In Flight Calibration of the Magnetospheric Multiscale Mission Fast Plasma Investigation

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Each orbit, the MCPs will be ramped from 5 to full operating voltage before operating point cal and before each data survey leg. During the main MCP ramp before operating point cal, integrative commands will be performed every 200V for the 1200V at and preceding the operating voltage. These integrations will be used to examine the aging behavior of the MCPs.

A sample plot of the pixel noise burst rates is shown. Each panel has 4 columns. Each of the 4 columns represents a decade in burst rate. For example, the first column represents how many times per second a burst of between 10 and 100 Hz occurred. A value of 5 in this column would mean 5 times per second, a burst occurred with a count rate corresponding to between 10 and 100 Hz. Each panel represents a simple complete ramp.

Over time, radiation will alter the behavior of the HVPS, requiring periodic recalibration of the voltage command settings. The purpose of the HV Monitor Check is to determine the extent to which the HV stepper values have drifted and to check for early signs of component failure within the HVPS.

The housekeeping packet returns the HV monitor values, which can drift independently of the actual output voltage. For this reason, the HV monitor by itself cannot be used for calibration – i.e., a monitor offset of 5V does not mean that the voltage should simply be adjusted by 5V. Rather, the drift of the monitor over time gives an idea of the effect of radiation on the HVPS in general indicating that a more involved calibration is required. Current is also measured with high voltages applied on each steppe. Elevated current at high voltages is a sign of pending component failure, which may be mitigated if detected early.

Abstract: The Fast Plasma Investigation (FPI) on the Magnetospheric Multiscale mission (MMS) combines data from eight spectrometers, each with four detection states, into a single map of the sky. Any systematic discontinuity, artifact, noise source, etc. present in this map may be incorrectly interpreted as legitimate data and incorrect conclusions reached. For this reason it is desirable to have all spectrometers return the same output for a given input, and for this output to be low in noise sources or other artifacts. While many missions use statistical analyses of data to calibrate instruments in flight, this process is insufficient with FPI for two reasons: 1. Only a small fraction of high resolution data is downloaded to the ground due to bandwidth limitations and 2. The data that is downloaded is, by definition, scientifically interesting and therefore not ideal for calibration. FPI uses a suite of new tools to calibrate in flight. A new method for detection system gain calibration has been developed involving sweeping the detection threshold to fully define the pulse height distribution. This method has now been extended for use in flight as a means to calibrate MCP voltage and threshold together forming the operating point of the Dual Electron Spectrometers (DES) and Dual Ion Spectrometers (DIS). A method of comparing higher energy data (which has low fractional voltage error) to lower energy data (which has a higher fractional voltage error) will be used to calibrate the high voltage outputs. Finally, a comparison of pitch angle distributions will be used to test remaining discrepancies among sensors.

Burst Data Calib is a method of acquiring burst resolution data for a period of one spin (20s) at a chosen point in each orbit and using this data to perform statistical analyses of various calibration errors. This data is chosen by the FPI team and marked for download through a similar interface to the Scientist in the Loop. This activity does not require any commanding to the spacecraft as it occurs on the ground via the data ranking system.

For gyroscopic plasma with a small (<30 km) bulk velocity (e.g., plasma sheet),

1. For each burst map, calculate magnetic pitch angle sampled by each pixel using Local polar and azimuth targets
2. Accumulate counts from pairs of pixels that sample the same magnetic pitch angle
3. From large (square) matrix of equations that asserts that each pixel measuring the same pitch angle should report the same phase space density
4. Solve the matrix (linear least-squares) for the effective efficiency of each pixel

Burst data calibration will also be used to calibrate the HV deflection steppers. As highly structured plasma passes across the set of anamplers, look directions can be calibrated based on the observed location.