Test Stand Question: Can we find the thrust and torque constants for a particular motor?

To fly a quadrotor aircraft autonomously we need to be able to calculate the thrust and torque that each motor is producing.

$$K_T = \frac{T}{\rho n^2 D^4}$$

$$K_Q = \frac{Q}{\rho n^2 D^5}$$

Where

$T = Thrust$

$Q = Torque$

$K_T = Thrust\ Constant$

$K_Q = Torque\ Constant$

$\rho = Air\ Density$

$n = Rotation\ Speed$

$D = Rotor\ Diameter$

Tests with no load:

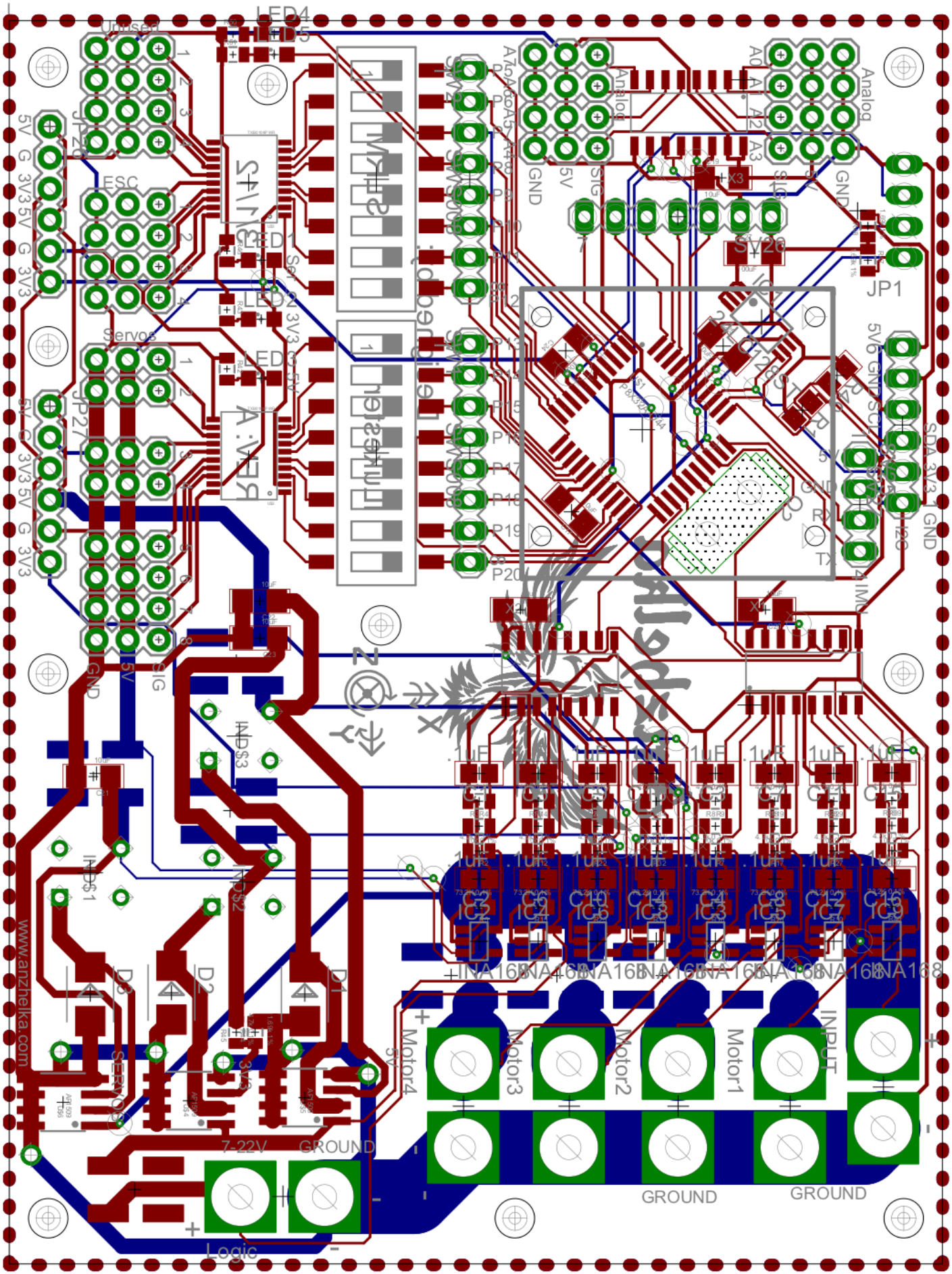
Thrust: the force with which the motor pulls

Torque: the force with which the motor tries to spin whatever it is attached to.

Measuring Thrust

The frame is in an **L** shape, with the motor mounted at the long end of the **L**. As the motor pulls on it's mounting it creates a torque in the L. This is then transmitted to the base, where there is a pressure sensor. This sensor can directly read the motor force.

By building a suitable test stand we should be able to measure the thrust, torque, and RPM of each motor as it is running. Combined with the constants of rotor diameter and air density, we can calculate the K_T and K_Q constants. These constants are specific to each motor and don't change.


LED4
LED5
Unused
JP26
ESC
LED1
LED2
LED3
Servos
JP27
5V G 3V3
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5V G 3V3
Analog
A0 A1 A2 A3
GND 5V SIG
SV26
JP1
5V6 GND SCL SDA 3V3 GND
P0 P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P20
RX TX
IMU
SDA 3V3 GND
SIG 5V GND
IND$1
IND$2
IND$3
D1
D2
D3
SERVO 5V
7-22V
GROUND
Logic
Motor4
Motor3
Motor2
Motor1
INPUT
GROUND
GROUND
INA168
www.anzhelka.com

Measuring Torque

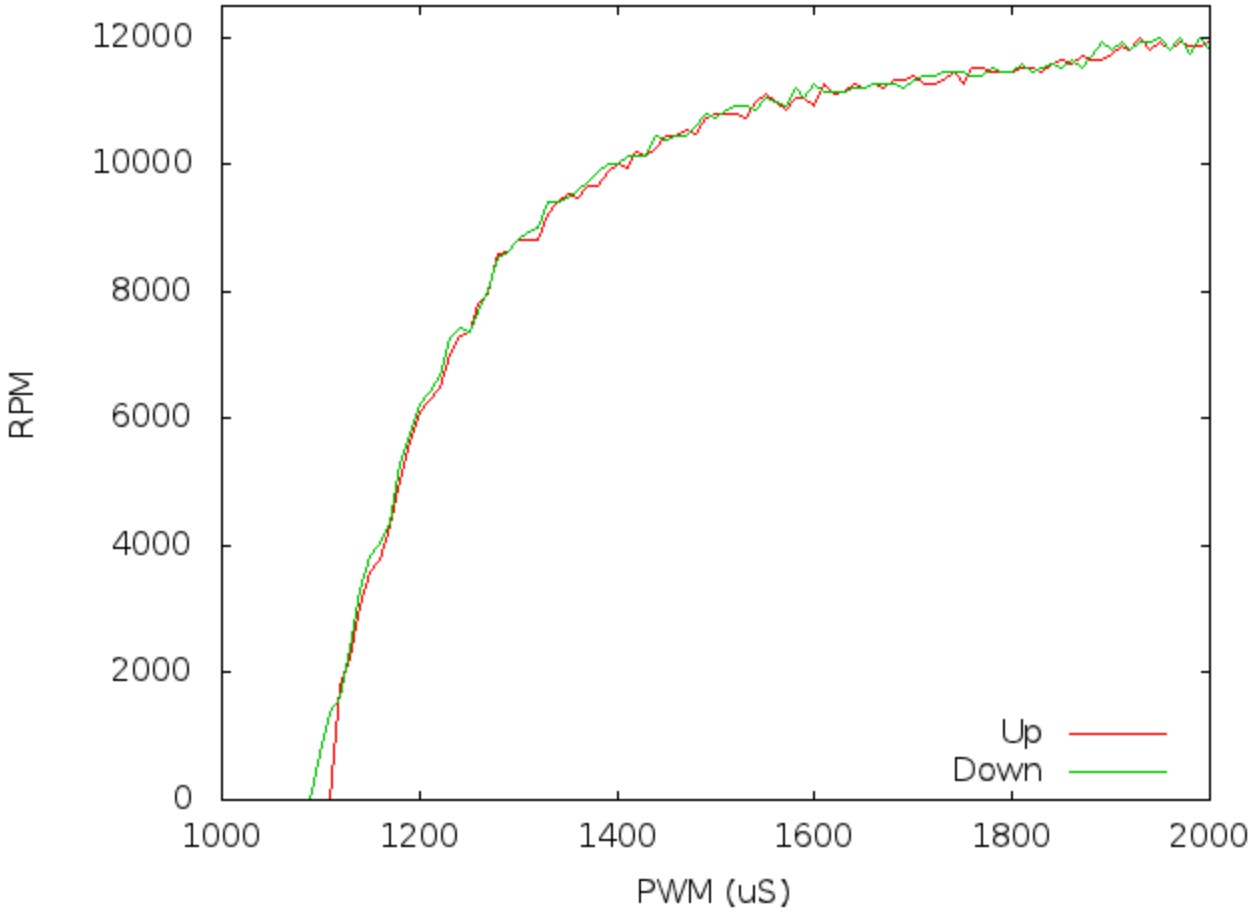
The motor is mounted to a shaft that is aligned with the motor shaft. The mounting shaft has a lever arm attached that presses down due to the motor torque. This lever arm then presses on a pressure sensor, and the torque can then be calculated.

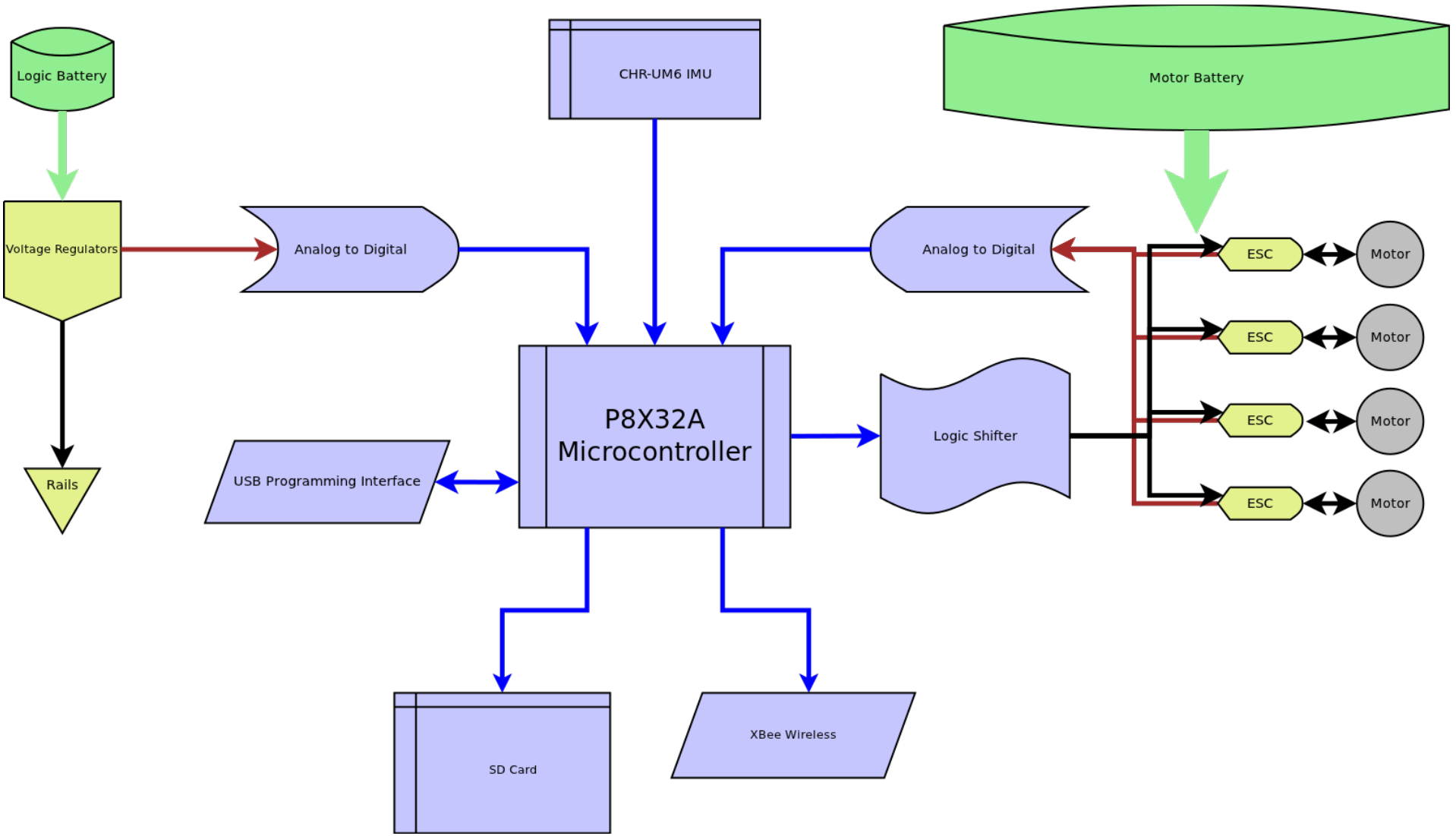
System Components

Pressure Sensors: two FlexiForce pressure sensors. These sensors vary resistance in proportion to the pressure on the sensing surface.

Eagle Tree Brushless RPM Sensor: These sensors read the control pulses sent to the motor and generate PWM signal representing RPM.

INA169 and Voltage Divider: This chip measures the current drawn by the motor, and the voltage divider measures the motor input voltage.


12000
10000
8000
6000
4000
2000
0
RPM
1000
1200
1400
1600
1800
2000
PWM (uS)
Up
Down


Logic Battery
CHR-UM6 IMU
Motor Battery
Voltage Regulators
Analog to Digital
Analog to Digital
ESC
Motor
ESC
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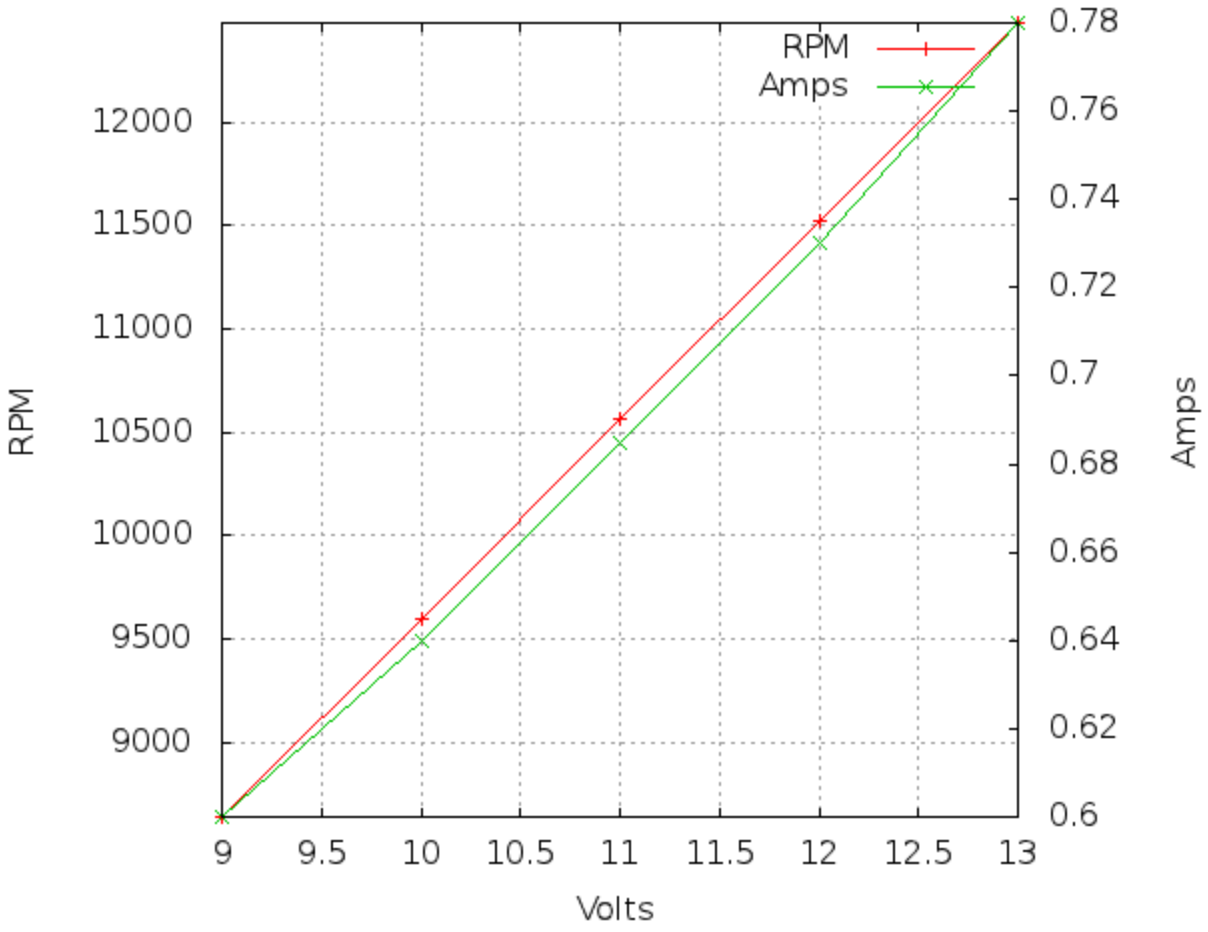
Motor
P8X32A
Microcontroller
Logic Shifter
Rails
USB Programming Interface
SD Card
XBee Wireless


RPM
Amps
12000
11500
11000
10500
10000
9500
9000
0.78
0.76
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.6
9
9.5
10
10.5
11
11.5
12
12.5
13
Volts
RPM
Amps

About Us

This project is being developed by Luke De Ruyter and Cody Lewis, both from the University of California, Riverside. Building an autonomous quadrotor is their senior capstone engineering project.

Resources

http://blog.anzhelka.com/

http://code.anzhelka.com/

The Project

We are working on developing an open source Propeller based autonomous quadrotor. The project is being developed from the ground up. We have built or are building all of the hardware and software necessary to achieve stable flight.

The PCB

The PCB has been custom designed to support all of the features needed to fly. It features a Propeller microcontroller, logic rail buck regulators, 24 channels of ADC, 24 channels of 5v to 3.3v level shifting, voltage and current sensing for motors and logic rails, mounting holes for SD card, IMU, Quickstart, and BoE formfactor.

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Workshop: Elmar Palma

Anzhelka