ELECTRONIC STAR-DELTA STARTER FOR INDUCTION MOTOR

Project Report

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SYNOPSIS

This project comprises the designing and fabrication of an electronic circuit to be used with conventional Star-Delta Starter. The electronic circuit is operated on low voltage. By this means a simple method of preventing the motor against faulty operations is achieved. This project has brought a low cost and efficient device for starting induction motors.

Introduction

1. INTRODUCTION

The aim of this project is to develop an electronic starter for induction motor which is able to prevent the motor from maloperation due to single phasing, high/low voltage and dry running of pump motor.

A timer circuit has been designed to get automatic conversion of motor windings from star to delta. The water level monitor circuit monitors the raise and fall of waterlevel in tanks, wells etc. The high-low voltage cut-off circuit operates the motor at optimum voltage.

Single phase preventer and phase sequencer circuit prevents the motor from operation, if one of phase cuts-off, and the phase sequencer sequences the supply phases appropriately.

Due to the incorporation of these circuits the motor is prevented from abnormal operating condition which might damage the motor.

The following chapters begins with the different methods of starting induction motors and also describes the construction and the operation of fault prevention circuits.

Starting of Induction Motors

2. STARTING OF INDUCTION MOTOR

2.1 Operating Principle

Of all the a.c. motors, the polyphase induction motor is the one which is extensively used for various kinds of industrial drive. This chapter deals with the operating principle of induction motor which is exactly same way as the secondary of a transformer receives its power from primary.

The reason for the rotation of rotor of induction motor is explained as follows. When 3 phase windings are fed by a 3 phase supply, then a magnetic flux of constant magnitude but rotating at synchronous speed is setup. The flux passes through the airgap sweeps past the rotor surface and so cuts the rotor conductor which are stationary. Due to the relative speed between the rotating flux and stationary conductors, an emf is induced in the rotor.

Since the rotor bars and conductors form a closed circuit, rotating current is produced such as to oppose the very causes producing it. Here the cause which produces the rotor current is the relative velocity between the rotating flux of the stator and the stationary rotor conductors. Hence to reduce the relative speed, the rotor starts running in the same direction as that of flux and tries to catchup with the rotating flux.

2.2 Derivation of Starting Torque

The torque developed by the motor at the instant of starting is called starting torque. In some cases, it is greater than the normal running torque whereas in some other cases it is somewhat less.

Let,

E_2 = rotor e.m.f. perphase at stand still.

R_2 = rotor resistance perphase.

X_2 = rotor resistance perphase at stand still.

$$Z_2 = \sqrt{R_2^2 + X_2^2}$$

Z_2 = rotor impedance perphase at stand still.

Then

$$I_2 = \frac{E_2}{Z_2} = \frac{E_2}{\sqrt{R_2^2 + X_2^2}}$$

$$\cos \phi_2 = \frac{R_2}{Z_2} = \frac{R_2}{\sqrt{R_2^2 + X_2^2}}$$

Stand still or starting torque

$$T_{st} = K_1 \; E_2 \; I_2 \; \cos \phi_2$$

$$\text{or } T_{st} = K_1 \; E_2 \frac{E_2}{\sqrt{R_2^2 + X_2^2}} \times \frac{R_2}{\sqrt{R_2^2 + X_2^2}}$$

$$= \frac{K_1 \; E_2^2 \; R_2}{R_2^2 + X_2^2}$$

If supply voltage v is constant, then the flux ϕ and hence E_2 both are constant

$$T_{st} = K_2 \frac{R_2}{R_2^2 + X_2^2}$$

$$= K_2 \frac{R_2}{Z_2^2}$$

where K_2 is some other constant.

Where K_2 is some other constant, if the motor is started without using starter, the current drawn by the motor is high but starting torque is less. To get high starting torque with minimum current, starters are used.

2.3 Methods of Starting of Induction Motor

Induction motors take about six to eight times its rated full load current at the time of starting. This heavy current although may not be dangerous for a motor because of the short duration of time during which such a large current flows through the motor windings, will cause a largedrop in the line voltage supplying the motor. It is therefore recommended that large 3 phase squirel cage induction motors be started with reduced voltage applied across the stator terminals at starting.

Various methods of starting induction motors are

a) Direct on-line stator

b) Reduced voltage-line resistance method.

c) Auto transformer starting.

d) Wound rotor method.

e) Star-delta starter

2.4 a) Direct on Line Starter

A cage motor may be switched directly to a normal supply voltage, momentarily taking several times full load current at low power factor. The magnitude of torque is small and it depends upon the rotor resistance. The rate of rise of temperature is high and the motor may be damaged if a start is delayed by

a) an execessive load torque or b) in-sufficient rotor resistance or c) a fall in supply voltage. This method may be applied to a few horse power on low voltage distribution net works.

b) REDUCED VOLTAGE LINE RESISTANCE METHOD: Here resistors connected in series with each phase of stator winding drops a fraction of the normal voltage and a reduced voltage applied to the stator winding of the motor, reduces the current during taken from the supply starting. The resistors cause unnecessary power loss which is not advisable.

c) AUTO-TRANSFORMER STARTING In this method, a reduced voltage is applied to the stator windings of the induction motor by transformation using an auto transformer, so that the line current and power input are reduced. This method is not an economical one, because of the high cost of the auto transformer which has limited use, ie for starting only. But the star-delta starter is cheaper and gives a better torque.

d) WOUND-ROTOR METHOD: Starting torque equation of an induction motor is $K_2 \frac{R_2}{Z_2^2} (\text{voltage})^2$

By increasing the rotor resistance R , the starting torque is increased; This method can't be applied for squirrel cage induction motor but only for wound rotor motor.

Y-Δ starter is found to be more advantageous than the methods described. Hence it is given more emphasis which follows the page.

2.5 Star-Delta Starting

In this project STAR-DELTA is being used with additional circuits for protection of motor towards various abnormal operations. So it is necessary to have a good knowledge of STAR-DELTA Starter.

For this method, a motor must be built to run normally with a mesh connected stator winding. At starting the winding is connected temporarily in star. The phase voltage is thus reduced to 0.58 of normal and the motor behaves as a auto transformer. The starting current for phase is 0.58 Isc. Line current is 0.58^2 Isc = 0.33 Isc. The starting torque is 1/3 of short circuit value and the ratio of starting to full load torque $T_S/T_N = 1/3\,(I_{sc}/I_N)^2\,S_N$.

It consists of a two way switch which connects the motor in the star for starting and then in delta for normal running. The need for conversion of connections can be explained as follows. The torque of an induction motor can be improved by increasing the resistance of the rotor circuit. However, it is feasible only to slipring induction motor not for squirrel cage induction motor. However, in this case the initial current in-rush is controlled by applying a reduced voltage to the stator during the starting period, full normal voltage being applied when the motor has a run upto normal speed. For this action to takes place, We use star-delta starter which initially applies reduced voltage to the stator by running in star connection and then latter normal voltage is applied to the stator of the motor by conversion of connection from star to delta when the motor has run upto speed.

This is the main advantage of star-delta starter over other starters used for induction motor starting.

2.6 Effect of change in supply voltage:

The starting torque is proportional to square of the voltage. Hence the torque is very sensitive to any change in the supply voltage. A change of 5% in supply voltage for eg. will produce a change of approximately 10% in the rotor torque. This fact is of greater importance in star-delta starters.

The usual connection for star-delta technique is shown in fig. 2.1

When star connected the applied voltage over each motor phase is reduced by a factor of $1/\sqrt{3}$ and hence the torque developed becomes 1/3 of that which would have been developed if motor were directly connected in delta. The live current is reduced to 1/3. Hence during starting period when motor is Y connected, it takes 1/3 as much starting current and develops 1/3 as much torque as would have been developed if were it directly connected in delta.

2.7 Relation between starting and full load torque

Starting current per phase = 1/ 3 Isc per phase

Where

Isc is the current per phase which Δ connected motor would have taken if switched on to the supply directly

(However line current at start equals 1/3 of line current).

Now

$$T_{st} \propto I_{st}^2$$

$$T_f \propto I_f^2 / S_f$$

$$\frac{T_{st}}{T_f} = \left(\frac{I_{st}}{I_f}\right)^2 \times Sf = \left(\frac{I_{sc}}{\sqrt{3}I_f}\right)^2 \times sf$$

$$= 1/3 \left(\frac{I_{sc}}{I_f}\right)^2 \times sf$$

Here Ist & Isc represent phase values. It is cleared that star-delta switch is equivalent to an auto transformer of ratio 1/3 or 58% approximately.

This method is cheapest and effective provided the starting torque is required not to be more than 1.5 times the full load torque. Hence it is used for machine tools, pumps and motor, generator etc.

2.8 Star-Delta Operation

The motor generally consists of windings A_1, B_1, C_1 and A_2, B_2, C_3. These windings should be connected in such a way that motor operates in star and delta connections. For star and delta connections the combination of windings should be as shown in fig. 2.2

For star connection, the 3 ϕ supply R,Y,B is connected to one end of each stator windings A_1, B_1, C_1 while the other end of the windings ie. A_2, B_2, C_2 are shorted. For this initially the main contactor and star contactor should be in close position and delta contactor should be open position. In this case R phase is directly connected to A_1, Y phase to B_1 and B phase to C_1. Now current flows from R phase to B phase through both main and star contactor coils, no current flows through the Delta contactor coil. The conversion of star-delta connection is done by changing the position of the relay after few seconds from A to B. So the current flows through delta and main contactor coils and it is closed. Star contactor coil is deenergised and contactor gets opened.

Now R phase is connected to A_1 and B_2 of the windings, Y phase to C_2 and B_1 and B phase to C_1 and A_2 respectively of the windings. Now the motor runs in delta connection.

Under normal operating conditions the relay contactors form a closed path and during abnormal conditions the corresponding relay connected to various circuits trips therby opening the main contactor by deenergising the relay coil hence supply to the motor cuts off. Arrangements are made such that it can be operated manually also. However having seen the details of star-delta starter. In next chapter the additional circuits incorporated on electronic control circuit is considered.

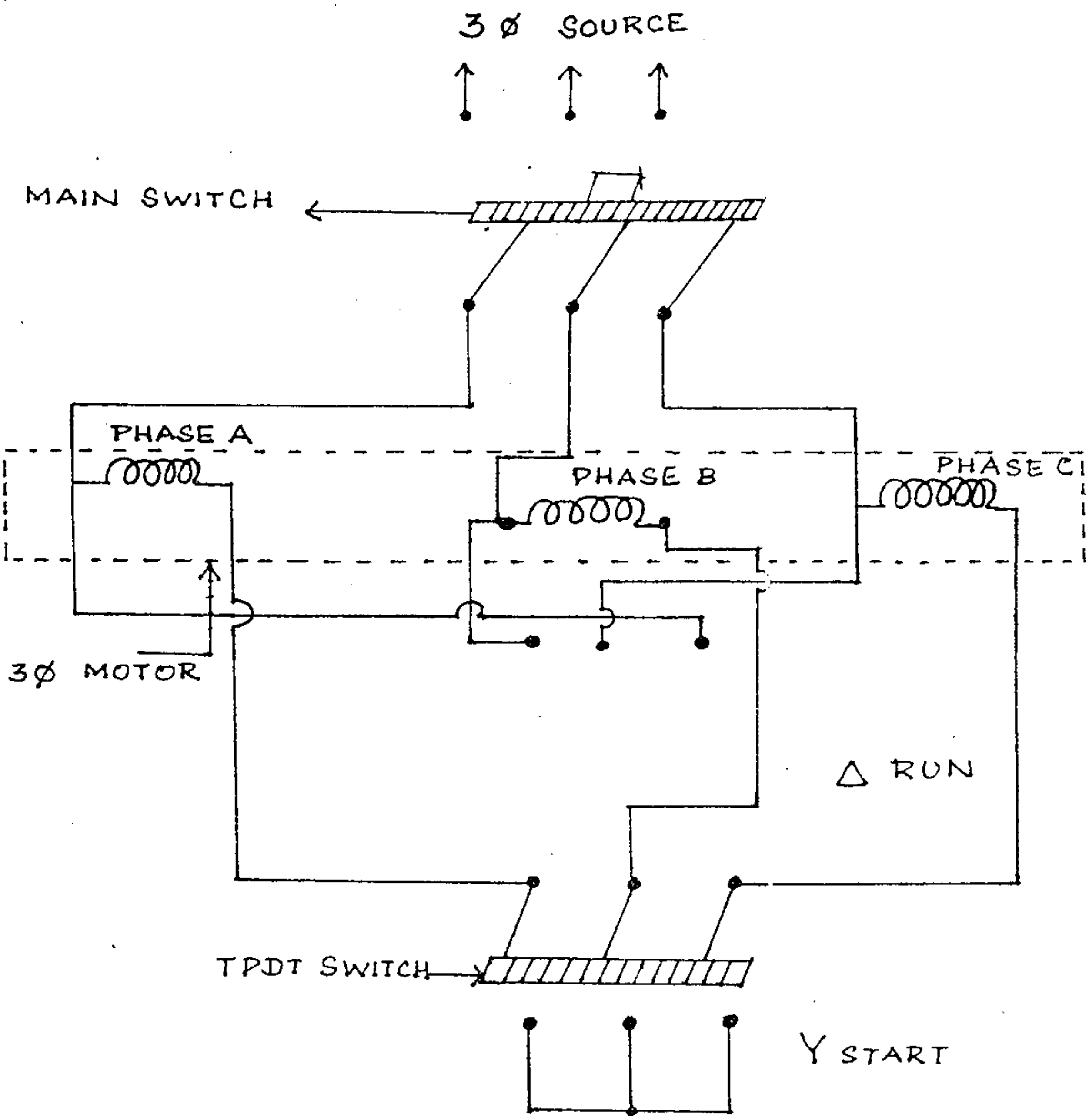
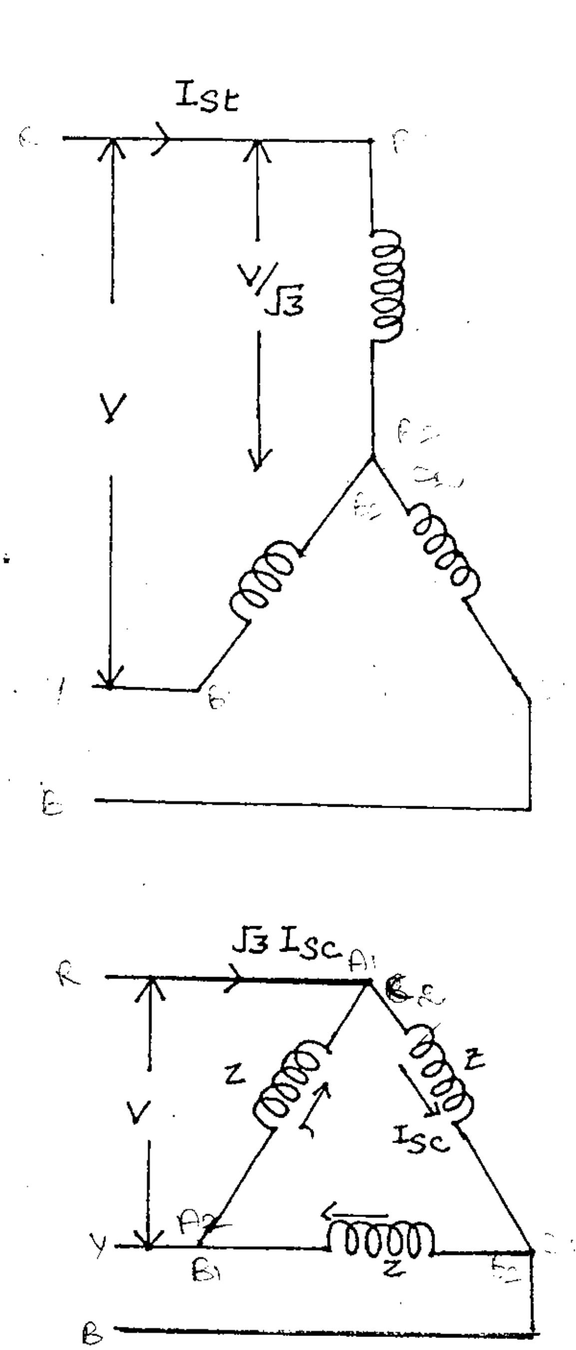


FIG 2.1 WIRING DIAGRAM FOR Y-Δ METHOD



I_{st}/phase $= I_{st}$/line

$= \frac{V}{\sqrt{3}Z}$

I_{sc}/phase $= \frac{V}{Z}$

I_{sc}/Line $= \frac{\sqrt{3}V}{Z}$

FIG. 2.2. WINDING ARRANGEMENT FOR STAR-DELTA

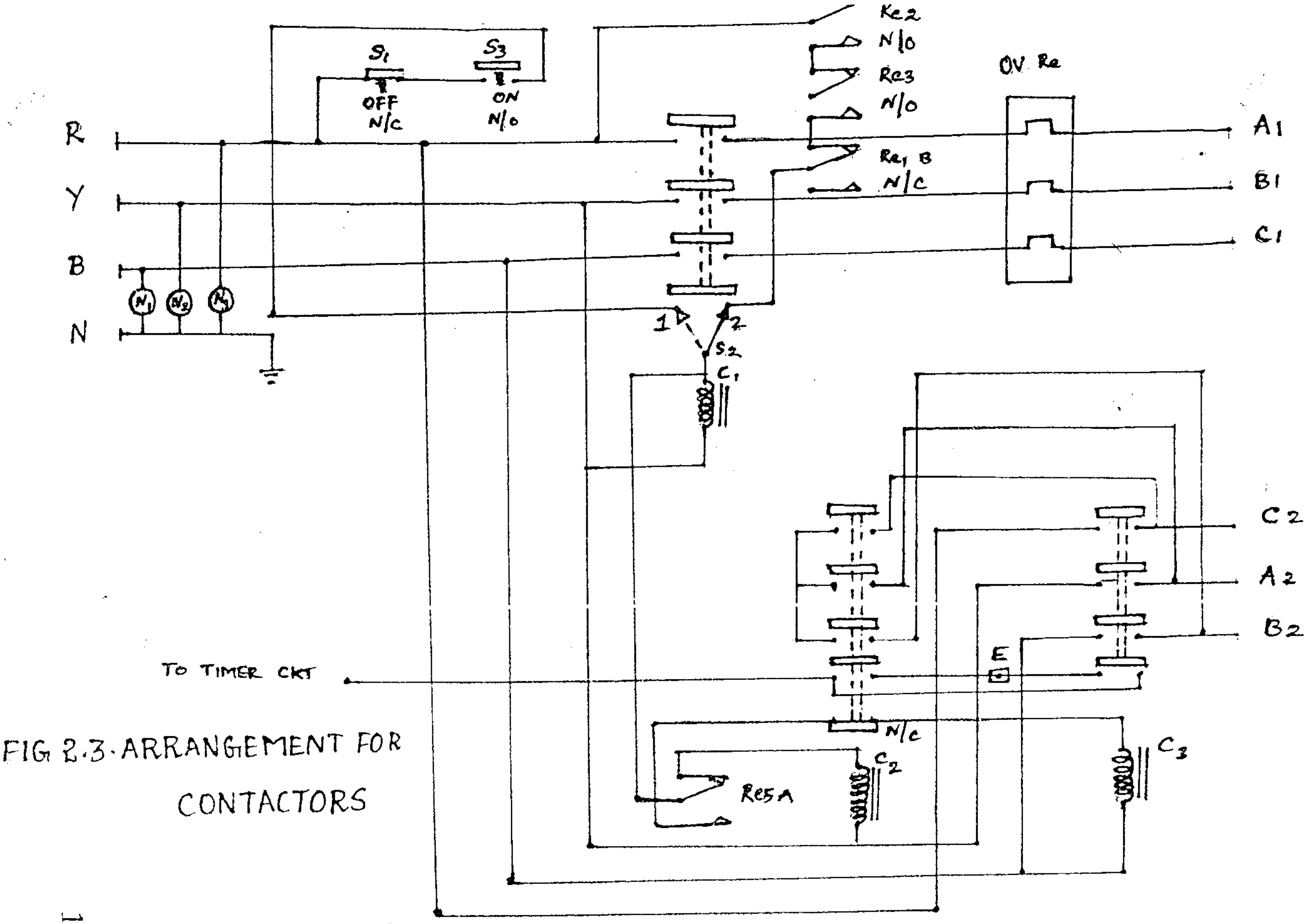


FIG 2.3. ARRANGEMENT FOR CONTACTORS

Design of Timer Circuits

3. DESIGN OF TIMER CIRCUIT

3.1 Timer Circuit

A TIMER CIRCUIT is designed and fabricated to get a time delay set by the timing circuit for automatic conversion of motor winding from star connection during starting to delta connection under running condition. An IC555 integrated circuit timer is used for this purpose.

IC555 used is of 8 pin V package type. The package styles of 555 timer is shown in figure. (3.2a)

Inside the 555 timer is the equivalent of over 20 transistors, 15 resistors and 2 diodes depending on the manufacturer.

The 555 timer can be operated both as monostable and Astable multivibrators. In our case we have present the operating mode as an Astable multivibrator.

3.2 Astable Multivibrator

The circuit connection for an Astable multivibrator is given in figure. (3.2b)

It has two states but is stable in neither. That means, it will remain in one state for some time and switch to the other state. Here it remains for sometime before switching back to the original state. This continuous switching back and forth produces a square wave. This multivibrator is called a free running multivibrator as no input signal is required to get the output. We can use two transistors to get the square wave. One transistor is saturated while other is cut off. To achieve this we make Rb/Rc resistances in the circuit shown less than h_{FE} of the transistors. The action of the circuit is similar to that of the schmitt triggers and flip flops. Because of the capacitor coupling, the two states are unstable. In other words, the capacitor will charge and discharge during a cycle causing first one transistor to conduct and then the other.

Frequency of the output square wave is given by

$f = 0.7/R_BC$. If the two base resistors and capacitors are identical in value, output waveform is square. However it is possible to get rectangular waveform by using differe base resistors and capacitors.

3.3 555 Timer Connected for Astable Operation

OPERATION:

Here the timing resistor is split into two sections Ra & Rb, with the discharge transistor (Pin 7) connected to the junction of Ra and Rb. When the power supply is connected, the timing capacitor C charges toward 2/3 Vcc through Ra and Rb. When the capacitor voltage reaches 2/3 Vcc, the upper comparator triggers the flip flop and the capacitor starts to discharge towards ground through Rb. When the discharge reaches 1/3 Vcc, the lower comparator is triggered and a new cycle is started. The capacitor is then periodically charged and discharged between 2/3 Vcc and 1/3 Vcc respectively. The output state is high during the charging cycle for a time period T_1, so that the output state is low during the discharge cycle for a time period of t_2.

Thus the total period of charge and discharge is

$T = T_1 + T_2$

$= 0.693\ (R_a + 2R_b)\ C.$

In our case R_b is taken as infinity and values of R_a & C are so designed that the on time of The relay incorporated together with the timer circuit is 15secs such that

$R_a = 150 \times 10^3$

$C = 100\,\mu F$, 16V.

Then $T = 0.693\ (150 \times 10^3)\ (100 \times 10^{-6}) =$ 15 secs

3.4 Power Supply for Electronic Circuit

The power supply circuit is provided to have low dC voltage for operation of Electronic circuits incorporated in this scheme. The normal dc voltage required varies from 0-15 V for all electronic circuits achieve this voltage, we have used two transformers rated as 230/12-0-12 & 440/15-0-15 volts along with rectifier ckts.

The primary of 440V/15V transformer is connected to two phases R and Y. The secondary of the same transformer is connected to a bridge rectifiers having diodes D_{16}, D_{17}, D_{18} & D_{19} to have rectified dc voltage. This rectified dc voltage is further smoothened by capacitor C5. The output from the rectifier circuit 'T' is an unregulated voltage and it varies with primary voltage. This supply is used as actual voltage in the High, low voltage cut off circuit.

The other transformer of rating 230 V/12-0-12V, whose secondary is connected to a rectifier circuit having diodes D_{20}, D_{21}. The output of the rectifying circuit is smoothed by capacitor c_6. This rectified and smoothened voltage 'E' is used for operating the relays provided in the Electronic circuits.

A zener diode D_{25} & a resistor R_1 is connected shunt across E and neutral voltage D and a regulated voltage of 9V ie 'R' is got from the zener diode terminals. This voltage is used as reference voltage in the high, low voltage cut off circuit.

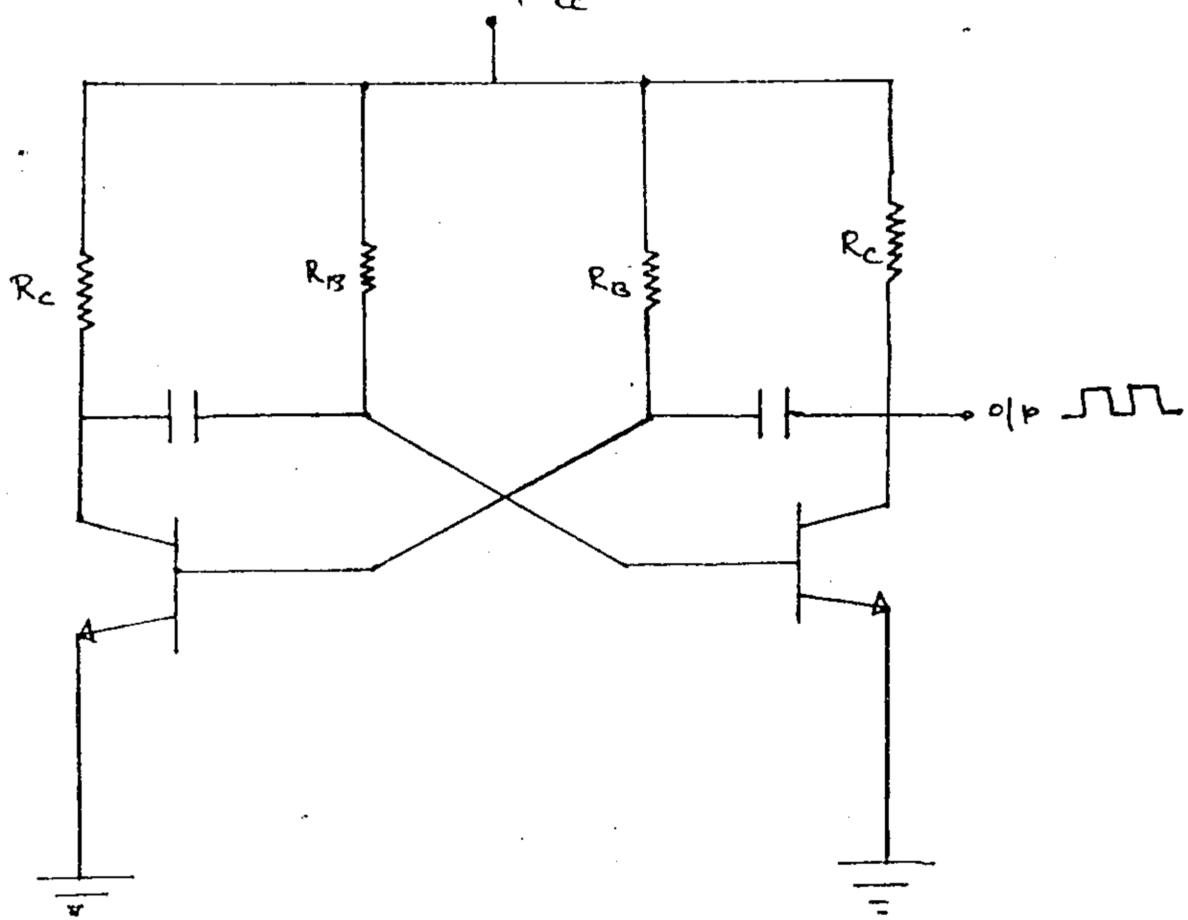


FIG 3.1 ASTABLE MULTIVIBRATOR

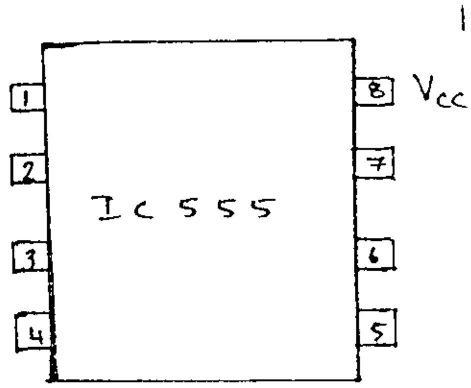


FIG 3.2(a) 8 PIN-V-PACKAGE

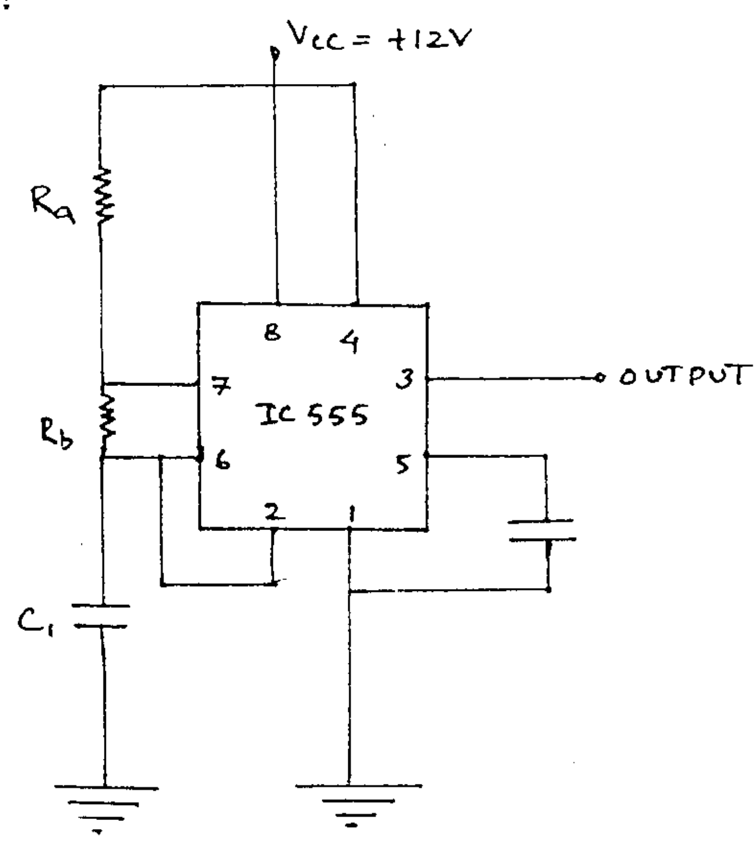


FIG. 2(b) 555 TIMER FOR ASTABLE OPERATION

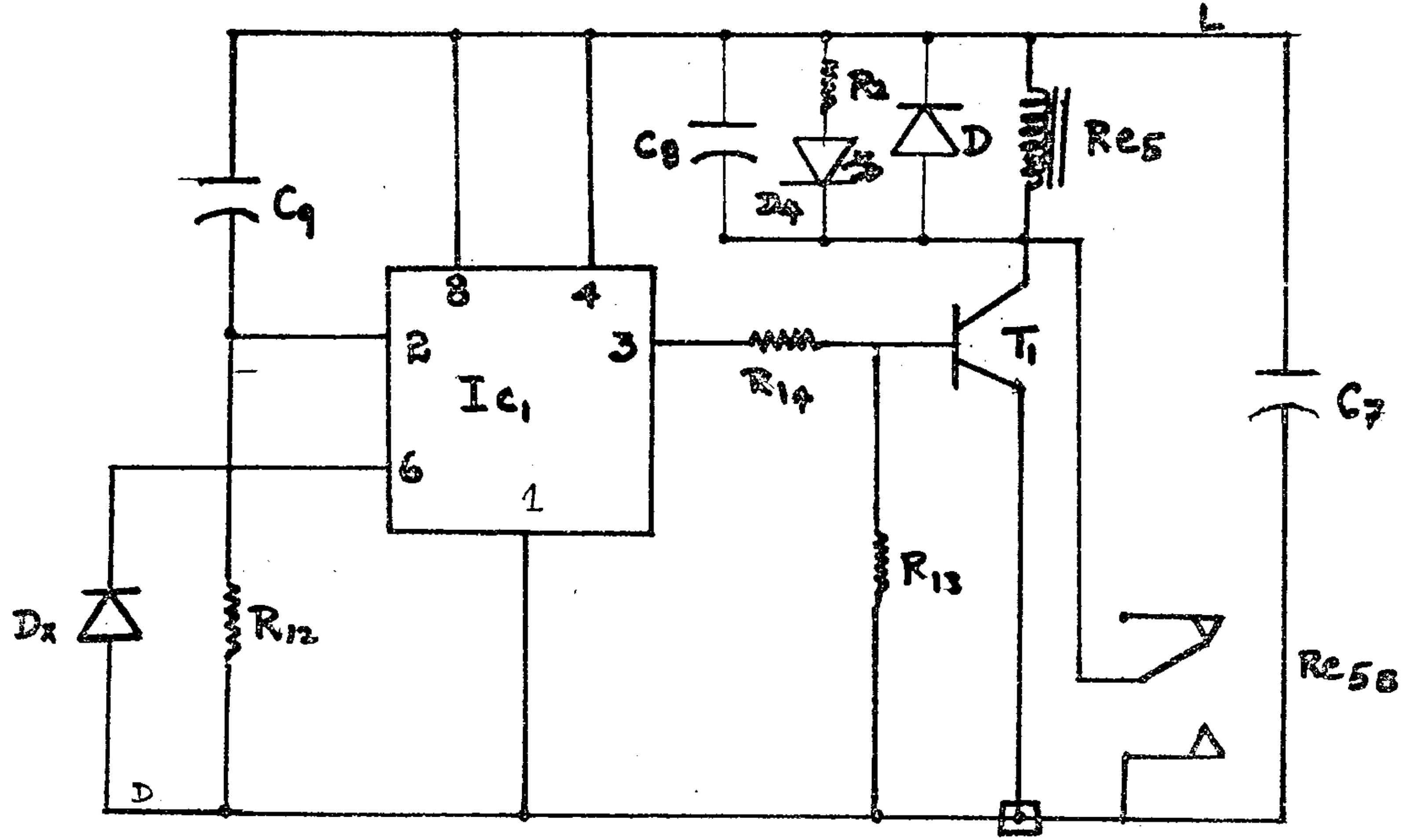


FIG 3·3 TIMER FOR OPERATING Y-Δ CONTACTORS

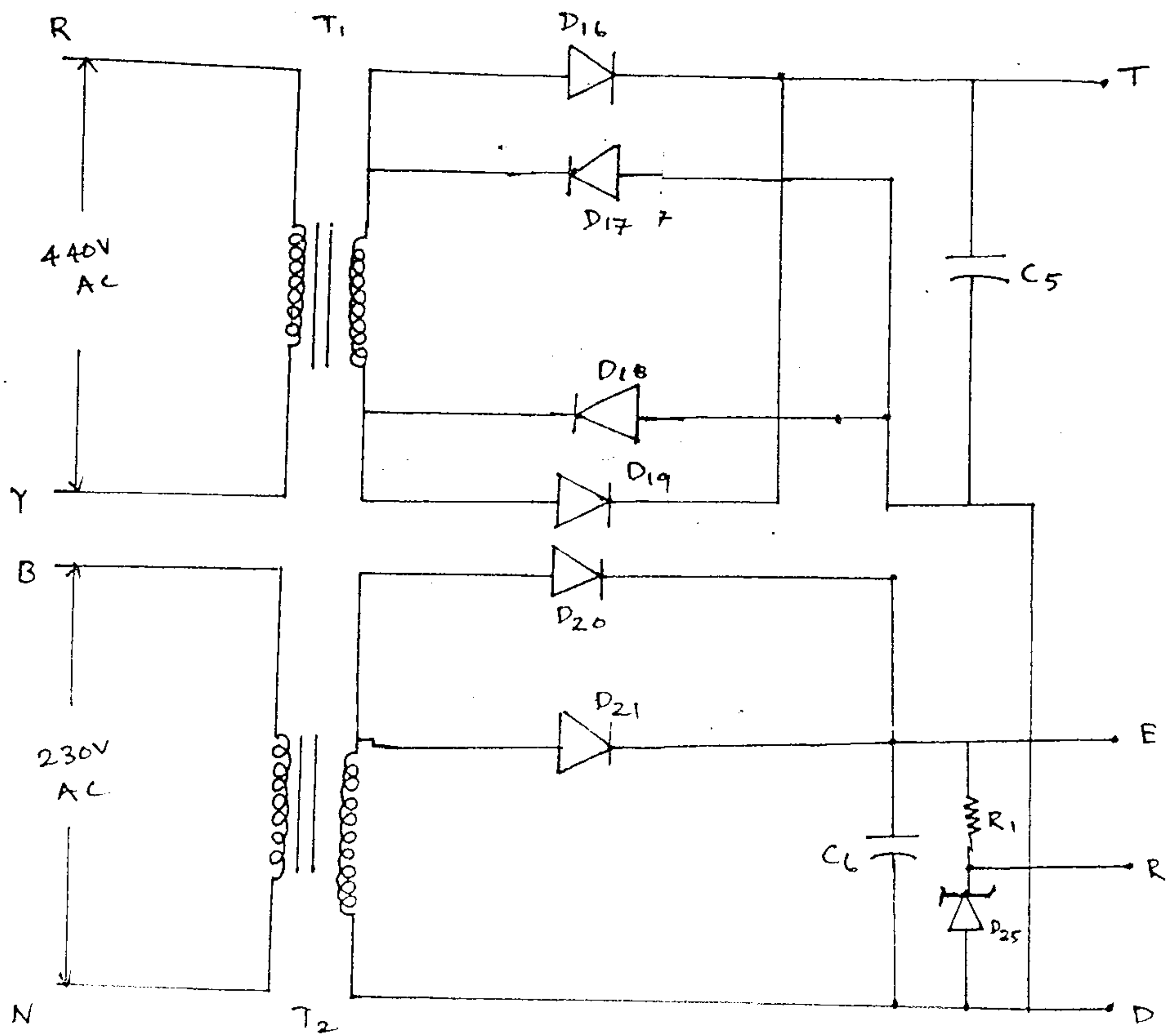


FIG 3.4. DC SUPPLY FOR ELECTRONIC CIRCUIT

Fault Prevention Circuits

4. OPERATION OF FAULT PREVENTION CIRCUITS

4.1 Single phase preventer and Phase sequencer

The purpose of this circuit is to prevent the operation of motor when one of the phase of the supply mains fails. If at all the motor is allowed to run on load even when one of the phase had failed, then the motor may develop large torque hence large current and voltages which may lead to damage of motor windings due to over heating.

The phase sequencer circuit together with single phase preventer circuit sequences the phase supplies R , Y & B i.e it prevents the over lap of one phase with another which may cause serious damage to the motor. Hence this circuit sequences the phases of supply mains in appropriate path (ie) R in R phase, Y in Y phase & B in B phase respectively.

For a 3 phase induction motor, it is necessary that all the three phases of the supply are present. If any one of the phases is missing, or a fuse in blouwn the motor will continue to run with two phases only. and it may draw large current and may burn, the windings unless switched off immediately.

Starters used in induction motors provide only over load protection, they cannot prevent motor burn-out under above conditions. This preventer circuit protects the motor by stopping it automatically under such conditions.

The input to this circuit is from a step-down transformer, primary of which is connected to 440 volts AC supply, its secondary denoted as 'T' is given to the circuit, which is the input for operation of the circuit. The output from the transformer is 15v which is sufficient for circuit operation.

4.2 Circuit Description:

The output from the secondary of the transformer comprising diodes, D_{16} to D_{19} is given as input to the circuit and voltage is then smoothened by capacitance C_5. The 3ø supply consisting of 3 equal voltages R, Y, B with phase differences of 120° each other is applied to one end of the circuit.

Due to the phase differences between the voltage, the sum of 3 phase voltages is 0. Thus when all the 3 phases are present, the net voltage at point A is 0. If any one the phases is missing, or if a fuse gets blown a voltage equal to half the line voltage appears at point 'A'. This is the main basic principle of this preventer circuit.

Adjacent to the 3 phase supply line, a capacitance - resistance bank together with a preset is arranged to get the reduced voltage. The other end of the capacitor circuit is connected to the rectifier circuit comprising diodes "D_{11}, D_{12}, D_{13}, D_{10}". At point A a capacitor C_{12} is provided with respect to ground to reduce the ripples present in the rectifier output. Point A is also connected to base of the transistor T_1 and grounded through a resistor. The other input to the circuit from the transformer is used to energise the relay coil.

4.3 Operation:

When all the 3 phases R,Y,B are present, voltage at point "A" is 0. Hence the voltage at the base transistor T_7 is 0 and it will not conduct. The net voltage from 'T' will appear at the base of the transistor T_6. This voltage at the base of the transistor is reduced to 4v by zenerdiode due to which the transistor starts conducting. As the collector of the transistor T_6 is connected to the relay coil, it gets energised and so the relay is turned 'ON'. The relay Re_3 is normally 'ON' position, irrespective of the 3 phase supply.

If any of the 3 phase is missing, the rectified voltage equal to the half the line voltage appears at point A. So this voltage appears at the base of the transistor T_7 and makes it to conduct. This less magnitude voltage appears at point X, and is not sufficient for conduction of transistor T_6 and it cuts off. So the relay coil will deenergise and it turns off and prevents the motor operation.

4.4 High low voltage cut off circuit:

In the previous section we have seen about single phase preventing and phase sequencing circuit which prevents the motor from operation under abnormal conditions. Now we will see about the high, low voltage cutoff circuit to prevent operation of motor under abnormal operating conditions.

This circuit allows the motor to operate only when the voltage unit is within 350-440v, below and above which the supply to the motor is cut off.

The need for high voltage protection is that due to high voltage the motor may draw current more than its rated value and burns a part of the motor.

The low voltage protection is provided since during low voltage conditions, the motor may not receive the required voltage and hence the rotor may not rotate, due to this no back emf will be there and so the current drawn by motor will be more than its rated value and hence motor windings may burn out quickly.

4.5 Circuit Description:

The circuit in general consist of five transistors, a diode and a few resistor together with a relay.

The input to the circuits are terminals T, E & R taken from power supply circuit. Here 'T' refers to the sensing voltage which is unregulated, R the reference regulated voltage, the voltage 'E' is used for relay operation. Reference voltage is given to emitters of transistors T_8, T_{10}, T_{12} and bases of transistors T_9, T_{11} through resistors. A biasing resistor R_{27} is connected to the base of transistor T_9. The bases of transistors T_8 and T_{10} are provided with presets R_{23} and R_{33} which can be adjusted for transistor conduction. A capacitor C_{21} is provided in shunt with relay coil to provide a constant voltage across the coil. Also the collector of transistor T_{12} is connected to base of transistor T_9.

4.6 Operation:

Here there are 3 modes of operation. One is during normal voltage and the other during high and low voltages.

Under normal operating condition the base of transistor T_8 gets more positive voltage compared with its emitter and since it being a PNP transistor, it doesn't conduct due to this and a high positive voltage appears at the base of T_9 and it being a NPN, it starts conducting, hence the relay coil is energised and the relay is in 'ON' position. At the same time transistors T_{11} & T_{12} are in cutoff because T_{10} acheives conducting state. Preset R_{29} is adjusted to get this condition.

During low voltage input less voltage appears at the base of transistor T_8 compared with its emitter and its starts conducting. Now transistor T_9 cuts off and deenergises the relay coil and the relay trips preventing the motor from operation.

During voltage more than the normal voltage range 350-440v, the transistor T_{10} cuts off because of high positive voltage at its base, due to this transistors T_{11} & T_{12} conduct, thereby a -ve potential appears at the base of transistor T_9 and hence it cuts off and denergises the relay coil due to which the relay trips and prevents the motor from operation. Once the normal condition returns, the motor automatically starts operating. Thus our aim of keeping the motor away from operation during abnormal voltages is acheived.

4.7 Water level Moniter:

This is an important indicator used with induction motor, which moniters the rise and fall of water level in tanks, wells etc and prevents the motor from running dry due to fall of water level, thus preventing the motor from heating which may lead to failure of the entire set causing serious damages to the motor stator windings. For this purpose, the water level monitoring circuit is provided.

In most of the cities and towns in our country the corporation or municipal water supply is restricted to a few hours in the morning and evening. So now-a-days most of the urban houses are equipped with over head water tanks to ensure 24-hour water supply. Water to these tanks is pumped from a low-level tank which gets water from the corporation supply lines. Level of water in these tanks is generally maintained by Mechanical float values.

Maintanence of the minimum water level in the overhead tanks is not so easy. Usually only after the water is completely finished will we come to know about that. The unit described here will switch on an switch off the pump. So as to maintain the level within the desired units. This method can also be adopted in wells for pumping water upto the foot value and prevents the motor from running dry once the water level goes down. Whenever the level reaches the lower set unit the pump is switched off and it will be switched on when the water level reaches the upper unit, hence this method can be extensively used in wells. The unit in this circuit is powered by output from a step down transformer of 12v supply on its secondary and 230 Ac supply in its primary. Hence this circuit consumer very little power.

A special probe is however required to sense the level of water.

4.8 Circuit Description:

The circuit uses four transistor, 5 diodes, 7 reintors, 3 capacitors, one relay and a powersupply.. The 12v input to the circuit is from a step down transformer whose input is 230v. The stepdown voltage is applied to point E through a rectifier circuit. Point B and C are connected to the base of the transistor T_2 & T_5 through preset R_3 & R_8. Point B is connected to one pole of the 2 pole relay, Which is normally open. The collectors of T_2 and T_5 and the other pole of the relay is connected to the base of the transistors T_3, T_4 through diodes. The collector of the transistor T_3 is connected to the one end of the relay coil and other end to the point A.

Fig. 4.3 shows the probe used. The probe can be made from a PVC tube with length as desired. Three brass or copper rings are fitted to the tube with Araldite. The positioning of the upperr and middle rings determines the upper and lower limits.

Wire connections to the rings can be made from inside before fixing them. The bottom end of the tube must be sealed with a plastic cap and Araldite. A 3 core cable must be used for connecting the probe to the unit. This ensures complete protection of the leads from moisure and rain. Here point c is this upper limit point B is lower limit and A contact is common.

4.9 Operation:

When water level is sufficiently high, the probe is completely immersed in water and all the conductor provided in the probe to web the water. Thus points A & B and point A & C will be connected through water as water is treated as a conductor of electricity,(only pure water is an insulater). Now the points A & B, A&C are closed and hence the applied voltage from the transformer appears at base of the transistor T_2 through rectifying circuit and preset, which reduces the voltage to the value required for saturation of transistors T_2 & T_5 ie approximately about 4v. Now both transistors T_2 & T_5 conduct. Hence the transistors T_3 & T_4 doesnot conduct due to the less voltage at the base.

Normally the relay coil is not energised and is in on position and the motor is in running condition.

When the water level is in between B & C, the relay coil remains deenergised, because transistor T_3 is not conducting, but transistor T_4 is conducting. So the circuit is not closed, and hence the relay will not be energised.

When the waterlevel goes beyond B ie in between A &B both contacts AB & AC are opened. Since the transistor T_3 & T_4 conduct, because of higher voltage at their base, the relay will get energised and turns off the motor and so the other pole of the relay moves from off to ON position.

If the waterlevel raises upto point B, the motor should not operate. Only when the waterlevel reaches the point C the motor should operate. Let the waterlevel be in between B&C, the contacts A&B are closed and the voltage is grounded through the relay contact. Since the voltage at the base of the transistor T_3 is 0 it does not conduct. The relay will remain energised and the motor will not operate.

Once the waterlevel reaches point C both contacts A&B and A&C are closed the transistor T_2 conducts and T_3 cuts off. So the coil is deenergised and makes relay contacts to move from off to on position and motor starts running.

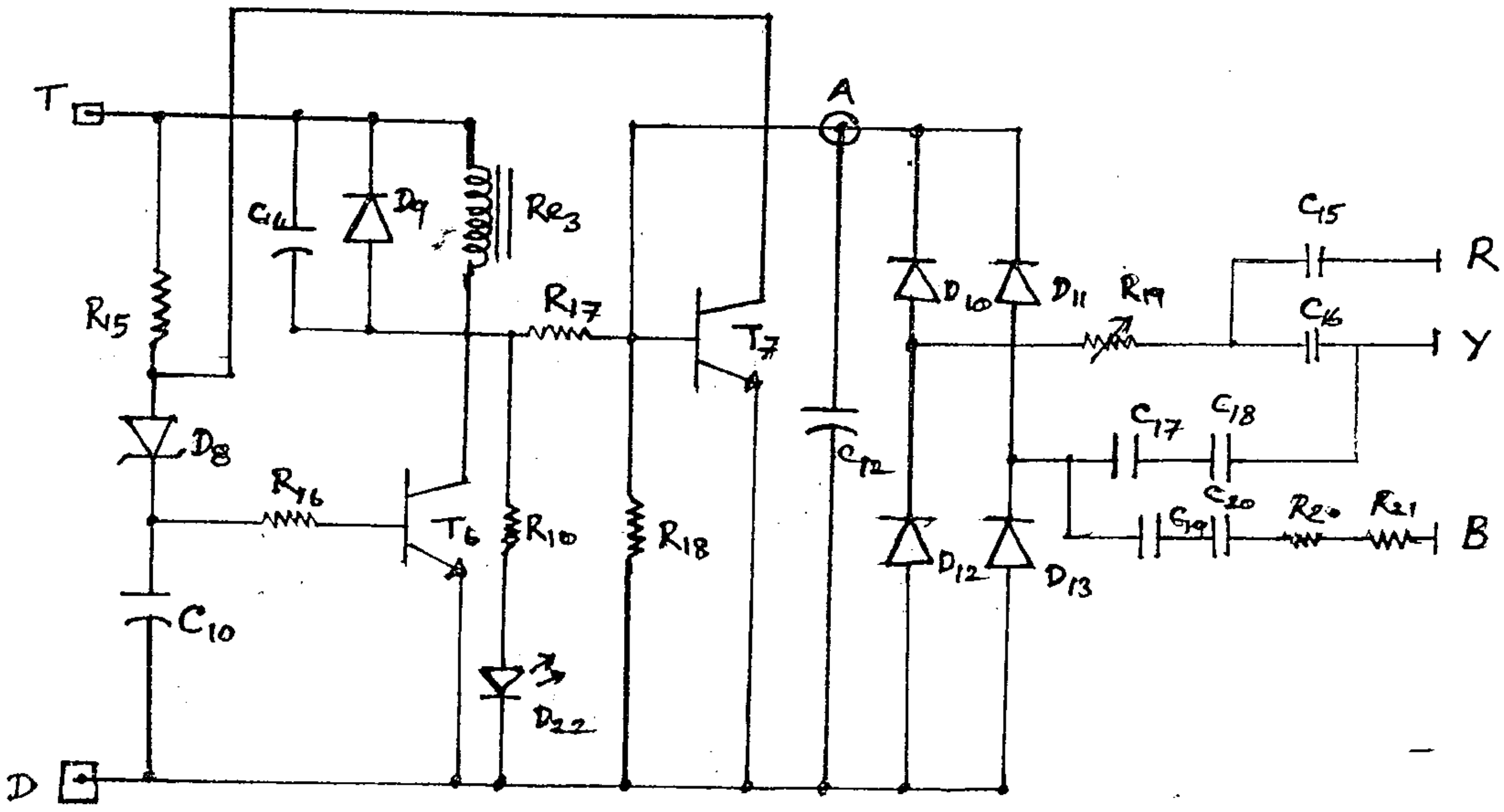


FIG. 4·1 SINGLE PHASING PREVENTER AND PHASE SEQUENCER

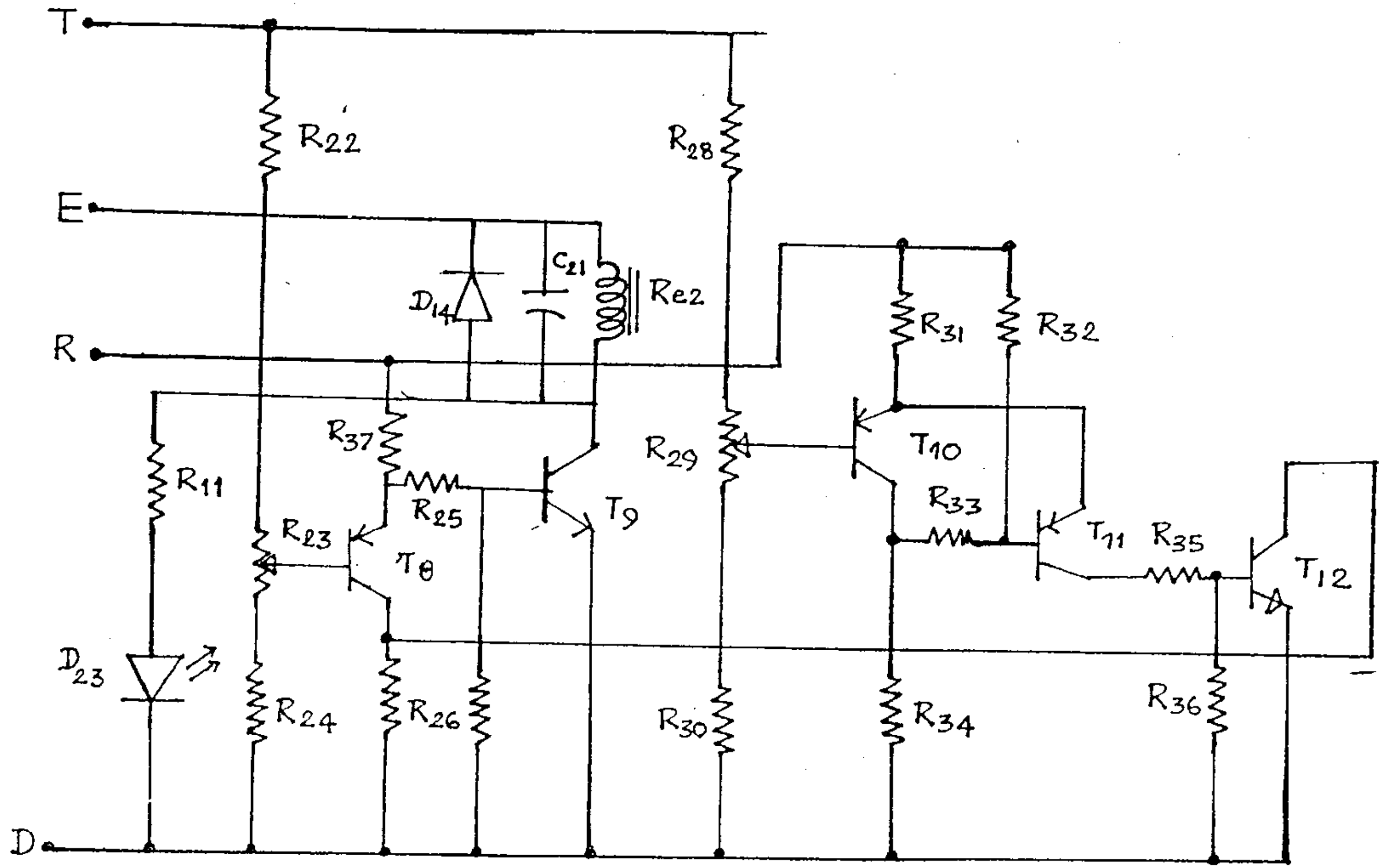


FIG 4.2 HIGH-LOW VOLTAGE CUTOFF

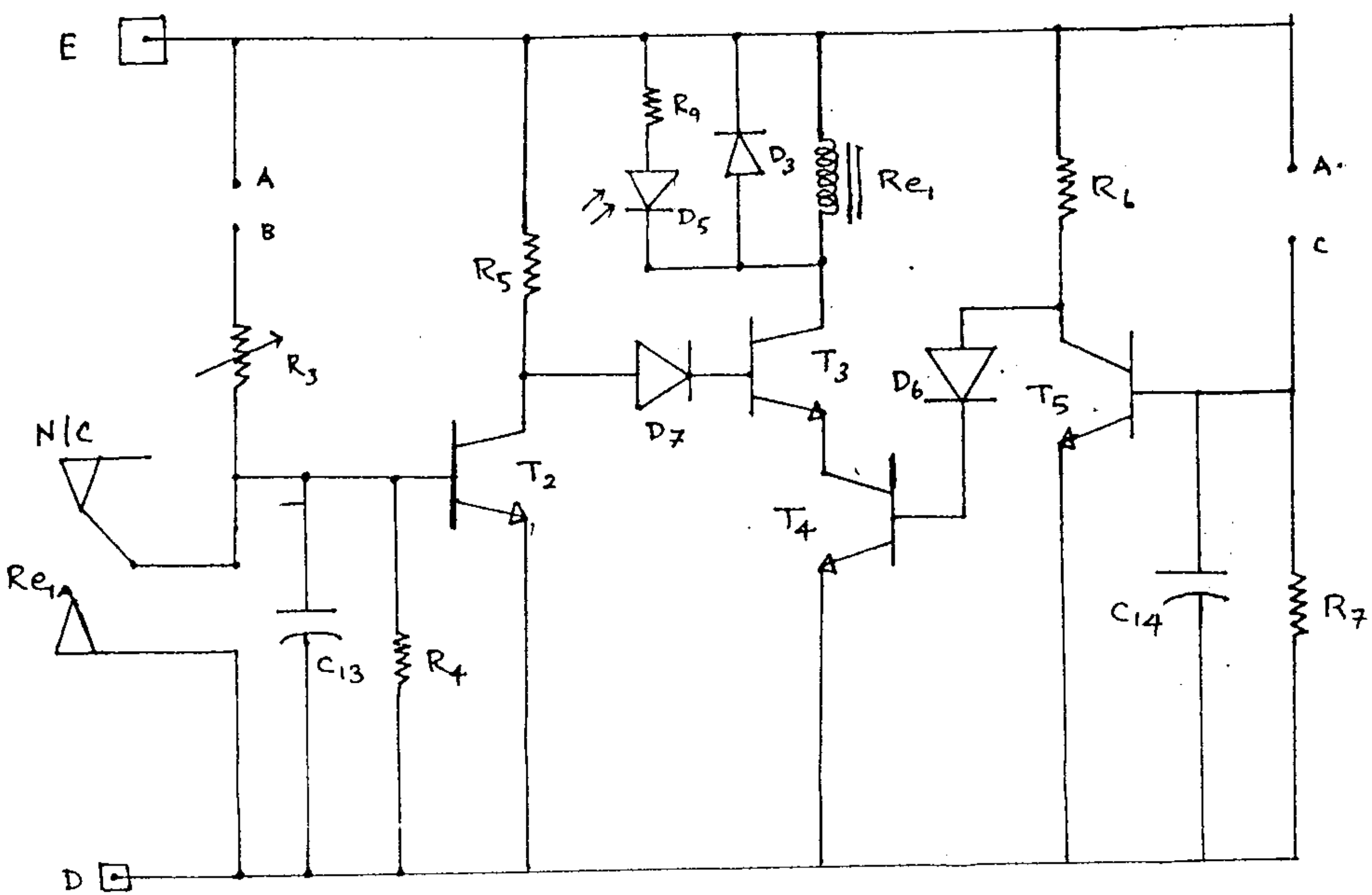
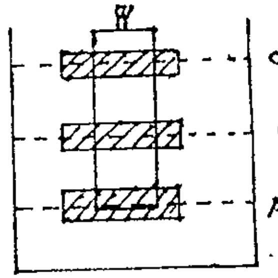


FIG. 4·3 WATER LEVEL MONITOR



3 CORE CABLE.

Testing of Circuits

5. TESTING OF CIRCUITS

5.1 Timer Circuit:

The timer circuit is for automatic conversion of motor from star during starting to delta when the motor has gained 80% of rated speed.

The timer was designed to give pulses after 15 seconds. The timer functioned properly converting the Y to Δ exactly after 15 secs from the instant of starting.

5.2 High Low voltage Cutoff:

This circuit is provided to prevent the motor operation at low and high voltages.

The motor is able to operate normally for range of 350-440 volts. When the supply voltage fell to 325v, the relay Re_2 was found to energise and the supply to the motor was cut off.

Similarly when a voltage of 450V was given the relay was again found to energise preventing the motor from operation when the normal voltage was restored, the relay was deenerrgised and normal operation of motor was regained.

5.3 Single Phase preventer and Phase sequencer:

When the supply was changed from 3ø to 2ø, the relay Re_3 is de-energised, cutting off the supply to the motor, thus preventing it to run. Again, when the 3-ø supply was restored, smooth operation of the motor was observed, confirming theø operation of the single phase preventer circuit.

The phase sequencer circuit operates when the supply Sequence was reversed, prohibiting the motor to run in the reverse direction.

5.4 Water level Monitor:

When water level was above the lower-reference level B, the motor operated smoothly. When water level decreases beyond B the relay Re1 was energised supply to the motor was cut-off, thus preventing the motor to get heated up due to dry running. Again only when the level increases to upper reference level the relay Re_1 de-energised enabling the functioning of the motor.

5.5 Overall Testing of the System:

When the supply voltage increased to 450V which is beyond the normal voltage ie 410V the relay Re_2 energised causing the motor to stop . When the voltage was reduced to 320v, the relay Re_2 energised, preventing motor operation.

Further tests were conducted to check the functioning of the other relays. When the 3ø was changed to 2-ø succesful operation of relay Re_3 prevented the running of motor. Water level monitoring system prevented the dry-running of the motor by the operation of the Re_1 relay when the water level decreased below the lower reference level.

In each case, when the normal condition was restored, the corresponding relay de-energised ensuring the smooth operation of the motor.

Conclusion

6. CONCLUSION

With modest pride, we would like to endorse that a electronic starter for induction motor has been designed, fabricated and tested successfully.

The protection circuits incorporated has the following advantages.

1. Prevents motor from high and low voltage operation.
2. Ensuring the motor to function only for 3ø operation
3. Prevents pump motor from dry running.
4. Prevents the reverse running of motor.

Field of Application:

1. It can be used in agrriculture pumpsets.
2. Used in over head tanks in premises.
3. Used in power station to pump oil from storage tank to day tank.

The cost of the unit was Rs.1500/- but if produced commercially in large scale the cost could be brought down to Rs.1000/- per piece.

The starter has been designed up to 5 H.P motor. The electronic circuits are transistorised one. Improvements can be made by designing the circuit using Ics.

References

7. REFERENCES

1. ELECTRONICS FOR YOU - APRIL 1987

2. ELECTRONICS PROJECTS VOL I - APRIL 1987
PUBLISHERS EFY (PVT) LTD.

3. VOLTAGE STABILIZERS & AUTOMATIC CUTOUTS
-M.C. SHARMA

4. 555 TIMER APPLICATIONS SOURCE BOOK WITH EXPERIMENTS
- HOWARD. M. BERLIN

5. A.C & D.C MACHINES VOL II
- B.L. THEARAJA

6. ELECTRICAL MACHINES - S.K. BATTACHARYA

7. ELECTRICAL MACHINES - SISKIND
~~PUBLISHERS~~ MCRAW-HILL BOOK COMPANY - 1985

8. FRACTIONAL & SUBFRACTIONAL
HORSE POWER ELECTRIC MOTOR
- CYRIL G. VEINOTT
JOSEPH E. MARTIN

9. ELECTRIC MOTOR HANDBOOK, E.H.WERNINCK

8. APPENDIX - I

Parts List:

Diodes:

D_4 - Motor on Indicator

D_5 - Water level Indicator

D_{22} - Uneven phase sequence Indicator

D_{24}, D_{23} - Voltage cutoff Indicator

D_2 - IN914

D_{25} - 9.1V/400MW Zener

D_1, D_3, D_5, D_6, D_7, D_9, D_{10}, D_{11}, D_{12},
D_{13}, D_{14}, D_{15}, D_{16}, D_{17}, D_{18}, D_{19} IN 4002
D_{20}, D_{21}

Transistor:

T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_{12}, T_{17} - BC148

T_9, T_{14} - SL100

T_8, T_{10}, T_{11}, T_{12}, T_{13}, T_{15}, T_{16} - BC158

Capacitors:

C_7, C_5, C_6 - 1000 uF/16v

C_{21}, C_8 - 100 uF/16v

C_9 - Timing Capacitor

C_{10} - 100 uF/25v

C_{11} - 220 uF/25v

C_{12}	- 47 uF/25v
C_{13}, C_{14}	- 0.01 uF
C_{15}, C_{16}, C_{19}, C_{20}	- 150 KF
C_{17}, C_{18}	- 0.047 K/400V

Resistors:

R_1, R_2, R_9, R_{10}, R_{11}	- 560 /¼w
R_3, R_8	- 100K, preset
R_4, R_7	- 22K/¼w
R_5, R_6	- 12K/¼w
R_{12}	- Timing Resistor
R_{13}	- 10 K/¼w
R_{14}	- 1 K/¼w
R_{15}	- 1 K/1w
R_{16}	- 3.9 K/½w
R_{17}	- 390 K/½w
R_{18}	- 12 K/½w
R_{19}	- 470 K/preset
R_{20}	- 12 K/½w
R_{21}	- 18 K/½w
R_{32}, R_{22}	- 5.6 K/¼w
R_{23}, R_{29}	- 2.2 K/preset
R_{24}	- 8.2 K/¼w
R_{25}	- 3.3 K/¼w

R_{27}, R_{26} - 10 K/¼w

R_{33}, R_{28} - 6.8 K/¼w

R_{30} - 2.7 K

R_{31} - 3.3 K

R_{34} - 1.2 K

R_{35} - 6.8 K

R_{36} - 10 K

R_{37} - 2.2 K

Relays:

Rc_1 = 200OHM/ 12v

RRc_2, Rc_3, Rc_5 = 200 OHM/12v