

**The Thermal Plasma Measurement Unit (TPMU)** was designed and manufactured as a part of scientific payload of the PROBA II satellite. It is intended for research of the cold plasma parameters like electron temperature, ion density, ion temperature and floating potential of the satellite. Scientific aim of the instrument observation is to study parameters of thermal plasma which are crucial for the electromagnetic waves propagation in the upper ionosphere. TPMU data will be used primarily for construction and improvement of ionospheric models. The goal is to get enough data to obtain actual global model in altitude given by satellite orbit. The second important TPMU goal is the validation and testing of the novel design of the instrument which is necessary for possible applications of TPMU design on future scientific missions.

TPMU was proposed under the PRODEX programme in 2002 and approved in 2003. The project was planned for three years as construction of a separate device, and extended until the end of 2008 due to the delay of PROBA 2 launch. Since 2004, it was developed as a one mechanical unit with the Dual Segmented Langmuir Probe (DSLPL). Flight version of the instrument was delivered in late 2006 to the company Verhaert, where were held a pre-flight testing and integration. The device was designed and developed at the Institute of Atmospheric Physics ASCR, flight model of the instrument was manufactured in cooperation with the Czech Space Research Centre (CSRC) in Brno. PROBA 2 satellite with the TPMU on board was launched on 2 November 2009 by a Rockot vehicle from the Plesetsk Cosmodrome in northern Russia. Measured plasma parameters:



- Ion temperature
- Ion density
- Ion composition
- Electron temperature
- Electron density
- Floating potential

### **Short description of the device**

TPMU is placed in a box made of aluminium alloy containing the electronics block and block of measuring sensors with the retarding potential analyzer (RPA) and two RF sensors. The entire box is mounted on the upper side of the control unit DSLP that for TPMU provides both power and data processing. Ion measurement is based on the retarding potential analyzer and uses planar sensor, which contains a set of internal electrodes. The electrodes are gradually fed by increasing positive voltage, which controls flow of ions from the surrounding plasma. On collecting

electrode is then given only ions with certain energies. The dependence of current on voltage gives data for calculation of the total ion concentration, temperature and approximate composition (it can distinguish ions of oxygen, hydrogen and helium). To obtain the electron temperature another type of the sensor and high frequency measurement method are used. Electrode of the sensor is fed with pulses of radio frequency signals around 50 kHz. Signal amplitude is regulated so that the output voltage is maintained at a constant level. The magnitude of this amplitude is determined as the value for electron temperature calculation. Maxwell distribution of velocities of the electrons is assumed. The same type of sensor is also used for determining the spacecraft floating potential. The theoretical range of densities and temperatures measured are approximately 10 to 1 million ions per cubic centimetre, respectively 800-10 000 K. The floating potential of the satellite is measured in the range of  $\pm 12$  volts. Data obtained from the device will be used to study processes in thermal plasma and after accumulation of sufficient data also for the construction and improvement of empirical models, especially the construction of a new global model at the height of the satellite orbital path.

### **TPMU status 2/2011**

TPMU is regularly switched on together with the DSLP. Common data are downloaded from REDU web site, processed and stored. The device is working with limitations of scientific measurements caused very probably by installed onboard software. This brings lower data volume as it was planned. Affected are Ion measurement and partially electron temperature measurement. The measurement of the floating potential and housekeeping measurements are not affected. This limited function of the instrument is stable and lasting since the beginning of the mission. The TPMU hardware is in a good condition and its behaviour is stable. No anomalies have been observed. The internal temperature and power consumption are in expected limits.

TPMU data are extracted from raw BINDSLP files and further processed to give final data file that comprises time, electron temperature and floating potential. These data are visualised to obtain quick look plots. Then data are completed with orbital parameters and submitted to scientific exploration. Regularly is evaluated technological part of the project and the long-term stability of the TPMU onboard electronics is measured.