Smart Trap

Team 63

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## 1. Introduction

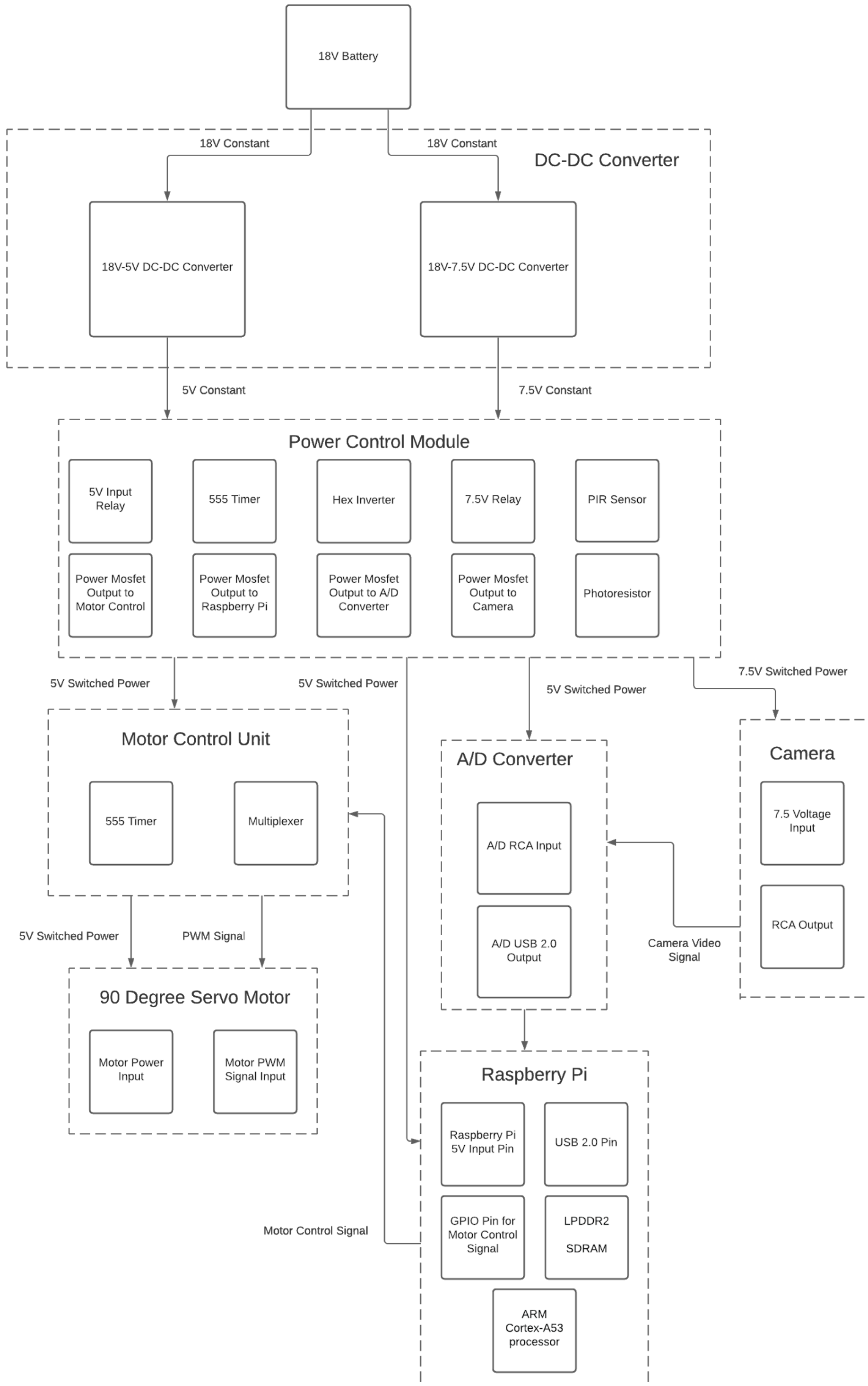
Animals like raccoons and foxes have been a problem facing homeowners since the dawn of time. While these animals seem harmless, they actually are responsible for a large amount of property damage, as well harming pets like cats. While there exist traditional traps in the market meant to capture these animals, they have the major problem of accidentally capturing other animals like rabbits, or even worse your own pet. This problem is particularly amplified in the case that the trap setter is inexperienced [8]. This is where the Smart Trap comes in. The Smart Trap will take your existing trap, and prevent it from capturing the wrong animal, so you don't have to worry about Spike going into the trap. This is done by implementing a camera and object detection to identify if an animal is a targeted animal, and to allow the trap to be set if it is. Our goal is to ensure our customers can live a pest free life without their animals getting harmed.

## 2. High-level Requirements

Our trap should have an accuracy of at least 95%. That is, the trap should only mistakenly trigger at most 5% of the time. The trap should fail safely, meaning that it is more desirable to let the target animal leave untrapped than to capture the wrong animal. Our trap should also run at 18V and have a minimum of twelve hours of battery life. The trap lastly should make a decision within five seconds of the animal entering the cage.

## 3. Design

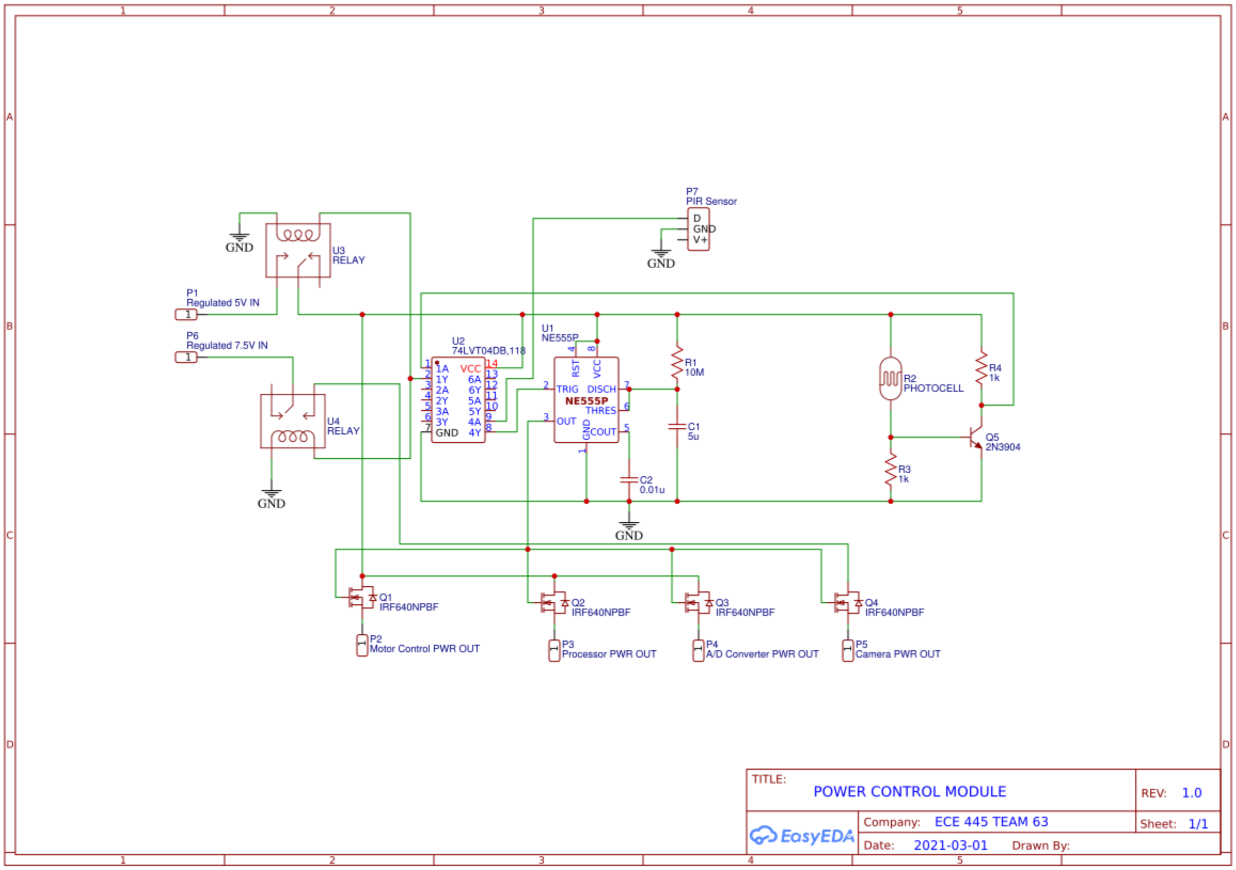
Block Diagram



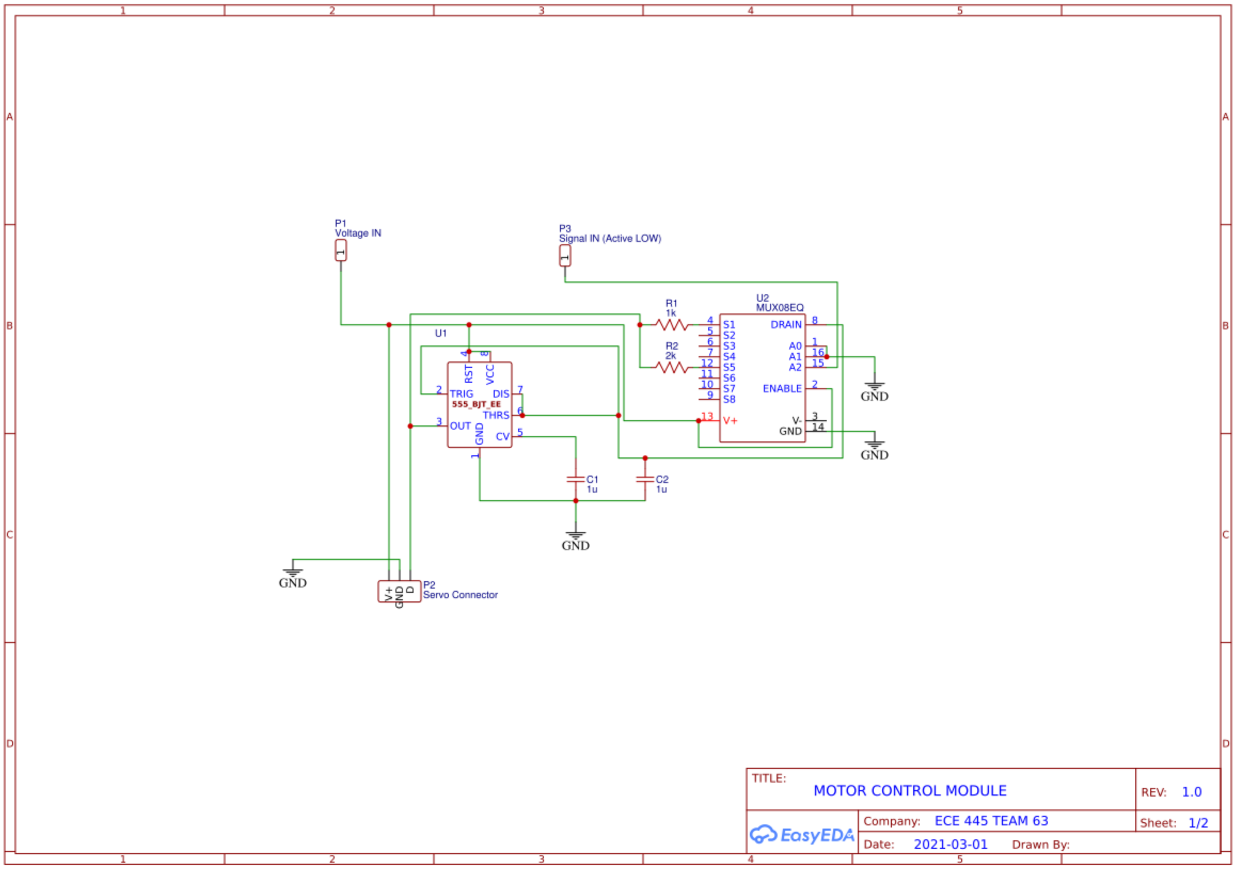
Requirements & Verification Tables

| Requirements | Verifications |
|---|---|
| Our trap should have an accuracy of at least 95%. | We will do sample tests to make sure our accuracy is over 95 percent. |
| Our trap should run at 18V (+/- 0.9V) | 1. Use 18V DC battery<br>2. Connect a DC-DC converter in series to our battery to regulate output voltages. |
| Trap should have a minimum of twelve hours of battery life. | 1. The system is ready to detect when the outside environment is getting dark.<br>2. Our night vision camera only works when the infrared sensor detects movement.<br>3. We use a minimal number of circuit components in our design.<br>4. The actual measured run-time of the trap is twelve hours. |
| The trap should make a decision within five seconds of the animal entering the cage. | 1. Our night vision camera should be able to capture at least 30 frames per second.<br>2. Our determined process in Raspberry Pi should be as fast as possible to make a decision.<br>3. This criteria can be verified through benchmark testing. |

## Schematics




Schematic for Power Control Module




Schematic for Motor Control Module

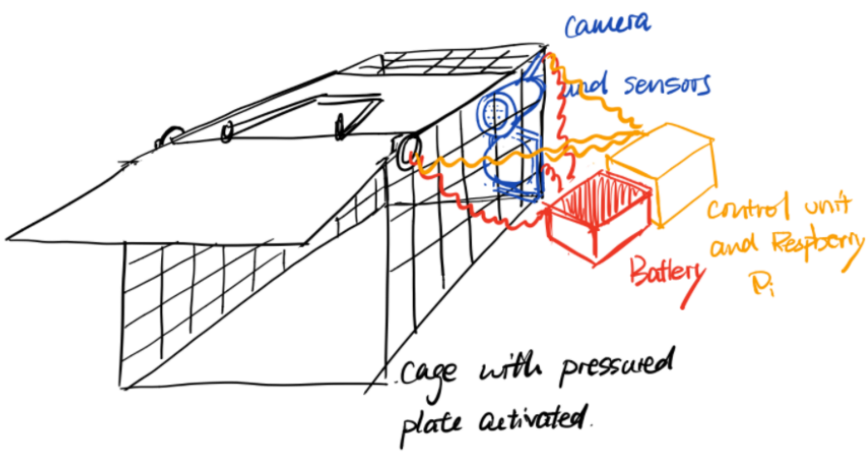


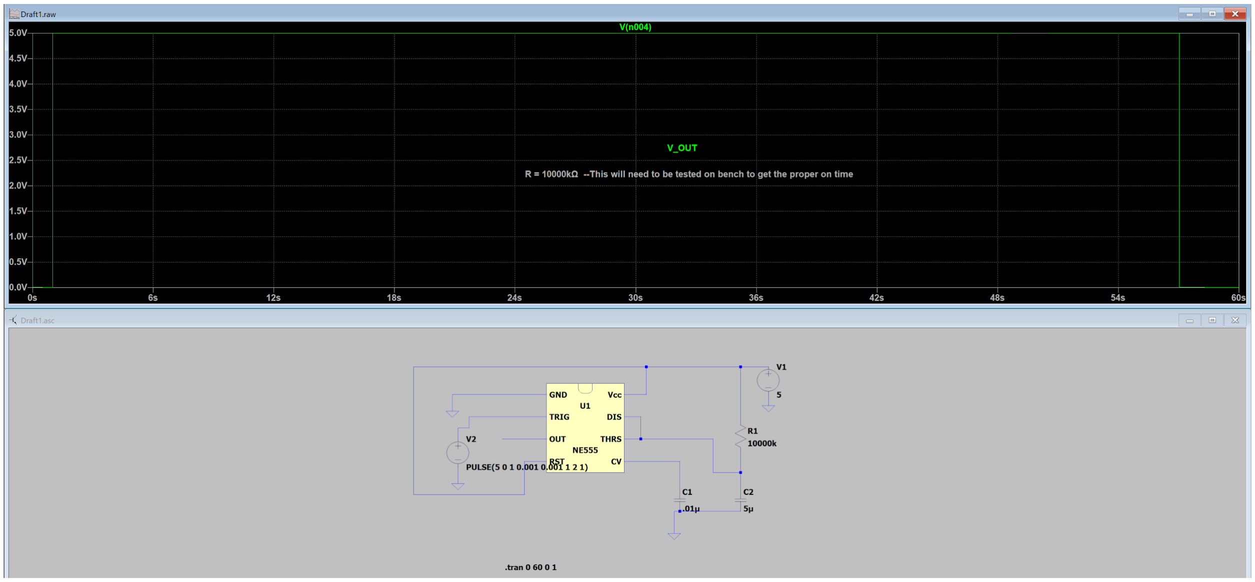

Image of Smart Trap with Cage

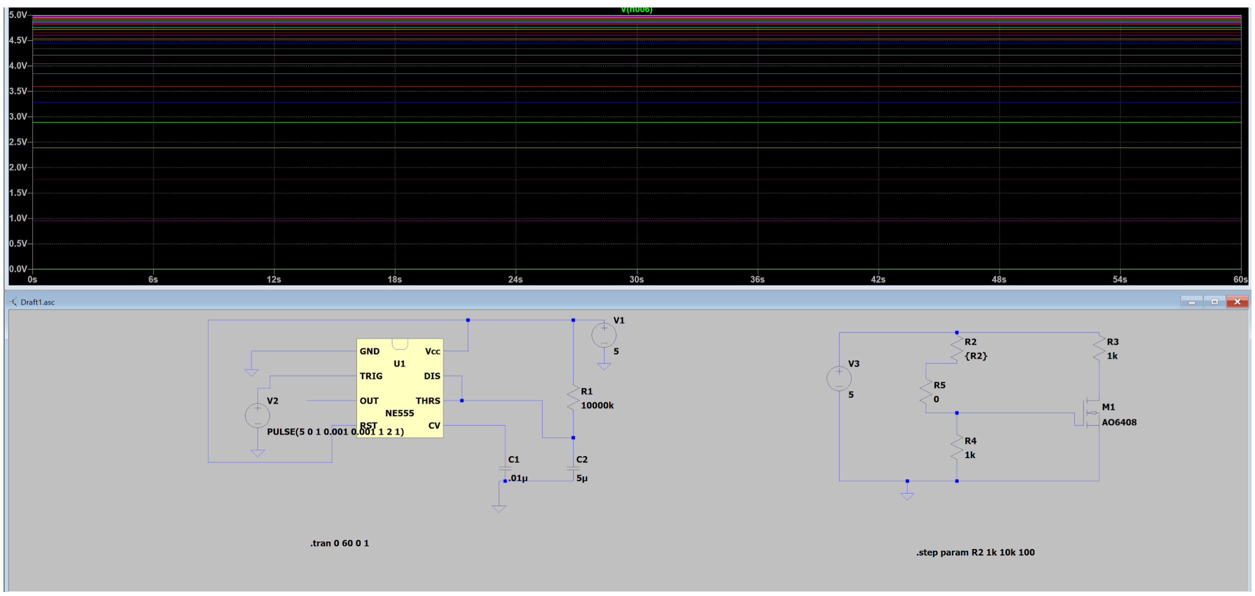
## Calculations and Simulations

Below are two simulations of the power control module. The top simulation shows that when the PIR sensor sends out a pulse, a logic one is output by the 555 timer for about 55 seconds. In practice, we will need to test this circuit on a bench to get the RC time constant correct. We should also take into consideration the non-idealities introduced by temperature since this product is designed to be used outdoors.

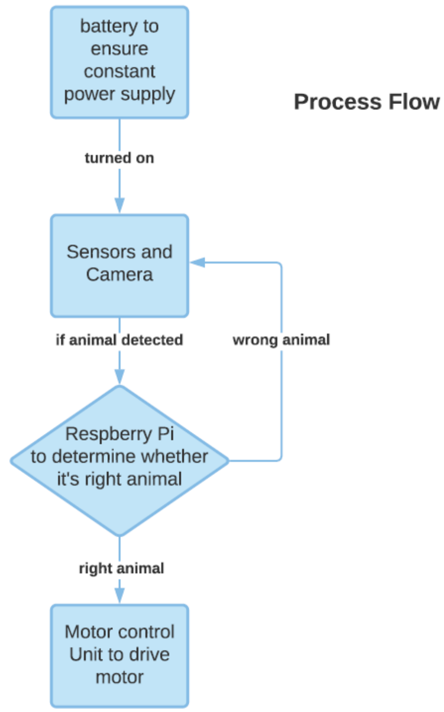
The bottom simulation shows that the light sensor sub-circuit can control main power to the entire device. The pull-down resistor may need adjustment depending on exactly which light conditions we desire for the on state, but we can find this by testing the photocell when it has arrived.

Additional simulations must be down to show that the motor control can create the two desired square wave signals for actuating the servo motor. In our preliminary design, we have chosen to use a mux to change between two resistors in a 555 timer circuit. This may not work in practice, but the desired effect could be achieved with a MOSFET arrangement for selecting which resistor path controls the 555 RC constant. In either scenario, testing on a bench with the required semiconducting components will be needed to ensure that both RC time constants create a square wave which places the motor in the desired position.


Draft1.raw
V(n004)
V_OUT
R = 10000kΩ --This will need to be tested on bench to get the proper on time
Draft1.asc
GND
Vcc
U1
TRIG
DIS
OUT
THRS
NE555
RST
CV
V1
5
V2
PULSE(5 0 1 0.001 0.001 1 2 1)
R1
10000k
C1
.01µ
C2
5µ
.tran 0 60 0 1


V(n006)
Draft1.asc
GND
Vcc
U1
TRIG
DIS
OUT
THRS
NE555
RST
CV
V1
5
V2
PULSE(5 0 1 0.001 0.001 1 2 1)
R1
10000k
C1
.01µ
C2
5µ
R2
{R2}
R3
1k
V3
5
R5
0
M1
AO6408
R4
1k
.tran 0 60 0 1
.step param R2 1k 10k 100

Flowchart Software



## Cost Analysis

| Part name | Quantity | Specs | Link | Cost (total) |
|---|---|---|---|---|
| Raspberry Pi 3 B+ | 1 | • ARM Cortex-A53 quad core processor clocked at 1.4GHz<br>• 4 × USB 2.0 ports (300 Mbps)<br>• Extended 40-pin GPIO header pins<br>• 1GB LPDDR2 SDRAM | https://www.digikey.com/en/products/detail/raspberry-pi/RASPBERRY-PI-3-MODEL-B/8571724 | $45 |
| Weatherproof Color Security Camera With Night Vision | 1 | • 300 x 380 pixels<br>• Analog signal<br>• RCA cable output<br>• 7.5 volts DC input | https://www.harborfreight.com/weatherproof-color-security-camera-with-night-vision-69654.html | $30 |
| PIR Sensor | 1 | • 7 feet/2.1 meter sensing distance<br>• 5-12 volt DC input<br>• 3.3 volt digital output<br>• 30 centimeter cable | https://www.adafruit.com/product/189 | $10 |
| Photoresistor | 1 | • About 10k Ohm resistance in the dark<br>• About 1k Ohm | https://www.adafruit.com/product/161 | $1 |

| | | | | |
|---|---|---|---|---|
| | | resistance in the light | | |
| Analog to Digital Converter (RCA to USB for camera) | 1 | • RCA to USB 2.0<br>• Resolution of 720 x 480 pixels at 30 fps | https://www.amazon.com/USB-2-0-Audio-video-Converter/dp/B06XJKSJZ8/ref=sr_1_5?dchild=1&keywords=rca+to+usb+converter&qid=1614644278&sr=8-5 | $12 |
| 90 degree Servo Motor | 1 | • Can rotate 90 degrees total (45 degrees counterclockwise and clockwise)<br>• 4.8-6 volt DC input<br>• 0.01 sec/60 degrees at 4.8V, 0.08 sec/60 degrees at 6V DC | https://www.adafruit.com/product/1143 | $10 |
| Ryobi 18V battery | 1 | • Powers 18V, 4 Ah<br>• Rechargeable Lithium Ion Battery | https://www.amazon.com/Ryobi-Compatible-Replaces-Rechargeable-Recharge/dp/B0781B4R4C/ref=sr_1_9_mod_primary_new?crid=3V7OZIY102BG8&dchild=1&keywords=18v+battery+ryobi&qid=1614644694&sbo=RZvfv%2F%2FHxDF%2BO5021pAnSA%3D%3D&sprefix=18v+battery%2Caps%2C189&sr=8-9 | $42 |
| 18V to 5V DC converter | 1 | • 18V DC input<br>• Outputs 5V DC, 25-50 W | https://www.alibaba.com/product-detail/Dc-Converter-18v-To-5v-18v_60820581157.html?spm=a2700.7724857.normal_offer.d_title.608e326eflyKNs&s=p | $5 |

| | | | | |
|---|---|---|---|---|
| 555 Timer | 2 | • Standard 555 timer IC with negative trigger pulse | https://www.sparkfun.com/products/16473 | $1/pc. |
| Power Mosfets | 4 | • Rated 30A, 60V (1800W) | https://www.amazon.com/Luckkyme-RFP30N06LE-N-Channel-Mosfet-Arduino/dp/B07CTJFG7M/ref=zg_bs_306919011_2?_encoding=UTF8&psc=1&refRID=C4GNB0EJP98S759XNMST | $8 for 10 Pcs. |
| Animal Cage (Pressure Plate Activated) | 1 | • 24 inches/61 centimeters cage length<br>• Pressure plate activated trap | https://www.amazon.com/ANT-MARCH-Squirrel-Chipmunks-Groundhog/dp/B08GYCZ7W9/ref=sr_1_5?dchild=1&keywords=raccoon+trap&qid=1614652928&sr=8-5 | $35 |

## Schedule

| Week | Goals |
|---|---|
| Week 6 (2/28-3/6) | ● Complete Design Document Draft for Design Check<br>● Complete Design Document Final Draft by 3/4<br>● Order Parts |
| Week 7 (3/7-3/13) | ● Design Review on 3/9<br>● Start implementing machine learning algorithm on laptop<br>● Test circuit schematic for the DC-DC converter<br>● Test circuit schematic for the Power Control Unit<br>● Test circuit schematic for the photoresistor<br>● Test circuit schematic for the motor driver circuit<br>● Test circuit schematic for the passive infrared sensor<br>● Test circuit schematic for the camera/Digital Signal Processor |
| Week 8 (3/14-3/20) | ● Complete Eagle PCB designs of different circuits by 3/17<br>● Teamwork evaluation due on 3/17<br>● First PCB order due on 3/19<br>● Simulation/Soldering assignment due on 3/20 |
| Week 9 (3/21-3/27) | ● Begin to transfer machine learning algorithm onto Raspberry Pi<br>● Interface the Raspberry Pi with video camera to begin machine learning trials<br>● Second PCB order due on 3/26 |
| Week 10 (3/28-4/3) | ● Continue running machine learning trials<br>● Solder circuit schematic for the DC-DC converter<br>● Solder circuit schematic for the Power Control Unit<br>● Solder circuit schematic for the photoresistor<br>● Solder circuit schematic for the motor driver circuit<br>● Solder circuit schematic for the passive infrared sensor<br>● Solder circuit schematic for the camera/Digital Signal Processor<br>● Start testing motor component on a pressure |

| | |
|---|---|
| | plate |
| Week 11 (4/4-4/10) | ● Individual progress report by 4/5<br>● Third PCB order due on 4/6<br>● Start testing on cat/RC car |
| Week 12 (4/11-4/17) | ● Make any last minute additions |
| Week 13 (4/18-4/24) | ● Mock demo |
| Week 14 (4/25-5/1) | ● Final demo |
| Week 15 (5/2-5/6) | ● Final paper due on 5/5<br>● Lab checkout on 5/6 from 3:00-4:30pm<br>● Lab notebook due on 5/6<br>● 2nd teamwork evaluation due on 5/6 |

## Tolerance Analysis

An important tolerance for this product is the time it takes for the animal to be detected and the trap to be set. Assuming the detection algorithm takes on average 2 seconds to process a frame [6], and there has to be a positive result in at least 9 frames to prevent a false flag, this means that it can take up to 18 seconds to successfully detect the animal. This may or may not be acceptable depending on how long the animal stays in the cage. If there is bait, it seems more likely that the animal will be in the cage for the 20 seconds. While things like propagation delays from the circuits also contribute towards the time delay, the detection algorithm is the bottleneck of the project.

## Ethics and Safety

A primary safety concern we have with our product is potential damage to the components from either animals or the weather, causing the circuit components to be exposed. We wish to address this by reinforcing the components to minimize likelihood of damage occurring. We may include the use of weatherproof connectors and enclosures.

Another safety concern is the safe handling of animals tested and trapped within the cage, and we will follow the USDA Animal Welfare Act and the NIH Public Health Service Policy as stated by Illinois Institutional Animal Care and Use Committee.

To prevent any kind of dangerous reactions occuring in our product and harming the customer, we decided not to incorporate hazardous or volatile materials in our project. All components we will use are consumer grade and can be purchased legally online.

Concerns regarding lab safety such as knowing what different warning symbols stand for is paramount for the success of our group constructing the product, so all group members have completed lab safety training according to the safety guidelines of UIUC.

## Citations and References


[1] Raspberry Pi Foundation, "Raspberry Pi 3 Model B+ Product Brief", Available: https://static.raspberrypi.org/files/product-briefs/Raspberry-Pi-Model-Bplus-Product-Brief.pdf. [Accessed Feb. 17, 2021].

[2] Bunker Hill Security, "Weatherproof Color Security Camera Manual", Available: https://manuals.harborfreight.com/manuals/95000-95999/95914.pdf. [Accessed Feb. 17, 2021].

[3] Adafruit, "PIR Motion Sensor Data Sheet", Available: https://cdn-learn.adafruit.com/downloads/pdf/pir-passive-infrared-proximity-motion-sensor.pdf. [Accessed Feb. 17, 2021].

[4] Adafruit, "Photocells Data Sheet", Available: https://au.mouser.com/datasheet/2/737/photocells-932884.pdf. [Accessed Feb. 17, 2021].

[5] "Buck Converter – Circuit, Design, Operation and Examples", *electricaltechnology.org*, Available: https://www.electricaltechnology.org/2020/09/buck-converter.html. [Accessed Feb. 17, 2021].

[6] J. Brownlee, "A Gentle Introduction to Object Recognition With Deep Learning", *machinelearningmastery.com*, May 22, 2019. [online]. Available: https://machinelearningmastery.com/object-recognition-with-deep-learning/. [Accessed Feb. 17, 2021].

[7] "Servo Motor SG-90", *components101.com*, Available: https://components101.com/motors/servo-motor-basics-pinout-datasheet. [Accessed Feb. 17. 2021].

[8] “Avoiding Common Trapping Mistakes,” MDWFP. [Online]. Available: https://www.mdwfp.com/wildlife-hunting/habitat-and-predator-management/habitat-and-predator/avoiding-common-trapping-mistakes/. [Accessed: 02-Mar-2021].