

MINIATURE FREE-FLYING MAGNETOMETER UTILIZING SYSTEM-ON-A-CHIP TECHNOLOGY.

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Four Free-Flying Magnetometers (FFMs), developed at the Jet Propulsion Laboratory (JPL) for the Enstrophy mission (lead by University of New Hampshire), were successfully deployed from the payload of a sounding rocket launched from Poker Flats, Alaska on February 11, 1999 [1]. The FFMs functioned successfully by synchronously measuring the vector magnetic field at 4 points separate from the payload and at relative distances up to 3 km, and communicated their data, in bursts, to the ground. This is the first time synchronized in-situ multipoint measurements of the Earth’s magnetic field utilizing miniature spin-stabilized “sensorcraft” have been performed. The data they provided have enabled, for the first time, the direct measure of field-aligned current density and are enabling new science by determining the fine-scale structure of the currents in the Earth’s ionosphere involved in the production of aurora.

These proof-of-concept "hockey puck" (80 mm diameter, 38 mm height, 250 gram mass) FFMs were built using off-the-shelf commercial, industrial, and military grade surface-mount electronic components. Radiation-hard electronics was not required for the Enstrophy mission’s short sub-orbital flight. The successful design, implementation, and flight demonstration of this 1st generation FFM design has provided a solid base for further development of a 2nd generation FFM design for planetary science applications. A reliable ultra-miniature radiation-hard 2nd-generation FFM utilizing System-On-A-Chip (SOAC) technologies is proposed [2]. This design would be targeted for long-term planetary missions to investigate magnetospheric field configurations in regions having small-scale structure and to separate spatial and temporal variations. A fleet of short-lived (expendable) FFMs would be deployed into a targeted region to gather multiprobe vector magnetic field data. The FFMs would be ejected from a parent spacecraft at a speed of a few m/sec and would cover spatial volumes of order tens of kilometers for times of order one hour. The parent spacecraft would carry a sufficient number of FFMs for multiple deployments.

The FFM consists of 1) a sensitive 3-axis magnetometer sensor; 2) synchronized 3-channel Analog-To-Digital Converter (ADC); 3) an accurate clock used to determine the attitude of the FFM; 4) sun sensor used in conjunction with the clock for determining the spin orientation of the FFM; 5) Radio-Frequency (RF) transmitter to relay data to parent spacecraft; 6) a wireless umbilical interface used to communicate with

the FFM prior to deployment; 7) a data subsystem for acquiring, formatting, and storing data in memory and controlling power and data transmission; and 8) power source with conditioning and management, electronics. The eight components are integrated into the architecture shown in Fig. 1. The data subsystem manages continuous data acquisition from magnetometers, sun sensors, and system health monitoring. Data is communicated to the deploying parent spacecraft via a RF transmitter whose carrier frequency is programmable prior to deployment.

High-level SOAC integration of all FFM electronics onto one or a few silicon chips utilizing a radiation-hard SOI foundry is technically feasible. The development of a 3-axis magnetic field sensor meeting the FFM application requirements is the greatest challenge. Presently a high-sensitivity MEMS Lorentz-force-oscillator based magnetometer is being considered for the FFM.

Acknowledgement:

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References:

- [1]Blaes B. et al (1999) Proc. DASC 0-7803-5749-3 7.D.4-1
- [2]Blaes B. et al (1999) Proc. AIAA Space Tech. Conf. 9-28

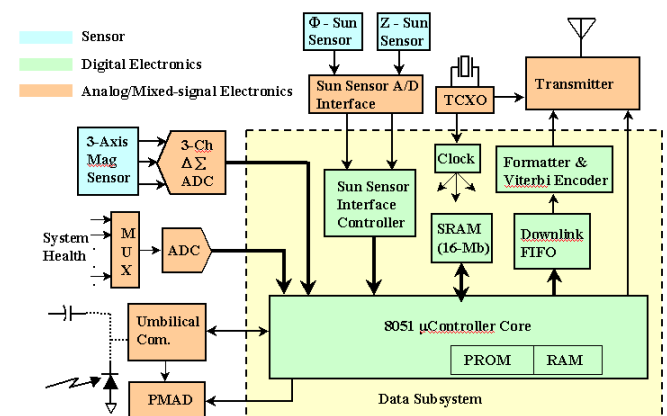


Fig. 1 FFM architecture