Contribution ID: **786** Type: **Oral**

Practical Tunable Electrically Small Antenna Design for Transportable Ionospheric Heating

Tuesday 25 June 2019 09:45 (15 minutes)

A tunable electrically small antenna (ESA) designed for transportable ionospheric heating (TIH) is presented as a practical implementation of a previously presented, basic design. Traditionally, Ionospheric Heating is achieved using large multi-element arrays of dipoles or similar antennas. One such array, the HAARP IRI, occupies 0.14 km2 in Gakona, Alaska with 180 crossed dipole elements. The presented research is aimed at eventually reducing the footprint of the array such that it becomes transportable enabling the study of ionospheric effects at any accessible location on the globe, including previously unstudied equatorial regions where the Earth's magnetic field is nearly parallel to the ground. Utilizing a vertically oriented capacitive gap in a capacitively loaded loop (CLL) coupled to a small loop antenna (SLA) driven element, the design covers a range of frequencies suitable for TIH –3 to 10 MHz (30-100 MHz in 1/10th scale) –with greater than 80% efficiency across the range, whilst being a fraction of the size of an equivalent dipole. A natural match to a 50 Ω source negates the need for any lossy matching networks and allows for a more compact and efficient transmitter system. The CLL, comprised of two quarter-cylinder shells and two capacitor plates, are hinged to allow for tuning of the CLL capacitance thereby tuning the resonant frequency of the antenna. Additionally, tuning of the coupling between SLA and CLL is added to maintain the good port matching and gain with decreasing frequency throughout the tuning range. An electro-mechanical tuning system implemented on the prototype antenna with stepper motor driven components enables continuous angle tuning of 0-16° included and 90-14° with respect to the ground plane for CLL and SLA, respectively. A gain of approximately 5 dBi is observed in simulation with a similar measured result.

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Session Classification: 2.6 Non-Fusion Microwave Systems and 2.7 Microwave Plasma Interaction I

Track Classification: 2.6 Non-Fusion Microwave Systems