Pool-AID

GROUP 23

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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.

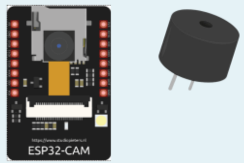
- Allow the user to interact with their history of events.
- Notify the user of any activity near or in the pool.

Project Features

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

Overview

Pool-AID is a system designed to detect any drowning activity in a pool using a gyros cope and PIR sensor to verify that the object is a person and not inanimate.



Receiver

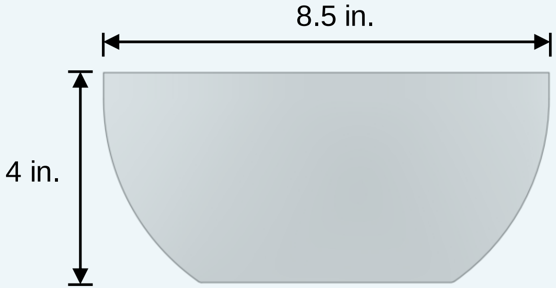
Transmitter

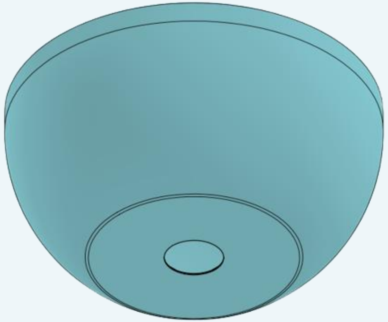
Mobile App

Specifications

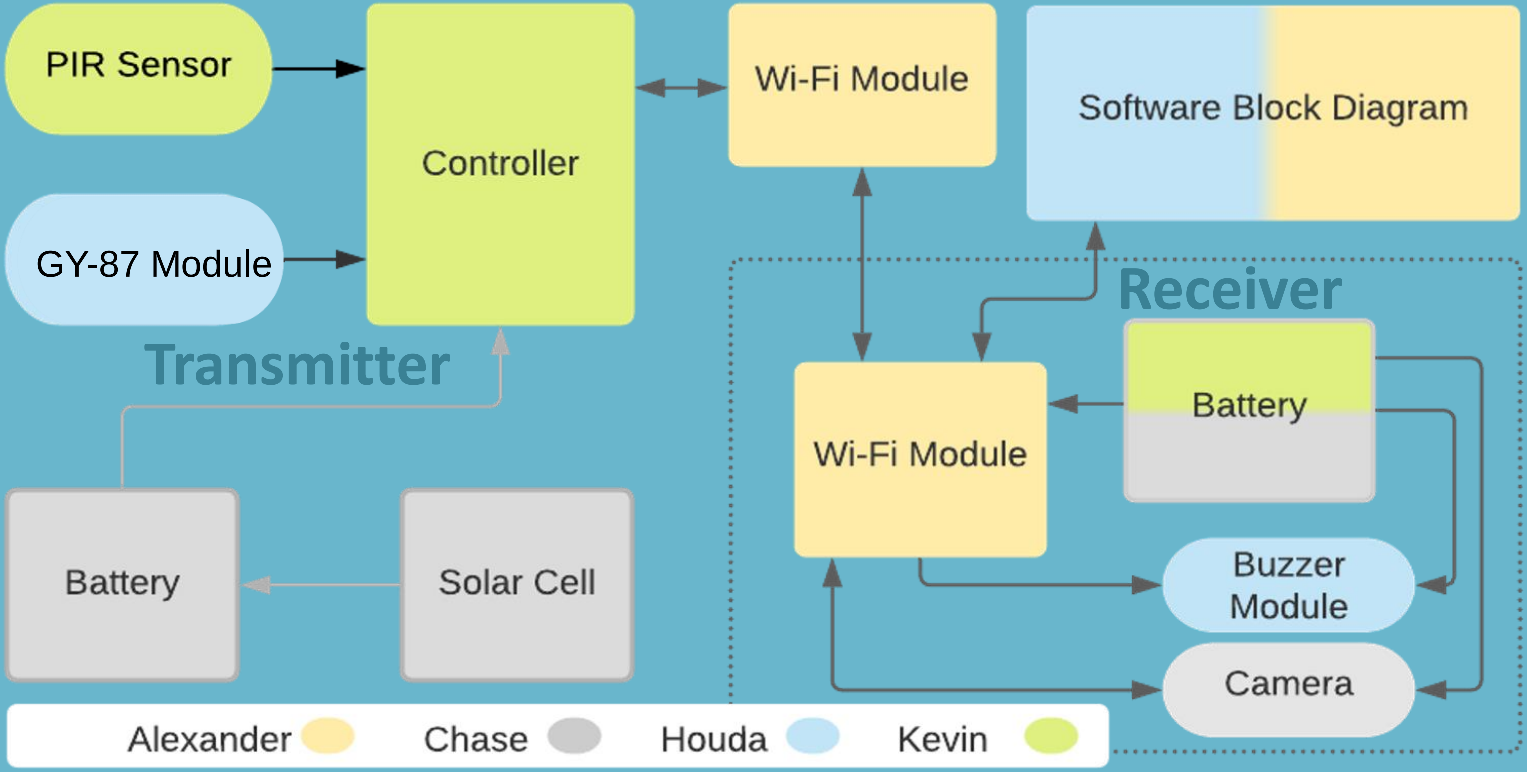
Engineering Requirement	Specification
The system shall not exceed the specified dimensions.	L x W x H ≤ 12 x 12 x 12 in
Receiver’s response time shall trigger the alarm in no longer than the specified duration.	≤ 8 seconds after activity is confirmed in the pool
The mobile application shall retrieve and display images in a reasonable timeframe.	≤ 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

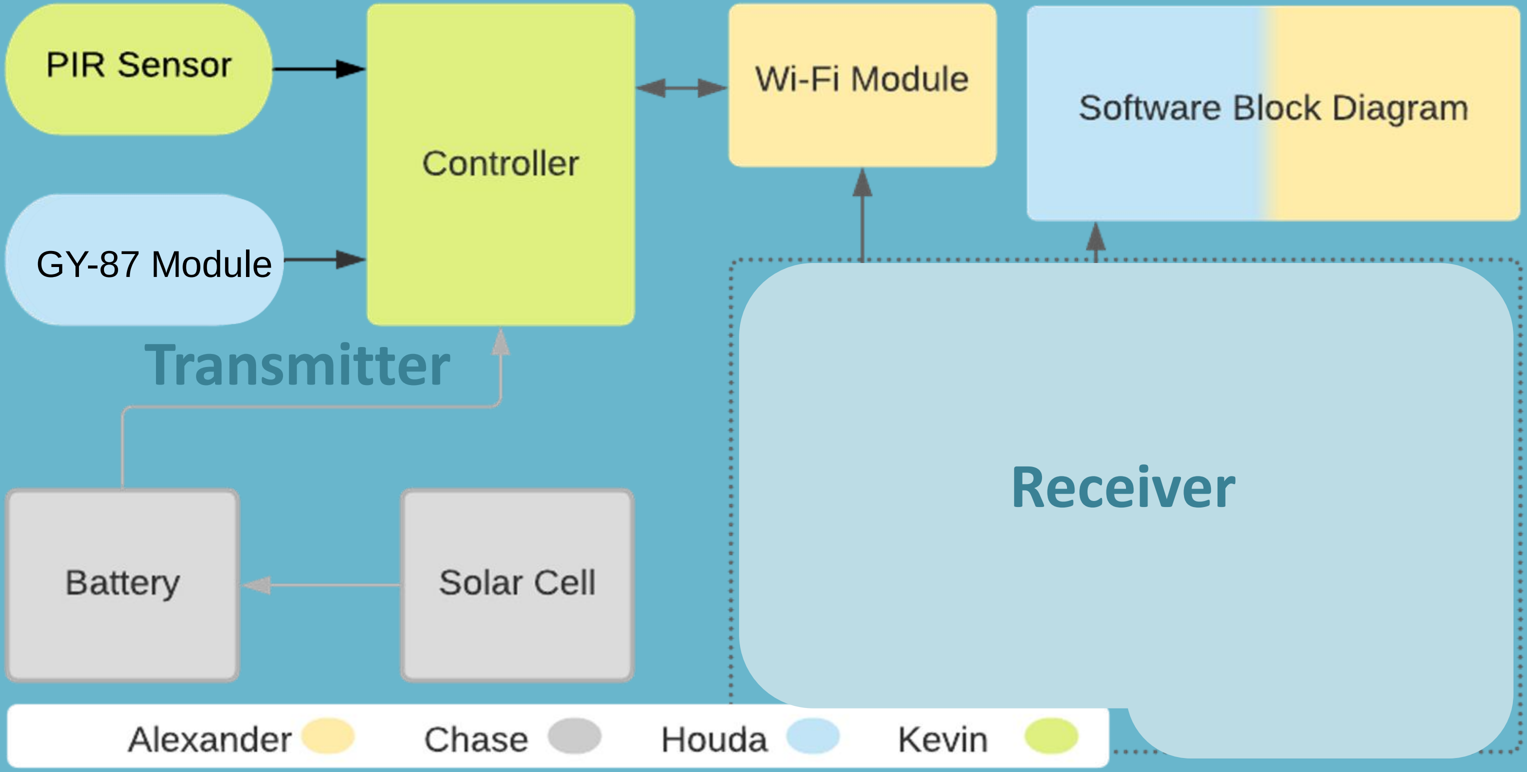




Overall Hardware Block Diagram



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, DMA, ADC 12-bit SAR, 2 Timers with 3 channels each	6 timers, UART, SPI, I2C, PWM, 16 channel 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

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

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

Wireless Technologies Considerations

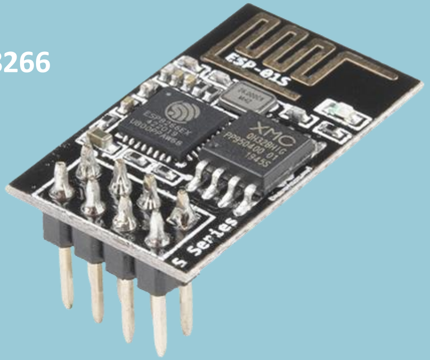
	WiFi	Bluetooth	Zigbee
Transfer Rate	300 Mbps	3 Mbps	250 Kb/s
Frequency band	2.4GHz – 5GHz	2.4GHz	2.4GHz
Range	100m	10m	10-100m
IEEE	IEEE 802.11	IEEE 802.15.1	IEEE 802.15.4
Power consumption	High	Low	Low

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)

Design Challenge: Sonar Sensor

Our initial 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.

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.

	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

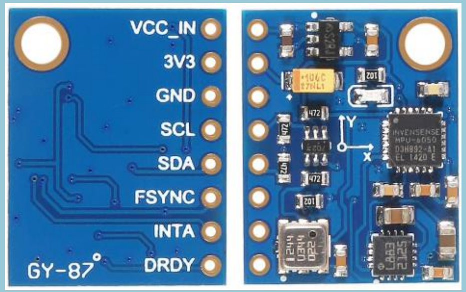
Component Selections: IMU Module

- All of the following modules are interfaced using I^{2}C.
- Does not need to be waterproof, it functions insid e a container.
- Can be interfaced with our controller via I^{2}C and only require 2 analog input pins from the ATmega 328P to support the serial clock line and serial dat a.

	GY-521	MPU9250+BMP 180	GY-87
Operating V	4.3 V – 9 V	3.3 V – 6.5 V	3 V – 5 V
Number of Axes (DOF)	6	10	10
Gyroscope Range	+/- 250 – 2000 º / s	+/- 250 – 2000 º / s	+/- 250 – 2000 º / s
Acceleration Range	+/- 2g – 16g	+/- 2g – 16g	+/- 2g – 16g
Price	$4.75	$16.95	$10.30

We selected the GY-87 because of its compatibility with our system, low power consumption, has a high accuracy rate, and is relatively cheap.

Selection: GY-87

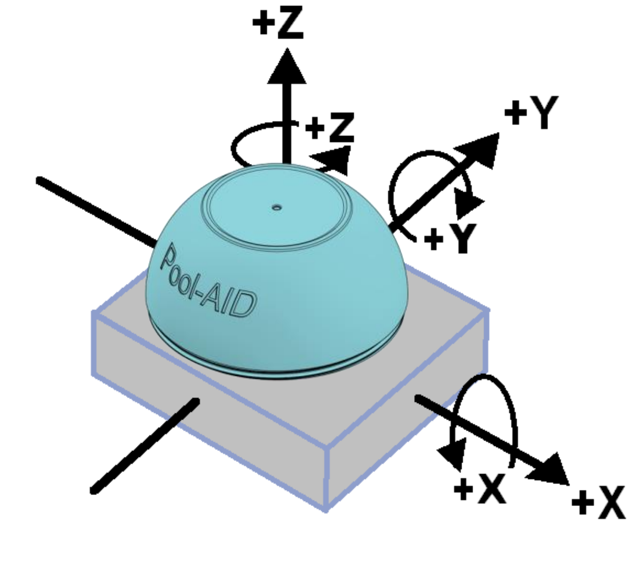


Motion Calculations

The motion generated from the falling objects will be calculated using the MPU6050's (gyroscope and accelerometer) 6-axis motion tracking ca pabilities. It will give us measurements based on the rotational veloc ity around the X, Y, and Z axes.

Using those readings, we can determine the tilting degree based on the weight of the object. How significant the difference between the measur ed angles is helps us determine whether the object is lightweight, meaning inanimate, versus a toddler with a weight of at least 18 pounds.

- We use the Arduino MPU6050 library's built-in functions to proce ss the 3D readings from the gyroscope and the accelerometer.



MPU-6050
Orientation & Polarity of Rotation

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

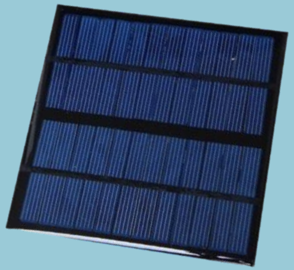
Component	Maximum Current Draw
ESP32-CAM	310 mA
Grove Active Piezo Buzzer	20 mA
Total	330 mA

Component Selections: Solar Panel

Solar panel

- The SunnyTech solar panel was sel ected in order to provide enough current and power to recharge the bat tery in a timely manner.
- Under maximum current draw, one Su nnyTech solar panels would be need ed 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



Component Selections: Battery

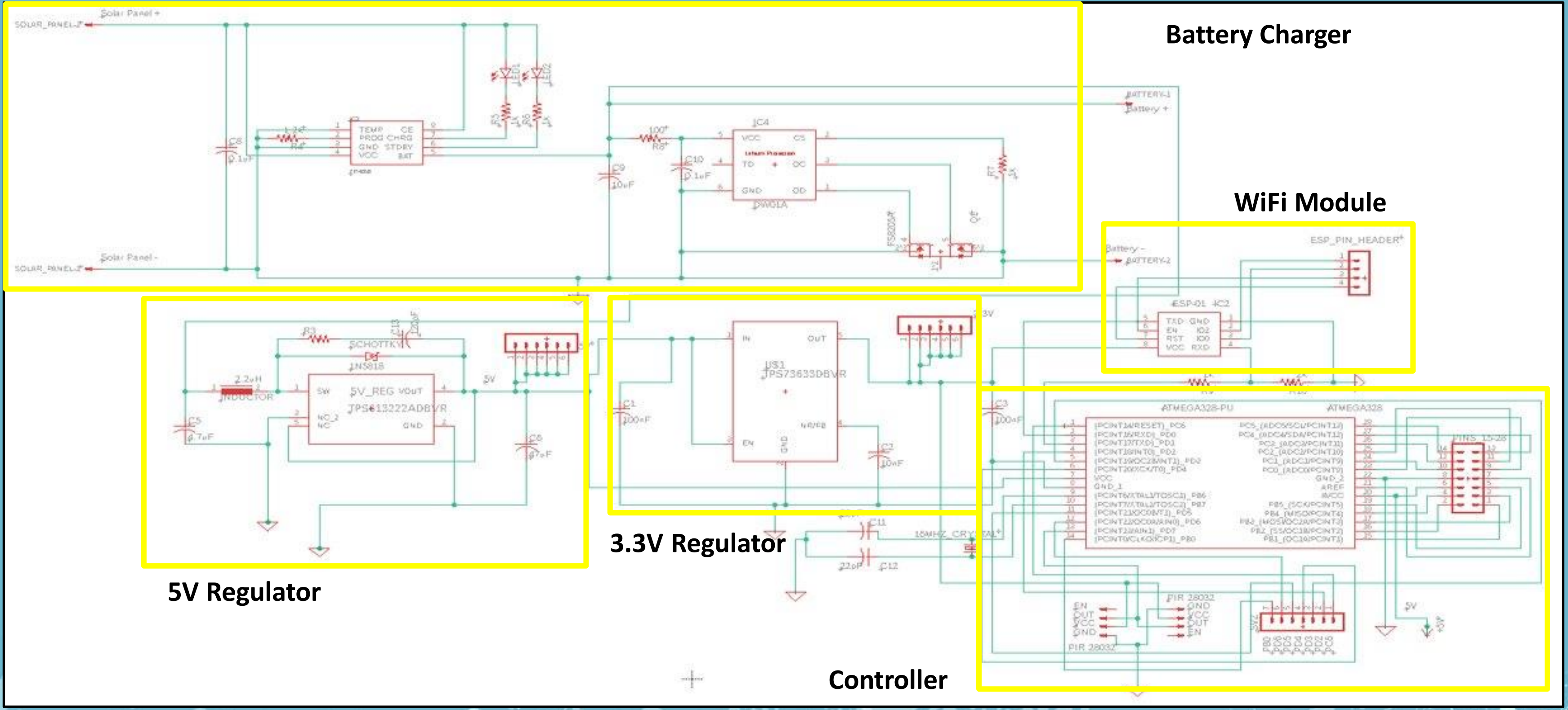
Battery

- 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

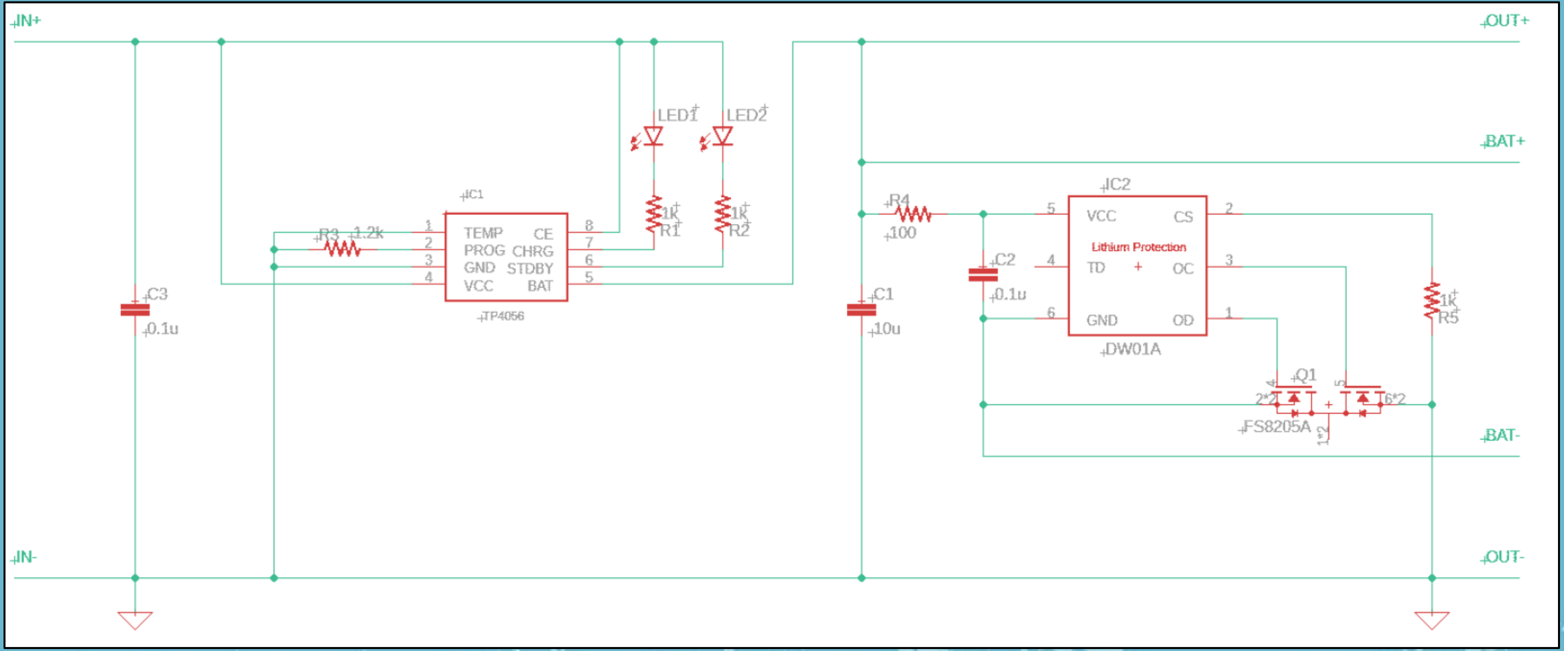


A Closer Look: Battery Charger

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.



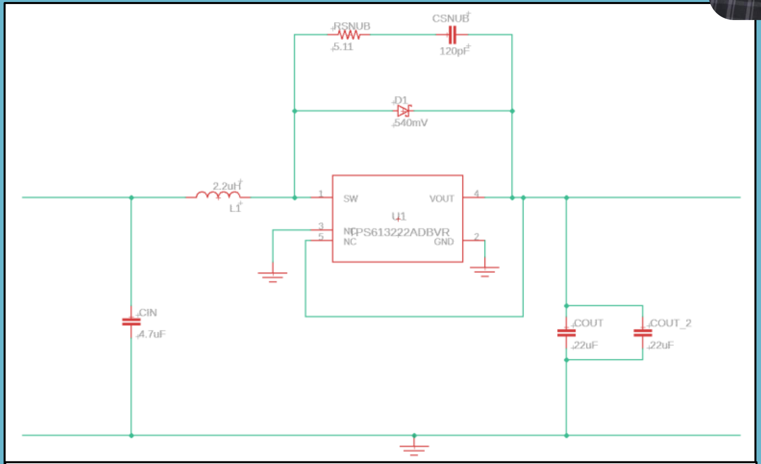
A Closer Look: Voltage Regulators

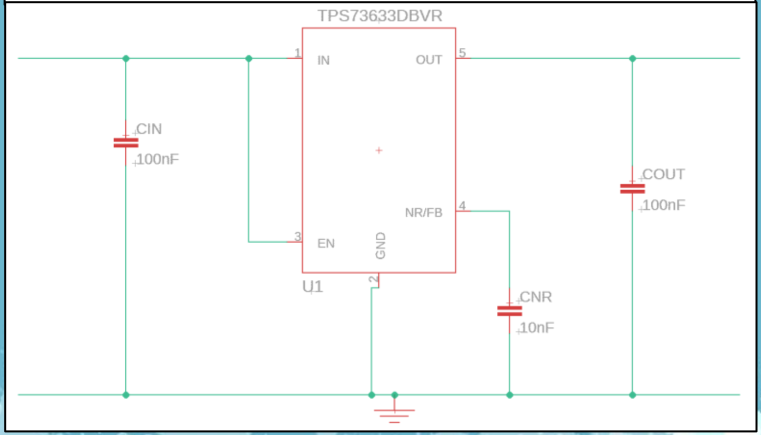
Transmitter

- Step-up 5V boost converter for the 3.7V L iPo battery
- Step-down 3.3V buck converter for the 3. 7V LiPo battery

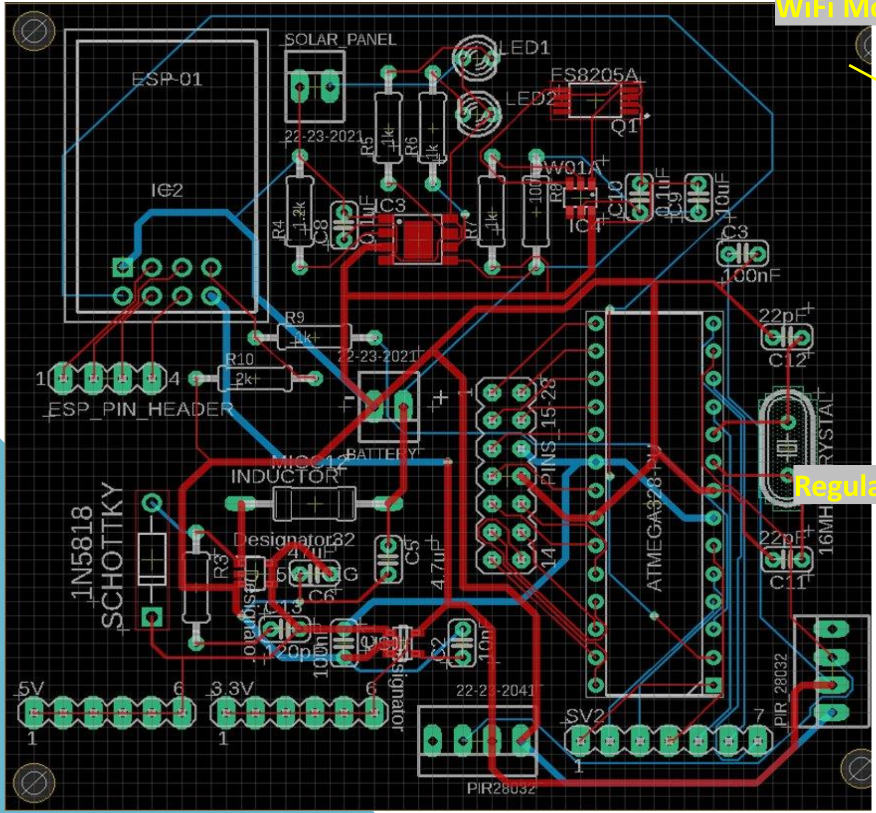
Receiver

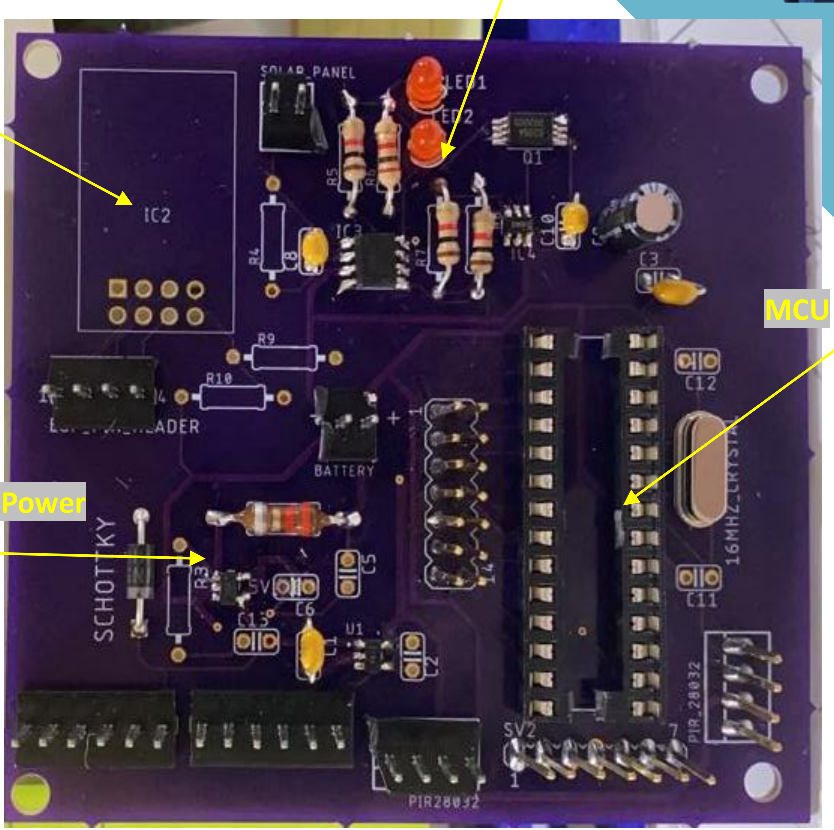
- Step-up 5V boost converter for the two 1. 5V AA batteries (combined 3V)



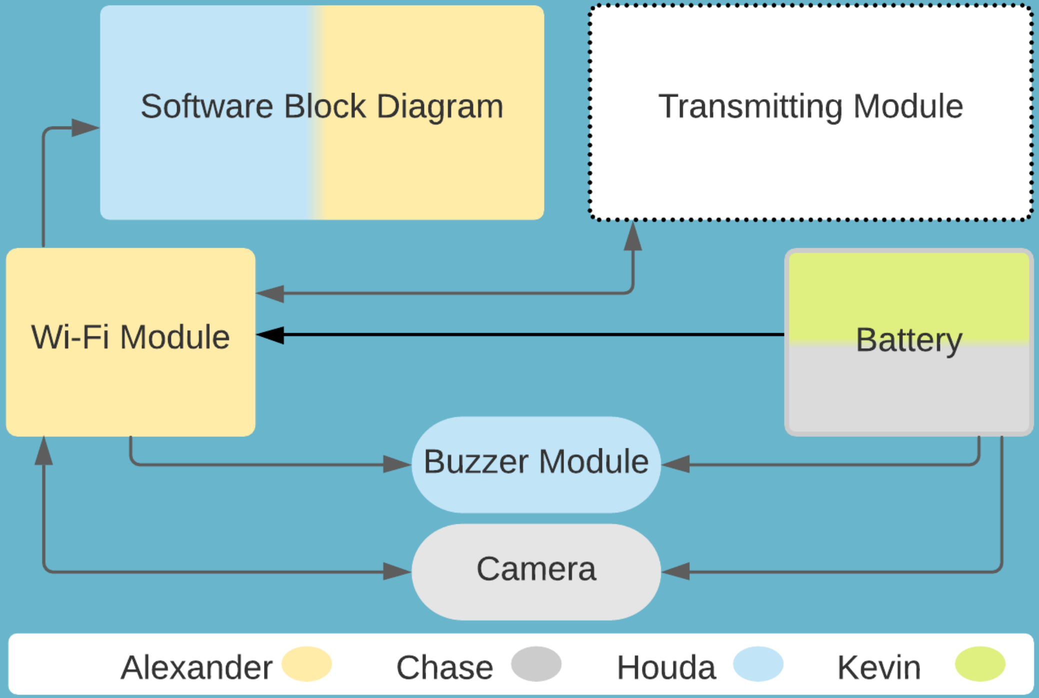


PCB Layout Transmitter





Receiver Block Diagram



Component Selection: Camera Module

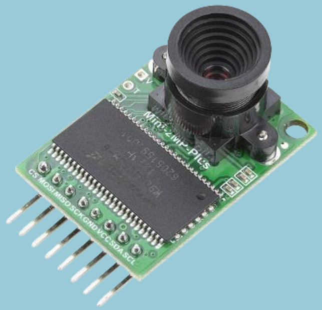
Design Challenge: ArduCAM takes captures using an external software tool.

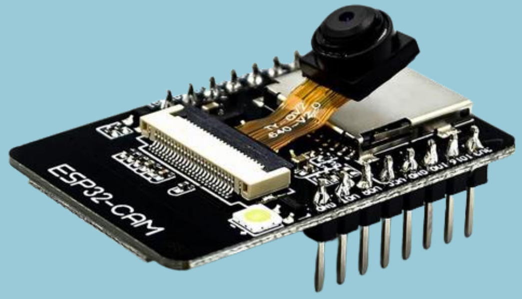
Specifications

- Built in Wi-Fi chip to communicate with the transmitter
- Low cost and uses the same camera module 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





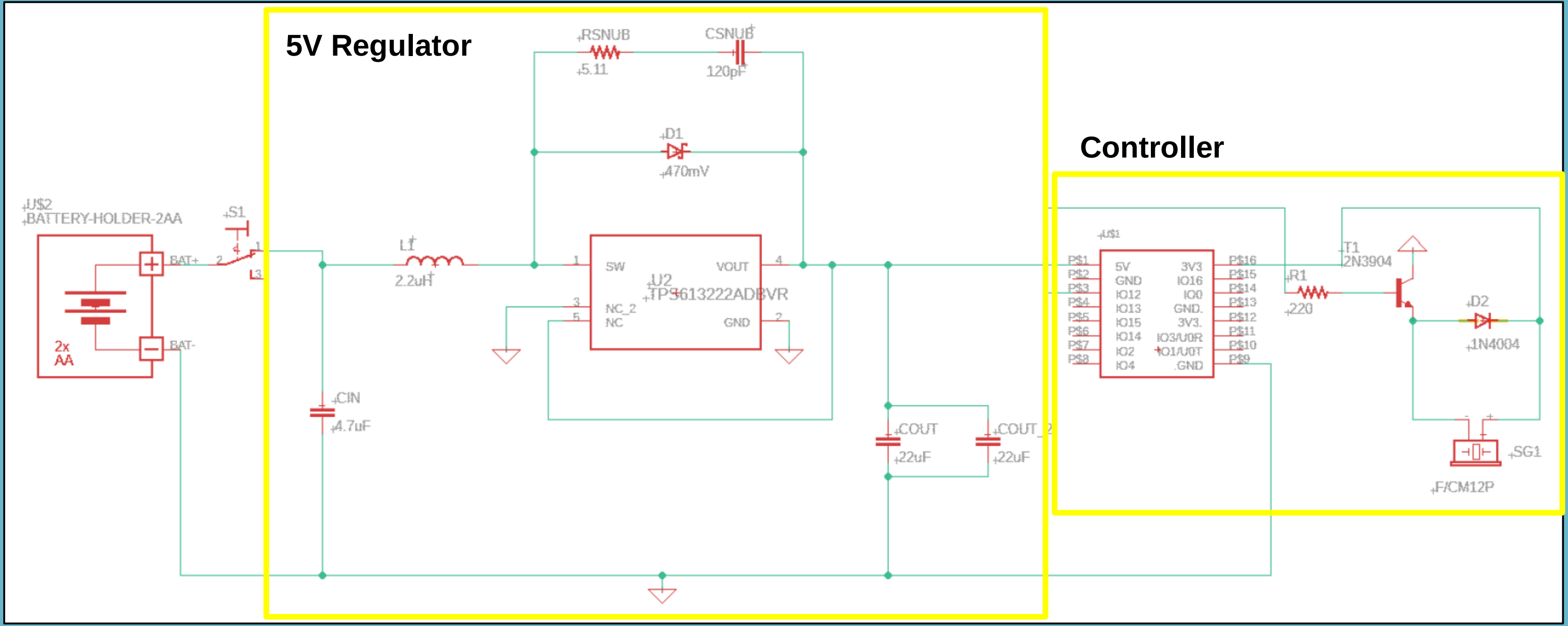
Component Selection: Buzzer Module

Piezo Buzzer vs. Magnetic Buzzer

- Magnetic buzzer has a non-linear relationshi p between the input drive signal strength an d the output audio power.
- Piezo buzzer can deliver a higher sound pres sure level.
- Piezo buzzer consumes less power as it is driv en by voltage rather than the magnetic buzze r 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

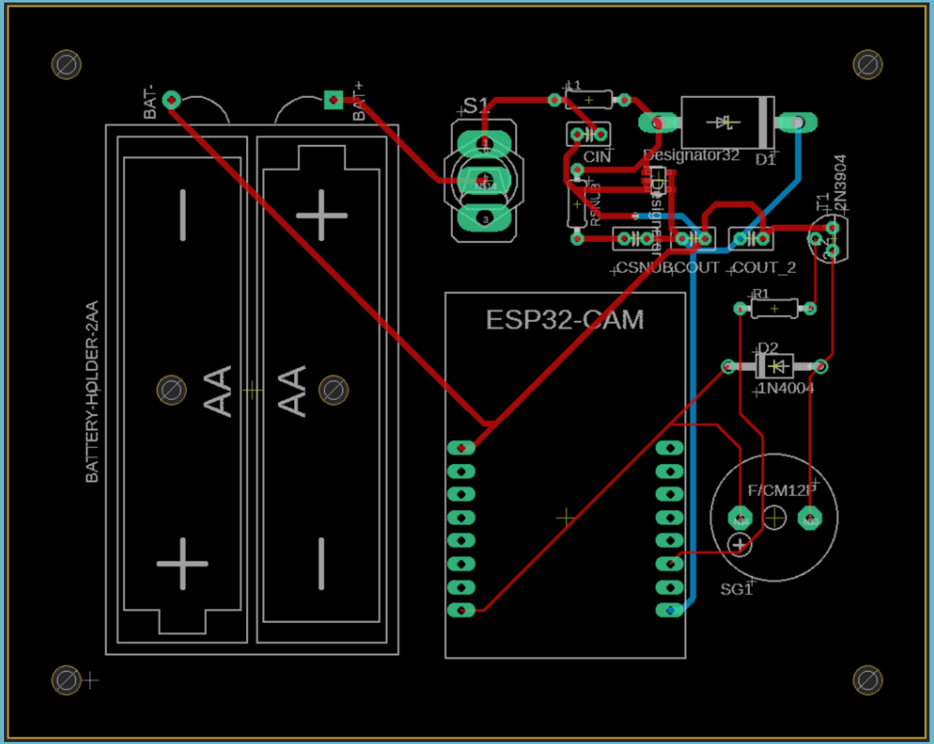
Receiver Schematic



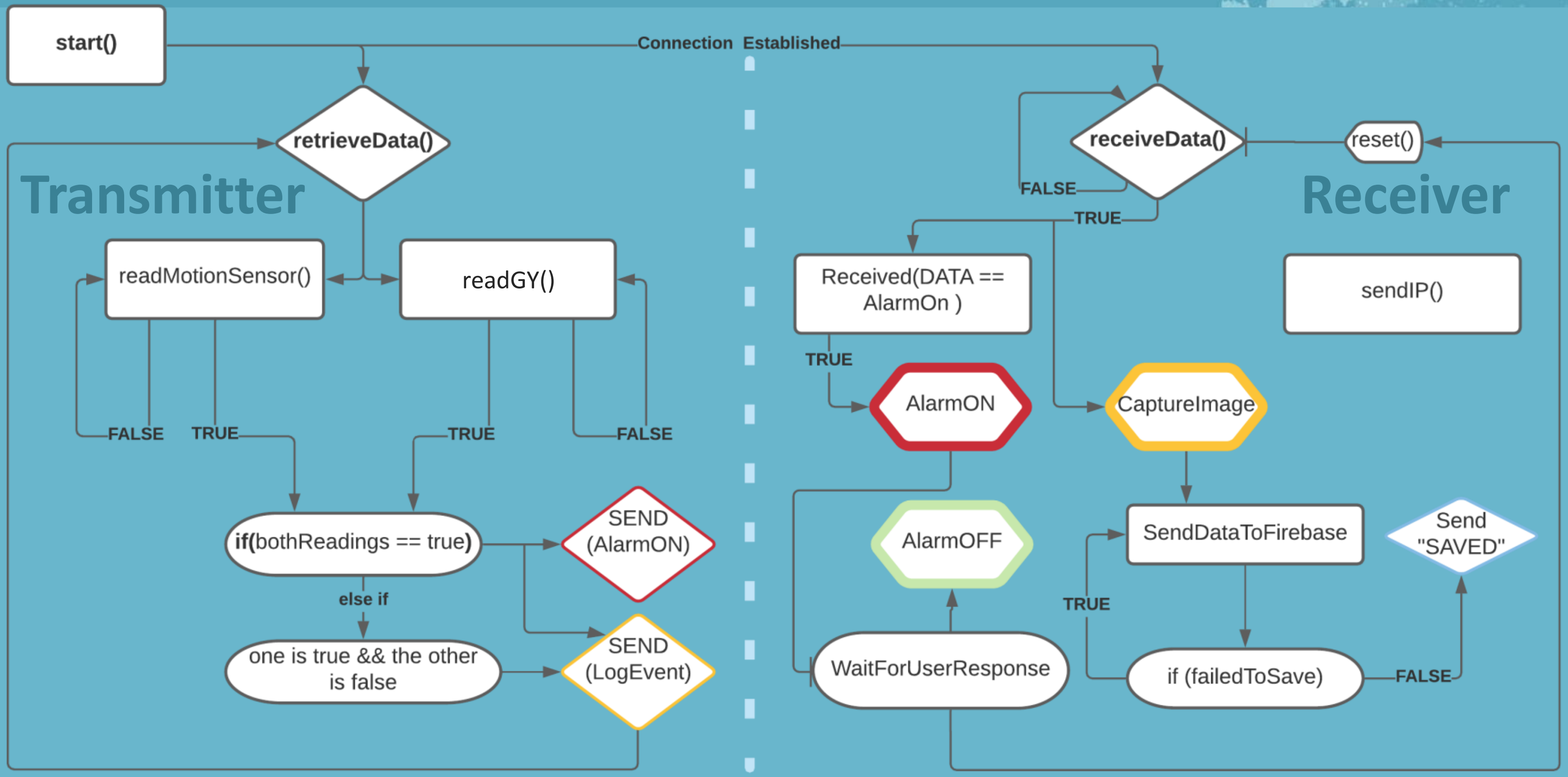
Receiver PCB

PCB Design

- Battery holder for 2x AA batteries is use d 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, dio de, and NPN BJT for operation.



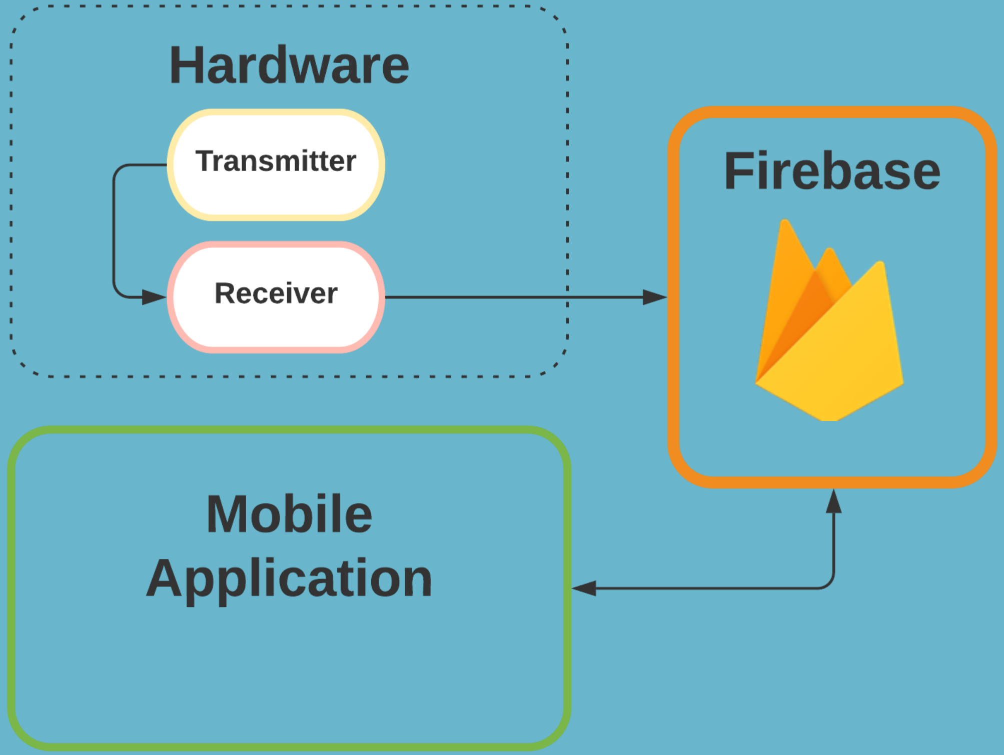
Transmitter Verification



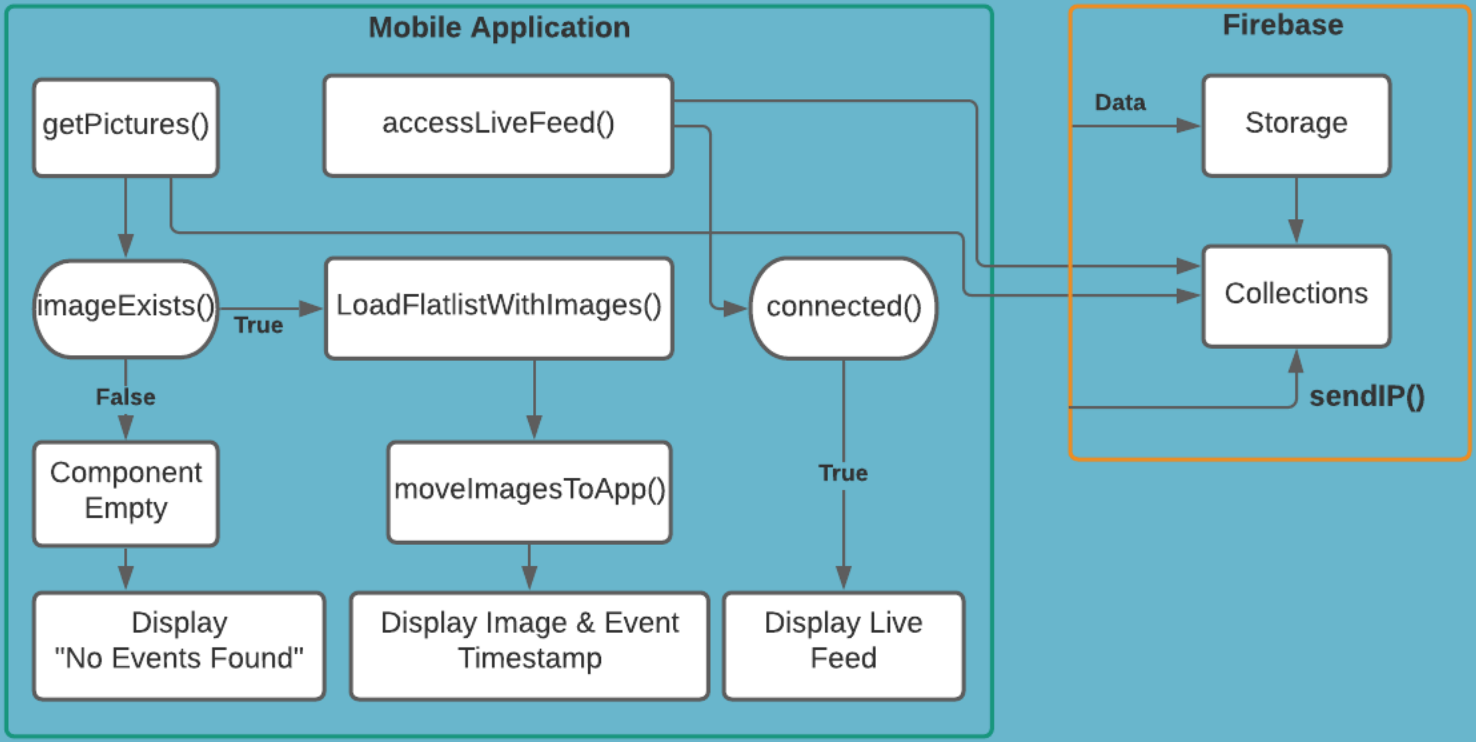
Overall Software Block Diagram

Development Tools

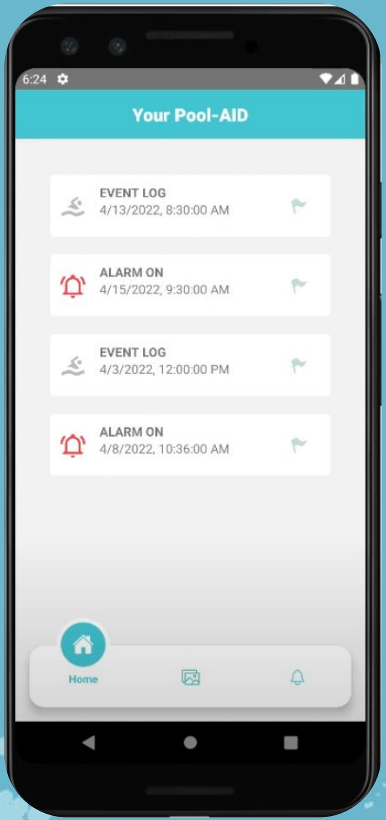
- Google Firebase
- React Native
- React Navigation
- Vector icons
- Android Studio
- React Native Firebase
- Cloud messaging

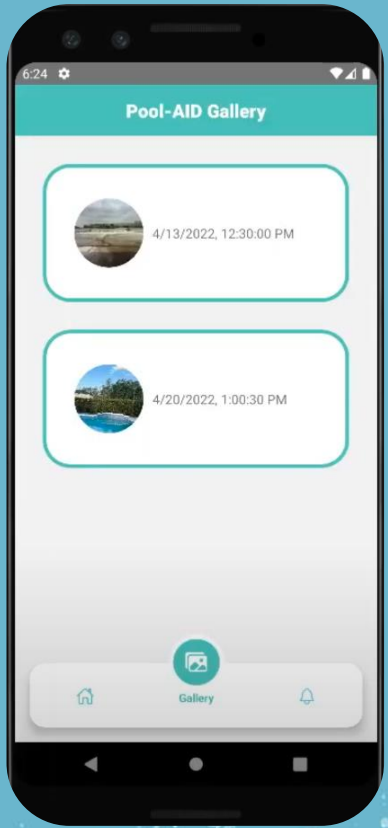


Mobile Application Software



User Interface





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

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

Pool-AID Budget & Financing

Total Budget:
$200

System Cost:
$118.15

R&D Total:
$215.70

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
Enclosure	Resin Material	$44.33	$44.33	1	$44.33

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

Constraints

Economic –

Project was financed by all four team members.

Manufacturability –

Functionality of components underwater, and enclosure dimensions.

Sustainability –

Waterproof enclosure and protection of electronics around water.

Testing –

Environment to test the systems functionalities.

Future Milestones

- **Mobile Application**
  1. Provide more control options (Live view, log video captures, and more remote control)
  2. Compatibility with other mobile operating systems (iOS)
- **Transmitter**
  1. Enhance the system's logic to further decrease the response time
  2. Improve the enclosure's internal setup with custom made holders to keep everything in pla ce
- **Receiver**
  1. As it is powered using two AA batteries, the receiver could be made more eco-friendly usin g a solar panel.
  2. Camera quality of the ESP32-Cam

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 hardware's system logic, the mobile application, and 3D design. She manages the team's documentations, presentations, and meetings.

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

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

- Mobile application development primary
- Wireless communication between the receiver and the mobile app primary
- Programming & interfacing sensors 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

QUESTIONS?

Thank you!