Pool-AID

GROUP 23

Alexander Chan Vielsis | Computer Engineer
Houda El Hajouji | Computer Engineer
Chase Willert | Electrical Engineer
Kevin Reim | Electrical Engineer

Motivation

The number of drowning-related accidents.

- Drowning is responsible for 7% of all accidental deaths worldwide. Of these accidents, 87% occurred in backyard pools [1].

Lack of pool safety technologies in the market.

- Existing designs can be improved by combining modern sensors.

The long-term impact drowning has on nonfatal accidents.

- The impact can be minimized based on how fast one can get help.

[1] Stop Drowning Now Organization

Goals & Objectives

Minimize drowning-related accidents, fatal and nonfatal ones.

- Create a system that alerts nearby adults of a possible drowning incident in their pool.
- Develop a real-time mobile app for remote notifications.

Build a compact and ergonomic tool to be used in homes with pools.

- A waterproof, floating device that is reasonably priced.
- A two-part system that will allow the alarm to be further away from the poo l and closer to where the adult may be.

Design a user-friendly and functional mobile application.

- Allow the user to interact with their history of events.
- Notify the user of any activity near or in the pool.

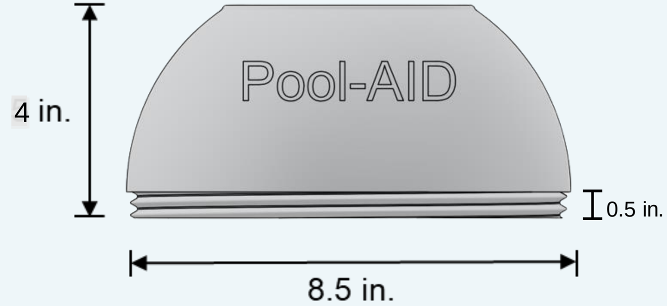
Project Features

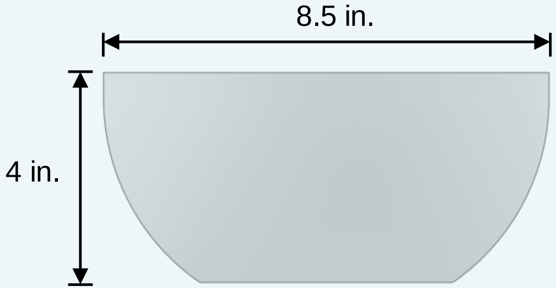
- Drowning detection technology
- Alarm
- Mobile application
- Event log with images
- Real-time mobile notifications

Specifications

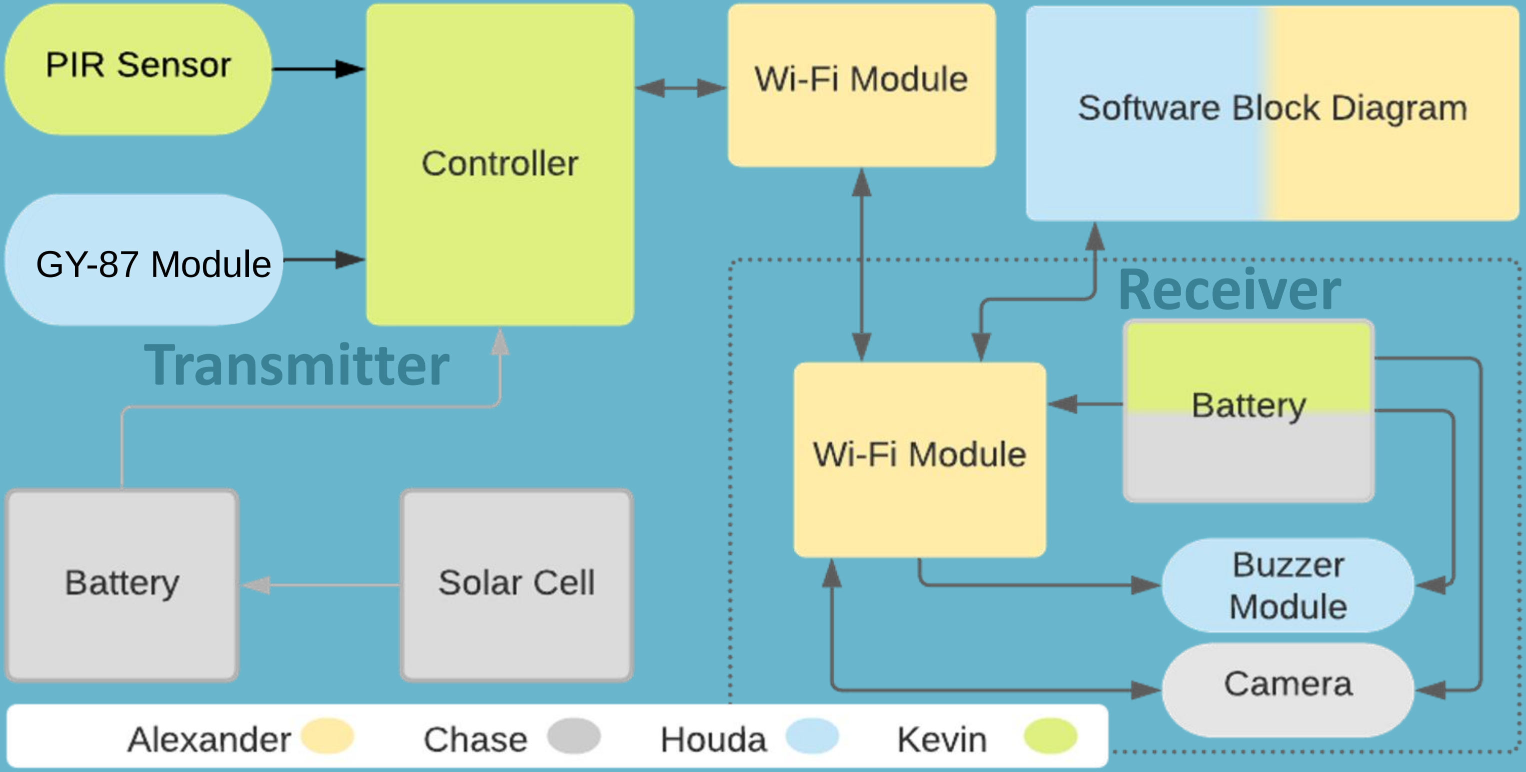
Engineering Requirement	Specification
The system shall not exceed the specified dimensions.	L x W x H ≤ 12 x 12 x 12 in
Receiver's response time shall trigger the alarm in no longer than the specified duration.	≤ 8 seconds after activity is confirmed in the pool
The alarm shall meet or exceed a certain sound level.	≥ 90 dB
Mobile application notification latency	≤ 15 seconds after alarm sounds
Navigation across the application pages shall have low latency.	≤ 3 seconds between different app page
The system shall maintain a minimal fault rate.	≤ 15 %
The system shall provide coverage for a wide field of view.	300° > FOV > 360°

Pool-AID Prototype

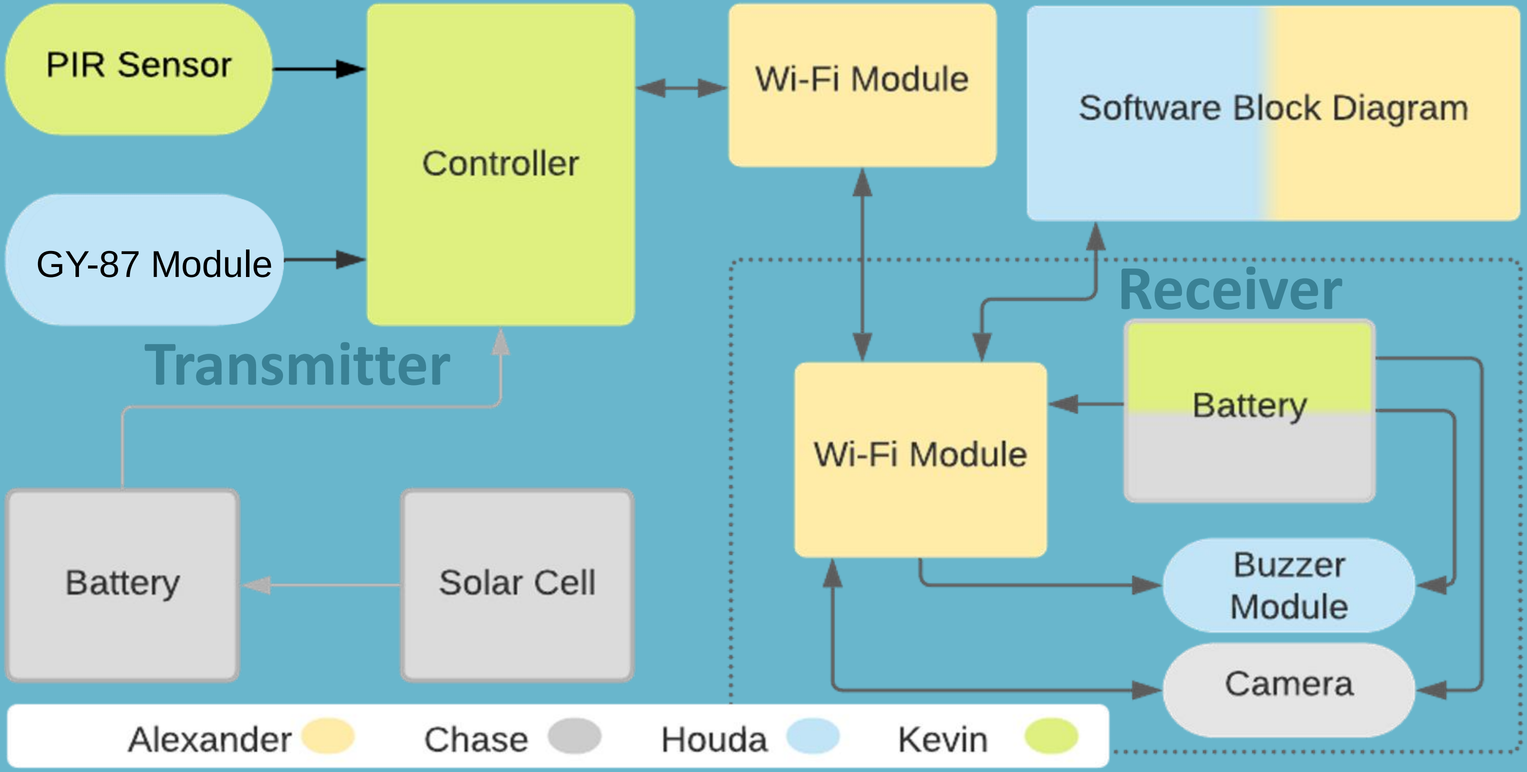




Overall Hardware Block Diagram



Transmitter Block Diagram



Component Selection: Controller

Our Controller Requirements

- ❑ Minimum 32 KB programmable me mory
- ❑ Low power or sleep modes available
- ❑ Operating voltage of 5 V
- ❑ Enough I/O pins for the following compo nents:
  - Wi-Fi module (2 pins)
  - PIR sensor (2 pins)
  - GY-87 (2 pins)
- ❑ Supports UART, SPI, I^2C
- ❑ Clock frequency supports 8 MHz

Selection: ATmega328P

	MSP430FR6989	ATmega2560	ATmega328P
Operating V	1.8V – 3.6V	1.8V – 5.5V	1.8V – 5.5V
GPIO	83	86	23
Max CLK Freq.	16MHz	16MHz	8MHz
Memory	128KB FRAM (non-volatile)	256KB flash	32KB flash
Peripherals	UART, SPI. I2C, DM A, ADC 12-bit SAR, 2 Timers with 3 cha nnels each	6 timers, UART, SPI, I2C, PWM, 16 chan nel ADC 10-bit	3 Timers (1 of 16-bit, 2 of 8-bit), UART, SPI, I2C , 6 PWM channels
Price	$10.00	$14.10	$2.24

Component Selection: PIR Sensor

Our PIR Requirements

- ❑ Covers a minimum range of 3 meters
- ❑ Low operating current
- ❑ Operating voltage of 3.3 - 5 V
- ❑ Minimum FOV 90 degrees

This PIR sensor's exterior is waterproof and provides us with the 180° coverage we need underwater. It is not as expensive as other units and has low power consumption (3 mA active).

Selection: Parallax 28032

Sensor	EKMB1306112K	EKMC1691113	EKMB1301111K	Parallax 28032
Operating V	2.3 – 4 V	3 – 6 V	2.3 – 4 V	3 – 6 V
Current (uA)	6	170	6	150
Range (m)	12 – 17 m	2.5 – 3.5 m	5 m	9.144 m
Radius	62 °	97 °	82 °	180 °
Price	$15.56	$18.60	$25.65	$12.99

Design Challenge: Sonar Sensor

Our intial design was based on the MaxSonar MB 1040.

- **Cost per unit would have dramatic strain on the bud get**
- **Would have required minimum of 6-8 sensors for des ired FOV.**

	LV-MaxSonar-EZ MB1040	HC-SR04
Operating V	2.5 V – 5 V	5 V
Distance FOV	Max – 6.45 Max – 60°	Max – 4 m Max – 15°
Cost	$27.445 for 9	$3.95 for one

Our alternative design choice was the HC-SR04 as it was much cheaper.

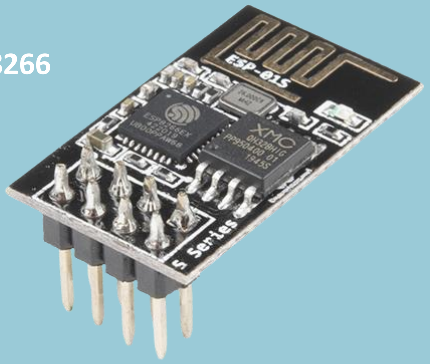
- **Ultrasonic sensor is not inherently waterproof.**
- **Would have required at least 12 units.**

Component Selections: Wi-Fi Module

Our Wi-Fi Module Requirements

- ❑ Low power consumption
- ❑ Frequency band of 2.4 GHz to allow the modules to connect wirelessly.
- ❑ Component is available immediately wi th no lead time.
- ❑ Can be interfaced with our controller selection.

Selection: ESP8266



	ESP32-WROOM-32D	W600 Module	ESP8266
Operating V	3.0V – 3.6V	3.3V	2.5V – 3.6V
GPIO	34	16	17
Radio Frequency	2.4GHz – 2.5GHZ	2.4GHz	2.4GHz
Memory	520KB SRAM	1MB Flash	512KB flash
CLK Frequency	80MHz to 240MHz	80MHz	26MHz to 52MHz
Temperature	-40C to 85C	-40C to 85C	-40C to 125C
Price	$4.20 (Module) $10.00 (Board)	$3.79 (Module) $10.60 (Wio Lite)	$6.95 (Module) $8.20 (NodeMCU)

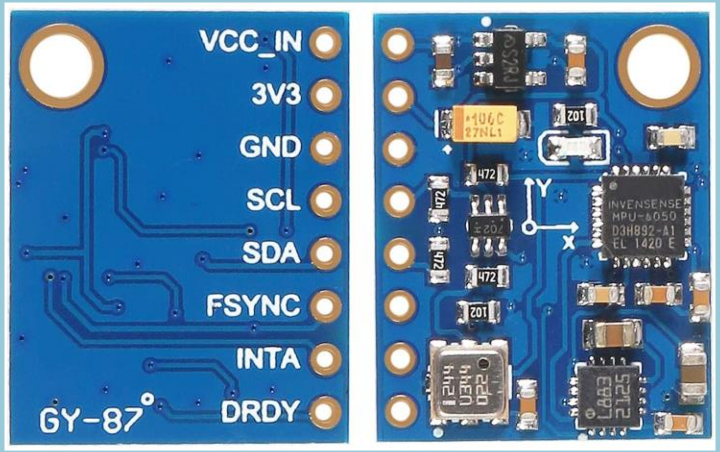
Updated Design Plan: GY-87 Module

- Does not need to be waterproof, it functions inside a container.
- It is made up of
  - 3-axis gyroscope & 3-axis accelerometer
    - 3.9 mA Maximum
  - Barometric pressure sensor
    - 1000 uA Maximum
  - Magnetometer (*not using this feature)*
- Can be interfaced with our controller via I^2C. It only requires 2 anal og input pins from the ATmega328P.

While the ICs are out of stock or have a significant lead time, we were able to acquire the module. Our choice was based on **availability** and the only one available was the GY-87.

Selection: GY-87

GY-87 Module
- MPU6050
- BMP180
- HMC5883L

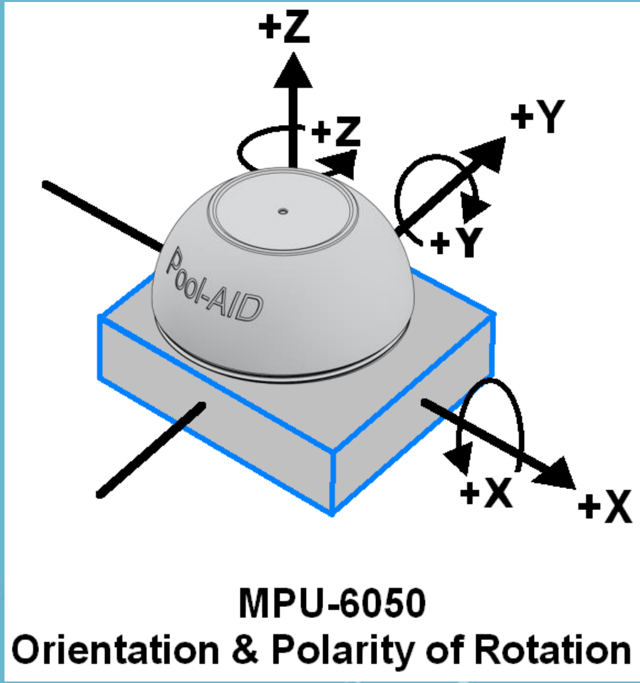


Motion Calculations

Motion will be determined using the MPU6050's (gyroscope and accelerometer) 6-axis motion tracking capabilities. It will give us measure ments based on the rotational velocity around the X, Y, and Z axes.

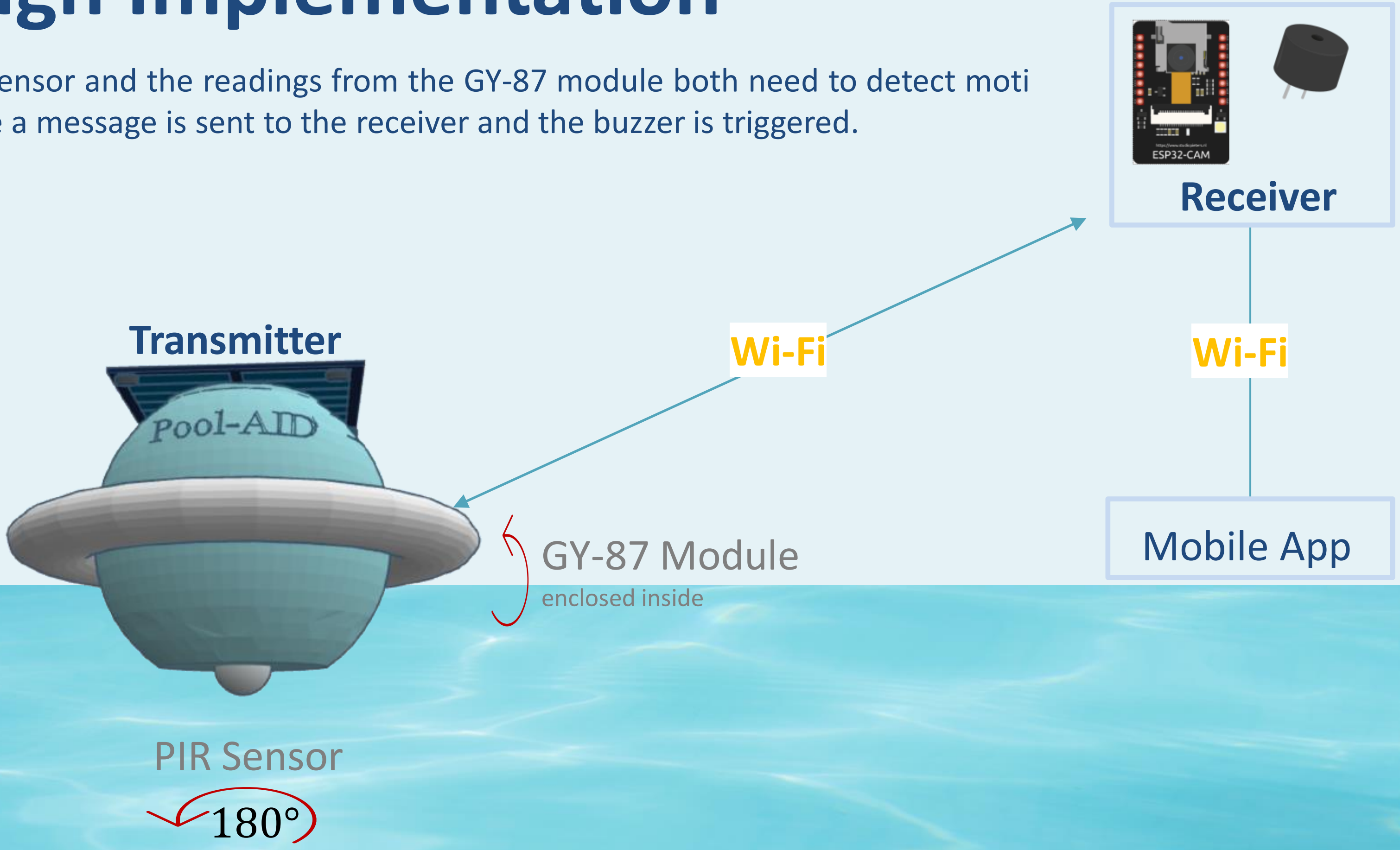
Vertical velocity will be determined using the barometer. From the pressure readings of the BMP180, we can calculate the height of the wav e caused by the object or person falling to determine whether someone is drowning.

- We will be using Adafruit's BMP085 library for the pressure and altitu de readings.
- Arduino MPU6050 library exists for the gyroscope and accelerometer.



Design Implementation

The PIR sensor and the readings from the GY-87 module both need to detect moti on before a message is sent to the receiver and the buzzer is triggered.



Power Consumption

- Maximum current draw is used to determine overall power draw of the devices.
- Power consumption can be used to determine battery sizing.
- Actual average current draw will be lower, as these numbers are based on a theoretical worst-case scenario where all components are drawing maximum current.

Transmitter

Component	Maximum Current Draw
ATMEGA328P	200 mA
ESP8266	170 mA
28032 PIR	0.3 mA
GY-87	3.7 mA
Total	374 mA

Receiver

Component	Maximum Current Draw
ESP32-CAM	310 mA
Grove Active Piezo Buzzer	20 mA
Total	330 mA

Component Selections: Solar Panel & Battery

Solar panel

- The SunnyTech solar panel was selected in order to provide enough current and power to recharge the battery in a timely manner.
- Under maximum current draw, one SunnyTech solar panels would be needed to provide the necessary 3.16 W.

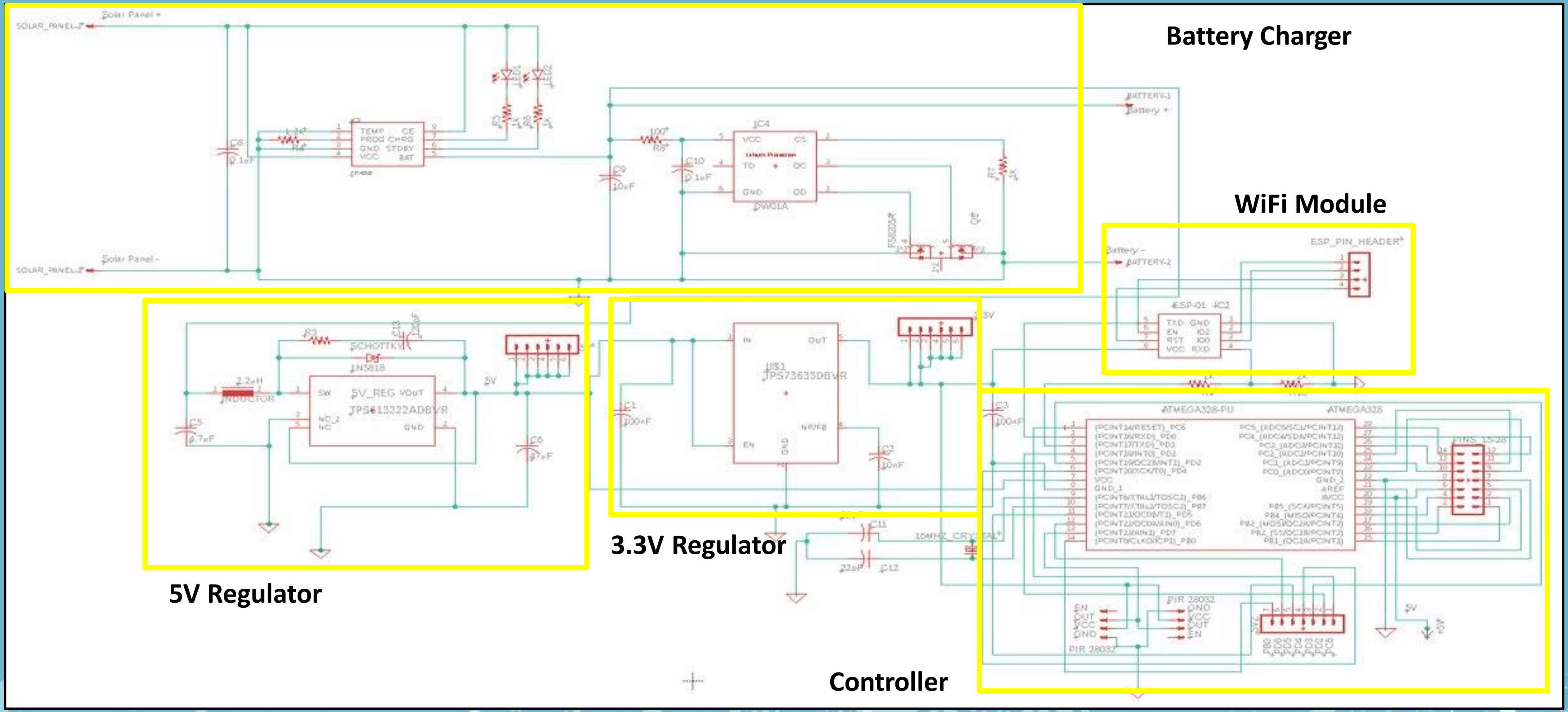
	Sunyima Tech	AMX3d	Sunnytech
Voltage	5-6 V	5-6 V	6 V
Current	50-220 mAh	500 mAh	580 mAh
Power	0.2-2 W	2.5 W	3.5 W
Size	40-80 mm^2	150x150 mm	165x135 mm
Price	$9-12	$13	$13-17

Battery

- The main contenders for battery chemistry were the lithium-iron phosphate (LiFePo4) and lithium polymer (LiPo) chemistries due to their energy density.
- LiPo was chosen over LiFePo4 due to its generally higher energy density.

	Lead-Acid	Nickel-Cadmium	Nickel-Metal Hydride	Li-Po	Li-Fe-PO4
Energy Density	80-90 Wh/L	50-150 Wh/L	140-300 Wh/L	250-730 Wh/L	325 Wh/L
Operating °F	-40°F-120°F	70°F-90°F	68°F-113°F	-4°F-140°F	-4°F-140°F
Cost	7-18 Wh/USD	3 Wh/USD	3 Wh/USD	3-12 Wh/USD	3-12 Wh/USD
Safety	↑	↑	↑	↓	—
Memory Effect	X	✓	X	X	X

Transmitter Schematic

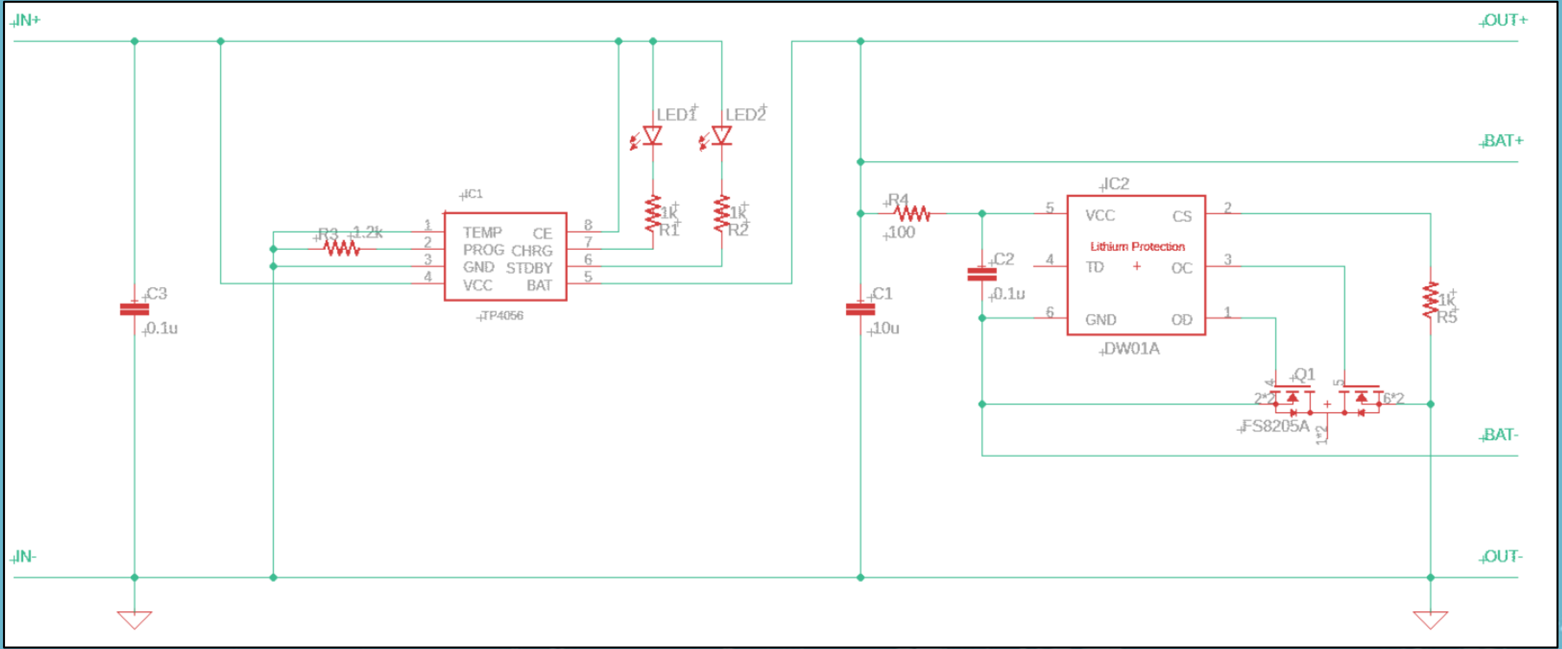


A Closer Look: Battery Charger

Two main ICs –

TP4056 — Li-Ion battery charger controller that handles constant current/constant voltage charging application.

DW01A — Li-Ion protection IC that prevents overcharge, over-discharge, and overcurrent to ensure the battery operates in safe conditions.



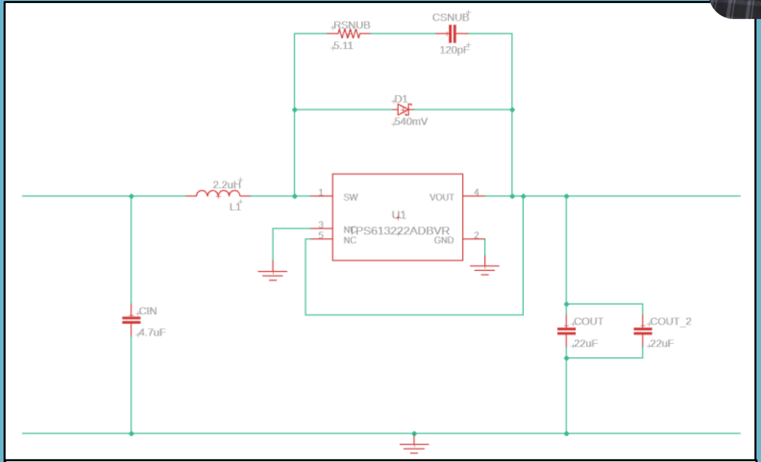
A Closer Look: Voltage Regulators

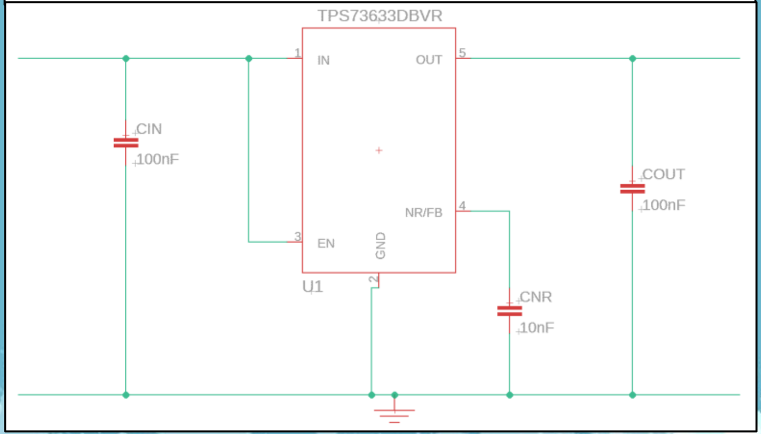
Transmitter

- Step-up 5V boost converter for the 3.7V LiPo battery
- Step-down 3.3V buck converter for the 3.7V LiPo battery

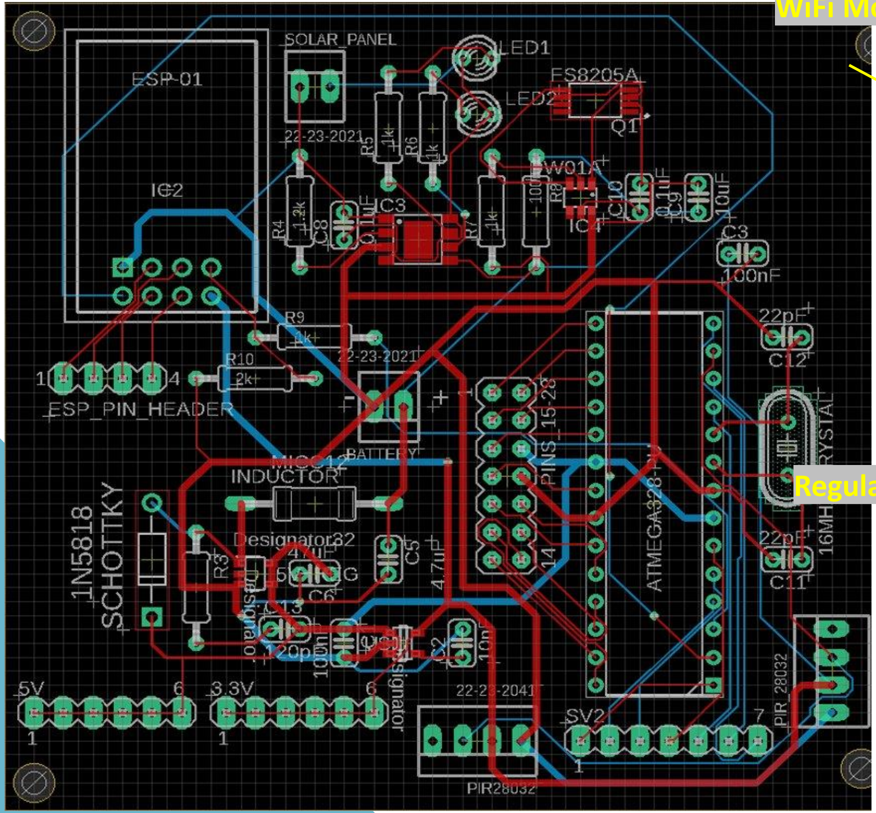
Receiver

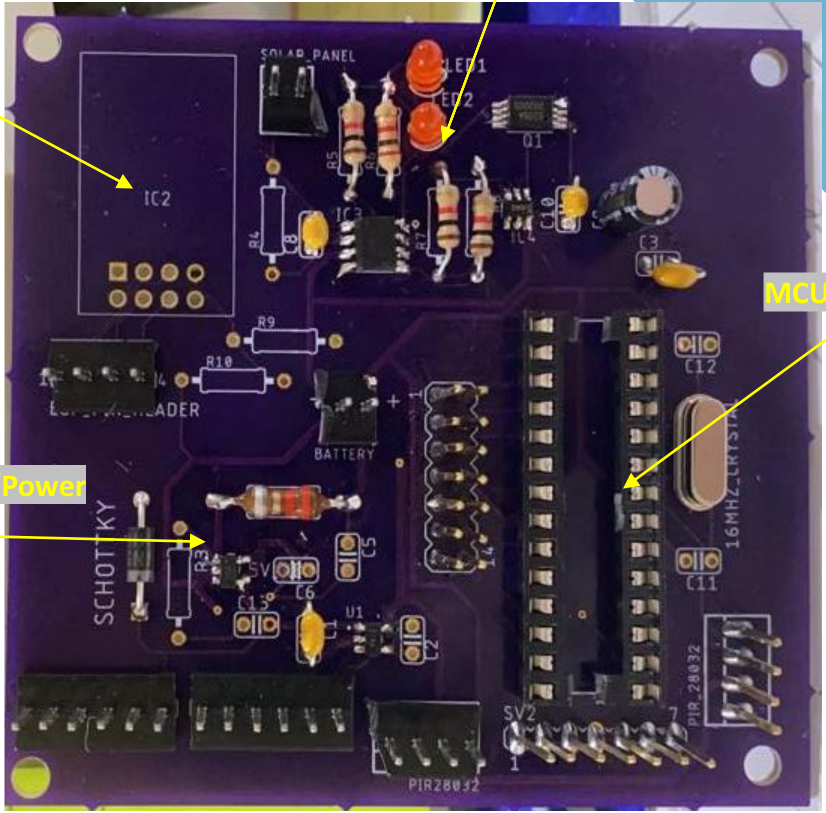
- Step-up 5V boost converter for the two 1.5V AA batteries (combined 3V)



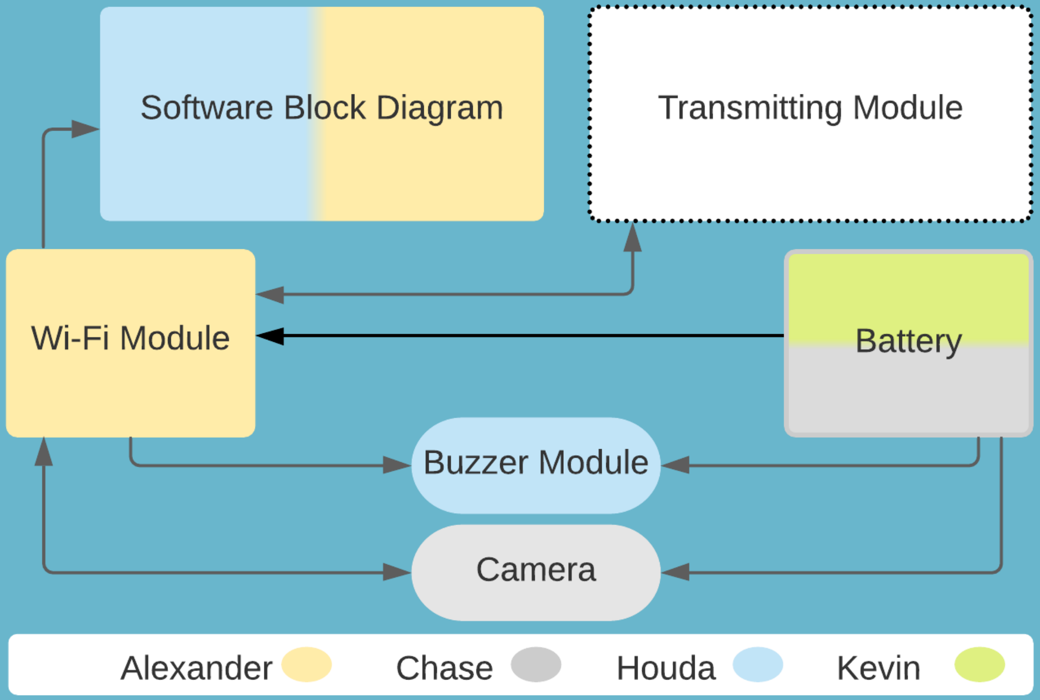


PCB Layout Transmitter





Receiver Block Diagram



Component Selection: Camera Module

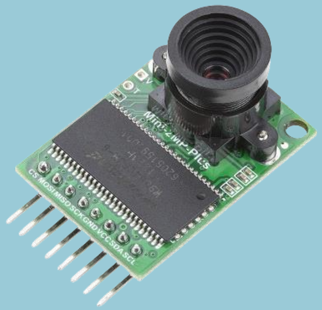
Design Challenge: ArduCAM takes captures using an external software tool.

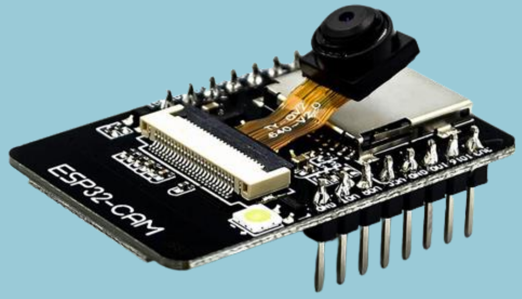
Specifications

- Built in Wi-Fi chip to communicate wit h the transmitter
- Low cost and uses the same camera m odule as the ArduCAM
- Can be used to control the buzzer

	ArduCAM mini	ESP32-CAM
Voltage	5 V	5 V
Current	70mAh	310 mAh
Power	350mW	900mW
Size	34x24 mm	40.5x27 mm
Price	$25.99	$10

Selection: ESP32-CAM





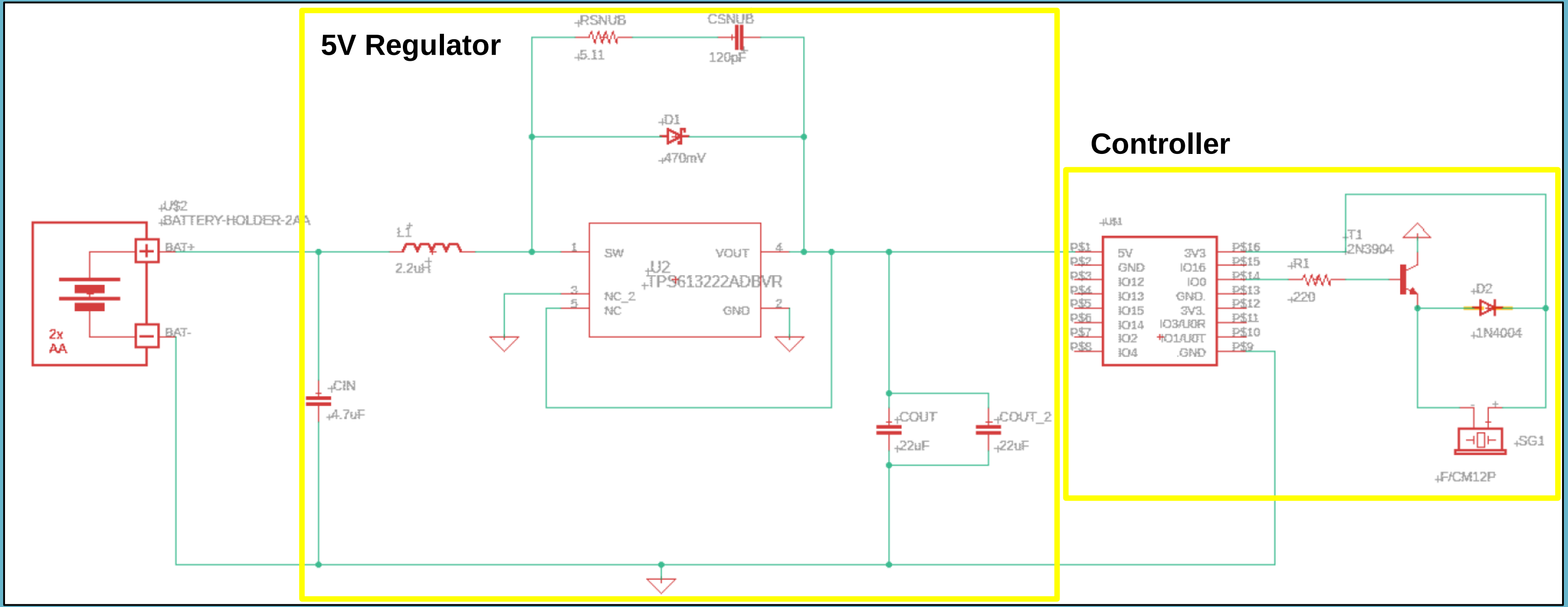
Component Selection: Buzzer Module

Piezo Buzzer vs. Magnetic Buzzer

- Magnetic buzzer has a non-linear relationship between the input drive signal strength and the output audio power.
- Piezo buzzer can deliver a higher sound pressure level.
- Piezo buzzer consumes less power as it is driven by voltage rather than the magnetic buzzer which is driven by current.

	CEM-1205-IC Buzzer	Grove Active Piezo Buzzer
Sound Pressure Level	Max 92 dB	Max 120 dB
Current Draw	30 mA	20 mA
Rated Frequency	2400 Hz	2400 Hz – 3000 Hz
Indicator or Transducer	Indicator	Indicator

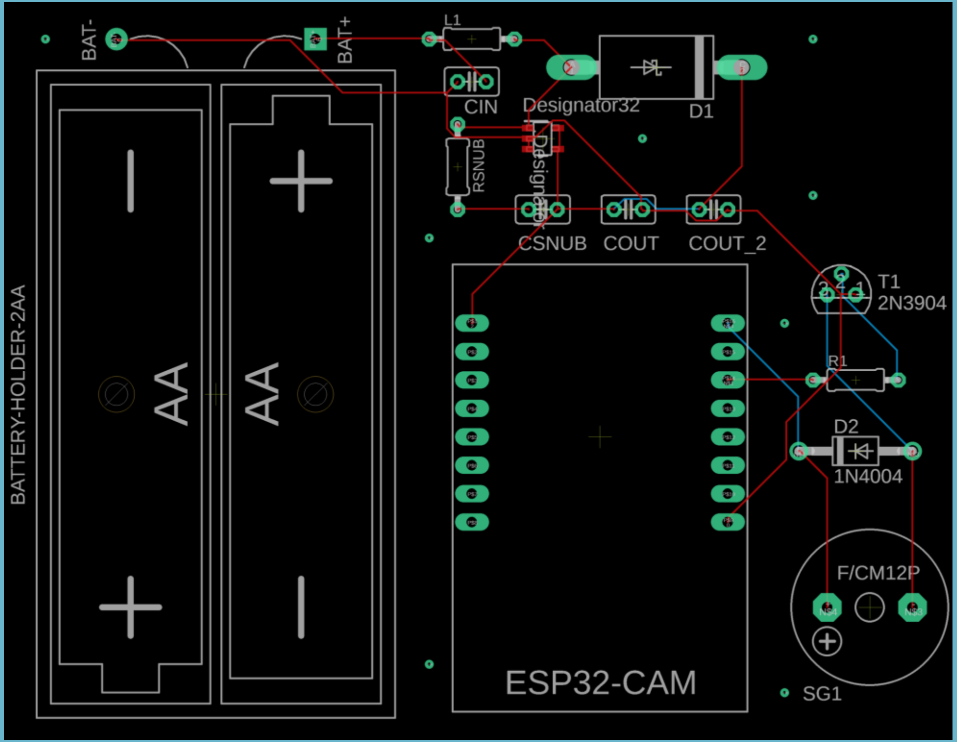
Receiver Schematic



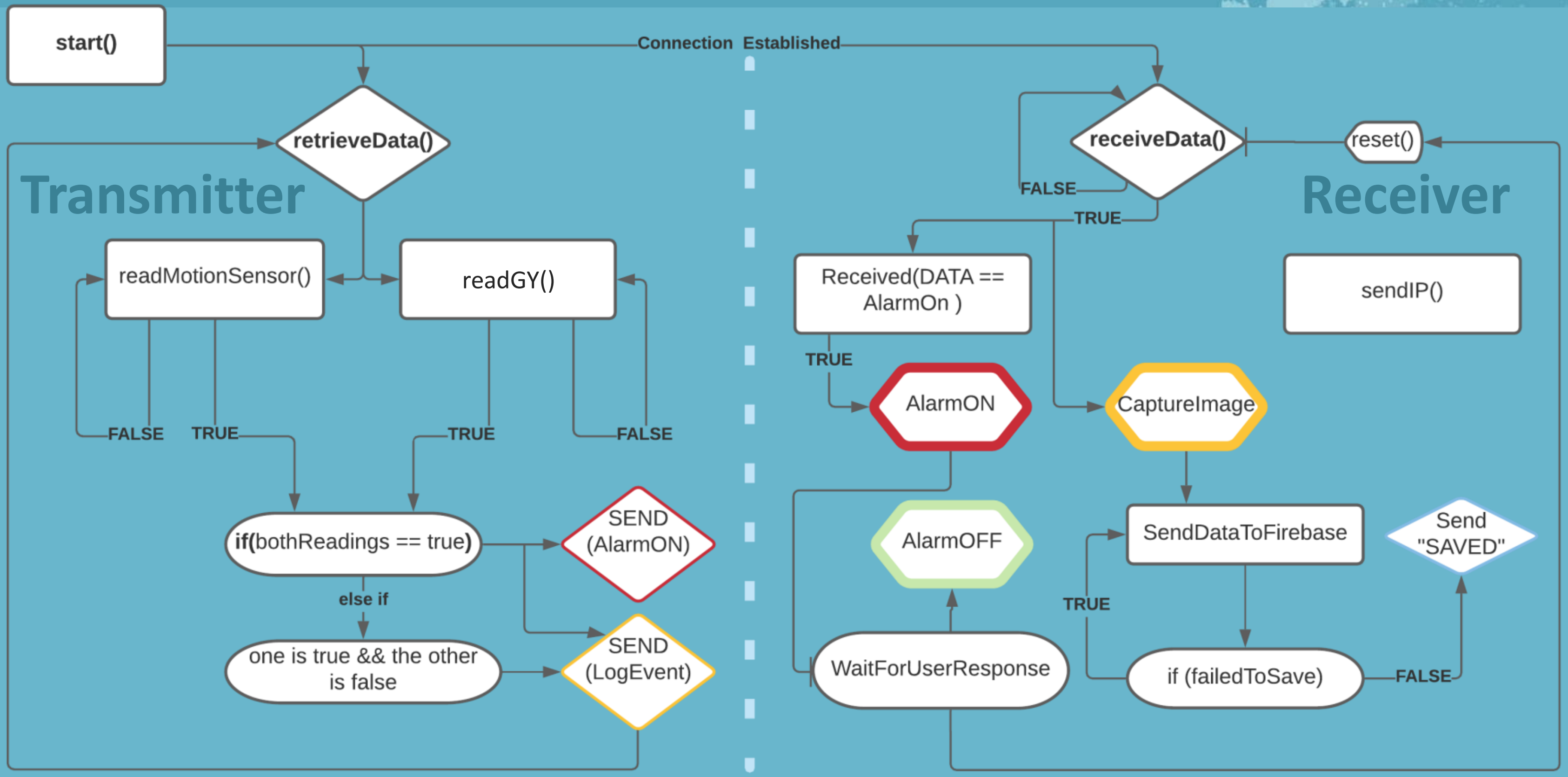
Receiver PCB

PCB Design

- Battery holder for 2x AA batteries is used for power supply.
- TPS613222A 5V regulator comes in DBVR package.
- The AI Thinker ESP32-CAM module will be mounted to the board.
- Piezo buzzer circuit requires a resistor, diode, and NPN BJT for operation.



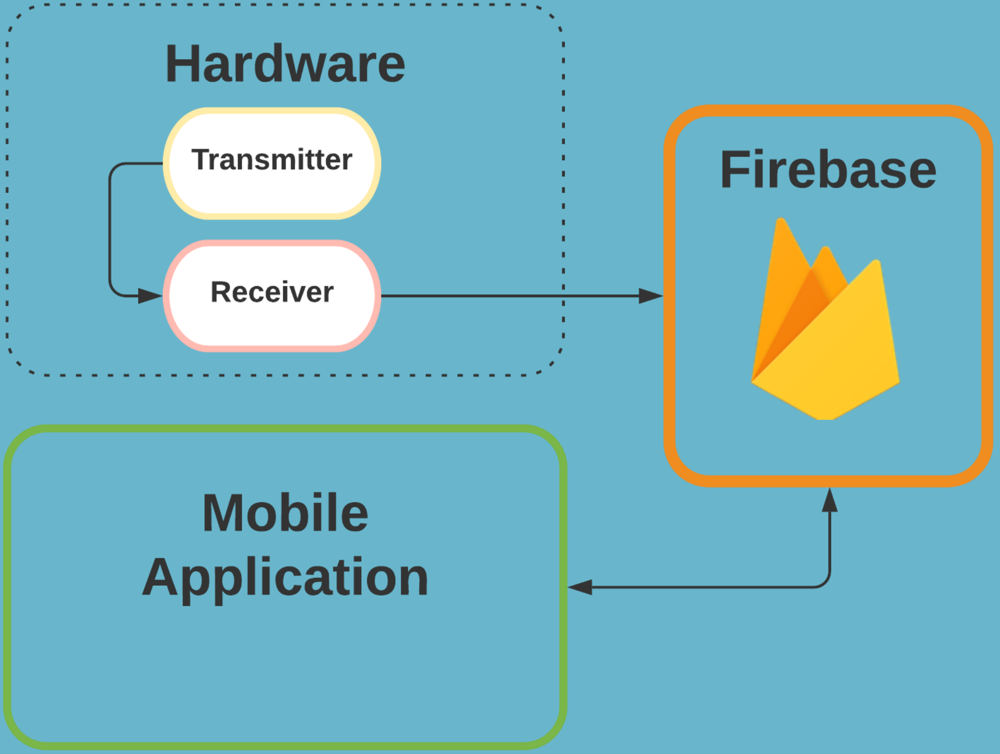
Transmitter & Receiver Software



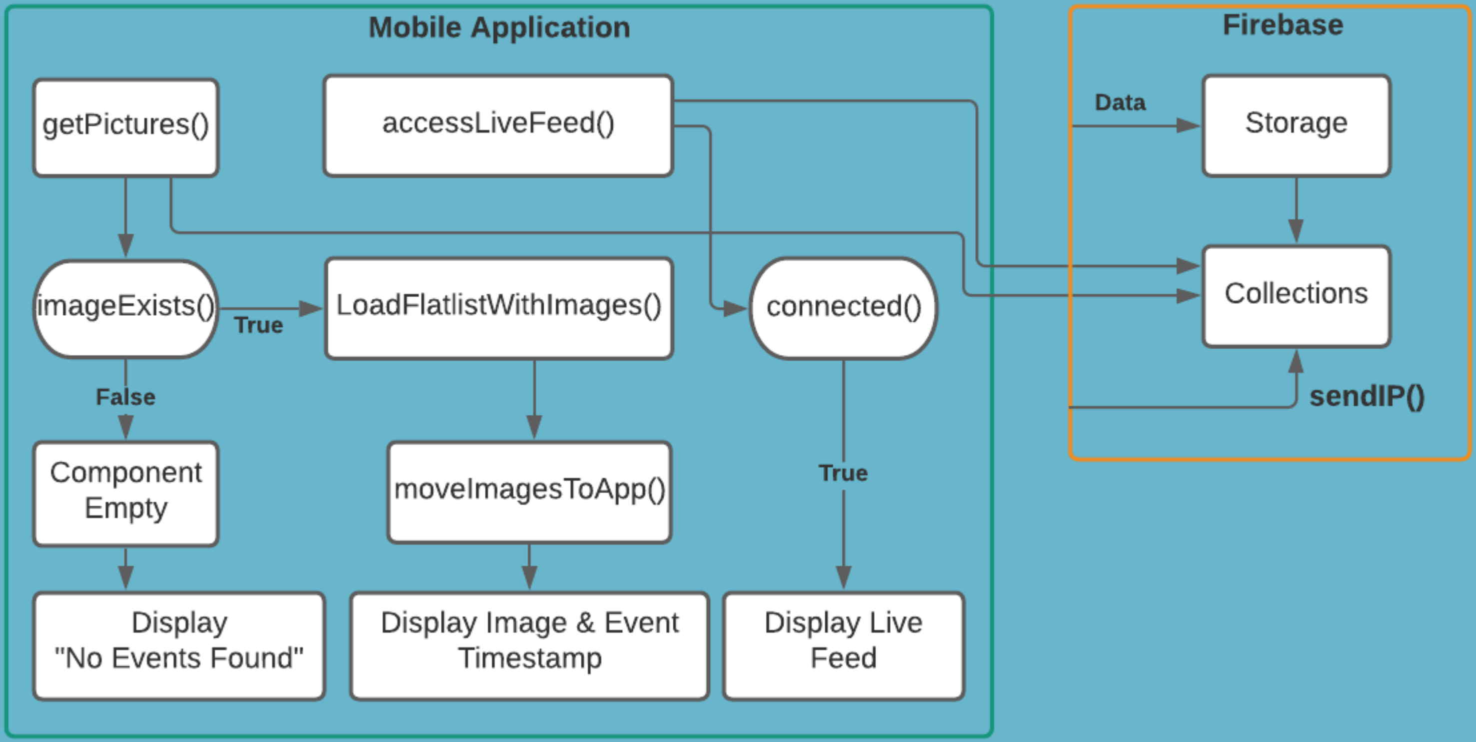
Overall Software Block Diagram

Development Tools

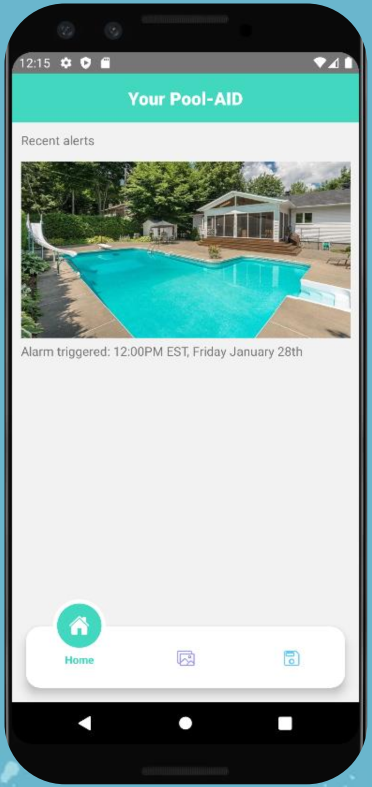
- Google Firebase
- React Native
- React Navigation
- Vector icons
- Android Studio
- Xcode
- React Native Firebase
- Cloud messaging

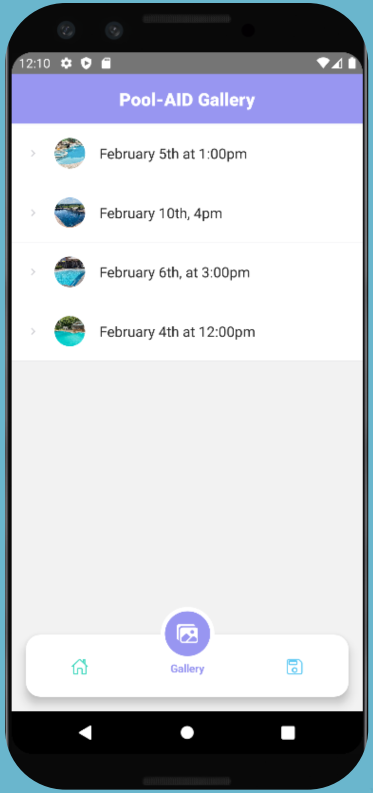


Mobile Application Software



User Interface





The Pool-AID mobile application will be the main way the user interacts with their Pool-AID device. The application will have three main features supported:

- **Provide access to user's data.**
- **Show history of events in the pool with corresponding timestamps.**
- **Notify the user of any activity in the pool.**

Issues Encountered

- Battery Charger on PCB
- Solar panel placement on 3D model
- Posting image to Firebase overwrites previous image capture
- Mobile Application portability between Android and iOS
- Component shortage & lead time

Pool-AID Budget & Financing

Total Budget:
$200

Current Total:
$73.82

R&D Total:
$171.37

Transmitter	Part	Cost	Unit Price	Quantity	TOTAL
PCB	OSHPark	$45.00	$15.00	3	$15.00
GY-87 Module	10DOF UMLIFE GY-87	$20.59	$10.30	2	$10.30
3000 mAh Battery	755068 Lipo Battery	$13.89	$13.89	1	$13.89
Wi-Fi module	ESP8266-01	$10.99	$3.66	3	$3.66
Solar Panel	SunnyTech B033	$12.99	$12.99	1	$12.99
Battery Charger IC	TP4056	$1.98	$0.20	10	$0.20
Battery Protection IC	DW01A	$4.24	$0.08	50	$0.08
Dual N-Channel MOSFET	FS8205A	$1.55	$0.16	10	$0.16
5V Regulator Controller	TPS613222ADBVT	$10.38	$1.04	10	$1.04
3.3V Regulator Contoller	TPS73633DBVR	$12.50	$2.50	5	$2.50

Receiver	Part	Cost	Unit Price	Quantity	TOTAL
Camera Module	ESP32-CAM	$20.00	$10.00	2	$10.00
AA Battery Holder	Lampvpath	$6.48	$2.16	3	$2.16
5V Regulator Controller	TPS613222ADBVT	$10.38	$1.04	10	$1.04
PCB	JLCPCB	$4.00	$0.80	5	$0.80

Milestones & Next Steps

- Test the updated design upon the arrival of the GY-87 module
- Set-up Wi-Fi communication between transmitter and receiver
- Print & assemble 3D model
- Prepare for the mid-semester demo

Work Distribution

Kevin Reim is responsible for designing the PCB, testing components, and prototyping Pool-AID's container.

- PCB schematics & design primary
- Functionality of peripherals primary
- Prototyping & building model secondary

Houda El Hajouji focuses primarily on the mobile application, software logic, and 3D design. She manages the team's documentations, presentations, and meetings.

- Mobile application primary
- Prototyping and building model primary
- Programming & interfacing sensors secondary

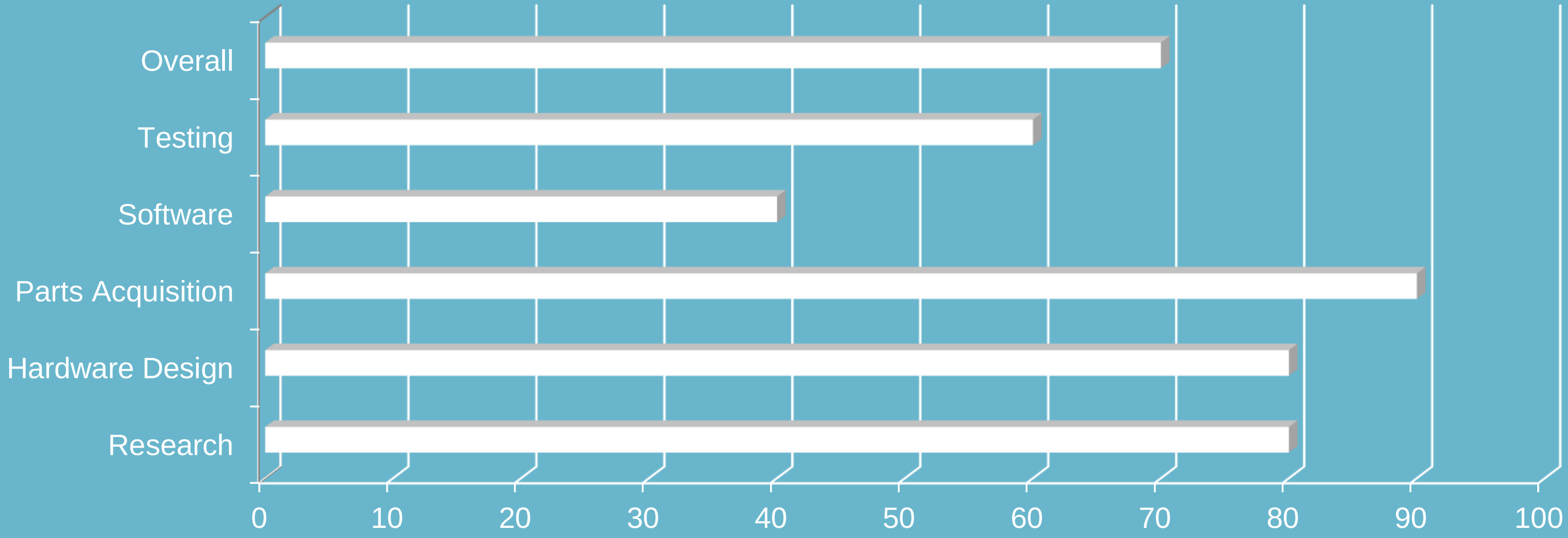
Alexander Chan Vielsis is the software lead of the team and is responsible for building the mobile application & interfacing Pool-AID's modules.

- Mobile application development primary
- Programming & interfacing sensors primary
- Wireless communication secondary

Chase Willert oversees the system's power supply and distribution. He is also responsible for the wireless connections between the receiver and transmitter.

- Power distribution & components primary
- Wireless communication between the transmitting and receiving unit primary
- PCB schematics & design secondary

Progress



Overall
Testing
Software
Parts Acquisition
Hardware Design
Research
0
10
20
30
40
50
60
70
80
90
100

QUESTIONS?

Thank you!