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Instrumentation for SEAMS: Phase I

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Low frequency radio astronomy (less than 30 MHz) is trying to push the limits of the observable universe. However, at these frequencies telescopes become severely limited by near opacity of the ionosphere. Thus, space-based radio astronomy instruments are necessary to probe this largely unexplored band of frequencies. Missions are being proposed to place low frequency radio telescope on far side of the Moon to observe various phenomenon like CMEs, planetary AKR, magnetic re-connection events occurring in Earth's Magnetosphere. The Space Electric And Magnetic Sensor (SEAMS) is a proposed payload for such studies. The work will be carried out in two phases. In the first phase, the payload will be placed on the 4^{th} stage of a PSLV to study the RFI from Earth and to understand the nuances of data acquisition and analysis. Considering the effect of man-made RFI and its consequences on astronomical data, Phase I is mainly targeted towards measuring the RFI in low earth orbit. The data generated would provide valuable information for all groups working on low frequency radio astronomy payloads. Phase I will be designed with COTs components which would considerably reduce the cost and further it would help in testing the utility of COTs components in Low Earth Orbit (LEO).

The system would consist of two orthogonal active monopole antennae along with base-band digital signal receiver. A preliminary estimation of RFI levels at LEO has been made using previously reported measurements [1]. The calculations show that the RFI levels are expected to be approximately 50-60 dB above galactic background even after excluding the ionospheric attenuation. In order to achieve high SNR of measurements, a low noise high impedance wide-band, stable active matching network for phase I has been designed and tested using a low noise Op-Amp from Texas Instruments. A sensitivity of approximately 30-40 dB above galactic background has been achieved considering a 1 meter monopole. The sensitivity can further be improved by extending the anteena length upto 3 meters. Fabricating an antenna and its deployment mechanism which can sustain conditions of LEO for such a long length is a challenging task and requires mechanical expertise. The active matching network is capable of providing a wide dynamic range of 50 dB for a white noise input. This makes the design most suitable for the present application. A gain block along with a LC filter is used to condition the signal for getting sampled in the digital receiver. The receiver consists of a virtex 5 FPGA to compute real-time binned power spectra with high frequency resolution. The acquired data can be used to map the RFI as function of location and its variation over time at LEO. This would be of great use in upgrading the design of SEAMS for phase II and beyond. The study of variation in the characteristics of ionosphere and its effect on low frequency radio signals, would help in designing further versions of such payloads.

References

[1] Mark J. Bentum; Albert Jan Boonstra; Wouter Horlings; Pieter van Vugt, "The radio environment for a space-based low-frequency radio astronomy instrument," 2019, pp. 1–7, doi:10.1109/AERO.2019.8741975