Electric Vehicle Power Converters

Sam Emrie
Jacob Anderson
Advisor:
Dr. W. Na

Outline

- Project Summary
- Project Goals
- Background
- Detailed Description
  - Functional Description and Requirements
  - Equipment and Parts List
  - Preliminary Lab Work
- Schedule of Spring Tasks

Project Summary

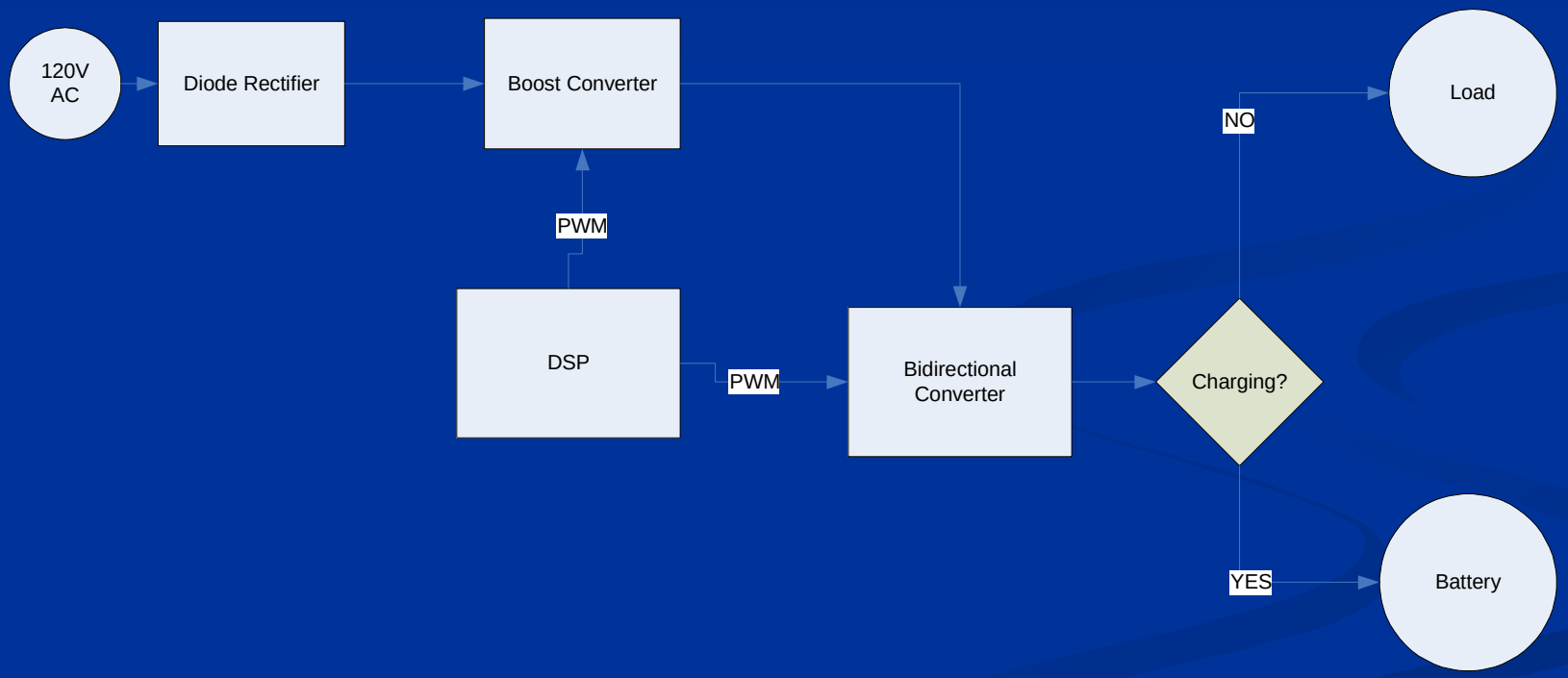


Figure 1: Block Diagram of Power Converter

Project Goals

- Being able to charge the battery throughout the wall power outlet, 120 Vrms, 60Hz.
- Having the DC able to charge a battery by making the signal approximately 52V.
- Analyzing charging and discharging voltage current characteristics of 400W, 52 V Li-Ion battery.
- Developing a more safe and efficient charging and discharging control algorithm of the battery

Background

- Previous work done by Matt Daly, Peter Burrmann, and Renee Kohl
  - Completed Small Scale System
  - Simulated and Designed Large Scale System
  - Found Internal Resistance of Battery

Detailed Description

- Power Factor Correction Circuit
- Bidirectional Converter Circuit
- Gate Driver Circuit
- DSP Protection Circuit
- Battery Testing Circuit
- Digital Signal Processor

Power Factor Correction

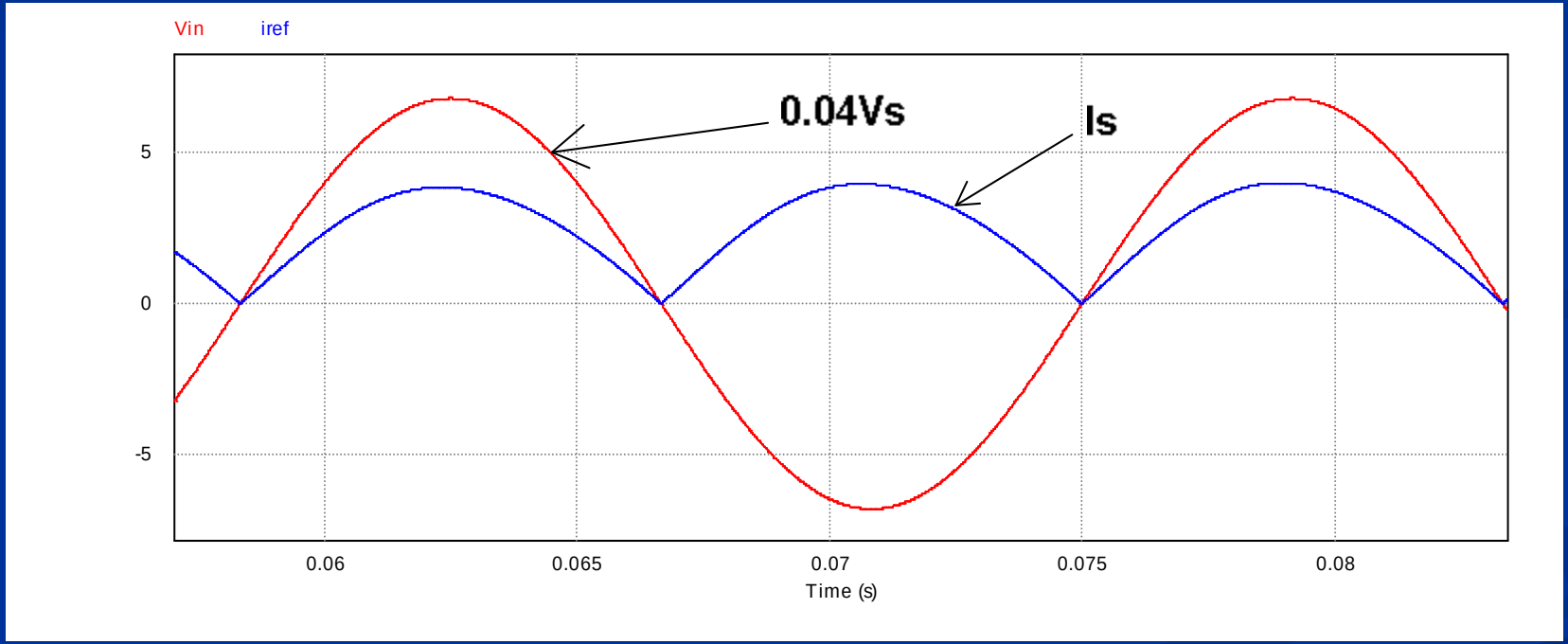


Figure 2: Power Factor Correction Output

Power Factor Correction

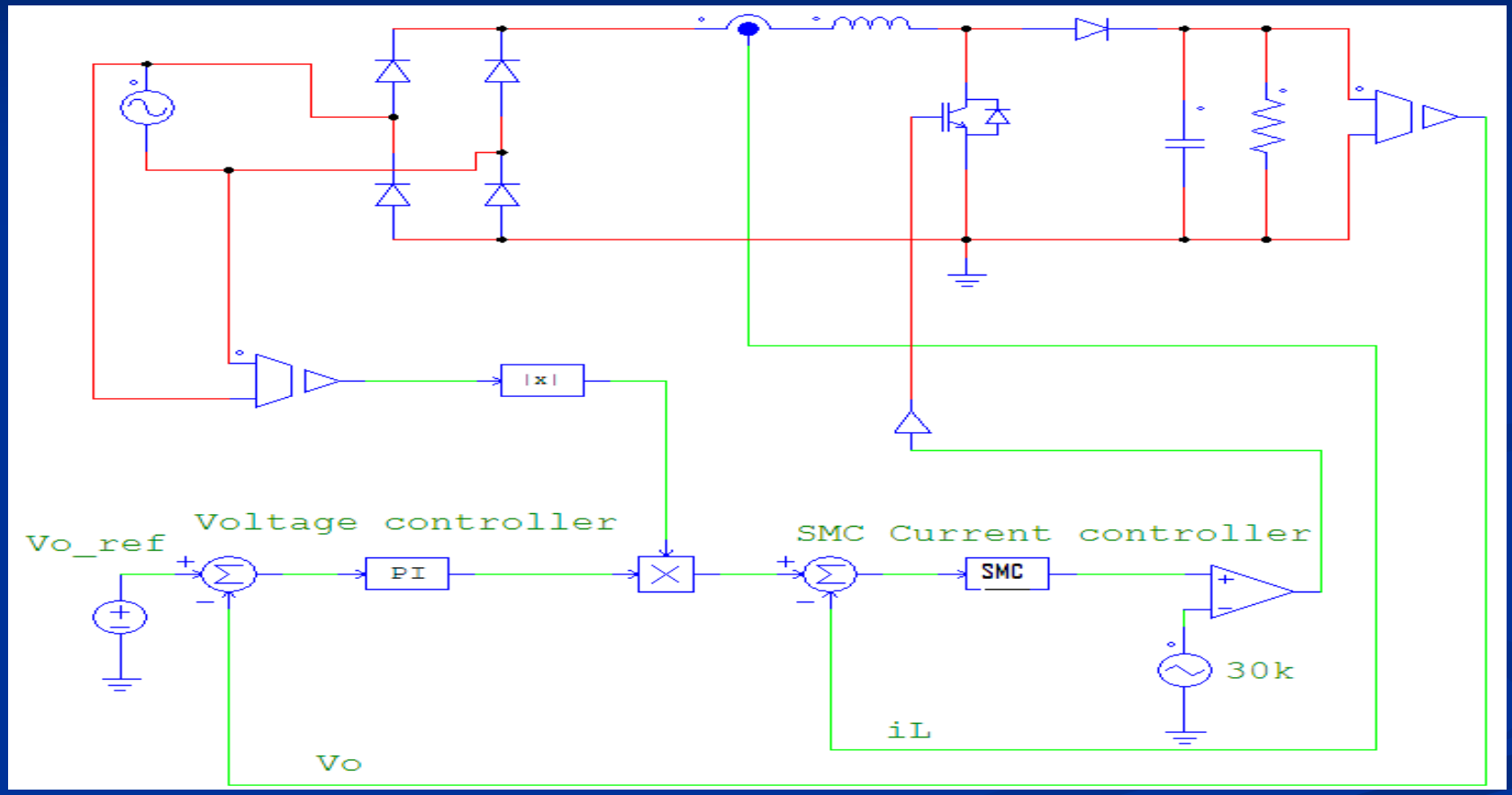


Figure 3: Diagram of Power Factor Correction Circuit

Bidirectional Converter

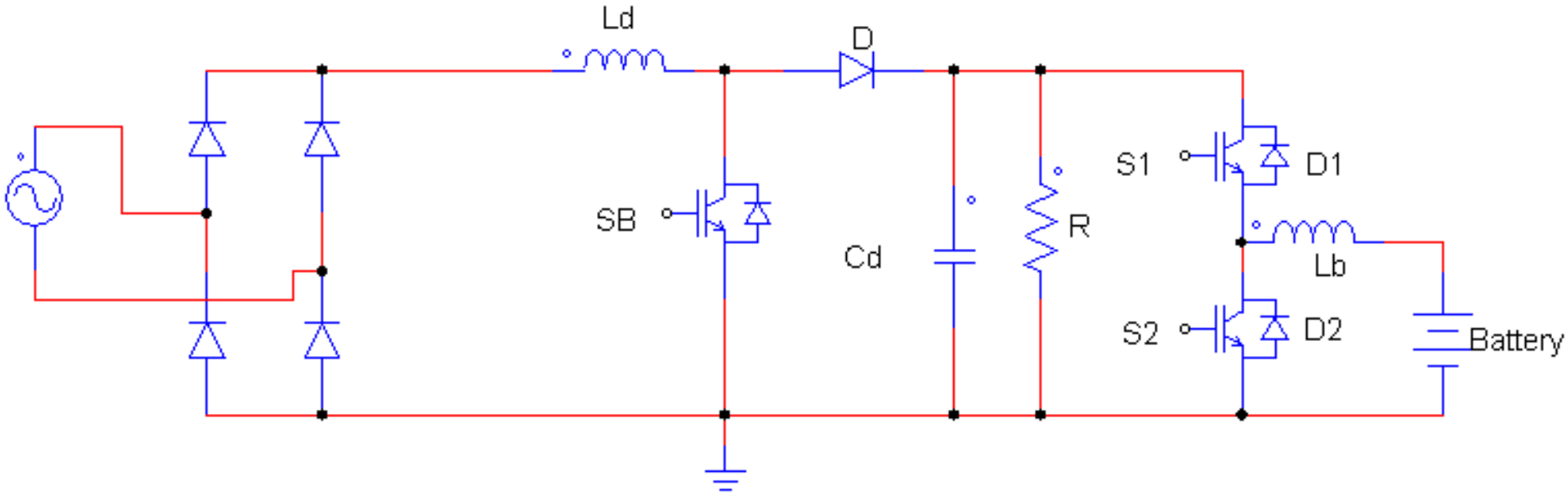


Figure 4: Diagram of Bidirectional Circuit

Gate Driver Circuit (IR2110)

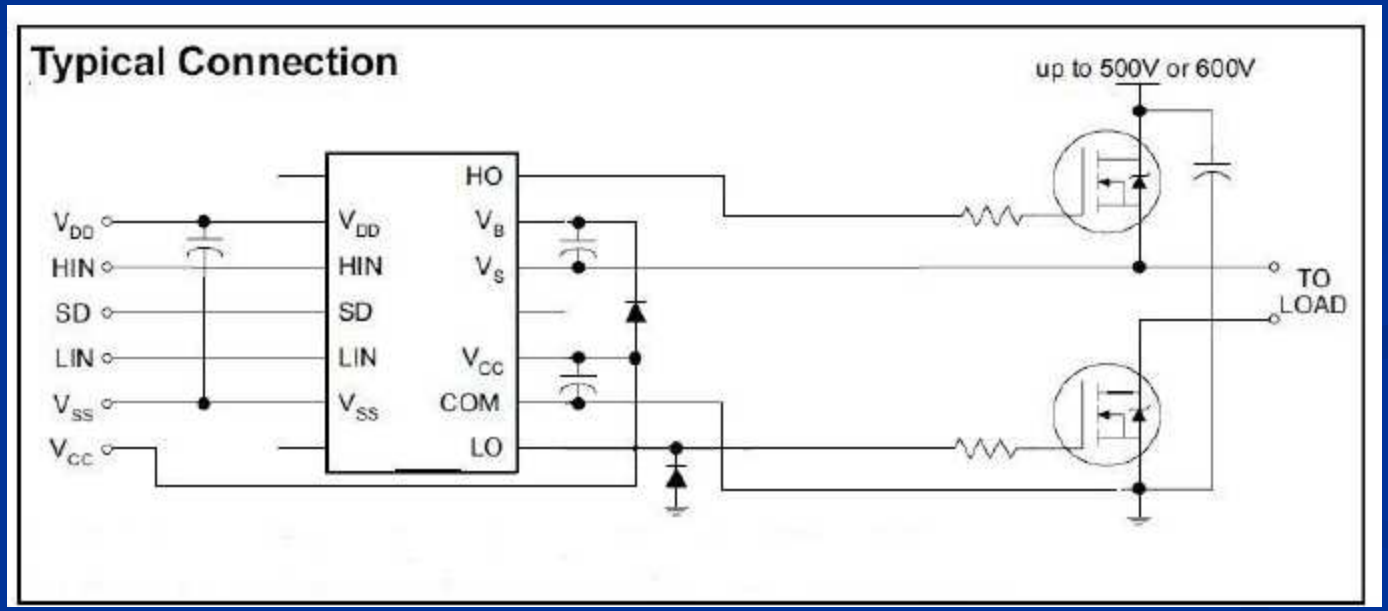


Figure 5: Diagram of Gate Driver Circuit

DSP A/D Sensing Circuit

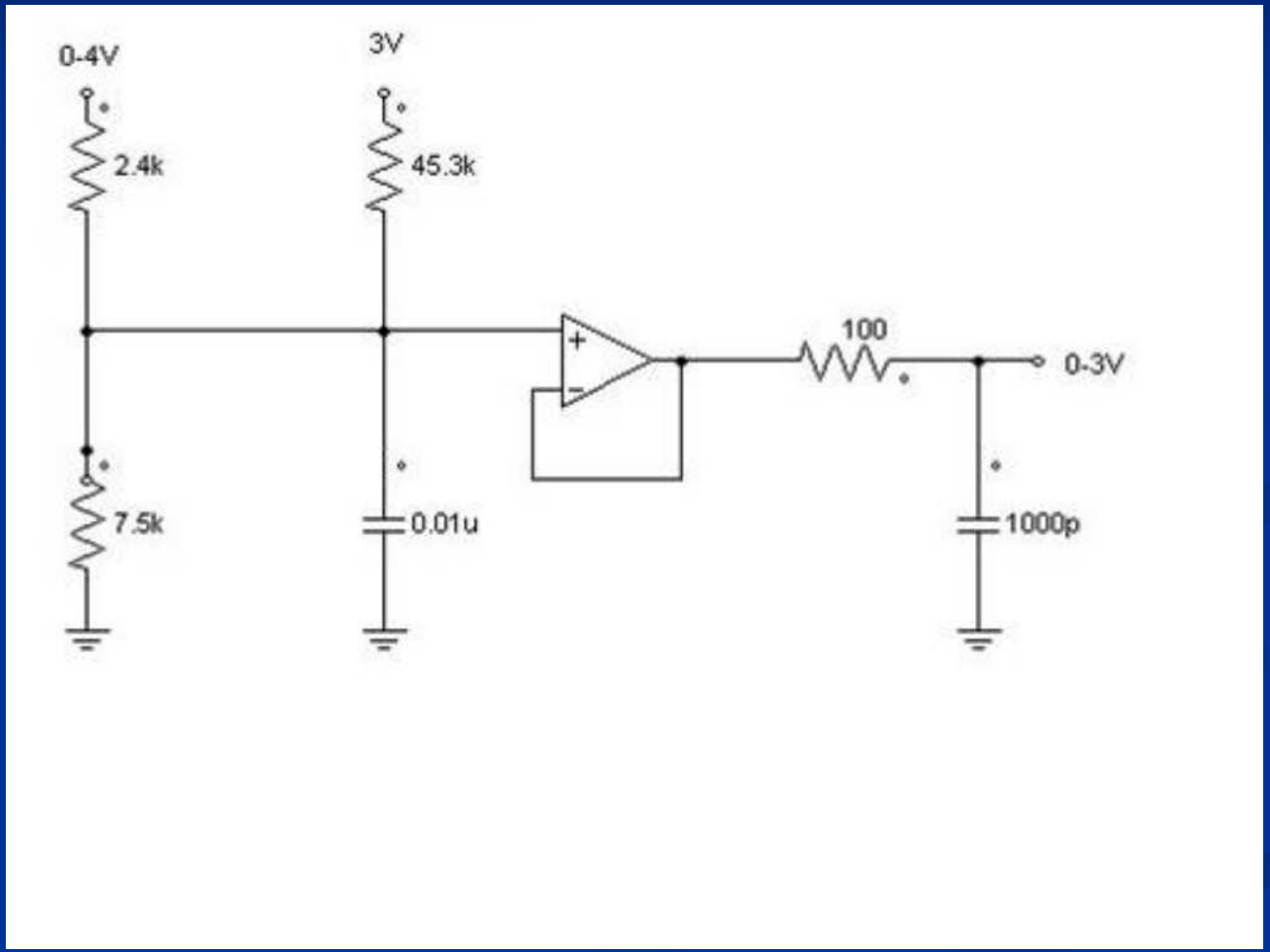


Figure 6: Diagram of the A/D Sensing Circuit

Battery Testing

National Renewable Energy Laboratory Saft-Battery Model

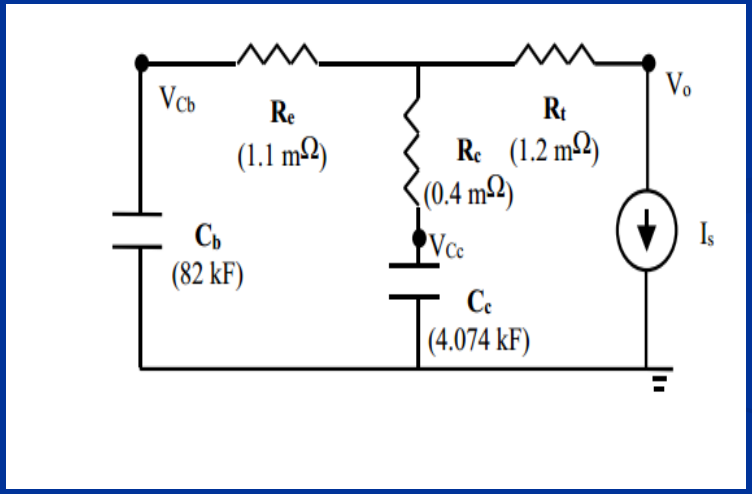


Figure 7: Diagram of the Saft-Battery Model

Battery Test Circuit in Simulink

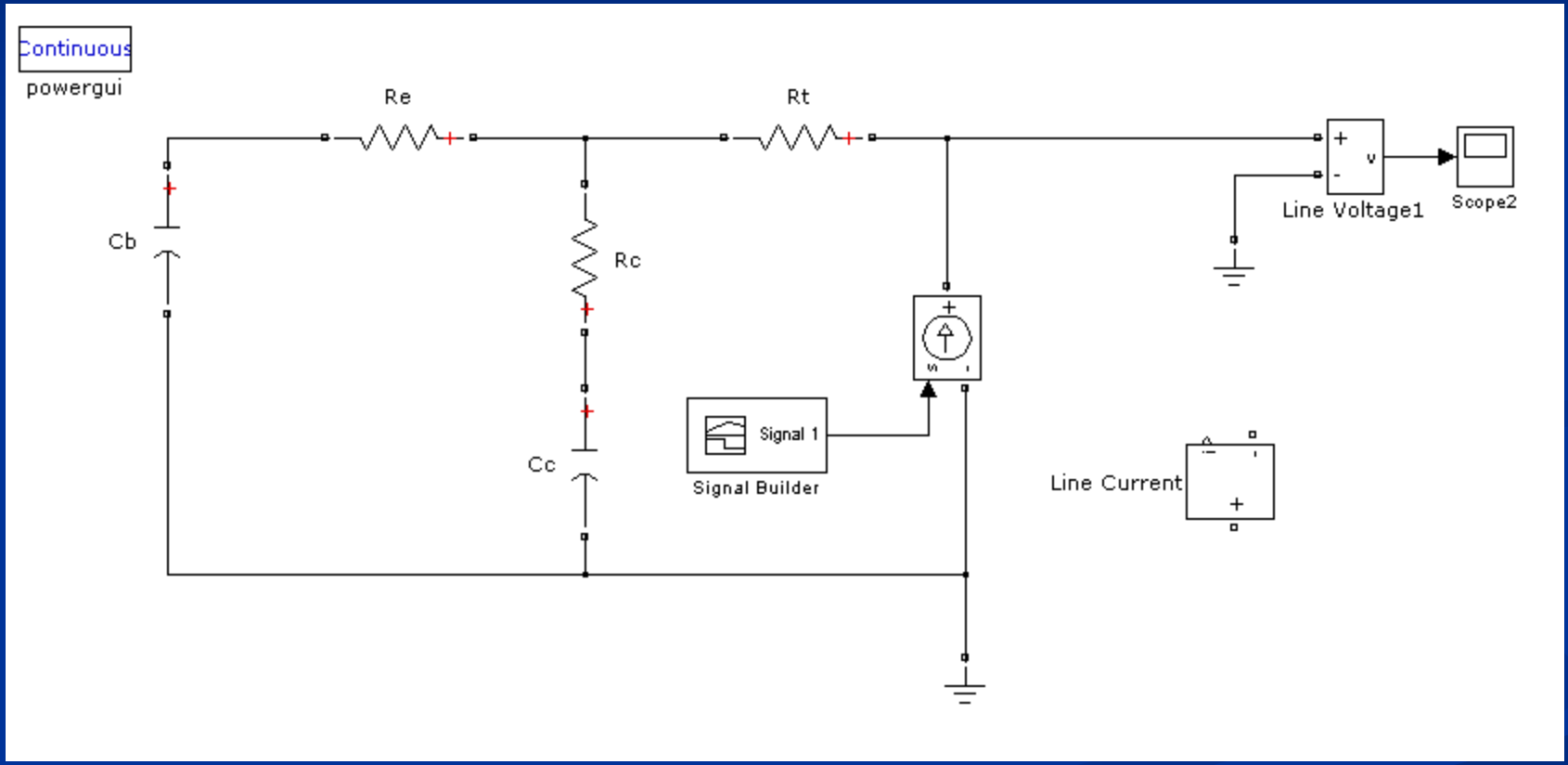
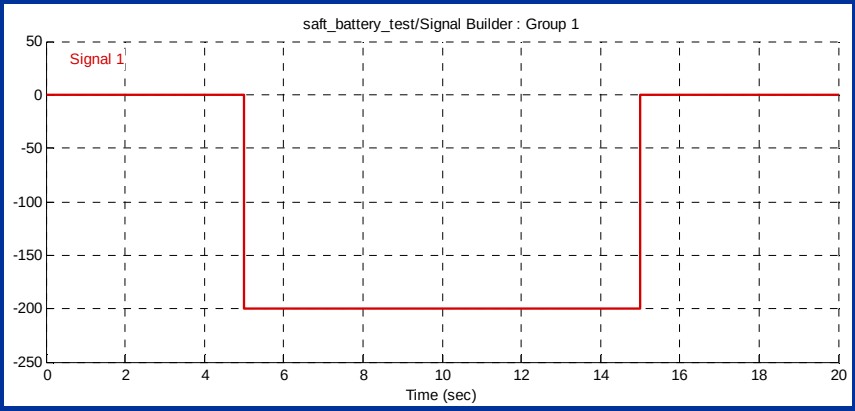


Figure 8: Diagram of the Battery Test Circuit in Simulink

Simulation Result



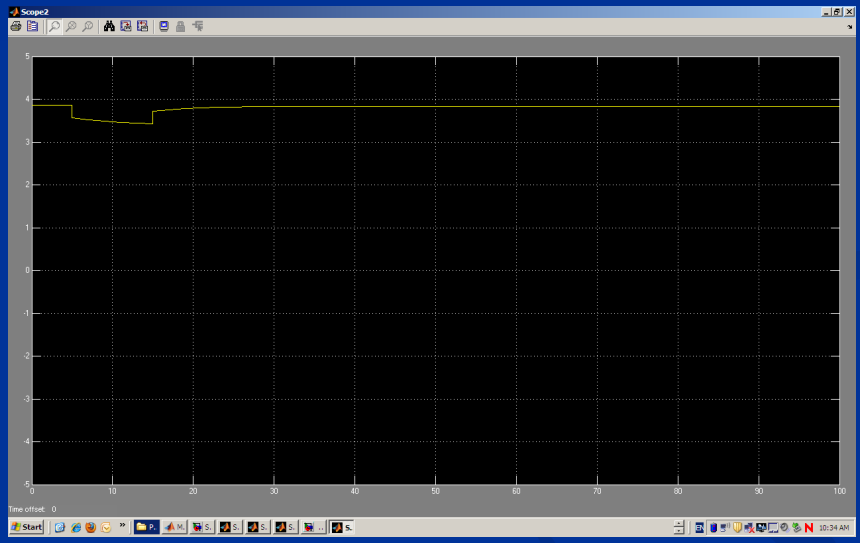


Figure 9 and Figure 10: Battery Simulation Results

DSP

- Using TMS320F2812 DSP board to control the PWM duty cycle
- Switching frequency between 10-50kHz
- Sensing frequency between 10-50kHz
- A/D inputs 0-3V
- PWM output 0-3V

Digital Signal Processor

- TMS320F2812 DSP
- 32-Bit CPU
- 150 MHz Board
- 16 Channel ADC = 3V input
- 16 PWM Channels
- Programmable via Simulink and Code Composer

MOSFET and Heat Sink

- IRFP460A N-Type
- V_DS = 500V
- I_D = 20A
- Low Voltage High Freq.
- 55ns Rise Time
- SK 145 Heat Sink
- Thermal Resistance 13.2K/W

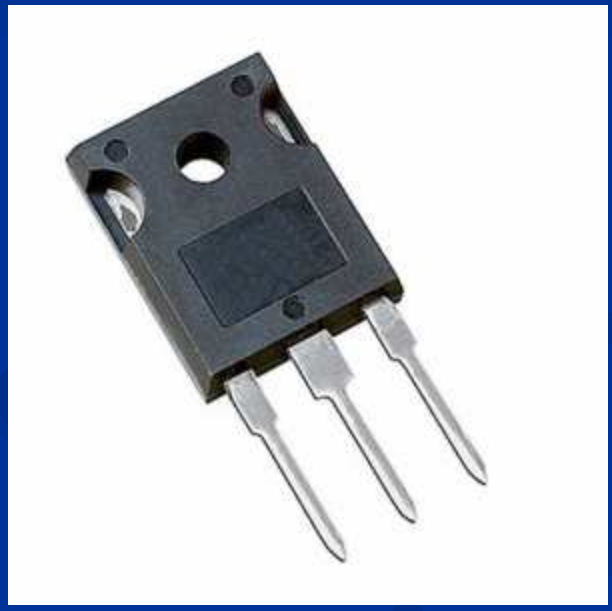


Figure 11: Picture of MOSFET (IRFP460A)

MOSFET Gate Driver

- HCPL-3180-060E
- 2.5 A maximum peak output current
- Power Supply VCC-VEE 10Vmin 20Vmax
- 250 kHz maximum switching speed PWM input

Diode Rectifier

- NTE5328 – Bridge Rectifier
- Maximum RMS Bridge Input Voltage = 700V
- Surge Overload Rating: 400A (Peak)
- Average Forward Current (TC = +75°C), IF (AV) = 25A

Figure 12: Picture of Diode Rectifier (NTE5328)

Diode

- VS-HFA50PA60CPBF
- VR = 600 V
- Maximum continuous forward current 25A per leg 50A per device

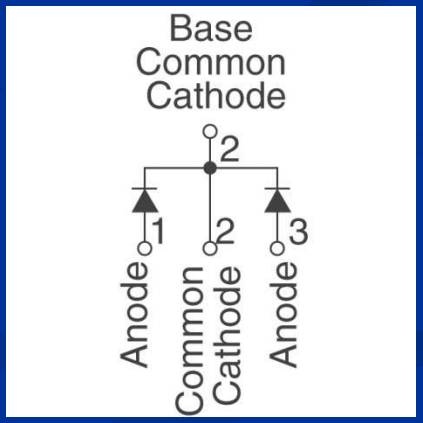


Figure 13 and Figure 14: Picture of Diode and Diode Circuit

Current Transducer

- L08P050D15 Current Transducer
- Power Supply VCC ±15V±5%
- Nominal Primary DC current
- I_f = 50AT (wrapping)
- Maximum Current I_fmax = ±150AT
- Output Voltage V_OUT = 4V±0.040V @ ±I_f
- Uses hall effect via cable winded through opening to sense current

Figure 15: Picture of Current Transducer

Op-Amp

- OP484FPZ Op-Amp
- Supply Voltage Range VS = 3V - 36V
- Output Voltage High = 2.8Vmin
- Output Voltage Low = 125mVmax
- Overvoltage protection

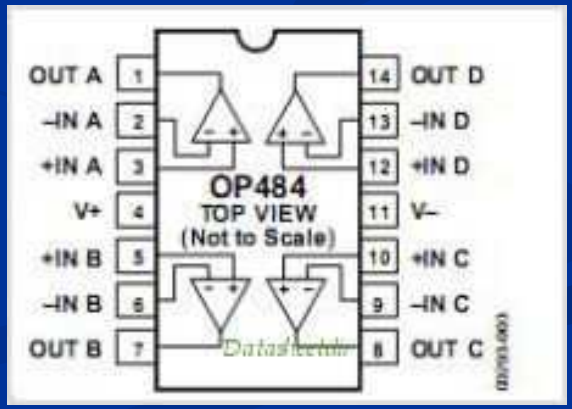


Figure 16: Chip Layout of Op-Amp

Hex Inverter

- NXP - 74HC04N
- Inverts input
- VCC supply voltage = 5.0V

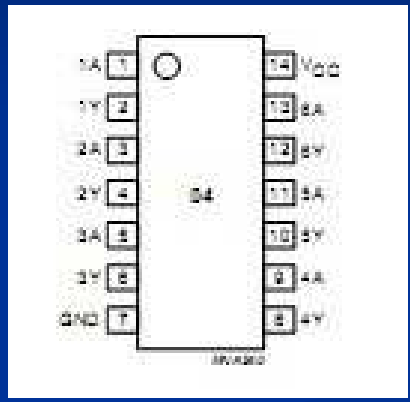


Figure 17: Chip Layout of Hex Inverter

Capacitors and Inductors

- Aluminum Electrolytic Capacitor
- Capacitance = 1500UF
- Voltage = 400V
- Inductance =500UH,
- Current = 35A

Voltage Regulators

- LD1117V33C
- Vin = 15V
- Vo = 3.3V
- LM1117T-5.0/NOPB
- Vin = 15V
- Vo = 5V

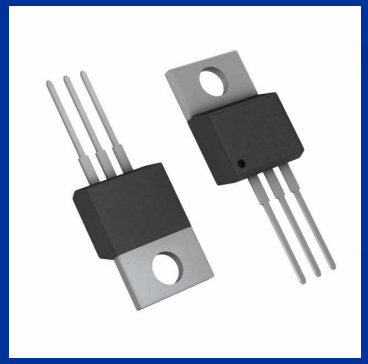


Figure 18 and Figure 19: Picture of Voltage Regulator

Future Work

- Small Scale Test Battery
- Large Scale Test Battery
- PCB Design
- DSP Design

Spring Schedule

- Week 1 Any Extra Battery Research
- Weeks 2-3 Small Scale Battery Testing
- Weeks 4-6 PCB Design
- Weeks 7-9 DSP Design
- Weeks 10-11 Large Scale Battery Testing
- Week 12 Implementation

References

- Daly, Matt, Renee Kohl, and Peter Burrmann. "Electric Vehicle Charger for Plug-In Hybrid Electric Vehicles." *PHEV: Plug in Hybrid Electric Vehicle Charger*. 26 Sept. 2011. Web. 24 Sept. 2012.
- N. Mohan, *First Course on Power Electronics.* Minneapolis: MNPERE, 2009.

Questions?