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Design and Implementation of a Low Cost Passive Infrared Based Movement Detector and Deterrent System

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Abstract – Home security systems are solutions for overcoming intrusion when residents are not around. There are many types of home security systems which are expensive and complicated to use. This paper focuses on the development of a home security system with a passive infrared sensor as a motion detector and is integrated with a voice recorder/playback system that deters the intruder with a recorded voice alert. The system is made up of hardware and software modules. A passive infrared sensor, a microphone and keypad are the input components of the system while the siren, Closed Circuit Television (CCTV) camera and loudspeaker are the output components. The PIR sensor accommodates itself to the background conditions in the area of coverage within 30 seconds. The PIR sensor registers a change in heat as a result of human movement within 290cm range, the system perceives the intruder as a change in its previous state of equilibrium, then the Microcontroller activates the voice alarm system and the recorded warning message is playback and CCTV camera is activated to start recording. However, if the intruder stays within the area of coverage after a preset 20 seconds delay, the system activates a strident siren. The system components used are relatively cheap; the system also saves cost by reducing power and memory usage of the CCTV system.

Keywords: CCTV, Microcontroller, Passive Infrared, Security, Siren

1. Introduction

Security is the degree of protection against danger, damage, loss or any criminal activity, it is a condition whereby one can develop and progress freely (Khiyal, Khan and Shehzadi, 2009). An important aspect of security is the Home Security. It is very important, because crime is increasing day by day and people have less time to spend at home. Through the use of security cameras, users are able to monitor the situation at their homes and get timely information about persons visiting their homes (Udaya, Murty, and Kumar, 2013). There are several types of security systems available at the present with varying degrees of sophistication, complexity and cost (Gill, Yang, Yao, and Lu, 2009). Many researches proposed a system that allows user to control home appliances ubiquitously and also provide security alerts to the home owners on detection of an intrusion via short messaging system (SMS) using Global System of Mobile Communication (GSM) technology (Khiyal et al, 2009; Azid and Kumar, 2011).

Many Home automation techniques are already available to reduce the system complexity and lower fiscal costs. It described a system that endeavours not to incorporate complex and expensive components, the system is flexible and scalable, allowing additional home appliances designed by multiple vendors, to be securely and safely added to the home network with the minimum amount of effort. A home gateway is implemented to facilitate interoperability between heterogeneous networks and provide a consistent interface, regardless of the accessing device (Udaya et al, 2013). The financial cost of the previous systems can be reduced further by replacing the dedicated computer with a microcontroller, removal of other High end devices and removal of the cost of network charges. This is an objective of this research. Large amount of data collected from video visualization needs to be analyzed by an intelligent

and automatic system. This intelligent system needs to have the ability to scan the surrounding area and extract useful information for further consideration. The proposed system will eliminate this cost by engaging the active components of the security system only when an intrusion is detected and returning to standby mode when the intrusion has been eliminated. This work will design an electronic circuit that can sense human movement into an area of coverage using passive infrared detector, combine it with an electronic circuit that can record and playback a voice message then provide a control circuit built around a microcontroller. The system will activate a closed circuit television system (CCTV), the recorded voice message playback and switch ON a siren after a delay of specific interval. The electronic circuit then deactivates the CCTV, the voice warning and the siren when the intruder retreats from the area of coverage.

2. Methodology

2.1 Types of Movement Sensor

There are different types of sensors used in movement detectors spectrum, these includes continuous wave radar detectors, active ultrasonic sensors, vibration sensors, active infrared detectors and passive infrared detectors (Zamshed, Haider and Moinul, 2011). Continuous wave radar movement detectors work through the use of microwave signals. These detectors are more sensitive than passive infrared PIR detectors and thus cost more (Anil and Rambabu, 2014). Active ultrasonic sensors send out pulses of ultrasonic waves and measure the reflection off a moving object. The detector emits a sound frequency in waves that sweep across the space that the detector is monitoring. When the wave encounters an object, its frequency is disrupted and the alarm in set off. These detectors will be set off by a nonliving object moving across the area of interest, this is not helpful in the detection of human intruders (Pema, Devi and Gopal, 2013).

Active infrared movement detectors use an infrared sensor, as well as a source of radiation. The sensor is able to detect interruptions in the radiation it receives from the radiation source. This basically means that an infra-red movement detector is able to detect the signal of heat energy emitted by an intruder as it differs from the constant infrared scanning activity of the detector, as long as the intruder passes through its detection range. This sensor will also consume more energy relative to the passive infrared sensor. Vibration movement sensor detects vibrations using the piezoelectric effect (the ability of some materials to generate an electric field) in order to detect movement. This sensor however has its limitations when intruder decides to use suction grips to climb on another plane instead of walking on the plane of coverage.

Passive infrared sensors (PIR) are relatively inexpensive compared to detectors that utilize other technologies. A PIR sensor is able to use an optical collection system in combination with several different sensing elements. This allows the sensor to detect any changes that occur in ambient infrared radiation. The sensor is able to recognize a thermal infrared image (created by infrared technology combined with a heat sensor. Dual-technology movement detectors use a combination of different technologies. These dual-technology detectors benefit with each type of sensor, and false alarms are reduced. However the cost of dual technology detectors is higher compared with that of PIR.

2.2 Hardware system design

Figure 1 shows the block diagram of the home security system. The system was implemented with a star network topology consisting of four nodes. One node is used for the detection of motion of the intruder, the second node is for activating/deactivating the recorded voice warning while the third node is for activating/deactivating the CCTV system and the fourth node is for activating/deactivating the siren system. The data acquired from the CCTV system is placed on the recorder's memory.

2.3 The power supply unit

The power supply circuit involves the conversion of 220 volts, 50Hz AC into 12V and 5V DC. This is achieved by using step down 12-0-12 centre tapped transformer with full wave rectifier. The AC

ripples are eliminated using the capacitor and the LM78 and LM79 voltage regulator series used to regulate the output voltages (Figure 2). The 5V DC is used to power the Microcontroller and the ISD2560P Voice alert system. The 12V DC is used to power the relay circuits that activate the CCTV camera and the siren.

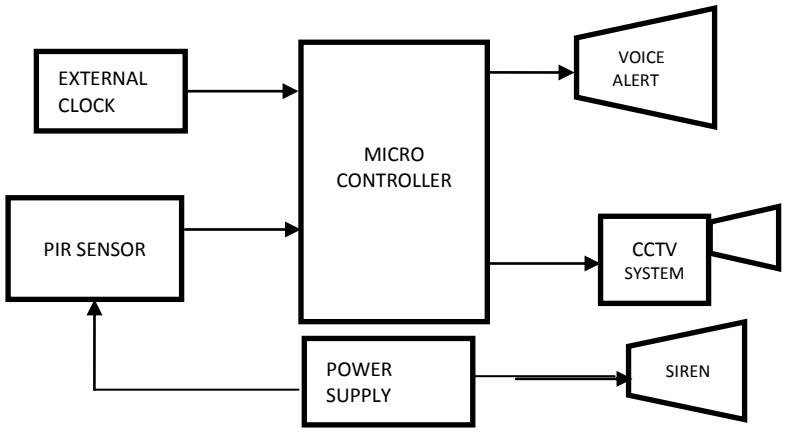
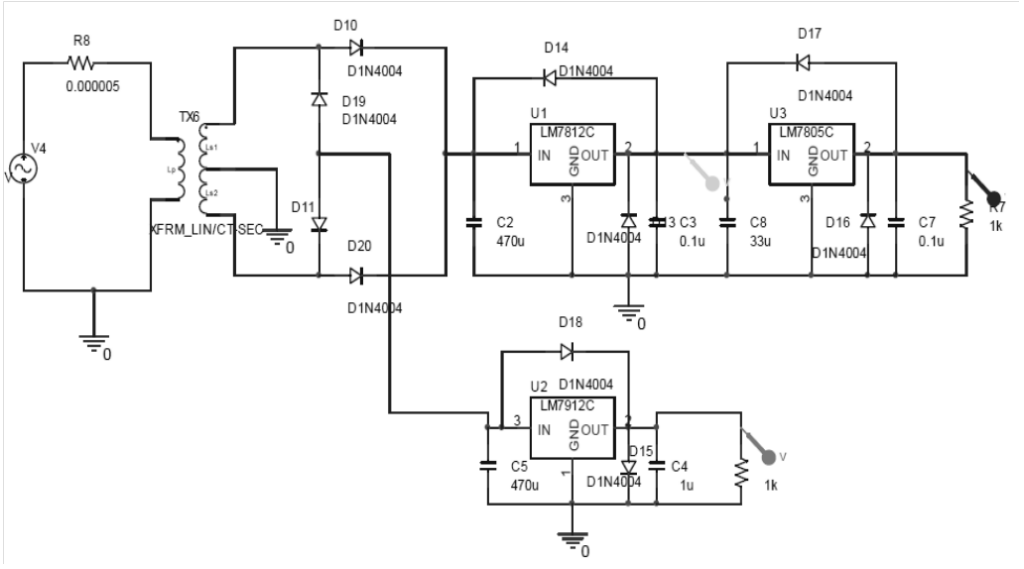


Figure 1: Block diagram of the home security system.

Figure 2: Power supply circuit of the passive infra red security system.

2.4 PIR Sensor



The PIR325 sensor used has two sensing elements connected in a voltage bucking configuration (Figure 3). This arrangement cancels signals caused by vibration, temperature changes and sunlight. A body passing in front of the sensor will activate at first one element and then the other, whereas other sources will affect both elements simultaneously and then get cancelled. It has three pins (gate, drain and source). After it has detected IR radiation difference, a High is sent to the signal pin. As shown in Figure 4, the radiation source must pass across the sensor in a horizontal direction when sensor pins 1 and 2 are on a horizontal plane so that the elements are sequentially exposed to the infrared source.

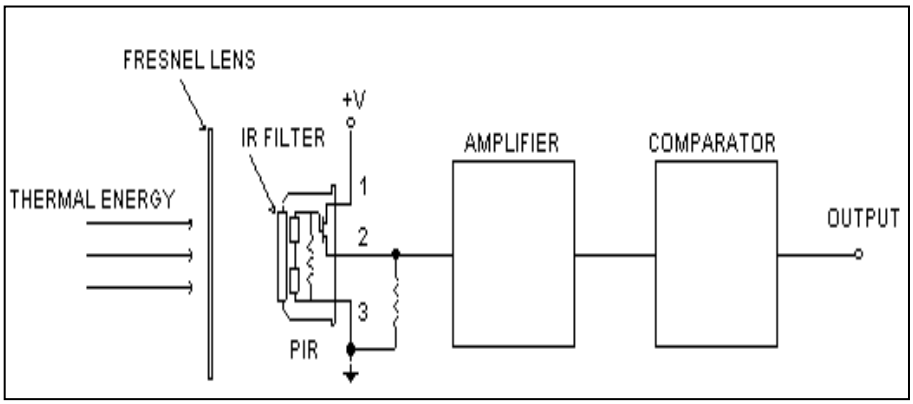


Figure 3: Operational configuration of the PIR sensor.

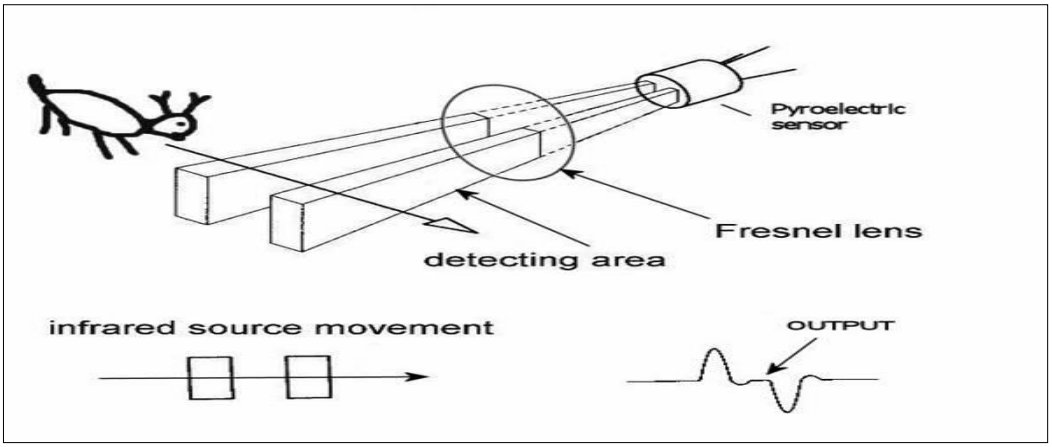


Figure 4: Coverage pattern of the PIR sensor.

2.5 The voice alert system

The Information Storage Device (ISD2560P) series used is designed with several built in operational modes that provide maximum functionality with minimum additional components. The ISD2560P series include devices offered at 4.0, 5.3, 6.4 and 8.0KHZ sampling frequencies which allows the user a choice of speech quality options, increasing the duration decreases the sampling frequency and bandwidth, which affect sound quality. The speech samples are stored directly into on-chip non-volatile memory without the digitization and compression associated with other solutions. The series offers single chip solution to meet the end system requirement at 60, 75, 90 and 120 seconds, to minimize the noise,

the analog and digital circuits in the ISD2560P series device use separate power busses. The playback input is latched by the falling edge of the CE pin. A HIGH level selects a playback cycle while a low level selects a record cycle (Figure 5). For a record cycle, the address inputs provide the starting address and recording continues until PD or CE is pulled high or an over flow is detected (i.e. the chip is full). When a record cycle is terminated by pulling PD or CE high, an end-of-message marker is stored at the current address in memory. For a playback cycle, the address inputs provide the starting address and the device will play until an EOM marker is encountered. The microphone input transfers its signal to the on-chip preamplifier. An on-chip automatic gain control (AGC) circuit controls the gain of preamplifier from -15dB to 24 dB. The external microphone is coupled to the pin via a series capacitor. The capacitor value together with the internal 10kΩ resistance on the pin determines the low frequency cut-off for the ISD2560P series voice pass band. The ISD2560P series include an on-chip differential speaker driver, capable driver of driving 50mW into 16Ω from the AUX IN and about 15mW from memory.

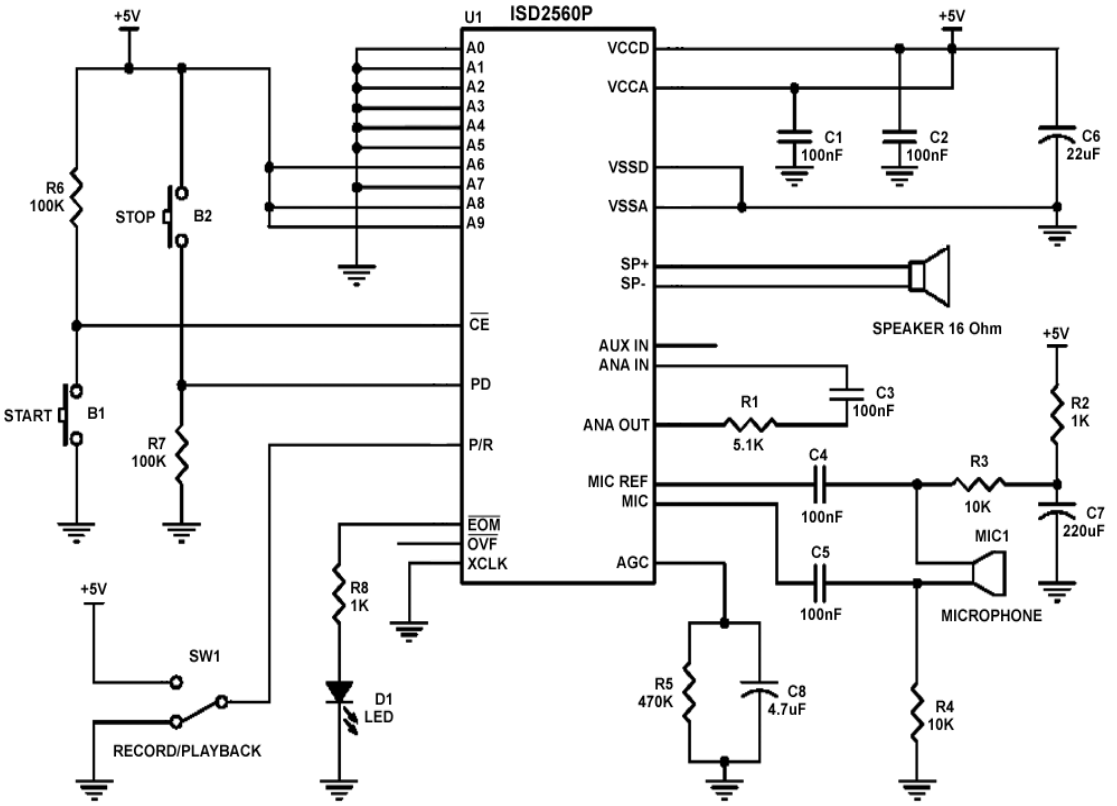


Figure 5: Circuit diagram of the Voice Alert System.

2.6 The siren

The siren used is a 12V DC powered multi tone device which is switched on by the relay. The relay is energized by the amplified signal from the Microcontroller. The siren has an output of about 62dB which could be heard several meters away from its location. The siren has a power consumption of about 12W which makes it ideal for its use in this research. The siren is set to be turned on after about 60 seconds of intruder detection.

2.7 Microcontroller

A microcontroller is a microprocessor which has I/O circuitry and peripherals built-in, allowing it to interface more or less directly with real-world devices such as lights, switches, sensors and motors (Zamshed et. al., 2011). However, unlike the general purpose computer, the microcontroller is used for single control applications and can be re-programmed to suit whatever application needs to be addressed.

The PIC18F452 has 16k of program memory and 1536 Bytes of RAM and because the RAM is linear, large arrays can be declared. It is packaged in a 40 pin DIP. It also has a 4x internal phase locked loop oscillator - so we can supply an external clock signal of 10MHz and it will run at 40MHz internally but it should be noted that the maximum internal instruction rate is $f_{osc}/4$. The microcontroller has no internal oscillator, thus an external crystal oscillator was used for clocking purpose (Figure 6)

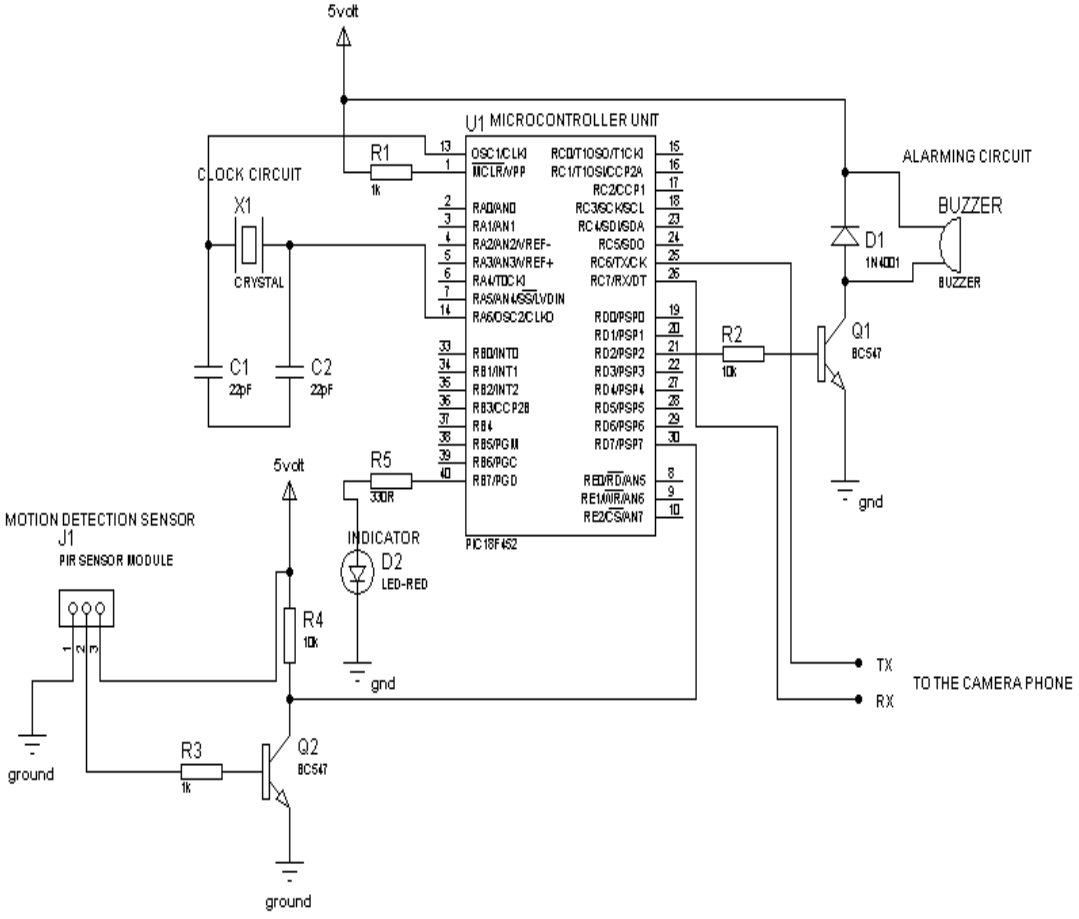


Figure 6: Circuit diagram of the microcontroller connection to PIR sensor.

3. Results and Discussion

In the initial state of the PIR when there is no human (heat difference) detected the output voltage at the sensor terminal was 0V. When the PIR registers a heat difference after a person walked into the coverage area, the output voltage at the sensor terminal changed to 1.95V and the indicator light emitting diode lit up. The maximum range of detection during the PIR testing was approximately 290 cm. It was observed that the voice alert and the CCTV gets turned ON as soon as the power is supplied to the circuit without even having intruder in the detection range of the sensor. This actually happens because

the PIR sensor requires an initial stabilization period of 10 to 35 seconds in order to function properly. During this time, the sensor gets familiar with the surrounding environment, and any motion in its field of view should be avoided and this was taken care of when subsequent tests were done. After 15 seconds, the voice alert and CCTV gets turned OFF because was no intruder in the PIR detection range of the system.

The sensor took approximately 15 seconds to get back to idle state after the intruder has left the range of detection. Consequently, this keeps the voice alert and the CCTV ON for that duration; the video captured during this period will be recorded and it will be saved in the memory of the system. This results in wastage of memory used by the video captured by webcam in those 15 seconds. This problem could be solved by using a PIR sensor of higher sensitivity.

4. Conclusion

In this paper, a low cost PIR sensor based security system with voice deterrent has been developed and implemented. Despite slight delays in capturing the video, it was observed that the proposed system saves the memory space of the recording system as it only starts recording when an intrusion occurs. Also the power consumed by the CCTV system is reduced because the system is switched off when there is no intrusion. The voice alert deters the intruder from progressing, however if he is insistent, the wailing siren alerts the neighbourhood and chases the intruder away. All these have been achieved using low cost components and methods without losses in functionality and high system reliability.

5. Recommendations

Only one CCTV is used in this research, this could only capture images in the area it is facing. The system may not work if the intruders enter from other sides of the building. Considering this, future works can improve the system by using more than one CCTV and integrating them with the system. Provision of an uninterruptible power supply for the system is essential in case of power outages. This will enable a seamless and uninterrupted service. Also incorporating a means of remotely alerting the home owners in cases of intrusion will make the system more functional.

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APPENDIX A : Flow Chart of the PIR Security system microcontroller program.