Projects Discussion

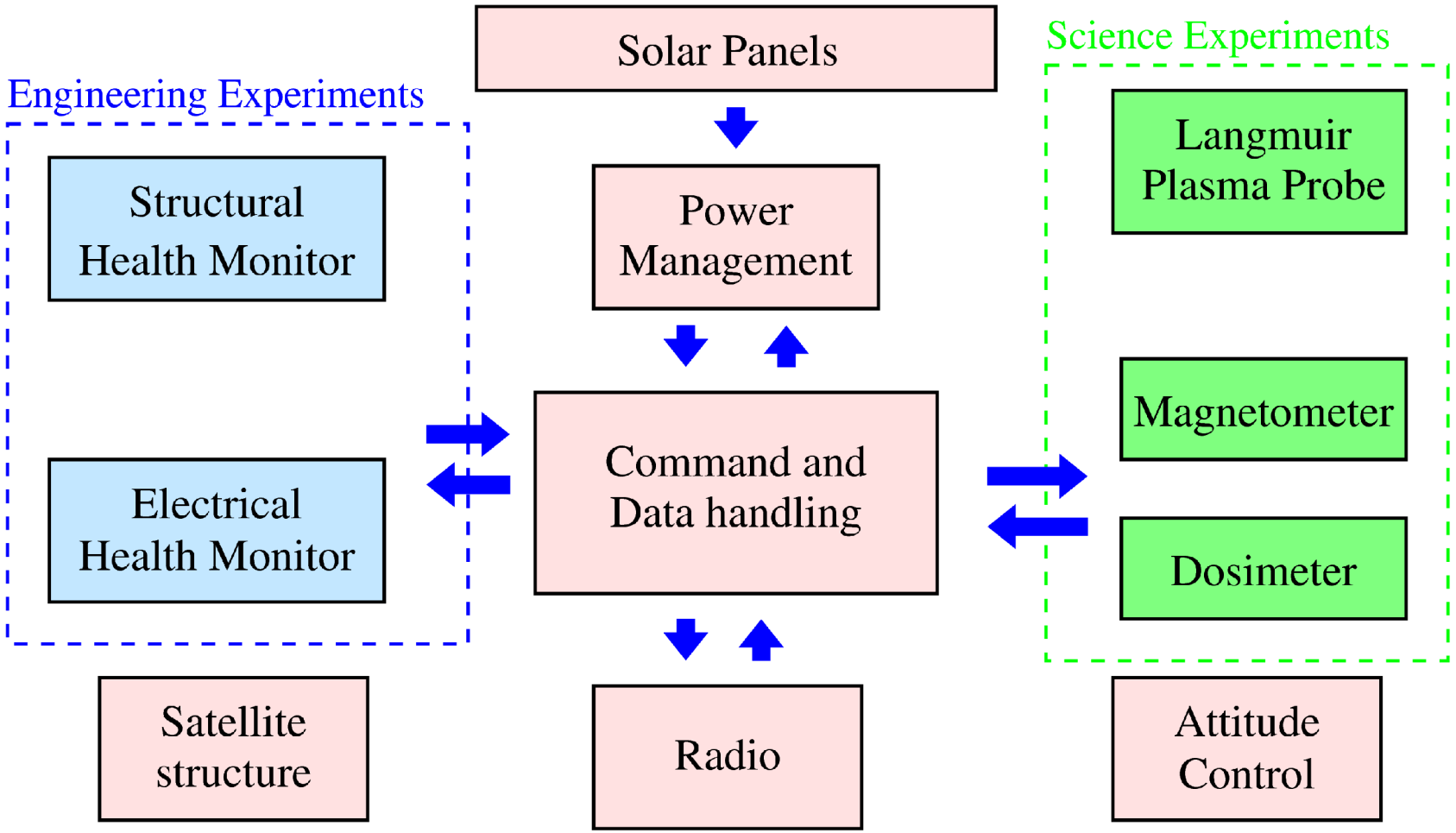
EE 521 2012/2/6

Overview

- NMTSat
- Projects
  - Requirements
  - Assignments

NMTSat overview

- Satellite with two “experiments” each consisting of several “instruments”

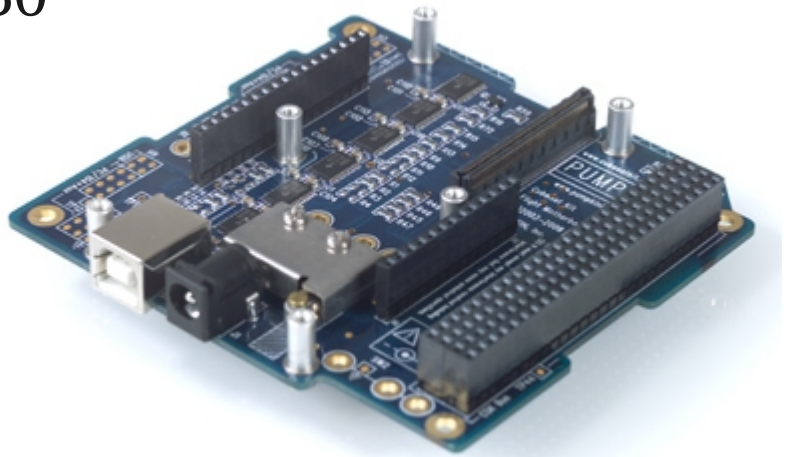


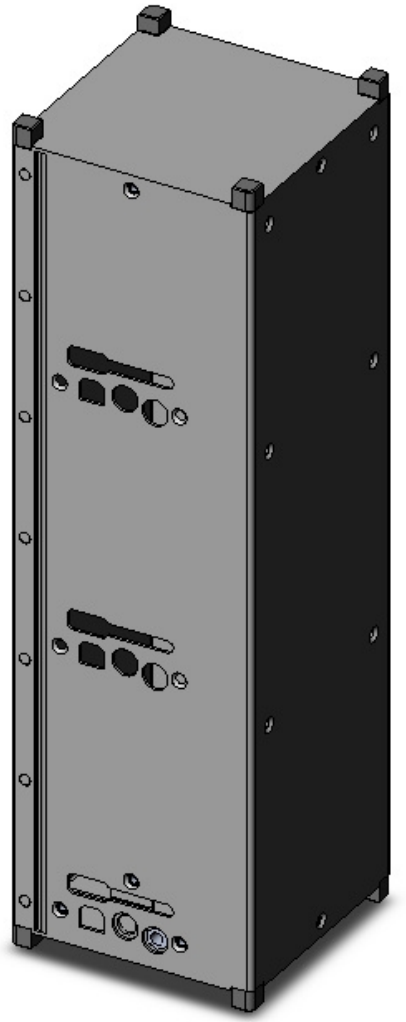
NMTSat CubeSat Kit

- Will be based on a CubeSat “kit”

NMTSat Structure and Control

- A 3 U cubesat 10 x 10 x 30 cm
- Off-the-shelf C&DH CPU based on MSP430

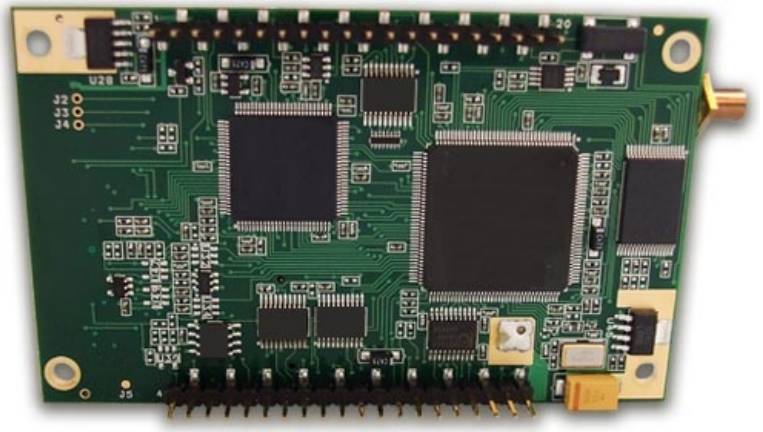


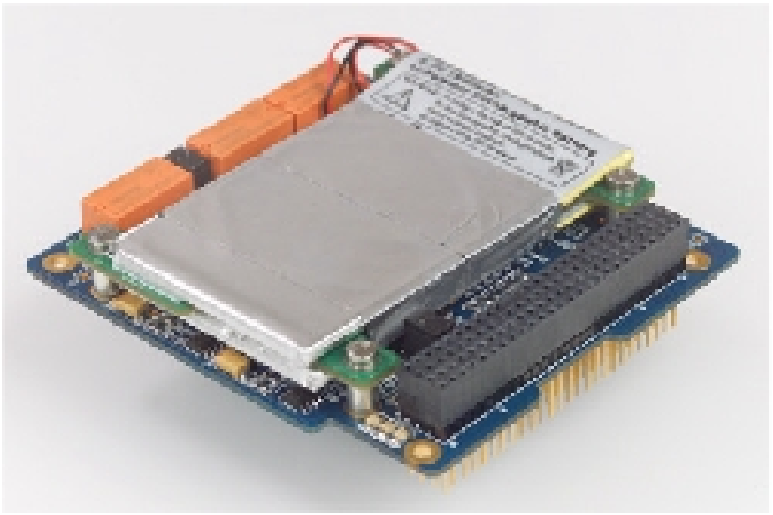


3U Solid
CAD Model RevD

NMTSat Comm and Power

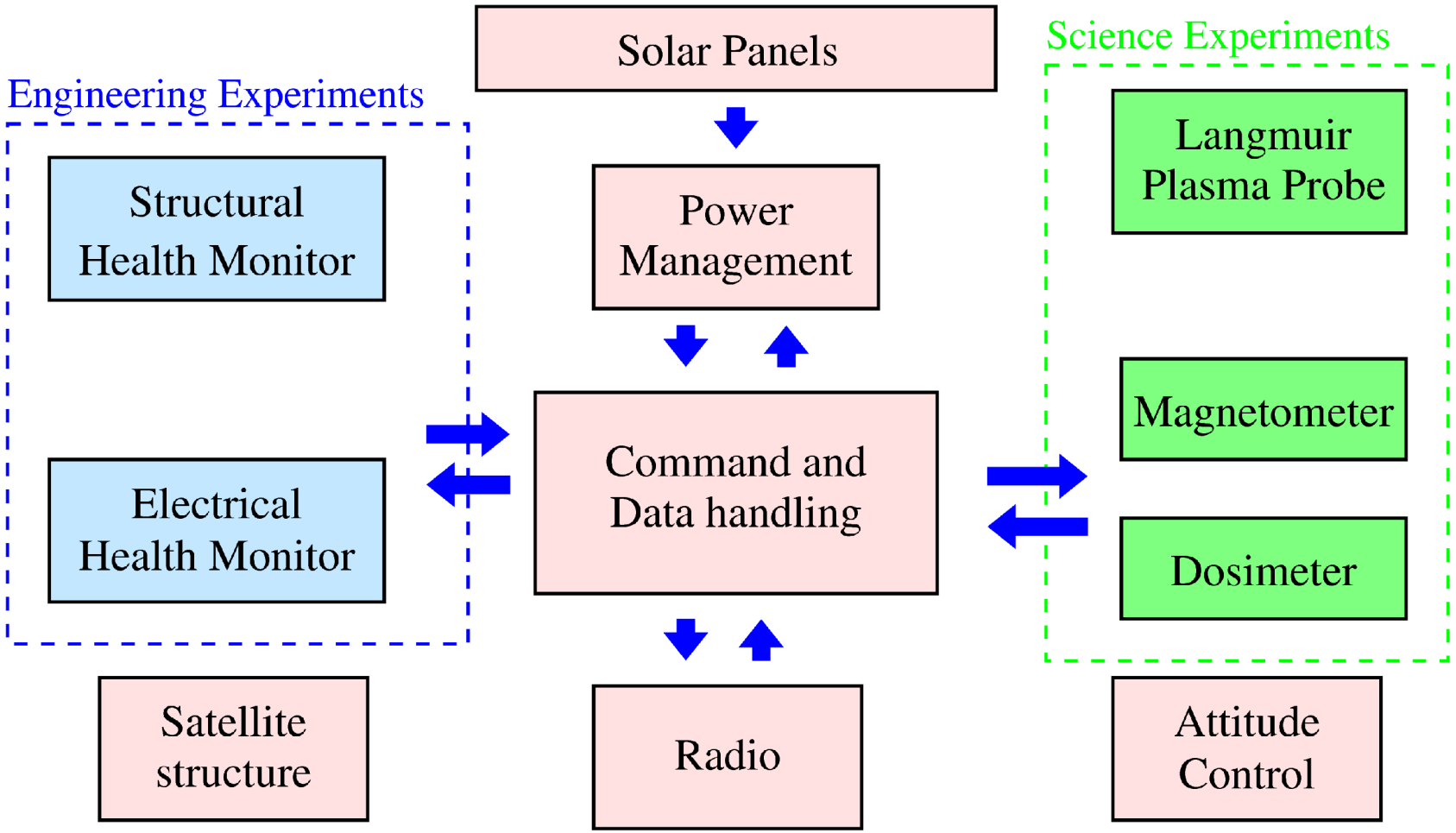
- Off-the-shelf radio
  - But in-house patch antenna
- Off-the-shelf power management subsystem
  - But in-house solar panels





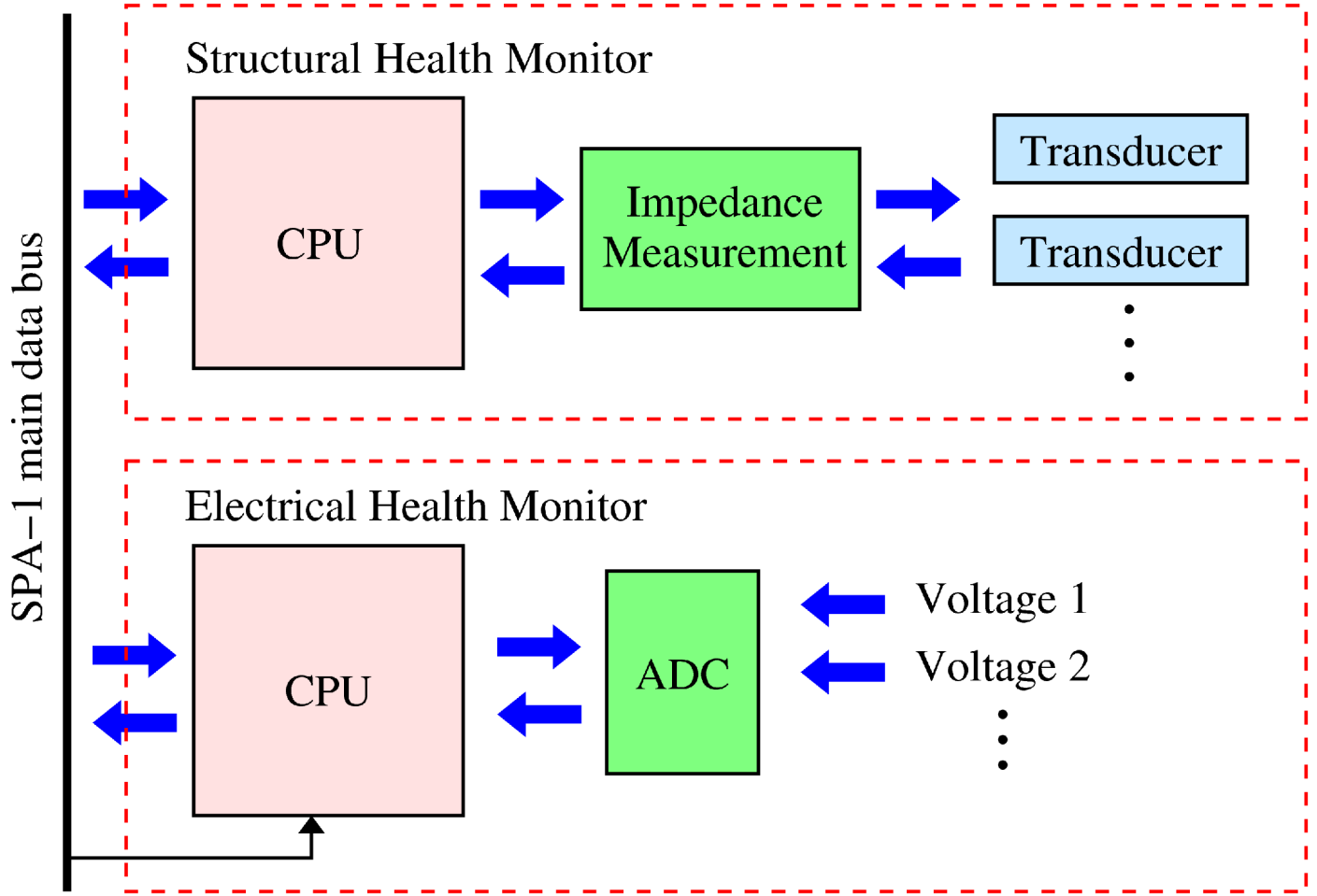
NMTSat overview

- Satellite with two “experiments” each consisting of several “instruments”



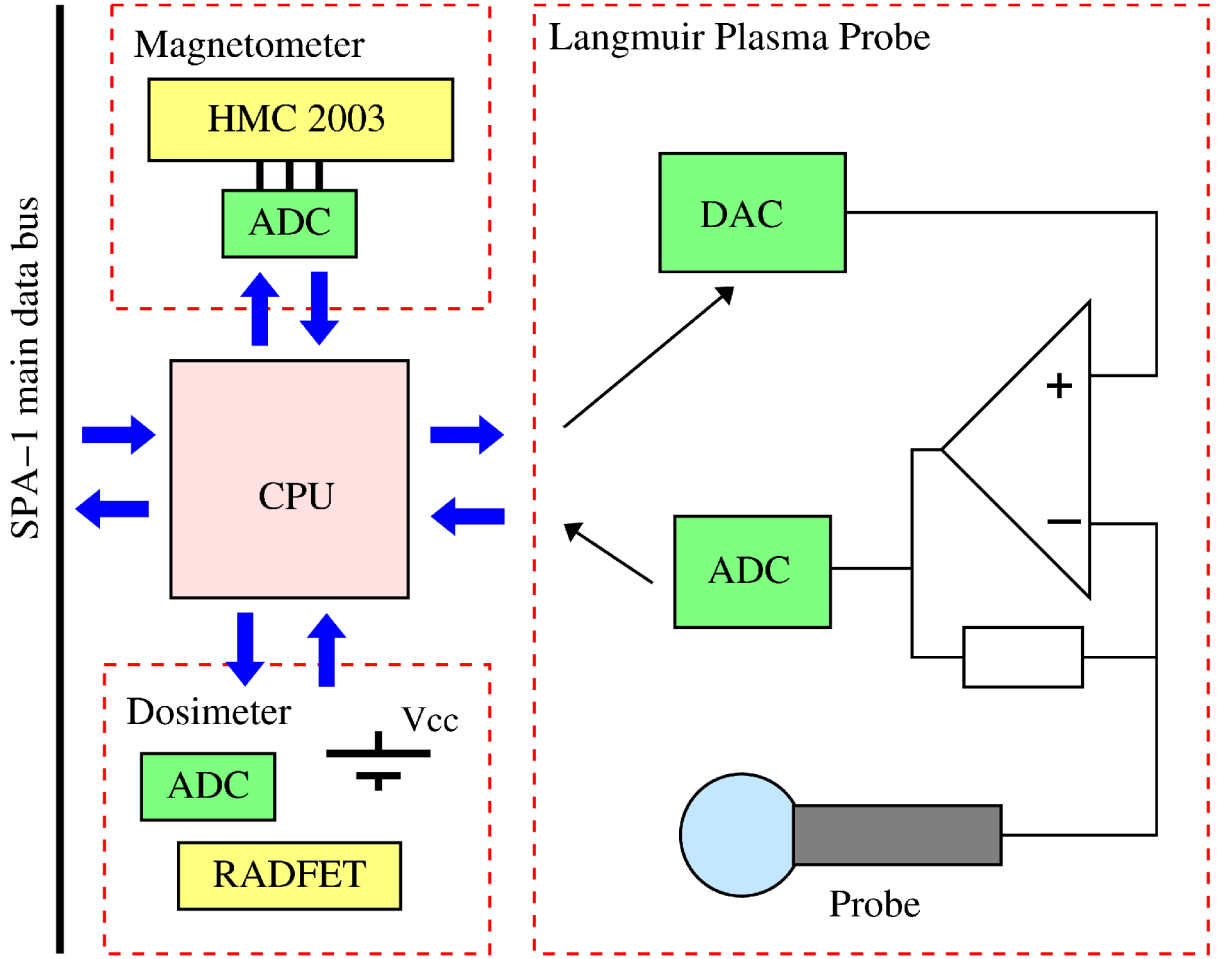
NMTSat Engineering Experiment

- Two engineering instruments



NMTSat Science Experiment

- Three Science Instruments



Projects

- Magnetometer
  - Measures the vector magnetic field
- Dosimeter
  - Measures cumulative radiation dose
- Electrical Health Monitor
  - Measures noise on analog lines
  - Measures Entropy of digital data

Project Requirements

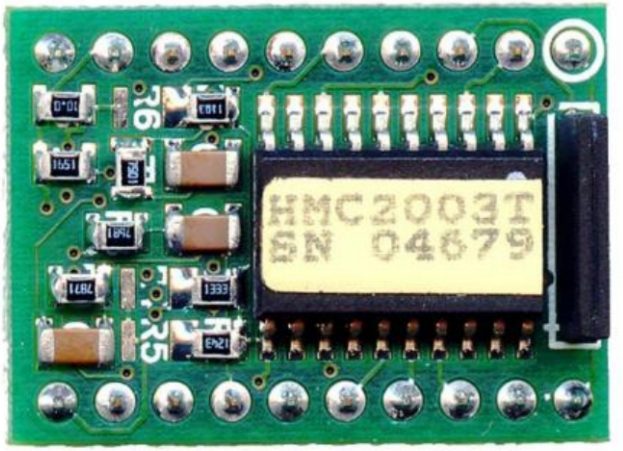
- Design the instrument electronics
- Test the instrument electronics design on a prototype board in the lab
- Program and test the instrument microprocessor to SPA-1 protocol
- Design a 4-layer PCB using Multisim/Ultiboard
  - Board will be manufactured and assembled externally
- Test the manufactured PCB
- Comprehensive report/manual

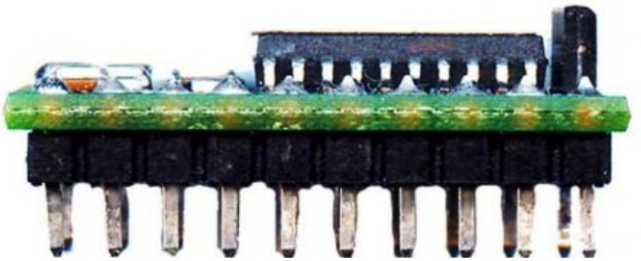
General Specifications

- Low power consumption of few hundred mW
  - May require duty cycling instrument
- Must use MSP 430 processor programmed for SPA-1 communications protocol.
- Available power supply voltages are TBD
- Low mass
  - Few hundred grams
- Small size
  - PCB area few centimeters on a side

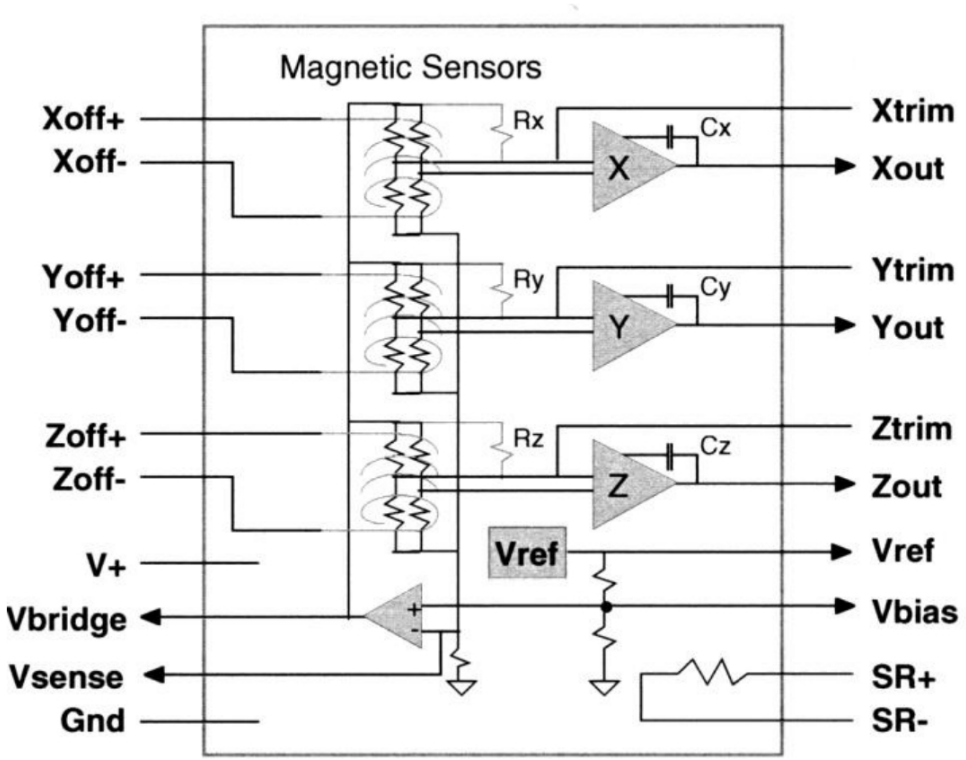
Magnetometer

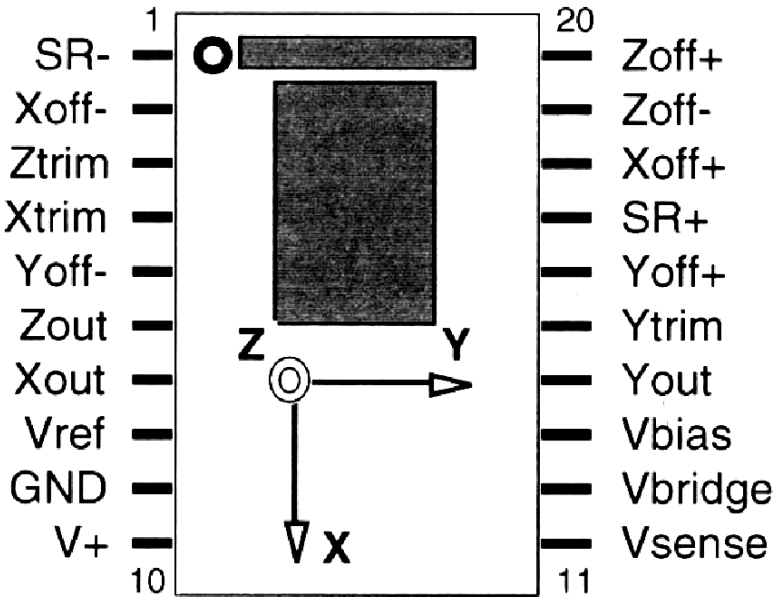
- Measures magnetic field
- Suggestion is Honeywell HMC 2003
- Budget for magnetometer chip only is a few hundred $.
- Ideally we want to measure to an accuracy of a few nT, but few 10's of nT is OK
  - May be 1:10^5 resolution
- Time resolution
  - Max 10 Hz readout rate, but in reality limited by telemetry





Magnetometer

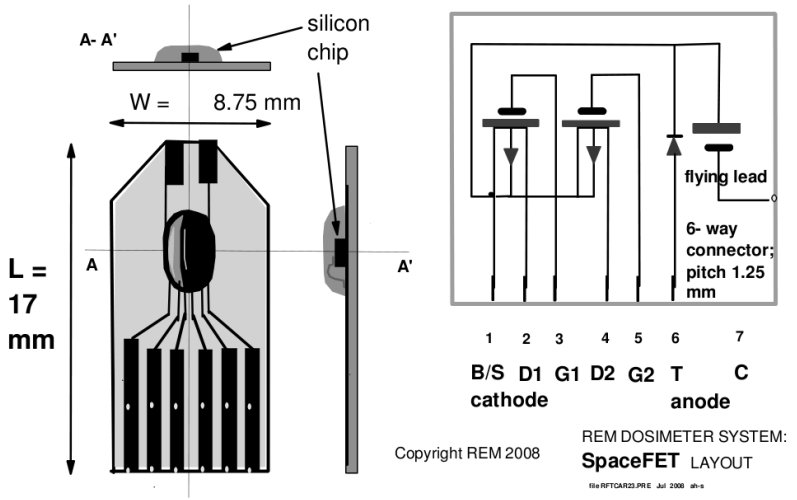




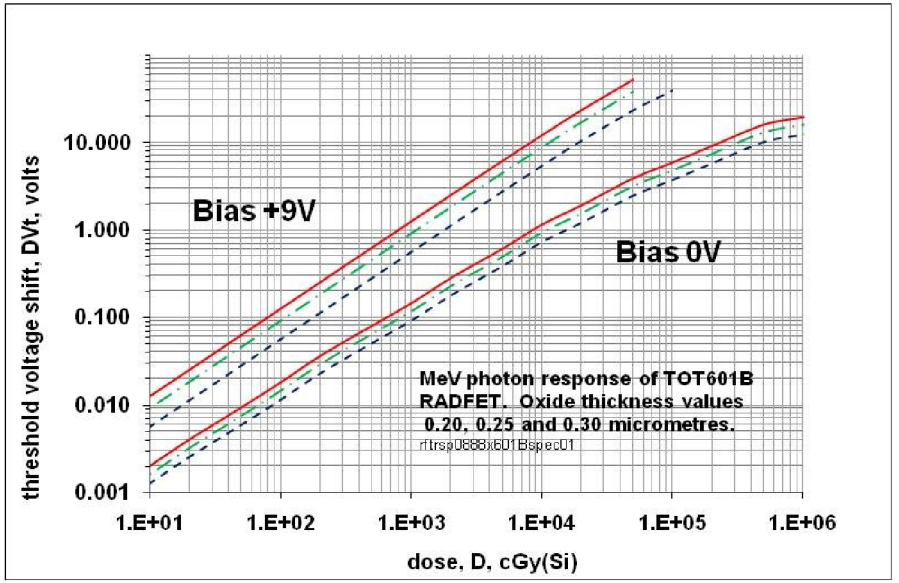
Dosimeter

- This will be a FET dosimeter
  - Measuring the change in the threshold voltage, Vt, over time gives the cumulative radiation dose.
- Possible collaborations
  - Chad Lindstrom from AFRL. He is working with a different dosimeter chip
  - Dr. Marcus Mendenhall from Vanderbilt University is possible
- Time resolution unknown – minutes to hours

Type **RFT300-CC10G1**
REM LOW-FADE SILICON MOSFET DOSIMETER
Two RADFETs, Diode & Capacitor / Lid technology: "glob"



Dosimeter



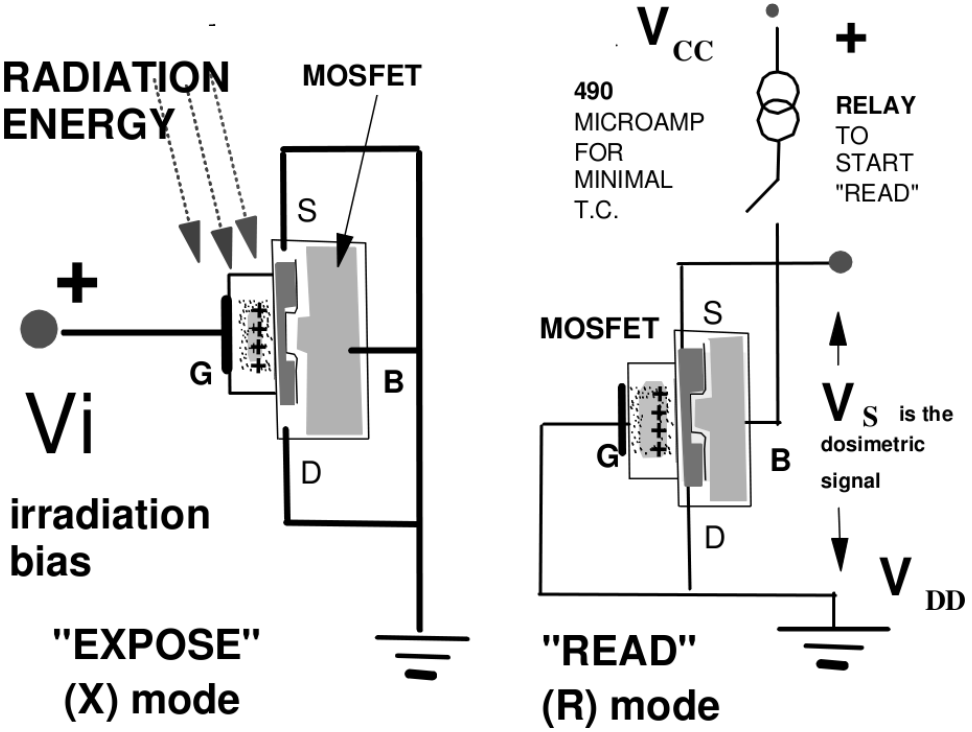


Fig 1. Specification for shift in threshold voltage with dose of MeV photons for REM Model TOT601B RADFETs at 0V or +9V bias during exposure. Solid line : 0.30 micrometre oxide ; chain dots 0.25 ; dashes 0.20. Devices with this range of response are suitable for Earth orbits and nuclear hot cells.

Dosimeter

Characterization of Teledyne Microdosimeters for Space Weather Applications

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[b]Institute for Scientific Research, 400 St. Clements Hall, Boston College;
[c]Assurance Technology Corporation, 84 South Street, Carlisle, MA 01741

ABSTRACT

The Teledyne microdosimeter is a novel miniature dosimeter that has become recently available to satellite manufacturers and programs to provide awareness of the total radiation dose received by the satellite and its associated subsystems. A characterization of the response of the dosimeter to protons of energies from 30 – 200 MeV as a function of angle, energy and dose rate is presented in this paper. In addition, the response of the dosimeter to a simulated Solar proton event with several different levels of shielding has been measured. These results show that the dosimeter response is relatively uniform over a wide range of conditions for protons. Monte Carlo modeling of the dosimeter for isotropic particle fluxes (both electrons and protons) has also been accomplished. It is shown that a simplified model is appropriate in determining the response of the dosimeter when using it to design low cost, simple instruments for space weather and situational awareness applications.

Electrical Health Monitor

- Measures “noise” on analog lines
  - in voltage and/or current
- Need a auto-ranging sampling circuit
  - Automatically adjusts offset and gain to get the “noise” optimally into the ADC
- Also measures Entropy of the digital data stream inside the satellite
- Need to understand how Entropy is computed and interpreted

First Assignments

- Review the requirements
- Present a preliminary design solution, including some proposed components
- Understand the SPA-1 protocol which is implemented on the MSP430 processors
- What are unanswered questions?
  - What needs more work?
- Specifics for each instrument.....

Assignment: Magnetometer

- Understand the proposed magnetometer module: Honeywell HMC2003
- Is its power consumption reasonable and compatible with requirements?
- What are some alternative modules?
- Preliminary design of a circuit which measures vector magnetic field to required precision, using the MSP430 MCU

Assignment: Dosimeter

- Review Chad Lindstrom paper
- Compare dosimeter used by Lindstrom to RADFET module
- Design a circuit for each of the chips
  - How is the measurements normally made?
  - Given the high accuracy required, what calibration can be done?
- What kind of dose do we expect at LEO? 500 km orbit? 600 km orbit?
  - How does this affect the required accuracy if we want daily or hourly or more frequent measurements? What is realistic?

Assignment: Electrical Health Monitor

- Design concept for auto-ranging ADC
  - Offset and gain adjustment
    - Automatic or....
    - by MCU control as a result of data processing
- Discussion of which analog signals to measure
- Discussion of which statistical measures to compute and how to compute them given limited memory
  - Perhaps not enough memory to store long data stream at 10 kHz
- Discussion of Entropy of digital data stream
- Algorithm for Entropy computation
  - Considering limited memory

Who works on what?

Each person is assigned to two instruments

Magnetometer

Charles Bernson

Tom Hall

Dosimeter

Alan Huynh

Ryan Jackson

Electrical Health Monitor

David Park

Vinny Ranvindran

Presentations February 15

- 35 minutes per instrument
- Each person presents for both instruments
- All questions raised in these slides should be addressed
  - And any questions which arise while doing the research should be addressed as well

After Feb 15 presentations

- If possible we would like to be in a position to purchase parts to build prototypes in the lab
- Consider what parts to order, where from, and their costs
- Consider any additional parts or interfaces required to build prototypes