Wireless Power Transfer on the Lunar Surface: Experimental Results Using Magnetically Coupled Resonators in Presence of Lunar Simulants.

S. M. Garman[1] and J. R. Smith[1,2], [1]Department of Electrical & Computer Engineering, University of Washington, Seattle, WA, [2]Department of Computer Science & Engineering, University of Washington, Seattle, WA. (Contact: shantig@uw.edu)

Introduction: Wireless power transfer using magnetically coupled resonators (MCR) is widely employed in biomedical and consumer electronics applications and has been deployed successfully in Earth-based mobile applications, such as UAV recharging and warehouse robot fleet charging scenarios [1-4]. A primary advantage of MCR is its ability to maintain high power transfer efficiencies even with significant misalignments between power transfer antennas. MCR is one technology under investigation for lunar surface power infrastructure, specifically for charging mobile units from a base station [5]. Presence of lunar regolith and fine metallic particles with iron content is an important consideration for wireless power transfer using MCR, because lunar dust adhesion to the power transfer antennas could cause loss of signal power and antenna detuning due to interaction between metallic iron in the regolith and the MCR's magnetic field.

In this work, we present experimental results for wireless power transfer efficiency and frequency response of the power transfer antennas in the presence of four different lunar simulants and two iron powders. Lunar simulants used include LHS-1, LHS-1D, JSC-1A, and OPRH4W30. Experimental results with four lunar simulants show minimal impact to power transfer efficiency and frequency response of the resonant coils, while results with equivalent amounts of pure iron powder show measurable impact to both parameters.

Experimental Setup: A wireless power transfer system from WiBotic, Inc. was used for all tests, including a TR-301 transmitter, OC-251 charger, TC-200 transmit antenna coil, and RC-100 receive coil. A rechargeable UAV battery was used as a target load. Power transfer efficiency was measured using WiBotic's control software, and frequency response was measured with a nanoVNA.

Results & Discussion: Lunar simulants are shown to have minimal impact to power transfer efficiency and frequency response of the resonant coils, while certain amounts of pure iron powders show significant impact to both parameters.

Impact of Lunar Simulants. Results show the system is able to charge at ≥98.5% of peak efficiency with lunar simulants in amounts up to 1kg coating the power transfer antennas (surface density of 1.4g/cm^2). Frequency response results show negligible shift of the antenna coil resonance due to presence of lunar simulants (see Fig. 1).

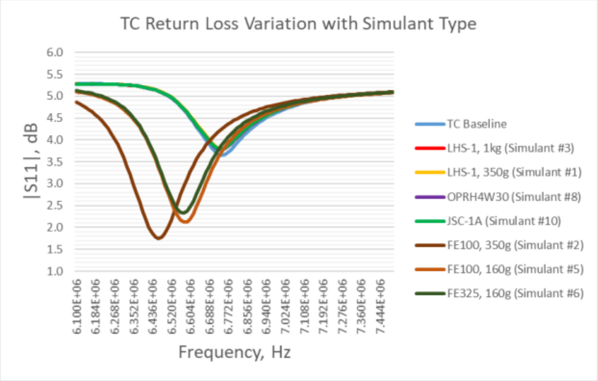

Figure 1. Measured frequency response of transmit coil return loss (S_{11}) in presence of lunar simulants and iron powders.

Impact of Fine Fe-Based Metallic Particles. Results show impact to power transfer and frequency response is proportional to surface density of iron powder present. Full power transfer is achieved even in the presence of iron powder at a surface density of 0.1g/cm^2, while a very dense sample of 1.4g/cm^2 blocks all power transfer, effectively acting as a solid metal sheet. Similarly, frequency response data show a shift to the antenna coil resonance which is proportional to the amount of iron powder coating the coils (see Fig. 1).

Conclusion: Wireless power transfer using magnetically coupled resonators (MCR) in the lunar environment should be feasible, and effects of regolith on wireless charging appear manageable, enabling new wireless charging scenarios for lunar surface power infrastructure.

Acknowledgments: This work was conducted as part of NASA's Tipping Point program together with Astrobotic, Bosch Research, and WiBotic, Inc. *For disclosure of competing financial interest, see http://sensor.cs.washington.edu/disclosure.*

References: [1] A. P. Sample et al. (2010) *IEEE Transactions on Industrial Electronics 58 (2)*, 544–555. [2] A. P. Sample et al. (2013) *IEEE Proceedings, Vol. 101, No. 6,* 1343–1358. [3] A. Kurs et al. (2007) *Science, Vol. 317,* 83–86. [4] http://www.wibotic.com. [5] NASA Tipping Point Project 80LARC21CA001.