SDMay19-30

http://sdmay19-30.sd.ece.iastate.edu

# STROBOSCOPE

Adviser: Matthew Post

Client: Matthew Post

# Project Plan

SDMay19-30, Stroboscope

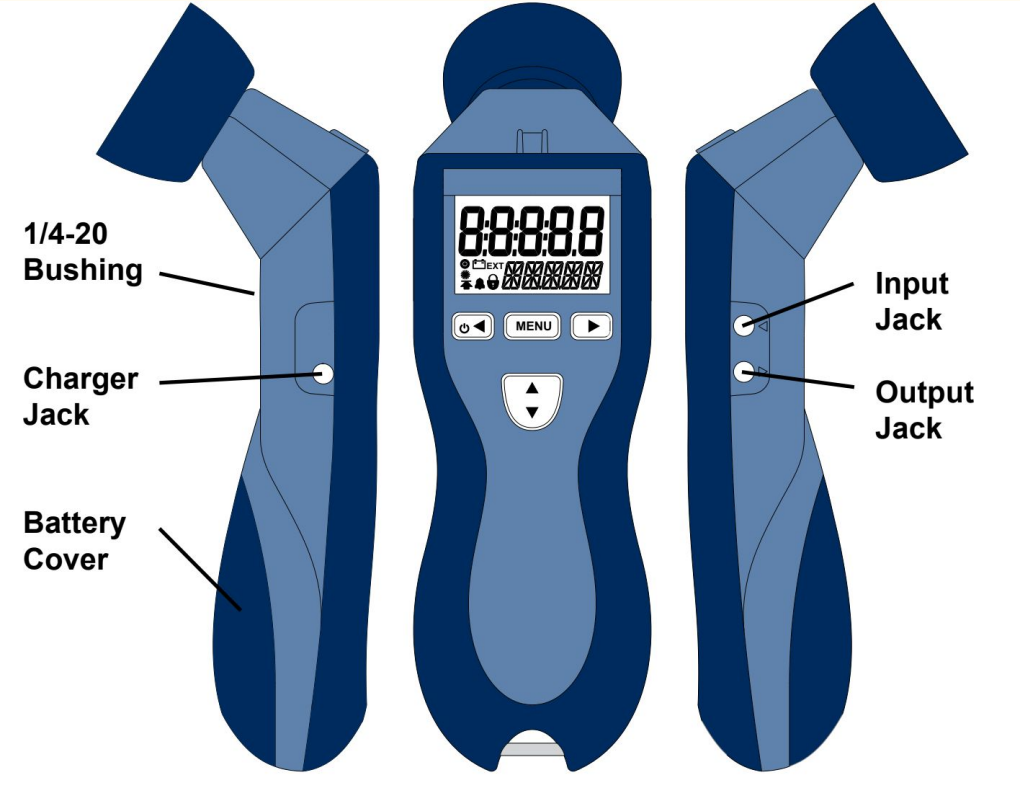
# Problem Statement

## Problem:

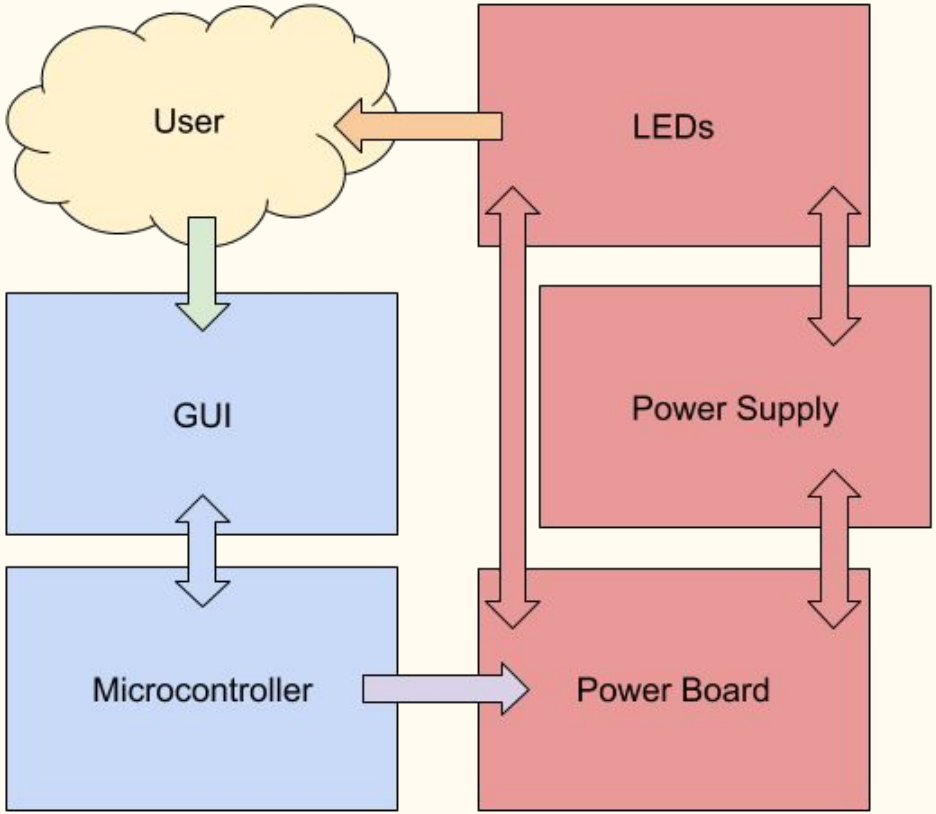
The stroboscope for an EE lab is an unnecessary cost.

## Solution:

Design a new stroboscope.



# Conceptual Sketch / System Description




| Functional Requirements | Non-functional requirements |
| --- | --- |
| • It will be able to perform all the functions required by the lab<br>• It will be able to have 0.5% accuracy<br>• It will range from 100 to 3000 RPM<br>• Average 3300 Lux at 6000 RPM, 12” away from target<br>• It will have a GUI for user interaction | • It will be more cost-effective to replace than the current version<br>• It will be user friendly in a manner consistent with the backgrounds of EE 448 students<br>• It will be documented sufficiently<br>• It will be flexible enough to allow potential future changes to the lab<br>• It will be resistant to breaking due to physical abuse by students<br>• It will have easily accessible parts for the ETG |

# Constraints and Considerations

- Students will be Mechanical Engineering majors
- Not all students are respectful of lab equipment
- Users will include:
  - Students
  - ETG staff
  - TAs
  - Professor

# Similar Stroboscopes

| | | | | |
|---|---|---|---|---|
| Pictures |  |  |  |  |
| Manufacturer | Monarch Instruments | Fluke Electronics | Shimpo Instruments | Newark |
| Name | PLS Pocket LED Stroboscope | Fluke 820-2 Stroboscope | DT-326B High Performance LED Stroboscope | Testo 477 - LED Stroboscope |
| Price | $499 | $1,399.99 | $695 | $886.75 |

# Potential Risks & Mitigation

| Risk | Party at Risk | Mitigation |
|---|---|---|
| Strobe effect can trigger seizures in some individuals | User | Shield the light |
| Shipping time | Timeline | Awareness, order early |
| Lack of circuit board design experience | Hardware design | On-campus resources (including Matt Post, Lee Harker) |
| Delay in the hardware will alter speed of the strobe compared to software output | Accuracy | Calibration |

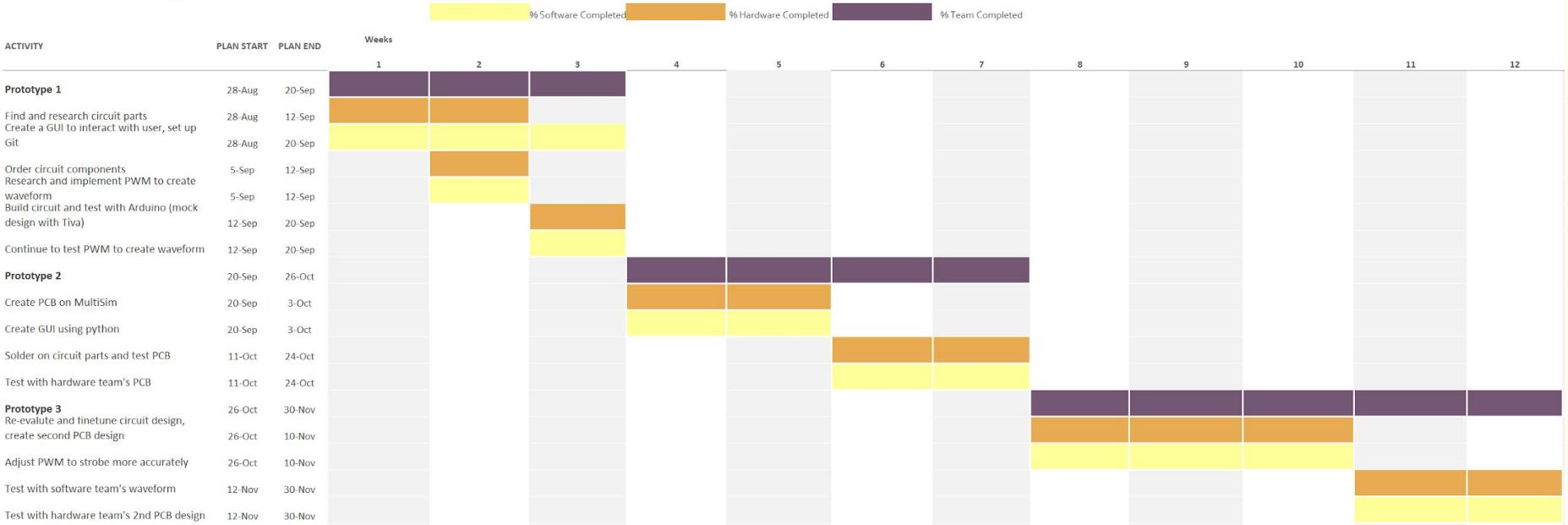
# Resource/Cost Estimate

| One-time Costs | | | | | Recurring Costs | | | |
|---|---|---|---|---|---|---|---|---|
| Part | Price / unit | # | Total | | Part | Price / Unit | # | Total |
| Prototypes | $40 | 5 | $200 | | Single case replacement | $5 | 1 | $5 |
| Cases for all lab stations | $5 | 8 | $40 | | Single circuit replacement | $40 | 1 | $40 |
| Circuit board for all lab stations | $40 | 8 | $320 | | Assemble pieces (on replacement) | 10 mins | 1 | 10 mins of ETG time |
| | | | $560 | | | | | |

*** $45 per station as opposed to $499 per station

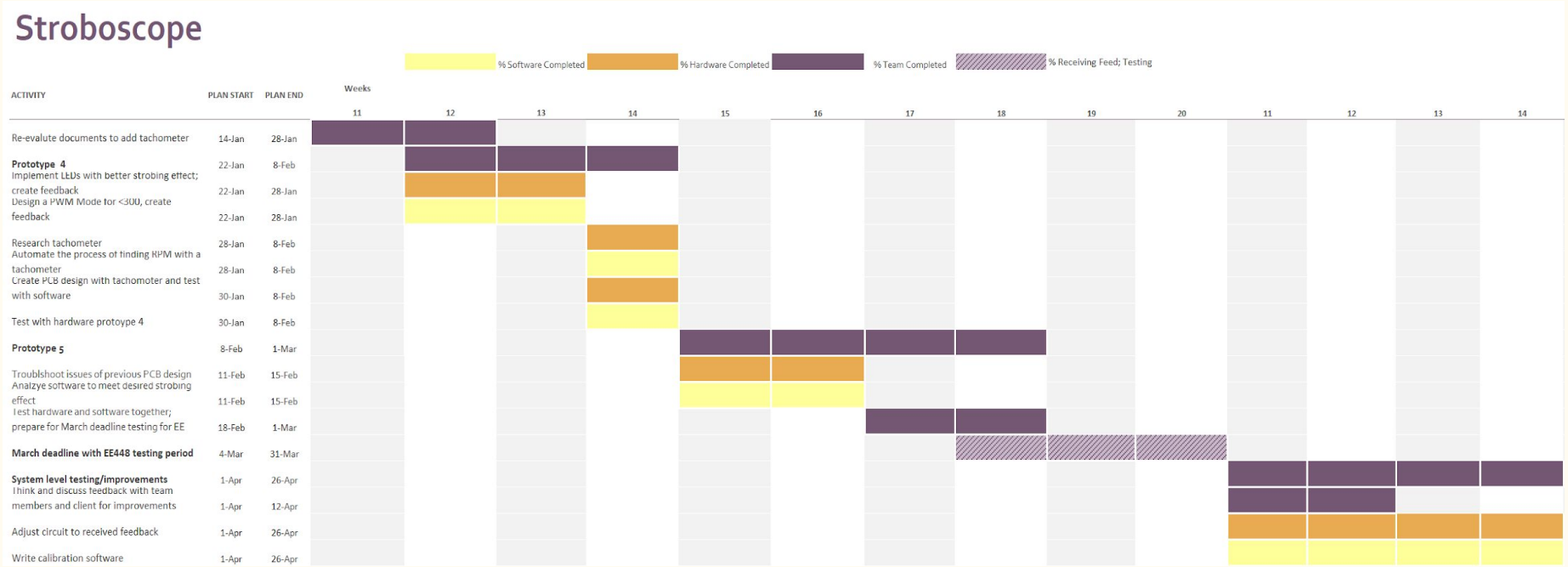
# Project Milestones & Schedule - Semester 1

## Stroboscope




| ACTIVITY | PLAN START | PLAN END |
|---|---|---|
| **Prototype 1** | 28-Aug | 20-Sep |
| Find and research circuit parts | 28-Aug | 12-Sep |
| Create a GUI to interact with user, set up Git | 28-Aug | 20-Sep |
| Order circuit components | 5-Sep | 12-Sep |
| Research and implement PWM to create waveform | 5-Sep | 12-Sep |
| Build circuit and test with Arduino (mock design with Tiva) | 12-Sep | 20-Sep |
| Continue to test PWM to create waveform | 12-Sep | 20-Sep |
| **Prototype 2** | 20-Sep | 26-Oct |
| Create PCB on MultiSim | 20-Sep | 3-Oct |
| Create GUI using python | 20-Sep | 3-Oct |
| Solder on circuit parts and test PCB | 11-Oct | 24-Oct |
| Test with hardware team's PCB | 11-Oct | 24-Oct |
| **Prototype 3** | 26-Oct | 30-Nov |
| Re-evalute and tinetune circuit design, create second PCB design | 26-Oct | 10-Nov |
| Adjust PWM to strobe more accurately | 26-Oct | 10-Nov |
| Test with software team's waveform | 12-Nov | 30-Nov |
| Test with hardware team's 2nd PCB design | 12-Nov | 30-Nov |

# Project Milestones & Schedule - Semester 2



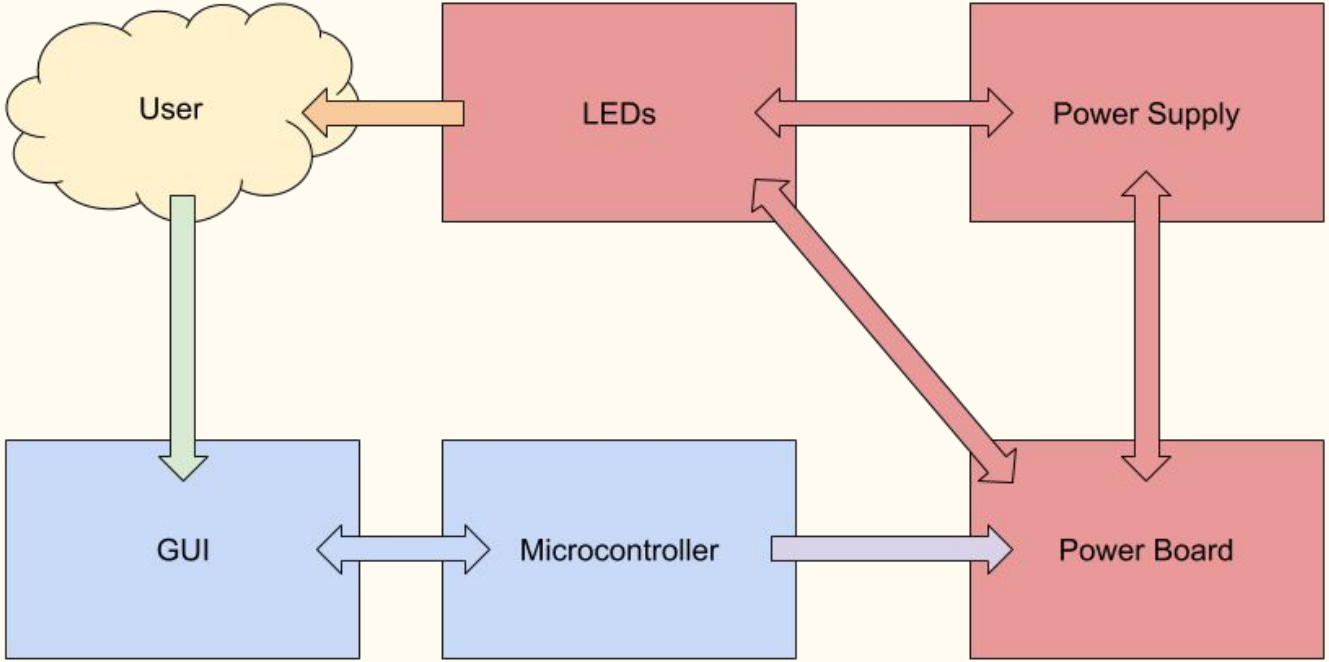
# System Design

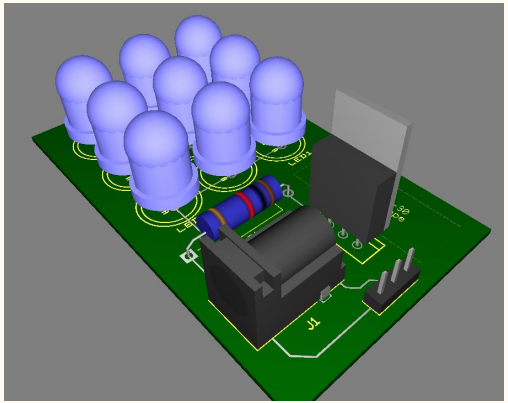
SDMay19-30, Stroboscope

# Functional Decomposition

| System Requirements | Where it is met | Analysis (how it is met) |
|---|---|---|
| It will be able to have 0.5% accuracy | Hardware | Small enough time delay in the circuit to allow this level of accuracy |
| | Software | Calibration of the waveform to this level of accuracy |
| It will range from 100 to 3000 RPM | Hardware | Small enough time delay to allow circuit to function in this range |
| | Software | Waveform output can go as slow as 100 RPM or as fast as 3000 RPM. Output needs to be proportional to input |
| Average 3300 Lux at 6000 RPM, 12” away from target | Hardware | Sufficient ratio between LED specs and circuit voltage at all frequencies |
| It will have a GUI for user interaction | Software | GUI |

# Detailed Design

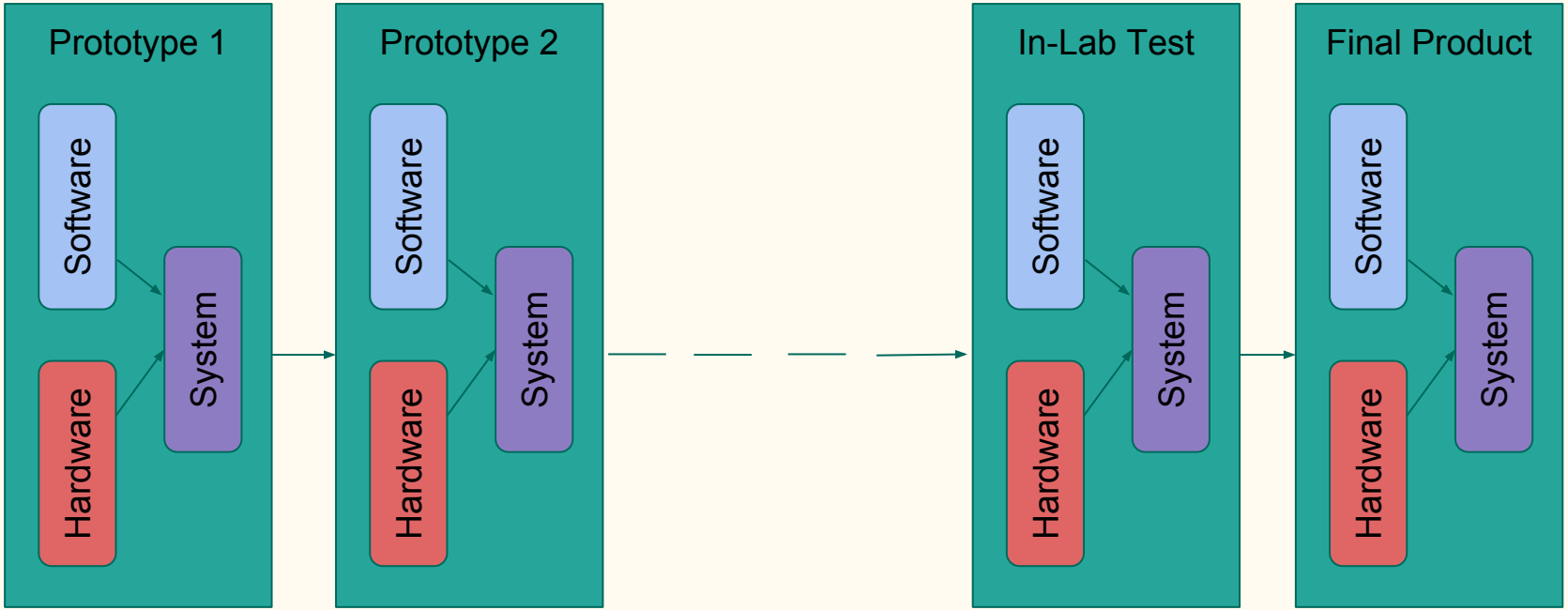


# HW/SW/Technology Platforms used

| Software | Hardware |
| --- | --- |
| • Code Composer Studio (Tiva Board)<br>  ○ C<br>• Pycharm (GUI)<br>  ○ Python<br>• GIT (repository)<br>• Oscilloscope (debugging) | • MultiSim (circuit simulation)<br>• Ultiboard (PCB design)<br>• Arduino (waveform generation)<br>• Waveform generator<br>• Oscilloscope (debugging) |

# Test Plan


Prototype 1
Software
Hardware
System
Prototype 2
Software
Hardware
System
In-Lab Test
Software
Hardware
System
Final Product
Software
Hardware
System

# Test Case

**Functional Requirement #2:** It will have an accuracy of 0.5%

**Test Case:**

For this requirement, we want to make sure the stroboscope is accurate within the required range of 100 to 3,000 RPM with an accuracy within 0.5%

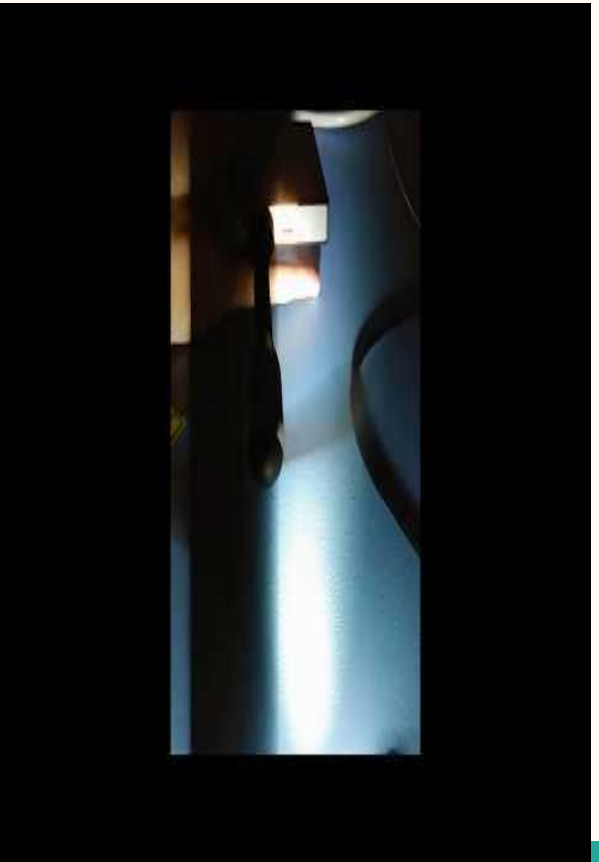
**Test Steps:**

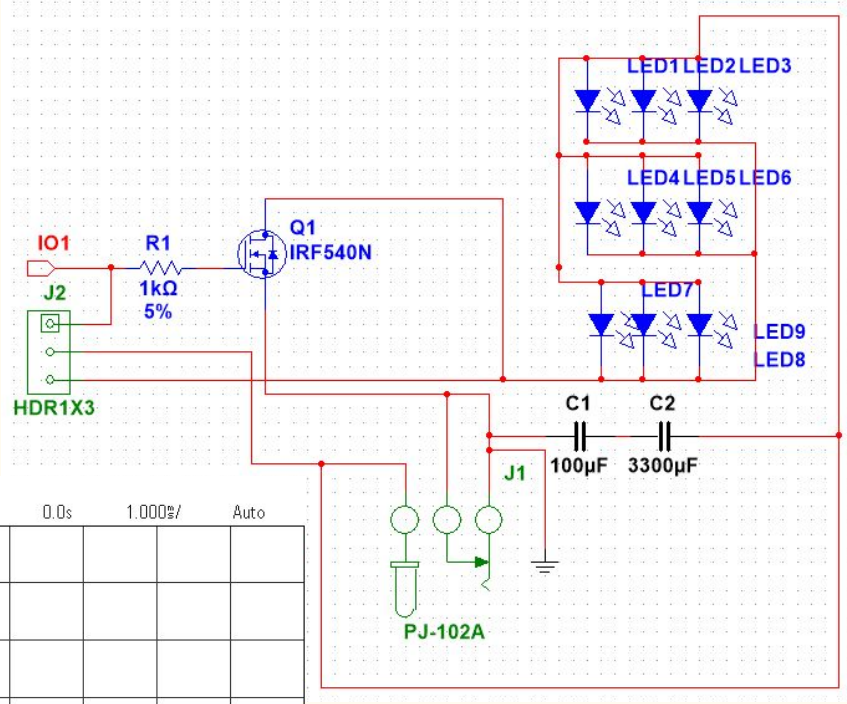
1. Rotate the motor at 100 RPM
2. Measure the speed with our stroboscope
3. Measure the speed with the original stroboscope
4. Determine if the measurement is within 0.5% of the original strobe because it has 0.005% accuracy
5. Repeat the first 4 steps at increments of 200 RPM up to 3,000 RPM

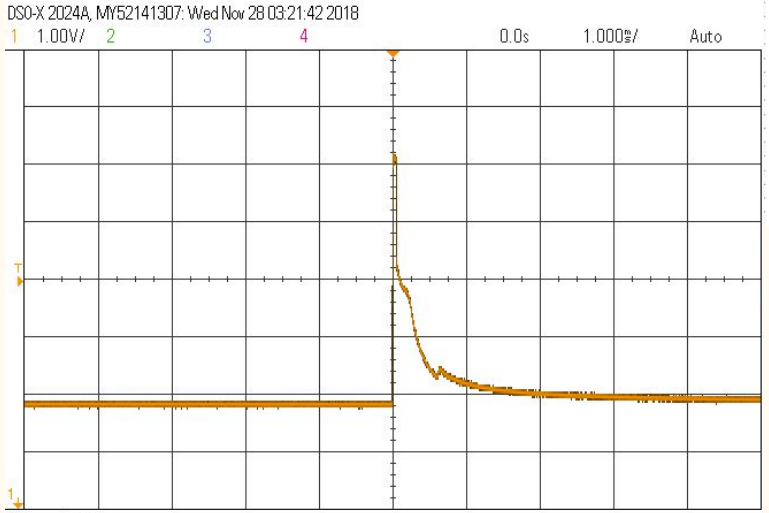
**Expected Results:**

The rotational speed we measure using our stroboscope should be 0.5% accurate in comparison to the rotational speed measured from the original stroboscope.

# Prototype Implementations





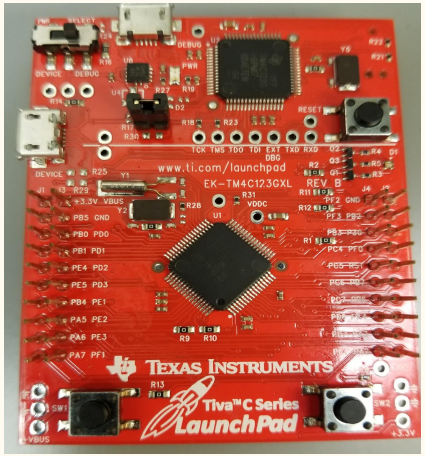
# Current Constraints

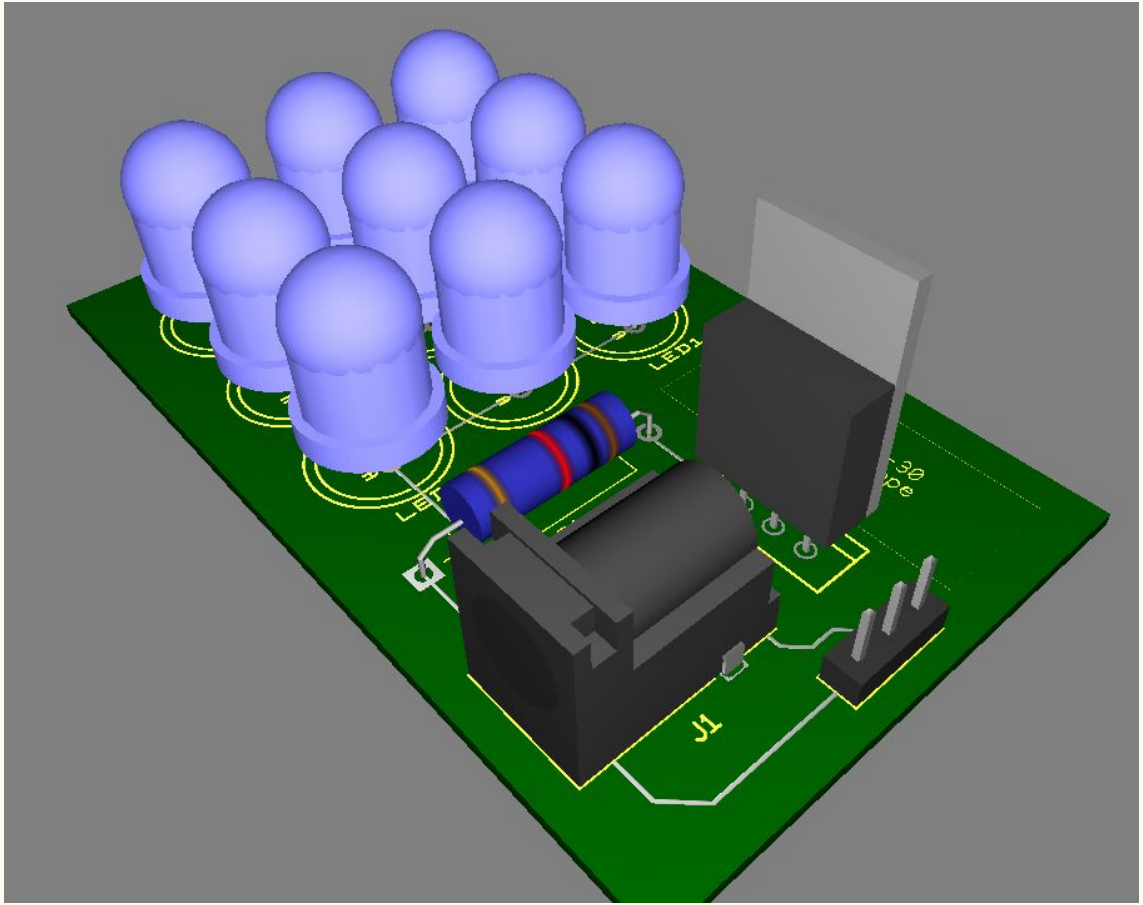
| Cause of Constraint | Time | | Limit to RPM |
|---|---|---|---|
| Tiva board's PWM mode | 210ms | > | 300 RPM |
| Pulse width (microcontroller output) | 100µs | < | 300,000 RPM |
| Resulting pulse width (hardware output) | 132µs | < | 227,272 RPM |
| Current total hardware time delay | 1.2ms | < | 50,000 RPM |
| MOSFET fall time | 1.1ms | < | 54,545 RPM |
| LED + capacitor fall/discharge time | 10µs | < | 6,000,000 RPM |
| Total rise time | 110µs | < | 545,455 RPM |

Assumption: time low is at least as long as time high

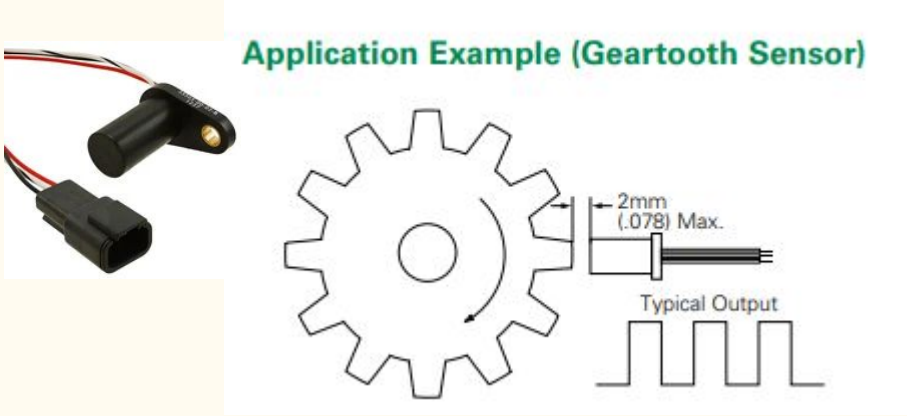
# Conclusion

# Current Status

# Plan for Next Semester




| Full Team | Hardware | Software |
|---|---|---|
| • Redesign system<br>• Redefine interfaces<br>• Update documentation<br>• Prototypes 3/4/5<br>• In-lab testing<br>• Create instruction documentation | • Finish tachometer implementation<br>• Clean up pulse width and brightness<br>• Testing<br>• Mount circuit to motor | • Calibrate stroboscope<br>• Calculation software based on tachometer output<br>• PWM mode for < 300 RPM<br>• Calibration software |

# Task Division

| Role | Responsibilities | Person |
|---|---|---|
| Hardware Engineers | • Lead hardware design<br>• Manage hardware-related tasks<br>• Update accomplishments<br>• Manage hardware documentation | Katrina, Seth, Kyle |
| Software Engineers | • Lead software design<br>• Manage software-related tasks<br>• Update accomplishments<br>• Manage software related documentation | Meghna, Jessie |
| Systems Engineer | • Keep track of overall project progress<br>• General understanding of project<br>• Mediator<br>• Stay up to date on progress, design, and problems of all parts | Kyle, Seth |
| Timeline Manager | • Keep track of due dates<br>• Create intermediate goals so we get assignments completed on time<br>• Communicate timelines to group members<br>• Keep members on the timeline to ensure no missed deadlines | Katrina |
| Communication Manager | • Send all emails for the group<br>• Check email in a timely manner | Jessie |

# Questions?

# Additional Slides

# PWM Mode Calculations

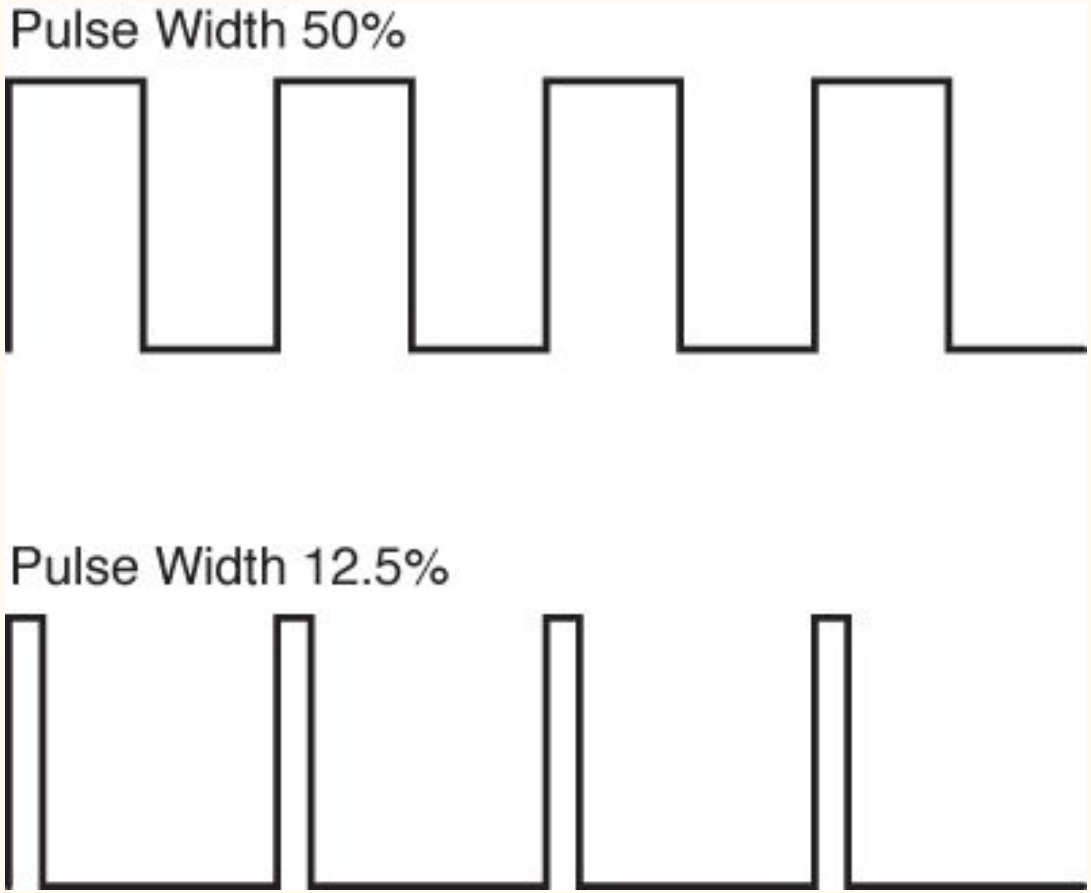
- 24 bits for the period counter and match = 0d16777215
- Tiva board has an 80Hz processor

(slowest speed is limited by how high the Tiva board can count)

16777215 units / 80000000 (units / s) = 0.2097 s **(300 RPM)**

(highest speed is limited by our 100us rise period on a square wave)

1 / 0.0002 (s / rotation) = 5,000 RPS **(300,000 RPM)**


Pulse Width 50%
Pulse Width 12.5%