A few approaches to firmware projects design
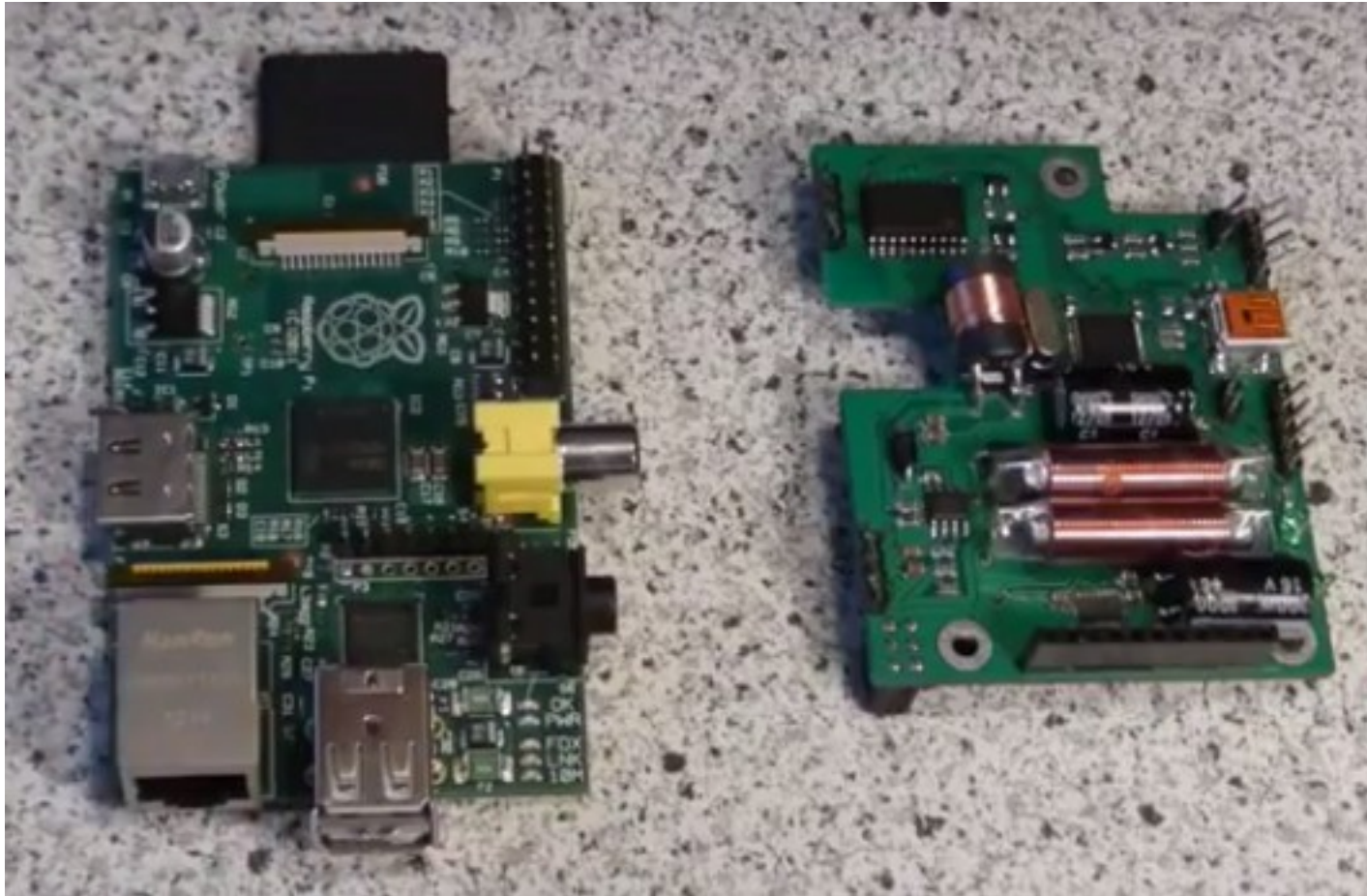
Prototyping boards set for Raspberry Pi extension.

- **Python** based computer side SDK.

- **Pawn** embedded scripting machine.

- Boards in stack are driven by either main board, PC or Raspberry Pi.

- If coupled with Raspberry can provide it with power when needed.

Prototyping boards set for Raspberry Pi extension.

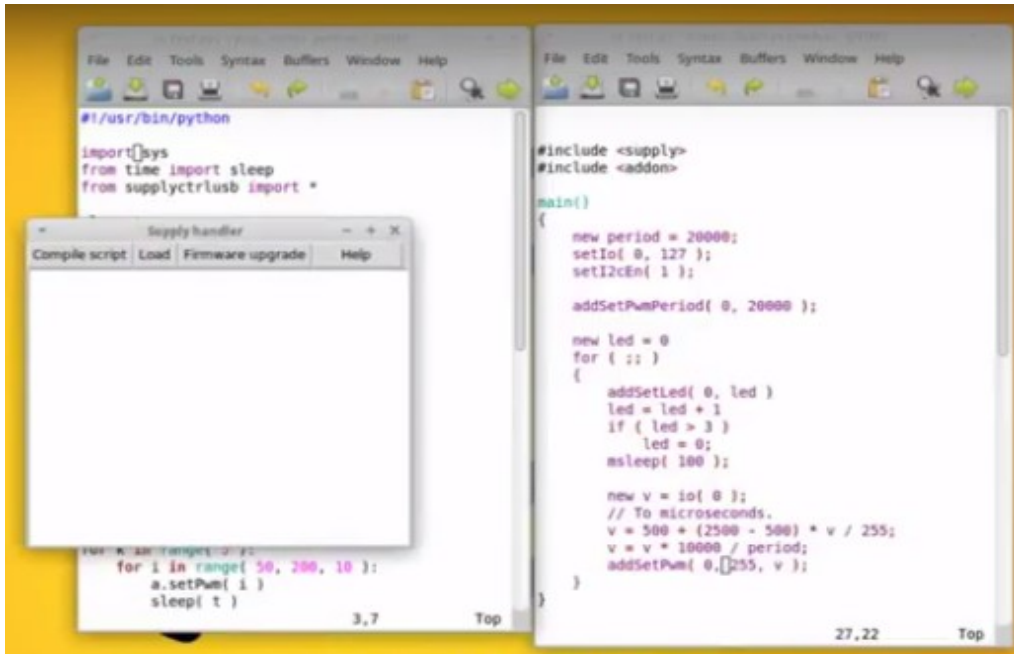# Prototyping boards set for Raspberry Pi extension.

- Two extension boards with motor drivers, PWM, IO pin arrays.

- Main board with adjustable Puck, Boost converters, USART, SPI, I2C, USB interfaces.
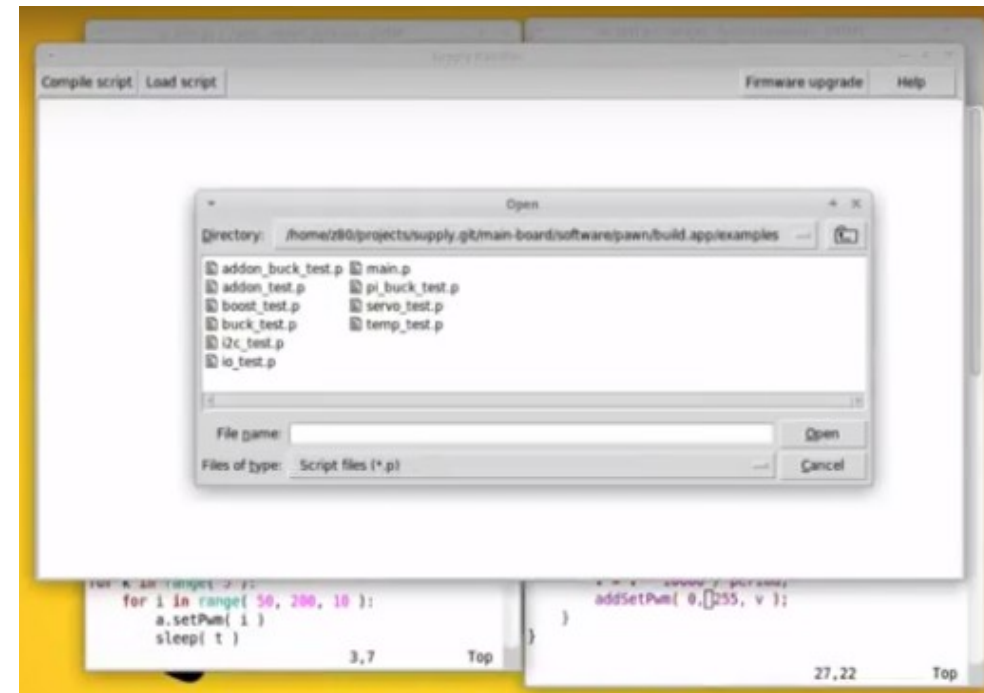
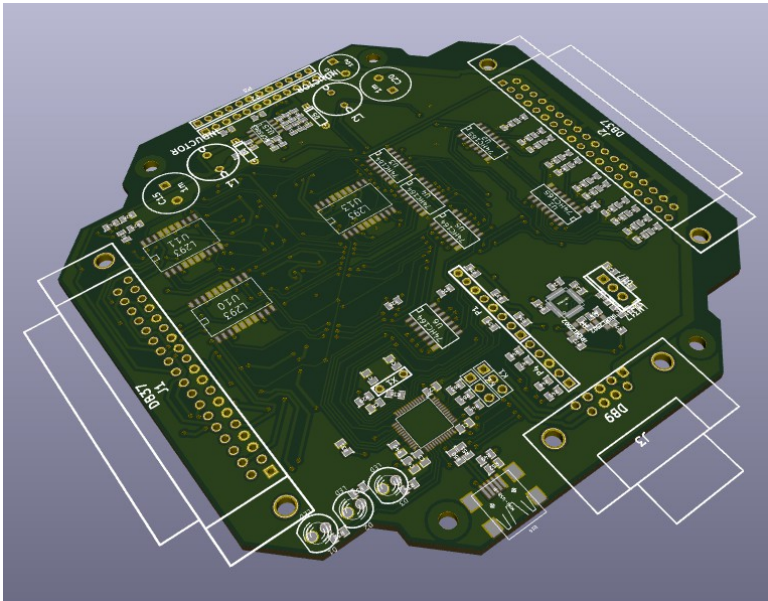# Prototyping boards set for Raspberry Pi extension.
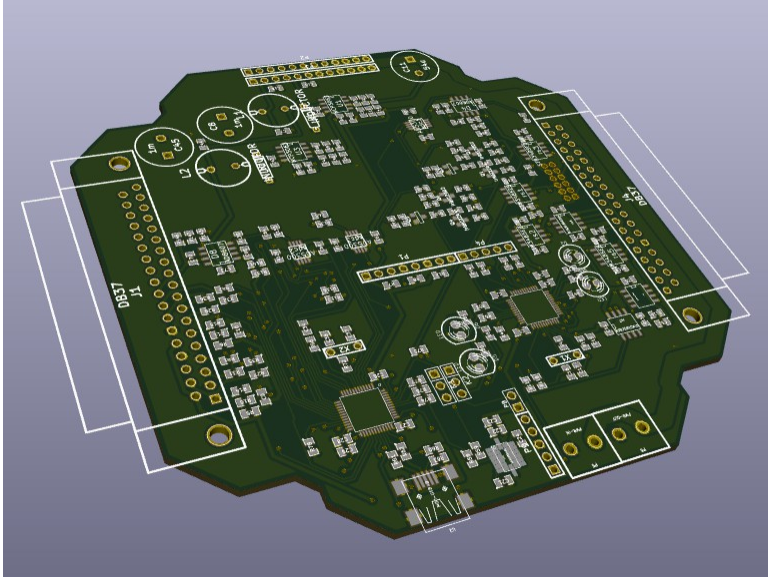

- **Python** and **Pawn** scripts examples side by side.

- New embedded script flashing dialog.

# Scalable controller for pneumatic mechanism.

- The goal was to design cheap controller for a few mechanisms driven by pneumatic valves and electric motors.

- Minimize parts cost and PCB tooling cost.

- Number of controllers was small.

- Number of elements to control was not fixed and was relatively large ~150-200.

Scalable controller for pneumatic mechanism.
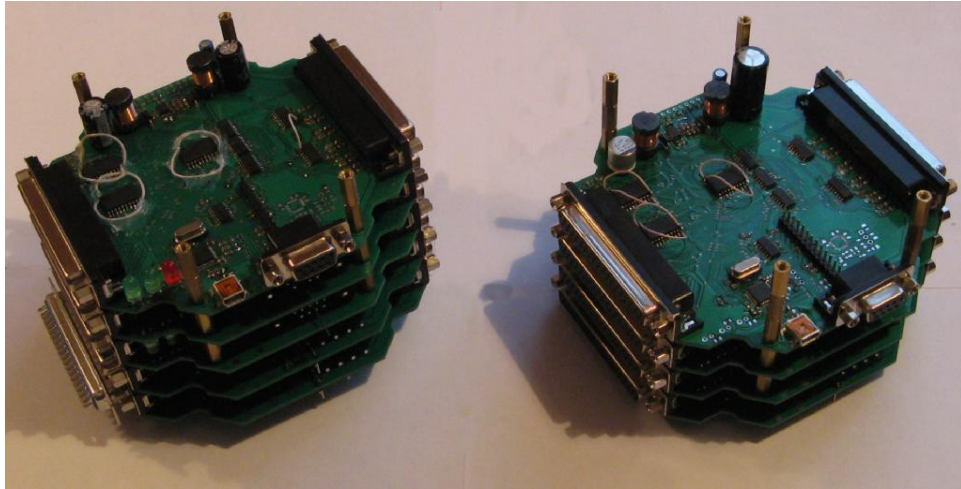
- Taking into account all possible combinations of pneumatic actuators, motors and sensors in all mechanism configurations

- it turned out that *"optimal"* numbers of different PCB types was 2.

- Boards are interconnected by *power* lines, common *I2C* bus and 2 *digital* lines for synchronous triggering.

- External communication was performed by either *I2C* or *USB* by single board computer running Linux OS.

- During debugging stage also was equipped by embedded *Pawn* machine for easy movement algorithms trying/implementing.
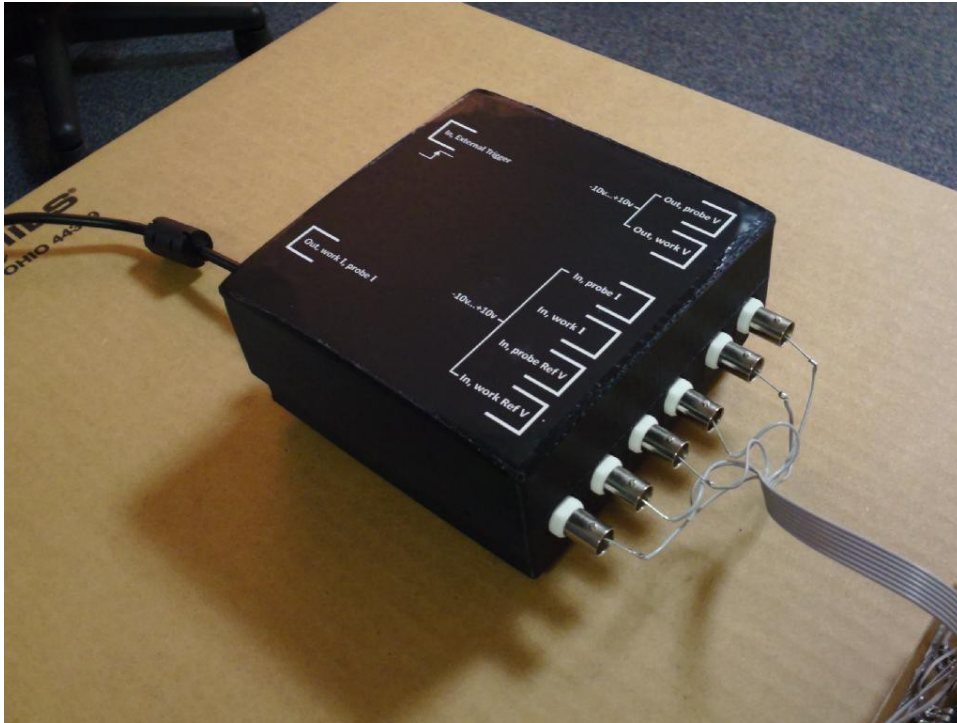
3rd party bipotentiostat control module.
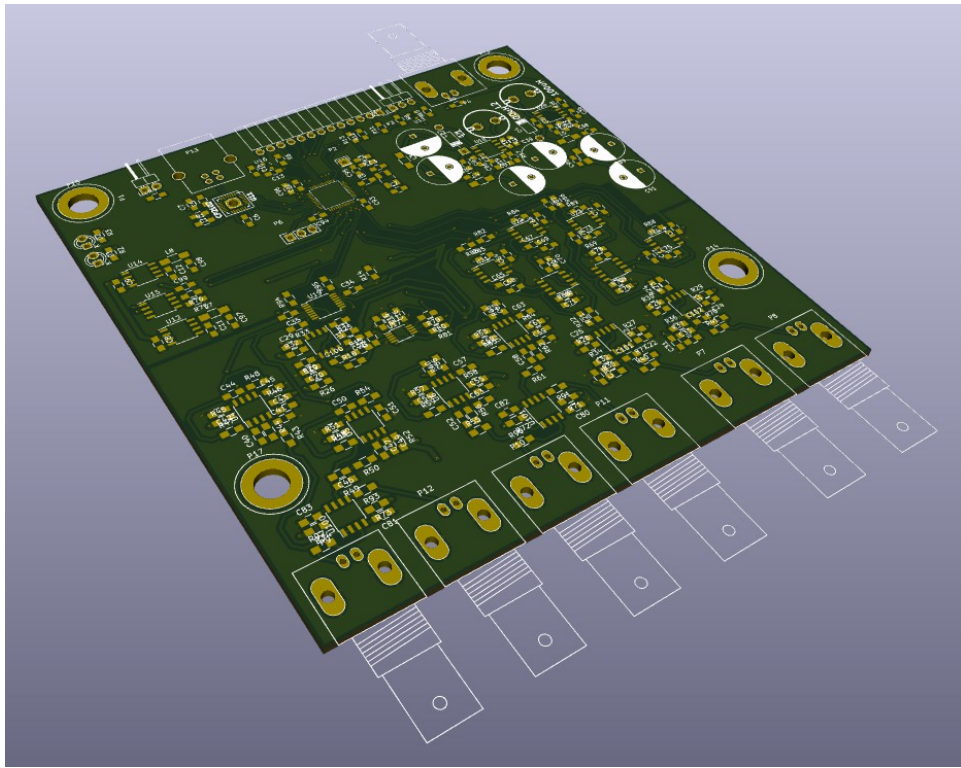
- 2 analog outputs +/-10V
- 4 analog inputs +/-10V
- External digital trigger
- One switchable analog output
- Analog precision to achieve 1mV
- USB computer interface
- Spend minimum resources as client had no extra money to finance the development.

3rd party bipotentiostat control module.

- Mostly used 5% or 1% resistors

- Built in *mcp3063* based *boost* and *inverting 5V* to *12V* switching sources.

- On board *temperature sensor* for calibration purposes.

- Calibration stand was equipped with potentiometers and a heater under near the device for statistical data acquisition

3rd party bipotentiostat control module.
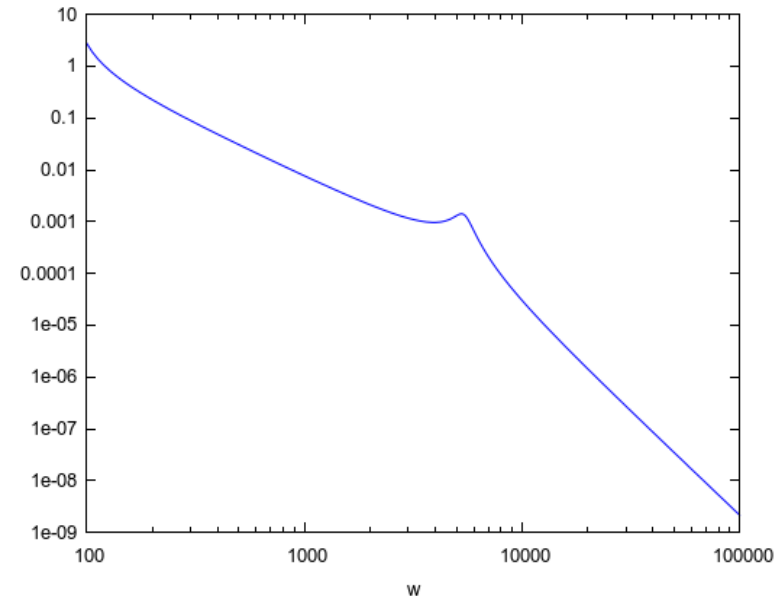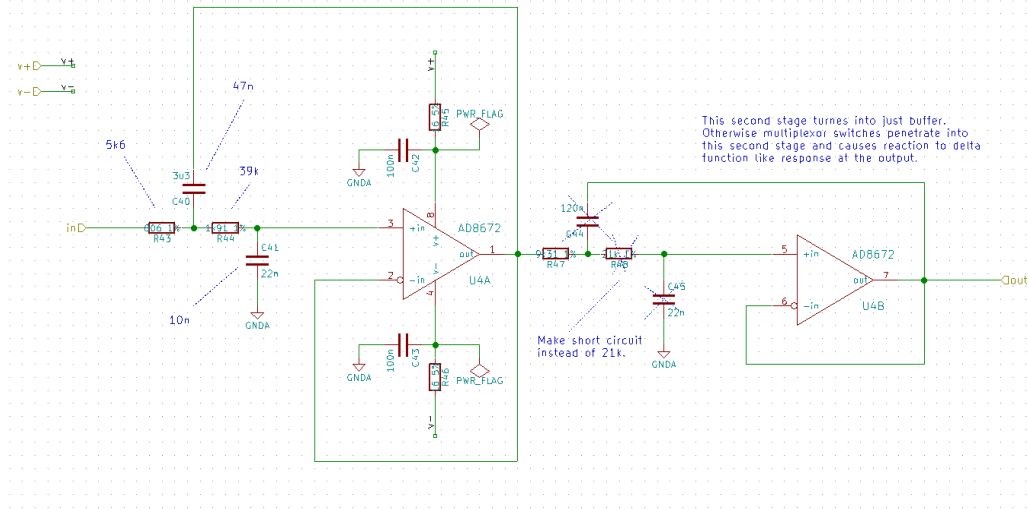
- Input filter design and Bode plot.
- Based on Chebyshev filter but with lowered response near cutoff requency to reduce oscillations caused by step response.

3rd party bipotentiostat control module.
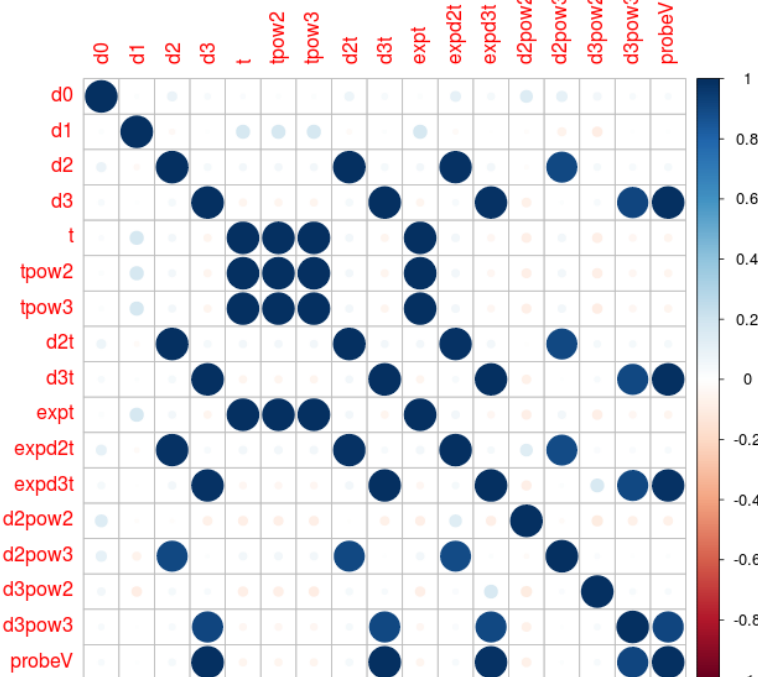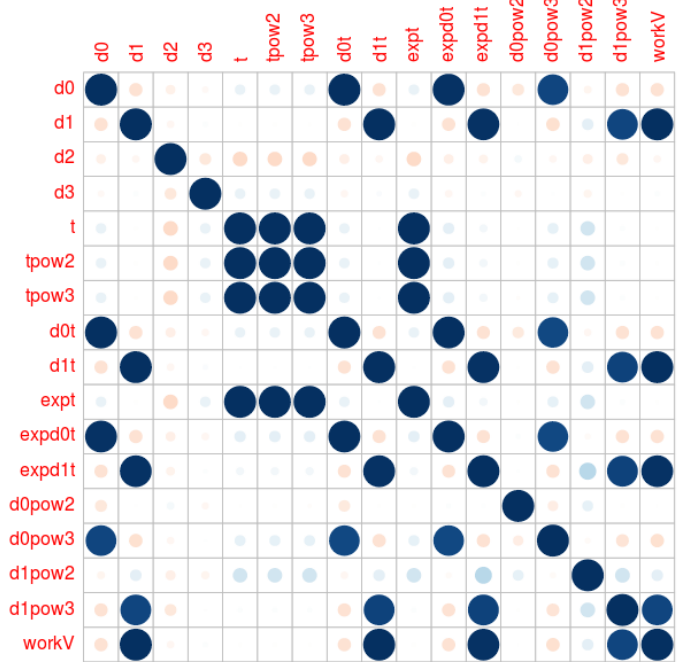
- Examples of parameters and outputs cross correlations

- After gaining statistical data went to higher dimensional space by involving first few powers of each parameter, exponentiation and a few parameter products.

- Used this data set to find the best mean out of sample error by applying linear regression to all possible parameter combinations.

- Obtained formulas and dropped parameters which didn't improve match better then chosen margin (1^{-5})
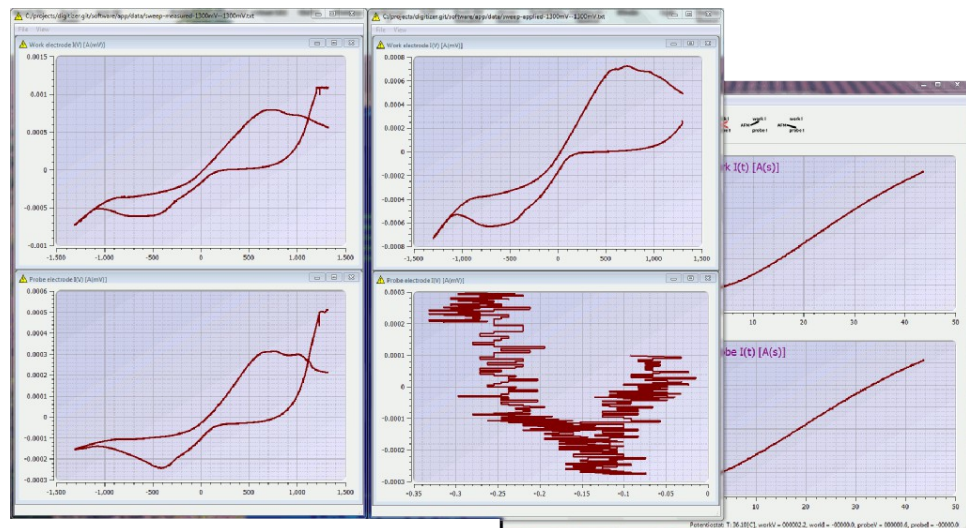
3rd party bipotentiostat control module.

- Formulas obtained for data readings conversion

$$V_{out} = a_1 * dac_1 + a_2 * dac_2 + a_3 * dac_1 * T + a_4 * dac_2 * T + a_5 * T^3 + a_6$$

$$V_{in} = a_1 * adc + a_2 * T + a_3 * T^2 + a_4 * T^3 + a_5$$

3rd party bipotentiostat control module.

- PC based software for driving control module.

- Just nice looking electrochemical cycling I(V) curve obtained during system testing.