# Interaction Between an Antenna and a Shelter

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September 25, 2008

## Contents



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# 1 Summary

LWA Memo 129 [1] describes the effect that a fence has on the pattern of a nearby antenna. We now consider the effect that an equipment shelter on an antenna. The shelter in this case is modeled as a perfectly-conducting box of dimensions 4 m × 4 m × 10 m, and is located 3 m and 23 m from a collinearly-oriented thin, straight half-wave dipole at 74 MHz. The effect on the co-polarized H-plane pattern is found to be dramatic for 5 m separation, and subtle but significant for 25 m separation.

# 2 Methodology

Figure 1 shows the scenario considered in this memo. This scenario is analyzed using a NEC2-based method of moments code. The scenario consists of a single thin half-wave dipole in the vicinity of an equipment shelter, which is modeled as a rectangular box. The dipole is 2.027 m long (one-half wavelength at 74 MHz), placed 1.0135 m (one-quarter wavelength at 74 MHz) above the ground, and is 0.1 mm in radius. The ground is assumed to be a smooth perfectly-conducting surface of infinite extent. The antenna-ground model is not intended to be a close match to the actual LWA scenario, but is intended instead to provide a well-understood reference scenario against which the effects of the shelter can be evaluated. Nevertheless, the effects shown here will be qualitatively similar in the actual LWA circumstances.

The shelter is modeled as a perfectly-conducting box of dimensions 4 m × 4 m × 10 m, with the bottom surface of the box 1 m above the ground plane. The box is itself modeled using a wire grid model, as shown in Figure 1. The spacing of wires forming the grid is 0.5 m (0.12 wavelengths) in both dimensions, and the grid wire radius is 39.8 mm (0.01 wavelengths). For the purposes of NEC modeling, the wire between grid junctions is further subdivided into 7 segments. All wires are perfectly-conducting.

The long axis of the shelter is arranged to be collinear with the dipole as shown in Figure 1, as this is likely to generate the strongest interaction. Furthermore, it is expected that in this configuration that the co-polarized component in the H-plane (the $xz$ plane as shown in Figure 1) will be most strongly effected.

# 3 Results

Three cases were considered: (1) no shelter, (2) shelter-antenna separation of 3 m, and (3) shelter-antenna separation of 23 m. The only frequency considered was 74 MHz. The calculated antenna self-impedances were found to be $97.8 + j78.0\ \Omega$, $91.7 + j82.2\ \Omega$, and $97.9 + j77.7\ \Omega$ for cases (1), (2), and (3), respectively; in other words, the presence of the shelter has only a small effect on the antenna self-impedance, even when the separation is small.

Figure 2 shows the patterns obtained for each of the three cases considered. Only the co-polarized H-plane patterns are shown. Not surprisingly, the pattern is distorted in the presence of the shelter, and the distortion is worse when the shelter-antenna separation is small. The pattern distortion can be interpreted as being due to reflection from the shelter. For 3 m separation, a large range of low-elevation angles is blocked by the shelter, and the reflection increases gain in the opposite direction. For 23 m separation, the low-elevation blockage is much less but the reflection manifests as a ripple created by constructive and destructive interference as the direct path and relatively weak multipath component goes in and out of phase.

It should also be noted that in the presence of the shelter, polarization is also significantly affected. Whereas the H-plane axial ratio is zero when the shelter is absent, it is as high as 0.6 (occurring at a zenith angle of 74°) for 3 m separation. For 23 m separation, the axial ratio is

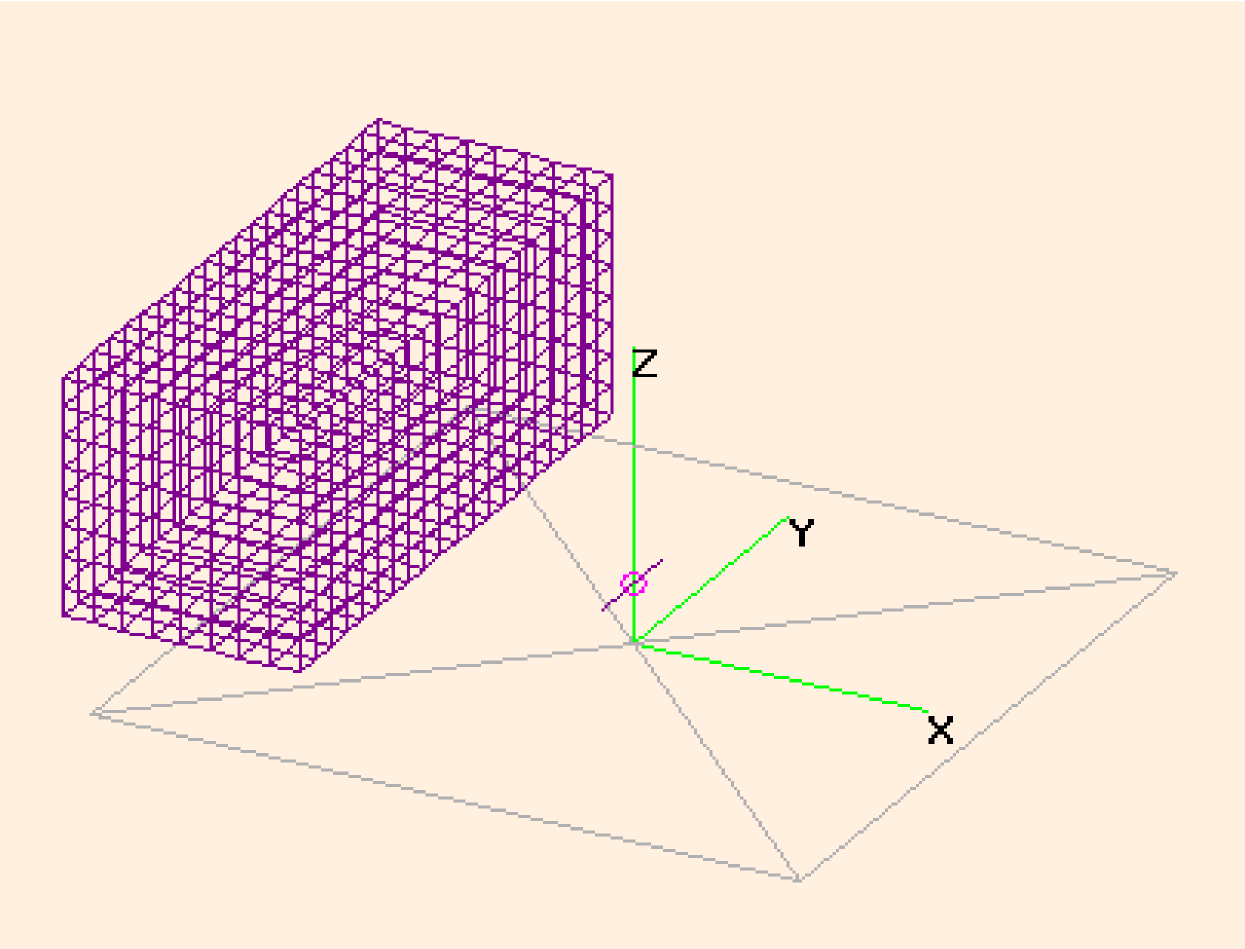


Figure 1: Diagram of the antenna-shelter interaction scenario considered in this memo. The dipole is shown as the straight line located above the origin of the coordinate system. In this figure, the separation between shelter and antenna is 3 m.

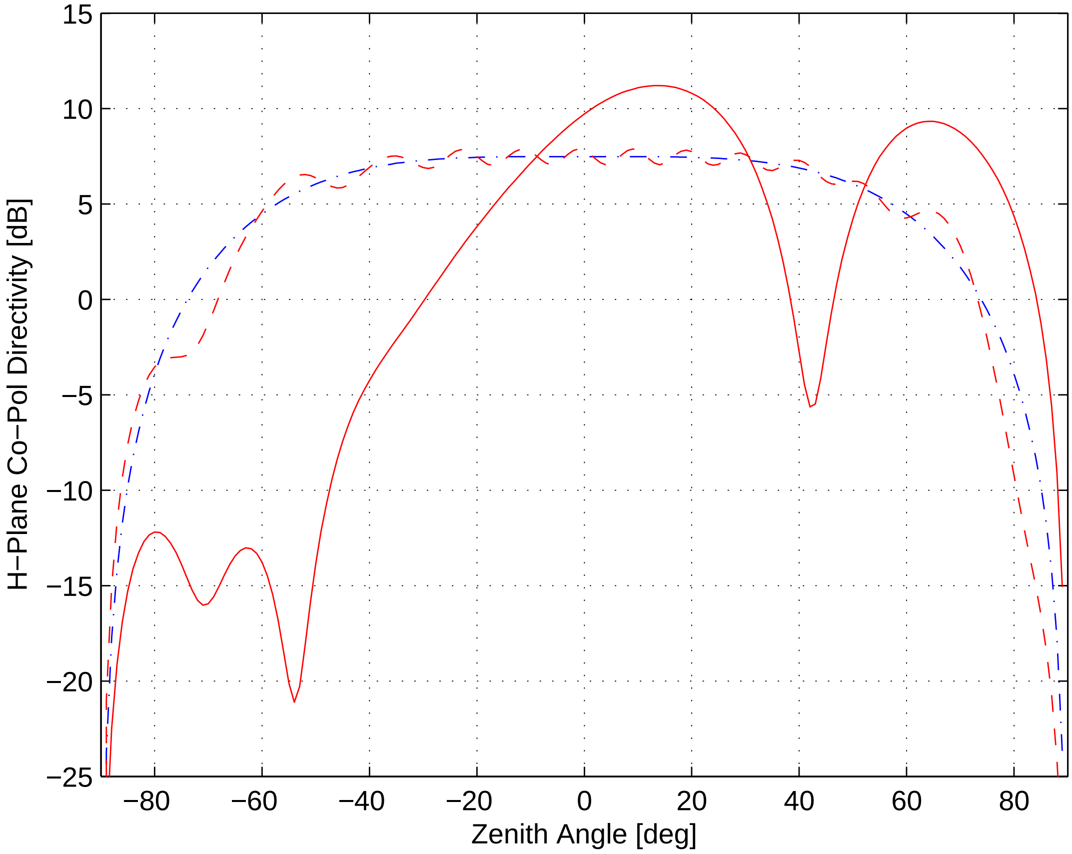


Figure 2: Co-polarized H-plane directivity at 74 MHz for the no-shelter case (*Blue, Dash-dot*), 3 m separation (*Red, Solid*), and 23 m separation (*Red, Broken dash*) . The shelter is on the left with respect to the orientation of the pattern cut shown in this figure.

roughly an order of magnitude smaller and peaks closer to the horizon.

Clearly, the shelter should be placed as far from the LWA antennas as possible so as to reduce the distortion of pattern. It may also be helpful to orient the long axis of the shelter radially with respect to the array, so as to minimize the area that can contribute to scattering. The results here were computed at 74 MHz, where sides of the shelter are electrically large (a wavelength or greater in each dimension) and so are efficient reflectors. At lower frequencies the shelter becomes electrically smaller and so will scatterer less effectively; however at the same time the electrical distance between the shelter and antennas will decrease, which will increase the potential for parasitic modification to the dipole pattern. Thus, the effects at lower frequencies is uncertain and can probably only be determined by additional modeling. It is recommended that a complete candidate site layout be considered, including sizes and positions of the shelter, fence, and antennas; and then the patterns of selected antennas should be examined using the method described here in order to assess the situation.

## References

[1] S. Ellingson, "Interaction Between an Antenna and a Fence," Long Wavelength Array Memo 129, Mar 24, 2008.