DEPARTMENT OF **ELECTRICAL** ENGINEERING

AHMADU BELLO **UNIVERSITY ZARIA**

DESIGN AND CONSTRUCTION OF ELECTRONICS SECURITY ASSISTANT

BY

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DESIGN AND CONSTRUCTION OF ELECTRONICS SECURITY ASSISTANT

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A thesis submitted to the postgraduate school of Ahmadu Bello University, Zaria, in partial fulfillment of the requirements for the award of Master of Science (M.Sc.) in Electrical Engineering

CERTIFICATION

This thesis **"Design and construction of Electronics Security Assistant"** by Kabir Ahmad meets the requirements for the award of degree of Master of Science in Electrical Engineering by Ahmadu Bello University Zaria and is approved for its contribution to knowledge and literature.

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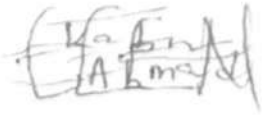
Date

in

DECLARATION

I Kabir Ahmad hereby declare that this work titled **"Design and Construction of Electronics Security Assistant"** was carried out by me under the supervision of Prof B. G. Bajoga and Dr. D. D. Dajab of department of Electrical Engineering of Ahmadu Bello University Zaria as part of the requirements necessary for the award of the degree of Master of Science in Electrical Engineering.

This work is original since it has never been submitted anywhere for the award of any degree to the best of my knowledge. However, all literature used have been acknowledged through references.



Date 20/07/07

Kabir Ahmad

DEDICATION

This work is dedicated to my beloved parents and my entire family.

ACKNOWLEDMENT

I first of all thank the Almighty Allah for his mercy in my entire life. I am happy to say thank you to my beloved and respected parents who take care of my life from cradle to date. My profound gratitude goes to my major supervisor Prof. B.G. Bajoga who gave all the support and guidance from the beginning of this work to the end. I also thank my minor supervisor Dr. D.D. Dajab.

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ABSTRACT

Security men play a very important role of protecting lives and properties of people in different places, including residential, industrial or other places of work. Hut due to inadequate provision of facilities that would make their work easy and effective. they face many problems that affect the quality of their service which sometimes lead to inability to discharge their duties well. Ibis thesis therefore, is a Design and Construction of Electronics Security assistant which could be used lor enhancing the performance ol security men. It includes a two terminal intercommunication between the securit) man and his employer when the need arises. There is an Automatic emergency light that conies on when the mains power supply tails and goes off when the mains power supply is *on.* The system also contains Door/ Gate alarm section which gives out an alarm when an unauthorized person tries to open the door gate. There is a IX motor direction controller that could be used by the security man to open and close the gale(s) from his office \ laser beam trespassers alarm is also included tor alerting the security man that someone is closing gate path of the beam within the premises. In addition the system has an automatic nighl light portion which turns on the security light automatically in the night and switches it off in the morning, finally, there is a morning alarm that alerts the security man in the morning to switch oil some sections that are need only in the night. This system was developed and tested and its performance was satisfactory.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The issue of security is indispensable in the fields of man's life and that of other creatures and materials as well. The man that is charged with the responsibility of provision of security services has a lot of short comings that make it very difficult for him to discharge his duty to a high degree of efficiency. The sense organs of man have some limitations that make it impossible for him to monitor multiple situations simultaneously and with high accuracy. For this reason some unfortunate situations happen when man is given the responsibility of taking care of particular places as a security agent particularly when the place is big in size. Some efforts have been made in trying to provide some assistance for the security personnel to enhance the quality and effectiveness of their services to the society through engineering researches by different people across the world. But most of these works concentrate on basically one or two functions. For instance, a communication gadget is provided to facilitate communication in case of emergency and in some projects only alarm system is provided with the hope of helping the security personnel to do their work more effectively.

All these projects and similar ones serve an important purpose in enhancing the work of security men in one way or another. But the criminals that are ready to achieve their goal at all cost use different strategies to break the traps and go ahead with their illegal operations. In view of these conditions, it is decided to come up with a system that would have multiple functions which can prevent the criminals from achieving their aims. This is because, if they escape one trap of the system they would definitely fall in another

for the multiple functions it serves. In line with this, the system would provide some relief and comfort to the security man for him to do his work effectively.

1.2 THESIS MOTIVATION

Engineering is basically concerned with the application of the fundamental principles of pure science into practical situations so as to solve some basic problems of life in general. The main motivation of this study is therefore to come up with a system that would be very useful in enhancing the services of the security men in residential, industrial and other public places. This thesis work is expected to make the work of security men very simple and effective and well secured. This system if successfully completed is hoped to help in reducing the rate of burglary in the society thereby saving the properties and lives of people, especially the security men who are at risk of being killed by the criminals in the process of their operations.

1.3 LITERATURE REVIEW

Over along period of time many devices were designed and constructed by different people with the aim of enhancing the security measures to protect the life and properties of people in different places. Most of these inventions look at particular area where the problem usually arises that result in the loss of certain important items as a result of the intruder activities.

Thomas Scarborough in 1994 designed and constructed an anti-burglary gate alarm [23]. Ron Jones designed and constructed a modular burglar alarm in 2001 [25]. A radio wave alarm was also designed and constructed by

Thomas Scarborough in 2002 [23]. Automatic Intruder alarm was designed by Ron Jones in 2001 [24]. However, An Optical Obstacle switch was designed by Mourns J. M. in 2003 [24]. In addition, a Dark activated switch was designed by Gorge Levis in 2004 [24].

Yusha'u Shehu (ABU) worked on the design and construction of an infra-red security system in 2006[28]. Agbanuji David Adieza (ABU) designed and constructed an electronic system that could be used for detecting an intruder as he opened a door[29]. Haruna Josiah Okpanachi worked on a security device that deals with a zone alarm in 2004. However, Abba Ousmane worked on the design and construction of a light-on warning system for security purpose[30].

All these works and similar ones serve an important purpose in enhancing and facilitating the work of security men in some ways. But their basic limitation is their restriction to only one or sometimes two functions. This thesis is therefore going to eliminate or greatly reduce the problems due to its ability to serve many functions in deterring the criminals from succeeding in their operations.

1.4 PROBLEM DEFINITION

The problem to be solved by this thesis work is that of security concern. The aim of the work is the design and construction of an electronic security system that would have the following sub-units:

- a two terminal Intercom communication between the security man and his employer if the need arises.

- an Automatic emergency light that comes on when the mains power supply fails and goes off when the mains is on,
- a Door/ Gate alarm section which gives out an alarm when an unauthorized person tries to open the door/ gate,
- a DC motor direction controller that could be used by the security man to open and close the gate(s) from his office,
- a laser beam trespassers alarm for alerting the security man that someone is crossing the path of the beam within the premises,
- an automatic night light portion which turns on the security light automatically in the night and switches it off in the morning, and
- finally, there is a morning alarm that alerts the security man in the morning to switch off some sections that are needed only in the night.

1.5 METHODOLOGY

The methodology that was adopted in solving the basic problem of this investigation includes the design of the various sub-circuits in the system in the step-by-step analysis methods where the basic calculations done would be shown clearly with any basic assumptions made in arriving at the value of the components of the circuit. However, the procedure followed for the selecting of the components would be given. After designing the different sub-sections of this security system, the whole work would be constructed to give a single system with one central control unit with connections to all remote parts being under the control of the system. Finally, measurements would be taken on the

constructed system to know the actual performance of the system as compared with the design goals.

1.6 THESIS OUTLINE

This thesis comprises five chapters. Chapter one is an introduction to the basic idea of the project where the basic motivation, definition of the problem and the methodology of solving the problem are discussed. Chapter two is the theoretical background of the study. In this chapter the basic theoretical aspect on which the project is based are discussed. In chapter three the basic design calculations and the analysis in the design of the entire system are presented. Chapter four is dedicated to the laboratory measurements and the basic experiments carried out on the system. Then the thesis report is concluded in the chapter five.

CHAPTER TWO

THEORETICAL BACKGROUND OF THE STUDY

2.0 INTRODUCTION

This chapter deals with the details on which the theoretical background of the design and construction of an electronic security assistant is based. The chapter gives the general overview of the theoretical aspects that has to do with this system. The fundamental operation principles of the different parts of the circuit are discussed step-by-step in order to give the basic understanding on the designed system as well as its mode of operation. However, the major components used in the design and construction of the circuit are treated where their characteristics and mode of operation and applications are discussed.

2.1 OPTOELECTRONICS

Optoelectronics is the study and application of electronic devices that source, detect and control light, usually considered a sub-field of photonics. In this context, **light** often includes invisible forms of radiation such as gamma rays, X-rays, ultraviolet and infrared, in addition to visible light. Optoelectronic devices are electrical-to-optical or optical-to-electrical transducers, or instruments that use such devices in their operation. **Electro-optics** is often erroneously used as a synonym, but is in fact a wider branch of physics that deals with all interactions between light and electric fields, whether or not they form part of an electronic device.

Optoelectronics is based on the quantum mechanical effects of light on semiconducting materials, sometimes in the presence of electric fields. [24]

2.1.1 PHOTORESISTOR



Fig. 2.1 Light Dependent Resistor

A **Photoresistor** or **Light Dependent Resistor** or **CdS Cell** as shown on Fig. 2.1, is a resistor whose resistance decreases with increasing incident light intensity. It can also be referred to as a **photoconductor**. A Photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, e.g. silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire bandgap. Extrinsic devices have impurities, also called dopants, added whose ground state energy is closer to the conduction band; since the electrons don't have as far to jump, lower energy photons

(i.e., longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor.

2.1.2 APPLICATIONS

Photoresistor comes in many different forms. Inexpensive cadmium sulfide cells can be found in many consumer items such as camera light meters, street lights, clock radios, security alarms, and outdoor clocks.

They are also used in some dynamic compressors together with a small incandescent lamp or light emitting diode to control gain reduction.

Lead sulfide and indium antimonide LDRs are used for the mid infrared spectral region. Ge:Cu photoconductors are among the best far-infrared detectors available, and are used for infrared astronomy and infrared spectroscopy

2.1.3 *PHOTODIODE*

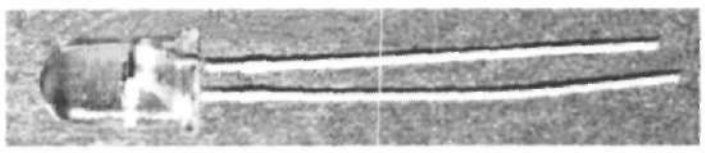


Fig. 2.2 Photodiode

A **photodiode as shown on Fig.2.2,** is a type of photodetector capable of converting light into either current or voltage, depending upon the mode of operation.

Photodiodes are similar to regular semiconductor diodes except that they may be either exposed (to detect vacuum UV or X-rays) or packaged with a window or optical fiber connection to allow light to reach the sensitive part of the device. Many diodes designed for use specifically as a photodiode will also use a *PIN* junction rather than the typical *PN* junction. [11]

2.1.4 PRINCIPLE OF OPERATION

A photodiode is a PN junction or PIN structure. When a photon of sufficient energy strikes the diode, it excites an electron thereby creating a mobile electron and a positively charged electron hole. If the absorption occurs in the junction's depletion region, or one diffusion length away from it, these carriers are swept from the junction by the built-in field of the depletion region. Thus holes move toward the anode, and electrons toward the cathode, and a photocurrent is produced.

Although this mode is faster, the photovoltaic mode tends to exhibit less electronic noise. (The leakage current of a good Photodiode diode is so low – < 1nA – that noise of the load resistance in a typical circuit often dominates.)

2.1.5 APPLICATIONS

P-N photodiodes are used in similar applications to other photodetector, such as photoconductors, charge-coupled devices, and photomultiplier tubes.

Photodiodes are used in consumer electronics devices such as compact disc players, smoke detectors, and the receivers for remote controls in television sets.

In other consumer items such as camera light meters, clock radios (the ones that dim the display when it's dark) and street lights, photoconductors are often used rather than photodiodes, although in principle either could be used.

2.2 ELECTRONIC OSCILLATOR

An **electronic oscillator** is an electronic circuit that produces a repetitive electronic signal, often a sine wave or a square wave from a DC source.

A low-frequency oscillator (LFO) is an electronic oscillator that generates an AC waveform between 0.1 Hz and 10 Hz. This term is typically used in the field of audio synthesizers, to distinguish it from an audio frequency oscillator.

Oscillators designed to produce a high-power AC output from a DC supply are usually called inverters. [10]

2.2.1 TYPES OF ELECTRONIC OSCILLATOR

There are two main types of electronic oscillators: the harmonic oscillator and the relaxation oscillator.

- **Harmonic oscillator**

The harmonic oscillator produces a sinusoidal output. The basic form of a harmonic oscillator is an electronic amplifier with the output attached to a narrow-band electronic filter, and the output of the filter attached to the input of the amplifier. When the power supply to the amplifier is first switched on, the amplifier's output consists only of noise. The noise travels around the loop, being filtered and re-amplified until it increasingly resembles the desired signal.

A piezoelectric crystal (commonly quartz) may be coupled to the filter to stabilise the frequency of oscillation, resulting in a crystal oscillator.

There are many ways to implement harmonic oscillators, because there are different ways to amplify and filter.

(a) HARTLEY OSCILLATOR

Hartley oscillator is an LC electronic oscillator that derives its feedback from a tapped coil in parallel with a capacitor (the *tank circuit*). Although there is no requirement for there to be mutual coupling between the two coil segments, the circuit is usually implemented as such. A Hartley oscillator is essentially any configuration that uses a pair of series-connected coils and a single capacitor. [4]

Hartley oscillators may be series or shunt fed. A Hartley oscillator is made up of the following:

- Two inductors which need not be mutual (may be a two-winding transformer)
- One tuning capacitor

Advantages of the Hartley oscillator include;

- The frequency is varied using a variable capacitor;
- The output amplitude remains constant over the frequency range; and
- The feedback ratio of the tapped inductor remains constant.

Disadvantages include:

- Harmonic-rich content of the output; ar d
- It is not suitable for a pure sine wave.

(b) COLPITTS OSCILLATOR

A **Colpitts oscillator**, is one of a number of designs for electronic oscillator circuits. One of the key features of this type of oscillator is its simplicity and robustness. It is not difficult to achieve satisfactory results with little effort. [11]

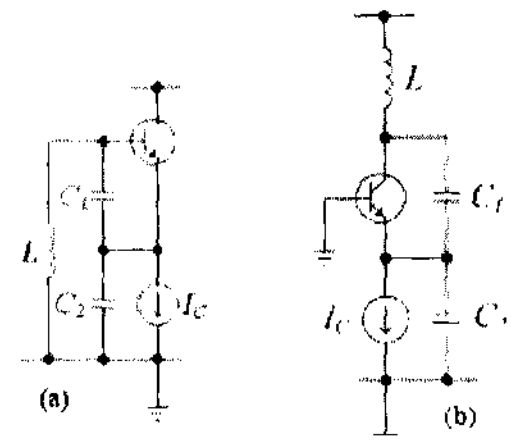


Fig. 2.3 Two configurattions of Colttts Oscillator

The ideal frequency of oscillation for the circuits shown in Fig. 2.3 (a) and (b) are given by the equation:

$$f_0 = \frac{1}{2\pi\sqrt{L \cdot \left(\frac{C_1 \cdot C_2}{C_1 + C_2}\right)}} \quad \text{..... (2.1)}$$

Where the series combination of C1 and C2 creates the effective capacitance of the LC tank.

Real circuits will oscillate at a slightly lower frequency due to junction capacitances of the transistor and possibly other stray capacitances.

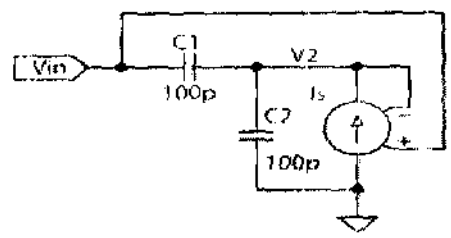


Fig. 2.4 Oscillator configuration

One method of oscillator analysis is to determine the input impedance (as shown in Fig. 2.4) of an input port neglecting any reactive components. If the impedance yields a negative resistance term, oscillation is possible. This method will be used here to determine conditions of oscillation and the frequency of oscillation. [12]

2.2.2 OPTO-ELECTRONIC OSCILLATOR

An opto-electronic oscillator (OEO) is an opto-electronic circuit that produces repetitive electronic sine wave and/or modulated optical continuous wave signals.

Opto-electronic oscillator is based on converting the continuous light energy from a pump laser to radio frequency (RF) and microwave signals. The OEO is characterized by having very high quality factor (Q) and stability, as well as other functional characteristics that are not readily achieved with the electronic oscillator. Its unique behavior results from the use of electro-optical (E/O) and photonic components, which are generally characterized by high efficiency, high speed, and low dispersion in the microwave frequency regime. [15]

2.3 INTERCOMMUNICATION DEVICE

An intercommunication device (Intercom) is an electronic communications system intended for limited or private dialogue, direction, collaboration or announcements. Intercoms can be portable or mounted permanently in buildings and vehicles. Intercoms can incorporate connections to walkie talkies, telephones, cell phones and to other intercom systems over phone or data lines and to electronic or electro-mechanical devices such as signal lights and door latches.

Permanent intercoms installed in buildings are generally composed of fixed microphone/speaker units which connect to a central control panel by wires. A small home intercom might connect a few rooms in a house. Larger systems might connect all of the rooms in a school or hospital to a central office. Intercoms in larger buildings often function as public address systems, capable of broadcasting announcements.

In many schools, tones signaling the change of classes are sounded over the intercom, taking the place of the electromechanical bells used in older schools. Additionally many schools now use audio / video intercoms to identify visitors trying to gain access to a locked school building. Many intercom systems can be interfaced with the building's access control system.

Intercom systems can be found on many types of vehicles including trains, aircraft and armoured fighting vehicles.

Portable intercoms are commonly used by special event production crews and professional sports teams. Performing arts venues such as theaters and concert halls often have a combination of permanently mounted and portable intercom elements.

BASIC TERMS

- **Master Station** or **Base Station** - These are units that can control the system, i.e., initiate a call with any of the stations and make announcements over the whole system.
- **Sub-station** - Units that are capable of only initiating a call with a Master Station but not capable of initiating calls with any other stations (sometimes called slave units).
- **Door Station** - Like sub-stations, these units are only capable of initiating a call to a Master Station. They are typically weather-proof.
- ***Intercom Station*** - *Full-featured remote unit that is capable of initiating and receiving party-line conversation, individual conversation and signalling.* May be rack-mounted, wall-mounted or portable.
- **Wall Mount Station** - fixed-position intercom station with built-in loudspeaker. May have flush-mounted microphone, hand-held push to talk microphone or telephone-style handset.
- **Belt Pack** - portable intercom station worn on the belt. Requires a headset or handset.
- **Handset** - permanent or portable telephone-style connection to an intercom station. Holds both an earpiece and a push to talk microphone.

2.3.4 *Wireless intercoms*

For installations where it is not desirable or possible to run wires to support an intercom system, wireless intercom systems are available. There are two major benefits of a wireless intercom system over the traditional wired intercom. The first is that installation is much easier since no wires have to be run between intercom units. The second is that you can easily

move the units at any time. With that convenience and ease of installation comes a risk of interference from other wireless electrical devices and adverse wheather conditions.

2.4 LASER

A **laser** is a device that emits light (electromagnetic radiation) through a process called **stimulated emission**. The term "laser" is an acronym for **Light Amplification by Stimulated Emission of Radiation**. Laser light is usually spatially coherent, which means that the light either is emitted in a narrow, low-divergence beam, or can be converted into one with the help of optical components such as lenses. The coherent nature simply means all the beams are converged in such a way that all beams move parallel to each other. Typically, lasers are thought of as emitting light with a narrow wavelength spectrum ("monochromatic" light). This is not true of all lasers, however: some emit light with a broad spectrum, while others emit light at multiple distinct wavelengths simultaneously. The coherence of typical laser emission is distinctive. Most other light sources emit *incoherent* light, which has a phase that varies randomly with time and position. [26]

A laser consists of a gain medium inside a highly reflective optical cavity, as well as a means to supply energy to the gain medium. The gain medium is a material with properties that allow it to amplify light by stimulated emission. In its simplest form, a cavity consists of two mirrors arranged such that light bounces back and forth, each time passing through the gain medium. Typically one of the two mirrors, the output coupler, is partially transparent. The output laser beam is emitted through this mirror.

Light of a specific wavelength that passes through the gain medium is amplified (increases in power); the surrounding mirrors ensure that most of the light makes many passes through the gain medium, being amplified repeatedly. Part of the light that is between the mirrors (that is, within the cavity) passes through the partially transparent mirror and escapes as a beam of light.

The process of supplying the energy required for the amplification is called pumping. The energy is typically supplied as an electrical current or as light at a different wavelength. Such light may be provided by a flash lamp or perhaps another laser. Most practical lasers contain additional elements that affect properties such as the wavelength of the emitted light and the shape of the beam. [16]

2.4.1 LASER PHYSICS

The glowing ray in the middle (centre of the parallel beam) is an electric discharge producing light in much the same way as a neon light. It is the gain medium through which the laser passes, *not* the laser beam itself, which is visible there. The laser beam crosses the air and marks a red point on the screen to the right.

Spectrum of a helium neon laser showing the very high spectral intrinsic purity is typical example of pure laser. When compared with the relatively broad spectral emittance of a light emitting diode, the gain medium of a laser is a material of controlled purity, small size, and shape, which amplifies the beam by the process of stimulated emission. Laser can be in any state of matter: gas, liquid, solid or plasma. The gain medium absorbs pump energy, which raises some electrons into higher-energy ("excited") quantum states. Particles can interact with light both by absorbing photons and by emitting photons. Emission can be spontaneous or

stimulated. In the latter case, the photon is emitted in the same direction as the light that is passing by. When the number of particles in one excited state exceeds the number of particles in some lower-energy state, population inversion is achieved and the amount of stimulated emission due to light that passes through is larger than the amount of absorption. Hence, the light is amplified. By itself, this makes an optical amplifier. When an optical amplifier is placed inside a resonant optical cavity, one obtains a laser. [27]

2.4.2 MODES OF OPERATION

The output of a laser may be a continuous constant-amplitude output (known as *CW* or *continuous wave*); or pulsed, by using the techniques of Q-switching, mode-locking, or gain-switching. In pulsed operation, much higher peak powers can be achieved.

Some types of lasers, such as *dye lasers* and *vibronic solid-state lasers* can produce light over a broad range of wavelengths; this property makes them suitable for generating extremely short pulses of light, in the order of a few femto-seconds (10^{-15} s).

In the continuous wave (CW) mode of operation, the output of a laser is relatively consistent with respect to time. The population inversion required for lasing is continually maintained by a steady pump source.

In the pulsed mode of operation, the output of a laser varies with respect to time, typically taking the form of alternating 'on' and 'off' periods. In many applications one aims to deposit as much energy as possible at a given place in as short time as possible.

2.4.3 SEMICONDUCTOR LASERS

Semiconductor lasers are actually solid-state lasers, too, but because semiconductor lasers have a different mode of laser operation, they have a different name. This can be confusing to someone who knows the term solid-state electronics.

Commercial laser diodes emit at wavelengths from 375 nm to 1800 nm, and wavelengths of over 3 μm have been demonstrated. Low power laser diodes are used in laser printers and CD/DVD players. More powerful laser diodes are frequently used to optically pump other lasers with high efficiency. The highest power industrial laser diodes, with power of up to

10 kW (70dBm), are used in industry for cutting and welding. External-cavity semiconductor lasers have a semiconductor active medium in a larger cavity.

Vertical cavity surface-emitting lasers (VCSELs) are semiconductor lasers whose emission direction is perpendicular to the surface of the wafer. VCSEL devices typically have a more circular output beam than conventional laser diodes, and potentially could be much cheaper to manufacture. [26]

2.4.4 APPLICATIONS

Lasers range in size from microscopic diode lasers (top) with numerous applications.

Some of the other applications include:

- Medicine: Bloodless surgery, laser healing, surgical treatment, kidney stone treatment, eye treatment, dentistry;
- Industry: Cutting, welding, material heat treatment, marking parts;
- Defense: Marking targets, guiding munitions, missile defence, alternative to radar;
- Research: Spectroscopy, e.t.c;
- Product development/commercial: laser printers, CDs, barcode scanners, thermometers, laser pointers, holograms;
- Laser lighting displays: Laser light shows; and
- Laser skin procedures such as acne treatment, cellulite reduction, and hair removal.

2.5 RELAY

A **relay** is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier. (See Fig. 2.5)

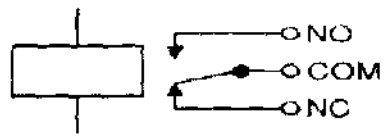


Fig. 2.5 Electromagnetic Relay

When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned by a

force approximately half as strong as the magnetic force to its relaxed position. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

If the coil is energized with DC, a diode is frequently installed across the coil, to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a spike of voltage and might cause damage to circuit components. Some automotive relays already include that diode inside the relay case. The typical connection of the protection diode is shown in Fig. 2.6.

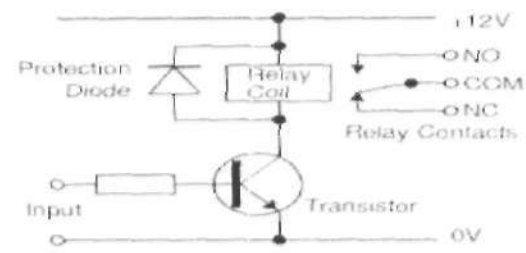


Fig. 2.6 Connection of diode across relay

Alternatively a contact protection network, consisting of a capacitor and resistor in series, may absorb the surge. If the coil is designed to be energized with AC, a small copper ring can be crimped to the end of the solenoid. This "shading ring" creates a small out-of-phase current, which increases the minimum pull on the armature during the AC cycle. By analogy with the functions of the original electromagnetic device, a solid-state relay is made with a thyristor or other solid-state switching device. [19]

2.5.1 TYPES OF RELAY

(a) LATCHING RELAY

A **latching relay** has two relaxed states (bistable). These are also called 'keep' or 'stay' relays. When the current is switched off, the relay remains in its last state. This is achieved with a solenoid operating a ratchet and cam mechanism, or by having two opposing coils with an over-center spring or permanent magnet to hold the armature and contacts in position while the coil is relaxed, or with a remnant core.

(b) Reed relay

A **reed relay** has a set of contacts inside a vacuum or inert gas filled glass tube, which protects the contacts against atmospheric corrosion. The contacts are closed by a magnetic field generated when current passes through a coil around the glass tube. Reed relays are capable of faster switching speeds than larger types of relays, but have low switch current and voltage ratings.

(c) MERCURY-WETTED RELAY

A **mercury-wetted reed relay** is a form of reed relay in which the contacts are wetted with mercury. Such relays are used to switch low-voltage signals (one volt or less) because of its low contact resistance, or for high-speed counting and timing applications where the mercury eliminates contact bounce. Mercury wetted relays are position-sensitive and must be mounted vertically to work properly.

(d) POLARIZED RELAY

A **Polarized Relay** placed the armature between the poles of a permanent magnet to increase sensitivity. Polarized relays were used in middle 20th Century telephone exchanges to detect faint pulses and correct telegraphic distortion. The poles were on screws, so a technician could first adjust them for maximum sensitivity and then apply a bias spring to set the critical current that would operate the relay.

(e) CONTACTOR RELAY

A **contactor** is a very heavy-duty relay used for switching electric motors and lighting loads. With high current, the contacts are made with pure silver. The unavoidable arcing causes the contacts to oxidize and silver oxide is still a good conductor. Such devices are often used for motor starters. A motor starter is a contactor with overload protection devices attached. The overload sensing devices are a form of heat operated relay where a coil heats a bi-metal strip, or where a solder pot melts, releasing a spring to operate auxiliary contacts. These auxiliary contacts are in series with the coil. If the overload senses excess current in the load, the coil is de-energized. Contactor relays can be extremely loud to operate, making them unfit for use where noise is a chief concern.

(f) SOLID-STATE RELAY

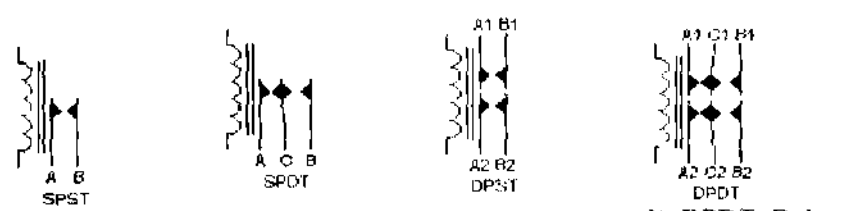
A **solid state relay (SSR)** is a solid state electronic component that provides a similar function to an electromechanical relay but does not have any moving components, increasing long-term reliability. With early SSR's, the tradeoff came from the fact that every transistor has a small voltage drop across it. This collective voltage drop limited the amount of current a

given SSR could handle. As transistors improved, higher current SSR's, able to handle 100 to 1,200 amps, have become commercially available.

(g) OVERLOAD PROTECTION RELAY

One type of electric motor overload protection relay is operated by a heating element in series with the electric motor . The heat generated by the motor current operates a bi-metal strip or melts solder, releasing a spring to operate contacts. Where the overload relay is exposed to the same environment as the motor, a useful though crude compensation for motor ambient temperature is provided.

2.5.2 POLE & THROW



(a) SPST Relay (b) SPDT Relay (c) DPST Relay (d) DPDT Relay

Fig. 2.7 Pole and Throw configurations of Relay

Since relays are switches, the terminology applied to switches is also applied to relays. A relay will switch one or more *poles*, each of whose contacts can be *thrown* by energizing the coil in one of three ways:

- Normally-open (**NO**) contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a **Form A** contact or "make" contact;

- Normally-closed (**NC**) contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called a **Form B** contact or "break" contact; and
- Change-over (**CO**), or double-throw (**DT**), contacts control two circuits: one normally-open contact and one normally-closed contact with a common terminal. It is also called a **Form C** contact or "transfer" contact ("break before make"). If this type of contact utilizes a "make before break" functionality, then it is called a **Form D** contact. [17]

The following designations are commonly encountered:

- **SPST - Single Pole Single Throw**. These have two terminals which can be connected or disconnected. Including two for the coil, such a relay has four terminals in total. It is ambiguous whether the pole is normally open or normally closed. The terminology "SPNO" and "SPNC" is sometimes used to resolve the ambiguity.
- **SPDT - Single Pole Double Throw**. A common terminal connects to either of two others. Including two for the coil, such a relay has five terminals in total.
- **DPST - Double Pole Single Throw**. These have two pairs of terminals. Equivalent to two SPST switches or relays actuated by a single coil. Including two for the coil, such a relay has six terminals in total. The poles may be Form A or Form B (or one of each).
- **DPDT - Double Pole Double Throw**. These have two rows of change-over terminals. Equivalent to two SPDT switches or relays actuated by a single coil. Such a relay has eight terminals, including the coil.

2.5.3 APPLICATIONS

Relays are used to :

- control a high-voltage circuit with a low-voltage signal, as in some types of modems or audio amplifiers;
- control a high-current circuit with a low-current signal, as in the starter solenoid of an automobile;
- detect and isolate faults on transmission and distribution lines by opening and closing circuit breakers (protection relays);
- isolate the controlling circuit from the controlled circuit when the two are at different potentials;
- perform logic functions. For example, the Boolean AND function is realised by connecting NO relay contacts in series, the OR function by connecting NO contacts in parallel.

2.5.4 SELECTION OF AN APPROPRIATE RELAY

Selection of an appropriate relay for a particular application requires evaluation of many different factors; such as:

- Number and type of contacts - normally open, normally closed, (double-throw),

There are two types. This style of relay can be manufactured two different ways: "Make before Break" and "Break before Make;

- Rating of contacts - small relays switch a few amperes, large contactors are rated for up to 3000 amperes, alternating or direct current;
- Voltage rating of contacts - typical control relays rated 300 VAC or 600 VAC, automotive types to 50 VDC, special high-voltage relays to about 15,000 V;
- Coil voltage - machine-tool relays usually 24 VAC or 120 VAC, relays for switchgear may have 125 V or 250 VDC coils, "sensitive" relays operate on a few milliamperes; and
- Switching time - where high speed is required.

2.6 ELECTRONIC AMPLIFIER

An electronic amplifier is a device for increasing the power and/or amplitude of a signal. It does this by taking power from a power supply and controlling the output to match the input signal shape but with larger amplitude. In this sense, an amplifier may be considered as modulating the output of the power supply.

2.6.1 VOLTAGE, CURRENT, AND POWER AMPLIFICATION

Amplifiers can be specified according to their input and output properties. They have some kind of **gain**, i.e. a ratio of the output and input signal. The gain may be specified as "output voltage/input voltage", "output power/input power" or any other combination of current, voltage and power. In many cases, with input and output in the same units, gain will be unitless; for this is not necessarily so – for example, a transconductance amplifier has a gain with units of conductance (output current per input voltage).

In most cases an amplifier should be linear, that is the gain should be constant for any combination of input and output signal. If the gain is not linear, e.g. by clipping the output signal at the limits of its capabilities, the output signal is distorted.

2.6.2 CLASSIFICATION OF AMPLIFIER STAGES AND SYSTEMS

There are many alternative classifications that address different aspects of amplifier designs, and they all express some particular perspective relating the design parameters to the objectives of the circuit. Amplifier design is always a compromise of numerous factors, such as cost, power consumption, real-world device imperfections, and a multitude of performance specifications. Below are several different approaches to classification:

(a) INPUT AND OUTPUT VARIABLES

Electronic amplifiers use two variables: current and voltage. Either can be used as input, and either as output leading to four types of amplifier. In idealized form they are represented by each of the four types of dependent source used in linear analysis, as presented in Table 2.1

Table 2.1 Types of amplifier

Input	Output	Dependent source	Amplifier type
I	I	current controlled current source CCCS	current amplifier
I	V	current controlled voltage source CCVS	transresistance amplifier

V	**I**	voltage controlled current source **VCCS**	transconductance amplifier
V	**V**	voltage controlled voltage source **VCVS**	voltage amplifier

Each type of amplifier in its ideal form has an ideal input and output resistance that is the same as that of the corresponding dependent source:[1]

In practice the ideal impedances are only approximated. For any particular circuit, a small-signal analysis often is used to find the impedance actually achieved. A small-signal AC test current I_x is applied to the input or output node, all external sources are set to zero, and the corresponding alternating voltage V_x across the test current source determines the impedance seen at that node as $Z = V_x / I_x$.

Amplifiers designed to attach to a transmission line at input and/or output, especially RF amplifiers, do not fit into this classification approach. Rather than dealing with voltage or current individually, they ideally couple with an input and/or output impedance matched to the transmission line impedance, that is, match *ratios* of voltage to current. Many real RF amplifiers come close to this ideal. Although, for a given appropriate source and load impedance, RF amplifiers can be characterized as amplifying voltage or current, they fundamentally are amplifying power.

(b) COMMON TERMINAL

One set of classifications for amplifiers is based on which device terminal is common to both the input and the output circuit. In the case of bipolar junction transistors, the three classes are

common emitter, common base, and common collector. For field-effect transistors, the corresponding configurations are common source, common gate, and common drain; for triode vacuum devices, common cathode, common grid, and common plate.

(c) INVERTING OR NON-INVERTING

Another way to classify Amplifiers is the phase relationship of the input signal to the output signal. An **inverting** amplifier produces an output 180 degrees out of phase with the input signal (that is, an inversion or mirror image of the input as seen on an oscilloscope). A **non-inverting** amplifier maintains the phase of the input signal waveforms. An **emitter follower** is a type of non-inverting amplifier, indicating that the signal at the emitter of a transistor is following (that is, matching with unity gain but perhaps an offset) the input signal.

This description can apply to a single stage of an amplifier, or to a complete amplifier system.

2.6.3 FUNCTIONS

Other amplifiers may be classified by their function or output characteristics. These functional descriptions usually apply to complete amplifier systems or sub-systems and rarely to individual stages.

- A **linear** amplifier responds to different frequency components independently, and does not generate harmonic distortion or inter-modulation distortion. A ***nonlinear*** amplifier does generate distortion.
- A **wideband** amplifier has a precise amplification factor over a wide range of frequencies, and is often used to boost signals for relay in communications systems. A

narrowband *amp is made to amplify only a specific narrow range of frequencies, to the exclusion of other frequencies.*

- An **RF** amplifier refers to an amplifier designed for use in the radio frequency range of the electromagnetic spectrum, and is often used to increase the sensitivity of a receiver or the output power of a transmitter.
- An **audio** amplifier is designed for use in reproducing audio frequencies. This category subdivides into small signal amplification, and power amplifiers which are optimised for driving speakers, sometimes with multiple amplifiers grouped together as separate or bridgeable channels to accommodate different audio reproduction requirements.

The performance of an operational-amplifier with these characteristics would be entirely defined by the (usually passive) components forming a negative feedback loop around it, that is, **the amplifier itself has no effect on the output.**

Today, operational-amplifiers are usually provided as integrated circuits, rather than constructed from discrete components. All real-world operational-amplifiers fall short of the idealised specification above – but some modern components have remarkable performance and come close in some respects.

2.6.4 INTERSTATE COUPLING METHOD

Amplifiers are sometimes classified by the coupling method of the signal at the input, output, or between stages. Different types of these include:

- ***R-C* coupled amplifier, using a network of resistors and capacitors.** By design these amplifiers cannot amplify DC signals as the capacitors block the DC component

of the input signal. RC-coupled amplifiers were used very often in circuits with vacuum tubes or discrete transistors.

- ***L-C* coupled amplifier, using a network of inductors and capacitors.** This kind of amplifier is most often used in selective radio-frequency circuits.
- **Transformer coupled amplifier, using a transformer to match impedances or to decouple parts of the circuits.**
- **Direct coupled amplifier**, using no impedance and bias matching components. This class of amplifier was very uncommon in the vacuum tube days when the anode (output) voltage was at several 100 V plus and the grid (input) voltage at a few voltages minus.

2.6.7 POWER AMPLIFIER CLASSES

Power amplifier circuits (output stages) are classified as A, B, AB and C for analog designs, and class D and E for switching designs based upon the conduction angle or 'angle of flow' θ of the input signal through the amplifying device, that is, the portion of the input signal cycle during which the amplifying device conducts. The image of the conduction angle is derived from amplifying a sinusoidal signal. (If the device is always on, $\theta = 360°$.) The angle of flow is closely related to the amplifier power efficiency. The various classes are introduced below, followed by more detailed discussion under individual headings later on.

(a) CLASS A

Class A amplifying devices as shown on fig. 2.5 operate over the whole of the input cycle such that the output signal is an exact scaled-up replica of the input with no clipping. Class A amplifiers as shown in Fig. 2.5 are the usual means of implementing small-signal amplifiers. They are not very efficient; **a theoretical maximum of 50% is obtainable with inductive output coupling and only 25% with capacitive coupling**.

In a Class A circuit, the amplifying element is biased so the device is always conducting to some extent, and is operated over the most linear portion of its characteristic curve (known a its transfer characteristic or transconductance curve). Because the device is always conducting, even if there is no input at all, power is drawn from the power supply. This is the chief reason for its inefficiency.

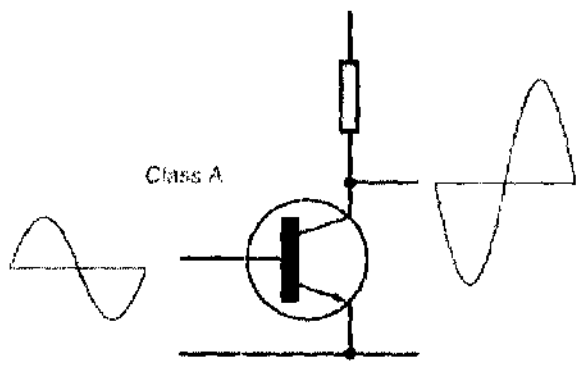


Fig. 2.5 Class A Amplifier

If high output powers are needed from a Class A circuit, the power waste (and the accompanying heat) will become significant. For every watt delivered to the load, the amplifier itself will, at best, dissipate another watt. For large powers this means very large ar expensive power supplies and heat sinking

(b) CLASS B AND AB

Class B amplifiers only amplify half of the input wave cycle. As such they create a large amount of distortion, but their efficiency is greatly improved and is much better than Class A. **Class B shown in fig. 2.6 has a maximum theoretical efficiency of 78.5% (i.e., $\pi/4$).** This is because the amplifying element is switched off altogether half of the time, and so cannot dissipate power. A single Class B element is rarely found in practice, though it can be used in RF power amplifier where the distortion levels are less important. However Class C is more commonly used for this.

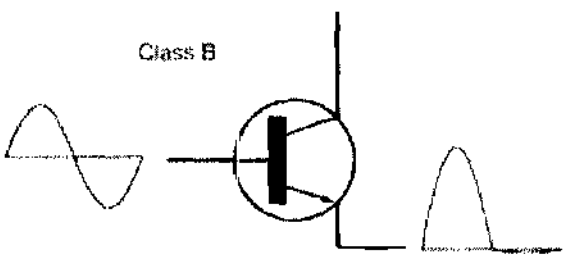


Fig. 2.6 Class B Amplifier

A practical circuit using Class B elements is the complementary pair or "push–pull" arrangement shown in Fig. 2.7. Here, complementary or quasi-complementary devices are used to each amplify the opposite halves of the input signal, which is then recombined at the output. This arrangement gives excellent efficiency, but can suffer from the drawback that there is a small mismatch at the "joins" between the two halves of the signal. This is called crossover distortion.

Class AB sacrifices some efficiency over class B in favor of linearity, so will always be less efficient (below 78.5%). It is typically much more efficient than class A.

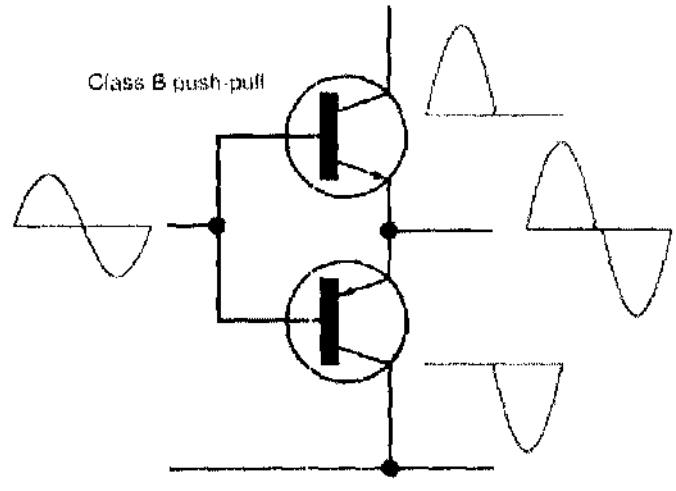


Fig. 2.7 Class B Push-Pull

Class B or AB push–pull circuits (shown in Fig. 2.7) are the most common design type found in audio power amplifiers. Class AB is widely considered a good compromise for audio amplifiers, since much of the time the music is quiet enough that the signal stays in the "class A" region, where it is amplified with good fidelity, and by definition if passing out of this region, is large enough that the distortion products typical of class B are relatively small.

(c) CLASS C

Class C amplifiers conduct less than 50% of the input signal and the distortion at the output is high, but high efficiencies (up to 90%) are possible. Some applications (for example, megaphones) can tolerate the distortion. A much more common application for Class C amplifiers is in RF transmitters, where the distortion can be vastly reduced by using tuned loads on the amplifier stage. The input signal is used to roughly switch the amplifying device on and off, which causes pulses of current to flow through a tuned circuit.

The Class C amp has 2 modes of operation: tuned, and untuned [6]. The diagram of figure 2.8 shows a waveform from a simple class C circuit without the tuned load. This is called untuned operation, and the analysis of the waveforms shows the massive distortion that appears in the signal. When the proper load (e.g., a pure LC filter) is used, 2 things happen. The first is that the output's bias level is "clamped", so that the output variation is centered at one-half of the supply voltage. This is why tuned operation is sometimes called a "clamper".

The tuned circuit will only resonate at particular frequencies, and so the unwanted frequencies are dramatically suppressed, and the wanted full signal (sine wave) will be extracted by the tuned load (e.g., a high-quality bell will ring at a particular frequency when it is hit periodically with a hammer). Provided the transmitter is not required to operate over a very wide band of frequencies, this arrangement works extremely well. Other residual harmonics can be removed using a filter.

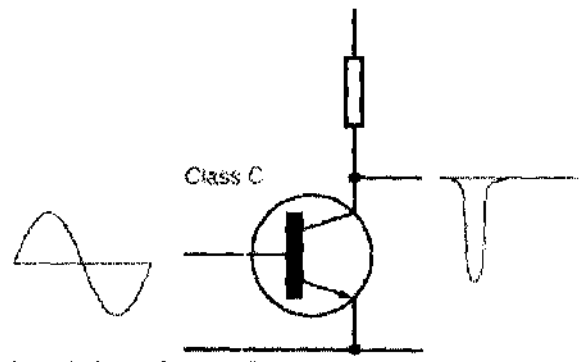


Fig. 2.8 Class C Amplifier

CHAPTER THREE

DESIGN OF THE SYSTEM

3.0 INTRODUCTION

The electronic projects that involves the design and construction of some systems always has some defined procedures that must be followed in order to achieve the goal of the project. These procedures include the definition of the actual problem that is going to be solved. Then the methodology that would be used for achieving the goal is specified. From this defined methodology the design of the actual system is carried out. After this, the designed system is then constructed to verify its workability. When the system constructed is made to work properly after some adjustment, measurements are carried out on the constructed system.

This chapter gives the design details of the of the electronic security assistant system. The step-by-step design calculations and the analysis of the different sub-circuits of the system are shown in the sub-headings that follow. However, the methods adopted for selecting some components as well as the reasonable approximations and assumptions made in choosing actual components used in the circuits are given in the design analysis of the different circuits that made up the whole system. The components of the circuits designed are presented in the tables of components (table 3.1 to table 3.9).

3.1 DESIGN AND ANALYSIS OF THE SECURITY ALARM (FOR DOORS AND GATES)

This security alarm for gates and doors is designed and implemented using the circuit diagram shown in Fig. 3.1:

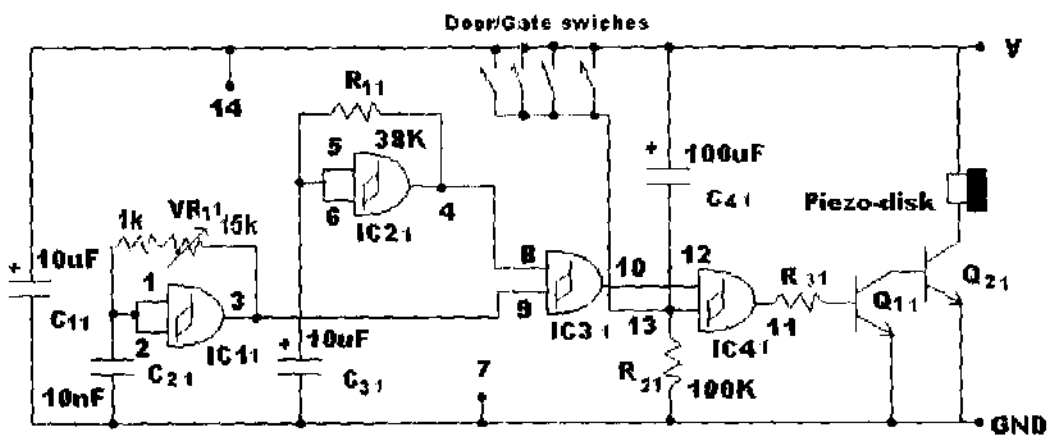


Fig. 3.1 Door alarm circuit diagram

This electronic security alarm for doors and gates is designed and constructed using Schmitt trigger IC as the active component that generates the oscillation. The IC11, Two-input Schmitt trigger AND gate is a fast oscillator that generates a high frequency audio signal. The frequency of the oscillator is controlled using a variable resistor VR_{11} together with the capacitor C_{21}. The IC21 on the other hand is a low frequency oscillator whose frequency is determined by the capacitor C_{31} and feedback resistor R_{11}. Since the resistor R_{11} is of fixed value, the frequency of IC21 is constant which only replacing the R11 with other values can change. The outputs of the two oscillators IC11 and IC21 are connected to the input of IC31, which serves as the mixer and produces the final warning alarm signal.

Furthermore, the output of IC41 is delivered to one input of IC41 with the other input terminal connected to an RC network that works as the timing circuit to determine the duration of the alarm when a door or gate is closed and opened. Finally the output of IC41 is further

amplified using a Darlington pair amplifier to improve the loudness of the signal produced by a piezo disk.

To design for the operating frequency of the IC11 (the fast oscillator), we use the relation [2]:

$$f = \frac{1}{6.28RC} \quad \text{..... (3.1)}$$

The operating frequency of the IC11 oscillator is selected to be in the range of 1 kHz to 16 kHz in the audio frequency spectrum. In this case, the value of the capacitor C_{21} was selected to be 10nF (0.01μF), fast discharge type. The range of values of variable resistor is calculated as follows;

$$R = \frac{1}{6.28FC} \quad \text{..... (3.2)}$$

When f= 1 kHz and C = 10nF

$$R = \frac{1}{6.28 \times 1000 \times 10 \times 10^{-9}} = 15923.6\Omega \quad \text{..... (3.3)}$$

When f= 16 KHz and C = 10nF

$$R = \frac{1}{6.28 \times 16000 \times 10 \times 10^{-9}} = 995.2\Omega \quad \text{..... (3.4)}$$

According to the values calculated in equations (3.3) and (3.4) the resistance is in the range of 995 Ω to 15924 Ω. To achieve this design requirement a 1kΩ is used in series with 15k Ω variable resistor which gives the resistance value range required. The frequency of operation of IC21 is designed, using the same expression used in equation (3.1), since the two oscillators have the same configuration.

This oscillator is low frequency type and therefore the capacitor is of electrolytic type with slow discharge. A 10μF capacitor is used here. The slow oscillating frequency is selected to be 500Hz.

$$R = \frac{1}{6.28FC}$$

$$R = \frac{1}{6.28 \times 500 \times 10 \times 10^{-6}} = 31.88K\Omega \quad \text{.....(3.5)}$$

A 32KΩ resistor with ±10% tolerance is used as it is practically available within the range.

The RC timing for the IC41 is designed using the relation:

$$T = 1.1 \ln RC \quad \text{.....(3.6)}$$

The delay time is taken as 10s and the capacitor of 100μF is used as C_{41}, the resistor R_{21} is calculated as follows;

From equation (3.6) above $\ln RC = \frac{T}{1.1}$ $\qquad RC = e^{\frac{T}{1.1}}$

$$R = \frac{1}{C} e^{\frac{T}{1.1}} \qquad R = \frac{1}{100 \times 10^{-6}} e^{\frac{10}{1.1}} = 88.7K\Omega \text{.....} \quad (3.7)$$

This resistance value is made to be 100kΩ to increase the delay time to about 11s.

The Darlington pair amplifier is designed using NPN transistors BC548 with specifications given as: **current amplification β = 100 and collector resistor (load) R_C = 1kΩ.**

Maximum power output P_D = 0.6W, Maximum collector current I_C = 0.5A [5]

The overall gain of the amplifier is evaluated as:

$$A = A_1 A_2 \text{.....} \quad (3.8)$$

Where, A_1 and A_2 are the gains of the two stages respectively. The combined current amplification β =10,000. R_L 8Ω, Input resistance R_{in} 3K Ω. Supply voltage V_{cc} = 9v.

The base resistance is evaluated as follows:

$$R_{in} = R_B \| \beta \| R_L \quad [1] \qquad (3.9)$$

$$3K\Omega = R_B \left\| \frac{1000 \times 3}{1000 - 3} \right\| \qquad (3.10)$$

Solving the equation we have $R_B = 2.21k\Omega$

Quiescent collector current I_{CQ}

$$I_{CQ} = \frac{V_{cc}}{R_1 - R} = \frac{9}{8 - 11.98} = 0.45A \qquad (3.11)$$

$$I_{CQ} = 450mA \qquad (3.12)$$

Power output

$$P_C = \frac{1}{2} \left| \frac{V_{CC}}{2} \right|^2 R_L \qquad (3.13)$$

$$P = 200mW \qquad (3.14)$$

The power gain A_P

$$A_P = \frac{P_o}{P_{in}} = \frac{P_o}{\frac{(V_{CC})^2}{R_{EE}}} = \frac{200mW}{\frac{(450mA)^2}{100}} = 64.4 = 18dB \qquad (3.15)$$

Table 3.1 Door alarm circuit's components and devices

COMPONENT	CALCULATED VALUE	USED VALUE
R_{11}	$31.88K\Omega$	32kΩ
R_{21}	$88.7K\Omega$	100kΩ
C_{11}	10uF	10uF
C_{21}	10nF	10nF
C_{31}	10uF	10uF
C_{41}	100uF	100uF
VR_{11}	995.2Ω -- 15923.6Ω	1k + 15k variable

The designed circuit of security alarm for doors and gates was constructed temporarily on a breadboard to test its workability and was found working properly after all the required arrangement of the components in their places.

3.2 DESIGN AND ANALYSIS OF MORNING ALARM

The morning alarm is designed and implemented from the circuit diagram in Fig.3.2;

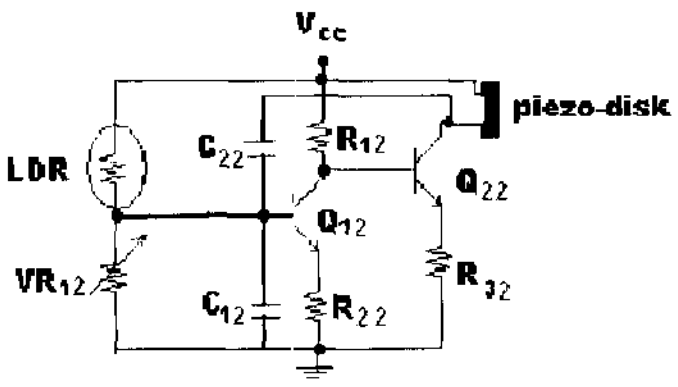


Fig. 3.2 Morning alarm circuit diagram

The circuit is made up of two transistors Q12 and Q22. The first transistor acts as a switch, which is turned on and off based on the light intensity falling on the light dependent resistor (LDR). When the LDR is illuminated, the resistance reduces to few ohms. This supplies enough base current to turn on transistor Q12, but in the darkness the resistance of the LDR greatly increases and thus turns off the Q12 by cutting the supply of the base current. The output at the collector of Q12 is connected to the base of transistor Q22 for further amplification and finally Q22 produces the output to drive the piezo- disk which generates the alarm.

The light intensity at which the Q12 turns on and off is controlled using variable resistor VR_{12}. The transistors Q12 and Q22 are BC547 NPN transistors with the following specifications [5]:

Cut-in voltage $V_r = 0.7v$, Min current gain ß = 100, Max collector current $I_C = 600mA$

Max. Power dissipation $P_D = 450mW$. The circuit is powered with V_{CC} -9v being within the range the transistors can operate [5]

To obtain the value of resistor R1, the following relation is used:

$$R_{12} = \frac{V_{CC} - V_{CE}}{I_C} \quad \text{..... (3.16)}$$

Where V_{CE} is the potential difference between collector and the emitter.

$$R_{12} = \frac{9v - 0.2v}{0.6mA} = 14.667k\Omega \quad \text{..... (3.17)}$$

So 15KΩ is used for resistor R_{12}. The resistors R_{22} and R_{32} are similar, used to connect the emitters of the two transistors in order to improve noise immunity.

The values of these resistors are obtained from

$$R_{22} = \frac{V_{BE}}{I_E} = V_{BE} / \frac{I_C}{\beta} \quad \text{..... (3.18)}$$

$$Since\ I_E \approx \beta I_C \quad \text{..... (3.19)}$$

$$R_{22} = \frac{I_C}{I_E} x100 = 116.67\Omega \quad \text{..... (3.20)}$$

Resistor R_{22} and R_{32} are taken as 120Ω. The maximum base current of the transistor Q12 is

$$I_B = \frac{I_C}{\beta} = \frac{600}{100} = 6mA \quad \text{..... (3.21)}$$

The required base resistance is evaluated using the relation:

$$R = \frac{V_{cc} - V_{BE}}{I_{B(max)}} \quad \text{[2] ..... (3.22)}$$

$$R = \frac{9 - 0.7}{6mA} = 1.38k\Omega \quad \text{.....(3.23)}$$

Since when the LDR is in total darkness the resistance is in order of megaohms and when fully illuminated the resistance reduces to some few ohms (less than 1 KΩ).

Here variable resistor 1K Ω was used as potential divider with LDR at the base to set the point of switching on and off of the transistor Q12. The Piezo- disk used is the type with internal oscillation so that the output of transistor Q22 sets it into oscillation.

Table 3.2 Morning alarm circuit's components

COMPONENT	CALCULATED VALUE	USED VALUE
R_{12}	14.667kΩ	15KΩ
R_{22}	116.67Ω	120Ω.
R_{32}	116.67Ω	120Ω.
C_{12}	-	10nF
C_{22}	-	100nF
Q_{12}	-	BC547
Q_{22}	-	BC547
LDR	-	Gen. purpose
VR_{12}	-	1k Ω
PIEZO-DISK	-	Gen. purpose

This circuit of morning alarm was constructed temporarily on a breadboard to test its workability and make needed adjustments and was found working properly after all the required arrangement of the components in their positions.

3.3 DESIGN AND ANALYSIS OF AUTOMATIC NIGHT LIGHT

The automatic night-light is designed and implemented as shown in Fig. 3.3

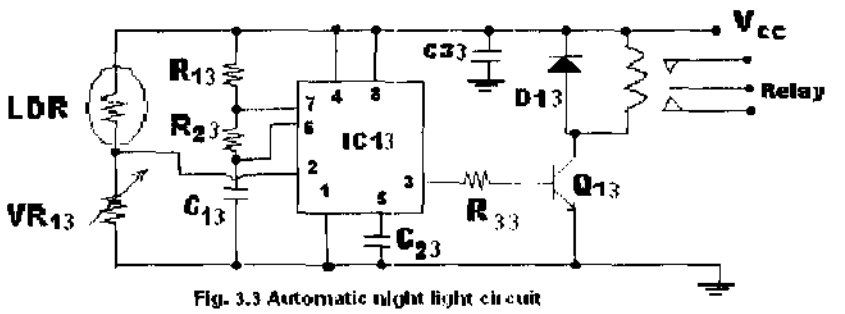


Fig. 3.3 Automatic night light circuit

As shown in the circuit diagram the automatic night light is controlled using 555-timer IC multivibrator. The level of the light intensity on the light dependent resistor (LDR) determines when the trigger signal to pin-2 is available. When the LDR is illuminated its resistance goes low thereby allowing enough current to flow to turn on the IC which produces an output at pin-3. This output of the IC is further amplified by the transistor Q13 whose output is used to trigger the relay. In total darkness, the triggering current for the IC is blocked so the output of the IC is low so that the transistor Q13 is cut-off: consequently, the relay is also turned-off. As it is known, the normally-closed and the normally-open relay terminals are used based on the desired operation.

To find the triggering period of the multivibrator we use [1]:

$$T = 1.1\,(R_{13} + R_{23})\,C_{13} \quad \ldots\ldots (3.24)$$

Choosing the period as T = 15mS and the capacitor C_{13} is selected as 0.1uF, the value of the resistor R_{13} can be calculated if R_{23} is selected as $R_{23} = 120K\Omega$

$$R_{13} = \frac{T}{1.1C_{13}} - R_{23} \quad \ldots\ldots (3.25)$$

$$R_{13} = \frac{15 \times 10^{-3}}{1.1 \times 0.1 \times 10^{-6}} - 120000 \quad \ldots\ldots (3.26)$$

R_{13}= 16363.64Ω..... (3.27)

The resistor R_{23} is selected as 16KΩ due to its availability and this would have negligible effect on the value of the period. Capacitor C_{21} of value 0.01uF is used to connect pin-5 of the IC to the ground to filter out any noise. Also capacitor C_{33} of 0.1uF is used as fast discharge filter to further smoothen the dc supply.

The triggering current to pin-2 of the IC can be in the range of 2.5mA and 15mA. The needed resistance is calculated as follows:

$$R = \frac{V_{cc}}{I_c} \quad \text{..... (3.28)}$$

$$R = \frac{9}{2.5mA} = 3.6K\Omega \quad \text{..... (3.29)}$$

$$R = \frac{9}{15mA} = 0.6K\Omega \quad \text{..... (3.30)}$$

Therefore a potential divider with variable resistor of 2.2KΩ together with the LDR is used. In this way, depending on the light intensity falling on the LDR the variable resistor is varied to set the triggering point of the IC.

The output of the timer IC at pin-3 is connected to the base of transistor Q13 through resistor R_{31} for further amplification. The transistor used is a general purpose, NPN transistor with the following specifications:

Turn-on voltage V_t = 0.7v, Collector current I_C = 450mA, Power dissipation

P_D = 500mW Current gain factor β =100 (min). The part number of the transistor is BC548 [7].

The base current of the Q13 is obtained as follows:

$$I_B = \frac{I_C}{\beta} = \frac{450mA}{100} = 4.5mA \quad \text{.....(3.31)}$$

This base current is delivered to the Q1 through a resistor R_{13} = 1KΩ which limits the current to the safe, maximum value. The dc power output produced by the Q13 is evaluated as follows:

$$P_{o(dc)} = V_{cc} I_{CQ} - \frac{(V_{cc})^2}{R_{13}} \quad [3] \text{.....(3.32)}$$

$$P_{o(dc)} = 9 \times 225mA - \frac{9^2}{1000} = 375mW \quad \text{.....(3.33)}$$

The *output of the Q13 drives the relay with the following specifications:*

Part number, JZC 4088, DC trigger voltage = 9v, Maximum current capacity = 10A, AC frequency = 50-60Hz. The peak reverse voltage (PRV) of Diode D1 is 1000v with maximum current of 2.5A. Based on the specifications of the relay, 10A 230v-AC, it can carry the following lighting loads safely. (Total rating = 10 x 230 = 2300W).

Table 3.3 Load values for the morning alarm's circuit

Power rating	**Number of Bulbs**	**Total Load**
60w Bulb	38	2280W
100W Bulb	23	2300W
200W Bulb	11	2200W
500W Security light	4	2000W

Table 3.4 Morning alarm circuit's components

COMPONENT	CALCULATED VALUE	USED VALUE
R_{13}	16363.64Ω	16k Ω
R_{23}	120k Ω	120k Ω
R_{33}	1kΩ	1kΩ
C_{13}	0.1uF	0.1 uF
C_{23}	0.01 uF	0.01 uF
C_{33}	0.1 uF	0.1 uF
VR_{13}	-	2.2k Ω
D_{13}	-	1N4007
LDR	-	**Gen. purpose (CSc)**

The automatic night light, after the design was constructed temporarily; was found working according to the design requirements.

3.4 DESIGN AND ANALYSIS OF INTERCOMMUNICATION UNIT

The intercommunication unit designed in this project is made up of an amplifier that accepts the input signal (voice), amplifies it and passes it to the other end for the two people to communicate. The second part is the oscillator that generates the alarm signal to alert people being called. The amplifier used is shown in Fig. 3.4

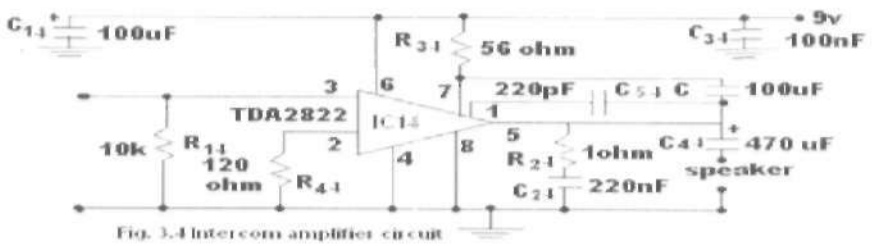


Fig. 3.4 Intercom amplifier circuit

The amplifier is designed using an integrated circuit TDA2822 (see Fig. 3.4). The circuit diagram of the IC14 is shown in fig. 3.4(b); [5]



Fig. 3.4 (b) TDA2822 Pin-Out

The IC14 can produce a maximum power output of 2W in the range of audio frequency spectrum. The voltage supply to the IC14 is in the range of 3V to 12V from a direct current source. The output is delivered to a loud speaker of 8 Ω impedance. The input signal is taken into the IC through pin-3 while pin-5 produces the output. Pins 6 and 4 serve as the V_{CC} and the ground respectively. Pin-8 is a ripple reject which is used to control any distortion in the input signal. Pins 7 and 1, (bootstrap and frequency comparator) are used to nullify any frequency interference that can distort the signal. Finally the gain of the amplifier is controlled using the gain-adjust pin-2. This design used three-quarter of the maximum voltage (9V) to avoid any distortion. The capacitors C14 and C_{34} are used to remove any dc that may be present in the supply to further make it smooth. These capacitors may take values from 47uF to 150uF [2]. This design used 100uF which is intermediate. Pin-7, bootstrap used for controlling interference, is connected to the V_{CC} through the resistor R_{34} and feedback is taken from the output to the pin-7 through feedback capacitor C_{54}. The value of this capacitor as given by the manufacturers can be between 100uF and 150uF [4]. In this design 100uF was used to limit the feedback signal to its minimum value.

The value of the resistor R_{34} is calculated as follows:

$$R_{34} = \frac{V_{CC} - V_B}{I_B} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.34)$$

Where V_{CC} = supply voltage

I_B = bootstrap current

V_B = bootstrap voltage

The supply voltage is V_{CC} = 9v, the bootstrap voltage; V_B = $^3/_4 V_{CC}$ to V_{CC} [5]. Here V_B = 7v was taken which is in the range and I_B = 36mA (Typical).

To find R_{34}:

$$R_{34} = \frac{9-7}{36mA} = \frac{2}{36mA} = 55.56\Omega \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.35)$$

Therefore, 56Ω was used as the R_{34} as it is the available practical value in the range.

The frequency comparator is connected to the output via a feedback capacitor which is used to compare the frequency of the output signal with the standard operating frequency for the stability to be maintained. The value of the feedback capacitor is calculated using the relation:

$$C_{64} = \frac{1}{6.28 f X_C} \quad [3] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where f = frequency of the system X_C = reactance of the capacitor.

The operating frequency is chosen to be 2.67 kHz. The reactance of the feedback capacitor is supposed to be big in the range of 10M Ω to 30M Ω [3]. The bigger the value, the more stable is the frequency of the system. In this case it is taken as X_C = 27M Ω.

$$C_{64} = \frac{1}{6.28 \times 2.67 \times 10^3 \times 27 \times 10^6} = 2.2088 \times 10^{-14} F \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.36)$$

$$C_{64} \cong 220 \times 10^{-12} F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.37)$$

Therefore, C_{64} is approximately 220pF.

The resistor R_{14} connected between the input terminal and the ground is used as a bypass resistor to any dc component that may be present in the input signal. The value of the resistor is calculated as follows;

$$R_{14} = \frac{V_{in}}{I_{in}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.38)$$

Where V_{in} = maximum possible input voltage. I_{in} = maximum possible input current.

From the data sheet [5] for IC, V_{in} = 2v and I_{in} = 220uA.

To find R_{14} substitute Iin = 220uA in the equation (3.38).

$$R_{14} = \frac{2}{220 \times 10^{-6}} = 9090.901\Omega \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.39)$$

In this design a 10k**Ω** is used as R_{14} because it is the standard available value in the range of the calculated values.

The gain of the amplifier is adjustable which can be varied up to the point it would give the maximum power of 2Watt. But by the designer's specification, it is not good to operate the IC at its maximum power output. The gain adjustment resistor takes the value in the range of 100 Ω to 150 Ω. At 100 Ω [3] the gain is maximum and it decreases with the increase of R_{44}.

A 120 Ω is used as R_{44} to give a safe gain.

The output of the IC from pin-5 is partly bypassed to the ground to improve the distortion prevention in the circuit. This is achieved by a series network of capacitor C_{24} and resistor R_{24} The resistor takes a value of 1 Ω while the capacitor value is evaluated as follows:

$$C_{24} = \frac{1}{6.28 f X_C} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where f = 2.67 kHz as before and the reactance of the capacitor C_{24} is taken as one-tenth of one percent of that of C_{64} [2]. That is 27kΩ. Hence:

$$C_{24} = \frac{1}{6.28 \times 2.67 \times 10^{3} \times 27 \times 10^{3}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.40)$$

$C_{24} = 2.2088 \times 10^{-11}F$, $= C_{24} = 220.88 \times 10^{-9}$ F $C_{24} \approx 220nF$

The capacitor C_{44} is used to couple the output to the loud speaker. This capacitor should be chosen in such a way that it should supply the full output to the load from the IC. The manufacturers show that it can take a value from 220uF to several hundreds of microfarads and operate efficiently [5]. A 470uF was selected for this purpose.

Table 3.5 Intercom's amplifier circuit components

COMPONENT	CALCULATED VALUE	USED VALUE
Integrated circuit	-	TDA2822M
Resistor R_{14}	9090.901Ω	10kΩ
R_{24}	-	1Ω
R_{34}	55.56Ω	56Ω
R_{44}	-	120 Ω
Capacitor C_{14}	-	100uF
C_{24}	2.2088×10^{-9}F	220nF
C_{34}	-	100uF
C_{44}	-	470uF
C_{54}	-	100uF
C_{64}	2.2088×10^{-11}F	220pF
Loud speaker	-	8 Ω

The oscillator used as the ringer that generates the alerting signal at the receiving end to alert the person that there is a call is designed as in the circuit diagram shown in Fig. 3.5.

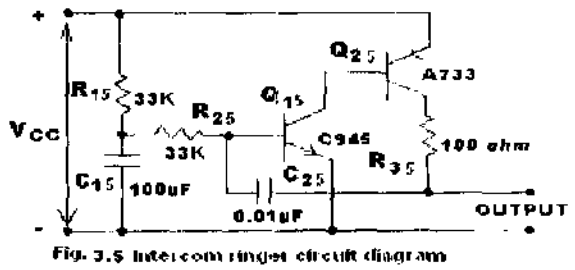


Fig. 3.5 Intercom ringer circuit diagram

The oscillator is designed with two transistors Q_{15} and Q_{25} which are NPN and PNP type. The NPN is C945 and the PNP is A733. The Q_{15} is used as the main oscillator that generates the basic oscillation frequency. This is achieved using a network of resistor R_{25} and capacitor C_{15}. While the capacitor C_{25} is used for providing feedback to the base of transistor Q_{15} which is necessary for the maintenance of the oscillation. The output of transistor Q_{15} is directly coupled to the base of Q_{25} for further amplification. The final output of the second transistor is delivered to the load through resistor R_{35}. The two transistors are general purpose, silicon transistors with the following specifications:

Cut-in voltage $V_\gamma = 0.7v$. Minimum current gain β 80:

Maximum collector current $I_C = 0.4A$, Maximum power dissipation $P_D = 0.5W$;

Chosen value of base current $I_B = 250\mu A$.

To find the value of the resistor R_{15}:

$$R_{15} = \frac{V_{cc}}{I_B} = \frac{5}{250 \times 10^{-6}} \quad \text{..... (3.41)}$$

$R_{15} = 32142.9\Omega$ ..... (3.42)

A 33k Ω was used as the value of R_{15} since it is the standard available value within the range of the calculated value.

The value of the feedback capacitor C25 should be as small as possible in the range of 0.01μF to 0.03μF for fast discharge. In this design 0.01 μ F is used.

To find the value of the capacitor C_{15}, its capacitive reactance should be the total of the reactance between the base and the ground.

To find the reactance, the following relation is used:

$$X_c = \frac{V_{CE} - V_c}{I_C} \quad \text{.....(3.43)}$$

But $I_C = \beta I_B = 80 \times 250 \times 10^{-6} = 0.0224A$

$X_c = \frac{24 - 0.7}{0.0224} = 1040.14\Omega$ .....(3.44)

The selected frequency of the oscillator is 1500Hz. To find the capacitor C_{15}, use

$C_{15} = \frac{1}{6.28 f X_c}$ .....(3.1)

$C_{15} = \frac{1}{6.28 \times 1500 \times 1040.14}$ .....(3.45)

$C_{15} = 102 \times 10^{-6}F$ .....(3.46)

In this design a 100 μF is used as the approximate value.

In case of resistor R_{25} it is equivalent to R_{15}. So R_{25} = 33k Ω. The resistor R_{35} is a load coupling resistor which is used to couple the output of the oscillator to the load. Its value can be taken arbitrarily in the range of 100 Ω to 470 Ω. A 100 Ω is used in this work in order to get high current to the load.

Table 3.6 Intercom's ringer circuit components

COMPONENT	CALCULATED VALUE	USED VALUE
Transistor NPN(Q15)	-	C945
PNP(Q25)	-	A733
Resistor R_{1S}	3214.9 Ω	33k Ω
R_{2S}	3214.9 Ω	33k Ω
R_{3S}	-	100 Ω
Capacitor C_{1S}	102×10^{-6}F	100 μF
C_{2S}	-	0.01 μF

The combined circuits of amplifier and alarm were constructed temporarily on a breadboard to test the workability of the intercom and was found working properly.

3.5 DESIGN OF AUTOMATIC EMERGENCY LIGHT

The automatic emergency light that comes on automatically in the event of power failure and goes off when the power is back is designed and implemented as in the circuit diagram shown in Fig. 3.6

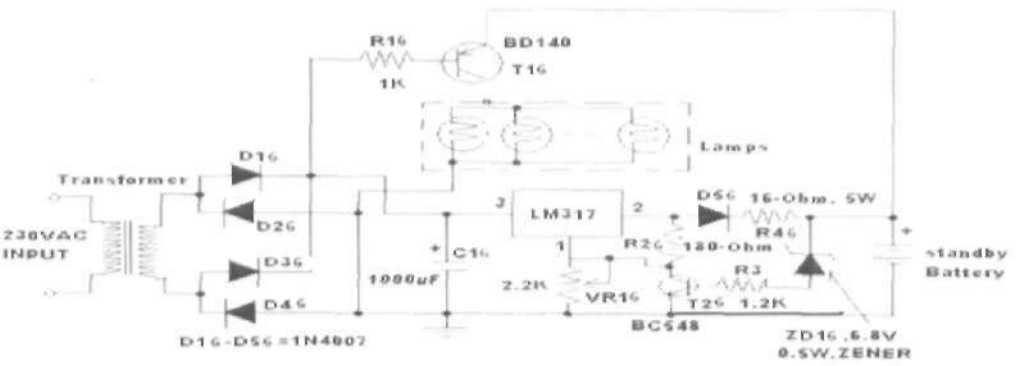


Fig. 3.6 Emergency Light's circuit diagram

The circuit as shown above is made up of two basic parts. They are the battery charging unit and the switching unit. The battery charging unit used for charging the standby battery consists of a transformation section made with a step down transformer, the rectification unit made with rectifier diodes $D_{16} - D_{46}$, and the filtration unit using a capacitor C_{16}. The output of the filter capacitor is passed through an adjustable voltage regulator, LM317 for adjusting the level of voltage to the desired value. There is a charging control circuit used for controlling the charging of the battery. That is, when the battery is fully charged to a voltage of about 6.8V the control transistor is cut-off so that the charging of the battery stops. As the voltage of the battery drops the charging continues.

The switching unit of the circuit is made up of a switching transistor and the base resistor to the capacitor.

The transformer is a step-down type of 230V / 12V and 500mA current output.

The diodes for rectification are $D_{16} - D_{46}$ = 1N4007 of peak reverse voltage 1000V and maximum current capacity of 2.5A. The filter capacitor C_{16} is selected using the relation

$$C = \frac{V_{max}}{\Delta V f_{PP} R_L} = \frac{6.8}{0.01 \times 56000 \times 120} = 0.0010119F \quad \ldots\ldots (3.47)$$

$$C \cong 1000\mu F. \quad \ldots\ldots (3.48)$$

Where the V_{max} is the maximum voltage required for charging the battery, 6.8v in this case, ΔV is the ripple factor, 0.01 in this case. The f_p is the peak to peak frequency of the full wave rectification which is twice the maximum frequency in the input (50Hz). R_L is the load resistance to the output of the circuit.

The variable voltage regulator used can take in voltage in the range of 3v to 42v and can give an output voltage of 1.2V to 37V with maximum current of 1.5A. The level of the output

voltage is adjusted using a variable resistor VR_{16}. As given by the IC manufacturers the 2.2KΩ is the resistor range that can give this voltage range.

A diode D56 (1N4007) is used in series with a power resistor R_{46} (5W, 16Ω) to regulate the charging current of the battery and prevent the backward movement of the voltage (or current) from the battery when the power fails. A Zener diode ZD_{16}, as stated before, limits the voltage to the battery at its breakdown value of 6.8V.

As long as the voltage does not exceed the maximum value of 6.8V the Zener diode conducts and therefore, the base of the transistor T16 gets supply and the T16 conducts and the output of the regulator continues to flow to the battery.

Since the base current of the transistor is as low as 6mA (from the data sheet), the base resistor is calculated as follows:

$$R_{BE} = \frac{V}{I_E} = \frac{6.8}{6m} \quad \text{.....(3.49)}$$

$$R_{BE} = 1133.33\Omega \quad \text{.....(3.50)}$$

A 1.2kΩ resistor, with ±10% tolerance which can serve the purpose.

The switching transistor T16 has a base current of 15mA (max), here a 1kΩ base resistor is used to regulate the current to the base of the transistor, where in this case the current is obtained as follows

$$I_B = \frac{V_B}{R_B} = \frac{9}{1000} = 9mA \quad \text{.....(3.51)}$$

This current (9mA) is a safe base current that can turn on the transistor without damaging it since it is less than the maximum value a (i.e. 15mA).

The transistor T16 is BD140 which is used as the switching device that turns on and off the emergency light as the mains goes off and come on respectively. When there is mains supply, the base of the transistor which is connected to the to the output of the rectifier through a base

resistor R_{16} is high and therefore the transistor is not conducting since it is PNP type. So the emergency light is off in this situation, but in the event of mains power failure the base of the transistor is low and therefore the transistor begins to conduct and this results in turning on the emergency light. The resistor R_{16} is used to limit the base current to the transistor to a safe value. Here a 1kΩ resistor is used which keeps the base current to the maximum value of 9mA which safe for the transistor as follows;

$$I_B = \frac{\cdot\cdot}{R_{\cdot\cdot}} = \frac{\cdot\cdot}{1000} \approx 9mA \quad \text{.....(3.52)}$$

This transistor can withstand a maximum load current of 1.5A. Where the load current is higher than this, a transistor with more current capacity is used and a battery that produces more energy (ampere-hour) should be used depending on the amount of load and the duration of operation of the emergency light

Table 3.7 Automatic Emergency Light Circuit's Components

COMPONENTS	CALCULATED VALUE	USED VALUE
D16 - D56	-	1N4007
R16	-	1kΩ
R26	-	180Ω
R36	1133.33Ω	1.2kΩ
R46	-	16Ω, 5W
VR16	-	2.2kΩ
T16	-	BD140
T26	-	BC548
ZD16	-	6.8V, 0.5W

The circuit of emergency light was constructed temporarily on a breadboard to test its workability and was found working properly.

3.6 DESIGN AND ANALYSIS OF LASER BEAM SECURITY ALARM

The laser beam security alarm is designed and implemented based on the arrangement shown in Fig. 3.7

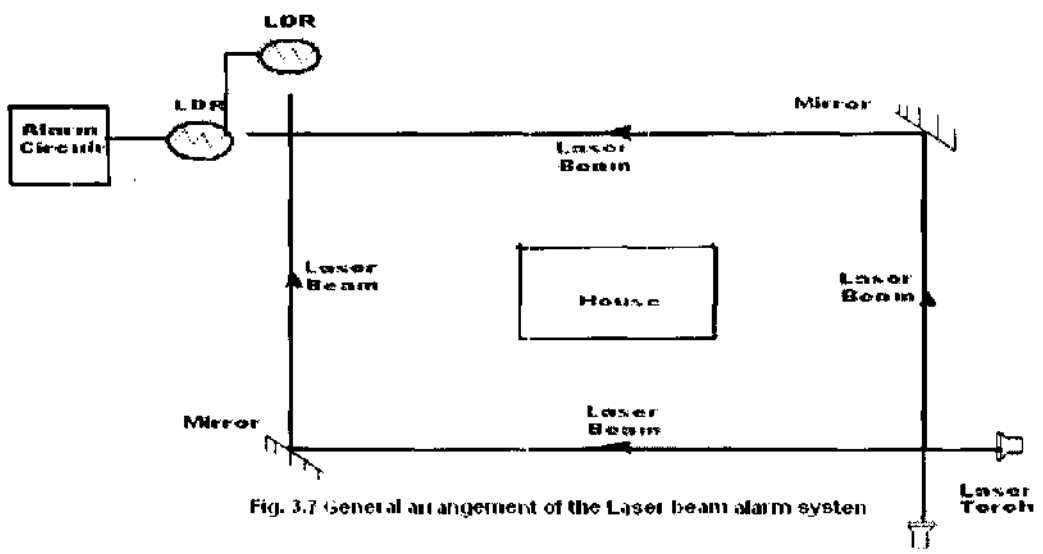


Fig. 3.7 General arrangement of the Laser beam alarm system

As shown in Fig. 3.7, the whole security system is made up of a laser torch which generates the laser beam. A combination of plane mirrors (M1 – M2) is used to direct the beam around the building (e.g. House) to form a net. A light dependent resistor is used as a sensor to detect the beam. The laser torch used has a part number LST 1390 and the strength of the beam is un-attenuated if the total distance does not exceed 500m. The arrangement of the plane mirrors is done using the law of reflection of the plane mirror which says 'the angle of incidence is equal to the angle of reflection'.

The LDR is kept in a along pipe to protect it from other sources of light around. The LDR is connected directly to an alarm circuit that produces warning alarm whenever someone crosses the net of the beam and blocks the beam from reaching the LDR. This blockage serves as the trigger pulse to the alarm circuit.

The whole system of the alarm is designed and implemented using the circuit arrangement shown in Fig. 3.8

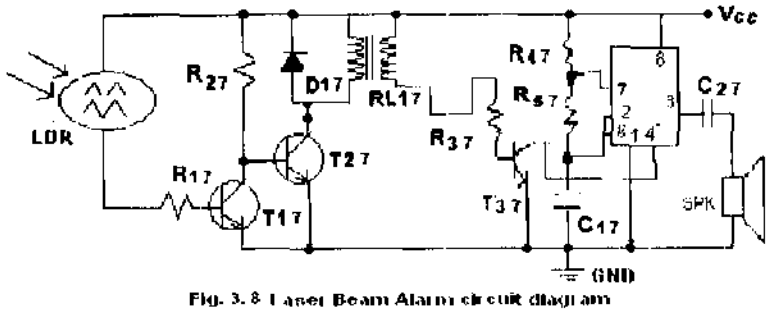


Fig. 3.8 Laser Beam Alarm circuit diagram

In the first place when the light falls on the LDR its resistance goes very low in such a way that current flows from the source and turns on transistor T17 through a base resistor R_{17}. In this case the resistance between the collector and the emitter of the T17 is very low so that the current flowing from the source through resistor R_{27} goes directly to the ground and therefore, the base of the transistor T27 would not have enough current to turn it on. In this situation the transistor T27 is off and consequently the relay is off and hence the alarm is also off. The Laser light is the one that provides the illuminating light to the LDR as a result of the Laser beam directed to it.

When someone crossed the path of the Laser beam, the LDR is in darkness. In this case the transistor T17 is turned off because, there is no base current to it due to the high resistance of the LDR that is in darkness. The current from the source through the resistor R_{27} serves as the base current to the transistor T27 which turns it on. The output of the T27 at its

collector is used to trigger the relay which in turn connects the base of the transistor T37. The output of this transistor supplies the trigger input to the pin-4 of the 555-timer circuit and hence sets it into oscillation. The output of the oscillator is used as the alarm signal.

The whole circuit is powered using 6V DC supply which is enough to drive the 6V relay. When illuminated with the beam of Laser, the LDR has an average resistance of 600Ω and the transistor T17 requires a base current of 2mA to 5mA to be on [5]. When the resistor R_{17} is arbitrarily chosen as 1kΩ, the corresponding base current is obtained as follows.

$$I_B = \frac{V_{CC}}{R_{17} - R_{LDR}} = \frac{6}{1000 - 600} = 3.75mA \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3.53)$$

Therefore with a base resistance R_{17} = 1kΩ and LDR illuminated the base of the transistor T1 gets a current of 3.75mA which is enough to turn it on. But in total darkness the LDR has a resistance of average value 1.12MΩ. Using this value the base current now is as follows:

$$I_B = \frac{V_{CC}}{R_{17} - R_{LDR}} = \frac{6}{1000 - 1120000} = 5.35uA \quad \ldots\ldots\ldots\ldots \quad (3.54)$$

This current is far less that the minimum base current 2mA so that the T17 is turned off.

The value of the resistor R_{27} which supplies the base current to the transistor T27 is obtained as follows;

$$R_{27} = \frac{V_{CC} - V_{BE}}{I_B} \quad \ldots\ldots\ldots\ldots \quad (3.55)$$

Where the supply voltage V_{CC} =6V, cut-in voltage V_{BE} = 0.7V and the transistor is BC547with low base current of 0.5mA and a minimum gain of 100 [5]:

$$R_{27} = \frac{V_{CC} - V_{BE}}{I_B} = \frac{6 - 0.7}{0.5mA} = 10600\Omega \quad \ldots\ldots\ldots\ldots \quad (3.55)$$

A 10kΩ ±10% tolerance is used as the R_{27} since it can give the required calculated value.

The output of this transistor is used to trigger the relay on and off as the LDR experiences light and darkness. The Diode D_{17} is placed in parallel to the input terminals of the relay in order to protect the transistor from the effect of back electromotive force from the relay due to its self induction. The diode is a general purpose type with number 1N4007, peak inverse voltage of 1000Vand maximum current of 2.5A.

The output of the relay is delivered to the base of the transistor T37 which serves as the driver to the reset input terminal (pin-4) of the 555-timer IC. The relay directly connects the base of the transistor to the circuit supply voltage (V_{CC}) when it is on. The value of the base resistance is evaluated as follows;

$$R_B = \frac{V_{BB} - V_{BE}}{I_B} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.56)$$

Where V_{BB} = 6v, V_{BE} = 0.7V, $I_{C(max)}$ = 0.4A and β = 100 (min) for the transistor used [5]. The base current is therefore obtained as follows:

$$I_B = \frac{I_C}{\beta} = \frac{I_C}{100} = 4mA(max) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.57)$$

The base resistor is then calculated thus

$$R_B = \frac{6 - 0.7}{0.004} = 1325\Omega \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.58)$$

To keep the base current below the maximum value (i.e. 4mA) R_{37} is taken as 1.5kΩ which helps in making the base current less than its maximum value.

The astable multivibrator circuit using 555-timer IC is designed to produce the alarm audio signal. The frequency of its oscillations is calculated using the relation:

$$f = \frac{1.44}{C_1(R_{47} + 2R_{57})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.59)$$

The frequency should be within the audio range (20Hz to 20 kHz), here 5 kHz is selected. The capacitor C_{17} = is chosen as 0.01µF (making sure that it is above 500pF, below which noises can be introduced to the circuit due to the effect of stray capacitances [1]). The value of either of the resistors can be selected arbitrarily provided R_{47} + R_{57} is greater than 1kΩ and less than 3.3MΩ [1]. So R_5 is chosen as 4.7kΩ and R_{47} is evaluated thus;

$$5000 = \frac{1.44}{0.01 \times 10^{-6} \times (R_{47} + 2 \times 4.7 \times 10^3)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.60)$$

After simplifying this, R_{47} is obtained as R_{47} = 19400Ω. But a standard 20kΩ resistor is used as the R_{47} which produces a small change in the selected frequency without any negative effect on the circuit performance. A 1µF electrolytic capacitor is used to couple the output of the oscillator with the loud speaker.

Table 3.8 Laser-Beam alarm circuit's components

COMPONENT	CALCULATED VALUE	USED VALUE
LDR	-	GEN PURPOSE
T17	-	BC547
T27	-	BC547
T37	-	C945
R_{17}	-	1k
R_{27}	10600Ω	10k
R_{37}	1325Ω	1.5k
R_{47}	19400Ω	20k
R_{57}	-	4.7k

C_{17}	-	0.01μF
C_{27}	-	1μF
D_{17}	-	1N4007
IC17	-	555-TIMER
RELAY	-	6v DC, 10A

The circuit of laser alarm was constructed based on the design and the arrangement of the sensors and it was found working after some adjustments.

3.7 DESIGN AND ANALYSIS OF DC-MOTOR GATE CONTROL CIRCUIT

The circuit that is used to control the DC motor used for opening and closing the gate is shown in Fig. 3.9.

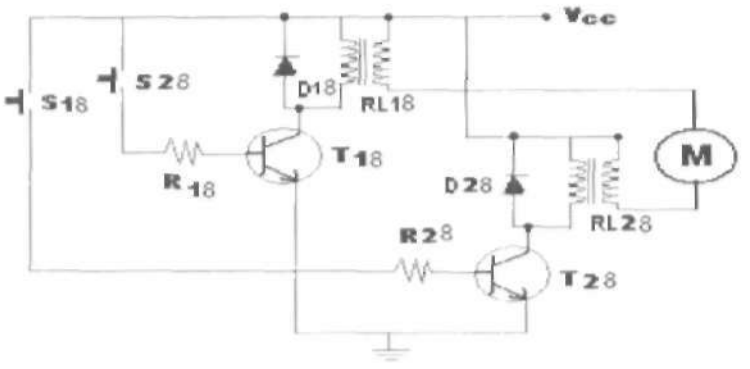


Fig. 3.9 DC-Motor Gate control circuit diagram

As shown in the circuit diagram of Fig. 3.9, two identical transistor-switches are used for triggering two relays that finally drive the motor in forward and backward directions as the two relays are triggered on and off alternatively.

The transistors are of NPN type each supplied with a base current that turns it on through a base resistor. Each transistor has its emitter connected directly to the ground and the collector output is delivered to the input of the relay. Diodes D_{18} and D_{28} are connected to the input terminals of the relays to protect the collectors of the transistors from the effect of the back

electromotive force from the self induction of the relays which can damage the transistors. The output terminals of the two relays are connected to the two input terminals of the DC motor. In this way, when switch S18 is pressed the relay RL_{18} is on while the relay RL_{28} is off so that the motor is driven in one direction and when the switch S28 is pressed the relay RL_{28} is on and RL_{18} is off. Therefore the polarity of the voltage supplied to the motor changes and hence the direction of its motion also changes. Therefore by pressing the two switches (S18 and S28) the motor is driven in forward and backward directions. Connecting the motor to the mechanism of the gate properly, it can be used to open and close the gate remotely.

The value of the resistor R_{18} which supplies the base current to the transistor T18 is obtained as follows;

$$R_{1B} = \frac{V_{CC} - V_{BE}}{I_B} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.61)$$

Where the supply voltage V_{CC} = 12V, cut-in voltage V_{BE} =0.7V and the transistor is BC337with base current of 0.5mA and a minimum gain of 120 [5].

$$R_{1B} = \frac{V_{CC} - V_{BE}}{I_B} = \frac{12 - 0.7}{0.5\,mA} = 22600\Omega \ldots\ldots\ldots\ldots\ldots (3.62)$$

A 22 kΩ resistor with ±10% tolerance is used as R_{18} since it can give the required calculated value. Since the resistor R_{18} and R_{28} are similar they have the same value of 22 kΩ. Similarly the transistor T28 is identical to the T18 (BC337)

The protecting diodes are general purpose type with number 1N4007, peak reverse voltage 1000v and maximum current of 2.5A.

The relays used are triggered with 12V DC and can carry a maximum load current of 10A. In a situation where the motor controlling the gate needs higher current the relays are simply replaced with others that can withstand the required current.

Table 3.9 DC-Motor Gate control circuit's components

COMPONENT	CALCULATED VALUE	USED VALUE
R_{18}	22600Ω	22kΩ, 10% tolerance
R_{28}	22600Ω	22kΩ, 10% tolerance
D_{18}	-	1N4007
D_{28}	-	1N4007
T18	-	BC337
T28	-	BC337
RL_{18}	-	6VDC, 10A
RL_{28}	-	6VDC, 10A

The DC motor gate control circuit was constructed temporarily on a breadboard for testing its workability and was found working properly after all the required connection. It could open and close the gate.

3.8 DESIGN OF POWER SUPPLY UNIT

The general circuit of the power supply unit of the project is shown in Fig. 3.10.

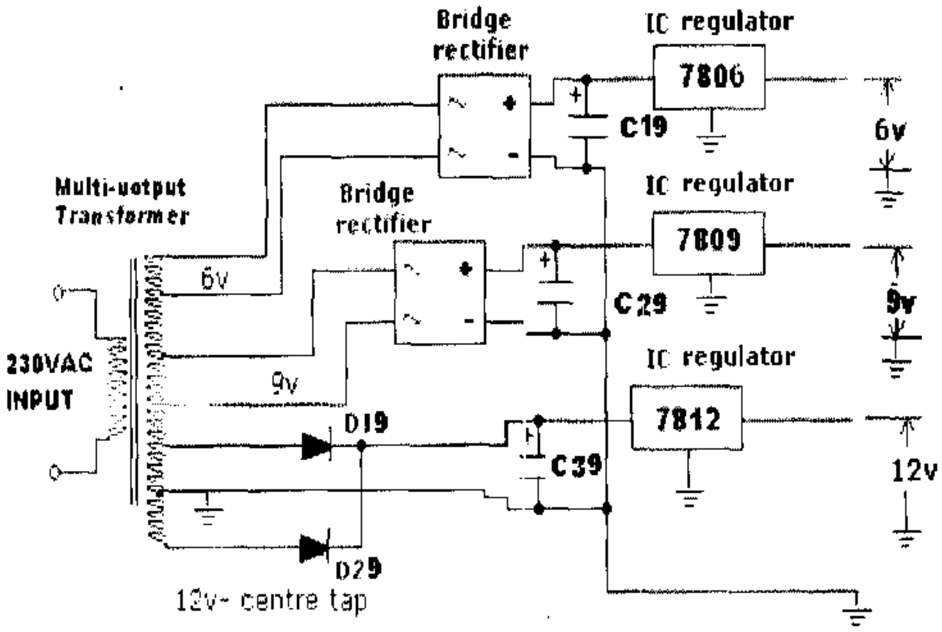


Fig. 3.10 General power supply circuit diagram

A multiple-output transformer that takes in 220V-230V from mains source and produces various stepped down voltage of 6V, 9V and 12V. For 6V and 9V four-pin bridge rectifiers are used to rectify the stepped down voltages to direct-current voltages. But for the centre tap 12v output two diodes are used to get the full-wave rectified 12V output. The outputs of the rectifiers are passed through filter capacitors to remove the ripple components to make the outputs smoother. The values of these filter capacitors are calculated using the relation below;

$$C = \frac{V_{max}}{\Delta V f_p R_L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.63)$$

Where the V_{max} is the maximum voltage required, ΔV is the ripple factor. The f_p is the peak to peak frequency of the full wave rectification which is twice the maximum frequency in the

input (50Hz). R_L is the load resistance to the output of the circuit. The filtered outputs are then connected to integrated circuit regulators to produce the fixed voltages required. In this power supply system 12V, 9V and 6V regulators are used to give 12V, 9V and 6V respectively. These voltages are the ones needed by the different parts of the system of this project.

NOTE

After the design of the various sub-circuits above and testing, the whole system was also constructed temporarily based on the complete circuit diagram shown in fig. 3.11. The circuit was found working after all the necessary adjustment on the different sections. *Finally, the whole circuit was constructed permanently on a veroboard.*

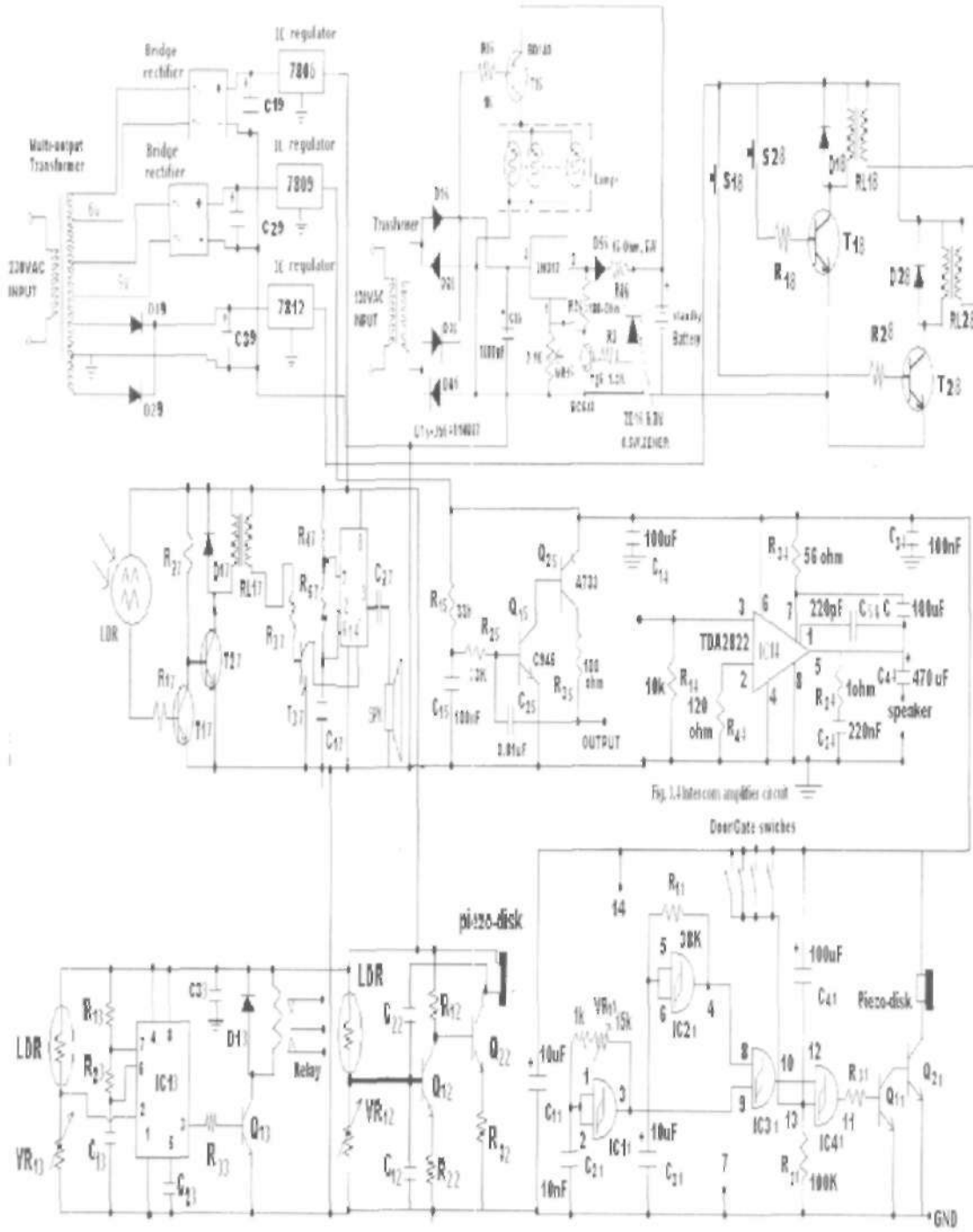


Fig.3.11 Complete circuit diagram

CHAPTER FOUR

MEASUREMENT ON THE SYSTEM

4.0 INTRODUCTION

This chapter presents the measurements carried out on the designed circuits in this project. The aim of these measurements and experiments is mainly to help to visualize the actual operating condition of the system using devices like oscilloscope that gives the waveforms as well as the values of parameters like time and voltages

Different measurements were carried out which include, testing the intercom amplifier, gain measurement of the amplifier, testing the oscillator the using oscilloscope, frequency measurement for door alarm, measurement of input power for door alarm and frequency measurement of laser alarm. The other measurements are of power consumption of the dc-motor gate control circuit, power consumption of the automatic night light circuit, frequency of daylight alarm and of power consumption of the emergency light circuit.

4.1 TESTING THE INTERCOM AMPLIFIER

The amplifier was tested using a signal generator that gives sinusoidal signal waveform as the input and oscilloscope was used to visualize the output signal as shown in block diagram of Fig. 4.1.

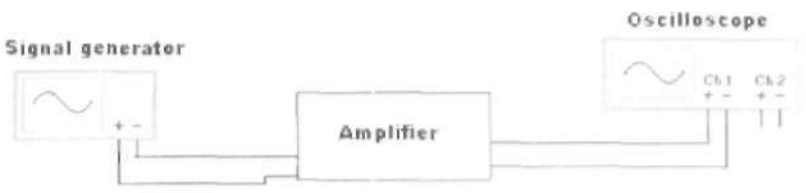


Fig. 4.1 INTERCOM AMPLIFIER TEST'S BLOCK DIAGRAM

The signal generator was used to apply input signal of different frequencies and the output waveform was observed at the output terminal (oscilloscope). In each case the output waveform is an amplified version of the sinusoidal input signal with some distortion as shown in the Figure 4.2. The oscilloscope used is a dual channel type and in this experiment, one of the channels was used.

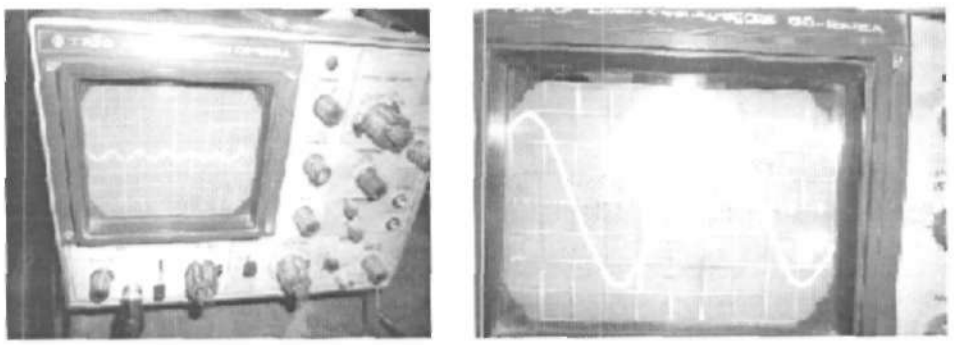


Fig 4.2 (a) Input Waveform (b) Output Waveform

4.2 GAIN MEASUREMENT OF THE AMPLIFIER

The amplifier was also tested to determine the levels of the peak-to-peak input and the output voltage signals on the waveform from the oscilloscope and hence evaluate the approximate gain of the amplifier. A signal generator was used to apply input of different frequencies and the corresponding outputs peak-to peak are measured from the waveforms. The block diagram of the experiment is as given in Fig 4.3 below;

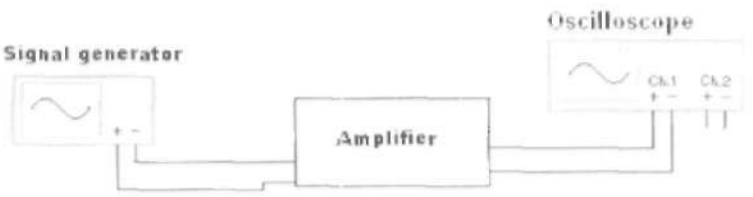


Fig. 4.3 GAIN MEASUREMENT'S BLOCK DIAGRAM

Table 4.1. Gain measurement data.

Input Frequency	Peak-to-peak Input voltage (V_{in})	Peak-to-peak Output voltage (V_O)	Gain (V_O/V_{in})
100Hz	3.8mV	427.6mV	101.3
2.5kHz	3.8mV	561.3mV	147.7
4.9kHz	3.8mV	503.9mV	148.2
7.3kHz	3.8mV	533.2mV	148.1
9.7kHz	3.8mV	561.6mV	147.8
12.1kHz	3.8mV	385.7mV	101.5

The table as said earlier gives the values of the measured voltages at the input and the output peak-to-peak of the amplifier. The gain at each input frequency is evaluated as given above. The plot of the gain against the frequency is given by the Fig. 4.4

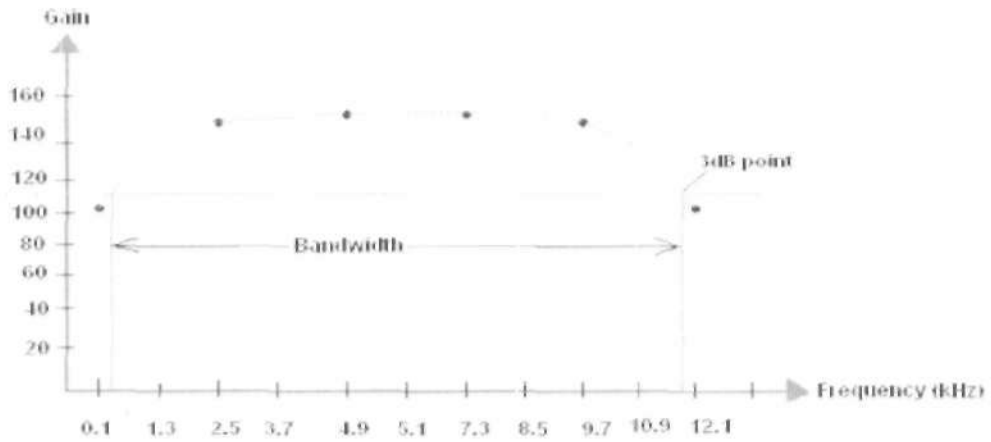


Fig. 4.4 Graph of Gain-Frequency of the amplifier

From the graph, the gain at the horizontal line is 110.4 which is the 0.7071 of the maximum gain (148.2), the bandwidth is therefore, approximately (0.35 kHz to 11.9 kHz).

4.3 TEST OF THE OSCILLATOR USING OSCILLOSCOPE

The oscillator used as a ringer was tested using an oscilloscope to visualize the waveform of the output signal and to determine frequency of the oscillation. Figure 4.5 depicts the arrangement used for the experiment.



Fig. 4.5 Intercom's Ringer test Block diagram

The oscilloscope was used to visualize the waveform of the signal from the oscillator. The waveform observed is time varying signal, which is approximately a square wave in shape as shown in Figure 4.6.

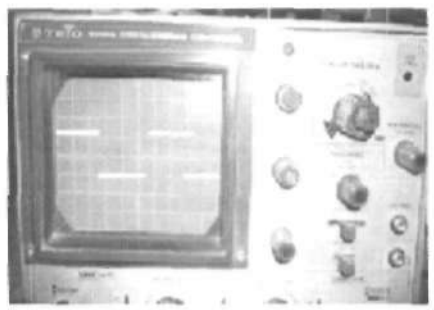


Fig. 4.6 Ringer (Oscillator) Waveform

To measure the fundamental frequency of the oscillation of the oscillator, the period of the fundamental frequency of the signal was taken from the oscilloscope which was obtained as 0.7 msec. The frequency was evaluated as follows;

$$Frequency = \frac{1}{Time} = \frac{1}{0.7 \times 10^{-3}} = 1428.57\ Hz \quad \text{..... (4.1)}$$

This value of the fundamental frequency obtained is not exactly equal to the design value (1500Hz), but within the range of the design value. **The variation is due to some design**

problems of deviation in the values of the parameters of the components used or from the mistakes on the side of the designer.

4.4 FREQUENCY MEASUREMENT FOR DOOR ALARM

The fundamental frequency of the door alarm was measured using an oscilloscope. The block diagram for the measurement is shown in Fig. 4.7.

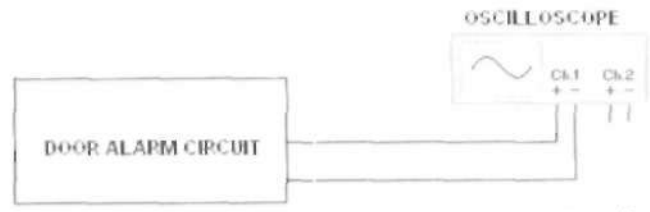


Fig. 4.7 Block diagram of frequency measurement of door alarm

When the variable resistor was turned to its maximum resistance the output terminals of the oscillator (alarm circuit) were connected to the oscilloscope as shown in Fig. 4.7 and the waveform was observed on the oscilloscope as shown in Fig 4.8 below.

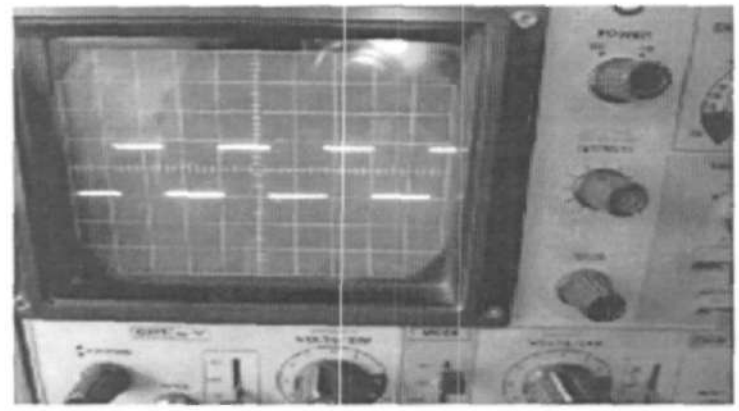


Fig. 4.8 Waveform of the Door alarm Oscillator

Each division on the horizontal (time) axis is 0.1mS and as seen in Fig. 4.8 the period of the fundamental frequency waveform was made up of eleven such smaller divisions. Therefore, the period:

T= 1.1mA. So the fundamental frequency was calculated as follows;

$$f = \frac{1}{T} = \frac{1}{1.1 \times 10^{-3}} = 900\ Hz \quad \text{.....(4.2)}$$

But when the variable resistor was reduced to its minimum value the waveform observed had the same shape with the one in Fig 4.8 but the period then was T = 0.65mS. The fundamental frequency was therefore evaluated as follows;

$$f = \frac{1}{T} = \frac{1}{0.65 \times 10^{-3}} = 1538.46\ Hz \quad \text{.....(4.3)}$$

These fundamental frequencies are not exactly equal to the designed values (1 kHz to 16 kHz) but are very much close to the values in the range.

4.5 MEASUREMENT OF INPUT POWER FOR DOOR ALARM

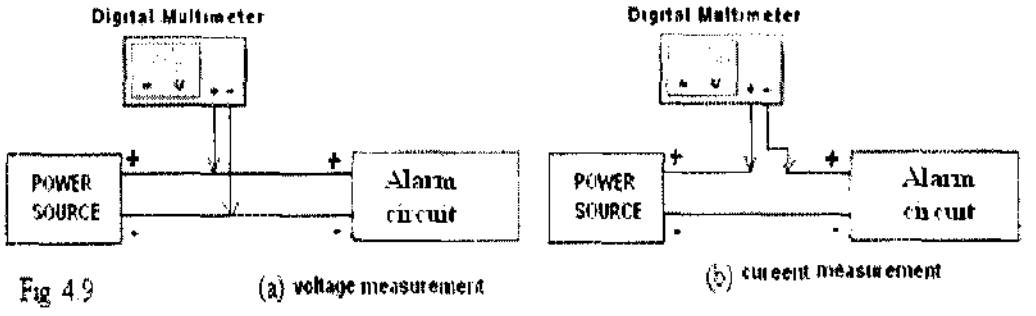


Fig 4.9 (a) voltage measurement (b) current measurement

The input voltage for three different measurements and the corresponding input current are as presented in Table 4.2.

Table 4.2 Input power for Door alarm data.

Serial Number	Input voltage (v)	Input Current (mA)
1	8.67	3.21
2	8.82	3.34
3	8.51	3.51
Average	8.67	3.35

Power consumed = 8.67V x 3.35mA = 29.07mW ..... (4.4)

4.6 *FREQUENCY MEASUREMENT OF LASER ALARM*

The operating fundamental frequency of the laser-beam based security alarm was measured using the arrangement shown in Fig 4.10. The circuit diagram of the Laser alarm is given by the block diagram. While the Oscilloscope used is as shown in Fig. 4.10.



Fig. 4.10 Block diagram for laser alarm frequency measurement

The waveform of the signal as observed on the screen is given by the graph shown in Fig 4.11.

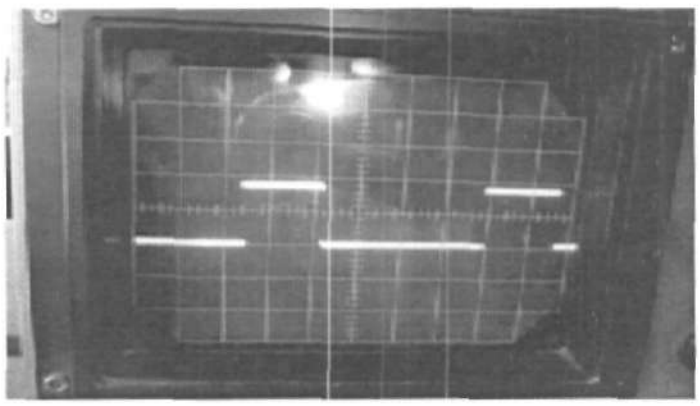


Fig. 4.11 Waveform of Laser beam alarm (Oscillator)

The waveform of the signal as observed on the oscilloscope was rectangular as shown in Figure 4.11 above. The fundamental frequency of the oscillation was calculated as follows: The period of the signal as obtained from the graph of the waveform is 120μS. And the fundamental frequency is given by the reciprocal of the period as follows:

$$f = \frac{1}{T} = \frac{1}{120 \times 10^{-6}} \quad \text{..... (4.5)}$$

$$f = 8333.33Hz \quad \text{..... (4.6)}$$

4.7 MEASUREMENT OF POWER CONSUMPTION OF THE DC-MOTOR GATE CONTROL CIRCUIT

The power consumed by the DC-motor gate control circuit when it is in operation was measured in the following experiments. Figure 4.12 illustrates the arrangement used for the measurements.



Fig. 4.12 a) Voltage measurement (b) Current measurement

When the motor was moving forward and backward to close and open the gate, the values of the voltage and the current were measured. Table 4.3 presents a summary of the measurements taken.

Table 4.3 Data for power consumption measurement of DC-motor

Serial No.	Input voltage Forward (V_{in})	Input current Forward (I_{in})	Input voltage Backward (V_{in})	Input current Backward (I_{in})
1	11.4V	35mA	11.6V	33mA
2	11.5V	37mA	11.4V	37.7mA
3	11.8V	33mA	11.9V	33mA
4	11.3V	36mA	11.4V	37.7mA

The average power consumption of the motor is **405.2mW** from the table above.

4.8 MEASUREMENT OF POWER CONSUMPTION OF THE AUTOMATIC NIGHT LIGHT CIRCUIT

The power consumed by the lamps was determined by multiplying their power ratings with their number. But the power consumed by the circuit that controls the lamps (by putting them ON and OFF) was determined by measurement as shown by the block diagrams of Figure 4.13.

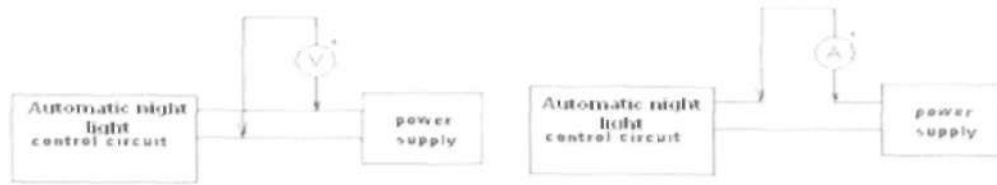


Fig. 4.13 a) Voltage measurement b) Current measurement

When the light dependent resistor (LDR) was covered to trigger the circuit, the lamps came ON and the voltage and the current consumed by the power supply were measured and tabulated in Table 4.4.

Table 4.4 Data for power consumption measurement of Automatic Night light

Experiment Number	Input Current	Input Voltage
1	85.2mA	8.87V
2	86.1mA	8.90V
3	88.4mA	8.76V
Average	86.57mA	8.84V

The average power consumed by the control circuit is given by:

$P_{ave} = V_{ave} \times I_{ave}$ ..... (4.7)

$P_{ave} = 8.84V \times 86.57mA$..... (4.8)

$P_{ave} = 765.28mW = 0.765W$..... (4.9)

4.9 FREQUENCY MEASUREMENT OF DAYLIGHT ALARM

The waveform and fundamental frequency of the daylight alarm circuit were analyzed using the block diagram shown in Fig.4.14.



Fig. 4.14 Block diagram of frequency measurement of Daylight alarm

Figure 4.15 gives the actual picture of the waveform as seen on the screen of the oscilloscope.

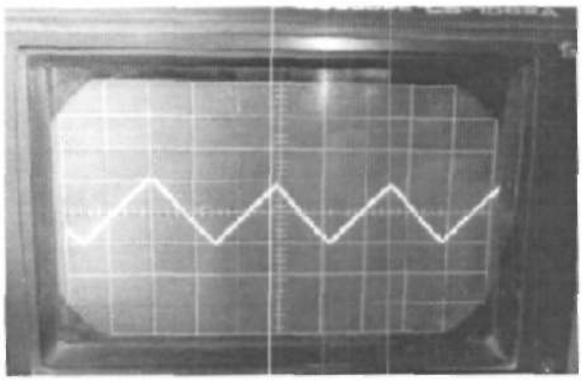


Fig. 4.15 Waveform of Daylight alarm (Oscillator)

The waveform of the output of the daylight alarm as shown in Fig.4.15 is a triangular wave. The fundamental frequency of the waveform is evaluated by first finding the period of the waveform. The period of the wave was obtained as 480μS. The fundamental frequency was then calculated as follows:

$$F = \frac{1}{T} = \frac{1}{480 \times 10^{-6}} = 2083.33Hz \quad \text{.....(4.10)}$$

4.10 MEASUREMENT OF POWER CONSUMPTION OF THE EMERGENCY LIGHT CIRCUIT

The Emergency light comes on only when the mains supply fails. The Light gets its supply directly from the standby battery. The power consumed by the emergency light was measured using a digital multimeter.

The voltages and the currents were measured for three different times when the light (emergency) is on and the readings are tabulated in Table 4.5.

Table 4.5 Data for power consumption measurement of Emergency light Circuit

Experiment Number	Input Current	Input Voltage
1	25.3mA	5.81V
2	26.1mA	5.90V
3	28.1mA	5.72V
Average	26.5mA	5.81V

The average power consumed by the light circuit is given by:

$P_{ave} = V_{ave} \times I_{ave}$ ..... (4.11)

$P_{ave} = 5.81V \times 26.5mA$..... (4.12)

$P_{ave} = 153.965mW = 0.154W$..... (4.13)

4.11 OVERALL PERFORMANCE OF THE SYSTEM

The system after final construction was tested to access its overall performance in terms of operation and stability. The system was found working with high quality performance because, all the various sections of the system were working satisfactorily as expected. However, the stability of the system's operation was found very satisfactory since it was kept in operation in the laboratory for a period of five hours and no any malfunction was observed during the period.

CHAPTER FIVE

CONCLUSION, LIMITATIONS, RECOMMENDATIONS AND REFERENCES

5.1 CONCLUSION

This thesis work of design and construction of an electronic security assistant is aimed at coming up with a system that would help in enhancing the security services in our life environment. The system was designed and constructed. However, measurements and experiments were done mainly to help to visualize the actual operating condition of the system using devices like oscilloscope that gives the waveforms as well as the values of parameters like time and voltages and also devices like digital multimeter which is used for measuring the actual values of voltages, currents and other parameters. These measurements enable us to know the actual working condition of the system which is very much close to the expected performance from the design of the system.

The system was found working as expected from the design stage. This system when produced in industry in the size that could be used practically in our homes and other parts of the environment it would definitely help in making the work of the security personnel easy, effective and very safe. Moreover, if the production of this system is done in large quantity it would help in making the system affordable to the people and it would definitely help in providing employment to many people in the society.

5.2 LIMITATIONS

The electronics projects like this are definitely useful to the people due to the roles they play in making life easy and comfortable to the users. But no matter how useful a project is to the users it must have some limitations to its applications. This project being not an exception has limitations to its applications.

Some of the limitations of this project include the fact that its intercom unit is not wireless and can be used for communication between only two people. Also the automatic emergency light that is used in this project can work for not very long time due to the small capacity of the storage battery used. In addition, the door / gate alarm sub-circuit could only give a warning alarm when the door or gate is actually opened. This could enable the criminals to have an access to the place by drilling a hole on the door without necessarily opening it. Another limitation of the application of this project work is that it could only be used for alerting the security man about the presence of a criminal person but it can not take any action in helping to trap the criminal.

5.3 RECOMMENDATIONS

As seen above, this project has some limitations to its application. For this reason some suggestions would be given on the further work that should be done in order to improve its performance by eliminating the basic limitations associated with it. These recommendations include the following:

- The intercom unit of the system should be made wireless so as to improve its reliability in such a way that the criminals can not deactivate it by cutting the connecting wire;

- The number of the terminals and the range should be improved to enable the security to have contact with other people especially the police in case of emergency;
    - The duration of operation of the automatic emergency light should be improved by using a storage battery with higher storage capacity;
    - The door / gate alarm should be made to have the ability to give an alarm when someone touches it without necessarily opening. This would make the doors and gate more secure;
    - Finally, it is recommended that the system should be made more intelligent by incorporating a provision that can serve as a trap for arresting the criminals when detected by the system.

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