Cambium Networks

ePMP™

User Guide
For Regulatory Review Only

System Release 2.6.1

- Product Description
- System Planning
- Configuration
- Operation and Troubleshooting
- Legal and Reference Information

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Safety and regulatory information

This section describes important safety and regulatory guidelines that must be observed by personnel installing or operating ePMP equipment.

IMPORTANT SAFETY INFORMATION

 Warning

To prevent loss of life or physical injury, observe the safety guidelines in this section.

Power lines

Exercise extreme care when working near power lines.

Working at heights

Exercise extreme care when working at heights.

Grounding and protective earth

Connectorized ePMP devices 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 Section 810 of the *National Electric Code, ANSI/NFPA No.70-1984* (USA). 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 be contracted to a professional installer.

Powering down before servicing

Always power down and unplug the equipment before servicing.

Primary disconnect device

The ePMP 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.

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 ePMP device before undertaking maintenance activities in front of the antenna.

Minimum separation distances

Install the ePMP device so as to provide and maintain the minimum separation distances from all persons.

The minimum separation distances for each frequency variant are specified in Calculated distances and power compliance margins on page 193.

IMPORTANT REGULATORY INFORMATION

The ePMP 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).

Radar avoidance

In countries where radar systems are the primary band users, the regulators have mandated special requirements to protect these systems from interference caused by unlicensed devices. Unlicensed devices must detect and avoid co-channel operation with radar systems.

The ePMP provides detect and avoid functionality for countries and frequency bands requiring protection for radar systems.

Installers and users must meet all local regulatory requirements for radar detection. To meet these requirements, users must set the correct country code during commissioning of the ePMP equipment. If this is not done, installers and users may be liable to civil and criminal penalties.

Contact the Cambium helpdesk if more guidance is required.

USA and Canada specific information

The USA Federal Communications Commission (FCC) has asked 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 ePMP for operation in the USA or Canada. These variants are only allowed to operate with license keys and country codes that comply with FCC/IC rules. In particular, operation of radio channels overlapping the band 5600-5650 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.

 Note

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 Avoidance of weather radars on page 86.

Other variants of the ePMP are available for use in the rest of the world, but these variants are not supplied to the USA or Canada except under strict controls, when they are needed for export and deployment outside the USA or Canada.

Specific expertise and training required for professional installers

To ensure that the ePMP 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. This is particularly important when installing and configuring an ePMP system for operation in the 5 GHz band (5150 – 5250 MHz – FCC only, 5250 – 5350 MHz, 5470 – 5725 MHz and 5725 – 5850 MHz).

Avoidance of weather radars

The installer must be familiar with the requirements in FCC KDB 443999. Essentially, the installer must be able to:

- Access the FCC database of weather radar location and channel frequencies.
- Use this information to correctly configure the product (using the GUI) to avoid operation on channels that must be avoided according to the guidelines that are contained in the KDB and explained in detail in this user guide.

In ETSI regions, the band 5600 MHz to 5650 MHz is reserved for the use of weather radars.

External antennas

When using a connectorized version of the product (as compared to the version with an integrated antenna), the conducted transmit power must 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 antenna cable losses.

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 are entered into the GUI.

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 ePMP can be found in section System planning on page 82.

Training

The installer needs to have basic competence in radio and IP network installation. The specific requirements applicable to the ePMP must be gained by reading this user guide and by performing sample setups at base workshop before live deployments.

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About This User Guide

This guide describes the planning, installation, configuration and operation of the Cambium ePMP Series of point-to-multipoint wireless Ethernet systems. It is intended for use by the system designer, system installer and system administrator.

For radio network design, see:

- Product description
- System hardware
- System planning
- Legal and reference information

For system configuration, monitoring and fault finding, see:

- Configuration
- Operation and Troubleshooting

For radio equipment installation, refer to the following guides:

- The *ePMP Quick Start Guide*
- The *ePMP Installation Guide*

 Note

The *ePMP Installation Guide* is reproduced as an addendum to this user guide.

General information

VERSION INFORMATION

The following shows the issue status of this document:

Issue	Date of issue	Remarks
001v000	October 2013	System Release 1.0 (Software Release 1.1.6)
002v000	December 2013	System Release 1.0 (Software Release 1.2.3)
003v000	January 2014	System Release 1.0 (Software Release 1.3.4)
004v000	March 2014	System Release 1.0 (Software Release 1.4.1)
005v000	March 2014	System Release 1.0 (Software Release 1.4.3)
006v000	April 2014	System Release 1.0 (Software Release 1.4.4)
007v000	June 2014	System Release 2.0 (Software Release 2.0)
008v000	July 2014	System Release 2.1 (Software Release 2.1)
010v000	September 2014	System Release 2.2 (Software Release 2.2)
011v000	October 2014	System Release 2.3 (Software Release 2.3)
012v000	November 2014	System Release 2.3.1 (Software Release 2.3.1)
013v000	December 2014	System Release 2.3.3 (Software Release 2.3.3)
014v000	December 2014	System Release 2.3.4 (Software Release 2.3.4)
015v000	March 2015	System Release 2.4 (Software Release 2.4)
016v000	April 2015	System Release 2.4.1 (Software Release 2.4.1) System Release 2.4.2 (Software Release 2.4.2)
017v000	June 2015	System Release 2.4.3 (Software Release 2.4.3)
018v000	August 2015	System Release 2.5 (Software Release 2.5)
019v000	October 2015	System Release 2.5.1 (Software Release 2.5.1)
020v000	November 2015	System Release 2.5.2 (Software Release 2.5.2)
021v000	December 2015	System Release 2.6 (Software Release 2.6)
022v000	February 2016	System Release 2.6.1 (Software Release 2.6.1)
023v000	June 2016	ePMP 2000 Release

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
Telephone number list:	http://www.cambiumnetworks.com/support/contact-support/
Address:	Cambium Networks Limited, 3800 Golf Road, Suite 360 Rolling Meadows, IL 60008

Purpose

Cambium Networks ePMP documents are intended to instruct and assist personnel in the operation, installation and maintenance of the Cambium ePMP equipment and ancillary devices. It is recommended that all personnel engaged in such activities be properly trained.

Cambium disclaims all liability whatsoever, implied or expressed, 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 green text in electronic versions, are active links to the references.

Feedback

We appreciate feedback from the users of our documents. This includes feedback on the structure, content, accuracy, or completeness of our documents.

For feedback, e-mail to support@cambiumnetworks.com.

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:
   http://www.cambiumnetworks.com/support/
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:
   http://www.cambiumnetworks.com/support/contact-support

Repair and service

If unit failure is suspected, obtain details of the Return Material Authorization (RMA) process from the support website.

Warranty

Cambium's standard hardware warranty is for one (1) year from date of shipment from Cambium or a Cambium distributor. Cambium 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 products or activate warranties, visit the support website.

For warranty assistance, contact the reseller or distributor.

 Caution

Do not open the radio housing for repair or diagnostics; there are no serviceable parts within the housing.

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.

Cambium Networks ePMP equipment is shipped with default web management interface login credentials. It is highly recommended that these usernames and passwords are modified prior to system deployment.

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, see http://www.cambiumnetworks.com/support

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.

Product description

This chapter provides a high level description of the ePMP product. It describes the function of the product, the main product variants and typical deployment. It also describes the main hardware components.

The following topics are described in this chapter:

- The key features, typical uses, product variants and components of the ePMP are explained in Overview of ePMP on page 21.
- How the ePMP wireless link is operated, including modulation modes, power control and security is described under Wireless operation on page 23.
- The ePMP management system, including the web interface, installation, configuration, alerts and upgrades is described in System management on page 27.

Overview of ePMP

This section introduces the key features, typical uses, product variants and components of the ePMP.

PURPOSE

Cambium ePMP Series products are designed for Ethernet bridging over point-to-multipoint microwave links in the unlicensed 5 GHz and 2.4 GHz bands. Users must ensure that the ePMP Series complies with local operating regulations.

The ePMP Series acts as a transparent bridge between two segments of the operator and customers' networks. In this sense, it can be treated as a virtual wired connection between the Access Point and the Subscriber Module. The ePMP Series forwards 802.3 Ethernet packets destined for the other part of the network and filters packets it does not need to forward.

KEY FEATURES

The ePMP is a high performance wireless bridge for Ethernet traffic with a maximum UDP throughput of 200+ Mbps (40 MHz Channel Bandwidth). It is capable of operating in line-of-sight (LOS) and near-LOS conditions. Its maximum LOS range is 13 mi (20 MHz channel bandwidth) or 9 mi (40 MHz channel bandwidth).

Utilizing GPS sync, the ePMP is an ideal fit for networks that require capacity and reliability for superior QoS in remote and underserved areas. The integrated PTP and PMP solution features an efficient GPS synchronized operational mode that permits highly scalable frequency reuse.

ePMP operates in the unlicensed 5 GHz and 2.4 GHz bands and supports a channel bandwidth of up to 40 MHz. It is available with an integrated antenna or in connectorized version for use with an external antenna.

The wireless link is primarily TDD based. System Release 1.2.3 added a Flexible Frame Ratio option which provides improved latency and throughput under unsynchronized operational mode.

From a network point-of-view, the ePMP wireless link is a transparent Layer 2 bridge. It offers limited switching capability in order to support a primary and a secondary (future release) Ethernet port on the Subscriber Module.

ePMP supports quality of service (QoS) classification capability and supports three traffic priorities. Management of the unit is conducted via the same interface as the bridged traffic (in-band Management).

System Release 1.3.4 adds support for RADIUS EAP-TTLS authentication and VSA support for MIR.

When deployed with a sector antenna, the ePMP 1000 GPS Sync Radio can be configured as a GPS synchronized Access Point serving ePMP Integrated Radios configured as Subscriber Modules. When deployed with a high gain point to point antenna, the ePMP GPS Sync Radio can be configured to be a GPS Synchronized Backhaul Master, forming a PTP link with another ePMP Radio module.

A summary of the main ePMP characteristics is listed under Table 1.

Table 1 Main characteristics of the ePMP Series

Characteristic	Value
Topology	PMP or PTP
Wireless link condition	LOS, near LOS
Range	5 MHz: Up to 21 mi 10 MHz: Up to 17 mi 20 MHz: Up to 13 mi 40 MHz: Up to 9 mi
Scheduler	TDD (Fixed or Flexible Ratios), ePTP, Standard WiFi
Connectivity	Ethernet
Operating frequencies	ePMP 2000 Unlicensed bands, 5 GHz
	ePMP 1000 Unlicensed bands, 5 GHz and 2.4 GHz
Channel bandwidth	5 MHz, 10 MHz, 20 MHz or 40 MHz
Data rate	200+ Mbps

TYPICAL DEPLOYMENT EQUIPMENT

The ePMP is a solution consisting of integrated or connectorized outdoor units, indoor power supply units/LAN injectors, cabling and surge suppression equipment.

The main hardware components of an ePMP deployment are as follows:

- **Connectorized Radio with GPS Sync:** A connectorized outdoor transceiver unit containing all the radio, networking, and surge suppression electronics.
- **GPS Sync Connectorized Radio:** An indoor power supply module providing Power-over-Ethernet (PoE) supply and 1000/100/10 Base-TX to the Access Point.
- **Connectorized Radio Cabling and lightning protection:** Shielded Cat5e cables, grounding cables, and connectors.
- **Integrated Radio:** An integrated-antenna outdoor transceiver unit containing all the radio, networking, antenna, and surge suppression electronics.
- **Integrated or Un-sync Connectorized Radio:** A connectorized outdoor transceiver unit containing all the radio, networking and surge suppression electronics.
- **Integrated Radio Power Supply:** An indoor power supply module providing Power-over-Ethernet (PoE) supply and 100/10 Base-TX to the Subscriber Module.
- **Integrated Radio Cabling and lightning protection:** Shielded Cat5e cables and connectors

For more information about these components, including interfaces, specifications and Cambium part numbers, see System hardware on page 30.

Wireless operation

This section describes how the ePMP wireless link is operated, including modulation modes, power control and security.

TIME DIVISION DUPLEXING

TDD cycle

ePMP links operate using Time Division Duplexing (TDD). The links employ a TDD cycle in which the APs determines which SMs may transmit and when based on the configured downlink/uplink ratio (duty cycle). Three fixed Downlink/Uplink frame ratios are available – 75/25, 50/50 and 30/70. A flexible frame ratio is available as a fourth option where the AP dynamically determines the downlink and uplink ratio based on data demand in each direction.

OFDM AND CHANNEL BANDWIDTH

The ePMP 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 all the sub-carriers is high.

The channel bandwidth of the OFDM signal is 5 MHz, 10 MHz, 20 MHz or 40 MHz, based on operator configuration.

Each channel is offset in center frequency from its neighboring channel by 5 MHz.

ADAPTIVE MODULATION

The ePMP series can transport data over the wireless link using a number of different modulation modes ranging from 64-QAM to QPSK. For a given channel bandwidth and TDD frame structure, each modulation mode transports data at a fixed rate. Also, the receiver requires a given signal to noise ratio in order to successfully demodulate a given modulation mode. Although the more complex modulations such as 64QAM will transport data at a much higher rate than the less complex modulation modes, the receiver requires a much higher signal to noise ratio.

The ePMP series provides an adaptive modulation scheme where the receiver constantly monitors the quality of the received signal and notifies the far end of the link of the optimum modulation mode with which to transmit. In this way, optimum capacity is achieved at all times.

MIMO

Multiple-Input Multiple-Output (MIMO) technique provides protection against fading and increases the probability of a received decoded signal to be usable.

The ePMP transmits two signals on the same radio frequency, one of which is 90 degrees offset from the other.

RADAR AVOIDANCE

In regions where protection of radars is part of the local regulations, the ePMP must detect interference from radar-like systems and avoid co-channel operation with these systems.

To meet this requirement, the ePMP implements the following features:

- The equipment can only transmit on available channels, of which there are none at initial power up. The radar detection algorithm will always scan a usable channel for 60 seconds for radar interference before making the channel an available channel.
- This compulsory channel scan will mean that there is at least 60 seconds service outage every time radar is detected and that the installation time is extended by at least 60 seconds even if there is found to be no radar on the channel

There is a secondary requirement for bands requiring radar avoidance. Regulators have mandated that products provide a uniform loading of the spectrum across all devices. In general, this prevents operation with fixed frequency allocations. However:

- ETSI regulations do allow frequency planning of networks (as that has the same effect of spreading the load across the spectrum).
- The FCC does allow channels to be avoided if there is actually interference on them.

Note

When operating in a region which requires DFS, ensure that the AP is configured with alternate frequencies and that the SM is configured to scan for these frequencies to avoid long outages.

ENCRYPTION

The ePMP supports optional encryption for data transmitted over the wireless link. The encryption algorithm used is the Advanced Encryption Standard (AES) with 128-bit key size. AES is a symmetric encryption algorithm approved by U.S. Government organizations (and others) to protect sensitive information.

COUNTRY CODES

Some aspects of wireless operation are controlled, enforced or restricted according to a country code. ePMP country codes represent individual countries (for example Denmark) or regulatory regions (for example FCC or ETSI).

Country codes affect the following aspects of wireless operation:

- Maximum transmit power
- Radar avoidance
- Frequency range

Caution

To avoid possible enforcement action by the country regulator, always operate links in accordance with local regulations

SMART BEAMFORMING

ePMP 2000 Smart Beamforming drastically reduces the effects of on-channel interference. The System learns the locations of each served Subscriber Module and forms a narrow beam towards the desired Subscriber Module while that radio is transmitting in the uplink. This reduces the gain on the uplink for on-channel interferers that are transmitting at an azimuth angle different than the Subscriber Module, delivering performance gains never before seen.

INTELLIGENT FILTERING

ePMP 2000 Intelligent Filtering improves both receive and transmit performance. It protects the network from off-channel interferers with a filter that dynamically moves around the channel. On the transmit side, it protects the RF environment by reducing off-channel transmission noise.

PMP NETWORKS

Using frequency planning

Frequency planning is the exercise of assigning operating channels to PMP units so as to minimize RF interference between links. Frequency planning must consider interference from any PMP unit to any other PMP unit in the network. Low levels of interference normally allow for stable operation and high link capacity.

The frequency planning task is made more straightforward by use of the following techniques:

- Using several different channels
- Separating units located on the same mast
- Configuring a 5 MHz guard band between adjacent sector operating band edges.

For help with planning networks, see System planning. You can also contact your Cambium distributor or re-seller.

FURTHER READING ON WIRELESS OPERATION

For information on planning wireless operation, see:

- The regulatory restrictions that affect radio spectrum usage, such as frequency range and radar avoidance is described under Radio spectrum planning on page 83
- The factors to be taken into account when planning links such as range, path loss and data throughput are described under Link planning on page 87.
- The safety specifications against which the ePMP has been tested are listed under on page . It also describes how to keep RF exposure within safe limits.
- How ePMP complies with the radio regulations that are enforced in various countries is explained in Compliance with radio regulations on page 206.
- Compliance with the radio regulations that are enforced in various regions is explained under Notifications on page 224.
- Tables and graphs to support calculation of the data rate capacity that can be provided by ePMP configurations are available at Data throughput tables on page 236.

For more information on configuring and operating the wireless link, see:

- The configuration parameters of the ePMP devices described under Configuration on page Error! Bookmark not defined..
- Post-installation procedures and troubleshooting tips explained under Operation and Troubleshooting on page 92.

System management

This section introduces the ePMP management system, including the web interface, installation, alerts and upgrades, configuration and management software.

MANAGEMENT AGENT

ePMP 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).

The management agent supports the following interfaces:

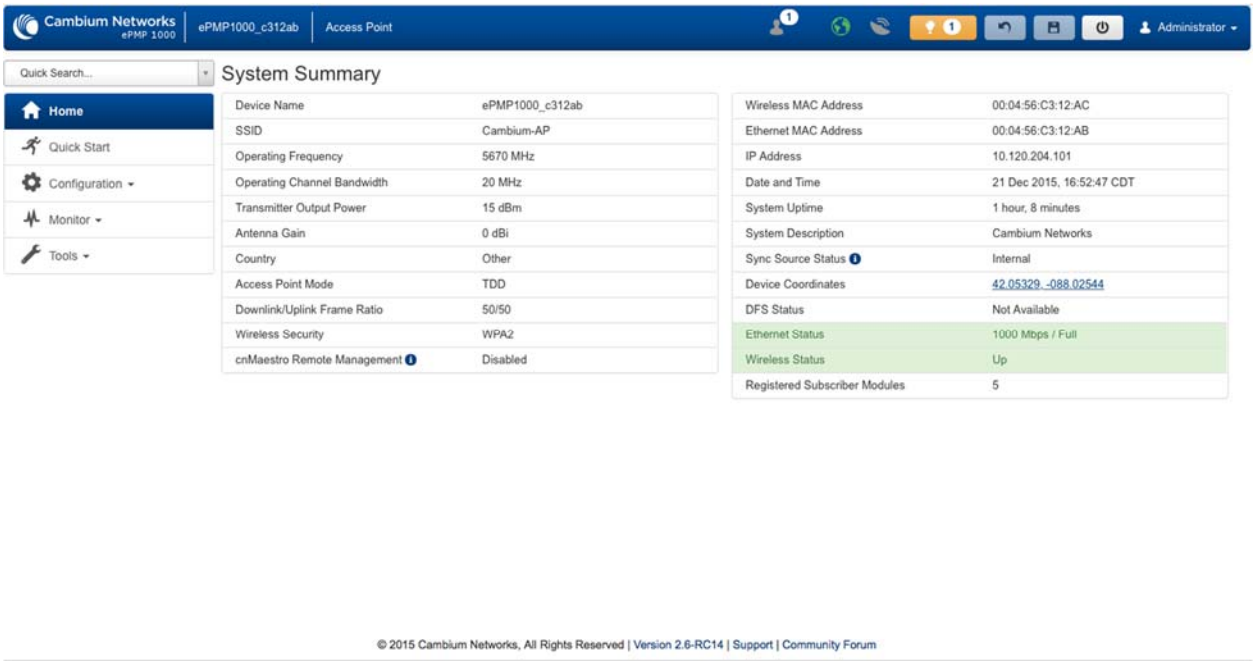
- Hypertext Transfer Protocol (HTTP)
- Hypertext Transfer Protocol secure (HTTPs)
- Simple Network Management Protocol (SNMP)
- Network Time Protocol (NTP)
- System logging (Syslog)
- Cambium Network Services Server (CNSS) software
- Dynamic Host Configuration Protocol (DHCP)

WEB SERVER

The ePMP management agent contains a web server. The web server supports access via the HTTP and HTTPs interfaces.

Web-based management offers a convenient way to manage the ePMP 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-based interfaces are the only interfaces supported for installation of ePMP, and for the majority of ePMP configuration management tasks.

Figure 1 AP web-based management screenshot



Web pages

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

Access Point and Subscriber Module web-pages:

- **Dashboard:** The Dashboard web-page reports the general device status, session status, remote subscriber status, event log information, and network interface status.
- **Configure:** The Configuration web-page may be utilized for configuring general device parameters, as well as IP, radio, SNMP, Quality of Service (QoS), security, time, VLAN, protocol filtering, and unit settings.
- **Monitor:** The Monitor web-page reports detailed operating statistics for the radio link and network, and reports system log information.
- **Tools:** The tools web-page offers useful tools for device installation, configuration, and operation including software upgrade, backup/restore, spectrum analyzer, throughput test, ping test, and traceroute.
- **Quick Start:** The Quick Start web-page provides quick access to requisite parameters for radio link establishment and network access.

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 (default username/password "admin"), who has full read and write permission.
- INSTALLER (default username/password "installer"), who has permission to read and write parameters applicable to unit installation and monitoring.
- HOME (default username/password "home"), who has permission only to access pertinent information for support purposes
- READONLY (default username/password "readonly"), who has permission to only view the Monitor page.

SNMP

The management agent supports fault and performance management by means of an SNMP interface. The management agent is compatible with SNMP v2c using one Management Information Base (MIB) file which is available for download from the Cambium Networks Support website (https://support.cambiumnetworks.com/files/epmp).

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.

ePMP devices may receive NTP data from a CMM3 or CMM4 module or an NTP server configured in the system's management network.

The Time Zone option is configurable on the AP's **Configure** => **System** page and may be used to offset the received NTP time to match the operator's local time zone.

CAMBIUM NETWORK SERVICES SERVER

The Cambium Network Services Server (CNSS) may be used to monitor, configure, and upgrade Cambium network equipment.

For Cambium Network Services Server download, see https://support.cambiumnetworks.com/files/cnss.

SOFTWARE UPGRADE

Software upgrades may be issued via the radio web interface (**Tools** => **Software Upgrade**) or via CNSS (Cambium Networks Services Server). For Software upgrades, see https://support.cambiumnetworks.com/files/epmp.

FURTHER READING ON SYSTEM MANAGEMENT

For more information on system management, see:

- AP System page on page Error! Bookmark not defined.
- SM System page on page Error! Bookmark not defined.
- Operation and Troubleshooting on page 92

System hardware

This chapter describes the site planning and hardware components of an ePMP link.

The following topics are described in this chapter:

- Factors to be considered when planning the proposed network is described under Site planning on page 31.
- The connectorized with sync module hardware, part numbers, mounting equipment, and specifications are described under ePMP 1000
- Connectorized Radio with Sync on page 41.
- The integrated hardware, part numbers, mounting equipment and specifications are described under Integrated Radio on page 49.
- The connectorized hardware, part numbers, mounting equipment and specifications are described under Connectorized Radio on page 55.
- The Force 180 hardware, part numbers, mounting equipment and specifications are described under Force 180 on page 63.
- The Force 200 hardware, part numbers, mounting equipment and specifications are described under Force 200 on page 69.
- The power supply hardware, part numbers and specifications are described under Power Supply on page 76.
- The AP antenna and part numbers are described under Connectorized Radio with Sync, antennas and antenna cabling on page 48.
- Cable standards and lengths are described under Ethernet cabling on page 79.
- Surge suppression requirements and recommendations are described under Surge Suppression unit on page 80.

Site planning

Conduct a site survey to ensure that the proposed AP and SM sites meet the requirements defined in this section.

SITE INSTALLATION

An ePMP site typically consists of a high supporting structure such as a mast, tower or building for the AP or SM.

There is only one Ethernet interface, a copper Cat5e connection from the AP or SM to the AP/SM power supply and network terminating equipment. If a 1000 Base-TX (Gigabit) Ethernet connection is required at the AP, ensure that power supply N000900L001A is utilized.

GROUNDING AND LIGHTNING PROTECTION

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 an ePMP installation, both ground bonding and transient voltage surge suppression are required.

 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.

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.

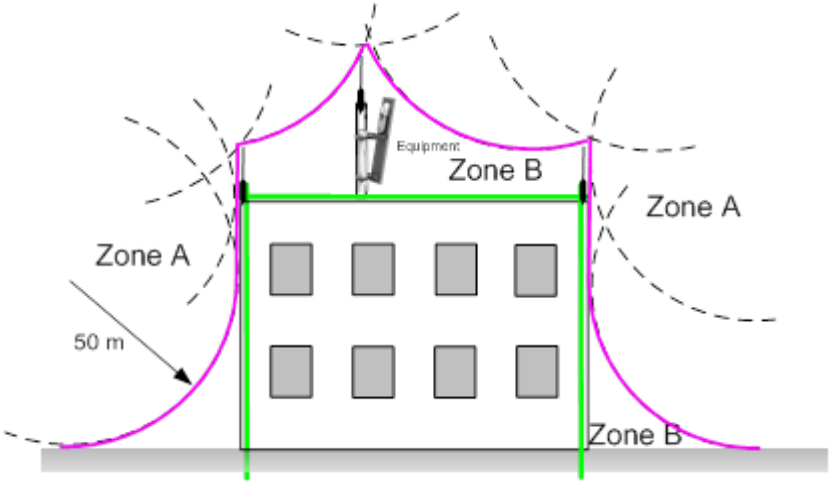
 Note

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

LIGHTNING PROTECTION ZONES

Use the rolling sphere method (Figure 2) 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 2 Rolling sphere method to determine the lightning protection zones



Assess locations on masts, towers and buildings to determine if the location is in Zone A or Zone B:

- **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

Do not mount equipment in Zone A which can put the equipment, structures and life at risk.

ePMP 2000

Connectorized Radio with Sync

For details of the ePMP connectorized hardware, see:

- Connectorized Radio with Sync description on page 33
- Connectorized Radio with Sync part numbers on page 34
- Connectorized Radio with Sync mounting bracket on page 35
- Connectorized Radio with Sync interfaces on page 35
- Connectorized Radio with Sync LEDs on page 36
- Connectorized Radio with Sync specifications on page 37
- Connectorized Radio with Sync heater on page 38
- Connectorized Radio with Sync and external antenna location on page 38
- Connectorized Radio with Sync wind loading on page 39
- Connectorized Radio with Sync software packages on page 39
- Connectorized Radio with Sync, antennas and antenna cabling on page 40

CONNECTORIZED RADIO WITH SYNC DESCRIPTION

The connectorized ePMP 2000 device is a self-contained transceiver unit that houses both radio and networking electronics. The connectorized unit is designed to work with externally mounted antennas that have high gains. Connectorized units can cope with more difficult radio conditions. The unit is designed with female RP-SMA 50Ω antenna connections located at the top of the unit. An ePMP connectorized unit may function as an Access Point (AP) or a Subscriber Module (SM) in a Point-To-Multipoint (PMP) or in a Point-To-Point (PTP) network topology.

Note

To select antennas, RF cables and connectors for connectorized units, see Connectorized Radio with Sync, antennas and antenna cabling on page 40.

Figure 3 ePMP 2000 Series Connectorized Radio with Sync

CONNECTORIZED RADIO WITH SYNC PART NUMBERS

Choose the correct regional variant: one is for use in regions where FCC or IC licensing restrictions apply (FCC/IC), and the other is for use in ETSI countries or non-FCC/IC/ETSI-restricted regions.

Each of the parts listed in Table 11 includes the following items:

- One connectorized unit
- One power supply 1000/100/10 Base-TX LAN injector

The GPS-capable parts listed in Table 11 also ship with a GPS antenna.

Table 2 ePMP 2000 Connectorized Radio with Sync part numbers

Cambium description	Cambium part number
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (EU)	C050900A033A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (FCC)	C058900A132A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (ROW) (no cord)	C050900A031A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (ROW) (EU cord)	C050900A231A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (ROW) (US cord)	C050900A131A
ePMP 2000: 5 GHz AP Lite with Intelligent Filtering and Sync (EU)	C050900L033A
ePMP 2000: 5 GHz AP Lite with Intelligent Filtering and Sync (FCC)	C058900L132A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (ROW) (no cord)	C050900A031A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (ROW) (EU cord)	C050900A231A
ePMP 2000: 5 GHz AP with Intelligent Filtering and Sync (ROW) (US cord)	C050900A131A
ePMP 2000 AP Lite License Key – Upgrade Lite (10 SM) to Full (120 SM)	C050900S2KLA

Table 3 Connectorized Radio with Sync accessory part numbers

Cambium description	Cambium part number
ePMP Power Supply for GPS Radio - no cord (spare)	N000900L001A
ePMP Power Supply for non-GPS Radio - no cord (spare)	N000900L002A

CONNECTORIZED RADIO WITH SYNC MOUNTING BRACKET

The connectorized unit is designed to be attached to a Cambium ePMP sector antenna (see Table 19). The Cambium ePMP sector antenna contains all of the mounting brackets, antenna cabling, and GPS antenna mounting for device deployment.

Figure 4 Connectorized Radio with Sync sector antenna

CONNECTORIZED RADIO WITH SYNC INTERFACES

The connectorized radio with sync interfaces are illustrated in Figure 5 and described in Table 4.

Figure 5 Connectorized Radio with Sync interfaces

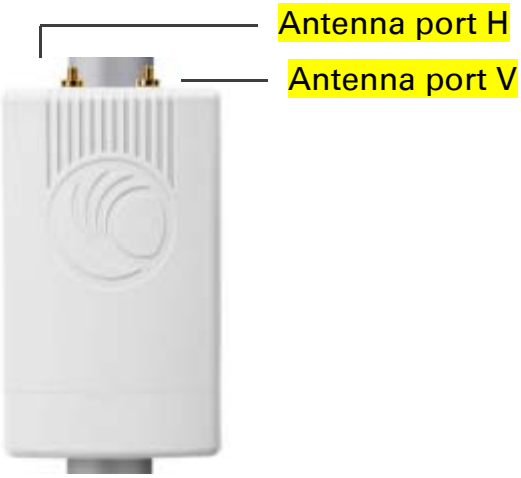
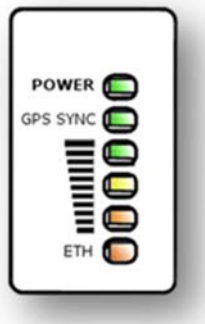


Table 4 Connectorized Radio with Sync interfaces

Name	Connector	Interface	Description
Antenna port H	RP-SMA, female	Antenna, H polarization	To/from H polarized antenna port
Antenna port V	RP-SMA, female	Antenna, V polarization	To/from V polarized antenna port
Smart Antenna port H	RP-SMA, female	Smart Antenna, H polarization	To/from H polarized Smart Antenna port
Smart Antenna port V	RP-SMA, female	Smart Antenna, V polarization	To/from V polarized Smart Antenna port
Ethernet	RJ45	PoE input	802.3at-compliant
		10/100/1000 Base-TX Ethernet	Management and data
GPS	SMA, female	Antenna, GPS	To/from GPS antenna
Reset Button	Physical button	N/A	For resetting the radio and for setting the radio back to its factory default configuration. See Using the device external reset button on page 101.

CONNECTORIZED RADIO WITH SYNC LEDS



LED	Function
POWER	Green: Power is applied to the device Unlit: No power is applied to the device or improper power source
GPS SYNC	Orange: AP has acquired a 1PPS GPS synchronization pulse either from the internal GPS module and antenna or from a connected CMM Unlit: 1PPS GPS not acquired, or **Synchronization Source** set to **Internal** (AP generating sync, not GPS-based)
	Reserved for future release
ETH	Once lit, blinking indicates Ethernet activity Red: 10BaseTX link

	Green: 100BaseTX link Orange: 1000BaseTX link Unlit: No Ethernet link established

CONNECTORIZED RADIO WITH SYNC SPECIFICATIONS

The ePMP connectorized module conforms to the specifications listed in Table 5 and Table 6. The connectorized module meets the low level static discharge specifications identified in Electromagnetic compatibility (EMC) compliance on page 191 and provides internal surge suppression but does not provide lightning suppression.

For a full listing of connectorized radio with sync specifications, see ePMP 1000 Connectorized Radio with Sync Specifications on page 241.

Table 5 Connectorized Radio with Sync physical specifications

Category	Specification
Dimensions (H x W x D)	Radio: 22.2 x 12.4 x 4.5 cm (8.75 x 4.9 x 1.75 in) without brackets Antenna:529 x 124 x 53 mm (20.8" x 4.9" x 2.1")
Weight	.7 kg (1.5 lbs) without brackets

Table 6 Connectorized Radio with Sync environmental specifications

Category	Specification
Temperature	-30°C (-22°F) to +55°C (131°F)
Wind loading	118 mph (190 kph) maximum. See Connectorized Radio with Sync wind loading on page 39 for a full description.
Humidity	95% condensing
Environmental	IP55

CONNECTORIZED RADIO WITH SYNC HEATER

At startup, if the ePMP connectorized module temperature is at or below 32° F (0° C), an internal heater is activated to ensure that the device is able to successfully begin operation. The unit's heater is only activated when the unit is powered on and will not apply heat to the device once startup is complete. When the unit temperature is greater than 32° F (0° C), the heater is deactivated and the unit continues its startup sequence.

The effect on device startup time at various temperatures is defined in Table 7.

Table 7 Connectorized Radio with Sync startup times based on ambient temperature

Initial Temperature	Startup time (from power on to operational)
-22° F (-30° C)	20 minutes
-4° F (-20° C)	6 minutes
14° F (-10° C)	2 minutes, 30 seconds

CONNECTORIZED RADIO WITH SYNC AND EXTERNAL ANTENNA LOCATION

Find a location for the device and external antenna 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 193.
- The equipment is lower than the top of the supporting structure (tower, mast or building) or its lightning air terminal.
- The location is not subject to excessive wind loading. For more information, see Connectorized Radio with Sync wind loading on page 39.

CONNECTORIZED RADIO WITH SYNC WIND LOADING

Ensure that the device and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed ePMP site. Wind speed statistics is available from national meteorological offices.

The device and its mounting bracket are capable of withstanding wind speeds of up to 190 Kph (118 mph).

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

Force (in kilograms) = $0.1045aV^2$

Where:	Is:
a	surface area in square meters
V	wind speed in meters per second

Force (in pounds) = $0.0042Av^2$

Where:	Is:
A	surface area in square feet
v	wind speed in miles per hour

Applying these formulae to the ePMP device at different wind speeds, the resulting wind loadings are shown in Table 17 and Table 18.

Table 8 Connectorized Radio with Sync wind loading (Kg)

Type of ePMP device	Largest surface area (square meters)	Wind speed (meters per second)				
		30	40	50	60	70
Connectorized	0.13	12.2 Kg	21.7 Kg	34 Kg	49 Kg	66.6 Kg

Table 9 Connectorized Radio with Sync wind loading (lb)

Type of ePMP device	Largest surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Connectorized	1.39	37.4 lb	58.4 lb	84.1 lb	114.4 lb	131.4 lb

CONNECTORIZED RADIO WITH SYNC SOFTWARE PACKAGES

Connectorized radios may be upgraded by downloading new software packages from the Cambium Networks website or by using the Cambium Network Services Server. The software packages applicable to ePMP connectorized radios are named:

- ePMP-GPS_Synced-v2.6.1.tar.gz

CONNECTORIZED RADIO WITH SYNC, ANTENNAS AND ANTENNA CABLING

Connectorized modules require external antennas connected using RF cable (included with Cambium ePMP sector antennas). For details of the antennas and accessories required for a connectorized ePMP installation, see:

- Antenna requirements on page 40
- FCC and IC approved antennas on page 40

ANTENNA REQUIREMENTS

For connectorized units operating in the USA or Canada 5 GHz bands, choose external antennas from those listed in FCC and IC approved antennas on page 40. For installations in other countries, the listed antennas are advisory, not mandatory.

FCC AND IC APPROVED ANTENNAS

For connectorized units operating in the USA or Canada, choose external antennas from Table 10. These are approved by the FCC for use with the product and are constrained by the following limits:

- 5 GHz – 18 dBi gain

Caution

Using other than approved antennas may cause measurements higher than reported for certification.

This radio transmitter (IC certification number 109W-0005) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio (Numéro de certification IC 109W-0005) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Table 10 Allowed antennas for deployment in USA/Canada

Cambium part number	Antenna Type	Gain (dBi)
C050900D021A	5 GHz Sector Antenna – 90/120 degree	18
C050900D020A	Smart Antenna (complimentary to Sector Antenna, does not replace Sector Antenna	

ePMP 1000

Connectorized Radio with Sync

For details of the ePMP connectorized hardware, see:

- Connectorized Radio with Sync description on page 41
- Connectorized Radio with Sync part numbers on page 42
- Connectorized Radio with Sync interfaces on page 43
- Connectorized Radio with Sync specifications on page 45
- Connectorized Radio with Sync and external antenna location on page 46
- Connectorized Radio with Sync wind loading on page 47
- Connectorized Radio with Sync software packages on page 47
- Connectorized Radio with Sync, antennas and antenna cabling on page 48

CONNECTORIZED RADIO WITH SYNC DESCRIPTION

The connectorized ePMP device is a self-contained transceiver unit that houses both radio and networking electronics. The connectorized unit is designed to work with externally mounted antennas that have high gains. Connectorized units can cope with more difficult radio conditions. The unit is designed with female RP-SMA 50Ω antenna connections located at the top of the unit. An ePMP connectorized unit may function as an Access Point (AP) or a Subscriber Module (SM) in a Point-To-Multipoint (PMP) or in a Point-To-Point (PTP) network topology.

Note

To select antennas, RF cables and connectors for connectorized units, see Connectorized Radio with Sync, antennas and antenna cabling on page 48.

Figure 6 ePMP Series Connectorized Radio with Sync

CONNECTORIZED RADIO WITH SYNC PART NUMBERS

Choose the correct regional variant: one is for use in regions where FCC or IC licensing restrictions apply (FCC/IC), and the other is for use in ETSI countries or non-FCC/IC/ETSI-restricted regions.

Each of the parts listed in Table 11 includes the following items:

- One connectorized unit
- One power supply 1000/100/10 Base-TX LAN injector

The GPS-capable parts listed in Table 11 also ship with a GPS antenna.

Table 11 Connectorized Radio with Sync part numbers

Cambium description	Cambium part number
ePMP GPS, Conn - 5 GHz - no power cord – ROW version	C050900A011A
ePMP GPS, Conn - 5 GHz – no power cord – EU version	C050900A013A
ePMP GPS, Conn - 5 GHz - US power cord – FCC version	C058900A112A
ePMP GPS, Conn - 2.4 GHz - US power cord	C024900A011A

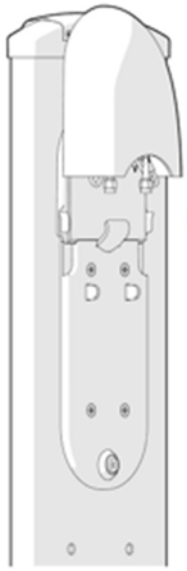
Table 12 Connectorized Radio with Sync accessory part numbers

Cambium description	Cambium part number
ePMP Power Supply for GPS Radio - no cord (spare)	N000900L001A
ePMP Power Supply for non-GPS Radio - no cord (spare)	N000900L002A

CONNECTORIZED RADIO WITH SYNC MOUNTING BRACKET

The connectorized unit is designed to be attached to a Cambium ePMP sector antenna (see Table 19). The Cambium ePMP sector antenna contains all of the mounting brackets, antenna cabling, and GPS antenna mounting for device deployment.

Figure 7 Connectorized Radio with Sync sector antenna



CONNECTORIZED RADIO WITH SYNC INTERFACES

The connectorized radio with sync interfaces are illustrated in Figure 8 and described in Table 13.

Figure 8 Connectorized Radio with Sync interfaces

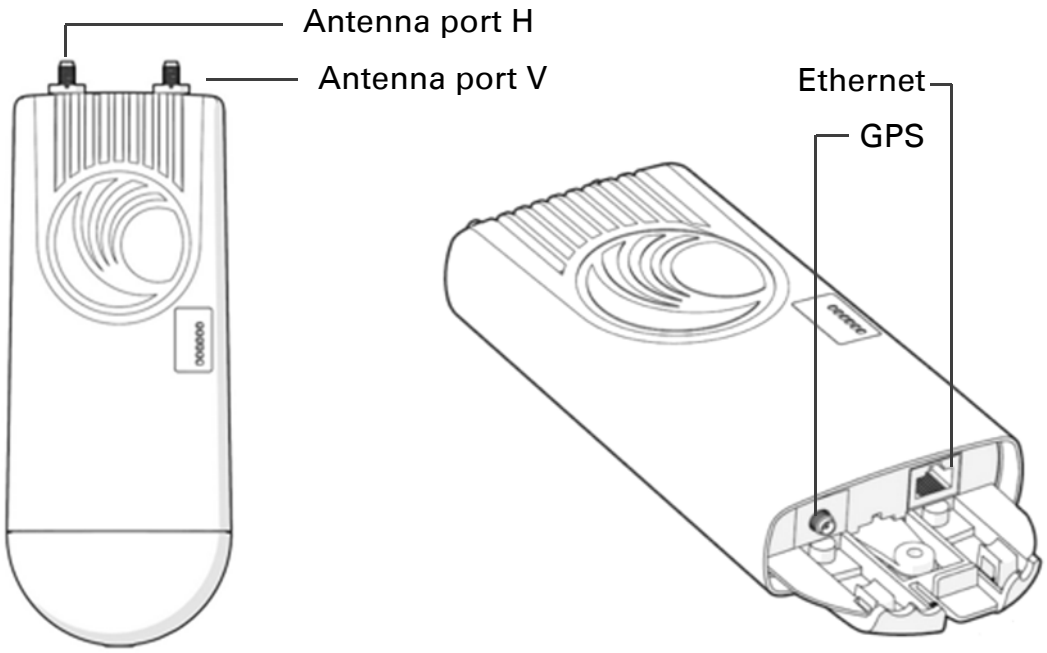


Table 13 Connectorized Radio with Sync interfaces

Name	Connector	Interface	Description
Antenna port H	RP-SMA, female	Antenna, H polarization	To/from H polarized antenna port
Antenna port V	RP-SMA, female	Antenna, V polarization	To/from V polarized antenna port
Ethernet	RJ45	PoE input	802.3af PoE Standard, as well as Proprietary power over Ethernet (PoE) twisted pair (for powering via CMM3/CMM4)
		10/100/1000 Base-TX Ethernet	Management and data
GPS	SMA, female	Antenna, GPS	To/from GPS antenna
Reset Button	Physical button	N/A	For resetting the radio and for setting the radio back to its factory default configuration. See Using the device external reset button on page 101.

CONNECTORIZED RADIO WITH SYNC LEDS

LED	Function
POWER	Green: Power is applied to the device Unlit: No power is applied to the device or improper power source
GPS SYNC	Orange: AP has acquired a 1PPS GPS synchronization pulse either from the internal GPS module and antenna or from a connected CMM Unlit: 1PPS GPS not acquired, or **Synchronization Source** set to **Internal** (AP generating sync, not GPS-based)
	Reserved for future release
ETH	Once lit, blinking indicates Ethernet activity Red: 10BaseTX link Green: 100BaseTX link Orange: 1000BaseTX link Unlit: No Ethernet link established

CONNECTORIZED RADIO WITH SYNC SPECIFICATIONS

The ePMP connectorized module conforms to the specifications listed in Table 14 and Table 15. The connectorized module meets the low level static discharge specifications identified in Electromagnetic compatibility (EMC) compliance on page 191 and provides internal surge suppression but does not provide lightning suppression.

For a full listing of connectorized radio with sync specifications, see ePMP 1000 Connectorized Radio with Sync Specifications on page 241.

Table 14 Connectorized Radio with Sync physical specifications

Category	Specification
Dimensions (H x W x D)	Radio: 227 x 88 x 33 mm (8.9″ x 3.5″ x 1.3″) Antenna: 529 x 124 x 53 mm (20.8″ x 4.9″ x 2.1″)
Weight	.521 kg (1.15 lbs) without antenna 4.5 kg (10 lbs) with antenna

Table 15 Connectorized Radio with Sync environmental specifications

Category	Specification
Temperature	-30°C (-22°F) to +55°C (131°F)
Wind loading	118 mph (190 kph) maximum. See Connectorized Radio with Sync wind loading on page 47 for a full description.
Humidity	95% condensing
Environmental	IP55

CONNECTORIZED RADIO WITH SYNC HEATER

At startup, if the ePMP connectorized module temperature is at or below 32° F (0° C), an internal heater is activated to ensure that the device is able to successfully begin operation. The unit's heater is only activated when the unit is powered on and will not apply heat to the device once startup is complete. When the unit temperature is greater than 32° F (0° C), the heater is deactivated and the unit continues its startup sequence.

The effect on device startup time at various temperatures is defined in Table 16.

Table 16 Connectorized Radio with Sync startup times based on ambient temperature

Initial Temperature	Startup time (from power on to operational)
-22° F (-30° C)	20 minutes
-4° F (-20° C)	6 minutes
14° F (-10° C)	2 minutes, 30 seconds

CONNECTORIZED RADIO WITH SYNC AND EXTERNAL ANTENNA LOCATION

Find a location for the device and external antenna 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 193.
- The equipment is lower than the top of the supporting structure (tower, mast or building) or its lightning air terminal.
- The location is not subject to excessive wind loading. For more information, see Connectorized Radio with Sync wind loading on page 47.

CONNECTORIZED RADIO WITH SYNC WIND LOADING

Ensure that the device and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed ePMP site. Wind speed statistics is available from national meteorological offices.

The device and its mounting bracket are capable of withstanding wind speeds of up to 190 Kph (118 mph).

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

Force (in kilograms) = $0.1045aV^2$

Where:	Is:
a	surface area in square meters
V	wind speed in meters per second

Force (in pounds) = $0.0042Av^2$

Where:	Is:
A	surface area in square feet
v	wind speed in miles per hour

Applying these formulae to the ePMP device at different wind speeds, the resulting wind loadings are shown in Table 17 and Table 18.

Table 17 Connectorized Radio with Sync wind loading (Kg)

Type of ePMP device	Largest surface area (square meters)	Wind speed (meters per second)				
		30	40	50	60	70
Connectorized	0.13	12.2 Kg	21.7 Kg	34 Kg	49 Kg	66.6 Kg

Table 18 Connectorized Radio with Sync wind loading (lb)

Type of ePMP device	Largest surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Connectorized	1.39	37.4 lb	58.4 lb	84.1 lb	114.4 lb	131.4 lb

CONNECTORIZED RADIO WITH SYNC SOFTWARE PACKAGES

Connectorized radios may be upgraded by downloading new software packages from the Cambium Networks website or by using the Cambium Network Services Server. The software packages applicable to ePMP connectorized radios are named:

- ePMP-GPS_Synced-v2.6.1.tar.gz

CONNECTORIZED RADIO WITH SYNC, ANTENNAS AND ANTENNA CABLING

Connectorized modules require external antennas connected using RF cable (included with Cambium ePMP sector antennas). For details of the antennas and accessories required for a connectorized ePMP installation, see:

- Antenna requirements on page 48
- FCC and IC approved antennas on page 48

ANTENNA REQUIREMENTS

For connectorized units operating in the USA or Canada 2.4 GHz, 5.2 GHz, 5.4 GHz or 5.8 GHz bands, choose external antennas from those listed in FCC and IC approved antennas on page 48. For installations in other countries, the listed antennas are advisory, not mandatory.

FCC AND IC APPROVED ANTENNAS

For connectorized units operating in the USA or Canada, choose external antennas from Table 19. These are approved by the FCC for use with the product and are constrained by the following limits:

- 5 GHz – 15 dBi gain
- 2.4 GHz - 15 dBi gain


Caution

Using other than approved antennas may cause measurements higher than reported for certification.

This radio transmitter (IC certification number 109W-0005) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio (Numéro de certification IC 109W-0005) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Table 19 Allowed antennas for deployment in USA/Canada

Cambium part number	Antenna Type	Gain (dBi)
C050900D003A	5 GHz Sector Antenna – 90 degree	15
C050900D002A	5 GHz Sector Antenna – 120 degree	15
C024900D004A	2.4 GHz Sector Antenna - 90 /120 degree	15

Integrated Radio

For details of the ePMP integrated hardware, see:

- Integrated Radio description on page 49
- Integrated Radio part numbers on page 50
- Integrated Radio mounting bracket on page 50
- Integrated Radio interfaces on page 51
- Integrated Radio specifications on page 52
- Integrated Radio heater on page 53
- Integrated Radio wind loading on page 53
- Integrated Radio software packages on page 54.

INTEGRATED RADIO DESCRIPTION

Figure 9 ePMP Series Integrated Radio

The integrated module is a self-contained transceiver unit that houses both radio and networking electronics. An ePMP integrated unit may function as an Access Point (AP) or a Subscriber Module (SM) in a Point-To-Multipoint (PMP) or in a Point-To-Point (PTP) network topology.

INTEGRATED RADIO PART NUMBERS

Choose the correct regional variant: one is for use in regions where FCC or IC licensing restrictions apply (FCC/IC) and the other is for use in ETSI countries or the rest of the world (ETSI/RoW).

Each of the parts listed in Table 20 includes the following items:

- One integrated module (with mounting bracket)
- One metal mounting strap
- Power supply

Table 20 Integrated Radio part numbers

Cambium description	Cambium part number
ePMP Integrated – 5 GHz – no power cord – ROW version	C050900C031A
ePMP Integrated – 5 GHz – EU power cord – EU version	C050900P033A
ePMP Integrated – 5 GHz – US power cord – FCC version	C058900C132A
ePMP Integrated - 2.4 GHz - US power cord	C024900C031A

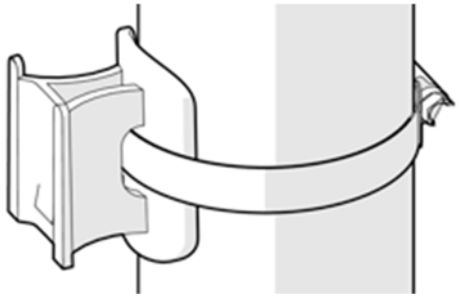
Table 21 Integrated Radio accessory part numbers

Cambium description	Cambium part number
ePMP Power Supply for non-GPS Radio - no cord (spare)	N000900L002A

INTEGRATED RADIO MOUNTING BRACKET

The integrated module is designed to be pole-mounted using the mounting strap and bracket provided in the box with the radio.

Figure 10 Integrated module mounting bracket



INTEGRATED RADIO INTERFACES

The integrated module interfaces are illustrated in Figure 11 and described in Table 22.

Figure 11 Integrated Radio interfaces

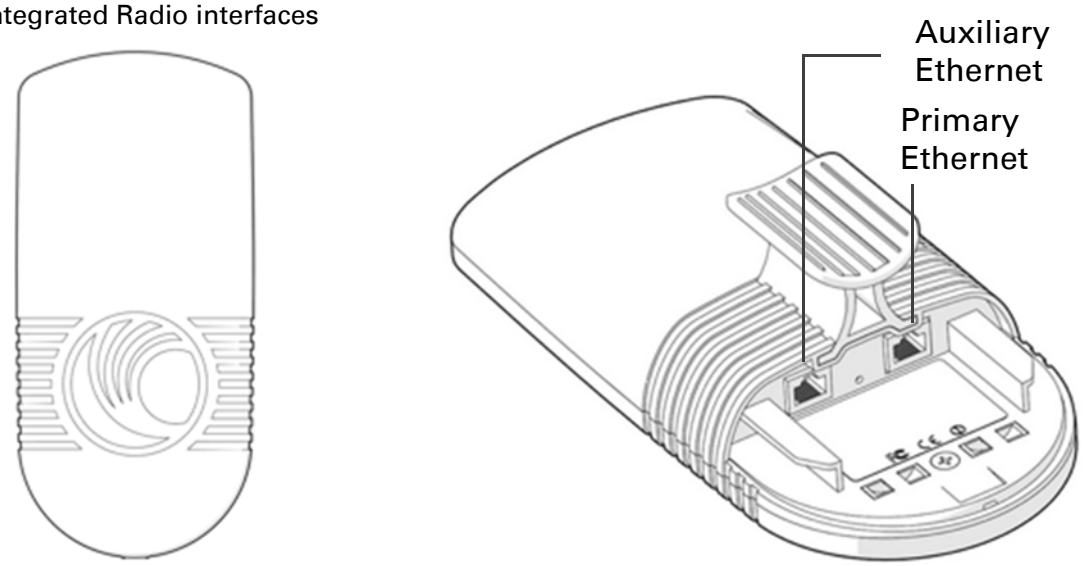
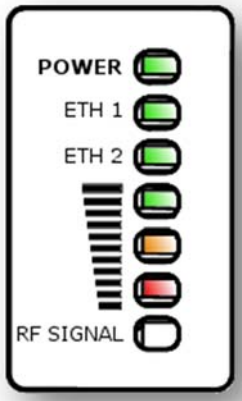


Table 22 Integrated Radio interfaces

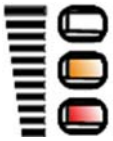
Port name	Connector	Interface	Description
Primary Ethernet	RJ45	PoE input	Proprietary power over Ethernet (PoE) twisted pair (for powering via CMM3/CMM4)
		10/100 Base-TX Ethernet	Management and data
Auxiliary Ethernet (future release)	RJ45	Cambium proprietary PoE output, data bridging	***Proprietary 30V PoE*** output for auxiliary devices (not 802.3af standard PoE)

INTEGRATED RADIO LEDS

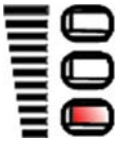


LED	Function
POWER	Green: Power is applied to the device Unlit: No power is applied to the device or improper power source
ETH 1	Main/Primary Ethernet port indicator Once lit, blinking indicates Ethernet activity Green: 10/100BaseTX link
ETH 2	Auxiliary/Secondary Ethernet port indicator Once lit, blinking indicates Ethernet activity Green: 10/100BaseTX link
	Radio scanning: LEDs light in an ascending sequence to indicate that the radio is scanning Radio registered: LEDs light to indicate the RSSI level at the device.

RSSI > -60 dBm



-70 dBm < RSSI ≤ -60 dBm



-80 dBm < RSSI ≤ -70 dBm

RSSI ≤ -80 dBm

INTEGRATED RADIO SPECIFICATIONS

The ePMP integrated module conforms to the specifications listed in Table 23 and Table 24.

The integrated device meets the low level static discharge specifications identified in Electromagnetic compatibility (EMC) compliance on page 191 and provides internal surge suppression but does not provide lightning suppression.

For a full listing of integrated radio specifications, see ePMP 1000 Integrated Radio Specifications on page 246.

Table 23 Integrated Radio physical specifications

Category	Specification
Dimensions (H x W x D)	Radio: 29.1 x 14.5 x 8.3 cm (11.4 x 5.7 x 3.3 in)
Weight	0.49 kg (1.1 lbs)

Table 24 Integrated Radio environmental specifications

Category	Specification
Temperature	-30°C (-22°F) to +60°C (131°F)
Wind loading	90 mph (145 kph) maximum. See Integrated Radio wind loading on page 53 for a full description.
Humidity	95% condensing
Environmental	IP55

INTEGRATED RADIO HEATER

Upon power on, if the ePMP integrated module device temperature is at or below 32° F (0° C), an internal heater is activated to ensure that the device is able to successfully begin operation. The unit's heater is only activated when the unit is powered on and will not apply heat to the device once startup is complete. When the unit temperature is greater than 32° F (0° C), the heater is deactivated and the integrated module continues its startup sequence.

The effect on integrated module startup time at various temperatures is defined in Table 25.

Table 25 Integrated module startup times based on ambient temperature

Initial Temperature	Startup time (from power on to operational)
-22° F (-30° C)	4 minutes
-4° F (-20° C)	2 minutes
14° F (-10° C)	1 minutes, 30 seconds

INTEGRATED RADIO WIND LOADING

Ensure that the integrated module and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed ePMP site. Wind speed statistics must be available from national meteorological offices.

The integrated module and its mounting bracket are capable of withstanding wind speeds of up to 145 Kph (90 mph).

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

Force (in kilograms) = $0.1045aV^2$

Where:	Is:
a	surface area in square meters
V	wind speed in meters per second

Force (in pounds) = $0.0042Av^2$

Where:	Is:
A	surface area in square feet
v	wind speed in miles per hour

Applying these formulae to the ePMP integrated module at different wind speeds, the resulting wind loadings are shown in Table 26 and Table 27.

Table 26 Integrated Radio wind loading (Kg)

Type of ePMP module	Largest surface area (square meters)	Wind speed (meters per second)				
		30	40	50	60	70
Integrated	0.042	4 Kg	7 Kg	11 Kg	15.8 Kg	21.6 Kg

Table 27 Integrated Radio wind loading (lb)

Type of ePMP module	Largest surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Integrated	0.45	12.1 lb	18.9 lb	27.2 lb	37 lb	42.5 lb

INTEGRATED RADIO SOFTWARE PACKAGES

Integrated radios may be upgraded by downloading new software packages from the Cambium Networks website or by using the Cambium Network Services Server. The software packages applicable to ePMP integrated radios are named:

- ePMP-NonGPS_Synced-v2.6.1.tar.gz

Connectorized Radio

For details of the ePMP connectorized hardware, see:

- Connectorized Radio description on page 55
- Connectorized Radio part numbers on page 56
- Connectorized Radio Interfaces on page 57
- Connectorized Radio specifications on page 59
- Connectorized Radio and external antenna location on page 60
- Connectorized Radio wind loading on page 61
- Connectorized Radio software packages on page 61
- Connectorized Radio antennas and antenna cabling on page 62

CONNECTORIZED RADIO DESCRIPTION

Figure 12 ePMP Series Connectorized Radio

The connectorized ePMP device is a self-contained transceiver unit that houses both radio and networking electronics. The connectorized unit is designed to work with externally mounted antennas that have high gains. Connectorized units can cope with more difficult radio conditions. The unit is designed with female RP-SMA 50Ω antenna connections located at the top of the unit. An ePMP connectorized unit may function as an Access Point (AP) or a Subscriber Module (SM) in a Point-To-Multipoint (PMP) or in a Point-To-Point (PTP) network topology.

Note

To select antennas, RD cables and connectors for connectorized units, see Connectorized Radio antennas and antenna cabling on page 62.

CONNECTORIZED RADIO PART NUMBERS

Choose the correct regional variant: one is for use in regions where FCC or IC licensing restrictions apply (FCC/IC) and the other is for use in ETSI countries or non-FCC/IC/ETSI-restricted regions.

Each of the parts listed in Table 28 includes the following items:

- One connectorized unit
- One power supply 100/10 Base-TX LAN injector

Table 28 Connectorized Radio part numbers

Cambium description	Cambium part number
ePMP Conn – 5 GHz – no power cord – ROW version	C050900A021A
ePMP Conn – 5 GHz – EU power cord – EU version	C050900A023A
ePMP Conn – 5 GHz – US power cord – FCC version	C058900A122A
ePMP Conn – 2.4 GHz – US power cord	C024900A021A

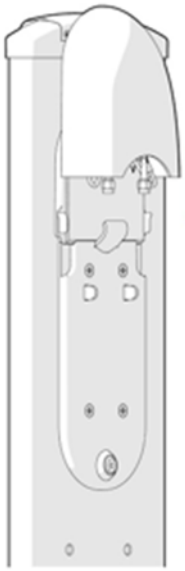
Table 29 Connectorized Radio accessory part numbers

Cambium description	Cambium part number
ePMP Power Supply for non-GPS Radio - no cord (spare)	N000900L002A

CONNECTORIZED RADIO MOUNTING BRACKET

The Connectorized unit is designed to be attached to a Cambium ePMP sector antenna or with a non-Cambium antenna.

Figure 13 Connectorized radio sector antenna



CONNECTORIZED RADIO INTERFACES

The connectorized radio with interfaces are illustrated in Figure 14 and described in Table 30.

Figure 14 Connectorized radio interfaces

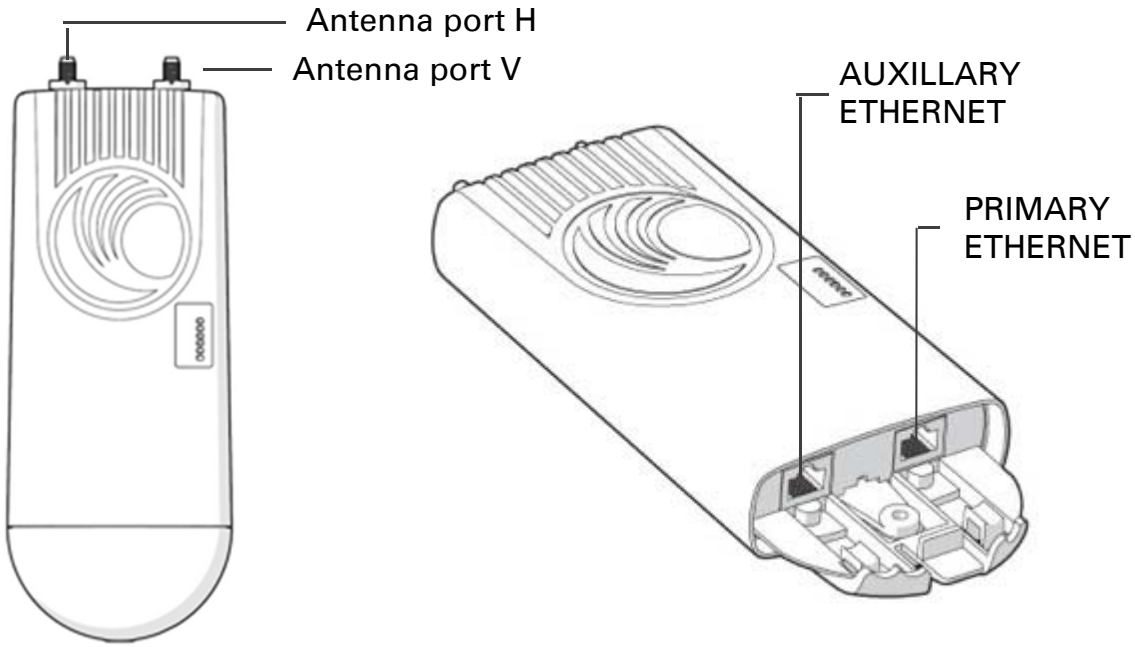
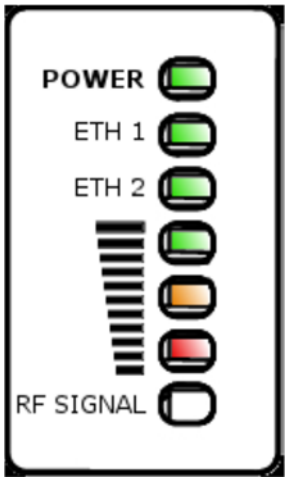


Table 30 Connectorized radio interfaces

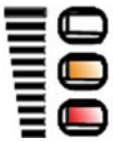
Name	Connector	Interface	Description
Antenna port H	RP-SMA, female	Antenna, H polarization	To/from H polarized antenna port
Antenna port V	RP-SMA, female	Antenna, V polarization	To/from V polarized antenna port
Primary Ethernet	RJ45	PoE input	Proprietary power over Ethernet (PoE) twisted pair (for powering via CMM3/CMM4)
		10/100 Base-TX Ethernet	Management and data
Auxiliary Ethernet (future release)	RJ45	Cambium propriety PoE output, data bridging	***Propriety 30V PoE*** output for auxiliary devices (not 802 3af standard Poe)
Reset Button	Physical button	N/A	For resetting the radio and for resetting the radio back to its factory default configuration, see Using the device external reset button on page 101.

CONNECTORIZED RADIO LEDS



LED	Function
POWER	Green: Power is applied to the device Unlit: No power is applied to the device or improper power source
ETH 1	Main/Primary Ethernet port indicator Once lit, blinking indicates Ethernet activity Green: 10/100BaseTX link
ETH 2	Auxiliary/Secondary Ethernet port indicator Once lit, blinking indicates Ethernet activity Green: 10/100BaseTX link Radio scanning: LEDs light in an ascending sequence to indicate that the radio is scanning Radio registered: LEDs light to indicate the RSSI level at the device.
	Reserved for future release

RSSI > -60 dBm



-70 dBm < RSSI ≤ -60 dBm

-80 dBm < RSSI ≤ -70 dBm

RSSI ≤ -80 dBm

CONNECTORIZED RADIO SPECIFICATIONS

The ePMP connectorized radio conforms to the specifications listed in Table 31 and Table 32.

The connectorized module meets the low level static discharge specifications identified in Electromagnetic compatibility (EMC) compliance on page 191 and provides internal surge suppression but does not provide lightning suppression.

For a full listing of connectorized radio specifications, see ePMP 1000 Connectorized Radio Specifications on page 250.

Table 31 Connectorized radio physical specifications

Category	Specification
Dimensions (H x W x D)	Radio: 227 x 88 x 33 mm (8.9″ x 3.5″ x 1.3″) Antenna: 529 x 124 x 53 mm (20.8″ x 4.9″ x 2.1″)
Weight	.521 kg (1.15 lbs) without antenna 4.5 kg (10 lbs) with antenna

Table 32 Connectorized radio environmental specifications

Category	Specification
Temperature	-30°C (-22°F) to +55°C (131°F)
Wind loading	118 mph (190 kph) maximum. See Connectorized Radio wind loading on page 61 for a full description.
Humidity	95% condensing
Environmental	IP55

CONNECTORIZED RADIO HEATER

On startup, if the ePMP Connectorized radio temperature is at or below 32° F (0° C), an internal heater is activated to ensure that the device is able to successfully begin operation. The unit's heater is only activated when the unit is powered on and will not transfer heat to the device until the startup completes. When the unit temperature is greater than 32° F (0° C), the heater is deactivated and the unit continues its startup sequence.

The effect on device startup time at various temperatures is defined in Table 33.

Table 33 Connectorized radio startup times based on ambient temperature

Initial Temperature	Startup time (from power on to operational)
-22° F (-30° C)	20 minutes
-4° F (-20° C)	6 minutes
14° F (-10° C)	2 minutes, 30 seconds

CONNECTORIZED RADIO AND EXTERNAL ANTENNA LOCATION

Find a location for the device and external antenna that meets the following requirements:

- The equipment is high enough to achieve the best radio path.
- People are 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 193.
- The equipment is lower than the top of the supporting structure (tower, mast or building) or its lightning air terminal.
- The location is not subjected to excessive wind loading. For more information, see Connectorized Radio wind loading on page 61.

CONNECTORIZED RADIO WIND LOADING

Ensure that the device and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed ePMP site. Wind speed statistics must be available from national meteorological offices.

The device and its mounting bracket are capable of withstanding wind speeds of up to 190 kph (118 mph).

Wind speeds on the device subjects the mounting structure to significant lateral force. The magnitude of the force depends on both the wind strength and surface area of the device. Wind loading is estimated using the following formulae:

Force (in kilograms) = $0.1045aV^2$

Where:	Is:
a	surface area in square meters
V	wind speed in meters per second

Force (in pounds) = $0.0042Av^2$

Where:	Is:
A	surface area in square feet
v	wind speed in miles per hour

Applying these formulae to the ePMP device at different wind speeds, the resulting wind loadings are shown in Table 34 and Table 35.

Table 34 Connectorized radio wind loading (Kg)

Type of ePMP device	Largest surface area (square meters)	Wind speed (meters per second)				
		30	40	50	60	70
Connectorized	0.13	12.2 Kg	21.7 Kg	34 Kg	49 Kg	66.6 Kg

Table 35 Connectorized radio wind loading (lb)

Type of ePMP device	Largest surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Connectorized	1.39	37.4 lb	58.4 lb	84.1 lb	114.4 lb	131.4 lb

CONNECTORIZED RADIO SOFTWARE PACKAGES

Connectorized radio may be upgraded by downloading new software packages from the Cambium Networks website or by using the Cambium Network Services Server. The software packages applicable to ePMP Un-synced connectorized radio are named:

- ePMP-NonGPS_Synced-v2.6.1.tar.gz

CONNECTORIZED RADIO ANTENNAS AND ANTENNA CABLING

Connectorized radio requires external antennas connected using RF cable (included with Cambium ePMP sector antennas). For details of the antennas and accessories required for a connectorized ePMP installation, see:

- Antenna requirements on page 48
- FCC and IC approved antennas on page 48

ANTENNA REQUIREMENTS

For connectorized units operating in the USA or Canada 2.4 GHz, 5.4 GHz or 5.8 GHz bands, choose external antennas from those listed in FCC and IC approved antennas on page 48. For installations in other countries, the listed antennas are advisory, not mandatory.

FCC AND IC APPROVED ANTENNAS

For connectorized units operating in the USA or Canada, choose external antennas from Table 36. These are approved by the FCC for use with the product and are constrained by the following limits:

- 5 GHz – 15 dBi gain
- 2.4 GHz - 15 dBi gain

Caution

Using other than approved antennas may cause measurements higher than reported for certification.

This radio transmitter (IC certification number 109W-0005) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio (Numéro de certification IC 109W-0005) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Table 36 Allowed antennas for deployment in USA/Canada – 5 GHz

Cambium part number	Antenna Type	Gain (dBi)
C050900D003A	5 GHz Sector Antenna – 90 degree	15
C050900D002A	5 GHz Sector Antenna – 120 degree	15
C024900D004A	2.4 GHz Sector Antenna - 90 /120 degree	15

Force 180

For details of the ePMP Force 180 hardware, see:

- Force 180 description on page 63
- Force 180 part numbers on page 64
- Force 180 mounting bracket on page 64
- Force 180 interfaces on page 65
- Force 180 LEDs on page 66
- Force 180 heater on page 67
- Force 180 wind loading on page 67
- Force 180 software packages on page 68

FORCE 180 DESCRIPTION

The Force 180 integrated module is a self-contained transceiver unit that houses both radio and networking electronics. An ePMP Force 180 unit may function as an Access Point (AP) or a Subscriber Module (SM) in a Point-To-Multipoint (PMP) or in a Point-To-Point (PTP) network topology. It is typically deployed as an SM in a PMP system.

Figure 15 ePMP Series Force 180

FORCE 180 PART NUMBERS

Choose the correct regional variant: one is for use in regions where FCC or IC licensing restrictions apply (FCC/IC) and the other is for use in ETSI countries or the rest of the world (ETSI/RoW).

Each of the parts listed in Table 37 includes the following items:

- One Force 180 module (with mounting bracket)
- One metal mounting strap
- Power supply

Table 37 Force 180 part numbers

Cambium description	Cambium part number
ePMP 5 GHz Force 180 Integrated Radio (FCC) (US cord)	C058900C072A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (no cord)	C050900C071A
ePMP 5 GHz Force 180 Integrated Radio (EU) (EU cord)	C050900C073A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (US cord)	C050900C171A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (EU cord)	C050900C271A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (UK cord)	C050900C371A
ePMP 5 GHz Force 180 Integrated Radio (EU) (UK cord)	C050900C373A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (India cord)	C050900C471A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (China cord)	C050900C571A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (Brazil cord)	C050900C671A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (Argentina cord)	C050900C771A
ePMP 5 GHz Force 180 Integrated Radio (ROW) (ANZ cord)	C050900C871A

FORCE 180 MOUNTING BRACKET

The Force 180 module is designed to be pole-mounted using the mounting strap and bracket provided in the box with the radio.

Figure 16 Force 180 module mounting bracket

FORCE 180 INTERFACES

The Force 180 module interfaces are illustrated in Figure 17 and described in Table 38.

Figure 17 Force 180 interfaces

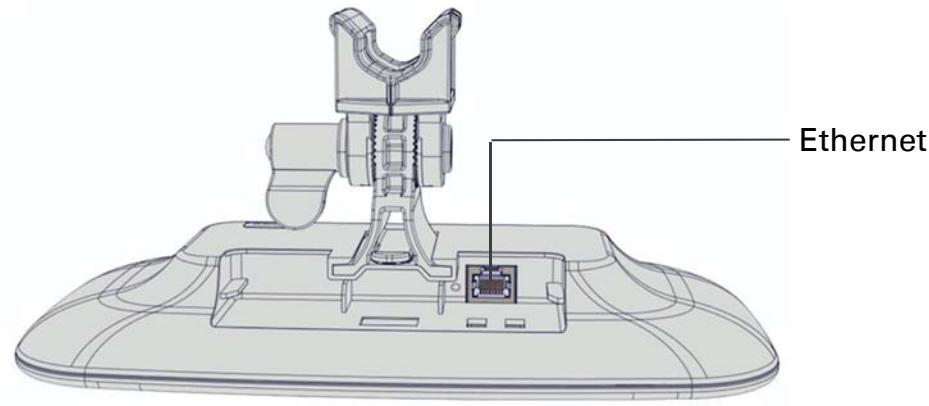


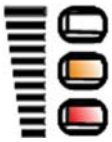
Table 38 Force 180 interfaces

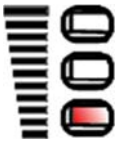
Port name	Connector	Interface	Description
Ethernet	RJ45	PoE input	10/100/1000BaseT, Compatible with Cambium PoE pinouts (V+ = 7 & 8, Return = 4 & 5) and Standard PoE pinouts (V+ = 4 & 5, Return = 7 & 8)
		10/100/1000 Base-TX Ethernet	Management and data
Reset Button	Physical button	N/A	For resetting the radio and for setting the radio back to its factory default configuration. See Using the device external reset button on page 101.

FORCE 180 LEDS

LED	Function
POWER	Green: Power is applied to the device Unlit: No power is applied to the device or improper power source
ETH	Ethernet port indicator Once lit, blinking indicates Ethernet activity Green: 10/100/1000 BaseTX link
	Radio scanning: LEDs light in an ascending sequence to indicate that the radio is scanning Radio registered: LEDs light to indicate the RSSI level at the device.


RSSI > -60 dBm


-70 dBm < RSSI ≤ -60 dBm


-80 dBm < RSSI ≤ -70 dBm


RSSI ≤ -80 dBm

FORCE 180 SPECIFICATIONS

The Force 180 module conforms to the specifications listed in Table 39 and Table 40.

The device meets the low level static discharge specifications identified in Electromagnetic compatibility (EMC) compliance on page 191 and provides internal surge suppression but does not provide lightning suppression.

For a full listing of Force 180 specifications, see Force 180 Specifications on page 254.

Table 39 Force 180 physical specifications

Category	Specification
Dimensions (H x W x D)	Radio: 12.5 x 25.1 x 11.9 cm (4.9 x 9.9 x 4.7 in) – with mounting bracket attached Radio: 12.5 x 25.1 x 4 cm (4.9 x 9.9 x 1.6 in) – without mounting bracket attached
Weight	0.50 kg (1.1 lbs)

Table 40 Force 180 environmental specifications

Category	Specification
Temperature	-30°C (-22°F) to +60°C (140°F)
Wind loading	90 mph (145 kph) maximum. See Force 180 wind loading on page 67 for a full description.
Humidity	95% condensing
Environmental	IP55

FORCE 180 HEATER

Upon power on, if the ePMP Force 180 device temperature is at or below 32° F (0° C), an internal heater is activated to ensure that the device is able to successfully begin operation. The unit's heater is only activated when the unit is powered on and will not apply heat to the device once startup is complete. When the unit temperature is greater than 32° F (0° C), the heater is deactivated and the integrated module continues its startup sequence.

The effect on Force 200 startup time at various temperatures is defined in Table 41.

Table 41 Force 180 startup times based on ambient temperature

Initial Temperature	Startup time (from power on to operational)
-22° F (-30° C)	4 minutes
-4° F (-20° C)	2 minutes
14° F (-10° C)	1 minutes, 30 seconds

FORCE 180 WIND LOADING

Ensure that the Force 180 and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed ePMP site. Wind speed statistics must be available from national meteorological offices.

The Force 180 and its mounting bracket are capable of withstanding wind speeds of up to 145 Kph (90 mph).

Wind blowing on the Force 180 will subject the mounting structure to significant lateral force. The magnitude of the force depends on both wind strength and surface area of the Force 180. Wind loading is estimated using the following formulae:

Force (in kilograms) = $0.1045aV^2$

Where:	Is:
a	surface area in square meters
V	wind speed in meters per second

Force (in pounds) = $0.0042Av^2$

Where:	Is:
A	surface area in square feet
v	wind speed in miles per hour

Applying these formulae to the ePMP Force 180 at different wind speeds, the resulting wind loadings are shown in Table 42 and Table 43.

Table 42 Force 180 wind loading (Kg)

Type of ePMP module	Largest surface area (square meters)	Wind speed (meters per second)				
		30	40	50	60	70
Force 180	0.031	3 Kg	5.2 Kg	8.2 Kg	11.8 Kg	16 Kg

Table 43 Force 180 wind loading (lb)

Type of ePMP module	Largest surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Force 180	0.33	9 lb	14.1 lb	20.3 lb	27.7 lb	31.8 lb

FORCE 180 SOFTWARE PACKAGES

Force 180 radios may be upgraded by downloading new software packages from the Cambium Networks website or by using the Cambium Network Services Server. The software packages applicable to ePMP Force 180 are named:

- ePMP-NonGPS_Synced-v2.6.1.tar.gz

Force 200

For details of the ePMP Force 200 hardware, see:

- Force 200 description on page 69
- Force 200 part numbers on page 70
- Force 200 mounting bracket on page 71
- Force 200 interfaces on page 72
- Force 200 LEDs on page 73
- Force 200 heater on page 74
- Force 200 wind loading on page 74
- Force 200 software packages on page 75

FORCE 200 DESCRIPTION

Figure 18 ePMP Series Force 200

The Force 200 integrated dish is a self-contained transceiver unit that houses both radio, parabolic dish and networking electronics. An ePMP Force 200 unit may function as an Access Point (AP) or a Subscriber Module (SM) in a Point-To-Multipoint (PMP) or in a Point-To-Point (PTP) network topology. It is typically deployed as an SM in a PMP system and either Master or Slave in a PTP system.

Figure 19 ePMP Series Force 200 (with optional radome – sold separately)

FORCE 200 PART NUMBERS

Choose the correct regional variant: one is for use in regions where FCC or IC licensing restrictions apply (FCC/IC) and the other is for use in ETSI countries or the rest of the world (ETSI/RoW).

Each of the parts listed in Table 44 includes the following items:

- Force 200 Radio Assembly
    - Power Cord (if applicable)
    - Power Supply
- Force 200 Dish
- Force 200 Pole Bracket Assembly
- Force 200 Pole Clamp Assembly
- Four M6 Bolts

Table 44 Force 200 part numbers

Cambium description	Cambium part number
ePMP 5 GHz Force 200AR5-25 High Gain Radio (FCC) (US cord)	C058900C062A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (no cord)	C050900C061A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (EU) (EU cord)	C050900C063A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (US cord)	C050900C161A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (EU cord)	C050900C261A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (UK cord)	C050900C361A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (EU) (UK cord)	C050900C363A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (India cord)	C050900C461A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (China/ANZ cord)	C050900C561A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (Brazil cord)	C050900C661A
ePMP 5 GHz Force 200AR5-25 High Gain Radio (ROW) (Argentina cord)	C050900C761A
ePMP 2.4 GHz Force 200AR2-25 High Gain Radio (US cord)	C024900C161A
ePMP 2.4 GHz Force 200AR2-25 High Gain Radio (EU cord)	C024900C261A
ePMP Force 200 Radome	N000900L021A

FORCE 200 MOUNTING BRACKET

The Force 200 module is designed to be pole-mounted using the mounting bracket and clamp assembly provided in the box with the radio.

Figure 20 Force 200 mounting bracket (side)

Figure 21 Force 200 mounting bracket (back)

FORCE 200 INTERFACES

The Force 200 module interfaces are illustrated in Figure 22 and described in Table 45.

Figure 22 Force 200 interfaces

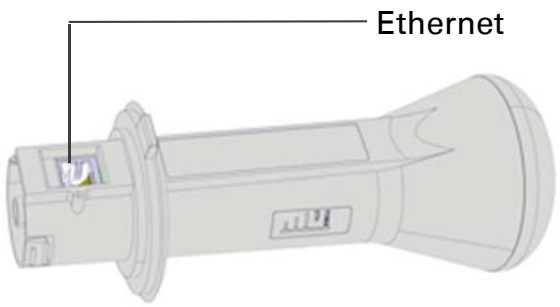


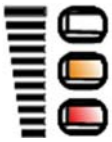
Table 45 Force 200 interfaces

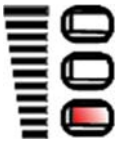
Port name	Connector	Interface	Description
Ethernet	RJ45	PoE input	10/100/1000BaseT, Compatible with Cambium PoE pinouts (V+ = 7 & 8, Return = 4 & 5) and Standard PoE pinouts (V+ = 4 & 5, Return = 7 & 8)
		10/100/1000 Base-TX Ethernet	Management and data
Reset Button	Physical button	N/A	For resetting the radio and for setting the radio back to its factory default configuration. See Using the device external reset button on page 101.

FORCE 200 LEDS

LED	Function
POWER	Green: Power is applied to the device Unlit: No power is applied to the device or improper power source
ETH	Ethernet port indicator Once lit, blinking indicates Ethernet activity Green: 10/100/1000 BaseTX link
	Radio scanning: LEDs light in an ascending sequence to indicate that the radio is scanning Radio registered: LEDs light to indicate the RSSI level at the device.


RSSI > -60 dBm


-70 dBm < RSSI ≤ -60 dBm


-80 dBm < RSSI ≤ -70 dBm


RSSI ≤ -80 dBm

FORCE 200 SPECIFICATIONS

The Force 200 module conforms to the specifications listed in Table 46 and Table 47.

The device meets the low level static discharge specifications identified in Electromagnetic compatibility (EMC) compliance on page 191 and provides internal surge suppression but does not provide lightning suppression.

For a full listing of Force 200 specifications, see Force 200 Specifications on page 256.

Table 46 Force 200 physical specifications

Category	Specification
Dimensions (Dia x Depth)	47 x 28 cm (18.5 x 11.2 in)
Weight	2.4 GHz: 2.8 kg (6.2 lbs) 5 GHz: 2.3 kg (5.1 lbs)

Table 47 Force 200 environmental specifications

Category	Specification
Temperature	-30°C (-22°F) to +60°C (140°F) – with radome attached maximum temperature is +47°C (116°F)
Wind loading	90 mph (145 kph) maximum. See Force 200 wind loading on page 74 for a full description.
Humidity	95% condensing
Environmental	IP55

FORCE 200 HEATER

Upon power on, if the ePMP Force 200 device temperature is at or below 32° F (0° C), an internal heater is activated to ensure that the device is able to successfully begin operation. The unit's heater is only activated when the unit is powered on and will not apply heat to the device once startup is complete. When the unit temperature is greater than 32° F (0° C), the heater is deactivated and the Force 200 module continues its startup sequence.

The effect on Force 200 startup time at various temperatures is defined in Table 48.

Table 48 Force 200 startup times based on ambient temperature

Initial Temperature	Startup time (from power on to operational)
-22° F (-30° C)	4 minutes
-4° F (-20° C)	2 minutes
14° F (-10° C)	1 minutes, 30 seconds

FORCE 200 WIND LOADING

Ensure that the Force 200 and the structure on which it is mounted are capable of withstanding the prevalent wind speeds at a proposed ePMP site. Wind speed statistics must be available from national meteorological offices.

The Force 200 and its mounting bracket are capable of withstanding wind speeds of up to 145 Kph (90 mph).

Wind blowing on the Force 200 will subject the mounting structure to significant lateral force. The magnitude of the force depends on both wind strength and surface area of the integrated module. Wind loading is estimated using the following formulae:

Force (in kilograms) = $0.1045aV^2$

Where:	Is:
a	surface area in square meters
V	wind speed in meters per second

Force (in pounds) = $0.0042Av^2$

Where:	Is:
A	surface area in square feet
v	wind speed in miles per hour

Applying these formulae to the ePMP Force 200 at different wind speeds, the resulting wind loadings are shown in Table 49 and Table 50.

Table 49 Force 180 wind loading (Kg)

Type of ePMP module	Largest surface area (square meters)	Wind speed (meters per second)				
		30	40	50	60	70
Force 200	0.13	12.3 Kg	22 Kg	34.4 Kg	49.5 Kg	67.4 Kg

Table 50 Force 180 wind loading (lb)

Type of ePMP module	Largest surface area (square feet)	Wind speed (miles per hour)				
		80	100	120	140	150
Force 200	1.44	38.7 lb	60.4 lb	87 lb	118 lb	136 lb

FORCE 200 SOFTWARE PACKAGES

Force 200 radios may be upgraded by downloading new software packages from the Cambium Networks website or by using the Cambium Network Services Server. The software packages applicable to ePMP Force 200 are named:

- ePMP-NonGPS_Synced-v2.6.1.tar.gz

Power Supply

For details of the ePMP power supply units, see:

- Power supply description on page 76
- Power supply part numbers on page 76
- Power supply interfaces on page 77
- Power supply specifications on page 78
- Power supply location on page 78

POWER SUPPLY DESCRIPTION

The power supply is an indoor unit that is connected to the ePMP module and network terminating equipment using Cat5e cable with RJ45 connectors. It is also plugged into an AC or DC power supply so that it can inject Power over Ethernet (PoE) into the module.

POWER SUPPLY PART NUMBERS

Each module requires one power supply and one power supply line cord. For cord part numbers, see Table 51. The power supplies listed in Table 51 may be used for all ePMP modules, however, only N000900L001A provides a Gigabit Ethernet interface.

Table 51 Power supply component part numbers

Cambium description	Cambium part number
ePMP Pwr Supply for GPS Radio - no cord (spare)	N000900L001A
ePMP Pwr Supply for non-GPS Radio - no cord (spare)	N000900L002A

POWER SUPPLY INTERFACES

The power supply interfaces are illustrated in Figure 23 and described in Table 52 and Table 54.

Figure 23 Power supply interfaces

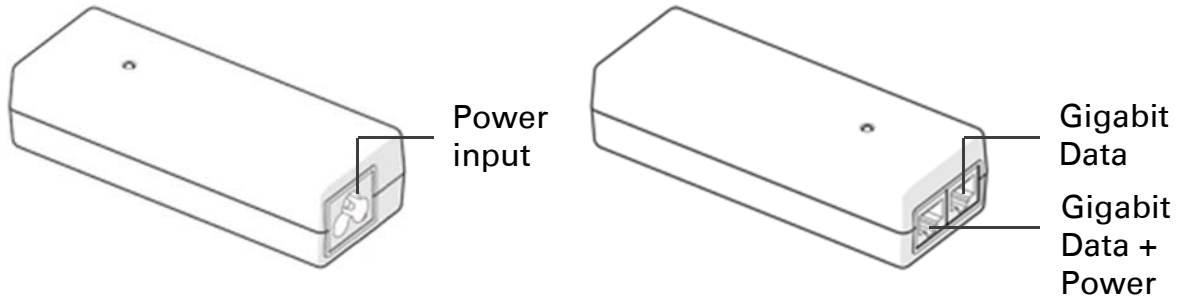


Table 52 Power supply interface functions - N000900L001A

Interface	Function
Power input	Mains power input.
Gigabit Data + Power	RJ45 socket for connecting Cat5e cable to radio Note This port provides a Gigabit Ethernet interface to ePMP GPS Synced connectorized radios. To ePMP integrated radios, this port provides a 10/100 Mbit/sec Ethernet interface.
Gigabit Data	RJ45 socket for connecting Cat5e cable to network.

Table 53 Power supply interface functions - N000900L002A

Interface	Function
Power input	Mains power input.
10/100 Mbit/sec Data + Power	RJ45 socket for connecting Cat5e cable to radio
10/100 Mbit/sec Data	RJ45 socket for connecting Cat5e cable to network.

Table 54 Power Supply LED functions

LED	Function
Power (green)	Power supply detection

POWER SUPPLY SPECIFICATIONS

The ePMP power supply conforms to the specifications listed in Table 55, Table 56 and Table 57. These specifications apply to all ePMP product variants.

Table 55 Power supply physical specifications

Category	Specification
Dimensions (H x W x D)	11.8 x 4.4 x 3.2 cm (4.66 x 1.75 x 1.25 in)
Weight	0.26 lbs

Table 56 Power supply environmental specifications

Category	Specification
Ambient Operating Temperature	0° C to +40° C
Humidity	20% - 90%

Table 57 Power supply electrical specifications

Category	Specification
AC Input	100 to 240 VAC
Efficiency	Meets efficiency level 'V'
Over Current Protection	Zener clamping (38V to 45V)
Hold up time	10 ms minimum at maximum load, 120 VAC

POWER SUPPLY LOCATION

Find a location for the power supply that meets the following requirements:

- The power supply can be mounted on a wall or other flat surface.
- The power supply is kept dry, with no possibility of condensation, flooding or rising damp.
- The power supply can be accessed to view status indicators.
- The power supply can be connected to the ePMP module drop cable and network terminating equipment.
- The power supply can be connected to a mains or dc power supply that meets the requirements defined in Table 57.

Ethernet cabling

For details of the Ethernet cabling components of an ePMP installation, see:

- Ethernet standards and cable lengths on page 79
- Outdoor Cat5e cable on page 79

ETHERNET STANDARDS AND CABLE LENGTHS

All configurations require a copper Ethernet connection from the power supply port to the power supply and network terminating equipment.

For each power supply, the maximum permitted drop cable length is specified in Table 58.

Table 58 Power supply drop cable length restrictions

Part number	Description	Maximum cable length (*1)
N000900L001A	Power Supply for Radio with Gigabit Ethernet (no cord)	330 feet (100m)
N000900L002A	Power Supply for Radio with 100Mbit Ethernet (no cord)	330 feet (100m)

(*1) Maximum length of Ethernet cable from AP/SM to power supply

OUTDOOR CAT5E CABLE

For copper connections from the device to the power supply, use Cat5e cable that is shielded with copper-plated steel.

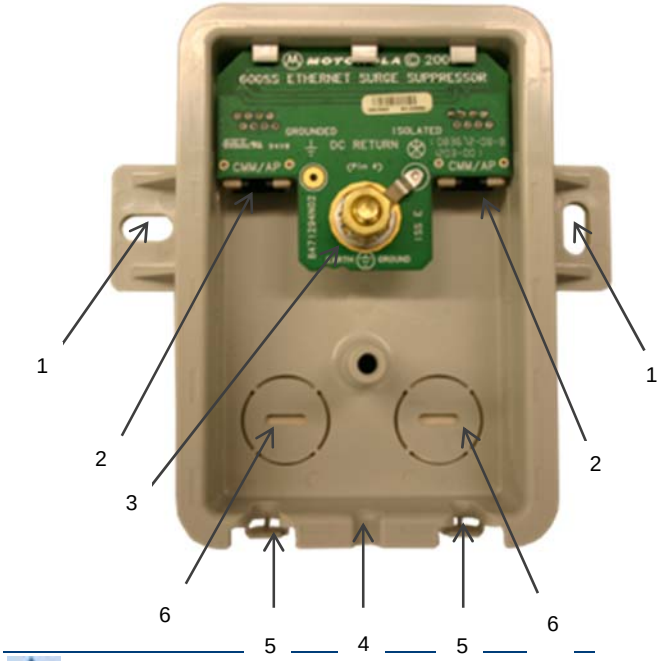
 Caution

Always use Cat5e cable that is shielded with copper-plated steel. Alternative types of Ethernet cables are not supported by Cambium Networks.

Surge Suppression unit

The ePMP integrated and connectorized units both contain 1 Joule-rated surge suppression built into the device. With this built-in surge suppression, it is not required to install a surge suppressor at the unit's mounting location. However, it is required to install a surge suppressor at the Ethernet cable's building ingress into the power supply's indoor location. For installations that do not require Gigabit (1000 Mbit/sec) Ethernet, a Cambium 600SSH surge suppressor may be used. For more details, see Cambium 600SSH details.

CAMBIUM 600SSH DETAILS



Note

For connectorized module installations requiring Gigabit (1000 Mbit/sec) Ethernet surge suppression, utilize the following:

Mfr	Part	Description
L-COM	AL-CAT6JW	Outdoor 10/100/1000 Base-T CAT6 PoE Compatible Lightning Protector
L-COM	AL-CAT6HPJW	Outdoor 10/100/1000 Base-T CAT6 PoE Compatible Lightning Protector – High Power (protection comparable to 600SSH)

1 Holes—for mounting the Surge Suppressor to a flat surface (such as an outside wall). The distance between centers is 4.25 inches (108 mm).

2 RJ-45 connectors—One side (neither side is better than the other for this purpose) connects to the product (AP, SM, or cluster management module). The other connects to the AC adaptor's Ethernet connector.

3 Ground post and washer—use heavy gauge (10 AWG or 6 mm^2) copper wire for connection. Refer to local electrical codes for exact specifications.

Note

The 600SSH surge suppressor is shipped in the "isolated" position (pin 4 isolated by 68V from protective earth). If packet error issues occur over the Ethernet link (verify by pinging the device through the 600SSH), configure the 600SSH to "grounded" position (by moving the 600SSH switch from "isolated" to "ground") to avoid ground loops that may be present in the system.

4 Ground Cable Opening—route the 10 AWG (6 mm^2) ground cable through this opening.

5 CAT-5 Cable Knockouts—route the two CAT-5 cables through these openings, or alternatively through the Conduit Knockouts.

6 Conduit Knockouts—on the back of the case, near the bottom. Available for installations where cable is routed through building conduit.

System planning

This chapter provides information to help the user to plan an ePMP link.

The following topics are described in this chapter:

- How to plan ePMP links to conform to the regulatory restrictions that apply in the country of operation is explained under Radio spectrum planning on page 83.
- Factors to be considered when planning links such as range, path loss and throughput are described under Link planning on page 87.
- Factors to be considered when planning to use connectorized APs with external antennas in ePMP links are described under Planning for connectorized units on page 88.
- The grounding and lightning protection requirements of a ePMP installation is described under Grounding and lightning protection on page 31.
- Factors to be considered when planning ePMP data networks are described under Data network planning on page 90.

Radio spectrum planning

This section describes how to plan ePMP links to conform to the regulatory restrictions that apply in the country of operation.

Caution

The user must ensure ePMP product operates in accordance to local regulatory limits.

Note

Contact the applicable radio regulator to check if registration of the ePMP link is required or not.

GENERAL WIRELESS SPECIFICATIONS

The wireless specifications that apply to all ePMP variants are listed under Table 59. The wireless specifications that are specific to each frequency variant are listed in Table 60 and Table 61.

Table 59 ePMP wireless specifications (all variants)

Item	Specification
Channel selection	Automatic and Manual selection (fixed frequency).
Manual power control	To avoid interference to other users of the band, maximum power can be set lower than the default power limit.
Integrated device antenna type	Patch antenna
Duplex scheme	Adaptive TDD (with optional Standard 802.11n Wi-Fi on SM)
Range	21 mi (5 MHz channel bandwidth) 17 mi (10 MHz channel bandwidth) 13 mi (20 MHz channel bandwidth) 9 mi (40 MHz channel bandwidth)
Over-the-air encryption	AES
Error Correction	FEC

Table 60 ePMP 2000 wireless specifications (per frequency band)

Item	5 GHz
RF band (GHz)	5150 - 5970 MHz
Channel bandwidth	5 MHz, 10 MHz, 20 MHz or 40 MHz
Typical antenna gain	Connectorized antenna – 18 dBi

Table 61 ePMP 1000 wireless specifications (per frequency band)

Item	5 GHz	2.4 GHz
RF band (GHz)	4900 - 5980 MHz	2407 - 2472 MHz
Channel bandwidth	5 MHz, 10 MHz, 20 MHz or 40 MHz	5 MHz, 10 MHz, 20 MHz or 40 MHz
Typical antenna gain	Connectorized antenna – 15 dBi Integrated patch antenna – 13 dBi Reflector dish antenna – 6 dBi	Connectorized antenna - 15 dBi Integrated patch antenna - 11 dBi Reflector dish antenna – 8 dBi
Antenna beamwidth (Integrated)	24° azimuth, 12° elevation	24° azimuth, 12° elevation
Antenna beamwidth (Relector dish)	10° azimuth, 25° elevation	10° azimuth, 28° elevation

REGULATORY LIMITS

The local regulator may restrict frequency usage and channel width and may limit the amount of conducted or radiated transmitter power. For details of these restrictions, see Examples of regulatory limits on page 208.

Many countries impose EIRP limits (Allowed EIRP) on products operating in the bands used by the ePMP Series. For example, in the 5 GHz and 2.4 GHz bands, these limits are calculated as follows:

- In the 5.2 GHz (5250 MHz to 5350 MHz) and 5.4 GHz (5470 MHz to 5725 MHz) band, the EIRP must not exceed the lesser of 30 dBm or (17 + 10 x Log Channel width in MHz) dBm.
- In the 5.8 GHz band (5725 MHz to 5875 MHz), the EIRP must not exceed the lesser of 36 dBm or (23 + 10 x Log Channel width in MHz) dBm.
- In the 2.4 GHz band (2400 MHz to 2500 MHz), the EIRP must not exceed the lesser of 36 dBm or (23 + 10 x Log Channel width in MHz) dBm.

Some countries (for example the USA) impose conducted power limits on products operating in the 5 GHz and 2.4 GHz band.

CONFORMING TO THE LIMITS

Ensure the link is configured to conform to local regulatory requirements by configuring the correct country code (located in the web management interface, under **Configure** => **Radio**). In the following situations, the country code does not automatically prevent operation outside the regulations:

- When using connectorized APs with external antennas, the regulations may require the maximum transmit power to be reduced. To ensure that regulatory requirements are met for connectorized installations, see Calculating maximum power level for connectorized units on page 88. When operating in ETSI regions, it is required to enter a license key in the ePMP web management interface to unlock 5.8 GHz band frequencies. This key may be obtained from https://support.cambiumnetworks.com/licensekeys/epmp.

- When installing 5.4 GHz links in the USA, it may be necessary to avoid frequencies used by Terminal Doppler Weather Radar (TDWR) systems. For more information, see Avoidance of weather radars on page 86.

AVAILABLE SPECTRUM

The available spectrum for operation depends on the region. When configured with the appropriate country code, the unit will only allow operation on those channels which are permitted by the regulations.

 Note

In Italy, there is a regulation which requires a general authorization of any 5.4 GHz radio link which is used outside the operator's own premises. It is the responsibility of the installer or operator to have the link authorized. For details, see:

http://www.sviluppoeconomico.gov.it/index.php?option=com_content&view=article&idmenu=672&idarea1=593&andor=AND&idarea2=1052&id=68433&sectionid=1,16&viewType=1&showMenu=1&showCat=1&idarea3=0&andorcat=AND&partebassaType=0&idareaCalendario1=0&MvediT=1&idarea4=0&showArchiveNewsBotton=0&directionidUser=0

For the form that must be used for general authorization, see:

http://www.sviluppoeconomico.gov.it/images/stories/mise_extra/Allegato%20n19.doc

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.

For details of these restrictions, see Examples of regulatory limits on page 208.

Where regulatory restrictions apply to certain channels, these channels are barred automatically by the use of the correct country code. For example, at 5.8 GHz in the UK and some other European countries, the RTTT band 5795 MHz to 5815 MHz is barred. With the appropriate country code configured for this region, the ePMP will not operate on channels within this band.

The number and identity of channels barred by the license key and country code is dependent on the channel bandwidth.

For more information about configuring the **Country Code** parameter, see AP Radio page on page Error! Bookmark not defined. and SM Radio page on page Error! Bookmark not defined..

CHANNEL BANDWIDTH

Select the required channel bandwidth for the link. The selection depends upon the ePMP frequency variant and country code, as specified on page 208.

Wider a channel bandwidth greater is its capacity. As narrower channel bandwidths take up lesser 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.

AVOIDANCE OF WEATHER RADARS

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.

The requirement for ensuring 30 MHz frequency separation is based on the best information available to date. If interference is not eliminated, a distance limitation based on line-of-sight from TDWR will need to be used. In addition, 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 PMP 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.

In ETSI regions, the band 5600 MHz to 5650 MHz is reserved for the use of weather radars.

Link planning

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

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.

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:

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

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)

Free space path loss is a major determinant in received (Rx) 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, the fade margin is the difference between strength of the received signal and the strength that the receiver requires for maintaining a 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.

Planning for connectorized units

This section describes factors to be taken into account when planning to use connectorized APs with external antennas in ePMP networks.

CALCULATING MAXIMUM POWER LEVEL FOR CONNECTORIZED UNITS

If a connectorized ePMP link is to be installed in a country that imposes an EIRP limit in the selected band, choose an external antenna and RF cable that will not cause the ePMP to exceed the EIRP limit. To calculate the highest setting of Maximum Power Level that will be permitted, use this formula:

Maximum Power Level (dBm) = Allowed EIRP (dBm) – Antenna Gain (dBi) + Cable Loss (dB)

Where:	Is:
Maximum Power Level (dBm)	the highest permissible setting of the Maximum Power Level attribute in the Step 2: Wireless Configuration page,
Allowed EIRP (dBm)	the EIRP limit allowed by the regulations,
Antenna Gain (dBi)	the gain of the chosen antenna,
Cable Loss (dB)	the loss of the RF cable connecting the AP to the antenna.

As the 2.4 GHz, 5.4 GHz and 5.8 GHz have an operating bandwidth of 5 MHz, 10 MHz, 20 MHz or 40 MHz then the maximum allowed EIRP depends on the operating bandwidth of the radio as shown in Table 62.

Table 62 Normal EIRP limits with operating channel bandwidth

Operating bandwidth (MHz)	Allowed EIRP (dBm) at 5.2 GHz	Allowed EIRP (dBm) at 5.4 GHz	Allowed EIRP (dBm) at 5.8 GHz	Allowed EIRP (dBm) at 2.4 GHz
5, 10, 20, 40	24 - 30	24 - 30	36	36

The settings to be used for regions with the EIRP limits in Table 62 are shown in Table 63.

Table 63 Setting maximum transmit power to meet general EIRP limits

Antenna	Maximum available antenna gain (dBi)	Operating bandwidth (MHz)	Transmitter Output Power parameter setting (dBm)			
			5.2 GHz	5.4 GHz	5.8 GHz	2.4 GHz
ePMP 2000 Connectorized module Sector antenna	18	5, 10, 20, 40	12	12	18	N/A
ePMP 1000 Connectorized module Sector antenna	15	5, 10, 20, 40	15	15	21	21

 Note

Calculations under Table 63 are on the basis of 0.5 dB cable loss and the highest gain antennas per size of which Cambium Networks are aware. At these operating frequencies, antenna cable losses even with short cables are unlikely to ever be below 0.5 dB for practical installations and cable diameters.

Data network planning

This section describes factors to be considered when planning ePMP data networks.

ETHERNET INTERFACES

The ePMP Ethernet ports conform to the specifications listed in Table 64 and Table 65.

Table 64 ePMP 2000 Ethernet bridging specifications

Ethernet Bridging	Specification
Protocol	10BASE-Te/100BASE-Tx/1000BASE-T IEEE 802.3 IEEE 802.3at (PoE) IEEE802.3u compliant Auto-negotiation
QoS	Proprietary QoS
Interface	10/100/1000BaseT (RJ-45)
Data Rates	See Data throughput tables on page 236.
Maximum Ethernet Frame Size	1700 bytes
Service classes for bridged traffic	3 classes

Table 65 ePMP 1000 Ethernet bridging specifications

Ethernet Bridging	Specification
Protocol	10BASE-Te/100BASE-Tx/1000BASE-T IEEE 802.3 IEEE 802.3af (PoE) IEEE802.3u compliant Auto-negotiation
QoS	Proprietary QoS
Interface	10/100/1000BaseT (RJ-45)
Data Rates	See Data throughput tables on page 236.
Maximum Ethernet Frame Size	1700 bytes
Service classes for bridged traffic	3 classes

 Note

Practical Ethernet rates will depend on network configuration, higher layer protocols and platforms used.

Over the air throughput will be capped to the rate of the Ethernet interface at the receiving end of the link.

MANAGEMENT VLAN

Decide if the IP interface of the AP/SM management agent will be connected in a VLAN. If so, decide if this is a standard (IEEE 802.1Q) VLAN or provider bridged (IEEE 802.1ad) VLAN, and select the VLAN ID for this VLAN.

Use of a separate management VLAN is strongly recommended. Use of the management VLAN helps to ensure that the AP/SM management agent cannot be accessed by customers.

QUALITY OF SERVICE FOR BRIDGED ETHERNET TRAFFIC

Decide how quality of service will be configured in ePMP to minimize frame loss and latency for high priority traffic. Wireless links often have lower data capacity than wired links or network equipment like switches and routers, and quality of service configuration is most critical at network bottlenecks.

ePMP provides three priority types for traffic waiting for transmission over the wireless link – Voice, High and Low. Low is the lowest priority and Voice is the highest priority. Traffic is scheduled using strict priority; in other words, traffic in a given priority is transmitted when all higher-priority transmissions are complete.

Operation and Troubleshooting

This chapter provides instructions for operators of ePMP networks. The following topics are described:

- General Planning for Troubleshooting on page 93
- Upgrading device software on page 95
- Testing hardware on page 97
- Troubleshooting the radio link on page 99
- Using the device external reset button on page 101
- Resetting ePMP to factory defaults by power cycling on page 103

General Planning for Troubleshooting

Effective troubleshooting depends in part on measures that you take before you experience trouble in your network. Cambium recommends the following measures for each site:

Procedure:

1. Identify troubleshooting tools that are available at your site (such as a protocol analyzer).
2. Identify commands and other sources that can capture baseline data for the site. These may include:
   - Ping
   - tracert or traceroute
   - Throughput Test results
   - Throughput data
   - Configure GUI page captures
   - Monitor GUI page captures
   - Session logs
3. Start a log for the site, including:
   - Operating procedures
   - Site-specific configuration records
   - Network topology
   - Software releases
   - Types of hardware deployed
   - Site-specific troubleshooting process
   - Escalation procedures
   - GPS latitude/longitude of each network element

GENERAL FAULT ISOLATION PROCESS

Effective troubleshooting also requires an effective fault isolation methodology that includes

- Attempting to isolate the problem to the level of a system, subsystem, or link, such as
  - AP to SM
  - AP to CMM
  - AP to GPS
  - CMM to GPS
  - power
- Researching System Logs of the involved equipment.
- Answering the questions listed in the following section.
- Reversing the last previous corrective attempt before proceeding to the next.
- Performing only one corrective attempt at a time.

QUESTIONS TO HELP ISOLATE THE PROBLEM

When a problem occurs, attempt to answer the following questions:

1. What is the history of the problem?
   - Have we changed something recently?
   - Have we seen other symptoms before this?
2. How wide-spread is the symptom?
   - Is the problem on only a single SM? (If so, focus on that SM.)
   - Is the problem on multiple SMs? If so:
     - is the problem on one AP in the cluster? (If so, focus on that AP)
     - is the problem on multiple, but not all, APs in the cluster? (If so, focus on those APs)
     - is the problem on all APs in the cluster? (If so, focus on the CMM and the GPS signal.)
3. Based on data in the System Log
   - Is intermittent connectivity indicated? (If so, verify your configuration, power level, CINR, cables and connections, and the speed duplex of both ends of the link).
   - Does the problem correlate to loss-of-sync events?
4. Are connections made via *shielded* cables?
5. Does the GPS antenna have an *unobstructed* view of the entire horizon?

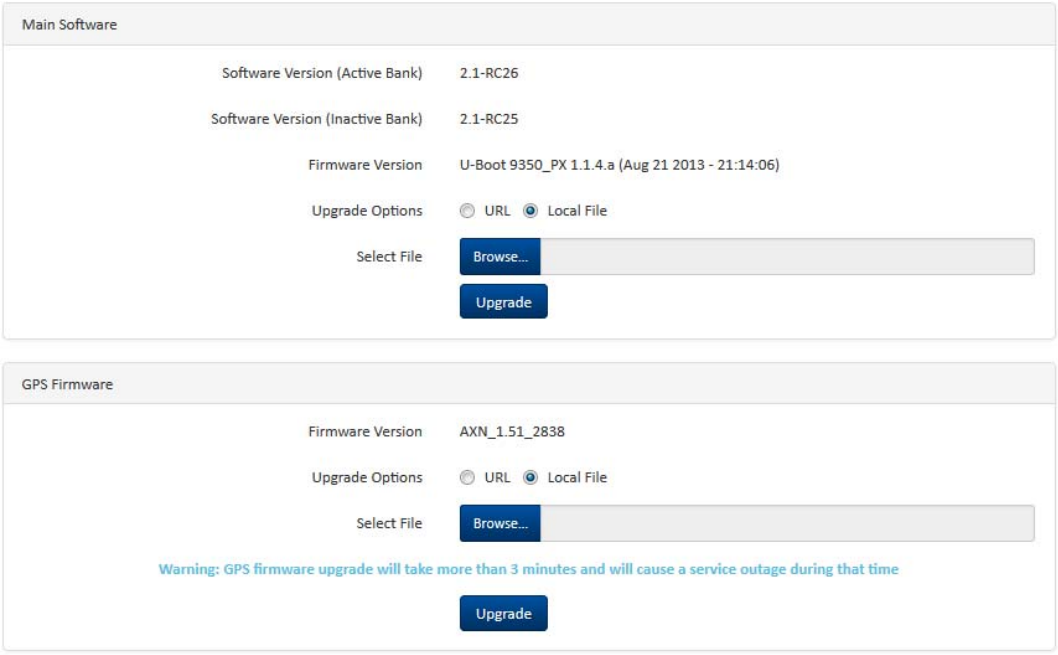
Upgrading device software

To take advantage of new features and software improvements for the ePMP system, monitor the Cambium Networks PMP Software website: https://support.cambiumnetworks.com/files/epmp

To upgrade the device software (AP or SM), follow this:

Procedure:

1. When upgrading multiple v1.0.3 integrated devices, ensure that the browser cache is cleared at the beginning of the upgrade process.
2. Log in to the device GUI via the management IP
3. Navigate to page **Tools**, **Software Upgrade**



4. Under the **Main Software** section, set the **Upgrade Option** to **URL** to pull the software file from a network software server or select **Local File** to upload a file from the accessing device. If **URL** is selected, enter the server IP address, Server Port, and File path.
5. If **Local File** is selected, click **Browse** to launch the file selection dialogue
6. Click **Upgrade**

Caution

Do not power off the unit in the middle of an upgrade process.

7. Once the software upgrade is complete, click the **Reset** icon.

Upgrading on-board GPS chip firmware

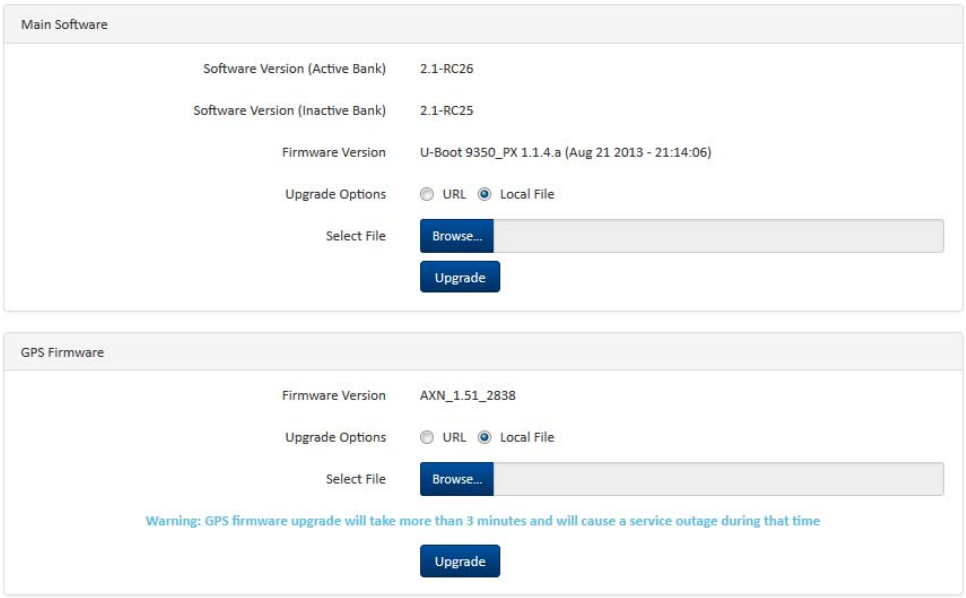
To upgrade the GPS Synchronized ePMP radio's on-board GPS chip, follow this:

Procedure:

1 When upgrading multiple v1.0.3 (or later) integrated devices, ensure that the browser cache is cleared at the beginning of the upgrade process.

2 Log in to the device GUI via the management IP

3 Navigate to page **Tools**, **Software Upgrade**



4 Under the section **GPS Firmware**, set the **Upgrade Options** to **URL** to pull the software file from a network software server or select **Local File** to upload a file from the accessing device.

Note

Use the same package that is used to upgrade the device's software. The new GPS firmware is part of the software upgrade packages.

5 If **Local File** is selected, click **Browse** to launch the file selection dialogue and click **Upgrade.**

Caution

Do not power off the unit in the middle of an upgrade process.

7 Once the software upgrade is complete, click the **Reset** icon.

Caution

In case of a locked GPS device the upgrade typically has a "GPS Firmware Version" as "Not Available"(although not always). The user must attempt the upgrade anyway. It is however likely to fail with a "GPS general communication error" displayed in the notification icon. If this occurs the user must power-cycle (not just reboot) the radio and attempt the upgrade again.

Testing hardware

This section describes how to test the hardware when it fails on startup or during operation.

Before testing hardware, confirm that all outdoor cables, that is those that connect the AP or SM to equipment inside the building, are of the supported type, as defined in Ethernet cabling on page 79

CHECKING THE POWER SUPPLY LED

When the power supply is connected to the main power supply, the expected LED behavior is:

- The Power (green) LED illuminates steadily.

If the expected LED operation does not occur, or if a fault is suspected in the hardware, check the LED states and choose the correct test procedure:

- Power LED is off on page 97
- Ethernet LED is off on page 97

POWER LED IS OFF

Meaning: Either the power supply is not receiving power from the AC/DC outlet, or there is a wiring fault in the unit.

Action: Remove the AP/SM cable from the PSU and observe the effect on the Power LED. If the Power LED does not illuminate, confirm that the mains power supply is working, for example, check the plug. If the power supply is working, report a suspected power supply fault to Cambium Networks.

ETHERNET LED IS OFF

Meaning: There is no Ethernet traffic between the AP/SM and power supply.

Action: The fault may be in the LAN or AP/SM cable:

- Remove the LAN cable from the power supply, examine it and confirm it is not faulty.
- If the PC connection is working, remove the AP/SM cable from the power supply, examine it, and check that the wiring to pins 1&2 and 3&6 is correct and not crossed.

Test Ethernet packet errors reported by AP/SM

Log into the AP or SM and click **Monitor**, **Performance**. Click **Reset System Counters** at the bottom of the page and wait until **LAN RX – Total Packet Counter** has reached 1 million. If the counter does not increment or increments too slowly, because for example the ePMP system is newly installed and there is no offered Ethernet traffic, then abandon this procedure and consider using the procedure Test ping packet loss on page 98.

Check the **LAN RX – Error Packet Counter** statistic. The test has passed if this is less than 10.

Test Ethernet packet errors reported by managed switch or router

If the AP/SM is connected to a managed Ethernet switch or router, it may be possible to monitor the error rate of Ethernet packets. Please refer to the user guide of the managed network equipment. The test has passed if the rate of packet errors reported by the managed Ethernet switch or router is less than 10 in 1 million packets.

Test ping packet loss

Using a computer, it is possible to generate and monitor packets lost between the power supply and the AP/SM. This can be achieved by executing the Command Prompt application which is supplied as standard with Windows and Mac operating systems.

Caution

This procedure disrupts network traffic carried by the AP or SM under test.

Procedure:

1. Ensure that the IP address of the computer is configured appropriately for connection to the AP or SM under test, and does not conflict with other devices connected to the network.
2. If the power supply is connected to an Ethernet switch or router then connect the computer to a spare port, if available.
3. If it is not possible to connect the computer to a spare port of an Ethernet switch or router, then the power supply must be disconnected from the network in order to execute this test:
   - Disconnect the power supply from the network.
   - Connect the computer directly to the LAN port of the power supply.
4. On the computer, open the Command Prompt application.
5. Send 1000 ping packets of length 1500 bytes. The process will take 1000 seconds, which is approximately 17 minutes.

   If the computer is running a Windows operating system, this is achieved by typing (for an IPv6 address, use the ping6 command):

   ping –n 1000 –l 1500 <ipaddress>

   where <ipaddress> is the IP address of the AP or SM under test.

   If the computer is running a MAC operating system, this is achieved by typing:

   ping –c 1000 –s 1492 <ipaddress>

   where <ipaddress> is the IP address of the AP/SM under test.
6. Record how many Ping packets are lost. This is reported by Command Prompt on completion of the test.

   The test has passed if the number of lost packets is less than 2.

Troubleshooting the radio link

This section describes how to test the link when there is no radio communication, when it is unreliable, or when the data throughput rate is too low. It may be necessary to test both the AP and the SM.

MODULE HAS LOST OR DOES NOT ESTABLISH RADIO CONNECTIVITY

If there is no wireless activity, follow this:

Procedure:

1. Check that the AP and SMs are configured with the same **Frequency Carrier**. Also, if operating in a region where DFS is required, ensure that the SM's **Frequency Carrier List** contains the frequencies configured in the AP's **DFS Alternate Frequency Carrier 1** and **DFS Alternate Frequency Carrier 2** fields.
2. Check that the **Channel Bandwidth** is configured the same at the AP and at the SM
3. On the AP, verify that the **Max Range** setting is configured to a distance slightly greater than the distance between the AP and the furthest SM that must register to the AP.
4. Check that the AP's **Synchronization Source** is configured properly based on the network configuration.
5. Verify the authentication settings on the AP and SM. if **Authentication Type** is set to **WPA2**, verify that the **Pre-shared Key** matches between the AP and the SM **Preferred AP List**
6. Check that the software at each end of the link is the same version.
7. Check that the desired AP's SSID is configured in the SM **Preferred AP List**.
8. On the SM, check the **DL RSSI** and **DL CINR** values. Verify that for the SM installed distance, that the values are consistent with see Table 114 on page 188 and Table 115 on page 189.
9. Check Tx Power on the AP and SM
10. Check that the link is not obstructed or the AP/SM misaligned.
11. Check the DFS status page (**Monitor**, **System Status**) at each end of the link and establish that there is a quiet wireless channel to use.
12. If there are no faults found in the configuration and there is absolutely no wireless signal, retry the installation procedure.
13. If this does not work then report a suspected AP/SM fault to Cambium Networks.

LINK IS UNRELIABLE OR DOES NOT ACHIEVE DATA RATES REQUIRED

If there is some activity but the link is unreliable or does not achieve the data rates required, proceed as follows:

Procedure:

1. Check that the interference has not increased by monitoring the uplink and downlink CINR values reported in the AP page **Monitor**, **Wireless Status**
2. Check that the RSSI values reported at the AP an SM are proper based on the distance of the link – see Table 114 on page 188 and Table 115 on page 189.
3. Check that the path loss is low enough for the communication rates required.
4. Check that the AP or SM has not become misaligned.
5. Review your Quality of Service configuration and ensure that traffic is properly classified and prioritized.

MODULE HAS LOST OR DOES NOT GAIN GPS SYNCHRONIZATION

To troubleshoot a loss of sync, perform the following steps.

Procedure:

1. If the AP is receiving synchronization via CMM, verify that the CMM is properly receiving sync via its attached GPS antenna (see *PMP Synchronization Solutions User Guide*). Verify that the cables from the CMM to the network switch are at most 30 Ft (shielded) or 10 Ft (unshielded) and that the network switch is not PoE (802.3af) capable.
2. If the CMM is receiving GPS synchronization pulses, verify that the AP's **Synchronization Source** is set to **CMM** and that the AP's GPS status bar icon is lit green.
3. If the AP is receiving synchronization via its internal GPS module and an external GPS antenna, verify the cabling from the AP to the GPS antenna, and verify that the AP's **Synchronization Source** is set to **GPS**.

Using the device external reset button

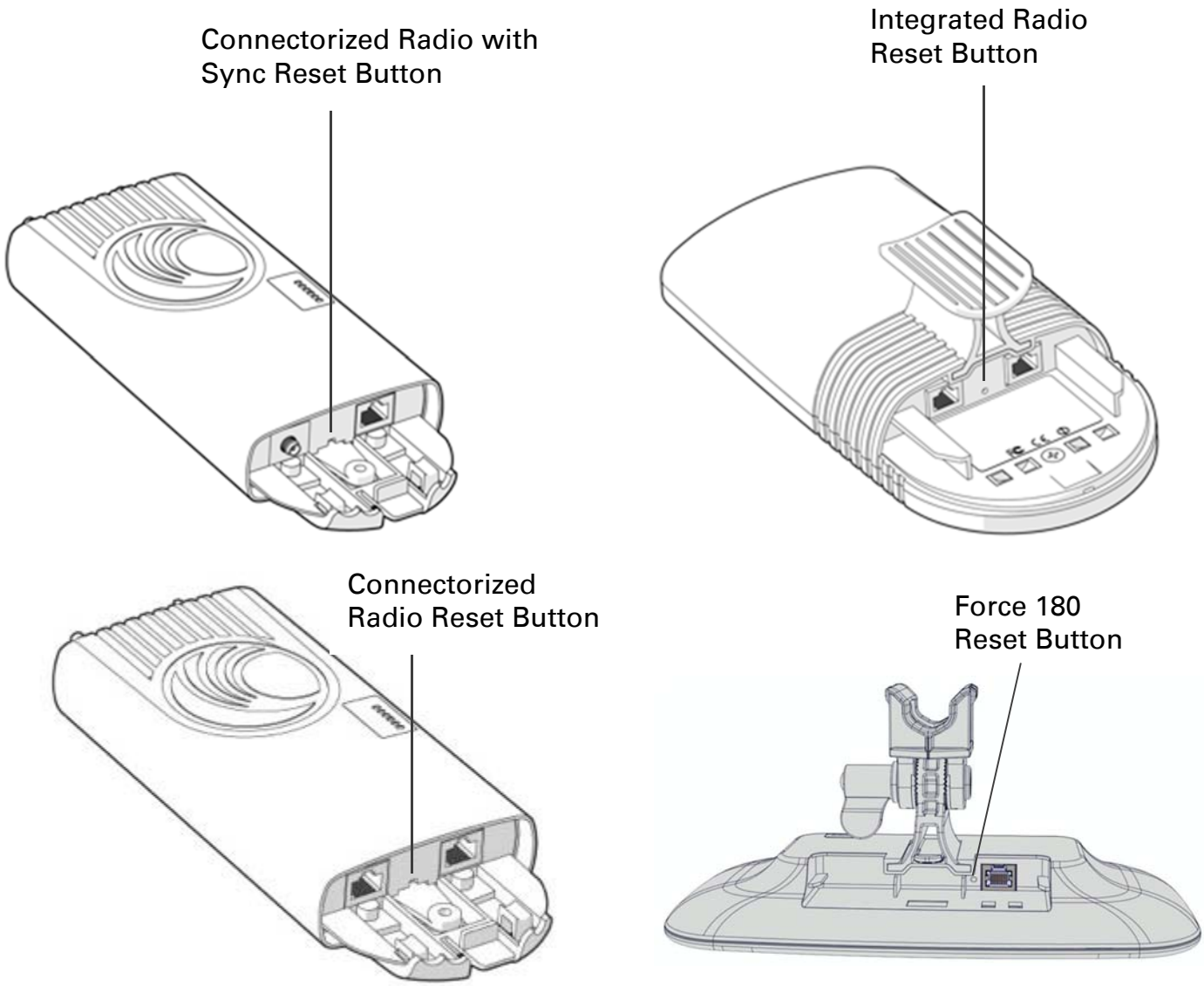
ePMP APs and SMs feature an external button which serves two purposes:

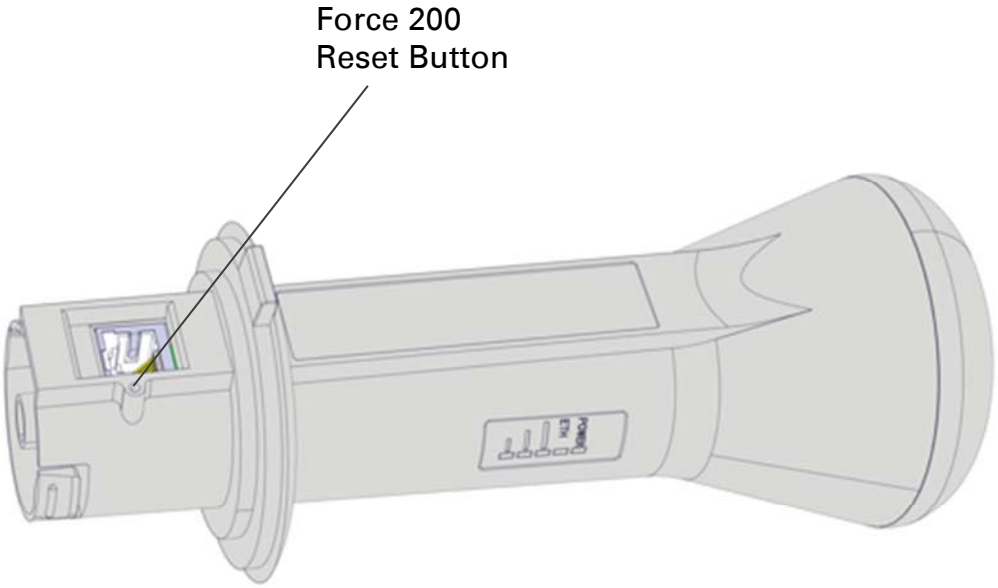
- To reset the device (briefly depress the button for more than two seconds but less than ten seconds then release)

  Caution

  If the reset button is pressed for more than ten seconds while powered on, the device will reset back to its factory default configuration

- To reset the device to its factory default configuration (depress the button for more than ten seconds then release)




Force 200
Reset Button

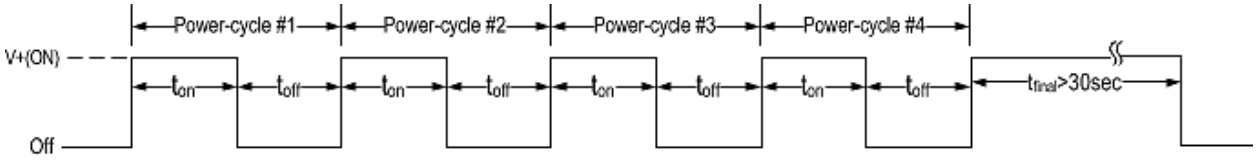
Resetting ePMP to factory defaults by power cycling

Operators may reset an ePMP radio to default factory configuration by a sequence of power cycling (removing and re-applying power to the device). This procedure allows operators to perform a factory default reset without a tower climb or additional tools. The procedure is depicted in Figure 76.

Procedure:

1. Remove the Ethernet cable from PoE jack of the power supply for at least 10 seconds.
2. Reconnect the Ethernet cable to re-supply power to the ePMP device for **3-5 seconds** and disconnect cable to power off the ePMP device for **3-5 seconds**. (1st power cycle)
3. Reconnect the Ethernet cable to re-supply power to the ePMP device for **3-5 seconds** and disconnect cable to power off the ePMP device for **3-5 seconds**. (2nd power cycle)
4. Reconnect the Ethernet cable to re-supply power to the ePMP device for **3-5 seconds** and disconnect cable to power off the ePMP device for **3-5 seconds**. (3rd power cycle)
5. Reconnect the Ethernet cable to re-supply power to the ePMP device for **3-5 seconds** and disconnect cable to power off the ePMP device for **3-5 seconds**. (4th power cycle)
6. Reconnect the Ethernet cable to re-supply power to the ePMP device for at least **30 seconds** and allow it to go through the boot up procedure (Note: Device will go through an additional reset automatically). This will reset the current configuration files to factory default configuration (e.g. IP addresses, Device mode, RF configuration etc.). The device can be pinged from a PC to check if boot up is complete (Successful ping replies indicates boot up is complete).
7. Access the ePMP device using the default IP address of 192.168.0.1 (AP) or 192.168.0.2 (SM).

Figure 24 Power cycle timings



Where:	Is:
V+(ON)	Power through PoE has been applied to the device
Off	Power through PoE has been removed from the device
t_{on}	Time duration for which the device has been powered on. This should be 3-5 seconds.
t_{off}	Time duration for which the device has been powered off. This should be 3-5 seconds.

Legal and reference information

This chapter provides legal notices including software license agreements.

Caution

Intentional or unintentional changes or modifications to the equipment must not be made unless under the express consent of the party responsible for compliance. Any such modifications could void the user's authority to operate the equipment and will void the manufacturer's warranty.

The following topics are described in this chapter:

- Cambium Networks end user license agreement on page 105
- Hardware warranty on page 186
- Limit of liability on page 187
- Compliance with safety standards on page 189 lists the safety specifications against which the ePMP has been tested and certified. It also describes how to keep RF exposure within safe limits.
- Compliance with radio regulations on page 206 describes how the ePMP complies with the radio regulations that are enforced in various countries.
- Notifications on page 224 contain notes made to regulatory bodies for the ePMP.
- Data throughput tables on page 236 contain tables and graphs to support calculation of the data rate capacity that can be provided by ePMP configurations.

Cambium Networks end user license agreement

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```

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udevtigger

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klish

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*/

/*
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  (C) 2002  David Woodhouse <dwmw2@infradead.org>

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  linux/lib/rbtree.c
*/
```

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 */
```

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libnfnetlink

```
/* iftable - table of network interfaces
 *
 * (C) 2004 by Astaro AG, written by Harald Welte <hwelte@astaro.com>
 * (C) 2008 by Pablo Neira Ayuso <pablo@netfilter.org>
 *
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 */


/* libnfnetlink.c: generic library for communication with netfilter
 *
 * (C) 2002-2006 by Harald Welte <laforge@gnumonks.org>
 * (C) 2006-2011 by Pablo Neira Ayuso <pablo@netfilter.org>
 *
 * Based on some original ideas from Jay Schulist <jschlst@samba.org>
 *
 * Development of this code funded by Astaro AG (http://www.astaro.com)
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 *
 * 2005-09-14 Pablo Neira Ayuso <pablo@netfilter.org>:
 *  Define structure nfnlhdr
 *  Added __be64_to_cpu function
 * Use NFA_TYPE macro to get the attribute type
 *
 * 2006-01-14 Harald Welte <laforge@netfilter.org>:
 *  introduce nfnl_subsys_handle
```

```
 *
 * 2006-01-15 Pablo Neira Ayuso <pablo@netfilter.org>:
 *  set missing subsys_id in nfnl_subsys_open
 *  set missing nfnlh->local.nl_pid in nfnl_open
 *
 * 2006-01-26 Harald Welte <laforge@netfilter.org>:
 *  remove bogus nfnlh->local.nl_pid from nfnl_open ;)
 *  add 16bit attribute functions
 *
 * 2006-07-03 Pablo Neira Ayuso <pablo@netfilter.org>:
 *  add iterator API
 *  add replacements for nfnl_listen and nfnl_talk
 *  fix error handling
 *  add assertions
 *  add documentation
 *  minor cleanups
 */


/* rtnl - rtnetlink utility functions
 *
 * (C) 2004 by Astaro AG, written by Harald Welte <hwelte@astaro.com>
 *
 * Adapted to nfnetlink by Eric Leblond <eric@inl.fr>
 *
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 *
 */
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System threshold, output power and link loss

The following tables specify the system threshold (dBm), output power (dBm) and maximum link loss (dB) per channel bandwidth and modulation mode:

- 5 GHz – Table 114
- 2.4 GHz – Table 115

Table 66 5 GHz threshold, power and link loss

Modulation mode	System threshold (dBm) per channel bandwidth				Output power (dBm)	Maximum link loss (dB) per channel bandwidth			
	5 MHz	10 MHz	20 MHz	40 MHz	All bands	5 MHz	10 MHz	20 MHz	40 MHz
MCS15	-74	-71	-68	-65	23	121	118	115	112
MCS14	-76	-73	-70	-67	23	123	120	117	114
MCS13	-79	-76	-73	-70	23	126	123	120	117
MCS12	-83	-80	-77	-74	23	130	127	124	121
MCS11	-87	-84	-81	-79	23	134	131	128	126
MCS10	-89	-86	-83	-80	23	136	133	130	127
MCS9	-92	-89	-86	-84	23	139	136	133	131
MCS7	-77	-74	-71	-68	23	124	121	118	115
MCS6	-79	-76	-73	-70	23	126	123	120	117
MCS5	-82	-79	-76	-73	23	129	126	123	120
MCS4	-86	-83	-80	-77	23	133	130	127	124
MCS3	-90	-87	-84	-82	23	137	134	131	129
MCS2	-92	-89	-86	-83	23	139	136	133	130
MCS1	-95	-92	-89	-87	23	142	139	136	134

Table 67 2.4 GHz threshold, power and link loss

Modulation mode	System threshold (dBm) per channel bandwidth				Output power (dBm)	Maximum link loss (dB) per channel bandwidth			
	5 MHz	10 MHz	20 MHz	40 MHz	All bands (Example)	5 MHz	10 MHz	20 MHz	40 MHz
MCS15	-74	-71	-68	-65	23	121	118	115	112
MCS14	-76	-73	-70	-67	23	123	120	117	114
MCS13	-79	-76	-73	-70	23	126	123	120	117
MCS12	-83	-80	-77	-74	23	130	127	124	121
MCS11	-87	-84	-81	-79	23	134	131	128	126
MCS10	-89	-86	-83	-80	23	136	133	130	127
MCS9	-92	-89	-86	-84	23	139	136	133	131
MCS7	-77	-74	-71	-68	23	124	121	118	115
MCS6	-79	-76	-73	-70	23	126	123	120	117
MCS5	-82	-79	-76	-73	23	129	126	123	120
MCS4	-86	-83	-80	-77	23	133	130	127	124
MCS3	-90	-87	-84	-82	23	137	134	131	129
MCS2	-92	-89	-86	-83	23	139	136	133	130
MCS1	-95	-92	-89	-87	23	142	139	136	134

For up-to-date data, please refer to the **ePMP Capacity Planner Tool** available at **https://support.cambiumnetworks.com/files/epmp/**

Dynamic transmitter output power

The ePMP system uses dynamic Tx power based on the current modulation at which it is operating to avoid EVM (Error Vector Magnitude) limitation ensuring optimal operation of the system. The following table specifies the system transmitter output power (dBm) per band and modulation mode:

Table 68 Max Tx power (dBm) per band and modulation

Modulation Mode	2412-2472 MHz	4920-4990 MHz	4990-5080 MHz	5080-5150 MHz	5150-5480 MHz	5460-5725 MHz	5725-5980 MHz
MCS0	30	15	19	27	27	30	30
MCS1	30	15	19	27	27	30	30
MCS2	29	15	19	27	27	29	30
MCS3	29	13	17	26	26	27	30
MCS4	28	11	15	24	24	25	30
MCS5	28	11	15	22	22	23	27
MCS6	27	10	14	20	20	21	25
MCS7	27	8	12	19	18	19	23
MCS8	30	15	19	27	27	30	30
MCS9	30	15	19	27	27	30	30
MCS10	29	15	19	27	27	29	30
MCS11	29	13	17	26	26	27	30
MCS12	28	11	15	24	24	25	30
MCS13	28	11	15	22	22	23	27
MCS14	27	10	14	20	20	21	25
MCS15	27	8	12	18	18	19	23

Compliance with safety standards

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

ELECTRICAL SAFETY COMPLIANCE

The ePMP hardware has been tested for compliance to the electrical safety specifications listed in Table 117.

Table 69 ePMP safety compliance specifications

Region	Standard
USA	UL 60950-1, 2nd Edition
Canada	CSA C22.2 No.60950 2nd Edition
International	International CB certified and certified to IEC 60950-1:2005 (modified) plus EN60950-1:2006 + A1:2010

ELECTROMAGNETIC COMPATIBILITY (EMC) COMPLIANCE

The ePMP complies with European EMC Specification EN301 489-1 with testing carried out to the detailed requirements of EN301 489-4.

The EMC specification type approvals that have been granted for ePMP are listed under Table 118.

Table 70 EMC emissions compliance

Region	Specification (Type Approvals)
USA	FCC CFR 47 Part 15 class B
Canada	RSS210, Issue 8 RSS247, Issue 1 (May 2015)
Europe	ETSI EN301 489-4

HUMAN EXPOSURE TO RADIO FREQUENCY ENERGY

Standards

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 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 http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/99ehd-dhm237/limits-limites_e.html and Safety Code 6.
- EN 50383:2002 Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base Subscriber Modules and fixed terminal Subscriber Modules for wireless telecommunication systems (110 MHz - 40 GHz).
- BS EN 50385:2002 Product standard to demonstrate the compliances of radio base Subscriber Modules and fixed terminal Subscriber Modules 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 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 ePMP family of PMP wireless solutions so as to provide and maintain the minimum separation distances from all persons.

The applicable power density exposure limit from the standards (see Human exposure to radio frequency energy on page 192) is:

- **10 W/m²** for RF energy in the 5 GHz and 2.4 GHz frequency bands.

Calculation of power density

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

Note

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.

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

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

The calculated minimum separation distances, recommended distances and resulting margins for each frequency band and antenna combination is shown in Table 120 through Table 140. 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.

Explanation of terms used Table 120 through Table 140:

Tx burst – maximum average transmit power in burst (Watt)

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

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

S – power density (W/m^2)

d – minimum distance from point source (meters)

R – recommended distances (meters)

C – compliance factor

Below are the power compliance margins for the following ePMP 2000 devices:

Part Number	Model Number (HVIN)	FCC ID	Industry Canada
C058900A132A C050900L132A	C058900P132A	Z8H89FT0020	109W-0020

Table 71 ePMP 2000 Power compliance margins, 5.1 GHz, AP

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
PMP PTP	5 MHz	Connectorized Antenna, 6 dBi	0.22	4	9.011	0.09	0.3	
PMP PTP	40 MHz	Connectorized Antenna, 6 dBi	0.115	4	9.011	0.06	0.3	
PMP PTP	5 MHz	Connectorized Antenna, 17 dBi	0.02	50	9.011	0.10	0.3	
PMP PTP	40 MHz	Connectorized Antenna, 17 dBi	0.01	50	9.011	0.07	0.3	

Table 72 ePMP 2000 Power compliance margins, 5.8 GHz, AP

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
PMP PTP	5 MHz	Connectorized Antenna, 6 dBi	0.724	4	9.011	0.16	0.3	
PMP PTP	40 MHz	Connectorized Antenna, 6 dBi	0.684	4	9.011	0.16	0.3	
PMP PTP	5 MHz	Connectorized Antenna, 17 dBi	0.069	50	9.011	0.17	0.3	
PMP PTP	40 MHz	Connectorized Antenna, 17 dBi	0.07	50	9.011	0.18	0.3	

Table 120 to Table 123 below are the power compliance margins for the following ePMP 1000 devices:

Model Number	Part Number	FCC ID	Industry Canada
C058900P112A	C058900C112A	Z8H89FT0006	109W-0006

Table 73 ePMP 1000 Power compliance margins, 5.1 GHz, AP

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
PMP	5/10 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.011	0.03	0.1	99.8
PMP	5/10 MHz	Connectorized Sector Array, 16 dBi	0.032	39.8	9.011	0.10	0.3	89.8
PTP	5/10 MHz	Connectorized Patch Panel Array, 23 dBi	0.010	199.5	9.011	0.13	0.3	56.7
PTP	5/10 MHz	Connectorized Dish, 30 dBi	0.002	1000.0	9.011	0.13	0.3	56.7
PMP	20/40 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.011	0.03	0.1	99.8
PMP	20/40 MHz	Connectorized Sector Array, 16 dBi	0.100	39.8	9.011	0.19	0.4	45.5
PTP	20/40 MHz	Connectorized Patch Panel Array, 23 dBi	0.008	199.5	9.011	0.12	0.3	64.3
PTP	20/40 MHz	Connectorized Dish, 30 dBi	0.001	1000.0	9.011	0.11	0.3	80.9

Table 74 ePMP 1000 Power compliance margins, 5.2 GHz, AP

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
PMP	5/10 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.130	0.03	0.1	91.1
PMP	5/10 MHz	Connectorized Sector Array, 16 dBi	0.032	39.8	9.130	0.10	0.3	82.0
PTP	5/10 MHz	Connectorized Patch Panel Array, 23 dBi	0.010	199.5	9.130	0.13	0.3	51.7
PTP	5/10 MHz	Connectorized Dish, 30 dBi	0.002	1000.0	9.130	0.13	0.3	51.7
PMP	20/40 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.130	0.03	0.1	91.1
PMP	20/40 MHz	Connectorized Sector Array, 16 dBi	0.100	39.8	9.130	0.19	0.4	46.1

PTP	20/40 MHz	Connectorized Patch Panel Array, 23 dBi	0.008	199.5	9.130	0.12	0.3	65.1
PTP	20/40 MHz	Connectorized Dish, 30 dBi	0.001	1000.0	9.130	0.10	0.3	82.0

Table 75 ePMP 1000 Power compliance margins, 5.4 GHz, AP

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
PMP	5/10 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.390	0.03	0.1	93.7
PMP	5/10 MHz	Connectorized Sector Array, 16 dBi	0.032	39.8	9.390	0.10	0.3	84.3
PTP	5/10 MHz	Connectorized Patch Panel Array, 23 dBi	0.010	199.5	9.390	0.13	0.3	53.2
PTP	5/10 MHz	Connectorized Dish, 30 dBi	0.002	1000.0	9.390	0.13	0.3	53.2
PMP	20/40 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.390	0.03	0.1	93.7
PMP	20/40 MHz	Connectorized Sector Array, 16 dBi	0.100	39.8	9.390	0.18	0.4	47.4
PTP	20/40 MHz	Connectorized Patch Panel Array, 23 dBi	0.008	199.5	9.390	0.12	0.3	67.0
PTP	20/40 MHz	Connectorized Dish, 30 dBi	0.001	1000.0	9.390	0.10	0.3	84.3

Table 76 ePMP 1000 Power compliance margins, 5.8 GHz, AP

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
PMP	5/10 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.687	0.03	0.1	96.6
PMP	5/10 MHz	Connectorized Sector Array, 16 dBi	0.032	39.8	9.687	0.10	0.3	87.0
PTP	5/10 MHz	Connectorized Patch Panel Array, 23 dBi	0.010	199.5	9.687	0.13	0.3	54.9
PTP	5/10 MHz	Connectorized Dish, 30 dBi	0.002	1000.0	9.687	0.13	0.3	54.9
PMP	20/40 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.687	0.03	0.1	96.6
PMP	20/40 MHz	Connectorized Sector Array, 16 dBi	0.100	39.8	9.687	0.18	0.4	48.9

PTP	20/40 MHz	Connectorized Patch Panel Array, 23 dBi	0.008	199.5	9.687	0.11	0.3	69.1
PTP	20/40 MHz	Connectorized Dish, 30 dBi	0.001	1000.0	9.687	0.10	0.3	87.0

Table 124 through Table 128 below are the power compliance margins for the following devices:

Model Number	Part Number	FCC ID	Industr
C058900P122A	C058900C122A	Z8H89FT0005	109V

Table 77 ePMP 1000 Power compliance margins, 5.1 GHz, SM

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
PMP	5/10 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.011	0.03	0.1	89.9
PMP	5/10 MHz	Integrated Patch Array, 16 dBi	0.100	39.8	9.011	0.19	0.4	45.5
PMP	5/10 MHz	Connectorized Sector Array, 16 dBi	0.100	39.8	9.011	0.19	0.4	45.5
PTP	5/10 MHz	Integrated Patch Array, 16 dBi	0.100	39.8	9.011	0.19	0.4	45.5
PTP	5/10 MHz	Connectorized Patch Panel Array, 23 dBi	0.013	199.5	9.011	0.15	0.3	40.6
PTP	5/10 MHz	Connectorized Dish, 30 dBi	0.001	1000.0	9.011	0.09	0.2	45.3
PMP	20/40 MHz	Connectorized Omni, 3 dBi	0.063	2.0	9.011	0.03	0.1	89.9
PMP	20/40 MHz	Integrated Patch Array, 16 dBi	0.032	39.8	9.011	0.11	0.2	36.0
PMP	20/40 MHz	Connectorized Sector Array, 16 dBi	0.032	39.8	9.011	0.11	0.3	80.9
PTP	20/40 MHz	Integrated Patch Array, 16 dBi	0.032	39.8	9.011	0.11	0.2	36.0
PTP	20/40 MHz	Connectorized Patch Panel Array, 23 dBi	0.005	199.5	9.011	0.09	0.2	45.3
PTP	20/40 MHz	Connectorized Dish, 30 dBi	0.001	1000.0	9.011	0.09	0.2	45.3

 Caution

For countries that follow FCC regulations, the combined conducted power must be reduced according to Table 125, for the lower edge of the 5.1 GHz band in order, to meet restricted band requirements.

Table 78 FCC conducted power (combined) for lower edge of 5.1 GHz

Channel Bandwidth	Antenna	Conducted Power (combined)
5/10 MHz	Connectorized Omni, 3 dBi	18 dBm
5/10 MHz	Integrated Patch Array, 16 dBi	7 dBm
5/10 MHz	Connectorized Sector Array, 16 dBi	7 dBm
5/10 MHz	Connectorized Patch Panel Array, 23 dBi	0 dBm
5/10 MHz	Connectorized Dish, 30 dBi	-7 dBm
20/40 MHz	Connectorized Omni, 3 dBi	15 dBm
20/40 MHz	Integrated Patch Array, 16 dBi	7 dBm
20/40 MHz	Connectorized Sector Array, 16 dBi	7 dBm
20/40 MHz	Connectorized Patch Panel Array, 23 dBi	2 dBm
20/40 MHz	Connectorized Dish, 30 dBi	-5 dBm

Table 79 ePMP 1000 Power compliance margins, 5.2 GHz, SM

Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
Integrated Patch Array, 13 dBi	0.020	20.0	9.130	0.06	0.2	115.2
Integrated Patch Array, 13 dBi with Reflector Dish, 6 dBi	0.020	79.4	9.130	0.12	0.3	65.1
Connectorized Patch Panel Array, 23 dBi	0.020	199.5	9.130	0.19	0.4	46.1
Connectorized Dish, 30 dBi	0.020	1000	9.130	0.42	1	57.5

Table 80 ePMP 1000 Power compliance margins, 5.4 GHz, SM

Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
Integrated Patch Array, 13 dBi	0.020	20.0	9.390	0.06	0.2	118.5
Integrated Patch Array, 13 dBi with Reflector Dish, 6 dBi	0.020	79.4	9.390	0.12	0.3	67.0
Connectorized Patch Panel Array, 23 dBi	0.020	199.5	9.390	0.18	0.4	47.4
Connectorized Dish, 30 dBi	0.020	1000	9.390	0.41	1	59.1

Table 81 ePMP 1000 Power compliance margins, 5.8/5.9 GHz, SM

Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
Integrated Patch Array, 13 dBi	0.200	20.0	9.687	0.18	0.4	48.9
Integrated Patch Array, 13 dBi with Reflector Dish, 6 dBi	0.200	79.4	9.687	0.36	0.8	49.1
Connectorized Patch Panel Array, 23 dBi	0.200	199.5	9.687	0.57	1.2	44.0
Connectorized Dish, 30 dBi	0.200	1000	9.687	1.28	2.5	38.1

Table 82 ePMP 1000 Power compliance margins, 2.4 GHz, AP (FCC ID: Z8H89FT0012)

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
PMP	20 MHz	Connectorized, 8 dBi Omni	0.631	6.3	5.348	0.24	0.5	42.2
PMP	40 MHz	Connectorized, 8 dBi Omni	0.100	6.3	5.348	0.10	0.2	42.6
PMP	20 MHz	Connectorized, 17 dBi Sector	0.079	50.1	5.348	0.24	0.5	42.2
PMP	40 MHz	Connectorized, 17 dBi Sector	0.025	50.1	5.348	0.14	0.3	48.0
PTP	20 MHz	Connectorized, 25 dBi Dish	0.010	316.2	5.348	0.22	0.5	53.1
PTP	40 MHz	Connectorized, 25 dBi Dish	0.006	316.2	5.348	0.17	0.4	53.9

Table 83 ePMP 1000 Power compliance margins, 2.4 GHz, SM (FCC ID: Z8H89FT0011)

Conn Type	Channel Bandwidth	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
PMP	20 MHz	Connectorized, 8 dBi Omni	0.631	6.3	5.348	0.24	0.5	42.2
PMP	20 MHz	Integrated, 12 dBi Patch	0.251	15.8	5.348	0.24	0.5	42.2
PMP	20 MHz	Integrated 12 dBi Patch with 8 dBi Reflector Dish	0.398	100.0	5.348	0.77	1.5	38.0
PMP	20 MHz	Connectorized, 17 dBi Sector	0.079	50.1	5.348	0.24	0.5	42.2
PMP	20 MHz	Connectorized, 19 dBi Panel	0.050	79.4	5.348	0.24	0.5	42.2
PMP	20 MHz	Connectorized, 25 dBi Dish	0.010	316.2	5.348	0.22	0.5	53.1
PMP	40 MHz	Connectorized, 8 dBi Omni	0.100	6.3	5.348	0.10	0.2	42.6

PMP	40 MHz	Integrated, 12 dBi Patch	0.050	15.8	5.348	0.11	0.3	76.1
PMP	40 MHz	Integrated 12 dBi Patch with 8 dBi Reflector Dish	0.050	100.0	5.348	0.27	0.6	48.2
PMP	40 MHz	Connectorized, 17 dBi Sector	0.025	50.1	5.348	0.14	0.3	48.0
PMP	40 MHz	Connectorized, 19 dBi Panel	0.020	79.4	5.348	0.15	0.3	38.1
PMP	40 MHz	Connectorized, 25 dBi Dish	0.006	316.2	5.348	0.17	0.4	53.9
PTP	20 MHz	Integrated, 12 dBi Patch	0.398	15.8	5.348	0.31	0.7	52.2
PTP	20 MHz	Integrated 12 dBi Patch with 8 dBi Reflector Dish	0.398	100.0	5.348	0.77	1.5	38.0
PTP	20 MHz	Connectorized, 17 dBi Sector	0.158	50.1	5.348	0.34	0.8	54.1
PTP	20 MHz	Connectorized, 19 dBi Panel	0.050	79.4	5.348	0.24	0.5	42.2
PTP	20 MHz	Connectorized, 25 dBi Dish	0.010	316.2	5.348	0.22	0.5	53.1
PTP	40 MHz	Integrated, 12 dBi Patch	0.050	15.8	5.348	0.11	0.3	76.1
PTP	40 MHz	Integrated 12 dBi Patch with 8 dBi Reflector Dish	0.050	100.0	5.348	0.27	0.6	48.2
PTP	40 MHz	Connectorized, 17 dBi Sector	0.025	50.1	5.348	0.14	0.3	48.0
PTP	40 MHz	Connectorized, 19 dBi Panel	0.020	79.4	5.348	0.15	0.4	67.8
PTP	40 MHz	Connectorized, 25 dBi Dish	0.006	316.2	5.348	0.17	0.4	53.9

 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 2.4 GHz, 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.

 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.

Table 131 through Table 138 below are the power compliance margins for the following devices:

Model Number	Part Number	FCC ID	Industry Canada
C058900P072A	C058900C072A	Z8H89FT0015	109W-0015
C058900P062A	C058900C062A	Z8H89FT0015	109W-0015

Table 84 ePMP 1000 Power compliance margins, 5.1 GHz, AP

Connection Type	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
PMP	Modular Array, 17 dBi	0.079	50.1	9.011	0.19	0.4	45.5
PMP	Modular Dish, 24 dBi	0.016	251.2	9.011	0.19	0.4	45.5
PMP	Module Dipole, 2 dBi	0.398	1.6	9.011	0.07	0.2	71.8
PTP	Modular Array, 17 dBi	0.398	50.1	9.011	0.42	1	56.7
PTP	Modular Dish, 24 dBi	0.398	251.2	9.011	0.94	2	45.3
PTP	Module Dipole, 2 dBi	0.398	1.6	9.011	0.07	0.2	71.8

Table 85 ePMP 1000 Power compliance margins, 5.2 GHz, AP

Channel Bandwidth	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
10 MHz	Modular Array, 17 dBi	0.010	50.1	9.130	0.07	0.2	93.2
10 MHz	Modular Dish, 24 dBi	0.002	251.2	9.130	0.06	0.2	94.7
10 MHz	Module Dipole, 2 dBi	0.118	1.6	9.130	0.04	0.1	61.3
20/40 MHz	Modular Array, 17 dBi	0.019	50.1	9.130	0.09	0.2	48.8
20/40 MHz	Modular Dish, 24 dBi	0.004	251.2	9.130	0.09	0.2	49.6
20/40 MHz	Module Dipole, 2 dBi	0.112	1.6	9.130	0.04	0.1	64.8

Table 86 ePMP 1000 Power compliance margins, 5.4 GHz, AP

Channel Bandwidth	Antenna	P (W)	G	S (W/m²)	d (m)	R (m)	C
10 MHz	Modular Array, 17 dBi	0.008	50.1	9.390	0.06	0.2	118.2
10 MHz	Modular Dish, 24 dBi	0.002	251.2	9.390	0.06	0.2	103.2

10 MHz	Module Dipole, 2 dBi	0.095	1.6	9.390	0.04	0.1	77.9
20/40 MHz	Modular Array, 17 dBi	0.010	50.1	9.390	0.07	0.2	90.7
20/40 MHz	Modular Dish, 24 dBi	0.003	251.2	9.390	0.08	0.2	69.5
20/40 MHz	Module Dipole, 2 dBi	0.163	1.6	9.390	0.05	0.1	45.7

Table 87 ePMP 1000 Power compliance margins, 5.8 GHz, AP

Connection Type	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
PMP	Modular Array, 17 dBi	0.079	50.1	9.687	0.18	0.4	48.9
PMP	Modular Dish, 24 dBi	0.016	251.2	9.687	0.18	0.4	48.9
PMP	Module Dipole, 2 dBi	0.398	1.6	9.687	0.07	0.2	77.1
PTP	Modular Array, 17 dBi	0.501	50.1	9.687	0.45	1	48.4
PTP	Modular Dish, 24 dBi	0.501	251.2	9.687	1.02	2	38.7
PTP	Module Dipole, 2 dBi	0.501	1.6	9.687	0.08	0.2	61.3

Table 88 ePMP 1000 Power compliance margins, 5.1 GHz, SM

Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
Modular Array, 17 dBi	0.398	50.1	9.011	0.42	1	56.7
Modular Dish, 24 dBi	0.398	251.2	9.011	0.94	2	45.3
Module Dipole, 2 dBi	0.398	1.6	9.011	0.07	0.2	71.8

Table 89 Power compliance margins, 5.2 GHz, SM

Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
5/10 MHz	Modular Array, 17 dBi	0.010	50.1	9.130	0.07	0.2	93.2
5/10 MHz	Modular Dish, 24 dBi	0.002	251.2	9.130	0.06	0.2	94.7
5/10 MHz	Module Dipole, 2 dBi	0.118	1.6	9.130	0.04	0.1	61.3
20/40 MHz	Modular Array, 17 dBi	0.019	50.1	9.130	0.09	0.2	48.8
20/40 MHz	Modular Dish, 24 dBi	0.004	251.2	9.130	0.09	0.2	49.6

20/40 MHz	Module Dipole, 2 dBi	0.112	1.6	9.130	0.04	0.1	64.8

Table 90 ePMP 1000 Power compliance margins, 5.4 GHz, SM

Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
5/10 MHz	Modular Array, 17 dBi	0.008	50.1	9.390	0.06	0.2	118.2
5/10 MHz	Modular Dish, 24 dBi	0.002	251.2	9.390	0.06	0.2	103.2
5/10 MHz	Module Dipole, 2 dBi	0.095	1.6	9.390	0.04	0.1	77.9
20/40 MHz	Modular Array, 17 dBi	0.010	50.1	9.390	0.07	0.2	90.7
20/40 MHz	Modular Dish, 24 dBi	0.003	251.2	9.390	0.08	0.2	69.5
20/40 MHz	Module Dipole, 2 dBi	0.163	1.6	9.390	0.05	0.1	45.7

Table 91 ePMP 1000 Power compliance margins, 5.8 GHz, SM

Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
Modular Array, 17 dBi	0.501	50.1	9.687	0.45	1	48.4
Modular Dish, 24 dBi	0.501	251.2	9.687	1.02	2	38.7
Module Dipole, 2 dBi	0.501	1.6	9.687	0.08	0.2	61.3

Table 140 below is the power compliance margins for the following device

Model Number	Part Number	FCC ID	Industry Canada
C024900P161A	C024900C161A	Z8H89FT0019	109W-0019

Table 92 ePMP 1000 Power compliance margins, 2.4 GHz (FCC)

Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
40/20/10 MHz	Modular Dish, 17 dBi	0.293	50.1	5.348	0.47	1	45.7
40/20/10 MHz	Module Dipole, 2 dBi	0.807	1.6	5.348	0.14	0.3	47.3
5 MHz	Modular Dish, 17 dBi	0.287	50.1	5.348	0.46	1	46.6
5 MHz	Module Dipole, 2 dBi	0.802	1.6	5.348	0.14	0.3	47.6

Table 93 ePMP 1000 Power compliance margins, 2.4 GHz (IC)

Channel Bandwidth	Antenna	P (W)	G	S (W/m^2)	d (m)	R (m)	C
40/20/10 MHz	Modular Dish, 17 dBi	0.293	50.1	5.348	0.47	1	45.7
40/20/10 MHz	Module Dipole, 2 dBi	0.807	1.6	5.348	0.14	0.4	84.0
5 MHz	Modular Dish, 17 dBi	0.287	50.1	5.348	0.46	1	46.6
5 MHz	Module Dipole, 2 dBi	0.802	1.6	5.348	0.14	0.3	47.6

Compliance with radio regulations

This section describes how the ePMP complies with the radio regulations that are enforced in various countries.

 Caution

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

TYPE APPROVALS

This system has achieved Type Approval in various countries around the world. This means that the system has been tested against various local technical regulations and found to comply. The frequency bands in which the system operates may be unlicensed and, in these bands, the system can be used provided it does not cause interference. The system is not guaranteed protection against interference from other products and installations.

The radio specification type approvals that have been granted for ePMP frequency variants are listed under Table 118.

Table 94 ePMP 2000 Radio certifications

Frequency band	Region	Regulatory approvals
5 GHz	USA	FCC Part 15 Class B
	Canada	IC RSS-210 Issue 8, Annex 8 (or latest) IC RSS247 Issue 1 (May 2015)
	Europe	ETSI EN302 502 v1.2.1 ETSI EN301 893 v1.7.1

Table 95 ePMP 1000 Radio certifications

Frequency band	Region	Regulatory approvals
2.4 GHz, 5 GHz	USA	FCC Part 15 Class B
	Canada	IC RSS-210 Issue 8, Annex 8 (or latest) IC RSS247 Issue 1 (May 2015)
	Europe	ETSI EN302 502 v1.2.1 ETSI EN301 893 v1.7.1

FCC AND ETSI COMPLIANCE TESTING

The system has been tested for compliance to both US (FCC) and European (ETSI) specifications. It has been shown to comply with the limits for emitted spurious radiation for a Class B digital device, pursuant to Part 15 of the FCC Rules in the USA and appropriate European ENs. These limits have been designed to provide reasonable protection against harmful interference. However the equipment can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to other radio communications. There is no guarantee that interference will not occur in a particular installation. To comply with FCC RF exposure limits for general population or uncontrolled exposure, the antenna(s) used for the ePMP transmitter must be installed to ensure a separation distance specified in Table 120 through Table 140 from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

OEM Responsibilities to comply with FCC and Industry Canada Regulations

The ePMP Module is certified for integration into products only by OEM integrators under the following conditions:

1. The antennas(s) must be installed such that a minimum separation distance specified in Table 120 through Table 140 is maintained between the radiator (antenna) and all persons at all times.

2. The transmitter module must not be co-located or operate in conjunction with any other antenna or transmitter. As long as the two conditions above are met, further transmitter testing is not required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).


Note

In the event that these conditions cannot be met (for certain configurations or co-location with another transmitter), then the FCC and Industry Canada authorizations are no longer considered valid and the FCC ID cannot be used.


Note

A Class B Digital Device is a device that is marketed for use in a residential environment, notwithstanding use in commercial, business and industrial environments.

Notwithstanding that Cambium Networks has designed (and qualified) the ePMP products to generally meet the Class B requirement to minimize the potential for interference, the ePMP product range is not marketed for use in a residential environment.

End Product Labelling

The ePMP Module is labelled with its own FCC ID and IC Certification Number. If the FCC ID and IC Certification Number are not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labelled in a visible area with the following:

Table 96 ePMP 2000 Product labeling

Region	Label
Access Point (AP)	"Contains Transmitter Module FCC ID: Z8H89FT0020" or "Contains FCC ID: Z8H89FT0020"

Table 97 ePMP 1000 Product labeling

Region	Label
Access Point (AP)	"Contains Transmitter Module FCC ID: Z8H89FT0006" or "Contains FCC ID: Z8H89FT0006"
Subscriber Module (SM)	"Contains Transmitter Module FCC ID: Z8H89FT0005" or "Contains FCC ID: Z8H89FT0005"
Access Point (AP) / Subscriber Module (SM)	"Contains Transmitter Module FCC ID: Z8H89FT0015" or "Contains FCC ID: Z8H89FT0015"
Access Point (AP) / Subscriber Module (SM)	"Contains Transmitter Module FCC ID: Z8H89FT0019" or "Contains FCC ID: Z8H89FT0019"

EXAMPLES OF REGULATORY LIMITS

Examples of the regulatory limits that apply in typical regions of operation are in the following tables:

- 4.9 GHz – Table 145
- 5.1 GHz – Table 146
- 5.2 GHz – Table 147
- 5.3 GHz – Table 148
- 5.4 GHz – Table 149
- 5.8 GHz/5.9 GHz – Table 150
- 2.4 GHz – Table 151

Table 98 Regulatory limits – 4.9 GHz

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band	Conducted Power
Other	4900-5150	4920 to 5155 every 5MHz	4930 to 5165 every 5MHz	4920 to 5150 every 5MHz	15 for 4920 to 4995, 19 for 5000 to 5080, 27 for 5085 to 5165

Table 99 Regulatory Limits - 5.1 GHz

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band	Conducted Power	EIRP Power
Armenia	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Argentina	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Azerbaijan	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Belarus	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Ecuador	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Georgia	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Guam	5150-5250	5180-5240 every 5 MHz	5190-5230 every 5 MHz	5160-5245 every 5 MHz	20	36 for non PTP AP. 53 for other modes.
Kyrgyzstan	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Kazakhstan	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Moldova	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Malaysia	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Other	5150-5250	5160-5250 every 5 MHz	5170-5250 every 5 MHz	5155-5250 every 5 MHz	27	
Peru	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Philippines	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Puerto Rico	5150-5250	5180-5240 every 5 MHz	5190-5230 every 5 MHz	5160-5245 every 5 MHz	20	36 for non PTP AP. 53 for other modes.
Russia	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band	Conducted Power	EIRP Power
Tajikistan	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Turkmenistan	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Ukraine	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	18	
Uganda	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	27	30
United States	5150-5250	5180-5240 every 5 MHz	5190-5230 every 5 MHz	5160-5245 every 5 MHz	20	36 for non PTP AP. 53 for other modes.
Uzbekistan	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
Venezuela	5150-5250	5160-5240 every 5 MHz	5170-5230 every 5 MHz	5155-5250 every 5 MHz	20	
U.S. Virgin Islands	5150-5250	5180-5240 every 5 MHz	5190-5230 every 5 MHz	5160-5245 every 5 MHz	20	36 for non PTP AP. 53 for other modes.

Caution

For countries that follow FCC regulations, the combined conducted power must be reduced according to Table 147 for the lower edge of the 5.1 GHz band in order to meet restricted band requirements.

Table 100 Regulatory limits - 5.2 GHz

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[1]	Conducted Power	EIRP Power	DFS
Armenia	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		No
Argentina	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Azerbaijan	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Belarus	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Canada	5250-5350	5280 to 5320 every 5MHz	5290 to 5310 every 5MHz	5280 to 5320 every 5MHz	12 for 20 MHz, 13 for 40 MHz	30 for 20 MHz and 40 MHz, 27 for 10 MHz, 24 for 5 MHz	Yes
Chile	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Colombia	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Ecuador	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Georgia	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Ghana	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Guam	5250-5350	5245 to 5320 every 5MHz	5235 to 5310 every 5MHz	5250 to 5320 every 5MHz	13	30 for 20 MHz and 40 MHz, 27 for 10 MHz, 24 for 5 MHz	Yes
Hong Kong	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Kazakhstan	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Kenya	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Kyrgyzstan	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Malaysia	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Moldova	5250-5350	5255 to 5350 every 5MHz	5255 to 5350 every 5MHz	5255 to 5350 every 5MHz	27		No
Other	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		No
Peru	5250-5350	5245 to 5320 every 5MHz	5235 to 5310 every 5MHz	5250 to 5320 every 5MHz	13	30 for 20 MHz and 40 MHz, 27 for 10 MHz, 24 for 5 MHz	Yes
Philippines	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Puerto Rico	5250-5350	5280 to 5320 every 5MHz	5290 to 5310 every 5MHz	5255 to 5345 every 5MHz	13		Yes

[1] 5 MHz Channel bandwidth not available for DFS regions/bands.

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[1]	Conducted Power	EIRP Power	DFS
Russia	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Taiwan	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	13	23	Yes
Tajikistan	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Thailand	5250-5350	5245 to 5320 every 5MHz	5235 to 5310 every 5MHz	5250 to 5320 every 5MHz	13	30 for 20 MHz and 40 MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Turkmenistan	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
U.S. Virgin Islands	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Uganda	5250-5350	5270 to 5330 every 5MHz	5280 to 5320 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Ukraine	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
United States	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		Yes
Uzbekistan	5250-5350	5260 to 5340 every 5MHz	5270 to 5330 every 5MHz	5255 to 5345 every 5MHz	18		No
Venezuela	5250-5350	5280 to 5320 every 5MHz	5290 to 5310 every 5MHz	5280 to 5320 every 5MHz	12 for 20 MHz, 13 for 40 MHz	30 for 20 MHz and 40 MHz, 27 for 10 MHz, 24 for 5 MHz	No

Table 101 Regulatory limits - 5.3 GHz

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band	Conducted Power	EIRP Power	DFS
Other	5350-5470	5355 to 5470 every 5MHz	5355 to 5470 every 5MHz	5355 to 5470 every 5MHz	27		No

Table 102 Regulatory limits - 5.4 GHz

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[2]	Conducted Power	EIRP Power	DFS
Argentina	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Armenia	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Australia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40 MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Austria	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Azerbaijan	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Belarus	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Belgium	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Bosnia and Herzegovina	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Brazil	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30	FCC
Bulgaria	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Canada	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5495 to 5595 every 5MHz, 5655 to 5705 every 5 MHz	14	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Chile	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30	FCC
Colombia	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30	FCC
Croatia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Cyprus	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Czech Republic	5470-5600,5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Denmark	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20M and 40M, 27 for 10M, 24 for 5M	ETSI
Ecuador	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30 for 20 MHz and 40MHz, 27	None

[2] 5 MHz Channel bandwidth not available for DFS regions/bands.

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[2]	Conducted Power	EIRP Power	DFS
						for 10 MHz, 24 for 5 MHz	
Finland	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
France	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Generic ETSI	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Georgia	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Germany	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Ghana	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30	FCC
Greece	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Guam	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5495 to 5595 every 5MHz, 5655 to 5705 every 5 MHz	14	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Hong Kong	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	15	30	FCC
Hungary	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Ireland	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Italy	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Kazakhstan	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		
Kenya	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Kyrgyzstan	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Latvia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Liechtenstein	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[2]	Conducted Power	EIRP Power	DFS
Lithuania	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Luxembourg	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Macedonia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Malaysia	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Malta	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Mauritius	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Mexico	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	16	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Moldova	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Netherlands	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Netherlands Antilles	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Nigeria	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	15	36	None
Norway	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Oman	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Other	5470-5725	5475 to 5730 every 5MHz	5475 to 5740 every 5MHz	5475 to 5725 every 5MHz	30		None
Peru	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30	ETSI
Philippines	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19	26	None
Poland	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Portugal	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[2]	Conducted Power	EIRP Power	DFS
Puerto Rico	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5495 to 5595 every 5MHz, 5655 to 5705 every 5 MHz	14	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Romania	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Russia	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Serbia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Slovakia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Slovenia	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
South Africa	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	15	30	FCC
South Korea	5470-5650	5480 to 5640 every 5MHz	NA	5475 to 5645 every 5MHz	16	30	ETSI
Spain	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Sweden	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Switzerland	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Taiwan	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	14	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Tajikistan	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Thailand	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	16	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Turkey	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
Turkmenistan	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
U.S. Virgin Islands	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5495 to 5595 every 5MHz, 5655 to 5705 every 5 MHz	14	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Uganda	5470-5725	5480 to 5715 every 5MHz	5490 to 5705 every 5MHz	5475 to 5720 every 5MHz	30	30 for 20 MHz and 40MHz, 27	FCC

Country	Frequency range	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[2]	Conducted Power	EIRP Power	DFS
						for 10 MHz, 24 for 5 MHz	
Ukraine	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		
United Kingdom[3]	5470-5600, 5650-5725	5480 to 5590 every 5MHz, 5660 to 5715 every 5 MHz	5490 to 5580 every 5MHz, 5670 to 5705 every 5 MHz	5475 to 5595 every 5MHz, 5655 to 5720 every 5 MHz	15	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	ETSI
United States	5470-5600, 5650-5725	5495 to 5590 every 5MHz, 5660 to 5705 every 5 MHz	5510 to 5580 every 5MHz, 5670 to 5695 every 5 MHz	5495 to 5595 every 5MHz, 5655 to 5705 every 5 MHz	14	30 for 20 MHz and 40MHz, 27 for 10 MHz, 24 for 5 MHz	FCC
Uzbekistan	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19		None
Venezuela	5470-5725	5480 to 5730 every 5MHz	5490 to 5740 every 5MHz	5475 to 5725 every 5MHz	19	30	None

[3] The band 5600 MHz to 5650 MHz is reserved for the use of weather radars.

Table 103 Regulatory limits - 5.8/5.9 GHz

Country	Frequency ranges	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[4]	Conducted Power	EIRP Power	DFS
Argentina	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23		None
Armenia	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Australia	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
Azerbaijan	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Bahrain	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	33	ETSI
Bangladesh	5725-5825	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	30		None
Belarus	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Botswana	5725-5875	5735 to 5865 every 5 MHz	5745 to 5855 every 5 MHz	5730 to 5870 every 5 MHz	23	40	No
Brazil	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	36 for PMP AP. No limit for other modes.	None
Canada	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5740 to 5835 every 5 MHz	23 for PMP AP PMP, 30 for PTP and SM mode.	36 for PMP AP. No limit for other modes.	None
Chile	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
China	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	33	None
Colombia	5725-5825	5735 to 5815 every 5 MHz	5745 to 5805 every 5 MHz	5730 to 5820 every 5 MHz	23	36	None
Denmark	5725-5795, 5815-5875	5735 to 5785 every 5 MHz, 5825 to 5865 every 5 MHz	5745 to 5775 every 5 MHz, 5835 to 5855 every 5 MHz	5730 to 5790 every 5 MHz, 5820 to 5870 every 5 MHz	23	36	ETSI
Ecuador	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	53	None
Finland	5725-5795, 5815-5850	5735 to 5785 every 5 MHz, 5825 to 5840 every 5 MHz	5745 to 5775 every 5 MHz,	5730 to 5790 every 5 MHz, 5820 to 5845 every 5 MHz	23	36	ETSI
Georgia	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Germany	5755-5875	5765 to 5865 every 5 MHz	5775 to 5855 every 5 MHz	5730 to 5870 every 5 MHz	23	36	ETSI
Ghana	5725-5825	5740 to 5810 every 5 MHz	5750 to 5800 every 5 MHz	5730 to 5820 every 5 MHz	23	36	FCC

[4] 5 MHz Channel bandwidth not available for DFS regions/bands.

Country	Frequency ranges	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[4]	Conducted Power	EIRP Power	DFS
Greece	5725-5795	5735 to 5785 every 5 MHz	5745 to 5775 every 5 MHz	5730 to 5790 every 5 MHz	23	36	ETSI
Guam	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5740 to 5835 every 5 MHz	23 for PMP AP PMP, 30 for PTP and SM mode.	36 for PMP AP. No limit for other modes.	None
Hong Kong	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
Iceland	5725-5875	5735 to 5865 every 5 MHz	5745 to 5855 every 5 MHz	5730 to 5870 every 5 MHz	23	36	ETSI
India	5825-5875	5835 to 5865 every 5 MHz	5845 to 5855 every 5 MHz	5830 to 5870 every 5 MHz	23	36	None
Indonesia	5725-5825	5735 to 5815 every 5 MHz	NA	5730 to 5820 every 5 MHz	23	36	None
Ireland	5725-5875	5740 to 5860 every 5 MHz	5750 to 5850 every 5 MHz	5730 to 5870 every 5 MHz	23	33	None
Kazakhstan	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Kenya	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
Kyrgyzstan	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Liechtenstein	5725-5795, 5815-5875	5735 to 5785 every 5 MHz, 5825 to 5865 every 5 MHz	5745 to 5775 every 5 MHz, 5835 to 5855 every 5 MHz	5730 to 5790 every 5 MHz, 5820 to 5870 every 5 MHz	23	36	ETSI
Malaysia	5725-5875	5740 to 5860 every 5 MHz	5750 to 5850 every 5 MHz	5730 to 5870 every 5 MHz	23	30	None
Mauritius	5725-5850	5735 to 5840 every 5 MHz	NA	5730 to 5845 every 5 MHz	23	36	ETSI
Mexico	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
Moldova	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
New Zealand	5725-5875 for PMP, 5725-5825 for PTP	5735 to 5865 for PMP, 5735 to 5815 every 5 MHz for PTP	5745 to 5855 for PMP, 5745 to 5805 every 5 MHz for PTP	5730 to 5870 for PMP, 5730 to 5820 every 5 MHz for PTP	23	36	No
Nigeria	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23		ETSI
Norway	5725-5795, 5815-5850	5735 to 5785 every 5 MHz, 5825 to 5840 every 5 MHz	5745 to 5775 every 5 MHz,	5730 to 5790 every 5 MHz, 5820 to 5845 every 5 MHz	23	36	ETSI
Oman	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	33	ETSI
Other	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	30		None

Country	Frequency ranges	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[4]	Conducted Power	EIRP Power	DFS
Peru	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
Philippines	5725-5825	5740 to 5810 every 5 MHz	5750 to 5800 every 5 MHz	5730 to 5820 every 5 MHz	23	30	No
Portugal	5725-5875	5735 to 5865 every 5 MHz	5745 to 5855 every 5 MHz	5730 to 5870 every 5 MHz	23	36	ETSI
Puerto Rico	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5740 to 5835 every 5 MHz	23 for PMP AP PMP, 30 for PTP and SM mode.	36 for PMP AP. No limit for other modes.	None
Russia	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Serbia	5725-5875	5735 to 5865 every 5 MHz	5745 to 5855 every 5 MHz	5730 to 5870 every 5 MHz	23	36	ETSI
Seychelles	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	36	ETSI
Singapore	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	30	ETSI
South Africa	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	30	36	No
South Korea	5725-5825	5740 to 5810 every 5 MHz	5750 to 5800 every 5 MHz	5730 to 5820 every 5 MHz	23	30	No
Spain	5725-5795, 5815-5855	5735 to 5785 every 5 MHz, 5825 to 5845 every 5 MHz	5745 to 5775 every 5 MHz, 5835 to 5835 every 5 MHz	5730 to 5790 every 5 MHz, 5820 to 5850 every 5 MHz	23	36	ETSI
Switzerland	5725-5795, 5815-5875	5735 to 5785 every 5 MHz, 5825 to 5865 every 5 MHz	5745 to 5775 every 5 MHz, 5835 to 5855 every 5 MHz	5730 to 5790 every 5 MHz, 5820 to 5870 every 5 MHz	23	36	ETSI
Taiwan	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23 for PMP AP PMP, 30 for PTP and SM mode.	36 for PMP AP. No limit for other modes.	None
Tajikistan	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Thailand	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5730 to 5845 every 5 MHz	23	30	None
Turkmenistan	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
U.S. Virgin Islands	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5740 to 5835 every 5 MHz	23 for PMP AP PMP, 30 for PTP and SM mode.	36 for PMP AP. No limit for other modes.	None
Uganda	5725-5825	5735 to 5815 every 5 MHz	5745 to 5805 every 5 MHz	5730 to 5820 every 5 MHz	30	32 dBm + 2 + (Configured Antenna Gain/3)	No
Ukraine	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None

Country	Frequency ranges	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band[4]	Conducted Power	EIRP Power	DFS
United Kingdom[5]	5725-5795, 5815-5850	5735 to 5785 every 5 MHz, 5825 to 5840 every 5 MHz	5745 to 5775 every 5 MHz	5730 to 5790 every 5 MHz, 5820 to 5845 every 5 MHz	23	36	ETSI
United States	5725-5850	5740 to 5835 every 5 MHz	5750 to 5825 every 5 MHz	5740 to 5835 every 5 MHz	23 for PMP AP PMP, 30 for PTP and SM mode.	36 for PMP AP. No limit for other modes.	None
Uzbekistan	5725-5980	5735 to 5970 every 5 MHz	5745 to 5960 every 5 MHz	5730 to 5975 every 5 MHz	23		None
Venezuela	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	36	None
Vietnam	5725-5850	5735 to 5840 every 5 MHz	5745 to 5830 every 5 MHz	5730 to 5845 every 5 MHz	23	30	None

[5] 5795 MHz to 5815 MHz band is assigned for Road Transport and Traffic Telematics (RTTT).

Table 104 Regulatory limits - 2.4 GHz

Country	Frequency ranges	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band	Conducted Power	EIRP Power
Armenia	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Argentina	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	27	36
Australia	2400-2500	2412-2462 every 5MHz	2422-2452 every 5MHz	2407-2477 every 5MHz		36
Azerbaijan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Bahrain	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Brazil	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
Belarus	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Canada	2400-2500	2412-2462 every 5MHz	2427-2452 every 5MHz	2407-2467 every 5MHz		36 for PMP AP. 30 dBm + 6 + ((Configured Antenna Gain - 6)/3) for other modes.
Chile	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
China	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Colombia	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
Ecuador	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Georgia	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Ghana	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
Guam	2400-2500	2412-2462 every 5MHz	2427-2452 every 5MHz	2407-2467 every 5MHz		36 for PMP AP. 30 dBm + 6 + ((Configured Antenna Gain - 6)/3) for other modes.
Hong Kong	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Indonesia	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
India	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Kenya	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
Kyrgyzstan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	27	
South Korea	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Kazakhstan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Moldova	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Mexico	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36

Country	Frequency ranges	Valid Center Frequency for 20 MHz Band	Valid Center Frequency for 40 MHz Band	Valid Center Frequency for 5/10 MHz Band	Conducted Power	EIRP Power
Malaysia	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Nigeria	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
New Zealand	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Other	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Peru	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Philippines	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
Puerto Rico	2400-2500	2412-2462 every 5MHz	2427-2452 every 5MHz	2407-2467 every 5MHz		36 for PMP AP. 30 dBm + 6 + ((Configured Antenna Gain - 6)/3) for other modes.
Russia	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Singapore	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
Thailand	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		20
Tajikistan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	27	
Turkmenistan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	27	
Taiwan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
Ukraine	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		
Uganda	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	
United States	2400-2500	2412-2462 every 5MHz	2427-2452 every 5MHz	2407-2467 every 5MHz	27	36 for PMP AP. 30 dBm + 6 + ((Configured Antenna Gain - 6)/3) for other modes.
Uzbekistan	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	27	
Venezuela	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
U.S. Virgin Islands	2400-2500	2412-2462 every 5MHz	2427-2452 every 5MHz	2407-2467 every 5MHz		36 for PMP AP. 30 dBm + 6 + ((Configured Antenna Gain - 6)/3) for other modes.
Vietnam	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	23	36
South Africa	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz		36
CIS Countries	2400-2500	2412-2472 every 5MHz	2422-2462 every 5MHz	2407-2477 every 5MHz	27	36

Notifications

This section contains notifications of compliance with the radio regulations that are enforced in various regions.

2.4 GHZ, 5.4 GHZ REGULATORY COMPLIANCE

The ePMP complies with the regulations that are enforced in the USA, Canada and Europe. The relevant notifications are specified in this section.

2.4 GHz, 5.1 GHz, 5.4 GHz FCC and IC notification

U.S. Federal Communication Commission (FCC) and Industry Canada (IC) Notification.

This device complies with part 15.407 of the US FCC Rules and Regulations and with RSS-210 Issue 8 of Industry Canada. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation. In Canada, users must be cautioned to take note that high power radars are allocated as primary users (meaning they have priority) of 5250 – 5350 MHz and 5470 – 5725 MHz and these radars could cause interference and/or damage to license-exempt local area networks (LELAN). To comply with FCC/IC RF exposure limits for general population or uncontrolled exposure, the antenna(s) used for the ePMP transmitter must be installed at a separation distance specified in Table 145 through Table 151.

For the connectorized version of the product and in order to reduce potential radio interference to other users, the antenna type and its gain must be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that permitted by the regulations. The transmitted power must be reduced to achieve this requirement.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the US FCC Rules and with RSS-210 of Industry Canada. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with these instructions, may cause harmful interference to radio communications. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment on and off, the user is encouraged to correct the interference by one or more of the following measures:

- Increase the separation between the affected equipment and the unit;
- Connect the affected equipment to a power outlet on a different circuit from that which the receiver is connected to;
- Consult the dealer and/or experienced radio/TV technician for help.

FCC IDs and Industry Canada Certification Numbers are reproduced on the product label (Figure 77 and Figure 78).

End Product Labelling

The ePMP Module is labelled with its own FCC ID and IC Certification Number. If the FCC ID and IC Certification Number are not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labelled in a visible area with the following:

Table 105 ePMP 2000 Product labeling

Region	Label
Access Point (AP)	"Contains Transmitter Module FCC ID: Z8H89FT0020" or "Contains FCC ID: Z8H89FT0020"

Table 106 ePMP 1000 Product labeling

Region	Label
Access Point (AP)	"Contains Transmitter Module FCC ID: Z8H89FT0006" or "Contains FCC ID: Z8H89FT0006"
Subscriber Module (SM)	"Contains Transmitter Module FCC ID: Z8H89FT0005" or "Contains FCC ID: Z8H89FT0005"
Access Point (AP) / Subscriber Module (SM)	"Contains Transmitter Module FCC ID: Z8H89FT0015" or "Contains FCC ID: Z8H89FT0015"
Access Point (AP) / Subscriber Module (SM)	"Contains Transmitter Module FCC ID: Z8H89FT0019" or "Contains FCC ID: Z8H89FT0019"

Figure 25 FCC and IC certifications on 5 GHz product labels


PMN : 5GHz Force 180
VIN : 14-30V ⎓ ; IMAX : 500mA
Contains FCC ID : Z8H89FT0015
IC : 109W-0015
FVIN : R2.4.2
IMPORTANT
See the System User Guide
before connecting to AC
power. The guide is available online at
http://www.cambiumnetworks.com
MODEL NO / HVIN: C058900P072A
PART NO: C058900C072A
MSN: 6068RC00050
ESN: 000456F80844
Wireless MAC: 000456F80845
c UL US LISTED
I.T.E.
E221154
MADE IN XXXXX
24600001391A R01 XX XX

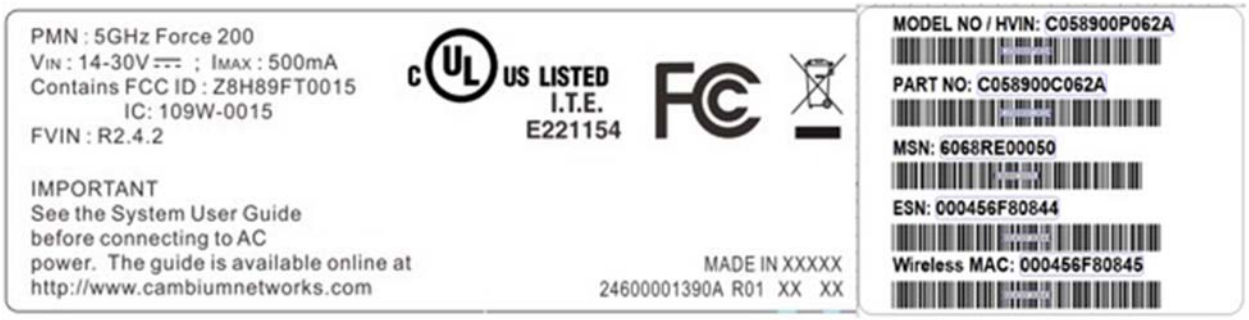
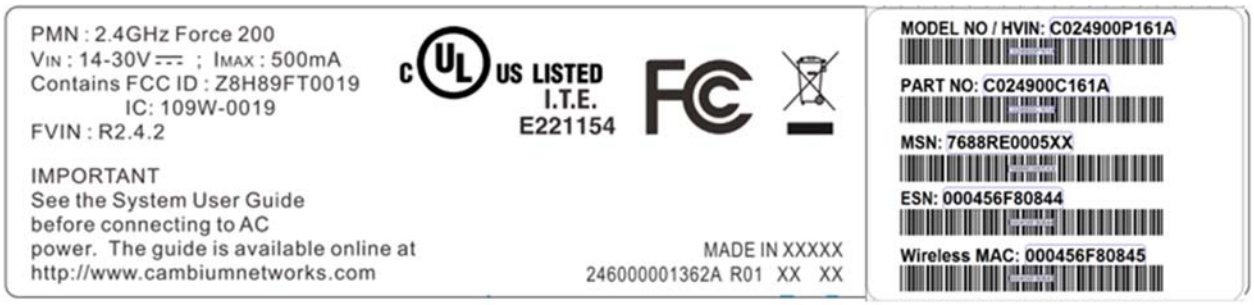

PMN : 5GHz Force 200
VIN : 14-30V ⎓ ; IMAX : 500mA
Contains FCC ID : Z8H89FT0015
IC: 109W-0015
FVIN : R2.4.2
IMPORTANT
See the System User Guide
before connecting to AC
power. The guide is available online at
http://www.cambiumnetworks.com
c UL US LISTED
I.T.E.
E221154
MADE IN XXXXX
24600001390A R01 XX XX
MODEL NO / HVIN: C058900P062A
PART NO: C058900C062A
MSN: 6068RE00050
ESN: 000456F80844
Wireless MAC: 000456F80845

Figure 26 FCC and IC certifications on 2.4 GHz product labels



Wherever 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 on the conditions of use for the bands in question and any exceptions that might apply.

5.4 GHz European Union notification

The ePMP product is a two-way radio transceiver suitable for use in Broadband Wireless Access System (WAS), Radio Local Area Network (RLAN), or Fixed Wireless Access (FWA) systems. It is a Class 1 device and uses operating frequencies that are harmonized throughout the EU member states. The operator 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.

Hereby, Cambium Networks declares that the ePMP product complies with the essential requirements and other relevant provisions of Directive 1999/5/EC. The declaration of conformity may be consulted at the support website.

The European R&TTE directive 1999/5/EC Certification Number is reproduced on the product label (Figure 79).

Figure 27 European Union certification on 5.4 GHz product label

5.8 GHZ REGULATORY COMPLIANCE

This system has achieved Type Approval in various countries around the world. This means that the system has been tested against various local technical regulations and found to comply. The frequency band in which the system operates is "license exempt" and the system is allowed to be used provided it does not cause interference. The licensing authority does not guaranteed protection against interference from other products and installations.

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.

U.S. Federal Communication Commission (FCC)

This device complies with part 15 of the US FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the US FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with these instructions, may cause harmful interference to radio communications. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment on and off, the user is encouraged to correct the interference by one or more of the following measures:

- Increase the separation between the affected equipment and the unit;
- Connect the affected equipment to a power outlet on a different circuit from that which the receiver is connected to;
- Consult the dealer and/or experienced radio/TV technician for help.

Industry Canada (IC)

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B conforme á la norme NMB-003 du Canada.

RSS-GEN issue 3 (7.1.3) Licence-Exempt Radio Apparatus:

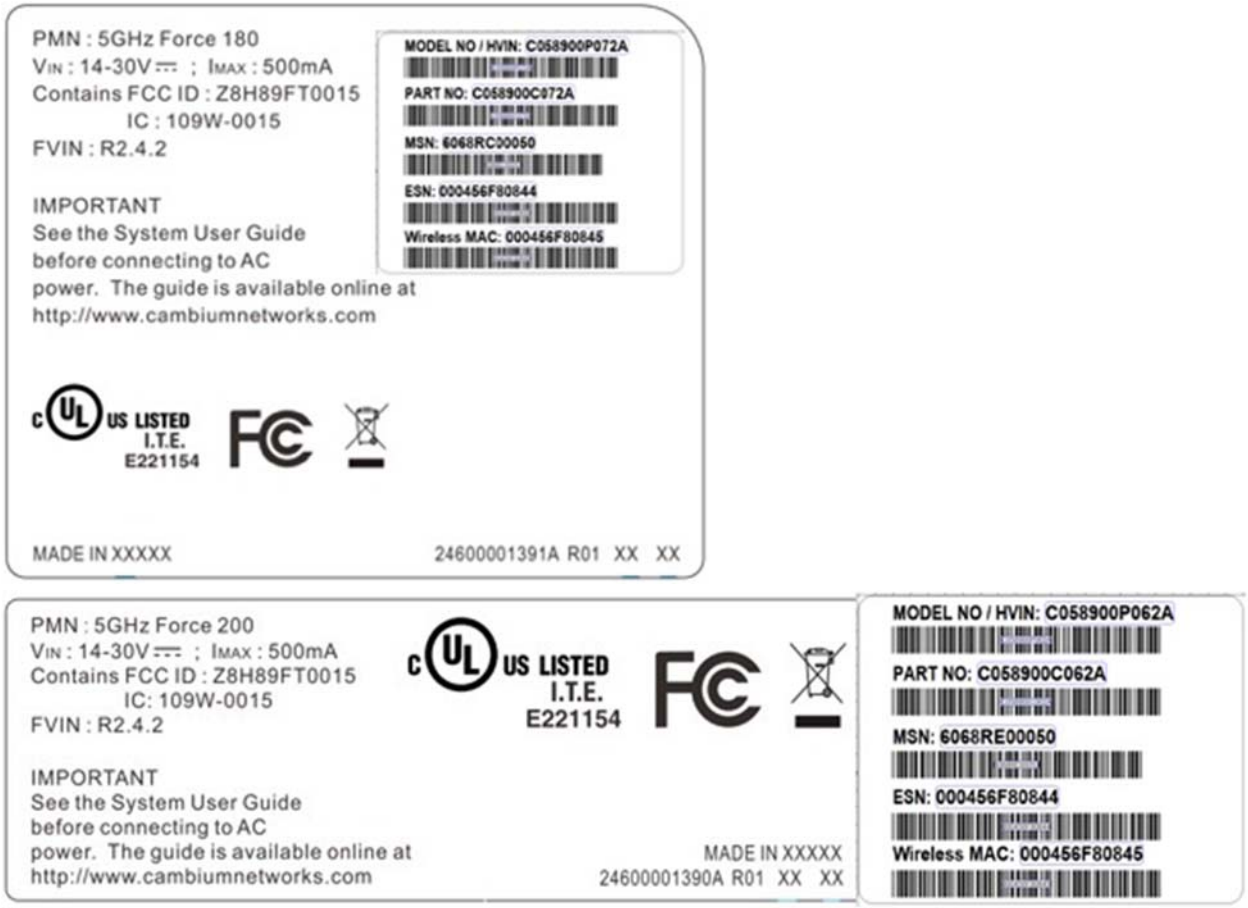
> This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.
>
> *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.*

In Canada, high power radars are allocated as primary users (meaning they have priority) of the 5650 – 5850 MHz spectrum. These radars could cause interference or damage to license-exempt local area network (LE-LAN) devices.

Product labels

FCC IDs and Industry Canada Certification Numbers are reproduced on the product label (Figure 80).

Figure 28 FCC and IC certifications on 5.8 GHz product label



Wherever 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 on the conditions of use for the bands in question and any exceptions that might apply.

5.8 GHz European Union notification

The ePMP is a Class 2 device as it operates on frequencies that are not harmonized across the EU. Currently the product may only be operated in the UK, Eire (IRL), Germany, Norway and Denmark. However, the regulatory situation in Europe is changing and the radio spectrum may become available in other countries in future. See www.ero.dk for further information. The operator 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.

Caution

This equipment operates as a secondary application, so it has no rights against harmful interference, even if generated by similar equipment, and must not cause harmful interference on systems operating as primary applications.

Hereby, Cambium Networks declares that the ePMP product complies with the essential requirements and other relevant provisions of Directive 1999/5/EC. The declaration of conformity may be consulted at the support website.

The European R&TTE directive 1999/5/EC Certification Number is reproduced on the product label (Figure 81).

Figure 29 European Union certification on 5.8 GHz product label

5.8 GHz operation in the UK

The ePMP connectorized product has been notified for operation in the UK, and when operated in accordance with instructions for use it is compliant with UK Interface Requirement IR2007. For UK use, installations must conform to the requirements of IR2007 in terms of EIRP spectral density against elevation profile above the local horizon in order to protect Fixed Satellite Services. The frequency range 5795-5815 MHz is assigned to Road Transport & Traffic Telematics (RTTT) in the U.K. and shall not be used by FWA systems in order to protect RTTT devices. UK Interface Requirement IR2007 specifies that radiolocation services shall be protected by a Dynamic Frequency Selection (DFS) mechanism to prevent co-channel operation in the presence of radar signals.

THAILAND NOTIFICATION

เครื่องโทรคมนาคมและอุปกรณ์นี
มีความสอดคล้องตามข้อกำหนดของ กทช.

This telecommunication equipment conforms to the requirements of the National Telecommunications Commission.

Data throughput tables

This section contains tables to support calculation of the data rate capacity that can be provided by ePMP configurations, as follows:

- See Data throughput capacity on page 236

DATA THROUGHPUT CAPACITY

The data throughput rates (Mbps) achieved with an AP/SM pair and the link distance (range) is 0 km as shown in Table 154, Table 155, Table 156, Table 157.

Table 107 Throughput for ePMP (Flexible Ratio)

MCS	Spatial Streams	Mod. Type	Coding Rate	5 MHz		10 MHz		20 MHz		40 MHz	
				DL	UL	DL	UL	DL	UL	DL	UL
MCS 15	2	64-QAM	5/6	23	20.4	48.4	48.4	95.6	88	202	135
MCS 14	2	64-QAM	3/4	20.8	20.2	43.6	44.2	88	83.4	182	128
MCS 13	2	64-QAM	2/3	18.6	18.8	38.7	38.7	79.3	76.1	163	116
MCS 12	2	16-QAM	3/4	13.7	13.7	29.1	28.7	59.6	58.1	123	61.7
MCS 11	2	16-QAM	1/2	9.27	9.37	19.3	19.1	39.8	38.7	82.2	61.9
MCS 10	2	QPSK	3/4	7.06	6.9	14.7	14.5	30	29.1	62.1	57.4
MCS 9	2	QPSK	1/2	4.85	4.5	9.64	9.59	20.1	19.4	41.6	41.1
MCS 7	1	64-QAM	5/6	11.5	11.6	24.4	24.3	49.7	48.4	103	61.8
MCS 6	1	64-QAM	3/4	10.7	10.5	22	21.8	44.6	43.6	92.1	61.6
MCS 5	1	64-QAM	2/3	9.3	9.37	19.3	19.3	39.9	38.7	82.1	61.6
MCS 4	1	16-QAM	3/4	7.08	6.69	14.7	14.5	30	29.1	61.9	57.6
MCS 3	1	16-QAM	1/2	4.85	4.56	9.67	9.64	20.1	19.4	41.5	41.2
MCS 2	1	QPSK	3/4	3.54	3.37	7.35	7.18	15	14.4	31	30.8
MCS 1	1	QPSK	1/2	2.56	2.25	5.01	4.75	10.2	9.67	20.8	20.5

Table 108 Throughput for ePMP (75/25 Ratio)

MCS	Spatial Streams	Mod. Type	Coding Rate	5 MHz		10 MHz		20 MHz		40 MHz	
				DL	UL	DL	UL	DL	UL	DL	UL
MCS 15	2	64-QAM	5/6	18.7	3.64	42.2	10.7	87	27	178	56
MCS 14	2	64-QAM	3/4	16.5	3.38	37.7	9.75	78.4	24.1	162	51.6
MCS 13	2	64-QAM	2/3	14.7	3.09	32.8	8.97	69.4	21	143	44.6
MCS 12	2	16-QAM	3/4	10.9	2.21	24.6	6.63	52.1	16.1	108	34
MCS 11	2	16-QAM	1/2	7.04	1.42	16.5	4.3	34.7	10.4	72.9	22.3
MCS 10	2	QPSK	3/4	5.47	1.03	12.3	3.2	25.9	7.8	54.4	16.6
MCS 9	2	QPSK	1/2	3.52	0.619	8.2	2.14	17.2	5.16	36.3	11.1
MCS 7	1	64-QAM	5/6	9.36	1.88	21.1	5.46	43.5	13.7	91.7	28.2
MCS 6	1	64-QAM	3/4	8.2	1.65	18.8	4.88	39.2	11.9	82.3	25.8
MCS 5	1	64-QAM	2/3	7.04	1.55	16.4	4.3	34.7	10.6	72.9	22.3

MCS 4	1	16-QAM	3/4	7.08	6.69	14.7	14.5	30	29.1	61.9	57.6
MCS 3	1	16-QAM	1/2	4.85	4.56	9.67	9.64	20.1	19.4	41.5	41.2
MCS 2	1	QPSK	3/4	3.54	3.37	7.35	7.18	15	14.4	31	30.8
MCS 1	1	QPSK	1/2	2.56	2.25	5.01	4.75	10.2	9.67	20.8	20.5

Table 109 Throughput for ePMP 50/50 Ratio)

MCS	Spatial Streams	Mod. Type	Coding Rate	5 MHz		10 MHz		20 MHz		40 MHz	
				DL	UL	DL	UL	DL	UL	DL	UL
MCS 15	2	64-QAM	5/6	10.5	11.4	25.9	26.9	56.5	58.4	115	114
MCS 14	2	64-QAM	3/4	9.35	10.3	23.4	24.2	50.6	51.8	104	105
MCS 13	2	64-QAM	2/3	8.19	9.17	21.1	21.5	44.6	46.7	94.2	95.7
MCS 12	2	16-QAM	3/4	6.23	6.9	15.6	16	33.6	34.8	70.4	72.3
MCS 11	2	16-QAM	1/2	4.09	4.56	10.5	10.6	22.4	23.1	46.9	47.8
MCS 10	2	QPSK	3/4	3.12	3.38	7.84	8.01	16.4	17.1	35.2	35.9
MCS 9	2	QPSK	1/2	1.95	2.24	5.08	5.27	11.1	11.3	23.4	23.5
MCS 7	1	64-QAM	5/6	5.26	5.85	12.9	13.7	28.2	28.7	58.9	60.8
MCS 6	1	64-QAM	3/4	4.68	5.33	11.7	12.2	25.8	25.9	54.1	53.7
MCS 5	1	64-QAM	2/3	4.21	4.69	10.5	10.7	22.3	23.1	47.1	48
MCS 4	1	16-QAM	3/4	3.12	3.45	7.82	8.01	16.8	17.1	35.2	36
MCS 3	1	16-QAM	1/2	2	2.26	5.16	5.3	11.1	11.3	23.4	23.8
MCS 2	1	QPSK	3/4	1.55	1.66	3.75	3.91	8.22	8.47	17.6	17.9
MCS 1	1	QPSK	1/2	0.938	1.07	2.35	2.35	5.49	5.63	11.8	11.8

Table 110 Throughput for ePMP (30/70 Ratio)

MCS	Spatial Streams	Mod. Type	Coding Rate	5 MHz		10 MHz		20 MHz		40 MHz	
				DL	UL	DL	UL	DL	UL	DL	UL
MCS 15	2	64-QAM	5/6	4.2	18	12.9	39.6	31.7	82	68.2	134
MCS 14	2	64-QAM	3/4	3.73	15.8	11.7	36	28.1	74.2	61.2	132
MCS 13	2	64-QAM	2/3	3.26	14.3	10.3	32.4	25.8	65.5	54.1	131
MCS 12	2	16-QAM	3/4	2.33	10.8	7.8	23.9	18.8	49.2	39.9	101
MCS 11	2	16-QAM	1/2	1.56	7.04	5.15	16	12.5	32.8	26.6	68
MCS 10	2	QPSK	3/4	1.17	5.34	3.9	11.7	9.36	24.4	20	51.2
MCS 9	2	QPSK	1/2	0.778	3.51	2.35	7.82	6.24	16.2	12.9	34
MCS 7	1	64-QAM	5/6	2.32	9.11	6.47	19.8	15.7	41	32.9	86.6
MCS 6	1	64-QAM	3/4	1.95	8.13	5.86	17.9	14.1	37.3	30.6	77
MCS 5	1	64-QAM	2/3	1.56	7.04	5.15	16	12.5	32.7	26.7	68
MCS 4	1	16-QAM	3/4	1.17	5.34	3.9	11.7	9.37	24.6	20	51.2
MCS 3	1	16-QAM	1/2	0.778	3.52	2.35	7.82	6.25	16.3	13.3	34.1

MCS 2	1	QPSK	3/4	0.469	2.62	1.88	5.86	4.67	12.1	9.85	25.5
MCS 1	1	QPSK	1/2	0.312	1.75	1.17	3.9	3.02	8.08	6.48	17

Radio Specifications

EPMP 2000 CONNECTORIZED RADIO WITH SYNC SPECIFICATIONS

Table 111 ePMP 2000 Connectorized Radio with Sync specifications, 5 GHz

Product	
PART NUMBERS	C050900A033A (EU), C058900A132A (FCC), C050900A031A (ROW), C050900A231A (ROW), C050900A131A (ROW) C050900L033A (EU), C058900L132A (FCC), C050900L031A (ROW), C050900L231A (ROW), C050900L131A (ROW)
MODEL NUMBERS	C050900P931A (EU), C058900P132A (FCC), C050900P931A (ROW)
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	5150 - 5970 MHz
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100/1000BaseT, rate auto negotiated (802.3at compliant)
POWERING METHODS SUPPORTED	56 V PoE (included), standard 802.3at PoE Supply, or CMM4 with 56 V and 5 pin to 7 pin cross over cable adapter
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
SUBSCRIBERS PER SECTOR	Up to 120
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -93 dBm to MCS15 = -69 dBm (per branch)

NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -90 dBm to MCS15 = -66 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MAXIMUM DEPLOYMENT RANGE @ 40 MHz CHANNEL	Up to 9 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)
LATENCY (nominal, roundtrip)	17 ms
GPS SYNCHRONIZATION	Yes, via Internal GPS, CMM3, or CMM4
QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Addr,
Link Budget	
ANTENNA Options	Antenna for 90°/120° sectors available Smart Antenna (beamforming) antenna available
TRANSMIT POWER RANGE	0 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	18 dBi (90°/120° sector)
MAXIMUM TRANSMIT POWER	30 dBm combined (5.8 GHz Band)
Physical	
SECTOR ANTENNA CONNECTION	50 , RP (Reverse Polarity) SMA, female
SECTOR ANTENNA CONNECTION	50 , RP (Reverse Polarity) SMA, female, DC Coupled (powering antenna)
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	0.7 kg (1.5 lbs) without brackets
WIND SURVIVAL	190 km/hour (118 mi/hour) with antenna
DIMENSIONS (H x W x D)	22.2 x 12.4 x 4.5 cm (8.75 x 4.9 x 1.75 in) without brackets
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006

INDUSTRY CANADA CERT	109W-0006
CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

EPMP 1000 CONNECTORIZED RADIO WITH SYNC SPECIFICATIONS

Table 112 ePMP 1000 Connectorized Radio with Sync specifications, 5 GHz

Product	
PART NUMBERS	C058900A112A (US/FCC), C050900A013A (EU), C050900A011A (ROW)
MODEL NUMBERS	C058900P112A (US/FCC), C050900P013A (EU), C050900P011A (ROW)
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	4900 - 5980 MHz
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100/1000BaseT, rate auto negotiated (802.3af compliant)
POWERING METHODS SUPPORTED	30V PoE Supply (included), CMM3 & CMM4, 802.3af PoE Supply
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
SUBSCRIBERS PER SECTOR	Up to 120
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -89 dBm to MCS15 = -68 dBm (per branch)

NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -87 dBm to MCS15 = -65 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MAXIMUM DEPLOYMENT RANGE @ 40 MHz CHANNEL	Up to 9 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)
LATENCY (nominal, roundtrip)	17 ms
GPS SYNCHRONIZATION	Yes, via Internal GPS, CMM3, or CMM4
QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Addr,
Link Budget	
ANTENNA Options	Antennas for 90° or 120° sectors are available
TRANSMIT POWER RANGE	-20 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	15 dBi (90° sector)
MAXIMUM TRANSMIT POWER	30 dBm combined (5.8 GHz Band)
Physical	
ANTENNA CONNECTION	50 , RP (Reverse Polarity) SMA, female
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	4.5 kg (10 lbs) with antenna 0.52 kg (1.1 lbs) without antenna
WIND SURVIVAL	190 km/hour (118 mi/hour) with antenna
DIMENSIONS (H x W x D)	Radio: 26.9 x 11 x 7.7 cm (10.6 x 4.3 x 3.0 in) Antenna (excl brackets): 80.4 x 16 x 6.3 cm (31.7 x 6.3 x 2.5 in)
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006
INDUSTRY CANADA CERT	109W-0006

CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

Table 113 ePMP 1000 Connectorized Radio with Sync specifications, 2.4 GHz

Product	
PART NUMBER	C024900A011A
MODEL NUMBER	C024900P011A
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	2402 - 2472 MHz (20 MHz) 2407 - 2472 MHz (40 MHz)
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100/1000BaseT, rate auto negotiated (802.3af compliant)
POWERING METHODS SUPPORTED	30V PoE Supply (included), CMM3 & CMM4, 802.3af PoE Supply
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
SUBSCRIBERS PER SECTOR	Up to 120
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -89 dBm to MCS15 = -68 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -87 dBm to MCS15 = -65 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MAXIMUM DEPLOYMENT RANGE @ 40 MHz CHANNEL	Up to 9 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)

LATENCY (nominal, roundtrip)	17 ms
GPS SYNCHRONIZATION	Yes, via Internal GPS, CMM3, or CMM4
QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP and MAC Address.
Link Budget	
ANTENNA Options	Antennas for 90° or 120° sectors are available
TRANSMIT POWER RANGE	-20 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	15 dBi (90° / 120° sector)
MAXIMUM TRANSMIT POWER	30 dBm combined
Physical	
ANTENNA CONNECTION	50 , RP (Reverse Polarity) SMA, female
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	4.5 kg (10 lbs) with antenna 0.52 kg (1.1 lbs) without antenna
WIND SURVIVAL	190 km/hour (118 mi/hour) with antenna
DIMENSIONS (H x W x D)	Radio: 26.9 x 11 x 7.7 cm (10.6 x 4.3 x 3.0 in) Antenna (excl brackets): 80.4 x 16 x 6.3 cm (31.7 x 6.3 x 2.5 in)
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006
INDUSTRY CANADA CERT	109W-0006
CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

EPMP 1000 INTEGRATED RADIO SPECIFICATIONS

Table 114 ePMP 1000 Integrated Radio specifications, 5 GHz

Product	
PART NUMBERS	C058900C132A (US/FCC), C050900C033A (EU), C050900C031A (ROW)
MODEL NUMBERS	C058900P132A (US/FCC), C050900P033A (EU), C050900P031A (ROW)
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	4900 - 5980 MHz
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100BaseT, Cambium PoE (V+ = pins 7 & 8, Return = pins 4 & 5)
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -89 dBm to MCS15 = -70 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -87 dBm to MCS15 = -65 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)
LATENCY (nominal, roundtrip)	17 ms

QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Addr, Broadcast, Multicast and Subscriber Module Priority
Link Budget	
ANTENNA BEAM WIDTH	24° azimuth, 12° elevation
TRANSMIT POWER RANGE	-20 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	13 dBi, integrated patch
MAXIMUM TRANSMIT POWER	30 dBm combined (5.8 GHz Band)
Physical	
ANTENNA CONNECTION	Integrated patch antenna
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	0.49 kg (1.1 lb.)
WIND SURVIVAL	145 km/hour (90 mi/hour) with antenna
DIMENSIONS (H x W x D)	29.1 x 14.5 x 8.3 cm (11.4 x 5.7 x 3.3 in)
POWER CONSUMPTION	7 W Maximum, 5 W Typical
INPUT VOLTAGE	24 to 30 V
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006
INDUSTRY CANADA CERT	109W-0006
CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

Table 115 ePMP 1000 Integrated Radio specifications, 2.4 GHz

Product	
PART NUMBER	C024900A031A
MODEL NUMBER	C024900P031A
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	2402 - 2472 MHz (20 MHz) 2407 - 2472 MHz (40 MHz)
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100BaseT, Cambium PoE (V+ = pins 7 & 8, Return = pins 4 & 5)
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -89 dBm to MCS15 = -70 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -87 dBm to MCS15 = -65 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)
LATENCY (nominal, roundtrip)	17 ms
QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Addr, Broadcast, Multicast and Subscriber Module Priority
Link Budget	

ANTENNA BEAM WIDTH	24° azimuth, 12° elevation
TRANSMIT POWER RANGE	-20 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	12 dBi, integrated patch
MAXIMUM TRANSMIT POWER	30 dBm combined
Physical	
ANTENNA CONNECTION	Integrated patch antenna
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	0.49 kg (1.1 lb.)
WIND SURVIVAL	145 km/hour (90 mi/hour) with antenna
DIMENSIONS (H x W x D)	29.1 x 14.5 x 8.3 cm (11.4 x 5.7 x 3.3 in)
POWER CONSUMPTION	7 W Maximum, 5 W Typical
INPUT VOLTAGE	24 to 30 V
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006
INDUSTRY CANADA CERT	109W-0006
CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

EPMP 1000 CONNECTORIZED RADIO SPECIFICATIONS

Table 116 ePMP 1000 Connectorized Radio specifications, 5 GHz

Product	
PART NUMBERS	C058900A122A (US/FCC), C050900A023A (EU), C050900A021A (ROW)
MODEL NUMBERS	C058900P122A (US/FCC), C050900P023A (EU), C050900P021A (ROW)
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	4900 - 5980 MHz
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100BaseT, Cambium PoE (V+ = pins 7 & 8, Return = pins 4 & 5)
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -89 dBm to MCS15 = -70 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -87 dBm to MCS15 = -65 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MAXIMUM DEPLOYMENT RANGE @ 40 MHz CHANNEL	Up to 9 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)
LATENCY (nominal, roundtrip)	17 ms

QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Addr, Broadcast, Multicast and Subscriber Module Priority
Link Budget	
ANTENNA Options	Antennas for 90° or 120° sectors are available
TRANSMIT POWER RANGE	-20 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	15 dBi (90° sector)
MAXIMUM TRANSMIT POWER	30 dBm combined (5.8 GHz Band)
Physical	
ANTENNA CONNECTION	50 , RP (Reverse Polarity) SMA, female
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	4.5 kg (10 lbs) with antenna 0.52 kg (1.1 lbs) without antenna
WIND SURVIVAL	190 km/hour (118 mi/hour) with antenna
DIMENSIONS (H x W x D)	Radio: 26.9 x 11 x 7.7 cm (10.6 x 4.3 x 3.0 in) Antenna (excl brackets): 80.4 x 16 x 6.3 cm (31.7 x 6.3 x 2.5 in)
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006
INDUSTRY CANADA CERT	109W-0006
CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

Table 117 ePMP 1000 Connectorized Radio specifications, 2.4 GHz

Product	
PART NUMBERS	C024900A021A
MODEL NUMBERS	C024900P021A
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	2402 - 2472 MHz (20 MHz) 2407 - 2472 MHz (40 MHz)
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	100BaseT, Cambium PoE (V+ = pins 7 & 8, Return = pins 4 & 5)
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS1 = -89 dBm to MCS15 = -70 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS1 = -87 dBm to MCS15 = -65 dBm (per branch)
MAXIMUM DEPLOYMENT RANGE @ 20 MHz CHANNEL	Up to 13 miles
MAXIMUM DEPLOYMENT RANGE @ 40 MHz CHANNEL	Up to 9 miles
MODULATION LEVELS (ADAPTIVE)	MCS1 (QPSK 1/2) to MCS15 (64QAM 5/6)
LATENCY (nominal, roundtrip)	17 ms

QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Addr, Broadcast, Multicast and Subscriber Module Priority
Link Budget	
ANTENNA Options	Antennas for 90° or 120° sectors are available
TRANSMIT POWER RANGE	-20 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
ANTENNA GAIN	15 dBi (90° / 120° sector)
MAXIMUM TRANSMIT POWER	30 dBm combined
Physical	
ANTENNA CONNECTION	50 , RP (Reverse Polarity) SMA, female
SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +55°C (-22°F to +131°F)
WEIGHT	4.5 kg (10 lbs) with antenna 0.52 kg (1.1 lbs) without antenna
WIND SURVIVAL	190 km/hour (118 mi/hour) with antenna
DIMENSIONS (H x W x D)	Radio: 26.9 x 11 x 7.7 cm (10.6 x 4.3 x 3.0 in) Antenna (excl brackets): 80.4 x 16 x 6.3 cm (31.7 x 6.3 x 2.5 in)
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0006
INDUSTRY CANADA CERT	109W-0006
CE	EN 302 502 v1.2.1 EN 301 893 v1.7.1

FORCE 180 SPECIFICATIONS

Table 118 Force 180 specifications, 5 GHz

Product	
PART NUMBER	C058900P072A (US/FCC), C050900P071A (EU/ROW) See Force 180 part numbers on page 64 for full list.
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	5 GHz 4910 – 5970 MHz (exact frequencies as allowed by local regulations)
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	10/100/1000BaseT, Compatible with Cambium PoE pinouts (V+ = 7 & 8, Return = 4 & 5) and Standard PoE pinouts (V+ = 4 & 5, Return = 7 & 8)
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS0 = -93 dBm to MCS15 = -72 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS0 = -90 dBm to MCS15 = -69 dBm (per branch)
MODULATION LEVELS (ADAPTIVE)	MCS0 (BPSK) to MCS15 (64QAM 5/6)
QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Address, Broadcast, Multicast and Station Priority
Link Budget	
TRANSMIT POWER RANGE	-17 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
INTEGRATED ANTENNA PEAK GAIN	16 dBi
MAXIMUM TRANSMIT POWER	30 dBm combined (subject to regional regulatory restrictions)

Physical	
ANTENNA CONNECTION	Integrated antenna
SURGE SUPPRESSION	2 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +60°C (-22°F to +140°F)
WEIGHT	0.50 kg (1.1 lb.) (includes mounting bracket)
WIND SURVIVAL	145 km/hour (90 mi/hour) with antenna
DIMENSIONS (H x W x D)	12.4 x 25.1 x 11.9 cm (4.9 x 9.9 x 4.7 in) – with mounting bracket attached
POWER CONSUMPTION	10 W Maximum, 5 W Typical
POLE DIAMETER RANGE	1 – 1.6 in (2.5 – 4.1 cm) with included clamp ; up to 2.25 in (5.7 cm) with larger clamp
INPUT VOLTAGE	10 to 30 V
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0015
INDUSTRY CANADA CERT	109W-0015
CE	5 GHz: EN 302 502 v1.2.1 5 GHz: EN 301 893 v1.7.1

PARAMETER	SPECIFICATION
FREQUENCY RANGE	4910 – 5970 MHz
ANTENNA TYPE	INTEGRATED
TYPICAL GAIN	16 dBi
3dB BEAMWIDTH-AZIMUTH	15°
3dB BEAMWIDTH-ELEVATION	30°
POLARIZATION(S)	DUAL LINEAR, H/ V
FRONT-TO-BACK ISOLATION	>20 dB
CROSS POLARIZATION	15 dB

FORCE 200 SPECIFICATIONS

Table 119 Force 200 specifications

Product	
PART NUMBER	C058900P072A (US/FCC), C050900P071A (EU/ROW) See Force 200 part numbers on page 70 for full list.
Spectrum	
CHANNEL SPACING	Configurable on 5 MHz increments
FREQUENCY RANGE	2402 - 2472 MHz (exact frequencies as allowed by local regulations) 5 GHz 4910 – 5970 MHz (exact frequencies as allowed by local regulations)
CHANNEL WIDTH	5 | 10 | 20 | 40 MHz
Interface	
MAC (MEDIA ACCESS CONTROL) LAYER	Cambium Proprietary
PHYSICAL LAYER	2x2 MIMO/OFDM
ETHERNET INTERFACE	10/100/1000BaseT, Compatible with Cambium PoE pinouts (V+ = 7 & 8, Return = 4 & 5) and Standard PoE pinouts (V+ = 4 & 5, Return = 7 & 8)
PROTOCOLS USED	IPv4, UDP, TCP, IP, ICMP, SNMPv2c, HTTPs, STP, SSH, IGMP Snooping, LLDP, DHCP, RADIUS, NTP
NETWORK MANAGEMENT	HTTPs, SSH, SNMPv2c, Cambium Networks cnMaestro™
VLAN	802.1Q with 802.1p priority
Performance	
ARQ	Yes
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 20MHZ CHANNEL	MCS0 = -93 dBm to MCS15 = -72 dBm (per branch)
NOMINAL RECEIVE SENSITIVITY (W/ FEC) @ 40MHZ CHANNEL	MCS0 = -90 dBm to MCS15 = -69 dBm (per branch)
MODULATION LEVELS (ADAPTIVE)	MCS0 (BPSK) to MCS15 (64QAM 5/6)
QUALITY OF SERVICE	Three level priority (Voice, High, Low) with packet classification by DSCP, COS, VLAN ID, IP & MAC Address, Broadcast, Multicast and Station Priority
TRANSMIT POWER RANGE	-15 to +30 dBm (combined, to regional EIRP limit) (1 dB interval)
Physical	

SURGE SUPPRESSION	1 Joule Integrated
ENVIRONMENTAL	IP55
TEMPERATURE	-30°C to +60°C (-22°F to +140°F) – with radome attached maximum temperature is +47°C (+116°F)
WEIGHT	2.4 GHz Model: 2.8 kg (6.2 lbs) 5 GHz Model: 2.3 kg (5.1 lbs)
WIND SURVIVAL	145 km/hour (90 mi/hour) with antenna
DIMENSIONS (Dia x Depth)	47 cm x 28 cm (18.5 in x 11.2 in)
POLE DIAMETER RANGE	6.4 cm – 7.6 cm (2.5 in – 3 in)
POWER CONSUMPTION	10 W Maximum, 5 W Typical
INPUT VOLTAGE	10 to 30 V
Security	
ENCRYPTION	128-bit AES (CCMP mode)
Certifications	
FCCID	Z8H89FT0019
INDUSTRY CANADA CERT	109W-0015
CE	N/A

PARAMETER	2.4 GHz SPECIFICATION
FREQUENCY RANGE	2402 – 2472 MHz
ANTENNA TYPE	DISH
TYPICAL GAIN	17 dBi
3dB BEAMWIDTH-AZIMUTH	17°
3dB BEAMWIDTH-ELEVATION	17°
FRONT-TO-BACK ISOLATION	>20 dB
CROSS POLARIZATION	>15 dB

PARAMETER	5 GHz SPECIFICATION
FREQUENCY RANGE	5150 – 5970 MHz
ANTENNA TYPE	DISH
TYPICAL GAIN	25 dBi
3dB BEAMWIDTH-AZIMUTH	7°

3dB BEAMWIDTH-ELEVATION	7°
FRONT-TO-BACK ISOLATION	>25 dB
CROSS POLARIZATION	>15 dB

Glossary

Table 120 Glossary

Term	Definition
AES	Advanced Encryption Standard
ANSI	American National Standards Institute
AP	Access Point
CINR	Carrier to Interference plus Noise Ratio
CMM	Cluster Management Module
CNSS	Cambium Network Services Server
DFS	Dynamic Frequency Selection
EIRP	Equivalent Isotropically Radiated Power
EMC	Electromagnetic Compatibility
EMD	Electromagnetic Discharge
ETH	Ethernet
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FEC	Forward Error Correction
GPS	Global Positioning System
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
IC	Industry Canada
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
LAN	Local Area Network
LED	Light Emitting Diode
LOS	Line of Sight
MIMO	Multiple In Multiple Out
MTU	Maximum Transmission Unit
nLOS	Near Line of Sight
NTP	Network Time Protocol
OFDM	Orthogonal Frequency Division Multiplexing
PC	Personal Computer
PMP	Point to Multipoint
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keyed
RF	Radio Frequency
RMA	Return Merchandise Authorization
RSSI	Received Signal Strength Indication
RTTT	Road Transport and Traffic Telematics
RX	Receive
SAR	Standard Absorption Rate
SNMP	Simple Network Management Protocol
SM	Subscriber Module
SW	Software
TDD	Time Division Duplex
TDWR	Terminal Doppler Weather Radar
TX	Transmit
UNII	Unlicensed National Information Infrastructure
URL	Uniform Resource Locator