HW2 Optical Tachometer

Johns Hopkins University

Real Time Software for Embedded Systems

Fall 2014

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Requirements

Hardware

- There shall be an IR led emitter and detector circuit
- There shall be a motor that is spun via electronic speed control (ESC)
- An Arduino board shall control the circuits
- External battery supply shall be used for the motor
- Blades shall be attached to the motor and pass through the emitter/detector pair

Software

- The software running on the Arduino shall use function queue scheduling design
- The software shall capture the rotations per minute (RPM) every second
- The software shall accept serial commands to control the ESC

Test

- The test shall issue various serial commands to the ESC to vary the speed of the blades
- The blades shall be attached to the motor and pass through the emitter/detector pair

Parts List

- (1) Arduino Uno
- (1) 10k resistor
- (1) 220 ohm resistor
- (1) spool of hobby wire
- (1) USB 2.0 A/B cable
- (1) breadboard
- (1) 12v battery
- (1) LED of any color
- (1) Infrared Emitter and Detector (Radio shack 276-142)
- (1) Turnigy Multistar 30 Amp Multi-rotor Brushless ESC 2-4S
- (1) Gemfan 9x4.7 Nylon Prop Set (1x CW & 1x CCW)
- (1) Turnigy Multistar ESC Programming Card
- Wood to hold motor and emitter/detector
- Nails
- Twist ties
- Black electrical tape

Required Software

- Arduino Sketch v1.0
- Microsoft Excel 2010

Architecture

Hardware

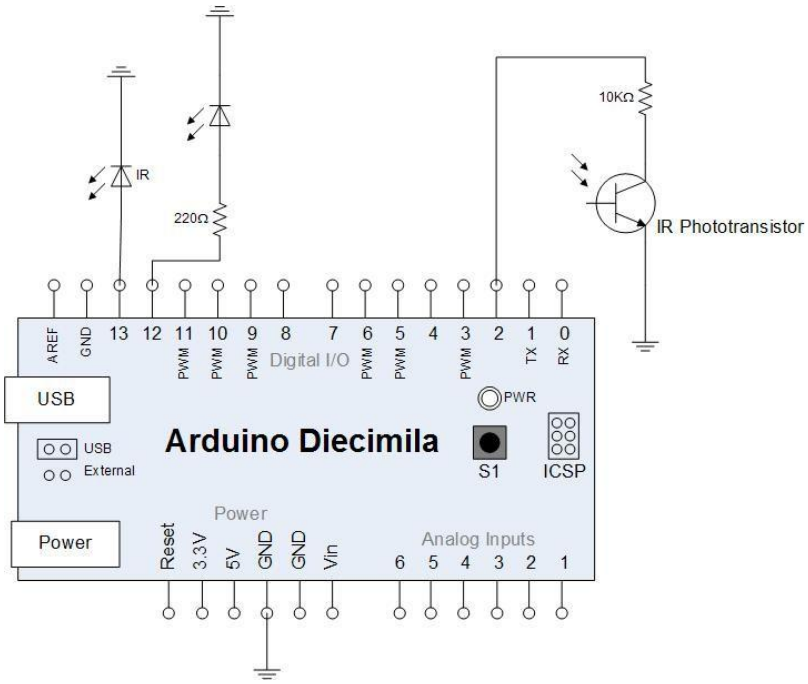


Figure 1 - Circuit Schematic [1]

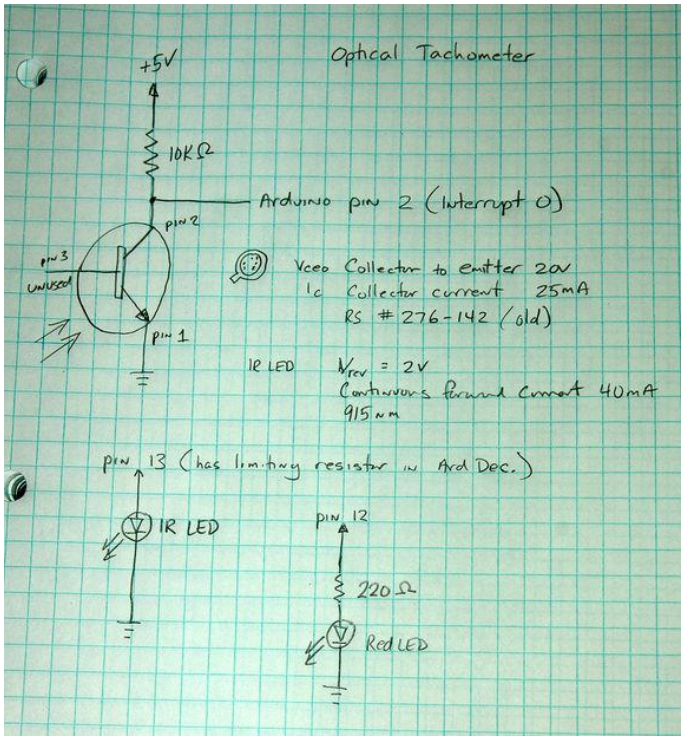


Figure 2 – Schematic Notes [1]

Figure 3 – Emitter Detector Sensors

Software

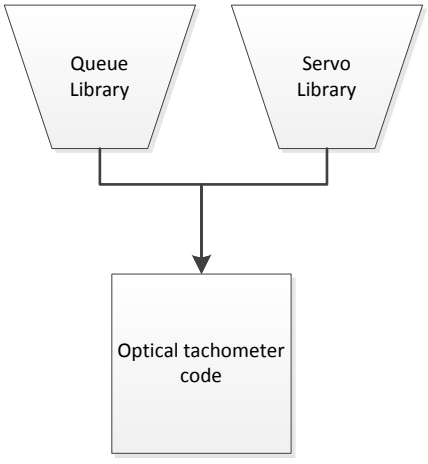


Figure 4 - Software Architecture Diagram

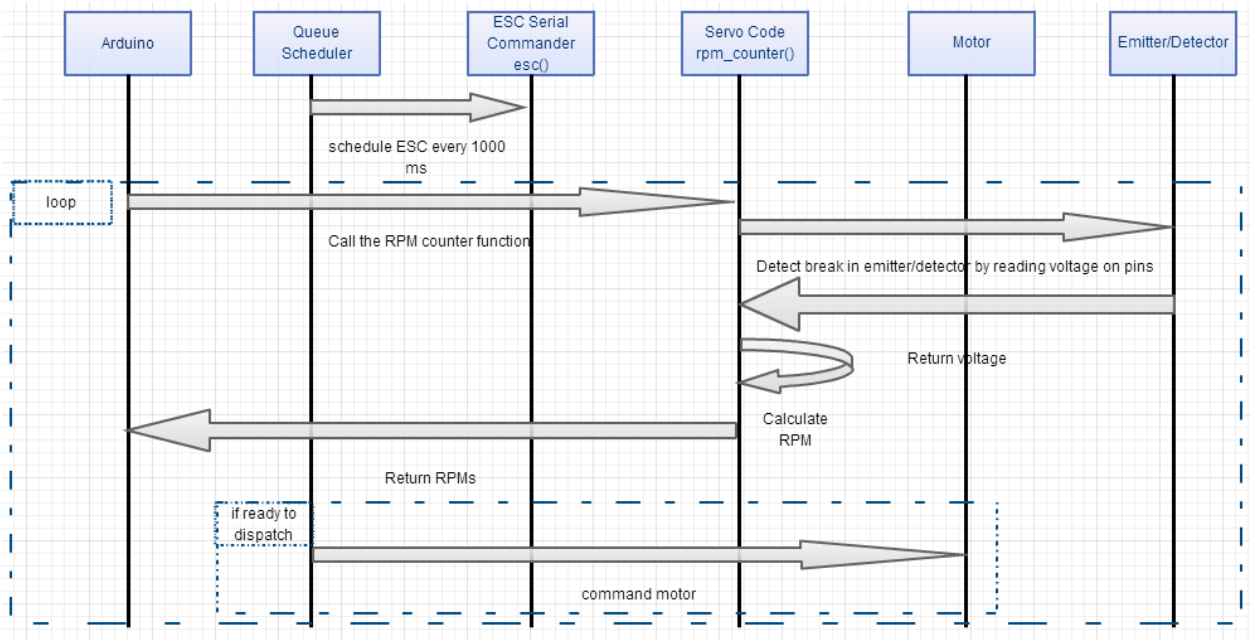
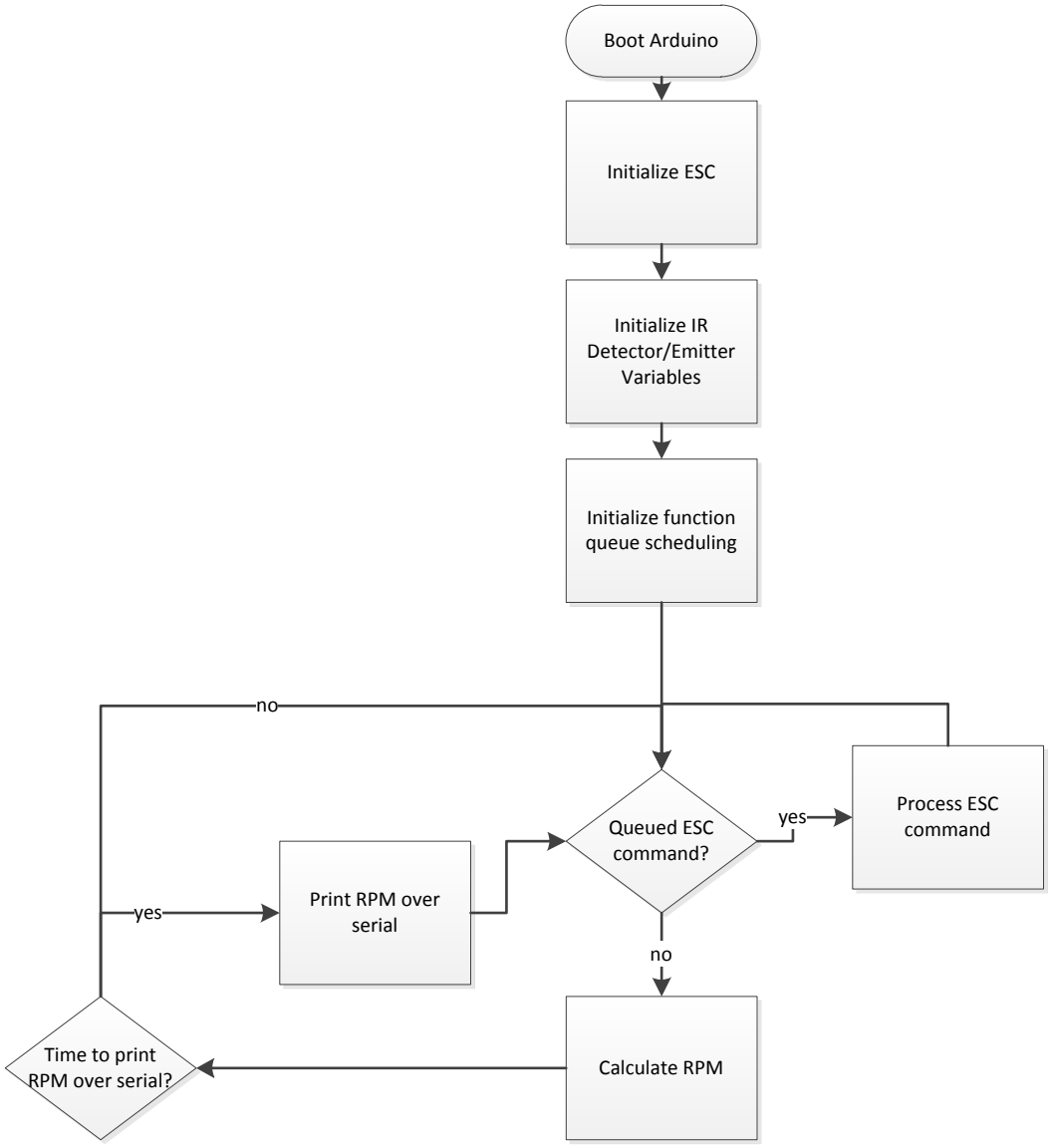


Figure 5 - Hardware/Software Sequence Diagram

Design

Software



Photos of the Hardware

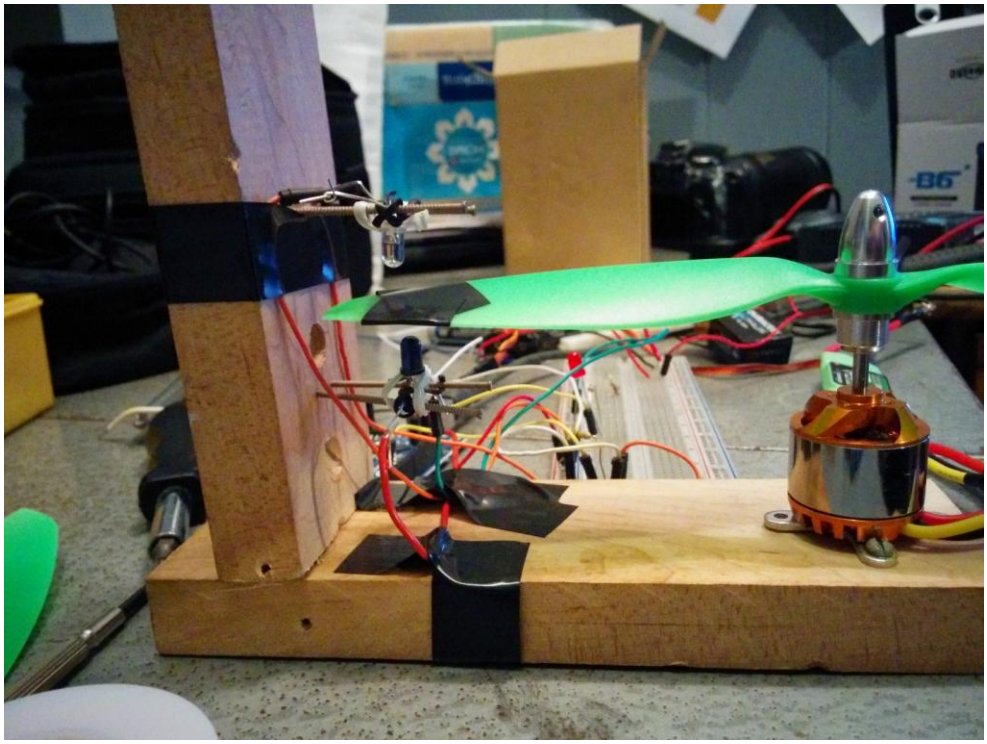


Figure 6 – Side View of the Test Setup

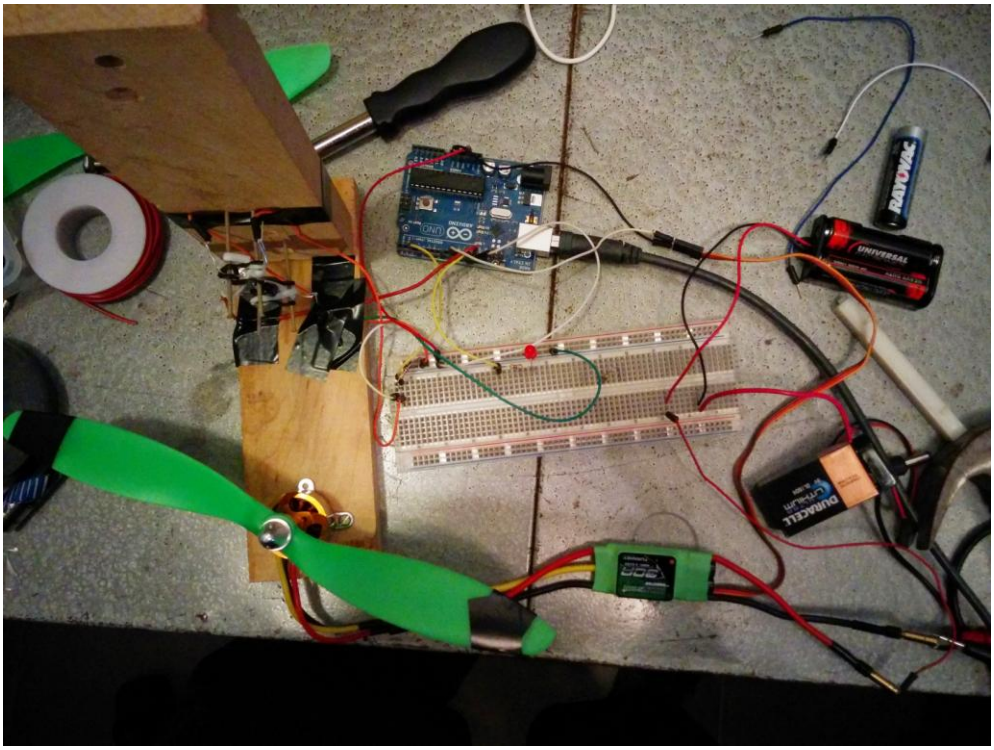


Figure 7 - Top View of the Test Setu

Implementation

```
#include <Queue.h>
#include <Servo.h>

//JHU RTSW HW 2 - Optical Tachometer
//Tony Florida
//2014-09-24
//References:
// http://www.instructables.com/id/Arduino-Based-Optical-Tachometer/
// http://techvalleyprojects.blogspot.com/2012/06/arduino-control-
escmotor-tutorial.html
// https://github.com/Zuph/AVRQueue

//ESC variables
// This is our motor.
Servo myMotor;
// This is the final output
// written to the motor.
String incomingString;

//IR Emitter Detector variables
int ledPin = 13;                // IR LED connected to digital pin 13
int statusPin = 12;             // LED connected to digital pin 12
volatile byte rpmcount;
volatile int status;
unsigned int rpm;
unsigned long timeold;

//IR Emitter Detector function
void rpm_fun()
{
   //Each rotation, this interrupt function is run twice, so take that
into consideration for
   //calculating RPM
   //Update count
      rpmcount++;

   //Toggle status LED
   if (status == LOW) {
     status = HIGH;
   } else {
     status = LOW;
   }
   digitalWrite(statusPin, status);
}

void setup() {
    // Required for I/O from Serial monitor
    Serial.begin(9600);
```

```
    //ESC setup
    Serial.println("Initializing ESC");
    // Put the motor to Arduino pin #9
    myMotor.attach(9);

    //IR Emitter Detector setup
    //Interrupt 0 is digital pin 2, so that is where the IR detector
is connected
    //Triggers on FALLING (change from HIGH to LOW)
    attachInterrupt(0, rpm_fun, FALLING);
    //Turn on IR LED
    pinMode(ledPin, OUTPUT);
    digitalWrite(ledPin, HIGH);
    //Use statusPin to flash along with interrupts
    pinMode(statusPin, OUTPUT);
    rpmcount = 0;
    rpm = 0;
    timeold = 0;
    status = LOW;

    //Function queue scheduling setup
    Serial.println("Initializing function queue scheduling");
    Queue myQueue;
    myQueue.scheduleFunction(esc, "ESC", 5000, 1000);

    while(1) {
        myQueue.Run(millis());
        rpm_counter();
    }
}

//Receive ESC commands via serial
int esc(unsigned long now)
{
  // If there is incoming value
  if(Serial.available() > 0)
  {
    // read the value
    char ch = Serial.read();

    /*
    *  If ch isn't a newline
    *  (linefeed) character,
    *  we will add the character
    *  to the incomingString
    */
    if (ch != 10){
      // Print out the value received
      // so that we can see what is
      // happening
      //Serial.print("I have received: ");
      //Serial.print(ch, DEC);
```

```
      //Serial.print('\n');

      // Add the character to
      // the incomingString
      incomingString += ch;
    }
    // received a newline (linefeed) character
    // this means we are done making a string
    else
    {
      // print the incoming string
      //Serial.println("I am printing the entire string");
      //Serial.println(incomingString);

      // Convert the string to an integer
      int val = incomingString.toInt();

      // print the integer
      //Serial.println("Printing the value: ");
      //Serial.println(val);

      /*
      *  We only want to write an integer between
      *  0 and 180 to the motor.
      */
      if (val > -1 && val < 181)
      {
       // Print confirmation that the
       // value is between 0 and 180
       //Serial.println("Value is between 0 and 180");
       // Write to Servo
       myMotor.write(val);
      }
      // The value is not between 0 and 180.
      // We do not want write this value to
      // the motor.
      else
      {
       //Serial.println("Value is NOT between 0 and 180");

       // IT'S a TRAP!
       //Serial.println("Error with the input");
      } //0 to 180

      // Reset the value of the incomingString
      incomingString = "";
    } //ch not 10
  }
}

//Count RPMs
void rpm_counter()
```

```
 {
   //Update RPM every second
   delay(1000);
   //Don't process interrupts during calculations
   detachInterrupt(0);
   //Note that this would be 60*1000/(millis() - timeold)*rpmcount if
the interrupt
   //happened once per revolution instead of twice. Other multiples
could be used
   //for multi-bladed propellers or fans
   rpm = 30*1000/(millis() - timeold)*rpmcount;
   timeold = millis();
   rpmcount = 0;

   //Write it out to serial port
   Serial.print(millis());
   Serial.print(" ");
   Serial.println(rpm,DEC);

   //Restart the interrupt processing
   attachInterrupt(0, rpm_fun, FALLING);
}

//not using the loop in this program
void loop() {
}
```

Results

Log

1000 0	20009 0	39020 0	58031 0	77041 0	96052 0
2000 0	21010 0	40020 0	59031 0	78042 0	97052 0
3001 0	22011 0	41022 0	60032 0	79042 0	98053 0
4001 0	23012 0	42022 0	61032 0	80043 0	99053 0
5002 0	24012 0	43023 0	62032 0	81043 0	100054 0
6002 0	25013 0	44023 0	63033 0	82043 0	101054 0
7003 0	26013 0	45024 0	64034 0	83044 0	102054 0
8003 0	27014 0	46024 0	65035 0	84044 0	103055 0
9004 0	28014 0	47025 0	66035 0	85045 0	104055 0
10004 0	29015 0	48025 0	67036 0	86046 0	105057 0
11004 0	30015 0	49026 0	68036 0	87047 0	106057 0
12006 0	31016 0	50026 0	69037 0	88047 0	107058 0
13006 0	32017 0	51026 0	70037 0	89048 0	108058 0
14007 0	33017 0	52028 0	71037 0	90048 0	109059 0
15007 0	34018 0	53028 0	72038 0	91048 0	110059 0
16008 0	35018 0	54029 0	73038 0	92049 0	111059 0
17008 0	36019 0	55029 0	74039 0	93049 0	112061 0
18009 0	37019 0	56030 0	75040 0	94050 0	113061 0
19009 0	38020 0	57030 0	76041 0	95050 0	114062 0

115062 0
116063 0
117063 0
118064 0
119065 0
120066 0
121066 0
122066 0
123067 0
124067 0
125068 0
126069 0
127070 0
128070 0
129071 0
130071 0
131072 0
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133073 0
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180101 0
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188106 0
189107 0
190107 0
191108 0
192108 0
193108 0
194110 0
195110 0
196111 0
197111 870
198112 667
199113 540
200114 522
201114 510
202115 522
203115 510
204116 522
205117 493
206117 510
207118 493
208119 493
209120 493
210120 510
211121 493
212122 493
213123 493
214123 510
215123 540
216125 493
217125 510
218126 493
219126 510
220128 464
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224131 2436
225131 2520
226131 2490
227133 2378
228133 2460
229134 2349
230135 2349
231136 2349
232136 2400
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238141 2262
239141 2340
240143 2233
241143 2310
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243145 2310
244146 2204
245146 2280
246147 2175
247148 2204
248148 2250
249149 2175
250150 2146
251151 2146
252151 2190
253152 2146
254153 2117
255154 2146
256154 2190
257156 2117
258156 2160
259156 2160
260158 2088
261158 2160
262159 2088
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265161 2130
266162 2088
267163 2059
268164 2088
269164 2130
270166 2088
271166 2130
272166 2160
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274168 2059
275169 2088
276169 2130
277171 2088
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280172 2130
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336215 2001
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338215 2070
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345221 2030
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348223 2070
349224 2030
350225 2001
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359232 2001
360232 2100
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363235 2001
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366237 2001
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368238 2070
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373242 2001
374243 1421
375243 660
376245 464
377245 480
378246 435
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384250 480
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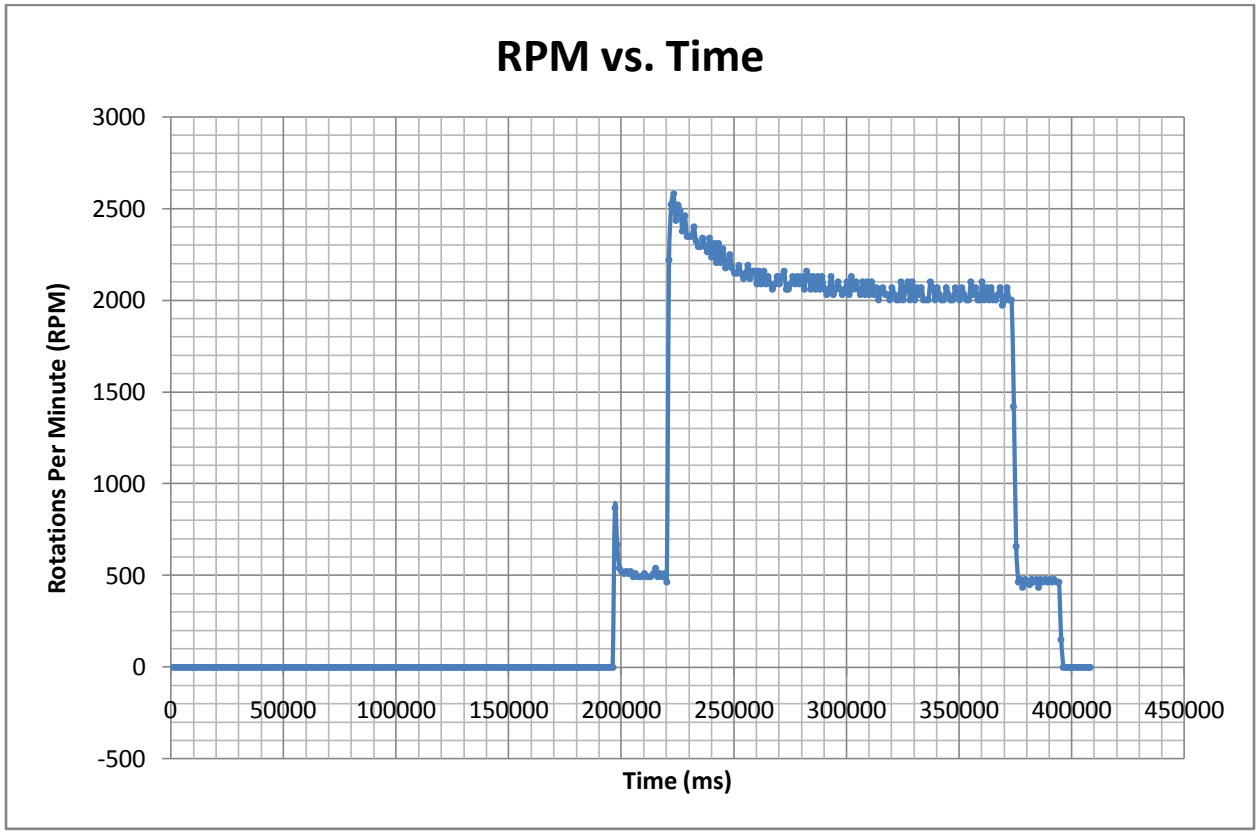
408265 0

Plot



Video Presentation

https://www.youtube.com/watch?v=vAZy4O3XNxI

References

[1] http://www.instructables.com/id/Arduino-Based-Optical-Tachometer/

[2] http://techvalleyprojects.blogspot.com/2012/06/arduino-control-escmotor-tutorial.html

[3] https://github.com/Zuph/AVRQueue