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Space Electric and Magnetic Sensor (SEAMS) antenna and its deployment mechanism

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Deployment of Antennas in space presents problems due to many factors; namely, the real estate occupied by the antenna element and the need for its compactness, its properties in the near vacuum of space, its inertia, rigidity, ease of storage, and certainty of release after liftoff, etc. In the context of the proposed launch of a Space Electric and Magnetic Sensor (SEAMS) payload, being developed in S. P. Pune University in collaboration with scientists from IIT Indore, PRL Ahmedabad, and RRI Bangalore, on the 4th stage of a PSLV (Kulkarni.A et al. 2022, in preparation) the above issues have been explored. The SEAMS Phase I mission operating at the low frequency (<16MHz), and at LEO altitude (~500 Kms), aims to deploy two electric antennas, mutually orthogonal, to collect both the man-made ground Radio Frequency Interference (RFI) signals as well any other Cosmic signals at the low frequencies. In this paper, the simulations of mechanical vibration and electrical characteristics of a STACER profile Antenna are briefly discussed. The STACER profile is an acronym for Spiral Tube and Actuator for Controlled Extension and Retraction [1]. This profile is popularly known and has been used for various aerospace and space applications [2]. For the SEAMS experiment, a ~2 m STACER using SS301 sheet metal is used.

Finite element model of STACER profile has been simulated for vibration and modal analysis. It shows that in the undeployed condition of STACER, the application of torque on the spirally wounded strip increases its natural frequency and the torque value also decides the length to be deployed. Increase in the torque value results in decrease in the deployed antenna length. Hence it is necessary to select the optimal torque value so as to achieve desired deployment length without vibration failure due to resonance. For deploying the STACER, a nichrome wire cutter has been used. The storing force required for STACER, to maintain itself in undeployed conditions has been calculated experimentally and will be described elsewhere (Kulkarni. A, et al., 2022, in preparation). It is seen that for deploying the STACER, a body and structure with large inertia is required, which can absorb the force after the STACER deployment. The Modal analysis of the STACER under undeployed conditions shows that the payload requirement is satisfied.

The testing for electrical characteristics of STACER made of SS301 has been carried out. To understand the effect of material and amount of the voltages picked up by the antenna, a ~2 m SS301 STACER antenna with curved ground plane (mimicking the body of PS4) was tested. Since it is an electrically short monopole antenna, its impedance is matched with a 50Ω receiver using a matching network having high input impedance. Since, the bulk resistance of the antennas is very low (few Ω) as compared to the input impedance (1MΩ) of the matching network, it does not significantly affect the voltages measured by the matching network. The simulation results and experiments carried out show that a ~2 m antenna of stainless-steel material (SS301) satisfies the requirements of the SEAMS-Phase I payload.

References:
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3. Kulkarni, A. et al. (2022), under preparation.