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IONOSPHERIC EXPERIMENTS ON BOARD THE BRAZILIAN SCIENTIFIC APPLICATIONS SATELLITES SACI-1 AND SACI-2

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ABSTRACT

A set of three plasma diagnostic experiments, known as PLASMEX, are developed for launch on board the Brazilian Scientific Applications Satellites SACI-1 and SACI-2. The main objective of the experiments is to investigate the phenomenon of ionospheric plasma bubbles, known to exist in the ionospheric region over a wide range of latitudes. It is intended to make measurements of the density, temperature and spectral distribution of the irregularities in the ionospheric plasma using (1) a High Frequency Capacitance Probe for measuring the plasma density, (2) a fixed-bias Langmuir Probe for measuring the electron density profile and the spectral distribution of plasma irregularities, and (3) an Electron Temperature Probe for measuring the kinetic temperature of the ionospheric electrons. While the satellite SACI-1, is to be launched this year from China on board a LONG MARCH rocket SACI-2 is also expected to be launched this year on board a Brazilian satellite launch vehicle VLS from Alcantara-MA. In the High Frequency Capacitance Probe a metallic sensor in the form of a sphere of about 60mm diameter is used as a capacitance element in the tank circuit of a "Clapp" type oscillator. In the fixed bias Langmuir Probe a metallic sensor, similar to that used in the HFC experiment, is used to collect the elctron or ion currents from the ambient plasma. The sensor potential is selected using telecommands, from four predetermined values namely -1V, 0V, +1V and +2V. In the Electron Temperature Probe two semicircular metallic sensors in the form of a circular disc, is used to determine the kinetic temperature of the ionospheric electrons. On board SACI-1 the HFC, LP and ETP sensors are mounted at the extremities of three of the four solar panels, while on board SACI-2 they are mounted at the extremities of three deployable booms about 1m long. The PLASMEX experiments will be operated by commands from an onboard Micro-controller. While SACI-1 has a near polar sun synchronous orbit, SACI-2 has a low inclination orbit. Thus SACI-1 can give a complete global coverage for the measurement of plasma parameters, while SACI-2 can give detailed information on the behaviour of these parameters in the low latitude and equatorial regions. A brief summary of the experiments PLASMEX along with details of the data acquisition system, on board processing of the LP ac data etc. is presented here.

INTRODUCTION

The SACI-1 spacecraft is a near earth orbit (750km circular) satellite dedicated fully for scientific studies. It is to be launched this year from China on board a LONG MARCH rocket. SACI-2 is also a near earth circular orbit satellite and is expected to be launched this year on board a Brazilian satellite launch vehicle VLS from Alcantara-MA While SACI-1 has a near polar sun synchronous orbit (98 deg. Inclination), SACI-2 has a low inclination orbit. Thus SACI-1 can give a complete global coverage for the measurement of plasma parameters, while SACI-2 can give detailed information on the behaviour of these parameters in the low latitude and equatorial regions. The plasma diagnostic experiments designated PLASMEX consist of three electron density and temperature probes and will be flown on board both the Brazilian scientific applications satellites SACI-1 and SACI-2. The main objective is to investigate the phenomenon of ionospheric plasma bubbles, known to exist in the ionospheric region over a wide range of latitudes. It is intended to make measurements of the density, temperature and spectral distribution of the irregularities, of the plasma using the following experiments.

- High Frequency Capacitance Probe for measuring the plasma density.
- Fixed bias Langmuir Probe for measuring the electron density profile and the spectral distribution of plasma irregularities.
- Electron Temperature Probe for measuring the kinetic temperature of the ionospheric electrons. (This probe will be fabricated in collaboration with the Institute of Space and Astronautical Science - ISAS, Japan).

Plasma bubbles are regions of magnetic flux tube aligned depletions, localised over the magnetic equator and extending over thousands of kilometres along the geomagnetic field lines on both the hemispheres. Since its discovery in the seventies by radars, satellites and rockets the phenomenon of ionospheric plasma bubbles has been the focus of scientific and technological investigations by international groups. The equatorial cross section of the bubbles has dimensions of hundreds of kilometres in the horizontal as well as vertical directions. The bubbles develop in the nocturnal equatorial ionosphere with its frequency of occurrence depending on the season of the year and the longitude of the equatorial sector. Its discovery in the Brazilian ionosphere was documented through measurements by rockets,

photometers and ionsondes from the Brazilian territories. The in situ measurement of the critical parameters of plasma bubbles proposed here, to be realised on board the first Brazilian scientific microsatellite, promises to offer important data fundamental for the detailed study of the electrodynamic processes for the generation and development of plasma bubbles. It is important to mention here that the development of plasma bubbles attains its maximum intensity around 2200 hours local time. Therefore the sun-synchronous orbit of the Brazilian satellite, also localised around 2200 hours local time offers perfect conditions for the observation of plasma bubbles.
The proposed experiments to be realized on board SACI-1 and SACI-2 have the objective of making in situ measurement of plasma bubbles with the principal objective of understanding the physical mechanisms of their generation, development and decay in the global ionospheric region in general and in the ionospheric region over Brazil in particular. It is now rather well established that the bubbles are produced in consequence of non-linear plasma instability processes, the most important among them being the Rayleigh-Taylor mechanism. Cascade processes result in the generation of plasma irregularities, associated with the bubble, whose space scale varies from centimetres up to tens of kilometres. However diverse aspects of this phenomenon, mainly the ambient ionospheric conditions and the electrodynamics that are responsible for its large variability in the occurrence frequency as well as the intensity of occurrence remain unknown till today. On the other hand, a better understanding of these aspects is fundamental in attaining our objectives of improving the predictability of the occurrence of these phenomena. The combined effect of these irregularities in the remote sensing diagnostic systems is known as equatorial "spread F". INPE operates in Cachoeira Paulista, São Luiz and Fortaleza, radio and optical instruments (Digissonde, Photometers, Imager etc.) of remote sensing of plasma bubbles.

EXPERIMENT DESCRIPTION

The general block diagram of the PLASMEX experiment package is shown in Figure 1. The different packages or experiment modules are represented in this block diagram. The block diagram of the microcontroller is given in figure 2.

High Frequency Capacitance Probe

The HFC experiment makes use of a metallic sensor, in the form of a sphere of about 60mm diameter mounted on a short boom at the extremity of a solar panel in SACI-1 and at the extremity of a deployable arm in the SACI-2 The sensor electrode functions as a capacitance element in the tank circuit of a "Clapp" type oscillator. The capacitance varies with the electron density along the trajectory of the satellite, varying the frequency of the oscillator that is measured on board the satellite. From the change in the oscillator frequency it is possible to determine the number density of electrons.

Langmuir Probe

A spherical metallic sensor, identical, in form and mounting, to the HFC sensor is used AS the LP sensor. The current of electrons and/or ions collected by the sensor depends very much on the geometric form of the sensor, the potential applied to the sensor, the physical characteristics of the ambient plasma and the sensor speed. The sensor can be maintained at the ambient plasma potential or at a negative potential to collect predominantly positive ions or at a positive potential to collect predominantly electrons. In the present case the sensor potential will be selected using commands, from four predetermined values namely -1V, 0V, +1V and +2V.

Electron Temperature Probe

A circular disc of diameter about 10cm consisting of two semicircular plane metallic sensors is used as the ETP sensor. The mounting of this sensor is similar to that of HFC and LP sensors. The two sensors function like two planar LP sensors. In the Electron Temperature Probe the current-voltage characteristic curve of a conventional Langmuir probe is deformed by superposing an rf potential over the potential applied to the sensor. An rf signal with two amplitudes is applied alternately superposed on a constant sensor potential and the deviations in the current-voltage characteristic curves introduced by the rf signal are measured in terms of the variations in the current collected by the sensor. The ratio R between the two deviations corresponding to the two amplitudes is used to determine the electron temperature.

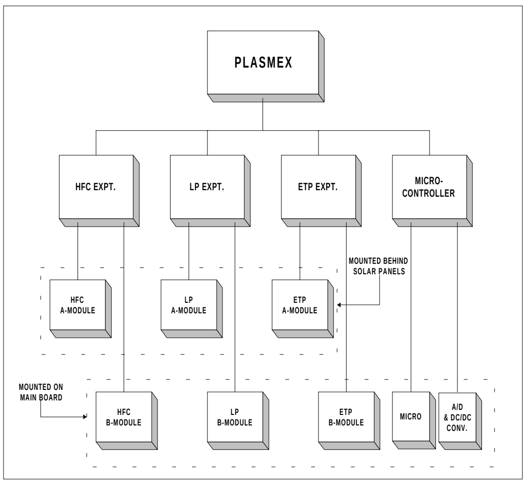

Figure 1: General Block Diagram of PLASMEX

The PLASMEX experiments namely the HFC Probe, Langmuir Probe and the Electron Temperature Probe will be operated by commands from an onboard Micro-controller. The specific commands needed to change the operational modes of the experiments will also be provided by the Micro-controller. The Micro-controller will also take care of the data transfer from the experiments to the OBC (On Board Computer).

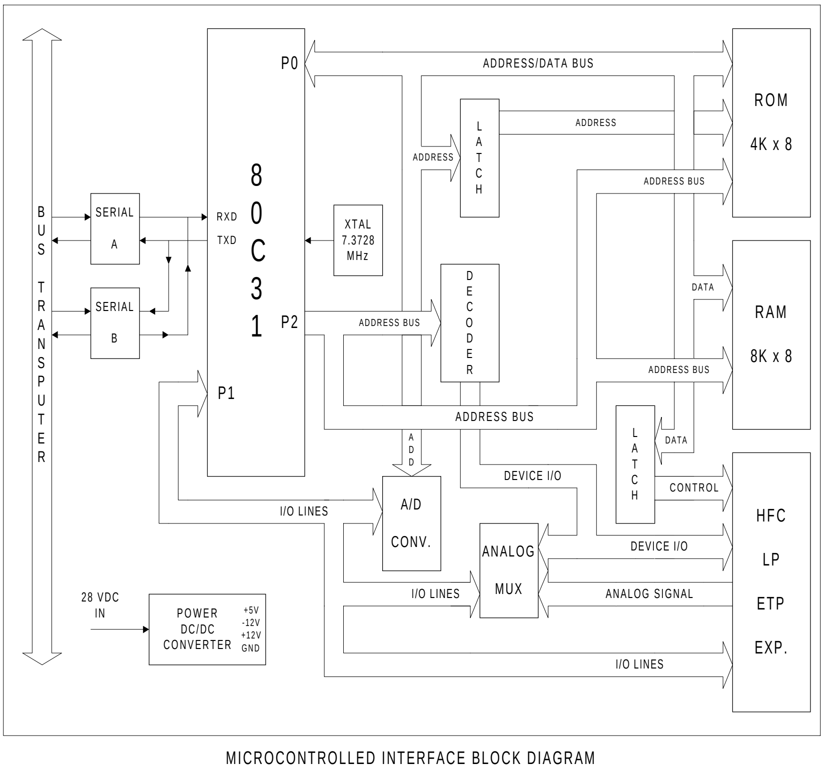

Figure 2: Microcontroller Block Diagram

MECHANICAL INTERFACE

The exploded view of the SACI-1 satellite showing the location and mounting of the scientific experiments including the PLASMEX is shown in the figure 3. As can be seen from the figure the A Modules of the HFC, LP and ETP experiments that contain the sensor and associated front end electronics are mounted behind three solar panels at their extremities to reduce interference from fluctuations in the satellite body potential.

The main electronics system containing the Module- B of the HFC, LP and ETP experiments and the Micro controller is mounted on a single printed circuit board and attached to a metallic frame (satellite segment) of approximate dimensions 345x365mm^2.

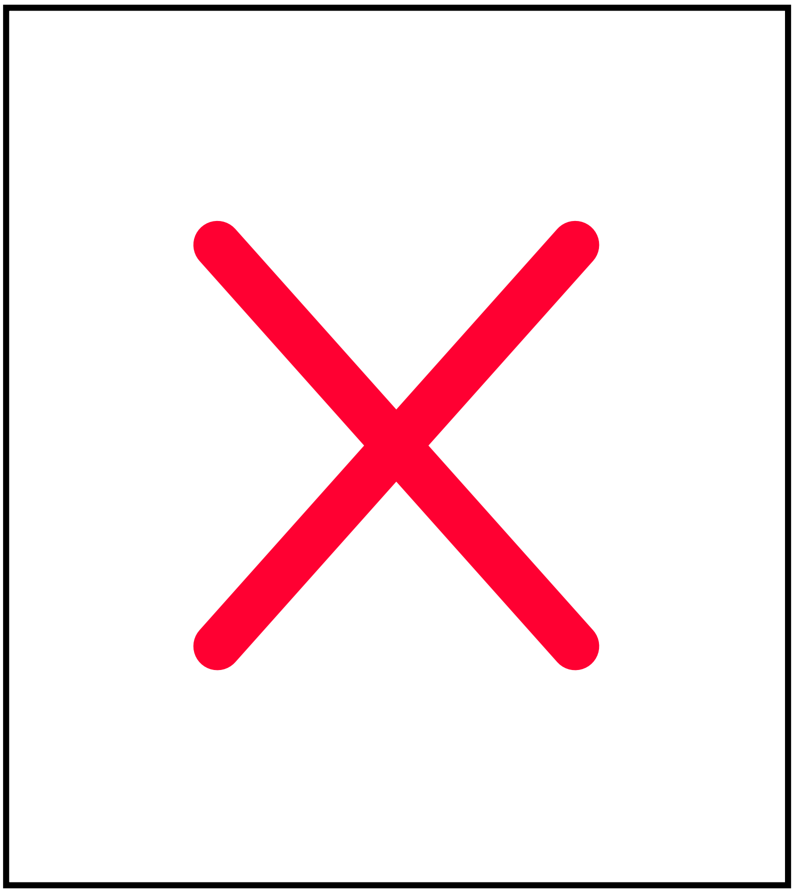

Figure 3: Exploded View of SACI-1 Satellite showing the Location of the Scientific Experiments

ENERGY AND MASS BUDGET

The PLASMEX experiment power consumption is given in Table 1. The values given are the estimated ones, but are very close to the measured ones. The total power consumed by the experiment is about 5.7 Watts. The mass budget of PLASMEX is shown in Table 2.

TABLE 1.

PLASMEX		VOLTAGE(V)	CURRENT(mA)	POWER(W)
HFC	MODULE-A	+12	30	0,360
		-12	20	0,240
	MODULE-B	+12	30	0,360
		+5	125	0,625
		-12	20	0,240
LP	MODULE-A	+12	30	0,360
		-12	20	0,240
	MODULE-B	+12	70	0,840
		-12	30	0,360
ETP	MODULE-A	----	----	----
		----	----	----
	MODULE-B	+12	20	0,240
		-12	20	0,240
ECI	MODUKLE-B	+12	25	0,300
		+5	200	1,000
		-12	25	
			TOTAL	5,700

TABLE 2.

UNIT	MASS (kg)
HFC MODULE-A	0,589
LP MODULE-A	0,575
ETP MODULE-A	0,093
MAIN BOARD	1,220
TOTAL	2,477

LAUNCH SCHEDULE

The SACI-I microsatellite launch is presently scheduled for the middle of 1999, from the Satellite Launching Center in China. This will go along with the CBERS satellite, scheduled for launch on board a Chinese Long March rocket. SACI-2 launch is also presently scheduled for launch on board a Brazilian VLS (Satellite Launch Vehicle) in the middle of this year.

ACKNOWLEDGMENTS

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