Proposal to the Air Force Research Laboratory

Development of a Langmuir Probe for the QuadSat/PnP satellite

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Abstract

We propose to design, build, and deliver a Langmuir probe instrument for the Swedish QuadSat/PnP Satellite. The instrument will be delivered to the Air Force Research Laboratory.

1 Introduction

The Swedish QuadSat/PnP satellite will be in a low-altitude Earth orbit. That is the region of the top-side ionosphere, thermosphere, and near the transition to the inner plasmasphere. In this region of space there is significant variability of the plasma density as a result of daily and seasonal variation of solar illumination, as well as on solar-cycle time-scales due to differences in the solar spectrum at different times in the solar cycle. Shorter-term variations due to geomagnetic activity, such as storms and substorms, are also observed. One of the important elements in understanding the physics of the ionosphere and thermosphere and specifying it is the low-energy plasma density of the top-side ionosphere. To allow us to measure and diagnose the plasma environment around the QuadSat/PnP satellite we propose to build the Langmuir probe instrument.

A Langmuir probe is a instrument which measures plasma density by taking advantage of the fact that plasma conductivity is a function of density. The Langmuir probe functions by measuring the current as a function of voltage applied to the probe.

2 Instrument specifications

The precise instrument constraints are to be defined in consultation with Dr. James Lyke at the Air Force Research Laboratory. A few general considerations are given here. The voltage range of the probe should be approximately $\pm 10\,\mathrm{V}$, and current measurements should exceed the maximum range to be expected in any of the anticipate orbital configurations. The instrument box (except for the probe itself) should fit within an envelope of 50 by 50 by 12.5 mm. The probe should be mounted directly on the instrument box, which will be mounted such that the probe protrudes from the spacecraft. The instrument should communicate with the spacecraft through a SPA interface. The power budget, mass budget, and telemetry budget still remain to be defined. When those become available the instrument will be designed in accordance with those parameters.

Figure 1 shows a block diagram of essential instrument components. The output of the variable voltage supply is controlled by the CPU in programmed steps. The current sensor measures the current between spacecraft ground, as supplied through the SPA interface, and the variable voltage supply. A power supply creates the supply voltages for the instrument from the single SPA interface voltage. The CPU communicates directly through the SPA interface using the I^2C protocol.

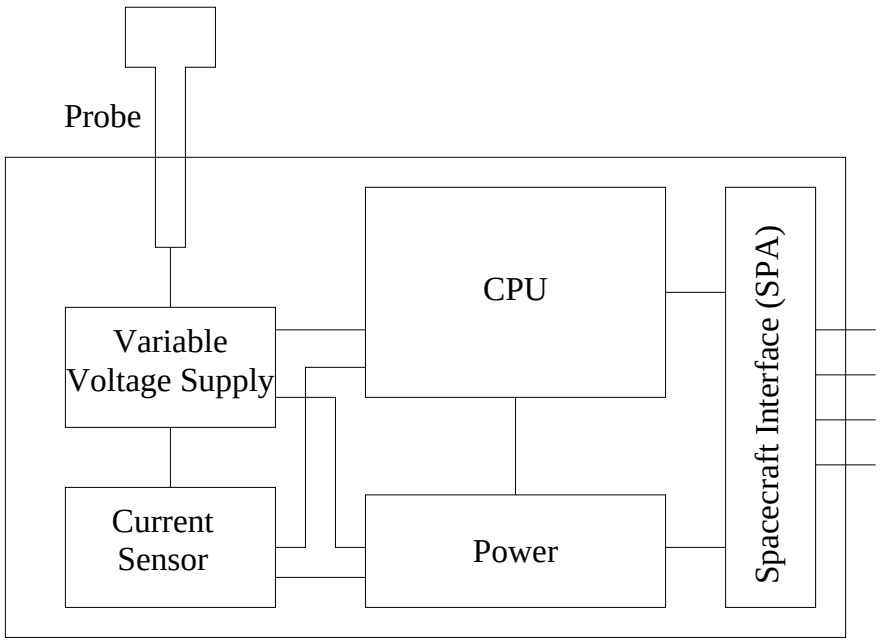

Figure 1: Block diagram of the principal component of the instrument.

3 Statement of work

The project will begin on January 18, 2011, and we are requesting a one-year period of performance. The instrument delivery is expected by the end of May 2011. The majority of the work under this project will be carried out by undergraduate students with minor assistance from graduate students. The PI will be primarily responsible for defining the instrument and will supervise the students and manage the project.

We will build a self-contained Langmuir probe instrument that conforms to the physical volume, power, mass, and telemetry constraints that will be given to us at the start of the project.

3.1 Preliminary schedule

We will follow approximately the following time-line:
January-February: Preliminary design and final design
February-March: Manufacture and assembly
March-April: Test, verification, and calibration
May: Delivery