DESIGN AND CONSTRUCTION OF AN INTRUSION DETECTOR USING INFRARED.

BY

OGWEZI ONYEKA ANDERSON

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DEDICATION

This project is dedicated to God Almighty for His loving kindness, mercies and protection. Also to my late uncle Engr. Enuosa G. Kingsley, my parents Mr. and Mrs. M. Ogwezi for their support.

DECLARATION

I, Ogwezi Onyeka Anderson, declare that this work was done by me under the Supervision of Mr. Michael David and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

Ogwezi O. Anderson
....
(Name of student)

....
(Signature and date)

Mr. Michael David
....
(Name of Supervisor)

....
(Signature and date)

Dr Y.A. Adediran
....
(Name of H.O.D)

....
(Signature and date)

....
(Name of External Examiner)

....
(Signature and date)

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ABSTRACT

The project is the design and construction of an intrusion detector using infrared. The work is based on the use of infrared technology to provide a high security protection or network to homes, banks, offices, hallways etc.

The system uses infrared sensor (IR sensor) to detect intrusion or movement. In the implementation, an unmodulated IR carrier signal is constantly generated by an IR transmitter or generator. An IR receiver operating at the same frequency with the IR transmitter is aligned with IR transmitter to obtain transmitter-receiver pair.

Any breakage in the transmitter-receiver beam results in the resetting of the bistable multivibrator use in the main circuit and subsequently, a sounding alarm will be generated indicating the breaking of the beam by illegal movement or intruder.

The system is powered with a 9volts DC supply and a 220/12volts AC transformer supplied by AC mains.

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CHAPTER ONE

1.1 INTRODUCTION

Infrared light was first discovered back in 1801 by W. Herschel. Infrared is a form of radiated energy which has wavelength longer than the wavelength of visible light.[1]

Our contributions to the society are most times fueled by personal experiences complemented by the knowledge of a particular field of study. I personally have come in contact with armed robbers and burglars. From my personal experience and stories told on the loss of properties and life are enough to stir one towards formulating a means of improving our security system.

This security system monitors what is happening around our homes, offices and banks when we are around or not. Since any form of infusion by human being is brought about by movement of something (His body), this makes it possible to device a system to detect the presence of someone.

Today, as was in the past, the means derived in order to bring nefarious activities of burglars to the barest minimum, borders on the resources and managerial know-how available to us. In the past, trenches were dug around storage houses for unsuspecting intruders to fall into. With time these hoodlums though I wouldn't want to credit the with so much intelligence derived better ways of going about their business. It is also true that the only tool available to these spineless fellows is the element surprise (for instance entering when the inhabitants of the premises are least expecting it).

This work becomes important in this regard as it serves as an alerting system thereby taking away the surprise element and making the intruders system thereby taking away the surprise element and making the intruders psychologically handicapped who normally would run away for fear of being caught on detection.

The functions of the motion detector which are to detect and alert could therefore not be over emphasized.

1.2 AIMS AND OBJJECTIVES

The project aims at showing that the security of our homes, offices or banks can be maintain using a simple and sensitive electronic circuit called the Intrusion Detector Using Infrared. The beauty of this project is that it uses natural means (i.e. human shadow/movement) to detect an intruder. The cost associated with other means security system is also taken care of in this project.

1.3 APPLICATIONS OF THE INTRUSION DETECTOR

There are many applications for the use of the detector. The most common is in the alarm system industry. Some of the new applications are automatic door openers, light switches in hallways, stairways and areas that increase safety for the public. Further applications can be seen in automatic production lines, switching of sanitary facilities, monitors and intercoms. With the ease of installation and the low susceptibility to interference from other forms of radiation, such as heaters or windows, the IR detectors are ideal devices. Some areas of application with little or no modification include:

In homes:

It is a well-known fact that even the highest fences and the most efficient security guards and dogs cannot make a home impenetrable. Record shows that on quite a number of occasions, priced possessions be given away to urchins for financial benefits or even bones for the dogs as the case may be. The use of motion detector whose principle of operation is not based on sentiments prove more reliable.

In offices:

Our private sections of the office are kept private by the use of tamper proof motion detector.

In banks:

The use of manpower for security though efficient is still not enough based on sentimental basis as mentioned before. The motion detector compliments the sincere efforts of the security personnel in order
to keep unauthorized personnel out vault.

1.4 METHODOLOGY

Intrusion detector alarm system in its scope describes how the radiation that falls on the sensor. The system uses sensor due to radiation falling on it, to reference voltage from the source. The infrared (IR) section contains only a few components, R1, R2, C1 and the IR sensor. Detectors are available with different fields of view, depending on the application. The maximum distance and total angle of view are important specifications needed in choosing a motion detector. A special device called the Field Effect Transistor (FET) is used to increase the power output. The FET can be compared to water pipes. The center of a small section of pipe is made of thin, flexible rubber surrounded by water from a third pipe called the gate. When pressure (voltage) is applied to the gate, the rubber tube closes and pinches off the flow of water (current) from source to drain. In a similar manner, as infrared radiation is detected, the crystals produce a voltage at the gate of the FET. This causes a change in current from the drain to source. Very little power is required at the gate to control the larger current flow from source to drain [1]. The benefits of this type of detector are low radio interference, low noise, specially suited response. The IR detector is sealed in a glass housing to prevent electromagnetic interference and to keep them clean.

CHAPTER TWO

2.1 LITERATURE REVIEW.

The security system falls into different categories, those concerned with fire protection, and those concerned with the protection against intruders of property of information. The later group includes burglar alarm, intrusion detector, of which this project falls into. There are many ways to detect intrusion or movement of people, for example, using trip wire in which any contact with the wire causes an alarm to switch on. Another example is the dark activated intruder alarm system, which uses shadow cast on the sensor to provide a form of trigger for the alarm system. All these are cost effect and inefficient because the trip wire must be planted so that the intruder will find in difficult crossing it without fetching the wire.

This shows that one will need more than one trip wire. Similarly, the intruder has to be very close to the dark activated intruder alarm for the shadow to be cast on the sensor. To overcome these problems, this project intends to provide a solution using infrared. Infrared can be thought of as heat radiation because the radiant energy is transformed into heat when it strikes a solid surface. All solid bodies at a temperature above absolute zero emit thermal radiation. As a body`s temperature rises, the shorter the resulting wavelengths become. The human body`s maximum thermal radiation is between 9μm and 10μm in the infrared stage. Motion can be detected by special elements which are highly sensitive in the infrared range. Such devices are called Pyroelectric infrared detectors.

2.2 PYROELECTRIC EFFECT

When certain materials change temperature, they produce electricity. A Pyroelectric crystal is an example of such a material. If a Pyroelectric crystal has been at the same temperature for a period of time, there will be no voltage across it's electrodes. When the crystal temperature changes, a voltage is produced at the electrodes of the crystal element. This type of crystal is used in this motion detector kit inside the infrared (IR) detector [1].

From research and sampled opinion it could be regarded as statement of fact to say that on quite a number of occasions the loss of life and property could be avoided if the presence of burglars or armed robbers could be ascertained at the breaking in stage To this, the development in the field of electronics that has contributed one of the greatest success stories of this century has the no-sentiments-attached motion detector as a contribution to make to the society. As an introductory time it should not escape us that alarm systems are either open loop or closed loop [feedback] systems. A typical example of an alarm system which implement s the requirements of an open loop system is the bell system used in the past where the disturbance of the rope tied to a bell by an intruder for instance causes the bell to ring. A closed loop system [alarm] which by the way is the subject of this write up engages the operation of electronic equipment like comparators [a typical closed loop tool] .To compare the intensity of the infrared beam [for this particular design] the output or after a disturbance and the specified intensity. The infrared is the basic feature of this design and so are the sensor which senses the infra red intensity and also the actuator which is based on the result from the sensor gives an output. The infra red was first discovered by w.Herschel. At this stage it seems obvious that this work is basically based on the properties of the infrared, which includes the following [2].

1. Infrared is a wave and thus follows the properties like refraction, reflection, diffraction interference etc.

2. Infrared is detected by its heating effect, which takes place when it is incident on a black body [The heating effect of the sun is mainly due to infra red.].

3. The long wavelength of the infrared makes it suitable for long range propagation than the visible light.

From the figure below, one can notice that the interference at the output is destructive because of the difference in the amplitude of the parent and visible wave

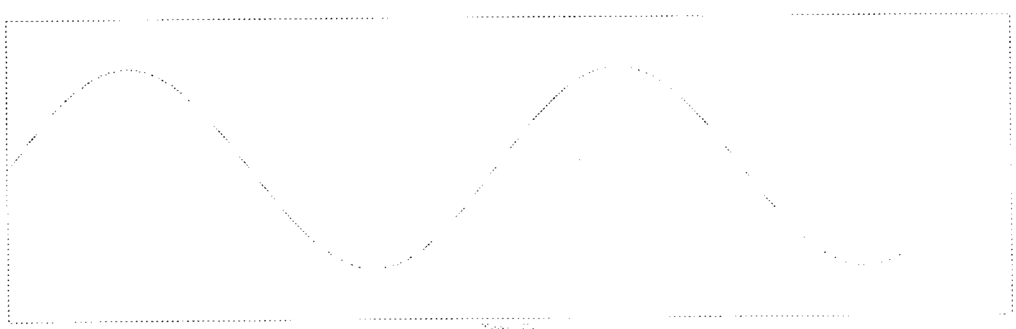


Fig 2.1 Parent wave [infrared]

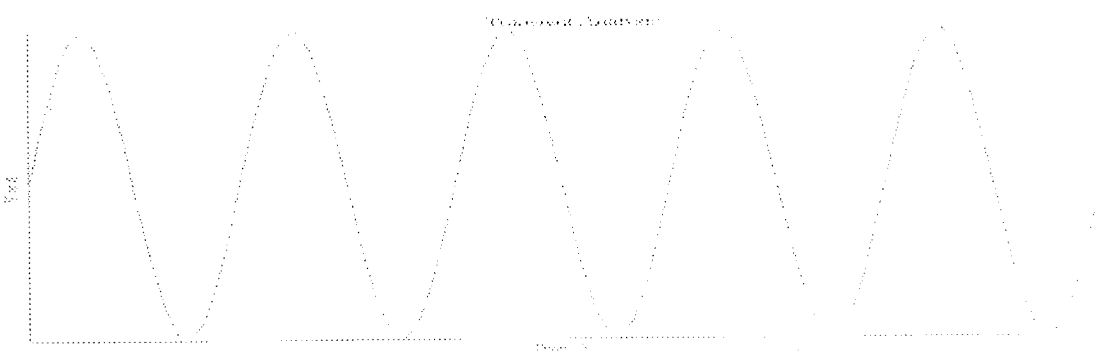


Fig 2.2 Visible Light

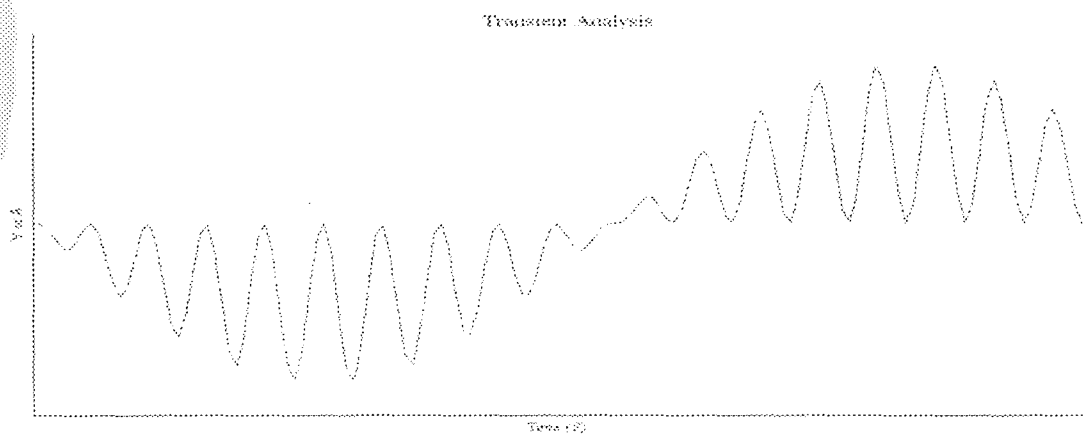


Fig 2.3 Output wave form

The use of filters to keep out waves of wavelength different from that of the infra-red is one solution to tackling this problem.

The second problem is the issue of external disturbances, which might not necessarily be from intruders. Since the sensor is making use of a differential amplifier, anything that causes a disturbance of the infrared thereby generating a differential voltage, for instance the movement of the curtains as a result of wind will activate the alarm. As a result of this sometimes-false calls are made. One of the remedies is to keep this unit in an environment that can kept as still as possible. Another solution could be attributed to the sensor use in this project where the sensitivity if this project is adjustable [2]. For this project we decided to construct an infrared motion detector. Originally i wanted to build an ultrasonic detector but that would require much time. When positioned in the entrance of a protected area, a person entering the area will interrupt the beam causing an alarm to be triggered. This therefore requires careful aligning when being installed.

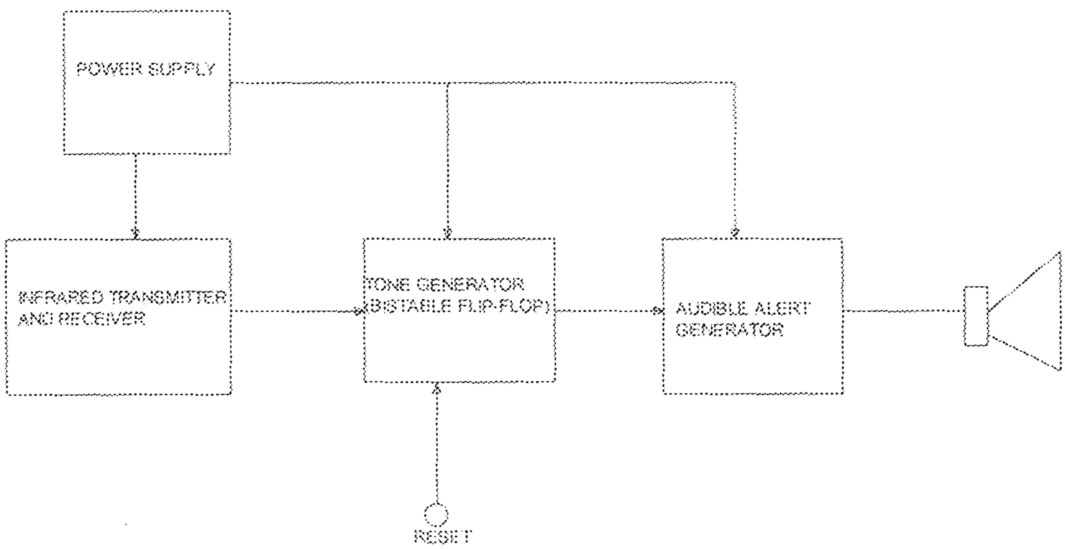
The choice of this project **"INTRUSION DETECTOR USING INFRA-RED"** is born out of the realization that with the use of resources and technological know-how humans should be able to play a role in deciding how and to whom his property is lost.

2.3 BLOCK DIAGRAM OF THE SYSTEM

The project used of infra-red in motion detection for houses, offices, bank etc. is implemented on a circuit board in four main modules which includes

1. Power supply unit
2. Infrared detector unit
3. Operational Amplifiers Filters/Circuit unit
4. Audio Alert Generator/Alarm unit

The objective of the project is to teach the operations of the four sections that make up the project. The four sections are shown in the block diagram below;



Sensor unit

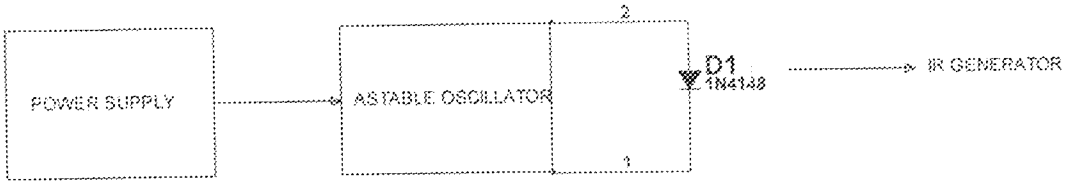


Fig 2.4 the Block diagram of Intrusion Detector Using Infrared.

The sensor incorporates the infra-red transmitter and receiver and in this design, the sensitivity if the beam making use of a differential amplifier is adjustable.

The power supply/battery charger unit: from the block diagram, it can be seen that all the other blocks are being powered by this unit.

The Alarm unit is put on when the switches are caused to open, either by opening a door or cutting across the beam from the sensor.

2.4 CHOICE OF COMPONENTS

The choice of components as in many engineering designs is considered as one of the major factors in carrying out an engineering design. As a result of this, the choice of components for this project was influenced by many factors, which include:

1. Availability of component
2. Types of component needed
3. Cost of components
4. Complexity of the system
5. Maintainability of the system
6. Reliability of the system
7. Safety and security
8. Cost effectiveness and marketability

Considering the whole factors mentioned above. this project is supposed to be a portable and affordable one. The whole project is based on hard-wired logic due to the high cost of microprocessor based designs or project. All the integral circuits were mounted on integrated circuit sockets for easy replacement or maintainability [3].

CHAPTER THREE

3.1 SYSTEM BOARD

The circuitry of this alarm project is soldered on a printed circuit board (Vero board).The board was made by clearing a blank copper clad and carefully drawing the connecting circuit with a marker pen.

The ink was allowed to dry before immersing in a ferric chloride solution for etching. After etching the marked areas were cleared off and holes drilled accordingly. After drilling the components were mounted and soldered.

3.2 SYSTEM ANALYSIS

The circuit used in implementing the design of this project could be explained in Subsystems. With detailed explanation of each component. The Infrared (IR) intrusion detection system embodies the following subsystems:

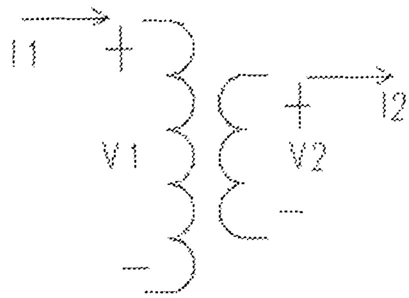
1. Power supply
2. Infrared Sensor
3. Bistable Flip-Flop.
4. Audio (Tone) Generator.

3.3 THE POWER SUPPLY STAGE.

3.3.1 THE TRANSFORMER

The system was designed to be run on both A.C and D.C. The A.C portion of the supply was derived from a 12V, 0.5A step-down transformer wired to a 4-diode full wave bridge rectifier as shown in figure 3.3.

A transformer is an electronic device which steps down or steps up an input primary voltage [v1] to a secondary voltage [v2]. They are used in electrical equipment to convert the 240volts coming from the wall socket to lower and safer voltages for use in equipments. The schematic diagram and defining equation for transformers are shown in figure 3.1.



$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = N$$

and

$$\frac{I_2}{I_1} = \frac{N_1}{N_2} = N$$

Figure 3.1 Transformer diagram

Where N is the ratio of primary turns to the secondary turns. Where V_1, V_2, I_1 and I_2 are defined as shown.

N_1 and N_2 are the number of windings on the primary and secondary coils respectively. Power transformers are usually not described in terms of N_1 and N_2 but instead are described in terms of the voltage output and assume a 220volts input. The transformer shown above is called a single tap transformer because there is only one output. The ac input voltage from the mains is a step down in this case of study and is brought to a lower voltage usable for consumption. This is illustrated below:

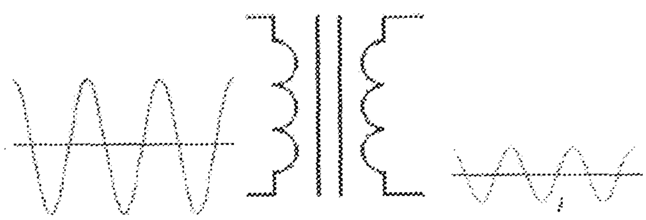


Fig.3.2 Single tap transformer

Larger transformers have better load regulation than smaller ones. The transformer transmits variations in the primary or line voltage directly to the secondary i.e. a 220v fluctuation +or-10% [198v to 242v] would cause a 12v rated secondary to fluctuate + or-10%[10.8v to 13.2v] [7].

3.3.2 RECTIFICATION

This is achieved by using a full wave rectifier. It uses four diodes to perform the rectification of an input ac voltage .Two diodes conduct during each half cycle, giving a full wave rectified output voltage. The top and bottom terminals can be used as the input terminals for the ac voltages, while the left and right terminals can be used as the output dc terminals.

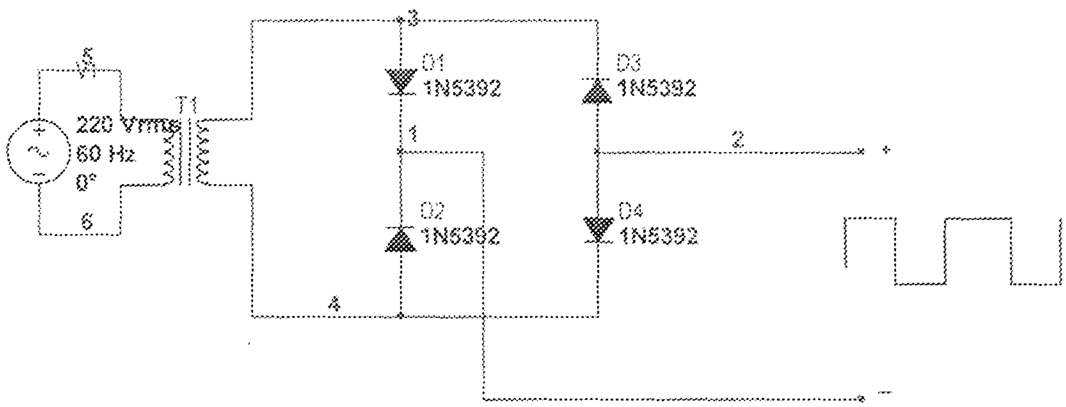


Fig 3.3 Power supply unit.

A full wave rectifier consists of four diodes as shown above. When the input cycle is positive, diodes D_1 and D_4 are forward biased and D_3 and D_2 are reversed biased. D_1 and D_4 thus conduct current in the direction shown. The voltage developed is identical to the positive half of the input sine wave the diode drops when the input cycle is negative, diodes D_3 and D_2 become forward biased and conduct current in the direction shown [7].

Hence the current flows in the same direction for both the positive and negative halves of the input wave. This removes the negative half cycle of the sine waveform from the secondary end of the transformer. A full wave rectifier voltage appears across the load. The low voltage A.C input was transformed into a pulsating 100Hz average output dc voltage at no load condition with amplitude given by:

$V_{dc}= [V_{rms}\sqrt{2} -1.4]V$

Where V_{rms} = the rms value of the transformer secondary.

$\sqrt{2}$ = rms to peak value conversion factor.

1.4 = voltage drop in the two adjacent diodes in the bridge rectifier.

For a 12V A.C output, $V_{dc}=12\sqrt{2} -1.4 = 15.6V$. The value is obtain on a 240V A.C line.

The voltage was smoothened by a capacitance of value deduced from the expression:

$C = It/V$. Where I = maximum load current, $t = 1/2F$.

V = Maximum A.C. ripple voltage.

A modest system current drain of 0.5A was selected.

A 7806 regulator was connected across the rectifier output. For a 6-Volt regulated output, the minimum input voltage into the 7806 regulator is 8V. (From the Manufacturer`s datasheet).

On a 15.6V input voltage, this corresponds to a maximum A.C. peak for peak ripple voltage of $(15.6-8)V = 7.6V$.

Thus, $C = It/V = 0.5*(1/2*50)/7.6 = 0.005/7.6 = 660\mu F$.

This value is the minimum acceptable capacitance across the power rating to meet the above system specifications.

The value was increased about three fold to 2200µF for improved system performance. The voltage was regulated down to 6Volts by a 7806 1A regulator as shown below.

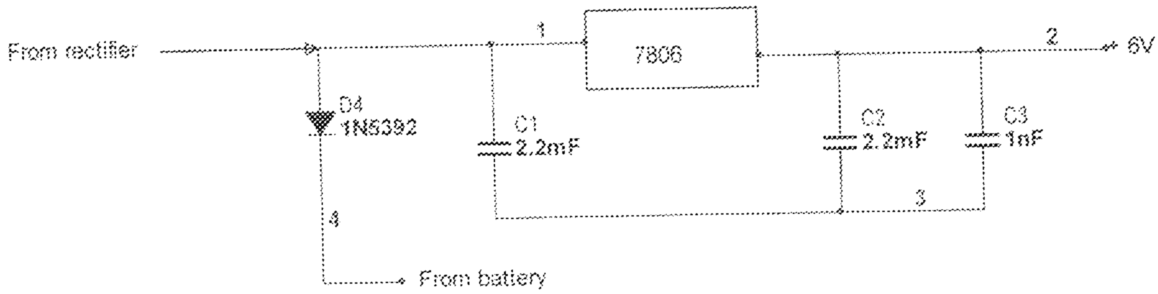


Fig 3.4 voltage regulator.

An auxiliary D.C supply was gotten from a 9-V D.C battery connected to the regulator input via a diode D_4.

The diode is always reversed biased with the system connected to mains (as long as the rectifier output is greater than the battery voltage +0.7V). This connection is for transfer of system power from mains to battery and vice versa.

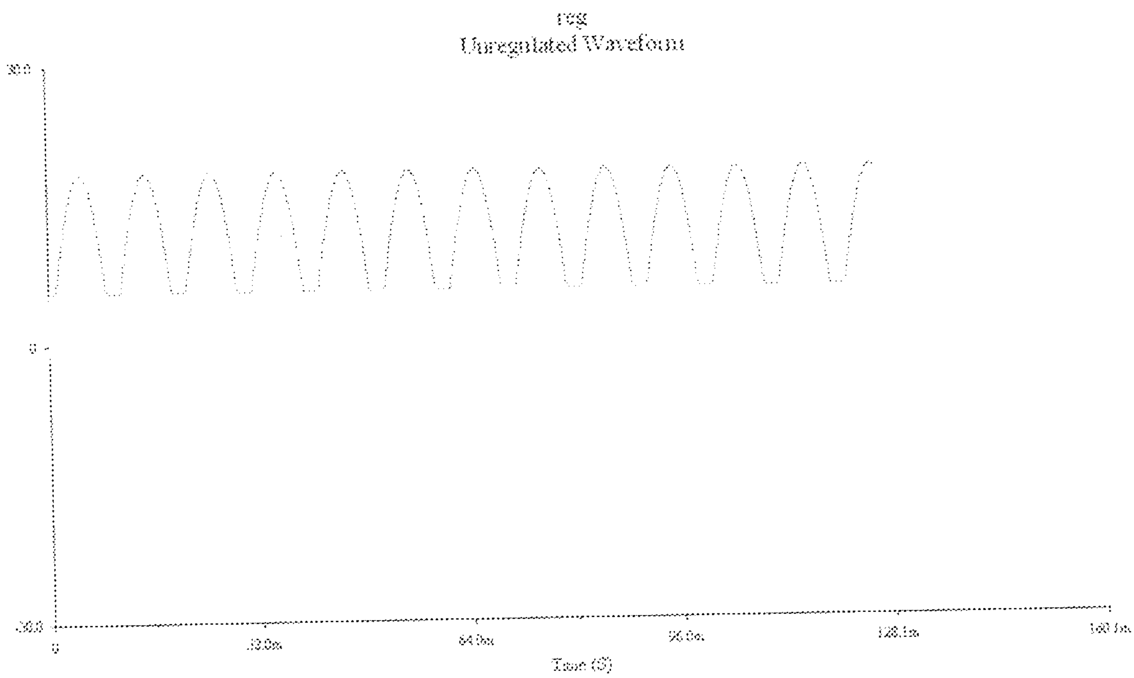


Fig 3.5 unregulated waveform

The secondary voltage of the transformer

V_{sec}=12V [rms]

This voltage rectified by the four diodes IN4001 diodes to dc voltage with an ac component superimposed to its ripples as illustrated in the waveform above.

Unstabilized voltage

$V_{rectified}=V_{dc}+V_{ripple}$

$= V_{peak}$

=15.6V

After the dc signal has been rectified, ripples are still significant which can be minimized by the use of a capacitor.

3.3.3 CAPACITOR FILTERING

As the diodes D_1 and D_2 conduct the terminals T_1 becomes positive . C charges up to the peak voltage Vpeak of the ac supply . During this time, current is also passing through the resistor R_L [R_1 and R_2].

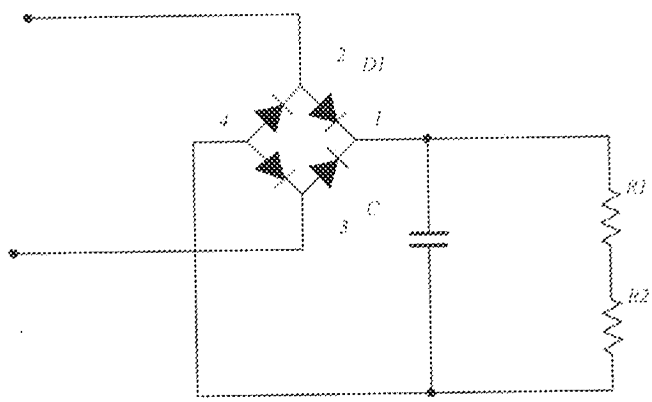


Fig. 3.6 Capacitor Filtering Circuit

This is 5 times greater than 1/50seconds and smoothening could be efficient.

When the voltage at T1 begins to fall, current still continues to pass through RL since C is discharging. If the time constant [CRL] is high enough then C takes some time to discharge. If the voltage on C falls a little during the time for the voltage at T1 to fall to zero, no negative and becomes positive again, then the DC is efficiently smoothened [6].

For a good smoothening or filtering action [i.e. small ripple voltage Vr, C $*R_L$ must be larger than 1/50seconds. This is the time for the voltage on T_1 to go from one positive peak to the next positive peak. If

C=100μF and R_L=1kΩ

Then CR_L =100*10^-6*10^3=1/10second

This is 5 times greater than 1/50seconds and smoothening would be efficient.

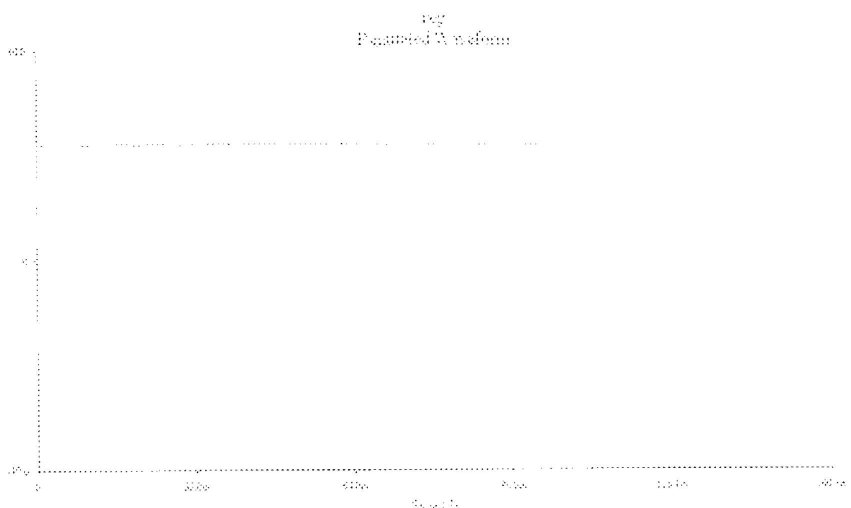


Fig. 3.7 regulated waveform

3.3.4 VOLTAGE REGULATION

It is measure of a circuit's ability to maintain a constant output voltage even when either input voltage or load current varies. A zener diode when working in the break down region can serve as a voltage regulator [8].

The sample voltage is compared to a zener voltage and the error is used to modulate the base of the current limiting transistor. The current is adjusted until

$V_{sampled} = V_{zener} + 0.6V$

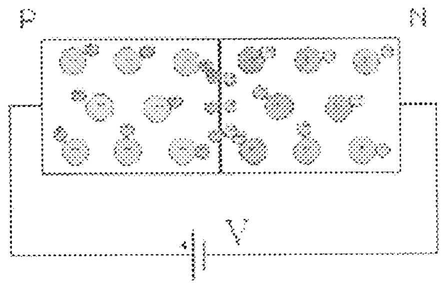
3.3.5 DIODES

These are pn devices, which allow current to flow in only one direction. It has two terminals known as the anode and cathode.

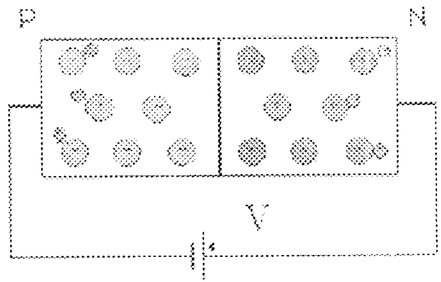
The cathode is usually marked with a colored mark. When the diode is forward biased i.e. if the applied voltage is positive on the p side, it opposes the contact potential and then reduces the height of the potential barrier. It begins to conduct with only a small power voltage across it. When the diode is reversed biased i.e. the applied voltage makes the n side more positive as is indicated in the diagram below, the barrier is increased. Only a negligible small leakage current flows through the device until reverse breakdown voltage is reached.

However in normal operation, the reversed biased voltage should not reach the break down Rating [5].

FORWARD BIASED



REVERSED BIASED



Diodes exhibit a number of useful characteristics such as predictable capacitance [that can be voltage controlled] and region of very stable voltage. They can therefore be used as switching devices. Voltage controlled capacitors [varactors] and voltage references [zener diodes]. Because diodes will conduct current easily in only one direction, they are used extensively as power rectifiers [5].

In summary for this stage, the transformer steps down the voltage from the utility company, the rectification circuit removes the negative half cycle. The output still having some ripples, is smoothened by the capacitor C_1; IC_1 is a voltage regulator that regulates the filtered dc voltage. This dc voltage is set to 12v by the combination of R_1 and R_2.This value further brought down to 11.3v by forward biasing the diode, which drops the voltage by 0.7v. This diode labeled D6 is referred to as a blocking diode .The regulated DC voltage of value 11.3v is used to charge the battery, which makes the value drop further to a

3.4 IR SENSOR/BISTABLE FLIP-FLOP.

A three pin 38 KHz infrared sensor was used as the front end between the system and the IR generator. The device was designed to respond to the 38 KHz DataStream generated by a 38KHz oscillator .It was interfaced with a 555 bistable latch as depicted in fig

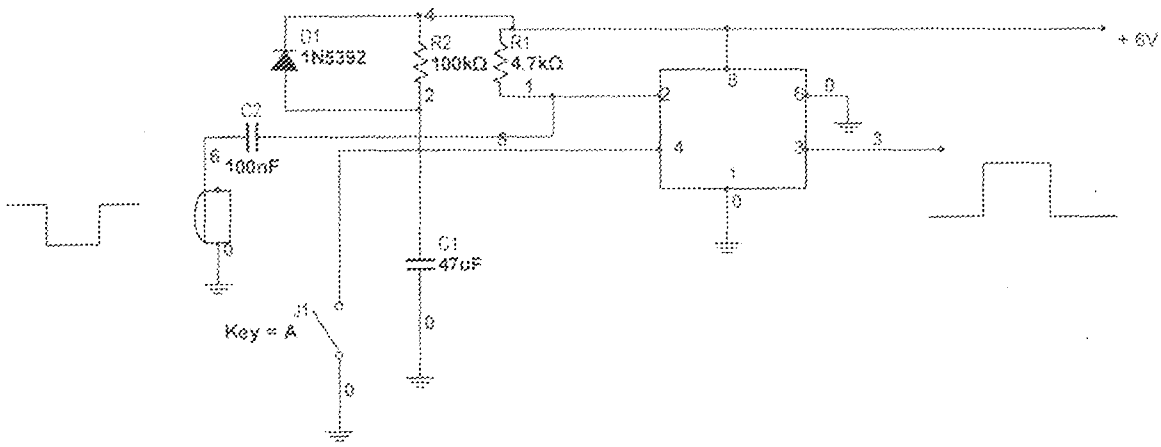


Fig3.8 Bistable multivibrator

The 555 device was configured for bistable operation by connecting pin6 to ground, pin2 is the active-low SET input and pin4 an active-low RESET input. The trigger pulse into pin2 was gotten from the IR sensor device via 0.1uF capacitor [6].

In the steady state, with sensor continuously irradiated by an IR source or not irradiated ,its output stays high, keeping the voltage level on pin 2 high. However, if a beam discontinuity occur between the sensor and the IR generator, the TSOP1738 switches its output low, pulling the voltage on pin 2 below $1/3V_{cc}$ and triggering the bistable which then switches pin 3 high. The bistable remains indefinitely set until reset by S_1 closing or power –up via pin 4.

Power-on reset logic was connected to pin 4 to keep the bistable reset at the time of connecting to a power source [6].

The reset logic is shown below

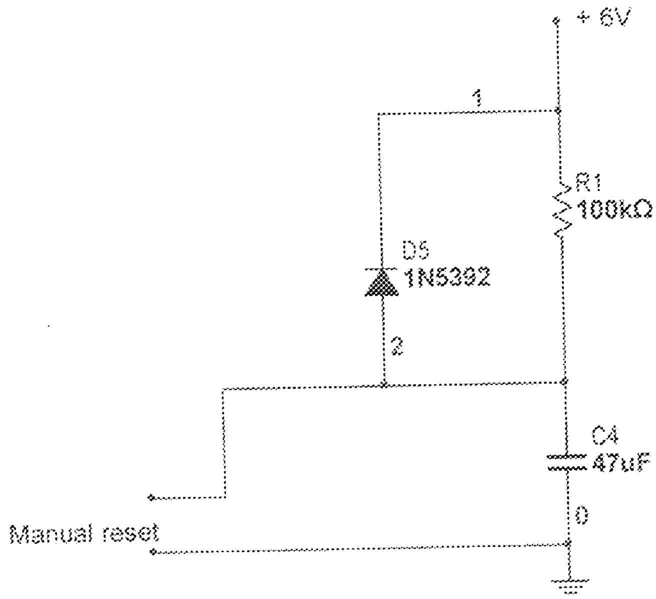


Fig 3.9 Reset circuit

At power-up C_1 is discharged with 0V across it .this immediately asset RESET logic on pin 4, forcing pin 3 low.

The RC combination then changes up and when the voltage on pin 4 rises above about 0.7V, RESET is reasserted and the system is ready to accept a SET logic on pin 2.

The pin 3 (output) of the device was used as the enable input into pin 4 on two other 555 timer used for generating the audible alert that is sounded during intrusion detection.

3.5 AUDIBLE ALERT GENNERATOR

This comprises of two NE555 devices, both wired as astable oscillators, to produce a modulated audio output. The low –frequency output of an astable device was used to modulate the high frequency output of a second astable device.

Both 555 devices were configured for astable operation as shown below:

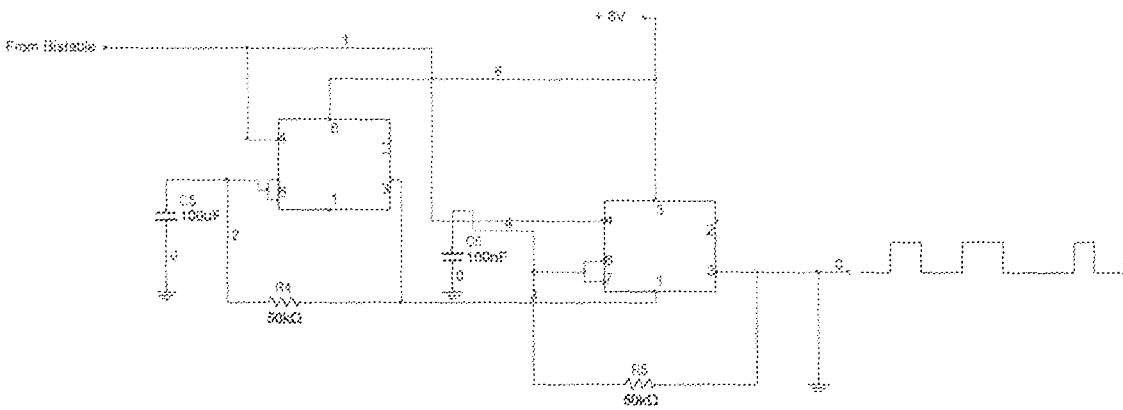


Fig 3.10 555 devices for Astable operation.

Both U1 and U2 were configured for astable operation with 50% duty cycle output according to the equation $F=1/2\Pi R_T C_T$

R_T=Resistance between output (3) and pin 6, 2.

C_T=Capacitance between pins 6, 2, and ground.

A low-frequency output from U1 was used to modulate the high frequency output of U2to produce an audio output that is not a single-tone frequency.

The frequency generated by U1and U2 was adjustable by reason of R_T being presettable potentiometers. This was done to improve system flexibility.

Modulation of the high frequency wave was effected over pin 5 of U2(modulation input)

The modulated output was fed into a medium power NPN transistor (TIP41C) which drives a loudspeaker to deliver an appreciable audio level.

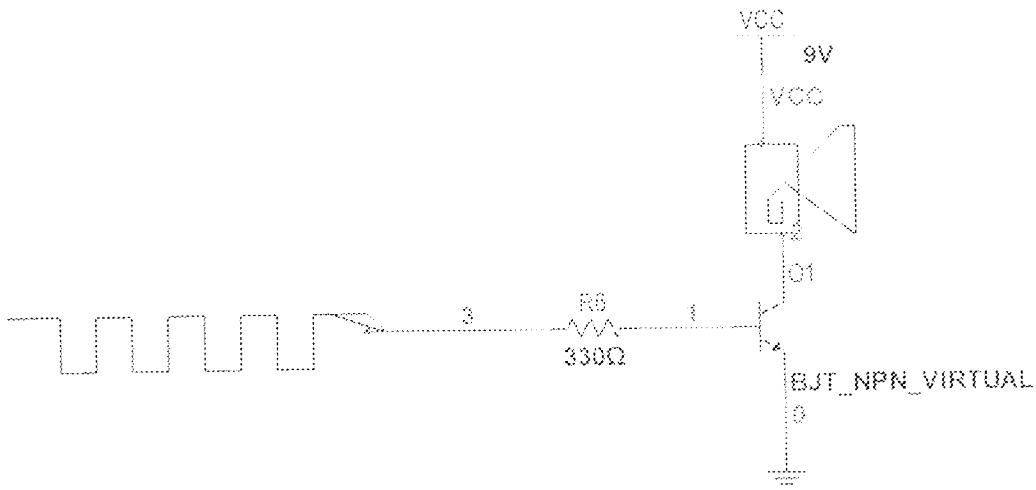


Fig 3.11 Modulated waveform fed into NPN Transistor.

The loudspeaker used had an 8Ω impedance with a maximum input power handling of 5W.

$P=I^2R$

$5=I^2(8)$; $I^2=0.625W$

$I=0.25A$, $I_C=0.25A$

$Ic = \beta I_B$, $\beta=40$

$I_B = Ic/\beta=0.25/40=0.0625A$

$R_B = (V_B-V_{BE})/I_B=(5-0.7/0.0625)=4.3/0.0625=700\Omega$

The value was reduced to330Ω to account for gradual battery deterioration with usage.

3.6 IR GENERATOR

An IR source was required for projecting an IR wave in the direction of the IR sensor. It was designed around an NE555 multivibrator configured as an astable multivibrator chip running at 38KHz. This mode of operation was chosen so as to generate a constant square wave form to be transmitted.

When operated in the astable mode, the 555 timer generates a constant frequency output of :

$$F = 1.44/(R_{16}+2R_{20})C \text{ Hz}$$

Using the above equation, for the 39KHz output, the values for the configuration were chosen for R_{16} and C. For easy setup, R_{20} was made variable. By varying R_{20}, the output was measured using a frequency meter unit. The values of R_{16}, R_{20} and C used in this design to achieve the 38KHz frequency are:

$R_{16} = 1K\Omega$, $R_{20} = 50K\Omega$ (variable) and $C = 0.001\mu F$.

The multivibrator oscillator turns the IR emitter diode ON-OFF through the 330KΩ Resistor.

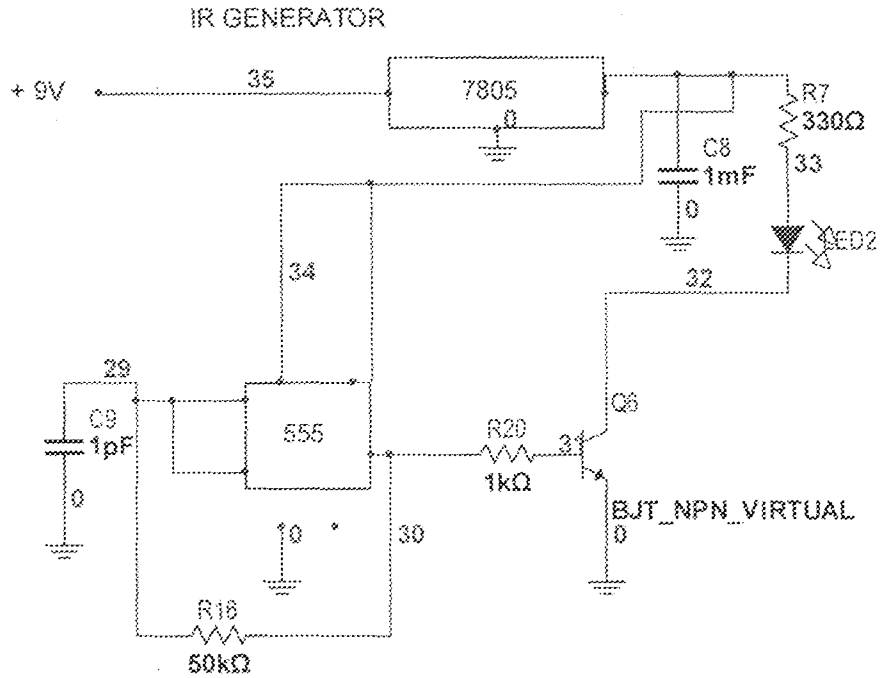


Fig 3.12 Infrared generator circuit

U4 was configured for 38 KHz operator with 50% duty cycle output. The power source for the generator was derived from 9V DC battery regulated down to 5V by a 7805 regulator. The 5V supply was buffered by a 16V, 1000µF capacitance.

The 50% square wave output was fed into the base emitter junction of Q_1 whole collector load was an IR emitter diode.

The current through the LED was pulsed at a 38 KHz rate being the on/off sustaining frequency of Q_1.

The current through the diode was limited to about 12mA by a 330Ω resistance according to equation.

$R_S = V_S - V_{LED}/I_{LED}$

$V_S = +5V$; $V_{LED} = 1V$, $I_{LED} = 12mA$

$R_S = 5-1/0.012 = 330\Omega$

The base current required to produce the 12mA collector current through the LED was derived from the expression.

$I_B = V_B - V_{BE}/R_B$

$I_B = I_C/\beta = 12mA/200$

$I_B = 60\mu A$

$R_B = 4-0.7/6*10^{-5} = 5.3/6*10^{-5} = 88K\Omega$

This value was reduced to 1K for emitter diodes can work on pulsed peak currents as high as 1A, this was not an issue.

3.6.1 CHARGING A CAPACITOR

he circuit arrangement below shows a capacitor, which may be charged through a high resistance R from a battery of V volts. When the switch S is connected to terminal [A]C is charged but when it is connected to [B], C is short circuited through R and is thus discharged , the voltage across the capacitor n plates continually being measured by the use of a voltmeter [5].

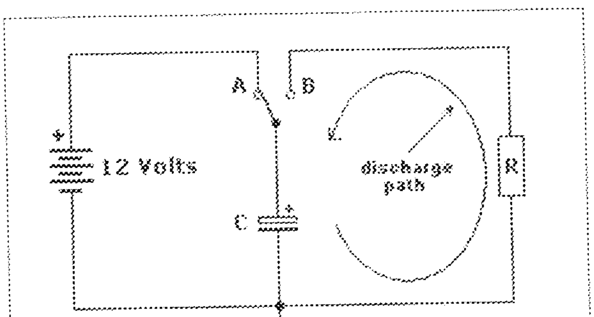
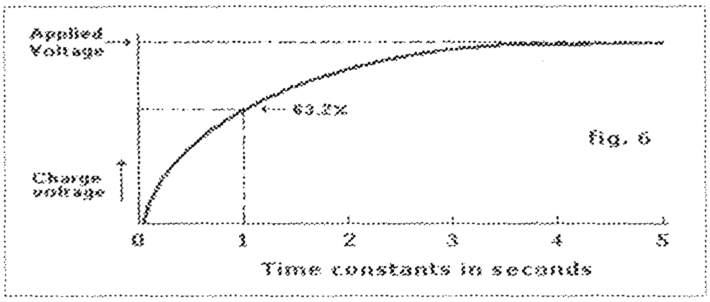
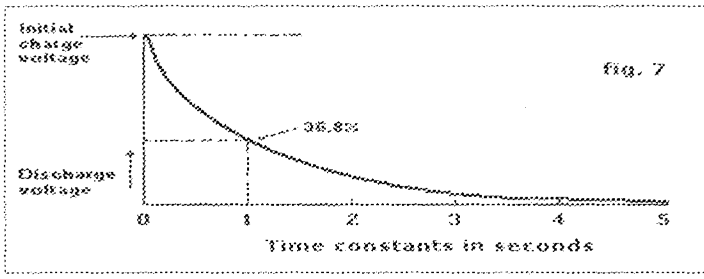


fig. 8





The voltage across C does not rise to v instantaneously but builds up slowly. Charging current is maximum at the start i.e. when C is unchanged then it gradually increases and finally ceases when P.D across capacitor plates becomes equal and opposite to that of the battery [5].

Note: In the circuit designs of the project it could be seen that the capacitor is also connected as explained above to the battery.

3.6.2 STATEMENTS ON TIME CONSTANT

Just at the start P.D across the capacitor is zero, hence applying Kirchhoff's law

Vs=Vr+Vc

But Vr=IR

Current flowing in the circuit is related to the voltage across the capacitor by

I=C[dv/dt]

Simple elimination then yields

$Vs=RCdVc/dt+Vc$

Introducing the time constant CR as f

$f=CR$

If Vs is aconstant i.e independent of time, then a particular solution for Vc can be found by

$Vcp=Vs$ the homogeneous solution is found by setting the source term to zero and solving

the resulting homogeneous differential equation

$dVch/dt+Vch/f+0$

$Vch=Vs+C1e^{-t/f}$

$Vc=Vcp+Vch$

$=Vs+C1e^{-t/f}$

This is equivalent to showing that the voltage across the capacitor is zero initially

$Vc[0]=Q[0]/C=0$

This implies $C1=-Vs$

Therefore $Vc=V\ [1-e^{-t/f}]$

If this rate of rise were maintained, then the time taken to voltage v would have been CR.

This time is known as the time constant of the circuit.

Statement 1

The time constant of an R-C circuit is defined as the time during which voltage across

capacitor would have reached its maximum value v had it maintained its initial rate of rise.

Also from $Vc=V\ [1-e^{-t/f}]$

We find that if t=f then

$Vc=V\ [1-e^{-t/f}]$

$=V\,[1-e^{-t/T}]$

$=V\,[1-e^{-1}]$

$=V\,[1-1/e]$

$=V\,[1-1/2.718]$

$= 0.632V$

Statement 2

The time constant of a circuit is also the time during which the charging current falls to 0.37 of its initial maximum value.

Recall that the time constant is a deciding factor of when the base of the emitter follower Q2 is biased. The time constant in this design, is kept at five minutes after which the emitter follower of Q2 falls to such a low level that Q1 comes out of saturation and eventually turns off thus energizing the relay which transfers to the normally open switch thus taking the system to the alarm mode [9].

A brief discussion on transistor biasing is in this stage important in this write up.

3.6.3 TRANSISTOR BIASING

A transistor is a three terminal semiconductor device. which is made up of two pn junctions it, is available in two varieties [npn and pnp]. For proper working of a transistor it is essential to apply voltages of correct polarity across its two junctions .It is worthwhile to remember that for normal operation.

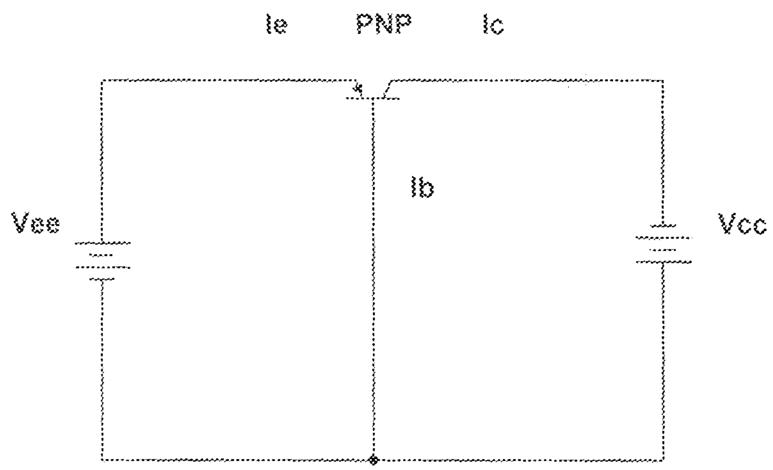


Fig 3.13 Common Base PNP Transistor connection.

In the figure above, the two batteries respectively provide the dc emitter supply voltage Vee and collector supply voltage Vcc for properly biasing the two junctions of transistor. I n the pnp transistor positive terminal of Vee is connected to p type emitter in order to repel or push holes into the base.

The negative terminal of Vcc is connected to the collector so that it may attract or push holes through the base [7].

Similar conditions apply to the npn transistor. Below are transistors connected into a simple common emitter and common base circuit. It is called a common emitter circuit because the emitter is common to both the input and output circuits. As a result of the forward bias on the base emitter junction, electrons from the n-type emitter easily cross into the p-type base where diffusion into the depletion layer at the base-collector junction takes place. The reverse bias on the collector facilitates electron motion through the base into the collector to establish the collector current Ic.In the common base emitter, the junction must be reverse-biased by battery Vcc while the base emitter junction is forward-biased by the battery Vee.

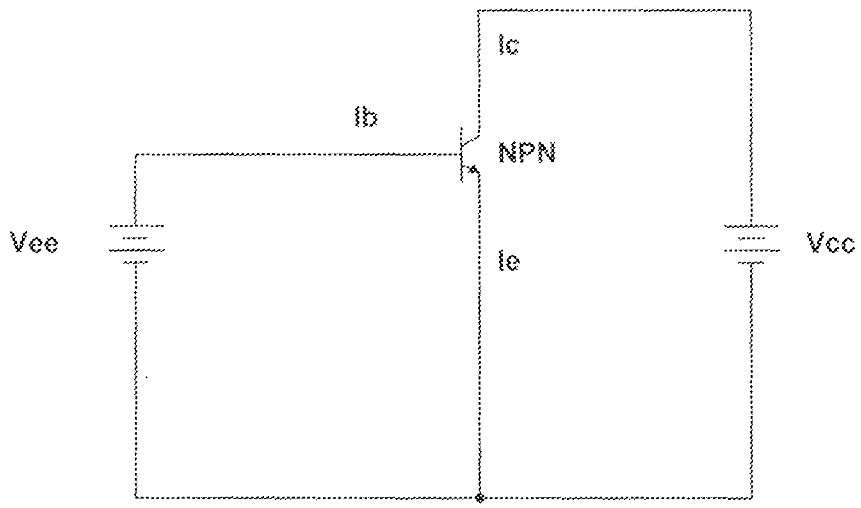
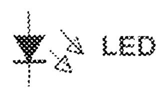


Fig 3.15 Common Emitter Transistor connection

It must be remembered that a transistor will never conduct any current if its emitter base is forward biased.

In the circuit diagram design of this project the combined effect of the transistor which is brought out of saturation after the time delay has elapsed and the relay Kd which is powered energizing by the output of the form the collector Q1 transfer the operations of the unit to alarm section by latching which is one of the functions of a relay.

3.6.4 THE LIGHT EMITTING DIODE (LED)



The LED is a pn junction device that emits light when biased in a forward direction. They are frequently used as pilot lights in electronic appliances to indicate whether the circuit is closed or not .The light emitted can either be invisible [infrared] or can be light in he visible spectrum. The flat side of the bulb or the shorter of the two wires extending from the LED is the negative end and should be connected to the negative side of the battery. LED's operate at relatively low voltages between 1 to 5 volts and draws current of about 10 to 50 milliamperes. Voltages and currents substantially above these values can melt a LED clip. From our cause of study of divides, the LED has two region separated by a function. The p region is dominated by the charges and the n region by negative elective charges. When a voltage is applied and the current starts to flow, electron in the n region have sufficient energy to move access the function into the p-region. Once in the p-region the electrons are immediately attracted to the charges due to the mutual coolomb forces of attraction between opposite elective charges. Each time an electron recombines with a positive charge; elective potential energy is converted into electromagnetic energy. A quantum of electromagnetic energy is emitted in the form of a photon of light. Different coloured LED's emit predominantly light [8].

Different colored LED's emit predominantly light of a single colour. The energy (E) of the light emitted by an LED is given as:

$E = qv$

Where q = electric charge of an electron

$= -1.6 \times 10^{-19}C$

v = voltage required to light the LED

Therefore to find the energy required to light the red LED

$E_R = 1.6 * 10^{-19}$ * voltage across red LED

$=-1.6*10^{-19}*1.99$

$=-3.18*10^{-19}$joules

Energy required lighting the green LED

$E_G = -1.6 * 10^{-19}*0.23$

$=3.68*10^{-20}$joules

The frequency of light is related to wavelength of light. A spectrometer is used to examine the light from the LED and to estimate the peak wavelength of the LED.

F = c/a

Where c =speed of light= $3*10^{8}$m/s

A =wavelength of light read from the spectrometer [in units of nanometer]

The wavelength of the red light as read from the spectrometer is a=660nm

Therefore Fr=$3*10^{8}$ ms-1/$660*10^{-9}$ m=$4.55*10^{14}$Hz

Where Fr is frequency of the red light

The function of the timing circuit is to provide a time delay for the user to exit the building before arranging the limit. Upon pressing the used button power is sent to the LED, which lights up to show that the system is the ready mode.

C5, R9, and R10 as shown in the circuit diagram for a time potential divider that is connected to the base of the emitter follower Q2. The emitter amplifier Q2 feeds into the base of the common emitter amplifier Q1 which uses k1relay as it`s collector load. C5 acts as a simple filter network that provides smooth DC, to the C5, R9 and R10 timing network. When power is first applied to the circuit the relay evil self latch thereby applying power to the alarm circuit arming the limit. Pressing the reset button again will transfer power to the timing circuit. The timing circuit will aim the units after a time interval of five minutes [8].

Understanding the concept of time constant, which provides a time delay by the combination of C5, R9 and R10 in the circuit is enhanced by the explanations of the capacitor characteristics.

CHAPTER FOUR

4.1 THE INTRUDION DETECTOR

In this work two switches or motion detectors are made use of. one is the contact switch could be kept at the door with one part of the switch permanently mounted on the door such that closing and opening the switch respectively.

The second motion detector is the sensor which incorporate the infra-red transmitter and receiver is the basis of this write-up.

4.2 PRINCIPLE OF OPERATION OF THE INFRARED INTRUSION DETECTOR

The infrared intrusion detector works on the basis of IR transmitter and IR receiver. The transmitter sends a signal into the space in such a way that it could be picked by the IR receiver and subsequently implemented by the main control unit.

Here the infrared radiated is used to send the signals. The aim is to bias the infrared diode so as to radiate energy. The radiated ray of the infrared is used as a carrier for the common signals.

There are various ways of modulating the infrared ray. Increasing the forward current increases the radiations because more electron hole pairs are created, but practical diode places a limit to the forward current to less the 100mA [3].

Which thus a break in the regular pattern of the infrared beam caused by an intruder or any other form of disturbance, then the receiver would no longer have the required amount of rays to keep the circuit close reaching it. This open circuit condition triggers off the alarm.

Recall that the infrared beam is invisible to the human eye and thus the intruder is unable to see the pattern of the beam. An experienced intruder may try to inactivate the receiver by shining bring light on it. This particular project is equipped to accept only a pulse beam of fixed frequency. Also destructive interference as a result of the light may also lead to the alarm been sounded.

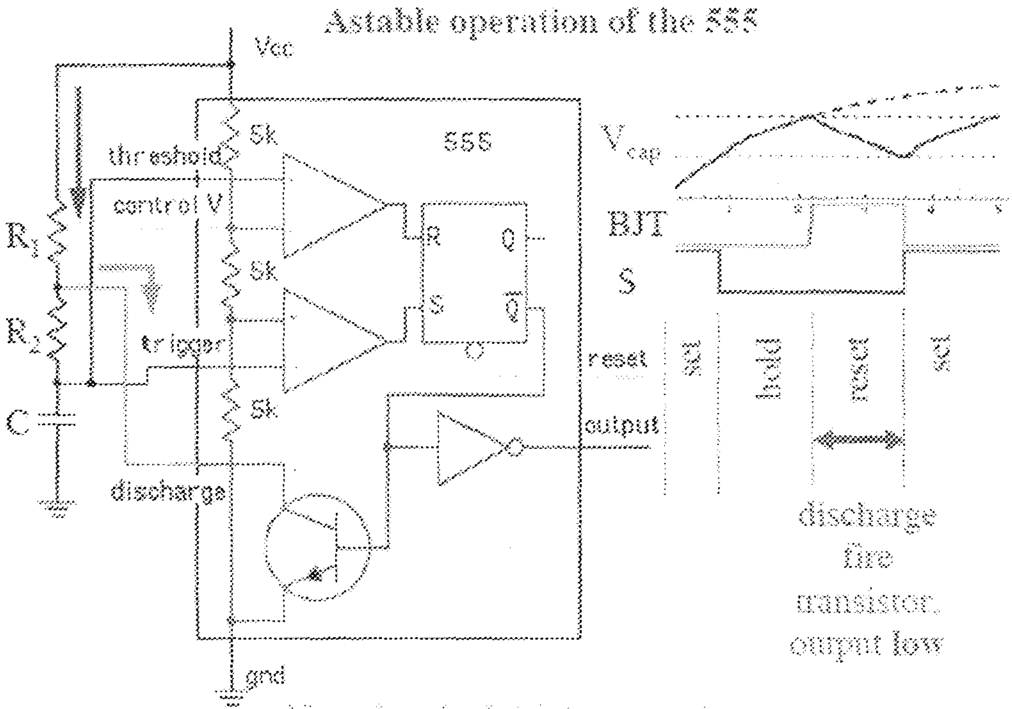
Trying also to cut the sensor wires would cause an open circuit condition and subsequent sounding of the alarm.

An infra-red beam of the same frequency may however be able to deactivate the sensor if pointed directly in the "eye" of the receiver.

Though the transmitter and receiver of infrared are incorporated in a sensor unit, below is an outline of the design of the basic transmitter and receiver unit.

4.3 DESIGN OF INFRARED TRANSMITTER UNIT

The compounds include a 555 timer, a transistor and a few biasing elements (Capacitors and resistors). The 555 timer is used in astable mode. The essence of the 555 timer is to generate the voltage wave form of particular frequency to switch on the transistor which consequently allows passage of current through the IR emitter it does this as explains below. A brief explanation on how the 555timer operates is important at this junction [6].



Note that the R high state is just momentary.

The use of the 555 as a oscillator (an astable) requires hooking up an external capacitor and a couple of resistors to have a pathway for charging and discharging. Notice how the op amps are connected, the S opamp is connected to be high when the capacitor voltage is less than 1/3 Vcc, the R op amp is connected to be high when the capacitor voltage is greater than 2/3 Vcc. In between 1/3 and 2/3 Vcc both R and S are low, so the flip flop holds the last outputs. The capacitor charges through R_1 and R_2 until it reaches 2/3 Vcc, then the flip flop resets, sending the inverting output high. This turns on the BJT which discharges the capacitor through R_2 (note, R_1 is out of the circuit). As the capacitor discharges R goes back low, and the flip flop is set again when it reaches 1/3 Vcc. The output is an inverted version of the digital signal that drives the discharging transistor.The transmitter unit will produces a frequency of about 38KHz [6].

4.4 DESIGN OF THE INFRA RED RECEIVER UNIT

This unit consists of the infrared sensor, bistable flip-flop and other components. The principal set-up is for the transmitted signal to be incident on the IR sensor [Phototransistor] and then unmodulated to a reasonable level by the bistable flip-flop

4.5 INSTALLATION

The circuit board is enclosed in a glass casing and screwed tightly shut. The casing has holes for the power supply leads and connection wires to the sensor, the siren and the contact switch.

The unit is mounted where there is only one entrance and exit. This means that there is only one way of entering and exiting the building. Although too much importance is not normally attached to the placement of the casing but care must be taken to make the sensor unit and contact switch as inconspicuous as possible.

The sensor is preferably kept above the doorframe on the inside wall such that an intruder is unable to try deactivating the unit before cutting the beam.

One part of the contact switch could be made stationary by mounting firmly on the immovable door frame while the other part is mounted on the door such that shutting the door implements a complete circuit while opening the door leads to an open circuit and thus sounding the alarm.

These locations of the sensor unit and the contact switch complement each other. Recall that the sensor unit and the contact switch are connected in series such that opening anyone of them sounds the alarm.

4.6 TESTING AND MEASUREMENT

The measurements obtained during the design are giving in the table below:

Power Unit	Tests	Results
	Output Current	7805 = 180mA
		7806 = 120mA
	Output Voltage	7805 = 5.0V
		7806 = 6.0V
Sensor Unit	Transmitter Frequency	38KHz

Table 4.1 Results of measurement

CHAPTER FIVE

5.1 RECOMMENDATIONS

The system design although implemented using hardwired logic could also be implemented using programmed logic. In a situation where programmed logic is used a variety of concepts may be introduced.

For instance in an organized society like in the developed country similar units are directly linked to the main frame computer of the police such that the police station is instantly alerted once the alarm is sounded i.e. when there is a break in.

Also in an office complex where there are different units at different locations of the building, the use of programmed logic provides a means of monitoring the different zones from a central monitor by the use of multiplexing techniques.

This work can also be implemented with microcontroller using GSM technology. The Householder will be alerted via GSM network when there is an intrusion.

Even in the hardwired design, circuitry could be implemented to power high light intensity bulbs to throw light when the alarm is sounded. This would enable the patrolling security team to know the precise location of the unit and to see the subject of intrusion at a glance.

Also for portability instead of passive components used the overall circuitry could be integrated with a very large scale integration (VLSI) chip. Miniaturization of cause would lead to better system binding.

5.2 CONCLUSION

The intrusion detector using the crossbeam principle in conjunction with a contact switch has been designed to a high degree of sensitivity and efficiency using simple readily available components.

The quality of electronic components can be attributed to the ease of Troubleshooting and change of faulty components, this device could therefore be said to be of high quality and showing a high degree of maintainability.

What would have resulted in a design and construction problem possibly leading to high cost of production was avoided by logic probe of the units making up the system before implementation on the circuit board.

Finally, it is hoped that with the continued technological awareness in the country and the world at large today, the use of programmed logic would leave a blazing trial as computer based design from security conscious minds which are born in this field of electronic intrusion system.

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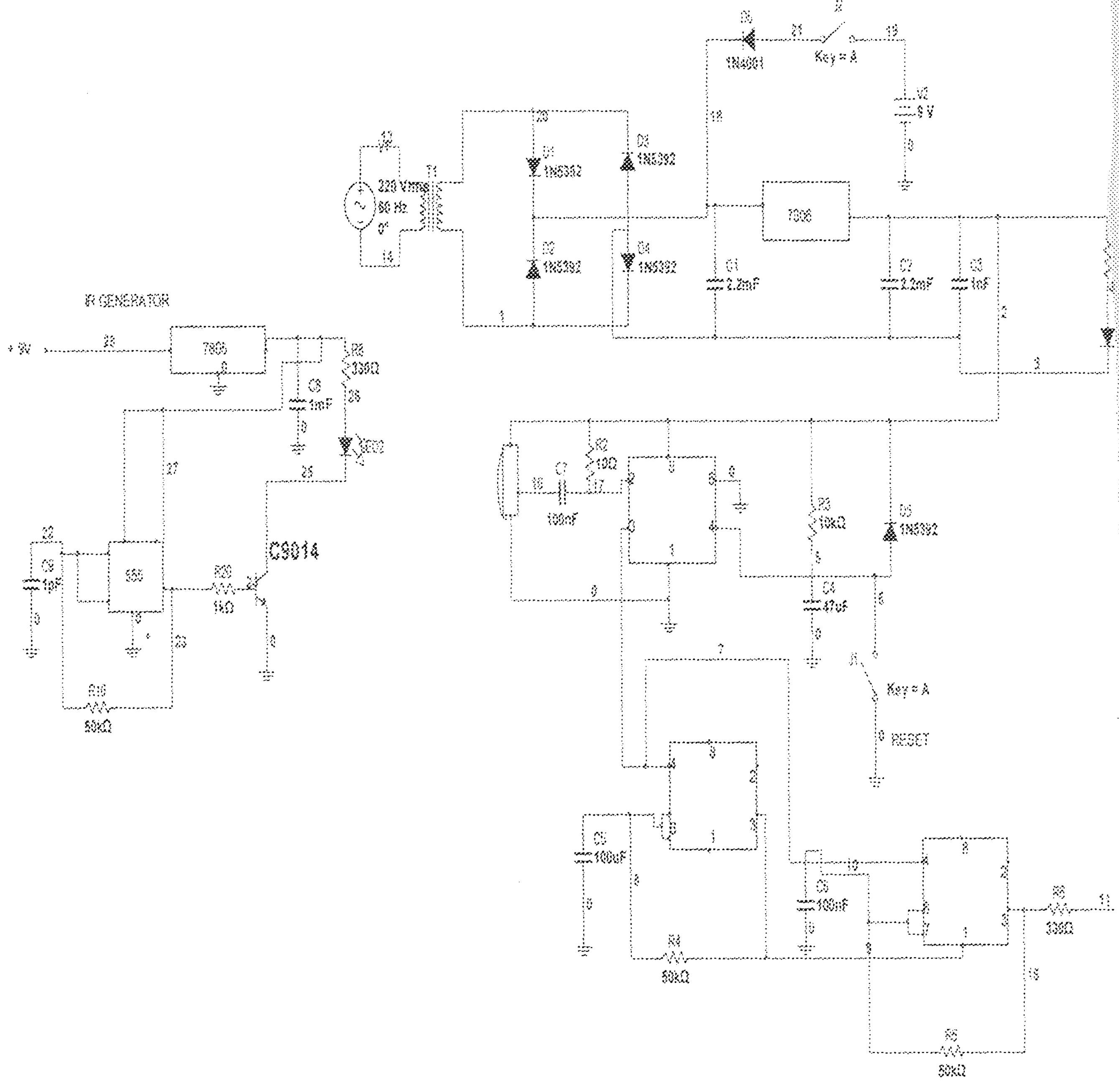
Appendix

MAIN CIRCUIT DIAGRAM



Appendix

MAIN CIRCUIT DIAGRAM