# Smart Mirror

**Group 8 – Fall ’16 / Spring ‘17**
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# Project Introduction

- The Smart Mirror is a mirror which displays information to the user such as:
  - Time, Weather, Social Media, News Feed, etc.
- Improves upon a popular DIY project
- Incorporates computer vision technologies

# Motivations

- Create a device the team would be excited to use
- Interest in computer vision technologies
- Develop skills in schematic and PCB design
- Develop skills in software architecture design and computer vision

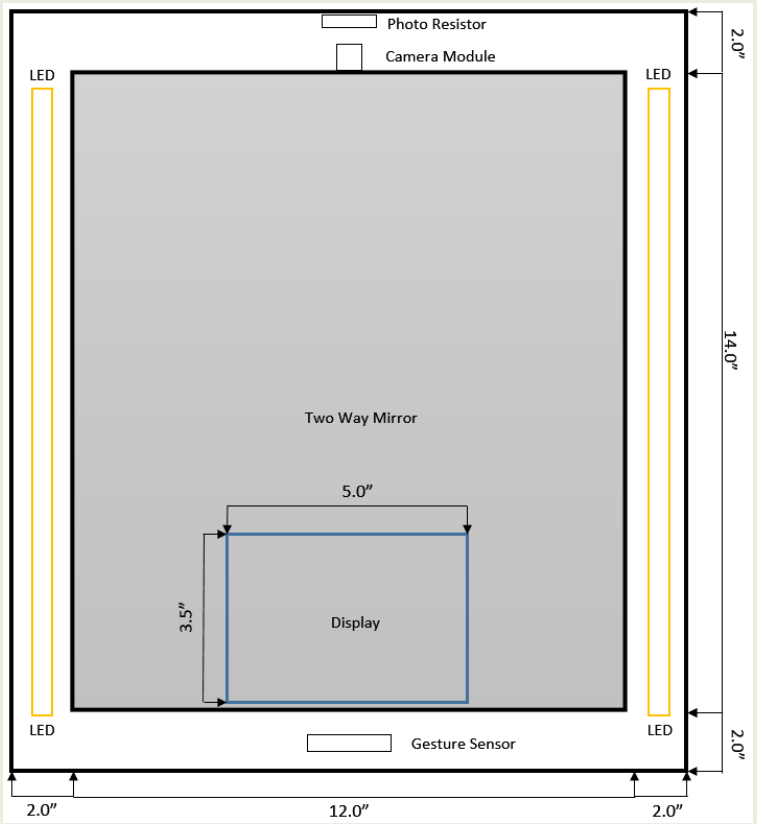
# Goals and Objectives

- Design a mirror to provide information *relevant* to the user
- Implement facial recognition software to determine user, thus which info to display
- Create an *active* device rather than a *passive* one
- A more user friendly UI system
- Be as power efficient as possible

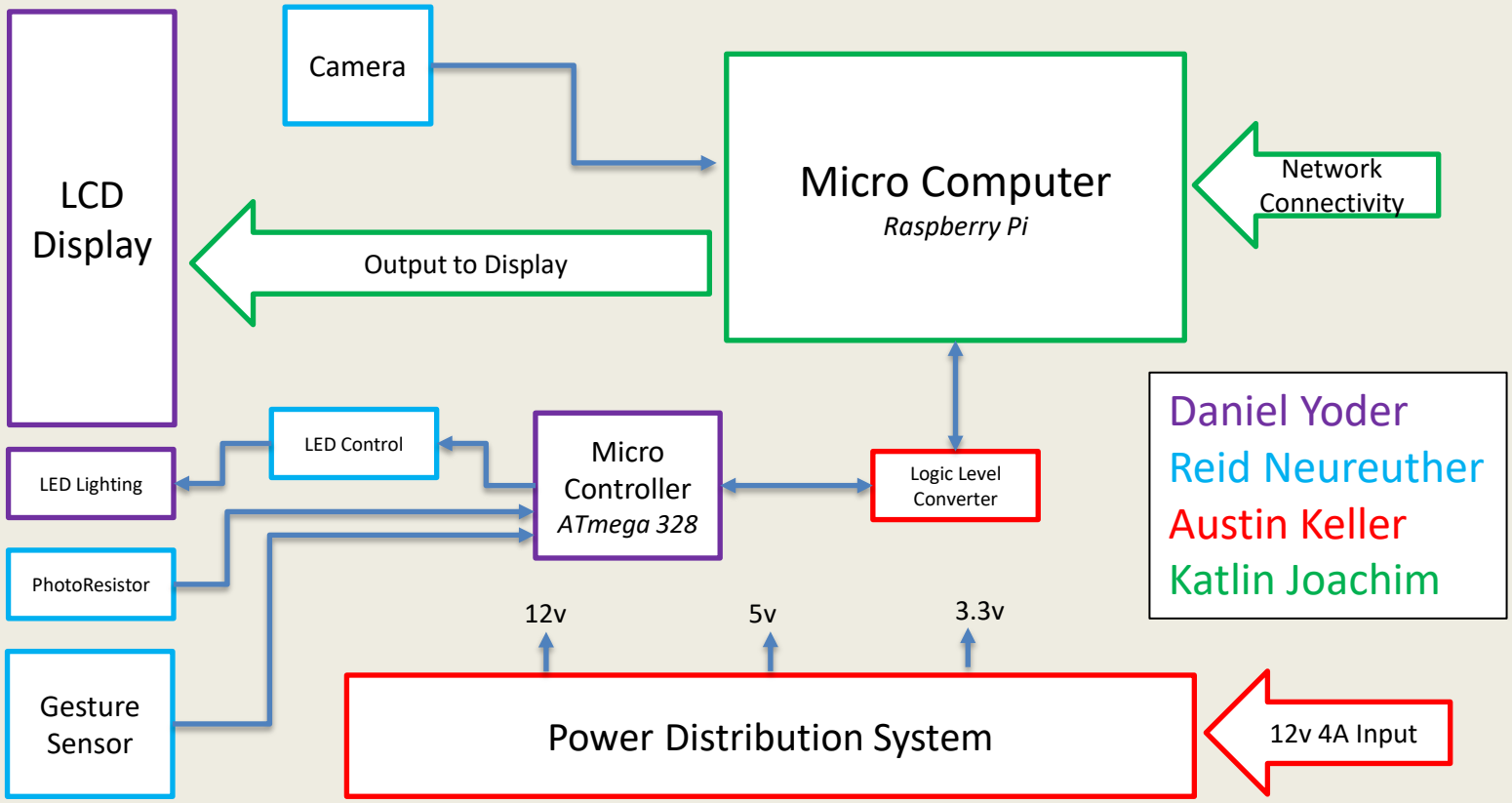
# Project Specifications

| Component | Parameter | Specification |
|---|---|---|
| Information Modules | Amount | 7 modules |
| Facial Recognition | Recognize Time | 6 seconds |
| Power Supply | Input Voltage | 12 Vdc |
| Low Power Mode | Power Saved | 8 watts |
| Gesture Response | Time | 0.5 seconds |
| Mirror | Weight | 10 lbs. max |

# Physical Layout




# Block Diagram



# Power System

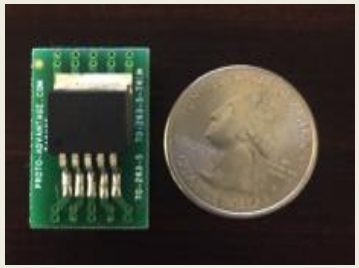
- Powered from AC power socket
  - Use an AC/DC wall plug converter for 12V input
- Needs to provide 3 rails: 12V, 5V, 3.3V
  - 12V: LED Strips
  - 5V: ATMega328, Raspberry Pi, Gesture Sensor, LLC
  - 3.3V: LLC Circuit for communication
- Efficient power usage

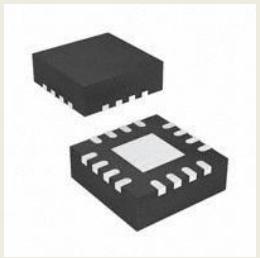
# Switching vs Linear Regulator

- 5V rail is the most demanding, most components need 5V
- Linear regulator would cause upwards of 14W of power
- Switching Regulator is a more efficient solution

# Regulator Selection

| Parameter | LM2596 (Switching) | TPS6213 (Switching) | L78S05 (Linear) |
|---|---|---|---|
| Vin | 4.5V-40V | 3V-17V | 10V-35V |
| Iout | 3A | 3A | 2A |
| Efficiency | 80% | 82% | 42% |
| Supporting Circuit Complexity | Medium | High | Low |
| Cost | $4.91 | $2.51 | $0.68 |
| Size | 14mmx10mm | 3.1mmx3.1mm | 10mmx29mm |





# 3.3V Regulator

- 3.3V rail only used for LLC circuit, very low current draw and voltage difference
- Chose the MCP1700T Linear Regulator
- Smaller, cheaper, easier to
- Size: 3mmx2.5mm

# Power Saving

- Save power by keeping LED's off and dimming the backlight when mirror is not in use.
- If microcontroller determines room bright enough for face recognition, LED's remain off.

# Power Saving

| Configuration | Power (Watts) |
|---|---|
| LED's On, Display On, Face Recognition Running | 15 |
| LED's On, Display On | 14 |
| Display On, Face Recognition Running | 7.9 |
| Display On | 6.5 |
| Low Power Mode | 4 |


Accurate within 0.2%

# Microcontroller

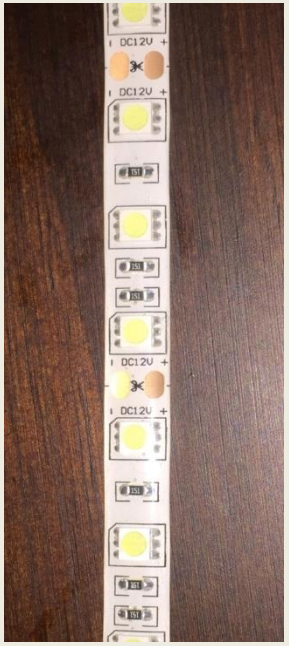
- Speeds
  - No intense need for very fast clock
- Power Saving
  - Less bits being transferred to/from Pi = Less power

| | Atmega328P | MSP430 |
|---|---|---|
| **Clock Speed:** | 20 MHz | 25 MHz |
| **Package:** | Dual In-line | Surface Mount |
| **Core Size:** | 8 bits | 16 bits |

# Design Considerations

- ATmega328P-PU
  - Through-hole mount
  - Larger package
  - Less Analog Ports
- Microcontroller choice:
  - Atmega328P-PU
- Perfect use for this project due to its simplicity and low power usage
  - Microcontroller is used for led control and sensor input/output
- ATmega328P-AU
  - Surface Mount
  - Smaller Package
  - More Analog Ports

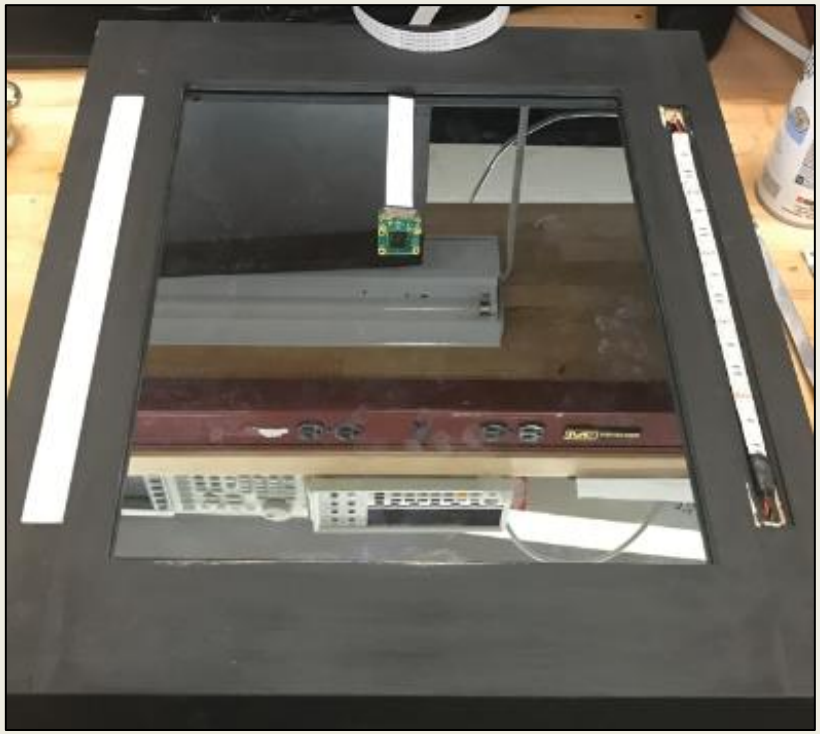
# LED Lighting



- LED Lighting
  - Enhances ambient lighting for facial recognition
  - Aesthetic purposes
- Power Saving
  - One of the most efficient options
  - Next closest had 300 lumens/m

| | Adafruit DotStar Digital LED Strip | Standard Density LED Flex Strips | Cool White LED Flexi-Strip |
|---|---|---|---|
| **Color:** | RGB | White | White |
| **Brightness:** | ~419 Lumens | ~300 Lumens | ~600 Lumens |
| **Max Current Draw** | ~60mA (per RGB LED) | ~20mA (per RGB LED) | ~20mA (per RGB LED) |

# LED Lighting



Front view of Smart Mirror

# LED Lighting

LEDs full power (dark ambient lighting)

LEDs medium power (brighter ambient lighting)

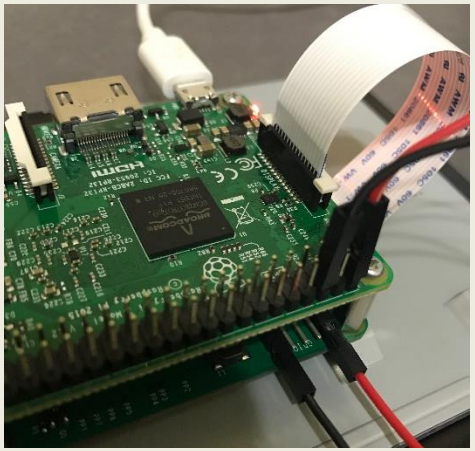
# Microcomputer

- Raspberry Pi Model 3B
  - Powerful processor for facial recognition
- Display
  - Interfaces and powers display seamlessly

| | TI Beaglebone Black | Raspberry Pi Model 2 | Raspberry Pi Model 3B |
|---|---|---|---|
| **Price:** | $60.00 | $35.00 | $35.00 |
| **Processor:** | AM3358 ARM Cortex A8 @ 1GHz | ARM Cortex-A7 @ 900MHz | LPDDR2 ARM Cortex A53 @ 1.2 GHz |
| **GPIO Pins:** | 46 | 40 | 40 |

# Display

- 7 inch LCD display unit
  - Compatible with the Raspberry Pi 3 Model B
- The Smart Mirror *shall* be powered via a single cord
- Interfaces seamlessly with existing components chosen
- Also helps minimize the overall weight of the system



| | 7” inch display for Raspberry Pi3 | Secondhand Computer Monitor | 13.3 inch widescreen HDTV |
|---|---|---|---|
| Cost: | $68.99 | >$30 | >$100 |
| Size: | 7-inch | Varies | 13.3 inch |
| Power Source: | Raspberry Pi | External | External |

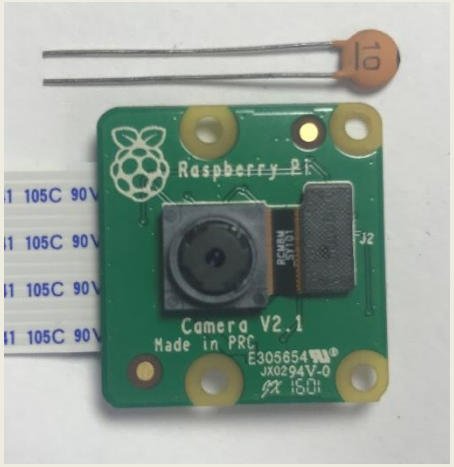
# Presence Sensor

- 5v Input
- Infrared Distance sensing
  - 1in to 2ft
- Gesture Sensing
  - Left, Right, Up
- I2C serial
  - Refresh rate every 20ms
  - Interrupts


| | Ultrasonic Sensor HC-SR04 | Passive IR Motion Sensor | ZX Distance Gesture Sensor |
|---|---|---|---|
| **Price:** | $15.00 | $10.00 | $25.00 |
| **Range:** | 13ft | 20ft | 2ft |
| **Data:** | Distance | True/False | Distance and Gestures |

# Camera

- Used for face recognition
- Small footprint
- Adequate resolution



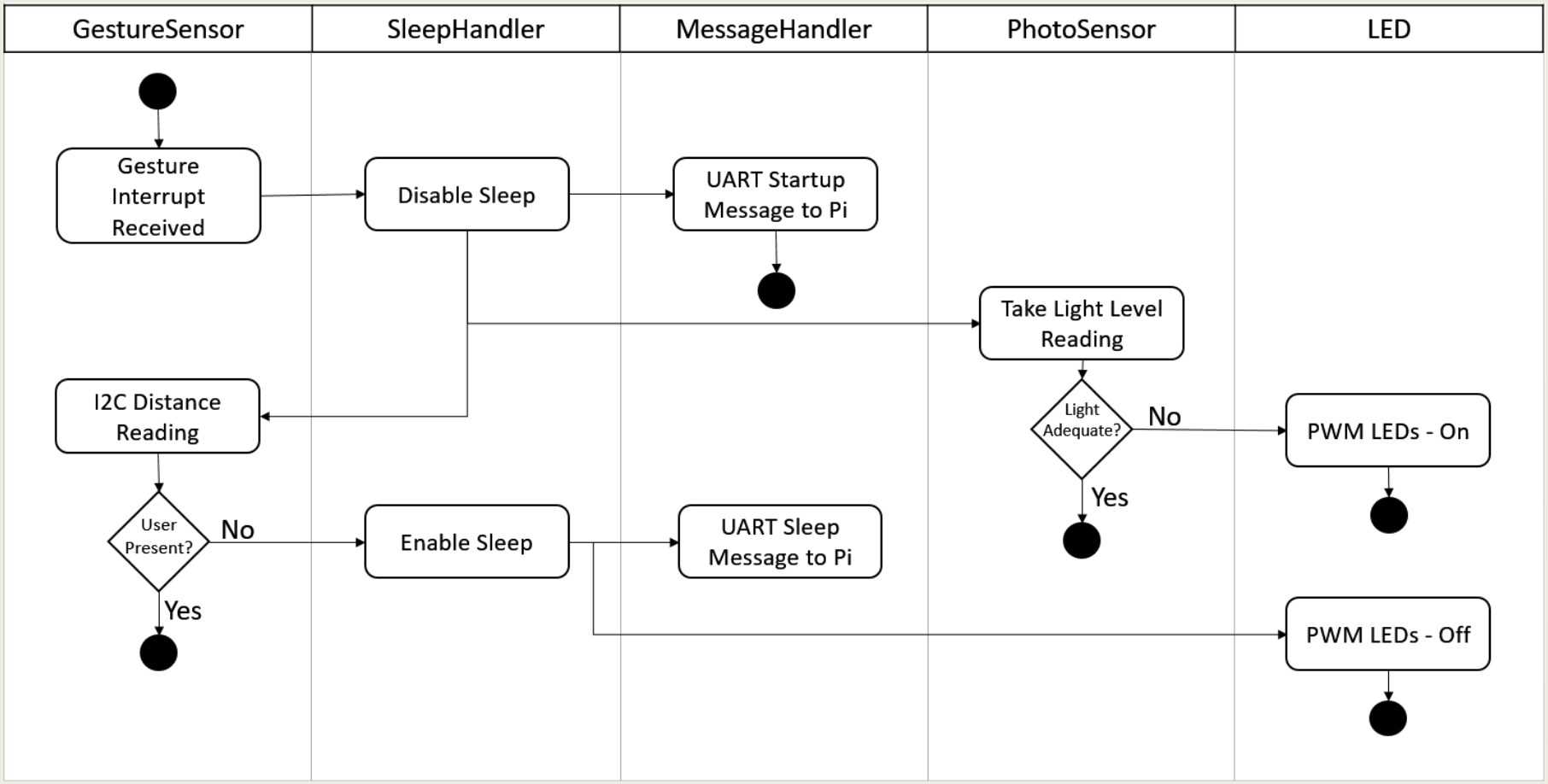

| | C920 Webcam | HP2100 Webcam | Rpi Camera Module v2 |
|---|---|---|---|
| **Price:** | $98.00 | $30.00 | $30.00 |
| **Resolution** | 15MP | 8MP | 8MP |
| **Size:** | 7.5x2in | 2.5x2.5in | 25x25mm |
| **Weight** | 450g | 30g | 3g |

# Load Sharing

- Sensor input
  - Gesture
  - Photoresistor
- LED Control
- Repeated polling

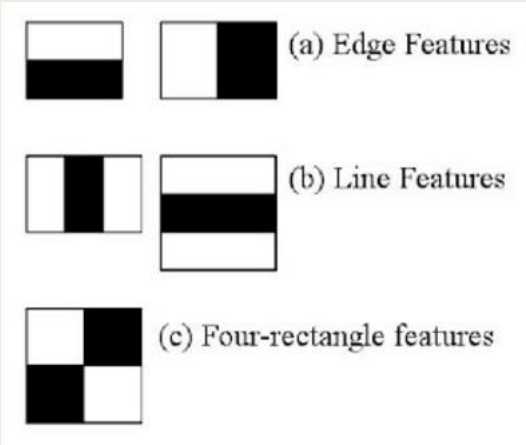
- Display
- Face Recognition
- Network Data

# ATmega Activity Diagram

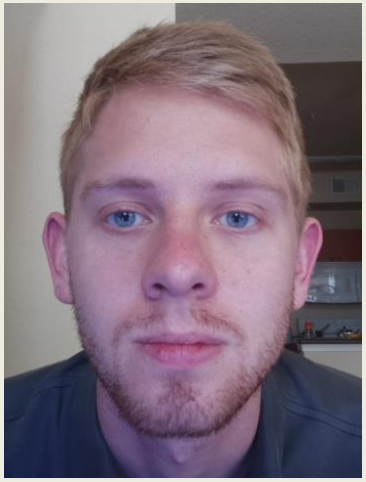


# Face Recognition

- Detect the current user
- OpenCV 2.4 and Python 2.7
- Multi-stage process
  - Detect & Train
  - Identify & Recognize
- Haar Cascade Identifiers
  - Face, Eyes, Mouth

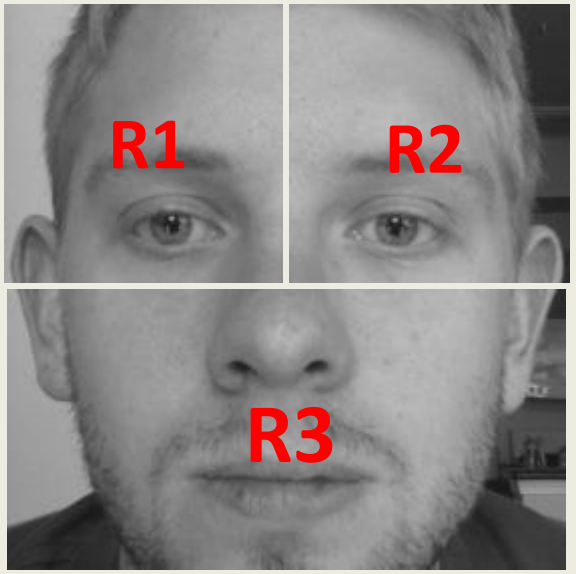


# Feature Based



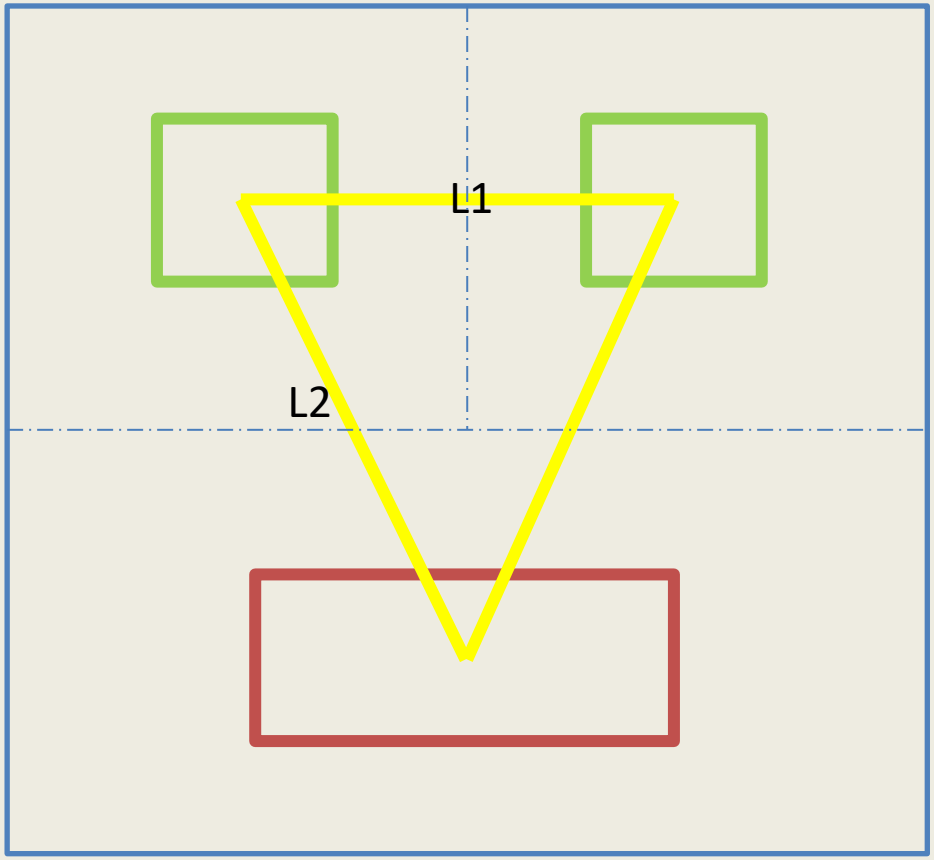
- Original image capture

- Greyscale
- Haar Cascade
- Crop




- Region based feature search
- Feature location validation

# Feature Based

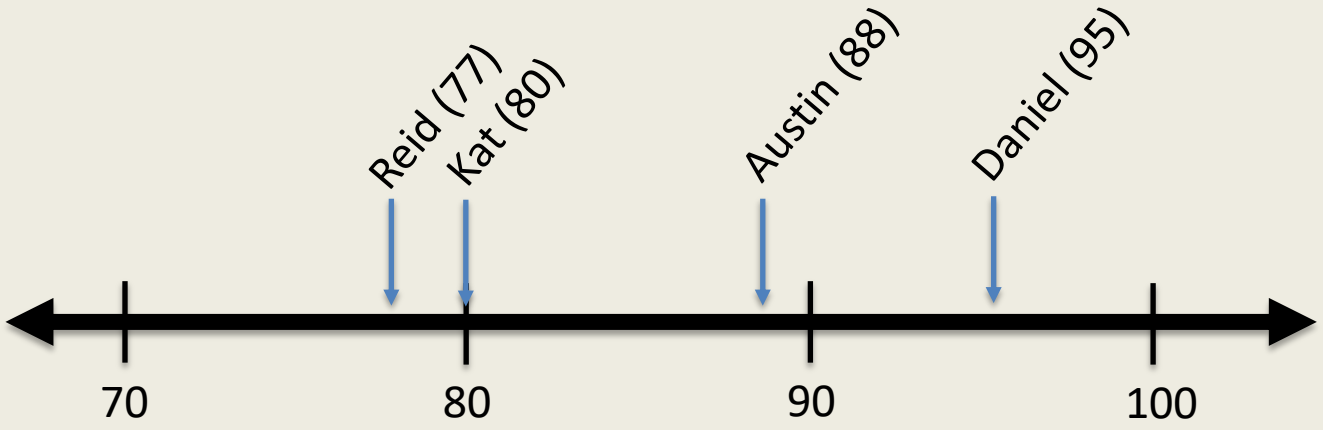



1. Identify the eyes and mouth
2. Calculate the midpoint
3. Rescale values based on regions

$$PersonalMetric = \frac{L1}{L2} * 100$$

- Typical Range: 75<M<100
- Highly dependent on face orientation

# Feature Based

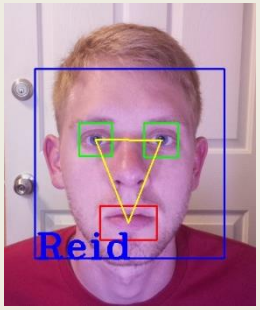


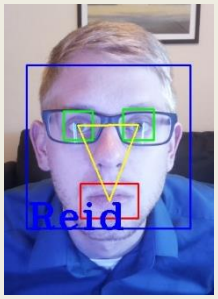

- Find the closest user
- Metrics are preconfigured during setup
- Send the ID to the framework

- Allow for a ±6.2% variability
  - Equates to ±6 metric points

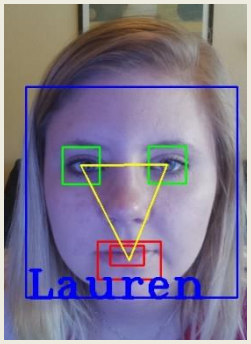
# Feature Based Results

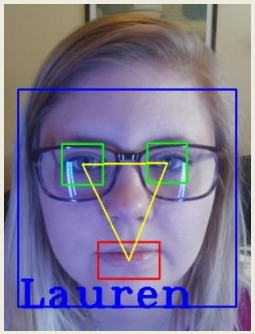
Restitch the regions for verification

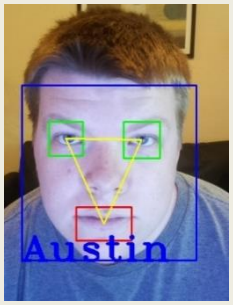


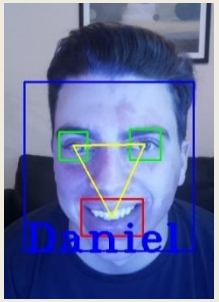



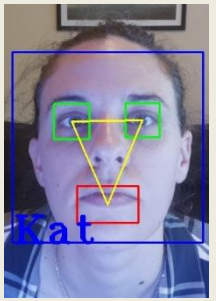

- Family Invariant
- Glasses Invariant

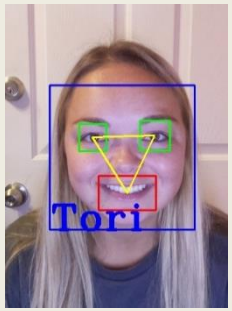


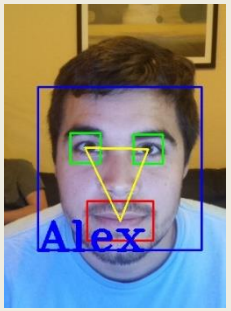



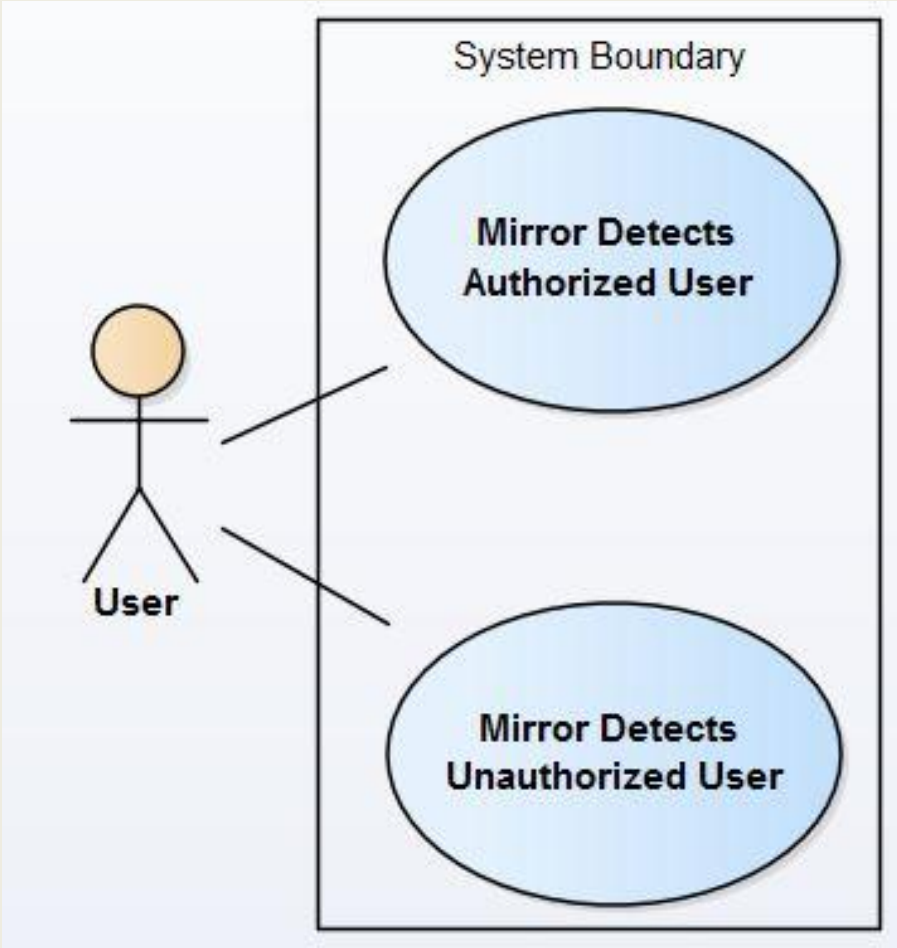



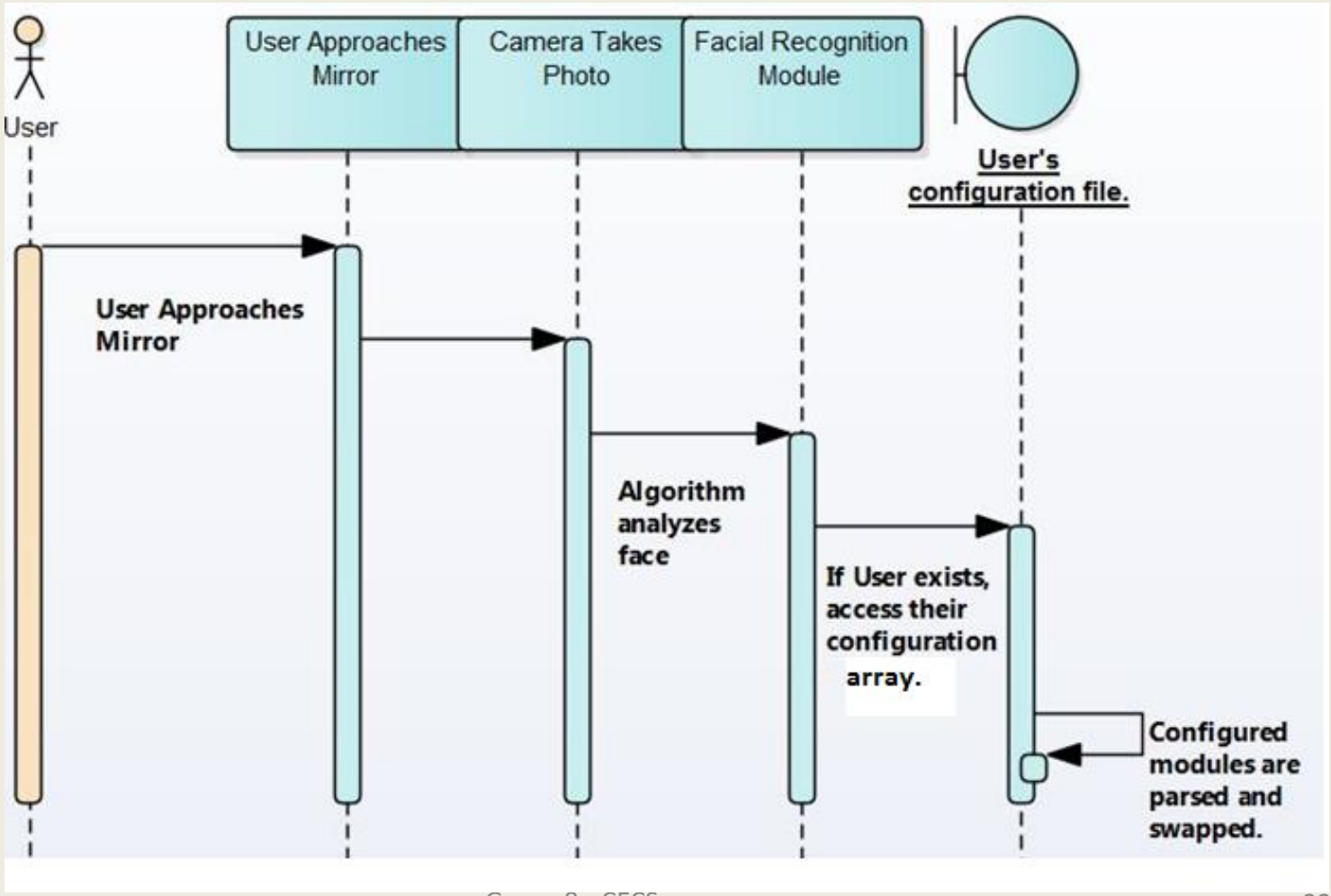



# User Story

- As a user, I wish to view:
  - Time & Date
  - News/Social Feed
  - Calendar
  - Current Weather
  - Weather Forecast



# Authorized User Use-Case



# Node.Js

- Utilizes the V8 Javascript Engine
- Event-Driven Architecture
- Good for persistent connections
- Allows code to be shared between browser and back-end

# Node Package Manager

- Easily shares Node.JS modules
- Node Package Manager handles nested dependencies
- Most commonly used with Node.JS runtime environment

# Angular 2

- Open sourced front-end web application framework
- Angular2 was released in May 2016
  - Good for small scale applications
  - Utilizes Typescript
  - Allows for dynamic loading

# Module Swapping

- Provides a solution to user privacy
- Allows user to have more control over what they view via gestures
  - Cycle through each of the available modules to see content
- Saves space on the current 7 in. display

# News Feed/Twitter Feed

- Mirror shows headlines based on RSS feed
- Shows recent tweets from user's followings.
  - Amount of tweets shown are configurable

# Message Datapath

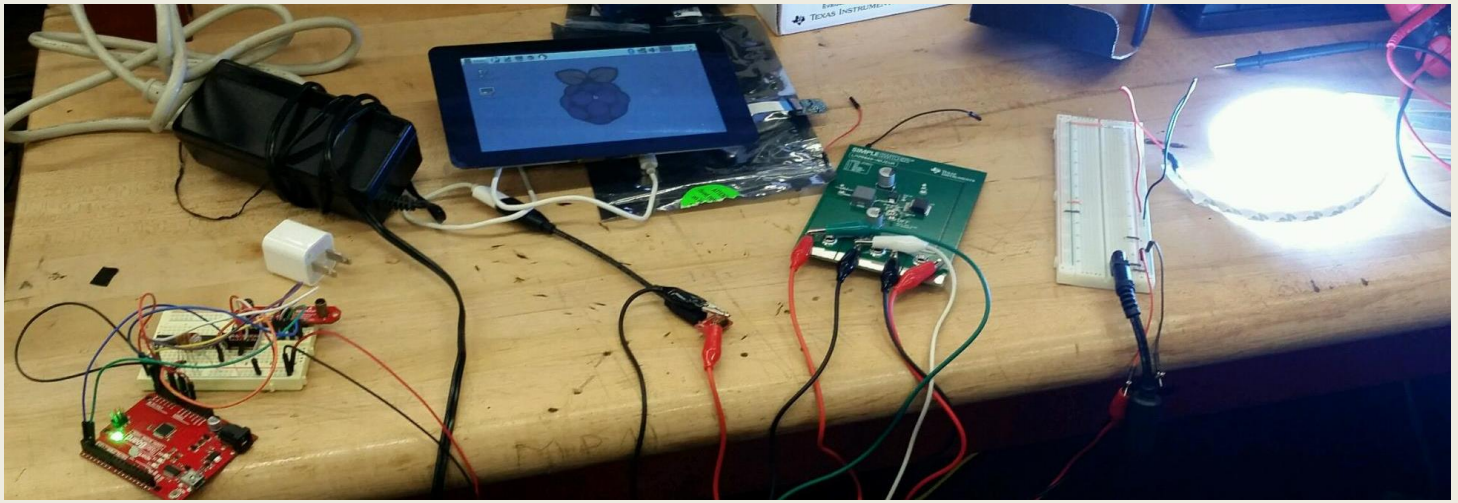


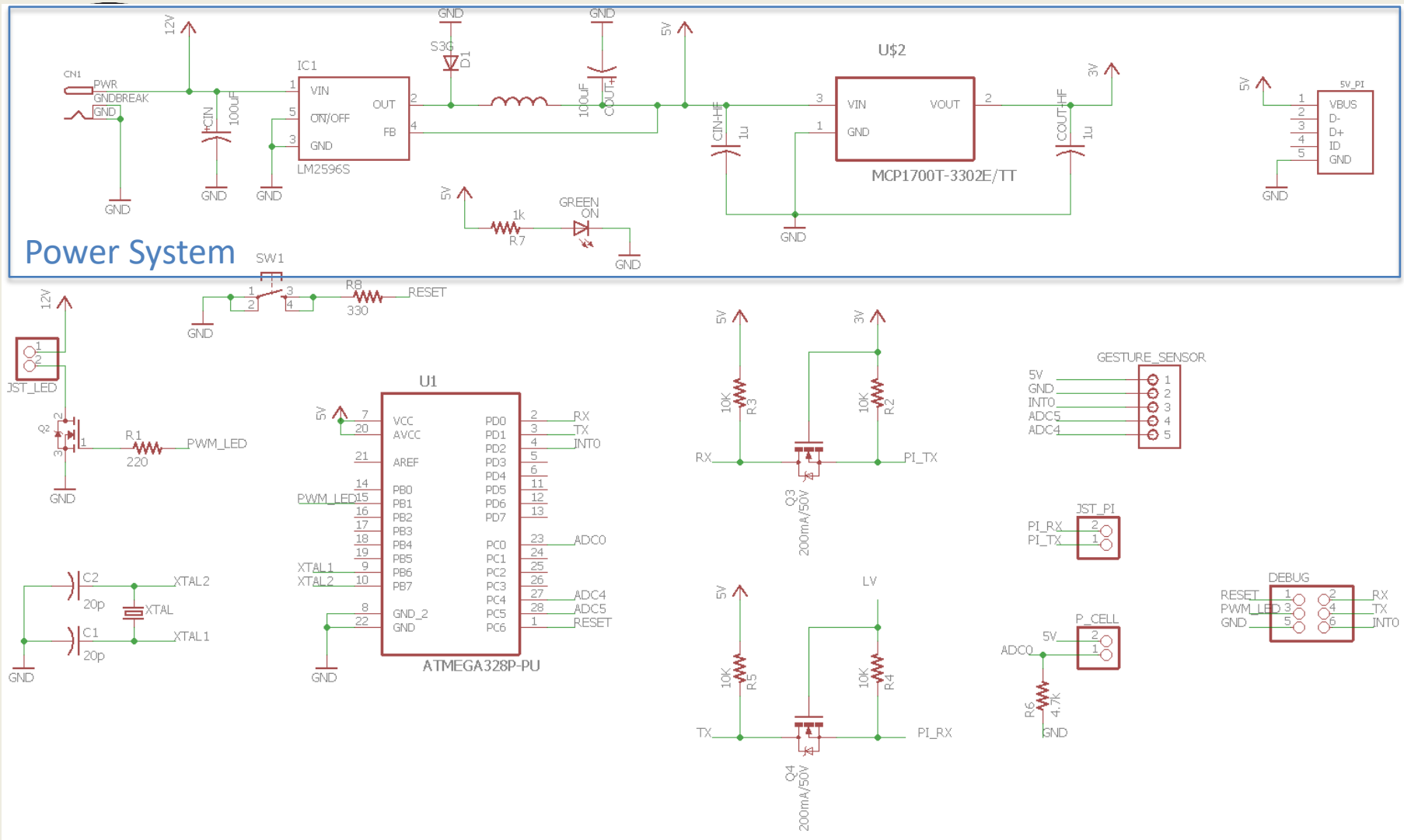


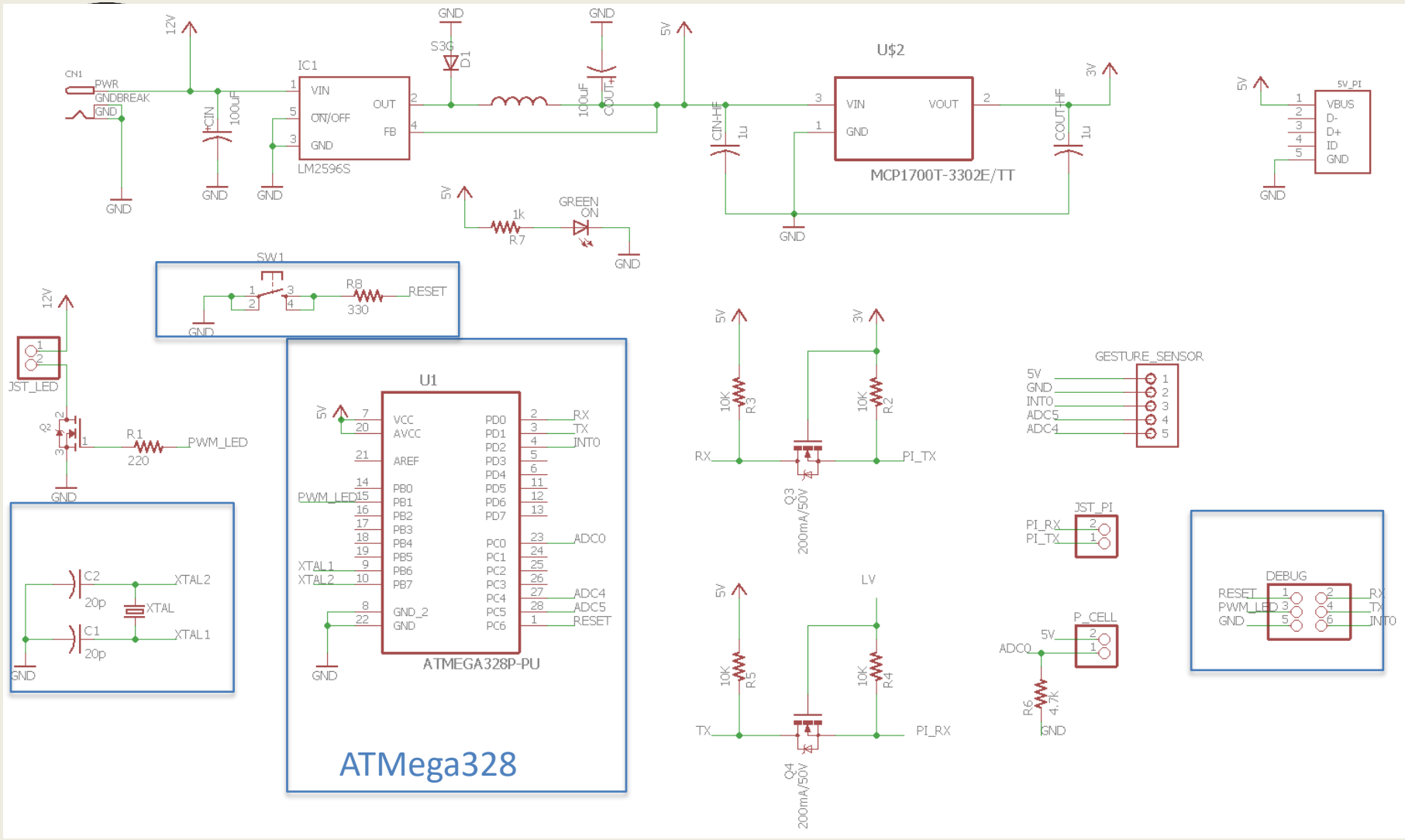
- The Module runs the logic
- The Helper runs data acquisition scripts
- Response Time
  0.5-1.0 sec
- Similar data path for camera

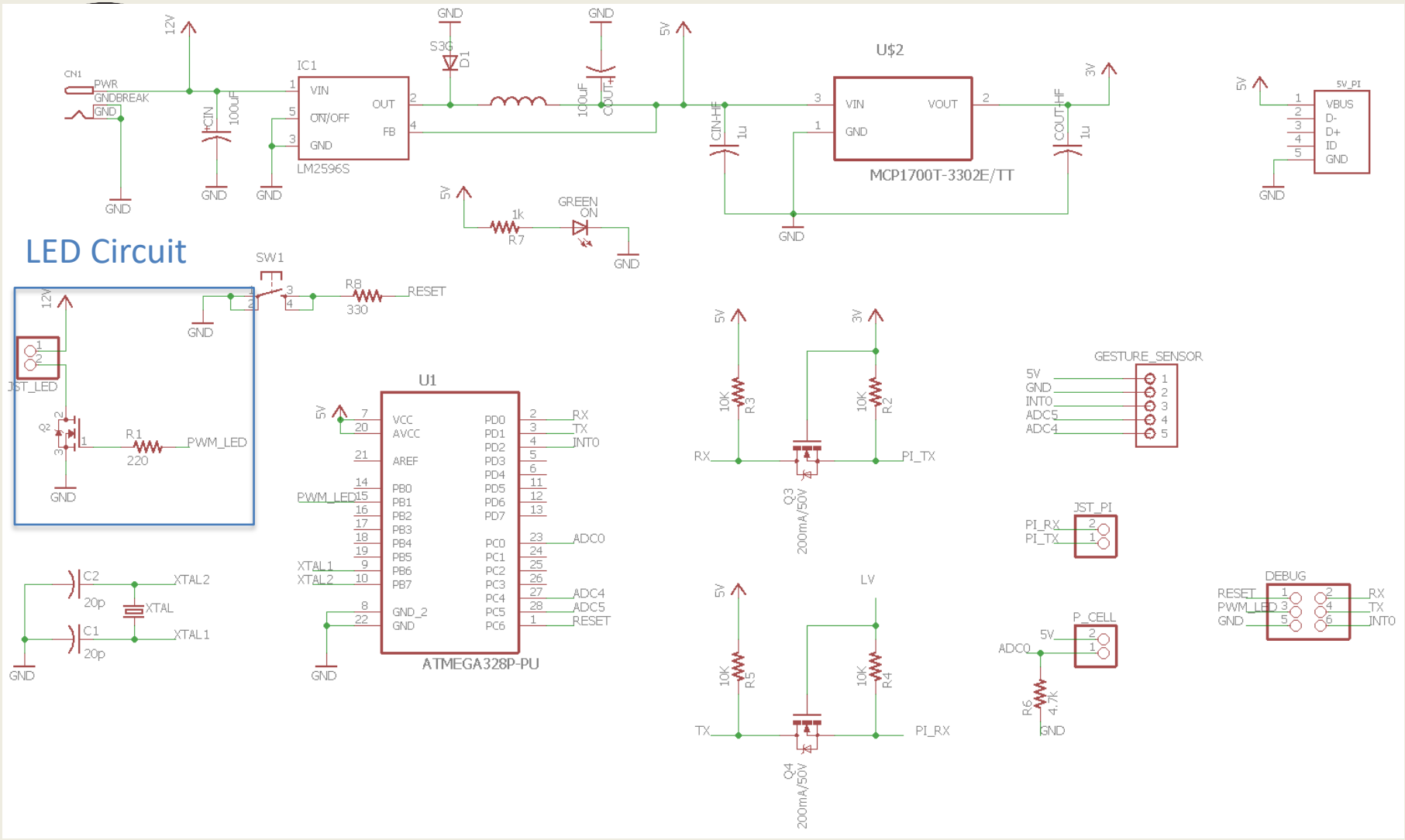
# Breadboard Testing

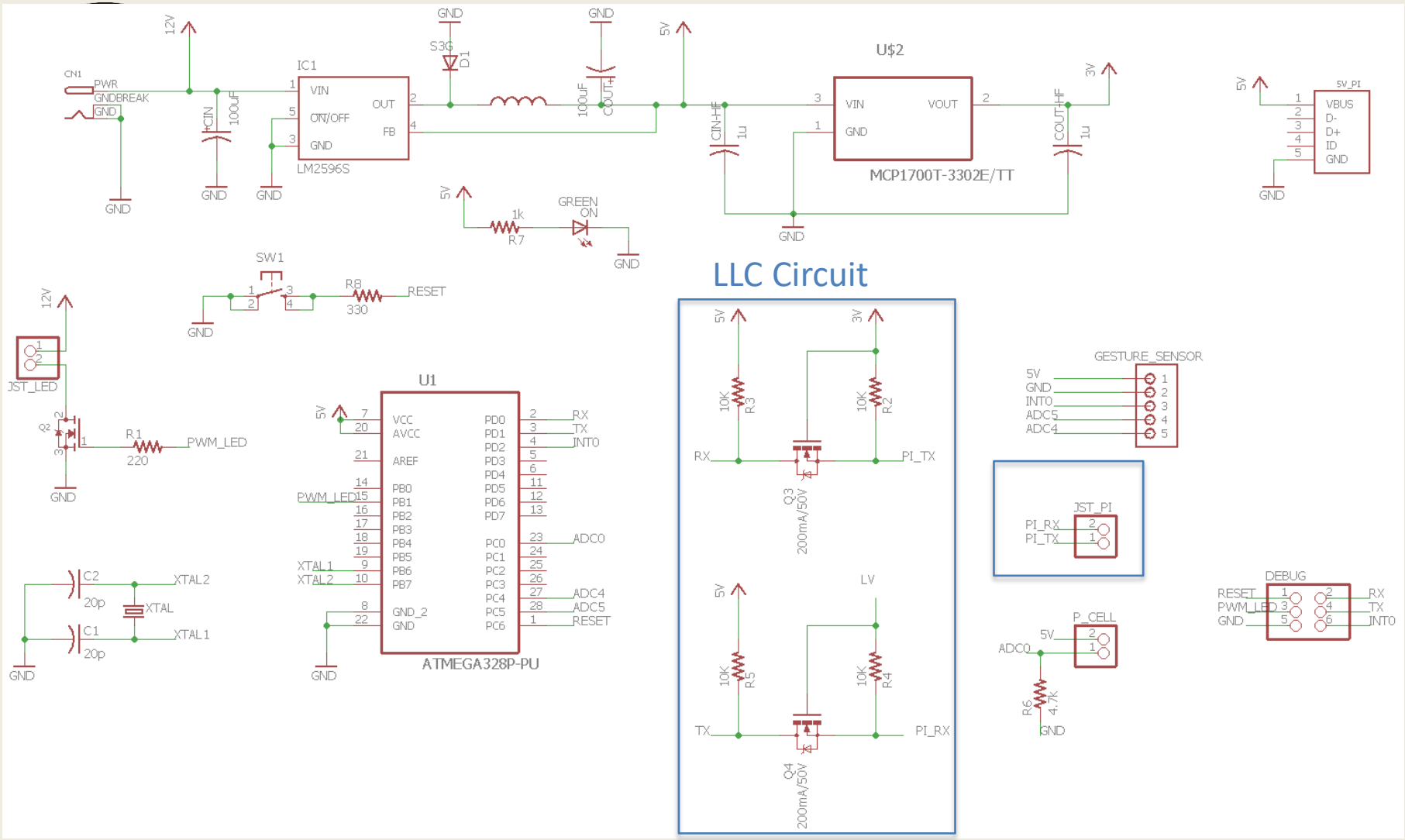
- Tested to ensure each subsystem function separately first, then began combining them together
- Operate all subsystems at same time to ensure no power or communication issues

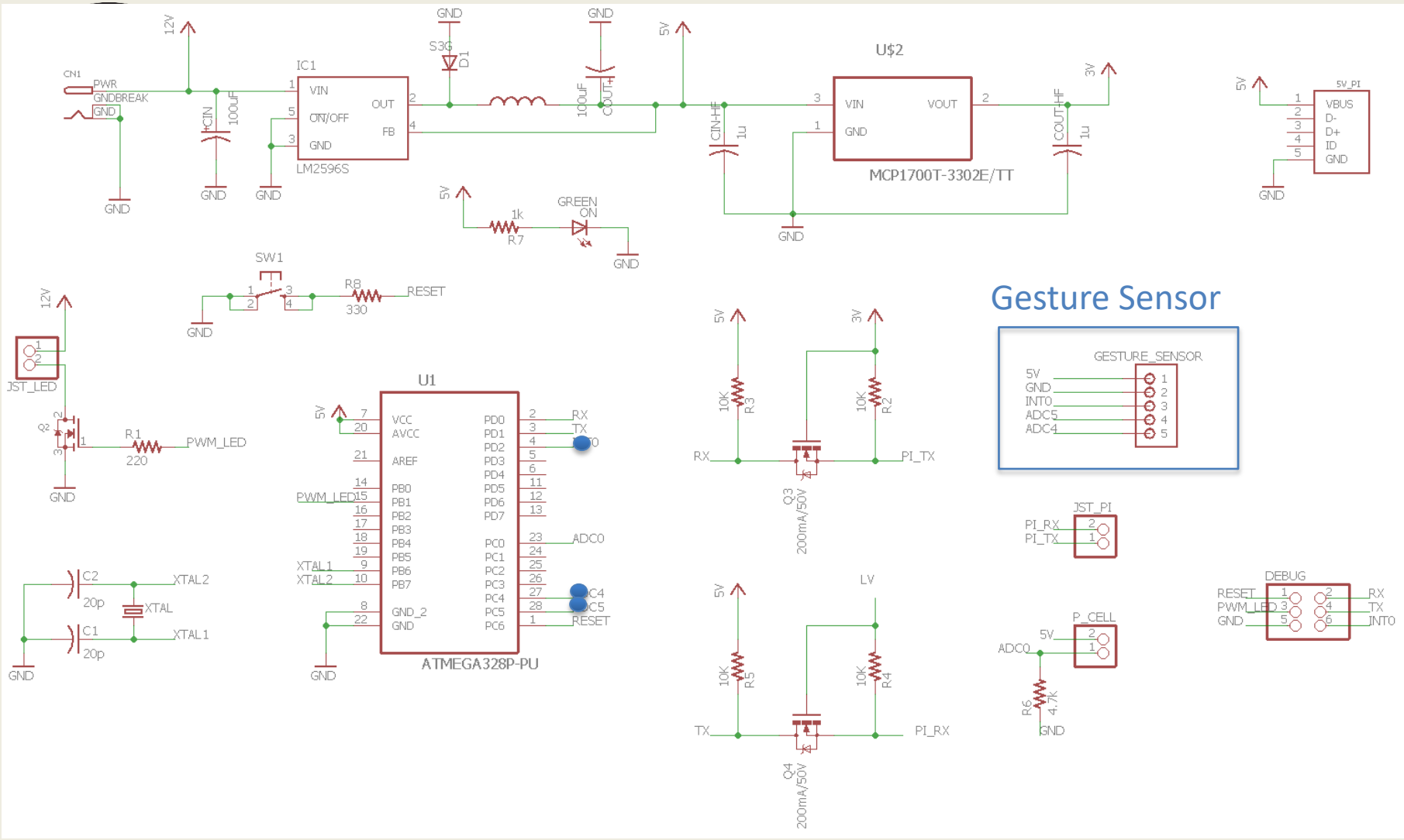


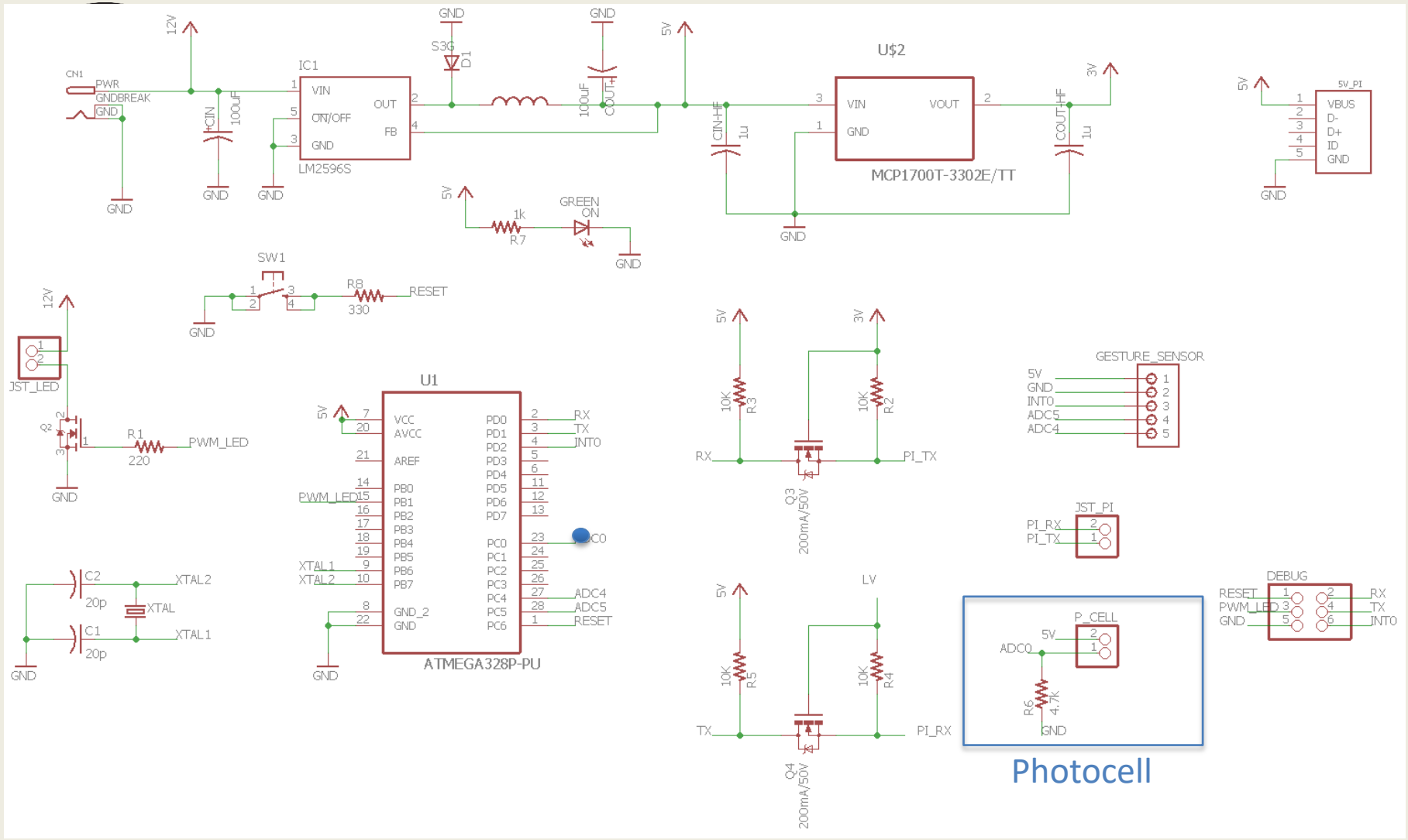

Power System
12V
CN1
PWR
GNDBREAK
GND
CIN
100uF
IC1
VIN
ON/OFF
GND
OUT
FB
LM2596S
S3G
D1
COUT
100uF
5V
U$2
VIN
GND
VOUT
MCP1700T-3302E/TT
CIN-HF
1u
COUT-HF
1u
3V
5V_PI
VBUS
D-
D+
ID
GND
1k
R7
GREEN
ON
SW1
R8
330
RESET
JST_LED
Q2
R1
220
PWM_LED
U1
VCC
AVCC
AREF
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
GND_2
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
RX
TX
INT0
ADC0
ADC4
ADC5
RESET
XTAL1
XTAL2
ATMEGA328P-PU
C2
20p
XTAL
C1
20p
10K
R3
R2
Q3
200mA/50V
PI_TX
RX
GESTURE_SENSOR
INT0
ADC5
ADC4
JST_PI
PI_RX
PI_TX
LV
10K
R5
R4
Q4
200mA/50V
TX
PI_RX
P_CELL
ADC0
R6
4.7k
DEBUG
RESET
PWM_LED


12V
GND
S3G
D1
100uF
5V
U$2
VIN
VOUT
GND
MCP1700T-3302E/TT
3V
1u
5V_PI
VBUS
D-
D+
ID
GND
CN1
PWR
GNDBREAK
IC1
CIN
COUT
LM2596S
ON/OFF
FB
1k
R7
GREEN
ON
SW1
R8
330
RESET
JST_LED
Q2
R1
220
PWM_LED
U1
VCC
AVCC
AREF
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
GND_2
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
RX
TX
INT0
ADC0
ADC4
ADC5
RESET
XTAL1
XTAL2
ATMEGA328P-PU
C2
20p
XTAL
C1
10K
R3
R2
Q3
200mA/50V
PI_TX
PI_RX
GESTURE_SENSOR
ADC5
ADC4
JST_PI
P_CELL
R6
4.7k
LV
R5
R4
Q4
DEBUG
ATMega328

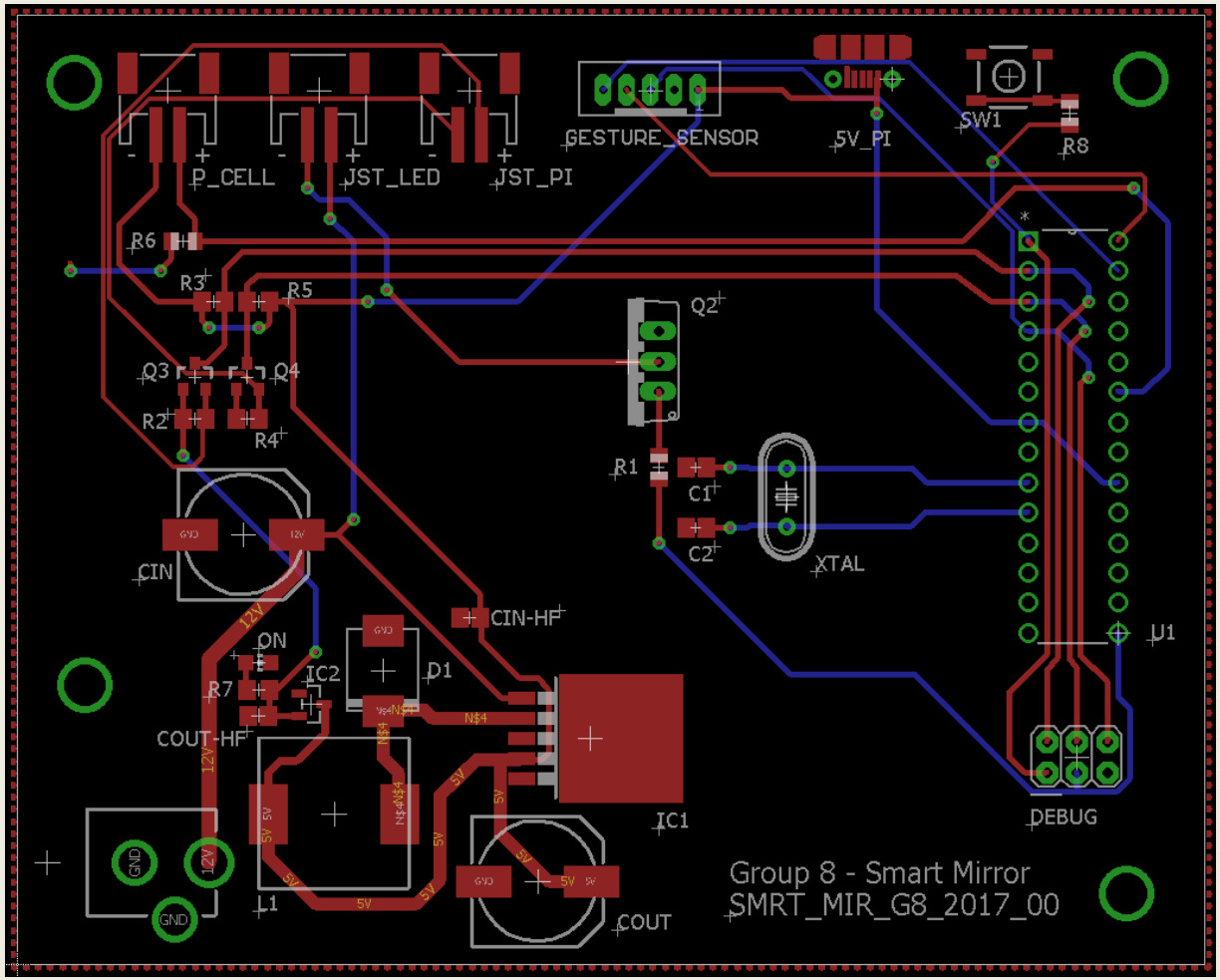

LED Circuit
12V
GND
S3G
D1
IC1
LM2596S
VIN
ON/OFF
FB
OUT
CIN
100uF
COUT
5V
U$2
MCP1700T-3302E/TT
VIN
VOUT
GND
CIN-HF
COUT-HF
1u
3V
5V_PI
VBUS
D-
D+
ID
GND
1k
R7
GREEN
ON
SW1
R8
330
RESET
JST_LED
Q2
R1
220
PWM_LED
U1
ATMEGA328P-PU
VCC
AVCC
AREF
GND_2
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
RX
TX
INT0
ADC0
ADC4
ADC5
RESET
XTAL1
XTAL2
C2
C1
20p
XTAL
10K
R3
R2
Q3
200mA/50V
PI_TX
PI_RX
GESTURE_SENSOR
ADC5
ADC4
JST_PI
LV
R5
R4
Q4
TX
P_CELL
R6
4.7K
DEBUG


LLC Circuit
IC1
LM2596S
U$2
MCP1700T-3302E/TT
U1
ATMEGA328P-PU
GESTURE_SENSOR
JST_PI
P_CELL
DEBUG
JST_LED
SW1
GREEN ON
LV
Q3 200mA/50V
Q4 200mA/50V

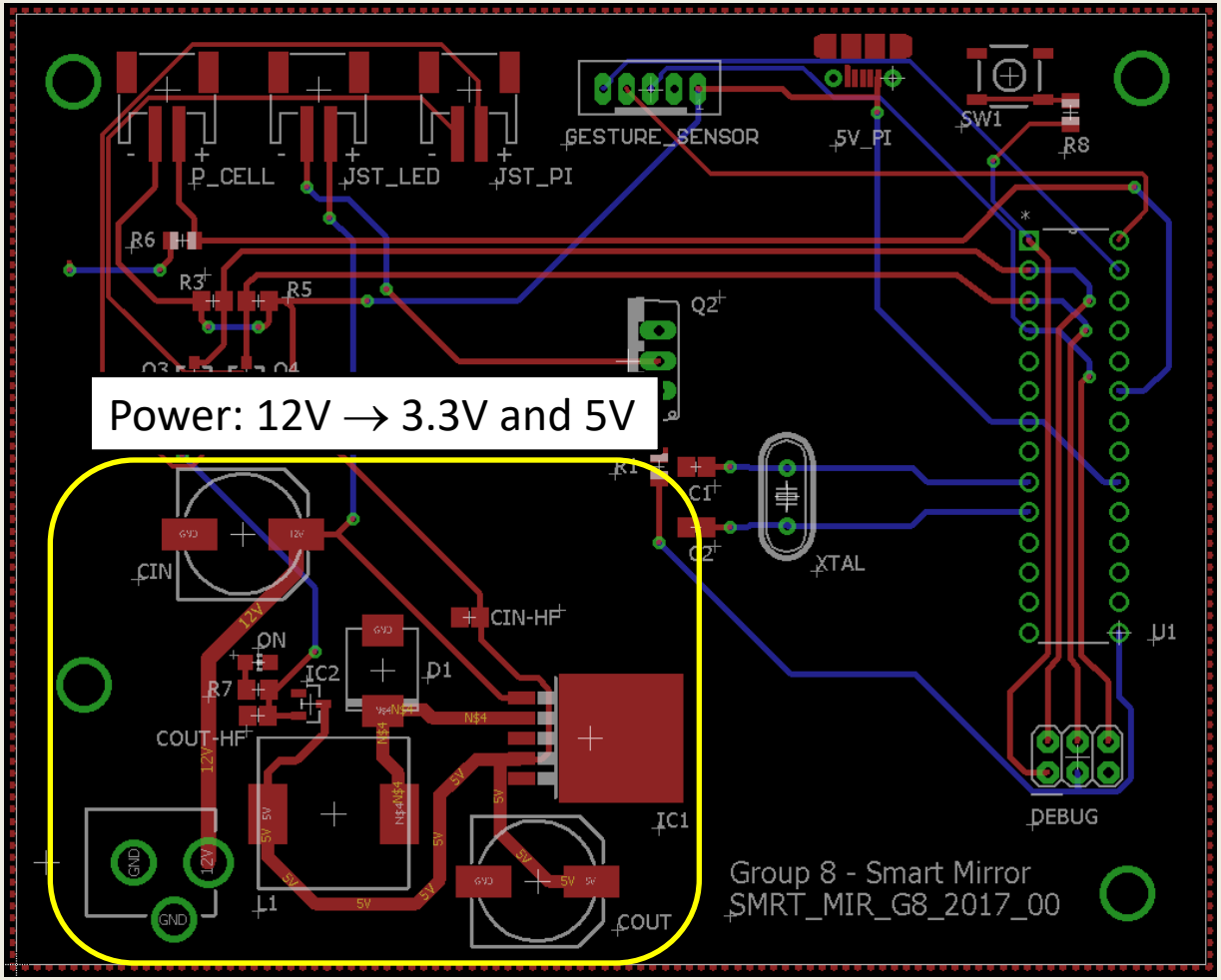

12V
CN1
PWR
GNDBREAK
GND
CIN
100uF
IC1
VIN
ON/OFF
GND
OUT
FB
LM2596S
S3G
D1
COUT
5V
U$2
VIN
GND
VOUT
MCP1700T-3302E/TT
CIN-HF
COUT-HF
1u
3V
5V_PI
VBUS
D-
D+
ID
GND
1k
R7
GREEN
ON
SW1
R8
330
RESET
JST_LED
Q2
R1
220
PWM_LED
U1
VCC
AVCC
AREF
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
GND_2
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
RX
TX
ADC0
RESET
XTAL1
XTAL2
ATMEGA328P-PU
C2
20p
XTAL
C1
10K
R3
R2
Q3
200mA/50V
PI_TX
PI_RX
LV
R5
R4
Q4
Gesture Sensor
GESTURE_SENSOR
INT0
ADC5
ADC4
JST_PI
P_CELL
R6
4.7k
DEBUG


12V
GND
S3G
D1
100uF
5V
U$2
VIN
VOUT
GND
MCP1700T-3302E/TT
3V
5V_PI
VBUS
D-
D+
ID
GND
IC1
PWR
GNDBREAK
CIN
LM2596S
ON/OFF
FB
COUT
CIN-HF
COUT-HF
1u
1k
R7
GREEN
ON
SW1
R8
330
RESET
JST_LED
Q2
R1
220
PWM_LED
U1
VCC
AVCC
AREF
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
GND_2
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
RX
TX
INT0
ADC4
ADC5
XTAL1
XTAL2
ATMEGA328P-PU
C2
20p
XTAL
C1
10K
R3
R2
Q3
200mA/50V
PI_TX
GESTURE_SENSOR
ADC5
ADC4
JST_PI
PI_RX
LV
R5
R4
Q4
P_CELL
ADC0
R6
4.7k
DEBUG
Photocell

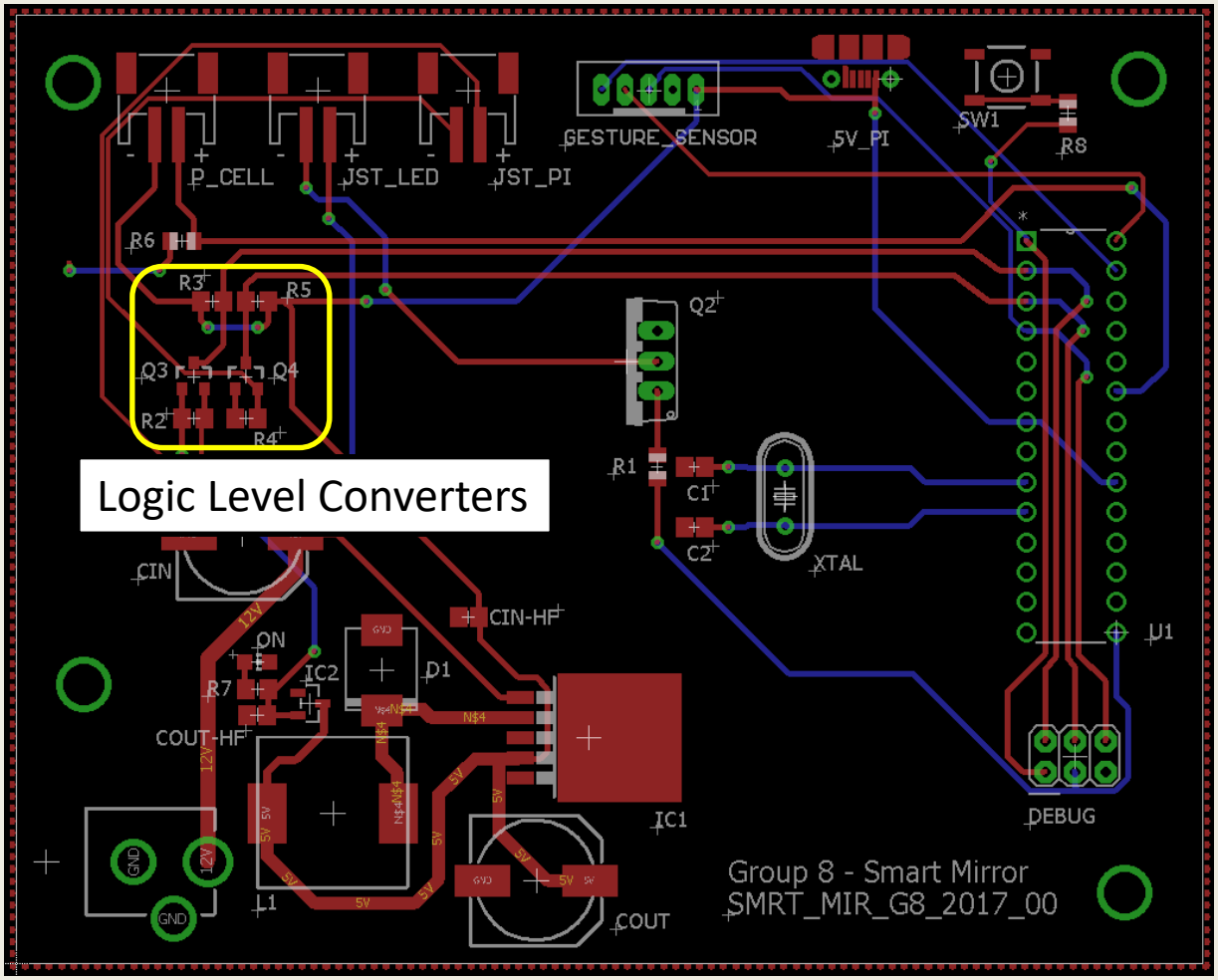
# PCB Layout


P_CELL
JST_LED
JST_PI
GESTURE_SENSOR
5V_PI
SW1
R8
R6
R3
R5
Q2
Q3
Q4
R2
R4
R1
C1
C2
XTAL
CIN
CIN-HF
ON
IC2
D1
R7
COUT-HF
IC1
U1
DEBUG
L1
COUT
Group 8 - Smart Mirror
SMRT_MIR_G8_2017_00

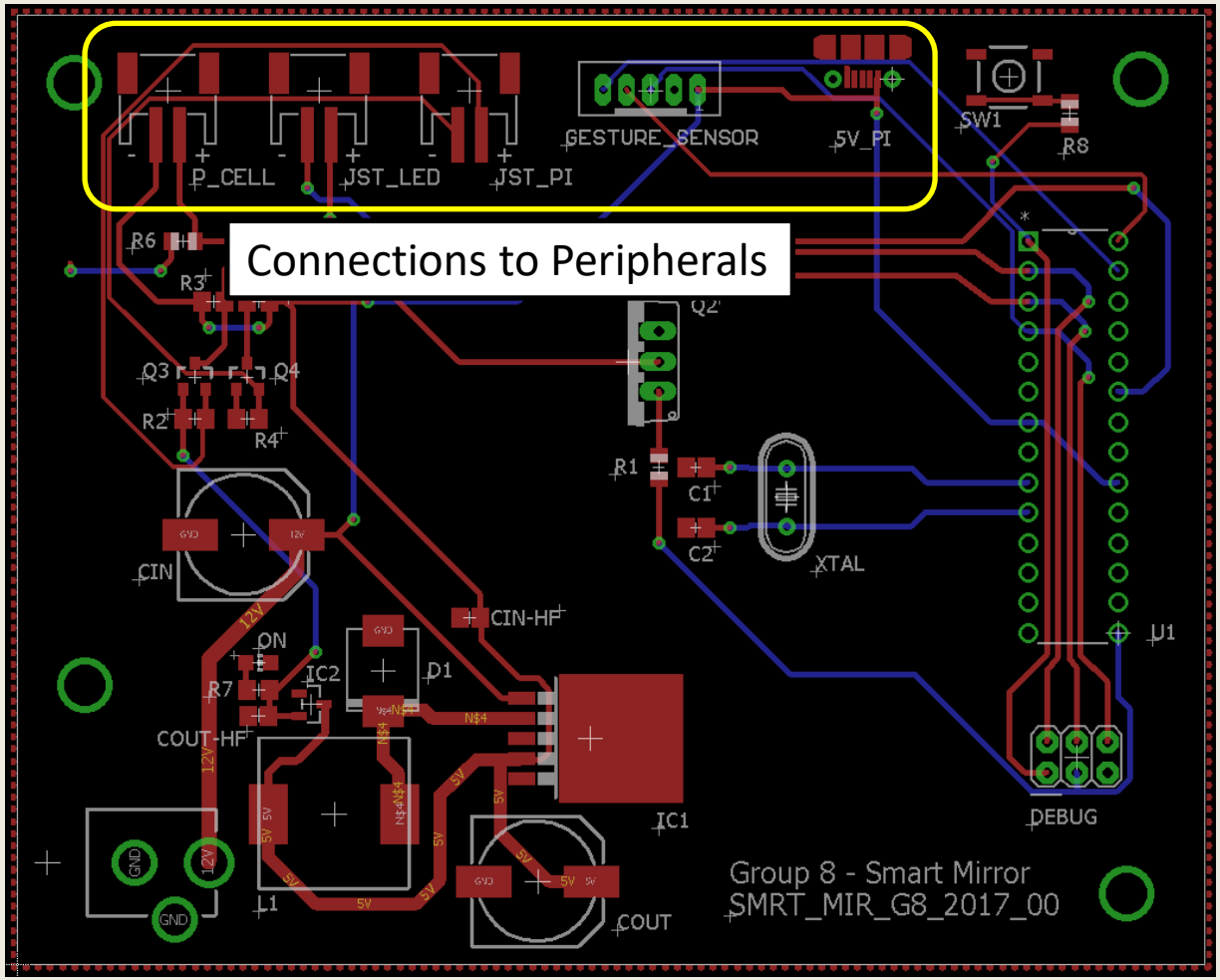
# PCB Layout


P_CELL
JST_LED
JST_PI
GESTURE_SENSOR
5V_PI
SW1
R8
R6
R3
R5
Q2
Power: 12V → 3.3V and 5V
R1
C1
C2
XTAL
U1
CIN
CIN-HF
ON
IC2
D1
R7
COUT-HF
IC1
DEBUG
L1
COUT
Group 8 - Smart Mirror
SMRT_MIR_G8_2017_00

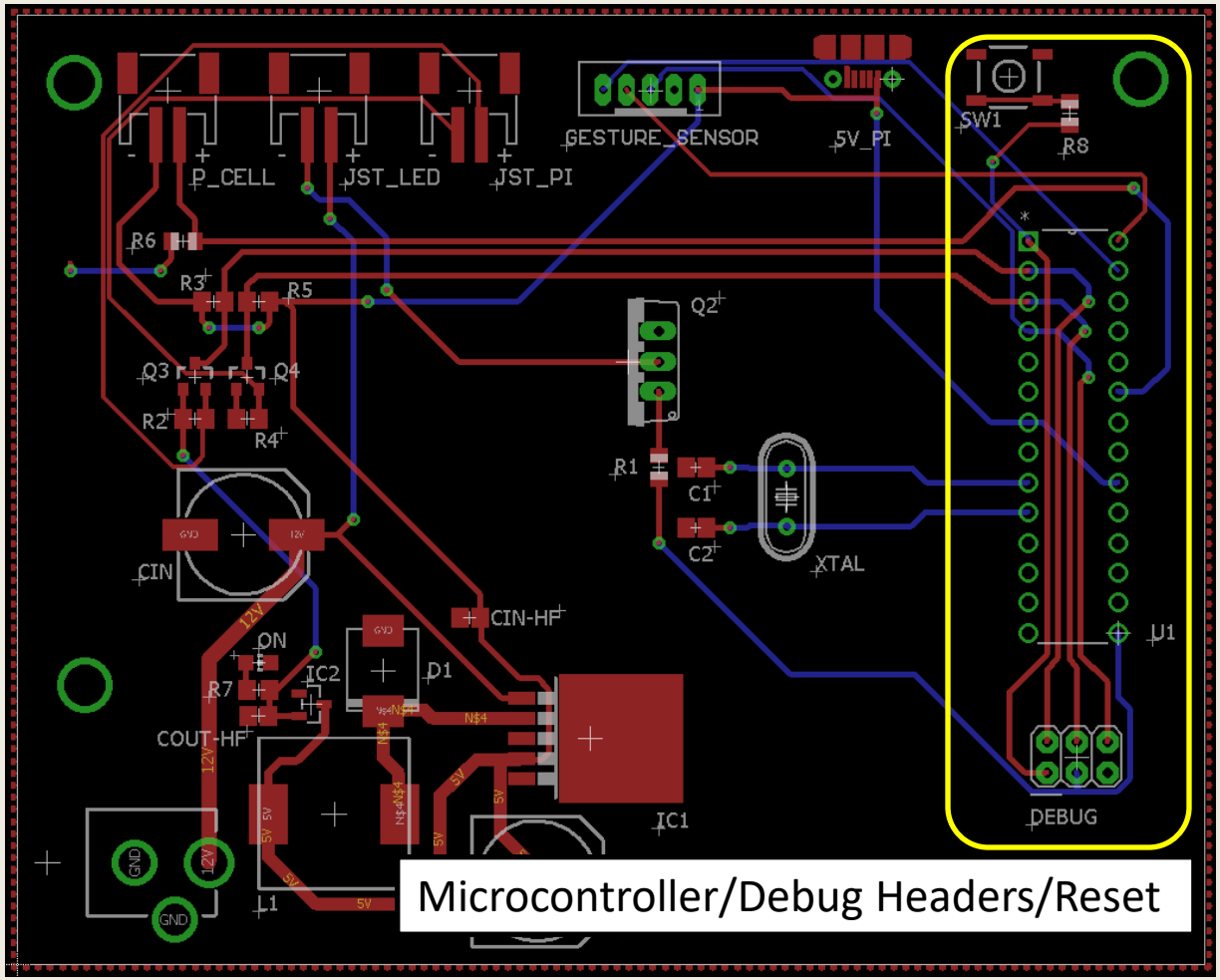
# PCB Layout


P_CELL
JST_LED
JST_PI
GESTURE_SENSOR
5V_PI
SW1
R8
R6
R3
R5
Q3
Q4
R2
R4
Logic Level Converters
Q2
R1
C1
C2
XTAL
U1
CIN
ON
IC2
R7
D1
CIN-HF
COUT-HF
IC1
DEBUG
L1
COUT
Group 8 - Smart Mirror
SMRT_MIR_G8_2017_00

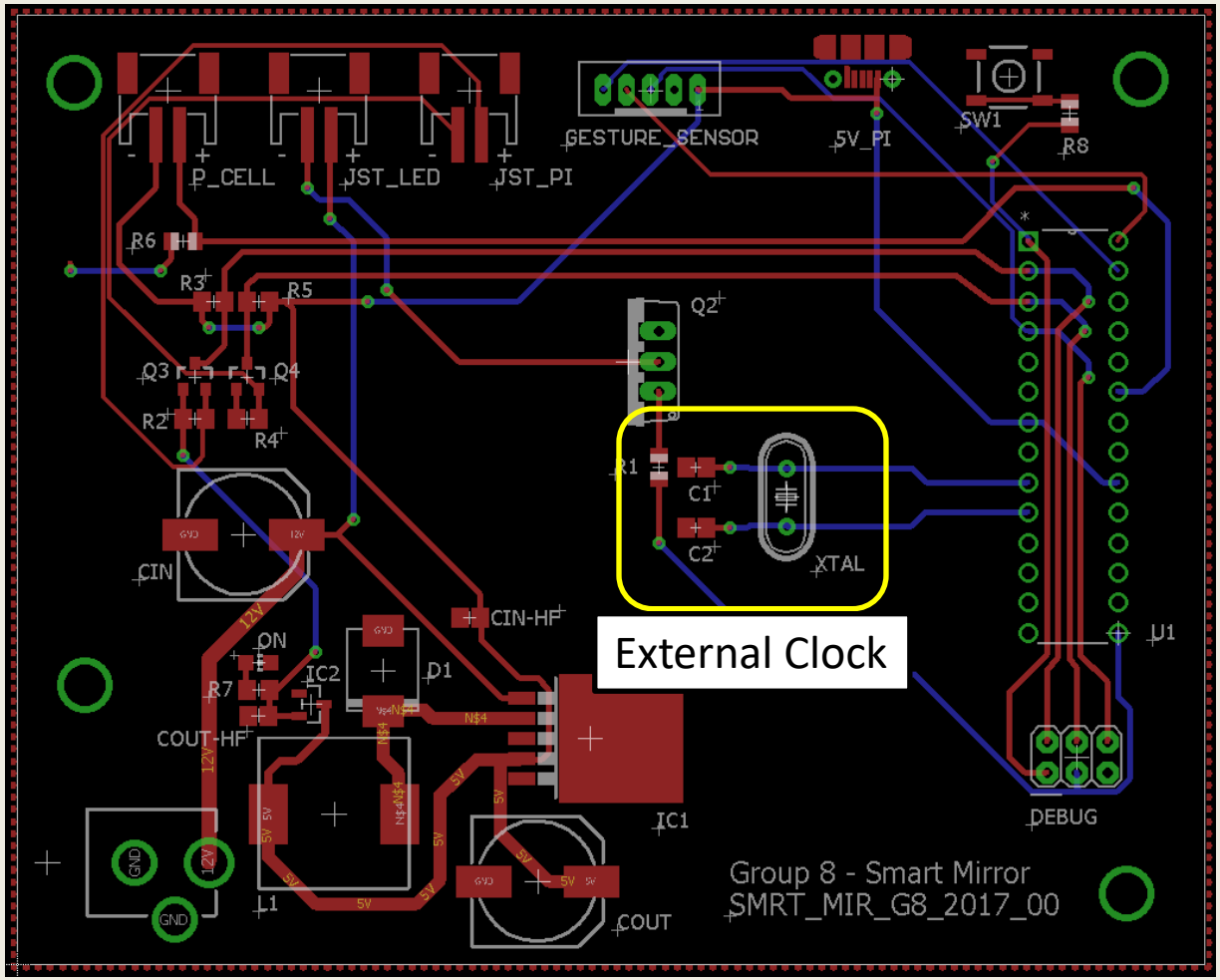
# PCB Layout


P_CELL
JST_LED
JST_PI
GESTURE_SENSOR
5V_PI
SW1
R8
R6
R3
Connections to Peripherals
Q2
Q3
Q4
R2
R4
R1
C1
C2
XTAL
CIN
CIN-HF
ON
IC2
D1
R7
COUT-HF
IC1
U1
DEBUG
L1
COUT
Group 8 - Smart Mirror
SMRT_MIR_G8_2017_00

# PCB Layout

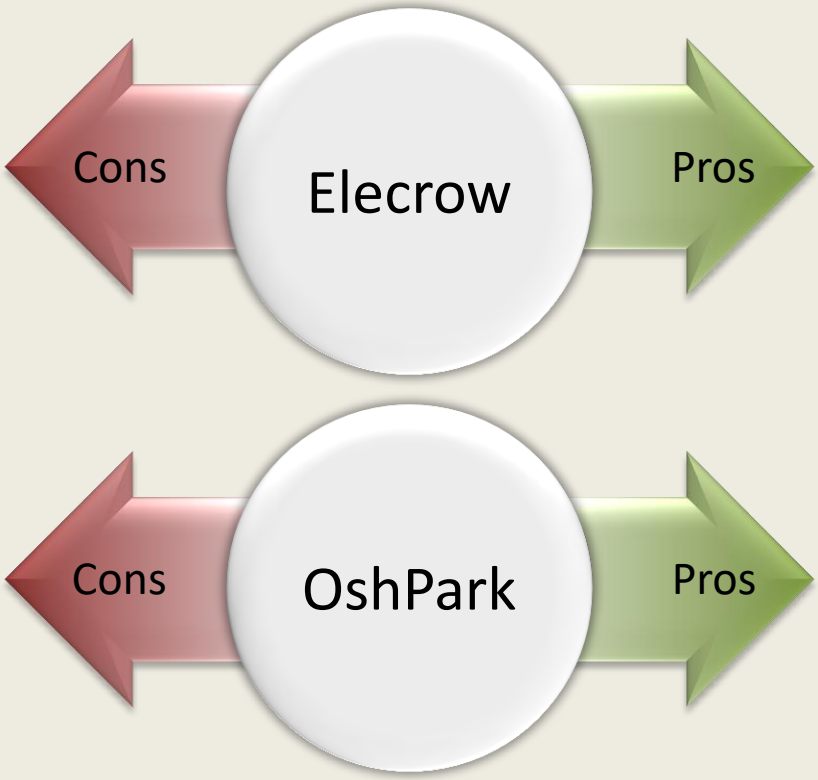

P_CELL
JST_LED
JST_PI
GESTURE_SENSOR
5V_PI
SW1
R8
R6
R3
R5
Q2
Q3
Q4
R2
R4
R1
C1
C2
XTAL
CIN
CIN-HF
ON
IC2
D1
R7
COUT-HF
IC1
L1
U1
DEBUG
GND
12V
5V
Microcontroller/Debug Headers/Reset

# PCB Layout


P_CELL
JST_LED
JST_PI
GESTURE_SENSOR
5V_PI
SW1
R8
R6
R3
R5
Q2
Q3
Q4
R2
R4
R1
C1
C2
XTAL
CIN
CIN-HF
ON
IC2
D1
R7
COUT-HF
IC1
J1
DEBUG
L1
COUT
External Clock
Group 8 - Smart Mirror
SMRT_MIR_G8_2017_00

# PCB Order

- Not in the U.S.

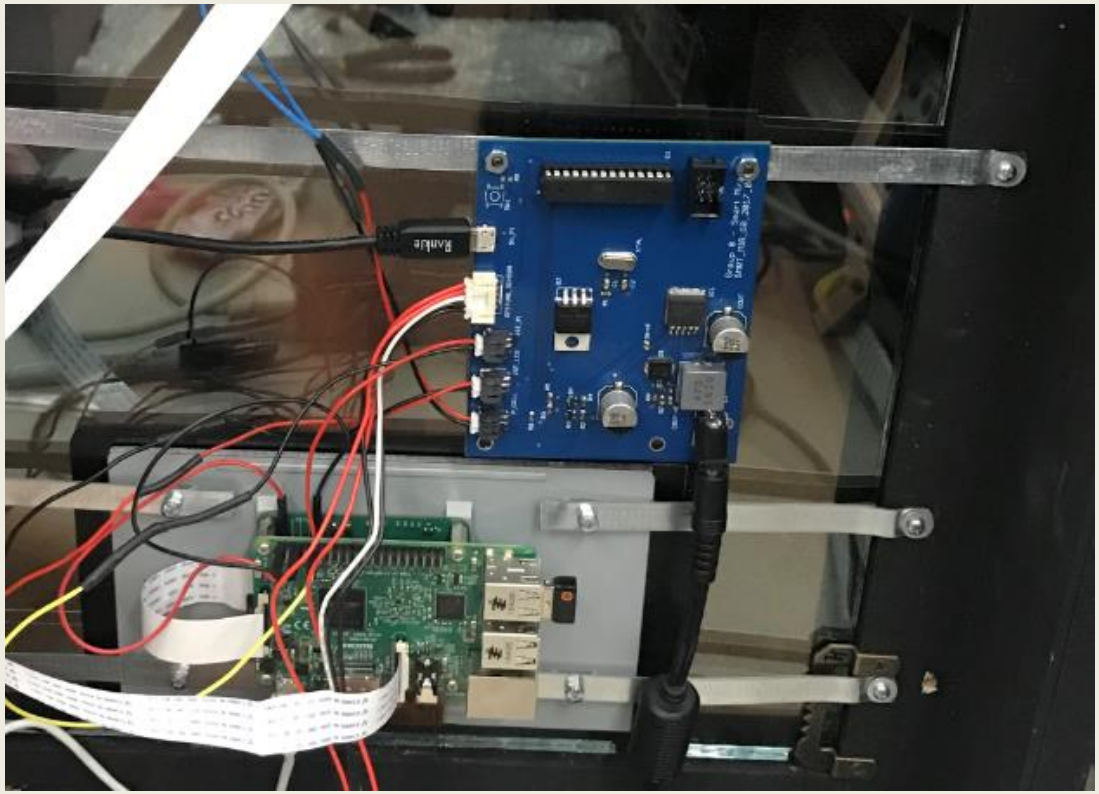



- 4-7 days to ship
- 5 boards for one price

- 20% Quality Issues
- 3 boards

- 12 days to ship
- Price per sq. in.

# PCB Layout



Backside of Smart Mirror

# Budget

| PART: | Vendor: | Budget: | Actual: | Over/Under |
|---|---|---|---|---|
| Two-way Mirror | TWM LLC | $ 150.00 | $ 68.43 | $ (81.57) |
| PCB Manuf. | Elecrow | $ 75.00 | $ 27.55 | $ (47.45) |
| PCB Components | Various | $ 75.00 | $ 50.00 | $ (25.00) |
| Display | Amazon | $ 40.00 | $ 68.99 | $ 28.99 |
| Camera Module | Amazon | $ 50.00 | $ 25.74 | $ (24.26) |
| Raspberry Pi 3 | Amazon | $ 50.00 | $ 35.70 | $ (14.30) |
| ZX Gesture Sensor | Sparkfun | $ 25.00 | $ 24.95 | $ (0.05) |
| Atmega Microcont. | Amazon | $ 10.00 | $ 2.23 | $ (7.77) |
| LED Strip | Adafruit | $ 30.00 | $ 19.95 | $ (10.05) |
| Framing Materials | Home Depot | $ 40.00 | $ 25.00 | $ (15.00) |
| **Total:** | | $ 545.00 | $ 348.54 | $ (196.46) |

# Work Distribution

| | Austin | Daniel | Kat | Reid |
|---|---|---|---|---|
| Power System | P | S | | |
| LED System | S | P | | |
| Sensor Input | | | S | P |
| Face Recognition | | | S | P |
| Architecture | | | P | S |
| Schematic | P | S | | |
| PCB Design | S | P | | |
| Physical Design | | | P | S |

P = Primary
S = Secondary


# Questions?