Linksys

Antenna Basics

Jim Harrington – 11/19/01

Antenna: Any structure or device used to collect or radiate electromagnetic waves.

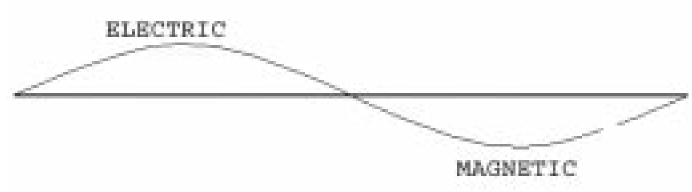
In 1895 Guglielmo Marconi, a twenty-year-old Italian inventor, created a device that transmitted and received electromagnetic radio waves over a one-kilometer distance. Later improvements to his antenna and the development of a crude amplifier enabled him to receive a British patent for his wireless telegraph.

How do antennae transmit and receive radio signals?

Transmitting antennae cause electrons to vibrate; this oscillating *electric* field creates an oscillating *magnetic* field. The result is the propagation of electromagnetic waves. When a receiver is tuned to the same frequency as a transmitter, the radio wave creates an electric current in the receiving antenna which is sent to the radio receiver.

What is a Wavelength?

Radio waves are composed of both an electrical field and a magnetic field. The wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crests.



One Wavelength

Frequency refers to the number of cycles of a wave passing a fixed point per unit of time. Frequency is normally measured in **Hertz** (Hz), equivalent to one cycle per second, and various multiples of Hertz. Therefore, the two are inversely related to each other. Shorter wavelengths create higher frequency - the longer the wavelength, the lower the frequency.

About Gain & Desired Coverage

This should be the first consideration of antenna selection. The only way to increase gain is to concentrate power in a more narrow beam. Think of a standard light bulb – it spreads light in every direction. A narrow-beam flashlight concentrates light in a more specific direction. With a narrow beam, we achieve greater gain.

Antenna performance is primarily established by its gain. There are three common references used when defining antenna gain: dBd, dBi and dBm (dB = decibel). Gain referenced to a dipole is listed as dBd. Gain referenced to an isotropic source is listed as dBi. dBm refers to gain compared to 1 milliwatt.

What is an isotropic source? If you pick an imaginary point in space and from that point all of your power is transmitted, that is an isotropic source. Gain referenced to this point is dBi.

When gain figures are listed as dBd, they are using a 1/4 wave dipole cut for the center frequency of the band of interest as the reference. If an antenna is specified in dBi gain, it will appear to have approximately 2.15 dB higher gain than dBd. This may be a nice way to inflate the numbers but it does not mean that there is more gain when dBi is the reference.

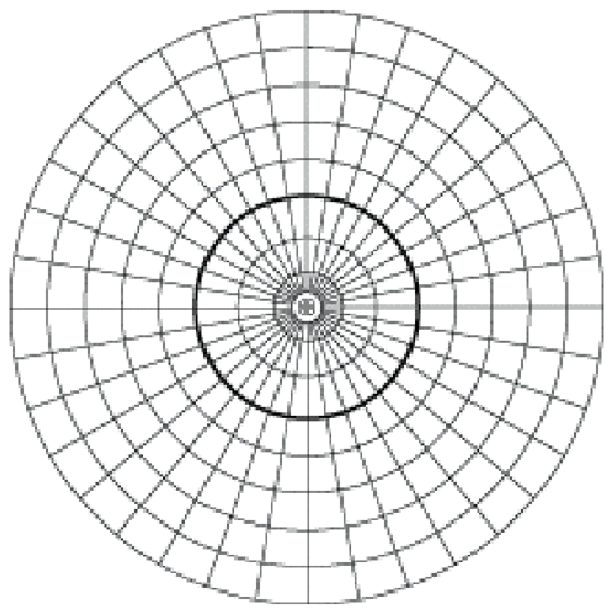
The table below shows a breakdown of dBm to milliwatt values.

(dBm)	mW		(dBm)	mW		(dBm)	mW
0	1		11	12.5		21	128
1	1.25		12	16		22	160
2	1.56		13	20		23	200
3	2		14	25		24	256
4	2.5		15	32		25	320
5	3.12		16	40		26	400
6	4		17	50		27	512
7	5		18	64		28	640
8	6.25		19	80		29	800
9	8		20	100		30	1 watt
10	10						

Gain usually influences the type and size of an antenna. Higher gain means a larger antenna.

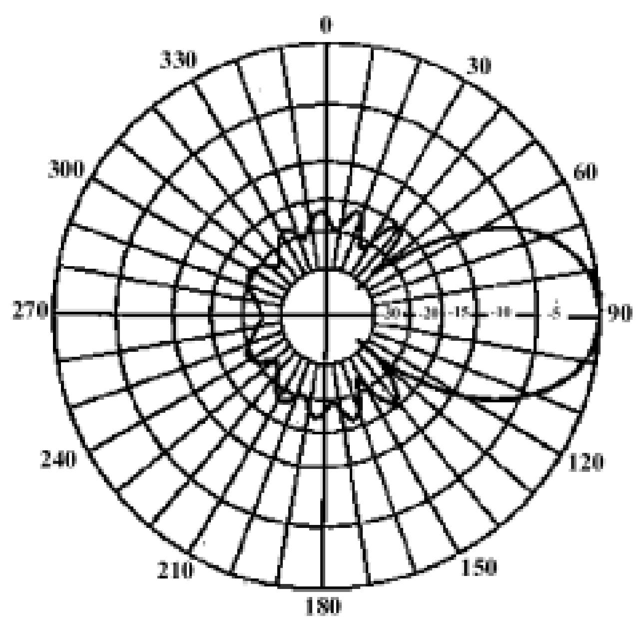
$$G = \frac{\text{Power radiated by an antenna}}{\text{Power radiated by reference antenna}}$$

Omni directional antennae are often used for line-of-sight communications with mobile stations spread out in all directions. They offer zero gain. So, since we don't need to broadcast to the clouds, the antenna gain can be increased by using a collinear type of omni that decreases the vertical beamwidth and concentrates more power on the horizon where it will be most beneficial. This is the type of antenna that is used in the Linksys Instant Wireless series.



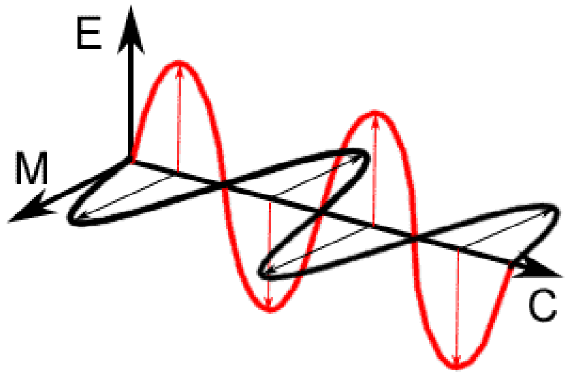
Omnidirectional Coverage

Likewise, panel antennae are used to concentrate the signal on a specific sector (typically 30 to 120 degrees in azimuth) with a narrow elevation beamwidth. Yagi antennae, parabolic dishes and patch arrays are usually designed for high gain and hence have a narrow beamwidth in both the azimuth and elevation plane. A typical high-gain Yagi antenna pattern is shown below:



Polarization

The polarization of an antenna may be linear, circular, or elliptical. Linear polarization, usually vertical, is used almost exclusively in the 802.11b arena. Below is an example of horizontally and vertically Polarized electromagnetic waves.



The polarization of each antenna in a system should be properly aligned. Maximum signal strength between stations occurs when both stations are using identical polarization. Transmitting and receiving antennae that have a misalignment of polarization of 90 degrees may degrade the signal up to 20dB. This is an especially important consideration when installing directional (e.g. flat panel) antennae.

VSWR – Voltage Standing Wave Ratio

Describes how much of the power the antenna is transmitting is being reflected back. If you have ever thrown a rock into a pond, you see a splash and a series of concentric circles spreading out from where the rock landed in the water. This is an analogy that can help demonstrate RF waves. This happens around an antenna when power is applied to it. Therefore, the more energy that goes away from the antenna, the better. However, when RF is transmitted some radiated energy is left behind and received by the antenna. This energy returns to the radio affecting the overall performance.

Linksys products contain antennas, receivers and transmitters are designed for peak performance when operating into a 50 Ohm transmission line. If the VSWR is too high, the transmitter power as well as the strength of the received signal may be reduced.

Final Thoughts

Whatever is true for transmission is true for reception. Antennae are affected by whatever is near. This is especially true for any metal object located within a wavelength of the antenna (about 125mm for 802.11b) as it will become parasitic.

An antenna, being a passive device, does not add any power to a signal. An antenna emits only the power it receives from an amplifier. Separating an antenna from the transmitter creates signal loss. When using an external antenna, it is important to keep cable lengths of high quality and of a short length.

There are no “typical” set of conditions in any environment. Every room has reflections and “dead” spots; every position and every frequency has different field intensity. Any antenna that is used should be as close as possible to the proper wavelength in ¼ wave lengths. Typically, 802.11b devices use the 2.4 GHz band, so the wavelength is about 125mm.

Glossary:

Beam: The major lobe of the radiation pattern.

dB: *Abbreviation for* **decibel(s).**

Dipole antenna: Usually a straight, center-fed, one-half wavelength antenna.

Gain: The ratio of output current, voltage, or power to input current, voltage, or power, respectively.

Hertz (Hz): A unit of frequency which is equivalent to one cycle per second.

Isotropic radiator: Refers to a hypothetical antenna having equal radiation intensity in all directions. Note: An isotropic radiator represents a convenient reference for expressing the directive properties of actual antennas.

Parabolic antenna: An antenna consisting of a parabolic reflector and a radiating or receiving element at or near its focus.

Polar diagram: The radiation pattern of an antenna.

VSWR: The voltage standing wave ratio of a component such as an antenna. It is referred to the characteristic impedance of the transmission line being used.

Yagi antenna: A Yagi antenna offers very high directivity and gain.