The Design and Construction of an Infrared Activated Security System at 9 Khz Frequency


1Department of Physics, Covenant University, Ota, Ogun State
2Department of Physics, Federal University of Technology, Akure, Ondo State, Nigeria

Corresponding Author: M. R. Usikalu

Abstract
This paper reports the design and construction of a security system. The system will produce sound of a barking dog at audible frequency of 9 KHz. The design procedure and principle of operation of the various modules as presented in this work are based on the locally available electronic components.

Keywords: infrared, transmitter, receiver, frequency, multivibrator, stable, monostable, voltage

INTRODUCTION
The opto-electronically controlled security system is to automatically detect the presence of unauthorized person(s) entering or leaving a given area and to notify the security personnel accordingly. In notifying the security personnel, a sound of a barking dog is produced by the system since it has been designed to operate at audible frequency of a barking dog. The system is therefore a dog in disguise. The system has many advantages over other security systems where the presence of intruders is detected by photocells. The cell has inherent inefficiency in that it is either shadow or light operated which the intruder can bypass. Opto-electronically controlled security system incorporates infrared emitting diode at the transmitter end and phototransistor at the receiver end. The design, construction and testing of this work were done in the Department of Physics, Federal University of Technology, Akure. The design of the work as presented in this report has been based on the locally available electronic components in Nigeria such as infrared transmitter and receiver, transistors, resistors, capacitors, 555 timer etc.

Technical Design and Operation of Various Modules
The block diagram of the work is presented in Fig 1. It consists of infrared transmitter, infrared receiver and other circuitry. The design procedure and selection of the components for the various units are hereby presented.

The Infrared Transmitter is the unit that generates the infrared light via infrared emitting diode (IR emitter). The transmitter uses the 555 timer configured in the astable mode as shown in Fig 2. The astable multivibrator is also called free running multivibrator and generates a continuous digital signal or train of pulses whose period is given as [Anyanwu et al., 1987]

\[ T = C_1 (R_1 + 2R_2) \ln 2 \]

The frequency \( F \) of the output pulses is also given by

\[ F = \frac{1}{T} \]

In this work, the frequency of operation has been taken as 9.0 KHz, which is within the range of audible frequency of a barking dog. The pulse therefrom has a period of 0.11 mS. \( C_1 \) is a capacitor and must have a low valued capacitance as to avoid unnecessary charging and discharging [Horowit and Winfield, 1997; Lehman, 1997]. The value chosen is 1.0 \( nF \). According to the design, \( R_2 \) is to be approximately twice that of \( R_1 \) [Horowit and Winfield, 1997]. Using Eq. (1), their calculated values are \( R_1 = 82 \text{K}\Omega \) and \( R_2 = 39 \text{K}\Omega \)

The output of the astable multivibrator at pin 3 is connected to a constant-current source transistor, \( TR_1 \). This then provides the infrared transmitting diode, \( D_1 \) with a current, which pulsates in rhythm with the output signal of the astable multivibrator. The circuit diagram of the infrared receiver in this work is presented in Fig 3. The transistor, \( TR_3 \) is the phototransistor and it senses the infrared signal emitted by the transmitter. The transistors \( TR_2 \) and \( TR_3 \) formed a cascaded amplifier, which then amplified the detected signal and ensures that the output signal from the unit is in phase with the incoming pulsating infrared light. The output voltage from \( TR_3 \) can be measured using [Maddock and Ca cut, 1988]

\[ V_0 = \left( 1 + \frac{R_8}{R_9} \right) \left( \frac{R_1 R_3}{R_2 R_4} \right) \]

Equation (2) gives \( V_0 = 1.33 \text{ V} \), which is reasonably comparable to the measured value of 1.46(5) V with 9.77 % difference. This difference may be due to the components tolerance. This output goes to the input of a non-inverting amplifier, \( A_1 \). This is to achieve more amplification of the signal. The output signal of...
Pulse circuit, the period of which is determined by pulses. The output of the clock pulse is determined by providing varying output signal typically of square waveform whose frequency can be adjusted by a dc voltage [Lehman, 1999; Jones and Scott, 1993]. The Voltage Control Amplifier (VCA) ensures that the single pulse generated by the VCO can only get to the band pass circuit when the switch S1 is closed. The circuit diagram of Fig 6 presents the VCO and VCA that have been used in this work. Potentiometer, P1 determines the highest frequency that can be generated at the final output while P2 is to set how we want the audible tone to decay. Their values are 1MΩ and 50KΩ respectively. It should be noted that comparators A1 to A3 are TL084 IC.

This circuit of band pass filter used in this work (Fig 7) permits the signal of desired frequencies to pass. The bandwidth of this type is the difference between the upper and lower frequencies. In this case the lower frequency F_L is 20 Hz while the upper frequency F_H is 200 KHz since the audio frequencies of a barking dog is between this range. The bandwidth of the filter and the center frequency F_0 are related by the Q factor, which is defined by [Maddock and Ca cut, 1988; Day et al., 1976]

\[ Q = \frac{F_0}{F_H - F_L} \]

For typical audio filters, the values of the capacitors are between 0.01 and 0.1 µF. In this work, C_9 = C_19 = C = 10 nF. The values of other components that made up the band pass filter have been calculated using Eqs. 7 – 9 with gain, G taken as 0.4 [Maddock and Ca cut, 1988].

\[ R_{27} = \frac{2Q}{2\pi F_Q GC} \]

\[ R_{29} + R_1 = \frac{Q}{(2Q^2 - G)^2\pi F_0} \]

\[ R_{29} = \frac{2Q}{2\pi F_Q C} \]

The output signal from the band pass is of low amplitude and must therefore be amplified before getting to the speaker. Two power amplifiers IC LM 386 have been used. They have been cascaded to enhance the efficiency of their operation. The arrangement of the components is presented in Fig 8. The unit that supplies necessary dc voltage to various units of the project is presented in Fig 9. C_25 – C_28 are smoothing capacitors to filter the ripples from the rectified voltage and to give a better approximation to the dc voltage. The voltage regulators that have been used in this unit are 7809 and 7909 to supply +Vcc and –Vcc respectively, to the appropriate unit of the project as required. The diodes D9 and D10 are protecting diodes, which are meant to protect the power supply against short circuit.

**CONSTRUCTION AND TESTING**

It should be noted that in drawing the circuit diagrams, an electronic workbench, which is a computer-drawing package has been employed. For effective and reliable operation the transmitter and the receiver are not to be more than 2 m apart.
SUMMARY AND CONCLUSION
This paper has reported the design procedure and construction of a security system. This has been designed to operate at an audible frequency of 9 KHz. This work would offer assistance to our security personnel on guard to have a thorough monitoring and control over the area of their operation.

REFERENCES


Lehman J. 1999. Calibration service for spectral responsivity of laser and optical-fiber power meters at wavelengths between 0.4 µm and 1.8 µm, NIST Special Publication 250-53


APPENDIX

Fig 1: Block diagram of opto-electronically controlled security system

Fig 2: Circuit diagram of the infrared transmitter

Fig 3: Circuit diagram of the infrared receiver

Fig 4: The time delay and Clock pulse generator circuits used in this work
Fig 5: The circuit of Monostable Relaxation Oscillator

Fig 6: Circuit diagram consisting the VCO and VCA

Fig 7: Circuit diagram of the band pass filter

Fig 8: The output power amplifier circuitry

Fig 9: The circuit diagram of the power supply