Basic Electronics Part 8
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When we talk about antennas, we sometimes use a theoretically perfect antenna, called an isotropic antenna, as a reference for comparisons. This isotropic antenna is a point suspended in space so there is nothing nearby to interfere with the antenna. This theoretical point-source antenna radiates equally well in all directions. That is, an isotropic antenna favors no direction at the expense of any other—it has absolutely no directivity. We use the designation dBi to indicate that we are comparing the power from one antenna with the power that would be sent out from the isotropic antenna. Therefore, if we have an antenna that is advertised to have a gain of 9 dBi, then we take that to mean this antenna transmits eight times more power in one direction than an isotropic antenna would.

If the concept of an isotropic antenna seems a bit too contrived, consider comparing to a half-wave dipole. Many hams use a half-wave dipole antenna, so it makes a good standard for comparison. We use dBd to indicate that we are comparing our antenna to a half-wave dipole. That is, if we have an antenna that is advertised with a gain of 6 dBd, then we think of this as equivalent to increasing the power four times over that of a half-wave dipole. Of course the beauty of using a gain antenna is that you get the benefits on receive as well as transmit.

A half-wave dipole antenna has a gain of 2.15 dB greater than an isotropic antenna. The dipole concentrates the energy in certain directions, so that the radiation in those directions is greater than the radiation from an isotropic source with the same input power. Therefore, the gain of an antenna referenced to an isotropic radiator is the gain referenced to a half-wave dipole plus 2.15 dB.

All practical antennas exhibit directivity. A directional antenna (including a half-wave dipole) can be considered to concentrate the available energy fed into the antenna, focusing the energy radiated from the antenna into the desired direction. The energy radiated in the desired direction(s) is increased by reducing the energy radiated in some other direction(s).

For example, the Hy-Gain Model EXP-14 Tribander 10, 15, 20 meter yagi has an advertised maximum gain on 20 meters of 7.5 dBi (5.35 dBd). This means that the main lobe of the antenna has a power level that is 7.5 dB greater than our isotropic antenna radiating in all directions. To calculate what this means in terms of power consider the following:

$$7.5\,dB = 10\ \log\left(\frac{P_0}{P_i}\right)$$

where P_0 is the power level from the EXP-14 main lobe and

P_i is the power level from the isotropic antenna.

We can solve this equation for the power ratio as follows:

$$\log\left(\frac{P_0}{P_i}\right) = 0.75$$

$$\frac{P_0}{P_i} = 10^{0.75}$$

$$\frac{P_0}{P_i} = 5.62$$

$$P_0 = (5.62)P_i.$$

That is, the power from the main lobe is 5.62 times greater than the power from the isotropic radiator.

You may use this same process to determine what the power gain would be relative to a dipole by using

$$5.35\,dB = 10\ \log\left(\frac{P_0}{P_i}\right).$$

This will yield

$$P_0 = (3.43)P_i\,.$$

This means the power from the main lobe is 3.43 times greater than the power from the isotropic radiator.

To get some idea of what antenna manufacturers use to establish their claims concerning gain consider the Hy-Gain LJ-203BA. It is a monobander that is advertised to have an average forward gain of 7.15 dBi (5.0 dBd). A footnote on the advertisement states that the gain is verified by computer modeling with MININEC 3 and radiation pattern measurements of full size antennas on Hy-Gain's antenna test range.