PLANNING AND INSTALLATION GUIDE

cnWave™ 5G Fixed

Release 3.3

Contents

About This Guide

This guide describes the planning and installation of the **cnWave™ 5G Fixed** platform of products from Cambium Networks. It is intended for use by system designers, system installers, and system administrators.

For radio network design, planning, and installation, refer to the following topics:

- Product Description

- System Hardware

- System Planning

- Preparing for Installation

- Installation

Purpose

cnWave™ 5G Fixed documents instruct and assist personnel in the operation, installation, and maintenance of the Point-to-MultiPoint (PMP) equipment (from Cambium Networks)and ancillary devices of the cnWave™ 5G Fixed platform family. 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 topics that are divided into sections. Sections are not numbered 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 Cambium Networks Support website.

Warnings, Cautions, and Notes

The following describes how warnings, cautions and notes 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.

Important regulatory information

The cnWave™ 5G Fixed platform of products are certified as an unlicensed device in frequency bands where it is not allowed to cause interference to licensed services (called primary users of the bands).

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. • 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.

Canada-specific information

Caution

This device complies with Innovation, Science and Economic Development Canada (ISEDC) license-exempt RSSs. Operation is subject to the following two conditions:

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

Note

Certification note from industry Canada: While this equipment meets the technical requirements for its operation in its rated paired block arrangement, this block arrangement is different than the 40 + 40 MHz block arrangement prescribed in documents RSS-191 and SRSP-324.25. The operation of this equipment IS NOT permitted if the out-of-band and spurious emission limits are not met at the edge of any contiguous licensed spectrum. It should be noted that all current relevant spectrum policies, licensing procedures, and technical requirements are still applicable. For additional information, contact the local Industry Canada office.

Renseignements spécifiques au Canada

Note

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 d'interférences; et

- L'utilisateur de l'appareil doit accepter toute interférence radioélectrique, même si elle est susceptible d'en compromettre le bon fonctionnement.

European-specific information

The cnWave™ 5G Fixed platform of 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 harmonization 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 cnWave™ 5G Fixed 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/.

Application software (firmware)

Download the latest cnWave™ 5G Fixed products family software and install it in the Base Transceiver System (BTS) and Customer Equipment Premise (CPE) before deploying the equipment. Instructions for installing software are provided in the cnWave™ 5G Fixed Planning and Installation Guide (available at https://support.cambiumnetworks.com/files/28cnwave/).

Ethernet networking skills

The installer must have the ability to configure IP address 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 specific to site selection, bonding, and grounding. Installation guidelines for the cnWave™ 5G Fixed platform of products are available in System Planning.

Specific expertise and training for professional installers

To ensure that the cnWave™ 5G Fixed series are installed and configured in compliance with the requirements of EU, ISEDC and the FCC, installers must have the radio engineering skills and technical training (specified by Cambium Networks).

Use the Training link to access the technical training program (from Cambium Networks).

Legal and Open-Source software statements

Refer to the cnWave™ 5G Fixed Legal and Open-Source Guide for:

- Cambium Networks end user license agreement and

- 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 for this document and the software Release Notes of supported releases.
2. Visit the Support site of Cambium Networks.
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 using email or telephone support.

Repair and service

If any unit failure is suspected, obtain details of the Return Material Authorization (RMA) process from the Support site.

Hardware warranty

Cambium Networks standard hardware warranty is for one (1) year from the date of shipment from Cambium Networks or a distributor (from Cambium Networks).

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 Networks 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 cnWave™ 5G Fixed products or activate warranties, visit the Cambium Networks Support site. 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 Networks 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 Networks 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.

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 https://www.cambiumnetworks.com/support/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 Networks equipment and all surplus packaging in accordance with national and regional regulations.

Product Description

This section provides a high-level description of the cnWave™ 5G Fixed platform of products. It describes, in general, the functions of products and their main hardware components.

This section covers the following topics:

- Overview of the Millimeter Wave (mmWave) spectrum introduces mmWave advantages, challenges, and applications.

- Overview of the cnWave™ 5G Fixed platform introduces the key features, typical uses, and components of the cnWave™ 5G Fixed platform of products.

- Wireless operation describes (in brief) how the cnWave™ 5G Fixed wireless link is operated, including modulation modes and link operation.

- System management introduces the cnWave™ 5G Fixed management system, including the web interface, configuration, security, and alerts.

Purpose

Cambium Networks cnWave™ 5G Fixed platform of products is a high-end Point-to-Multipoint (PMP) system that provides an easy, fast, and cost-effective solution. It supports wireless Gigabit connectivity for edge access solutions at a significantly lower cost than fiber infrastructure.

Operators and Service providers now have access to Gigabit for business and residential connectivity and backhaul for Wi-Fi access.

cnWave™ 5G Fixed platform of products provide carriers and Service Providers to offer high-speed broadband connectivity for customers in areas not reached by full-fiber networks.

Millimeter Wave spectrum for 5G NR networks

The fifth generation (5G) of wireless communications technology is fundamentally transforming the telecommunications industry. Mobile service providers are challenged over ever-growing mobile data traffic using smart devices. 5G is expected to address these demands and enable further digitization in many applications and verticals.

Although 5G Systems are being planned for deployment in a variety of low frequencies spectrum bands (less than 1 GHz), the underutilized millimeter-wave (mmWave) frequency range is seen to offer a much-needed larger amount of spectrum to boost the performance of the 5G cellular networks.

5G New Radio (NR) is the first mobile technology generation to make use of the mmWave spectrum. There are serious issues that must be overcome for efficient use of mmWave spectrum. But Massive multi-input-multi-output (MIMO) and beamforming are seen as key solutions for future 5G mobile deployments in millimeter-wave. One of the advantages of the mmWave spectrum is its large bandwidth, making it possible to deliver gigabit wireless services.

Although the mmWave spectrum falls in the range of 30 GHz to 300 GHz, the 5G industry is also using 24 GHz and 28 GHz frequency bands. Note that the cnWave™ 5G Fixed platform of products covers 24, 26, and 28 GHz bands.

Millimeter Wave (mmWave) challenges

Following are the mmWave challenges:

Losses in mmWave – Path loss

Path loss is the amount of attenuation of a radio signal that undergoes between the two ends of a link. It is a major consideration for all wireless communication systems to determine the link budget of the system. It is the sum of attenuation of the path if there were no obstacles in the way (Free space path loss) and the attenuation caused by obstacles (Excess path loss). It is also necessary to consider a margin to allow for possible fading of the radio signal (Fade margin) and an allowance for seasonal effects of foliage growth, to achieve a reliable link (Foliage loss).

Excess path loss

Excess path loss is the loss incurred due to obstacles between the two endpoints of the radio link. In general, mmWave signals tend to be more sensitive to obstacles in the environment because the mmWave wavelength is very small (less than a centimeter).

The mmWave signals may be subject to large signal absorption, making the mmWave products more suitable for Line of Sight (LoS) applications.

Fade margin

The Fade margin for the LoS links is a function of location, path length, and antenna heights. Cambium Networks provides a free planning tool (LINKPlanner), which helps in the design of such networks and calculates all of these parameters.

> **Note**
>
> Cambium Networks cnWave™ 5G Fixed platform of products can only operate in LoS environments.

Atmospheric loss

Absorption losses occur when radio frequency waves, traveling through the atmosphere, are absorbed by gas molecules via electric-magnetic-dipole absorption processes that couple the RF photon to internal degrees of freedom of the gas molecule. For 28 GHz, these losses are small (0.1 dB/km). In general, the densities of oxygen and water vapor depend upon the local temperature, atmospheric pressure, and humidity.

Rain fade

You can expect to see some rain fade for 28 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. Figure 1 describes the rain level and absorption loss. Figure 1 demonstrates how 28 GHz mmWave signals can suffer significant loss when they propagate in medium and high rainfall but have a low impact at short distances.
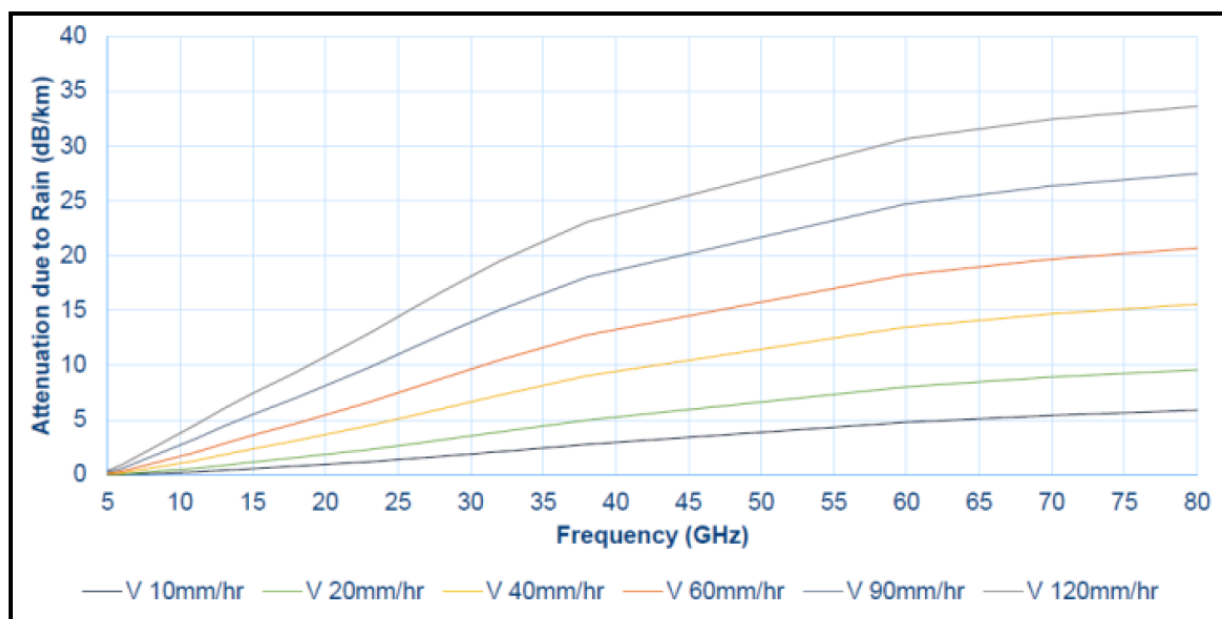
Advantages of mmWave

Larger bandwidth

Wireless spectrum is a finite resource, and it is easy to see how crowded the sub-6 GHz space has become. By contrast, the mmWave spectrum spans across a larger range (30-300 GHz) and is mostly less crowded, less intensively used, and licensed. Therefore, it is possible to use large bandwidth sizes that provide opportunities for more capacity and higher peak throughputs.

Larger antenna array in small form factor

mmWave products operate at short wavelengths. Hence, it is possible to design antenna arrays that are several times greater than the wavelength itself, while remaining physically small. Additional beamforming gain realized through greater array gain in mmWave frequencies, as compared to sub-6 GHz, allow beam shaping that is more conducive to Multi-user multi-input-multi-output (MU-MIMO) operation.

Shorter Time Transmission Interval (TTI) and reduced latency

Since mmWave products operate at short wavelengths, it is possible to design antenna arrays that are several times greater than the wavelength itself, while remaining physically small.

Higher densification

With higher densification that may pose challenges such as co-channel interference, but that can be mitigated by the use of highly directional antennas.

Channel reciprocity

Frequency bands available for mmWave communication are unpaired, which implies that the same frequency must be used for the downlink (DL) and uplink (UL) communications but at different times. Such systems are also called Time Division Duplex (TDD).

In such systems, when the downlink (DL) and uplink (UL) communications are performed within a certain period known as the channel coherence time, the UL and DL propagation channel characteristics are highly correlated. This phenomenon is termed channel reciprocity.

Channel reciprocity is important for mmWave communications, which typically relies on massive MIMO systems for achieving beamforming gains. Massive MIMO systems have a large number of antennas and hence, a significant amount of resources and cost is incurred in estimating the DL or UL channel state information (CSI), especially, CSI at the transmitter (CSIT) which is required for transmit side beamforming.

By leveraging channel reciprocity in massive MIMO systems, the measurement and sounding resources required for channel estimation are greatly reduced.

Applications and use cases for 5G mmWave

Wireless engineers and business planners commonly raise the question of where, when, and how mmWave will be used in 5G and beyond. Since a typical current generation network is not a new radio access standard, but instead an integration of networks for vertical markets with diverse applications, answers to the question depend on scenarios and use cases to be deployed.

As mentioned before, one important characteristic of the mmWave spectrum is its potential to support large bandwidths and high data rates that are ideal for increasing the capacity of wireless networks. In addition, the low latency characteristics of 5G mmWave will improve surveillance, video streaming or broadcasts, and VR online gaming experiences. Given the propagation challenges discussed in previous sections, the mmWave spectrum is generally best suited for short-range transmissions and ideally in LoS conditions.

5G mmWave solutions can be deployed for the following two target cases:

- Coverage Extension at the Edge – as a microcell to extend the coverage of the 5G network.

- Capacity Enhancement – to improve data throughput of the overall network.

Following are some of the use cases for deploying 5G mmWave products:

- Surveillance and video streaming or broadcast

- Crowded area capacity (stadium)

- Last mile fiber or copper complement

- Augmented Reality (AR) or Virtual Reality (VR) everywhere

- Smart factories industry

- Street macro applications

cnWave™ 5G Fixed frequency bands

Several mmWave bands have already been standardized, providing a tremendous amount of spectrum for mobile broadband, though not all of them may be available in a given country.

The cnWave™ 5G Fixed series of radio products (from Cambium Networks) are designed as high-end Point-to-Multipoint (PMP) wireless systems operating in the 24.25 to 29.50 GHz licensed bands (with various frequency ranges covered by these products, as shown in Table 1).

Table 1: 5G NR Frequency Bands

5G NR Band	Bands Limits (GHz)
n257	26.50 to 29.50 GHz
n258	24.25 to 27.50 GHz
n261	27.50 to 28.35 GHz (US)

All these bands follow Time Division Duplexing (TDD) mode that requires only a single frequency band for both UL and DL.

Overview of cnWave™ 5G Fixed platform family

The cnWave™ 5G Fixed platform consists of a B1000 Base Transceiver Station (BTS), which serves one or more C100 Customer Premises Equipment (CPE). Each CPE can be located at multiple locations within a sector.

A BTS is available as an integrated unit with a flat panel 90° sector antenna. A CPE is available as an integrated unit connected to an external dish antenna (as shown in Figure 4).

Figure 2 and Figure 3 show images of the radios B1000 BTS and C100 CPE, respectively.

Figure 2: cnWave™ 5G Fixed B1000 BTS

Figure 3: *cnWave™ 5G Fixed C100 CPE*

Figure 4: *C100 CPE Dish Antenna (assembled)*

For information about the technical specifications of the products, refer to <u>System Technical Specifications</u>.

> **Note**
>
> In the later sections of this guide, the term BTS is used to refer to B1000 BTS and the term CPE to refer to C100 CPE.

Key features

Following are the main features of cnWave™ 5G Fixed platform of products:

- Performance:

    - BTS: Throughput of over 3 Gbps per sector

    - CPE: Up to 400 Mbps per CPE (112 MHz channel)

- 24, 26, and 28 GHz bands in a single SKU, covering the most common 5G bands globally

- Up to 112 MHz channel bandwidth

- Up to 19 MCS levels

- Transmit:

    - BTS: Max EIRP of 44 dBm

    - CPE: Max EIRP of 47 dBm

- Receive: <10.0 dB noise figure

- Channel aggregation at the BTS (not supported in Release 3.3):

    - Up to two channels (adjacent or not)

    - 4x4 MU-MIMO per channel in two aggregated channels mode

- BTS: Two SFP+ ports allow 1 Gbps and 10 Gbps optical interfaces

- CPE: Gigabit Ethernet Interface

- TDD Based

- OFDM modulation : Pilot-based channel estimation

- Adaptive Modulation

    - 19 MCS levels

    - Each MCS supports for mixed constellation and Forward Error Correction (FEC)

- IP67 and IP66

Wireless operation

This section describes how the cnWave™ 5G Fixed operates, including topology, modulation modes, power control, and security.

Wireless topology

The cnWave™ 5G Fixed is a carrier-grade Point-to-Multipoint (PMP) wireless infrastructure platform, operating in 24 to 30 GHz spectrum. Each cnWave™ 5G Fixed BTS will have a maximum capacity of up to 3.2 Gbps of traffic, and will cover up to a 90° sector. It can serve up to 240 CPEs endpoints (120 CPEs in Release 3.3).

The cnWave™ 5G Fixed platform operates in the 24, 26, or 28 GHz licensed bands in a single radio model. It supports a maximum channel size of 112 MHz and can be configured to operate in either Horizontal (H) or Vertical (V) polarization.

The cnWave™ 5G Fixed BTS is capable of aggregating two adjacent or non-adjacent channels of the same bandwidth at the BTS. It is a completely integrated (not externally connectorized antenna) and outdoor solution, supporting up to 8x8 MU- MIMO. At launch, the BTS will not support MU-MIMO and channel aggregation.

> **Note**
>
> The aggregation of two adjacent or non-adjacent channels is not supported in the initial release.

The wireless link air interface is based on the 3GPP Release 15 standard, which is also known as 5G New Radio (NR). It operates in TDD mode and supports near symmetric (57% downlink) and asymmetric configurations (71% or 85% downlink). It is very flexible and might be site or network synchronized to reduce or eliminate interference from other TDD wireless links. At launch, only 5:2 symmetry (corresponds to 71% downlink and 29% uplink) is supported.

Using the embedded GPS receiver, the BTS maintains timing across the network such that frequencies can be re-used, and precious spectrum resources can be effectively scaled, where needed.

> **Note**
>
> In Release 3.3, each BTS can manage up to 120 CPEs.

Modulation

cnWave™ 5G Fixed employs adaptive modulation, with 19 Modulation Coding Scheme (MCS) levels. Each MCS supports mixed constellation and Forward Error Correction (FEC). This allows fine-grain adjustment to adjust for different RF fading conditions while maintaining optimized system performance.

MCS depends on the radio's signal quality in a wireless link, better quality results in higher MCS, and poor signal quality results in lower MCS, which means less useful data can be transmitted within a symbol. In other words, MCS depends on the Blocker Error Code (BLER).

The BTS maximum EIRP is 48 dBm for all MCS and bandwidth. Table 2 indicates the CPE maximum EIRP per MCS.

Table 2: MCS Modes for maximum EIRP

MCS Mode	112 MHz Channel	100 MHz Channel	56 MHz Channel	50 MHz Channel
MCS 4	NA	NA	NA	52.0
MCS 5	NA	NA	NA	NA
MCS 6	52.0	52.0	52.0	NA
MCS 7	52.0	52.0	NA	52.0
MCS 8	52.0	52.0	52.0	NA
MCS 9	51.8	51.8	NA	51.3
MCS 10	51.1	51.8	51.3	NA
MCS 11	50.5	51.1	NA	50.1
MCS 12	49.9	50.5	50.1	NA
MCS 13	49.3	49.9	NA	49.0
MSC 14	48.8	NA	49.0	NA
MCS 15	48.1	49.3	NA	NA
MSC 16	48.0	48.8	48.0	48.0
MCS 17	48.0	48.1	NA	NA
MCS 18	48.0	48.0	48.0	48.0
MCS 19	48.0	48.0	NA	NA
MCS 20	48.0	48.0	48.0	48.0
MCS 21	48.0	48.0	NA	NA
MCS 22	48.0	48.0	48.0	48.0
MCS 23	48.0	48.0	NA	NA
MCS 24	NA	NA	48.0	NA

Time Division Duplexing (TDD) structure and synchronization

cnWave™ 5G Fixed makes use of a 5G NR compatible TDD structure. It has the following key characteristics:

Table 3: TDD Structure

TDD structure characteristics	Value
Frame duration	1 ms
Slots per frame (DL:Transition:UL)	8 (7 active, 1 for Tx/Rx transition) 6:1, 5:2 and 4:3
Slot duration	125 µs
OFDM symbols per slot	14
OFDM symbol duration	-8.9 µs

TDD Synchronization

The cnWave™ 5G Fixed 5G system supports network-wide synchronization of its TDD structure to avoid network self-interference.

The reference signal required at BTS for TDD synchronization is either:

- a one PPS signal provided by onboard GPS,

- a one PPS signal over the Cambium Sync-Over-Power interface, or

- derived from an on-board IEEE1588v2 Slave Clock.

> **Note**
>
> Currently, Cambium Networks does not offer any Sync-Over-Power injectors but recommends a third-party equipment on request. For more details, contact Cambium Networks Sales.

The TDD structure of the BTS can be locked to a 1 Pulse Per Second (pps) signal to provide network wide TDD synchronization. When enabled and TDD lock is achieved, the timing of the TDD structure is fixed with the 1 pps. In this state, the frequencies of the carrier and sampling are locked to the 1 pps.

The TDD sync is associated with slow tracking loops, which can take some 10 seconds to establish a lock. A configuration option determines whether TX is disabled while the TDD remains unlocked. This prevents an unlocked BTS from interfering with other sectors.

The parameter attribute **TDD Sync Control** (as shown in Figure 5 is used to enable the TDD sync. When this parameter is enabled, you can enable or disable TX while the TDD sync remains unlocked.

The source of the 1 pps signal is selectable being either the internal GNS receiver or the Sync Over Power interface. The parameter attribute used to control the source is **TDD Sync Source**.

The status of the TDD sync is reported by the parameter status attribute - **State**.

The number of relocks of the TDD sync is reported by the parameter status attribute - **Relock Count**.

Following attributes control how the BTS enables and disables the TX state of the radio:

- TX_disable

- Override

In the normal state, the radio must blank the TX if the BTS could be a source of interference or operate outside of its regulatory approval.

Figure 5 is an example of the **Synchronisation** page available for configuration in the BTS B1000 user interface (UI).

The Synchronisation UI page for BTS
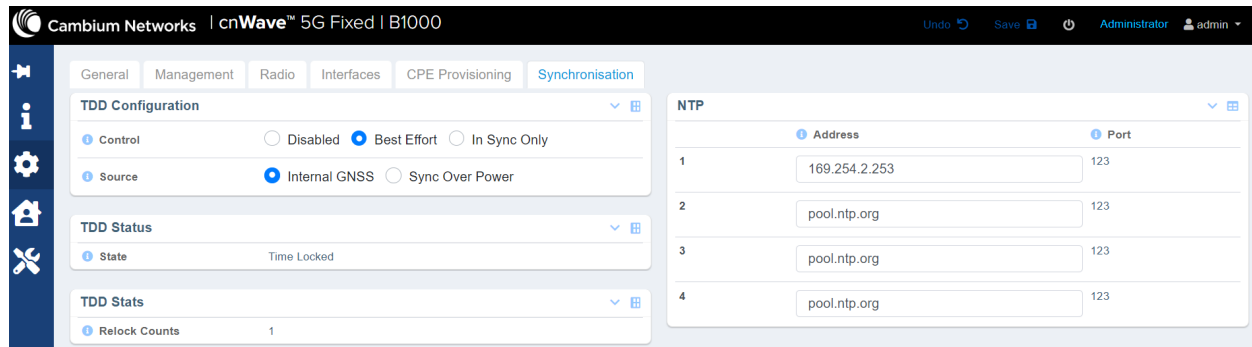
For more information about each parameter in the **Synchronisation** UI page, refer to the *cnWave™ 5G Fixed Configuration Guide*.

GPS for synchronisation

Figure 6 shows the location of a GPS antenna on B1000 BTS.

Figure 6: *Top Side Handle on B1000 BTS*
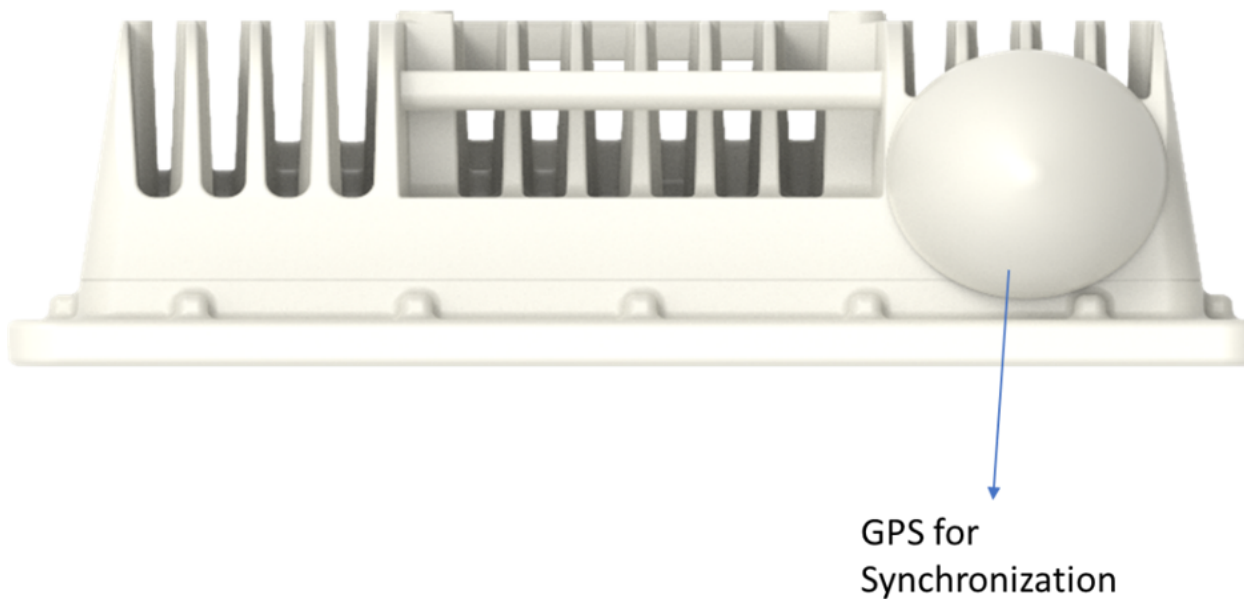
Built-in GPS receiver

The B1000 BTS has a built-in GPS receiver. E2E Controller manages the TDD synchronization.

Wireless encryption

The cnWave™ 5G Fixed platform of products support optional encryption for data transmitted over the wireless link using a choice of two different encryption algorithms:

- **128-bit AES**: Both ends of the link are configured with the same 128-bit pre-shared key (PSK) as a master secret. The wireless link is encrypted using 128-bit AES.

- **256-bit AES (Requires optional license)**: Both ends of the link are configured with the same 256-bit pre-shared key as a master secret. The wireless link is encrypted using 256-bit AES.

The Advanced Encryption Standard (AES) is a symmetric encryption algorithm approved by the US. Government organizations (and others) to protect sensitive information. The use of AES encryption in the cnWave™ 5G Fixed products 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.

Ethernet bridging

Similar to other PMP products from Cambium Networks, cnWave™ 5G Fixed products provide an Ethernet bridge between the BTS and the CPEs.

While LTE only supports Layer 3 bridging, the 5G NR standard natively supports Ethernet packets either at Layer 2 or Layer 3 natively. As Cambium Networks customers are familiar with Layer 2 Ethernet bridging, this will be the first supported option. Layer 3 bridging may be introduced in the future.

Ethernet ports

The cnWave™ 5G Fixed platform of products supports the following Ethernet ports:

- 1 x 10GE Ethernet port

- 1 x 1GE SFP+ port

- 1 x 10GE SFP+ port

Classification

The cnWave™ 5G Fixed platform of products implements four-level QoS classification. The classification is based on Layer 2 or Layer 3 and can be individually allocated based on the following:

- Each of the supported Layer 2 control protocols

- VLANs Ethernet priority

- MPLS TC values

- IPv4 or IPv6 DSCP values

- Untagged frames

Scheduling

Scheduling is based on prioritization with a round-robin manner at each level of priority. Apart from the internal management of traffic (which is the highest priority), the VLAN tagged traffic is at the top of the priority list than the non-VLAN traffic. The three most significant bits in the tag determine who goes first at each priority level and if there are many CPEs at the same priority level, then the scheduling is based on a round-robin scheme.

There are also other mechanisms in the software to deal with fairness such as dealing with users who are not using the bandwidth efficiently. This is done by applying small delays to allow the servicing of other users. Note that a more complex algorithm such as Medusa and CPE grouping will be used with MU-MIMO.

Maximum MTU size

The maximum MTU size is 1970 bytes for the data path. This is deemed adequate for an access network.

Summary of system advantages

Following are the advantages of the cnWave™ 5G Fixed platform of products:

- Future proof investment:
    - Standard rather than vendor-proprietary air interface.
    - Cambium Networks SDR architecture enables future enhancements.

- 5G NR/3GPP Release 15:
    - Designed for mmWave frequency (Frequency range 2).
    - Appropriate for Fixed Wireless Access (FWA) than 4G or LTE.

- Enables cost-effective CPE based on 5G chipsets (roadmap):
    - The BTS (from Cambium Networks) supports Cambium Networks and third-party 5G NR CPEs.
    - Multiple generations of CPEs can co-exist in the same sector.

- Optimized end-to-end for Fixed Wireless Access:
    - Benefits from cnWave™ include world-class Massive MU-MIMO expertise and field-proven performance.
    - Low cost and complexity solution designed from inception for Fixed Wireless Access and not repurposed mobile technology.
    - Optimized to exploit good signal quality and provide high throughput.
    - Lower latency (1-2 ms), optimized for TCP/IP traffic.
    - Better multi-user sharing granularity (Multiple MIMO groups in DL, OFDMA in UL).

- Simple to deploy and operate:
    - Cambium Networks 5G NR network infrastructure is as simple as its industry leading PMP450 family.
    - BTS can be stand-alone, with no SIM card required on CPEs.
    - Mobile operator core networks are not required.

> **Note**
>
> Most of these system advantages (described above) are not supported in Release 3.3. These advantages will be supported in the full system later.

Interfaces for system management

The management of the unit is done using IP over Ethernet. The cnWave™ 5G Fixed platform of products supports both IP Version 4 (IPv4) and IP version 6 (IPv6).

The following protocols are supported:

- HTTP (Web browser)

- HTTPS (Secure Web browser)

- SNMP (v2c and v3)

- TELNET

- RADIUS Authentication

The cnWave™ 5G Fixed platform of products may also support a secure shell (SSH) protocol.

Web server

The cnWave™ 5G Fixed platform family's management agent contains a web server. The webserver supports access through the HTTP or HTTPS interface.

The Web based management offers a convenient way to manage the cnWave™ 5G Fixed platform family radios from a locally connected computer or a network management workstation connected through a management network, without requiring any special management software. The web and SNMP are the interfaces supported for the installation of cnWave™ 5G Fixed platform family radios and for configuration management tasks.

Web pages

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

Table 4: List of web user interface (UI) pages

B1000 (BTS)	C100 (CPE)
Dashboard	Dashboard
System	System
Statistics	Statistics
Subscribers	Tools
Tools	Accounts
Accounts	Install Wizard
Quick Start	Copyright
Copyright	

Identity-based user accounts

When identity-based user accounts are configured (not all supported in Release 3.3), a security officer can define from one to five user accounts, each of which may have one of the five following user roles:

- **Administrator**: This role has visibility of the device configuration and status. These role can view, configure, and change everything in the UI, but cannot access the sensitive security information who has full read and write permissions.

- **Guest**: This role has limited, read-only access to the device configuration and status. All fields in the web UI are read-only and some of them are also not available for guest roles. The guest roles have limited SNMP access with a read-only view of MIB II.

- **User**: This role has limited access to the device configuration and status. Some UI fields are read-only and some fields are not available on the web UI. The user roles cannot change any parameters on the UI.

- **Security**: This role (for example, a security officer) has visibility of the device configuration and status, including sensitive security information.

- **Support**: This role (for example, a support agent) can access diagnostics information for the product support purpose.

- **Engineer**: This role (for example, an engineer) has privileged write access to specific engineering settings and read access to engineering status information.

- **Factory**: This role (for example, a factory operator) has privileged write access to the device customisation settings such as ESN and SKU.

- **Installer**: This role has permissions identical to those of administrator except for that the installer cannot add or delete users or change the password of any other user (not in Release 3.3).

- **Technician**: This role has permissions to modify basic radio parameters and view informational web pages (not supported in Release 3.3).

- **Administrator**, **Installer**, and **Technician accounts** can be configured as READ-ONLY. This will allow the account to only view the items (not supported in Release 3.3).

Authentication

The CPE will support SIM card authentication as required by the 3GPP Release 15 standard (not in Release 3.3). However, the CPE also supports a SIM-less authentication, like other Cambium Networks PMP family of products, using RADIUS.

Support for RADIUS configuration

The configuration of the cnWave™ 5G Fixed platform family includes support for Remote Authentication Dial-In User Service (RADIUS) protocol functionality, including the following:

- **CPE Authentication**: Allows only known CPEs onto the network (blocking rogue CPEs). This configuration helps you to ensure that CPEs are connecting to a known network (preventing CPEs from connecting to rogue BTS). RADIUS authentication is used for CPEs, but not used for BTS.

- **CPE Configuration or provisioning:** Configures authenticated CPEs with attributes such as IP address and Virtual LAN (VLAN) parameters from the RADIUS server when a CPE registers to a BTS.

- **User authentication**: Allows users to configure a separate User authentication server along with the CPE authentication server. If the firmware is upgraded while using this functionality and no User authentication servers are configured, then the BTS continues to use the CPE authentication server for User authentication.

- **CPE Accounting**: Provides support for RADIUS accounting messages for usage-based billing. This accounting includes indications for subscriber session establishment, subscriber session disconnection, and bandwidth usage per session for each CPE that connects to the BTS.

- **Centralized BTS and CPE username and password management**: Allows BTS and CPE usernames and access levels (Administrator, Installer, Technician, and Read-Only) to be centrally administered in the RADIUS server instead of on each radio. It is used to tracks access events (logon or logoff) for each username on the RADIUS server. This accounting does not track, and report specific configuration actions performed on radios or pull statistics such as bit counts from the radios. Such functions require an Element Management System (EMS) such as Cambium Networks cnMaestro X. This accounting cannot have the ability to perform accounting functions on the subscriber, end-user, or customer account.

> **Note**
>
> For more information on configuring cnMaestro X, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Support for network management tools

The cnWave™ 5G Fixed platform of products support the following management modes:

- **In-Band (IB)**: Management traffic is on the same physical port as the user traffic.

- **Out-Of-Band (OOB)**: Management traffic is on a different physical port than the user traffic IPv4 or 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 has only multicast.

The cnWave™ 5G Fixed platform of products use Stateless Address Autoconfiguration (SLAAC) 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.

Wireless interface

The cnWave™ 5G Fixed wireless interface is based on the 5G NR standard, Release 15. Only a subset of all the 5G NR functionality is supported. Example: No CPE roaming capability, which simplifies the overall design. Furthermore, the features implemented are restricted to what makes sense for our targeted customers and FWA.

While the initial release only supports Cambium Networks' CPE, the BTS hardware platform will be able to support third-party CPE in the future. This is due to a set of functionalities used is being mostly controlled by the BTS, based on its capability and the capability of the CPE.

CPE Frequency Scan

The Frequency Scan feature allows the CPE to scan for up to 16 pre-programmed BTS frequencies in both polarizations automatically at startup.

The scan continues until a signal is detected. Once detected, the signal then tracks the frequency. If the tracked signal is lost, the CPE first attempts to reacquire the same frequency. If this fails after a timeout, the scan is restarted.

The scan is configured through the CPE configuration UI parameter, which allows a list of up to 16 frequencies to be specified for the scan. The scan mask allows frequencies in the list to be enabled or disabled without needing to modify the list (bit 0 corresponds to frequency 0, bit 1 to frequency 1, and others). A 1 in the bit position enables the corresponding frequency. The `scanPol` attribute allows the scan to be configured to scan either V or H only or scan both polarizations.

The scan can be monitored through the status attributes. The current frequency and polarization are reported during the scan and when the **State** parameter displays **Tracking** (in the UI). This implies that the radio has successfully acquired the operating frequency.

For information about configuring the CPE frequency scan using UI, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Extended range support

The maximum distance range between a CPE and the BTS can be extended from 5 Km to 10 Km.

Using the **System** > **Radio** page in the B1000 UI, you can enable the **Extended Range** parameter. Using the **Subscribers** > **CPE Radio Status** page, you can view the range details. For more information about enabling the **Extended Range** parameter, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Figure 7 shows the performance of a 7.8 km long trial link, which is installed near Cambium Networks UK office.

Figure 7: *A trial link indicating the extended range*
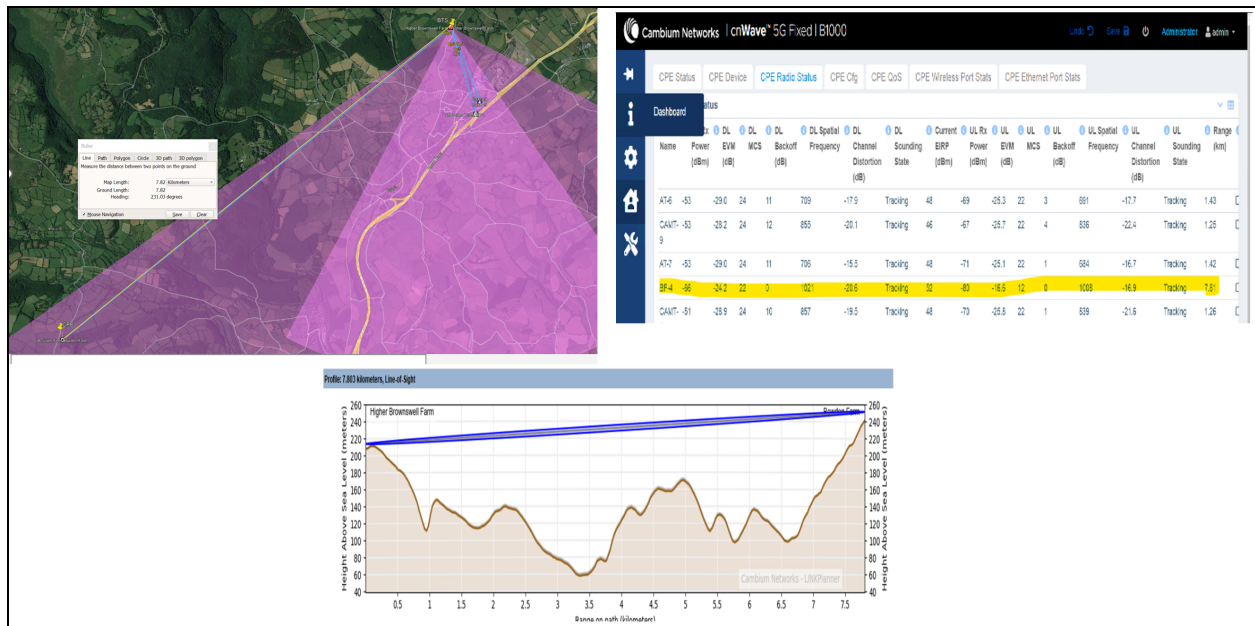
MU-MIMO performance reporting

The MU-MIMO performance report is available on the **Dashboard** > **Radio** page in the B1000 UI. The **Radio** page displays additional performance indicators (through a chart and table), as shown in Figure 8. These indicators show the percentage of time used by the radio for each MU-MIMO group size in the last second, minute, hour, and day (24 hours).

Figure 8: *MU-MIMO performance reporting*

General | Device | Radio | GNSS

Status

Frequency	28000.000 MHz
Max EIRP	26.0 dBm
Polarisation	Vertical
Link Symmetry	5:2
Bandwidth	56 MHz
UL Target Rx Power	-50 dBm
UL Tx Power Initial Adjust	Enabled
UL Tx Power Continuous Adjust	Enabled
MUMIMO Control	Enabled

Radio Resource Control

Rx RACH Counts	24
Tx SRB Messages	120
Rx SRB Messages	144

Reset RACH Counts

MU-MIMO Group Size Configuration

DL MUMIMO Max Group Size	1
UL MUMIMO Max Group Size	1

MU-MIMO Group Utilisation Chart

MUMIMO Group Utilisation Details

Interval	DL sec	DL min	DL hr	DL 24hr	UL sec	UL min	UL hr	UL 24hr
Idle (%)	99.7	51.7	63.9	63.9	99.0	50.3	62.2	62.2
Ungrouped (%)	0.2	48.2	33.6	33.6	0.9	49.6	35.2	35.2
Groups of 2 (%)	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Groups of 3 (%)	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Groups of 4 (%)	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0
Groups of 5 (%)	0.0	0.0	0.2	0.2	0.0	0.0	0.2	0.2
Groups of 6 (%)	0.0	0.0	0.5	0.5	0.0	0.0	0.4	0.4
Groups of 7 (%)	0.0	0.0	0.6	0.6	0.0	0.0	1.0	1.0
Groups of 8 (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7
Avg	1.0	1.0	1.3	1.3	1.0	1.0	1.4	1.4
Max	1	1	7	7	1	1	8	8

For information about the MU-MIMO performance report, refer to the *cnWave™ 5G Fixed Configuration Guide*.

System logging

For information on logging into the system, refer to the Preparing for Configuration section in the *cnWave™ 5G Fixed Configuration Guide*.

Software upgrade

For information on upgrading the software, refer to the Configuring tools section in the *cnWave™ 5G Fixed Configuration Guide*.

System Hardware

This section provides details of hardware components of the cnWave™ 5G Fixed platform of products. The section also lists accessories, lightning protection units (LPUs) and grounding kits, cables, and part numbers (required for ordering) for the cnWave™ 5G Fixed platform of products.

Package contents

Table 5 lists the package contents of the cnWave™ 5G Fixed platform of products.

Table 5: Package contents - cnWave™ 5G Fixed

Product name	Package contents
B1000 BTS	A B1000 BTS package box contains the following items: • One cnWave™ 5G Fixed B1000 BTS • One 28 GHz BTS Radio • One 28 GHz BTS mounting bracket • One DC Power connector kit 18AWG, which contains: One connector, plug housing, cable mounted, 4-pin, MiniFitJR, required crimp terminals, a connector and a crimp terminal, 18AWG, MiniFitJR, and a tin-plated copper tape of 3M 1345 and 1/4 inch (6.35mm) wide • One cable gland - M25, CAT5E, EMC, environmental seal, silver body black cap
C100 CPE	A C100 CPE package box contains the following items: • One cnWave™ 5G Fixed CPE • One screw or bolt, Flange head cap W/Socket, M6x1x28 mm • One cable gland, M25, ID10.0 mm, plastic with O-Ring • One product leaflet

B1000 BTS

B1000 BTS is equipped with the latest 5G NR technology. It is fitted with a Global Navigation Satellite System (GNSS) Receiver System (as shown in Figure 9) and heatsinks for efficient thermal management under specified ambient conditions.

The current release supports up to 120 CPEs and a standard Ethernet port.

Figure 9: *cnWave™ 5G Fixed B1000 BTS*
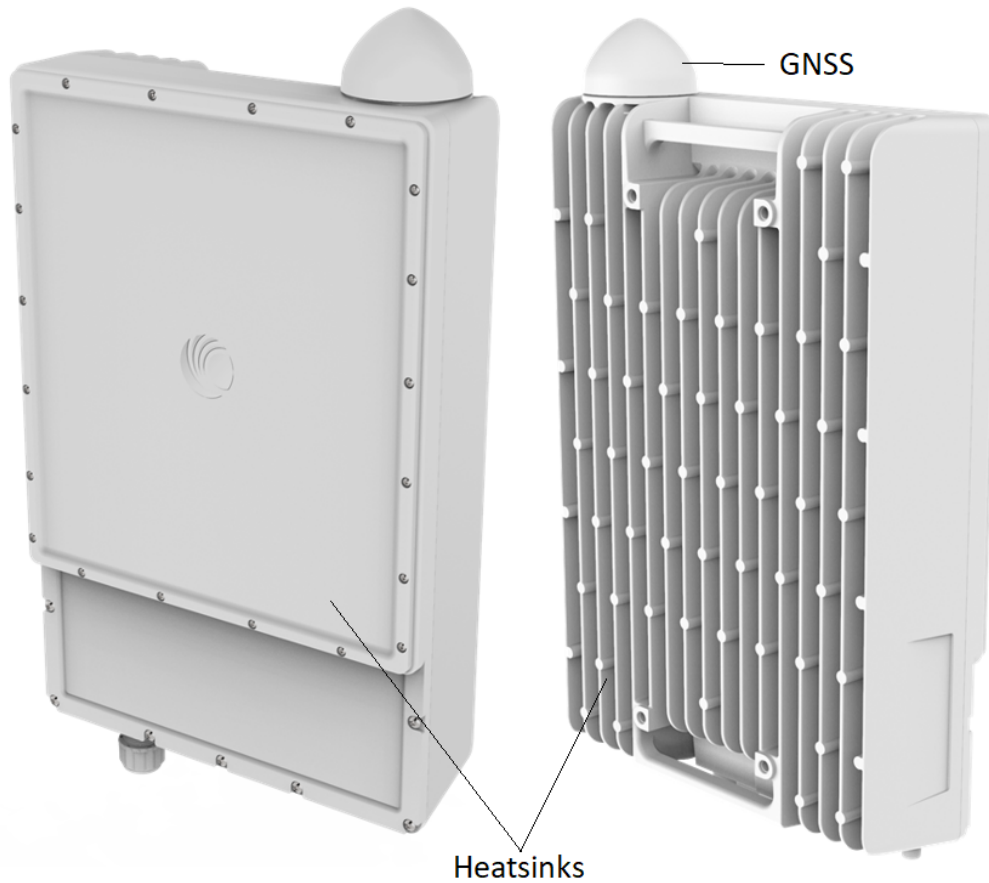
BTS - Part numbers

Order the B1000 BTS using part numbers (as specified in Table 6) from Cambium Networks Distributors or Resellers. Each B1000 BTS is supplied with a mounting bracket for pole mount.

Table 6: B1000 BTS Part numbers

Product	Part number
cnWave™ 5G Fixed B1000 Base Station, Single Sector	C280500A001A
cnWave™ 5G Fixed B1000 Base Station, Single Sector, Fully licensed	C280500A101A

> **Note**
>
> Release 3.3 contains all the license keys that are described in Table 7.

BTS - License key part numbers

Consider the following points:

- License keys are per BTS, and there are no licenses for CPE.

- License keys are managed through cnMaestro X and can be reassigned to alternate hardware (floating).

> **Note**
>
> Not all the features (such as SIM Card support and Carrier Aggregation) are available in Release 3.3.

Table 7: B1000 BTS license key part numbers from Cambium Networks

Product	Part numbers
cnWave™ 5G Fixed License - 10 GE port, per port	C280500K001A
cnWave™ 5G Fixed License - UpLink MU-MIMO	C280500K002A
cnWave™ 5G Fixed License - DownLink MU-MIMO Upgrade from 4x4 to 8x8	C280500K003A
cnWave™ 5G Fixed License - Support 100/112 MHz channel	C280500K004A
cnWave™ 5G Fixed License - 50 CPE Attach	C280500K006A
cnWave™ 5G Fixed License - 100 CPE	C280500K007A
cnWave™ 5G Fixed License - 240 CPE	C280500K008A
cnWave™ 5G Fixed License - 256-bit AES Encryption	C280500K009A
cnWave™ 5G Fixed License – QoS/VLAN Enabled	C280500K010A
cnWave™ 5G Fixed License - RADIUS Support	C280500K013A
cnWave™ 5G Fixed License – SIM Card support	C280500K014A
cnWave™ 5G Fixed License – Carrier Aggregation	C280500K015A
cnWave™ 5G Fixed License – All Licensed features	C280500K100A

BTS - External interfaces

Figure 10 shows location and description of the interface ports on BTS.

Figure 10: *BTS Interface ports*
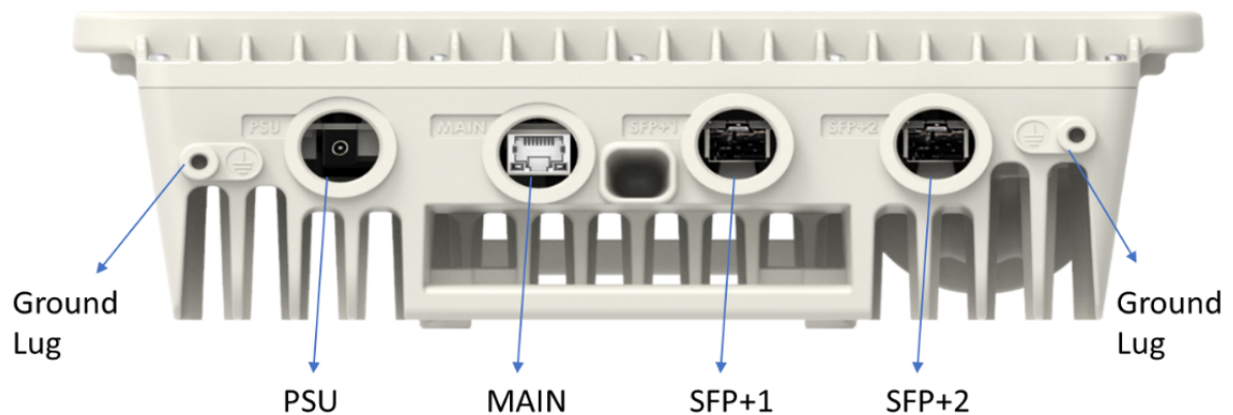
Table 8: Details of BTS Interface ports

Interface	Connector	Interface	Description
PSU	4-pin Power	DC Power	0.75 mm x 2 to 1.3 mm x 2 - 4 conductor power cable to provide DC power to radio
MAIN	RJ45	100/1000/10000 BaseT	Management and/or data
SFP+1	SFP+	Optical Gigabit Ethernet (1 or 10 Gbps)	OOB management, user data, user data with IB management
SFP+2	SFP+	Optical Gigabit Ethernet (1 or 10 Gbps)	OOB management, user data, user data with IB management

C100 CPE

The current release supports up to 120 CPEs per BTS sector for 50 MHz and 56 MHz channel sizes, and 120 CPEs per BTS sector for 100 MHZ and 112 MHZ channel sizes.

The maximum Effective Isotropic Radiated Power (EIRP) per CPE is 48 dBm. Figure 11 shows the back and front views of the CPE.

Figure 11: *Back and front views of C100 CPE*
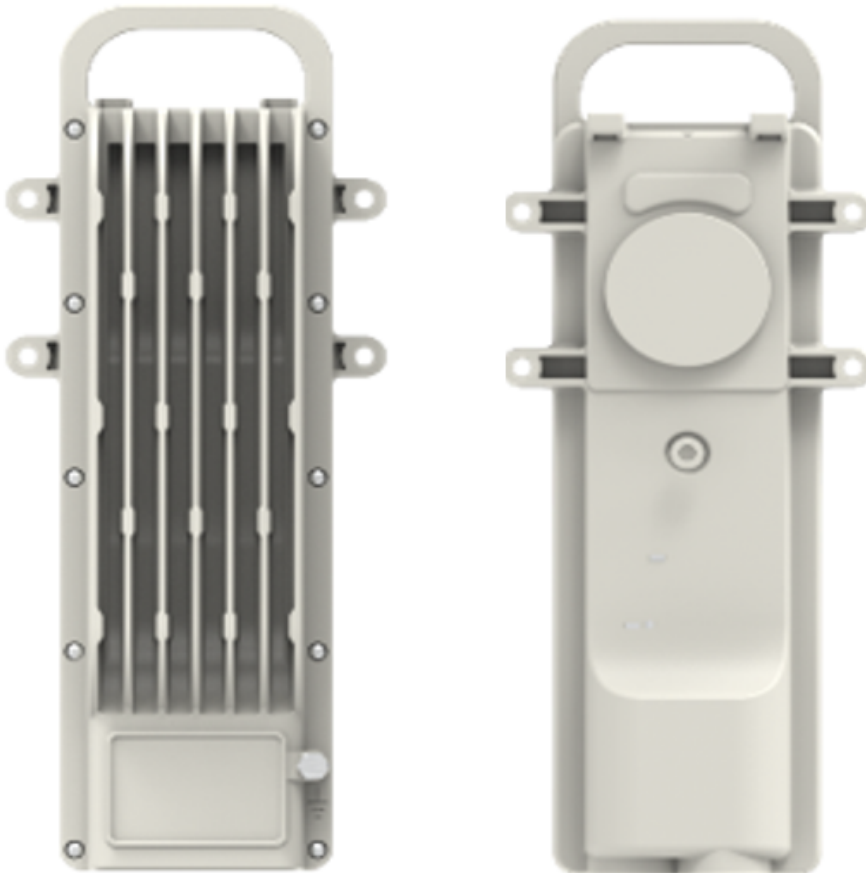
CPE - Part number

Each CPE is supplied with a mounting bracket for pole mount and an all-weather gland. Table 9 lists part number specified by Cambium Networks for the CPE.

Table 9: C100 CPE Part number

Product	Part number
cnWave™ 5G Fixed C100 CPE – Radio, 4-Pack packaging	C280500C001A

CPE - External interfaces

Figure 12 shows location and interface ports on CPE.

Figure 12: *CPE Interface ports*
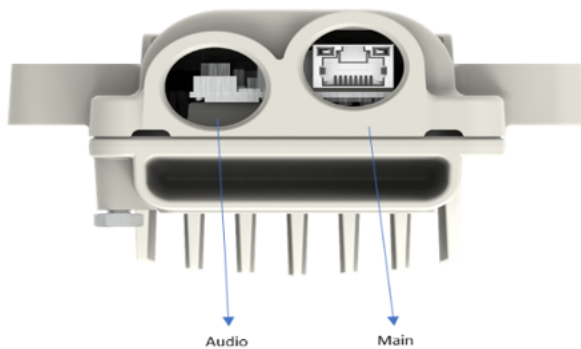
Table 10 provides function and cabling details of each CPE interface ports.

Table 10: Details of CPE interface ports

Interface	Function	Connector/Cabling
Main (Power Port)	IEEE 802.3at (42.5 - 58 V), 10/100/1000 Base-T Ethernet, and no Canopy Sync-over- power	RJ45/CAT5e/CAT6/CAT6e
Audio Port	Used for tones to align radio	Two lines. one for the 3.5 mm connector and one for the SIM card 3.5 mm TRRS audio/standard Headphones or custom sync + nano-SIM card

cnWave™ 5G Fixed specifications

The cnWave™ 5G Fixed platform conforms to the specifications listed in Table 11.

Table 11: Radio specifications

Category	Specification	
Dimensions	BTS	690 mm × 610 mm × 175 mm (27.2 inches × 24

Category	Specification	
		inches ×7 inches)
	CPE	348 mm x 415 mm x 349 mm (13.7 inches x 16.3 inches x 13.7 inches)
Weight	BTS	20.5 kg (45 lbs) without mounting brackets
	CPE	4.7 kg (10.3 lbs) without mounting brackets
Temperature	40°C (-40°F) to +60°C (140°F)	
Wind survival	200 kph (124 mph) maximum	
Humidity	100% non-condensing	
Liquid and particle ingress	IP66, IP67	
Power consumption	BTS	150 W
	CPE	35 W, up to 60 W with PoE out enabled
Power input interface	BTS	IEEE 802.3af
	CPE	Passive PoE
Power output interface	BTS	IEEE802.3af/at, 25 W maximum
	CPE	IEEE 802.3af/at, 25 W maximum

Mounting brackets for cnWave™ 5G Fixed platform of products

This section lists the mounting brackets required for the BTS and the CPE.

BTS - Tilt bracket

The tilt bracket (as shown in Figure 13) is provided with the BTS and can be used to provide elevation adjustments when it is mounted on a pole or mast. The tilt bracket works with poles with diameters ranging from 25 mm to 80 mm (0.98 inches to 3.14 inches). The tilt bracket assembly can be used with third-party band clamps to mount the ODU on larger poles with a diameter ranging from 90 mm to 230 mm (3.54 inches to 9.05 inches).

Details of the bracket assembly are available in the Installation section.

	Note
	The BTS tilt bracket is included in the BTS package box. It can also be purchased, separately.
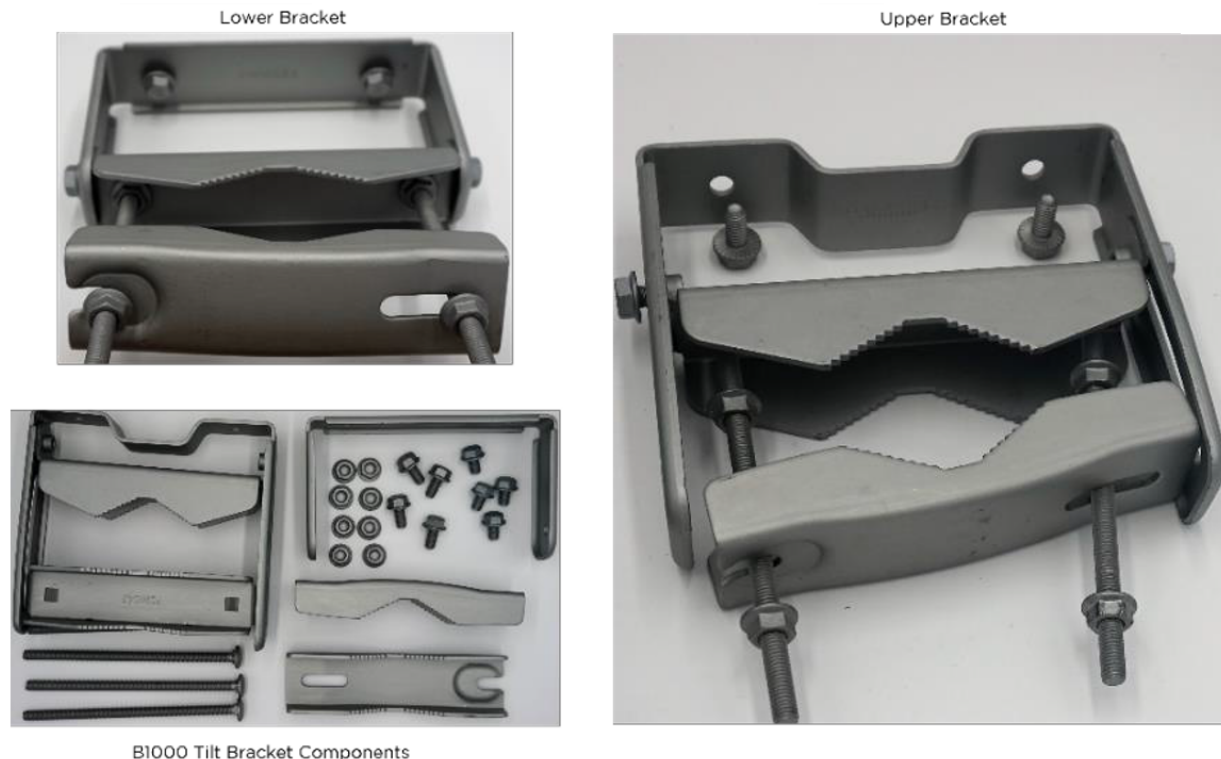
Part number for the BTS mounting bracket

Order the mounting bracket using the part number specified by Cambium Networks (as listed in Table 12).

Table 12: BTS Antenna and mounting bracket part number

Product	Part number
cnWave™ 5G Fixed B1000 BTS Tilt bracket	C000000L125A

CPE-Fine adjustment bracket

The fine adjustment or precision bracket (as shown in Figure 14) is used to mount the CPE 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 CPE. Details of the bracket assembly are available in the Installation section.

> **Note**
>
> In Release 3.3, the CPE must be connected to a dish using the precision brackets.

Figure 14 shows the precision bracket components and an assembled precision bracket.
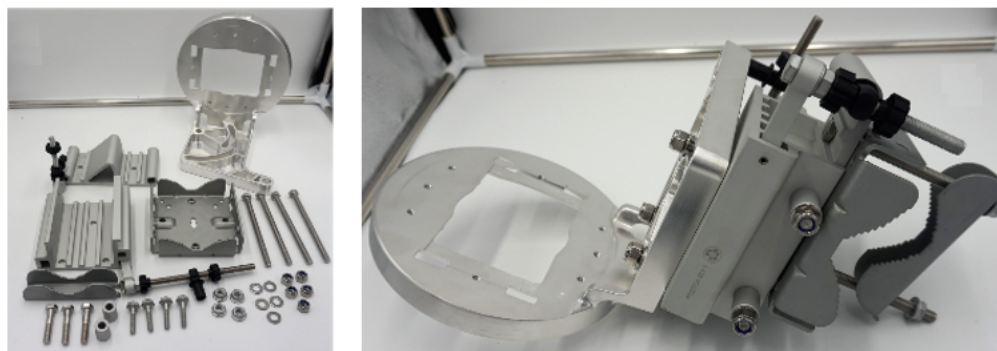
Part numbers for CPE mounting brackets

Order mounting brackets using the part numbers specified by Cambium Networks (as listed in Table 13).

Table 13: CPE Antenna and mounting bracket part numbers

Product	Part number
cnWave™ 5G Fixed CPE Antenna Assembly, 4-Pack packaging	C280500D001A
cnWave™ 5G Fixed CPE Fine Adjust Bracket Kit	N000000L159A
cnWave™ 5G Fixed CPE Basic Bracket Kit	N000000L160A

Accessories for cnWave™ 5G Fixed platform of products

This section lists the radio and power supply accessories, including part numbers and power supply units (PSU) specifications, for BTS and CPE.

Radio accessories

Telescope mounting kit for precision brackets

An optional telescope provides the most accurate alignment of the precision bracket during installation. The telescope is temporarily mounted on the dish 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. Details on how to use it with the CPE are available in the Precision bracket alignment – An optional telescope section.

Figure 15: *Telescope mounting kit*

Figure 16: *An assembled alignment - Telescope*

Part number for the telescope mounting kit

Order the telescope mounting kit using the part number specified by Cambium Networks (as listed in Table 14).

Table 14: Part number - Telescope mounting kit

Product	Radio	Part number
Telescope mounting kit	C100 CPE	C000000L139A

Power supply units (PSU) and accessories

Order the following accessories that are compatible with the cnWave™ 5G Fixed platform of products:

BTS - PSU and accessories

Table 15 lists the required PSU and accessories for BTS.

Table 15: Details of B1000 BTS - PSU and accessories

Accessory	Key attributes	Inputs	Temperature range
DC Power supply	Main Power Supply, 54V 240W PSU, IP65	90-305 VAC	-40° C to +70° C -40° F to 158° F
Crimp tool	Tool to apply crimps for DC Power Connectors	Not applicable	Not applicable
Crimp extractor tool	Manual tool to extract crimps from the connector	Not applicable	Not applicable
Connector & Crimps	DC Power Connector Kit Package that contains 10 connectors, 50 crimps, 18 AWG or 16 AWG, respectively (sold as spares kit)	Not applicable	Not applicable
Cable	0.75 mm^2 or 1 mm^2 Four Conductor cable Sold in 100 m or 300 m reels	Not applicable	Not applicable

Accessory	Key attributes	Inputs	Temperature range
10G Ethernet LPU for the data cable (recommended by Cambium Networks)	Surge protector for the data cable	Not applicable	Not applicable
DC LPU for the power cable	DC Surge Suppressor (DC LPU Kit) with 2 x 4-pin power connectors	Not applicable	Not applicable

Cambium Networks provides accessories for BTS such as DC LPU and Grounding Kit and SFP gland (as described in the SFP Module kits section).

Part numbers

Table 16 provides part numbers and product descriptions for PSUs and accessories specific to BTS.

Table 16: Part numbers and product description - BTS

Product	Part number
DC Power Supply, AC, 54V 240W	N000000L054B
Crimp tool for Molex MiniFitJr	N000000T001A
Crimp removal tool for Molex MiniFitJr	N000000T002A
DC Power Connector Kit 18 AWG, pkt of 10	N000000L123A
DC Power Connector Kit 16 AWG, pkt of 10	N000000L124A
4- Conductor 1 mm x 2 DC cable - 100 m	N000000L116A
4-Conductor 0.75 mm x 2 DC cable – 300 m	N000000L117A
4-Conductor 1 mm x 2 DC cable – 300 m	N000000L118A

Product	Part number
10G Ethernet LPU for the data cable	TBD
DC Surge Suppressor Kit (DC LPU Kit) with 2 x 4-pin power connectors	C000000L114A
10G SFP+ SMF LR Transceiver, 1310 nm -40C to 85C	SFP-10G-LR
10G SFP+ MMF SR Transceiver, 850 nm -40C to 85C	SFP-10G-SR
1000 Base-T (RJ45) SFP Transceiver -40C to 85C	SFP-1G-Copper
1G SFP SMF LX Transceiver, 1310 nm -40C to 85C	SFP-1G-LX
BTS - PSU part numbers	
Outdoor AC/DC PSU, 100W, 54V DC (Radio mode - BTS)	N000000L054B
Waterproof PSU Cable Joiner 14-16 AWG (Radio mode - BTS)	N000000L180A
Cable Gland, Long, M25, Qty 5 (Radio mode - BTS, CPE)	C000000L124A

> **Note**
>
> The outdoor PSU can be installed indoors, inside street furniture, or outdoors in an outdoor-rated enclosure.

BTS - PSU specifications

Table 17 lists the PSU specifications for BTS.

Table 17: PSU Specifications - BTS

Category	Specification
Dimensions	240W (N000000L054B) 251 mm (9.9 in) x 68 mm (2.67 inches) x 38.8 mm (1.53 inches)
Power	240W
Temperature	-40°C (-40°F) to +80°C (176°F)
Humidity	20 to 95 % non-condensing
Waterproofing	IP65/IP67
AC Input	90-305 VAC; 12-431 VDC; 47-63 Hz
DC Output Voltage	54V
DC Output current	2 A
Efficiency	Better than 93% at full load
Over Current Protection	Hiccup mode, recovers automatically after fault condition is removed
Hold up time	At least 15 milliseconds
Power factor	Better than 0.95

CPE - PSU and accessories

Table 18 lists the accessories required for CPE.

Table 18: Details of PSU and accessories - CPE

Accessory	Key attributes
EEE802.3at 30W Power brick	PoE, 30.5W, 56V, GbE DC Injector, Indoor, Energy Level 6 Supply, accepts C5 connector
1G Ethernet LPU (recommended by Cambium Networks)	1G Surge Suppressor for CPE

For details on how to use and install accessories, refer to the Installation section.

Part numbers

Table 19 provides part numbers and product descriptions for PSU and accessories specific to the CPE.

Table 19: Part numbers for PSU and accessories - CPE

Product	Part number
PoE, 30.5W, 56V, GbE DC Injector, Indoor, Energy Level 6 Supply, accepts C5 connector	N000000L034B
AC line cord, US Type B, 720 mm, C5 connector	N000900L031A
AC line cord, EU Type B, 720 mm, C5 connector	N000900L032A
AC line cord, UK Type B, 720 mm, C5 connector	N000900L033A
Gigabit Surge Suppressor (56V), 10/100/1000 BaseT	C000000L033A

CPE - PSU specifications

Table 20 lists the PSU specifications for CPE.

Table 20: PSU Specifications - CPE

Category	Specification
Dimensions	140 mm (5.5 inches) x 53 mm (2.08 inches) x 35 mm (1.37 inches)
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 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+

Warning

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

Overview of BTS antenna

The cnWave™ 5G Fixed BTS is a multi-user multi-input-multi-output (MU-MIMO) platform available in a single, 90° sector - all integrated antenna. The antenna arrays in the BTS can be configured electrically to be either H or V polarized.

Note	
	A single sector variant is included in Release 3.3.

Table 21 provides high-level specifications of the antennas required for various configurations.

Table 21: Antenna specifications for BTS

Antenna type	Columns per sector	Azimuth beamwidth	Elevation beamwidth
Single sector	8	90º	10º

Figure 17 shows the Base Transceiver antenna patterns (Sector mode).
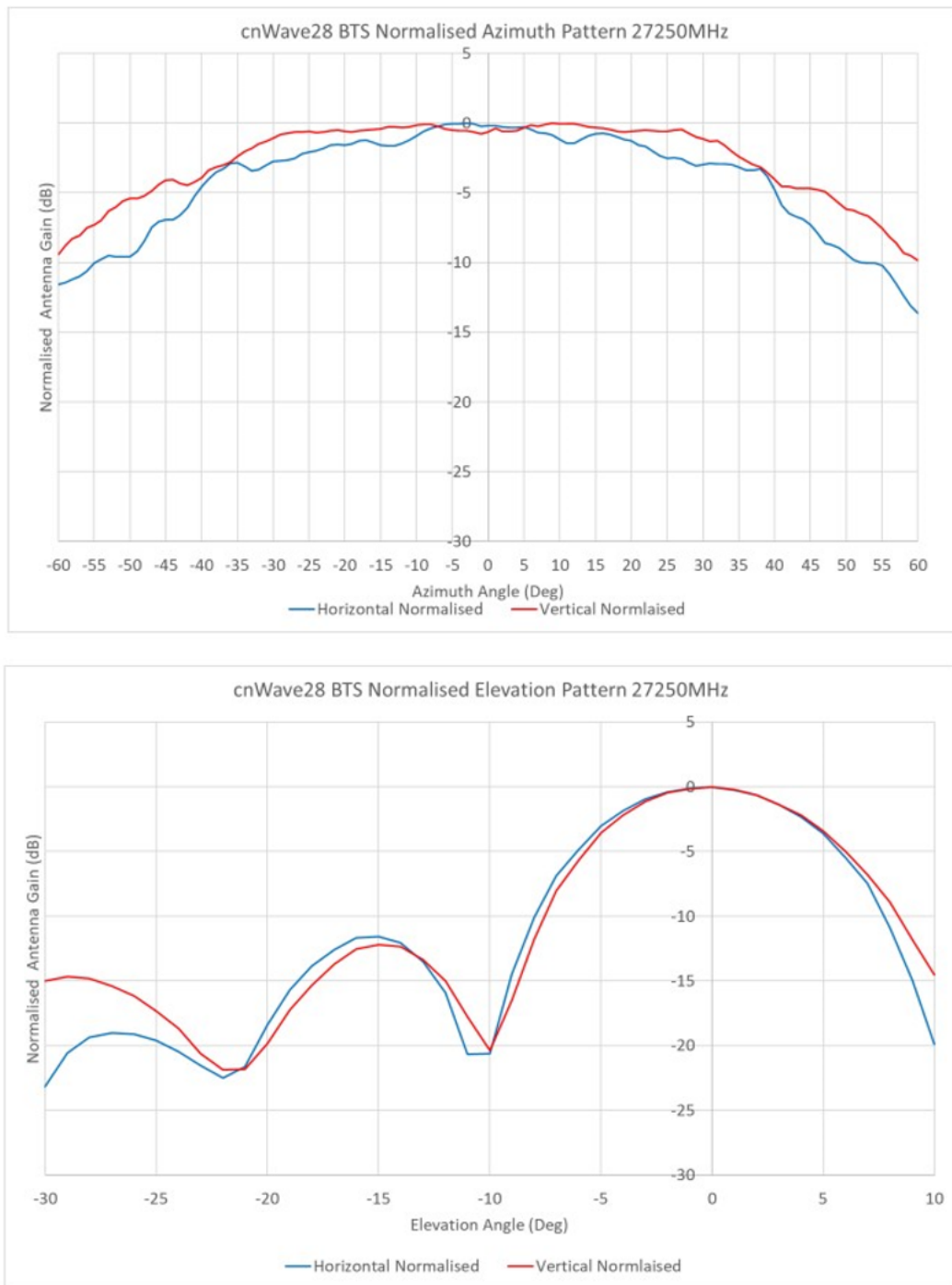
Overview of CPE antenna dish

The CPE uses a high gain dish antenna. As per the BTS, the CPE can be configured to dynamically operate in either vertical or horizontal polarization. The overall antenna gain is made up of a combination of the dish gain and the antenna array used as its source.

Table 22 provides high-level specifications of the antennas required for CPE configuration.

Table 22: Antenna specifications for CPE

Antenna type	Gain	Elevation beamwidth
400 mm diameter dish	36 dBi	~2.0º

	Note
	The fine adjustment bracket maximizes the CPE range by allowing precision alignment and higher wind load tolerance.

Figure 18 shows the views of CPE with an external antenna and a precision bracket.

Figure 18: *Back and right side views of a CPE with antenna dish*
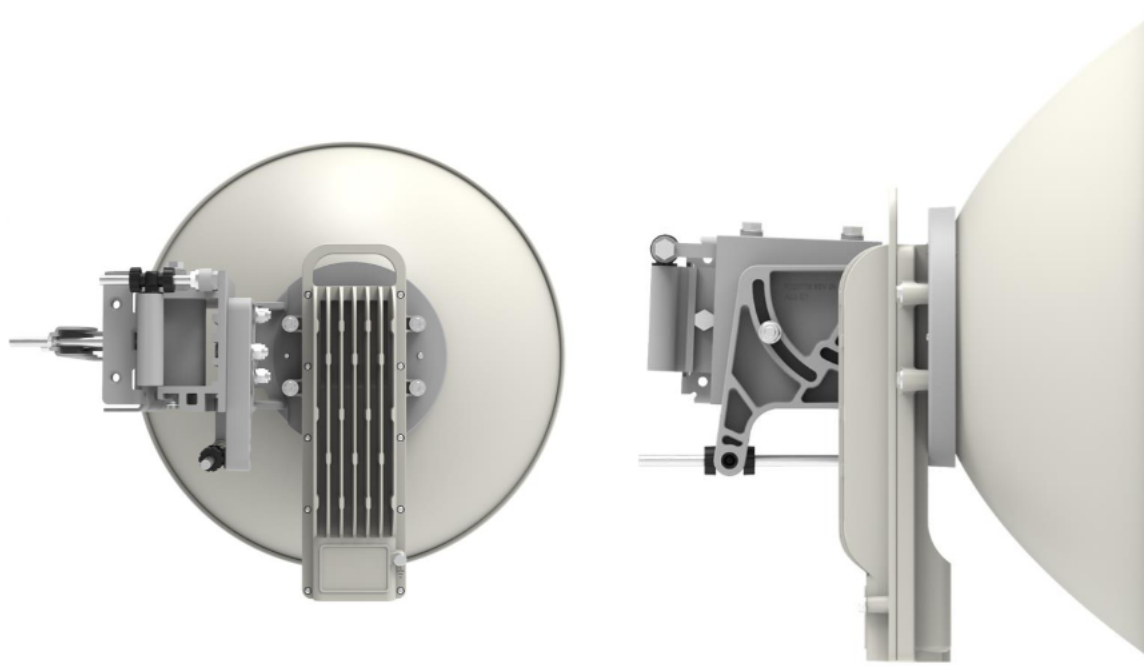
	Note
	A 400 mm diameter dish is included in Release 3.3.

Ethernet and DC cables

For all the cnWave™ 5G Fixed 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 an outdoor-rated CAT6A cable for BTS and outdoor-rated CAT5e cable for CPE.

The maximum cable length for fiber Ethernet (10GBASE-SR, 10GBASE-LR) connections depends on the fiber used. Refer to the n the SFP Module kits section for details of the Ethernet standards supported and maximum permitted cable lengths.

AC/DC PSU with a DC power feed

Two cable types - 0.75 mm^2 and 1.0 mm^2 cross-sectional area - are recommended. Assuming that the recommended power supply is used, trimmed up to 57 V (as described in the Power Supply section), Table 23 guides on which to choose.

Table 23: Maximum cable length for DC power

Auxiliary port PoE load (note 1)	Maximum cable length 0.75 mm^2 cable	Maximum cable length 1.0 mm^2 cable
No auxiliary port PoE load	130 m	170 m
With auxiliary port PoE load	110 m	150 m

Outdoor copper CAT6A Ethernet cable

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

- 25 m

- 50 m

- 100 m

	Note
	Cambium Networks offers the following cable bundles as accessories: - 305m (N000082L172B - which can be used to make 25m, 50m, 100m, or any other length cables depending on the requirement at the time of installation) - 100m (N000000L155A)

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

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

Part numbers - Ethernet cables

Table 24 lists the part numbers (specified by Cambium Networks) for the terminated Ethernet cables.

Table 24: Part numbers - Terminated Ethernet cable

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

Cable accessories

Cable accessories, which are available at Cambium Networks, are as follows:

- Standard cable glands

	Note
	The metal gland is used for the BTS and the plastic one is used for the CPE.

- Long cable gland

Table 25 lists the part numbers of the cable accessories.

Table 25: Part numbers - Cable accessories

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

SFP Module kits

SFP module kits allow the connection of a BTS radio to a network over a 1 or 10 Gigabit optical Ethernet interface in one of the following full-duplex modes:

- 10 GBASE-SR

- 10 GBASE-LR

Order SFP+ module kits from Cambium Networks (part numbers listed in Table 26). The SFP+ module must be used with a long cable gland.

Table 26: Part numbers - SFP module

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

Optical cables and connections

Order an optical cable with LC connectors from a specialist fabricator using the specification, as shown in Figure 19. It must be of the correct length to connect the ODU to the other device LC connectors.

Figure 19: Optical cable and connector specification
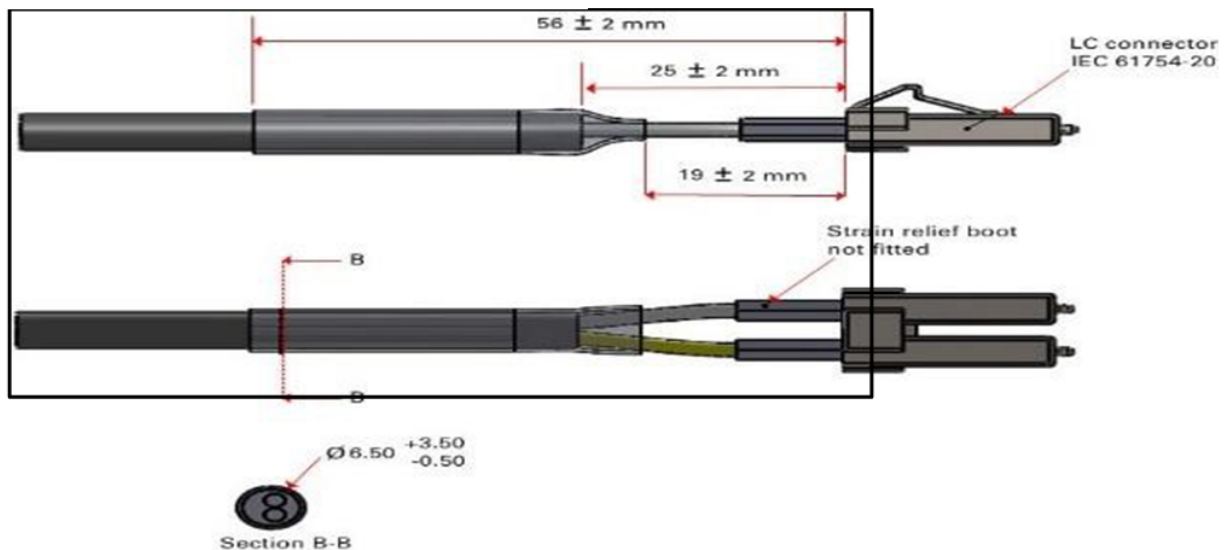
Table 27 lists the part numbers for optical cables.

Table 27: Part numbers - Optical cables

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

Lightning Protection Units (LPUs)

For the cnWave™ 5G Fixed BTS, two types of LPUs are required:

- DC LPU for the power cable

- 10G Ethernet LPU for the data cable

For the cnWave™ 5G Fixed CPE, one type of LPU is required:

- 1G Ethernet LPU for the data cable

DC LPU and grounding kit

This section describes the components of the DC LPU and Grounding Kit (Cambium part number C000000L114A).

This kit can be used to protect the BTS (power port – MAIN – only) from the cnWave™ 5G Fixed family of products. The kit contains two lightning protection units (LPUs) and LPU ground cables. One kit is used for the DC power port of the BTS.

Copper CAT5E Ethernet interfaces to the BTS must be protected with the LPU (part number not available, currently). You must require expertise in outdoor radio equipment installation.

Components and tools

The DC LPU and Grounding Kit contains the following components:

- Lightning protection units (LPUs) - LPU grounding point nuts and washers

For information on how to install the DC LPU, refer to the Installation section.

- EMC strain relief cable glands

- U-bolts, nuts and washers for mounting LPUs

- ODU to top LPU ground cable (M6 lugs at both ends), bolt and washers

- ODU to grounding system ground cable, bottom LPU ground cable (2 pieces, M6 and M10 lugs), bolt and washers

- 4-pin connector kits (4 kits, for example, one is shown below)
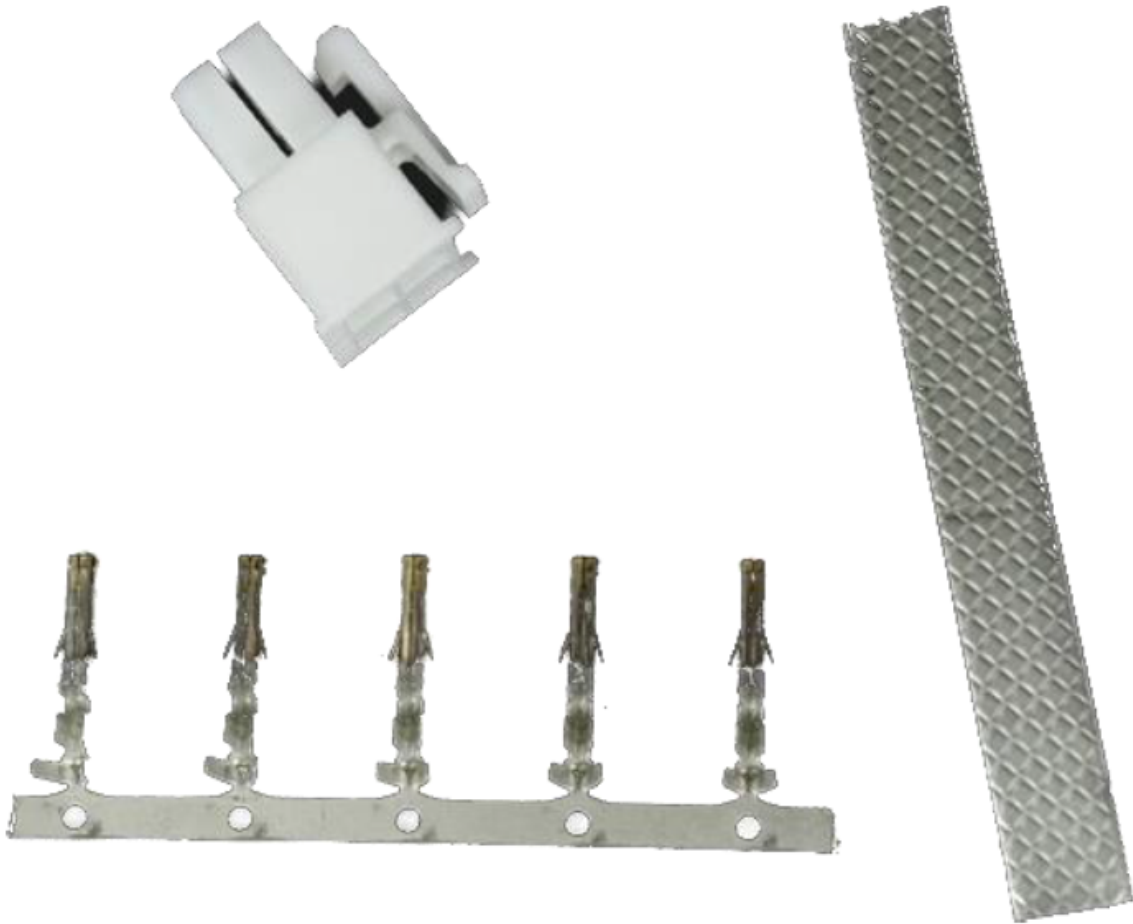
> **Note**
>
> The four-pin connector may be supplied with a black or a white shell.
>
> When installing LPUs, use only EMC cable glands supplied in the ODU and LPU kits (with black caps). Do not use the non-EMC cable glands supplied in other kits (with silver caps), as these should only be used in other radios or ODU installations without LPUs.

10G Ethernet LPU

Figure 20 shows an Ethernet LPU product (TBD) that is recommended by Cambium Networks for BTS.

Figure 20: *10G Ethernet LPU - BTS*

1G Ethernet LPU for CPE

For the CPEs, Cambium Networks recommends the 1G Ethernet LPU product (as shown in Figure 21).

Figure 21: *1G Ethernet LPU - CPE*

Outdoor power cable and accessories

For power connections from the BTS to the PSU, DC LPUs and other devices, use 2-pair (4-core) power cable that has conductor size 0.75 mm^2 or 1.0 mm^2, a UV-resistant sheath and is shielded with copper-braid.

Suitable cable is Lapp type 1032126 (0.75 mm^2) or 1032131 (1.0 mm^2).

Four-pin connectors are required for connecting power cables into ODUs and LPUs. Order spare power connectors and the crimp tool from Cambium Networks, as listed in Table 28.

Table 28: Part numbers - Output cable accessories

Product description	Part number
DC Power connector kit, 18 AWG, packet of 10 (for 0.75 mm^2 cable)	N000000L123A
DC Power connector kit, 16 AWG, packet of 10 (for 1.0 mm^2 cable)	N000000L124A
Molex crimp tool (Molex 63819-0901) for 18 AWG crimp terminals	N000000T001A
Molex crimp terminal removal tool (for rework) (Molex 11-03-0044)	N000000T002A

Cable shields must be bonded to the grounding system to prevent lightning strikes creating a potential difference between the structure and the cable, which could cause arcing, resulting in fire risk and damage to equipment. One grounding kit is required for each grounding point on the power cable.

Order the Cable Grounding Kits from Cambium Networks (part number listed in Table 29).

Table 29: Part number - Cable grounding kit

Product description	Part number
Cable Grounding Kit For 1/4" And 3/8" Cable	01010419001

System Planning

This topic provides information about planning a cnWave™ 5G Fixed platform link. The topic covers the following points:

- Typical network deployment describes the cnWave™ 5G Fixed network architecture.

- Remote BTS deployment describes how to deploy a remote BTS.

- Site planning describes factors to consider when planning the proposed link end sites, including grounding, lightning protection, and equipment location

- Radio frequency planning describes how to plan cnWave™ 5G Fixed platform links to conform to the regulatory restrictions that apply in the country of operation.

- Network management planning describes how to plan for cnWave™ 5G Fixed platform links to manage remotely using SNMP.

- Security planning describes how to plan for cnWave™ 5G Fixed platform links to operate in a secure mode.

- Link planning describes factors to consider when planning links, such as range, path loss, and throughput.

- Planning for connectorized units describes factors to consider when planning to use CPEs with external antennas in cnWave™ 5G Fixed platform links.

Typical network deployment

Any typical cnWave™ 5G Fixed deployment can comprise multiple AP clusters (BTS clusters), each providing data access connectivity to a coverage area. The network can be managed by cnMaestro X. For more information about configuring cnMaestro X using the B1000 UI (BTS), refer to the *cnWave™ 5G Fixed Configuration Guide*.

Figure 22: *Typical cnWave™ 5G Fixed network architecture*
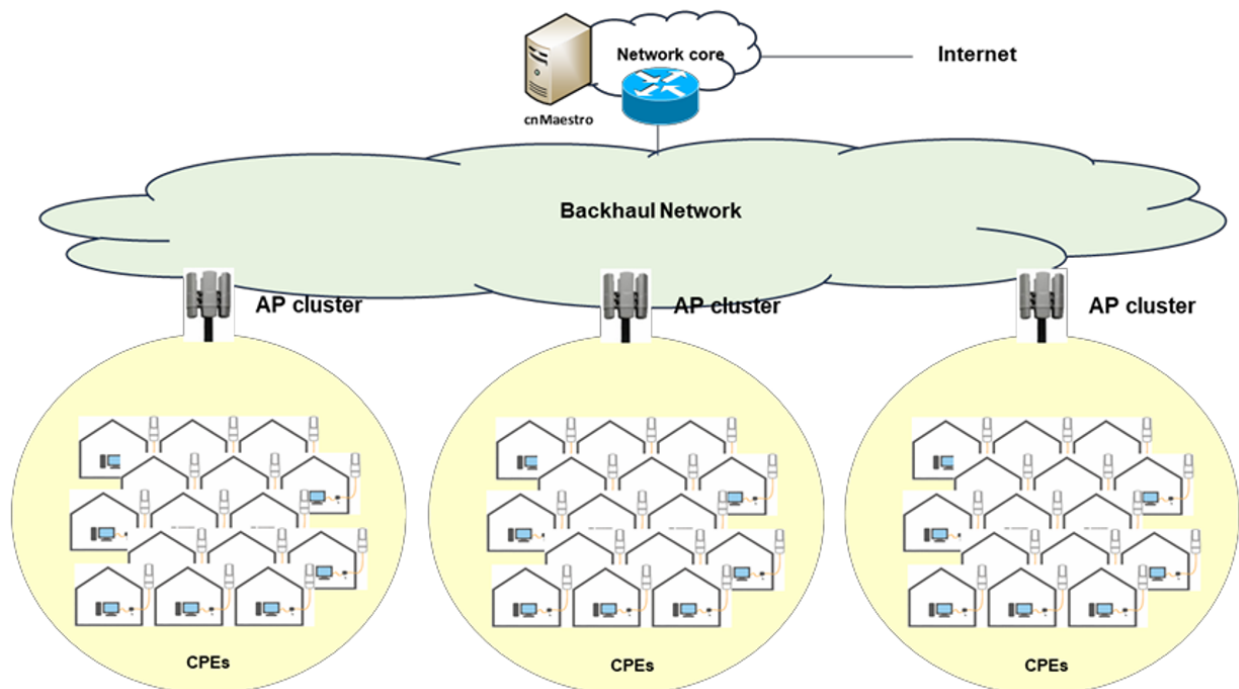
This section contains diagrams illustrating a typical cnWave™ 5G Fixed platform site deployments.

Typical B1000 BTS deployment

In the basic configuration, there is only one Ethernet interface, a copper cable for Power over Ethernet (PoE) from the PSU to the CPE (PSU port), as shown in Figure 23.

Figure 23: *Tower or Mast BTS Installation*
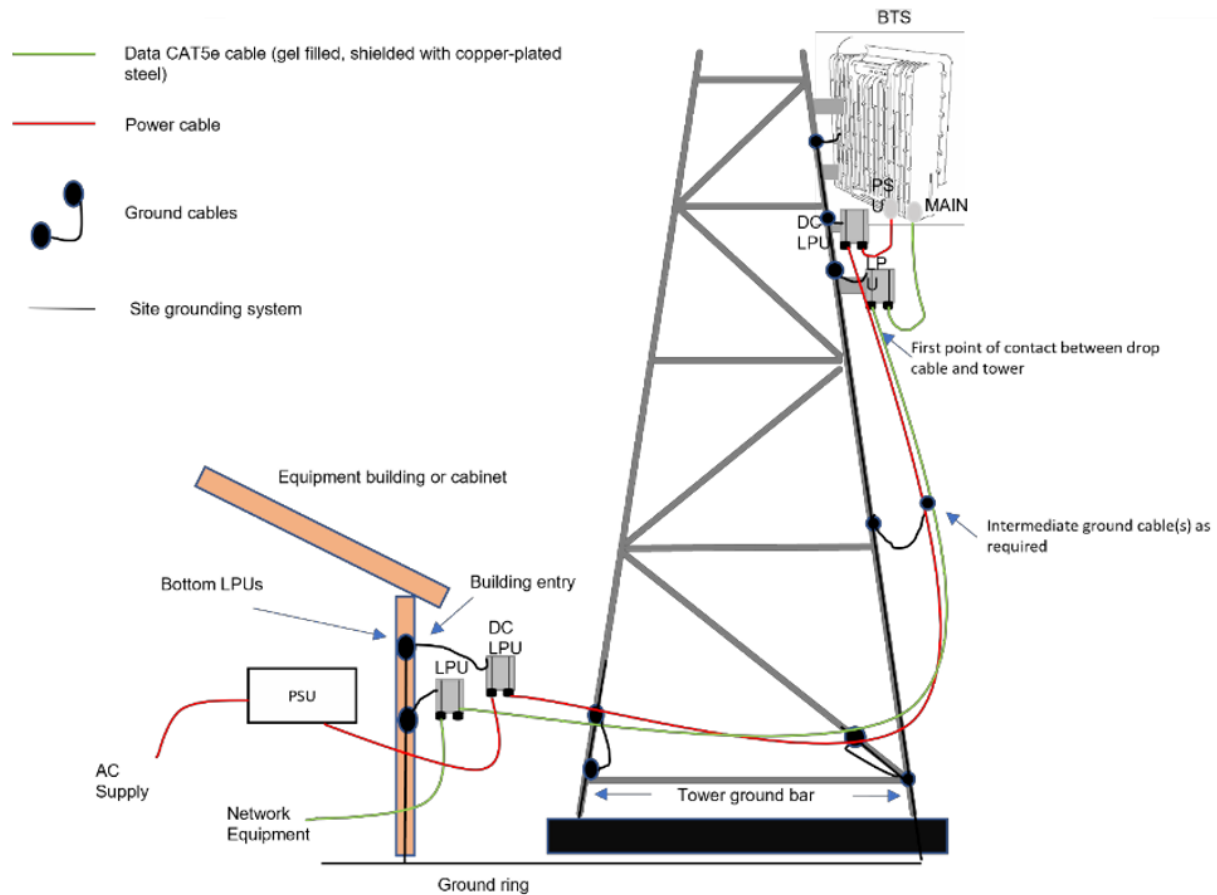
Site planning

This section describes factors that you must consider when planning for the proposed link end sites, including grounding, lightning protection, and equipment location for the BTS, CPE, and PSU.

Site selection for BTS/CPE radios

When selecting a site for the BTS and/or CPE, consider the following factors:

- Height and location to ensure that people are kept away from the antenna.

- Height and location to achieve the best radio path.

- Indoor location where the power supply LED indicators will be visible (CPE), so the drop cable length will not exceed the maximum recommended length. For more details, refer to the Site selection for power supply section.

- Ability to meet the requirements specified in the Grounding and lightning protection section.

- Aesthetics and planning permission issues.

- Cable lengths - For more details, refer to the Ethernet standards and cable lengths section.

- Effect of strong winds on the installation - For more details, refer to Table 30.

Site selection for power supply

When selecting a site for the BTS or CPE power supply, consider the following factors:

- Indoor location with no possibility of condensation, flooding, or high humidity.

- Availability of main electricity supply.

- Located in an environment where it is not likely to exceed its operational temperature rating, allowing for natural convection cooling.

- Accessibility for viewing status indicator LED and connecting Ethernet cables (CPE).

- Cable lengths.

For details on cable lengths, refer to the Ethernet standards and cable lengths section.

Maximum cable lengths

When installing cnWave™ 5G Fixed CPE, the maximum permitted length of the shielded copper Ethernet cable is 330 feet (100m) from CPE to their associated power supplies.

When installing cnWave™ 5G Fixed BTS using the MAIN port, the maximum permitted length of the shielded copper Ethernet interface cable is 330 feet (100m) from BTS to the network interface equipment.

> **Note**
>
> Using SFP will allow longer cable lengths.

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 best protection from the harmful effects of EMD to users. 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 cnWave™ 5G Fixed 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/NFPANo. 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 (for determining 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 24: *Rolling sphere method to determine the lightning protection zones*
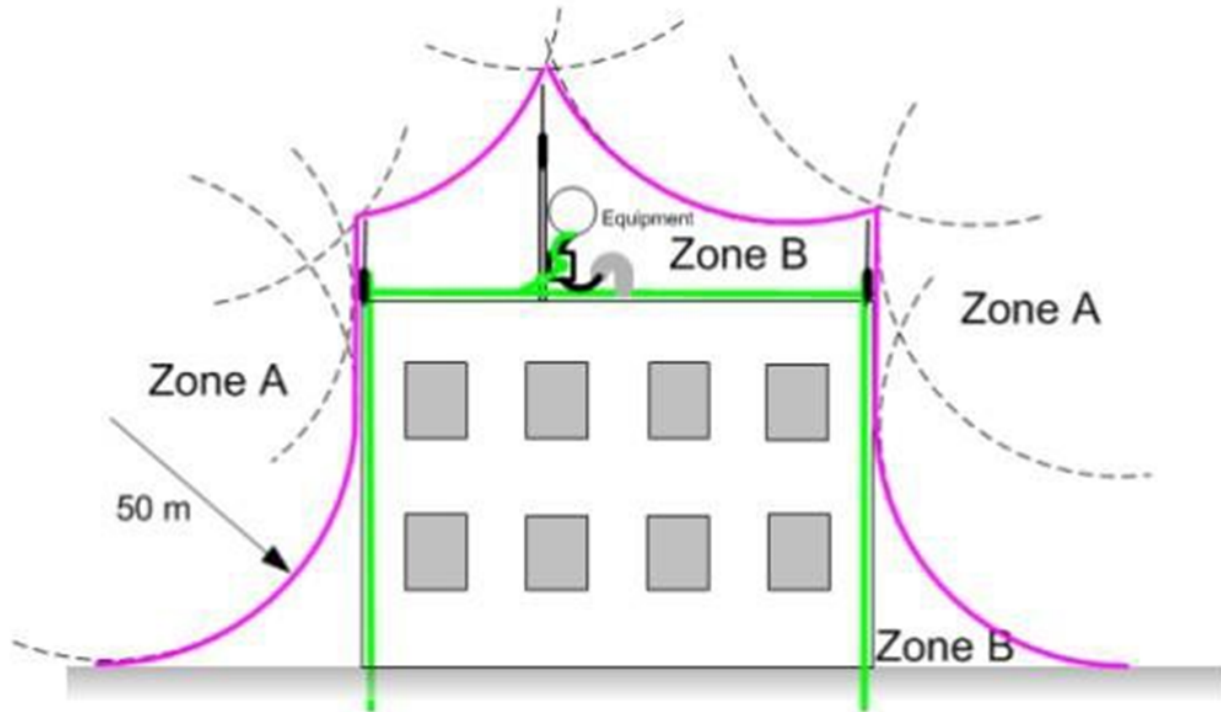
> **Warning**
>
> Never mount equipment in Zone A. Mounting in Zone A may put equipment, structures, and life at risk.

Site grounding system

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

Refer to the Installation section for instructions on installing the outdoor equipment on the roof of a high building.

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.

BTS Location

Find a location for the BTS 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.

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 BTS 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 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 BTS 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 the national meteorological offices.

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

Wind blowing on the BTS 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 formula:

Force (in newtons) = $0.5 \times \rho \times V^2 \times A \times C_d$

Where:

- 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 is measured when the cover plate or antenna is perpendicular to the air flow.

Apply the above formula to the cnWave™ 5G Fixed BTS at different wind speeds, and view the resulting wind loadings as listed in Table 30.

Table 30: Wind loading (Newtons)

Type of ODU	Maximum surface area (square meters) Wind speed	Wind speed - 145 (km/h Newtons)	Wind speed - 200 (km/h Newtons)
BTS	0.155432	130	246
CPE	0.168266	207	395

Equivalent results in US customary units are shown in Table 31.

Table 31: Wind loading (Pound Force)

Type of ODU	Maximum surface area (square meters) Wind speed	Wind speed (km/h lbf) 200 km/h (from measured data)
BTS	0.155432	89
CPE	0.168266	55

PSU DC power supply

Use the PSU DC (recommended by Cambium Networks) 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 the AC power supply, recommended by Cambium Networks, for wireless nodes. Ensure that the power cords and cables are appropriately rated and follow the regulations of the country of use.

PSU Location

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

PoE Power injector:

- The DC power injector can be mounted on a flat surface.

- PSU should be installed in a dry location where no condensation, flooding, or rising water is possible.

- The PSU should be 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 dampness 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 on the 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 can be used.

Lightning Surge Protection Units (LPU)

All drop cables connected to the ODU (for example, PSU and AUX drop cables) require their Lighting Protection Unit (LPU) or Gigabit Surge Suppressor installed close to the ODU and the enclosure/building entry point.

The copper SFP drop cable requires surge protection. However, Optical cables do not require lightning surge protection or ground cables. Guidance on the positioning of the required lighting surge protection is provided in the Lightning Surge Protection Units Location section.

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 the ground cables to 61 m (200 ft) or less.

- In high lightning-prone geographical areas, the drop cable shield must be grounded at a 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's grounding system at its top entry point (usually on the roof).

- The drop cable shield must be bonded to the building's 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 way: Top LPU to ODU and 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.

Radio spectrum planning

This section provides details of wireless specifications, RF environment, Link planning, and other network-related requirements.

General wireless specifications

Table 32 lists the wireless specifications that apply to all cnWave™ 5G Fixed frequency bands.

Table 32: cnWave™ 5G Fixed 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 default power limit.
Integrated antenna type	Antenna types are: - BTS 23 dBi - CPE 35 dBi (Dish – additional 16 dBi)
Duplex schemes	Asymmetric fixed (6.1, 5:2, and 4.3 are supported)
Range	100 m to 10 km, depends on the following factors: - Rain condition - Availability - EIRP limitation
Over-the-air encryption	- 128 -bit AES - AES 256-bit (optional license)
Weather sensitivity	Highly sensitive due to rain range conditions.

Analyzing the RF environment

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

- At various times of the day

- On various days of the week

- Periodically into the future

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

Channel bandwidth

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

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

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

Anticipating reflection of radio waves

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

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

- 12 inches for 900 MHz signals.

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

Obstructions in the Fresnel Zone

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

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

Link planning

This section describes factors to be taken into account when planning links, such as range, obstacles pathloss and throughput. It is highly recommended to use Cambium LINKPlanner software when planning the links.

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 use for configuration, alignment, and operation. Use the installation report to compare predicted and actual link performance.

You can download the LINKPlanner software and User Guide (from Cambium Networks) from the Support website (https://support.cambiumnetworks.com/files/linkplanner/).

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 cnWave™ 5G Fixed radios are designed to operate in LoS environments.

The cnWave™ 5G Fixed radios operate at ranges from 15 m (49 ft) to 10 km (6 miles). 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 link can be installed:

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

Where,

- L_{free_space} is the Free Space Path Loss (dB).

- L_{excess} is the Excess Path Loss (dB).

- L_{fade} is the Fade Margin Required (dB).

- $L_{seasonal}$ is the Seasonal Fading (dB).

- $L_{capability}$ is the Equipment Capability (dB).

Calculating link loss

The link loss is the total attenuation of the wireless signal between two PMP units. The link loss calculation is presented below:

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

Calculating Rx signal level

Figure 25 determinants in Rx signal level.
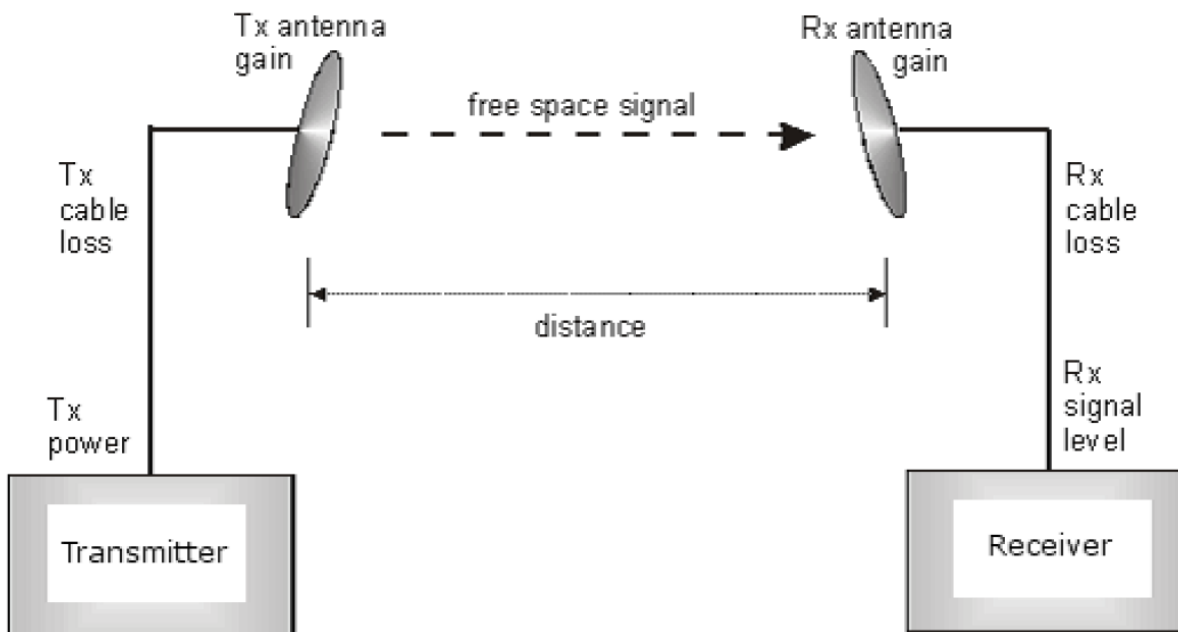
Rx signal level is calculated, as follows:

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

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

Calculating fade margin

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

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

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

Adaptive modulation

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

For details of the system throughput, link loss and maximum distance for each frequency band in all modulation modes, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Network addressing

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

IP Address

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

Dynamic or static addressing

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

- Use DHCP (Dynamic Host Configuration Protocol). In this case, when not connected to the network, the computer derives an IP address on the 169.254 network within two minutes.

- Have an assigned static IP address (for example, 169.254.1.5) on the 169.254 network.

When a DHCP server is not found

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

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

DNS Client

The DNS Client is used to resolve names of management servers within the operator's management domain (as shown in Figure 26). This feature allows hostname configuration for NTP servers, Authorization Servers, DHCP relay servers, and SNMP trap servers. Operators may choose to either enter in the FQDN (Fully Qualified Domain Name) for the hostname or to manually enter the IP addresses of the servers.
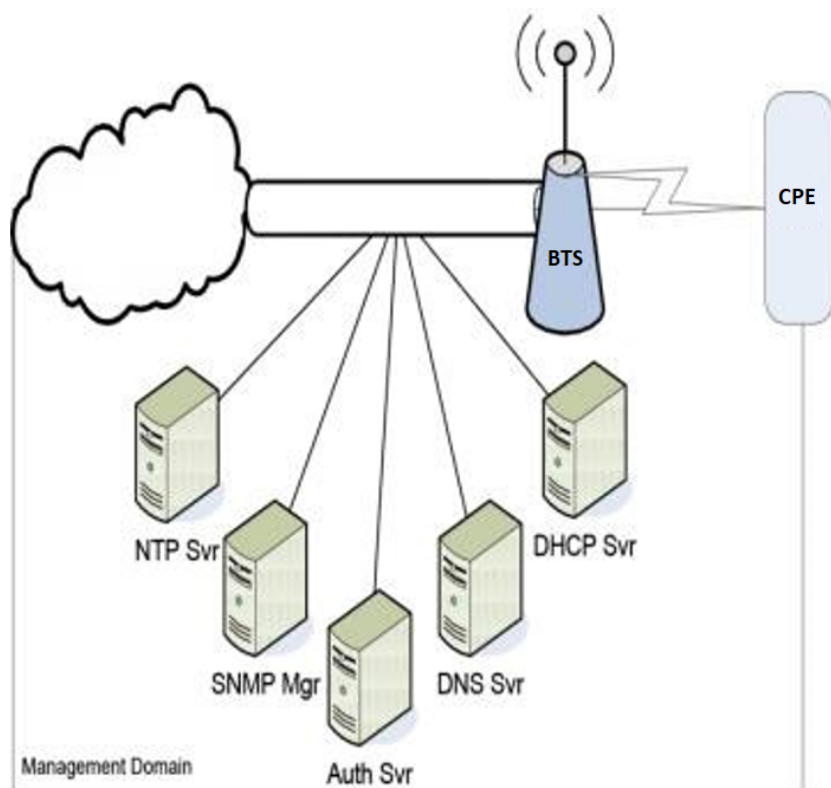
DHCP

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

In conjunction with the NAT features, each SM provides:

- A DHCP server that assigns IP addresses to computers connected to the SM by Ethernet protocol.

- A DHCP client that receives an IP address for the SM from a network DHCP server.

Developing an IP addressing scheme

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

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

- Assign a non-routable IP address.

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

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

Address Resolution Protocol

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

- Communications between modules.

- The data that modules store about each other.

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

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

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

Allocating subnets

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

Example IP address and subnet mask

In this below example of IP address in Class B subnet (as shown in Table 33), the first 16 bits of the 32-bit IP address identify the network:

Table 33: Example of IP address in Class B subnet

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

In this example, the network address is 169.254 and 216 (65,536) hosts are addressable.

Selecting non-routable IP addresses

The factory default assignments for network elements are:

- Unique MAC address

- IP address of 169.254.1.1

- Subnet mask of 255.255.0.0

- Network gateway address of 169.254.0.0

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

- 10.0.0.0 – 10.255.255.255

- 172.16.0.0 – 172.31.255.255

- 192.168.0.0 – 192.168.255.255

Also, the subnet mask and network gateway for the Radius Server can be assigned.

Engineering VLANs

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

- Protocols:

    - Generic Attribute Registration Protocol (GARP) GARV

    - Spanning Tree Protocol (STP)

    - Multiple Spanning Tree Protocol (MSTP)

    - GARP Multicast Registration Protocol (GMRP)

- Embedded source routing (ERIF) in the 802.1Q header

- Multicast pruning

- Flooding unknown unicast frames in the downlink

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

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

Special case VLAN numbers

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

Table 34: Special case VLAN IDs

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

CPE membership in VLANs

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

- Each CPE can be a member in its own VLAN.

- Each CPE can be in its own broadcast domain, such that only the radios that are members of the VLAN can see broadcast and multicast traffic to and from the CPE.

- The network operator can define a work group of CPEs, regardless of the BTS(s) to which they register.

Network management planning

This section describes how to plan for cnWave™ 5G Fixed platform management remotely using SNMP.

Planning for SNMP operation

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

- **coldStart**, which signals that the SNMPv2c element is reinitializing itself and that its configuration may have been altered

- **warmStart**, which signals that the SNMPv2c element is reinitializing such that its configuration is unaltered

- **authenticationFailure**, which signals that the SNMPv2c element has received a protocol message that is not properly authenticated (contingent on the snmpEnableAuthenTraps object setting)

- **linkDown**, as defined in RFC 1573

- **linkUp**, as defined in RFC 1573

- **egpNeighborLoss**, as defined in RFC 1213

- **whispGPSInSync**, which signals a transition from not synchronized to synchronized

- **whispGPSOutSync**, which signals a transition from synchronized to not synchronized

- **whispRegComplete**, which signals registration completed

- **whispRegLost**, which signals registration lost

- **whispRadarDetected**, which signals that the one-minute scan has been completed, radar has been detected and the radio will shut down

- **whispRadarEnd**, which signals that the one-minute scan has been completed, radar has not been detected and the radio will resume normal operation

> **Note**
>
> The proprietary MIBs are provided with the cnWave™ 5G Fixed platform software. You can download files from the Support site (Cambium Networks).

Enabling SNMP

Enable the SNMP interface for use by configuring the following attributes in the **Management** page of the B1000 and the C100 UI:

- SNMP State

- SNMP Version

- SNMP Port Number

- SNMP Accounts and authentication

For more information on how to enable the SNMP interface, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Security planning

This section describes how to plan for cnWave™ 5G Fixed platform operation in secure mode.

Isolating BTS from the Internet

Ensure that the IP addresses of the BTS in the network:

- are not routable over the Internet.

- do not share the subnet of the IP address of your user.

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

- /8 subnets have one reserved network, 10.0.0.0 to 10.255.255.255

- /16 subnets have 16 reserved networks, 172.16.0.0 to 172.31.255.255

- /24 subnets have 256 reserved networks, 192.168.0.0 to 192.168.255.255

Encrypting radio transmissions

Cambium Networks fixed wireless broadband IP systems employ the Advanced Encryption Standard (AES) form of encryption to secure the wireless link. AES is an over-the-air link encryption option that uses the Rijndael algorithm and 128-bit keys to establish a higher level of security than DES. AES products are certified as compliant with the Federal Information Processing Standards (FIPS 197) in the U.S.A.

The default encryption setting for cnWave™ 5G Fixed platform family ODU is None.

Planning for HTTPS operation

Before configuring the HTTPS operation, ensure that the cryptographic material listed in HTTPS security material is available.

Table 35: HTTPS Security material

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

Planning for SNMPv3 operation

SNMP Security mode

You must decide on how SNMPv3 security is configured.

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

Web-based security management allows an operator to configure users, security levels, privacy and authentication protocols, and passphrases using the cnWave™ 5G Fixed platform family web-based management interface. The capabilities supported are somewhat less flexible than those supported using the MIB-based security management but will be sufficient in many applications. Selection of web-based management for SNMPv3 security disables the MIB-based security management. The cnWave™ 5G Fixed platform family does not support concurrent use of MIB-based and web-based management of SNMPv3 security.

Web based management of SNMPv3 security

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

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

- MAC address (default)

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

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

- Read Only

- System Administrator

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

- No authentication, no privacy

- Authentication, no privacy

- Authentication, privacy

If authentication is required, identify the protocol. Following authentication protocols are available:

- MD5

- SHA1

If privacy has to be used, identify the protocol. Following privacy protocols are available:

- Data Encryption Standard (DES)

- AES

Managing module access by passwords

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

- An admin account is created.

- Both admin and root inherit the password that was previously used to access the module if:

- Full Access password, if one was set.

- Display-Only Access password, if one was set and no Full Access password was set.

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

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

- **Administrator**, who has full read and write permissions. This is the level of the root and admin users, as well as any other administrator accounts that one of them creates.

- **Installer**, who has permissions identical to those of administrator, except for that the installer cannot add or delete users or change the password of any other user.

- **Technician**, who has permissions to modify basic radio parameters and view informational web pages.

- **Guest**, who has no write permissions and only a limited view of the **General Status** tab in the UI.

- **Admin, Installer, and Tech accounts** can be configured as Read-Only. This will allow the account to only see the items.

The ability to view the **General Status** tab information can be controlled by the Site Information Viewable to Guest Users under the **Management** tab in the UI.

From the factory default state, configure passwords for both the root and admin accounts at the ADMINISTRATOR permission level, using the **Account > Change Users Password** UI page (If you configure only one of these, then the other will still not require a password for access into the module and remain a security risk). If you configure only one of them, delete the admin account. The root account is the only account that CNUT uses to update the module.

After a password has been set for any Administrator-level account, initial access to the module UI opens the view of the Guest level.

Planning for RADIUS operation

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

- Password management can be centralized.

- Passwords can be updated without reconfiguring multiple network elements.

- User account management can be more sophisticated. For example, users can be prompted by a network manager to change passwords at regular intervals. As another example, passwords can be checked for the inclusion of dictionary words and phrases.

- User accounts can be disabled without reconfiguring multiple network elements.

Remote authentication has one significant disadvantage in a wireless link product such as the cnWave™ 5G Fixed platform family. If the wireless link is down, a unit on the remote side of the broken link may be prevented from contacting a RADIUS Server, with the result that users are unable to access the web-based interface.

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

The cnWave™ 5G Fixed product family provides a choice of the following authentication methods:

- Phase 1:

    - EAP-MSCHAPv2

    - EAP-TTLS

    - EAP PEAP

- Phase 2:

    - PAP

    - CHAP

    - MSCHAPv2

Ensure that the authentication method selected in cnWave™ 5G Fixed platform family is supported by the RADIUS server.

Using the LINKPlanner to design a cnWave™ 5G Fixed System

You are strongly recommended to use Cambium LINKPlanner to design their cnWave™ 5G Fixed system before the installation. It will allow them first and foremost to confirm that the BTS and CPEs are in LoS, which is a condition for the operation of this platform of products.

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

Download the Cambium LINKPlanner software and user guide from the Support site.

Another advantage of using the LINKPlanner is the possibility to print installation reports to help installers when aligning the products. These reports give azimuth and Receive Power predictions that can be used during the alignment process. Refer to the LINKPlanner guide on how to install and use LINKPlanner. In this section, a simple cnWave™ 5G Fixed network and the main parameters that you need to enter in the LINKPlanner are shown.

Figure 27 shows an example of a simple network using one BTS (one sector) and four CPEs close to Cambium Networks offices in Ashburton (UK). The BTS is installed at Higher Brownswell Farm and the CPEs in a 90-degree sector at four different locations, including one CPE on the Cambium Networks tower.

Figure 27: *A simple cnWave™ 5G Fixed Network using LINKPlanner*
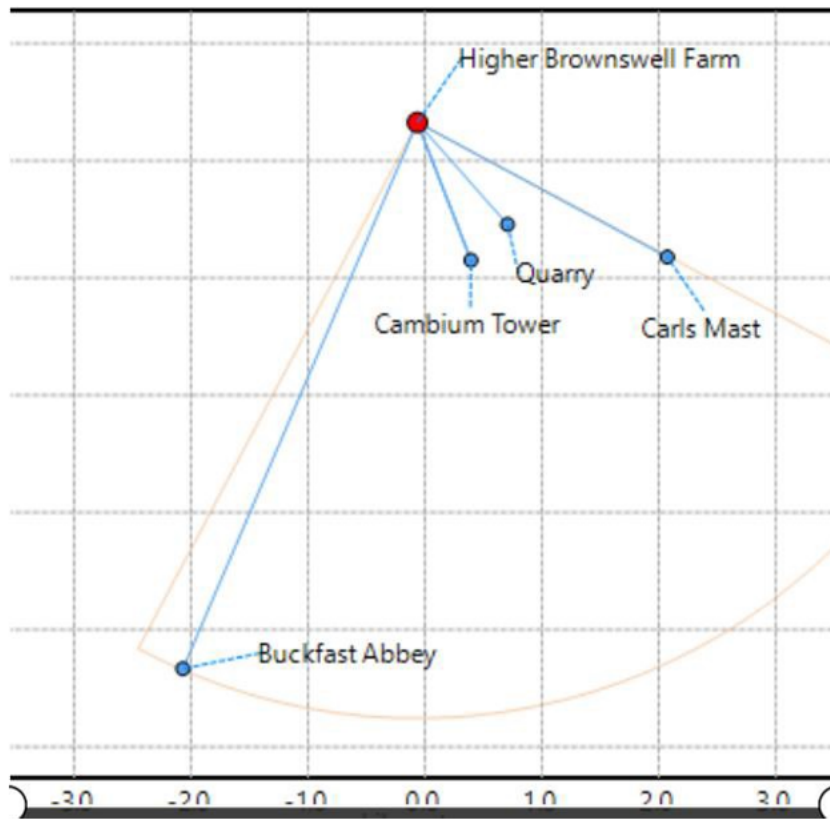
Figure 28 is an example of Google Earth representation of the LINKPlanner System.
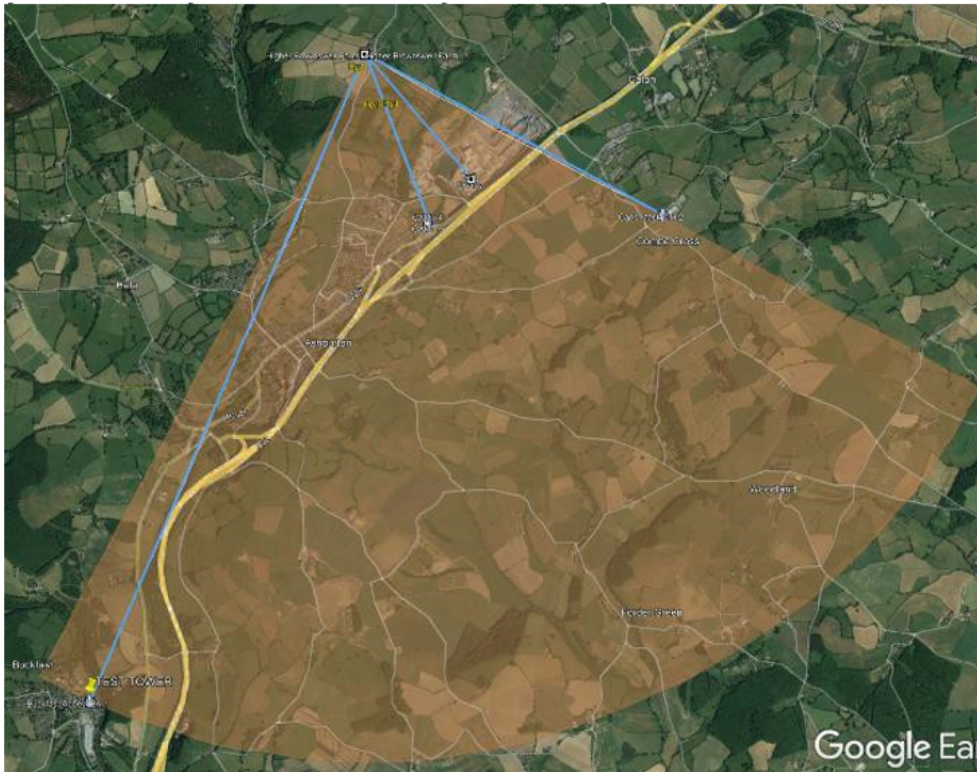
To configure the BTS using the LINkPlanner (as shown in Figure 29), you must enter only a few parameters such as the antenna height, the azimuth, polarization, and any regulatory power limits. You can use the **Calc Tilt** button to automatically determine the optimal tilt needed on the BTS.

Figure 29: *BTS Configuration using the LINKPlanner*

For the CPE, less parameters are required (antenna height). Figure 30 shows the LINkPlanner configuration screen for CPE.

Figure 30: *CPE Configuration using the LINKPlanner*

Subscriber Module Equipment

Region and Equipment Selection

Band	Product	Country
28 GHz	cnWave 28 CPE	Other

cnWave 28 CPE Configuration

Bandwidth	SM Range	Symmetry	Polarization
56 MHz	5.000 km	5:2	Vertical
	Max: 5 km		

Antenna Configuration

Antenna Selection	Antenna Height	Antenna Azimuth	Antenna Tilt	AP Antenna Gain
Cambium Networks 2° cnWave 28 GHz CPE (36.4dBi)	47 meters	23.3°	1.4° (uptilt)	18.9 dBi
	(Max height at site is 48.0 m)	(40.3° from boresight)		

Power

EIRP	Power	User Limit ☐	Interference? ☐
48 dBm	12 dBm		
	(Max Power is 12 dBm)		

Once the BTS and CPEs are configured, then the LINKPlanner does the rest and predicts the performance to be obtained. Figure 31 (which is an example) shows that the system is predicted to give an aggregate throughput of 176.30 Mbps across the sector and also shows the different modulation modes obtained in both uplink and downlink.

Figure 31: *Example of Performance Summary LINKPlanner*

Performance Summary (ITU-R P.530-17)

View in Spreadsheet

SMs per DL modulation				SMs per UL modulation				Total Mean Predicted Throughput	
MCS24	0	0.0%	0.00 Mbps	MCS24	2	40.0%	17.13 Mbps	MCS24	17.13 Mbps
MCS22	4	80.0%	106.77 Mbps	MCS22	0	0.0%	0.00 Mbps	MCS22	106.77 Mbps
MCS20	0	0.0%	0.00 Mbps	MCS20	1	20.0%	8.57 Mbps	MCS20	8.57 Mbps
MCS18	1	20.0%	26.69 Mbps	MCS18	0	0.0%	0.00 Mbps	MCS18	26.69 Mbps
MCS16	0	0.0%	0.00 Mbps	MCS16	1	20.0%	8.57 Mbps	MCS16	8.57 Mbps
MCS14	0	0.0%	0.00 Mbps	MCS14	0	0.0%	0.00 Mbps	MCS14	0.00 Mbps
MCS12	0	0.0%	0.00 Mbps	MCS12	0	0.0%	0.00 Mbps	MCS12	0.00 Mbps
MCS10	0	0.0%	0.00 Mbps	MCS10	1	20.0%	8.57 Mbps	MCS10	8.57 Mbps
MCS8	0	0.0%	0.00 Mbps	MCS8	0	0.0%	0.00 Mbps	MCS8	0.00 Mbps
MCS6	0	0.0%	0.00 Mbps	MCS6	0	0.0%	0.00 Mbps	MCS6	0.00 Mbps
Total	5	100.0%	133.46 Mbps	Total	5	100.0%	42.83 Mbps	**Total**	**176.30 Mbps**

You can check each CPE for predicted performance. As mentioned, LINKPlanner also helps with the installation process. To do this, you can generate an Installation report, which gives details on bearings and receive power predictions for the BTS and each CPE (as shown in Figure 32).

Physical Installation Notes for SM BA-1	
Link Name	HB-40 to BA-1
Access Point	HB-40
Group Name	
Hub Name	Higher Brownswell Farm
Latitude	50.49279N
Longitude	003.77525W
Site Elevation	91 meters AMSL
Platform Variant	28 GHz cnWave 28GHz
Antenna Type	Cambium Networks 2° cnWave 28 GHz CPE
Antenna Beamwidth	1.6°
Antenna Gain	36.4 dBi
Antenna Height	47.0 meters AGL
Antenna Tilt Angle	1.4° (uptilt)
Antenna Azimuth	23.26° from True North 24.02° from Magnetic North
Magnetic Declination	0.76° W ±0.36° changing by 0.20° E per year

Radio Commissioning Notes for CPE BA-1	
Link Name	HB-40 to BA-1
Site Name	Buckfast Abbey
Latitude	50.49279N
Longitude	003.77525W
Altitude	91 meters
Type	CPE
Model	cnWave 28GHz
Maximum EIRP	48.4 dBm
Predicted Receive Power	-60 dBm ± 5 dB while aligning
Predicted Link Loss	135.87 dB ± 5.00 dB

Installation Instruction

Perform the following checks during the installation (Check the deployment guide and the User Guide.)

1. Check with a GPS that you are installing at the correct location.

2. Check carefully the direction to Access Point. Either use a corrected compass or use the GPS waypoint feature about 300 meters from the installation location.

3. When aligning antenna, it is important to find the centre of the main beam. This is done by adjusting the antenna and monitoring the receive level until the peak is found. Once the peak level is found, it should be checked against the prediced receive power to ensure that the antenna has not been aligned on a side lobe.

Using the Capacity Planner Sheet

Cambium Networks provides a Capacity Planner sheet (as shown in Figure 33) to help customers view how the system performs using different plans. It is provided as a guide. Customers can toggle different parameters such as MU-MIMO capabilities to decide how to plan their networks.

The Capacity Planner sheet is available on the Cambium Networks Support Center.

Figure 33: *Link Budget using Capacity Planner Sheet*

cnWave CAPACITY PLANNER
Cambium Networks confidential, not commercially binding

SYSTEM CONFIGURATION

BTS INFORMATION

BTS Tx Power [dBm]	21	Max value = 21 dBm
Carrier Aggregation?	Yes	
Carrier 1 Frequency [MHz]	27800.50	Range: 24,250 - 29,500 MHz
Carrier 1 Bandwidth [MHz]	112	
Carrier 2 Frequency [MHz]	27856.50	Range: 24,250 - 29,500 MHz
Carrier 2 Bandwidth [MHz]	112	
Downlink average group size	2.5	Range: 1-4
Uplink average group size	2.5	Range: 1-4

FRAME INFORMATION

TDD Structure	5:2	
Display distance	km	
Range (km)	4	Max range = 10 km

ENVIRONMENT INFORMATION

Environment	LOS	Include Rain Fading	Yes	
Fade Margin [dB]	0	Latitude [degrees]	-25.748	
Interference measured?	No	Longitude [degrees]	28.316	
		Polarity	Vertical	
		Assumption: rain probability = 0.01%		

CPE INFORMATION

CPE Tx Power [dBm]	12	Max value = 12 dBm

LINK BUDGET AND CAPACITY

DOWNLINK CARRIER 1
CONFIGURATION: Center freq = 27800.5 MHz - Channel BW = 112 MHz

BTS Tx Power [dBm]	21
BTS Antenna Gain [dBi]	23
BTS EIRP [dBm]	44
CPE Antenna Gain [dBi]	36

BTS DL Capacity Carrier 1 = 313.8 Mbps

MCS LEVEL	DL SENSITIVITY (dBm)	DL GAIN (dBm)	DL RANGE (km)	DL THROUGHPUT (Mbps)
6	-75.8	155.8	4.0	188.4
7	-74.6	154.6	4.0	219.8
8	-73.4	153.4	3.8	251.3
9	-72.2	152.2	3.6	282.7
10	-71.0	151.0	3.4	314.1
11	-69.8	149.8	3.2	345.5
12	-68.6	148.6	3.0	377.0
13	-67.4	147.4	2.8	408.4
14	-66.2	146.2	2.6	439.8
15	-64.9	144.9	2.4	471.1
16	-63.7	143.7	2.3	502.5
17	-62.5	142.5	2.1	533.9
18	-61.3	141.3	2.0	565.4
19	-60.1	140.1	1.8	596.8
20	-58.9	138.9	1.7	628.2
21	-57.7	137.7	1.6	659.6
22	-56.5	136.5	1.4	691.1
23	-55.3	135.3	1.3	722.5

DOWNLINK CARRIER 2
CONFIGURATION: Center freq = 27856.5 MHz - Channel BW = 112 MHz

BTS Tx Power [dBm]	21
BTS Antenna Gain [dBi]	23
BTS EIRP [dBm]	44
CPE Antenna Gain [dBi]	36

BTS DL Capacity Carrier 2 = 283.9 Mbps — Total BTS DL Capacity = 597.7 Mbps

DL SENSITIVITY (dBm)	DL GAIN (dBm)	DL RANGE (km)	DL THROUGHPUT (Mbps)	TOTAL DL THROUGHPUT (Mbps)
-75.8	155.8	3.8	188.4	376.8
-74.6	154.6	3.6	219.8	439.6
-73.4	153.4	3.4	251.3	502.5
-72.2	152.2	3.2	282.7	565.4
-71.0	151.0	3.0	314.1	628.2
-69.8	149.8	2.9	345.5	691.1
-68.6	148.6	2.7	377.0	753.9
-67.4	147.4	2.5	408.4	816.8
-66.2	146.2	2.4	439.8	879.6
-64.9	144.9	2.2	471.1	942.1
-63.7	143.7	2.0	502.5	1005.0
-62.5	142.5	1.9	533.9	1067.9
-61.3	141.3	1.8	565.4	1130.7
-60.1	140.1	1.6	596.8	1193.6
-58.9	138.9	1.5	628.2	1256.4
-57.7	137.7	1.4	659.6	1319.3
-56.5	136.5	1.3	691.1	1382.1
-55.3	135.3	1.2	722.5	1445.0

Note: With carrier aggregation each CPE only operates on one of the two carriers

UPLINK CARRIER 1
CONFIGURATION: Center freq = 27800.5 MHz - Channel BW = 112 MHz

CPE Tx power [dBm]	12
CPE Antenna Gain [dBi]	36
CPE EIRP [dBm]	48
BTS Antenna Gain [dBi]	23

BTS UL Capacity Carrier 1 = 107.5 Mbps

MCS LEVEL	UL SENSITIVITY (dBm)	UL GAIN (dBm)	UL RANGE (km)	UL THROUGHPUT (Mbps)
6	-75.8	146.8	2.7	75.4
7	-74.6	145.6	2.5	87.9
8	-73.4	144.4	2.4	100.5
9	-72.2	143.2	2.2	113.1
10	-71.0	142.0	2.1	125.6
11	-69.8	140.8	1.9	138.2
12	-68.6	139.6	1.8	150.8
13	-67.4	138.4	1.6	163.4
14	-66.2	137.2	1.5	175.9
15	-64.9	135.9	1.4	188.4
16	-63.7	134.7	1.3	201.0
17	-62.5	133.5	1.2	213.6
18	-61.3	132.3	1.1	226.1
19	-60.1	131.1	1.0	238.7
20	-58.9	129.9	0.9	251.3
22	-56.5	127.5	0.7	276.4
23	-55.3	126.3	0.6	289.0

UPLINK CARRIER 2
CONFIGURATION: Center freq = 27856.5 MHz - Channel BW = 112 MHz

CPE Tx power [dBm]	12
CPE Antenna Gain [dBi]	36
CPE EIRP [dBm]	48
BTS Antenna Gain [dBi]	23

BTS UL Capacity Carrier 2 = 108.5 Mbps — Total BTS UL Capacity = 215.5 Mbps

UL SENSITIVITY (dBm)	UL GAIN (dBm)	UL RANGE (km)	UL THROUGHPUT (Mbps)	TOTAL UL THROUGHPUT (Mbps)
-75.8	146.8	2.4	75	150.7
-74.6	145.6	2.3	88	175.9
-73.4	144.4	2.1	101	201.0
-72.2	143.2	2.0	113	226.1
-71.0	142.0	1.8	126	251.3
-69.8	140.8	1.7	138	276.4
-68.6	139.6	1.6	151	301.6
-67.4	138.4	1.5	163	326.7
-66.2	137.2	1.4	176	351.9
-64.9	135.9	1.2	188	376.9
-63.7	134.7	1.1	201	402.0
-62.5	133.5	1.0	214	427.1
-61.3	132.3	1.0	226	452.3
-60.1	131.1	0.9	239	477.4
-58.9	129.9	0.8	251	502.6
-56.5	127.5	0.7	276	552.9
-55.3	126.3	0.6	289	578.0

Note: With carrier aggregation each CPE only operates on one of the two carriers

Using the Capacity Planner Sheet (as shown in Figure 33), the customer must insert the following parameters:

- Frequencies

- Whether Carrier Aggregation is used (not supported in Release 3.3)

- Download average group size for both Uplink and Downlink. This parameter will be used to determine the CPE group sizes when using MU-MUMO.

- TDD Structure or symmetry of the system (6.1, 5:2, and 4.3 are supported)

- Polarity (Vertical or Horizontal)

The calculation sheet will then determine the link budget calculations at each modulation mode.

The next step is for the customer to determine the plans for different services (business, home users) and use that to establish a sector size. The sheet will also indicate a return of investment according to prices and costs. One of the parameters that will make a difference is the oversubscription rate to manage all the subscribers' demands.

Figure 34 shows an example of network capacity using an oversubscription rate of 4 and a simple plan of services.

Figure 34: *Network Planning using Capacity Planner Sheet*
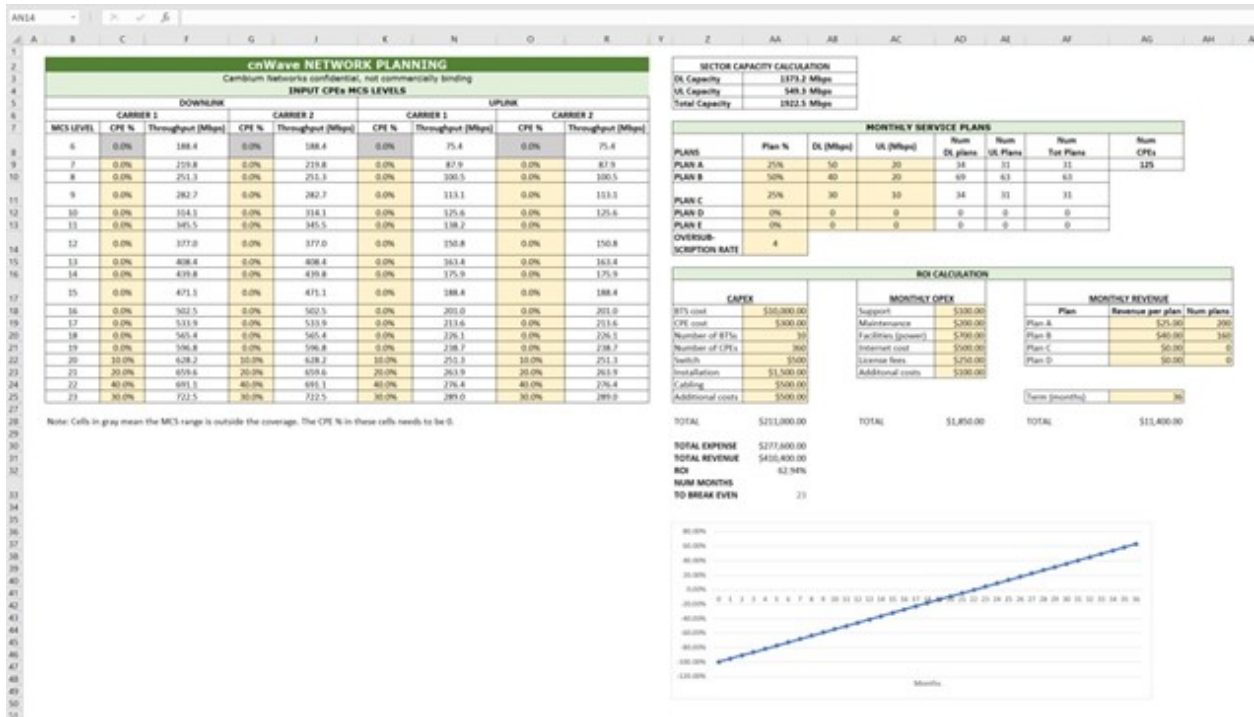
Preparing for installation

This topic describes how to stage and test the hardware for a cnWave™ 5G Fixed platform network. The topic covers the following points:

- Safety and precautions that must be observed and checked before proceeding with the installation. For more details, refer to the Safety section.

- Preparing for installation includes the pre-configuration procedure or staging before proceeding with installation. For more details, refer to the ODU Pre-installation configuration section.

- Testing system components covers the procedures for unpacking, performing prerequisite configurations, and initial staging of the cnWave™ 5G Fixed platform of products. For more details, refer to the Testing system components section.

- Configuring link for test covers the procedures required for testing the equipment's radio links. For more details, refer to the Staging section.

- Preparing the cables for connections. For more details, refer to the Preparing the cables section.

Safety

Mounting the ODU and soundness of structure

Ensure that the ODU equipment and the structure to which it is mounted can withstand the maximum wind speeds at a proposed site. Refer to Table 30 for wind loading guidance on ODU wind loading (Newtons).

Working at heights and near power lines

Consider the following points:

- Exercise extreme care when working at heights.

- Observe national regulations specific to working at heights. Use the trained competent staff.

- Exercise extreme care when working near power lines.

Power supply and power safety

Consider the following points:

- Always use a Cambium Networks specified cnWave™ 5G Fixed platform family power supply unit (PSU) to power the ODU. Failure to use a supplied PoE (by Cambium Networks) can result in equipment damage and may cause a safety hazard.

- Ensure the equipment is not powered during installation.

- Always power down and disconnect the equipment from its power source before servicing.

- The ODU power supply is the primary disconnect device.

External cables

- Use outdoor-rated cables for connections that are exposed to the outdoor environment.

- Install Cambium Networks recommended cables.

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

- For the outdoor copper CAT6E Ethernet interfaces, always use the CAT6E cable that is gel-filled and shielded with copper-plated steel.

RF Exposure near the antenna

Harmful levels of RF radiation are present close to the antenna when the transmitter is ON. Consider the following points:

- Observe the minimum safe distance limit for the cnWave™ 5G Fixed products. For details, refer to the *cnWave™ 5G Fixed Product Leaflet* or *cnWave™ 5G Fixed Configuration guide*.

- Ensure that equipment is installed in a position by avoiding any radiation hazard to humans.

- Always turn off the power to the ODU equipment before undertaking maintenance activities in front of the antenna.

- Note that the units start to radiate RF energy as soon as they are powered up.

Grounding and lightning protection requirements

Consider the following points to protect structures, equipment, and people against electrostatic discharge:

- Use the ODU equipment in a lightning protection zone.

- Install the ODUs, external antennas, and GPS receivers in Zone B as they are not designed to survive direct lightning strikes. For more details, refer to the Lightning protection zones section.

- Mounting in Zone A may put the equipment, structures, and life at risk.

- Install appropriate lightning conductors to conduct the surge current to the ground through a separate preferential solid path.

- Ground bonding and transient voltage surge suppression are recommended. Use Cambium Networks specified surge suppressors.

- Grounding conductor runs are as short, straight, and smooth as possible, with bends and curves kept to a minimum.

- All bends must have a minimum radius of 200 mm (8 inches) and a minimum angle of 90°. A diagonal run is preferable to a bend, even though it does not follow the contour or run parallel to the supporting structure.

- All bends, curves, and connections must be routed towards the grounding electrode system, ground rod, or ground bar.

- Grounding cables must not be installed with drip loops.

- 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.

Ensure that the installation meets the requirements, as described in the Grounding and lightning protection section.

Grounding and protective earth

The ODU equipment must be properly grounded to protect against lightning. It is your responsibility to install the equipment following 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 ODU, 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 ODU must be contracted to a professional installer.

Thermal Safety

The ODU enclosure may be hot to touch when in operation. The ODU must not be operated in ambient temperatures exceeding 40°C unless mounted in a Restricted Access Location (RAL). For more information about the thermal safety of the ODU, refer to the ODU ambient temperature limits section.

> **Warning**
>
> Do not install the ODU in a location where the ambient temperature could exceed 40°C unless that is a RAL as defined by EN 60950-1.

> **Warning**
>
> L'unité externe ne doit pas être installée dans un endroit où la température ambiante est supérieure à 40C à moins que l'accès soit limité au personnel autorisé.

ODU Pre-installation configuration

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

- Connecting to the unit

- Configuring IP and Ethernet interfaces

- Upgrading the software version

- General configuration

- Configuring security

- Configuring radio parameters

- Setting up SNMP agent

- Configuring remote access

- Monitoring the Link

- Configuring a RADIUS server

For more information about the pre-configuration tasks, refer to the *cnWave™ 5G Fixed Configuration Guide*.

If the units are to be pre-configured during staging, the following safety precautions must be observed:

Preparing personnel

In no event, Cambium Networks shall be liable for any injury or damage caused during the installation of the cnWave™ 5G Fixed platform of products.

Ensure that only qualified personnel undertake the installation of cnWave™ 5G Fixed platform of products. Ensure that all safety precautions are observed.

Preparing inventory

Perform the following inventory checks:

- Check that the correct components are available, as described in the System Hardware section.

- Check the contents of all packages against their packing lists.

Preparing tools

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

- RJ45 crimp tool (it must be the correct tool for the type of RJ45 being used)

- Personal Computer (PC) with 10 or 100 or 1000 BaseT Ethernet port

- Web browser

- Ethernet patch cables

Testing system components

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

Unpacking components

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

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

Preparing the ODU

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

Use either of the following two methods to configure the BTS:

- Use the Quickstart feature of the product through UI menu **Quick Start** (not available in Release 3.3).

- Manually set each parameter in the UI.

After changing the configuration parameters on the UI web page, ensure to perform the following actions:

- Before you leave a web page, click the **Save** button to save the change(s).

- After making change(s) on multiple UI web pages, click the **Reboot** button to reboot the module and implement the change(s).

Configuring the management PC

If the computer is configured for Dynamic Host Configuration Protocol (DHCP), disconnect the computer from the network. If the computer is instead configured for a static IP address, then perform the following tasks:

- Set the static address in the 169.254.X.X network.

- Set the subnet mask to 255.255.0.0.

For more information about the configuration, refer to the Configuring the Management PC section.

Factory default configuration

From the factory, the BTSs and the CPEs are configured to not transmit on any frequency. This configuration ensures that the equipment operators do not accidentally turn on an unsynchronized modules. Site synchronization of modules is required.

ODU Interfaces

For details on the ODU interfaces, refer to the B1000 - External Interfaces section.

Recommended tools for installation

Table 36 lists tools that might be required for installation.

Table 36: Tools required for cnWave™ 5G Fixed platform installation

Equipment to be installed	Tools required
BTS	- **3 mm Allen Wrench** - Used for connecting the antenna mating bracket to the rear of the BTS housing. - **Crescent Wrench Pair** - Used for tightening cable glands. - **Self-amalgamating and PVC Tape** - Used for weatherproofing N-type connections.
BTS or CPE dish Antenna	- **13 mm Spanner Wrench (or Ratchet Spanner Wrench) Pair** - Used for connecting the antenna (dish for CPE) base to the pole or mast mounting bracket. - **Self-amalgamating and PVC Tape** - Used for weatherproofing N-type connections. - **N-type Torque Wrench (not required but recommended)** - Used for assuring proper tightening of N-type connectors terminating the RF cables.
CPE	- **Wrench/driver (depending on operator's choice of clamps)** - Used for tightening clamps to the pole. - **Alignment tone adapter/ headset** - Used for aligning the CPE to the BTS.
Cabling	- **Electrician's Scissors or Wire Cutters** - Used for cutting wire to length. - **RJ-11/RJ-45 Crimping Tool** - Used for stripping RJ-11/RJ-45 cables and for terminating cable ends.

Equipment to be installed	Tools required
	• **Cable Testing Device** - Used to ensure that cables are properly constructed.

Standards for wiring

Modules automatically sense whether the Ethernet cable in a connection is wired as straight-through or crossover. Operators may use either straight-through or crossover cable to connect a network interface card (NIC), hub, router, or switch to these modules. This guide follows the EIA/TIA-568B colour code standard.

Best practices for cabling

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

- Use only shielded cables to resist interference.

- For vertical runs, provide cable support and strain relief.

- Include a 2-ft (0.6 m) service loop on each end of the cable to allow for thermal expansion and contraction and to facilitate terminating the cable again when needed.

- Include a drip loop to shed water so that most of the water does not reach the connector at the device.

- Properly crimp all connectors.

- Use dielectric grease on all connectors to resist corrosion.

- Use only shielded connectors to resist interference and corrosion.

Wiring connectors

This section contains diagrams that correlate pins to wire colors and illustrate crossovers where applicable.

Pin 1, relative to the lock tab on the connector of a straight-through cable is located (as shown in Figure 35).

Figure 35: *RJ45 Pin 1 location*
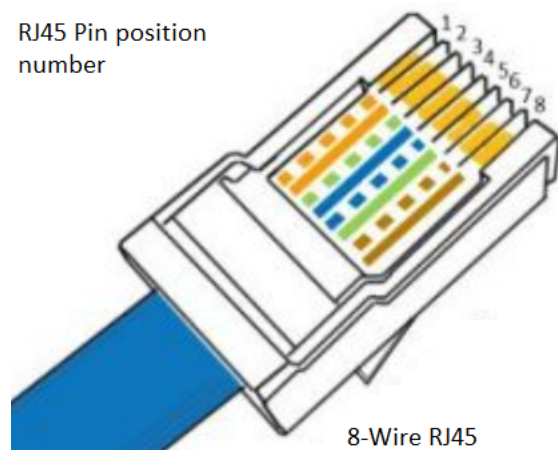
Table 37 lists the main port pinout details.

Table 37: Main port pinout

RJ45 Pin	Description
1	+TxRx0
2	-TxRx0
3	+TxRx1
4	+TxRx2
5	-TxRx2
6	-TxRx1
7	+TxRx3
8	-TxRx3

Figure 36 shows the RJ-45 pinout for a straight-through Ethernet cable.

Figure 36: *Straight-through Ethernet cable*
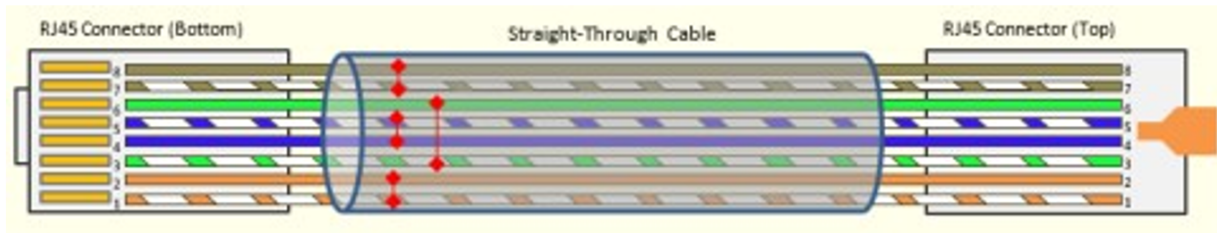
Table 38 lists the RJ-45 pinout for straight-through Ethernet cable.

Table 38: RJ-45 pinout for straight-through Ethernet cable

Pin	Signal	Pair	Color
1	TP1+	2	White/orange stripe
2	TP1-	2	Orange solid
3	TP2+	3	White/green stripe
4	TP3+	1	Blue solid
5	TP3-	1	White/blue stripe
6	TP2-	3	Green solid
7	TP4+	4	White/brown stripe
8	TP4-	4	Brown solid

Figure 37 shows the RJ-45 pinout for crossover Ethernet cable.
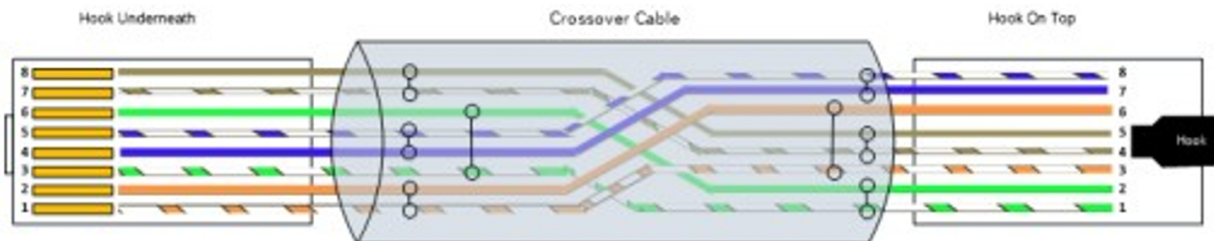
Table 39 lists the RJ-45 pinout for crossover Ethernet cable.

Table 39: RJ-45 pinout for crossover Ethernet cable

	Connection 1			Connection 2		
	Signal	Pair	Color	Signal	Pair	Color
1	TP1+	2	White/orange stripe	TP2+	3	White/green stripe
2	TP1-	2	Orange solid	TP2-	3	Green solid
3	TP2+	3	White/green stripe	TP1+	2	White/orange stripe
4	TP3+	1	White/blue stripe	TP4+	4	White/brown stripe
5	TP3-	1	Blue solid	TP4-	4	Brown solid
6	TP2-	3	Green solid	TP1-	2	Orange solid
7	TP4+	4	White/brown stripe	TP3+	1	Blue soli
8	TP4-	4	Brown solid	TP3-	1	White/blue stripe

Alignment tone cable (for CPE)

The alignment tone cable is constructed using an RJ45 plug and a Stereo plug. The pin configuration is shown in Figure 38.

Figure 38: *Alignment tone cable pin configuration*
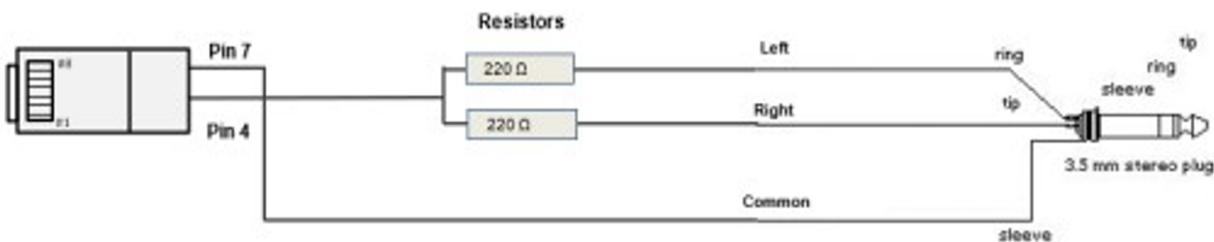
Staging

Prepare the power cables for connection at the ODU or LPUs, as described in the Lightning Surge Protection Units (LPU) section.

It is important to stage the BTS and the CPE units first to verify proper registration before deploying the modules to the site. To begin with configuring the modules for testing, refer to the following sections:

Configuring the management PC

To configure the local management PC to communicate with the BTS or the CPE, follow the steps as described in the *cnWave™ 5G Fixed Configuration Guide.* This action helps you to ensure that the PC is on the same subnet of the BTS or the CPE.

Use a laptop or PC to do this step using only the BTS at this stage. To communicate with a BTS or a CPE with a default address of 169.254.1.100, perform the following steps:

1. On Windows PC, click **Start** > **Settings** > **Network & Internet**.

   The **Network Status** page appears with multiple options on the left navigation column.

2. Select **Ethernet** > **Change adapter settings**.

   The **Network Connections** page appears.

3. Select **Ethernet** and right-click to select **Properties**.

   The **Ethernet Properties** dialog box appears with Networking and Sharing tabs, as shown in Figure 39.

   Figure 39: *The Ethernet Properties dialog box*
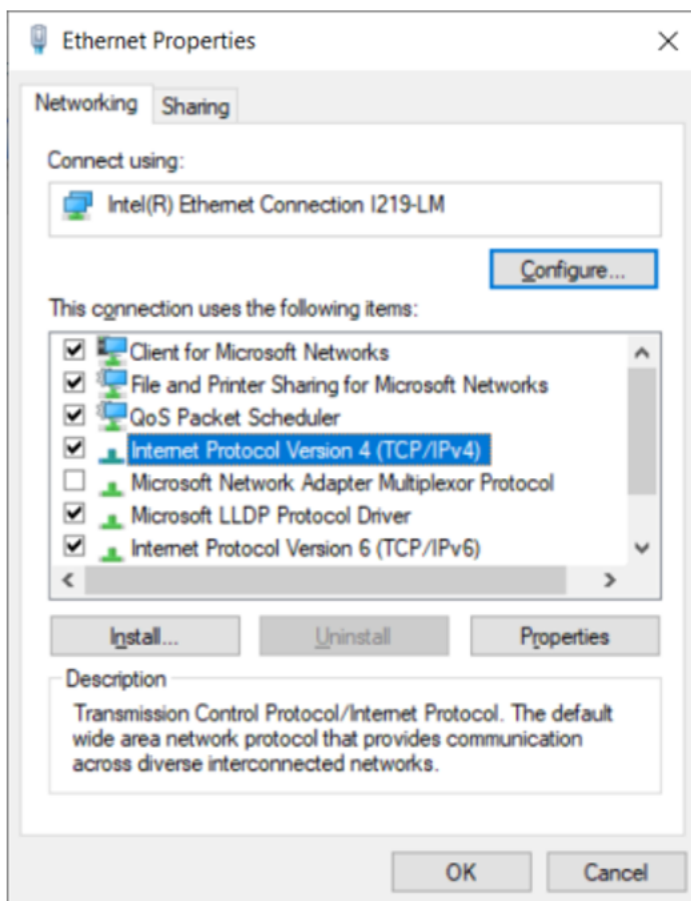
   By default, the **Networking** tab is selected.

4. Select **Internet Protocol Version 4 (TCP/IPv4)** from the available list of connections (as shown in Figure 39).

5. Click **Properties**.

The **Internet Protocol Version 4 (TCP/IPv4) Properties** dialog box appears, as shown in Figure 40.

Figure 40: *The Internet Protocol Version 4 Properties dialog box*
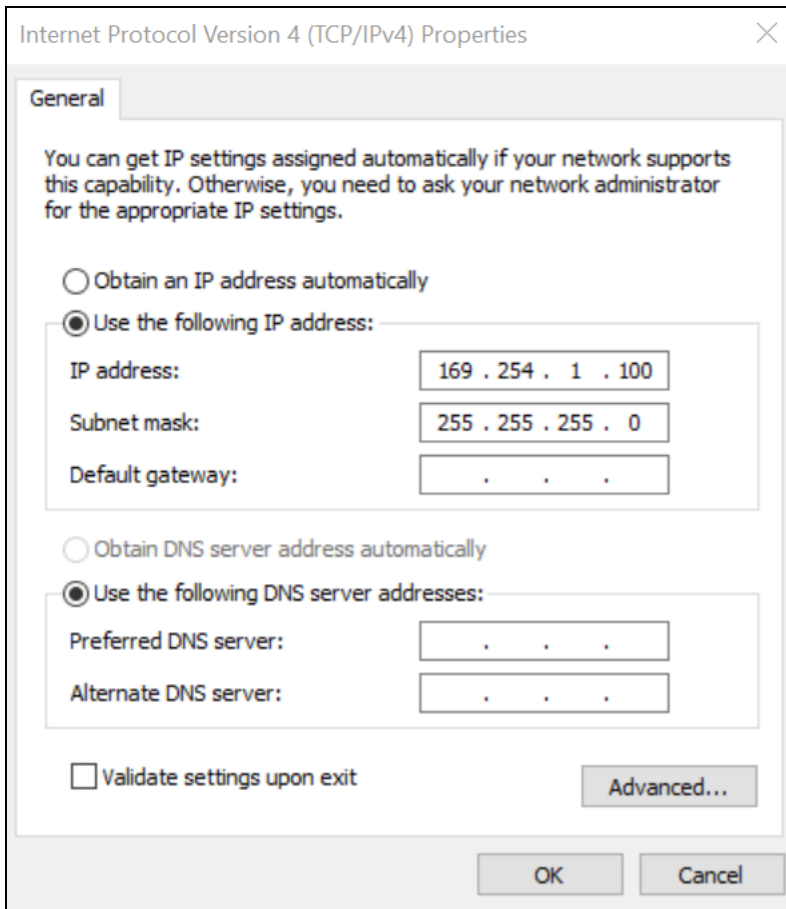
6. In the **Use the following IP address** section, type an appropriate IP address in the **IP address** text box. Example: 169.254.1.1

   If you are using 169.254.1.1 as the default address, you must avoid using 169.254.0.0 and 169.254.1.1 IP addresses.

7. In the **Subnet mask** text box, type 255.255.255.0.

8. Leave the **Default gateway** text box blank and click **OK**.

9. Ensure that you can communicate with the BTS by running a continuous PING session at a command prompt.

   Example: You must run a command prompt and type `Ping -t 169.254.1.1`. If the PING is successful, you can access the login page of B1000 (BTS) by using the http://169.254.1.1 URL.

Powering up the BTS

To power up the BTS, perform the following tasks:

1. Plug one end of a CAT6 Ethernet cable into the MAIN port on the BTS.

2. Plug the other end of the CAT6 Ethernet cable into the Ethernet port of the PC or laptop.

3. From the PSU, plug the power cable connector (as shown in Figure 41) labeled OUTPUT into the PSU port of the BTS (as shown in Figure 42).

> **Note**
>
> Before plugging the power cable connector into the PSU port, fit the gland body on the black cable and then the white connector. Finally, screw the gland to the PSU port.

Figure 41: *B1000 AC-DC PSU connector*

Figure 42: *B1000 Interface connections*

4. Plug the power supply into an electrical outlet.

	Warning
⚠	From this point until you remove power from the ODU, stay far away from the AP following the minimum separation distance limit specified in the Legal and Open Source Guide, (available on the Cambium Networks Support site).

5. Power up the PC or laptop.

6. Start the browser in the PC or laptop.

The BTS interface provides a series of web pages to configure and monitor the unit. Access web-based interface through a PC or laptop that is either directly connected or connected through a network to the BTS. If the PC or laptop is not connected to a network when it is being configured for test environment, and if the PC or laptop has used a proxy server address and port to configure a module, then the operator may need to first disable the proxy setting in the computer.

	Note
	Both short and long glands can be used to connect the BTS AC/DC to an indoor PSU.

Disabling proxies (if required)

Perform the following steps to toggle the computer to not use the proxy setting.

1. Open a web browser.

2. Select **Tools > Internet Options > Connections, > LAN Settings**.

   Alternate web browser menu selections may differ.

3. Uncheck the **Use a proxy server** check box.

In the address bar of your web browser, enter the IP address of the BTS (for example, enter http://169.254.1.1 to access the BTS through its default IP address). The BTS responds by opening the **Sign In** page of B1000 UI.

Logging into the web interface of BTS

On the **Sign In** page of the B1000 UI (as shown in Figure 43), type admin for **Username** and admin for **Password**. The **Profile** page appears. You can use this page to change the password and set your preferences. For more information about the **Profile** page, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Figure 43: *The B1000 Sign In page*

The B1000 dashboard page provides information such as connected subscribers and software version (as shown in Figure 44). Note that it should show zero for connected and registered CPEs for the first time. When there is a connection to the BTS, you can start configuring the frequencies, bandwidth, and IP addresses. For information about configuring the B1000 dashboard, refer to the *cnWave™ 5G Fixed Configuration Guide*.

Figure 44: *The B1000 dashboard*
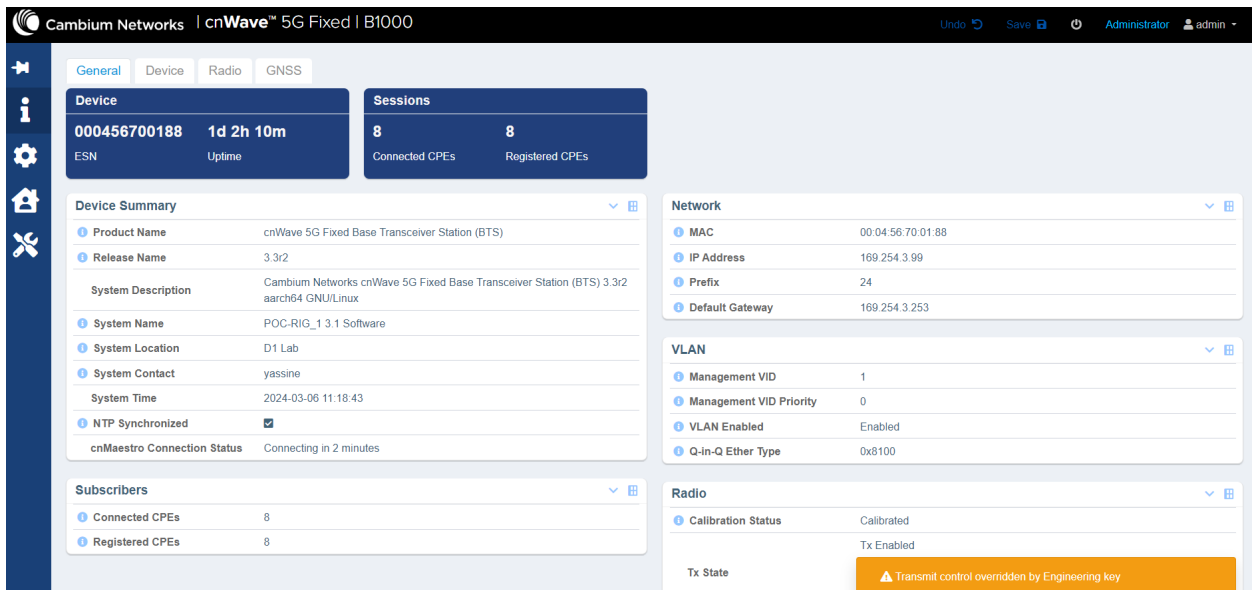
Powering up the CPE

To power up the CPE, perform the following tasks:

1. Plug one end of a CAT6 Ethernet cable into the DATA port of the CPE.

2. Plug the other end of the CAT6 Ethernet cable into the PoE 30W port of the CPE PoE power block (as shown in Figure 45).

3. Plug a second CAT6 Ethernet cable into the 1GbE LAN port of the CPE PoE power block.

4. Plug the other end of the CAT6 Ethernet cable into the RJ45 port of the management PC (as shown in Figure 46).

Figure 45: *30W DC Power injector*

Figure 46 shows how the CPE is connected to the power Injector.

⚠	**Warning**
	From this point until you remove power from the ODU, stay far away from the AP following the minimum separation distance limit specified in the Legal and Open Source Guide, (available on the Cambium Networks Support site).

5. Power up the PC or laptop.

6. Connect the PoE power cable to the power source.

7. Start the browser in the PC or laptop.

For information on configuring the PC or laptop connectivity to a network, refer to the Configuring the management PC section.

Disabling proxies (if required) - CPE

Perform the following steps to toggle the computer to not use the proxy setting.

1. Open a web browser.

2. Select **Tools > Internet Options > Connections > LAN Settings**.

   Alternate web browser menu selections may differ.

3. Uncheck the **Use a proxy server** check box.

In the address bar of your browser, enter the IP address of the CPE (for example, enter http://169.254.1.1 to access the CPE through its default IP address). The CPE responds by opening the **Sign In** page of its web UI.

Logging into the web interface of CPE

On the **Sign In** page of the C100 UI (as shown in Figure 47), type admin for **Username** and admin for **Password**.

Figure 47: *The C100 Sign In page*
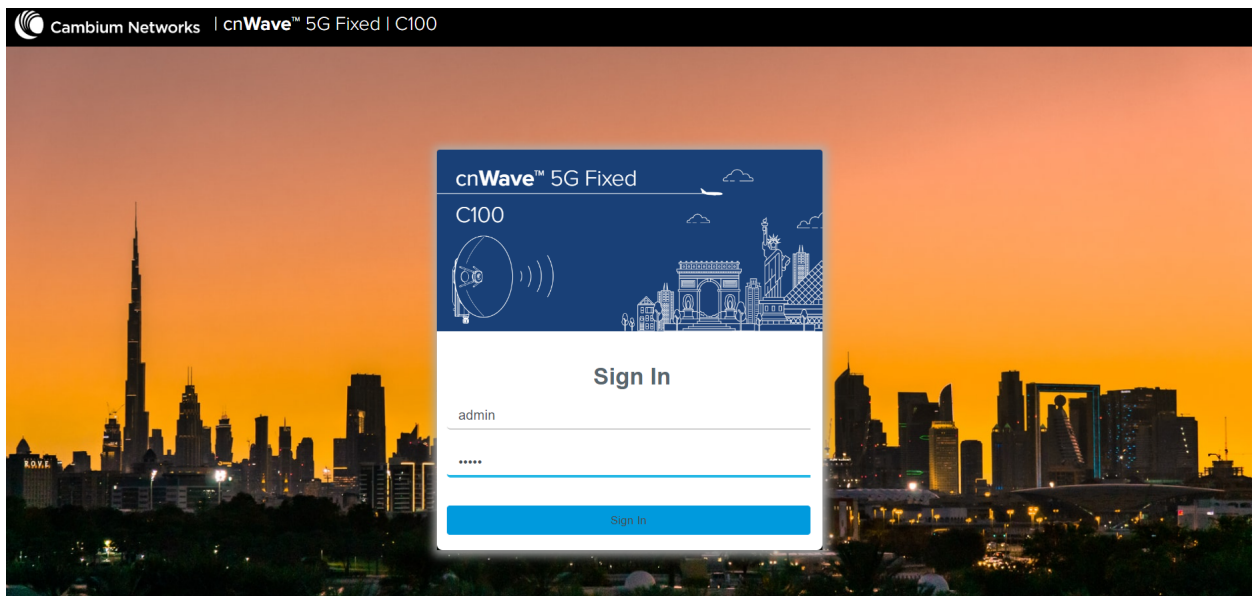
The C100 CPE dashboard (as shown in Figure 48) shows the status of fully configured and registered CPEs. It is necessary to set some initial configurations to each of the CPEs such as the operational frequency (in MHz).

Figure 48: *The C100 dashboard*
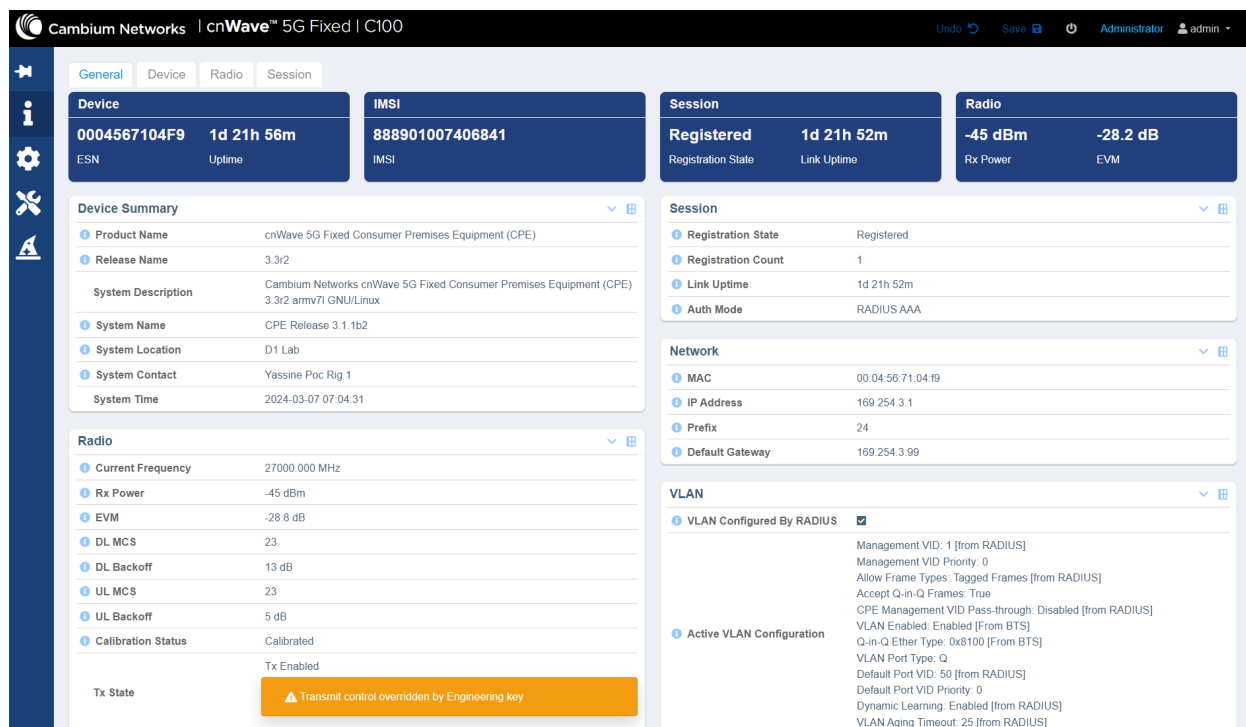
At this point, the BTS and the CPEs are communicating with the management PC and can therefore be configured for the initial use. Refer to the *cnWave™ 5G Fixed Configuration Guide* for details on parameters required to configure for establishing a link between the BTS and the CPEs.

Preparing the cables

For the BTS B1000 and the LPU connections (a sample design as shown in Figure 73), the following cables are required to install the BTS starting from the top of the mast:

- **Power cable** (Black) from BTS PSU port to DC LPU – This is a cable that is provided with the DC LPU kit. It must be less or equal than 600 mm (24 inches) and EMC metal glands (also provided) will need to be attached (as described in DC LPU and Grounding Kit).

- **CAT5E/CAT6 Data cable** (Green) will need to be made and has metal glands attached (as shown in Standard cable gland).

- **Grounding cables** (dash) are provided with the DC LPU kit for the DC LPUs (top and bottom).

- **BTS grounding cable** must be made (as described in Drop cable grounding points).

- **Grounding cable for the 10G Ethernet Surge Suppressor** is attached to the device and can be connected to the grounding system.

- Both the **drop cables for the Power and the data** must be prepared according to the length required and cannot exceed maximum lengths, as described in Table 23.

- Finally, the **power and Ethernet data cables** connecting the LPUs to the PSU and the LAN will also be required to be made the same way as above and fitted with the corresponding glands.

Power cable preparation and termination

Prepare the power cables for connection at the ODU or LPUs as shown in the following illustrations:

> **Note**
>
> Cable construction and colors may vary between suppliers. The termination at the PSU is not illustrated in this guide.

1. Ensure that you have the parts (as shown in Figure 49 of cable and connector kit. The connector kits may contain a 5th (spare) crimp terminal.

   Figure 49: *Cable and connector parts*

2. Remove 29 mm of the outer sheath. as shown in Figure 65.

   Figure 50: *Removing the outer sheath*

3. Trim the braid back to a length of 10 mm. And ensure that there are no loose strands.

Figure 51: *Turning the braid back*

10 mm
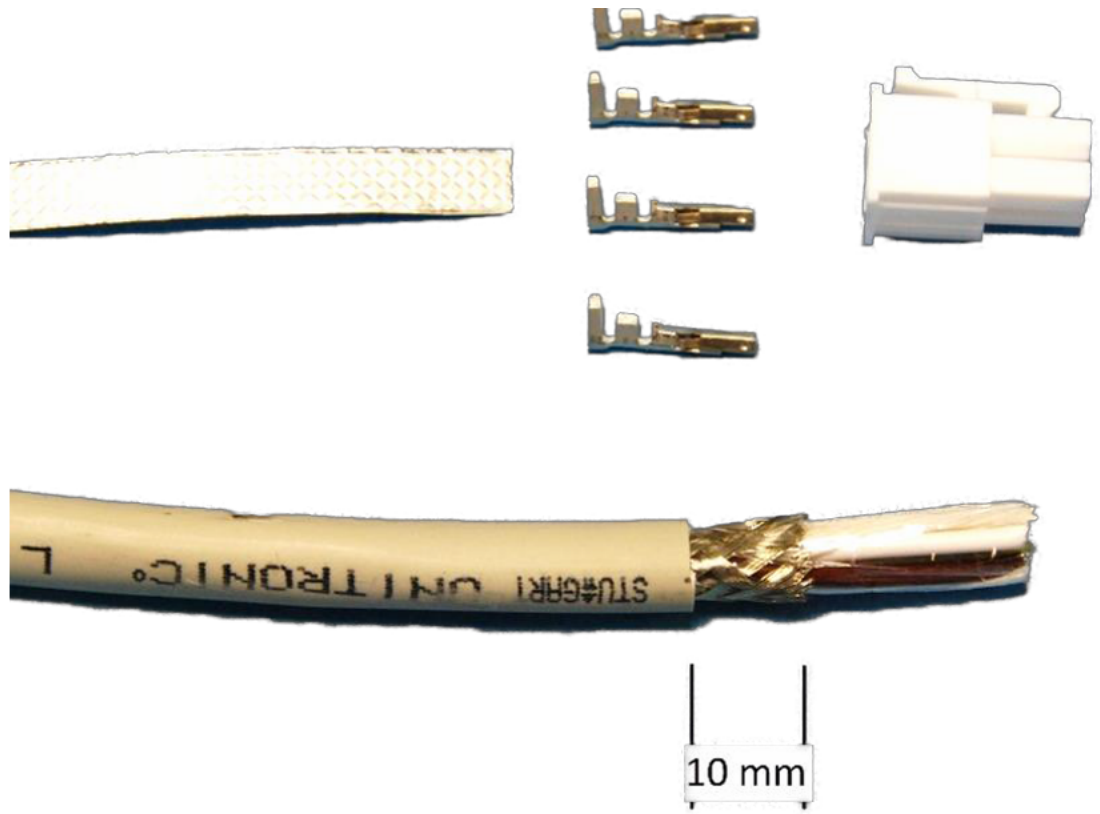
4. Remove the backing from the tin-plated copper tape. Then, wrap the tape firmly around the braid for 12 mm (so the tape extends 2 mm beyond the trimmed braid).

   You must ensure that there are no loose strands.
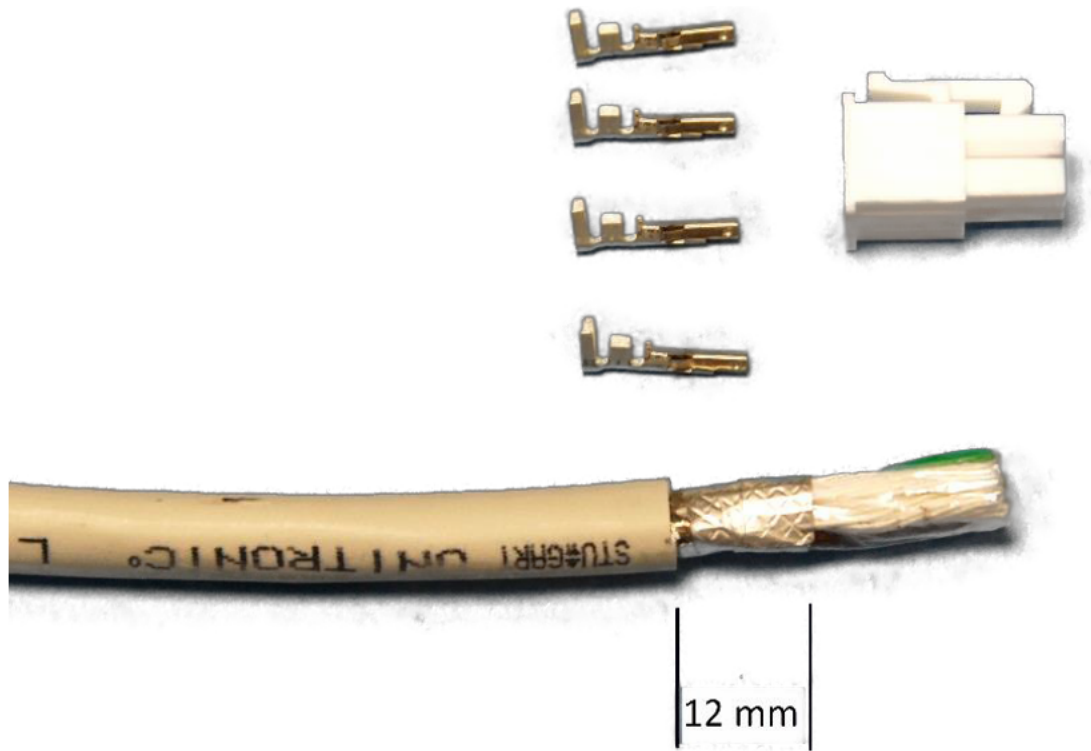
5. Trim away any wrappings and filling and strip 3 mm of insulation from the end of each wire.

   The wires must be of equal length.
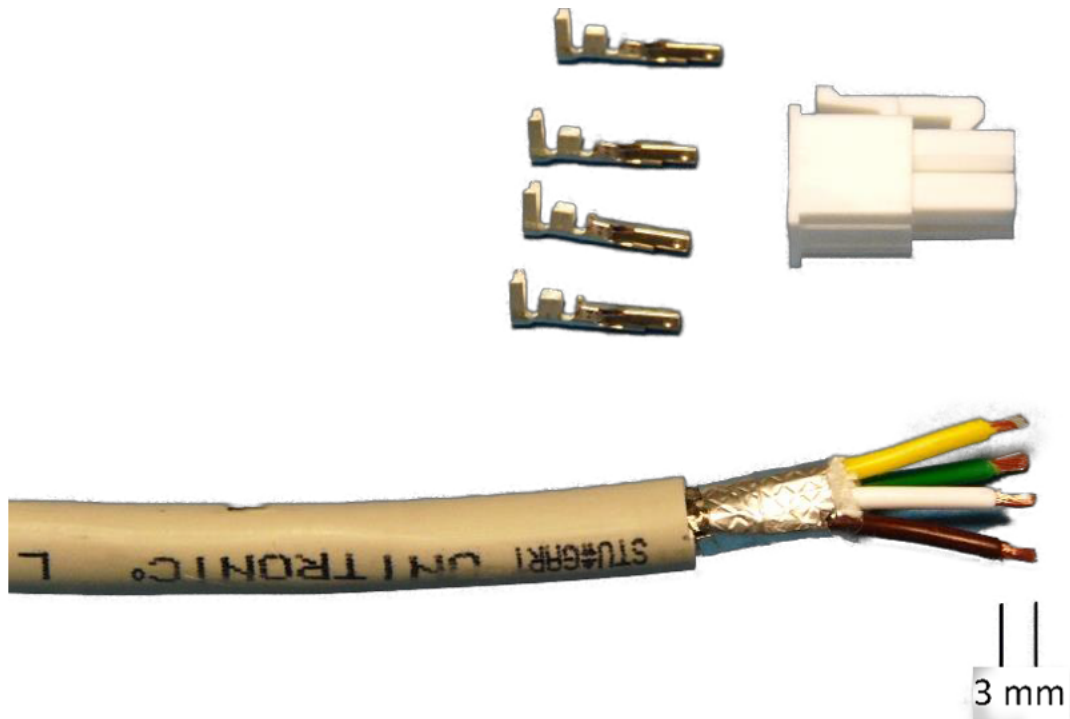
6. Fit the crimp terminals to each wire. Ensure that the outer wings secure only the insulation, and that the inner wings secure only the conductor (copper).

Figure 54: *Fixing the crimp terminals to wires*
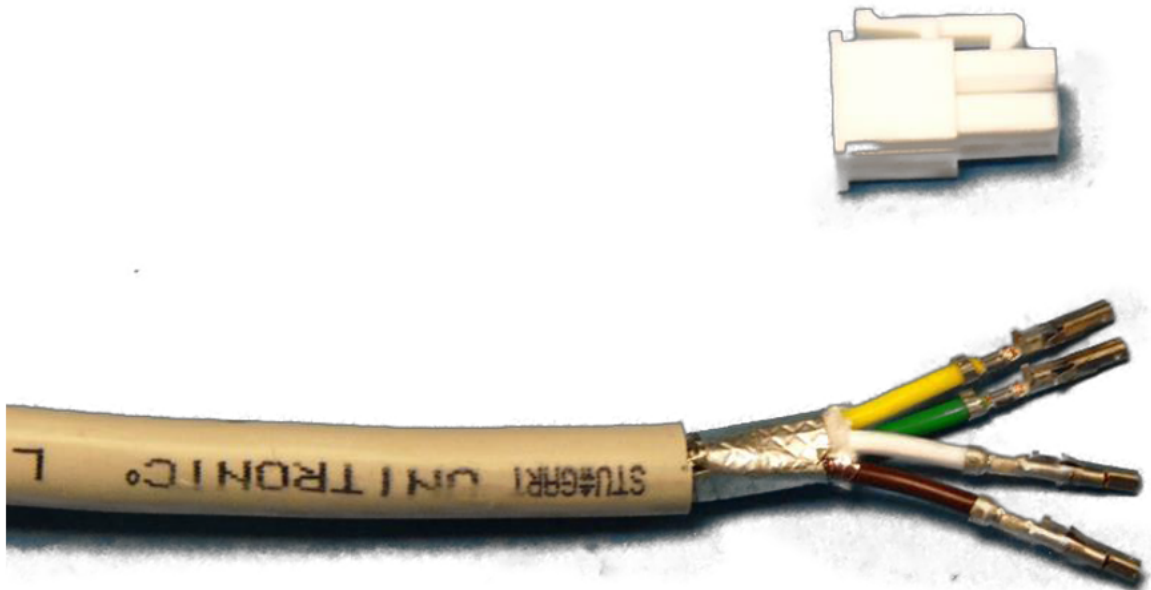
7. Fit the gland nut, seal and cage over the wire.

	Caution
⚡	Do this step before fitting the plug body. Otherwise, it is not possible to fit the glands.

Fixing the gland nut

8. Fit the crimp terminals into the plug body.

    The crimp wings are uppermost, facing the plug latch. You must ensure that the nut, seal, and cage are fixed before fitting the plug.

    Fixing the crimp terminals to plug

    A four-core cable arranged as two twisted pairs is recommended. The pairs must be connected as shown in Figure 57. The colors shown are those in the Lapp 1032126 (0.75 mm^2) and 1032131 (1.0 mm^2) cables.

Figure 57: *color cables*
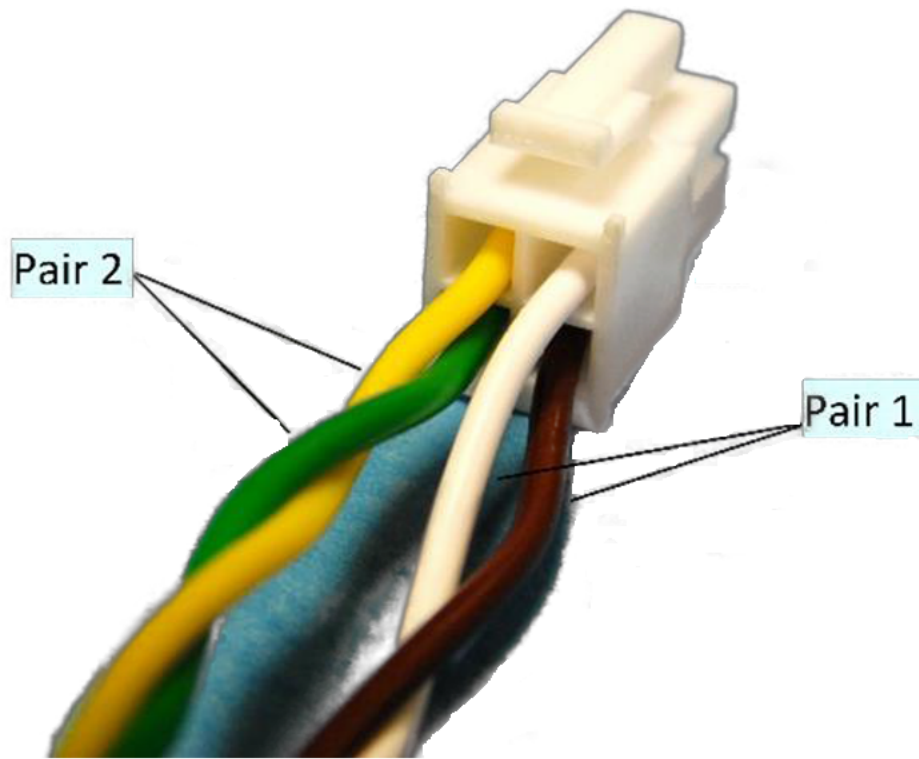
9. Push the crimped terminals fully into the plug body. Then, move the plug body from side to side to ensure that all four terminals are snapped into place.

Figure 58: *Pushing the crimp terminals completely into the plug*
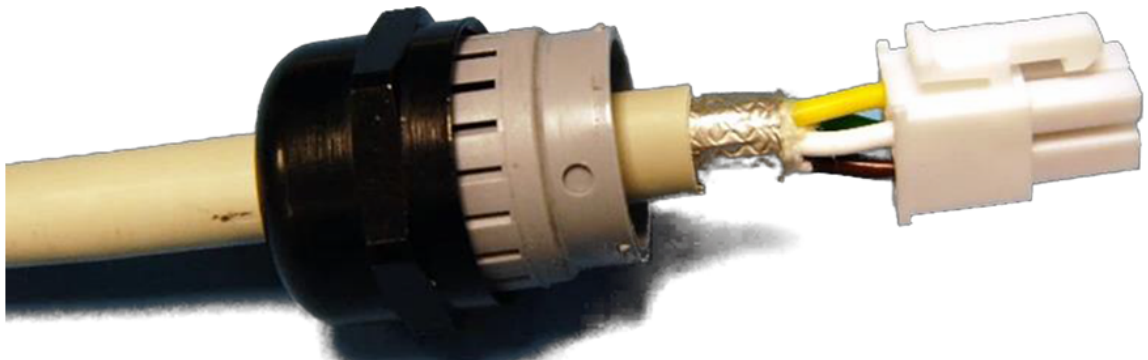
Connector pin numbering

Figure 59 shows how the plug pins are numbered for the power supply connection.

Figure 59: *Plug pin numbering*
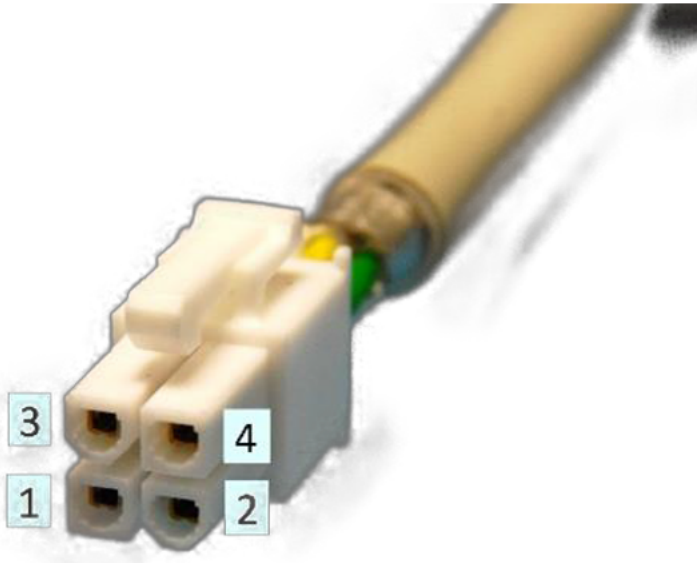
Table 40 provides the plug pin numbering details.

Table 40: Numbering details of plug pin

Pin	Power supply connection
1,2	Positive
3,4	Negative

Power cable connections

A typical installation includes a mains power supply, DC LPUs, and the radio (as illustrated in Figure 60). Note that data cables are not shown in Figure 60.

	Note
	This document is not a substitute for the LPU installation guide. Significant installation and grounding details are omitted for clarity in this document.
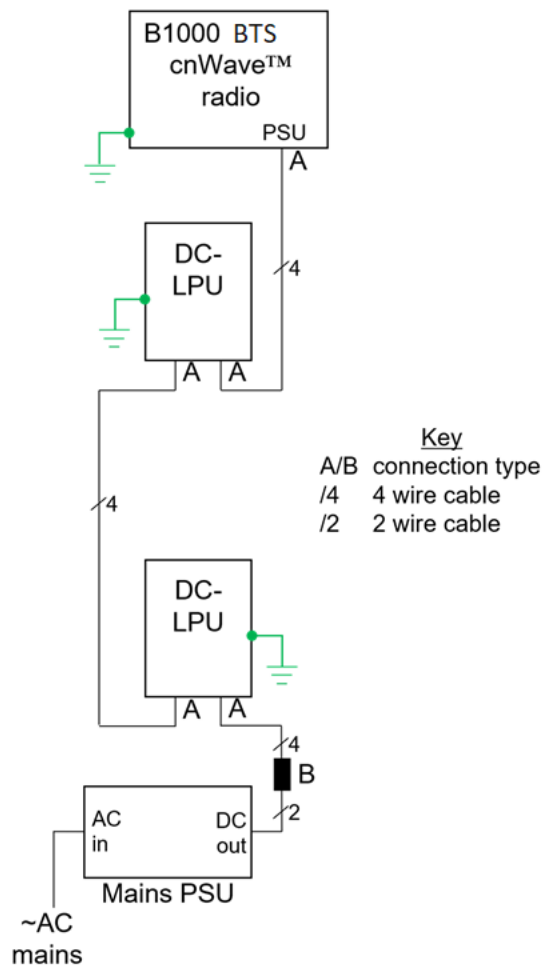
In Figure 60, there are two types of connection:

- **Type A – At the cnWave™ 5G Fixed BTS and at the DC-LPUs**: 4-wire cable to 4-pin plug, as described and illustrated in cnWave™ 5G Fixed BTS radio and DC LPU connections (type A).

- **Type B – At the PSU**: 4-wire cable to 2-wire cable, as described and illustrated in Power supply connection (type B).

cnWave™ 5G Fixed BTS radio and DC LPU connections (type A)

The recommended cable is connected, as shown in Figure 61, using the parts in the 4-pin connector kits (N000000L123A and N000000L124A). The plug body (as shown in Figure 61 for illustration) may be either black or white.
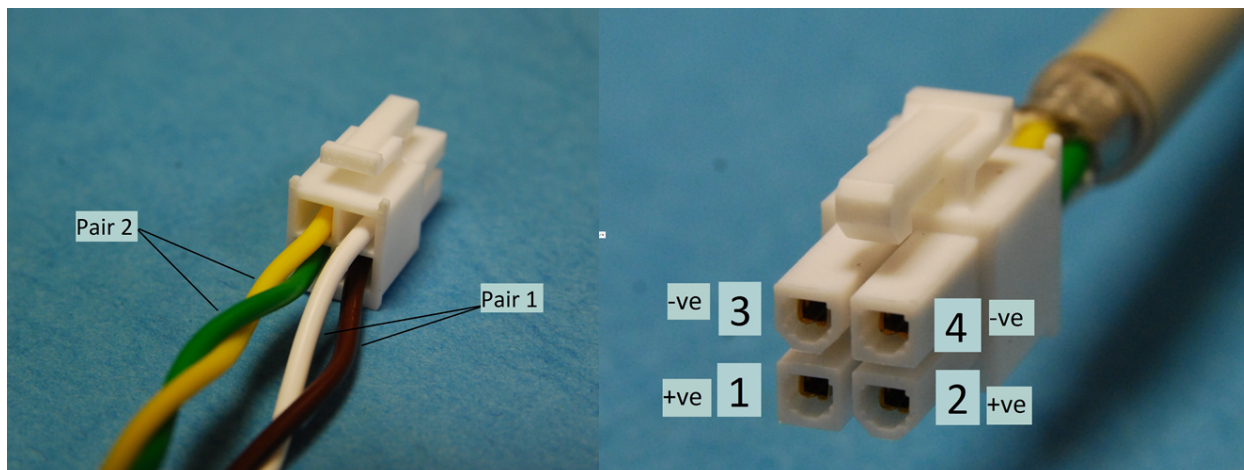
Details of what pin numbers, wire colors (when using the recommended cable), and power supply polarities represent are given in Table 41.

Table 41: Details of pin number, wire color, and DC polarity

Pin number	Wire color	DC Polarity	Notes
1	Brown	Positive (+ve)	
2	Green	Positive (+ve)	
3	White	Negative (-ve)	Negative pins are closest to the plug latch.
4	Yellow	Negative (-ve)	

Power supply connection (type B)

Ensure to review the cable testing section before making the connections to the power supply.

The connection between the four wires of the drop cable and the two wires of the power supply must be made, as shown in Figure 62.

In Figure 62, two examples are shown using a terminal block and using crimps. Cambium Networks do not supply this connector. The installer must use any similar suitable means that fits the site installation.

Figure 62: *Cable to PSU wiring, terminal block (left), crimps (right)*
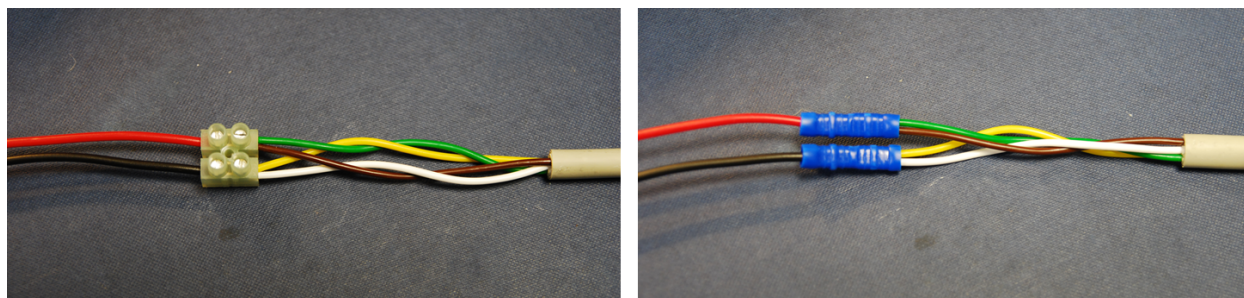
Details of what wire colors (when using the recommended cable) and power supply polarities represent are given in Table 42.

Table 42: Details of pin number, wire color, and DC polarity

450m Wire color	PSU Wire color	DC Polarity	Notes
Brown	Red	Positive (+ve)	
Green		Positive (+ve)	
White	Black	Negative (-ve)	Negative wires are closest to the B1000 plug latch.
Yellow		Negative (-ve)	

Note

1. If the power supply wire strands are consolidated with solder, then snip the soldered part off. Soldered strands must not be used in screwed or crimped connections.

2. When using a screw-terminal connector such as that shown on the left of FIGURE 47, make sure that the wire strands are protected from the terminal screw. Use a terminal block with wire protectors, such as leaf springs or a rising cage type, to fit crimp sleeves to the conductor strands.

Power supply

The recommended power supply from Meanwell has a default output voltage of about 54 V. It can be adjusted over a limited range using the trimmer under the black sealing bung labelled - Vo ADJ - on the top face. It is recommended, particularly, for longer cable runs, or for installations with an Auxiliary port PoE load, to trim the output voltage up to between 57 V and 58 V. Gently prise the bung out, use a small screwdriver with a DMM (meter) to set the voltage, and replace the bung before use.

If a different power supply is used, it must be fitted with fold-back current limiting means such as a hiccup mode or fuse.

Testing

It is recommended that the wiring to the LPUs and radio is tested before making the connections to the power supply. Use a meter, ideally a DMM (digital multi-multimeter) with a diode test range, to check the following measurements. The LPUs and the radio must be connected, the power supply must not be connected.

Table 43: Details of cable testing

| Test number	Meter positive	Meter Negative	Approximate value	Notes
1	Brown (pin 1)	Green (pin 2)	0.6 ohms per 10 m cable	Proportionate to cable length
2	White (pin 3)	Yellow (pin 4)	8 ohms maximum	
3	Brown+Green (pins 1+2)	White+Yellow (pins 3+4)	10 K (kohms) minimum or 2 V minimum	Ohms test range or Diode test range
4	White (pin 3)	Brown (pin 1)	0.7 V typical	Diode test range (note)
5	Yellow (pin 4)	Green (pin 2)		
6	White+Yellow (pins 3+4)	Brown+Green (pins 1+2)		

Note

The cnWave™ 5G Fixed BTS radio includes a reverse-polarity protection diode wire across the supply. Tests 4, 5, and 6 (as listed above) sense this diode and help to confirm the correct wiring.

Stripping data drop cable

When preparing the drop cable for connection to the cnWave™ 5G Fixed platform of products or LPU, use the measurements as shown in Figure 63.

Figure 63: *Drop cable preparation - cnWave™ 5G Fixed platform of products*
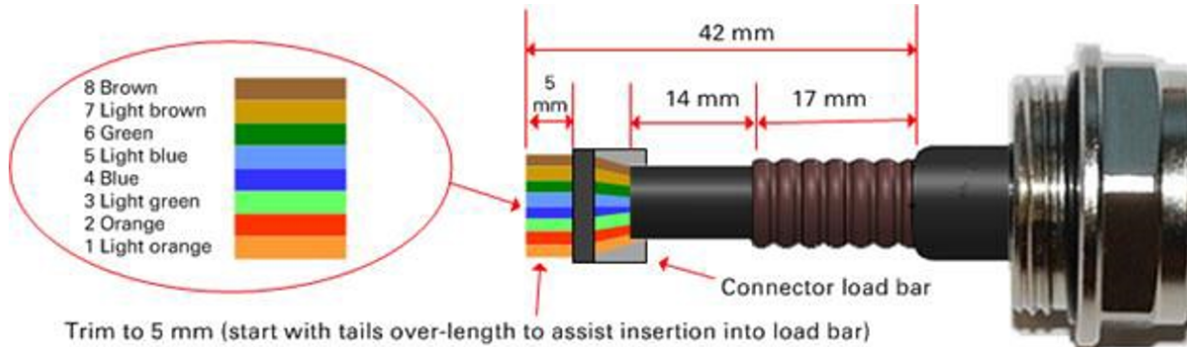
When preparing the drop cable for connection to the cnWave™ 5G Fixed platform PSU (without a cable gland), use the measurements as shown in Figure 64.

Figure 64: *Drop cable preparation - 450 Platform PSU*
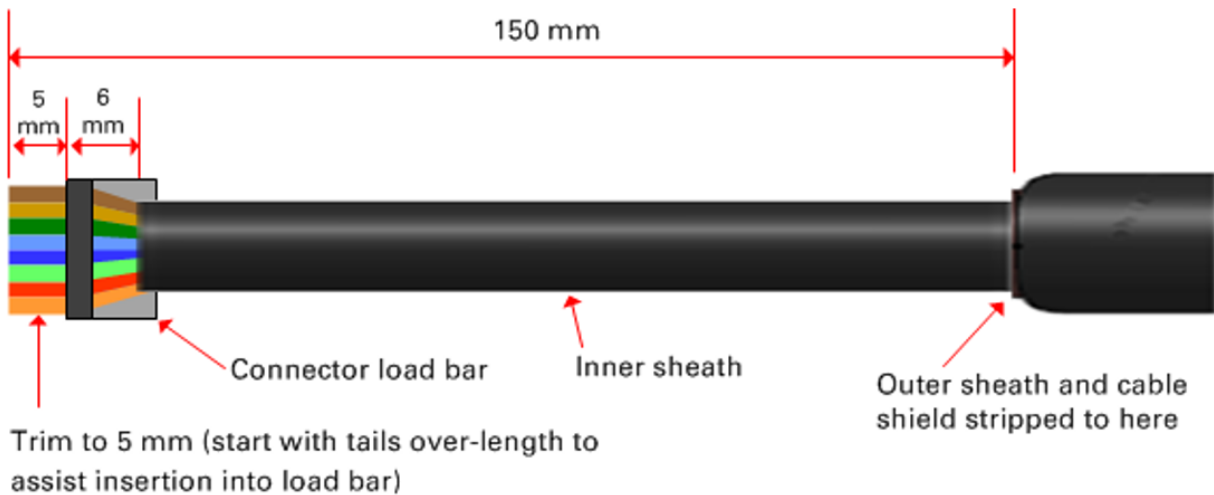
Creating a drop cable grounding point

Use the procedure (as described below) to connect the screen of the main drop cable to the metal of the supporting structure using the cable grounding kit (Cambium Networks specified part number - 01010419001). To identify suitable grounding points, refer to Hazardous locations.

To create a drop cable grounding unit, perform the following steps:

1. Remove 60 mm (2.5 inches) of the drop cable outer sheath, as shown in Figure 65.

   Figure 65: *Removing the outer sheath of the drop cable*
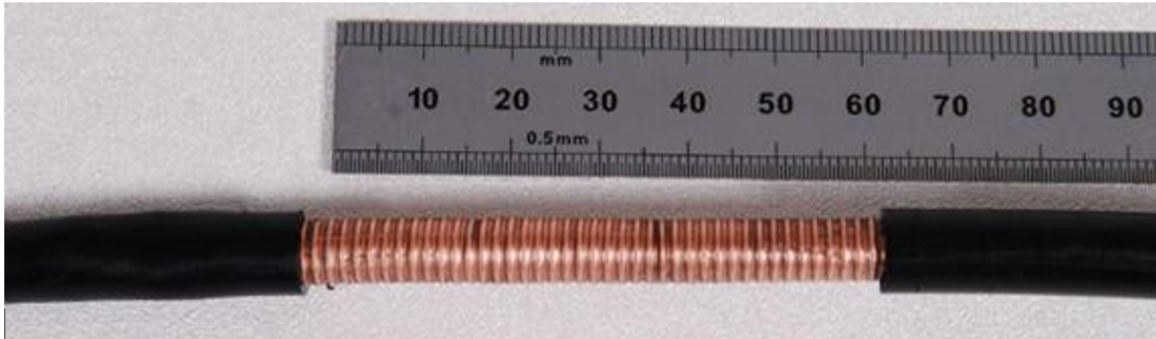
2. Cut 38 mm (1.5 inches) of rubber tape (self-amalgamating) and fit the ground cable lug. Wrap the tape completely around the lug and cable.

   Figure 66: *Cutting the rubber tape*

3. Fold the ground wire strap around the drop cable screen and fit cable ties.

   Figure 67: *Folding the ground wire strap*

4. Tighten the cable ties with pliers.

   You must cut the surplus from the cable ties.

Figure 68: *Tightening the cable*

5. Cut a 38 mm (1.5 inches) section of self-amalgamating tape and wrap it completely around the joint between the drop and ground cables.

Figure 69: *Cutting the self-amalgamating tape*

6. Use the remaining self-amalgamating tape to wrap the complete assembly.

   You must press the tape edges together so that there are no gaps.

Figure 70: *Wrapping the complete assembly*

7. Wrap a layer of PVC tape from bottom to top, starting from 25 mm (1 inch) below and finishing 25 mm (1 inch) above the edge of the self-amalgamating tape, overlapping at half-width (as shown in Figure 71).

Figure 71: *Wrapping a layer of PVC tape*

8. Repeat with a further four layers of PVC tape, always overlapping at half-width. Wrap the layers in alternate directions (top to bottom, then bottom to top as shown in Figure 72).

   The edges of each layer should be 25 mm (1 inch) above (A) and 25 mm (1 inch) below (B) the previous layer.

9. Prepare the metal grounding point of the supporting structure to provide good electrical contact with the grounding cable clamp. Remove paint, grease, or dirt, if present. Apply antioxidant compound liberally between the two metals.

10. Clamp the bottom lug of the grounding cable to the supporting structure using site-approved methods. Use a two-hole lug secured with fasteners in both holes. This provides better protection than a single-hole lug.

Installation

The installation and operation of the cnWave™ 5G Fixed products are complex. Hence, Cambium Networks recommends for professional installation and management of the system to ensure the operation compliance with regulations of the region (where the product is installed).

Ensure to follow the instructions provided in this guide. Further guidance on the cnWave™ 5G Fixed installation and operation is available in the *cnWave™ 5G Fixed Configuration Guide* and other training materials available on the Cambium Networks Training site.

You must have sufficient skills, knowledge, and experience to perform the installation tasks. An installer must have:

- Familiarity with current applicable national regulations, including radio regulations, electrical installation regulations, surge protection regulations, and regulations specific to working at heights.

- Knowledge to install, following instructions given by Cambium Networks.

- Familiarity with training materials available on the Cambium Networks Training site.

The installer must ensure to fit the cnWave™ 5G Fixed series equipment with the latest software code. The required software is available on the Cambium Networks Support site.

Installing and connecting the cnWave™ 5G Fixed platform of products

Review national regulations and ensure that all appropriate regulatory licenses are obtained before deployment. Before installing, plan the location of BTS carefully to ensure good radio coverage and to minimize interference. Installation and commissioning of equipment must be carried out by trained personnel.

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

	Note
	As the PSU is not waterproof, keep it away from sources of moisture. Place it either in the equipment building or in a ventilated moisture-proof enclosure. Do not locate the PSU in a position where it might exceed its temperature rating.

	Caution
	Do not plug any device other than the cnWave™ 5G Fixed BTS into the ODU port of the PSU. There might be damage to other devices due to the non-standard techniques, employed to inject DC power into the Ethernet connection between the PSU and the BTS.
	Do not plug in any device other than the cnWave™ 5G Fixed PSU into the PSU port of the BTS. Plugging any other device into the PSU port of BTS might damage the BTS and the device.

The previous sections described (in brief) how to prepare the products for installation and how to prepare the cables needed to connect the products to the power supplies or network. It also contains details of LPUs and cables.

This section provides information about various steps required to perform a full installation of a BTS and a CPE.

Installing BTS on a Mast and connecting BTS to power

To install BTS on a Mast and connect the BTS to power, perform the following steps:

1. Ensure that structures, equipment, and people are protected from power surges (typically, caused by lightning) by conducting the surge power to the ground through a separate preferential solid path.

   It is recommended to use a DC LPU to protect the BTS from potential lighting surge damages.

   It is also recommended to use an LPU to protect the BTS data port which uses a CAT5e or CAT6e (recommended) cable. The actual degree of protection required depends on local conditions and applicable local regulations. To adequately protect an installation, both ground bonding and transient voltage surge suppression are required.

2. Follow your best practices for grounding and lightning protection.

   With the best practices, network operators can minimize network outages and reduce the associated costs of tower climbs and equipment repair or replacement.

3. Review national regulations and ensure that all appropriate regulatory licenses are obtained prior to deployment.

4. Before installing, plan the location of BTS carefully to ensure good radio coverage and to minimize interference. Trained personnel must carry out installation and commissioning of the equipment.

5. Ensure that the BTS is powered through an AC power injector installed at the bottom of the tower.

   Consider DC LPUs (as shown in Figure 73) and grounding guidelines to power up the BTS.

6. Connect ground at multiple points on the mast, as shown in Figure 73.

Figure 73: *A sample design of BTS and LPU connections*
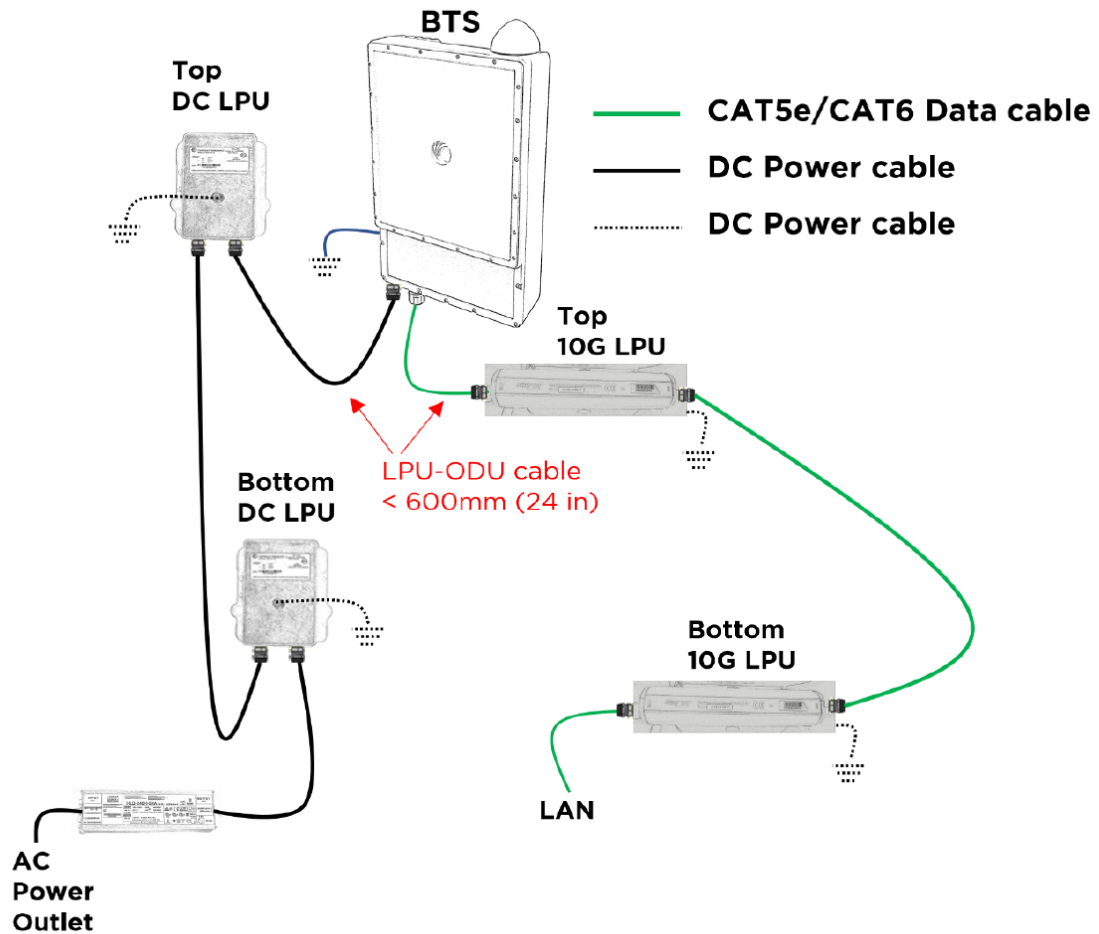
> **Note**
>
> You can improve the lightning-prone installations by performing the following tasks:
>
> - Installing a lightning protection device near the Outdoor Unit (ODU).
>
> - Grounding the ODU to the pole.
>
> - Lowering the installation of the ODU below the highest point of the pole. It must not be the highest metallic object.

Assembling the Tilt mounting bracket for BTS

The BTS Tilt brackets are inside the BTS box, as shown in Figure 74. You must first assemble the bottom side and the top side (by following the steps described in this section). Then, use a 13 mm (1/2 inch) wrench to secure clamps with four M8x25 mm nuts with the max torque 5Nm onto the BTS and the pole or mast.

To assemble and mount the BTS Tilt bracket, perform the following steps:

1. Unpack the box that contains the BTS Tilt brackets.

   You must ensure that the box contains the following components (as shown in Figure 75):

   - 8 x M8 flange nuts

   - 4 x 25 mm M8 bolts

   - 4 x 20 mm M8 bolts

   - 4 x 160 mm M8 long bolts

   - 1 x top fixed clamp (with the tilt)

   - 1 x Bottom fixed clamp

   - 2 x front pole mount brackets

   - 2 x rear pole mounts brackets

Figure 75: *BTS Tilt bracket components*
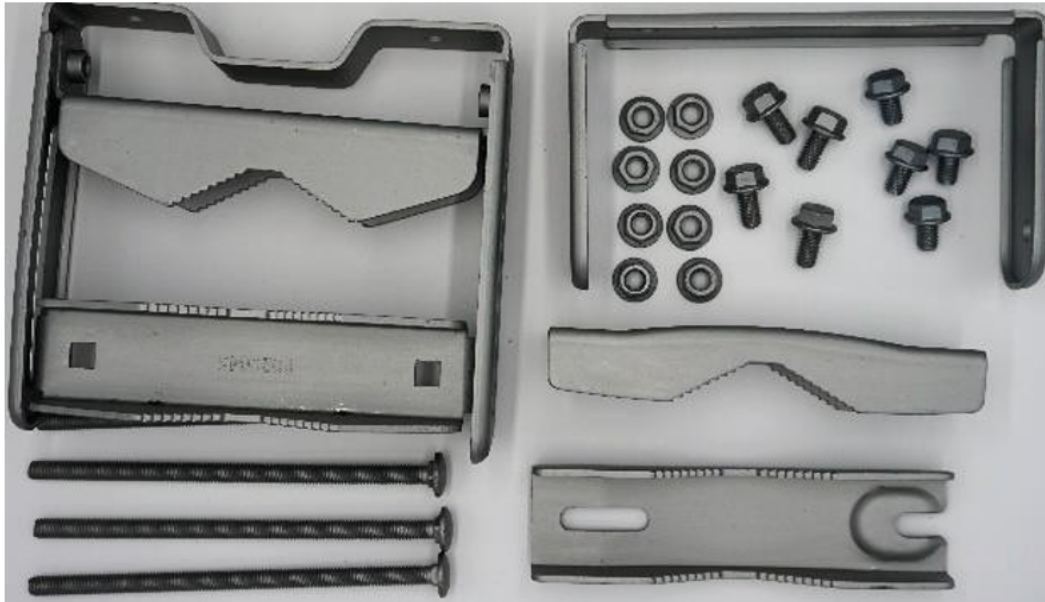
2. Assemble the bottom clamp and lower bracket mount by using the components, as shown in Figure 76.

Figure 76: *Assembling the bottom clamp for the Tilt bracket*

Perform the following steps to assemble the bottom clamp:

a. Insert one rear pole bracket into the lower fixed clamp and secure using two 20 mm M8 bolts on the side.

You might need to use a bit of force to spread the two sides of the clamp to insert the rear pole bracket.
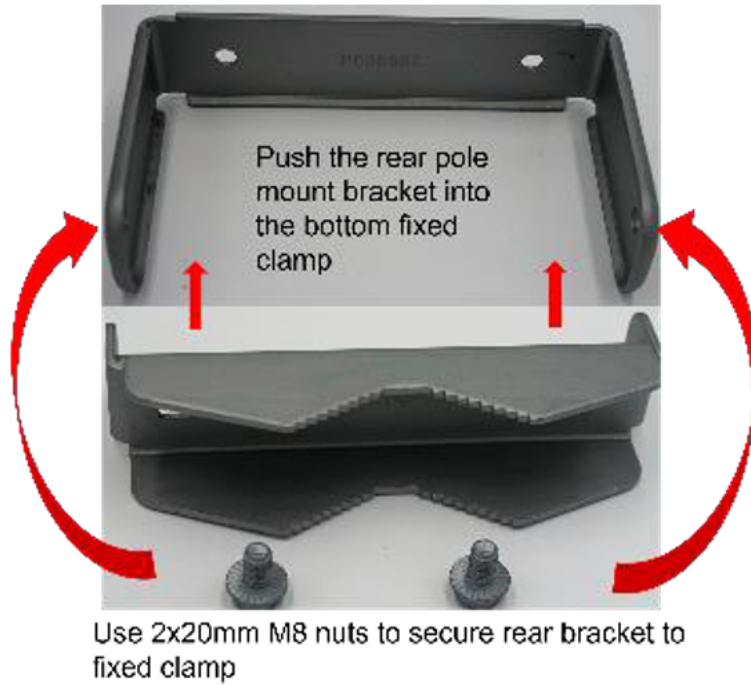
b. Insert the long M8x160 mm bolts and use two flange nuts to secure the rear pole mount bracket to the fixed lower clamp.

Figure 78: *Inserting the long M8x160 mm bolts*

c. Place the front fixed pole mount and secure it loosely with two other flange nuts.

Figure 79: *Fixing the pole mount with nuts*
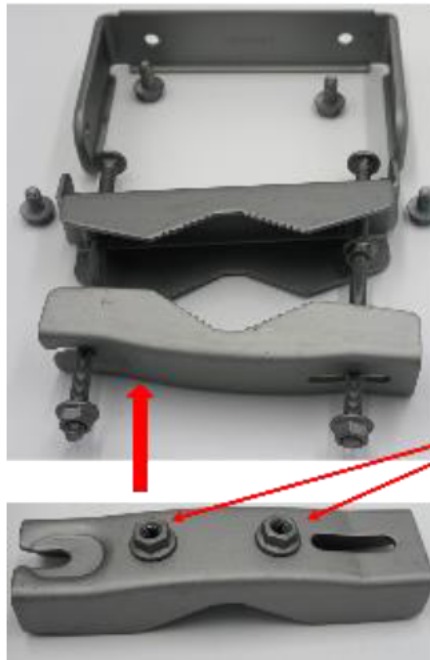
Attach the front fixed pole mount bracket to the clamp of the lower bracket assembly and secure loosely using two flange nuts

d. Use the two 25 mm M8 screws to attach to the rear of the BTS.

Figure 80: *Fully assembled BTS lower Tilt bracket*

3. Assemble the upper Tilt bracket by using the components, as shown in Figure 81.

Figure 81: *Assembling the upper Tilt bracket*
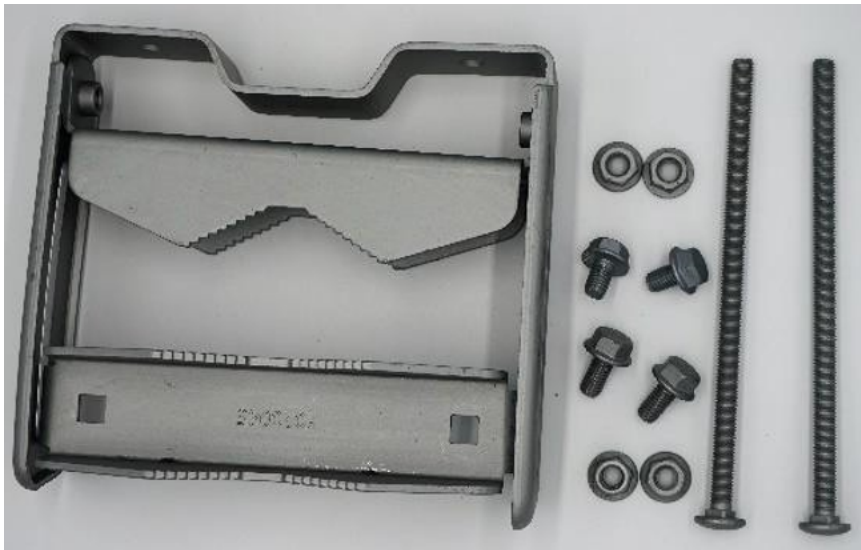
Perform the following steps to assemble the upper Tilt bracket:

a. Ensure that the rear pole bracket is inside the upper fixed clamp (the one with the tilt) and secure loosely using the two M8x 20 mm bolts on both sides. Then, use the two long M8x160 mm bolts and secure them loosely to the rear bracket using the flange nuts.

Figure 82: *Inserting long screws in the clamp*
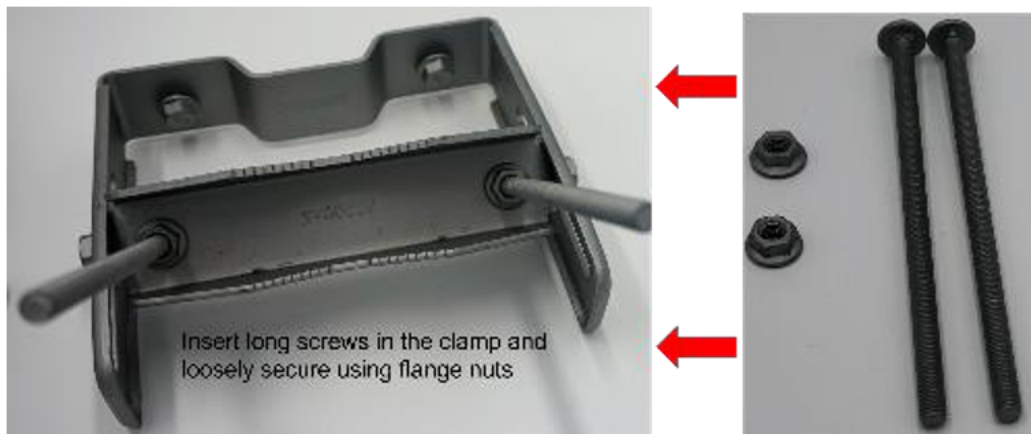
b. Attach the front fixed pole mount bracket to the clamp to the upper bracket assembly and secure it loosely by using two flange nuts.

Figure 83: *Attaching the front pole mount bracket*

Attach the front fixed pole mount bracket to the clamp to the upper bracket assembly and secure loosely using two flange nuts
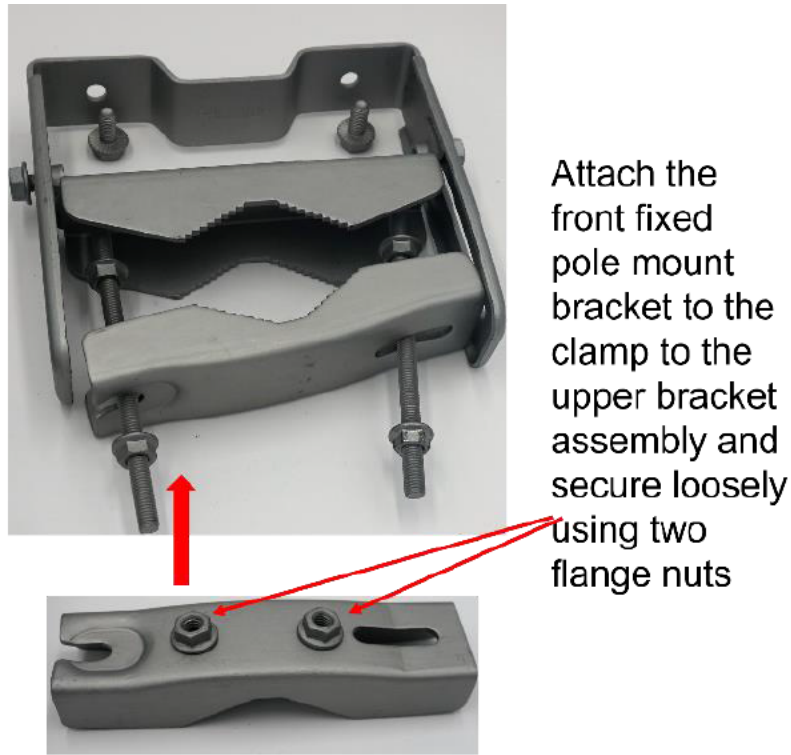
c. Use the two M8 x 25 mm bolts to attach to the rear side of the BTS.

Figure 84: *Fully assembled BTS upper Tilt bracket*

Figure 85 is an example of the BTS in a lab environment on a tripod.

Figure 85: *BTS attached to a pole with upper and lower brackets*

Installing and grounding the BTS

To install and ground the BTS, perform the following steps:

1. Fasten an AWG 10 (or 6mm^2) copper ground cable to the BTS grounding point using the M6 (small) lugs.

   Figure 86: *Fastening the copper ground cable*

2. Secure the M6 grounding bolts by applying 3 Nm torque.

Figure 87: *Securing the M6 grounding bolts*

3. Connect the copper wires securely to the grounding system (Protective Earth) and DC LPU, or Gigabit Ethernet Surge Suppressor according to the applicable regulations.

Mounting the ODU on the Mast

To mount the ODU on the Mast, perform the following steps:

1. Fix the mounting plates to the back of the BTS using the four bolts.

   You must tighten the bolts.

2. Remove the rear bracket strap from the upper and lower brackets of the BTS.

3. Attach the upper and lower bracket of BTS to the mount point by closing the rear strap around the pole.

4. Secure the four-serrated flange M8 nuts by applying 10 Nm torque on the upper and lower rear strap using a 13 mm spanner wrench.

   These must be tightened evenly on the pole to avoid jumping or stripping threads.

5. Adjust the elevation and azimuth to achieve visual alignment.

6. Secure the bolts on four sides by applying 8 Nm torque as per the angle of the antenna.

Mounting the DC LPU

To mount the LPU, perform the following steps:

1. Mount the BTS and top LPU, by ensuring that the LPU is vertical with cable entry points facing downwards. Tighten all BTS bracket bolts to a torque of 14 Nm (11 lb-ft).

ODU to top LPU
ground cable

Top LPU mounted on
pole with U-bolt from
LPU kit

ODU to grounding
system

ODU to top LPU
power cable

Power cable to
bottom LPU

Grounding
system
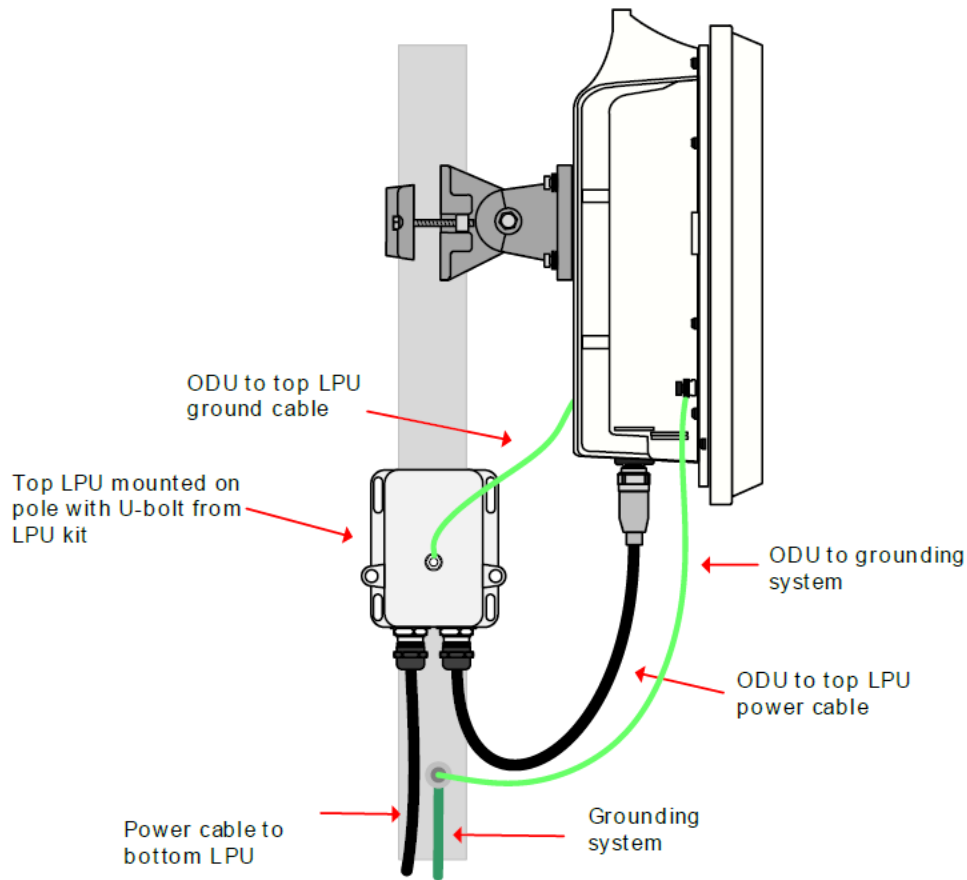
2. Connect the BTS (PSU port) to the top LPU (either port), following the procedure described in Connecting power cables to the LPU. Ensure that this cable is shorter than 600 mm (24 inches).

3. Ensure that the power cable is fixed to the tower or building. Connect the remaining port of the top LPU to the power cable, following the procedure described in Connecting power cables to the LPU. Fasten the two power cables such that they are not coiled together and do not cross each other.

4. Fasten one ground cable to each ODU grounding point using the M6 (small) lug. one is for the top LPU (M6 lug at the other end) and the other is for the tower or building (M10 lug at the other end). Tighten both grounding bolts to a torque of 5 Nm (3.9 lb-ft).

Figure 90 is an example of a radio device showing the ground cable and ODU connections.

Figure 90: *Fastening a ground cable to ODU*

M6 lug

M6 lug

M6 lug to
top LPU

M10 lug
to ground

Bolt
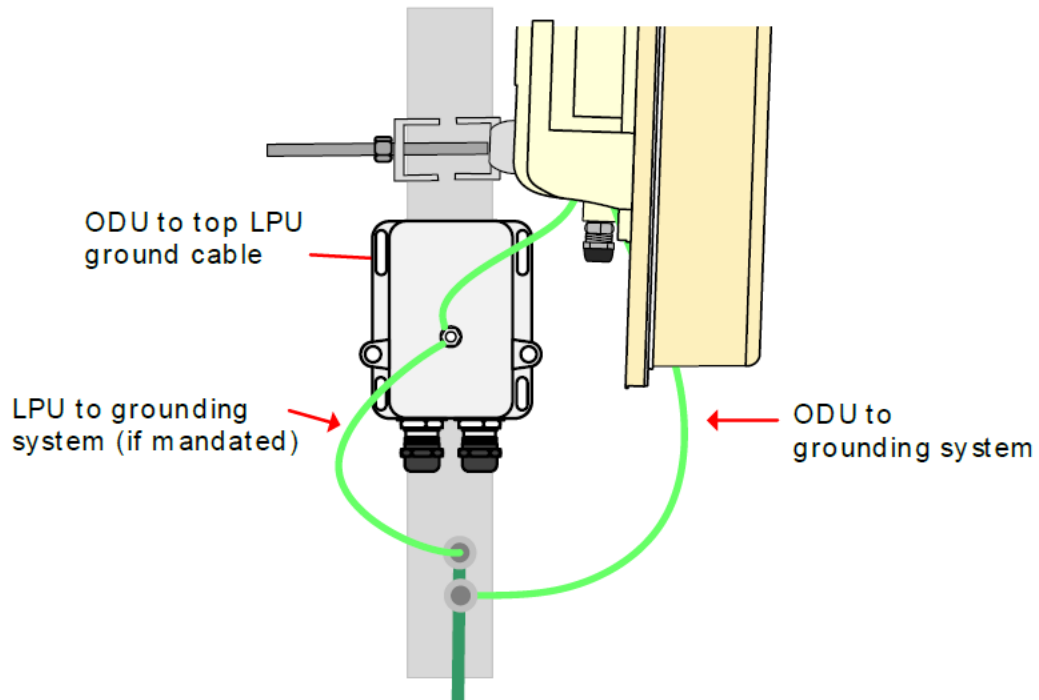Toothed washer
M6 lug
Toothed washer
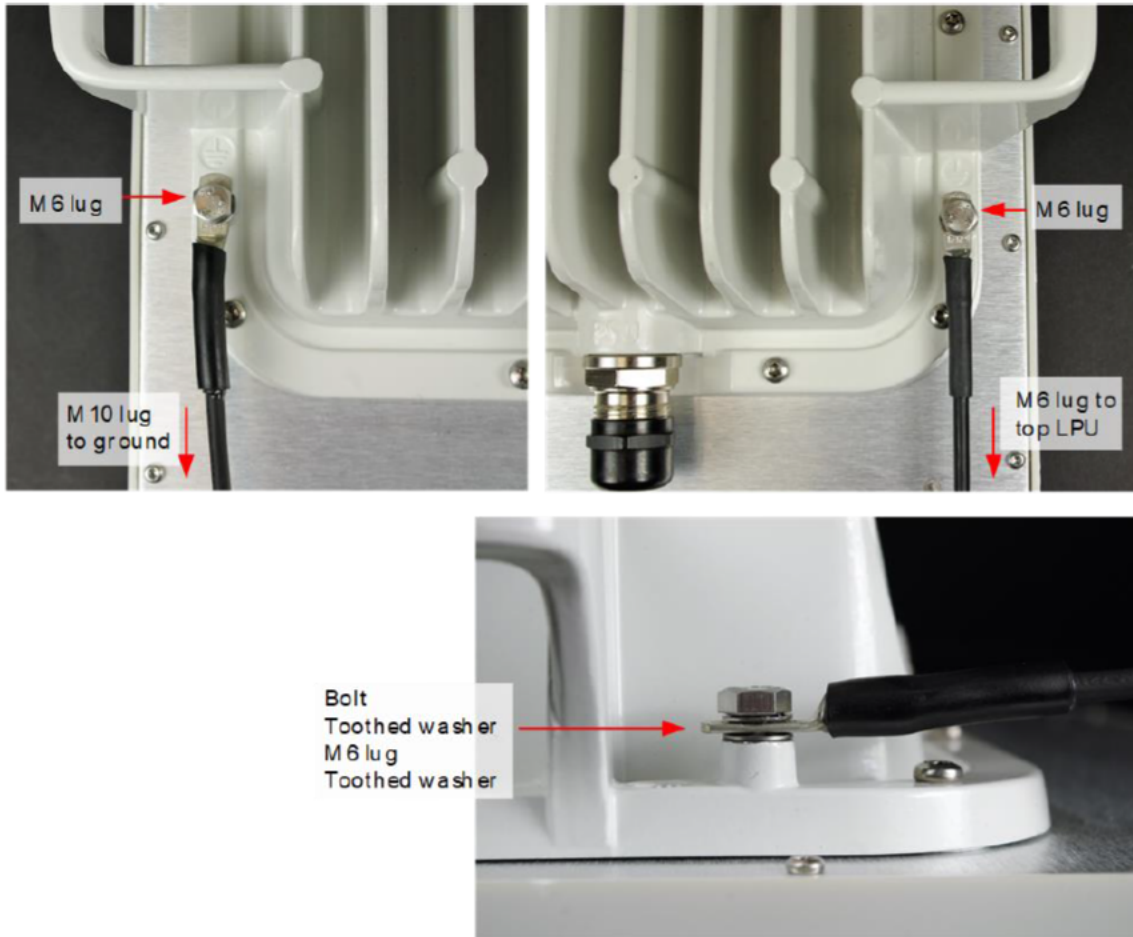
5. Fasten one ground cable to the top LPU using the M6 (small) lug. Tighten both nuts to a torque of 5 Nm (3.9 lb-ft).

Figure 91: *Fastening the ground cable to LPU*

Locking nut
Washer
M6 lug
Washer
Nut
Toothed washer

M6 lug to ODU or M10 lug to ground
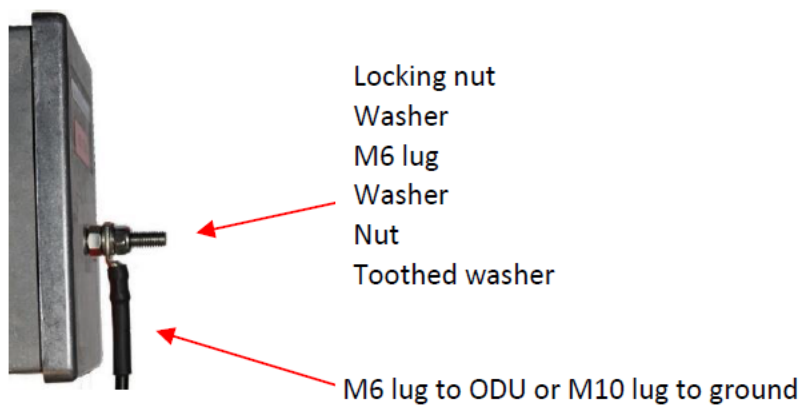
6. Select a tower or building grounding point within 0.3 meters (1 ft) of the BTS bracket on the same metal. Remove paint from the surface and apply the antioxidant compound. Fasten the BTS grounding cable to this point using the M10 (large) lug.

7. If local regulations mandate the independent grounding of all devices, add a third ground cable to connect the top LPU directly to the grounding system.

Figure 92: *Adding the third cable*

Bottom LPU

To mount the bottom LPU, perform the following steps:

1. Select a mounting point for the bottom LPU within 600 mm (24 inches) of the building entry point.

   The LPU can be inside or outside the building. You must mount the LPU vertically with cable entry points facing downwards.

   Figure 93: *Selecting the mounting point - bottom LPU*
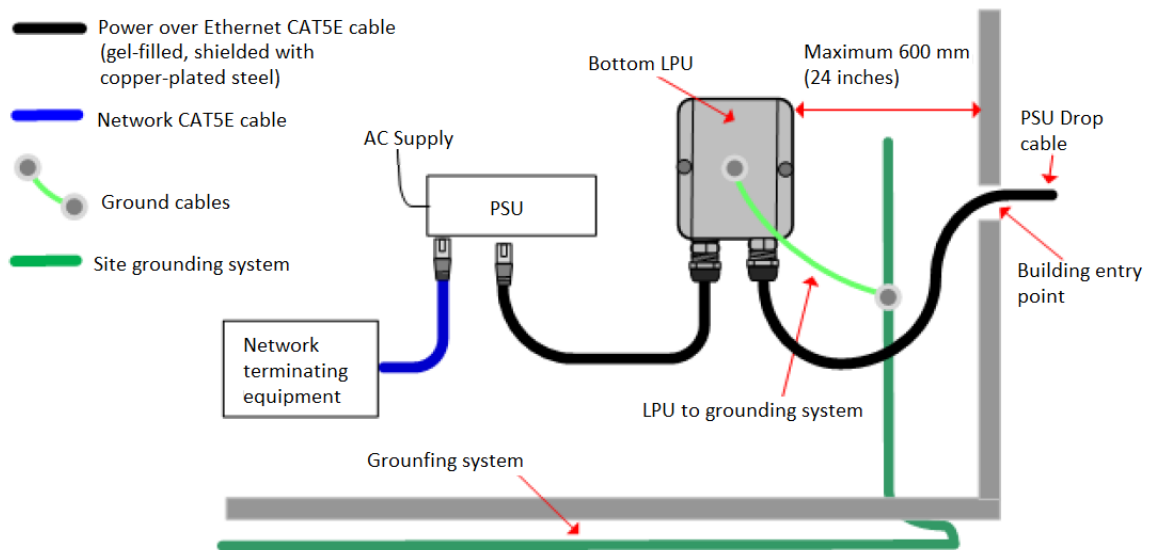
2. Connect the two power cables into the ports of the bottom LPU, following the procedure described in Connecting power cables to the LPU.

3. Fasten one ground cable to the bottom LPU using the M6 (small) lug. Tighten both nuts to a torque of 5 Nm (3.9 lb-ft).

   Figure 94: *Fastening the ground cable - bottom LPU*
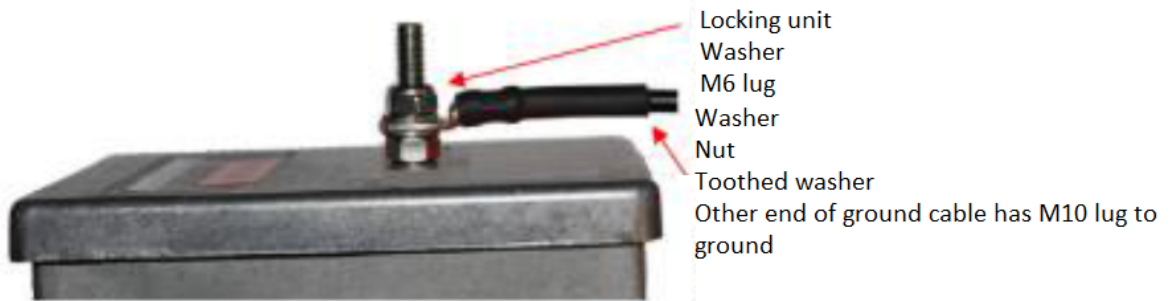
4. Select a building grounding point near the LPU bracket and on the same grounding structure. Remove paint from the surface and apply the antioxidant compound. Fasten the LPU ground cable to this point using the M10 (large) lug.

Connecting power cables to the LPU

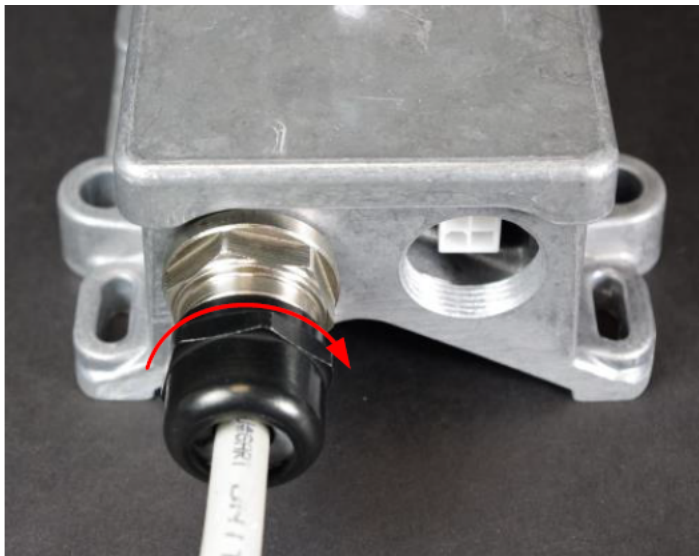To connect the power cables to the LPU, perform the following steps:

1. Thread the plug through the gland body.

2. Plug the connector into the socket in the unit, by ensuring that it snaps home. Fit the gland body to the LPU port and tighten it to a torque of 5.5 Nm (4.3 lb-ft).

    Figure 95: *Plugging in the connector*
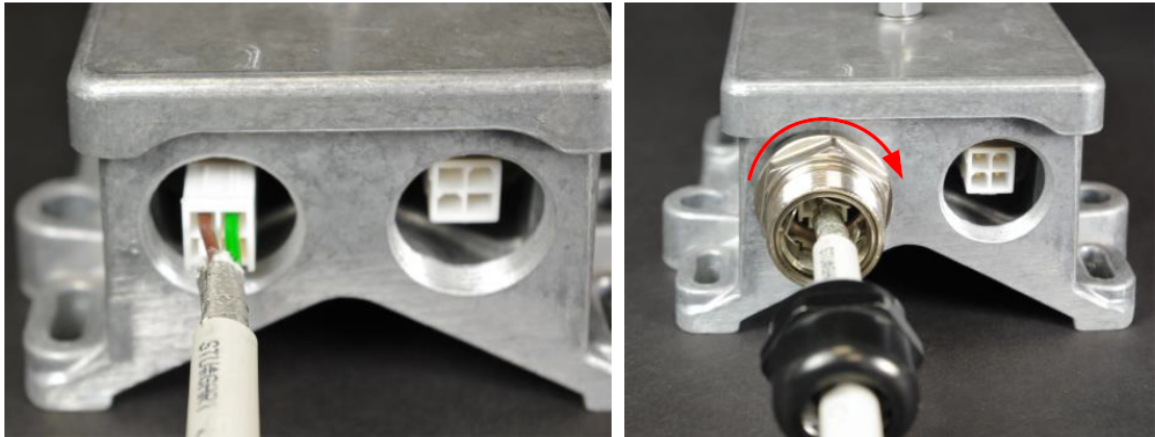
3. Fit the gland nut and tighten until the rubber seal closes on the cable.

    Do not over-tighten the gland nut, as there is a risk of damage to its internal components.

    Figure 96: *Fitting the gland nut*

4. To dismantle the gland, loosen the nut first, before removing the gland body.

Connecting power cables to the cnWave™ 5G Fixed BTS

To connect power cables to the cnWave™ 5G Fixed BTS, perform the following steps:

1. Thread the plug through the gland body.

2. Plug the connector into the socket in the unit, ensuring that it snaps home. Fit the gland body to the ODU power port and tighten it to a torque of 5.5 Nm (4.3 lb-ft). Fit the gland nut and tighten until the rubber seal closes on the cable. Do not over-tighten the gland nut.

Figure 97: *Plugging in the connector to socket*
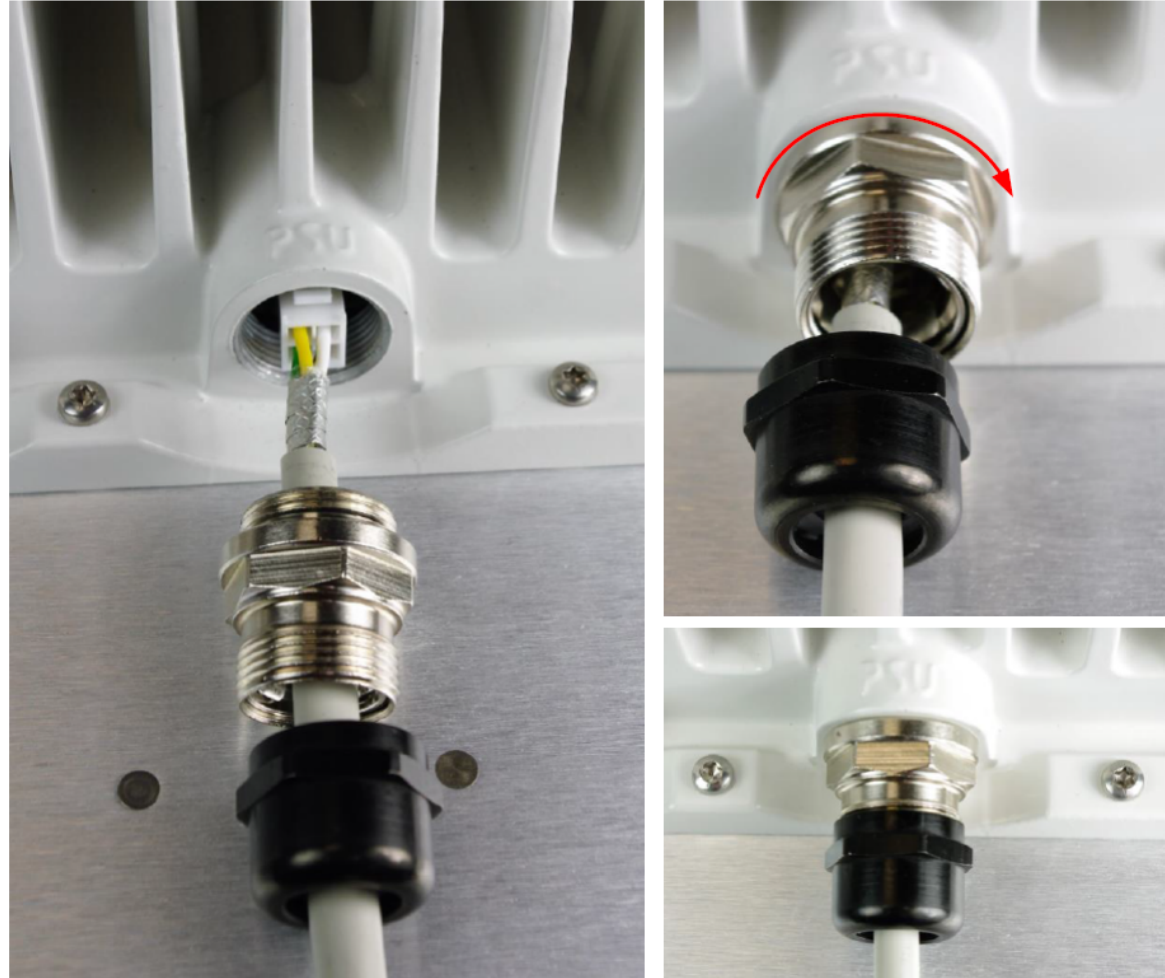
Testing resistance of the power cable

Before connecting the bottom end of the power cable to the PSU, measure the resistances between pins. If any of the tests fail, examine the power cable for wiring faults. Table 44 provides the expected resistances from the bottom of the cable up to the ODU (which must be connected) and back again. It must be the same with or without DC-LPUs fitted.

Table 44: Details of the expected resistances

Cable length		Approximate resistance (O hm), using 0.75 mm² cable		
Ft	m	Between pins 1 and 2 Between pins 3 and 4	Between pins 1 and 3 and Between pins 2 and 4	Between any pin and the cable shield
0	0	0.5	>10K (all cable lengths)	> 100K (all cable lengths)
33	10	1.0		
66	20	1.5		
99	30	2.0		
131	40	2.5		
164	50	3.0		
197	60	3.5		
230	70	4.0		
262	80	4.5		
295	90	5.0		
328	100	5.5		

> **Note**
>
> Ensure that the 1-2 and 3-4 resistances are within 10% of each other by multiplying the lower resistance by 1.1. If the other resistance is greater than this, the test has failed.

Installing and grounding Data 10G Ethernet LPU

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 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

Consider the following points before 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.

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

To fit the long cable gland, perform the following steps:

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

2. Disassemble the long cable gland used for copper SFP interface.

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

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

Optical

Copper

Inserting the SFP module

Note

The equipment (shown in below figures in this section) is not a B1000 BTS product but the same procedures apply for installing 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, as shown in Figure 98.

   Figure 98: *Removing the blanking plug*

   Optical SFP+ module   **Copper SFP module**

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

   Figure 99: *Inserting the SFP module*

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

Figure 100: *Pushing the module*

Optical

Copper

4. Rotate the latch to the locked position.

Figure 101: *Rotating the latch*

Optical

Copper

Connecting the cable

> **Caution**
>
> 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.

To connect the cable, perform the following steps:

1. Remove the LC connector dust caps from the ODU end (optical cable only).
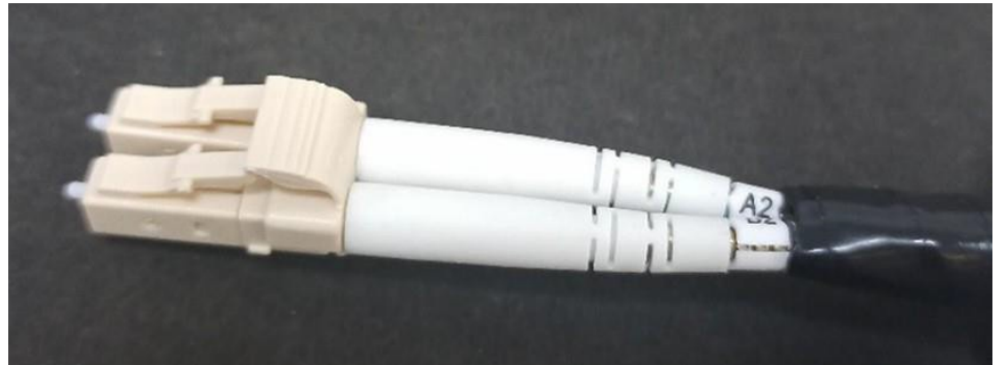
2. Plug the connector into the SFP module, ensuring that it snaps home.

Fitting the gland

To fit the gland, perform the following steps:

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

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.

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).

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.

To remove the cable and the SFP module, perform the following steps:

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

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

Optical

Copper

Assembling and connecting the cnWave™ 5G Fixed CPE

To assemble and connect the cnWave™ 5G Fixed CPE, perform the following tasks:

- Assembling the CPE to a dish

- Assembling the Precision bracket for CPE

- Attaching the dish to the CPE

Assembling the CPE to a dish

In Release 3.3, the CPE is connected to a 400 mm dish. CPE dishes are packed in a box of four dishes. Each dish box contains the following components (as shown in Figure 102):

• 1 x Metal dish 400 mm white

• 1 x Sub reflectors

• 4 x Washer, M4 Crinkle, stainless steel

• 4 x Screws, Pan Head Torx, M6 x 12 mm

• 4 x Washers, M6 plain

• 4 x Nuts, M4

Figure 102: *CPE Dish components*

To assemble the CPE dish, perform the following steps:

1. Insert the sub reflector into the corresponding four small holes of the antenna dish, as shown in Figure 103.

    Figure 103: *Inserting the sub reflector*

2. Secure the sub reflector from the back of the dish using the M4 washers and M4 nuts, as shown in Figure 104.

    You must use a spanner to tighten the screws.

Figure 104: *Securing the sub reflector*

3. Use the remaining M6 screws and M6 washers to attach the dish assembly to the mounting bracket of the CPE precision bracket (as described in the Assembling the precision bracket for CPE section).

Figure 105: *Attaching the dish assembly to the bracket*

Figure 106 shows an assembled image of the C100 dish.

Assembling the Precision bracket for CPE

The Fine adjustment or Precision bracket is used to mount the CPE with a 400 mm external dish antenna on a vertical pole, with a diameter ranging from 25 mm to 80 mm (0.98 inches to 3.14 inches). The precision bracket provides fine adjustments up to 18° in azimuth and +/-30° in elevation for accurate alignment of CPE.

You must first assemble the CPE Fine adjust bracket by using a 13 mm (1/2") wrench with a maximum torque of 5Nm.

To assemble the Precision bracket for the CPE, perform the following steps:

1. Unpack the Precision bracket package box and ensure that the box contains the following components (as shown in Figure 107):

Figure 107: *Precision or Fine adjustment bracket components*

The Precision bracket box must contain the following components:

- 4 x M8 flange nuts

- 3 x 28 mm M6 bolts

- 4 x 20 mm M8 bolts

- 4 x 120 mm M8 long bolts

- 5 x M8 plain washers

- 5 x M8 nyloc nuts

- 2 x M8 spacers

- 1 x bracket body

- 1 x azimuth arm

- 1 x pole mount clamp

- 1 x CPE dish mount

- 1 x bracket base

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

3. Fit two flange M8 nuts to the long screws on the back of the bracket body, as shown in Figure 108.

   You must tighten the screws using a 13 mm spanner.

   Figure 108: *Fitting the two flange M8 nuts on the bracket*
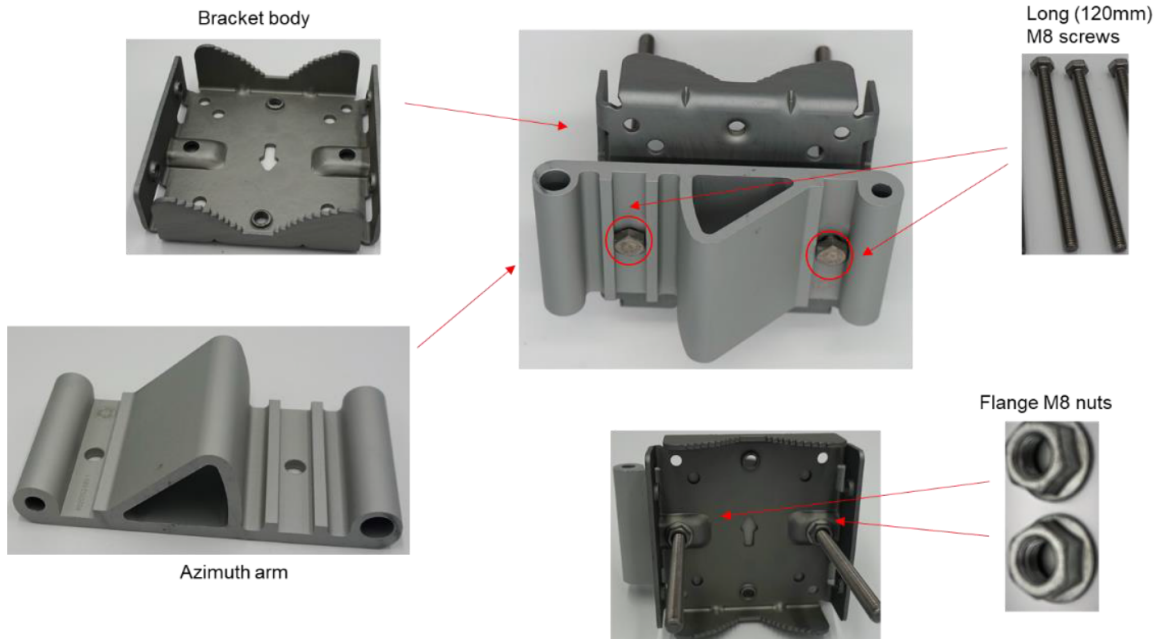
4. Insert the three length (40 mm) M8 screws through the bracket base and the CPE dish mount. The screws locate in the slots in the bracket base.

5. Ensure that the pivot pin in the elevation adjuster is located in the circular hole in the CPE dish mount.

6. Fit plain washers and M8 Nyloc nuts to the screws on the back of the bracket base.

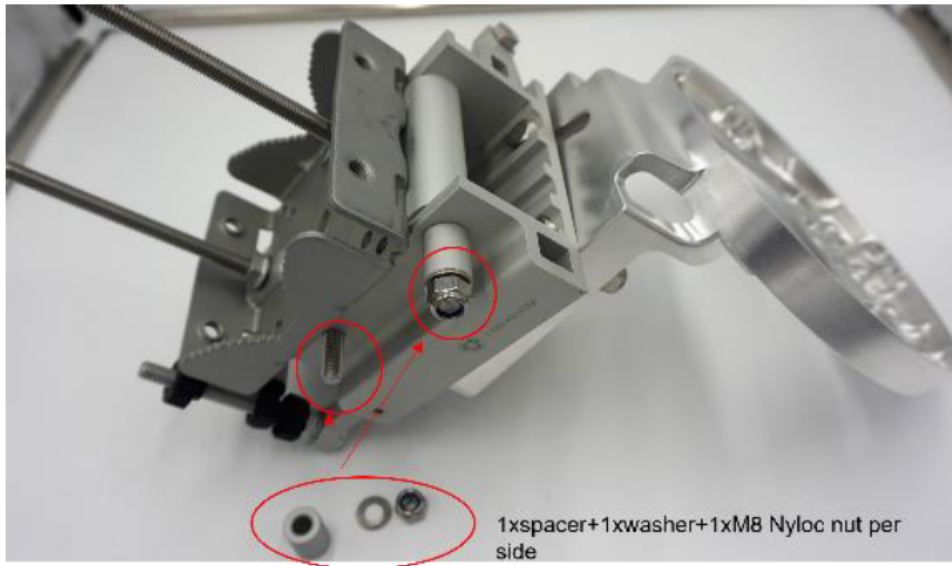   You must tighten the screws using a 13 mm spanner.
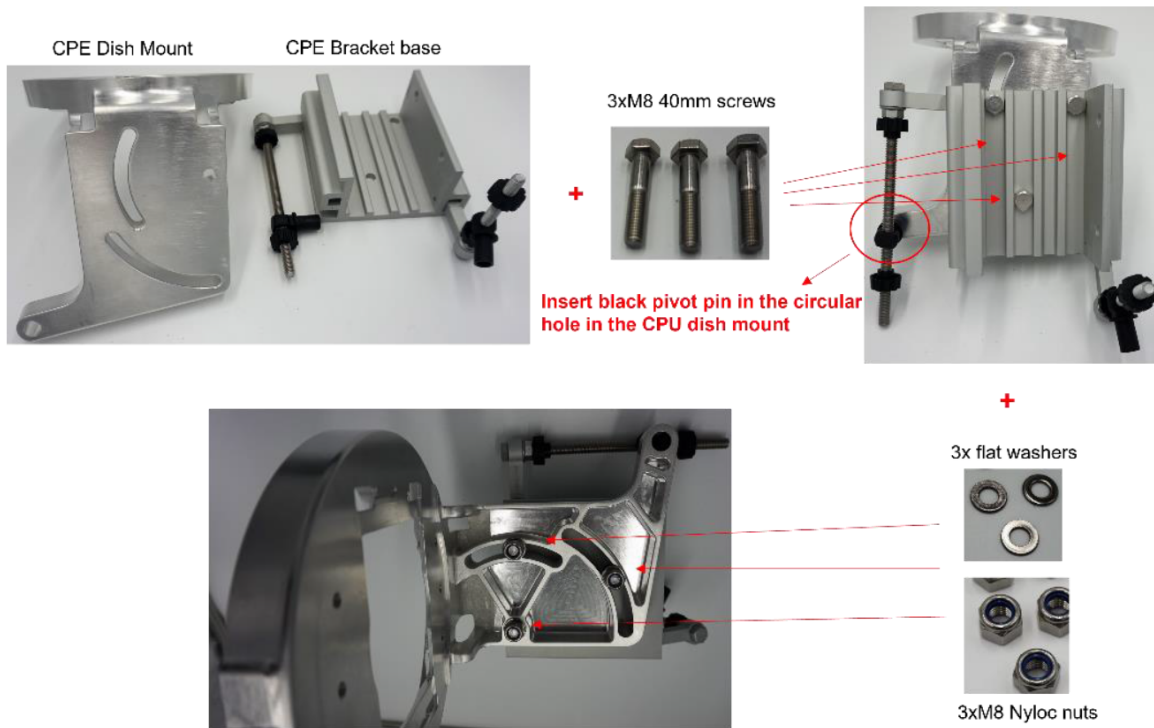
7. Insert the two remaining long (120 mm) M8 screws through the bracket body and the azimuth arm. The screws locate in the slots in the bracket body.
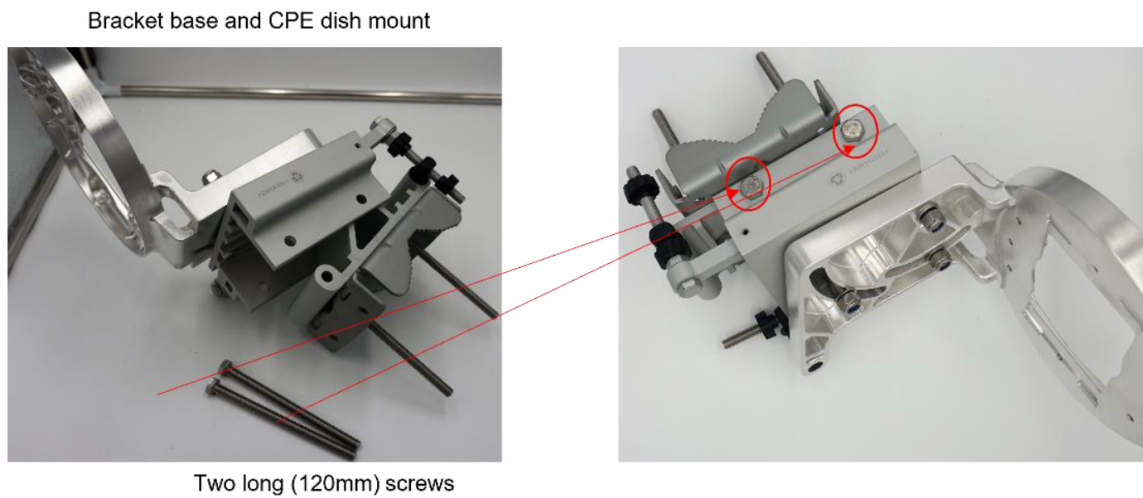
8. Fit two sets of spacers, plain washers and M8 Nyloc nuts to the screws on the underside of the bracket base.

    You must tighten the nuts using a 13 mm spanner.

Figure 111: *Fitting the spacers, plain washers and M8 Nyloc nuts*


1xspacer+1xwasher+1xM8 Nyloc nut per side

9. Attach the CPE mount to the radio using the four short M6 bolts.

   You must tighten the four bolts to a torque setting of 5.0 Nm (3.7 lb ft) using a 13 mm spanner or socket.

Figure 112: *Attaching the CPE mount to the radio*

10. 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 113: *Attaching the Precision bracket to the pole*
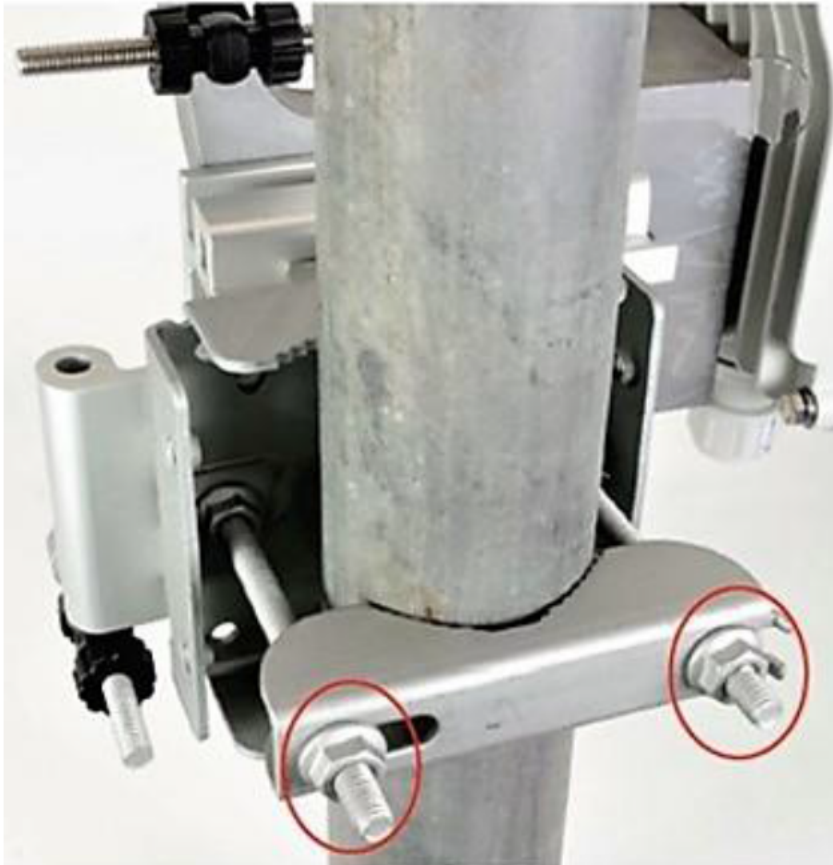

Attaching the dish to the CPE

To attach the dish to the CPE, perform the following steps:

1. Connect the CPE to the dish, by using the four screws provided with the CPE box.

2. Place the CPE and ensure that the radome is aligned with a hole inside the dish and the four screws in a secured way.

Figure 114 shows a side view and rear view of an assembled CPE and dish.

Figure 114: *Views of an assembled CPE and dish*
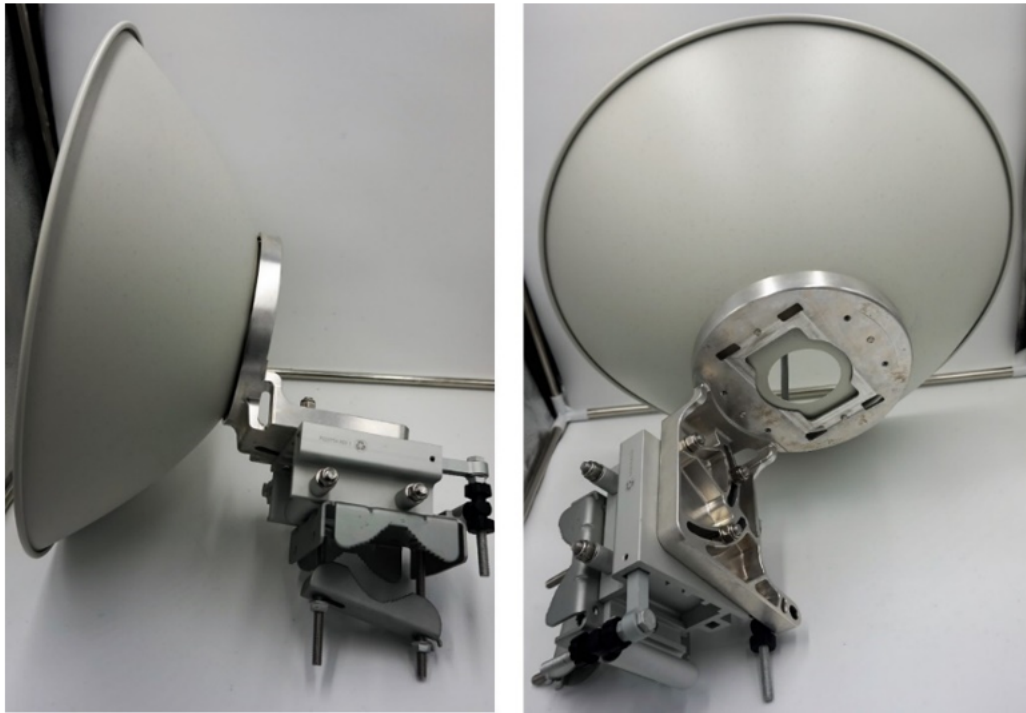
Aligning the CPE with Precision bracket

To align the CPE with the Precision bracket, perform the following steps:

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.

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

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.

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

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.

8. 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 using the optional telescope

To align the Precision bracket with an optical telescope, perform the following steps:

1. Attach the telescope mount to the CPE dish using the magnetic connectors.

2. Pin the telescope by placing the white magnetic plate over the edge of the dish, ensuring that the telescope is located securely in the mount.

Figure 115: *Telescope aligned with the dish*
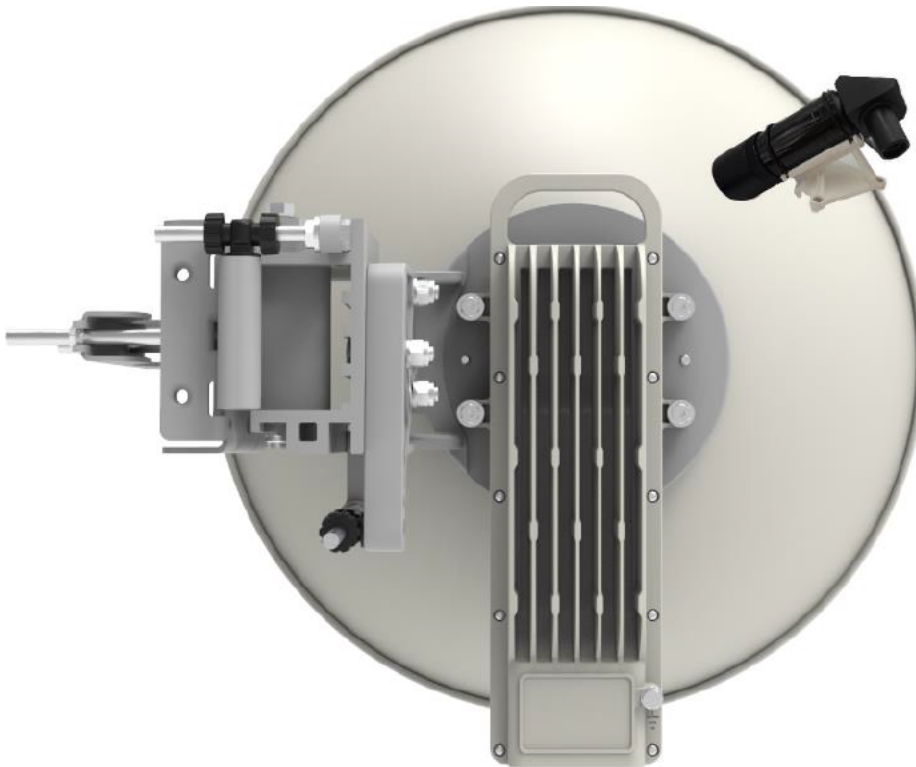
3. Follow the previously described precision bracket alignment method and align the radio starting with the site and later fine tune using the telescope for increased accuracy.

Configuring the link

For the link configuration details, refer to the configuring BTS and CPE specific sections in the *cnWave™ 5G Fixed Configuration Guide*.

Monitoring the link

For details on the link monitoring, operation procedures, and troubleshooting, refer to the *cnWave™ 5G Fixed Operation and Troubleshooting Guide*.

Checking the BTS installation using satellite details

Using the **GNSSS** page in the B1000 UI, you can check whether the BTS device is installed in a clear sky. This action helps you to ensure the BTS installation for optimal GPS synchronisation.

When you complete the installation of the BTS device on Mast, you must install it in a clear sky using the GNSS data (satellite information) available on the B1000 dashboard (UI).

To check and install the BTS device in a clear sky, perform the following steps:

1. Using the B1000 UI (BTS), navigate to the **System** > **Synchronisation** page from the main B1000 Dashboard.

   The **Synchronisation** page appears. Ensure to complete the following configuration steps:

a. Select **Best Effort** as the **Control** parameter value.

The **Best Effort** option indicates that the BTS device uses the satellite signal for the reference. Even if all satellites go down, the BTS device uses the reference time for a specific period (for example, 5 minutes) before it loses the reference signal.

b. Select **Internal GNSS** as the **Source** parameter value.

The **Internal GNSS** option indicates that the BTS device is using an integrated GPS as a reference for the operation of TDD.

c. Ensure that the value of **State** parameter displays **Time Locked** in the TDD Status section.

The **Time Locked** state indicates that a pulse per second (PPS) reference signal is detected, the frequency is locked, and the TDD is synchronized.

Figure 116 is an example of the Synchronisation settings.

Figure 116: *The Synchronisation page*
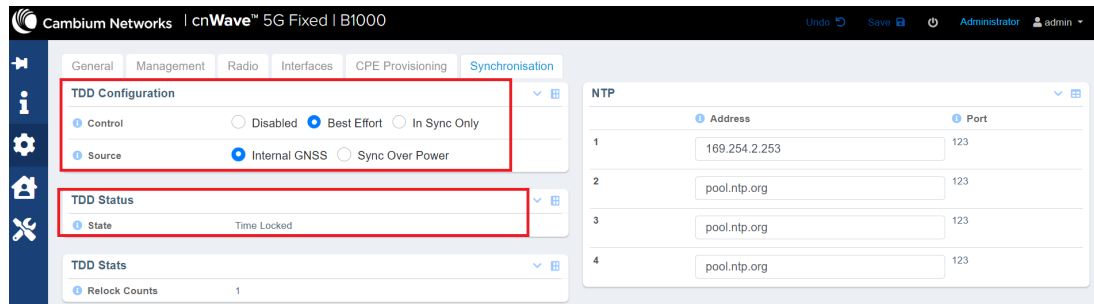
2. On the main B1000 Dashboard page, select the **GNSS** tab.

The **GNSS** page appears, displaying the satellite information.

To check details of the satellites used by the BTS device, perform the following actions using the GNSS page:

a. Check the value of **In Use** parameter in the **Satellites** section.

The **In Use** parameter indicates the number of GNSS satellites that are in use by the device. The value of this parameter must be more than two.

> **Note**
>
> The BTS device relies on minimum three or four satellites.

b. If the value of **In Use** parameter is less than three or four satellites, then check your BTS installation setup, in terms of possible obstructions for the integrated GPS and the BTS device.

You must check whether the GPS antenna is hidden or blocked by any other radios or metal devices.

c. Check the **Fix Count** value in the **Statistics** section.

The fixed count value must not be high and it must be constant for all the satellites in use.

d. Check SNR, azimuth, and elevation values in the **Sky View** section.

If the SNR value of any satellite is not optimal (typically, 20 dB and higher), then the BTS device does not use GPs when the signal goes down (below 20). If the SNR value is good (for example, more than 20), the BTS device uses GPS for synchronisation. Figure 117 is an example of the **GNSS** page.

You can also check the **Sky Map** section for SNR value of each satellite.

Figure 117: *The GNSS page - B1000 UI (BTS)*
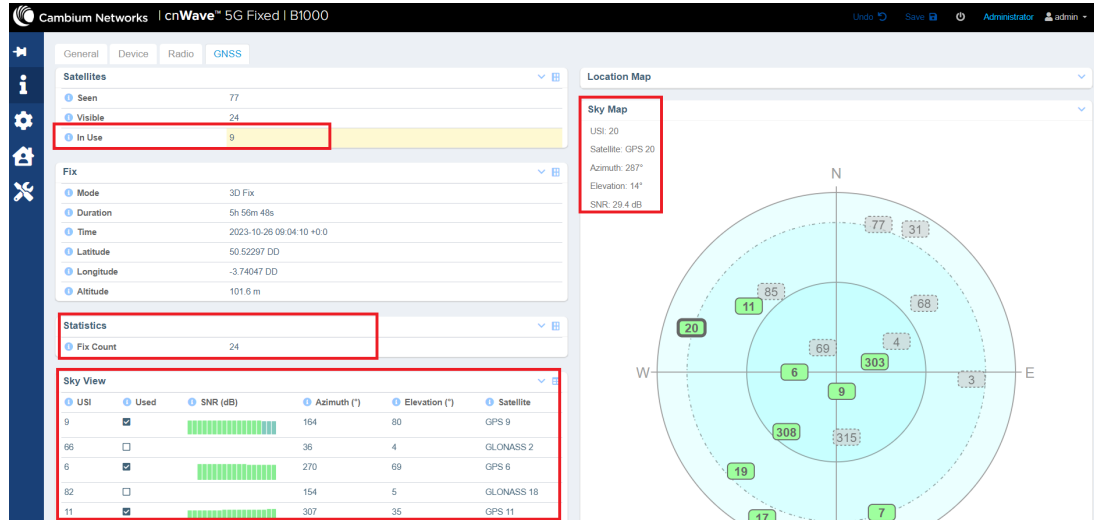
> **Note**
>
> on the **Sky Map** section of the **GNSS** page, green coloured satellites are the ones in use.

With these synchronisation and GNSS satellite details, you can ensure that the BTS device is installed in a clear sky and GPS is not hidden.

For more information on using **Synchronisation** and **GNSS** pages in the B1000 UI, refer to the *cnWave 5G Fixed Configuration Guide*.

Appendix 1: System Technical Specifications

This release focuses specifically on the execution of Proof of Concepts (POCs), with limited number of customers.

Table 45: System technical specifications

Feature	Release details
5G Core Network	Integrated
5G NR Chipset based Cambium CPE	No
5G Third-Party CPE	No
Authentication and Authorization	RADIUS
Beamforming modes	Directed and Sector
Channel bandwidth	50, 56, 100, 112 MHz
Connectivity	Ethernet (Layer2)
CPE SIM support	Emulated
Downlink MU-MIMO	8 x 8 using 50 MHz and 56 MHz (8 streams and max CPE grouping size = 8) 6 x 6 using 100 MHz and 112 MHz
Downlink OFDMA	1 group/slot
Max BTS Data Rate	1.8 Gbps DL and 600 Mbps UL
Max Cell size	Up to 10 Km
Max CPE Data Rate	Up to 400 Mbps
Max CPEs per BTS	120 for 100 and 112 MHz Channel size 60 for 50 and 56 MHz Channel size
Max EIRP - BTS	44 dBm
Max EIRP - CPE	48 dBm
Modulation Range	QPSK to 256 QAM (MCS 6 to 23)
Operating frequencies	Licensed bands, 24.250 to 29.50 GHz
QoS Levels	4
TDD period	1 ms
TDD structure, downlink slots; uplink slots	6.1, 5.2, and 4:3
TDD sync	Integrated GPS
Topology	PMP
Uplink OFDMA	No
Uplink MU-MIMO	Yes
Vertical Beam Steering	Static

The cnWave™ 5G Fixed platform supports the 28 GHz band (as indicated in the product's name). It also covers 24, 26, and 28 GHz bands (as shown in Table 46).

Table 46 lists the 3GPP standard 5G NR frequency bands. The exact frequency limits are from 24.250 GHz to 29.500 GHz.

Table 46: 5G NR Bands

5G NR Band	Bands Limits (GHz)
n257	26.50 to 29.50 GHz
n258	24.25 to 27.50 GHz
n261	27.50 to 28.35 GHz

Appendix 2: Acronyms and Abbreviations

Table 47 lists the terms that are used in this guide.

Table 47: List of acronyms and abbreviations

Term	Definition
5G NR	5G New Radio (From Release 15, the 3GPP consortium refers to the air interface as 5G New Radio)
BTS	Base Transceiver Station
C-RNTI	Call-Radio Network Temporary Identifier
CIR	Committed information rate
CPE	Customer Premise Equipment
dBm	Decibel relative to a milliwatt
DNS	Domain Name System
DL	Downlink
EIRP	Effective Isotropic Radiated Power
ESN	Electronic Serial Number
EVM	Error Vector Magnitude
GHz	Gigahertz
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LoS	Line of Sight
LPU	Lightning Protection Unit
MAC	Media access control
MCS	Modulation and Coding Scheme
MHz	megahertz
MU-MIMO	Multi- user multi-input-multi-output (MU-MIMO)
ms	Millisecond
MSN	Mechanical Serial Number
NTP	Network Time Protocol
OFDMA	Orthogonal Frequency Division Multiple Access
ODU	Outdoor Unit
PMP	Point-to-MultiPoint
POC	Proof of Concept
PoE	Power over Ethernet

Term	Definition
PPS	Pulse Per Second
PSU	Power Supply Unit
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RADIUS	Remote Authentication Dial-In Service
SFP	Small form-factor pluggable (transceiver)
SIM	Subscriber Identification Module
SNMP	Simple Network Management Protocol
TDD	Time Division Duplexing
UI	User Interface
UL	Uplink
VLAN	Virtual Local Area Network

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