ROLSS Antenna Measurements: Implications for LWA Antenna Simulations

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Abstract

Measurements of the feed point impedance of a prototype dipole antenna, constructed for the ROLSS project, show good agreement with simulated values. This antenna, deployed directly on the ground, provided a sensitive test of our numerical simulation techniques. In common with LWA designs, this antenna had wide, planar arms, but without the added complication of active feed point electronics. These results imply that our numerical models of LWA antennas should be equally useful.

The Radio Observatory for Lunar Sortie Science (ROLSS) project proposes an antenna consisting of metal elements deposited on a thin polyimide substrate to be deployed directly on the lunar surface. We tested a prototype thin-film dipole antenna by comparing its measured and calculated feed-point impedance between 1 and 10 MHz. The goal of this work was to see if our antenna performance simulations give credible results when applied to this unusual antenna design in direct contact with the ground.

The antenna was constructed from a 25 μm thick Kapton film with a 5 μm thick Cu layer deposited on it. As shown in Figure 1, each arm was 8 m long and 30.5 cm wide. At the feed point the arms were separated by approximately 10 cm. The inner 1 m of each arm tapered to a point where a 1:1 wideband balun was attached. Coaxial cable connected the balun to an AIM4170 vector impedance antenna analyzer. A calibration procedure removed the effects of the cable from the measurements shown below. Measurements without the balun were similar and are not shown.

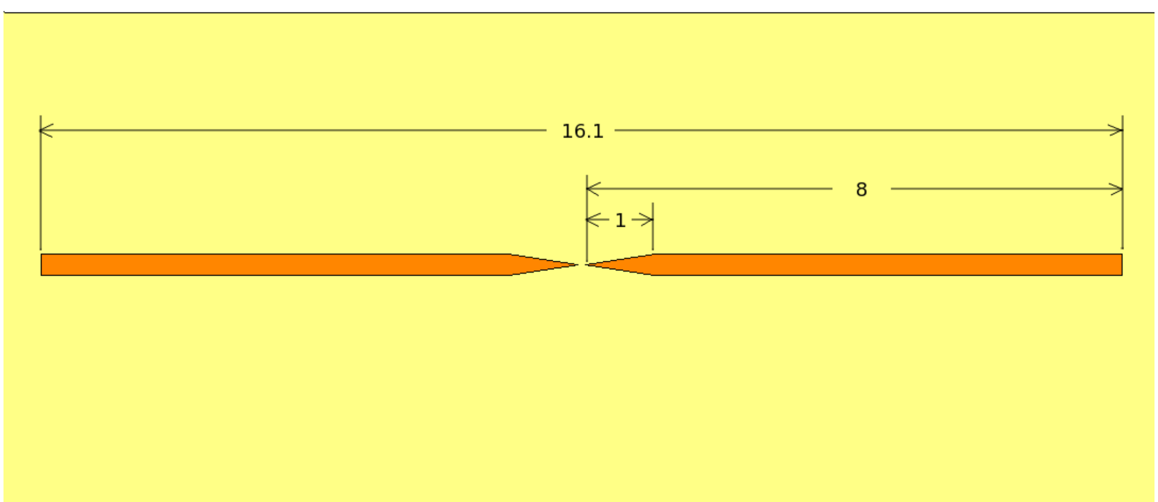

Figure 1: Antenna dimensions in meters.

The feed-point impedance was measured for two different antenna positions. For the first test the dipole arms were placed on top of an asphalt road. The measurements were repeated after the antenna was moved onto the dry, sandy soil next to the road, as shown in Figure 2. Stones were placed along the edges of the antenna to prevent it from blowing away in the wind.

Figure 2: The antenna was tested in two positions: (1) on sandy, partially grass-covered soil (as shown), and (2) on an asphalt road (visible on the right side of the picture).

CST Microwave Studio 3D electromagnetic simulation software was used to model the performance of the antenna on different types of ground. The dielectric constant and conductivity of the ground were adjusted to give the best fit to the measured data. These values are listed in Table 1.

Table 1: Best-fit values for ground dielectric constant and conductivity.

	Dielectric Constant	Conductivity (mS/m)
Asphalt	11	0.8
Soil	6	0.3

The feed-point impedance calculated using these values, along with the measured data, are plotted in Figures 3 and 4.

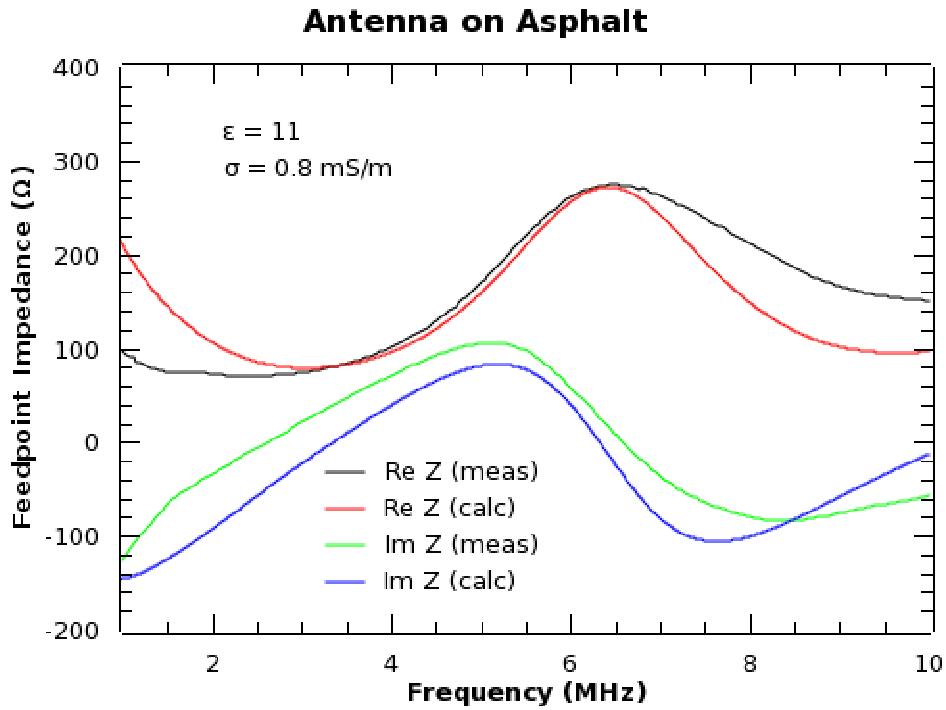

Figure 3: Measured and calculated impedance of the antenna on an asphalt-covered road.

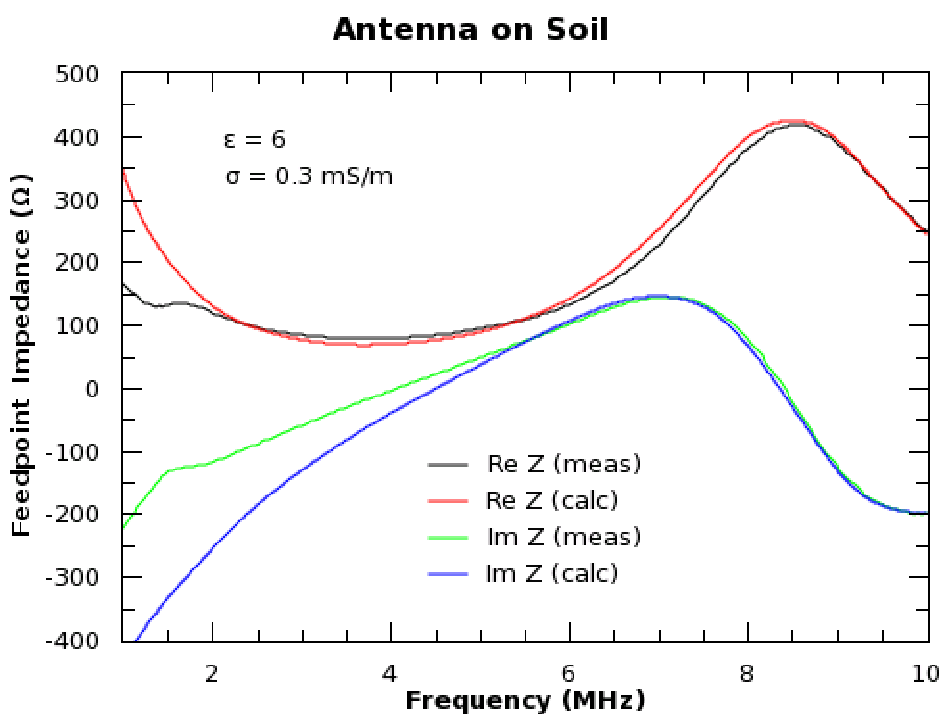

Figure 4: Measured and calculated impedance of the antenna when placed on sandy, grass-covered soil.

Possible sources of disagreement between theory and measurement are:

- The simulated volume around the antenna was necessarily finite. In particular, the depth of the ground was limited to 15 m in order to give reasonable memory requirements and calculation times. This caused the increasing discrepancy at low frequencies.
- The thicknesses of the Cu and Kapton films were such a small fraction of the wavelength that the tiny mesh size required for the finite-element algorithm in the volume around the antenna reduced the simulation accuracy.
- The simulations assumed perfect contact between the Kapton substrate and the ground surface. In reality, the film was a small, varying distance above the ground due to gravel, grass, etc. The effects of a small air gap between the antenna and ground were not modeled. This probably resulted in lower effective ground dielectric constant and conductivity.
- The dielectric constant of asphalt is influenced by moisture and dry aggregate content. The dielectric constant of water is ~80 at these frequencies and temperature, and that of the dry aggregates varies from 2.6 to 5. Therefore, the dielectric constant can vary significantly depending on when precipitation last occurred and the porosity of the asphalt being measured.

Given these possible sources of error the agreement between theory and measurement is remarkably good, and increases confidence that models using ground properties appropriate for the LWA sites will give accurate predictions of antenna performance. The experience we gained in refining simulation techniques and removing instrumental error should prove useful for future work related to the LWA.

Related Resources

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