

Joe Carr's Radio Tech-Notes

Directional or Omnidirectional Antenna?

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Do you need a directional antenna or an omnidirectional antenna? That question is basic for amateur radio operators, shortwave listeners and scanner operators. The answer is simple: *It depends*. I would like to give you a simple rule for all situations, but that is not possible. With radio antennas, the "global solution" is rarely the correct solution for all users. In this paper you will find a discussion of the issues involved so that you can make an informed decision on the antenna type that meets most of your needs. But first, let's take a look at what we mean by "directional" and "omnidirectional."

Antenna Patterns

Radio antennas produce a three dimensional radiation pattern, but for purposes of this discussion we will consider only the *azimuthal* pattern. This pattern is as seen from a "bird's eye" view above the antenna. In the discussions below we will assume four different signals (A, B, C, D) arriving from different directions. In actual situations, of course, the signals will arrive from any direction, but we need to keep our discussion simplified.

Omnidirectional Antennas. The omnidirectional antenna radiates or receives equally well in all directions. It is also called the "non-directional" antenna because it does not favor any particular direction. Figure 1 shows the pattern for an omnidirectional antenna, with the four cardinal signals. This type of pattern is commonly associated with verticals, ground planes and other antenna types in which the radiator element is vertical with respect to the Earth's surface.

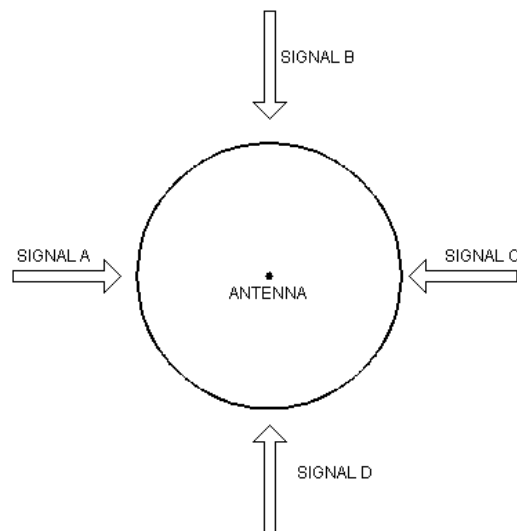


FIGURE 1

The key factor to note is that for receivers all four signals (or signals from *any* direction, for that matter) are received equally well. For transmitters, the radiated signal has the same strength in all directions. This pattern is useful for broadcasting a signal to all points of the compass (as when calling "CQ"), or when listening for signals from all points.

Directional Antennas. *Gain* and *directivity* are intimately related in antennas. The directivity of an antenna is a statement of how the RF energy is focussed in one or two directions. Because the amount of RF energy remains the same, but is distributed over less area, the apparent signal strength is higher. This apparent increase in signal strength is the antenna gain. The gain is measured in decibels over either a dipole (dBd) or a theoretical construct called an *isotropic radiator* (dBi). The isotropic radiator is a spherical signal source that radiates equally well in all directions. One way to view the omnidirectional pattern is that it is a slice taken horizontally through the three dimensional sphere.

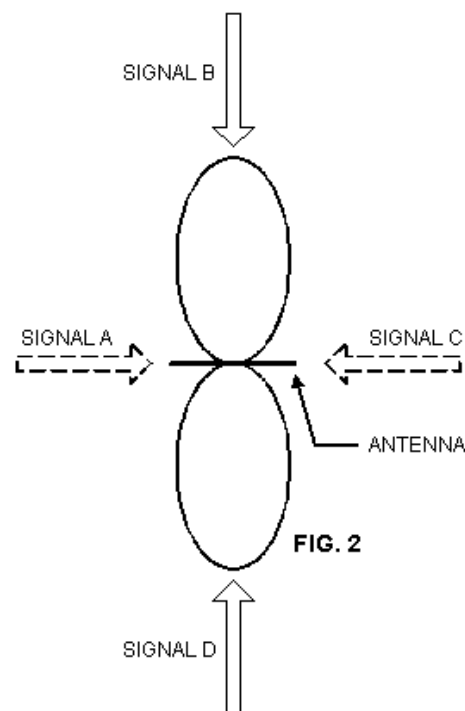


Figure 2 shows a *bidirectional* or *Figure-8* antenna pattern. This pattern is associated with half wavelength dipoles, quad loops, and a number of other antennas. There are two preferred directions (maxima) and two null directions (minima). In the half wavelength dipole the minima and maxima are positioned as shown. For receivers, signals arriving from the direction of the minima (Signal "A" and Signal "C") are suppressed because the antenna is not sensitive in that direction. The suppression is not complete, but it can be tremendous (e.g. 60 dB). The signals arriving from the direction of the maxima (Signal "B" and Signal "D") are received the loudest. For transmitters, the radiated signal is the lowest in the direction of the minima and greatest in the direction of the maxima. Again, the signal level radiated off the ends of the antenna, i.e. in the direction of the minima, is not zero, but is very low.

Local installation factors can affect the radiation pattern. In "free space," i.e. the antenna is installed at great distance from the surface of the Earth, trees, houses, wiring and so forth, the pattern will be nearly perfect. But in practical situations, the two lobes might not be equal, or the minima might be less distinct.

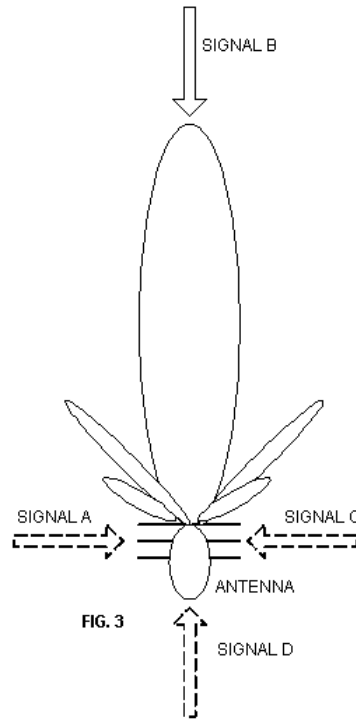
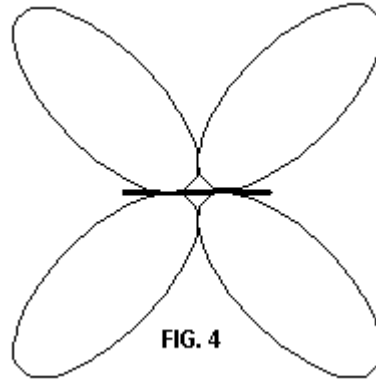


Figure 3 shows a unidirectional pattern such as found on Yagi and quad beams and certain other antennas. The main lobe is the direction of maximum radiation or reception. In addition to the main lobe, there are also *sidelobes* and *backlobes*. These lobes represent lost energy so good antenna designs attempt to minimize them. In the unidirectional antenna pattern, signals "A", "C" and "D" are suppressed, while signal "B" is maximized.

The *beamwidth* of the antenna is a measure of its directivity. In the case of the pattern of Fig. 3, the beamwidth is the width, in degrees, of the main lobe. The beamwidth is typically measured between the -3 dB points, i.e. the points on the main lobe where the signal strength drops off -3 dB (one-half) from the maximum signal point. The gain of the antenna is inversely proportional to the beam width: the narrower the beamwidth the higher the gain.

It is common practice to mount unidirectional antennas in a manner that allows the main lobe to be positioned in any direction. This approach is easily achievable on the higher frequencies of the HF shortwave bands and throughout the VHF/UHF spectrum. At lower frequencies, however, the size of the antenna is usually too large. For example, the Yagi beam uses elements about half wavelength long, so at 15-MHz the elements are about 9.5-meters (31.2-feet) long. At 4 MHz, on the other hand, they are 36-meters (118-feet) long. For any given installation a decision has to be made on the mechanical aspects because the larger beams are also very expensive to install.

Our last pattern is the *clover leaf* pattern of Fig. 4. This pattern is seen on long-wires, on center-fed dipoles that are 3/4-wavelengths long, and certain other antennas. Note that there are four main lobes positioned at angles from the antenna wire. The number and angle of these lobes is a function of the antenna design and the frequency of operation.



There are other patterns found on various forms of antennas. Indeed, the same antenna style will produce different patterns at different frequencies. We will not look at those because we only need representative patterns for our discussion.

The Decision

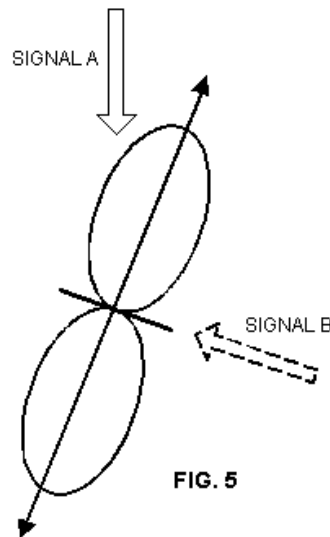
The main issue in receiving radio signals is *signal-to-noise ratio* (SNR). In this case, SNR includes undesired signals as well as more traditional forms of noise. Most authorities recommend an SNR of 3 dB (desired signal 3 dB stronger than the undesired signals or other forms of noise) for listening, and 10 dB for "comfortable" listening. Improving the SNR means that you: a) increase the signal strength, b) decrease the strength of the noise signals, or c) do both.

If you use an omnidirectional antenna all signals are noise sources look into the same antenna gain. There is neither increase of the desired signal, nor suppression of undesired signals. On a crowded band, the omnidirectional antenna confers no SNR advantage.

But, as mentioned above, the answer is "*...it depends.*" A transmitting station might wish to send signals in all directions sometimes. For example, when calling CQ when you don't care where the answers come from, the omnidirectional antenna maximizes the chances of a contact. Similarly, receiver operators may wish to listen for signals from all points on the compass. In both of these cases, the solution is an omnidirectional antenna.

Bidirectional and unidirectional antennas can be used to increase the signal strength by positioning the main lobe in the desired direction. They can also be used to null the

undesired signal or noise source by placing the minima in the right direction. Sometimes, the best use for these antennas is to compromise and attempt both tactics.



Consider Fig. 5. A desired signal ("A") and an undesired signal ("B") are both arriving at the antenna. If we wanted to maximize signal "A" then we would point the antenna maxima (indicated by the double-headed arrow) in the desired direction. We can gain a large SNR advantage if we position the null in the direction of the undesired signal, even if it means it is not optimally pointed at the desired signal. Remember, your goal is to maximize SNR.

If you use a half wavelength dipole, and it is not too large, then you can build it of aluminum tubing and rotate it like a beam.

The "Best" Solution?

Perhaps the best solution is to erect two or more antennas, and switch between them. You can purchase *coaxial switches* that allow two or more (up to sixteen) antenna feedlines to be connected to the receiver or transmitter, one at a time.

Several different schemes are popular. For example, you can erect two identical half wavelength dipoles at right angles to each other. The maxima of one dipole will be in the same direction as the minima of the other. Another scheme is to erect a vertical antenna for omnidirectional coverage and either a dipole or a beam for directional operation. A coaxial switch can be used to select between them. One amateur radio operator I know has about ten antennas, with different patterns and angles of radiation, and he uses a 16-port coaxial switch to select the antenna that's "perfect" for each case.

