National Aeronautics and Space Administration

Very Long, Variable Frequency, Dipole Antenna for Ground Penetrating Radar Science with Tethered Rovers

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Program: Spontaneous Concept

Project Objective:
The DuAxel rover system employs two tethers in order to link the rover system together. This spontaneous R&TD investigates the possibility of using these tethers as a variable length dipole antenna for GPR measurements. The high-level objectives of this effort were to determine the feasibility of a variable-length, spooling dipole antenna as it would be deployed on the lunar surface for ground penetrating radar measurements. The main challenges are:

- What effect does spooling on the end of the tether have for the resonance of the structure with respect to a traditional dipole?
- What is the performance for various deployed lengths?
- What is the response of an antenna that is in contact with the lunar surface?
- What are the penetration depths possible on the moon?

Significance of Results:

- **Wound dipoles shown to behave as a typical dipole with respect to antenna characteristics. This allows for its use as a variable frequency antenna as a function of the linear exposed element**
- **Tethers from rovers can be used for their ability to act as variable length antenna, and can support wide-bandwidth GPR measurements of planetary bodies, such as the moon**
- **With tether lengths >600 m, low kHz measurements are possible, allowing for penetration depths of up to tens of kilometers, comparable to the thickness of the lunar crust**

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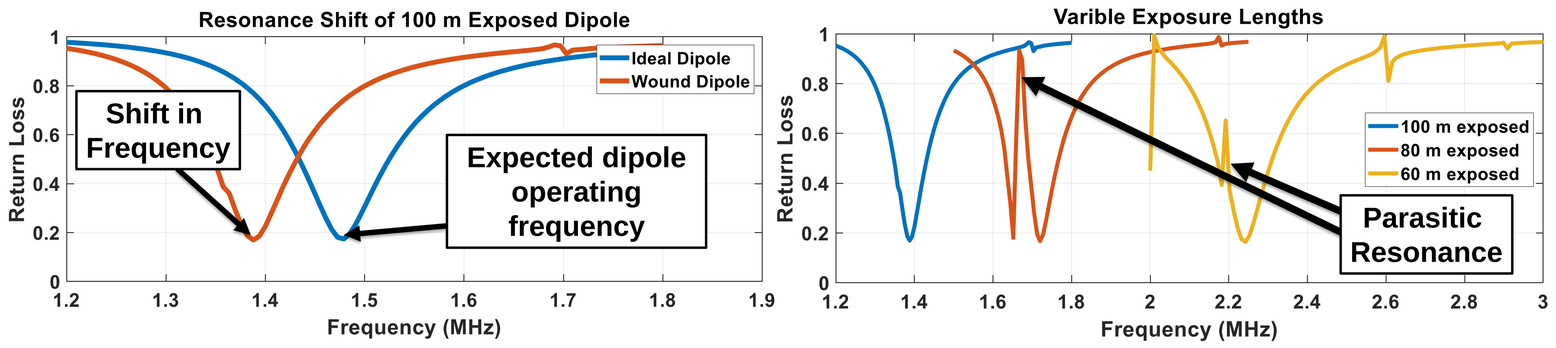
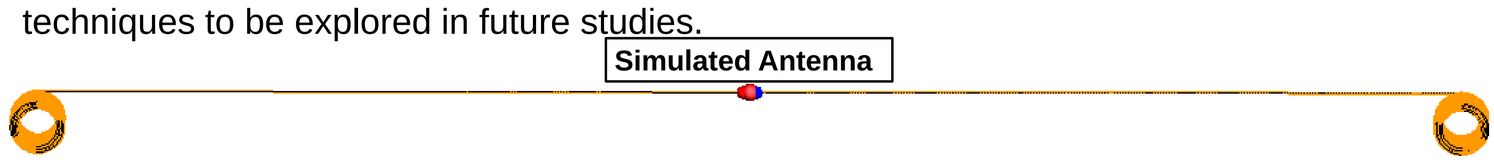
Results: The study demonstrates through simulation that a spooled, variable length, tether antenna shares similar antenna characteristics to that of an ideal dipole. While perturbations caused by spooling the ends of the radiating antenna result in a shift of the resonance, the effect is minimal with regards to the parameters of a typical dipole antenna and can be reduced through tether design. This antenna could be used for very deep (10's of km) GPR measurements.

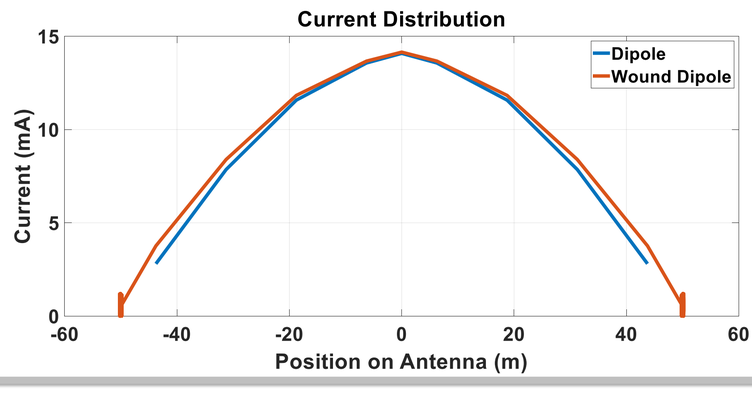
Resonant Frequency Shift and Antenna Parameters

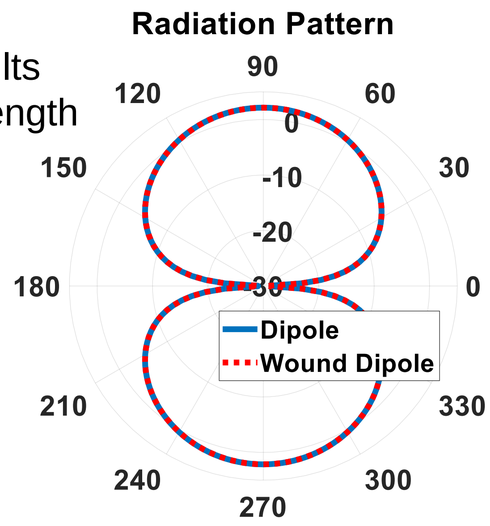


- Resonances shifts from ideal dipole due to windings at ends of coils
- Parasitic resonances also occur due to stray capacitances of inter-windings. Mitigation techniques to be explored in future studies.

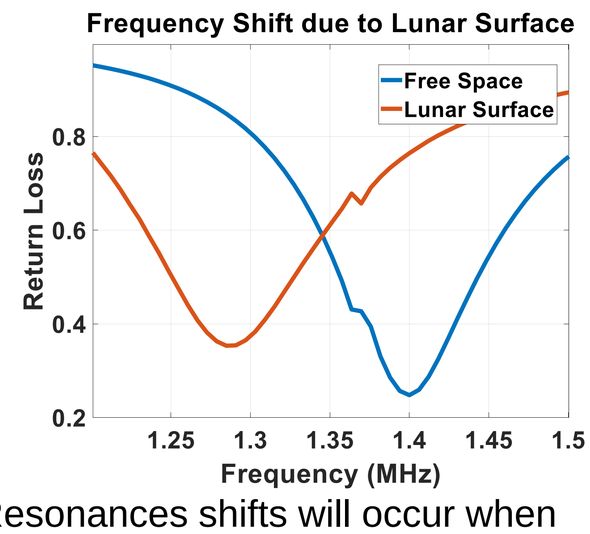


- Comparing the simulated data of a dipole and a wound configuration, the antenna design shows near identical results
- These findings are promising for the ability of the variable length structure to be used as a radiator

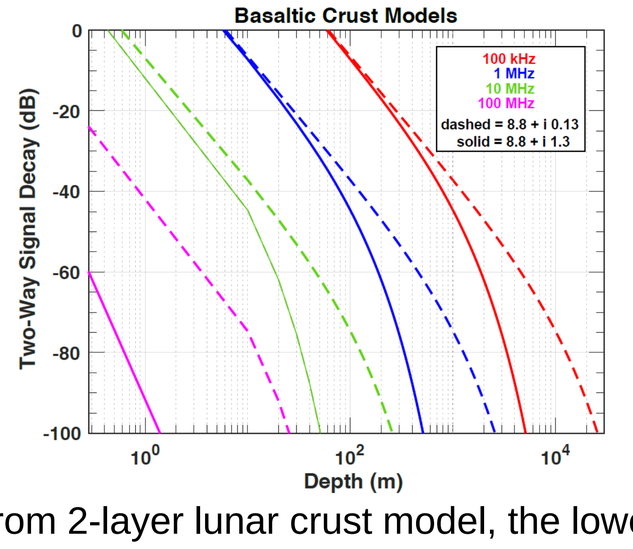




Dipole Reaction to Lunar Surface and Penetration Depths



- Resonances shifts will occur when antennas make contact with mediums different dielectric constants. With a priori knowledge of the ground electrical parameters, these shifts can accounted for



- From 2-layer lunar crust model, the lower end of the frequency range of this structure can penetrate between 5 to 25 km, depending on the lossiness of the material

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