
# How to extend range? Practical tips to eliminate blind spots.

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**Topic**

- Amplifier
- Antennas
- Antennas: AP Side
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- Dipole
- Directional
- Yagi
- Parabolic
- Electronically steer-able antenna
- Lightning protection & grounding

There are two ways to increase the range of WiFi systems – antennas and amplifiers. We are going to examine the pros and cons of the choice under various situations, so that you can determine the best option to extend range.

## Amplifier

It is best practice to use the minimum power required. However, sometimes the range with off-the-shelf equipment is simply not enough to do the job. It is possible to extend the range of an AP by increasing the transmitter power, but this is limited by the legal limit, the receive link, and ultimately interference. OFTA regulation limits the transmission power output. If you use an amplifier to increase the transmitter power, the transmit range will be increased, but it will also be necessary to either increase the power of the other transmitter or increase the receive sensitivity of the receiver since the link budgets have to be more or less balanced. Increasing the power also has another drawback: It causes interference to other users and does not eliminate sources of interference on the receive side. Both amplifiers used on the transmitter and receiver also have another drawback. Amplifiers blindly increase both the signal and the noise. Usually, amplifiers are used in combination with good antenna systems.

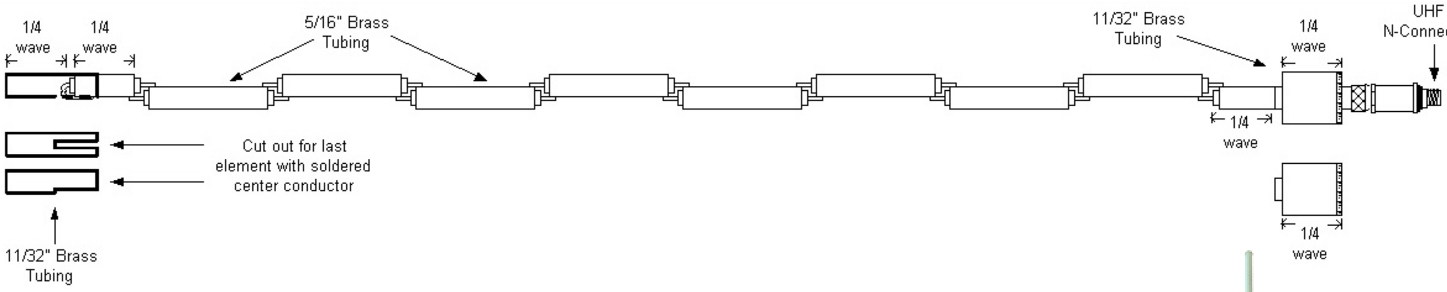
Amplifiers are available for use in the 2.4 to 2.4835 ISM band with a power output up to 1 watt. Models with more power output can be used, but they are only usually sold to licensed amateur radio operators or to export and military accounts. Amplifiers are built for a variety of applications on the ISM band. Thus, it is important to buy one that is suitable or optimized for the modulation (FHSS, DSSS, and/or OFDM) that is being used. Most amplifiers are usually intended to mount right at the antenna and are often fed DC power over coax with an injector. The amplifier has to have a signal applied to it that is within a certain power level. Feeding the amplifier with too much signal will cause it to have more power in the sidebands or “splatter.” With not enough power, the amplifier will transmit too much noise on the signal.

Certain specifications should be considered when buying amplifiers. These include harmonic products (which should be less than 70 dB), the noise figure of the receiver (the lower the better), a fast-acting auto-sense TX/RX switch (which should be fast enough for 802.11), and an AGC receiver (which prevents overloading the receiver in the presence of string signals).

## Antennas

Antennas offer another way to increase the range. Antennas limit energy directed in certain areas and redirect the energy in other areas. All antennas exhibit this to a certain extent. A theoretical antenna point

# Collinear antenna



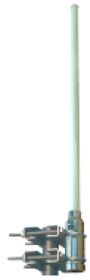



*Figure 2*

source called isotropic is used as a reference for all other antennas. Thus, the gain of an antenna is measured in terms of dBi, which stands for decibels relative to an isotropic radiator or decibels over isotropic. Omni-directional antennas generally have between 2 and 10 dBi, whereas directional antennas can have between 3 and 25 dBi of gain.

OFTA regulations limit how much gain a transmitting antenna can have, but antennas have to distinct advantages over amplifiers. One, an antenna offers gains in both the transmit side and the receive side. Thus, the impact on the link budget is balanced. The other is that antennas help the interference problem. The transmitter only transmits the signal where it is needed and the receiver only listens to where the antenna is pointed. This has the effect of limiting interference by not transmitting where other users are while receiving more of the intended signal and less of the interfering station (unless of course the interfering station is located in the same antenna path as the intended station).

A number of antennas are available for both AP side are omni-directional antennas like dipoles and collinear, as well as directional antennas like path, yagi, grid, and dish antennas. Also, special phased arrays are available that are combined with APs. On the client adapter side are desk antennas, handheld yagis, and magnet mounts.

## Antennas: AP Side

It can be said that the wireless internet resolution is a silent and invisible revolution except for one thing: antennas. Antennas are the one visible aspect of 802.11. The type of antenna employed determines the range and application involved with a given deployment. The following paragraphs describe the characteristics of the different antenna technologies employed in 802.11.

# Omni-directional antenna

## Omni-directional

Omni-directional antennas transmit their signal in all horizontal directions almost equally. The radiation pattern has the shape of a large donut around the vertical axis, as in Figure 1.

The gain is in the horizontal direction at the expense of coverage above and below the antenna. The rubber duckies (the flexible antenna structures on popular access point units) that come with many APs are dipoles that usually have 2.2 dBi of gain. Plenum-rated APs with external dipoles work well mounted above ceiling tiles. Some APs have integrated dipoles antennas and are suitable for both walls and ceilings.

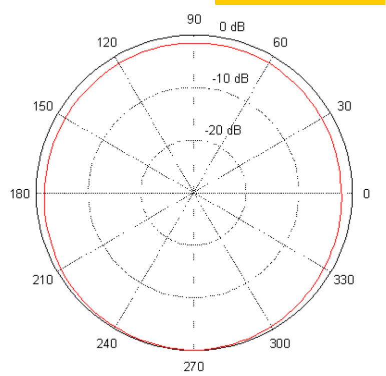
For more gain, or an outdoor omni-directional, consider a collinear antenna. Typically, a collinear omni-directional antenna looks like a permanent vertical circuit (PVC) pipe that is between one and five feet tall and has an N connector at the end. Gain for these antennas is between 3 and 12 dBi. A collinear antenna is shown in Figure 2 above.

## Vertical

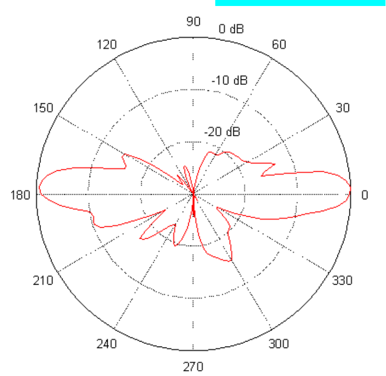
This is a garden variety omni-directional antenna. Most vendors sell several differ-

*Radiation pattern of an omni-directional antenna*
*Figure 1*

**H-Plane**




**E-Plane**



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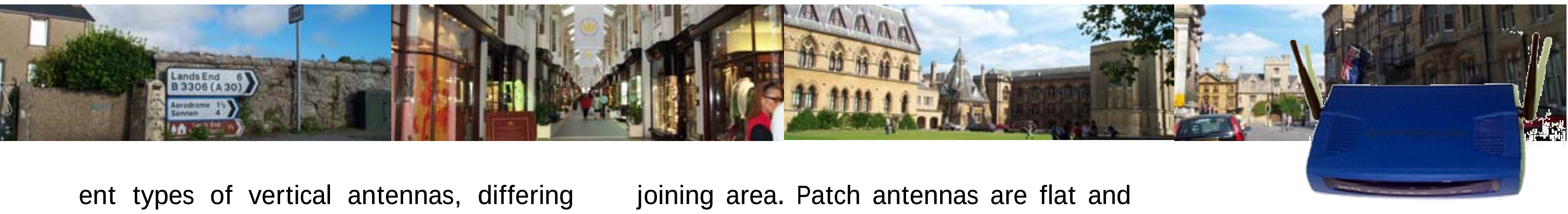
# Dipole antenna

*Radiation pattern of a dipole antenna*
*Figure 3*



ent types of vertical antennas, differing primarily in their gain; you might see a vertical antenna with a published gain as high as 10 dBi or as low as 3 dBi. How does an omni-directional antenna generate gain? Remember that a vertical antenna is omni-directional only in the horizontal plane. In three dimensions, its radiation pattern looks something like a donut. A higher gain means that the donut is squashed. It also means that the antenna is larger and more expensive, though no antennas for 802.11 service are particularly large.

Vertical antennas are good at radiating out horizontally; they are not good at radiating up or down. In a situation like this, it is better to mount the antenna outside a first- or second-story window. Verticals, like the rubber 2.2dBi rubber duckies, are in a sense vertical dipoles.

## Dipole

A dipole antenna has a figure-eight radiation pattern, which means it's ideal for covering a hallway or some other long, thin area. Physically, it won't look much different than a vertical. Some vertical antennas are simply vertically mounted dipoles. See Figure 3.

## Directional

To shape an antenna to a particular part of a building, patch antennas can be used. For example, one may place a patch antenna near the outside of a building to aim the signal toward the inside of the building. In another case, a patch antenna can be used to limit the signal in an adjoining area. Patch antennas are flat and typically between four and six inches square and have a variety of coax connectors available. They are typically wall mounted. The coverage pattern for a directional antenna looks like Figure 4. The gain for a patch antenna is typically between 2 and 15 dBi, and it has a wide beam width.

Sector panel antennas are often used outdoors to cover a sector of a cell. They typically cover 180, 120, or 90 degrees in beam width and have gains between 12 and 20 dBi. These antennas are commonly fitted with an N connector.

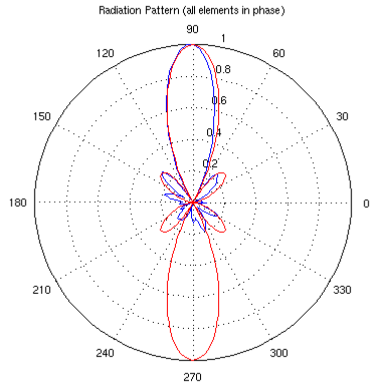
## Yagi

For a point-to-point shot, consider a Yagi antenna. A Yagi antenna is a moderately high-gain unidirectional antenna. It looks somewhat like a classic TV antenna or like washers threaded on a rod. Often, Yagi antennas are mounted inside a PVC pipe to protect them from the weather. A number of parallel metal elements are set at right angles to a boom. Commercially made Yagis are enclosed in a radome. Yagi antenna for 802.11 service have gains between 12 and 18 dBi; aiming them is not as difficult as aiming a parabolic antenna, though it can be tricky. A Yagi in a radome is shown in Figure 5. The gain is fairly high, around 15 to 20 dBi.

## Parabolic

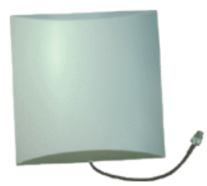
For long distance point-to-point shots, choose a parabolic grid or a disk antenna. This is a very high-gain antenna. Figure 6 shows a parabolic grid antenna. Because

**H-Plane**

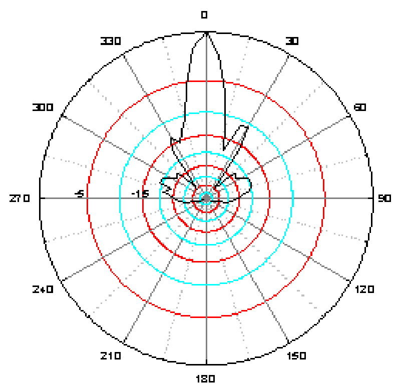



# Patch antenna

*Radiation pattern of a patch antenna*
*Figure 4*



**H-Plane**



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# Yagi antenna in a radome

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parabolic antennas have very high gains (up to 24 dBi for commercially made 802.11 antennas), they also have very narrow beam widths. Parabolic antennas are used for a link between buildings. Because of the narrow beam width, they are not useful for providing services to end users Vendors publish ranges of up to 20 miles for their parabolic antennas. Presumably, both ends of the link use a similar antenna. Front-to-back ratios and wind load are important factors to consider in parabolic grid antennas.

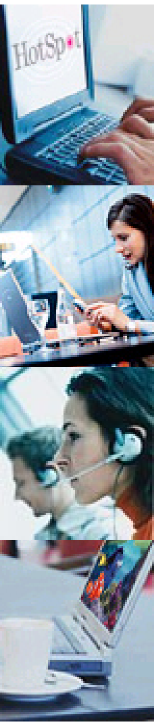
lead should run from the rooftop antenna clear down to the ground rod with a minimum of bends in the line. The Ethernet connection should have a lightning arrestor on it that is connected to the ground system before going into the building. Also, it is helpful to put a loop in the Ethernet cable near the AP or bridge and near where it goes into the building. d

## Electronically Steer-able Antenna

The best approach to optimize network performance is to maximize the antenna gain to and from the intended subscriber and minimize it elsewhere. Recently, hockey-push-shaped steer-able antennas, six inches across and three inches high, have become available on 2.4 GHz and offer 6 dBi of gain. These can be used with a laptop. Models that can be adapted to APs will follow.

## Lightning Protection & Grounding

It is important to properly ground any external antenna. Many volumes have been written about lightning protection, grounding, and bonding. Refer to these and the manufacturer's suggestion. However, if these are not provided, one of the key things to do is to provide an adequate ground through a ground rod. A ground



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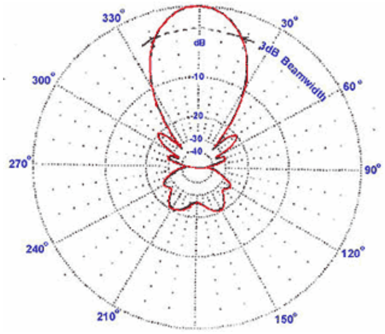
*Radiation pattern of a yagi antenna*
*Figure 5*

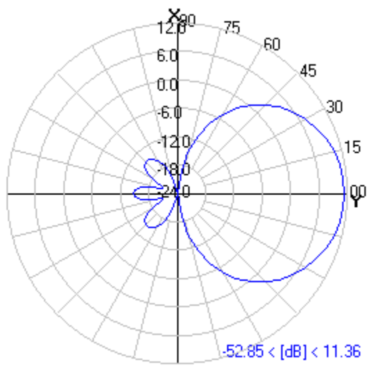
**H-Plane**




# Parabolic antenna

*Radiation pattern of a parabolic antenna*
*Figure 6*

**H-Plane**



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