Infrared Security Alarming System

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Abstract: A low-powered (4.5-5 V) security alarming system using infrared sensor and detector mechanism has been constructed and tested. An IR transmitter (IR diode) and a receiver (Photo transistor) have been used. The system is connected to a multidirectional buzzer/siren or any kind of sounder to alert people from any threat to make sure the property is completely protected.

Key words: Security, sensor, infrared, detector, designed, transistor

INTRODUCTION

Rapid growth in world population with incommensurate employment opportunities and pressures of a more complex society, the incidences of human intrusion and burglaries and crime in private and public places are on the increase. Heightened security concerns at homes, banks, shopping malls, schools, offices, etc. have led to continued search for different and improved security gadgets.

Such concerns are apparent in the form of installations of remote cameras, the presence of security guards and other monitoring devices and alarm systems which are in constant use (Hart, 1995). However, many such devices and services are relatively costly and usually require a high and steady power supply for their operation (Hart, 1995). An infrared sensor security alarming system which has been constructed and tested, offers the advantages of low cost and low power consumption in its operation (Osuwa and Divino, 2010).

Not so long ago an alarm was a fairly rare sight, however now almost every house has an alarm of some kind. One common kind of security system is an infrared home security system. These are so popular because they are easy to install without having to drill holes and lay cables. Infrared radiation is invisible to the human eye but can be detected by electronic devices designed for such a purpose.

The sensors are set at the door (entrance point) and/or some supervised area and an alarm is triggered when an intruder passes within its range of coverage to notify/alert the people/security personnel (Schefken, 2008).

Principle of operation: The complete block diagram of the security alarming system is shown in Fig. 1. The regulated low voltage power supply produces 5 V for IR transmitter and receiver, amplifier, switching circuit, trigger circuit (one shot multivibrator), driver circuit and buzzer (sounder).

The anode of the transmitter and receiver (detector) are connected to the 5 V power supply and cathodes are connected to the ground. When the bias voltage is applied to the security alarm circuit, the transmitter emits the Infra-Red ray (IR).

This ray receives the receiver (detector) and produced an output signal. The output signal of the receiver is very weak to drive the buzzer and need to amplify. Then this signal is coupled to the amplifier by a coupling capacitor. The amplifier amplifies the weak signal
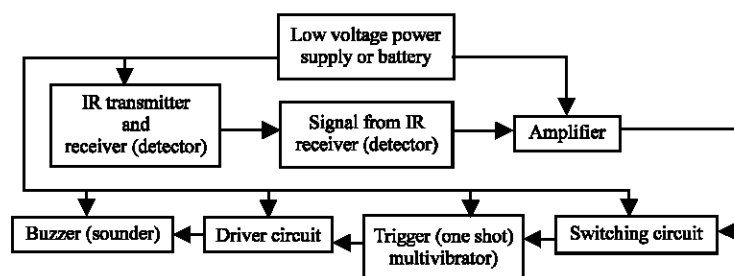

Fig. 1: Block diagram of security alarming system

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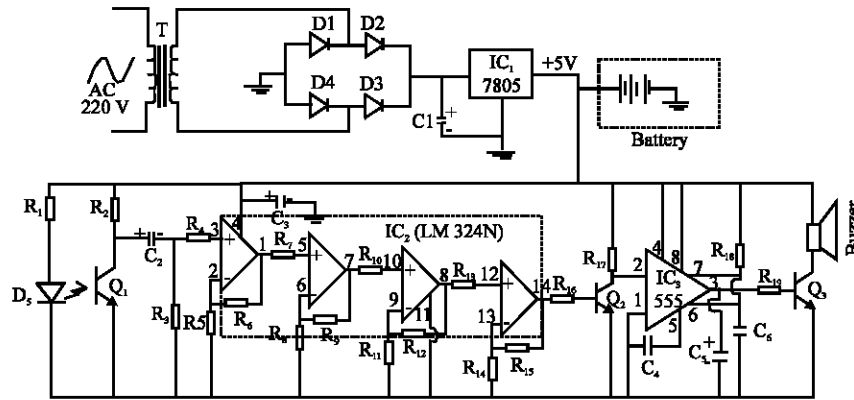
Fig. 2: Complete circuit diagram of security alarming system using IR

four times to operate the output device (e.g., speaker). After amplification the switching circuit switches this signal to the input of trigger (one shot multivibrator) circuit. When trigger input is applied i.e., amplified IR signal comes, the output of the trigger circuit goes high and produces an output signal every time when input is present.

The driver circuit conveys this triggered pulse and operates the buzzer (sounder). When the trigger pulse is applied the transistor of the driver circuit, it becomes ON and current flows through buzzer and begins sounding at a period specified by the one shot multivibrator. IR security alarm system works by sending out a beam of light, if this beam is broken by intruder the alarm will be sounded (Schefken, 2008) (Fig. 2).

Circuit explanation

IR transmitter (emitter) and receiver (sensor) circuit: The source (emitter) is a high efficiency GaAs infrared emitting diode and the sensor (receiver) is an NPN silicon phototransistor which has exceptionally stable characteristics and high illumination sensitivity. In the security alarm system, IR emitter (diode D_5) and receiver (phototransistor T_1) are connected as shown in Fig. 3.

Bias voltage (+3 to +5V) is applied to the anode through a current limiting resistor R_1 of the diode D_5 and the cathode is connected to the ground. As soon as the bias voltage applied, the diode is ON and emits Infrared Ray (IR). This ray receives the phototransistor T_1 (sensor) and becomes ON via the resistor R_2 and producing an output signal. This signal is very weak to drive the buzzer and need to amplify.

Infrared signal amplification circuit: In general, a practical amplifier circuit consists of several stages that
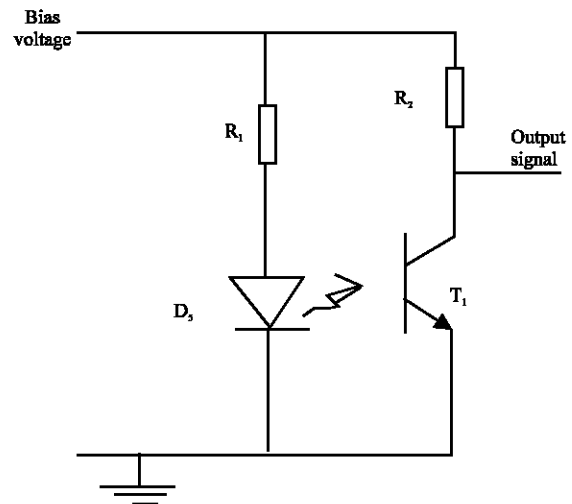

Fig. 3: IR transmitter (emitter) and receiver (sensor) circuit

amplify weak signal until sufficient power is available to operate the output device (like loudspeaker). The designed amplifier circuit (Fig. 4) uses operational amplifier (OP-AMP). Basically OP-AMP consists of a very high gain d.c. amplifier with feedback having high input impedance, a low output impedance and acting as a differential amplifier. As stated, OP-AMP is basically a difference amplifier whose basic function is to amplify the difference between two input signals (Gupta and Kumar, 1994).

The designed amplification circuit (Fig. 4) uses four stages of the operational amplifiers (LM324) and it about 1384 times amplifies the signal that was detected with the infrared sensor. Each stage does about 6 times of amplification.

When saying correctly, the each stage is (1+R5/R6) = 6.1 times because it is the noninverting gain
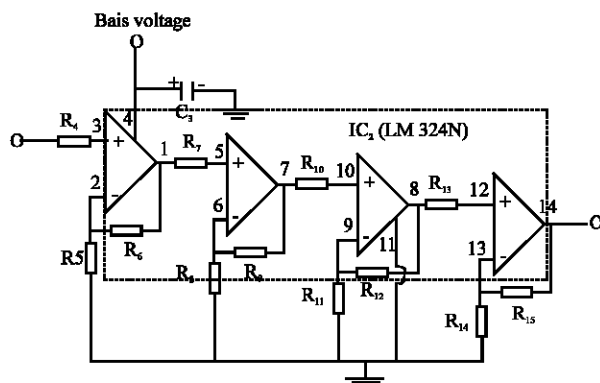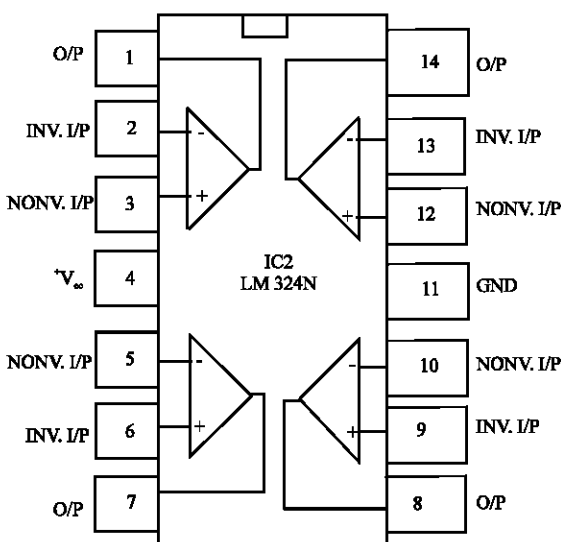
Fig. 4: Infrared signal amplification circuit

Fig. 5: Pin configuration of IC-LM 324N (OP AMP)

amplification. To make detect only the move of the person or the animal as much as possible, it is making the amplifier noise free by using capacitor filter. The circuit this time is using the operational amplifier with the single power supply. So, when not applying the electrode bias, the amplitude of vibration cannot be equally amplified and the distortion occurs. In case of the operational amplifier at the 1st stage, the offset voltage (0.2-1.0 V) which is superimposed with the output of the infrared sensor, becomes the electrode bias (Fig. 5).

Switching circuit: Transistors, though they fall for short of perfection, represent the best available components for switching application especially in the high-speed equipment. When transistor is used as a switch, it is either biased OFF or biased ON condition to its maximum collector current (Bell, 1989). The OFF and ON conditions are depends on the input base signal polarity. Although
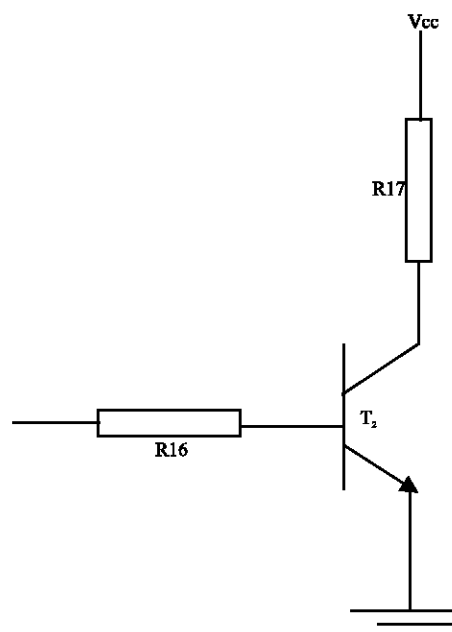

Fig. 6: Transistor switching circuit

too unpredictable for biasing amplifier circuits, fixed current bias is quite satisfactory for switching circuits. Thus in the research, a fixed current bias switching circuits is used that is shown in Fig. 6.

When a positive going input signal applied to the base of the transistor then the voltage over the emitter voltage. So the transistor becomes OFF position. In this case the only current flowing is the collector base leakage current. So, when the transistor goes OFF, collector current ceases to flow and the output voltage goes from Vce (saturation) to approximately Vcc. Again, when a negative going pulse is applied to the base, the transistor becomes ON position and collector current flow with its maximum value and minimum drop across the transistor. In our design we used a fast switching transistor, 2N3906, for which t = 35nsec, ts = 225nsec, td = 35nsec and tr = 75nsec.

Trigger Circuit (IC 555 timer as monostable mode): Monostable multivibrator (One shot) has only one stable state and one quasi-stable state known as timing state. The circuit as shown in Fig. 7 is to be triggered by the amplified IR signal (externally) for monostable (one shot) mode of operation. We note that (Gupta and Kumar, 1994):

- When no trigger is applied, capacitor C is held in the discharged state. In this state output is low
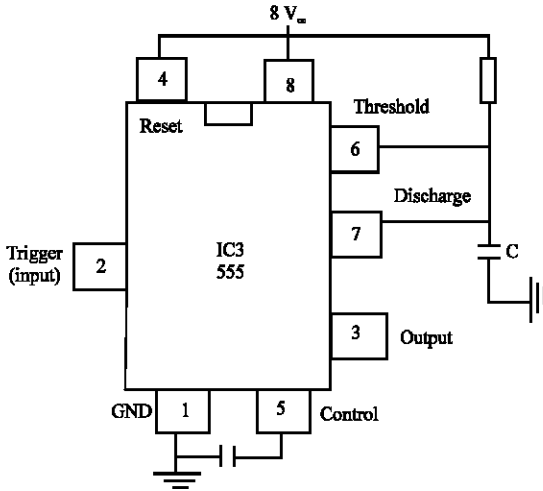
Fig. 7: Pin configuration of IC-555 timer (trigger circuit) and circuit connection as monostable mode

Fig. 8: Internal architecture of IC-555 timer

- When trigger input is applied i.e., IR signal comes and as the trigger voltage passes through Vcc/3 (threshold level of comperator-2, Fig. 2), comperator-2 changes its output state so that flip-flop is set, i.e, Q = 0 and transistor Q_1 becomes OFF. Therefore, timing cycle begins i.e, capacitor C charges up exponentially through R towards Vcc with time constant RC, according to:

$$Vc = Vcc(1 - e^{-t/RC}) \qquad (1)$$

where, Vc is the voltage across the capacitor at time t.

- When this voltage Vc reaches 2Vcc/3 (threshold level of comperator-1) as it is connected to the threshold terminal, comperator-1 changes the output state so that flip-flop is reset, i.e., Q = 1. This makes the transistor Q_1 ON and the capacitor discharges rapidly to ground; the timing cycle is completed. Once the circuit is triggered, it is insensitive to further triggering pulses until the timing cycle is completed
- It is note that time period of the timing cycle is the time required for the capacitor to charge from zero to 2Vcc/3. This period can be obtained on putting (Fig. 8):

$$Vc = 2Vcc/3 \text{ at } t = T$$

In Eq. 1 that is:

$$2Vcc/3 = Vcc(1 - e^{-T/RC})$$
$$\text{or } T = RC.\log_e Vcc/Vx2/3Vcc$$
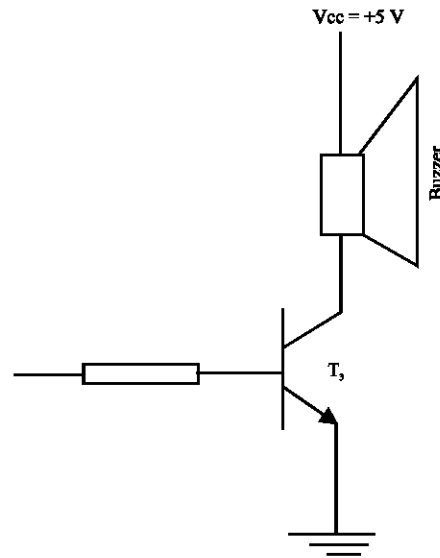$$\approx 1.1RC$$

Fig. 9: Driver circuit

Driver circuit: The Transistor driver circuit is used to drive the buzzer (sounder) as desired condition. When transistor is used as a driver (switch), it is either biased OFF or biased ON condition to its maximum collector current (Bell, 1989). The OFF and ON conditions are depends on the input base signal polarity. In the design we used a fast audio driving NPN transistor, BC337 for which P_T = 625 mW at 45°C, Ic = 500 mA, V_{CEO} = 45 V, V_{CBO} = 50 V, h_{FE} = 100-600 and f_T = 200 MHz. When trigger pulse from one shot multivibrator is applied to the base of the Transistor T3, the transistor becomes ON and current flows from Vcc to ground the buzzer begins sounding at a period specified by the one shot (Fig. 9).
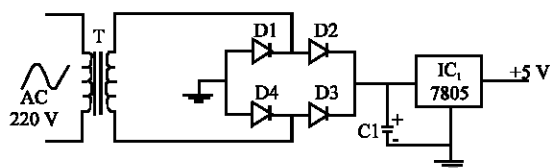
Fig. 10: Complete circuit diagram of DC power supply unit

DC power supply circuit: IR Transmitter (Emitter) and Receiver (Sensor) and other components which are used in designing the security alarming system, require a DC voltage of +4.5 to +5 V. The complete circuit diagram of a regulated DC power supply is shown in Fig. 10 using IC1 as a voltage regulating device (Osuwa and Divino, 2010). A step-down transformer T, a full weave bridge rectifier (diodes D1-D4) circuit with well-known capacitor filter C1 and regulator IC1 (7805) has been used for designing the power supply (Hart, 1995).

CONCLUSION

The designed infrared alarming system works by sending out a beam of light, if this beam is broken by human across the path of the infrared sensor with a transistor output that activates an alarm and the buzzer will be sounded.

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