PROJECT E.A.S.I.

ELECTRONIC ASSISTANT FOR THE SIGHT IMPAIRED

GROUP 35

HEATH CISSELL	CPE
STEPHEN MILES	EE
PATRICK SHIVER	EE
HUNG TRAN	CPE

MOTIVATION

- 285 million people worldwide are visually impaired
- Of those, 39 million are blind
- Guide dogs can be cumbersome and often attract unwanted attention
- White cane is too noticeable and has a limited range
- Need an alternative that is discreet and provides more features

*Statistics are taken from World Health Organization's fact sheet updated in August 2014

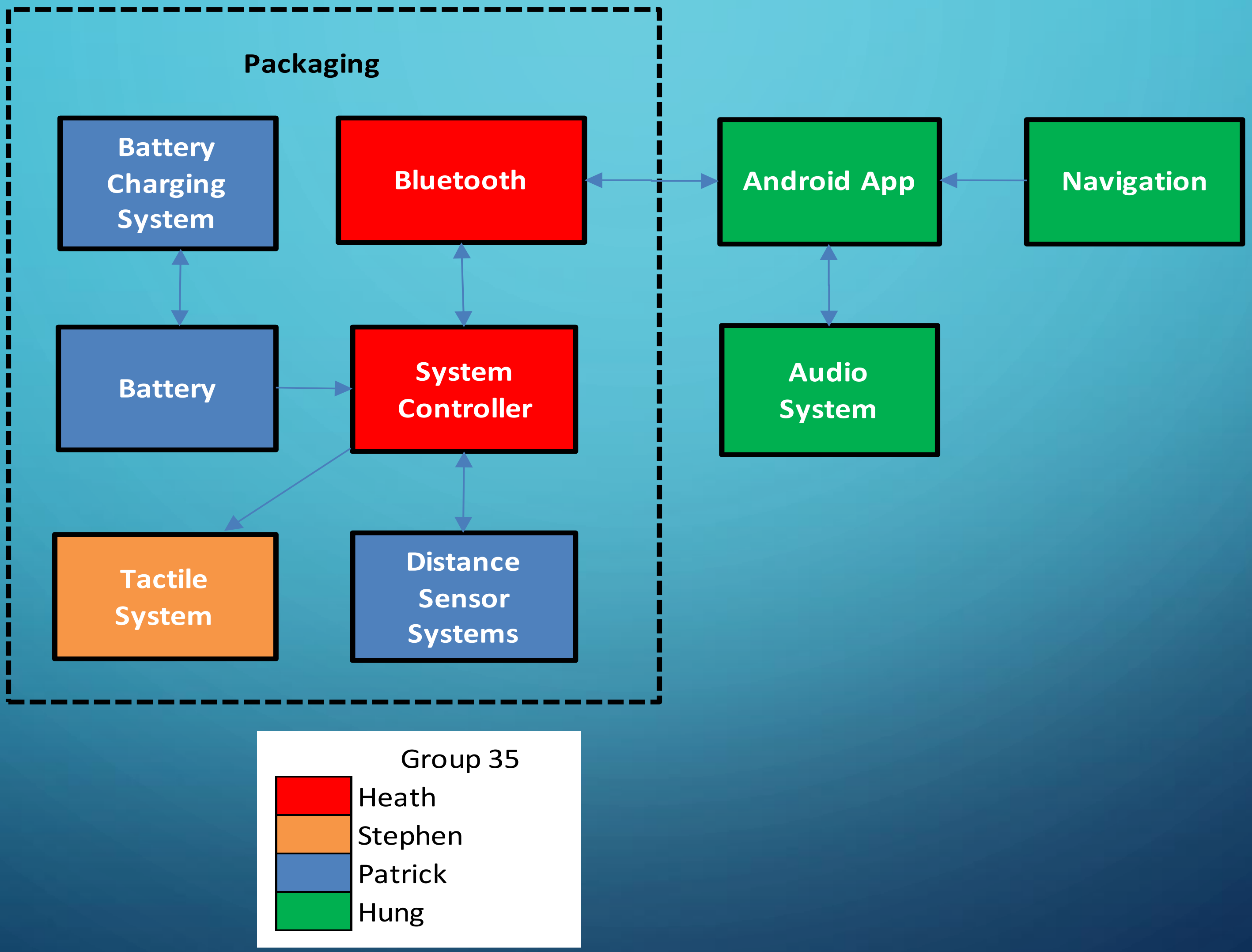
PROJECT DESCRIPTIONS

- Sensor array to detect obstacles
- Tactile feedback system to communicate information to the user
- Device will be connected to a smartphone app through Bluetooth
  - Audio tones to indicate distance and alerts
  - Navigation directions sent to device's tactile feedback system

SPECIFICATIONS/REQUIREMENTS

Component	Parameter	Design Specification
Packaging	Weight	≤ 2.2 kg
Packaging	Dimensions	≈ 6.5cm x 6.5cm x 25cm
Battery	Charge time	≤ 6 hours
Battery	Discharge time	≥ 12 hours
Sensors	Max Sensing Distance	≥ 2 meters
Sensors	Field of View	Between 1° and 90°
User Interaction	Feedback	Tactile and Audio

BLOCK DIAGRAM

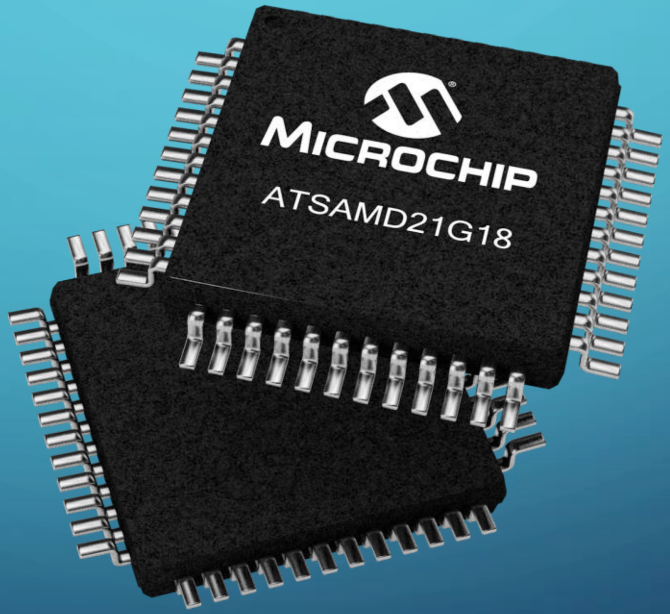


WORK DISTRIBUTION

System	Primary	Secondary
Distance Sensors	Patrick Shiver - EE	Heath Cissell - CpE
Power	Patrick Shiver - EE	Stephen Miles - EE
Linear Actuators	Stephen Miles - EE	Patrick Shiver - EE
Vibration Motors	Stephen Miles - EE	Patrick Shiver - EE
Bluetooth	Heath Cissell - CpE	Hung Tran - CpE
Microcontroller	Heath Cissell - CpE	Hung Tran - CpE
Mobile Application	Hung Tran - CpE	Heath Cissell - CpE
Navigation	Hung Tran - CpE	Heath Cissell - CpE

MICROCONTROLLER SUBSYSTEM

PRIMARY: HEATH CISSELL - CPE
SECONDARY: HUNG TRAN - CPE

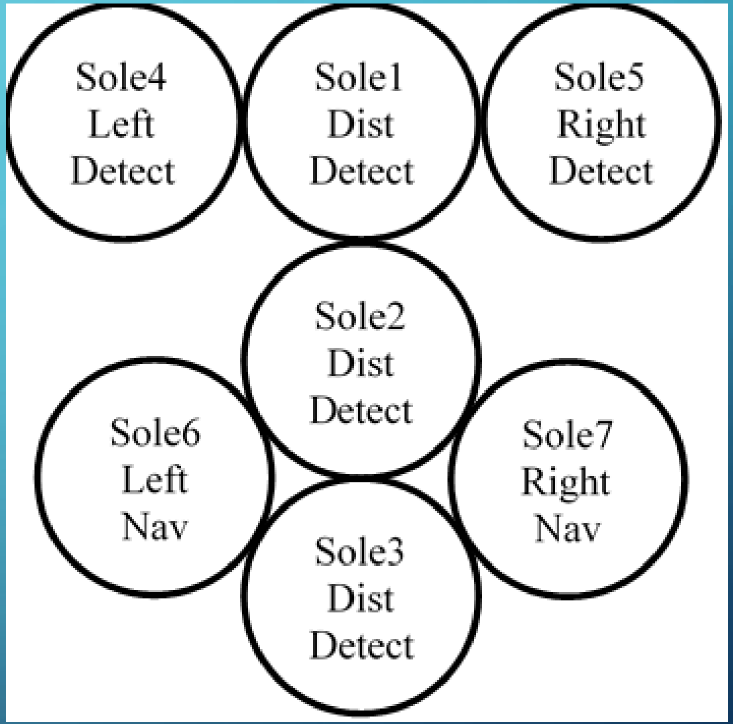


MICROCONTROLLER

	Atmel ATSAMD21G18 A-AUT	MK66FXM0VMD18	MSP430F6766	Project Requirements
Clock (MHz)	48	180	25	>20 MHz
Voltage (V)	3.3	3.3	3.3	≥3.3
Flash (KB)	256	1000	256	≥256
GPIO	38	100	90	>20
Active Power Consumption	10.3mA	116mA	346uA	<30mA

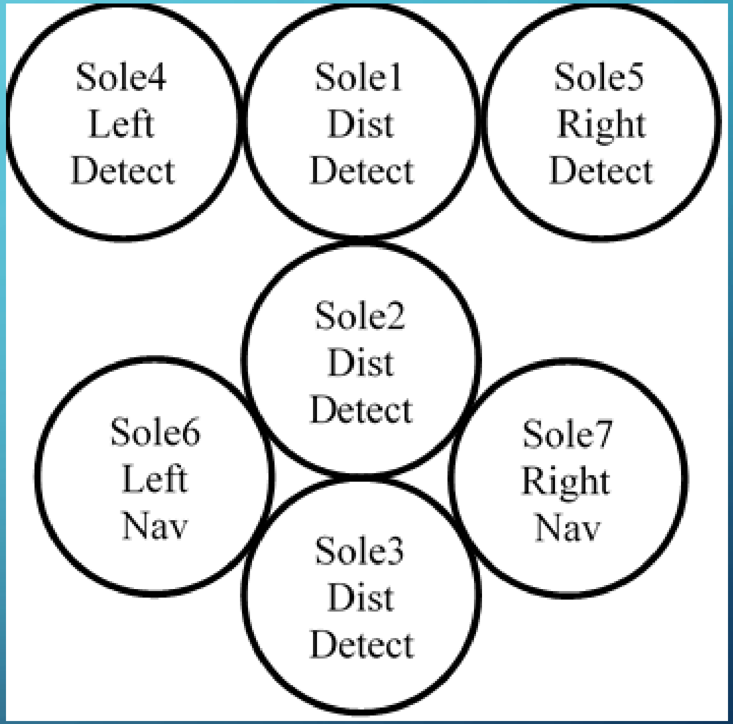
MICROCONTROLLER SOFTWARE DESIGN

- Processes data from distance sensor
  - Determine which 3ft range the distances falls into
    - 0-3ft, 3-6ft, 6-9ft
    - Raise/Lower appropriate distance solenoids
    - Within distance ranges, pulse vibration motor
  - Sends distance value to smartphone through Bluetooth



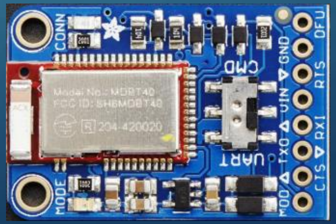
MICROCONTROLLER SOFTWARE DESIGN

- Processes data from left and right sensors
  - If an object is detected within 5ft, raise corresponding solenoid
  - Sends left/right values through Bluetooth
- Processes data received through Bluetooth
  - Navigation solenoids and vibration motor

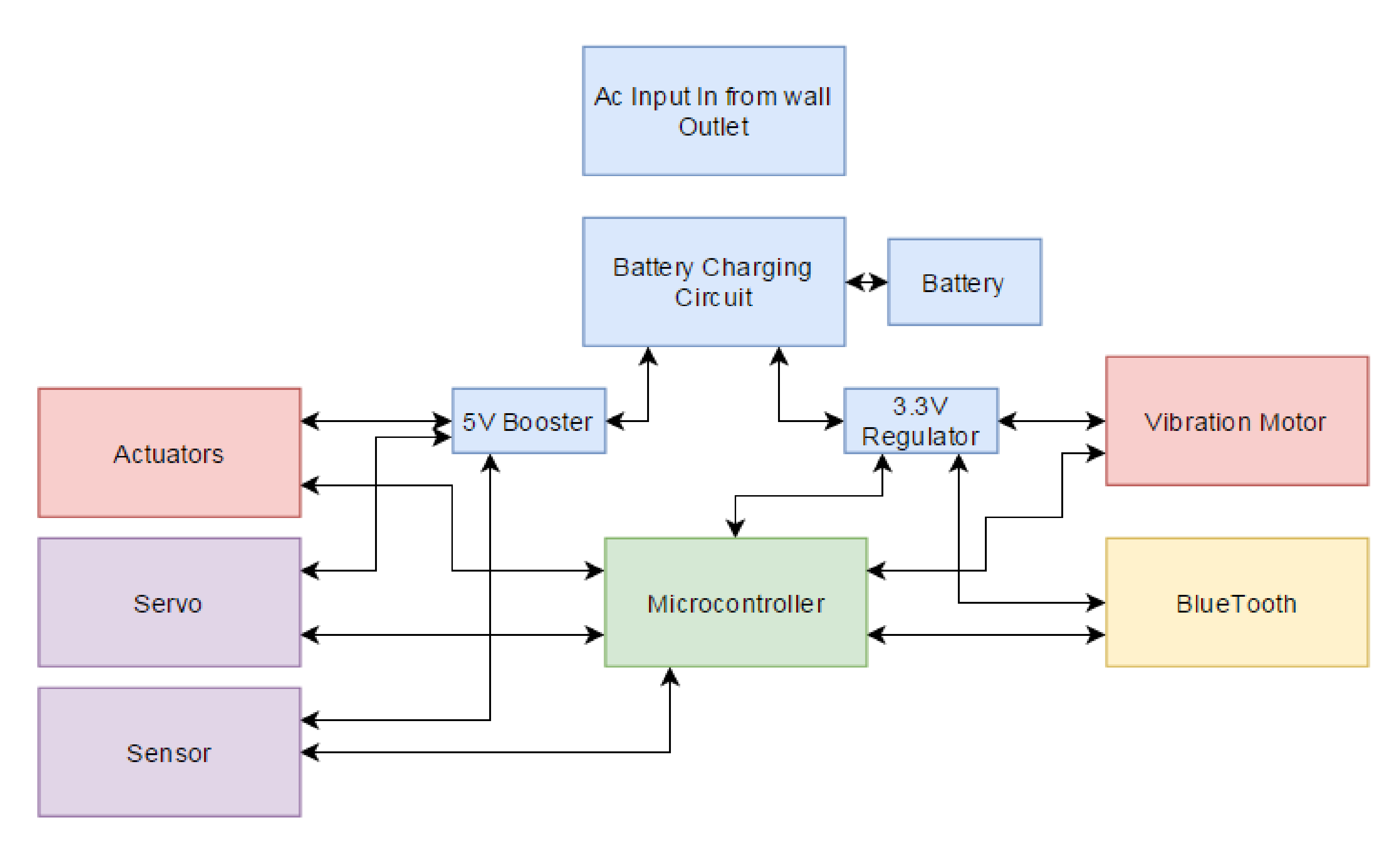


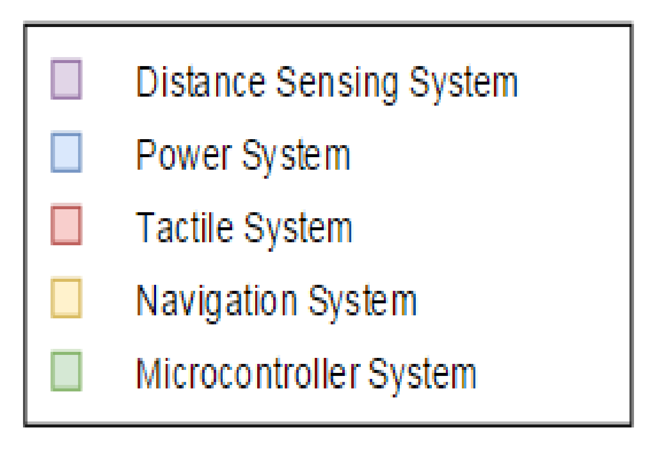
BLUETOOTH MODULE

	HM-13	Adafruit Bluefruit LE UART Friend	Project Requirements
Bluetooth Version/Mode	Bluetooth 4.0 Dual Mode	Bluetooth 4.0 BLE	Bluetooth 4.0
Serial Profile	EDR mode allows use of SPP	Nordic UART RX/TX connection profile	Any profile that allows rapid implementation
Packet Size	EDR: 90 bytes BLE: 20 bytes	20 bytes	≥ 4 bytes
Active Power Consumption	EDR: 13.5 mA BLE: 9.5 mA	2 mA	Minimize



HARDWARE ARCHITECTURE





POWER SUBSYSTEM

PRIMARY: PATRICK SHIVER - EE
SECONDARY: STEPHEN MILES- EE

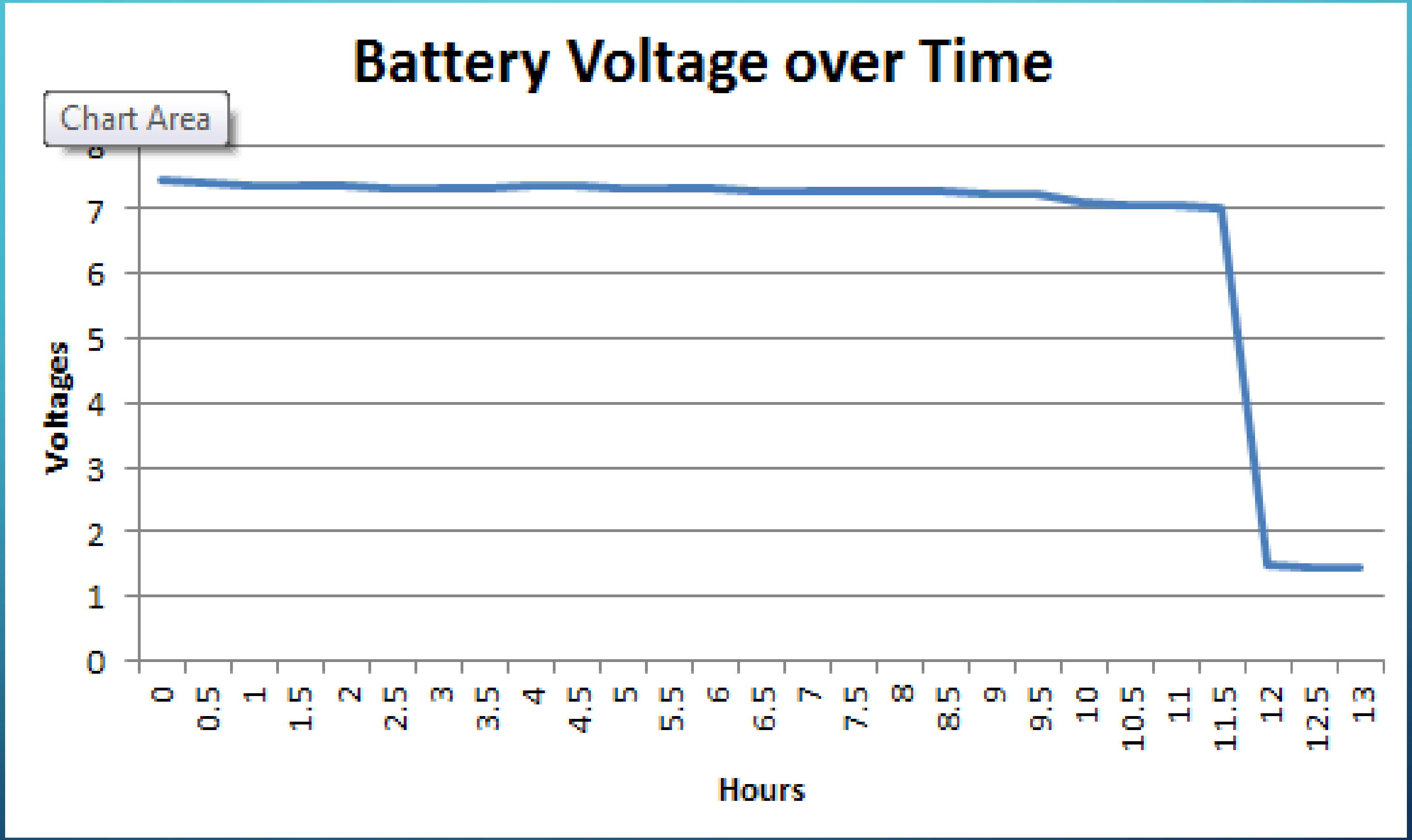
BATTERY

Specification	Tenergy 18650	Tenergy LiPo 7.4V	Project Req.(R) and Desires(D)
Nominal Voltage	7.4V DC	7.4V DC	≥7.4V (D)
Capacity	6600 mAh	6000 mAh	Greater is better (D)
Max Cont. Discharge Curr.	5A	5A	Greater is better (D)
Battery Charge Curr.	Standard 1.3A Rapid 3A	Standard 1.3A Rapid 3A	Lower is better (D)
C Rating	7	6	Not a major Factor
PCB Protection	6V<Protect>8.4V	4.8V<Protect>8.7V	YES (D)
Over Current	8±2A	11±3A	Not a major Factor
Weight	311g	150g	Lower is better (D)
Dimension	66*54*36mm	110*59*22mm	Lower is better (D)
Fast Charge Capable	YES	YES	Not a major Factor
Battery Chemistry	Li-Ion	Li-Po	Li-Po (D)
Cost	59.99	47.99	Lower is better (D)

BATTERY OVERVIEW

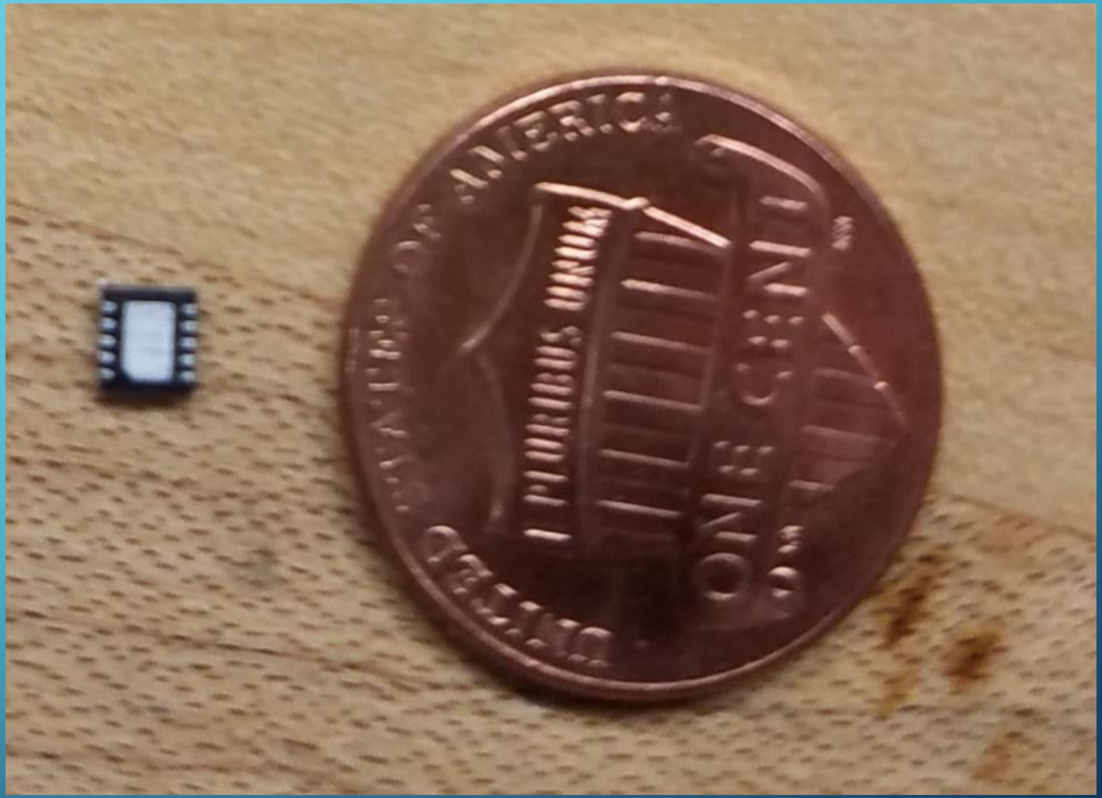
- We choose a Lipo battery due to its size, stability and energy density. Though we would of preferred something smaller and more custom. Cost and power restraints wouldn't allow it.
- The extreme power restraints are mainly due to the mechanical actuators and servos which draw for more power then we initially expected.
- This battery met our capacity needs while its long dimensions fell in line with our design

BATTERY PERFORMANCE



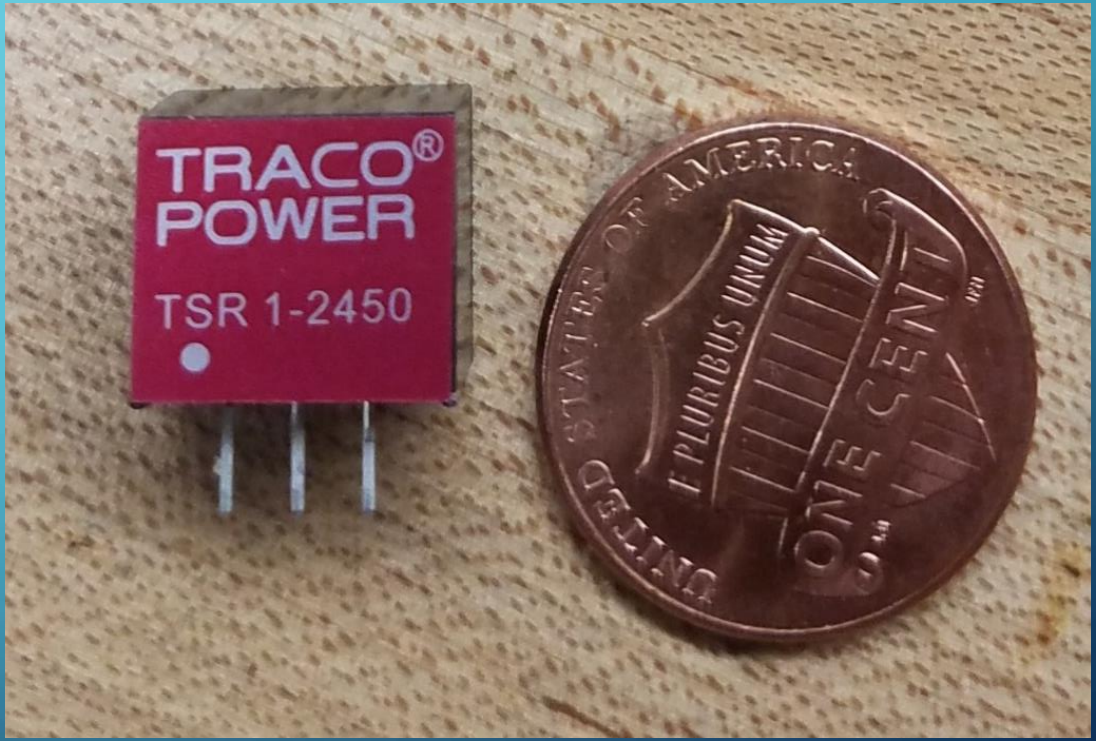
BATTERY MANAGER OVERVIEW

- Charge battery safely
- Less components compared to other battery managers allowing for a smaller design
- Provides charging status
- Allows for us to control the rate in which our battery charges. Up to Fast charging levels
- We chose to not use fast charging for it reduces the battery capacity by an average of 15 percent.



SWITCHING REGULATORS OVERVIEW

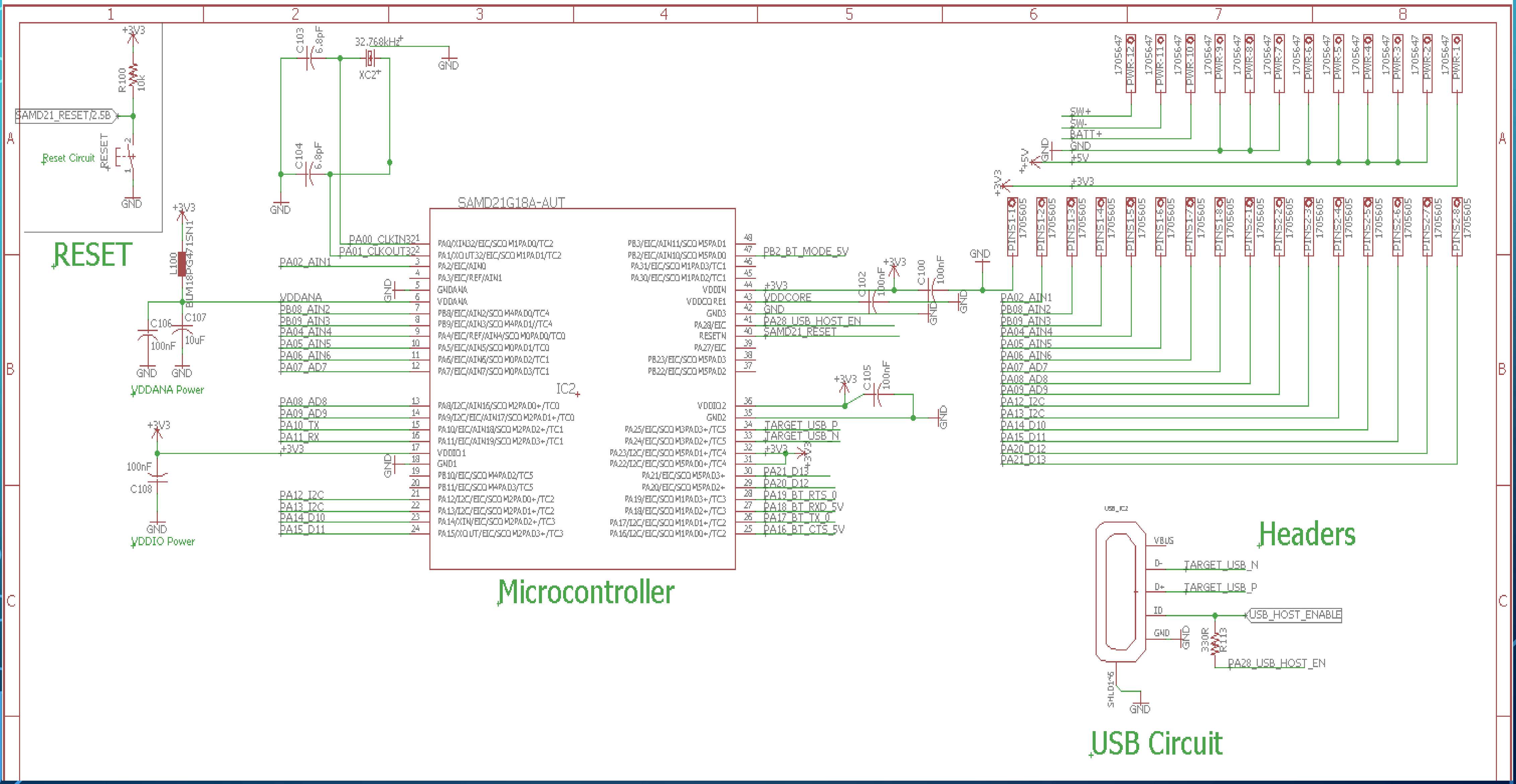
- We used Switching regulators for efficiency to get the most out of our battery life.
- We have 3 switching regulators in our design. 2 for 5V bus and 1 for 3V3 bus
- 5V bus
  - Actuators/Servos/Haptic Motor
  - Sensors
- 3V3 bus
  - MCU's/Bluetooth/LED's



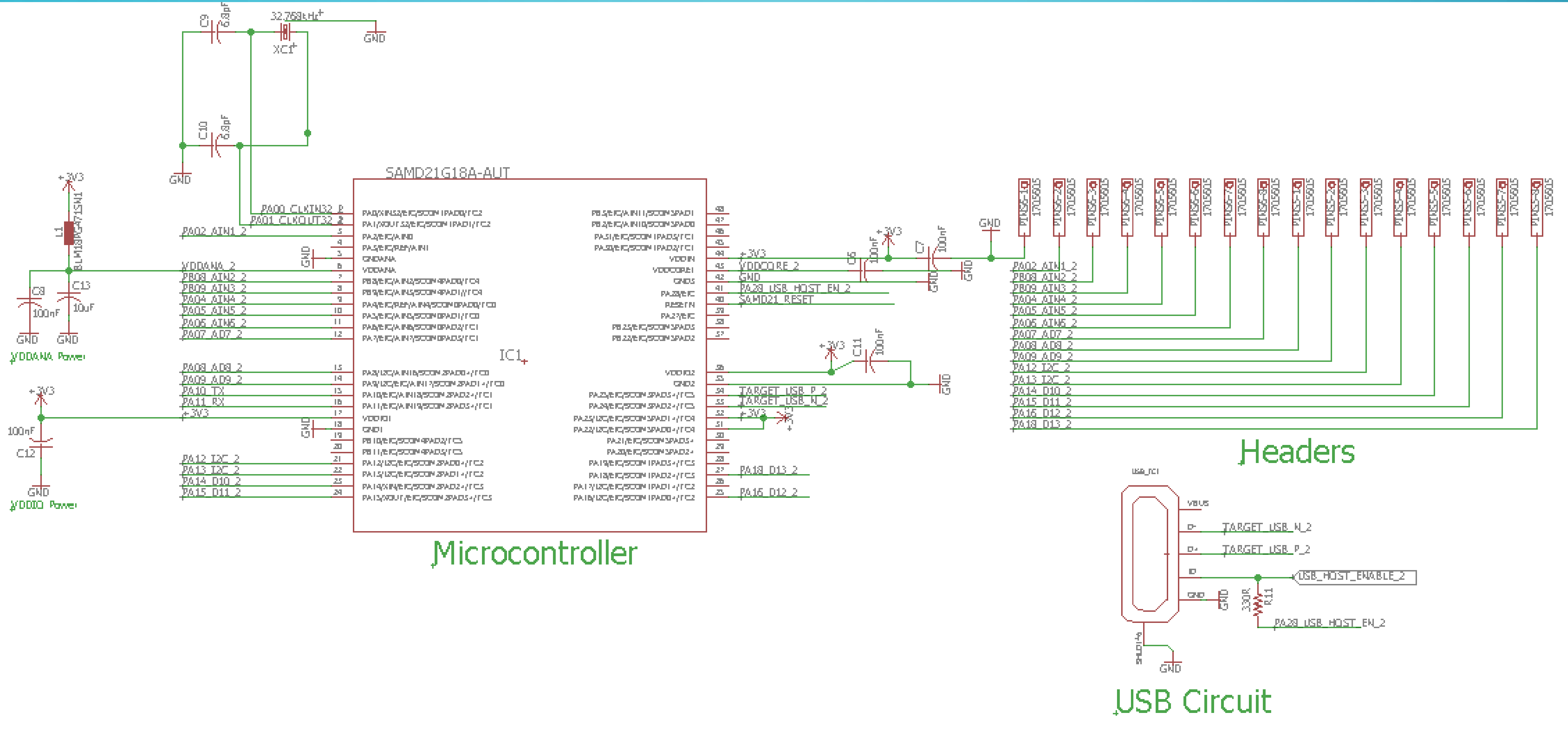
POWER/MICROCONTROLLER PCB DESIGN

- Our MCU PCB went through many design changes. Initially Power, the MCU and the Bluetooth was separate, but due to the cost of making individual pcb's it made sense to combine them.
- Initially we wanted use USB power as that is a common standard today but due to efficiency we found we are able to get more out of the battery if we step down
- We first added a 2nd MCU because we underestimated the processing constraints of the Bluetooth module for communication. Adding a second MCU removed the sluggishness from our design however further optimization proved the most helpful
- Phoenix connectors are being used for headers as they are perfect for our prototyping stage

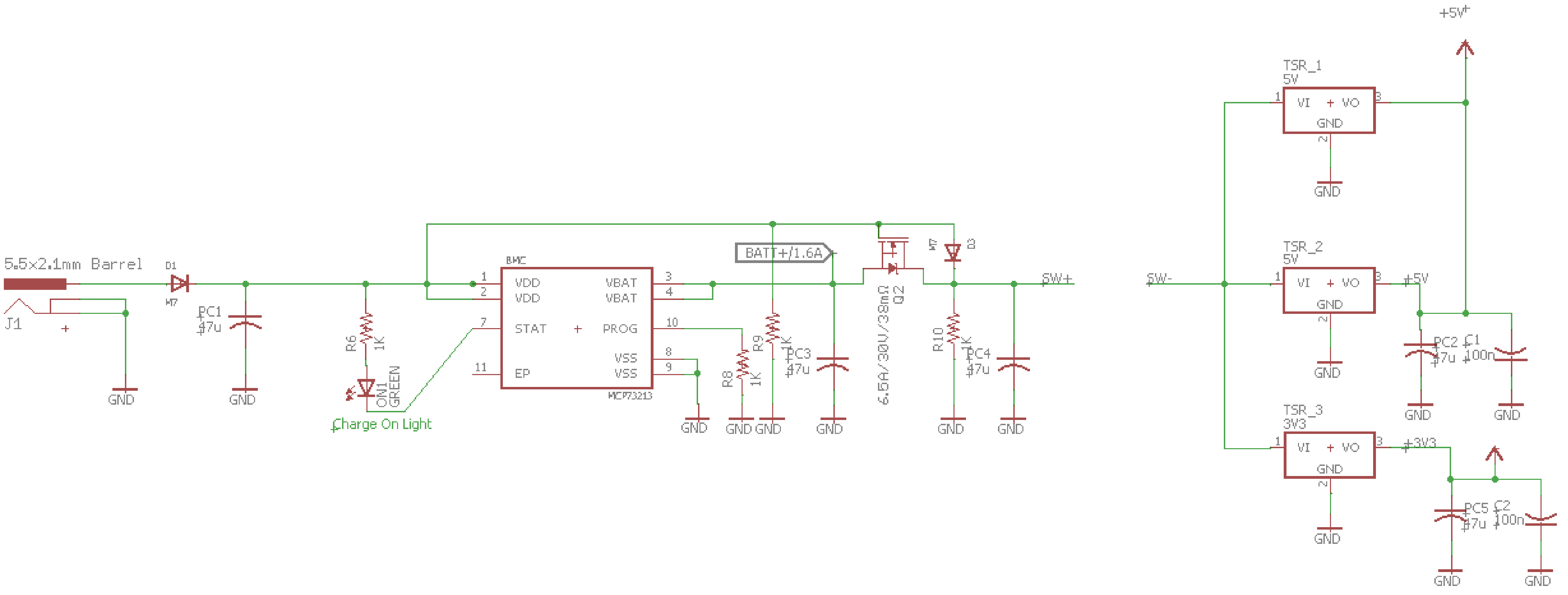
SCHEMATIC MCU 1



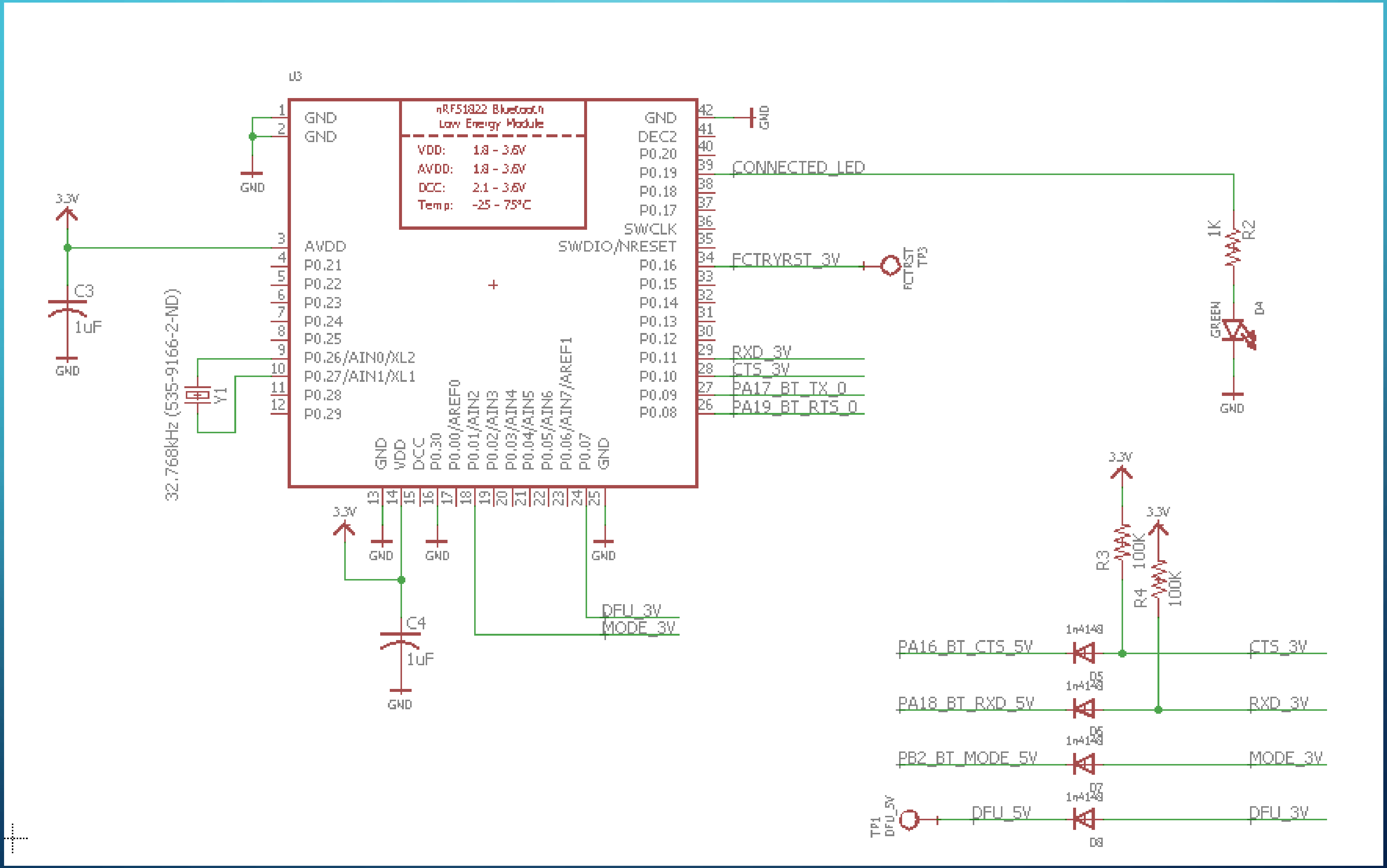
SCHEMATIC MCU 2



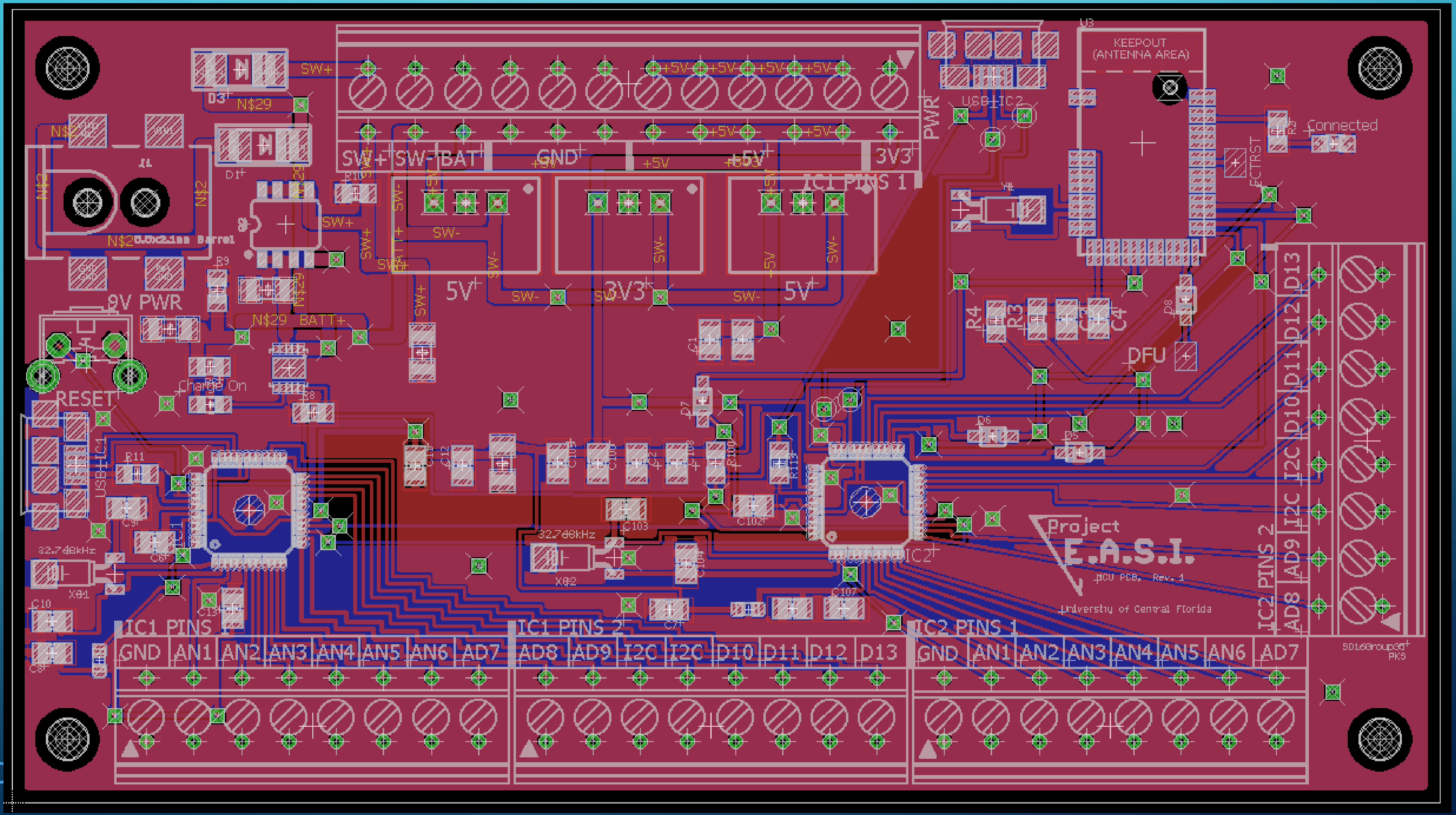
SCHEMATIC POWER



SCHEMATIC BLUETOOTH

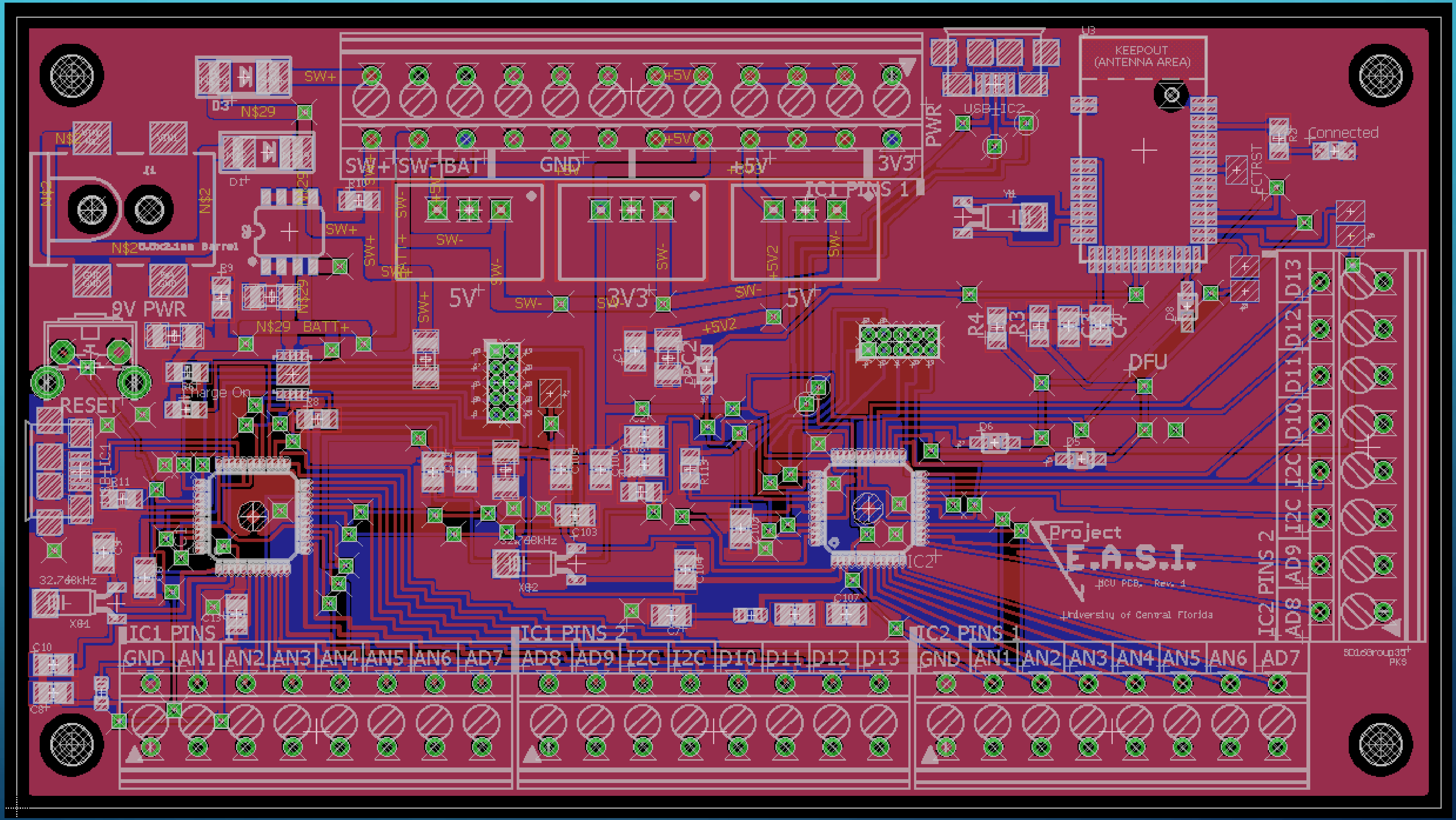


PCB LAYOUT REV1

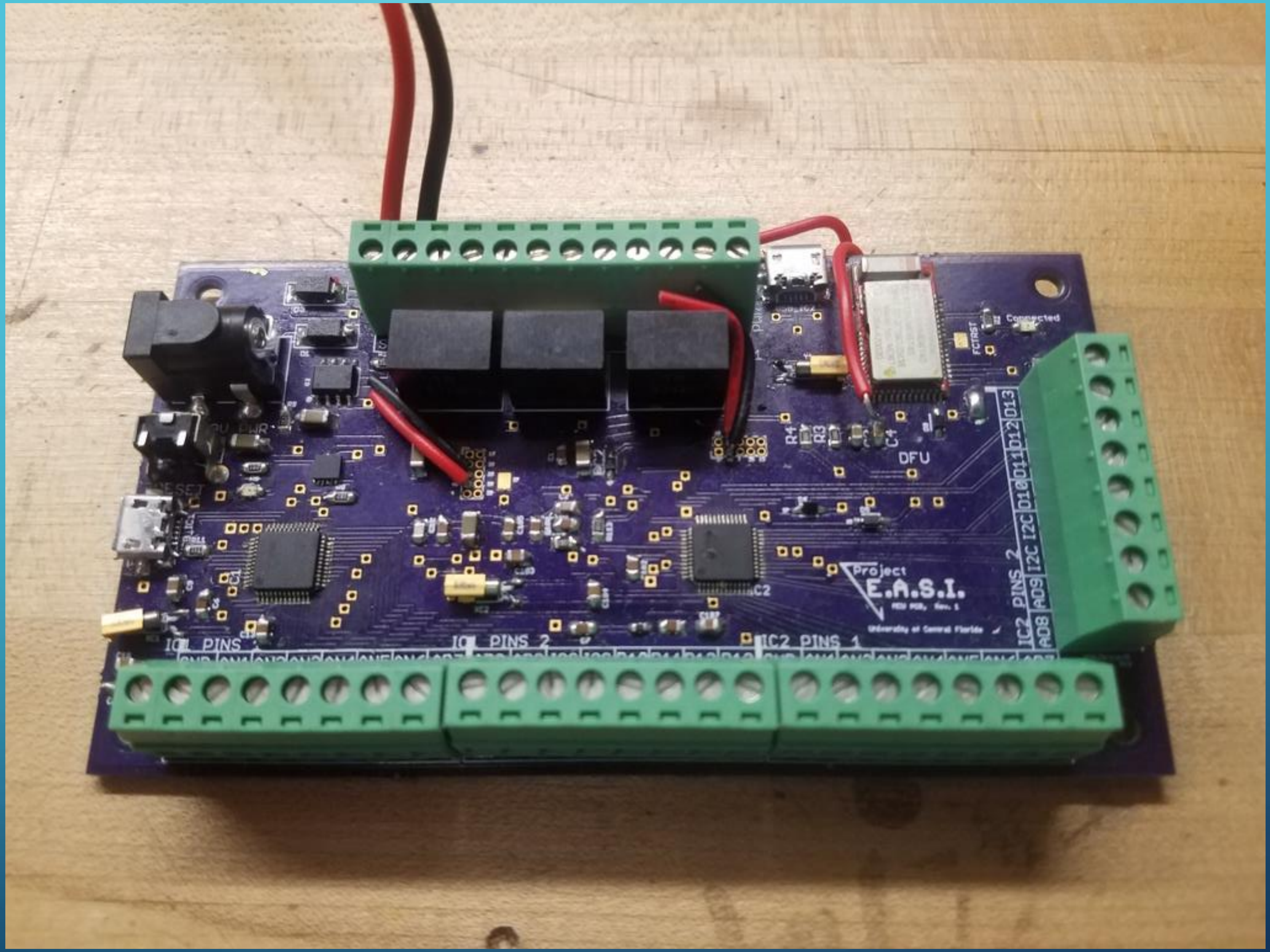


PCB REV1

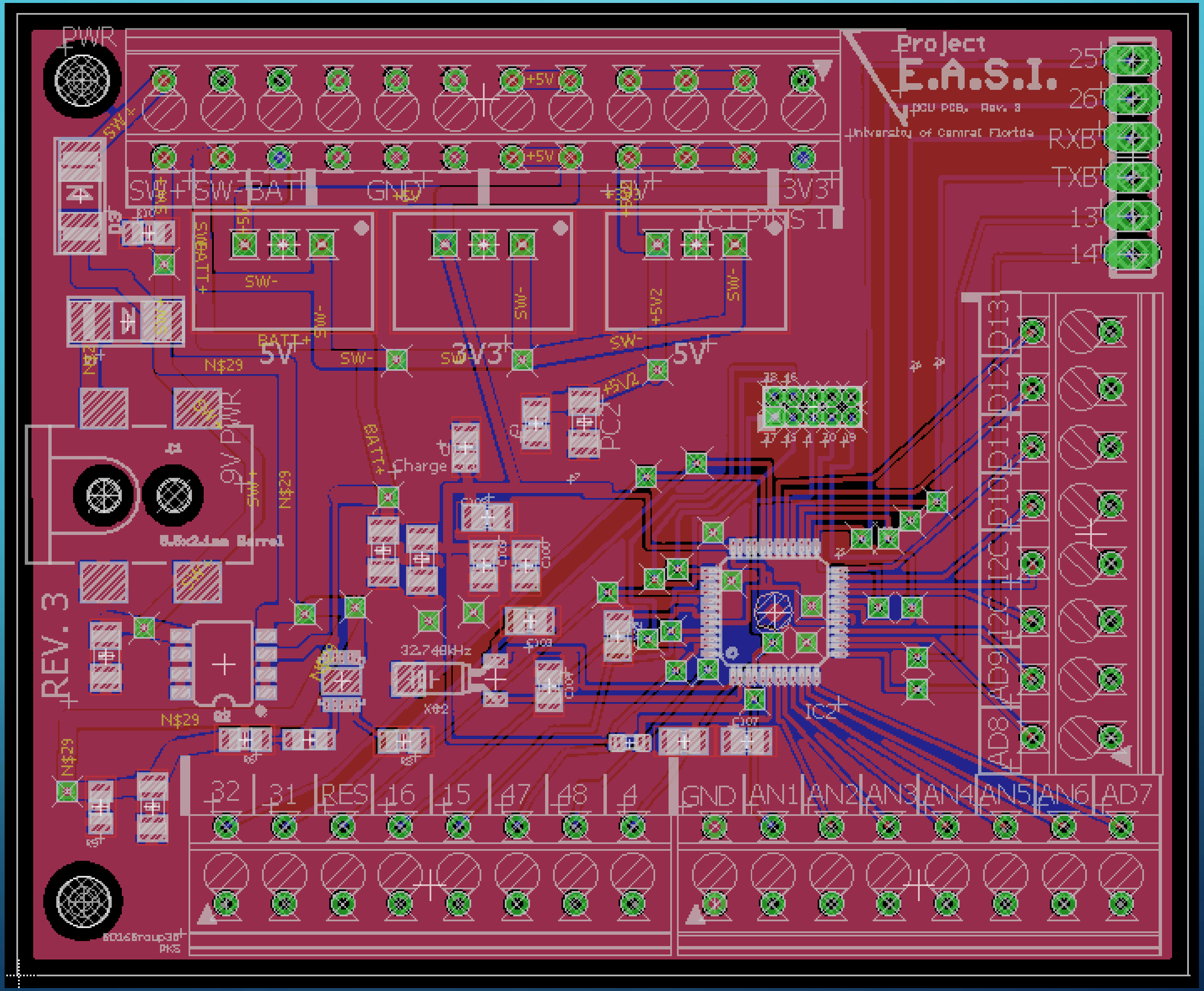
PCB LAYOUT REV 2



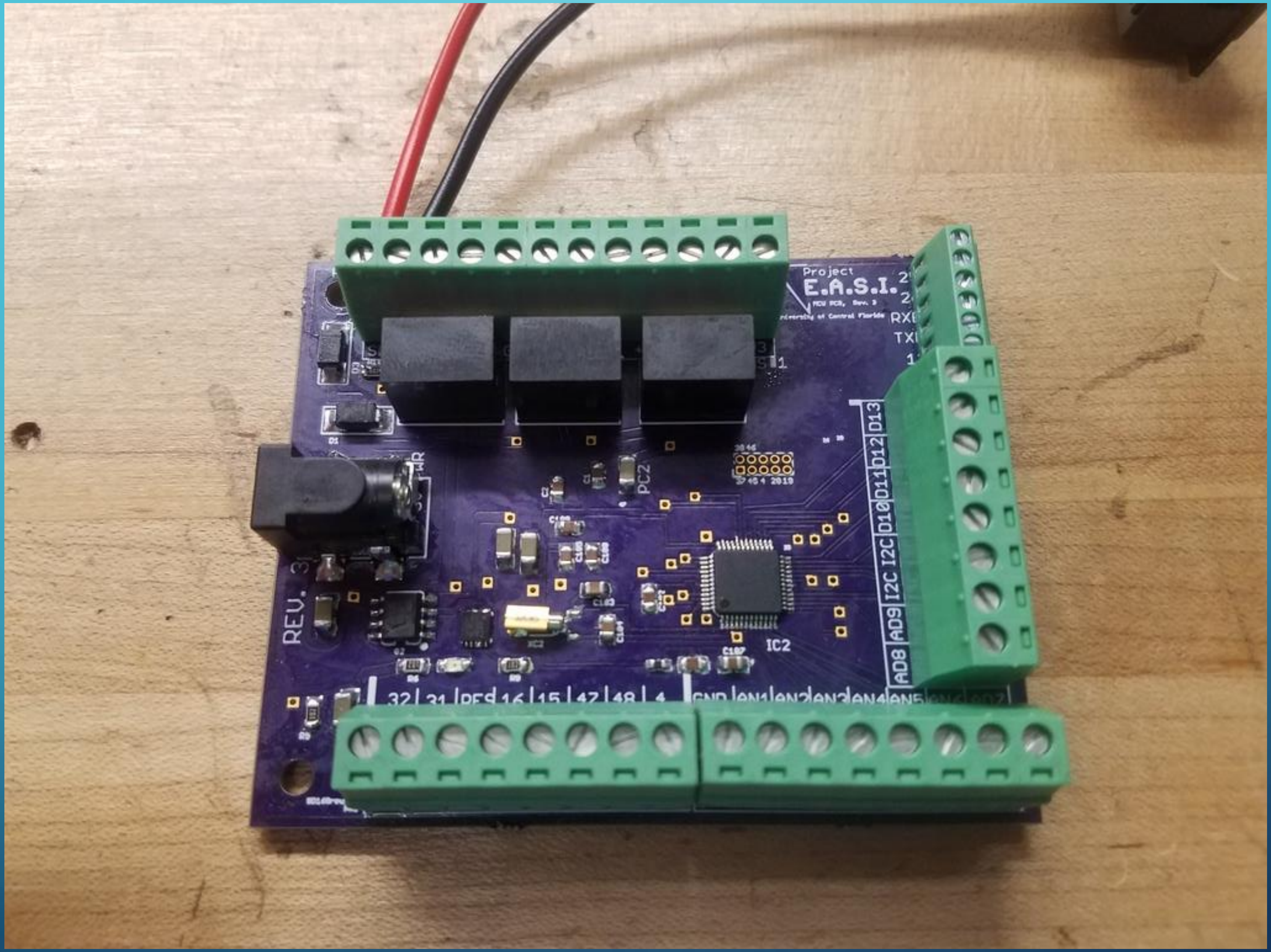
PCB REV 2



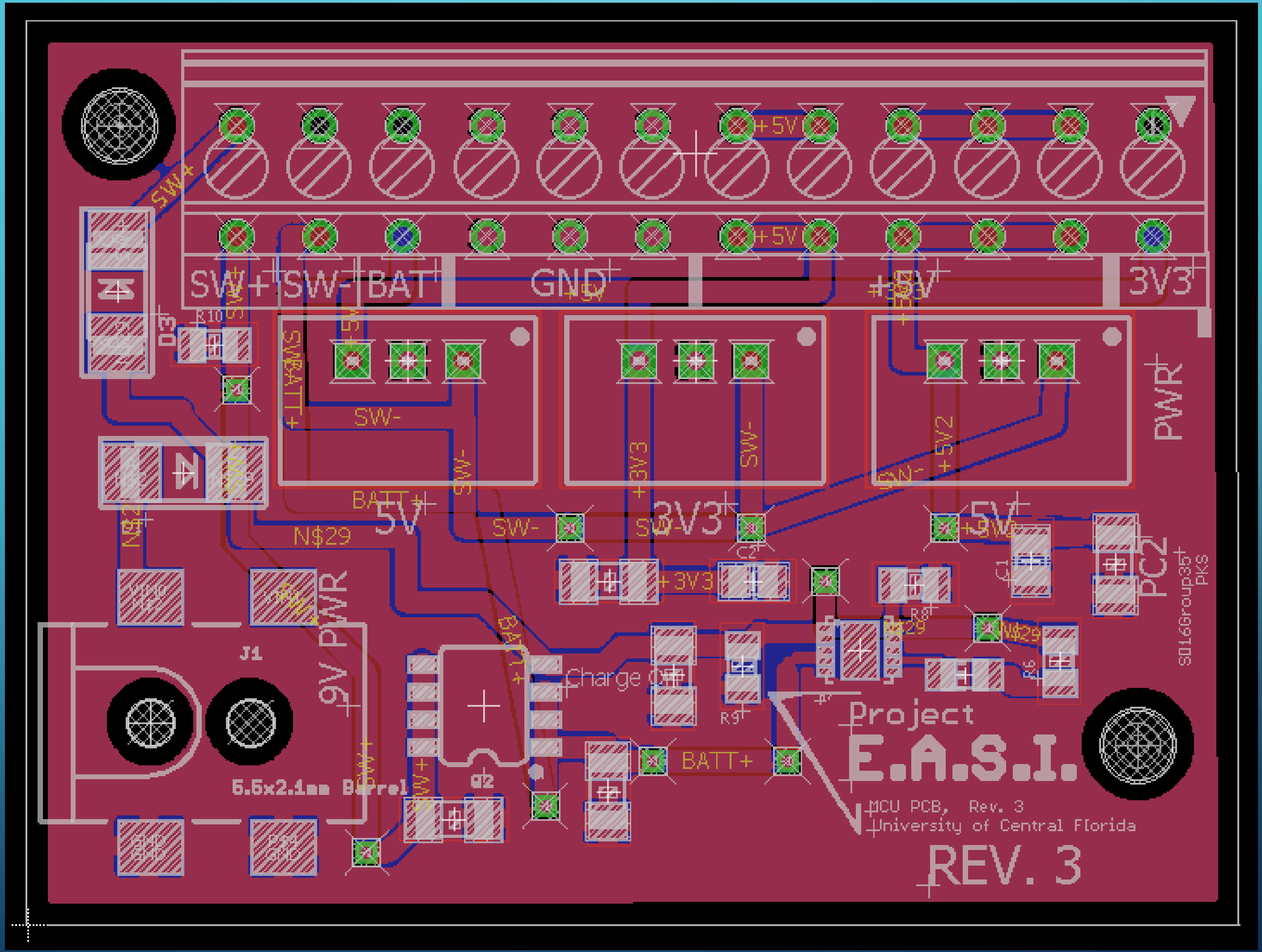
PCB LAYOUT REV 3A



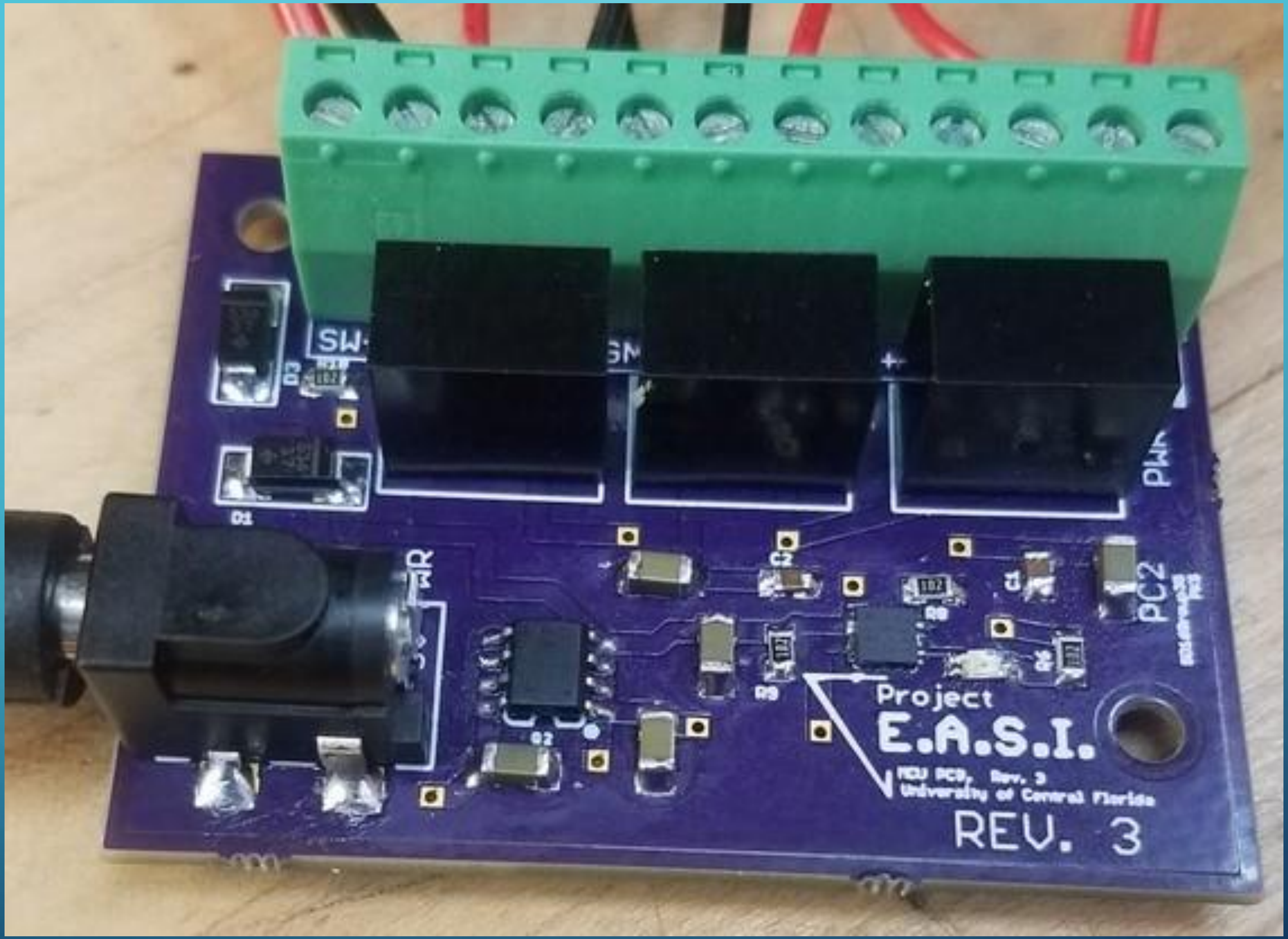
PCB REV 3A



PCB LAYOUT REV 3B

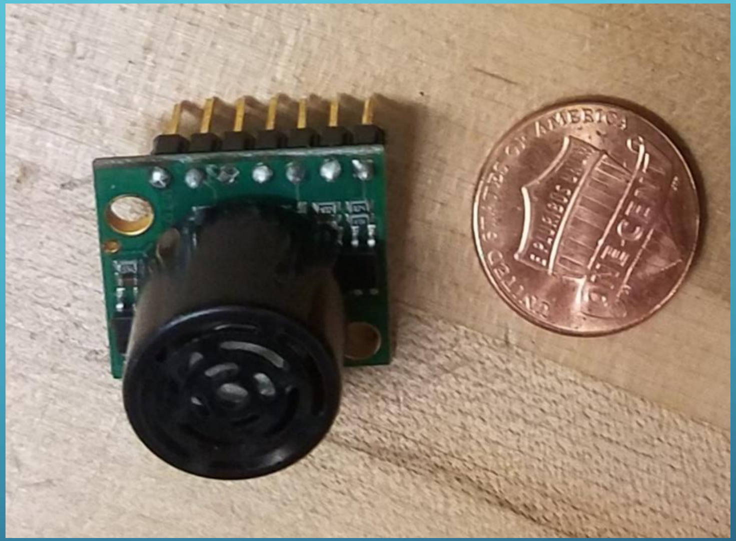


PCB REV 3B



DISTANCE SENSING SUBSYSTEM

PRIMARY: PATRICK SHIVER - EE
SECONDARY: HEATH CISSELL - CPE

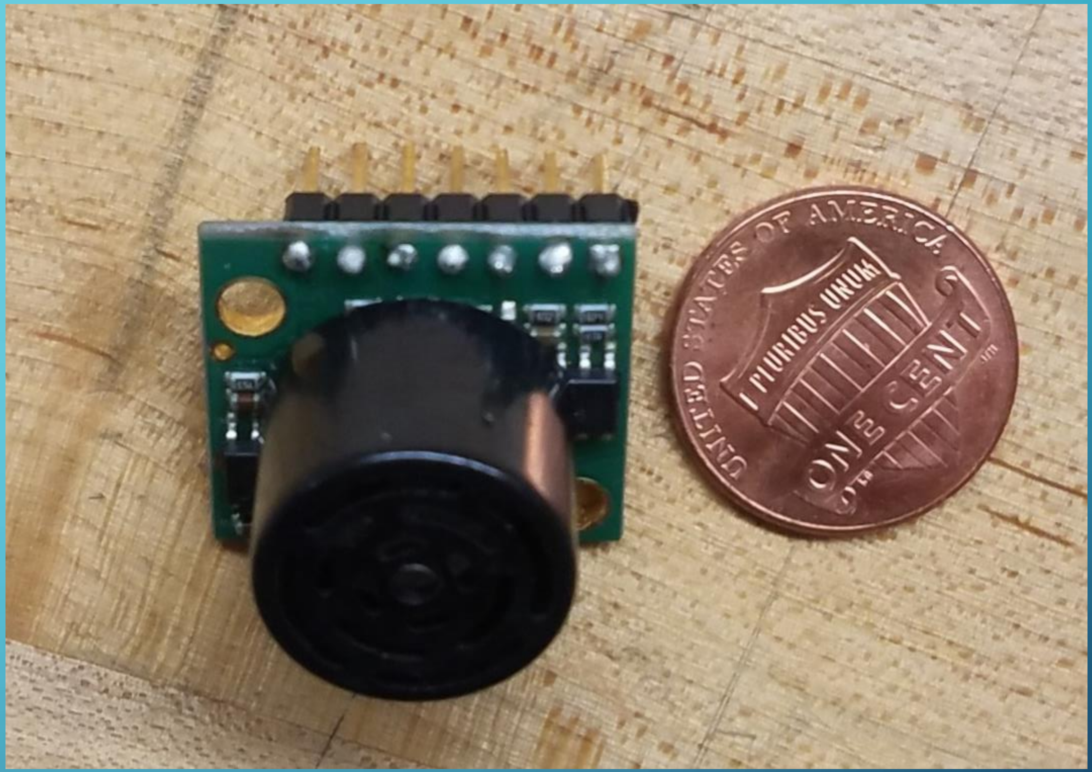


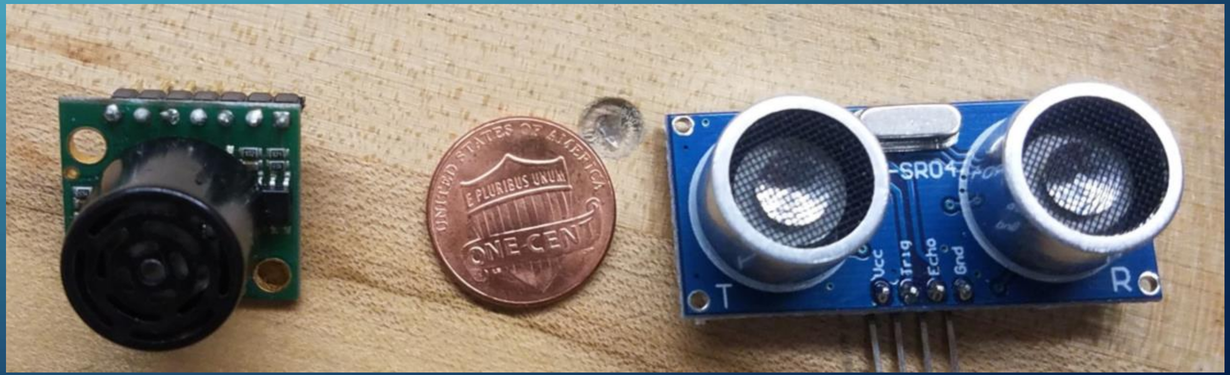
ULTRASONIC SENSOR COMPARISON

Specification	HC-SR04	MaxSonar-EZ1	MaxSonar-EZ4	Project Req.(R) and Desires(D)
Working Voltage	5V DC	2.5-5.5V DC	2.5-5.5V DC	≤7.4V (D)
Working Current	15mA	2mA	2mA	Lower is better (D)
Max range	4m	6.45m	6.45m	>2m (R)
Min Range	2cm	1mm	1mm	≥1inch (D)
Min 100% read range	12in.	6in./15.2cm	6in./15.2cm	≤1foot (D)
Beam Width	15 degrees	4feet	4feet	Lower is better (D)
Resolution	2mm	1in.	1in.	Lower is better (D)
Measurement Cycle	Not Given	50ms	50ms	Lower is better (D)
Operating Temperature	Not Given	-15°C to +65°C	-15°C to +65°C	Not a major Factor
Dimension (HxWxD)	45*20*15mm	19.9*22.1*15.5mm	19.9*22.1*15.5mm	Lower is better (D)
Cost	3.49	29.99	29.99	Lower is better (D)

SENSOR OVERVIEW

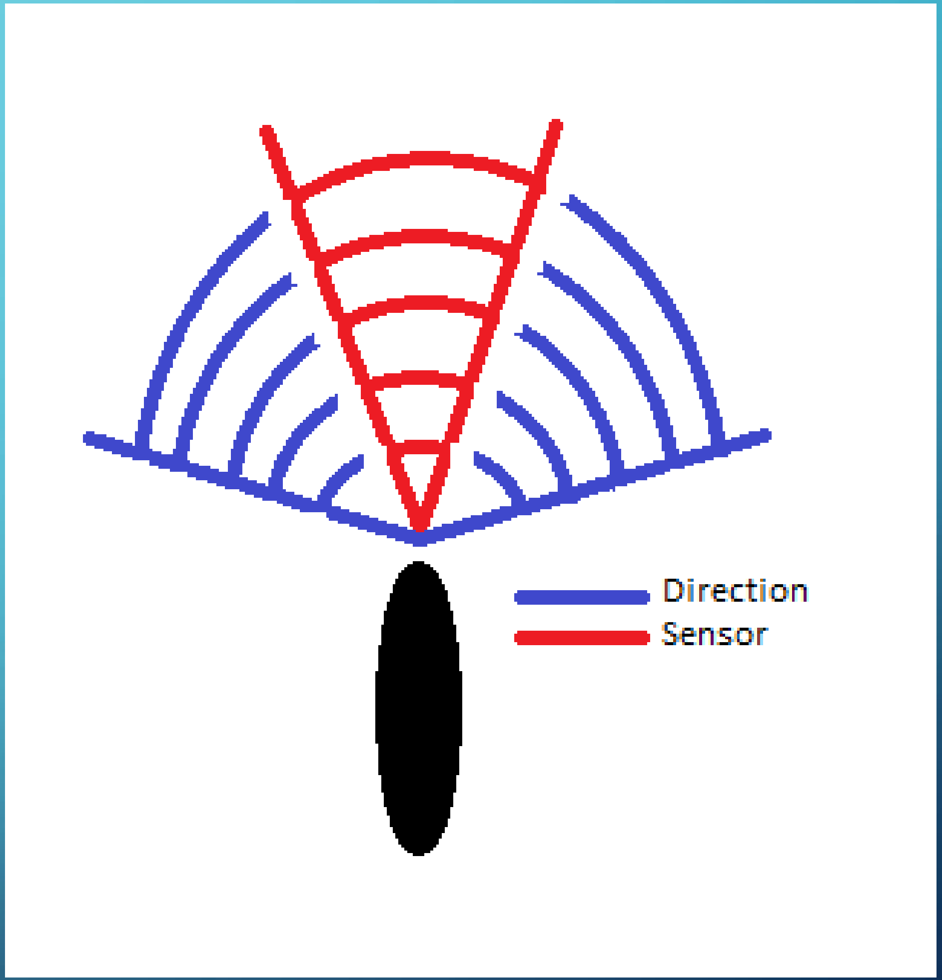
- We initially wanted to use LIDAR but the minimum distance ultimately proved to be an issue and our design limits the need for accuracy
- We chose the max sonar sensor mainly due to its size and its linear design reduces crosstalk in our device.
- In testing the range for this sensor more then exceeds our requirements of 2m. The Beam for EV1 is roughly 2-3ft wide and the EV4 beam is roughly 1ft wide





LINEAR AND DIRECTIONAL OVERVIEW

- Directional Sensor in Blue monitors left and right by sweeping back and forth on a servo. This creates a radar like picture which can detect multiple objects.
- Linear Sensor in Red detects objects using a more narrow beam. Relaying distance data to the MCU



HAPTIC FEEDBACK SUBSYSTEM

PRIMARY: STEPHEN MILES- EE
SECONDARY: PATRICK SHIVER - EE

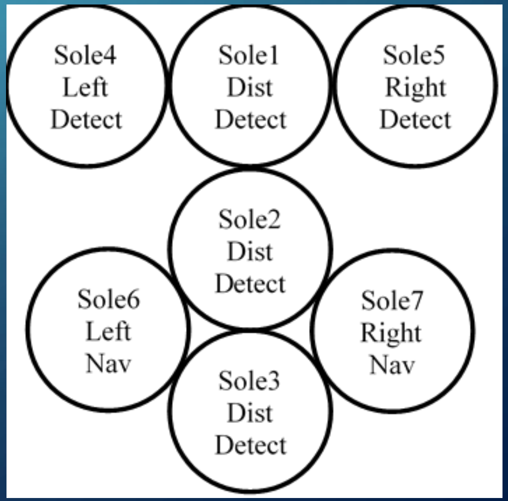
HAPTIC FEEDBACK SUBSYSTEM

Design Considerations:

- Portability
- Power Consumption
- Signal Variety
- Response Granularity

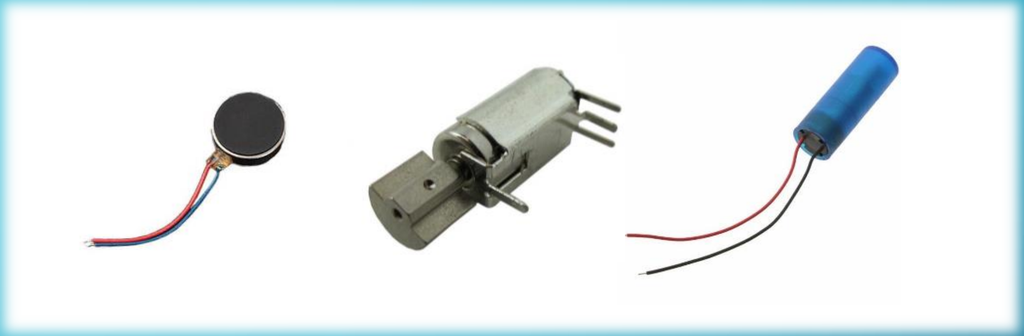
Solution:

- Two left/right oriented ERM (Vibration) motors
- Seven small-scale Linear Actuators



ERM MOTOR CONTROL

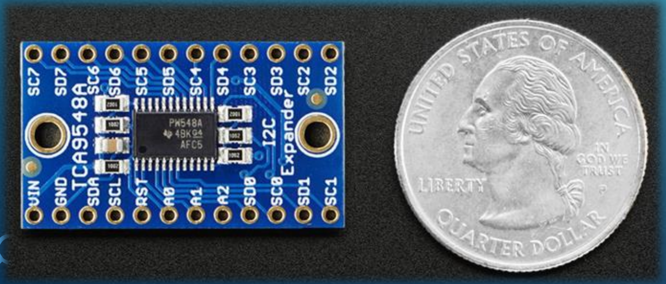
- Direct Drive vs Haptic IC Controller?



Haptic IC Advantages	Haptic IC Disadvantages
No complex PWM generation on MCU	Power consumption
Ease of implementation	Cost
Reference designs	Learning curve
Design flexibility	

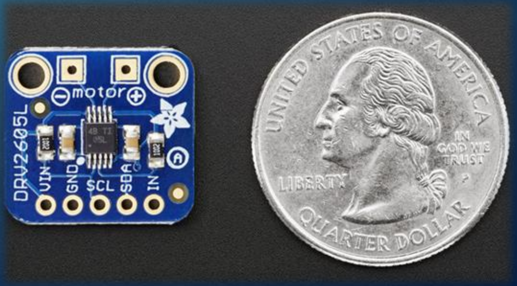
HAPTIC IC SELECTION

	TI DRV8601	Fairchild FAH4820	TI DRV2605
Compatibility	ERMs or LRAs	ERMs	ERMs or LRAs
Control	PWM controlled	I2C or PWM controlled	I2C or PWM controlled
Documentation	Moderate documentation	Minimal documentation	Extensive documentation and examples
Memory	No onboard memory	I2C config registers only	I2C config registers & ROM waveform library
Prototyping	SOIC breakout required	BGA/SOIC - No Lead breakout required	Adafruit breakout available
Selection	X	X	O



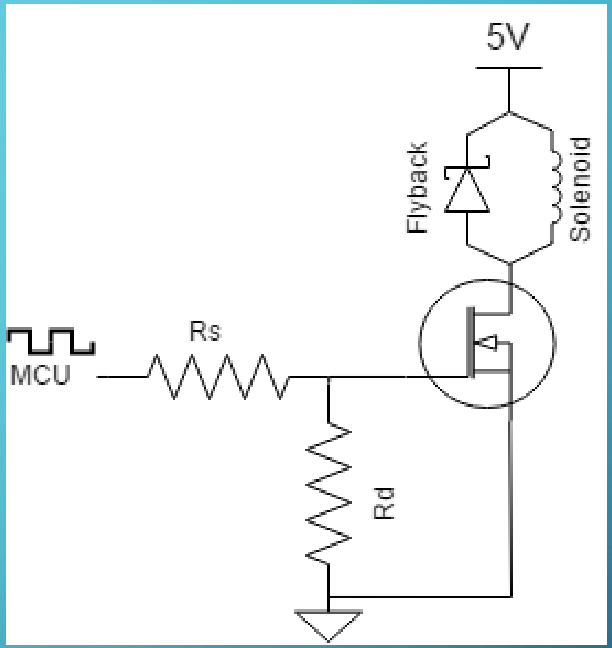
TCA9458
I2C Multiplexer

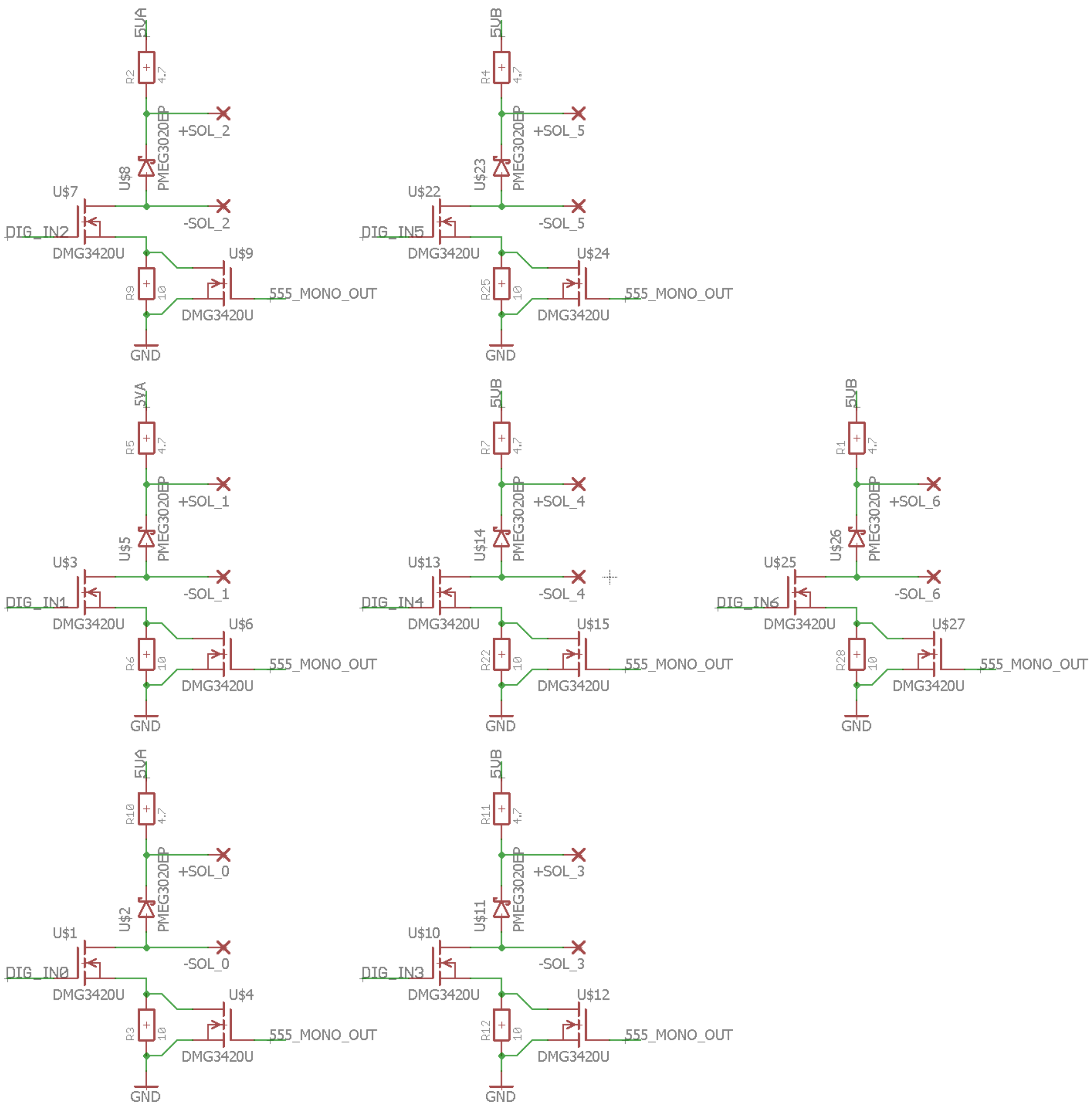
DRV2605
Haptic Driver



LINEAR ACTUATOR CONTROL

- Direct N-FET switching from MCU's GPIO pins
- Minimizing Power Consumption
- Actuation Current vs Holding Current
- Actuator Duty Cycle

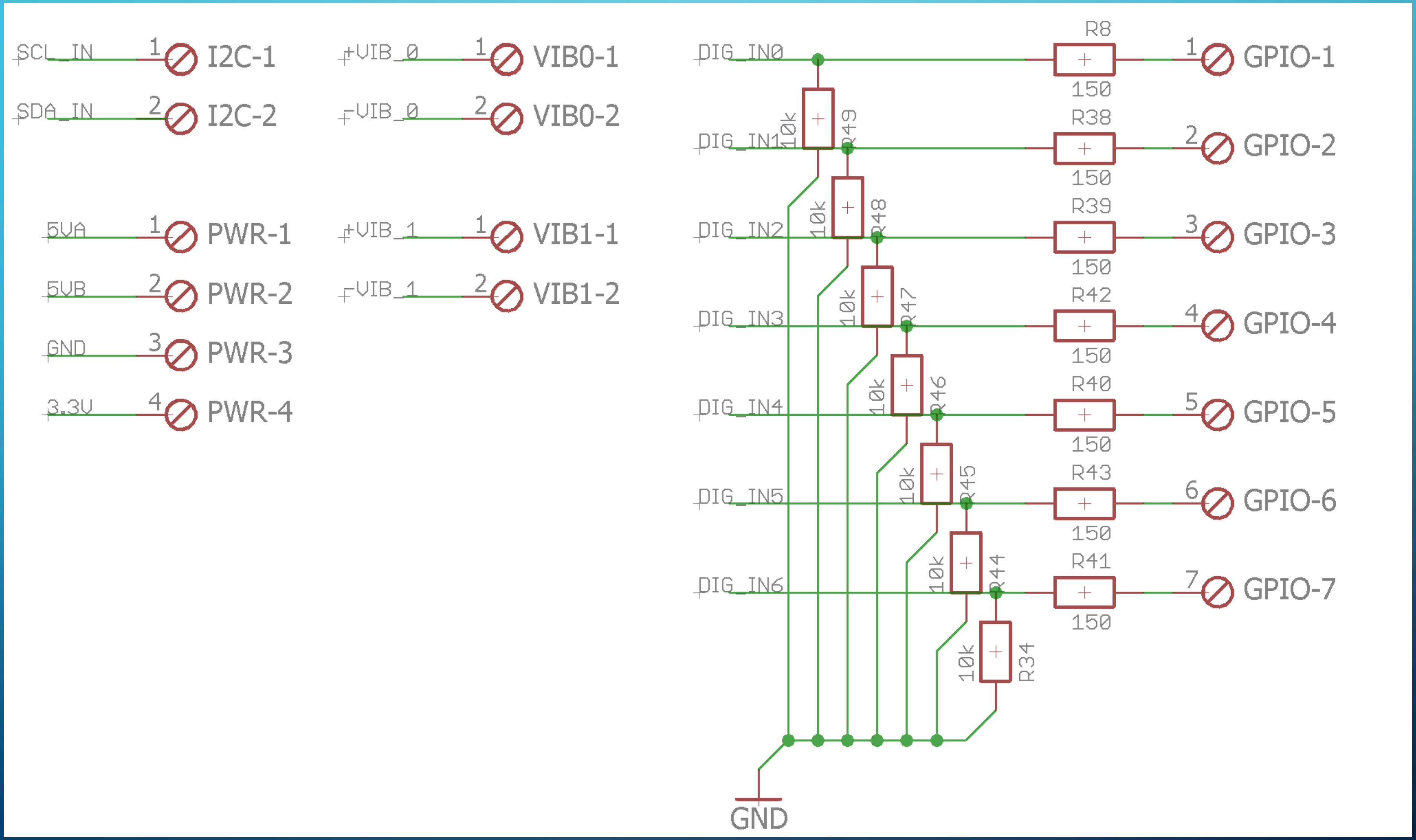




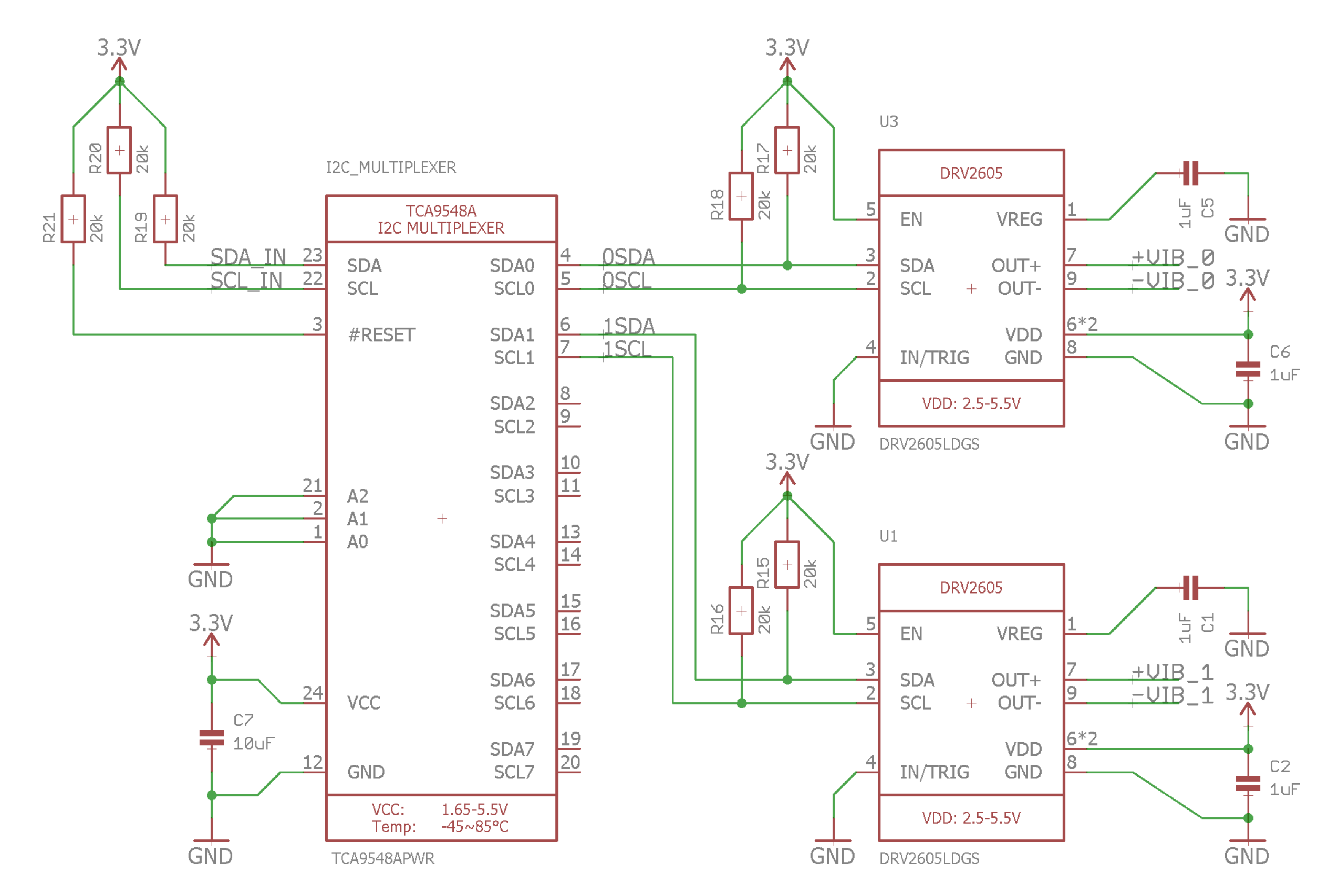
LINEAR ACTUATOR SCHEMATIC

Result: 67.2% reduced current draw from rated levels

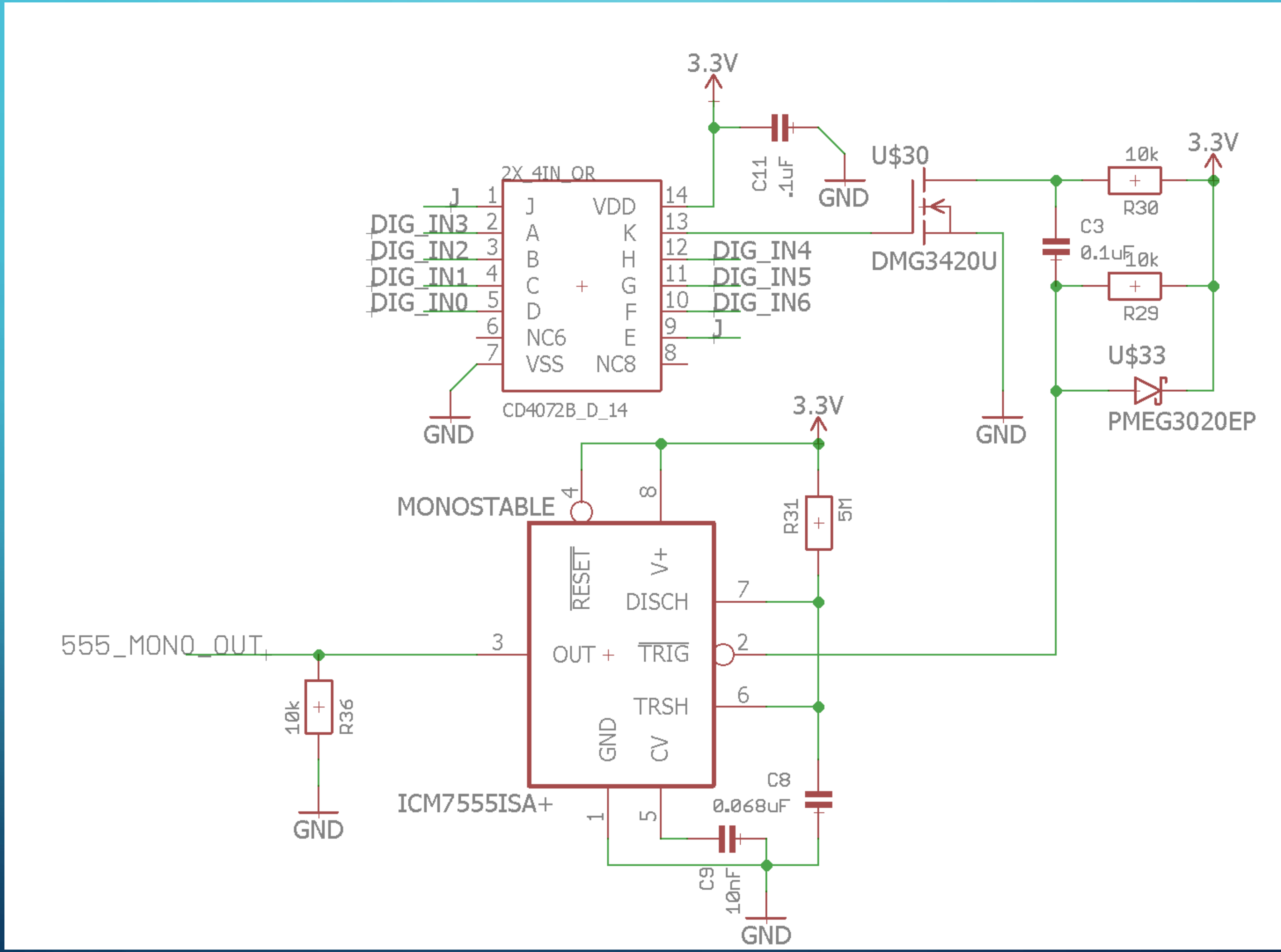
LINEAR ACTUATOR SCHEMATIC



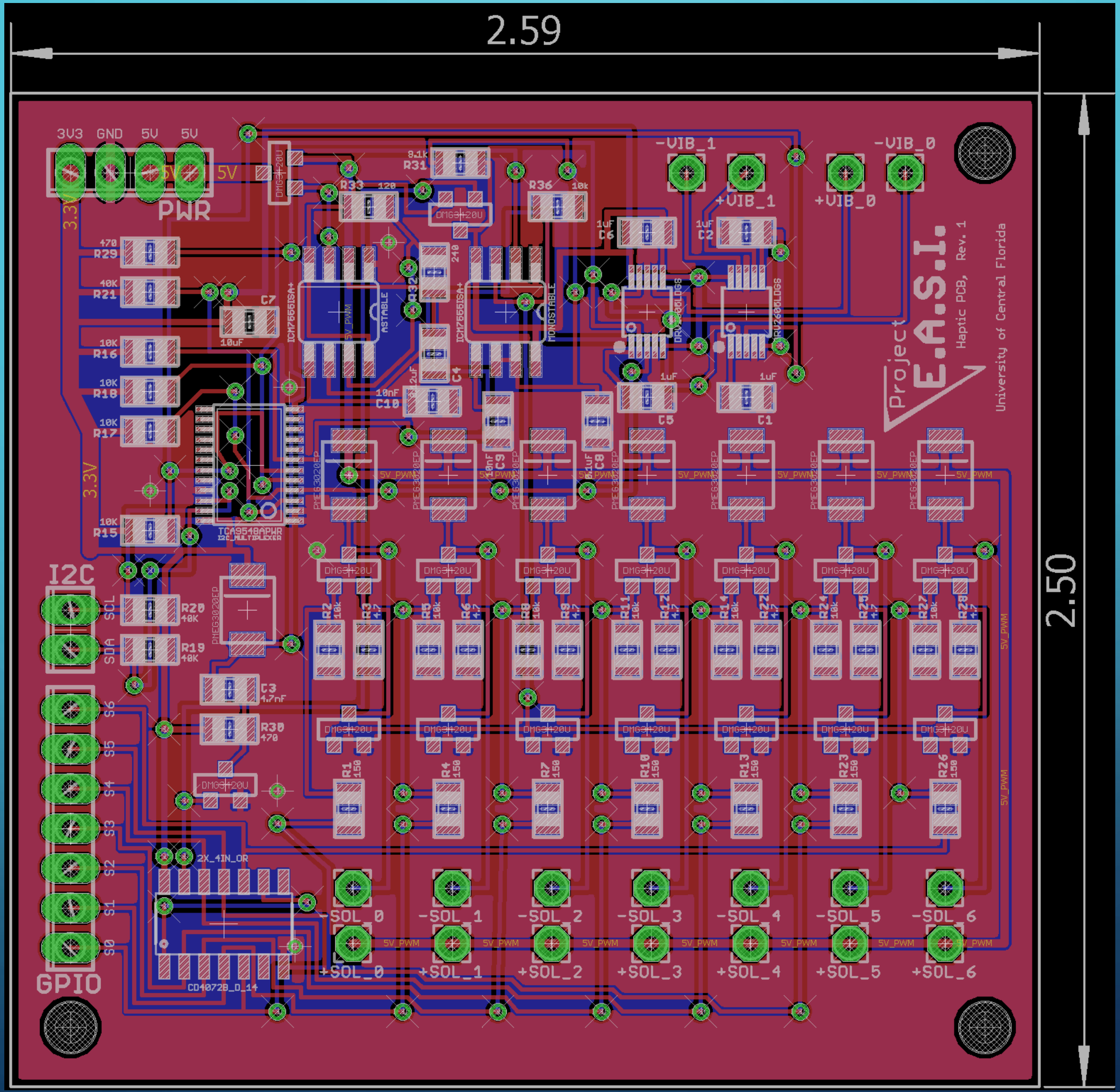
HAPTIC DRIVER SCHEMATIC



TIMER SCHEMATIC



REV. 1

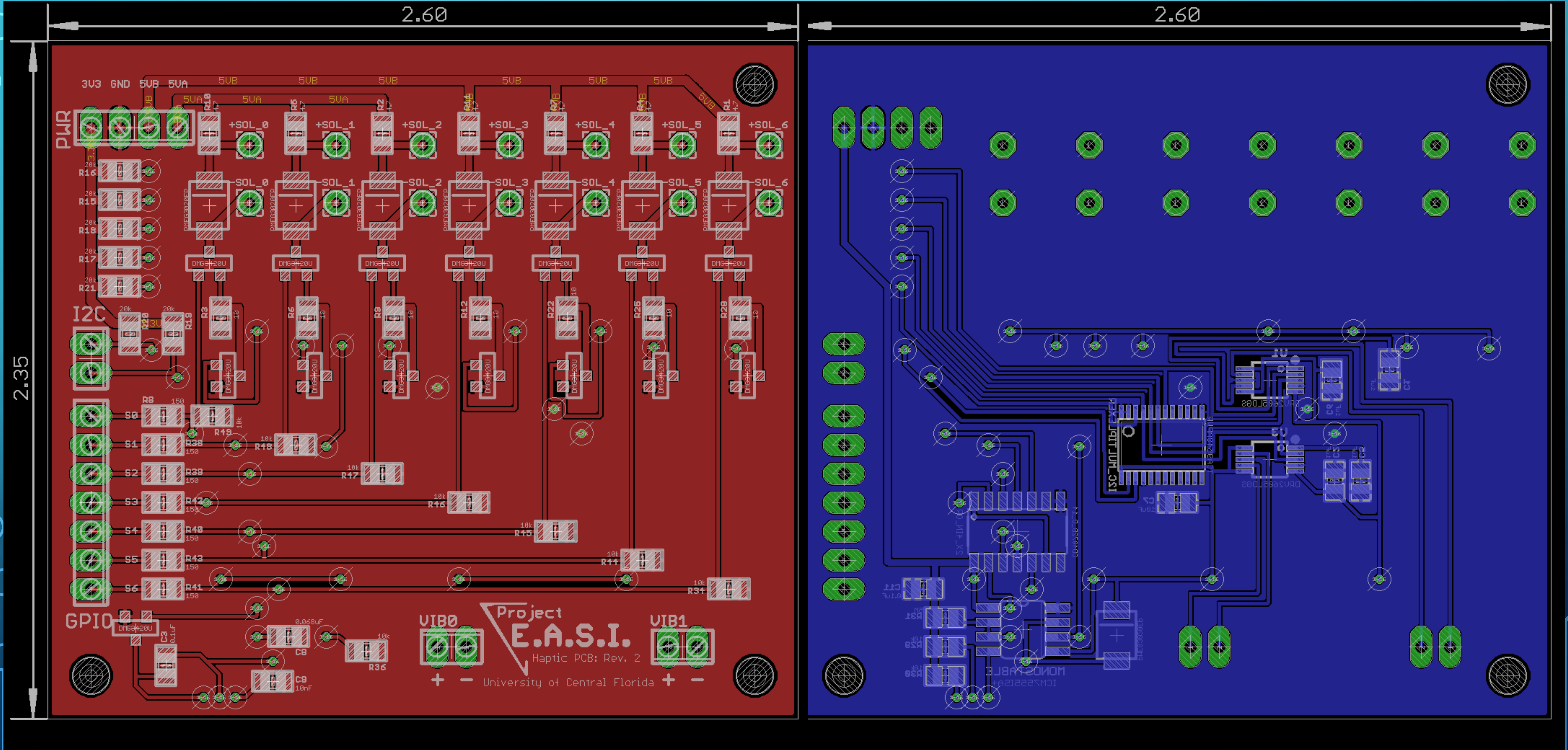

2.59
2.50
3V3
GND
5V
5V
PWR
I2C
SCL
SDA
GPIO
-VIB_1
+VIB_1
-VIB_0
+VIB_0
-SOL_0
-SOL_1
-SOL_2
-SOL_3
-SOL_4
-SOL_5
-SOL_6
+SOL_0
+SOL_1
+SOL_2
+SOL_3
+SOL_4
+SOL_5
+SOL_6
Project E.A.S.I.
Haptic PCB, Rev. 1
University of Central Florida

REV. 1

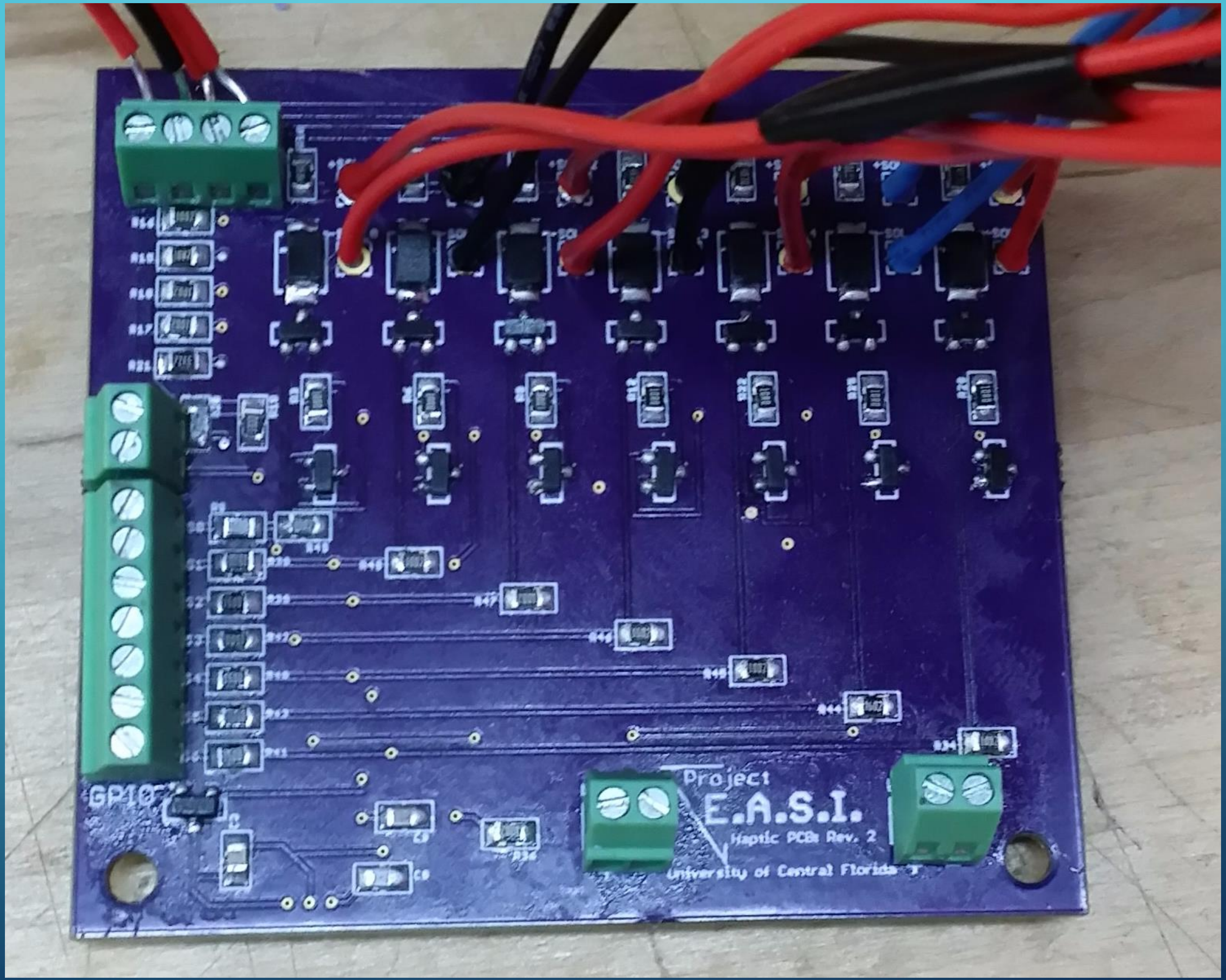
REV. 2

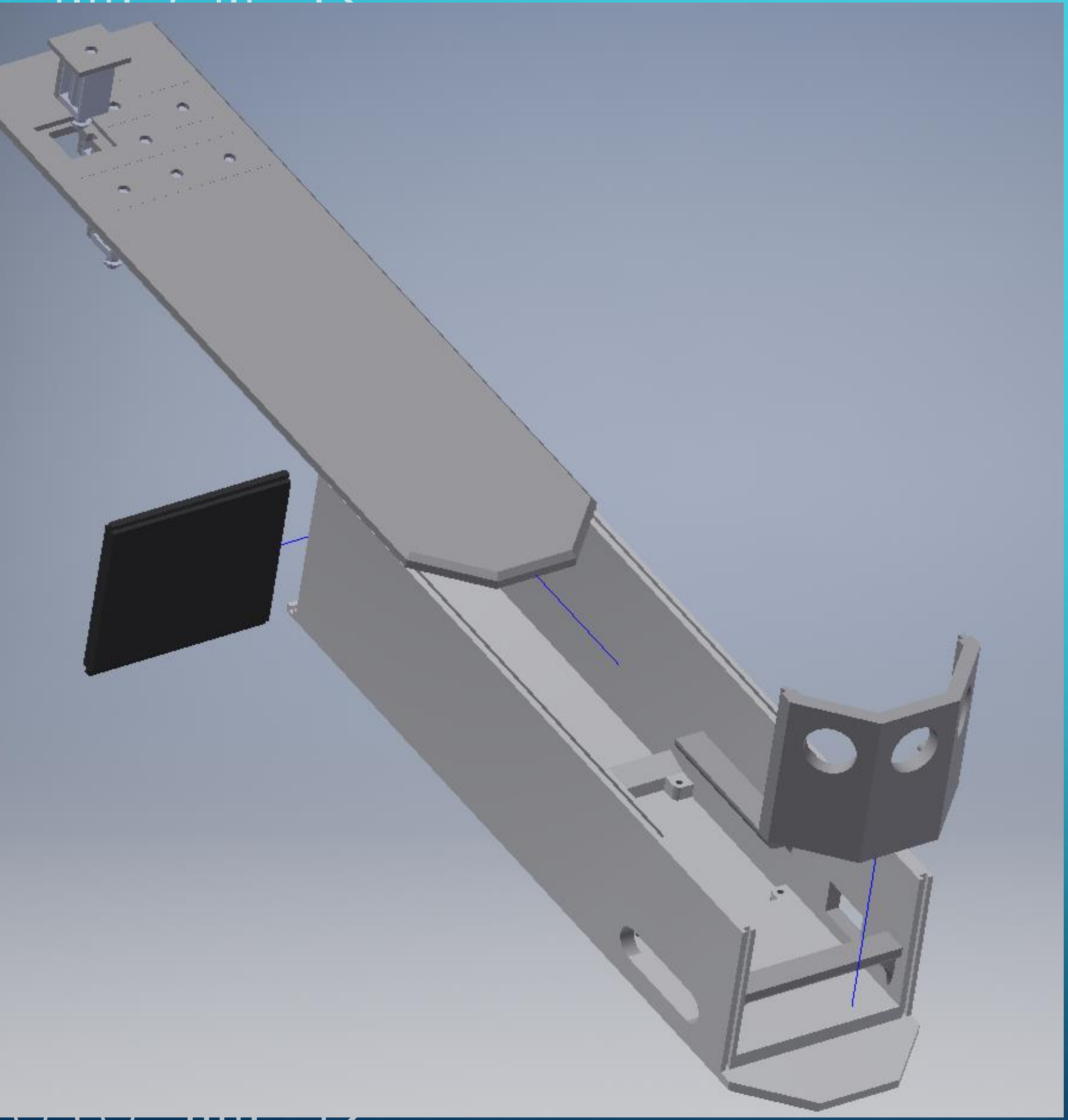
TOP LAYER

BOTTOM LAYER



REV. 2


GPIO
Project
E.A.S.I.
Haptic PCB: Rev. 2
University of Central Florida



CASE DESIGN

- Designed and Modeled in Autodesk Inventor
- 3D Printed with ABS filament

SMARTPHONE SUBSYSTEM

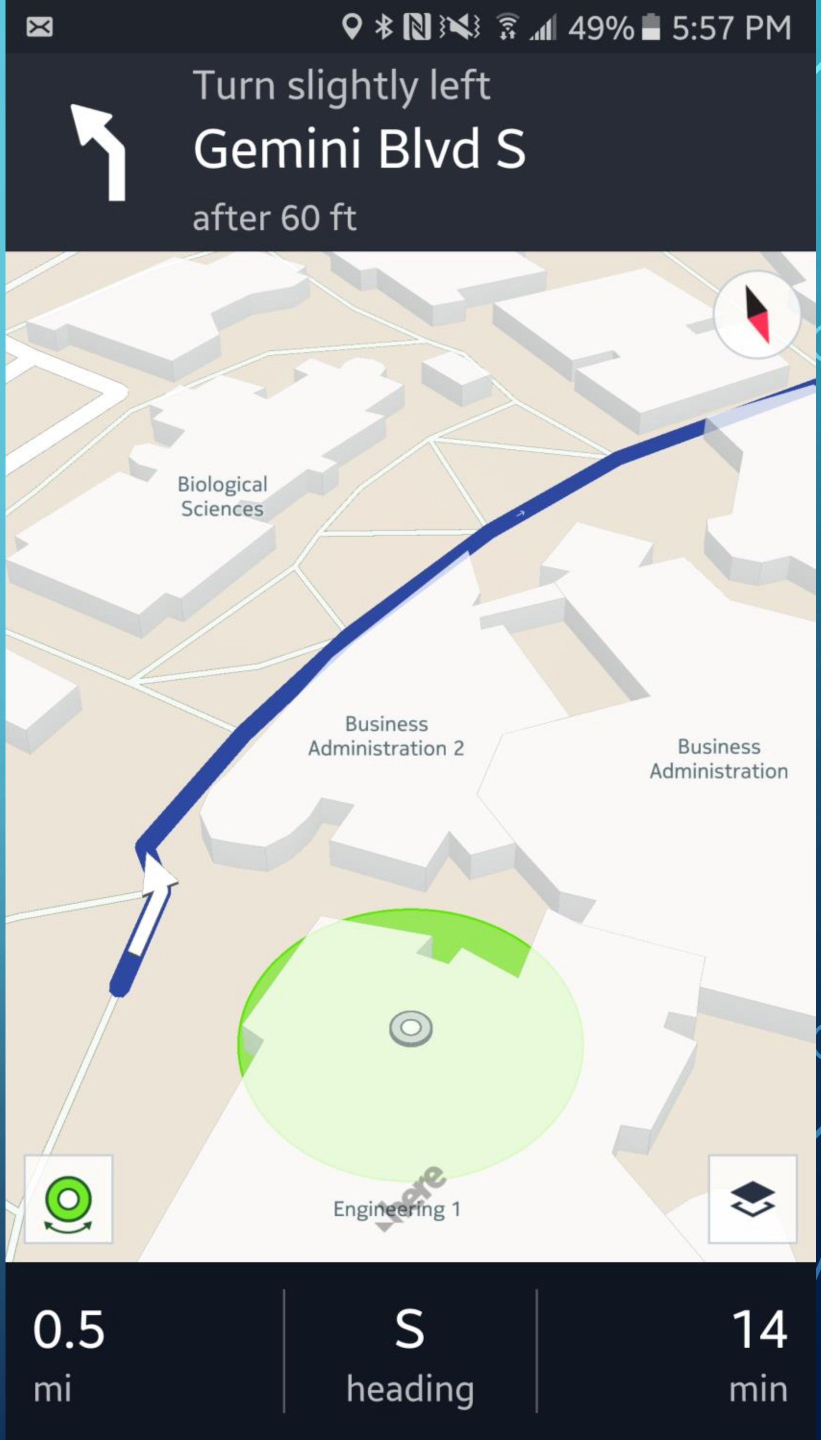
- Navigation
- Mobile Application
- Bluetooth Connections

NAVIGATION

Google Maps	HERE Maps
Popular	No API restrictions for turn by turn navigation
By Google terms and conditions, their API cannot be used to generate turn by turn navigations	Good documentation
	Developer friendly
	Free basic API plan and meets project needs

NAVIGATION

- Implementation of HERE Maps API
- Turn-by-turn navigations
- Two pre-installed addresses
- Background running



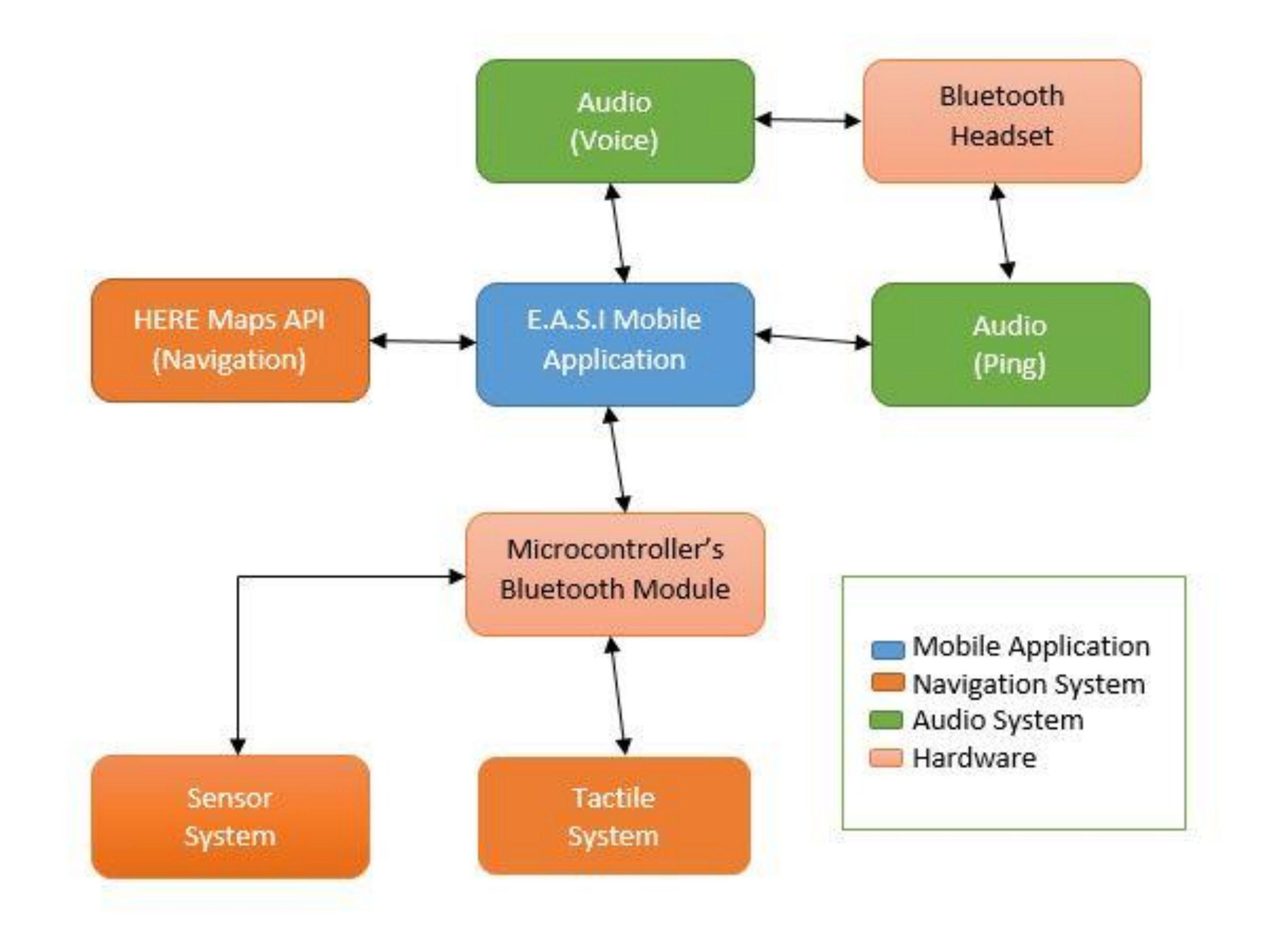
NAVIGATION OBSTACLE

- HERE Maps API location is not accurate enough for pedestrian navigations
- Possible solution:
  - Adding a GPS module to the device for location.
  - Adding local map into the application for direction calculating.

MOBILE APP

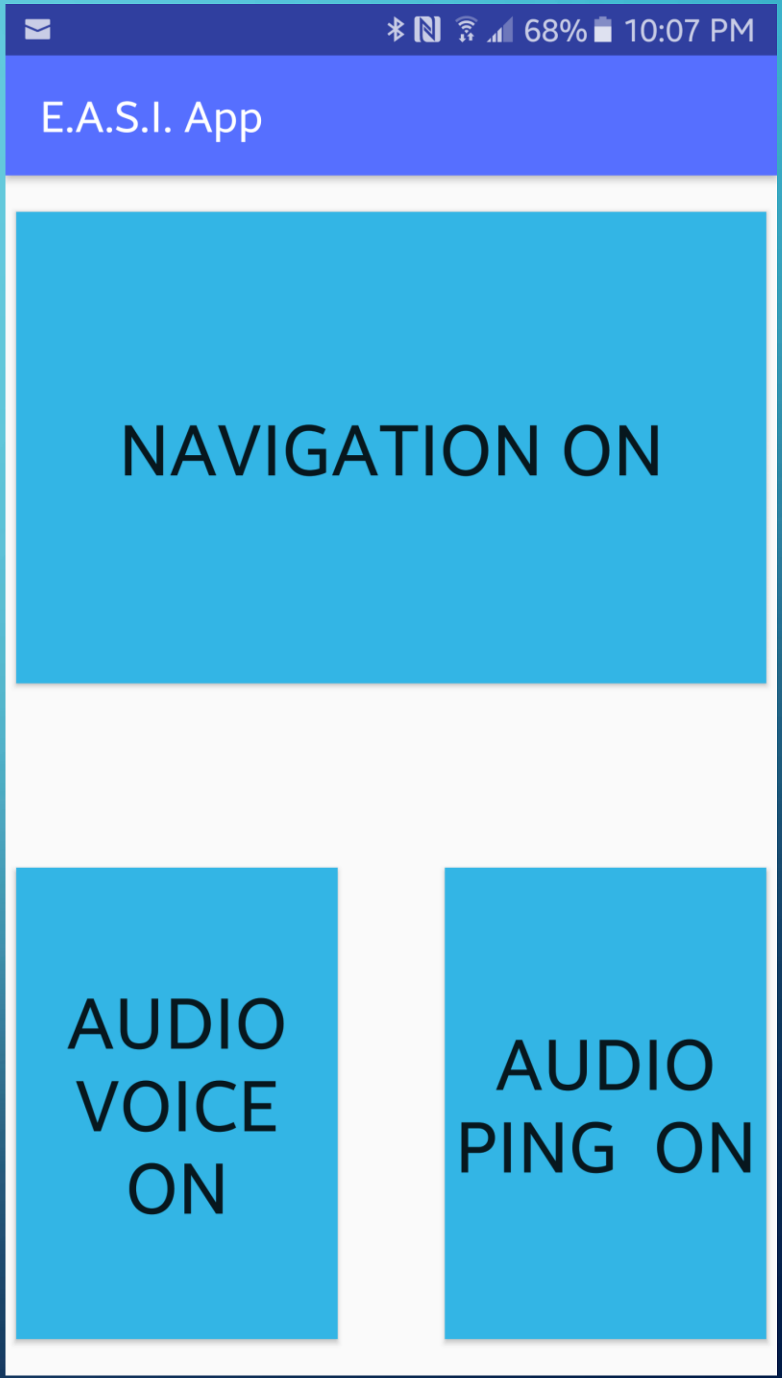
- Android Platform: open source
- Android Studio: simple and popular
- Easy and simple to use user interface
- Voice recognition for navigation

MOBILE APP ARCHITECTURE



E.A.S.I APP

- Simple buttons to turn functions on/off
- Function switch voice prompts.
- Voice prompts object's location.
- Ping pulses object's distances.



BLUETOOTH CONNECTIONS

- Microcontroller Connections
  - Object's locations and distance
  - Turn navigations

- Bluetooth Headset Connections
  - Object's location via voice
  - Object's distance via voice and ping

BUDGET

- Self sponsoring
- Total up-to-date budget: $2400

DEVICE UNIT COST

Items	Cost per Unit	Quantity	Total
Sonar Sensor	30	3	90
Tenergy LiPo Battery Pack	48	1	48
Battery Controller	1.79	1	1.79
Step-Down Converters 3.3V and 5V	15	3	45
Bluetooth Module	7.50	1	7.50
Solenoid	5	7	35
Vibration Motor	3	2	6
Vibration Motor Driver	8	1	8
ATSAMD21G18A-AUT	55	1	50
PCB		2	91.50
Housing	60	1	60
Miscellaneous			170
		Total	612.79

FUTURE WORK

- Further actuator power optimization
- Second case revision
- Continue GPS App Development
- Properly boot load and program MCU on custom PCB
- Linear Actuator technology choice
- Chosen a more widely used microcontroller such as the Atmega328

THE END

- Questions?