ECE 445

SENIOR DESIGN LABORATORY

Garden Guardian Project Proposal

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1 Introduction

1.1 Problem

A widespread problem when it comes to owning a garden is protecting your garden. People spend countless hours working hard to produce a healthy and fruitful garden. They invest in highest quality soil, pesticides, and seeds to produce the best garden that they can. But even with the most elite equipment, gardens are still prone to being attacked and destroyed by animals in nature.

An easy solution to this problem is to surround one's garden with a fence. While effective in preventing some animals from damage, it is not effective in keeping out all animals based on varying size and abilities in terms of travel over, though, or under fences. Another simple solution is to use different pesticides and traps throughout one’s garden. With this approach, while protecting the garden in some ways, introduction of these pesticides and traps into nature toxically harms animals and the garden itself. Additionally, this method comes with a high cost of upkeep to repurchase and reapply pesticides to be an effective deterrent against animals. Our solution is one that is low-cost, effective, and does not cause negative harm to the environment, wildlife, or one’s garden.

1.2 Solution

Our solution is to create a device that will identify, locate, and deter all animals that approach a person’s garden. This device will be easily mobile and can be placed anywhere in one’s garden so that any approaching animal will be spotted. The device will then turn toward the detected animal and make a loud, alarming noise during the day or a strobe-like light at night to deter the animal. The reason we chose to use noise during the day and a light at night is that we did not see the light as very effective during the day due to the sun being out and we did not want noise going off at night to disrupt any neighbors.

This device is very beneficial towards garden owners, because it is very easy to move and set up anywhere in one’s garden. The device will be height adjustable and have a bird on the top to be able to ‘blend in’ with the garden. The owners can change the device to change the render distance and height. Our goal is to create a device that everyone can place in their garden and adjust to their own preference to match their needs and keep out all animals.

1.3 Visual Aid

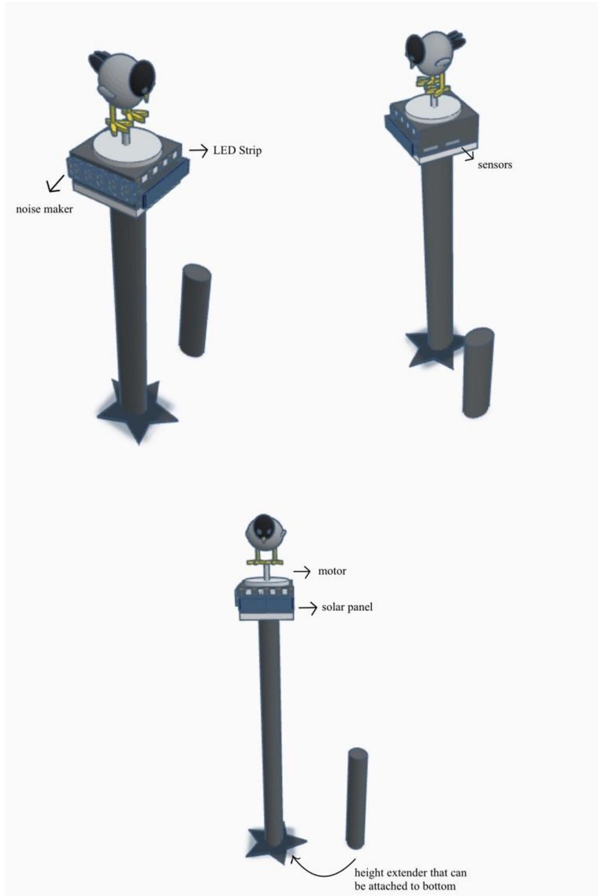

Figure 1: Visual Aid of Garden Guardian Design

1.4 High Level Requirements

To consider the project a success, we plan to achieve the following goals.

1. The device can detect motion up to a seven-meter radius from its sensors, and then send a signal to the microcontroller to turn on either the noise or light deterrent.
2. The device will determine from which direction the motion is detected from, rotates the bird platform which is at the top to the correct number of degrees (this will change due to moving animals) so that it faces the animal directly. This rotation can rotate at the full 360 degrees with a speed of 10 RPM.
3. Solar panel can power the device and all its needs at 8.2 Volts and 1 Watt, without any dependence on an external power source.

2 Design

2.1 Block Diagram

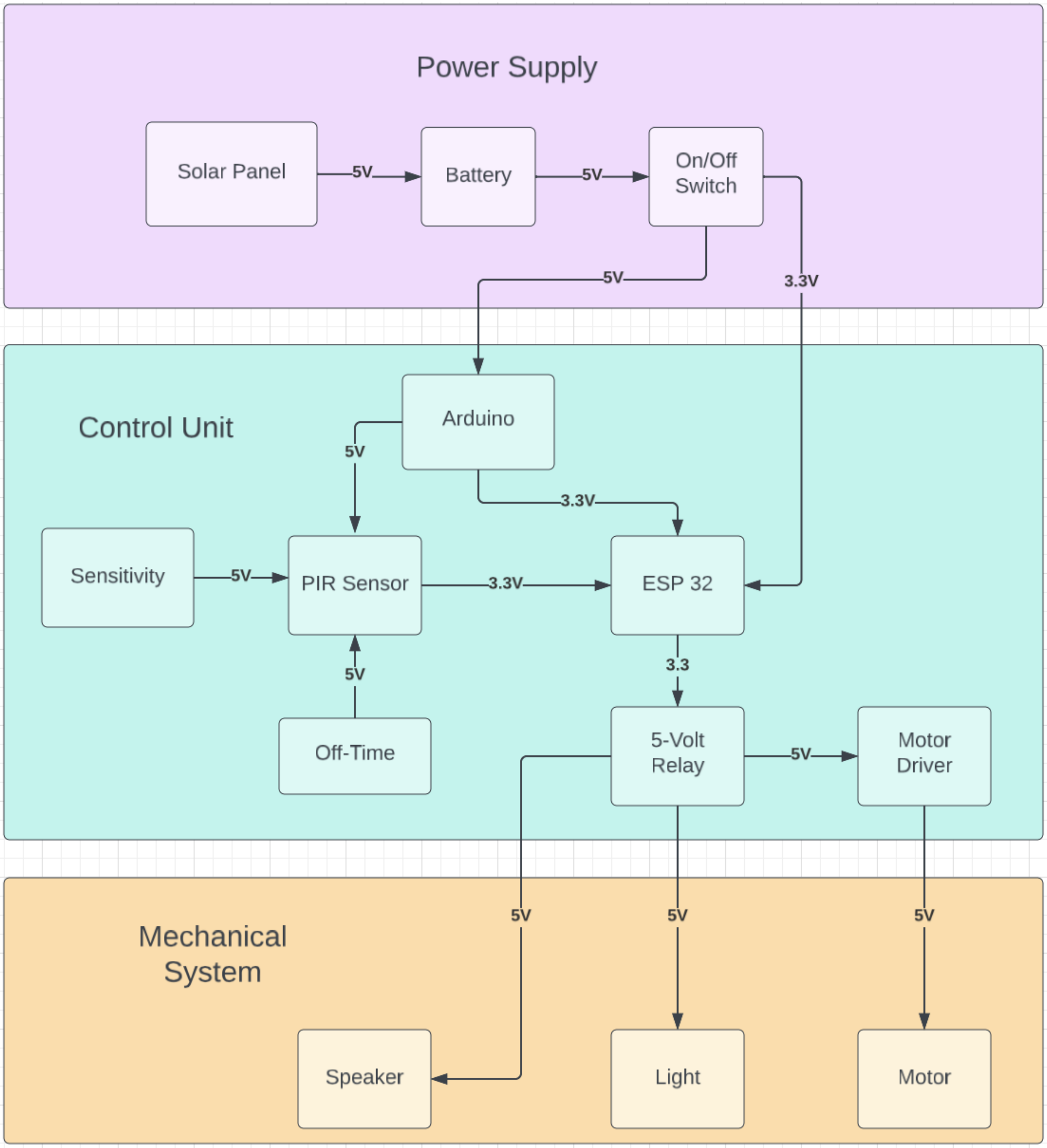

Figure 2: Block Diagram

2.2 Subsystem Overview

Our design is divided into three subsystems, which are implemented mainly in hardware with limited use of software.

2.2.1 Power Supply

For the power subsystem, there are 3 main components to it. The components are a solar panel, a battery, and an on/off switch. The power system begins with the solar panel generating electricity and sending this to the battery. The next step is the battery that will store excess energy to use overnight when the solar panel is unable to generate electricity. The battery holder will hold two rechargeable 3.7 V lithium-ion batteries that also has an on/off switch that will control power to the rest of the device.

The solar panel needs to be able to completely power all components of the device. Because of this, the solar panel will be able to generate 8.2 watts to be used for the whole device. The battery holder we will use has output ports for specifically 3.3V and 5V. This means that we won’t need any type of voltage divider here. This is sent to the rest of the components of the device to power everything.

2.2.2 Control Unit

The control unit has 7 main components: PIR sensor, microcontroller, sensitivity, off time, Arduino board, 5-volt relay, and motor driver. All humans and animals emit infrared radiation. PIR sensors use pyroelectric sensors to detect heat energy in an environment. Multiple sensors will be by each other and if there is a difference in heat signal from one sensor to the other, the sensor will read high. This high signal will go to the microcontroller [4]. The microcontroller will be programmed to determine if it is daytime or nighttime to send out light or noise. If the solar panel reads a current of less than 25mA, then it will be determined that it is night. If the solar panel reads a current of more than 25mA, then it will be determined that it is day. It will also be programmed to turn the device toward the detected motion. The way we will do this is by centering the motion to the middle of the front sensor. The front sensor will be aligned with the bird. From the microcontroller, the signal will relay to a 5-volt relay. The output signal of the 5-volt relay will power the device's mechanical components. One signal also goes to the motor driver which will control the movement and direction of the motor. The sensitivity sensor is a sensor that can be adjusted to change the distance of which the PIR sensor can detect motion.

The bigger the garden, the higher the sensitivity needs to be. The off-time sensor is also adjustable. This sensor leaves the signal from the PIR sensor and microcontroller too high for an additional amount of time after the PIR sensor has stopped detected motion. This way the flashing lights/noise goes on for a couple extra seconds after the animal has been eluded.

2.2.3 Mechanical System

The three components of the mechanical system are the strobe-light, noise producer, and the stepper motor. The strobe-light and noise producer both receive signals from the 5-volt relay to turn on both devices when needed. The light and noise buzzer will be receiving signals on a 50% duty cycle which will create the strobe-like sensation that is wanted. The stepper motor is a programmable motor that will be able turn the top of the device a full 360 degrees toward the motion.

2.3 Subsystem Requirements

Requirements that need to be met for each subsystem.

2.3.1 Power Supply

- Solar panel must supply all power needed for the device
- Battery receives and stores all power from solar panel for overnight use

2.3.2 Control Unit

- PIR sensor can detect motion for a 7-meter radius
- PIR sensor output signal remains high for an additional 3 seconds after all motion has stopped
- Microcontroller can determine between day and night

2.3.3 Mechanical System

- Device produces strobe-like sound when motion is detected during the day
- Device produces strobe-like light when motion is detected during the night
- Bird rotates on top of motor to face any motion that is detected

2.4 Tolerance Analysis

The power supply system for our project needs to be carefully designed to ensure stable voltage regulation for all its subsystems. There are a couple considerations when using a linear voltage regulator: the dropout voltage and thermal performance. The dropout voltage ($V_{dropout}$) is the minimum voltage between the input and output required for the regulator to operate. One example from our design is that we are inputting 5 V to the voltage regulator and want to output 3.3 V to the microcontroller. We should take our maximum input to be 4.8 V to account for the maximum amount of ripple. In this case, $V_{dropout}$ must be greater than or equal to 1.5 V. The thermal concerns can be addressed by determining the power dissipation (P_D). If too much power is dissipated, then the regulator will overheat. We can calculate the power dissipated using the expression $P_D = i_{out} * (v_{in} - v_{out})$. To find i_{out}, we must perform ohms law on the thermal circuit. Using the simple thermal circuit from the wiki page, we can solve ohms law and find that the junction temperature, $T_j = i_{out} * (v_{in} - v_{out})(\theta_{jc} + \theta_{ca}) + T_a$.

Variable	**Value**	**Comment**
Maximum Operating Temperature (T_j)	125 ºC	From LM317 datasheet
Ambient Temperature (T_a)	38 ºC	Assuming warm board as they did in the example on the wiki
i_{out}	171 mA	Maximum current drawn from 3.3 V components
v_{in}	4.8 V	Assuming input voltage to be 5 V, choose 4.8 V to account for ripple
v_{out}	3.3 V	Desired output

Junction-to-Case Thermal Resistance (θ_{jc})	4.2 ºC/W	From LM317 datasheet
Case-to-Ambient Thermal Resistance (θ_{ca})	50 ºC/W	From LM317 datasheet

With these selected values, we can solve for the junction temperature, T_j = 51.9 ºC which is less than the maximum operating temperature of 125 ºC, so our linear voltage regulator should operate correctly for our design.

3 Ethics and Safety

3.1 Ethics

Through this project development, our highest priority is considering and addressing all ethical and safety concerns. Our project is one that approaches the intersection of humans and nature, and we recognize that we are at risk of causing potential damage.

1. To disclose promptly factors that might endanger the public or the environment. [5]
2. To seek and offer honest criticism of technical work. [5]
3. To improve our technical competence. [5]

While completing this project, we will strive to uphold the IEEE Code of Ethics and use it as our framework in maintaining ethical standards. Since our project aims to assist the public with a task, we will be mainly upholding the IEEE Code of Ethics [4] to ensure the safety of those using our product as well as the surrounding environment.

3.2 Safety

Our project poses minimal safety concerns since it operates as a standalone device moving only rotationally and alternating between noise or light repellent. However, we have identified potential safety hazards and listed them below. By remaining attentive about these concerns and strictly following all lab and general safety protocols, we will ensure the overall safety of our project.

3.2.1 Solar Panel

The primary safety consideration revolves around the solar panel. Given its continuous activity, there is a potential risk of electrical shock that demands careful handling and adherence to safety protocols.

3.2.2 Motor

Our use of a motor introduces another safety consideration, as there is a potential risk of being pinched during its operation. By following all proper lab safety and PPE regulations, we will ensure that we will not be injured throughout the process of our project assembly.

3.2.3 Battery Safety

An issue that can present itself is working with rechargeable lithium-ion batteries. If not maintained properly, lithium-ion batteries present themselves as a potential fire hazard. Ways to prevent exposure to any type of hazard include frequently checking the batteries to see if there is any type of change in odor, color, or temperature. This will be achievable in our project by keeping the battery holder accessible in the control box [2].

3.2.4 Seizure Warning

Any individual with epilepsy may experience seizures caused by the flashing red and green light produced by the LED strips attached to our device for overnight protection. We plan to have the light emitting frequency at 50 percent duty ratio, with half being red and the other half being green. To prevent any issues of this concern, we plan to include attaching a hazard sticker on the main box of our device.

4 References

[1] “IEEE Code of Ethics.” *IEEE*, www.ieee.org/about/corporate/governance/p7-8.html.

[2] *LM317 3-Terminal Adjustable Regulator Datasheet (Rev. Y)*, Texas Instruments Incorporated, 18 Oct. 2023, www.ti.com/lit/ds/symlink/lm317.pdf. Accessed 08 Feb. 2024.

[3] Services, Engineering IT Shared. “Cloud-Controlled Quadcopter.” :: *:: ECE 445 - Senior Design Laboratory*, courses.physics.illinois.edu/ece445/wiki/#/regulators/index.

[4] “Understanding Active & Passive Infrared Sensors (PIR) and Their Uses.” *Arrow.Com*, 13 Oct. 2022, www.arrow.com/en/research-and-events/articles/understanding-active-and-passive-infrared-sensors.