THYRISTOR CONTROLLED VARIABLE SPEED DC DRIVE

PROJECT WORK

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Submitted by

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NARAYAN INDUSTRIES

SINGLE & THREE PHASE
ELECTRICAL MOTORS &
BENCH GRINDERS

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CERTIFICATE

This is to certify that the following students

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Of KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE have successfully complted their project tittled " THYRISTOR CONTROLLED-VARIABLE SPEED DC DRIVE" in the above said indusyry.

During that period, they exhibited very good technical skills and their conduct was good.

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SYNOPSIS

The project deals with the design and fabrication of a circuit for the speed control of a DC Shunt motor using SCRs. A reference AC signal is converted into a pulsating DC. A zero crossing detector is used in order to determine the zero crossing points of this pulsating DC. A ramp waveform is generated and is given to a comparator. The other reference input to the comparator is a feedback signal. The cross over signal from the ramp and the reference input which is a change in delay angle obtained as pulses is given to a 555 timer in the monostate mode, inorder to get pulses of equal width. The output of 555 timer is given to a Darlington pair amplifier which amplifies the signal. This signal is used for triggering the SCR.

The instant at which the SCR is triggered depends upon the feedback signal. The delay is obtained as a change in set point altered with the help of a potentiometer. The change in delay angle causes a change in reference input to the comparator and produces a proportional pulse which is used for triggering the SCR and thus controlling the speed of motor.

CONTENTS

CHAPTER I

INTRODUCTION

In the later half of the nineteenth century, development in the field of electric drives came into existance. Ward-Leonard system was a significant step in the evolution of DC drives. Nowadays thyristors, transistors and diodes are used for controlling the speed of electric motors. Depending upon the necessity in the industry either AC or DC motor is used. Speed control of DC motors is much more easier and is not sophisticated as in case of AC motors.

Controlling the speed of a DC shunt motor can be done by

1) Adjusting the field resistance R
2) Adjusting the terminal voltage applied to the armature.
3) Inserting a resistor in series with armature

By adjusting the field resistance in the field circuit the flux linking with the armature can be changed and a change in speed can be achieved. By this method, speed change above the rated speed can be achieved. This method of control is called as constant power control.

By adjusting the terminal voltage applied to the armature of the motor without changing the voltage applied to the field, the speed of the motor can be adjusted. By this speed control from zero to maximum rated speed can be obtained. This method of control is termed as constant torque control.

The third method of speed control is done by inserting a resistor in series with armature, which inturn reduces the voltage applied to the armature. The principle behind this is same as that of variable terminal voltage. Since, the power loss in this method is very high, normally it is not adopted for speed control.

In this prject, the speed control is achieved by adjusting the terminal voltage applied to the armature.

CHAPTER II

ELECTRIC DRIVES

2.1 CONCEPT OF AN ELECTRICAL DRIVE :

An electric drive is defined as a form of machine equipment designed to convert electric energy into mechanical energy and provide electric control of the process.

Most of the production equipment used in modern industrial undertakings consist of three important components, viz., the prime mover, the energy transmitting device and the actual apparatus of equipment that performs the desired job. The function of the first two components is to impart motion and operate the third one. The most commonly used prime mover is, ofcourse, an electric motor. Since it is superior in performance to steam, hydraulic, diesel and other types of engines. Electric motors are, often, operated directly from a supply line, under their own inherent speed-torque characteristics and their operating conditions are dictated by the mechanical loads, connected to them. However, in many applications, the motors are provided with a control equipment by which their characterisitics can be adjusted and their operating conditions with respect to the mechanical load varied to suit specfic requirements. The most common control adjustment is of motor speed, but torque and acceleration or deceleration can also be adjusted. The control equipment usually consists of relays, contactors, master switchs and soild state devices such as diodes, transistors and thyristors.

The aggreate of electric motor, the energy transmitting shaft and the control equipment by which the motor characteristics are adjusted and their operating conditions with respect to mechanical load varied to suit particular reqipments, is called an electrical drive. The drive together with the load constitutes the drive systems.

2.1.1 CLASSIFICATION OF ELECTRICAL DRIVES :

In general, electrical drives may be classified into three catagories : group drive,individual drive and multimotor drive.

Group drive consists of a single motor which actuates several mechanisms or machines by means of one or more line shafts supported on bearings. It is also called a line shaft drive .The line shaft is fitted with multistepped pulleys and belts that connect these pulleys and the shafts of the driven machines serve to vary their speed .

Even after taking into account the cost of line shafts, pulleys, belts and other installation, the group is the most economic one, since the rating of the motor used may be comparatively less than the aggregate of ratings of the individual motors required to drive each equipment, because all of them may not be working simultaneously.

But, seldom is the group drive used, nowadays, due to the following disadvantages:

(a) Any fault that occurs in the driving motor renders all the driven equipment idle.

(b) Considerable power loss takes place in the energy transmitting mechanisms.

(c) Flexibility of layout of the different machines is lost, since they have to be located as to suit the layout of the line shaft.

(d) The use of line shaft, pulleys and belts make the drive untidy in appearance and less safe to operate.

(e) The level of noise produced at the work site is quite high.

In the individual drive, an electric motor is used for transmitting motion to various parts or mechanisms belonging to a single equipment . For example, such a drive in a lathe rotates the spindle, moves the feed and also with the help of gears, imparts motion to the lubricating and cooling pumps of the lathe.

In many applications, the individual drive consists of a motor, which is specially designed to form an integral part of the equipment.

In the case of individual drive too, the energy is transmitted to the different parts of the same mechanism by means of mechanical parts like gears, pulleys etc. Hence, there occurs some power loss. This disadvantage is removed in the case of multimotor drives.

In multimotor drives, separate motors are provided for actuating different parts of the driven mechanism. For example, in travelling cranes, there are three motors one for hoisting another for long travel motion and the third for cross travel motion. Paper mills, rolling mills, rotary printing machines, metal working machines etc, employ a large number of multimotor drives.

The use of individual drives and multimotor drives has enabled introduction of automation in production process, which in turn has considerably increased the productivity of different industrial undertakings. Complete or partial automation helps to operate various mechanisms at optimum conditions and to increase reliability and safety of operations.

2.2 FUNDAMENTAL PARAMETERS OF SPEED CONTROL IN ELETRIC DRIVE :

Modern industry employs a great many machines operated at different and variable speeds. The numerous units which employ electric drives are metal-cutting machine tools, electric cranes of various types, electric traction units, equiments used in the paper, coal mining, textile and other industries.

For example, the electric drive of a metal-cutting machine tool must have its speed set in accordance with the kind of metal to be worked, the quality and kind of cutting tool to be used,the size of the workpiece, and other factors. In all the equipment mentioned above, as well as in many other kinds of equipment, the drive must have speed control to attain high productivity, proper operation , and high quality products. By speed control is meant intentional change of the drive speed to a value needed for performing the required work process.

The fundamental parameters by which various methods of electric drive speed control may be characterised are :

(a) LIMIT OR RANGE OF SPEED CONTROL :

This is determined by dividing the maximum speed W max at which the drive may operate by its minimum permissible speed W min. The speed control range is therefore expressed as the coefficient or ratio D = W max / W min. For example : 2:1, 4:1, 10:1, 20:1 and so forth.

(b) SMOOTHNESS OF SPEED CONTROL :

This is characterised by the number of steady operating speeds provided by the drive with a given range . The so called smoothness factor K sm may be expressed as the ratio of the speeds on any two adjacent steps of control i.e. Ksm = Wn/Wn-1

where,

Wn is the speed on the nth and Wn-1 is the speed on the n-1th step of speed control. The less the speed change on transfer from one step of control to the other, the smoother the speed control.

(c) ECONOMIC JUSTIFIABILITY :

Economic justifiability of any speed control system is assessed on the basis of least capital cost and least energy losses involved in speed control. Besides these two factors, assessment of the economic advantages should include consideration of the realiablity of the adjustable-speed electric drive in service, and the availability of the materials and equipment needed for setting it up.

(d) STABILITY OF OPERATION :

Stability of operation at a given speed is characterised by the change in speed produced by a given change or variation in the load torque. It depends on the hardness of the speed-torque characteristic, the stability being the greater the harder the characteristic.

(e) DIRECTION OF SPEED CONTROL :

The direction in which the change is made from the base speed of the motor, depends on the methods of control.

By the base speed is meant the speed that the motor develops at a nominal rated voltage and full field excitation. In speed control by insertion of resistance into the armature circuit of dc motor, the speed of the motor, will drop with the increase in the resistance. This means the speed control can only be accomplished in the downward direction with respect to the base speed.

If speed control is achieved by weakening the field flux in a DC motor, the speed will rise as the field is weakened . In this case, speed control is accomplished in the upward direction with respect to the base speed .

(f) PERMISSIBLE LOAD AT DIFFERENT SPEEDS :

Permissible load at different speeds of the motor during speed control will also depend on the method of control employed. Dependence of the load torque on speed varies in accordance with the type of equipment involved. For example, many kinds of equipment such as cranes, hoists, certain kinds of rolling mills require speed control at constant torque. On the other hand, speed control may have to be accomplished at constant power output. One example of such a case is a metal- cutting lathe.

2.3 EVOLUTION OF DC DRIVES :

Direct current motors have been used in variable-speed drives for a long time . The versatile control characteristics of DC motors have contributed to their extensive use in industry .

DC motors can provide :

(a) High starting torques, which are required for traction drives.

(b) Control over a large speed range both below and above the rated speed can be easily achieved .

(c) The methods of control are simpler and less expensive than these of alternating current motors

Although commutators prohibit their use in certain applications, such as high-speed drives and operation in hazardous atmospheres, DC motors play a significant role in many industrial drives. The technology of speed control of DC drives has evolved considerably. The present state of art of DC motor drives is far advanced compared to what it was just a quarter century ago. A brief history of the evolution of the DC drives is presented in the following section.

2.3.1. BRIEF HISTORICAL BACKGROUND :

During the last century, the available power supply was constant voltage direct current, and the use of electric power was confined to large cities. In industrial plants, located in urban areas, DC motors were used to drive machinery. The DC motors were operated from constant voltage bus. Variable-speed drives were made possible only by the adjustment of motor field flux. This inturn produced such severe problems as commutator sparking and the consequent limitation on the life of brushes and commutators. Infact, the phenomenon of commutation was not well understood at that time. As a result , most drives were constant speed drives. Any variable speed drives, achieved by changing field flux as shown in figure 2.1 used rugged durable motors that generally had poor mechanical and electrical time constants.

But the demand for wider ranges of speed control rapidly increased. The commutation phenomenon became better understood. Interpole and pole phase winding were developed to improve commutation and were put to use with fair success.

2.3.2 WARD-LEONARD SYSTEM :

The development of the Ward-Leonard system, which was introduced in the 1890s, was a significant step in the evolution of DC drives. The system uses a motor generator set to power the DC drive motor. The motor of the M-G set runs at constant speed. By varying the generator field excitation, the generator voltage is changed, which, inturn, can provide continuous control of speed of the drive motor over a wide range. In this method of speed control, by armature voltage control, the field flux of the drive motor is kept constant, thereby avoiding the attendant problem of poor motor commutation. Figure 2.2 shows the basic schematic diagram of the Ward-Leonard speed control system. The Ward-Leonard system provides a constant torque as well as constant horse power drive. In the constant torque mode, the field flux of the drive motor is kept constant and the armature voltage is controlled. In the constant horse power mode, the armature voltage is held constant at the rated value and the field current is controlled. This system was the first to provide successfully the beter performance in terms of increased speed range, improved commutation, and precise speed control.

The Ward-Leonard system has the following advantages:

(a) Full forward and reverse speed can be achieved.

(b) Power is automatically regenerated to the ac line through the M-G set when speed is achieved.

(c) Short-time overload capability is large.

(d) The armature current of the motor is smooth.

However, it has the following disadvantages:

(a) The capital cost is high .

(b) The overall efficiency is low, less than 80 % .

(c) A large amount of space is required.

(d) Periodic inspection and lubrication are necessary.

2.3.3 ELETRONIC CONTROL :

In the late 1940s and early 1950s electronic control brought about a significant improvement in the DC drive systems. In the initial phase, industrial type gas-filled rectifer and controlled rectifier (thyratron) tubes where used in exciters and regulators for the M-G set. This system provides improved response and better accuracy and allowed automatic closed-loop control to be used in place of earlier manual or electro mechanical control methods. Later on, these tubes became available in high current capacity and were used in rectifier circuits to convert AC to DC for speed control of the DC drive motor. Single phase rectifier circuits using tube-type rectifiers were used in low horse-power drives. In ratings above 10 h.p, tube-type rectifier systems were not found reliable.

2.3.4 SOLID STATE CONTROL :

In the late 1950s solid state devices, silicon diodes, and silicon controlled rectifiers (SCRs) became available in the market at economic prices. These devices were first available in low power ratings and therefore were used in genrator field regulator as a replacement for tube-type regulators. Solid state regulators offered long life, high reliability, a smaller package, and significant improvement in performance.

Later on, high power versions of silicon diodes and SCRs (also called thyristors) became available. These solid state devices were used to convert AC power to DC power for direct control of the drive motor. At first, silicon diodes of high power rating were developed and were used with saturable reactors in variable speed DC drives, as shown in figure 2.3. compared to M-G set systems, saturable reactor drive systems were rugged, more reliable and provided better performance. However, they were fairly large and expensive.

Availability of high power thyristors in their early 1960s brought about a minor revolution in Industrial control equipment and drive system performance. Figure 2.4 shows the block diagram of a thyristor controlled DC drive. Virtually all new variable speed dc drives use thyristor converters. The M-G set that was used in variable speed DC drives for over 50 years has been largely replaced by thyristor converters.

The thyristor drive has the following advantages :

(a) The thyristor-power module eliminates the electrical time lag of the generator field and armature. Time response is therefore faster, limited only by DC motor commutating ability and the inertia of the drive.

(b) Basic operation is simple and reliable.

(c) Minimal maintenance is required.

(d) Operating efficiency is high, above 95%.

(e) Small size, less weight, and packaging flexibility result in reduced space requirements, lower initial cost, and lower installation and operating costs.

(f) It provides better performance.

The thyristor drive has the folowing disadvantages :

(a) The higher ripple content of the converter adds to motor heating and commutation problems. The addition of a reactor in the armature circuit may be required to smooth out the ripple current.

(b) Under certain operating conditions, the power factor in the AC supply is low. In the M-G set system, if a synchronous motor is used, the supply power factor can be kept high by adjusting the field excitation of the synchronous motor.

(c) Distortion of the AC supply voltage and telephone interference may be provided due to the switching action of SCRs.

(d) The over load capability is lower than that of a comparable M-G set.

(e) An M-G set can regenerate automatically. In the thyristor converter, complex control circuitary is required to achieve regeneration. Either a dual convertor (two bridges back to back) or a single convertor together with a reversing switch of some kind is required to achieve regeneration. Both methods are complex and expensive.

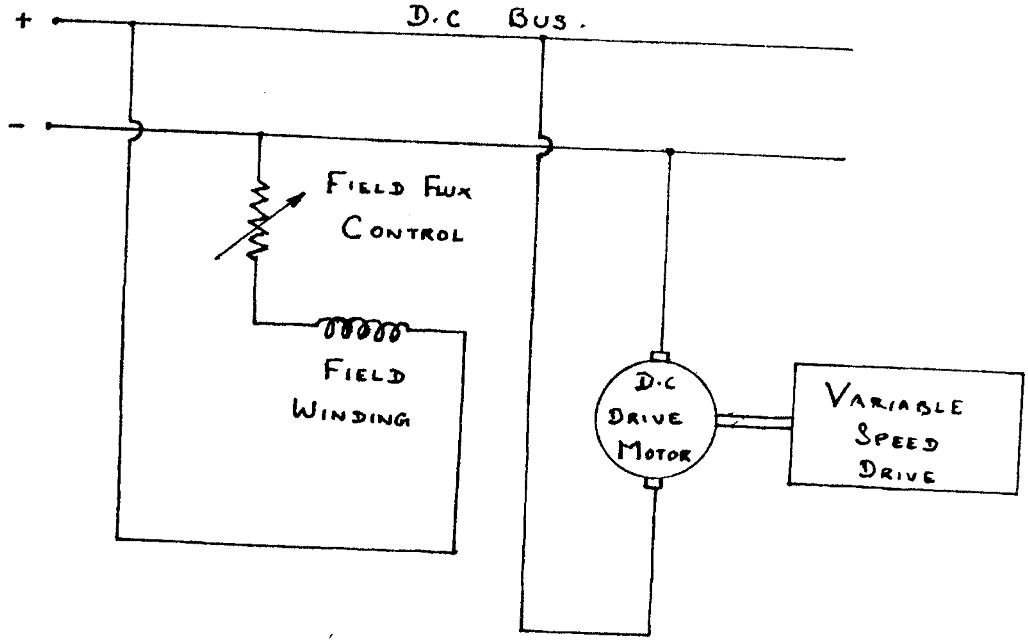

FIGURE 2.1, BASIC SCHEMATIC DIAGRAM OF THE CLASSICAL VARIABLE-SPEED DC DRIVE

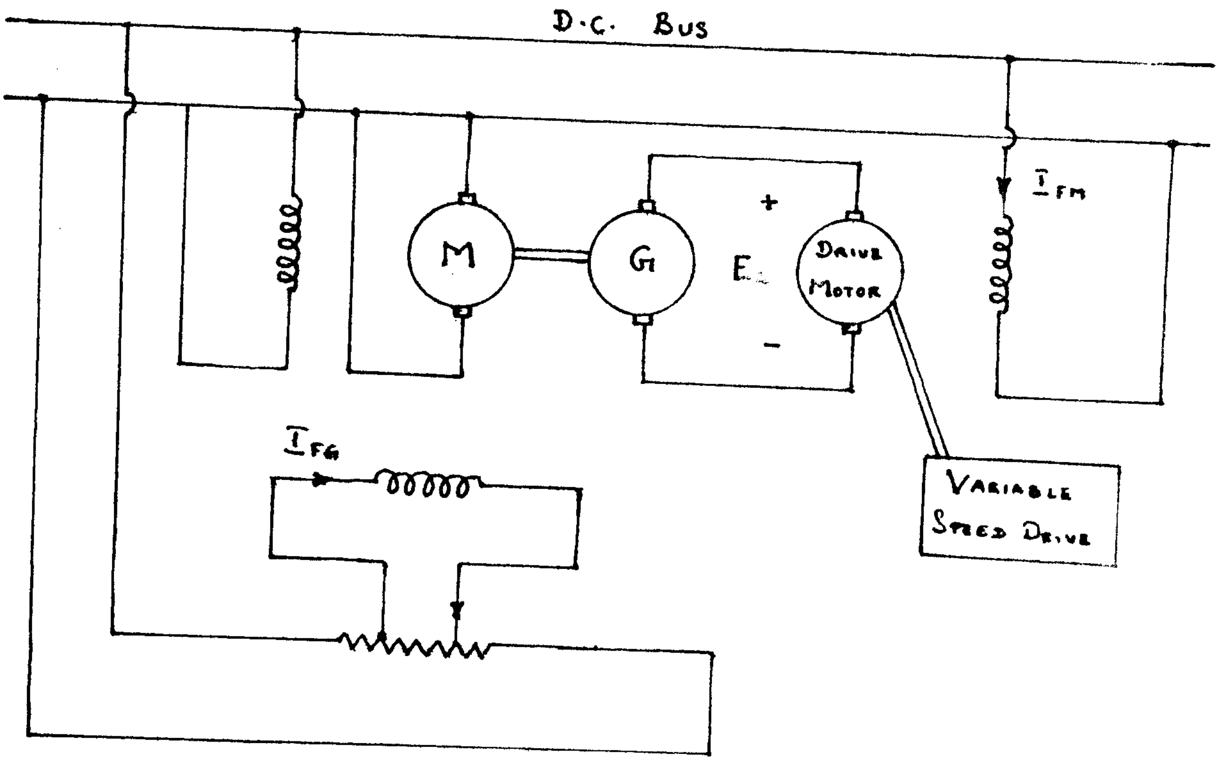

FIGURE 2.2, BASIC SCHEMATIC DIAGRAM OF THE WARD-LEONARD SYSTEM

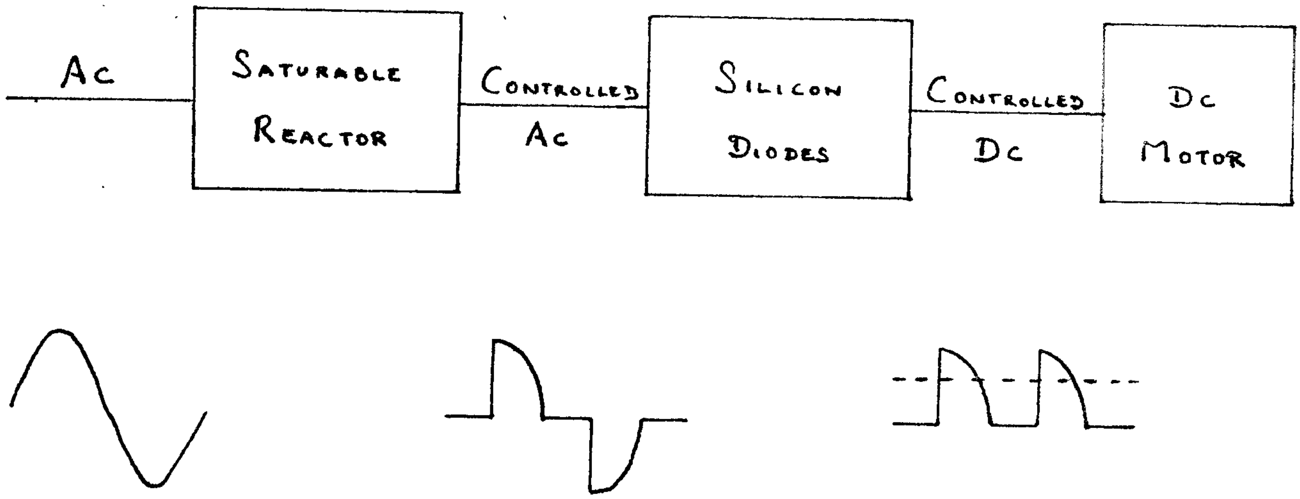

FIGURE 2.3, BLOCK DIAGRAM AND WAVEFORMS OF SATURABLE REACTOR, ADJUSTABLE SPEED, DC DRIVE SYSTEM

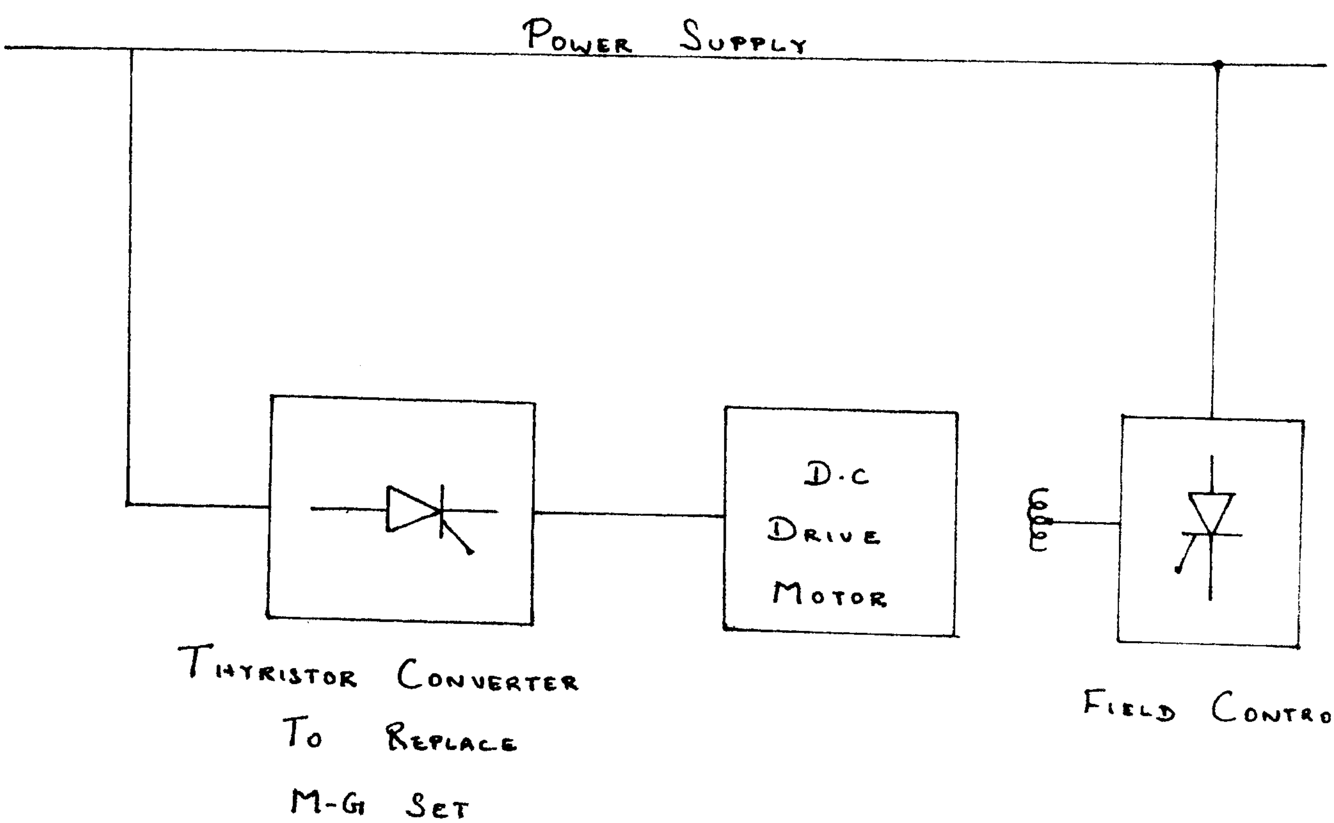

FIGURE 2.4, BLOCK DIAGRAM OF THYRISTOR-CONTROLLED DC DRIVE

CHAPTER III

DC SHUNT MOTOR

3.1 CHARACTERISTICS OF SHUNT MOTORS :

3.1.1 Ta/Ia CHARACTERISTICS :

Assuming flux to be practically constant (though at heavy loads, flux decreases somewhat due to increased armature reaction) we find that Ta directly proportional to flux.

Hence, the electrical characteristic as shown in figure 3.1 is practically a straight line through the origin. Shaft torque is shown dotted. Since a heavy starting current, shunt motor should never be started on (heavy) load.

3.1.2 N/Ia CHARACTERISTICS :

If flux is assumed contant, then N is directly proportional to Eb. As Eb is also practically constant, speed for most purposes, is constant.

But strictly speaking both Eb and flux decrease with increasing load. However, Eb decreases slightly more than flux hence, on the whole, there is some decrease in speed.

Hence, the actual speed curve is slightly drooping as shown by the dotted line in figure 3.2. But for all practical purposes, shunt motor is taken as a constant speed motor.

Because there is no appreciable change in the speed of a shunt motor from no load to full load, it may be connected to loads which are totally and suddenly thrown off without any fear of excessive speed resulting. Due to the constancy of their speed, shunt motors are suitable for driving shafting, machine tools, lathes, wood-working machines and for all other purposes where an approximately constant speed is required.

3.1.3 N/Ta CHARACTERISTICS :

It can be deduced from Ta/Ia and N/Ia characteristics above and shown in figure 3.3.

3.2 SPEED CONTROL TECHNIQUES IN DC SHUNT MOTORS :

There are three methods by which speed of a DC shunt motor can be controlled. Out of this there are two common methods and less common method in use. The common ways in which the speed of a shunt dc machine can be controlled are by :

(a) Adjusting the field resistance Rf.

(b) Adjusting the terminal voltage applied to the armature.

(c) Inserting a resistor in series with the armature circuit.

These methods are discussed in detail as below.

3.2.1 CHANGING THE FIELD RESISTANCE :

When the field resistor of DC motor is changed, assume that field resistor increases and observe the response. If the field resistance increases, then the field current decreases, and as the field current decreases, the flux decreases with it. A decrease in flux causes an instantaneous decrease in the internally generated voltage Ea which causes a large increase in the machine's armature current, since

$$Ia = (Vt - Ea)/Ra \qquad \text{---------- 3.1}$$

The induced torque in a motor is given by

$$T\ ind = K\ 0\ Ia \qquad \text{---------- 3.2}$$

The increase in current predominates over the decrease in flux and the induced torque rises.

Since T ind > T load, motor speeds up.

However as the motor speeds up, the internally generated voltage Ea rises, causing Ia to fall. As Ia falls the induced torque T ind falls too and finally T ind again equals T load at a higher steady state speed than orginally.

To summarise the cause and effect behaviour involved in this method of speed control :

(a) Increasing Rf causes If to decrease.

(b) Decreasing If decreases 0.

(c) Decreasing 0 lowers Ea.

(d) Decreasing Ea increases Ia.

(e) Increasing Ia increases T ind, with the change in Ia dominant over the change in flux.

(f) Increasing T ind makes T ind > T load, and the speed W increases.

(g) Increasing W increased Ea again.

(h) Increasing Ea decreases Ia.

(i) Decreasing Ia decreases T ind until T ind = T load at a higher speed W.

The effect of increasing in the field resistance on the output characterristics of a shunt motor is shown in figure. Notice that as the flux in the machine decreases the no load speed of the motor increases, while the slope of the torque-speed curve becomes steeper. Naturally, decreasing Rf would reverse the whole process and the speed of the motor would drop.

Fig 3.4 shows the terminal characteristics of the motor over the range from no load to full load conditions. Over this range an increase in field resistance increases the motor's speed as said above.

Figure 3.5 shows the terminal characteristics of the motor over the full range from no load to stall conditions. It is apparent from the figure 3.5 that at very slow speeds an increase in field resistance will actually decrease the speed of the motor. This effect occurs because at very low speeds, the increase in armature current caused by the decrease in Ea is no longer large enough to compensate for the decrease in the flux in the induced torque equation. With the flux decrease, actually larger than the armature current increases the induced torque, decreases and the motor slows down.

3.2.2 CHANGING THE ARMATURE VOLTAGE :

The second form of speed control involves changing the voltage applied to the armature of the motor without changing the voltage applied to the field. A connection similar to that in figure 3.6 is necessary for this type of control. In effect, the motor must be separately excited to use armature voltage control.

If the voltage Va is increased, then the armature current in the motor must rise. As Ia increases, the induced torque T ind increases, making T ind > T load and the speed W of the motor increases.

But as the speed W increases, the internally generated voltage Ea increases, casuing the armature current to decrease. This decrease in Ia decreases the induced torque causing T ind to equal T load at a higher rotational speed W.

To summarise the cause and effect behaviour in this method of speed control.

1. An increase in Va increases Ia
2. Increasing Ia increases T ind
3. Increasing T ind makes T ind > T load, increasing W
4. Increasing W increases Ea
5. Increasing Ea decreases Ia
6. Decreasing Ia decreases T ind until T ind = T load at higher W

The effect of an increase in Va on the torque - speed characteristics of a separatly excited motor is shown in fig.3.7. Notice that the no-load speed of the motor is shifted by this method of speed control but the slope of the curve remains constant.

3.2.3 INSERTING A RESISTOR IN SERIES WITH THE ARMATURE CIRCUIT :

If a resistor is inserted in series with the armature circuit, the effect is to drastically increase the slope of the motor's torque-speed characteristics, making it to operate slowly if loaded as more slowly if loaded as shown in fig.3.8. The insertion of a resistor is a very wasteful method of speed control, since the losses in the inserted resistor are very large. For this reason it is rarely used. It will be found only in applications in which the motor spends almost all its time operating at full speed or in applications too inexpensive to justify a better form of speed control.

3.3 FULL WAVE HALF CONTROLLED BRIDGE RECTIFIER :

A variable DC voltage is required to vary the speed of the DC motor. This is obtained by controlling the firing angle of SCR. The circuit used for controlling the firing angle is called as controlled rectifier or converters.

Figure 3.9 shows a half controlled bridge circuit. The main difference between a fully-controlled circuit and a half-controlled circuit is that the former can operate as an inverter when the firing angle is between 90 and 180 , and the latter can operate only in the rectifying mode as the firing angle changes from zero to 180 .

Since the cathodes of the two SCRs are at the same potential, their gates can be connected and a single gate pulse can be used for triggering either SCR. The SCR which has the forward bias at the instant of firing will turn on.

In the figure 3.9, the free wheeling action will take place through 1 and 1' or 2 and 2' when the input voltage polarity is reversed. Therefore, SCR 1 will not be turned off even though the input current iL and the output voltage

Eo go to zero. The output voltage and current waveforms are as shown in figure 3.10. In the circuit discussed above, the input power factor is poor when the DC power output is low. Therefore, to control the DC output voltage and power, it is necessary to devise a method by which the phase angle of the line current iL with respect to the input voltage can be kept reasonably small as the firing angle of the SCRs is varied. This is achieved by connecting a fully controlled bridge in series with an uncontrolled bridge.

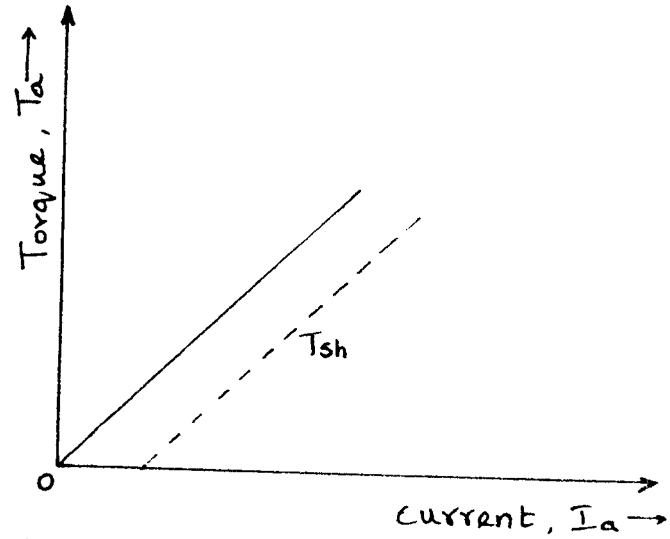

FIGURE 3.1, Ta/Ia CHARACTERISTIC

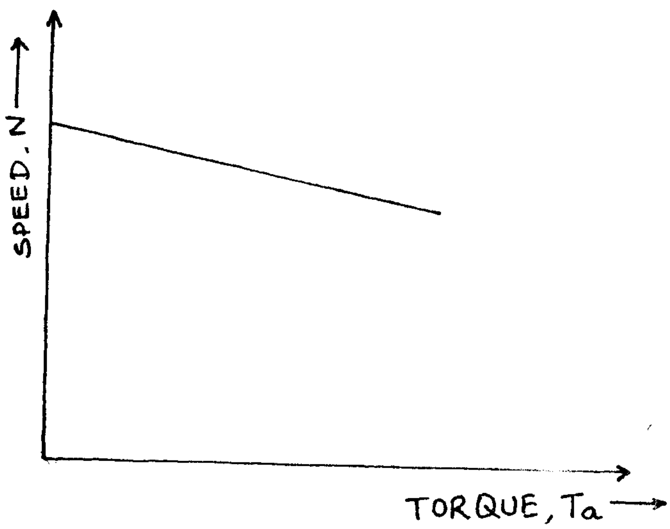

FIGURE 3.2, N/Ia CHARACTERISTIC

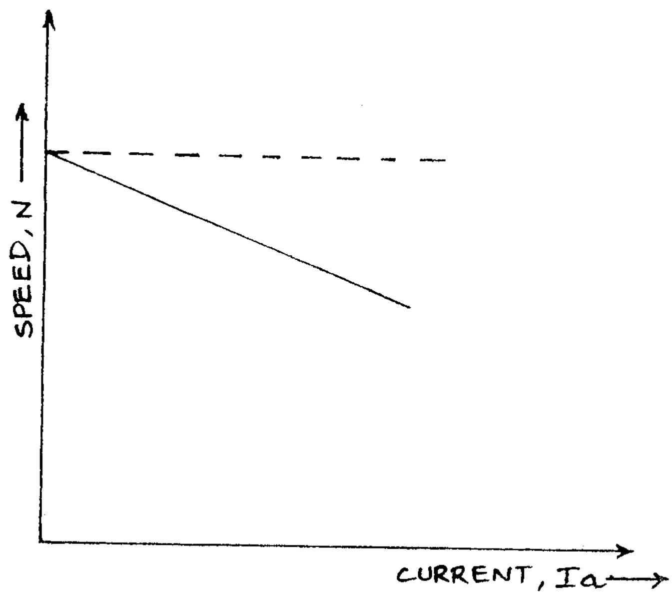

FIGURE 3.3, N/Ia CHARACTERISTIC

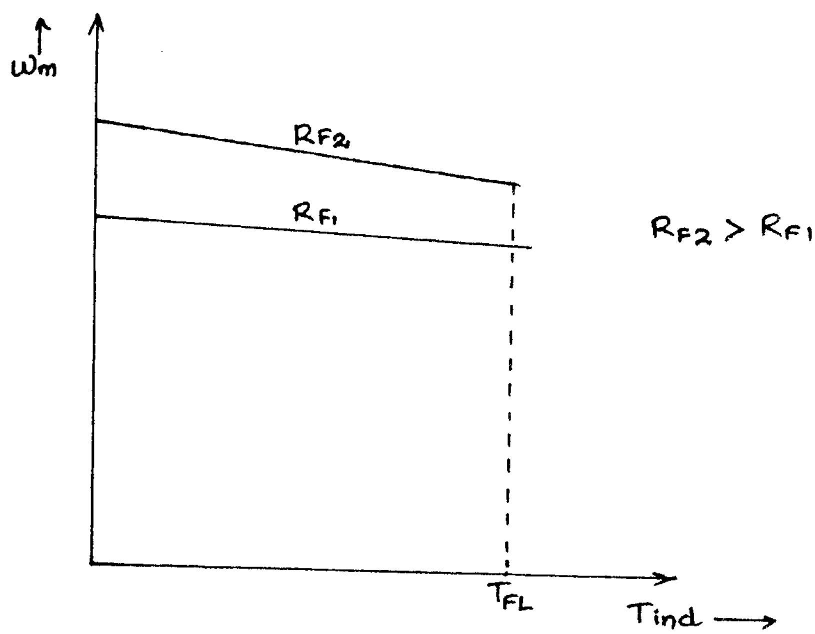

FIGURE 3.4, NORMAL OPERATING RANGE OF MOTOR

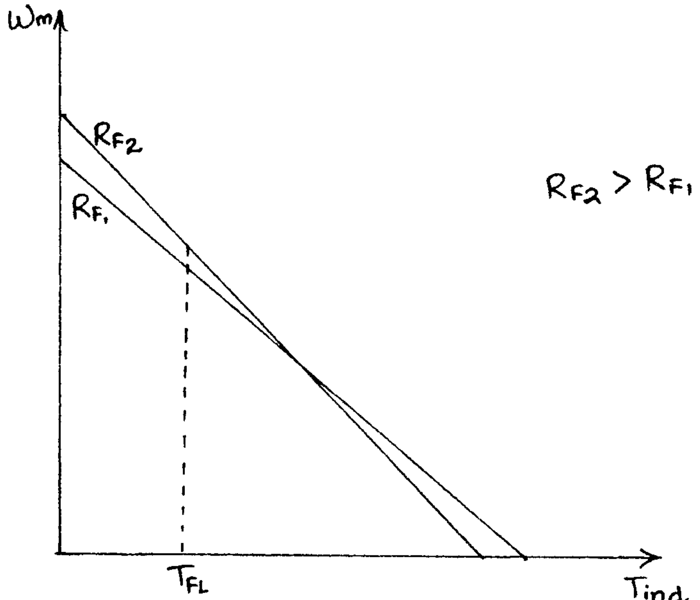

FIGURE 3.5, THE ENTIRE RANGE OF OPERATION, FROM NO LOAD TO STALL CONDITION

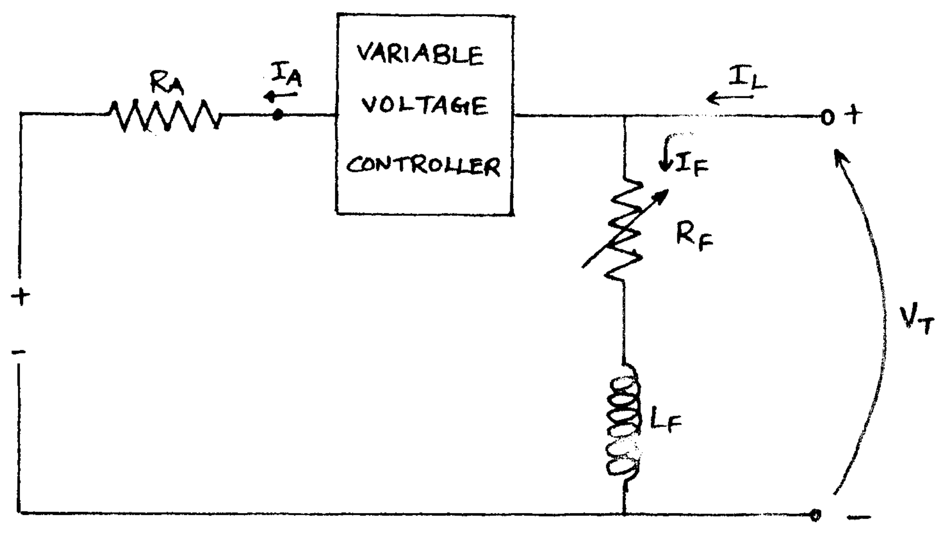

FIGURE 3.6, ARMATURE CONTROL OF A DC SHUNT MOTOR

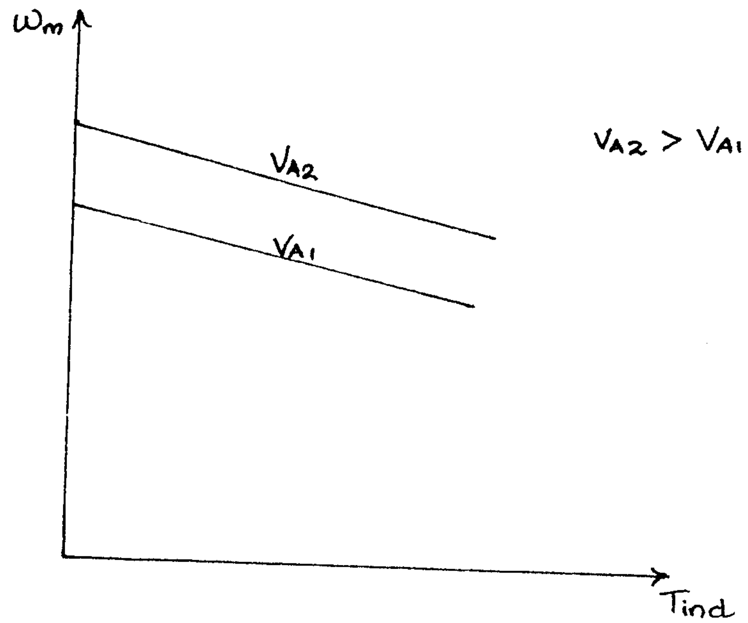

FIGURE 3.7, THE EFFECT OF ARMATURE SPEED CONTROL ON A SHUNT MOTOR'S TORQUE-SPEED CHARACTERISTICS

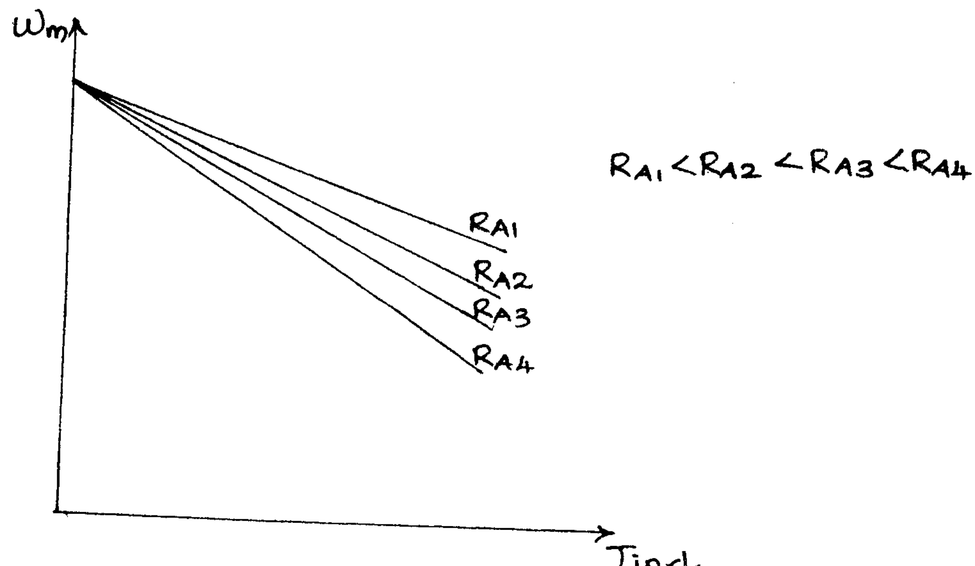

FIGURE 3.8, THE EFFECT OF ARMATURE RESISTANCE SPEED CONTROL ON A SHUNT MOTOR'S TORQUE-SPEED CHARACTERISTICS

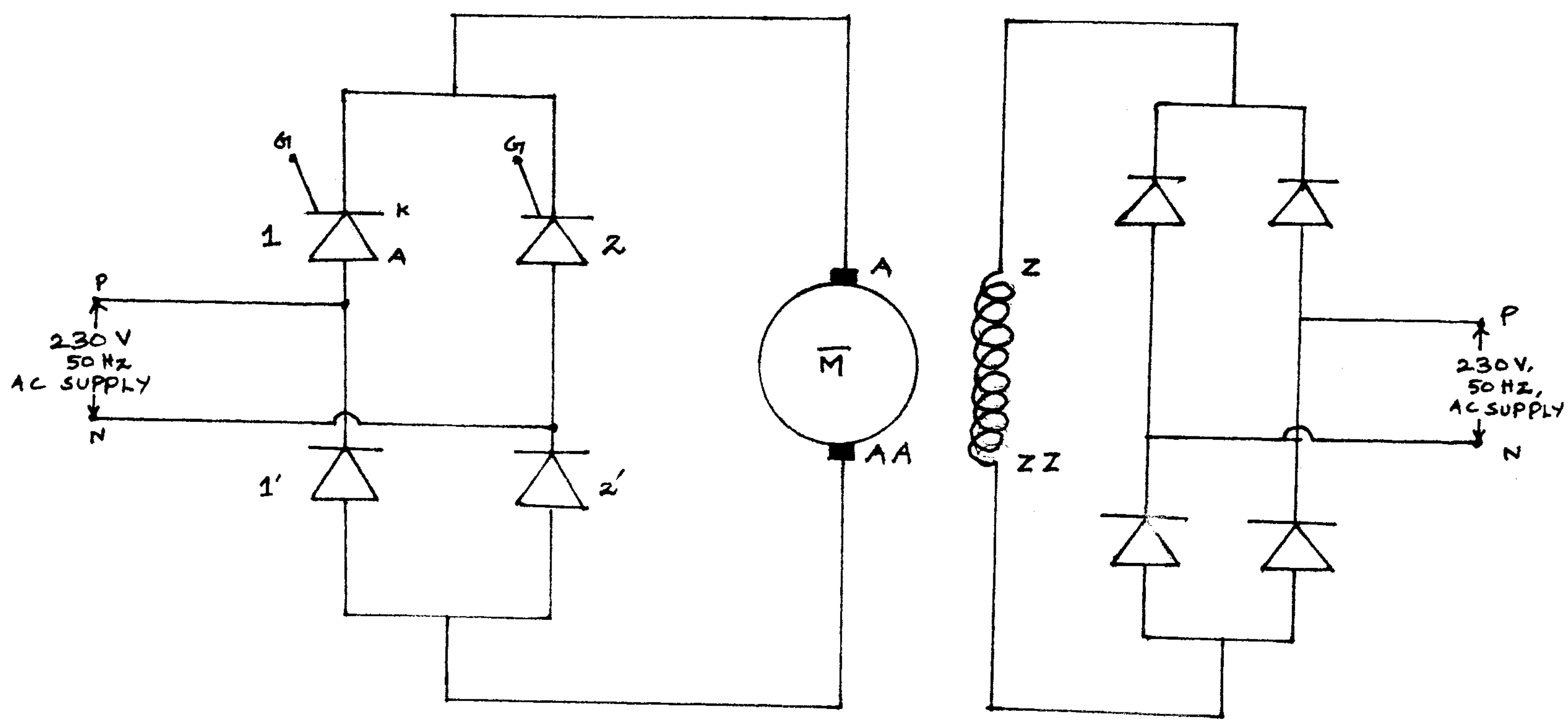

FIGURE 3.9, HALF CONTROLLED BRIDGE CIRCUIT

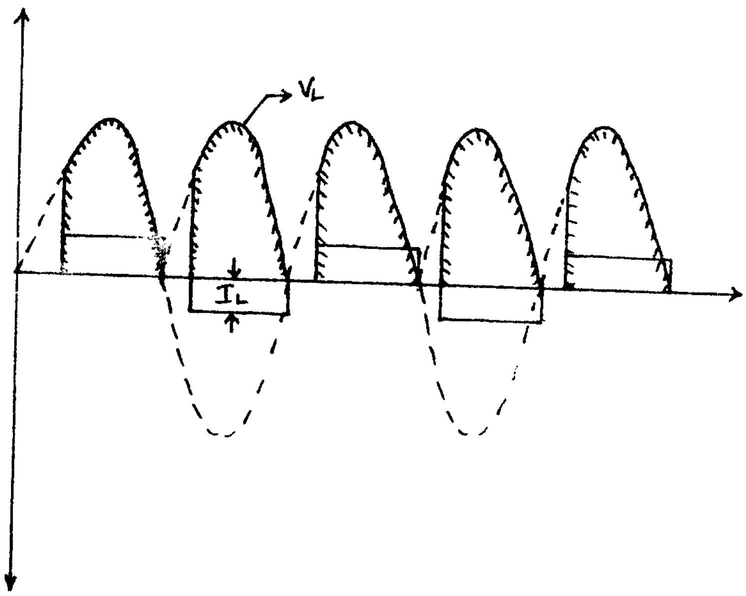

FIGURE 3.10, OUTPUT VOLTAGE AND CURRENT WAVEFORMS OF A HALF CONTROLLED BRIDGE CIRCUIT

CHAPTER IV

HARDWARE DESCRIPTION AND OPERATION

4.1 HARDWARE DESCRIPTION :

The circutary can be broadly sub-divided into three portions for the purpose of simplicity. The sud-divisions are as follows :

1) Power Circuit
2) Control Circuit
3) Display Circuit

4.1.1 POWER CIRCUIT :

The power circuit acts as the heart of the hardware. It is implemented for the purpose of the supplying power to various ICs. It consists of a centre tapped transformer, a rectifying unit (Bridge Rectifier) and a regulator unit.

The centre tappeed transformer steps down the 230V, 50Hz source to 12-0-12V, 50Hz supply. This alternating supply is fed to the bridge rectifier whose output is a pulsating DC. The pulsating DC is fed to a 3 pin IC regulator 7805 whose output is a regulated +5V DC. We also make use of 7812 and 7912, 3 pin IC regulators for providing +12V and -12V DC, which is needed for LM324.

4.1.2 CONTROL CIRCUIT :

The main aim of the project is to maintain a constancy in speed of motor at any condition for which we are in need of the control circuit. The control circuit is used to produce gate control to the SCR. Now we shall have an outlook of various ICs which plays a major role.

We have used a proximity switch to get the feed back signal. An LM331 IC is used whose main function is conversion of frequency in to voltage. LM324 used in the hardware is an integrated circuit, consisting of 4 operational amplifiers. Each one can be used as a comparator, an adder, a zero crossing detector, a buffer and an inverting amplifier. We have designed an integrated circuit comprising of a transistor, resistor, capacitor which converts a pulse input at the base of transistor into a ramp output at the collector terminal. A 555 timer in monostable mode is used as a wave shaper. A Darlington pair is used to drive the pulse transformer.

In the above paragraph we have given a general idea of the ICs used . The following section deals with the principle of operation.

4.1.3 DISPLAY CIRCUIT :

A provision for displaying speed in digital form is made using SL562, common cathode seven segment display. The circuit is designed in such a way that for every three second we can get the information about the speed of the motor i.e. it update the speed after every three seconds. We have used IC5369 which reduces the frequency of crystal from 3.579 KHz to 60 KHz. Two 4518, dual decade counter is used for further reduction in frequency. A dual monostable multivibrator, 4528 is used for the purpose for introducing a small time delay which is in the order of nano seconds. A 74C926 IC is used which counts the number of pulses occuring in three seconds and latches the output to the seven segment display. Each seven segment display is selected on a multiplexed basis. The multiplexed signal is generated within the IC.

4.1.4 OPERATIONAL AMPLIFIER :

An operational amplifier is a direct-coupled high gain amplifier usually consisting of one or more differential amplifiers. The operational amplifier is a versatile device that can be used to amplify DC, AC input signals and also it can be used for computing such mathematical functions as addition, subraction, multiplication and integration. Thus the name operational amplifier stems from its original use for these mathematical operations and is abbreviated to op-amp.

Here we use the op-amp as inverting amplifier, comparator, adder and zero crossing detector.

4.1.5 INVERTING AMPLIFIER :

Here, the output voltage is fed back to the inverting input terminal through feedback resistor. Input signal is applied to the inverting input terminal and noninverting input terminal of op-amp is grounded.

The closed loop gain, Acl = Vo / Vi = -Rf / R1

The negative sign indicates a phase shift of 180 between input and output voltages. Figure 4.1 shows an inverting amplifier.

4.1.6 COMPARATOR :

A comparator is a circuit which compares a signal voltage applied at one input of an op-amp with a known reference voltage at the other input. It is basically an open loop op-amp.

There are basically two types of comparators

1) Non-inverting comparator

2) Inverting comparator.

Figure 4.2 and 4.3 show ideal and practical noninverting comparator respectively.

Figure 4.4 and 4.5 show input and output waveforms for positive and negative reference voltages repectively.

In noninverting comparator, a fixed reference voltage V ref is applied to negative input and time varying signal Vi is applied to positive input. The output voltage is at -V sat for Vi < V ref and Vo goes into +V sat for Vi > V ref. Figure 4.6 shows an inverting comparator.

Fig 4.7 and 4.8 show input and output wave forms for positive and negative reference voltages respectively.

4.1.7 ZERO CROSSING DETECTOR :

The basic comparators can be used as a zero crossing detector provided that V ref is set to zero. An inverting zero crossing detector is shown in figure 4.9 and the output wave form for a sinusolid input signal also shown in fig.4.10

4.1.8 ADDER :

The figure 4.11 shows the inverting summing amplifier. Here, the number of inputs is two- Va, Vb.

The clossed loop gain, Acl = Vo / Vi

= Vo / (Va + Vb) ------- 4.1

= -Rf / R

where,

R = Ra = Rb.

if Ra # Rb then,

output voltage Vo = -[Va(Rf/Ra) + Vb(Rf/Rv)] -------- 4.2

Thus the output voltage is the sum of individual gain of the respective loop.

4.1.9 VOLTAGE FOLLOWER :

The lowest gain that can be obtained from a non-inverting amplifier with feedback is 1. When the non-inverting amplifier is configured for unity gain, it is called a voltage follower because the output voltage is equal to and in phase with the input. In other words, in the voltage follower the output follows the input.

Although it is similar to the discrete emitter follower, the voltage follower is preferred because it has much higher input resistance, and the output amplitude is exactly equal to the input.

The voltage follower circuit is as shown in the figure 4.12. In this figure all the output voltage is fed back into the inverting terminal of the op-amp; consequently the gain of the feedback circuit is 1 (B = Af = 1).

Since the voltage follower is a special case of the non-inverting amplifier, all the formulae developed from the later are indeed applicable to the former except that the gain of the feedback circuit is 1 (B = 1). The formulae are :

Af = 1

Rif = AR i

Rof = Ro / A

Ff = Afo

Vout = + Vsat / A, since (1+A) __ A

where,

Af is closed loop voltage gain

Rif is input resistance with feed back

Rof is output resistance with feed back

Ri, Ro are input & output resistances without feedback

A is open loop voltage gain

Fo is breaking frequency of op-amp

Ff is bandwidth with feedback

Vout is total output offset voltage with feedback

Vsat is saturation voltage.

The voltage follower is also called a NONINVERTING BUFFER because when placed between two networks it removes the loading on first network.

4.1.10 MONOSTABLE MULTIVIBRATOR :

The 555 is a monolithic timing circuit that can produce accurate and highly stable time delays or oscillation. It operates in one of the two modes : either as a monostable (one shot) or as an astable (free running).

A monostable multivibrator is a pulse generating circuit in which the duration of a pulse is determined by the RC network connected externally to the 555 timer. In a stable or stand by state the output of the circuit is approximately zero or at logic low level. When an external trigger pulse is applied, the output is forced to go high.

The time the output remains high is determined by the external RC network connected to the timer. At the end of the timing interval, the output automatically reverts back to its logic-low stable state. The output stays low until the trigger pulse is again applied. Then the cycle repeats. The monostable circuit has only one stable state (output low), hence the name monostable. Normally, the output of the monostable multivibrator is low.

Figure 4.13 shows input and output wave forms of 555 monostable multivibrator.

The time during which the output remains high is given by $t = 1.1\ R\ C$ (seconds) -------- 4.3

where,

R is in Ohms

C is in farads

4.1.11 PROXIMITY SENSOR :

The proximiy sensor consists of an oscillator, a rectifier and and a comparator. The purpose of the sensor is to sense the speed of the motor and sends pulses to the display circuit.

The internal configuration of proximity sensor is as shown in figure 4.14. Its principle of operation is as follows :

When there is no magnetic material near the inductance I, the oscillator output at point A is high, so the rectified DC output at B is also high. The Comparator compares the dc output with a constant voltage, which is also high.

When a magnetic material comes near I, the oscillation at point A decreases and the rectified output at B decreases and the comparator output is zero (low).

4.2 FUNCTIONAL DESCRIPTION :

In the preceding section, the need and functions of various ICs have been listed out. Now in this section we will deal with the working principle of the hardware in detail.

The block diagram of the hardware is shown in figure 4.15.

AC supply of 12V, 50Hz is fed to the full wave rectifying unit which produces a pulsating DC output. This is fed to the inverting pin of zero crossing detector. From a resistor divider network a fraction of voltage is fed to the non inverting input of zero crossing detector. A pulse output is obtained at the zero crossing points of the pulsating DC.

A ramp generator is designed using a transistor, a resistor and a capacitor. When the output of the zero crossing detector is low, the transistor is in cut-off state, which results in charging of the capacitor. The transistor will be in the active region when the output of the zero crossing detector goes high. The capacitor discharges suddenly through the transistor, when the transistor is properly biased. The consequence of this action is generation of a ramp signal. An op-amp in buffer mode is used for impedance matching. Now the ramp signal from the buffer is fed to the inverting pin of comparator.

The pulse output from the proximity sensor is fed to the base of the transistor. The output of the transistor is in the inverted form of actual input. This signal is differentiated by a RC network and the negative going edge at pin 6 causes the input comparator to trigger the timer circuit. The current at the output terminal can be changed by varying the resistance at pin 2. The output current at pin 1 is given by

$$i = (1.1\ R\ C)\ .\ f \qquad \text{------ 4.4}$$

where,

f = frequency of the supply at pin 6

R, C = resistance & capacitor value at pin 8 and pin 6 respectively.

By changing the values of Rt and Ct the current through the capacitor can be varried. The filtering action is done by R1 = 100 K & C = 1 f. The output voltage is fed through an inverting amplifier with unity gain which results in negative value of the actual input, to the inverting amplifier.

A 1 K pot is used for the purpose of setting the speed at a particular value. The inverted output of f/v converted is added with the reference voltage in the adder circuit constructed using op-amp. The 4.7 K at the non-inverting pin is used for the purpose of thermal stability. Initially when there is no output from the adder, the potential at the non-inverting input is about 6V. As the voltage at the adder output terminal is sensed, potential at the non-inverting pin reduces gradually. The peak value of the ramp input at the non-inverting pin of the comparator is about 5V. The comparator compares the ramp input and the potential at non-inverting input and its output is in the form of a pulse. The width of the pulse is proportional to the speed of the motor. The pulse output is differentiated through a RC network.

A 555 timer in mono stable mode is used to detect the transients from low to high and vice versa. By this gate dissipation can be minimised. This pulse signal is fed to the base of the BC 147, common emitter transistor whose output is in the inverted form of the input. This negative going pulse biases the transistor BC 157 and the positive going pulse is produced at the collected output to which the pulse transformer primary is connected. The pulse transformer drives the gate of the SCR1 and 2. The major advantage of BC 157 and BC 147 is that the pulse width in the former can be minimum so that the gate dissipation is kept at a minimum.

In the sections discussed above, the controling action of SCR which governs the speed of the motor has been dealt with. The following section deals with the principle of operation of the display unit.

The display circuit is designed in a such a way that it updates the speed for every three seconds. Hence to achieve this we have made use of ICs 5369, 4518, 4528 & 74C926.

IC 5369 is used for the purpose of frequency reduction from crystal frequency of 3.579 KHz to 60 Hz. The supply to this IC is unregulated supply about ten to thirty volts. The 10 pf capacitor is used for stabilizing the crystal. The output frequency is 60Hz and the output voltage level is about 10V.

At the next stage we have used a level shifter to maintain the output level at 5V. This output of level shifter is fed to the 2nd pin of IC 4518, a dual decade counter. The purpose of using a level shifter is to maintain the output level at 5V as the power requirement of IC 4518 is within 5V.

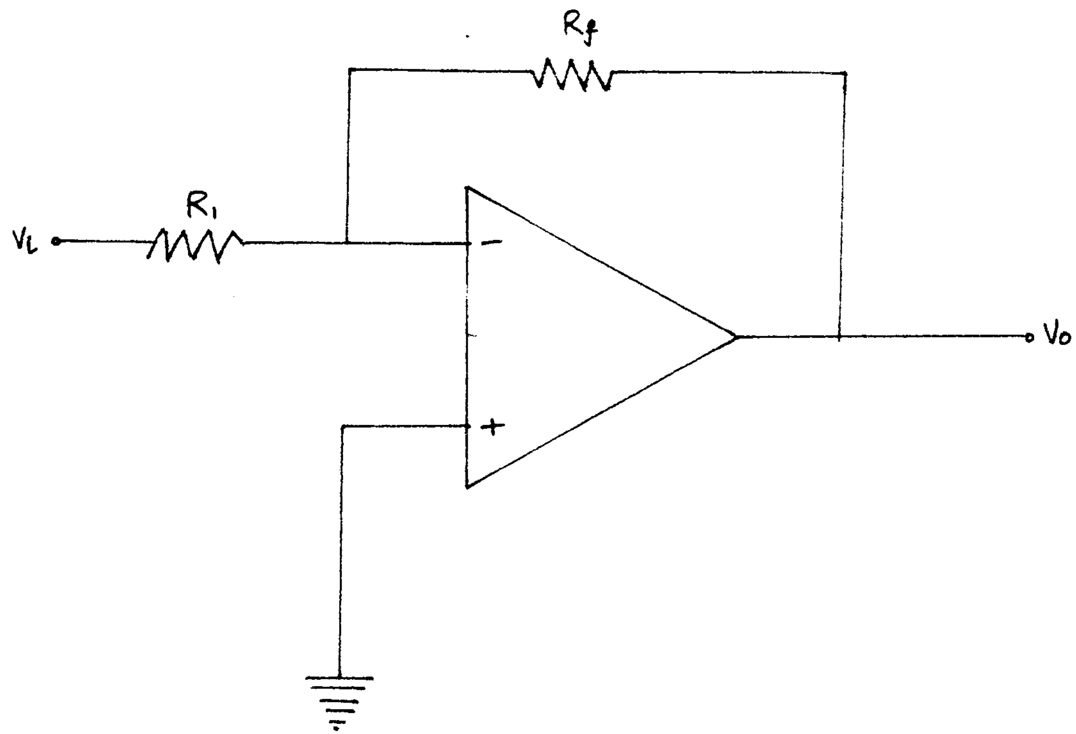

FIGURE 4.1, INVERTING AMPLIFIER

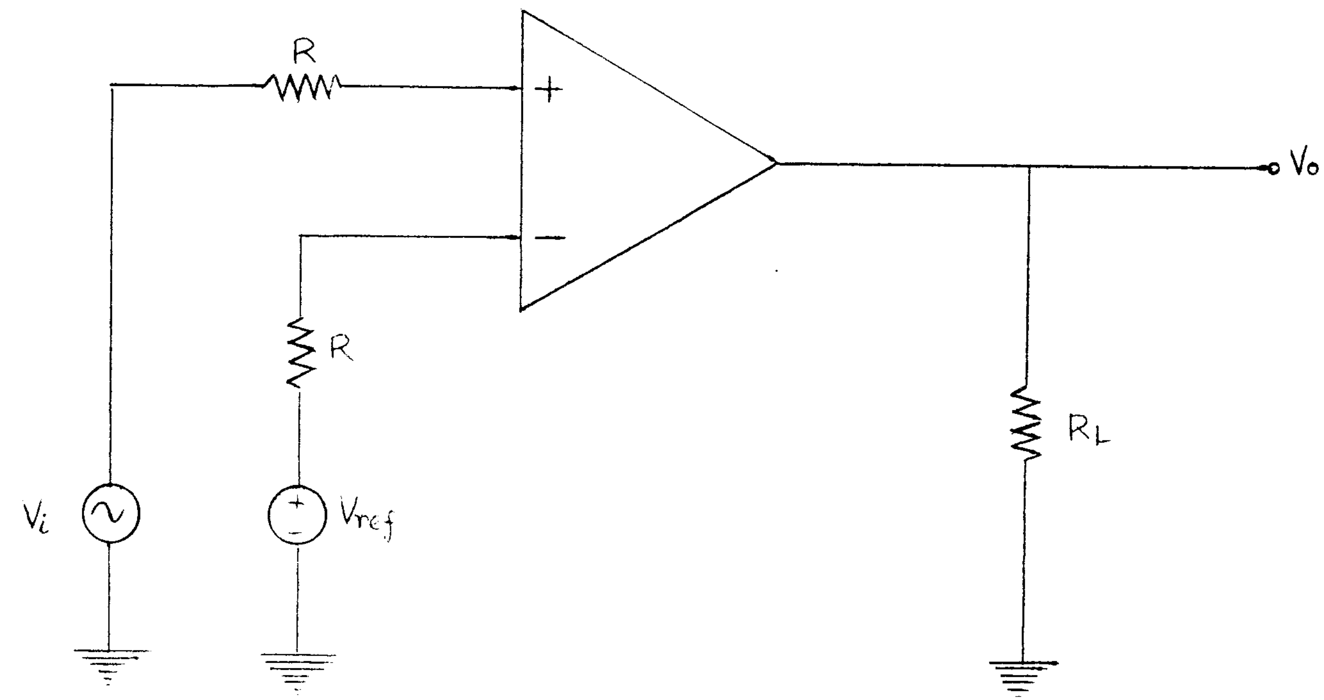

FIGURE 4.2, NONINVERTING COMPARATOR

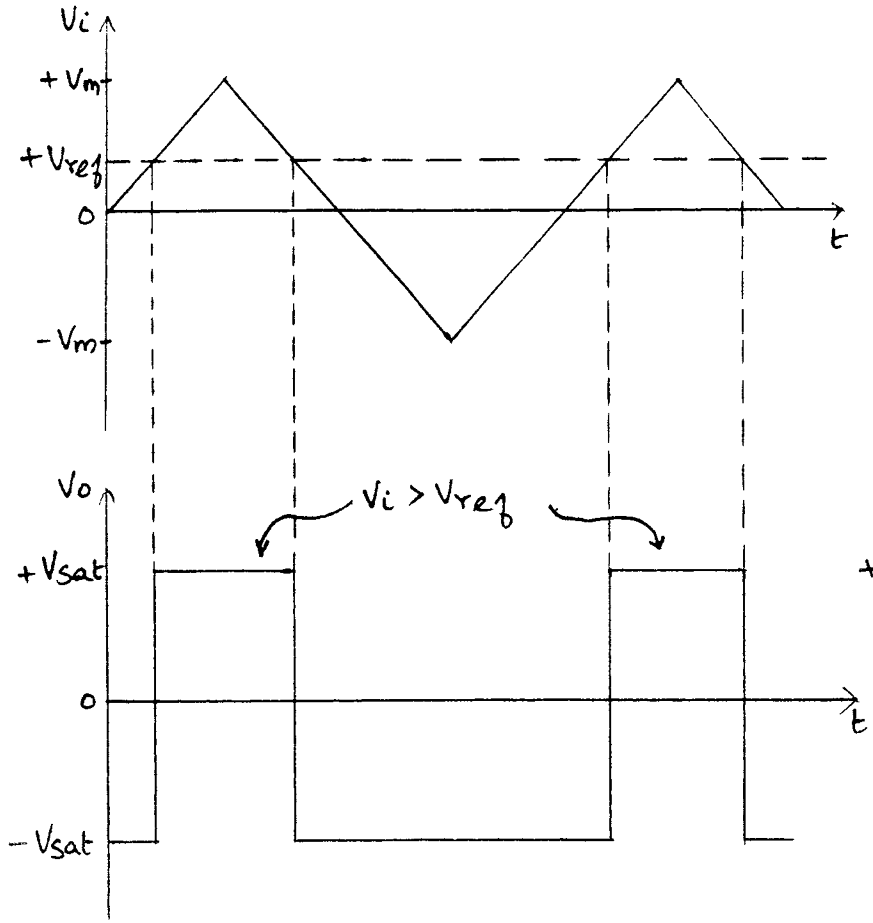

FIGURE 4.4, I/O WAVEFORMS FOR V ref Positive

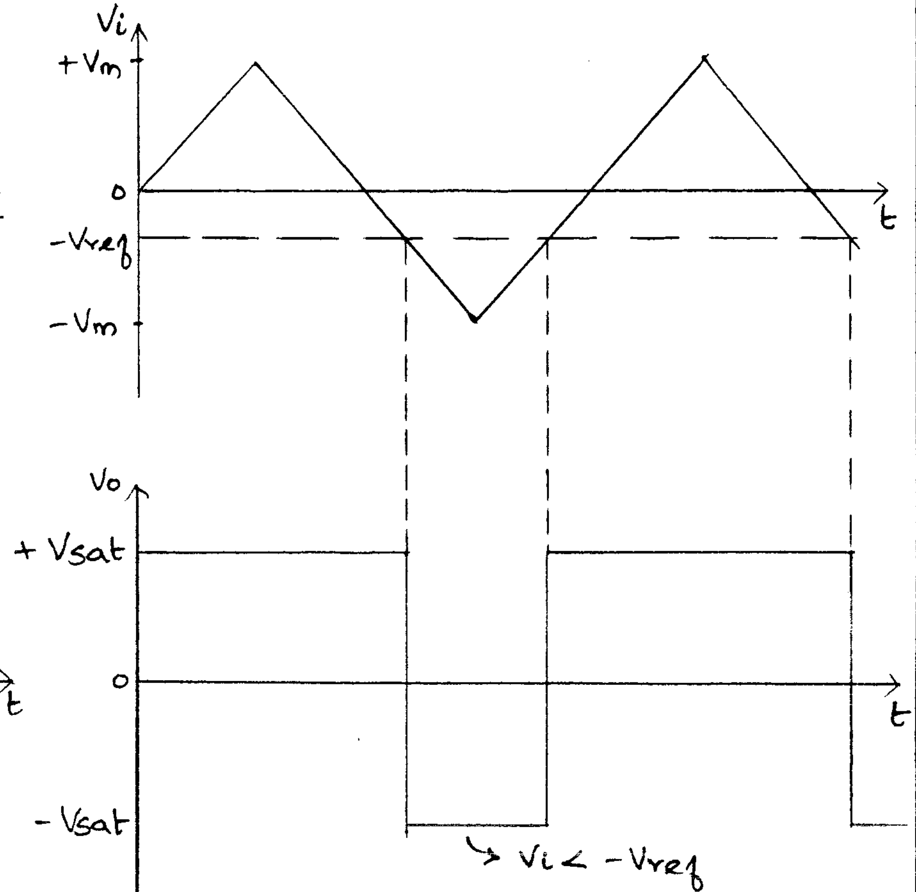

FIGURE 4.5, I/O WAVEFORMS FOR V ref Negative

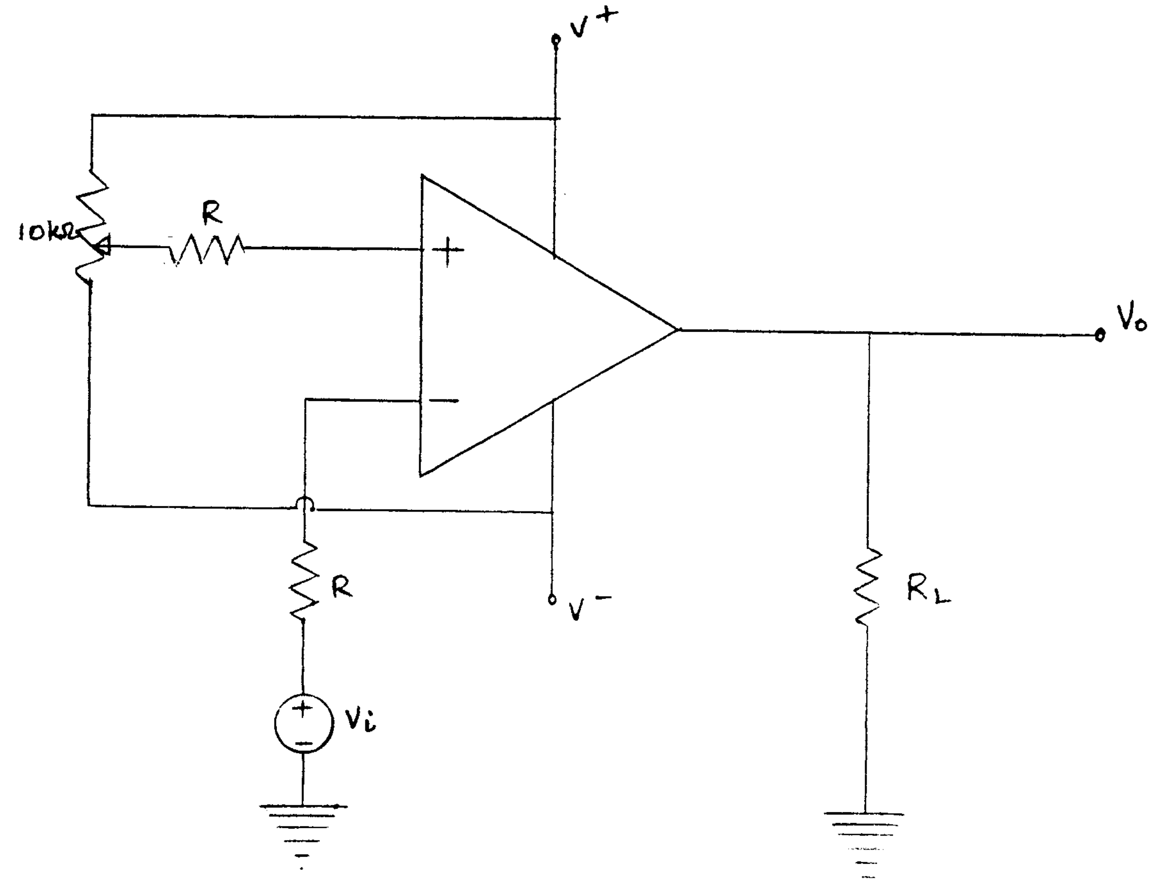

FIGURE 4.6, INVERTING COMPARATOR

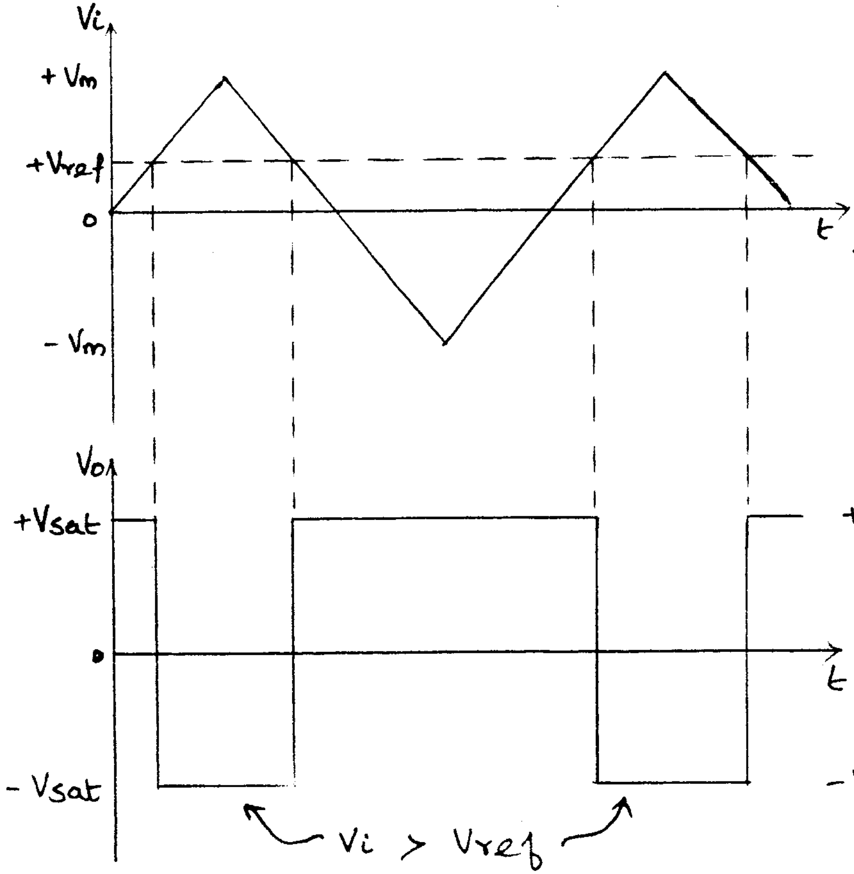

FIGURE 4.7, I/O WAVEFORMS FOR
V ref POSITIVE

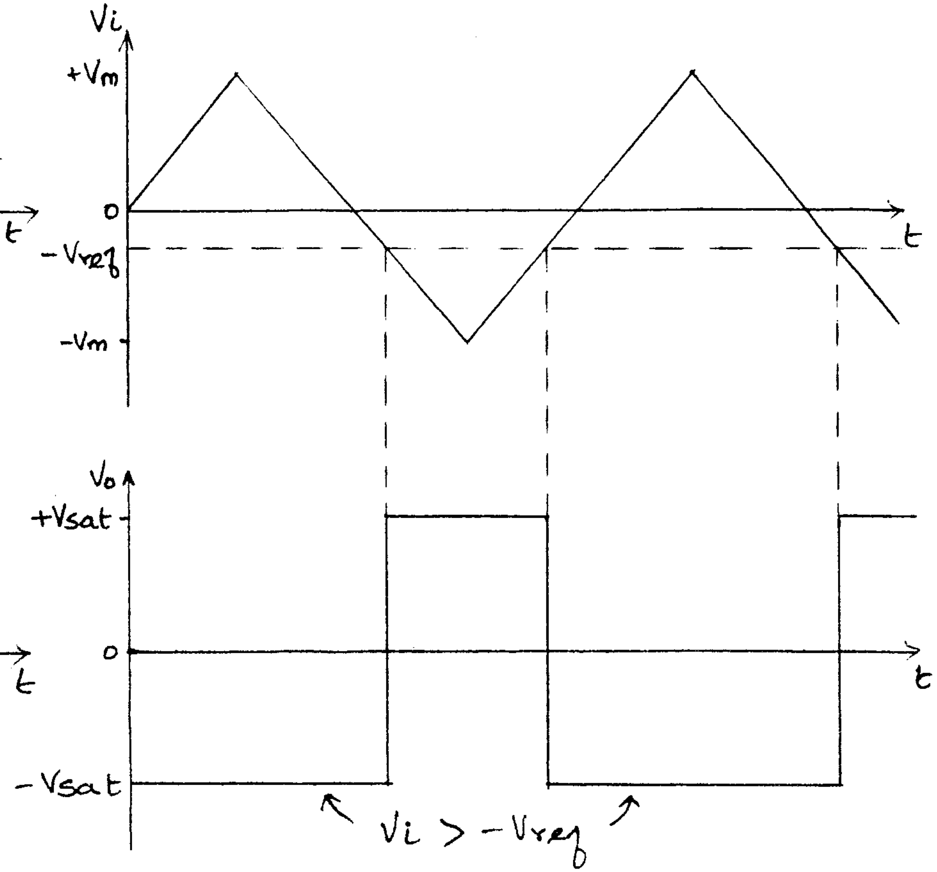

FIGURE 4.8, I/O WAVEFORMS FOR
V ref NEGATIVE

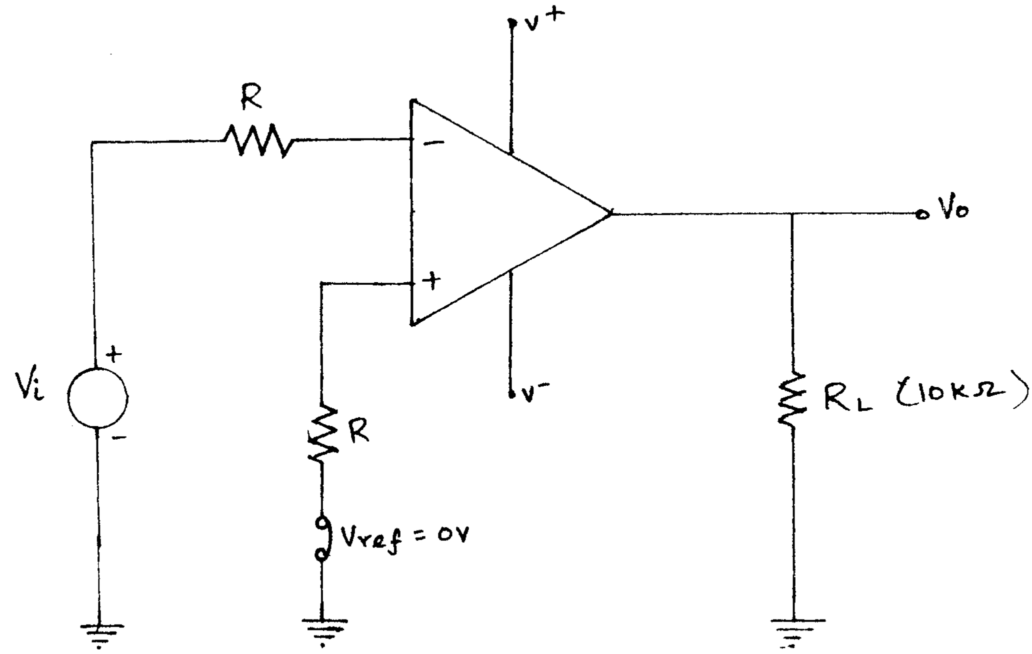

FIGURE 4.9, ZERO CROSSING DETECTOR

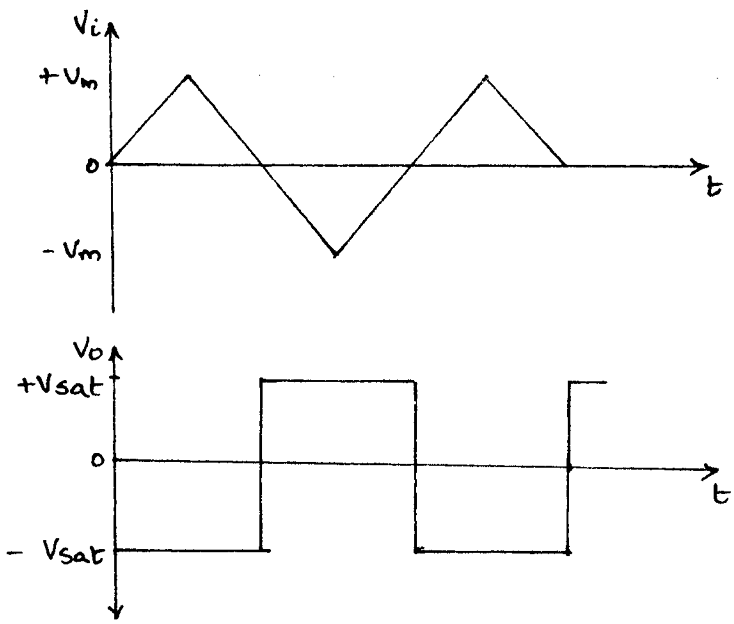

FIGURE 4.10, I/O WAVEFORMS

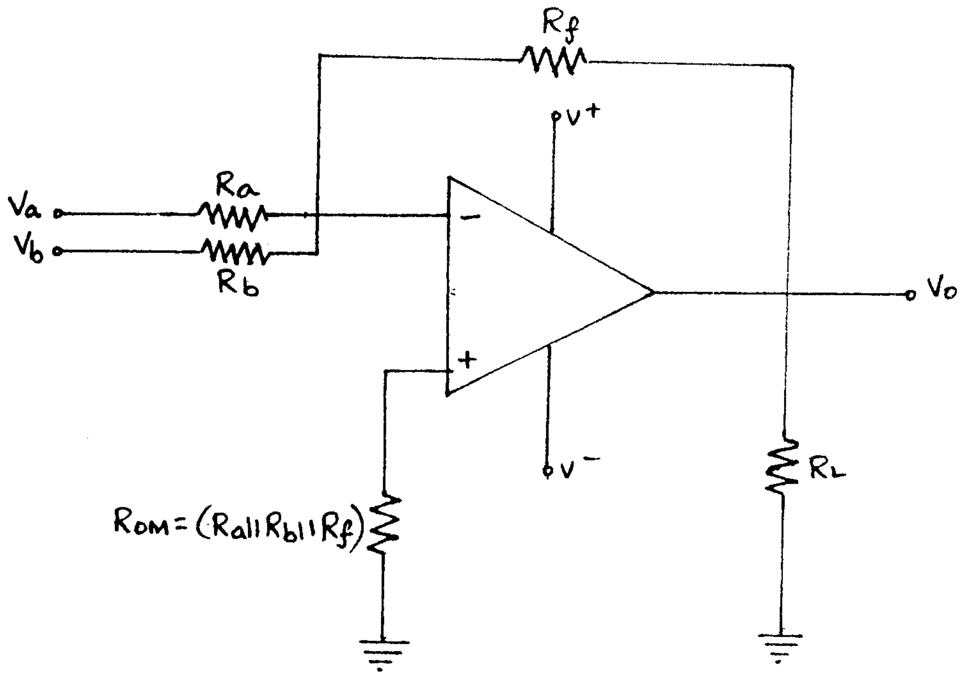

FIGURE 4.11, INVERTING SUMMING AMPLIFIER

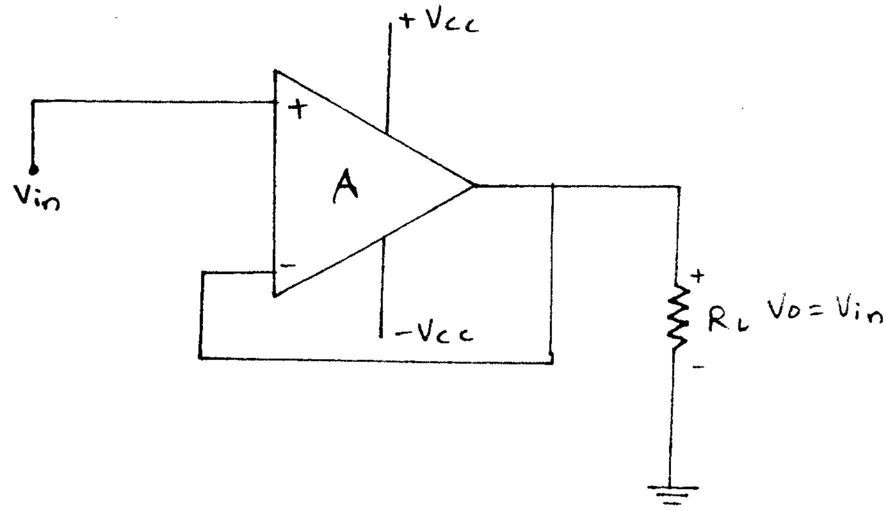

FIGURE 4.12, VOLTAGE FOLLOWER

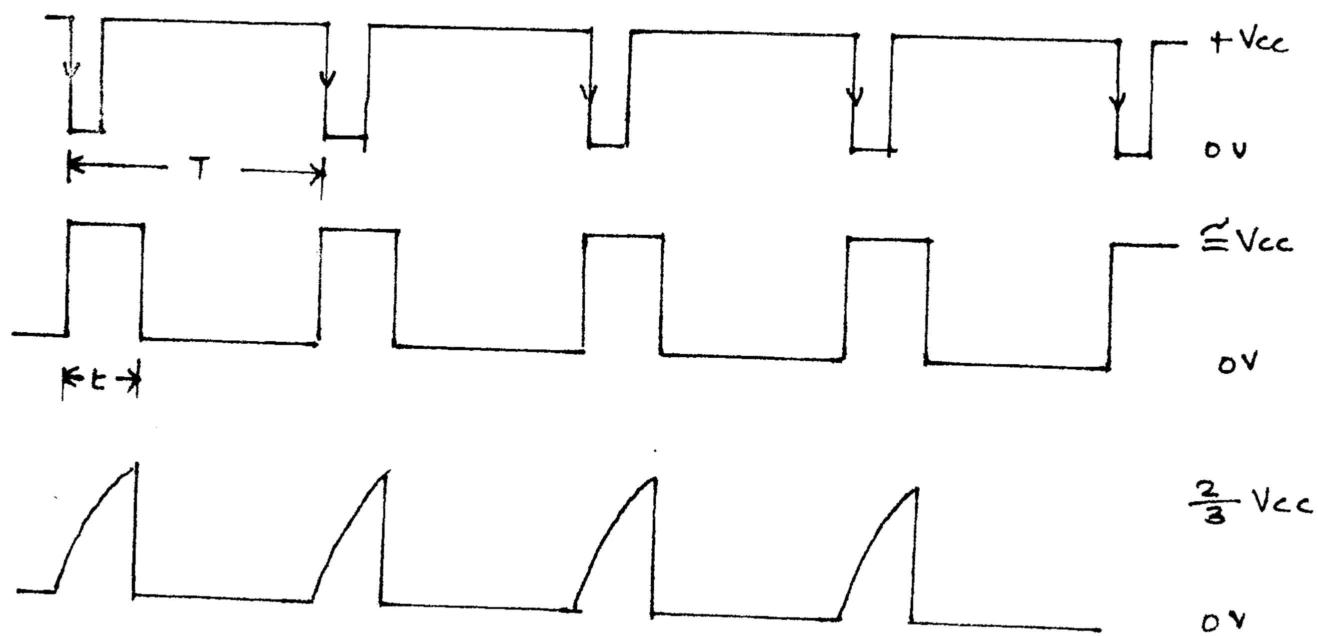

FIGURE 4.13, I/O WAVEFORMS OF 555 MONOSTABLE MULTIVIBRATOR

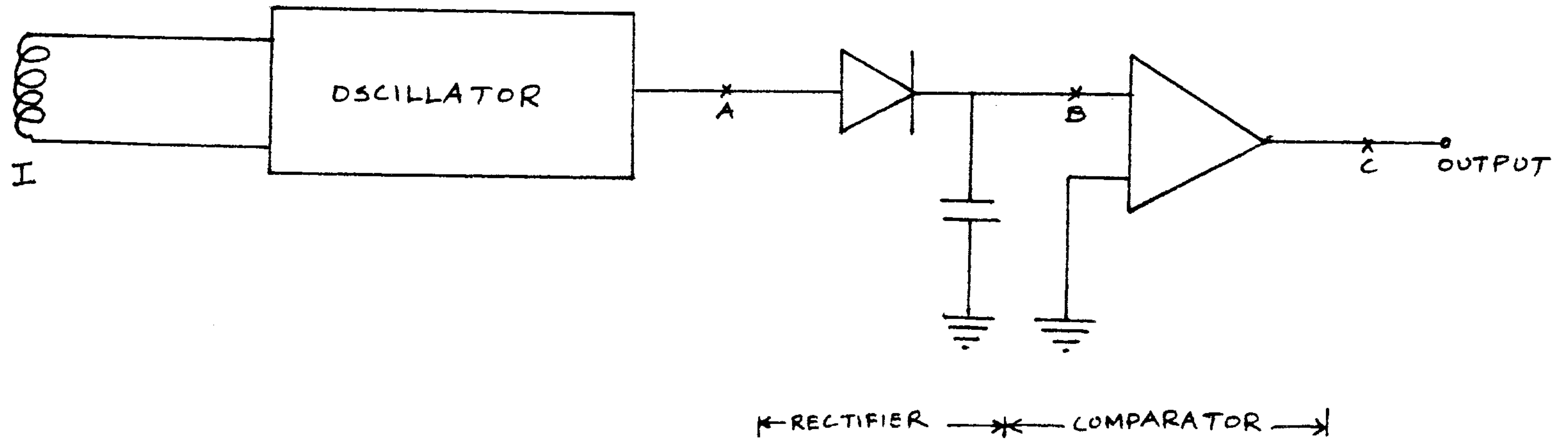

FIGURE 4.14, INTERNAL CONFIGURATION OF PROXIMITY SENSOR

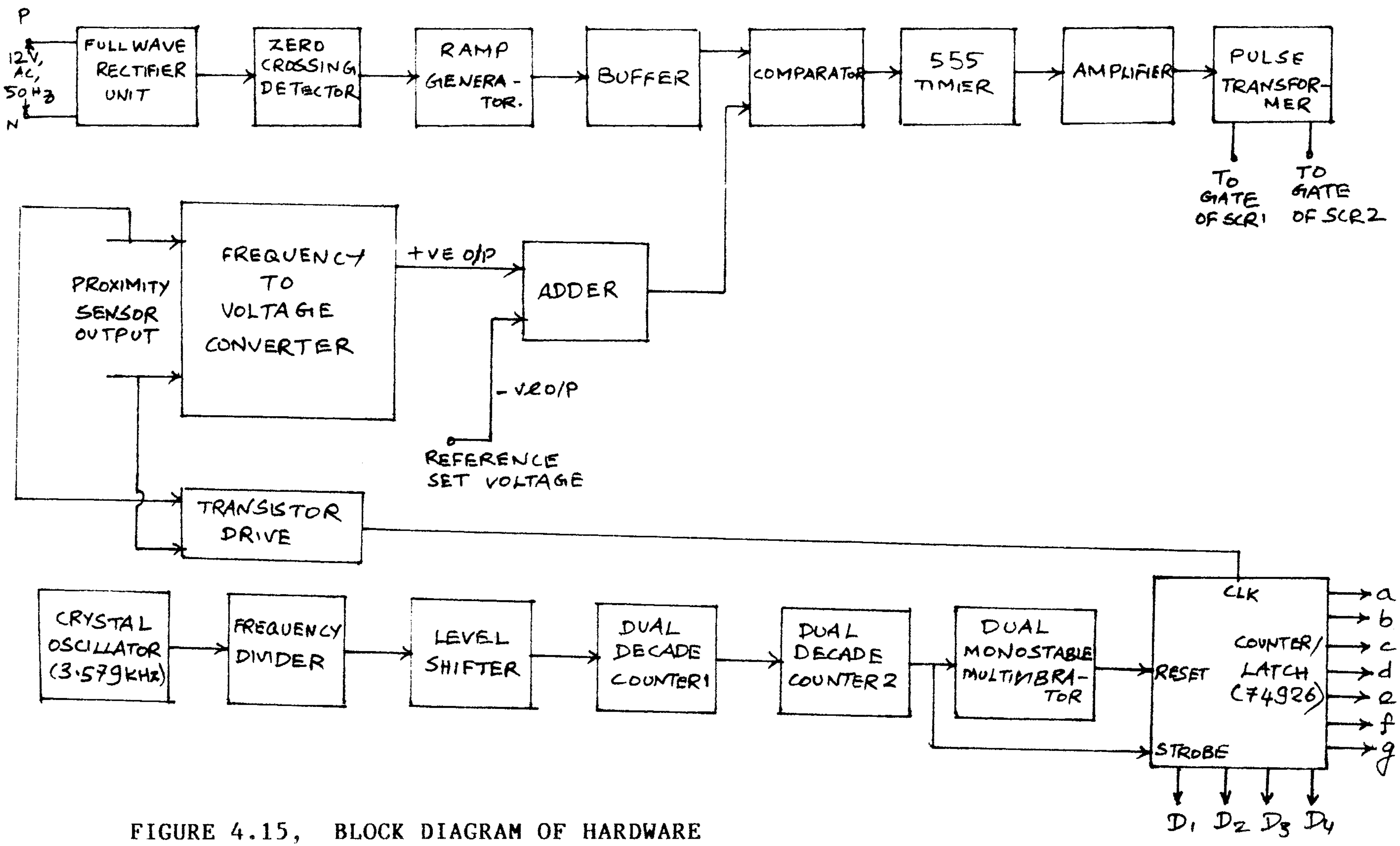

FIGURE 4.15, BLOCK DIAGRAM OF HARDWARE

CHAPTER V

INDUSTRIAL APPLICATIONS

5.1 PAPER INDUSTRIES :

Pulp making and paper making are the two main process that take place in a paper mill. Here paper making process is done by thyristor controlled DC drive.

The machine that makes paper in a paper mill has to perform the job of forming sheets, removing water from sheets, drying of sheets, pressing of sheets and reeling up of sheets. Therefore, the paper is made in the following five sections :

(i) Couch Section (wire section)
(ii) Press Section
(iii) Dryer Section
(iv) Calender Section
(v) Reel Section

5.1.1 REQUIREMENTS OF PAPER MACHINE DRIVE :

1. For the actual formation and production of sheets and from the point of view of economy, it is necessary to maintain the speed of paper machine constant.

2. For a paper machine to be multipurpose, its speed should be adjustable over a range as large as 10:1.

3. In the wet end of the paper machine, the web becomes elongated by about 5%. Care should be taken to allow for this elongation by varying the speeds of individual sections. As this elongation is a function of the quality of the paper, speeds of sections must be independently adjustable.

In dry end of paper machine, the web hangs freely between sections without any support. Therefore, a definite amount of tension must be set and regulated. This also necessitates a definite difference between the speeds of successive sections.

The relative speeds of two sections have a direct bearing on the pull on the sheet. Hence steady state accuracy of 0.1 percent or better is specified for the speed control system so as to avoid tearing and folding of sheet.

4. While cleaning the wire, it has to be moved forward a few centimetres at a time so that it can be cleaned and inspected properly. Hence, the motor should be capable of running at inching speed of 10 - 25 m/min as long as a particular button is pressed.

5. Each section should be able to run at the crawling speed of 10-25 m/min for running in felts, wire and heating up of dryer cylinders.

6. Smooth and quick starting of the sections, without causing excessive starting current, are required.

7. Control system employed should be flexible in nature.

5.1.2 TYPES OF DRIVES USED FOR PAPER MACHINE :

There are two types of drives employed for making paper from pulp :

1. Line shaft drive and
2. Sectional drive.

LINE SHAFT DRIVES :

Normally, electric motors are employed to drive the transmission shaft. Both AC and DC drives can be used for practically loss-less speed control.

In AC drive, only the AC commutator motor with shunt characteristic is of use for obtaining an economic speed control system. However, the speed of an AC commutator motor depends on load and, hence, its use as a paper machine drive with stringent requirements of constant speed is no longer advisable. Also, its speed range (usually of the order 1:3) as well as the power required greatly affects the size of the motor. The open loop speed control of the ac commutator motor is sluggish. So, DC drives whose speed can be controlled by thyristors are widely used. The speed of the paper machine is controlled by varying the voltage of a separately excited DC motor. The variable DC voltage is obtained from alternating voltage supply by means of static converters.

SECTIONAL DRIVE :

In sectional drive each section of the paper machine has its own electrical motor. All the motors are operated from a common supply bar. By varying the voltage the speed of the paper machine can be controlled.

5.2 CEMENT MILLS :

The driving motors used in the cement industry can be broadly classified as follows :

(i) Raw mill and cement mill drives
(ii) Kiln drives
(iii) Crusher drives
(iv) Waste gas fan drives
(v) Compressor drives etc.,

Kiln drive system and waste gas fan drive system use thyristor controlled DC drives.

5.2.1 KLIN DRIVES :

The rotary kiln is an indispensable part of a cement plant.

In early years, variable speed AC commutator motors we employed for kiln drives. However due to requirements of higher output ratings and of speed range in excess of 1:2, the commutator motor became an expensive proposition in addition to maintenance problems. This was followed by Ward-Leonard drives. In account of higher capital cost, lower efficiencies and greater maintenance problems as compared to thyristor controlled DC drives, the Ward-Leonard drive has been suspended by the DC motor with static supply.

The rating of the motors used for driving the kilns vary from 100 to 1000 Kw. The maximum speed of the kiln is about 1 rpm and the kiln motor has to be designed for a speed range of the order of 1:10. The starting torque required may be between 200% to 250% of full load torque. The motors are also specially designed to pick up speed at full load within the normal time of 15 seconds. Quite often, kiln motors have to cater to overloads to the tune of 200% to 250% for small period of time. The motor and control equipment have also to be specially designed for inching and spotting of the kiln during maintenance and routine checks.

5.2.2 FAN DRIVES :

In early years slipring induction motor was used. Due to higher frequency and finer control, thyristorised DC drives are replacing slipring motors. The starting torque is around 120% of the full load torque.

5.3 STEEL MILLS :

Steel mills usually produce blooms, slabs, rails, rods, sheets, strips, beams, bars or angles.

Technologically the rolling mills are divided into four types.

1) Continuous cold rolling mills (Unidirectional)
2) Reversing cold rolling mills (Bidirectional)
3) Continuous hot rolling mills (Unidirectional)
4) Reversing hot rolling mills (Bidirectional)

5.3.1 REQUIREMENTS OF DRIVES FOR ROLLING MILLS :

(i) Wide range of speed variation

(ii) Ability of the motor and its control equipment to permit frequent starts and reversals

(iii) Reversal of the direction of rotation of the motor without causing serious disturbances in the power handling circuits

(iv) Automatic control of operation

(v) High reliability

(vi) Accuracy

(vii) The speed of the motor must be restored to its set value as quickly as possible.

There are a number of auxiliary drives which are used to convey the ingot, bloom or slab to or from the mill and in making mechanical adjustments to the mill or metal on a pass by pass basis. All these variable speed drives must be integrally controlled for effective functioning of the mill.

Use of thyristor controlled DC motors is universally accepted for choosing the main drives in both reversing and unidirectional continuous mills.

CHAPTER 6

CONCLUSION

A variable speed thyristor controlled drive for a DC shunt motor has been designed, constructed and tested successfully. The control circuitary consists of SCRs, transistors, diodes, ICs etc. Testing of the drive was carried out for a separately excited DC motor and the result was satisfactory.

This drive has the following advantages :

1. Easy and smooth speed control
2. Wide range of speed control
3. Quick response of speed is possible
4. High operating efficiency
5. The operation is simple and reliable
6. Space requirement is less
7. Low initial and installation cost.

This DC drive is also equipped with a display unit which displays the speed. The display unit has a unique feature of updating the speed after three seconds. The variation in speed is obtained by armature voltage control.

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Operational Amplifiers/Buffers

National Semiconductor

LM124/LM224/LM324, LM124A/LM224A/LM324A, LM2902 Low Power Quad Operational Amplifiers

General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5 V_{DC} power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15 V_{DC} power supplies.

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.

Advantages

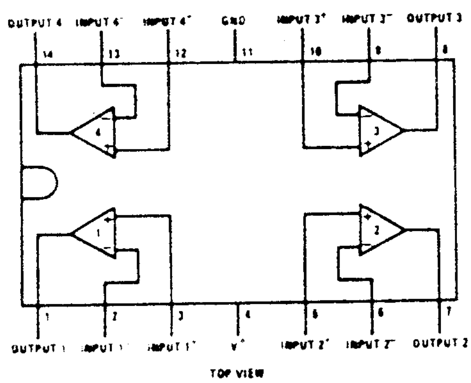
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large dc voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  - Single supply 3 V_{DC} to 30 V_{DC}
  - or dual supplies ±1.5 V_{DC} to ±15 V_{DC}
- Very low supply current drain (800μA) — essentially independent of supply voltage (1 mW/op amp at +5 V_{DC})
- Low input biasing current 45 nA_{DC} (temperature compensated)
- Low input offset voltage 2 mV_{DC} and offset current 5 nA_{DC}
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0 V_{DC} to $V^+ - 1.5$ V_{DC}

Connection Diagram

Dual-In-Line Package

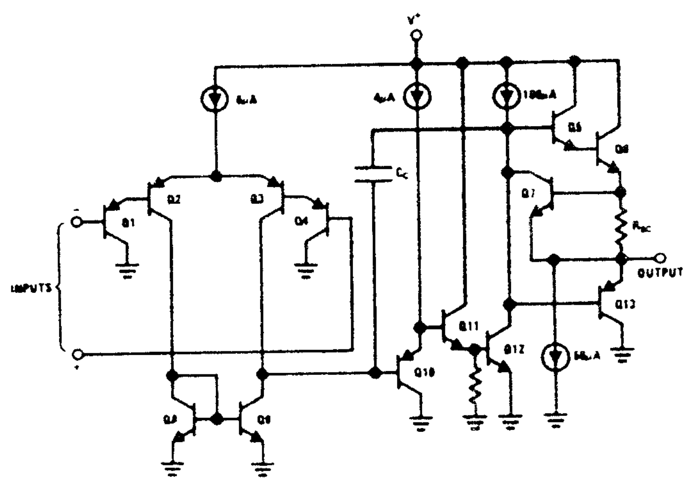


TOP VIEW

Order Number LM124J, LM124AJ, LM224J, LM224AJ, LM324J, LM324AJ or LM2902J
See NS Package J14A

Order Number LM324N, LM324AN or LM2902N
See NS Package N14A

Schematic Diagram (Each Amplifier)



National Semiconductor

LM131A/LM131, LM231A/LM231, LM331A/LM331 Precision Voltage-to-Frequency Converters

General Description

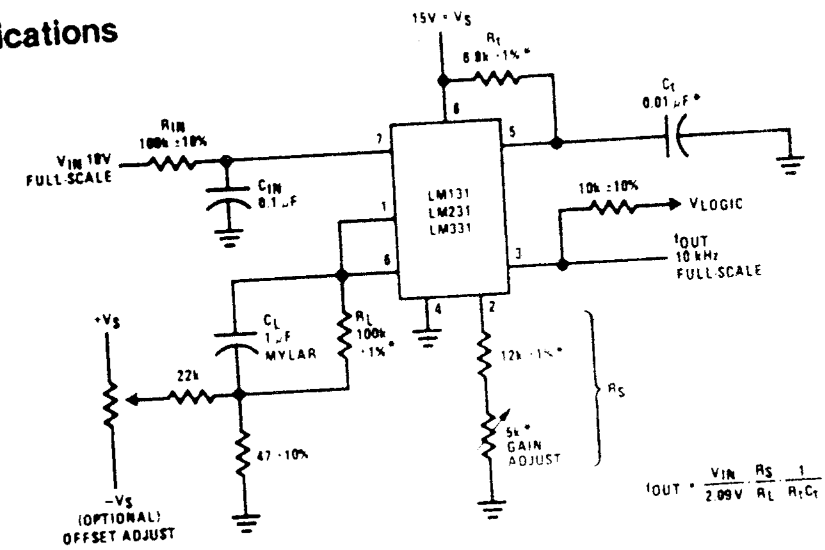
The LM131/LM231/LM331 family of voltage-to-frequency converters are ideally suited for use in simple low-cost circuits for analog-to-digital conversion, precision frequency-to-voltage conversion, long-term integration, linear frequency modulation or demodulation, and many other functions. The output when used as a voltage-to-frequency converter is a pulse train at a frequency precisely proportional to the applied input voltage. Thus, it provides all the inherent advantages of the voltage-to-frequency conversion techniques, and is easy to apply in all standard voltage-to-frequency converter applications. Further, the LM131A/LM231A/LM331A attains a new high level of accuracy versus temperature which could only be attained with expensive voltage-to-frequency modules. Additionally the LM131 is ideally suited for use in digital systems at low power supply voltages and can provide low-cost analog-to-digital conversion in microprocessor-controlled systems. And, the frequency from a battery powered voltage-to-frequency converter can be easily channeled through a simple photoisolator to provide isolation against high common mode levels.

The LM131/LM231/LM331 utilizes a new temperature-compensated band-gap reference circuit, to provide excellent accuracy over the full operating temperature range, at power supplies as low as 4.0V. The precision timer circuit has low bias currents without degrading the quick response necessary for 100 kHz voltage-to-frequency conversion. And the output is capable of driving 3 TTL loads, or a high voltage output up to 40V, yet is short-circuit-proof against V_{CC}.

Features

- Guaranteed linearity 0.01% max
- Improved performance in existing voltage-to-frequency conversion applications
- Split or single supply operation
- Operates on single 5V supply
- Pulse output compatible with all logic forms
- Excellent temperature stability, ±50 ppm/°C max
- Low power dissipation, 15 mW typical at 5V
- Wide dynamic range, 100 dB min at 10 kHz full scale frequency
- Wide range of full scale frequency, 1 Hz to 100 kHz
- Low cost

Typical Applications



*Use stable components with low temperature coefficients. See Typical Applications section.

FIGURE 1. Simple Stand-Alone Voltage-to-Frequency Converter with ±0.03% Typical Linearity (f = 10 Hz to 11 kHz)

QUADRUPLE EXCLUSIVE-OR GATE

The HEF4070B provides the positive quadruple exclusive-OR function. The outputs are fully buffered for highest noise immunity and pattern insensitivity of output impedance.

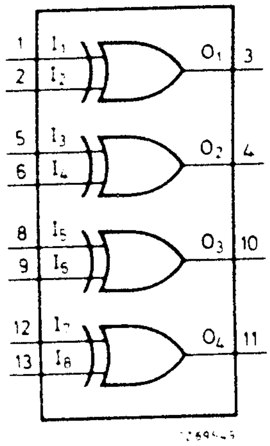


Fig. 1 Functional diagram.

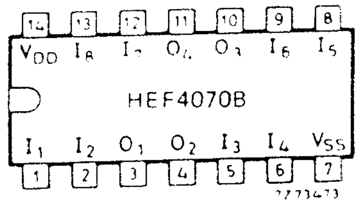


Fig. 2 Pinning diagram.

HEF4070BP : 14-lead DIL; plastic (SOT-27K, M, T).
HEF4070BD: 14-lead DIL; ceramic (cerdip) (SOT-73).
HEF4070BT : 14-lead mini-pack; plastic (SO-14; SOT-108A).

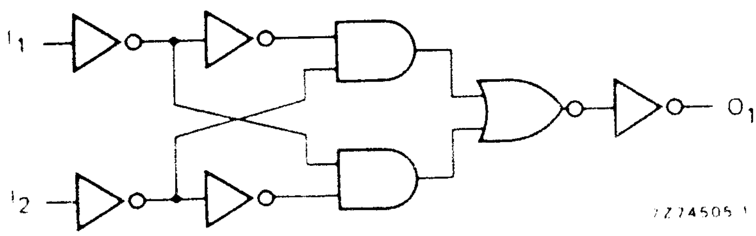


Fig. 3 Logic diagram (one gate).

APPLICATION INFORMATION

Some examples of applications for the HEF4070B are:

- Logical comparators
- Parity checkers and generators

TRUTH TABLE

I_1	I_2	O_1
L	L	L
H	L	H
L	H	H
H	H	L

H = HIGH state (the more positive voltage)
L = LOW state (the less positive voltage)

FAMILY DATA	see Family Specifications
I_{DD} LIMITS category GATES	

QUADRUPLE 2-INPUT AND GATE

The HEF4081B provides the positive quadruple 2-input AND function. The outputs are fully buffered for highest noise immunity and pattern insensitivity of output impedance.

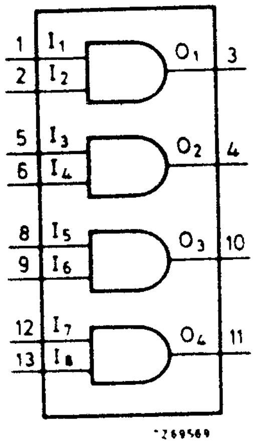


Fig.1 Functional diagram.

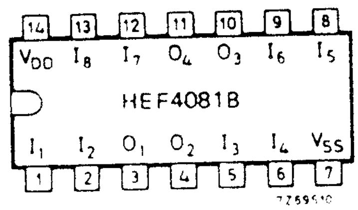


Fig.2 Pinning diagram

HEF4081BP : 14-lead DIL; plastic (SOT-27K, M, T).
HEF4081BD: 14-lead DIL; ceramic (cerdip) (SOT-73).
HEF4081BT : 14-lead mini-pack; plastic (SO-14; SOT-108A).

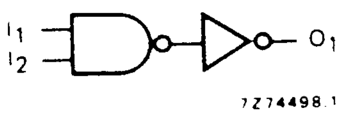


Fig.3 Logic diagram (one gate).

FAMILY DATA	see Family Specifications
I_{DD} LIMITS category GATES	

DUAL BCD COUNTER

The HEF4518B is a dual 4-bit internally synchronous BCD counter. The counter has an active HIGH clock input (CP_0) and an active LOW clock input ($\overline{CP}_1$), buffered outputs from all four bit positions (O_0 to O_3) and an active HIGH overriding asynchronous master reset input (MR). The counter advances on either the LOW to HIGH transition of the CP_0 input if $\overline{CP}_1$ is HIGH or the HIGH to LOW transition of the $\overline{CP}_1$ input if CP_0 is LOW. Either CP_0 or $\overline{CP}_1$ may be used as the clock input to the counter and the other clock input may be used as a clock enable input. A HIGH on MR resets the counter (O_0 to O_3 = LOW) independent of CP_0, $\overline{CP}_1$.
Schmitt-trigger action in the clock input makes the circuit highly tolerant to slower clock rise and fall times.

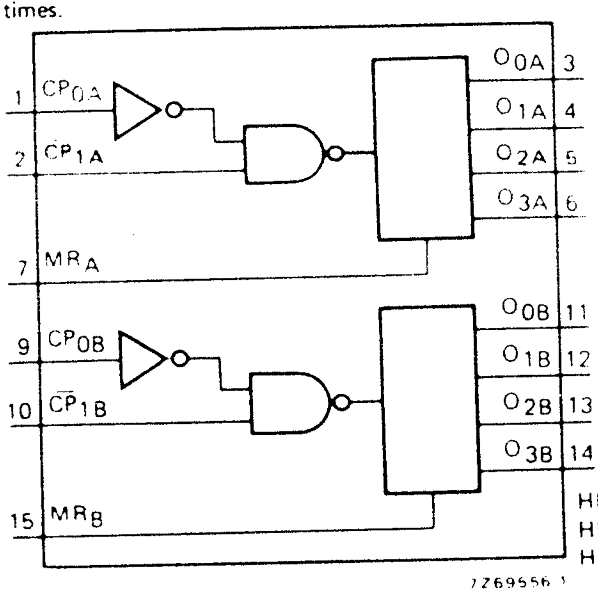


Fig. 1 Functional diagram.

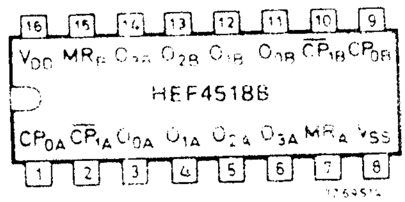


Fig. 2 Pinning diagram.

HEF4518BP : 16-lead DIL; plastic (SOT-38Z).
HEF4518BD: 16-lead DIL; ceramic (cerdip) (SOT-74).
HEF4518BT : 16-lead mini-pack; plastic (SO-16; SOT-109A).

PINNING

CP_{0A}, CP_{0B}	clock inputs (L to H triggered)
$\overline{CP}_{1A}$, $\overline{CP}_{1B}$	clock inputs (H to L triggered)
MR_A, MR_B	master reset inputs
O_{0A} to O_{3A}	outputs
O_{0B} to O_{3B}	outputs

APPLICATION INFORMATION

Some examples of applications for the HEF4518B are:

- Multistage synchronous counting
- Multistage asynchronous counting
- Frequency dividers

FAMILY DATA

I_{DD} LIMITS category MSI

see Family Specifications

DUAL MONOSTABLE MULTIVIBRATOR

The HEF4528B is a dual retriggerable-resettable monostable multivibrator. Each multivibrator has an active LOW input ($\overline{I}_0$), and active HIGH input (I_1), an active LOW clear direct input ($\overline{C}_D$), an output (O) and its complement ($\overline{O}$), and two pins for connecting the external timing components (C_{TC}, RC_{TC}).

An external timing capacitor (C_t) must be connected between C_{TC} and RC_{TC} and an external resistor (R_t) must be connected between RC_{TC} and V_{DD}. The duration of the output pulse is determined by the external timing components C_t and R_t.

A HIGH to LOW transition on $\overline{I}_0$ when I_1 is LOW or a LOW to HIGH transition on I_1 when $\overline{I}_0$ is HIGH produces a positive pulse (LOW-HIGH-LOW) on O and a negative pulse (HIGH-LOW-HIGH) on $\overline{O}$ if the $\overline{C}_D$ is HIGH. A LOW on $\overline{C}_D$ forces O LOW, $\overline{O}$ HIGH and inhibits any further pulses until $\overline{C}_D$ is HIGH.

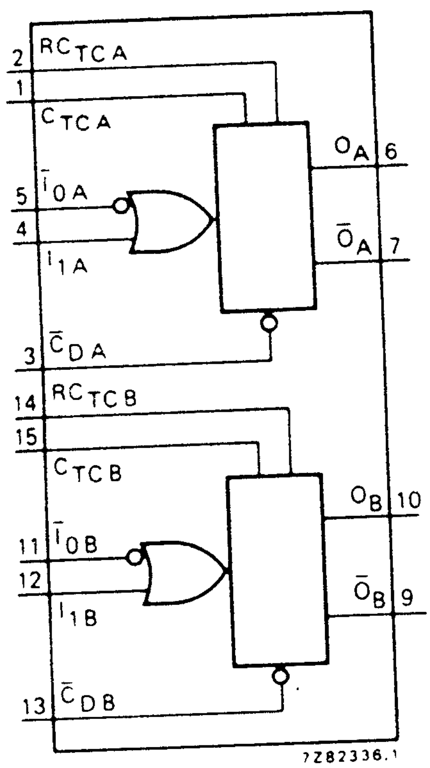


Fig. 1 Functional diagram.

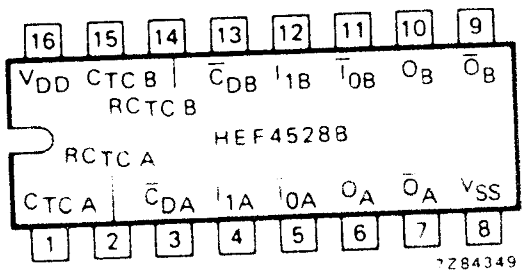


Fig. 2 Pinning diagram.

HEF4528BP : 16-lead DIL; plastic (SOT-38Z).
HEF4528BD: 16-lead DIL; ceramic (cerdip) (SOT-74).
HEF4528BT : 16-lead mini-pack; plastic (SO-16; SOT-109A).

PINNING

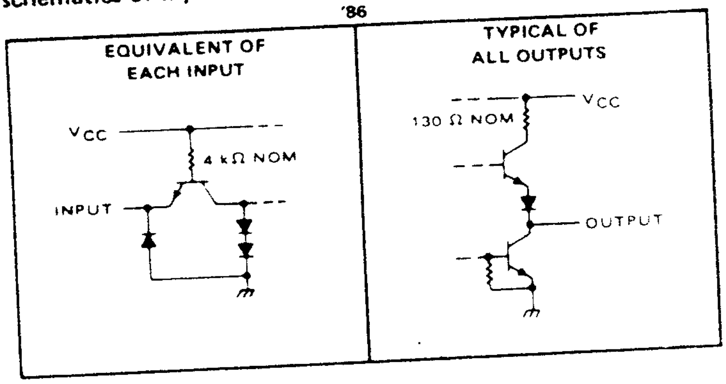
$\overline{I}_{0A}$, $\overline{I}_{0B}$	input (HIGH to LOW triggered)
I_{1A}, I_{1B}	input (LOW to HIGH triggered)
$\overline{C}_{DA}$, $\overline{C}_{DB}$	clear direct input (active LOW)
O_A, O_B	output
$\overline{O}_A$, $\overline{O}_B$	complementary output (active LOW)
$C_{TC\,A}$, $C_{TC\,B}$	external capacitor connections
$RC_{TC\,A}$, $RC_{TC\,B}$	external capacitor/ resistor connections

FAMILY DATA	see Family Specifications
I_{DD} LIMITS category MSI	

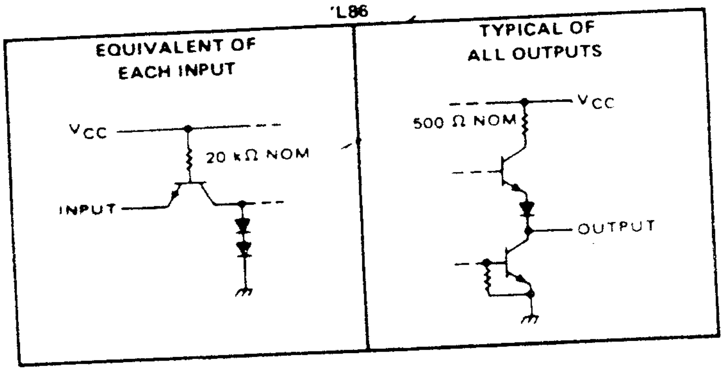
DECEMBER 1972 – REVISED DECEMBER 1983

schematics of inputs and outputs

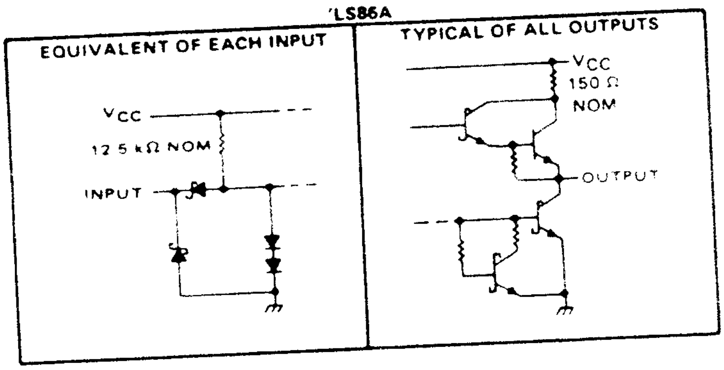
'86



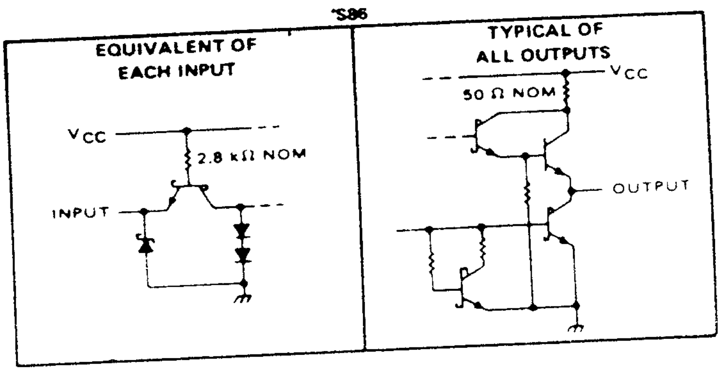
'L86



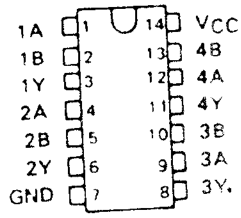
'LS86A



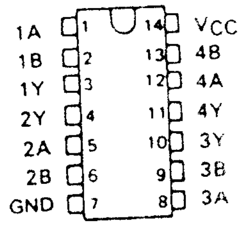
'S86



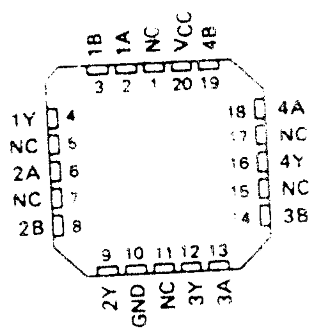
SN5486, SN54LS86A, SN54S86 . . . J OR W PACKAGE
SN7486 . . . J OR N PACKAGE
SN74LS86A, SN74S86 . . . D, J OR N PACKAGE
(TOP VIEW)



SN54L86 . . . J PACKAGE
(TOP VIEW)



SN54LS86A, SN54S86 . . . FK PACKAGE
SN74LS86A, SN74S86 . . . FN PACKAGE
(TOP VIEW)



NC – No internal connection

FUNCTION TABLES

INPUTS		OUTPUT
A	B	Y
L	L	L
L	H	H
H	L	H
H	H	L

H = high level, L = low level

TYPE	TYPICAL AVERAGE PROPAGATION DELAY TIME	TYPICAL TOTAL POWER DISSIPATION
'86	14 ns	150 mW
'L86	55 ns	15 mW
'LS86A	10 ns	30.5 mW
'S86	7 ns	250 mW

LM78LXX Series 3-Terminal Positive Regulators

General Description

The LM78LXX series of three terminal positive regulators is available with several fixed output voltages making them useful in a wide range of applications. When used as a zener diode/resistor combination replacement, the LM78LXX usually results in an effective output impedance improvement of two orders of magnitude, and lower quiescent current. These regulators can provide local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow the LM78LXX to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM78LXX is available in the metal three lead TO-39(H) and the plastic TO-92 (Z). With adequate heat sinking the regulator can deliver 100 mA output current. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

Features

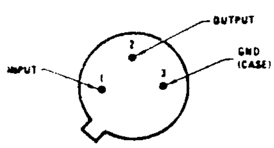
- Output voltage tolerances of ±5% (LM78LXXAC) and ±10% (LM78LXXC) over the temperature range
- Output current of 100 mA
- Internal thermal overload protection
- Output transistor safe area protection
- Internal short circuit current limit
- Available in plastic TO-92 and metal TO-39 low profile packages

Voltage Range

LM78L05	5V
LM78L12	12V
LM78L15	15V

Connection Diagrams

Metal Can Package



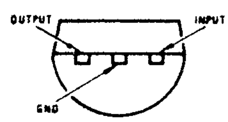
BOTTOM VIEW

Order Numbers:

LM78L05ACH	LM78L05CH
LM78L12ACH	LM78L12CH
LM78L15ACH	LM78L15CH

See Package H03A

Plastic Package



BOTTOM VIEW

Order Numbers:

LM78L05ACZ	LM78L05CZ
LM78L12ACZ	LM78L12CZ
LM78L15ACZ	LM78L15CZ

See Package Z03A

National Semiconductor

Voltage Regulators

LM79XX Series 3-Terminal Negative Regulators

General Description

The LM79XX series of 3-terminal regulators is available with fixed output voltages of −5V, −12V, and −15V. These devices need only one external component—a compensation capacitor at the output. The LM79XX series is packaged in the TO-220 power package and is capable of supplying 1.5A of output current.

These regulators employ internal current limiting safe area protection and thermal shutdown for protection against virtually all overload conditions.

Low ground pin current of the LM79XX series allows output voltage to be easily boosted above the preset value with a resistor divider. The low quiescent current drain of these devices with a specified maximum change with line and load ensures good regulation in the voltage boosted mode.

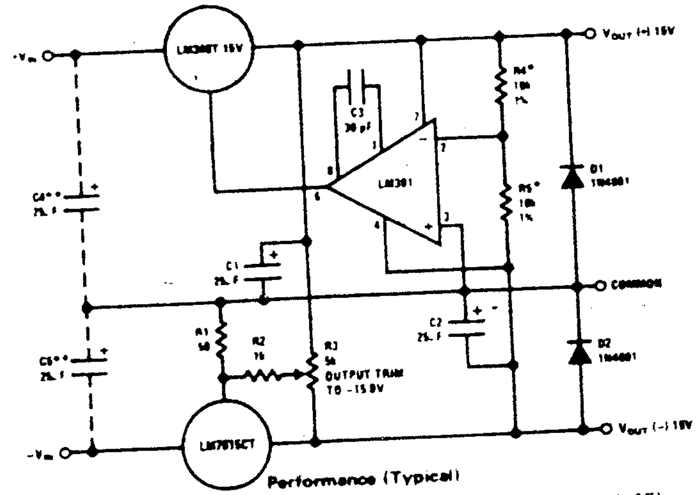
For applications requiring other voltages, see LM137 data sheet.

Features

- Thermal, short circuit and safe area protection
- High ripple rejection
- 1.5A output current
- 4% preset output voltage

Typical Applications

±15V, 1 Amp Tracking Regulators



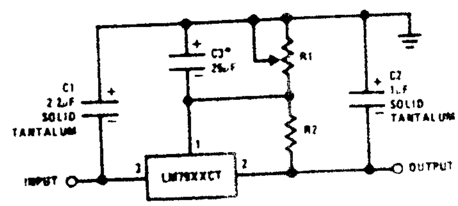
Performance (Typical)

	(−15)	(+15)
Load Regulation at ΔI_L = 1A	40 mV	2 mV
Output Ripple, C_{IN} = 3000µF, I_L = 1A	100µVrms	100µVrms
Temperature Stability	50 mV	50 mV
Output Noise 10 Hz ≤ f ≤ 10 kHz	150µVrms	150µVrms

*Resistor tolerance of R4 and R5 determine matching of (+) and (−) outputs

**Necessary only if raw supply filter capacitors are more than 3" from regulators

Variable Output



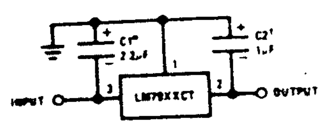
*Improves transient response and ripple rejection. Do not increase beyond 50µF

$$V_{OUT} = V_{SET}\left(\frac{R1 + R2}{R2}\right)$$

Select R2 as follows

LM7905CT	300Ω
LM7912CT	750Ω
LM7915CT	1k

Fixed Regulator



*Required if regulator is separated from filter capacitor by more than 3". For value given, capacitor must be solid tantalum. 25µF aluminum electrolytic may be substituted.

†Required for stability. For value given, capacitor must be solid tantalum. 25µF aluminum electrolytic may be substituted. Values given may be increased without limit.

For output capacitance in excess of 100µF, a high current diode from input to output (1N4001, etc.) will protect the regulator from momentary input shorts.

Dual Trimmed Supply