Lunar University Network for Astrophysics Research

MEMO SERIES

MEMO A-5

ROLSS Antenna Measurements

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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, with dimensions 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. The effects of the cable were removed from the measurements shown below. Measurements without the balun were similar and are not shown.

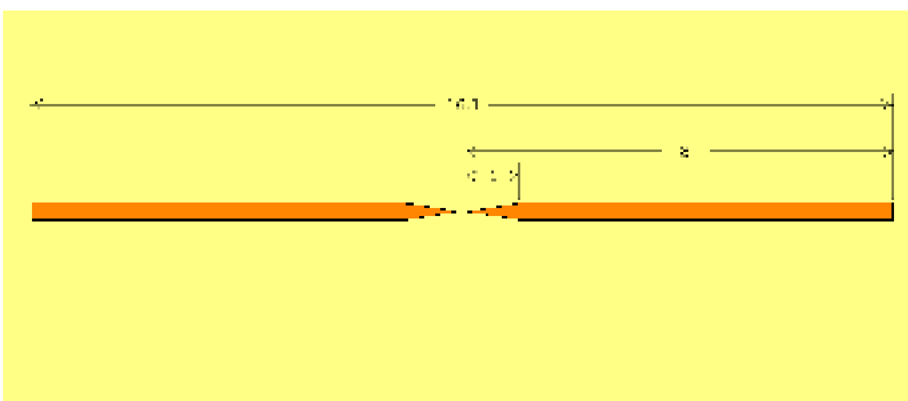

Figure 1: Antenna dimensions in meters.

The feed-point impedance was measured for two different antenna positions.

For the first test the dipole arms were laid out 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. The best values found so far 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.

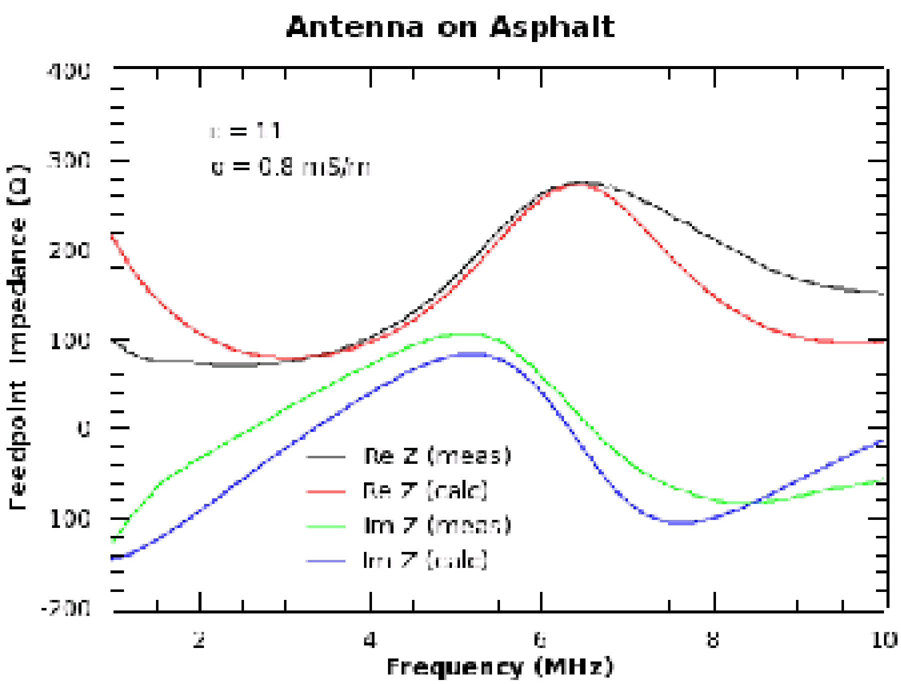

Figure 3: Measured and calculated impedance of the antenna on an asphalt-covered road.

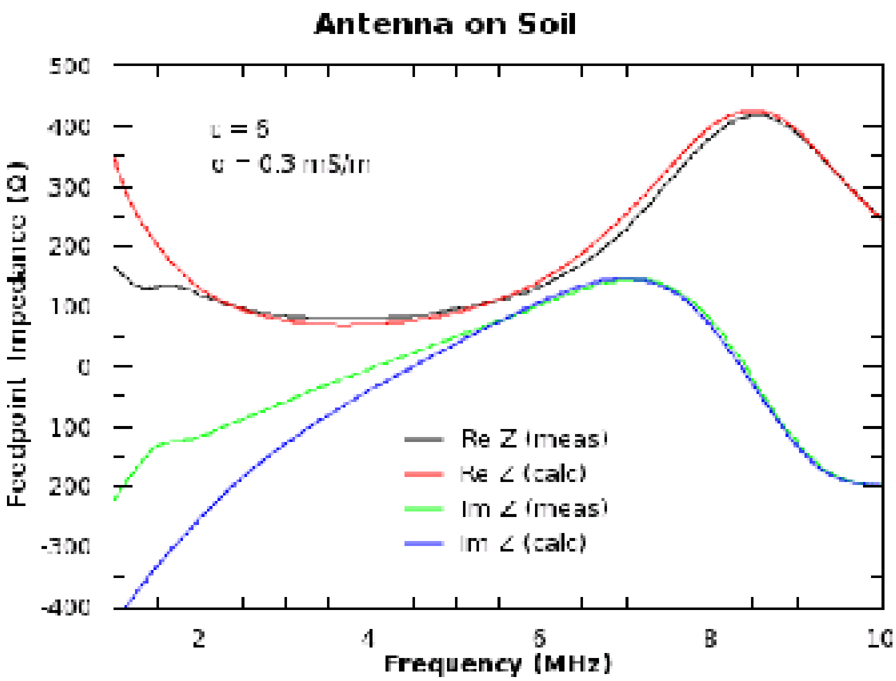

Figure 4: Measured and calculated impedance of the antenna when placed on sandy, grass-covered soil.

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.

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 lunar surface will give reasonably accurate predictions of antenna performance.