PTP 450i site. Wind speed statistics are available from national meteorological offices.

The ODU and its mounting bracket are capable of withstanding wind speeds of up to 323 kph (200 mph).

Wind blowing on the ODU will subject the mounting structure to significant lateral force. The magnitude of the force depends on both wind strength and surface area of the ODU. Wind loading is estimated using the following formulae:

- Force (in kilogrammes) = $0.1045aV^2$
  where:
  - "a" is the surface area in square meters, and
  - "V" is the wind speed in meters per second.
- Force (in pounds) = $0.0042Av^2$
  where:
  - "A" is the surface area in square feet, and
  - "v" is the wind speed in miles per hour.

Applying these formulae to the PMP/PTP 450i ODU at different wind speeds, the resulting wind loadings are shown in Table 28 and Table 29.

Table 28 ODU wind loading (Newton)

Type of ODU	Max surface area (square meters)	Wind speed (kilometer per hour)				
		160	170	180	190	200
Connectorized	0.035	59	66	74	83	92
Directional	0.093	156	176	197	220	243
90 degree sector	0.126	211	238	267	298	330

Table 29 ODU wind loading (lb force)

Type of ODU	Max surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Connectorized	0.377	13	15	16	18	19
Directional	1.001	35	39	43	47	51
90 degree sector	1.356	48	53	58	64	69

For a connectorized ODU, add the wind loading of the external antenna to that of the ODU. The antenna manufacturer should be able to quote wind loading.

Drop cable grounding points

To estimate how many grounding kits are required for each drop cable, refer to the site installation diagrams (Figure 15 , Figure 16 and Figure 17) and use the following criteria:

- The drop cable shield must be grounded near the ODU at the first point of contact between the drop cable and the mast, tower or building.
- The drop cable shield must be grounded at the building entry point.

For mast or tower installations (Figure 15), use the following additional criteria:

- The drop cable shield must be grounded at the bottom of the tower, near the vertical to horizontal transition point. This ground cable must be bonded to the tower or tower ground bus bar (TGB), if installed.
- If the tower is greater than 61 m (200 ft) in height, the drop cable shield must be grounded at the tower midpoint, and at additional points as necessary to reduce the distance between ground cables to 61 m (200 ft) or less.
- In high lightning-prone geographical areas, the drop cable shield must be grounded at spacing between 15 to 22 m (50 to 75 ft). This is especially important on towers taller than 45 m (150 ft).

For roof installations (Figure 17), use the following additional criteria:

- The drop cable shield must be bonded to the building grounding system at its top entry point (usually on the roof).
- The drop cable shield must be bonded to the building grounding system at the entry point to the equipment room.

LPU location

Find a location for the bottom LPU that meets the following requirements:

- The bottom LPU can be connected to the drop cable from the ODU.
- The bottom LPU is within 600 mm (24 in) of the point at which the drop cable enters the building, enclosure or equipment room within a larger building.
- The bottom LPU can be bonded to the grounding system.

Radio Frequency planning

This section describes how to plan PMP/PTP 450i links to conform to analysis of spectrum and the regulatory restrictions that apply in the country of operation.

Regulatory limits

Many countries impose EIRP limits (Allowed EIRP) on products operating in the bands used by the PMP/PTP 450i Series.

Refer to Maximum transmit power per Country Code (Chapter 10: Reference Information) on page 10-19 to determine what the maximum transmitted power and EIRP for PMP/PTP 450i Series that can be used in each of countries and frequency band.

⚠ **Caution**

It is the responsibility of the user to ensure that the PMP/PTP product is operated in accordance with local regulatory limits.

Note

Contact the applicable radio regulator to find out whether or not registration of the PMP/PTP 450i link is required.

Conforming to the limits

Ensure the link is configured to conform to local regulatory requirements by configuring the PMP 450i AP or PTP 450i BHM for the correct country. In the following situations, this does not prevent operation outside the regulations:

- When using connectorized ODUs with external antennas, the regulations may require the maximum transmit power to be reduced.

Available spectrum

The available spectrum for operation depends on the regulatory band. When configured appropriately, the unit will only allow operation on those channels which are permitted by the regulations.

Certain regulations have allocated certain channels as unavailable for use:

- ETSI has allocated part of the 5.4 GHz band to weather radar.

- UK and some other European countries have allocated part of the 5.8 GHz band to Road Transport and Traffic Telematics (RTTT) systems.

The number and identity of channels barred in a given regulatory band is dependent on the channel bandwidth and channel raster selected.

Analyzing the RF Environment

An essential element in RF network planning is the analysis of spectrum usage and the strength of the signals that occupy the spectrum. Regardless of how these parameters are measured and log or chart the results (through the Spectrum Analyzer feature or by using a spectrum analyzer), ensure measurements are performed:

- At various times of day.
- On various days of the week.
- Periodically into the future.

As new RF neighbors move in or consumer devices proliferate in currently used spectrum, this keeps the user aware of the dynamic possibilities for interference within the network.

Channel bandwidth

Select the required channel bandwidth for the link. The selection depends upon the regulatory band selected.

The wider the channel bandwidth, the greater the capacity. As narrower channel bandwidths take up less spectrum, selecting a narrow channel bandwidth may be a better choice when operating in locations where the spectrum is very busy.

Both ends of the link must be configured to operate on the same channel bandwidth.

Anticipating Reflection of Radio Waves

In the signal path, any object that is larger than the wavelength of the signal can reflect the signal. Such an object can even be the surface of the earth or of a river, bay or lake. The wavelength of the signal is approximately

- 2 inches (or 5 cm) for 5.4 GHz and 5.8 GHz signals.

A reflected signal can arrive at the antenna of the receiver later than the non-reflected signal arrives. These two or more signals cause the condition known as multipath. Multipath may increase or decrease the signal level, resulting in overall attenuation that may be higher or lower than that caused by the link distance. This is problematic at the margin of the link budget, where the standard operating margin (fade margin) may be compromised.

Obstructions in the Fresnel Zone

The Fresnel (pronounced fre·NEL) Zone is a three-dimensional volume around the line of sight of an antenna transmission. Objects that penetrate this area can cause the received strength of the transmitted signal to fade. Out-of-phase reflections and absorption of the signal result in signal cancellation.

The foliage of trees and plants in the Fresnel Zone can cause signal loss. Seasonal density, moisture content of the foliage, and other factors such as wind may change the amount of loss. Plan to perform frequent and regular link tests if you must transmit through foliage.

Planning for co-location

The first step to avoid interference in wireless systems is to set all AP/BHMs to receive timing from a synchronization source (Cluster Management Module, or Universal Global Positioning System). This ensures that the modules are in sync and start transmitting at the same time each frame.

The second step to avoid interference is to configure parameters on all AP/BHMs of the same frequency band in proximity such that they have compatible transmit/receive ratios (all stop transmitting each frame before any start receiving). This avoids the problem of one AP/BHM attempting to receive the signal from a distant SM/BHS while a nearby AP/BHM transmits, which could overpower that signal.

The following parameters on the AP/BHM determine the transmit/receive ratio:

- Downlink Data percentage
- (reserved) Contention slots

If OFDM (PMP/PTP 450, PMP/PTP 230) and FSK (PMP/PTP 1x0) APs/BHMs of the same frequency band are in proximity, or if you want BHMs set to different parameters then you must use the Frame Calculator to identify compatible settings for APs/BHMs.

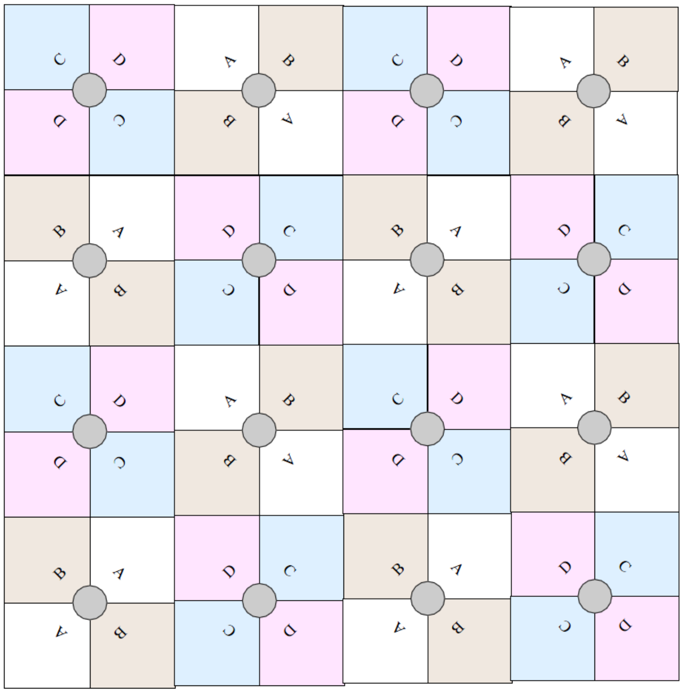
The Frame Calculator is available on the web management interface **Tools > Frame Calculator**. To use the Frame Calculator, type into the calculator various configurable parameter values for each proximal AP/BHM and then record the resulting AP/BHM Receive Start value. Next vary the Downlink Data percentage in each calculation and iterate until a calculated AP/BHM Receive Start for all collocated APs/BHMs are within 300 bit times; if possible, within 150 bit times. In Cambium Point-to-Multipoint systems, 10 bit times = 1 µs.

For more information on PTP 450 co-location, see http://www.cambiumnetworks.com/solution-papers

Multiple OFDM Access Point Clusters

When deploying multiple AP clusters in a dense area, consider aligning the clusters as shown below. However, this is only a recommendation. An installation may dictate a different pattern of channel assignments.

Figure 21 Example layout of 16 Access Point sectors (ABCD), 90 degree sectors

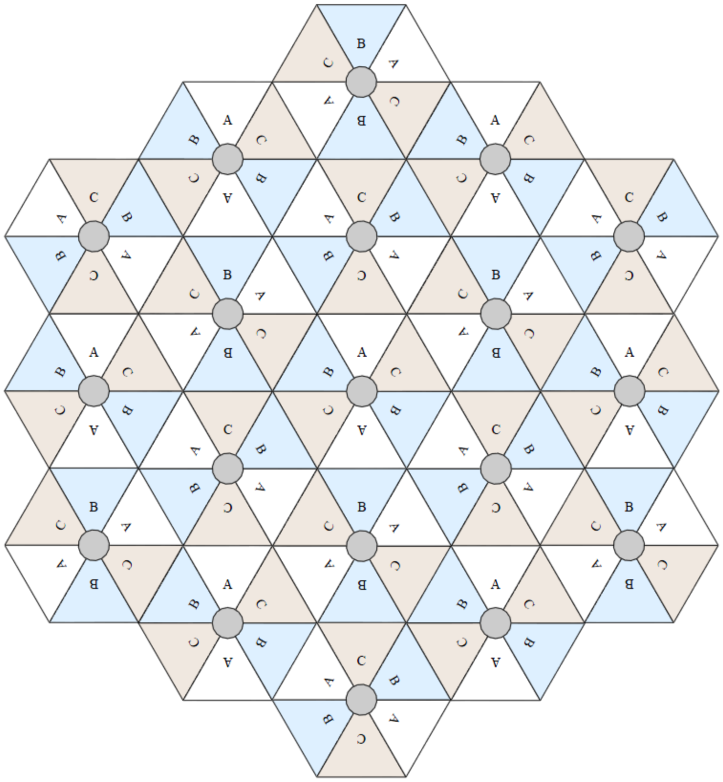


An example for assignment of frequency channels is provided in the following table.

Table 30 Example 5.8-GHz OFDM channel assignment by sector

Symbol	Frequency
A	5.740 GHz
B	5.760 GHz
C	5.780 GHz
D	5.800 GHz

Figure 22 Example layout of 6 Access Point sectors (ABC), 60 degree sectors



An example for assignment of frequency channels and sector IDs is provided in the following table.

Table 31 Example 5.8 GHz OFDM channel assignment by sector

Symbol	Frequency
A	5.740 GHz
B	5.760 GHz
C	5.780 GHz

Link planning

This section describes factors to be taken into account when planning links, such as range, obstacles path loss and throughput. LINKPlanner is recommended.

Range and obstacles

Calculate the range of the link and identify any obstacles that may affect radio performance.

Perform a survey to identify all the obstructions (such as trees or buildings) in the path and to assess the risk of interference. This information is necessary in order to achieve an accurate link feasibility assessment.

The PMP/PTP 450i Series is designed to operate in Non-Line-of-Sight (NLoS) and Line-of-Sight (LoS) environments. An NLOS environment is one in which there is no optical line-of-sight, that is, there are obstructions between the antennas.

OFDM technology can often use multi-pathing to an advantage to overcome nLOS, especially in cases where the Fresnel zone is only partially blocked by buildings, “urban canyons”, or foliage. OFDM tends to help especially when obstacles are near the middle of the link, and less so when the obstacles are very near the ODU.

However, attenuation through walls and trees is substantial for any use of the 5.4 GHz and 5.8 GHz frequency bands. Even with OFDM, these products are not expected to penetrate walls or extensive trees and foliage.

Path loss

Path loss is the amount of attenuation the radio signal undergoes between the two ends of the link. The path loss is the sum of the attenuation of the path if there were no obstacles in the way (Free Space Path Loss), the attenuation caused by obstacles (Excess Path Loss) and a margin to allow for possible fading of the radio signal (Fade Margin). The following calculation needs to be performed to judge whether a particular link can be installed:

$$L_{free\_space} + L_{excess} + L_{fade} + L_{seasonal} < L_{capability}$$

Where:	Is:
L_{free_space}	Free Space Path Loss (dB)
L_{excess}	Excess Path Loss (dB)
L_{fade}	Fade Margin Required (dB)
$L_{seasonal}$	Seasonal Fading (dB)
$L_{capability}$	Equipment Capability (dB)

Calculating Link Loss

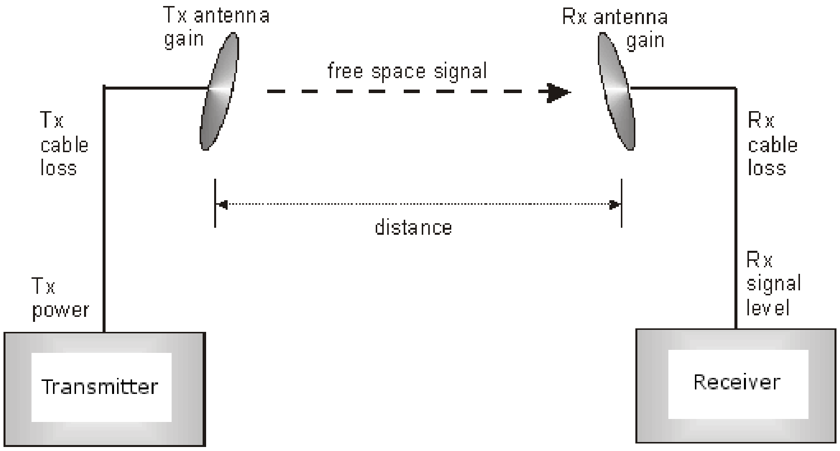
The link loss is the total attenuation of the wireless signal between two point-to-multipoint units. The link loss calculation is presented below:

Link Loss (dB) = Transmit power of the remote wireless unit (dBm) – Tx Cable loss (dB) – Received power at the local unit (dBm) – Rx cable loss (dB) + Antenna gain at the remote unit (dBi) + Antenna gain at the local unit (dBi)

Calculating Rx Signal Level

The determinants in Rx signal level are illustrated in Figure 23.

Figure 23 Determinants in Rx signal level



Rx signal level is calculated as follows:

Rx signal level dB = Tx power – Tx cable loss + Tx antenna gain – free space path loss + Rx antenna gain – Rx cable loss

Note

This Rx signal level calculation presumes that a clear line of sight is established between the transmitter and receiver and that no objects encroach in the Fresnel zone.

Calculating Fade Margin

Free space path loss is a major determinant in Rx (received) signal level. Rx signal level, in turn, is a major factor in the system operating margin (fade margin), which is calculated as follows:

System operating margin (fade margin) dB = Rx signal level dB – Rx sensitivity dB

Thus, fade margin is the difference between strength of the received signal and the strength that the receiver requires for maintaining a reliable link. A higher fade margin is characteristic of a more reliable link.

Adaptive modulation

Adaptive modulation ensures that the highest throughput that can be achieved instantaneously will be obtained, taking account of propagation and interference. When the link has been installed, web pages provide information about the link loss currently measured by the equipment, both instantaneously and averaged. The averaged value will require maximum seasonal fading to be added, and then the radio reliability of the link can be computed.

For details of the system throughput, link loss and maximum distance for each frequency band in all modulation modes, see Link on page 10-15.

Planning for connectorized units

This section describes factors to be taken into account when planning to use connectorized ODUs with external antennas in PMP/PTP 450i links.

When to install connectorized units

The majority of radio links can be successfully deployed with the integrated ODU. However the integrated units may not be sufficient in some areas, for example:

- Where the path is heavily obscured by dense woodland on an NLOS link.
- Where long LOS links are required.
- Where there are known to be high levels of interference.

In these areas, connectorized ODUs and external antennas should be used.

Choosing external antennas

When selecting external antennas, consider the following factors:

- The required antenna gain.
- Ease of mounting and alignment.
- Use dual-polarization antenna (as the integrated antenna).

Note

Enter the antenna gain and cable loss into the Installation Wizard, if the country selected has an EIRP limit, the corresponding maximum transmit power will be calculated automatically by the unit.

Calculating RF cable length (5.8 GHz FCC only)

The 5.8 GHz band FCC approval for the product is based on tests with a cable loss between the ODU and antenna of not less than 1.2 dB. If cable loss is below 1.2 dB with a 1.3 m (4 ft) diameter external antenna, the connectorized PMP/PTP 450i may exceed the maximum radiated spurious emissions allowed under FCC 5.8 GHz rules.

Cable loss depends mainly upon cable type and length. To meet or exceed the minimum loss of 1.2 dB, use cables of the type and length specified in Table 32 (source: Times Microwave). This data excludes connector losses.

Table 32 RF cable lengths required to achieve 1.2 dB loss at 5.8 GHz

RF cable type	Minimum cable length
LMR100	0.6 m (1.9 ft)
LMR200	1.4 m (4.6 ft)
LMR300	2.2 m (7.3 ft)
LMR400	3.4 m (11.1 ft)
LMR600	5.0 m (16.5 ft)

Data network planning

This section describes factors to be considered when planning PMP/PTP 450i data networks.

Understanding addresses

A basic understanding of Internet Protocol (IP) address and subnet mask concepts is required for engineering your IP network.

IP address

The IP address is a 32-bit binary number that has four parts (octets). This set of four octets has two segments, depending on the class of IP address. The first segment identifies the network. The second identifies the hosts or devices on the network. The subnet mask marks a boundary between these two sub-addresses.

Dynamic or static addressing

For any computer to communicate with a module, the computer must be configured to either

- use DHCP (Dynamic Host Configuration Protocol). In this case, when not connected to the network, the computer derives an IP address on the 169.254 network within two minutes.
- have an assigned static IP address (for example, 169.254.1.5) on the 169.254 network.

Note

If an IP address that is set in the module is not the 169.254.x.x network address, then the network operator must assign the computer a static IP address in the same subnet.

When a DHCP server is not found

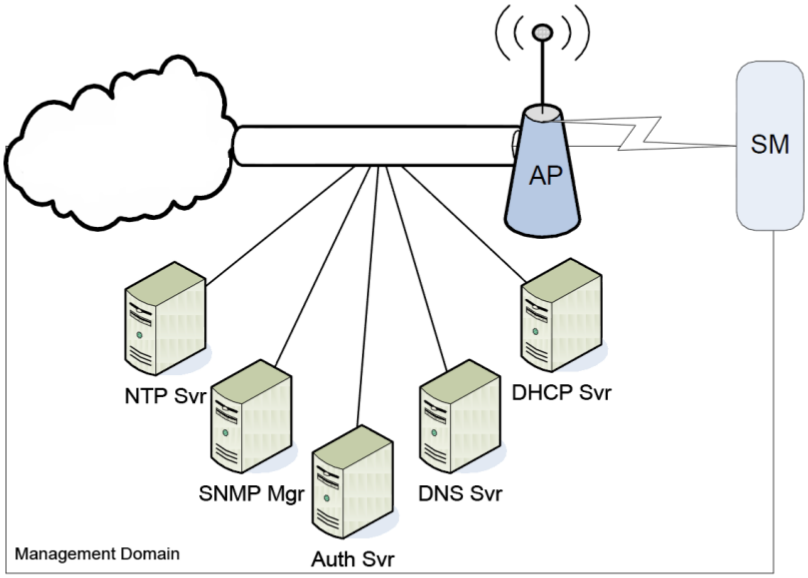
To operate on a network, a computer requires an IP address, a subnet mask, and possibly a gateway address. Either a DHCP server automatically assigns this configuration information to a computer on a network or an operator must input these items.

When a computer is brought on line and a DHCP server is not accessible (such as when the server is down or the computer is not plugged into the network), Microsoft and Apple operating systems default to an IP address of 169.254.x.x and a subnet mask of 255.255.0.0 (169.254/16, where /16 indicates that the first 16 bits of the address range are identical among all members of the subnet).

DNS Client

The DNS Client is used to resolve names of management servers within the operator's management domain (see Figure 24). This feature allows hostname configuration for NTP servers, Authorization Servers, DHCP relay servers, and SNMP trap servers. Operators may choose to either enter in the FQDN (Fully Qualified Domain Name) for the host name or to manually enter the IP addresses of the servers.

Figure 24 Cambium networks management domain



Network Address Translation (NAT)

NAT, DHCP Server, DHCP Client and DMZ in SM

The system provides NAT (network address translation) for SMs in the following combinations of NAT and DHCP (Dynamic Host Configuration Protocol):

- NAT Disabled
- NAT with DHCP Client (**DHCP** selected as the **Connection Type** of the WAN interface) and DHCP Server
- NAT with DHCP Client(**DHCP** selected as the **Connection Type** of the WAN interface)
- NAT with DHCP Server
- NAT without DHCP

NAT

NAT isolates devices connected to the Ethernet/wired side of a SM from being seen directly from the wireless side of the SM. With NAT enabled, the SM has an IP address for transport traffic (separate from its address for management), terminates transport traffic, and allows you to assign a range of IP addresses to devices that are connected to the Ethernet/wired side of the SM.

In the Cambium system, NAT supports many protocols, including HTTP, ICMP (Internet Control Message Protocols), and FTP (File Transfer Protocol). For virtual private network (VPN) implementation, L2TP over IPSec (Level 2 Tunneling Protocol over IP Security) and PPTP (Point to Point Tunneling Protocol) are supported.

DHCP

DHCP enables a device to be assigned a new IP address and TCP/IP parameters, including a default gateway, whenever the device reboots. Thus DHCP reduces configuration time, conserves IP addresses, and allows modules to be moved to a different network within the Cambium system.

In conjunction with the NAT features, each SM provides:

- A DHCP server that assigns IP addresses to computers connected to the SM by Ethernet protocol.
- A DHCP client that receives an IP address for the SM from a network DHCP server.

DMZ

In conjunction with the NAT features, a DMZ (demilitarized zone) allows the assignment of one IP address behind the SM for a device to logically exist outside the firewall and receive network traffic. The first three octets of this IP address must be identical to the first three octets of the NAT private IP address.

Developing an IP addressing scheme

Network elements are accessed through IP Version 4 (IPv4) addressing.
A proper IP addressing method is critical to the operation and security of a network.

Each module requires an IP address on the network. This IP address is for only management purposes. For security, you must either:

- Assign a non-routable IP address.
- Assign a routable IP address only if a firewall is present to protect the module.

You assign an IP addresses to computers and network components by either static or dynamic IP addressing. You will also assign the appropriate subnet mask and network gateway to each module.

Address Resolution Protocol

As previously stated, the MAC address identifies a module in:

- Communications between modules.
- The data that modules store about each other.

The IP address is essential for data delivery through a router interface. Address Resolution Protocol (ARP) correlates MAC addresses to IP addresses.

For communications to outside the network segment, ARP reads the network gateway address of the router and translates it into the MAC address of the router. Then the communication is sent to MAC address (physical network interface card) of the router.

For each router between the sending module and the destination, this sequence applies. The ARP correlation is stored until the ARP cache times out.

Allocating subnets

The subnet mask is a 32-bit binary number that filters the IP address. Where a subnet mask contains a bit set to 1, the corresponding bit in the IP address is part of the network address.

Example IP address and subnet mask

In Figure 25, the first 16 bits of the 32-bit IP address identify the network:

Figure 25 Example of IP address in Class B subnet

	Octet 1	Octet 2	Octet 3	Octet 4
IP address 169.254.1.1	10101001	11111110	00000001	00000001
Subnet mask 255.255.0.0	11111111	11111111	00000000	00000000

In this example, the network address is 169.254 and 2^{16} (65,536) hosts are addressable.

Selecting non-routable IP addresses

The factory default assignments for network elements are:

- Unique MAC address
- IP address of 169.254.1.1
- Subnet mask of 255.255.0.0
- Network gateway address of 169.254.0.0

For each radio and CMM4, assign an IP address that is both consistent with the IP addressing plan for your network and cannot be accessed from the Internet. IP addresses within the following ranges are not routable from the Internet, regardless of whether a firewall is configured:

- 10.0.0.0 – 10.255.255.255
- 172.16.0.0 – 172.31.255.255
- 192.168.0.0 – 192.168.255.255

Also, the subnet mask and network gateway for each CMM4 can be assigned.

Translation bridging

Optionally, the AP can be configured to change the source MAC address in every packet it receives from its SMs to the MAC address of the SM/BHS that bridged the packet, before forwarding the packet toward the public network. In this case:

- Not more than 128 IP devices at any time are valid to send data to the AP from behind the SM.
- SM populates the Translation Table tab of its Statistics web page, displaying the MAC address and IP address of all the valid connected devices.
- Each entry in the Translation Table is associated with the number of minutes that have elapsed since the last packet transfer between the connected device and the SM.
- If 128 are connected, and another attempts to connect:
  - If no Translation Table entry is older than 255 minutes, the attempt is ignored.
  - If an entry is older than 255 minutes, the oldest entry is removed and the attempt is successful.
- The **Send Untranslated ARP** parameter in the General tab of the Configuration page can be:
  - Disabled, so that the AP overwrites the MAC address in ARP packets before forwarding them.
  - Enabled, so that the AP forwards ARP packets regardless of whether it has overwritten the MAC address.

This is the **Translation Bridging** feature, which you can enable in the General page of the Configuration web page in the AP. When this feature is disabled, the setting of the **Send Untranslated ARP** parameter has no effect, because all packets are forwarded untranslated (with the source MAC address intact). See Address Resolution Protocol on Page 3-26.

Engineering VLANs

The radios support VLAN functionality as defined in the 802.1Q (Virtual LANs) specification, except for the following aspects of that specification:

- Protocols:
  - Generic Attribute Registration Protocol (GARP) GARV
  - Spanning Tree Protocol (STP)
  - Multiple Spanning Tree Protocol (MSTP)
  - GARP Multicast Registration Protocol (GMRP)
- Embedded source routing (ERIF) in the 802.1Q header
- Multicast pruning
- Flooding unknown unicast frames in the downlink

As an additional exception, the AP/BHM does not flood downward the unknown unicast frames to the SM/BHS.

A VLAN configuration in Layer 2 establishes a logical group within the network. Each computer in the VLAN, regardless of initial or eventual physical location, has access to the same data. For the network operator, this provides flexibility in network segmentation, simpler management, and enhanced security.

Special case VLAN numbers

This system handles special case VLAN numbers according to IEEE specifications:

Table 33 Special case VLAN IDs

VLAN Number	Purpose	Usage Constraint
0	These packets have 802.1p priority, but are otherwise handled as untagged.	Must not be used as a management VLAN.
1	Although not noted as special case by IEEE specifications, these packets identify traffic that was untagged upon ingress into the SM and must remain untagged upon egress. This policy is hard-coded in the AP.	Must not be used for system VLAN traffic.
4095	This VLAN is reserved for internal use.	Must not be used at all.

SM membership in VLANs

With the supported VLAN functionality, the radios determine bridge forwarding on the basis of not only the destination MAC address, but also the VLAN ID of the destination. This provides flexibility in how SMs are used:

- Each SM can be a member in its own VLAN.
- Each SM can be in its own broadcast domain, such that only the radios that are members of the VLAN can see broadcast and multicast traffic to and from the SM.
- The network operator can define a work group of SMs, regardless of the AP(s) to which they register.

PMP 450i modules provide the VLAN frame filters that are described in Table 34.

Table 34 VLAN filters in point-to-multipoint modules

Where VLAN is active, if this parameter value is selected ...	**then a frame is discarded if...**		**because of this VLAN filter in the software:**
	entering the bridge/ NAT switch through...		
	Ethernet...	**TCP/IP...**	
any combination of VLAN parameter settings	with a VID not in the membership table		Ingress
any combination of VLAN parameter settings		with a VID not in the membership table	Local Ingress
Allow Frame Types: Tagged Frames Only	with no 802.1Q tag		Only Tagged
Allow Frame Types: Untagged Frames Only	with an 802.1Q tag, regardless of VID		Only Untagged
Local SM Management: Disable in the SM, or **All Local SM Management: Disable** in the AP	with an 802.1Q tag and a VID in the membership table		Local SM Management
	leaving the bridge/ NAT switch through...		
	Ethernet...	**TCP/IP...**	
any combination of VLAN parameter settings	with a VID not in the membership table		Egress
any combination of VLAN parameter settings		with a VID not in the membership table	Local Egress

Priority on VLANs (802.1p)

The radios can prioritize traffic based on the eight priorities described in the IEEE 802.1p specification. When the high-priority channel is enabled on a SM, regardless of whether VLAN is enabled on the AP for the sector, packets received with a priority of 4 through 7 in the 802.1p field are forwarded onto the high-priority channel.

Operators may configure priority precedence as 802.1p Then Diffserv (Default) or Diffserv Then 802.1p. Since these priority precedence configurations are independent between the AP and SM, this setting must be configured on both the AP and SM to ensure that the precedence is adhered to by both sides of the link.

VLAN settings can also cause the module to convert received non-VLAN packets into VLAN packets. In this case, the 802.1p priority in packets leaving the module is set to the priority established by the DiffServ configuration.

If VLAN is enabled, immediately monitor traffic to ensure that the results are as desired. For example, high-priority traffic may block low-priority.

Q-in-Q DVLAN (Double-VLAN) Tagging (802.1ad)

PMP and PTP modules can be configured with 802.1ad Q-in-Q DVLAN (Double-VLAN) tagging which is a way for an operator to put an 802.1Q VLAN inside of an 802.1ad VLAN. A nested VLAN, which is the original 802.1Q tag and a new second 802.1ad tag, allows for bridging of VLAN traffic across a network and segregates the broadcast domains of 802.1Q VLANs. Q-in-Q can be used with PPPoE and/or NAT.

The 802.1ad standard defines the S-VLAN as the Service Provider VLAN and the C-VLAN as the customer VLAN. The radio software does 2 layer Q-in-Q whereby the C-VLAN is the 802.1Q tag and the S-VLAN is the second layer Q tag as shown in Table 35.

Table 35 Q-in-Q Ethernet frame

Ethernet Header	S-VLAN EthType 0x88a8	C-VLAN EthType 0x8100	IP Data EthType 0x0800

The 802.1ad S-VLAN is the outer VLAN that is configurable on the **Configuration > VLAN** web page of the AP/BHM. The Q-in-Q EtherType parameter is configured with a default EtherType of 0x88a8 in addition to four alternate EtherTypes that can be configured to aid in interoperability with existing networks that use a different EtherType than the default.

The C-VLAN is the inner VLAN tag, which is the same as 802.1Q. As a top level concept, this operates on the outermost tag at any given time, either “pushing” a tag on or “popping” a tag off. This means packets will at most transition from an 802.1Q frame to an 801.ad frame (with a tag “pushed” on) or an untagged 802.1 frame (with the tag “popped” off. Similarly, for an 802.1ad frame, this can only transition from an 802.1ad frame to an 802.1Q frame (with the tag “popped” off) since the radio software only supports 2 levels of tags.

Network management planning

This section describes how to plan for PMP/PTP 450i links to be managed remotely using SNMP.

Planning for SNMP operation

Cambium modules provide the following SNMP traps for automatic notifications to the NMS:

- coldStart, which signals that the SNMPv2c element is reinitializing itself and that its configuration may have been altered.
- warmStart, which signals that the SNMPv2c element is reinitializing such that its configuration is unaltered.
- authenticationFailure, which signals that the SNMPv2c element has received a protocol message that is not properly authenticated (contingent on the snmpEnableAuthenTraps object setting).
- linkDown, as defined in RFC 1573
- linkUp, as defined in RFC 1573
- egpNeighborLoss, as defined in RFC 1213
- whispGPSInSync, which signals a transition from not synchronized to synchronized.
- whispGPSOutSync, which signals a transition from synchronized to not synchronized.
- whispRegComplete, which signals registration completed.
- whispRegLost, which signals registration lost.
- whispRadarDetected, which signals that the one-minute scan has been completed, radar has been detected and the radio will shut down.
- whispRadarEnd, which signals that the one-minute scan has been completed, radar has not been detected and the radio will resume normal operation.

Note

The proprietary MIBs are provided in the PMPT/PTP 450i Series software download files in the support website (see Contacting Cambium Networks on page 1).

Enabling SNMP

Enable the SNMP interface for use by configuring the following attributes in the SNMP Configuration page:

- SNMP State (default disabled)
- SNMP Version (default SNMPv2c)
- SNMP Port Number (default 161)

Security planning

This section describes how to plan for PMP/PTP 450i links to operate in secure mode.

- Managing module access by passwords
- Flitering protocols and ports
- Port Configuration

Isolating AP/BHM from the Internet

Ensure that the IP addresses of the AP/BHM in the network:

- are not routable over the Internet.
- do not share the subnet of the IP address of your user.

RFC 1918, Address Allocation for Private Subnets, reserves for private IP networks three blocks of IP addresses that are not routable over the Internet:

- /8 subnets have one reserved network, 10.0.0.0 to 10.255.255.255.
- /16 subnets have 16 reserved networks, 172.16.0.0 to 172.31.255.255.
- /24 subnets have 256 reserved networks, 192.168.0.0 to 192.168.255.255.

Encrypting radio transmissions

Cambium fixed wireless broadband IP systems employ the following form of encryption for security of the wireless link:

- **DES (Data Encryption Standard)**: An over-the-air link encryption option that uses secret 56-bit keys and 8 parity bits. DES performs a series of bit permutations, substitutions, and recombination operations on blocks of data. DES encryption does not affect the performance or throughput of the system.
- **AES (Advanced Encryption Standard):** An over-the-air link encryption option that uses the Rijndael algorithm and 128-bit keys to establish a higher level of security than DES. AES products are certified as compliant with the Federal Information Processing Standards (FIPS 197) in the U.S.A.

Planning for HTTPS operation

Before starting to configure HTTPS operation, ensure that the cryptographic material listed in Table 36 is available.

Table 36 HTTPS security material

Item	Description	Quantity required
User Defined Security Banner	The banner provides warnings and notices to be read by the user before logging in to the ODU. Use text that is appropriate to the network security policy.	Normally one per link. This depends upon network policy.
Port numbers for HTTP, HTTPS and Telnet	Port numbers allocated by the network.	As allocated by network.

Planning for SNMPv3 operation

SNMP security mode

Decide how SNMPv3 security will be configured.

MIB-based security management uses standard SNMPv3 MIBs to configure the user-based security model and the view-based access control model. This approach provides considerable flexibility, allowing a network operator to tailor views and security levels appropriate for different types of user. MIB-based security management may allow a network operator to take advantage of built-in security management capabilities of existing network managers.

Web-based security management allows an operator to configure users, security levels, privacy and authentication protocols, and passphrases using the PMP/PTP 450i web-based management interface. The capabilities supported are somewhat less flexible than those supported using the MIB-based security management, but will be sufficient in many applications. Selection of web-based management for SNMPv3 security disables the MIB-based security management. PMP/PTP 450i does not support concurrent use of MIB-based and web-based management of SNMPv3 security.

Web-based management of SNMPv3 security

Initial configuration of SNMPv3 security is available only to HTTP or HTTPS user accounts with security role of Security Officer.

Identify the format used for SNMP Engine ID. The following formats are available:

- MAC address (default)
- 5 and 32 hex characters (the hex character input is driven by RFC 3411 recommendations on the Engine ID)

Identify the user names and security roles of initial SNMPv3 users. Two security roles are available:

- Read Only
- System Administrator

Identify the security level for each of the security roles. Three security levels are available:

(a) No authentication, no privacy

(b) Authentication, no privacy

(c) Authentication, privacy

If authentication is required, identify the protocol. The authentication protocol available is MD5.

If privacy will be used, identify the protocol. The privacy protocol available is cbc-des.

Managing module access by passwords

From the factory, each module has a preconfigured administrator-level account in the name `root`, which initially requires no associated password. When you upgrade a module:

- An account is created in the name `admin`.
- Both `admin` and `root` inherit the password that was previously used to access the module, if:
  - **Full Access** password, if one was set.
  - **Display-Only Access** password, if one was set and no Full Access password was set.

⚠ **Caution**

If you use Wireless Manager, do not delete the root account from any module. If you use a NMS that communicates with modules through SNMP, do not delete the root account from any module unless you first can confirm that the NMS does not rely on the root account for access to the modules.

Each module supports four or fewer user accounts, regardless of account levels. The available levels are

- ADMINISTRATOR, who has full read and write permissions. This is the level of the `root` and `admin` users, as well as any other administrator accounts that one of them creates.
- INSTALLER, who has permissions identical to those of ADMINISTRATOR except that the installer cannot add or delete users or change the password of any other user.
- TECHNICIAN, who has permissions to modify basic radio parameters and view informational web pages.
- GUEST, who has no write permissions and only a limited view of General Status tab.
- Admin, Installer and Tech accounts can be configured as READ-ONLY. This will allow the account to only see the items.

The ability to view information of General Status tab can be controlled by the "Site Information Viewable to Guest Users" under the SNMP tab.

From the factory default state, configure passwords for both the `root` and `admin` account at the ADMINISTRATOR permission level, using the **Account > Change Users Password** page. (If configure only one of these, then the other will still require no password for access into it and thus remain a security risk.) If you are intent on configuring only one of them, delete the `admin` account. The `root` account is the only account that CNUT uses to update the module.

After a password has been set for any ADMINISTRATOR-level account, initial access to the module GUI opens the view of GUEST level.

Planning for RADIUS operation

Configure RADIUS where remote authentication is required for users of the web-based interface. Remote authentication has the following advantages:

- Control of passwords can be centralized.
- Management of user accounts can be more sophisticated. For example; users can be prompted by a network manager to change passwords at regular intervals. As another example, passwords can be checked for inclusion of dictionary words and phrases.
- Passwords can be updated without reconfiguring multiple network elements.
- User accounts can be disabled without reconfiguring multiple network elements.

Remote authentication has one significant disadvantage in a wireless link product such as PMP/PTP 450i. If the wireless link is down, a unit on the remote side of the broken link may be prevented from contacting a RADIUS Server, with the result that users are unable to access the web-based interface.

One useful strategy would be to combine RADIUS authentication for normal operation with a single locally-authenticated user account for emergency use.

PMP 450i SM provides a choice of the following authentication methods:

- EAP-MSCHAPv2
- EAP-TTLS

Ensure that the authentication method selected in PMP/PTP 450i is supported by the RADIUS server.

Filtering protocols and ports

Configure filters for specified protocols and ports from leaving the AP/BHM and SM/BHS and entering the network. This protects the network from both intended and inadvertent packet loading or probing by network users. By keeping the specified protocols or ports off the network, this feature also provides a level of protection to users from each other.

Protocol and port filtering is set per AP/SM/BH. Except for filtering of SNMP ports, filtering occurs as packets leave the AP/SM/BH.

For example, if SM is configured to filter SNMP, then SNMP packets are blocked from entering the SM and, thereby, from interacting with the SNMP portion of the protocol stack on the SM.

Port Filtering with NAT Enabled

Where NAT is enabled on the SM/BHS, the filtering can be enabled for only the user-defined ports. The following are examples for situations where the configure port can be filtered where NAT is enabled:

- To block a subscriber from using FTP, you can filter Ports 20 and 21 (the FTP ports) for both the TCP and UDP protocols.
- To block a subscriber from access to SNMP, you can filter Ports 161 and 162 (the SNMP ports) for both the TCP and UDP protocols.

Note

In only the SNMP case, filtering occurs before the packet interacts with the protocol stack.

Protocol and Port Filtering with NAT Disabled

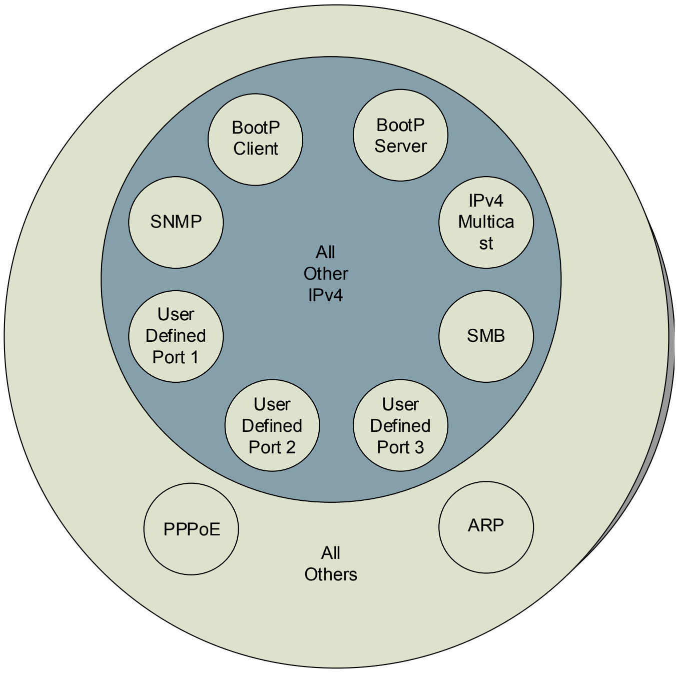
Where NAT is disabled on the SM/BHS, the filtering can be enabled for both protocols and the three user-defined ports. Using the check boxes on the interface, it can be either:

- Allow all protocols except those that user wish to block.
- Block all protocols except those that user wish to allow.

Allow or block any of the following protocols:

- PPPoE (Point to Point Protocol over Ethernet)
- Any or all of the following IPv4 (Internet Protocol version 4) protocols:
- Any or all of the following IPv4 (Internet Protocol version 4) protocols:
  - SMB (Network Neighborhood)
  - SNMP
  - Bootp Client
  - Bootp Server
  - Up to 3 user-defined ports
  - All other IPv4 traffic (see Figure 29)
- Any or all of the following IPv6 (Internet Protocol version 6) protocols:
  - SMB (Network Neighborhood)
  - SNMP
  - Bootp Client
  - Bootp Server
  - Up to 3 user-defined ports
  - All other IPv6 traffic (see Figure 29)
- Filter Direction – Upstream and Downstream
- ARP (Address Resolution Protocol)

Figure 26 Categorical protocol filtering



The following are example situations in which the protocol filtering is configured where NAT is disabled:

- If a subscriber is blocked from only PPPoE and SNMP, then the subscriber retains access to all other protocols and all ports.
- If PPPoE, IPv4, and Uplink Broadcast are blocked, and also check the **All others** selection, then only Address Resolution Protocol is not filtered.

The ports filtered as a result of protocol selections in the **Protocol Filtering** tab of the SM/BHS are listed in Table 37.

Table 37 Ports filtered per protocol selections

Protocol Selected	Port Filtered (Blocked)
SMB	Destination Ports UDP : 137, 138, 139, 445, 3702 and 1900 Destination Ports TCP : 137, 138, 139, 445, 2869, 5357 and 5358
SNMP	Destination Ports TCP and UDP : 161 and 162
Bootp Client	Source Port 68 UDP
Bootp Server	Source Port 67 UDP
User Defined Port 1..3	User defined ports for filtering UDP and TCP
IPv4 Multicast	Block IPv4 packet types except other filters defined
IPv6 Multicast	Block IPv6 packet types except other filters defined
ARP	Filter all Ethernet packet type 806
Upstream	Applies packet filtering to traffic coming into the FEC interface
Downstream	Applies packet filtering to traffic destined to exit the FEC interface

Port Configuration

PMP/PTP 450i supports access to various communication protocols and only the ports required for these protocols are available for access by external entities. Operators may change the port numbers for these protocols via the radio GUI or SNMP.

Table 38 Device default port numbers

Port	Usage	Port Usage	Device
21	FTP	Listen Port	AP, SM
80	HTTP	Listen Port	AP, SM
443	HTTPs	Listen Port	AP, SM
161	SNMP port	Listen Port	AP, SM
162	SNMP trap port	Destination Port	AP, SM
514	Syslog Server port	Destination Port	AP, SM
1812	Standard RADIUS port	Destination Port	AP
1813	Standard RADIUS accounting port	Destination Port	AP, SM

Encrypting downlink broadcasts

An AP can be enabled to encrypt downlink broadcast packets such as the following:

- ARP
- NetBIOS
- broadcast packets containing video data on UDP.

The encryption used is DES for a DES-configured module and AES for an AES-configured module. Before the Encrypt Downlink Broadcast feature is enabled on the AP, air link security must be enabled on the AP.

Isolating SMs in PMP

In an AP, SMs in the sector can be prevented from directly communicating with each other. In CMM4, the connected APs can be prevented from directly communicating with each other, which prevents SMs that are in different sectors of a cluster from communicating with each other.

In the AP, the **SM Isolation** parameter is available in the General tab of the Configuration web page. Configure the SM Isolation feature by any of the following selections from drop-down menu:

- **Disable SM Isolation** (the default selection). This allows full communication between SMs.
- **Enable Option 1 - Block SM destined packets from being forwarded**. This prevents both multicast/broadcast and unicast SM-to-SM communication.
- **Enable Option 2 - Forward SM destined packets upstream**. This not only prevents multicast/broadcast and unicast SM-to-SM communication but also sends the packets, which otherwise may have been handled SM to SM, through the Ethernet port of the AP.

In the CMM and the CMM4, SM isolation treatment is the result of how to manage the port-based VLAN feature of the embedded switch, where all traffic can be switched from any AP to a specified uplink port. However, this is not packet level switching. It is not based on VLAN IDs.

Filtering management through Ethernet

Configure the SM to disallow any device that is connected to its Ethernet port from accessing the IP address of the SM. If the **Ethernet Access Control** parameter is set to **Enabled**, then:

- No attempt to access the SM management interface (by http, SNMP, ftp, or tftp) through Ethernet is granted.
- Any attempt to access the SM management interface over the air (by IP address, presuming that **LAN1 Network Interface Configuration, Network Accessibility** is set to **Public**, or by link from the Session Status or Remote Subscribers tab in the AP) is unaffected.

Allowing management from only specified IP addresses

The Security sub-menu of the Configuration web page in the AP/BHM and SM/BHS includes the **IP Access Control** parameter. Specify one, two, or three IP addresses that must be allowed to access the management interface (by HTTP, SNMP, FTP or TFTP).

If the selection is:

- **IP Access Filtering** Disabled, then management access is allowed from any IP address, even if the Allowed Source IP 1 to 3 parameters are populated.
- **IP Access Filtering** Enabled, and specify at least one address in the Allowed Source IP 1 to 3 parameter, then management access is limited to the specified address(es).

Configuring management IP by DHCP

The **Configuration > IP** web page of every radio contains a **LAN1 Network Interface** Configuration, DHCP State parameter that, if enabled, causes the IP configuration (IP address, subnet mask, and gateway IP address) to be obtained through DHCP instead of the values of those individual parameters. The setting of this DHCP state parameter is also viewable, but is not settable, in the Network Interface tab of the Home page.

In the SM/BHS, this parameter is settable

- in the **NAT** tab of the Configuration web page, but only if NAT is enabled.
- in the **IP** tab of the Configuration web page, but only if the Network Accessibility parameter in the IP tab is set to Public.

Controlling PPPoE PADI Downlink Forwarding

The AP supports the control of forwarding of PPPoE PADI (PPPoE Active Discovery Initiation) packets. This forwarding is configured on the AP GUI **Configuration > Radio** page by parameter **PPPoE PADI Downlink Forwarding**. When set to “Enabled”, the AP allows downstream and upstream transmission of PPPoE PADI packets. When set to “Disabled”, the AP does NOT allow PPPoE PADI packets to be sent out of the AP RF interface (downstream) but will allow PPPoE PADI packets to enter the RF interface (upstream) and exit the Ethernet interface.

Chapter 4: Legal and regulatory information

This chapter provides end user license agreements and regulatory notifications.

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- Compliance with radio regulations on page 4-27 describes how the PMP/PTP 450i complies with the radio regulations that are in force in various countries, and contains notifications made to regulatory bodies for the PMP/PTP 450i.

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February 14, 2009

Bzip2

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USB library functions

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Compliance with safety standards

This section lists the safety specifications against which the PMP/PTP 450i has been tested and certified. It also describes how to keep RF exposure within safe limits.

Electrical safety compliance

The PMP/PTP 450i hardware has been tested for compliance to the electrical safety specifications listed in Table 39.

Table 39 PMP/PTP 450i safety compliance specifications

Region	Standard
USA	UL 60950-1, 2nd Edition; UL60950-22
Canada	CAN/CSA C22.2 No.60950-1-07, 2nd Edition; CAN/CSA C22.2 No.60950-22-07
EU	EN 60950-1:2006 + Amendment 12:2011, EN 60950-22
International	CB certified to IEC 60950-1: 2005 (modified); IEC 60950-22: 2005 (modified)

Electromagnetic compatibility (EMC) compliance

The PMP/PTP 450i complies with European EMC Specification EN301 489-1 with testing carried out to the detailed requirements of EN301 489-4.

Note

For EN 61000-4-2: 1995 to 2009 Electro Static Discharge (ESD), Class 2, 8 kV air, 4 kV contact discharge, the PMP/PTP 450i has been tested to ensure immunity to 15 kV air and 8 kV contact.

Table 40 lists the EMC specification type approvals that have been granted for PMP/PTP 450i products.

Table 40 EMC emissions compliance

Region	Specification (Type Approvals)
Europe	ETSI EN301 489-4

Human exposure to radio frequency energy

Relevant standards (USA and EC) applicable when working with RF equipment are:

- ANSI IEEE C95.1-1991, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
- Council recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC) and respective national regulations.
- *Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004* on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).
- US FCC limits for the general population. See the FCC web site at http://www.fcc.gov, and the policies, guidelines, and requirements in Part 1 of Title 47 of the Code of Federal Regulations, as well as the guidelines and suggestions for evaluating compliance in FCC OET Bulletin 65.
- Health Canada limits for the general population. See the Health Canada web site at http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/99ehd-dhm237/limits-limites_e.html and Safety Code 6.
- EN 50383:2002 to 2010 Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunication systems (110 MHz - 40 GHz).
- BS EN 50385:2002 Product standard to demonstrate the compliances of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz – 40 GHz) – general public.
- ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines for the general public. See the ICNIRP web site at http://www.icnirp.de/ and Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields.

Power density exposure limit

Install the radios for the PMP/PTP 450i family of wireless solutions so as to provide and maintain the minimum separation distances from all persons.

The applicable power density exposure limit for RF energy in the 4.9, 5.4 and 5.8 GHz frequency bands is **10 W/m^2**. For more information, see Human exposure to radio frequency energy on page 4-23.

Calculation of power density

The following calculation is based on the ANSI IEEE C95.1-1991 method, as that provides a worst case analysis. Details of the assessment to EN50383:2002 can be provided, if required.

Peak power density in the far field of a radio frequency point source is calculated as follows:

$$S = \frac{P.G}{4\pi d^2}$$

Where:	Is:
S	power density in W/m^2
P	maximum average transmit power capability of the radio, in W
G	total Tx gain as a factor, converted from dB
d	distance from point source, in m

Rearranging terms to solve for distance yields:

$$d = \sqrt{\frac{P.G}{4\pi.S}}$$

Calculated distances and power compliance margins

Table 41 and Table 42 shows calculated minimum separation distances, recommended distances and resulting margins for each frequency band and antenna combination for the USA and Canada. These are conservative distances that include compliance margins. At these and greater separation distances, the power density from the RF field is below generally accepted limits for the general population.

PMP 450i equipment adheres to all applicable EIRP limits for transmit power when operating in MIMO mode. Separation distances and compliance margins include compensation for both transmitters.

Explanation of terms used in Table 41 and Table 42:

P burst – maximum average transmit power during transmit burst (Watt)

P – maximum average transmit power of the radio (Watt)

G – total transmit gain as a factor, converted from dB

S – power density (Watt/m2)

d – minimum safe separation distance from point source (meters)

Table 41 FCC minimum safe distances

Band	Antenna	P burst (W)	P (W)	G (dBi)	S (W/ m$_2$)	d (m)
4.9 GHz	Omni-directional	0.25	0.21	20.0 (13 dBi)	10.0	0.17
	90° sector	0.25	0.21	50.0 (17 dBi)	10.0	0.26
	2ft directional flat plate	0.25	0.21	631.0 (28 dBi)	10.0	0.93
	4ft directional parabolic	0.10	0.85	2344.0 (34.9 dBi)	10.0	1.14
	6ft directional parabolic	0.04	0.03	5248.0 (37.2 dBi)	10.0	1.07
5.1 GHz	Omni-directional	0.1700	0.2000	20.0 (10 dBi)	10.0	0.15
	90° sector	0.0339	0.0398	50.0 (17 dBi)	10.0	0.10
	2ft directional flat plate	0.0017	0.0020	708.0 (28.5 dBi)	10.0	0.09
	4ft directional parabolic	0.1070	0.0126	3388.0 (35.3 dBi)	10.0	0.44
5.8 GHz	Omni-directional	0.28	0.24	20.0 (13 dBi)	10.0	0.18
	90° sector	0.12	0.10	50.0 (17 dBi)	10.0	0.18
	2ft directional flat plate	0.63	0.54	708.0 (28.5 dBi)	10.0	1.57
	4ft directional parabolic	0.63	0.54	3388.0 (35.3 dBi)	10.0	3.43
	6ft directional parabolic	0.63	0.54	6457.0 (38.1 dBi)	10.0	4.74

Table 42 IC minimum safe distances

Band	Antenna	P burst (W)	P (W)	G (dBi)	S (W/ m$_2$)	d (m)
4.9 GHz	Omni-directional	0.25	0.17	20.0 (13 dBi)	10.0	0.17
	90° sector	0.25	0.17	50.1 (17 dBi)	10.0	0.26
	2ft directional flat plate	0.25	0.17	631.0 (28 dBi)	10.0	0.93
	6ft directional parabolic	0.17	0.11	5248.0 (37.2 dBi)	10.0	2.19
5.8 GHz	Omni-directional	0.28	0.19	20.0 (13 dBi)	10.0	0.18
	90° sector	0.12	0.08	50.1 (17 dBi)	10.0	0.18
	2ft directional flat plate	0.63	0.44	707.9 (28.5 dBi)	10.0	1.57
	4ft directional parabolic	0.63	0.44	3388.4 (35.3 dBi)	10.0	3.43

(*1) P: maximum average transmit power capability of the radio including cable loss (Watt)

Capacité de puissance d'émission moyenne maximale de la radio comprenant la perte dans les câble de connexion (W)

(*2) G: total transmit gain as a factor, converted from dB

Gain total d'émission, converti à partir de la valeur en dB

(*3) S: power density (W/m^2)

Densité de puissance (W/m^2)

(*4) d: minimum distance from point source (meters)

Distance minimale de source ponctuelle (en mètres)

Note

Gain of antenna in dBi = 10 * log(G).

The regulations require that the power used for the calculations is the maximum power in the transmit burst subject to allowance for source-based time-averaging.

At 5.4 GHz and EU 5.8 GHz, the products are generally limited to a fixed EIRP which can be achieved with the Integrated Antenna. The calculations above assume that the maximum EIRP allowed by the regulations is being transmitted.

Remarque

Gain de l'antenne en dBi = 10 * log(G).

Les règlements exigent que la puissance utilisée pour les calculs soit la puissance maximale de la rafale de transmission soumis à une réduction pour prendre en compte le rapport cyclique pour les signaux modulés dans le temps.

Pour une opération dans la CEE dans les bandes 5,4 GHz et 5,8 GHz, les produits sont généralement limités à une PIRE qui peut être atteinte avec l'antenne intégrée. Les calculs ci-dessus supposent que la PIRE maximale autorisée par la réglementation est atteinte.

Note

If there are no EIRP limits in the country of deployment, use the distance calculations for FCC 5.8 GHz for all frequency bands.

At FCC 5.8 GHz, for antennas between 0.6m (2ft) and 1.8m (6ft), alter the distance proportionally to the antenna gain.

Remarque

Si aucune limite de PIRE existe pour le pays de déploiement, utilisez les calculs de distance pour FCC 5,8 GHz pour toutes les bandes de fréquence.

Pour la band FCC 5,8 GHz et les antennes entre 0,6 m (2 pieds) et 1,8 m (6 pieds), modifier la distance proportionnellement au gain de l'antenne.

Compliance with radio regulations

This section describes how the PMP/PTP 450i complies with the radio regulations that are in force in various countries.

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Where necessary, the end user is responsible for obtaining any National licenses required to operate this product and these must be obtained before using the product in any particular country. Contact the appropriate national administrations for details of the conditions of use for the bands in question and any exceptions that might apply.

Caution

Changes or modifications not expressly approved by Cambium Networks could void the user's authority to operate the system.

Caution

For the connectorized version of the product and in order to reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the Effective Isotropically Radiated Power (EIRP) is not more than that permitted for successful communication.

Attention

Le cas échéant, l'utilisateur final est responsable de l'obtention des licences nationales nécessaires pour faire fonctionner ce produit. Celles-ci doivent être obtenus avant d'utiliser le produit dans un pays particulier. Contactez les administrations nationales concernées pour les détails des conditions d'utilisation des bandes en question, et toutes les exceptions qui pourraient s'appliquer

Attention

Les changements ou modifications non expressément approuvés par les réseaux de Cambium pourraient annuler l'autorité de l'utilisateur à faire fonctionner le système.

Attention

Pour la version du produit avec une antenne externe, et afin de réduire le risque d'interférence avec d'autres utilisateurs, le type d'antenne et son gain doivent être choisis afin que la puissance isotrope rayonnée équivalente (PIRE) ne soit pas supérieure au minimum nécessaire pour établir une liaison de la qualité requise.

Type approvals

The system has been tested against various local technical regulations and found to comply. Table 43 to Table 44 list the radio specification type approvals that have been granted for PTP 450i products.

Some of the frequency bands in which the system operates are "license exempt" and the system is allowed to be used provided it does not cause interference. In these bands, the licensing authority does not guarantee protection against interference from other products and installations.

Table 43 Radio certifications (4.9 GHz)

Region	Regulatory approvals
USA	FCC 47 CFR Part 90
Brazil	ANATEL Certification No: 0934-06-3277

Table 44 Radio certifications (5.1 GHz)

Region	Regulatory approvals
USA	FCC 47 CFR Part 15 E

Table 45 Radio certifications (5.8 GHz)

Region	Regulatory approvals
USA	FCC 47 CFR Part 15 C

Chapter 5: Preparing for installation

This chapter describes how to stage and test the hardware for a PMP 450 network. This chapter is arranged as follows:

- Safety on page 5-2: Describes the precautions to be observed and checks to be performed before proceeding with the installation
- Preparing for installation on page 5-5: Describes the pre-configration procedure before proceed with installation.
- Testing system components on page 5-7: Describes the procedures for unpacking and performing and initial staging of the PMP/PTP 450i equipment
- Configuring Link for Test on page 5-15: Describes the procedures for testing the equipment's radio links.

Safety

Warning

To prevent loss of life or physical injury, observe the following safety guidelines. In no event shall Cambium Networks be liable for any injury or damage caused during the installation of the Cambium PMP/PTP 450i. Ensure that only qualified personnel install a PMP/PTP 450i link.

Power lines

Exercise extreme care when working near power lines.

Working at heights

Exercise extreme care when working at heights.

Power supply

Always use one of the Cambium PMP/PTP 450i Series power supply units (PSU) to power the ODU. Failure to use a Cambium supplied PoE could result in equipment damage and will invalidate the safety certification and may cause a safety hazard.

Grounding and protective earth

The Outdoor Unit (ODU) must be properly grounded to protect against lightning. It is the user's responsibility to install the equipment in accordance with national regulations. In the USA follow the requirements of the National Electrical code NFPA 70-2005 and 780-2004 *Installation of Lightning Protection Systems*. In Canada, follow Section 54 of the *Canadian Electrical Code*. These codes describe correct installation procedures for grounding the outdoor unit, mast, lead-in wire and discharge unit, size of grounding conductors and connection requirements for grounding electrodes. Other regulations may apply in different countries and therefore it is recommended that installation of the outdoor unit be contracted to a professional installer.

Powering down before servicing

Always power down and unplug the equipment before servicing.

Primary disconnect device

The ODU power supply is the primary disconnect device.

External cables

Safety may be compromised if outdoor rated cables are not used for connections that will be exposed to the outdoor environment. For outdoor copper Cat5e Ethernet interfaces, always use Cat5e cable that is gel-filled and shielded with copper-plated steel.

RF exposure near the antenna

Strong radio frequency (RF) fields will be present close to the antenna when the transmitter is on. Always turn off the power to the ODU before undertaking maintenance activities in front of the antenna.

Minimum separation distances

Ensure that personnel are not exposed to unsafe levels of RF energy. The units start to radiate RF energy as soon as they are powered up. Never work in front of the antenna when the ODU is powered. Install the ODUs so as to provide and maintain the minimum separation distances from all persons. For minimum separation distances, see Calculated distances and power compliance margins on page 4-24.

Grounding and lightning protection requirements

Ensure that the installation meets the requirements defined in Grounding and lightning protection on page 3-8.

Grounding cable installation methods

To provide effective protection against lightning induced surges, observe these requirements:

- Grounding conductor runs are as short, straight and smooth as possible, with bends and curves kept to a minimum.
- Grounding cables must not be installed with drip loops.
- All bends must have a minimum radius of 200 mm (8 in) and a minimum angle of 90°. A diagonal run is preferable to a bend, even though it does not follow the contour or run parallel to the supporting structure.
- All bends, curves and connections must be routed towards the grounding electrode system, ground rod, or ground bar.

- Grounding conductors must be securely fastened.
- Braided grounding conductors must not be used.
- Approved bonding techniques must be used for the connection of dissimilar metals.

Siting ODUs and antennas

ODUs, external antennas and GPS receivers are not designed to survive direct lightning strikes. For this reason they must be installed in Zone B as defined in Lightning protection zones on page 3-9. Mounting in Zone A may put equipment, structures and life at risk.

Thermal Safety

The ODU enclosure may be hot to the touch when in operation. The ODU must not be operated in ambient temperatures exceeding 40°C unless mounted in a Restricted Access Location. For more information, see ODU ambient temperature limits on page 3-10.

⚠	**Warning** Do not install the ODU in a location where the ambient temperature could exceed 40°C unless this is a Restricted Access Location as defined by EN 60950-1.
⚠	**Alerte** L’unité externe ne doit pas être installée dans un endroit où la température ambiante est supérieure à 40C à moins que l’accès soit limité au personnel autorisé.

Preparing for installation

ODU pre-configuration

It is common practice to pre-configure the units during staging before site installation by performing the following tasks:

- Connecting to the unit
- Configuring IP and Ethernet interfaces
- Upgrading the software version and using CNUT
- Configuring General and Unit Settings
- Configuring security
- Configuring radio parameters
- Setting up SNMP agent
- Configuring syslog
- Configuring remote access
- Monitoring the Link
- Configuring quality of service
- Zero Touch Configuration Using DHCP Option 66
- Configuring Radio via config file
- Configuring a RADIUS server

If the units are to be pre-configured during staging, the safety precautions below MUST be observed.

Preparing personnel

In no event shall Cambium Networks be liable for any injury or damage caused during the installation of the Cambium PMP/PTP 450i equipment.

Ensure that only qualified personnel undertake the installation of a PMP/PTP 450i system.

Ensure that all safety precautions are observed.

Preparing inventory

Perform the following inventory checks:

- Check that the correct components are available, as described in Ordering the components on page 2-26.
- Check the contents of all packages against their packing lists.

Preparing tools

Check that following specific tools are available, in addition to general tools:

- RJ45 crimp tool (it must be the correct tool for the type of RJ45 being used).
- Personal Computer (PC) with 10 or 100 or 1000 BaseT Ethernet port
- Internet Explorer or Firefox
- Ethernet patch cables

Testing system components

The best practice is to connect all components—AP/BHM, SMs/BHS, GPS antenna (if applicable) and CMM (if applicable)—in a test setting and initially configure and verify them before deploying them to an installation. In this way, any configuration issues are worked out before going on-site, on a tower, in the weather, where the discovery of configuration issues or marginal hardware is more problematic and work-flow affecting.

Unpacking Components

When a delivery arrives, inspect all packages immediately for damages.

Carefully unpack the equipment, verify that all the components have arrived as per order and are in good condition. Save all packaging materials for equipment transportation to the installation site.

Preparing the ODU

After the equipment is unpacked, the units may be configured for staging tests.

Use either of two methods to configure an AP/BHM:

- Use the Quick Start feature of the product (via GUI menu **Quick Start**)
- Manually set each parameter

After changing configuration parameters on a GUI web page:

- Before you leave a web page, click the **Save** button to save the change(s)
- After making change(s) on multiple web pages, click the **Reboot** button to reboot the module and implement the change(s)

Configuring the Computing Device for Test

If the computer is configured for Dynamic Host Configuration Protocol (DHCP), disconnect the computer from the network. If the computer is instead configured for static IP addressing

- Set the static address in the 169.254 network
- Set the subnet mask to 255.255.0.0.

For detailed instructions, see section Configuring the management PC on page 5-15.

Factory default Configuration

From the factory, the APs/BHMs and SMs/BHSs are all configured to *not transmit* on any frequency. This configuration ensures that equipment operators do not accidentally turn on an unsynchronized module. Site synchronization of modules is required because

- modules:
  - cannot transmit and receive signals at the same time.
  - use TDD (Time Division Duplexing) to distribute signal access of the downlink and uplink frames.
- when one module transmits while an unintended module nearby receives signal, the transmitting module may interfere with or desense the receiving module. In this context, interference is self-interference (within the same network).

ODU interfaces

See section AP/SM/BHM/BHS interfaces on page 2-5

ODU diagnostic LEDs

See section AP/BHM LEDs on page 2-7.

See section SM/BHS LEDs on page 2-7.

Recommended Tools for Installation

The following tools may be needed for installation:

Table 46 Tools for PMP and PTP 450i equipment installation

Equipment to Be Installed	Tools Required
AP or BHM	• 3 mm Allen Wrench Used for connecting the antenna mating bracket to the rear of the AP housing • Crescent Wrench Pair Used for tightening cable glands • Self-amalgamating and PVC Tape Used for weatherproofing N-type connections

Equipment to Be Installed	Tools Required
AP or BHM or BHS Antenna	• 13 mm Spanner Wrench (or Ratchet Spanner Wrench) Pair Used for connecting the antenna (sector or omni for AP, or directional for BH)base to the pole/mast mounting bracket • Self-amalgamating and PVC Tape Used for weatherproofing N-type connections • N-type Torque Wrench (not required but recommended) Used for assuring proper tightening of N-type connectors terminating the RF cables
SM	• Wrench/driver (depending on operator's choice of clamps) Used for tightening clamps to the pole • Alignment tone adapter / headset Used for aligning the SM to the AP
Universal Global Positioning System	• Philips Screwdriver Used for attaching the UGPS unit to the pole/mast mounting bracket • 13mm Spanner Wrench (or Ratchet Spanner Wrench) Used for connecting the mounting bracket's U-bolt to the antenna or mast
Cabling	• Electrician's Scissors or Wire Cutters Used for cutting wire to length • RJ-11/RJ-45 Crimping Tool Used for stripping RJ-11/RJ-45 cables and for terminating cable ends • Cable Testing Device Used to ensure that cables are properly constructed

Standards for Wiring

Modules automatically sense whether the Ethernet cable in a connection is wired as straight-through or crossover. Operators may use either straight-through or crossover cable to connect a network interface card (NIC), hub, router, or switch to these modules. For a straight-through cable, use the EIA/TIA-568B wire color-code standard on both ends. For a crossover cable, use the EIA/TIA-568B wire color-code standard on one end, and the EIA/TIA-568A wire color-code standard on the other end.

Best Practices for Cabling

The following practices are essential to the reliability and longevity of cabled connections:

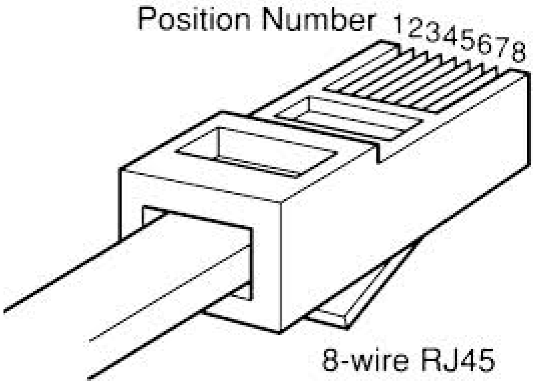
- Use only shielded cables to resist interference.
- For vertical runs, provide cable support and strain relief.
- Include a 2-ft (0.6-m) service loop on each end of the cable to allow for thermal expansion and contraction and to facilitate terminating the cable again when needed.
- Include a drip loop to shed water so that most of the water does not reach the connector at the device.
- Properly crimp all connectors.
- Use dielectric grease on all connectors to resist corrosion.
- Use only shielded connectors to resist interference and corrosion.

Wiring Connectors

The following diagrams correlate pins to wire colors and illustrate crossovers where applicable.

Pin 1, relative to the lock tab on the connector of a straight-through cable is located as shown below.

Figure 27 Pin 1 location



Main port pinout

Table 47 Main port pinout

RJ45 pin	Description
1	+TxRx0
2	–TxRx0
3	+TxRx1
4	+TxRx2
5	–TxRx2
6	–TxRx1
7	+TxRx3
8	–TxRx3

Aux port pinout

Table 48 Aux port pinout

RJ45 pin	Description
1	+TxRx0
2	–TxRx0
3	+TxRx1
4	GPS power out, Alignment tone out, GPS data out
5	GPS data in
6	–TxRx1
7	GPS 0v
8	GPS Sync in