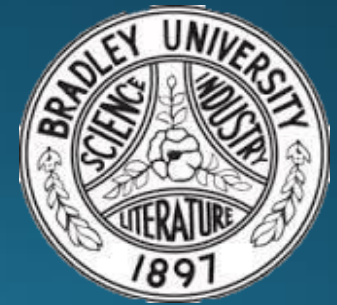


# Autonomous Underwater Robots Progress Presentation

RYAN LIPSKI, CAMERON PUTZ, AND NICK SIKKEMA  
ADVISOR: DR. JOSEPH DRISCOLL

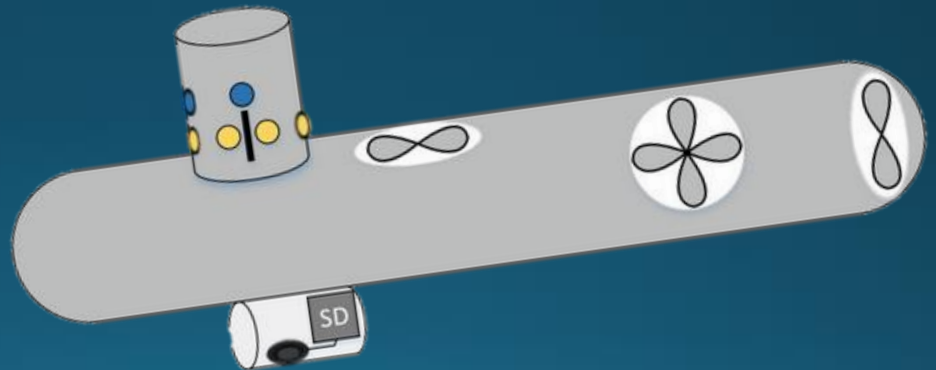
DEPARTMENT OF ELECTRICAL AND COMPUTER  
ENGINEERING, BRADLEY UNIVERSITY

NOVEMBER 20, 2014

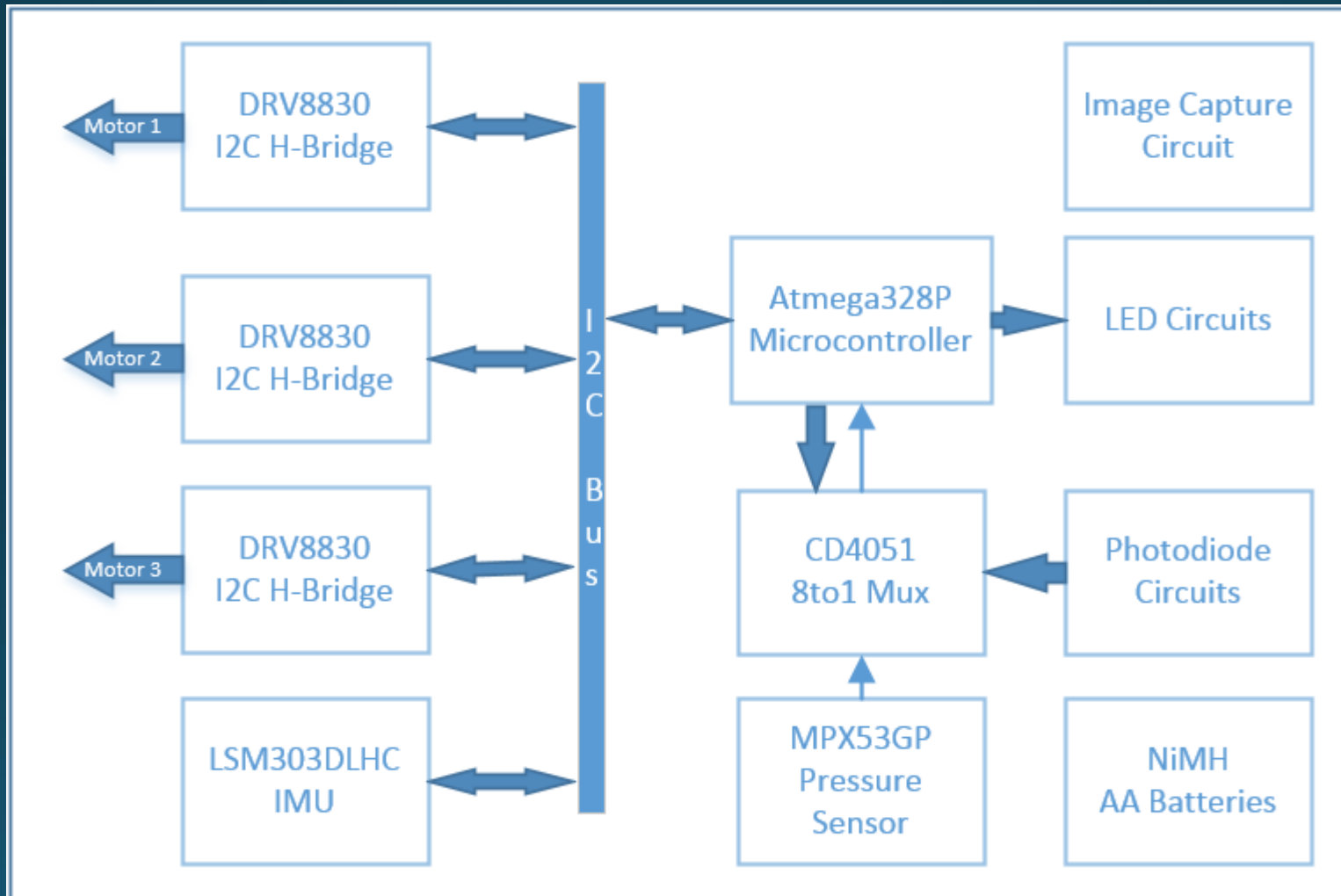


# Project Objectives

- Map underwater terrain
  - Swarm of UAV's
  - Avoid obstacles
  - Generate final image

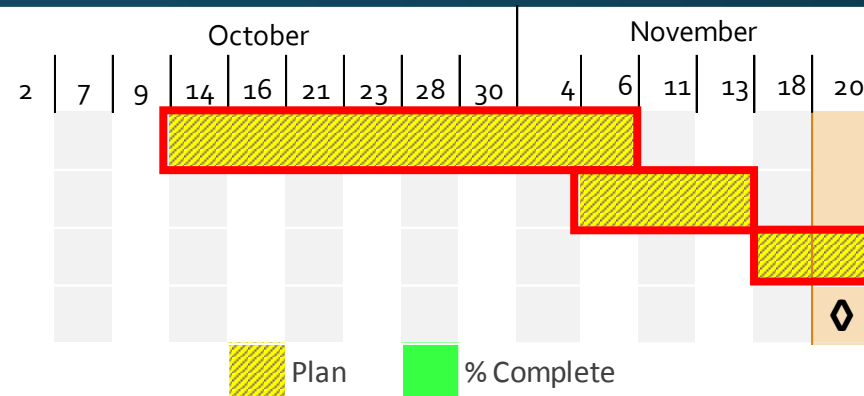


# System Block Diagram



# Original Gantt Chart – Cameron Putz

ACTIVITY	DURATION	PERCENT COMPLETE
Detection Array Simulation and Testing	27	0%
Circuit and System Layout	8	0%
Assemble and Test Single Submarine	34	0%
Fall Progress Presentation		



# Task 1: Detection Array

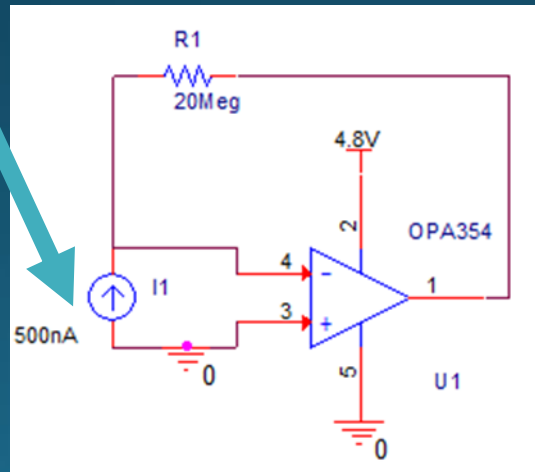
## Experiment

- Amplifier testing
  - Amplifier Design

Model of photodiode



Osram photodiode [1]



Transimpedance amplifier



Everlight photodiode [2]

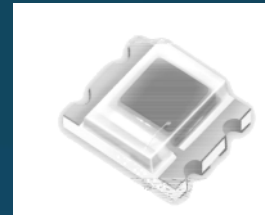
# Task 1: Detection Array

## Results

- Photodiode testing



Osram photodiode [1]



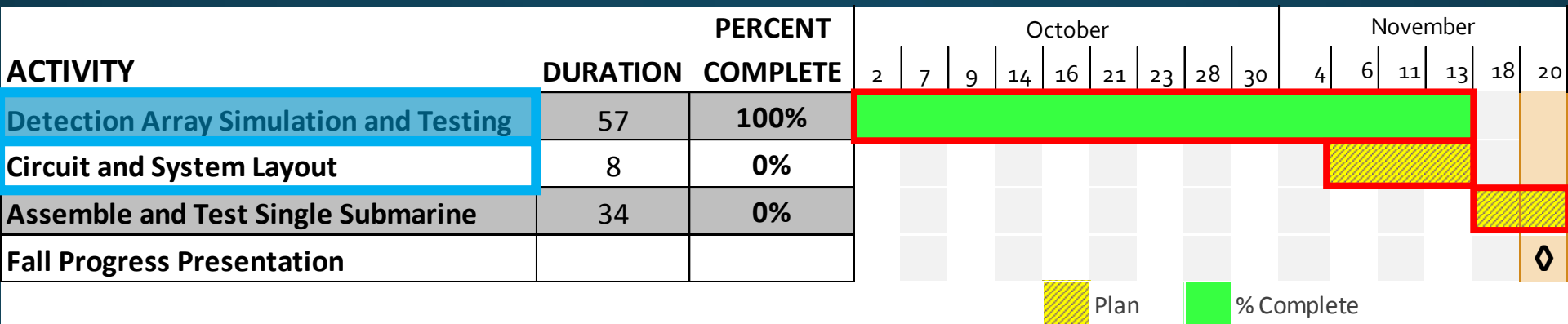
Everlight photodiode [2]

<b>Saturation</b>	<b>36 inches – 4.9 Volts</b>	<b>4 inches – 4.89 Volts</b>
<b>Max Distance</b>	<b>180 inches – 0.6 Volts</b>	<b>132 Inches -- 0.120 Volts</b>
<b>Linearity</b>	<b>Linear</b>	<b>Non-Linear</b>
<b>Ambient Light</b>	<b>100% Saturation</b>	<b>29% Saturation</b>
<b>Price</b>	<b>\$8.85</b>	<b>\$0.59</b>

Photodiode comparison

# Updated Gantt Chart – Cameron Putz

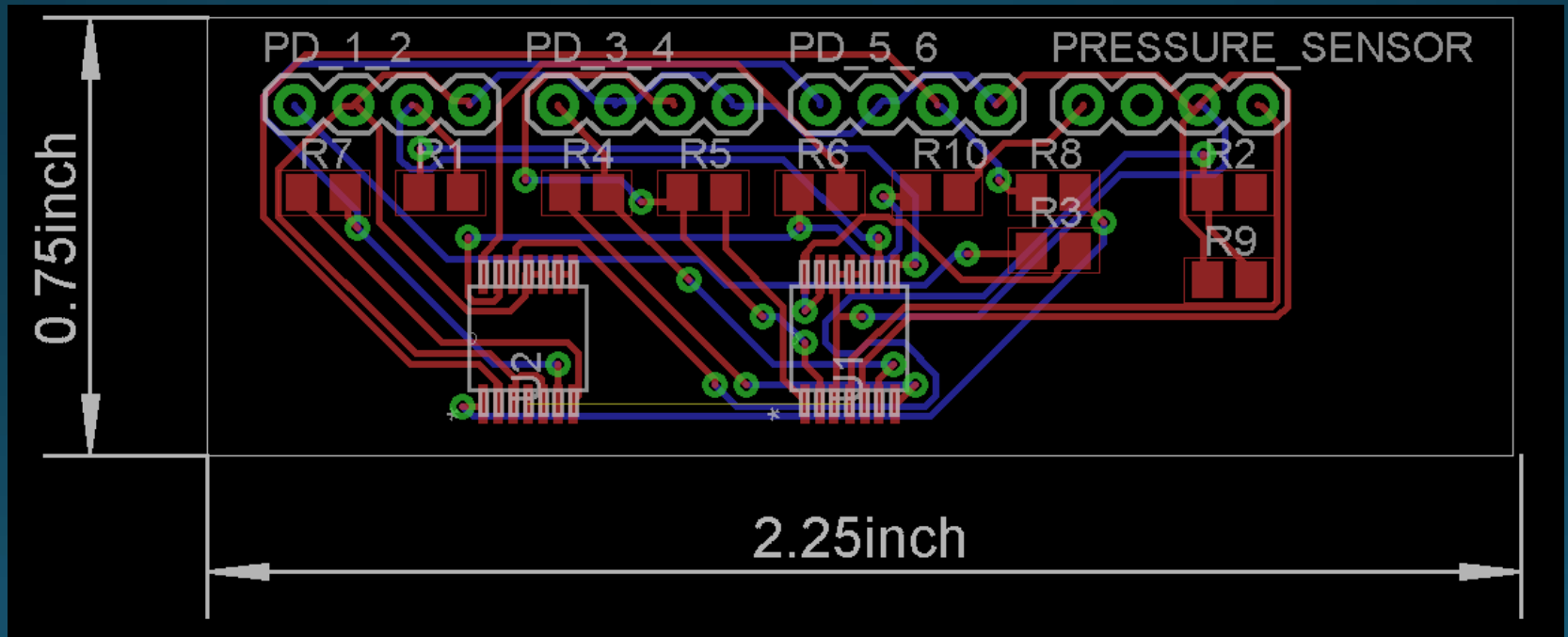
## Task 2



# Task 2: Circuit Layout

## Results

- Eagle 7.1.0
  - Dr. Driscoll has experience



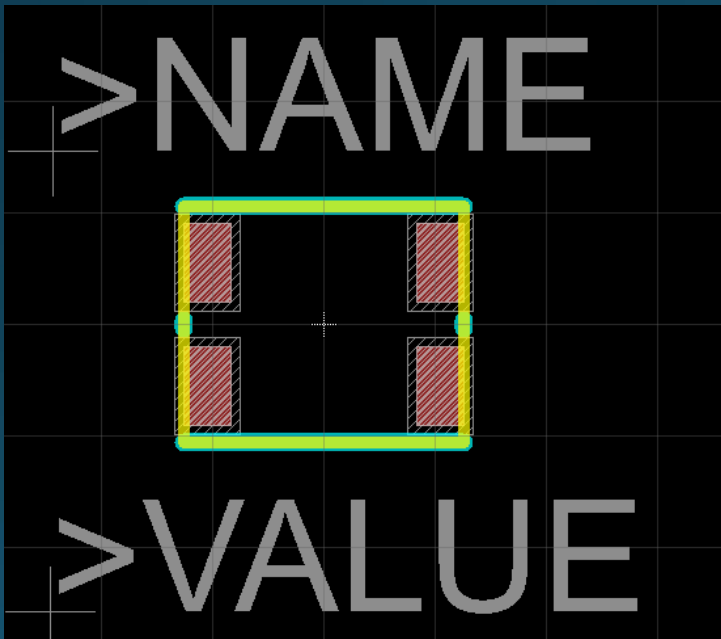
First iteration of the detection array surface mount board



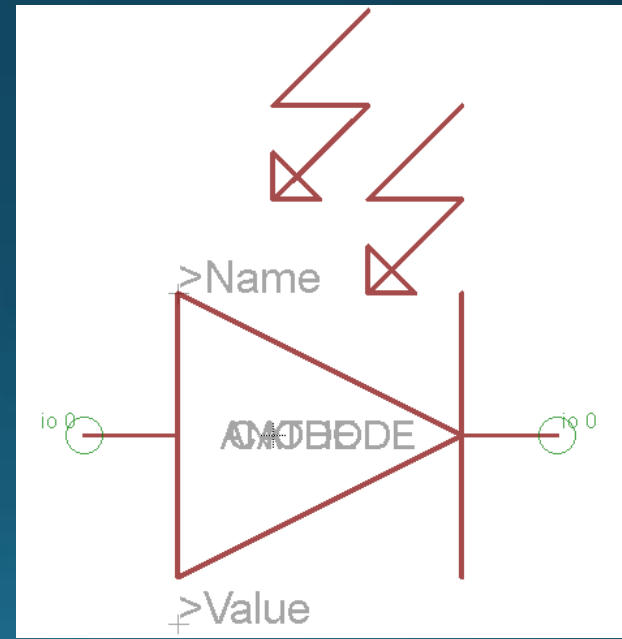
# Task 2: Circuit Layout

## Results

- Eagle 7.1.0
  - Still a lot to learn



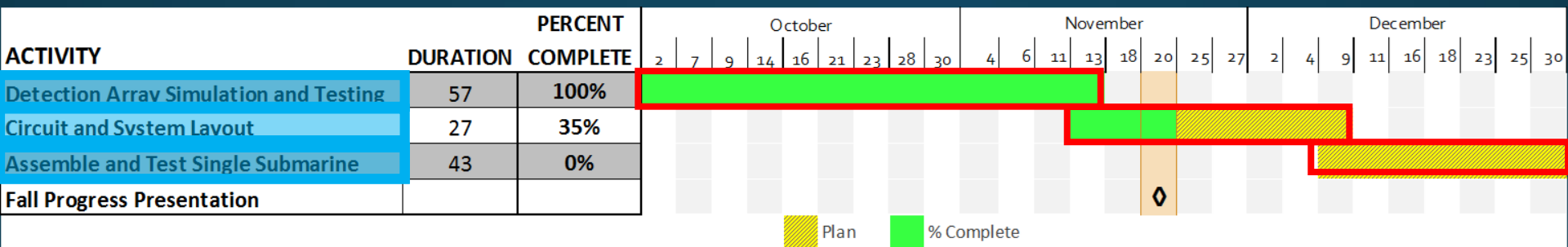
First library package Everlight photodiode



First library symbol Everlight photodiode

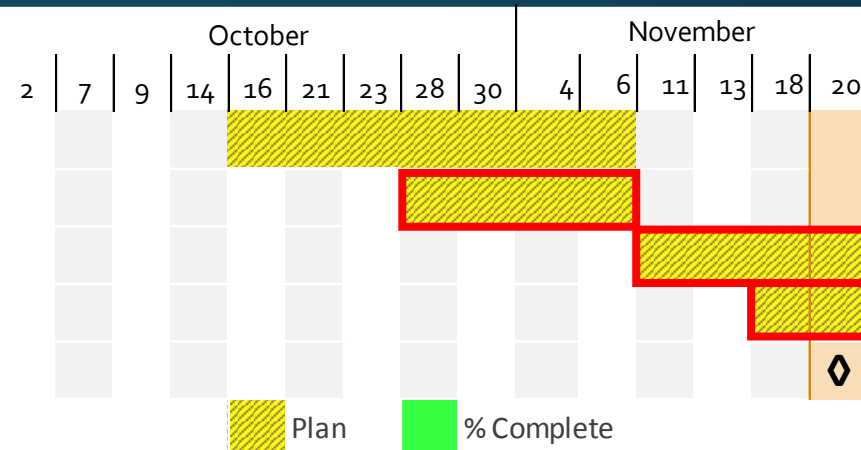
# Updated Gantt Chart – Cameron Putz

Future work



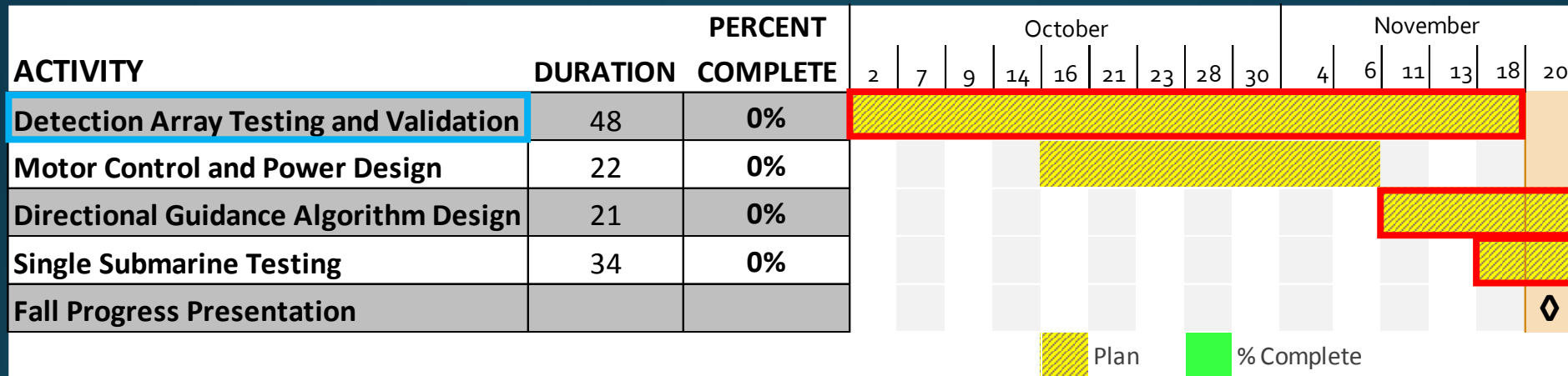
# Original Gantt Chart – Ryan Lipski

ACTIVITY	DURATION	PERCENT COMPLETE
Motor Control and Power Design	22	0%
Detection Array Testing and Validation	15	0%
Directional Guidance Algorithm Design	21	0%
Single Submarine Testing	34	0%
Fall Progress Presentation		



# Updated Gantt Chart – Ryan Lipski

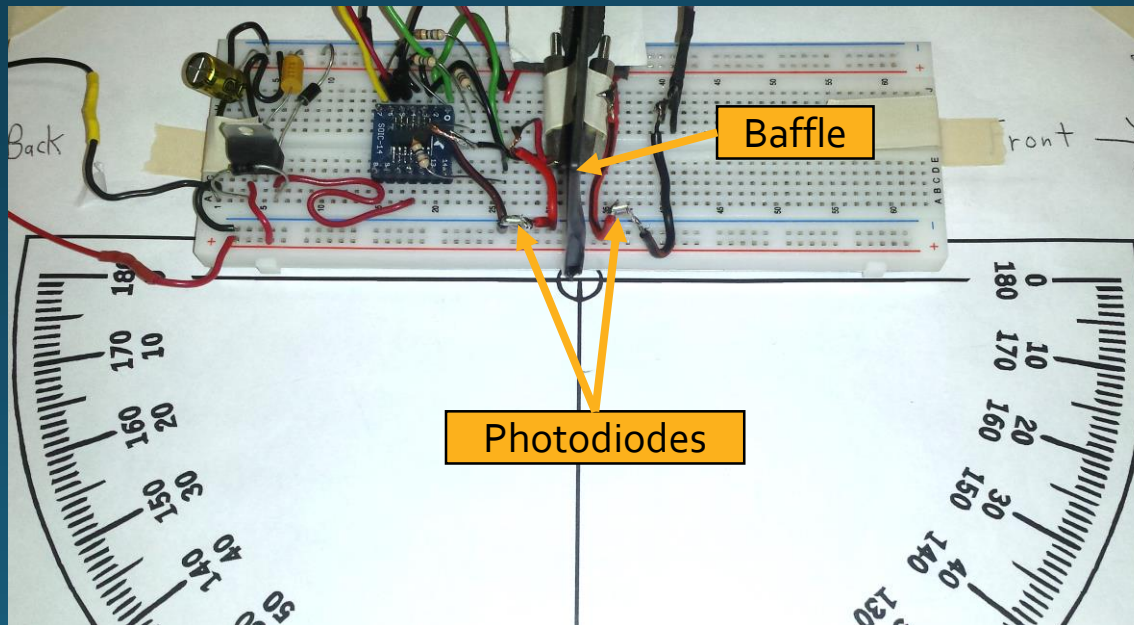
## Task 1



# Task 1: Detection Array

## Experiment

- Bench top detection array
  - Baffle configuration testing
    - Baffle protrusion distance and LED distance experimented with
    - LED swept from 0 to 180° while recording light intensity

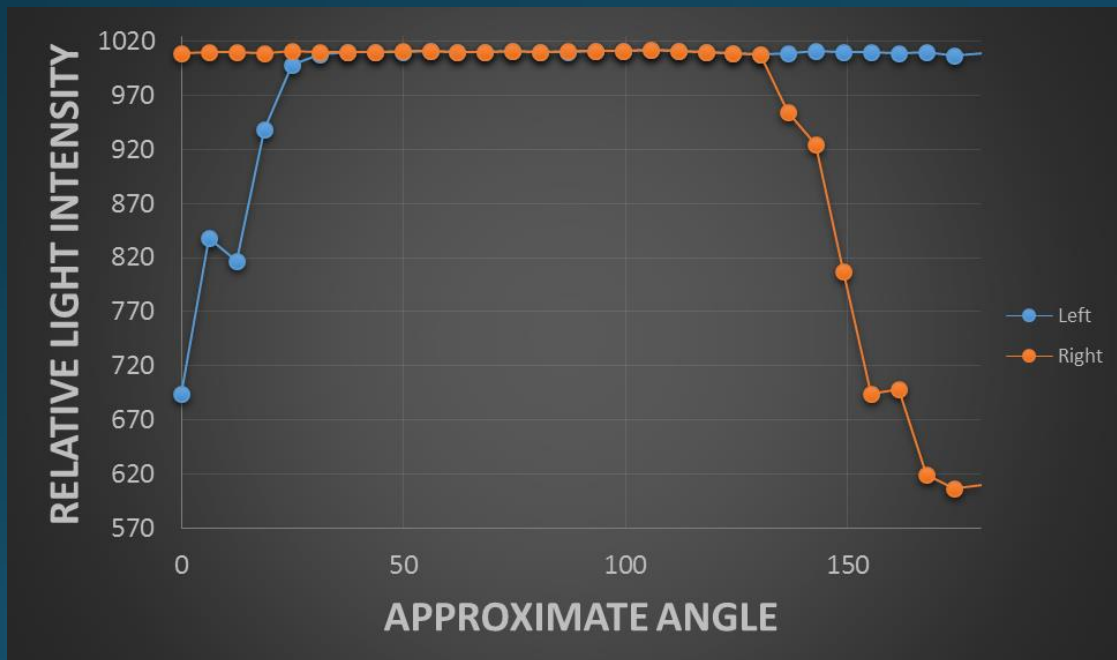


Baffle test setup

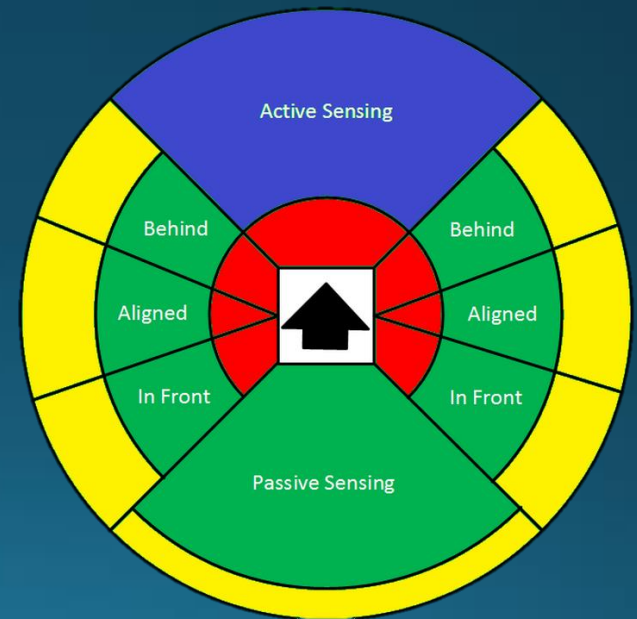
# Task 1: Detection Array

## Results

- Bench top detection array
  - Baffle configuration testing
    - 12cm LED distance



Left vs right photodiode (5 mm baffle)



Detection zones

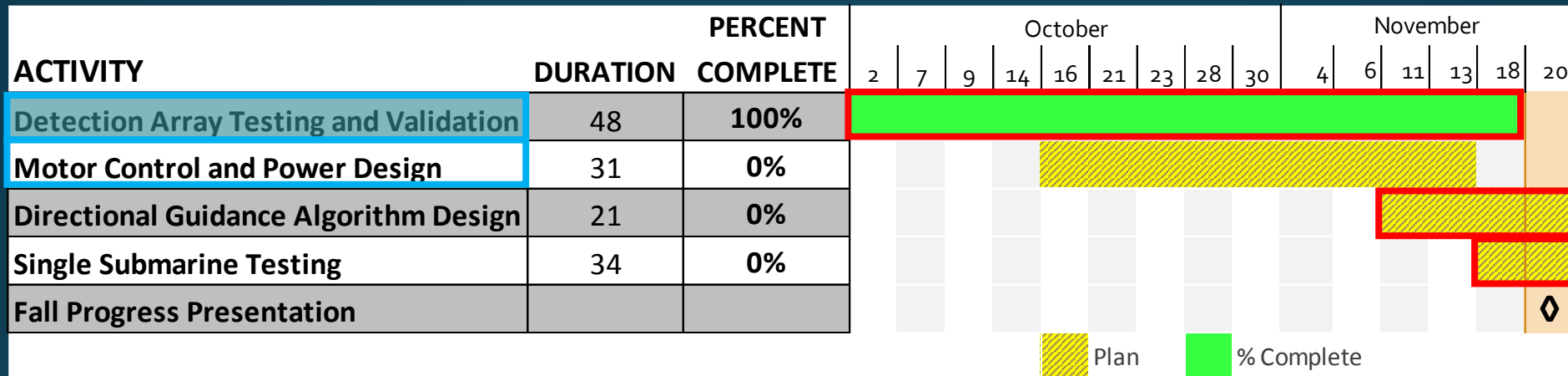
# Task 1: Detection Array

## Experiment

- Additional related work
  - Detection array testing/validation
    - Assisted Cameron with testing different op-amp/photodiode combinations
    - Both in lab testing and off campus/through water testing

# Updated Gantt Chart – Ryan Lipski

## Task 2





# Task 2: Motor Control and Power

## Design and Experiment

- 3 DC brushed motors (x, y, z configuration)
  - Y motor highest current draw: 860 mA peak draw
    - Recorded with only rear propeller submerged
  - X and y motor feedback: IMU
  - Z motor feedback: pressure sensor

# Task 2: Motor Control and Power

## Design

- I2C h-bridge (DRV8830)
  - Single channel, PWM controlled h-bridge
  - 1 A, 2.75 - 6.8 V
  - Cost: \$2.44
  - Total cost per submarine:  $\$2.44 * 3 = \$7.32$

# Task 2: Motor Control and Power

## Design

- H-bridge and I2C PWM generator
  - H-Bridge (SN754410)
    - 1.1 A
    - Cost: \$2.57
  - I2C PWM generator (PCA9685)
    - Cost: \$2.47
  - Requires more PCB surface area
  - Total cost per submarine:  $\$2.57 * 2 + \$2.47 = \$7.61$

# Task 2: Motor Control and Power

## Design

- PID control
  - All 3 motors in same interrupt control loop
  - ECE467 PID code used as starting point
  - Updated to work with the I2C h-bridge (DRV8830)

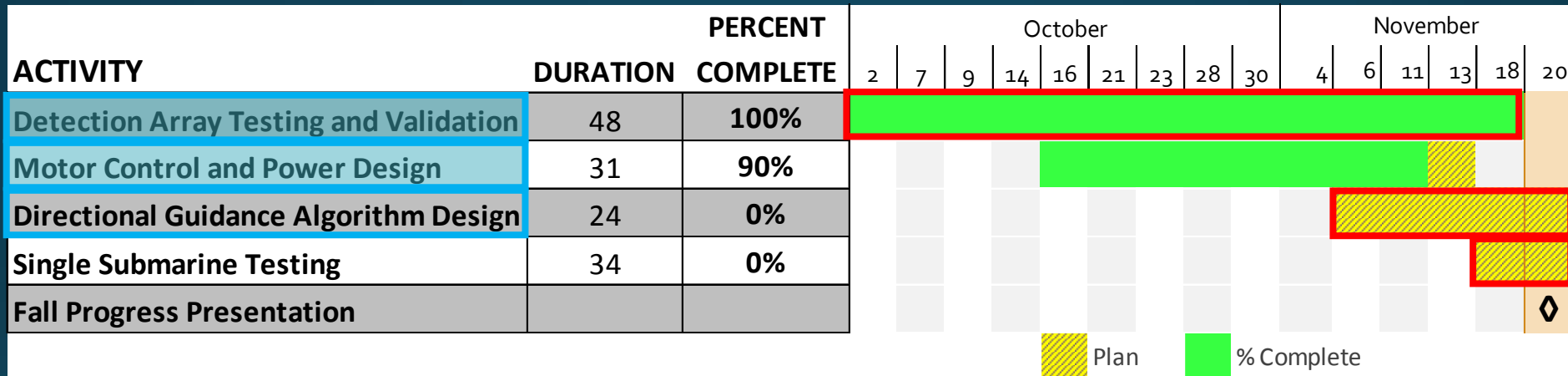
# Task 2: Motor Control and Power

## Design

- Power
  - 4 NIMH AA batteries
    - 1.2 V per cell
    - 2500 mAh
  - Battery life estimation
    - Estimated average current draw: 1770 mA
    - Estimated run time: 1.4 hours

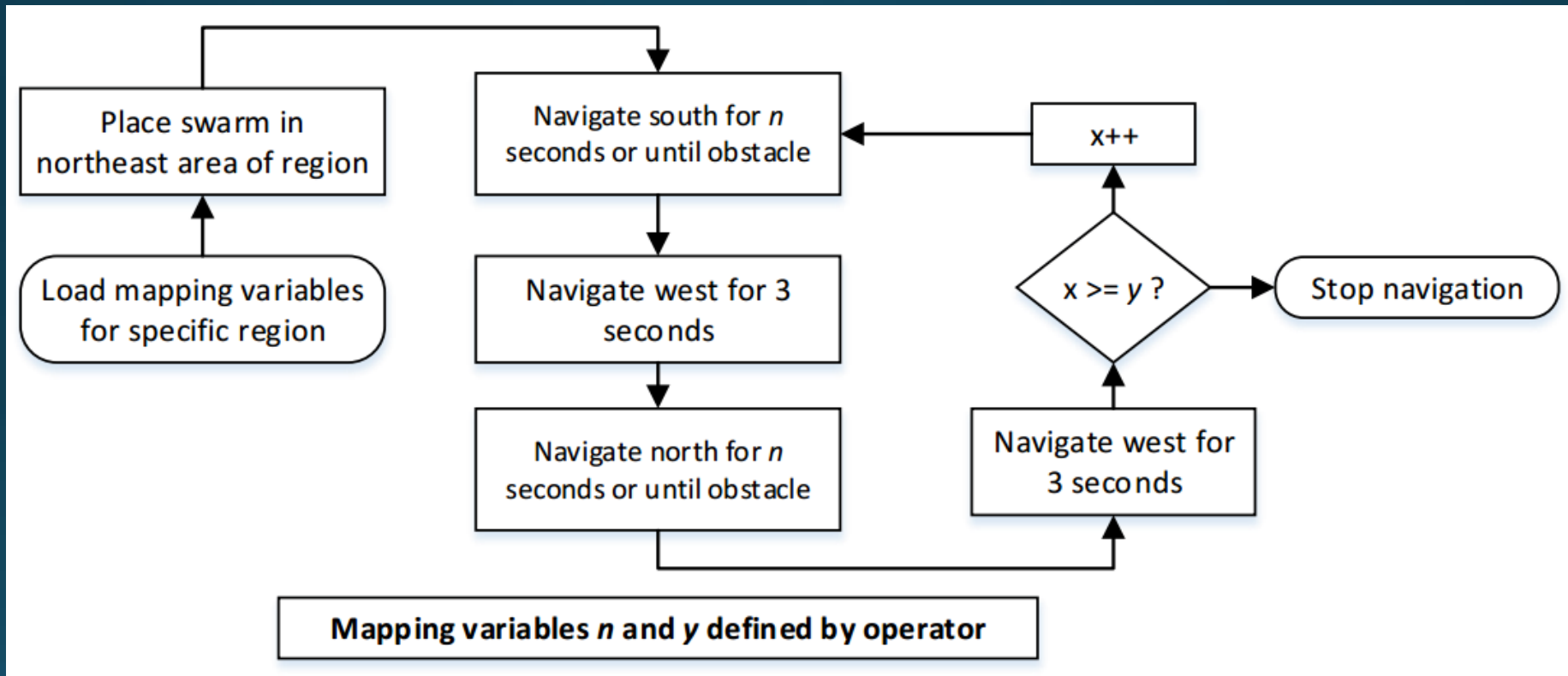
# Updated Gantt Chart – Ryan Lipski

## Task 3



# Task 3: Directional Guidance Algorithm

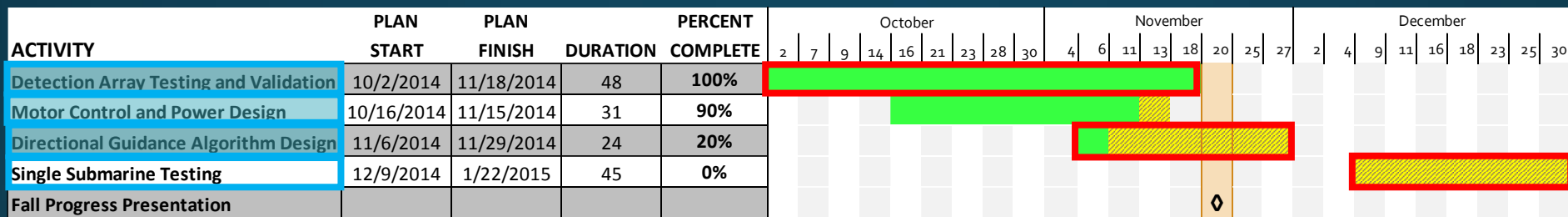
## Design



Directional Guidance Flowchart

# Updated Gantt Chart – Ryan Lipski

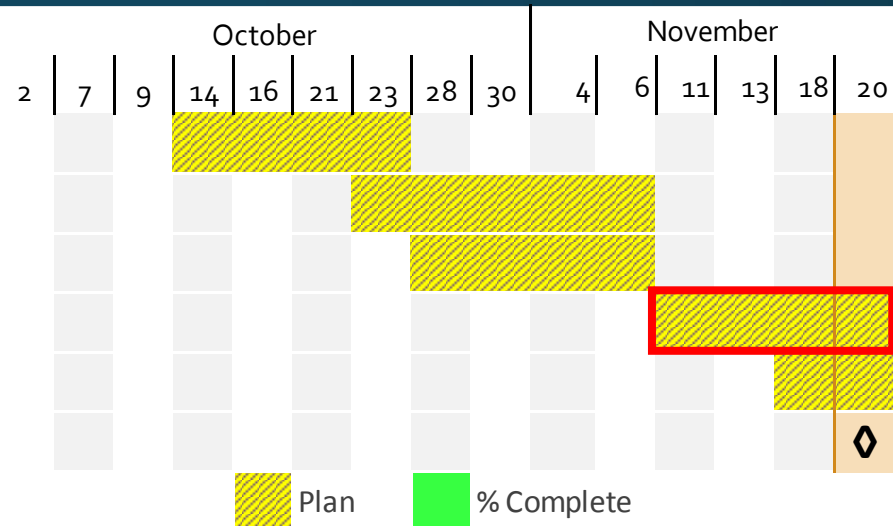
## Future work





# Original Gantt Chart – Nick Sikkema

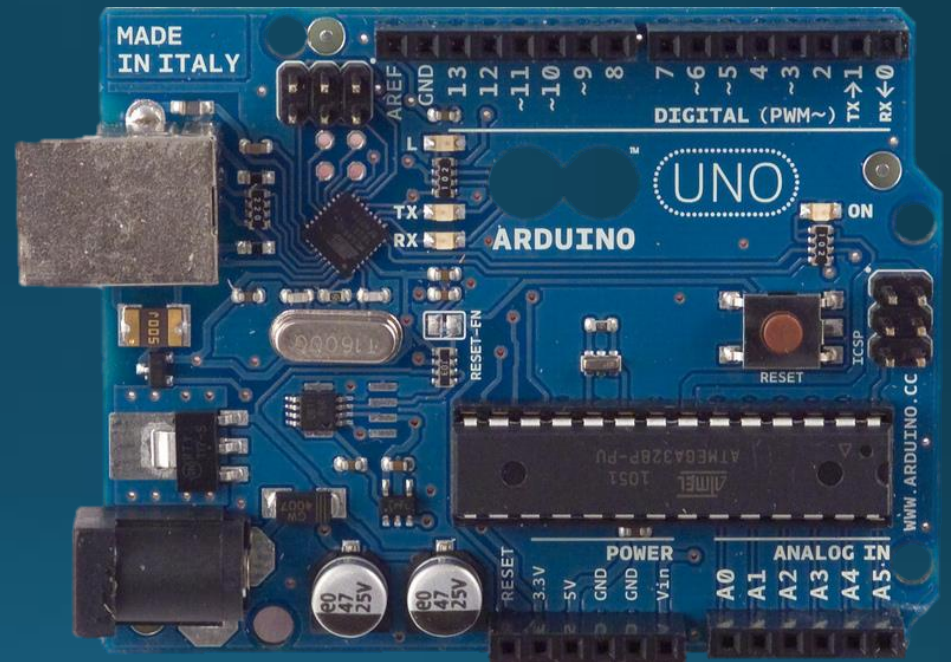
ACTIVITY	DURATION	PERCENT
		COMPLETE
Research Parts	13	0%
Multiplexer and Pressure Sensor	15	0%
Compass and Accelerometer	10	0%
Directional Guidance Algorithm	21	0%
Test Single Submarine	34	0%
Fall Progress Presentation		



# Task 1: Research Parts

## Research

- Microcontroller
  - ADC
  - Multiplexer (CD4051)
  - Atmega328P

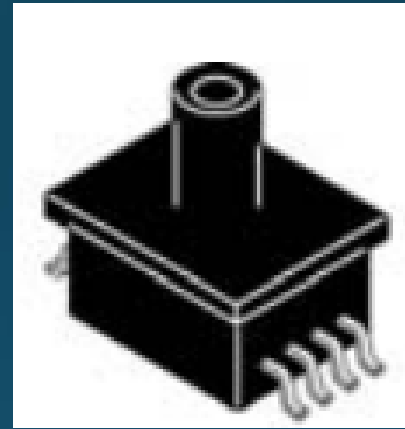


Atmega328P breakout board  
[3]

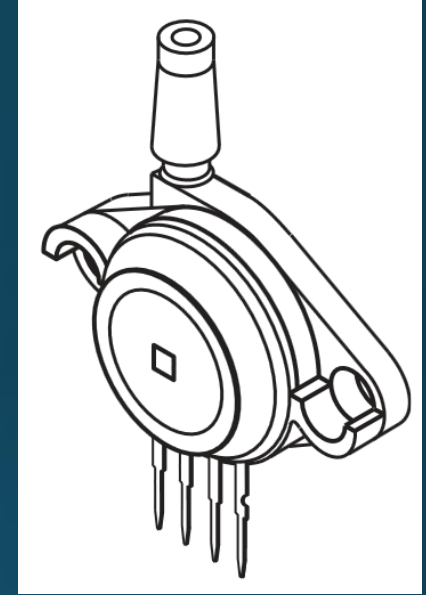
# Task 1: Research Parts

## Research

- Pressure sensor
  - Package
  - Gauge vs absolute



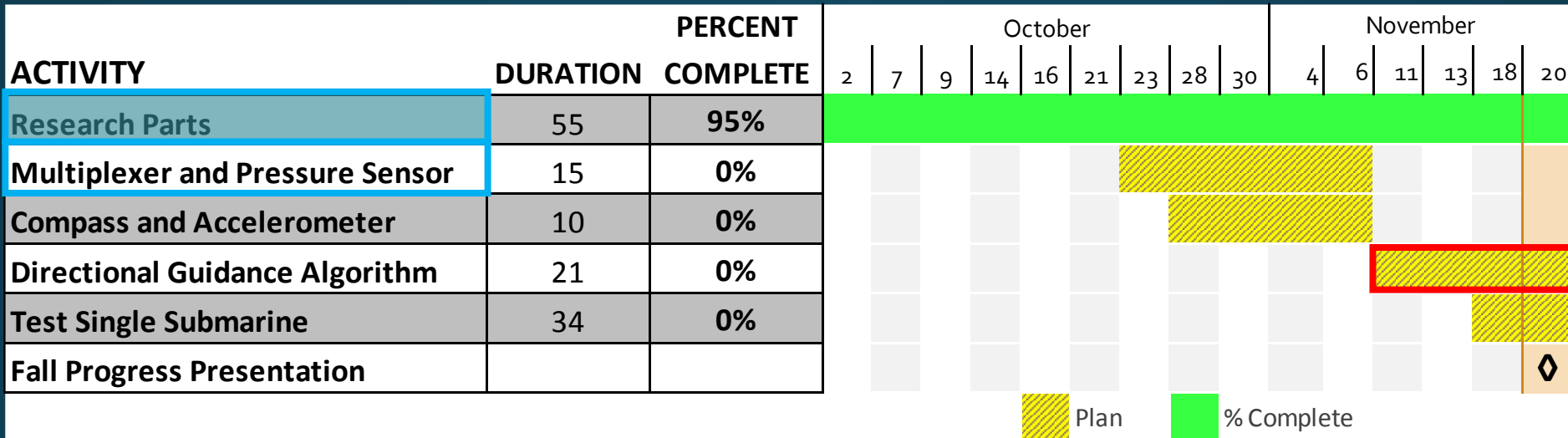
MPAK  
package [4]



Unibody  
package [4]

# Updated Gantt Chart – Nick Sikkema

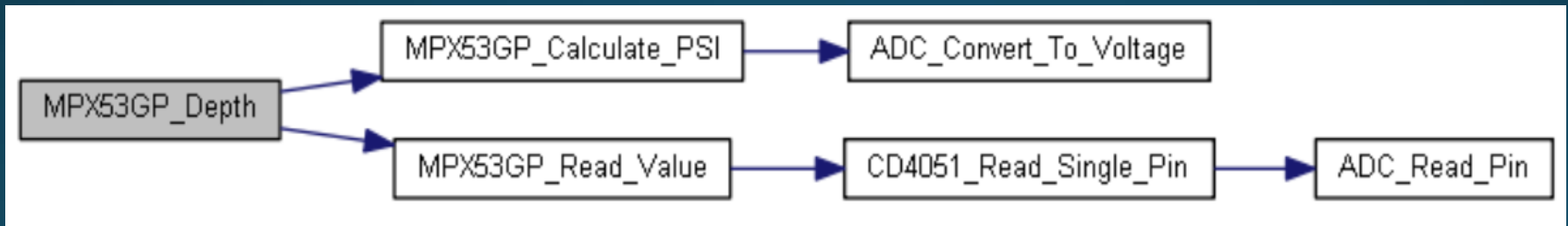
## Task 2



# Task 2: Multiplexer and Pressure

## Design and Experiment

- 8 to 1 multiplexer (CD4051)
- Pressure sensor (MPX53GP)
  - Differential output
  - Gauge vs absolute



Call graph for the depth function

# Task 2: Multiplexer and Pressure

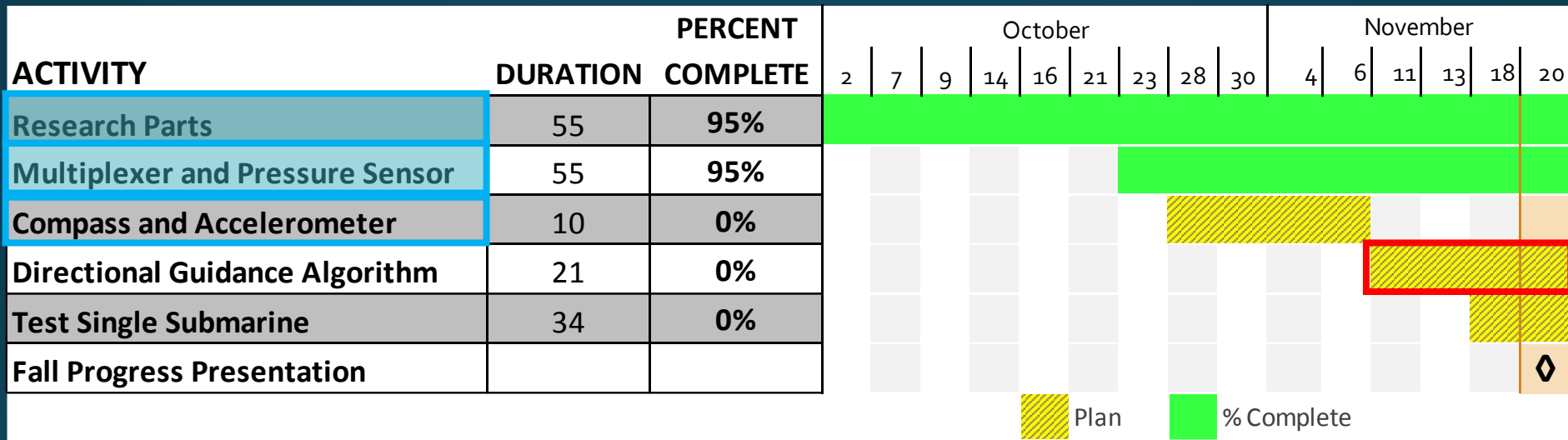
## Results

```
1023, 0, 1023, 968, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 950, 1023, 0, 0, 1022 Pin 5: 1023
1023, 0, 1023, 981, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 977, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 946, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 972, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 972, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 970, 1023, 0, 0, 1023 Pin 5: 1023
1022, 0, 1023, 963, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 967, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 961, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 972, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 981, 1023, 0, 0, 1023 Pin 5: 1023
1023, 0, 1023, 952, 1023, 0, 0, 1023 Pin 5: 1023
```

Multiplexer ADC test output

# Updated Gantt Chart – Nick Sikkema

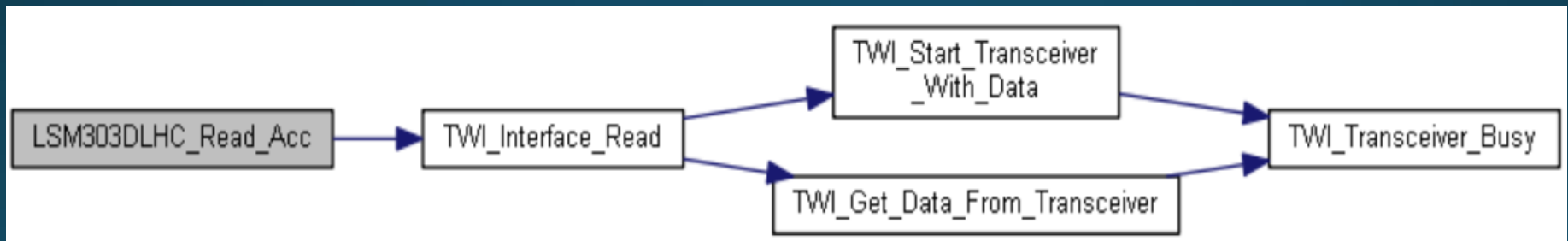
## Task 3



# Task 3: Compass and Accelerometer

## Design and Experiment

- Pololu library
  - C++ conversion
  - Code cleanup
- I2C

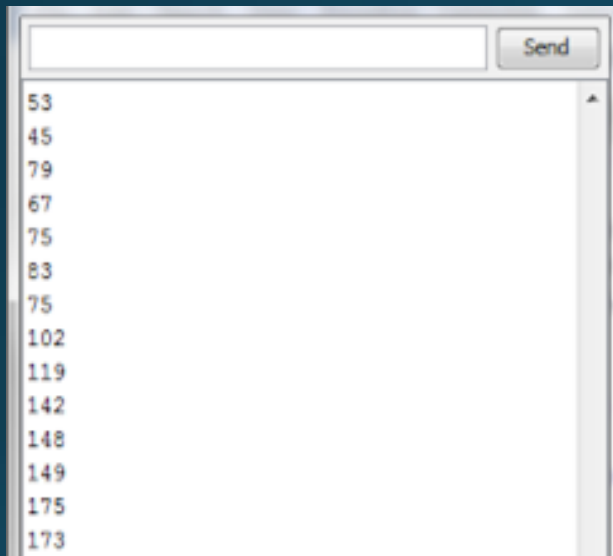


Call graph for the read acceleration register function



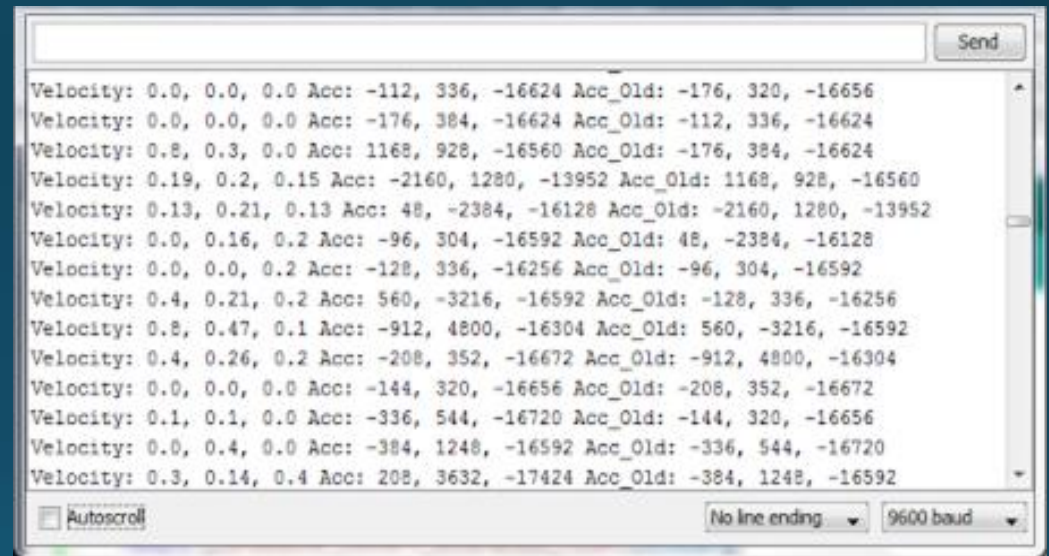
# Task 3: Compass and Accelerometer

## Results



A serial terminal window with a 'Send' button at the top right. The main area contains a list of numbers: 53, 45, 79, 67, 75, 83, 75, 102, 119, 142, 148, 149, 175, 173. The numbers are arranged in a column, with some appearing to be line numbers or indices.

Heading test output



A serial terminal window with a 'Send' button at the top right. The main area contains multiple lines of data, each starting with 'Velocity:' followed by three floating-point numbers, 'Acc:' followed by three integers, and 'Acc\_Old:' followed by three integers. The data is as follows:

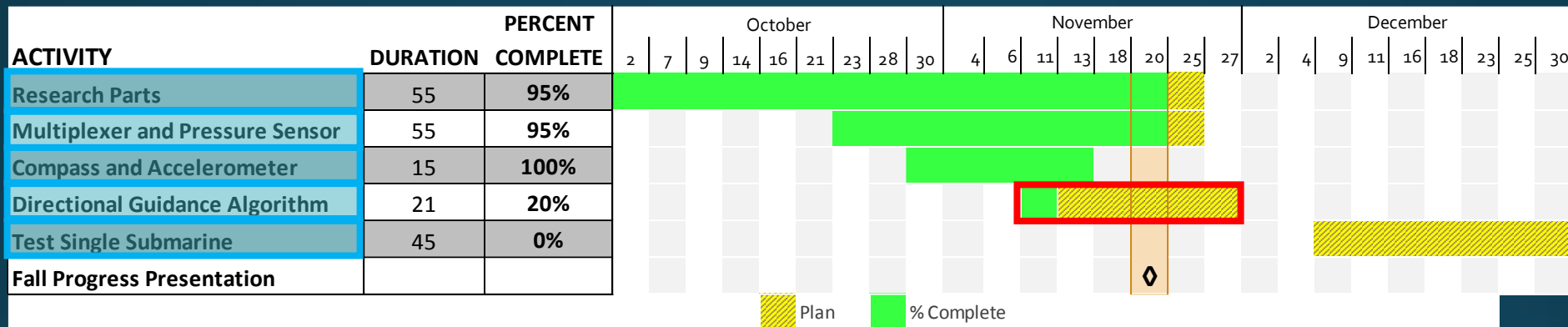
```
Velocity: 0.0, 0.0, 0.0 Acc: -112, 336, -16624 Acc_Old: -176, 320, -16656
Velocity: 0.0, 0.0, 0.0 Acc: -176, 384, -16624 Acc_Old: -112, 336, -16624
Velocity: 0.8, 0.3, 0.0 Acc: 1168, 928, -16560 Acc_Old: -176, 384, -16624
Velocity: 0.19, 0.2, 0.15 Acc: -2160, 1280, -13952 Acc_Old: 1168, 928, -16560
Velocity: 0.13, 0.21, 0.13 Acc: 48, -2384, -16128 Acc_Old: -2160, 1280, -13952
Velocity: 0.0, 0.16, 0.2 Acc: -96, 304, -16592 Acc_Old: 48, -2384, -16128
Velocity: 0.0, 0.0, 0.2 Acc: -128, 336, -16256 Acc_Old: -96, 304, -16592
Velocity: 0.4, 0.21, 0.2 Acc: 560, -3216, -16592 Acc_Old: -128, 336, -16256
Velocity: 0.8, 0.47, 0.1 Acc: -912, 4800, -16304 Acc_Old: 560, -3216, -16592
Velocity: 0.4, 0.26, 0.2 Acc: -208, 352, -16672 Acc_Old: -912, 4800, -16304
Velocity: 0.0, 0.0, 0.0 Acc: -144, 320, -16656 Acc_Old: -208, 352, -16672
Velocity: 0.1, 0.1, 0.0 Acc: -336, 544, -16720 Acc_Old: -144, 320, -16656
Velocity: 0.0, 0.4, 0.0 Acc: -384, 1248, -16592 Acc_Old: -336, 544, -16720
Velocity: 0.3, 0.14, 0.4 Acc: 208, 3632, -17424 Acc_Old: -384, 1248, -16592
```

At the bottom of the window, there is an 'Autoscroll' checkbox (unchecked), a 'No line ending' dropdown menu, and a '9600 baud' dropdown menu.

Velocity test output

# Updated Gantt Chart – Nick Sikkema

## Future work

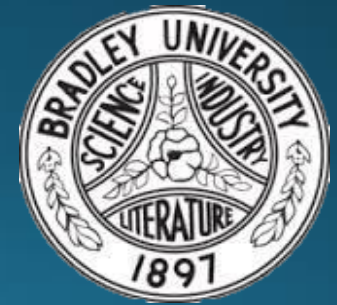


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ENGINEERING, BRADLEY UNIVERSITY

NOVEMBER 20, 2014



# References

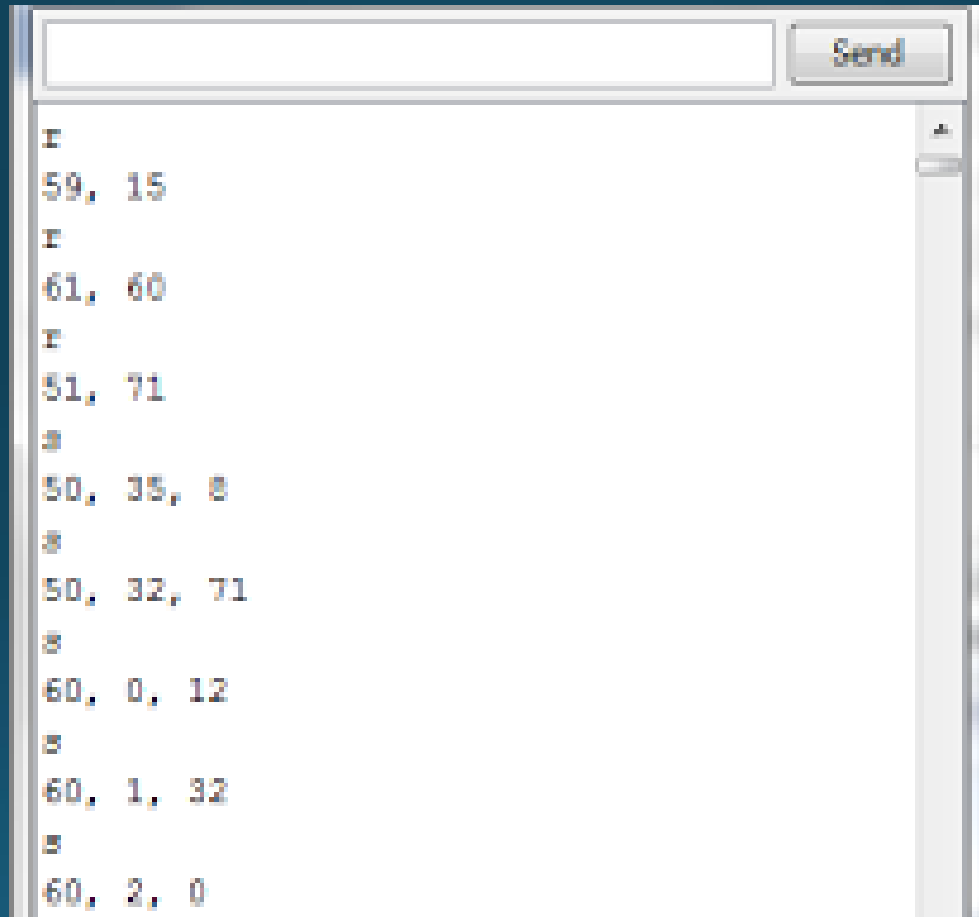
- [1] Silicon Photodiode for the Visible Spectral Range, OSRAM, [online] 2014, <http://www.everlight.com/file/ProductFile/201407061648128798.pdf> (Accessed: 19 November 2014).
- [2] RGB Color Light Sensor Surface – Mount, Everlight, [online] 2013, <http://www.everlight.com/file/ProductFile/201407061648128798.pdf> (Accessed: 19 November 2014).
- [3] "Arduino," Arduino SA, [Online]. Available: <http://arduino.cc/en/Main/arduinoBoardUno>. [Accessed 19 11 2014].
- [4] "Freescale," 10 2012. [Online]. Available: [http://cache.freescale.com/files/sensors/doc/data\\_sheet/MPX2202.pdf](http://cache.freescale.com/files/sensors/doc/data_sheet/MPX2202.pdf). [Accessed 19 11 2014].

# Collision Detection

```
Collision: 0 Acc: -1744, 2272, -18000 Tilt_Acc: -1, 1, -10
Collision: 0 Acc: -1216, 304, -16640 Tilt_Acc: 0, 0, -9
Collision: 1 Acc: -3552, 864, -16752 Tilt_Acc: -2, 0, -9
Collision: 0 Acc: -736, -368, -16592 Tilt_Acc: 0, 0, -9
Collision: 0 Acc: 1984, -336, -16320 Tilt_Acc: 1, 0, -9
Collision: 3 Acc: 7664, 160, -14208 Tilt_Acc: 4, 0, -7
Collision: 3 Acc: 7040, 464, -16448 Tilt_Acc: 3, 0, -9
Collision: 0 Acc: -2304, -160, -13616 Tilt_Acc: -1, 0, -8
Collision: 0 Acc: -1360, 288, -16768 Tilt_Acc: 0, 0, -10
Collision: 1 Acc: -7760, 2984, -7024 Tilt_Acc: -3, 1, -2
Collision: 1 Acc: -3904, -1392, -16944 Tilt_Acc: -2, 0, -9
Collision: 4 Acc: 4176, -3296, -21360 Tilt_Acc: 2, -1, -12
Collision: 0 Acc: -800, 304, -16656 Tilt_Acc: 0, 0, -9
Collision: 0 Acc: -1568, 112, -16768 Tilt_Acc: 0, 0, -9
Collision: 0 Acc: 1408, -32, -16608 Tilt_Acc: 0, 0, -9
Collision: 0 Acc: -2464, -2160, -20992 Tilt_Acc: -1, -1, -12
Collision: 0 Acc: -1456, -4368, -14160 Tilt_Acc: 0, -1, -8
Collision: 0 Acc: -1440, -3600, -15216 Tilt_Acc: 0, -1, -8
Collision: 0 Acc: -1088, -1584, -16864 Tilt_Acc: 0, 0, -10
Collision: 0 Acc: -1424, -448, -16752 Tilt_Acc: 0, 0, -9
Collision: 0 Acc: -944, 448, -16992 Tilt_Acc: 0, 0, -10
```

Collision detection and tilt  
compensation

# I2C Test LSM303DLHC

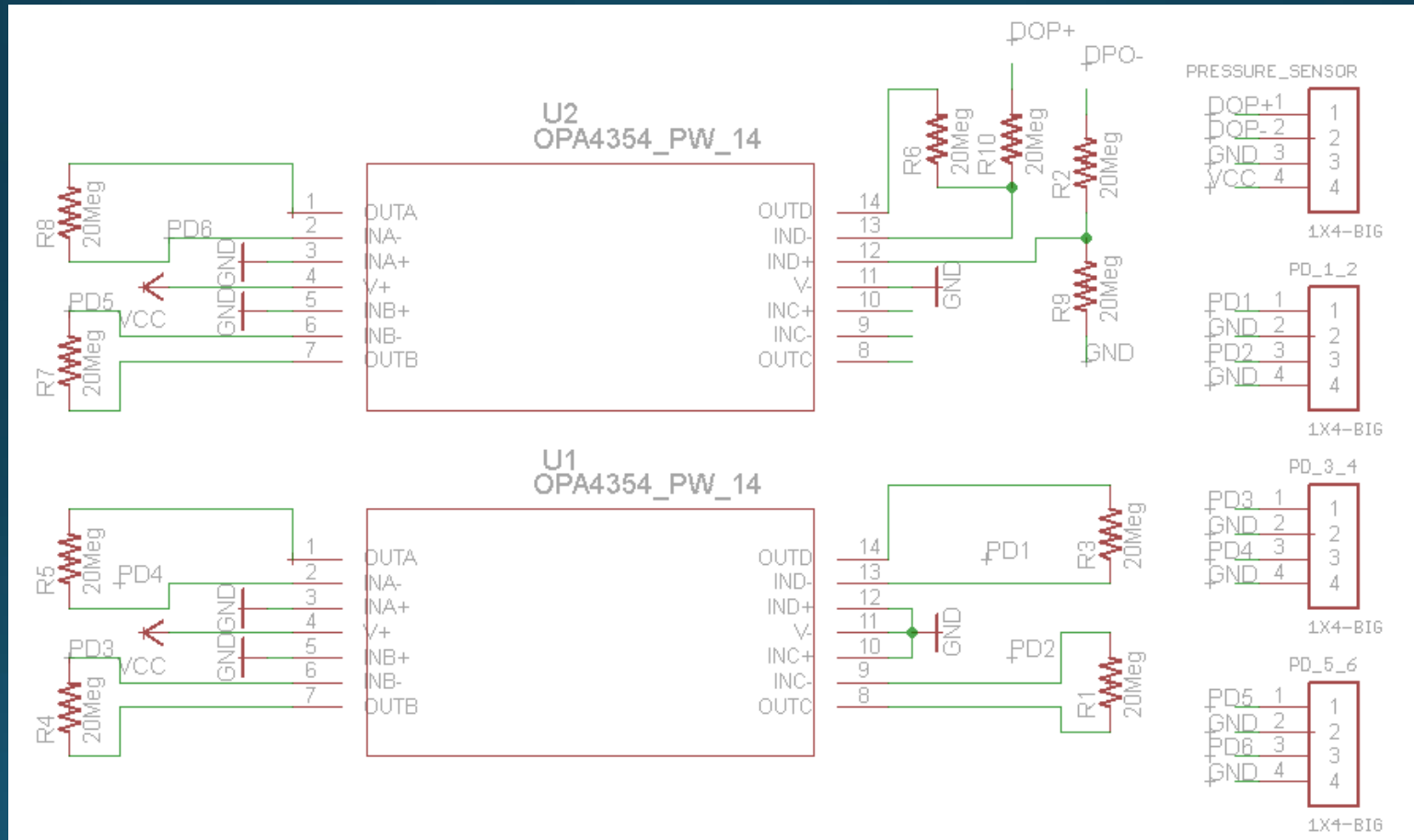


The screenshot shows a window with a 'Send' button at the top right. The main area contains a list of data points, each preceded by a label 'F' or 'S'. The data points are:

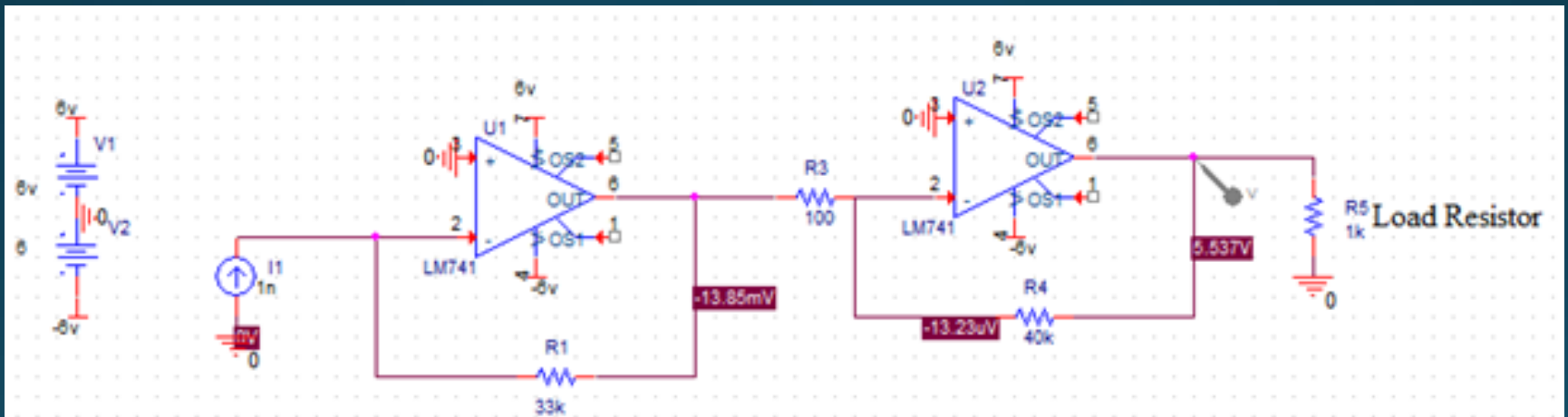
- F 59, 15
- F 61, 60
- F 51, 71
- S 50, 35, 8
- S 50, 32, 71
- S 60, 0, 12
- S 60, 1, 32
- S 60, 2, 0

Initialization I2C test

# Eagle Schematic

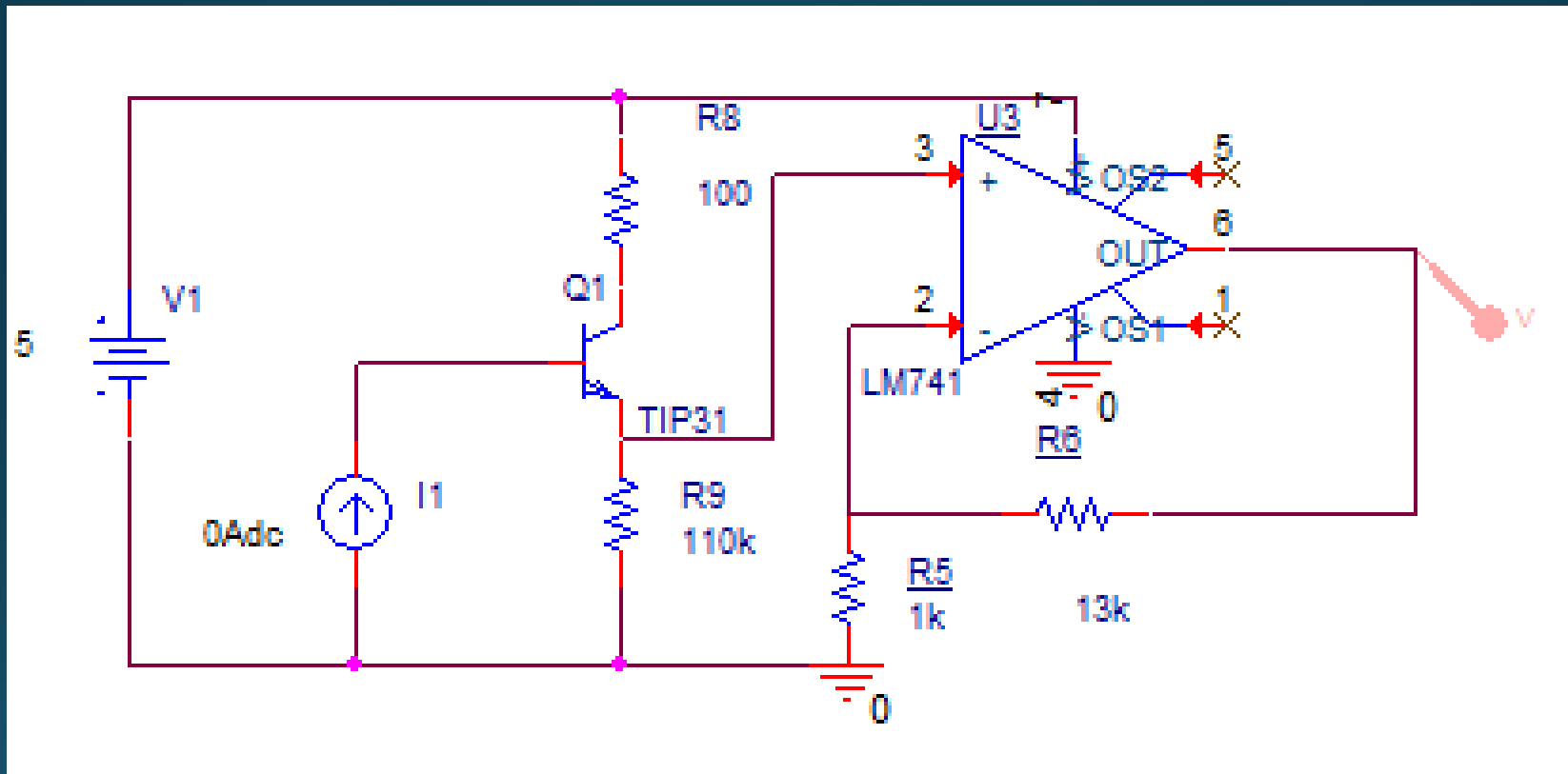


# First amplifier design





# Second photodiode design



# Second design iteration output

