Sensitivity Analysis and Testing of Electrically Short Dipole Antenna for Lightning Instrument for Venus (LIVE). S. Jitarwal[1]*, J. P. Pabari[1], V. R. Dinesh Kumar[2], S. Nambiar[1], Rashmi[1], T. Upadhyaya[4], K. Acharyya[1], V. Sheel[1], [1]Physical Research Laboratory, Ahmedabad, INDIA, (sonam@prl.res.in), [2]BITS Pilani, Hyderabad, [4]CHARUSAT, Changa.

Introduction: Lightning is a sudden electrical discharge of very short duration on the order of few tens of microseconds. These electrical discharges produce optical signals, electromagnetic waves over a broad frequency range and acoustic waves. The emitted electromagnetic radiation by electrical discharges can escape into space and be detected by orbiters. Due to ionospheric interference, only waves with frequency below gyro frequency and above plasma frequency are expected to escape. To detect the waves escaping, a Lightning Instrument for Venus (LIVE) is proposed for Future Venus mission to understand the lightning phenomenon on Venus in detail [3]. This paper presents the sensitivity analysis of LIVE with respect to an earlier mission, i.e., Pioneer Venus Orbiter (PVO). Accordingly, prototype for different antenna configurations have been fabricated in Physical Research Laboratory (PRL) workshop and tested using an artificial source of lightning, i.e., the Van de Graaff generator.

Sensitivity Analysis: A sensitivity analysis is carried out to understand the achievable induced voltages compared to the Orbiter Electric Field Detector (OEFD) onboard PVO, and the results are depicted in Figure 1. The OEFD had an electrically short dipole antenna with a length of 0.75 m long with a 60° angle between two arms. The induced voltage on the cylindrical-shaped dipole antenna is given by $E \times L \times \sin(\theta/2)$, where E is the incident electric field, L is the length of each arm of V antenna, and θ is the separation angle [4]. The sensitivity level of the OEFD was ~60 µV/m [5]. The processed bandwidth was smaller (i.e., 30 % of the center frequency of each channel) for the OEFD on PVO. In the case of LIVE, we plan to process the total bandwidth of the signal up to 30 kHz. Hence, the instrument noise levels will be different as compared to that of OEFD on PVO. As per the figure 1, if we take the length is 1.5 m and angle between two arms of antenna is 120° we can get three times of the sensitivity as in PVO. The dot marked in the figure 1 shows the parameters of the PVO instrument.

Antenna Testing Results: The spark of 3 kV generated by Van de Graaff generator emits electromagnetic radiation which is incident on the antenna terminals. The induced voltage across the antenna terminals is recorded using oscilloscope. The figure 2 shown below displays the induced voltage of both antenna configurations i.e. 75 cm and 60° (yellow) as in PVO and another one with 1500 cm and 120° (green), where the latter gives induced voltage ~3 times the former one.

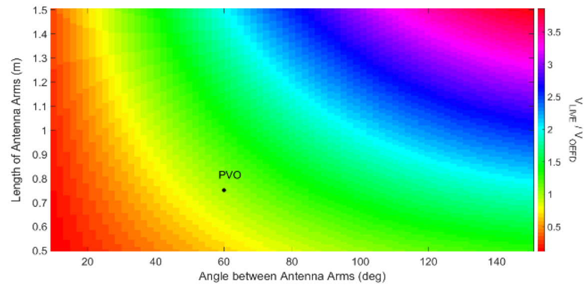

Figure 1: Ratio of the induced voltage across the antenna terminals of LIVE to that of the OEFD as a function of antenna length and the angle between two arms.

Figure 2: Time domain pulse captured by different antenna configurations using oscilloscope at a voltage scale of 20V and time duration of 5 microsecond

Summary: This study has presented sensitivity analysis of the LIVE antenna with respect to OEFD antenna. To achieve a similar sensitivity level by LIVE (as that of OEFD on PVO), it is necessary to increase the antenna length and angle between two arms of antenna. The practical testing results validate the theoretical analysis of antenna sensitivity. Further work is ongoing.

References: [1] Russell et al. (2011), *PSS*, 965-973. [2] Esposito L.W. et al. (1983) *Uni. Ariz. Press, Tucson*, 484-564. [3] Pabari J. et al. (2018) *LPSC XLIX*, Abstract # 1391. [4] Kumar et al. (2019) IMICPW, 348-352. [5] Scarf et al (1980), IEEE, GE-18, 36-38.