



USER GUIDE

60 GHz cnWave™

System Release 1.2.2



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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 Federal Communications Commission (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 Innovation, Science and Economic Development Canada (ISED) 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 spécifiques 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).

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.

United Kingdom (UK) specific information

Cambium Networks 60 GHz cnWave products are compliant with applicable United Kingdom (UK) Regulations required for UKCA marking:

- Radio Equipment Regulations 2017 (SI 2017 No. 1206, as amended)
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (SI 2012 No. 3032, as amended) (RoHS)

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.

UK Unmetered Supplies Operational Charge Codes:

- **V3000**: 8820022000100
- **V5000**: 8820029000100

For more details, check <https://www.elexon.co.uk/operations-settlement/unmetered-supplies/charge-codes-and-switch-regimes/>.

UK 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 Radio Equipment Regulations 2017 (SI 2017 No. 1206, as amended) The declaration of conformity may be consulted at https://www.cambiumnetworks.com/ukca_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 user interface (UI).

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 platform of products are available in [System Hardware](#) and [System Planning](#) sections.

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 following 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 Networks 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 the UK and EU countries

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

Disposal of Cambium equipment

European Union (EU) Directive 2012/19/EU Waste Electrical and Electronic Equipment (WEEE) and UK Statutory Instrument The Waste Electrical and Electronic Equipment Regulations 2013 No. 3113.

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 and UK, it is the individual recipient's responsibility to ensure that packaging materials are collected and recycled according to the requirements of EU and UK environmental law.

In non-EU countries

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

Product Description

This section provides information about the 60 GHz cnWave product (from Cambium Networks). It also describes about its features, characteristics, and other related concepts.

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.

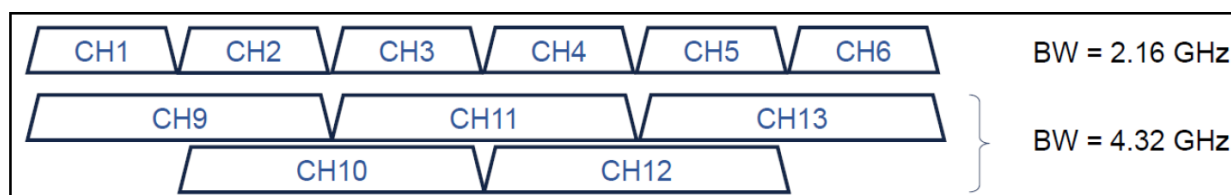
The millimeter-wave portion of the RF spectrum has been largely unexploited for commercial wireless applications. 60 GHz Wireless has used its well-established expertise in millimeter-wave products and technologies to develop wireless products operating in that spectrum that enable two-way wireless communications 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)	Minimum (GHz)	Maximum (GHz)
CH1	2.16	58.32	57.24	59.40
CH2	2.16	60.48	59.40	61.56
CH3	2.16	62.64	61.56	63.72
CH4	2.16	64.80	63.72	65.88
CH9	4.32	59.40	57.24	61.56

Channel	Bandwidth (GHz)	Center (GHz)	Minimum (GHz)	Maximum (GHz)
CH10	4.32	61.56	59.40	63.72
CH11	4.32	63.72	61.56	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.

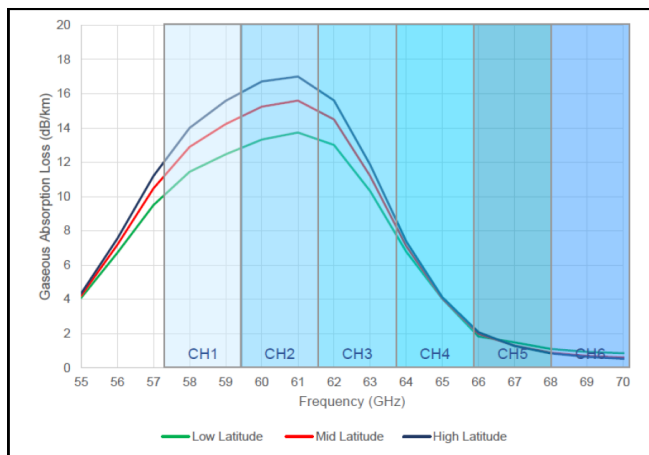
- **Unlicensed and interference-free**

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**

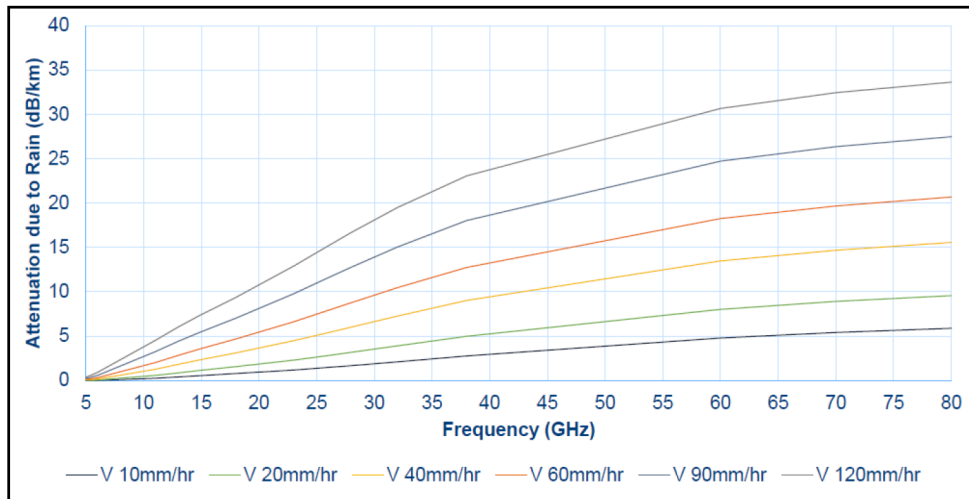
The user can expect to see significant rain fade for 60 GHz links, particularly those pushing the longer distances. Attenuation depends on the rain rate which must be factored in while planning the network. Rain attenuation depends on the level of the rain. The following table describes the rain level 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**

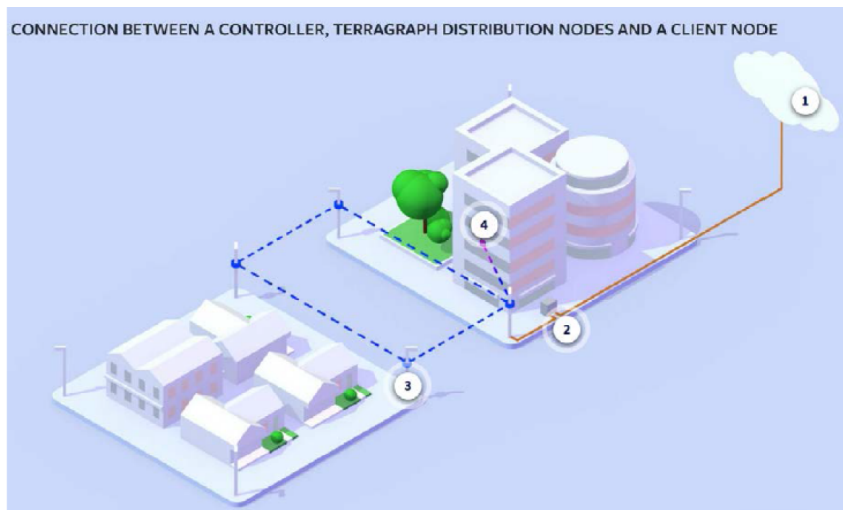
- cnWave V5000 is 280-degree coverage with dual-sector. Installation is simple, uses beam forming for installation. No need for a site router.

- 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 31 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

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.

The 60 GHz solution consists of a Destination Node (DN), which acts as an Access Point (AP), and a Client Node (CN), which acts as a cnWave client.

60 GHz cnWave consists of the following **four variants** (as shown in [Figure 5](#)):

- **V5000: A dual-sector Destination Node (DN)** that contains two sectors covering up to 280 degrees with beamforming. 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.
- **V3000: A Client Node (CN)** that is available in two sizes - 44.5 dBi high-gain antenna and 40.5 dBi lower gain antenna, both with beamforming. These client nodes can support up to 7.2 Gbps, with a channel bonding, for PTP and PMP configurations.

- **V2000**: A **CN** that contains a 34.5 dBi antenna with beamforming. This client node can support up to 3.6 Gbps, with a channel bonding, for PTP and PMP configurations.
- **V1000** : A **CN** that contains a wide-range, 80 degrees beamforming for easy installation. This CN is powered by 802.3af PoE and supports up to 2 Gbps for PTP and PMP configurations.

Figure 5: 60 GHz cnWave products



Features

This section lists the features of each product of 60 GHz cnWave.

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

V2000 Client Node (CN)

- Supports modulations BPSK to 16 QAM (MCS1 to MCS12)
- 34.5 dBi Ultra gain antenna with beam forming 49 dBm EIRP
- 2.5 Gigabit Ethernet Main interface
- 2.5 Gigabit Ethernet Auxiliary interface
- 1.8 Gbps UL/1.8 Gbps DL throughput
- 802.3at POE (2-pair or 4-pair for higher wattage)

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

V3000 Client Node (CN)

- Supports modulations BPSK to 16 QAM (MCS1 to MCS12)
- 44.5 dBi Ultra gain 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 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 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

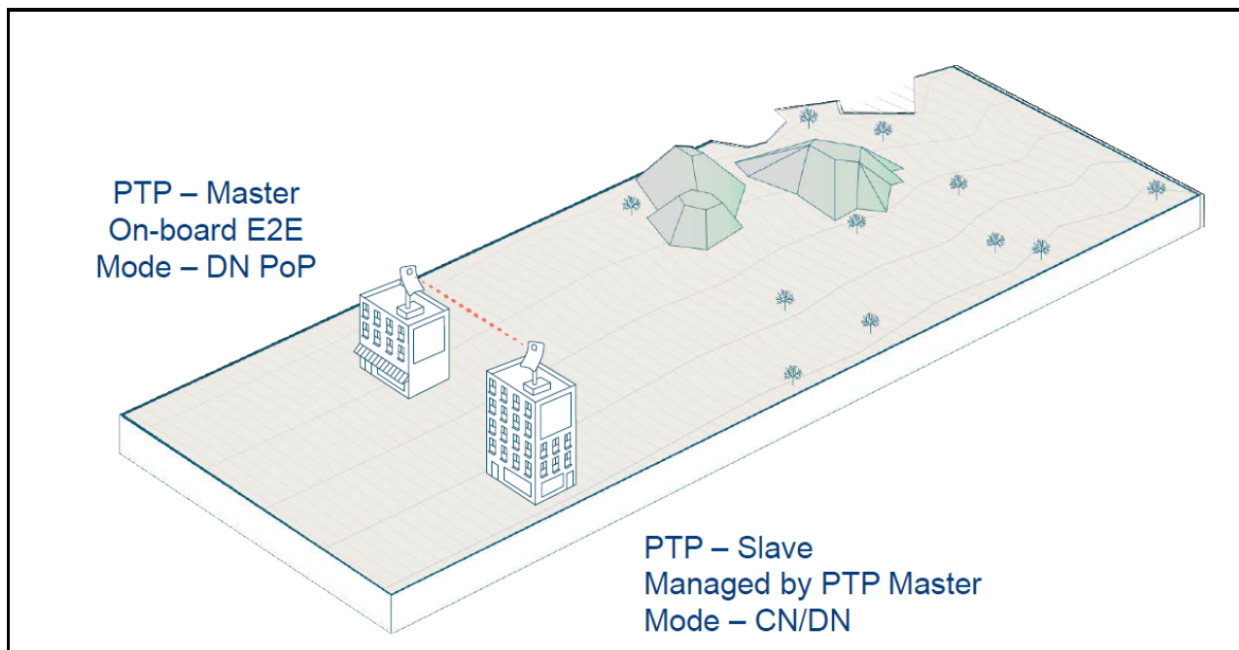
The PTP topology provides a point-to-point link using V1000, V2000, V3000, and V5000.



Note

V1000 to V1000 point-to-point topology is supported. And, V2000 to V2000 point-to-point topology is also supported.

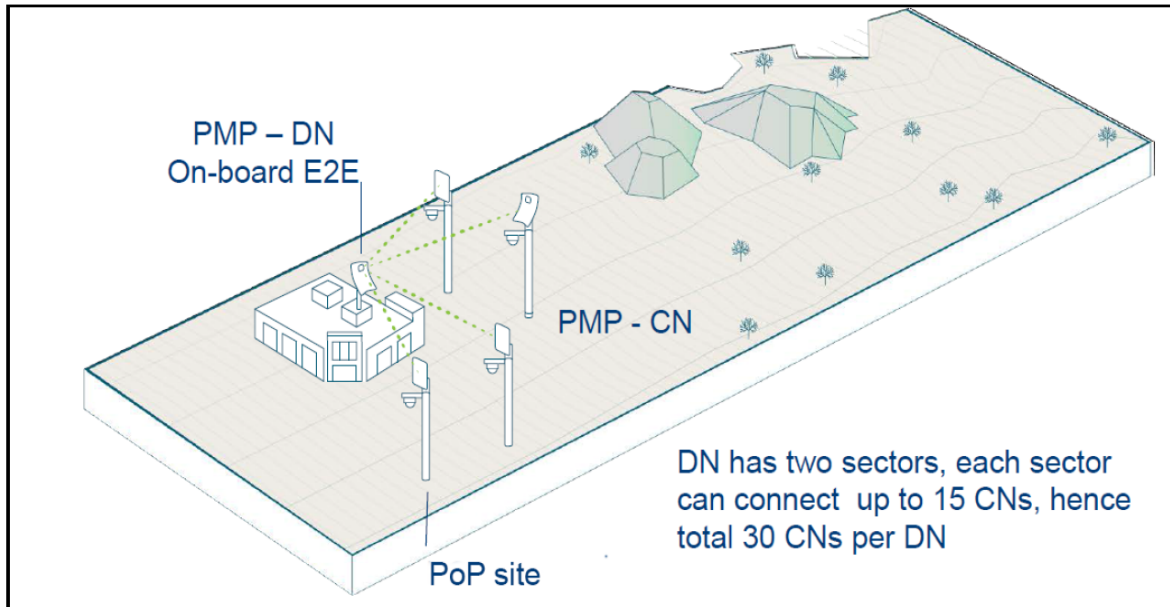
Figure 6: PTP Topology



PMP

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

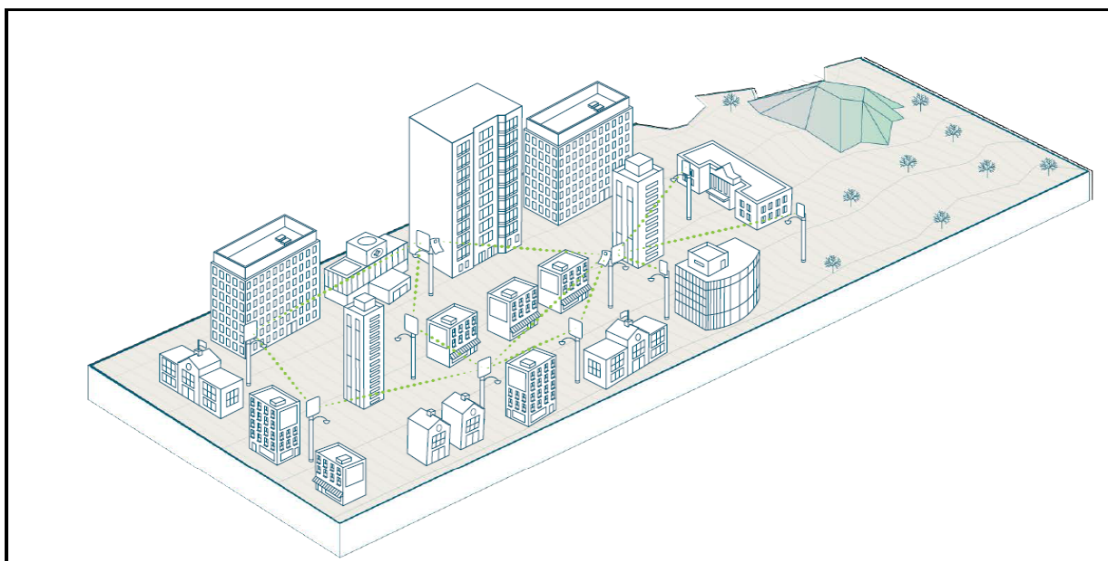
Figure 7: PMP Topology



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

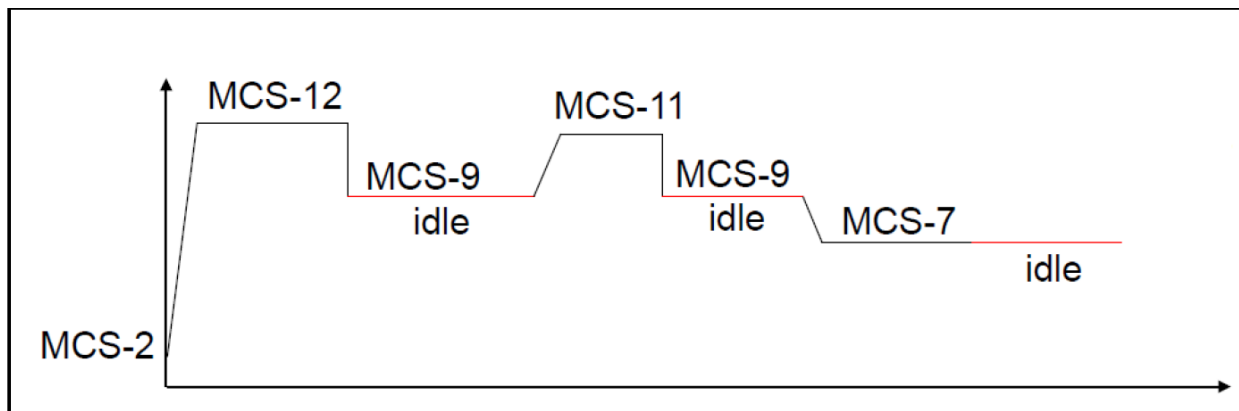
MCS	Modulation	Coding Rate	L2 Throughput (Mb/s) (2.16 GHz Channel)	L2 Throughput (Mb/s) (4.32 GHz Channel)
2	BPSK	1/2	733.0	1466.0
3	BPSK	5/8	914.0	1828.0
4	BPSK	3/4	1085.0	2170.0
5	BPSK	4/5	1175.0	2350.0
6	QPSK	1/2	1421.0	2842.0
7	QPSK	5/8	1748.0	3496.0
8	QPSK	3/4	2059.0	4118.0
9	QPSK	4/5	2221.0	4442.0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



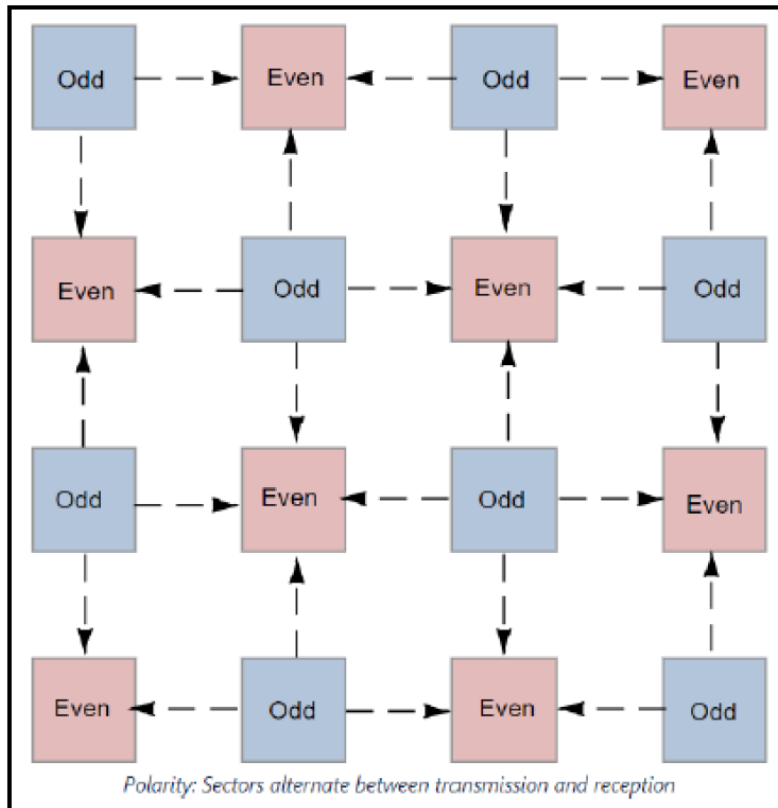
Start from MCS2, adjust based on signal quality, when the session is idle, fall back to MCS-9 or any highest MCS achieved below MCS-9.

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:

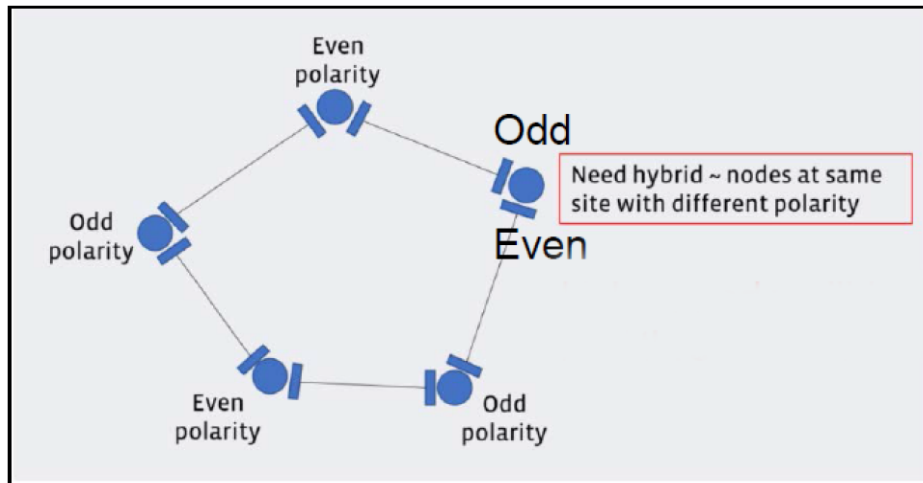
- Odd (if Odd nodes are Tx)
- Even (if Even nodes are Rx)

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

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
- V2000 Client Node
- V3000 (44.5 dBi and 40.5 dBi) Client Node
- V5000 Distribution Node

V1000 Client Node (CN)

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 CN's front and rear views



V1000 CN - Part numbers

Order the V1000 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

Product description	Part number
60GHz cnWave V1000 Client Node with US cord	C600500C001A
60GHz cnWave V1000 Client Node with EU cord	C600500C003A

Product description	Part number
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
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 - for Israel Only	C600500C016A
60GHz cnWave V1000 Client Node with no Cord and no Power supply	C600500C017A

V2000 Client Node (CN)

V2000 is an outdoor CN that can be connected (wireless) to a DN or another V2000 CN. V2000 supports a 2.5 Gigabit Ethernet Main interface and a 2.5 Gigabit Ethernet Aux interface.

A V2000 CN can be powered using 30W passive POE or using 802.3at compliant POE switch. For more information about the supported power supply and cable lengths, refer to the [Power supply units \(PSU\)](#) section.

A V2000 CN can also power 802.3af/at compliant auxiliary device through the Aux Ethernet interface.

Figure 13: V2000 CN's front and rear views



V2000 CN - Part numbers

Order the V2000 CN from Cambium Networks (as listed in [Table 5](#)). A V2000 CN radio is supplied without a mounting bracket and with or without power supply.

Table 5: V2000 CN part numbers

Product description	Part number
60GHz cnWave V2000 Client Node 30W with Israel Cord	C600500C026A
60GHz cnWave V2000 Client Node 30W with South Africa Cord	C600500C027A
60GHz cnWave V2000 Client Node 30W with India Cord	C600500C028A
60GHz cnWave V2000 Client Node 30W with no Cord	C600500C029A
60GHz cnWave V2000 Client Node no power supply, no power cord	C600500C030A
60GHz cnWave V2000 Client Node 30W with EU cord	C600500C031A
60GHz cnWave V2000 Client Node 30W with UK Cord	C600500C032A
60GHz cnWave V2000 Client Node 30W with ANZ Cord	C600500C033A
60GHz cnWave V2000 Client Node 30W with Brazil Cord	C600500C034A
60GHz cnWave V2000 Client Node 30W with Argentina Cord	C600500C035A

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 14: V3000 Client Node without antenna assembly and with 44.5 dBi and 40.5 dBi antenna assemblies

