

Electronic Rotor Resistance Control Starter With Power Factor Improvement

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2-342

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Who dedicated their 'TODAY'
FOR THE BETTERMENT OF OUR 'TOMORROW'.

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SYNOPSIS

The second half of the twentieth century is the age of miniaturising technology. The electronic equipment play a role in reframing all the mechanical process, that are existing in various fields.

As a part of the above mentioned technology, this project deals with the **Electronic Rotor Resistance Control Starter with power factor improvement.**

In industries, the slip - ring Induction motor is started by a mechanical starter where a rotary switch is present, which has to be manually controlled and it also occupy space and produce sparking.

A new electronically controlled resistance starter for starting the slip-ring induction motor is proposed. The soft starting is achieved by cutting down the external resistance using the Electronic Sequential Timer.

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CHAPTER – 1

INTRODUCTION

Almost all the industries, nowadays employ poly phase induction motors. The poly phase induction motors include slip-ring induction motors and squirrel cage induction motors. The slip-ring motors are put in use where high starting torque is required. Almost all industries employ this type of motor when high starting torque is required. The Starting of Squirrel Cage induction motor is very easy but some special arrangements is necessary for starting the slip-ring induction motors.

1.1) Need for starter

The current drawn by the motor during starting is 5-7 times its rated current when the load torque during starting is less and the load inertia is not large, as in the case of small capacity motors. The temperature rise does not exceed the permissible value,. But for the large capacity motors, some special arrangements are necessary for reducing the starting current and to keep the temperature within limit.

At the time of starting full supply voltage is given to the starter. During Starting, the slip of the motor is 1. The voltage across the rotor is equal to the stator voltage. Since the resistance of the rotor is very less, the voltage will cause a heavy current to flow in the rotor winding. So the copper loss is very high in rotor which cause heating of the windings. So the introduction of some external resistance is necessary during starting to limit the high starting current. This is made possible using the starter.

1.2) Requirement of good starting

Motor should develop enough starting torque to overcome load torque, friction and inertia of motor load system.

The Magnitude of starting current should be within a limit such that it does not cause over heating of the machine windings.

There should not be a dip in the source voltage beyond the permissible value during the starting process.

1.3) EXISTING METHOD

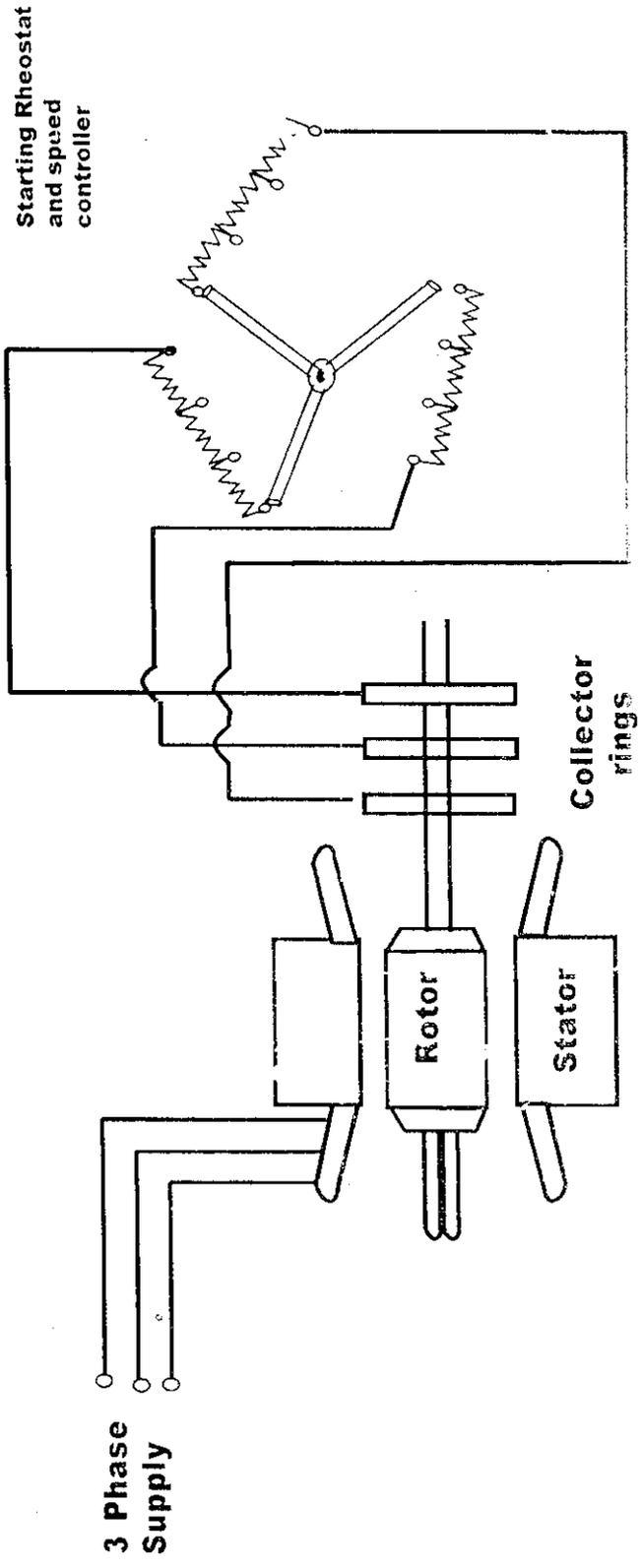
1.3.1) ROTOR RESISTANCE STARTING

Operation : The slip ring induction motor also called as external resistance induction motor can be started effectively by including external resistance to the rotor circuit during starting to minimise the starting current . Internally the three phases of rotor are started. The other winding terminals are brought out and connected to three insulated slip rings mounted on the shaft with brushes resting on them. The above arrangement in the case of slip-ring induction motor makes it possible for, the introduction of additional resistance in the rotor circuit. The introduction of additional resistance is also helpful in changing the speed-torque or speed-current characteristics as desired. After the motor is started, the external resistance is removed from the rotor and the slip-rings are automatically short-circuited.

1.3.2 LIMITATIONS

The present rotor resistance starter consist of a mechanical change-over switch which has to be manually controlled while starting. This project emerges amidst this manual starting, Sparking takes place Occupy more space

ROTOR RESISTANCE CONTROL



1.4) ELECTRONIC ROTOR RESISTANCE STARTER

The term 'Electronic' implies the use of electronic components for the starting of slip-ring I.M. This project make use of 555 timers in order to control the external resistance via relays. The timers are connected sequentially so that every time when timer operate the resistance connected externally are removed and at last stage the terminals of rotor gets short-circuited.

1.4.1) OBJECTIVES

- Frictional losses should be absent during starting
- Quick starting should be achieved
- Should not consume more power
- Starting torque should be high
- Power factor should be improved
- Starting should not affect running conditions
- Should be reliable and effective
- Should be cost effective product
- Should be compact

1.4.2) ADVANTAGES

Most of the copper loss occur in external resistors, so the rotor temperature rise during starting is substantially reduced in electronic resistance starter when compared to other methods.

In other methods, inspite of decrease in the starting current there is a reduction in starting torque which is not a desirable feature. But in this method of starting there is no decrease in torque.

In this method, the starting torque and torque current ratio are high.

- No sparking is enhanced while starting
- Manual interpretation is not needed
- Protecting devices and measuring instruments are inbuilt

CHAPTER-2

CIRCUIT DESIGN

2.1 BLOCK DIAGRAM AND MODULES

Fig 2.1 shows the general block diagram of Electronic rotor resistance control starter.

Fig 2.2 shows the schematic diagram of Electronic rotor resistance control starter

The modules that are present in this project are

- Timer unit
- External resistance unit
- Rectifier and Filter unit
- Measuring instruments and Protective devices

2.1.1 TIMER UNIT

Fig 2.2 shows the Sequential Timer consisting of three 555 timers connected in Monostable mode. A low level triggering given to the first timer enables the output to be high. This output remains high for a time period which is decided by the resistance and capacitance connected to it, according to the relation,

$$\text{Time delay} = 1.1 RC$$

After this time delay, the output of the first timer goes low, this low level output is given as a trigger pulse to the second timer. In this way, all the timers are triggered by the previous stage. Thus, the output of the timers are obtained in sequence and hence the name.

2.1.2 EXTERNAL RESISTANCE UNIT

Fig 2.2 shows the setup of external resistance at the rotor side during starting. The external resistance unit consists of three resistances connected in series for each phase. Relays are connected across each pair. At the initial stage, all are kept open, so that all the resistances are included. After a few seconds the output of the first timer closes the relay across the first resistance pair, this excludes one resistance unit. After a lapse of time second resistance is excluded by the timer circuit. In this way external resistances are removed and the rotor is directly shorted without any external resistances. By this time the rotor would have reached its rated speed.

2.1.3 RECTIFIER AND FILTER UNIT

Rectifier Operation

Fig 2.3 shows the arrangement of power supply unit which supplies the power to the control circuits.

It consists of centre-tapped transformer of rating 230 V/ (12-0-12) V.A bridge rectifier circuit made up of semiconductor diodes are connected between points A and B. The alternating voltage available at the terminals A and B are 180 degrees out phase with each other.

For a timer circuit we need +12 V and Gnd. for proper operation which can be obtained using this circuit.

When the terminal A is positive w.r.t B, the diodes D1 and D2 are forward biased and thus they conduct. Diodes D3 and D4 are reverse biased and they are not conducting. When the terminal B is positive w.r.t A, diodes D3 and D4 are conducting and diodes D1 and D2 are reverse biased. Thus, entire cycle is rectified.

We can take +12 V and Gnd. at the output terminals and can connect to the Timer circuit.

Filter Operation

Filter circuits are employed to reduce the ripple in rectifier output. This is achieved by either bypassing the ac output components around the load or by a shunt capacitance.

The capacitor filter circuit is as shown in Fig 2.5. The capacitor is so chosen that

$$X_c \ll R_L$$

and the ac finds a low resistance shunt in C. Only small ac component pairs in load produce a small ripple voltage.

The capacitor filters the conditions under which the diode operates. When the diode output voltage is increasing the capacitor stores energy by charging to the peak of the input cycle with the falling source voltage. The diode disconnects the source from the load at the instant when the source voltage starts to fall faster than the capacitor, voltage can fall as determined by the time constant of C and the load.

The capacitor continues to maintain the load voltage at a higher value and lower ripple than if the capacitor were not present.

2.1.4 MEASURING INSTRUMENTS AND PROTECTIVE DEVICES

The instruments that are used in this starter includes,

- Voltmeter
- Ammeter

and the devices that enhance the protection of the circuit are Relays and Fuses.

Voltmeter

A Moving Iron type voltmeter is used with a rating of (0-500) V. This is connected between any two phases to record the voltage present in the mains. The proper value of voltage from E.B. can be viewed from the voltmeter for starting the motor.

Ammeter

A Moving Iron type ammeter is used to indicate the current at the stator side of the slip-ring induction motor. This is used to check for the rated current during starting. This is also connected between any two phases.

Protective Devices

The relays that are used at the rotor side acts as protective devices for under voltage conditions. When there is a dip in voltage, the contactors of relay do not close and hence starting cannot be achieved. Thus, the provision of relay that is used for cutting down the resistance is of multi-purpose.

The over-current protection circuit can be made use of Fuses. A fuse is a thin wire connected between two terminals which are mounted on an insulated bore and the fuse wire melts when a current of a value beyond its rating pass through. The fuse rating has to be double the value of rated motor current.



2.2 DESIGN OF EXTERNAL RESISTANCE

2.2.1 PRE-DETERMINATION OF RESISTANCE

2.2.1.1 No-load test

The aim of this test is to determine the rotational and core losses and constants R_o and X_o of equivalent circuit. The stator is fed with a 3 ph. rated voltage supply as shown in Fig 2.4. The rotor is allowed to rotate freely without any external mechanical load on the shaft. The power input is measured by Two Wattmeter method. Since, the motor is not supplying any load. The no-load current is small and copper losses are negligible. The input equals the mechanical and core losses. The no load power factor is low (because I_m is much larger than I_w) Therefore, it is usually necessary to reverse the current coil (or potential coil).

The no-load power factor,

$$\cos \phi_0 = \frac{W_o}{3V_o \cdot I_o}$$

$$R_o = V_o / I_w = V_o / I_o \cos \phi_0$$

$$X_o = V_o / I_m = V_o / I_o \sin \phi_0$$

2.2.1.2 Blocked-Rotor test

The aim of this test is to determine the winding resistance ($R_1 + R_2$) and leakage reactances ($X_1 + X_2$). It is similar to short circuit test on a transformer. Fig 2.5 shows the connection. The motion of the rotor is blocked by a brake. A low voltage 3 ph. supply (obtained from 3 ph. auto-transformer) is applied to the stator. The magnitude of applied voltage is adjusted so that the ammeter reads the line current of stator. The power input is measured by the two wattmeters. (In this case also p.f. < 0.5 and may be necessary to reverse either the current coil or potential coil. Connections of wattmeter being negative).

Let,

W_{sc} be the total power input

V_{sc} be the per phase value of applied voltage

I_{sc} be the per phase value of applied current

Then,

$$\cos \phi_{sc} = W_{sc} / 3V_{sc} I_{sc}$$

$$r_1 + r_2' = V_{sc} / I_{sc} * \cos \phi_{sc}$$

$$x_1 + x_2' = V_{sc} / I_{sc} * \sin \phi_{sc}$$

It is seen that this test gives the total resistance $R_1 + R_2$. The resistance R_1 measured by passing a dc through the stator winding. The magnitude of dc should be equal to rated stator current so that winding is heated to its operating temperature. Since, dc is being applied to stator, there is no induced current in rotor. The reactance is also zero. Therefore, the ratio of dc voltage across one phase to the dc gives resistance R_1 .

This test gives total leakage reactance $x_1 + x_2'$

2.2.1.3 EQUIVALENT CIRCUIT

From Blocked rotor test,

$$R_{01} = P_{sc} / I_{sc}^2$$

$$Z_{01} = V / I$$

$$X_{01} = (Z_{01}^2 - R_{01}^2)^{0.5}$$

Rotor eq. resistance,

$$R_2 / K^2 = R_2' = R_{01} - R_1$$

where R_1 - stator resistance

PRACTICAL DESIGN

By applying dc to 2ph. of rotor, find R

By applying ac to 2ph. of rotor, find Z

$R_r = R * 1.2 / 2$ - rotor resistance in one arm

Starting current, $I_{st} = V/Z$ (wrt rotor side)

This starting current has to be minimised by adding external resistance.

Ref. fig 2.7

$$E_2 = sKE_1$$

$s = 1$ at starting

$$\Rightarrow E_2 = KE_1$$

$$\Rightarrow V_d = E_2 / 3^{.5} - IZ$$

And therefore, External Resistance is

$$R_e = V_d / I$$

I - rated current

THEORETICAL DESIGN

It is assumed that motor starts against constant torque and the rotor current fluctuates between minimum and maximum values of rotor current as shown in fig (). In fig (), three phase of external resistance with n steps and rotor circuit are given

Let,

R_1, R_2, \dots, R_n be the total resistance of the rotor circuit on different steps namely first, second, etc.,

The resistances R_1, R_2 includes the rotor resistance per phase R_2 and the external resistances P_1, P_2, \dots , the corresponding value of slips are given by S_1, S_2, S_3, \dots at I, II, III, etc.... At the commencement of each step, the current is I_{2max} and at the instant of leaving, the current is I_{2min} .

Let

E_2 be standstill emf induced in each phase of rotor.

When all the external resistance is included, the current rises to maximum value I_{2max} which is given by

$$I_{2max} = \frac{S_1 E_2}{(R_1^2 + (S_1 X_2)^2)^{0.5}} = \frac{E_2}{((R_1/S_1)^2 + X_2^2)^{0.5}} \quad \dots (4.1)$$

Where S_1 - Slip at starting.

The current reduces to minimum value before cutting the resistance P_3 ,

$$I_{2min} = \frac{E_2}{((R_1/S_2)^2 + X_2^2)^{0.5}} \quad \dots (4.2)$$

When the resistance P_3 is cutdown, the current increases to maximum value,

$$I_{2max} = \frac{E_2}{((R_2/S_2)^2 + X_2^2)^{0.5}} \quad \dots (4.3)$$

The current again reduces to minimum value,

$$I_{2min} = \frac{E_2}{((R_2/S_3)^2 + X_2^2)^{0.5}} \quad \dots (4.4)$$

When the next resistance P_2 is cut-off the current rises to maximum value,

$$I_{2\text{max}} = \frac{E_2}{((R_2/S_3)^2 + X_2^2)^{0.5}} \quad \dots (4.5)$$

After sometime, the current decreases to minimum value

$$I_{2\text{min}} = \frac{E_2}{((R_3/S_4)^2 + X_2^2)^{0.5}} \quad \dots (4.6)$$

When all the resistances P_1, P_2, P_3, \dots are cut-off the speed becomes

$$I_{2\text{max}} = \frac{E_2}{((V_2/S_{\text{max}})^2 + X_2^2)^{0.5}} \quad \dots (4.7)$$

Where, S_{max} - maximum slip

It is found that,

$$I_{2\text{max}} = \frac{E_2}{((R_1/S_1)^2 + X_2^2)^{0.5}} \quad \dots (4.8)$$

$$= \frac{E_2}{((R_2/S_2)^2 + X_2^2)^{0.5}} \quad \dots (4.9)$$

$$= \frac{E_2}{((V_2/S_{\text{max}})^2 + X_2^2)^{0.5}} \quad \dots (4.10)$$

$$\text{(or)} \quad \frac{R_1}{S_1} = \frac{R_2}{S_2} = \frac{R_3}{S_3} = \frac{V_2}{S_{\text{max}}} \quad \dots (4.11)$$

Also,

$$I_{2\text{min}} = \frac{E_2}{((R_1/S_2)^2 + X_2^2)^{0.5}} \quad \dots (4.12)$$

$$= \frac{E_2}{((R_2/S_3)^2 + X_2^2)^{0.5}} \quad \dots (4.13)$$

$$= \frac{E_2}{((R_3/S_4)^2 + X_2^2)^{0.5}} \dots (4.14)$$

$$(or) \frac{R_1}{S_1} = \frac{R_2}{S_2} = \frac{R_3}{S_4} \dots (4.15)$$

From 4.11 & 4.15

$$(or) \frac{R_1}{S_1} = \frac{V_2}{S_{max}} \dots (4.16)$$

$$\Rightarrow R_1 = \frac{V_2 \times S_1}{S_{max}} \dots (4.17)$$

During starting slip $S = 1$

$$\therefore 4.17 \Rightarrow R_1 = \frac{V_2}{S_{max}} \dots (4.18)$$

2.3 DESIGN OF SEQUENTIAL TIMER

Sequential Timer in Fig 2.2 is used to control the opening and closing of relays. These opening and closing of relays controls the starting of the induction motor by cutting down the external resistances in proper steps so that high starting torque is achieved. The background behind this sequential circuit is the 555 Timer operated in monostable mode.

2.3.1 555 TIMER

It is a 8 PIN DIP timer with the voltage and current rating of (5 to 18) V and (200 to 500) mA respectively. Its pin configuration is shown in Fig A.1. And its mode of operation on the connection between these 8 pins. The common modes of operation of 555 timer are,

- Monostable operation
- Asable operation
- Bistable operation

2.3.2 MONOSTABLE OPERATION

In monostable multivibrator a single output pulse is generated in response to one triggered pulse. When a negative going pulse is applied at the trigger input (pin 2), this results in output (pin 3) to go high at $+V_{cc}$. The trigger pulse causes the comparator 2 (as in Fig 2.9) to drop below its voltage $1/3 V_{cc}$ and thus in turn causes the flip-flop to go to its low state. A negative voltage to the discharge transistor causes its resistance to become infinite. This in turn removes the short to ground for capacitor. Hence, the voltage across c begins to rise in accordance with the time constant RC . When this voltage exceeds $2/3 V_{cc}$, it causes the comparator to change state and results in discharge transistor, again becoming conductive. Capacitor then discharges very quickly to ground through pin 7. The output voltage drop to its low or ground state. Thus, the output stage follows the change in trigger level.

The duration of the trigger pulse may be either shorter or longer than the generated output pulse. The time duration T , of the output is given by,

$$T = 1.1 RC$$

Accordingly, the time duration of the output voltage may be varied as required. We may thus use a short duration input pulse to produce long duration output pulse. When so used, monostable multivibrator is called Pulse Stretcher.

Design of time delay is obtained as per the change in rotor speed, considering R in Megaohms and C in Microfarads so that the resulting time delay is in seconds.

2.3.3 SEQUENTIAL OPERATION

The three timers are connected sequentially as shown in Fig 2.10 and are named as timer 1,2 and 3. The external low level trigger is given to the timer 1's pin 2, so that the relay connected to its output operates. The relay operates for a time delay as specified by the value of resistor and capacitor connected across pin 7 and pin 6 respectively. And it opens thereby giving a low level trigger to pin 2 of timer 2, so that the second relay operates. In a similar fashion timer 3 is also triggered after the second relay opens. This timer is provided with an infinite time delay so that the third relay provides a short circuited path for the rotor through motor operation.

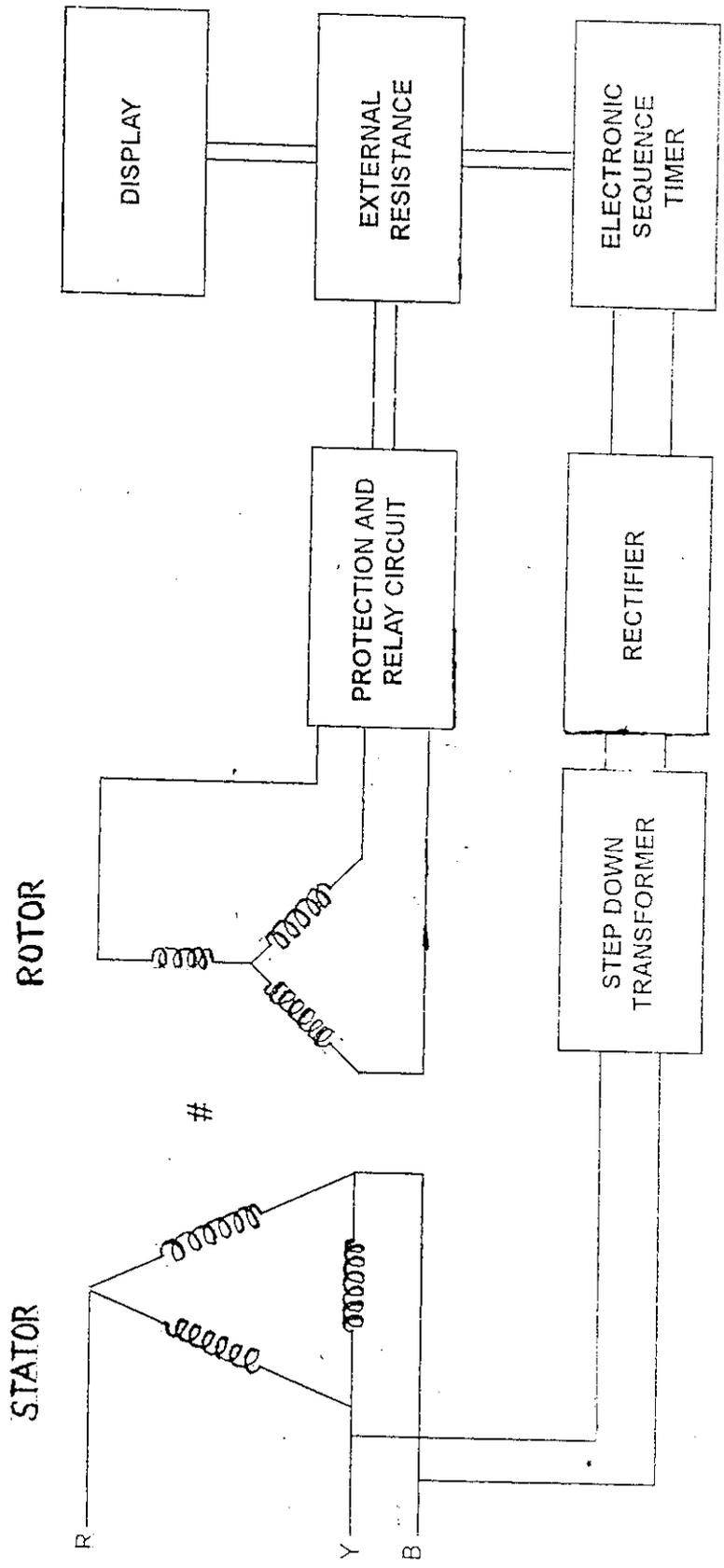
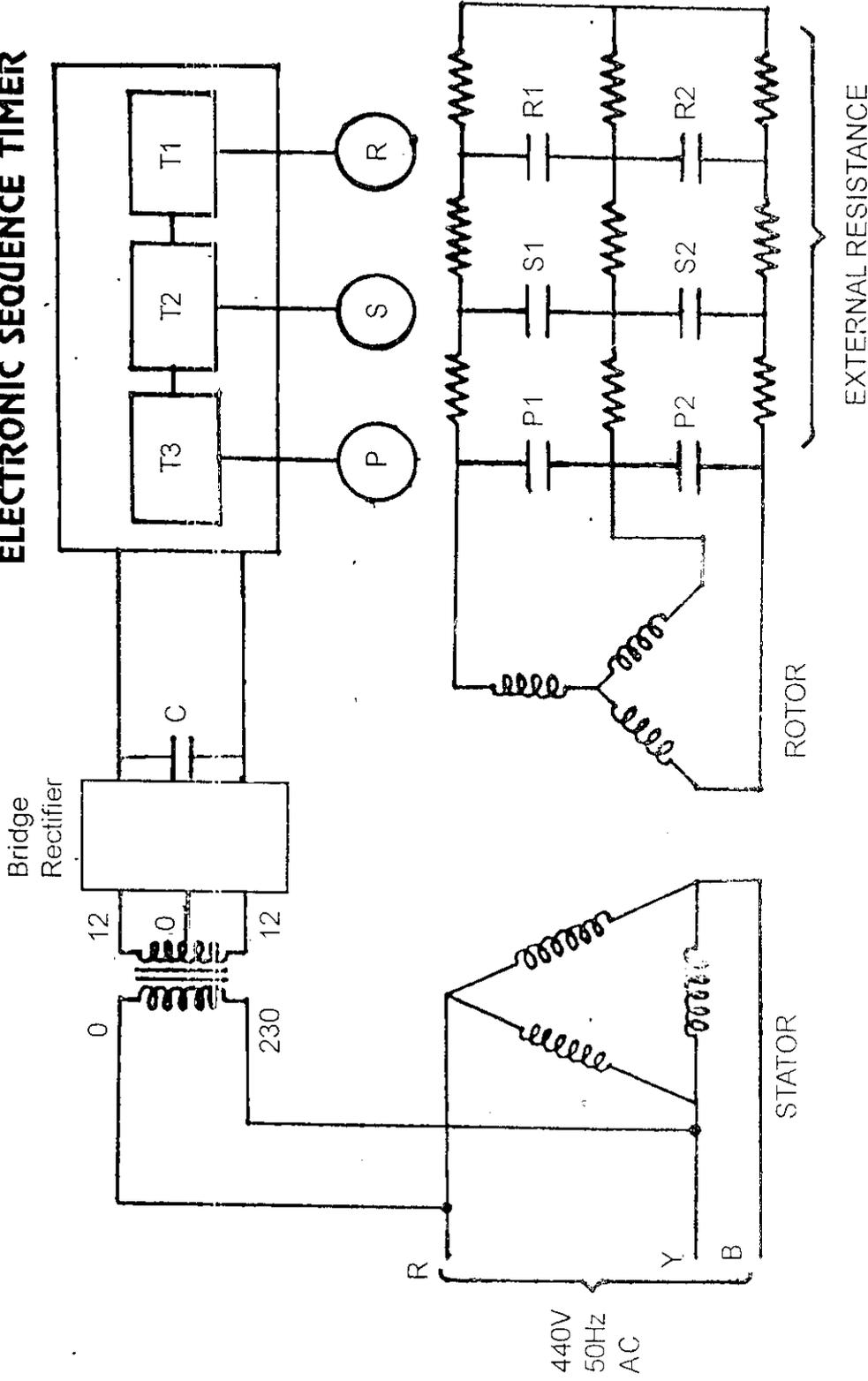


Fig 2.1

ELECTRONIC SEQUENCE TIMER



SCHEMATIC DIAGRAM

Fig 2.2

R, S, P	POWER RELAY
T1, T2, T3	555 TIMERS
C	CAPACITOR

POWER SUPPLY UNIT

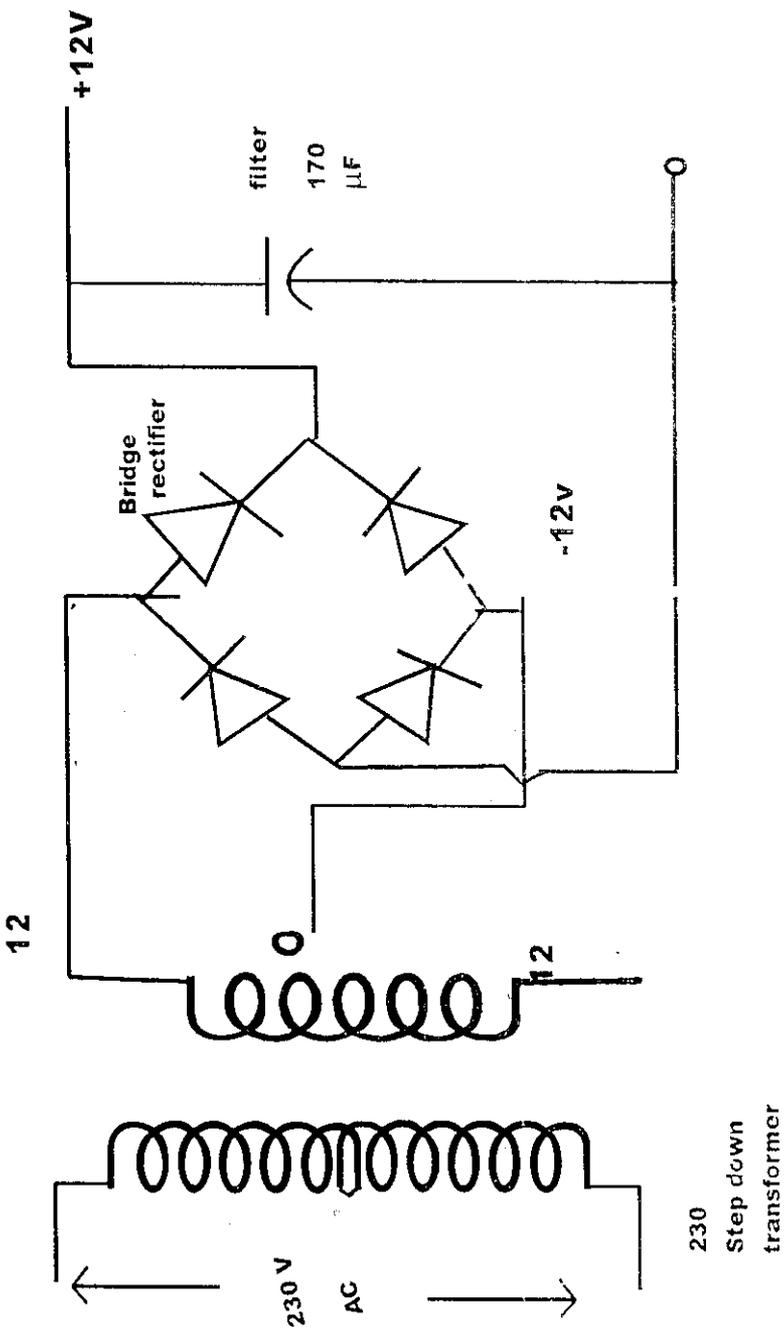


Fig 2.18

NO - LOAD TEST

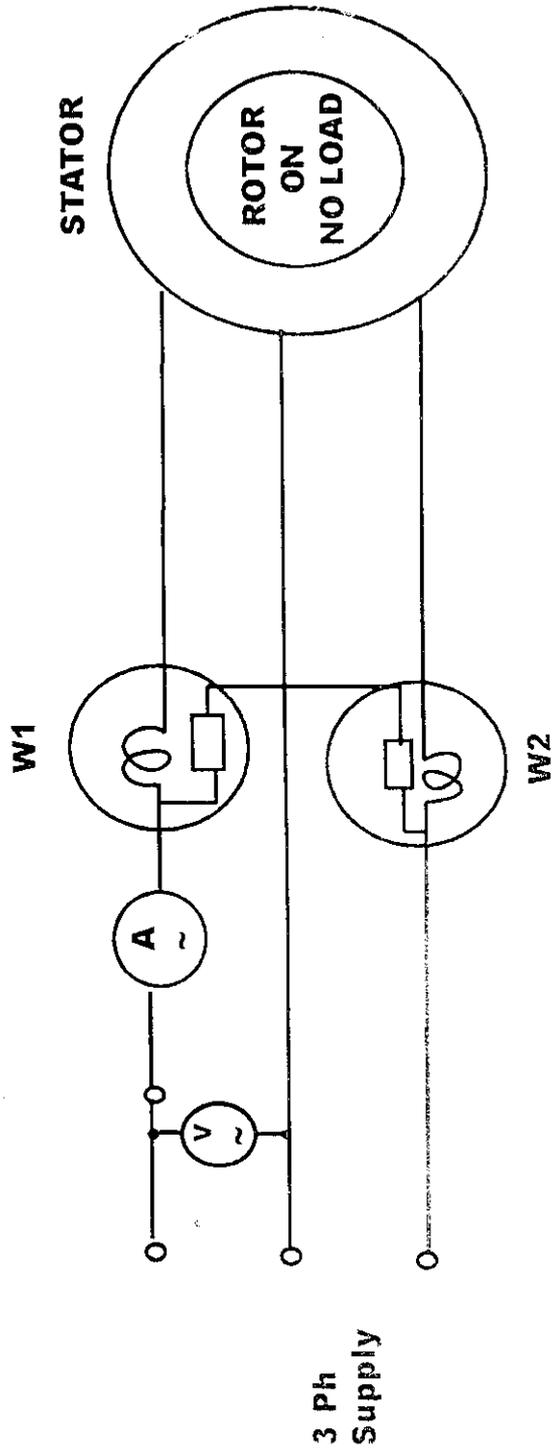


Fig 2.4

BLOCKED ROTOR TEST

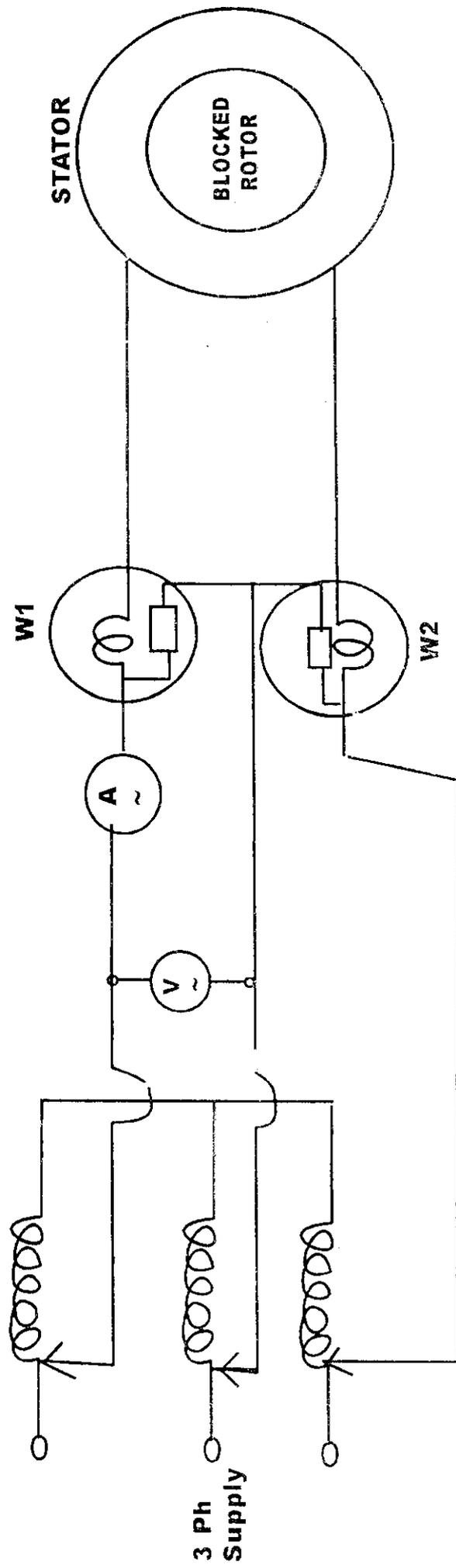
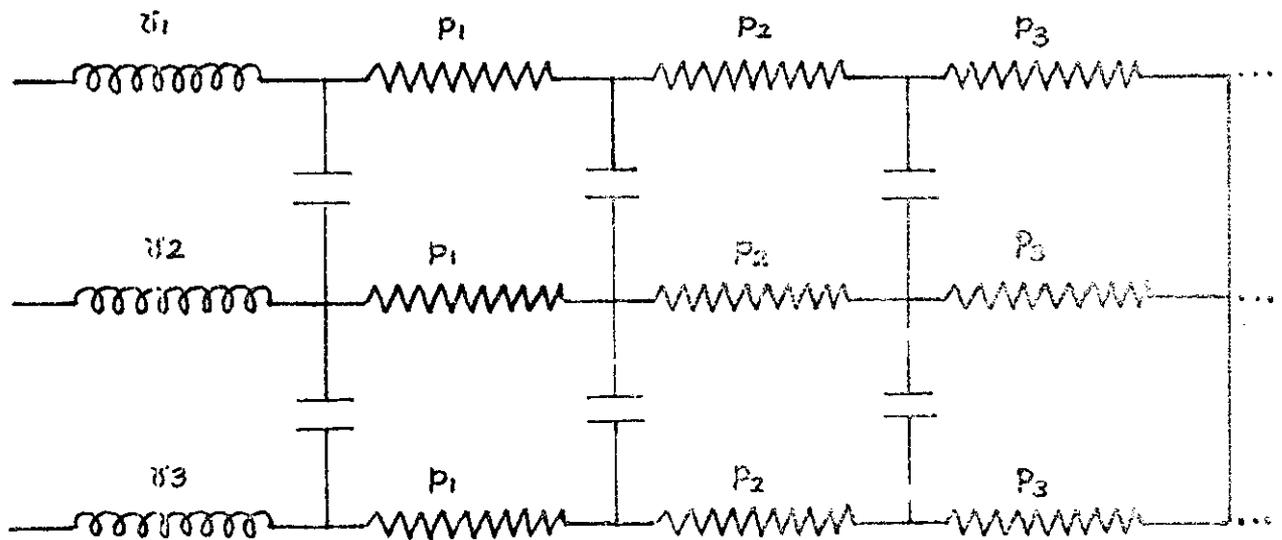
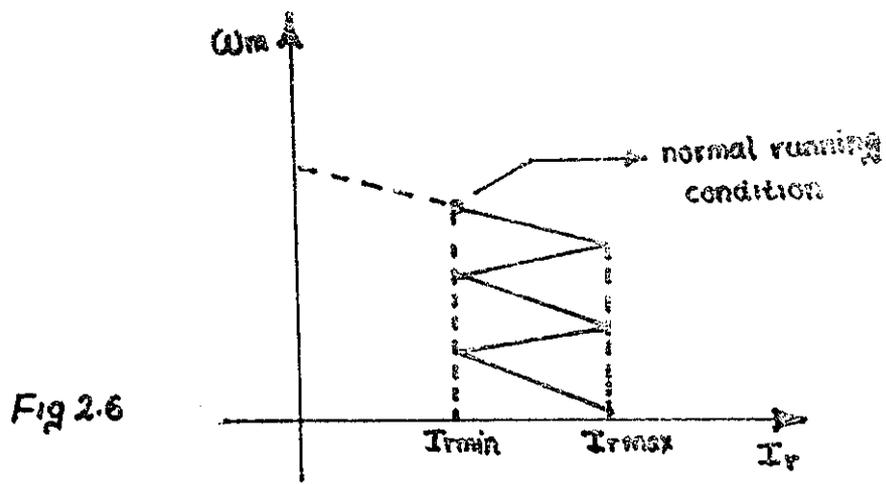
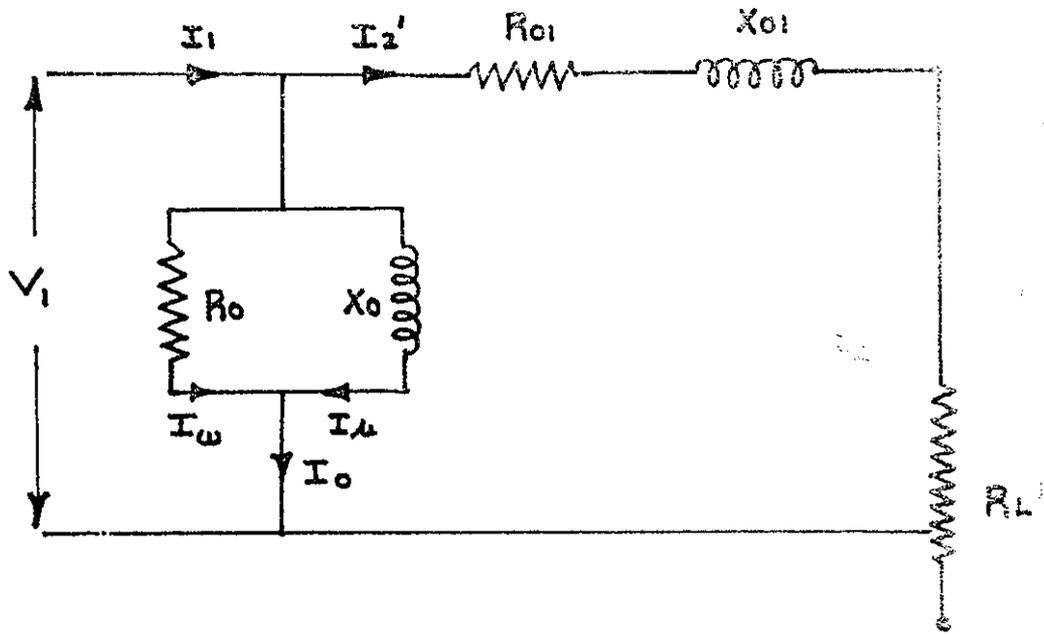


Fig 2.5



EXTERNAL RESISTANCE AT ROTOR SIDE

Fig 2.7



EQUIVALENT CIRCUIT

Fig 2-8 (i)

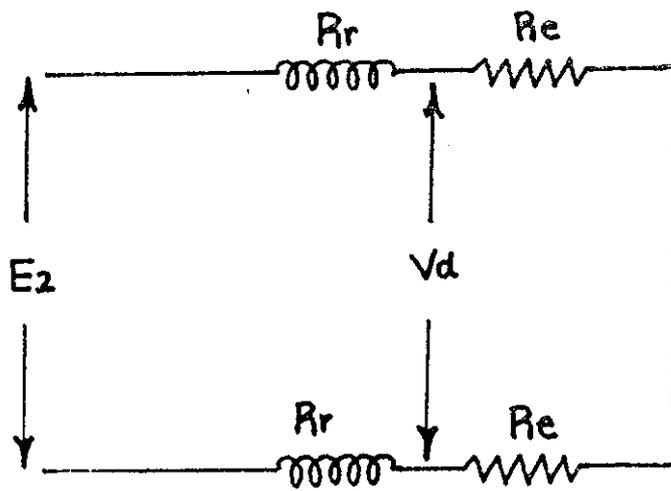
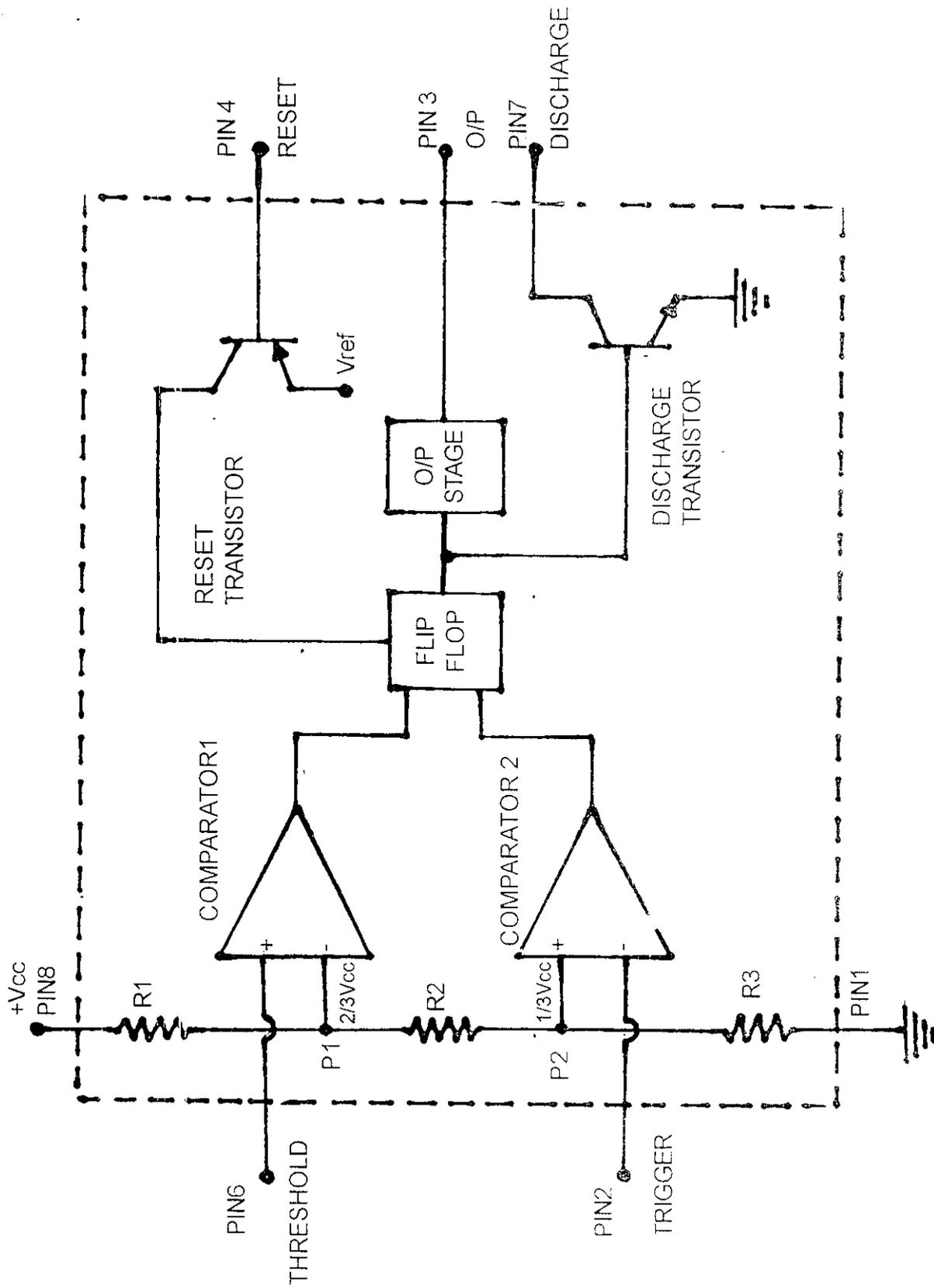


Fig 2-8 (ii)



Functional Block Diagram of 555 Timer in Monostable Mode

Fig 2.9

ELECTRONIC SEQUENCE TIMER

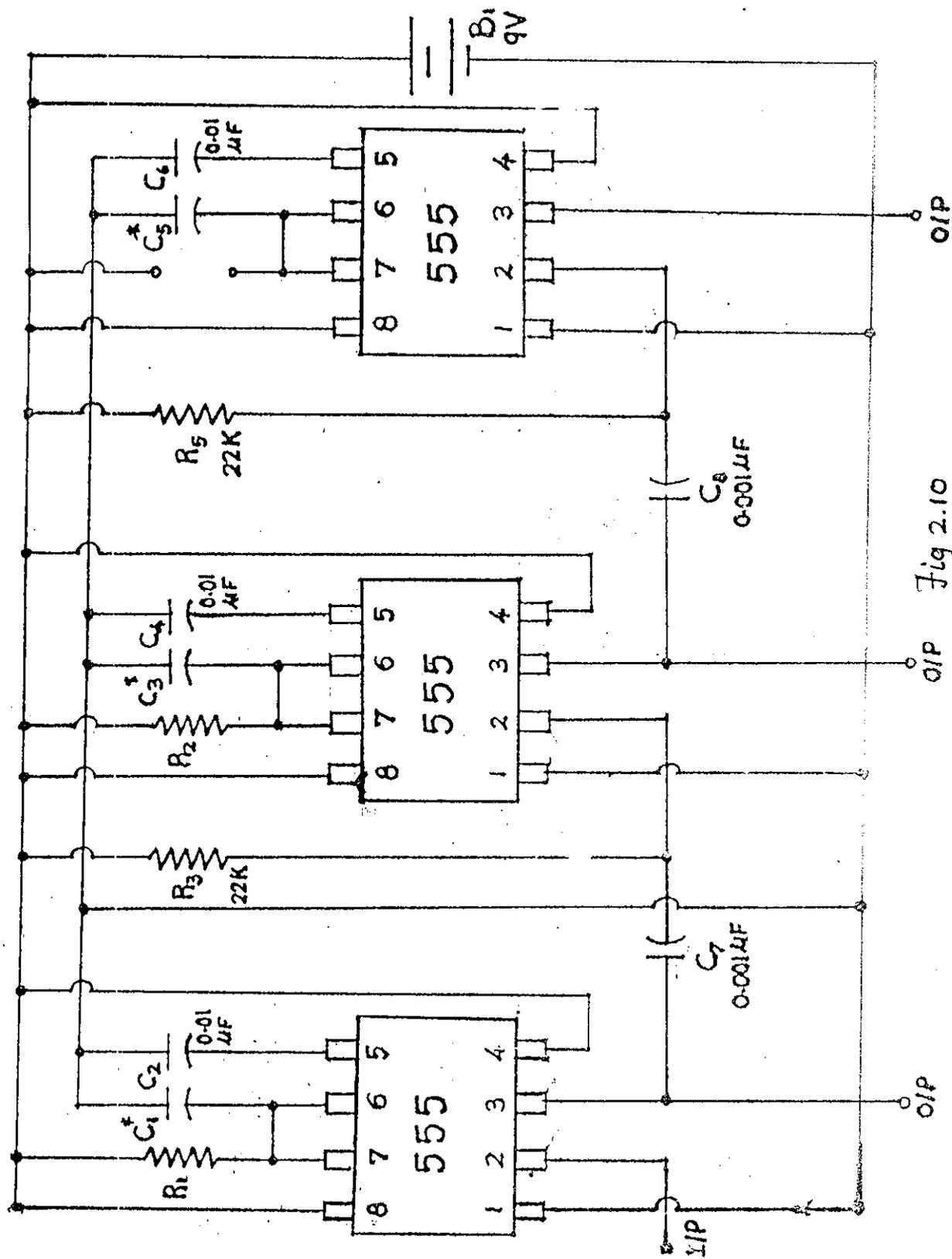


Fig 2.10

CHAPTER – 3

3.1 POWER FACTOR IMPROVEMENT BY ADDING RESISTANCE

The improvement of power factor should not affect the increasing torque, which is necessary criteria for starting. The direct relationship existing between the powerfactor and the torque is made use of improving the powerfactor.

$$T \propto \phi I_2 \cos\phi_2$$

Where ϕ is rotating flux

I_2 is rotor current per phase

$\cos\phi_2$ is rotor powerfactor

Since rotor emf / phase, $E_2 \propto \phi$

$$T \propto E_2 I_2 \cos\phi_2 \quad \dots\dots\dots 1$$

$$\Rightarrow T = K E_2 I_2 \cos\phi_2 \text{ where } K - \text{constant}$$

rotor current per phase is given by,

$$I_2 = \frac{SE_2}{\sqrt{(R_2)^2 + S^2 X_2^2}} \quad \dots\dots\dots 2$$

$$\begin{aligned}
\text{Power factor} &= R / Z \\
&= R_2 / Z \\
&= R_2 / \sqrt{(R_2)^2 + (S X_2)^2} \dots\dots\dots 3
\end{aligned}$$

Since the power factor $\text{Cos}\phi_2$ is proportional to the rotor resistance R_2 , the increasing resistance will result in improvement of power factor.

It is also to be noted from 1 that torque is proportional to power factor $\text{Cos}\phi_2$.

$$(\text{i.e.,}) T \propto I_2 \text{Cos}\phi_2 \dots\dots\dots 4$$

So, the improvement in power factor will further increase the torque during starting.

3.2 LIMITATIONS OF POWER FACTOR IMPROVEMENT

Power factor is improved by including external resistance in the rotor circuit. Addition of external resistance however increases the rotor impedance and so the rotor current reduces. At first, the effect of improved power factor predominates the decreasing current, hence the starting torque is increased. But after the motor attains its rated speed, the effect of reduced current predominates the effect of improved power factor, so the torque starts decreasing.

CHAPTER -4

FABRICATION AND TESTING

4.1 FABRICATION OF CIRCUITS AND CABIN

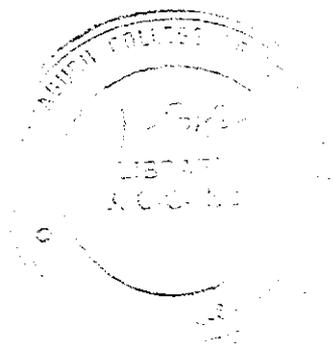
The sequential timer circuit is fabricated in a PCB with transformers and bridge rectifier circuit unit. The external resistance wound in the form of spring along with PCB and relays are assembled in the hylum sheet. The resistances are kept in an asbestos sheet.

The entire setup in hylum sheet is fabricated in the cabin provided with voltmeter, ammeter and terminals for switching the starter.

A trigger switch is provided at the cabin to provide a low level trigger to the timer 1 of the sequential timer circuit.

Another push button switch is provided in order to view the input and output voltages in the voltmeter.

The connecting terminals includes input, output and slip-ring connections.



4.2 TESTING OF CIRCUITS

4.2.1 TESTING OF TIMER CIRCUIT

The 555 timers in sequential mode can be tested using LED's first, connected at the output of each timer. The trigger (low level) is given at the second pin of the first timer. The delay setting for each timer is previously set using the resistor and capacitor values. The timer 1 glows for a period of eight seconds and when it turns-off, the timer 2 is triggered and its LED glows. This timer is set to on for a period of six seconds and it gets off by triggering the the next timer. The timer 3 output is on for an infinite time delay.

4.2.2 TESTING OF RELAY

The relays that are used in this project are Power relays. The relay has two contacts which has to be connected between RY and YB phases. The relay is first checked with 12 V battery for its operation. The LED's at the output of the timers are replaced by relays. The output of the timer is amplified using SL100 transistor, since the output of the timer is not sufficient to drive the relay. And one of the relay terminal is connected to the collector of the transistor and the other is connected to the positive 12 V supply. The supply is given to this setup and the sequential operation of the relays are tested.

4.2.3 TESTING OF EXTERNAL RESISTANCE

The resistance wire is wound in the form of spring and in each phase of rotor the resistance is 12 ohm, splitted into three sections(each of 4 ohms).An auto-transformer is used to check for the ability of the resistance to bear the surge / starting current of induction motor. The heating nature of the resistances are tested using the loading rheostat. And is also connected with relays. to check for its proper cut-off during starting.

4.2.4 TESTING OF STARTER

With every circuits assembled in the hylum sheet, the supply is given for the transformer and trigger is given to the timer I. The proper relay operation for cutting down the resistance are checked. The speed at every stage is noted and finally the rated speed of motor is noted with the third timer switched on. The testing is per the table.

Time (Secs)	Led1	Led2	Led3
0-8	ON	OFF	OFF
8-14	OFF	ON	OFF
14-20	OFF	OFF	ON

TESTING OF TIMER

Fig - 4.2.1

	Timer I	Timer II	Timer III
Time (Secs)	8	6	Infinite
Speed (rpm)	790	860	960

Fig (4.24) TESTING OF STARTER

CHAPTER - 5

CONCLUSION

An **Electronic rotor resistance control starter with Power factor improvement** has been designed, fabricated and tested successfully.

This starter operates without any mechanical change-over switch. The timer circuit that is built in PCB, operates in a sequential manner such that soft starting of motor with high starting torque is achieved. As external resistances are included in the rotor circuit while starting the power factor is very much improved automatically.

The developed system has the following advantages,

1. No need for change-over switch.
2. Power factor is improved.
3. Quick starting.
4. Low cost.

Field of Application

Used where slip-ring induction motors are employed in producing high starting torque is required.

1. Paper mills.
2. Lifts.
3. Cranes.
4. Conveyors.

Further Improvements

As the slip-ring induction motor has the provision of adding external resistances to its windings, we achieved Electronic starting. And this can also be improved as Electronic starter with Speed control of induction motors. The speed control can be achieved by injecting emf into the slip-rings. (i.e) after soft starting is achieved, the SCR's can be used to vary the speed by varying the resistance for all load conditions by varying its duty cycle. Kd. A Microprocessor can be interfaced to count the pulses during one revolution in order to maintain constant speed at all load conditions.

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3. Arthur B. Williams,"Designer Handbook of Integrated Circuits",MCGRAW-HILL Book Company,United States,1984.
4. William D. Stanley."Electronic Devices Circuits and Applications".Prentice Hall,New Jersey,1989.
5. A.E.Fitzgerald,"Electronic Machinery",Metric Edition,Singapore,1979.
6. D.R.Malhotra,"Dynamics of Machinery",Shri Ram P.Handa,New Delhi,1979.
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APPENDIX

A.1 SPECIFICATIONS

...of Motor

Type - Slip Ring Induction Motor

Phase - 3

Hz - 50

Volts - 415 V

R.Volts - 110 V

Amps - 5.1 A

R.Amps - 13 A

KW - 2.2

H.P - 3

RPM - 960

...of Relay

Type - Power Relay

Contacts - 2

Ohms - 60

Volts - 12 V (dc)

230 V (ac)

Amps - 20 A (ac)

A2 SPECIFICATIONS

...of Timer

Type - 555 Timer-8 pin DIP

Volts - (5 to 18) V

Amps - (200 to 500) mA

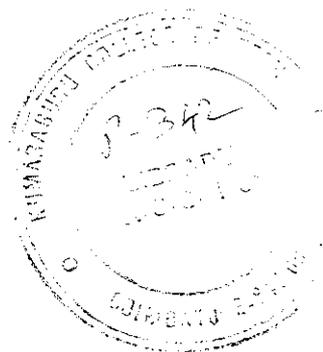
...of External Resistance

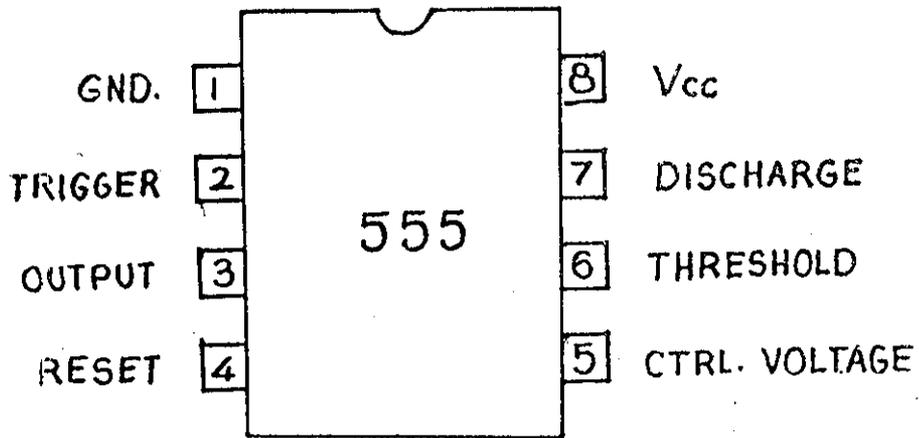
Type - Nichrome Wire

Gauge - 20 SWG

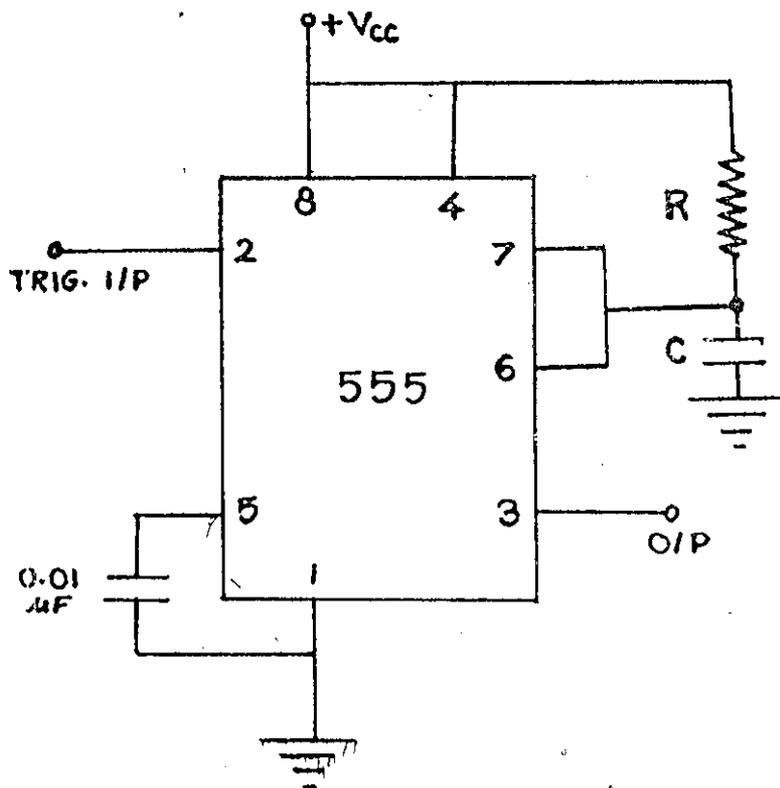
Diameter - 0.91 mm

Resistance - 12 ohms per phase

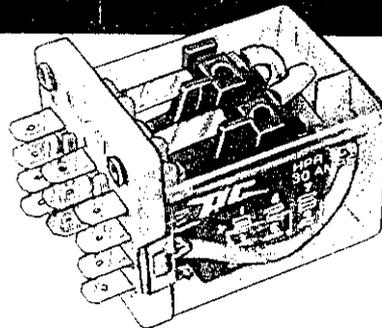
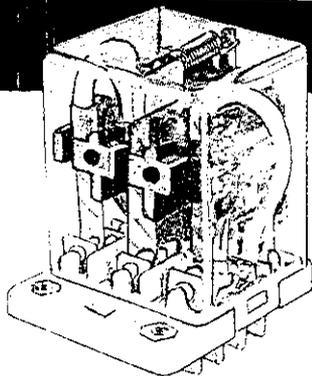




PIN DIAGRAM



MONOSTABLE MODE



MINIATURE HEAVY DUTY POWER RELAY 30 AMPS RESISTIVE AT 250V AC/24V DC

SPECIFICATIONS

Contact Form and Rating	up to 3C/O Contacts 30 Amps 250V AC/24V DC (Resistive)
Contact Resistance	< 50m Ohms at 1A 30V DC
Contact Material	Agcdo
Ambient Temperature	-40°C to +70°C
Dielectric Strength (initial)	2500V AC (1 minute) between coil & contacts or coil to ground
Insulation Resistance	1000 Meg-Ohms at 500V DC
Operate Time	20 ms at nominal Voltage
Release Time	10 ms at nominal Voltage
Life Expectancy	10 ⁵ at nominal rated load
Coil Consumption	2.5W DC, 4.5V A
Weight	125 grams approx. (Max.)

COIL-DATA

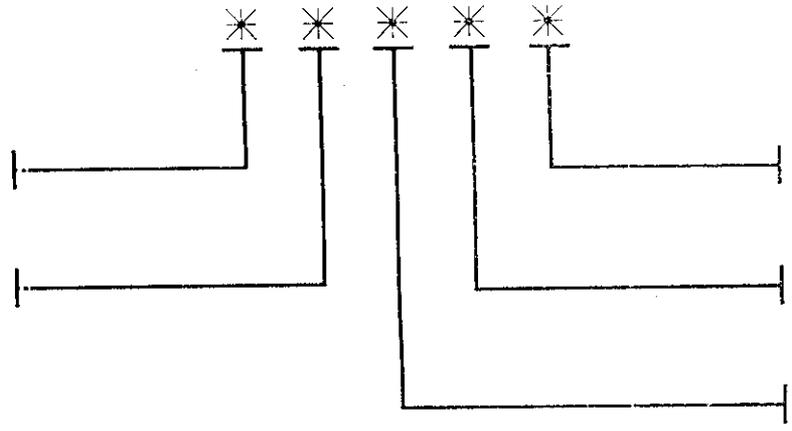
(All values at 27° c + 20 ambient)

Nominal Voltage	Resistance in Ohms + 10%		Must operate Voltage @ 25° C
	DC Relays	AC Relays	
12	74	65	10
18	150		15
24	300	25	20
110	5500		90
115		570	95
220	21500		170
240		2300	190

WIRING CODE

RIES HPR
Amps Relays

NO. OF CONTACTS
= 1 contact
= 2 contacts
= 3 contacts

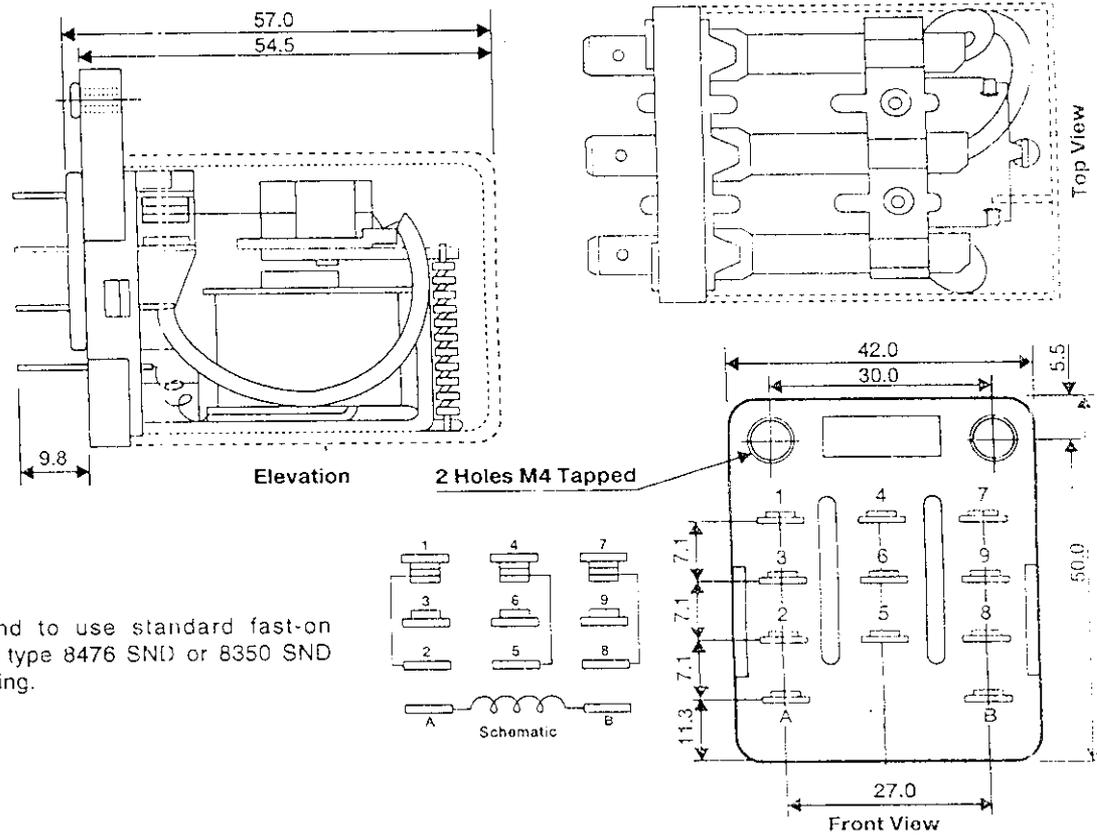


A = Designate AC Coil
Delete A for DC Coil

COIL VOLTAGE
specify Coil Voltage
12, 18, 24, 110,
115, 220, 240

CONTACT FORM
C = Change Over
A = Normally Open
B = Normally Closed

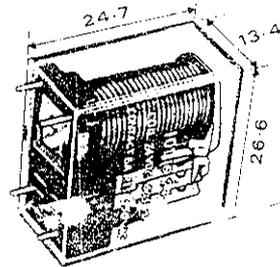
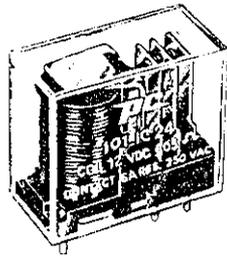
DIMENSIONS (in mm)



We recommend to use standard fast-on terminals Lugs type 8476 SNI) or 8350 SND for ease in wiring.

APPLICATIONS

- VOLTAGE STABILIZER
- FURNACE CONTROLS
- U.P.S.
- PROCESS CONTROL SYSTEM
- PHOTOCOPYING MACHINES
- INVERTOR
- AUTOMATION EQUIPMENT
- MOTOR STARTER
- VENDING MACHINES



SPECIFICATIONS

Contact Material	Silver Cadmium Oxide	Initial Contact Resistance	0.050 Ohm's (max)
Contact Arrangement	1A, 1B or 1C	Ambient Temp	-40°C to +65°C
Contact Ratings	6 amps resistive at 28V DC/250V AC	Dielectric strength	1000 volts RMS for 1 minute
Sensitivity	0.75 Watts Max.	Insulation Resistance	10 ¹⁰ ohms min. at 500V DC at 27°C & 30% RH
Coil Dissipation	1.5 Watts Max.	Enclosure	Polycarbonate
Operate Time	0.012 sec. max. at Nominal voltage	Max Weight	15 grams
Release Time	0.008 sec. max. at Nominal voltage	Life Expectancy	Mechanical 10,000 operations Rated Load 10 ⁷ operations

ORDERING CODE

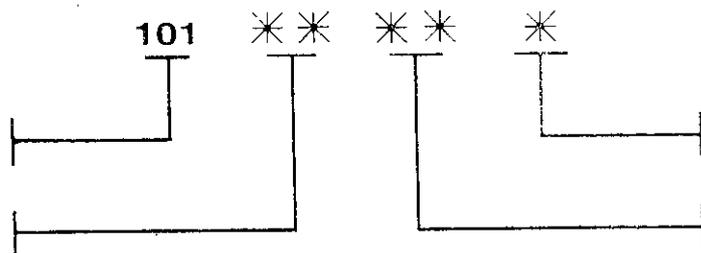
SERIES 101

CONTACT ARRANGEMENT

1 N/O

1 N/C

1 C/O



SPECIAL FEATURES

COIL VOLTAGE

36 - 6V DC

12 - 12V DC

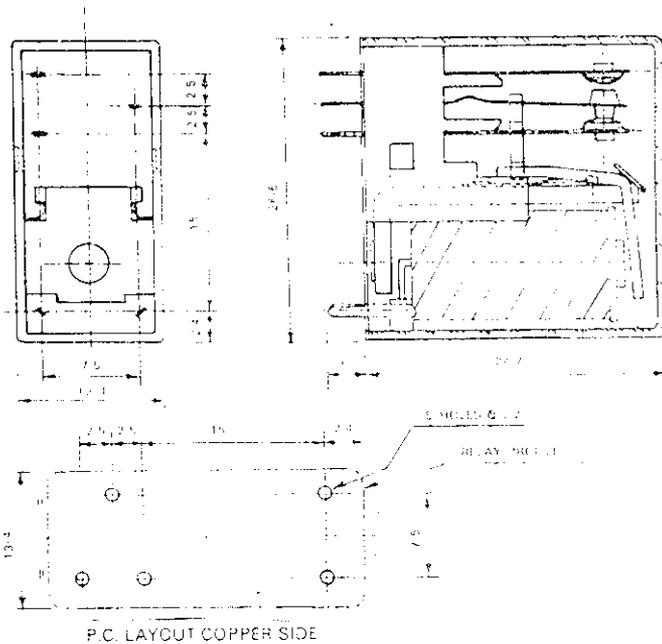
24 - 24V DC, etc.

COIL-DATA

(All values at 27°C ± 2°C Ambient)

Nominal voltage Volts DC	Resistance in ohms ± 10%	Must Operate voltage Volts DC
6	43	4.5
12	150	9.5
18	360	13
24	605	18
48	2390	36
115	11500	85

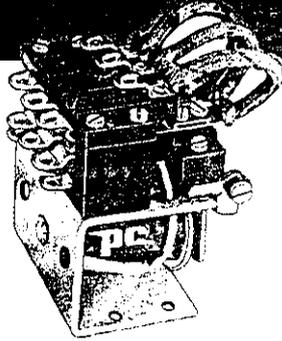
DIMENSIONS (in mm)



APPLICATIONS

- Voltage Stabilisers upto 0.5 KVA
- Household Electrical Appliances
- Machine Tools • Control Panels
- Instrumentation • Telecommunication
- Textile Machineries
- Industrial & Consumer Electronics
- Automation & Remote Control Systems

CAT-101-0186



RS 275

POWER RELAYS 20 AMPS RESISTIVE AT 24V DC/250V AC

SPECIFICATIONS	
Contact Material	Fine Silver
Initial Contact Resistance	100M ohms (Max.)
Ambient Temp.	-40°C to +70°C
Die-electric Strength	2KV between contacts or coil to ground
Insulation Resistance	100 Meg ohms Min. at 500 VDC at 27°C & 65% R.H.
Operate Time	0.030 sec. Max. at nominal voltage
Release Time	0.010 sec. Max. at nominal voltage
Life Expectancy	10 ⁶ operations at rated load
Max. Weight	200 gms.

COIL VOLTAGE (All values at 27°C ± 2°C Ambient)			
Nominal Voltage	Resistance in Chms ± 10%		
	DC Relays		AC Relays
	1 C/O 2 C/O	3 C/C	1 C/O 2 C/O 3 C/O
12	60	50	32
24	250	200	148
48	1000	800	60
110	4800	4000	298
240	25000	16000	1600

Must Operate Vol. 80% of Nominal Coil Vol.
Must Release Vol. 10% of Nominal Coil Vol.

ORDERING CODE

NO. OF CONTACTS

2 or 3

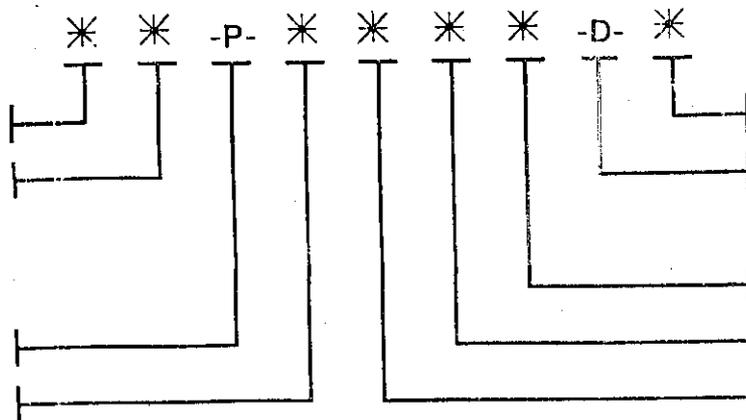
CONTACT FORM

O = change over
 O = normally open
 C = normally close

SERIES P POWER RELAYS

OUNTING

= chassis mounting



SPECIAL FEATURES

Please ask for details

QUALITY

D = defence quality
 Omit D for commercial quality

A = AC RELAY

D = DC RELAY

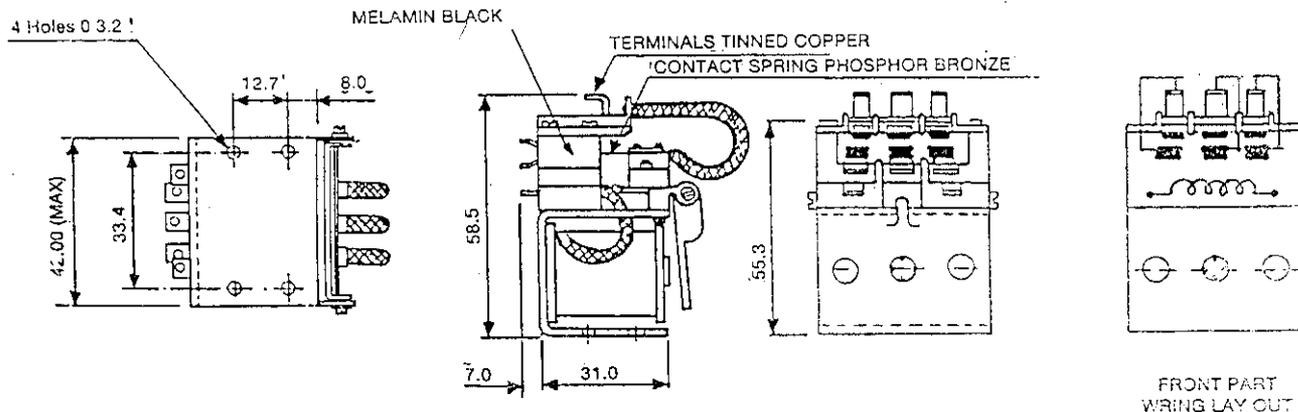
COIL VOLTAGE

12, 24, 48, 110, 240

ENCLOSURE

O = open

DIMENSIONS



NOTE : ALL METAL PARTS ARE ZINC PLATED AND PASSIVATED.

ALL DIMENSIONS ARE IN MM.

APPLICATION NOTES :

- Basic construction being open, user is advised to provide dust proof covering as settling of dust/metal particles in the gap between core and armature or in between the contacts would affect the relay performance. In worst case, coil burning cases have also been reported.
- Though rated for 20 amps. breaking capacity for general applications, these relays are not recommended for use in voltage stabilizers beyond 2.5 KVA ratings as it has been seen that at the time of tap-changing through contact transfer, contact gap is momentarily shorted, through heavy spark which results into full short circuit current passing through the contact and buck/boost winding. This short circuit current depends upon buck/boost winding impedance and in best stabilizer, this impedance is too low to cause short circuit current of the order of 500 to 700 amperes to flow resulting into contact welding in few thousand operations. Therefore it is recommended to use these power relays in higher KVA stabilizers only after assessing their performance for contact welding in actual sets.

APPLICATIONS AREAS :

- 1 Control Panel
- 2 Defence Appliances
- 3 Machine Tools
- 4 Power Instrumentation
- 5 Inverters
- 6 Photocopying Machines