Department of Electronic & Telecommunication Engineering
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EN2160 - Electronic Design Realization

Laser Tripwire Alarm

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Contents

Laser Tripwire alarm system

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Abstract

A laser tripwire device is a security device that uses a laser beam to detect intrusions and trigger an alarm or other response. The device consists of a laser transmitter and a receiver, placed opposite each other and separated by a distance. When the laser beam is interrupted, the receiver detects the change in the beam and triggers an alarm. The device can be used in various applications such as home security, outdoor perimeter protection, and industrial safety. It offers several advantages over traditional motion sensors, including greater accuracy and sensitivity, and the ability to detect small movements at longer distances. The development of laser tripwire devices has opened up new possibilities for advanced security systems, making them an essential tool for those looking to protect their property and assets.

1 Introduction

Security has become a primary concern for individuals and organizations these days, and the need for advanced security systems has never been greater. Traditional security measures, such as locks and fences, can be breached, and intruders can go undetected, causing significant damage and losses.A laser tripwire device is a security system that uses a laser beam to detect movement and trigger an alarm or other response. The system consists of a laser transmitter and a receiver, placed opposite to each other. When the laser beam is interrupted by an object, the receiver detects the change in the beam and triggers an alarm.

This report aims to provide an in-depth understanding of laser tripwire devices and their potential as a reliable and effective security solution.

2 Specifications of the product

The laser tripwire alarm system is equipped with several features that enhance user security. These features are listed below:

- Consist of two units: Transmitter and Receiver.
- Utilizes a laser beam to create a virtual tripwire for intrusion detection.
- Equipped with a GSM module for SMS notifications and call alerts.
- GSM module compatible with standard SIM cards.
- Audible buzzer for local alert.
- Low power consumption for extended battery life.

3 Design and Components

3.1 Power

The power source of the device is two Li-ion 18650 batteries with a nominal voltage of 3.7V. Then the 7.4V input voltage from the Li-ion battery regulates down to a constant 5V output voltage using an L7805 voltage regulator. This is a cost effective and widely available voltage regulator.

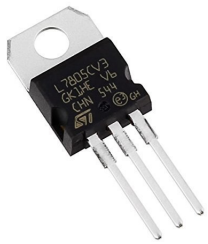


Figure 1: *L7805 voltage regulator IC*

3.2 GSM module

The SIM900A GSM GPRS module is used send an alert message to a pre-programmed phone number when the laser beam interrupted. It has following features.

- Power Supply: 4.5V - 5V
- Can operate on both the 900MHz and 1800MHz GSM frequencies
- By the AT command control

Figure 2: *SIM900A GSM module*

3.3 Micro controller

The ATmega328P micro controller which is a versatile, powerful, and easy-to-use micro controller used in laser tripwire system as the micro controller.

- Operating Voltage: 1.8V - 5V
- Flash memory: 32Kbytes
- Has several number of power-saving modes, which can be used to reduce the power consumption of the microcontroller.

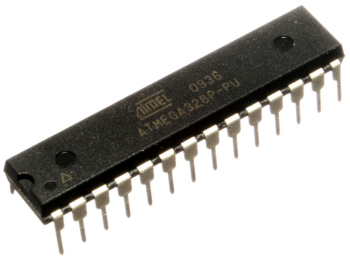


Figure 3: *ATMEGA328P*

4 Operation and Functionality

The operation of a laser tripwire system is relatively simple, yet highly effective. When the device is activated, the laser transmitter generates a narrow, laser beam that is directed towards the light dependent resistor (LDR) of the receiver. When an object interrupts the laser beam, the receiver detects the change in light intensity and triggers an alarm.

The ATMEGA328P-PU micro-controller is the brain of the laser tripwire device. It is responsible for processing the output signal from the receiver, triggering the buzzer, and sending a signal to the GSM module. When the receiver detects an interruption in the laser beam, it sends a signal to the micro-controller. Then it triggers the buzzer and sends a signal to the GSM module.The GSM module then sends a text message to the pre-programmed phone number.

One of the key advantages of a laser tripwire device is its ability to detect motion or intrusion over a wide area, without the need for physical barriers or other types of sensors. This makes it an ideal solution for a variety of security applications, such as perimeter monitoring, asset protection, and intrusion detection. Overall, the operation and functionality of a laser tripwire device are highly effective and versatile, providing a reliable and efficient solution for advanced security applications. With its advanced technology and compact design, the device is an ideal solution for organizations and businesses looking to enhance their security capabilities.

5 Simulation & Testing

Simulation was done using **Proteus 8 professional** software. Results obtained from the simulation process are as follow.

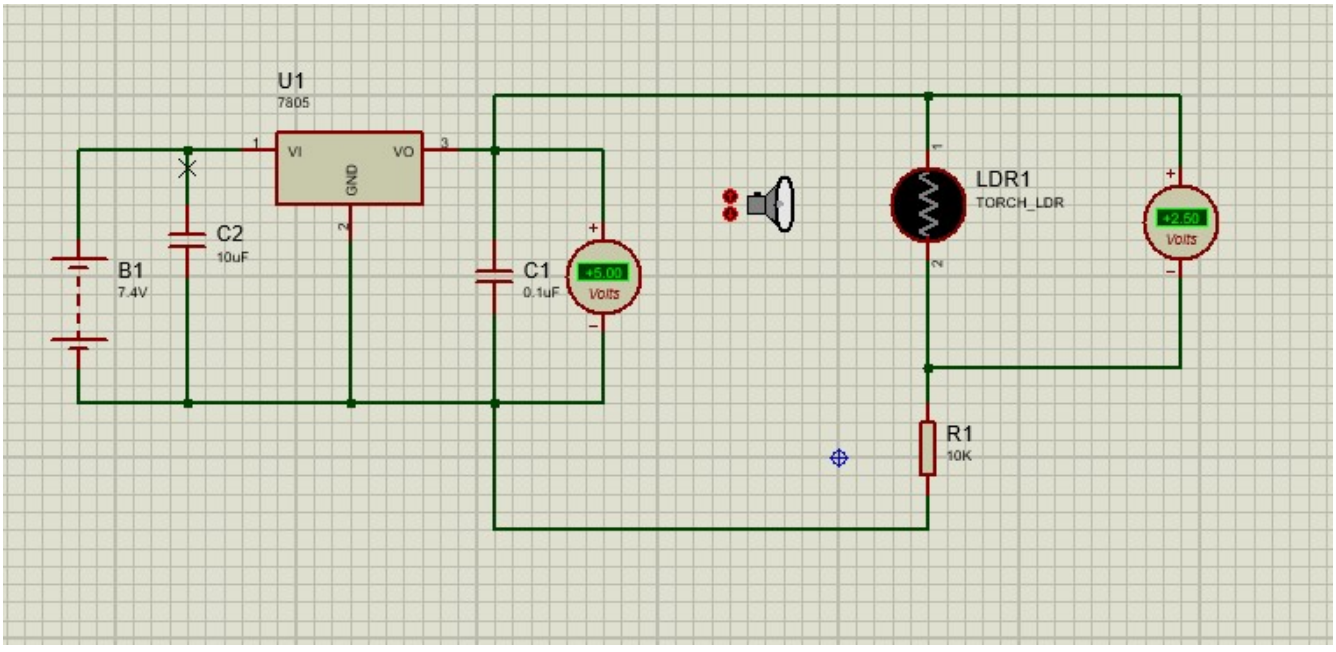


Figure 4: *Simulation results*

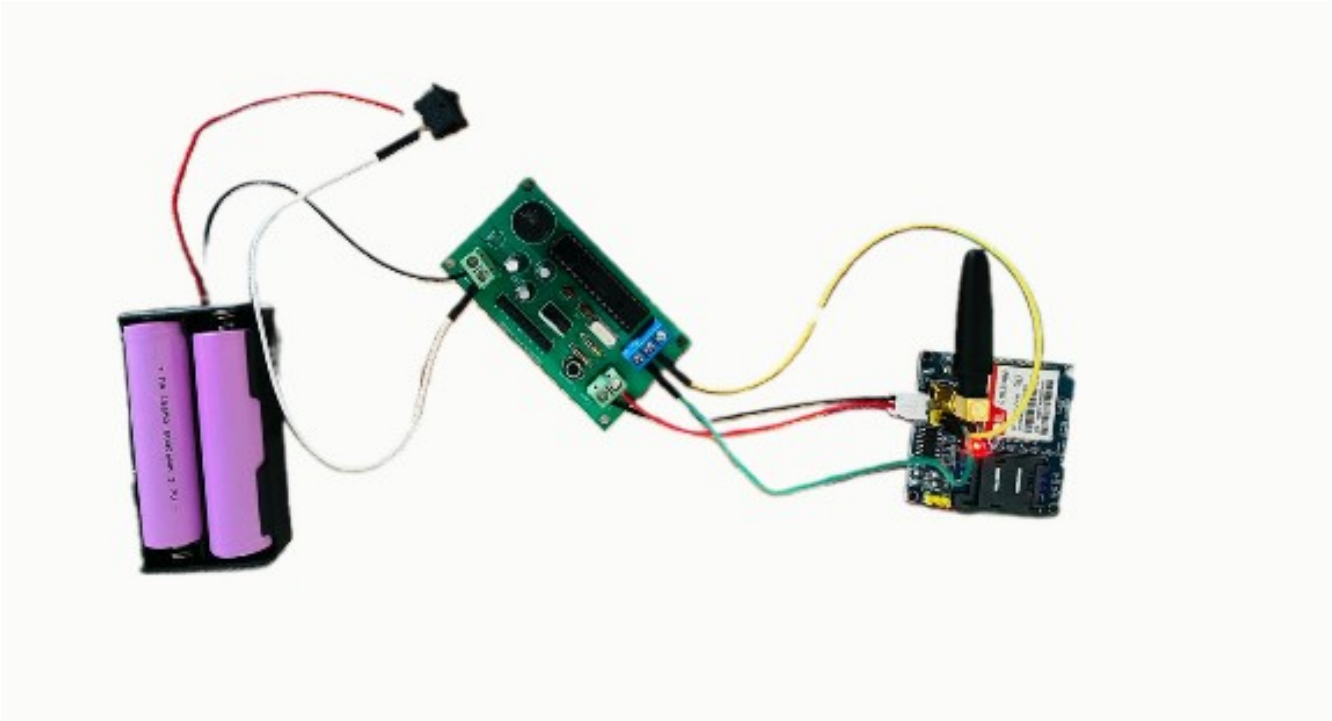


Figure 5: *Testing the circuit*

6 PCB Design

The PCB design for the electronic device was created using the Altium Designer software. The schematic design was first created, and then the PCB layout was created based on the schematic. The PCB layout was carefully designed to ensure that the components were placed in an optimal location and that the traces were routed in a way that minimized noise and interference. The PCB design was then sent to a PCB manufacturer for fabrication.

The PCB manufacturing process involved several steps, including:

- **Gerber file generation:** The PCB design was exported as a set of Gerber files, which are the files that are used to fabricate the PCB.
- **PCB fabrication:** The Gerber files were sent to a PCB manufacturer, who used them to fabricate the PCB. The PCB manufacturing process typically takes several days.
- **PCB assembly:** The PCB was then assembled with the components.

The completed PCB was then tested to ensure that it was functioning properly. The testing process typically involves testing the PCB for functionality, electrical performance, and environmental resilience.

The PCB design for the electronic device was a critical part of the project. The PCB design was carefully created to ensure that the device would function properly.

6.1 Schematic Design

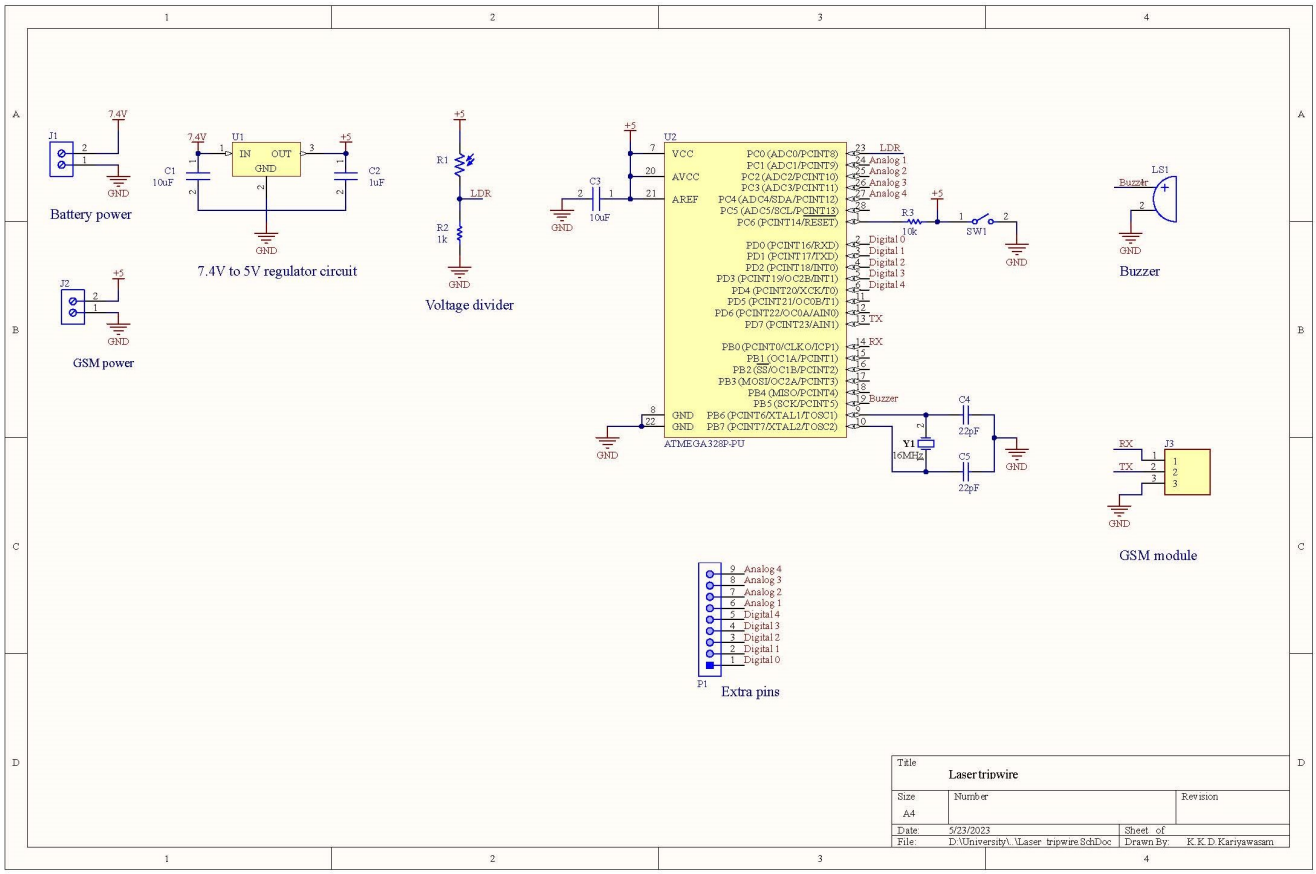


Figure 6: *Schematic of the circuit*

6.2 PCB Layout Design

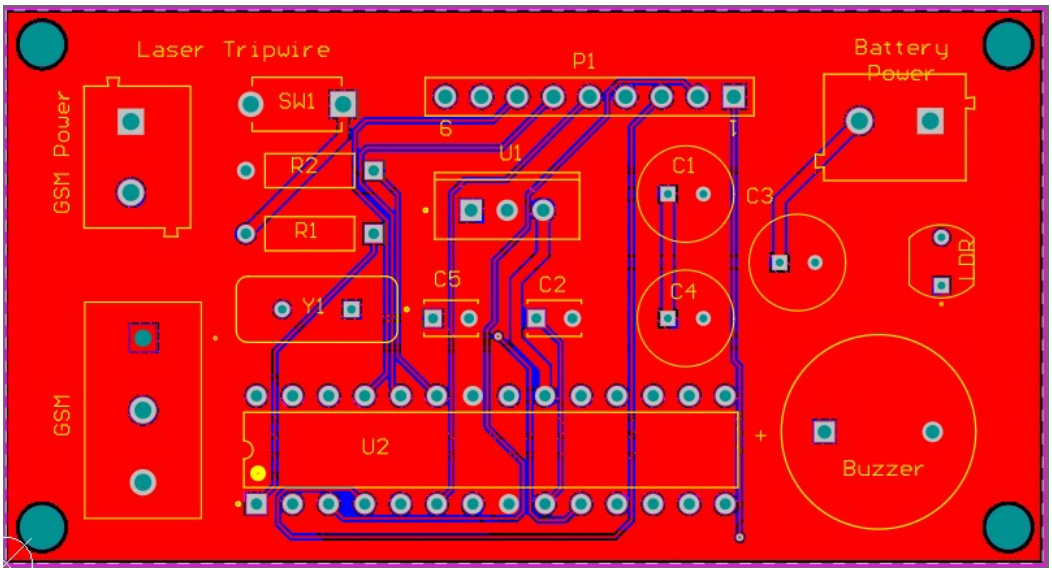


Figure 7: *2D view of the PCB*

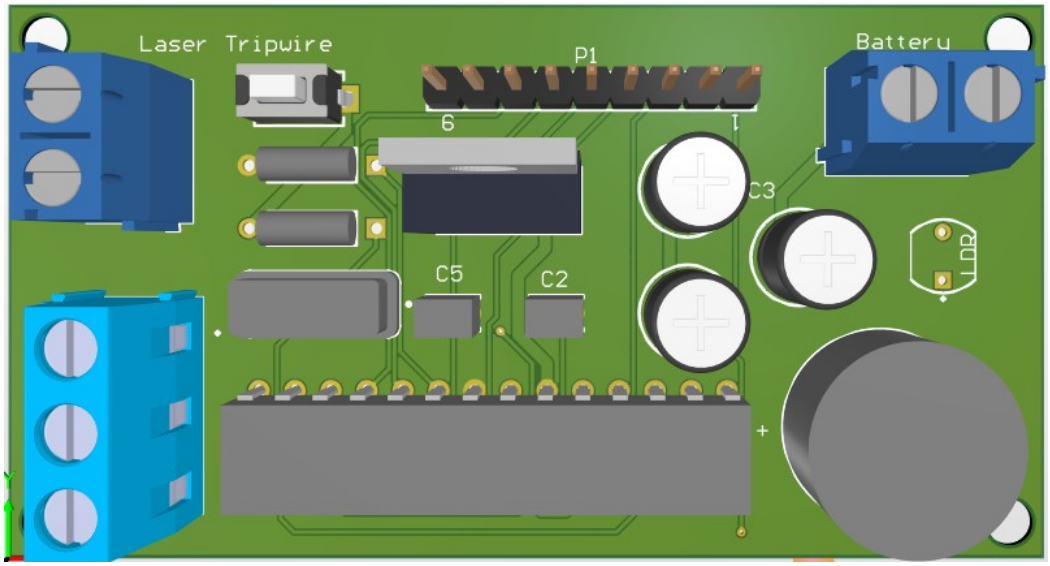


Figure 8: *3D view of the PCB*

7 Enclosure Design

An enclosure for the laser tripwire was designed using the SolidWorks software. The enclosure was manufactured by 3D printing using a high-quality ABS plastic. Two enclosures were designed, one for the transmitter and one for the receiver. The enclosures were designed to be durable and to protect the electronics from damage. The enclosures were also designed to be lightweight and portable, making them easy to deploy.

7.1 Receiver Side Enclosure

Solidwork design

(a) *Bottom Part* **(b)** *Upper Part*

Figure 9: *Receiver side enclosure design*

3D printed enclosure

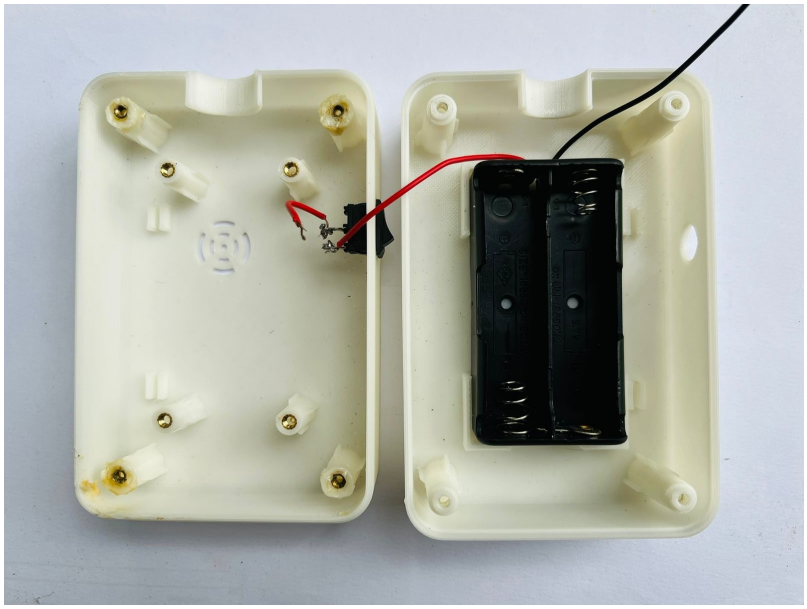


Figure 10: *3D printed receiver enclosure*

7.2 Transmitter Side Enclosure

Solidwork design

(a) *Bottom Part* **(b)** *Upper Part*

Figure 11: *Transmitter side enclosure design*

3D printed enclosure

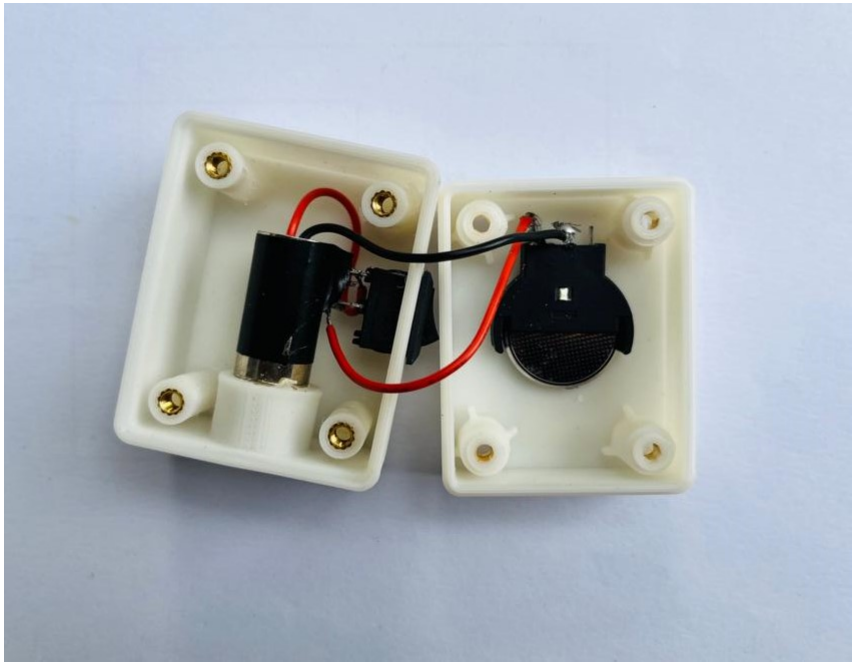


Figure 12: *3D printed receiver enclosure*

8 Device Code

This section contains the Arduino code for the device. The code is used to control the device's functionality, including the ability to send a SMS and make a call. The code makes use of the SoftwareSerial library to allow the device to communicate with a GSM module.

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(7, 8);
char msg;
char call;

int PR = 0; // Analog 0 to LDR
int Loud = 13; // Pin 13 to Buzzer

void setup() {
  pinMode(PR, INPUT); // LDR is set as an input
  pinMode(13, OUTPUT);
  Serial.begin(9600);
  mySerial.begin(9600);
}

void loop() {
  int Read = analogRead(PR); // "Read" reads analog 0 data
  Serial.println(Read); // Print that data

  if (Read < 500) { // If the value is less than 500
    digitalWrite(Loud, HIGH); // Speaker turns on
    SendMessage();
    MakeCall(); // Send an SMS
  } else {
    digitalWrite(Loud, LOW); // Speaker turns off
  }
  delay(100); // Run every 100 milliseconds
}

void SendMessage() {
  mySerial.println("AT+CMGF=1"); // Sets the GSM module in Text Mode
  delay(500);
  mySerial.println("AT+CMGS=\"xxxxxxxxxx\"\r");
  delay(500);
  mySerial.println("Speaker is turned on."); // The SMS text to send
  delay(100);
  mySerial.println((char)26);
  delay(500);
}

void MakeCall()
{
  mySerial.println("ATDxxxxxxxxxx;");
  Serial.println("Calling  ");
  delay(1000);
}
```

The code begins by defining the pins that are used for the LDR and the buzzer. The setup() function then initializes the pins and the serial ports. The loop() function continuously reads the value of the LDR and takes

action based on the value. If the value is less than 500, the speaker is turned on and an SMS is sent to the phone number provided. If the value is greater than or equal to 500, the speaker is turned off.

The **SendMessage()** function is used to send an SMS. The function first sets the GSM module in text mode. It then sends the phone number of the recipient and the SMS text. The **MakeCall()** function is used to make a call. The function sends the phone number of the recipient to the GSM module.

Note : The 'xxxxxxxxxx' placeholder should be replaced with the desired phone number before the code is executed.

9 How to Test

Power On and Initial Setup:

- Switch on both the Transmitter and Receiver units.Then check the LED indicator to confirm that power is supplied. The LED indicator should be lit if power is supplied to the unit. If the LED indicator is not lit, check the power supply to ensure that it is connected properly.

Align the Laser Beam:

To align the laser beam follow the following steps.

1. Position the Transmitter and Receiver units facing each other at the desired detection distance.
2. Adjust the Transmitter unit's laser to align with the Receiver's LDR to create the virtual tripwire. Aim for precise alignment for accurate detection.

Test the Tripwire Alarm:

- Carefully pass an object, such as your hand, through the laser beam to interrupt it. Check for Alarm Activation.When the laser beam is interrupted, the alarm should be triggered immediately. Verify that the audible alarm (buzzer) is activated.

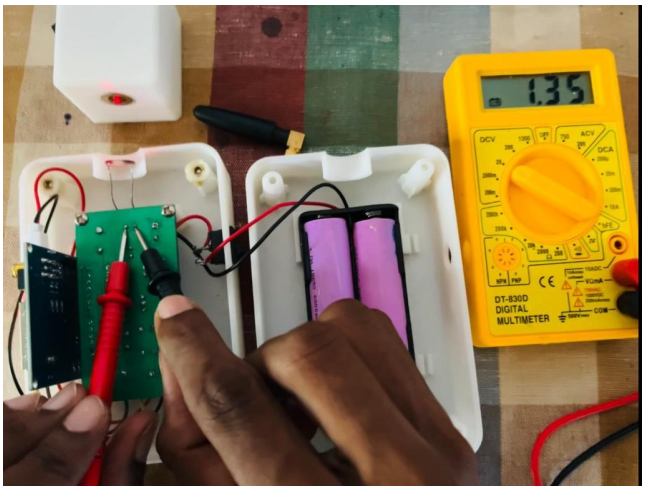
GSM Module Test:

To test the GSM module follow the below steps.

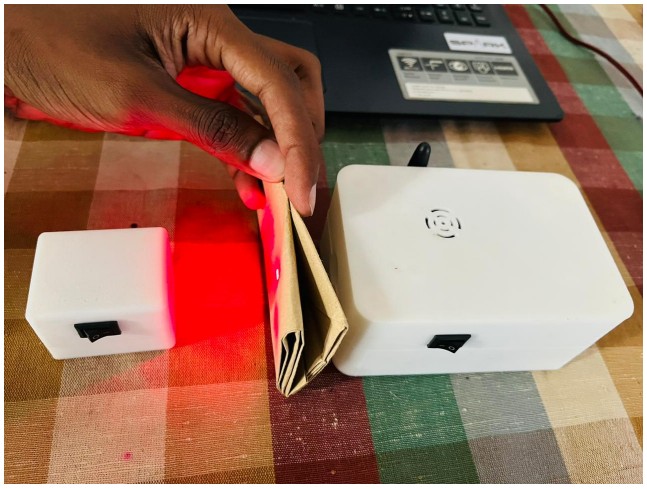
1. Add your phone number to the system using the configuration options (if not already done during initial setup).
2. Repeat the tripwire test to trigger the alarm and intrusion.
3. Confirm that the system sends an SMS notification to the designated phone number.
4. Additionally, ensure the system makes a call to the provided phone number as part of the intrusion alert.

Adjust Sensitivity:

If the system is overly sensitive or not sensitive enough, adjust the sensitivity settings using the code. Re-test the system to ensure it responds appropriately to the revised sensitivity.



(a) *Testing*



(b) *Obstructing the laser beam and testing*

Figure 13: *Testing the product*

10 Bill of Materials (BOM)

Component	Quantity	Unit Price (Rs)	Total Price (Rs)
ATmega328P	1	915.00	915.00
Laserpoint Module	1	550.00	550.00
CR3202 3.3V Battery	1	150.00	150.00
18650 Li-ion Battery	2	480.00	960.00
L7805 IC	1	50.00	50.00
Capacitors	5	-	25.00
5V Buzzer	1	40.00	40.00
SIM900A GSM Module	1	2000.00	2000.00
LDR (Light Dependent Resistor)	1	20.00	20.00
On/Off Switches	2	20.00	40.00
16MHz Oscillator	1	40.00	40.00
Resistors	2	5	10.00
PCB	-	-	1700.00
Enclosure	-	-	6850.00
Total	-	-	**13350.00**

Table 1: *Bill of Materials for Laser Tripwire Alarm System*

11 Assembly Instructions

Installing the GSM Module:

- Identify two grooves on enclosure.
- Align the GSM module with the grooves.
- Gently push the GSM module into the slots until it is firmly locked in place.

Connecting Components:

- Connect the power wires to the connector on the PCB labeled as 'Battery Power'.
- Connect the Rx and Tx pins of the GSM module to the connector on the PCB labeled as 'GSM'.
- Connect the power wires of the GSM module to the connector on the PCB labeled as 'GSM Power'.

Mounting the PCB:

- Place the PCB upside down on a flat surface.
- Align the mounting holes of the PCB with the corresponding mounting bosses on the enclosure.
- Carefully secure the PCB in place by fastening screws through the mounting holes into the bosses.

Positioning the LDR (Light Dependent Resistor):

- Locate the LDR component on the PCB.
- Notice that the enclosure has a designated curve surface where the LDR needs to be placed.
- Carefully position the LDR on the curve surfaceB.

Placing the Li-ion 18650 Batteries:

- Insert the Li-ion 18650 batteries into the battery case, paying attention to the correct polarity (+ and -).

Completing the Circuit:

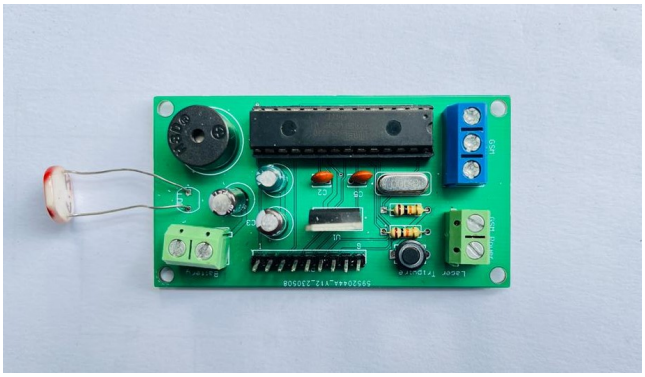
- Double-check all the components and connections for any possible errors or loose solder joints.
- Perform a visual inspection to ensure that there are no misplaced or misaligned components.

Final Testing:

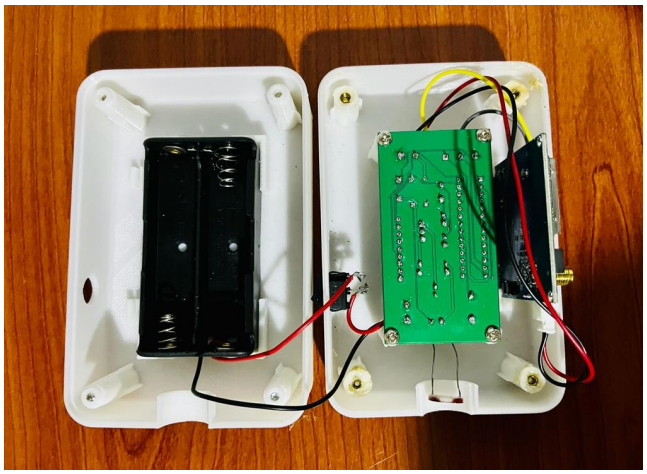
- Before powering on the system, recheck all the assembly steps to avoid any potential issues.
- Power on the laser tripwire alarm system and verify that the system is functioning correctly.
- Test the tripwire functionality by obstructing the laser beam and observing if the buzzer is triggered.

Safety Precautions:

- Always disconnect the power source when making changes to the system or conducting maintenance.
- Avoid exposing the laser to the eyes, as it can be harmful.
- Be cautious with soldering iron and other tools to prevent burns or electrical hazards.



(a) *Assembled PCB*



(b) *Assembled product (Without batteries)*

Figure 14: *Assembling the product*

References

[1] *SIM900A GSM Module*. URL: https://microcontrollerslab.com/sim900a-gsm-module-pinout-examples-applications-datasheet/.

[2] *ATMEGA328P datasheet*. URL: https://pdf1.alldatasheet.com/datasheet-pdf/view/241077/ATMEL/ATMEGA328P.html.

[3] *Laser Tripwire Alarm*. URL: https://www.instructables.com/Laser-Tripwire-Alarm/.

[4] *Interface GSM SIM900A With Arduino*. URL: https://www.instructables.com/GSM-SIM900A-With-Arduino/.

[5] *Building an Arduino on a Breadboard*. URL: https://docs.arduino.cc/hacking/hardware/building-an-arduino-on-a-breadboard.