THERMAL PLASMA MEASUREMENT UNIT FOR PROBA II MICROSATELLITE

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ABSTRACT

An instrument for cold plasma measurements suitable for small satellites is presented. Thermal Plasma Measurement Unit (TPMU) has been developed for PROBA II mission as well as for future scientific projects. The TPMU objectives are to provide a measure of the electron temperature, floating potential, the ion temperature, concentration and composition. This data is used in studies of the space weather and for ionosphere modeling. TPMU uses radio-frequency (RF) method for the electron temperature measurement and retarding potential analyzer (RPA) for the ion measurements. The flight model of the instrument passed all specified tests and it is ready for integration to the satellite. The launch is expected at the end of 2008.

1. INTRODUCTION

The goal of our PROBA II experiment is the study of the ionosphere, its dynamics and response to solar and geomagnetic activity. Measurement of basic thermal plasma parameters could help to improve empirical models of electron temperature, density and ion composition in the topside ionosphere. The main purpose of the TPMU is to extend series of similar measurements carried out during last two decades onboard MAGION and INTERCOSMOS satellites using the well known and proven measurement methods. Another aim is to develop a new more reliable and accurate but still low cost instrument suitable for micro-satellites by implementing state of art electronic design.

The PROBA micro-satellites are dedicated to provide flight opportunities for testing small instruments and prototype payloads. Micro-satellites with a total mass of about 100 kg provide a low-cost route for carrying out in-orbit testing and demonstration of high-risk technologies, novel instruments and new concepts in support of ESA's future needs. PROBA II is being developed by a European consortium lead by the Prime Contractor, Verhaert Design and Development NV of Belgium, a subsidiary of QinetiQ (UK). The launch is planned for December 2008 to the Sun-synchronous circular orbit with altitude 700km.

2. MEASUREMENT METHOD

The ion measurement is based on retarding potential analyzer (RPA). RPA consists of planar sensor which is directed approximately along the spacecraft velocity vector. The sensor has internal grids. Subsequent steps of positive voltage are applied to the grids to retard the incoming ion flux that reaches the collector. The resulting ion-flux versus retarding potential measurements is used to derive the total ion concentration Ni, the ion temperature Ti and the approximate ion composition. The electron temperature measurement uses another principle and sensor. It is based on radio frequency probe method using the RF signal (~50 kHz) which is modulated by square wave. The amplitude of RF is controlled in such a manner that the shift of probe potential is constant. The probe potential is periodically searched for minimum of electron temperature. The electron temperature is measured under the assumption of Maxwellian distribution.

Ranges of measurement:

Total ion density:	$2.10^{7} – 8.10^{12}$ m^{-3}
Electron temperature:	800 – 20000 K
Ion temperature:	800 – 10000 K
Floating potential of the satellite:	±12 V

3. TECHNICAL DESCRIPTION

The TPMU is housed in an aluminum box together with the electronics of the Dual Spherical Langmuir Probe (DSLP) experiment. Both experiments have the Digital Processing Unit (DPU) in common. Digital part of the TPMU is built on the 8051 clone (ADuC845), containing among others single-cycle core 8051-based core running on 12.58 MHz, 62kBytes program memory, 2304 bytes on-chip data RAM, two independent 24-bit ADCs with 8 input channels, 12 bit D/A converter. It provides proper timing and control signals for the analog part, primary data processing and necessary calculations. It also communicates via an optocoupler-isolated interface with the DPU. Programs are written in 8051 Pascal, mode and time resolution are set by commands from DPU.

Analog part manages conditioning of signals from sensors. Small signals are amplified and adjusted for A/D conversion. Low noise and high impedance operational amplifiers are used throughout.

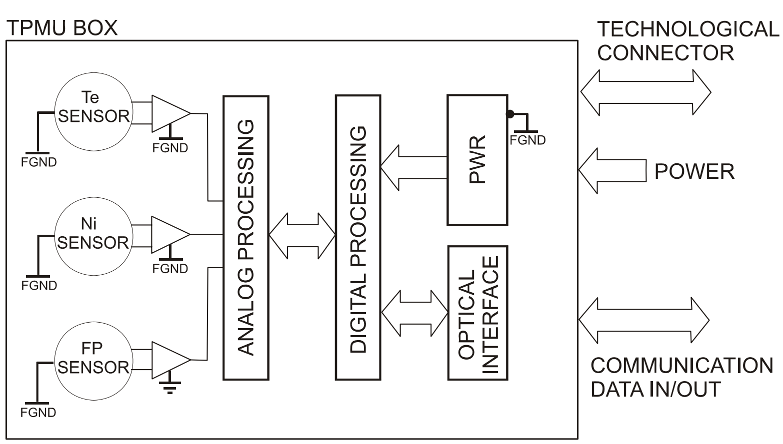

Fig.1. TPMU Block Diagram

The power supply unit performs a voltage conversion from the 28V voltage of the satellite power system to the galvanically isolated floating +5V voltage used for the digital part, and the floating +/-12V voltage used for the analog part. The floating +5V voltage is also converted by low power DC/DC converters to provide auxiliary voltages of +20V, +40V for RPA, and +20/-20V which are used for the floating potential compensation. The TPMU is protected with over-current and latch-up protection circuit. All the electronics is accommodated on one PCB plate.

Planar sensors were developed in the Institute of Space Research, Moscow, Russia. The box is made out of high-strength aluminium-base alloy and has a sandwich structure. The top part with planar sensors is equipped with the TPMU electronics, the bottom with the DSLP electronics, interface and DC/DC converters. The technical realization of TPMU and DSLP box was made in cooperation with Czech Space Research Centre (CSRC) Brno, Czech Republic. All soldering and assembly operations were made in CSRC clean room in Kroměříž, Czech Republic.

Technical data

Dimensions: 130x320x63 mm
Mass: 2426 g
Power: 950 mW

Fig.2. TPMU board and top plate with sensors

Fig.3. Assembled TPMU/DSLP box

8. CONCLUSION

The TPMU instrument was developed for cold plasma measurement onboard PROBA II satellite. Together with DSLP constitute complex apparatus for further ionosphere and near Earth space environment research. Both instruments passed all specified tests and were delivered in December 2006 to Verhaert, Belgium for further integration to the PROBA II satellite.

9. REFERENCES

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