Wireless Antenna Properties

What is F/B?

F/B stands for Front-to-Back Ratio. It is the ratio (in dB) between the forward gain to the gain off the rear of the wireless antenna. The forward gain is the peak gain on the main lobe of the wireless antenna. The gain off the rear may be defined as the gain at exactly 180 degrees from the main lobe, or it may be defined as the average or peak gain from 90 degrees to 270 degrees from the main lobe. The second definition of rear gain is the best to use. A F/B of 10-15 dB is considered fair or poor. A F/B of 15-20 dB is considered good, and F/B of 20-30 dB is very good. F/B above 30 dB is superior!

What Antenna Polarization should I use?

Most Point-to-Multipoint Wireless LAN systems use V-Pol (vertical polarization). This allows the use of inexpensive vertical omni directional wireless antennas. Higher-density areas are beginning to use more H-Pol (horizontal polarization) antennas for PTMP. Point-to-Point (backhaul) systems may use either vertical or horizontal polarization as long the same polarization is used at each end. Horizontal polarization may perform slightly better when transmitting through a forested area, otherwise there is very little difference in propagation effects. Most standard Telex Wireless antennas are vertical polarization except -H versions of the dish antennas and the 2445AA sector antenna. The 2401 patch antenna may be mounted for either polarity.

Will CP (Circular Polarization) help my system?

Normally, a wireless LAN or wireless ISP has a set of channels or frequency sets that are either vertically-polarized or horizontally-polarized, or some of each. Since the Circular Polarized wireless antenna responds (theoretically) equally to either polarization at a level of 3 dB down from maximum signal, there is not much reason to add CP to a system that already has vertical, horizontal or both polarizations. This won't gain additional spectrum for the wireless ISP. Polarization discrimination is generally a good thing, and CP wireless antennas have no discrimination against linear-polarized signals or interference. However, CP wireless antennas do work well in situations where the polarization is not pure vertical or pure horizontal, such as in downtown areas with lots of multiple reflections from buildings, airborne applications, over-water systems and indoor applications where the client antenna can be either vertical or horizontal or anywhere in between (such as a laptop or PDA antenna). The 2405 circular polarized, ceiling-mount wireless antenna works great in these indoor situations.

What is the Half-Power beamwidth?

In a radiation pattern cut containing the direction of the maximum of a lobe, the angle between the two directions in which the radiation intensity is one-half the maximum value". The Half-power beamwidth is also commonly referred to as the 3-dB beamwidth. Beamwidth typically decreases as antenna gain increases.

What is VSWR?

VSWR stands for Voltage Standing Wave Ratio. It is the ratio of the maximum/minimum values of standing wave pattern along a transmission line to which a load is connected. VSWR value ranges from 1 (matched load) to infinity for a short or an open load. For most wireless LAN antennas the maximum acceptable value of VSWR is 2.0. VSWR of 1.5 or less is excellent. This is approximately the same as a Return Loss of 14.5 dB. What this means is that most of the signal from the transmitter to the wireless antenna is being radiated. (96% radiated and 4% reflected) A VSWR of 2.0 (return loss of 9.5 dB) means that 90% is radiated and 10% reflected.

What is a Yagi Antenna and how is it different from a Panel Antenna?

A Yagi-Uda antenna array, commonly called a Yagi Antenna, is made up of linear wire or rod-type elements, each having a length of approximately 1/2 wavelength. These elements are arranged in a row, with each element parallel to each other. The rear element in this array is called the reflector. The second element is the driven element, which is connected to the transmission line, and all other elements in front of the driven are called directors. The gain of a single Yagi antenna ranges from about 6 to 20 dBi, depending upon the length of the array. Multiple Yagi antennas may be connected together side by side in larger arrays, which may have gains from 10 to 26 dBi or higher. A single Yagi Antenna has a long, narrow profile and UHF Yagi Antennas are usually enclosed in radome tubes to protect them from the environment. Gain, sidelobe and F/B performance of a Yagi Antenna is very similar to a Panel Antenna. The main differences are the appearance and that single Yagi Antennas have approximately the same beamwidth in each plane, while a Panel Antenna may be designed for different beamwidths in each plane.

Wireless Client Equipment

For a WISP system, what wireless antennas should I use for my clients (CPE)?

This depends upon the hub antenna, cable type and length, distance, data rate and terrain. You should test your system first before a final wireless antenna selection. For WISP systems using +36 dBm EIRP at the AP and clear LOS, use the following table as a guide:

Distance (miles)	CPE Antenna Gain
0.5 - 2	7 - 9 dBi
2 - 5	9 - 15 dBi
5 - 7	15 - 20 dBi
7 +	20 - 24 dBi

FCC Wireless Rules and Regulations

How much power can I transmit on a 2.4 GHz, 10 dBi omni antenna and still be legal?

The FCC regulations for Point to Multi-Point allows only 36 dBm (4 watts) EIRP. This is 30 dBm (1 watt) into a 6 dBi antenna. If you use a 10 dBi wireless antenna, you must limit your transmitter (or amplifier) to 26 dBm (10 + 26 = 36 dBm). For a 14 dBi panel wireless antenna, this allows a 22 dBm transmitter (or amplifier). Power is measured at the antenna connector, so subtract any cable loss between the amplifier and the antenna. Refer to the following table:

Power at Antenna (dBm/Watts)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (watts)
30 dBm (1 W)	6	36	4
27 dBm (500 mW)	9	36	4
24 dBm (250 mW)	12	36	4
21 dBm (125 mW)	15	36	4
18 dBm (62 mW)	18	36	4
15 dBm (31 mW)	21	36	4
12 dBm (15 mW)	24	36	4

How much power can I transmit with in my Point-to-Point system?

According to FCC regulations, 2.4 GHz Part 15.247 point-to-point transmitters may use a 30 dBm transmitter with a 6 dBi antenna. For a 3 dB increase in antenna gain, the transmitter power output must be reduced by 1 dB. Power is measured at the antenna connector, so subtract any cable loss between the amplifier and the antenna. Refer to the following table.

Power at antenna (dBm/watts)	Max Antenna Gain (dBi)	EIRP (dBm)	EIRP (watts)
30 dBm (1 W)	6	36	4
29	9	38	6.3
28	12	40	10
27 dBm (500 mW)	15	42	16
26	18	44	25
25	21	46	39.8
24 dBm (250 mW)	24	48	63
23	27	50	100
22	30	52	158

Is the Customer or Client (CPE) system considered Point to Multi-Point or Point to Point?

If the CPE system (or Subscriber Unit - SU) only talks with the POP/AP and is at a fixed location, then it is considered to be PtP and can use power and antenna gain associated with PtP systems, as shown below. (This has been verified by FCC Certified systems using a 26 dBm radio and a 17 dBi antenna) If a CPE system is part of a mesh network, then it is considered PtMP.

How much power can I transmit on a 5.3 GHz 10 dBi omni and still be legal?

The FCC regulations for PtMP and PtP allows only 30 dBm (1 watt) EIRP in the UNII-2 band. This is 24 dBm (250 mW) into a 6 dBi antenna. If you use a 10 dBi antenna, you must limit your transmitter (or amplifier) to 20 dBm (10 + 20 = 30 dBm). For a 15 dBi panel antenna, this allows a 15 dBm transmitter (or amplifier). Power is measured at the antenna connector, so subtract any cable loss between the amplifier and the antenna.

Power at Antenna (dBm/Watts)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (watts)
24 dBm (250 mW)	6	30	1
21 dBm (125 mW)	9	30	1
18 dBm (62 mW)	12	30	1
15 dBm (31 mW)	15	30	1
12 dBm (15 mW)	18	30	1
9 dBm (7 mW)	21	30	1
6 dBm (4 mW)	24	30	1

How much power can I transmit on a 7 dBi omni on 5.8 GHz and still be legal?

The FCC regulations for PtMP allows only 36 dBm (4 watts) EIRP in the UNII-3 band. This is 30 dBm (1 watt) into a 6 dBi antenna. If you use a 7 dBi antenna, you must limit your transmitter (or amplifier) to 29 dBm (7 + 29 = 36 dBm). For a 15 dBi sector antenna, this allows a 21 dBm transmitter (or amplifier). Power is measured at the antenna connector, so subtract any cable loss between the amplifier and the antenna.

Power at Antenna (dBm/Watts)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (watts)
30 dBm (1 W)	6	36	4
27 dBm (500 mW)	9	36	4
24 dBm (250 mW)	12	36	4
21 dBm (125 mW)	15	36	4
18 dBm (62 mW)	18	36	4
15 dBm (31 mW)	21	36	4
12 dBm (15 mW)	24	36	4

How much power can I legally transmit on a 23 dBi panel at 5.8 GHz?

Power at Antenna (dBm/Watts)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (watts)
30 dBm (1 W)	6	36	4

30 dBm (1 W)	9	39	8
30 dBm (1 W)	12	42	16
30 dBm (1 W)	15	45	31
30 dBm (1 W)	18	48	62
30 dBm (1 W)	21	51	125
30 dBm (1 W)	23	53	200

Wireless Antennas in Point to Multi-Point

How do I know which wireless access point antenna to select for my outdoor WLAN / WISP?

This depends on how your subscribers or clients are located with respect to the access point and what type of terrain is in between. You can place an omni-directional antenna such as our 2439 (10 dBi gain) near the middle of your group of clients at a hub (Access Point) location. This works best if your facilities/customers are no more than 6 miles (9.5 km) from the hub and unobstructed by hills, trees or buildings. You may also select to use several sector antennas at an Access Point location.

How high should I place my outdoor wireless Access Point antenna?

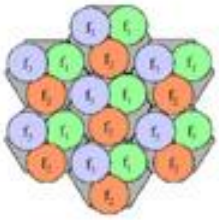
This depends upon a lot of factors. If you have a building with roof access, this is usually the best option, since the feedline losses may be minimized if the equipment can be placed near the antennas. A minimum height is usually around 75 feet. This places the antennas above most trees. This height will also give a radio horizon of approximately 12 miles, assuming flat terrain. If you have taller trees, or tall buildings nearby, you may wish to use an antenna height of 200 feet or more. This gives a radio horizon of 14 miles. As towers may fall under local zoning ordinances, you may also wish to consider water towers, grain elevators or utility poles as other options. Placing Aceess Point antennas higher than 100 feet exposes them to greater amounts of interference, more feedline losses, zoning restrictions, FAA lighting requirements, and larger cell areas.

What are the advantages of using Sector Antennas instead of an Omni-Directional Antenna?

There are several good reasons to use sector antennas:

- **More capacity** - By using 3 sector antennas on DSSS channels 1, 6 and 11 with 3 AP's, you can triple the number of clients in a given area.
- **Better signal levels** - Sector antennas usually have more gain than omni's and can be mechanically down tilted to focus where the users are. This results in fewer retries and less packets lost. A WIPOP sector antenna will pay for itself if just one customer did not need an amplifier.

- **Channel Re-Use** - Because the sector antenna can be down tilted, the signals are not thrown out to the horizon. This allows that channel to be re-used several miles away at a different cell site.
- **Eliminate interference** - Because a sector antenna is directive and usually has good front-to-back (F/B), it can reduce or eliminate interference from sources that are behind the sector antenna.



Example of channel reuse

How do I hook up four 90 degree sector antennas on one tower?

Conventional thought says that there aren't enough non-overlapping 2.4 GHz DSSS channels to put 4 channels on one tower. Usually, panel antennas with high F/B are selected, and channel 1 antennas are placed on opposite sides (e.g. North & South) and channel 11 antennas are also placed on opposite sides (e.g. East & West). If separate access-points are used for all 4 antennas, the isolation may need to be increased between antennas on the same channel by spacing them farther from the tower face or on opposite corners of a building. FHSS systems may use separate frequency sets on each panel without problems.

However, there is new evidence that supports the use of DSSS channels 1,4,8 and 11 on the same tower. Isolation will need to be increased between antennas in this case by spacing them farther from the tower face, or by vertical separation of 10 feet or more.

What wireless antenna should I use to cover a small campus area of a few buildings?

If your coverage area is small with distance to the hub of less than a mile (1.6 km), a small omni directional antenna such as our 2437AA (7.5 dBi gain) may be used. If the AP will be located on the edge of the campus, a 120 degree sector antenna such as our 2443AA 12 dBi panel antenna may be used.

What wireless antennas should I use for my clients (CPE)?

This depends upon the hub antenna, cable type and length, distance, data rate and terrain. You should test your system first before a final wireless antenna selection. For WISP systems using +36 dBm EIRP at the AP and clear LOS, use the following table as a guide:

Distance (miles)	CPE antenna gain
0.5 - 2	7 - 9 dBi
2 - 5	9 - 15 dBi
5 - 7	15 - 20 dBi
7 +	20 - 24 dBi

Wireless Antennas in Point to Point

What wireless antennas should I use for Point to Point wireless data transmission?

Directional antennas should be used for point-to-point wireless transmission. The type of directional antenna depends upon the power output, cable type and length, height, distance, data rate and terrain. We recommend the use of a range table to estimate the wireless antenna types. Whichever wireless antenna you choose, make sure that it is FCC certified with your radio!

Is the Customer or Client (CPE) system considered Point to Multi-Point or Point to Point wireless?

If the CPE system (or Subscriber Unit - SU) only talks with the POP/AP and is at a fixed location, then it is considered to be Point to Point wireless and can use power and antenna gain associated with Point to Point wireless systems, as shown below. (This has been

verified by FCC Certified systems using a 26 dBm radio and a 17 dBi antenna) If a CPE system is part of a mesh network, then it is considered Point to Multi-Point.

How do I perform a Point to Point wireless site survey?

Initially, create a path profile using one of the various mapping programs. If LOS and Fresnel zone clearance seems good, check for trees and other unusual obstacles to LOS. A good way to check this is to place a person at each end of the path with a high-powered flashlight and a cell-phone. While talking with each other, flash the light so that the other person can see it. UHF hand-held radios (FRS or commercial frequencies) also work well to determine LOS. Use 1 watt radios for up to 4 miles and 5 watt radios for up to 15 miles. If results look promising, place an AP at one end and a CPE at the other and try connecting using 19-24 dBi grid or panel antennas. (Do not swing both directional antennas at the same time!) Look for interference at each end by using a spectrum analyzer and both vertical and horizontal polarized antennas.

How much power can I use on the new 3.65 GHz band?

Power at Antenna (dBm/Watts)	Max Antenna Gain (dBi)	EIRP (dBm)	EIRP (watts)
30 dBm (1 W)	14	44	25
29	15	44	25
28	16	44	25
27 dBm (500 mW)	17	44	25
26	18	44	25
25	19	44	25
24 dBm (250 mW)	20	44	25
23	21	44	25
22	22	44	25
21	23	44	25
20	24	44	25