DESIGN AND CONSTRUCTION OF A LIGHT OPERATED DOMESTIC ALARM

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A Project Report Submitted in Partial Fulfillment of the Requirements for the Award of Bachelor of Engineering (B.ENG.) Degree in the Department of Electrical and Computer Engineering, School of Engineering Technology, Federal University of Technology, Minna, Nigeria.

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DECLARATION

It is hereby declared that this project was conducted by me under the supervision of Mr. Paul Attah of the Electrical and Computer Engineering Department, Federal University of Technology, Minna.

MR. ADUNBARIN, OLANIYI STEPHEN

24/03/2000

SIGNATURE AND DATE

MR. PAUL ATTAH

24/03/2000

SIGNATURE AND DATE

CERTIFICATION

This is to certify that this project titled "Design and Construction of a Domestic Alarm System" was carried out by ADUNBARIN, OLANIYI STEPHEN under the supervision of MR. PUAL ATTAH and submitted to Electrical and Computer Engineering Department, Federal University of Technology, Minna in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.ENG.) degree in Electrical and Computer Engineering.

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DEDICATION

This work is dedicated to God Almighty, the Author and finisher of my faith.

ABSTRACT

Alarm systems are systems which operate a warning device after the occurrence of an abnormal or dangerous condition. They are used to signal undesirable or dangerous situation such as the presence of an intruder or the existence of a runaway condition in a petroleum refinery process. In factories, these system detects such things as excessive process temperature, or pressure or rapid change in a process condition. Over the years, the use of intruder alarms to protect an area has become widespread in industrial, commercial and private uses. Its design, construction and application has also increased in sophistication and style.

Alarm system can be grouped into classes viz: space intrusion detection, perimeter detection and contact detection. Space intrusion detection is three dimensional while contact detection is by touch.

This project is on domestic alarm system and falls under the contact detection. It is based on the widespread use of photocell and amplifiers. This was achieved by using astable multivibrator and electronic bulb and a relay. The signal processing which forms part of the detecting circuit is made up of a pulse amplifier and the astable multibrator.

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CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 INTRODUCTION

Alarm systems are systems which operate a warning device after the occurrence of an abnormal or dangerous condition. Today, there are various forms of alarm systems used in detection of an unauthorized entry each one with its merits and demerits. But some facts needed to be considered for choosing a particular alarm system which must have a unique advantage of perceiving an intrusion without subjection to a false alarm production.

This alarm system (***Light Operated Domestic Alarm***), has been designed to have a unique advantage of triggering ON a light source followed by an alarm immediately an unwelcome guest is detected. The circuit will work as a **single interrupted touch sensitive switching circuit,** thereby switching a light source directed to a sensor through a relay. An alarm circuit triggers on as quick as the light flashes unto a photocell.

The device consists of four (4) parts: **the power circuit, touch sensitive circuit light sensing circuit or control panel unit and the alarm circuit.** The power unit consists of a transformer which steps down the 220V utility supply alternating current *(rms value)* to 12V D.C. The A.C is then rectified, filtered and regulated by means of a bridge rectifier to a pulsating direct current. Filtering was done by the capacitor to remove the fluctuations or pulsation (ripples) present in the output voltage supplied by the rectifier to the filter.

The Touch Sensor circuit and the control panel will work in conjunction and harmony as the brain of the whole circuit for detection and transmission of the detection message to the alarm circuit. Therefore, the input of this device is the human hand or finger of an intruder forming a closed circuit with a touch sensitive switch thereby switching ON a light source (beam) through a relay powered by Monolithic Darlington Transistor (MDT) to achieve a maximum output. This serves as the detector or the controlling quantity (Remote – Control System) by sending a beam message(signal) on the sensor (photocell) and exchanging light energy after absorption.

The control panel functions through a relay by monitoring the alarm circuit and providing sequence switching to other peripherals e.g. an audible warning device like loudspeaker. This output is the controlled quantity which serves as the indicator of an intrusion. This is done by the photocell sending out an alarm message through the speaker thereby alerting the people in the building of the presence of an unwelcome guest.

1.2 AIMS AND OBJECTIVES

The presence of some unwelcome guest and thefts in a house especially in this age of mass unemployment, causing slated workers to look for alternatives in a wrong direction by intruding houses and cars to steal what is not theirs, has been posing a great problem in our economy. This calls for a sensitive and reliable security or alarm system for detection and indication of the presence of these intruders or unwelcome guest so that protective measures can be taken to combat their attacks.

In this age of very loose security, stolen cars and stolen properties from houses were being announced almost everyday in our media without any later recovery from the hoodlums or their detection. Due to these disheartening state of economy and safety, it is inevitably necessary to sit down, design and construct a reliable security system which can be used to detect and implicate the presence of an intruder or any unwelcome guest so that workable measures can be taken e.g. alerting a police nearby.

These threatening issues of our age led to the design and construction of an ever workable ***Light Operated Domestic Alarm System*** which is Touch Sensitive to detect the presence of an intruder (hoodlums and unwelcome guest) by alerting us so that needed urgent measure can be taken.

1.3 METHODOLOGY

The method employed is the Doppler Shift Effect (DSE) method whereby a transmitted signal is altered in frequency. The photocell produces a signal which holds the system in a non-alarm condition until a base current (I_b) is supplied from the human hand for the completion of the alarm circuit (closed circuit) which thereby switches ON a light source through a control panel (Relay) unto the light photocell (LDR) causing a breakage or an interruption in its signal flow and setting-off an alarm. The light sensor serves as a transducer.

The detector is operated in parallel with the alarm and light there-by permitting simultaneous triggering of the two (light and alarm). Detector output is fed into a 12V relay whose contact enables visual indication and audio indication (alarm).

The detector is remotely located from the indicator i.e. open loop control system. When light falls at normal incidence on the photocell, a current is produced proportional to the field E and there is an exchange of energy, linear momentum and exchange of angular momentum.

From the electromagnetic theory, every detector of light is an energy transducer (converters) given as

$$W = \in E^2$$

where W = energy per unit volume

E = electric Field intensity

$\in$ = electric field constant

The block diagrams of Figure 1.1. shows the stages involved in this project.

According to Einstein, an electromagnetic wave consists of a stream of energy particles called photon with an electron during the photoelectric effect of the sensor. This results in transmission of energy to the electron there-by sending the signal to the indicator (speaker) through the Astable Multivibrator **(CD4047 BCN)** serving as an intermediary of communication between them.

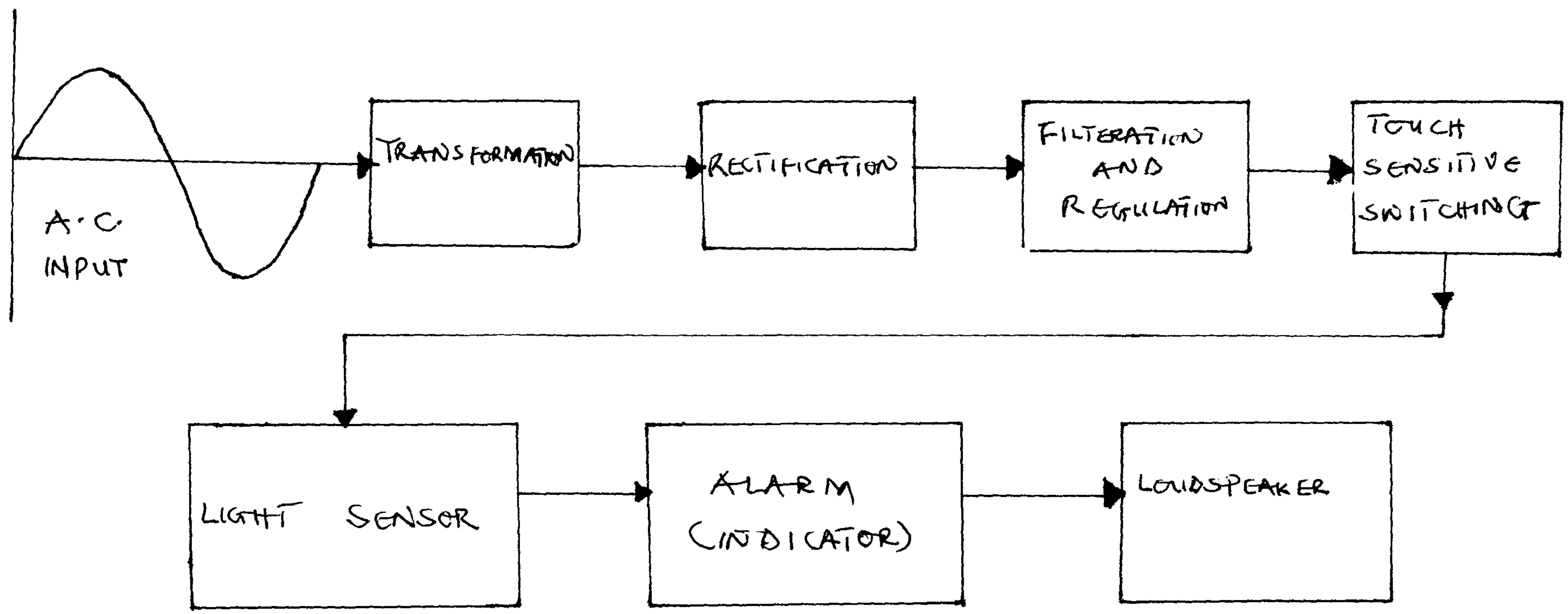


FIGURE 1.1: BLOCK DIAGRAM OF THE ALARM SYSTEM.

The control panel (touch sensitive switch) serves as the nerve centre monitoring the circuit for a continuous flow of signals, thereby monitoring the alarm circuit and providing sequence-switching to the audible warning device(loudspeaker).

1.4 LITERATURE REVIEW

An alarm system is a system which operates a warning device immediately after an abnormal or dangerous occurrence. They are used to signal undesirable or dangerous situations such as the presence of an intruder or an unwelcome guest. In factories, these systems detects such things as excessive process temperature or pressure or rapid changes in a processing condition.

The main function of a security alarm system is to detect and indicate the intrusion of an unauthorized entry into a defined area, and an undesirable or dangerous situations as fast as possible. Furthermore, an ideal security system should be difficult to bypass, highly reliable, highly sensitive and must operate under adverse conditions. For example, it must not be subject to false alarm, have to cover or protect a volumetric space (3 dimensions) and must not be an alarm system that can be easily "jumped" if the intruder has a prior knowledge of the system being installed there. False alarms may be a problem if the system can be triggered by movements of small animals or objects which may be shifted by air movements.

Basic alarm systems are usually open-loop control systems containing two essential components: **an alarm detector and an alarm indicator.** Frequently, they are remote – control systems, i.e. the detector is located remotely from the indicator (open-loop control system and remote control system). Most systems are designed to monitor a continuous signal by means of a control panel; and, when the circuit producing this signal is broken by an intruder or by a failure in the equipment, the signal is interrupted and an alarm is set off.

Opening of doors, windows, ventilation openings or breaking a pane of glass, interrupts the circuit, causing an alarm either locally or at some locations which is continuously staffed.i.e. where people are always available to sense or receive any detection signal.

Newer types of alarm systems may use beams of light either visible or invisible, or narrow radar beams and ultrasonic energy which effectively create a fence. Interruption of this beam triggers an alarm. If the intruder succeeds in penetrating the fence without triggering the alarm, detection is unlikely. Movement within the covered area produces a doppler shift in one or more receiving units, causing an alarm.

There are two basic categories of security alarm:

(1) Perimeter Intrusion Detection

(2) Space (Volumetric) Detection

1.4.1 PERIMETER INTRUSION DETECTORS

These are detectors that protect the circumference of an area such as detectors that use magnetic switches. When the magnet is moved away from the switch it triggers an alarm. Another example of a perimeter detector is the Mat or the so-called Ribbon type always installed at the entrance point of the area to be protected. Stepping on the closes an electrical contacts, thus triggering an alarm.

The disadvantage of the perimeter detection is that it can be "jumped" by paralleling the electrical connection prior to breaking.

1.4.2 SPACE (VOLUMETRIC) INTRUSION DETECTION

It detects intrusion in volumetric (three dimensions) and generates an energy yielded in all directions e.g. light beam employing a light source and photo-electric cell. Whenever the beam is broken by someone passing through it an alarm is triggered on. Pressure mats are also widely used and constructed from two pieces of foil held apart by a perforated piece of foam. The metallic tape has an electrical current passing through it which causes an electromechanical relay to be activated. Any intruder breaks the tape by interrupting the current to the relay. This de-energizes the relay and causes its contacts to operate the alarm indicators.

The space intrusion detector is a sophisticated type. One of its major advantages is that an intruder has to pass through its energy field before the intruder can get to the device; so intruder might not be able to 'jump' it or cut off its power supply. **But,** what of an object thrown by the passer-by or small animals like rats that stays around the compound?

Due to this disadvantage, I have chosen to design an alarm (security) system that will function using light and a touch sensitive (contact) switch as the intrusion detector. This cannot be electrically shunted because it will respond to only human touch which produces a base current for a closed circuit. It can also detect intrusions both day and night and not seasonal. It can be classified as a ***CONTACT DETECTION*** method.

Many other type of alarm system are used in industry to alert personnel to the presence of an abnormal condition requiring corrective actions. An alarm system is useful only if it will perform reliably when needed, perhaps months since the time it last operated. This suggests the need for a warning device that announces failures in the alarm system.

Alarm system has two major circuits: Detector circuit and Indicator circuit. The detector monitors situations and provides the information required to decide whether or not an abnormal or dangerous condition exists. This information passes through the control panels and thereafter to an indicator which translates information from alarm detector into a warning signal when a predetermined limit is exceeded and an intrusion occurs. There are also fire alarms and smoke detectors.

1.5 PROJECT OUTLINE.

Undesirable and dangerous situations such as the presence of an intruder, smoke and fire outbreak has led to the invention of alarm system and detectors to either sound a warning or an awareness so that proper preparation or measures can be taken to combat it.

Chapter One of this project deals with the introduction, literature review and the methodology used in the design and construction of this alarm system. They all serve as a brief preface to the whole content.

Chapter Two discusses the design procedures of the project. It started from the power unit, transformation of the 220V a.c. (line supply) to 12V d.c. supply which is rectified, regulated, smoothened and filtered before it is being supplied to the rest of the circuit.

In addition, Chapter Two involves the design of the most sensitive part which is the touch sensitive switch comprising of an npn darlington pair (BC108), touch sensitive plate and a 12V relay working in conjunction with a limiting resistor. This sensitive part is the detector of intrusion when touched. It triggers a light source through the help of the 12V relay (serving as a switch) unto the alarm section.

Design of the alarm system is the third stage of Chapter Two which comprises an npn darlington pair (BC337), an astable multivibrator (IC_1), photocell (LDR), ceramic capacitor, resistor and electrolytic capacitor working dependently to sound an alarm through the speaker (loudspeaker) indicating a detection from the touch sensitive section through the sensor in the dark.

Chapter Three deals with the conceptual mode of operation of the alarm system, the construction aspect with the materials used and the constructed system, the result, possible modification, casing, precautions and the economic importance of the constructed system.

Chapter Four caps it all with the conclusion, recommendation and the references consulted.

CHAPTER TWO

2.0 SYSTEM DESIGN

2.1 DESIGN STAGES

The design of a light operated alarm system undertaken in this work is of three modules: The power supply unit, detector and the alarm circuit (indicator).

The power circuit serves as the actuating circuit or energizing circuit for the rest of the circuits. **The detector** of intrusion is the touch sensitive switching circuit detecting through a touch plate. **The indicator** is the alarm circuit itself outputting through a 2.5 inches sound speaker notifying the inhabitants of the intrusion of an unwelcome guest.

2.2 POWER SUPPLY UNIT

This unit supplies a regulated power to both the alarm circuit and the touch sensitive switch circuit. It is made up of the transformer, rectifier, filter and voltage regulator, requiring 12V d.c. supply (Figure 2.1). Power to the system must be supplied from a reliable source and a standby alternate power source is more desirable because security check must be on a constraint basis.

2.3 POWER TRANSFORMER

Power transformer is the static electrical machine used in stepping-down or stepping-up the electrical voltage and current. The one used in this project is a 220V/12V/500mA step-down transformer with the 220V as its primary winding voltage (v_1) and 12V as its secondary winding voltage (V_2). This is shown in Figure 2.2.

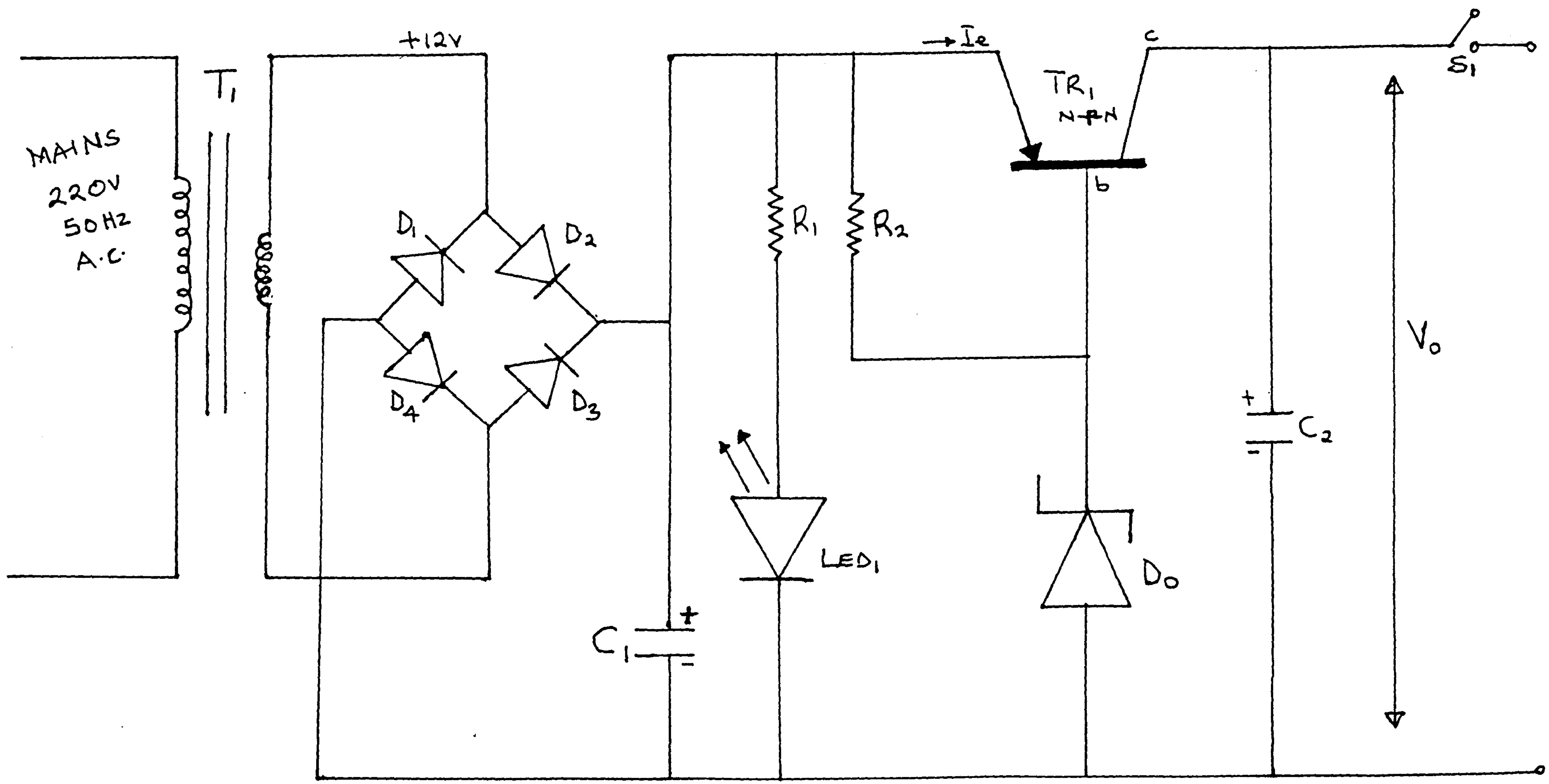


FIGURE 2.1: POWER UNIT FOR THE ALARM SYSTEM

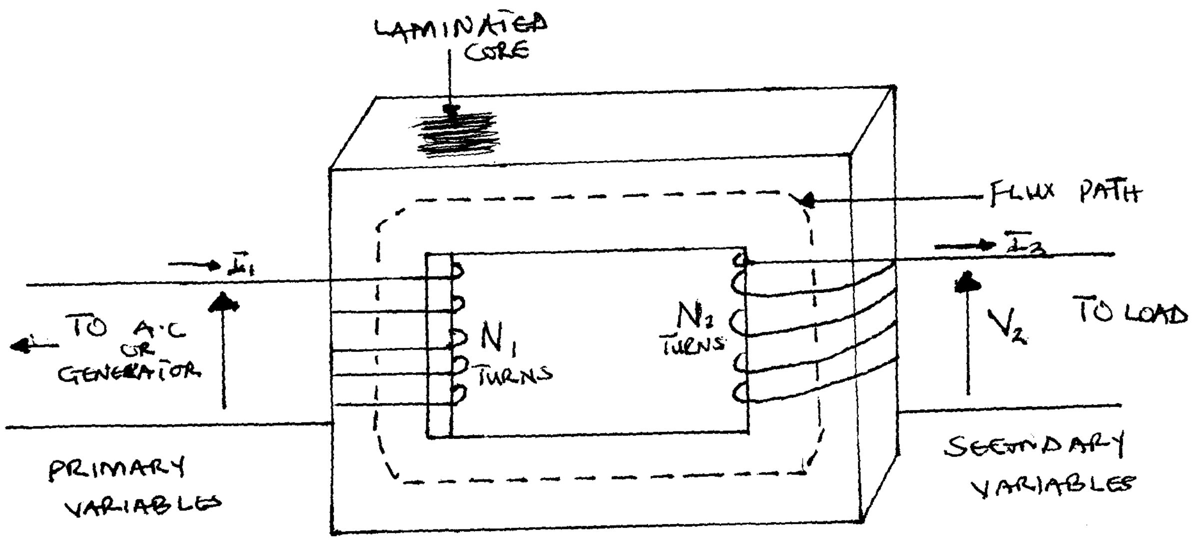


Figure 2:2 POWER TRANSFORMER

2.4. OPERATION OF THE TRANSFORMER

When an alternating voltage is applied to a transformer i.e. through the primary winding (N_1), an alternating , limited in value by the inductance of the winding flows. This magnetizing current produces an alternating magnetomotive force (mmf) which operates an alternating magnetic flux (φ) in Weber. The flux is constrained within the magnetic circuit and induces a voltage in the linked secondary winding (V_2) which produces an alternating current if it is connected to an electric load. This secondary load (I_2), in turn produces its own mmf (E) and creates a further alternating flux which links back with the primary winding (V_1).

A load current then flows in the primary winding (V_1) of sufficient magnitude to balance the mmf produced by the secondary load current (I_2) so the primary winding turn (N_1) carries load current, and the magnetic circuit or core (Fig. 2.2.) carries only the flux produced by the magnetizing current.

The relative voltages across each winding and the current flowing in them are related by the ratio of turns in the two windings as follows:

<u>Voltage Relation</u>

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

where a = winding turns ratio or transformer turns ratio

Current Relation

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

where I_1 = Induced primary current

I_2 = Induced secondary current

V_1 = Primary voltage (rms voltage)

V_2 = Secondary Voltage

N_1 = Primary winding turns

N_2 = Secondary winding turns

From Fig. 2.2, primary voltage = 220V

Secondary Voltage = 12V

$$\Rightarrow \frac{N_1}{N_2} = \frac{220}{12} = 18.3 = a$$

The instantaneous value of induced e.m.f in winding of N – turns is given by:

$$E = \frac{Nd\varphi}{dt}$$

Where $\frac{d\varphi}{dt}$ is the rate of change of flux linkages with the turns.

$$\text{Thus} \quad \frac{V_1}{V_2} = \frac{N_2}{N_1} = \frac{I_1}{I_2}$$

To determine the number of turns, we know from the data book that there is 0.778V per turn for sWG 44 and sWG 28 copper wire.

∴ Number of turns of primary winding (N_1)

$$= \frac{\text{Primary Voltage}}{\text{Voltage/Turn}}$$

$$N_1 = \frac{220}{0.778} = 282.78 \text{ turns}$$

For tolerance sake, we can take the turns to be 285 turns

Number of turns of secondary winding (N_2)

$$= \frac{\text{Secondary Voltage}}{\text{Voltage/turn}}$$

$$N_2 = \frac{12}{0.778} = 15.42 \text{ turns}$$

$$\text{Voltage per turn (VPT)} = \frac{|V_1|}{N_1} = \frac{w\,\Phi max}{2} = \frac{|V_2|}{N_2} \text{ (V/turns)}$$

$$\therefore \text{VPT} = \frac{2\pi f}{\sqrt{2}} \text{ABmax} = 4.44\text{fABmax V/turns}$$

Where f = frequency corresponding to 50Hz

B = flux density measured in Tesla

A = core area of the Transformer

$$\text{VPT primary} = \frac{220 \text{ rms}}{283} = 0.777\text{V/turn}$$

The secondary voltage follows from

$$|V_2| = \frac{|V_1|}{a} = \frac{220}{a}$$

but $a = \frac{N_1}{N_2} = 18.3$

$$|V_2| = \frac{220}{18.3} = 12.02\text{V} \approx 12\text{V}$$

N.B. The transformer is assumed ideal; so its core lacks losses. In other words, there exists neither hysteresis nor eddy-current losses and copper loss is assumed to be negligible.

2.4.1 THE BRIDGE RECTIFIER

The waveform of the transformer secondary voltage (V_2) is an alternating sinusoidal voltage which corresponds to 12V and assumes a sinusoidal voltage of V = Vmaxsinwt. This a.c. has a property of changing its polarities which can either be positive or negative half cycles. The process of converting this sinusoidal a.c. voltage to a direct component (d.c) of 12V is called rectification and employs the use of rectifiers (mostly diodes) to change a.c. voltage into d.c. by eliminating the negative (-ve) half cycle of the a.c. voltage.

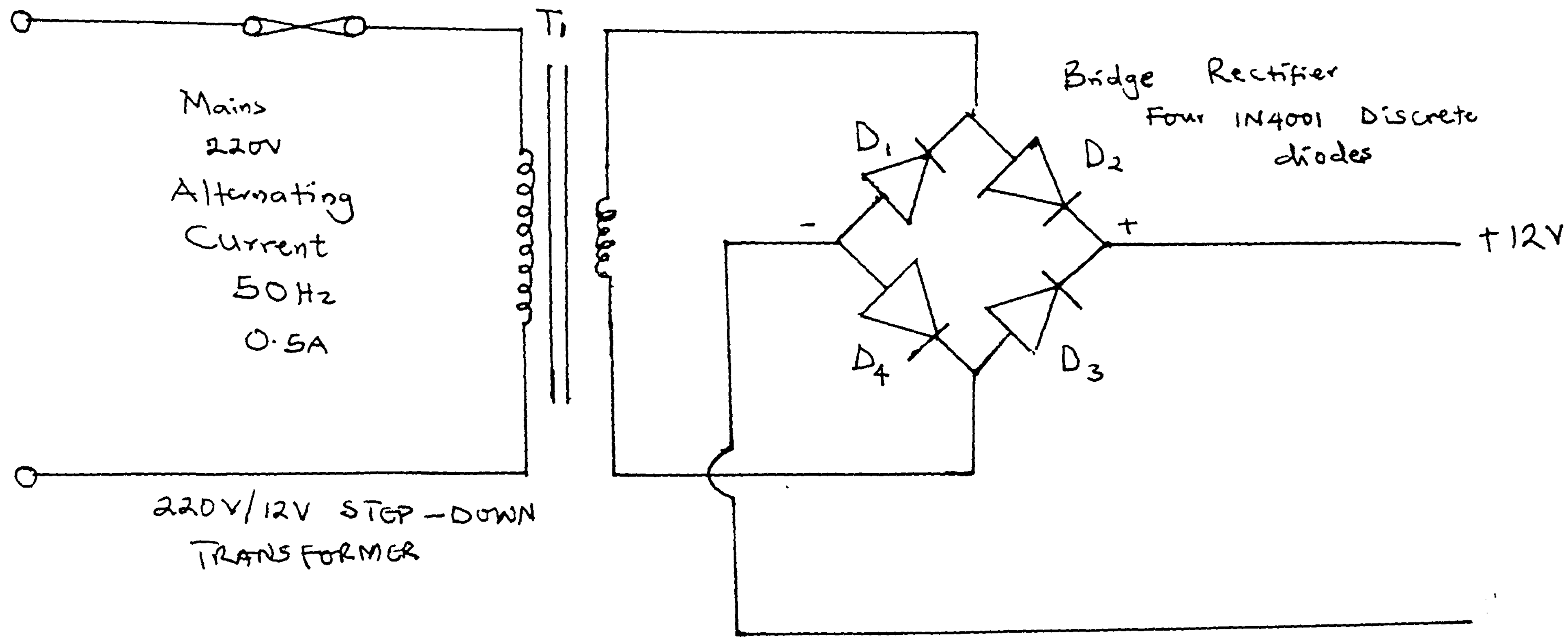


FIGURE 2.3: FULL-WAVE BRIDGE RECTIFIER

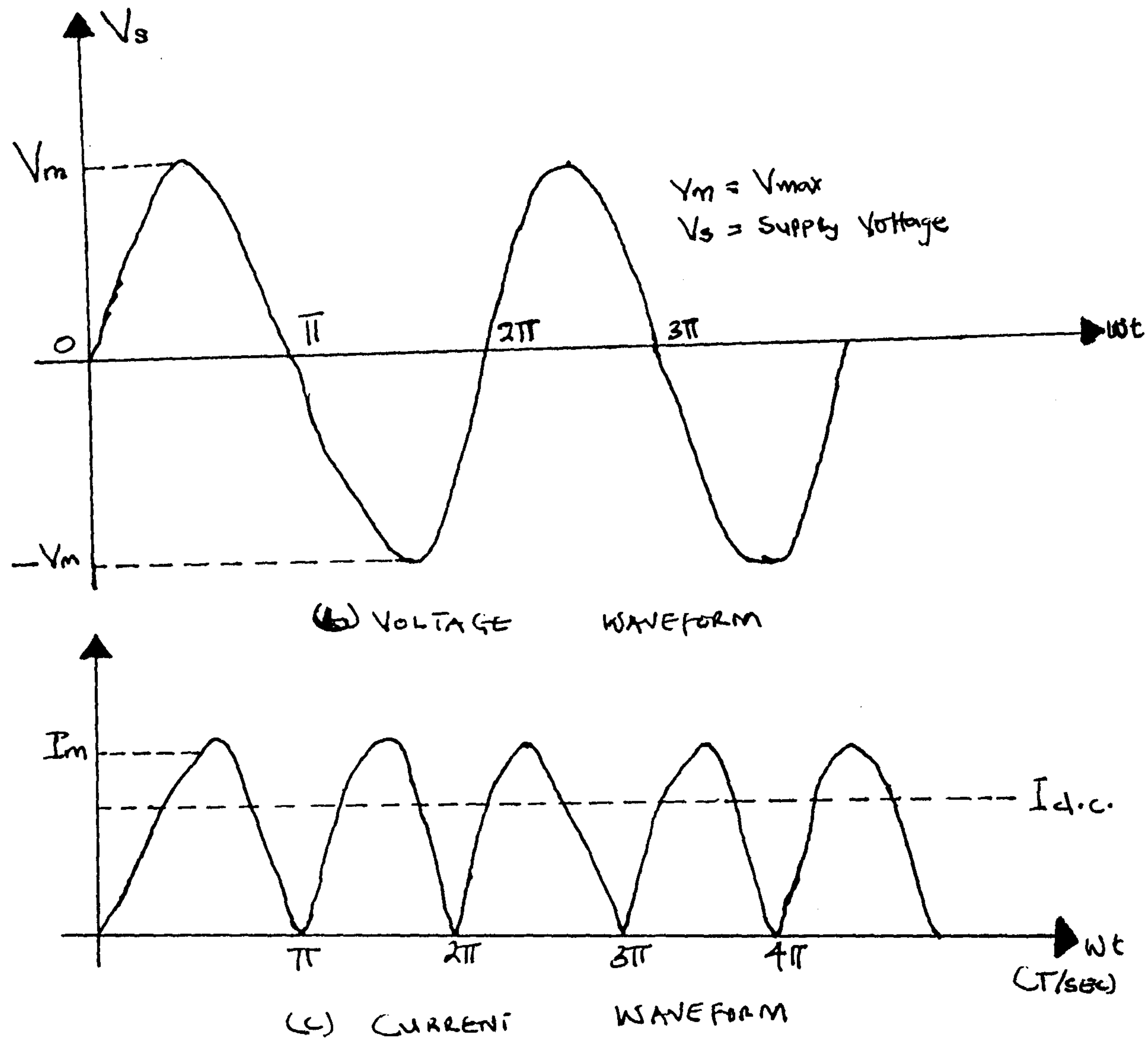


Figure 2.4. FULL- WAVE RECTIFICATION

The maximum reverse voltage (break down voltage) of a diode is known as the Peak Inverse Voltage (PIV) and for the bridge rectifier, it is twice the input voltage [Vpeak from the rectifier].

PIV = 2Vm = 2 x 12V = 24V

A safety of 2.0 is allowed for the IN4001 diode which implies that:

PIV = 24V x 2.0 = 48V

Hence, IN4001 diode was chosen since it has a PIV of 100V.

2.5 FILTERING

The output of the rectifier power supply are not pure forms of direct current since the amplitude of the output d.c. energy of the full-wave rectifier changes at an undesirable rate as in half-wave rectifier e.g. a change at the rate of 120times per second instead of 60times per second. This is known as ripple frequency and a high frequency ripple is introduced hereby.

In order to obtain a pure form of direct current, a filtering circuit is employed comprising of a filter of an electrolytic capacitor of 1000μF/25V connected across a 1Ωk (1000Ω) load resistor.

When the diodes are conducting, the capacitor is being charged and the applied pulse increases in amplitude thereby charging the capacitor to the peak values of the pulse. When the pulse starts to drop (discharge), the accumulated charge on the resistor flows through the load resistor in a discharging action (form).

Assuming the capacitor discharges linearly,

$$\text{Capacitance } C = \frac{\text{charge quantity}}{\text{Voltage}}$$

Assuming the current value to be 0.01A(as measured) and the period t to be 1 second,

$$Q = CV \text{---------------------------------} (2.1)$$

If a low or small capacitor value is used for filtering, (may be of 25μf), the output current will be lower compared to that of 1000μF. Thus C_1 is a determining factor for the output current and must be of higher value. The 1000μF capacitor(**C_1**) filters the high frequency ripples from a.c. input to give a steady stable d.c. output through charging and discharging processes.

From equation 2.1, Charge quantity = Current x Time of charging

$$\text{======>} \quad Q = 0.01 \times 1 = 0.01\text{Coulomb}$$

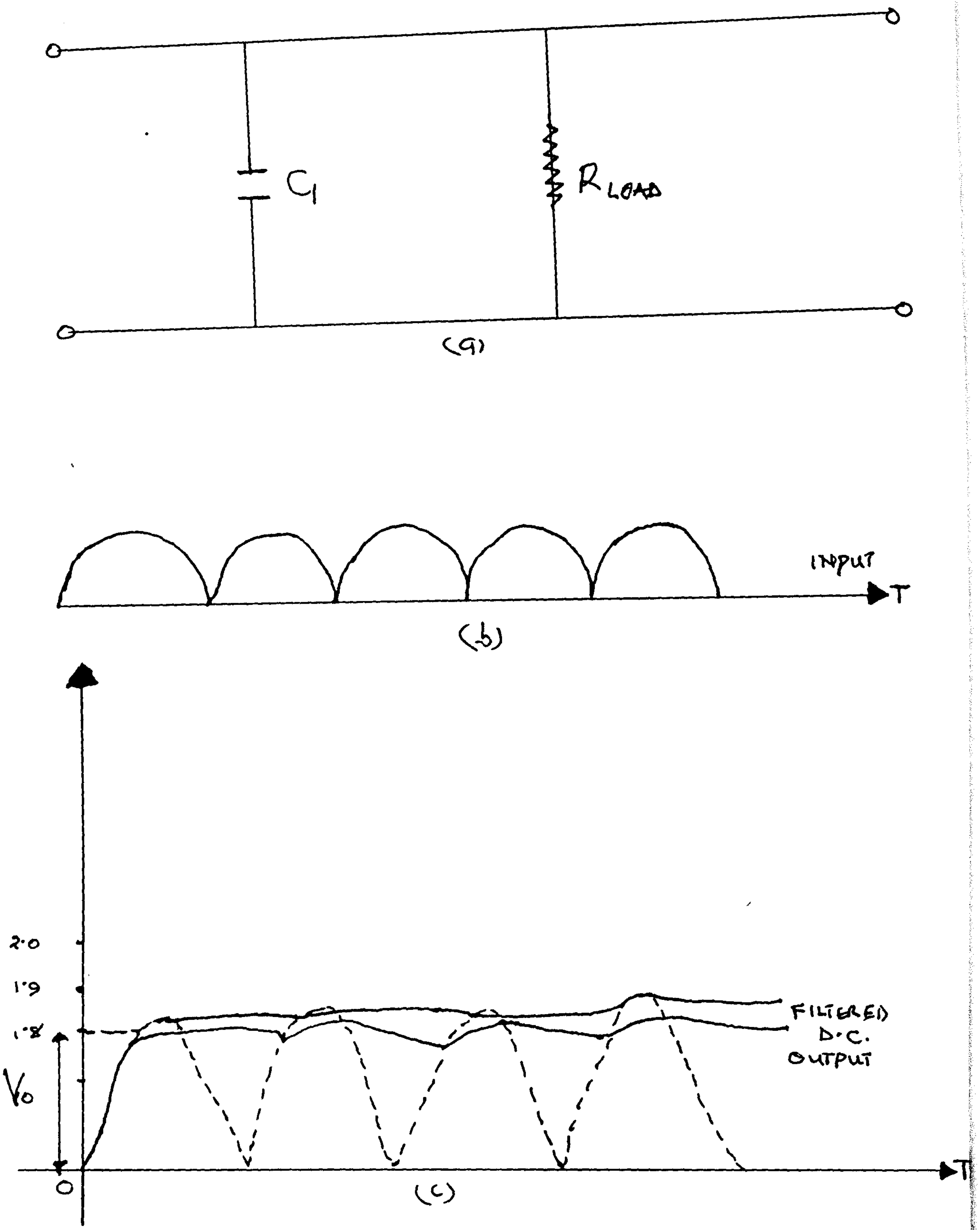


Fig. 2.5: RECTIFICATION WAVE-FORM

From above,

$$C = \frac{\Delta q}{\Delta v} = \frac{0.01}{12} = 0.0008333F$$

$$\therefore \quad C_1 \cong 0.001F = 1000\mu F$$

Thus, Capacitor C_1 introduced a new path for a.c. and left d.c. on the path. This is shown in Figure 2.5.

2.5.1 THE RED LED (LIGHT EMITTING DIODE)

It is basically a semi-conductor P-N junction diode which when supplied with electrical energy, is capable of emitting light under the forward-biased condition. It serves as the power supply indicator or a display device indicating the presence of power in the system. The resistor used in series with the LED_1 is serving as a limiting resistor to the red LED by preventing it from getting damaged by a large or over-voltage surge due to possible flow of high current in the component. Thus, its value needs to be high enough to combat this occurrences.

From data book,

Forward voltage drop of LED = 2V

Maximum forward current = 10mA

Supply voltage (V_2) = 12V

$$\text{Limiting resistor } (R_1) = \frac{12-2}{0.01} = \frac{10}{0.01} = 1000\Omega = 1k\Omega$$

2.6 VOLTAGE REGULATION

Zener diode provides a reasonably stable voltage output or controlled output and are installed in the circuit with the proper orientation (reverse-biased condition). It stabilizes the supply voltage and is frequently used when the current demand is small.

In general, if the current demand exceeds 50mA or if an increased stability is required in the circuit, or a variable output voltage is required, a series transistor voltage regulator (Regulating transistor) is used as shown in Figure 2.6. A stable 12V Zener diode (D_o) is used (applied) between the base and the emitter of the **C945** npn bipolar transistor. It has its breakdown voltage to be 12V d.c.

The potential difference across the resistor R_2 provides the emitter-base voltage (V_{EB}). The output voltage (V_o) is therefore given by the addition of V_{EB} and the constant potential difference across the zener diode (V_z).

$$V_O = V_z + V_{EB}$$

where V_{EB} = base to emitter voltage and is approximately 0.8V since its current gain is less than the total input current and its voltage gain is high.

V_z = the constant potential different across the zener diode

Thus, a regulator is needed to make the rest circuit work effectively to give the desired detection and indication of an intrusion. Resistor **R_2** serves as a limiting resistor. It is a high-rated resistor used as a power resistor for limiting the input voltage to the power transistor (TR_1) for regulation. It is applied through the base terminal of the transistor to a 12V zener diode (D_o).

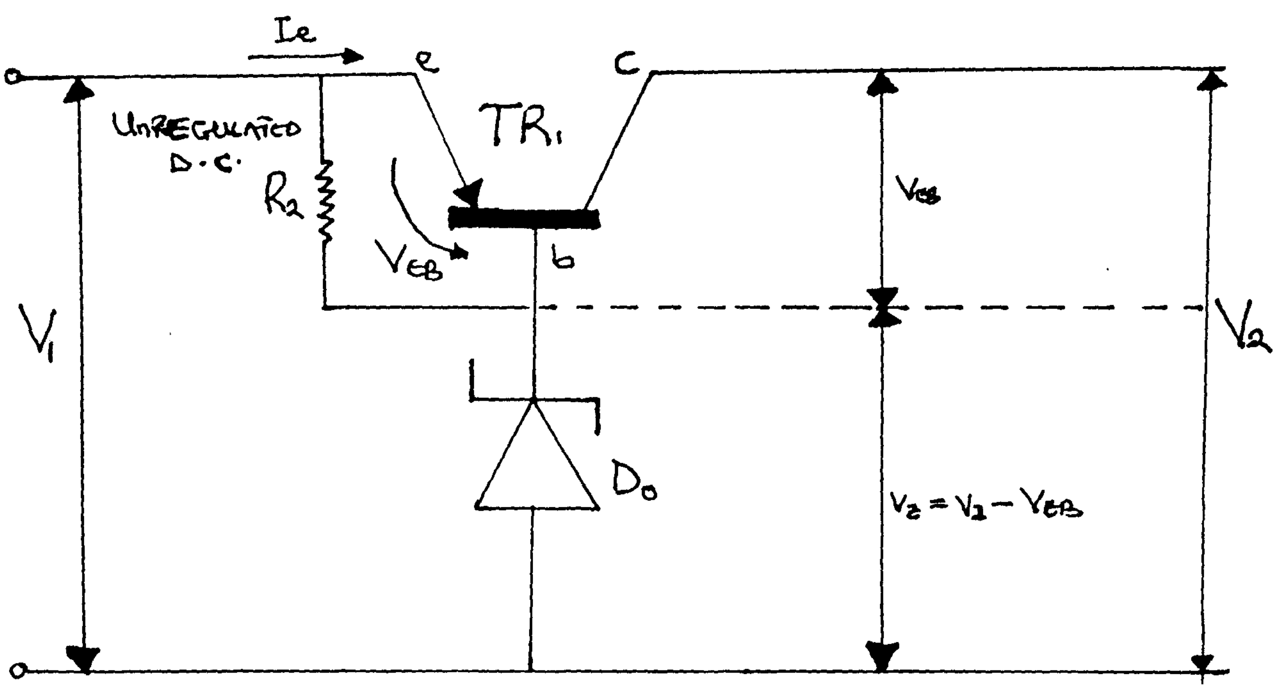


Figure 2.6: REGULATING TRANSISTOR (SERIES)

R_2 supplies operating current for the zener diode (D_o) and base current for the transistor (TR_1). Variation of the emitter current (Ie) will be between resistor R_2 and zener diode Do.

$$\Rightarrow Vo = V_2 = V_{EB} + V_Z$$

but V_{EB} = 0.8V and V2 = 12V

$\therefore \quad V_Z = V_2 - V_{EB}$

$= 12 - 0.8 = 11.2V$

Taking the voltage across Do and R_2 to be V_Z and VR_2 respectively:

Ie is divided to R_2 and Do (through TR_1).

Let their resistance value be Re where $Re \overset{x}{=} R_2 + R_Z = R_{total}$

V_Z is assumed an input voltage

i.e $V_Z = V_i$

Assuming $R_Z = R_2$

Ie = the emitter current = 0.01A

$$\therefore \quad \frac{V_i}{I_e} = \frac{V_Z}{I_e} = R_e$$

$$\Rightarrow \frac{11.2V}{0.01} = R_e = 1120\Omega$$

But $R_T = R_e$ and $R_2 = R_Z$

$\Rightarrow R_T = R_2 + R_Z$

$R_T = 2R_2$

$$\therefore \quad R_2 = \frac{R_e}{2} = \frac{1120}{2} = 560\Omega$$

2.6.1 SMOOTHING

Smoothing is sometimes necessary after filteration just to attain a more stable steady supply of d.c. output.

A ripple voltage is determined by the value of the **reservoir capacitor**, the load current and the supply frequency (which determines the time over which the capacitor discharges). A smoothing capacitor also called **Reservoir capacitor (C_2)** of 100μF, 16V capacitor is used here for smoothing of the filtered voltage to desired ripple-free d.c. output. This capacitor tries to eradicate any 'stubborn' ripple which might have escaped the filter. C_2 thus gives a neat pulsating d.c. output. It reduces the ripples to the bearest minimum.

The peak value of the rectified voltage waveform is 96V and the supply voltage frequency is 50Hz (line source). The ripple must not exceed 18.3V (the turns ratio of the transformer winding as calculated in section 2.4.) else distortion will be introduced into the output voltage. The load current is 10mA (0.01A) maximum.

2.7 TOUCH SENSITIVE SWITCHING CIRCUIT

The touch sensitive switching circuit serves as the detector intrusion. When the intruder (unwelcome guest) touches a car door (serving as the touch plate) connected to the touch sensitive switch, comprising 2 NPN transistors (TR_2 and TR_3) forming a darlington pair and a 12V relay, the input current which flows through the finger-tip passes through the two parallel resistors becoming the base current (I_4) and (I_3) for the BC108 darlington pair transistors (after the circuit might have been closed by the intruder's finger-tip) which thereafter turns the transistors ON (Figure 2.7).

The BC108 transistor's collector current (I_c) was used to amplify the signals going through a silicon diode (IN4001) to trigger the light source ON. This is an example of a latching circuit. The amount of the base current that will start up the transistor through a limiting resistor will be:

$$I_4 = \frac{V_{cc}}{R_4}$$

where $V_{cc} = V_2 = 12V$

$$\Rightarrow \frac{V_{cc}}{R_4} = I_4 = \frac{12}{R_4} = \frac{12}{R_4}$$

From Figure 2.7, R_3 and R_4 act as a voltage divider (potential divider).

$\Rightarrow$ Equivalent potential $V_T = V_2\ VR_3 + VR_4 = 12V$ d.c.

from Figure 2.8, resistor R_3 and R_4 are in parallel and taking the equivalent resistance to be R_{Total},

$$R_{total} = \frac{R_1\ R2}{R_1 + R_2} \text{ ---------------------------(2.2)}$$

Resistor R_3 will improve the operation of the circuit by serving as a limiting resistor while resistor R_4 serves the same purpose by limiting the voltage input

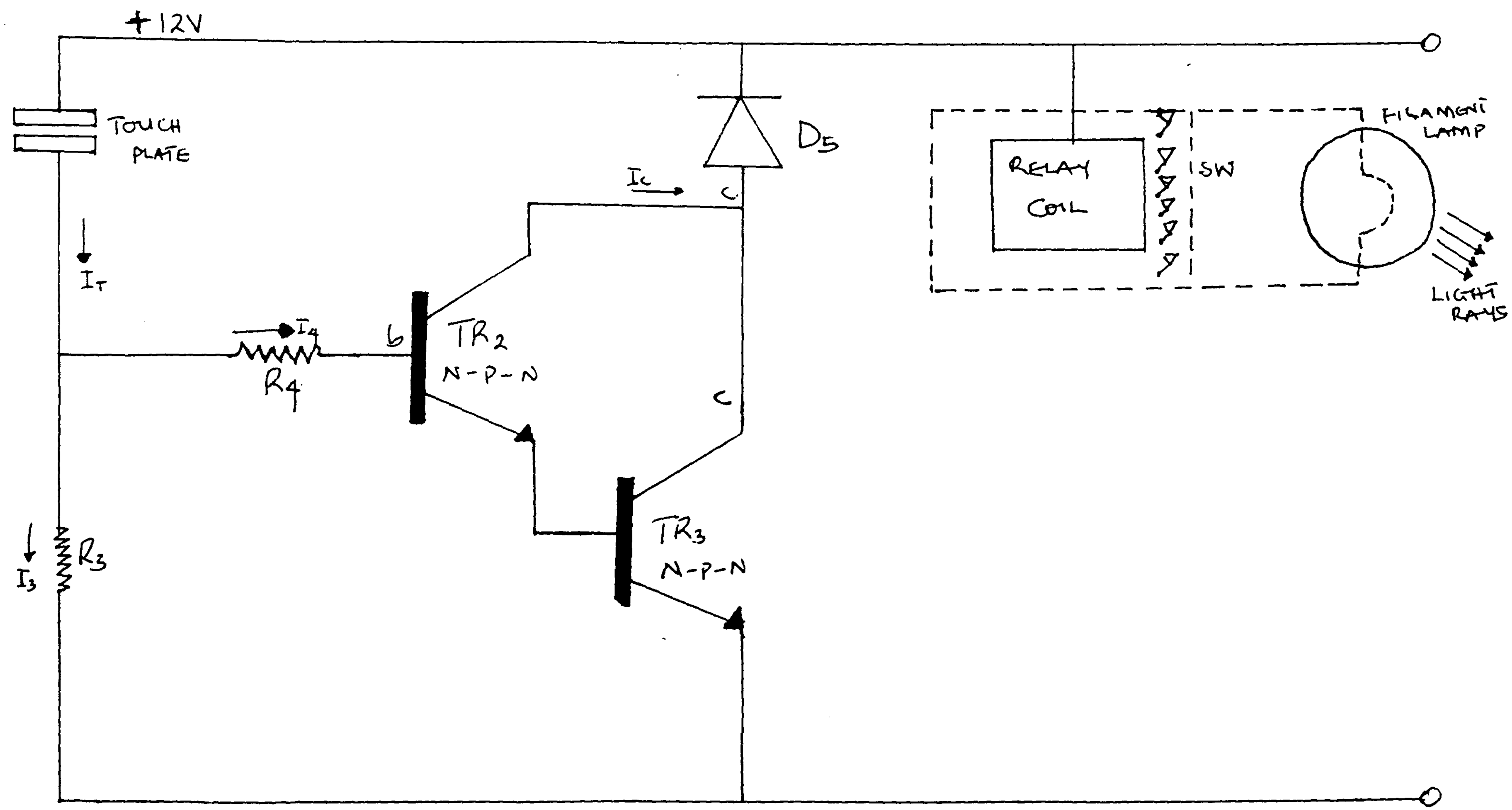


FIGURE 2·17: TOUCH SENSITIVE SECTION OF THE ALARM SYSTEM.

level into the BC 108 transistors (darlington pair TR_2 & TR_3) by putting a check on the entering voltage into them.

The darlington pair collector current (I_4) in Figure 2.8. will amplify or actuate the triggering of the light sources which shines with its intensity upon the photocell (sensor) through the relay coil thereby carrying a detection message signal to the alarm circuit. The sensor is covered (encased) to give it a dark environment. The TR_2 and TR_3 supplies its collector current output (I_c) through a diode (D_5) to trigger on the bulb (light source).

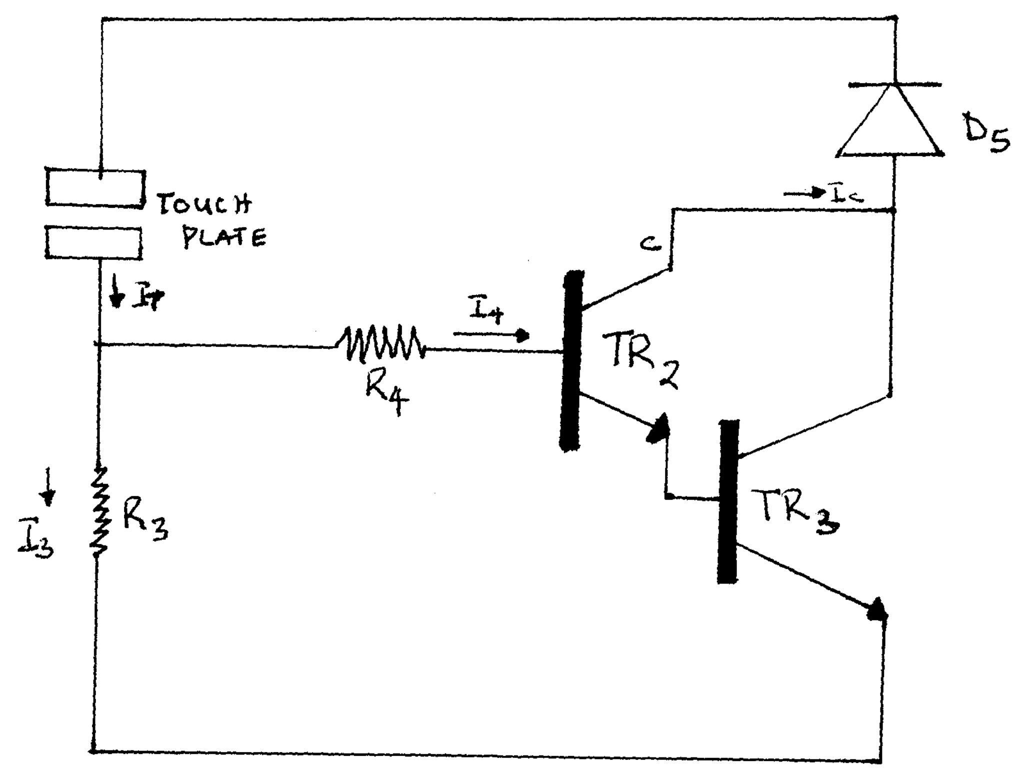


Figure 2 8: TOUCH SENSITIVE DARLINTON PAIR

The base and collector are biased positively with respect to the emitter. The arrow is the direction of current flow.

From Figure 2.8,

$$I_T = I_3 + I_4 \text{...}(2.3)$$

The base emitter diode is forward biased. The base collector diode junction is negatively or reversed-biased. With no base current, there won't be current flow in the collector circuit due to the reverse biased collector-base junction but with current flow into the base circuit, current flows in the collector circuit. The value of I_c is much higher than the base current (I_b). $\Rightarrow I_C > I_b$

$$\text{Current gain of the transistor } (\beta) = \frac{\text{Change in collector current}}{\text{Change in base current}}$$

$$\therefore \beta = \frac{I_C}{I_b}$$

$$\text{Base Potential } V_B = \left(\frac{R_3}{R_3 + R_4}\right) Vs = \text{Voltage divider}$$

Emitter potential will be $V_e = V_b - V_{BE}$

The circuit has a low output impedance and high input impedance. Potential of base and emitter are the same resulting in a unit current gain (β). Diode D_5 (IN4001) is used here as a semiconductor diode conducting in only one direction. It conducts I_C in only direction. The diode is reverse-biased so its maximum reverse breakdown voltage (which is its Peak Inverse Voltage (PIV)) is 100V

$$PIV = 2Vm$$

$$= 2 \times 12V = 24V$$

For a safety of 2.0, $PIV = 24 \times 2.0 = 48V$

This diode prevents damages to the BC 108 darlington pair from a back-voltage which may be produced in the opposite way (reverse-biased). So the back-voltage goes through the diode. From equation 2.3 and the current value measured during one of the operation of the system, current I_4 was measured to be 0.00534A and I_3 to be 0.00521A Addition of I_3 and I_4 gives our equivalent current value I_T

$$=> I_3 + I_4 = I_T$$

$$0.00534 + 0.00521 = 0.01055A.$$

$$\text{Total power input} = I^2R = IV$$

$$= (0.01055)(12) = 0.1266W$$

The base-emitter voltage (VR_4) will be:

$$VR_4 = \left(\frac{R_4}{R_3 + R_4}\right) Vcc$$

where $Vcc = V_2 = 12V$ d.c.

From above,

$$\frac{VR_4}{I_4} = 1 + R_4$$

where $VR_4 = 11.75V$ $\therefore$ $\frac{11.75}{0.00534} = (1 + R_4)$

$$11.75 = 0.00534 + 0.00534R_4$$

$$R_4 = \frac{11.75 - 0.00534}{0.00534}$$

$$= 2199\Omega \cong 2200\Omega \quad \text{or} \quad 2.2k\Omega$$

From the TR_2 and TR_3 (darlington pair),

$$V_{cc} - VR_4 = I_3R_3$$

$$=> \quad V_{cc} = VR_3 + VR_4$$

$$R_3 = \frac{12 - 11.75}{0.00534} = \frac{0.25}{0.00534}$$

$$R_3 = 46.8\Omega \cong 47\Omega$$

$$VR_3 = I_3 \cdot R_3 = \left(\frac{R_3}{R_3 + R_4}\right) V_T$$

where $V_T = V_2$

$$VR_3 = \frac{(47)}{(47+2.2K)} \cdot 12V = 0.25001V = 0.25V$$

Hence voltage across resistor R_4 will be:

$$(VR_4 = I_4 \cdot R_4 = \left(\frac{V_T}{R_T}\right) R_4$$

$$VR_4 = \left(\frac{V_T}{R_3 + R_4}\right) R_4 = \frac{(12)}{(22 + 47)} 2.2k = 11.74899V \cong 11.75$$

Therefore for confirmation of the voltage division,

$$V_T = VR_3 + VR_4 = 0.25 + 11.75 = 12V$$

I_T is the input current and when the finger-tip applied triggers the BC 108 to work and this can be a variable value depending on the intruder's finger resistance value. From the darlington pair (BC 108) of TR_2 and TR_3, the resistance values are determined by

$$\frac{VR_4}{I_4} = (1 + R_4)$$

$\therefore$ Power into the Transistor $TR_2 = \Delta Ib^2 R_B = (0.00534)^2 (R_4)$

$$\frac{VR_4}{I_4} = 1 + R_4$$

$$R_{total} = \frac{R_3 R_4}{R_1 + R_2} = \frac{2.2k \times 47}{2.2k + 47} = \frac{103.4k}{2.247k} = R_T = 46.02\Omega$$

2.7.1 LIGHT SOURCE AND RELAY

The relay serves as a switch to the light source. It is powered through a silicon diode (IN4001) across a darlington pair (BC108).

Every light ray (source) has its own specific intensity which can be low, high, accurate or moderate. Light generally has a speed (velocity) of **3.0×10^8m/s** denoted as c. When the light from the 12V bulb shines on the photocell (sensor), it senses the light rays, and transfers the signal (detection signal) unto the astable multivibrator (IC_1) which in turn decodes the signal by sounding an alarm through the loudspeaker.

If **c** is the velocity of light, λ, is the wavelength of the generated waveform with, **h**, as the **Planck's constant,**

$$h = eV = \frac{hc}{\lambda min}$$

where $h = 6.625 \times 10^{-34}J$, $c = 3 \times 10^8 m/s$ and

$e = 1.6 \times 10^{-19}$ Coulomb

$$\lambda min = \frac{hc}{eV} (m) = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{(1.60 \times 10^{-19})(12)}$$

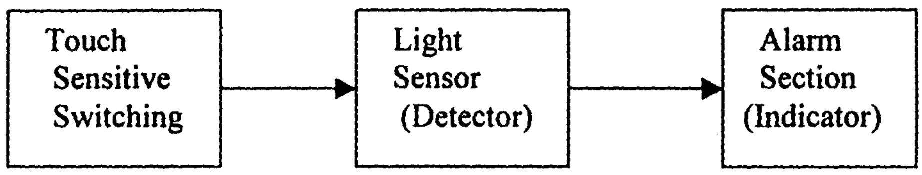
$$\lambda min = 1.03 \times 10^{-7} m$$

2.8 PHOTOCELL (SENSOR)

Photocell or light dependent resistor (l.d.r.) is an electronic component whose resistance depends upon the amount of light falling on it. When light falls on it in a dark environment, its resistance becomes reduced depending on the intensity of the light falling on it. When the light falling on it decreases, its resistance increases. It is also called a light sensor and serves as a transducer (since every detector of light is an energy transducer).

The response-speed depends on the intensity of light falling on it, which can be low, high, accurate or moderate. They pick up small changes in the input qualities and translate these often tiny changes into useful electrical signals. They experience changes in their electrical characteristics when light energy releases charge carriers in its conductivity.

The transducing stages are shown below in a block form.



This sensor (photocell) will hold the system in a non-alarm condition. If the beam, however is flashed on it, an alarm signal is created. The photocell used here is an **NSL type of photocell**. When the NSL photocell resistance is less than that of R_5 (10kΩ), only a small part of the input voltage (12V) supply appears across the sensor (most across R_5) and this is not enough to 'enable' the astable to work. When the resistance of the photocell is much greater than 10kΩ, as it is in the dark, the voltage across the photocell will be more than 6V. This shows that voltage divides in the ratio of the resistances across which it is applied. As the sensor absorbs or receives the light, there are three (3) mechanical effects:

(1) An exchange of energy (Transducer)

(2) An exchange of linear momentum

(3) An exchange of angular momentum

The maximum energy required to liberate an electron is $h = W$

where h = Planck's constant = 6.625×10^{-34}Js

The maximum kinetic energy that can be imparted $E_k (max) = h - W$

Clearly, no electron appears when hv_o is less than W (work function).

where V_o = Threshold frequency

$$\therefore \quad W = hV_o \text{ (eV)}$$

$$h = eV = \frac{hc}{\lambda min}$$

where λ = wavelength of the generated signal to the Ic

c = speed of light on the photocell

= 3×10^8m/s

But 1eV = 1.60×10^{-19}Js

$\Rightarrow W = 6.625 \times 10^{-34} \times 1.6 \times 10^{-19} = 7.9512 \times 10^{-38}$ Joule

$$\therefore \lambda min = \frac{hc}{eV} = \frac{(3 \times 10^8)(6.63 \times 10^{-34})}{(12)(1.60 \times 10^{-19})}$$

$$\lambda min = 1.03 \times 10^{-7} m$$

2.9 ABSTABLE MULTIBRATOR (IC)

Transistor, diodes, resistors and capacitors are connected together on a tiny 'chip' of silicon to give any desired circuit, e.g. a counter, logic gate, multistage amplifier etc. A complementary metal oxide semiconductor IC is used here (CD 4047BCN). It needs only one external resistor (R_6) of 100kΩ in value and disc ceramic capacitor (C_3) of 0.01μF because of its higher frequency so that the LED will be able to sense the generated square wave through pin 10 of the CD4047BCN.

Transistors TR_4 and TR_5 Transistor amplifier) operate the loudspeaker through capacitor C_4 transforming the a.c. to d.c. for the LED_2. The astable outputs are denoted as 'Q', '$\bar{Q}$' (Q bar) and 'Oscillator' and are shown to be opposite. (Figure 2.9). 'Q' and '$\bar{Q}$' are complements i.e. one is 'high' when the other is 'low' and they form a square wave.

The frequency of these complements (Q and $\bar{Q}$) square wave is the same and given as:

$$f_1 = \frac{0.23}{R \times C} = \frac{0.23}{(100k)(0.01 \times 10^{-6})}$$

$$= 0.23 \times 1000 = 230Hz$$

Thus the frequency f_2 of the Oscillator output is $2f_1$ and in this case:

$$f_2 = 2f_1 = 2 \times 230 \text{ Hz}$$

$$= 460Hz$$

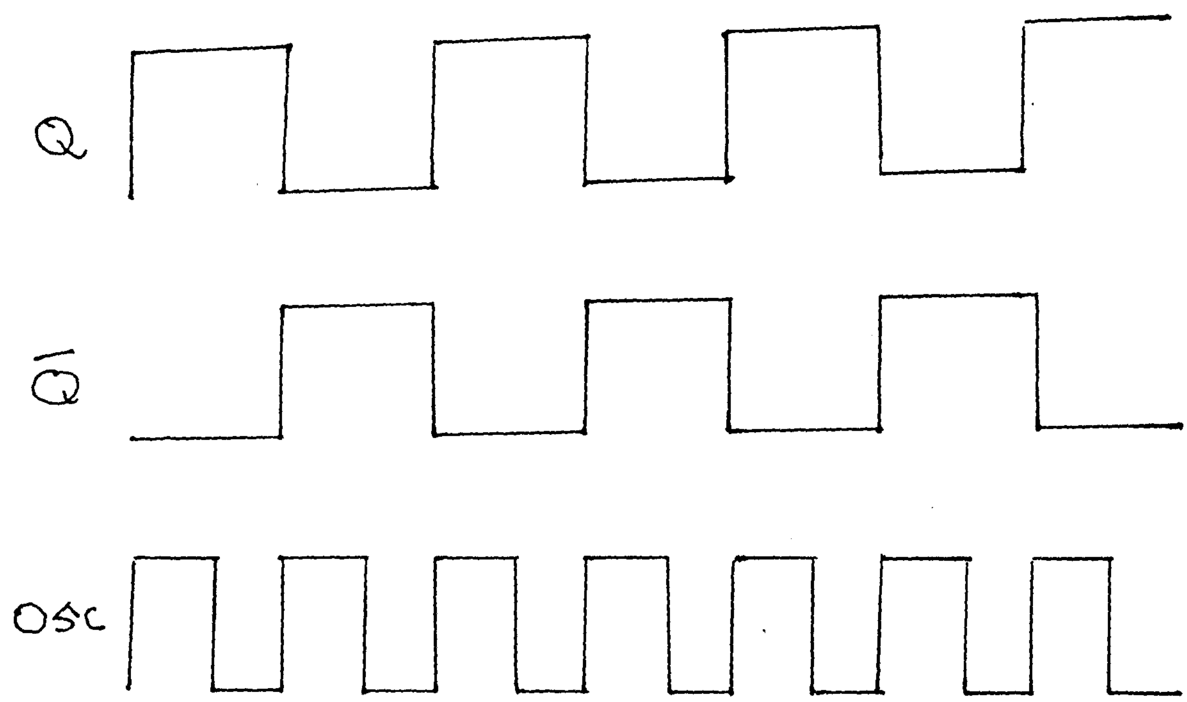


Figure 2.9: ASTABLE OUTPUTS OF CD4047 BCN.

CD4047BCN is a 14-pin Dual-Inline package (DIP) which is able to operate as an astable and produces square wave pulses (at a frequency decided by R_6 and C_3) when the voltage at pin 5 ('astable enable') is greater. Its 14-pins are labelled as shown in Figure 2.10 with the small dot or notch at one end of the case (pin 1). A square wave is generated at pin 10 which now biases the power transistors (TR_4 & TR_5). To produce a higher note, a lower value of C is used and this calls for the use of electrolytic capacitor (C_4) transforming the a.c. to d.c. for the LED to senses the square waves.

Figure 2.10: 14-PIN DUAL INLINE PACKAGE (DIP) IC CONNECTIONS OF CD4047BCN ASTABLE MULTIVIBRATON

CHAPTER THREE

3.0 CONSTRUCTION AND TESTING

3.1 TESTING AND CONSTRUCTION

The actual connections of the components as shown in the design was first tested out on a breadboard and powered by a 12V d.c. battery (Hi-Watt) for transistor radios. This is to avoid over voltage-surge and to prevent the components involved. Faulty connections were troubleshooted and the circuit eventually worked.

Components were transferred to a strip board or veroboard and soldered with a hot soldering iron of 40W. Veroboard and the transformer were then mounted with screws unto the wooden box. The project was tested and proved to be working fine. The sensor was covered first with handkerchief before the transformation unto a veroboard.

3.2 RESULTS AND DISCUSSION

From the test conducted, it was verified that the system is in good working condition. A touch on the touch plate by an intruder gave rise to triggering of a light source through the 12V relay coil there-by sounding an alarm of an unwelcome guest through the loudspeaker (SP1).

A higher frequency is needed for LED 2 to sense the wave (square wave) through pin 10 of the Astable multivibrator so 0.01μF capacitor was used as C_3. Power failure to the system should also be avoided to ensure maximum security.

3.3 ECONOMIC IMPORTANCE/APPLICATION

One major economic importance is its application within a building in detecting the intrusion of an unwelcome guest by raising an audible alarm if the intruder made a touch. The intruder is unaware that he has been detected and consequently police are more likely to make an arrest.

In addition, it is applicable in protection of cars from an unauthorized entry and thefts. Lastly, it is more economical to build although maximum security demands for money.

CHAPTER FOUR

4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

Knowing that quality cannot be built into a component but the standard of the design would determine the reliability of the device, care was taken at the design stage of this project.

Security is very paramount and safety is needed on our properties, assets and lives.

4.2 RECOMMENDATION

I would want to recommend that in future a switchover control switch from a.c. to d.c. and vice versa be incorporated into the system so that a constant security and safety will be achieved because power failure to the system is equivalent to insecurity.

A warning device announcing failures in the alarm system cam also be designed and incorporated into the system.

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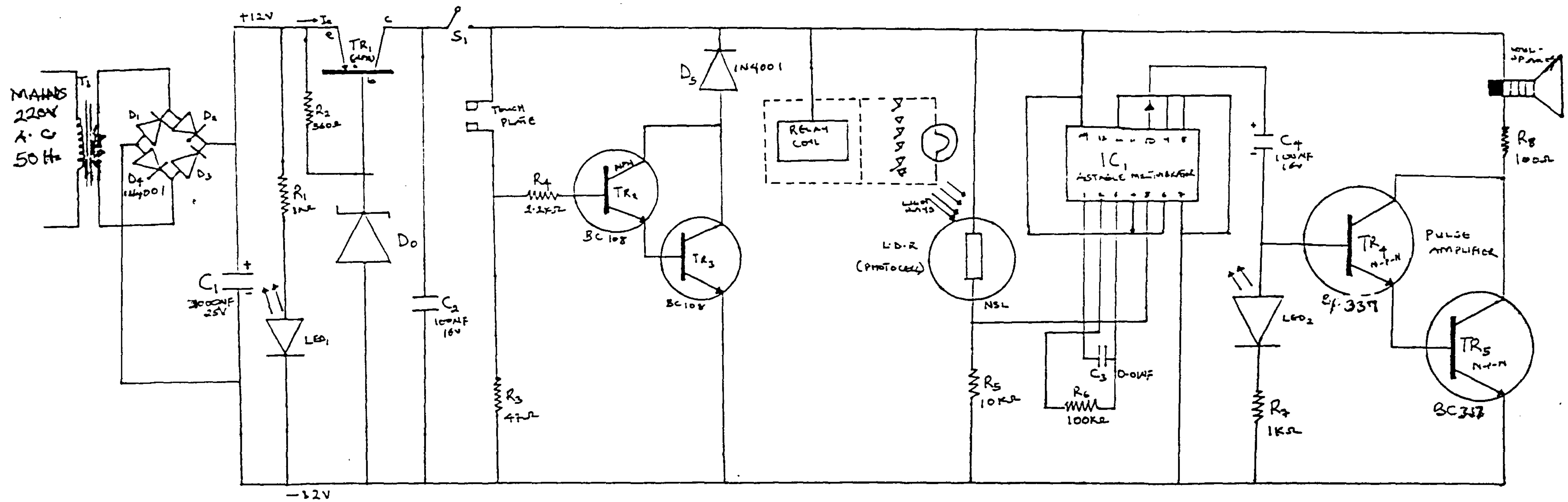

A LIGHT OPERATED DOMESTIC ALARM SYSTEM