XE3-4TN Antenna Selection Guide

Overview

To optimize the overall performance of a Cambium Networks WLAN in an outdoor deployment, it's important to understand how to maximize coverage with the appropriate antenna selection and placement. This document provides guidelines for anyone who wishes to use Cambium antennas and related accessories with Cambium's outdoor XE3-4TN Access Points (APs).

Types of External Antennas

The tables below detail the specifications of the antennas Cambium offers for use with its APs in the 2.4 GHz, 5 GHz, and 6 GHz bands. Each type of antenna offers certain coverage capabilities suited for specific applications. As a rule of thumb, as the gain of an antenna increases, there is some trade-off to its coverage area. High-gain antennas typically will offer longer coverage distance but smaller (and more directed) coverage area.

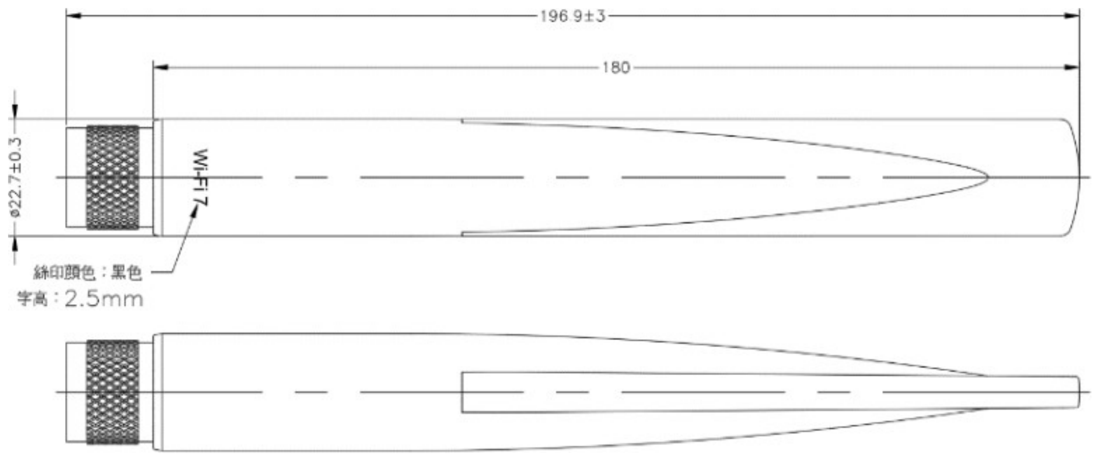
Antenna and Cables (per Radio) for XE3-4TN AP

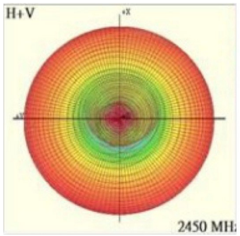
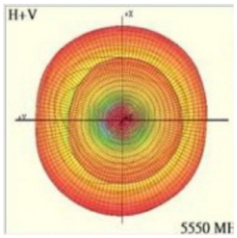
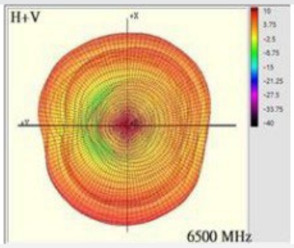
Antenna	Coverage Type	Bands	Antenna Chains	Antennas per AP	Cables per AP Quantity
ANT-OM-1X1-05	Omni	2.4 GHz/ 5 GHz/ 6 GHz	1x1	Up to 6	-
ANT-D30-2X2-02	30°	2.4 GHz/5 GHz	2x2	1	2
ANT-D60-2X2-02	60°	2.4 GHz/5 GHz	2x2	1	2
ANT-D35-4X4-01	35°	5 GHz/6 GHz	4x4	1	4
ANT-D60-4X4-02	70°	5 GHz/6 GHz	4x4	1	4
ANT-GPS-01	Sky	GPS	-	-	-

XE3-4TN Antenna Selection Guide

Omnidirectional Antennas

P/N: ANT-OM-1X1-05

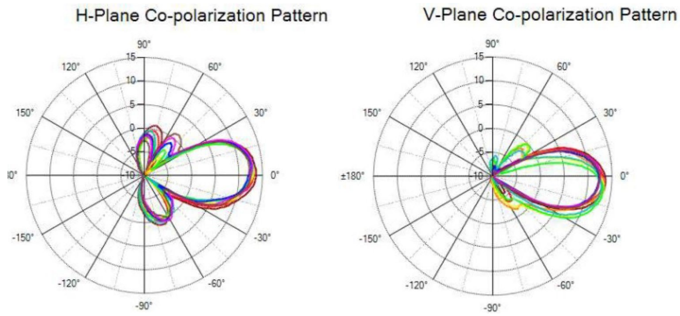


Gain Pattern			
Frequency Range	**2.4 MHz**	**5 GHz**	**6 GHz**
Impedance	50 Ωs	50 Ωs	50 Ωs
VSWR (50 Ωs)	2.0:1	2.0:1	2.0:1
Peak Gain, dBi	4.4	5.5	5.5
Polarization	Linear	Linear	Linear
Connector	N type plug		
Dimensions	22.7 x 196.9		
Weight	75 g		
Operating Temp	-40°C to 85°C		

Directional Antennas

30° Antenna - P/N: ANT-D35-4X4-01

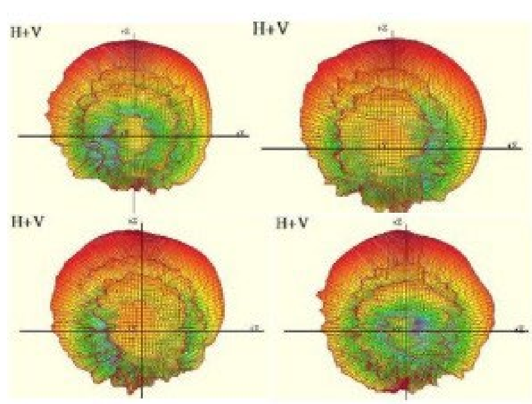
Gain Patterns



Frequency Range	5150–7125 MHz	**Maximum Power**	5W
Impedance	50 Ω	**Connector**	N female x4
VSWR (50 Ω)	2.0:1 (max)	**Dimensions**	258 mm x 228 mm x 51 mm
Peak Gain (dBi)	14 +/- 1 dBi	**Weight**	1,257 g
Polarization	4 x slant +/-45°	**Operating Temperature**	-40°C to 85°C
Half-Power Beamwidth AZ (H)	30°	**Mounting Options**	Pole mount or wall mount (attachments included)
Half-Power	15°		

70° Antenna - P/N: ANT-D60-4X4-02

Gain Patterns



Frequency Range	5150–7125 MHz	**Maximum Power**	5W
Impedance	50 Ω	**Connector**	N female x4
VSWR (50 Ω)	2.0:1 (max typical)	**Dimensions**	220 mm x 140 mm x 49 mm
Peak Gain (dBi)	11 +/- 1 dBi	**Weight**	900 g
Polarization	4 x slant +/-45°	**Operating Temperature**	-40°C to 85°C
Half-Power Beamwidth AZ (H)	70°	**Mounting Options**	Pole mount or wall mount (attachments included)
Half-Power	15°		

XE3-4TN Antenna Selection Guide

30° Antenna - P/N: ANT-D30-2X2-02

Frequency Range	2.3–2.7 MHz/4.9–5.925 MHz	**Maximum Power**	6W
Impedance	50 Ω	**Connector**	N female x2
VSWR (50 Ω)	2.0:1 (max) 2.4–2.7 GHz & 5.15–5.925 GHz	**Dimensions**	305 mm x 305 mm x 15 mm (max)
Peak Gain (dBi)	11.5 dBi/14 dBi	**Weight**	1,000 g
Polarization	Dual slant	**Operating Temperature**	-45°C to 70°C
		Mounting Options	MT-120018/A/H

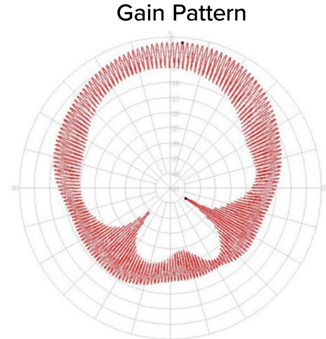
60° Antenna - P/N: ANT-D60-2X2-02

Frequency Range	2.4–2.49 MHz/4.9–6 MHz	**Maximum Power**	6W
Impedance	50 Ω	**Connector**	2 x N-type connectors
VSWR (50 Ω)	1.6:1 (typical), 2.0:1 (max)	**Dimensions**	190 mm x 190 mm x 31 mm (max)
Peak Gain (dBi)	7.5 +/- 1 dBi	**Weight**	1,000 g
Polarization	Dual slant	**Operating Temperature**	-45°C to 70°C
		Mounting Options	MT-120018/A/H

Omnidirectional Antennas

P/N: ANT-GPS-01

Gain Pattern



Frequency Range	1574–1610 MHz	**Connector**	SMA (M)
Impedance	50 Ω	**Dimensions**	35 mm x 35 mm x 3 mm
VSWR (50 Ω)	2.5 max	**Weight**	350 g
Peak Gain (dBi)	1575.42 MHz: 3 dBic typical @zenith 1602 MHz: 4.5 dBic typical @zenith	**Operating Temperature**	-40°C to 85°C
Polarization	RHCP	**Mounting Options**	Pole mount or wall mount (attachments included)
Axial Ratio	GPS typical 10, GNSS typical 8	**Cable Specs**	Captured 1.5 m cable (included)

XE3-4TN Antenna Selection Guide

Technical Background

SM Bands

The US Federal Communications Commission (FCC) authorizes commercial wireless network products to operate in the industrial, scientific, and medical (ISM) bands using spread spectrum modulation. The ISM bands are located at three different frequencies ranges: -900 MHz, 2.4 GHz, and 5 GHz. This document covers products that operate in the 2.4 GHz and 5 GHz bands.

ISM bands allow manufacturers and users to operate wireless products in the US without requiring specific licenses. This may vary in other countries. The products themselves must meet certain requirements to be certified for sale, such as Maximum Transmit Power (Tx Power) and Effective Isotropic Radiated Power (EIRP) ratings.

Each of the ISM bands has different characteristics. The lower-frequency bands exhibit better range but with limited bandwidth and, hence, lower data rates. Higher-frequency bands have less range and are subject to greater attenuation from solid objects.

Antenna Properties, Ratings, and Representation

At the most fundamental level, an antenna provides a wireless communication system, has three main attributes that are inter-related to each other, and, ultimately, influences the overall radiation pattern produced by the antenna:

- Gain
- Directivity
- Polarization

Gain of an antenna is a measure of the increase in power that the antenna provides. Antenna gain is measured in decibels (dB), a logarithmic unit used to express the ratio between two values of a given physical quantity. The gain is the antenna directivity including all the factors controlling the antenna's efficiency, such as:

- Insertion losses
- Aperture efficiency
- Radiation efficiency

In the general case, the gain in dB is a factor of the ratio of output power (or radiated power) to the input power of the antenna (that ratio is also called the efficiency of the antenna). In practice, the gain of a given antenna is commonly expressed by comparing it to the gain of an isotropic antenna.

An *isotropic antenna* is a theoretical antenna with a perfectly uniform three-dimensional radiation pattern. When expressed relative to an isotropic antenna, the gain of a given antenna is represented in dBi (i for isotropic). By that measure. a truly isotropic antenna would have a power rating of 0 dB. The US FCC uses dBi in its calculations.

Directivity is the ability of an antenna to focus electromagnetic energy in a particular direction in space. Directivity does not change when transmitting or receiving; it remains the same. When considering directivity, the efficiency is 100%. The antenna beamwidth is proportional to the directivity/gain (as the directivity goes up, the beamwidth narrows). The directivity/gain is expressed in dBi, which means it's referenced to an isotropic antenna with 0 dB gain (isotropic antenna transmits evenly in all directions). The magnitude of directivity is directly related to the size of the antenna relative to the wavelength of the antenna.

Polarization is defined as the orientation of the electric field of an electromagnetic wave. Every antenna has certain polarization characteristics. These could be:

- Linear polarization–vertical orientation
- Linear polarization–horizontal orientation
- Linear polarization–slant +/- 45 orientation
- Circular polarization

The polarization of an antenna is determined by the physical structure of the antenna and by its orientation. A simple straight-wire antenna will have one polarization when mounted vertically and a different polarization when mounted horizontally. It's important when establishing a communication link that the antennas on either end of the link will have similar polarization/orientation. If not, there would be some polarization mismatch loss factor that will affect the efficiency of the communication link. As an example, if a linearly polarized antenna with vertical orientation is used on one end of a communication link, the antenna on the other end needs to be vertically oriented as well. If the antenna is horizontally oriented, the two antennas will be orthogonal to each other, and the polarization mismatch factor could be greater than 20 dB.

XE3-4TN Antenna Selection Guide

When using a slant 452 antenna, it could be assumed that the antenna can receive or transmit any polarization-oriented electric field (when the electric field is not oriented exactly as the antenna on the other end, there will be some polarization loss involved—more in the 3 dB range).

When the antenna is circularly polarized (CP), it could be either right-hand CP or left-hand CP. It's important when using CP antennas to use the same sense for the communication link. When using a CP antenna on one end of a communication link, the antenna on the other end could have any polarization characteristics (vertical, horizontal, or slant 452). In such cases, there will be a polarization mismatch loss involved that could be in the 3 dB range.

Radiation pattern of an antenna is a plot of the relative strength of the electromagnetic field of the radio waves emitted by the antenna at different angles. The radiation pattern of theoretical isotropic antenna, which radiates equally in all directions, would look like a sphere. *Impedance matching* is an important consideration in the design of the overall wireless communication system. At each interface, depending on the impedance mismatch, some fraction of the propagating radio wave's energy will reflect into the source. This reflecting wave is called a *standing wave* and the ratio of maximum power to minimum power in the standing wave is called the *Voltage Standing Wave Ratio* (VSWR). A VSWR of 1:1 is ideal.

Design Considerations and Reference Use Cases

There are several factors that impact the performance of a wireless LAN and must be kept in mind while designing for a deployment. Some of the key considerations are:

- **Mobility of the Application:** The mobility of the clients that will be connecting to the array through the antenna system is the first thing to think about when planning a deployment. An application that has many mobile users, such as a convention center, is best served by many omnidirectional microcells. A point-to-point application, which connects two or more stationary users, may be best served by a directional antenna.
- **Physical Environment**: Some of the things to watch for in the environment where the WLAN deployment is planned include:
  - Building construction: The density of the materials used in a building's construction determines the number of walls the RF signal can pass through and still maintain adequate coverage. The following is a good reference but the actual effect of the walls on RF must be tested through a site survey. A thick metal wall such as an elevator reflects signals, resulting in poor penetration of the signal and low quality of reception on the other side. Solid walls and floors and precast concrete walls can limit signal penetration to one or two walls without degrading coverage, but this can vary greatly depending on the amount of steel reinforcement within. Concrete and concrete block walls will likely limit signal penetration to three or four walls. Wood or drywall will typically allow for adequate signal penetration through five or six walls. Paper and vinyl walls have little effect on signal penetration.
  - Ceiling height must be considered.
  - Internal obstructions: Product inventory and racking are factors to consider in an indoor environment, such as a warehouse. In outdoor environments, many objects can affect antenna patterns including trees, vehicles, and buildings.
  - Available mounting locations must be considered.

In addition, some consideration should also be given to aesthetic appearance.

Access to Network Connections (Minimize Antenna Cable Runs): Cabling between the array or AP and the antenna introduces losses in the system; therefore, the length of this cable run must be minimized as much as possible.

Warehouse Use Case: In most cases, these installations require a large coverage area. Experience has shown that multiple omnidirectional antennas mounted at 20 or 25 feet typically provide the best coverage. Of course, this is also affected by the height of the racking, the material in the racks, and the ability to locate the antenna at this height. The antenna should be placed in the center of the desired coverage cell and in an open area for best performance. In cases where the ceilings are too high and the array or AP will be located against a wall, a directional antenna may be used.

Small Office or Small Retail Store: An omnidirectional dipole antenna provides the best coverage for this type of scenario.

Enterprise or Large Retail Store: In most such deployments, there is a need for a large coverage area and a combination of omnidirectional and directional antennas must be used. Omnidirectional antennas should be located just below the ceiling girders or just below the drop ceiling, and directional antennas should be located at the corners. Also, for areas that are long and narrow, such as long store aisles, a directional antenna at one end may provide better coverage. Keep in mind that the radiation angle of the antenna will also affect the coverage area.

Apartment Complex Backhaul (Point-to-Point): For an application where last mile connectivity is being provided using Wi-Fi (such as apartment complexes or senior living complexes that may not have traditional wiring infrastructure), point-to-point (PTP) connections are common. When establishing PTP connections in outdoor environments, the distance, obstructions, and antenna locations must be considered. For short distances (several hundred feet), a standard dipole antenna may be used. For very large distances (1/2 mile or more) high-gain directional antennas must be used. The antennas must be installed as high as possible, above obstructions, such as trees or buildings. If directional antennas are used, they must be aligned so that their main radiated power lobes are directed at each other.

05312024