AUTOMATED SECURITY PASSAGE GATE CONTROLLER

BY

YAHAYA ABDUL-RAFIU A.

97/6196EE

DEPARTMENT OF ELECTRICAL AND
COMPUTER ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLODGY,
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TITLE PAGE

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(POSITION CONTROL METHOD)

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97/6196EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING.

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY.

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. Eng.) IN ELECTRICAL AND COMPUTER ENGINEERING.

CERTIFICATION

This is to certify that tjhis project design, construction and report- writing was undertaken by **Yahaya Abdul-Rafiu A.** under the full supervision of Dr. (Engr') Y. A. Adediran.

Dr. (Engr') Y. A. Adediran.
Project Supervisor ______________ Signature ______________ Date

Engr. M. N. Nwohu.
Ag. Head of Department ______________ Signature 7/4/04 Date

External Examiner ______________ Signature ______________ Date

DECLARATION

I hereby declare that this project design, construction and report write-up was undertaken by me with the support and under the full supervision of my diligent project supervisor Dr.(Engr') Y.A. Adediran.

Name : Yahaya Abdul-Rafiu A. Sign. : Afolayan

Registration Number: 97/6196 EE Date : 23/08/03

DEDICATION

I dedicate the success of this project to the glory of the Almighty Allah (S.W.) who made it possible in all ways. I would also like to dedicate this report to my bundle of support at all times, my parents; Alh. A.H. Yahaya and Hajia Adamat Yahaya and Dr.(Engr') S.A. Yahaya (FNSE).

ACKNOWLEDGEMENT

My ever-profound acknowledgment goes to the Almighty Allah (S.W.) who in has made it possible for me to witness the successful completion of this report. Indeed glory is to Allah. I would like to acknowledge the amiable support of my project supervisor, Dr. (Engr') Y. A. Adediran who was able to provide the needed supervisory support amidst his tight schedules. More grease to your elbow sir. The support of my father, Alh. A. H. Yahaya, my mother, Hajia A. Yahaya and a source of inspiration and support to me, my uncle; Dr. (Engr') S. A. Yahaya (FNSE). May Allah (S.W.) continue to shower his mercies and blessings on them. I would also like to acknowledge the support of my step-mothers Hajia R.A. Yahaya and Mrs. E.O. Yahaya who at different times and occasions gave me the necessary motherly support. Worthy of mention are my fathers; Alh. Salman Akano, Mallam Ola Yusuf, Alh. Gbadamosi, Alh. Umar Oloriegbe, Alh S. Ayinla, Alh. A. Yahaya (Baba), Mallam K.K. Gold and Alh. A.Gafar who all have contributed and supported me in different ways. Similarly my mothers such as Alhaja A. Yahaya, Hajia (Mrs.) H. Dembo, Hajia A. Gafar, Hajia H. Gold. May Allah (S.W.) continue to guide them all in their respective endeavours.

I would like to acknowledge the support of my friends, brothers and sisters such as Suleiman Garba, Basheer Kuranga, 2nd Lt. Abdul-Rasheed Yahaya, Lt. Saka Jimoh, Kabir Yahaya, Mariam Yahaya, Bilkis (Ayodele) Yahaya, Aishat(Bukola), Aishat (Iya), Fawaz, Tunde Ani, Adeniyi, Kunle, Ariks, Ismail Baba, Bilqees Kasum, Tope Gold, all the members of the Raufu family, Izuchi, uncle Toyin Kasum. The names that do not appear in this acknowledgement page are as dear to me as those that do appear. May Allah continue to be with you all (Amen).

ABSTRACT

Apart from the ideological issue that it is morally wrong to employ human being to do laborious soul destroying repetition work which require no judgment and is for better done by machines, there a

number of very sound engineering reason why automatic control system are preferred to human operations, some of which are:

1. The effect of human reaction time (0.3sec) prevents manual control being used where high response speed is required (e.g. A. A guns or radar sets which are required to engage high speed targets.)

2. Continuous operation over long period cause bored and fatigue and subsequent determination of performance. Also great stress or danger to operator causes a rapid falling off in efficiency.

As human being are subject to fatigue, one could sometime be so tired that standing up to open or close a gate could be a problem to the operator. There is therefore, the need for a system to enable such a tired person and any other to open and close the gate from his place of rest, be it bedroom, parlous or society post.

This project work is an attempt to demonstrate how the opening and closing of a gate can be achieved by applying the principle of a gate position control system.

The project has been designed and constructed, tested and found to work properly, it is hoped that its application in homes or industries will go a long way in saving human energy (labour) and enhancing comfort.

To enable this project design to attain a better status in terms of versatility and functionality, a resistive sensitive touch alarm system has been incorporated into this design. This encloses the entire design unit as both a control system and a security device against unauthorised passage.

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CHAPTER ONE

INTRODUCTION

The design and construction of this project was undertaken with the aim of producing a prototype of a position control system incorporated with a sensitive touch alarm. The touch alarm is expected to activate a warble alarm circuit via a relay.

This project is a security design for places where maximum security and highly streamlining of human traffic through the place are of prior importance. Though the target of this project are places like bank vaults, maximum prisons and other places whose security are matters of national interest such as weapon storage facilities, it can however be incorporated for domestic use in offices.

The position control system functions mainly on a principle of applying an error signal to the control element. The error signal is related to the difference in the displacement between the reference (input) and the feedback signal. With the aid of an amplifier element, the error signal is used to subsequently reduce the error to zero. The typical block diagram is given in figure 1.0.

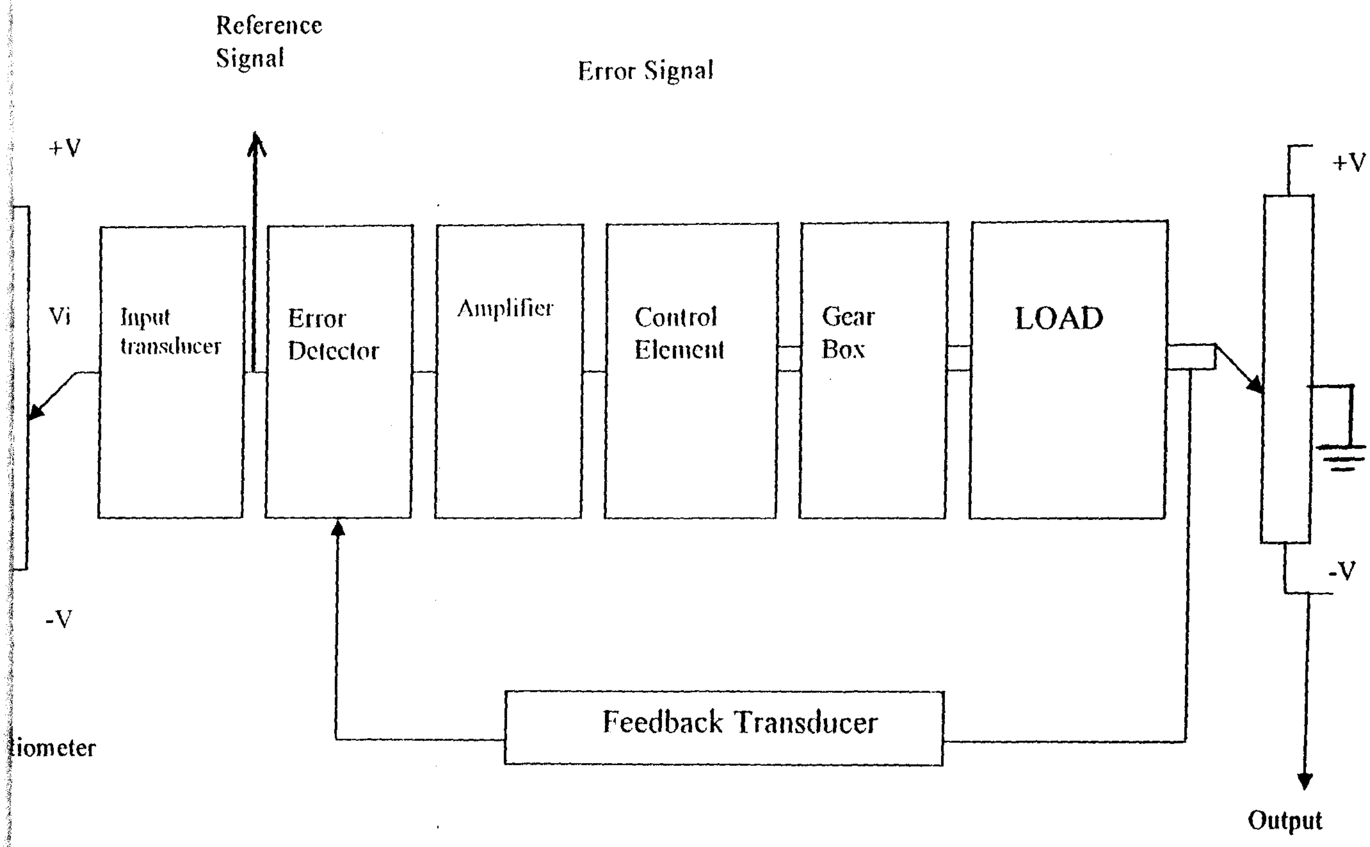


Figure 1.0. ***Typical block diagram of the Position Control System for Opening and Closing a Passage Gate***

1.0 CONTROL SYSTEMS

Control system engineers have made very important contributions to our advancement in the 20th century and they are building the foundation for greater advancements in the 21st century.

The control of systems is an inter-disciplinary subject and cuts across all specialised fields of engineering.

Control systems can be defined as devices, which regulate the flow of energy, matter or other resources. The arrangement, complexity and appearance vary with their purpose and functions. In general, control systems can be categorised as being either open loop or close-loop. The distinguishing feature between the two types of control systems is the use of feedback comparison for closed loop operation.

1.1 AUTOMATIC CONTROL SYSTEMS.

During the early stages of ***control systems***, most of the systems were manually operated. The arrival of the ***Automatic Control Systems*** was in the middle of the eighteenth century.

The first automatic feedback controller used in an industrial process was James Watts' Fly ball Governor (1769) which was used to control the speed of a steam engine. Prior to ***World War II***, one main impetus for the use of feedback control in the United States of America was the development of telephone systems and electric feedback amplifiers.

All precision control systems involve the feedback of information about the control quantity in such a way that if the control quantity differs from the desired value, an error is observed and the control system operates so as to reduce the observed error.

1.1.1 Open and closed- loop control systems.

The basis for analysis of a control system is the foundation provided by linear system theory, which assumes a ***cause-effect relationship*** for the components of the system. A component or process to be controlled senses an input (cause) and output (effect). The input-output relationship represents the cause-and-effect relationship of the process; which in turn represents a processing of the input signal to provide and output signal variable, often with power amplification.

An open- loop control system utilises a controller or control actuator in order to obtain the desired response.

1.1.2 Close- loop Control Systems.

These systems derive their valuable accurate reproduction of the input from feedback comparison. An error detector drives a signal proportional to the difference between the input and output. The close-loop control system drives the output until it equals the input and the error is **zero**. Any differences between the actual and desired output will be automatically corrected by a close-loop system. Through proper design, the system can be made relatively independent of secondary input and changes in component characteristics.

In contrast to an open-loop control system, a closed loop control system utilises an additional measure of the actual output in order to compare it with the desired output response. A standard definition of a feedback control system is a control system, which tends to maintain a prescribed relationship of one system variable to another by comparing functions of these variables and using the differences as a means of control.

A feedback control system often uses a function of a prescribed relationship between the output and the reference input to control the process. Often, the difference between the output of the process under control and the reference input is amplified and used to control the process so that the difference is continually reduced.

1.1.3 Advantages of Feedback Control.

Reduction in sensitivity: - In the open-loop system, errors arising from changing environment, aging, ignorance of the exact values of the process parameters and other natural factors. A close-loop system however senses these changes in the output due to the process changes and attempts to correct the output. A primary advantage of a close-loop system is its ability to reduce the system's sensitivity.

Control of transient response: - One of the most important characteristics of control systems is their transient response, which often must be adjusted to yield the desired response by adjusting the feedback loop parameters.

Reduction of effects of disturbance: - The third and perhaps the most important effect of feedback in control systems is the control and partial elimination of the effect of disturbance signals. Many control systems are subject to extraneous disturbance signals, which cause the system to provide an inaccurate output. Feedback systems have the beneficial aspect that the effect of distortion, noise and unwanted disturbances can effectively be reduced.

CHAPTER TWO

LITERATURE REVIEW

2.0 Position Control Systems

Most of the early control systems were limited to speed control, until during the ***First World War*** when the importance of positioning heavy masses was revealed. Since then more works have been done by various people to achieve a precise and accurate result in the field of position control. Its applications were extended to other areas. Infact, the rapid growth of technology since ***Second World War*** has made it necessary to control machine and processes with ever increasing accuracy and speed.

Position control systems can be applied to virtually all fields of human endeavour. Its applications in industries save both human labour and cost (labour) in addition to improved product quantity. Applying it in every day life saves a lot of human energy. An example of this application is in the opening and closing of a passage gate. Position control system enables the operator (who at a particular instant may be fatigued) to open or close a gate from his place of rest, which could either be, a bedroom, living room or security post to any desired position.

There are several methods of controlling the opening and closing of a passage gate, notable amongst which are,

Pneumatic control system method

Hydraulic control system method

Electrical control system method

This project design forms its basis from the electrical control system method.

2.1 ELECTRICAL CONTROL SYSTEM METHOD OF OPENING AND CLOSING OF A PASSAGE GATE.

Electricity as a source of energy has versatility as one of its most valuable properties. Hence it can be manipulated as desired to control the position (opening and/or closing) of a passage gate. The notable electrical control circuits used for this purpose are as follows:

The Two Push- Button Gate Control.

The Sequential Gate Control

The Remote Gate Control

2.1.1. The Two Push-Button Switch Gate Control

This method entails the use of two push-button switches, an electric motor and a power supply (which could be either a.c or d.c.). The two push-button drive the control element(motor) with voltage values of different directions (though the voltage values may be of equal magnitude). This is similar to the mechanism used in the control of a car window. A typical circuit diagram of this method is shown in figure 2.1.

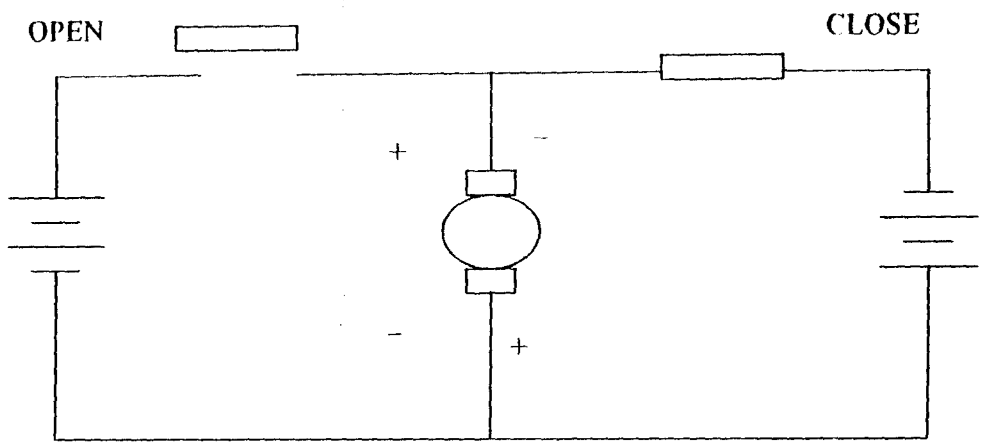


Figure 2.1. ***Circuit diagram of a two push-button switch method of opening and closing a passage gate.***

The basic principle of this method is that, pushing a particular button to close the circuit reverses the electric motor connection thereby reversing the direction of rotation of the motor. With the aid of the gear box connection (or any other similar arrangement), the motor is able to open and/or close the gate depending on which push button is activated.

The major disadvantage of this method is that the operator is required to physically estimate the level to which the gate is required to be opened or closed by continually looking at the gate. This in its capacity could cause some amount of stress to the operator. Difference in reaction time of different operators makes this system error-prone too. Another disadvantage is that, once the operator lifts his hand off any of the two push buttons the supply to the circuit is disengaged and hence the system ceases to function.

2.1.2 THE SEQUENTIAL GATE CONTROL METHOD.

As the name of this method implies, it is an on-off system of opening and closing a gate in simpler terms. The major components of this system are a two-throw switch, two relays, a power source, an electric motor and two limit switches each situated at the two extremes of fully open and fully closed positions.

2.1.3 REMOTE CONTROL METHOD OF GATE CONTROL.

This is a relatively recent method and can be termed as a more digitalised approach to position control.

This electronic system uses a transmitter-receiver relationship to effect the necessary transformations of electrical signals to linear motion of the load (gate) the receiver and the transmitter are not physically connected. A sensor is fitted with the receiver circuit. The sensor 'receives (collects) infrared or ultraviolet radiation from the transmitter. The received rays are collectively processed by the receiver circuitry. This gives the operator the ability to open and close the gate at some remote location. The output of the receiver circuitry serves as the energizing source for an electric motor. The motor thus controls the gearbox system to either open or close the gate in accordance to the transmitted signal from the operator's remote transmitter.

A very important advantage of this method is that the operator can conveniently open or close the gate anywhere around the vicinity of the range of the transmitter. However, the operator using this method has to have physical visual contact with the passage gate to estimate the position to which the gate is desired open or closed to. This disadvantage could result in errors (which would vary from operator to operator). These errors could be due to sight defects; reaction time differences and improper positioning of the transmitter to accurately '**see**' the receiver. The three methods previously described above are all methods falling under the open loop method of controlling the opening and closing of a passage gate.

2.1.4 POSITION CONTROL METHOD OF CONTROLLING OPENING AND CLOSING OF A PASSAGE GATE

This is a typical example of a closed loop system. In this method a control mechanism is achieved with the aid of feedback phenomenon. The actual position of the gate at any particular instant is fed back into the control circuit, which in turn initiates the appropriate control action. This ensures that the gate can be opened or closed to any desired position simply by turning a knob (the input transducer).

A very interesting aspect of this design is the ability of re-adjustment of the system to its originally set position when altered by an external force. In other words, the gate can return to its preset position when an external force causing it to move in the opposite direction is removed. This and many other features make the position control system method more desirable and advantageous over the other methods previously discussed.

CHAPTER THREE.

DESIGN OF THE CONTROL SYSTEM.

3.1 Preamble

The design is the production of a servomechanism for position-control. The mechanism must reproduce at some remote point, the motion applied to the input transducer. The mechanical input and output signals are first converted into proportional electrical signals and then transmitted through wires to the error detector, which produces a signal proportional to the error. The low-power error signal is used to drive the amplifier circuit, which then delivers controlled power to the motor.

The combination of transducers and subtracting element (differential amplifier) forms the ***error detector***, the amplifier forms the ***controller*** block and the control element (d.c. motor) together with its gear box forms the ***output element.***

3.2 The Electrical/Electronic Circuit of the System.

This circuit composes of the control circuitry that enables the position control system principle to be practically implemented in the design.

The controller is an operational amplifier (**μA 741**) connected along with its external components to form a differential amplifier as shown in figure 3.1. the differential amplifier serves as an error detector of the control potential difference across the two input terminals (pins 2 and 3of the operational amplifier through each of the **2.2 KΩ** resistors)

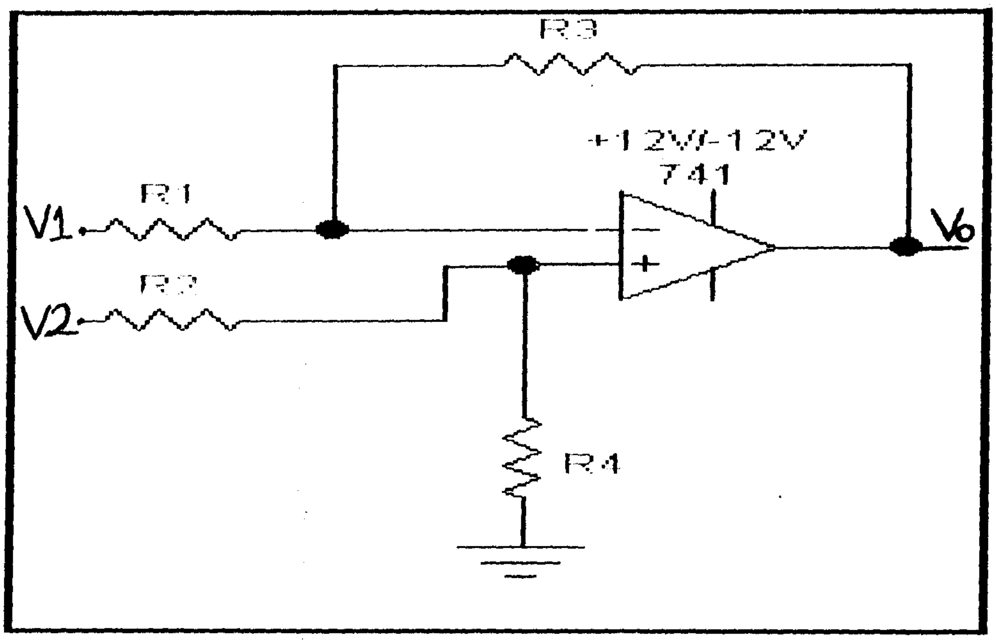


Figure 3.1 the **μA741** ***operational amplifier connected with its external components to form a differential amplifier.***

According to the differential amplifier design, **V2** is the voltage output of the reference potentiometer while **V1** is that of the feedback potentiometer. The output of the amplifier **Vo** (error signal) is difference signal between the two input signals. Hence **Vo = A (V2-V1)**. The resistor **R1** is the input resistance for **V1**, while **(R2+R4)** is the input resistance for **V2**. Resistor **R3** is the feedback resistor, and **R4** is offset biasing resistor.

For the circuit a. in figure 3.2.,**Vo** can be obtained from the two input voltage sources of **V1** and **V2.**

Using superposition theorem and considering the input voltage **V1** i.e. grounding voltage source **V2,**

$$\mathbf{Vo1 = A1 \times V1}$$

Where **A1** is the operational amplifier gain due to input **V1** only.

Vo1 = voltage output due to input **V1** only.

Here we note hat this forms an ***inverting amplifier*** with amplifier gain

A1 = -R3/R1. Thus;

$$\mathbf{Vo1 = -R3/R1 \times V1}$$

Considering the input voltage **V2** will produce the equivalent diagram of figure 3.2 (b) shown below;

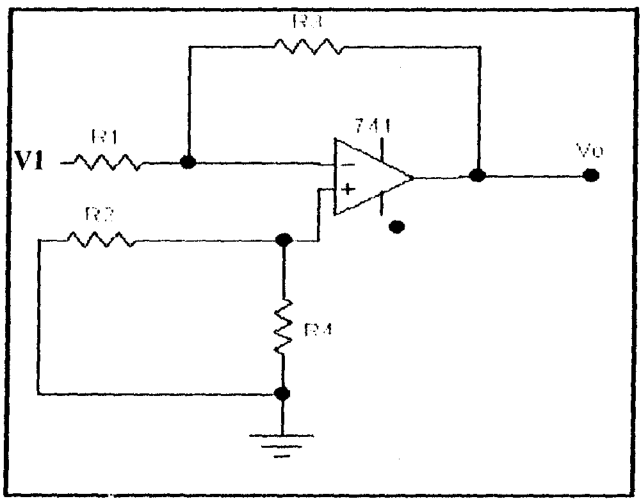


Fig 3.2a ***The differential amplifier using only input V1***

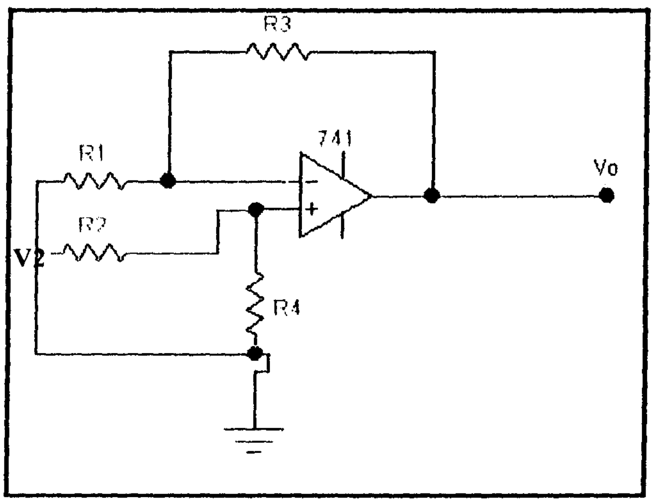


Fig 3.2b ***The differential amplifier using only input V2***

The voltage **V2** considered as the input means grounding input source **V1**. This will have an output **Vo2** which can be evaluated thus;

Vo2 = A2xV2--I

When the input **V1** is grounded, **R3** and **R1** form a ***voltage divider*** for the nput voltage into the voltage source **V2**. Terming this input voltage as **V2+** gives the following expression;

V2+ = [R1/(R3+R1)] x Vo2 --------------------------------II

V2+ now forms the input voltage into the non-inverting input of the operational amplifier. Using voltage- divider theorem;

V2+ = [R4/(R2+R4)] x V2-----------------------------------III

Substituting equation III into equation II gives the following expression

$$[R4/(R2+R4)] \times V2 = [R1/(R1+R3)] \times Vo2$$

Thus, $Vo2 = [R4/(R2+R4)] \times [(R1+R3)/R1] \times V2$

The output of the controller (differential amplifier) **Vo** is the sum of the output due to the two input sources of the operational amplifier. Thus;

$$Vo = Vo1 + Vo2 = (-R3/R1) \times V1 + [R4/(R2+R4)] \times [(R1+R3)/R1] \times V2$$

$$= K2\,(V2) - K1(V1) \text{-------------------------------} IV$$

where $K2 = [R4/(R2+R4)] \times [(R1+R3)/R1]$

and

$$K1 = R3/R1$$

The resistor values used to obtain the differential amplifier are stated thus;

$R1 = R2 = 2.2\ K\Omega$

$R3 = R4 = 47\ K\Omega$

Hence $K1 = (47\ K\Omega/2.2\ K\Omega) = 21.36$

$$K2 = [47\ K\Omega/(2.2+47)\ K\Omega] \times [(47+2.2)\ K\Omega/2.2\ K\Omega]$$

$$= 47/2.2$$

Hence equation IV gives

Vo=47/2.2 (V2) - 47/2.2 (V1)

Thus **Vo = 47/2.2 (V2-V1)= 21.36 (V2-V1)-----------------V**

Hence from the equation

Vo= A (V2-V1), we can deduce from equation V that

A = 21.36.

The resistor values as can be observed from the design and from the explanations made above were chosen to obtain a match of resistance to obtain the subsequent voltage gain for the amplifier. The differential amplifier also serves as the first stage of error voltage signal amplification. It can be deduced that its output is ideally zero **(0)** when **V1= V2.**

3.2.1 <u>The Input and Output Transducers.</u>

These are a source of voltage divider supplying varying potentials across a stable reference supply voltage. The transducers are required to convert the input gate position set by an operator and the actual linear position of the gate into reference (input) and feedback voltage signals respectively.

For this design, potentiometers of resistance value of **50 KΩ** have been chosen to serve as input and output transducers. Below is the circuit symbol of a potentiometer in figure 3.3

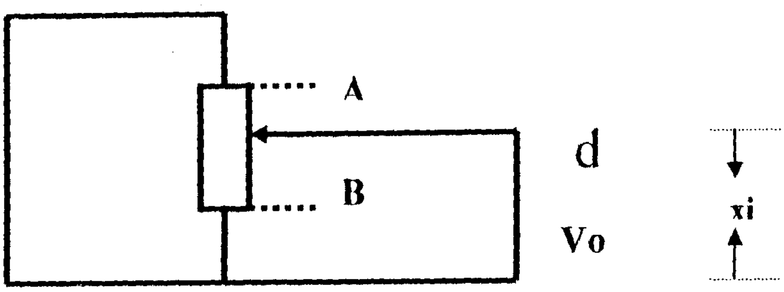


Figure 3.3 ***Circuit Symbol of a Potentiometer***

From the diagram above, we can deduce that the potentiometer is a form of potential divider across a 'stable' reference supply voltage, which in this design is a **12 Volts** d.c. Voltage supply. As the wiper arm, **d** is being varied, the output voltage **Vo** is simultaneously being varied, the value of variation being dependent on the direction along which the potentiometer arm **d,** is being varied. The displacement of the wiper arm causes a change in the ratio between the resistance from one end of the element to the wiper arm and the end-to-end resistance of the element. In its most common applications, this resistance ratio is used as the voltage ratio. The output therefore is an electrical voltage signal proportional to the angular rotation of the potentiometer knob or wheel.

The output voltage **Vo** is maximum when the wiper arm, d is at position A which corresponds to a maximum value of the wiper arm's, **d** displacement, **xi**. **Vo** is minimum when d is at a position **B**. Consequently, at **B**, **xi** is minimum. Conclusively, **Vo** is an electrical signal (voltage signal) whose value is proportional to the angular rotation of the potentiometer wheel or knob.

3.2.2 Power Amplifier.

From the introductory part of this technical write-up, the initial stage of the design is the derivation of an error detector. The error signal is linearly dependent on the voltage input from the input transducer. The current amplitude and consequently the power of this error signal from the error detector is too low to drive the final control element. For this design, the control element is a d.c. motor. The current amplitude from the error signal detector is in the order microamperes (μA). Therefore a power amplifier is required to step up the error signal current and hence the power delivery level to a value required for successfully driving the control element (d.c. motor).

The designing of the power amplifier circuit is achieved by putting the following requirements into consideration:

(i) Voltage, Current and Power Requirement of The Control Element (D.C.Motor).

The requirement for reversibility of the output voltage (the error signal) which is of utmost importance for position control to be achieved. Considering the d.c. motor as the load to be driven by the power amplifier circuit, the maximum voltage requirement of the load used in this design is **12 volts** (d.c). The current demand of the load ranges from **10 mA** at no load to about **240-500 mA** at full load. This equates to a full load power requirement ranging from **2.88 Watts** to about **10 Watts**.

The power amplifier circuit chosen for this design is capable of supplying about **500 mA** at **12 V** safely giving a full load power of between **2.88** to **10 Watts.**

(ii) Reversibility

The second requirement has been taken care of in this design by employing a push-pull emitter follower circuit for power amplification. This ensures reversibility of the output voltage, which will be used to drive the load. This design consists of three (3) NPN and PNP transistors which are connected to form a NPN and PNP Darlington pair arrangement respectively. These

Darlington pairs (NPN and PNP) are in turn connected to give a push-pull emitter follower (**class AB**) power amplifier circuit. The arrangement and choice of the electronic components required for the power amplifier circuit was made based on the following considerations:

(i) The Darlington pair has unity voltage gain.

(ii)The choice of the Darlington pair is from the fact that it has high current gain, (β) capabilities.

(iii)The Darlington pair also has a good feature of low output impedance from a high input impedance.

The circuit diagram of the power amplification circuit is shown in figure 3.4.

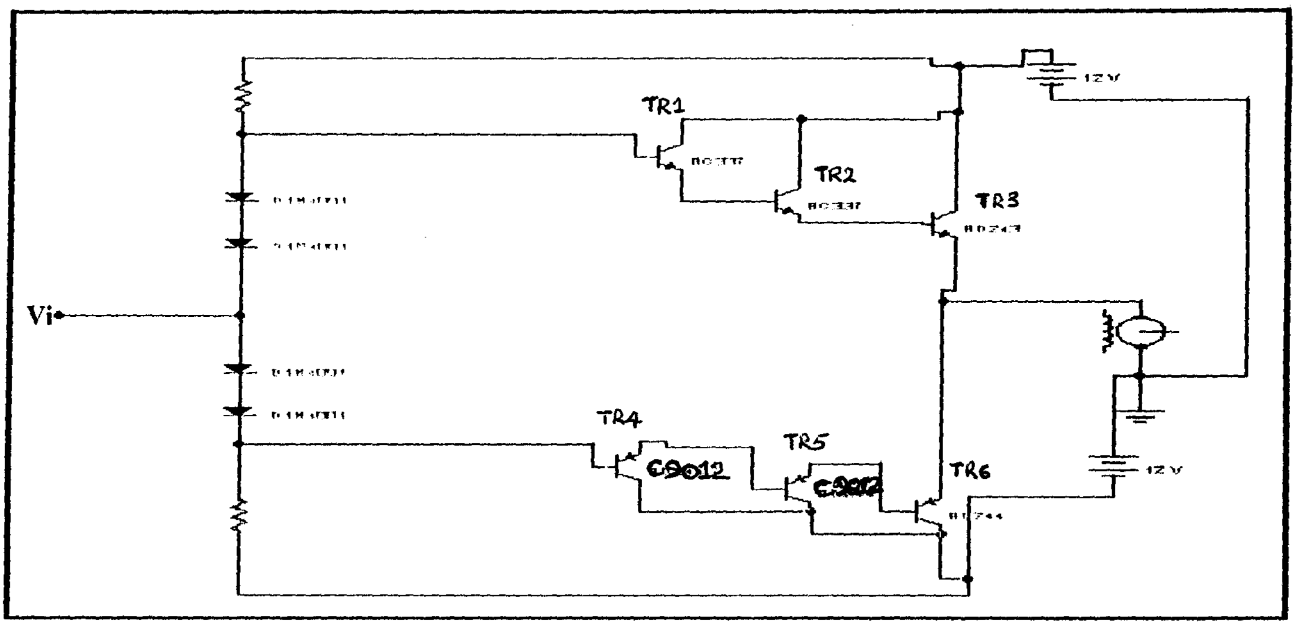


Figure 3.4 PUSH-PULL EMITTER FOLLOWER CLASS AB POWER AMPLIFIER FROM TWO DARLINGTON PAIR.

The part list of transistors, resistors and diodes used is given in appendix B.

The amplifier circuit reverses the output voltage that is used in driving the changing direction of the error signal Vi which in accordance to the input to the push –pull amplifier circuit. This is the input source idea behind opening and closing of the passage gate. The polarity of the error signal determines the Darlington pair that will be on at a particular time.

The diodes D1, D2, D3 and D4 and the resistors R are used to bias the two Darlington pairs in accordance with the polarity of input error signal. The diodes and resistor combination for each half of the amplifier circuit (the NPN and PNP respectively) hold the base potentials of the two transistors TR1 and TR4) at **+0.7V** and **-0.7V** respectively. This means that the transistors TR1 and TR4 are just conducting when the error signal input **Vi = 0** but with the output signal **Vo = 0**. This clears the problem that could be encountered by the region of insensitivity which occurs when the input signal is less than the turn-on voltage of the transistors; i.e. when $V_i < V_{BE}$.

A Darlington pair produces a signal with very high current gain. The current gain of a Darlington pair is given by the expression below;

$\beta = \beta_M \beta_D + \beta_M + \beta_D$

Where

β_M = current gain of main transistor (driven transistor)

β_D = current gain of driving transistor

From the equation above, we can deduce that the current gain of the output signal from a combination (Darlington pair) of TR1, TR2 for the NPN half and TR4 and TR5 for the PNP half of the amplifier circuit will be very high. Hence the last transistor for each half (i.e. TR3 and TR6) carries the largest current through them. The transistors must then be able to withstand very high current. For this design, **BD 243** and **BD 244** are used for TR3 and TR6 respectively. These transistors can withstand and deliver current value as high as **6 Amperes**. Thus the amplifier circuit can safely deliver the highest current demanded by the load (d. c. motor).

3.2.4. THE FINAL CONTROL ELEMENT

The project design is just a demonstration of what can actually be achieved using the appropriate mechanism and electrical/electronic design, thus a **12 V** d.c motor has been used for this design as the control element. The gate used for this demonstration is very light and thus will present very little load on the d. c.

motor. Practical application would require a bigger motor of higher power rating. Reversibility of the direction of rotation of the motor should be highly considered in practical application of this design.

3.3. THE MECHANICAL PART OF THE DESIGN.

The final control element (d. c. motor) produces rotational energy as its output. However the load to be activated is expected to move linearly. To achieve this translation of energy three methods were considered. They are as stated below

(1) Using Rack and Pinion arrangement

(2) Gears and Pulley arrangement

(3) Chain and Sprocket arrangement

For simplicity of design and cost-effectiveness, the gear and pulley system was chosen for this design.

3.3.1 THE GEAR AND PULLEY SYSTEM ARRANGEMENT

In order to achieve the conversion of the rotational motion of the motor to linear motion expected to activate the position control of the gate, a system of gear and pulleys have been arranged in a system as shown in figure 3.4.

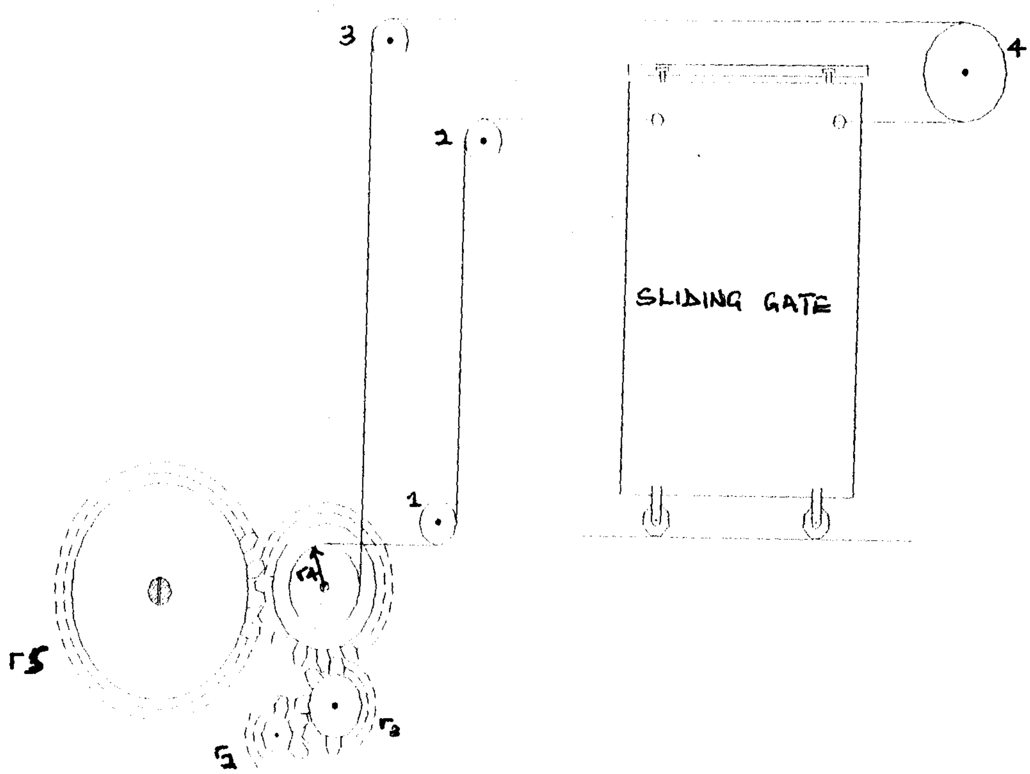


Figure 3.4. The Gear and Pulley arrangement system

3.3.2. PRINCIPLE OF OPERATION OF THE SYSTEM

The rotational motion of the motor is transmitted through a pulley and a driving belt to the driving pinion. The driving pinion drives the idler gear and hence the driven gear into rotation. The driven pulley has been made integral with the driven gear so that they are both driven through equal revolutions by the idler gear. The driven gear is subsequently used to drive another gear of a higher gear ratio whose revolution has been made integral with the feedback transducer (potentiometer). This system means the driven gear combines the tasks of operating a pulling force on a string passed over the pulley's (driven pulley) grooved rim and rotating the feedback transducer to effect stability.

The string passed over the driving pulley's grooved rim is tied to each end of the load, (i.e. the gate) and passed over other pulleys as arranged in ***figure 3.4*** for stability of the gate's linear motion. The other pulleys (rollers) are labeled 1, 2, 3 and 4 in ***figure 3.4***. Through this arrangement the gate is pulled to open or close depending on the direction of rotation of the motor.

3.3.3. SPEED REDUCTION.

The actual motion of the electric motor cannot be directly applied to the linear motion of the gate. The motion is too fast and thus unsafe for this design or for actual practical applications. The problem is tackled by using a suitable gear ratio combination that will limit this speed to safe limits.

The gear ratio of this system is simply defined as the ratio of the number of teeth on the driven gear divided by the number of teeth on the driving gear. The calculation and necessary formulae that were used in the gears and pulleys arrangement design are as stated below.

The gear ratio can be measured in terms of the angular velocities ratio with respect to the frames (shaft) supporting the gears. Thus for n given as the speed of the frames in revolutions per unit time and E as the gear ratio;

$$E = \frac{\text{rpm of driven gear (last)}}{\text{rpm of driving gear (first)}} = \frac{n_4}{n_2} \quad \text{............ (VI)}$$

Since gear 4 is the last driven gear in this design to activate the motion of the gate. Expanding **VI** gives

$$E = \frac{n_3}{n_2} \times \frac{n_4}{n_3}$$

However any two gears in mesh have the speeds as inversely proportional to the number of teeth, hence **E** can be evaluated (ignoring sign of direction) and given **N** as number of gear teeth as;

$$E = \frac{N_2}{N_3} \times \frac{N_3}{N_4}$$

3.4 THE SENSITIVE TOUCH ALARM SYSTEM

Alarm systems are used to signal undesirable situations such as the presence of an intruder. Alarm systems are usually open-loop systems. A basic alarm system contains two essential components: ***an alarm detector*** and ***an alarm indicator***. Frequently, there are remote control systems, where the detector is located remotely from the indicator.

An alarm detector is used to monitor a given situation and provide the information required to decide whether or not an abnormal condition exists at a given time. The type of detector is determined by the particular application and by the nature of the physical quantity being detected.

Alarm indicators are used to translate the information from alarm detectors into a warning signal when a predetermined limit is exceeded. The warning is usually accomplished by means of a visual or an audible signal.

3.4.1 TOUCH ALARM CIRCUITS

Touch alarm circuits are intended to activate when a person or object touches a fixed contact point. They work in a number of ways. They may be activated by touching and closing a simple micro-switch, as in the case of the contact alarm circuits, or they may work on the capacitive loading principle. Alternatively, they may be activated by the a. c. hum that is picked up by an electrical contact when it is touched by a human finger (in equipment that is connected to a. c power lines), or by the relatively low resistive (less than a few mega ohms) that appears across a pair of contacts when they are bridged by a human finger.

3.4.2 THE RESISTANCE SENSITIVE TOUCH ALARM

This device uses one of the few features of the monolithic CMOS integrated circuit, the ***CD4001*** integrated circuit to accomplish the task of a resistance-sensing touch alarm circuit. The ***CD4001*** I. C. is briefly described thus.

CD 4001 Integrated Circuit

This is a monolithic ***complementary metal-oxide semiconductor (CMOS) integrated circuit***. It is basically constructed with units of N- and P-enhancement mode transistors. These constructions result in a package of four, two input NOR-gates, each with an output, hence it is called a ***Quad 2-Input NOR Buffered B Series Gate Integrated Circuit***. The package contains 14 pins with pins **14** and 7 used as the supply and ground pins respectively (referred to as the V_{SS} and V_{DD} pins).

A very important feature of this integrated circuit can be deduced from its name which is its 'buffered' output feature. This gives improved transfer characteristics by providing very high gain.

Another important feature is its ability to function within a parametric rating range of **5v - 10v - 15v**. This integrated circuit also gives symmetrical output characteristics with a maximum input leakage of **1 μA** at **15 V** over full temperature range. It can basically be used in circuits as a ***Pulse Inverter, Pulse-Tone Generator*** or even as a gated ***Astable Multivibrator***.

In the application to this project design, the ***CD4001*** is used as a pulse inverter which is powered directly from a **12 volts** d.c power supply. However, only one of the 4 gates is used in the design. The input of the inverter is strapped to the positive supply line via a 10mr resistor R_{T1}, so that its output is normally low. The output of the inverter is then used to drive an N-P-N transistor (specified in the design circuit as 2N3704 but replaced with an equivalent transistor BC 337 in the construction) and the **12 volts** d.c. relay through an **18kΩ** resistor R_{T3}. a diode D_{T1} **(1N4001)** is used to protect the relay from over-voltages that may result from the source supply line. Two probes are used to act as the touch contacts, one connected to the ground rail and he other to the node connecting the inputs of the inverter and the **10MΩ** resistor via another resistor of **10kΩ**.

3.4.3 PRINCIPLE OF OPERATION OF THE TOUCH ALARM CIRCUIT.

The circuit action is such that the output of the inverter is low and the transistor and the relay are off when a resistance much greater than **10M Ω** appears across the ***touch contacts***, but the output of the inverter goes high and the transistor and the relay turn on when a resistance less than **10M Ω** appears across the touch contacts.

If the ***touch contacts*** have a surface area of at least half a square centimeter each, a resistance of less than **10MΩ** will appear between than when they are simultaneously touched by an area of human skin, so this circuit acts effectively as a touch alarm.

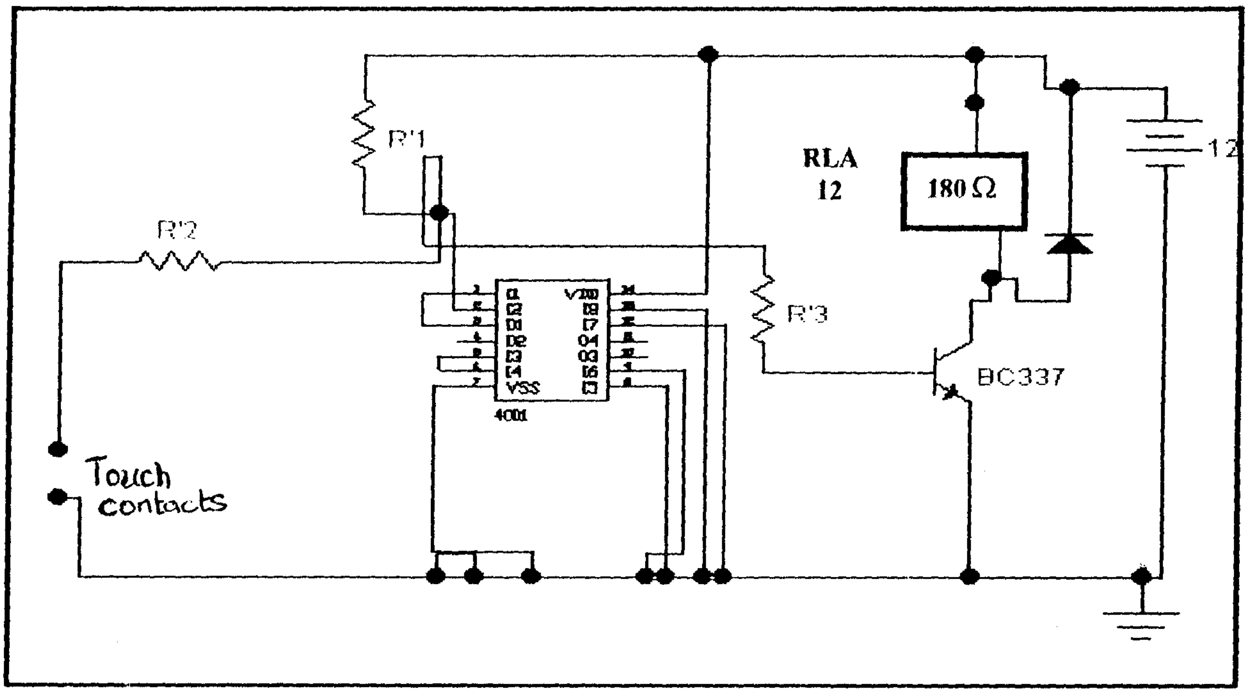


Figure 3.5: ***Circuit Diagram of the Resistive- Sensitive Touch Alarm***

The circuit consumes a typical standby current of only **1 μA.** The relay contacts can activate any type of alarm circuit (device). The circuit diagram is given in **figure 3.5** above.

3.5 THE WARBLE ALARM CIRCUIT

This circuit has been chosen as the alarm circuit for this design to compose an effective ***security alarm device*** in combination with the other two circuits. The circuit uses two ***555 timer integrated circuits*** with other electronic components. ***The 555 timer*** is briefly outlined below

THE 555 TIMER CIRCUIT

This is a monolithic integrated circuit which was first introduced by Signetics Corporation in 1972.

Using bi-polar technology. The **555** is a **general purpose integrated circuit** that can be used for precision **timing, pulse generation, pulse Width Modulation, Pulse Position Modulation and Linear Ramp Generation.** The **555** can operate in both in ***Astable*** and **M*onostable*** mode, with timing pulse ranging from microseconds to hours. It has an adjustable duty cycle and can generally source or sink output current up to **200mA.**

The **555 timer** can be used with supply voltage in the range of **+5v** to + **18v**. It is compatible with both **TTL** and **CMOS** logic circuits and can be used for burglar, traffic light control, voltage monitor and a range of other applications

3.5.1 PRINCIPLE OF OPERATION OF THE WARBLE ALARM CIRCUIT.

Two **555 timer** integrated circuits are connected both in ***Astable multivibrator*** modes to produce ***pulsating signals (warble)***. The lower half of the **warble circuit** (using the second **555 timer)** is used as '**fast**' astable producing square pulses at the rate decided by the values of the resistor R^16, R^15.and the capacitor **C4**. The upper half of the alarm circuit operates as a '**slow**' astable, generating square pulses with a frequency decided by the values of R^11, R^12 and **C1**.

To obtain a **warble position**, the square wave output pulses from the '**slow**' as table (pin 3 of the upper part of the circuit i.e. the first **555 timer** I.C.) are applied to the control voltage terminal (pin 5 of the lower part of the circuit, i.e the second **555 timer**) of the '**fast**' astable via the resistor R^14. Each pulse causes the voltage at pin 3 of the first ***integrated circuit*** (first **555 timer**) to remain at **12 V** for a period equal to a pulse and then charges abruptly to **0 V** for a roughly equal period equal to the off (low) state of the pulse train.

The supply rail is provided by the output of the relay from the resistiv sensitive touch alarm. The circuit diagram is given in ***figure 3.6*** **.** the frequenc of a multivibrator can be obtained from the following formula;

$$F = \frac{1.4}{(R_1 + 2R_2) \times C1}$$

where R., R2, C are the resistors and capacitor which determine th frequency valued of the multivibrator .

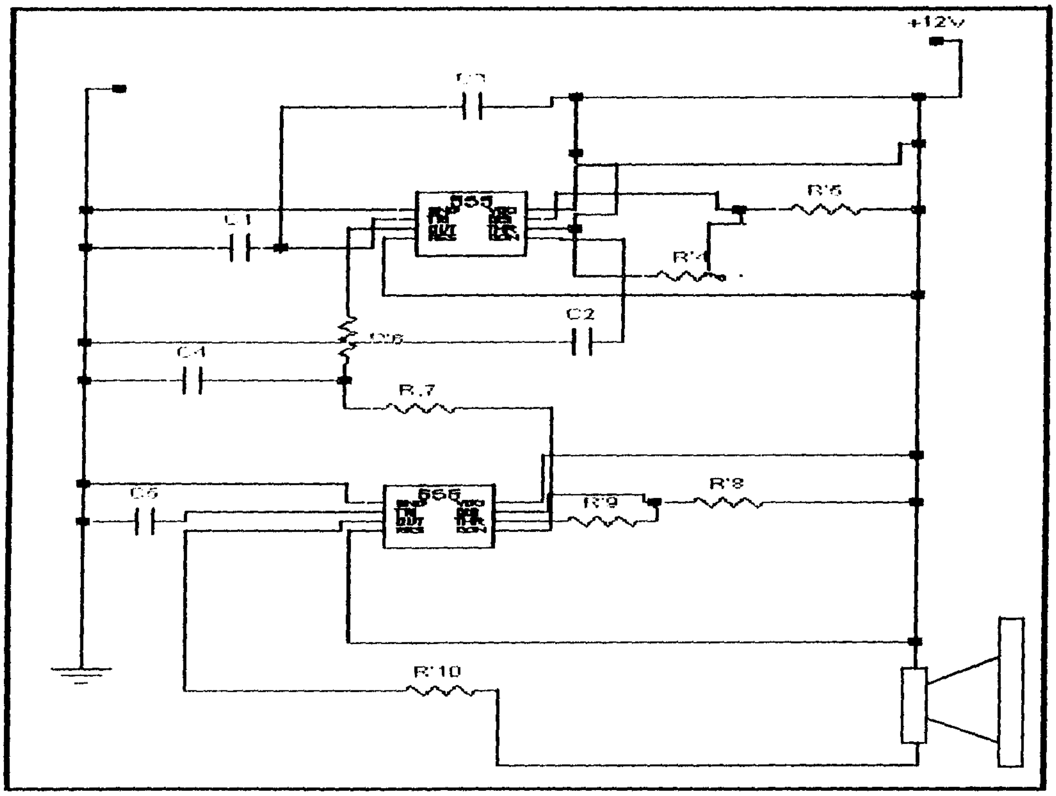


Figure 3.6: ***The Warble Alarm Circuit.***

Hence for the upper part of the warble alarm arrant can be obtained as:

$$F = \frac{1.4}{(R_4' + 2R_5')C_1'}$$

$R_4' = R_5' = 1M\Omega$

C1=0.1 μF

$$\therefore F=\frac{1.4}{\left(10^6+2\times10^6\right)0.1\times10^{-6}}$$

$$=\frac{1.4}{0.3}=4.7Hz$$

for the lower stage of the alarm circuit, the frequency of the astable multivibrator is determined by R_8' , R_9'and C_4

$$\therefore F_2=\frac{1.4}{\left(R_8^{'}+2R_9^{'}\right)C_4}$$

Where

R_8'=R_9'=33K

C4=0.01 μF

$$\therefore F=\frac{1.4}{\left(33+2\times33\right)\times10^3\times10^{-8}}$$

$$=\frac{1.4}{99\times10^{-5}}=1.41KHz$$

CHAPTER FOUR

CONSTRUCTION, TESTING AND INSTALATION.

4.1 DESIGN CONSTRUCTION (POSITION CONTROL CIRCUIT).

For ease of testing and prevention of unnecessary damage to the components purchased for this design, a project board was first used to assemble the design. Alterations and assembly errors were thus noted and corrected and the output found satisfactory before transferring the design to the vero-board.

In soldering the components, care was taken in properly identifying terminals of transistors (Base, Collector and Emitter terminals) and diodes (Cathode and Anode terminals) in conformity with the design diagram and standard data catalogues. An I.C. socket was used for the ***741 operational amplifier***.

The voltage sources **(+12V, -12V and ground)** which had earlier being constructed on a separate vero- board were carefully placed on a part of the casing construction for easy connection to all points where the voltage sources were required.

During the soldering process care was taken to prevent excessive heat being applied to the terminals of al the components. All points of discontinuity were carefully noted and promptly discontinued to prevent short-circuiting in the construction (in conformity with the design diagrams). This was done by 'cutting off' the copper strips on the vero-board at the point(s) where discontinuity was required with the aid of razor blade.

The wood work construction (to simulate the fences, the gate, the ground and the casing) to house the construction were carefully outlined and measured before constructing

4.2 Construction of The Resistive- Sensitive Touch Alarm Circuit And The Warble Alarm Circuit.

All the components required for the construction were precisely tested and verified functional before purchasing. The **2N3704** transistor could not be obtained, however an equivalent transistor (**BC 337**) was used in the construction instead.

The three integrated circuits components used were fitted through I.C. sockets. Care was taken in ensuring discontinuity between the adjacent legs of the I.C. sockets by cutting out part of the copper strips on the ***vero-board*** where it was necessary.

For the sensitive touch alarm circuit, the 12v relay was required to have a resistance of **180**Ω between its coils. The available relay was thus 'paralleled' with a **330**Ω resistor to make up approximately **180**Ω.

The relay output was soldered on to parts (points) on the ***vero-board*** so that its output would serve as supply to points where **12 volts** d.c.supply are required in the **Warble Alarm Circuit.**

4.3 TESTING AND AMENDEMENT OF THE CONSTRUCTION

The first and most important test carried out on the construction was continuity test between all the points on the ***vero- board***. This test was also carried out on adjacent points on the copper strips of the ***vero –board*** for points where there were to be discontinuity (to ensure that there was no short –circuit). A digital multi-meter was used for this to obtain better accuracy of the readings. In testing the ***position control system***, the **12 volts** dual ray d.c. Power supply was connected to the circuit. The feedback potentiometer was also connected. The first test carried out was that of the differential amplifier. The input transducer and the feedback transducer were both positioned at different points (using the knobs) and the corresponding voltage output due to each of these position (at each point) were noted. This proved the satisfactory operation or otherwise of the potentiometers. Afterwards, all connections were made according to the differential amplifier circuit diagram of figure 3.1. The output was measured through the output pin of the operational amplifier {*pin 6*} for varying angular displacements of the transducer knobs.

When both potentiometers {**1and 2**} are set to **0 volts**, the error voltage signal was measured with a digital multi-meter tester. The output was found to be **0 volts**. Potentiometer 2 (***feedback potentiometer)*** was set to maximum (***12 volts***) with potentiometer 1 (***feedback potentiometer***) set to **0 volts** (i.e. unaltered as with the previous test), the output of the amplifier {*pin 6*} was measured to be approximately **10 volts**. The next test was conducted by turning the knob of the feedback potentiometer to maximum (i.e. **12volts**) without altering the position of potentiometer 2{***input potentiometer***}. The output of the amplifier was essentially **0 volts**. The input potentiometer was then set to fully off position (i.e **0 volts)** without altering the feedback potentiometer. The output of the amplifier was measured and it was observed to be a negative output (***approximately -10volts***).

The output of the differential amplifier was then connected to the input of the power amplifier of ***figure 3.4***. The tests carried out with the differential amplifier (as was carried out above) were repeated with the now cascaded connection of the differential amplifier and the power amplifier. The results are as {tabulated} below.

Potentiometer 1 Feedback Potentiometer *(Volts)*	**Potentiometer 2 Input Potentiometer** *(Volts)*	**Output** *(Volts)*
0	**0**	**0**
12	**0**	**- 10.15**
12	**12**	**0.02**
0	**12**	**9.92**

The results tabulated above prove the fact that a Darlington pair has unity voltage gain.

These results proved that the ***Position Control System*** was functional. However to obtain the functionality of the power amplifier circuit (i.e. to test the current gain property of the circuit) a 12 volts d.c. Motor was connected to the output the system {as in *figure 3.4*}. The motor was observed to rotate in either clockwise or anticlockwise directions based on the direction of the error signal from the *error detector*. The motor was essentially stationary when the error signal was measured as **0 volts** {i.e when both potentiometers were either ***'fully on'*** or ***'fully off'***}. This proved that the Darlingon connection has high current amplification capabilities else the motor would not have been driven into rotation.

The **Sensitive-Touch Alarm** Circuit was tested to be all right after its construction. The source probes were touched simultaneously with the face of the palm. It was observed that the relay snapped to close the output terminals to produce an output of **12 volts d.c**. The output was then connected to serve as the input to the Warble Alarm Circuit. This design was tested to be working and fully functional.

With all the tests carried out above, the whole system was fully ready for installation.

The last gear made integral with the feedback potentiometer ensuresthat an equal displacement of the input potentiometer is ***'fedback'*** into the inverting input terminal of the operational amplifier. This closes the error signal output as zero and thus the gate stops. The rotation of the gear labeled r4 is used to determine the length {width} of opening or closing of the gate according to the calculations made in **section 3.3.3.**

The probes of the sensitive touch alarm circuit were connected to the handle of the gate. This acts as a security deterrent to unauthorised persons who might want to forcefully open the gate to gain entrance or exit.

The whole control circuit casing may be located in the operator's bedroom or security post and connected to other parts of the design (the gear and pulley arrangement and the gate) through cables.

CHAPTER FIVE

OBSERVATIONS, CONCLUSION AND RECOMMENDATIONS.

5.1 OBSERVATIONS:

During the course of this project design, it has been observed that all the theories studies on poison control have been fully encountered practically. The project design has in other words fluffed all theoretical studies and manifested the expected stumbling block in the practical design. One of such problems encountered in the practical design is the effect of the ***dead zone (dead band)*** which is the region of insensitivity of the control element.

The **dead zone** is manifested in the fully opening position desired of the gate when the error signal is too small to dive the control element even after being amplified by the power amplified. For fear of running into oscillation problem that may take up too much time and effort and hamper the satisfactory completion of the project on attempt has made to solve the problem.

5.2. CONCLUSION

With strict adherence to the theory of the project design and within acceptable experimental errors, it is worth stating that this project design has been successfully designed. The aim of the project has been successfully achieved. The project has provided wider knowledge on the field of control systems and their practical application.

During the course of this interesting design and construction, the following problems were encountered.

PROBLEMS ENCOUNTERED

1. In the design of the electronic part of the position control system, the ***choice*** of design of the ***amplifier circuit*** suitable for the system.

2. Most of the components used in the design were ***scarce*** in the electronic parts market. This resulted in loss of valuable time and spending of more money in searching for the components.

3. Availability of ***sub-standard components*** and the inavailability of testing methods for ***integrated circuits*** resulted in the repurchasing of some component.

4. In the design of the ***gear pulley system***, gears whose calculated ratings wer expected to be used cold not be obtained in the market. Hence ingenuity had t be applied in obtaining the desired results by making use of what was available.

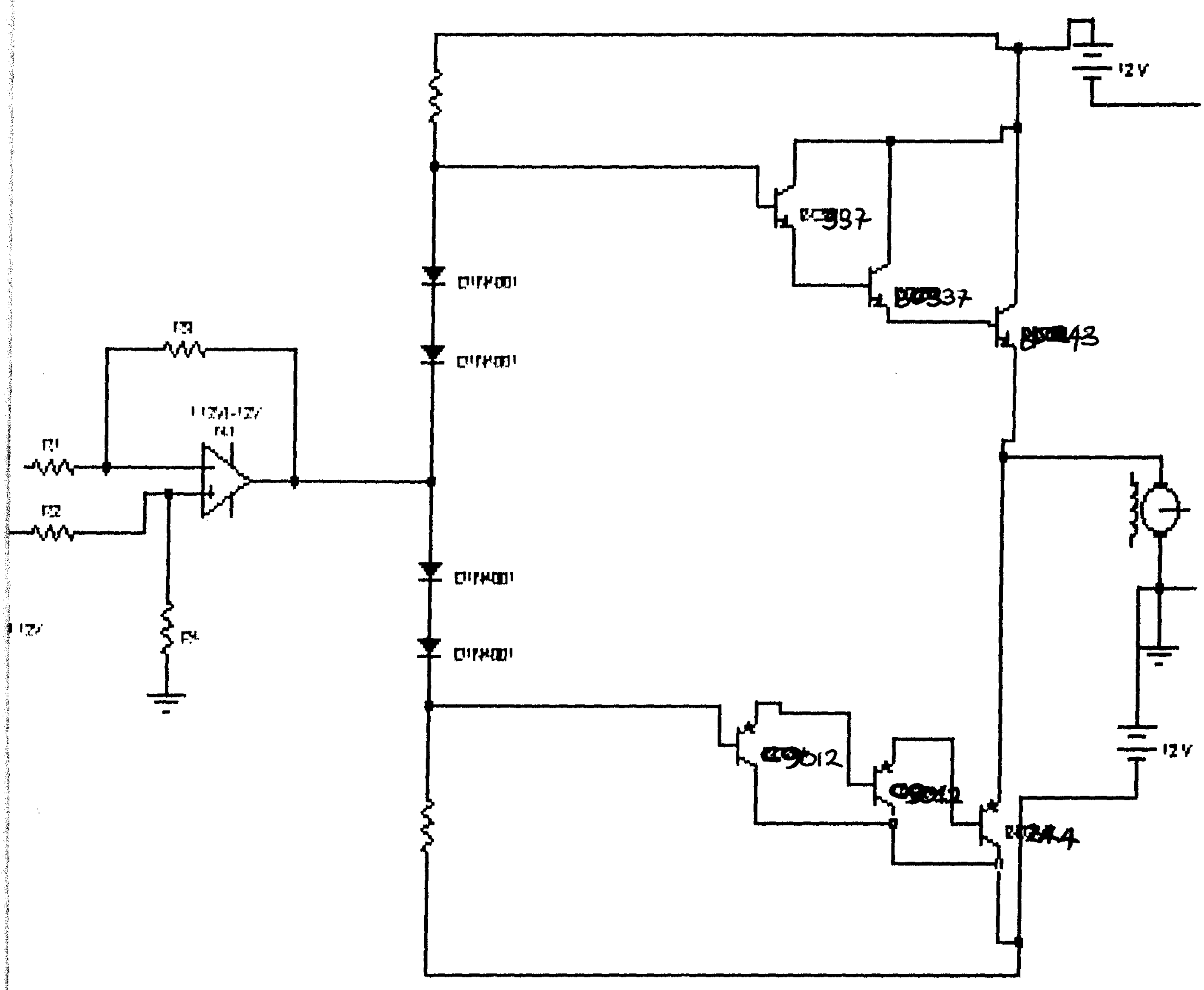
5.3. RECOMMENDATIONS

In line with the processes under taken in the completion of this project, would make some recommendation as.

I. Most of the **designs and constructions** made in fulfilling the requirement of th bachelor's degree (**B. Eng**) by students can go a long way in bringing the mucl needed indigenous ***technological revolution*** to the country. In this wise I woul recommend the support of the government and private agencies in th development of these projects.

II. I would also like to suggest the provision of facilities that would aid students ii broadening their scope of knowledge in their different respective fields in th university. Lack of some of these **facilities** limit the perspective of what students cai design and **fabricate into the local environment**. Such facilities include internet an intranet facilities, subscription for educational materials from other schools within an outside the country through the university e.t.c.

Appendix A



AUTOMATED PASSAGE GATE CONTROLLER (POSITION CONTROI METHOD)

Appendix B.

List of components used

	Name of component	Type/	Value/ label of component
TR 1 & TR2	Transistor	NPN-Si	BC 337
TR4 & TR5	Transistor	PNP-Si	C 9012
TR3	Transistor	NPN-Si	BD 243
TR6	Transistor	PNP-Si	BD 244
R1 & R2	Resistor	carbon	2.2 KΩ.
R3 & R4	Resistor	carbon	47 KΩ.
C1 & C3	Capacitor	Disc	0.1 μf (104)
C2 & C4	Capacitor	Disc	0.01 μf (103)
R'1 & R'2	Resistor	Carbon	1MΩ
R'3	Resistor	Carbon	4.7KΩ
R'4	Resistor	Carbon	10KΩ
R'6 & R'7	Resistor	Carbon	33KΩ

R'7	**Resistor**	**Carbon**	**220Ω**
R"1	**Resistor**	**Carbon**	**10MΩ**
R"3	**Resistor**	**Carbon**	**4.7KΩ**

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