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Application Note

VHETH Antenna Series Ground Plane Optimization

Linx Technologies VHETH series compact surface-mount monopole antennas require a ground plane on the printed circuit board (PCB) to which they are mounted. Linx datasheets use a 100 mm x 100 mm ground plane to report antenna performance, but other size ground planes may be used with proper design considerations as described in this application note.

This application note presents simulated performance data and matching circuit component recommendations to optimize performance for the 868 MHz and 915 MHz VHETH series antennas on ground plane sizes ranging from 50 mm x 50 mm to 200 mm x 200 mm.

Please refer to the VHETH antenna series datasheets for other design requirements for the VHETH antennas or contact Linx to help optimize solution performance.

Ground Plane Effects

Reducing the ground plane size narrows the bandwidth of the antenna. This is most noticeable in the VSWR performance. The use of a matching network allows VSWR to be optimized for the ground plane conditions but cannot completely account for a ground plane that is too small for target frequencies. There is no limitation on how large a ground plane may be in support of a monopole antenna and a larger ground plane will generally improve antenna performance.

Matching Networks

Linx recommends the inclusion of at least a 3-element, surface-mount pi matching network of two parallel components, (X1, X3) and one serial component, (X2) in all designs to allow for best possible performance. Figure 1 shows the recommended matching network circuit diagram.

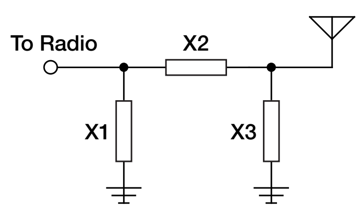

Figure 1. Recommended Matching Network Circuit Diagram

Comparing Antenna Performance

When comparing performance of the VHETH antenna series against other helical antennas or across varying sizes of ground planes it is important to review more than just VSWR (See the VHETH antenna series datasheets and definitions provided at the end of this application note). The peak gain and efficiency of the antenna also reflect the performance that can be expected in an end-solution.

Ground Plane Sizes Addressed

Figure 2 shows the relative ground plane sizes that are addressed in this application note ranging from 50 mm x 50 mm to 200 mm x 200 mm, which includes the 100 mm x 100 mm ground plane size used to produce the VHETH datasheets.

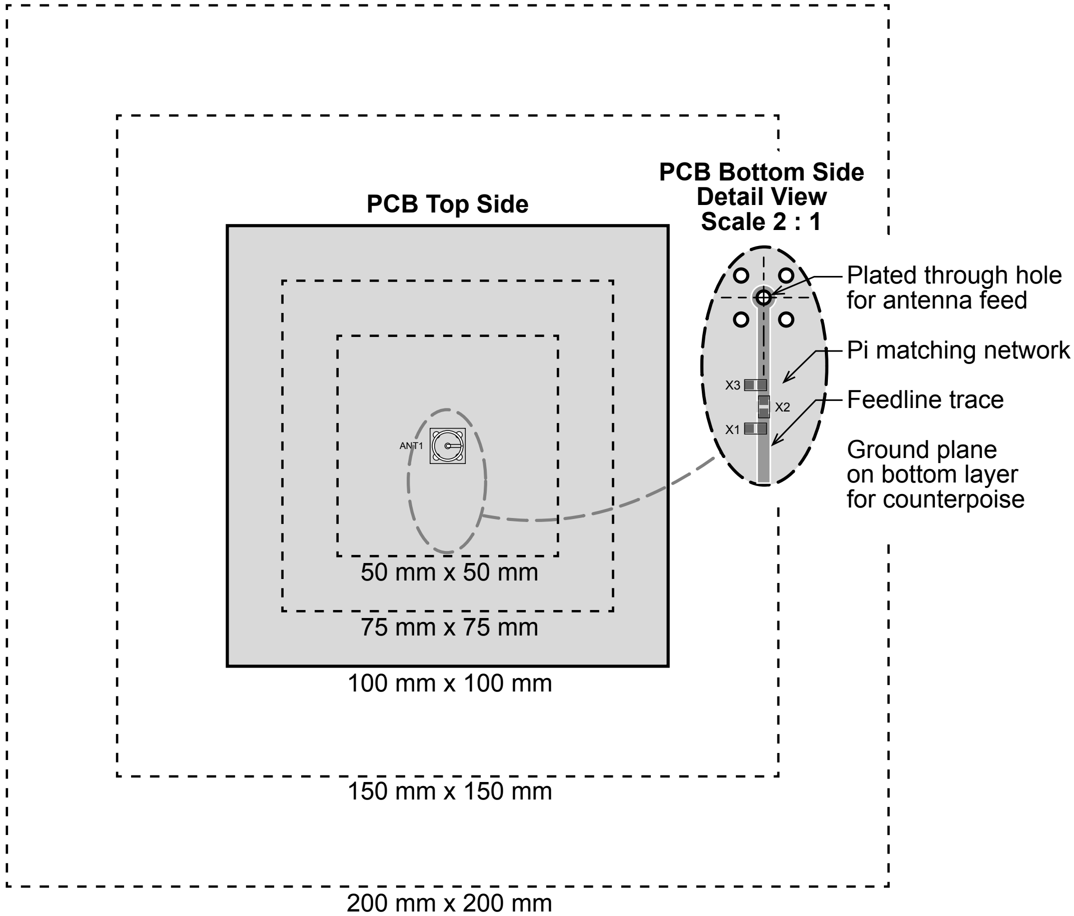

Figure 2. VHETH Antenna Series Referenced Ground Plane Sizes

Optimizing Performance with a Matching Network

The data presented in this application note provides a starting point for matching network component values for the different ground plane sizes. The included performance charts show the simulated performance of the antenna on the ground plane using the associated matching network. By adjusting the matching network the effect of ground plane size is largely eliminated. Note, however, that in real-world applications with other components, enclosure, etc., it is likely that additional tuning will be required to optimize performance.

868 MHz VHETH Antenna Performance (ANT-868-VHETH)

Performance data for the 868 MHz VHETH antenna simulated on various ground plane sizes is shown in Figure 3 through Figure 5 using measured data for the 100 mm x 100 mm ground plane.

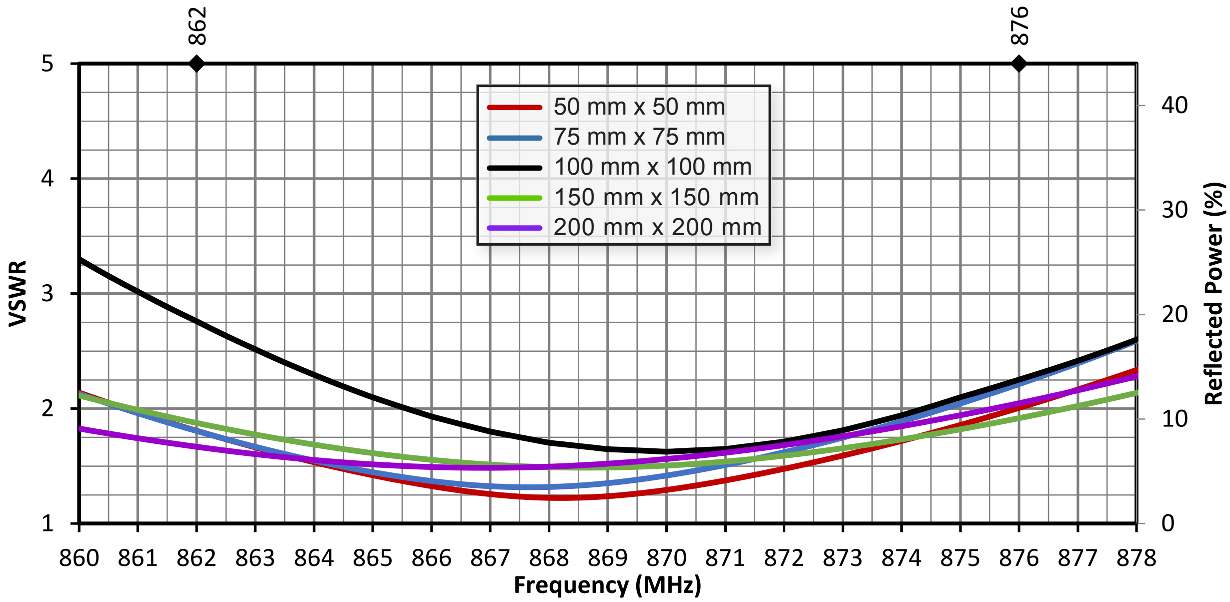

Figure 3. ANT-868-VHETH Antenna VSWR

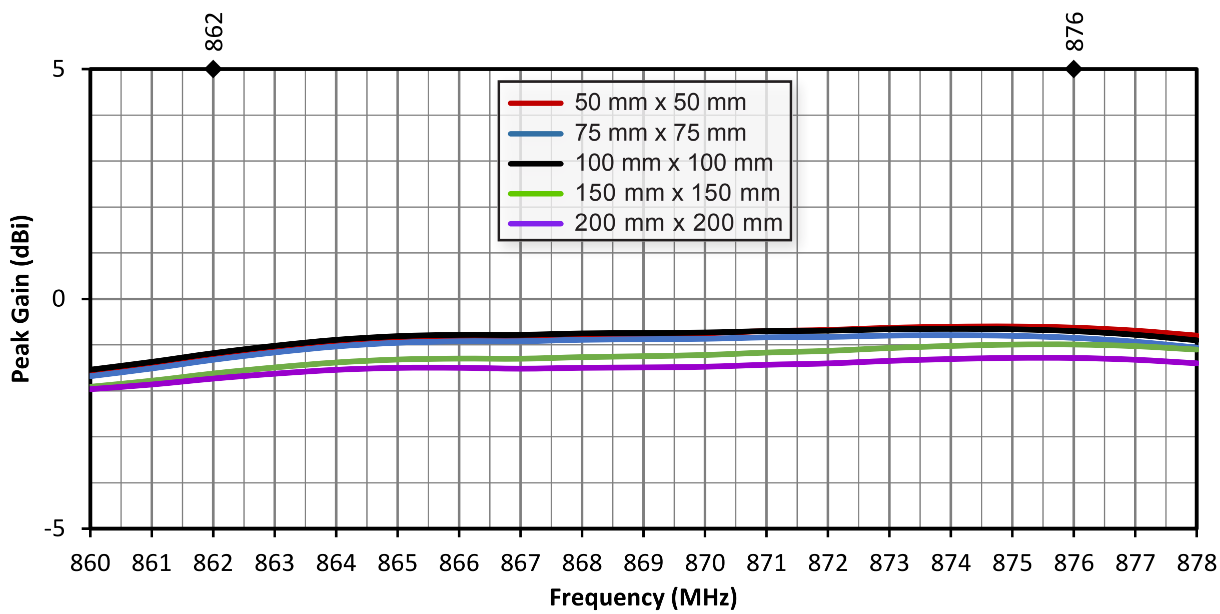

Figure 4. ANT-868-VHETH Antenna Peak Gain

868 MHz VHETH Antenna Performance (Continued)

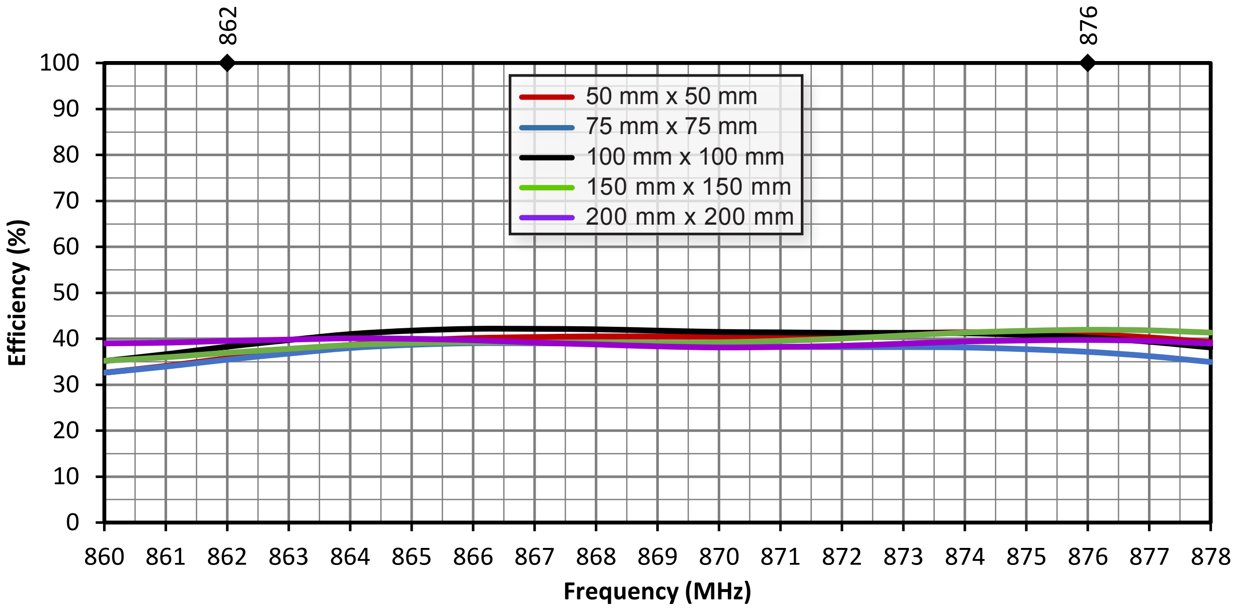

Figure 5. ANT-868-VHETH Antenna Radiation Efficiency

Matching Network Recommendations - 868 MHz

A matching network circuit is required to achieve the results shown for the simulated performance graphs. The recommended components and values are provided in Table 1 for each ground plane size. Note that these values provide a starting point for tuning the antenna to a target system, but will likely require modification based on the specifics of the target design.

Table 1. Recommended Matching Network Components for the ANT-868-VHETH.

ANT-868-VHETH	Matching Network Component Recommendations		
Ground Plane Size	X1	X2	X3
50 mm x 50 mm (1.97 in x 1.97 in)	2.5 nH inductor	7.5 pF capacitor	–
75 mm x 75 mm (2.95 in x 2.95 in)	2 nH inductor	5 pF capacitor	5.6 nH inductor
100 mm x 100 mm* (3.94 in x 3.94 in)	2.7 nH inductor	4.3 pF capacitor	–
150 mm x 150 mm (5.91 in x 5.91 in)	8 nH inductor	2.2 pF capacitor	–
200 mm x 200 mm (7.87 in x 7.87 in)	–	11 nH inductor	3 pF capacitor

* Ground plane size used for VHETH series antenna datasheets

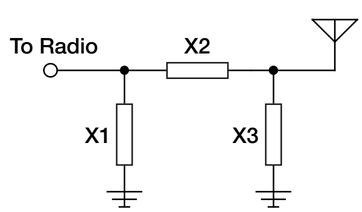

Figure 6. Matching Network Circuit Diagram

915 MHz VHETH Antenna Performance (ANT-915-VHETH)

Performance data for the 915 MHz VHETH antenna simulated on various ground plane sizes is shown in Figure 7 through Figure 9 using measured data for the 100 mm x 100 mm ground plane.

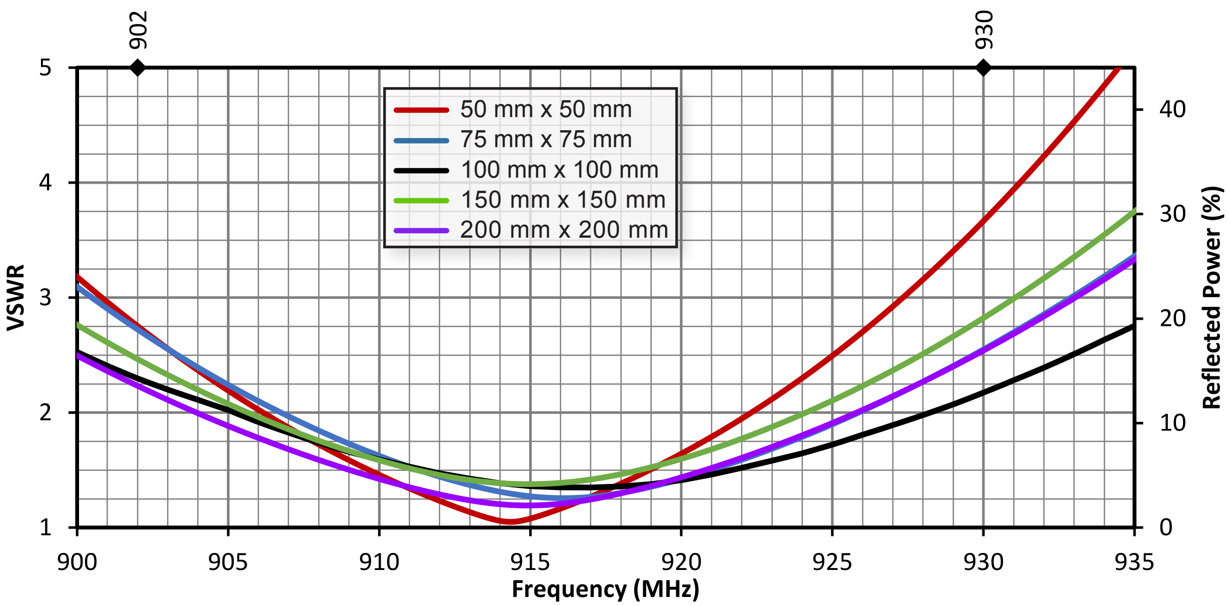

Figure 7. ANT-915-VHETH Antenna VSWR

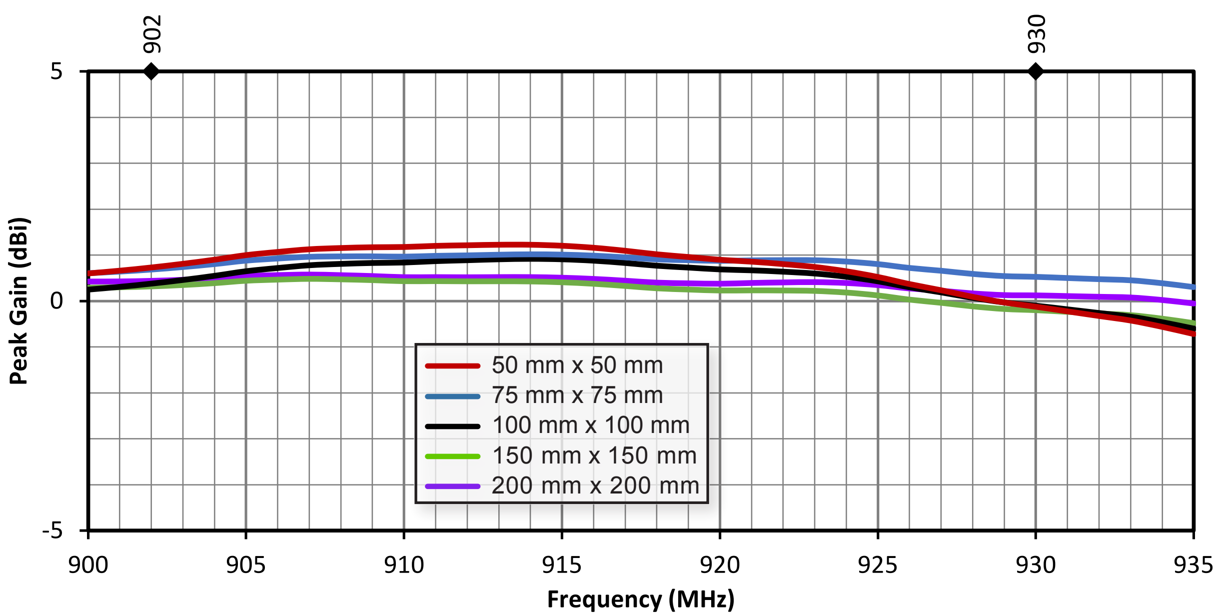

Figure 8. ANT-915-VHETH Antenna Peak Gain

915 MHz VHETH Antenna Performance (Continued)

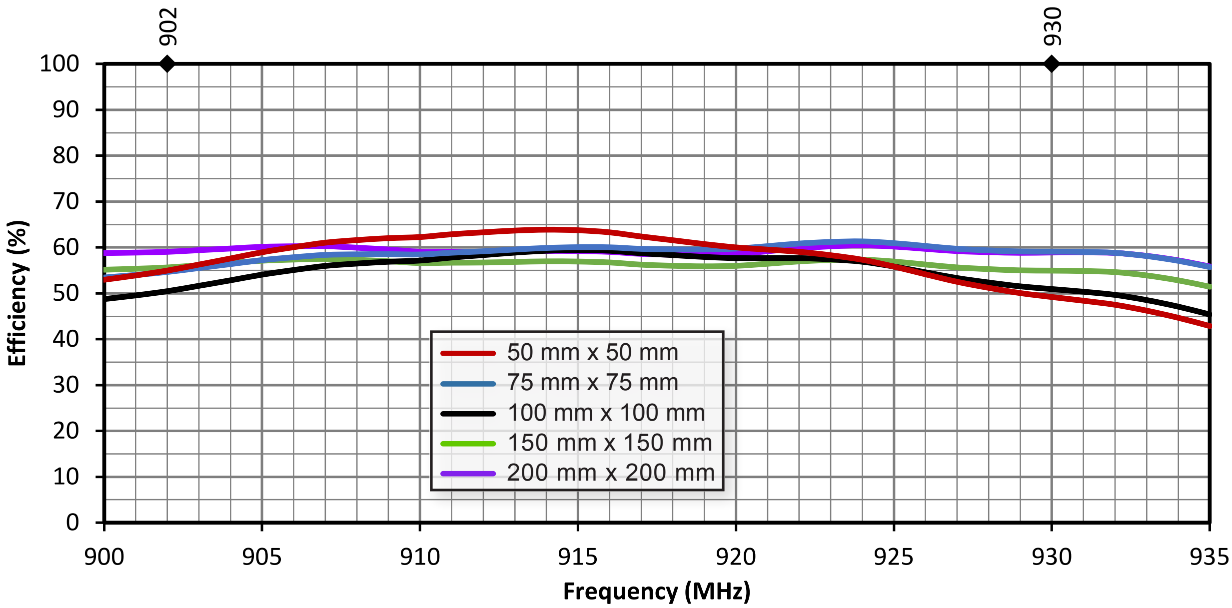

Figure 9. ANT-915-VHETH Antenna Radiation Efficiency

Matching Network Recommendations - 915 MHz

A matching network circuit is required to achieve the results shown for the simulated performance graphs. The recommended components and values are provided in Table 2. Note that these values provide a starting point for tuning the antenna to a target system, but will likely require modification based on the specifics of the target design.

Table 2. Recommended Matching Network Components for the ANT-915-VHETH

ANT-915-VHETH	Matching Network Component Recommendations		
Ground Plane Size	X1	X2	X3
50 mm x 50 mm (1.97 in x 1.97 in)	–	6 nH inductor	4.3 pF capacitor
75 mm x 75 mm (2.95 in x 2.95 in)	–	1.7 pF capacitor	–
100 mm x 100 mm* (3.94 in x 3.94 in)	–	2.7 pF capacitor	–
150 mm x 150 mm (5.91 in x 5.91 in)	–	18 nH inductor	10 pF capacitor
200 mm x 200 mm (7.87 in x 7.87 in)	–	20 nH inductor	1.2 pF capacitor

* Ground plane size used for VHETH series antenna datasheets

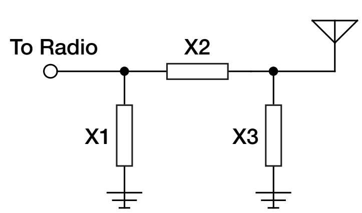

Figure 10. Matching Network Circuit Diagram

Antenna Definitions and Useful Formulas

VSWR - Voltage Standing Wave Ratio. VSWR is a unitless ratio that describes the power reflected from the antenna back to the radio. A lower VSWR value indicates better antenna performance at a given frequency. VSWR is easily derived from Return Loss.

$$\text{VSWR} = \frac{10^{\left[\frac{\text{Return Loss}}{20}\right]} + 1}{10^{\left[\frac{\text{Return Loss}}{20}\right]} - 1}$$

Return Loss - Return loss represents the loss in power at the antenna due to reflected signals, measured in decibels. A lower return loss value indicates better antenna performance at a given frequency. Return Loss is easily derived from VSWR.

$$\text{Return Loss} = -20\log_{10}\left[\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right]$$

Efficiency (η) - The total power radiated from an antenna divided by the input power at the feed point of the antenna as a percentage.

Total Radiated Efficiency - (TRE) The total efficiency of an antenna solution comprising the radiation efficiency of the antenna and the transmitted (forward) efficiency from the transmitter.

$$\text{TRE} = \eta \cdot \left(1 - \left(\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right)^2\right)$$

Gain - The ratio of an antenna's efficiency in a given direction (G) to the power produced by a theoretical lossless (100% efficient) isotropic antenna. The gain of an antenna is almost always expressed in decibels.

$$\text{G}_{\text{db}} = 10\log_{10}(\text{G})$$

$$\text{G}_{\text{dBd}} = \text{G}_{\text{dBi}} - 2.51\text{dB}$$

Peak Gain - The highest antenna gain across all directions for a given frequency range. A directional antenna will have a very high peak gain compared to average gain.

Average Gain - The average gain across all directions for a given frequency range.

Maximum Power - The maximum signal power which may be applied to an antenna feed point, typically measured in watts (W).

Reflected Power - A portion of the forward power reflected back toward the amplifier due to a mismatch at the antenna port.

$$\left(\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right)^2$$

decibel (dB) - A logarithmic unit of measure of the power of an electrical signal.

decibel isotropic (dBi) - A comparative measure in decibels between an antenna under test and an isotropic radiator.

decibel relative to a dipole (dBd) - A comparative measure in decibels between an antenna under test and an ideal half-wave dipole.

Dipole - An ideal dipole comprises a straight electrical conductor measuring 1/2 wavelength from end to end connected at the center to a feed point for the radio.

Isotropic Radiator - A theoretical antenna which radiates energy equally in all directions as a perfect sphere.

Omnidirectional - Term describing an antenna radiation pattern that is uniform in all directions. An isotropic antenna is the theoretical perfect omnidirectional antenna. An ideal dipole antenna has a donut-shaped radiation pattern and other practical antenna implementations will have less perfect but generally omnidirectional radiation patterns which are typically plotted on three axes.

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