Space Dynamics LABORATORY
Utah State University Research Foundation

FPMU

Floating Potential Measurement Unit

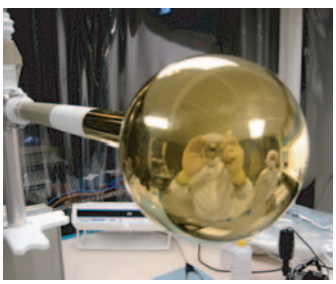
Utah State University and the Space Dynamics Laboratory (USU/SDL) designed and built the Floating Potential Measurement Unit (FPMU) in cooperation with NASA Johnson Space Center. This instrument monitors surface charging of the International Space Station (ISS) and the space environment parameters that affect it. NASA has identified excessive charging of the ISS as a hazard to vehicle and crew. The FPMU is an important diagnostic tool that will assist in the effort to understand and control ISS charging.

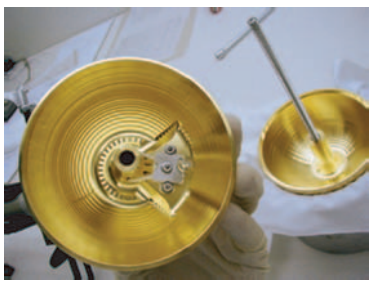
FPMU Functions

The FPMU consists of four probes: a Floating Potential Probe (FPP), a Wide-Sweeping Langmuir Probe (WLP), a Narrow-Sweeping Langmuir Probe (NLP), and a Plasma Impedance Probe (PIP). This set of instruments measures ISS charging (V_{ISS}), electron density (N_e), and electron temperature (T_e).

Space station charging is unique because the ISS solar panels are operated at higher voltages with more cells connected in a series than on a standard spacecraft. The exposed interconnects on the solar panels can drive the ISS to a higher potential than the surrounding ionospheric plasma. This charging can be especially significant when the space station passes through cold, low-density plasma, which often occurs near the terminator. NASA has identified a risk to astronauts on Extra Vehicular Activity (EVA) if the ISS charges to more than 40 volts. Prolonged charging of the ISS can result in degradation of the surface coatings through sporadic arcing. These issues were recognized during the development of the ISS, and plasma contactors were installed to control charging.

Instrument	Parameter	Rate	Effective Range
FPP	V_{ISS}	128Hz	-180V to + 180V
WLP	N_e T_e V_{ISS}	1Hz 1Hz 1Hz	10^9 m^{-3} to $5x10^{12}$ m^{-3} 500K to 3000K -50V to 20V
NLP	N_e T_e V_{ISS}	1Hz 1Hz 1Hz	10^9 m^{-3} to $5x10^{12}$ m^{-3} 500K to 3000K -180V to +180V



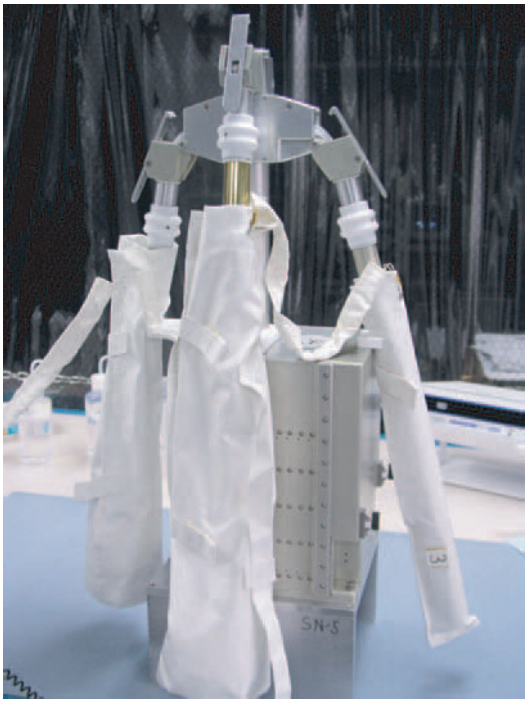


FPMU's Quality & Reliability

The failure or improper operation of the plasma contactors on the International Space Station is a hazard to both astronauts and vehicles. To mitigate this hazard, the ISS floating potential must be monitored and the space station charging models updated as the ISS configuration changes. The FPMU is vital to this process and will be used for every configuration change.

The FPMU has to be placed in the clear flow of plasma around the ISS, so it will be located on the tip of the S-1 truss. The FPMU assimilates data and system status from its instruments and transmits the information through the ISS video data system to the ground for analysis and storage.

To ensure the FPMU's quality and reliability, USU/SDL and NASA performed a number of tests on the unit. The NASA FPMU team conducted power quality testing and practiced deployment procedures in NASA's underwater Neutral Buoyancy Laboratory with a USU/SDL-supplied mock-up of the unit. USU/SDL also conducted electromagnetic interference (EMI) and electromagnetic compatibility (EMC) testing to determine how a noisy electro-magnetic environment would affect the FPMU sensor. This testing was followed by vibration, thermal vacuum, and plasma testing.



USU/SDL has extensive experience building this type of sensor, but until recently the sensors had been used only in scientific research of the upper atmosphere. This is the first time the sensors will be used in an operational setting. Because the FPMU effort was a high-priority, short-timeline project for NASA, it required USU/SDL to draw upon innovative engineering practices. The FPMU was installed by ISS crewmembers, during an Extra Vehicular Activity (EVA), on the starboard (SI) truss of the ISS on August 3, 2006.

Measurement Quantity		Rate (Hz)	Range	Accuracy	Resolution	Units
Floating Potential	V_{ISS}	128	-87–87	±0.02	0.01	Volts
Electron Density	N_e	512	10^2–10^7	100	50	cm^2
Electron Temperature	T_e	1	500–4800	500	100	K

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