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Surveillance System Using Passive Infrared (PIR) Sensor and Infrared Sensor

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ABSTRACT—

The necessity for security systems is critical due to the rise in crime and burglaries. It is necessary to have a security system that keeps an eye on the region and responds to threats promptly. The application of radio detection and ranging in different places such as military installation, commercial use is done with the help of RADAR SYSTEM which uses electromagnetic waves for detection of different physical components such as distance, speed, position, range, direction, size etc. which can be either fixed or be in motion. Use of radar system has been developed greatly specially in field of navigation. In this research we study about existing navigation technologies and propose an Arduino based radar system. It has advantage over other radar system as kit reduces power consumption and connect programmer to wide range of Arduino programmers and open-source code. The system consists of a PIR sensor connected to a Wi-Fi module which detects human body using infrared radiation and sends alert to the device. This system also consists of an ultrasonic sensor placed upon a servo motor which rotates at a certain angle and speed. This ultrasonic sensor is connected to Arduino digital input output pins and servo motor also connected to digital input output pins. The project aims at making a Radar that is cost-efficient and accurate. Due to its insensitivity, it can withstand harsh working conditions such as dirt, dust, rain. The system constantly monitors a limited range and alerts the presence of obstacles if any. If the object is very close to the sensor, then it is alerted by a buzzer and a red LED while if an object is at short distance buzzer and green LED turn on but if the object is out of limited range alert system is off.

Keywords— **Security System, PIR Sensor, Ultrasonic Sensor**

I. Introduction

With several terrorist attacks occurring often in various regions of the world, the menace of terrorism has gained international attention. Terrorists continue to strike with impunity, showing little regard for human lives and leaving a path of devastation and death in their wake. The degree of security in many places is seriously compromised by human activity that is undesired, such as trespassing attempts and destructive behavior. The level of security must be considered in order to guard against criminals and similar risk. Today's population is fighting for their lives as a result, providing security is crucial

Numerous security systems, including CCTV, microwave, photoelectric detectors are available on the market for both indoor and outdoor use. The existing system shares the maximum responsibility and will reduce human efforts. Using this system, we can identify how many strangers or intruders are entering. The main objective of this existing system is to alert about the number of intruders entering. The main concept behind this existing system is known as “Visitor Counter” which measures the number of intruders trespassing. These systems do however have certain drawbacks, such as higher cost, higher electrical power consumption intricate circuitry.

The proposed system, which is an automatic border security system uses Arduino, ultrasonic sensor, passive infrared (PIR) sensor, as an intrusion detection technique to alert the controller room. This system is fully automated and needs only one or two persons for maintenance purposes. This system has ultrasonic sensors which are responsible for the detection of intrusion as well as a PIR sensor to specifically detect humans. As they are mounted over the section pillars. The sensors continuously rotate back & forth in the range of certain degrees (30-180) & show the intrusion over the radar with its location. Another set of sensors senses the intrusion & shows over the LEDs & activation of the alarm. As the sensors detect the intrusion transmitter sends a signal to a device signaling an intrusion has been detected.

II. System Architecture

The system consists of microcontroller (Arduino Uno), Ultrasonic sensor, transformer (step down), a full wave bridge rectifier LEDs, servo motor, buzzer, and LCD display

A. Arduino Uno

Arduino microcontroller is an open-source that can be easily programmed and can update at any time [1]. Microcontroller board based on Microchip ATmega328P microcontroller and developed by Arduino.cc and initially released in 2010. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

Fig. 1. Arduino uno

B. Full Wave Rectifier

The full wave rectifier converts both halves of each waveform cycle into pulsating DC signal using four rectification diodes. In the previous power diodes tutorial, we discussed ways of reducing the ripple or voltage variations on a direct DC voltage by connecting smoothing capacitors across the load resistance.

In a Full Wave Rectifier circuit two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common centre tapped connection.

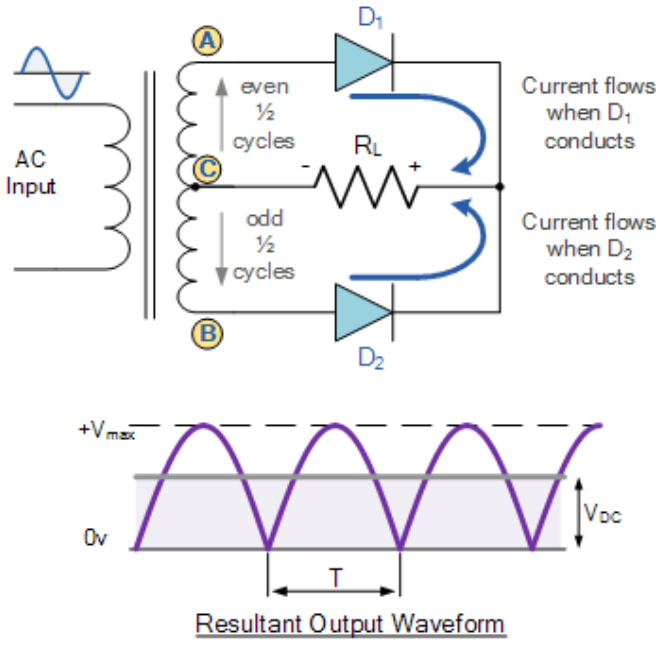

Fig. 2. Full Wave Rectifier Circuit

C. LCD Display

LCDs (Liquid Crystal Displays) are used in embedded system applications for displaying various parameters and status of the system. LCD 16x2 is a 16-pin device that has 2 rows that can accommodate 16 characters each. LCD 16x2 can be used in 4-bit mode or 8-bit mode. It is also possible to create custom characters. It has 8 data lines and 3 control lines that can be used for control purposes.

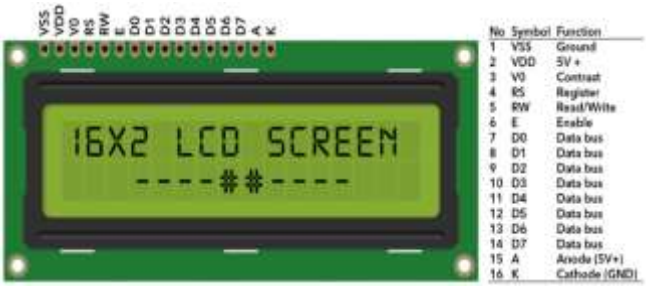

Fig. 3. Liquid Crystal Display

D. Ultrasonic Sensor

The ultrasonic sensor is a non-contact type of sensor used to measure an object's distance and velocity. This sensor operates on sound wave property to measure the velocity and distance of the object [2]. The main application of ultrasonic sensors is as proximity sensors. They are present in anti-collision safety systems, home theft detection systems, self-parking car technologies, and surveillance systems. In addition to being employed in industrial technology, ultrasonic sensors are also used in robotic obstacle detection systems. While the physical components of ultrasonic sensors are still impacted by external factors like heat, they are less vulnerable to interference from smoke, gas, and other airborne particles than infrared (IR) sensors in proximity sensing applications.

Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target). In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is D = ½ T x C (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second).

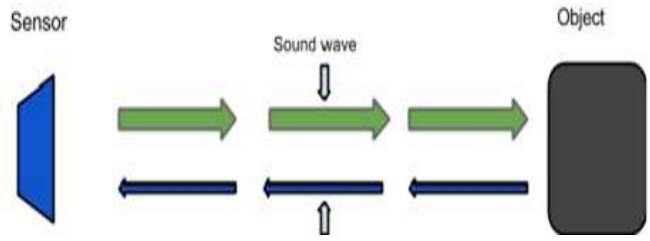

Fig. 4. Sound Wave Bouncing Off Object

E. Passive Infrared (PIR) Sensor

A passive infrared (PIR) sensor is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view [3]. Passive word indicates PIR Sensor does not generate or radiate any energy for detection purpose. PIR Sensors don't detect or measure "HEAT"; they detect the infrared radiation emitted or reflected from objects. PIR sensor is widely used in security system to detect the motion of human. Infrared (IR) light is electromagnetic radiation with a wavelength between 0.7 and 300 micrometers. Human beings are the source of infrared radiation. It was found that the normal human body temperature radiate IR at wavelengths of 10 micrometer to 12 micrometer [4]. A PIR (Passive Infrared) sensor works by detecting changes in infrared radiation within its field of view.

Here is a simplified explanation of how a typical PIR sensor works:

Pyroelectric Material: The heart of a PIR sensor is a pyroelectric material, which is capable of generating an electric charge when exposed to infrared radiation. This material is usually made from a crystalline substance like lithium tantalate or lithium niobate.

Sensor Design: The PIR sensor is designed with multiple segments or zones, each containing a pair of pyroelectric elements. These elements are sensitive to changes in infrared radiation and are electrically connected to form a differential amplifier circuit.

Infrared Detection: The PIR sensor is positioned to monitor a specific area, typically a room or an outdoor space. When a warm object, such as a human or animal, enters the sensor's field of view, it emits infrared radiation in the form of heat.

Detection of Changes: As the warm object moves across the sensor's field of view, it causes a change in the distribution of infrared radiation within the segments of the sensor. The pairs of pyroelectric elements in each segment detect these changes.

Signal Processing: The differential amplifier circuit compares the electrical signals generated by the paired pyroelectric elements. If there is a significant difference in the signals, it indicates a change in the infrared radiation pattern and suggests the presence of movement.

Output Activation: Based on the detection of movement, the PIR sensor generates an output signal, usually in the form of a digital signal or a voltage pulse. This signal can be used to trigger a response or activate connected devices, such as turning on lights, sounding an alarm, or capturing video footage.

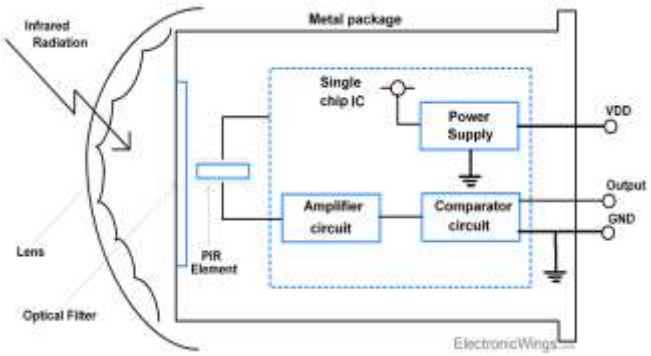

Fig. 5. Schematic Diagram of Pir Sensor and it's Working

F. Wi-Fi Module

Wi-Fi modules or Wi-Fi microcontrollers are used to send and receive data over Wi-Fi. They can also accept commands over the Wi-Fi. Wi-Fi modules are used for communications between devices. They are most commonly used in the field of Internet of Things.

G. Servo Motor

One kind of motor that has extremely precise rotation is a servo motor. Typically, this kind of motor is made up of a control circuit that gives feedback on the motor shaft's present location. This feedback enables the servo motors to rotate extremely precisely. A servo motor is used when you wish to rotate an object at a certain angle or distance. It consists only of a basic motor that is driven by a servo mechanism. A motor is referred to as a DC servo motor if it is powered by a DC power supply and as an AC servo motor if it is supplied by AC power.

H. Buzzer

An Arduino buzzer is also called a piezo buzzer. A piezo buzzer is a type of electronic device that's used to produce a tone, alarm or sound. It's lightweight with a simple construction, and it's typically a low-cost product. Yet at the same time, depending on the piezo ceramic buzzer specifications, it's also reliable and can be constructed in a wide range of sizes that work across varying frequencies to produce different sound outputs [5]. The buzzer produces the same noisy sound irrespective of the voltage variation applied to it. It consists of piezo crystals between two conductors. When a potential is applied across these crystals, they push on one conductor and pull on the other. This, push and pull action, results in a sound wave. Most buzzers produce sound in the range of 2 to 4 kHz

Fig. 6. Piezo Buzzer [5]

III. Working And Methodology

A. Methodology

The objective of the system is to build an implanted intruder identification framework in border using Ultrasonic Sensor and a PIR sensor. Technological advancement is needed to create a security system [6]. There are numerous sensors being used today however the sensor that is utilized will identify the soundwaves that are reflected back from a human body or an object. It is able to provide round the clock video surveillance at the places where human deployment is not possible due to geographical, climatic or some other reasons. In order to testify the working of this system, after its designing, construction and programming we placed few objects in front of the ultrasonic sensor. As the motor started to rotate, our monitor started to display the output through processing IDE. Hence, when the sensor crossed over the object, the buzzer goes off and the distance and angle where the object is placed is displayed on the LCD display. The first object was placed at the distance of 29.5cm measured through a ruler and the system measured the distance at 31cm.While the second object was placed at a distance of 15 cm and the system measured it as 16cm. Hence the calculated efficiency turned out to be 95%.

B. Working

1. Arduino board sends a signal of +5V to the trig pin of Ultrasonic Sensor HC-SR04 which triggers the sensor.
2. Then it provides rotational action at the servo motor mechanically fitted along with ultrasonic Sensor HC-SR04 so that it can detect the moving objects and locate within 180 degrees
3. The Arduino sends a HIGH pulse width of (10 S) on the TRIGGER pin of the sensor to regenerate a series of ultrasonic waves that propagate through the air until it touches an obstacle and returns in the opposite direction towards the sensor pin ECHO.
4. The sensor detects the width of the pulse to calculate the distance.The signal on pin ECHO the sensor remains at the HIGH position during transmission, thereby measuring the duration of the round trip of ultrasound and thus determine the distance.
5. The LCD display displays the calculated distance and the angle of rotation.
6. The buzzer is an additional component; it rings when there is a detection (Tone1 and Tone2) along with LEDs. Both LEDs along with the buzzer determine the field where the object is located (near or distant).

C. Block Diagram

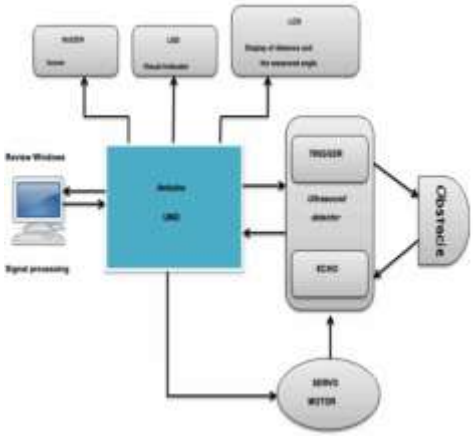

Fig. 7. Block Diagram

D. Flowchart

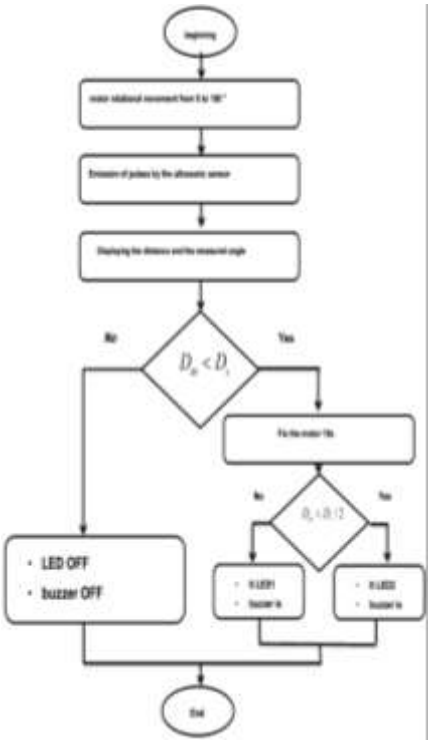

Fig. 8. Flowchart

IV. Advantages

- Not affected by colour or transparency of objects - Ultrasonic sensors reflect sound off of objects, so the colour or transparency have no effect on the sensor's reading.
- Can be used in dark environments - Unlike proximity sensors using light or cameras, dark environments have no effect on an ultrasonic sensor's detection ability.
- Not highly affected by dust, dirt, or high-moisture environments.
- Although our sensors work well in these environments, they can still give incorrect readings with a heavy build-up of dirt or water, especially in extreme conditions.
- They have greater accuracy than many other methods at measuring thickness and distance to a parallel surface.
- Their high frequency, sensitivity, and penetrating power make it easy to detect external or deep objects.
- ultrasonic sensors are easy to use and not dangerous during operation to nearby objects, people or equipment.
- Highly secure electronic system.
- Low power consumption.
- Circuit is inexpensive and a low-cost option.
- Easy setup and wiring connection.

V. Conclusion

- Safety and security being the first priority for every nation. Many nations are suffering from multiple cease fire violations, terrorist attacks on border leading to huge number of casualties of brave soldiers. Not just terror attacks, multiple smuggling cases and forced intrusion by criminals are on the rise. To help protect them modern technologies are being implemented.
- One such surveillance device is this Border Security System using both PIR and Ultrasonic sensor. In this era when the number of intruders is growing at a high rate, this system provides the users with a very simple, cheap and also very safe security system. Not just intruder. This device senses humans with the help of Ultrasonic and PIR Sensor. It is very reliable even during night as well. Ultrasonic Radar systems are very efficient and does not need much maintenance.
- The PIR sensor utilizes infrared rays emitted from human body and easily detects human movement. It has the benefit of setting certain parameters to detect only human body as it has distinct body temperature as compared to other animals.
- This is a cost effective and reliable alternative to already existing expensive surveillance systems.

VI. Future Scope

A better version of this system can be designed using a thermal imaging device which can detect humans by detecting their heat signature and thermals.

Similarly, we can also use a TFMini-S LiDAR Distance Sensor. This can help in achieving more accuracy and better distance up to 1200 meters.

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