Cal Poly SuPER Project: Sustainable Power for Electrical Resources

Master's Thesis Brief

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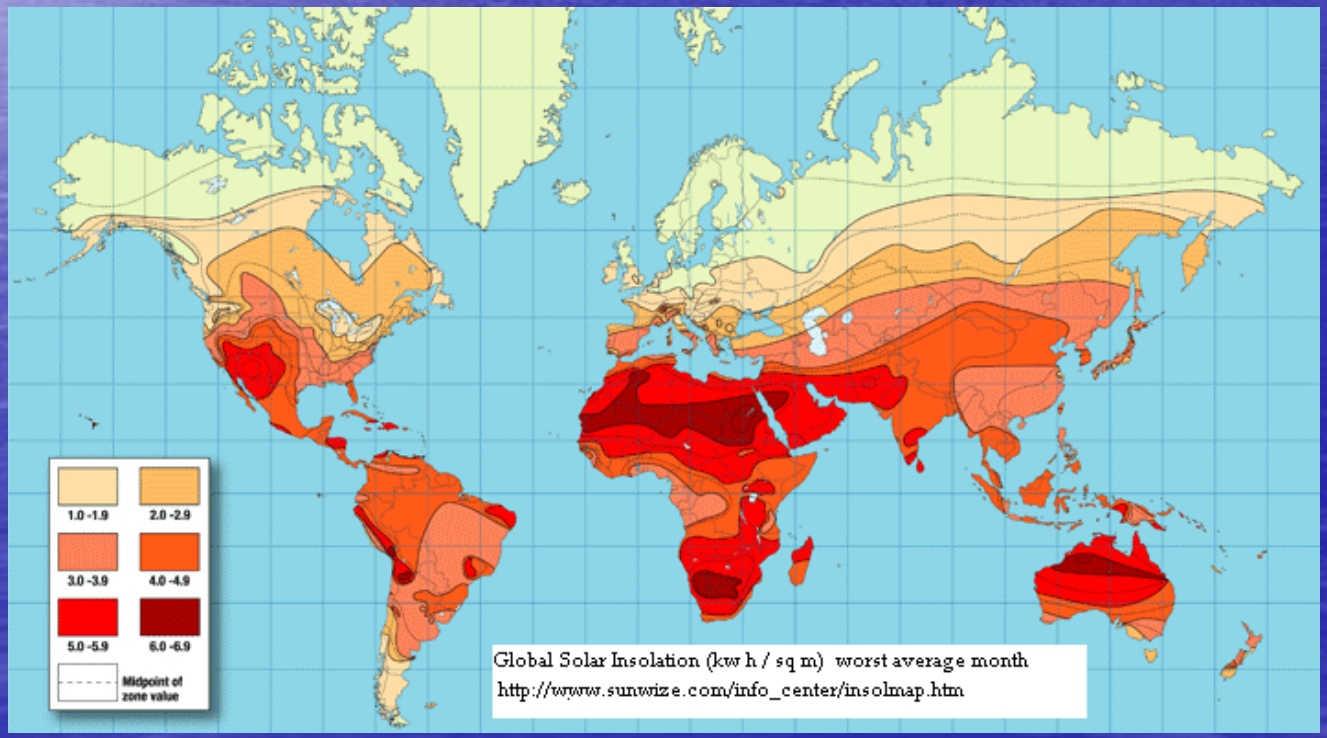
Background – Solar Insolation

- Goal to provide electrical resources to people in underdeveloped countries



Background – DC Power Loads

- Efficiency of electrical motors: few horsepower
  - Permanent magnet DC motors
- Electrical appliances
  - Computer: 50W laptop (DC)
  - TVs, radios use DC power
  - RV 12V DC market: kitchen appliances
  - Portable power tools – battery powered (DC)
- Computers: wireless connection
  - Internet, phone (voice over IP), TV, radio,
  - Education: MIT Media Lab $100 laptop project

Background: Overall Cal Poly SuPER System Goals

- Design lifecycle of 20 years
- Total Cost: less than $500 for 1 sq m PV module including battery replacements
- Mean time between failures (MTBF): 25 years
- Mean time to repair (MTTR): 1 hour
- Power depends on PV efficiency and battery storage capacity

SuPER Academic Presentations

- Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, 16 August 2007
- Solar 2008 Conference, San Diego, 2 May 2008
- North American Power Symposium, Boston, 4 Aug 2011

Diagram of SuPER System

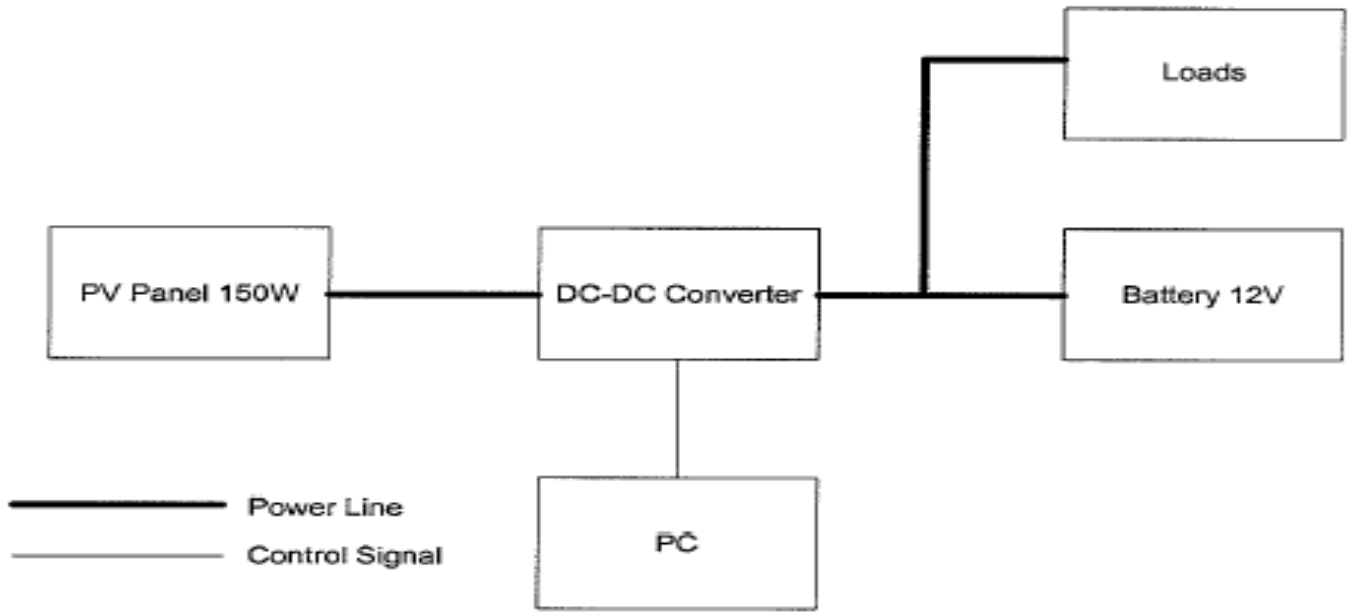
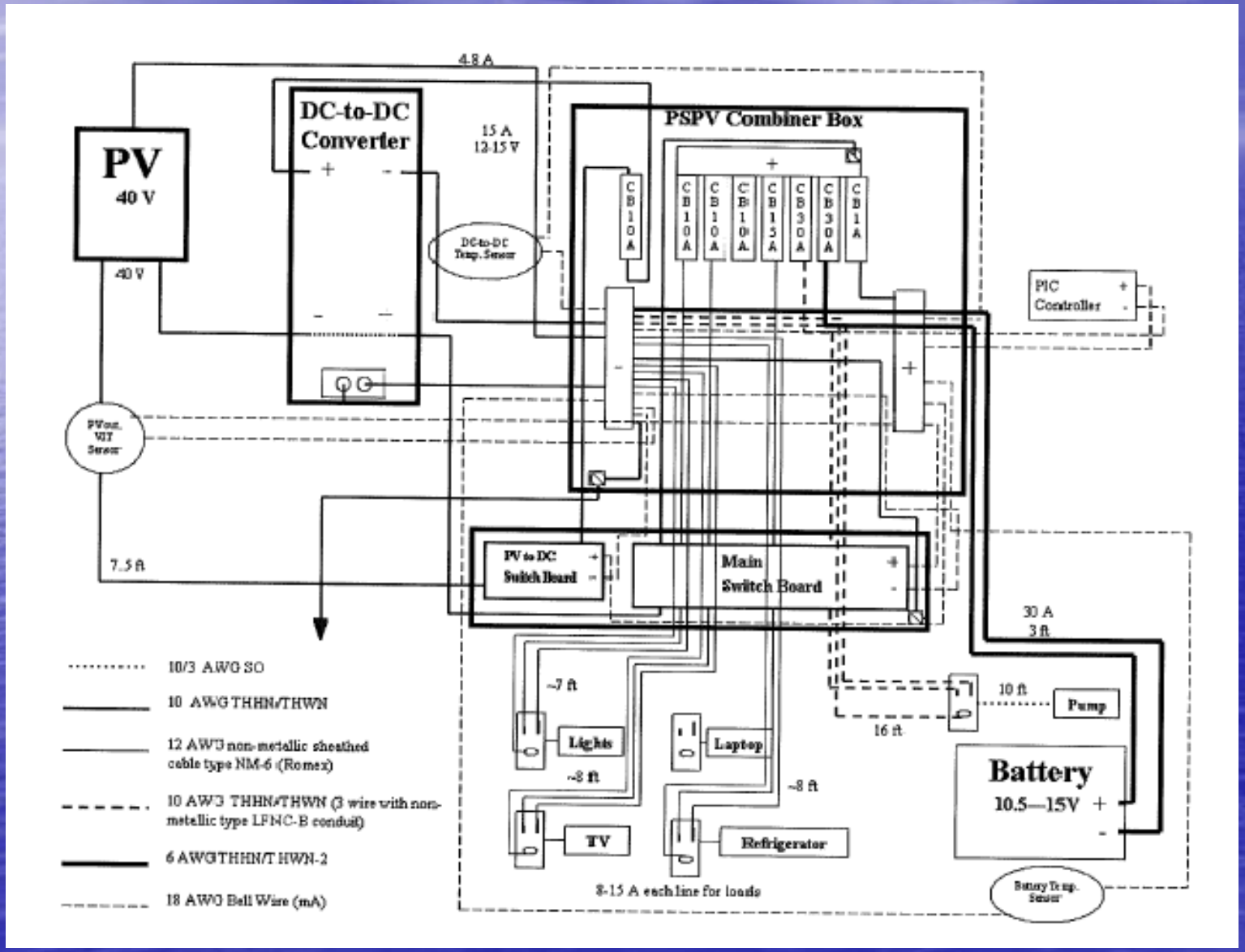
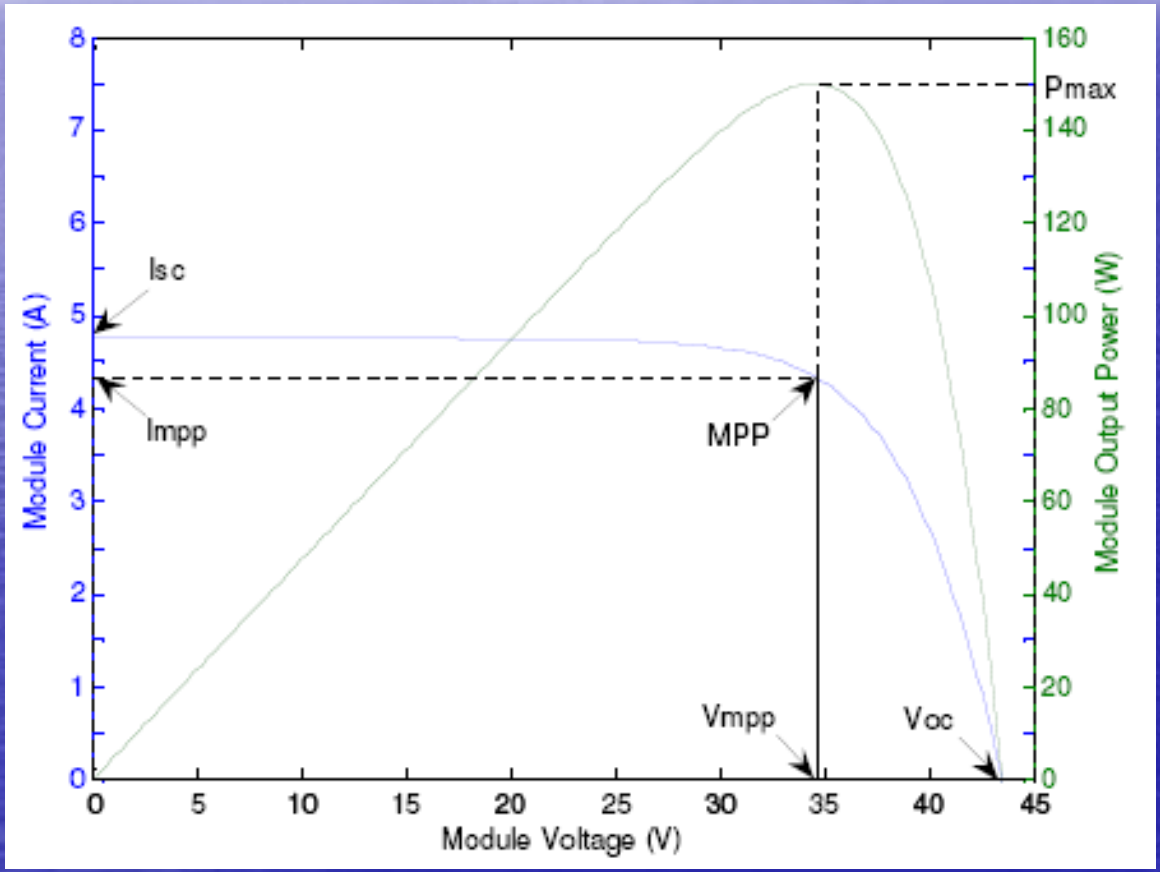


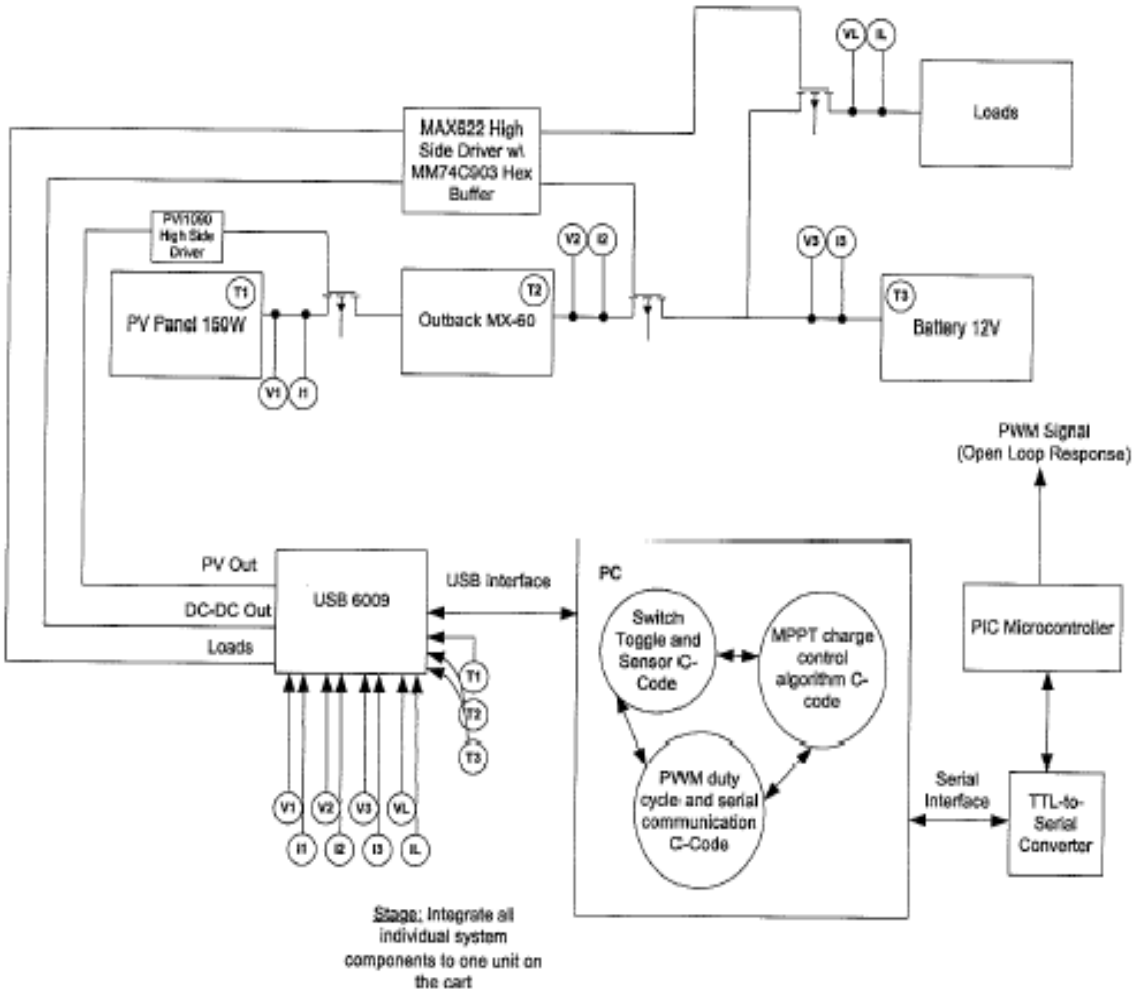
Figure 3.1 – SuPER Simplified Block Diagram

Electrical Connections



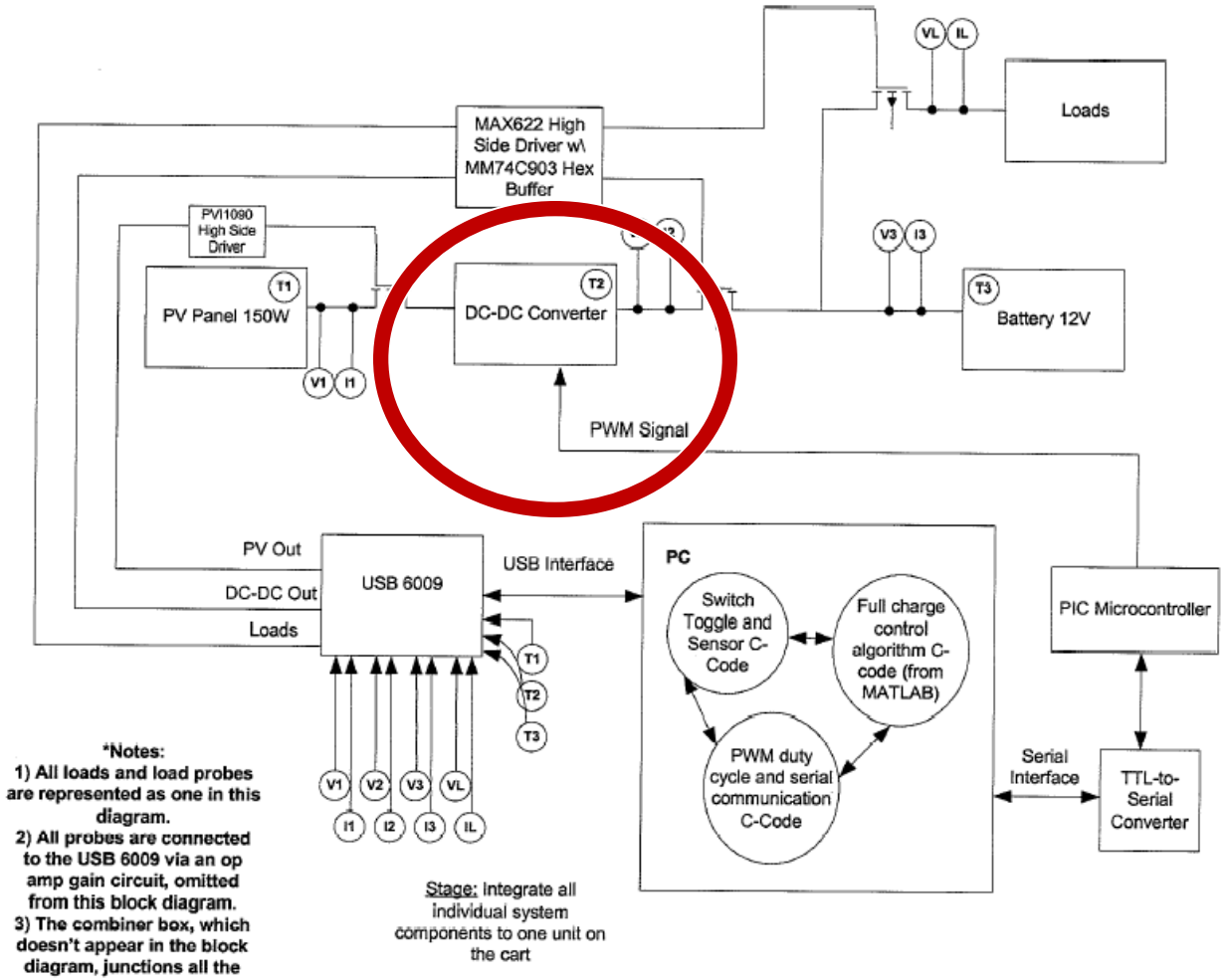
BP150X I-V Power Curve





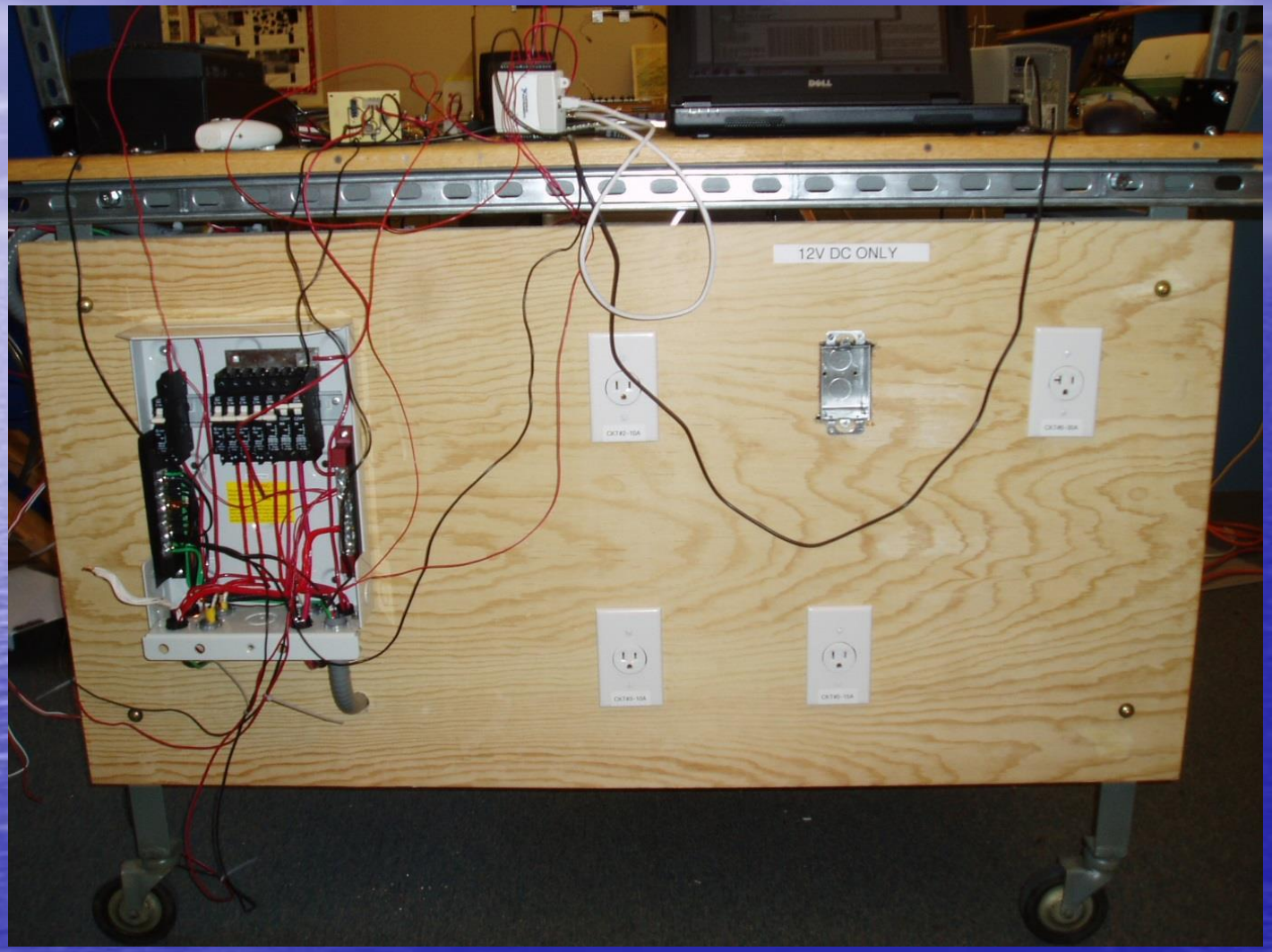
System Testing Block Diagram

Figure 6.1 – Open Loop SuPER System Block Diagram

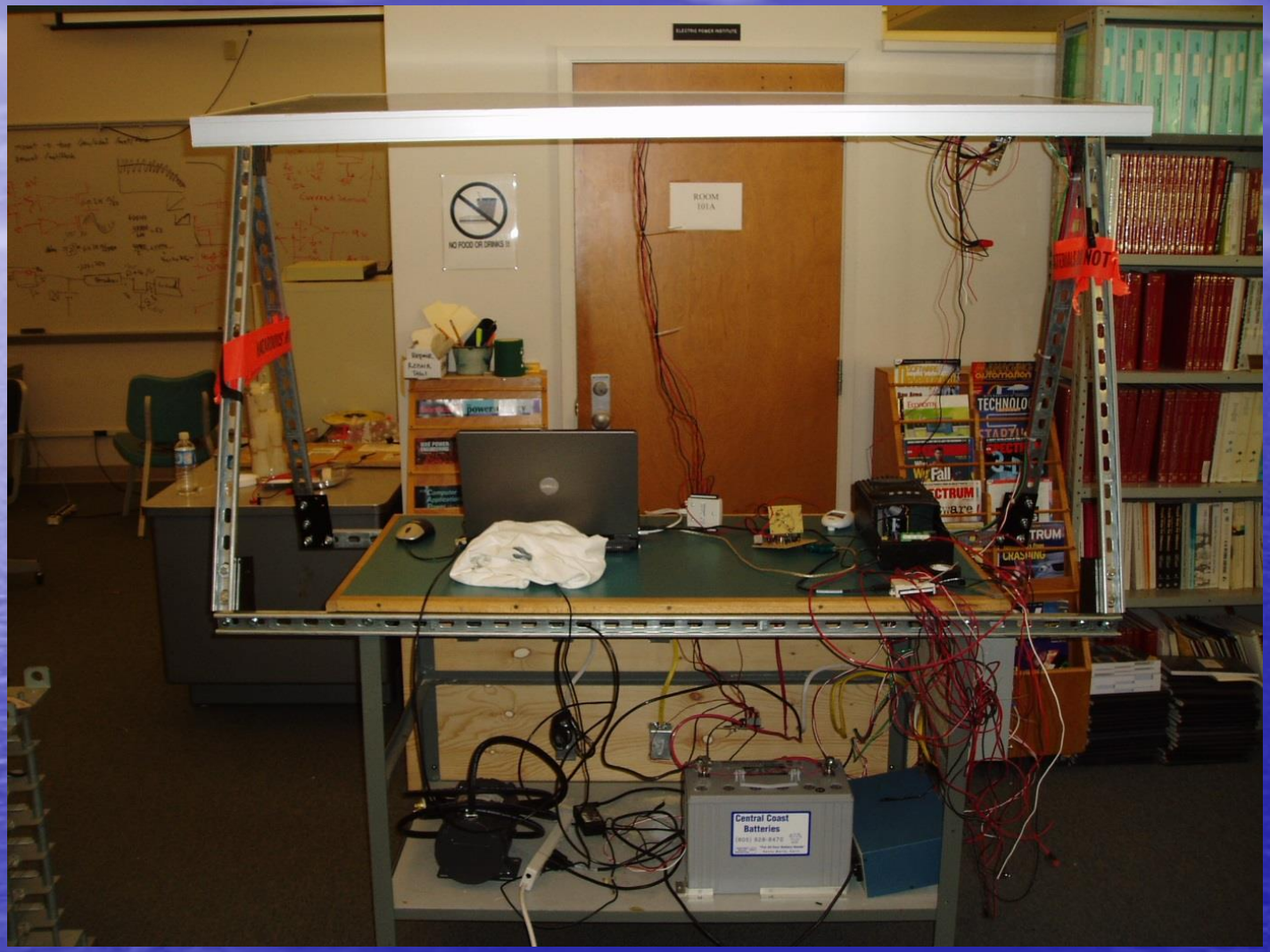


System Block Diagram – Phase 1

Figure 4.1 – System Block Diagram



Prototype SuPER System Cart protection and load distribution
12V DC service panel with five load circuits (four in service)

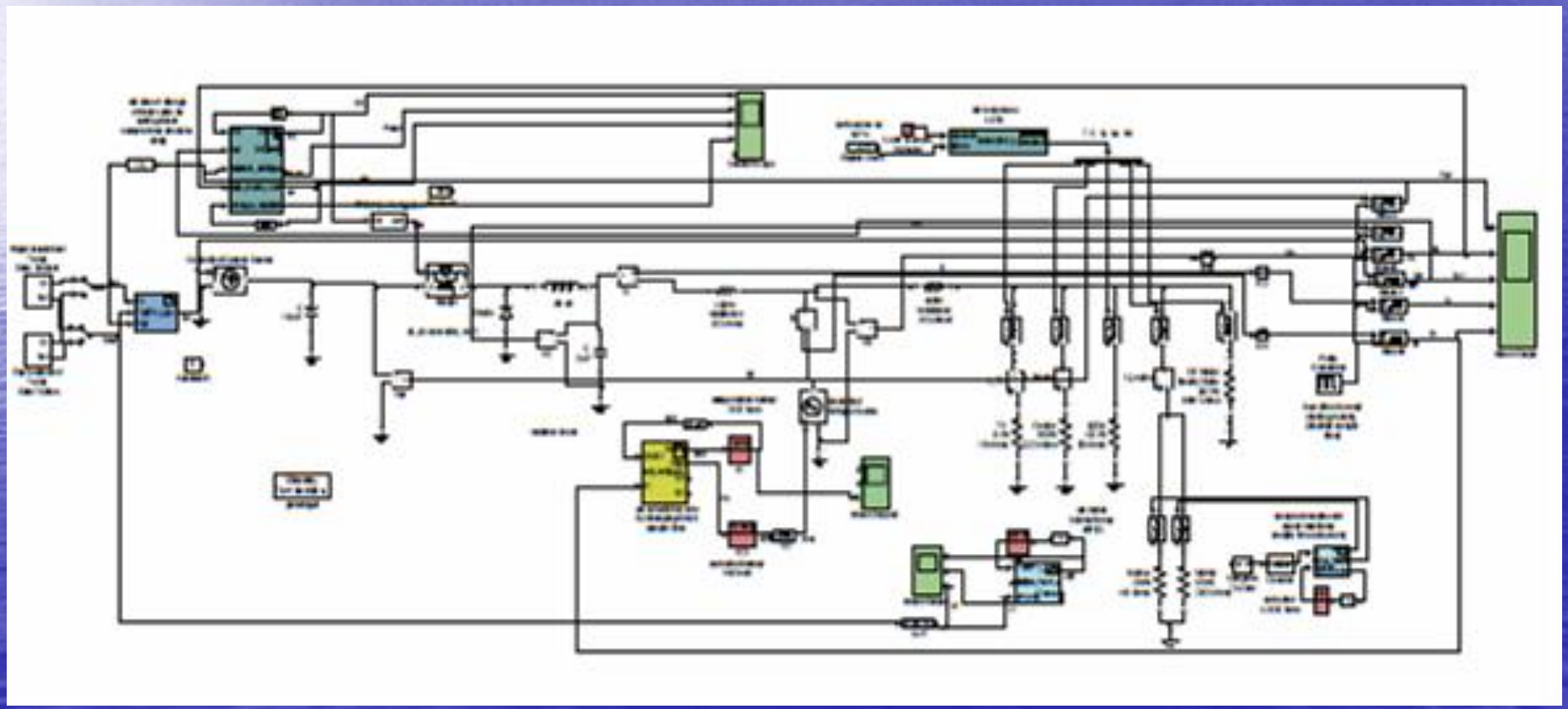


Prototype SuPER System Cart top shelf view
Laptop computer, interface circuits, MX-60 controller

Variety of Engineering Tasks

- Simulation of system with MatLab/Simulink using SimPowerSystems package
- NI DAQ device sensor data processing (Linux host, LabView API) for pyranometer, voltage, current sensors, and switch control
- PWM signal drive PIC programming and validation
- Battery and ultra-capacitor technology: electrical power storage research and modeling, charge optimization
- Modeling of DC loads: white LED lighting, DC motor, refrigerator, TV, laptop
- Test of prototype to validate simulation

The Simulink Model



SOC Simulations

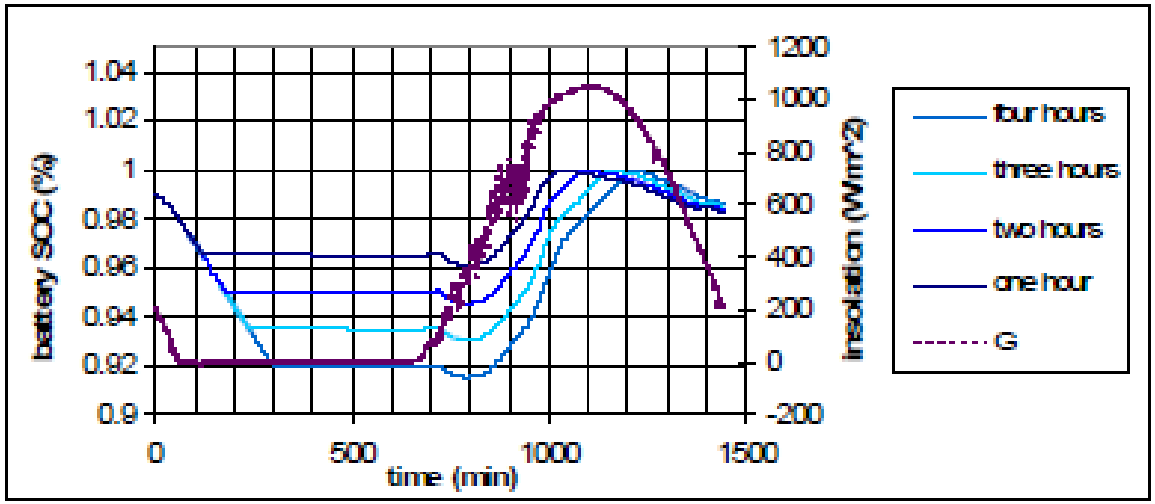


Figure 5.3 – Nighttime LED Operation Simulation

Model Validation

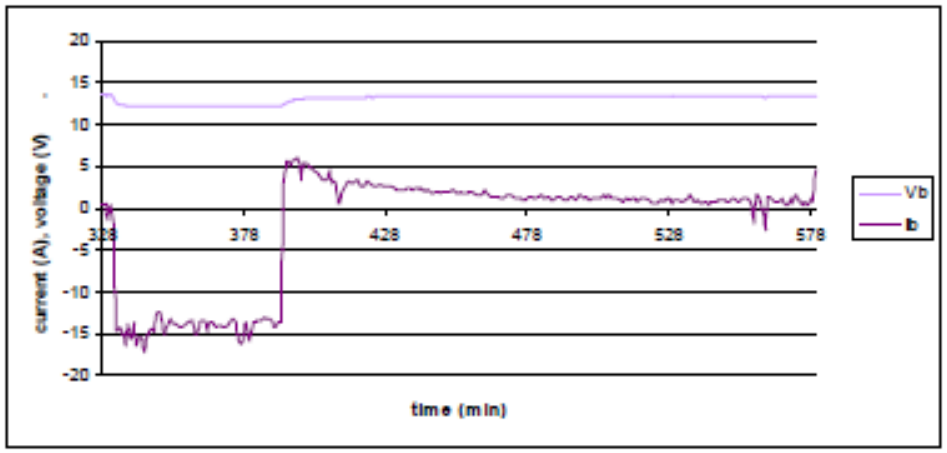


Figure 5.8 – March 19th 2007 Motor Operation Measurements

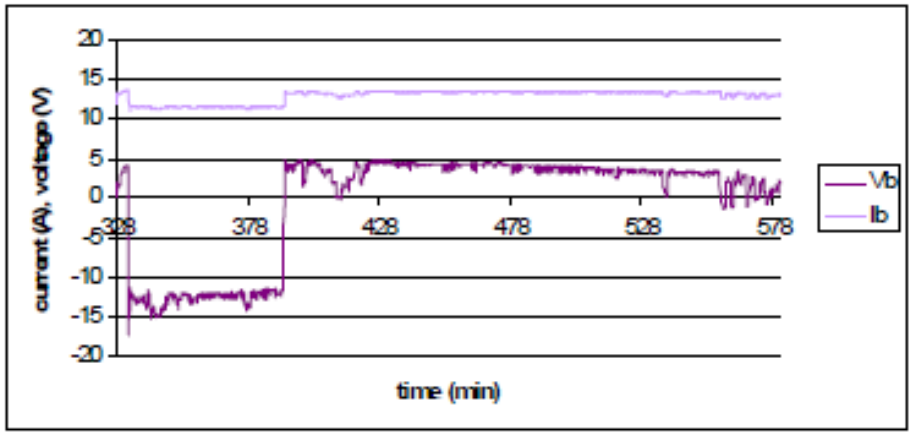


Figure 5.9 – March 19th 2007 Motor Simulation