Peplink Antenna and Connectors Selection Guide

Version 2

Feb 2024

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Section 1: Theory

Antennas

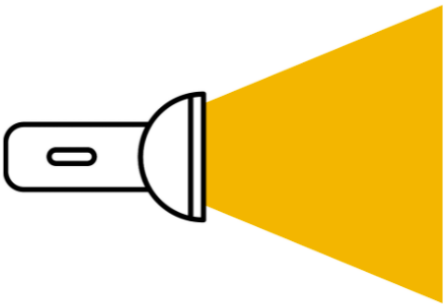
Antennas are selected for the environment of the installation, and the cables and connectors are selected depending on how the equipment is to be installed. In this document we will have a look at which type of antennas are suited for which environments, and how different types of connectors should be used for different installations.

Antennas are an extremely important part of any cellular deployment and should be given appropriate consideration. Would you drive a Ferrari with the cheapest tires you can find?

There are two main types of antennas, Omnidirectional and Directional.

Omnidirectional Antennas

Directional Antennas

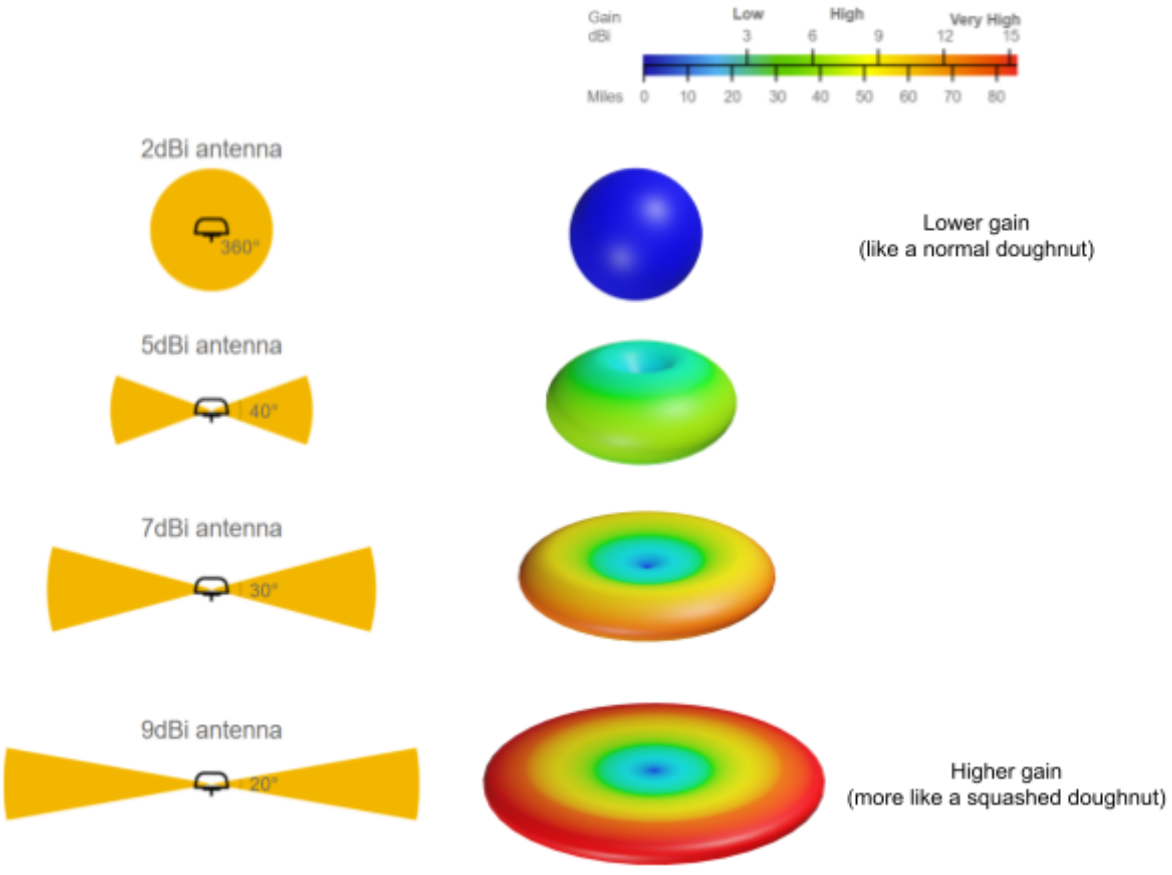


Omnidirectional Antennas

Omnidirectional antennas are used in situations where the installation is mobile. Their radiation pattern can be thought about like a donut.

These antennas are great for applications such as maritime, buses, cars, trains and moving machinery.

Pros	Cons
• Rotatable Platform • Stable Signal	• Lots of Noise

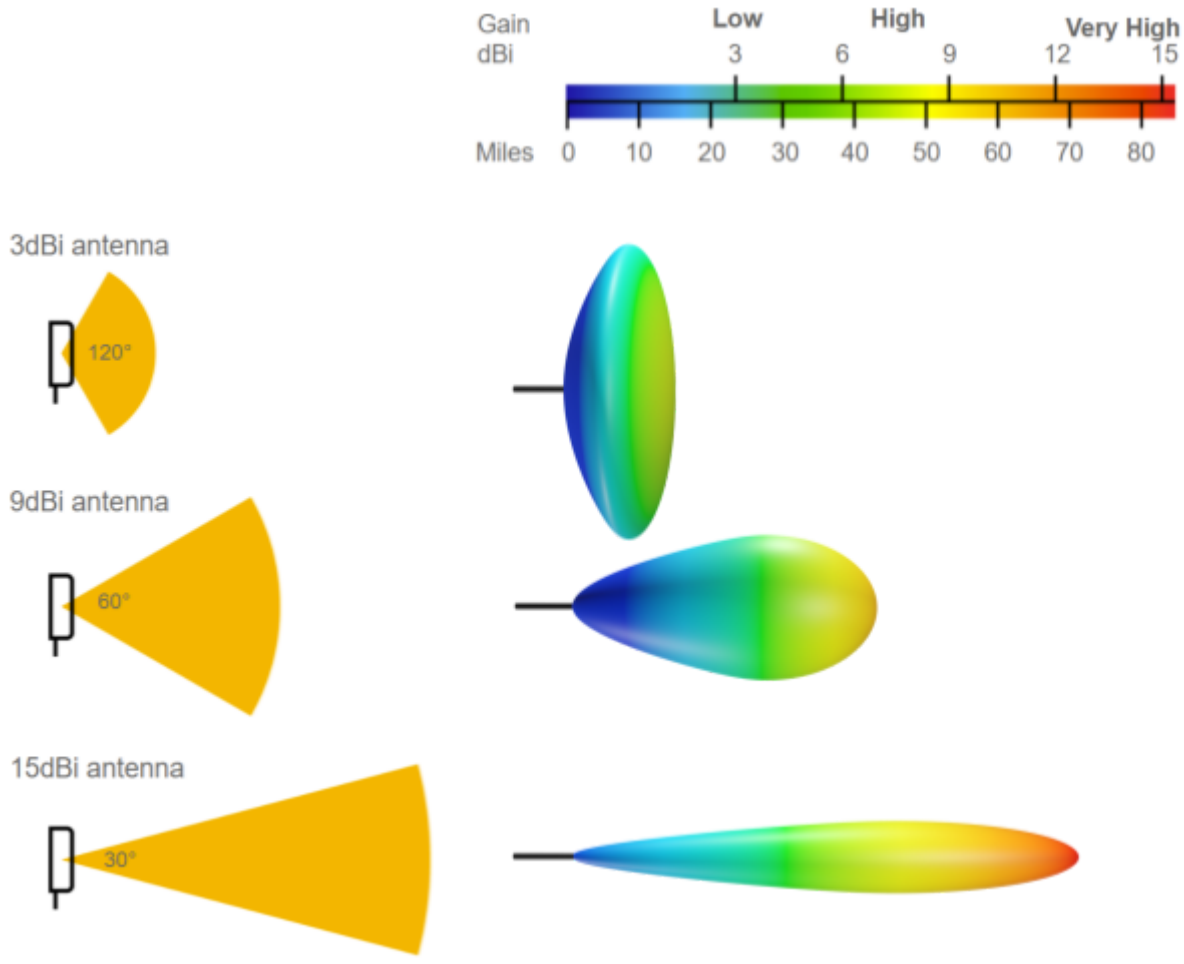


Directional Antennas

Directional antennas are used for fixed installations, usually in areas where there is a weak signal or in very noisy environments. Think of their radiation pattern like a cone.

These antennas are great for static applications in remote locations with poor signal strength, and crowded locations with high levels of interference such as residential, offices, fixed-installation IoT devices and utilities.

Pros	Cons
• Longer Range • Higher Gain	• Easily Misaligned

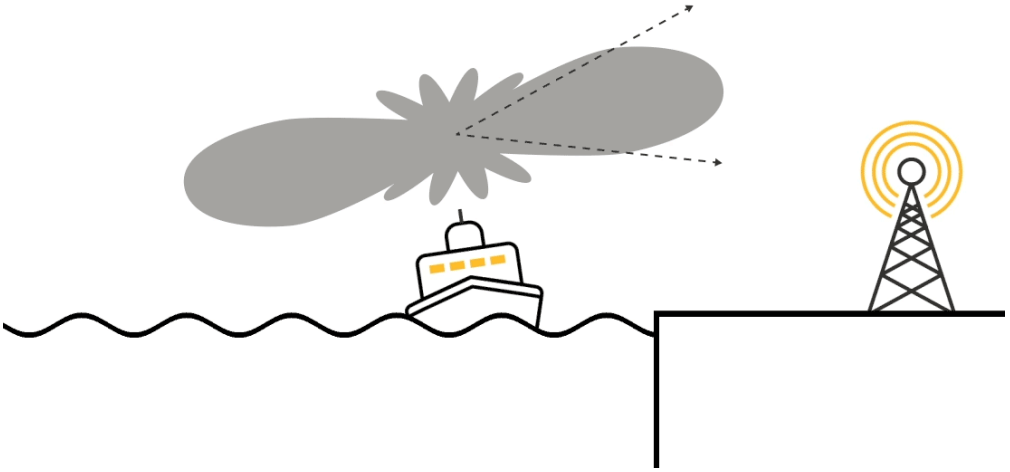


Key Parameters

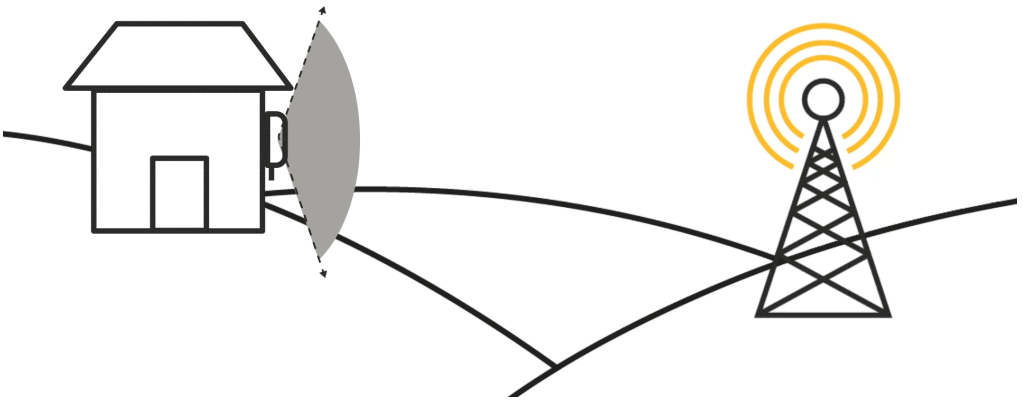
Gain

Gain can be thought about like focusing the signal. The higher the gain, the more focused the antenna is on the signal in a particular direction. For an omnidirectional antenna, this means that the donut is squished down and extends further out. For a directional antenna, it means that the cone is made longer but the base of the cone is made smaller.

How these affect signals in the real world:

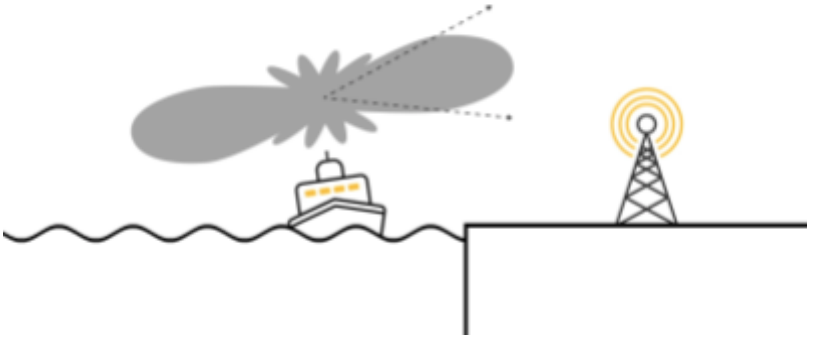


A rural property with a directional antenna:



Lower Gain Antenna

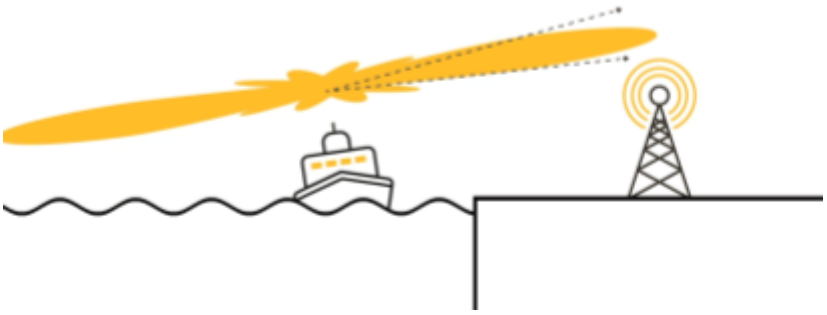
Antenna gain of 4 to 7 dBi equals 40º to 20º elevation on the beam width. This allows for 20º to 10º of roll in either direction.



Pros	Cons
• Easier to install • Less likely to be misaligned and lose signal • Compact antenna housing	• Shorter range

Higher Gain Antenna

Ships commonly roll to 10° or more on moderate seas, (depends on the vessel and sea conditions). An antenna with a gain of 9dBi equals 12° of elevation beam-width which allows for ±6° roll in either direction.

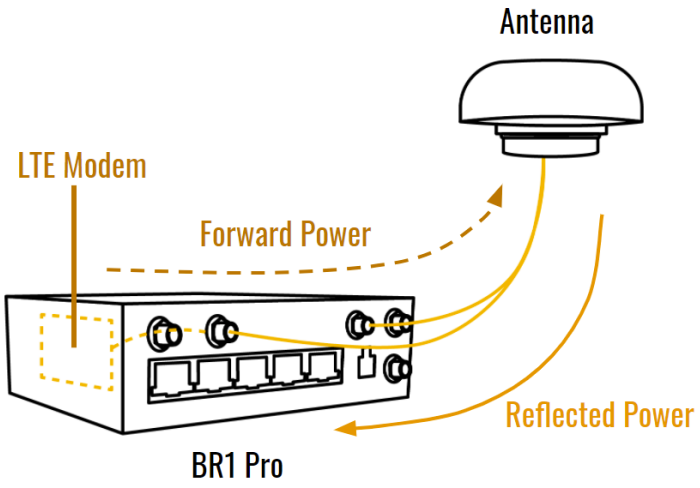


Pros	Cons
• Longer range	• May be misaligned and degrade signal • Larger antenna housing

- Too high gain = overshooting the target base stations on shore
- Too low gain = inefficiency

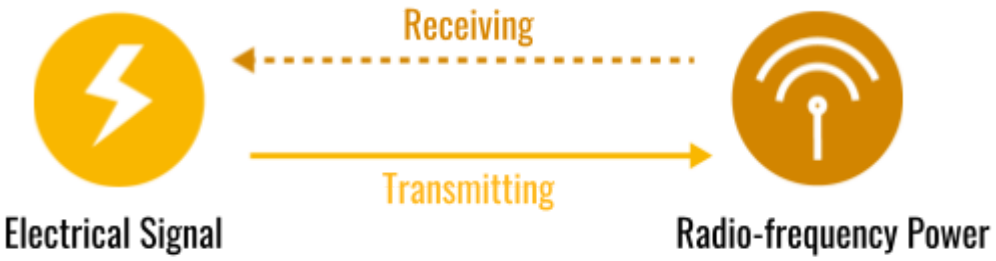
VSWR

VSWR stands for Voltage Standing Wave Ratio. Sometimes it is also called the Standing Wave Ratio (SWR). VSWR shows the reflection coefficient, which indicates how much power is reflected from the antenna when the cellular modem is transmitting. It also directly affects the antenna efficiency. It is important to note that it is possible to permanently damage cellular modem if the VSWR is too high. Most of the cellular modems maximum allowed VSWR is up to 2.5-3 when transmitting.



Efficiency

Efficiency is a very important factor. It states how efficient an antenna is in converting received signals into electrical currents and vice versa. Many manufacturers don't publish information about this. In simple terms, it indicates how well the electrical signal is converted into the radio-frequency power when transmitting, and radio-frequency power to the electrical signal when receiving. In theory the antenna may have a high gain and even a good VSWR, but poor efficiency will lead to poor signals and therefore, low cellular router performance. Typically, efficiency varies from 30% up to 90% depending on the frequency band and antenna type.



Frequency Bands

Typically, frequency bands are split into several ranges. The exact working frequency depends on the country and differs from region to region.

- Low band: 600-960MHz
- Mid band: 1700-2700MHz
- High band: 3400-4200MHz (5G)
- ISM band: 5100-6000MHz (5G)

Note: The frequency band naming is not official and was made for easier explanation and comparison.

Signal attenuation (reduction of signal strength during transmission) is mainly caused by three factors:

- A. Frequency (higher frequency == higher attenuation)
- B. Physical Surroundings (e.g. hills, buildings, trees, walls)
- C. Distance (longer distance == higher attenuation)

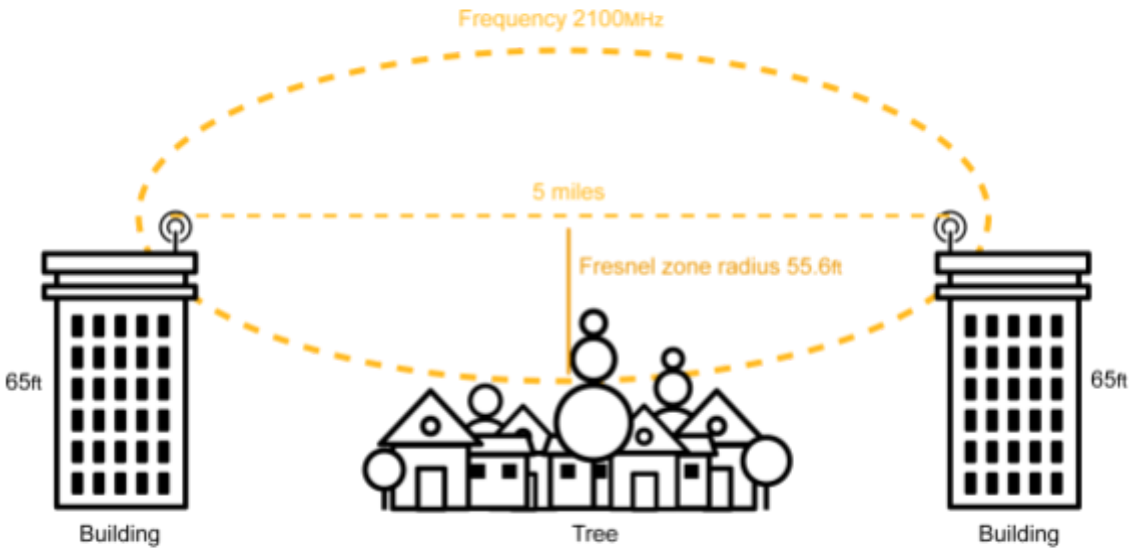
	Rural	Suburban	Urban
Description	Low population. Typically farming or open fields.	Mildly populated areas. Typically a small population with residential areas or small offices.	Densely populated areas. Typically with high rise buildings for residential or commercial use.
Frequency Bands	Mainly **Low**	Mix of **Low** and **Mid**	Mix **Mid** and **High**
			
Signal attenuation	Low	Medium	High
Cell tower coverage	Large	Medium	Small
Cell tower density	Low	Medium	High
Throughput	Low	Medium	High
Cell tower density	Low	Medium	High

Consideration Criteria

The goal when installing an antenna is to get the best possible received signal.

Line-of-sight

Firstly, the best signal reception is achieved when the cellular router antenna and the base station antenna are in line-of-sight of each other, or in other words, there are no objects in between. However there is also an effect called Fresnel Zone. If there are reflective surfaces along the path, such as water or smooth terrain or building roofs, the radio waves will reflect and may affect the received signal strength. We have provided a picture showing a particular example for one frequency. There are many online calculators you can find to check the fresnel zone.



Cell Tower Congestion

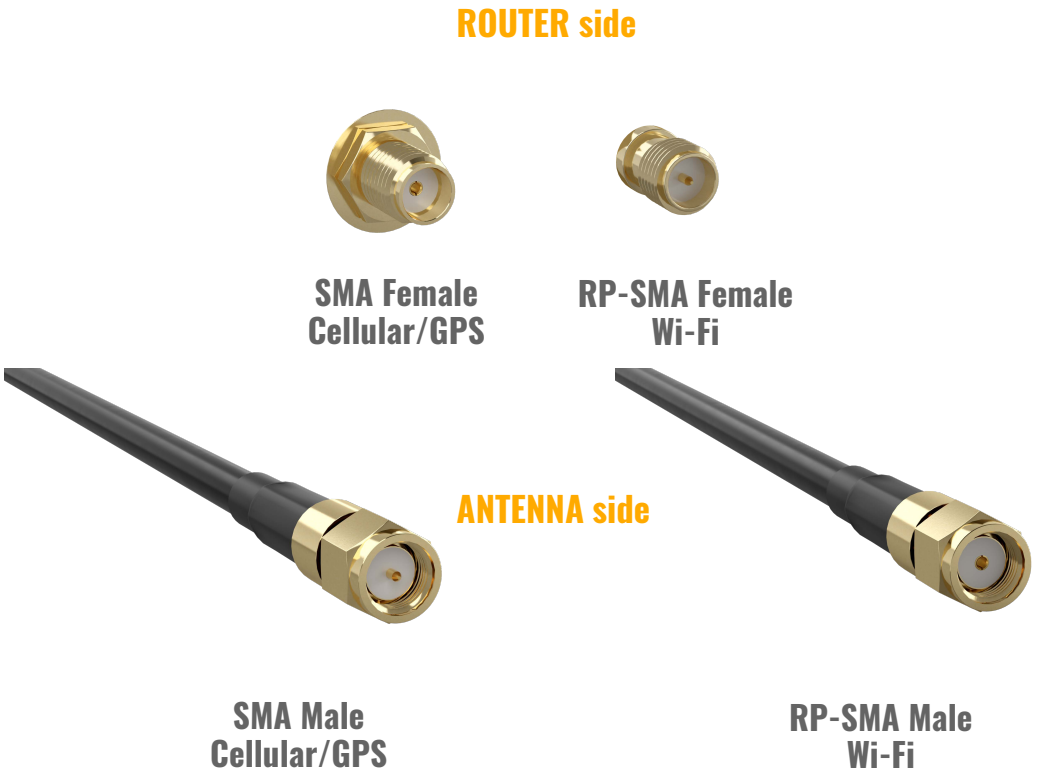
Another thing to consider is cell tower congestion. It may happen during weekends or rush hours. If that is the case, an omnidirectional antenna can help as it will allow them to connect to several cell towers rather than one using a directional antenna.

Cables and Connectors

For indoor routers, Peplink offers two different connector types. SMA for most models and QMA for the CAT-18 MBX and 5G MBX. For antennas and cables, we offer the two previously mentioned plus N-Type.

SMA

Our most common connector is the SMA. SMA stands for Subminiature type A. These come in four different versions.



QMA

QMA connectors are used on our CAT-18 and 5G MBX. QMA comes in two forms, male and female.

ANTENNA side

Male

ROUTER side

Female

For installations where a CAT-12 MBX is to be upgraded, Peplink offers an adapter to convert from QMA to SMA - “QMA-to-SMA adapters (Pack of 4) ACW-816”. This is perfect if the existing antennas support the frequencies of the new modems, but do note that when upgrading from CAT-12 to a higher standard, twice as many antennas are required.

N-Type

The N-Type connectors are used on some of our IP67 routers (e.g. HD2 IP67, HD4 IP67). N-Type connectors are designed for outdoor use.

Male (Antenna)

Female (Router)

Antennas and Cables

Cable type	Loss	Notes	Connector	Loss @ 900MHz 6 ft (2.1m)	Loss @ 2000MHz 6 ft (2.1m)	Loss @ 2500MHz 6 ft (2.1m)	Loss @ 5000MHz 6 ft (2.1m)
RG-174	Moderate	Flexible, 0.1” (2.5mm) in diameter, up to 2.7GHz	SMA or QMA	2.24 dB	3.43 dB	3.85 dB	-
CFD-200	Low	Flexible, 0.2” (5mm) in diameter, up to 6GHz	SMA or QMA	0.66 dB	0.99 dB	1.11 dB	1.73 dB
LMR-400	Very low	0.45” (10mm) in diameter, >6GHz	N-type	0.28 dB	0.42 dB	0.49 dB	0.84 dB
0.84 dB	Ultra low	0.59” (15mm) in diameter, >6GHz	N-type	<0.07 dB	<0.07 dB	<0.07 dB	0.7 dB

RG-174 cable is used for GPS:
- Loss @ 1500MHz is ~2.63 dB (6 ft / 2.1m)

Section 2: Applications

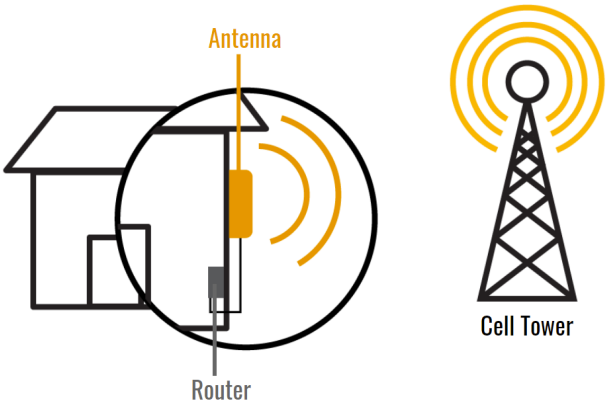
Most Typical Applications

Applications could be split into three main categories:

- Fixed
- Mobile
- Maritime

Fixed Installations

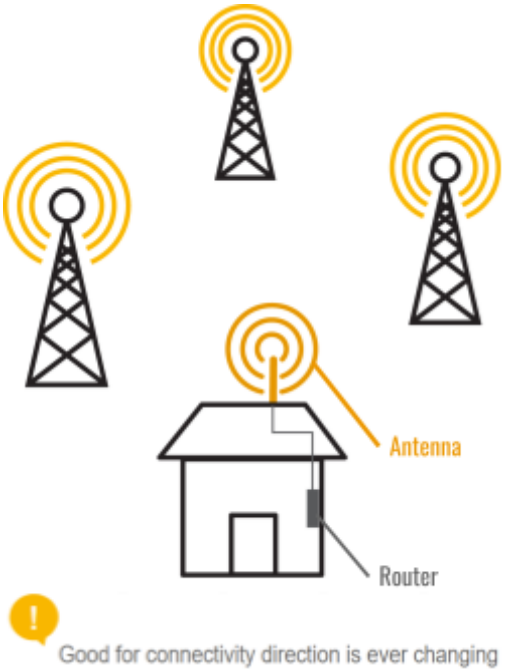
Fixed installations are typically used in offices, factories, or homes. External antennas are needed mostly for rural or suburban areas where indoor antennas do not work or the performance is very poor.



Peplink has several solutions. For the best signal reception, our directional antenna, the Hummingbird, is recommended. Directional antennas also help to decrease the noise received from other directions, thus even further improving overall connectivity performance. The antenna comes in two options:

- 5m cable with SMA connectors which can be directly connected to the cellular router.
- 0.5m cable with N-Type connectors which are useful, if the extension cable runs longer than 5m, which allows using a low loss LMR cable.

The Hummingbird supports robust and reliable wall and pole mounting, which are the most common option for fixed installations. It also contains active GPS, which is located in the top middle position of the enclosure.



Another option is to use our omnidirectional antenna, the Stingray. This option is useful if there are several towers and the cellular router may connect to any of those (connectivity direction is not clear).

The antenna cable length is 2 meters and has SMA connectors. In most cases, this will require additional extension cables. SMA connectors are not waterproof and would require additional sealing. It is recommended to use self amalgamating tape to seal the connectors. The antenna supports both wall and pole mount options and was designed to withstand winds up to 160 km/h.

Mobile Installations

Mobile installations, as the name suggests, are for mobile applications such as first responder vehicles, trucks, buses, trains or RVs. In all cases, the antenna is moving and therefore, the only option in this case is to use an omnidirectional antenna. It is recommended to use our Puma series of antennas which are available in different configurations.

Puma antennas support panel, pole, and wall mounting options. The Puma series antennas are designed to withstand harsh weather conditions and are IP68 rated. In addition, their construction is very robust against mechanical damage, making them vandal-proof. Their small size and low profiles minimize drag, making them suitable to be installed on vehicle roof tops.

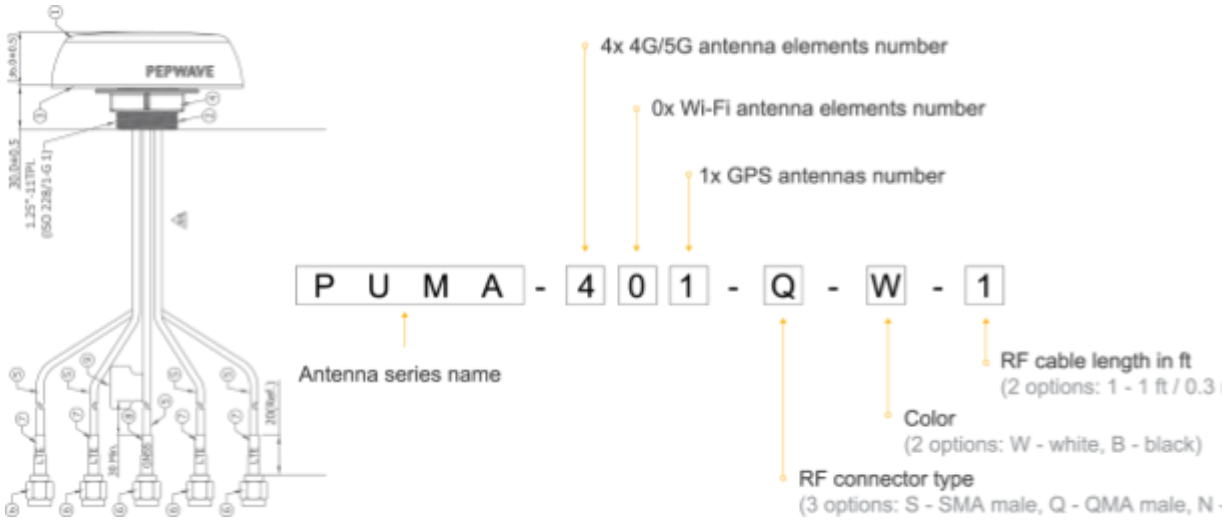
Maritime Installations

Maritime installations are difficult due to many different factors. One of the main factors is the fact that the vessel can be operating in extremely diversified cellular environments, meaning that the setup should be configured to work under different conditions. The Stingray 201 and 401 are perfect due to their high gain omnidirectional RF properties. Installing the antennas and routers as close together as practically possible helps reduce RF loss.

Comparison Table

	Puma Series	Stingray Series	Hummingbird Series
Models	421, 401, 221, 201	401, 201	401
Type	Omnidirectional	Omnidirectional	Directional
Applications	Mobile, Maritime	Maritime, Fixed	Fixed
Bandwidth	Very wide (600-6000MHz)	Ultra wide (400-6000MHz)	Very wide (600-6000MHz)
Performance	Medium	High	Very high
Ruggedness	High	Medium	Medium
Active GPS	Yes	Yes	Yes

Numbering System



Cable and Connector Options

	Puma Series	Stingray Series	Hummingbird Series
Connectors	1) QMA connectors, 1ft (30cm) cable* 2) QMA connectors, 6.5 ft (2m) cable* 3) SMA connectors, 6.5 ft (2m) cable	SMA connectors, 6.5 ft (2m) cable	1) SMA connectors, 16 ft (5m) cable 2) N-Type connectors, 2 ft (0.5m) cable
Extension Cables	For LTE/5G: 1) 4.5m SMA male to QMA 2) 4.5m QMA to QMA For Wi-Fi: 1) 4.5m RP-SMA male to QMA	-	-

* extension cable available

SKU Combination

	Puma 401	Puma 221	Puma 020	Puma 421
SMA connector	6.5ft / 2m only	6.5ft / 2m only	6.5ft / 2m only	6.5ft / 2m only
QMA connector	1ft / 0.3m Or 6.5ft / 2m	1ft / 0.3m only	1ft / 0.3m only	1ft / 0.3m Or 6.5ft / 2m
N type connector	6.5ft / 2m only	-	-	-
Extension cable	+ 15ft / 4.5m	+ 15ft / 4.5m	+ 15ft / 4.5m	+ 15ft / 4.5m

Q Why is there no 0.3m option for the SMA Connector?

A QMA connectors are designed as **snap-on locking replacements** for the standard SMA connectors. In the case of an extension, using a QMA connector is **quick to install** and **prevents any interventions in the future** in comparison to SMA or N-Type.

More About SMA and QMA

	Pros	Cons
SMA connector	• Affordable price • Easy to buy	• Takes time to attach • Needs to double check connection
QMA connector	• Can be plugged in very quickly • Secure and reliable connection	• Expensive • Not common

Q Why do the CAT-18 & 5G ??? have 4 connectors?

A All of our CAT-12 and below routers have two connectors per cellular modem. Starting with CAT-18, there are four connectors per modem. The reason for this is MIMO suppose which requires additional antenna, which allows achieving higher throughput and increased reliability.

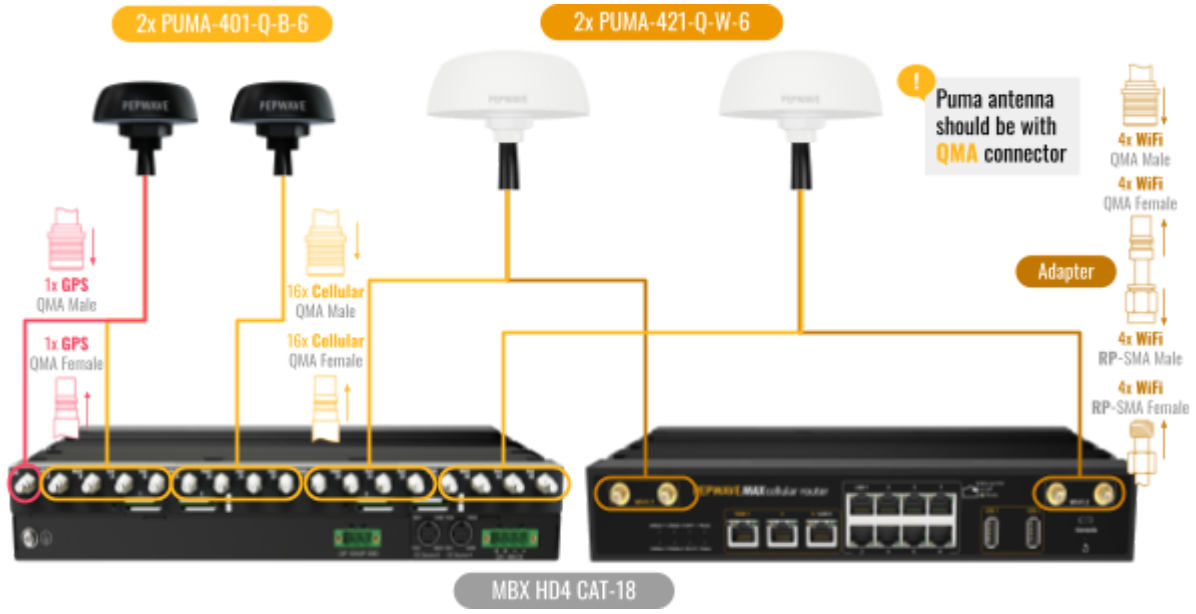
Suggested Puma Antennas for Peplink routers

Peplink router	Puma model
Balance 20X	221
Balance 30	221
MAX BR1 (Classic, Mini, Mini Core, MK2, Pro) MAX Transit Mini, MAX Transit	221
MAX Transit (CAT-18, Duo)	421
MAX HD2	421 + 020
MAX HD2 Mini	401
MAX HD4	2x 401 + 2x 020 OR 2x 421
MAX HD4 MBX CAT-12	2x 401 + 2x 020 OR 2x 421
MAX HD4 MBX CAT-18 / 5G	2x 401 + 2x 421 (QMA Puma required)
SpeedFusion Engine	401 (adapter required)

Configuration Examples of our Routers, Antennas and Extension Cables

MBX - 6 ft (2m) scenario

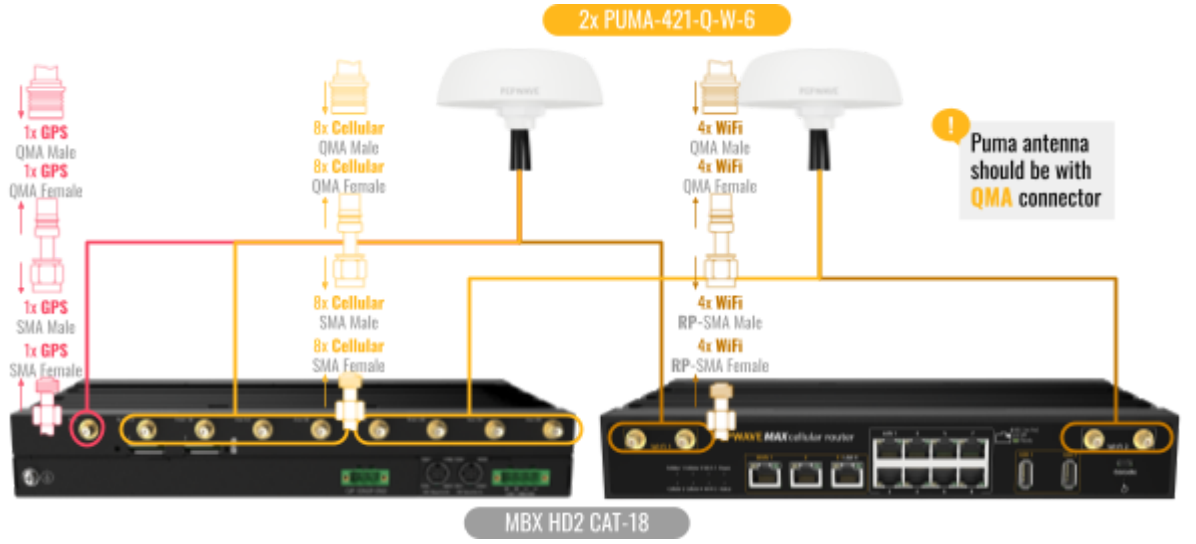
MBX connected directly to Puma antennas*



MBX HD4 CAT-18	2x PUMA-401-Q-B-6	Adapter	2x PUMA-421-Q-W-6
1x GPS QMA Female	1x GPS QMA Male		
16x Cellular QMA Female	8x Cellular QMA Male		8x Cellular QMA Male
4x Wi-Fi RP-SMA Female		4x Wi-Fi RP-SMA Female - QMA Male	4x Wi-Fi QMA Male

MBX - with 15ft (4.5m) extension cables scenario

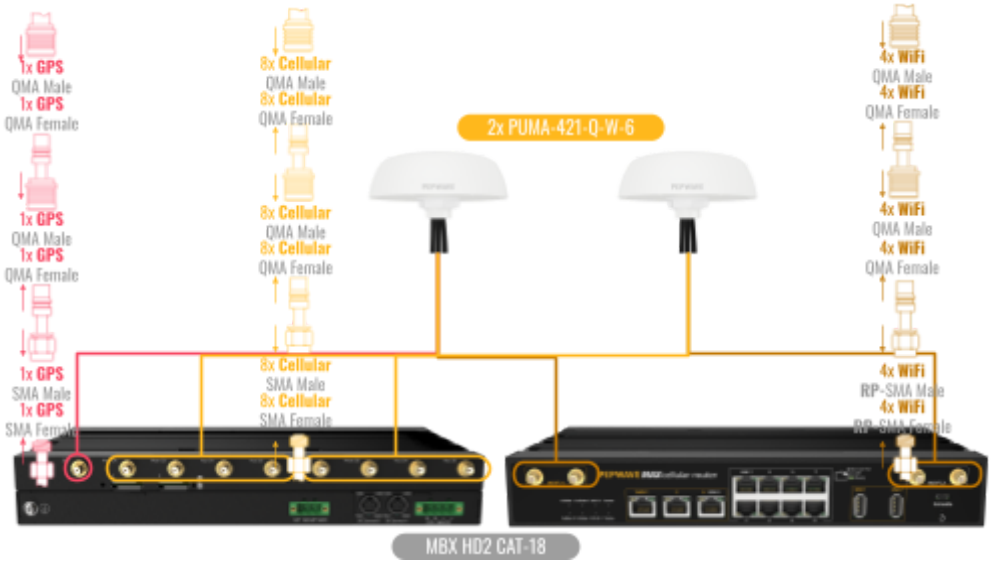
MBX connected to Puma antennas* with 15ft (4.5m) extension cables



MBX HD2 CAT-18	Extension cables 15ft (4.5m)	2x PUMA-421-Q-W-6
1x GPS SMA Female	1x SMA Male - QMA Female (EXC-SQ-15)	1x GPS QMA Male
8x Cellular SMA Female	8x SMA Male - QMA Female (EXC-SQ-15)	8x Cellular QMA Male
4x Wi-Fi RP-SMA Female	4x RP-SMA Male - QMA Female (EXC-RQ-15)	4x Wi-Fi QMA Male

MBX - with 30ft (9m) extension cables scenario

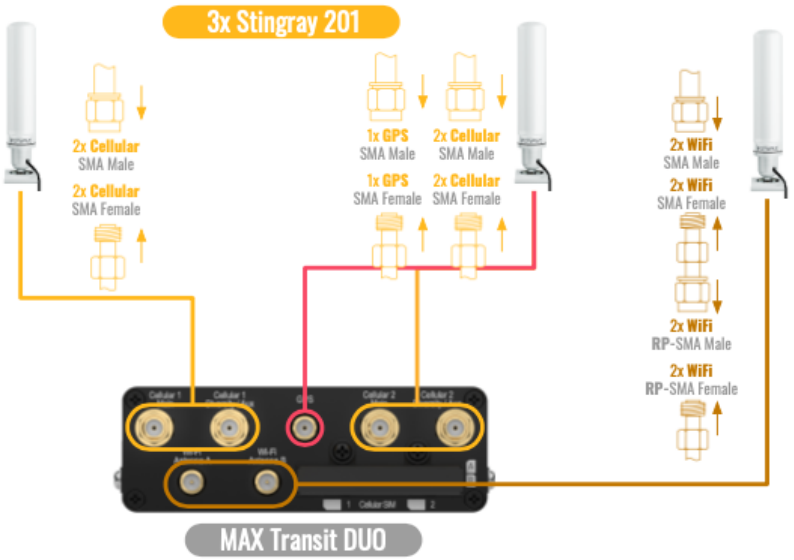
MBX connected to Puma antennas with x 15ft (4.5m) extension cables



MBX HD2 CAT-18	Extension cable 15ft (4.5m)	Extension cable 15ft (4.5m)	2x PUMA-421-Q-W-6
1x GPS SMA Female	1x SMA Male - QMA Female (EXC-SQ-15)	1x QMA Male - QMA Female (EXC-QQ-15)	1x GPS QMA Male
8x Cellular SMA Female	8x SMA Male - QMA Female (EXC-SQ-15)	8x QMA Male - QMA Female (EXC-QQ-15)	8x Cellular QMA Male
4x Wi-Fi RP-SMA Female	4x RP-SMA Male - QMA Female (EXC-RQ-15)	4x QMA Male - QMA Female (EXC-QQ-15)	4x Wi-Fi QMA Male

Transit DUO

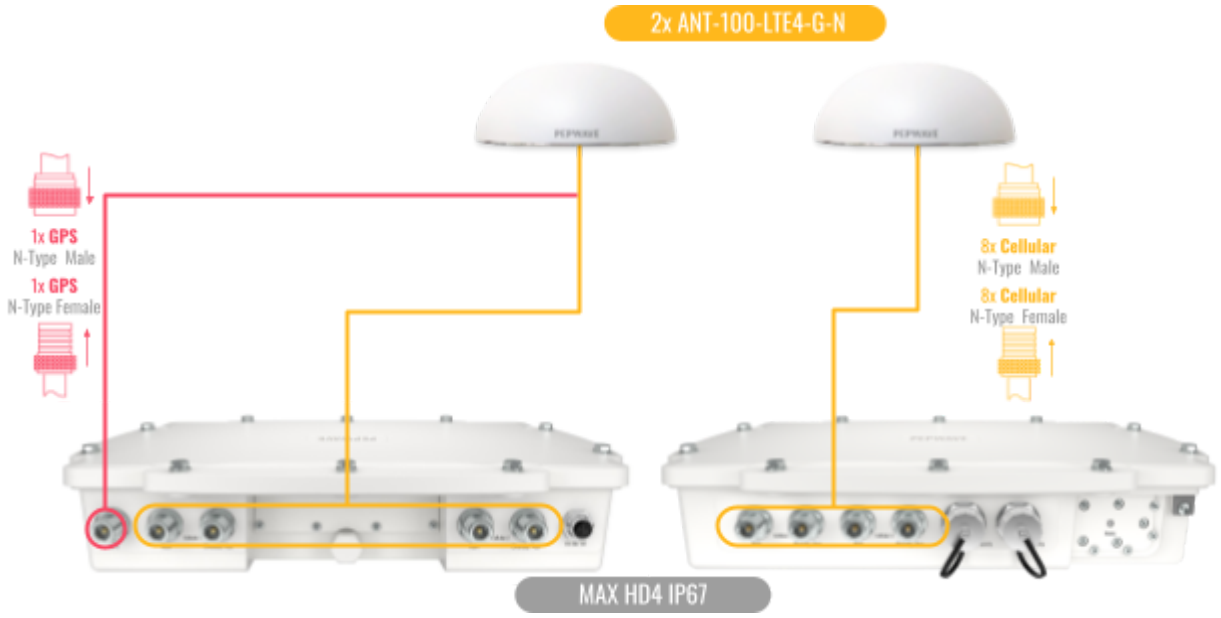
Transit DUO with Stingray antennas



MBX Transit DUO	Adapter	2x Stingray 201
1x GPS SMA Female		1x GPS SMA Male
4x Cellular SMA Female		4x Cellular SMA Male
2x Wi-Fi RP-SMA Female	2x Wi-Fi RP-SMA Male - SMA Female	2x Wi-Fi SMA Male

IP67 HD4

IP67 HD4 with ANT-100-LTE4-G-N



IP67 HD4	2x ANT-100-LTE4-G-N
1x GPS N-Type Female	1x GPS N-Type Male
8x Cellular N-Type Female	8x Cellular N-Type Male

Causes of Low Signal

Cable & Antenna Installation Checklist

	Dos	Don'ts
Cables	• No splitters • Short cable runs • High-quality cables • Few connectors	• Passive splitters • Long cable runs • Low-quality cables • Lots of connectors
Antenna	• Good antenna placement (360º unobstructed) • Good antenna selection	• Bad antenna placement (blind spots) • Bad antenna selection

Further reading for Peplink Partner:
https://forum.peplink.com/t/antenna-selection-guide-for-peplink-partners/13969

