



# Home Safety and Automation System

**GROUP 14**

**FELIX HENRIQUEZ, CPE**

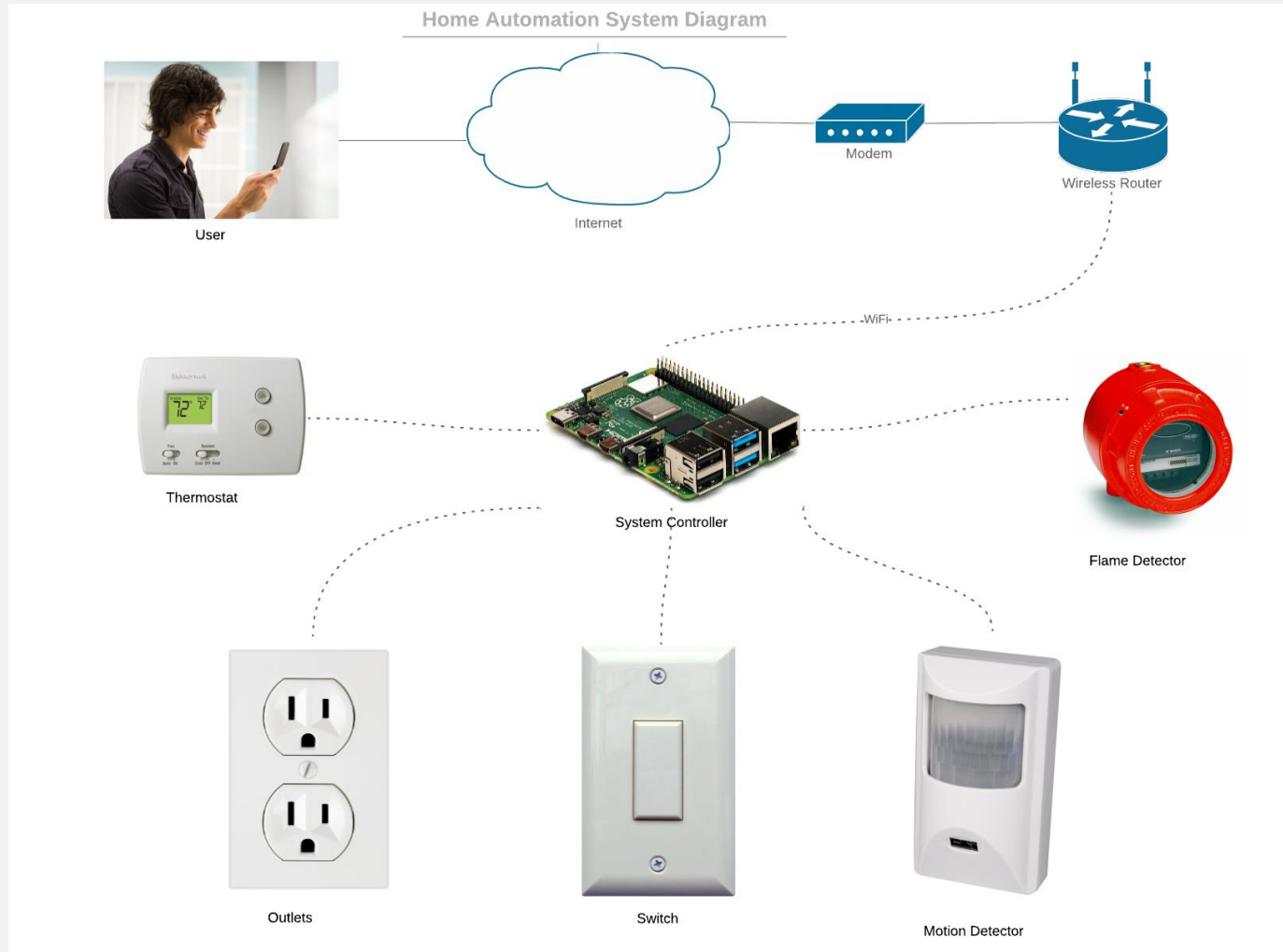
**GUILHERME COSTA, CPE**

**MATTHEW ALLEN, CPE**

**AVERY STEVENSON, PSE**

# Executive Summary

The main objective of our project is to create a modular and simple to use Home Safety and Automation System that can be easily installed and maintained by anyone in their household.



# Motivation

- ▶ Cost Effective Home Automation
- ▶ More Secure Data Management
- ▶ Manage Home Energy Efficiency
- ▶ Seamless Installation with Modular Components
- ▶ Reliability
- ▶ User Friendly Configurable UI

# Sensors and Accessories

- ▶ Motion Sensors
- ▶ Fire Detectors
- ▶ Fire Detector Housing and Baseplate
- ▶ Lens

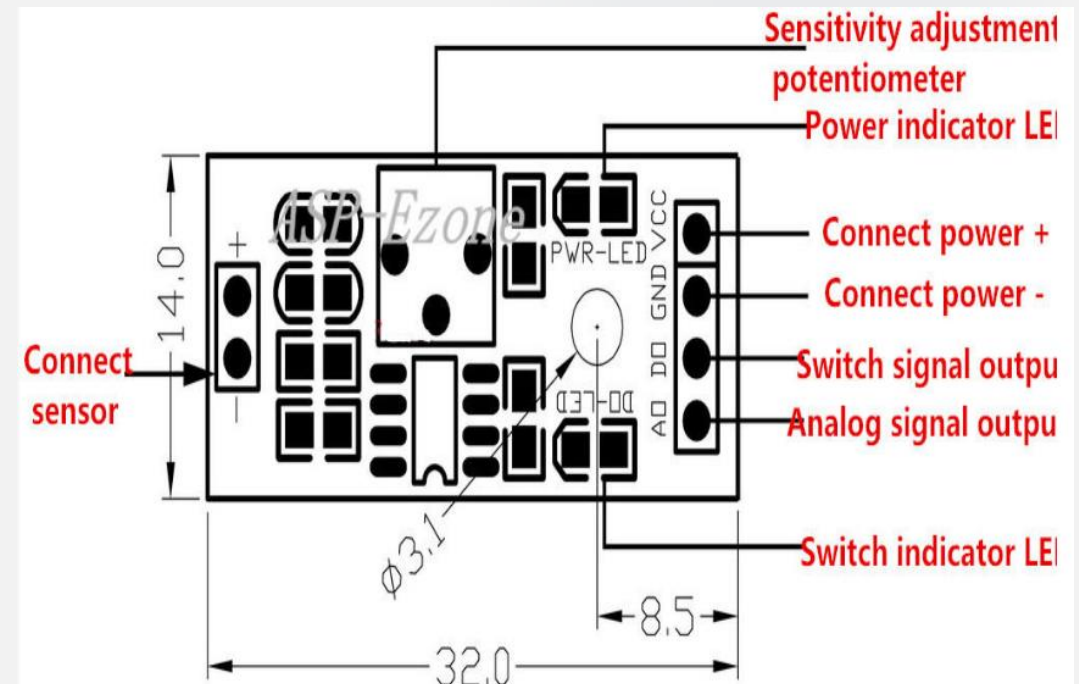
# Fire Detection Unit

- ▶ NIR photodiode
- ▶ LM2596 step-down voltage regulator with 9V battery
- ▶ Potentiometer adjustment



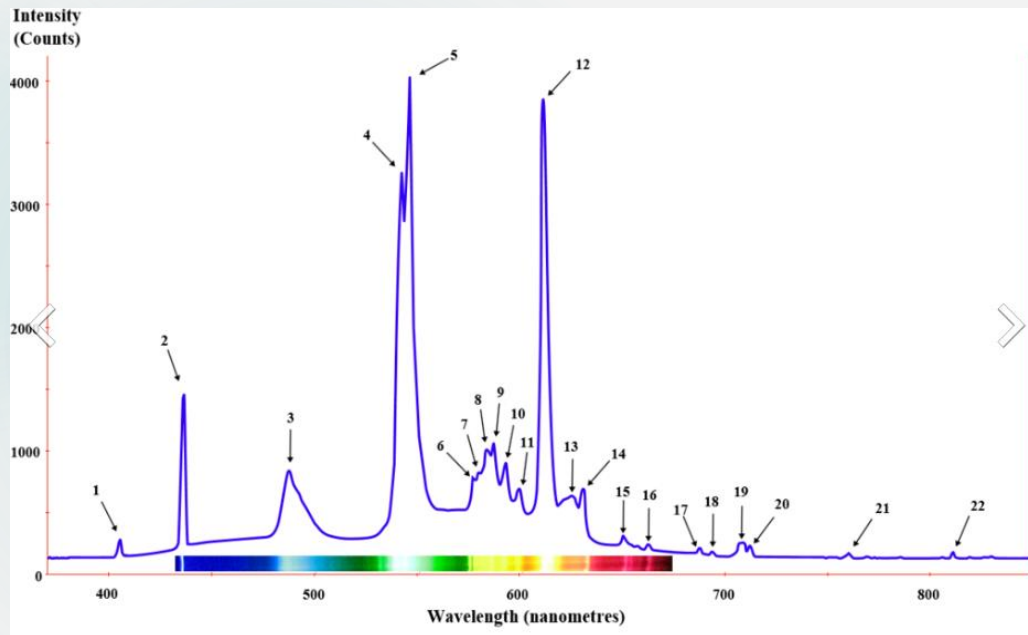
NIR Photodiode

Specification	Value
Input Voltage	5V
'On' Output Voltage	0V
'Off' Output Voltage	5V
Steady State Current	90uA
Range	2 Feet
Steady State Power Consumption	450uW
Angle of Detection	60 Degrees
Optical Bandwidth	0.7-1.1um

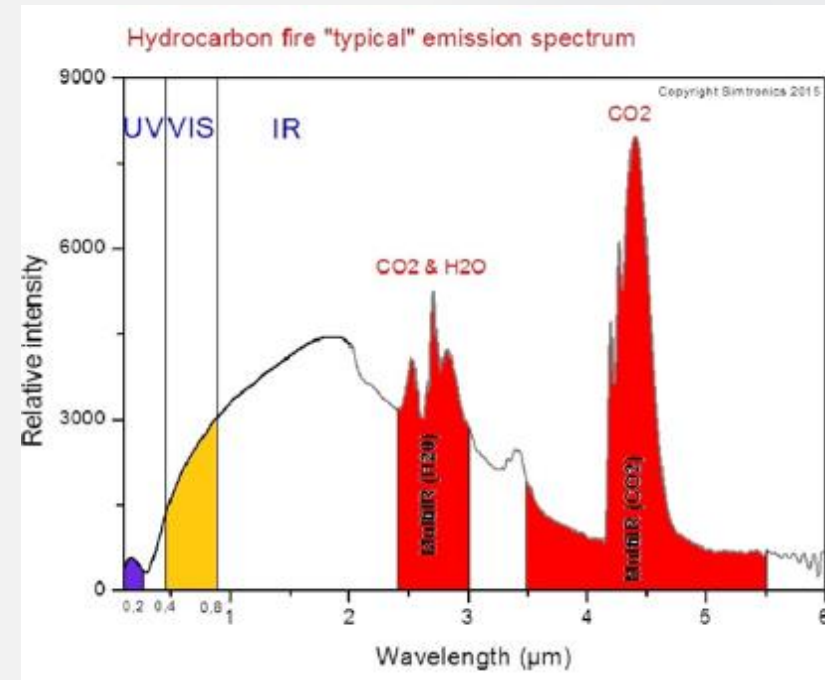


# Fire Detection Limitations

- ▶ Cannot be in direct sunlight
- ▶ Cannot be directly in lighting
- ▶ Detects objects over 250F



Fluorescent Lamp Spectrum



Typical Fire Emission Spectrum

# Fire Detector Housing

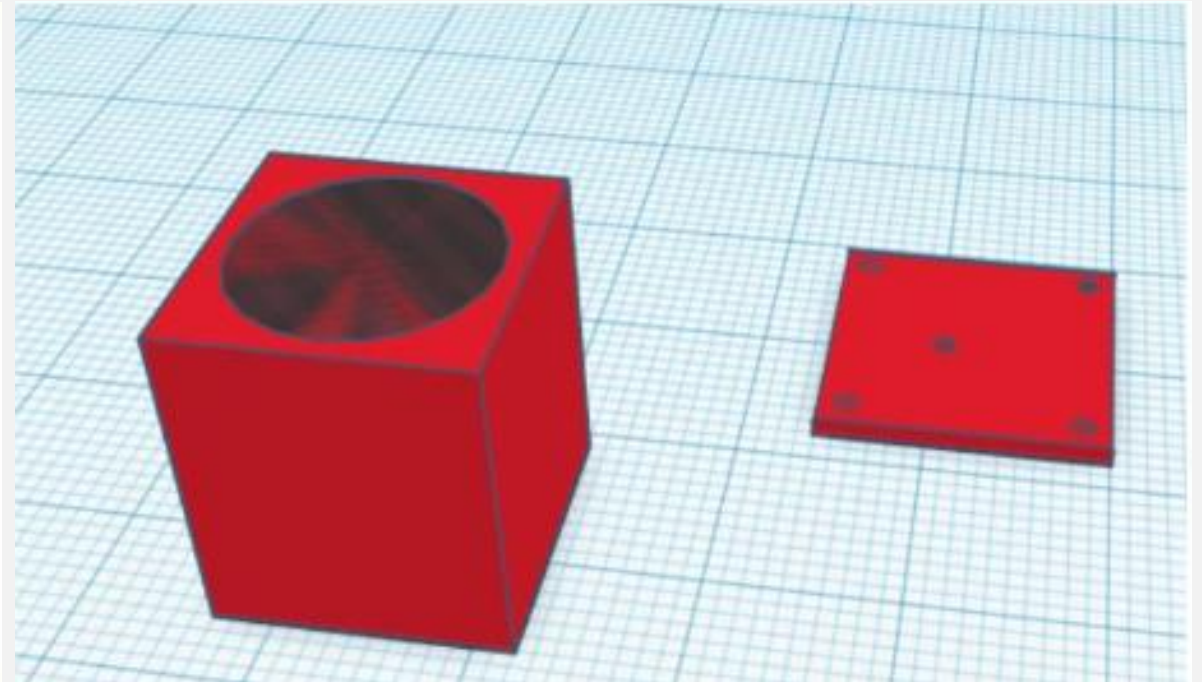
- ▶ N-BK7 plano-convex lens
- ▶ 1" focal length
- ▶ Acrylic baseplate and housing
- ▶ Housing Dimensions: 1.4"x 2.5"x 1.5"



N-BK7 Lens



N-BK7 Transmission Spectrum



Sensor Housing and Baseplate

# Motion Sensor Module

- ▶ PIR sensors
- ▶ Fresnel lenses
- ▶ Potentiometer Adjustment

Specification	Value
Range	5m
Angle of Detection	120 Degrees
Input Voltage	9V
'Off' Output Voltage	3.32V
'On' Output Voltage	40mV
Steady-State Current	5mA
Steady-State Power Consumption	16.5mW

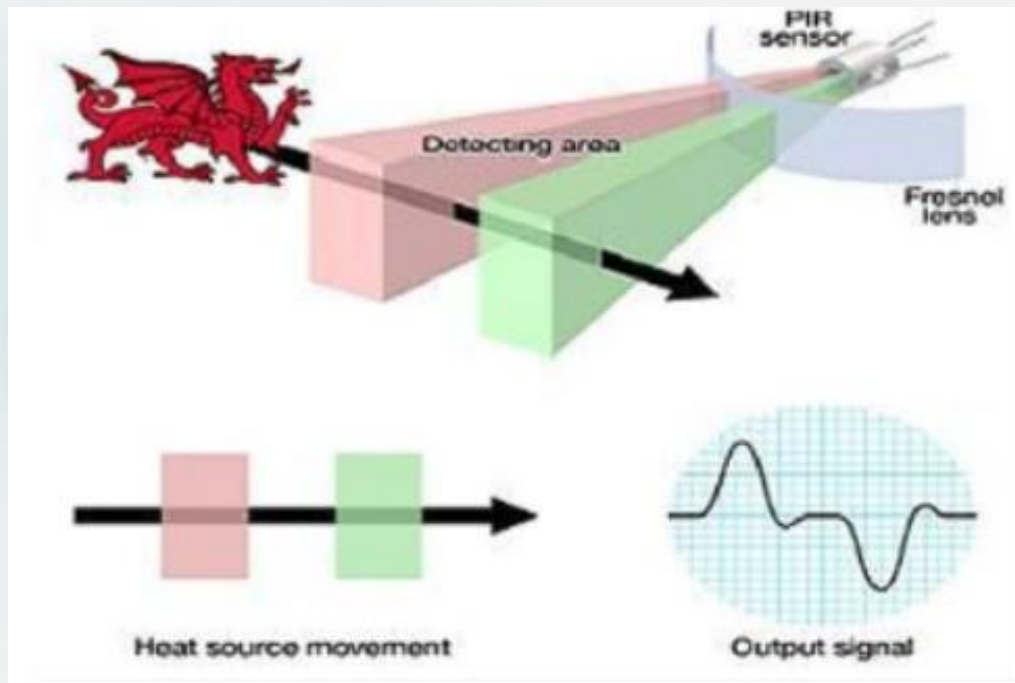


PIR Sensor

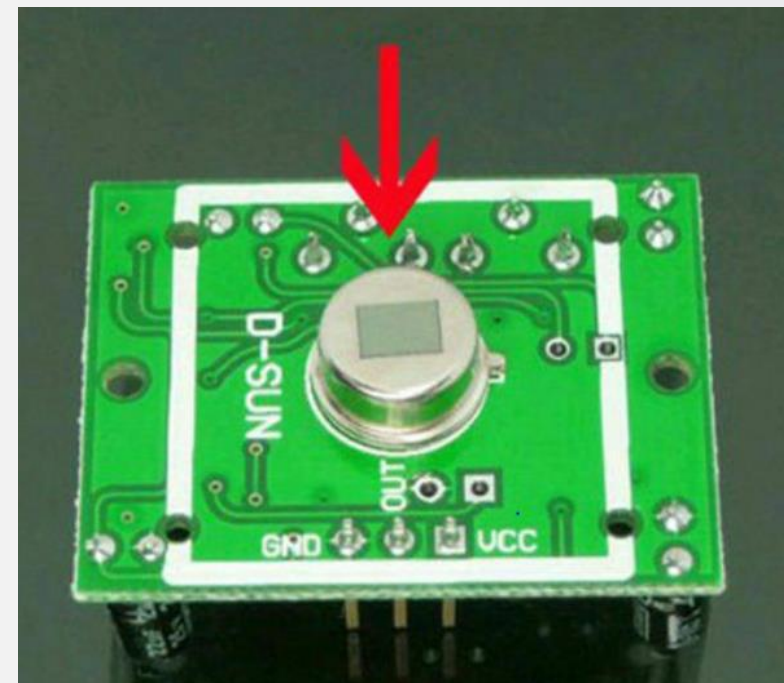


# Motion Sensor Limitations

- ▶ Only Detects Motion
- ▶ Positive and Negative Polarized Detection Areas



Motion Detection Diagram



Motion Sensing Photodiode

# Home Automation Devices

## Design Overview

- ▶ Standard Sizes
- ▶ Standard Current and Voltage Compliance
- ▶ Meets NEC Standards
- ▶ Functional Regardless of Connection

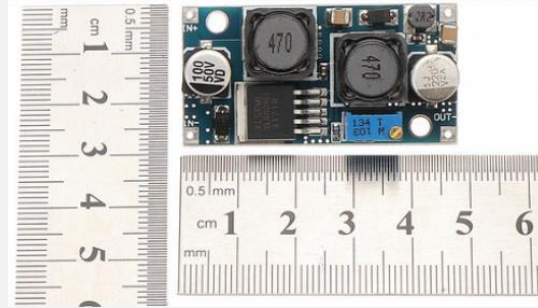
# Product Requirements

Specification	Requirement
Outlet/Switch Minimum Max Current	15A
Outlet/Switch PCB Max Dimensions	<3"x2"x2"
Wireless Range	30M
AC Thermostat input/Output	24VAC
Display Room Temp (AC)	<5% error
Wire Size	12AWG

# Smart Outlet

## Components Needed

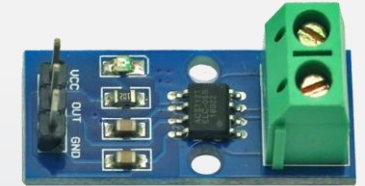
- ▶ Boost Converter
- ▶ AC-DC 3V3
- ▶ 20 Amp Relay
- ▶ Current Limiting Resistor
- ▶ Optocoupler
- ▶ Current Sensor
- ▶ WiFi MCU
- ▶ Config Button
- ▶ Frame
- ▶ Outlet



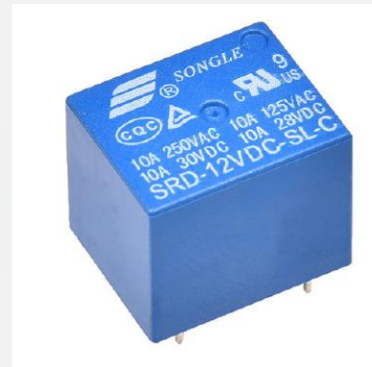
XI6009 Step-Up Converter



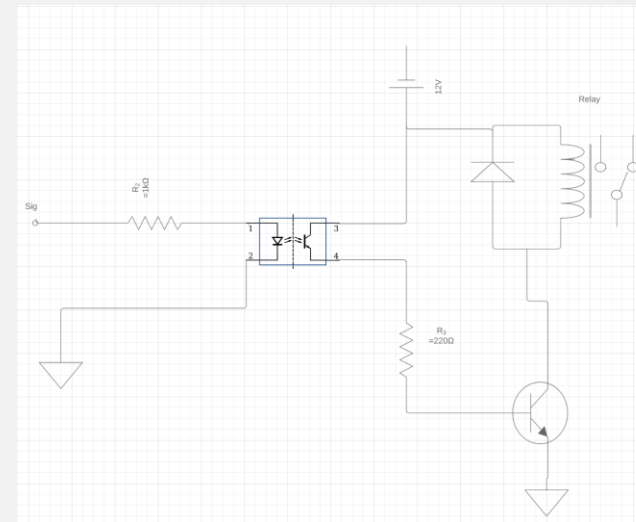
AC-DC Power Module



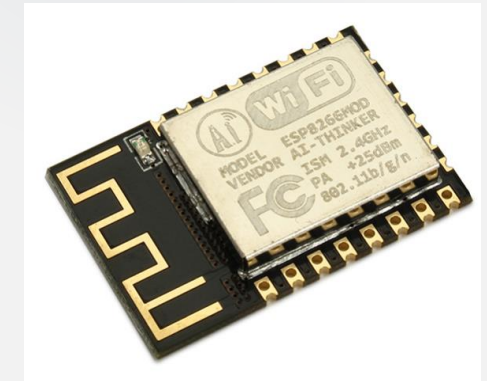
ACS Hall Effect Sensor



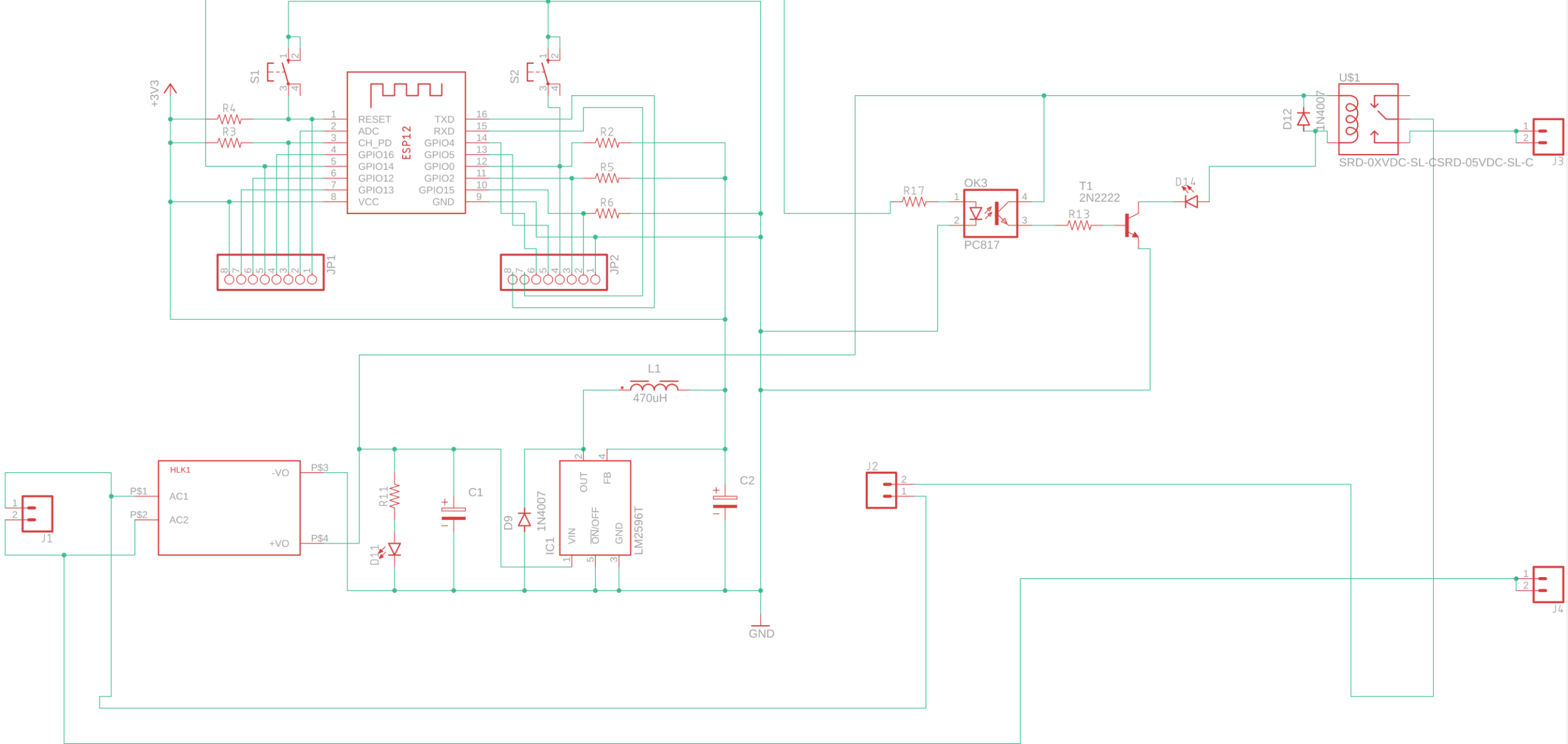
Relay



Relay Driver Circuit



ESP-12f



Outlet Schematic



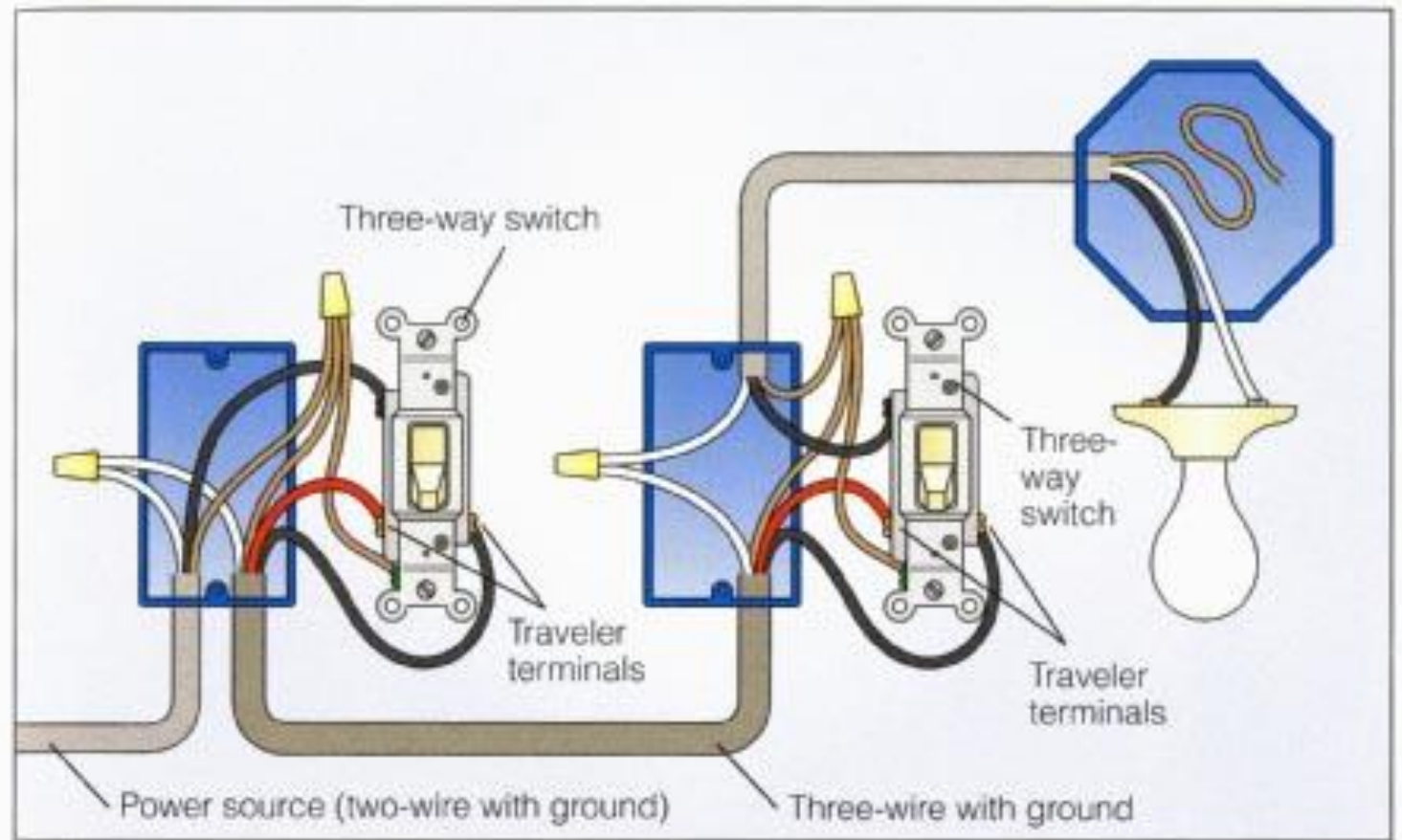
# BOM Smart Outlet

Name	Designator	Footprint	Quantity	Manufacturer Part	Manufctr	Price
XL6009	U1	XL6009	1	XL6009	LC Tech	\$ 1.60
HLK-PM01	U2	PWRM-TH_HLK-PM01	1	HLK-PM01	HI-LINK	\$ 2.50
4N35	U3	DIP-6	1	4N35	EVERLIGHT	\$ 0.10
SRA-12VDC-CL	K1	SRA-12VDC-CL	1	SRA-12VDC-CL	SONGLE	\$ 0.25
1k	R1	AXIAL-0.3	1	Generic	Generic	\$ 0.01
ACS712	U7	ACS712 MODULE REV01	1	ACS712	LC Tech	\$ 1.24
ESP-01S	U4	ESP-01S	1	ESP-01S	Ai-Thinker	\$ 1.22
40mm x 60mm PCB	PCB	PCB	2	Generic	Generic	\$ 0.44
Dual Receptacle	SW	None	1	Switch SPDT	Levington	\$ 1.60
Surface Mount Box	HS	None	1	Box Mount	Levington	\$ 5.99
Switch Frame	SF	None	1	Frame	Generic	\$ 1.00
					Total	\$15.95

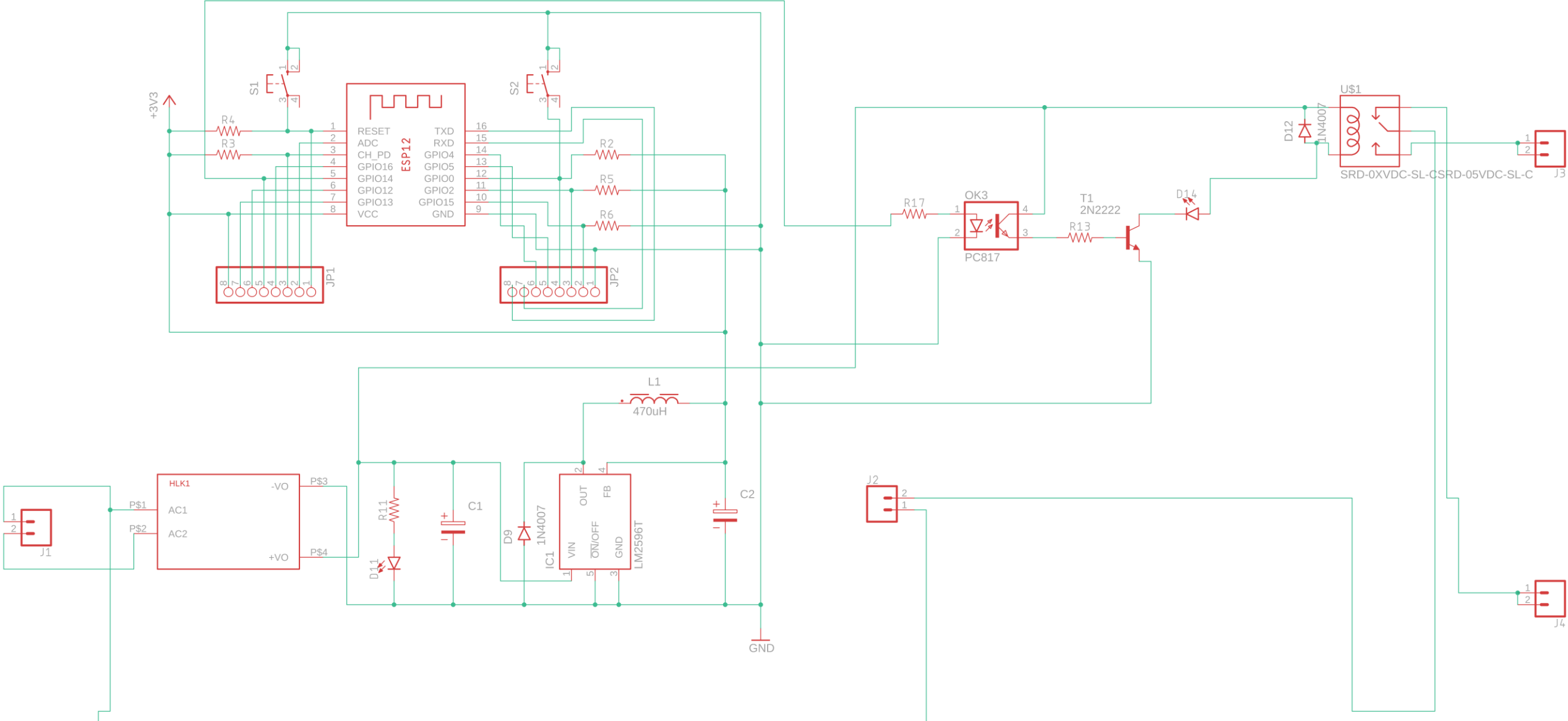
# Smart Switch

## Components Needed

- ▶ Boost Converter
- ▶ AC-DC 3V3
- ▶ Relay
- ▶ Current Limiting Resistor
- ▶ Optocoupler
- ▶ Current Sensor
- ▶ WiFi MCU
- ▶ Config Button
- ▶ Frame
- ▶ 3-Way Switch







# Switch Schematic



# BOM Smart Switch

Name	Designator	Footprint	Quant	Manufacturer Part	Manufacturer	Price
XL6009	U1	XL6009	1	XL6009	LC Technologies	\$ 1.60
HLK-PM01	U2	PWRM-TH_HLK-PM01	1	HLK-PM01	HI-LINK	\$ 2.50
4N35	U3	DIP-6	1	4N35	EVERLIGHT	\$ 0.10
SRA-12VDC-CL	K1	SRA-12VDC-CL	1	SRA-12VDC-CL	SONGLE	\$ 0.25
1k Resistor	R1	AXIAL-0.3	1	Generic	Generic	\$ 0.01
ACS712	U7	ACS712 MODULE REV01	1	ACS712	LC Technologies	\$ 1.24
ESP01S	U4	ESP-01S	1	ESP-01S	Ai-Thinker	\$ 1.22
40mm x 60mm PCB	PCB	PCB	2	Generic	Generic	\$ 0.44
3-Way Paddle Switch	SW	None	1	Switch SPDT	Levington	\$ 5.82
Surface Mount Box	HS	None	1	Box Mount	Levington	\$ 5.99
Switch Frame	SF	None	1	Frame	Generic	\$ 1.00
					Total	\$20.17

# Smart Thermostat

## Components Needed

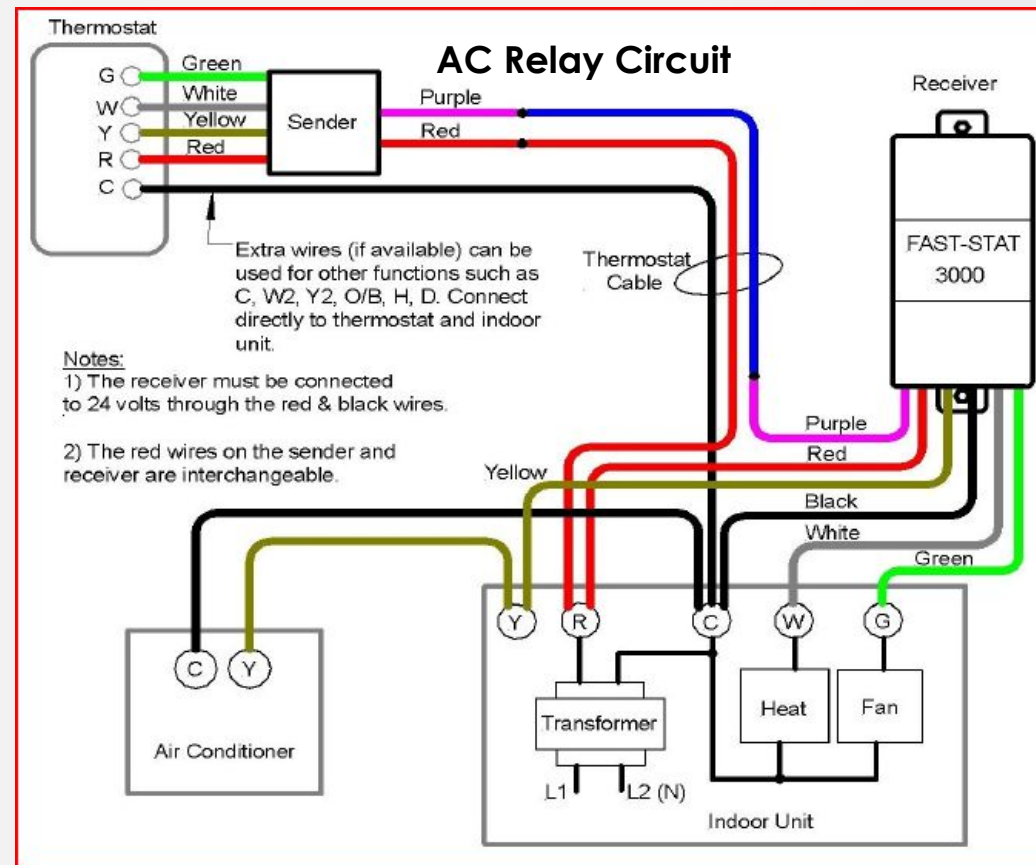
- ▶ 4x Relay Circuit
- ▶ ESP-12F
- ▶ Stepdown Converter
- ▶ Diode
- ▶ Capacitor
- ▶ Temp and Humidity Sensor DHT21
- ▶ 12AWG Connector Headers
- ▶ I2C Display
- ▶ Config Buttons
- ▶ Multiplexer
- ▶ Acrylic Housing



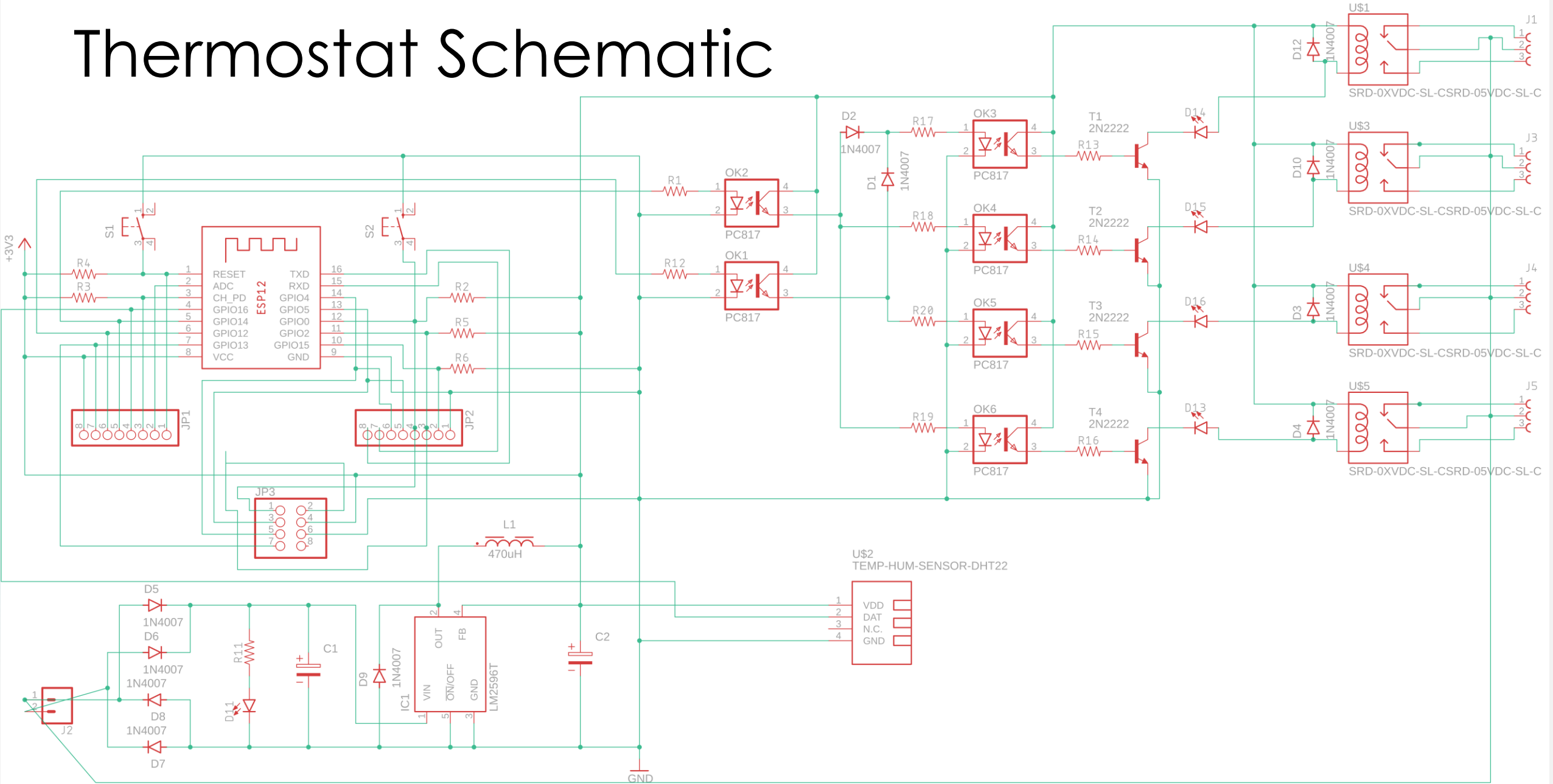
DHT21 Temp Sensor



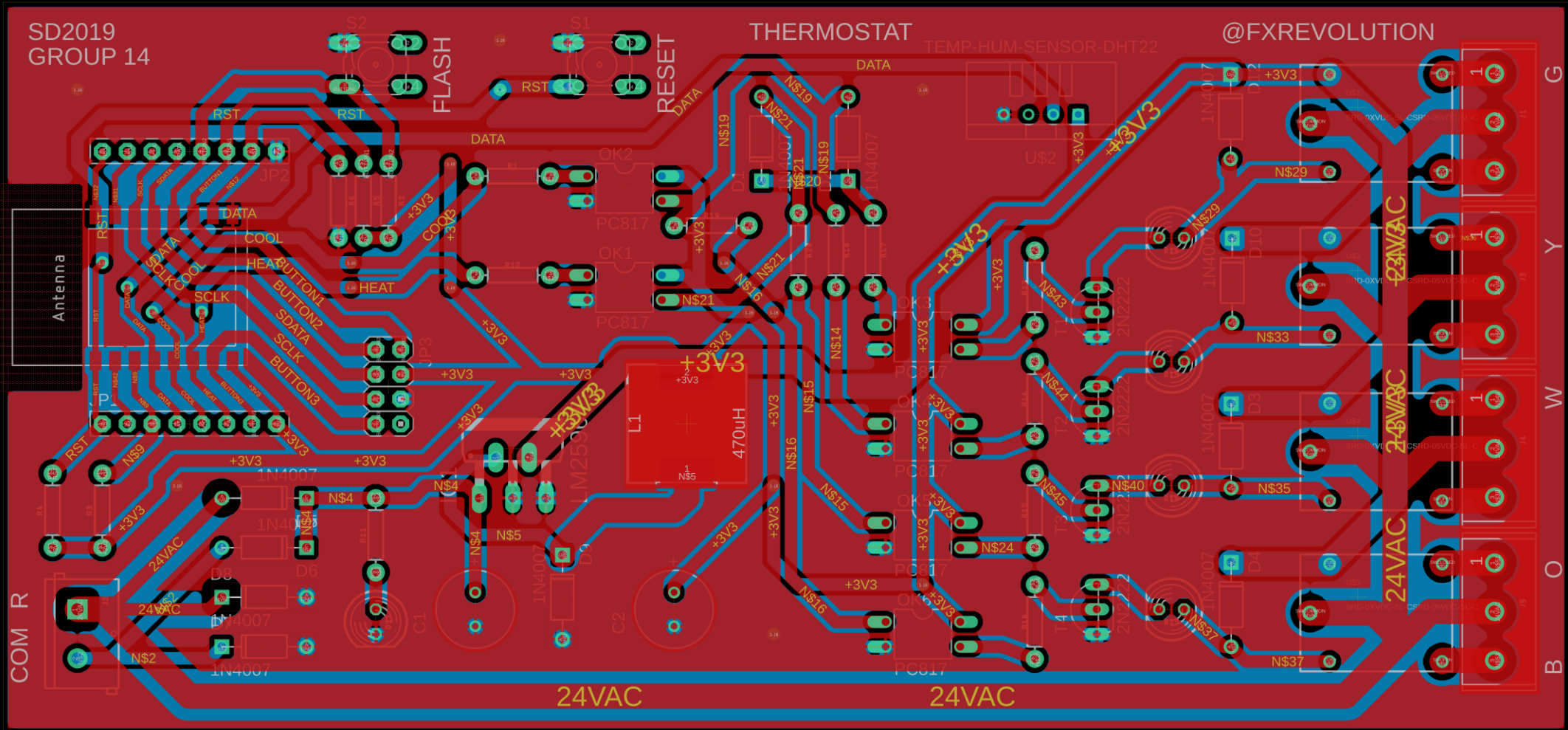
1.8" OLED Display



# Thermostat Schematic



# PCB Layout of Components



# BOM Smart Thermostat

Name	Designator	Footprint	Quantity	Manufacturer	Price
ESP8266 Relay Module	X4	Custom PCB	1	LC Technologies	\$ 5.50
NodeMcu ESP8266 V3 CH340 (Version 1.0)	U1	NEW PCB NODEMCUV3	1		\$ 2.14
LM2596 Module	U2	LM2596 DC-DC BUCK CONVERTER ADJUSTABLE POWER SUPPLY STEP DOWN MODULE	1		\$ 0.99
1N4448	D1	DO-35	1	SEMTECH	\$ 0.10
1u	C1	CAP-D3.0XF1.5	1		\$ 0.10
DHT22	U3	DHT22_AM2303_HORIZ	1		\$ 2.69
Header-Female-2.54_1x5	H2	HDR-5X1/2.54	1	BOOMELE	\$ 0.15
WJ2EDGVC-5.08-3P	P1	WJ2EDGVC-5.08-3P	1	ReliaPro	\$ 0.12
OLED_Display_I2C PM	P2	0.96 AND 1.3 I2C OLED SSD1306	1		\$ 1.76
CD74HC4052M96	U4	SOIC-16_150MIL	1	TI	\$ 0.25
Acrylic Housing	HO	NONE	1	Generic	\$ 5.00
				Total	\$18.80

# Flame And Motion Detectors

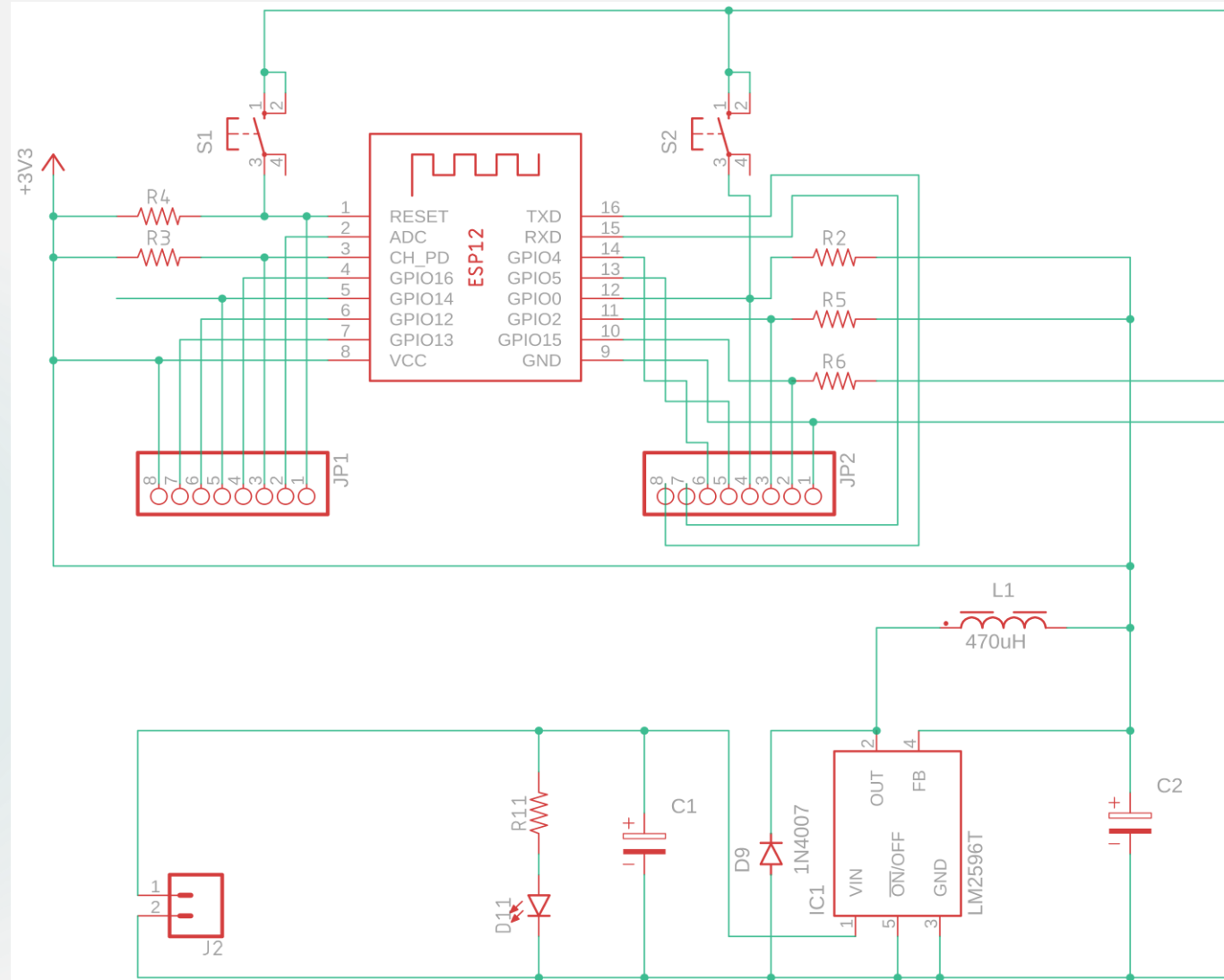
## Components Needed

- ▶ Battery
- ▶ Step-down Converter
- ▶ Step-up Converter
- ▶ ESP-12F
- ▶ Detector
- ▶ Battery Connector
- ▶ Housing
- ▶ Lens

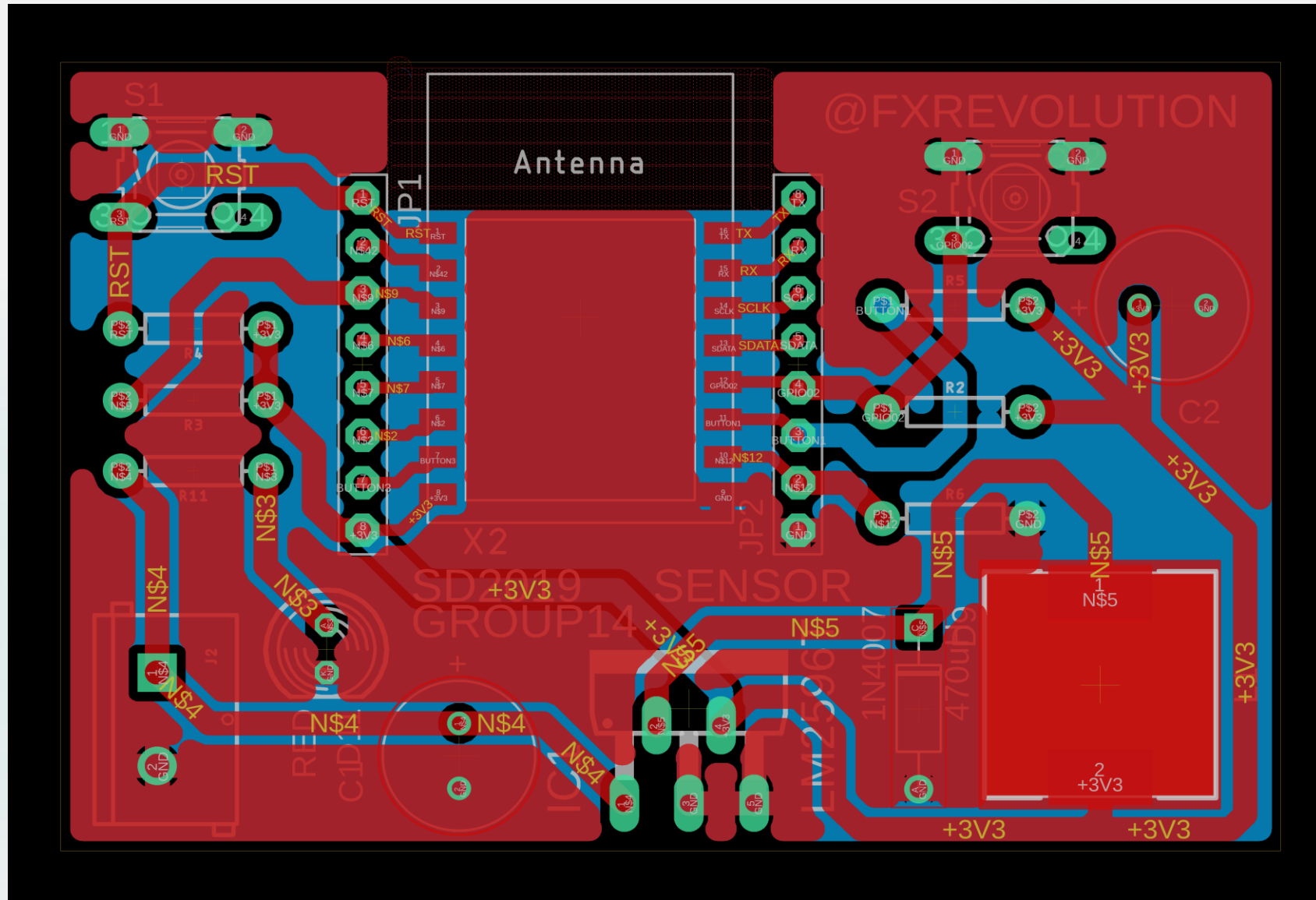




# Flame Detector and Motion Sensor Circuit Schematic



# PCB Layout of Components



# BOM Detectors

Name	Footprint	Quantity	Manufacturer Part	Manufacturer	Price
9_Volt Battery	BH9VW	1	No.7	ReliaPro	\$1.00
LM2596	STEP_DOWN_LM2596S	2	LM2596	LC Technologies	\$1.40
FLAME-DETECTOR	FLAME-DETECTOR	1	LM393	LC Technologies	\$0.50
ESP01S	ESP01S	1	ESP8266-01s	Zuc Zuc	\$1.67
Battery Connector	N/A	1		Generic	\$0.25
Housing	N/A	1		3D Print	\$5.00
Lens	N/A	1			\$10.00
					19.82

# Component Software Design

## Key Features

- ▶ MQTT Machine-2-Machine Communication between System Controller and Device.
- ▶ Works by Publishing or Subscribing to data streams.
- ▶ Either Sends Data or responds to commands, Does not need to perform calculations.
- ▶ Only 512KB of available memory.
- ▶ Connects directly to System Hub
- ▶ Using Arduino IDE C++ Scripting

# Classes

<p>Main</p> <ul style="list-style-type: none"><li>• Setup</li><li>• Loop</li><li>• Reset</li></ul>	<p>Connection</p> <ul style="list-style-type: none"><li>• Setup</li><li>• HubConnect</li></ul>	<p>Communications</p> <ul style="list-style-type: none"><li>• Setup</li><li>• Publish</li><li>• Subscribe</li><li>• Listen</li><li>• Respond</li></ul>
<p>RelayControl (Outlet/Switch)</p> <ul style="list-style-type: none"><li>• Setup</li><li>• Trigger</li></ul>	<p>SensorControl</p> <ul style="list-style-type: none"><li>• Setup</li><li>• ReadData</li></ul>	<p>AC Control (Thermostat)</p> <ul style="list-style-type: none"><li>• Setup</li><li>• SetTemp</li><li>• ReadTemp</li><li>• ProcessChanges</li></ul>

# System Diagram

- ▶ Needs to be re-done

A decorative blue vertical bar is located in the top right corner. Several light blue circles of varying sizes are scattered across the background, with a prominent one in the top right and another in the bottom right.

# Back-end and Front-end Design

# Requirements Specifications

Component	Parameter	Requirement
Security	Security of System	System will prevent unauthorized access attempts
Capacity	Minimum Users	System should be able to support a minimum of 10 user accounts
Stability	Control of System	Up to 5 concurrent users logged in
Interface	Ease to Use	GUI is intuitive and unobtrusive



# Back-end Framework

- ▶ Allows for rapid deployment
- ▶ Written in Python
- ▶ Great documentation
- ▶ Many extra modules available
- ▶ Versatile features



# Database Selection

Feature	MySQL	MongoDB
Easy Integration	x	✓
Organization	Tie	Tie
Support	✓	✓
Documentation	✓	✓
Load Handling	x	✓

# Cloud Computing Service

Service	Cost (\$)	Top Feature(s)
Amazon Web Services	15	Variety of Services
Digital Ocean	5	Cost Effective and Freedom
Heroku	Free	Cost

## Amazon Web Services

Features in Use
Simple Storage Service (S3)
Simple Email Service
WorkMail

## Digital Ocean

Features in Use
Droplet
Domain Handling

# Front-end Design

Choices:

- ▶ Plain HTML/CSS
- ▶ Bootstrap
- ▶ **Material Design Bootstrap**
- ▶ Materialize CSS

Login

Username\*

Password\*

LOGIN

Or Login Using Your Social Account.

GOOGLE FACEBOOK

Forgot Your Password? [Click Here](#)

Don't Have an Account Yet? [Register Here](#)

Material Design Bootstrap

# User Registration Example

When creating a local account the user should fill out a similar form

### Sign up

**Username\***

Required. 150 characters or fewer. Letters, digits and @/./+/-/\_ only.

**First name**

**Last name**

**Email\***

**Password\***

- Your password can't be too similar to your other personal information.
- Your password must contain at least 8 characters.
- Your password can't be a commonly used password.
- Your password can't be entirely numeric.

**Password confirmation\***

Enter the same password as before, for verification.

Already Have an Account? [Sign In](#)

# View and Edit Profile

The User will also have the option to view and edit their profile information

### Profile Information

Username	TestUser1
First Name	Test
Last Name	User1
Email	testuser@hsas.site

[EDIT PROFILE](#)

[MANAGE DEPENDENTS](#)

[DELETE ACCOUNT](#)

### Edit Profile

←

First name

Last name

Email address

[SAVE](#)

---

[CHANGE PASSWORD](#)

# Dashboard

### Dashboard

Welcome

#### Motion Sensor

Current Status  
**No Activity**

[EDIT](#)

Last Triggered:  
Nov. 11, 2019, 2:33 p.m.

#### Your HVAC

Current Temperature  
**75°F**

Mode: Cooling

[CHANGE MODE](#) [EDIT](#)

Average Usage:  
4 KW/day

#### Fire Detector

Current Status  
**OK**

[EDIT](#)

Last Triggered:  
None

#### Your Lights

SN	Location	Status	Switch	
4	Room	Off	<a href="#">ON</a>	<a href="#">EDIT</a>

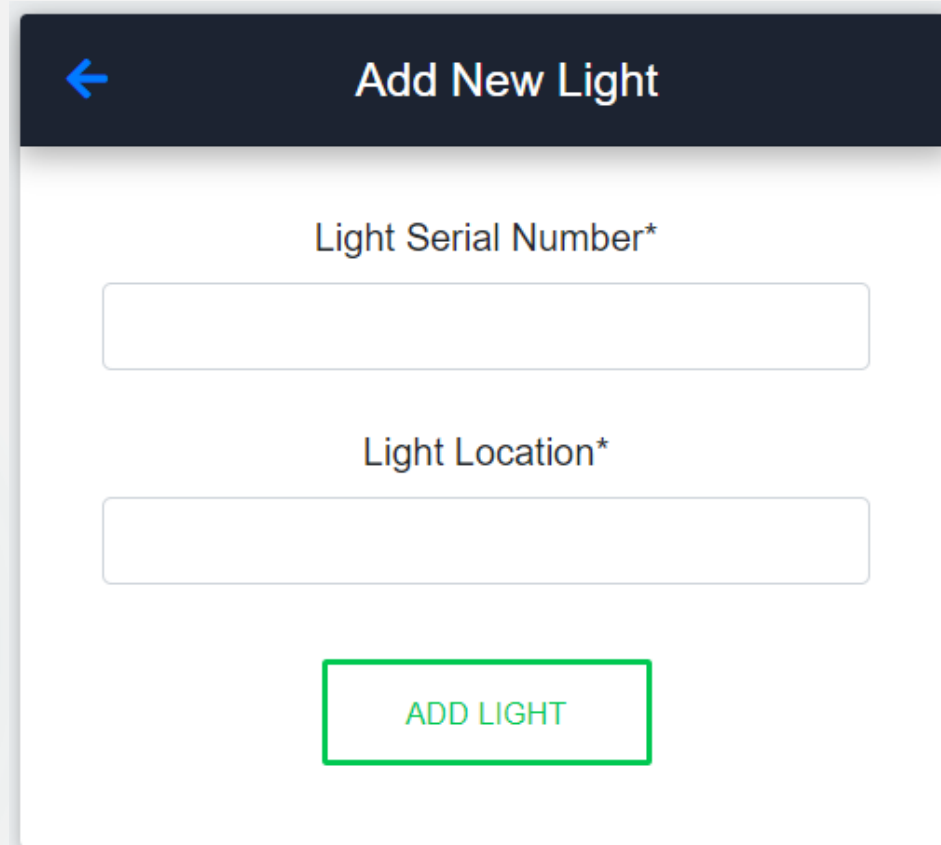
[+ ADD NEW LIGHT](#)

#### Your Outlets

SN	Location	Status	Switch	
5	Room	On	<a href="#">OFF</a>	<a href="#">EDIT</a>

[+ ADD NEW OUTLET](#)


# Dashboard – Adding Device



The screenshot shows a mobile application interface for adding a new light. At the top, there is a dark blue header with a white back arrow on the left and the text 'Add New Light' in white. Below the header, the form contains two text input fields. The first field is labeled 'Light Serial Number\*' and the second is labeled 'Light Location\*'. Both fields are currently empty. At the bottom of the form, there is a green rectangular button with the text 'ADD LIGHT' in white.



# Dashboard – Tasks

 **New Light Task**


Light Serial Number\*

4 ▾

Action

Turn On ▾

Run on\*

2019-11-22 11:35:00 

**SUBMIT**


< November 2019 >

Su	Mo	Tu	We	Th	Fr	Sa
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
1	2	3	4	5	6	7

↑   ↑   ↑

**11** : **35** : **00**

↓   ↓   ↓

2019-11-22 11:35:00 

# System Hub Design

# System Hub

- ▶ Raspberry Pi 3 Model B+ with Raspbian operating system chosen to serve as the system hub.
- ▶ Provides robust suite of hardware including Wi-Fi and Bluetooth connectivity, can interface directly with other components via USB, HDMI, GPIO pins, etc.
- ▶ Serves to connect smaller, simpler components of the system spread throughout the house with the online management system proper.

Component	Specification
CPU	Broadcom BCM2836B0 Cortex-A53 (ARMv8) 64-bit SoC @ 1.4 GHz
Memory	1GB LPDDR2 SDRAM
Wireless Networking	2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
Wired Networking	Gigabit Ethernet over USB2.0 (maximum throughput 300 Mbps)
Pin I/O	Extended 40-pin GPIO header
USB	4 USB 2.0 Ports
Digital Video	Full-size HDMI
Analog AV	4-pole stereo output and composite video port
Storage	Micro SD port
Power	5V/2.5A DC Power input

# Networking Overview

- ▶ Client-Server Communication
  - ▶ Use webservice-based communication as a means of simplifying data interchange between client and server.
  - ▶ Use Django REST framework to facilitate creation of REST API.
  - ▶ Connect to internet via user's local area network, either via wired connection or Wi-Fi.
- ▶ Hub-Device communication
  - ▶ Long-distance communication carried out via Wi-Fi-direct connection between hub and Wi-Fi capable devices.
  - ▶ Short-range communication can be carried out via more direct means if devices are positioned near hub, via GPIO pins, etc.

# Networking Cont'd.

- ▶ User should not be required to perform networking configuration in order to get system working.
- ▶ Design client-server networking such that port forwarding will not be necessary.
  - ▶ Query server for updates of device information stored in database
  - ▶ Send information on changes observed on the client-side to the server.

# JSON Data

- ▶ Information about the state of supported devices will be transmitted and received in JSON format, as JSON is the format of choice for REST based web service frameworks.
- ▶ Generalized object format for devices in general which includes device ID and device type, with nested device-specific JSON object which contains information related to the device in question.
- ▶ I.E. 'wire' status and target temperatures for thermostat tie-in device, on/off state for lightbulbs and power consumption readings for smart outlets, etc.
- ▶ Example: Chart of fields for a smart outlet internal JSON object:

Field	Data Type
Toggle Status	Boolean
Current (is present)	Boolean
Current (consumption)	Integer

# MQTT topic hierarchy

- ▶ Topics separated by device-type and placed under an all-encompassing 'devices' parent topic.
  - ▶ Examples:
    - ▶ Devices/HVAC\_control
    - ▶ Devices/Sensors\_control
- ▶ Allows for reduction of clutter in messages which the modules are expected to interpret while allowing the hub to listen in on all communications via the "devices/#" multi-level wildcard string.



# Administrative Content



# Division of Work

System Component	Primary	Secondary
<b>Sensors</b>	Avery	Felix
<b>Embedded Systems</b>	Felix	Avery
<b>Back-End</b>	Costa	Matthew
<b>Database</b>	Costa	-
<b>API</b>	Costa	-
<b>Communication</b>	Matthew	-
<b>Front-End</b>	Matthew	Costa

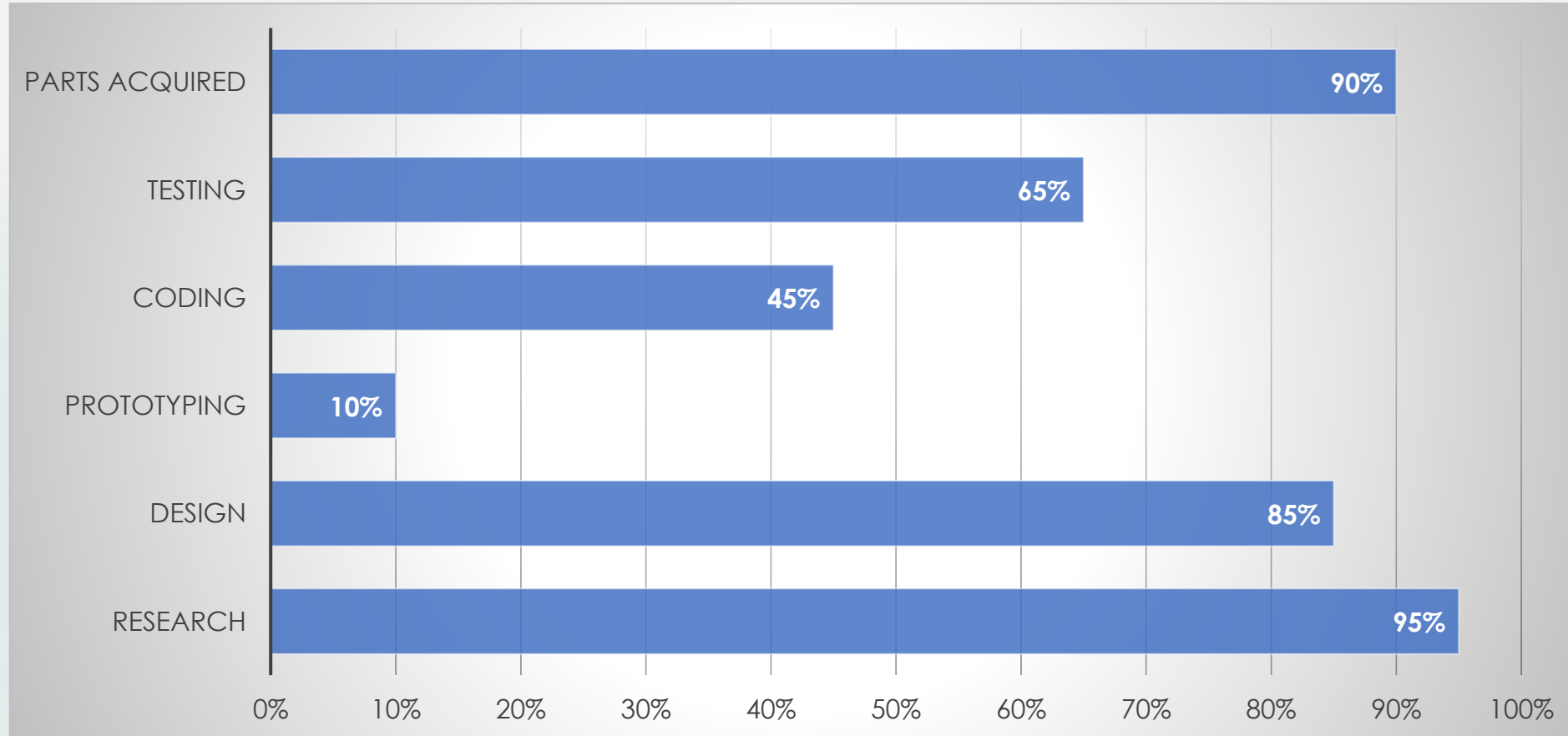
# Milestones

Milestone	Deadline	Status
<b>Parts Ordered</b>	September 1st	Completed
<b>Sensor Testing</b>	September 30th	In Progress
<b>Communication Testing</b>	September 30th	Planned
<b>Initial Coding</b>	October 6th	In Progress
<b>Initial Prototyping</b>	October 13th	Planned

# Budget

Component	Price (\$)
Thermostat	35
Outlet	30
Switch	30
Sensors	20
Lens	40
System Controller	40
Web Services	30
<b>Total</b>	225
<b>Planned</b>	< 250

# Project Progress





Questions?