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SEAMS Phase I- RF Frontend for RFI measurement in LEO

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The main hurdle to Earth-based radio astronomy below 30MHz is the opaqueness of the ionosphere (more below ~20 MHz) as well as distortions caused due to man-made RF interference. The measured RFI [1] at different frequencies was extrapolated to obtain an estimate of the RFI at the Low Earth Orbit and it was observed that it is much higher than the received power from celestial radio sources. This may saturate the receivers or a spectrum of frequencies may become contaminated by the RFI with high power. Experimentation for RFI measurement, calibration, testing, and characterization particularly for low frequency observations would help to ensure the quality of radio astronomy data.

This paper describes the RF Frontend for the SEAMS payload Phase I, designed to measure RFI in the low earth orbit as a proof-of-concept experiment. A more advanced payload is under development for Phase II [2], wherein the payload will be placed on the far-side of the moon for low frequency radio astronomy below 16 MHz. This is being done in collaboration with scientists from IIT Indore, RRI, Bangalore and PRL, Ahmedabad.

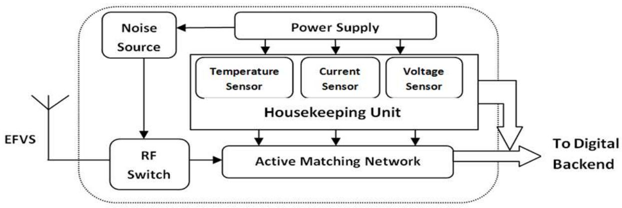

Figure 1. Block diagram of SEAMS RF Front-end

The RF frontend for SEAMS consists of Electric Field Vector Sensor (EFVS) with two orthogonal short monopoles followed by active matching network to form the active antenna. The system also includes sensors to monitor housekeeping data like temperature, power supply current, and voltage (as shown in Figure 1). For calibration, an onboard noise source is implemented. RF switch is used to select the calibration and observation modes. The RF switch chosen has low parasitic capacitance, preventing it from affecting the sensitivity of the receiver. Since the circuit may experience large temperature variations due to exposure to the LEO environment, a temperature sensor is also used to monitor the system's temperature. The digital backend then samples the signal and keeps track of housekeeping information. A prototype has been built and fabricated in the S. P. Pune University lab and is being tested for launch in an ISRO PSLV PS4 platform in early 2023.

The length of the antenna and the input-referred voltage noise of the receiver both affect the receiver's sensitivity. RFI values are predicted to be 60–80 dB above the cosmic background [3]. The length of antenna for SEAMS has been optimized to 2-meters [4]. A number of experiments have been carried out to characterize the active antenna and RF front end. The test results show a sensitivity of 25–35dB above the galactic background as required, to map the RFI as a function of location and its changes over time at LEO.

1. Bentum, M.J., Boonstra, A.J., Horlings, W. and van Vugt, P., 2019, March. The radio environment for a space-based low-frequency radio astronomy instrument. In 2019 IEEE Aerospace Conference (pp. 1-7). IEEE.
2. Kulkarni, A. et al. (2022), under preparation.
3. Atharva Kulkarni, Aditi Nagulpelli, Rasika Sali, Nikhil Navale, D.C. Gharpure, Avinash Deshpande, S. Ananthakrishnan, “Instrumentation for SEAMS Phase I" presented at URSI GASS 2021, Rome.
4. Nikhil Navale, "SEAMS- EFVS design and deployment" URSI GASS 2022, IIT Indore.