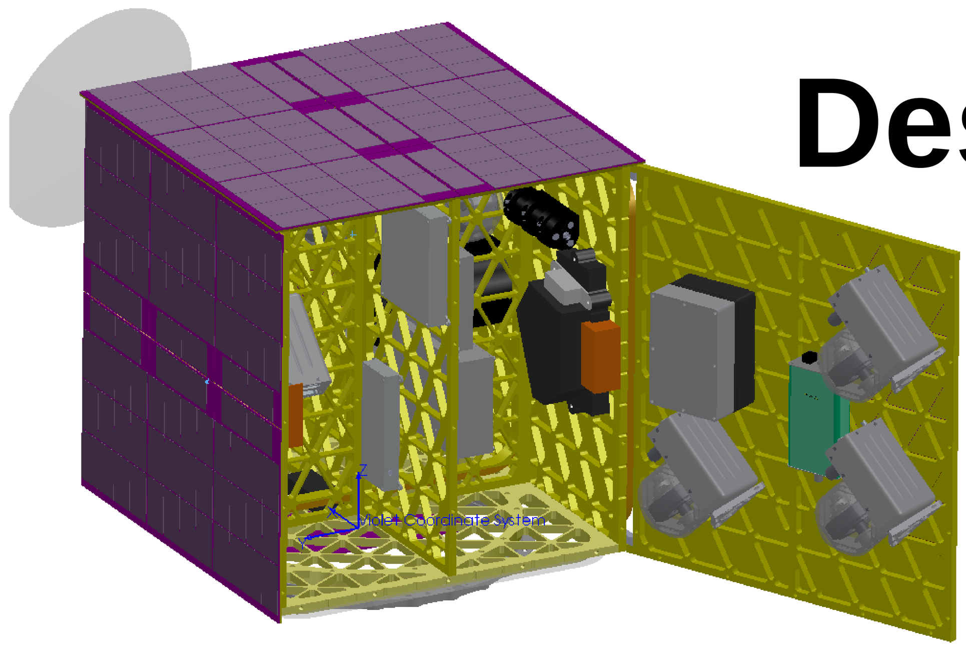

Design of Embedded Power System of Violet Satellite

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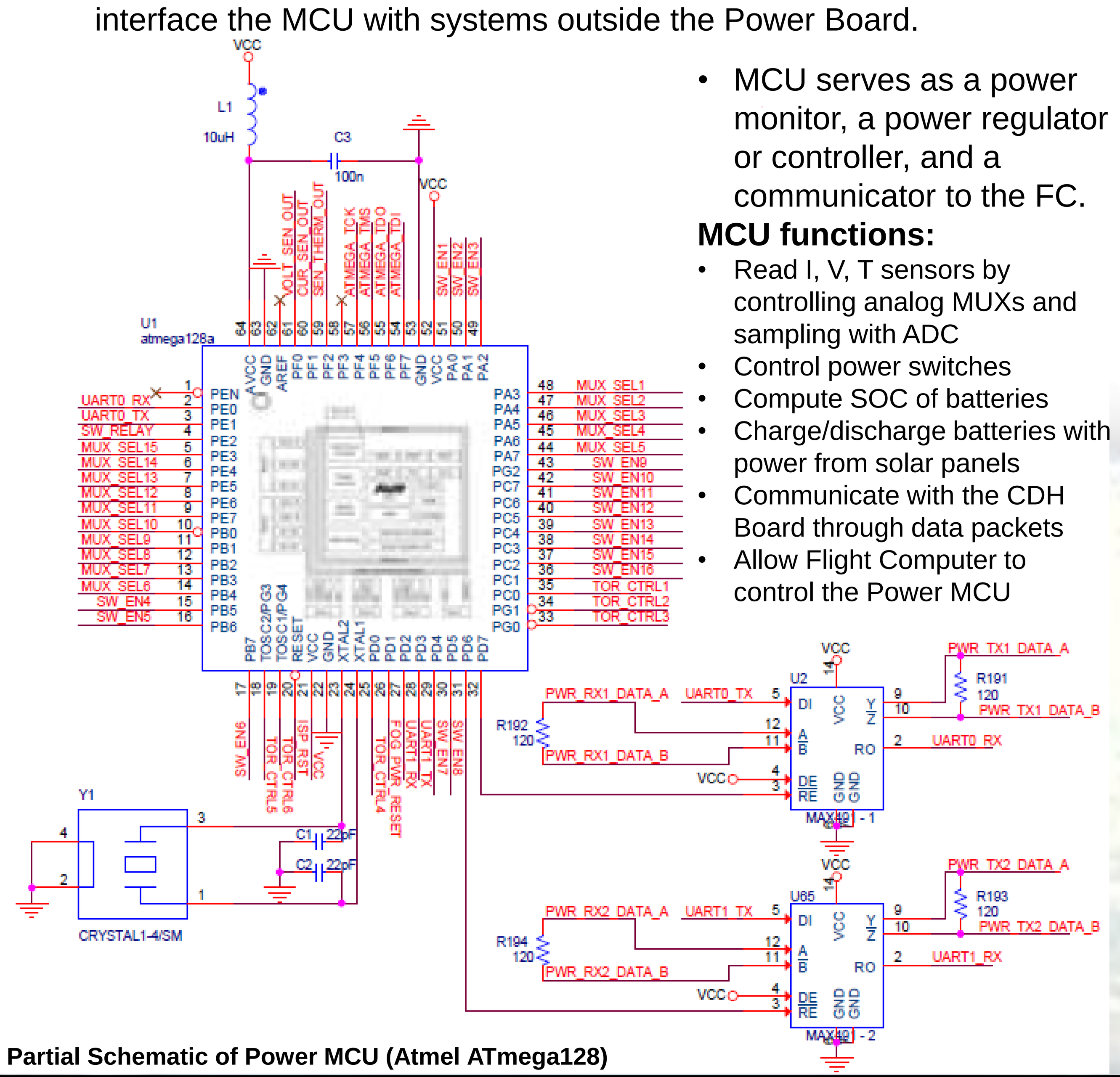
Abstract

Out of Violet's electrical subsystems, the Power subsystem is the most critical because it is housed on a single board that supplies power to all other subsystems and is designed in-house. The Power System functions include using solar panels to collect energy, storing energy in batteries with appropriate protection systems, distributing and monitoring power from solar cells and batteries, employing inhibits to isolate the satellite from all power sources during launch, acting as a controller for the Flight Computer, and communicating with the Flight Computer through data packets. Hence, the Power microcontroller (MCU) serves as power controller and power monitor. Revision 1 of the Power Board layout was completed, and the populated board was tested in a Flat-sat setup. MCU code was written to execute the major control, monitoring, and communication functions. Correct functionality of the software functions was verified on a STK500-based testbench, which closely resembles the interfaces of the power system in the satellite. In the near future, further testing of the software will be done on a Revision 2 Power Board with a programmed MCU in order to model flight-like conditions.

Introduction

- Power Board contains the Power MCU (Atmel ATmega128), switches connecting to all subsystems, power sensor circuits, and other hardware to interface the MCU with systems outside the Power Board.

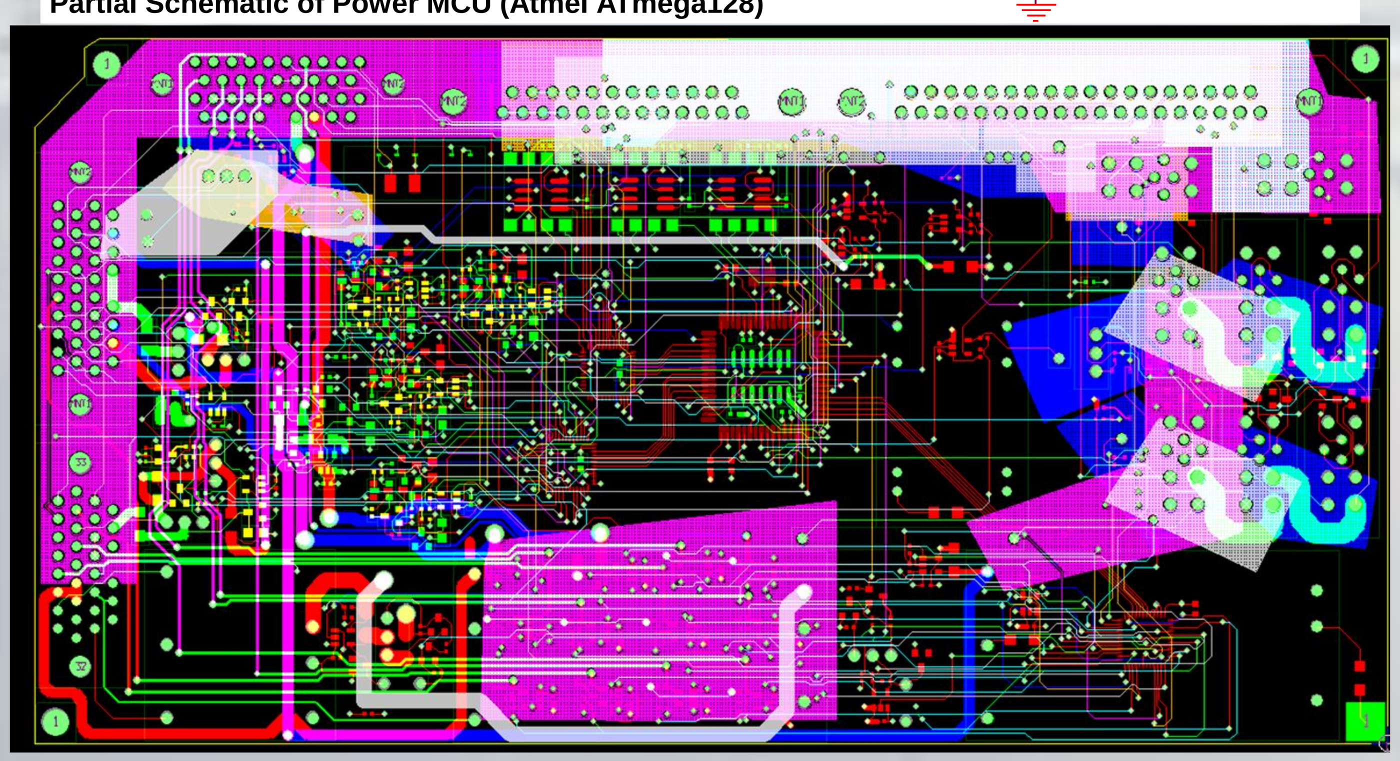


Partial Schematic of Power MCU (Atmel ATmega128)

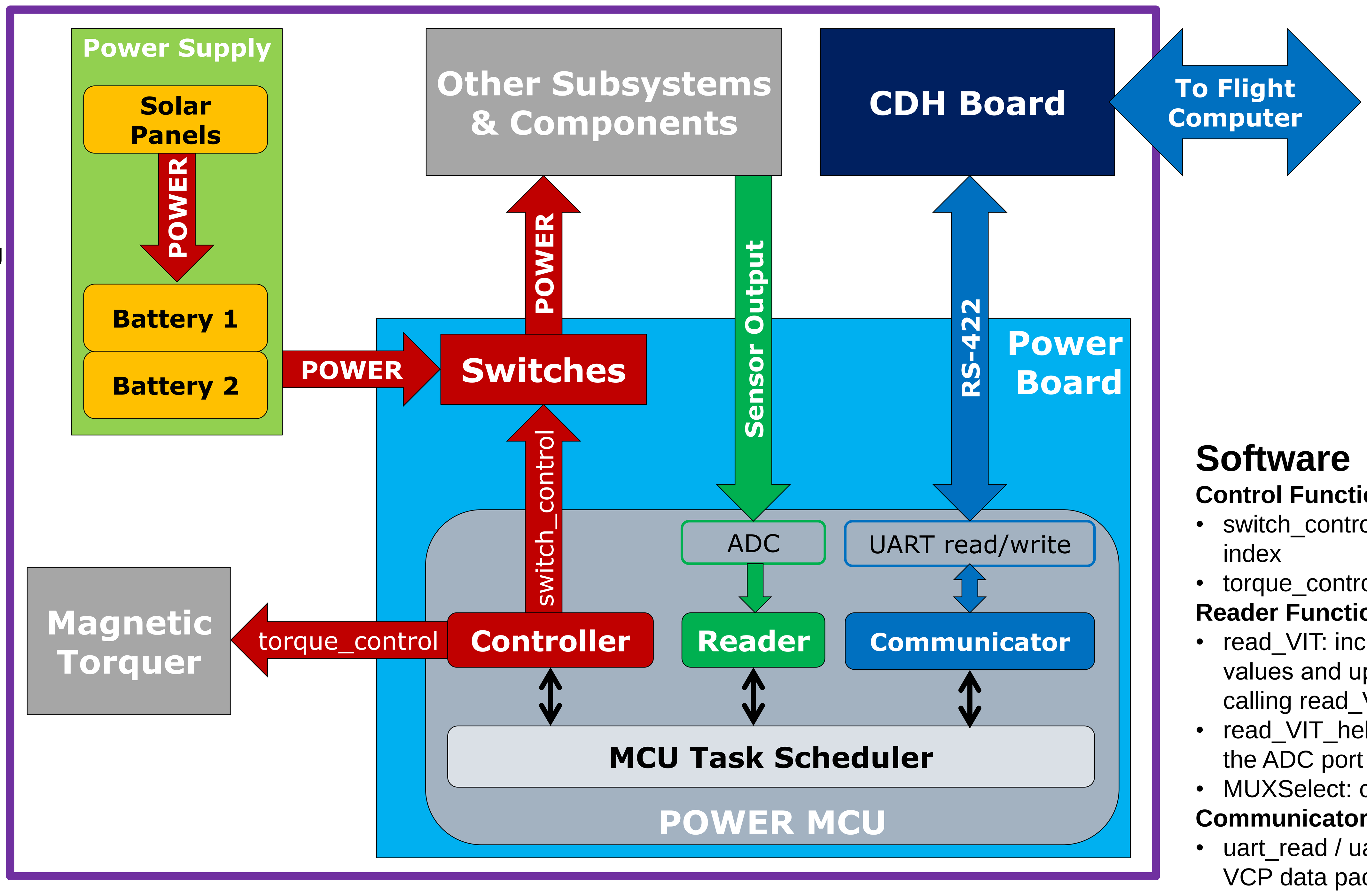
- MCU serves as a power monitor, a power regulator or controller, and a communicator to the FC.

MCU functions:

- Read I, V, T sensors by controlling analog MUXs and sampling with ADC
- Control power switches
- Compute SOC of batteries
- Charge/discharge batteries with power from solar panels
- Communicate with the CDH Board through data packets
- Allow Flight Computer to control the Power MCU



Layout of Power Board, Revision 1

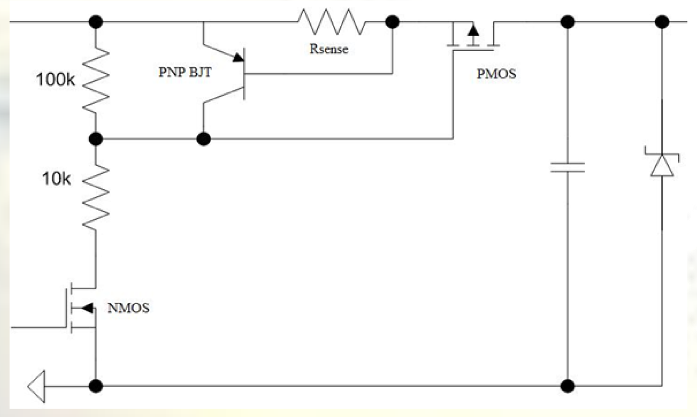


Block Diagram of Power System and its Interfaces

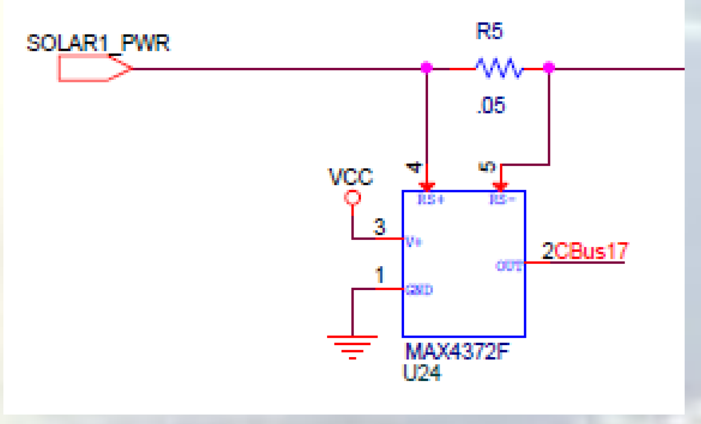
Hardware

- **Power Board**
- 10-layer printed circuit board with components on both sides
- Dimensions of 98.00 mm x 187.91 mm
- 8 routing layers, some of which contain large copper pours
- Contains more than 400 chips and discrete parts
- 4 different supply voltages on Board

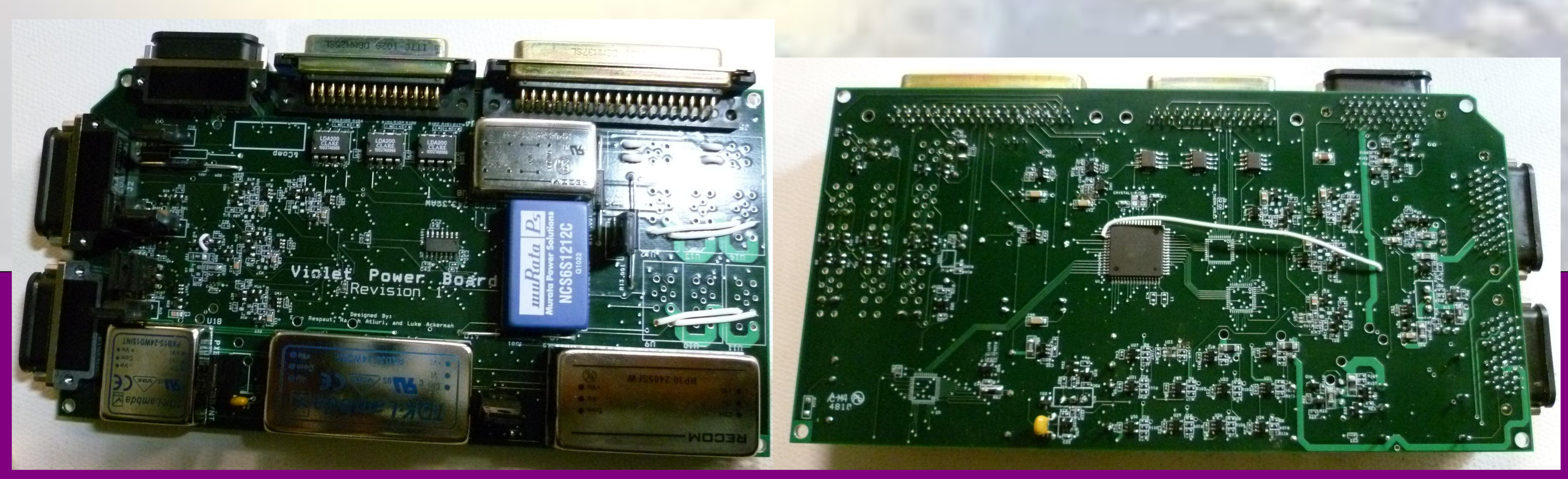
- MCU: Atmel ATmega128 8-bit microcontroller
- Analog Multiplexer (ADG732BCP): Three 32-input MUXs are connected to 3 MCU ADC ports for sampling of all power sensor signals, and MCU output ports control the select bits of the three MUXs
- Power electronics: DC-DC convertors, Voltage regulators, high voltage power switches
- Current Sense Amplifiers for current sensors, Voltage Dividers for voltage sensors, and Thermistors for temperature



Schematic of high voltage power switch



Schematic of current sensor



Populated Power Board (Rev. 1) for Flat-sat Test

"Flat-sat" Test Setup

Software

Control Functions:

- switch_control: turns on/off the switch to a subsystem given the corresponding index
- torque_control: controls the magnetic torquer through pulse width modulation

Reader Functions:

- read_VIT: increments the index of a locally-stored array of sampled sensor values and updates that array's sensor values with the just-sampled values by calling read_VIT_helper
- read_VIT_helper: sets the appropriate select bits of the MUX and samples from the ADC port that is connected to the MUX selected for the given sensor
- MUXSelect: called on by read_VIT_helper to set the select bit lines of MUXs

Communicator Functions:

- uart_read / uart_write: uses UART0 to communicate with the CDH board through VCP data packets. Read function parses the received VCP packet to determine the sent command and take the appropriate action. Write function makes the outgoing VCP packet and loads it into the transmit buffer.

Testing Results

- The Power MCU correctly controlled the power switches in a Flat-sat testbench prior to Violet's Final Competition Review.
- Accurate sampling of all types of sensors has been verified by attaching test sources to the MCU's ADC ports and comparing stored sensor values to manual measurements made on an oscilloscope.
- Using a Python script that sends bytes over a serial line, correct communication via data packets has been verified by sending model commands to the Power MCU on a STK500. Also, the Python script verified that the Power MCU constructs VCP packets correctly.

Conclusion / Future Directions

Hardware:

- Revision 1 of Board showed that switches were functioning correctly.
- Valuable lessons were learned from Rev. 1 of the board layout.
- Mistakes from Rev. 1 have been corrected on the Rev. 2 layout.
- Revision 2 Board needs to be tested with a programmed MCU.

Software:

- Latest version of the MCU code was verified for correct functionality on the STK500 board using tests that were modeled on actual operations in space.
- Battery charge-monitoring algorithm needs to be added to the MCU code since the algorithm has yet to be determined.
- Latest version of MCU code needs to be tested on a more flight-like testbench.

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