Introduction

Orbiting approximately 400 km above the Earth, the International Space Station (ISS) is a unique research laboratory used to conduct ground-breaking science experiments in space. The ISS has eight Solar Array Wings (SAW), and each wing is 11.7 meters wide and 35.1 meters long. The SAWs are controlled individually to maximize power output in response to the changing power needs of the ISS. They are also controlled to mitigate interference with other ISS operations such as vehicle dockings and Extra-Vehicular Activities (EVA). The Solar Arrays are designed to operate at 160 Volts. These large, high power solar arrays are negatively grounded to the ISS and collect charged particles (predominately electrons) as they travel through the space plasma in the Earth’s ionosphere.

During normal operations, the arrays are approaching ram at eclipse exit and all strings are unshunted in order to supply power to the loads and recharge the batteries. The potential on the unshunted arraysquickly rises to 160 Volts. The exposed portions of the semiconductor and interconnects collect electrons increasing the negative floating potential of the ISS. The cover glass on the arrays collects electrons developing a potential barrier that slows the collection of electrons on the array. These are strings of solar cells that are controlled individually to meet the changing power needs of the ISS.

The arrays rotate via Beta Gimbal Assemblies (BGA) and Solar Alpha Rotary Joints (SARJ) to maximize power production, minimize stress to the structure, and also move for other specific operations such as vehicle dockings. During insolation, the Sequential Shunt Unit (SSU) provides the automatic regulation of the arrays by turning strings of cells off and on as needed to support loads. When a string is “shunted” all generated current is sent back to the array, and the voltage on that string is zero. During the eclipse portion of the orbit, the Battery Charge Discharge Units (BCDU) provide the regulation of the current. The current flows into the Direct Current Switching Unit (DCSU) and is sent to the ISS loads [4].

The Charging Mosaic illustrates a number of floating potential profiles currently being investigated for ISS. These are plots of the ISS floating potential (Volts) versus time. Each plot is a five minute time interval. They range from simple, well understood potential fluctuations to complex potential variations with currently unknown causes.

Floating Potential Measurement Unit

The Floating Potential Measurement Unit (FPMU) is a collection of four probes: the Plasma Impedance Probe (PIP), Wide-sweep Langmuir Probe (WLP), Narrow-sweep Langmuir Probe (NLP), and the Floating Potential Probe (FPP). Together, these instruments are able to determine the ISS floating potential (FP) as well as the ion and electron density (Ni, Ne) and electron temperature (Te) of the local plasma environment [160,161].

The collected data is downlinked to the FPMU Workstation at MSFC where it is processed and archived. The Space Environments Team at MSFC analyzes the collected data with respect to the ISS position along the orbital path, the timing of ISS eclipse and sunlit phases, and the current space weather conditions to determine the environmental sources causing significant changes in floating potential. We focus on FPP and WLP observations for this work. The FPP measures ISS frame potentials relative to the ambient plasma environment at a rate of 128 Hz allowing detailed monitoring of frame potential variations at high time resolution. Plasma density measurements are obtained from the WLP Ni parameter at a rate of 1 Hz. Electron density is assumed to be equal to the ion density due to quasi-neutrality. A description of the data analysis algorithms used to obtain the potentials and plasma density parameters from the FPMU instrument suite is described by Wright et al. [2].

References


Acknowledgements: The authors would like to thank the ISS Electrical Power Systems team at Johnson Space Center for their help in collecting and understanding the ISS solar array data, especially Raymond Kaminski, Matthew Scudder, and Aaron You.