Motion Detection Using Pir Sensor and Arduino

A. M. Rekha, Duruganna and Pandith Aradhya Hiremutt

Abstract--- *This project features the design and implementation of a PIR (Passive Infrared) movement sensor system without using an Arduino Uno or any microcontroller. The system is built with simple digital components like a PIR sensor module, transistor, relay, and power supply to detect human movement and automatically control a connected load such as a light bulb or buzzer. The PIR sensor detects the infrared radiation emitted by the change of human bodies and hence generates an output signal. This output is then amplified and used to operate a relay circuit that switches on the connected device. The device serves as a dependable and low-cost small-scale movement detection system solution for security, automated lighting, and power-saving applications. The removal of a microcontroller makes the design simpler, less expensive, and more system reliable, thus, it is perfect for small-scale and standalone automation systems.*

Keywords--- *Passive Infrared Sensor, PIR Sensor, Movement Detection, Transistor, Relay Circuit, Automation, Low-Cost System, Energy Saving, Security System*

I. INTRODUCTION

AUTOMATION and security systems are fundamentally what the life of the 21st century is all about. As an example, motion detection is central to the functionalities of such systems as automatic lighting, alarms, and energy management solutions [1]. Among different gadgets, a PIR (Passive Infrared) motion sensor is probably the most common in the detection of human movements, as it detects changes in the infrared radiation that is naturally emitted by the human body [2]. The current project is about creating a PIR motion sensor-circuit which does not require an Arduino Uno or any other microcontroller for its operation. Analog electronic components such as transistors, resistors, capacitors, and relay module instead of the programmable components are used to process the output signal of the PIR sensor. If a person is moving within the sensor's range the PIR sensor will output a voltage that a relay will switch on a connected load, such as a light or a buzzer.

The first and foremost goal of this project is to come up with the design of a low-cost, energy-saving, and simple-to-construct community-oriented motion detection system that is suitable for homes, offices, and public places. By removing the microcontroller, the circuit can become more robust, energy-efficient, and cheaper, however, the work of the circuit in terms of motion detection is still as effective as before. The project serves as an example of how simple electronic components can be used to achieve smart automation without complex programming or expensive hardware.

II. PIR SENSOR WORKING PRINCIPLE

Passive Infrared sensors do not energize a given environment. Instead, they receive infrared radiation from objects, especially from the human body, and on this basis, an alarm is initiated. Even objects with a temperature of absolute zero emit infrared rays to their surroundings. The human body with a surface temperature that ranges from 27°C to 36°C is the major emitter of its radiant power in the wavelength range of 8 µm to 12 µm [4].

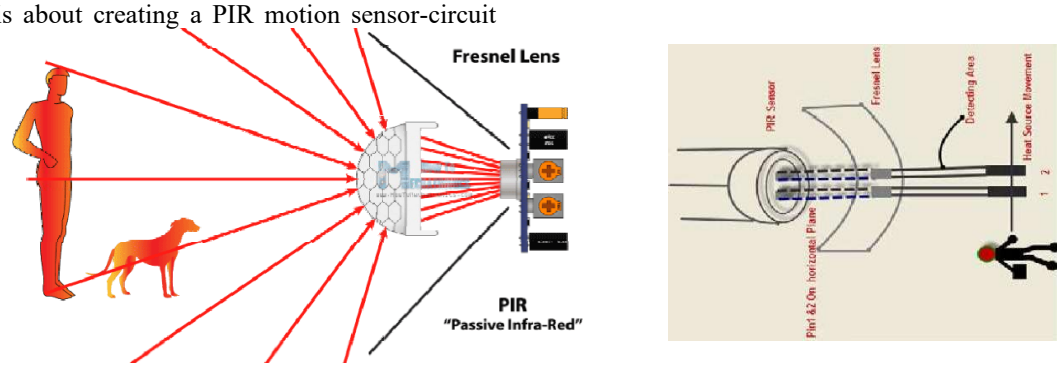

Figure 1: Working Principle of a PIR Sensor with Fresnel Lens

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As Figure 1, the PIR sensor lens in the detection zone receives radiation energy in the infrared range, which is the energy released by the human body, even though clothing. This radiation is then sent to the pyroelectric sensor. If a human body moves within the sensor area and then goes out, the pyroelectric sensor notices the temperature changes and thus produces the alarm signal.

Components Listing

- Arduino UNO
- PIR motion Sensor
- mild-Emitting Diode (any color, normally crimson for indication)
- 220Ω Resistor for LED
- Breadboard and jumper wires

How It Works

The PIR sensor detects infrared light emitted by humans and animals. Normally, it looks for changes in the detected infrared light, which means someone or something has moved within its detection field. When a motion is detected, the sensor outputs a HIGH signal. This signal can be read by the Arduino, which in turn, activates the LED.

How to Build the Arduino PIR Sensor Circuit

Set your computer Arduino and connect the USB cable. Grab the IR sensor and connect it to the Arduino's 5V and GND for power. Link the PIR sensor signal output to digital pin2 on the Arduino. Connect the LED's anode (the longer leg) to digital pin13 on the Arduino. Connect the cathode (the shorter leg) a 220Ω resistor to GND

Block Diagram

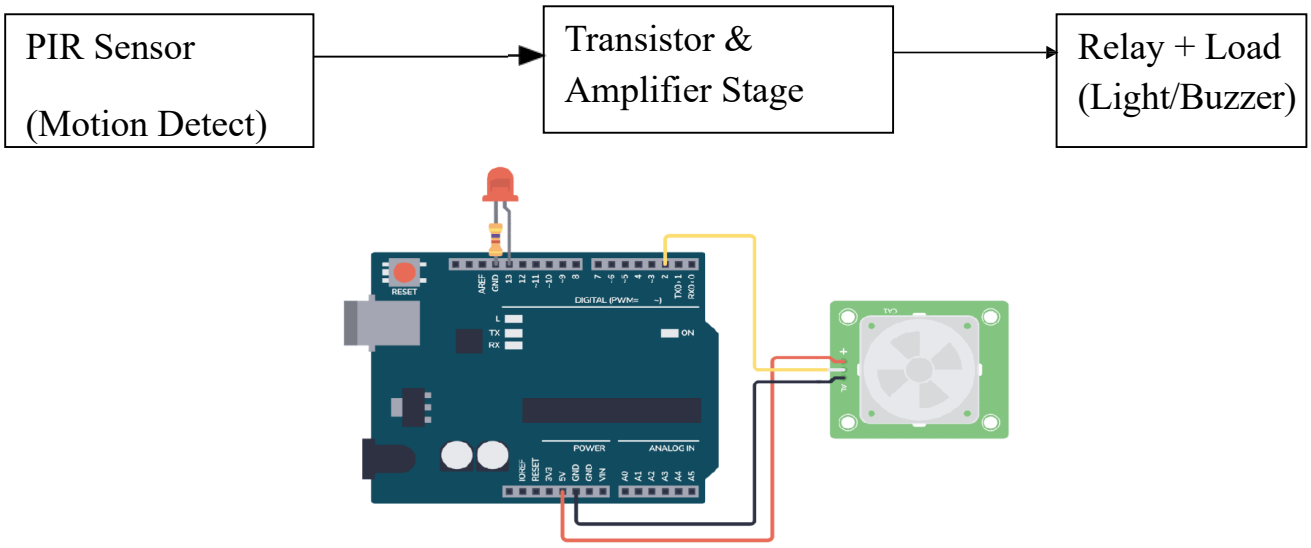

Figure 2: Block Diagram of PIR Sensor–Based Motion Detection System

The figure 2 depicts the flow of a PIR-based motion detection system connected with an Arduino controller. The transistor and amplifier stage receives the signal from the PIR sensor when it detects motion. After the output is strengthened, and the relay circuit is driven by the transistor, the relay gets the command to turn on a light or a buzzer connected to it. The figure's lower part also shows the real-world wiring of the hardware, with the PIR sensor connected to the Arduino board and an LED employed as the visual output that the motion activates.

Capabilities, Benefits, Drawbacks, and Applications of PIR Sensors

PIR (Passive Infrared) sensors are the first choice in interfacing circuits for identical motion detection applications because of their attractive features and capabilities. These devices work on a very wide voltage range that varies from 4.5V up to 20V DC and the current used during the operation is very minimal, less than 60 microamperes. Besides a detection angle of over 140 degrees, the PIR distance can be adjusted from 25 centimeters to 20 meters. The default blockade time has a value of 2.5 seconds, and the operating temperature range is from -20 to +80 degrees Celsius which shows that it can be used in different kind of environment.

The positive side of a PIR sensor is the combination of its small size, the wide range of the lens, the simplicity of the connection, and low-power consumption. What is more, the sensor is quite cheap, easy to use, and capabilities to not wear over time, thus being very reliable and viable choice for a myriad kind of applications. Nevertheless, PIR technology is not devoid of its pitfalls. In particular, it possesses lower sensitivity than other types of sensors such as microwave sensors and its coverage area is relatively constrained. Moreover, PIR sensors are less effective in detecting motion from the angles or in the corner areas and their sensitivity may be lowered in a room where it is hot. Besides that, PIR can have trouble in detecting extremely low motion and may have issues with "sleeping" or being too sensitive to minor movements.

Firstly, PIR sensors have been implemented in security systems for houses and business establishments, secondly, they are a part of automated lighting systems, and thirdly, their usage is extensive in the field of commercial equipment monitoring, structural health tracking, manufacturing, transportation, and

the aerospace industry. With the help of their motion-detecting features, they can change the situation accordingly, hence, their importance can hardly be overestimated as a component of new technologies.

Experimental Setup

The PIR motion sensor circuit was put together on a breadboard with the components that were mentioned: PIR sensor (HC-SR501), NPN transistor (BC547), relay module(5V), diode (1N4007), resistors, and a 5V DC power supply. A buzzer and LED bulb were also connected to the circuit as output loads to visually and audibly depict motion detection. The circuit was tested indoors under normal room temperature and lighting conditions.

Testing and Observation

The PIR sensor detects motion when a human enters its detection area and thus the sensor output goes to HIGH. This output signal enables one transistor to conduct and thus the relay connected to the circuit is activated. Hence a device such as a light or a buzzer which is connected to the load is turned ON automatically. The relay, according to the delay setting of the PIR module, switches OFF and the load turns OFF once no further movement is detected after a few seconds.

Performance

The PIR sensor that is the part of this arrangement can detect at about 4-6 meters distance depending on the direction of the sensor with the angle of detection being around 120°. It takes less than a second to react to the motion so if the connected device is to be enabled it will be done very quickly. Also, a variable resistor is provided on the module so that changing from 5 seconds to 200 seconds will determine the delay or resetting time. The whole system is run from a 5 VDC power supply which is to provide a current of about 500 mA and the relay attached to the system is the one that its load can be anything in the range of 5V to 230V but it is dependent on its rating.

Practical

Once a person enters the detection area, the transistor is activated by the HIGH output of the PIR sensor, the relay is energized. Consequently, the light or buzzer which is connected to the circuit is turned ON automatically to give an indication of successful motion detection. The sensor output goes back to LOW when the person leaves or no further movement is detected and the load is turned OFF after a short delay. The system was able to perform in subsequent tests without any failures; thus, it was motion-sensing that was stable and reliable, and no microcontroller intervention was necessary.

III. RESULT

The PIR motion sensor system has efficiently done the job of detecting motion, and it has also executed the instructions to change connected loads (light/buzzer) without requiring any microcontroller intervention, thus making it a cheap and simple type of application device for motion detection. The device orientation was found to have an impact on the exact distance as the range varied between 4 to 6 meters. However, in the same way, the detection angle was approximately 120°. The time taken for the sensor to respond to a motion detection event was less than one second, and the reset delay could be anywhere from 5 to 200 seconds and could be selected through the PIR module's potentiometer. Motion of a human within the range of detection of the sensor resulted in a HIGH output from the PIR sensor, which consequently activated the transistor and relay, thereby causing the connected load to be switched on. After a short period (as per the delay settings) when no motion was detected, the load would be turned off.

IV. DISCUSSION

The PIR motion sensor circuit was put through various tests and proved to be dependable each time. The low cost, good functionality, simple design, and power saving features of the motion sensor make it ideal for a basic security system or any other application with very basic motion detection requirements. The removal of the microcontroller from the system not only simplified the overall structure but also improved power efficiency and the general reliability of the unit. These detection capabilities of the device, which include an adjustable delay time as well as a moderate detection range, make it a versatile function-perfect solution in different scenarios e.g., home security, automated lighting, and small-scale automation systems. Nevertheless, the system could only partially meet the sensitivity requirements of the PIR sensor as it had difficulty in recognizing very slight motions or small objects. Moreover, there are some factors such as the temperature inside the room, which can affect the sensitivity of the sensor. The limited field of view of 120° and short-range of about 4-6 m also limit where this detector can be placed, e.g., it cannot be properly used in large or complicated spaces.

V. CONCLUSION

The PIR motion detection system that was put together using ordinary electronic parts without the need for a microcontroller proved to be a successful, cheap, and reliable means of detecting motions. It did show some weak points in terms of the distance from which it can detect and the sensitivity, but it was still able to deliver a consistent performance in all of its practical tests, thereby proving that it is suitable for the security of homes and businesses, automated lighting systems, and other basic automation applications. The advantage of the present system over other sophisticated microcontroller-based systems is that it is simple and affordable, which is an important factor when it comes to deciding whether a small-scale project is feasible or not.

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