PARTICLES AND FIELDS ENGINEERING DATA ANALYSIS AND TRENDING FOR THE ENTIRE MAVEN MISSION (2013-2021)

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Introduction

The MAVEN spacecraft was launched in November 2013, to investigate the upper atmosphere and ionosphere of Mars and how the solar wind strips volatile compounds from this atmosphere. It is important to monitor and make sure that the instruments are functioning within their operational limits in order for the mission to proceed collecting valuable data from Mars. During this research project we used level 0 (raw, unprocessed) data to analyze various engineering analog housekeeping telemetry diagnostics from the MAVEN Particle and Fields instruments throughout the mission. Since we didn't have a computing power to download data for each year and the entire mission, we decided to download two full days of data per month since starting in January 2014 through to August 2021 (the most recent data). We used this data to plot and analyze the Maven Particles and Fields Data Processing Unit (PFDPU) voltages and all 8 of the Particles and Fields Instruments currents, voltages, and temperatures with respect to time.

Methods

In order to analyze the Particles and Fields (PF) instruments analog engineering data for the entire MAVEN mission, we did the following:

- Used level 0 (raw, unprocessed) PFDPU housekeeping packets (ApID 0x23)
- Downloaded data from the 14th and 28th of each month to avoid recurring activities (such as calibration that take place on the first of each month)
- Filtered out instrument power off times by checking when the current was below 20 mA
- Calculated the mean and the standard deviation for each year and the overall mission for:
- PFDPU internal voltages and currents
- All PF instruments' (MAG, SEP, LPW/EUV, SWIA, STATIC, SWEA) voltages and currents
- Checked times of unusual spikes or variances in analog telemetry against the operations log spreadsheet (Ops log), which contains all instrument and spacecraft activities
- Correlated anomalous voltages and currents against temperature (as an indicator of SC attitude)
- Worked with instrument scientists and design engineers to understand possible issues

Results

Our analysis revealed:

- The PFDPU and the SEP, LPW/EUV, and MAG instruments have operated in stable and consistent ways throughout the mission
- SWEA, as previously analyzed by Dave Mitchell, has a safe but bi-stable power supply resulting in 2 different current states.
- Artifacts in the telemetry of SWIA and STATIC (two MAVEN plasma instruments) revealed increasing and variant current draws starting in Aug 2018 and Sept 2019. Some possibilities for the SWIA and STATIC current increase are:

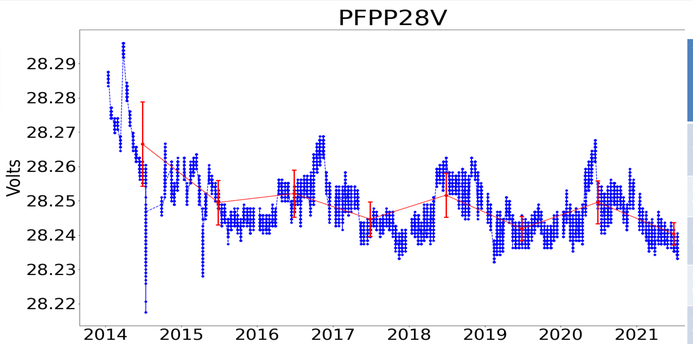
1. Orbit orientation or attitude, however SWIA temp did not indicate any changes
2. The PFDPU EEPROM load on August 28, 2018, modified the instrument sweep lookup tables (LUTs)
3. The sampling rate (1 housekeeping packet every 32 seconds) may be beating against the faster instrument current cycling, hiding earlier current sweeps
4. Instruments or power supplies may be degrading

PFPP28V results

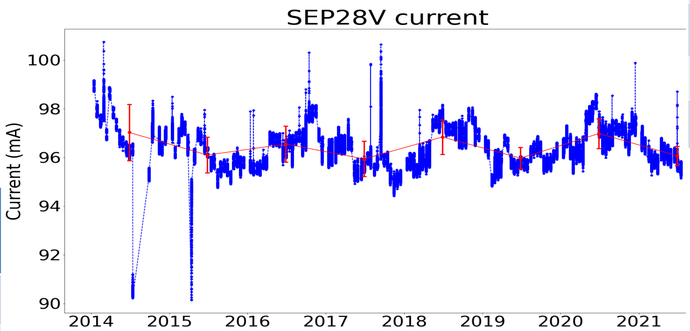
Year	Mean	Std Dev
2014	28.27	0.012
2015	28.25	0.0065
2016	28.25	0.0069
2017	28.24	0.0050
2018	28.25	0.0065
2019	28.24	0.0035
2020	28.25	0.0062
2021	28.24	0.0032
All	28.25	0.0097

SEP results

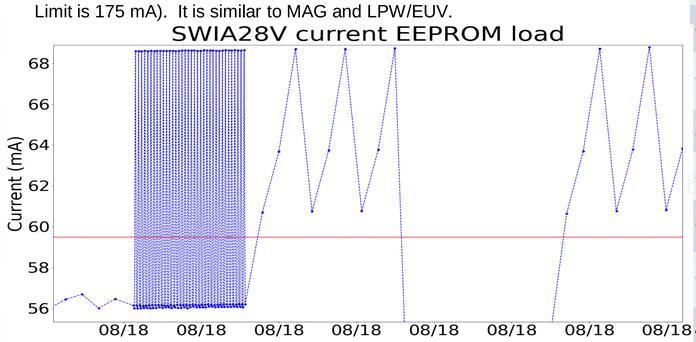
Year	Mean	Std Dev
2014	97.03	1.16
2015	96.10	0.73
2016	96.550	0.74
2017	95.94	0.72
2018	96.84	0.71
2019	96.07	0.44
2020	96.98	0.61
2021	96.07	0.39
All	96.44	0.84



This plot shows the PFDPU 28V instrument Voltage is operating and functioning consistently throughout the mission. The Martian 2-year cycle can be seen.



This plot shows that the SEP instrument current is stable and healthy (Yellow Limit is 175 mA). It is similar to MAG and LPW/EUV.



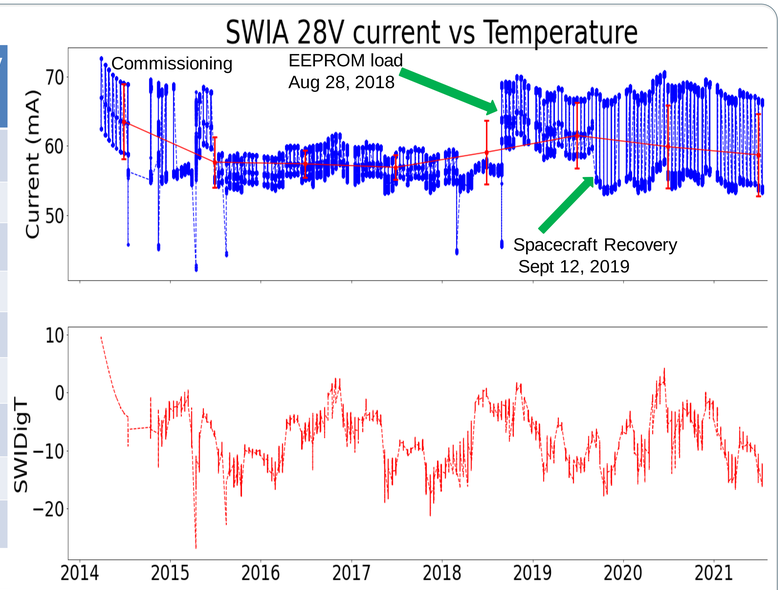
This plot shows the increased telemetry rate during the EEPROM load.

SWIA results

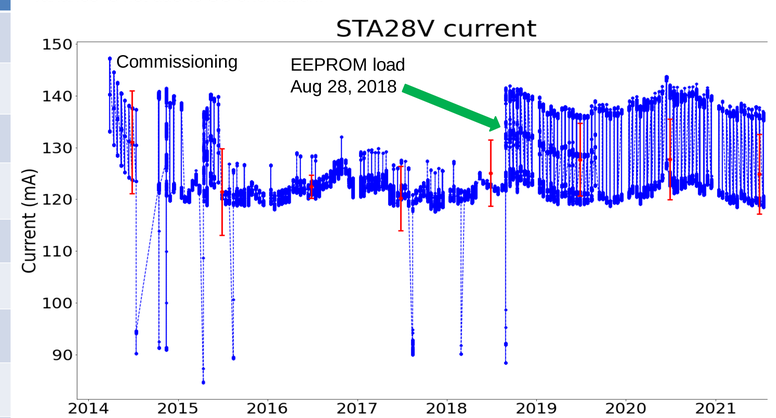
Year	Mean	Std Dev
2014	63.49	30.20
2015	57.66	12.01
2016	57.41	1.91
2017	56.91	1.78
2018	59.08	4.56
2019	61.50	4.74
2020	59.89	5.98
2021	58.70	5.93
All	56.61	12.59

STATIC results

Year	Mean	Std Dev
2014	131.06	9.94
2015	121.44	8.37
2016	122.43	2.24
2017	120.19	6.22
2018	125.09	6.36
2019	127.65	7.01
2020	127.74	7.78
2021	124.89	7.68
All	124.69	7.68



This plot shows the SWIA current and temperature for the entire mission. On 8/28/2018 and again on 9/12/2019 the SWIA current increases. Correlating against temperature, the current variance is not due to SC orientation.



This plot shows STATIC current for the entire mission. The STATIC current changes on 8/28/2018 but not in 2019.

Conclusion

PF analog housekeeping engineering data was analyzed for the entire MAVEN mission in an attempt to verify the ongoing safe operation of the PFDPU and the PF instruments. The PFDPU and SEP, SWEA, LPW/EUV, and MAG internal voltages and currents look stable and consistent. Artifacts in SWIA and STATIC telemetry of increasing and variant current draws starting in August 2018 and again for SWIA only in September 2019 are not concerning because both instruments are still well within the safe limits and are generating good quality science data. Nothing else in instrument telemetry reveals any issues. The variant currents are likely due to under sampling of the housekeeping telemetry revealed when the housekeeping rate was increased during the EEPROM load.

Future work

- Ongoing analysis and trending
- Continue conversations with instrument scientists and design engineers about SWIA and STATIC current changes
- Develop database software to store and plot data from every day of the mission

References

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