DESIGN AND CONSTRUCTION OF D.C MOTOR SPEED CONTROL USING THYRISTORS AT DIFFERENT FIRING ANGLES

BY

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2003/15346EE

DEPARTMENT OF ELECTRICAL AND

COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND

ENGINEERING TECHNOLOGY

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A THESIS SUBMITTED TO THE ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER, 2008

DEDICATION

This project is dedication to God almighty for his infinite mercy, life, and guidance and provision through out the course of my study. Also this project is dedicated to my parents Mr. and Mrs. Chuks Chikeluba and to my sisters and brother; Mrs. Maureen .U. Nnakwelugo, Ms. Vivian .N. Chikeluba, Ms. Jane .I. Chikeluba and Mr. Henry .U. Chikeluba. Also to my in-law Mr. Sunday Nnakwelugo and my nieces Ms. Chioma .J. Nnakwelugo and Ms. Chinazo Nnakwelugo for their encouragement, guidance, and support both financially and morally.

This project is also dedicated to my friends Mr. Ifeanyi Obi, Mr. Jimmy John, Lt Oladapo OLaleye. And also a priceless jewel Ms. Maureen .O. Nwankwo. For their inspiration and unparallel advice throughout the course of this project. May God bless you all.

DECLARATION

I Chikeluba Tochukwu Stanley hereby declare that this project titled D.C motor speed control using thyristors at different firing angles was carried out by me and has never been presented elsewhere for the award of a degree. I also relinquish the copyright to the Federal University of Technology Minna.

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(Signature and Date)	(Signature and Date)

ACKNOWLEGDEMENT

It is impossible to list all persons that have contributed either directly or indirectly to the success of this project.

First and foremost, I wish to acknowledge my greatest indebtedness to Almighty God for his guidance, support, protection and immeasurable assistance to witness the completion of my (B. ENG) Degree study.

My sincere gratitude to my supervisor Engr. J. G kolo, I thank you very much sir for your guidance, advice patience and supervision over the completion of this project. I want to appreciate the Head of Department Prof Y. A. Adediran and the entire staff of Electrical and computer Engineering Department of Federal University of technology, minna

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My gratitude also go to Engr M .C. Azodo for his hospitality and support during my research.

ABSTRACT

This project is based on the design and construction of a D.C motor speed control using thyristors at different firing angles is carried out to provide an efficient and effective control of D.C motor. The circuit contains the power supply unit which supply controllable 9V dc source to the motor, the second stage of the circuit is the Astable multivibrator which generates waves or pulses that is used for triggering of the thyristor gates and the third stage is the commutation circuit.

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Chapter three: Design and implementation

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CHAPTER ONE

1.0: INTRODUCTION

Generally, a machine is a device that can convert energy from one form to another. A machine is capable of performing useful work. A machine varies widely in appearance, functions, construction and operational principles.

Thus, electric machines can be classified into two main categories;

i. Generator

ii. Motor

These two categories of machines operate on the fundamental principles of magnetic and electromagnetic induction of devices which are capable of converting energy from one form to another, i.e. electrical and mechanical which appear in either input or output.

The generator converts mechanical energy to electrical energy by the interaction of moving conductors cutting across in magnetic field in the air gap to produce an induced emf. While motor converts electrical energy to mechanical energy in reverse process.

Due to its advantages, the electric motor has largely replaced other power both in industries, transport, business firms, and homes. Electric motors are convenient, economical to operate, safe, free from smoke and odour, comparatively silent.

They operate in wide range of applications such as starting, accelerating, and running, breaking, holding and stopping a load. They are also available in variety of sizes from small fraction of horse power to many thousand of horse power and in a wide range of speed. The speed may be fixed (synchronous) constant for even load conditions, adjustable or variable.

For uniformity and interchangeability motors are standardized in size, types, speed. Electric motors can operate be in alternating current (A.C) or direct current (D.C). There are many types of each, although Ac motors are more common, dc motors are preferred for applications requiring simple, inexpensive, speed control or sustained high torque under low voltage conditions.

1.0.1: THYRISTORS: A thytristor is a PNPN 4 layer semi-conductor device. It is widely used as a switching device. It can control load by switching current OFF and ON up to many thousand times, there by delivering selected amount of power to the load, compared to the transistor, it has a very fast response, very high efficiency, very high reliability and very long life.

The applications of thyristors are found in the following;

- Phase control
- Inverter
- Relay control
- Battery charger
- Heater control and also most importantly,
- D.C motor speed control

In motor speed control, the thyristors controls the energizing of the motor.

1.1: AIMS AND OBJECTIVES

- Also the aim of this project is provide motor control system which exhibits small velocity variation as a result of variation of power supply and frequency.
- Also to provide a motor speed control system having a fast response time.

1.2: SCOPE OF PROJECT

The project covered the construction of D.C motor speed control using thyristors at different angles of firing from the power supply unit to the commutation unit.

1.3: METHODOLOGY

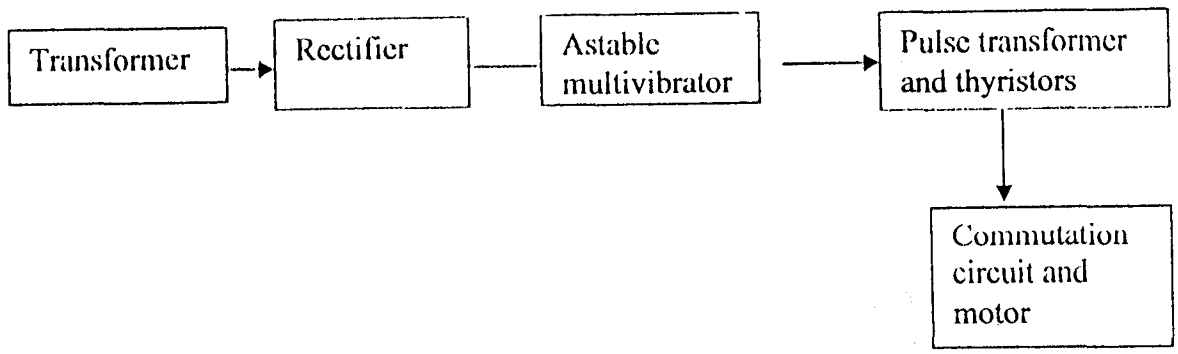


Fig 1 block diagram of D.C motor speed control using thyristors at different firing angles

Fig. 1 above gives the block diagram of this project (D.C motor speed control using thyristors at different firing angles.) A regulated D.C supply is obtained from an A.C source via transformer T1.

The Astable multivibrator generates the pulses to trigger the thyristors. It oscillates and produces pulses of certain mark-to-space ratio. Moreover the outputs of the transistors of the Astable multivibrator are 180° out of phase with each other. The chare and discharge of the capacitors C1 and C2 in the Astable multivibrator determines the waveform.

The output of transistor Q1 drives the primary windings of the pulse transformer T3 and the output of Q2 drives the primary windings of pulse transformer T2.

The pulse transformers transmit pulses that have quick rise and fall time at constant amplitude to the thyristors through their secondary windings (i.e. firing the thyristors). As a result the pulse transformers deliver pulse signals generated by the astable multivibrator to the thyristors. The thyristors which are now triggered into conduction by the pulse transformers now control the speed of the motor. The pulse transformers also provide isolation between their input and output.

The commutation circuitry is used for switching OFF due to the fact that thyristors are semi-controllable devices i.e. their ON state can be controllable but the OFF state is uncontrollable. Therefore the commutation circuit now comes in handy.

1.5: SOURCES OF MATERIALS

The sources of the materials for this project are as follows;

- Electrical laboratory (FUTMINNA)
- School Library
- Mr. Kasim Idris (staff PC&M department of shiroro hydro power station)
- Mrs. Caroline(ECE 514 lecturer)
- ECE 514 lecture note
- Internet.

CHAPTER TWO

LITERATURE REVIEW

2.1: HISTORICAL BACKGROUND

The D.C motor is based on the Michael faraday's electromagnet theory.

Faraday used Ostend's discovery, that electricity could be used to produce motion, to build the world's first electric motor. In 1921, faraday demonstrated a device in which a conductor carrying D.C rotates around a magnet, in fact his device was a primitive homopolar machine. In the years that followed, several more devices capable of converting electrical energy to mechanical energy were made [6] [7].

In 1824, Barlow described a device resembling a homopolar machine, in which a copper disc is placed within the field of a permanent magnet would rotate when supplied with current. In 1833, Ritchie described the first working model of a heteropolar commutator motor. In his device, the field was excited by horse-shoe magnet between the poles fed with D.C via the commutator. A unidirectional torque was produced by the interaction of the permanent magnet and the electromagnet in which the direction of current flow was reversed in a periodic fashion [7].

In 1834, Jacobi built an electromagnetically excited D.C motor which could be used as a drive for various machines: ''it has two groups of u-shape magnets, with four magnets per group. One group was mounted on a rotating disc, so that the two groups faced each other. The coils of all the magnets were connection (today we could call it "series excited" or "series wound) Direct current was supplied by a battery of primary cells. The polarity of the rotating magnet was periodically changed by a commutator". In 1838, Jacobi built a better and larger motor which could propel a small boat. In fact, it was a combination of 40 small units each of which differed from the machine of the rotating and stationary magnets were arranged radially and on the same plane. A major limitation of Jacobi motor was the pulsating torque, salient pole core [7].

In 1859, Pacinotti built an electric motor which had a non-salient pole, distributed winding armature and produced a practically constant torque. The armature torque was a toothed steel ring mounted on a shaft by means of brass spokes. The slot receives coils brought out to commutator bars. The commutator has as many bars as there were armature coils. Current was conveyed to the commutator bars by contact rolls placed across the armature teeth where two electromagnets of opposite polarity fitted with pole-pieces. The electromagnet was connected in series with the armature winding and took a small current for excitation (owing to the teeth on the armature core). For all of its advantages Pacinotti's motor failed to become a practical machine because like Jacobi motor, it required an economical D.C source which was non- existent at that time [7][8].

John Lincoln, an engineer that founded variable speed in 1905.

Alex Mc Cutcheon, of the same reliance company in 1913 designed a new motor for steel rolling mills which require more power.

In 1920, Jim Correy, a sales man with reliance engineering, despite his limited engineering inclination invented the first adjustable voltage multi-motor control for paper and textile industries. After this improvements' were carried out intermittently till mow [8].

2.2: THEORITICAL BACKGROUND

The speed characteristic of a motor usually represents the variation of speed with input current or input power. The speed of a D.C motor can be altered by varying either the flux or armature voltage or both. The methods which are commonly employed include:

- Variable Resistors
- Resistance
- Thyristor control [2].

2.2.1: VARIABLE RESISTORS

A variable resistor called a field regulator is connected in series with the shunt winding in shunt and compound motors. When the resistance is increased, the field current and the flux generated are reduced. Consequently, more currents flow through the armature and the increased torque enables the armature to accelerate until the generated EMF is again nearly equal to applied voltage.

With this method it is possible to increase the speed three or four times than at full excitation, but it is not possible to reduce the speed below the value. Also with any given setting of the regulator, the speed remains approximately constant between no-load [2][9].

2.2.2: RESISTIVE CONTROLLER

This method of controlling the speed of D.C motor involves the use of resistor called controller which is usually connected in series with the armature. The electrical connections for the controller are exactly the same as for a starter, the only difference being that in a controller, the resistor elements are designed to carry the armature current indefinitely where as in a starter they can only do so for a comparatively short time without getting excessively hot.

For a given armature current, the larger the controller resistance in the circuit, the smaller the potential difference across the armature and lower the speed [10].

2.2.3: ADVANTAGES OF RESISTIVE CONTROLLER METHOD FOR SPEED CONTROL

1. Speeds from zero upwards are easily obtainable by this method.

2. The method is majorly used for controlling the speed cranes, hoists, trains etc. where the motor are frequently started and stopped and where efficiency is of secondary importance [2].

2.2.4 DIS-ADVANTAGES OF RESISTIVE CONTROLLER METHOD

1. High cost of controller.

2. High percentage of input energy may be dissipated in the controller and the overall efficiency of the motor reduced.

3. The speed may vary with variation of load due to change in the potential difference across the controller [13]

2.2.5: THYRISTOR CONTROLLER

This method involves the application of the available A.C supply to the thyristor which controls the voltage applied the armature of the motor. The thyristor is a solid state rectifier which is normally non-conducting in the forward and reverse directions. It is provided with an extra electrode, called the gate such that when a pulse current is applied to the gate circuit, the thyristor begin to conduct in the forward direction. Once the thyristor is fired, it continues to conduct until the current falls below the holding value of the current.

As compared to other methods of controlling the speed of a motor, the thyristor method of controlling motor speed have higher accuracy, greater reliability, quick response and also higher efficiency, as there are no IR losses in moving parts.

Thyristor control speed of motor can be achieved by adjusting either;

1. The voltage applied to the motor armature.

2. The field current.

3. By varying the firing angle of the thyristor.

As stated above, the average output a thyristor controlled rectifier can be changed by varying its firing angle and hence the armature voltage of the D.C motor can be adjusted to control its speed.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

The design and construction of this project is an important aspect that requires a very high level of skill and absolute carefulness.

In the construction, a bread board was initially used and after a demonstration test, it was then transferred to the Vero board.

On the far end horizontal line was chosen as the ground terminal (-Vcc) and the other end as the power supply or array terminal (+9 Vcc). The mounting of the components started with the bridge rectifier, which serves as a reference for the incoming A.C and outgoing D.C supply, followed by the two transistors T1 and T2 whose emitter ends are connected to the ground terminal, while the collectors were connected to the (+ Vcc) through the collector resistors Rc1 and Rc2 with the collector of T1 connected to the base of T2 and vice versa. With these connections, these complete the Astable Multivibrator.

The next stage is the connection of the pulse transformers. One of the outputs of the Astable Mubltivibrator is connected to the primary of the pulse transformer through a capacitor. And also the other output is also connected to the primary of the other pulse transformer. Their corresponding secondary winding is connected to the gates of the thyristors Th1 and Th2 with their cathode terminals connected to the ground.

Also the gates of the thyristors Th1 and Th2 are connected to the cathodes of diodes D5 and D6 while their anode terminals are connected to the ground.

The anode of thyristor Th2 is connected to the motor with respect to + Vcc while the anode of the thyristor Th1 is connected a resistor with respect to + Vcc. The commutation capacitor is connected in series with the free-wheeling diode D7, which is connected in parallel to the motor and to the thyristors anodes to complete commutation.

The last stage was the connection of the potentiometer to vary the duty cycles of the astable multivibrator, which in turn vary the triggering angle of the thyristors.

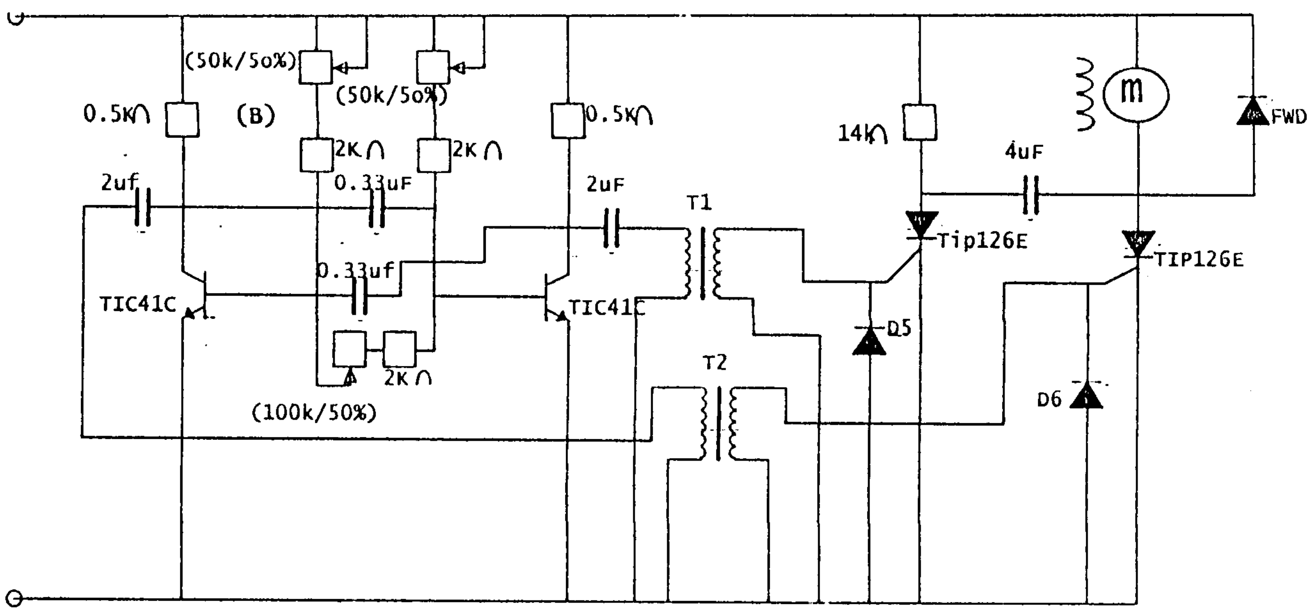


Fig 3.1: circuit diagram of D.C motor speed control using thyristors at different firing angles

3.2: STAGES OF THE CIRCIUT

The design and construction of a D.C motor speed control using thyristors at different firing angles involves the following stages;

- The construction of the power supply
- The construction of the astable multivirator
- The construction of the commutation circuit and the mounting of the motor

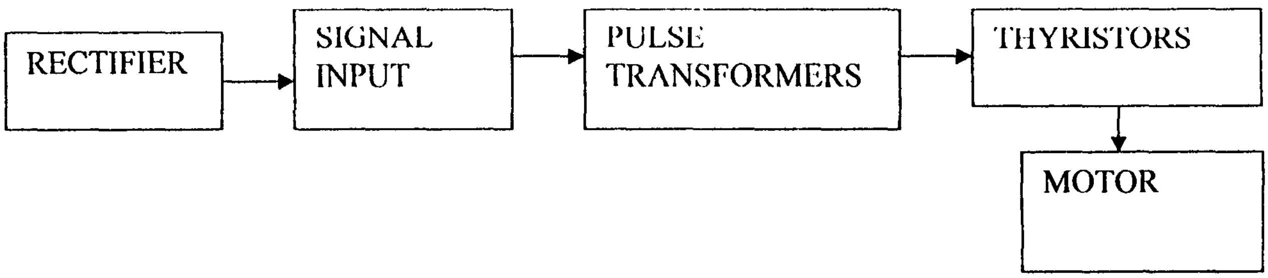


Fig.3.2. block diagram of D.C motor speed control circuit.

3.2.1: CONSTRUCTION OF THE POWER SUPPLT UNIT

As stated earlier, rectifier is used for an A.C to D.C conversion that is when the supply is alternating but the motor to b e controlled is a D.C machine.

A transformer of 240V ac is used to step down the input voltage to the required out put voltage value, the single phase, full-wave rectifier (four semi-conductor diodes) are connected across the output of the transformer.

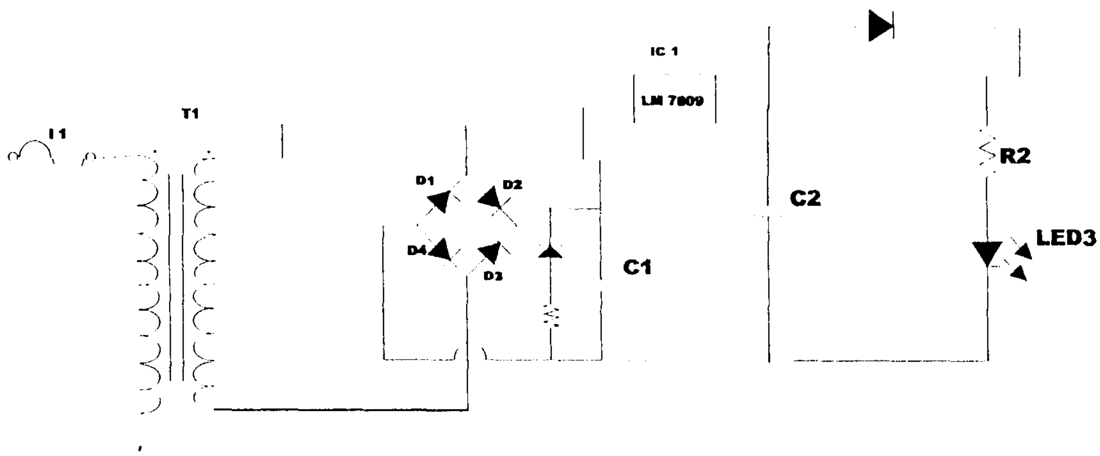


Fig3.3. Power supply unit

During the positive half cycles, the diodes D1 and D2 conducts where as during the negative half cycles the diodes D3 and D4 conducts.

The average Vdc across the load during half cycles is given as;

$$V = \frac{\sqrt{2}}{\pi} V_{rms} = 0.45\ V_{rms}\ \text{(half cycle)}$$

V_{max} for full cycle = 2 * 0.45 = 0.9 V_{rms}.

$$V_{dc} = \frac{0.9}{\sqrt{2}} \qquad V_{dc} = 0.636\ V.$$

3.2.2: DESIGN OF THE ASTABLE MULTIVIBRATOR

The astable multivibrator is used to generate pulse of variable width to trigger the thyristors. The astable multivibrator starts oscillating due to the slight difference between the conduction of transistors T1 and T2 that is due to mis-match. When the collector supply is switched "ON" both transistors will start to conduct as base currents flow via their respective base resistors. The D.C current gain and switching time of the two transistors will not be identical and so one will surely conduct greater than the other.

Suppose transistor T1 starts to conduct more than transistor T2 when + Vcc is applied, the conduction of T1 causes longer voltage drop across Rc1 and consequently a less positive voltage at the collector of T1. This negative going signal is coupled through capacitance C1 to the base of T2 which decrease the forward bias of T2 and T2 is driven to cut off. A decreasing current in T2 causes its collector to become positive going voltage coupled to the base of T1 quickly drives it into saturation.

At this time, capacitor C2 charges to the collector voltage of T2 and C2 discharges to the collector voltage of transistor T1 according to the time constant. After an interval, the base end of T2 becomes negative and the base of T1 becomes positive and this decrease the forward bias of T1 and decrease the conduction of T1. Also the positive voltage at the base of T2 increase the forward bias and T2 is driven into conduction.

Thus, the alternate cut off and saturation periods produce a square wave, the frequency depends on the time constant of the circuit (RC), and this can be varied by the use of potentiometer.

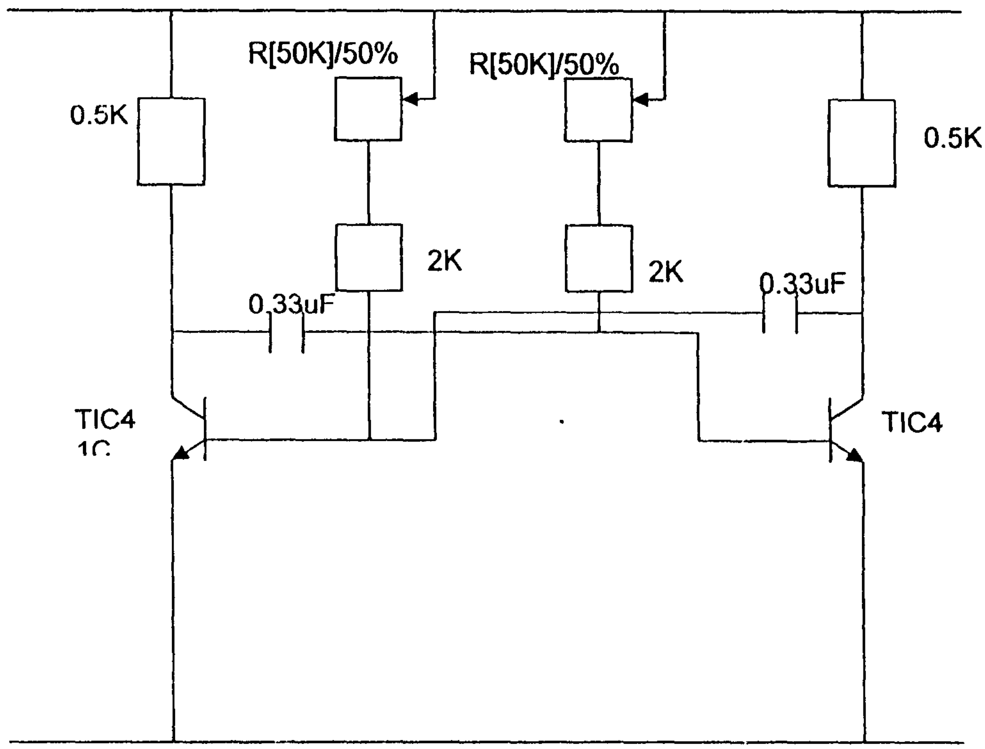


Fig 3.3: circuit of Astable multivibrator

3.2.3: MARK-TO-SPACE RATIO OF AN OSCILLATOR

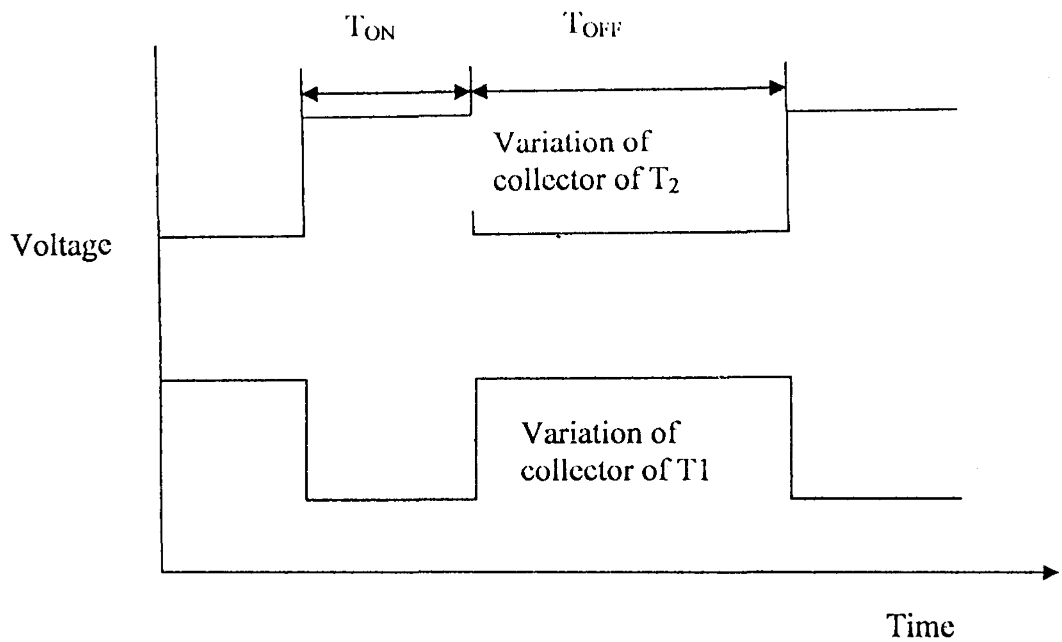


Fig. 3.4: show the wave form of an astable multivibrator

For a circuit where C1=C2 and R1=R2, the "ON" and "OFF" times for each transistor will be equal.

I.e. $T=T_{on} + T_{off}$ where $T_{on} = T_{off}$

Then;

Duty cycle $\delta = T_{on} \div (T_{on}+T_{off})$

The duration of the input or delay time of the astable multivibrator circuit is termed the Pulse Repetition Frequency.

$$\text{Frequency} = \frac{1}{T_{on} + T_{off}}$$

Where

"Ton"= time for which transistor T2 is ON and T1 is OFF per total cycle time of $T_{on} + T_{off}$.

"T_{off}"= time for which transistor T2 is ON and T1 is OFF per total cycle time of $T_{on} + T_{off}$.

The frequency domain to time-domain transformation can be proof mathematically below;

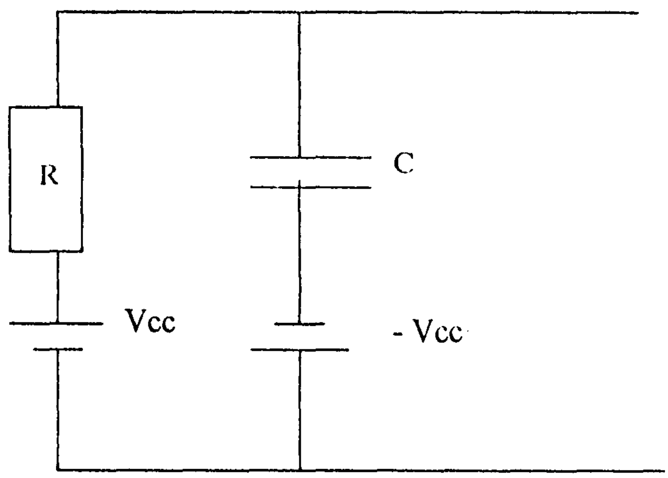


Fig. 3.6 freq domain to time-domain transformation circuit.

Using Nodal Analysis,

Vb (1/R + Sc) + V(s)/R+ Vsc =0

Therefore,

$$Vb = \frac{V\,(1/R - Sc)}{1/R + Sc}$$ but V = Vs / S

Then;

$$Vb = \frac{V}{Rsc\,(1/R + S)} - \frac{V}{1/Rc + S}$$

Therefore,

$V_b(t) = V(1 - 2e^{-t/RC})$.

Thus the relaxation equation for each base of the transistors is,

$V_{b1}(t) = Vcc(1 - 2e^{-t1/R1C1})$ and

$V_{b2}(t) = Vcc(1 - 2e^{-t2/R2C2})$.

For symmetrical multivibrator, the time required each base voltage to rise from - Vcc to zero is given by;

1. $0 = Vcc - 2\,Vcc^{-t1/R1C1}$

For the circuit where C1=C2 and R1=R2, the ON and OFF times for each of the transistors will be equal.

i.e. $T = T_{ON} + T_{OFF}$

Where $T_{ON} = T_{OFF}$

Therefore, duty cycle $\delta = \dfrac{T_{ON}}{T_{ON} + T_{OFF}} = \dfrac{1}{2}$

$= 50\,\%$ (giving low speed)

From the circuit diagram,

If,

$R1 = 2K\Omega$	$R2 = 2K\Omega$
$R_a = 0\ k\Omega$	$R_b = 0\ k\Omega$
$C1 = 0.33\mu F$	$C2 = 0.33\ \mu F$

$T_{ON} = 0.693 * C1 * (R2 + R_b)$

$= 0.693 * 0.33 * 10^{-6} * (2+0) * 10^3$

$= 0.693 * 0.33 * 10^{-6} * 3 * 2 * 10^3$

$= 4.57 * 10^{-4}$

$T_{OFF} = 0.693 * C2 * (R2 + R1)$

$= 0.693 * 0.33 * 10^{-6} * (2+2) * 10^{3}$

$= 0.693 * 0.33 * 10^{-6} * 4 * 10^{3}$

$= 9.15 * 10^{-4}$

Therefore,

Duty cycle $\delta = \dfrac{4.57 * 10^{-4}}{9.15 * 10^{-4}} * 100\ \% \quad = \quad 49.9\ \% \quad \approx 50\ \%$

If R_a and R_b are varied and where R_b is the variable resistance for the ON period and Ra is the variable resistance for the OFF period.

When,

Ra =.0 kΩ Rb = 50kΩ

R1 = 2 kΩ R2 = 2 kΩ

$T_{ON} = 0.693 * C2 * (Rb + R2)$

$= 0.693 * 0.33 * 10^{-6} * (50+2) * 10^{3}$

$= 0.693 * 0.33 * 10^{-6} * 52 * 10^{3}$

$= 0.00189$

$Toff = 0.693 * C2 * ((Ra+R1) + (Rb + R2)) * 10^{3}$

$= 0.693 * 0.33 * 10^{-6} * (52 + 2) * 10^{3}$

$= 0.01235$

Duty cycle $\delta = \dfrac{0.01189}{0.01235} * 100\ \%$

$\approx 96\ \%$ (giving a very high speed)

For,

$Ra = 10\ k\Omega$ $Rb = 40\ k\Omega$

$R1 = 2\ k\Omega$ $R2 = 2\ k\Omega$

$C1 = 0.33\mu F$ $C2 = 0.33\mu F$

$T_{ON} = 0.693 * C2 * (Rb + R2)$

$= 0.693 * 0.33 * 10^{-6} * (40+2) * 10^{3}$

$= 0.0960$

$Toff = 0.693 * C2 * ((Ra+R1) + (Rb + R2)) * 10^{3}$

$= 0.693 * 0.33 * 10^{-6} * ((10 + 2) + (40+2)) * 10^{3}$

$= 0.0125$

$$\text{Duty cycle} = \frac{0.00960}{0.0125} * 100\ \%$$

$= 76.8\ \%$

It is observed that speed is reducing as the Rb is reducing.

Lastly,

When,

$Ra = 50\ k\Omega$ $Rb = 0\ k\Omega$

$R1 = 2\ k\Omega$ $R2 = 2\ k\Omega$

$C1 = 0.33\ \mu F$ $C2 = 0.33\ \mu F$

$T_{ON} = 0.693 * C2 * (Rb + R2)$

$= 0.693 * 0.33 * 10^{-6} * (0+2) * 10^{3}$

$= 0.000457$

$Toff = 0.693 * C2 * ((Ra+R1) + (Rb + R2)) * 10^{3}$

$= 0.693 * 0.33 * 10^{-6} * ((50+ 2) + (0+2)) * 10^{3}$

$= 0.01235$

$$\text{Duty cycle } \delta = \frac{0.000457}{0.001235} * 100\ \%$$

$= 37\ \%$ (giving very low speed)

The duration of the input pulse or the delay time of the astable multivibrator circuit is obtained as follows;

$$PRF = \frac{1}{T_{on} + T_{off}} = \frac{1}{2CR\ Loge^2}$$

$$= \frac{1}{1.4\ CR} \qquad \text{where } CR = C_1 R_2 = C_1 R_2$$

3.2.4: CONSTRUCTION OF PULSE TRANSFORMERS

The pulse transformers are constructed in such a way that the input and the output of the pulse transformer are made of secondary windings giving the turn ratio to be 1: 1. The construction of the pulse transformer involves getting two 6V power transformers, the primary windings of the two transformers were removed and the secondary winding of one of the transformers is coiled to the primary of the other transformer to give a secondary input and a secondary output. Thus making the turn ratio to be 1:1.

3.2.5: THE CONSTRUCTION OF THE COMMUTATION CIRCIUT

When a thyristor is fired into conduction, the gate loses control and the thyristor continue to conduct. The commutation circuit is used for switching OFF. Thus, enabling it to perform ON-OFF switching function. From the diagram below, when thyristor Th_1 is fired into conduction by the control circuit (which is not shown in the diagram below), current is set up between the load and the commutation capacitor get charged via the resistor R with the polarity during the ON period of thyristor Th_2.

For switching OFF, the second thyristor Th_2 is triggered into conduction allowing commutation capacitor C to discharge through it (since it act like a shunt circuit while conducting) which reverse- bias thyristor Th_1 thus turning it OFF. The discharge from C leaves Th_2 with reverse polarity so that it is turned OFF where as Th_1 triggered into conduction again.

Note: R, Th_2 and C are used for the commutation purpose.

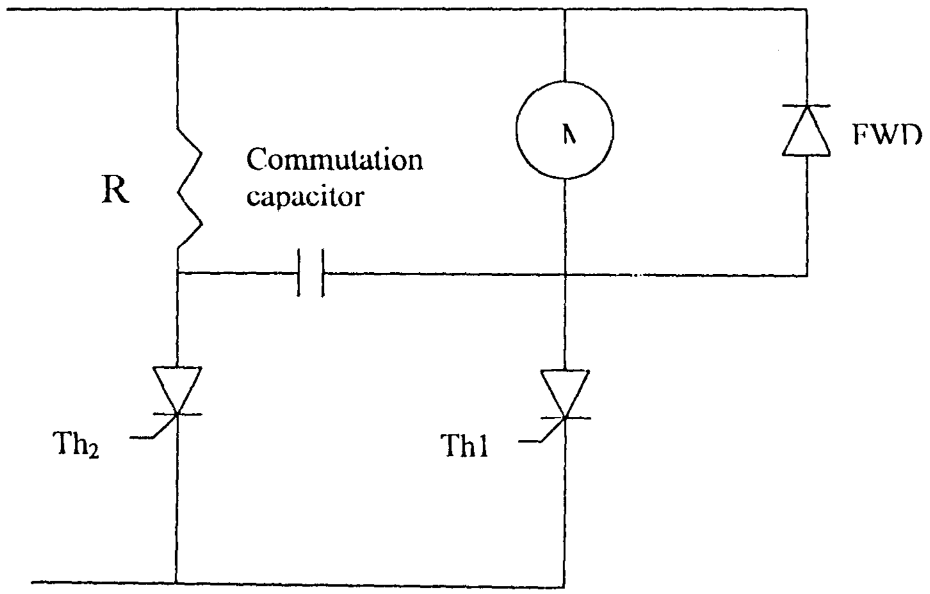
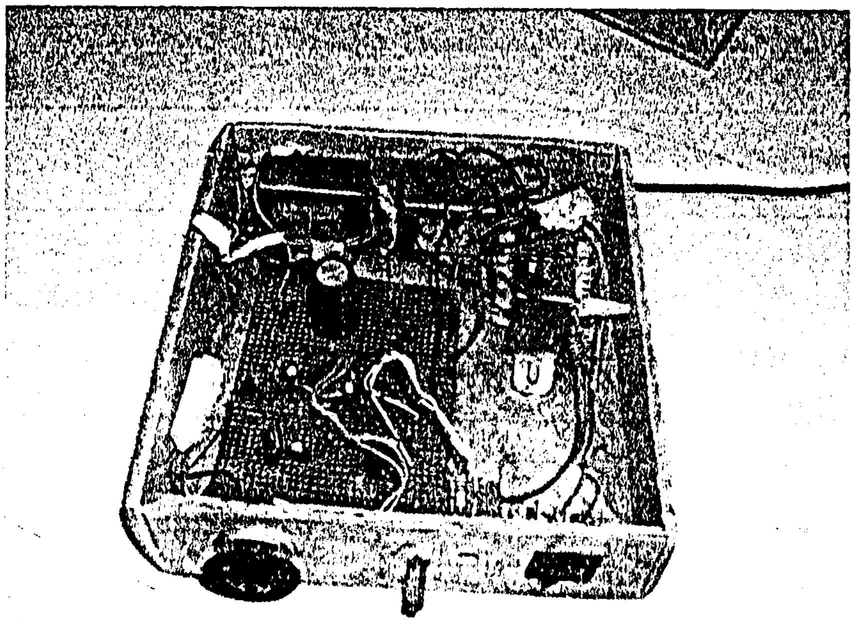


Fig: 3.7 commutation circuit

3.2.6: PACKAGING

Production process is considered as being completed only when the product is made readily available for the consumers use. This require a very good handy and safe finishing of the product, therefore there is a very high need to provide a qualitative and protecting packaging for the project.



CHAPTER FOUR

4.1: CONSTRUCTION

The semi conductor devices such as the capacitors, resistors, diodes, transistors, thyristors ad the D.C motor was mounted on the breadboard. The input terminal was placed on the panel inside the casing.

4.2: TESTING

After carrying out all the paper design and analysis, the project was tested to ensure its working ability, and was finally constructed to meet desired specification. The process of testing involves use of a digital multimeter.

Also the following tests were conducted, giving results as stated below;

1. Visual inspection and checks for dry joints and shorts.
2. Measurement of practical values of voltages at various stages of the circuit.

4.2.1: Visual inspection of dry joints

After the circuit construction, it was visually inspected and continuously checked for defective soldering such as unsoldered leads of components and short-circuiting between leads and wrong connection of components. From the checks all board links that require opening were broken to avoid short circuits.

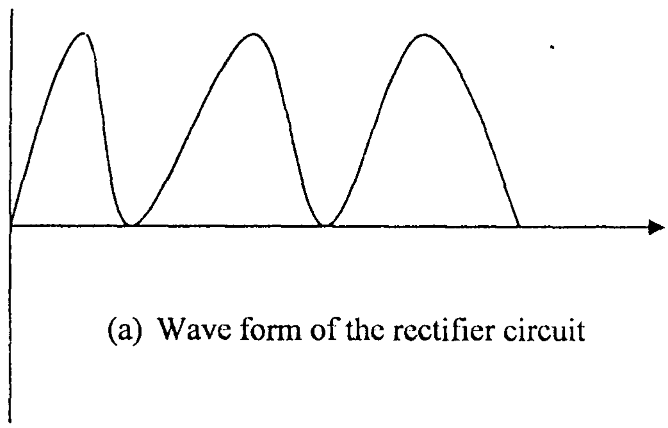
4.2.2: measurement of practical values of voltages

Measurement of practical values of voltages was conducted using a digital multimeter for better reliability.

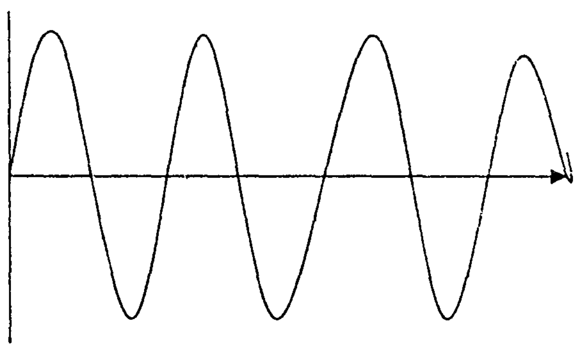
4.3: RESULTS

At the end of the construction and testing, the following results were obtained;

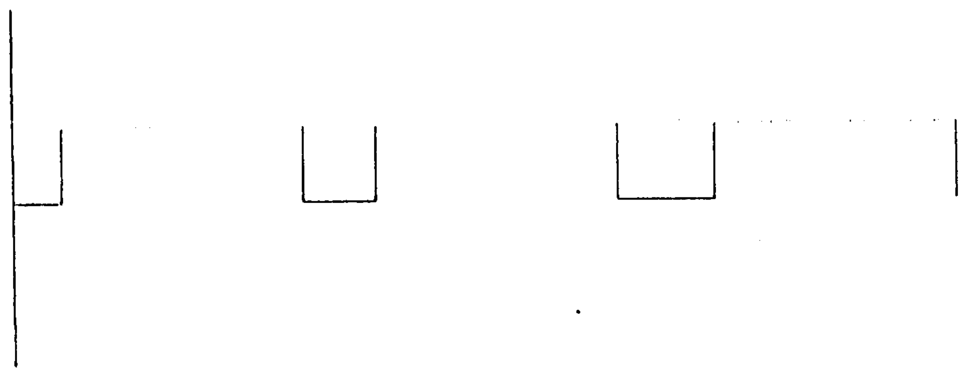
1. The output voltage from the rectifier circuit was 9V dc and output current was 25mA.
2. The oscillator voltage from the multivibrator varies between 2.74V ac to 1.5Vac.
3. The output voltage and current from the chopper drive circuit which is the input to the motor was found to vary between 0.8Vac to 3V ac.



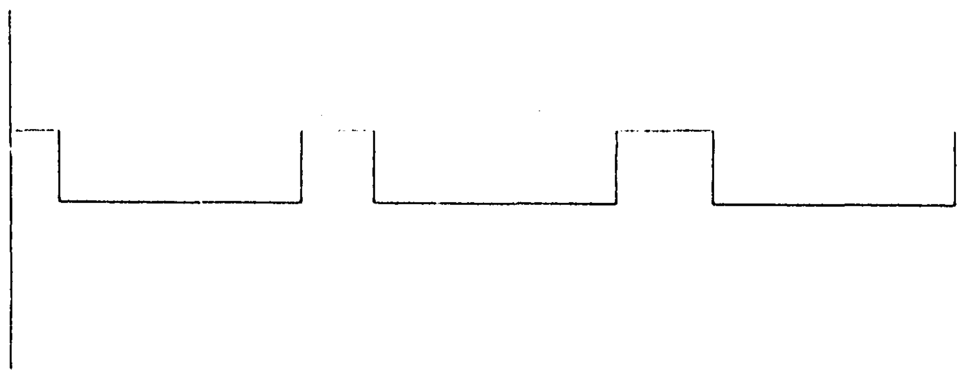
(a) Wave form of the rectifier circuit



(b) wave form from the oscillator output



(c) Waveform for high speed



(d) Waveform for low speed

4.4 DISCUSSIONS

Though the project was completed and tested successfully, some precautionary measures were adopted from the start to the end. Measures such as using fewer components in order to reduce the cost of the project, careful selection of the components look simple and easy to handle in case of trouble shooting or replacement. Also some components used in this project were not actually equal to the values of the components obtained during design are not standard values, so standard values close to the calculated ones were chosen.

CHAPTER FIVE

5.1: CONCLUSION

Speed control of motors is central to the human experience. It is an essential element in our society due to the ever increasing demand for it therefore working on this project was challenging, but it turned out to be interesting and very enlightening.

The objective of this project was to design a simple circuit that can be used to control the speed of a D.C motor and this aim was actually achieved.

The various units that constituted the whole system were individually tested and confirmed okay. They were then coupled together to form the whole system. This was tested and the results were not far from the designed values.

5.1.1: PROBLEMS ENCOUNTERED

While carrying out this project work, several constraints were encountered. Amongst these difficulties are:

- Difficulty encountered while sourcing for components especially the pulse transformers,
- Irregular power supply during construction.
- Wastage of resources, time and energy resulting to damage of some components during soldering.

5.2: RECOMMENDATION

The project was designed and constructed using two (2) NPN transistors of the same values for the construction of the Astable multivibrator circuit. In this case a single integrated circuit (IC) can be used to give the same output signal. Therefore it is recommended for use.

The circuit is not designed to perfection, it is therefore recommended for improvement and development to compensate for load variation and protection against over heating of power supply unit. Further improvement can be made in the design by using a micro-controller to control the speed of the D.C motor.

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