

Design and Construction of an Automatic Triggered Bell Ringer Circuit

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ABSTRACT

This research work deals with the design and construction of an automatic triggered bell ringer circuit. Several previous attempts have been developed on intruder alert and a motion detection system, complex systems that operate excellently well. The automatic triggered bell ringer circuit integrates knowledge of these previous models and utilizes more readily available components. It also introduces the use of two sensors, thereby increasing its sensitivity. Major components used in the work are the Force and Light sensors, sensors that depict the concepts of pressure and light resistivity/conductivity respectively, and a laser beam directly projected permanently on the light sensor's surface. A force exerted on the Force sensor triggers a buzzer alarm and likewise, an obstruction in the path of the laser triggers the buzzer alarm. Once there is pressure exerted on the Force sensor, the resistance tends to infinity and voltage dropped across it biases the diode and transistor and the voltage reaching the buzzer triggers it. Likewise, the resistance of the light sensor tends to infinity when in darkness and the voltage dropped across it also biases a diode and transistor and triggers on the buzzer alarm. The work has been tested and seen to have a higher sensitivity, and is much cheaper than its counterparts.

Keywords: Automatic Triggered Bell Ringer, Light Sensors, Light Dependent Resistor.

1. INTRODUCTION

Security of lives and property is a major challenge globally, and Nigeria is not an exception. Security is one of the important concepts of the world and every country is always security conscious of her domain. The increasing rate of insecurity in the nation has necessitated the implementation of security measures for most houses and commercial premises. In most developing countries, the demand for increased security measures is on the rise on a daily basis, making security one of the highest basic necessities [1]. In Nigeria, there is rather an increase in crime rate ostensibly due to its huge population size. Hence, the need to have strong security architecture in both domestic and commercial vicinities is of paramount necessity. In reacting to this challenge which has become a national issue, the idea of the construction of an automatic triggered bell ringer circuit (which could also be regarded as a motion detector or an intruder alert) came into consideration and was likely to be successful in a reasonable and agreeable extent. As it is crucial to have a security system which would not only secure the premises but also increases the chance to capture criminals due to initial ignorance of the device's presence. Unlike False alarms, normal motion detectors are capable of distinguishing the presence of both human and animal, hence avoid false alarms. Most security systems implement this approach to overcome false alarm problems without involving high costs. Additionally, it is also significant to have a simple alarm base that will be difficult to be hacked into as it lacks any programming features, and can be conveniently operated without the requirement of wireless internet connections.

In [2], the author categorized security systems as hardwired, wireless and hybrid systems. He stated that most alarm systems are hardwired as this method gives little or no room for hacking or breakthrough, and that it is cost effective with little maintenance. Most security systems implement this approach to overcome false alarm problems without involving high costs.

This research work can be used everywhere, including homes, offices, airports, showrooms, industries and others where proper security is to be ensured. In a wider view, this research work can generally be referred to as a motion detector or an intruder alert. Apart from its basic use in homes as home security systems, motion detectors have other various uses:

- In manufacturing, electric eye detectors can count products on an assembly line, and perform other tasks that people would find tedious. Some dangerous machinery is equipped with active infrared or electric eye beams of light as a safety device. Should an operator's hand get dangerously close to the machinery, the beam is broken, the circuit is interrupted, and the machine shuts down.
- Garage doors with automatic door openers can be equipped with beams that sense a child under the door and stop the downward movement before the child is injured.

- Outdoor porch or patio lights fitted with motion detectors can be turned on automatic when motion is detected.
- One common everyday application is activation of automatic door openers in businesses and public buildings. One of the most common and convenient applications of motion detectors is found at modern grocery stores, where doors automatically open as customers enter and leave.
- In show rooms where a stock of valuables is kept in restricted areas that should not be traversed, it can be placed around the marked area so as to detect whenever an intrusion occurs.
- Motion sensors also find applications in activating street lights or indoor lights in walkways, such as lobbies and staircases.
- A motion detector may be among the sensors of a burglar alarm that is used to alert the home owner or security service when it detects the motion of a possible intruder. Such a detector may also trigger a security camera in order to record the possible intrusion.

2. REVIEW OF RELEVANT WORKS ON DEVELOPMENT OF AN AUTOMATIC BELL RINGER CIRCUIT

Traditional intruder alarm system focuses on low level attacks or anomalies and raises alerts. In situations where intensive alerts are involved, the amount of alerts becomes unmanageable, as a result, it is difficult for human users or intrusion response systems to understand the alert and take appropriate actions. Moreover, most of the alerts are not isolated as they are usually steps in a multi stage alert which try to compromise the security of a system.

In the work done by Antunes and Grilo [3] on web- based intruder alert system, they described new developments for distributed web-based intruder alarm system monitoring and control hardware. The work explained that web-based intruder alert system may include the use of distributed nets (grids) giving each node the ability to dynamically configure its functions. They described a basic intruder alert system as one composed of at least a control panel, rechargeable battery, power backups and internal or external keypads, several interior and perimeter intrusion detectors and one external sounder. In [3], intruder alert was categorized as hardwired, wireless or hybrid systems. Hybrid systems allow simultaneous installation of wireless and hard wired detectors. -based on the other hand, involves how the internet protocol (IP) modules allow the communication between an intruder alarm system and a remote monitoring station. Some connect directly to the existing control panel main telephone lines, transmitting in standard interface adapter (SIA) protocols to an internet protocol (IP) receiver station. A very low cost IP module can be made by using an embedded standard micro web server with built in IP connectivity that is able to send and receive digital commands via transmission control protocol/internet protocol (TCP/IP) [2, 3]. Fig.1 shows an alarm circuit for low-cost web-control and monitoring.

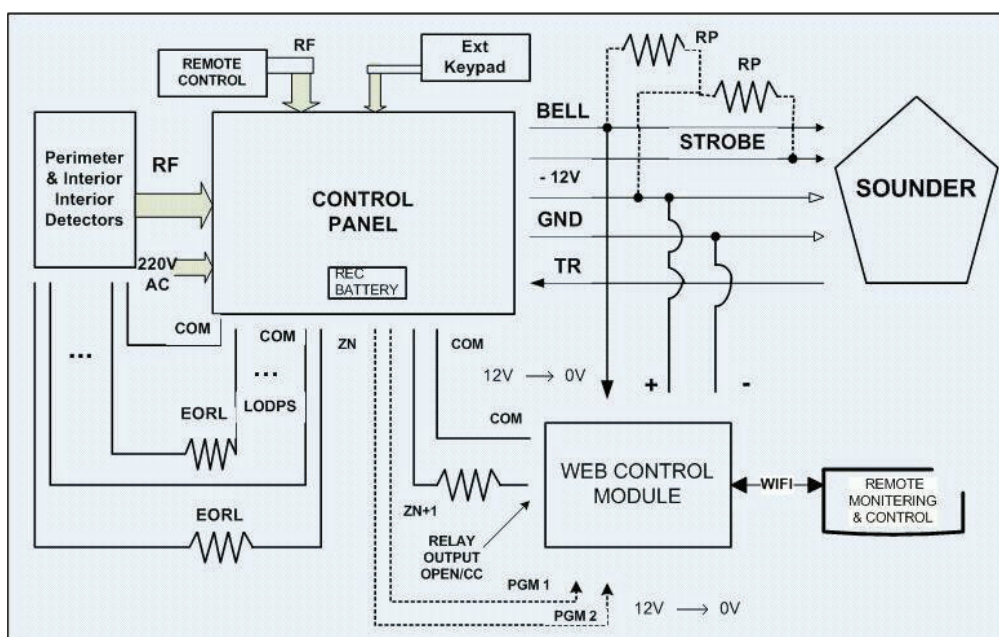


Fig. 1: Alarm circuit for low-cost web-control and monitoring.

In [4], we saw an intruder alert system via short message service (SMS) for motorcycle. This type alerts the owners of possible intrusion on their motorbike through an alarm and via short message service (SMS) using programming of a PIC microcontroller. The research work involved interfacing a PIC16F877A microcontroller with nokia6100 mobile phone, connected in a simple duplex mode. The major drawback was the restriction of the device to motorbike system and a sound knowledge of programming to be able to set up the device. A related work cited in [3] utilizes the use of a Bluetooth triggered alarm system, which involves alert by alarm and a message via Bluetooth communication to the neighbor's phone. It utilizes a PIC16F877 microcontroller, whose configuration is a full duplex communication mode, a Bluetooth module and a motion detector.

2.1 WORKING PRINCIPLES OF THE RESEARCH WORK

2.1.1 Photoconductivity/Resistivity

Photoconductivity is the tendency of a substance to conduct electricity to an extent that depends on the intensity of light-radiant energy (usually infrared transmission or visible light) striking the surface of a sample. Most semiconductors have this property. When there is no illumination, a photoconductive material has a conductance, which depends on its dimensions, the nature of the material, and on the temperature. In most cases, the conductance of the material increases with radiant energy of a specific wavelength that strikes the surface. This increase, sometimes, can go up to maximum when further increase in the radiation will produce no change in the conductance. Photoconductive materials are used in the manufacture of photoelectric devices. Typical photoconductive substances consist of germanium, gallium, selenium, or silicon with impurities, also known as *dopants*, added.

Light Dependent Resistor (LDR), which is a type of photoconductive cell or photo-resistor, is a low-cost photosensitive element and is used in photographic light meters as well as other applications such as flame, smoke and burglar detectors, card readers and lighting controls for street lamps. The photo-resistor or LDR is attractive in many electronic circuit designs owing to its low cost, simplicity and ruggedness. Though it may lack some of the features of the photo-diode and photo-transistor, it ideal for many applications. As a result, the photo-resistor finds applications in circuits such as photographic meters, flame, smoke and burglar detectors, card readers and lighting controls for street lamps, and many others [5, 6].

2.1.2 Force Sensing Resistor

Force sensing resistors (FSRs) are a polymer thick film (PTF) device which exhibits a decrease in resistance in the force applied to the active surface. Its force sensitivity is optimized for use in human touch control of electronic devices. FSRs are not a load cell or strain properties. FSRs are not suitable for precision measurements [7].

A force-sensing resistor is a material whose resistance changes when a force or pressure is applied. They are also known as "force-sensitive resistor" and are sometimes referred to by the initials "FSR".

Force-sensing resistors consist of a conductive polymer, which changes resistance in a predictable manner following application of force to its surface. Applying a force to the surface of the sensing film causes particles to touch the conducting electrodes, changing the resistance of the film. As with all resistive based sensors, force-sensing resistors require a relatively simple interface and can operate satisfactorily in moderately hostile environments. Compared to other force sensors, the advantages of FSRs are their size (thickness typically less than 0.5 mm), low cost and good shock resistance [8].

3.0 DESIGN AND IMPLEMENTATION

3.1 Design Process: The design process involves the selection of required components, the various ratings and sizes of the required components. The design of the circuit was first done on the breadboard (temporary construction). This temporary construction allows the research work to be tested so as to ensure that all components are in good working condition and to ensure that the work will work when finally transferred to the permanent construction board (Vero board). At the end, the work was transferred to the Vero board and further testing was carried out to guarantee its functionality as some components could be affected by heat or other conditions during the process of soldering and coupling. Packaging was also an important process, as improper packaging could affect efficiency and consequently reduce market values. Since the product is a security device, its small-size nature becomes imperative so that it is not easily noticeable by an intruder.

Fig. 2 shows the bread-board circuit of an automatic triggered bell-ringer.

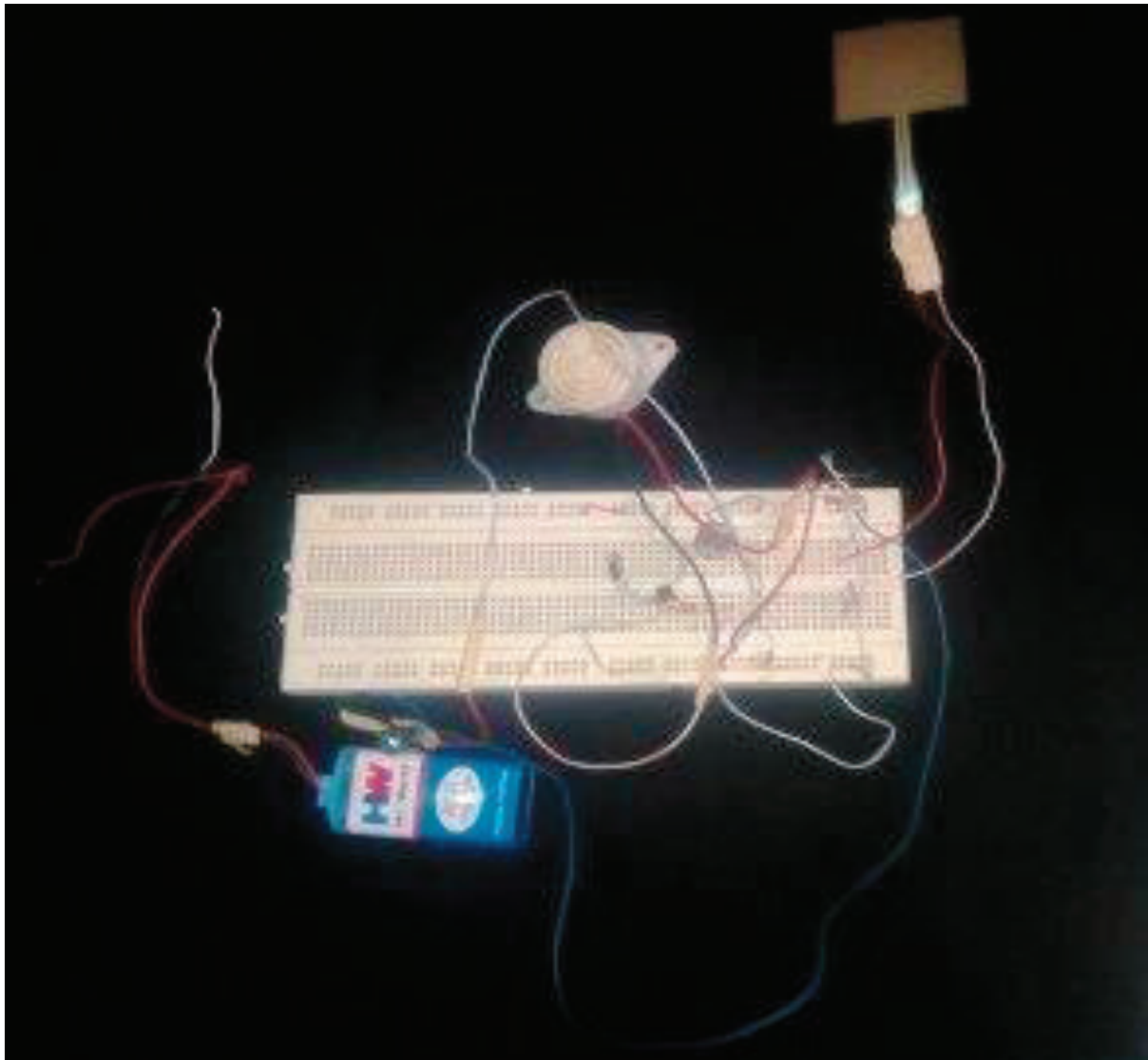


Fig. 2: Bread-board Circuit of an Automatic Triggered Bell-ringer.

3.2 Design Methodology: This takes account the decisions made to ensure appropriate utilization of the components that make up each of the units of the research work. The research work is divided into four major units, namely power unit, motion sensor unit, pressure unit and buzzer alarm unit. The power unit involves the 9V direct current (DC) battery and a limiting resistor connected in series to the DC source. The motion sensor is achieved with a light dependent resistor (LDR) connected in parallel to create a voltage divider network, which is then connected to the power supply unit via a limiting resistor. The pressure sensor unit is achieved with a force sensing resistor (FSR) connected in parallel to both a resistor and the DC source. Finally, the buzzer alarm unit involves a buzzer and a transistor connected to the power unit and the motion sensor unit.

3.3 Design Analysis:

The research work consists of four major units; the power unit, the motion sensor unit, the pressure sensor unit and the buzzer alarm. The block diagram in Fig.3.2 illustrates this.

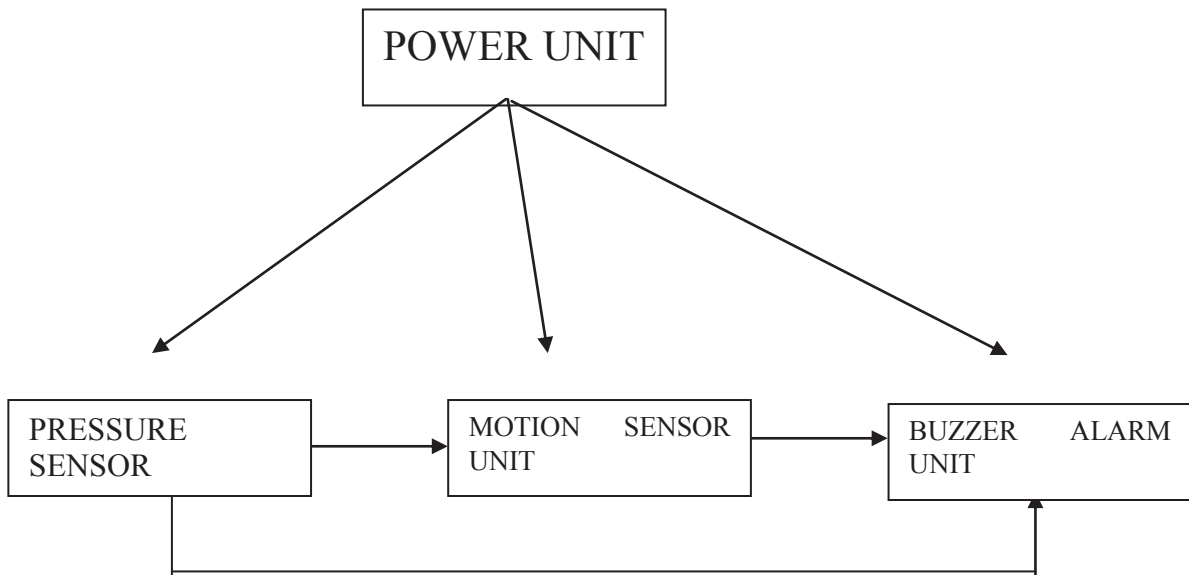


Fig. 3: Block Diagram of an Automatic Triggered Bell-Ringer Circuit.

3.3.1 The Power Unit: Most electronic devices and circuits require a DC source for their proper operation, and a typical regulation and load. The power unit consists of a DC battery of 9V. A limiting resistor of 100Ω is also part of the power unit. It serves as a fuse to regulate the voltage reaching the other units, and checkmates power surge. A DC is used in order to give compatibility to the device and to avoid the often problem of power outage associated with AC sources [9].

3.3.2 The Motion Sensor Unit: This unit comprises a voltage divider network of a light dependent resistor (LDR) and a 100kΩ resistor. The voltage divider rule is a simple way of determining the output voltage across one of two impedances connected in series. According to [10], the voltage divider rule can be used with resistive, inductive or capacitive circuit elements connected across ac or dc input sources. However, depending on the type of circuit elements, the equation for calculating the output voltage may differ [11, 12]. For instance, for a resistive divider, the output voltage for ac or dc is calculated as follows:

$$V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2} \tag{1}$$

Hence, for the circuit in Fig. 3.4, the output voltage would be:

$$V_{out} = 9V \times \frac{10k}{5k + 10k}$$

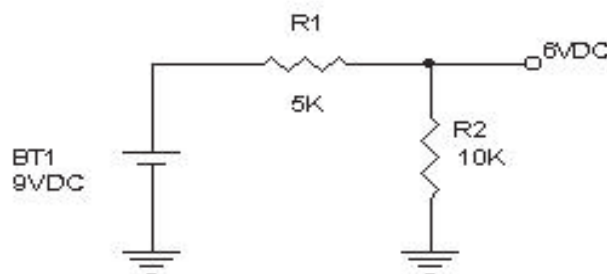


Fig. 4: Voltage divider network

As stated earlier, the two major sensors used in the design are the dependent resistor (LDR) and the force sensing resistor (FSR), both of which have a resistance output.

The circuit diagram of an automatic triggered bell-ringer is shown in Fig. 5

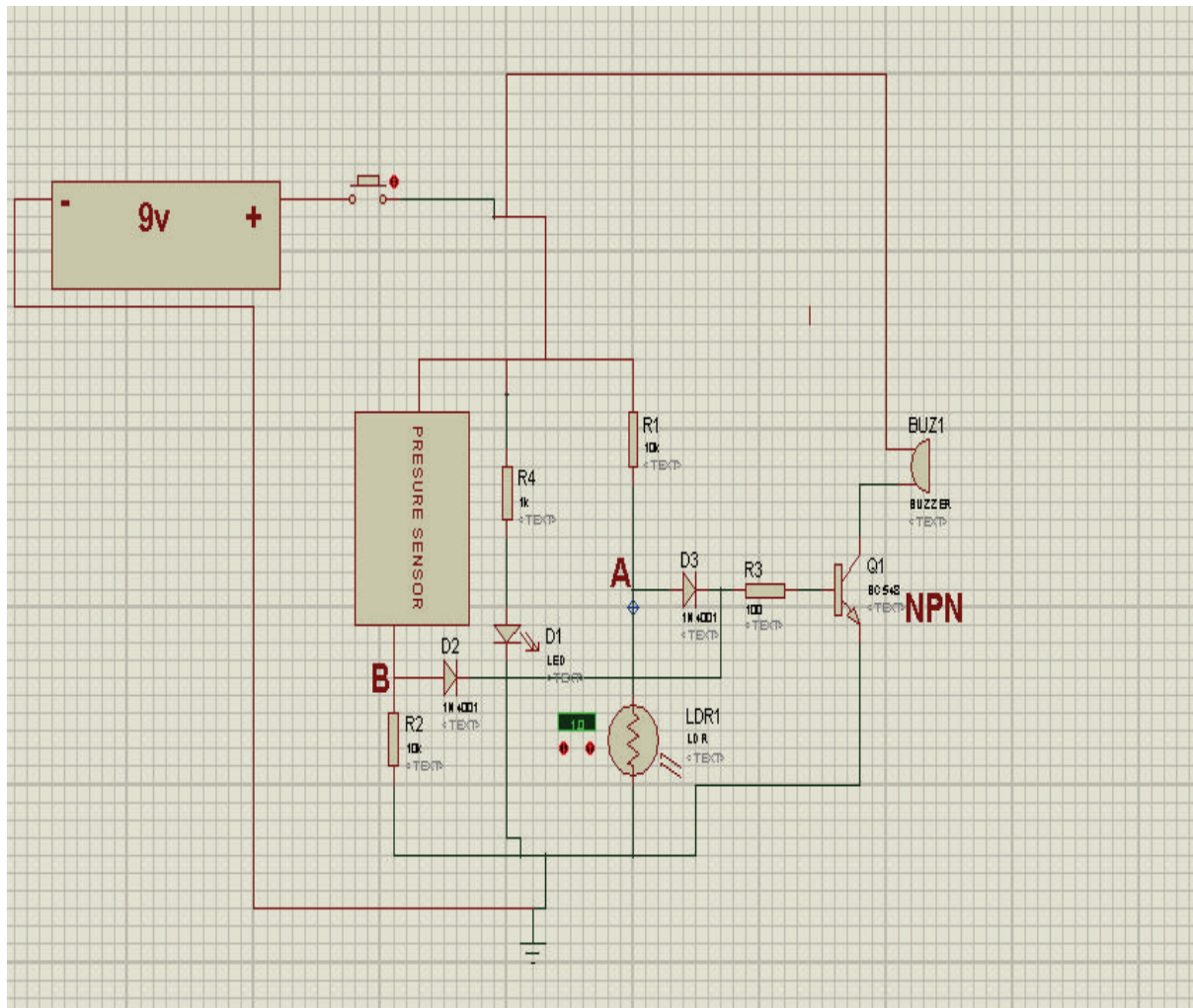


Fig. 5: Circuit Diagram of Automatic Triggered Bell-Ringer.

Let R_6 be the resistance of LDR. The resistance (R_6) of LDR before and after anyone passes between the LDR and the laser light is $\leq 2k\Omega$ and $\geq 200k\Omega$ respectively. From the above circuit diagram, when $R_6 \leq 2k$ and $R_4 = 10k$, the output voltage can be calculated as:

$$V_{out} = \frac{R_6 \times 5V}{R_4 + R_6} = 0.833V = \text{logic 0/Low or OFF state}$$

Also, when $R_6 \geq 200k$ and $R_4 = 10k$, the $V_{out} = \frac{R_6 \times 5V}{R_4 + R_6} = 4.7V = \text{logic 1/High or ON state}$.

From the above calculations, it is observed that when nobody passes, the light from the laser reflects on the LDR, thereby lowering the resistance of the LDR. The voltage across the 100 Ω base resistor to transistor (BC548, NPN) is also low, so the transistor remains in OFF state. Hence, the buzzer does not sound. But when anyone passes thereby blocking the laser light from reflecting on the LDR surface, the resistance becomes very high and the output voltage is also high, so the transistor is ON and the buzzer sounds.

3.3.3 The Pressure Sensor Unit: The pressure sensor unit is predominantly the Force Sensing Resistor (FSR). This FSR functions as a switch which is closed whenever a force or pressure is applied perpendicular to its surface. The force sensing resistor is then connected to a resistance in series; the function of this resistor is to limit the current reaching the sensor.

Likewise, applying the voltage divider rule to the circuit diagram of fig. 5, we have:

The resistance of pressure sensor R_7 before anyone stands on the sensor is $\geq 500k$ and when anyone passes R_7

is $\leq 1k$.

So V_{out} at point B from the above circuit diagram is:

When R_7 is $\geq 500k$ and $R_2 = 10k$

$$V_{out} = 5V \times \frac{R_2}{R_7 + R_2} = 0.098V = \text{logic0/ Low or OFF state.}$$

Also, when R_7 is $\leq 1k$ and $R_2 = 10$

$$V_{out} = 5V \times \frac{R_2}{R_7 + R_2} = 4.545V = \text{Logic1/ High or ON state.}$$

So from the above calculations, it can be observed that when nobody stands on the sensor, the V_{out} at point B, which is the voltage across the 100Ω base resistor to transistor (BC548, NPN), is low so the transistor remains off, being NPN and the buzzer does not sound.

But when anyone stands on the sensor, the V_{out} is high, so the transistor is ON and the buzzer sounds.

3.3.4 The Buzzer Alarm Unit: The buzzer alarm unit comprises a buzzer and a NPN transistor. It is connected directly to both the motion sensor unit and the pressure sensor unit to achieve an “OR” gate network. Hence, it can be triggered by any or both of the units [13]. To build a functionally complete logic system, relays valves or transistors can be used. Resistor-transistor logic (RTL) happens to be the simplest family of logic gates and was replaced by Diode-transistor Logic (DTL) in order to achieve optimum speed. Later on, transistor-transistor logic (TTL) supplanted DTL with the observation that a single transistor could do the job of two diodes with greater speed, and using up limited space [13].

3.4 Selection and Assembling of Components: Care was chosen to ensure that the components selected met the purpose for which they were selected and could be affordable in case of repair or replacement. The components were carefully selected and assembled with the aid of a soldering iron on a printed circuit board (PCB). The components utilized in this research work include the following:

- ✓ Photo-resistor or light dependent resistor (LDR).
- ✓ A Force sensing Resistor (FSR)
- ✓ Laser light
- ✓ Conductor wires
- ✓ Diodes (IN4001)
- ✓ NPN Transistor
- ✓ Switch
- ✓ Soldering iron and solder alloy
- ✓ Buzzer
- ✓ Bread board
- ✓ Vero board (PCB)
- ✓ DC Source
- ✓ Resistors

5. CONCLUSION

The buzzer alarm sounds each time the light from the light emitting diode (LED) bulb is projected away from the surface of the light dependent resistor (LDR). The device therefore acts as an intruder alert that detects the presence of an object or person or any obstacle that cuts across the path of the light that is permanently projected to the surface of the LDR. The device is arranged in such a way that the light from the LED is permanently turned ON and is projected directly towards the surface of the LDR. Whenever this path of this light is intercepted by an obstacle, the buzzer alarm gives a high pitch sound. In a similar manner, whenever pressure is

applied to the force sensing resistor by an object or person that steps or presses on the surface of FSR, the buzzer alarm is caused to sound, thus alerting the presence of an intruder. The system works according to specifications.

However, for better performance of the entire system, it is recommended that, rather than connect the sensors in an “OR” logic, they can be connected in an “AND” logic. This would cause the alarm to sound when both the light and pressure sensors are simultaneously triggered, and therefore reduce the noise produced by the device. Also, a software programming could be incorporated into the design that would alert the police or even send an SMS to neighbors, hence making the device to achieve greater purposes.

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