RoboSim

FRC Team 1736 Robot Casserole

Overview

- What:
  - A flexible platform to simulate FRC robot hardware components
  - A tool to increase development speed, test coverage, code and electrical robustness
  - A platform for teaching concepts such as Plant Models, Design-For-Test, C coding, Digital Logic, Analog-Digital conversion, low-level embedded coding.

Overview

- Why
  - Historically, electrical and software validation has been slowed due to lack of hardware to use for test
    - Mistakes can also be costly as mechanical components are damaged by errors in SW or wiring.
    - Mass permutation and regression testing is not feasible
    - Importance of testing has not been addressed.

Overview

- How
  - Core real-time plant model running on Arduino Uno
    - Modularized SW for stable HW interface code with easy-to-modify plant model
  - Visualization through connected PC
    - Python-based GUI
  - Custom-built interface electronics to replicate CIM motors, encoders, analog sensors, limit switches, etc.

Design Philosophy

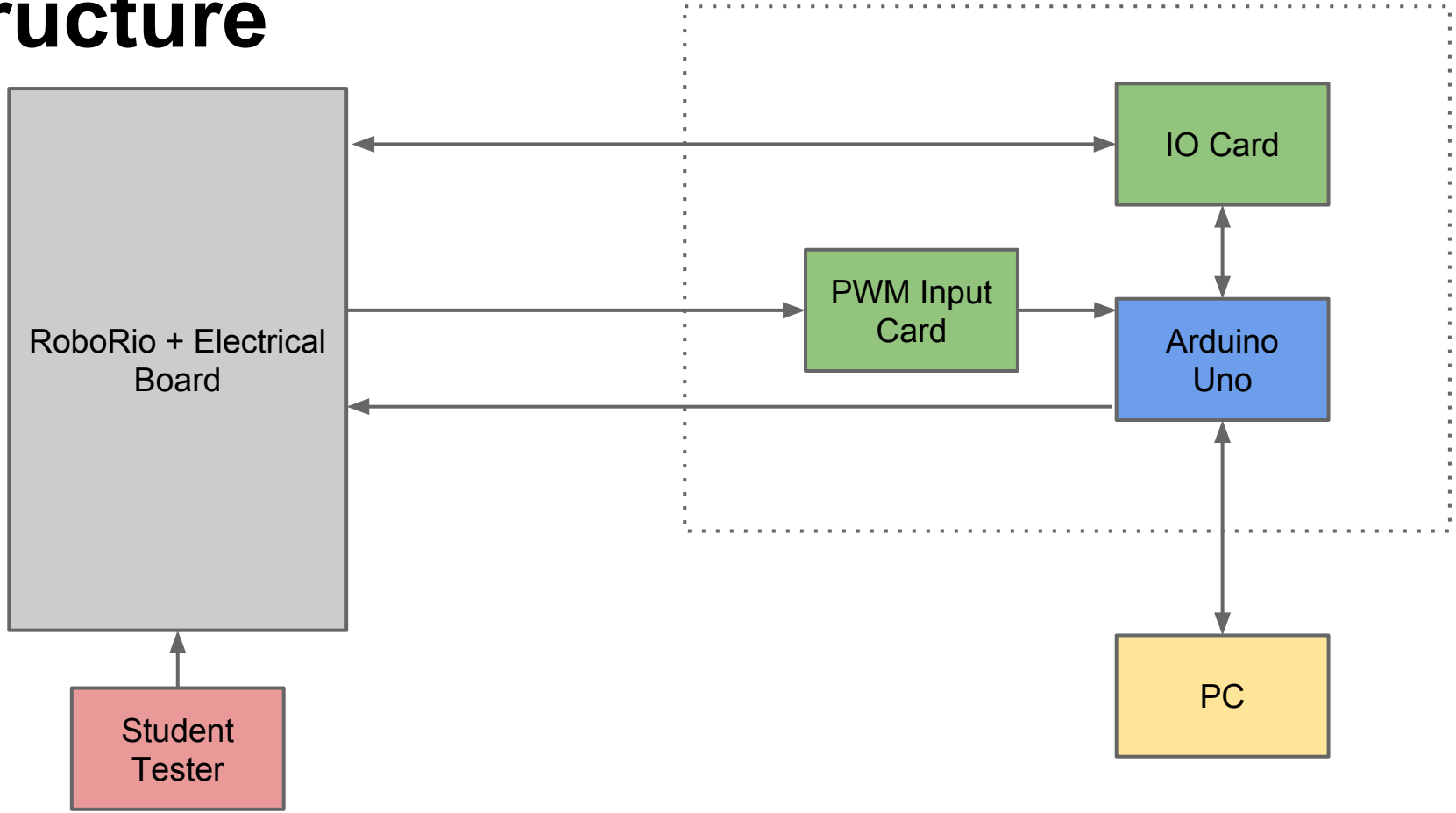
- Simulate Motors, Mechanical linkages & mechanisms, and sensor feedback only
  - Input is voltage from motor controllers, output is simulated response of sensors and visualization
  - Agnostic to electronics hardware technology
  - Zero intrusion into electrical or SW design
  - 100% of SW which impacts control can be tested

Software Technologies Involved

- Arduino
  - Embedded C & C++
- Python
- Git
- Future potential for Matlab/Simulink or Dynasty integration

MathWorks®

Structure


RoboRio + Electrical Board
IO Card
PWM Input Card
Arduino Uno
PC
Student Tester

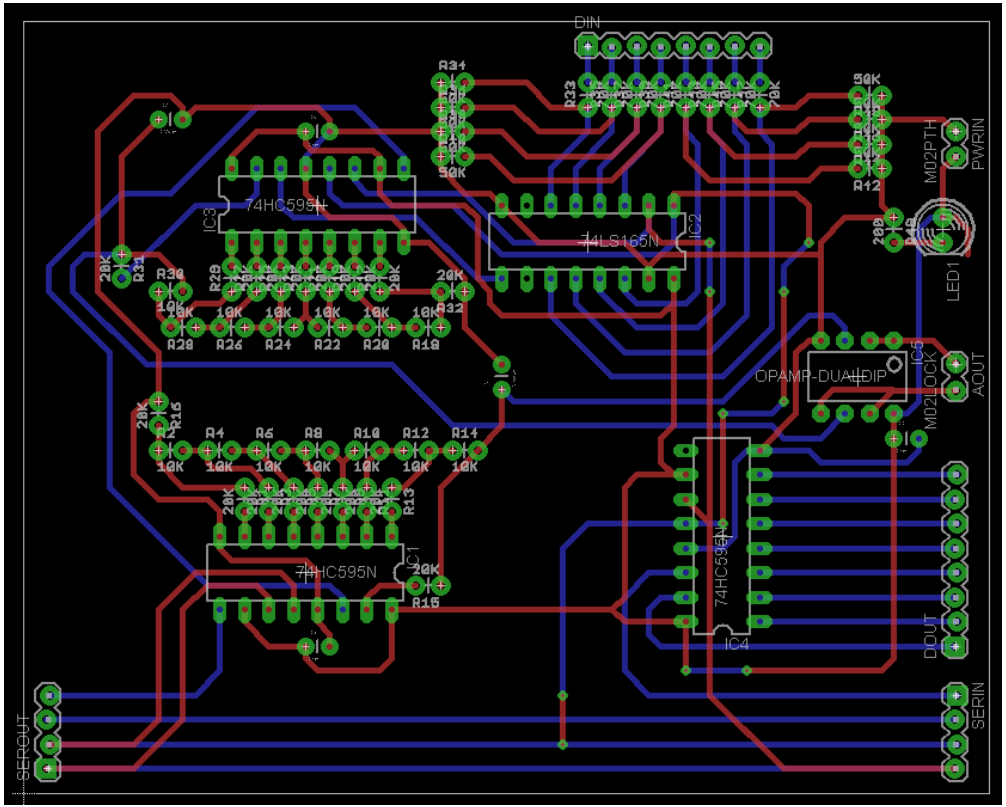
Initial Spec for IO Capabilities

- 6 Motor Inputs (analog)
  - Filtered by PWM Card, read by Arduino
- 8 Solenoid Inputs (digital)
  - Read by IO card
- 8 Limit Switch Outputs (digital)
  - Produced by IO Card
- 2 Analog Sensor Outputs
  - R-R2 ladder DAC on IO Card, 0-5V
- 4 Quadrature Encoder Outputs
  - Emulated in SW by Arduino

Initial Spec for SW Capabilities

- 100ms Main plant model loop
  - Processor load metric generated
- Serial port broadcast of state
  - User defined update rate and message contents
- Interrupt-based emulation of Encoders onboard
- Isolated HW interfacing and Plant model code
  - Plant custom to year, while HW interfacing stays constant

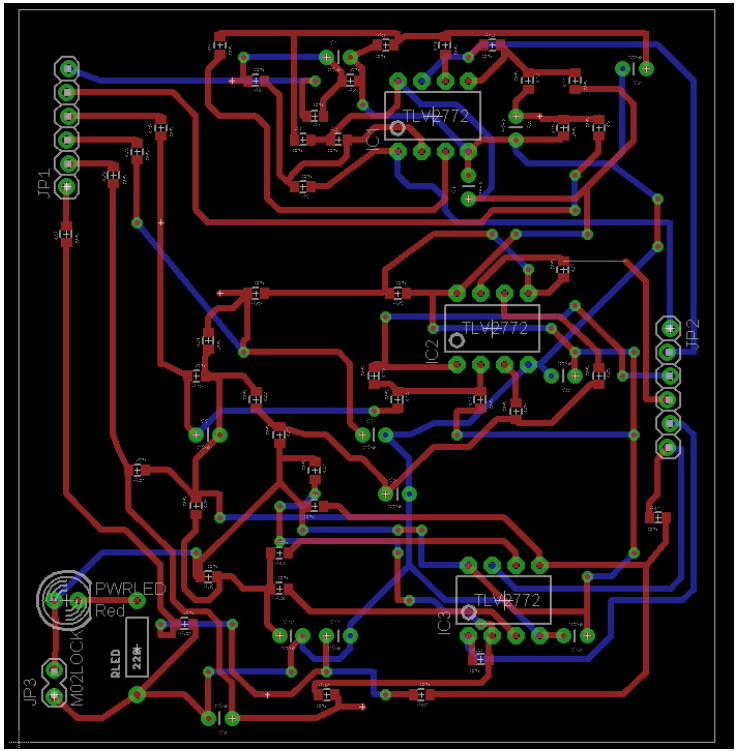
IO Board


DIN
74HC595N
74LS165N
OPAMP-DUALDIP
74HC595N
74HC595N
M02PTH
PWRIN
LED1
M02CLOCK
AOUT
DOUT
SERIN
SEROUT

IO Board - Description

- Eight Digital Inputs
- Eight Digital Outputs
- Two Analog Outputs
- Serial/Clock/Sync interface with Arduino
- Can stack an arbitrary number of boards to increase IO

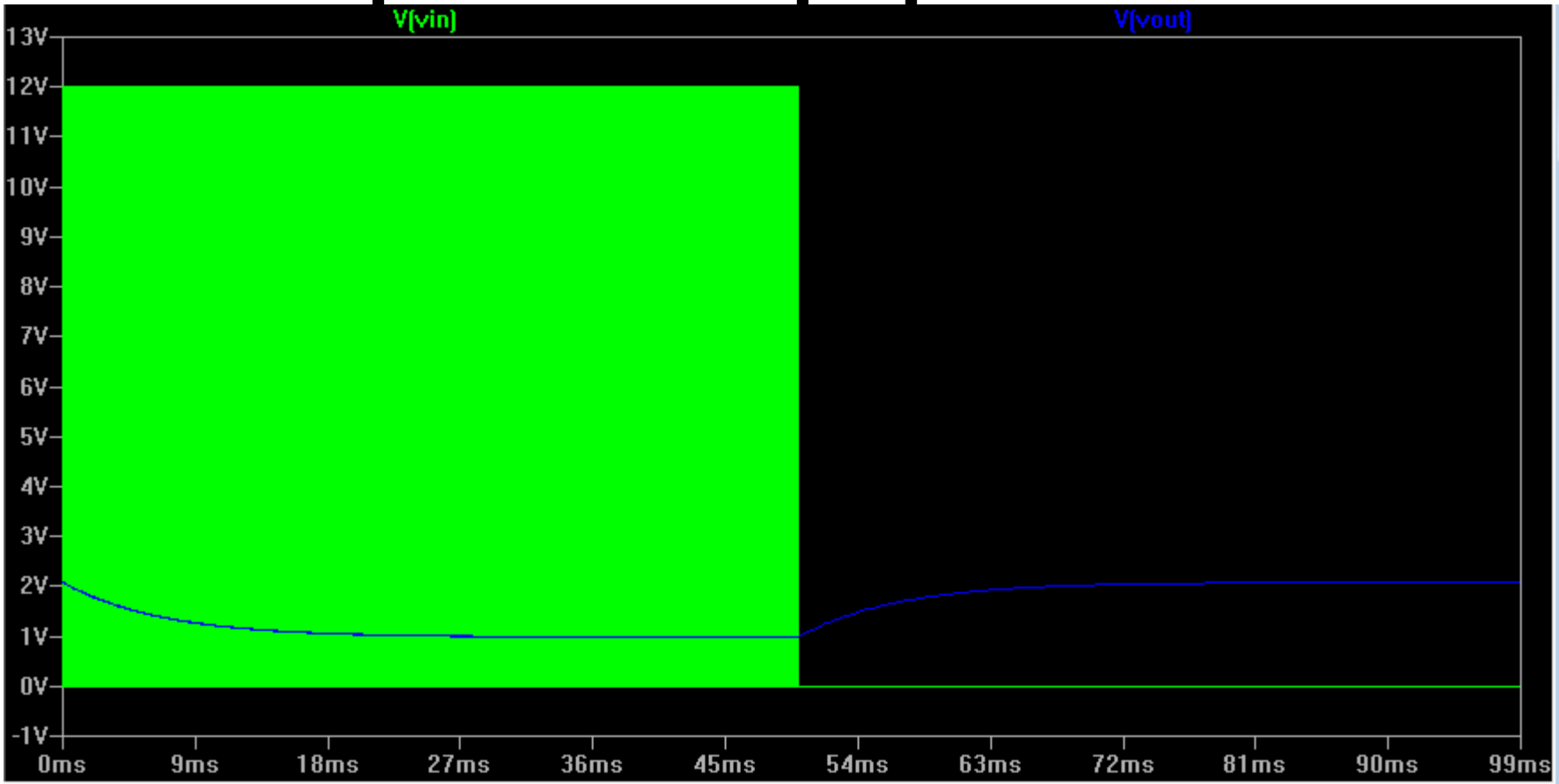
PWM Input Card



PWM Input Card - Description

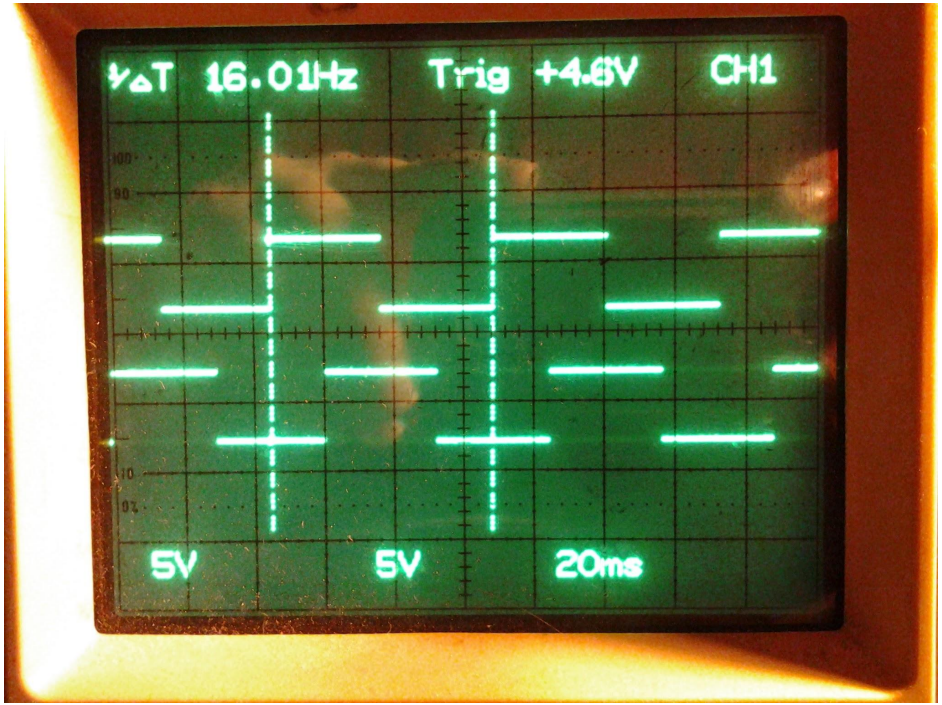
- Six Low-Pass Filter and Offset Units
- Converts PWM output from any Motor Controller into 0-5V signal readable by Arduino Analog Inputs
- One card for Arduino Uno

PWM Input Card - pSpice Simulation



PWM Input Card - pSpice Simulation

Quadrature Encoder Emulation



Initial Cost Estimates

- Arduino Uno - $30.00 New
  - Can use existing
- 1 IO Card + 1 PWM Card = $58.68
  - No spare parts included in cost
  - Can possibly source some parts from Cat B-Stock

Community

- Prototype source code is already available
  - https://github.com/RobotCasserole1736/RoboSim
- All designs will be open source
  - Software (Arduino and PC)
  - Hardware (Schematics, BOM, PCB designs)
  - Documentation

Future Expandability

- Design and validate plant models in Matlab, run generated code on Arduino
- Use larger Arduino with more Analog or Digital IO
- Controllable electronic loads to simulate motors in various operating conditions
- GPIB control of power supply to simulate battery voltage fluctuation with load
- Hardware-based Encoder Emulation
- More-robust electrical fault protection
- Automated regression testing routines