# Interaction Between an Antenna and a Fence

Steve Ellingson*

March 24, 2008

## Contents

---

*Bradley Dept. of Electrical & Computer Engineering, 302 Whittemore Hall, Virginia Polytechnic Institute & State University, Blacksburg VA 24061 USA. E-mail: `ellingson@vt.edu`

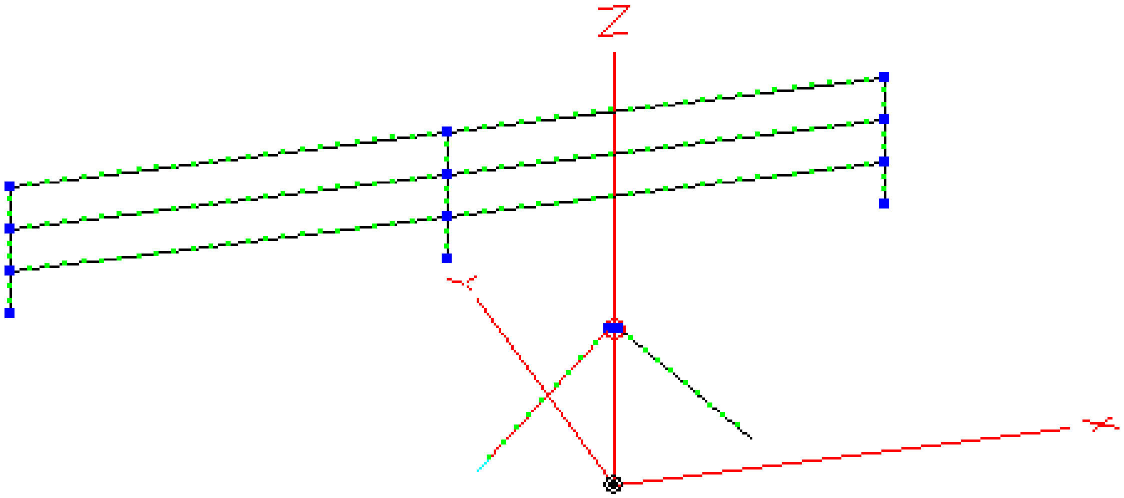

Figure 1: Diagram of the antenna-fence interaction scenario considered in this memo.

# 1 Summary

LWA stations are to be enclosed by a fence in order to provide some protection against wildlife. This memo attempts to quantify the effect of the fence on the electromagnetic performance of nearby antennas. The problem is investigated using a single thick-wire inverted-V dipole in the vicinity of a single section of barbed-wire fence 8 m long (including 3 metal vertical post supports) × 1.23 m high. It is found that the fence can be expected to have only a small effect on antenna impedance, but a potentially significant impact on pattern. When the fence is 5 meters from the antenna terminals ($\sim$ 3.7 m from the closest point on the orthogonally-oriented dipole in a dual-polarization antenna stand), the co-polarized H-plane pattern is perturbed by about ±0.5 dB at 38 MHz. The perturbation increases to about ±0.8 dB at 80 MHz with proportionally faster ripple. The ripple magnitude decreases by roughly a factor of 2 when the separation is increased to 10 m, however the ripple rate doubles. The results are very similar regardless of the ground treatment; i.e., for perfectly-conducting ground or the usual lossy dielectric earth ground model ($\epsilon_r$=13, $\sigma$ = 5 mS/m), and do not appear to be sensitive to the manner in which the fence is attached to the ground.

# 2 Methodology

Figure 1 shows the scenario considered in this memo. The scenario is analyzed using a NEC2-based method of moments code. The scenario consists of a single V-shaped dipole in the vicinity of a section of fencing. The dipole arms are 68 mm in diameter, which is about 0.02$\lambda$ at 88 MHz. The highest point of the dipole is 1.5 m and the dipole arms extend 45° from the vertical. The feed region is a horizontal wire 10 cm in length, and the arms are each 1.7 m long. The resulting impedance is shown in Figure 2. Note that two cases are shown. The first case assumes the dipole is located over a perfect electric conductor (PEC) material, whereas the second case assumes a realistic earth ground modeled as a lossy dielectric with relative permittivity 13 and conductivity 5 mS/m. As expected, the results are similar but with noticeable differences.

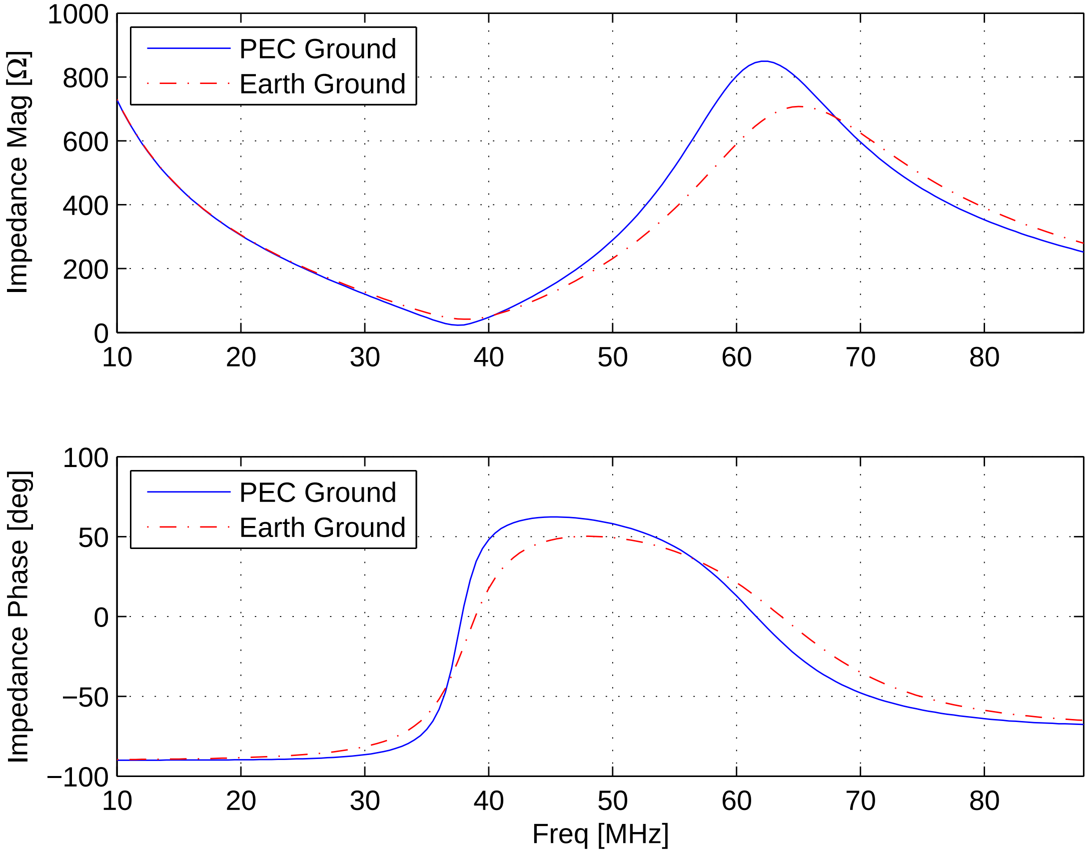

Figure 2: The impedance of the dipole used in this study when no is fence present. Results shown for PEC ground and the earth ground model discussed in the text.

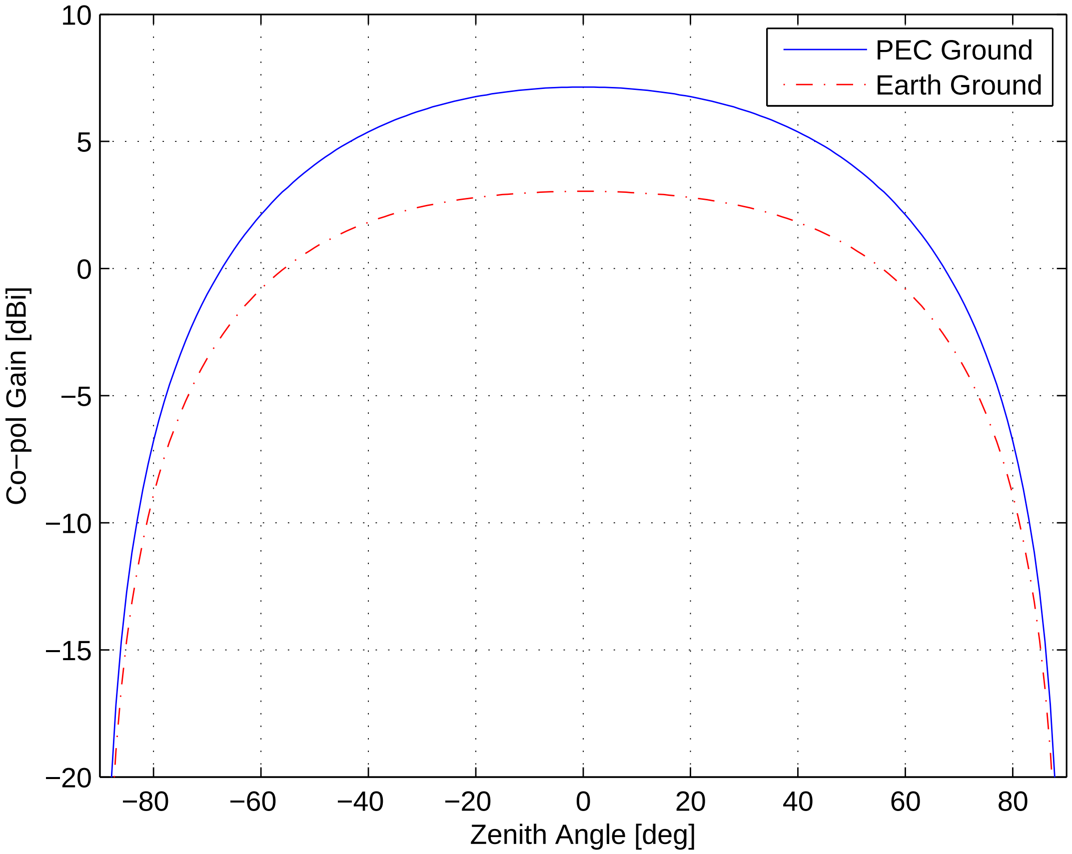

Figure 3: Co-polarized H-plane pattern at 38 MHz for the isolated antenna (i.e., no fence) in both ground conditions. Note that the reduced gain in the earth ground scenario is due almost entirely to dissipation in the lossy earth.

The fence shown in Figure 1 is designed following common practices for livestock fence construction [1]. The fence consists of vertical posts extending from the ground to a height of 123 cm, with 4 m spacing. Running between the posts are wires at heights of 41 cm, 82 cm, and 123 cm. It is assumed that the wires and the posts are bonded at every possible point (bond points appear as blue dots in Figure 1). The posts are modeled as thick wires having diameter 36 mm, whereas the horizontal wires, consisting of 3 strands of 12-$\frac{1}{2}$-ga barbed wire, are modeled as a single wire of diameter 4 mm. Only two sections of fencing, for a total length of 8 m, are included. All wires comprising the antenna and fence are assumed to be PEC material.

The antenna and the fence are arranged to be collinear 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 $yz$ plane as shown in Figure 1) will be most strongly effected, and therefore we limit our focus to that aspect of performance. For reference, Figure 3 shows this pattern at 38 MHz for the isolated antenna (i.e., no fence) in both ground conditions.

| Dist. to Fence | Posts Touch Ground? | Magnitude Diff. WRT no fence | Phase Diff. WRT no fence |
|---|---|---|---|
| 5 m | Yes | $< \pm 1.0\%$ | $< \pm 0.5^\circ$ |
| 5 m | No | $< \pm 1.5\%$ | $< \pm 0.8^\circ$ |
| 1 m | Yes | $< \pm 25.0\%$ | $< \pm 15.0^\circ$ |

Table 1: Effect of fence on antenna terminal impedance. "Dist. to Fence" is distance along the $y$-axis between the antenna terminals and the fence. Results are expressed in terms of change with respect to ("WRT") the same scenario without the fence. Results are approximately independent of ground type. Results are evaluated over the range 10–88 MHz; maximum difference is noted.

## 3 Results

Table 1 summarizes the effect of the fence on the impedance of the antenna. Note that the impact for a fence located 5 m from the antenna terminals ($\sim 3.7$ m from the edge of the other dipole in a dual-polarized stand) is relatively small. To understand the extent to which the results might be sensitive to the manner of contact between the fence and the ground, the analysis was also conducted with a modified "floating" fence for which the three 41-cm-long wire segments connecting the fence to the ground were removed. As shown in the second row in Table 1, the effect on the impedance was slightly increased, but is still quite small. A final experiment was to move the fence to a distance of just 1 m from the antenna terminals. As might be expected, the impact on the impedance in this case is relatively large.

Figure 4 shows the effect of the fence on the co-polarized H-plane pattern of the dipole at 38 MHz in both ground conditions. Note that fence has a significant effect, introducing a peak ripple on the order of $\pm 0.5$ dB. The effect is slightly larger in the earth ground case with respect to the PEC ground case.

Figure 5 shows the effect of the fence on the co-polarized H-plane pattern of the dipole at 80 MHz in earth ground conditions, for two cases: one in which the fence is 5 m distant, and another in which the fence is 10 m distant. In the 5 m case, we observe that the ripple introduced by the presence of the fence is both somewhat larger ($\pm 0.8$ dB) and faster than observed in the 38 MHz case. The larger magnitude is probably attributable to the increased efficiency of the fence as a scatterer at 80 MHz, for which the fence is $2.13\lambda$ wide by $0.33\lambda$ high. Since the ripple rate approximately doubles going from 38 MHz to 80 MHz, it appears to be attributable to a fringing effect between the isolated pattern of the antenna and scattering from the fence. Also note that increasing the distance to the fence from 5 m to 10 m results in $\sim 50\%$ reduction in ripple magnitude, but also another doubling of the ripple rate.

Issues which may affect the applicability of these results to the actual situation are as follows. A short section of fence was considered here, whereas the actual fence is of course longer. However, given that the fence appears to be acting as a simple scatterer it seems unlikely that a longer fence will have a dramatically larger or smaller effect. A longer fence might be a more efficient scatterer at lower frequencies, however the vertical dimension in terms of wavelength becomes proportionally smaller and the pattern ripple becomes hard to notice below 38 MHz because the antenna-fence separation becomes small compared to a wavelength. The nature of the attachment between horizontal wires and vertical posts in the fence could possibly be significant. The vertical spacing between wires is always small compared to a wavelength and so is not likely to be a factor, however the horizontal spacing between posts is on the order of a wavelength at the highest frequencies and so could possibly have some impact on the results. Finally, it should be noted that an actual LWA station array consists of many antennas, and the resulting mutual coupling will affect the results. However, it seems unlikely that any of these issues is likely to dramatically change the findings reported here.

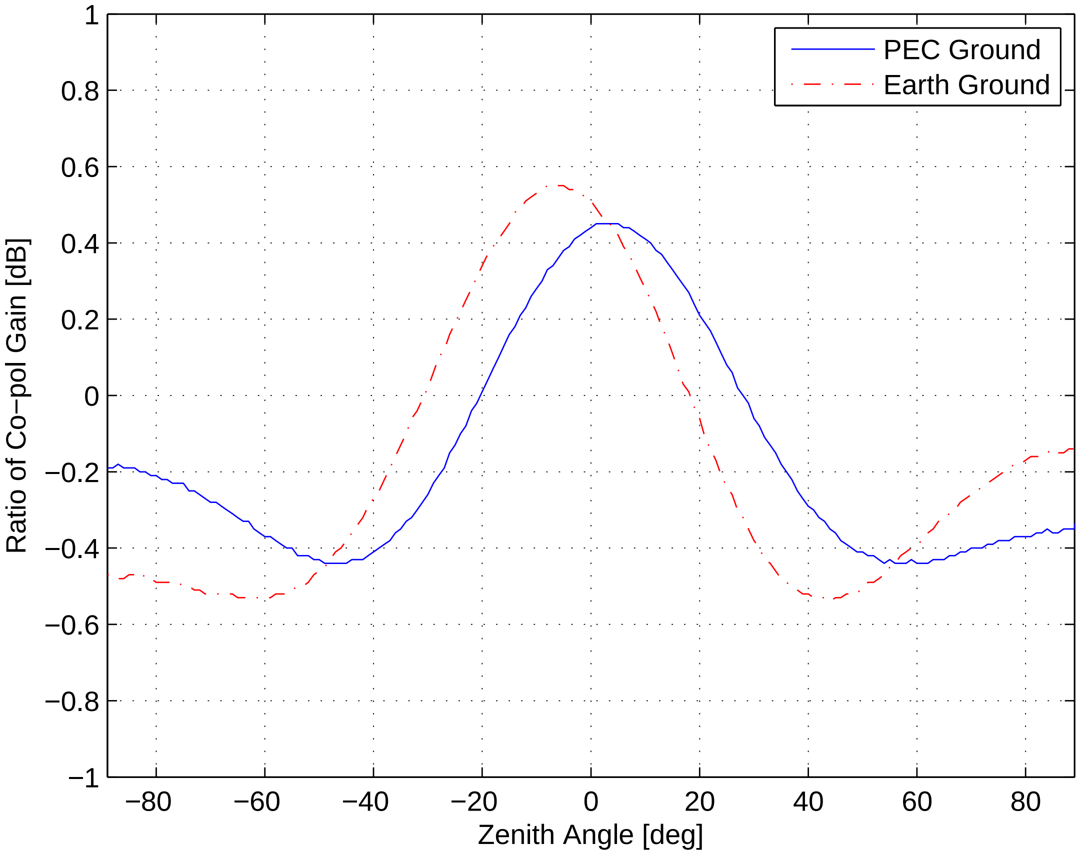

Figure 4: Co-polarized H-plane pattern at 38 MHz in the presence of the fence and for both ground conditions. Result is expressed as the ratio of the result when the fence is present to the result when the fence is absent (as in Figure 3). Fence is 5 m from antenna terminals. The result for a "floating" fence (which is not connected to the ground) is nearly identical.

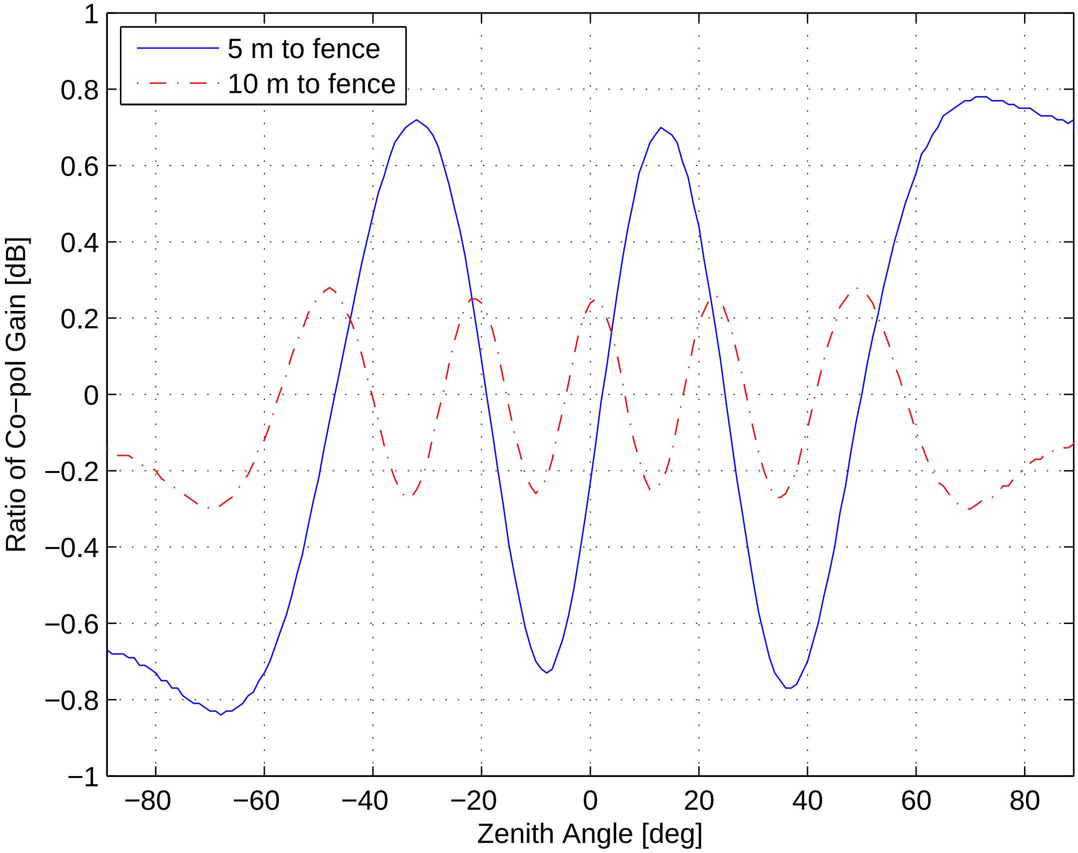

Figure 5: Co-polarized H-plane pattern at 80 MHz in the presence of the fence in earth ground conditions. Fence is 5 m or 10 m from antenna terminals. The result for the “floating” fence (which is not connected to the ground) is nearly identical.

# References

[1] S.W. Gay and R.D. Heidel, “Fencing Materials For Livestock Systems,” Virginia Cooperative Extention Pub. No. 442-131, Revised 2003, available on-line: http://www.ext.vt.edu/pubs/bse/442-131/442-131.html.