BATTERY BENCH DISCHARGE SYSTEM

INDUSTRIAL ELECTRONICS AND INSTRUMENTATION COURSE A.A. 2017/2018

INTRODUCTION

The goal of this project was to build a instrument that identifies the electrical/thermal parameters for a Li-Ion cell’s model.
The model are then used to estimate the SoC (State of Charge) of a battery for a Formula SAE car.
The identification process can be done in several ways, the one that I choose was using discharge’s pulses.

The requirements for this instrumentation were:

- Be able to discharge at least one battery module with different current profiles (pulse, ramp etc.).
- High discharge current (almost 240A – Full car throttle)
- Cheaper as possible (1000 euros budget)
- Acquisition and logging of current, batterie’s voltages and batterie’s temperature at a reasonable speed (at best 150 Hz).

BATTERY

The battery pack is composed by several modules, in my case Energus 6p1s Sony VTC5.

Capacity: 15.6 Ah
Nominal voltage: 3.6V
Maximum voltage: 4.2V
Cut-off voltage: 2.5V
Max discharge current: 280A (5s pulse)
Max continuous discharge current: 180A

Just rough calculations, if I want to discharge the module at 200A (assuming nominal voltage) I need to dissipate 720 W.

ON MARKET SOLUTIONS

There are two ways in which the test can be done: using programmable DC loads as:

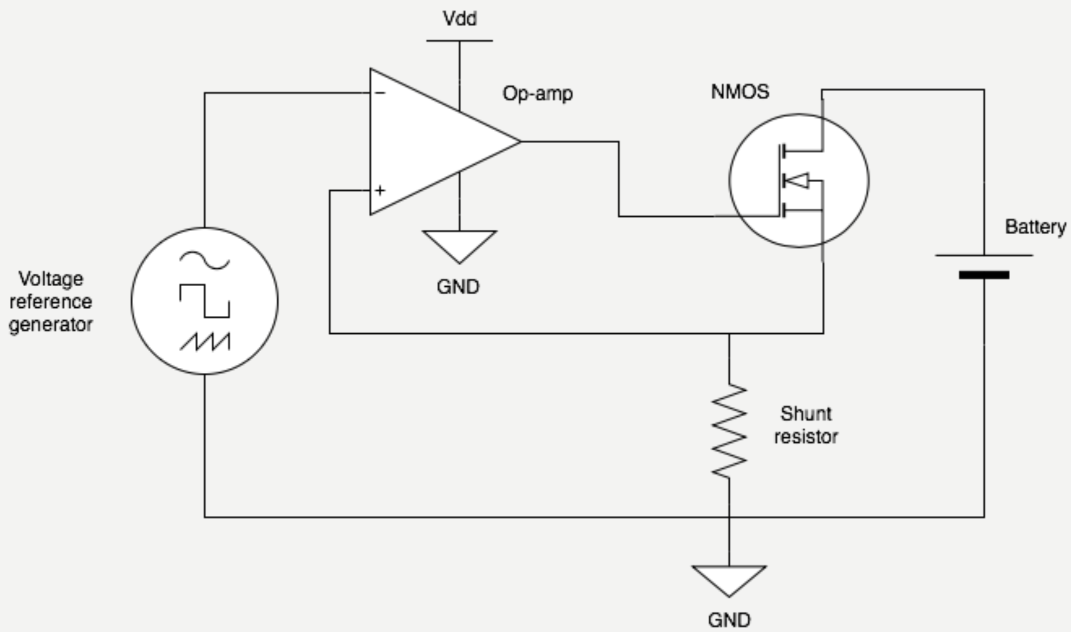
BK 8600 Series
Max load voltage: 60V-120V
Current: up to 240A
Built-in DAS
Price: 4000-10000

or can be obtained using very expensive and sophisticated instrumentations (HPPC test instrument)

Neware CT-4002
Load voltage: 0.025V-5V
Current: up to 300A
Built-in DAS
Price: > 10000$

CONSTANT CURRENT LOAD

The easiest and cheaper solution that I found was to use the so called ”constant current load”, here the schematic

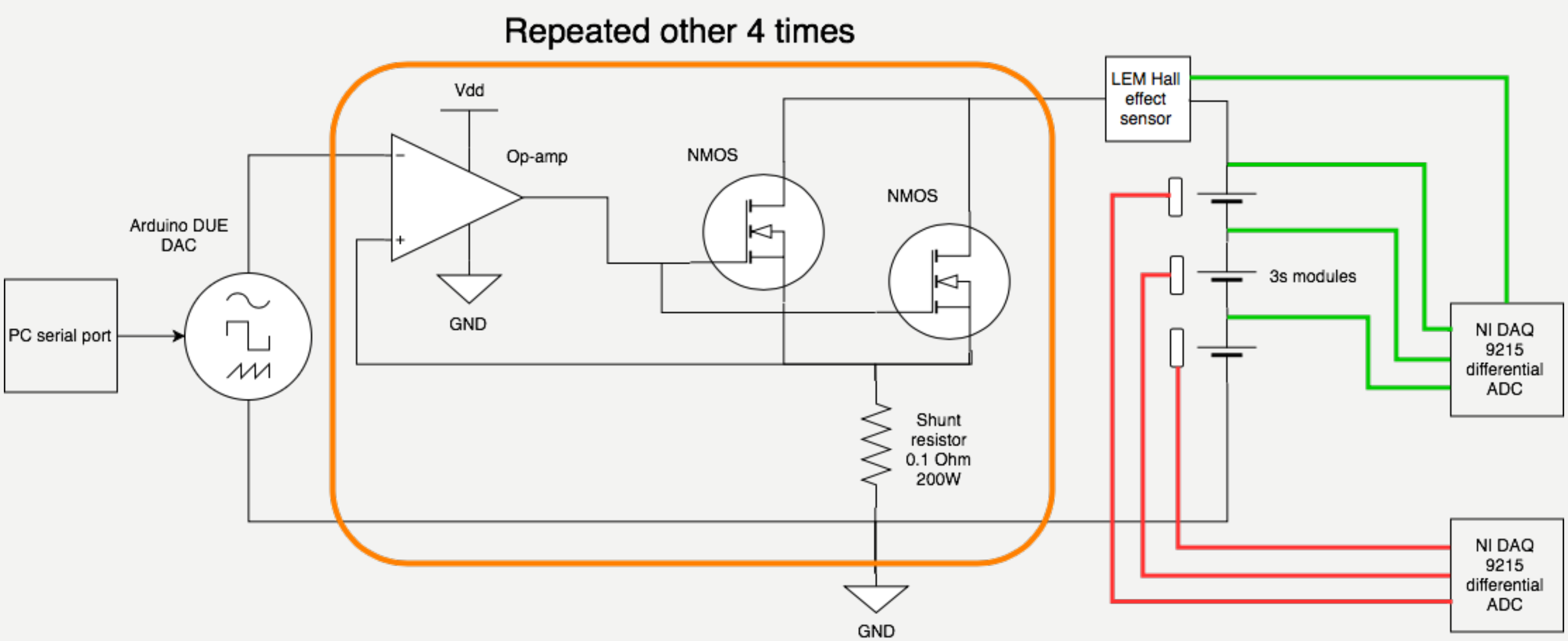


The basic principle is that the voltage that I apply on the inverting side of the Op-amp is the same that I apply between the resistor’s terminals.
So, if I use a 0.1 Ohm resistor and I apply one Volt as reference voltage the current that flows through the battery, the NMOS and the resistor is 10A.

FINAL CIRCUIT DIAGRAM

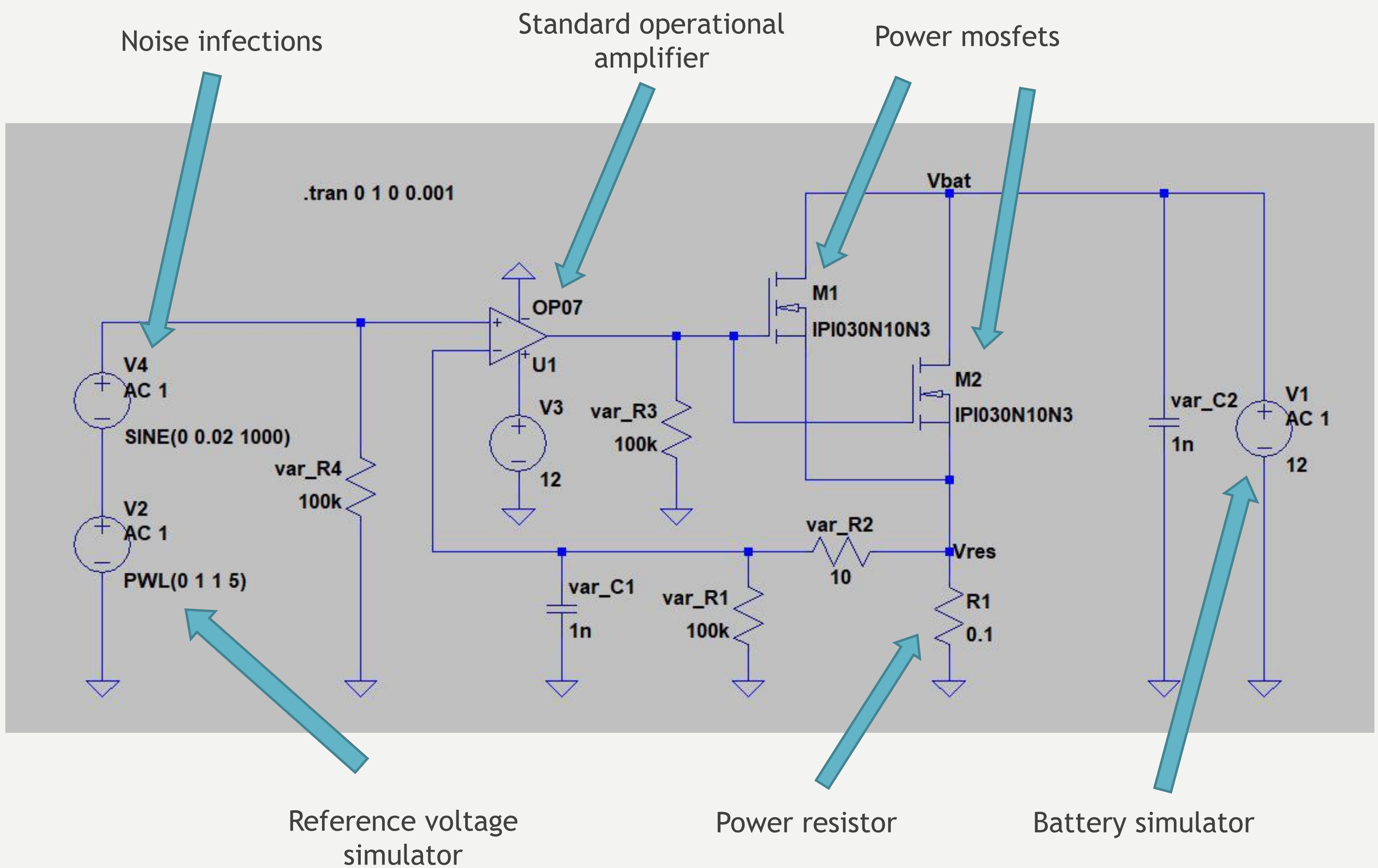
After a long time spent on LTSpice I finally reach the final circuit. The main problems that I found were:

- Parallels of mosfets are difficult to manage (parameters mis-matching)
- Heat dissipation
- Oscillating behaviours
- Finding electrical components which were able to meet my requirements



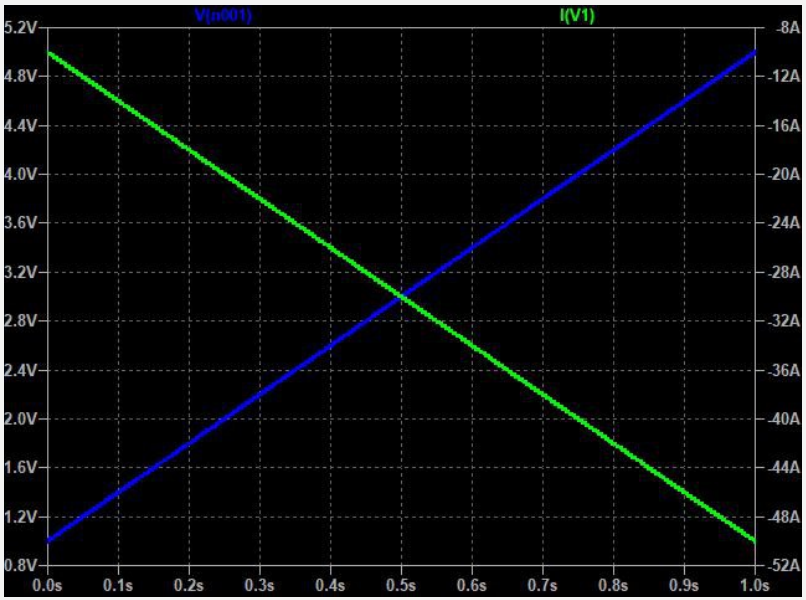
LTSPICE SCHEMATIC

Here the schematic of one of the five circuit's section:

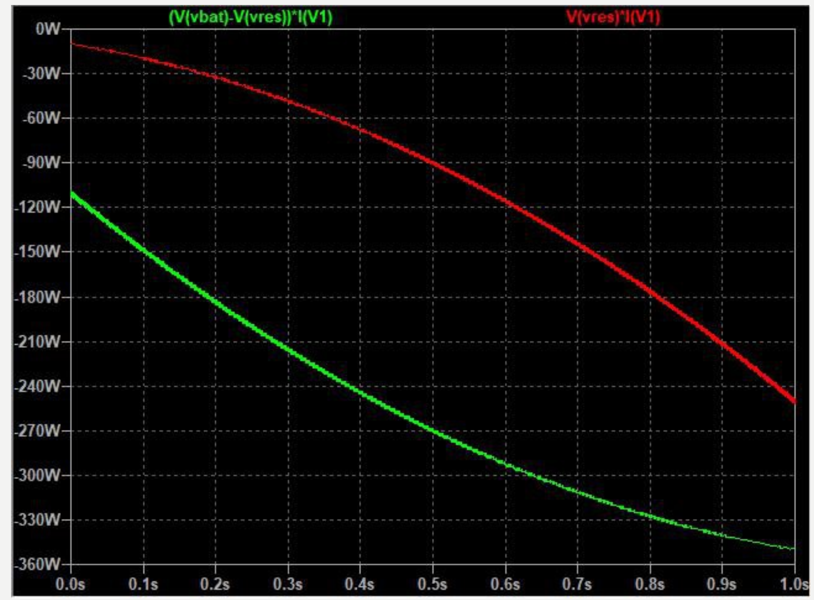


HEAT DISSIPATION

From the simulation I found that the power that the mosfets and the resistor have to dissipate.
Here 2 simulations, one at low current and one at high current:



(Blue: reference voltage Green: total current drawn)



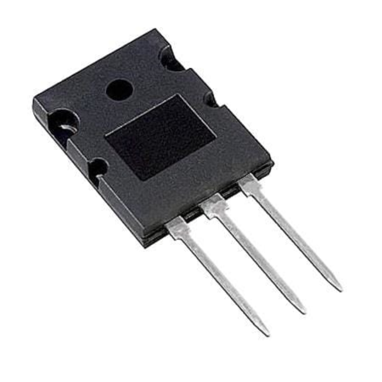
(Green: mosfet’s power Red: resistor’s power)

A cooling system was needed, so I started looking on the market which kind of solution is better. In order to correctly design the cooling I choose the maximum power dissipate for each device. This idea is conservative (explain better)

POWER COMPONENTS

The power components were:
10x Mosfet IXIS IXFK360N10T

- Rds of 2.9 mOhm
- Vdss 100V
- Idmax 360A
- Pmax 1250 W
- Rthjc 0.12W/°C
- Rthcs 0.05 W/°C

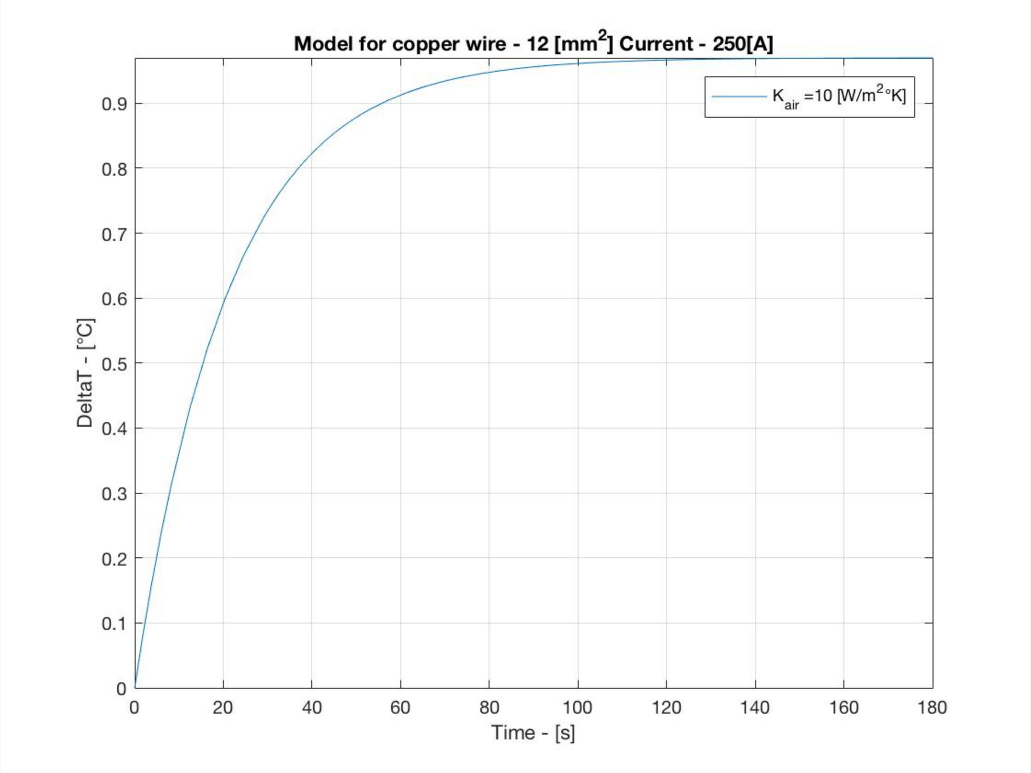


5x 0.1Ohm +/-5% Arcol HS200 R1 J

- 200W power rating
- 50W without cooling

BUSBAR DESIGN

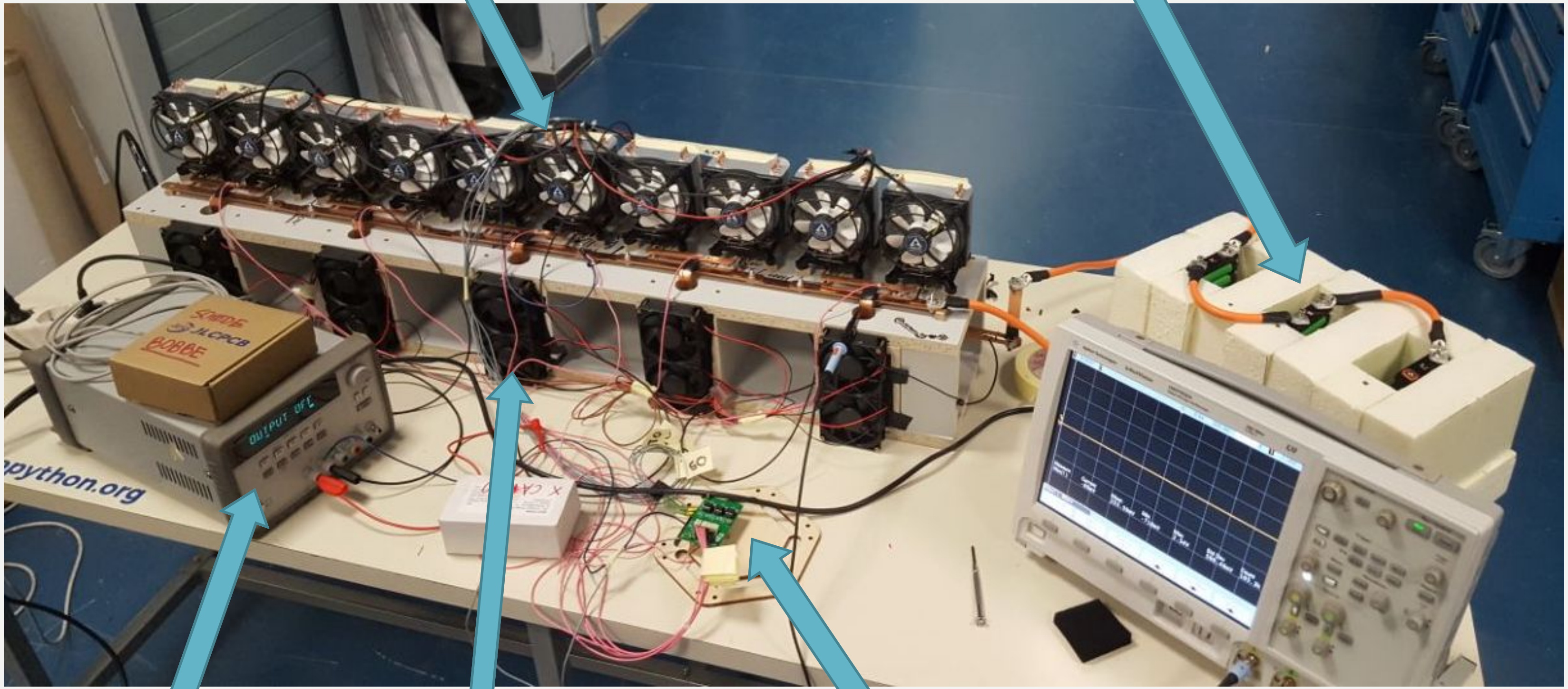
Thanks to ProM I was able to design my own busbar starting from a cupper sheet of 1.5mm thickness. For the design/simulation I used a well known 1DoF thermal model implemented using Matlab, here the final simulation of the positive busbar (1.5m length).



FINAL RESULT

Mosfet's cooling

Batteries and adiabatic case



Reference generator

Resistor's cooling

Control board

DATA LOGGER - HARDWARE

NI USB-6008

- USB connection
- Up to 8 Differential ADC
- +/- 10V
- 12 bit of resolution
- 10 KS/s

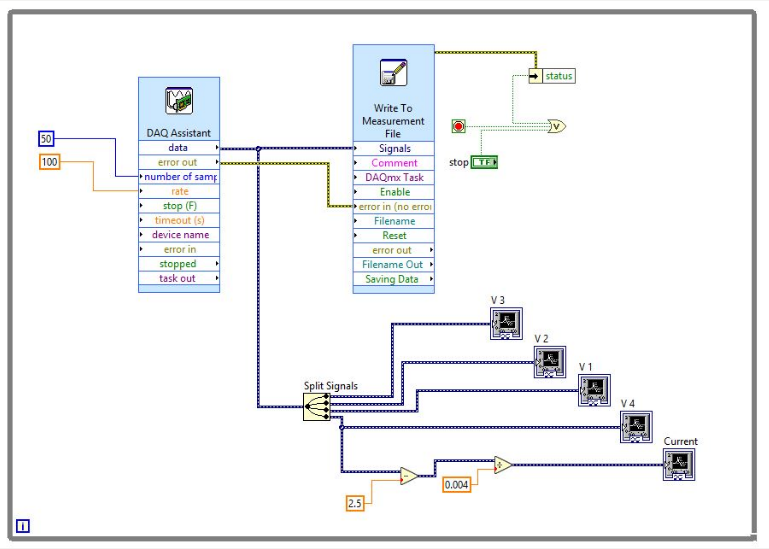
NI cDAQ-9181

- TCP/IP connection
- Up to 4 Differential ADC
- +/- 10V range
- 16 bit of resolution
- 100 KS/s

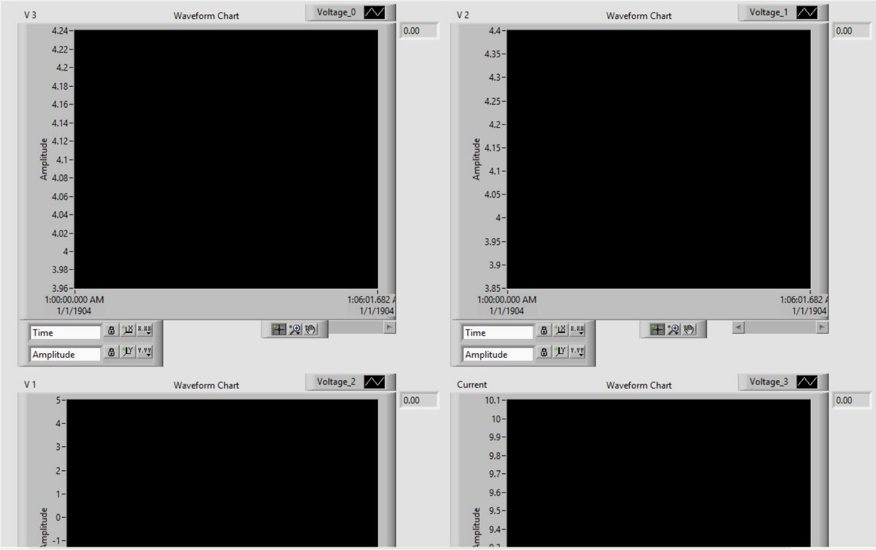
DATA LOGGER - SOFTWARE

After choosing and setting the hardware I created the VI which logs and plots all the data. This VI can be used with both hardwares.

Code



User interface



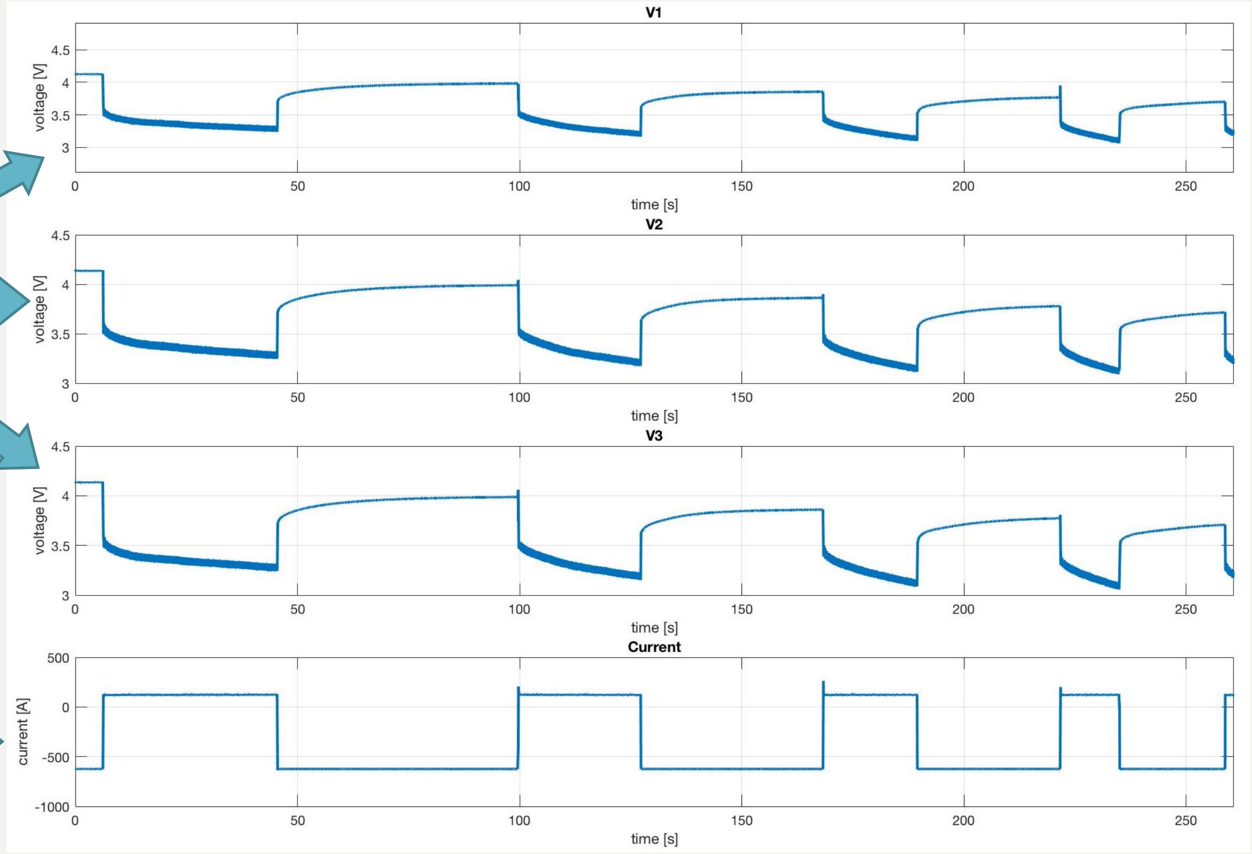
CURRENT SENSOR

DHAB-S24 Hall effect current sensor

- Single 5V supply
- +/- 500A of current range
- 4mV per Ampere of sensitivity

DATA ANALYSIS

Here a slice of a discharge test at 120A sampled at 50 Hz and with a resolution of 3mV.



Batteries voltages

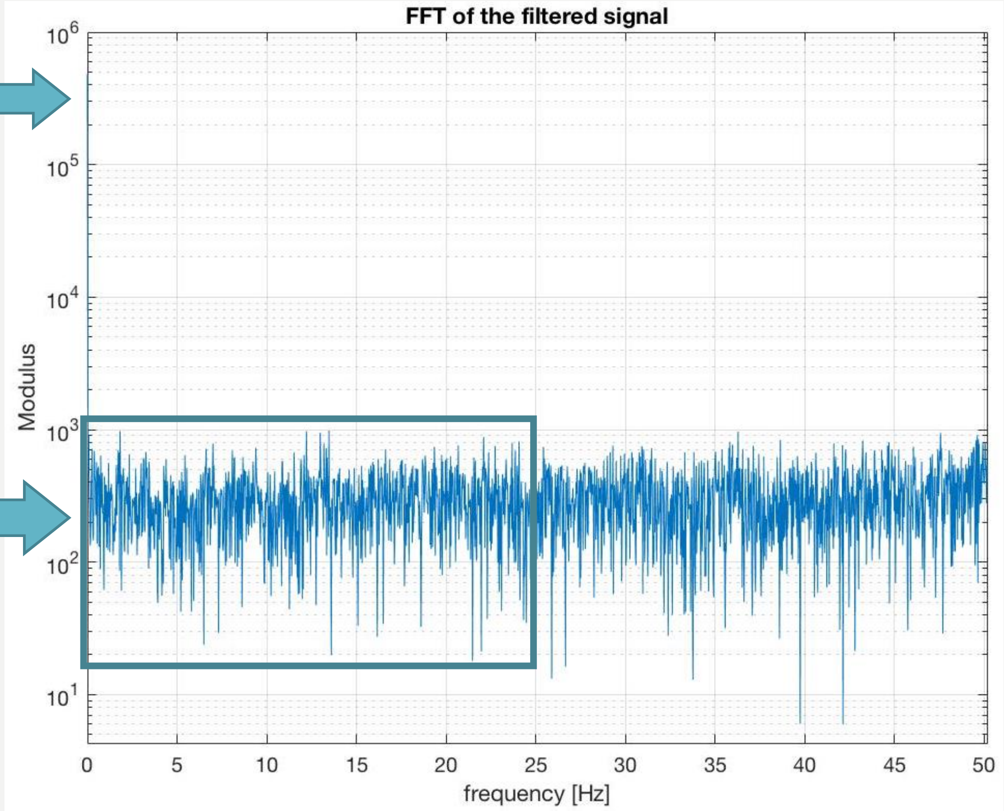
Current

DATA ANALYSIS PT.2

Here the FFT of the current during the discharge pulse without any filtering.

DC component

White noise



Fs = 50 Hz
Resolution = 3mV

THANKS FOR THE ATTENTION