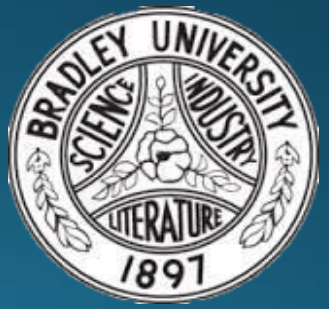
Autonomous Underwater Robots Progress Presentation

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

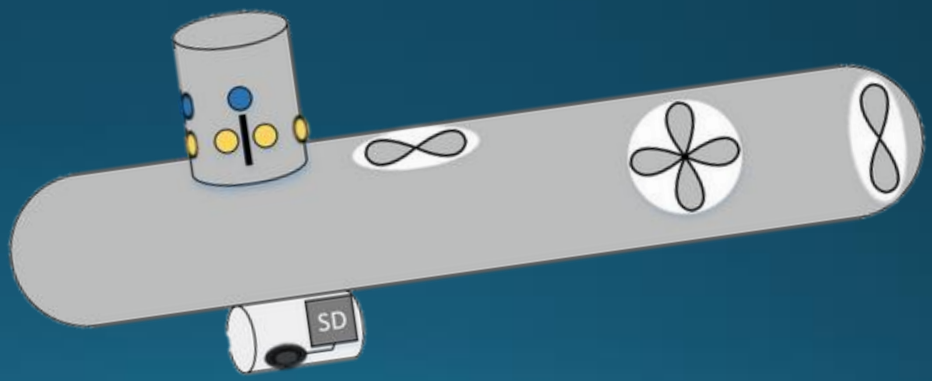
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, BRADLEY UNIVERSITY

NOVEMBER 20, 2014

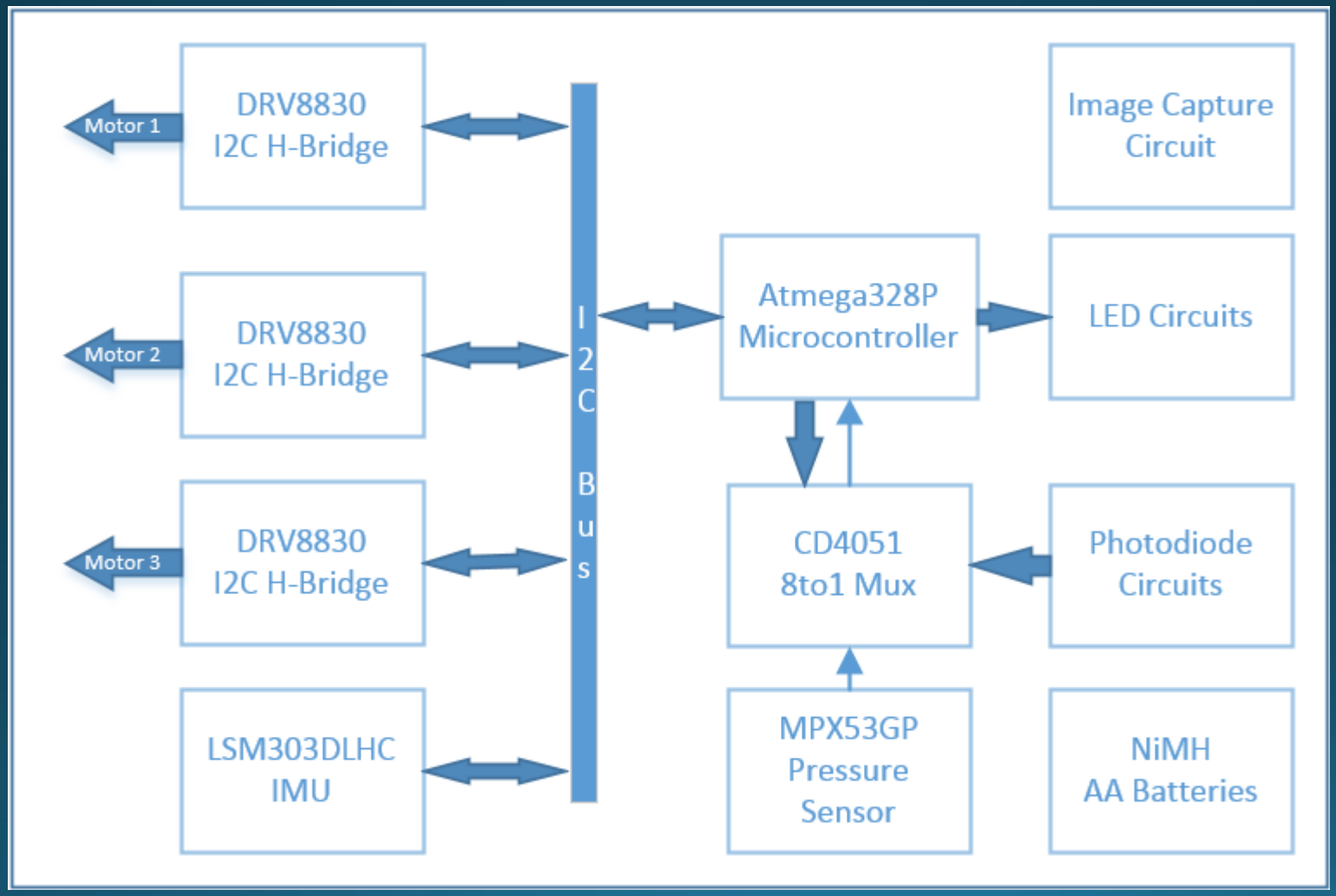


Project Objectives

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

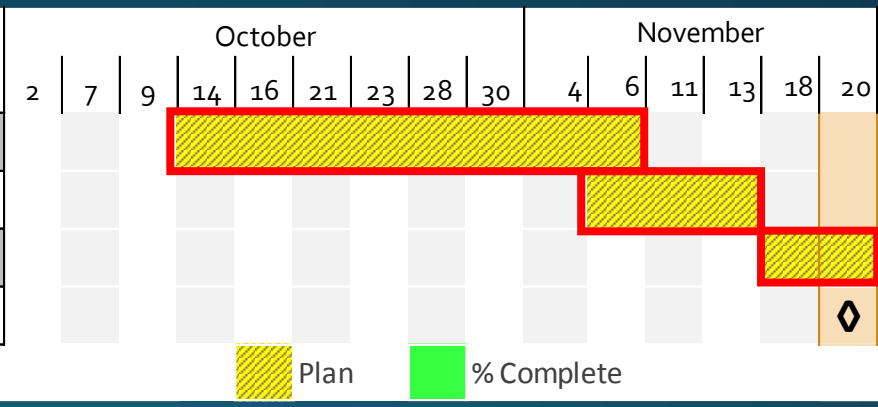


System Block Diagram



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		



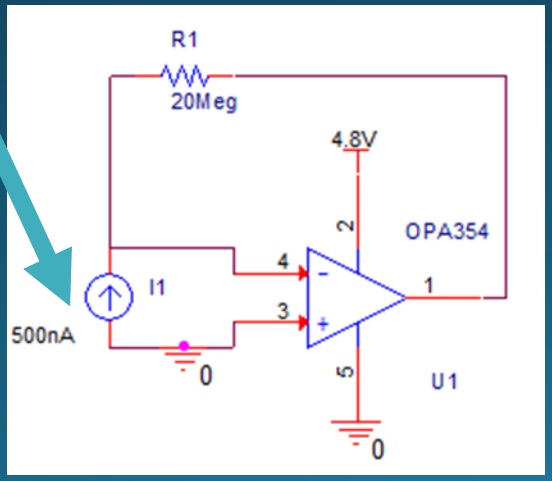
Task 1: Detection Array

Experiment

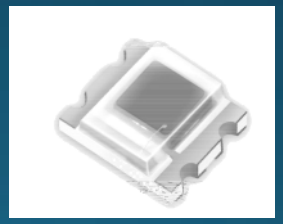
- Amplifier testing
  - Amplifier Design

Model of photodiode

Osram photodiode [1]



Transimpedance amplifier



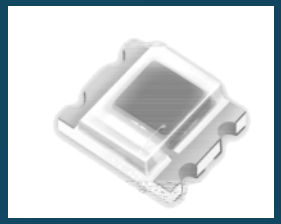
Everlight photodiode [2]

Task 1: Detection Array

Results

- Photodiode testing

Osram photodiode [1]



Everlight photodiode [2]

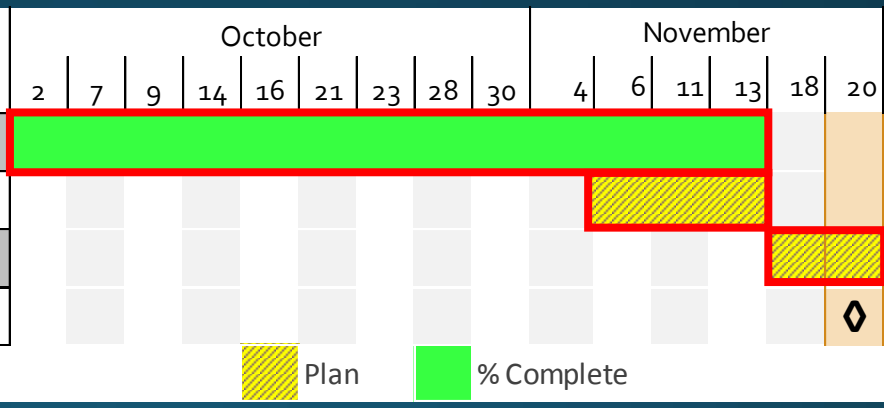
Saturation	**36 inches – 4.9 Volts**	**4 inches – 4.89 Volts**
Max Distance	**180 inches – 0.6 Volts**	**132 Inches -- 0.120 Volts**
Linearity	**Linear**	**Non-Linear**
Ambient Light	**100% Saturation**	**29% Saturation**
Price	**$8.85**	**$0.59**

Photodiode comparison

Updated Gantt Chart – Cameron Putz

Task 2

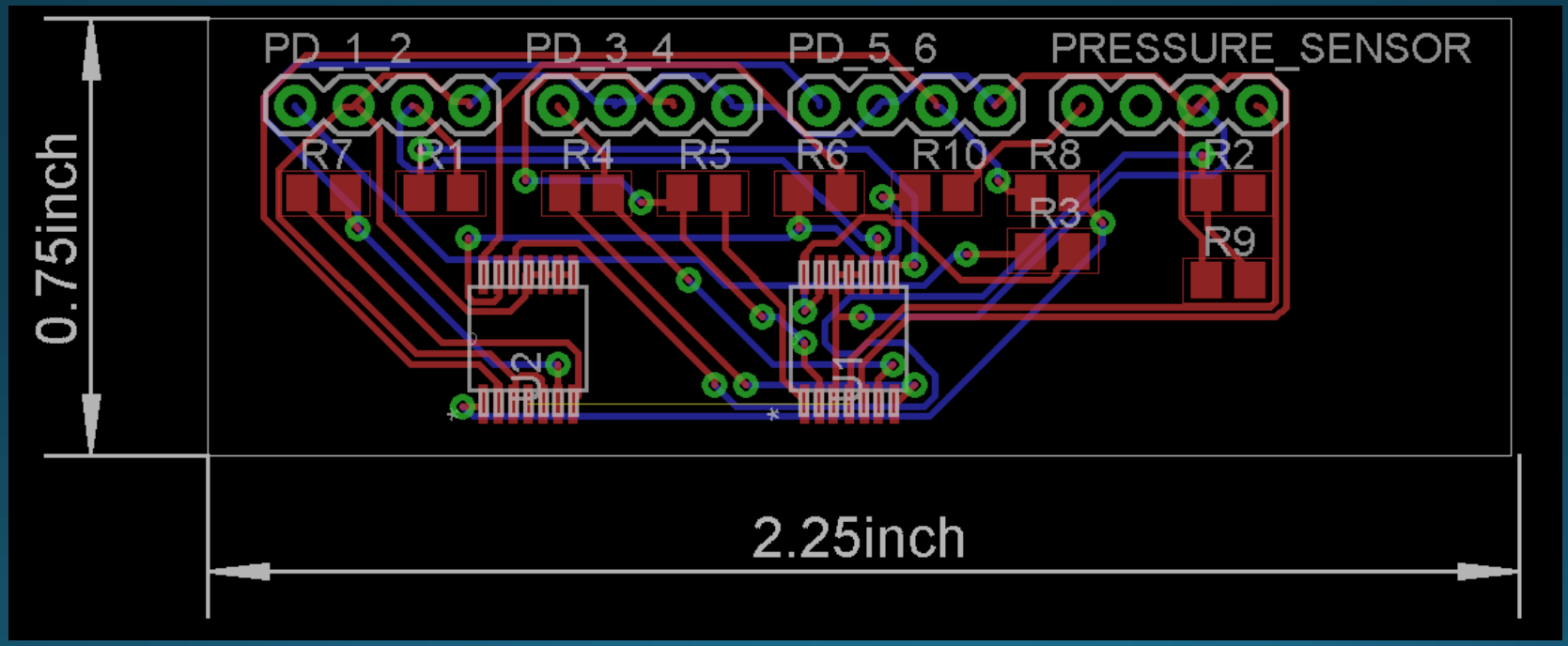
ACTIVITY	DURATION	PERCENT COMPLETE
Detection Array Simulation and Testing	57	100%
Circuit and System Layout	8	0%
Assemble and Test Single Submarine	34	0%
Fall Progress Presentation		



Task 2: Circuit Layout

Results

- Eagle 7.1.0
  - Dr. Driscoll has experience

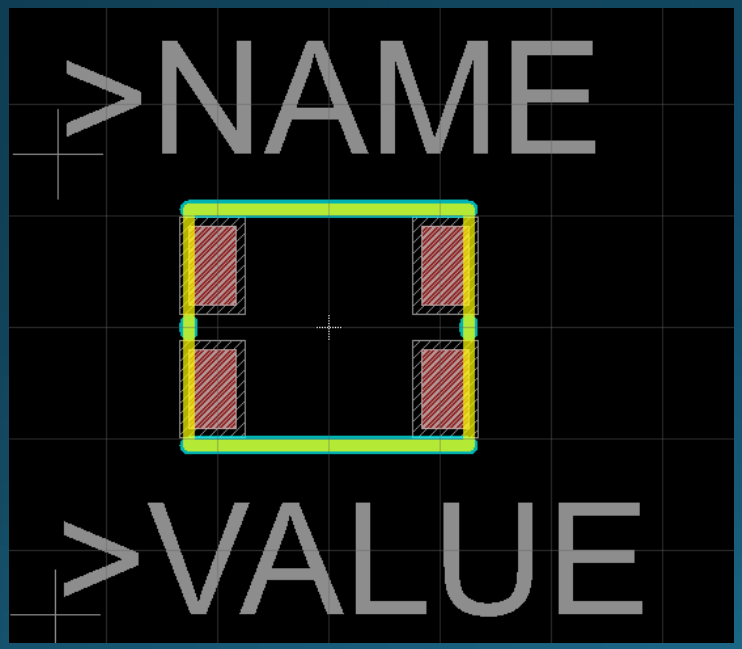


First iteration of the detection array surface mount board

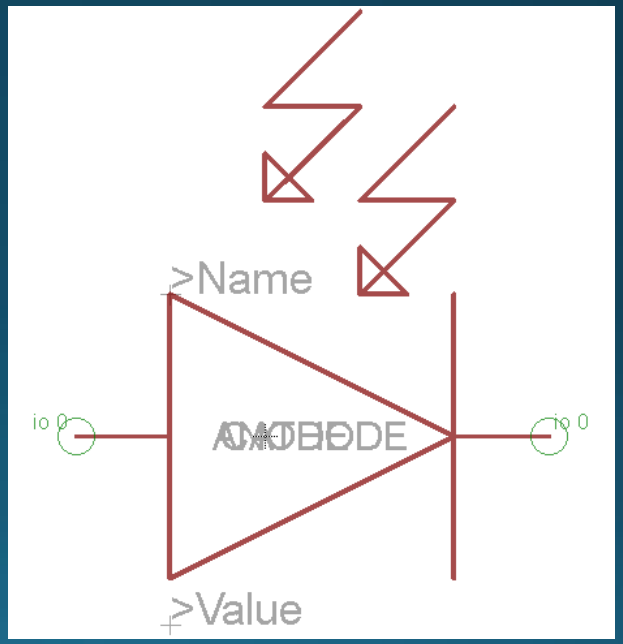
Task 2: Circuit Layout

Results

- Eagle 7.1.0
  - Still a lot to learn



First library package Everlight photodiode

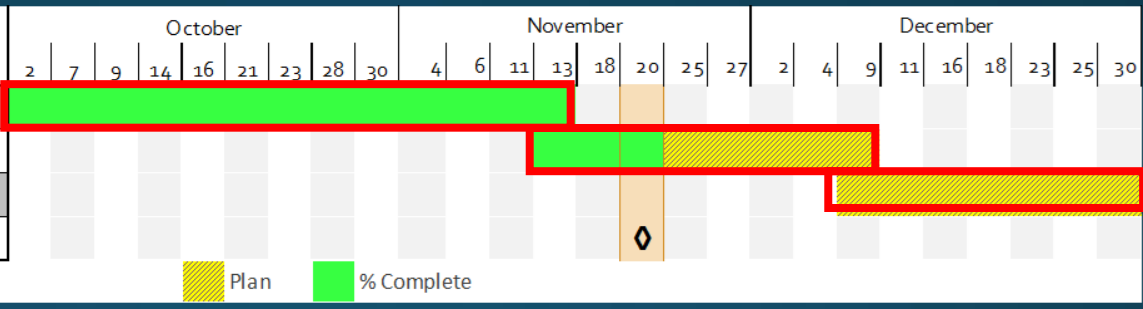


First library symbol Everlight photodiode

Updated Gantt Chart – Cameron Putz

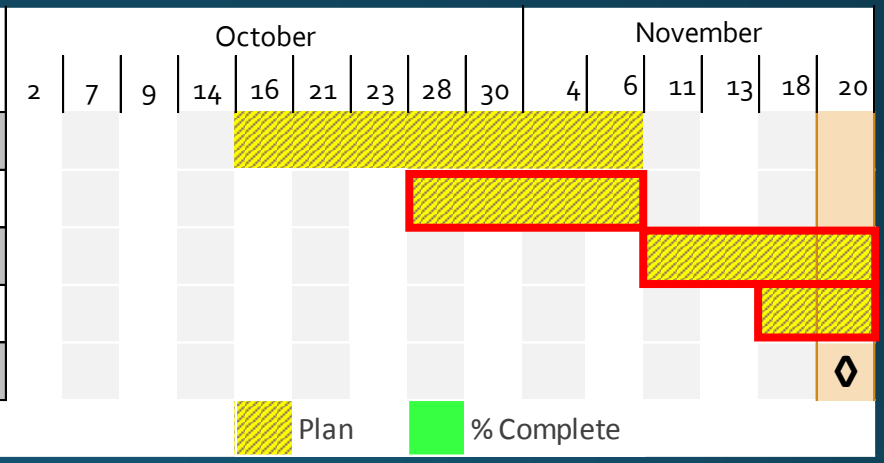
Future work

ACTIVITY	DURATION	PERCENT COMPLETE
Detection Array Simulation and Testing	57	100%
Circuit and System Layout	27	35%
Assemble and Test Single Submarine	43	0%
Fall Progress Presentation		



Original Gantt Chart – Ryan Lipski

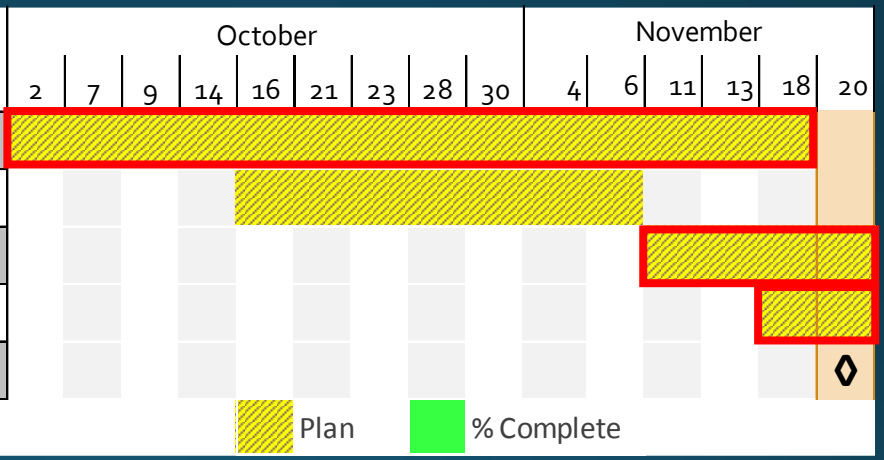
ACTIVITY	DURATION	PERCENT COMPLETE
Motor Control and Power Design	22	0%
Detection Array Testing and Validation	15	0%
Directional Guidance Algorithm Design	21	0%
Single Submarine Testing	34	0%
Fall Progress Presentation		



Updated Gantt Chart – Ryan Lipski

Task 1

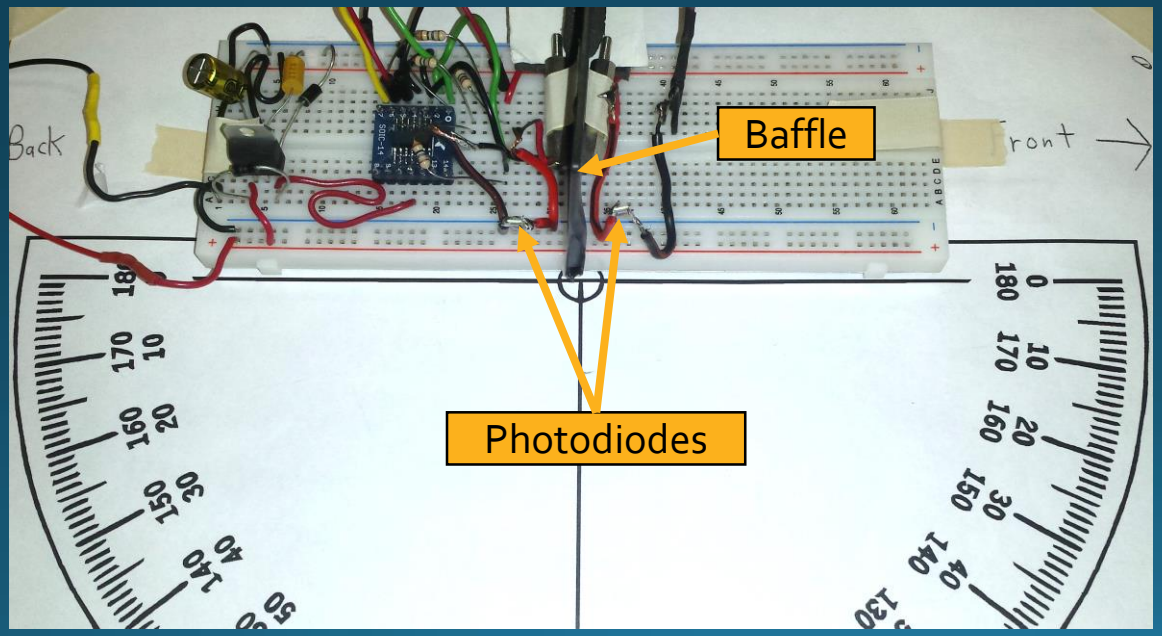
ACTIVITY	DURATION	PERCENT COMPLETE
Detection Array Testing and Validation	48	0%
Motor Control and Power Design	22	0%
Directional Guidance Algorithm Design	21	0%
Single Submarine Testing	34	0%
Fall Progress Presentation		



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

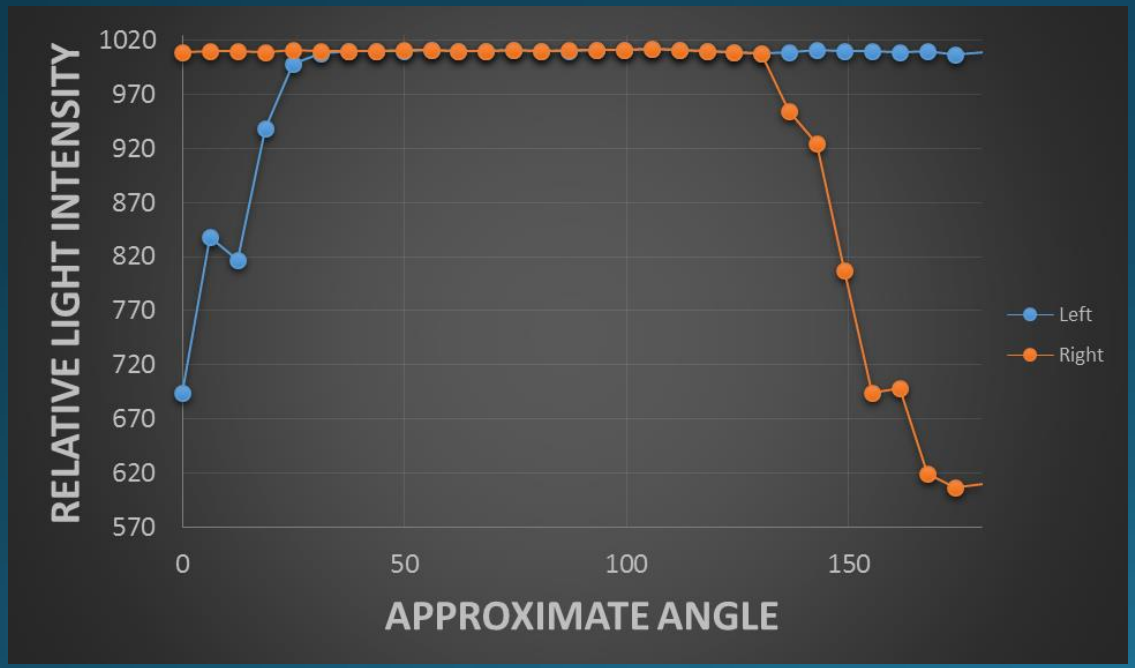


Baffle test setup

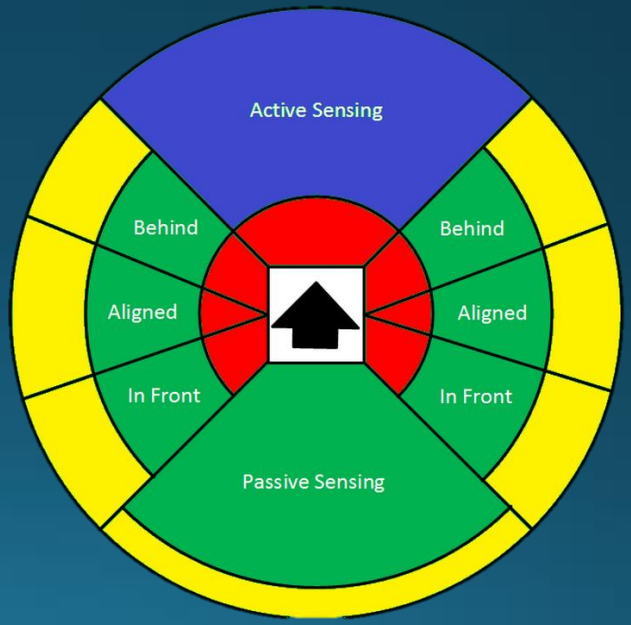
Task 1: Detection Array

Results

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



Left vs right photodiode (5 mm baffle)



Detection zones

Task 1: Detection Array

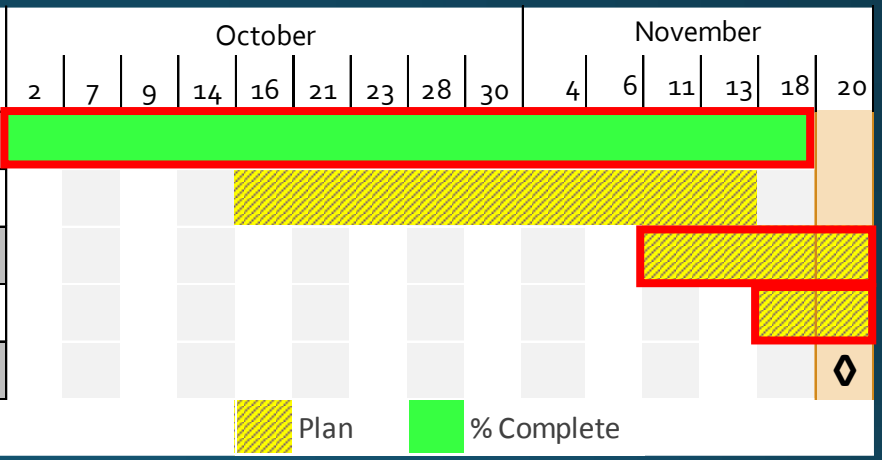
Experiment

- 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

ACTIVITY	DURATION	PERCENT COMPLETE
Detection Array Testing and Validation	48	100%
Motor Control and Power Design	31	0%
Directional Guidance Algorithm Design	21	0%
Single Submarine Testing	34	0%
Fall Progress Presentation		



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

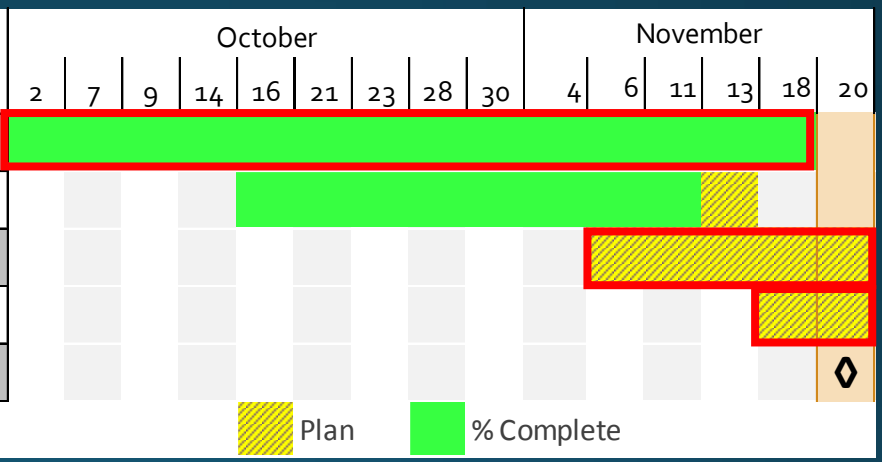
Design

- 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

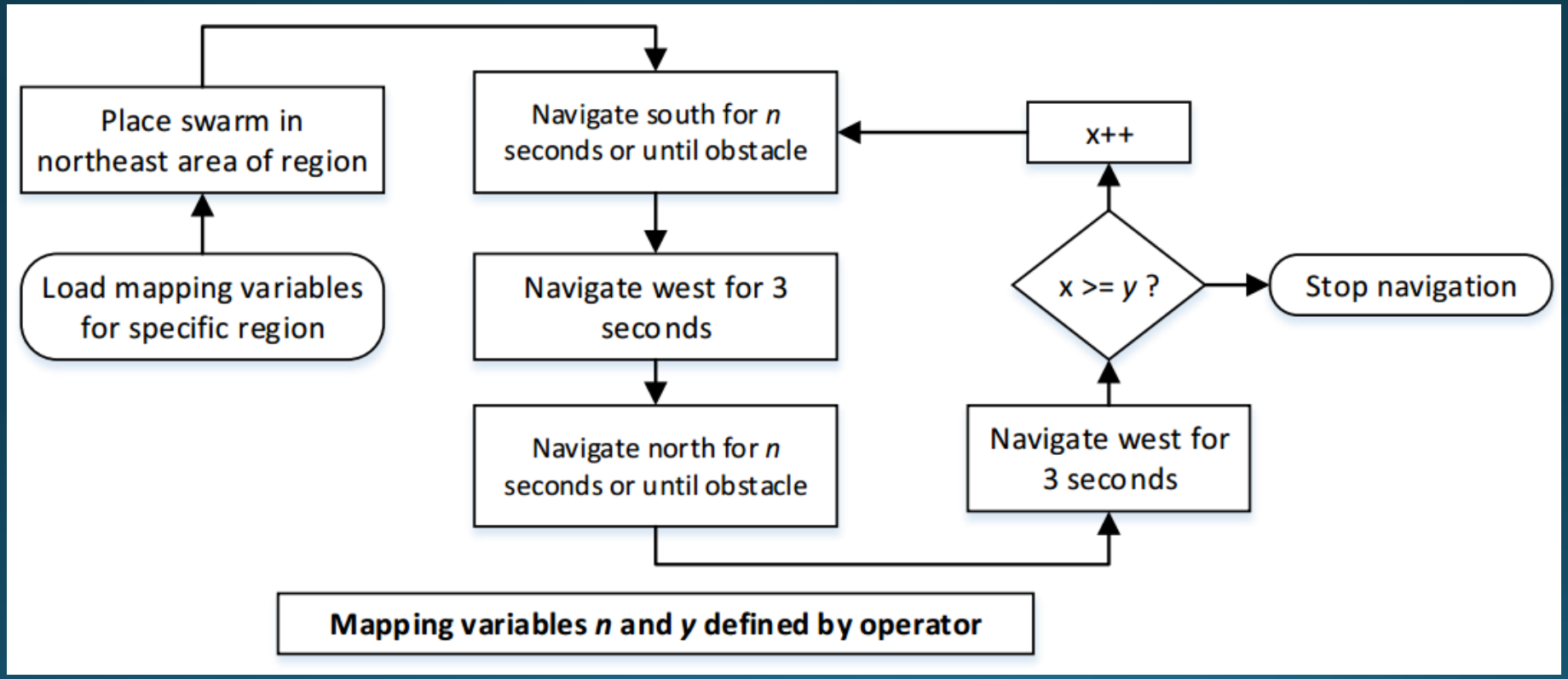
Task 3

ACTIVITY	DURATION	PERCENT COMPLETE
Detection Array Testing and Validation	48	100%
Motor Control and Power Design	31	90%
Directional Guidance Algorithm Design	24	0%
Single Submarine Testing	34	0%
Fall Progress Presentation		



Task 3: Directional Guidance Algorithm

Design

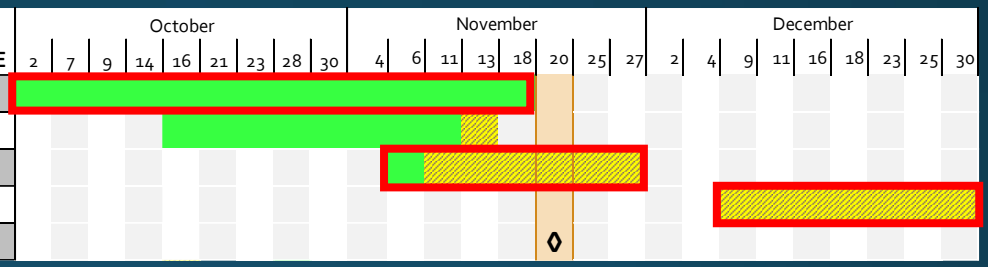


Directional Guidance Flowchart

Updated Gantt Chart – Ryan Lipski

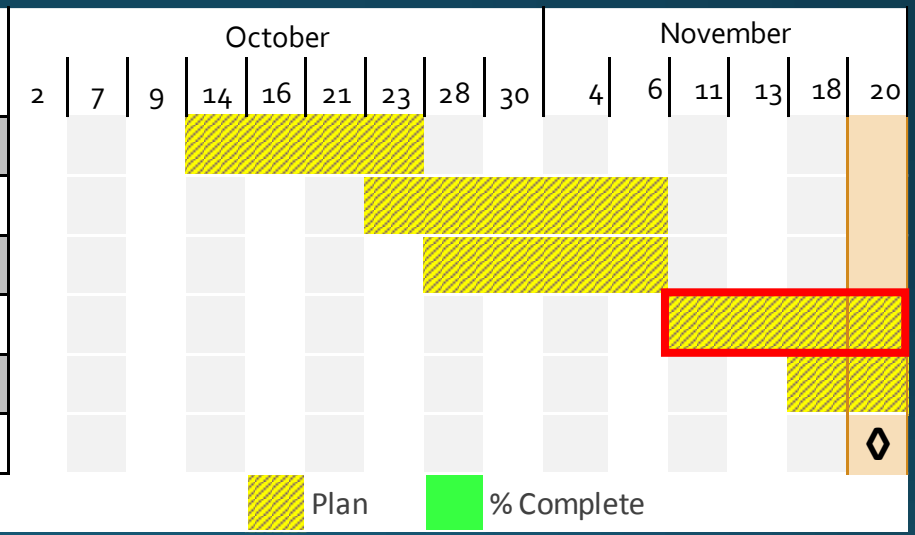
Future work

ACTIVITY	PLAN START	PLAN FINISH	DURATION	PERCENT COMPLETE
Detection Array Testing and Validation	10/2/2014	11/18/2014	48	100%
Motor Control and Power Design	10/16/2014	11/15/2014	31	90%
Directional Guidance Algorithm Design	11/6/2014	11/29/2014	24	20%
Single Submarine Testing	12/9/2014	1/22/2015	45	0%
Fall Progress Presentation				



Original Gantt Chart – Nick Sikkema

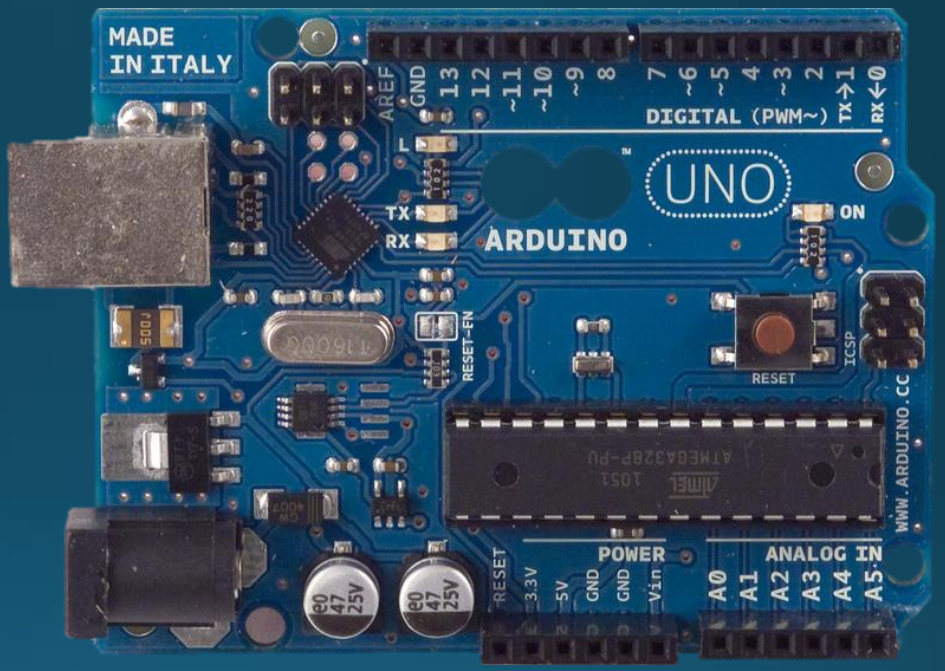
ACTIVITY	DURATION	PERCENT COMPLETE
Research Parts	13	0%
Multiplexer and Pressure Sensor	15	0%
Compass and Accelerometer	10	0%
Directional Guidance Algorithm	21	0%
Test Single Submarine	34	0%
Fall Progress Presentation		



Task 1: Research Parts

Research

- Microcontroller
  - ADC
  - Multiplexer (CD4051)
  - Atmega328P

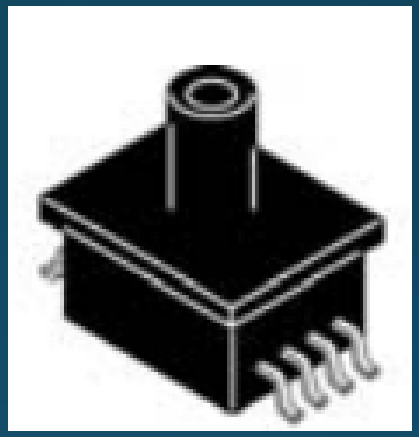


Atmega328P breakout board [3]

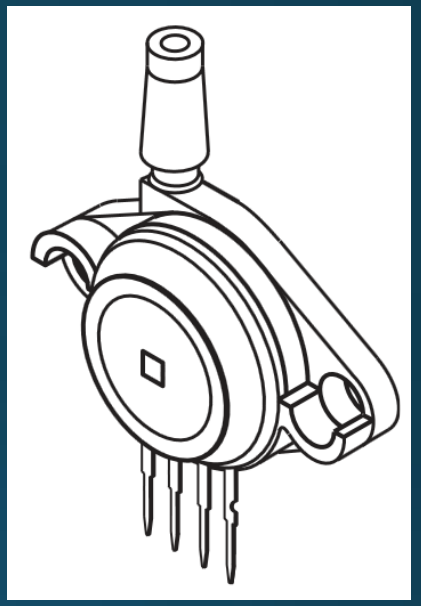
Task 1: Research Parts

Research

- Pressure sensor
  - Package
  - Gauge vs absolute



MPAK package [4]

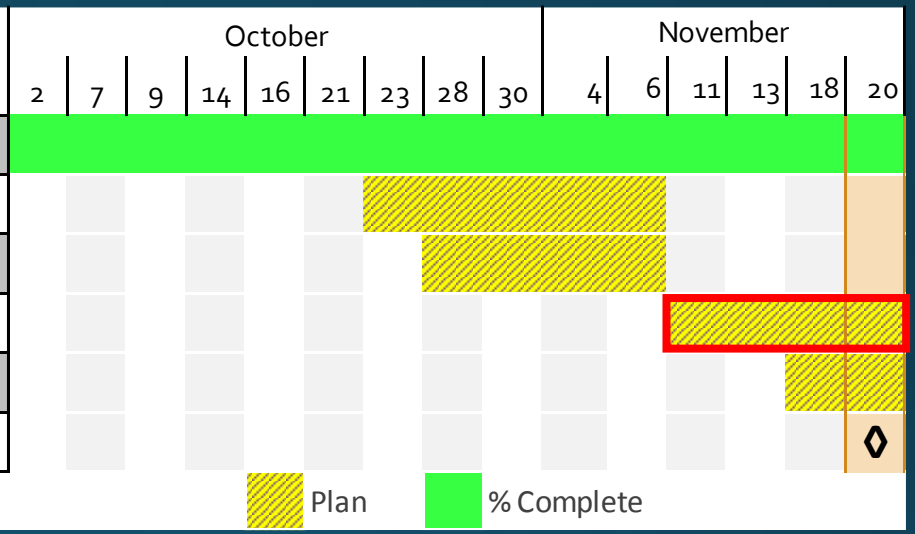


Unibody package [4]

Updated Gantt Chart – Nick Sikkema

Task 2

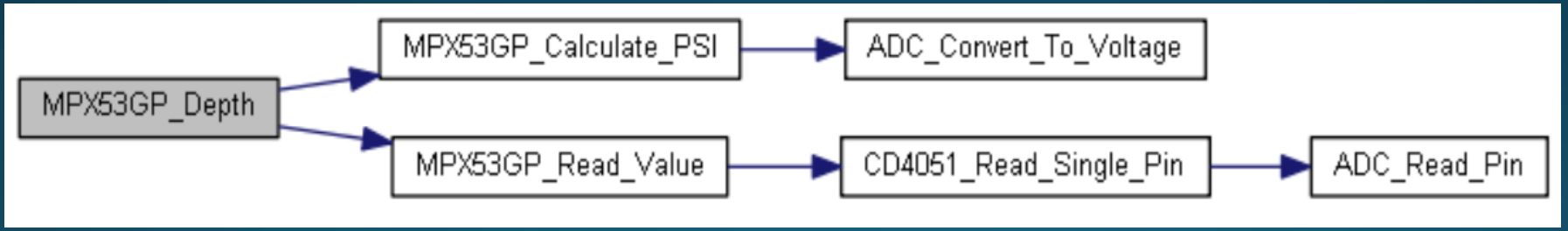
ACTIVITY	DURATION	PERCENT COMPLETE
Research Parts	55	95%
Multiplexer and Pressure Sensor	15	0%
Compass and Accelerometer	10	0%
Directional Guidance Algorithm	21	0%
Test Single Submarine	34	0%
Fall Progress Presentation		



Task 2: Multiplexer and Pressure

Design and Experiment

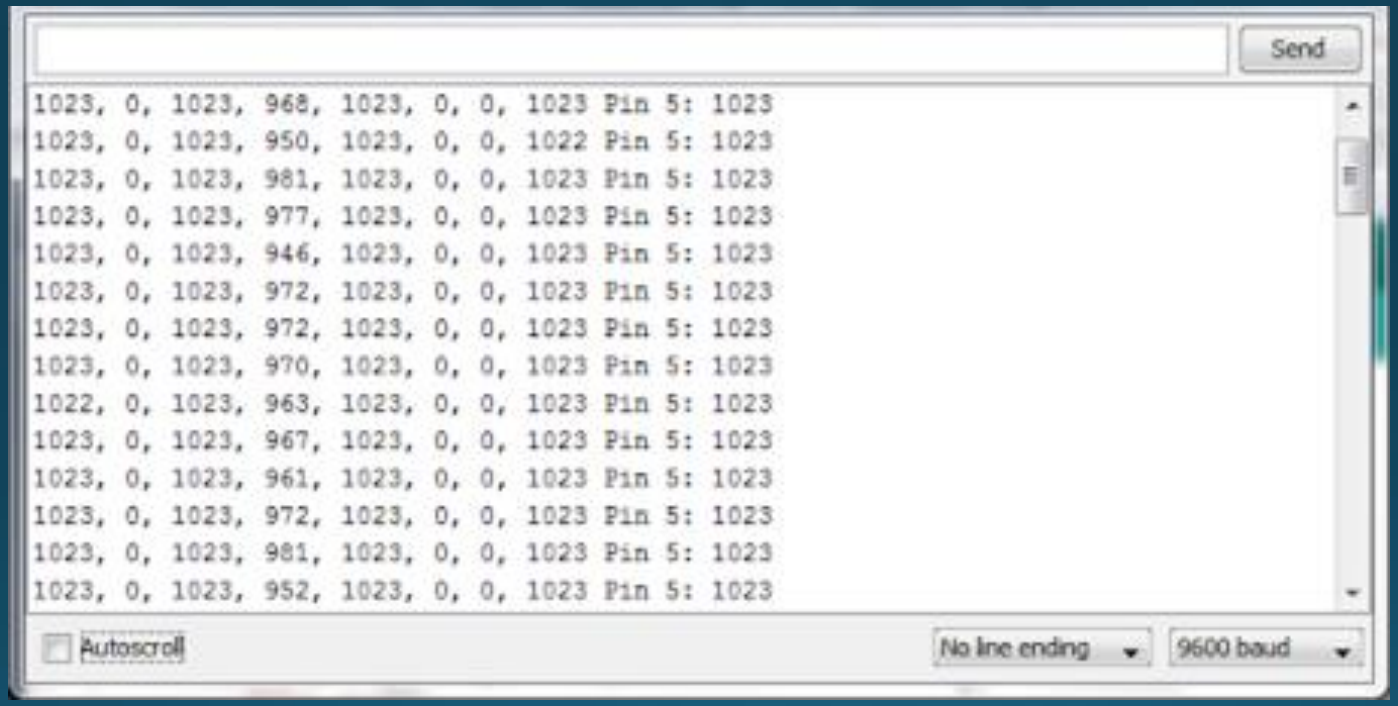
- 8 to 1 multiplexer (CD4051)
- Pressure sensor (MPX53GP)
  - Differential output
  - Gauge vs absolute



Call graph for the depth function

Task 2: Multiplexer and Pressure

Results

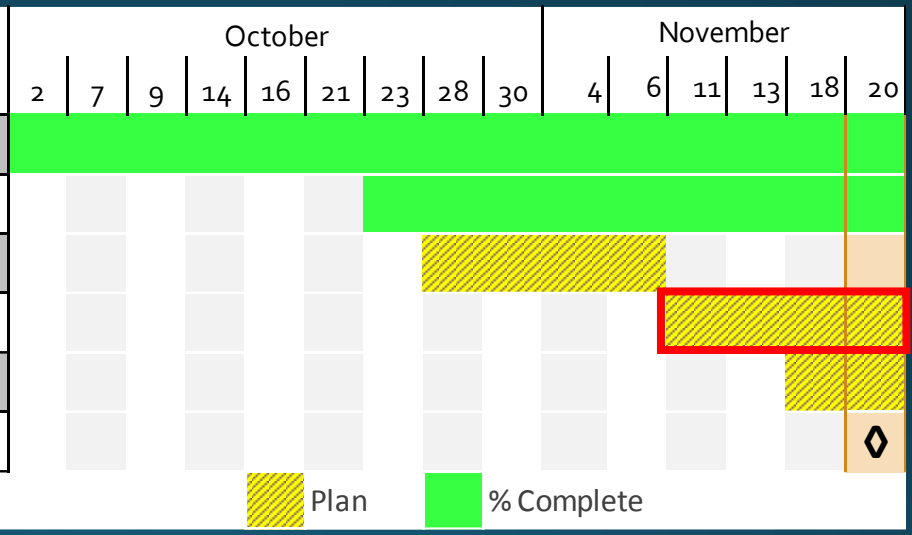


Multiplexer ADC test output

Updated Gantt Chart – Nick Sikkema

Task 3

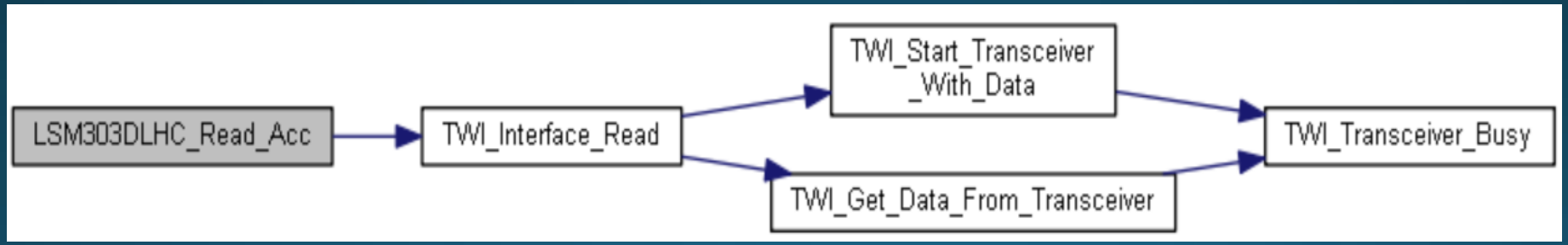
ACTIVITY	DURATION	PERCENT COMPLETE
Research Parts	55	95%
Multiplexer and Pressure Sensor	55	95%
Compass and Accelerometer	10	0%
Directional Guidance Algorithm	21	0%
Test Single Submarine	34	0%
Fall Progress Presentation		



Task 3: Compass and Accelerometer

Design and Experiment

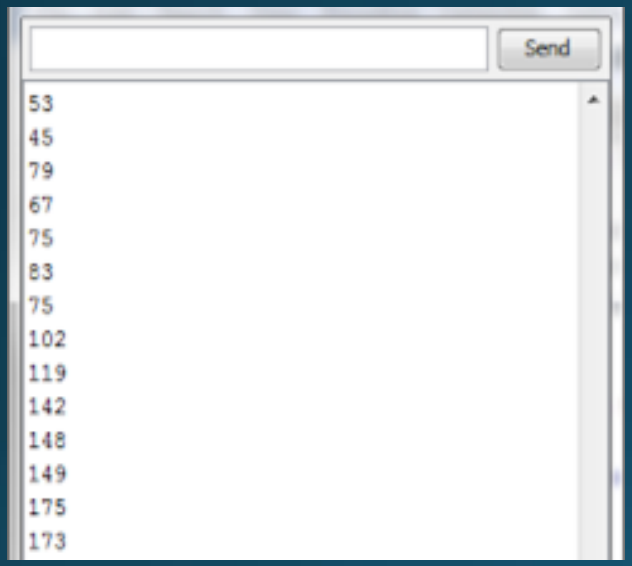
- Pololu library
  - C++ conversion
  - Code cleanup
- I2C



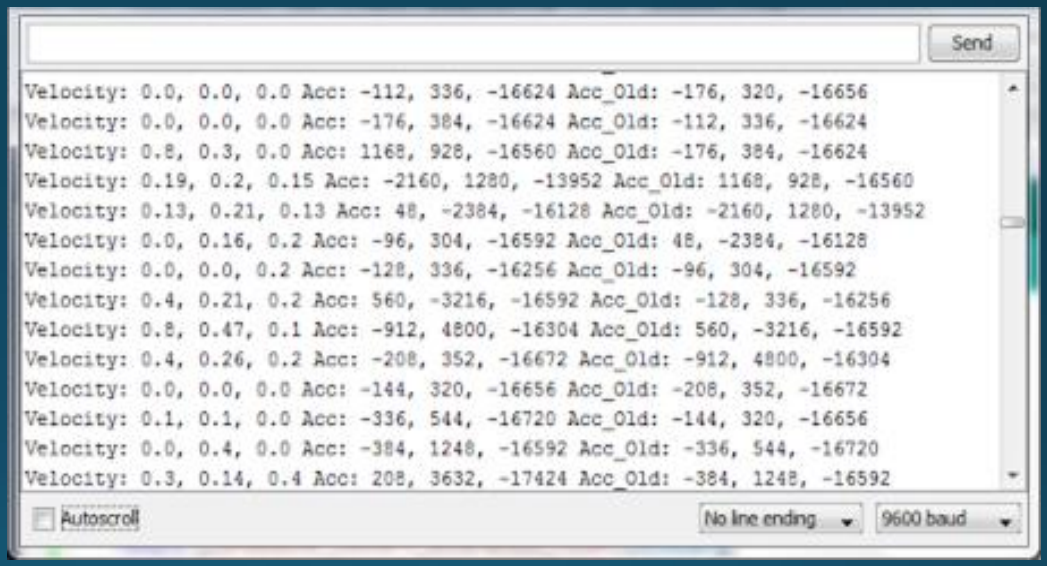
Call graph for the read acceleration register function

Task 3: Compass and Accelerometer

Results



Heading test output

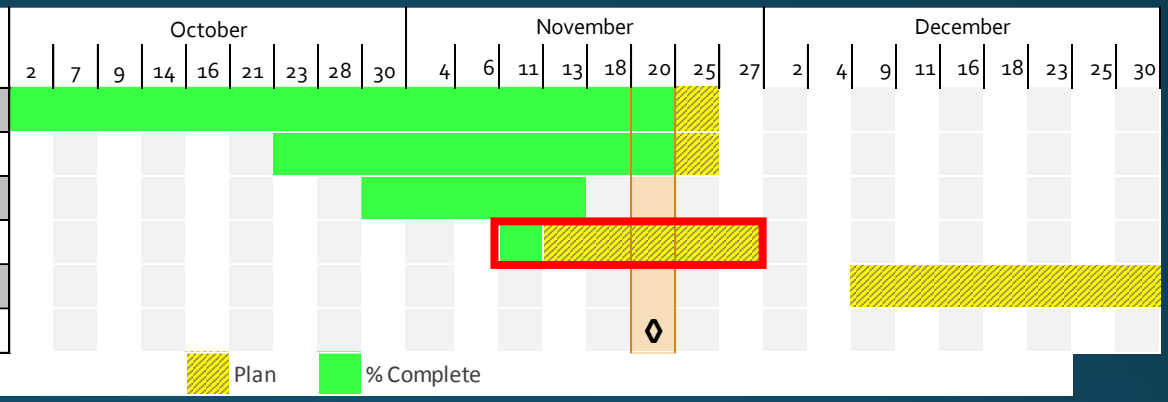


Velocity test output

Updated Gantt Chart – Nick Sikkema

Future work

ACTIVITY	DURATION	PERCENT COMPLETE
Research Parts	55	95%
Multiplexer and Pressure Sensor	55	95%
Compass and Accelerometer	15	100%
Directional Guidance Algorithm	21	20%
Test Single Submarine	45	0%
Fall Progress Presentation		



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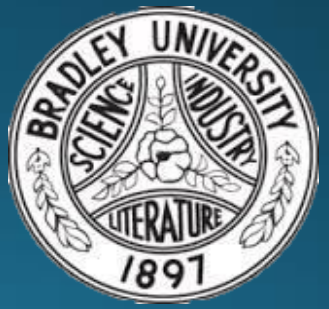
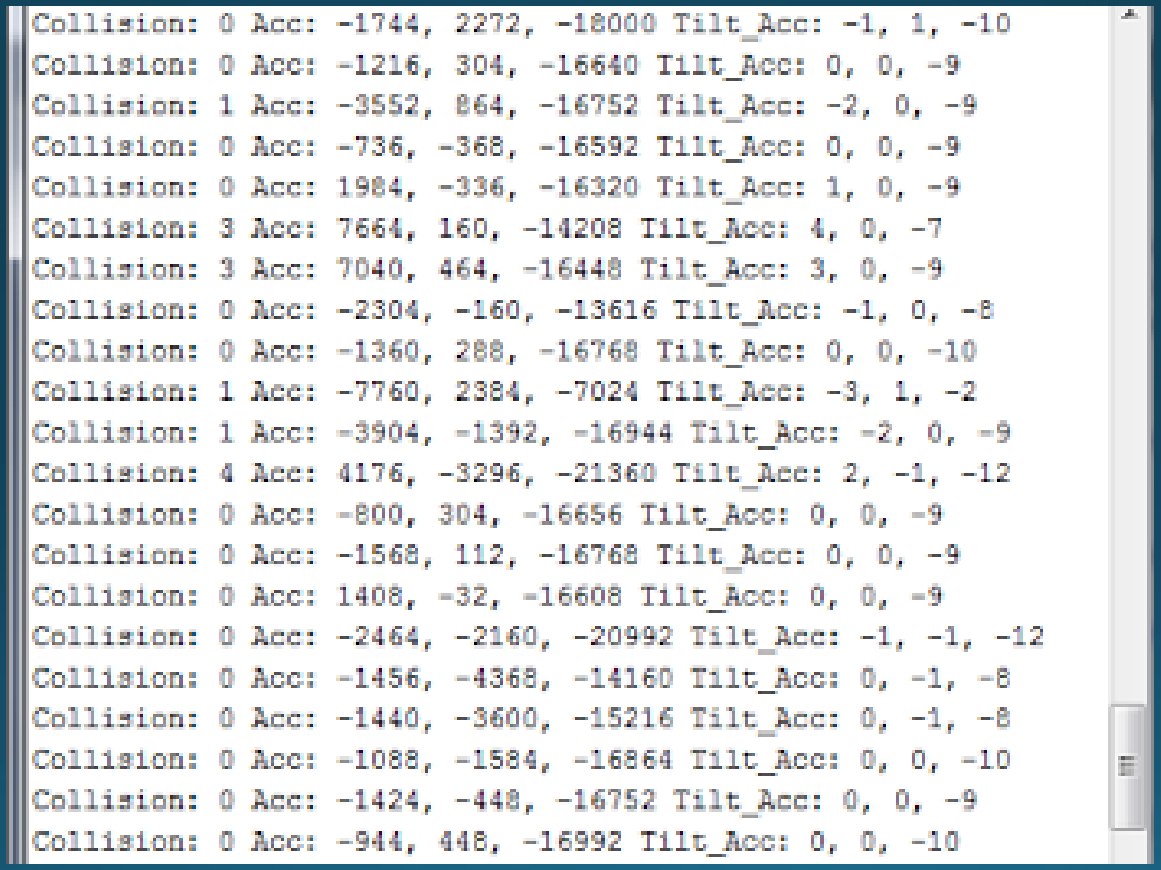


References

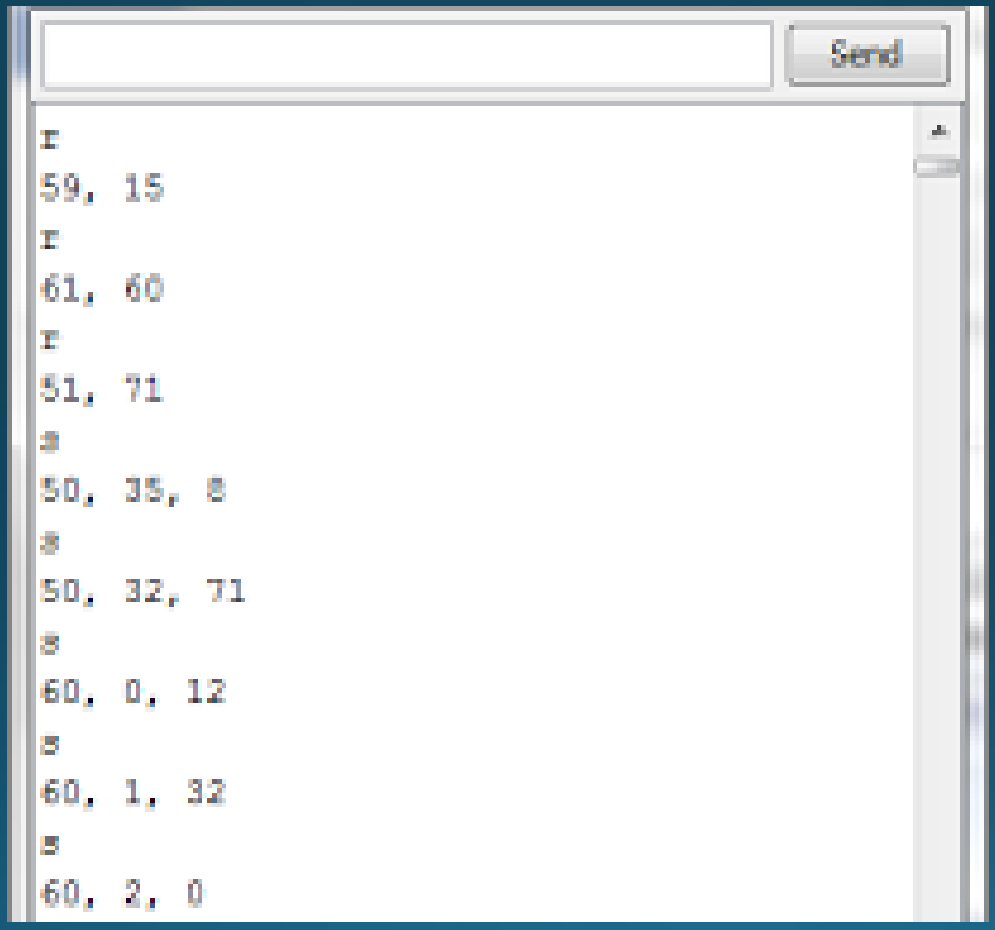
- [1] Silicon Photodiode for the Visible Spectral Range, OSRAM, [online] 2014, http://www.everlight.com/file/ProductFile/201407061648128798.pdf (Accessed: 19 November 2014).
- [2] RGB Color Light Sensor Surface – Mount, Everlight, [online] 2013, http://www.everlight.com/file/ProductFile/201407061648128798.pdf (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. [Accessed 19 11 2014].

Collision Detection



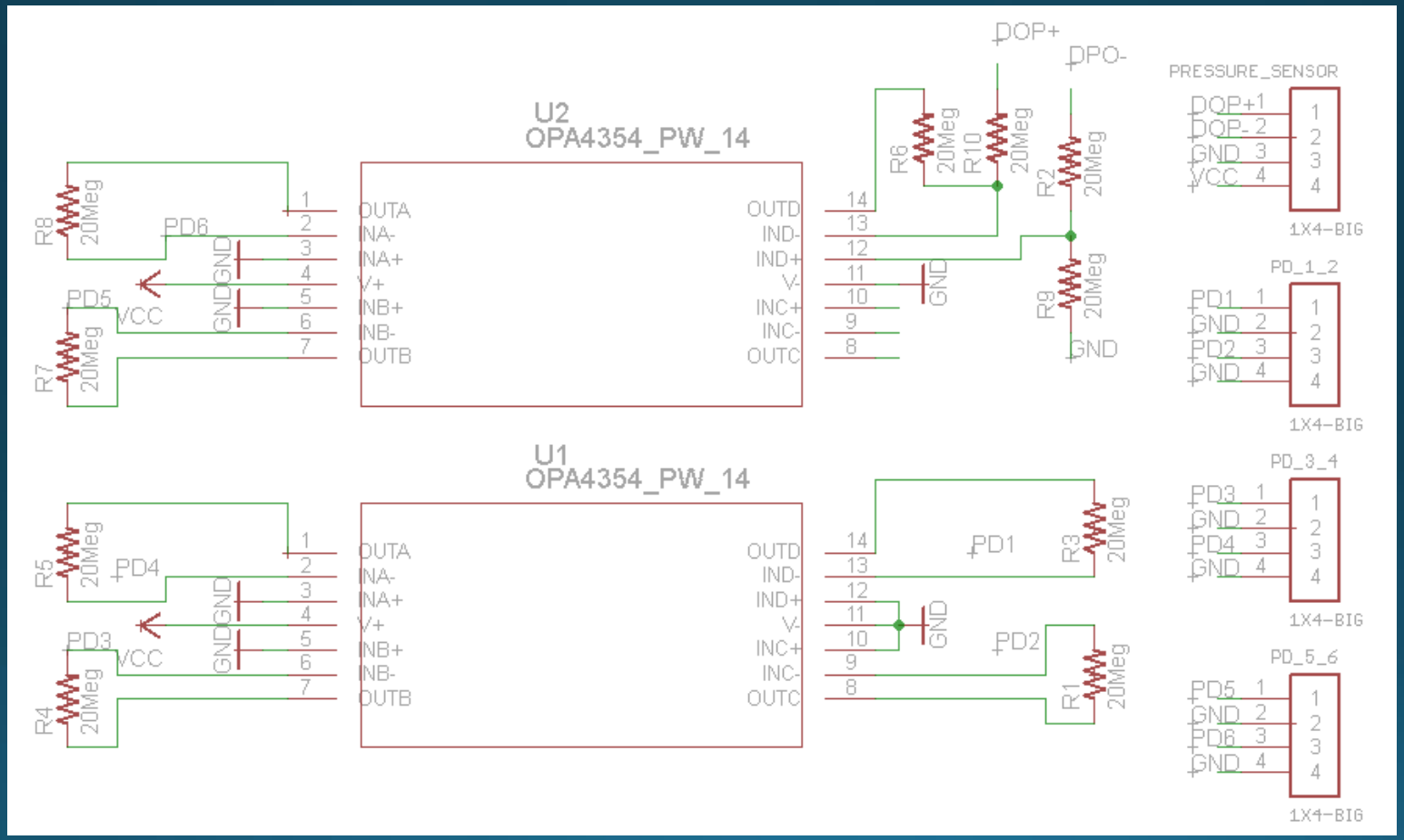
Collision detection and tilt compensation

I2C Test LSM303DLHC

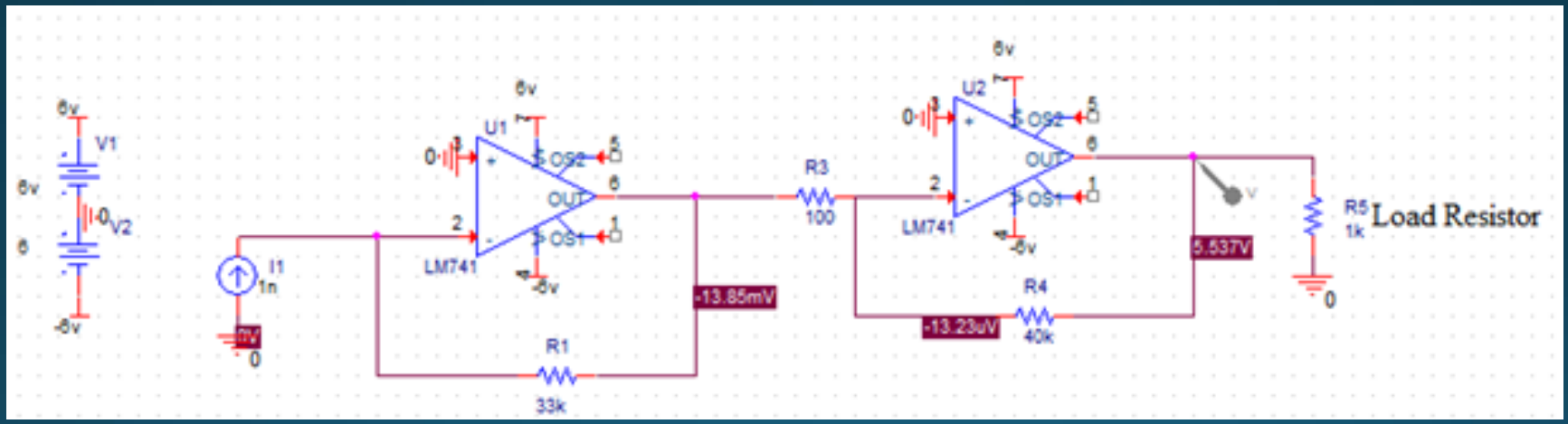


Initialization I2C test

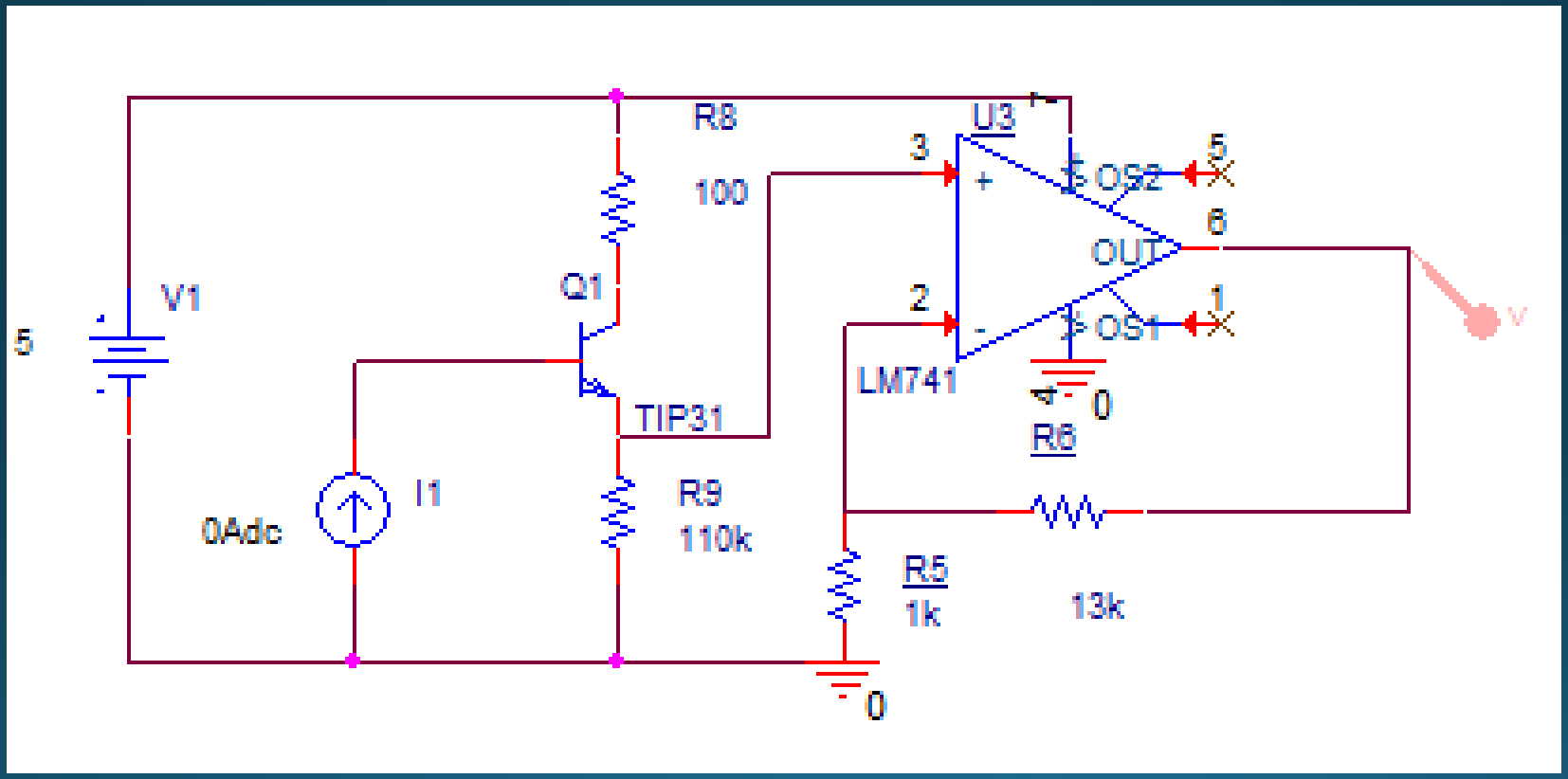
Eagle Schematic



First amplifier design



Second photodiode design



Second design iteration output