Laboratory of Optoelectronics and Photonics

Optoelectronics Project

Projects Name:
"Light Beam Barrier"
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Contents

1 Introduction

The concept we want to actualize in this project is the application of laser diodes in the creation of a system that will notify us when the light beam produced by the laser diode [4] is interrupted. To name it coherently and add significance to the project we will use the working name - Laser Security Alarm - within a paper, and officially call it "Light Beam Barrier".

To achieve fully working laser security system [1] we created consecutively the plan of action. Firstly we needed to determine the purpose of our creation and its assumptions. It needed to be stated what our project will be and will not be able to do, what are its limitations and how can we achieve intended upshot.

The next step was collecting the hardware components and mounting them all together in a coherent way. Within the hardware we also placed microcontroller on which we before performed the software part of the project. The software component required us to create program collecting information from previously installed in the system LDS and after that further equip it to adequately react to retrieved information.

2 Theoretical Introduction

The laser Security alarm is a device used for security purposes. It has a wide application in fields of security and defense starting from the security of simple households to a very highly valued material of an organization.

Lasers differ from other light sources in a few significant ways. Two features are important for security systems. Unlike a light bulb or flashlight, laser light doesn't spread out, it is a narrow beam. And laser light is essentially a single color. Because laser light doesn't spread much, it can be sent a long way and still have enough energy in a small area to trigger the security system detector. Laser light travels in a straight line.

The laser-based security system [1]is a type of security and alarm system that uses laser light and a light sensor to detect intrusions or unauthorized movement within a protected area. These systems work by emitting a laser beam across space and detecting any changes in the beam that may indicate movement or tampering. If the beam is interrupted anywhere between the laser and the detector, the electronics will put the warning signal.

There are several advantages to using a laser alarm system. One of the main benefits is that laser beams are very difficult to detect as they are only visible at the source and the destination point, so intruders may not realize they are being monitored. It is known that laser light goes through long distances without any scattering effect. Additionally, laser alarm systems are very precise and can accurately detect even small movements, making them effective at detecting intrusions.

However, there are also some limitations to laser alarm systems. For example, they may be affected by changes in ambient light levels or other environmental factors, which could cause false alarms. Overall, laser alarm systems can be an effective option for protecting space from intrusions.

There are three essential components to a laser security system [2] : a laser, a detector, and a sensing circuit. The laser is a concentrated light source that puts out a straight line, a beam of light of a single color. The detector is sensitive to light and puts out a voltage when the laser light hits it. The detector is connected to the sensing circuit. When the laser beam is interrupted and cannot reach the detector, its voltage output changes, and the circuit sense the change and put out a warning signal.

3 Assumptions

The following were assumed while creating the project:

1. The beam created by laser diodes has to be unbroken and be properly aligned in straight-line travel to LDRs
2. The microcontroller used has to be compatible with the created system and used components
3. The microcontroller has to be programmed to accurately detect and respond to changes in the laser beam
4. The alarm system has to be properly set up and configured to receive signals from the microcontroller and notify in the event of light beam interruption
5. The interruption of light has to be immediately detected and signalized
6. System will be transportable(easily be moved/carried around due to the compactness of system)
7. System will be powered by some battery.

To fulfill those assumptions we did the following:

1. We designed and created a clearly defined area and the layout of the space so that we could mount laser diodes and LDRs in stable positions and ailing them
2. The microcontroller - Arduino UNO - is compatible with all chosen hardware devices
3. The microcontroller - Arduino UNO - is programmed using C++ a language and tested for receiving and responding to the events occurring within whole system We added both the light indication of where if any interruption in light beam signal occurs and correctly responding to any interruption sound signal
4. We recalled zones of interruption and assigned them corresponding to the LED's to indicate in which area of created space the interruption occurred

4 Hardware

The hardware part of a project refers to the physical components and devices used to build a system or solution. These components include circuit board, sensors, lasers, and other electronic components. The hardware part of a project is a crucial aspect, as it determines the functionality and performance of the system. Comparisons between the Figure 1 and Figure 2 can be made, which is basically the similarities between the block diagram of the hardware and real life hardware components assembled.

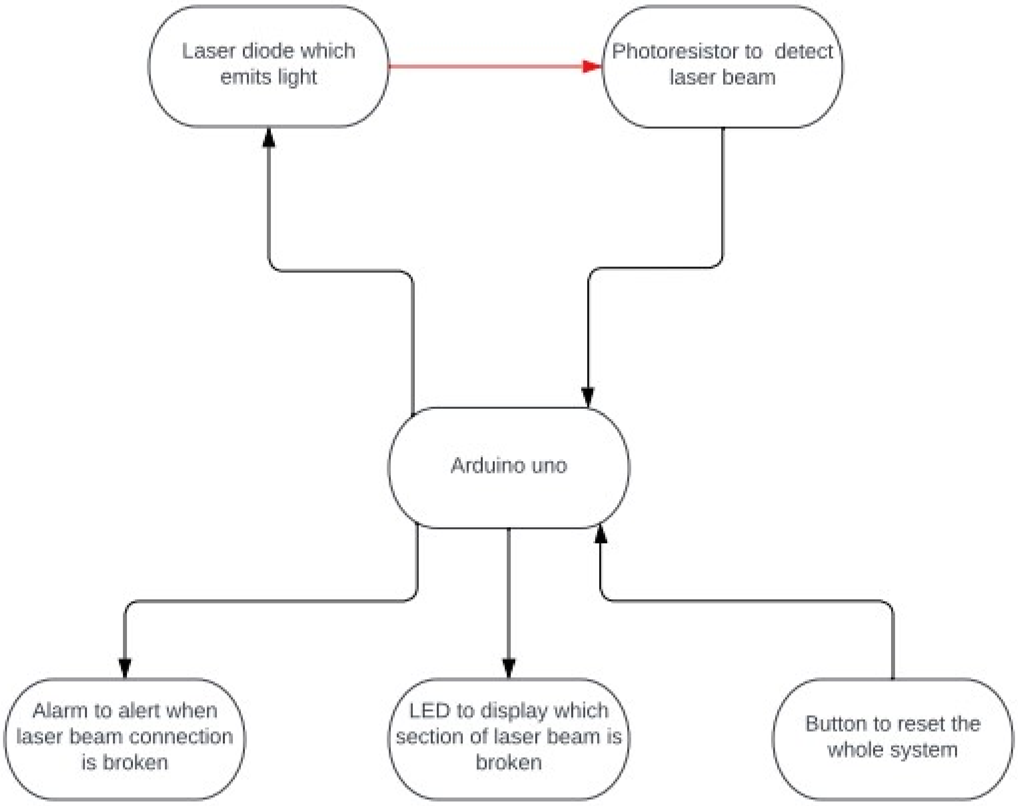

Figure 1: Block diagram.

In Figure 2 we can see the Laser security system in its complete state, that is all hardware components have been assembled (It can also be seen that it was assembled according to the schematic in Figure 3 for further reference)

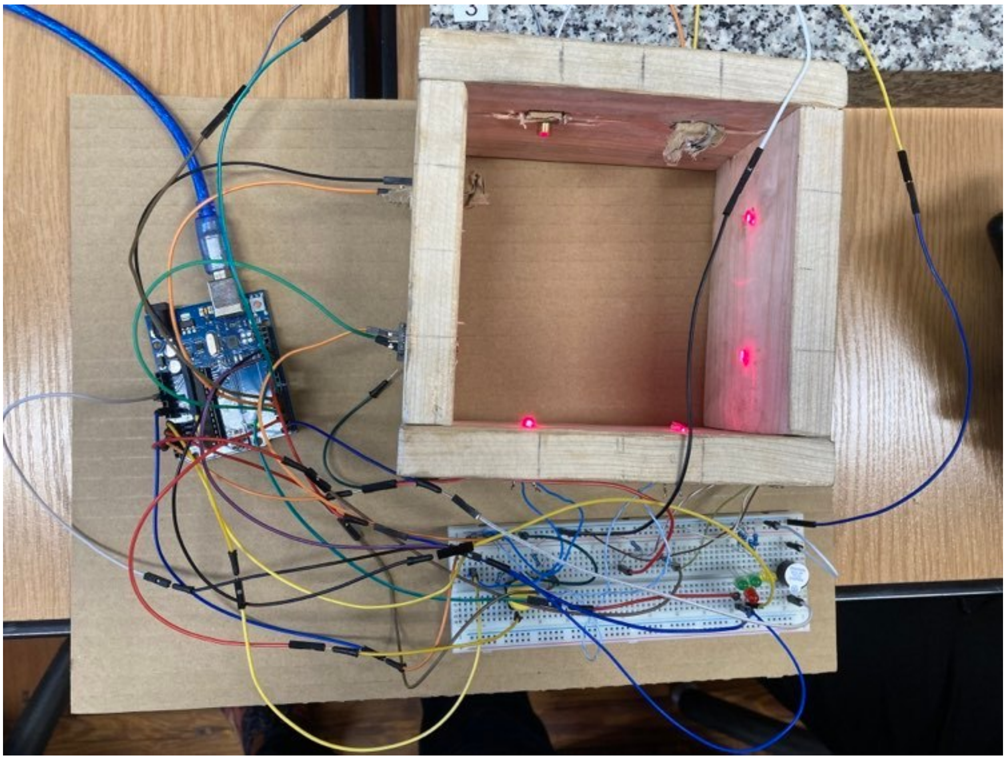

Figure 2: Whole system

Below in Figure 3 we can see the schematic of the real life hardware components as a simulation further details can be found in Figure 3 description

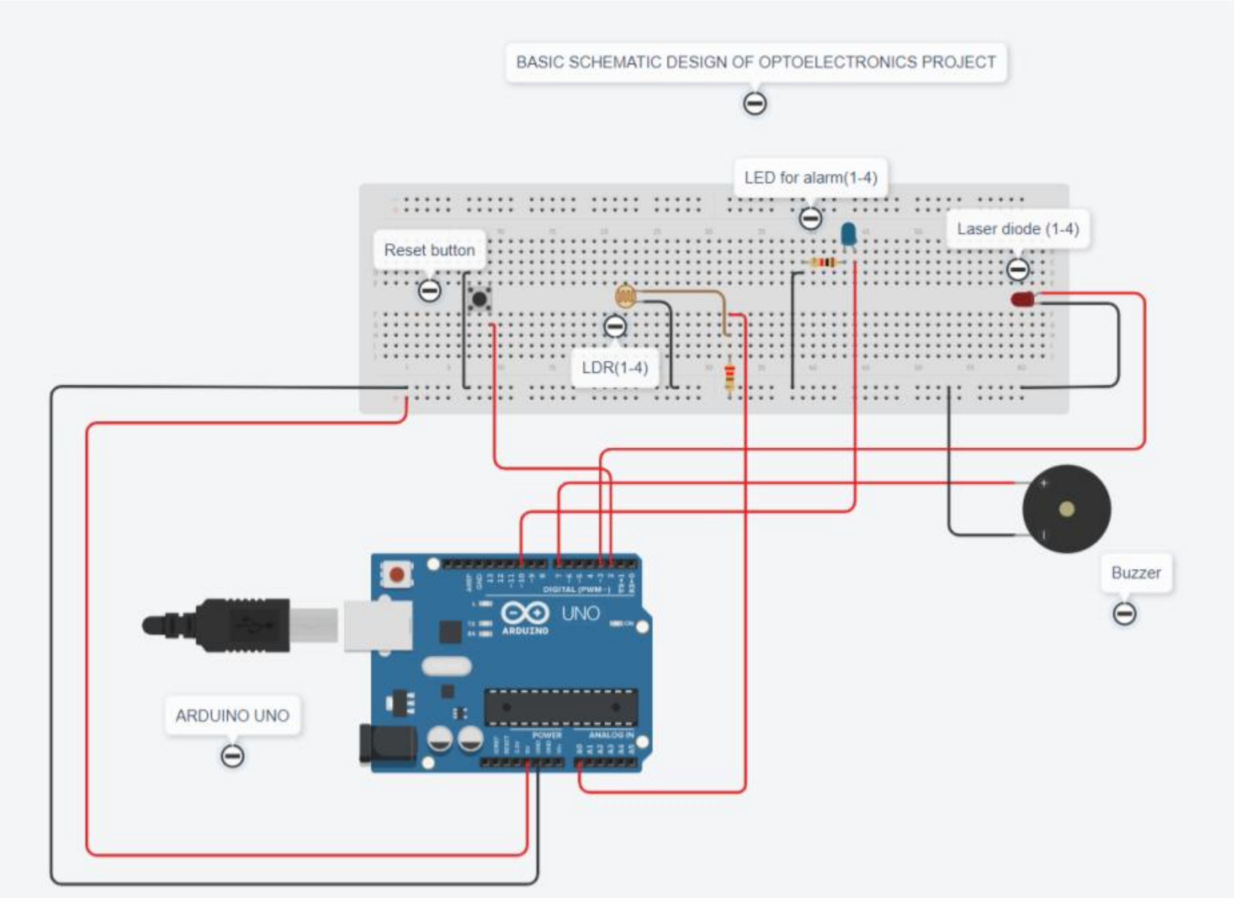

Figure 3: NOTE This basic design includes only one laser diode [4] and one LDR and one LED but the main project includes four of each (laser diode [7] , LDR, and LED). The design was simplified and other laser diodes, LDR, and LED's can be connected the same way, to reduce the number of components on the basic design to prevent it from looking ambiguous, they were omitted.

In the Table 1 below we can see the needed components in order for this project to take place.

NO.	Component	Quantity
1	Laser Diode	4
2	LDR(Light Dependent Resistor)	4
3	Arduino UNO	1
4	LED (Light Emitting Diode)	4
5	Buzzer	1
6	Button	1
7	Resistor	-
8	Connecting Wires	-
9	Breadboard	1

Table 1: Basic components

Hardware Component Description

1. Laser Diode — Laser sensor Module 650nm 6mm 5V 5mW Red Laser Dot Diode KY-008

In this project, the laser diode [4] acts as the main source of light that is used to trigger an alarm in a situation where the light emitted from the diode is disrupted. The laser diode [7] [4] used requires a power of about 5mW. The laser emits red light and has an output wavelength of 650nm(dimensions(19x15mm)). Link: https://allegro.pl/oferta/450-modul-laser-z-dioda-laserowa-650nm-5mw-10481212707

2. LDR(Light Dependent Resistor) — GL12528 12mm LDR Photoresistor Light-dependent Resistor

In this project, the LDR [3] acts as the light sensor. Whereas the intensity of light falling on the LDR increases, the resistance of the LDR decreases and vice-versa. The LDR is used in combination with a laser to form the light sensor and source. The maximum operating power is 100mW and the spectral peak is 540 nm. Other features are a response time of 20ms and a working temperature between -30°C and 70°C. Link: https://allegro.pl/oferta/fotorezystor-5mm-gl5539-ldr-50k-100k-10-szt-11322341961

3. Arduino Uno — Arduino UNO R3 ATMEGA328P-16AU

Arduino UNO [6] microcontroller (Figure 8) was chosen for the project as it is easy to use, inexpensive, has an active user community in case of problems where questions arise, and has a multitude of libraries. Requires a supply voltage of 5 volts and has a maximum clock frequency of 16MHZ. Link: https://allegro.pl/oferta/omega-zone-arduino-uno-r3-atmega328-ch340-avr-klon-7143402034

4. Buzzer — 5v Active Buzzer Continous Beep

In this project, the buzzer acts as an alarm that notifies us when the connection between the light sensor and the laser emitter has been disrupted. It has a pitch of about 2.54mm. Link: https://allegro.pl/oferta/modul-buzzer-buzer-brzeczyk-5v-arduino-avr-9515527742

In the Figure 4 below we see a close up version of the Arduino uno microcontroller and some basic connections. Hardware may be a bit complex to understand but this is where basic LED Laser diodes etc are connected to in order to get them to function properly.

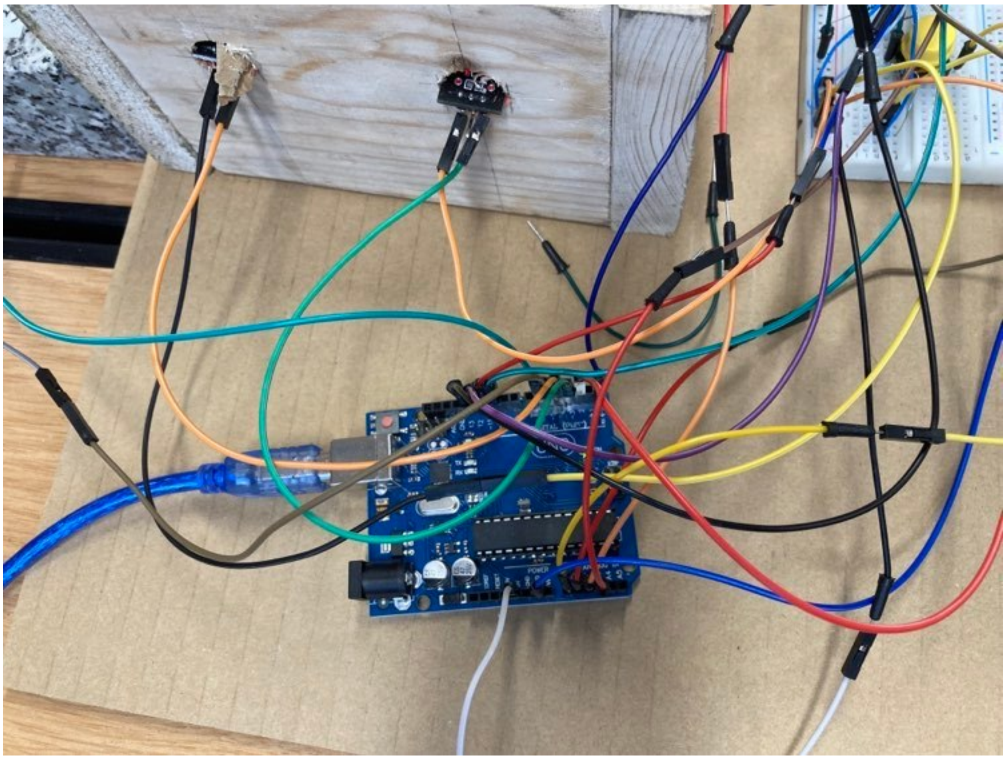

Figure 4: Arduino UNO close-up

In the Figure 5 we can see a close up version of the breadboard which presents a more detailed connection of other hardware components extending from the Arduino uno microcontroller eg.Reset button and resistors etc...

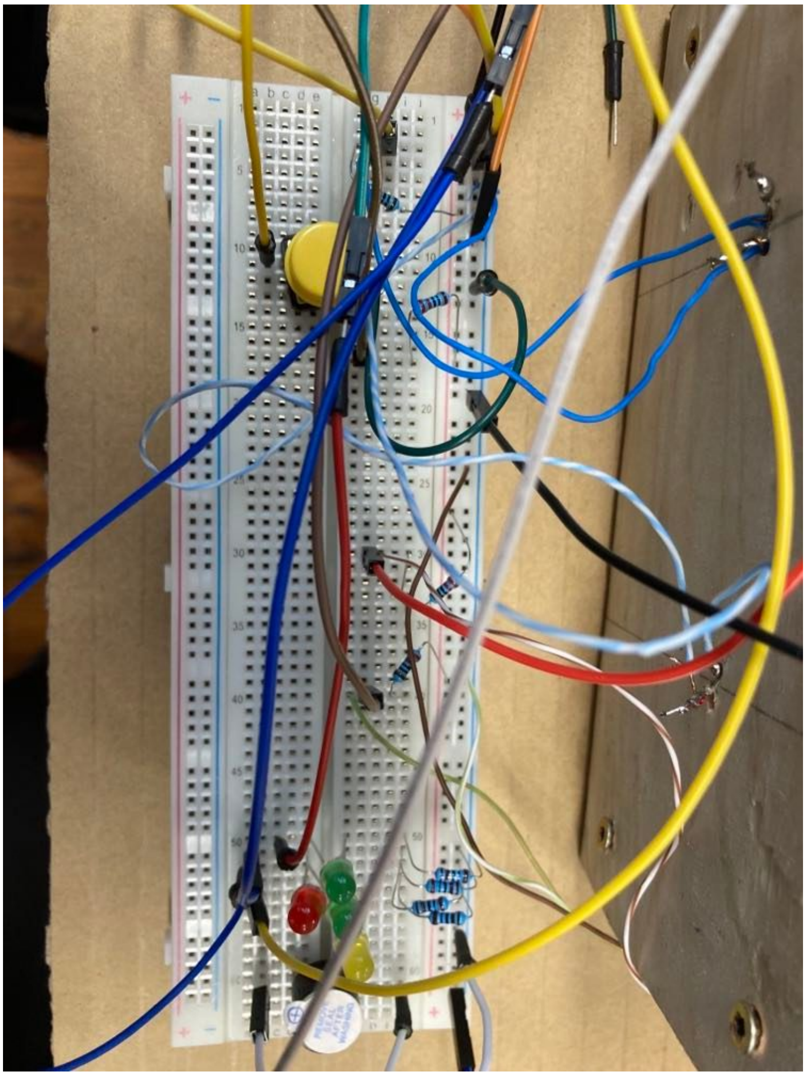

Figure 5: Breadboard close-up

In Figure 6 below the image shows how the laser modules are numbered which helps to differentiate which part of the system has been interrupted according to the led

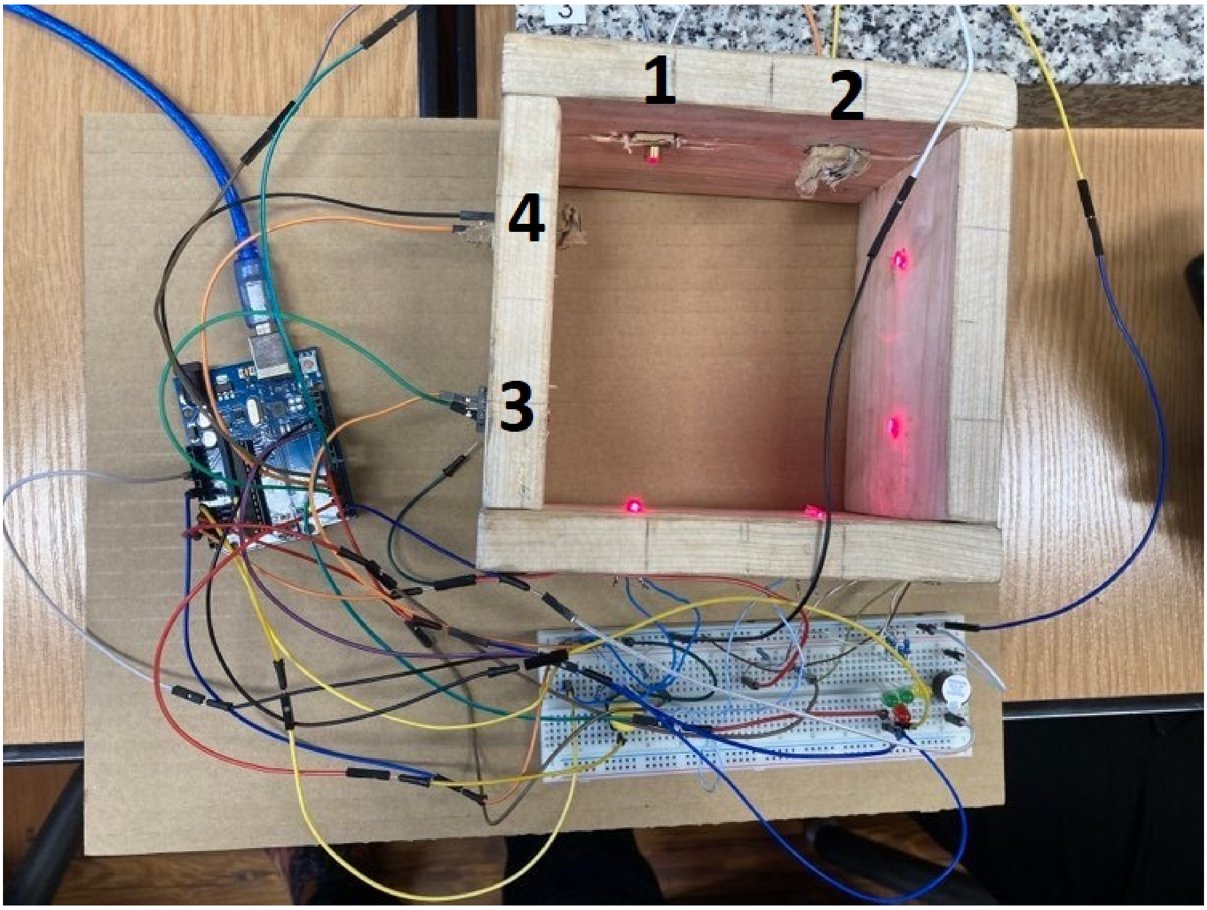

Figure 6: NOTE To distinguish which LED is lighting up after which Laser beam is interrupted they are numbered as follows

Figure 7 shows the an example of the LED lighting up according to the laser which is disrupted. From the image we can see that the first green LED lights up which corresponds to the first laser, therefore we can conclude there was an intrusion somewhere along the first laser

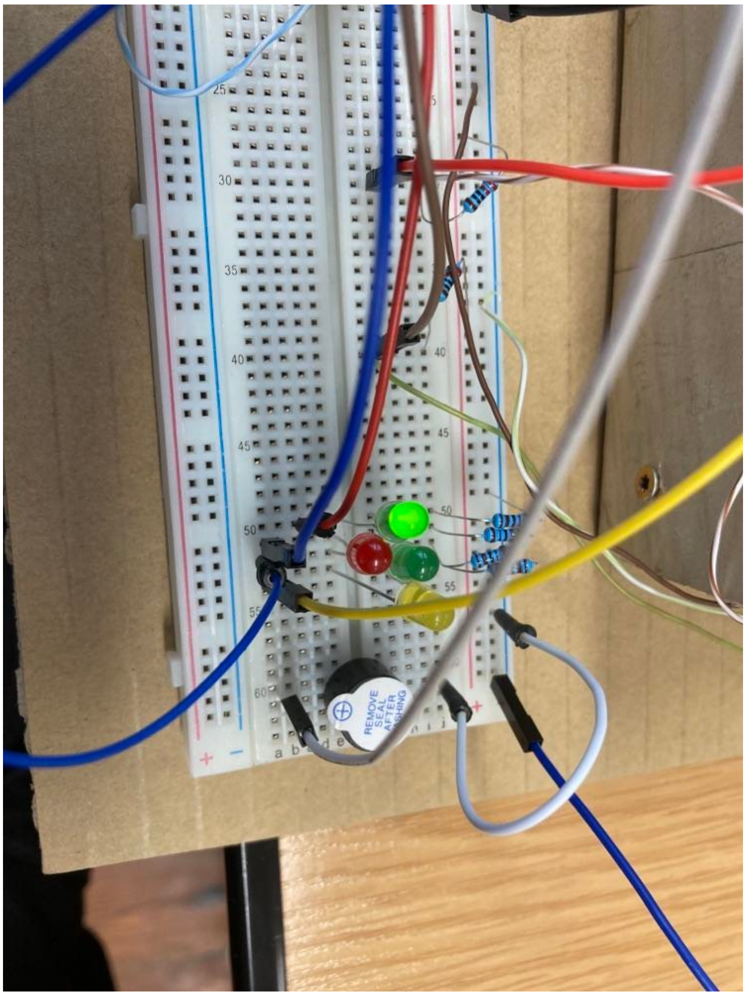

Figure 7: NOTE Each LED lights up when the corresponding Laser beam is interrupted. Therefore: Lighten up green LED - Laser no.1
Red Led - Laser no. 2
Yellow Led - Laser no.3
Other green LED - Laser no. 4

5 Software

The software component of a project refers to the computer program and algorithms that are used to achieve the desired goals and objectives of the project. The software component of a project is critical to its success and its correct execution will ensure that the created system is working and meeting our requirements. In Figure 8 below the working flowchart/block diagram can be observed and followed for the software section

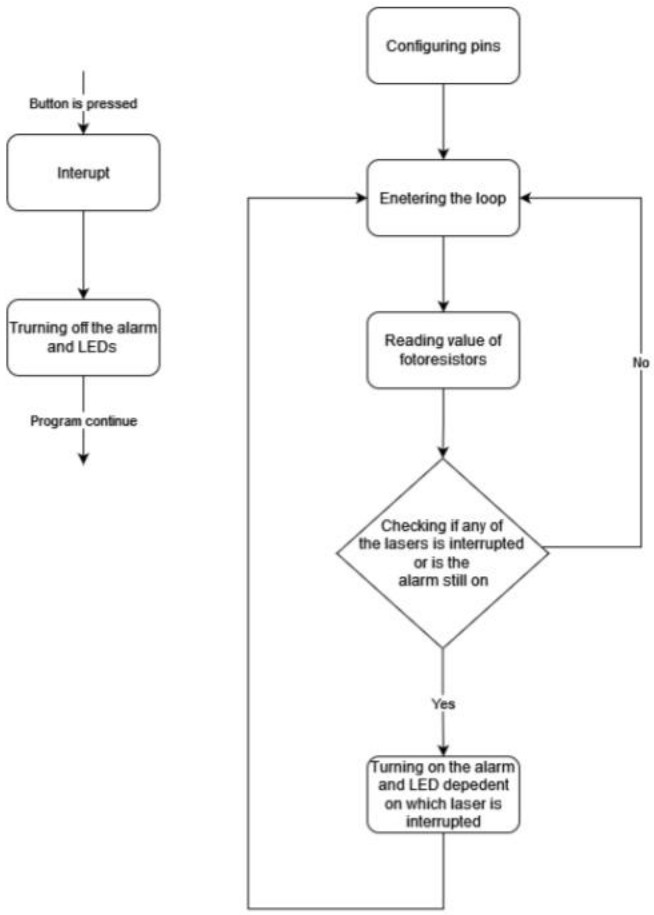

Figure 8: Block Diagram of Software Design

This project's code is comprised of three components: configuring pins, main loop, and button interrupt. Each pin is assigned a variable to indicate its purpose; photoresistors [8] are connected to analog pins, while the remaining pins are digital. The button is configured with an interrupt so that the alarm can be turned off at any time. To detect if the lasers are being blocked, photoresistors [8] are used in a voltage divider setup. Depending on the voltage of the photoresistors, it can be determined whether or not the laser is interrupted. The variable ALARM is used to turn on the alarm, while variables ALARM1, ALARM2, ALARM3, and ALARM4 indicate when one of the four lasers has been interrupted and can be used to turn on the corresponding LED.

The alarm will remain on regardless of the voltage of the photoresistors [8] until the button is pressed. When the button is pressed, the interrupt is enabled and sets ALARM, ALARM1, ALARM2, ALARM3, and ALARM4 to '0', turning off the LEDs and buzzer.

Variable initialization is from row 1st to 24th, setup of inputs and outputs is from 26th to 47th row. From 49th is starting the loop section. On 51st row are initialized variables las1, las2, las3, las4 which are '1' when the laser is interrupted. Rows 52nd to 55th initialized variables for collecting how high voltage is on photoresistors[8], 58th and 61st row are used for turning on the laser diodes. From 63th to 89th code is checking for each laser is one of them interrupted, and setting dedicated variable las1, las2, las3 or las4 to '1' and form 91st to 109th if the laser was interrupted the variable ALARM will be set to '1' and dedicated variable for that laser ALARM1, ALARM2, ALARM3 or ALARM4 to '1'. Row 111 to 125 is for blinking of LEDs depending on the interrupted laser and turning on and off the buzzer. Interrupt is set on rows 129 to 140 and is for setting ALARM, ALARM1, ALARM2, ALARM3, ALARM4 to '0' and turning off the LEDs and buzzer.

CODE

```
1
2  /*------------------------------------------------------------------------\
3  | LIGHT BEAM BARRIER                                                  |
4  +------------------------------------------------------------------------+
5  | 2022 Group 24                                                       |
6  +------------------------------------------------------------------------+
7  | This module was programmed by mainly Jacov Vrdoljak with assist of the
      rest |
8  | of the group                                                        |
9  +------------------------------------------------------------------------|
10 | Version 1.0                                                         |
```

```
+---------------------------------------------------------------------------+
| CODE DESCRIPTION                                                          |
| C++ code for Arduino created for operate on laser diodes and light
  sensors |
|                                                                           |
\--------------------------------------------------------------------------*/

const int ledPin1 = 10;
const int ledPin2 = 11;
const int ledPin3 = 12;
const int ledPin4 = 13;

const int buzzerPin = 7;

const int laserPin1 = 3;
const int laserPin2 = 4;
const int laserPin3 = 5;
const int laserPin4 = 6;

const int ldrPin1 = A0;
const int ldrPin2 = A1;
const int ldrPin3 = A2;
const int ldrPin4 = A3;

const int button = 2;

int ALARM = 0;
int ALARM1 = 0;
int ALARM2 = 0;
int ALARM3 = 0;
int ALARM4 = 0;

void setup () {

pinMode(ledPin1, OUTPUT);
pinMode(ledPin2, OUTPUT);
pinMode(ledPin3, OUTPUT);
pinMode(ledPin4, OUTPUT);

pinMode(button, INPUT_PULLUP);
attachInterrupt(digitalPinToInterrupt(button), ALARM_OFF, LOW); //SETING
  UP THE INTERRUPT

```

```
pinMode(buzzerPin, OUTPUT);

pinMode(ldrPin1, INPUT); //foto resistor 1
pinMode(ldrPin2, INPUT); // foto resistor 2
pinMode(ldrPin3, INPUT); // fofto resistor 3
pinMode(ldrPin4, INPUT); // foto resistor 4

pinMode(laserPin1, OUTPUT);
pinMode(laserPin2, OUTPUT);
pinMode(laserPin3, OUTPUT);
pinMode(laserPin4, OUTPUT); // CONFIGURING PINS
}

void loop() {

  int las1, las2, las3, las4;
  int ldrStatus1 = analogRead(ldrPin1);
  int ldrStatus2 = analogRead(ldrPin2);
  int ldrStatus3 = analogRead(ldrPin3);
  int ldrStatus4 = analogRead(ldrPin4); // READING VALUE OF FOTORESISTOR


  digitalWrite(laserPin1, HIGH);
  digitalWrite(laserPin2, HIGH);
  digitalWrite(laserPin3, HIGH);
  digitalWrite(laserPin4, HIGH); // TURNING ON THE LASERS

  if(ldrStatus1 > 900){ // CHECKING IF THE FIRST LASER IS INTERRUPTED
    las1 = 1;
  }
  else {
    las1 = 0;
  }

  if(ldrStatus2 > 900){ // CHECKING IF THE SECOND LASER IS INTERRUPTED
    las2 = 1;
  }
  else {
    las2 = 0;
  }

   if(ldrStatus3 > 900){ // CHECKING IF THE THIRD LASER IS INTERRUPTED
    las3 = 1;
```

```
  }
  else {
    las3 = 0;
  }

  if(ldrStatus4 > 920){ // CHECKING IF THE FOURTH LASER IS INTERRUPTED
    las4 = 1;
  }
  else {
    las4 = 0;
  }

if(las1 == 1){
  ALARM = 1;
  ALARM1 = 1;
  }

if(las2 == 1){
  ALARM = 1;
  ALARM2 = 1;
  }

if(las3 == 1){
  ALARM = 1;
  ALARM3 = 1;
  }

 if(las4 == 1){
  ALARM = 1;
  ALARM4 = 1;
  }

if(ALARM){ // CHECKING IF ALARM IS ON

      tone(buzzerPin, 1000);
      digitalWrite(ledPin1, ALARM1);
      digitalWrite(ledPin2, ALARM2);
      digitalWrite(ledPin3, ALARM3);
      digitalWrite(ledPin4, ALARM4);
      delay(100);
      noTone(buzzerPin);
      digitalWrite(ledPin1, LOW);
      digitalWrite(ledPin2, LOW);
```

```
      digitalWrite(ledPin3, LOW);
      digitalWrite(ledPin4, LOW); // TURNING ON AND OFF THE LEDS AND BUZZER
      delay(100);
  }

}

void ALARM_OFF(){ // INTERRUPT FOR TURNING OFF THE ALARM
    ALARM = 0;
    ALARM1 = 0;
    ALARM2 = 0;
    ALARM3 = 0;
    ALARM4 = 0;
    digitalWrite(ledPin1, LOW);
    digitalWrite(ledPin2, LOW);
    digitalWrite(ledPin3, LOW);
    digitalWrite(ledPin4, LOW);
    noTone(buzzerPin); }
```

6 Start-up & Calibration

For the Security System to work first we need to program Arduino with provided Software Part code. After that is done all the system requires is the power [5] source. Arduino needs electric power [5] to function. It can be provided via a battery connected to AC Socket or use a PC as a voltage source and connect it via a USB A-B cable to the USB B port.

When connecting the System to the power source and starting it up the first time blinking diodes will indicate that the system is correctly connected to the power [5] source. To be able to use it as intended in Security System we need to press the Button, which will also be the reset button that we will use after any interruption to go back to the unaffected state of the system.

7 Test Measurements

After calibration and the first start-up of our system, we tested if the system is working as intended in the beginning. We needed to check if the buzzer works anytime interruption occurs, if each LED is lighting up when the corresponding light beam is interrupted and if the reset button brings us back to the beginning state of the system.

When calibrating the software system we noted the voltage values as analog data in the terminal on the photoresistor[3] in a state of detection when the light beam is received and then when the light beam is interrupted. On basis of these values, we can distinguish if the light beam is interrupted or not seeing if it is above or below-measured values that set our threshold.Figure 9 below shows the space created for the Laser light beam to strike the LDR with no obstruction can be compared to hardware component of in Figure 6 to see how its implemented. An image of the how the calibration of these voltage values were carried out can be seen in the Figure 10 below

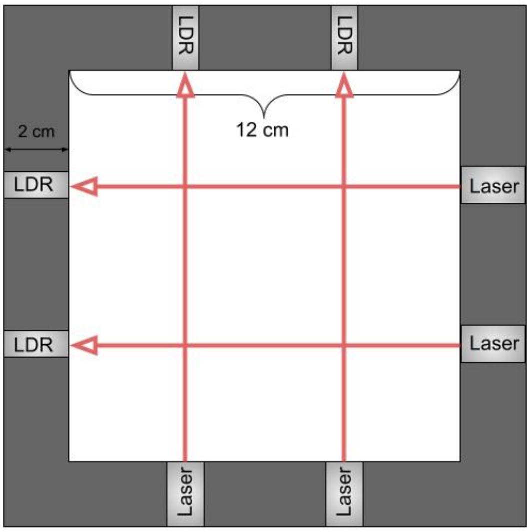

Figure 9: Created space

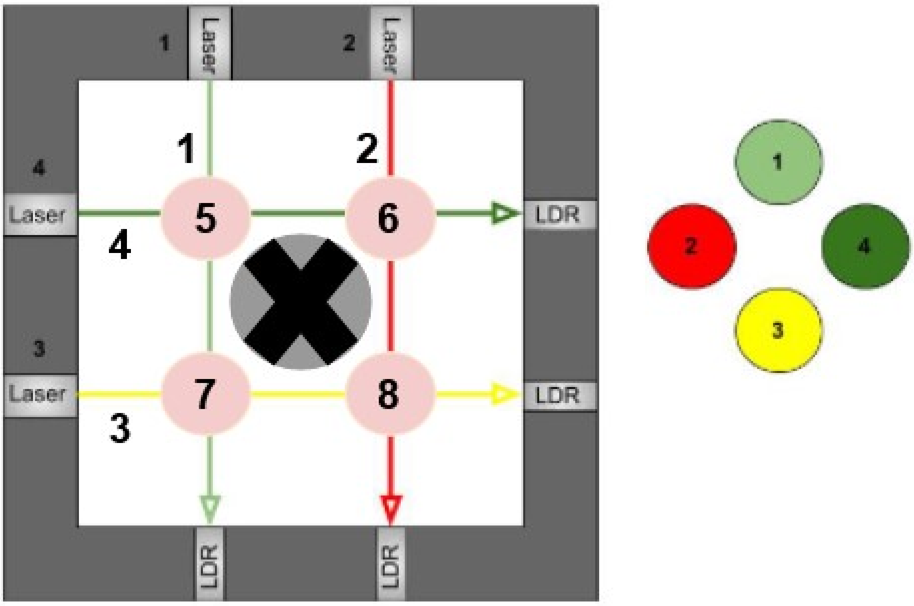

Figure 10: Depiction of possible interruption areas

There are 8 possible combinations of interruption of laser beam and all of those had to be tested:

1. At any point laser beam from laser nr 1 is interrupted but no other laser beam is interrupted at the same time LED nr 1 lights up as a result
2. At any point laser beam from laser nr 2 is interrupted but no other laser beam is interrupted at the same time LED nr 2 lights up as a result
3. At any point laser beam from laser nr 3 is interrupted but no other laser beam is interrupted at the same time LED nr 3 lights up as a result
4. At any point laser beam from laser nr 4 is interrupted but no other laser beam is interrupted at the same time LED nr 4 lights up as a result
5. At any point laser beam from laser nr 1 and laser beam nr 4 is interrupted at the same time LED nr 5 lights up as a result
6. At any point laser beam from laser nr 2 and laser beam nr 4 is interrupted at the same time LED nr 6 lights up as a result
7. At any point laser beam from laser nr 1 and laser beam nr 3 is interrupted at the same time LED nr 7 lights up as a result

8. At any point laser beam from laser nr 2 and laser beam nr 3 is interrupted at the same time LED nr 8 lights up as a result

In the images below we can make a comparison between Figure 11 and Figure 12 to understand what is going on with the resistance and voltage of the LDR. Further information can be found in the figures description

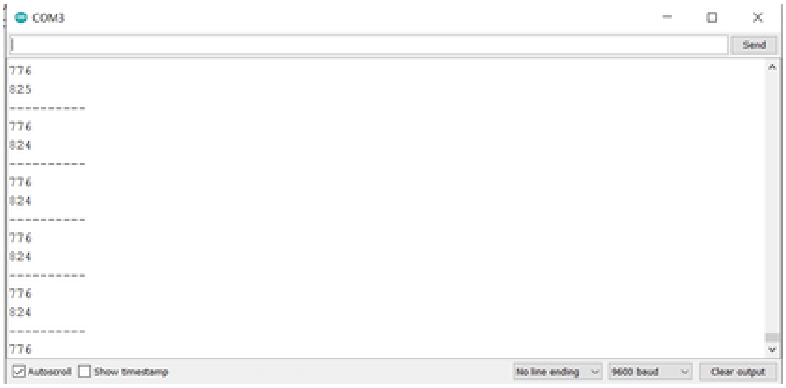

Figure 11: Analog data in program terminal representing voltage on photoresistors[8] while receiving light

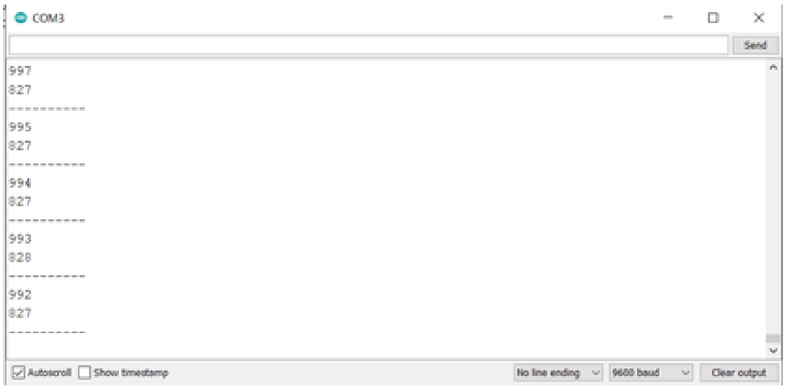

Figure 12: Analog data in program terminal representing voltage on photoresistors[8] while not receiving light

Figure 13 below shows a test of the laser security system where an object was placed to obstruct the 2ND and 4th laser module without touching any other laser which then caused the red LED in the second position and yellow Led in the 4th postion to go off to announce that an object is currently obstructing the 2ND and 4th laser diode which is then used to get area of instrusion/obstruction in our case

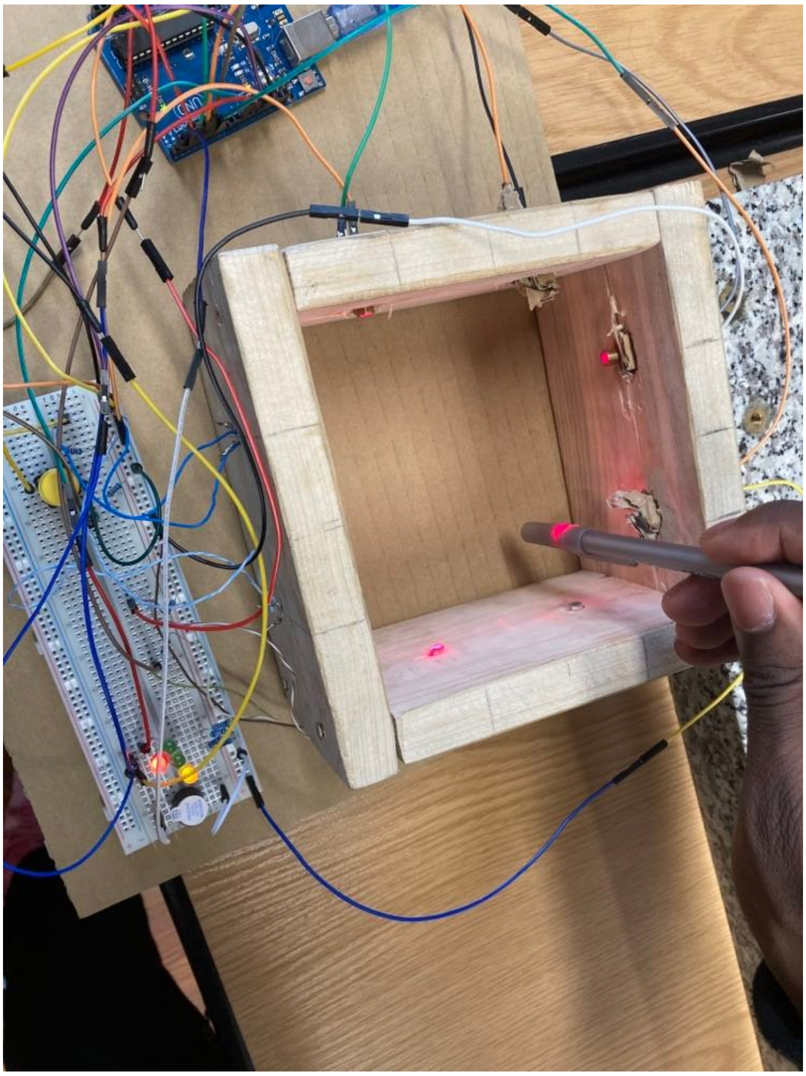

Figure 13: Laser beam path being obstructed by object

In Figure 14 we just made some different experiments to show the LED come on to announce the obstruction in laser path. In our case the red led came on and according to the picture it is the 2nd LED therefore you can conclude that there was an obstruction on the only the 2ND Laser module

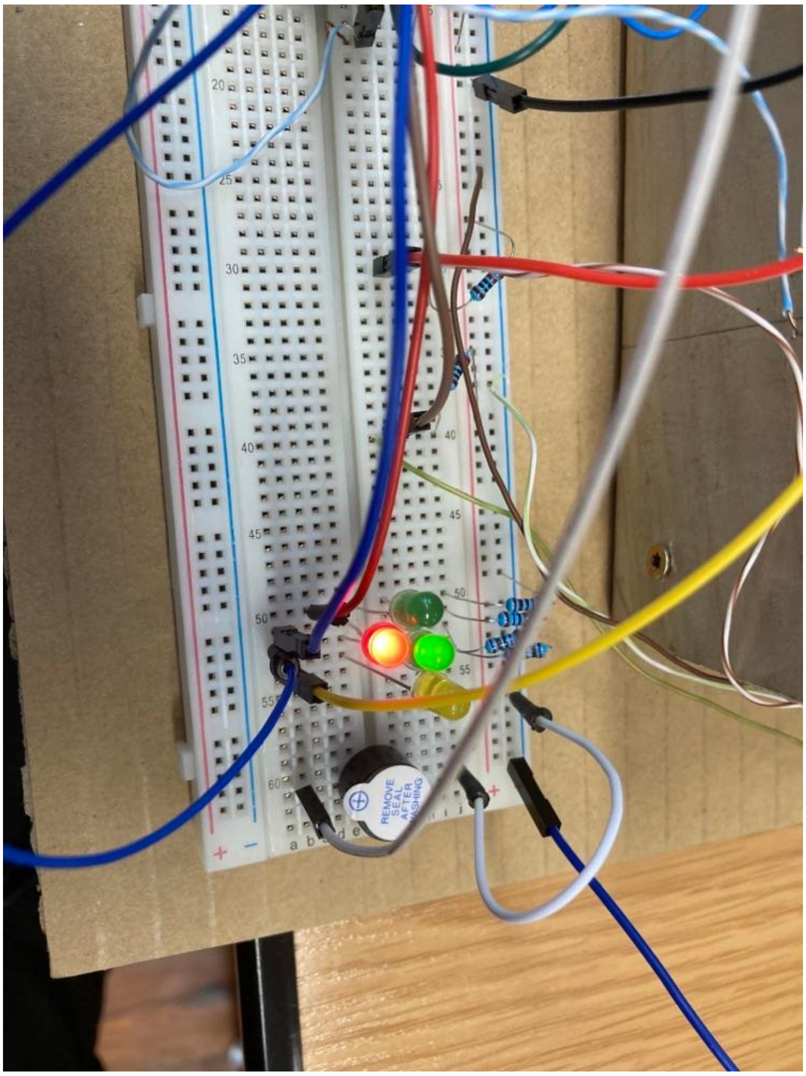

Figure 14: LED reacting to laser beam obstruction

8 User Manual

About Your Security System
Your Security System has been designed to provide you with the greatest possible security and convenience.

Read this manual carefully and have your installer instruct you on your system's operation and on which features have been implemented in your system. All users of this system should be equally instructed in its use.

General System Operation
Your security system is made up of a RESET BUTTON, an LED INTERRUPTION INFORMING SYSTEM, and Motion Detectors - Lasers.

The RESET BUTTON is used to set up the system to start and to silence the alter after an irruption. LED INTERRUPTION INFORMING SYSTEM is used to visualize where the irruption took place so it is known where can we expect our uninvited guests to be. Lasers are an essential part of the security system. There is normally no reason for anyone but the installer or service professional to have access to and modify the motion detection part - Lasers.

The RESET BUTTON and LED INTERRUPTION INFORMING SYSTEM are mounted in a convenient location outside the protected area to make it inaccessible for the burglar and reduce the possibility of switching off by intruders. The security system has several zones of area protection and each of these zones will be connected to one or more motion sensors. A sensor in alarm will be indicated by the corresponding zone lights flashing on a LED INTERRUPTION INFORMING SYSTEM.

Start of the System
After your Security System has been mounted and installed all that is left for you is to provide it with a stable power supply.

The indication that your system is correctly installed will be the blinking of all diodes on the LED INTERRUPTION INFORMING SYSTEM. If you do not see the blinking LEDs on your LED INTERRUPTION INFORMING SYSTEM please contact your systems provider. If LEDs on your LED INTERRUPTION INFORMING SYSTEM are blinking correctly you can press the RESET BUTTON to finally start your system. From now on Security System will provide you with protection and an alarm whenever there occurs an interruption.

LED INTERRUPTION INFORMING SYSTEM works as an information panel. From here you will know not only if your system is correctly working after connecting it to the power source but also where the interruption has occurred.

Figure 15 shows an example of how the system works where laser can be seen to correspond with led that is whichever laser is obstructed guarantees a reaction from same colored led to show the position where obstruction has taken place

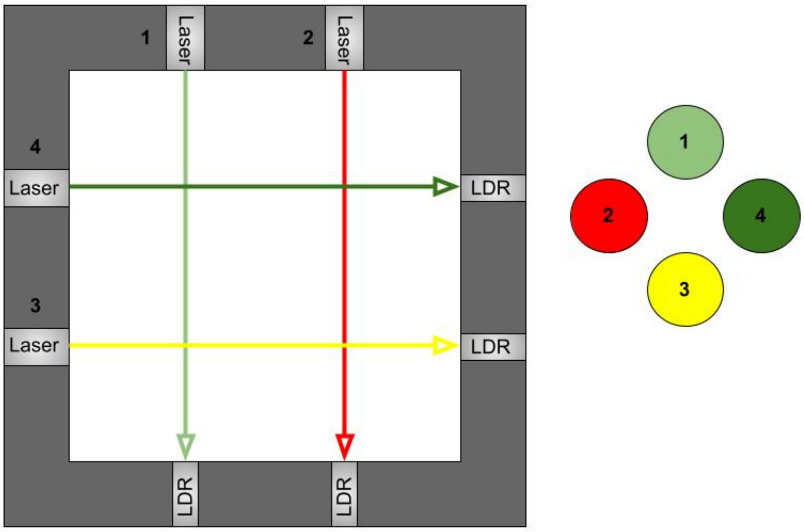

Figure 15: Led Interruption Informing System

! IMPORTANT NOTICE !

A security system cannot prevent emergencies. It is only intended to alert you and your monitoring station of an emergency situation. Security systems are generally very reliable but they may not work under all conditions and they are not a substitute for prudent security practices or life and property insurance. Your security system should be installed and serviced by qualified security professionals who should instruct you on the level of protection that has been provided and on system operations.

9 Summary

In this project, we designed a working alarm system mainly using Laser Diodes and Light Sensors. The system correctly detects laser light beam interruption and alters the user via the sound signal - alarm - when an interruption occurs in the system's working area.

For the system to work correctly the influence of ambient light must be taken into account. Our choice of using a Photoresistor [3] as a Light Sensor was a classic beginner's mistake because of its sensitivity to incident light from anywhere. Much more accurate would be using Photodiode as it is sensitive to incident light from a particular direction and insensitive from other directions. This way we would exclude the influence of artificial lighting and as well as sunlight peeking through a window.

Conclusions drawn from this experience for sure will make us consider more environmental factors while choosing elements for future real-life projects.

This time we managed to minimize this factor significantly by building a working space in form of a box consisting of parallel wood walls and an additional plexiglass cover. The designed setting blocked some unwanted light from our sensor. Additionally, to reduce the influence of ambient light we introduced LDR calibration in our code.

All those modifications lead us to a work security system designed around Laser diodes and LDRs and programmed on Arduino Uno [6]. Which instantaneously alarms us when the interruption in the beam of light occurs and allows us to silence the alarm and reset the system.

10 Bibliography

[1] hunker.com — https://www.hunker.com/13419297/how-do-laser-security-systems-work

[2] covesmart.com — https://www.covesmart.com/blog/what-is-a-laser-security-system/

[3] rfwireless-world.com — https://www.rfwireless-world.com/Terminology/Photoresistor-vs-Photodiode.html

[4] arduinomodules.info — https://arduinomodules.info/ky-008-laser-transmitter-module/

[5] support.arduino.cc — https://support.arduino.cc/hc/en-us/articles/360018922259-What-power-supply-can-I-use-with-my-Arduino-board-

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