Cambium Networks™

USER GUIDE

60 GHZ cnWave™

System Release 1.1

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About This User Guide

This document provides detailed information about the 60 GHz cnWave™ products, hardware, and supported features. The guide also explains how to deploy the product along with important safety measures. It is intended for system designers, system installers, and system administrators.

Purpose

The 60 GHz cnWave product documents are intended to instruct and assist personnel in operation, installation, and maintenance of the equipment and ancillary devices. It is recommended that all personnel engaged in such activities must be properly trained.

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

Cross-references

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

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

Feedback

We appreciate feedback from the users of our documents. This includes feedback on the structure, content, accuracy, or completeness of our documents. To provide feedback, visit our support website: https://support.cambiumnetworks.com.

Important regulatory information

Complying with rules for the country of operation

USA specific information

Caution

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

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

Note

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the 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 the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canada specific information

Caution

This device complies with ISEDC 's license-exempt RSSs. Operation is subject to the following two conditions:

- This device may not cause interference; and
- This device must accept any interference, including interference that may cause undesired operation of the device.

Renseignements specifiques au Canada

Attention

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

- l'appareil ne doit pas produire de brouillage, et
- l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

European specific information

Cambium Networks 60 GHz cnWave products are compliant with applicable European Directives required for CE marking:

- 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC; Radio Equipment Directive (RED).

- 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive).

The 59-63.9 GHz frequency band is subject to specific exclusion zones. For more information, see the 59 - 63.9 GHz transmission exclusion zones table.

EU Declaration of Conformity

Hereby, Cambium Networks declares that the Cambium Networks 60 GHz cnWave Series of Wireless Ethernet Bridge complies with the essential requirements and other relevant provisions of Directive 2014/53/EU. The declaration of conformity may be consulted at: https://www.cambiumnetworks.com/eu_dofc.

Application Firmware

Download the latest 60 GHz products family software and install it in the Outdoor Units (ODUs) before deploying the equipment. Instructions for installing software are provided in this guide.

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 60 GHz cnWave Family can be found in System Hardware and System Planning.

Specific expertise and training for professional installers

To ensure that the 60 GHz cnWave Series is installed and configured in compliance with the requirements of the EU, ISEDC and the FCC, installers must have the radio engineering skills and training described in this section.

The Cambium Networks technical training program details can be accessed from the below link: https://learning.cambiumnetworks.com/.

Legal and Open-Source Software statements

Refer to the *60 GHz cnWave™ Legal and Open-Source Guide* for:

- Cambium Networks end user license agreement
- Open-Source Software Notices

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.

Repair and service

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

Hardware warranty

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

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

Caution

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

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

Security advice

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

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

Warnings, cautions, and notes

The following describes how warnings and cautions are used in this document and all Cambium Networks document sets:

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 2012/19/EU Waste Electrical and Electronic Equipment (WEEE).

Do not dispose of Cambium equipment in landfill sites. For disposal instructions, refer to http://www.cambiumnetworks.com/support/weee-compliance

Disposal of surplus packaging

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

In non-EU countries

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

Product Description

The 60 GHz cnWave solution (from Cambium Networks) provides easy, fast, and cost-effective wireless Gigabit connectivity for edge access and/or high-capacity backhaul for edge access solutions at a significantly lower cost than fiber infrastructure. Service providers and enterprises now have access to Gigabit for business and residential connectivity, backhaul for Wi-Fi access. Certified for Facebook Terragraph, 60 GHz cnWave Mesh solutions are highly efficient at handling high-density deployments in cities and suburban areas.

Introduction

The 60 GHz cnWave portfolio boasts a wide spectrum of up to 9 GHz (57-66 GHz) that is typically divided into channels of roughly 2 GHz each. The 60 GHz band is largely uncongested compared to the 2.5 GHz and 5 GHz public bands currently used for Wi-Fi. The 60 GHz band is an unlicensed millimeter-wave band that can provide massive speeds and throughput with Line of Sight (LoS) applications.

The 60 GHz band is located in the millimeter-wave (30 GHz to 300 GHz) portion of the electromagnetic spectrum.

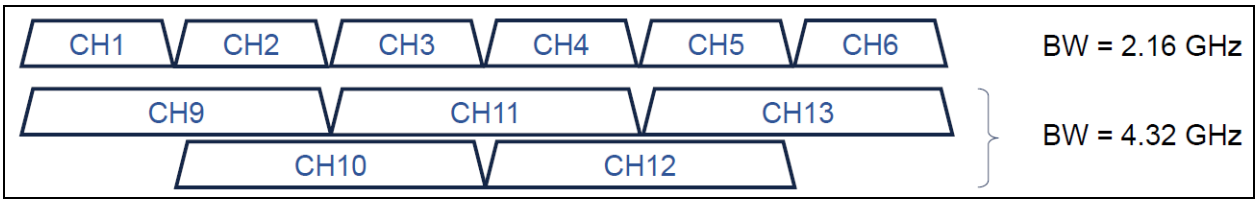
The millimeter-wave portion of the RF spectrum has been largely unexploited for commercial wireless applications. 60 GHz Wireless has used its well-established expertise in millimeter-wave products and technologies to develop wireless products operating in that spectrum that enable two-way wireless communications at data rates that previously could only be accomplished with fiber optic cable.

In addition to the high-data rates that can be accomplished in this spectrum, energy propagation in the 60 GHz band has unique characteristics that make possible many other benefits such as excellent immunity to interference, high security, and frequency reuse.

Frequency bands

It is proposed that the 60 GHz band is divided into 11 channels each with a bandwidth of 2.16 GHz starting from **57.24** to **70.2 GHz**. Channel 1 to 6 has 2.16 GHz bandwidth and are defined in 802.11ad, channel 9 to 13 has 4.32 GHz bandwidth and are added in 802.11ay.

Figure 1: *Frequency bands*



The following table describes the channels and corresponding bandwidths supported by 60 GHz cnWave:

Table 1: Channels and corresponding bandwidths

Channel	Bandwidth (GHz)	Center (GHz)	Min. (GHz)	Max. (GHz)
1	2.16	58.32	57.24	59.40

Channel	Bandwidth (GHz)	Center (GHz)	Min. (GHz)	Max. (GHz)
2	2.16	60.48	59.40	61.56
3	2.16	62.64	61.56	63.72
4	2.16	64.80	63.72	65.88

Characteristics of 60 GHz

The following are the important characteristics of 60 GHz cnWave:

- **High Throughput capability**

  With multi-gigabit channel bandwidth, it is possible to gain multi-gigabit capacity, based on 802.11ad it is possible to get a 5 Gbps PHY rate and with 802.11ay it is possible to get a 10 Gbps PHY rate. cnWave products are capable of providing 15 Gbps Ethernet rates with channel bonding enabled.

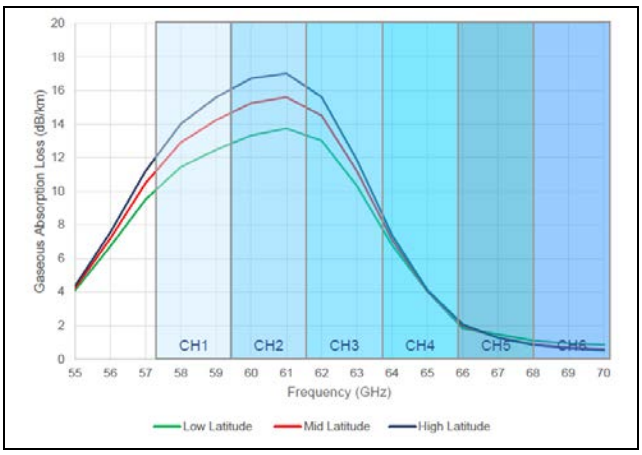
- **Unlicensed and interference-free**

  Typically, V Band is either an unlicensed or lightly licensed band, and since this band is a relatively new opening there will often be limited interference compared to 2.4 and 5 GHz bands.

- **Line of Sight (LoS)**

  60 GHz is affected by oxygen absorption, it varies throughout the band. The absorption gets reduced if the frequency gets increased. For example, the absorption is 15 dB/km in 60 GHz frequency, 5 dB/km in 64 GHz, and 0.5 dB/km in 68 GHz. If the total channel is divided into 6 channels, then the mid-channel that is channels 2 and 3 has more absorption loss. From channel 4, the absorption level starts to drop. So only Line of Sight links are available and Near LoS or non LoS does not work with 60 GHz.

  Figure 2: *Line of Sight*



- **Rain fade**

  The user can expect to see significant rain fade for 60 GHz links, particularly those pushing the longer distances. Attenuation depends on the rain rate which must be factored in while planning

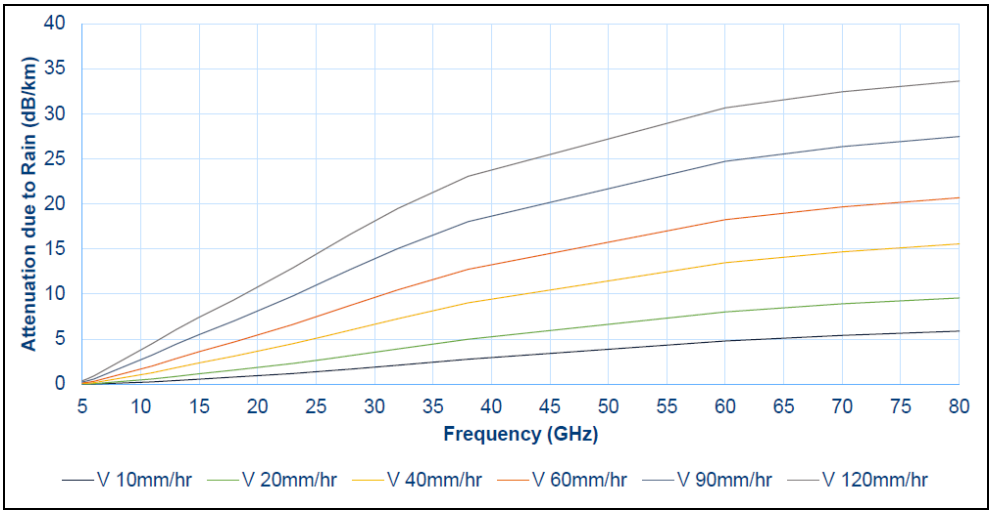
the network. Rain attenuation depends on the level of the rain. The following table describes the rain level and absorption loss:

Table 2: Rain and attenuation

Rain	Attenuation
Drizzle (0.25 mm/hr)	0.2 dB/km
Light Rain (2.5 mm/hr)	1.8 dB/km
Medium Rain (12.5 mm/hr)	5.6 dB/km
Heavy Rain (25 mm/hr)	9.5 dB/km
Downpour (50 mm/hr)	17 dB/km
Tropical (100 mm/hr)	28 dB/km
Monsoon (200 mm/hr)	38 dB/km

The following figure shows the absorption loss due to the rain level (seasons):

Figure 3: *Variation in Loss/km with frequency and rain rate*



Drizzle - 0.25 mm/hr; Light rain - 2.5 mm/hr; Medium rain - 12.5 mm/hr; Heavy rain - 25 mm/hr.

- **Short range**

  The range of a 60 GHz cnWave link can be limited due to oxygen absorption and rain fade which needs to be factored in for link planning. One advantage of a shorter range is frequency re-usability and security (since the signal does not travel long distances).

802.11ay Standards and advantages

IEEE 802.11ay is an IEEE standard that covers 60 GHz cnWave, this standard is an amendment of the IEEE 802.11ad standard. There are IEEE 802.11ay is designed with a higher throughput capacity of over 10 Gbps data rate over distances of 200 to 500 meters. 802.11ay includes features such as Channel Bonding and

Synchronization. 802.11ay based 60 GHz solution transforms fixed wireless access from a broadband option of last resort into a competitive alternative to fiber and cable-based solution.

This standard is designed with a throughput capacity of over 10 Gbps data rate over distances of 200 to 500 meters. 802.11ay includes features such as **Channel Bonding** and **Synchronization**. 802.11ay is WLAN type in the IEEE 802.11. It has a frequency of 60 GHz. It has also been noted that it is likely to have mechanisms for channel bonding and MU-MIMO technologies. 802.11ad uses a maximum of 2.16 GHz bandwidth, whereas 802.11ay bonds four of those channels together for a maximum bandwidth of 8.64 GHz.

802.11ay standard has the following advantages with the Terragraph solution:

- **Channel Bonding**

  802.11ay standard has channel bonding capability to combines adjacent channels to form wider channels, in this case, wider channels combine to form 4.32 GHz, there are additional wider channels created which provide double capacity throughput compared to 802.11ad standard.

- **Network Synchronization**

  Synchronization is used to control the transmit and receive signals to prevent self-interference. Radios assigned with the same polarity will be transmitting and receiving at the same time.

  There are four types of polarity:

  - Odd Polarity
  - Even Polarity
  - Hybrid odd Polarity
  - Hybrid Even Polarity

- **Mesh Routing**

  Mesh is an interconnection of devices that can have multiple paths between any two nodes, some advantages of using mesh are better connectivity, capacity sharing, load balancing, and re-routing in case of link failure.

- **Increased capacity**

  802.11ay supports Channel Bonding which allows two immediate channels to be merged into a single wide-band channel, thereby doubling the channel bandwidth to 4.32 GHz.

- **Supports a greater number of client nodes**

  802.11ay supports 15 client nodes per sector.

Advantages

- **802.11ay product, Terragraph certified**

  The 60 GHz cnWave is an 802.11ay product and Terragraph certified.

- **Highest capacity**

  It has highest the capacity in the industry, up to 7.2 Gbps per sector.

- **Low total cost ownership**
    - cnWave V5000 is 280-degree coverage with dual-sector. Installation is simple, uses beam forming for installation. No need for a site router.
    - cnWave V1000 and cnWave V3000 meet various range challenges.
    - Using beam forming, the V3000 has a super long range.
    - cnMaestro panel is used for device management.
    - cnHeat and LINKPlanner helps for easy planning.
- **Unlicensed and interference-free**

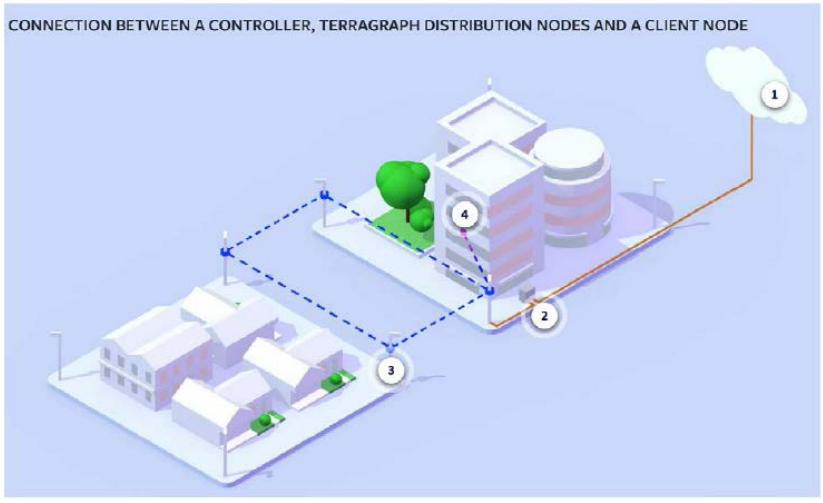
  This spectrum spans 57 - 66 GHz and is widely available, especially when compared to the 2.4 and 5 GHz bands. This 9 GHz of the spectrum can be divided up into channels ranging between 1 and 2 GHz wide.
- **Massive throughput**

  This band can allow for up to 15 Gbps of throughput from some products on the market today.

Terragraph

Terragraph is a connectivity solution from Facebook. The mission of Terragraph is to bring more people online to a faster internet. It is freely licensed technology that is designed to deliver cost-effective and reliable fiber like connectivity over a wireless mesh network (as shown in Figure 4).

Figure 4: *Terra graph*



1- Controller

2- PoP (Fiber, RF)

3- Distribution Node

4- Client Node

Key components

Terragraph contains the following key components:

- **Distribution Node (DN)** - DN connects with other DN to form a mesh in a distribution network.
- **Client Node (CN)** - CN is a customer premise radio that connects with a DN node to provide high-speed connectivity.
- **E2E Controller** - The E2E Controller allows for configuration, control, and monitoring of the nodes and network. Cambium Networks supports two methods to utilize the E2E Controller:
    - On-Premises installed as a VM and can be used for small or large deployment.
    - Onboard the PoP, for PTP, PMP, and small mesh networks the PoP can be configured to host the controller (limited to 21 nodes).

Features

The following are the features of Terragraph:

- **802.11ay** - Delivers multi-gigabit speeds over wide frequency bands.
- **Mesh** - Efficiently distributes capacity and improves availability, using Open/R.
- **Efficient MAC and PHY** - Scheduled MAC (TDD / TDMA) for scalability and dense deployments.
- **Cloud management** - Used for configuration, management, visualization, alarms, and monitoring.
- **Network planning** - Automated design and optimization using imagery, population, and optionally other data sources.

Responsibilities

Terragraph software initializes and configures radios (DN and CN). It tracks and optimizes meshed routing paths. It also monitors and maintains Syslog, alarms, and Firmware upgrades.

Overview of cnWave family

Cambium Networks 60 GHz cnWave solution provides easy, fast, and cost-effective wireless Gigabit connectivity for edge access and/or high-capacity backhaul for edge access solutions at a significantly lower cost than fiber infrastructure. Service providers and enterprises now have access to Gigabit for business and residential connectivity, backhaul for Wi-Fi access. Certified for Facebook Terragraph, 60 GHz cnWave mesh solutions are highly efficient at handling high-density deployments in cities and suburban areas.

Cambium Networks 60 GHz solution consists of a DN, which acts as an Access Point (AP) and CN which acts as a cnWave client. cnWave consists of 3 variants, V5000 a dual-sector Distribution Node, V3000 and V1000 are client nodes.

- 60 GHz cnWave V1000 is featured with wide-range, 80 degrees beamforming for easy installation. It is powered by 802.3af PoE and supports up to 2 Gbps for both PTP and PMP configurations.
- 60 GHz cnWave V3000 is featured with either a 44.5 dBi high-gain antenna or 40.5 dBi lower gain antenna both with beam-forming. The client nodes can support up to 7.2 Gbps with channel

bonding for PTP and PMP configurations.

- 60 GHz cnWave V5000 is featured with two sectors covering up to 280 degrees with beam-forming. A single V5000 can connect up to four other distribution nodes or up to 30 client nodes. V5000 can be used for PTP, PMP, and Mesh configurations.

Figure 5: *60 GHz cnWave products*

V1000

V3000 (44.5 dBi and 40.5 dBi Client Nodes)

V5000

Features

V1000 Client Node (CN)

- Supports modulations BPSK to 16 QAM (MCS1 to MCS12)
- Integrated antenna with beam forming
- 38 dBm EIRP
- Gigabit Ethernet
- 1 Gbps UL/1 Gbps DL throughput
- Powered by passive PoE or 802.3af/at PoE
- IP66/67

V3000 Client Node (CN)

- Supports modulations BPSK to 16 QAM (MCS1 to MCS12)
- 44.5 dBi UltraGain antenna with beam forming 60.5 dBm EIRP
- 40.5 dBi UltraGain antenna with beam forming 54.5 dBm EIRP
- 10 Gigabit Ethernet
- Supports 10G SFP+ or 1G SFP
- 1.8 Gbps UL/1.8 Gbps DL and 3.6 Gbps UL/3.6 Gbps DL with channel bonding throughput
- Gigabit Ethernet Auxiliary Interface

- Powered by passive PoE
- Supports Aux PoE out (802.3af/at PoE)
- IP66/67

V5000 Distribution Node (DN)

- Supports modulations BPSK to 16QAM (MCS1 to MCS12)
- Dual sector – 280-degree antenna with beamforming
- 38 dBm EIRP
- 10 Gigabit Ethernet
- Supports 10G SFP or 1G SFP
- 1.8 Gbps UL/1.8 Gbps DL and 3.6 Gbps UL/3.6 Gbps DL with channel bonding throughput per sector
- Gigabit Ethernet Auxiliary Interface
- Powered by passive PoE
- Supports Aux PoE out (802.3af/at PoE)
- IP 66/67

Wireless operation

This section describes how the 60 GHz cnWave is operated, including topology, modulation modes, power control, and security.

Wireless topology

60 GHz cnWave supports operation in three topologies:

- Point to point (PTP)
- Point to Multipoint (PMP)
- Mesh

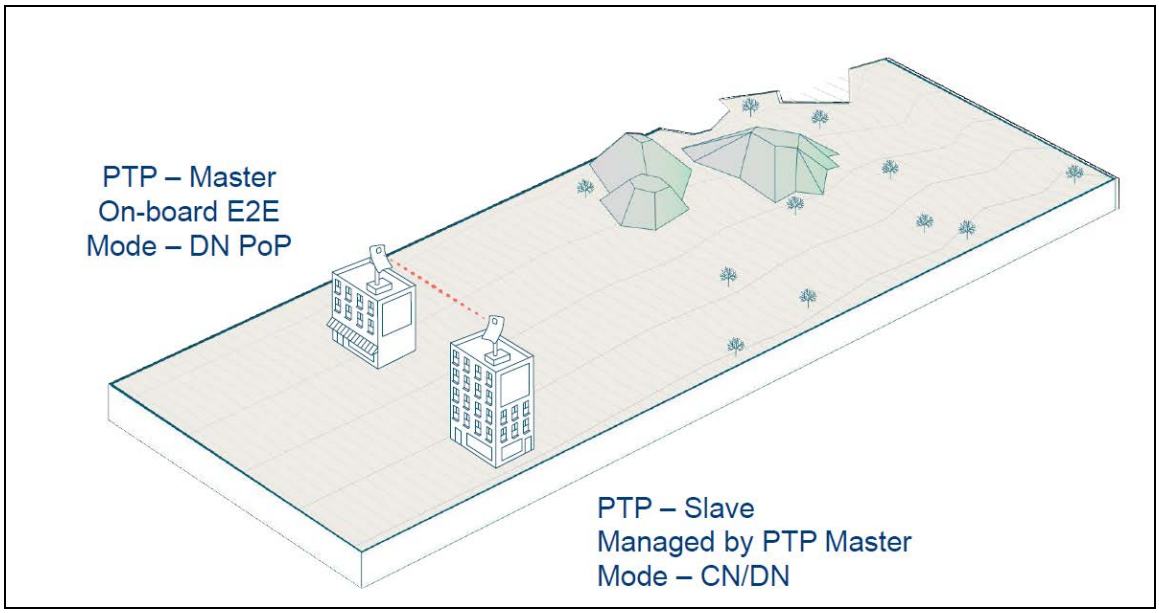
PTP

The PTP topology provides a point-to-point link using V1000, V3000, and V5000.

Note

V1000 to V1000 point-to-point topology is supported.

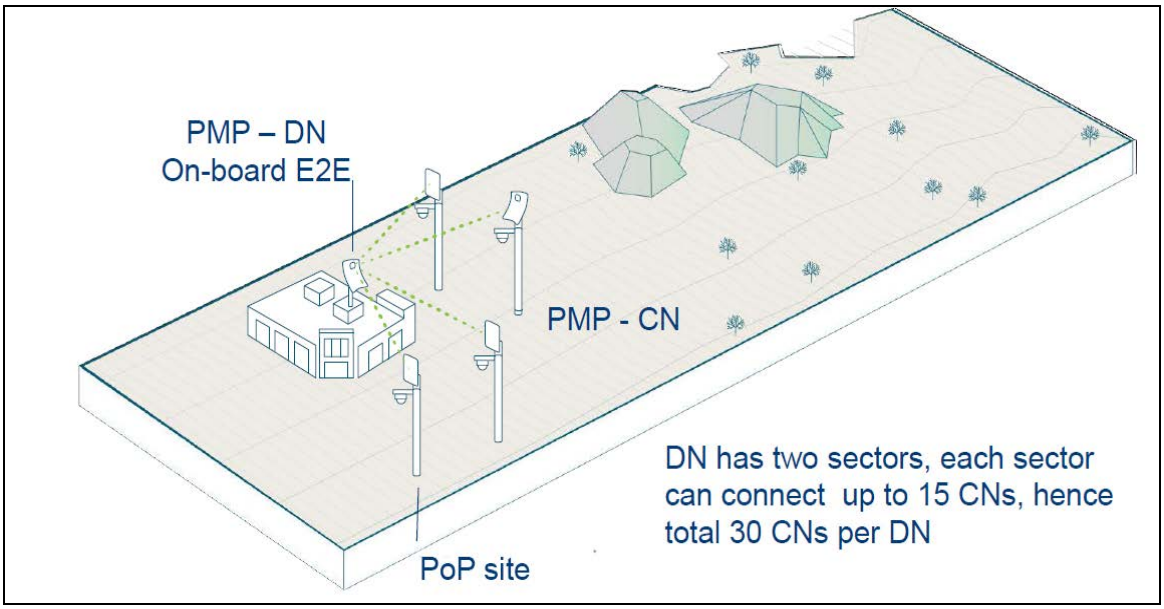
Figure 6: *PTP Topology*



PMP

The PMP topology provides a point to multi-point where a V5000 acts as PoP DN and V5000, V3000, V1000 acts as APs.

Figure 7: *PMP Topology*

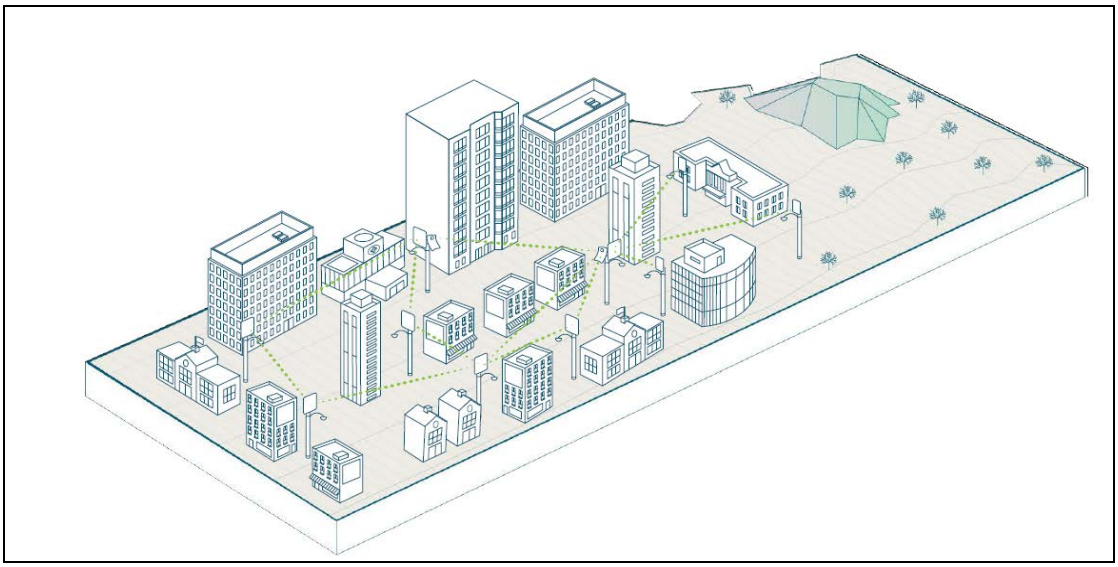


Mesh

Mesh efficiently distributes capacity and improves availability, using Open/R based layer 3 IPv6 meshing. It allows for route diversity which provides high network availability and supports up to 15 hops away

from a PoP node. Network bandwidth is reduced at each hop, and the total bandwidth available in the network is limited to a PoP node's network reappearance. Mesh is distributed network application platform that determines appropriate routes between the mesh nodes.

Figure 8: *Mesh topology*



Modulation

Following table lists modulation supported during L2 and L3 throughput:

Table 3: Modulation

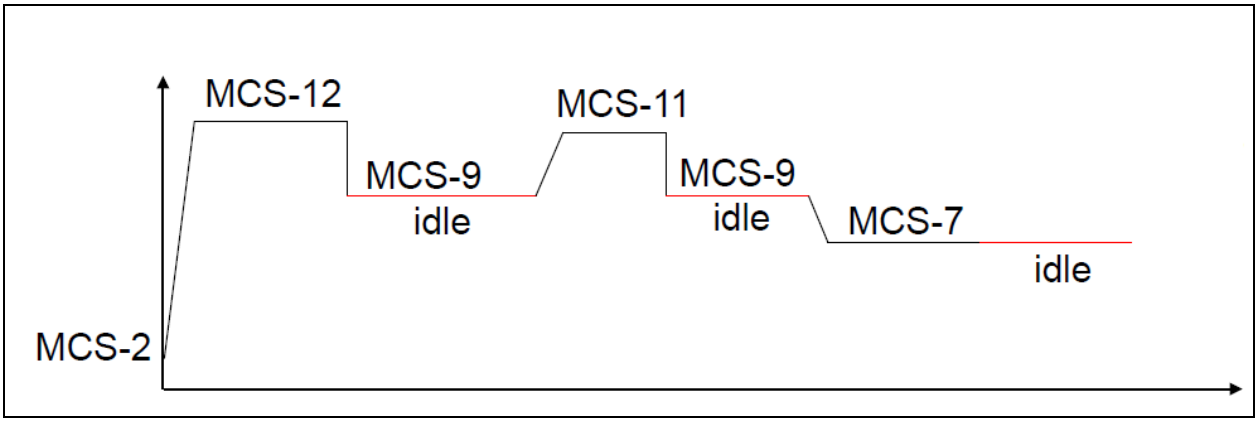
MCS	Modulation	Coding Rate	L2 Throughput (Mb/s) (2.16 GHz Channel)	L2 Throughput (Mb/s) (4.32 GHz Channel)
2	BPSK	1/2	733.0	1466.0
3	BPSK	5/8	914.0	1828.0
4	BPSK	3/4	1085.0	2170.0
5	BPSK	4/5	1175.0	2350.0
6	QPSK	1/2	1421.0	2842.0
7	QPSK	5/8	1748.0	3496.0
8	QPSK	3/4	2059.0	4118.0
9	QPSK	4/5	2221.0	4442.0
10	16-QAM	1/2	2673.0	5346.0
11	16-QAM	5/8	3245.0	6490.0
12	16-QAM	3/4	3737.0	7474.0

Link adaption

Link adaptation is performed independently for each link for data traffic, and it is closed-loop based. Adjusting the Tx modulation and coding scheme from MCS2 to MCS12 selected for transmission. It is adjusted based on the following:

- Packet Error Ratio (PER),
- SNR,
- local measurements of successful and unsuccessful frame transmissions (e.g. count of frames ACKed or Not ACKed).

Figure 9: *Adjusting links*



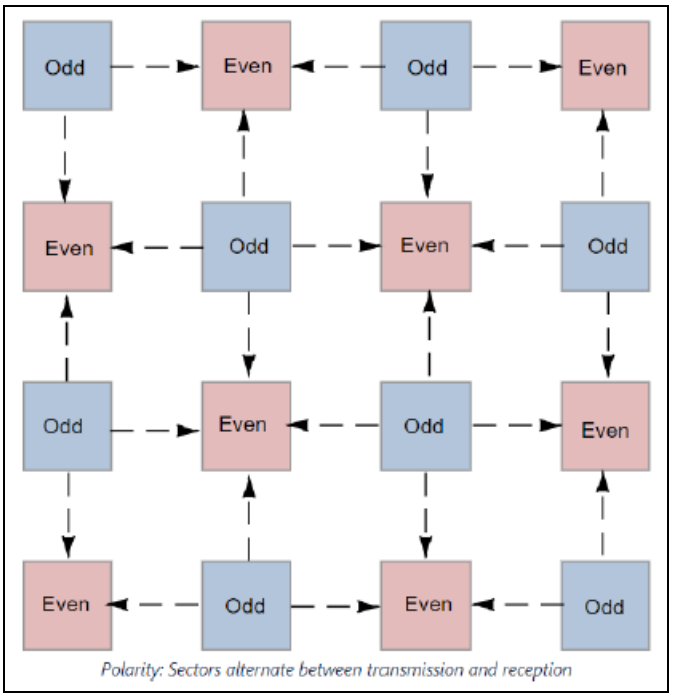
Start from MCS2, adjust based on signal quality, when the session is idle, fall back to MCS-9 or any highest MCS achieved below MCS-9.

Synchronization

Synchronization is used to control the transmit and receive signals to prevent self-interference. Radios assigned with the same polarity will be transmitting and receiving at the same time. There are two types of polarities:

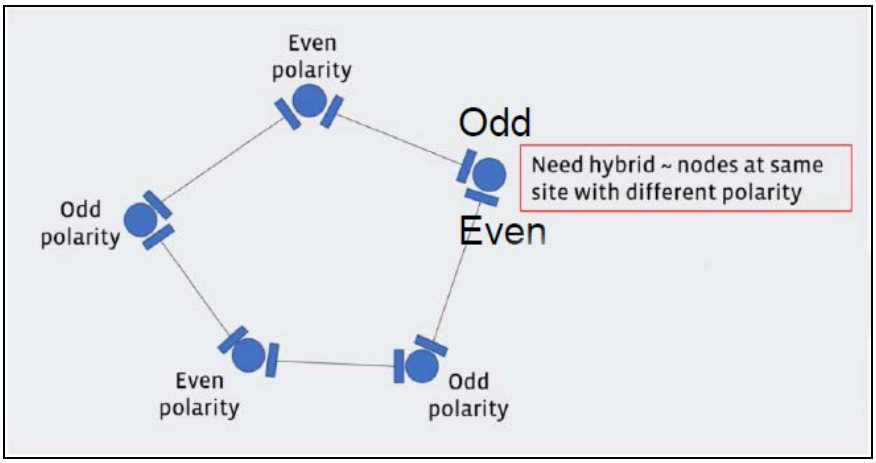
- Odd (if Odd nodes are Tx)
- Even (if Even nodes are Rx)

Figure 10: *Odd and even polarities*



The MAC synchronizes its timers to an external, accurate time source, such as GPS or IEEE 1588. A timing pulse that resets the Timing Synchronization Function (TSF) on the DN is repeated once every second. This timing pulse occurs exactly at the turn of each second.

Figure 11: *The MAC synchronization*



Time-division duplexing access mechanism

60 GHz cnWave uses a Time Division Duplex (TDD) channel access mechanism. All cnWave nodes are time-synchronized and this is achieved through internal GPS, IEEE 1588(roadmap), or Cambium Sync (roadmap), and each sector of a node is assigned specific times during which it can transmit or receive. A timing pulse that resets the Timing Synchronization Function (TSF) on the DN is repeated once every

second (1PPS). This timing pulse occurs exactly at the turn of each second and Sub-Frames begins every 200 microseconds.

General operation of MAC layer

MAC is highly modified from that in IEEE 802.11-2016. Use TDD MAC by substituting TDD access for all other access. 60 GHz cnWave supports a fixed 50-50 up/down ratio.

60 GHz cnWave uses only the following frames:

- Data
- QoS-Null (frame does not carry any data)
- Management Action (for example, beam-forming, and others.)
- Block ACK (used for sending an ACK to multiple nodes/packets at once)
- ACK

Frame types

Below are the types of frames in 60 GHz cnWave:

- **Management frames** - A node sends all management frames using the DMG control mode PHY, MCS 0.
- **Control frames** - A node sends the ACK frame using the DMG control mode PHY, MCS 0. A node sends the Block ACK frame using the DMG single carrier PHY, MCS 1.
- **Data frames** - A node sends data frames using MCS 2 through MCS 12 of the DMG single carrier PHY, as determined by the link adaptation algorithm.

Wireless encryption

The 60 GHz cnWave supports optional encryption for data transmitted over the wireless link using a choice of three different encryption algorithms:

- **TLS RSA**: The ODUs exchange RSA certificates to authorize the remote unit and agree on a randomly-generated master secret. The TLS RSA option supports the unencrypted operation of the wireless link, or encryption with 128-bit AES.
- **TLS PSK 128-bit**: Both ends of the link are configured with the same 128-bit pre-shared key as a master secret. The wireless link is encrypted using 128-bit AES.

The Advanced Encryption Standard (AES) is a symmetric encryption algorithm approved by U.S. Government organizations (and others) to protect sensitive information. The AES implementation in 60 GHz cnWave is approved to FIPS 197.

The use of AES encryption in 60 GHz cnWave is controlled by the AES license and enabled through the purchase of a capability upgrade.

Note

Encryption Algorithm cannot be configured as TLS RSA when Access Method is Link Name Access. In this case, only the TLS PSK algorithms are supported.

Designing wireless networks

For designing wireless networks, refer to LINKPlanner.

TDD synchronization

Built-in GPS receiver

V3000 and V5000 have built-in GPS receivers. E2E Controller manages the TDD synchronization.

System management

This section introduces the 60 GHz cnWave management system, including the web interface, installation, configuration, alerts, and upgrades.

Management agent

The 60 GHz cnWave equipment is managed through an embedded management agent. Management workstations, network management systems, or PCs can be connected to this agent using a choice of in-band or out-of-band network management modes.

The management agent includes an IPv4/IPv6 interface at the management agent. The IP interface operates in the following modes:

- IPv4 only
- IPv6 only
- Dual IPv4/IPv6

Network management

cnMaestro is a Cambium Network Management System (NMS). This is a single plane to manage the complete Cambium product portfolio. It uses secure WebSocket for management traffic that can be used to manage all Cambium products on the same system. Configurations can be pushed from the cnMaestro through E2E to the end devices.

cnMaestro NMS is used to:

- Manage cnWave network including E2E, CN, and DN.
- Show the connection topologies.
- Collect KPIs/statistics, alarms, logs (via the E2E device agent).
- Performs software upgrade.

IPv6

IPv6 address is 128 bits (16 Bytes) address. The subnet ID in IPv4, is called prefix in IPv6. In IPv6, Neighbor Discovery Protocol (NDP) is used with ICMPv6 to resolve the MAC address. IPV6 does not have broadcast but only has multicast.

cnWave products use SLAAC (Stateless Address Autoconfiguration) for dynamic IPv6 address assignment. The system gets the IP address dynamically by listening to Router Advertisement (RA) and forms the address in EUI-64 format. RA also publishes DNS information to the devices.

System logging

Refer to Logging into the web interface for system logging.

Software upgrade

Refer to Software Upgrade for more information.

System Hardware

This topic provides information about the hardware of 60 GHz cnWave.

Wireless nodes

The 60 GHz cnWave solution includes three types of wireless nodes:

- V1000 Client Node
- V3000 (44.5 dBi and 40.5 dBi) Client Node
- V5000 Distribution Node

V1000 Client Node

V1000 is an outdoor CN that can be connected to a distribution node wirelessly. V1000 supports a Gigabit Ethernet interface and is powered by 802.3af/at PoE compliant power supply or a passive PoE.

Figure 12: *V1000 Client Node front and rear views*

V1000 Part numbers

Order the V1000 Client Node (CN) from Cambium Networks (as listed in Table 4). Each V1000 CN is supplied with a mounting bracket for wall mount or pole mount, and an indoor power supply.

Table 4: V1000 CN part numbers

Cambium description	Cambium part number
60GHz cnWave V1000 Client Node with US cord	C600500C001A
60GHz cnWave V1000 Client Node with EU cord	C600500C003A
60GHz cnWave V1000 Client Node with UK Cord	C600500C004A
60GHz cnWave V1000 Client Node with ANZ Cord	C600500C008A
60GHz cnWave V1000 Client Node with Brazil Cord	C600500C009A
60GHz cnWave V1000 Client Node with Argentina Cord	C600500C010A

Cambium description	Cambium part number
60GHz cnWave V1000 Client Node with China Cord	C600500C011A
60GHz cnWave V1000 Client Node with South Africa Cord	C600500C012A
60GHz cnWave V1000 Client Node with India Cord	C600500C013A
60GHz cnWave V1000 Client Node with no Cord	C600500C014A
60GHz cnWave V1000 Client Node with Israel cord - Israel Only	C600500C016A

V3000 Client Node (CN)

V3000 is an outdoor CN that can be connected (wireless) to a DN or another V3000 DN. V3000 supports a 10 Gigabit Ethernet interface, an 10G SFP+ interface port, and a Gigabit Ethernet Aux interface.

V3000 can be powered using 60W passive POE or using an AC/DC PSU through a mini adapter (for more information, refer to the power supply and cable lengths supported in the Power supply units section). V3000 DN can also power 802.3af/at compliant auxiliary device through the Gigabit Aux interface.

Figure 13: *V3000 Client Node without antenna assembly and with 44.5 dBi and 40.5 dBi antenna assemblies*

V3000 Part numbers

Order the V3000 CN from Cambium Networks (V3000 CN part numbers). The V3000 CN radio is supplied without an antenna assembly, bracket, or power supply. See Precision brackets for details of suitable brackets and power supplies.

Note

Use a dedicated antenna assembly for V3000 CN.

Order the antenna assembly required for each CN radio.

Table 5: V3000 CN part numbers

Cambium description	Cambium part number
60 GHz cnWave V3000 CN radio only	C600500C024A

Cambium description	Cambium part number
60 GHz cnWave V3000 CN antenna assembly, 44.5 dBi	C600500D001A
60 GHz cnWave V3000 CN antenna assembly, 40.5 dBi, 4 Pack	C600500D002A
60 GHz cnWave V3000 CN antenna assembly, 44.5 dBi, 4 Pack	C600500D003A
60 GHz cnWave V3000 CN Radio only – Israel Only	C600500C025A

V5000 Distribution Node (DN)

V5000 is an outdoor DN that can be connected to multiple V1000 or V3000 CNs wirelessly. V5000 supports a 10 Gigabit Ethernet interface, an 10G SFP+ interface port, and a Gigabit Ethernet Aux interface.

V5000 can be powered using 60W passive POE or using an AC/DC PSU through mini an adapter (for more information, refer to the power supply and cable lengths supported in the Power supply units section). V5000 DN can also power 802.3af/at compliant auxiliary device through the Gigabit Aux interface.

Figure 14: *V5000 Distribution Node front and rear views*

V5000 Part numbers

Order the V5000 Distribution Node (DN) from Cambium Networks (as shown in below table). The V5000 DN is supplied without a mounting bracket or power supply.

Table 6: V5000 DN part numbers

Cambium description	Cambium part number
60GHz cnWave V5000 DN	C600500A004A
60GHz cnWave V5000 Distribution Node - Israel Only	C600500A005A

Radio mounting brackets

V1000 Wall and pole mount (C000000L136A and C000000L137A)

The V1000 CN is supplied with a mounting plate and a band clamp. The mounting plate can be used for mounting the V1000 on a wall, or it can be used with the band clamp to mount the V1000 on a pole with a diameter in the range of 40 mm to 77 mm (1.6 inches to 3.03 inches).

Figure 15: *V1000 mounting plate and band clamp*

V1000 Adjustable pole mount (N000900L022A)

The adjustable pole mount is used to provide elevation adjustment when a V1000 CN is mounted on a pole. The adjustable pole mount works with poles with diameters in the range of 40 mm to 77 mm (1.6 inches to 3.03 inches).

Figure 16: *V1000 adjustable pole mount*

V3000 Precision bracket (C000000L125A)

The precision bracket (Precision bracket figure below) is used to mount the V3000 CN on a vertical pole with a diameter in the range of 25 mm to 80 mm (0.98 inches to 3.14 inches). The precision bracket provides fine adjustment of up to 18° in azimuth and +/-30° in elevation for accurate alignment of the V3000.

Figure 17: *Precision bracket*

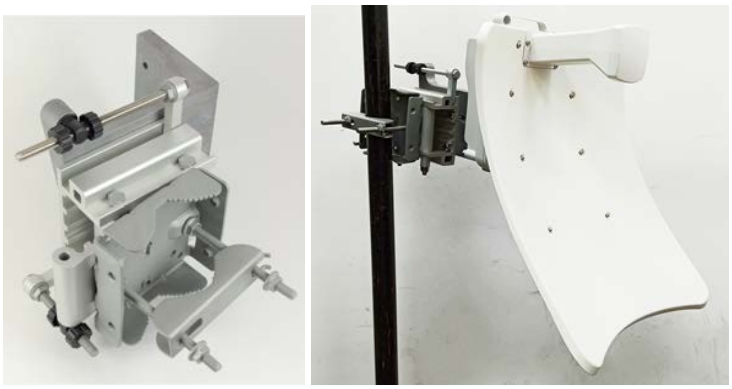


Figure 18: *Precision bracket components*

Bracket body

Azimuth arm

Long (120 mm) M8 screws and flange nuts

Bracket base

40 mm M8 screws, plain washers, and Nyloc nuts

V3000 mount

28 mm M6 screws, M8 spacers, and pole mount clamp

V3000 Tilt bracket (N000045L002A)

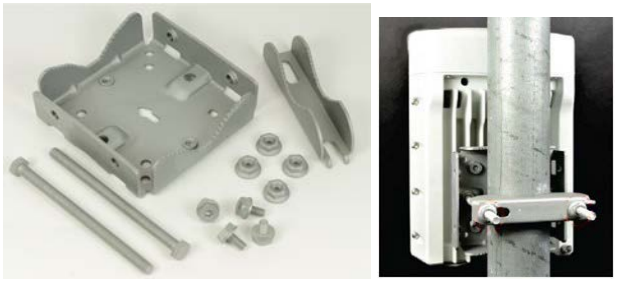
The tilt bracket (Tilt bracket assembly figure below) is used to provide elevation adjustment when a V3000 CN or V5000 DN is mounted on a pole. The tilt bracket works with poles with diameters in the range of 25 mm to 80 mm (0.98 inches to 3.14 inches). The tilt bracket assembly may be used with third-party band clamps to mount the ODU on a larger pole with a diameter in the range of 90 mm to 230 mm (3.54 inches to 9.05 inches).

Figure 19: *Tilt bracket assembly*

V5000 Pole mount (C000000L137A)

The pole mount (Pole mount figure below) is used to mount a V5000 DN on a vertical pole with a diameter in the range of 25 mm to 80 mm (0.98 inches to 3.14 inches). It provides coarse azimuth (but not elevation) adjustment.

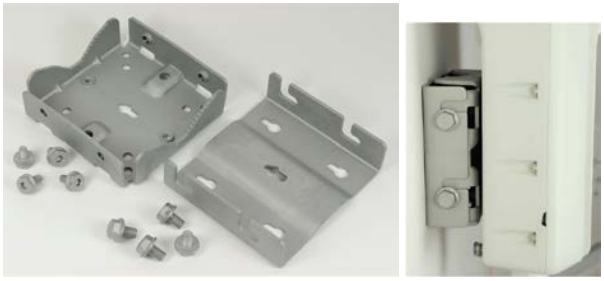
Figure 20: *Pole mount*



V5000 Wall mount (C000000L136A)

The wall mount (Wall mount figure below) is used to mount a V5000 DN on a vertical wall. It does not provide azimuth or elevation adjustment. The wall mount requires additional fixing hardware suitable for the type of wall.

Figure 21: *Wall mount*



Bracket part numbers

Order mounting brackets by using the Cambium part numbers listed in below table.

Table 7: Radio mounting bracket part numbers

Bracket	Radio nodes	Cambium Part Number
Adjustable pole mount	V1000	N000900L022A
Tilt bracket assembly	V3000	N000045L002A
Wall mount bracket	V5000	C000000L136A
Pole mount bracket	V5000	C000000L137A
Precision bracket	V3000	C000000L125A

Radio accessories

Telescope mounting kit for precision brackets

An alignment telescope provides the most accurate option for the alignment of the precision bracket during installation. The telescope is temporarily mounted on the bracket using the telescope mounting kit for precision brackets.

The telescope mounting kit consists of a mounting plate, a knurled screw, and two rubber O-rings.

Order the telescope mounting kit from Cambium Networks.

Figure 22: *Telescope mounting kit*

Order a suitable telescope from a specialist supplier specifying the following details:

Right angle, erecting, 9x50 mm alignment scope with 5° field of view

Figure 23: *Typical alignment telescope*

Accessory part numbers

Order radio accessories using the Cambium Part Number in the Radio accessory part numbers table below.

Table 8: Radio accessory part numbers

Accessory	Radio nodes	Cambium Part Number
Telescope mounting kit	V3000	C000000L139A

Radio external interfaces

V1000 Client node

Figure 24: *External interfaces for V1000 CN*

Table 9: External interfaces V1000 CN

Port name	Connector	Interface	Description
PSU	RJ45	PoE input	Standard 802.3af/at PoE
		100/1000 BASE-T Ethernet	Data and management

V3000 Client node

Figure 25: *External interfaces for V3000 CN*

Table 10: External interfaces V3000 CN

Port name	Connector	Interface	Description
SFP+	SFP	10G BASE-SR/10G BASE-LR/1G Base-SX using optional SFP+/SFP optical or copper module SFP-1G-SX / SFP-1G-LX using optional SFP optical or copper module	Data and management

Port name	Connector	Interface	Description
PSU	RJ45	PoE input	Passive PoE
		100m/1000m/2.5G BASE-T/5G BASE-T/ 10G BASE-T Ethernet	Data and management
AUX	RJ45	PoE output	Standard IEEE 802.3af/at
		100/1000 BASE-T Ethernet	Data and management

V5000 Distribution node

Figure 26: *External interfaces for V5000 DN*

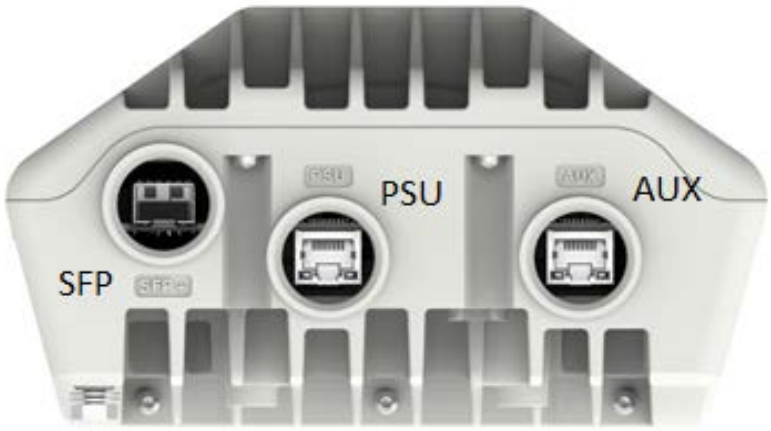


Table 11: External interfaces V5000 DN

Port name	Connector	Interface	Description
SFP+	SFP	10G BASE-SR/10G BASE-LR/1G Base-SX using optional SFP+/SFP optical or copper module SFP-1G-SX / SFP-1G-LX using optional SFP optical or copper module	Data and management
PSU	RJ45	PoE input	Passive PoE
		100m/1000m/2.5G BASE-T/5G BASE-T/ 10G BASE-T Ethernet	Data and management
AUX	RJ45	PoE output	Standard IEEE 802.3af/at
		100/1000 BASE-T Ethernet	Data and management

Radio specifications

The 60 GHz cnWave Radios conform to the specifications listed in Radio node specifications.

Table 12: Radio node specifications

Category	Specification	
Dimensions	V1000 Client Node	140 mm × 85 mm × 40 mm (5.5 in × 3.3 in × 1.6 in)
	V3000 Client Node (44.5 dBi) V3000 Client Node (40.5 dBi)	348 mm x 415 mm x 349 mm (13.7 in x 16.3 in x 13.7 in) 198 mm x 340 mm x 251 mm (7.8 in x 13.3 in x 9.9 in)
	V5000 Distribution Node	280 mm × 185 mm × 102 mm (11.0 in × 7.3 in × 4.0 in)
Weight	V1000 Client Node	0.25 kg (0.55 lbs)
	V3000 Client Node (44.5 dBi) V3000 Client Node (40.5 dBi)	4.7 kg (10.3 lbs) including antenna 3.9 kg (8.6 lbs) including antenna
	V5000 Distribution Node	4.0 kg (8.8 lbs) including antenna
Temperature	-40°C (-40°F) to +60°C (140°F)	
Wind survival	200 kph (124 mph) maximum	
Humidity	100% condensing	
Liquid and particle ingress	IP66, IP67	
Power consumption	V1000 Client Node	10 W
	V3000 Client Node	30 W, up to 55 W with PoE out enabled
	V5000 Distribution Node	35 W, up to 60 W with PoE out enabled
Power input interface	V1000 Client Node	IEEE 802.3af
	V3000 Client Node	Passive PoE
	V5000 Distribution Node	Passive PoE
Power output interface	V3000 Client Node	IEEE802.3af/at, 25 W maximum
	V5000 Distribution Node	IEEE 802.3af/at, 25 W maximum

Theory of operation

The 60 GHz cnWave devices support Facebook connectivity technology called **Terragraph**. cnWave devices implement IEEE 802.11ay WLAN standard and use 60GHz frequency band for wider spectrum and higher capacity. cnWave devices can provide multi-gigabit throughput from 100 M to 1.5 KM.

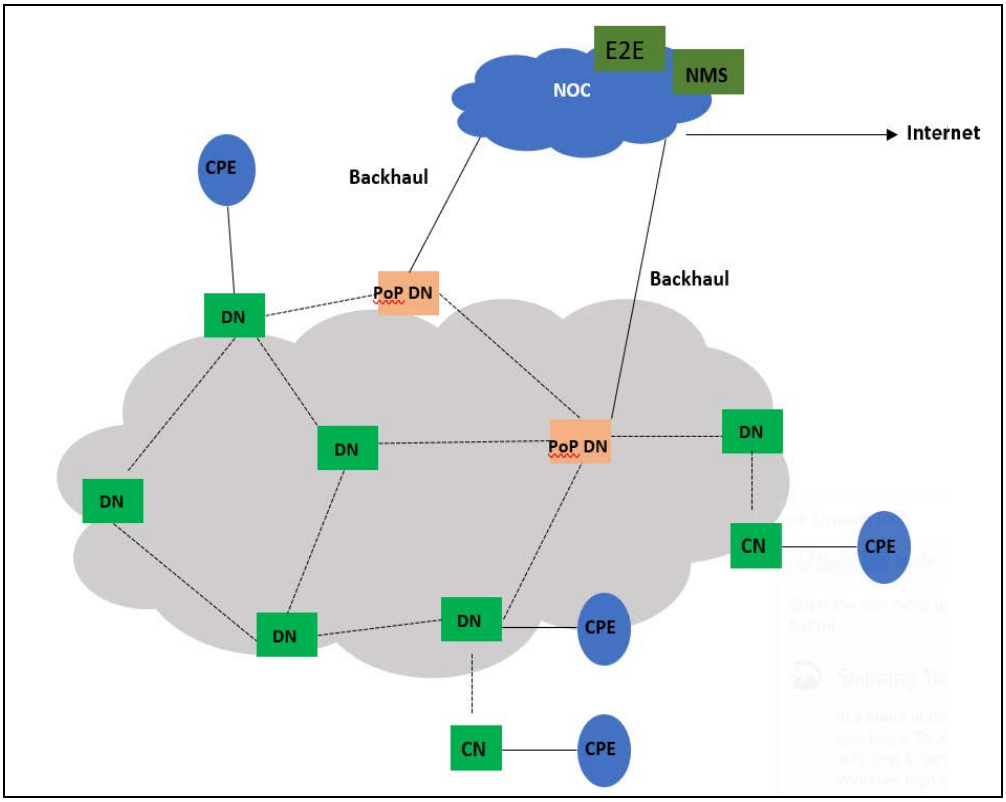
Deployment of the devices uses Open/R based layer3/IPv6 mesh for efficient distribution of traffic between the nodes and higher availability of the traffic. This also overcomes non-line of sight issues.

Devices use TDMA/TDD technology to achieve density deployment efficiency. Network and the nodes are configured, controlled, and monitored by a cloud-based E2E Controller.

Following terminologies are used for the network deployment:

- **Distribution Node (DN)** - DN connects with other DN for mesh network
- **Client Node (CN)** - CN connects to DN to provide high-speed connectivity
- **PoP** - DN connected to the back-haul
- **CPE** - Customer premises equipment devices like Wi-Fi router

Figure 27: *Deployment scenario*



Power supply units (PSU)

PSU Options

Order PSUs from Cambium Networks. The power supply component and the part numbers are described in the following table.

Table 13: Power supply component part numbers

Cambium description	Radio node	Cambium part number
Outdoor AC/DC PSU, 100W, 54V DC	V3000, V5000	N000000L179B
Waterproof PSU Cable Joiner 14-16 AWG	V3000, V5000	N000000L180A
DC to RJ45 Plug Power Adaptor	V3000, V5000	C000000L184A
Cable Gland, Long, M25, Qty 5	V3000, V5000	C000000L124A
PoE, 60W, 56V, 5GbE DC Injector, Indoor, Energy Level 6 Supply	V3000, V5000	N000000L142A
PoE, 60W, 56V, 10GbE DC Injector, Indoor, Energy Level 6 Supply	V3000, V5000	C000000L141A
PoE Gigabit DC Injector, 15W Output at 56V, Energy Level 6, 0C to 50C	V1000	N000900L017A
AC power Injector 56V, 60W	V3000, V5000	N000065L001C
CABLE, UL POWER SUPPLY CORD SET, 720mm, AUS/NZ	V1000, V3000, V5000	N000900L011A
CABLE, UL POWER SUPPLY CORD SET, INDIA	V1000, V3000, V5000	N000900L012A
CABLE, UL POWER SUPPLY CORD SET, ARGENTINA	V1000, V3000, V5000	N000900L013A
CABLE, UL POWER SUPPLY CORD SET, CHINA	V1000, V3000, V5000	N000900L015A
CABLE, UL POWER SUPPLY CORD SET, 720mm, US	V1000, V3000, V5000	N000900L031A
CABLE, UL POWER SUPPLY CORD SET, 720mm, EU	V1000, V3000, V5000	N000900L032A
CABLE, UL POWER SUPPLY CORD SET, 720mm, UK	V1000, V3000, V5000	N000900L033A
CABLE, UL POWER SUPPLY CORD SET, 720mm, Brazil	V1000, V3000, V5000	N000900L034A
CABLE, UL POWER SUPPLY CORD SET, 720mm, Israel	V1000, V3000, V5000	N000900L037A

Refer to Maximum cable lengths for details of the maximum cable lengths and the maximum PoE output power for different powering options.

V1000 Power over Ethernet

The V1000 CN is always powered using Power over Ethernet (PoE) at a nominal 56V, as shown in the PoE power supply to V1000 figure using the Gigabit power injector supplied with the radio, or using an IEEE 802.3af PoE output from an Ethernet switch.

Figure 28: *PoE power supply to V1000*

Table 14: PoE, 15W 56V, 1 Gigabit DC injector (N000900L017A)

Category	Specification
Dimensions	118 mm (4.64 in) x 43 mm (1.69 in) x 32.4 mm (1.27 in)
Weight	0.18 Kg (0.39 lbs)
Temperature	0°C (32°F) to +50°C (140°F)
Humidity	10% to 95 % non-condensing
AC Input	90-264V AC, 47-63 Hz
DC Output Voltage	56V
DC Output current	0.25A
Efficiency	Better than 84% at full load
Over Current Protection	Hiccup mode, recovers automatically after the fault condition is removed
Hold up time	At least 10 milliseconds
RJ45 POE Port	7,8 ---------- DC V- 5,6 ---------- DC V+

Note

The Gigabit power injector is supplied with the cnWave V1000 CN. Order part N000900L017A to obtain spares.

Warning

Always use an appropriately rated and approved AC supply cord-set in accordance with the regulations of the country of use.

V3000, V5000 Power over Ethernet

The V3000 CN and V5000 DN can be powered using DC power at a nominal 54V, using 14 AWG or 16 AWG cable, as shown in the DC power supply to V3000 or V5000 figure.

Figure 29: *PoE power supply to V3000 or V5000*

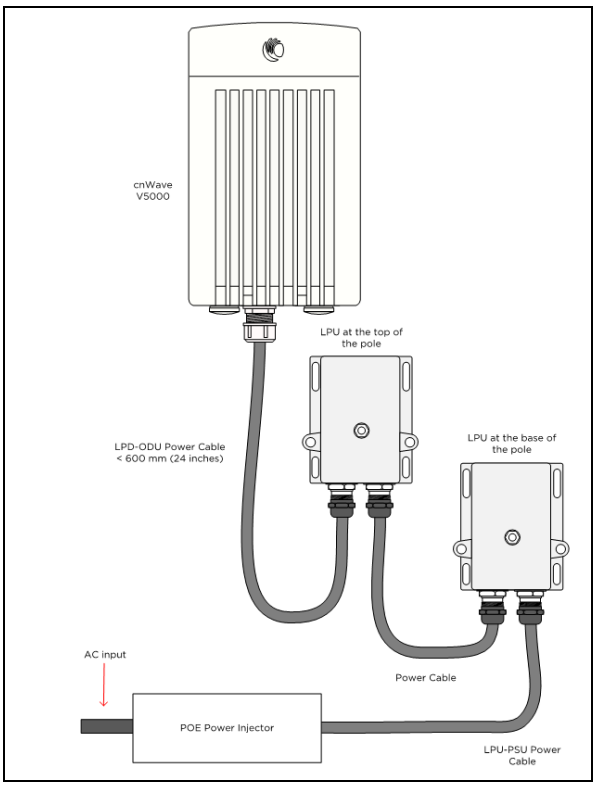
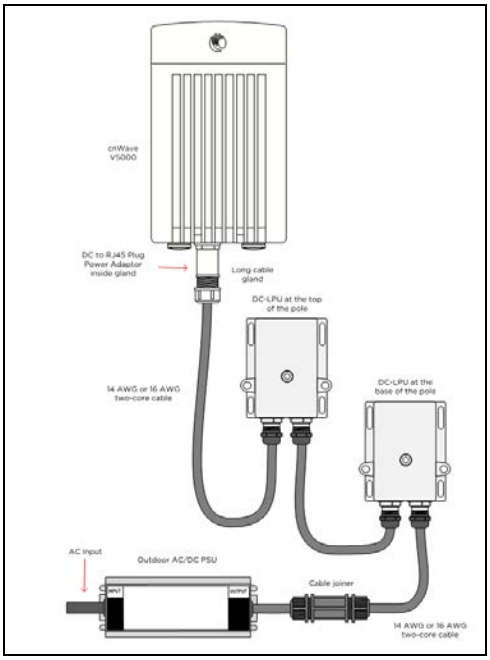


Table 15: PoE, 60W, 56V, 5 GbE DC injector (N000000L142A)

Category	Specification
Dimensions	140 mm (5.5 in) x 53 mm (2.08 in) x 35 mm (1.37 in)
Weight	0.24 Kg (0.5 lbs)
Temperature	0°C (32°F) to +50°C (140°F)
Humidity	10% to 95 % non-condensing
AC Input	90-264 V AC, 47-63 Hz
DC Output voltage	56V
DC Output current	1.07 A
Efficiency	Better than 88% at full load
Over Current Protection	Hiccup mode, recovers automatically after the fault condition is removed
Hold up time	At least 10 milliseconds
RJ45 POE Port	1,2,7,8 ---------- DC V- 3,4,5,6 ---------- DC V+

V3000, V5000 Outdoor AC/DC power supply unit

Figure 30: *DC power supply to V3000 or V5000*



The outdoor PSU can be installed indoors, in an outdoor cabinet, or inside street furniture.

Figure 31: *Outdoor AC/DC PSU, 60 W, 54 VDC*

Figure 32: *Outdoor AC/DC PSU, 100 W, 54 VDC (N000000L179B)*

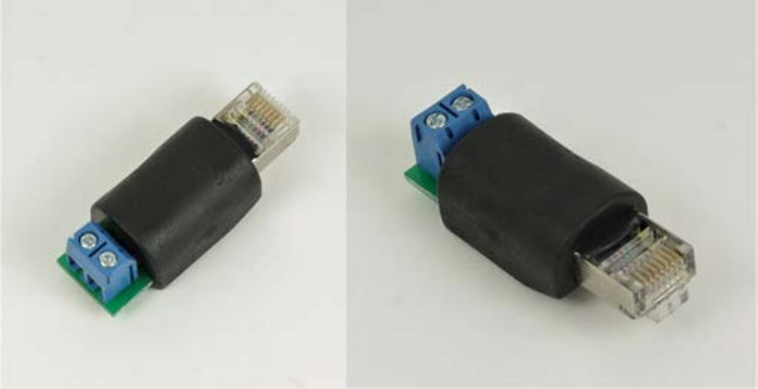
Table 16: Outdoor AC/DC PSU, 54 VDC

Category	PSU	Specification
Part number and Dimensions	N000000L178A (60W)	171 mm (6.7 in) x 62 mm (2.4 in) x 37 mm (1.5 in)
	N000000L179A(100W)	220 mm (8.7 in) x 68 mm (2.7 in) x 39 mm (1.5 in)
Power	60W	
	100W	
Temperature	-40°C (-40°F) to +60°C (140°F)	
Humidity	20 to 95 % non-condensing	
Waterproofing	IP65/IP67	
AC Input	90-305 V AC, 47-63 Hz	
DC Output Voltage	54V	
DC Output current	60W	1.15 A
	100W	1.77 A
Efficiency	Better than 90% at full load	

Category	PSU	Specification
Over Current Protection	Hiccup mode, recovers automatically after the fault condition is removed	
Hold up time	At least 16 milliseconds	
Power factor	Better than 0.95	

Figure 33: *Cable joiner*

Figure 34: *DC to RJ45 plug power adapter*



These cable joiners and DC to RJ45 cable adapters are used to connect to outdoor AC/DC PSU. Refer to Maximum cable lengths for details of the maximum cable lengths and the maximum PoE output power for different powering options.

PSU Specifications

The PSUs conform to the specifications are listed in Outdoor AC/DC PSU, 54VDC.

Ethernet and DC cables

Maximum cable lengths

Ethernet

For all cnWave radios, the maximum cable length for data transmission over copper Ethernet (100BASE-TX, 1000BASE-T, 2.5GBASE-T, 5GBASE-T, 10GBASE-T) is 100 m (328 ft) from the radio to the connected equipment.

It is recommended to use outdoor braided **CAT6A** cable for V3000, V5000, and outdoor braided **CAT5e** cable for V1000.

For installations where the auxiliary device is powered using ODU Aux POE port, refer to the Maximum cable lengths supported table.

The maximum cable length for fiber Ethernet (10GBASE-SR, 10GBASE-LR) connections depends on the fiber used. See SFP module kits on page 19 for details of the Ethernet standards supported and maximum permitted cable lengths.

Power over Ethernet (PoE)

The maximum length for supplying power from a 60 W DC injector over a CAT6A Ethernet cable is shown in the below table. 60W DC injector is used to power on the V3000 or V5000.

Table 17: Maximum cable length for PoE supported on V3000 and V5000

Radio	PoE enabled	Maximum cable length
V3000	-	390m
	25W	72m
V5000	-	330m
	25W	Not supported

The available output power for auxiliary Power over Ethernet output in V3000 and V5000 is reduced at longer PoE cable lengths, as shown in the below table.

Table 18: Maximum PoE output power

Radio	Cable length	Maximum Aux PoE output
V3000	0m to 72m	25.0W
	25m	24.6W
	100m	23.6W
V5000	10m	23.1 W
	20m	22.6W
	30m	22.1W
	40m	21.6W
	60m	20.6W
	80m	19.6W
	100m	18.6W

Using AC/DC PSU with a DC power feed

The maximum length for supplying power over a CAT6A Ethernet cable is shown in the Maximum cable length for DC power table.

Table 19: Maximum cable length for DC power

Radio	PSU	PoE enabled	Maximum cable length 14 AWG	Maximum cable length 16 AWG
V3000	60W	-	780m	490m
		25W	140m	90m
	100W	-	780m	490m
		25W	390m	250m
V5000	60W	-	660m	410m
		25W	Not supported	
	100W	-	660m	410m
		25W	360m	220m

Outdoor copper CAT6A Ethernet cable

Select an outdoor-rated CAT6A cable, ready terminated with RJ45 connectors in one of the following lengths:

- 25m
- 50m
- 100m

Alternatively, terminate bulk CAT6A cable with RJ45 connectors at a length to suit each installation.

Attention

Always use CAT6A or better cable that has an overall copper braid shield, is outdoor rated with a UV-resistant sheath.

Table 20: Terminated Ethernet cable part numbers

Cambium description	Cambium part number
CAT6A outdoor cable, 305m	N000082L172B
RJ45 connector for CAT6A cable	N000082L174B
CAT6A outdoor cable, 100m	N000000L155A
Cable gland for 4-6mm cable, M25, Qty 10	C000000L176A
Cable gland for 6-9mm cable, M25, Qty 10	C000000L123A
CAT5E Outdoor Cable, 100m drum	N000082L016A

Cable accessories

This section provides information about the required cable accessories.

Figure 35: *Standard cable gland*

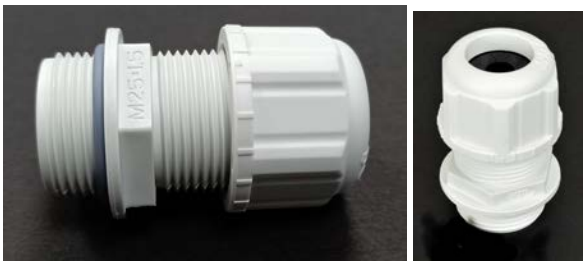


Figure 36: *Long cable gland*

Cable accessories available from Cambium Networks are listed in the Cable accessory part numbers table below.

Table 21: Cable accessory part numbers

Cambium description	Cambium part number
Cable gland for 6-9mm cable, M25, Qty 10	C000000L123A
Cable gland Long, M25, Qty 5	C000000L124A
Grounding cable, 0.6m with M6 ring to M6 ring	C000000L138A
Cable gland for 4-6mm cable, M25, Qty 10	C000000L176A
DC to RJ45 plug power adapter	C000000L184A
Grounding cable, 1m with M6 ring to M6 ring	N000082L116A

Note

One cable gland for 6-9mm cable size is included with each cnWave radio. Order additional cable glands as spares, where smaller cable size is to be used, or where the V3000 or V5000 Aux port is to be used.

SFP Module kits

SFP Module kits allow the connection of a V3000 CN or V5000 DN radio to a network over a 10 Gigabit optical Ethernet interface in one of the following full-duplex modes:

- 10GBASE-SR
- 10GBASE-LR

Order SFP+ module kits from Cambium Networks (SFP module part numbers).

The SFP+ module must be used with the long cable gland.

Table 22: SFP module part numbers

Cambium description	Cambium part number
10G SFP+ MMF SR Transceiver, 850nm. -40C to 85C	SFP-10G-SR
10G SFP+ SMF LR Transceiver, 1310nm. -40C to 85C	SFP-10G-LR
1G SFP MMF SX Transceiver, 850nm. -40C to 85C	SFP-1G-SX
1G SFP SMF LX Transceiver, 1310nm. -40C to 85C	SFP-1G-LX
10G SFP+ BaseT (RJ45), -40C to 85C	SFP-10G-Cu-EXT
1000Base-T (RJ45) SFP Transceiver. -40C to 85C	SFP-1G-Copper

Optical cable and connectors

Order an optical cable with LC connectors from a specialist fabricator, quoting the specification shown in the Optical optic cable and connector specification. It must be the correct length to connect the ODU to the other device. LC connectors should be supplied with dust caps to prevent dust build-up.

Figure 37: *Optical optic cable and connector specification*

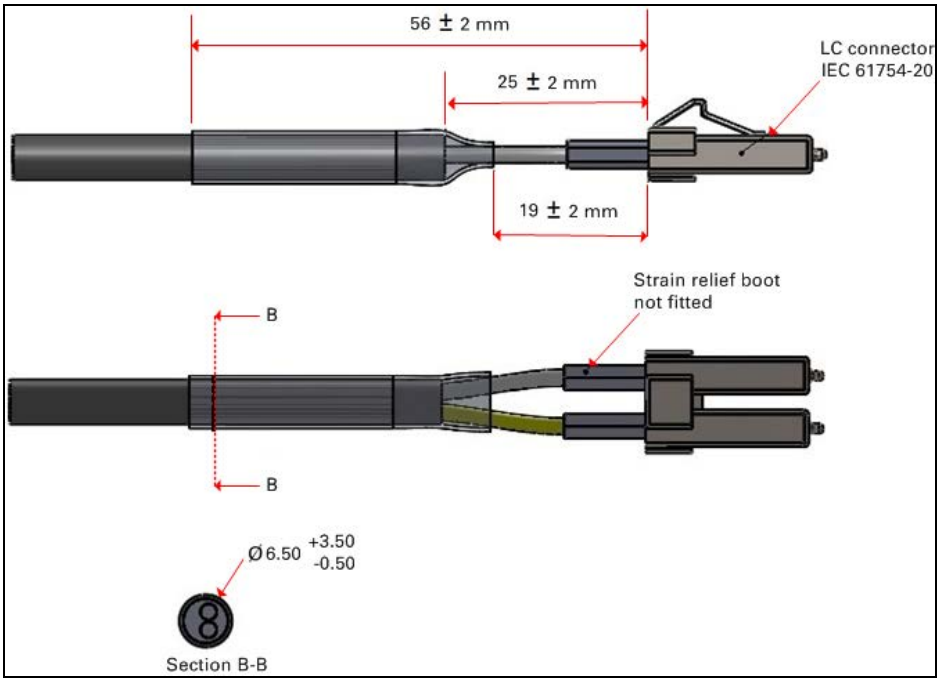


Table 23: Optical cable part numbers

Cambium description	Cambium part number
Optical CABLE,MM, 1m	N000082L215A
Optical CABLE,MM, 2.2m	N000082L191A
Optical CABLE,MM, 10m	N000082L192A
Optical CABLE,MM, 20m	N000082L193A
Optical CABLE,MM, 30m	N000082L194A
Optical CABLE,MM, 50m	N000082L195A
Optical CABLE,MM, 80m	N000082L196A
Optical CABLE,MM, 100m	N000082L197A
Optical CABLE,MM, 150m	N000082L198A
Optical CABLE,MM, 200m	N000082L199A
Optical CABLE,MM, 300m	N000082L200A
Optical CABLE,SM, 2.2m	N000082L186A
Optical CABLE,SM, 10m	N000082L187A
Optical CABLE,SM, 20m	N000082L188A
Optical CABLE,SM, 30m	N000082L139A
Optical CABLE,SM, 50m	N000082L140A
Optical CABLE,SM, 80m	N000082L141A
Optical CABLE,SM, 100m	N000082L142A
Optical CABLE,SM, 150m	N000082L143A
Optical CABLE,SM, 200m	N000082L189A
Optical CABLE,SM, 300m	N000082L190A

System Planning

Site planning

This section describes factors to be considered when planning the proposed link end sites, including grounding, lightning protection, and equipment location for the ODU and PSU.

Grounding and lightning protection

Warning

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

Structures, equipment, and people must be protected against power surges (typically caused by lightning) by conducting the surge current to the ground via a separate preferential solid path. The actual degree of protection required depends on local conditions and applicable local regulations. To adequately protect a 60 GHz cnWave installation, both ground bonding and transient voltage surge suppression are required.

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

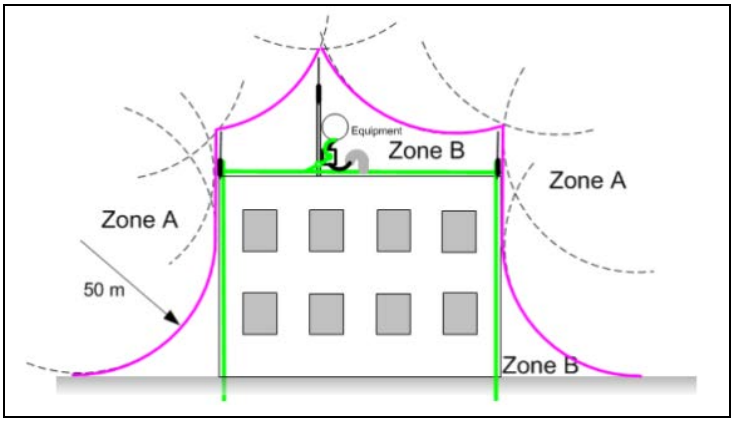
Note

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

Lightning protection zones

Use the rolling sphere method (Rolling sphere method to determine the lightning protection zones) 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 in the zone of protection (Zone B). Similarly, where the sphere rests on two finials, the space under the sphere is in the zone of protection.

Figure 38: *Rolling sphere method to determine the lightning protection zones*



Warning

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

Site grounding system

Ensure that the site has a correctly installed grounding system on a common ground ring with access points for grounding ODU.

If the outdoor equipment is to be installed on the roof of a high building, refer to the Installation section.

Ensure that the system meets the following additional requirements:

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

ODU location

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

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

Drop cable grounding points

To estimate how many grounding kits are required for each drop cable, refer to site installation and use the following criteria:

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

For mast or tower installations installation, use the following additional criteria:

- The drop cable shield must be grounded at the bottom of the tower, near the vertical to the horizontal transition point. This ground cable must be bonded to the tower or tower ground bus bar (TGB) if installed.

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

For roof installations, use the following additional criteria:

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

ODU wind loading

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

The ODU and its mounting bracket are capable of withstanding wind speeds of up to 325 kph (200 mph).

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

- Force (in newtons) = $0.5 \times \rho \times V^2 \times A \times C_d$
  - "ρ" is the density of air (1.225 kg/m^3)
  - "V" is the wind speed in meters per second
  - "A" is the projected surface area of the ODU in square meters
  - "C_d" is the drag coefficient = 1.385.

The drag co-efficient has been measured when the cover plate or antenna is perpendicular to the air flow.

Applying these formulae to the cnWave ODU at different wind speeds, the resulting wind loadings are shown in the following ODU wind loading (newtons) table:

Table 24: ODU wind loading (newtons)

Type of ODU	Max surface area (square meters)	Wind speed (km/h Newtons)					
		200*	225	250	275	300	325
V1000	0.017544	67	85	105	127	151	177
v3000**	0.1764	462	583	719	871	1036	1216
V5000	0.052597188	118	148	185	224	266	312

Equivalent results in US customary units are shown in following ODU wind loading (pounds force) table:

Table 25: ODU wind loading (pounds-force)

Type of ODU	Max surface area (square meters)	Wind speed (km/h lbf)					
		200*	225	250	275	300	325
V1000	0.017544	15	19	24	28	34	40
v3000**	0.1764	104	131	162	196	233	273
V5000	0.052597188	27	33	42	50	60	70

* 200 km/h is from measured data and used to calculate the remaining figures.

** Worst case setup with the product in -30° tilt position.

PSU DC power supply

Use Cambium Networks recommended DC PSU for wireless nodes and ensure the power cords and cables are appropriately rated and in accordance with the regulations of the country of use.

PSU AC power supply

Use Cambium recommended AC power supply for wireless nodes and ensure the power cords and cables are appropriately rated and in accordance with the regulations of the country of use.

PSU location

Find a location for the PSU that meets the following requirements:

DC PoE power injector

- DC power injector can be mounted on a flat surface.
- PSU is installed in a dry location where no condensation, flooding or rising damp is possible.
- The PSU is located in an environment where it is not likely to exceed its operational temperature rating, allowing for natural convection cooling and placed not close to any fire source.
- PSU can be connected to the ODU drop cable and network terminating equipment.
- PSU can be connected to a compatible power supply.

Outdoor AC/DC PSU

Find a location for the PSU that meets the following requirements:

- The PSU is installed in a dry location where no flooding or rising damp is possible.
- The PSU is located in an environment where it is not likely to exceed its operational temperature rating, allowing for natural convection cooling and placed not close to any fire source.
- The PSU is not stacked and placed adjacent to the heat-generating equipment.
- The PSU shall be connected to protective earth.

- The PSU shall be connected to ODU drop cable using cable joiner and appropriately rated cables should be used.

Lightning Surge Protection Units (LPU)

All drop cables connected to the ODU (e.g. PSU and AUX drop cables) requires their own Lighting Protection Unit (LPU) or Gigabit Surge Suppressor installed close to the ODU and close to the enclosure/building entry point. The copper SFP drop cable also requires surge protection. Optical cables do not require lightning surge protection or ground cables. Guidance on the positioning of required lighting surge protection is given in the Lightning Surge Protection Units Location.

Drop cable grounding points

To estimate how many grounding kits are required for each drop cable, use the following criteria:

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

For mast or tower installations, use the following additional criteria:

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

For roof installations, use the following additional criteria:

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

Lightning Surge Protection Units location

Lightning Surge Protection Units or Gigabit Surge Suppressors must be installed at two points on drop cables:

- There is room to mount the LPU, either on the ODU mounting bracket or on the mounting pole below the ODU.
- The drop cable length between the ODU and top LPU must not exceed 600 mm.
- There is access to a metal grounding point to allow the ODU and top LPU to be bonded in the following ways: top LPU to ODU; ODU to a grounding system.

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

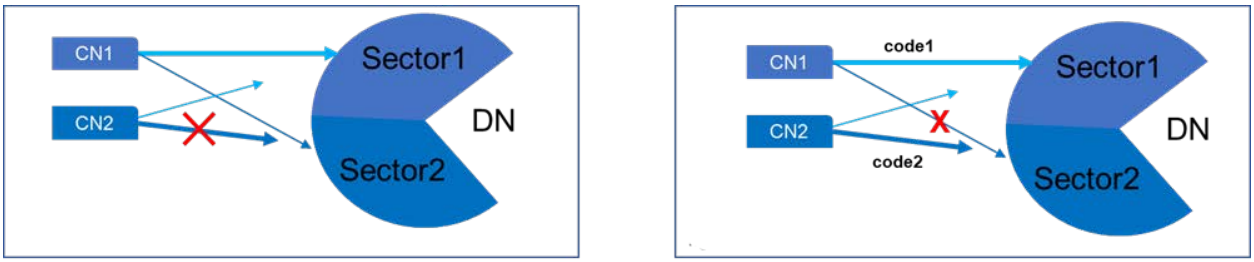
- The bottom LPU can be connected to the drop cable from the ODU.
- The bottom LPU is within 600 mm (24 in) of the point at which the drop cable enters the building, enclosure or equipment room within a larger building.
- The bottom LPU can be bonded to the grounding system.

Network Design Consideration

Golay Code assignment

Golay Code is used to prevent self-interference caused by early weak interference. For example, without Golay Code, a very weak signal can be picked up and processed by an unwanted device. Golay Code encoded with frame preamble makes the signal undecodable by the unwanted target device, thus prevent the unwanted target device from processing the frame. The following diagram shows how Golay Code may help with preventing early weak interference.

Figure 39: *Signal from CN1 without Golay Code*



The first figure shows that without Golay Code, the signal from CN1, although value weak when received by Sector2 of the DN, will be processed, even though the signal is targeting only Sector1. Meanwhile, Sector2 ignores signals from CN2 because it sends the data a little bit later than CN1 because Sector2 is busy processing signals from CN1.

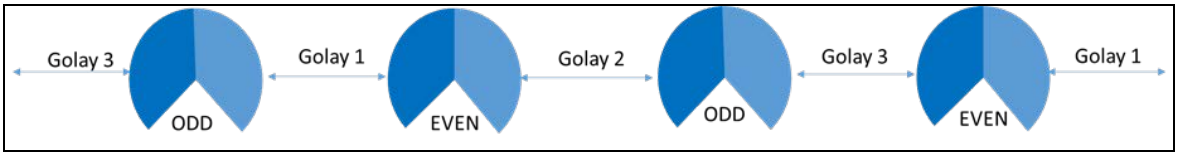
The second figure shows that because Sector1 and Sector2 use different Golay codes, the weak signal from CN1 (unwanted source for Sector2) will be rejected by Sector2 so the signal from CN2 will be processed because Sector2 would not be busy processing CN1's signal.

The following are best practice for Golay code using in system design:

1. Use different Golay codes for each sector at the DN same location.
2. Use different Golay codes for nodes that are within a short distance (usually two hops from each other) with opposite polarity.

   The following diagram shows an example of proper Golay code configuration, with three Golay codes in use:

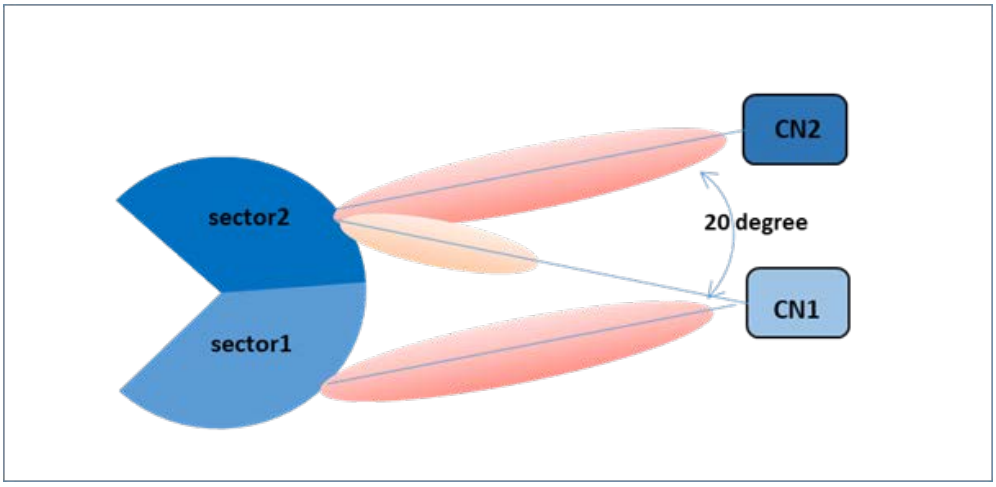
   Figure 40: *Example of roper Golay code configuration*



Angle separation

Suppose two CNs are connected to two different sectors of a DN. CN1 connects to Sector1 and CN2 connects to Sector2. If the angle separation of the CNs to the DN is smaller than 20 degrees, it is very possible that the side lobe beam from Sector2 to CN2 will be received by CN1 which may cause a high level of noise when CN1 is receiving data from Sector1. The solution to resolve this issue is to either have a higher angle separation or have both CNs connect to the same sector.

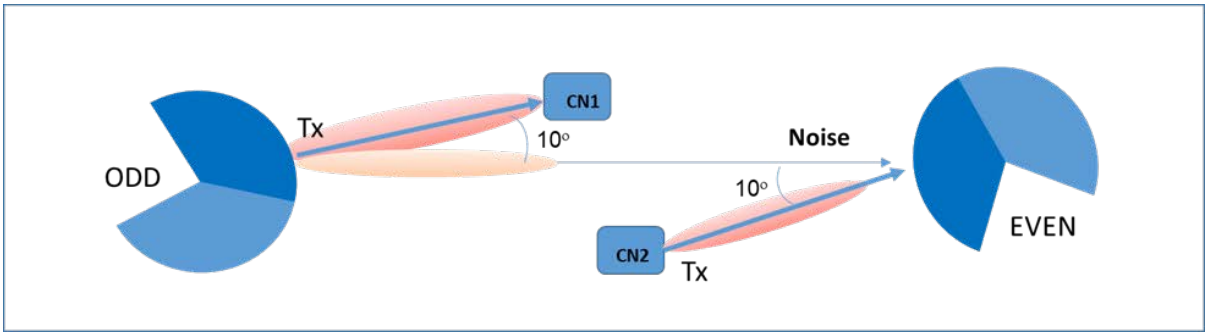
Figure 41: *Example of angle separation*



Avoid butterfly pattern

Consider two DNs next to each other, one in odd polarity and one in even polarity. When the odd DN is transmitting to CN1, CN2 can transmit to the even DN. If the angle separation is too small (for example, within +/- 10 degrees), the side lobe for the signal for CN1 can spill into the Even DN, thus coursing a very high level of noise, when the even DN is receiving data from CN2, which is in the same transmission cycle as the odd DN. This is called a butterfly pattern, which should be avoided.

Figure 42: *Example of butterfly pattern*

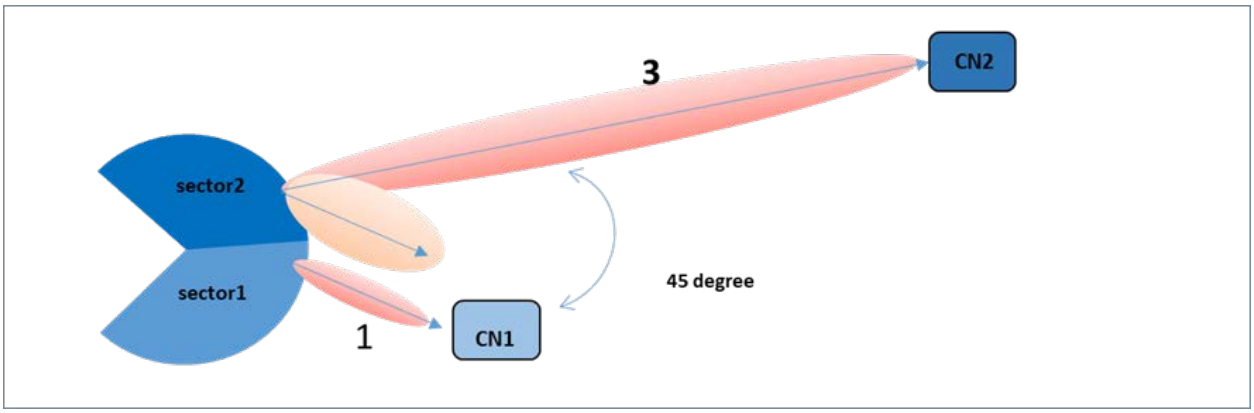


Near-far ratio

cnWave supports adaptive transmission power control. When two radios are close to each other, the transmission power is adapted lower and when two radios are far from each other, the transmission power is adapted higher to accommodate optimal signal quality.

When two CNs are connected to two different sectors of a DN, if they do not have an angle separation of greater than 45 degrees while the distance ratio between near-end CN to the DN and the far-end CN to the DN is less than 1/3, the side-lobe signal from Sector2 to CN2 is too strong for CN1, thus causing very high noise level on CN1 when it is receiving data from Sector1.

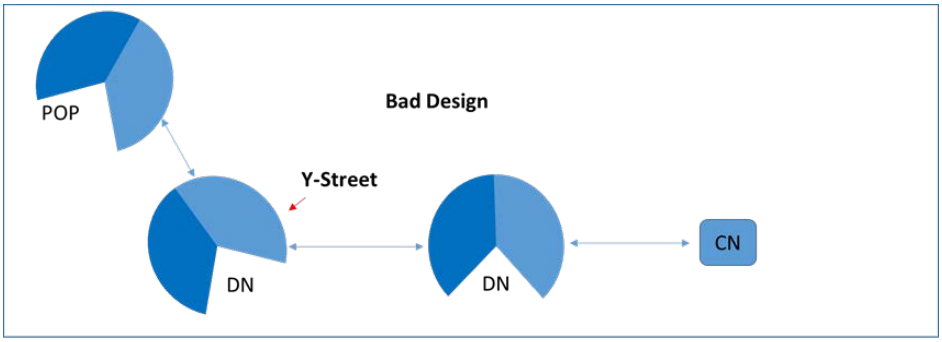
Figure 43: *Example of near-far ratio*

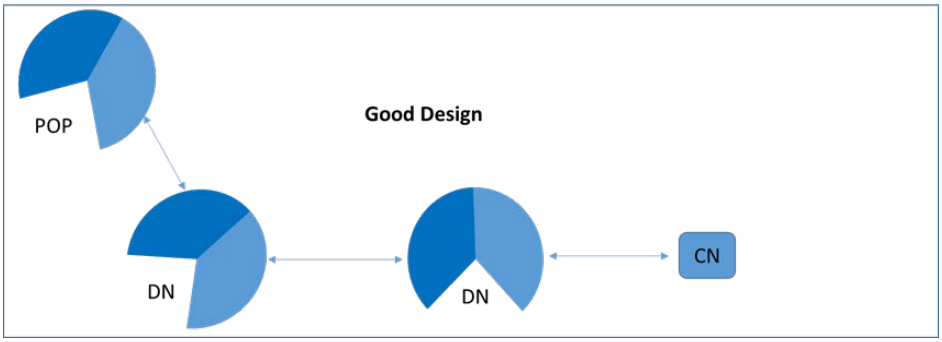


Y-Street avoidance

A DN with two peer DNs should be avoided in links that require high wireless capacity. The first few hops away from a PoP node should avoid the Y-street configuration. The following diagram shows two examples. In the first diagram below (which is a bad design), the first hop DN from the PoP node is relayed by the same sector that cuts the end-to-end capacity by 50%.

Figure 44: *Example of Y-Street*





Radio spectrum planning

General wireless specifications

The following 60 GHz cnWave wireless specifications (all variants) table lists the wireless specifications that apply to all 60 GHz cnWave frequency bands:

Table 26: 60 GHz cnWave wireless specifications (all variants)

Item	Specification
Channel selection	Open/R protocol or manual selection
Manual power control	Supports ATPC automatic transmit power control and maximum EIRP can be set lower than the default power limit.
Integrated antenna type	• V3000 44.5 dBi gain and 40.5 dBi gain • V1000 22.5 dBi gain
Duplex schemes	Symmetric 50:50 fixed and asymmetric fixed
Range	100 m to 2 KMs, depends on the following factors: • Frequency selected • Rain condition • Availability • EIRP limitation
Over-the-air encryption	AES 128-bit
Weather sensitivity	Highly sensitive due to rain range conditions. For more information in range, refer Rain and attenuation table.

Regulatory limits

Many countries impose EIRP limits (allowed EIRP) on products operating in the bands used by the 60 GHz cnWave. These are commonly identified by limitations on conducted transmit power or by antenna gain. For example:

Table 27: ERC recommendation (70-03)

Frequency Band		Power / Magnetic Field
c2	57 - 71 GHz	40 dBm E.I.R.P., 23 dBm/MHz E.I.R.P. density and maximum transmit power of 27 dBm at the antenna port/ports.
c3	57-71 GHz	55 dBm E.I.R.P., 38 dBm/MHz E.I.R.P. density and transmit antenna gain ≥ 30 dBi.

CFR47 Part 15.255(c)(ii):

For fixed point-to-point transmitters located outdoors, the average power of any emission shall not exceed 82 dBm and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.

Link planning

This section describes factors that must be considered when planning links, such as range, obstacles path loss, and throughput. It is highly recommended to use Cambium LINKPlanner software when planning the links.

LINKPlanner

The Cambium LINKPlanner software and user guide may be downloaded from the support website (see https://support.cambiumnetworks.com/files/linkplanner/).

LINKPlanner imports path profiles and predicts data rates and reliability over the path. It allows the system designer to try different antenna heights and RF power settings. It outputs an installation report that defines the parameters to be used for configuration, alignment, and operation. Use the installation report to compare predicted and actual link performance.

Exclusion zones for the 59 – 63.9 GHz band

In the three geographical areas outlined in 59 - 63.9 GHz Transmission Exclusion Zones (UK IR 2078 Section 4 and IR 2030 IR2030/7/4 (2018/316/UK)), no transmissions are permitted.

Table 28: 59 - 63.9 GHz transmission exclusion zones

Site Name	Site Location	Radius of exclusion zone from the center of site location
Site 1	07° 23’ 36.6” W, 57° 21’ 3.6” N	6 Km
Site 2	04° 58’ 21” W, 51° 37’ 16.8” N	6 Km
Site 3	00° 36’ 22.8” W, 52° 38’ 1.8” N	6 Km

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 to achieve an accurate link feasibility assessment. The 60 GHz cnWave radios are designed to operate in Line-of-Sight (LoS) environments.

The 60 GHz cnWave radios operate at ranges from 15 m (49 ft) to 2000 m (1.2 miles). The operation of the system depends on the frequency channel chosen.

Path loss

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

$$L_{free_space} + L_{excess} + L_{fade} + L_{seasonal} < L_{capability}$$

Table 29: Input details for the link calculation

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)

At 60 GHz cnWave the oxygen absorption is a key component of the free space path loss and varies substantially depending on the frequency channel selected. Use LINKPlanner to calculate the oxygen absorption component for the required path and frequency channel.

Data network planning

This section describes factors to be considered when planning 60 GHz cnWave data networks.

60 GHz cnWave network can be deployed as point-to-point backhaul-bridge, Point-to-Multipoint coverage network and mesh network that provide network rebound. Regardless of the network topology, the underlining routing protocol between cnWave radios is always IPv6 with OpenR routing protocol.

By default, the cnWave operates in IPv6 layer 3 network mode, requiring IPv6-based routing gears etc. While underlying routing in the cnWave network relies on IPv6 OpenR routing, the network can be designed to operate in pure IPv4 network mode, transporting layer two traffic (VLAN tagged and untagged) with GRE tunnels built-in by the system.

There is no fundamental difference between configurations of PTP vs. PMP vs. Mesh because the underlying routing mechanism of the cnWave network is always IPv6-based OpenR routing.

In a PTP network, you have one PoP DN and a CN to form a link. In a PMP network, you have one PoP DN and multiple CNs (up to 30 CNs if V5000 is used) to form a PMP cluster. You can have multiple PMP clusters to form a coverage area network.

Users can have one PoP node with multiple DNs or CNs. If DNs are connected, the user gets a mesh network. User can them have multiple PoPs and DNs and if the link with each other and form a complex mesh network.

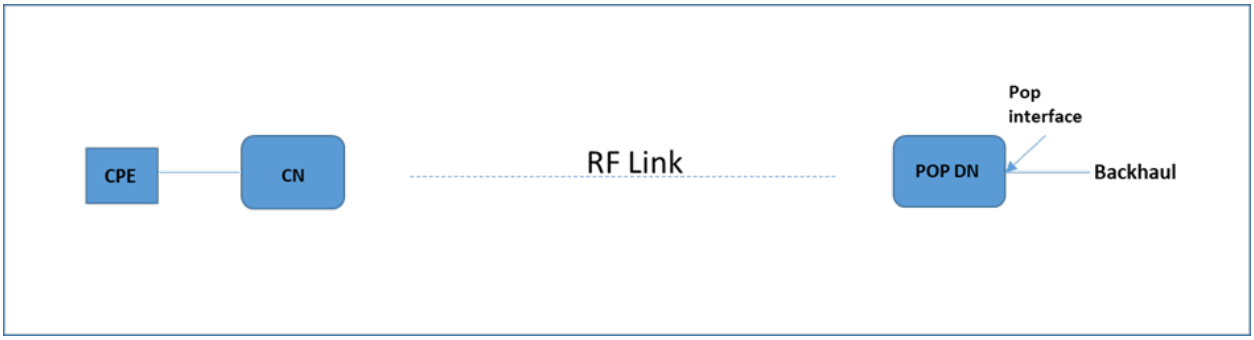
Point to Point-based single link Ethernet bridge

A Point to Point cnWave link can be configured to work as an Ethernet bridge. The operator needs to configure one end as PoP DN, and the other end as CN.

Enable Layer 2 Bridge. While the radios still run on IPv6, the Layer 2 Bridge configuration allows user Layer 2 data (VLAN tagged and untagged) to be transmitted transparently through the link.

IPv6 address of the PoP and CN can be automatically generated and they do not need to be routable through the external network as long as the E2E is collocated with the PoP DN or within the same VLAN of the PoP DN. The operator can assign IPv4 addresses to the radios for management purposes.

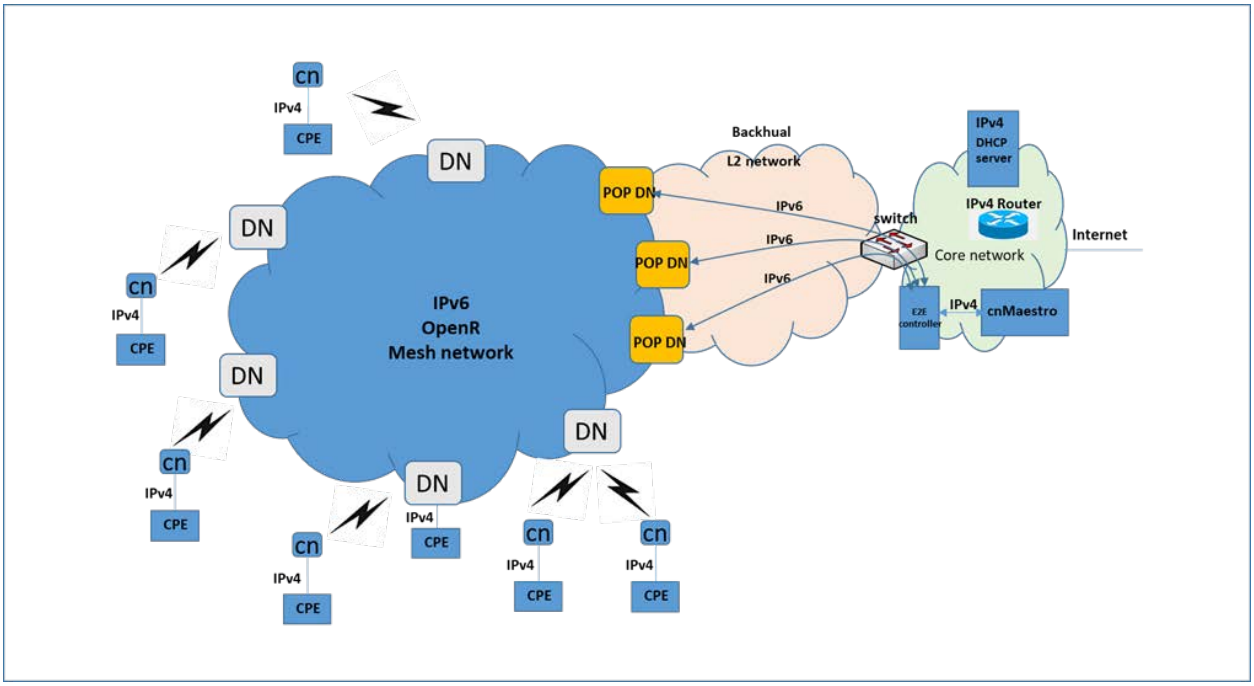
Figure 45: *Point to Point cnWave link*



IPv4/L2 based PMP and mesh network planning

The operator can build a complete IPv4-based network without the need for any IPv6 routers. The following figure shows the network:

Figure 46: *Example of IPv4-based network*



60 GHz cnWave IPv6 IP address is generated automatically by the system.

1. Single PoP, E2E resides in the PoP DN

   When configuring the PoP E2E, the operator can configure the IPv6 address to be generated automatically.

2. Multiple PoPs, E2E controls all the PoPs

   cnMaestro generates the IPv6 configuration for all the PoPs. The user can download the config file from cnMaestro. This config file contains all the PoPs IPv6 configuration. The IPv6 configuration is

associated with the MAC address of each PoP DN. When loading the config file to the PoP DN during initial configuration, the PoP DN chooses the IPv6 address by matching its MAC address, so there is no IPv6 address conflict.

The PoP DNs automatically use the E2E controller as the default gateway of IPv6 traffic. Since IPv6 traffic is used only for management purposes, there may be no concern about overloading the E2E. (IPv6 payload traffic should be disabled in the radio configuration).

The E2E chooses any one of the active PoP DN as the IPv6 default gateway. If the E2E detects that the default gateway PoP DN is down, it selects another PoP DN as a default gateway.

Control traffic from E2E to all cnWave radios will be sent to the default gateway PoP, which relies on OpenR to route through correlated POP to the target radio.

Select the **Relay Port Interface** for the PoP DN's Ethernet interface for inter-PoPs OpenR routing to work.

Note

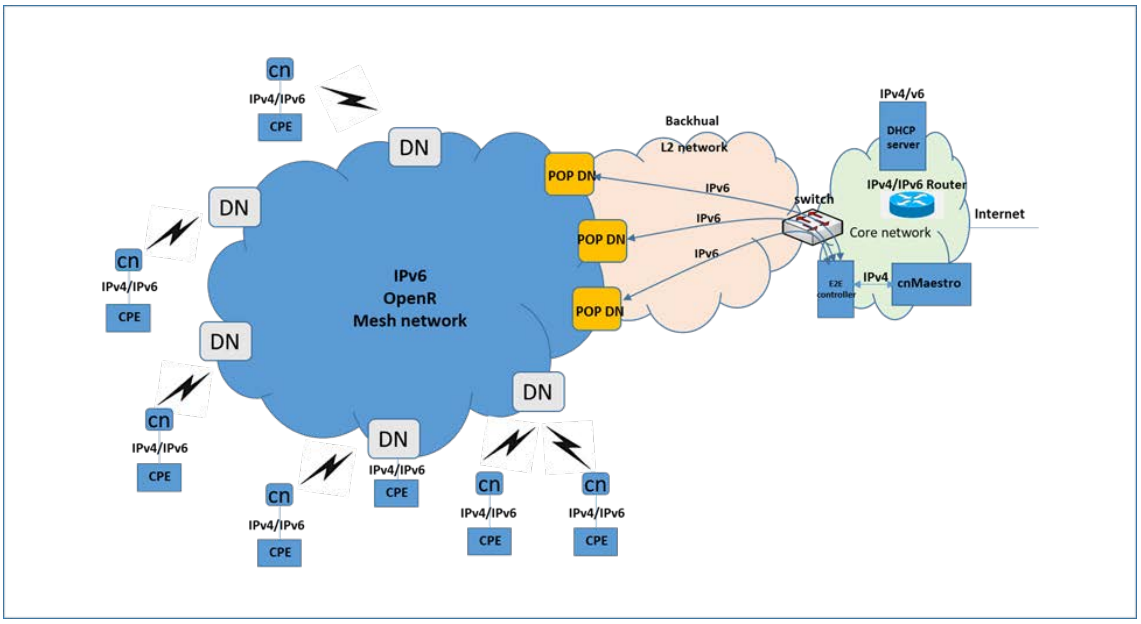
IPv6 routers in the network are not required. Ensure that the PoP DNs and the E2E be in the same VLAN.

Configure the IPv4 address of the radios manually. The CPE IPv4 address can be manually configured or use a DHCP server sitting in the core network. Depending on the complexity of the network, IPv4 based router may be required to route the IPv4 traffic from the CPEs.

Mixture of IPv4 and IPv6 support

The operator can design the network so that both IPv4 and IPv6 user data are supported. In this case, an IPv6 router is required at the core network. Ensure that if Layer 2 Bridge is enabled, by default all the user traffic including IPv6 is encapsulated in the GRE tunnel. The IPv6 user traffic is passed through the cnWave network in the GRE tunnel so that it does not be routed by the cnWave radios, but rather by an external IPv6 router.

Figure 47: *Example of IPv4 and IPv6 supported network*

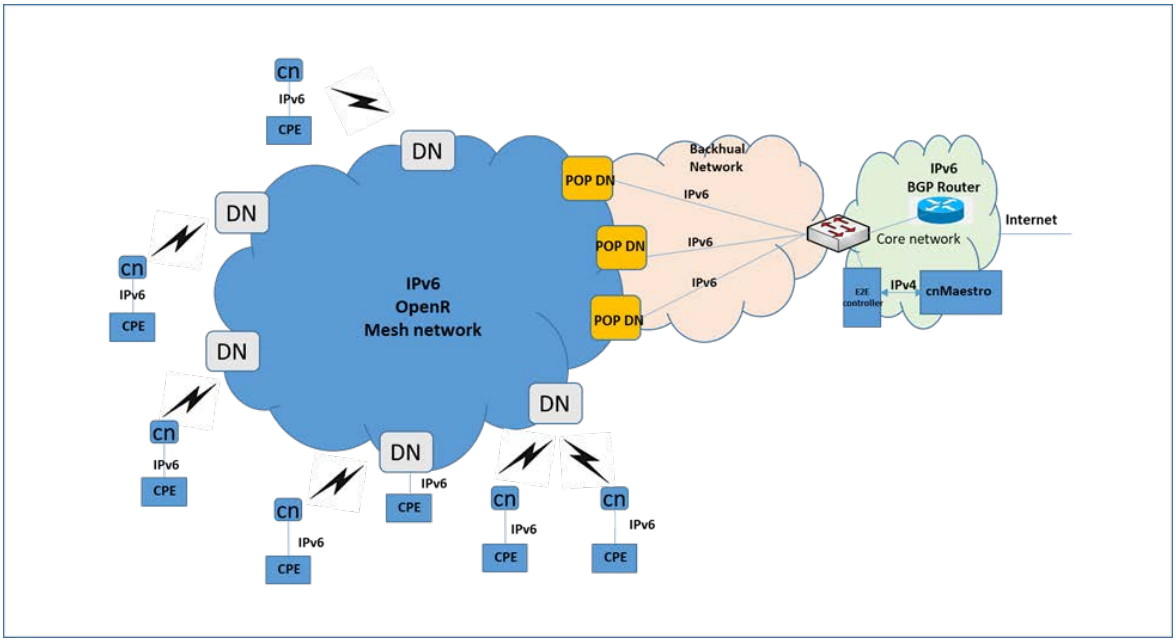


The operator can choose certain of the radio Ethernet port to be SLAAC based port or (CPE interface), user traffic from this port is only IPv6 based and does not be encapsulated into the GRE layer two bridge when transmitted over the wireless network. Although this reduces overhead, it is not recommended since this adds complexity to the network design (the operator may need to add a BGP router to the network).

IPv6 Mode network planning

If the operator chooses to have the network completely run on IPv6 mode, then GRE Layer 2 Bridge is not required and a BGP router is usually required to route traffic between the wireless network and the external network.

Figure 48: *Example of IPv6 mode network*



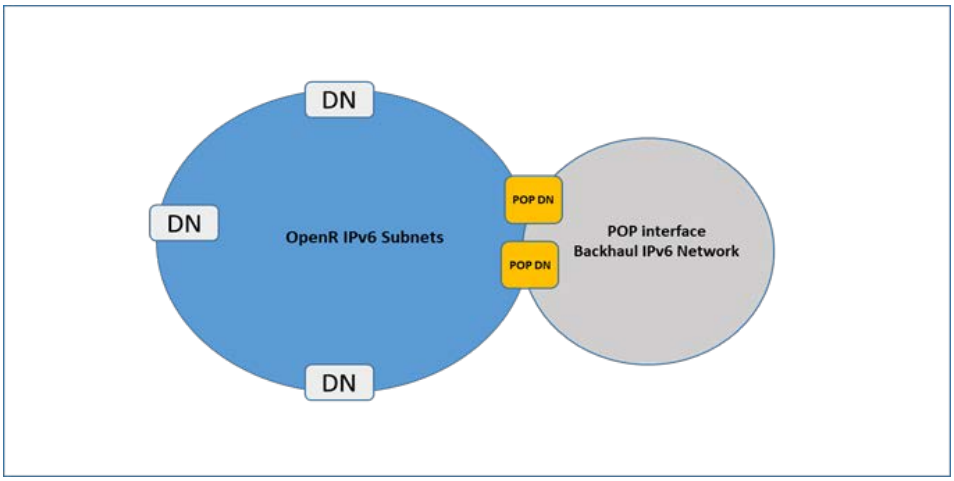
IPv6 Network design consideration

There are two sets of networks while designing the IPv6 network. one set is for the OpenR subnets (e.g. prefix of 56 bits and partition into multiple 64 bits subnet). Each cnWave node is assigned with a subnet.

Each PoP node, besides being part of the OpenR mesh network, has a subnet assigned to it and has an IPv6 address assigned to it as PoP interface IPv6 address.

If the operator lets the system automatically generates IP address configuration, the IP address always be in the format of FD00:xxxxxxx, which is a standard routable private IPv6 address.

Figure 49: *Example of an IPv6 network design*



Reserved IPv6 address space

If the operator let the system automatically generate the IPv6 addresses for the network, the following private IPv6 address spaces are reserved:

- FD00:CEED::0/32 for seed prefix of the mesh network
- FD00:BA5E::0/32 for all the PoP nodes and the E2E Controller

E2E and cnMaestro deployment consideration

While the E2E and cnMaestro are two separate entities, they can be hosted on separate computers or the same computer. While the E2E communicates with the cnMaestro using IPv4, the E2E communicates with the cnWave radios using IPv6.

Ethernet bridging or IP routing

Layer2 Bridging

L2 Bridge employs Ethernet over GRE (EoGRE) to carry the customer traffic across the Terragraph network. when L2 Bridge is enabled, all CNs and DNs automatically create an EoGRE tunnel with their PoP node and the PoP node creates a tunnel back to each of those CNs/DNs. The tunnel is capable of carrying both IPv4 and IPv6 customer traffic between CN and PoP. The IPv6 over the tunnel can be optionally disabled from the UI.

Broadcast/Multicast control

The downstream broadcast can be controlled by explicitly disabling it from the UI. Disabling IPv6 over the tunnel also reduces the downstream multicast traffic.

Limitations

- In bridge mode, the V5000 PoP node can forward 2.6 Gbps of TCP traffic and 1.5 Gbps UDP traffic in the down-link direction.

Layer 2 Bridge support in multi-PoP deployments

Note

Multi-PoP deployment is not recommended if on board E2E is enabled.

This feature applies to Layer 2 bridging and Deterministic Prefix Allocation (DPA) are configured to be used in the network.

In the Terragraph network, CNs and DNs are allocated prefixes from a seed prefix. There are various ways for allocating prefixes. In DPA, the controller assigns prefix zones to PoPs based on the network topology to allow PoP nodes to take advantage of summarizing the route and helps in load balancing ingress traffic.

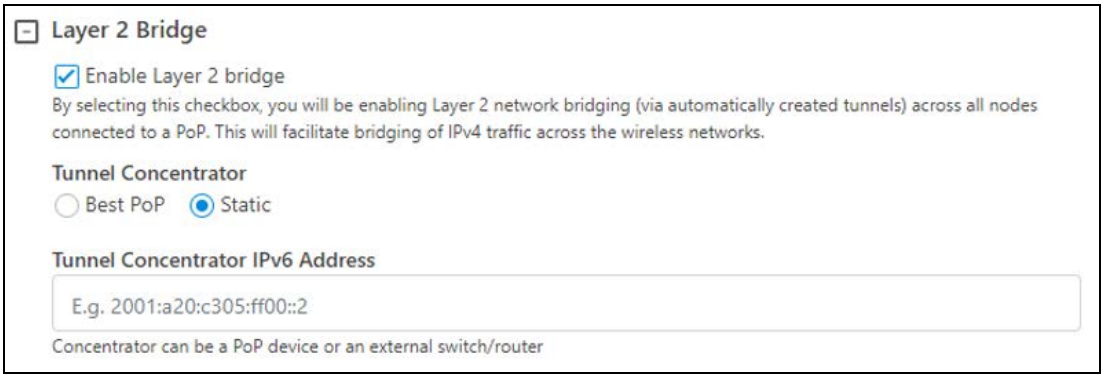
CNs and DNs get prefixes from the respective PoP zone which is allocated by the controller. CNs and DNs see multiple PoP nodes in the mesh, they select PoP to form GRE tunnel, by matching their lo IPv6 address with PoPs lo IPv6 address. The longest prefix match is selected as the best PoP for L2 GRE Tunnel establishment. The multi-PoP setup gives the advantage that user data traffic can take alternate routes if the best route is unavailable for some reason. Open/R makes this selection to route the traffic. If PoP is unavailable, CNs and DNs switch to the next best PoP. They however keep track of their primary PoP availability and switch to it once it becomes online.

External Layer 2 Concentrator support

The external device can be used as an L2 GRE Concentrator. In large mesh, it is advisable to use an external device as an L2 GRE concentrator. Concentrator could be a Linux server or any router or switch supporting IPv6 L2 GRE tunnels. Example: Juniper MX 100.

Select the **Static** tunnel concentrator option and provide an IPv6 address to configure the external concentrator IPv6 address.

Figure 50: *Layer 2 Tunnel Concentrator*



Multi-PoP deployments

The following aspects must be taken care of in cnWave multi-PoP deployments:

- Layer 2 domain
- Open/R on the PoP interface port

- MTU of upstream switch ports
- Prefix allocation

Layer 2 domain

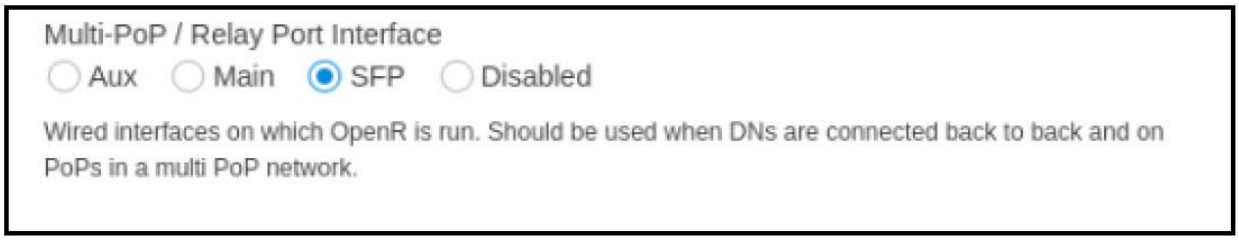
All cnWave PoP nodes must be connected to the same Layer 2 broadcast domain. PoP nodes learn about other PoP nodes using IPv6 multicast packets, which do not cross broadcast domain.

This allows cnWave PoP nodes to forward traffic to other cnWave PoP nodes via a wired connection when the routing path of the other PoP node is closer to the traffic's destination. This concept is called Tromboning, as the traffic enters one PoP node and then leaves to another PoP node.

Open/R on the PoP interface port

PoP interface port must be configured to run the Open/R protocol. To enable this option, select **Multi-PoP/ Relay port Interface**.

Figure 51: *Multi-PoP/Relay Port Interface*



MTU of upstream switch ports

PoP ports use a 2000 MTU size. So, all the switch ports must be at least 2000 MTU size. Even if the user traffic is limited to 1500 sized packets, switch ports should allow the higher MTU size. The following packets exchanged between the PoPs that can be of higher size:

- Open/R packets,
- L2GRE packets (in Layer 2 mode), and
- Software download packets.

Prefix allocation

It is recommended to select the Deterministic Prefix Allocation option for multi-PoP deployments.

Figure 52: *The prefix allocation options*

Layer two control protocols

60 GHz cnWave identifies layer two control protocols (L2CPs) from the Ethernet destination address or Ethertype of bridged frames. The QoS classification can be separately configured for these protocols.

Ethernet port allocation

The user must decide how the three ODU Ethernet ports are allocated to the data service, management service and Local Management Service based on the following rules:

- Map the Data Service to at least one of the available wired Ethernet ports.
- Map the Management Service to In-Band, or any combination of the remaining unused Ethernet ports. If the Management Service is mapped to In-Band, it shares all the ports selected for the Data Service. The Management Service can be disabled by mapping to None.
- Map the Local Management Service to any combination of the remaining unused Ethernet ports. The Local Management Service can be disabled by mapping to None.

The LAN configuration page ensures that the management agent can always be reached using either the management service or the local management service.

IP Interface

Select the IP version for the IP interface of the ODU management agent. 60 GHz cnWave can operate in IPv4 mode (via L2 tunneling), IPv6 mode. Choose one IPv4 address and/or one IPv6 address for the IP interface of the ODU management agent. The IP address or addresses must be unique and valid for the connected network segment and VLAN.

Find out the correct subnet mask (IPv4) or prefix length (IPv6) and gateway IP address for this network segment and VLAN.

Ensure that the design of the data network permits bidirectional routing of IP datagrams between network management systems and the ODUs. For example, ensure that the gateway IP address identifies a router or another gateway that provides access to the rest of the data network.

Daisy-chaining 60 GHz links

When connecting two or more 60 GHz cnWave links together in a network (daisy-chaining), do not install direct copper CAT5e connections between the PSUs. Each PSU must be connected to the network terminating equipment using the LAN port. To daisy-chain 60 GHz cnWave links, install each ODU-to-ODU links using one of the following solutions:

- A copper CAT5e connection between the Aux ports of two ODUs.
- A copper CAT5e connection between the Aux port of one ODU and the SFP port of the next ODU (using a copper SFP module).
- Optical connections between the ODUs (SFP ports) using optical SFP modules at each ODU.

Installation

Safety

Warning

To prevent loss of life or physical injury, observe the following safety guidelines. In no event shall Cambium Networks be liable for any injury or damage caused during the installation of the Cambium 60 GHz cnWave radio nodes. Ensure that only qualified personnel install 60 GHz cnWave radios.

Attention

Pour éviter toute perte de vie ou blessure physique, respectez les consignes de sécurité suivantes. En aucun cas Cambium Networks ne pourra être tenu responsable des blessures ou dommages causés lors de l'installation des nœuds radio Cambium 60 GHz cnWave. Assurez-vous que seul du personnel qualifié installe les radios cnWave 60 GHz.

Power lines

Exercise extreme care when working near power lines.

Working at heights

Exercise extreme care when working at heights.

PSU

Always use one of the approved power supply options. Failure to use the Cambium supplied PSUs can result in equipment damage and will invalidate the safety certification and may cause a safety hazard.

Grounding and protective earth

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

AC Supply

Always use an appropriately rated and approved AC supply cord-set in accordance with the regulations of the country of use.

Powering down before servicing

Before servicing 60 GHz cnWave equipment, always switch off the power supply and unplug it from the PSU.

Do not disconnect the RJ45 drop cable connectors from the radio while the PSU is connected to the power supply. Always remove the AC or DC input power from the PSU.

Primary disconnect device

The primary disconnect device is the main power supply.

External cables

Safety may be compromised if outdoor rated cables are not used for connections that are exposed to the outdoor environment.

Drop cable tester

The PSU output voltage may be hazardous in some conditions such as wet weather. Do not connect a drop cable tester to the PSU, either directly or via LPUs.

RF Exposure near the antenna

Strong Radio Frequency (RF) fields are present close to the antenna when the transmitter is ON. Always turn off the power to the radio before undertaking maintenance activities in front of the antenna.

Minimum separation distances

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

Grounding and lightning protection requirements

Ensure that the installation meets the requirements defined in the Installation section.

Grounding cable installation methods

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

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

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

Siting radios

Radios are not designed to survive direct lightning strikes. For this reason they must be installed in Zone B as defined in *Lightning protection zones*. Mounting in Zone A may put equipment, structures, and life at risk.

60 GHz cnWave radios and mounting bracket options

Mounting bracket options

The 60 GHz cnWave series supports eight mounting bracket options. Select the optimum mounting bracket arrangement based on the ODU type and the choice of wall or pole mounting. The wall mount plate for V1000 and V5000 are included with the ODU. Order the remaining brackets separately.

Table 30: ODU mounting bracket part numbers

Bracket	Pole diameter	ODU variants	Bracket part number
V1000 pole mount	40 mm to 77 mm (1.6 inches to 3.0 inches)	V1000	Included with V1000
V1000 wall mount	Wall mount	V1000	Included with V1000
V1000 adjustable pole mount	40 mm to 77 mm (1.6 inches to 3.0 inches)	V1000	N000900L022A
V3000 precision bracket	25 mm to 77 mm (1.0 inches to 3.0 inches)	V3000	C000000L125A
V3000 tilt bracket assembly	40 mm to 77 mm (1.6 inches to 3.0 inches)	V3000, V5000	N000045L002A
V3000 tilt bracket assembly with band clamps	90 mm to 230 mm (3.6 inches to 9.0 inches)	V3000, V5000	N000045L002A + third-party band clamps
V5000 pole mount	25 mm to 77 mm (1.0 inches to 3.0 inches)	V5000	C000000L137A
V5000 wall mount	Wall mount	V5000	C000000L136A

Installing the cnWave radio nodes

To install the radio, use the following procedure and guidelines:

1. Typical installation
2. ODU interface with LPU on the pole
3. SFP and Aux Ethernet interfaces

4. Attach ground cables to the radio
5. Mounting the ODU on the mast or wall

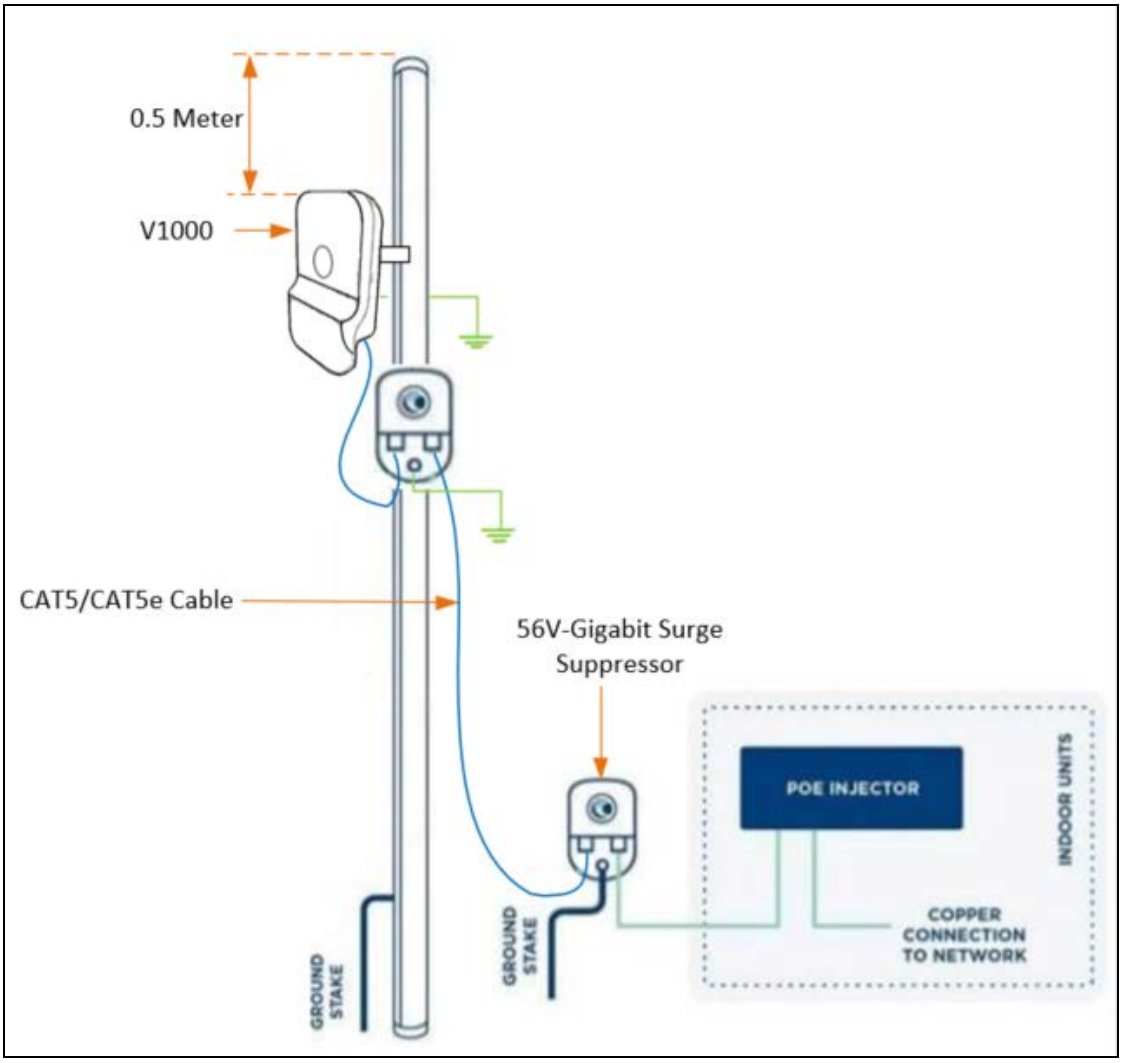
Typical installation

V1000

V1000 typical installation figure shows a typical installation of cnWave CN on a mast and powered through PoE Power Injector.

1. Use recommended grounding and Surge Suppressor connections.
2. Use recommended cables for interfacing ODU (refer to the Power supply units (PSU) for supported power supply and cable length details).
3. Always install ODU 0.5 meters below the tip of the pole.

Figure 53: *V1000 typical installation*

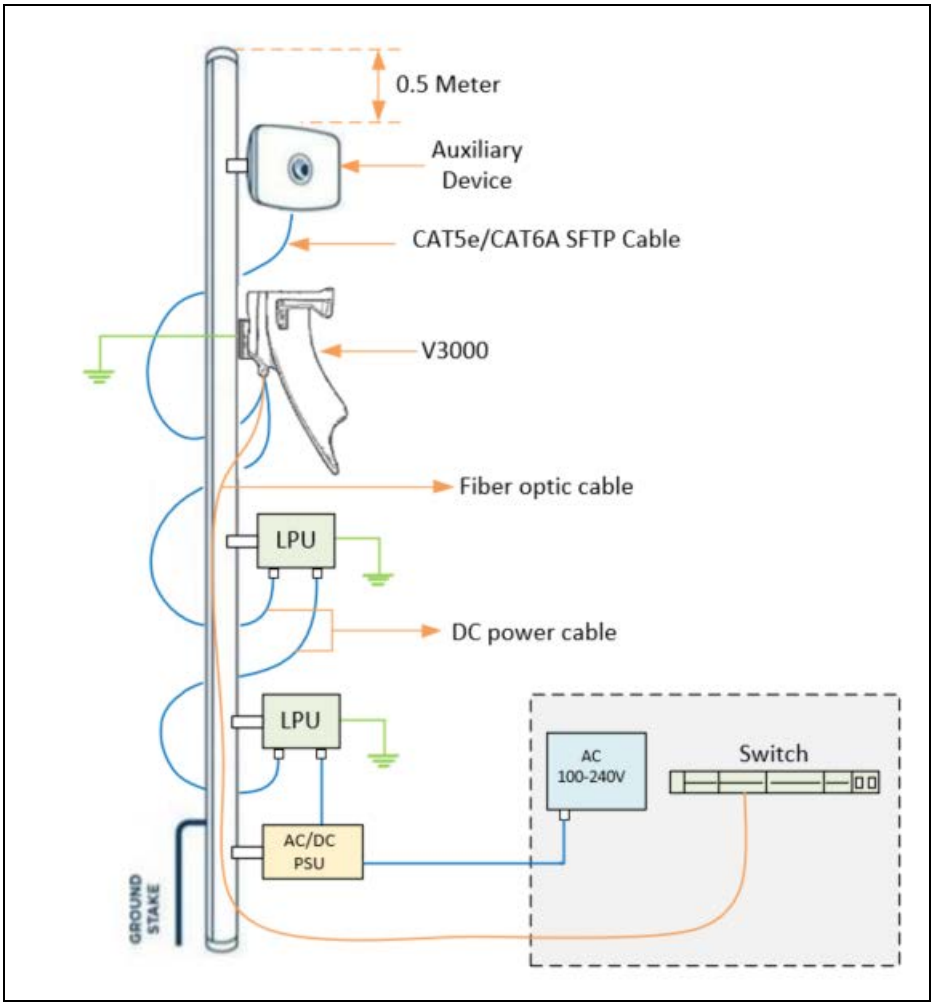


V3000

V3000 typical installation figure shows a typical installation of cnWave DN on a mast and powered through outdoor AC/DC PSU.

1. Use recommended grounding and LPU connections.
2. Use recommended cables for interfacing ODU (refer to the Power supply units (PSU) for supported power supply and cable length details).
3. Always install ODU 0.5 meters below the tip of the pole.

Figure 54: *V3000 typical installation*

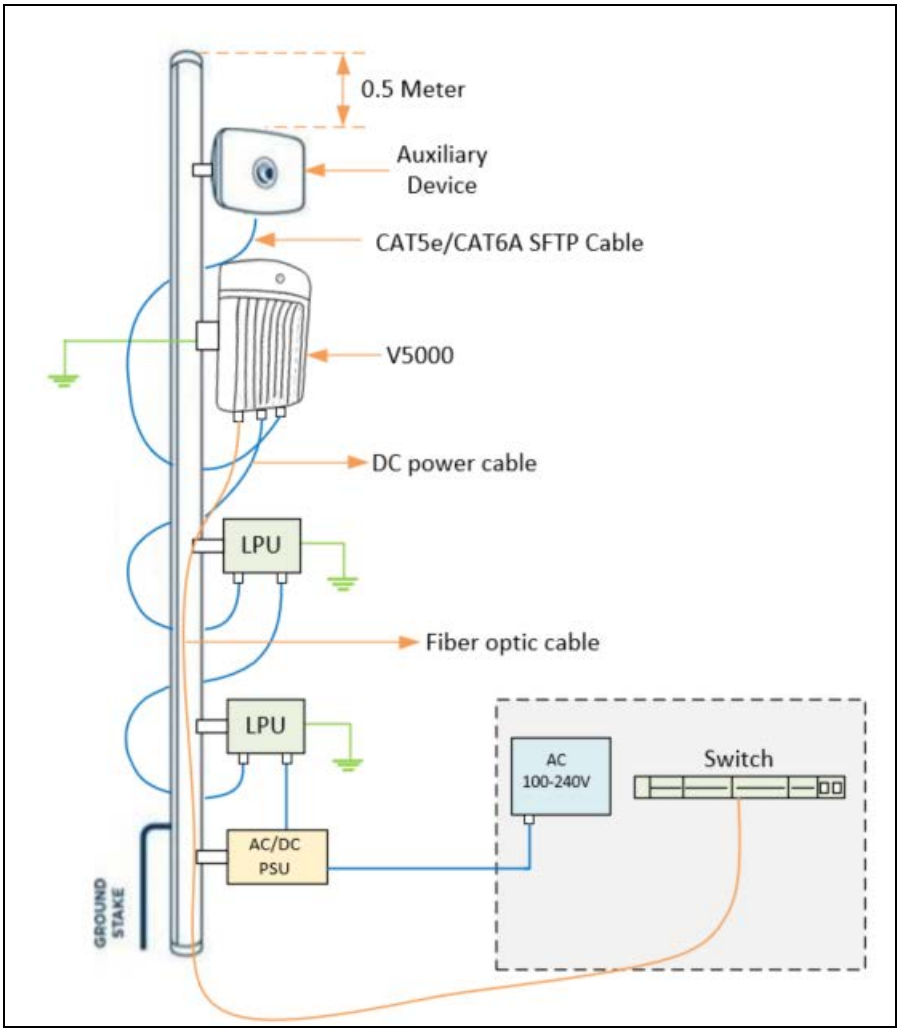


V5000

V5000 typical installation figure shows a typical installation of cnWave DN on a mast and powered through outdoor AC/DC PSU.

1. Use recommended grounding and LPU connections.
2. Use recommended cables for interfacing ODU (refer to the Power supply units (PSU) for supported power supply and cable length details).
3. Always install ODU 0.5 meters below the tip of the pole.

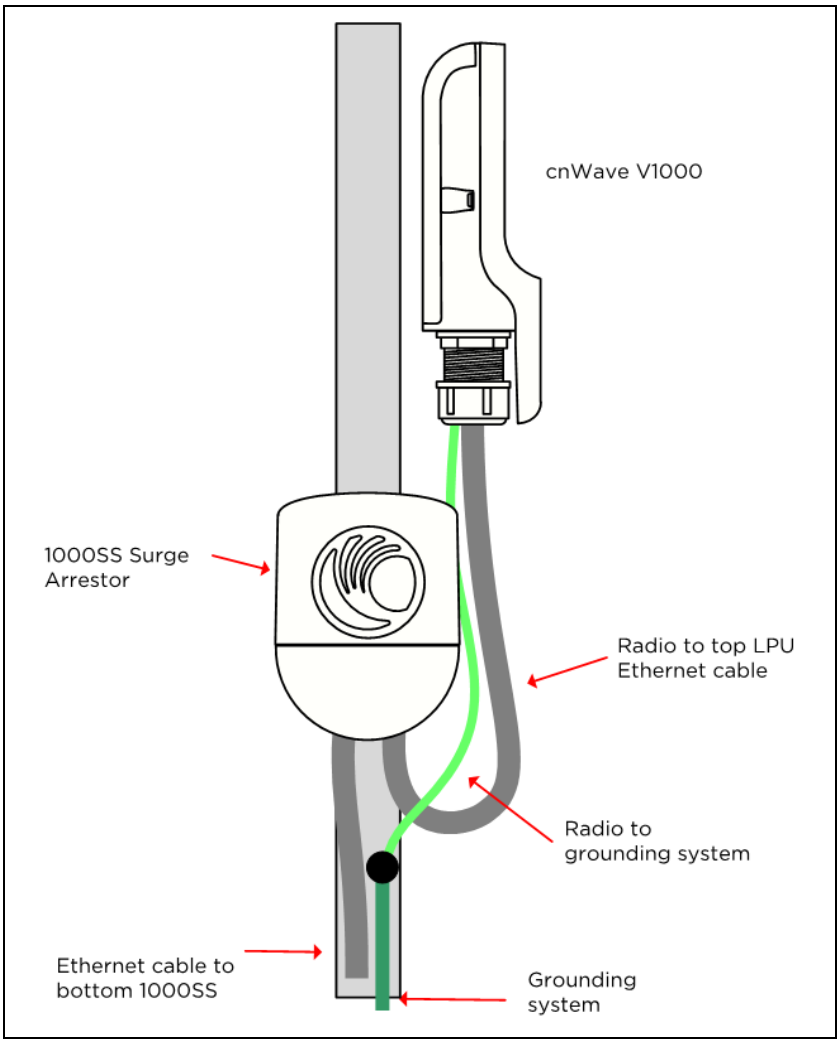
Figure 55: *V5000 typical installation*



ODU Interface with LPU on the pole

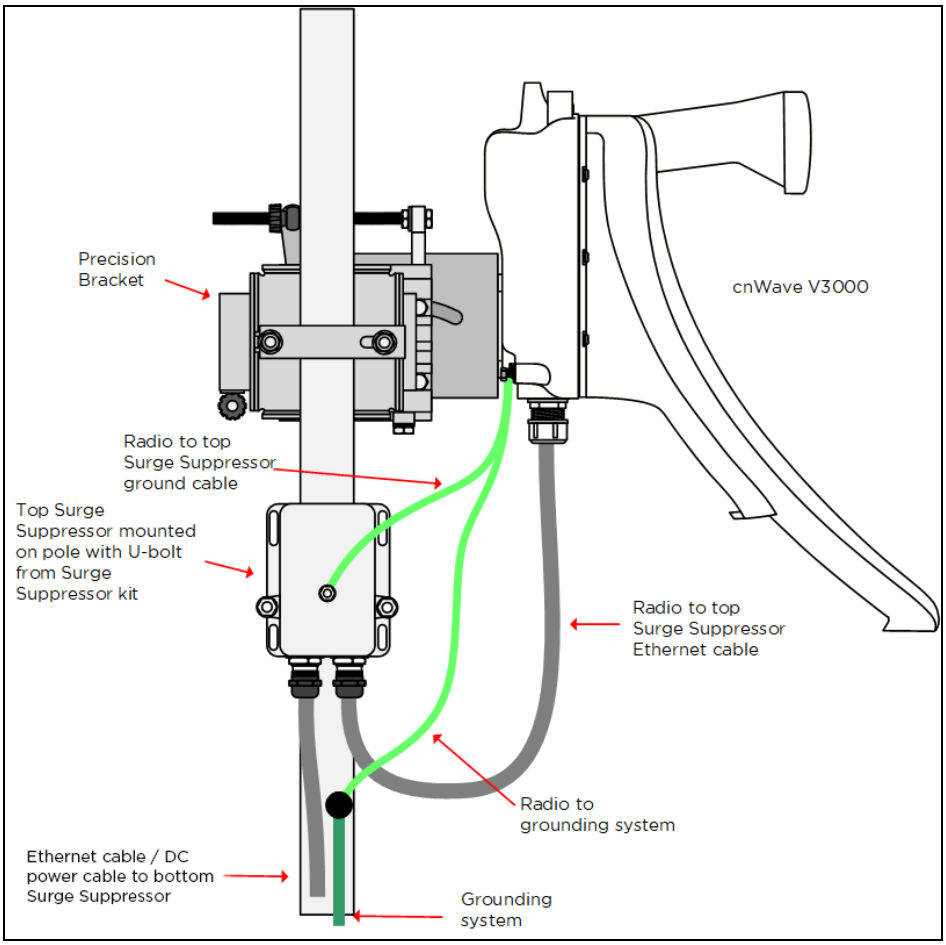
Installing V1000 on the pole below shows steps show the installation of V1000 CN on a pole. Use 56V Gigabit Surge Suppressor for lightning protection. Ensure that the cable glands and grounding connections are made as in the following figure:

Figure 56: *Installing V1000 on the pole*



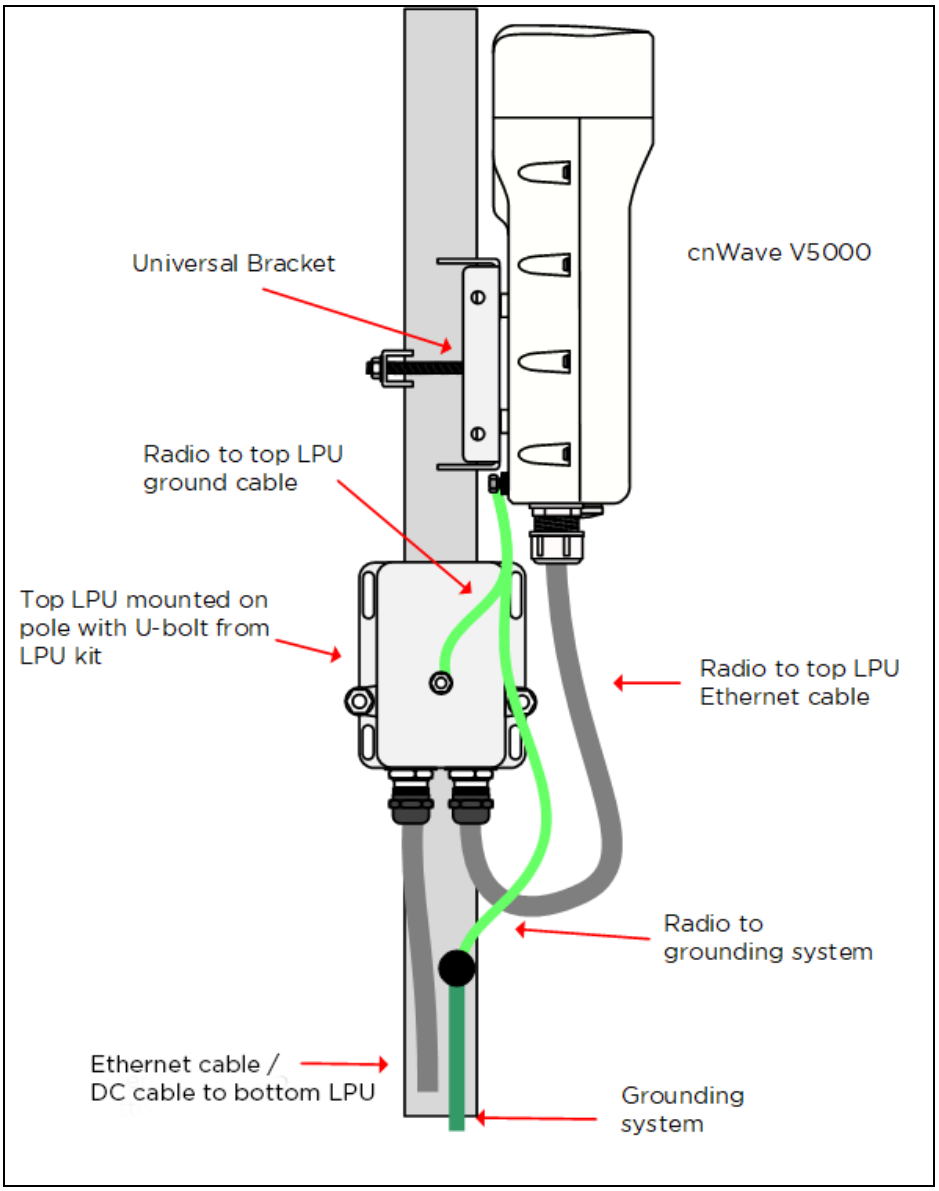
Installing V3000 on the pole shows an installation of V3000 CN on a pole using a precision bracket. Use a recommended LPU for surge protection. Ensure glands and grounding connections are made as in the following figure:

Figure 57: *Installing V3000 on the pole*



Installing V5000 on the pole shows an installation of V5000 DN on a pole using a tilt bracket. Use a recommended LPU for surge protection. Ensure glands and grounding connections are made as in the following figure:

Figure 58: *Installing V5000 on the pole*



Attach ground cables to the radio

1. Fasten the ground cable to the radio grounding point using the M6 lug.

   Figure 59: *Radio grounding point*

2. Tighten the ODU grounding bolt to a torque of 5 Nm (3.9 lb-ft).

Mounting the ODU on the mast or wall

Select the most appropriate bracket mounting arrangement from the options listed in the Mounting bracket options. Refer to individual procedures below for each of the options:

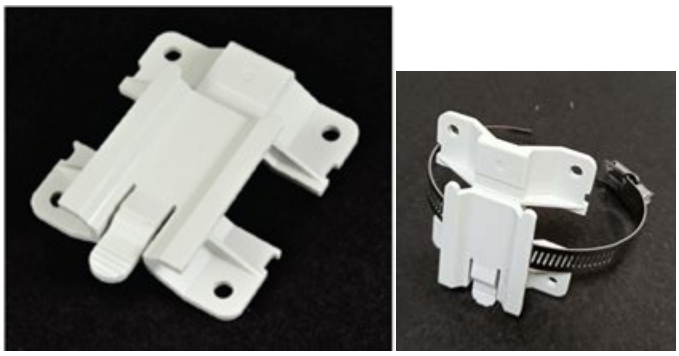
- V1000 pole mount
- V1000 wall mount
- V1000 adjustable pole mount
- V3000 precision bracket
- V3000 tilt bracket assembly
- V3000 tilt bracket assembly with band clamps
- V5000 pole mount bracket
- V5000 wall mount bracket

V1000 Pole mount

The V1000 CN can be installed to a pole using the supplied mounting plate and jubilee clip. Follow the below instructions to mount V1000 to the pole:

1. Insert the hose clamps through the mounting plate and clamp to the pole by applying 3.0 Nm torque.

Figure 60: *Inserting the hose clamps*



2. Insert the radio into the mounting plate on the pole.

Figure 61: *Inserting the radio*

V1000 Wall mount

Follow the below instructions to mount V1000 on the wall:

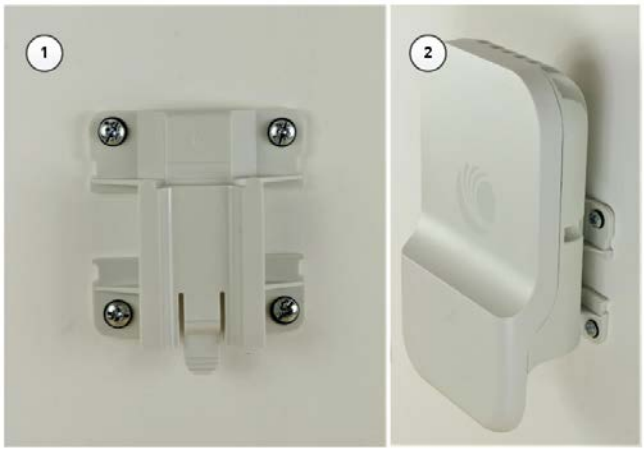
1. Fix the mounting plate (supplied with the V1000 ODU) securely to a vertical wall, using suitable fixings.

Note

Fixing hardware is not supplied with the V1000.

2. Slide the V1000 ODU onto the mounting plate from above, ensuring that the spring clip in the mounting plate clicks into place on the radio.

Figure 62: *Fixing the mounting plate and the spring clip*

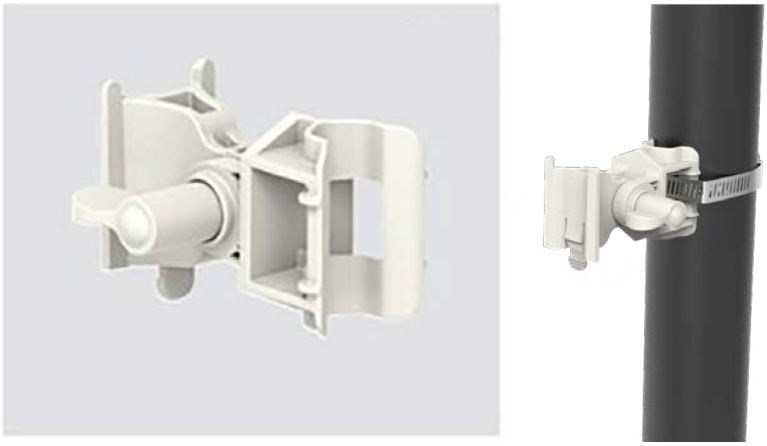


V1000 Adjustable pole mount

Follow the below instructions to mount V1000 to the adjustable pole:

1. Insert the hose clamps through the adjustable pole mount bracket and clamp to the pole by applying 3.0 Nm torque.

   Figure 63: *Fixing hose clamps through adjustable pole mount bracket*



2. Insert the radio into the adjustable pole mount bracket on the pole.

Figure 64: *Fixing the radio on the pole*

V1000 Alignment

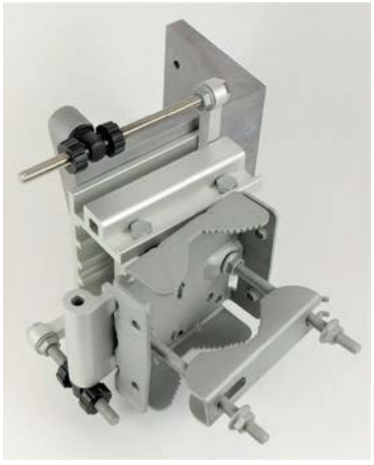
The V1000 CN requires minimal effort to align as the internal antenna can beam steer +/- 45 degrees in azimuth and +/- 20 degrees in elevation from boresight. If the unit is installed with the remote node visible within this range, no further adjustment is required.

V3000 Precision bracket

The precision bracket is used to mount the cnWave V3000 CN on a vertical pole, providing fine adjustment up to 18° in azimuth and +/-30° in elevation for accurate alignment of the V3000. The precision bracket is compatible with pole diameters in the range of 25 mm to 80 mm (1.0 inches to 3.1 inches).

These instructions illustrate the procedure for assembling and using the precision bracket. The mounting of the optional alignment telescope also explained.

Figure 65: *V5000 Precision bracket*

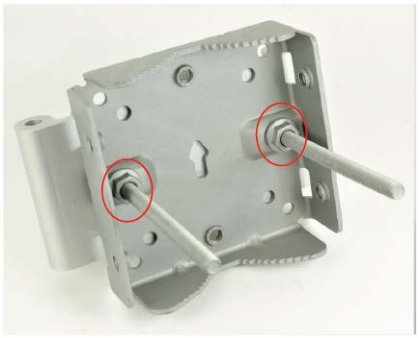


1. Insert two of the long (120 mm) screws through the azimuth arm and the bracket body. The screws locate in the slots in the azimuth arm.

   Figure 66: *Two screws in the slots of the azimuth arm*

2. Fit two flanged M8 nuts to the long screws on the back of the bracket. Tighten using a 13 mm spanner.

   Figure 67: *Two MB nuts on the back of bracket*



3. Insert the three medium-length (40 mm) M8 screws through the bracket base and the V3000 mount. The screws locate in the slots in the bracket base.

   Figure 68: *MB Screws in the slots in the bracket base*

You must ensure that the pivot pin in the elevation adjuster is located in the circular hole in the V3000 mount.

Figure 69: *The pivot pin in the circular hole of mount*

4. Fit plain washers and M8 Nyloc nuts to the screws on the back of the bracket base. Tighten using a 13 mm spanner.

Figure 70: *Plain washers and M8 Nyloc nuts on the back of the bracket*

5. Insert the two remaining long (120 mm) M8 screws through the bracket body and the azimuth arm. The screws must locate in the slots in the bracket body.

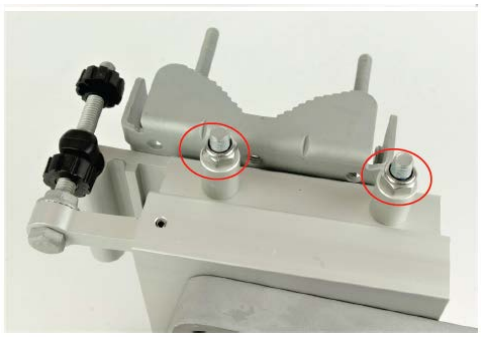
Figure 71: *MB Screws located in the slots in the bracket body*

You must ensure that the pivot pin in the azimuth adjuster is located in the circular hole in the bracket body.

Figure 72: *The pivot pin in the circular hole of bracket body*

6. Fit three sets of spacers, plain washers and M8 Nyloc nuts to the screws on the underside of the bracket base. Tighten using a 13 mm spanner.

Figure 73: *Fixing pacers, plain washers and M8 Nyloc nuts*



7. Attach the V3000 mount to the radio using the four short M6 bolts. Tighten the four bolts to a torque setting of 5.0 Nm (3.7 lb-ft) using a 13 mm spanner or socket.

Figure 74: *Attaching the V3000 mount*

8. Attach the precision bracket to the pole using the clamp and the remaining flanged nuts. Adjust azimuth approximately and tighten the nuts to 10 Nm (7.4 lbft) using a 13 mm spanner.

Figure 75: *Attaching the precision bracket*

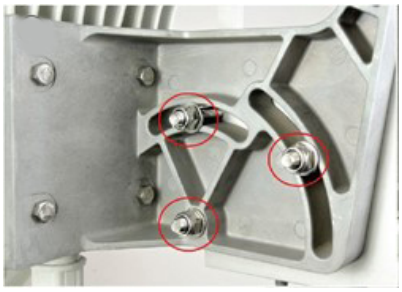
9. Lock the antenna alignment by tightening the five Nyloc nuts (see step 5 and step 8) to 10 Nm (7.4 lb-ft) using a 13 mm spanner or socket.

Figure 76: *Locking the antenna alignment*

Precision bracket alignment

1. Ensure that the three Nyloc screws for securing the bracket in elevation are loose and the fine elevation adjuster is holding the weight of the unit.

Figure 77: *Three Nyloc screws on the unit*



2. Ensure the two Nyloc screws for securing the bracket in the azimuth are loose.

Figure 78: *Two Nyloc screws in the azimuth*

3. Before starting the mechanical alignment, move the fine elevation adjuster 2/3 of the way across the screw until the unit is sitting at approximately 0 degrees in elevation.

Figure 79: *Moving the elevation adjuster*

4. Move the fine azimuth adjuster to approximately the center of the available range and lock in position.

Figure 80: *Moving the azimuth adjuster*

5. Loosen the clamp which attaches the bracket to the pole until there is enough freedom to rotate the unit in azimuth.

6. From behind the unit, using the sight to aim towards the remote node, rotate the unit until it is approximately aligned in azimuth. Tighten the clamp.

7. While looking for the far node through the site, rotate the fine elevation adjuster until the alignment is complete in the elevation plane. One turn of the adjustment wheel is equivalent to approximately one degree of elevation. Lock the fine elevation adjuster screws in place.

Figure 81: *Locking the fine elevation adjuster*

8. While looking for the far node through the site, rotate the fine azimuth adjuster until the alignment is complete in the azimuth plane. One turn of the adjustment wheel is equivalent to approximately one degree of azimuth. Lock the fine azimuth adjuster screws in place.

9. Make any remaining adjustments to the elevation and azimuth as required. Once complete, tighten the three Nyloc screws in place to fix the elevation alignment and do the same for the two Nyloc screws for azimuth alignment to 10 Nm (7.4 lbft) using a 13 mm spanner or socket.

Precision bracket alignment – optional telescope

1. Attach the telescope mount to the V3000 radio using the knurled screw.

2. Attach the telescope by looping the two elastic O-rings over the ears of the mount, ensuring that the telescope is located securely in the mount.

Figure 82: *Attaching the telescope*

3. If a telescope with a smaller body is used, shorten the O-rings by twisting.
4. Follow the previously described precision bracket alignment method, align the radio starting with the site and later fine-tune using the scope for increased accuracy.

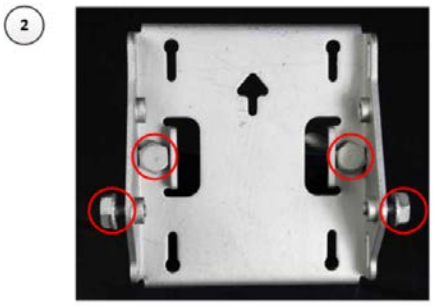
V3000 Tilt bracket assembly

1. Fix the mounting plate of the tilt bracket to the back of the radio using four of the short bolts, ensuring that the arrow in the plate points towards the top of the radio. Tighten the four bolts to a torque setting of 5.0 Nm (3.7 lb-ft) using a 13 mm spanner or socket.

   Figure 83: *Fixing the mounting plate of the tilt bracket*

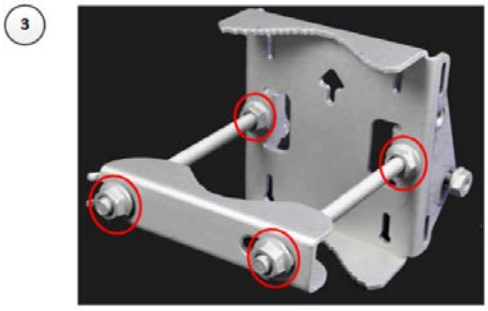
2. Fit the two long bolts through the bracket body so that the bolt heads engage in the slots as shown. Fit two of the short bolts into the side of the bracket body but do not tighten.

Figure 84: *Fixing two long and short bolts*



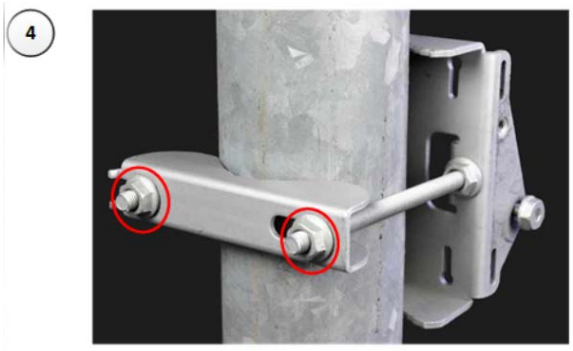
3. Thread two of the nuts to the long bolts and tighten against the bracket body using a 13 mm spanner. Fit the bracket strap and thread the remaining nuts onto the long bolts.

Figure 85: *Fixing the bracket strap*



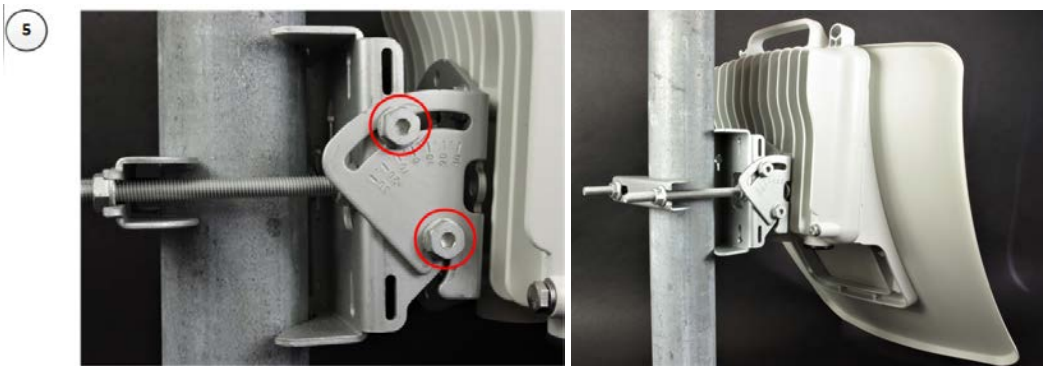
4. Fix the assembled bracket body to the pole, adjust the azimuth angle, and tighten the nuts to a torque setting of 10.0 Nm (7.4 lb-ft) using a 13 mm spanner, ensuring that the arrow in the body is pointing upwards.

Figure 86: *Fixing the assembled bracket body*



5. Fit the mounting plate to the bracket body by positioning the open- ended slots over the short bolts. Insert the remaining short bolts through the longer curved slots into the threaded holes in the bracket body. Adjust the elevation angle and tighten the bolts to a torque setting of 5.0 Nm (3.7 lb-ft) using a 13 mm spanner or socket.

Figure 87: *Fixing the mounting plate and adjusting the elevation*

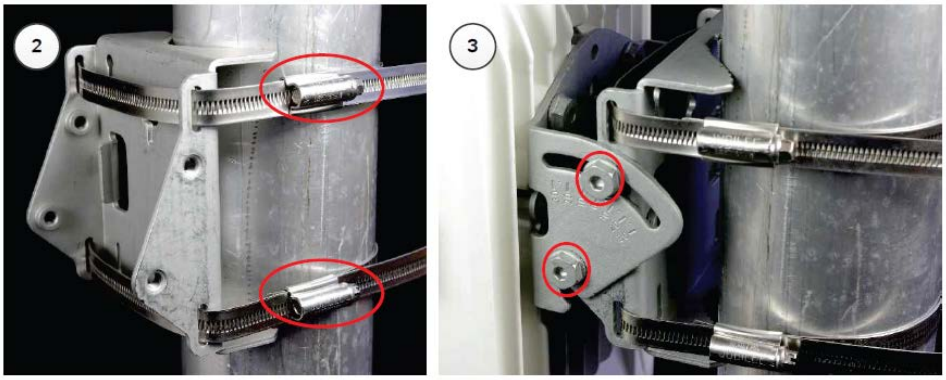


V3000 Tilt bracket assembly with band clamps

Follow the below instructions to assemble the tilt bracket with band clamps:

1. Follow step 1 of the V3000 tilt bracket assembly procedure.
2. Feed the band clamps through the slots in the bracket body. Secure the bracket body to the pole using band clamps (not supplied by Cambium), ensuring that the arrow in the body is pointing upwards. Adjust the azimuth angle, and tighten the band clamps to a torque setting of 6.0 Nm (4.5 lb-ft).
3. Fix the mounting plate to the bracket body with four of the short bolts, using a 13 mm spanner or socket. Adjust the elevation angle, and tighten the bolts to a torque setting of 5.0 Nm (3.7 lb-ft).

Figure 88: *Fixing the mounting plate of bracket body and adjusting the elevation angle*



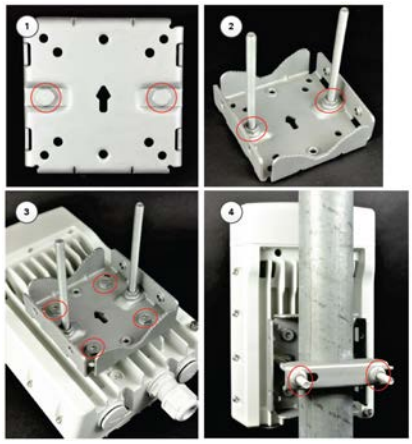
V5000 Pole mount bracket

1. Pass the long screws through the bracket body. The screws are located in the recess in the bracket.
2. Fit two flanged nuts to the long screws on the back of the bracket. Tighten using a 13 mm spanner.
3. Fix the bracket to the back of the radio using the four short M6 bolts, ensuring that the arrow in the plate points towards the top of the radio. Tighten the four bolts to a torque setting of 5.0 Nm

(3.7 lb-ft) using a 13 mm spanner or socket.

4. Attach the pole-mount bracket to the pole using the clamp and the remaining flanged nuts. Adjust azimuth and tighten the nuts to 10 Nm (7.4 lbft) using a 13 mm spanner.

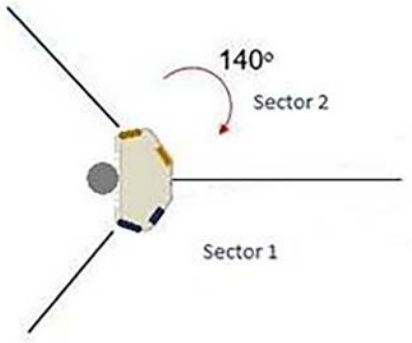
Figure 89: *Fixing the V5000 pole mount bracket*



V5000 Alignment

The V5000 distribution node has two sectors, situated side by side, each covering a 140-degree range in azimuth, giving a combined coverage of 280 degrees. In elevation, the antenna can beam steer in a +/- 20-degree range. The boundary between where Sector 1 ends and Sector 2 begins is the centerline/boresight from the unit.

Figure 90: *V5000 alignment - Top view*



V5000 Wall mount bracket

1. Install the mounting plate of the wall mount bracket securely on a vertical wall, using suitable fixing hardware.

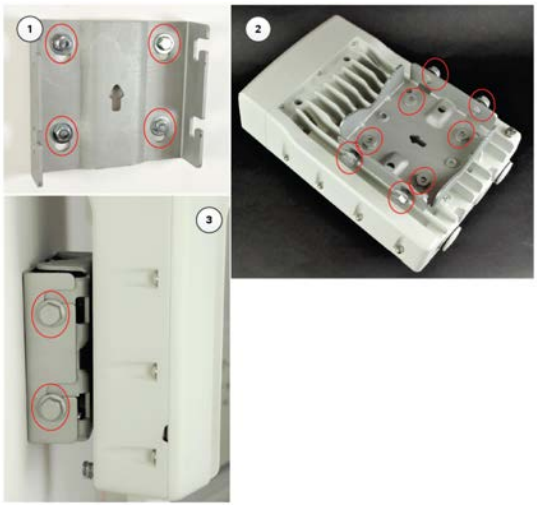
Note

Fixing hardware is not supplied with the wall mount bracket.

2. Fix the bracket body to the back of the radio using the four short M6 bolts, ensure that the arrow in the plate points towards the top of the radio. Tighten the four bolts to a torque setting of 5.0 Nm (3.7 lb-ft) using a 13 mm spanner or socket.
3. Insert the four short M8 bolts into the sides of the bracket body.
4. Fit the bracket body to the mounting plate by positioning the short bolts into the open-ended slots.

   Tighten the bolts to a torque setting of 5.0 Nm (3.7 lb-ft) using a 13 mm spanner or socket.

   Figure 91: *Fixing the V5000 wall mount bracket*



Connect to the PSU port of the radio

Using power over Ethernet (PoE)

1. Disassemble the gland and thread each part onto the cable (the rubber bung is split). Assemble the spring clip and the rubber bung.

   Figure 92: *Assembling the spring clip and the rubber bung*

2. Fit the parts into the body and lightly screw on the gland nut (do not tighten it).

Figure 93: *Fixing the gland nut*

3. Connect the RJ45 plug into the main PSU port of the ODU.

Figure 94: *Connecting the RJ45 plug*

4. Rotate the gland clock wise to tightly fit the gland on the PSU port.

Warning

Ensure that the cable clamp is not attached/ tightened at this stage, this may cause damage to the RJ45 or PCB.

Figure 95: *Rotating the gland*

5. Tighten the gland (cap or nut), this must be done last. Otherwise, it may damage the RJ45 or PCB.

Disconnecting drop cable from the radio

1. Loosen and remove the cable clamp by rotating anti-clockwise from the PSU port.

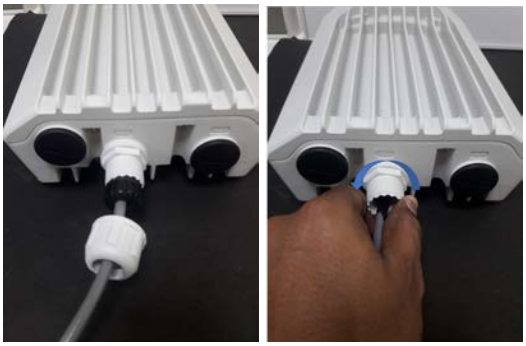
Figure 96: *Removing the cable clamp*

Warning

Loosen the cable clamp completely and then unscrew the gland. Not releasing the cable may cause damage to the RJ45 socket and/or PCB.

2. Remove the gland.

Figure 97: *Removing the gland*



3. Press tab on RJ45 plug to remove the cable from PSU port.
4. Remove the latch of the RJ45 plug to remove the cable from the PSU port.

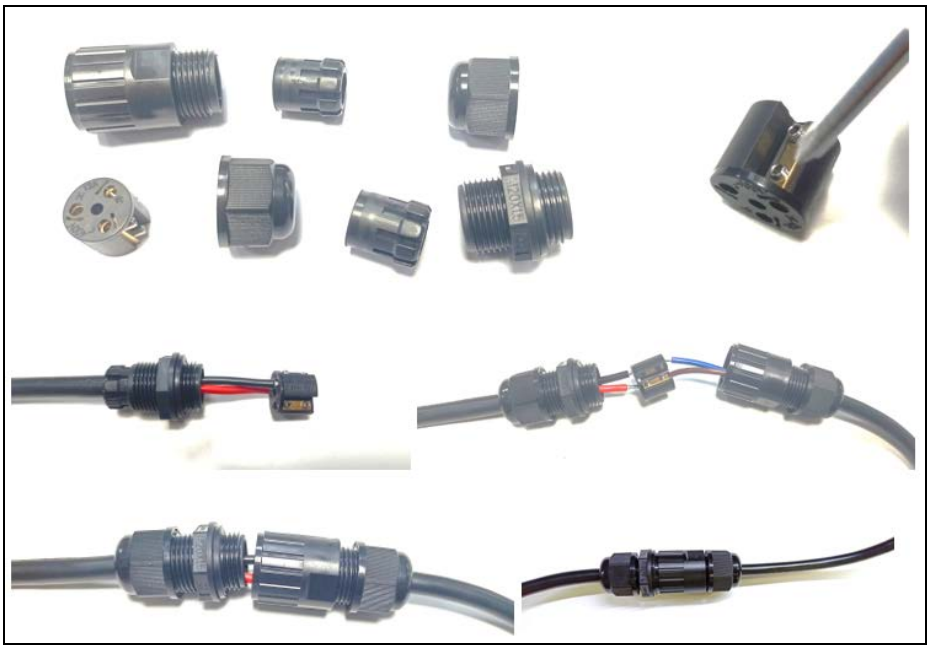
Figure 98: *Removing the latch of the RJ45 plug*

Using AC/DC PSU

Cable joiner

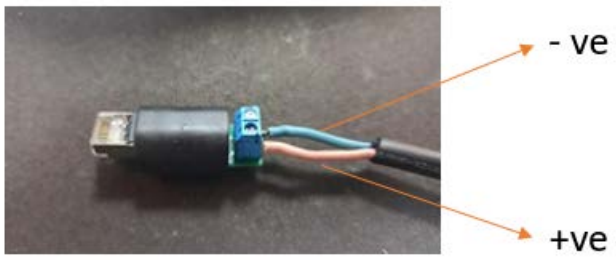
A cable joiner is used to connect the wires. Insert the wires into the cable joiner by loosening the screws on the joiner.

Figure 99: *Cable joining parts*



Connecting the mini adapter

Figure 100: *Mini adapter connections*



Fitting the long cable gland

Figure 101: *The long cable gland*

Connecting the mini adapter to ODU

1. Plug and connect the input side of the AC/DC PSU to the AC power line and tighten the gland. Tighten the cable clamp cap.

   Figure 102: *Connecting the input side of AC/DC PSU*

2. Connect output side of DC PSU to ODU through cable joiner and DC mini adapter.

   Figure 103: *Connecting the output side of AC/DC PSU*

Install the PSU

Install one of the following types of PSU:

- Installing the 60W DC power injector
- Installing the AC/DC PSU
- Installing the V1000 power injector

Warning

Always use an appropriately rated and approved AC supply cord-set in accordance with the regulations of the country of use.

Attention

As the 60W DC power injector and V1000 power injector are not waterproof, locate it away from sources of moisture, either in the equipment building or in a ventilated moisture-proof enclosure. Do not locate the PSU in a position where it may exceed its temperature rating.

Attention

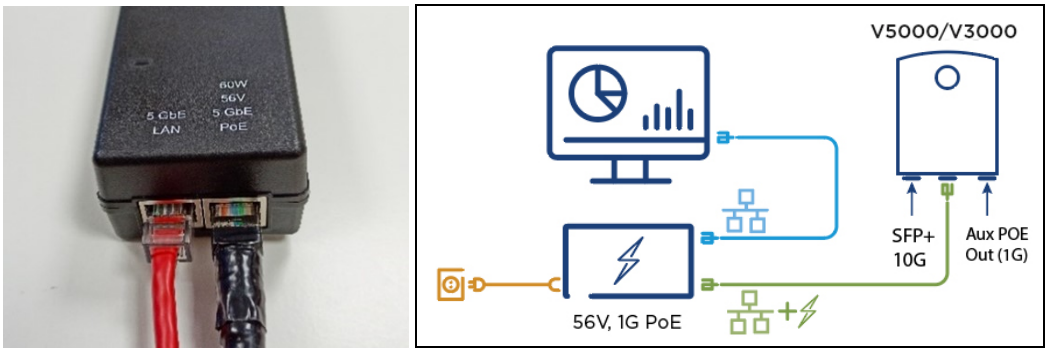
Do not plug any device other than a 60 GHz cnWave ODU into the ODU port of the PSU. Other devices may be damaged due to the non-standard techniques employed to inject DC power into the Ethernet connection between the PSU and the ODU.

Do not plug any device other than a Cambium 60 GHz cnWave PSU into the PSU port of the ODU. Plugging any other device into the PSU port of the ODU may damage the ODU and device.

Installing the 60W DC power injector

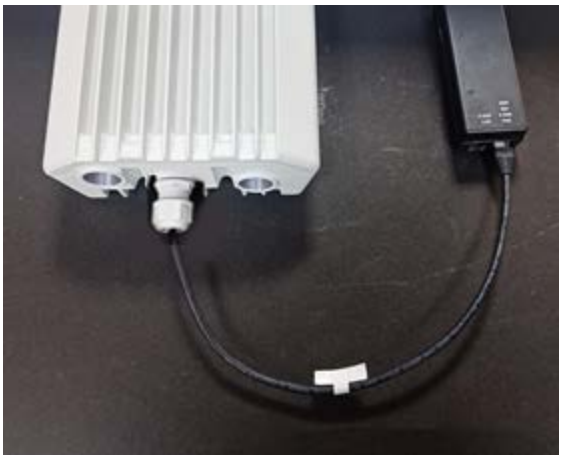
1. Connect the input side of the DC power injector to the AC power line.

   Figure 104: *60W DC power injector*



2. Connect 5 Gbe LAN port of the power injector to network equipment.
3. Connect 60 W 56V 5 GbE PoE port of the power injector to ODU drop cable.

   Figure 105: *Connecting the power injector to ODU drop cable*



Installing the AC/DC PSU

1. Connect the input side of the AC/DC PSU to the AC power line.
2. Connect output side of DC PSU to ODU through cable joiner and DC mini adapter. Refer to the Cable joiner section for connecting, installing cable joiner and mini adapter.

Figure 106: *AC/DC PSU (N000000L179B)*

Figure 107: *Cable joiner*

Figure 108: *DC to RJ45 plug, Mini adaptor*

Figure 109: *AC/DC powering diagram*

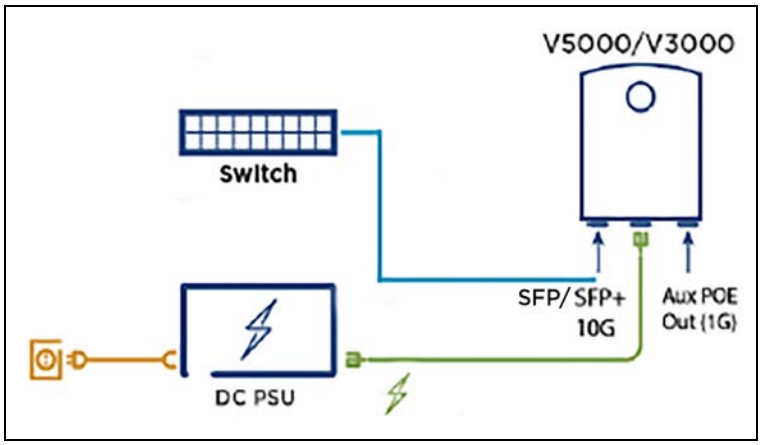


Figure 110: *AC/DC PSU*

For detailed assembly of cable joiner and mini adapter to ODU PSU port, refer to the Cable joiner section.

Note

Both short and long glands can be used to connect to outdoor PSU.

Installing the V1000 power injector

1. Connect the 56V Gigabit Data + power port to ODU and Gigabit data port to the network equipment.

Figure 111: *V1000 power injector*

Figure 112: *V1000 powering diagram*

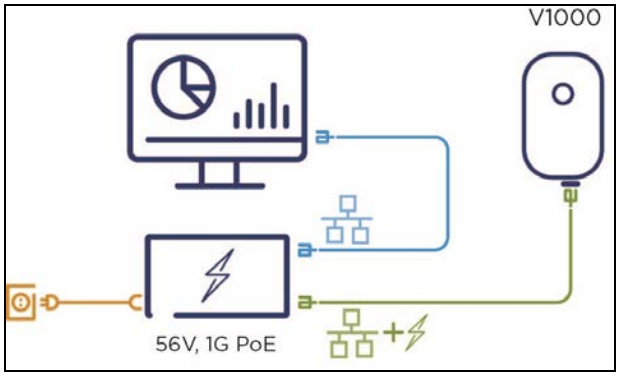


Figure 113: *Connecting the V1000 power injector*

Connecting to the SFP+ optical module or SFP+ to the copper module to ODU

When ODU is powered through AC/DC PSU, an optical or copper Cat6A Ethernet interface can be connected to the SFP port of the ODU for the data interface.

Adapt the installation procedures in this section as appropriate for SFP interfaces, noting the following differences from a PSU interface.

Fitting the long cable gland

Optical SFP interface: Disassemble the long cable gland and thread its components over the LC connector at the ODU end as shown below.

Copper CAT6A SFP interface: Disassemble the cable gland and thread its components over the RJ45 connector at the ODU end.

1. Disassemble the long cable gland used for the optical SFP interface.

   Figure 114: *Disassembling the long cable gland - optical SFP interface*

   You must also disassemble the long cable gland used for the copper SFP interface.

   Figure 115: *Disassembling the long cable gland - copper SFP interface*

2. Thread each part onto the cable (the rubber bung is split).

   Figure 116: *Threading the part onto the cable*

3. Fit the parts into the body and lightly screw on the gland nut (do not tighten it).

   Figure 117: *Fixing parts to the gland*

   Optical

   Copper

Inserting the SFP module

To insert the SFP module into the ODU, follow the below steps:

1. Remove the blanking plug from the SFP port of the ODU.

   Figure 118: *Removing the blanking plug from the SFP port*

Optical SFP+ module

Copper SFP module

2. Insert the SFP module into the SFP receptacle with the label on the bottom.

   Figure 119: *Inserting the SFP module*

Optical

Copper

3. Push the module home until it clicks into place.

Figure 120: *Pushing the module home*

Optical

Copper

4. Rotate the latch to the locked position.

Figure 121: *Rotating the latch*

Optical

Copper

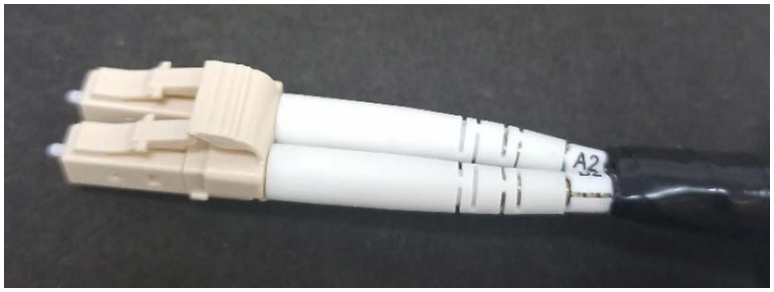
Connecting the cable

Attention

The Fiber optic cable assembly is very delicate. To avoid damage, handle it with extreme care. Ensure that the fiber optic cable does not twist during assembly, especially when fitting and tightening the weatherproofing gland. Do not insert the power over Ethernet drop cable from the PSU into the copper SFP module, as this will damage the module.

1. Remove the LC connector dust caps from the ODU end (optical cable only).

Figure 122: *Removing the LC connector dust caps*



2. Plug the connector into the SFP module, ensuring that it snaps home.

   Figure 123: *Plugging the connector into the SFP module*

Optical

Copper

Fitting the gland

1. Fit the gland body to the SFP port and tighten it to a torque of 5.5 Nm (4.3 lb-ft).

   Figure 124: *Fitting the land body*

2. Fit the gland nut and tighten until the rubber seal closes on the cable. Do not over-tighten the gland nut, as there is a risk of damage to its internal components.

Figure 125: *Fitting the gland nut*

3. Fit the gland nut to the rubble seal on the gland body and tighten it to a torque of 5.5 Nm (4.3 lb-ft).

Figure 126: *Fitting the gland nut to the rubble seal*

Removing the cable and SFP module

Do not attempt to remove the module without disconnecting the cable, otherwise, the locking mechanism in the ODU will be damaged.

1. Remove the cable connector by pressing its release tab before pulling it out.

   Figure 127: *Removing the cable connector*

Optical

Copper

2. Pull the bale clasp (latch) to the unlocked position. Extract the module by using a screwdriver.

   Figure 128: *Pulling the bale clasp (latch)*

Optical

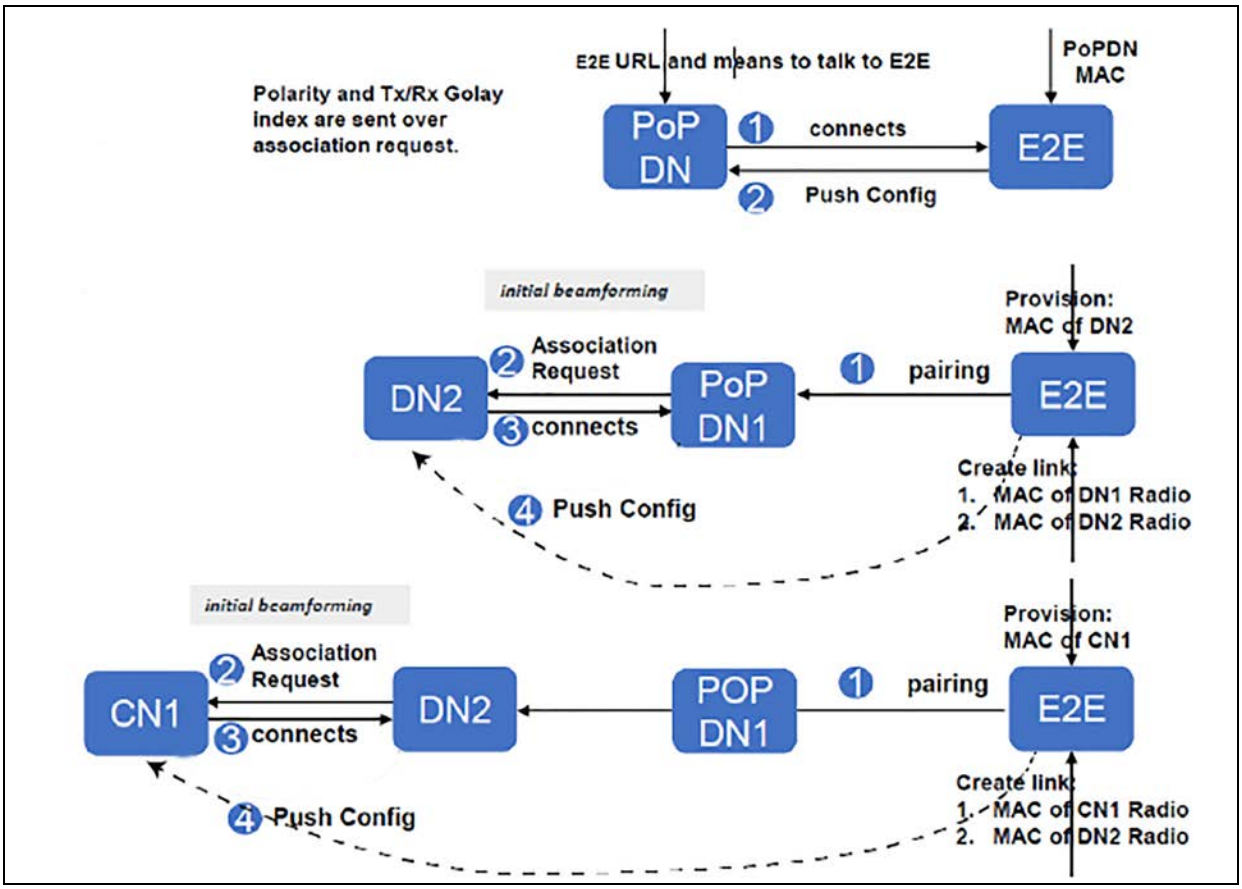
Copper

Configuring 60 GHz cnWave

Deploying nodes

The configuration of cnWave nodes is handled automatically by the E2E service. However, the first PoP node must be configured manually since connectivity to the E2E controller has not yet been established. After establishing communication with the E2E controller, the nodes report a hash of their local configuration file, and the controller automatically pushes configuration changes to the nodes upon seeing any mismatches. Centralized configuration management architecture implemented in which the E2E controller, serves as the single point of truth for configurations in the network.

Figure 129: *Node deployment*



Connecting to the unit

This section describes how to connect the unit to a management PC and power it up.

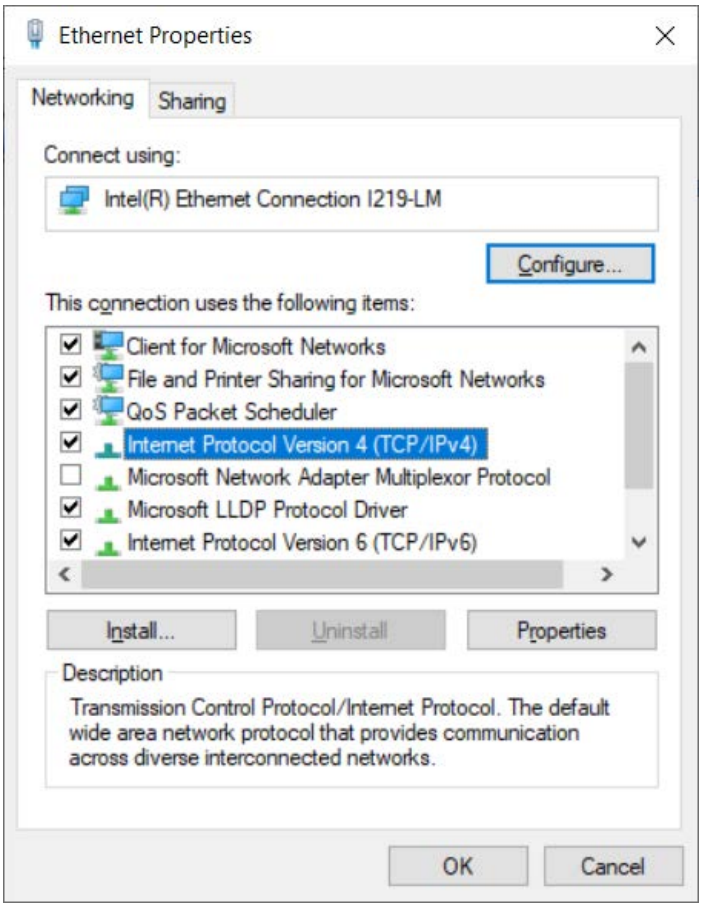
Configuring the management PC

Use this procedure to configure the local management PC to communicate with the 60 GHz cnWave devices.

Procedure:

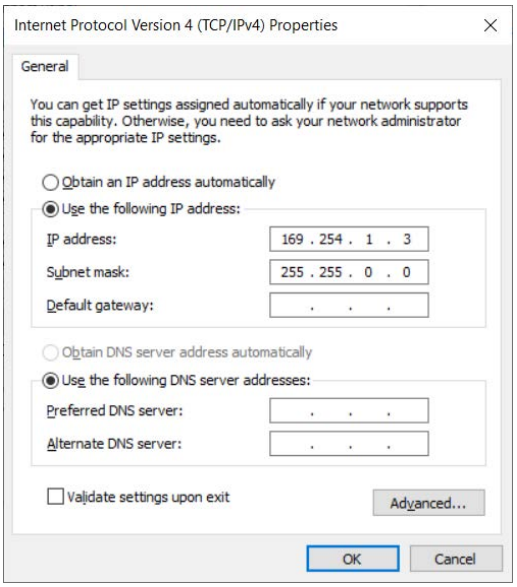
1. Select **Properties** for the Ethernet port. In Windows 7 this is found in **Control Panel** > **Network and Internet** > **Network Connections** > **Local Area Connection**.
2. Select **Internet Protocol Version 4 (TCP/IPv4)**.

   Figure 130: *The Ethernet Properties dialog box*



3. Click **Properties**.
4. Enter an IP address that is valid for the 169.254.X.X/16 network, avoiding 169.254.1.1 (eg: 169.254.1.3).

Figure 131: *The Internet Protocol Version 4 (TCP/IPv4) dialog box*



5. Enter a subnet mask of 255.255.0.0. Leave the default gateway blank.

Connecting to the PC and powering up

Use this procedure to connect a management PC and power up the 60 GHz cnWave devices.

Procedure:

1. Check that the ODU is connected to the power supply (AC/DC according to the configuration).
2. Connect the PC Ethernet port to the LAN port of the PSU or AUX port (according to device configuration).
3. Open a web browser and type: **169.254.1.1**.
4. When prompted, enter **admin/admin** to login to the GUI and complete the configuration.

Using the web interface

This section describes how to log into the 60 GHz cnWave web interface and use its menus.

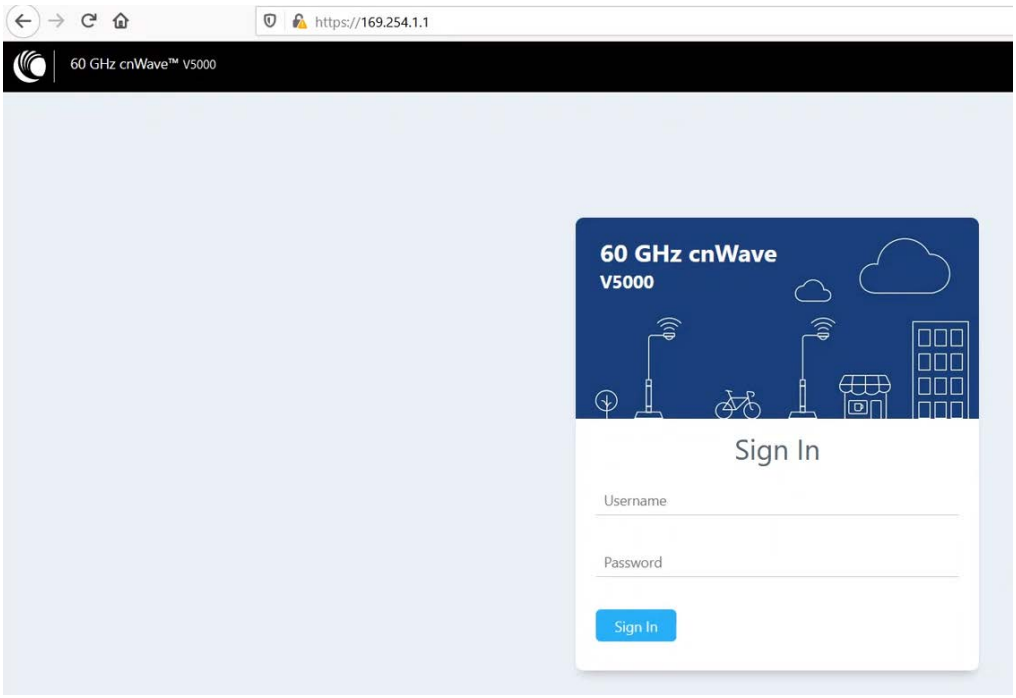
Logging into the web interface

Use this procedure to log into the web interface as a system administrator.

Procedure:

1. Start the web browser from the management PC.
2. Type the IP address of the unit into the address bar. The factory default IP address is **169.254.1.1** and press **Enter**.

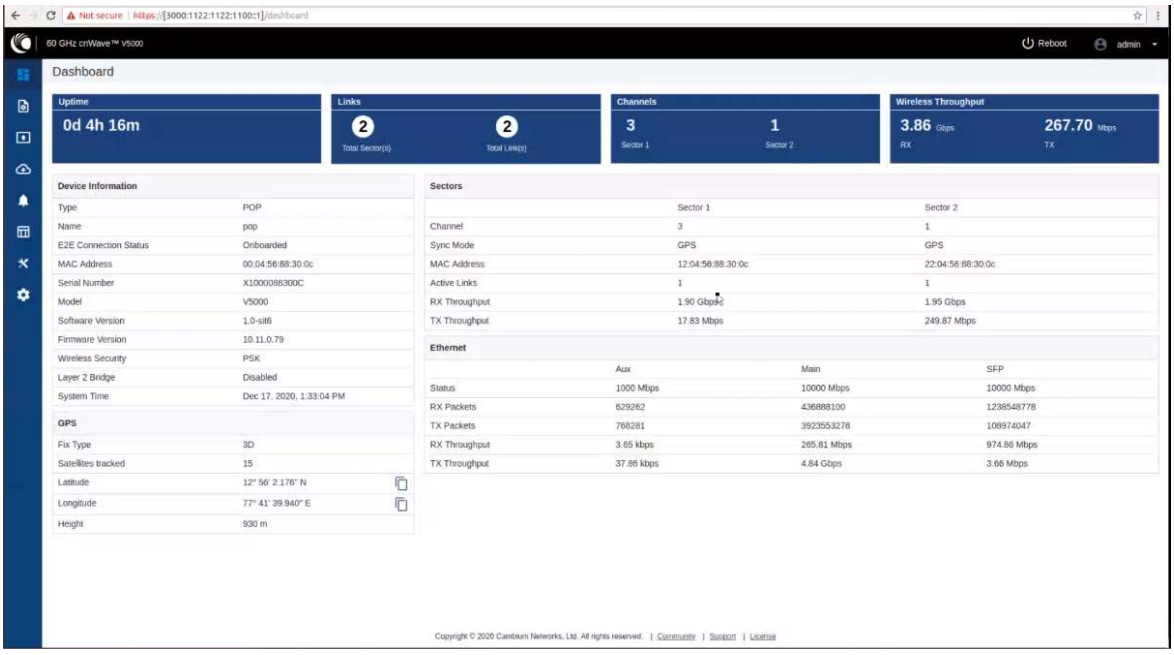
Figure 132: *The Sign In page*



3. Type the username and password as **admin** and **admin**. Click **Sign In**.

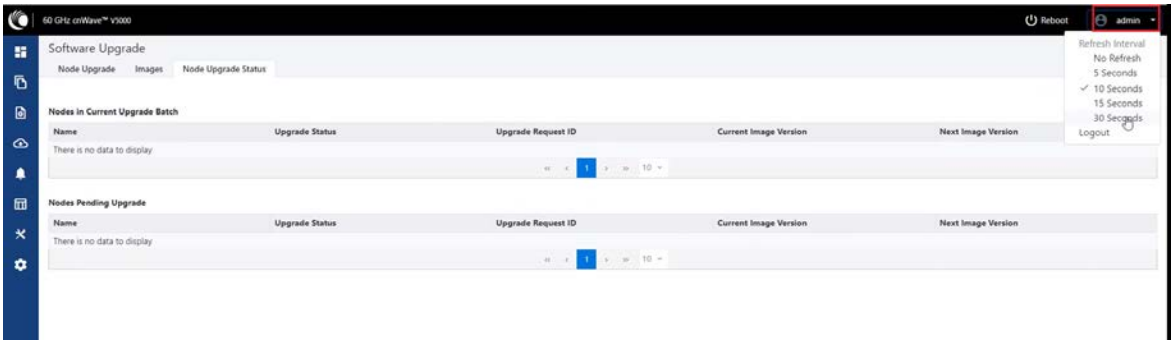
   The **Dashboard** page appears.

Figure 133: *The main dashboard page*



Users can select the refresh time interval. Click **admin** at the top-right and select **Refresh Interval** from the drop-down list.

Figure 134: *The Refresh Interval option*



The Dashboard contains the following options at the top:

- Uptime
- Links
- Channels
- Wireless Throughput

Uptime

Displays the total running time of the device.

Links

Displays the total number of active links which are connected to the 60 GHz cnWave device.

Channels

Displays the total number of channels (such as Sector 1 and Sector 2) which are connected to the 60 GHz cnWave device.

Wireless Throughput

Displays the transmitting and receiving throughput values.

Dashboard elements

Dashboard home page consist of the below elements:

- Device Information
- GPS
- Sectors
- Ethernet

Figure 135: *Dashboard - Device Information*

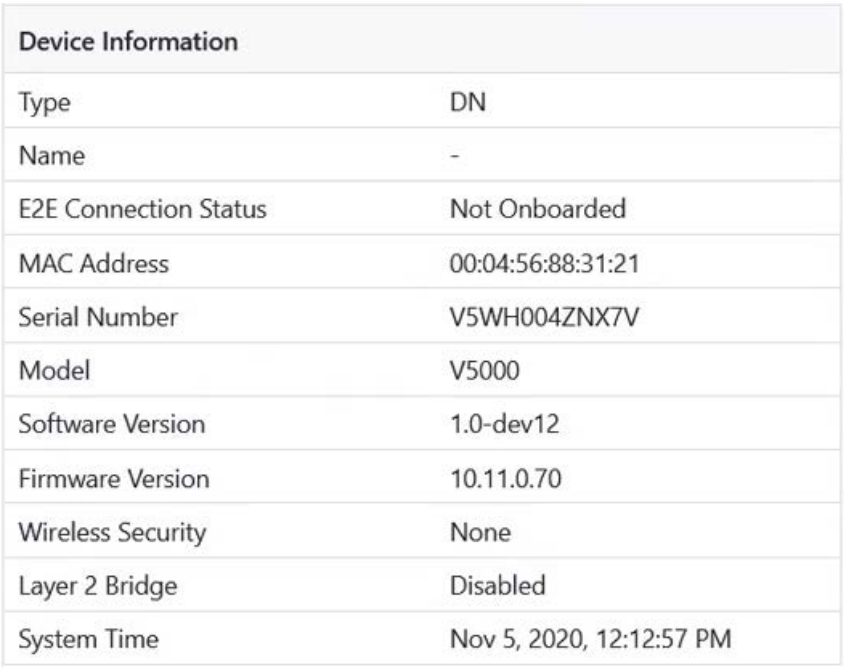


Table 31: Elements in the Device Information section

Element	Description
Type	Displays type of the device. The device types are: • DN • PoP DN • CN
Name	Displays name of the device.
E2E Connection Status	Displays the connection status of the E2E controller.
MAC address	Displays the MAC address of the 60 GHz cnWave device.
Serial Number	Displays the serial number of the 60 GHz cnWave device
Model	Displays the model of the 60 GHz cnWave device. The models are: • V1000 • V3000 • V5000
Software version	Displays the software version used in 60 GHz cnWave device.
Firmware version	Displays the Firmware version used in 60 GHz cnWave device.
Wireless security	Displays the security type. The types are: • Disabled

Element	Description
	• PSK • 802.1X
Layer 2 Bridge	Displays bridge status.
System Time	Displays current time.

GPS

GPS table displays the positioning information of the site.

Figure 136: *Dashboard - GPS*

Table 32: Elements in the GPS section

Element	Description
Fix Type	Fix Type
Satellites tracked	Number of registered satellites
Latitude	Displays latitude of the site
Longitude	Displays longitude of the site
Height	Displays height of the device

Sectors

Sectors table displays the number of nodes added to the device and its information.

Figure 137: *Dashboard - Sectors*

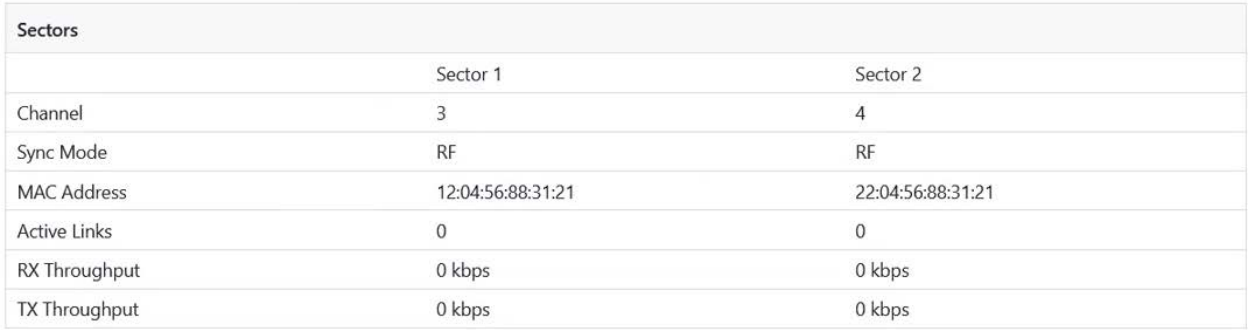


Table 33: Elements in the Sectors section

Element	Description
Channel	Displays the channel information used by the sector
Sync mode	Displays the sync mode of the sectors
MAC address	Displays the MAC address of the sectors
Active links	Displays the number of active links in connected sectors
RX Throughput	Displays RX Throughput of the individual sectors
TX Throughput	Displays TX Throughput of the individual sectors

Ethernet

Ethernet table displays the information about Aux, Main, and SFP ports.

Figure 138: *Dashboard - Ethernet*

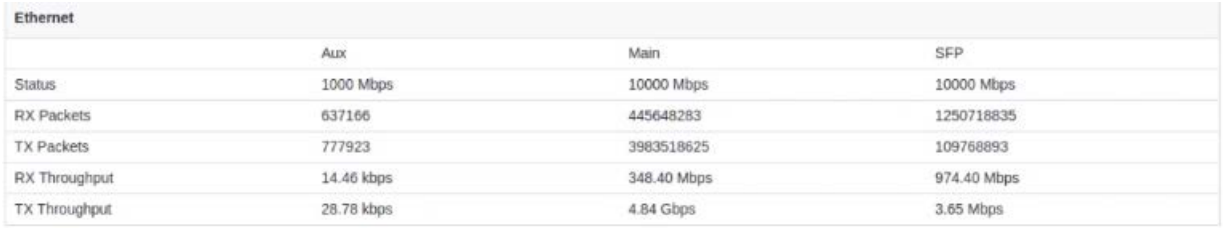


Table 34: Elements in the Ethernet section

Element	Description
Status	Displays the speed of Ethernet ports
RX Packets	Number of packets received
TX Packets	Number of packets transmitted
RX Throughput	Displays the RX Throughput of the Ethernet
TX Throughput	Displays the TX Throughput of the Ethernet

Enabling internal E2E Controller

E2E Controller handles important management functions such as link bring-up, software upgrades and configuration management, etc. Enable E2E Controller to configure and establish the connection. To enable E2E Controller, perform the following steps:

Note

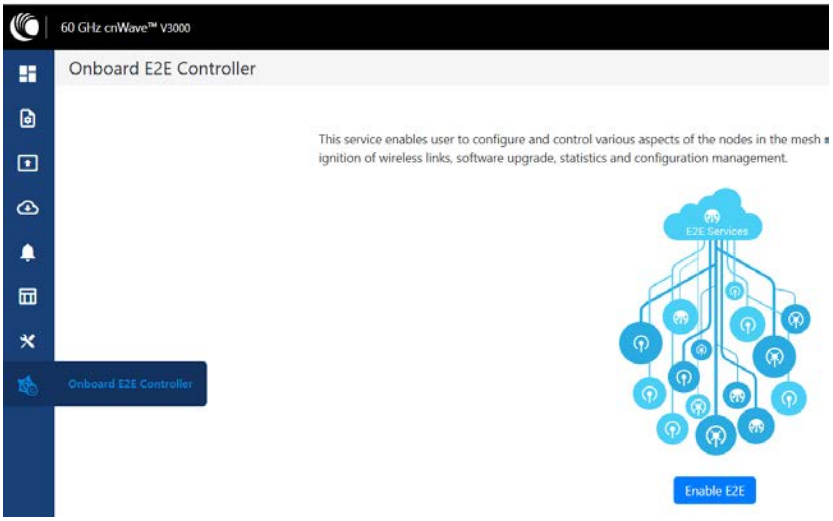
The internal E2E controller is not required if you intend to tun the E2E controller On-Premise (refer *E2E User Guide*) .

The internal E2E controller is restricted to 21 node.

1. Click the **E2E Controller** option on the left pane of the Dashboard.

   The Onboard E2E Controller page appears.

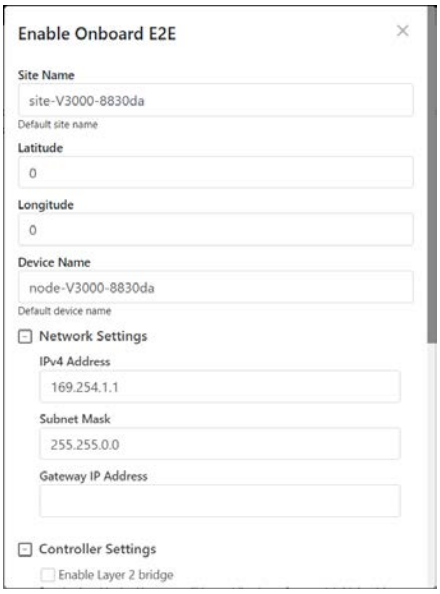
   Figure 139: *The Onboard E2E Controller page*



2. Click **Enable E2E**.

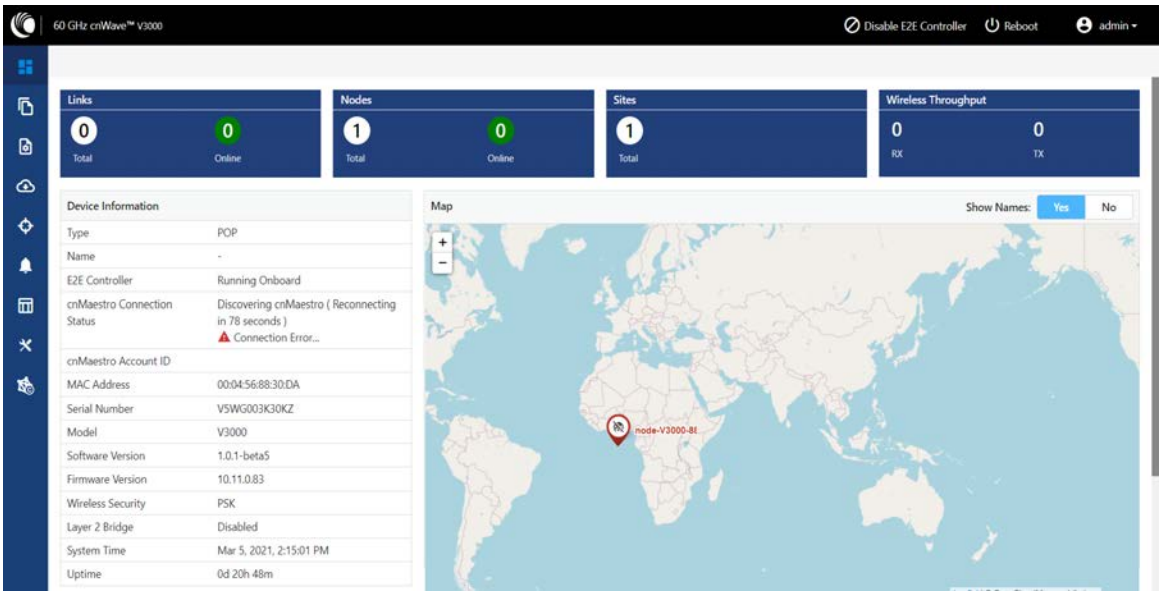
   The **Enable Onboard E2E** dialog box appears.

   Figure 140: *The Enable Onboard E2E dialog box*



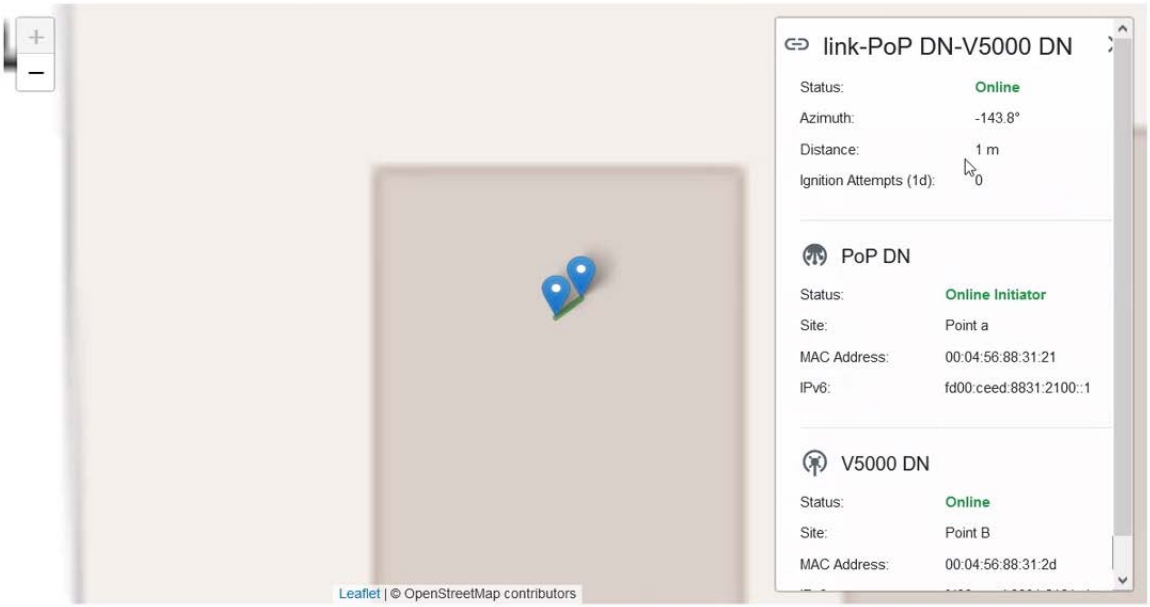
3. Enter the required details and click **Enable**.
4. After enabling E2E Controller, the dashboard displays the links which are connected to the device.

Figure 141: *Dashboard*



You must right-click on the site pin to see more information about the site.

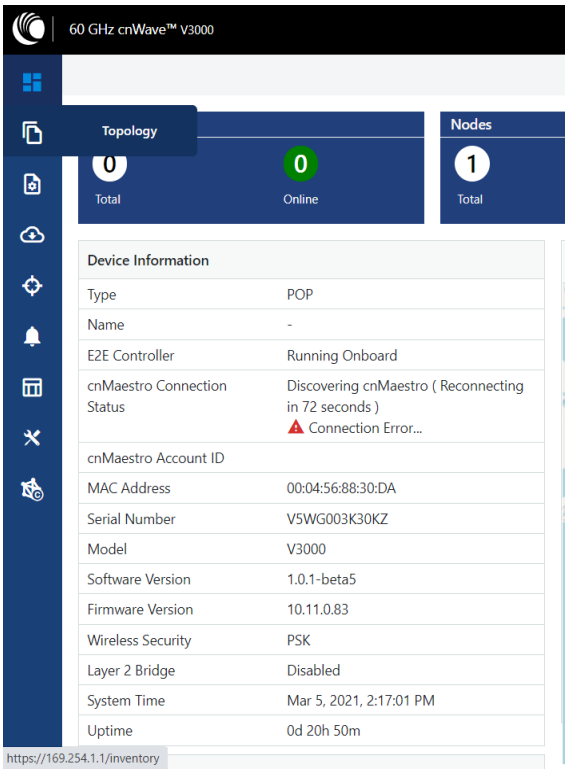
Figure 142: *Viewing site details*



Topology

After enabling E2E Controller, add Sites, Nodes and Links to establish the connection. Click **Topology** at the left-pane.

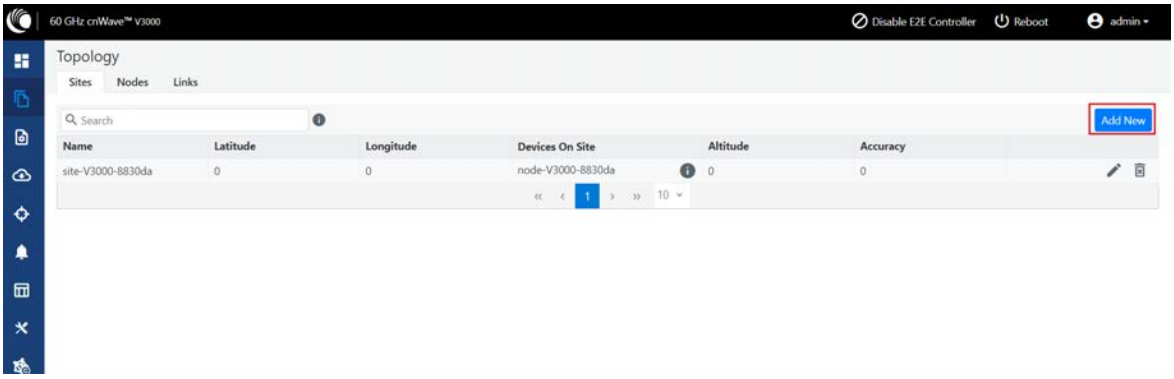
Figure 143: *Topology menu*



To add sites, nodes and links, perform the below steps:

1. Click **Sites** on the top and click **Add New** to add a new site.

   Figure 144: *The Sites page*

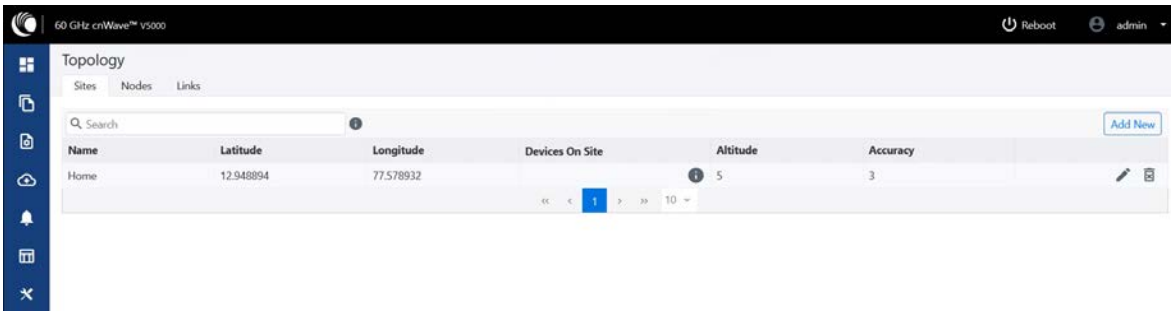


2. Enter the Name, Latitude, Longitude, Altitude, Accuracy information, and click **Save**.

Figure 145: *The Add Site dialog box*

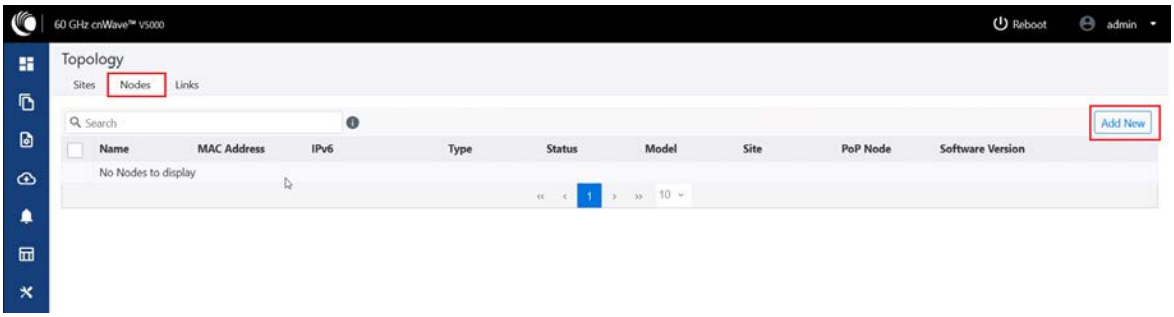
A new site is added to the topology.

Figure 146: *The updated Sites page*



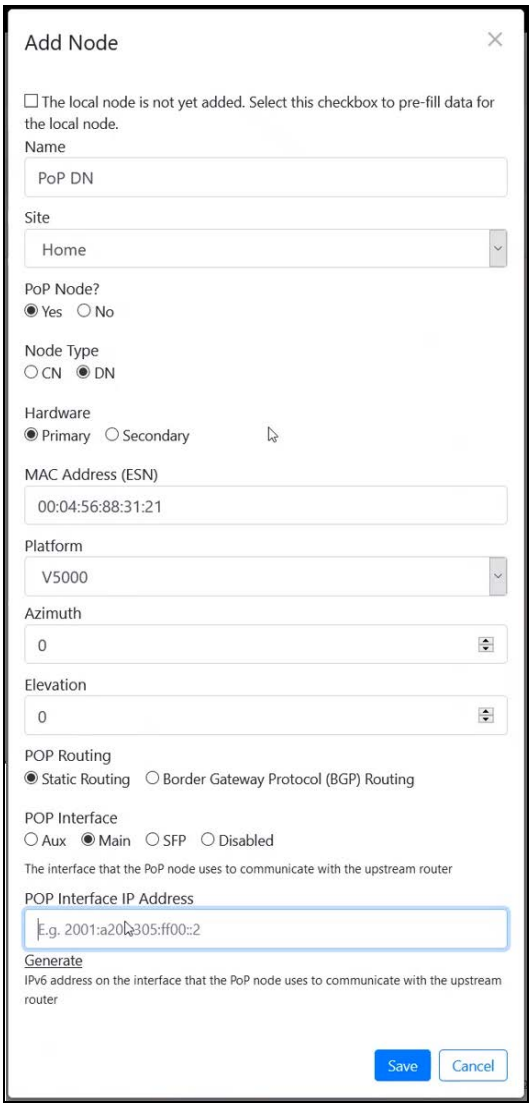
3. Click **Nodes** at the top and click **Add new**.

Figure 147: *The Nodes page*



4. Enter the required information and click **Save**.

Figure 148: *The Add Node dialog box*

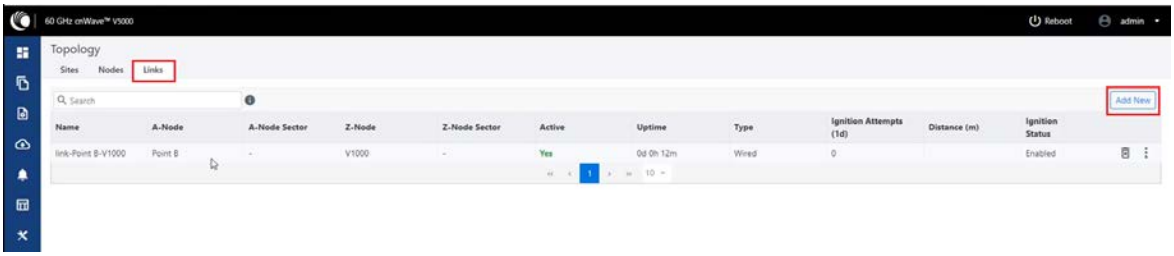


Note

For the first node, select **Yes** under **PoP Node** and select **Primary** under **Hardware** for primary node that is added after PoP node.

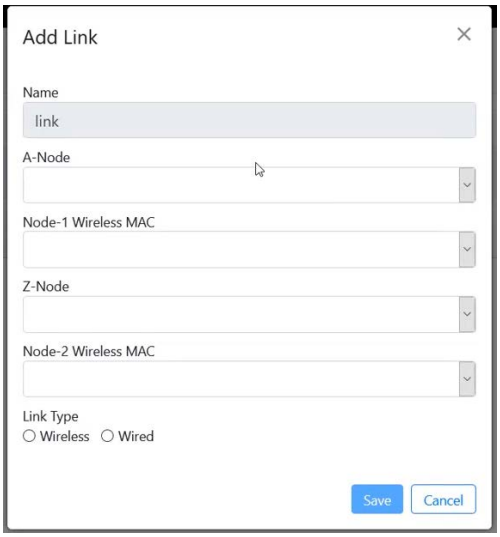
5. Click **Links** on the top and click **Add New**.

Figure 149: *The Links page*



Select nodes of the links, which form the sectors, and click **Save**.

Figure 150: *The Add Link dialog box*



Support for renaming nodes

A node can be renamed in the topology. To rename the node, perform the following steps:

1. Navigate to **Topology** > **Nodes**.
2. Select the required node, click ⋮, and select **Edit Node**.
3. Rename the node and click **Save**.

Figure 151: *The Edit Node dialog box*

Configuration

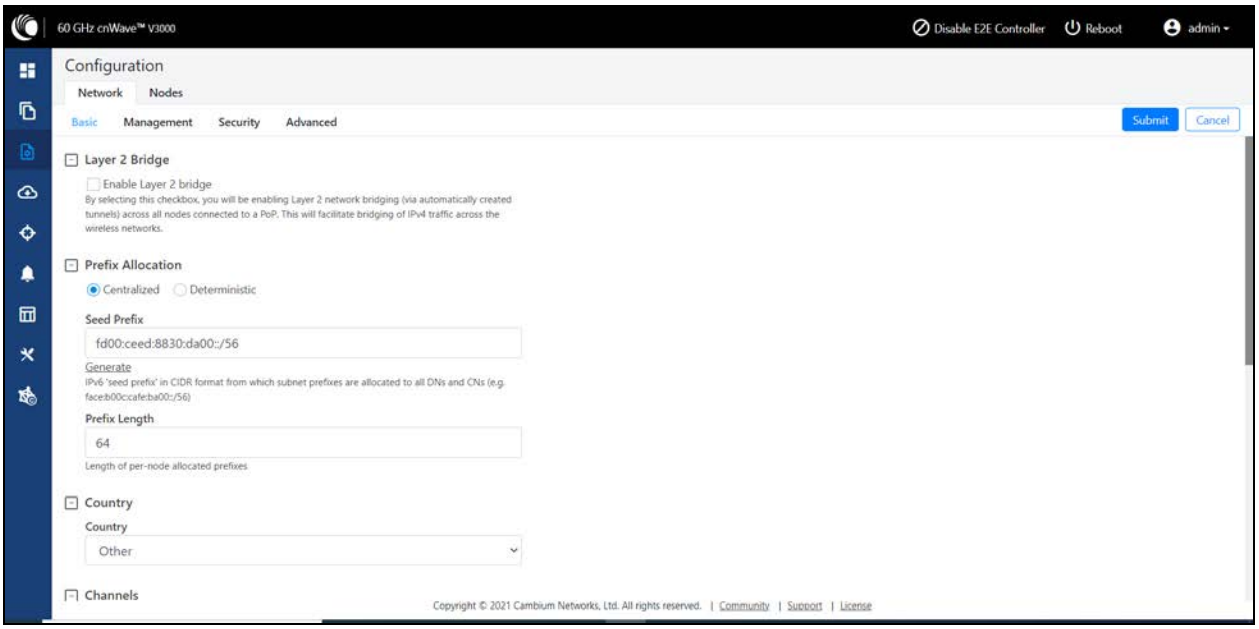
The **configuration** page contains the following two configuration options:

- Network configuration
- Node configuration

Network configuration

Network configuration is used to configure the network. User can modify the network settings. It has **Basic, Management, Security** and **Advanced** options for the configuration. Settings under **Network** apply to all the nodes in the network. Some apply to the **E2E Controller**. Enter the required information and click **Submit** to configure the network.

Figure 152: *The Network page with multiple tabs*



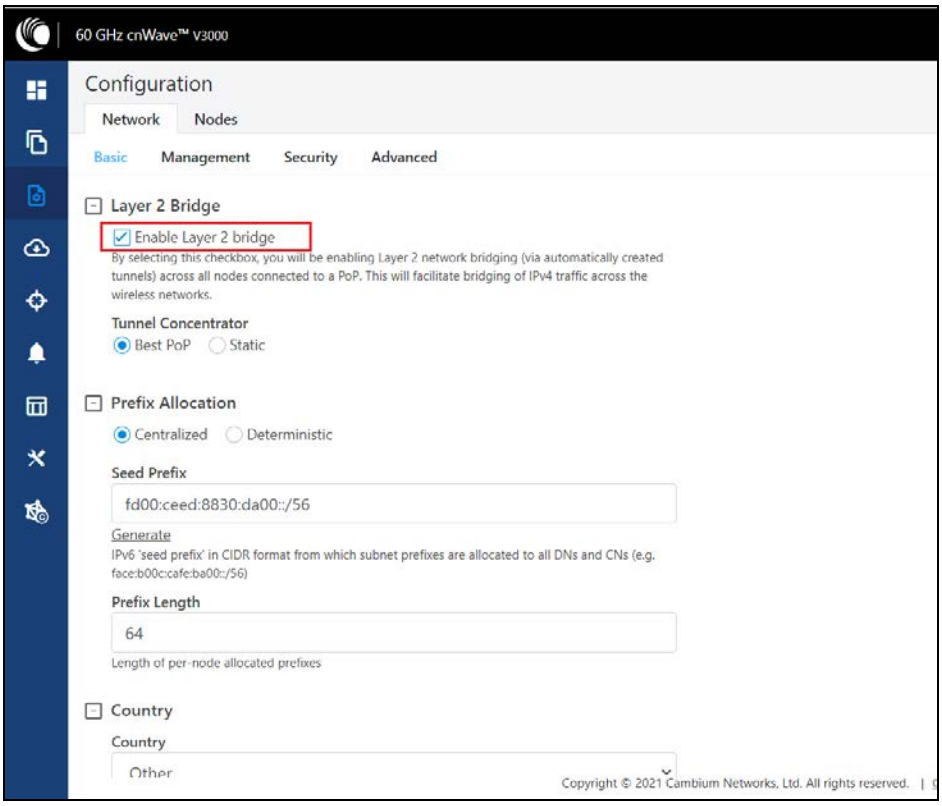
The **Network** page contains the following tabs:

- Basic tab
- Management tab
- Security tab
- Advanced tab

Basic tab

1. By default, cnWave is an IPv6-only network. By selecting this checkbox, Layer 2 network bridging is enabled (via automatically created tunnels) across all nodes connected to a PoP. This facilitates the bridging of IPv4 traffic across the wireless networks.

Figure 153: *The Layer 2 Bridge section in the Basic page*



The **Tunnel Concentrator** does encapsulation and de-encapsulation of GRE packets. If **Best PoP** is selected, then the node selects the best PoP as a Concentrator. If **Static** is selected, then the user can configure the external Concentrator that can be Linux machine/router/PoP.

2. Click **Generate** under **Prefix Allocation** to generate a unique local seed prefix automatically.

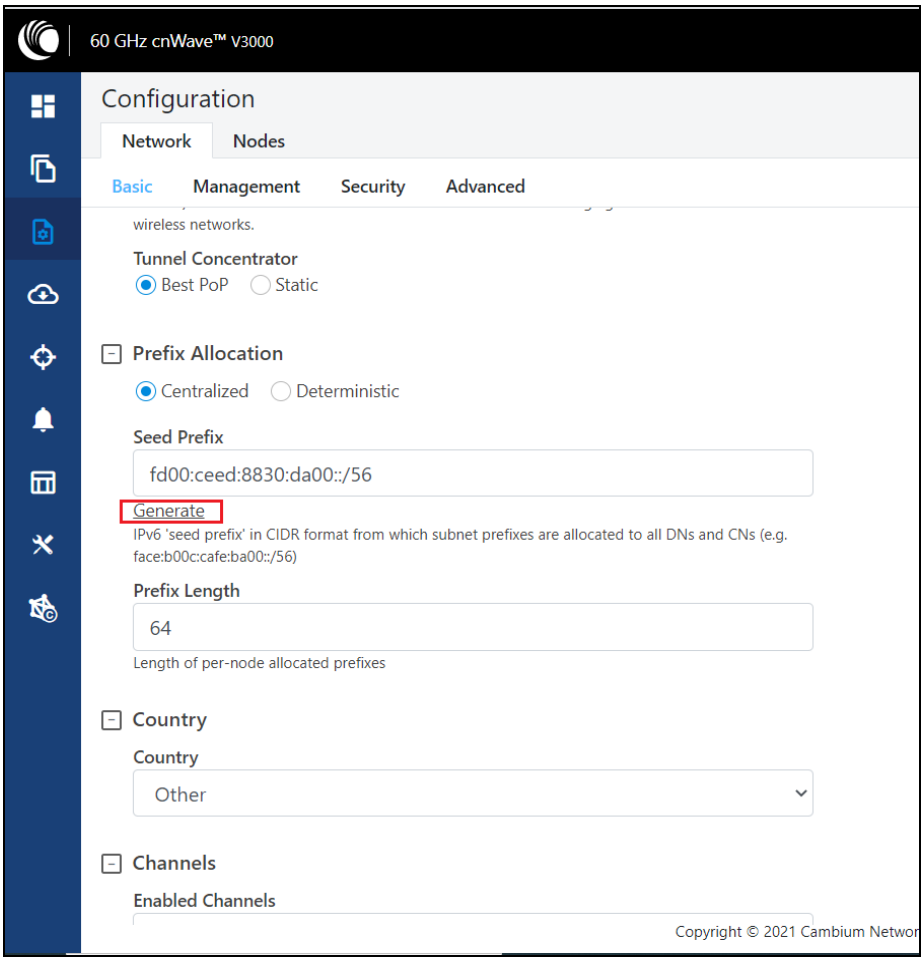
   cnWave networks are given an IPv6 **seed prefix** (e.g. face:b00c:cafe:ba00::/56) from which subnet prefixes are allocated to all DNs and CNs. There are two methods for allocating node prefixes with Open/R.

Note

PoP interface IPv6 address and seed prefix should not be in the same /64 prefix range to avoid the address conflict.

- **Centralized (default)** - Centralized prefix allocation is handled by the E2E controller. The controller performs all prefix allocations, which prevents collisions and enables more sophisticated allocation algorithms. This is recommended for single PoP networks
- **Deterministic** - Deterministic prefix allocation is also handled by the E2E controller. The controller assigns prefixes to nodes based on the network topology to allow PoP nodes to take advantage of route summarization and help load balance ingress traffic. This is recommended for multi-PoP networks.

Figure 154: *The Prefix Allocation section*



- **Seed Prefix**

  The prefix of the entire cnWave network, is given in CIDR notation.

3. Select **Prefix Length, Country, Channels, DNS Servers**, and **Time zone** from the drop-down.

   Prefix Length

   Specifies the bit-length of prefixes allocated to each node.

   Country

   Country for regulatory settings like EIRP limit, allowed channels.

   Channels

   The comma separates the list of channels given to the controller for auto-configuration. Manual settings in **Node > Radio** page do not depend on this setting. This setting is useful especially for PTP and small meshes that use a single channel for the entire network. In such cases, set the required channel here and do not override in the **node > Radio** page. Changing this setting alone does the channel change, .

   DNS Servers

DNS server list is used for :

- Resolution of NTP Server host name (can be IPv4 when Layer 2 bridge is enabled)
- Given to IPv6 CPE as part of router advertisement

Time Zone

Time zone for all the nodes. System time in the dashboard, time field in the Events section, Log files use this timezone.

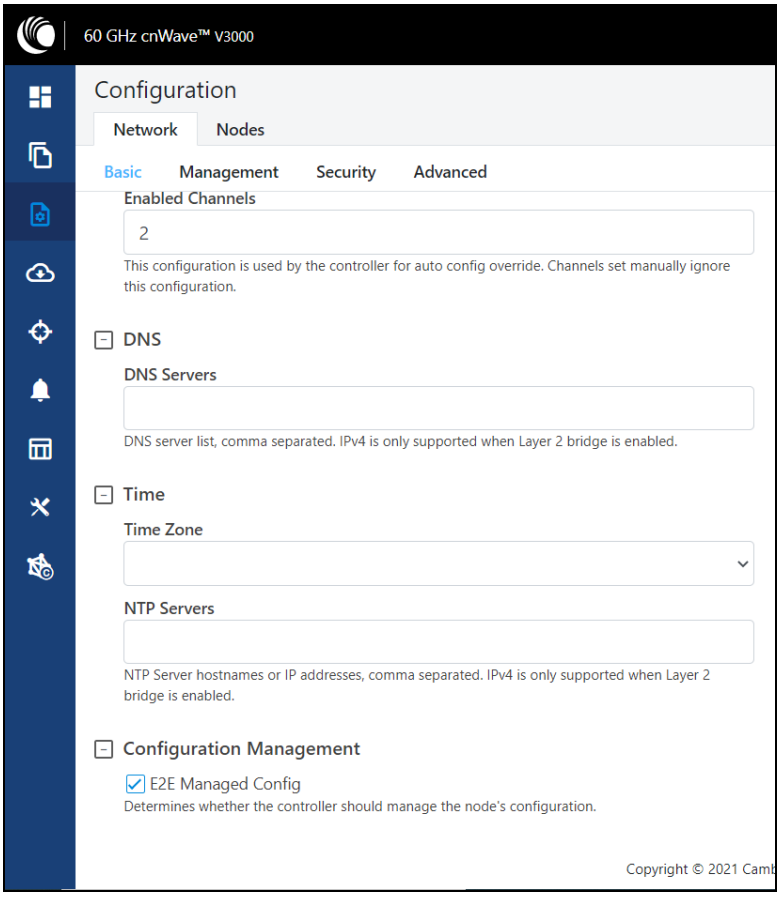
NTP Servers

This is NTP Server FQDN or IP Address. All nodes use this NTP Server to set the time. Node time is important when 802.1X radius authentication is used as it requires certificate validation. The time is reflected in the dashboard, time field in the Events section, and Log files .

4. Enable **E2E Managed Config**.

   E2E Managed Config determines whether the controller manages the node's configuration. It is highly recommended to keep it **enabled**.

   Figure 155: *The E2E Managed Config section*



5. **Wireless Scans (Scheduled Beam Adjustment)** - This feature runs a PBF scan at every defined Scan Interval. Navigate to **Configuration** > **Network** > **Basic** > **Wireless Scans** to run a PBF scan.

The 60 GHz cnWave products can align the wireless link within an azimuth/elevation range by selecting from a number of fixed beams.

A normal scan without Scheduled Beam Adjustment does the following operations:

- Beam selection occurs only on wireless link acquisition.
- Disassociating and re-associating the link or otherwise causing the link to drop and re-acquire is needed to perform a new beam selection.
- Any degradation in the wireless conditions does not trigger a new beam selection unless the link drops and reacquires.

The advantages of the Scheduled Beam Adjustment scan are:

- If the link is to acquire during heavy rain, then the optimal beam at that time may be suboptimal when the weather changes.
- If snow accumulation is present on the unit during acquisition, the optimally selected beam may be different when the snow has melted.
- Network-wide ignition in a dense deployment can cause interference when multiple nodes are acquiring. This interference can cause sub-optimal beam selection.
- Any physical change to alignment that is not severe enough to cause a link drop and subsequent beam scan can be corrected for.

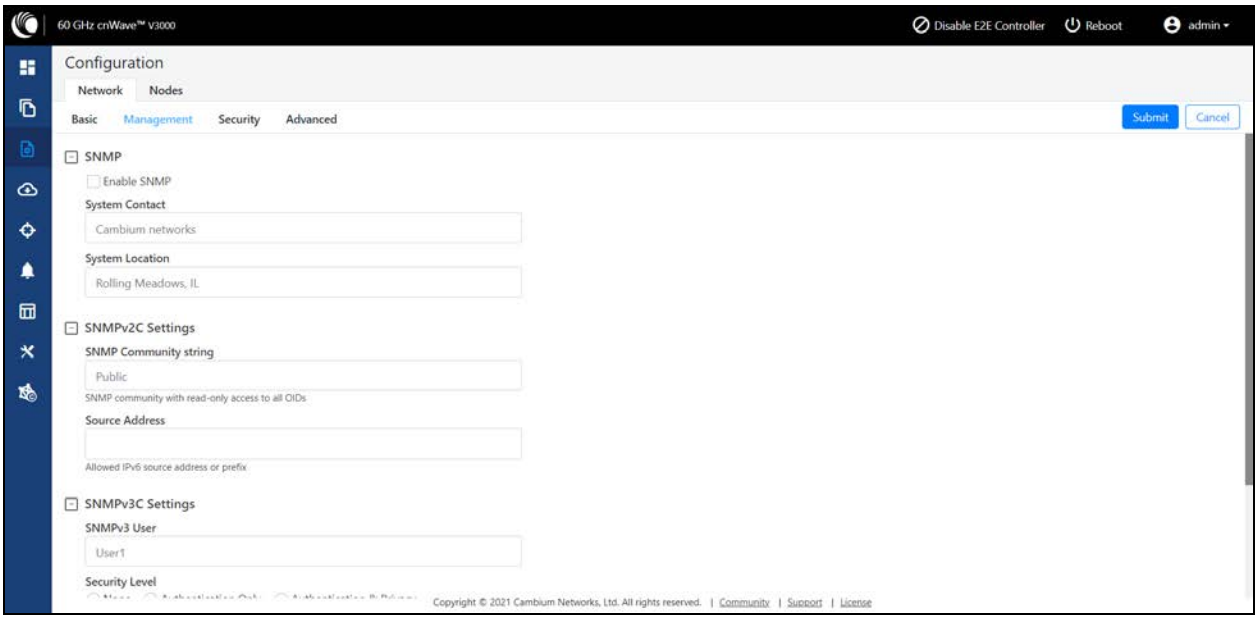
The cost of Scheduled Beam Adjustment is:

- This feature causes a network-wide outage of approximately **two minutes**. For this reason, unless there is a specific issue being addressed, it is recommended to either disable this feature or configure an interval of >=24 hours.
- Simple deployments (especially PTP links) without significant external factors such as snow may not benefit from regular beam adjustment.

Management tab

Click **Management** and select SNMP, SNMPv2 Settings, SNMPv3 Settings, GUI Username and password.

Figure 156: *The Management page*

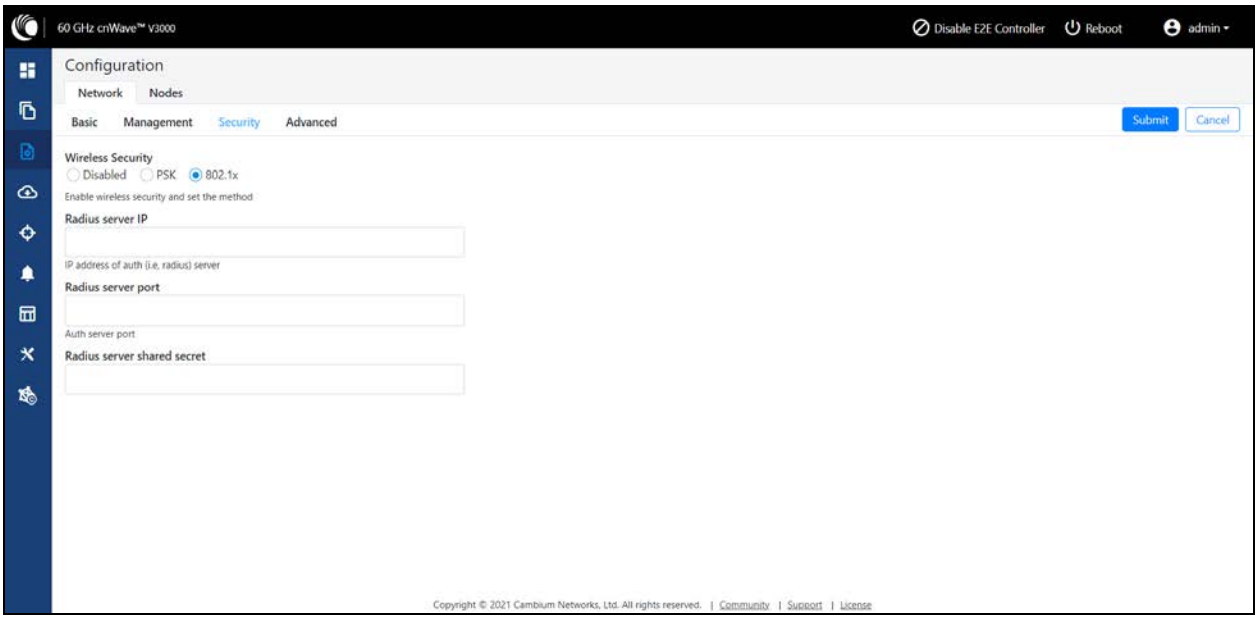


- **Enable SNMP** - Statistics can be read from the nodes using SNMP. This setting enables SNMP.
- **System Contact** - Sets the contact name as the System.sysContact.0 MIB-II variable.
- **System Location** - Sets the location name as the System.sysLocation.0 MIB-II variable.
- **SNMP Community string** - Read only SNMP community string
- **Source address** - When specified, SNMP queries are allowed from the hosts belonging to this IPv6 prefix.
- **User Passwords** - Password for the GUI users can be configured here. The monitor is a read only user.

Security tab

Security tab contains **Disabled**, **PSK**, and **RADIUS Server** options for Wireless Security. Select the required option.

Figure 157: *The Security page*



Wireless Security

- **Disabled** - there is no wireless security.
- **PSK** – WPA2 pre-shared key can be configurable. A default key is used if this configuration is not present. AES-128 encryption is used for data encryption.
- **802.1X** – Nodes are authenticated using radius server and use EAP-TLS. Encryption is based on the negotiated scheme in EAP TLS.

RADIUS Server IP - IPv6 address of radius authentication server.

RADIUS Server port - Radius authentication server port.

RADIUS server shared secret - The shared secret of a radius server.

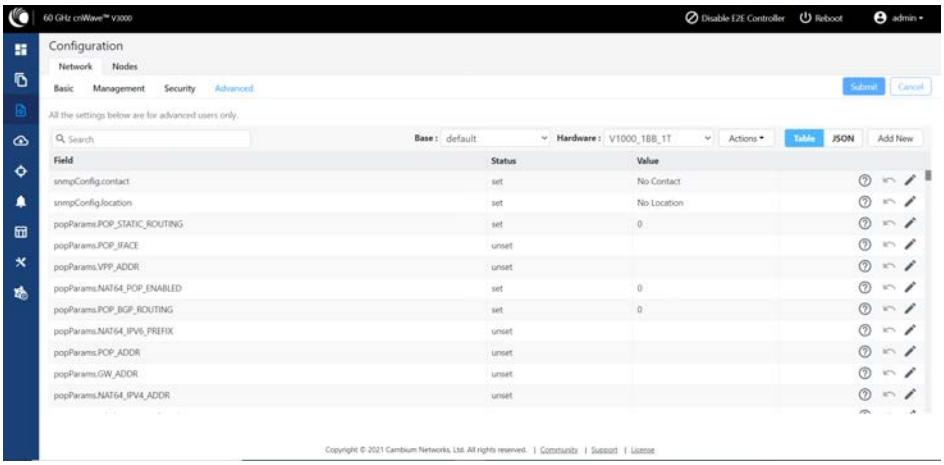
Advanced tab

These settings are for advanced users only. Displays the merged configuration off all layers for a particular node.

Caution

The users are not recommended to do these settings.

Figure 158: *The Advanced page*



Node configuration

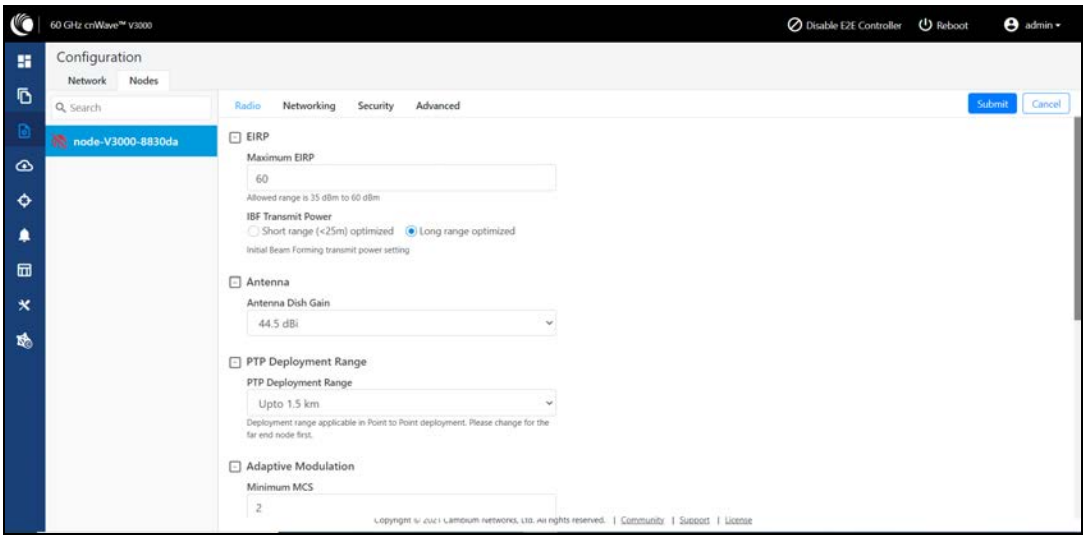
Node configuration is used to configure the nodes via E2E Controller. E2E Controller can modify the node settings. Select the node(Radio) on the left pane to modify the settings. Node configuration contains the following tabs:

- Radio tab
- Networking tab
- VLAN tab
- Security tab
- Advanced tab

Radio tab

These settings apply to individual nodes selected in the left side panel. Select the required options for Transmit Power, Adaptive Modulation, Sector 1, Sector 2 from the drop-down. Enable **Force GPS Disable** to establish the link between indoor nodes.

Figure 159: *The Radio page*



Radio tab contains the following elements:

Table 35: Elements in the Radio page

Elements	Description
Transmit Power	Transmit power of the radio • **Maximum EIRP** - The maximum EIRP transmitted by the radio. Range differs based on the platform and country selected (in the Network page). • **IBF Transmit power** - Transmit power using during initial beam forming. When all the links are in short-range, high transmit power can cause interference. Selecting short-range optimized will prevent this. Post beam forming, automatic power control will make sure the radio transmits at optimal power.
Adaptive Modulation	Select minimum and maximum coding scheme ranging from 2 to 12.
Sector 1	• Select the frequency channel and polarity. • **Channel and Polarity** - When link is created in topology, the controller automatically sets the sector's channel and polarity. To manually override, click the check box and select the channel in the node configuration. Note that changing channel/polarity breaks the link. It is important to change for leaf nodes first and then higher up on DNs.
Sector 1 Link (s) Golay	Golay codes help in avoiding inter-sector interference. In rare scenarios, individual links might require separate Golay codes. In most scenarios, all the links belonging to a sector are configured same Golay code. The controller automatically sets the Golay code. To manually override, select the check box and set the Golay from the drop-down. **Override All** button helps in setting the same Golay code for all the links.

Elements	Description
	Note Golay codes and frequency on both ends of the link should match.
Sector 2	Select the frequency channel and polarity.
Sector 2 Link (s) Golay	Golay code.
GPS	If enabled then, the radio uses internal sync rather than the GPS sync. In some scenarios like lab setups, it may be necessary to disable GPS.

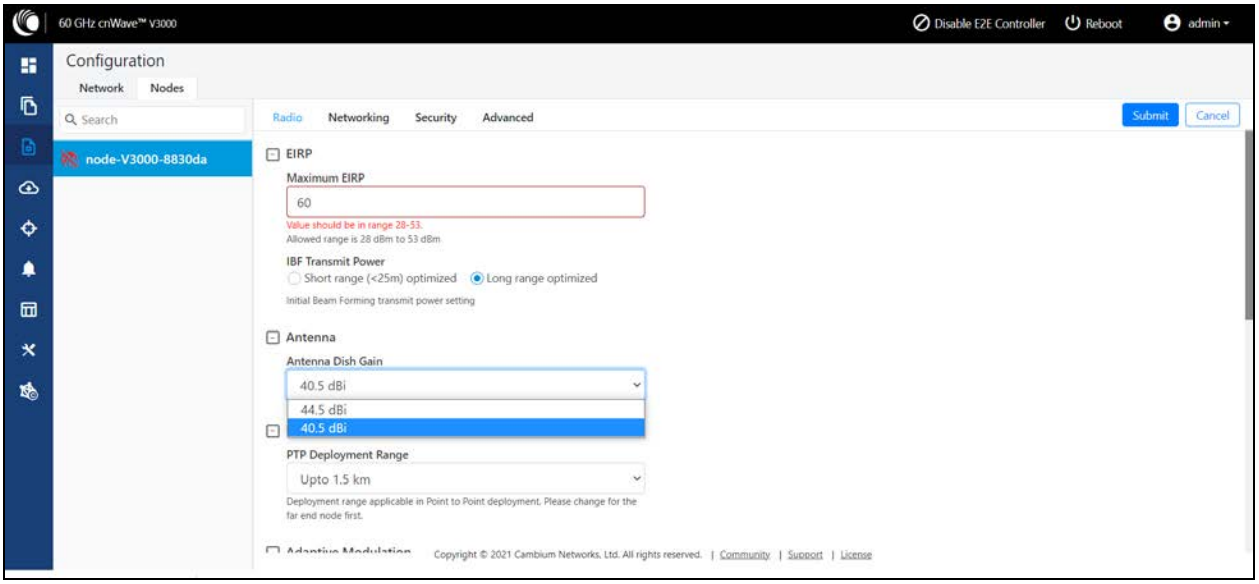
Caution

60 GHz cnWave V1000 and V3000 devices has only **Sector 1**.

V3000 Small dish support

The software allows the selection of smaller 40.5 dBi antenna dish. To select V3000 small dish, navigate to **Configuration** > **Nodes** > **Radio**. The **Antenna** section is available in the Radio page.

Figure 160: *The Antenna section*



Caution

Small dish is supported only for 60 GHz cnWave V3000.

Networking tab

When you navigate to **Nodes** > **Networking** from the home page, the **Networking** page appears.

In the **Networking** page, perform the following steps:

1. Enter the local IPv4 address.

   Figure 161: *The IPv4 Management section in the Networking page*

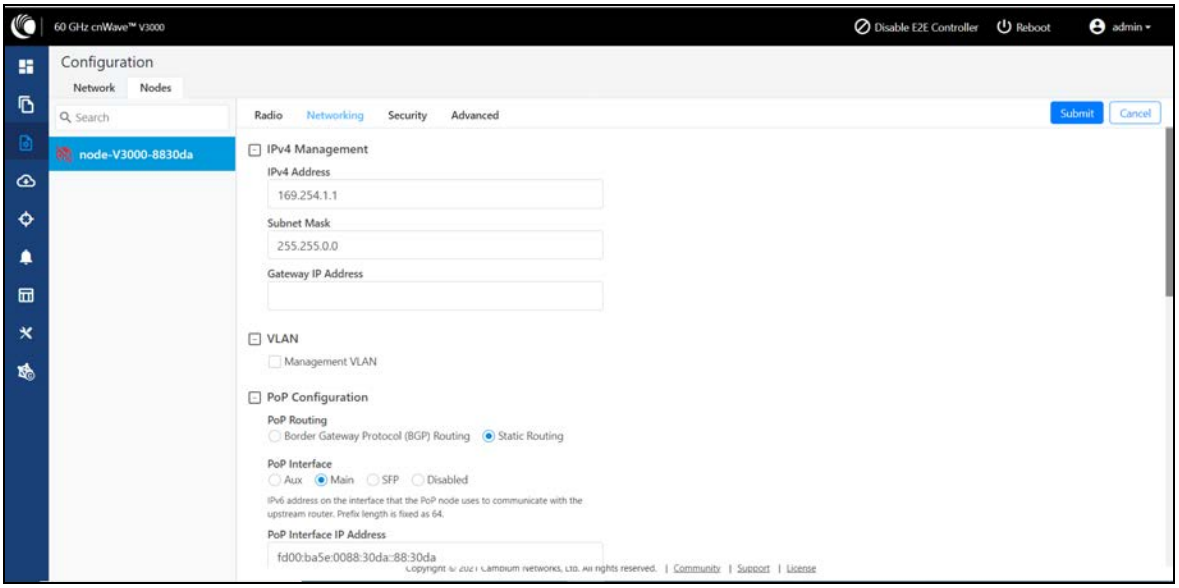


Table 36: Elements in the IPv4 Management section

Elements	Description
IPv4 Address	Static IPv4 address of the individual node. Node's GUI /CLI can be opened using this IP address when directly connected over Ethernet. For Over the air access, L2 Bridge should be enabled. Its predominantly used on PoP nodes with the onboard controller.
Subnet Mask	Subnet mask for the IPv4 address.
Gateway IP Address	IPv4 Gateway address.

2. Under **PoP Configuration**, select the options for **PoP Routing**, **PoP Interface**, and click **Generate** to generate **PoP Interface IP Address**.

Figure 162: *The PoP Configuration section in the Networking page*

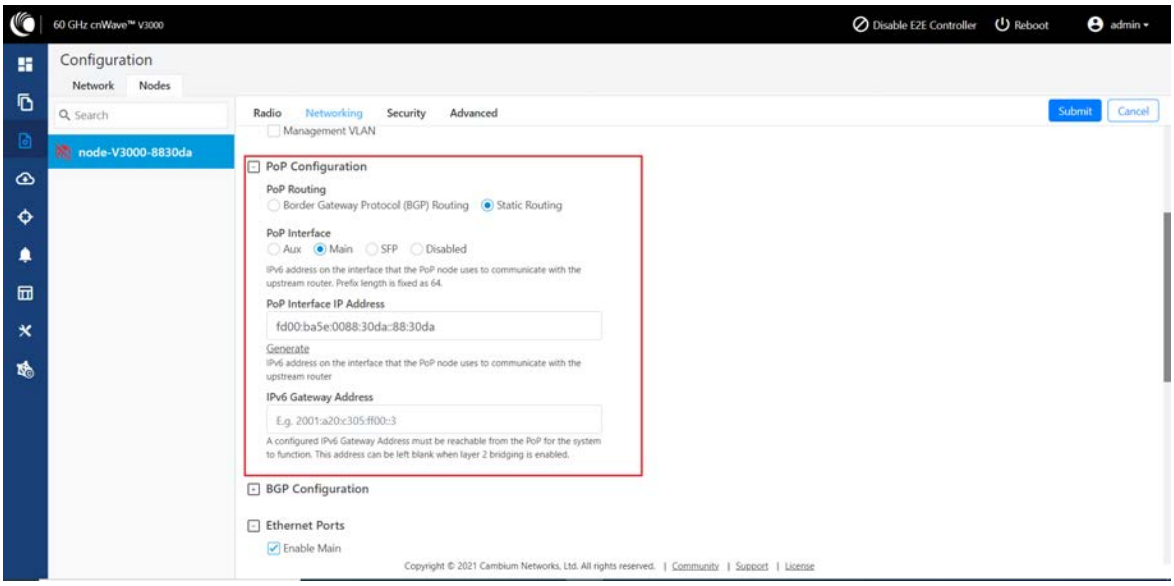


Table 37: Elements in the PoP Configuration section

Elements	Description
PoP Routing	PoP nodes connect to the upstream IPv6 router in one of two ways: • **BGP** – PoP acts as a BGP peer • **Static routing** – IP gateway address should be specified on the PoP and static route should be added on the upstream router. When the system is targeted for L2 traffic (Layer 2 bridge enabled) and an onboard controller is used, this configuration is of not much significance, recommended to set to static routing.
PoP Interface	The wired interface on which PoP communicates to an upstream router or switch when the L2 bridge is enabled.
PoP Interface IP Address	IPv6 address on the interface that the PoP node uses to communicate with the upstream router.
IPv6 Gateway Address	Gateway address. Can be left empty when the L2 bridge is enabled and no IPV6 services like NTP /Radius are used.

3. Under **E2E Controller Configuration**, enter E2E IPV6 Address (Address of E2E Controller). When using the onboard controller on the same node, can be left empty and GUI automatically fills the POP IPv6 address.

Note

If PoP DN is V5000/V3000 then, IPv6 both address is same.

Table 38: Elements in the E2E Controller Configuration section

Elements	Description
E2E IPv6 Address	Address of E2E Controller. When using the onboard controller on the same node, can be left empty and GUI automatically fills the POP IPv6 address.
E2E Network Prefix	Seed Prefix in the CIDR format followed by a comma and the prefix length. Should be specified when BGP is used. Otherwise, optional.
IPv6 CPE Interface	IPv6 SLAAC provides IP prefix to downstream CPE devices. Keep it disabled when L2 Bridge is active.

4. Select required BGP configuration.

Figure 163: *The BGP Configuration section*

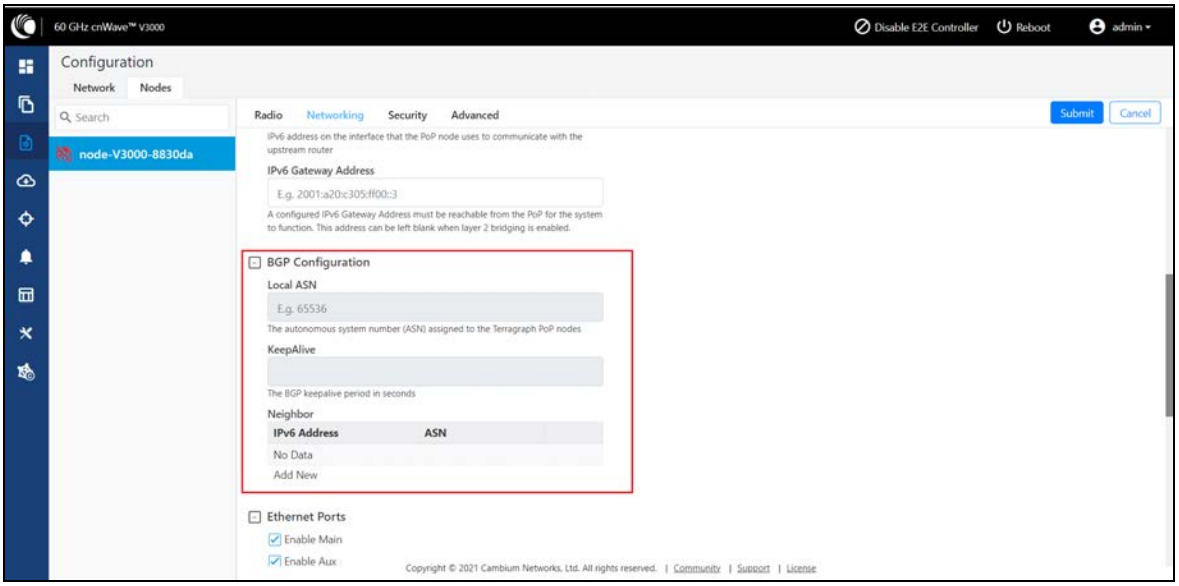
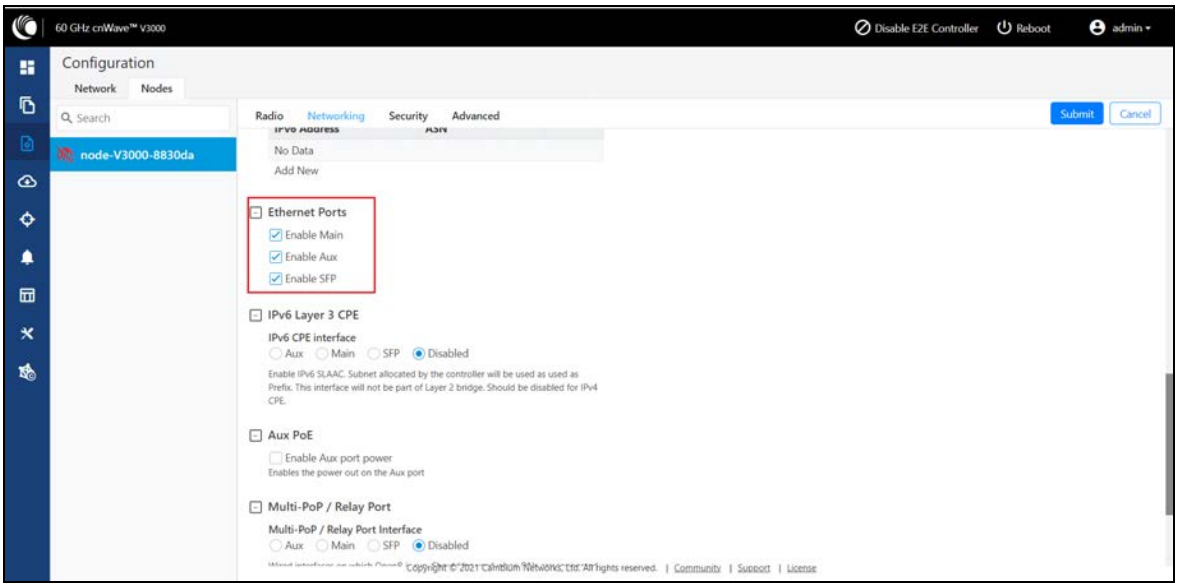


Table 39: Elements in the BGP Configuration section

Elements	Description
Local ASN	Local ASN
Neighbour ASN	Upstream router's ASN
Neighbour IPv6	Upstream router's IPv6 address
Specific Network prefixes	Specifically allocated network prefixes to be advertised via BGP

5. Enable the required Ethernet ports. Individual Ethernet ports can be turned off with this configuration.

Figure 164: *The Ethernet Ports section*



6. Select the required options for **Layer 2 Bridge**, **IPv6 Layer 3 CPE**, **AuX PoE** (enable to power on AuX port), and **Multi-PoP / Relay Port**. By default, this option is disabled and PoP floods any unknown unicast ingress packets on all the L2GRE tunnels. When the option is enabled, PoP drops such packets.

Figure 165: *The Layer 2 Bridge section in the Networking page*

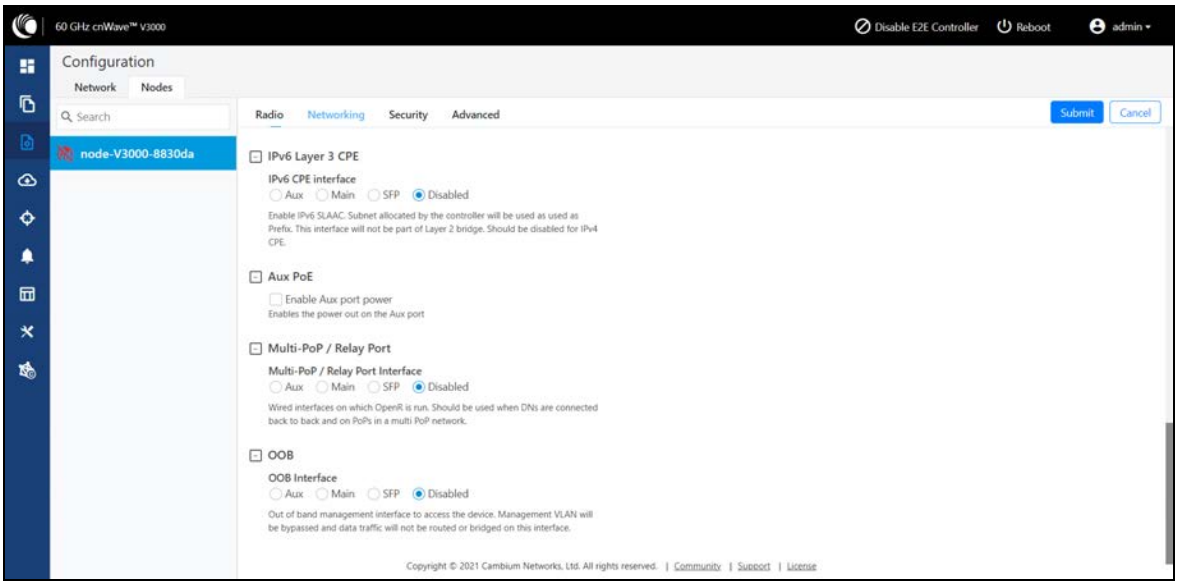


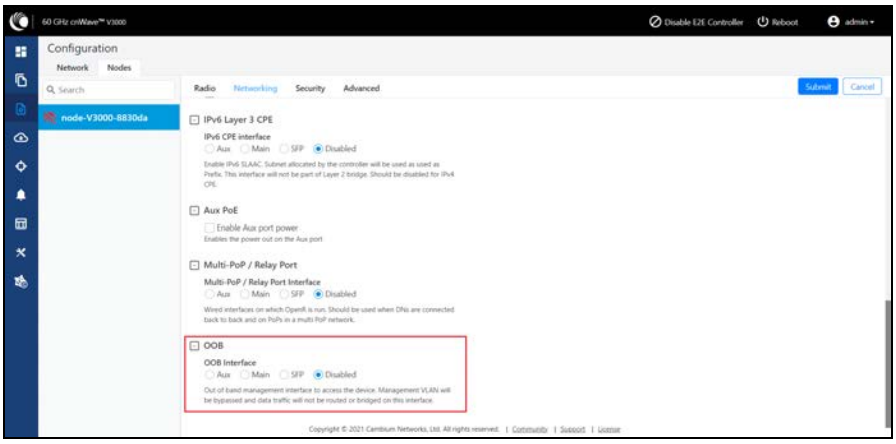
Table 40: Elements in the Layer 2 Bridge section

Elements	Description
Layer 2 Bridge	It has three options: • Disable Broadcast Flood • Disable Unknown Unicast Flood • Disable IPv6
CPE	IPv6 SLAAC provides IP prefix to downstream CPE devices. Disable this if the L2 bridge is active. Select the CPE interface: • Aux • Main • SFP • Disabled
Aux PoE	Enable PoE out (25 W) on V5000/V3000 aux port. 802.3af and 802.3at compliant devices could be powered up, passive PoE devices cannot be powered up. Note that the aux port cannot power another V5000/V3000.
Relay Port	Specify the Ethernet interfaces on which OpenR is running. It is needed in two cases: • When DNs are connected back-to-back. • When multiple PoPs are in the network. This allows PoP nodes to forward traffic to other PoP nodes via a wired connection when the routing path of the other PoP node is closer to the traffic's. destination.

Out of Band (OOB) interface

Out of band (OOB) management interface to access the device. Management VLAN is bypassed, and data traffic will not be routed or bridged on this interface. The OOB management interface is supported at PoP. A separate IPv4 address should be configured by bypassing the Management VLAN. Navigate to **Configuration** > **Nodes** > **Networking** > **OOB** and select the required option. Enter the IPv4 address and Subnet Mask to access the device.

Figure 166: *The OCB section in the Networking page*



VLAN tab

Data VLAN

The following 802.1Q features are supported per port:

- Adding single VLAN tag to untagged packets
- Adding QinQ/double-tag to untagged packets
- Adding QinQ outer tag to single tagged packets
- Transparently bridge single/double-tagged packets (default behavior)
- Remarking VLAN ID
- Remarking 802.1p priority
- Option to allow only the selected range of VLAN IDs
- Option to drop untagged packets
- Option to drop single tagged packets
- Option to select the ethertype of the outer tag

These options are per Ethernet port.

Note

VLAN configuration is applicable only when Layer2 bridge is enabled.

Port Type

Figure 167: *The port types*

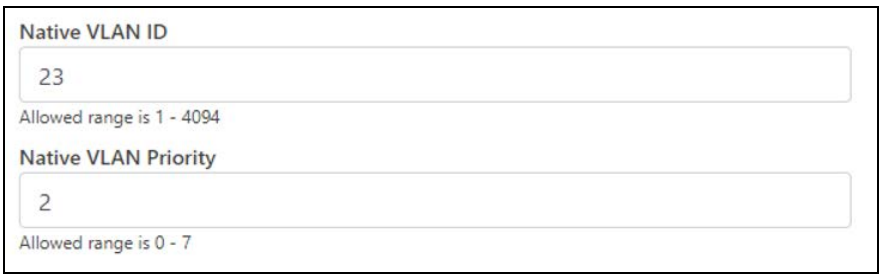
Transparent

By default, the Ethernet port is in transparent mode. Packets will be transparently bridged without any 802.1Q processing.

Q

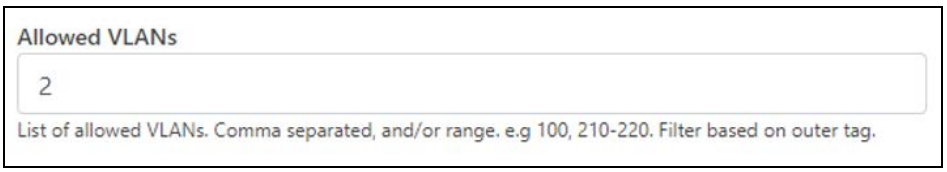
Q mode allows adding a single C-VLAN tag to untagged packets.

Figure 168: *Native VLAN ID and priority*



Native VLAN ID and priority fields define the C-VLAN tag properties.

Figure 169: *Allowed VLANs*



Allow only the listed range of VLAN IDs.

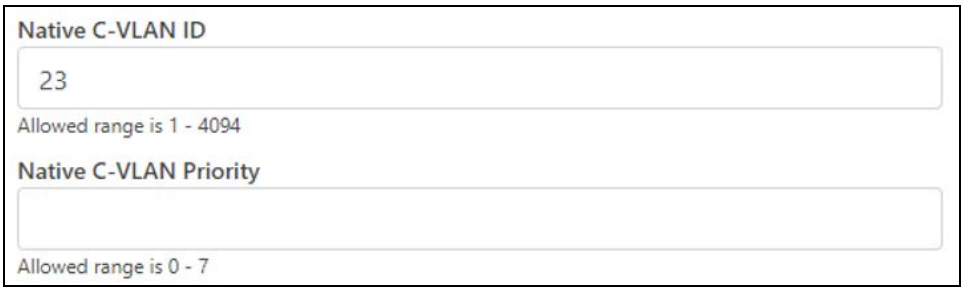
Figure 170: *Untagged types*

This option allows dropping untagged packets. Native VLAN properties are not necessary to fill when untagged packets are dropped.

QinQ

QinQ mode allows adding a double tag to untagged packets and outer S-VLAN to single-tagged packets.

Figure 171: *Native C-VLAN ID and priority*

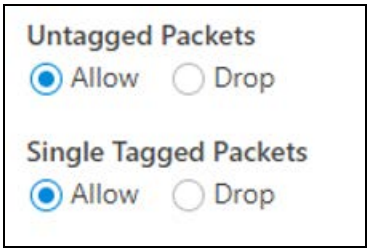


These are the C-VLAN tag properties of added tag.

Figure 172: *Native S-VLAN ID and priority*

These are the S-VLAN tag properties of the added outer tag.

Figure 173: *Untagged and Single tagged packets*



In QinQ mode, the above options allow dropping untagged/single-tagged ingress packets. Native C-VLAN fields are not necessary only when dropping single-tagged packets. Native S-VLAN fields are not necessary when dropping untagged and single tagged packets.

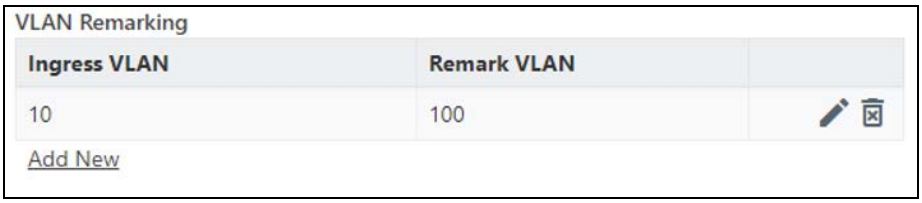
Figure 174: *Allowed VLANs*

Allow only the listed range of VLAN IDs. VLAN ID of the outer tag is used for this check.

Figure 175: *QinQ EtherType*

QinQ EtherType is used while adding an outer tag. There are no other checks for EtherType.

Figure 176: *VLAN ID Remarking*



VLAN ID of the ingress packet is remarked. In the above example, if a packet with VLAN ID 10 enters an Ethernet port, it is remarked to 100. In the egress path, the reverse remarking occurs. VLAN ID 100 is remarked to 10 and egresses the ethernet port.

The VLAN ID of the outer tag is used for remaking. For a double-tagged packet, S-VLAN ID gets remarked and for a single-tagged packet, C-VLAN 1D.

802.1p overriding

Priority field in the (outer) VLAN tag of ingress packet can be overwritten using this option.

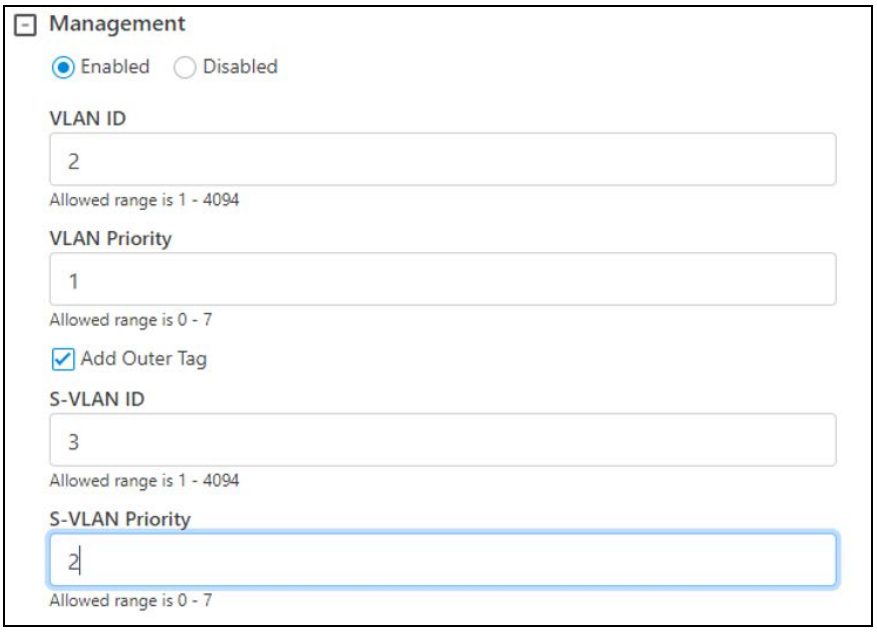
Figure 177: *VLAN Priority Override*

Priority field in the (outer) VLAN tag of ingress packet can be overwritten using this option.

Management VLAN

A Single tag or double tag can be added to Management traffic.

Figure 178: *The Management section*

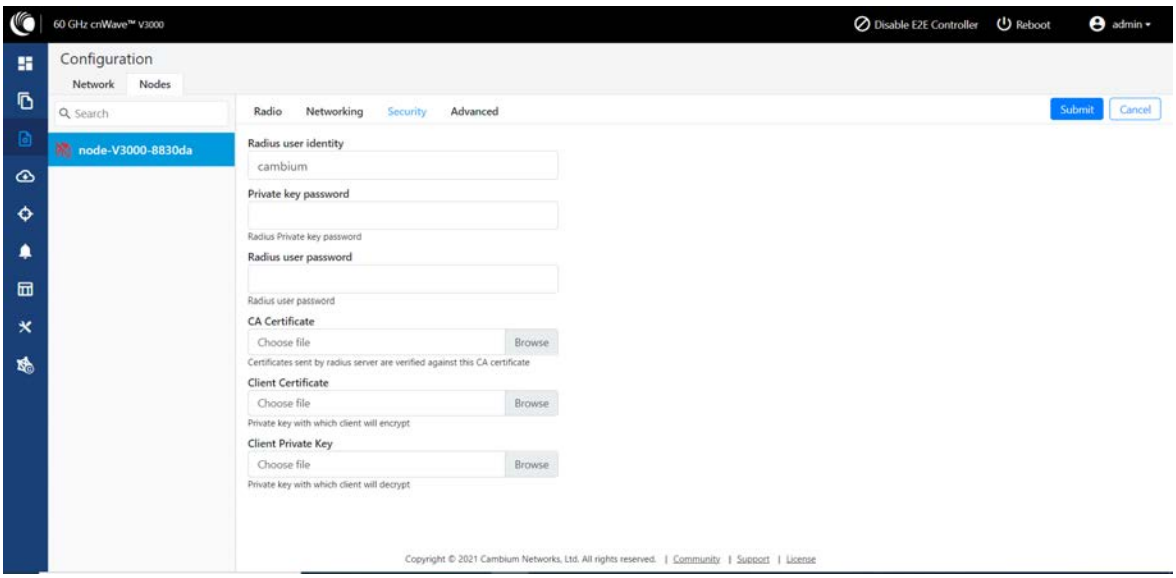


Security tab

In the **Security** tab, enter **Private key password** and **Radius user password**.

- Private key password
- Radius user password

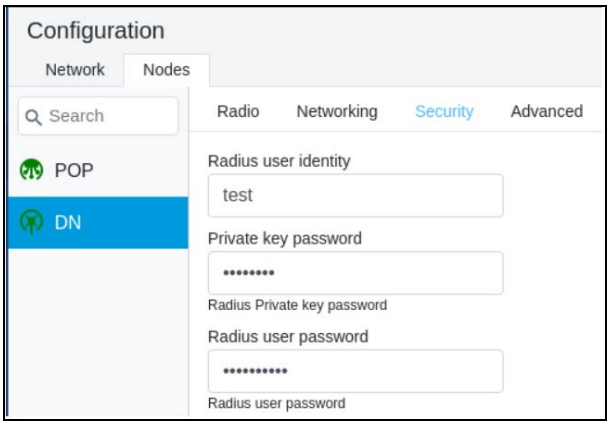
Figure 179: *Security tab*



Controller GUI configuration

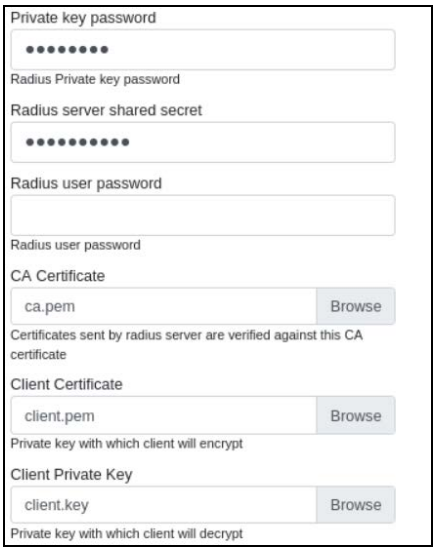
This Controller GUI configuration to be made on each DN.

Figure 180: *Elements specific to Controller configuration*



Node GUI configuration

Figure 181: *Elements specific to node configuration*



Note

Both the configurations are important for a successful authentication.

RADIUS Server configuration

Any RADIUS server can be used for authentication. Perform the following steps to configure the RADIUS Server:

1. Ensure RADIUS packets from IPv6 subnet (i.e., lo IP subnet is accepted in RADIUS configuration).
2. Configure EAP-TLS for RADIUS Server and setup server certificate, key.

Note

Server certificate is signed by CA uploaded in node configuration.

3. Set the CA certificate which signed the client certificate installed on each node.

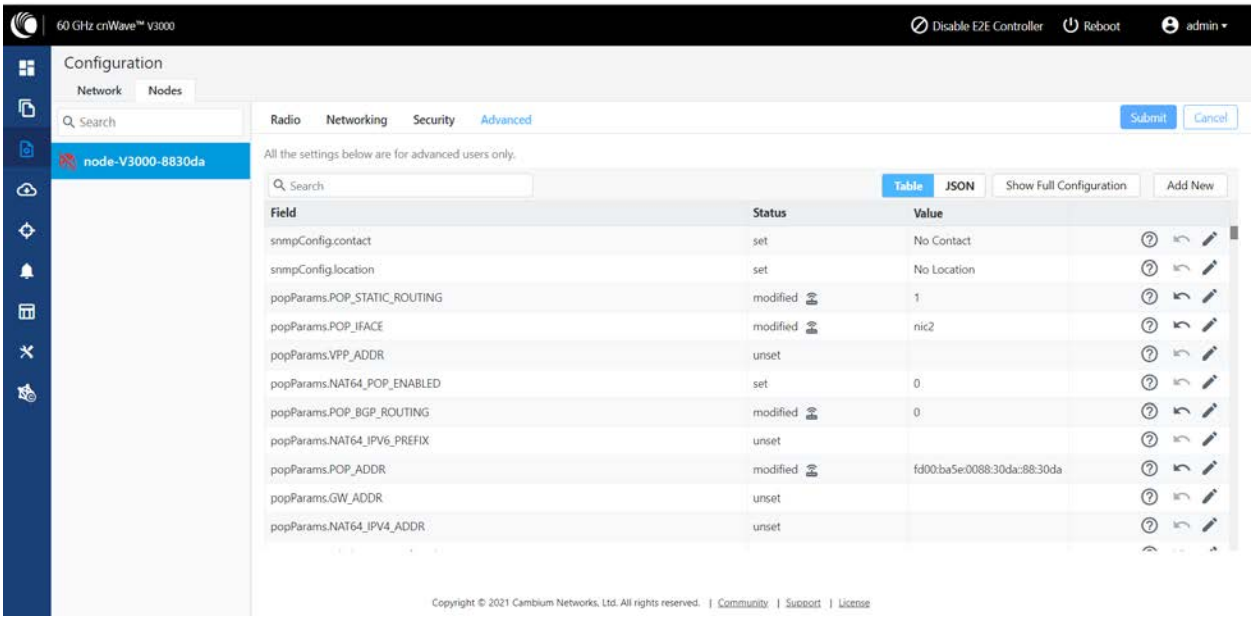
Advanced tab

These settings are for advanced users only.

Caution

Users are not recommended to do these settings.

Figure 182: *Advanced tab*



Configuration options under **Network > Advanced** and **Node > Advanced** are for advanced users who understand the cnWave configuration model well. It is not recommended to use these options. Shows the merged configuration from the Base layer to the Network override layer.

cnWave is based on Facebook's Terragraph architecture. It follows a layered configuration model, with a node's "full" configuration computed as the union of all layers in the following order:

- **Base configuration** - The default configuration, which is tied to a specific software version and is included as part of the image. The controller finds the closest match for a node's software version string and falls back to the latest if no match was found.
- **Firmware-specific base configuration** - The default configuration is tied to a specific firmware version, which is also included as part of the image. Values are applied on top of the initial base configuration layer.
- **Hardware-specific base configuration** - The default configuration is tied to a specific hardware type, which is also included as part of the image. Each hardware type supplies configuration that

changes with software versions. Values are applied on top of the firmware-based configuration layer.

- **Automated node overrides** - Contains any configuration parameters for specific nodes that were automatically set by the E2E controller.
- **Network overrides** - Contains any configuration parameters that should be uniformly overridden across the entire network. This takes precedence over the base configuration and automatic overrides.
- **Node overrides** - Contains any configuration parameters that should be overridden only on specific nodes (e.g. PoP nodes). This takes precedence over the network overrides.

The E2E controller manages and stores the separate configuration layers. The cnWave nodes have no knowledge of these layers, except the base configuration on the image. The nodes copy the latest base version (via natural sort order) if the configuration file on disk is missing or corrupt.

Click **Submit** to apply the changes.

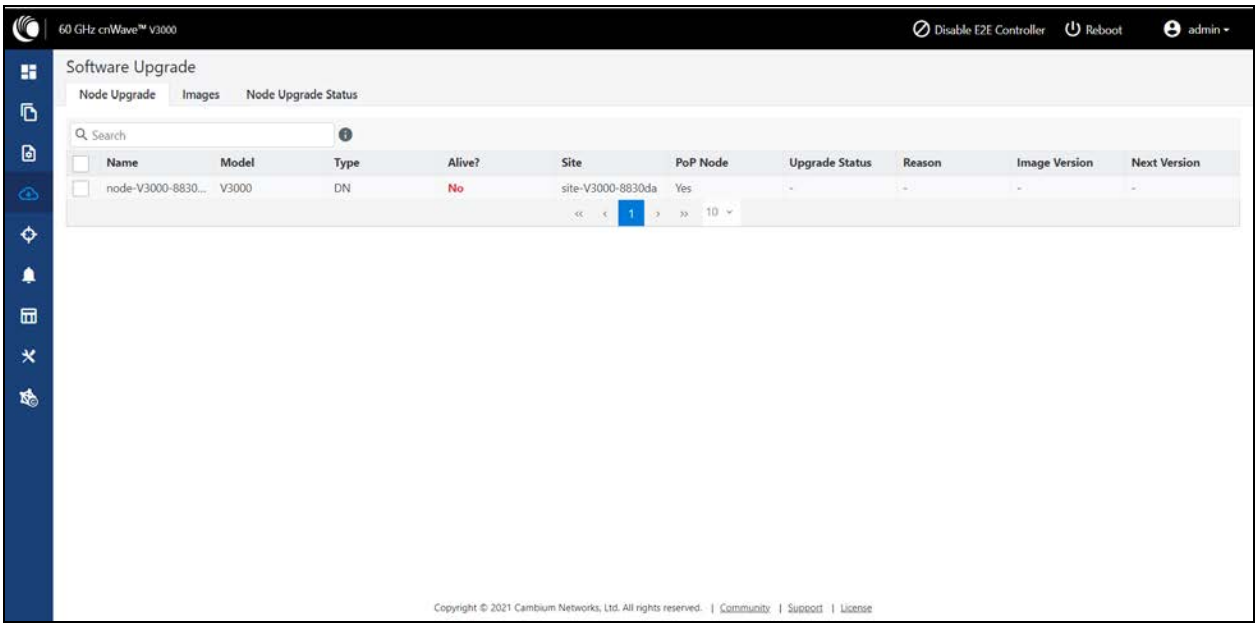
Operation

Software upgrade

Software Upgrade menu page is used to upgrade the installed software. This page contains three tabs:

- **Node Upgrade** - to upgrade the node.
- **Images** - to upgrade the software images.
- **Node Upgrade Status** - displays the upgrade status.

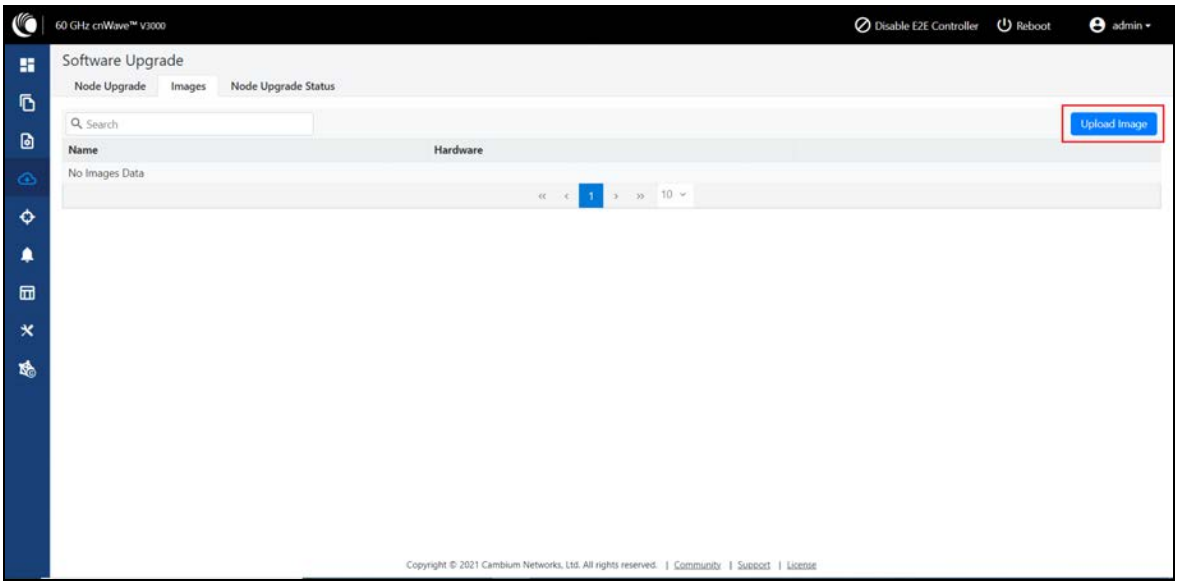
Figure 183: *The Software Upgrade menu*



To upgrade the node, perform the following steps:

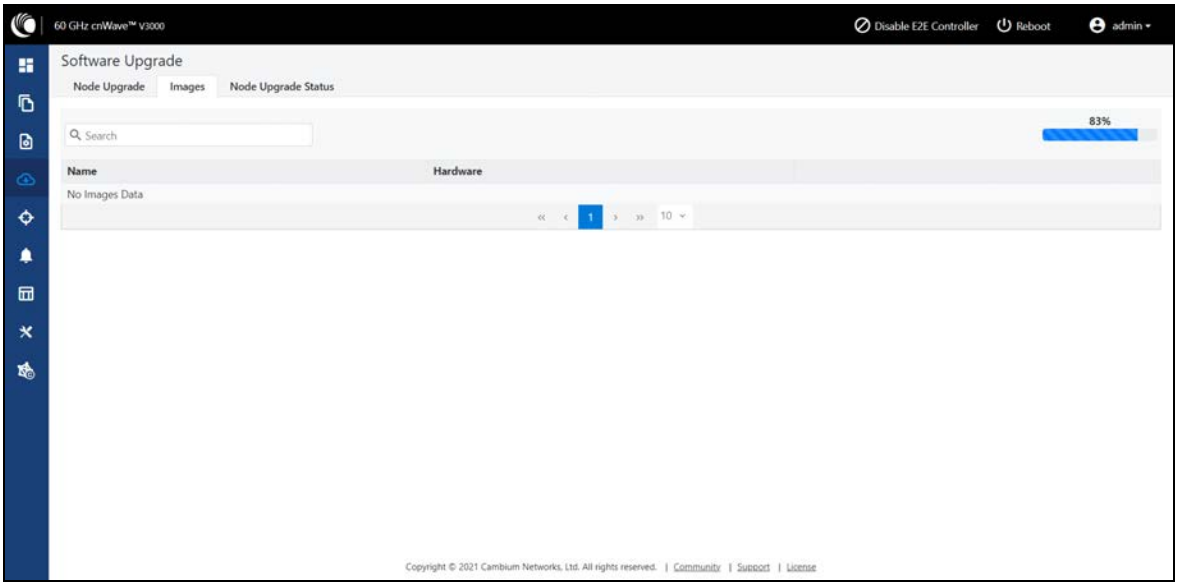
1. Click **Image** > **Upload Image**, browse and select the software image or package (**cnWave60-<release>.tar.gz**).

Figure 184: *The Software Upgrade page*



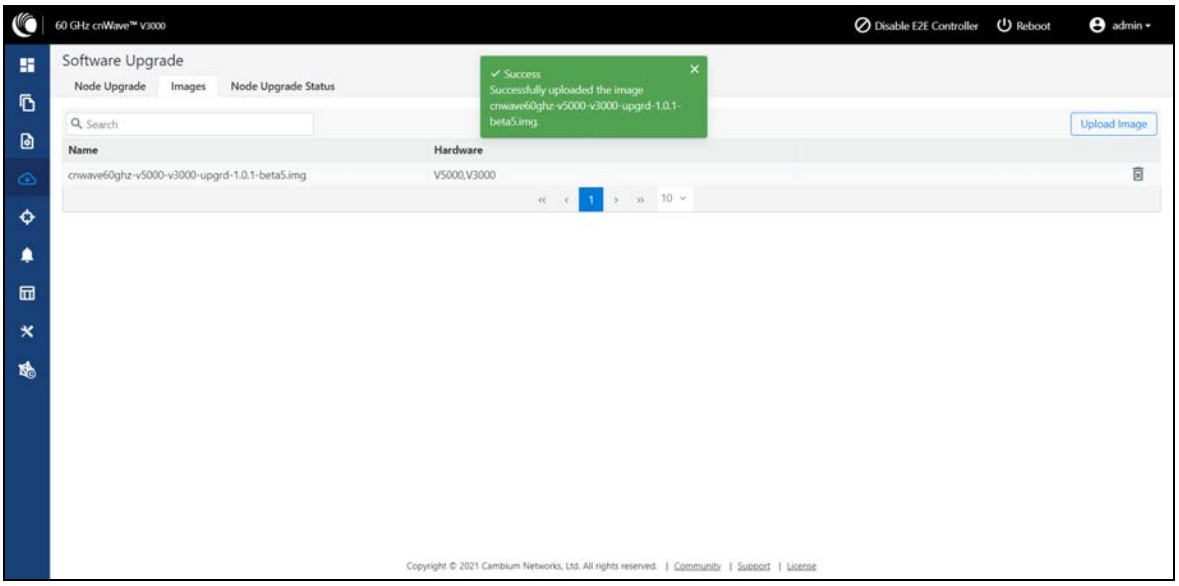
After selecting the software image, the upload status is displayed.

Figure 185: *The Images page*



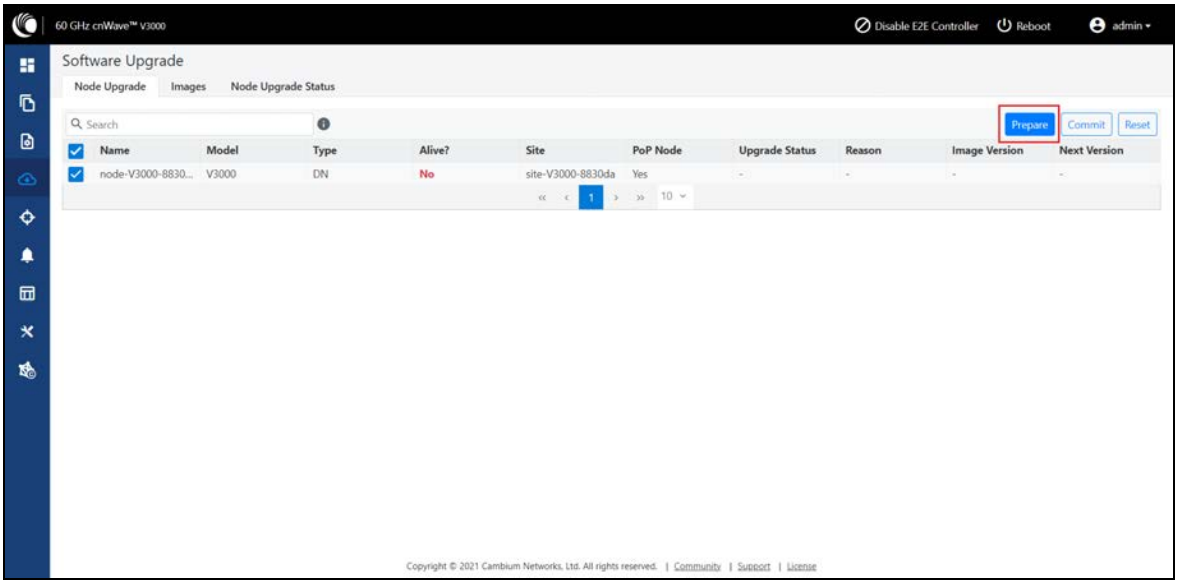
A pop-up message is displayed after the upload.

Figure 186: *On uploading the image*



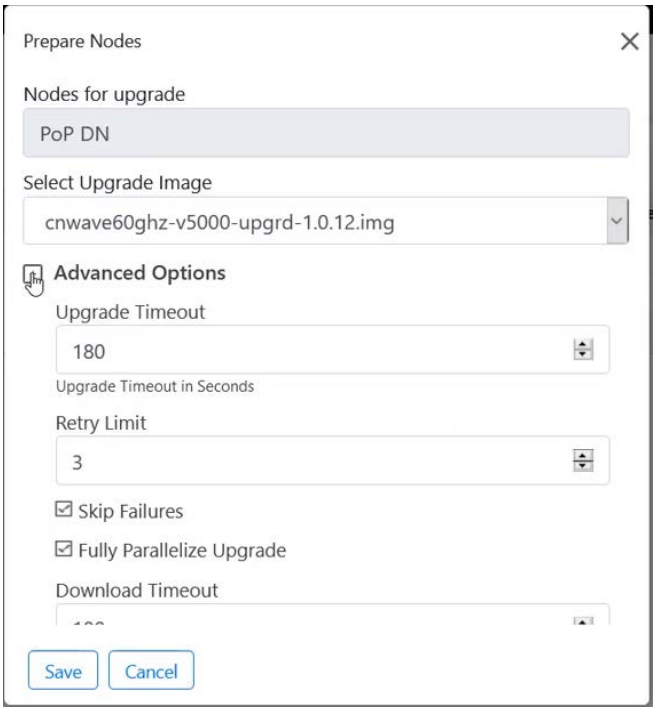
2. Click **Node Upgrade**, Select the device, and click **Prepare**.

Figure 187: *The Node Upgrade section*



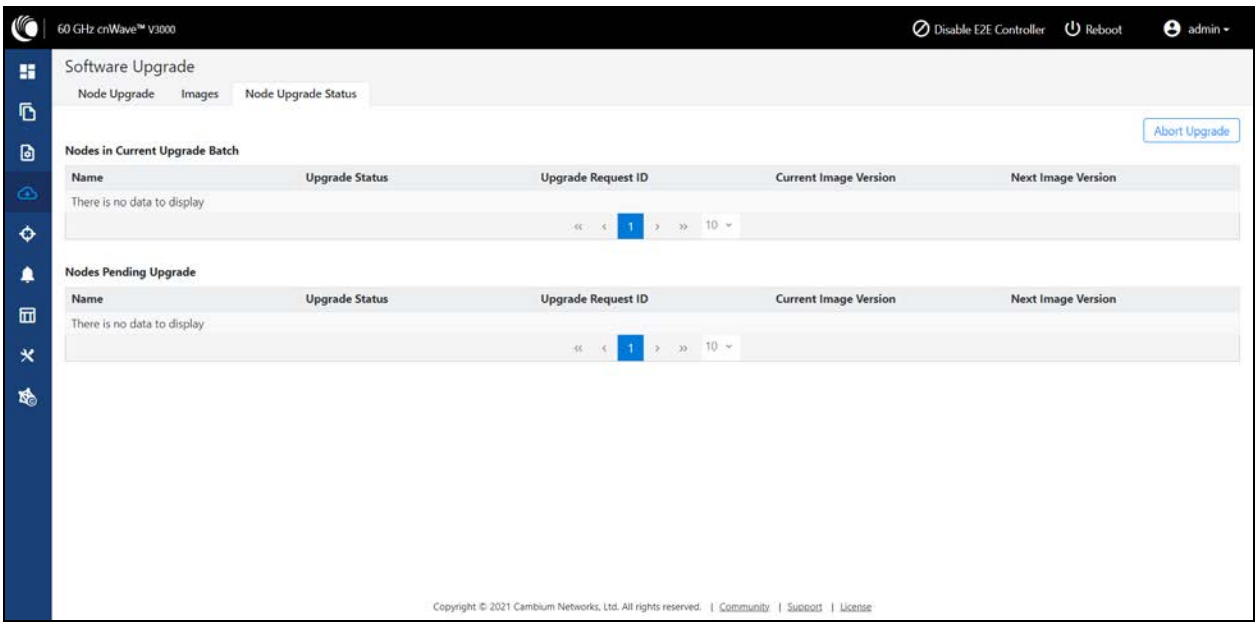
3. Select the required nodes to upgrade and click **Commit**.
4. Select the **Upgrade Image**, enter the required information and click **Save**.

Figure 188: *The Prepare Nodes section*



5. Click **Commit** to upgrade the software.
6. Click **Node Upgrade Status** to view the upgrade status.

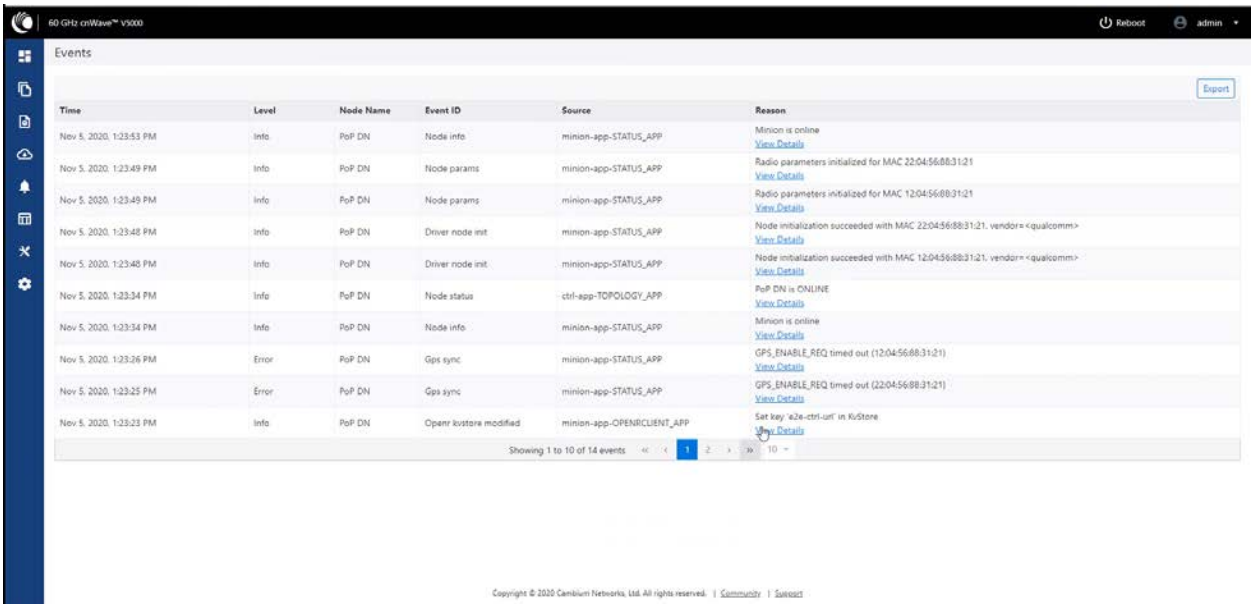
Figure 189: *Node Upgrade Status*



Events

The **Events** page displays the running and completed tasks list. These events can be exported. To export the event list click **Export**.

Figure 190: *Events menu*



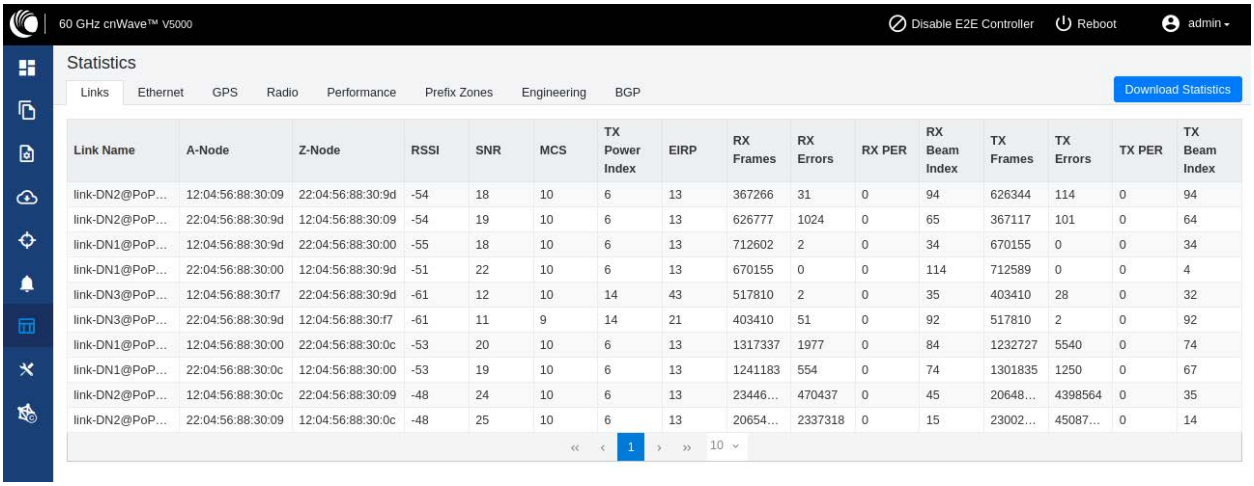
Statistics

The **Statistics** menu contains the following options:

- Links
- Ethernet
- GPS
- Radio
- Performance
- Prefix Zone Statistics
- Engineering
- Border Gateway Protocol (BGP)

Links

Figure 191: *The Links page*



The **Links** page has Uplink and Downlink statistical data. It displays TX and RX data of the nodes from A to Z and Z to A. Links page displays the following elements:

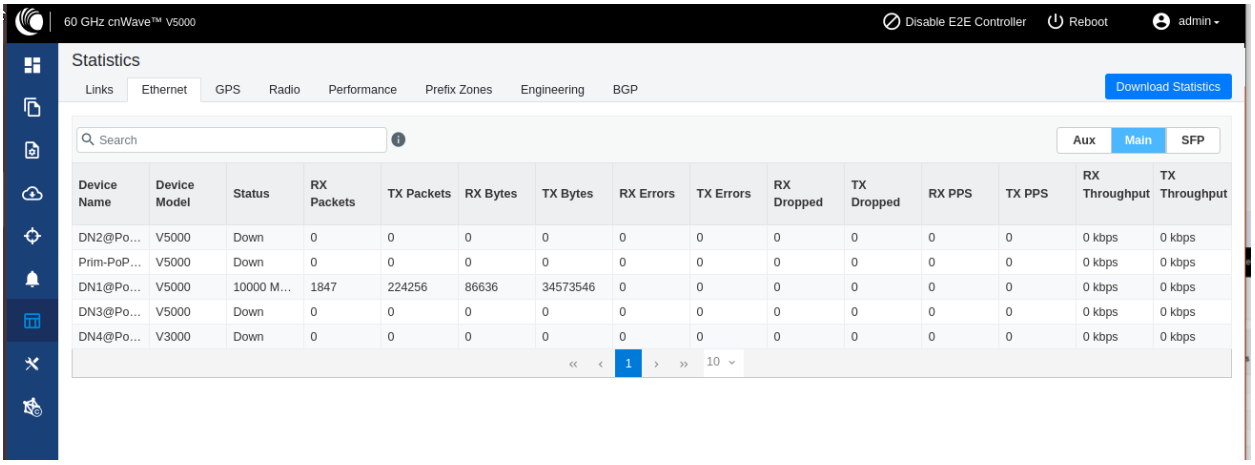
Table 41: Elements in the Links page

Elements	Description
Link Name	Link name
A-Node	Initiator Node
Z-Node	Responder Node
RSSI	Receiver Signal Strength Indicator

Elements	Description
SNR	Signal to Noise Ratio
MCS	Modulation Coded Scheme
TX Power Index	Transmitter power index
RX Frames	Receiver frames
RX Errors	Receiver errors
RX PER	Receiver packer error rate
RX Beam Index	Receiver beam index
TX Frames	Transmitter frames
TX Errors	Transmitter errors
TX PER	Transmitter packer error rate
TX Beam Index	Transmitter beam index

Ethernet

Figure 192: *The Ethernet page*



The **Ethernet** page displays Transmitting and receiving data of the nodes. The following elements are displayed:

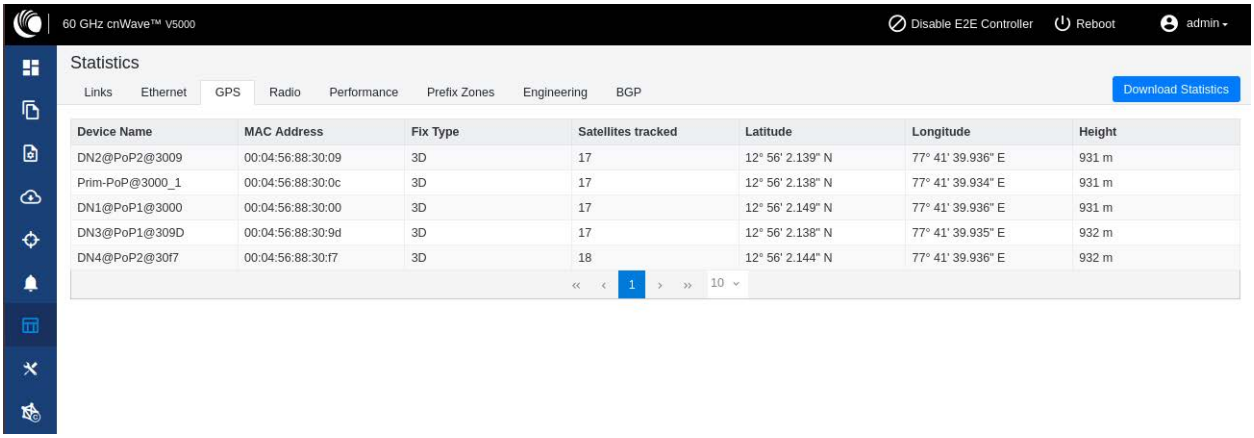
Table 42: Elements in the Ethernet page

Elements	Description
Device Name	Name of the device
Status	Ethernet link status
RX Packets	Receiver packets

Elements	Description
TX Packets	Transmitter packets
RX Bytes	Receiver bytes
TX Bytes	Transmitter bytes
RX Errors	Receiver errors
TX Errors	Transmitter errors
RX Dropped	Receiver dropped
TX Dropped	Transmitter dropped
RX PPS	Receiver Packets Per Second
TX PPS	Transmitter Packets Per Second
RX Throughput	Receiver throughput
TX Throughput	Transmitter throughput

GPS

Figure 193: *The GPS page*



The **GPS** page displays geographical data of the nodes. The following elements are displayed:

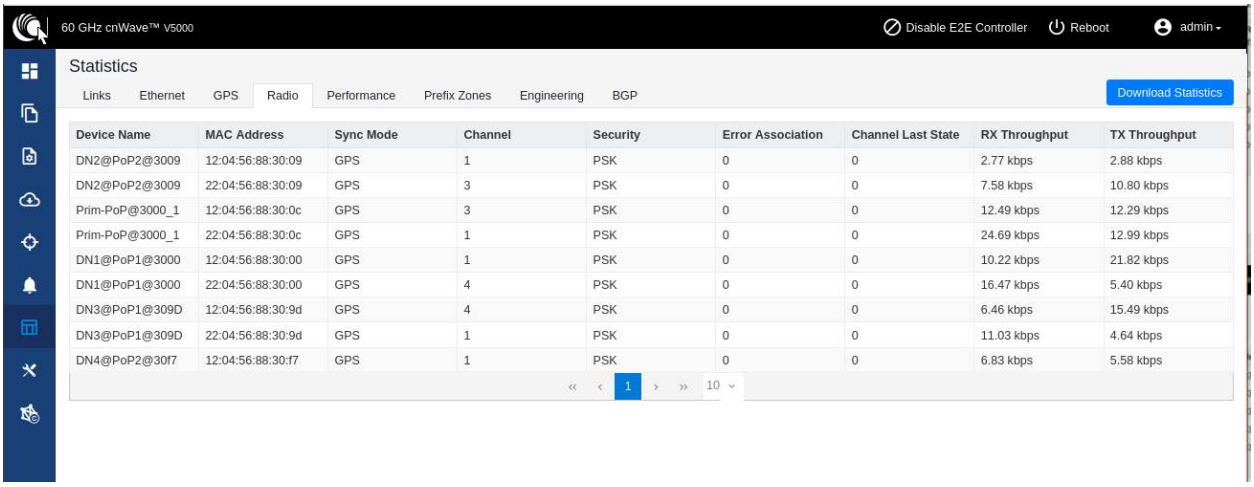
Table 43: Elements in the GPS page

Elements	Description
Device Name	Name of the device
MAC Address	MAC address of the device
Fix Type	GPS fix type. The fix status indicates the type of signal or technique being used by the GPS receiver to determine its location. The fix status is important for the GPS consumer,

Elements	Description
	as it indicates the quality of the signal, or the accuracy and reliability of the location being reported.
Satellites tracked	The number of satellites tracked
Latitude	Latitude of the device
Longitude	Longitude of the device
Height	Height of the device

Radio

Figure 194: *The Radio page*



The **Radio** page displays the radio data of the nodes. This page has the following elements:

Table 44: Elements in the Radio page

Elements	Description
Device Name	Name of the device
MAC Address	MAC address of the device

Sync Mode	• **GPS sync**:
	  • *Entry condition*: Valid samples from GPS have been received for a few consecutive seconds (typically 2 seconds).
	  • *Exit condition*: Valid samples from GPS have not been received for a few consecutive seconds (typically 10 seconds).
	• **RF sync**: Not in “GPS sync”, but is reachable to a DN with “GPS sync” over wireless links (1-2 hops away).
	  • *Entry condition*: Conditions for “GPS sync” have not been met, but a link exists to at least one other DN from which to derive timing.

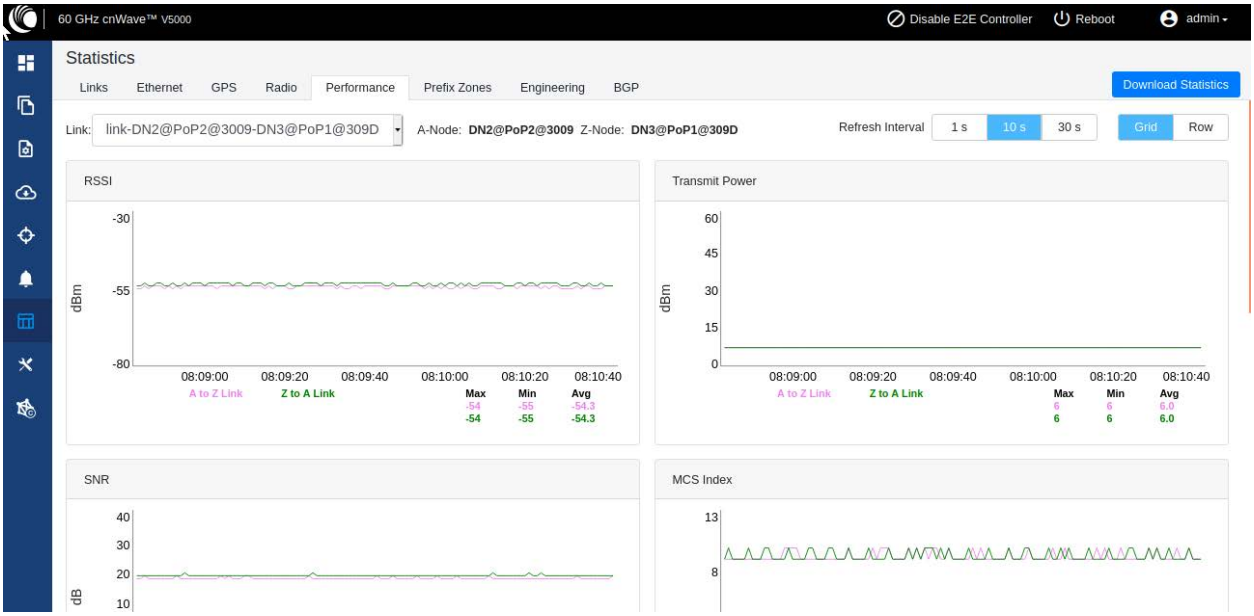
Elements	Description

	• *Exit condition*: Conditions for “GPS sync” have not been met and no links to other DNs exist from which to derive timing.
	• **No sync**: Neither in GPS sync nor RF sync. This is the default state.
	  • *Entry condition*: Conditions for “GPS sync” or “RF sync” are not met.
	  • *Exit condition*: Condition for “GPS sync” or “RF sync” are met.

Channel	Operating channel
Security	Security type
Error Association	Error Association
Channel Last State	Channel Last State
RX Throughput	Receiver throughput
TX Throughput	Transmitter throughput

Performance

Figure 195: *The Performance page*



The **Performance** page displays the performance graph. It includes the following graphs:

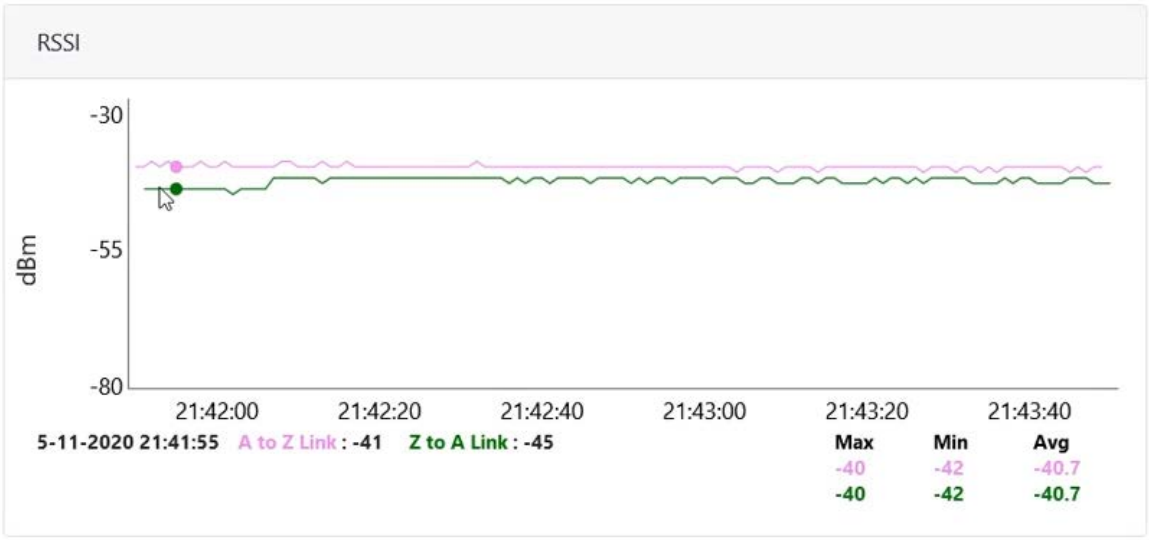
Table 45: Elements in the Performance page

Elements	Description
RSSI	Receiver Signal Strength Indicator. It is a measurement of the power present in a

Elements	Description
	received radio signal
Transmit Power	Transmitting power
SNR	Signal to Noise Ratio
MCS Index	Modulation and Coding Scheme (MCS) Index Values can be used to determine the likely data rate of your wireless connection. The MCS value essentially summarizes the number of spatial streams, the modulation type and the coding rate that is possible when connecting your wireless access point.
Packet Error Ratio	Packet error ratio. It is the ratio, in percent, of the number of Test Packets not successfully received by the node to the number of Test Packets sent to the node by the test set.
Received Frames	The number of frames received at the node.
Transferred Frames	The number of frames transferred from the node.

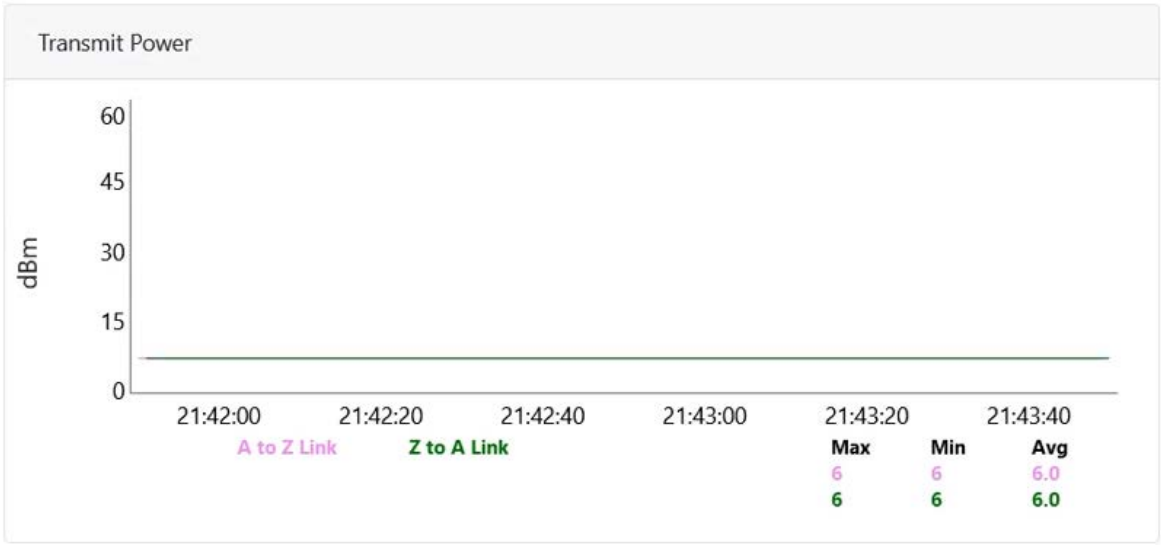
RSSI graph

Figure 196: *RSSI graph*



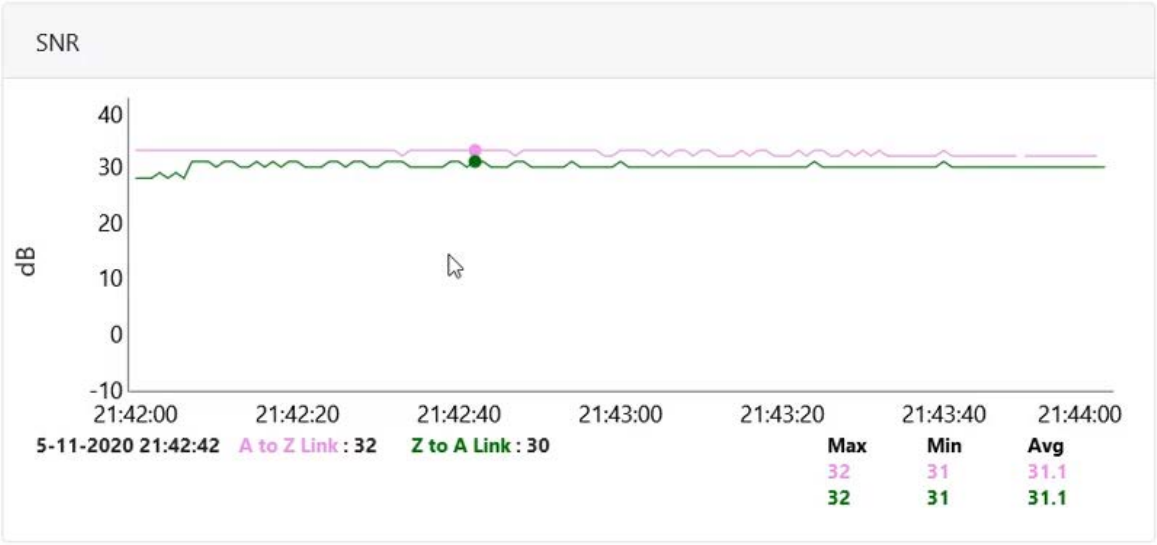
Transmit Power graph

Figure 197: *Transmit Power graph*



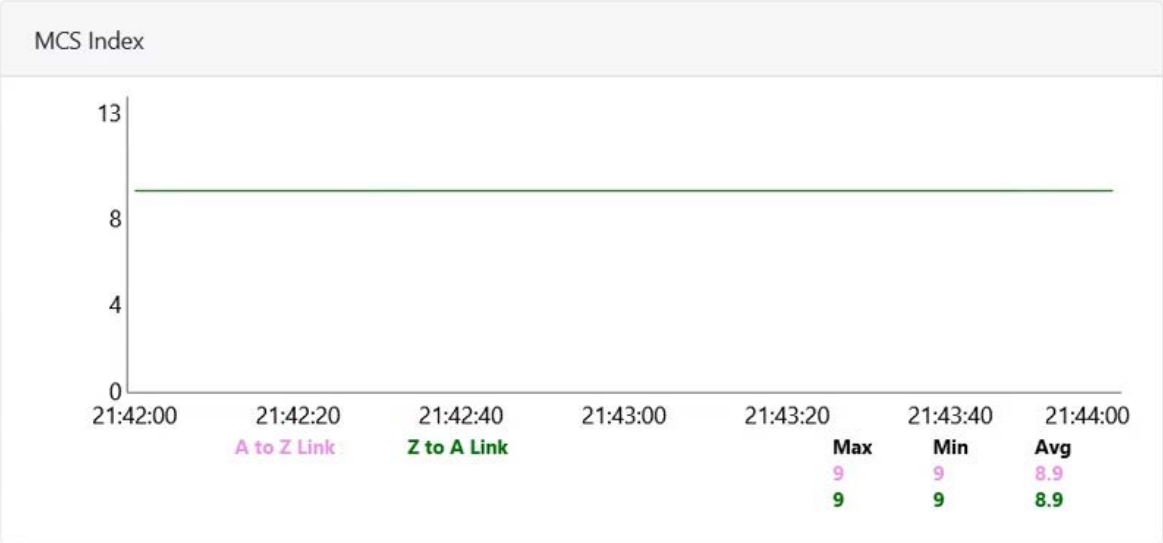
SNR graph

Figure 198: *SNR graph*



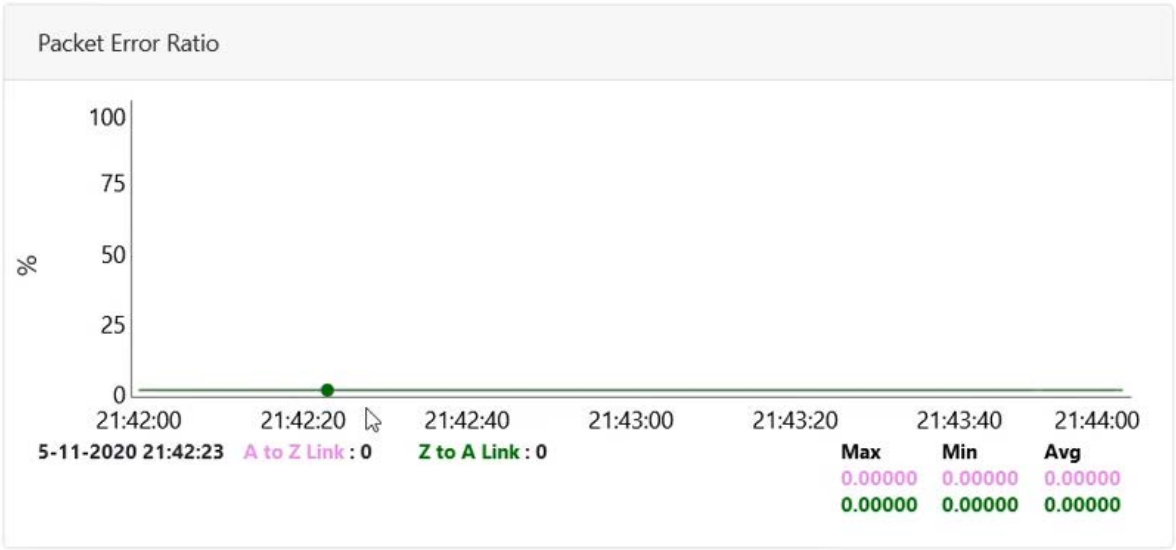
MCS Index graph

Figure 199: *MCS Index graph*



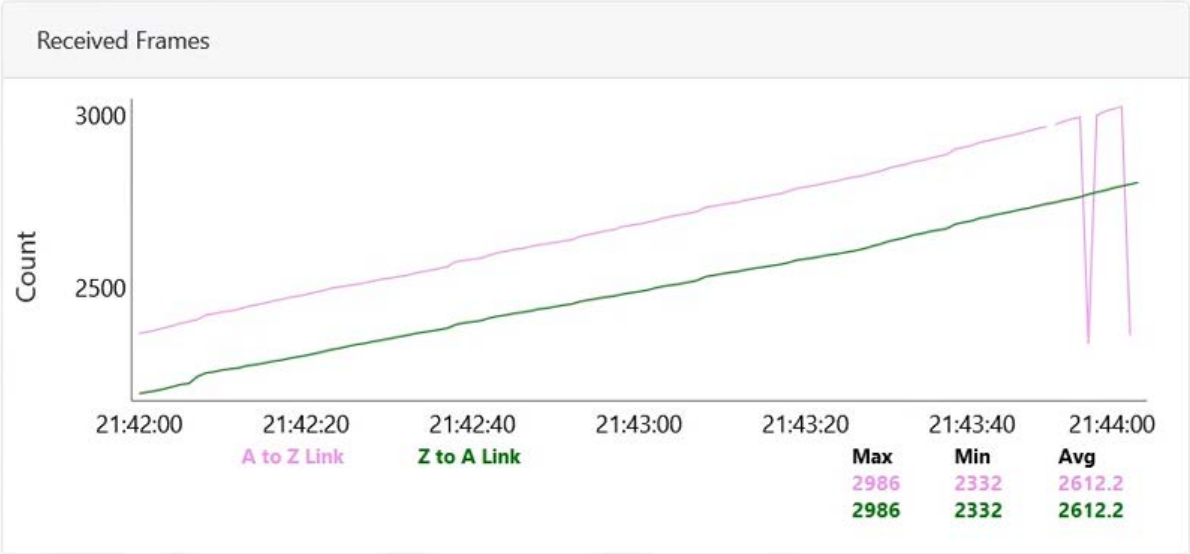
Packet Error Ratio graph

Figure 200: *Packet Error Ratio graph*



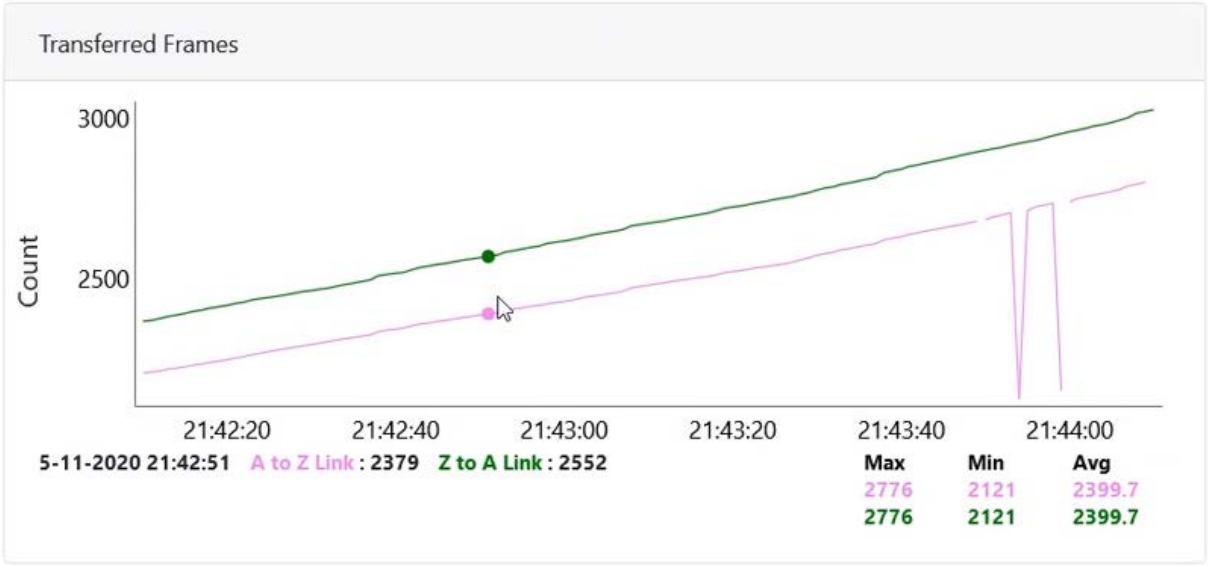
Received Frames graph

Figure 201: *Received Frames graph*



Transferred Frames graph

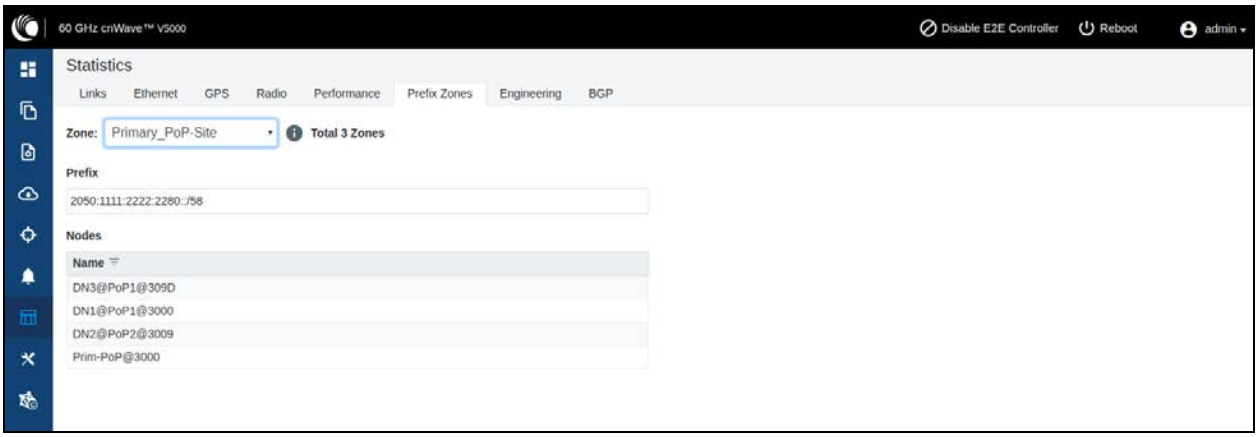
Figure 202: *Transferred Frames graph*



Prefix Zone Statistics

When a **Deterministic prefix** is enabled and in the multi-PoP deployments, the mesh is divided into prefix zones. Prefix Zone statistics are available on the **Statistics > Prefix Zone** page.

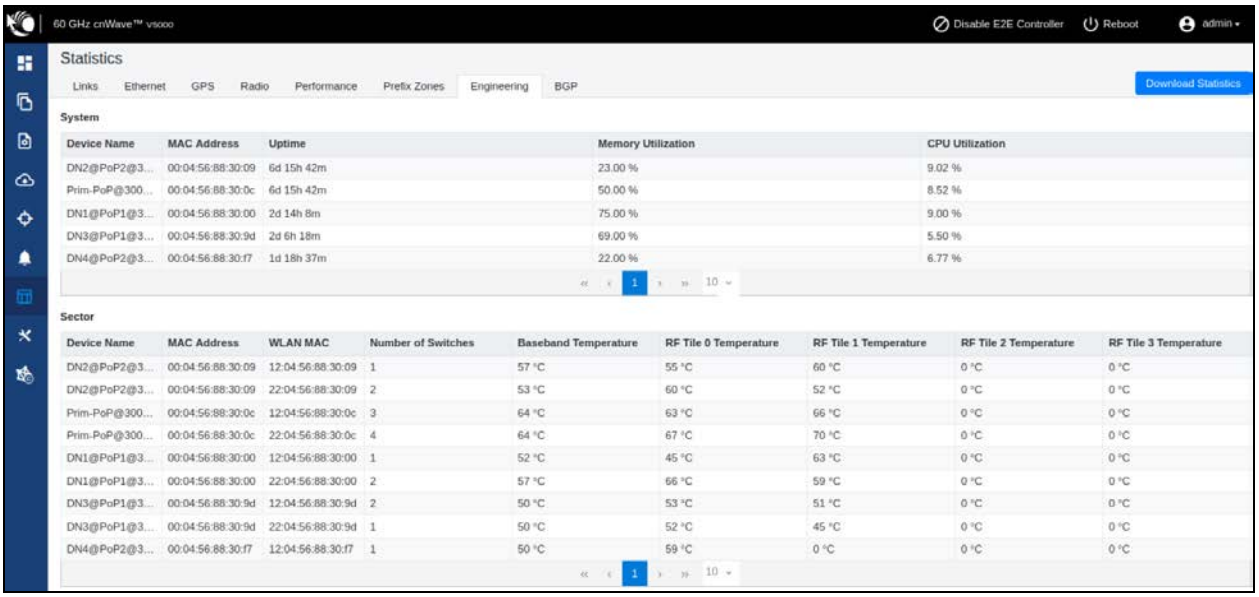
Figure 203: *The Prefix Zones page*



Engineering

The **Engineering** page displays the engineering information of the system and sector.

Figure 204: *The Engineering page*

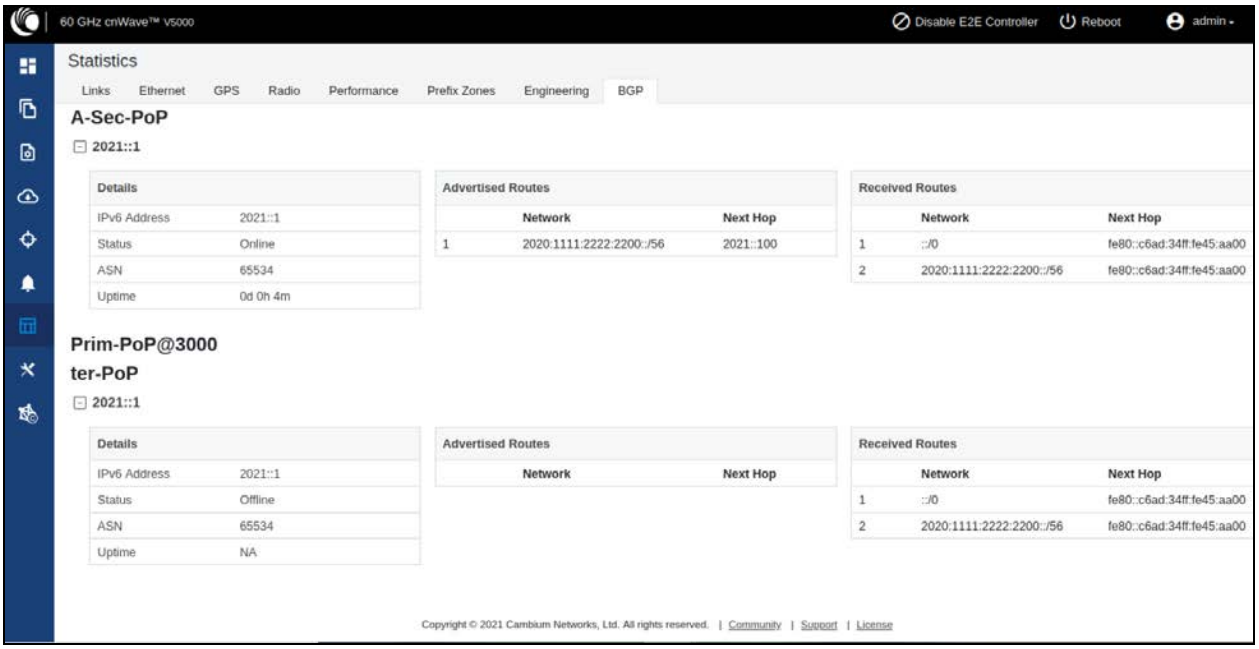


Border Gateway Protocol (BGP)

The BGP is the protocol used throughout the Internet to exchange routing information between networks. It is the language spoken by routers on the Internet to determine how packets can be sent from one router to another to reach their final destination. BGP has worked extremely well and continues to the be protocol that makes the Internet work.

To configure BGP, navigate to **Statistics** and select the **BGP** tab.

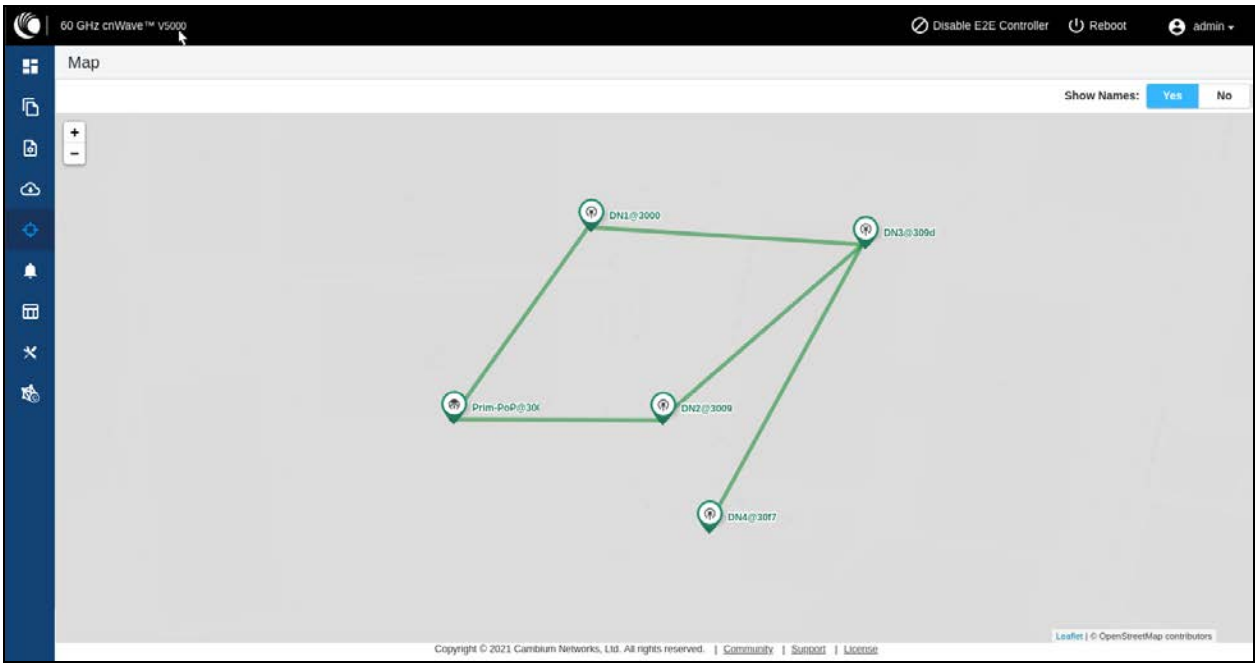
Figure 205: *The BGP page*



Maps

The **Maps** page displays the topology and location/sites of the deployed nodes in the cnWave network. Click the **Maps** icon on the left panel to display the nodes.

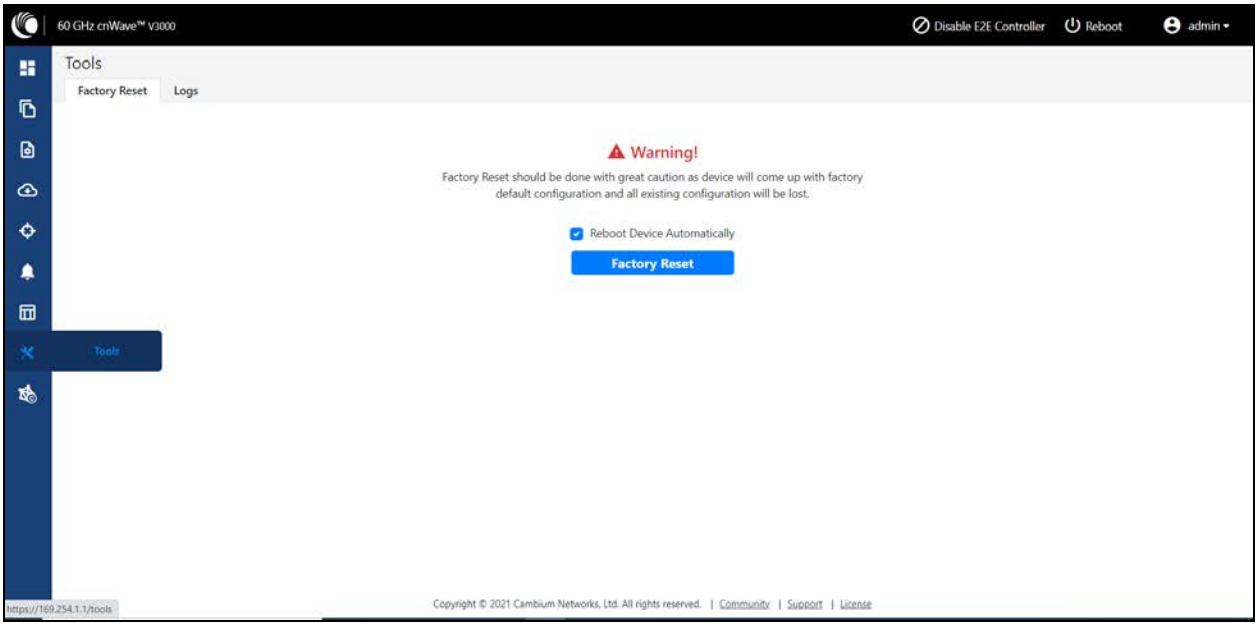
Figure 206: *The Map page*



Tools

The **Tools** menu contains **Factory Reset** and **Logs** options. Factory Reset is used to set the default settings.

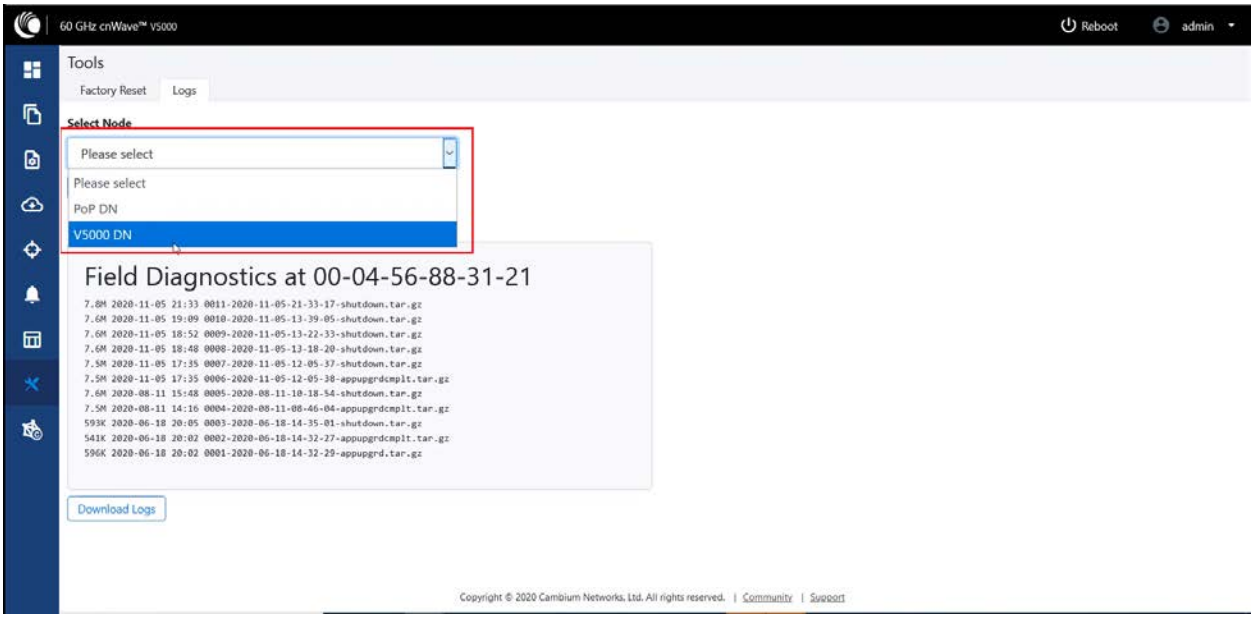
Figure 207: *The Factory Reset page*



.

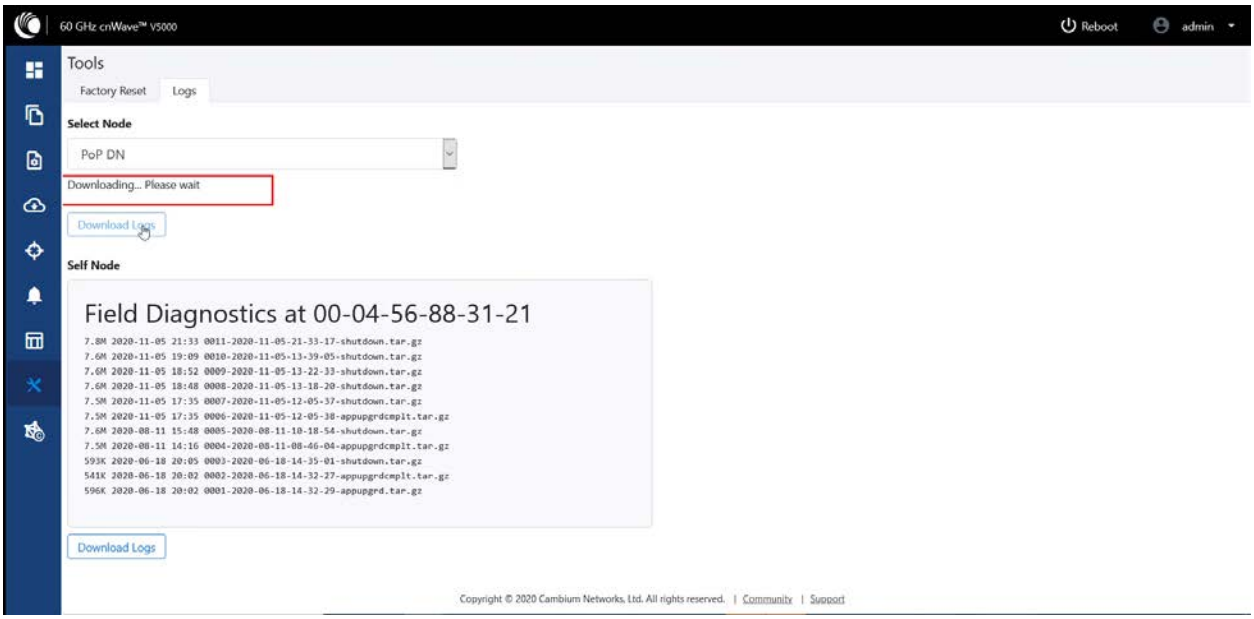
The **Logs** tab is used to view and download the error logs. To download the error logs select the node from the drop-down and click **Download Logs**.

Figure 208: *The Logs page*



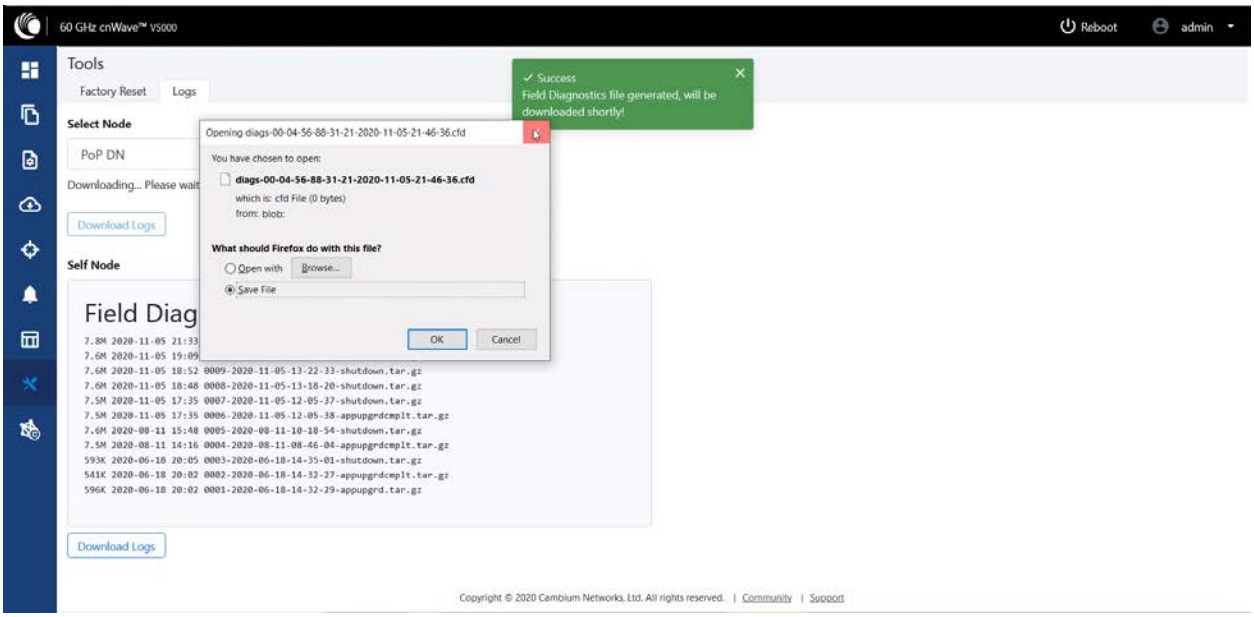
After clicking **Download Logs**, downloading status is displayed.

Figure 209: *Downloading logs*



To download the logs for self node, click **Download Logs** at the bottom and save the log file.

Figure 210: *Saving log files*

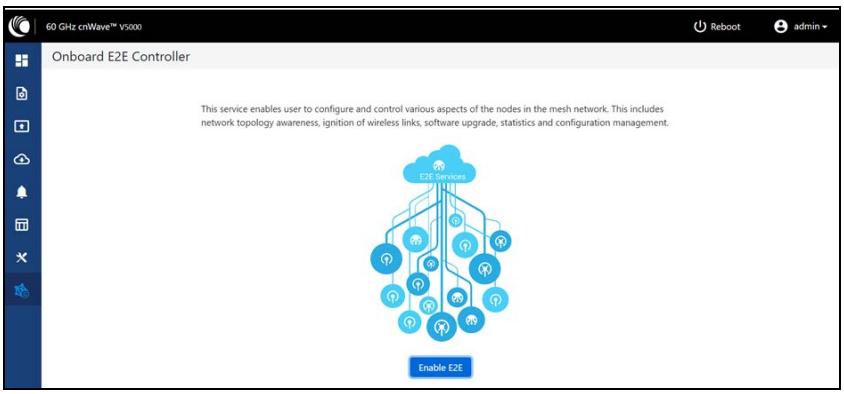


cnMaestro support for Onboard Controller

From System Release 1.0.1 onwards, The Onboard E2E controller can be managed by cnMaestro 2.5.0 (on-premises) for network management.

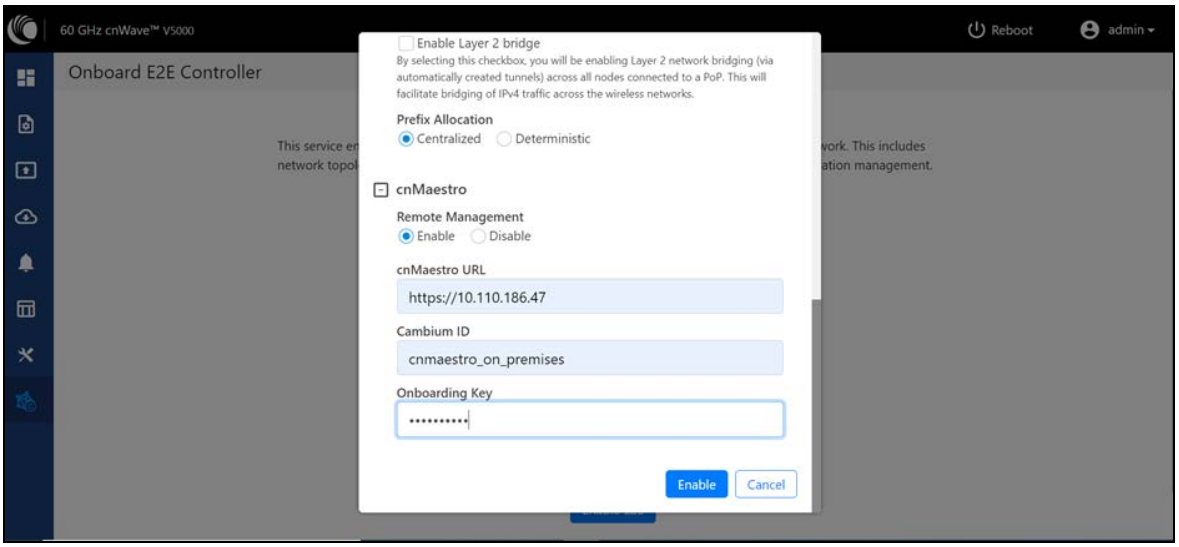
1. After the Onboard E2E controller is enabled from UI, enter the cnMaestro URL. If **Cambium ID based authentication** option is enabled in cnMaestro, then enter the Cambium ID and onboarding key.
2. Click **Enable E2E** on **Onboard E2E Controller** in UI.

   Figure 211: *The Onboard E2E Controller page*



3. Enter the cnMaestro management configuration information.
   - Remote Management - Select the required remote management option
   - cnMaestro URL - cnMaestro address
   - Cambium ID - Cambium ID of the device
   - Onboarding key - Password to onboard the device

     Figure 212: *The cnMaestro section*

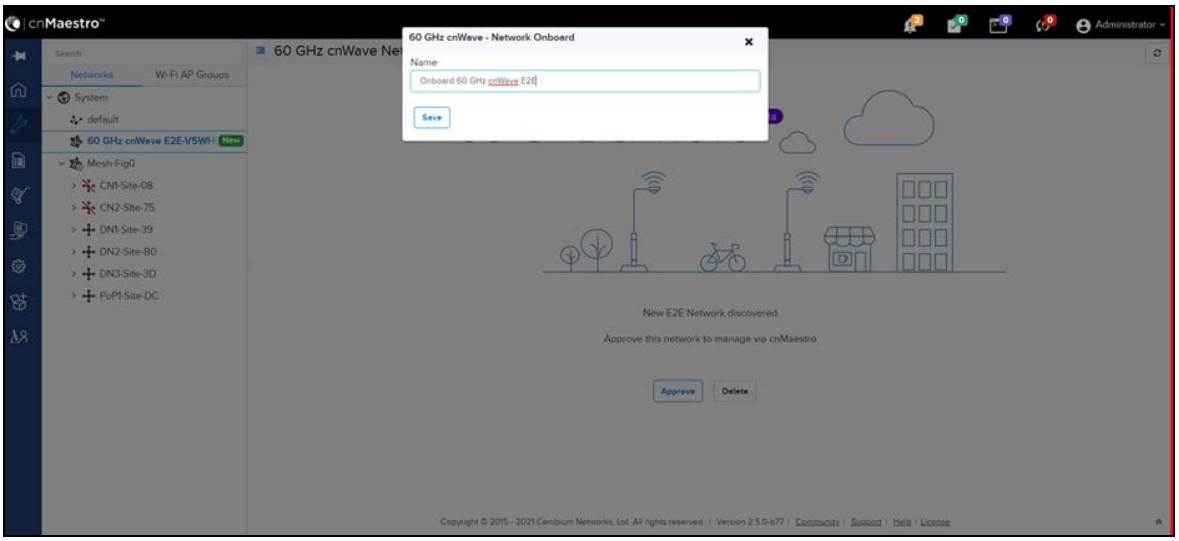


4. Click **Enable**.
5. A new E2E Network appears in cnMaestro. Click **Approve** to manage it.

Figure 213: *Information on the new E2E network*

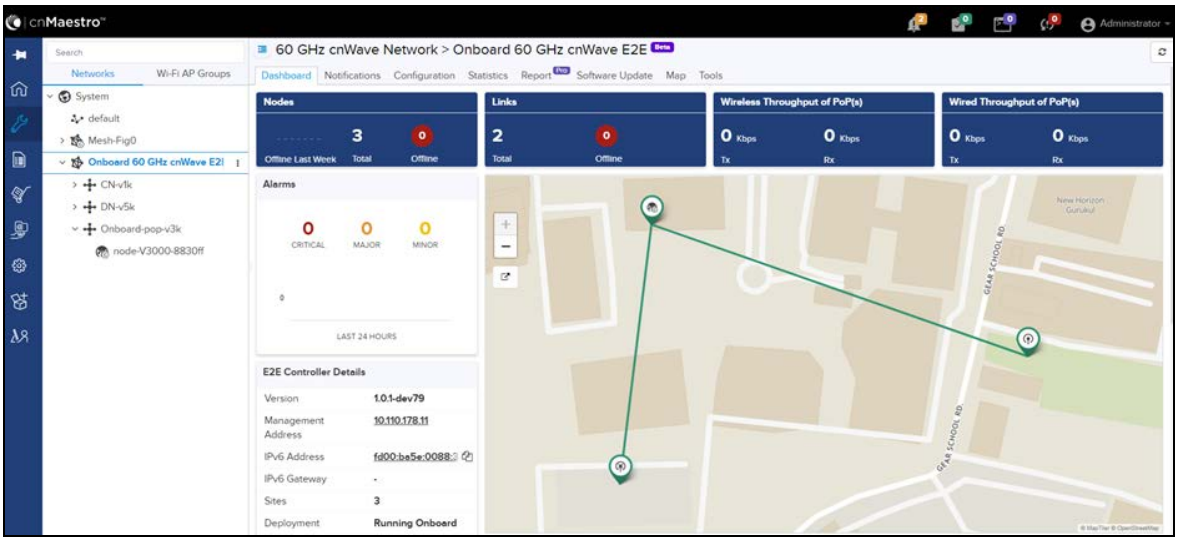
6. The **Network Onboard** window appears and provides an option to edit the network name.
7. Click **Save**.

Figure 214: *The 60 GHZ cnWave - Network Onboard*



After the successful onboarding of the E2E Network, it can be managed through cnMaestro.

Figure 215: *The Onboard 60 GHZ cnWave E2E dashboard page*



Regulatory Information

This chapter provides regulatory notifications.

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.

Attention

Les changements ou modifications intentionnels ou non intentionnels à l'équipement ne doivent pas être effectués sauf avec le consentement exprès de la partie responsable de la conformité. De telles modifications pourraient annuler l'autorisation de l'utilisateur à faire fonctionner l'équipement et annulera la garantie du fabricant.

The following topics are described in this chapter:

- Compliance with safety standards lists the safety specifications against which the 60 GHz cnWave family of ODUs has been tested and certified. It also describes how to keep RF exposure within safe limits.
- Compliance with radio regulations describes how the 60 GHz cnWave family of ODUs complies with the radio regulations that are in force in various countries.

Compliance with safety standards

This section lists the safety specifications against which the 60 GHz cnWave platform family is tested and certified. It also describes how to keep RF exposure within safe limits.

Electrical safety compliance

The 60 GHz cnWave platform family hardware is tested for compliance to the electrical safety specifications listed in following Safety compliance specifications table.

Table 46: Safety compliance specifications

Region	Specification
USA	UL 62368-1, UL 60950-22
Canada	CSA C22.2 No.62368-1, CSA C22.2 No. 60950-22
Europe	EN 62368-1, EN 60950-22
International	CB certified IEC 62368-1 Edition 2 IEC 60950 -22

Electromagnetic Compatibility (EMC) compliance

The EMC specification type approvals that are granted for 60 GHz cnWave platform family are listed in following table.

Table 47: EMC compliance

Region	Specification
USA	FCC Part 15 Class B
Canada	RSS Gen
Europe/International	EN 301 489-1 V2.2.3, EN 301 489-17 V3.2.4

Human exposure to radio frequency energy

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

- ANSI IEEE C95.1-2005, 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 2013/35/EU - electromagnetic fields* of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC.
- US FCC limits for the general population. See the FCC web site at http://www.fcc.gov, and the policies, guidelines, and requirements in Part 1 of Title 47 of the Code of Federal Regulations, as well as the guidelines and suggestions for evaluating compliance in FCC OET Bulletin 65
- Health Canada limits for the general population. See the Health Canada web site at https://www.canada.ca/en.html.
- EN 62232: 2017 Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure (IEC 62232:2017)
- EN 50385:2017 Product standard to demonstrate the compliance of base station equipment with radiofrequency electromagnetic field exposure limits (110 MHz - 100 GHz), when placed on the market
- ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines for the general public. See the ICNIRP web site at https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf and Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields.

Power density exposure limit

Install the radios for the 60 GHz cnWave platform family of wireless solutions to provide and maintain the minimum separation distances from all persons.

The applicable FCC power density exposure limit for RF energy in the 57 – 66 GHz frequency bands is 10 W/m^2. For more information, see Human exposure to radio frequency energy.

Calculation of power density

The following calculation is based on the ANSI IEEE C95.1-1991 method, as that provides a worst-case analysis.

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

$$S = \frac{P.G}{4\pi d2}$$

Where:

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:

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

Calculated distances and power compliance margins

The following table displays recommended calculated separation distances, for the 60 GHz cnWave for Europe the USA and Canada. These are conservative distances that include compliance margins.

Note

Les tableaux suivants indiquent les distances de séparation recommandées calculées pour le cnWave 60 GHz pour l'Europe, les États-Unis et le Canada. Ce sont des distances prudentes qui incluent des marges de conformité.

At these and greater separation distances, the power density from the RF field is below generally accepted limits for the general population.

Note

À ces distances de séparation et à des distances supérieures, la densité de puissance du champ RF est inférieure aux limites généralement acceptées pour la population générale.

60 GHz cnWave Platform Family ODU adheres to all applicable EIRP limits for transmit power when operating in MIMO mode. Separation distances and compliance margins include compensation for the antenna configuration of each product.

Note

L'ODU de la famille de plates-formes cnWave 60 GHz respecte toutes les limites EIRP applicables pour la puissance de transmission lors d'un fonctionnement en mode MIMO. Les distances de séparation et les marges de conformité incluent la compensation de la configuration d'antenne de chaque produit.

Table 48: Calculated distances and power compliance margins

Product	Countries	EIRP (dBm)	EIRP (W)	Maximum power density (W/m^2)	Compliance distance (m)
V1000	USA, Canada, EU	38	6.3	10	0.22
V3000	USA, Canada	60.5	1122	10	3.0
V3000	EU	55	316.2	10	1.6
V5000	USA, Canada, EU	38	6.3	10	0.22

Note

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.

The calculations above are based upon platform maximum EIRP and worst case 100% duty cycle.

Remarque

Les réglementations exigent que la puissance utilisée pour les calculs soit la puissance maximale de la rafale d'émission sous réserve de la moyenne temporelle basée sur la source.

Les calculs ci-dessus sont basés sur la PIRE maximale de la plate-forme et le pire des cas, un cycle de service de 100%.

Compliance with radio regulations

This section describes how the 60 GHz cnWave platform family complies with the radio regulations that are in force in various countries.

Caution

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

Attention

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

Caution

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

Attention

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

Type of approvals

The system is tested against various local technical regulations and found to comply. Radio specifications section list the radio specification type approvals that is granted for the 60GHz cnWave products.

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

Table 49: Approval types

Region	Regulatory approvals	FCC ID	IC ID
USA	Part 15C	QWP-60V1000 QWP-60V3000 QWP-60V5000	
Canada	ISED RSS-210		109AO-60V1000 109AO-60V3000 109AO-60V5000

FCC Compliance

The 60 GHz cnWave V1000, V3000 and V5000 comply with the regulations that are in force in the USA.

Caution

If this equipment does cause interference to radio or television reception.

FCC Notification

This device complies with part 15C 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.

ISEDC compliance

The 60 GHz cnWave V1000, V3000 and V5000 comply with the regulations that are in force in Canada.

Caution

If this equipment does cause interference to radio or television reception.

Attention

Si cet équipement cause des interférences à la réception radio ou télévision.

60 GHz cnWave example product labels

Figure 216: *60 GHz cnWave™ V5000 Distribution Node*

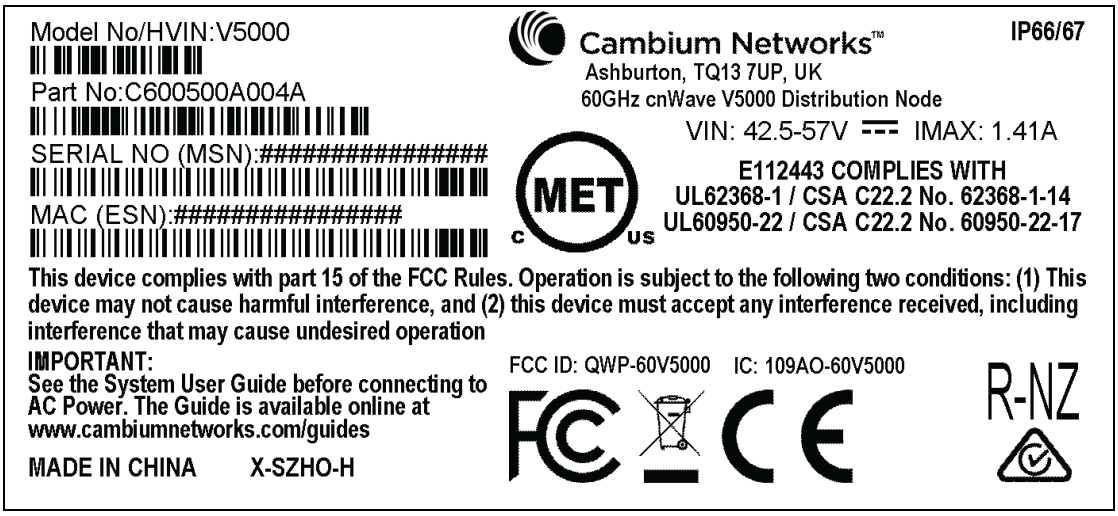


Figure 217: *60 GHz cnWave™ V3000 Client Node Radio only*

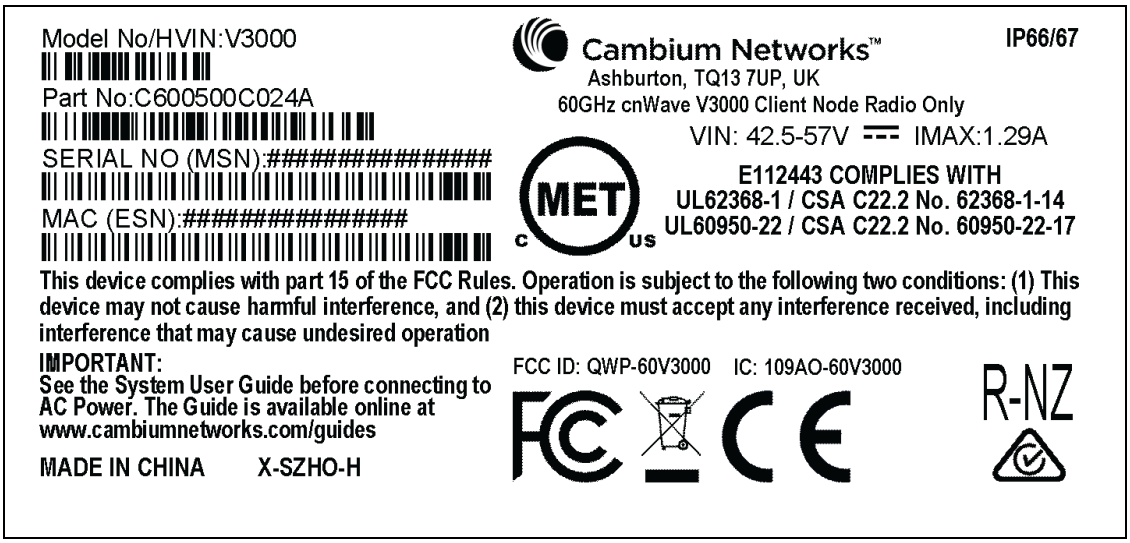


Figure 218: *60 GHz cnWave™ V1000 Client Node with no cord*

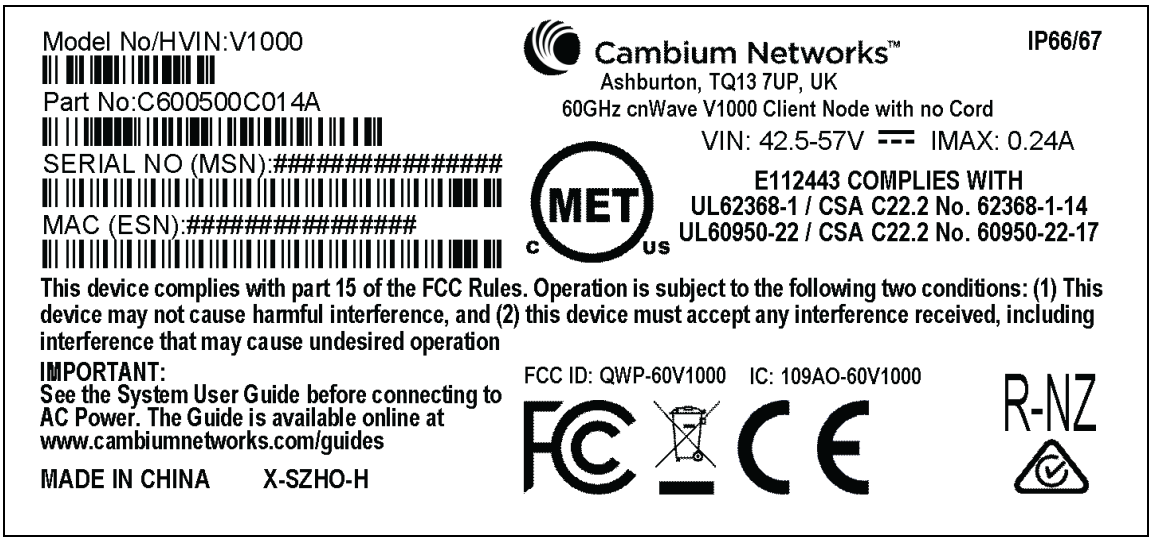


Figure 219: *60 GHz cnWave™ V1000 with US cord*

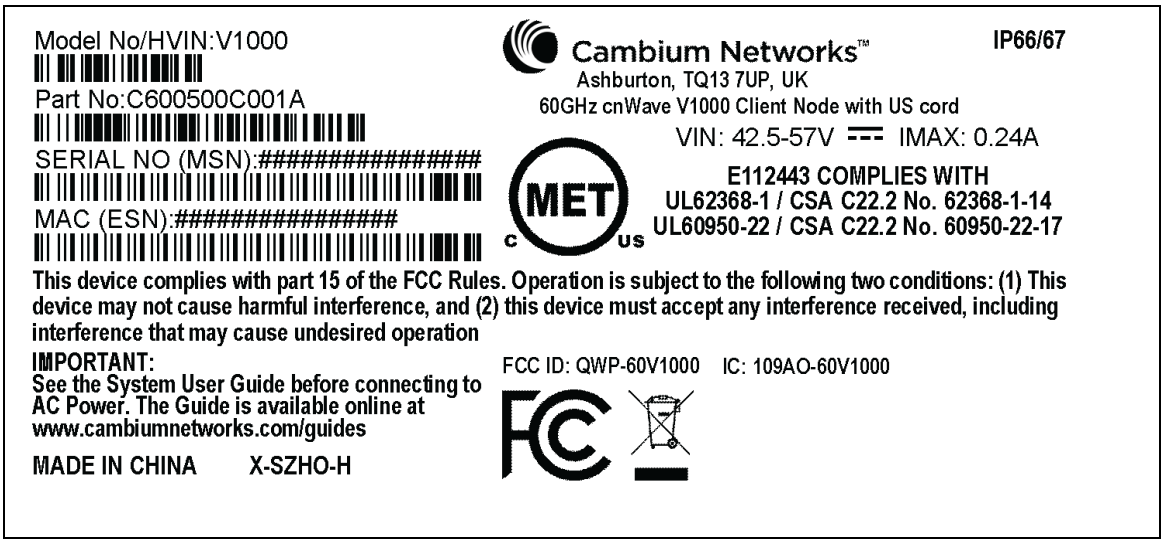


Table 50: Details of accessories, radio nodes, and part numbers

Accessories	Radio nodes	Cambium Part Number
60 GHz cnWave™ V5000 Distribution Node	V5000	C6000500A004A
60 GHz cnWave™ V3000 Client Node radio only	V3000	C600500C024A
60 GHz cnWave™ V1000 Client Node with no cord	V1000	C600500C14A
60 GHz cnWave™ V1000 with US cord	V1000	C600500C001A

Troubleshooting

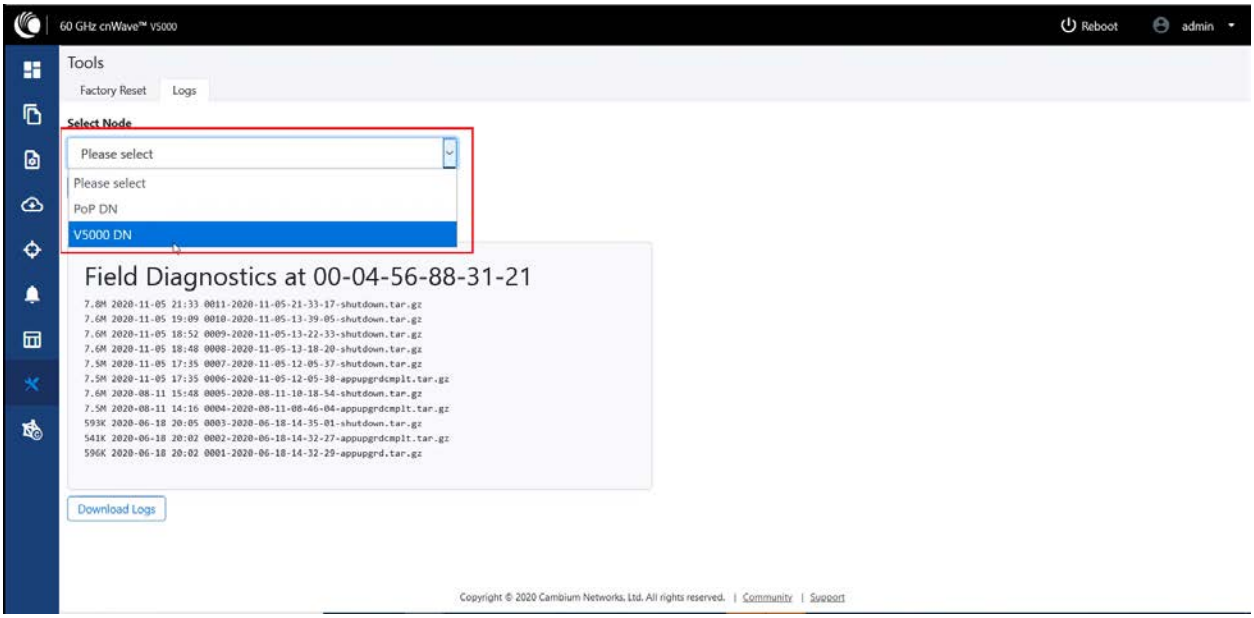
This section describes the troubleshooting steps and addresses frequently asked questions related to 60 GHz cnWave product deployment.

- Field diagnostics logs
- Setup issues in IPv4 tunneling
- Link is not established
- PoP not online
- Link is not coming up
- Link is not having expected throughput performance
- Factory reset

Field diagnostics logs

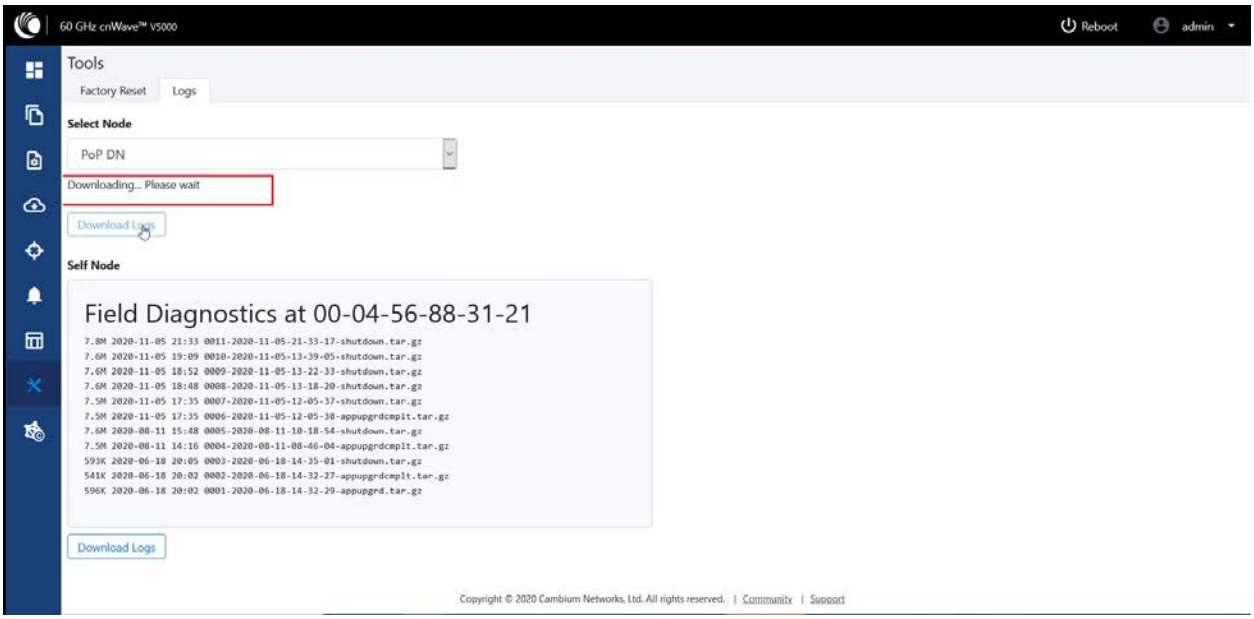
Download the logs to view more information about the error. To download the error logs select the node from the drop-down and click **Download Logs**.

Figure 220: *The Logs tab in the Tools page*



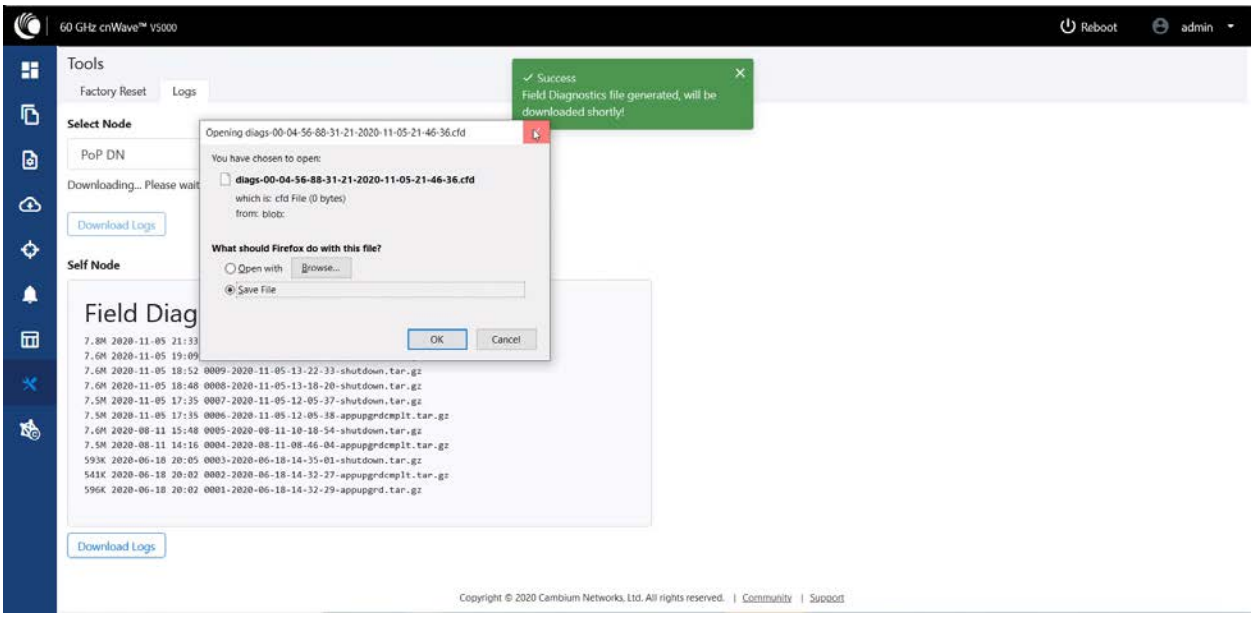
After clicking **Download Logs**, downloading status is displayed.

Figure 221: *Downloading the logs*



To download the logs for a self node, click **Download Logs** at the bottom and save the log file.

Figure 222: *Saving the log files*

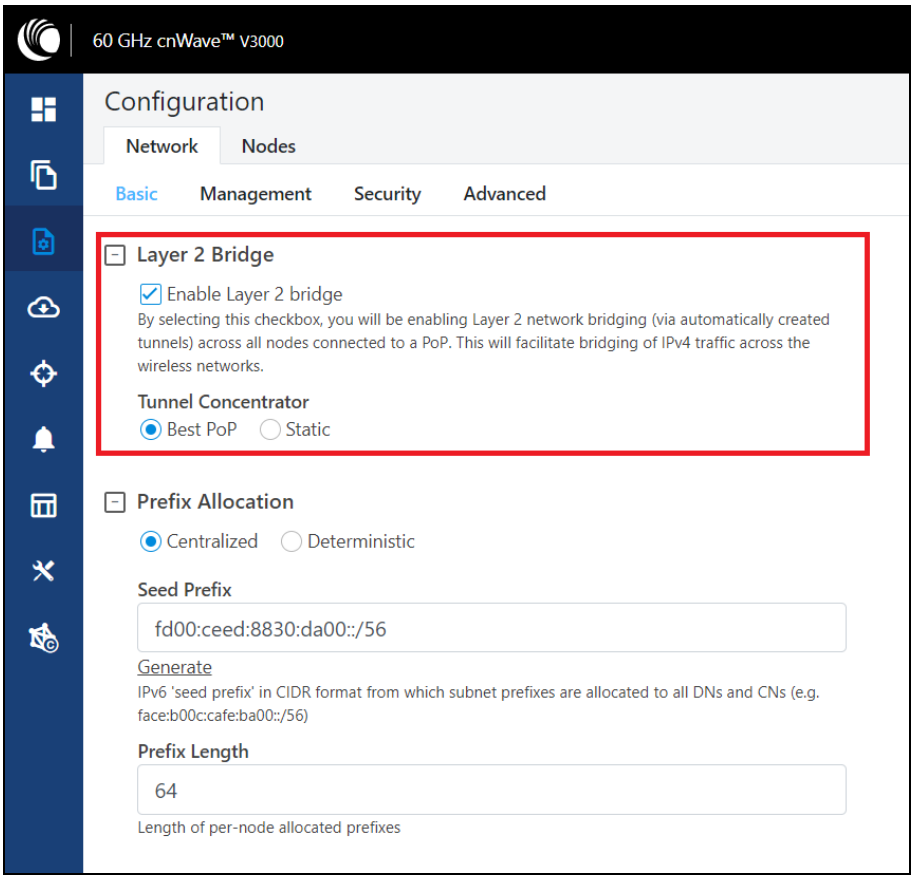


Setup issues in IPv4 tunneling

In IPv4 tunneling, if setup issues occur then perform the below steps:

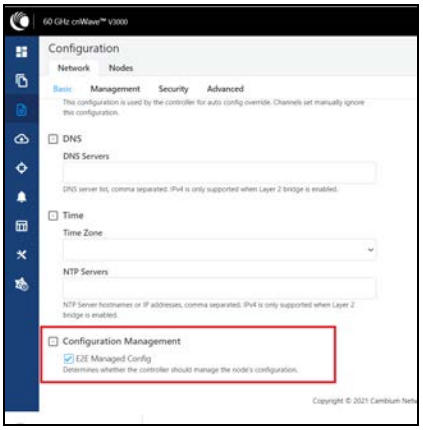
1. Click **Configuration** on the left pane, navigate to **Network** > **Basic** > **Layer 2 Bridge** and verify **Enable Layer 2 bridge** is selected.

Figure 223: *The Layer 2 Bridge section in the Network page*



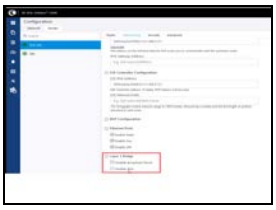
2. On the same page under **Configuration Management**, verify **E2E Managed Config** is selected.

Figure 224: *The E2E Managed Config section in the Basic page*



3. Click **Configuration** > **Nodes** > **PoP DN** > **Networking** > **Layer 2 Bridge** and verify **Disable Broadcast Flood** and **Disable IPv6** are disabled.

Figure 225: *The Layer 2 Bridge section in the Networking page*



4. Ensure that PoP DN and DNs are in the same subnet and verify gateway is correct.

Figure 226: *The Local IPv4 Management section - PoP DN*

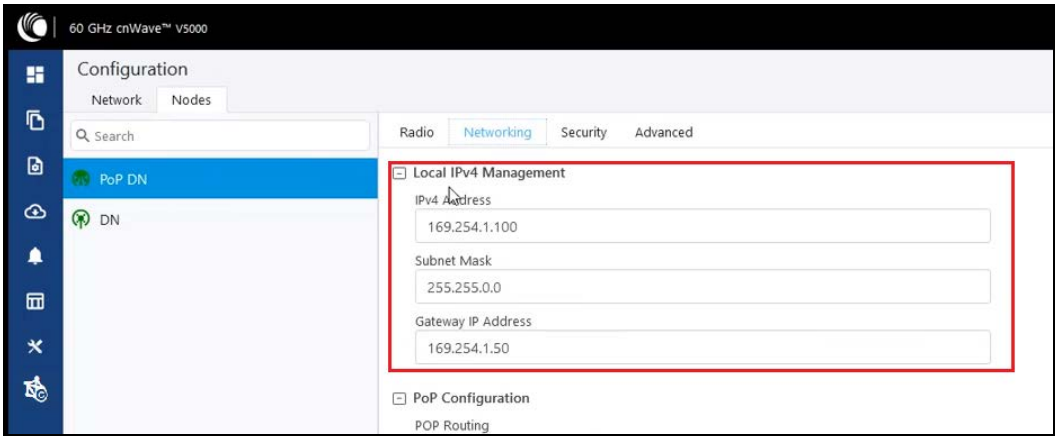
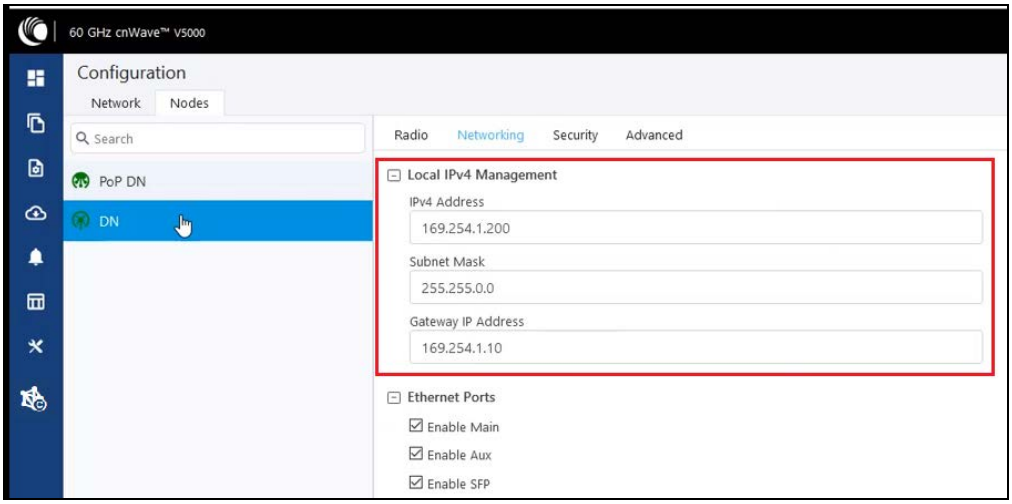


Figure 227: *The Local IPv4 Management section - DN*

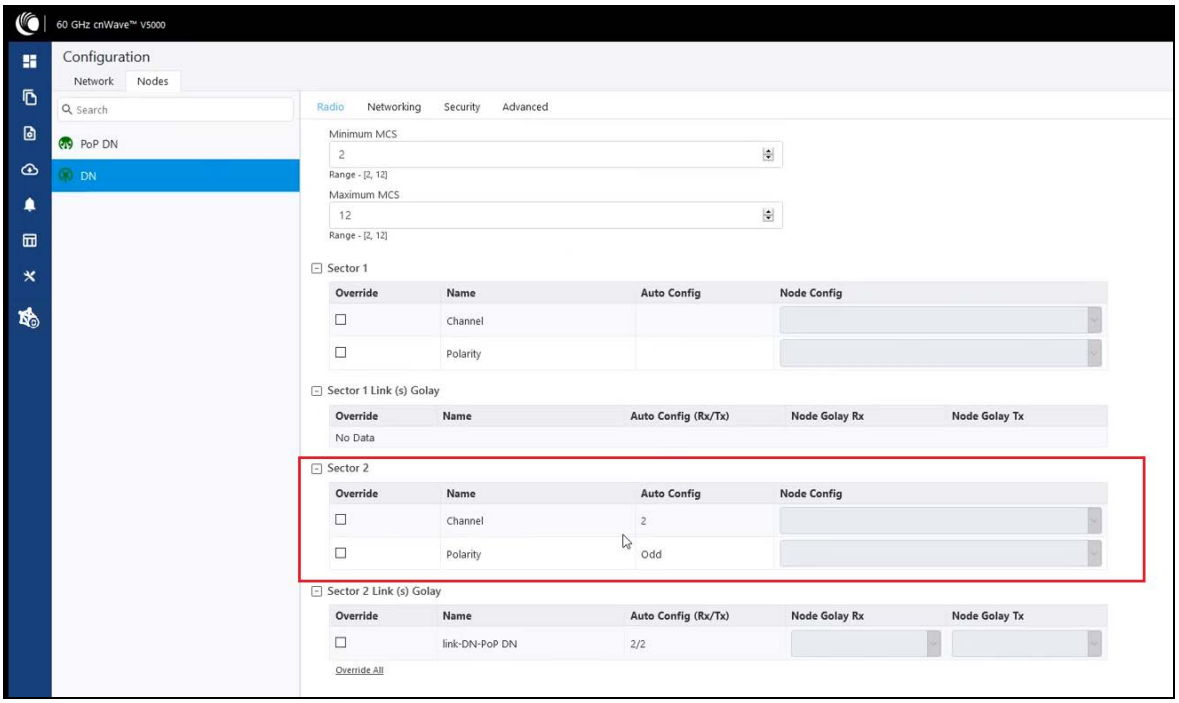


Link is not established

If link is not established between the nodes, then verify the below options:

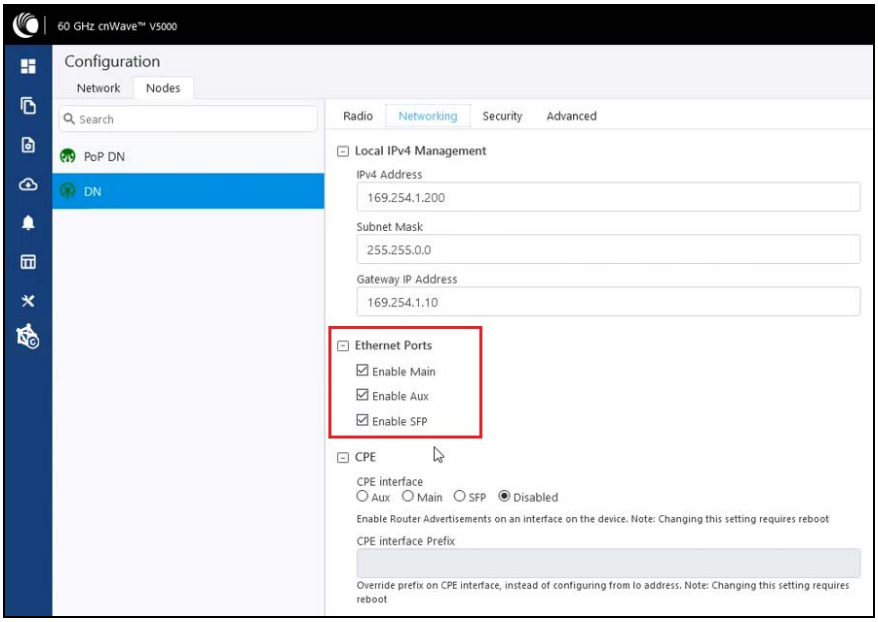
1. Click **Configuration** on the left panel.
2. Navigate to **Nodes** > **Radio** and verify Sector 2 PoP DN and DN's polarities, frequency and Golay codes.

   Figure 228: *The Sector 2 section in the Radio page*



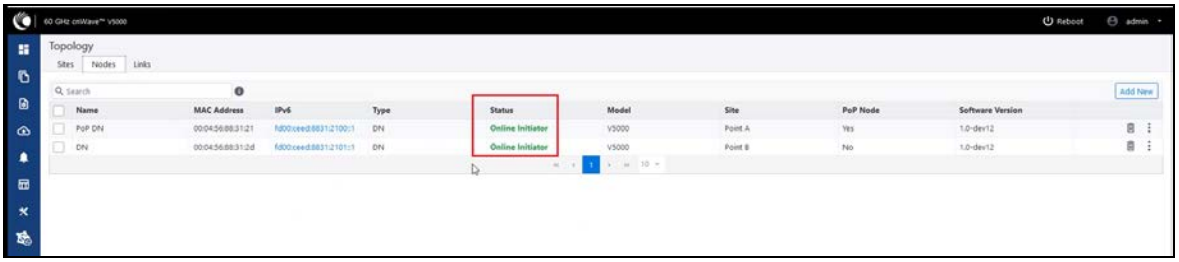
3. Select **DN** > **Networking** > **Ethernet Ports** and ensure that specific Ethernet ports are enabled.

   Figure 229: *The Ethernet Ports section in the Networking page*



4. Click **Topology** on left pane, go to **Nodes** and verify Status is **Online Initiator**.

   Figure 230: *Status of nodes in the Topology page*

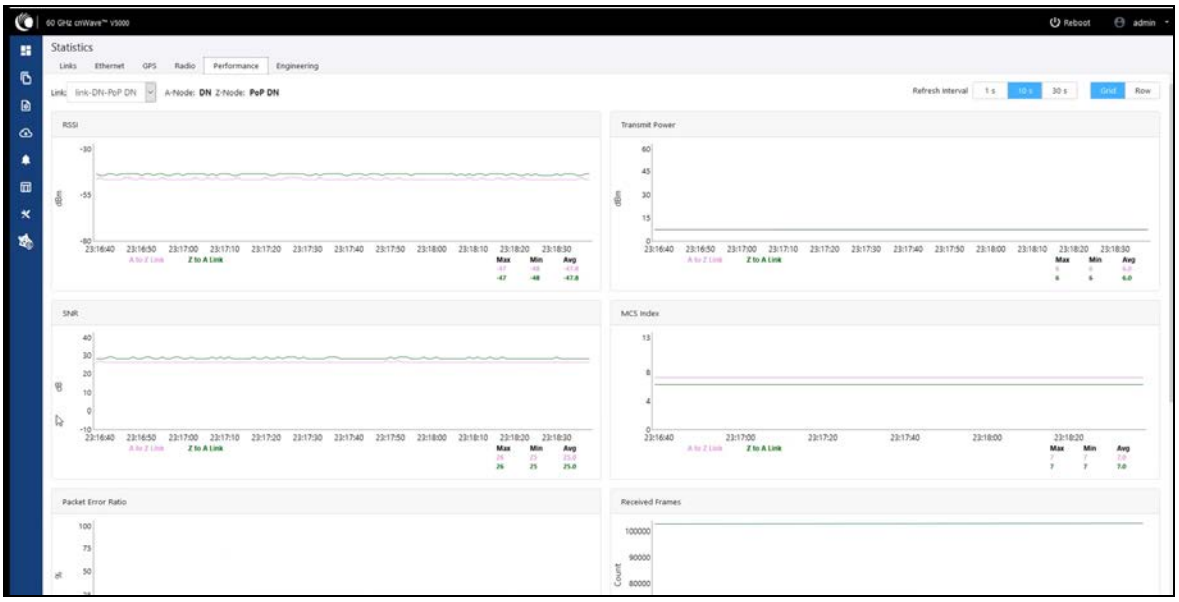


5. Click **Statistics** on left pane, go to **Links** and verify **RSSI**, **MCS**, **TX Power Index**.

Figure 231: *Link details in the Statistics page*

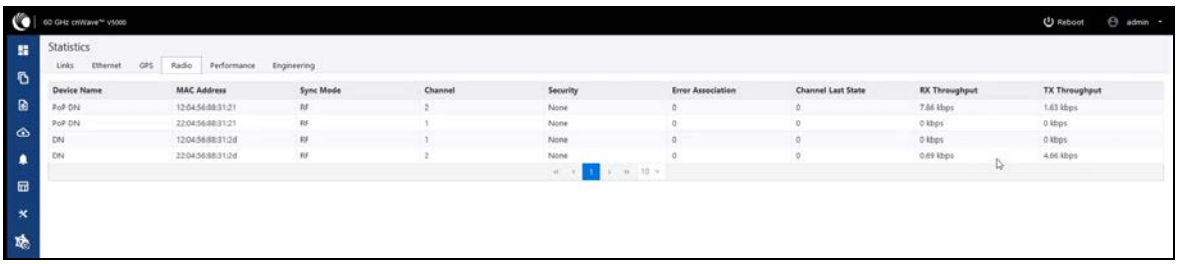
6. Go to **Performance** and verify the graphs.

Figure 232: *Graphs in the Performance page*



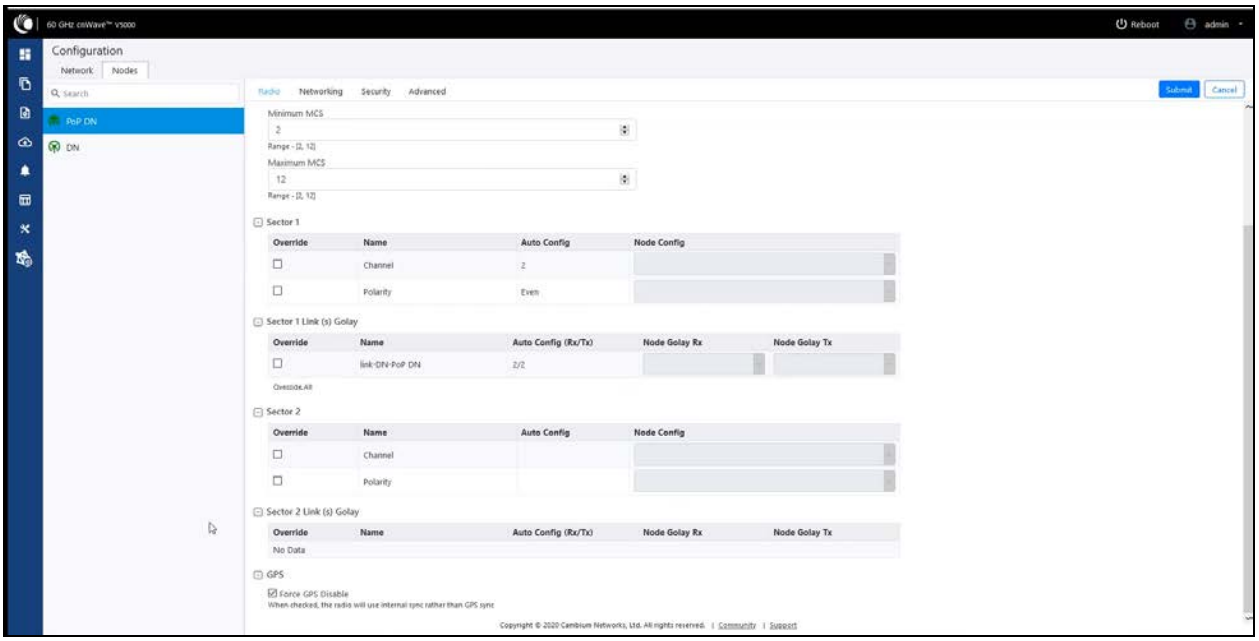
7. Go to **Radio** and monitor the throughput capacity.

Figure 233: *Monitoring the throughput in the Radio page*



8. If internal GPS is used, then verify **Configuration** > **Nodes** > **Radio** > **GPS** > **Force GPS Disable** is enabled.

Figure 234: *Verifying the Force GPS Disable check box*



PoP not online from E2E/cnMaestro GUI

This usually means that the PoP node is not able to talk to the E2E controller. Ensure that the PoP node has the E2E IPv6 configured properly. Also ensure that there is a route between the E2E controller and the PoP node, if they are not in the same VLAN. Try to ping the E2E from the PoP node (login to ssh).

Link is not coming up

1. Ensure that the two ends of the radios can see each other (clear line of sight in between). If the link is using V3000, ensure that they are properly aligned.
2. Ensure that MAC address of the radios is configured correctly in the E2E Controller.
3. Ensure that GPS sync is not enabled if indoor and ensure that GPS sync is enabled if outdoor.
4. Ensure that both ends of the link has the same software version.
5. Ensure to configure country code on the E2E GUI.
6. Ensure that the two ends of the link use opposite polarity and Golay codes that matches each other.
7. Ensure that the remote ends can reach the E2E Controller – IPv6 configuration (if beamforming is successful but the remote end cannot reach back to the E2E Controller, the E2E Controller/cnMaestro GUI displays link status as up, but the remote radio is offline).
8. If you already have experience setting up a link and you are trying to setup a daisy chain, ensure that there is not any interference caused by the existing link. For example, make sure that the two neighboring link use different Golay code.

Link does not come up after some configuration change

There is a possibility that the remote unit could be in a state that it uses different channel/Golay code/polarity from the near-end unit. Try to factory default the remote radio if possible.

On the E2E Controller/cnMaestro, it shows that the link is up, but the remote radio is NOT online - This means that link is established but the remote end radio cannot reply to the E2E Controller. Check the E2E configuration to make sure that the IPv6 default gateway is configured correctly to allow a route between the E2E controller and the remote radio.

Link is not having expected throughput performance

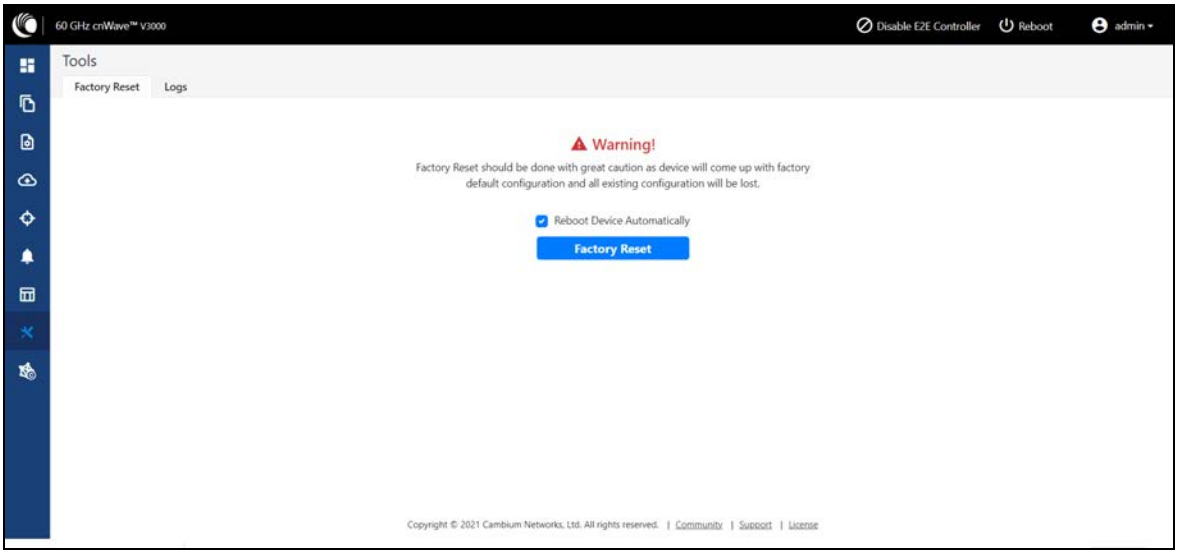
- Check the radio GUI to ensure that the link is running as the expected MCS mode when user data is passing through.
- Check to ensure that the Ethernet ports of the radios and the testing devices are negotiated to expected data rate (10Gbps).
- Ensure that your testing devices are capable of handling the throughput – run data throughput test by bypassing the radio link.
- Do not use radio internal iperf tool to test throughput.

Factory reset

Recovery mode is used to reset the configuration to the factory settings. To reset the configuration, perform the following steps:

1. Go to **Tools** menu and click **Factory Reset**.

   Figure 235: *The Factory Reset page*



   The **Confirm** message box appears. You must confirm to reset the device to factory reset

Figure 236: *The Confirm message box*

2. Click **Yes** to reboot.
3. After the reboot, access the device using IP address **169.254.1.1**.

Note

After factory reset, all configuration set to default mode.

Cambium Networks

Cambium Networks delivers wireless communications that work for businesses, communities, and cities worldwide. Millions of our radios are deployed to connect people, places and things with a unified wireless fabric that spans multiple standards and frequencies of fixed wireless and Wi-Fi, all managed centrally via the cloud. Our multi-gigabit wireless fabric offers a compelling value proposition over traditional fiber and alternative wireless solutions. We work with our Cambium certified ConnectedPartners to deliver purpose built networks for service provider, enterprise, industrial, and government connectivity solutions in urban, suburban, and rural environments, with wireless that just works.

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