APPLICATION NOTE

# Improving Wireless LAN Antenna Gain and Coverage

Most of the antennas provided with Wi-Fi access points, or purchased separately, are simple dipole antennas with an omni-directional pattern. Omni-directional means that the gain is the same in a 360º circle around the axis of the antenna.

However, the elevation gain pattern is different. In cross section, the elevation pattern is that of a doughnut, with the antenna axis running through the center of the doughnut. In the absence of a ground plane, the gain of the dipole is a maximum off the midpoint of the dipole, and is a minimum off the ends of the dipole.

In general, the maximum gain can be increased by using a longer antenna. The longer antenna has the effect of "squashing" the elevation pattern, creating a flatter doughnut with higher gain around the perimeter of the doughnut.

For a wireless LAN installation in a multi-floor building, this has the desirable effect of not only increasing gain, but reducing radiation directly above and below the antenna, which can help mitigate interference between floors. The only drawback is that the longer antenna may be somewhat less aesthetic.

Mounting a dipole antenna on a conductive ground plane has a similar effect as using a longer antenna. The elevation pattern is flattened, creating higher gain around the perimeter of the doughnut. Additionally, the ground plane mounted antennas pattern is maximized downward slightly (if the antenna is mounted beneath a ceiling ground plane). This is an ideal elevation pattern for a ceiling mounted antenna in a multi-story building. The ground plane has the effect of minimizing gain below and especially above the antenna.

Wi-Fi antennas may be classified as ground plane *dependent* and ground plane i*ndependent*. The ground plane *dependent* antenna must be mounted on a conductive, flat ground plane which is several wavelengths long and wide in order to provide the rated gain and impedance match. The ground plane *independent* antenna does not need to be mounted on a ground plane to provide the rated gain and impedance match. As shown in the following figures, however, the ground plane will improve the gain and pattern of the dipole antenna, whether it is ground plane *dependent*, or ground plane *independent*.

Oberon's wireless LAN access point enclosures for plenum installation are excellent conducting grounds planes for both ground plane dependent and ground plane independent antennas. The enclosures not only provide an aesthetic, secure mounting location for the access point, but they improve the antenna pattern as well.

GROUND PLANE *DEPENDENT* DIPOLE ANTENNA

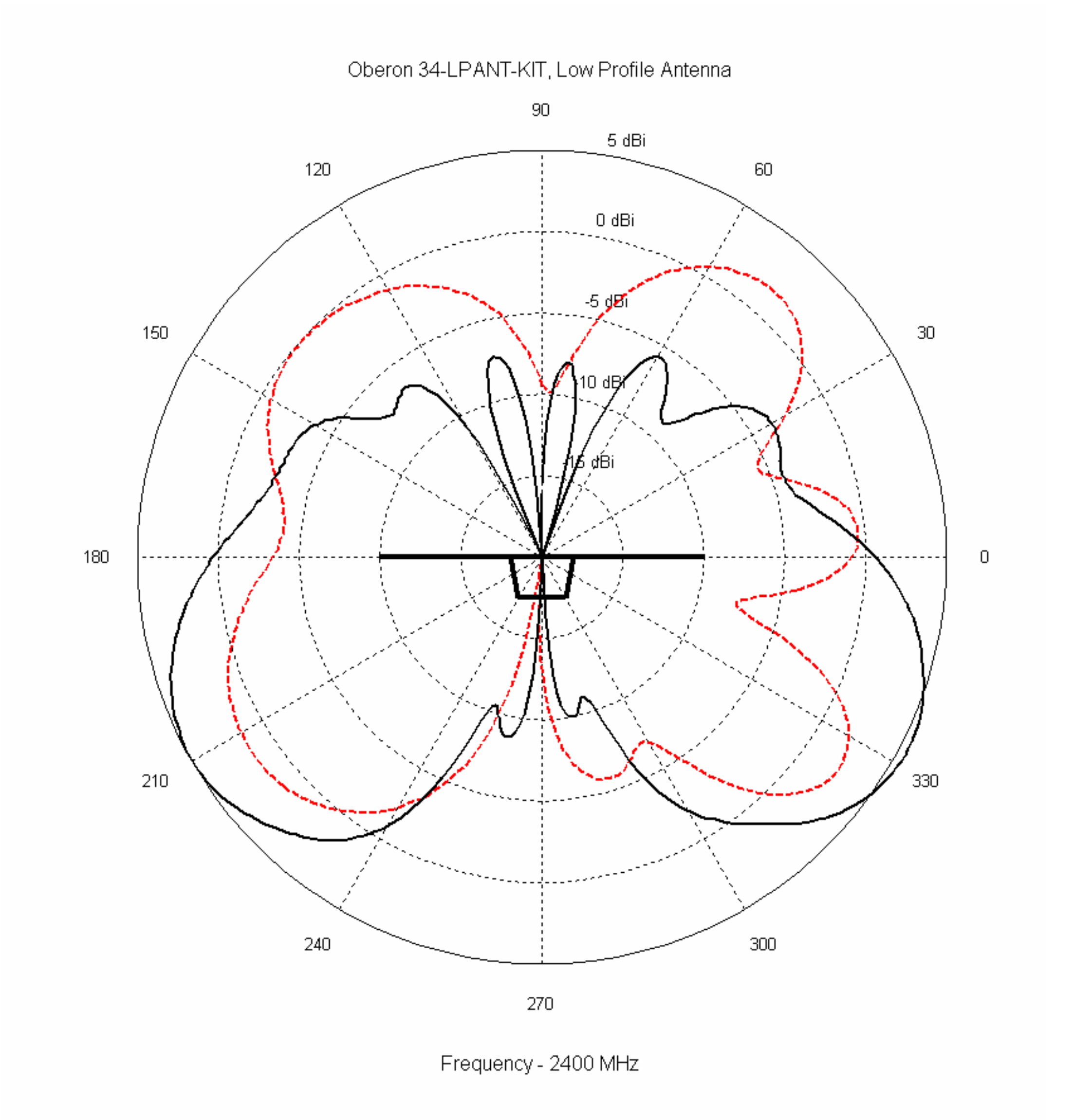


Figure 1 shows the measured elevation pattern for a typical ground plane *dependent* dipole antenna (34-LPANT-KIT). The dashed red curve shows the elevation pattern without a ground plane. The maximum gain is approximately 2.5 dBi, with significant gain above and below the dipole antenna. The solid black curve shows the elevation pattern when the antenna is mounted on a conductive ground plane, such as the Oberon model 1050 access point enclosure. The maximum gain for the same antenna is now over 5 dBi, and is desirably focused into the room space. The gain below, and especially above, is reduced, which can help mitigate interference in adjacent floors of a multi-floor building.

## GROUND PLANE *INDEPENDENT* DIPOLE ANTENNA

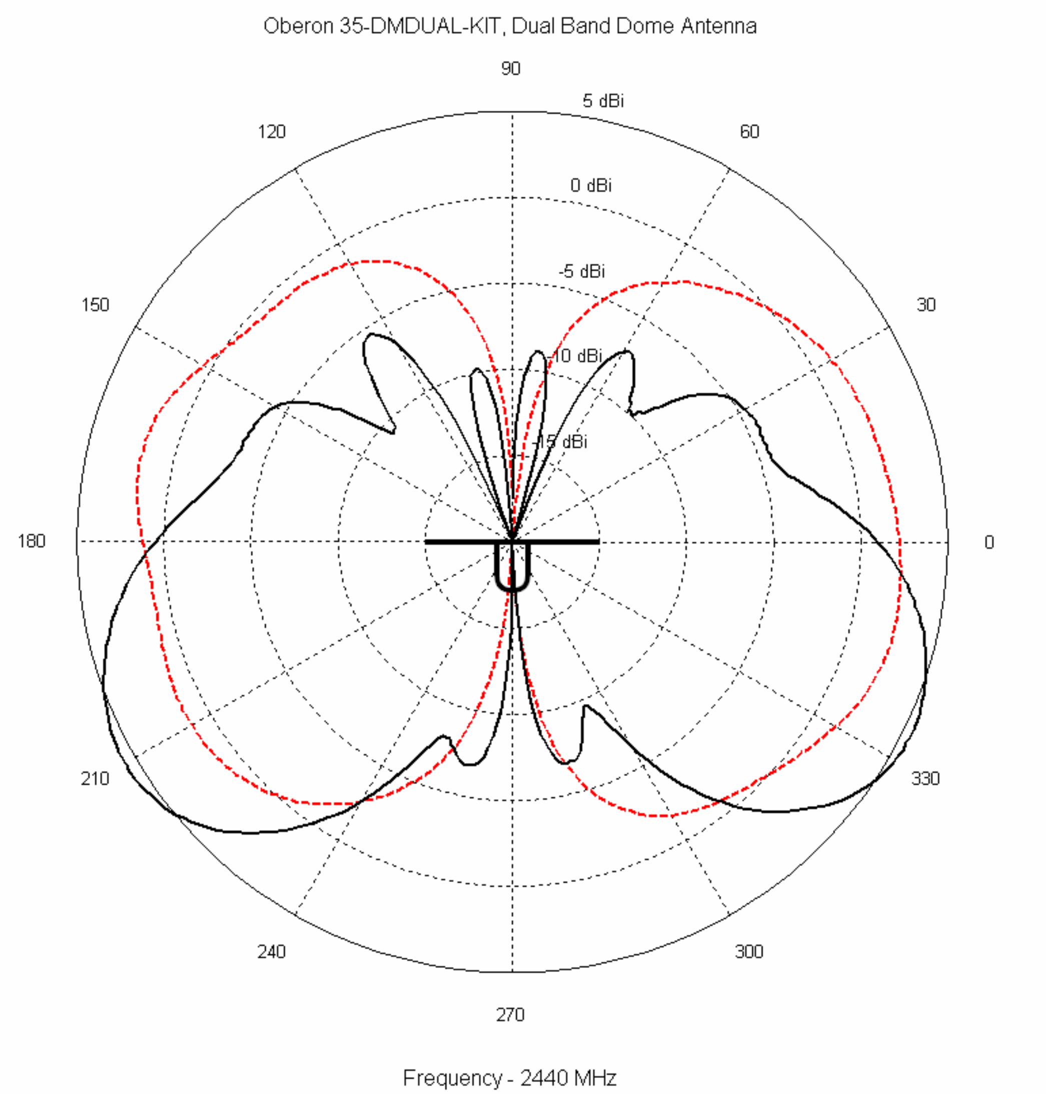


Figure 2 shows the measured elevation pattern for a ground plane *independent* antenna (34-DMDUAL-KIT). The dashed red curve shows the elevation pattern without a ground plane. The maximum gain is approximately 2.5 dBi at 0º and 180º elevation (approximately the ceiling line), with significant gain above and below the dipole antenna. The solid black curve shows the elevation pattern when the antenna is mounted on a conductive ground plane, such as the Oberon model 1050 access point enclosure. The maximum gain for the same antenna is now over 5 dBi, and is desirably focused into the room space. The gain below, and especially above, is reduced, which can help mitigate interference in adjacent floors of a multi-floor building.

# UNDERSTANDING ANTENNA VSWR

Commonly, manufacturers will specify an antenna's VSWR. The VSWR stands for Voltage Standing Wave Ratio and is a way of describing how well the antenna is impedance matched to a 50 Ω input impedance (50 Ω is commonly the impedance of the RF cables and access points). The lower the ratio, the better the antenna impedance match. Sometimes the impedance is specified as a Return Loss, which describes how much of the incident energy is reflected due to impedance mismatch. A higher dB value for Return Loss is desirable.

If the antenna is not impedance matched to the RF cable or access point, than the system suffers from mismatch loss, which is the same effect as reducing antenna gain. If the specified VSWR is 2:1, the mismatch loss is 0.5 dB. This has the effect of reducing antenna gain by 0.5 dB. This is the only effect the wireless LAN designer is really concerned about regarding antenna impedance. The table below translates commonly cited VSWR and Return Loss into Mismatch loss.

| VSWR | RETURN LOSS (dB) | MISMATCH LOSS (dB) | REDUCTION IN ANTENNA GAIN (dB) |
|---|---|---|---|
| 1.5:1 | 14 | <0.2 | <0.2 |
| 2:1 | 9.5 | 0.5 | 0.5 |
| 3:1 | 6 | 1.25 | 1.25 |
| 4.5:1 | 4 | 2.2 | 2.2 |

The VSWR, or impedance match, of the dipole antenna may be dependent on the absence or presence of a conductive ground plane. The antenna's manufacturer should specify whether it is ground plane dependent or independent.

If the antenna is ground plane *independent*, then the VSWR, or impedance match, should be as specified, whether the antenna is mounted on a ground plan or not. If the antenna is ground plane *dependent*, then the antenna must be mounted on a conductive ground plane, otherwise, the antenna will not be impedance matched and will introduce mismatch loss, effectively reducing the gain of the antenna.

If it cannot be determined whether the antenna is ground plane dependent or independent, the antenna should be mounted on a ground plane to ensure proper impedance match.

Figure 3 shows a microwave network analyzer return loss measurement of a ground plane *dependent* dipole antenna on a scale of return loss (5 dB/division) versus frequency. The solid black line is the 0 dB return loss reference. The two cursors mark the Wi-Fi frequency band at 2.4 GHz.

The red line shows the return loss of the dipole antenna measured without a ground plane. The return loss is only 4 dB, which manifests itself as 2.2 dB of reduction in antenna gain. The blue line shows the return loss of the same dipole antenna with a ground plane. The return loss is 9 dB, which manifests itself as 0.5 dB of reduction in antenna gain. Clearly, it's desirable to mount this dipole antenna on a ground plane.

Oberon's model 1050 access point enclosure serves as an excellent ground plane for ground plane dependent antennas, thereby ensuring impedance matching, while improving gain and mitigating interference in multi story buildings.

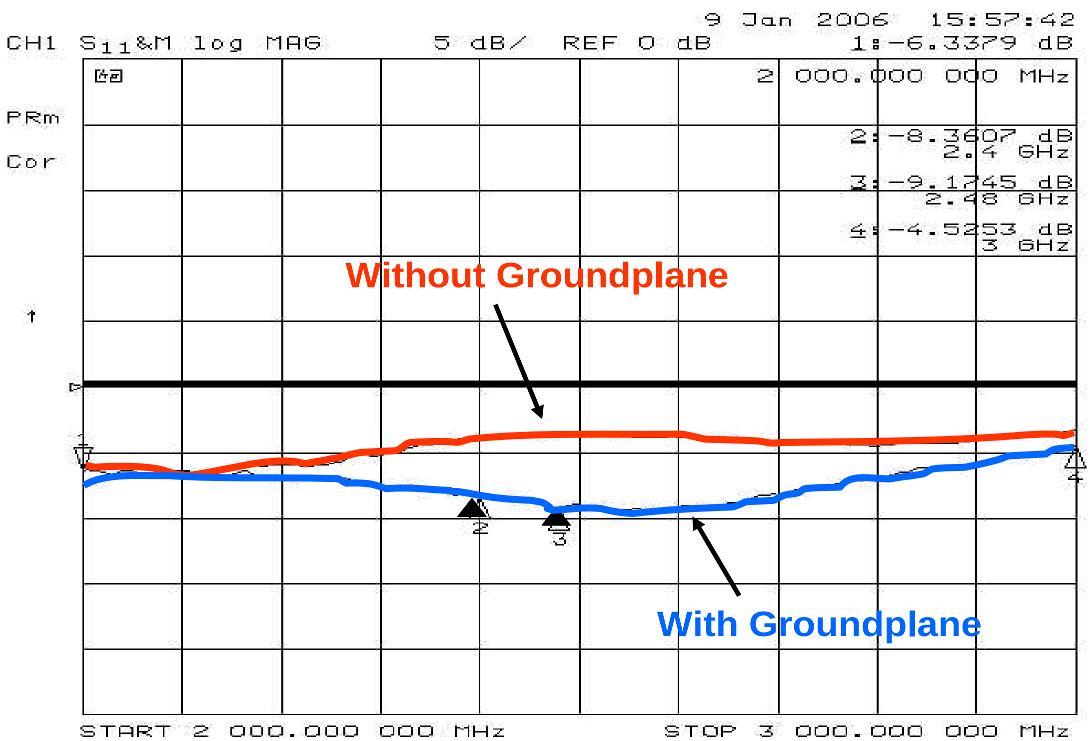


*Figure 3 – Impedance match of a ground plane dependent antenna with ground plane (blue) and without ground plane (red).*