Active Bird Deterrent to Reduce Bird Collisions with Windows

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Contents

1.0 Overview

1.1 Executive Summary

According to the Portland Audubon “Up to one billion birds die each year in the United States due to collisions with windows and research shows that 54-76 percent of window collisions are fatal.” [1]. The reason this happens is “In daylight, birds … see reflections of vegetation or see through the glass to potted plants or vegetation on the other side. At night, nocturnal migrants crash because they fly into lighted windows”. [3]

The following document contains the documentation, design decisions process, and construction of an Active Bird Deterrent device. When the device detects a bird flying towards a window, the device will alert the bird to allow the bird to change its flight path away. To accomplish this the design utilizes two main blocks, a sensor block and a deterrents block. For the sensor block, the main method to detect if a bird is flying towards a window is through a visual light camera with the aid of machine learning. After successfully detecting if a bird is flying towards a window, the device has two deterrent methods to alert the bird. A sound deterrent, which utilizes a speaker to audibly play a bird call signaling to the bird that there is danger nearby. The second deterrent is a light, which flashes towards the bird to show that it is flying towards the window.

1.2 Team Contacts and Protocols

Team Member	Role	Contact Info
Kelton Luu	Treasurer	luukel@oregonstate.edu
Hunter Pitzler	Scribe	pitzlerh@oregonstate.edu
Kalynne Whited	Team member	whitedk@oregonstate.edu
Kayla Osburn	Team member	osburnka@oregonstate.edu
Gerrad Jones	Project Partner	jonesger@oregonstate.edu

Table 1.1: Team Contact Table

Protocol	Standard
Distribution of workload	Tasks will be distributed to team members during weekly meetings. Members will also provide updates on their progress throughout meetings.
Task Completion timeline/Deadlines	Tasks will be completed at least 24 hours prior to the official deadline to give group

	members the chance to review work before submission.
Project Partner Communication	Updates will be sent to project partners about the progress the team has made after every other weekly meeting.Project Partner has indicated that he prefers to communicate using a Project Team on Microsoft Teams and does not require more frequent communication.
Team Communication	The group will primarily communicate through the team discord channel. Texting will be used as a secondary communication method if team members are unresponsive to discord communication attempts.
Meeting Agenda	Prior to the team meeting, group members will compile a list of topics to be discussed and document these in the meeting agenda shared google doc.
Missed Meetings	Group members will notify the team of any meetings they will miss by or before 10 minutes into the meeting. When a team member misses a meeting, meeting minutes will be uploaded into discord and summarized with respect to what's important to/for the missing team member.
Code	Microcontroller code will be stored on a github repository and the team will learn to use github versioning tools such as branches and approved merging.

Table 1.2: Team Protocols Table

1.3 GAP Analysis

Current bird collision prevention methods include many passive methods, such as attaching a light net to the window, creating patterns on windows, and using “UV-reflective glass [which] is visible to birds and transparent to humans” [4]. However, there doesn’t currently appear to be any active methods of preventing birds from colliding with windows. Currently, the only active bird deterrent methods are centered around planes. One such product is Puslelite, which uses strobe lights to make planes more visible and claims to “experience up to 60% fewer bird strikes, saving airlines millions of dollars annually” [2]. Another is a technology called LRAD (Long range acoustic Device) which is “a loudspeaker of sorts that is designed to broadcast sounds to scare away the birds” [5].

An active method of prevention to prevent bird-window collisions could provide increased peace of mind for animal and bird lovers who wish to cause no harm to local wildlife. Additionally, such a deterrent could be combined with previously mentioned passive bird deterrent methods to virtually eliminate the likelihood of a bird-window collision. Economic analysis suggests that normal living-wage individuals would not be a key demographic for purchasing an active bird deterrent device. However, businesses and other more affluent organizations and individuals may find such a device intriguing. Furthermore, potential support in government policy implementation and stakeholder concern regardless could provide the necessary support for bird collision prevention to be given funding and support. With the lives of millions of birds at stake, such a product clearly fills a pressing need in our society.

1.4 Timeline/Proposed Timeline

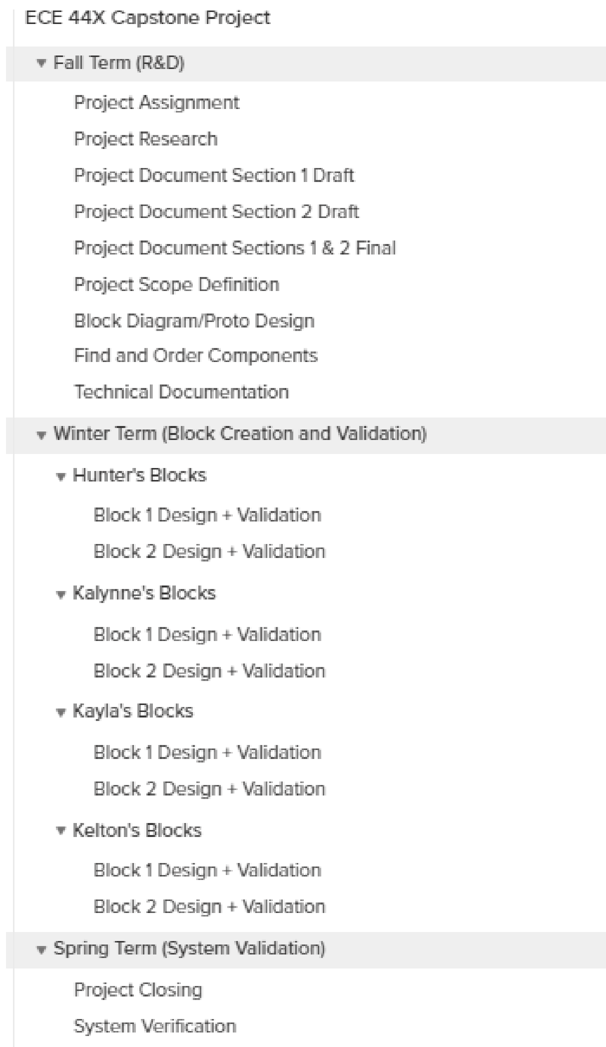


Figure 1.1 Close up of Timeline Event

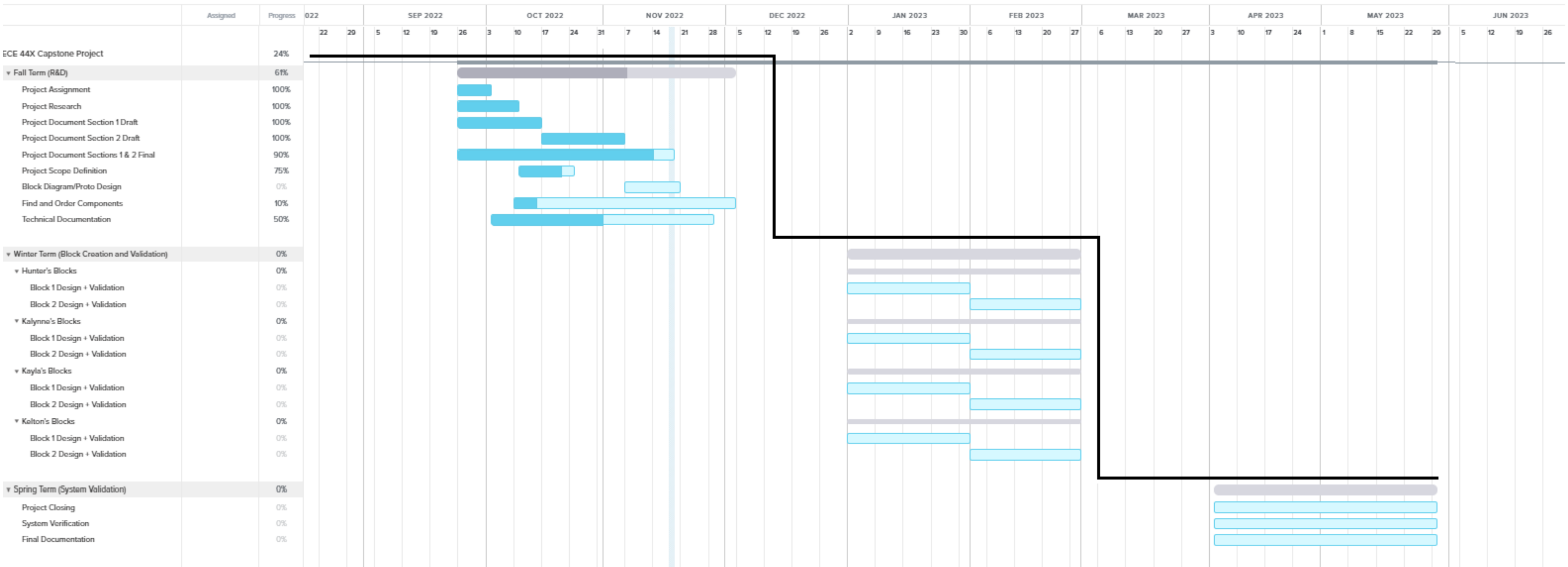


Fig 1.2 Proposed Timeline

1.5 References and File Links

1.5.1 References (IEEE)

[1] Audubon, Portland, "Birds and Windows", 5-April-2019. [Online]. Available: https://audubonportland.org/our-work/rehabilitate-wildlife/being-a-good-wildlife-neighbor/birds-and-windows/#:~:text=Up%20to%20one%20billion%20birds,a%20window%20after%20a%20collision. [Accessed: 10-Oct-2022]

[2] Flight, P. (2021, February 23). *Pulselite® Technoloy & Systems - Precise Flight*. Precise Flight Inc. Retrieved November 2, 2022, from https://preciseflight.com/pulselite-pulsing-aircraft-lights/

[3] Powell, Hugh, "Why birds hit windows-and how you can help prevent it", All About Birds, 5-May-2017 [Online]. Available:https://www.allaboutbirds.org/news/why-birds-hit-windows-and-how-you-can-help-prevent-it/#:~:text=In%20daylight%2C%20birds%20crash%20into,they%20fly%20into%20lighted%20windows. [Accessed: 10-Oct-2022]

[4] "Make your windows bird-safe", The Humane Society of the United States. Available: https://www.humanesociety.org/resources/make-your-windows-bird-safe. [Accessed: 10-Oct-2022]

[5] Tan, Y. (2017, August 18). *Lasers and giant speakers: How airports chase birds off the runway*. Mashable. Retrieved November 2, 2022, from https://mashable.com/article/runway-machines-birds

1.5.2 File Links

1.6 Revision Table

11/2/2022	Kelton: Edited Executive Summary
11/2/2022	Edited GAP Analysis to account for feedback. Edited references to include new sources cited in revised GAP Analysis.
11/1/2022	Team: Revised section 1, to account for comments
10/13/2022	Hunter Pitzler: Created digital form of Project Timeline (for Fall term) and added to Project Documentation. Also created link to meeting agenda document.
10/13/2022	Kelton Luu: Wrote Executive Summary

10/11/2022	Team: Created Team Protocols
10/10/2022	Hunter Pitzler: Wrote GAP Analysis Section and updated GAP Analysis References
10/4/2022	Hunter Pitzler: Created Document and Section 1 Outline.

Table 1.3: Section 1 Revision Table

2.0 Impacts and Risks

2.1 Design Impact Statement

This statement will briefly explore and analyze the potential impacts of creating an active bird deterrent design. For a refresher on what such a device would entail, please refer back to section 1.1. The reason for this analysis is to consider ahead of time the possible effects that such a device may have so that steps can be taken during the design process to mitigate any negative impacts.

One key factor we want to consider is the possibility of potential safety hazards related to the design. After analysis, we isolated the strobe light as the element of the design with the highest risk of creating an external safety hazard. It turns out that 1 in 4000 individuals are affected by photosensitive epilepsy [1]. As such, we need to consider how best to keep our device from triggering a negative response from anyone with that condition. Another key factor we're considering is the possible environmental effects the use of such a device might have. We discovered that the use of bird playbacks is somewhat of a contentious issue in bird watching circles. According to the Audubon Society, "Luring birds closer for photography/videography is often possible but should be done in a responsible way … Playback of bird calls shouldn't be used" [2]. Clearly, we need to determine how and where the use of our device would be appropriate, and where it would have the potential to do more harm than good.

Transitioning to another topic, we also did some research into what, if any, potential economic effects the production of an active bird deterrent device might have. One study in South Korea we looked at ranked common public structures from greatest to least priority based on effectiveness for reducing collisions. Expressways were ranked as the most effective, followed by public buildings, private buildings, and general roads [3]. A very important target stakeholder group for reduction in bird window collisions is residential buildings and homeowners according to a PLOS research study. As such, we expect support from homeowners and conservationist stakeholders to be high under satisfactory conditions.

Finally, we looked at the social impacts our device could have on varying communities. We determined that the design uses deterrent methods that have the potential to be seen as annoying, pointless, or harmful, which could cause consumers to not want to use the product and be upset with the methods implemented. Some research has stated "Bird-Friendly Lighting-Shields, bulbs, and other items [should be used to] prevent light from shining into the night sky, where birds migrate." [4] Clearly there are many important factors to take into account when attempting to integrate such a device into our society.

In conclusion, during our research we made many very important discoveries. Strobe lights can induce seizures in people with photo-sensitive epilepsy. Because of this, we will attempt to minimize the amount of time the strobe light is actively being used. We learned that artificial bird calls can affect birds. Consequently, we should only market the device where the playback of bird calls is legal and we should try to limit the frequency of playbacks. Economically we learned that normal living-wage individuals probably will not be a key demographic. However, businesses and other more affluent organizations and individuals may be more receptive to our product. Finally, we discovered that an active deterrent device such as the one proposed has a strong potential to negatively influence public opinion. To combat that possibility, we will conduct surveys to refine design choices, make sure deterrent methods employed are non-harmful, and attempt to make the device as consumer friendly as possible.

2.2 Risks

Risk ID	Risk Description	Risk category	Risk prob-ability	Risk impact	Performance indicator	Action Plan
1	Components become unavailable or lost in shipping process	Technical + Schedule	High	High	We don't have components	-create and have ready to order backup materials list
2	Outdoor testing before waterproof verification to avoid damage system	Environmental	Med	High	Internal components are wet and device is no longer responsive	-Plan testing when rain is unlikely -Focus on waterproofing first
3	Bird Collision with Box + causing damage	Safety	Low	Med	Bird Shaped dent in box	-Focus on casing stability -Build at least 2 prototypes -Create cushion during testing
4	Previous Group doesn't have their documentation or hardware or get back to us	Organizational	Med	Med	No response	-Research topics to design from scratch if necessary

5	Unheeded safety precaution	Safety	Low	High	Injured team member	-Prep safety protocols as a team before implementing
6	Deterrent mechanism may disturb environment	Public Health	Med	Med	Run study to evaluate level of disturbance	- Modify deterrent method if 6 out of 10 people find it disturbing - Verify strobe light not a risk for seizures
7	Delayed Block may push back integration stages	Schedule	Med	High	Integration stages get pushed back	- Weekly check in during meeting on block progress to identify issue before it's too late
8	End Product may have impactful commercial final price tag	Economic	Med	Med	Consumers aren't willing to buy units due to price	- Use survey to determine economic viability price range

Table 2.1 Risk Assessment Table

2.3 References and File Links

2.3.1 References (IEEE)

[1] Brna, P. .., and K. .. Gordon. "'Selfie-Epilepsy': A Novel Photosensitivity." Seizure (London, England), vol. 47, 2017, pp. 5–8, https://www.seizure-journal.com/article/S1059-1311(17)30128-0/fulltext.

[2] Groo, M., Kaufmann, K., & Verhagen, K. (2022, October 24). Audubon's Guide to Ethical Bird Photography and Videography. Audubon Magazine. Retrieved October 30, 2022, from https://www.audubon.org/get-outside/audubons-guide-ethical-bird-photography

[3] Chang-Min Kim, Ju-Hee Kim & Seung-Hoon Yoo, August 8th 2022; Economic benefits of preventing bird collisions in South Korea: findings from a choice experiment survey, Retrieved on November 1st 2022 https://link.springer.com/article/10.1007/s11356-022-22343-y

[4] Jennifer, H. (2022, February 3). Prevent birds from hitting windows with these products. BirdWatching- Your source for becoming a better birder. Retrieved November 2, 2022, from https://www.birdwatchingdaily.com/gear/preventing-bird-window-collisions/15-products-prevent-birds-hitting-windows/#:~:text=3%20simple%20ways%20to%20prevent%20birds%20from%20hitting,3%203.%20Move%20houseplants%20away%20from%20windows.%20

2.3.2 File Links

2.4 Revision Table

4/24/2023	Group: Created Design Impact Statement from Impact Assessment Paper. Updated Reference to reflect changes.
11/17/2022	Hunter Pitzler: Modified Action Plans to be more specific/applicable
10/25/2022	Group: Completed Risks Table
10/25/2022	Hunter Pitzler: Created Section 2 Outline.

Table 2.2: Section 2 Revision Table

3.0 Top Level Architecture

3.1 Block Diagrams

Figure 3.1: System Black Box Diagram

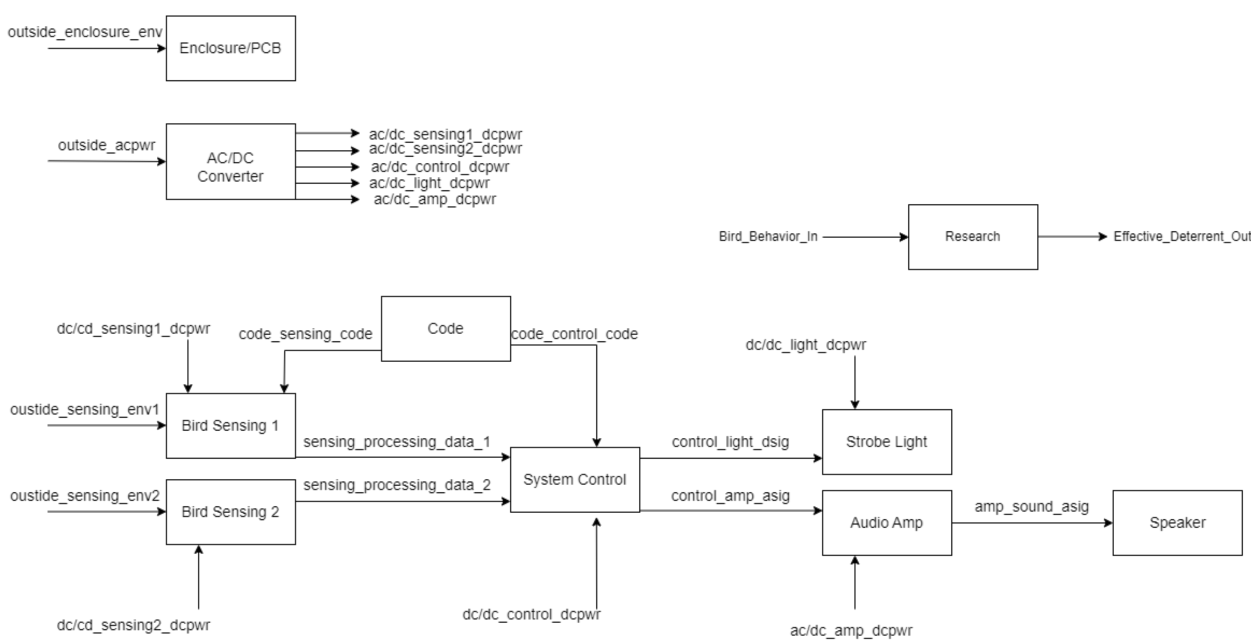


Figure 3.2: System Block Diagram

3.2 Block Descriptions

Power Champion: Hunter Pitzler	The Power block provides the power necessary for the system to operate. It will take in wall power input, 120 VAC RMS at 60 Hz, and transform it into 3 DC outputs that will power different elements of the system. As per our system engineering requirement, it will draw no more than 12W at any given time instance. This block does not directly interface with any other system requirements, but instead supports the functioning of everything else in the system by providing power to all of the separate components in the build. The first output will be a 10 V ± 300 mV DC output capable of supplying 3W. This output will be used to power the speaker. The second, a 5 V ± 300 mV DC output capable of supplying 4W. This output will be used to power the Open MV Cam and the supercapacitors that will power the strobe light. The third, a 3.3 V ± 300 mV DC output capable of supplying 3W. This output will be used to power the system microcontroller and microwave motion detector. The verification testing of this block will not evaluate the power drawn since without the real load of the system to apply; any conclusions reached would be spurious. As per the universal constraints, it also needs to be at least 65% efficient.
Motion Sensor Champion: Hunter Pitzler	This sensing block will consist of a sensor other than a camera capable of detecting the movement of a flying bird. When movement is detected, this block will generate an output that, at the least, signals to the system control block that movement consistent with that of a bird in flight was detected. This will be accomplished by using a 60 GHz Microwave sensor. This sensor will output microwaves and measure their reflections. By analyzing the doppler effect of the returned waves it can tell if an object around it is moving.
Bird Sensing 1 (Primary Sensor) Champion: Kelton Luu	This block will consist of an open mv camera that will detect when a bird is flying towards the camera. This will be accomplished through the use of machine learning algorithms, where a dataset of flying birds will be an input for the algorithm. This dataset will consist of at least 100 original pictures of flying birds alongside an additional of at least 5 variations of the original pictures. These variations include flipping and rotating the original picture to include in the dataset, resulting in a total of at least 600 images for the dataset that the algorithm will use. Then when the camera detects a bird flying towards the camera, it will output that it detects a bird.
Code (Code) Champion: Kelton Luu	Code that will control the open mv camera, it will have a data set of images of birds flying towards a camera in which it can base its detection. This block will also communicate with the system control block.

Microcontroller Champion: Kalynne Whited	Microcontroller used to program code required for operating the system. Incorporates all blocks to yield desired output from system inputs.
Research Champion: Kelton Luu	Research will consist of the design process for choosing which bird deterrent options the system will utilize. It will take into consideration different bird behaviors and determine what is an effective method to deter the bird’s flight path.
Enclosure Champion: Kayla Osburn	The Enclosure block consists of a water-resistant enclosure sized to the PCB that holds inside all components of the system/PCB with an open area for the camera, strobe light and speaker output to operate. The enclosure will additionally mount to windows.
Strobe Light Champion: Kayla Osburn	This Strobe Light block consist of an LED light that will aid in deterring birds from flying towards the window. When the strobe light block receives the digital control light signal from the system control block it will output light, helping aid in deterring birds away. The purpose of this block is to use the two interfaces to operate the block which function is to power the LED to turn on. This happens because the block is receiving the signal that the MV camera has detected the presence of a bird flying towards the device. The LED functions at the same time as the speaker and are the devices two deterrent methods in preventing birds from colliding with the window the device/system is attached to. This block is also one of the main outputs proving the validation of the system functioning correctly.
Audio Amp/Speaker Champion: Kalynne Whited	Audio Deterrent mechanism utilized to repel birds away when activated with an effective audio sound. If sensors detect bird movement the system control will activate the audio amplifier for a set duration using a sound best used for deterring birds without causing harm to them and with minimal disturbance to surroundings.

Table 3.1: Block Description Table

3.3 Interface Definitions

Name	**Properties**
otsd_pwr_acpwr	• **Inominal:** 50 mA RMS • **Ipeak:** 100 mA RMS • **Vnominal:** 120 V RMS

otsd_mtn_snsr_envin	• **Other:** Angle of detection 45 degrees • **Other:** Detect object of at least 7.5cmx7.5cmx10cm • **Other:** Range of 5 feet
otsd_brd_snsng_1_prmry_snsr_envin	• **Other:** Angle: Must see images within 45 degree angle of camera • **Other:** Min Range: 2 ft • **Other:** Max Range: 20 ft
otsd_cd_cd_envin	• **Other:** Machine Learning bird probability • **Other:** I2C Message being received in serial terminal • **Other:** Flashable Binary: OpenMV IDE
otsd_enclsr_envin	• **Other:** The enclosure has a vertical mounting point. • **Other:** Withstand a 5-ounce object thrown at the enclosure without causing any damage. • **Other:** The enclosure has an opening to connect to a power cable.
pwr_mtn_snsr_dcpwr	• **Inominal:** 128 mA • **Ipeak:** 200 mA • **Vmax:** 3.5 V • **Vmin:** 3.1 V
pwr_brd_snsng_1_prmry_snsr_dcpwr	• **Inominal:** 250 mA • **Ipeak:** 300 mA • **Vmax:** 5.3 V • **Vmin:** 4.7 V

pwr_mcrcntrllr_dcpwr	● **Inominal:** 250 mA ● **Ipeak:** 450 mA ● **Vmax:** 3.5 V ● **Vmin:** 3.1 V
pwr_strb_lght_dcpwr	● **Inominal:** 0.7 A ● **Ipeak:** 1.4 A ● **Vmax:** 5.3 V ● **Vmin:** 4 V
pwr_ad_mpspkr_dcpwr	● **Inominal:** 3mA ● **Ipeak:** 300 mA ● **Vmax:** 10.3 V ● **Vmin:** 9.7 V
mtn_snsr_mcrcntrllr_dsig	● **Logic-Level:** Active Low ● **Vmax:** 3.5V ● **Vmin:** 3.1V
brd_snsng_1_prmry_snsr_mcrcntrllr_data	● **Messages:** SCL Clock Rate: 100kHz ● **Other:** Vnominal of 3.3V ● **Protocol:** I2C
mcrcntrllr_mtn_snsr_comm	● **Messages:** Register Values ● **Protocol:** SPI ● **Vnominal:** 3.3 V
mcrcntrllr_strb_lght_dsig	● **Logic-Level:** Active (On) High ● **Vmax:** 5V ● **Vmin:** 2.5V ● **Vnominal:** 3.3 V

mcrcntrllr_ad_mpspkr_asig	• **Max Frequency:** Frequency: 4 KHz • **Other:** Nominal Frequency: 2 KHz • **Vmax:** 3.3 V • **Vrange:** 3.3 V
enclsr_otsd_envout	• **Light:** Output from the light block is visible through the enclosure. • **Other:** The speaker block output can be heard through the enclosure. • **Other:** The camera block output has visibility through the enclosure.
strb_lght_otsd_envout	• **Light:** Visible in daylight • **Light:** Can remain on for at least 5 seconds • **Light:** Visible at least 10 feet away
ad_mpspkr_otsd_envout	• **Electromagnetic:** Nominal Frequency: 2 KHz • **Other:** Audible within 10 feet away • **Other:** Max Frequency: between 4 KHz

Table 3.2: Interface Definition Table

3.4 Reference and File Links

3.4.1 References (IEEE)

3.4.2 File Links

3.5 Revision Table

3/3/2023	Hunter: Moved Section 3 material from student portal

Table 3.3 Section 3 Revision Table

4.0 Block Validations

4.1 Power Block

4.1.1 Description

The Power block provides the power necessary for the system to operate. It will take in wall power input, 120 VAC RMS at 60 Hz, and transform it into 3 DC outputs that will power different elements of the system. As per our system engineering requirement, it will draw no more than 12W at any given time instance. The first output will be a 10 V ± 300 mV DC output. This output will be used to power the speaker. The second, a 5 V ± 300 mV DC output. This output will be used to power the Open MV Cam and the supercapacitors that will power the strobe light. The third, a 3.3 V ± 300 mV DC output. This output will be used to power the system microcontroller and microwave motion detector. As per the universal constraints, it also needs to be at least 65% efficient.

4.1.2 Design

In order to accomplish the goals listed in the description section this block internally consists of 5 blocks. These blocks are AC/DC Converter, 10V Linear LDO, 5V Switching Regulator, 5V Supercapacitor charger + Cells, and 3.3V Linear LDO. Below are the block diagrams for the power supply.

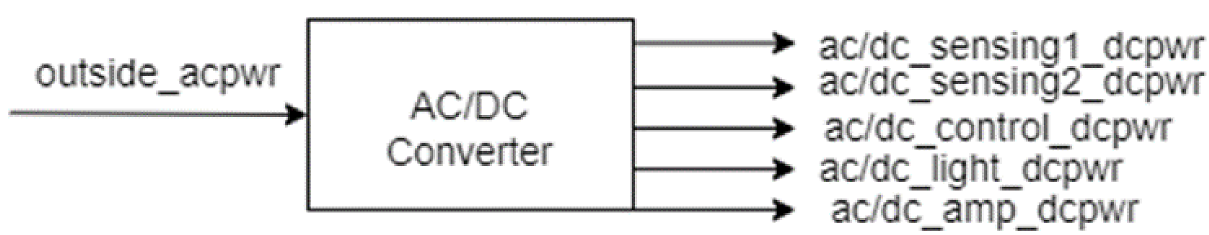


Figure 4.1: AC/DC Converter Black Box Diagram

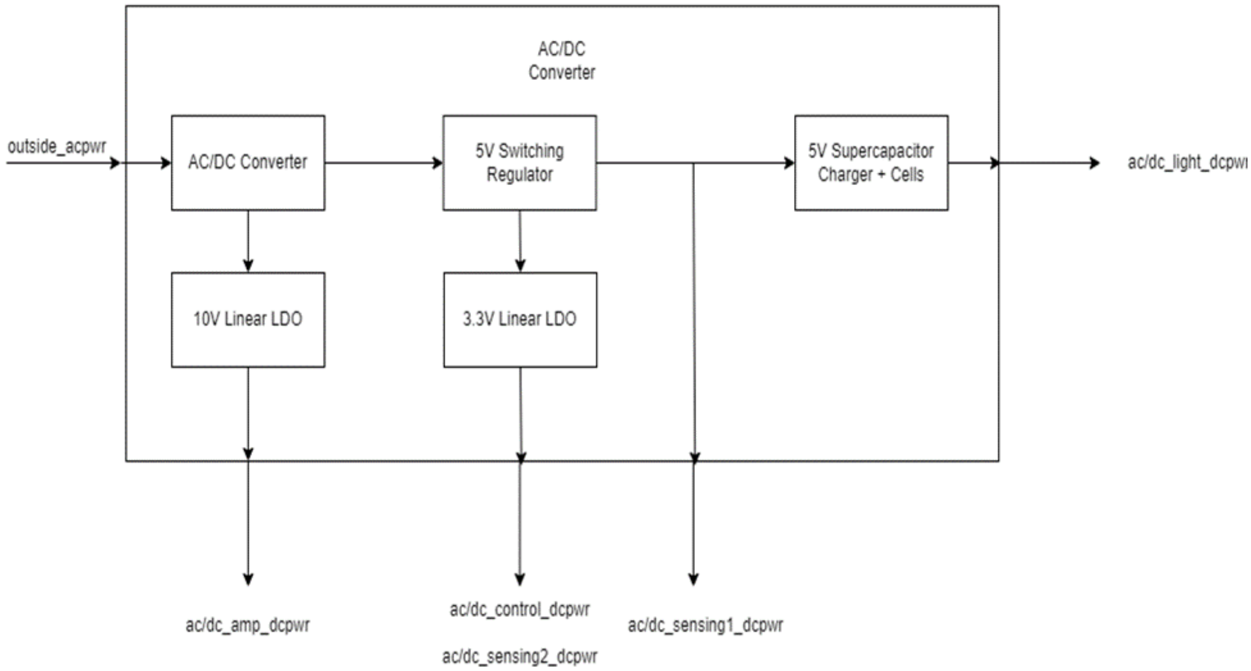


Figure 4.2: AC/DC Converter Internal Block Diagram

The next couple pages go into each sub-block in some detail.

First an AC/DC converter uses a 115:8 transformer to transform the 120 V RMS AC input into 8.3 V RMS (~11.8 V Amplitude) AC input. Then the converter rectifies the input wave using a full diode bridge, and smoothes that output using a large 470 uF electrolytic capacitor. This should create a roughly DC voltage of around 14.5 V. That 14.5Vs is then fed into two separate blocks.

One is a 10V output Linear LDO Block designed around the Texas Instrument LM2940IMPX-10/NOPB chip which is capable of outputting up to 1A DC at 10V with a maximum dropout voltage of 1V. This forms the output of the block that powers the speaker amp and speaker.

The second is a 5V output Switching Regulator Block designed around the Diodes Incorporated AP62250WU-7 chip which has a switching frequency of 1.3 MHz and is capable of outputting up to 2.5 A DC at 5V with a maximum efficiency of 90%. This chip forms the output that powers the Open MV Cam module as well as the input to the 3.3V LDO and the Supercapacitor Block.

Connected to the 5V Switching Regulator Block is the Super Capacitor Block. The purpose of this block is to slowly store enough energy to occasionally temporarily supply up to 7.5W to the strobe light/LED while onlyl ever drawing 1W from wall power at any given time. It does this by utilizing the Monolithic Power Systems MP62551DJ-LF-P chip to limit the supply current to the supercapacitors to 200 mA. Once the supercapacitors are fully charged, they can supply up to

1.5A at a fairly stable 5V (~4 – 5V) for up to 10s. Then they will slowly recharge again from the 200 mA supply current. This forms the output for the strobe light.

The final block is a 3.3V output Linear LDO Block designed around the Diodes Incorporated AZ1117IH-3.3TRG1chip which is capable of outputting up to 1.35A DC at 3.3V with a maximum dropout voltage of 1.3V. This forms the output of the block that powers the microwave sensor and system microcontroller.

Next are the complete schematic and BOM for the design.

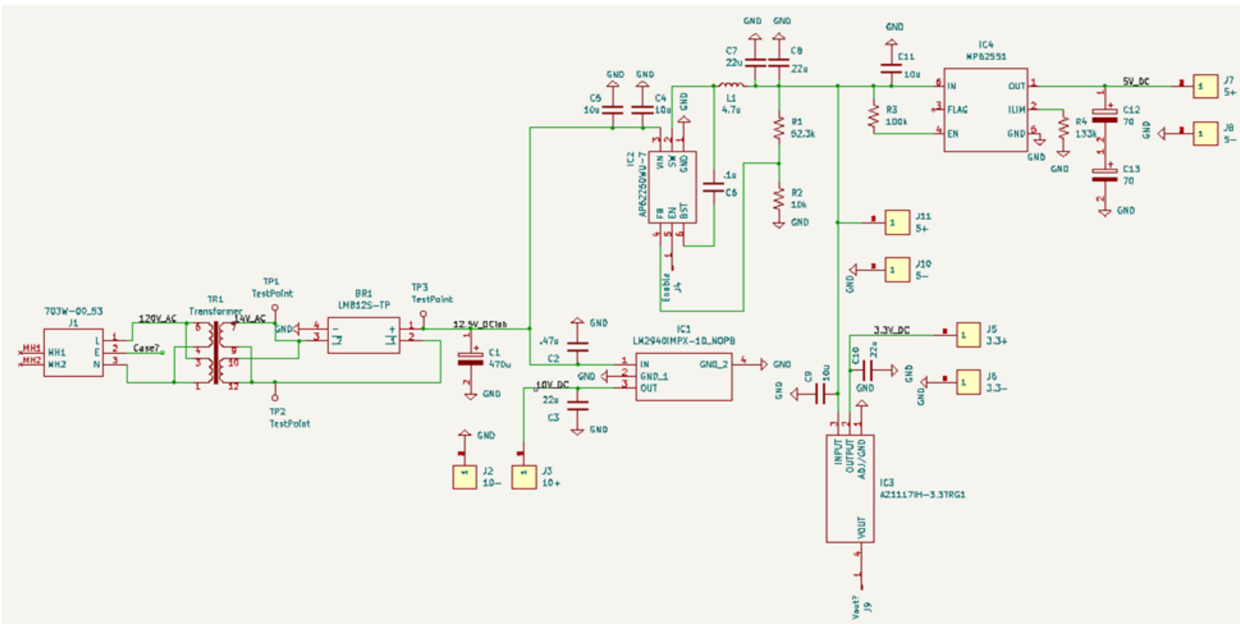


Figure 4.3: Power Supply Schematic

Power Supply v2 BOM							
Part Number	Manufacturer	Source	Part Name	Identifier	Quantity	Price per Unit ($)	Total Cost ($)
183H16	Hammond Manufacturing	Mouser	20VA 115:8 Stepdown Transformer	TR1	1	17.04	17.04
LM2940IMPX-10/NOPB	Texas Instruments	Mouser	10V 1A LDO Linear Voltage Regulator	IC1	1	1.99	1.99
AP62250WU-7	Diodes Incorporated	Mouser	5V 2.5A 1.3MHz Stepdown Switching Voltage Regulator	IC2	1	0.49	0.49
AZ1117IH-3.3TRG1	Diodes Incorporated	Mouser	3.3V 1.35A LDO Linear Voltage Regulator	IC3	1	0.4	0.4
MP62551DJ-LF-P	Monolithic Power Systems	Mouser	Current Limit Switch	IC4	1	1.84	1.84
833-LMB14S-TP	Micro Commercial Components (MCC)	Mouser	Bridge Rectifier	BR1	1	0.5	0.5
PA5432.472NLT	Pulse Electronics	Mouser	4.7 uH Inductor	L1	1	2.15	2.15
EMZL250ARA471MHA0G	United Chemi-Con	Mouser	470 uF Electrolytic Capacitor	C1	1	0.94	0.94
CL21B474KAFNFNE	Samsung Electro-Mechanics	Mouser	.47 uF Ceramic Capacitor	C2	1	0.1	0.1
CL21B104KBCNNNC	Samsung Electro-Mechanics	Mouser	.1 uF Ceramic Capacitor	C6	1	0.1	0.1
CL21A106KAYNNNE	Samsung Electro-Mechanics	Mouser	10 uF Ceramic Capacitor	C4, C5, C9, C11	4	0.16	0.64
CL21A226MAYNNNE	Samsung Electro-Mechanics	Mouser	22 uF Ceramic Capacitor	C3, C7, C8, C10	4	0.25	1
MAL223551008E3	Vishay / BC Components	Mouser	50 F Supercapacitor	C12, C13	2	6.07	12.14
ERJ-6ENF5232V	Panasonic	Mouser	52.3 kΩ Resistor	R1	1	0.1	0.1
CR0805-FX-1002ELF	Bourns	Mouser	10 kΩ Resistor	R2	1	0.1	0.1
CRCW0805100KFKEBC	Vishay / Dale	Mouser	100 kΩ Resistor	R3	1	0.1	0.1
RC0805FR-07133KL	YAGEO	Mouser	133 kΩ Resistor	R4	1	0.1	0.1
703W-00/53	Qualtek	Mouser	IEC-320 PCB Connector	J1	1	1.76	1.76
						Total:	41.49

Figure 4.4: Power Supply BOM

4.1.3 Lieutenant General Validation (Recently promoted!)

The design described above is not the only way to accomplish the goals described in section one. Another common solution to a power supply block is to purchase and incorporate an existing power supply, such as a PC power supply, that has already been subject to strenuous testing and verification. [1] However, I believe the custom solution described above is the better choice for this project for 3 reasons.

Firstly, the different blocks of the project require a variety of supply voltages (10V, 5V, 3.3V), and most off the shelf supplies only provide AC to a single DC voltage. [1] Secondly, one output requires a higher supply than the block is allowed to draw from the wall, necessitating significant energy storage within the power supply. Thirdly, a custom design gives us greater control of the layout, placement, and size of the power supply components within the enclosure relative to the rest of the design.

The power supply design described above meets the basic requirements of the block. It draws from 120V AC wall power and provides the DC supplies required for the other blocks in the project. Each block is rated to handle the current/power requirements of the blocks following it (see interface validation).

4.1.4 Interface Validation

The following section describes how the interfaces described in sections one and two are satisfied by the design described in section 2.

For reference purposes the following apply:

Claims as to the capabilities of the "10V Linear LDO" refer to the Texas Instrument's LM2940IMPX-10/NOPB chip and are acquired from its datasheet [2]

Claims as to the capabilities of the "5V Switching Regulator" refer to the Diode's Incorporated AP62250WU-7 chip and are acquired from its datasheet [3]

Claims as to the capabilities of the "3.3V Linear LDO" refer to the Diode's Incorporated AZ1117IH-3.3TRG1 chip and are acquired from its datasheet [4]

Interface Property	**Why is this interface this value?**	**Why do you know that your design details <u>for this block</u> above meet or exceed each property?**

otsd_acdc_cnvrtr_pwr_spply_acpwr : Input

Inominal: 50 mA RMS	The power supply is expected to draw 12W or less. As such a reasonable nominal supply is 6W which at 120V RMS is equivalent to 50 mA RMS.	50 mA is not really a concerning quantity. The real issue is the power going through the transformer. The transformer I selected is rated for 20VA and the nominal supply is (120*.05 = 6VA).
Ipeak: 100 mA RMS	The power supply is expected to draw 12W or less. As such the maximum current allowed at 120V RMS is 100 mA RMS.	100 mA is not really a concerning quantity. The real issue is the power going through the transformer. The transformer I selected is rated for 20VA and the max supply is (120*.1 = 12VA).

Vnominal: 120 V RMS	US AC Mains Power is specified to by 120V RMS 60Hz. [5]	This is the input the circuitry was designed around. After going through the transformer and bridge the voltage should be approximately 11.8V. The 10V LDO has a max dropout of 1V, so it should be fine with that. The 5V Switching Regulator has a max input of 18V, so it should be fine with that. Everything else connected at that node is rated to at least 25V, so there should be no problems.

acdc_cnvrtr_pwr_spply_brd_snsng_2_thr_snsr_dcpwr : Output

Inominal: 128 mA	According to the BGT60LTR11(B)AIP datasheet the chip has an active current draw of 128 mA. [6]	The 3.3V Linear LDO can supply up to a maximum current of 1.35A DC.
Ipeak: 200 mA	Given a nominal current of 128 mA, 200 mA seems a reasonable max current draw expectation.	The 3.3V Linear LDO can supply up to a maximum current of 1.35A DC.
Vmax: 3.5 V	The microwave sensor block contains a 3.3V to 1.5V Linear LDO supply with a maximum voltage rating of 6V so it can tolerate up to 3.5V.	The 3.3V Linear LDO has a maximum Vout of 3.365V which is well within the requirements.
Vmin: 3.1 V	The microwave sensor block contains a 3.3V to 1.5V Linear LDO with a maximum dropout voltage of 145 mV so it can tolerate down to 3.1V.	The 3.3V Linear LDO has a minimum Vout of 3.235V which is well within the requirements.

acdc_cnvrtr_pwr_spply_brd_snsng_1_prmry_snsr_dcpwr : Output

Inominal: 160 mA	According to the OpenMV website, the OpenMVCamH7 Plus module has an active power consumption of 240 mA @ 3.3V which is equivalent to 160 mA at 5V. [7]	The 5V Switching Regulator can supply up to a maximum current of 2.5A.
Ipeak: 250 mA	Given a nominal current of 160 mA, 250 mA seems a reasonable max current draw expectation.	The 5V Switching Regulator can supply up to a maximum current of 2.5A.
Vmax: 5.3 V	The OpenMVCamH7 Plus module contains a 5V to 3.3V Switching Voltage Regulator with a maximum voltage of 5.5V so it can tolerate up to 5.3 V.	The 5V Switching Regulator operational graph suggests that even at 2.5A output, the output voltage will reside within one grid (250mV) of the target. Therefore, it’s reasonable to expect the output voltage to stay below 5.25V < 5.3V.
Vmin: 4.7 V	The OpenMVCamH7 Plus module contains a 5V to 3.3V Switching Regulator with a minimum input voltage equal to the output, 3.3V, so it can tolerate down to 4.7V.	The 5V Switching Regulator operational graph suggests that even at 2.5A output, the output voltage will reside within one grid (250mV) of the target. Therefore, it’s reasonable to expect the output voltage to stay below 4.75V > 4.7V.

acdc_cnvrtr_pwr_spply_systm_cntrl_mcrcntrllr_dcpwr : Output

Inominal: 250 mA	According to the ESP32 The power supply requirements are as follows. 2.7V ≤ Vdd ≤ 3.6 and .5 ≥ Ivdd. [8]	The 3.3V Linear LDO can supply up to a maximum current of 1.35A DC.
Ipeak: 500 mA	Given a nominal current of 250mA, 500mA seems a reasonable max current draw expectation.	The 3.3V Linear LDO can supply up to a maximum current of 1.35A DC.
Vmax: 3.5 V	According to the ESP32 The power supply requirements are as follows. 2.7V ≤ Vdd ≤ 3.6 and .5 ≤ Ivdd. [8]	The 3.3V Linear LDO has a maximum Vout of 3.365V which is well within the requirements.

Vmin: 3.1 V	According to the ESP32 The power supply requirements are as follows. 2.7V ≤ Vdd ≤ 3.6 and .5 ≤ Ivdd. [8]	The 3.3V Linear LDO has a minimum Vout of 3.235V which is well within the requirements.

acdc_cnvrtr_pwr_spply_strb_lght_dcpwr : Output

Inominal: 2 A	The Strobe light will require somewhere in the vicinity of 2A when lit to fully operate.	The Supercapacitors are rated to supply up to 6.1 A [9]
Ipeak: 3.5 A	The strobe light's maximum allowed current is 3.5A, though we don't plan to push it that far.	The Supercapacitors are rated to supply up to 6.1 A [9]
Vmax: 5.3 V	The strobe light has a forward voltage drop of around 3.3V. The other 2 volts is used to allow the circuity that sets the current to operate properly. Really this value is somewhat arbitrary. It just needs to be low enough not to burn out the current setting circuitry.	See previous, the maximum output of the 5V Switching Regulator is expected to be less than 5.25V. Therefore, the Supercapacitors cannot charge to greater than 5.25V < 5.3V.
Vmin: 4 V	The strobe light has a forward voltage drop of around 3.3V. The other .7 volts is used to allow the circuity that sets the current to operate properly. Really this value is somewhat arbitrary. It just needs to be high enough that the current setting circuitry operates as intended.	Ignoring the minimal 200 mA charging current, the voltage at the Supercapacitor node can be calculated as follows. i = C(dv/dt). Therefore V = 5 – (i/C)*t. The total capacitance is 35F, so if the output draws 3.5A for 10 s the voltage will drop to around 4V.

acdc_cnvrtr_pwr_spply_ad_mpspkr_dcpwr : Output

Inominal: 3 mA	Testing of the prototype amp/speaker block shows a nominal current draw of 3 mA.	The 10V Linear LDO can supply up to a maximum current of 1A DC.
Ipeak: 300 mA	The speaker is rated to handle up to 3W, to 300 mA at 10V seems a	The 10V Linear LDO can supply up to a maximum current of 1A DC.

	reasonable maximum current draw limitation.	
Vmax: 10.3 V	Really the exact supply voltage to an amplifier doesn’t matter as long as you aren’t planning to actually hit the rails, the important quality is how DC the voltage is so you can avoid power supply noise.	The 10V Linear LDO has a maximum Vout of 10.3V.
Vmin: 9.7 V	Really the exact supply voltage to an amplifier doesn’t matter as long as you aren’t planning to actually hit the rails, the important quality is how DC the voltage is so you can avoid power supply noise.	The 10V Linear LDO has a minimum Vout of 9.7V.

Table 4.1 Power Supply Interface Definition Table

Those paying close attention, and I’ll venmo $20 to anyone who proves they have read this by emailing a screenshot to huntingmaster09@gmail.com, will have noticed that multiple interfaces draw current from the 3.3V Linear LDO and the 5V Switching Regulator.

- The 3.3V Linear LDO can expect a maximum current draw of 500mA from the system microcontroller and a maximum current draw of 200mA from the microwave sensor. This means it has to be able to supply at least 700mA. It is rated to supply a maximum of 1.35A.

- The 5V Switching Regulator supplies the 3.3V Linear LDO. 700mA at 3.3V is equivalent to 462mA at 5V. Additionally it needs to be able to supply 200mA to the Supercapacitors and 250mA to the OpenMVCamH7 Plus module. This means it has to be able to supply at least 912mA. It is rated to supply a maximum of 2.5A.

4.1.5 Verification Plan

Phase 1 (Single output max current load testing):

1. Plug Input to USA AC Mains Wall Power

2. Connect all outputs (10V, 5V, 3.3V) to 3 different Electronic Loads. - Leave the Supercapacitor node alone for now while it charges.

3. One by one, turn on a load connected to an output and set it to draw the maximum expected current of that output (300mA, 250mA, 700mA) for 20s.

4. Confirm that each output stays within specified voltage range during max current draw (9.7V – 10.3V, 4.7V – 5.3V, 3.0V – 3.6V).

Phase 2 (All outputs nominal current load testing):

5. Set each load to draw the nominal current expected from each output (3mA, 160mA, and 278mA) and turn them all on at the same time for 2 min. 4. Confirm that each output stays within specified voltage range during nominal current draw (9.7V – 10.3V, 4.7V – 5.3V, 3.0V – 3.6V).

Phase 3 (Supercapacitor testing):

6. Measure the Supercapacitor voltage and confirm that it rises to 5V.

7. Once it is at 5V connect the Supercapacitor output to a 4th Electronic load. Leave the other 3 Loads drawing their respective nominal currents, and set the new load to draw 3.5A from the supercapacitors.

8. Verify that for 10s the Supercapacitor voltage remains greater than 4V, and the other outputs stay within their specified voltage range (9.7V – 10.3V, 4.7V – 5.3V, 3.0V – 3.6V). Phase 4 (Conclusion + Cleanup):

9. If nothing blows up and the voltages meet spec, the power supply block passes.

10. After testing, draw current from the Supercapacitor node until the Supercapacitors are discharged.

4.1.6 References and File Links

[1] *How to Choose a Power* Supply. (2021). FSP Group. Accessed Jan. 20, 2023. [Online] Available: https://www.fsp-group.com/en/knowledge-tec-26.html

[2] *LM2940x 1-A Low Dropout Regulator*. (2014). Texas Instruments. Accessed Jan. 16, 2023. [Online] Available: https://www.ti.com/general/docs/suppproductinfo.tsp?distId=26&gotoUrl=https://www.ti.com/lit/gpn/lm2940-n

[3] *4.2V to 18V Input, 2.5A Low IQ Synchronous Buck Converter*. (2021). Diodes Incorporated. Accessed Jan. 17, 2023. [Online] Available: https://www.mouser.com/datasheet/2/115/DIOD_S_A0011756658_1-2543704.pdf

[4] *Low Dropout Linear Regulator with Industrial Temperature Range*. (2015). Diodes Incorporated. Accessed Jan 14, 2023. [Online] Available: https://www.mouser.com/datasheet/2/115/DIOD_S_A0001413888_1-2541960.pdf

[5] *Voltage Tolerance Boundary*. (1999). Pacific Gas and Electric Company. Accessed Feb 1, 2023. [Online] Available: https://www.pge.com/includes/docs/pdfs/mybusiness/customerservice/energystatus/powerquality/voltage_tolerance.pdf

[6] *BGT60LTR11(B)AIP Low power 60 GHz Doppler radar sensor with antennas in package*. (2021). Infineon. Accessed Jan 5, 2023. [Online] Available: https://www.mouser.com/datasheet/2/196/Infineon_BGT60LTR11AIP_DataSheet_v02_05_EN-2891971.pdf

[7] *OpenMV Cam H7 Plus*. (2021). OpenMV. Accessed Jan 1, 2023. [Online] Available: https://openmv.io/collections/cams/products/openmv-cam-h7-plus

[8] *ESP32-WROOM-32 Datasheet*. (2018). Espessif Systems. Accessed Jan 17, 2023. [Online] Available: https://cdn-shop.adafruit.com/product-files/3320/3320_module_datasheet.pdf

4.1.7 Revision Table

2/9/2023	Hunter: Update Document to reflect Instructor/TA feedback and to incorporate design changes since last edit
1/31/2023	Hunter: Updated Document to reflect peer review feedback
1/20/2023	Hunter: Minor edits made prior to draft submission
1/16/2023	Hunter: Initial Document Created

Table 4.2 Section 4.1 Revision Table

4.2 Motion Sensor Block

4.2.1 Description

This sensing block will consist of a sensor other than a camera capable of detecting the movement of a flying bird. When movement is detected, this block will generate an output that, at the least, signals to the system control block that movement consistent with that of a bird in flight was detected. This will be accomplished by using a 60 GHz Microwave sensor. This sensor will output microwaves and measure their reflections. By analyzing the doppler effect of the returned waves it can tell if an object around it is moving.

4.2.2 Design

In order to accomplish the goals listed in the description section, this block will utilize Infineon's BGT60LTR11(B)AIP Low power 60 GHz Doppler radar sensor with antennas in package. My goal in designing this block is to create a custom shield that successfully allows the microwave sensor to operate and interface with a 3.3V microcontroller.

Essentially this boils down to four challenges. Provide power to the board assuming that 3.3Vs is available as input. Create an interface that allows the microcontroller to write configuration commands to the sensor. Create an interface that allows the sensor to signal the microcontroller when motion is detected. Provide the external discrete components/connections needed by the BGT60LTR11(B)AIP sensor to properly operate.

The BGT60LTR11(B)AIP operates on 1.5Vs and is highly sensitive to input noise fluctuations as these can create false positives. This means a possibly noisy 3.3Vs needs to be transformed into a steady 1.5Vs for the sensor to operate properly. I achieved this goal by utilizing TI's TPS7A2015PDBVR chip, an ultra low noise, low Iq, high PSRR linear dropout voltage regulator. The chip is capable of transforming 3.3V input into 1.5V output and can supply up to 300 mA of current, more than is required by the BGT60LTR11(B)AIP chip.

The BBGT60LTR11(B)AIP has a built in SPI interface designed to allow an external microcontroller to setup/configure the sensor. Unfortunately, since the chip operates at 1.5Vs, the SPI interface expects 1.5V input signals. This required me to use Infineon's SN74AVC4T245PWR chip, a 4-bit dual supply bus translation chip capable of supporting voltage level translation of SPI signals in the 10s of MHz.

The BBGT60LTR11(B)AIP also has two native output pins, one that indicates when a target is detected and another that indicates whether that target is moving towards or away from the sensor. Like the SPI interface, the output only operates at 1.5V. To allow a 3.3V microcontroller to read the signals, I utilized two level shifting MOSFETs.

Finally, the sensor requires several external capacitor filters as well as an external 38.4 MHz crystal. I used the documentation provided by infineon to determine the correct capacitor configurations and values. I also provided the FH3840024Z 38.4 MHz crystal manufactured by Diodes Incorporated to satisfy the BGT60LTR11(B)AIP's operating requirements.

Next are the complete schematic, PCB Design, and BOM for the sensor.

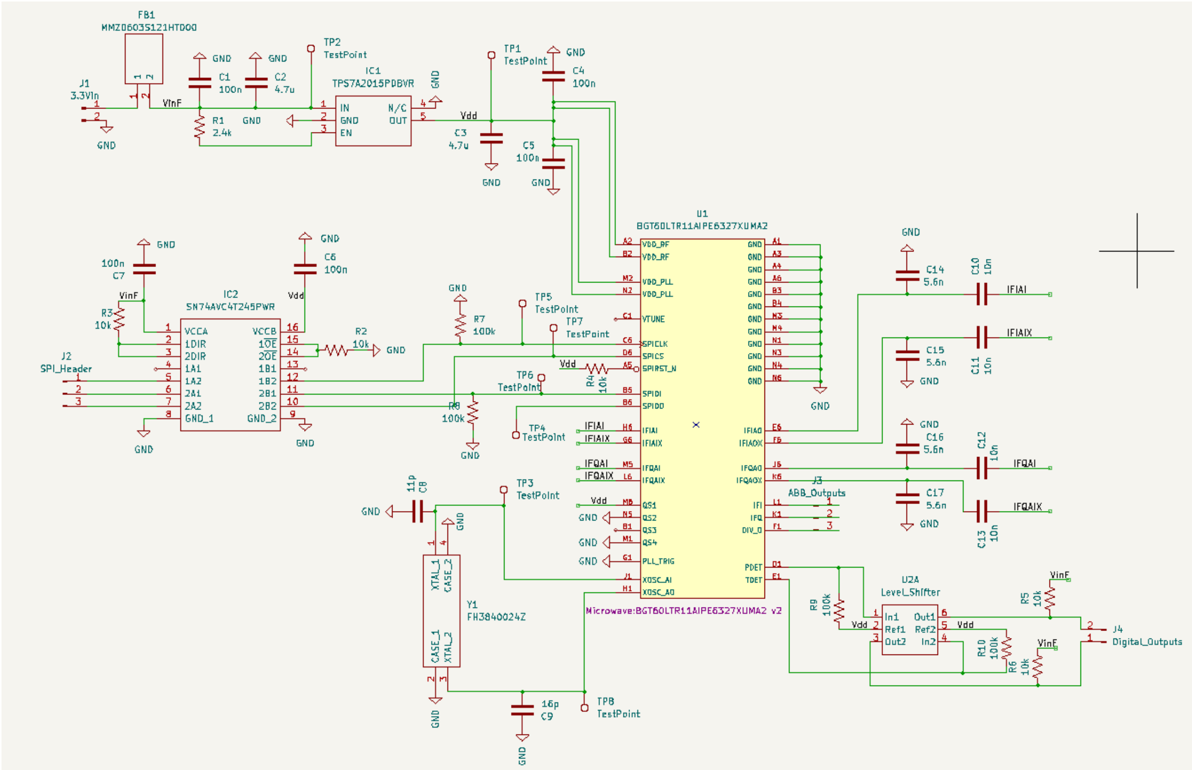


Figure 4.5: Microwave Sensor Schematic

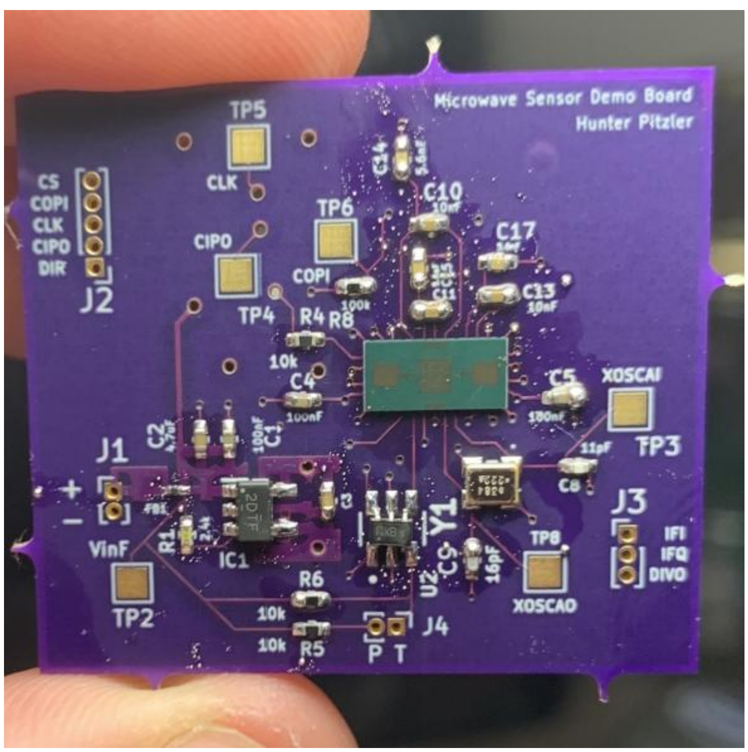


Figure 4.6: Microwave Sensor PCB Front Side

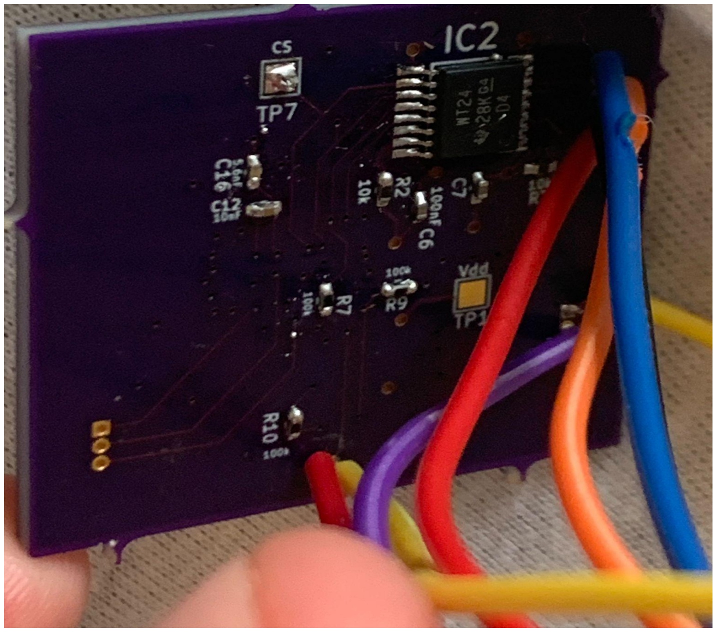


Figure 4.7: Microwave Sensor PCB Back Side

Microwave Sensor BOM							
Part Number	Manufacturer	Source	Part Name	Identifier	Quantity	Price per Unit ($)	Total Cost ($)
BGT60LTR11AIPE6327XUMA2	Infineon	Mouser	Microwave Sensor	U1	1	12.5	12.5
BSD840N H6327	Infineon	Mouser	Level Shifter	U2	1	0.42	0.42
FH3840024Z	Diodes Incorporated	Mouser	38.4 MHz Crystal	Y1	1	0.96	0.96
TPS7A2015PDBVR	Texas Instruments	Mouser	LDO Voltage Regulator	IC1	1	0.49	0.49
SN74AVC4T245PWR	Texas Instruments	Mouser	4-Bit Level Shifter	IC2	1	1.45	1.45
MMZ0603S121HT000	TDK	Mouser	Ferrite Bead/Inductor	FB1	1	0.13	0.13
CL05B104JO5NNNC	Samsung Electro-Mechanics	Mouser	100 nF Capacitor	C1, C4, C5, C6, C7	5	0.1	0.5
GRM155R60J475ME47J	Murata	Mouser	4.7 uF Capacitor	C2, C3	2	0.12	0.24
C0402C110K5HACTU	KEMET	Mouser	11 pF Capacitor	C8	1	0.1	0.1
GCM1555C1H160FA16D	Murata	Mouser	16 pF Capacitor	C9	1	0.1	0.1
GRT155R71H103KE01D	Murata	Mouser	10 nF Capacitor	C10, C11, C12, C13	4	0.1	0.4
GRM15XR71C562KA86D	Murata	Mouser	5.6 nF Capactior	C14, C15, C16, C17	4	0.1	0.4
RR0510P-242-D	Susumu	Mouser	2.4 kΩ Resistor	R1	1	0.12	0.12
RT0402FRE1310KL	YAGEO	Mouser	10 kΩ Resistor	R2, R3, R4, R5, R6	5	0.1	0.5
CRT0402-FZ-1003GLF	Bourns	Mouser	100 kΩ Resistor	R7, R8, R9, R10	4	0.11	0.44
	OSH Park	OSH Park	PCB		1	4.77	4.77
						Total:	23.52

Figure 4.8: Microwave Sensor BOM

4.2.3 General Validation

The design described above is not the only way to accomplish the goals described in section one. When researching sensors for this project, I came to the conclusion that there were four potential sensor technologies that could achieve our goals.

These were an ultrasonic sensor, a microwave sensor, a thermal camera, and an AI/Machine learning camera. We decided to incorporate two technologies into our design. We chose not to include an ultrasonic sensor since previous groups had attempted to utilize one to little success. According to their analysis, ultrasonic sensors simply aren't quick or sensitive enough to allow a system to detect and respond to bird size objects in flight.

Due to the expense of including a sophisticated camera, we chose to only include either a thermal camera or an AI/Machine learning camera. Since previous groups had already started work on an AI/Machine learning camera, we decided to continue developing that sensor. That left the microwave sensor for our secondary motion detection device.

There are not a lot of microwave motion sensors available on the market. The BGT60LTR11(B)AIP is a newer, well supported chip from infineon that fit our requirements and was fairly low cost/easy to integrate. As such, I picked it over its relatively few competitors.

The power supply design described above meets the basic requirements of the block. It can detect motion, be configured by a microcontroller, and signal a microcontroller when motion is detected.

4.2.4 Interface Validation

Interface Property	**Why is this interface this value?**	**Why do you know that your design details <u>for this block</u> above meet or exceed each property?**

otsd_mtn_snsr_envin: Input

Other: Range of 4 meters	We need to be able to detect the bird's motion from far enough away from the window to alert it in time to the danger.	Figure 27 of the datasheet for the sensor's shield [1] shows that it is capable of detecting motion up to 8m away at 0 degrees, and up to 4m away at up to 45 degrees.

Other: Angle of detection 45 degrees	We need to be able to detect the bird's motion from far enough away from the window to alert it in time to the danger.	Figure 27 of the datasheet for the sensor's shield [1] shows that it is capable of detecting motion up to 8m away at 0 degrees, and up to 4m away at up to 45 degrees.1
Other: Detect object of at least 9cmx9cmx6cm	We need to be able to detect the motion of a bird sized object.	Fingers crossed.

pwr_mtn_snsr_dcpwr : Input

Inominal: 128 mA	According to the BGT60LTR11(B)AIP datasheet the chip has an active current draw of 128 mA. [2]	According to the BGT60LTR11(B)AIP datasheet the chip has an active current draw of 128 mA. [2]
Ipeak: 200 mA	Given a nominal current of 128 mA, 200 mA seems a reasonable max current draw expectation.	Given a nominal current of 128 mA, 200 mA seems a reasonable max current draw expectation.
Vmax: 3.5 V	This seems like a reasonable variation for the power supply to support.	The microwave sensor block contains a 3.3V to 1.5V Linear LDO supply with a maximum voltage rating of 6V so it can easily tolerate up to 3.5V.
Vmin: 3.1 V	This seems like a reasonable variation for the power supply to support.T	The microwave sensor block contains a 3.3V to 1.5V Linear LDO with a maximum dropout voltage of 145 mV so it can easily tolerate down to 3.1V.

mtn_snsr_mcrcntrllr_dsig : Output

Logic-Level: Active Low	Really, active low or active high is inconsequential, one simply needs to be picked and agreed upon by the blocks on both sides of the interface	By default, the target detect pin output of the BGT60LTR11(B)AIP chip is active low.

Vmax: 3.5V	This keeps the signal within the acceptable Vmax range of the ESP32 input pins.	The output signal cannot be higher than the supply voltage, so it cannot be higher than 3.5V.
Vmin: 3.1V	This keeps the signal within the detectible Vmin range of the ESP32 input pins.	The output signal will be equivalent to the supply voltage, so it cannot be lower than 3.1V

mcrcntrllr_mtn_snsr_comm : Input

Messages: Register Values	According to the programming manual [3], the BGT60LTR11(B)AIP will interpret all SPI input messages as values to write to registers.	According to the programming manual [3], the BGT60LTR11(B)AIP will interpret all SPI input messages as values to write to registers.
Protocol: SPI	All modern microcontrollers have SPI interfaces and the BGT60LTR11(B)AIP has a built-in SPI interface for communication.	All modern microcontrollers have SPI interfaces and the BGT60LTR11(B)AIP has a built-in SPI interface for communication.
Vnominal: 3.3V	We plan to use a microcontroller that operates at 3.3V, so having the SPI communications occur at 3.3V keeps things simple.	This is actually problematic since the BGT60LTR11(B)AIP. I have included level shifting circuitry to translate the 3.3V SPI signal from the microcontroller into a 1.5V SPI signal the BGT60LTR11(B)AIP can read.

Table 4.3: Microwave Sensor Interface Definition Table

4.2.5 Verification Plan

Phase 1 (Motion Detection):

1. Place the sensor against a wall, and mark a point 4m away at 0 degrees in front of the sensor, a point 4m away at 45 degrees to the left of the sensor, and a point 4m away at 45 degrees to the right of the sensor

2. Standing 1m behind the marked points, throw a 9x9x6cm sized object at the sensor.

3. If the sensor indicates that motion is detected before the object gets to the point, the interface is validated.

Phase 2 (Power):

4. Plug the sensor into a DC power supply.

5. Set the power supply to 3.1V.

6. Check if the sensor is still operating properly and record the current being drawn.

7. Set the power supply to 3.5V.

8. Repeat step 6.

9. If the sensor was operating properly and drawing less than 200 mA at both supply voltages, the interface is validated.

Phase 3 (Digital Signal Output):

10. Connect a DMM to the TD output pin and gnd.

11. Measure the voltage when objects are moving in the sensor's FOV and when objects are not moving in the sensor's FOV.

12. If the voltage is 0V when objects are moving and within 3.1V to 3.5V when objects are not moving, the interface is validated.

Phase 4 (Microcontroller Input):

9. Use an O-scope to tap into the three SPI wires of significance connecting the microcontroller to the sensor (SCLK, CS, COPI).

10. Reset the microcontroller and observe the waveforms on each line.

11. For each message, the CS line should be pulled low, the SCLK line should rise and fall 24 times, and the COPI line should rise and fall in conjunction with SCLK in such a way as to communicate a symbol with the following structure.

- B0-B7 (seven bit register address)
- B8 (read/write indicator)(1 = write)
- B9-B23 (16 bit value to write to register)

12. The waveforms should have a low value of 0V and a high value of 3.3V

13. If the waveforms fit the descriptions listed in steps 11 and 12 and the sensor operates correctly, the interface is validated.

4.2.6 References and File Links

[1] *BGT60LTR11AIP shield*. (2023). Infineon. Accessed Feb. 26, 2023. [Online] Available: https://www.infineon.com/dgdl/Infineon-AN608_BGT60LTR11AIP_Shield-ApplicationNotes-v01_06-EN-ApplicationNotes-v01_07-EN.pdf?fileId=5546d4627550f4540175558b817a4d22

[2] *BGT60LTR11(B)AIP Low power 60 GHz Doppler radar sensor with antennas in package*. (2021). Infineon. Accessed Jan 5, 2023. [Online] Available: https://www.mouser.com/datasheet/2/196/Infineon_BGT60LTR11AIP_DataSheet_v02_05_EN-2891971.pdf

[3] *User's guide to BGT60LTR11AIP*. (2022). Infineon. Accessed Feb 26, 2023. [Online] Available: https://www.infineon.com/dgdl/Infineon-AN625_userguide_BGT60LTR11AIP-ApplicationNotes-v01_05-EN.pdf?fileId=5546d4627aa5d4f5017ae22fae336747

4.2.7 Revision Table

2/26/2023	Hunter: Completed Section 4.2
2/25/2023	Hunter: Completed Section 4.2

Table 4.4: Section 4.2 Revision Table

4.3 Primary Sensor (openMv Camera)

The purpose of this block will be to notify the rest of the system of when there is a bird flying towards the system. This is important for the system, because when a bird is detected, this will tell the system that the blocks that will deter the bird need to be activated. Without this block, the system will not accurately know when the deterring blocks should be activated, which could result in unnecessary disturbance to people passing the system.

4.3.1 Description

This block will consist of an open mv camera that will detect when a bird is flying towards the camera. This will be accomplished through the use of machine learning algorithms, where a dataset of flying birds will be an input for the algorithm. This dataset will consist of at least 100 original pictures of flying birds alongside an additional of at least 5 variations of the original pictures. These variations include flipping and rotating the original picture to include in the dataset, resulting in a total of at least 600 images for the dataset that the algorithm will use. Then when the camera detects a bird flying towards the camera, it will output that it detects a bird.

4.3.2 Design

The following section will provide a general overview of how this block will function, the inputs and expected output for which this block interacts, and a simple flowchart to show how the block works. The main module for this block was the OpenMV H7 plus camera module, which will implement the machine learning algorithm in order to detect when a bird is flying towards this block. The core purpose of this block will be to utilize a machine learning algorithm in order to detect when a bird is flying towards the main system. Therefore, this section will help to break down the process for how it will determine when a bird is being detected.

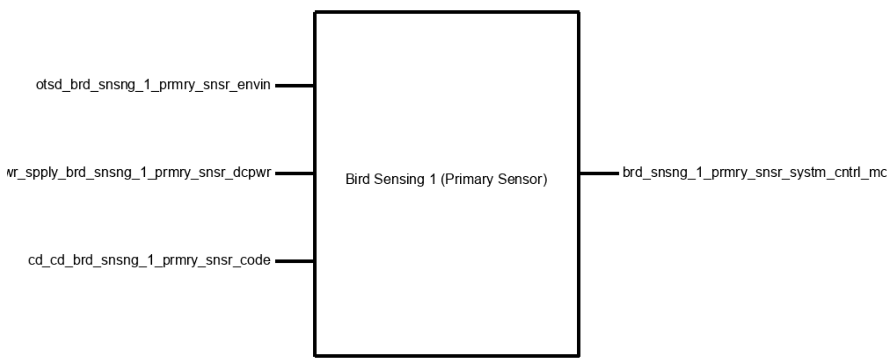


Figure 4.9: Bird Sensing 1 (Primary Sensor) Block Validation

This figure represents the black box image for this Bird Sensing 1 block. This block is expecting three inputs. The openMV IDE code which will be flashed onto the camera module, environment features, which the block will analyze to determine if it detects a bird, and power for which this block will turn on. Using these inputs the block will output whether or not it determines that it detects a bird.

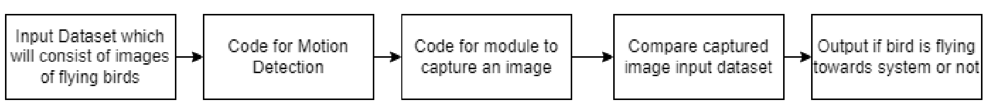


Figure 4.10: Design Flowchart for Bird Sensing 1 Block

This image refers to the general flow for how this block will function. There will be a dataset of images in which the machine learning algorithm will reference when determining if there is a bird flying towards the system. For the code of the camera module, it will first determine if it senses motion, and if that is true, the camera will then capture an image. That image will be analyzed and compared to the input dataset which the block will then determine if it detects a bird and that result will be the output of the block.

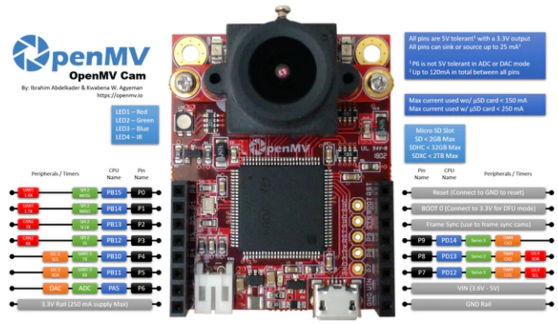


Figure 4.11: OpenMV Camera H7 Plus Module schematic

This image refers to the schematic for the OpenMV Camera H7 Plus module, which is the module that will be used in this block for the detection of flying birds. The camera will utilize a machine learning algorithm which will have various image of birds flying as the dataset to help determine when this block is detecting a bird and when it is detecting something else.

4.3.3 General Validation

The primary purpose of this block was for the detection of if a bird is flying towards the system. Therefore for the overall design of the block, it will take in inputs from the environment and using that data it should analyze and determine when a bird is approaching the system.

The image dataset the choice was to use images of flying birds as the input to the set. A previous group of this project also utilized a machine learning camera however, their image dataset consisted of any pictures with birds in them and when they tested their system, their camera did not accurately determine when a bird was flying towards their system but would send a signal that it detects a bird while it was stationary. Therefore, by limiting the image dataset to only pictures of birds flyings and including variations of those pictures, the idea is that when the camera captures a picture and tries to determine from that image if a bird is flying towards the system, by having a more specific dataset the accuracy in which it will detect a bird will increase.

The OpenMV module needs to detect birds flying towards the system, therefore this camera was chosen because of its ability to see far distances and has the capability of having a 45° range of motion. This range will allow the camera enough time and information to determine when/if a bird is flying towards the system.

4.3.4 Interface Validation

The following table will describe the various interfaces and its properties that will be interacting with this block. The table will indicate the interface and whether the interface is an input or output of this block, then detail the various properties for that interface, describing how those values were determined and why they are important.

Interface Property	Why is this interface this value?	Why do you know that your design details <u>for this block</u> above meet or exceed each property?

otsd_brd_snsng_1_prmry_snsr_envin : Input

Other: Min Range: 2ft		
Other: Max Range: 20 ft	The OpenMV Camera module needs time to analyze if it is detecting a bird, and to alert the rest of the system. It will constantly be taking inputs from the environment to determine when a bird is detected.	If the distance this block will function is too large it might consider birds that are not flying towards the system and falsely alert the deterring blocks to activate.
Other: Angle: Must see images within 45° angle of camera	The camera will be constantly taking in inputs from the environment, and needs a large enough view to properly determine when a bird is flying towards the system	The specification for the openMV camera H7 plus module states that it can support a 45° angle field of view

acdc_cnvrtr_pwr_spply_brd_snsng_1_prmry_snsr_dcpwr : Input

Inominal: 250 mA	According to the OpenMV website, on the page where it provides the specifications for the OpenMV Camera H7 Plus module, under power consumption states that it can handle 250mA	The switching power regulator that is designed in the module is specified to be able to withstand and input of up to 5.5V, with it expecting an input voltage in the range of 3.6V to 5V.
Ipeak: 300 mA	With an Inominal of 250mA, having a peak current of 300mA is seems reasonable	This bird sensing 1 block will be powered by a different block that contains a switching regulator, that specifies that it supply a current up to 2.5A
Vmax: 5.3 V	The OpenMV Camera H7 Plus module, contains a voltage regulator which specifies that it	This bird sensing 1 block will be powered by a different block that contains a switching regulator,

	can withstand up to 5.5V.	where the operational graph indicates that output voltage should stay below 5.25V
Vmin: 4.7 V	The OpenMV Camera module has a 5V to 3.3V switching regulator, where the minimum input is equal to its output.	This bird sensing 1 block will be powered by a different block that contains a switching regulator, where the operational graph indicates that the output voltage will be below 4.7V

brd_snsng_1_prmry_snsr_systm_cntrl_mcrcntrllr_data : Output

Other: Nominal of 3.3V	According to the specification of the openMV Camera module, it states it will operate at 3.3V	The microcontroller block that this module will be connected to can interface at this specified value.
Protocol: I2C	I2C will be used to allow for data to be transferred from this block to the other blocks	The microcontroller block that this module will be connected to can communicate to this block using i2C
Messages: SCL Clock Rate: 100kHz	According to the specification of the openMV Camera module, it states that it can support a SCL clock Rate of 100kHz	The microcontroller block has a default SCL clock rate of 100kHz, which will allow the two to communicate at this frequency

Table 4.5: OpenMV Cam Interface Definition Table

4.3.5 Verification Plan

The following steps will depict the process necessary to be followed in order to verify that this block is interacting with the other blocks properly, as well as functioning as intended. We want to check to make sure that this block is accurately detecting if a bird is flying towards the system, and when a bird is detected that it has a method to alert the rest of the system.

1. Plug OpenMV Camera H7 Plus module to laptop using a usb
2. Install and upload code to block module
3. Place the camera module facing towards a bird feeder, make sure camera is within the range of 15 feet from the bird feeder,
4. Wait until birds fly towards bird feeder and observe if OpenMV Camera H7 Plus module is taking pictures as the bird is flying towards the bird feeder
5. Observe if or if not the module is detecting the birds as they are flying to the feeder

4.3.6 References and File Links

[1] *OpenMV Cam H7 Plus*. (2021). OpenMV. Accessed Jan 1, 2023. [Online] Available: https://openmv.io/collections/cams/products/openmv-cam-h7-plus

[2] *PAM3205 1 A STEP-DOWN DC-DC CONVERTER*. (2013). Diodes Inc. Accessed Feb 25, 2023. [Online] Available: https://cdn.shopify.com/s/files/1/0803/9211/files/PAM2305AAB330.pdf?16766726301665544870

[3] *STM32H743xl 32-bit Arm Cortex M7 400MHz MCU*. (2018). STMicroelectronics. Accessed Feb 9 2023. [Online] Available: https://cdn.shopify.com/s/files/1/0803/9211/files/STM32H743VI.pdf?16766726301665544870

4.3.7. Revision Table

1/19/2023	Kelton: Created Document
2/9/2023	Kelton: Adjusted document based on feedback: added initial description for each section, added purpose statement
2/25/2023	Kelton: Updated Interface properties based on student portal
3/7/2023	Kelton: Updated information in general validation to reflect only relevant information for this block. Updated interface properties to student portal, to account for changes made from last edit

Table 4.6: Section 4.3 Revision Table

4.4 Code Block

4.4.1 Description

Code that will control the open mv camera, it will have a data set of images of birds flying towards a camera in which it can base its detection. This block will also communicate with the system control block.

4.4.2 Design

The following section will provide a general overview of how this block will function and the inputs and expected output for which this block interacts. This block will contain the machine learning algorithm for which the OpenMV H7 plus camera module will determine if an object is a bird or not. The code will also implement an I2C protocol with which it can communicate with the microcontroller, to inform it when the camera does and does not detect a bird.

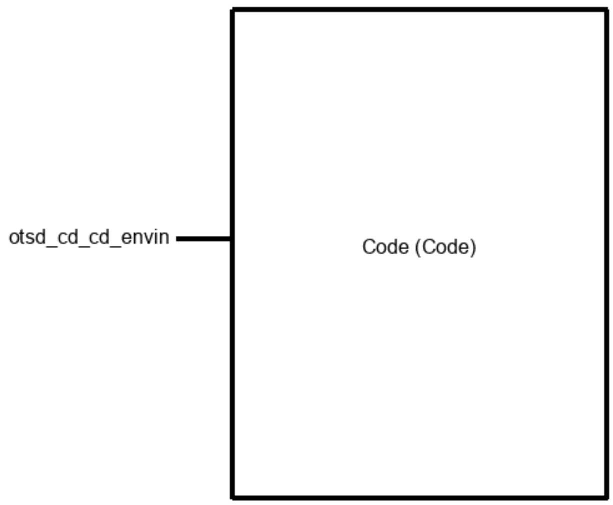


Figure 4.12: Code Black Box

This figure represents the black box image for this code block. This block has one bi-directional interface, in which it will communicate with the OpenMV module, and control the communication between the OpenMV module and the microcontroller.

4.4.3 General Validation

The primary purpose of this block was to develop a machine learning algorithm that would be implemented by the OpenMV camera, to accurately detect when a bird is flying towards the system and to alert the microcontroller of when a bird is detected. Therefore, this block will need to take in inputs from the environment and properly relay this information to the microcontroller.

First the code was designed to include a portion for which the module will determine if it senses/detects motion. The idea was that the camera would only be signaled to capture an image when it detects some kind of motion. This was implemented to avoid having the camera constantly capturing images and instead, regulate when it would take a picture

Secondly, the camera was coded to capture an image when motion is detected, this was to allow for the module to analyze and compare the captured image to determine if a bird is flying towards the system.

Lastly, after determining if a bird is flying towards the system, the block is designed to relay this information to the microcontroller, through the form of I2C communication. Regardless of if the object is a bird or not, this block will provide that information to the system microcontroller, and from there the microcontroller should properly react to the information it receives.

4.4.4 Interface Validation

The following table will describe the various interfaces and its properties that will be interacting with this block. The table will indicate the interface and whether the interface is an input or output of this block, then detail the various properties for that interface, describing how those values were determined and why they are important.

Interface Property	**Why is this interface this value?**	**Why do you know that your design details <u>for this block</u> above meet or exceed each property?**
otsd_cd_cd_envin : **Bi-Directional**		
Other: Machine Learning Bird Probability	To detect whether a bird is approaching or not. Machine learning can be used to train the camera when it will need to alert the other blocks that a bird is detected and when it may just be looking into nature.	These methods should work for this block because there have been designs done in the past that took a machine learning approach, and have seen some results. However, the algorithm used for this design will be slightly modified.
Other: I2C Message being received in serial terminal	The system needs to know when a bird is detected by the camera, so the microcontroller needs to communicate with the camera to know when it detects a bird	The specifications provided for the OpenMV camera and the esp32 microcontroller, shows that it supports I2C communication
Other: Flashable Binary: OpenMV IDE	To flash code onto the OpenMV Camera H7 plus module, the OpenMV IDE has to be used to communicate with the module.	When researching the OpenMV camera module, it specifies to interact with the module that this IDE should be worked with and used to flash code.

Table 4.7: Code Interface Definition Table

4.4.5 Verification Plan

The following steps will depict the process necessary to be followed in order to verify that this block is interacting with the other blocks properly, as well as functioning as intended. We want to check to make sure that this block is accurately detecting if a bird is flying towards the system, and when a bird is detected that it has a method to alert the rest of the system.

1. Connected SDA, SCL, and ground pins of OpenMV Camera H7 plus module and microcontroller to each other
2. Plug both OpenMV Camera H7 Plus module and microcontroller to laptop
3. Install and upload code to OpenMV Camera through the OpenMV IDE
4. Install and upload code to microcontroller through arduino IDE, this will be for showing the I2C communication working
5. Open Serial Monitor in arduino IDE
6. Place the camera module facing towards a bird feeder, make sure camera is within the range of 15 feet from the bird feeder
7. Wait until birds fly towards bird feeder and observe if OpenMV Camera H7 Plus module is taking pictures as the bird is flying towards the bird feeder
8. Observe if or if not the module is detecting the birds as they are flying to the feeder and
9. Observe if the camera is communicating with the microcontroller. This can be done by looking at the serial monitor and seeing if it is printing a bird is being detected.

4.4.6 References and File Links

[1] *OpenMV Cam H7 Plus*. (2021). OpenMV. Accessed Jan 1, 2023. [Online] Available: https://openmv.io/collections/cams/products/openmv-cam-h7-plus

[2] *PAM3205 1 A STEP-DOWN DC-DC CONVERTER*. (2013). Diodes Inc. Accessed Feb 25, 2023. [Online] Available: https://cdn.shopify.com/s/files/1/0803/9211/files/PAM2305AAB330.pdf?16766726301665544870

[3] *STM32H743xl 32-bit Arm Cortex M7 400MHz MCU*. (2018). STMicroelectronics. Accessed Feb 9 2023. [Online] Available: https://cdn.shopify.com/s/files/1/0803/9211/files/STM32H743VI.pdf?16766726301665544870

4.4.7 Revision Table

3/1/2023	Kelton: Created Document
3/4/2023	Kelton: Added information to the design, description, and general validation section
3/7/2023	Kelton: added information for interface validation and verification plan

Table 4.8: Section 4.4 Revision Table

4.5 Audio Amplifier and Speaker Block

4.5.1 Description

An audio Deterrent mechanism utilized to repel birds away when activated with an effective audio sound. If sensors detect bird movement the system control will activate the audio amplifier for a set duration using a sound best used for deterring birds without causing harm to them and with minimal disturbance to surroundings.

4.5.2 Design

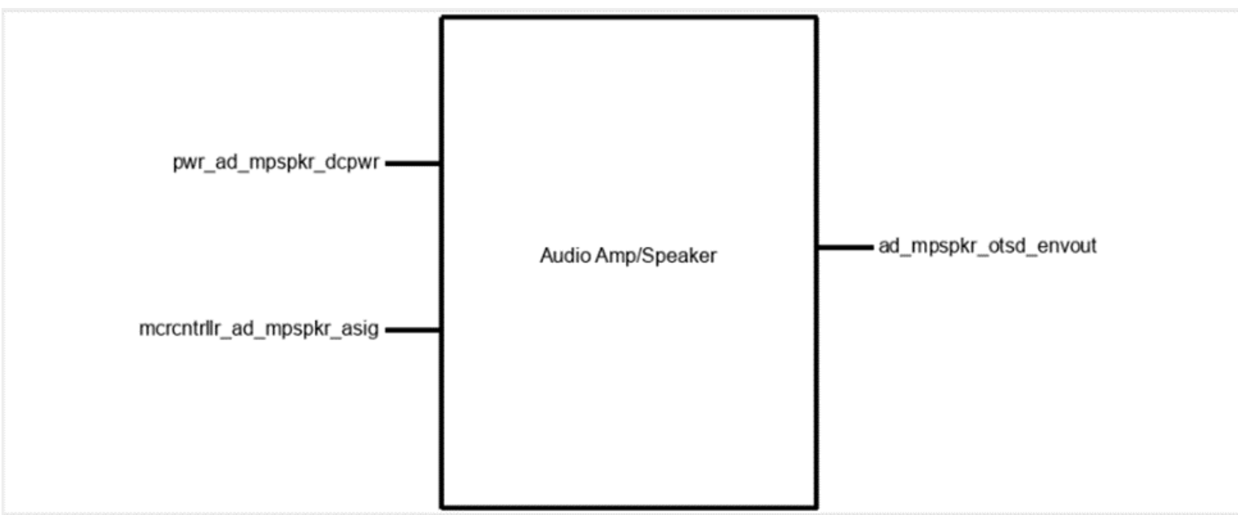


Figure 4.13: Black Box Diagram

Figure 1 above illustrates all the Audio Amplifier's input and output interfaces. For the Audio amplifier's black box inputs there is the power supply to speaker connection pwr_ad_mpspkr_dcpwr which supplies DC power to the device and all other blocks including the microcontroller and audio amplifier. The mcrcntrllr_ad_mpspkr_asig interface turns the audio amplifier on when a bird is detected. For output there is the environmental output ad_mpspkr_otsd_envout interface where the speaker is activated to alert incoming birds.

For the purposes of being capable of consuming low power and to output lower frequencies, an operational amplifier circuit using a low voltage audio amplifier such as an LM386 was drafted to be the initial design for the audio amplifier. In Figure 2 below each pin function is labeled for the LM386 operational amplifier. The LM386 used is an N-1 part, which has lower overall voltage specifications and is ideal for the project's power constraints.

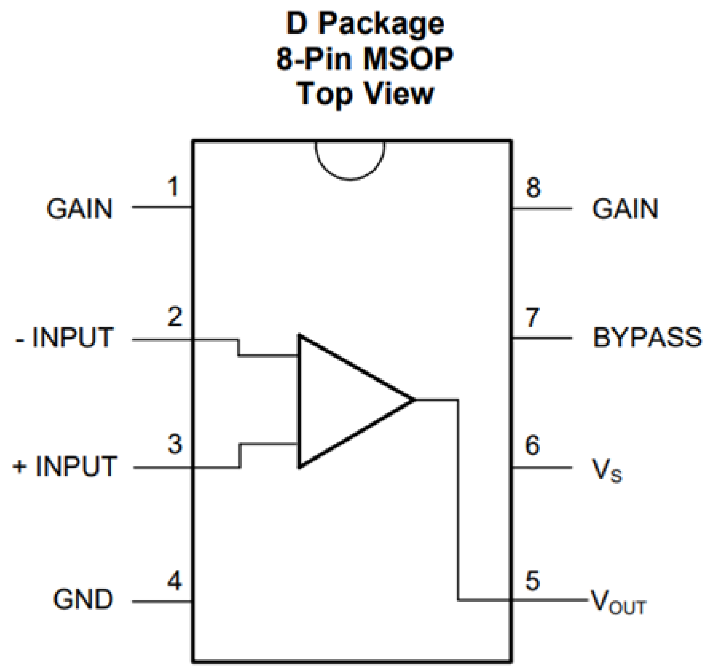


Figure 4.14: OpAmp Pin Configuration and Functions

Speaker components have been chosen as well as small components for building the OpAmp circuit such as capacitor and resistor values. Connection from microcontroller audio pins use low pass filter components using a 100 nano-farad capacitor, C1 as well as C2, and 1000 Ohm resistor in series, R1 as well as R2, for each audio pin connecting to the microcontroller. Both low pass filter connections connect to the operational amplifier's input pin 3. Both Opamp's gain pins are not needed and left with no connection. Input pin 2 connects to ground for the opamp. Power supply connection connects to Vs pin 6 with a 100 micro-farad capacitor, C3, connected to ground across the power supply connection, which was chosen for a higher voltage relative to the voltage rating for the LM386. The bypass pin 7 connects to ground across another 100 micro-farad capacitors, C4. Ground pin 4 also connects directly to ground with no added connections for the pin. Finally, Voltage output pin 5 connects to the speaker across a 1000 micro-farad capacitor, C6, alongside connection to ground across a 100 nano-farad capacitor, C5. All descriptions for the operational amplifier's pin connections are shown in the schematic in Figure 3 below.

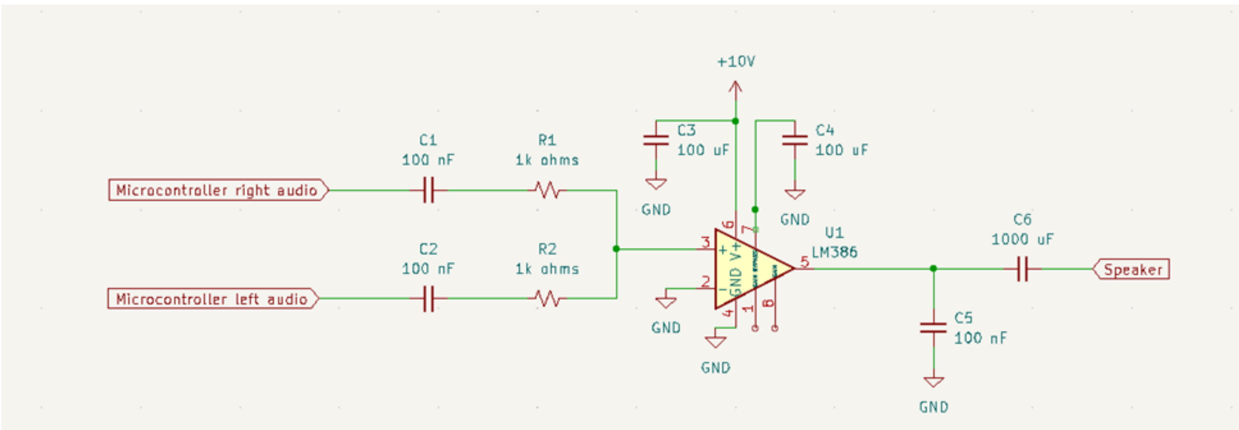


Figure 4.15: OpAmp Circuit Schematic

Power specifications from the project's power supply block are currently 10 V for nominal voltage as well as 3 mA for nominal current necessary to satisfy being operational for the system. The system can also operate with nominal voltage as low as 5 volts, which may be necessary moving forward to accommodate constraints currently with the power supply block. For the current design and testing 10 volts will be the nominal voltage for operating the block. Current frequency estimated to be required for desired result from output is between 4 KHz and 10 MHz. Ideal audio frequency is yet to be decided without making the requirement a constraint and serving the needs of the project for finalizing the device's functionality, so future adjustments will update the required range of frequency the audio amplifier will operate under. Further design additions and changes will be considered moving forward in the design process.

Bill of Materials

Components	Quantity
LM386N-1	1
Speaker	1
Testing Breadboard	1
Audio Jack cable	1
9V battery	1
.1 uF Capacitor	3
100 uF Capacitor	2
1000 uF Capacitor	1
1k Ohm Resistor	2

Figure 4.16: OpAmp BoM

For at home testing a 9-volt battery will be used and for verification demonstration purposes a breadboard will be used alongside an audio jack cable to connect to the microcontroller or for testing purposes a phone or mp3 player to test audio output from an operational amplifier device. Testing materials and Op Amp components are listed in the Bill of Materials for Figure 4 above.

The PCB board was made and sent to be fabricated. After testing the PCB design the team made a control PCB board with the audio amplifier's design integrated into the design alongside an ESP32_S2 and motion sensor board for a compact design.

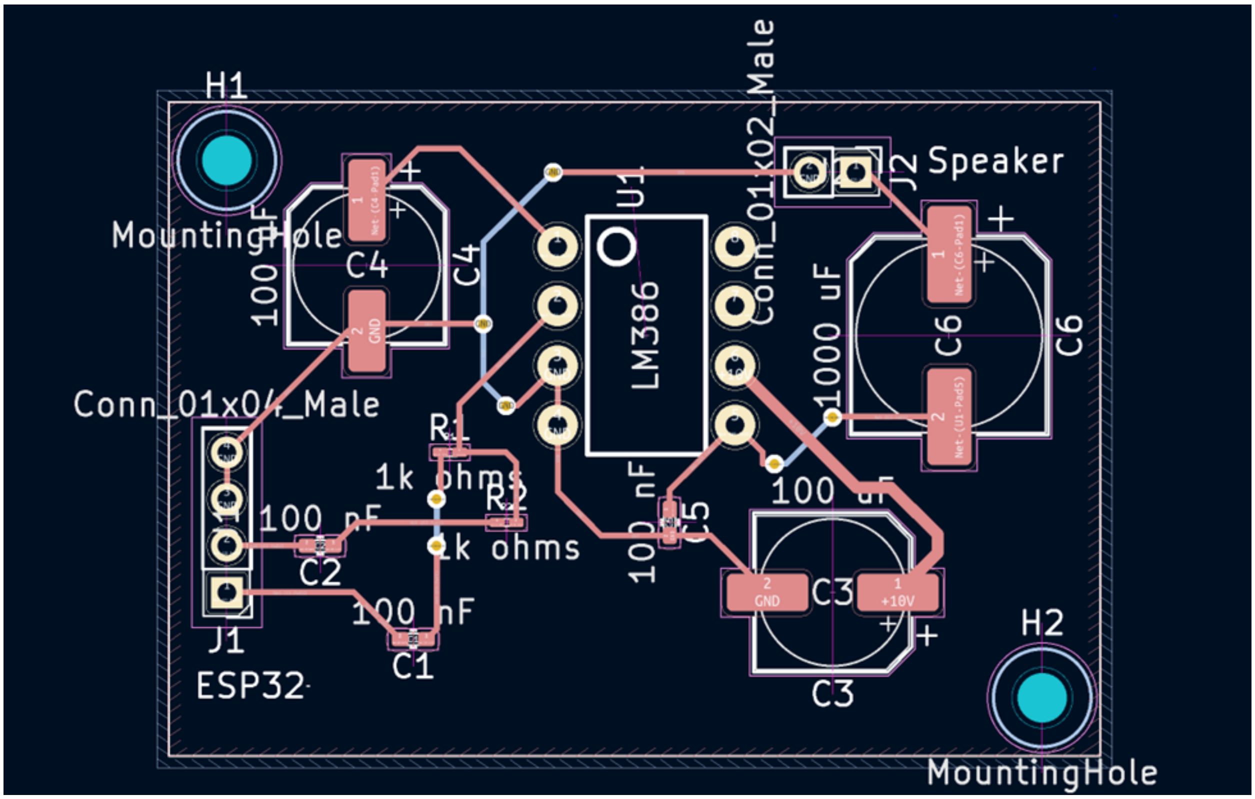


Figure 4.17: Audio Amplifier PCB Design

4.5.3 General Validation

The first design choices to consider are if an AC or DC power audio amplifier are needed, if the system requires multiple speakers, and if an audio board needs to be considered for user input audio control to increase, decrease, and turn off sound from the speakers on the device. AC powered audio amplifiers are much more complex to design and implement as opposed to the cost-efficient options DC powered audio amplifiers offer, therefore due to the marketability constraints of the project the more simplistic and cheaper option was chosen for the audio amplifier to run on a DC powered design. The system only requires one speaker so long as the speaker can produce sound audible for nearby birds to hear, and no volume control from a user's input was deemed necessary for the purposes of the project design, so no audio sound control board was implemented in the design for the audio amplifier.

The amplifier must meet the power specifications and frequency to drive sound sufficient for alerting a bird, so an LM386N-1 was chosen as an affordable DC operational amplifier to drive sound from a microcontroller to a speaker. I chose a simple operational amplifier circuit for each specification as a basis for design. Using a low pass filter across microcontroller inputs into the opamp would clear the audio frequency output further, which was why two low pass filters across each audio pin was ideal for higher frequency sounds such as universal bird calls to alert danger or louder construction noises. Any higher pitch deterrent will be accommodated from the filter input design choice, which allows for flexibility and range from the design to output several kinds of deterrent sounds in case the project's current deterrent output sounds show to be insufficient. From the bird deterrent project device's marketability requirement, the device requires a compact design with as lightweight components as possible. Given that the device must be compact, lightweight and has low demand on what is required for the audio amplifier to perform its function, this justifies a minimalistic setup that can meet the power supply and microcontroller's specifications.

The LM386N-1, according to the datasheet found under section 6 of the document, is rated to operate between 4 to 12 volts, which allots for flexibility for the device's power supply design. The current state of the project's power supply block is undergoing optimization changes and power constrictions, which may require voltage requirements to change to satisfy a lower minimum and maximum voltage threshold between 4 to 6 volts. The device has been rated and tested under lower voltage conditions without dropping in sound or sound quality, which allows the device to be carried over with minimal to no changes if the power supply adjustments are necessary for the project moving forward. More cost-efficient components such as resistors and capacitors were used in the design to further accommodate and satisfy marketability requirements without compromising the device's sound quality. The device in testing was operating with a speaker capable of high frequency output enough to be audible throughout a given room. Bird's ears have a much greater heightened sense of hearing, which greatly reduces the required frequency output necessary to alert a bird from a distance needed to give the bird a sufficient reaction time to respond to the sound. With the device operating with an ideal speaker sound output and under sufficient lightweight conditions of the block, and the device being operational between 4 and 12 volts as rated from the LM386 datasheet and tested with a voltage load, the conditions have been satisfied across each relevant project requirement and block interface until further blocks are developed.

4.5.4 Interface Validation

Below are interface properties defined for the devices input and output values, a description of why these are interface values for the interface property, and how the design can meet or exceed the specifications for each interface property.

Interface Property	**Why is this interface this value?**	**Why do you know that your design details <u>for this block</u> above meet or exceed each property?**

acdc_cnvrtr_pwr_spply_ad_mpspkr_dcpwr : Input

Inominal: 3mA	Amount power supply is designed to support	Leave device block operational measuring approximately close to Inominal on average
Ipeak: 300 mA	Amount power supply is designed to support	Leave device block operational measuring no higher than Ipeak
Vmax: 10.3 V	Amount power supply is designed to support	Leave device block operational measuring no higher than Vmax
Vmin: 9.7 V	Amount power supply can be designed to support	Leave device block operational measuring no lower than Vmin
Vripple: .2 V	Amount power supply can be designed to support	Leave device block operational measuring approximate to Vripple

systm_cntrl_mcrcntrllr_ad_mpspkr_asig : Input

Nominal Frequency: Frequency: 4 KHz	The frequency needed to alert a bird audibly from a further distance	Check if audio amp speaker can produce sound with frequency of 4 KHz
Vmax: 3.3 V	Amount power supply can be designed to support	Leave device block operational measuring at roughly Vmax
Vmin: 3 V	Amount power supply can be designed to support	Leave device block operational measuring at roughly Vmin

ad_mpspkr_otsd_envout : Output

Other: Frequency: 4 KHz	The frequency needed to alert a bird audibly from a further distance	Check if audio amp speaker can produce sound with frequency of 4 KHz

Table 4.9: Audio Amp and Speaker Interface Definition Table

4.5.5 Verification Plan

*(edit steps to be more specific step by step, clear instructions)

A: Power Supply Testing

1. Power on device by plugging 9-volt battery or power supply into device ground and the C1 100uF capacitor.

2. Power on voltage load and place probes onto power supply connections.

3. Measure Vmax and Vmin then verify if values meet specified properties measurements.

4. Also verify if nominal current and peak current meet specified properties measurements.

5. If all interface properties measurements satisfy conditions the test passes.

B: Audio Amplifier Output Testing

1. Turn on Oscilloscope for measuring device frequency output.

2. Connect Oscilloscope probes to Device.

3. Adjust Oscilloscope to view frequency and auto set display.

4. Adjust screen by lowering amplitude of the signal.

5. Verify if resulting frequency output meets within threshold of desired frequency for device.

6. If all interface properties measurements satisfy conditions the test passes.

C: Microcontroller to Audio Amplifier Testing **needs external blocks further developed to test fully**

1. Power on audio amplifier speaker.

2. Connect power to Audio Amplifier board's ground and Vcc.

3. Connect the microcontroller DAC pin to signal input on the Audio Amplifier board.

4. Build and flash code to microcontroller either to statically generate signal or to respond to input with audio signal output to the DAC when motion is detected.

5. Play sound using microcontroller or other device for testing speaker's audio output.

6. If the device is audible from 10 ft in general or when signal output is generated, the test passes.

4.5.6 References and File Links

[1] *LM386 Low Voltage Audio Power Amplifier*. (2022). Texas Instruments. Accessed Feb. 11, 2023. [Online] Available: https://www.ti.com/lit/ds/symlink/lm386.pdf?ts=1674260774336&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLM386%253FkeyMatch%253DPC817

[1] CLS0201MA-L152 Speaker. (2010). CUI Inc. Accessed Feb. 11, 2023. [Online] Available: https://resi.store/products/346/speaker.pdf

4.5.7 Revision Table

1/20/2023	Kalynne Whited: Document created and edited for rough draft submission
2/7/2023	Kalynne Whited: Made initial edits from peer review critiques for Design section and annotated additional changes to be made throughout the document.
2/8/2023	Kalynne Whited: Redefined and edited interface properties and added speaker datasheet link
2/9/2023	Kalynne Whited: Further detailed verification plan A and B
2/10/2023	Kalynne Whited: Added more detailed explanation for design section of audio amplifier block document
2/11/2023	Kalynne Whited: Added a further detailed explanation to general validation and interface validation sections of the document.
2/11/2023	Kalynne Whited: Finalized document before submitting block 1 validation to canvas.
3/12/2023	Kalynne Whited: Further updated and edited document with PCB information and testing.
5/14/2023	Kalynne Whited: Finalized updates to block design section.

Table 4.10: Section 4.5 Revision Table

4.6 Strobe Light Block

4.6.1 Description

This Strobe Light block consists of an LED light that will aid in deterring birds from flying towards the window. When the strobe light block receives the digital control light signal from the system control block it will output light, helping aid in deterring birds away. The purpose of this block is to use the two interfaces to operate the block whose function is to power the LED to turn on. This happens because the block is receiving the signal that the MV camera has detected the presence of a bird flying towards the device. The LED functions at the same time as the speaker and are the devices two deterrent methods in preventing birds from colliding with the window the device/system is attached to. This block is also one of the main outputs proving the validation of the system functioning correctly.

4.6.2 Design

This block's function is to produce a lumen output to the environment, so its design is based on the input being interfaced to the block which takes two interfaces to operate. The black box diagram for this block can be seen below in figure 1.

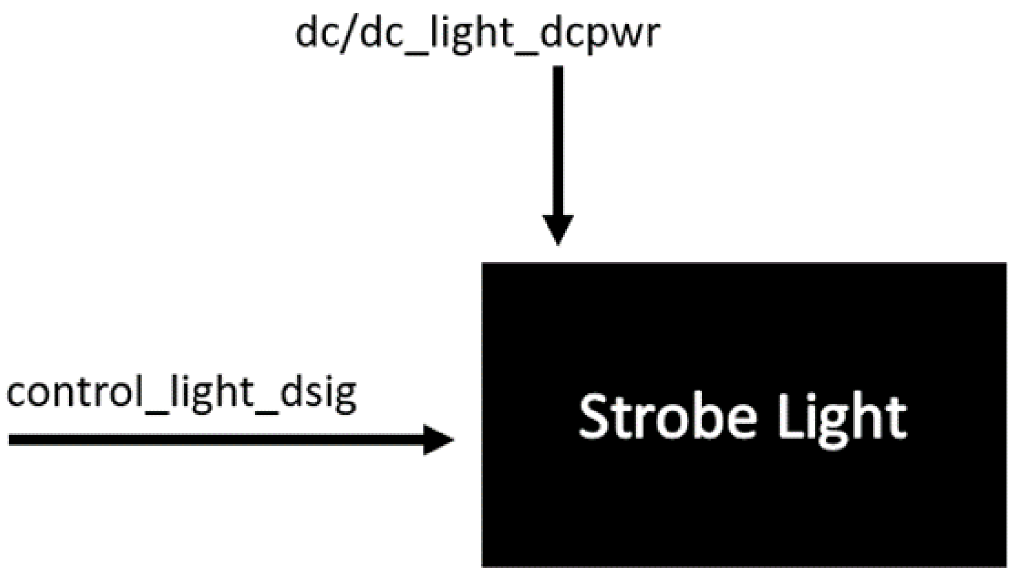


Figure 4.18: Black Box Diagram of Strobe Light Block

The first input is the power interface shown (acdc_cnvrtr_pwr_spply_strb_lght_dcpwr) which supplies the power to draw from when needed to operate the block/LED. The strobe light block has a power supply via this interface of up to 20W, a minimum of 4 volts, a maximum of 5.3 volts, around a 3.5A peak but can supply up to 4A at 4.5V-5V for a brief time (less than 10 seconds) that is used to power the block and LED to output lumens once a pull high signal from the system control is received. The LED being used for this block is from Cree LED and is one of their XLamp LED's that are usable for outdoor environments, the LED can be seen below in figure 2 and the datasheet [3] for this component can be viewed for reference.

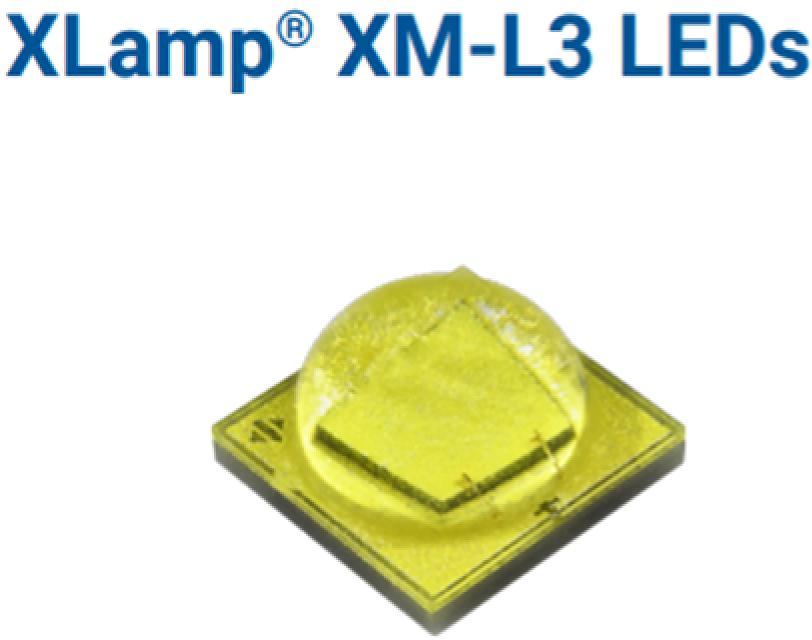


Figure 4.19: XM-L3 LED used in design

The next input needed for the block to function properly is the system control light digital signal (systm_cntrl_mcrcntrllr_strb_lght_dsig) that's being received via the system control block. This input supplies a voltage nominal of 3.3V and has a set logic level of active (ON) high that is used in the design of this block. This signal when active (OFF) low is set pulls to ground which sets the strobe light block in an off or unactive state causing the LED to turn off or remain off until the signal gets set to active (ON) high causing the active high mosfet that's in line with the signal and power to allow both to connect to the LED and turning it on for the time period set/until the signal pulls to active (OFF) low turning the LED off/causing the mosfet to go low and cut the connection of the signals to the LED off. The mosfet chosen for this design is from onsemi and can be seen below in figure 3 and the datasheet [4] for this component can be referenced. The tools Snap EDA [5] and Ultra Librarian [6] were used in retrieving the footprints for the mosfet to be used in the schematic and PCB design and are really great tools for engineers when designing systems.

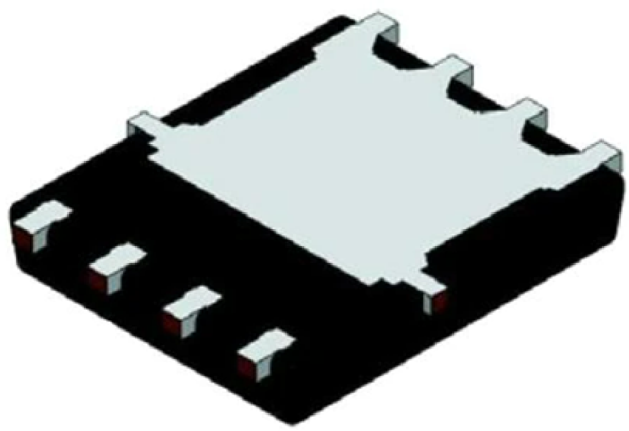


Figure 4.20: N-MOS Mosfet NTTFS1D2N02P1E used in design.

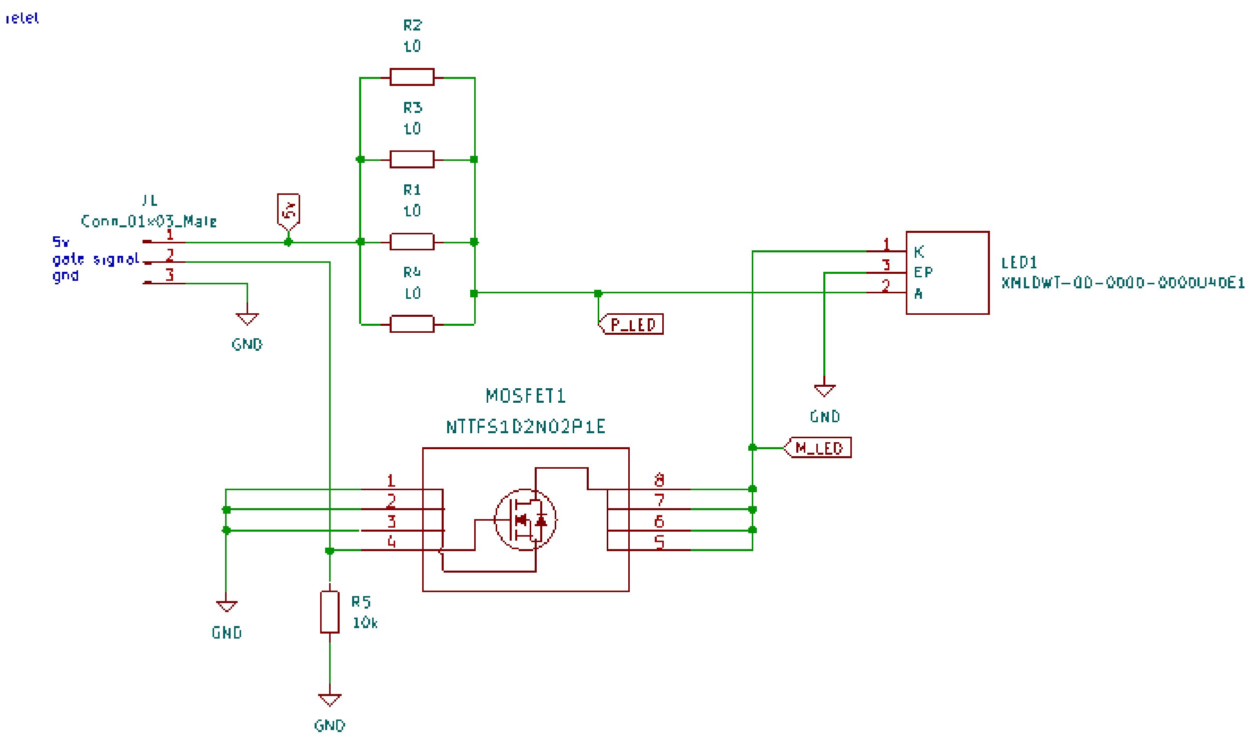


Figure 4.21: Strobe Light Schematic Design

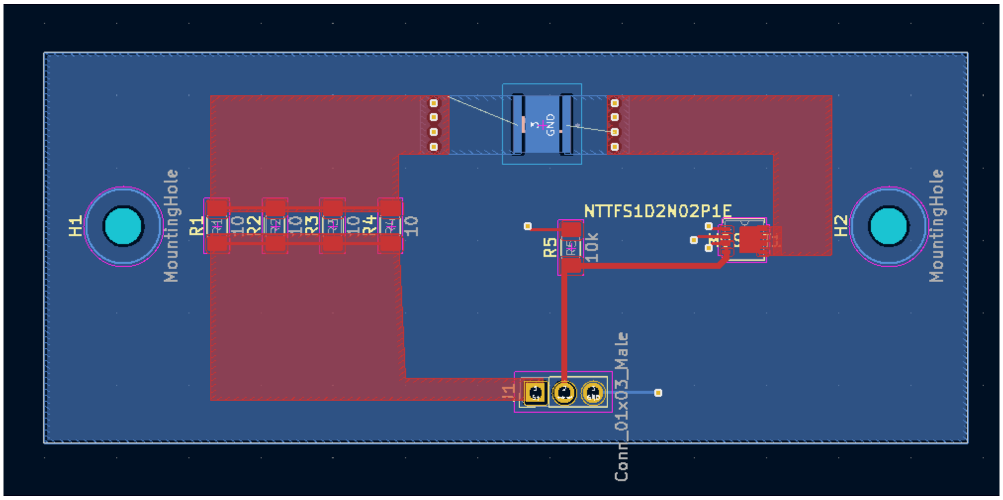


Figure 4.22: Strobe Light Board Front PCB Layout

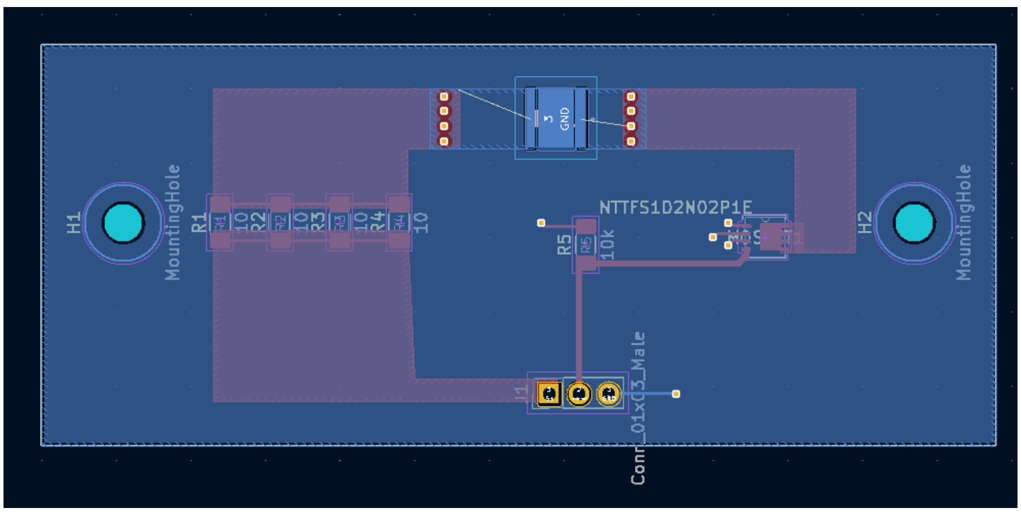


Figure 4.23: Strobe Light Board Back PCB Layout

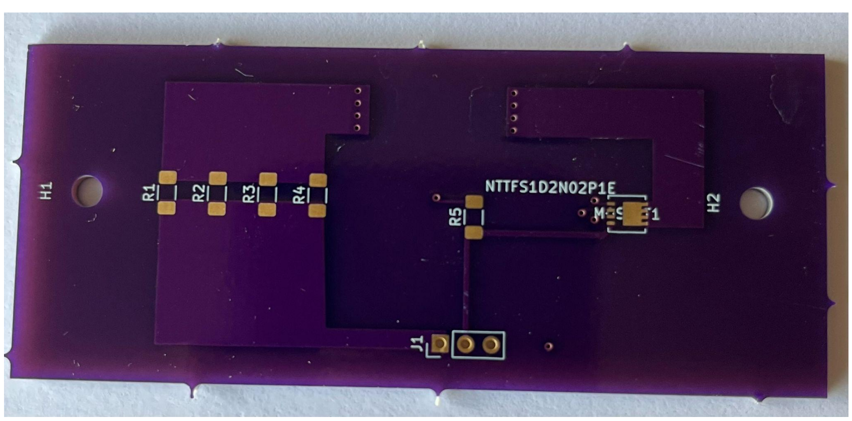


Figure 4.24: Strobe Light Board Front Unpopulated PCB

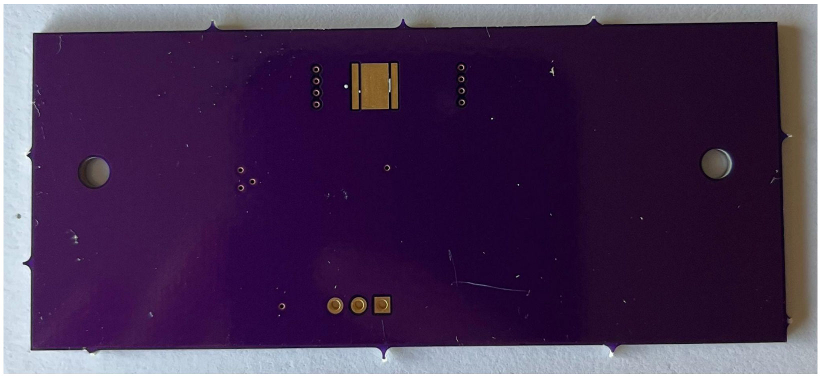


Figure 4.25: Strobe Light Board Back Unpopulated PCB

4.6.3 General Validation

I briefly discussed the reasoning behind my design and designed this block as described in the design section because of the importance of the interfaces interacting with the strobe light block. The two input interfaces directly operate the function of the block so it was designed to correctly direct the signals to be able to operate their functions and output the correct action. The blocks specific need is to interact with the interfaces and LED to output the proper response of turning on or turning off the LED. When the system detects a bird flying towards the device it needs to output lumens to deter the bird and when the system doesn’t detect any movement or birds flying towards the device the strobe light needs to remain off to conserve power and only be on when making efforts to deter the bird from impacting into the window.

This sets what the internal of the block design needs to be and by using the design created it properly handles the input signals by constructing the strobe light block to consist of an active high mosfet and high intensity lumen output LED to direct the input signals correctly and output correctly which meets the needs of this strobe light block.

This design also meets the needs of the constraints that come with the input signals, so handling the active (ON) high and active (OFF) low by using an active high mosfet and then using the power input voltage supply constraint to determine the LED that can be used/operated with those values.

4.6.4 Interface Validation

The design was based on these interfaces and their properties so all values and logic set for them was a predetermined value set in the blocks they were sent from in which being the system control block and one of the internal blocks of the AC/DC converter block that’s the 5V supercapacitor charger + cells block made in the AC/DC converter block that was specifically made to power the strobe light block. Resistors are then used to step down the voltage to operate the LED.

Interface Property	Why is this interface this value?	Why do you know that your design details <u>for this block</u> above meet or exceed each property?

acdc_cnvrtr_pwr_spply_strb_lght_dcpwr : Input

Inominal: 2 A	*Interface value explanation/value set is from the AC/DC Converter block supplying this input interface and was chosen in a range of being able to power class 3V LEDs in mind as specific LED had not been chosen at time of AC/DC Converter block design creation:* The Supercapacitors are rated to supply up to 6.1 A	The power supply/current needed to operate this block/the components of the NMOS and LED were designed/chosen to operate within these values of this interface. LED value is 0.7 A
Ipeak: 3.5 A	*Interface value explanation/value set is from the AC/DC Converter block supplying this input interface and was chosen in a range of being able to power class 3V LEDs in mind as specific LED had not been chosen at time of AC/DC Converter block design creation:* The Supercapacitors are rated to supply up to 6.1 A	The power supply/current needed to operate this block/the components of the NMOS and LED were designed/chosen to operate within these values of this interface. LED value is 5 A

Vmax: 5.3 V	*Interface value explanation/value set is from the AC/DC Converter block supplying this input interface and was chosen in a range of being able to power class 3V LEDs in mind as specific LED had not been chosen at time of AC/DC Converter block design creation:* See previous, the maximum output of the 5V Switching Regulator is expected to be less than 5.25V. Therefore, the Supercapacitors cannot charge to greater than 5.25V < 5.3V.	The power supply/current needed to operate this block/the components of the NMOS and LED were designed/chosen to operate within these values of this interface. LED value is 3.4 V
Vmin: 4 V	*Interface value explanation/value set is from the AC/DC Converter block supplying this input interface and was chosen in a range of being able to power class 3V LEDs in mind as specific LED had not been chosen at time of AC/DC Converter block design creation:* Ignoring the minimal 200 mA charging current, the voltage at the Supercapacitor node can be calculated as follows. $i = C(dv/dt)$. Therefore $V = 5 – (i/C)*t$. The total capacitance is 35F, so if the output draws 3.5A for 10 s the voltage will drop to around 4V.	The power supply/current needed to operate this block/the components of the NMOS and LED were designed/chosen to operate within these values of this interface. LED value is 2.9 V

Vnominal: 5 V	*Interface value explanation/value set is from the AC/DC Converter block supplying this input interface and was chosen in a range of being able to power class 3V LEDs in mind as specific LED had not been chosen at time of AC/DC Converter block design creation:* The 5V Switching Regulator has a typical Vout of 5V therefore the charge voltage of the Supercapacitors will be 5V.	The power supply/current needed to operate this block/the components of the NMOS and LED were designed/chosen to operate within these values of this interface.

systm_cntrl_mcrcntrllr_strb_lght_dsig : Input

Logic-Level: Active (On) High	The LED will be off more than it will be on so active high logic to turn on the LED saves energy/power by not having to drop power constantly.	The design for this block meets this property because the design implements the use of an active high mosfet (NMOS) to only draw power when the LED is on and handle the logic level argument correctly.
Vnominal: 3.3 V	This is the voltage the logic/microcontroller is using when outputting the signal to the strobe light block.	The block was designed with an active high mosfet (NMOS) and designed to only open the gate when it receives this signals voltage.

Table 4.11: Strobe Light Interface Definition Table

4.6.5 Verification Plan

This section goes over the plan to verify the functioning of the block for the strobe light. This plan was designed around the inputs being received from other blocks sending into the strobe light block and the output function expected from this block.

1. Connect a power supply of 4V to the power connection on the PCB.

2. Connect the microcontroller (system control) to the microcontroller signal connection on PCB if block is done, if not connect a power supply of 3.3V to that connection to be able to manually force active high to test block.

3. Turn on power supply and measure voltage after resistor to confirm voltage is in stepped down to correct value of 3.4V.

4. Measure connections to confirm the mosfet is not allowing signal through when active high signal has not been sent.

5. With the microcontroller or manual set up send an active (ON) high signal to the block.

6. Verify LED turns on and stays on for at least 8 seconds.

7. Verify once signal drops the LED turns off

8. Repeat this test around 10 times to confirm output is functioning correctly.

4.6.6 References and File Links

[1] Cree XLamp XM-L LEDs. (2017). Cree. Accessed Feb. 7, 2023. [Online] Available: https://www.mouser.com/datasheet/2/90/XLampXML-221774.pdf

[2] XLamp® XM-L3 LEDs. (2023). Cree. Accessed Feb. 7, 2023. [Online] Available: https://assets.cree-led.com/a/ds/x/Xlamp-XML3.pdf

[3] LED Components Product & Application Guide. (2023) Cree. Accessed Feb. 7, 2023. [Online] Available: https://assets.cree-led.com/a/fs/Product-Guide.pdf

[4] NTTFS1D2N02P1E Power MOSFET. (2019). ON Semiconductor. Accessed Mar 10, 2023. [Online] Available: https://www.mouser.com/datasheet/2/308/NTTFS1D2N02P1E_D-1814208.pdf

[5] NTTFS1D2N02P1E Symbol and Footprint. (2023). Snap EDA. Accessed Mar 10, 2023. [Online] Available: https://www.snapeda.com/parts/NTTFS1D2N02P1E/ON%20Semiconductor/view-part/?ref=search&t=NTTFS1D2N02P1E

[6] NTTFS1D2N02P1E Symbol and Footprint. (2023). Ultra Librarian. Accessed Mar 10, 2023. [Online] Available: https://app.ultralibrarian.com/details/744422c6-b772-11ea-b5d0-0aebb021a1ea/onsemi/NTTFS1D2N02P1E?uid=105857381&exports=KiCAD&open=exports

4.6.7 Revision Table

1/18/2023	Kayla Osburn: Draft of block validation created.
2/7/2023	Kayla Osburn: Final revision of block validation created and updates made suggested by peer reviews of draft submission.
3/10.2023	Kayla Osburn: Edits and combined to project document.

Table 4.12: Section 4.6 Revision Table

4.7 Microcontroller Block

4.7.1 Description

Microcontroller used to program code required for operating the system. Incorporates all blocks to yield desired output from system inputs.

4.7.2 Design

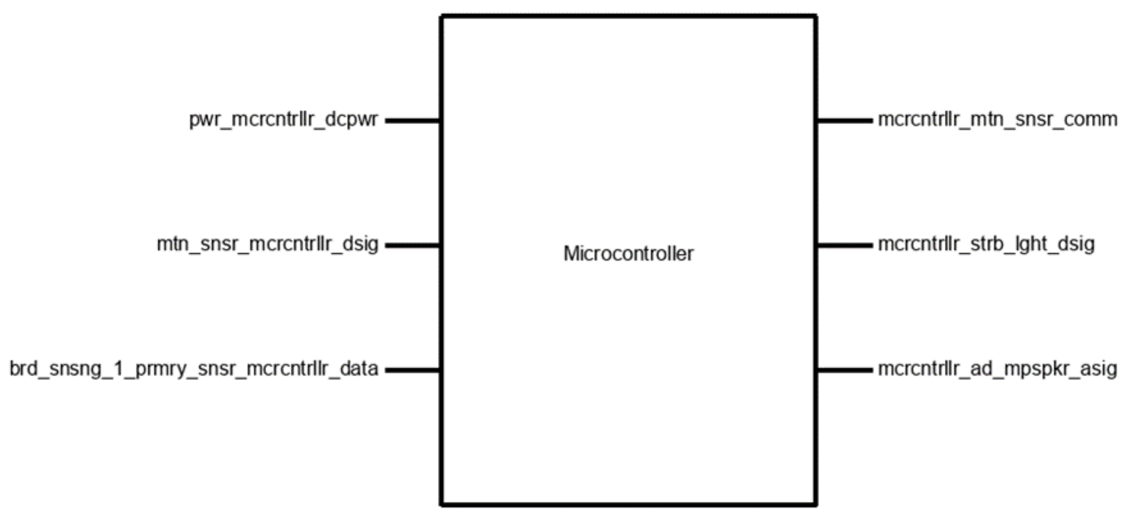


Figure 4.26: Black Box Diagram

Figure 1 above shows all the device's inputs and outputs with inputs from the DC power supply supplying about 3.3 Volts. The motion sensor and the primary MV Camera sensor send signal input from feed to the microcontroller. Outputs include communication back to the motion sensor based on the code's received inputs. The strobe light and speaker also are turned on as outputs if the sensors detect a bird and send that signal to the microcontroller.

An ESP32 design for the microcontroller was chosen since this design was developed prior and fits all specifications needed to run the system for the bird deterrent and it's individual blocks. The ESP32 has a digital to analog converter pin necessary to send the desired signal to the audio amplifier. The ESP32 also contains an RTC power domain, and a clock output needed for device output signal.

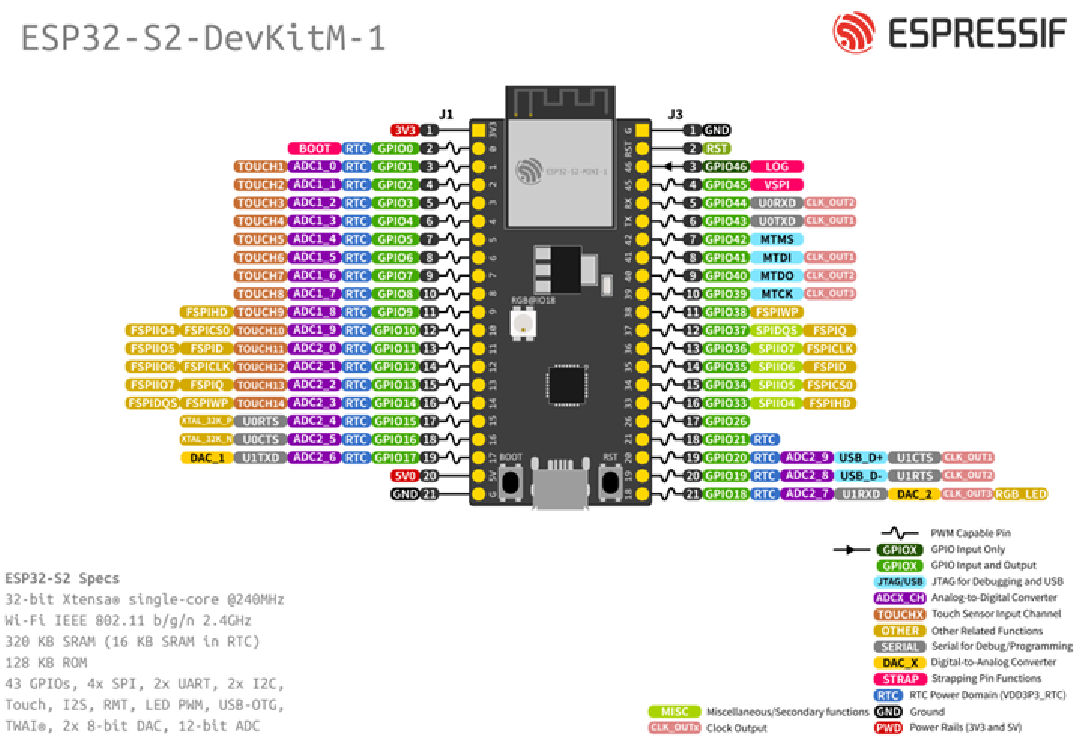


Figure 4.27: ESP32-S2 DevKitM-1 Pin Layout

The ESP32-S2 model will be the main demo board used for system verification, then a PCB board design incorporating a similar design to the ESP32-S2 will be incorporated in a joint board for the project system containing the audio amplifier board with other block's schematic in consideration of being added to the PCB board design for minimalistic space and a compact system within the enclosure. The final control board designed contained the ESP32-S2 alongside the audio amplifier circuit design and the motion sensor with external connections to the power supply, speaker and strobe light PCB.

4.7.3 General Validation

The current system required a microcontroller to operate where the team utilized different microcontrollers for testing their blocks. The ESP32 was the most accepted while utilizing coding in C and being a familiar system to design and build a PCB design for the team's final PCB design. The S2 design is a more adaptable and more recent ESP design with all the ideal requirements for the system's microcontroller.

4.7.4 Interface Validation

This section is about why the contents of the **design section** you presented above meet each of the properties. The table provided has 3 columns, be sure that you keep these three columns and complete them fully. Please adjust the column widths in your final document to best use whitespace.

Interface Property	**Why is this interface this value?**	**Why do you know that your design details for this block above meet or exceed each property?**

pwr_mcrcntrllr_dcpwr : Input

Inominal: 250 mA	Amount power supply is designed to support	Leave device block operational measuring at roughly Inominal
Ipeak: 450 mA	Amount power supply is designed to support	Leave device block operational measuring at roughly Ipeak
Vmax: 3.5 V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmax

Vmin: 3.1 V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmin

mtn_snsr_mcrcntrllr_dsig : Input

Logic-Level: Active Low	Really, active low or active high is inconsequential, one simply needs to be picked and agreed upon by the blocks on both sides of the interface	By default, the target detect pin output of the BGT60LTR11(B)AIP chip is active low.
Vmax: 3.5V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmax
Vmin: 3.1V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmin

brd_snsng_1_prmry_snsr_mcrcntrllr_data : Input

Messages: SCL Clock Rate: 100kHz	According to the programming manual [3], the BGT60LTR11(B)AIP will interpret all SPI input messages as values to write to registers.	According to the programming manual [3], the BGT60LTR11(B)AIP will interpret all SPI input messages as values to write to registers
Other: Vnominal of 3.3V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vnominal
Protocol: I2C	The system needs to know when a bird is detected by the camera, so the microcontroller needs to communicate with the camera to know when it detects a bird	The specifications provided for the OpenMV camera and the esp32 microcontroller, shows that it supports I2C communication

mcrcntrllr_mtn_snsr_comm : Output

Messages: Register Values	According to the programming manual [3], the BGT60LTR11(B)AIP will interpret all SPI input messages as values to write to registers.	According to the programming manual [3], the BGT60LTR11(B)AIP will interpret all SPI input messages as values to write to registers
Protocol: SPI	All modern microcontrollers have SPI interfaces and the BGT60LTR11(B)AIP has a built-in SPI interface for communication.	All modern microcontrollers have SPI interfaces and the BGT60LTR11(B)AIP has a built-in SPI interface for communication.

Vnominal: 3.3 V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vnominal

mcrcntrllr_strb_lght_dsig : Output

Logic-Level: Active (On) High	The LED will be off more than it will be on so active high logic to turn on the LED saves energy/power by not having to drop power constantly.	The design for this block meets this property because the design implements the use of an active high mosfet (NMOS) to only draw power when the LED is on
Vmax: 5V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmax
Vmin: 2.5V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmin
Vnominal: 3.3 V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vnominal

mcrcntrllr_ad_mpspkr_asig : Output

Max Frequency: Frequency: 4 KHz	The Maximum frequency needed to alert a bird audibly from a further distance	Check if audio amp speaker can produce sound with frequency no greater than 4 KHz using system's code
Other: Nominal Frequency: 2 KHz	The frequency needed to alert a bird audibly from a further distance	Check if audio amp speaker can produce sound with frequency of roughly 2 KHz
Vmax: 3.3 V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vmax
Vrange: 3.3 V	Amount power supply is designed to support	Leave device block operational measuring at roughly Vrange

Table 4.13: Microcontroller Interface Definition Table

4.7.5 Verification Plan

A: Power Testing

1. Power 3.3 Volts into ESP32-S1 or PCB microcontroller

2. Measure the microcontroller operating between Vmax and Vmin.

3. Measure the microcontroller operating between Inominal and no greater than Ipeak.

4. If the microcontroller satisfies all specifications, the test passes.

B: Code Testing

1. Plug mini USB into ESP32-S1 or PCB microcontroller from computer.

2. Flash code onto the ESP32-S1 or PCB microcontroller to run code.

3. If the microcontroller flashes and operates with the code the test passes.

C: Microcontroller to Audio Amplifier Testing

1. Connect power and ground pins on the microcontroller to pins Vcc and GND on the audio amplifier board.

2. Connect the DAC pin on the microcontroller to the signal pin on the audio amplifier.

3. Measure power consumption to be between Vmin and Vmax.

4. Flash code onto the microcontroller to produce a signal to the audio board. Measure if the speaker produces a signal that is nominally 2 Khz and no greater than 4 kHz.

5. If all specifications are satisfied and the device is audible within 10 feet the test passes.

D: Microcontroller to Strobe Light Testing

1. Connect power and ground pins on the microcontroller to pins Vcc and GND on the strobe light board.

2. Connect the microcontroller to the input pin on the strobe light board.

3. Measure power consumption to be between Vmin and Vmax at approximately Vnominal.

4. Flash code onto the microcontroller to produce an output to the strobe light.

5. If all specifications are satisfied and the strobe light is visibly on the test passes.

E: Microcontroller to Motion Sensor Testing

1. Connect power and ground pins on the microcontroller to pins Vcc and GND on the motion sensor board.

2. Connect the microcontroller to the output pin on the motion sensor board.

3. Measure power consumption to be between Vmin and Vmax at approximately Vnominal.

4. Flash code onto the microcontroller to read an input from the motion sensor.

5. If all specifications are satisfied and a signal is sent from the motion sensor board the microcontroller can read, the test passes.

F: Microcontroller to Primary Sensor Testing

1. Connect power and ground pins on the microcontroller to pins Vcc and GND onto the MV camera.

2. Connect the microcontroller to the output pin on the MV camera.

3. Measure power consumption to be between Vmin and Vmax at approximately Vnominal.

4. Flash code onto the microcontroller to read an input from theMV camera.

5. If all specifications are satisfied and a signal is sent from the MV camera that the microcontroller can read, the test passes.

4.7.6 References and File Links

[1] ESP32-S2-DevKitM-1. (2023). Espressif. Accessed Feb. 20, 2023. [Online] Available: https://docs.espressif.com/projects/esp-idf/en/latest/esp32s2/hw-reference/esp32s2/user-guide-devkitm-1-v1.html

[2] ESP-WROVER-KIT V4.1 Getting Started Guide. (2023). Espressif. Accessed Feb. 20, 2023. [Online] Available: https://docs.espressif.com/projects/esp-idf/en/latest/esp32/hw-reference/esp32/get-started-wrover-kit.html

4.7.7 Revision Table

2/20/2023	Kalynne Whited: Document was created and formatted for further revision
3/12/2023	Kalynne Whited: Document was further updated on developed progress of block since creation including changes to ESP32 type used.
3/14/2023	Kalynne Whited: Finalized draft before submitting with group project document on week 20's system verification.
5/14/2023	Kalynne Whited: Finalized document edits with the block design section

Table 4.14: Section 4.7 Revision Table

4.8 Enclosure Block

4.8.1 Description

The Enclosure block consists of a water-resistant enclosure sized to the PCB that holds inside all components of the system/PCB with an open area for the camera, strobe light and speaker output to operate. The enclosure will additionally mount to windows.

4.8.2 Design

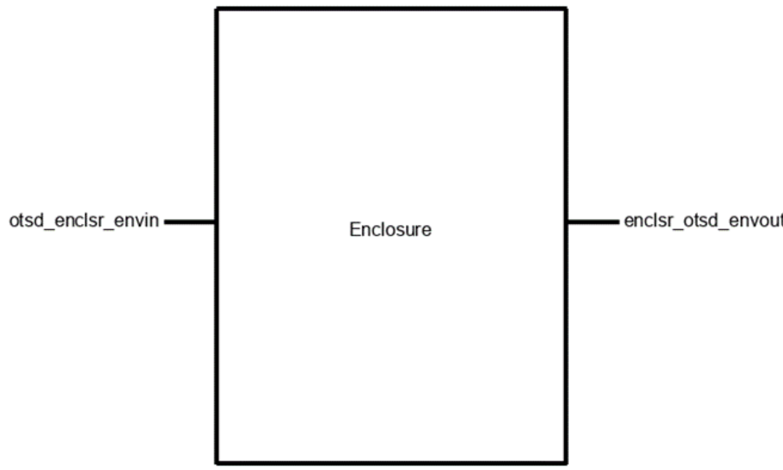


Figure 4.28: Black box diagram

The design of this block is to have an enclosure that the system can be held within and operate its functions correctly in ideal environments and non-ideal. The enclosure was made to be able to have openings for multiple interfaces. The opening for a power connector was designed around an AC power module connector and placed on the bottom of the enclosure to be easily accessible and help aid with waterproofing. Similarly with the speaker holes placed on the bottom to help aid with waterproofing. See figure 2.

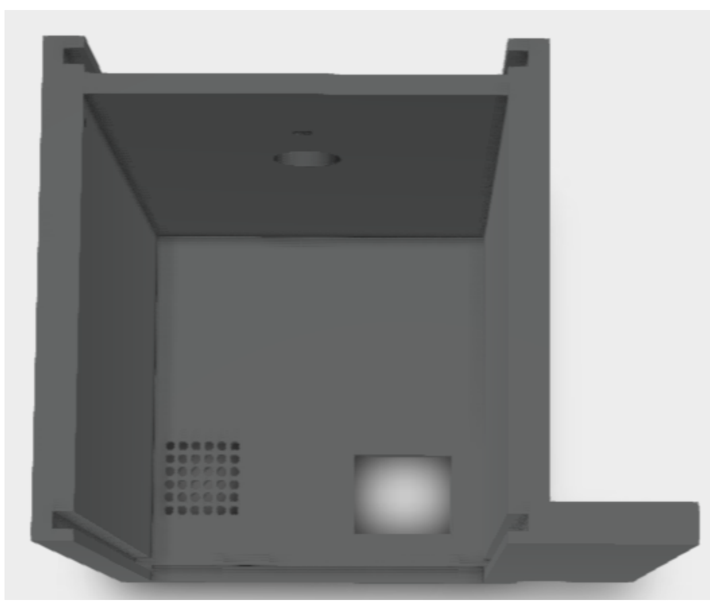


Figure 4.29: Top view of enclosures main body design

The use of a slide in panel was designed to make mounting the system inside easier and be the placement for the main PCB to then connect to the power module connector. See figure 3.

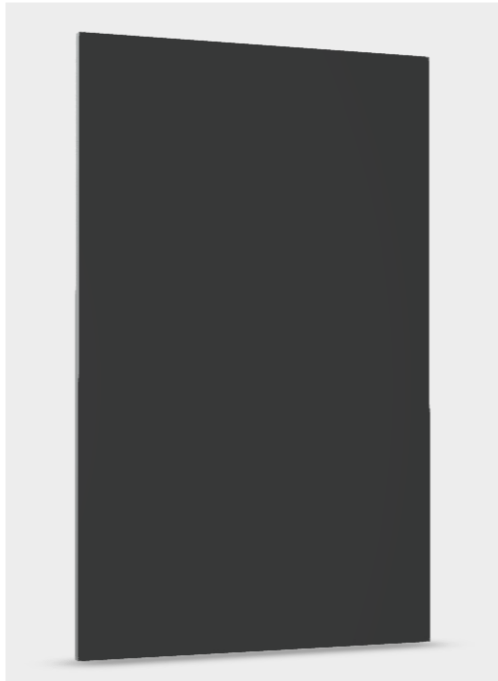


Figure 4.30: Slide in back panel of enclosure

The front of the enclosure was made with two openings, one for the LED and one for the MV camera and then a slide in indent was made so acrylic material could be slid in to help with waterproofing while maintaining the function needed for the system and enclosure. See figure 4.

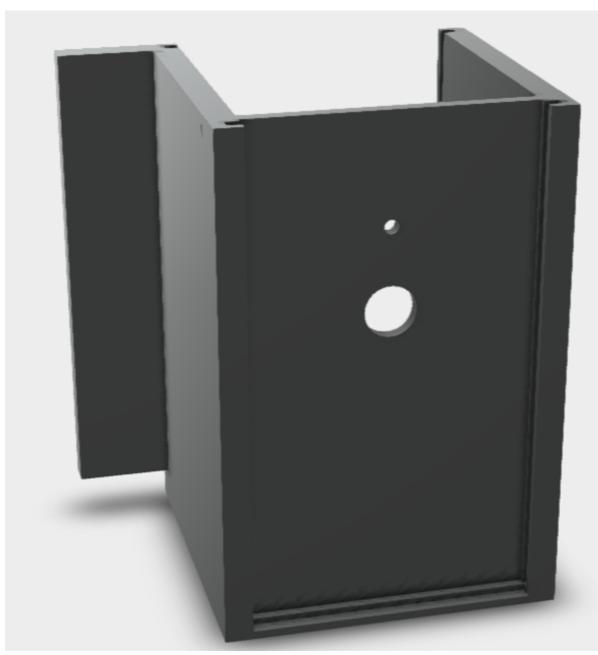


Figure 4.31: Front view of the enclosure's main body.

Lastly a side mounting access area was also designed so the enclosure had a strong mounting point to be able to mount vertically to a surface. See figure 5.

Figure 4.32: Back of enclosures main body

The last part of the design is the top that was designed with a lip so water would run down off the side instead of going into any seals. See figure 6 and 7.

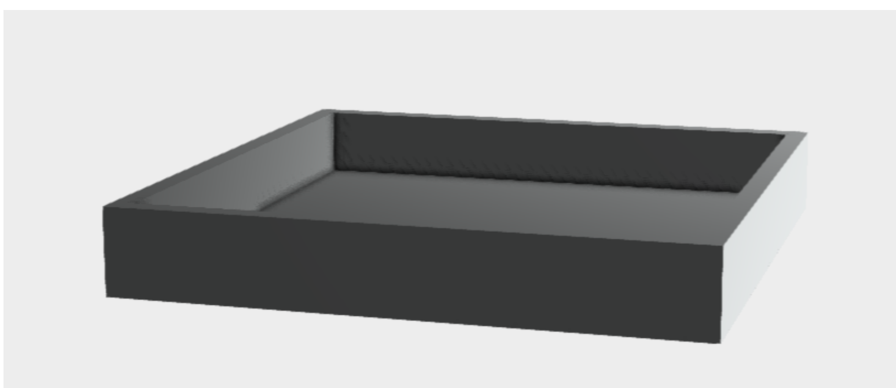


Figure 4.33: Bottom view of lid for enclosure.

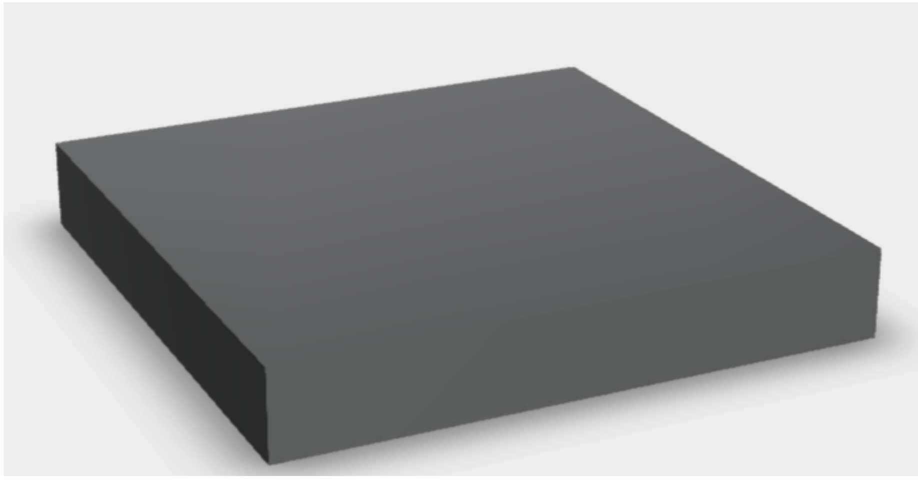


Figure 4.34: Top view of lid on enclosure.

4.8.3 General Validation

This block is one of the most important aspects to the overall design of the system because this block is what contains the system in whole and prevents it from damage. The block was designed as explained above in the design section to take into account the role this block plays and all it needs to do for the system. It needs to be able to let the system output what is needed so the camera, led, speaker, and power input which is why the openings were designed to fit these elements around the dimensions of these components. Placement of the openings were to aid in waterproofing as well as that interfaces role hence the camera and led in the front as it's interface needs to be looking straight on and having a design in place that can fit an acrylic sheet to aid in waterproofing the enclosure to avoid the system being damaged from external environment properties.

4.8.4 Interface Validation

This section goes over the blocks interfaces and discusses a little of why these were chosen and how it meets these.

Interface Property	Why is this interface this value?	Why do you know that your design details <u>for this block</u> above meet or exceed each property?
otsd_enclsr_envin : Input		

Other: Withstand a 5-ounce object thrown at the enclosure without causing any damage.	The enclosure will be interacting with common backyard birds with an average weight of 5-ounces.	The thickness of the enclosure was made to be able to withstand force thrown at the enclosure.
Other: The enclosure has an opening to connect to a power cable.	The system needs to be able to see outside of the enclosure and have an led output light outside of the enclosure.	The enclosure was made with openings for an ac power connector dimension.
Other: The enclosure has a vertical mounting point.	The enclosure needs to be able to mount to a house by a window or on a window frame.	The enclosure was designed with a vertical mounting access point to be able to attach a bracket and mount vertically.

enclsr_otsd_envout : Output

Light: Output from the light block is visible through the enclosure.	The system needs to be able to have an led output light outside of the enclosure.	The enclosure was made with openings for the LED's dimensions.
Other: The speaker block output can be heard through the enclosure.	The system needs to be able to have sound output from the system outside.	The enclosure was made with openings for speaker output.
Other: The camera block output has visibility through the enclosure.	The system needs to be able to see outside of the enclosure.	The enclosure was made with openings for the MV camera dimensions.

Table 4.15: Enclosure Interface Definition Table

4.8.5 Verification Plan

This section goes over the plan to verify the functioning of the block for the Enclosure This plan was designed around the inputs being received from other blocks and the output function expected from this block.

1- Throw a 5-ounce object at the enclosure from 10 feet away 10 times and have no damage to the enclosure.

2- The AC module power connector fits in it’s designed opening.

3- The enclosure can be mounted to wood vertically.

4- When the LED is placed in it’s designed opening, light can be seen coming out.

5- When the speaker is placed on it’s designed opening, sound can be heard coming out of the enclosure.

6- When the camera is placed in it’s designed opening it can see clearly outside the enclosure.

4.8.6 References and File Links

[1] Cree XLamp XM-L LEDs. (2017). Cree. Accessed Feb. 7, 2023. [Online] Available: https://www.mouser.com/datasheet/2/90/XLampXML-221774.pdf

[2] XLamp® XM-L3 LEDs. (2023). Cree. Accessed Feb. 7, 2023. [Online] Available: https://assets.cree-led.com/a/ds/x/Xlamp-XML3.pdf

[3] LED Components Product & Application Guide. (2023) Cree. Accessed Feb. 7, 2023. [Online] Available: https://assets.cree-led.com/a/fs/Product-Guide.pdf

[4] NTTFS1D2N02P1E Power MOSFET. (2019). ON Semiconductor. Accessed Mar 10, 2023. [Online] Available: https://www.mouser.com/datasheet/2/308/NTTFS1D2N02P1E_D-1814208.pdf

[5] NTTFS1D2N02P1E Symbol and Footprint. (2023). Snap EDA. Accessed Mar 10, 2023. [Online] Available: https://www.snapeda.com/parts/NTTFS1D2N02P1E/ON%20Semiconductor/view-part/?ref=search&t=NTTFS1D2N02P1E

[6] NTTFS1D2N02P1E Symbol and Footprint. (2023). Ultra Librarian. Accessed Mar 10, 2023. [Online] Available: https://app.ultralibrarian.com/details/744422c6-b772-11ea-b5d0-0aebb021a1ea/onsemi/NTTFS1D2N02P1E?uid=105857381&exports=KiCAD&open=exports

4.8.7 Revision Table

2/26/2023	Kayla Osburn: Initial document made.
3/8/2023	Kayla Osburn: Details and more information added to document regarding design.

Table 4.16: Section 4.8 Revision Table

5.0 System Verification Evidence

5.1 Universal Constraints

5.1.1: The system must not include a breadboard
✓ Our system meets this constraint by not including a breadboard. (see below)

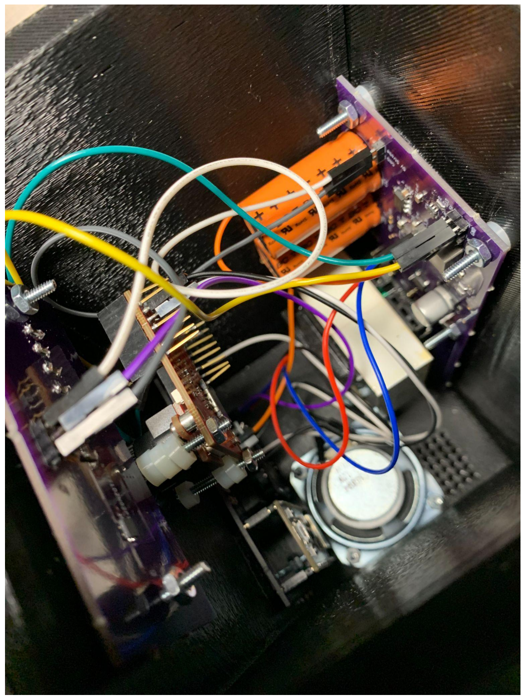


Figure 5.1: Internal Arrangement of Final System

As you can see, there are 5 components inside the enclosure. (see artifacts)
Front Panel (bottom): Control Board. (student designed PCB)
Front Panel (middle): OpenMV Cam. (PCB Module)
Front Panel (Top): Strobe Light PCB. (student designed PCB)
Rear Panel: Power Supply Board (student designed PCB)
Bottom/Floor: Speaker

5.1.2: The final system must contain a student designed PCB.
✓ The power supply, motion sensor, strobe light, and audio amp/speaker blocks were all implemented on student designed PCBs.

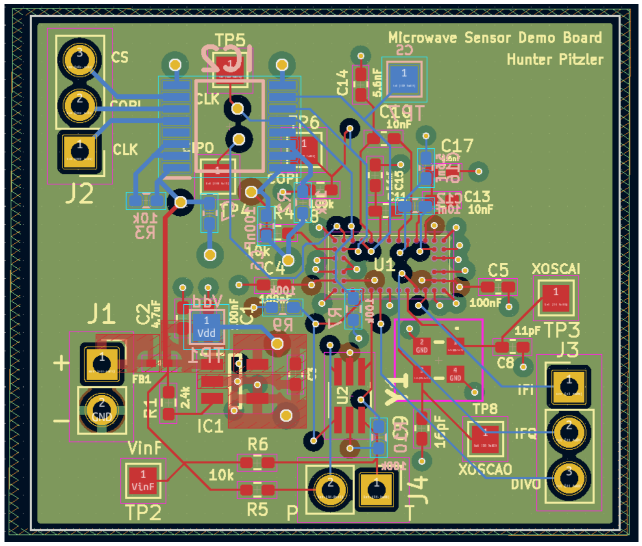


Figure 5.2: Microwave Motion Detector PCB Layout

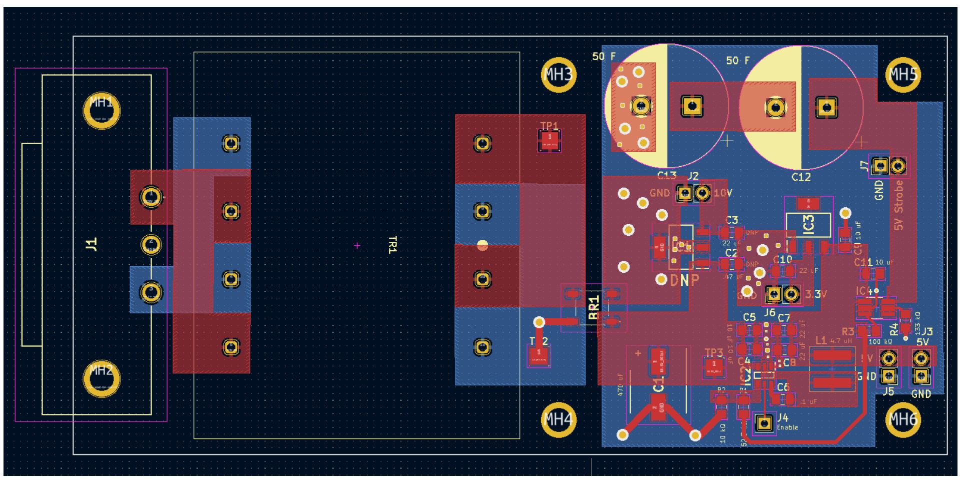


Figure 5.3: Power Supply PCB Layout

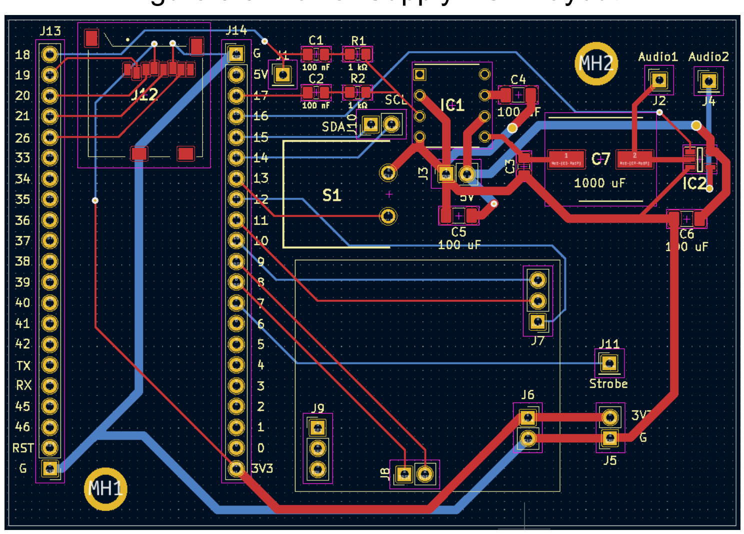


Figure 5.4: System Control PCB Layout

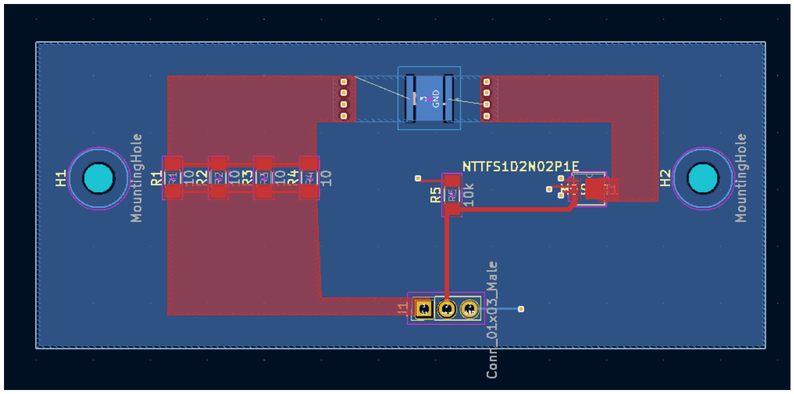


Figure 5.5: Strobe Light PCB Layout

Total SMT Pads: 226 (includes 34 BGA pads, we assumed those counted)

5.1.3: All connections to PCBs must use connectors
✓ Our system meets this constraint by using jumper wire connectors instead of directly soldering wires onto the PCBs.

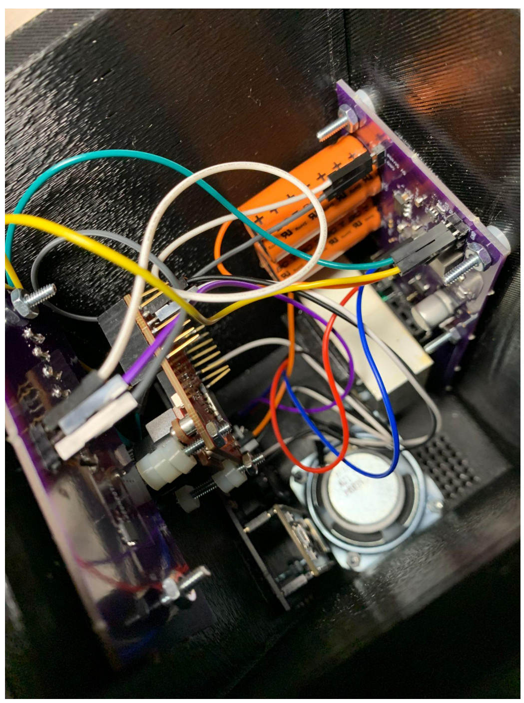


Figure 5.6: Internal Arrangement of Final System
The system uses 12 Jumper Wires

1. OpenMV Cam to System Control I2C SDA (Black)
2. OpenMV Cam to System Control I2C SCL (White)
3. System Control to Speaker Audio Waveform (White)
4. System Control to Speaker Audio Gnd (Black)
5. System Control to Strobe Light Enable (Purple)

6. Power Supply to System Control 3V3 (Blue)
7. Power Supply to System Control gnd (Red)
8. Power Supply to System Control 5V (Orange)
9. Power Supply to OpenMV Cam 5V (Green)
10. Power Supply to OpenMV Cam gnd (Yellow)
11. Power Supply to Strobe Light 5V (White)
12. Power Supply to Strobe Light gnd (Grey)

5.1.4: All power supplies in the system must be at least 65% efficient.
✓ The Power supply contains two Linear Regulators.

1. A 5V to 3.3V LDO which has an efficiency of 66% [1]
    a. Efficiency Calculation for LDO is $\frac{Vo}{Vi} = \frac{3.3}{5} = 0.66$

✓ The Power supply also contains one 14.5V to 5V switching regulator which operates with an efficiency greater than 80% [2]

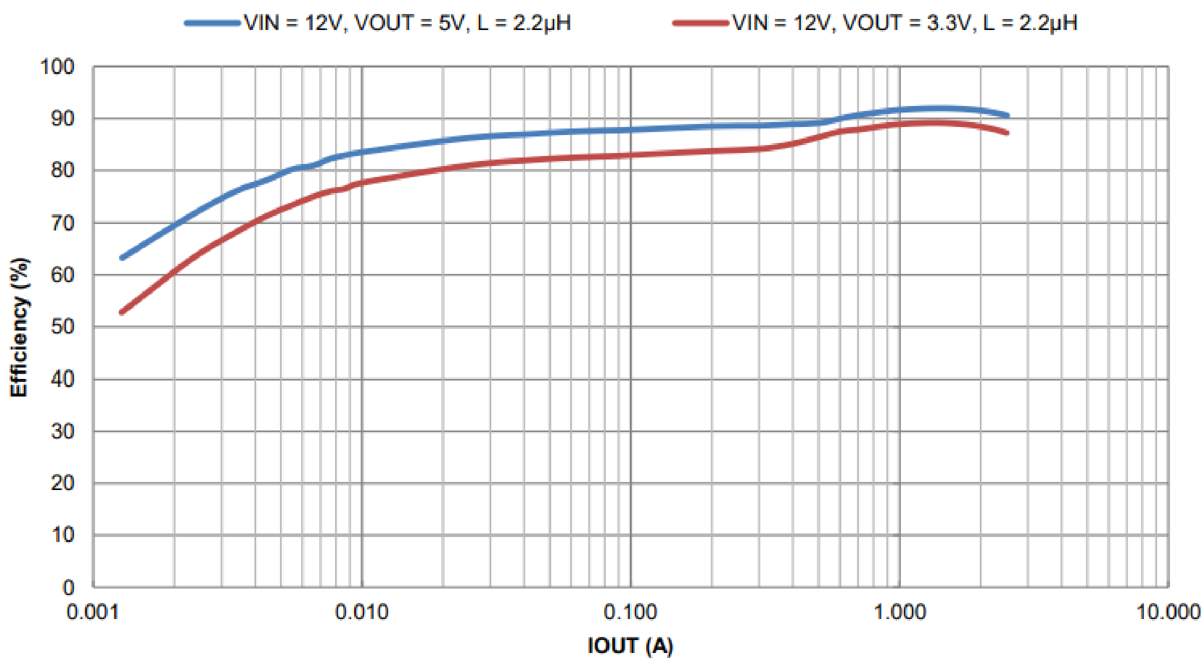


Figure 2. Efficiency vs. Output Current

Figure 5.7: Switching Regulator Chip Power Efficiency vs Supplied Current

5.1.5: The system may be no more than 50% built from purchased 'modules.'
✓ Only two blocks in the system utilize a pre-built ‘module’. These are the Camera Sensor block which utilizes the OpenMV Cam H7 Plus and the System Controller block which utilizes the
ESP32-S2-DevKitM-1R. This means that only ¼ or 25% of the system is built from purchased ‘modules’

Enclosure	Custom	Strobe Light	Custom
Code	Custom	Audio Amp	Custom
Motion Sensor	Custom	Camera	Pre-built module
Power Supply	Very Custom	Microcontroller	Pre-built module

Table 5.1: Custom vs Module Blocks Table

5.2 Requirements

5.2.1 Accuracy

1. **Project Partner Requirement:** System must be able to identify birds flying at the system
2. **Engineering Requirement:** System must successfully identify a bird flying at it 9 out of 10 times. Additionally the system will not respond to something other than a bird flying at it 7 out of 10 times
3. **Testing Method:** Test
4. **Verification Process:**

   1. Setup system on a bird feeder.

   2. Setup a video camera facing the bird feeder.

   3. Record 10 birds attempting to land on the bird feeder from the direction the system is facing.

   4. Record throwing an object of size 7.5cmx7.5cmx10cm at or slightly above the system 10 times total.

   Pass Condition: System responds to birds 9 out of 10 times and does not respond to not birds 7 out of 10 times.

5. **Testing Evidence:** Unproven, though not for lack of trying.

5.2.2 Bird Dataset

1. **Project Partner Requirement:** For this project we must create a dataset of images for ourselves and future projects.

2. **Engineering Requirement:** The project will generate a dataset of at least 100 relevant original pictures and 500 total variations of those pictures including the originals.
3. **Testing Method:** Inspection
4. **Verification Process:**

   1. Training dataset will be examined

      a. Total number of original pictures must be greater than 100

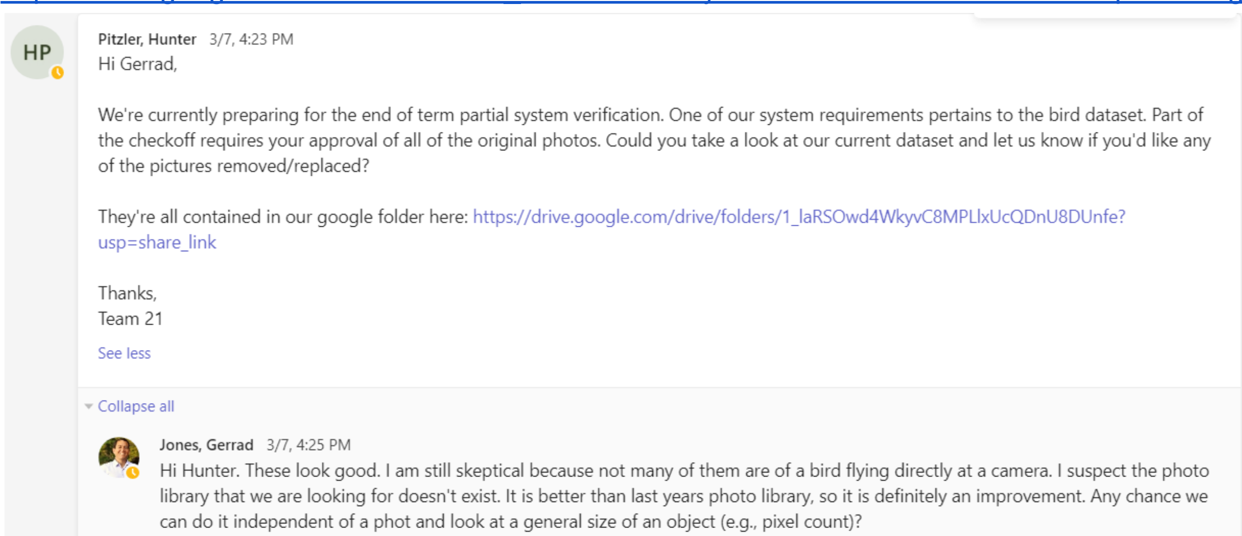
      b. All original pictures will pass project partner evaluation of relevance

      c. Total number of pictures (with augments) must exceed 500

   Pass Condition: Dataset meets conditions

5. **Testing Evidence:**

https://drive.google.com/drive/folders/1_IaRSOwd4WkyvC8MPLIxUcQDnU8DUnfe?usp=sharing


HP

Pitzler, Hunter 3/7, 4:23 PM

Hi Gerrad,

We're currently preparing for the end of term partial system verification. One of our system requirements pertains to the bird dataset. Part of the checkoff requires your approval of all of the original photos. Could you take a look at our current dataset and let us know if you'd like any of the pictures removed/replaced?

They're all contained in our google folder here: https://drive.google.com/drive/folders/1_laRSOwd4WkyvC8MPLlxUcQDnU8DUnfe?usp=share_link

Thanks,
Team 21

See less

Collapse all

Jones, Gerrad 3/7, 4:25 PM

Hi Hunter. These look good. I am still skeptical because not many of them are of a bird flying directly at a camera. I suspect the photo library that we are looking for doesn't exist. It is better than last years photo library, so it is definitely an improvement. Any chance we can do it independent of a phot and look at a general size of an object (e.g., pixel count)?

Figure 5.8: Project Partner Approval of Bird Dataset

Date Verified: 3/7

5.2.3 Effective

1. **Project Partner Requirement:** System must be able to deter a bird from hitting a window.
2. **Engineering Requirement:** System must include a deterrent method proven to alter birds flight paths. 7 out of 10 deterred birds must not collide with the window.
3. **Testing Method:** Test
4. **Verification Process:**

1. Setup system on a bird feeder.

2. Setup a video camera facing the bird feeder.

3. Record the reaction of 10 birds which the system responds to.

Pass Condition: Bird is successfully deterred from landing on the bird feeder 7 out of 10 times.

5. **Testing Evidence:** Unproven, though not for lack of trying.

5.2.4 Marketability

1. **Project Partner Requirement:** System must be marketable
2. **Engineering Requirement:** The system will be reported as something a user wants to buy after taking into account cost, usability/complexity, and setup/maintenance by 9 out of 10 users.
3. **Testing Method:** Analysis
4. **Verification Process:**

1. Survey will be created on google forms. Survey will be distributed by email to the local Audubon Society and to the OSU bird nerds. Email will request that the recipient forward the survey to people they know so that a diverse sample group can be obtained.

Pass Condition: 9 out of 10 people indicate they would be interested in buying the product or believe that there would be a consumer demand for the product. (Question 2, any response except Not interested at all)

5. **Testing Evidence:** (See Project Artifacts for Full Survey)

OSU Bird Deterrent Project

Team 21 <osuactivebirddeterrent@gmail.com>
to Audubon.Corvallis

Hello Audubon,

We are a group of engineering students at Oregon State University working on our capstone project to develop an active window bird deterrent in order to reduce bird collisions. The idea is to have the device constantly scanning for birds, and when one is detected approaching the window, it will use light/sound to warn the bird off.

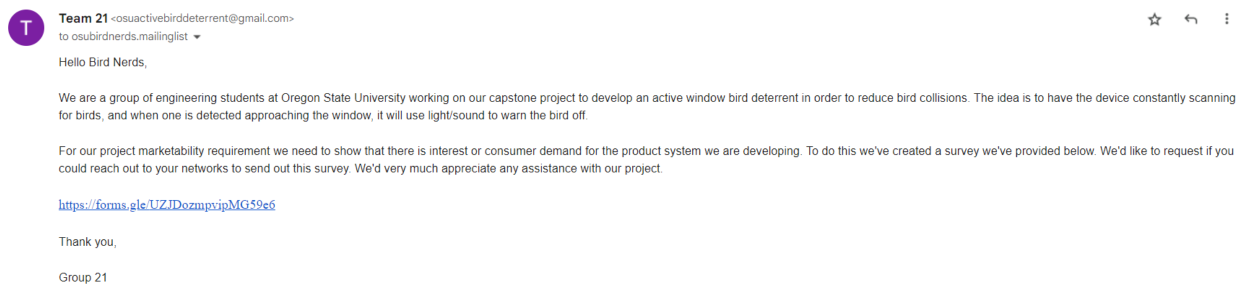
For our project marketability requirement we need to show that there is interest or consumer demand for the product system we are developing. To do this we've created a survey we've provided below. We'd like to request if you could reach out to your networks to send out this survey. We'd very much appreciate any assistance with our project.

Bird Deterrent Survey

Thank you,

Group 21

Figure 5.9: Survey Distribution to Audubon Societies


Team 21 <osuactivebirddeterrent@gmail.com>
to osubirdnerds.mailinglist

Hello Bird Nerds,

We are a group of engineering students at Oregon State University working on our capstone project to develop an active window bird deterrent in order to reduce bird collisions. The idea is to have the device constantly scanning for birds, and when one is detected approaching the window, it will use light/sound to warn the bird off.

For our project marketability requirement we need to show that there is interest or consumer demand for the product system we are developing. To do this we've created a survey we've provided below. We'd like to request if you could reach out to your networks to send out this survey. We'd very much appreciate any assistance with our project.

https://forms.gle/UZJDozmpvipMG59e6

Thank you,

Group 21

Figure 5.10: Survey Distribution to OSU Bird Nerds Club

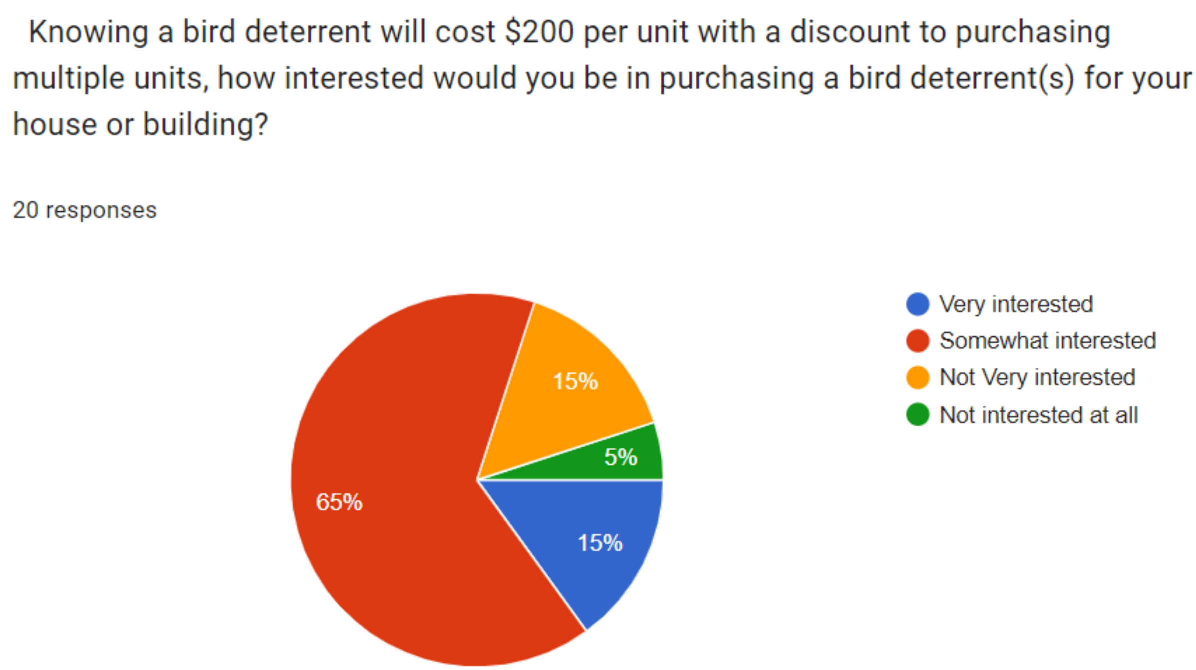


Figure 5.11: Survey Interest Results Pi-Chart

https://docs.google.com/forms/d/1_7Jsg2OnA8TdC-ZB4AkoRlof1R3DPEqISJn9XdULWbM/edit#responses

Date Verified: 5/9/23

5.2.5 Mountable and Compact

1. **Project Partner Requirement:** System must be portable/mountable.
2. **Engineering Requirement:** The system must be smaller than 3600 cm3 and have a permanent outdoor mounting mechanism.
3. **Testing Method:** Test

4. **Verification Process:**
   1. Measure maximum dimension of square(ish) enclosure.

   2. Test mounting by mounting the device to a vertical surface (plywood equivalent).

5. **Pass Condition:** Dimensions cubed don't exceed 3600 cm3 and system stays connected to mounting surface without human support
6. **Testing Evidence:**
   i. **Compact:** The enclosure is 12cm x 12cm x 19.5cm which equals 2,808 cm3 which is well below the size constraint of 3600 cm3. See photos below for proof of measurement.
   ii. **Mountable:** See photos below of proof of vertical mounting.

Figure 5.12: Horizontal Measurement of System Enclosure

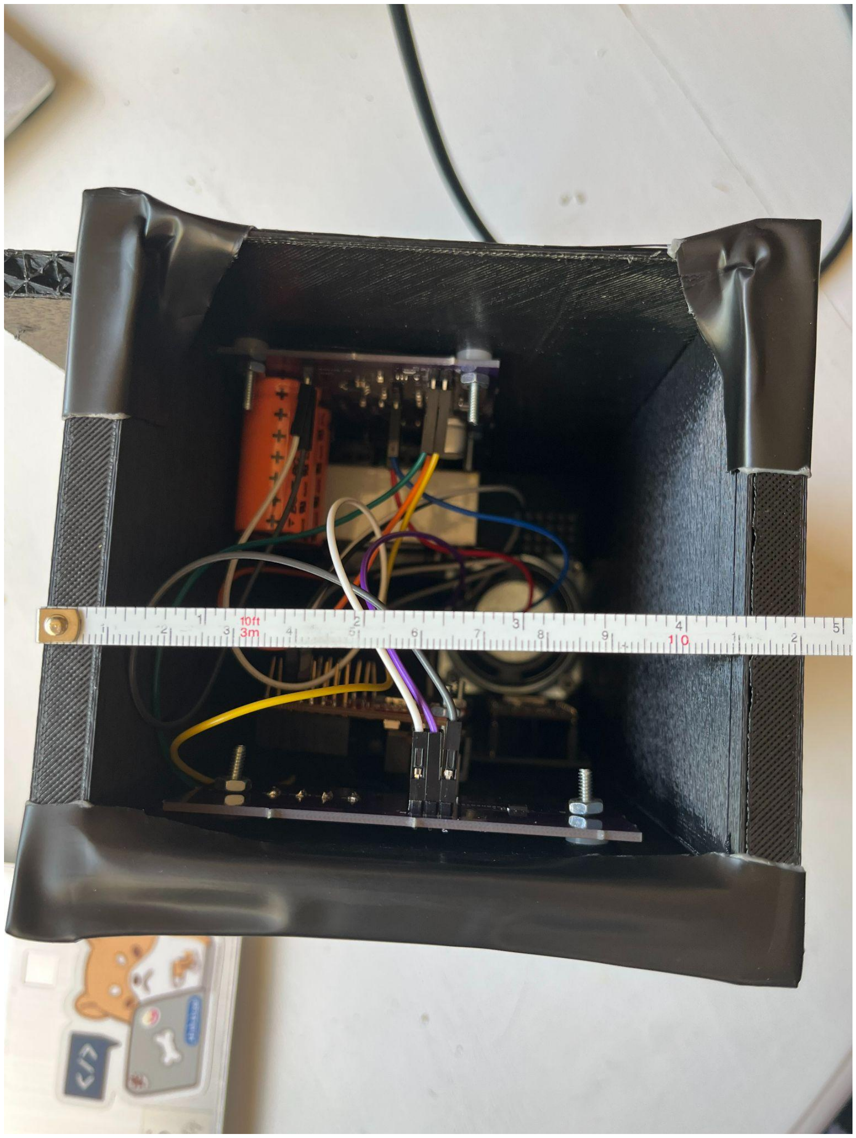


Figure 5.13: Horizontal Measurement of System Enclosure

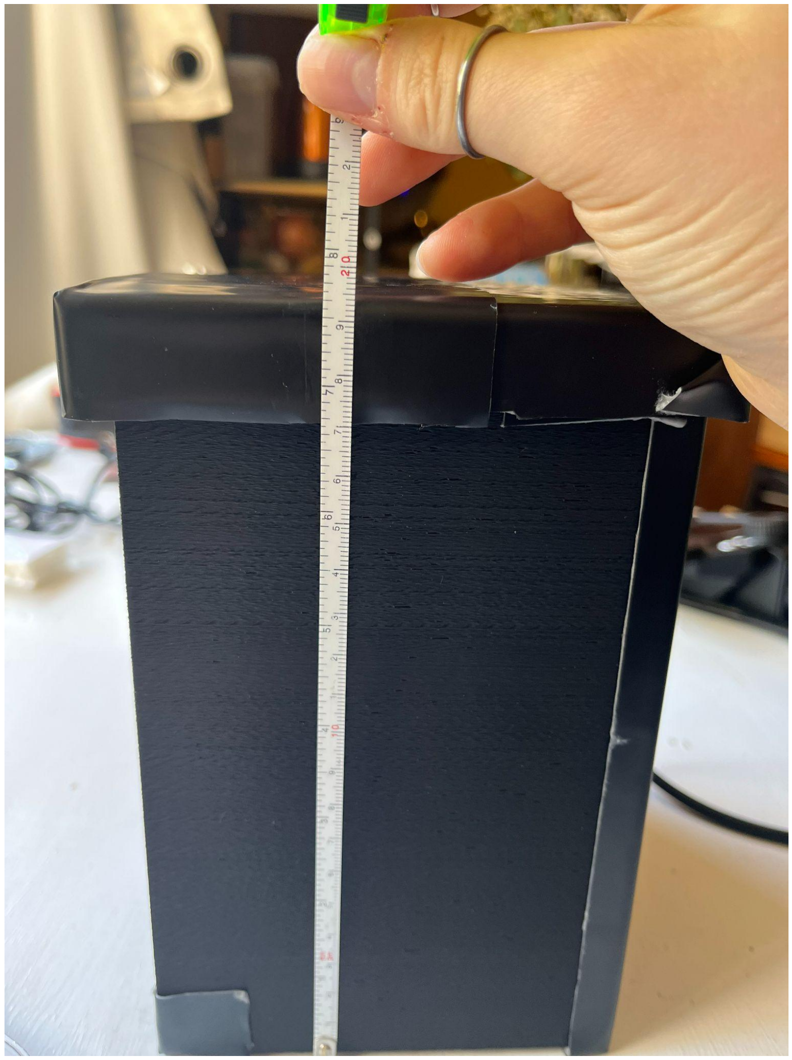


Figure 5.14: Vertical Measurement of System Enclosure

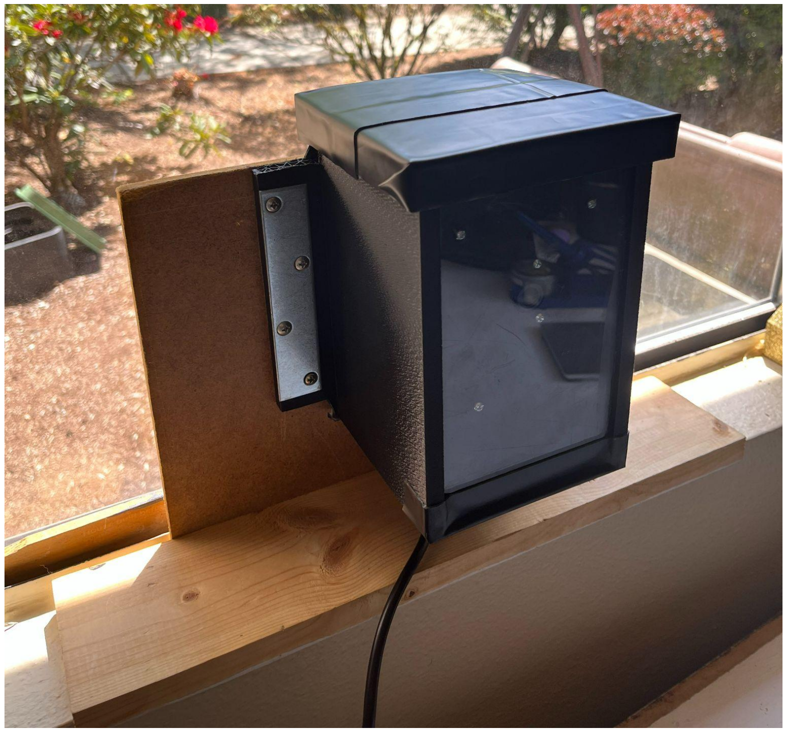


Figure 5.15: Mounted System

Date Verified: 4/16/23

5.2.6 Outdoors

1. **Project Partner Requirement:** System must be able to operate outdoors
2. **Engineering Requirement:** System must operate in the temperature range of 0 to 100°F and must not allow water to enter the enclosure when exposed to a spray of at least 1 gallon per minute sprayed from above for 30 seconds.
3. **Testing Method: Test**
4. **Verification Process:**

1. Temperature Range

a. Place the system and a thermometer in a freezer.

b. Wait until thermometer indicates temperature is at 0°F

c. Observe if the system is still operational (obstruct camera to elicit response).

d. Place the system and a thermometer in a cardboard box and heat the interior using a hot air gun.

e. Repeat steps b and c for 100°F.

2. Water Resistant

a. Using a hose and spray nozzle, choose a spray rate and verify it fills a 4.25 gallon bucket in under 4 minutes 15 seconds.

c. Spray enclosure for 30 seconds at verified spray rate.

d. Observe if the system is still operational (obstruct camera to elicit response).

Pass Condition: System operates at extreme temperatures and after showering.

5. **Testing Evidence:**

Part 1 (Cold): https://youtube.com/shorts/nweHWIyEbL8

Part 2 (Hot): https://youtu.be/4KEIBeLm0FU

Part 3 (Wet): https://youtu.be/K820F_TXeXs

Date Verified: 5/7/23

5.2.7 Power Consumption

1. **Project Partner Requirement:** System must be marketable.
2. **Engineering Requirement:** The system must not exceed an average power consumption of 5W (calculated over hour span) and must not draw more than 12W instantaneously.
3. **Testing Method:** Analysis
4. **Verification Process:**

1. Using a Wall Power meter, such as the Floureon TS-836A Plug Power Meter, AC input power will be analyzed during normal operating mode and peak operating mode (bird is detected and system responds).

2. Based on analysis of the estimated number of bird detections per hour, the average power consumption will be calculated.

- Calculation only required if max power draw exceeds 5W, otherwise the average power cannot exceed 5W and calculation is unnecessary.

Pass Condition: Power consumption during peak operating mode is under 12W and average power consumption is under 5W.

5. **Testing Evidence:** https://youtu.be/v6s8aSXus3M

   Date Verified: 5/7/23

5.2.8 Sensor Redundancy

1. **Project Partner Requirement:** The project should continue last year's progress with using an AI Camera to detect birds, but should also incorporate an additional sensing method to augment the AI Camera's ability to respond to birds.
2. **Engineering Requirement:** The system will detect and respond to motion when the camera is obstructed.
3. **Testing Method:** Test
4. **Verification Process:**
   1. Camera will be covered (with post it note or similar obstruction).

   2. An object of size 7.5cmx7.5cmx10cm will be thrown at or slightly above the system 10 times total.

   3. The throws will be conducted from at least 5 feet away from the system.

   Pass Condition: System detects and responds to motion of bird sized object when camera view is obstructed 9 out 10 times.

5. **Testing Evidence:** https://youtu.be/4JkqF3t_Xdo

   Date Verified: 5/7/23

5.3 Reference and File Links

[1] *Low Dropout Linear Regulator with Industrial Temperature Range*. (2015). Diodes Incorporated. Accessed Jan 14, 2023. [Online] Available: https://www.mouser.com/datasheet/2/115/DIOD_S_A0001413888_1-2541960.pdf

[2] *4.2V to 18V Input, 2.5A Low IQ Synchronous Buck Converter*. (2021). Diodes Incorporated. Accessed Jan. 17, 2023. [Online] Available: https://www.mouser.com/datasheet/2/115/DIOD_S_A0011756658_1-2543704.pdf

5.4 Revision Table

5/8/2023	Hunter: Added testing evidence and revised testing procedures where necessary
4/27/2023	Hunter: Revised testing procedures for spring term requirements
3/7/2023	Hunter: Moved Section 5 material from student portal and reformatted

Table 5.2: Section 5 Revision Table

6.0 Project Closing

6.1 Future Recommendations

6.1.1 Technical Recommendations

Recommendation 1: For this project we used OpenMV's OpenMV Cam H7 Plus to visually inspect and run ML to identify what was moving when the motion detector was activated. However, the OpenMV Cam H7 Plus is expensive, recently has been hard to obtain, and consumes a lot of power. We believe a future group should spend some time exploring alternate camera + ML solutions or figure out how to build an H7 Plus equivalent (since OpenMV is open source). [1]

Recommendation 2: While the OpenMV Cam draws a lot of power, the rest of the system doesn't consume much power when no motion is detected. We believe that future groups should consider optimizing power consumption for the system, and look into the viability of using a battery or some alternate power source to power the system. [2]

Recommendation 3: With the Power source size/weight reduced and other optimizations, we believe future groups should consider making the enclosure as small as operationally possible. This year's enclosure was bigger than was strictly necessary to house the system, and the system was perhaps a bit bigger than strictly necessary to perform its required actions.

Recommendation 4: Our system creates should by using the ESP32s2's DAC to write a waveform which is then amplified and played on a speaker. However, the DAC is only 8 bits and the ESP32s2 isn't designed for audio playback. We believe a future group should consider incorporating more specialized hardware such as the MCP4725 [3] for crisper audio playback.

6.1.2 Global Impact Recommendations

Recommendation 1: Consider public safety, the environmental, cultural, and social impacts of any deterrent method chosen for use in a bird deterrent. For instance a sound you can use as an audio deterrent may be disruptive to the communities where these devices are being used. [4] Take careful consideration with deterrent mechanisms the team is considering to build their project with in mind. Test these deterrent methods early if possible before implementing within the design.

Recommendation 2: Take careful stock of the costs associated with implementing any deterrent method chosen for the project's marketability. Consider device costs into overall production costs and availability of that cost to users.

Recommendation 3: Consider dimming the brightness of LED, to accommodate those that are photosensitive. From our research we determined that approximately 1 out of 4000 individuals are affected by photosensitive epilepsy [5] which is why it may be important to look into this issue of the brightness of the light. Some suggestions that we have for this would be increasing the resistance to decrease the amount of current going to the LED. Additionally, you can look into a different LED that is not as bright.

6.1.3 Teamwork Recommendations

Recommendation 1: Upon first glance this class appears to be laid out so that Fall term is for high level research and planning, Winter term is for low level implementation and testing, and Spring is for integration of low level blocks into the high level system + Verification. However, you really should start implementing in Fall and plan to have the system complete by the end of Winter. Spring is then for testing, writeup, and general verification. Everything happens quicker than you think it will.

Recommendation 2: Talk to your project partner early and really listen to what he has to say. Garret has been working on this project for a couple of years now, and he's gathered quite a few good ideas related to it. Make sure to touch base with him often and keep him in the loop.

Recommendation 3: Plan to have two meetings per week, at least one of which is in person. This allows for stronger communication, as well as adaptability. There are going to be times when someone can't make a regularly scheduled meeting. By having two scheduled per week, you should still be able to have at least one meeting per week that everyone attends. This should help keep everyone on track and on the same page. [6]

Recommendation 4: Plan at least one or two times a term to meet with your group in person to do something fun like a game night or bowling or any type of hangout so you can get to know your team more and become more comfortable with each other so each person feels supported more and more comfortable communicating, asking for help and working together. [7]

6.2 Project Artifact Summary with Links

In this section we lay out as much of the technical artifacts as we can reasonably include in a document format. In order to make this document self-sufficient, we include copies of all relevant schematics and layout here. However, everything needed to understand and replicate our design can be accessed through the following link to our open source project github page.

Link to Project Github: https://github.com/pitzlerha/Bird-Detterent
Link to Microcontroller Final Code:
https://github.com/pitzlerha/Bird-Detterent/blob/main/Final_Artifacts/Microcontroller_Code/main/microwave_board_test_main.c

The first artifact we include is the Control Board. The Control Board is screwed to the bottom of the front panel of the enclosure through mounting holes 1 and 2. The control board contains the system microcontroller board, the ESP32-S2-DevKitM-1R, on the left as well as the ability to add a sd card reader, though we ultimately did not do so. On the bottom right it has connections to interface with the motion detector PCB which faces towards the Control Board PCB to look through the board and enclosure towards oncoming birds. Finally in the top right the board contains the Audio Amp circuitry.

This board contains 9 pin headers that need to be routed to other PCBs in the design. The connections are as follows:

3V3 (bottom right): -> 3.3V output of Power Supply PCB
G (bottom right): -> 3.3V Ground output of Power Supply PCB
Strobe (bottom right): -> Gate signal input of Strobe Light PCB
Audio2 (Top Right): -> Input signal for Speaker
Audio G (Top Right): -> Ground for Speaker
5V (Top Middle): -> 5V output of Power Supply PCB
G (Top Middle): -> 5V Ground output of Power Supply PCB
SCL (Top Left of Center): -> I2C SCL pin of OpenMV Cam
SDA (Top Left of Center): -> I2C SDA pin of OpenMV Cam

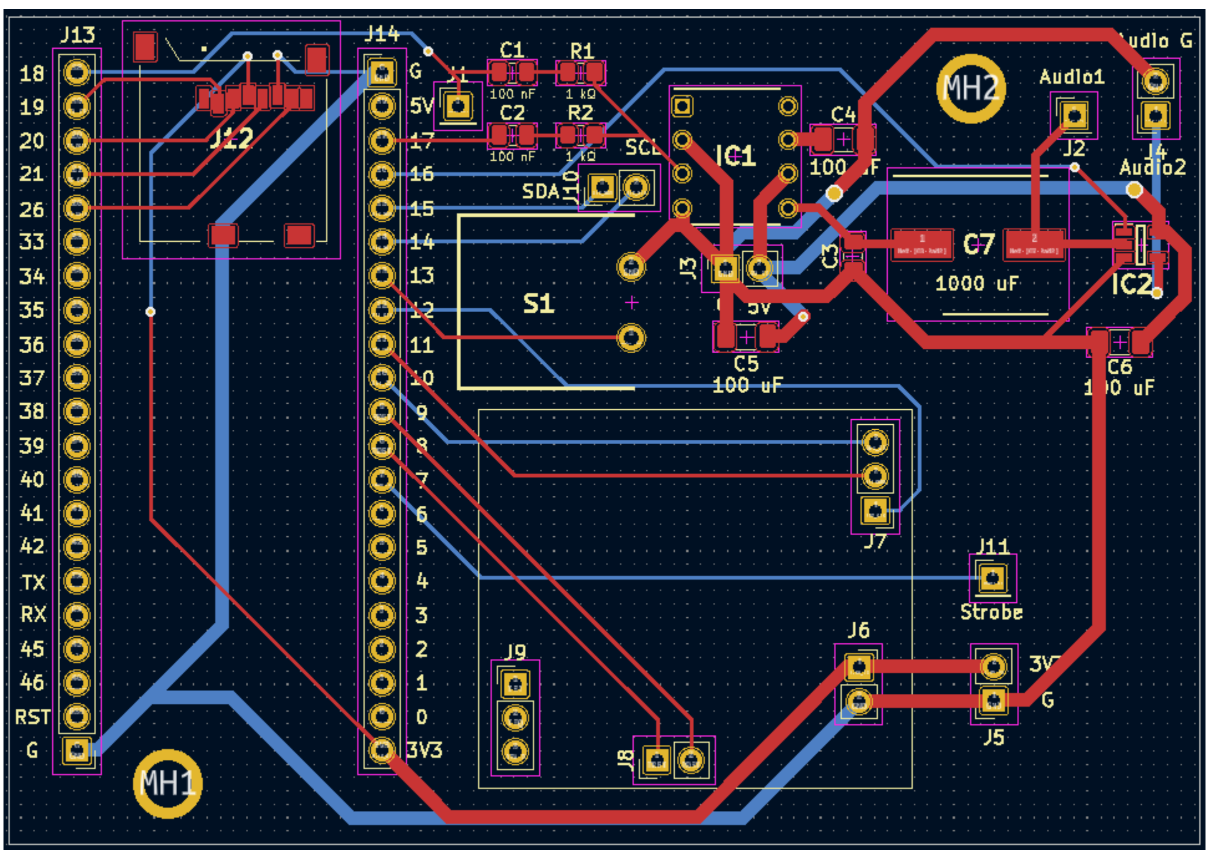


Figure 6.1: Control Board PCB Layout

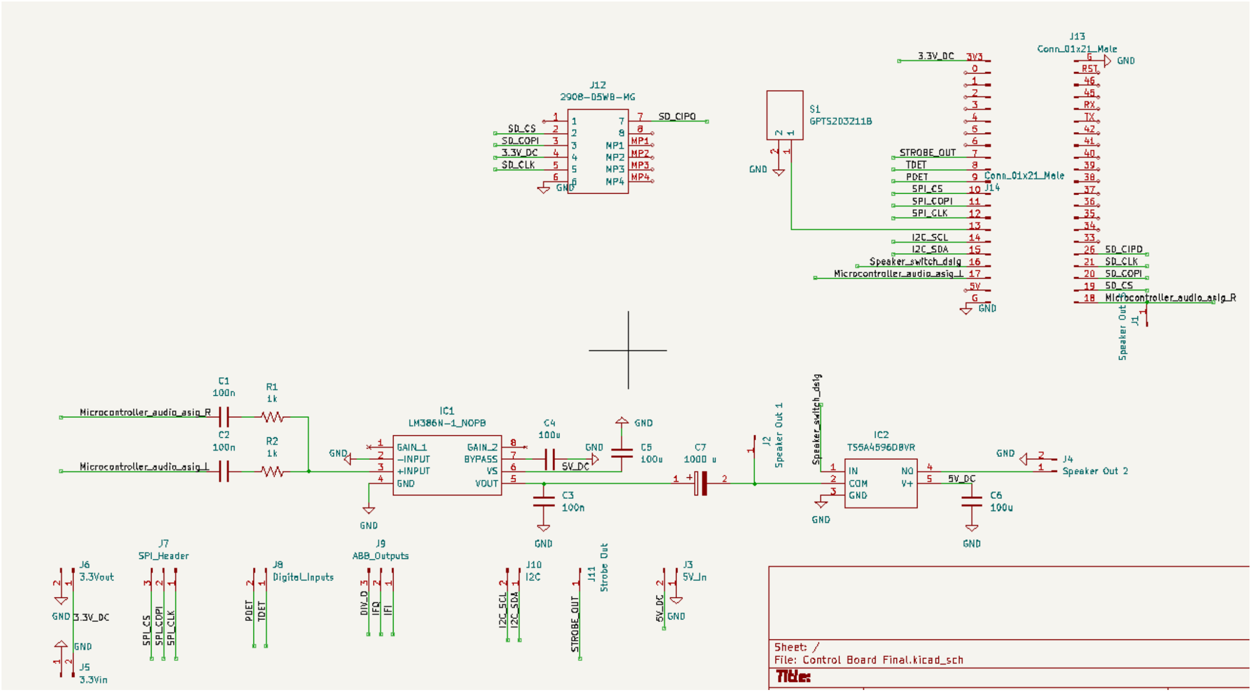


Figure 6.2: Control Board Schematic

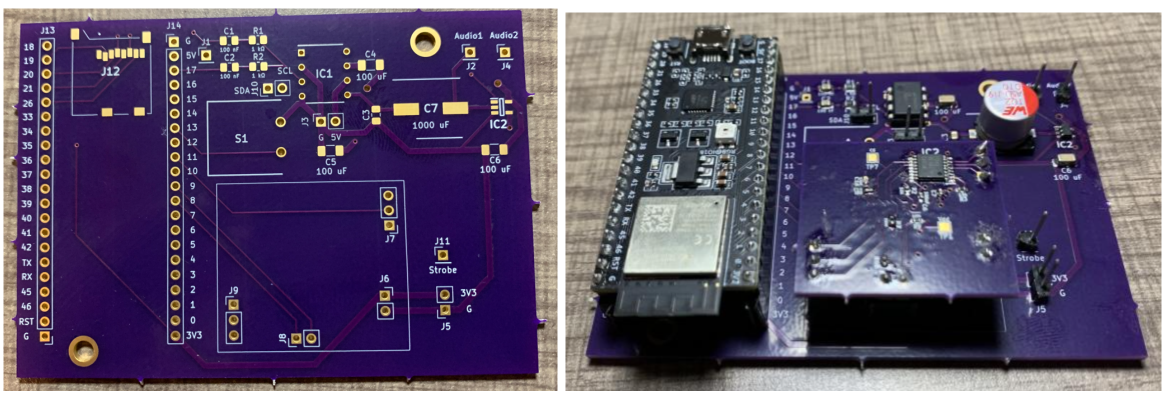


Figure 6.3: Control Board PCBs (Unpopulated and Populated)

The second artifact we include is the Motion Sensor PCB. The Motion Sensor PCB has male pin headers that connect directly to the corresponding female pin headers on the Control PCB. When connected, the green doppler radar MMIC should face down towards the Control PCB. The 60 Ghz radar transmitted and received by the board has the ability to transverse through the PCB and enclosure to detect motion outside in front of the system.

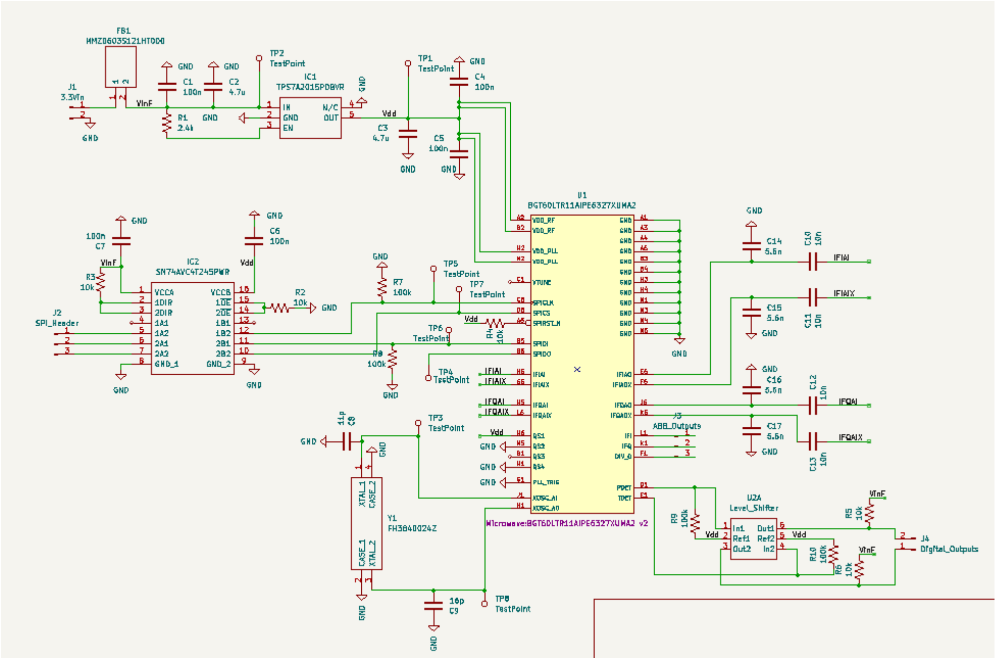


Figure 6.4: Motion Sensor Schematic

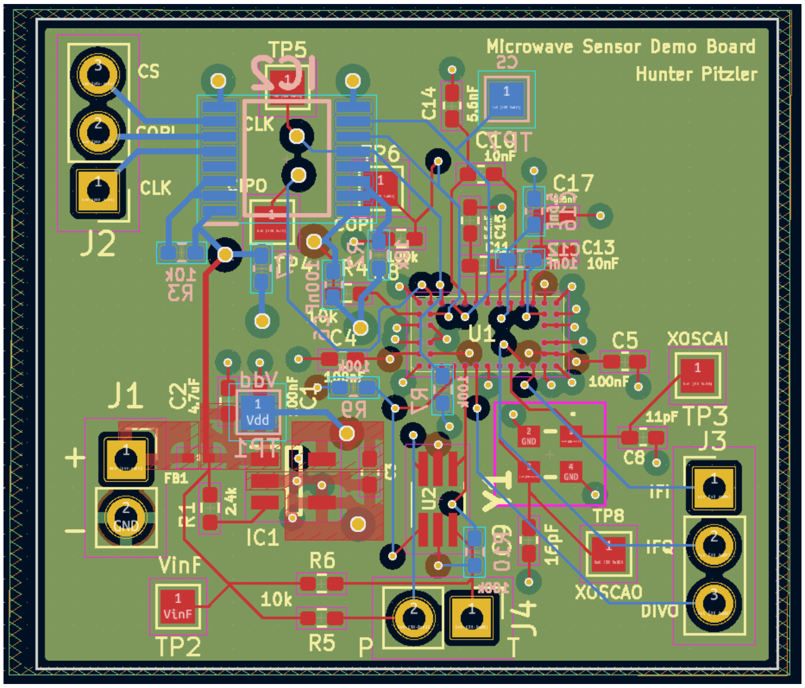


Figure 6.5: Motion Sensor PCB Layout

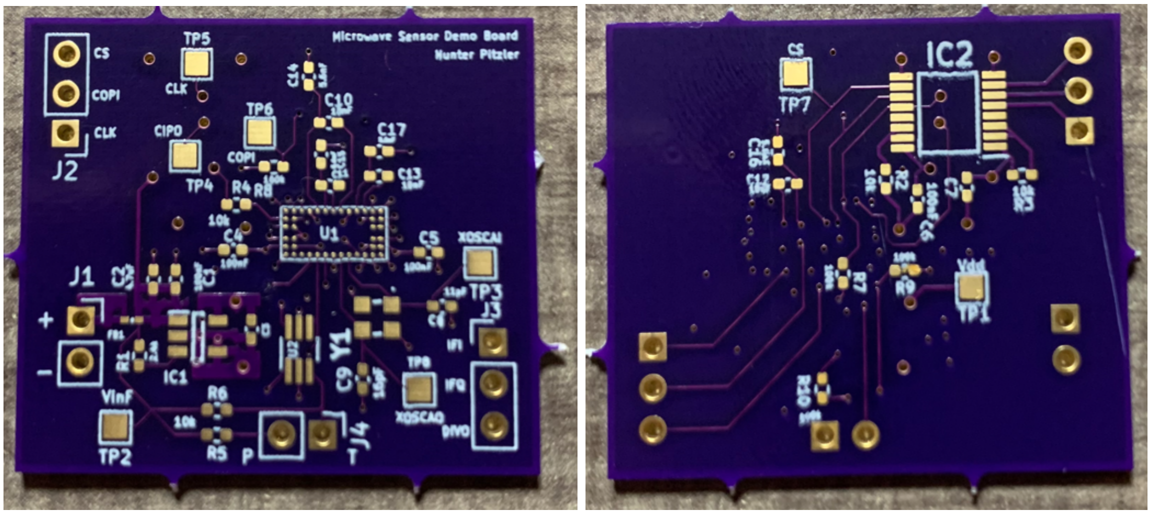


Figure 6.6: Unpopulated Motion Sensor PCB (Front and Back)

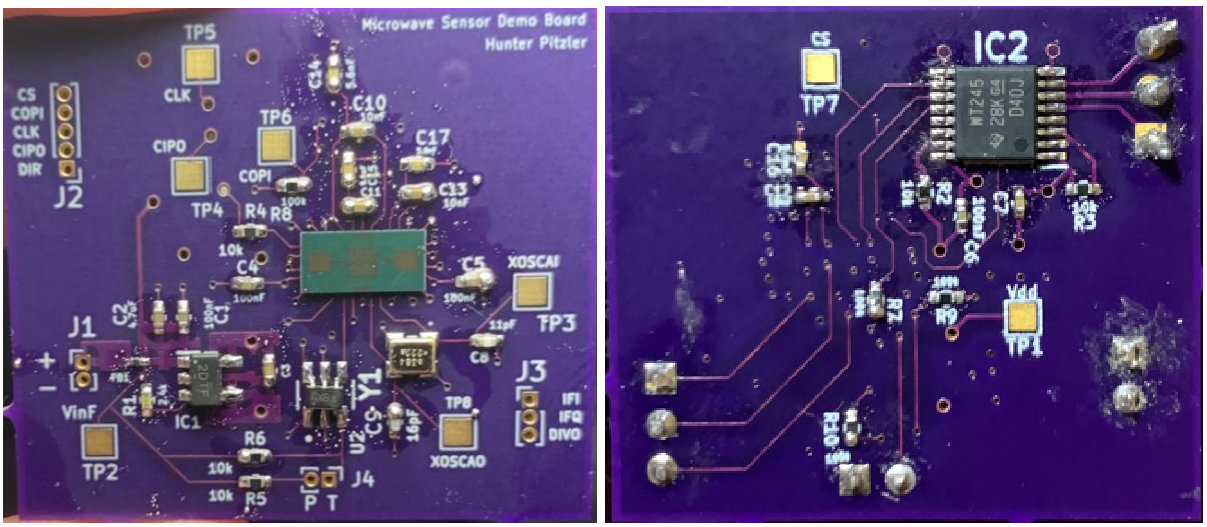


Figure 6.6: Populated Motion Sensor PCB (Front and Back)

Provided in the link below is firmware written to be run on the ESP32-S2-DevKitM-1R microcontroller board. If the Motion Sensor PCB is assembled and connected properly, the DevBoard's LED will turn blue when no motion is detected, and green or red when motion is detected, depending on the directionality of the motion relative to the sensor.

Link to ESP32s2-BGT60LTR11(B)AIP firmware:
https://github.com/pitzlerha/Bird-Detterent/tree/main/Microwave-Sensor/Demo-Code

The third artifact we include is the Power Supply Board. The Power Supply Board is screwed to the bottom of the back panel of the enclosure through mounting holes 1-6. The Power Supply Board contains the circuitry necessary to power the system from 120 VAC 60 Hz Wall Power. Originally we planned to power the audio amp with a 10V supply, but we later changed that supply to 5V. As such IC1 no longer needs to be included when the board is assembled, and the 10V output header pins can be ignored.

This board contains 9 pin headers that need to be routed to other PCBs in the design. The connections are as follows:

3.3V (Right Center): -> 3.3V input of Control Board PCB
GND (Right Center): -> 3.3V ground input of Control Board PCB
5V (1) (Bottom Right): -> 5V input of Control Board PCB
GND (1) (Bottom Right): -> 5V ground input of Control PCB
5V (2) (Bottom Right): -> 5V input of OpenMV Cam
GND (2) (Bottom Right): -> 5V ground input of OpenMV Cam
5V Strobe (Top Right): -> 5V input of Strobe Light PCB
GND (Top Right): -> 5V ground input of Strobe Light PCB

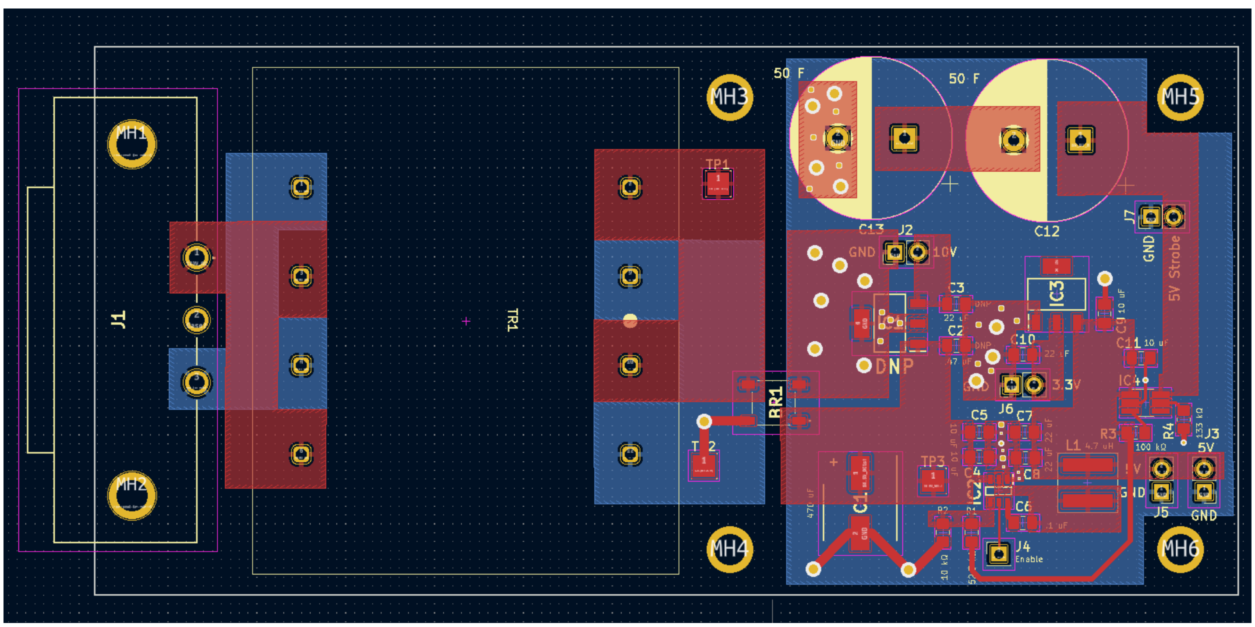


Figure 6.7 Power Supply Board PCB Layout

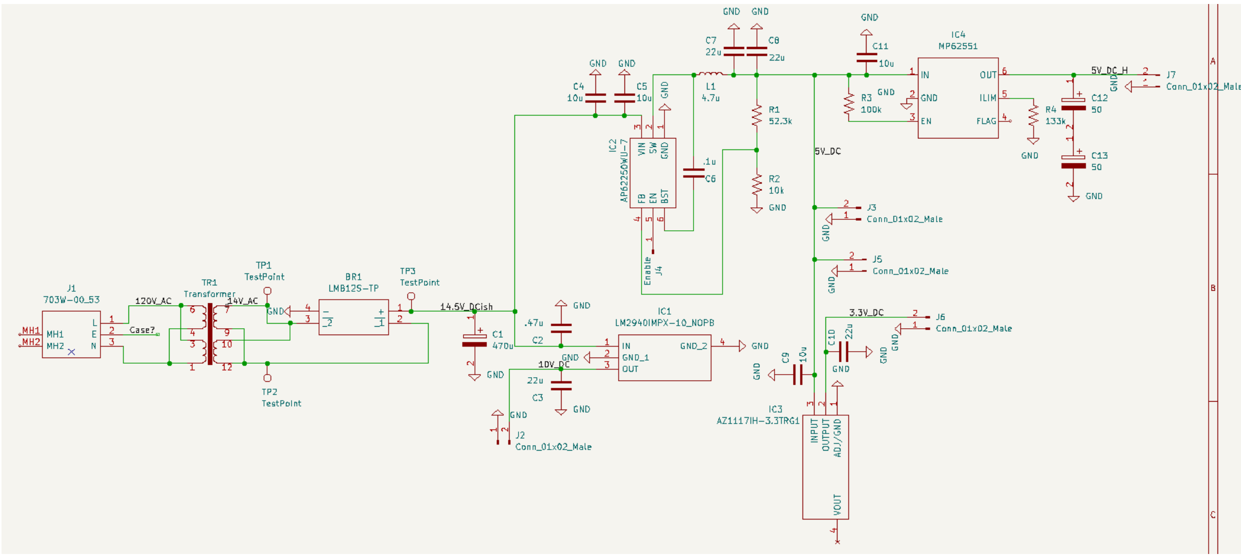


Figure 6.8: Power Supply Schematic

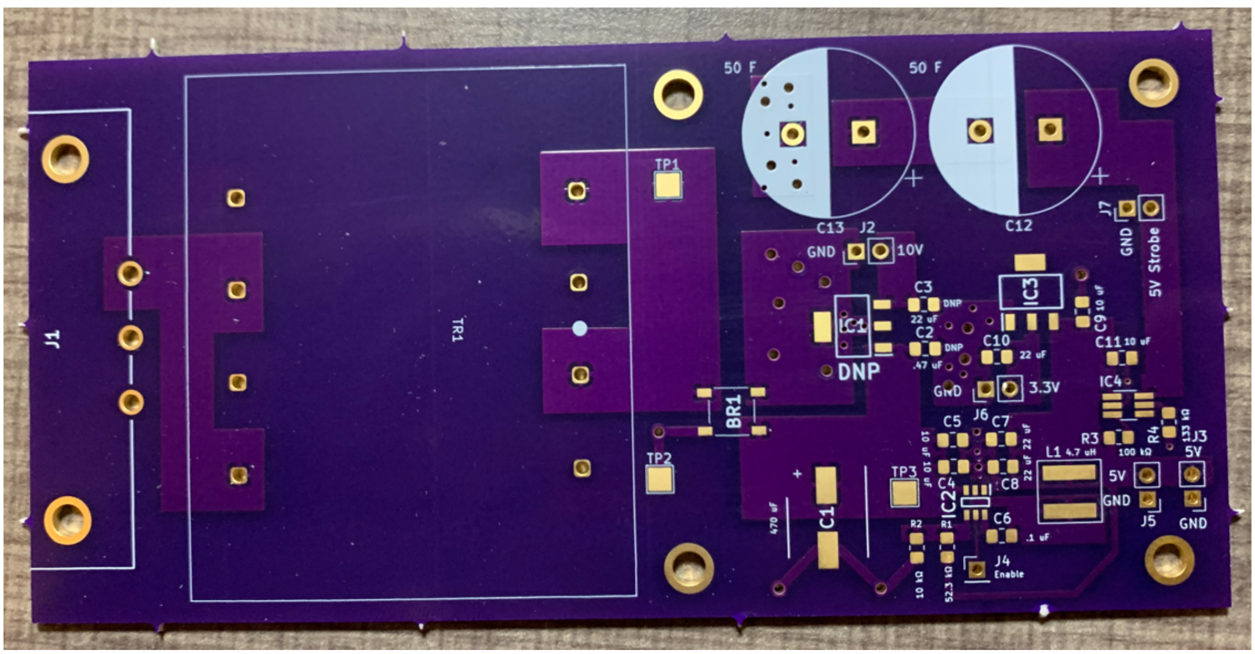


Figure 6.9: Power Supply Board Unpopulated PCB

Figure 6.10: Power Supply Board Populated PCB

The fourth artifact we include is the Strobe Light PCB. The Strobe Light PCB is screwed to the Top of the front panel of the enclosure through mounting holes 1 and 2. The PCB should be mounted with the light facing outwards (even with the hold in the enclosure). The Strobe Light PCB contains the circuitry necessary to power and control the strobe light. When the gate signal input is high (3.3V) the light is on. When the gate signal input is low (GND) the light is off.

This board contains 3 pin headers that need to be routed to other PCBs in the design. The connections are as follows:

5V Strobe (Side with resistors): -> 5V Strobe output of Power Supply PCB
Gate Signal (Middle): -> Strobe Control Signal output of Control Board PCB
GND (Side without resistor): -> 5V Strobe ground output of Power Supply PCB

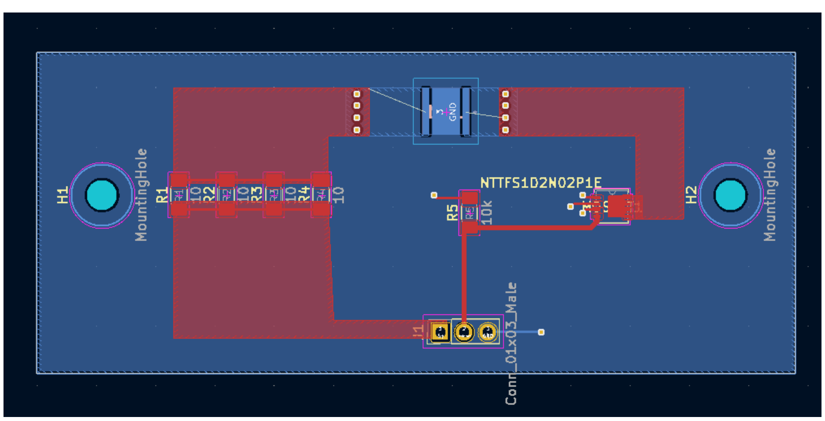


Figure 6.11: Strobe Light Board PCB Layout

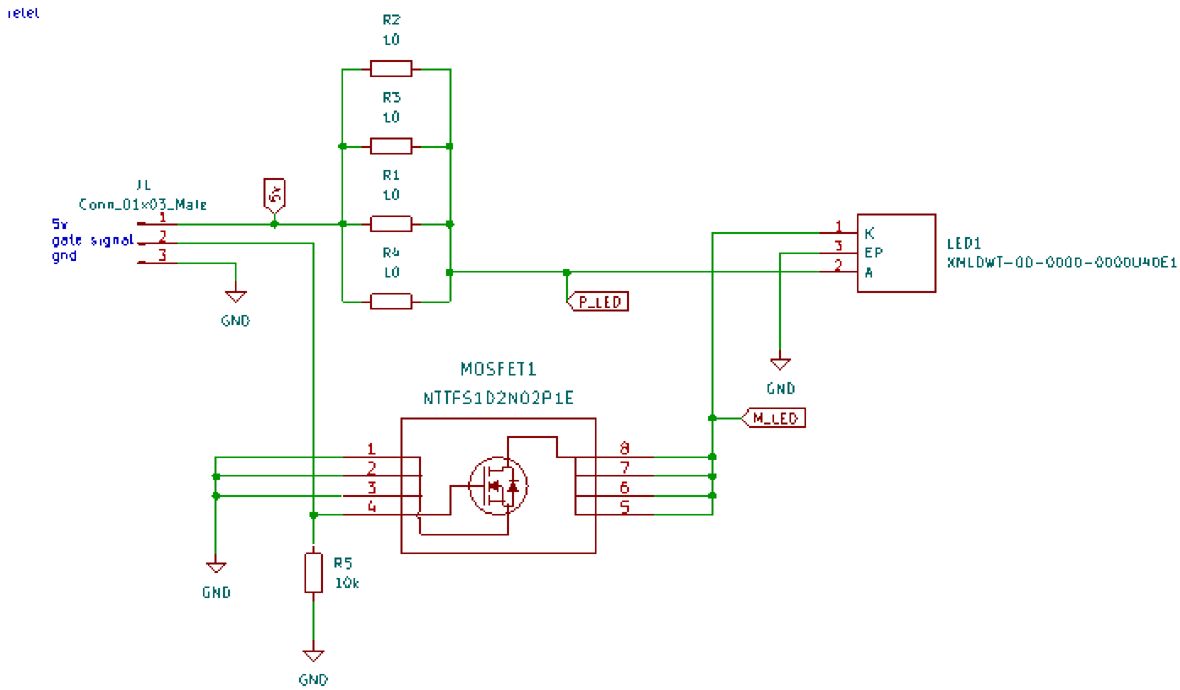


Figure 6.12: Strobe Light Schematic Design

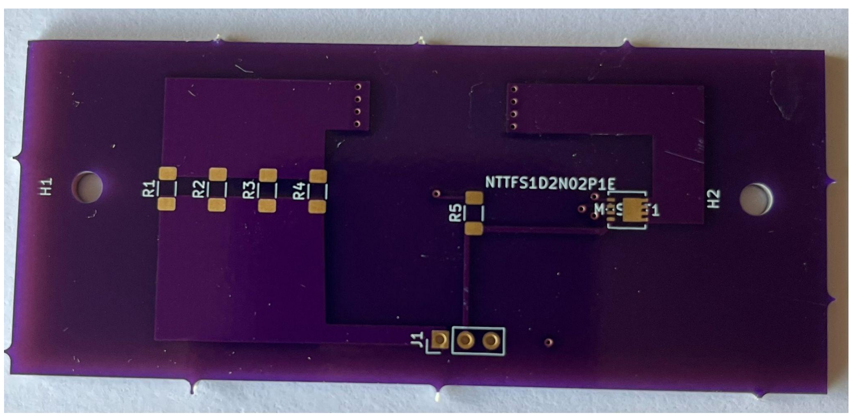


Figure 6.14: Strobe Light Board Front Unpopulated PCB

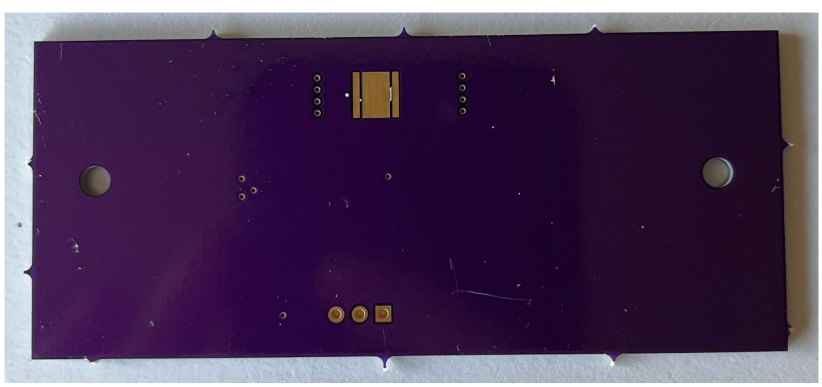


Figure 6.15: Strobe Light Board Back Unpopulated PCB

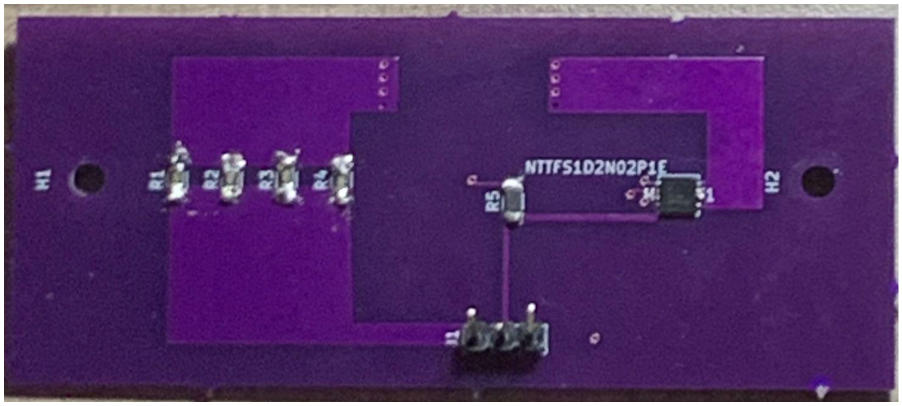


Figure 6.16: Strobe Light Board Front Populated PCB

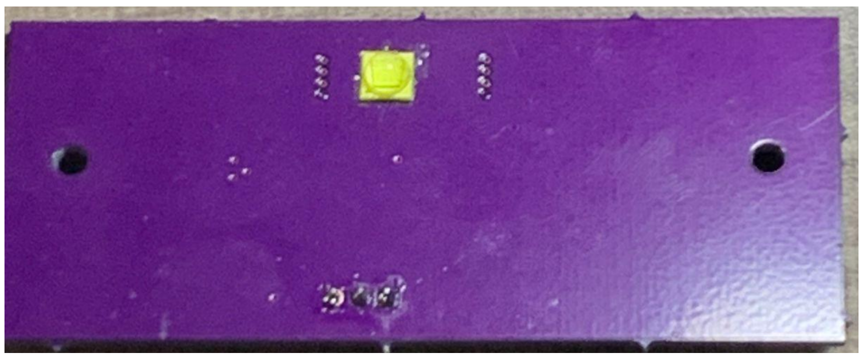


Figure 6.17: Strobe Light Board Back Unpopulated PCB

The fifth artifact we include is the Enclosure. The Enclosure is made up of 5 pieces. The main body which the 4 PCBs (Control Board, OpenMV Cam, Strobe Light, Power Supply) and Speaker are attached to, a back sliding panel, a front sliding panel, A clear front sliding panel, and a lid. Once the entire enclosure is assembled, black waterproof Gorilla tape is used to waterproof all the seams and layer of the Lid ensuring the enclosure is completely water resistant.

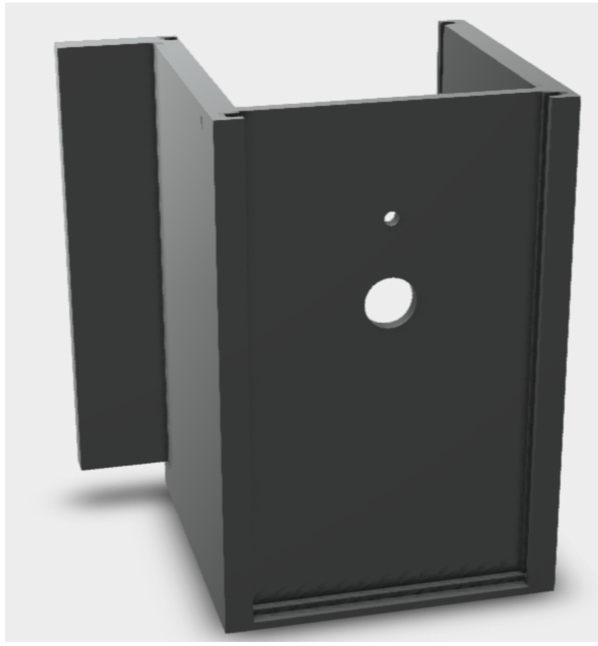


Figure 6.18: Front view of the enclosure’s main body.

Figure 6.19: Back of enclosures main body

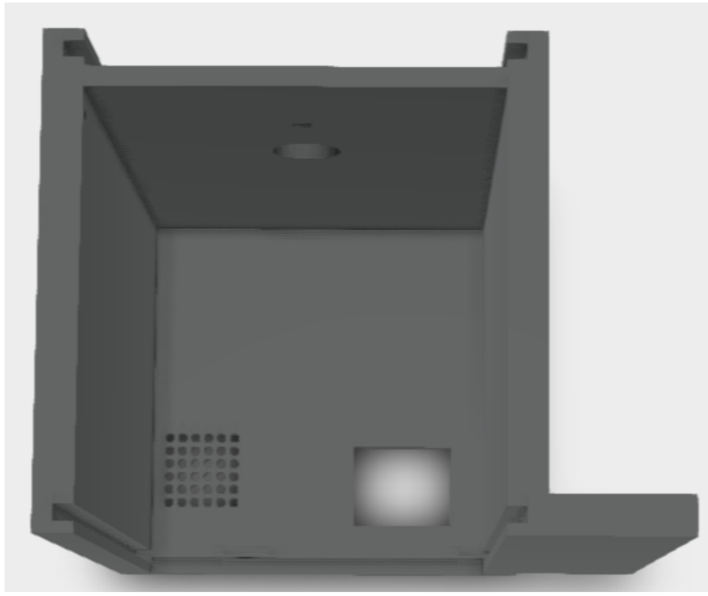


Figure 6.20: Top view of enclosures main body design

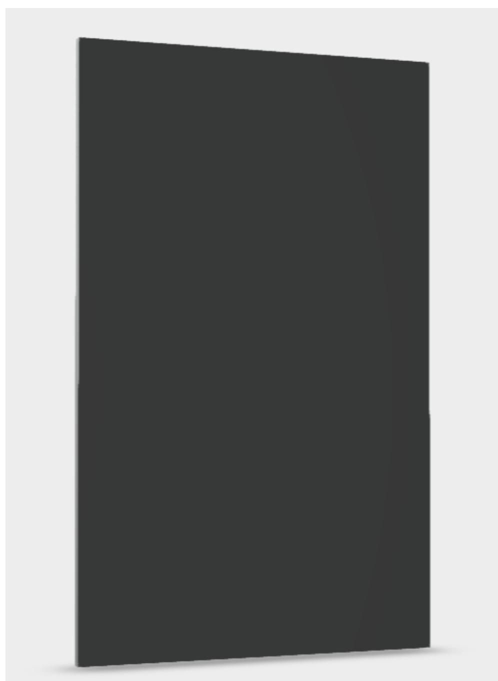


Figure 6.21:Slide in back panel of enclosure

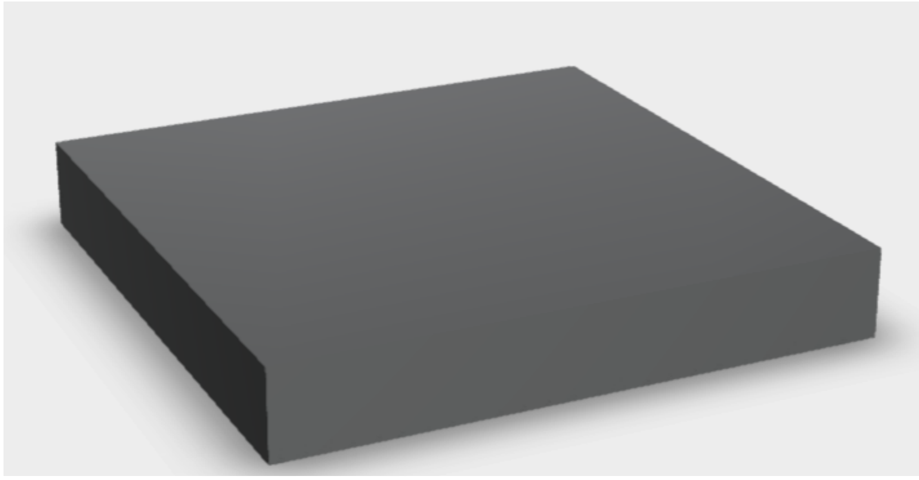


Figure 6.22: Top view of lid on enclosure.

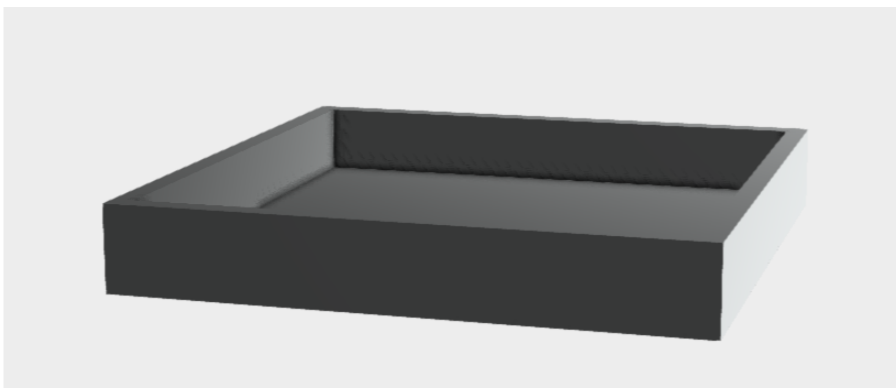


Figure 6.23: Bottom view of lid for enclosure.

Figure 6.24: Printed Enclosure Assembled

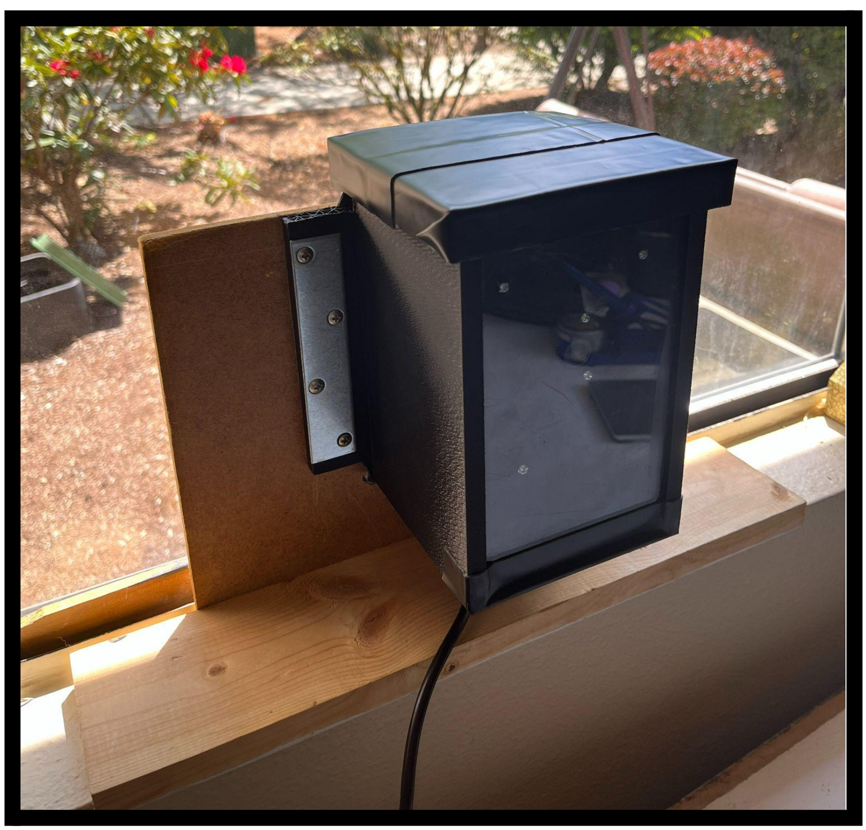


Figure 6.25: Complete System

Finally, included below is a link to the marketing survey we sent out, as well as a written transcript of its contents.

Link to Marketing survey: https://forms.gle/UZJDozmpvipMG59e6

Bird Deterrent Device Description:

The purpose of this device is to prevent bird-window collisions. When the device detects a bird flying towards a window, the device will alert the bird to allow the bird to change its flight path away. To accomplish this, the design utilizes two main sections, a sensors section, and a deterrents section. For the sensors section, the main method to detect if a bird is flying towards a window is through a visual light camera with the aid of machine learning.

After successfully detecting if a bird is flying towards a window, the device has two deterrent methods to alert the bird. A sound deterrent, which utilizes a speaker to audibly play a bird warning call signaling to the bird that there is danger nearby. The second deterrent is a light, which flashes towards the bird to show that it is flying towards the window.

The device must be mounted with screws to a wall above or below a window, and a power connection with a female IEC-320-C14 connector must be routed from a wall socket to the device to supply power. Once the device is established no further work or maintenance is required.

How concerned are you about the issue of bird collisions on house or building windows?

- Very Concerned
- Somewhat Concerned
- Not Very Concerned

Knowing a bird deterrent will cost $200 per unit with a discount to purchasing multiple units, how interested would you be in purchasing a bird deterrent(s) for your house or building?

- Very Interested
- Somewhat Interested
- Not Very Interested
- Not Interested at All

How much demand do you believe there will be for a bird deterrent device commercially?

- Very High Demand
- Somewhat High Demand
- Moderate Demand
- Somewhat Low Demand
- Very Low Demand

How much demand do you believe there will be for a bird deterrent device for the company you work for or other companies you were affiliated with?

- ○ Very High Demand
- ○ Somewhat High Demand
- ○ Moderate Demand
- ○ Somewhat Low Demand
- ○ Very Low Demand

6.3 Presentation Materials

Figure 6.25: Project Poster

Link to Project Showcase Site:
https://eecs.engineering.oregonstate.edu/project-showcase/projects/?id=pkDZUbNvu7oIsat2

Link to Virtual Expo Site:
https://events.engineering.oregonstate.edu/expo2023/project/active-bird-defense

6.4 References and File Links

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