ELECTRICAL MACHINE-II LAB

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LABORATORY PRACTICE

SAFETY RULES

1. **SAFETY** is of paramount importance in the **Electrical** **Engineering** Laboratories.

2. Electricity NEVER EXECUSES careless persons. So, exercise enough care and attention in handling **electrical** equipment and follow **safety** practices in the laboratory. ***(Electricity is a good servant but a bad master)***.

3.Avoid direct contact with any voltage source and power line voltages. (Otherwise, any such contact may subject you to **electrical shock**)

4.Wear rubber-soled shoes. (To insulate you from earth so that even if you accidentally contact a live point, current will not flow through your body to earth and hence you will be protected from **electrical shock**)

5.Wear laboratory-coat and avoid loose clothing. (Loose clothing may get caught on an equipment/instrument and this may lead to an accident particularly if the equipment happens to be a rotating machine)

6.Girl students should have their hair tucked under their coat or have it in a knot.

7.Do not wear any metallic rings, bangles, bracelets, wristwatches and neck chains. (When you move your hand/body, such conducting items may create a short circuit or may touch a live point and thereby subject you to **electrical** shock)

8.Be certain that your hands are dry and that you are not standing on wet floor. (Wet parts of the body reduce the contact resistance thereby increasing the severity of the shock)

9.**Ensure that the Power is OFF** before you start connecting up the circuit.(Otherwise you will be touching the live parts in the circuit)

10.Get your circuit diagram approved by the staff member and connect up the circuit strictly as per the approved circuit diagram.

11.Check power chords for any sign of damage and be certain that the chords use **safety** plugs and do not defeat the **safety** feature of these plugs by using ungrounded plugs.

12.When using connection leads, **check for any insulation damage in the leads** and avoid such defective leads.

13.Do not defeat any **safety** devices such as fuse or circuit breaker by shorting across it. **Safety** devices protect YOU and your equipment.

14.**Switch ON the power** to your circuit and equipment only after getting them checked up and approved by the staff member.

15.Take the measurement with one hand in your pocket. (To avoid shock in case you accidentally touch two points at different potentials with your two hands)

16.Do not make any change in the connection without the approval of the staff member.

17.***In case you notice any abnormal condition in your circuit*** (like insulation heating up, resistor heating up etc), ***Switch OFF the power to your circuit immediately*** and inform the staff member.

18.Keep hot soldering iron in the holder when not in use.

19.**After completing the experiment** show your readings to the staff member and **switch off the power to your circuit** after getting approval from the staff member.

20.While performing load-tests in the **Electrical Machines** Laboratory using the brake-drums:

i. Avoid the brake-drum from getting too hot by putting just enough water into the brake-drum at intervals; use the plastic bottle with a nozzle (available in the laboratory) to pour the water.(When the drum gets too hot, it will burn out the braking belts)

ii. **Do not stand in front of the brake-drum when the supply to the load-test circuit is Switched OFF**. (Otherwise, the hot water in the brake-drum will splash out on you)

iii. **After completing the load-test**, **suck out the water in the brake-drum** using the plastic bottle with nozzle and then dry off the drum with a spongewhich is available in the laboratory.(The water, if allowed to remain in the brake-drum, will corrode it)

21.Determine the correct rating of the fuse/s to be connected in the circuit after understanding correctly the type of the experiment to be performed: no-load test or full-load test, the maximum current expected in the circuit and accordingly use that fuse-rating.(While **an over-rated fuse will damage the equipment and other instruments** like ammeters and watt-meters in case of over load, an under-rated fuse may not allow one even to start the experiment)

22. At the time of starting a motor, the ammeter connected in the armature circuit overshoots, as the starting current is around 5 times the full load rating of the motor. Moving coil ammeters being very delicate, may get damaged due to high starting current. A switch has been provided on such meters to disconnect the moving coil of the meter during starting. This switch should be closed after the motor attains full speed. Moving iron ammeters and current coils of wattmeters are not so delicate and hence these can stand short

time overload due to high starting current. No such switch is therefore provided on these meters. Moving iron meters can be used for both a.c. and d.c. measurement. Moving coil instruments are however more sensitive and more accurate as compared to their moving iron counterparts and these can be used for d.c. measurements only. Good features of moving coil instruments are not of much consequence for you as other sources of errors in the experiments are many times more than those caused by these meters.

NOTE : More care must be taken in Lab to avoid damage of Instruments by mishandling in the following ways:

i. Keeping unnecessary material like Books, Lab Records, unused meters, Rheostats etc. causing the instruments to fall down the table.
ii. Putting pressure on the meter (especially glass) while making connections or while talking or listening somebody.

TO AVOID SHORT CIRCUIT while conducting any Experiments on DC-Motors.

1. *Please check the DC Motor Starter's Handle Position at OFF Condition before Switch ON the DC- Supply*
2. *Always keep the DC Motor Starter's Stud Clean by rubbing with a sand paper*
3. *Also keep the Commutator Surface of the DC Motor Clean using a sand paper*

TROUBLE SHOOTING HINTS

1. Be Sure that the power is turned ON
2. Be sure the ground connections are common
3. Be sure the circuit you build is identical to your circuit diagram (Do a node by node check)
4. Be sure that the supply voltages are correct
5. Be sure that the equipment is set up correctly and you are measuring the correct parameters
6. If steps I through 5 are correct then you probably have used a component with the wrong value or one that doesn't work. It is also possible that the equipment does not work (although this is not probable) or the protoboard you are using may have some unwanted paths between nodes. To find your problem you must trace through the voltages in your circuit node by node and compare the signal you expect to have. Then if they are different use your engineering judgment to decide what is causing the different or ask your Lab Assistant.

AIM OF THE EXPERIMENTS

Experiment No. 1

To determine the voltage regulation of an alternator by Synchronous Impedance Method. And to determine the voltage regulation of an alternator by zero power factor method.

APPARATURS REQUIRED:

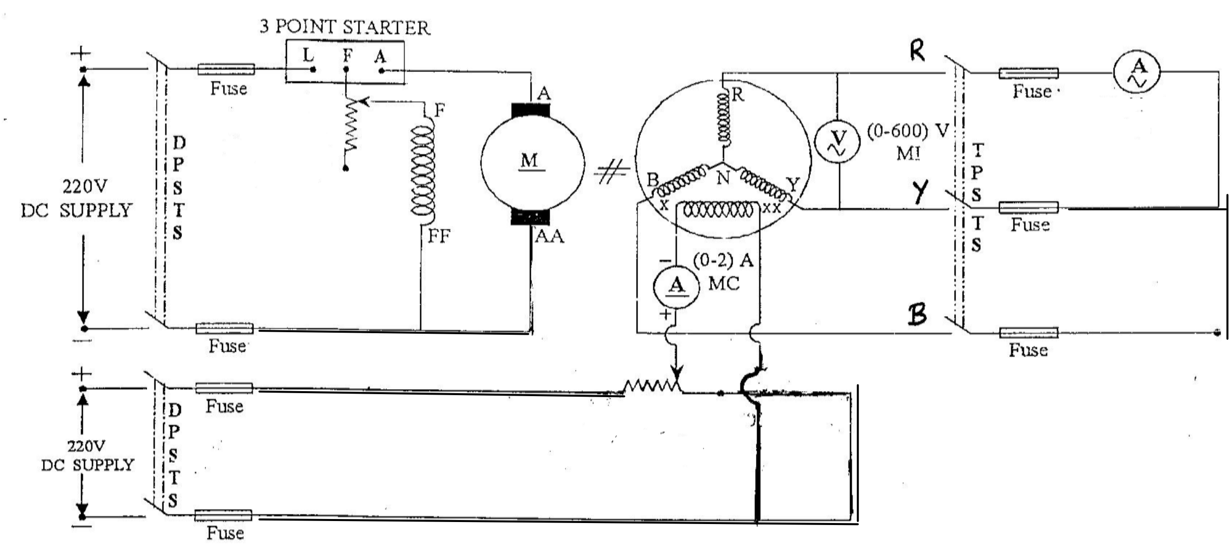
SL.NO	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	01
2	Ammeter	MI	0 – 5/10 A	01
3	Voltmeter	MC	0 – 30 V	01
4	Voltmeter	MI	0 – 600 V	01
5	Rheostat	Wire wound	750 Ω, 1.2 A	01
6	Rheostat	Wire wound	1000Ω, 0.8 A	01
7	Tachometer	Digital	0-9999rpm	01
8	TPST knife switch	--	3Pole, 32A	01
9.	Inductive Load	Air core	3-Phase	01

Machine Specification:

Sl. No.	Machine	Range	Quantity
1.	DC Shunt Motor	7.5HP,220V DC, 1500 rpm	01 No
2.	Alternator (Salient Pole type)	3KVA, 3-Phase, 415V AC,	01 No

Regulation of 3-Phase Alternator by EMF & MMF Method

(Open Circuit & Short Circuit Tests)



THEORY:

The regulation of a 3-phase alternator may be predetermined by conducting the Open Circuit (OC) and the Sort Circuit (SC) tests.

The methods employed for determination of regulation are

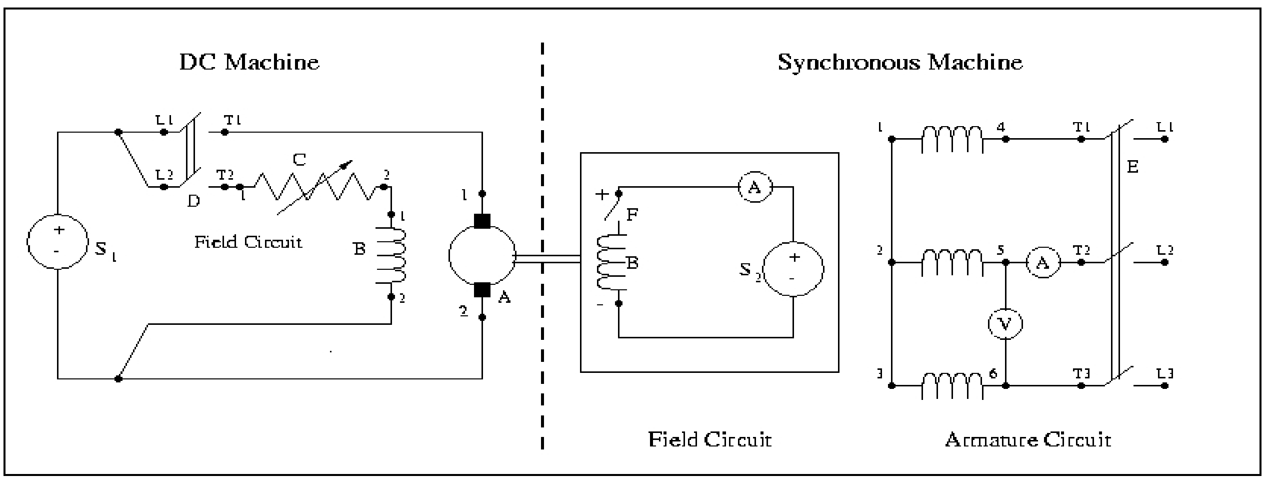
1) *EMF or Synchronous Impedance Method,*
2) *MMF or Ampere Turns Method and*
3) *ZPF or Potier Triangle Method.*

In this experiment, the EMF and MMF methods are used. The OC and SC graphs are plotted from the two tests. The synchronous impedance is found from the OC test. The regulation is then determined at different power factors by calculations using vector diagrams. The EMF method is also called pessimistic method as the value of regulation obtained is much more than the actual value. The MMF method is also called optimistic method as the value of regulation obtained is much less than the actual value. In the MMF method the armature leakage reactance is treated as an additional armature reaction. In both methods the OC and SC test data are utilized.

PRECAUTIONS:

(i) The DC-Motor field rheostat should be kept in the minimum resistance position.
(ii) **The alternator field potential divider should be kept in the minimum voltage position**.
(iii) Initially all switches are in open position.

Circuit Diagram of Open Circuit Test:



PROCEDURE TO CONDUCT OPEN CIRCUIT TEST:

1. Keep the panel board switch (on/off-Rotary switch) at off position connect field regulator terminals R1 and R2 to DC-Supply terminal '+' and '-' respecting.

2. Now connected the alternator field winding terminals F1 and F2 to field regulators common point 'C' and R2 respectively.

3. Keep the alternator terminal R, Y and B open.

4. Connect the prime mover as per the DC-Shunt motor connection done earlier. Switch on the rotary switch and run prime mover using 3-point starter.

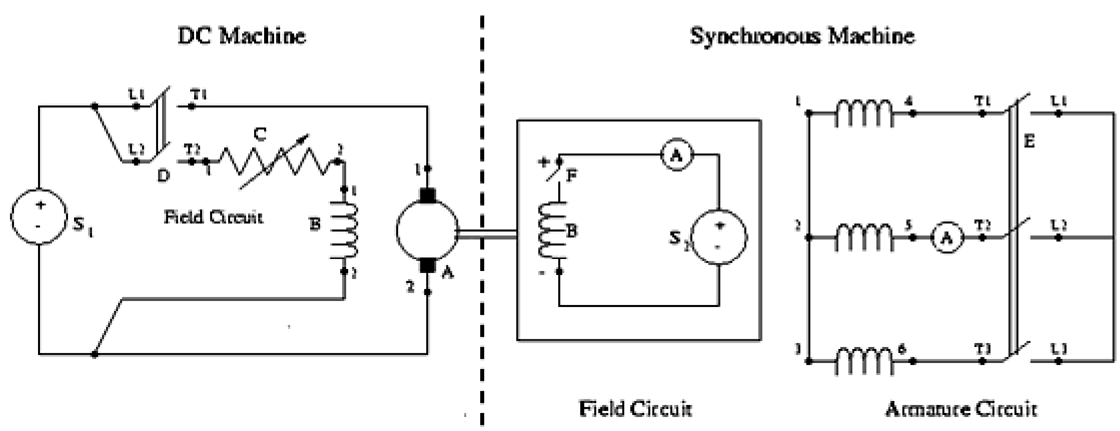
Measure the speed of the alternator, if required bring the alternator speed to 1500 rpm by decreasing the field current of the prime mover (here prime mover is a shunt motor) while increase the resistance of the field regulator.

Now increase the field current of the alternator by decreasing the added field resistance of the alternator field regulator, resistance of the field regulator decreases and field current increases and hence alternator output voltage increases.

(I_f) and Va can be measure at 1500 rpm.

Once field regulator knob reaches at minimum position, added resistance become zero and field current remain constant as per the resistance of the Alternator field winding here the terminal voltage is maximum and it is called open circuit voltage and graph can be drawn.

Circuit Diagram for Short Circuit Test:



The short circuit characteristics will be taken by connecting AC- Ammeters of rating 0-5A in the line to line i.e., (R to Y) and (Y to B) to record the line current as per the figure shown above.

The field current of alternator is adjusted to zero and Alternator is brought to its rated speed says 1500rpm. (Readings are taken of DC field current (I f) versus AC- Short Circuited Armature current. The graph will be plotted between dc-field current I f and short circuit armature phase current (Ia)).

PROCEDURE TO CONDUCT SHORT CIRCUIT TEST:

Procedure: step (1), (2) & (3) remain same as above.

4 Keep the panel board switch (on/off-Rotary switch) at off position connect field regulator terminals R1 and R2 to DC-Supply terminal '+' and '-' respecting.

5 Now connected alternator field winding terminals F1 and F2 to field regulators common point 'C' and R2 respectively.

6 Keep the alternator terminal R, Y and B open.

7 Apply DC supply to field regulator by switch on the panel. Measure the field current by varying the rheostat knob. ***See that, before connecting the short circuit test, bring the rheostats to maximum position and current must be zero***.

8 Now switch off the power supply and connected the AC Ammeter of 5A rating as per the diagram.

9 Switch on the panel board and run the DC motor and bring the motor speed to 1500rpm, by adjusting the field regulator for DC Motor.

10 Now slowly increase the field current of the alternator by Varying the field regulator knob and reducing the added resistance value up to short circuit current.

Beyond 4A Alternator will burn.

Conclusion: Full load current Rating of the Alternator was measured.

Precautions:

Do not short circuited the alternator without keeping alternator field current to zero.
Do not increase the field current suddenly.
Increase the field current of the alternator very slowly and observe short-circuit current till it reaches the machine rated current i.e, Ia=3.4A here.

PROCEDURE TO MEASSUREVOLTAGE REGULATION OF AN ALTERNATOR BY SYNCHRONOUS IMPEDANCE METHOD.

1. Note down the name plate details of the motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch ON the supply by closing the DPST switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by adjusting the motor field rheostat.
5. Conduct Open Circuit test by varying the potential divider for various values of field current and tabulate the corresponding Open Circuit Voltage readings.
6. Conduct Short Circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current.
7. The Stator resistance per phase is determined by connecting any one phase stator winding of the alternator as per the circuit diagram using MC voltmeter and ammeter of suitable ranges.

PROCEDURE TO DRAW GRAPH FOR EMF METHOD:

1. Draw the Open Circuit Characteristic Curve (Generated Voltage per phase VS Field current).
2. Draw the Short Circuit Characteristics Curve (Short circuit current VS Field current)
3. From the graph find the open circuit voltage per phase (E_1 (ph) for the rated short circuit current (Isc).
4. By using respective formulae find the Zs, Xs, Eo and percentage regulation.

PROCEDURE TO DRAW GRAPH FOR MMF METHOD:

1. Draw the Open Circuit Characteristic curve (Generated Voltage per phase VS Field current).
2. Draw the Short Circuit Characteristics curve (Short circuit current VS Field current)
3. Draw the line **OL** to represent

FORMULAE:

1. Armature Resistance Ra = Ω
2. Synchronous Impedance Zs = $\dfrac{\text{O.C. voltage}}{\text{S.C. current}}$

3. Synchronous Reactance $Xs = \sqrt{Zs^2 - Ra^2}$

4. Open circuit voltage for lagging p.f = $\sqrt{(V\cos\Phi + IaRa)^2 + (V\sin\Phi + IaXs)^2}$

5. Open circuit voltage for leading p.f. = $\sqrt{(V\cos\Phi + IaRa)^2 + (V\sin\Phi - IaXs)^2}$

6. Open circuit voltage for unity p.f = $\sqrt{(V + IaRa)^2 + (IaXs)^2}$

7. Percentage regulation = $\frac{Eo - V}{V} \times 100$

RESULT:

Thus the regulation of 3-phase alternator has been predetermined by the EMF and MMF methods.

VIVA QUESTIONS:

1. What is meant by voltage regulation?
2. What is meant by Synchronous Impedance?
3. What is OC test ?
4. What is SC test?
5. What is meant by mmf or field ampere turns?

REGULATION OF 3-PHASE ALTERNATOR BY EMF

TABULAR COLUMNS

OPEN CIRCUIT TEST:

S.No.	Field Current (I_f)	Open Circuit Line Voltage (Eo_L)	Open circuit Phase Voltage (Eoph)
	Amps	Volts	Volts

SHORT CIRCUIT TEST:

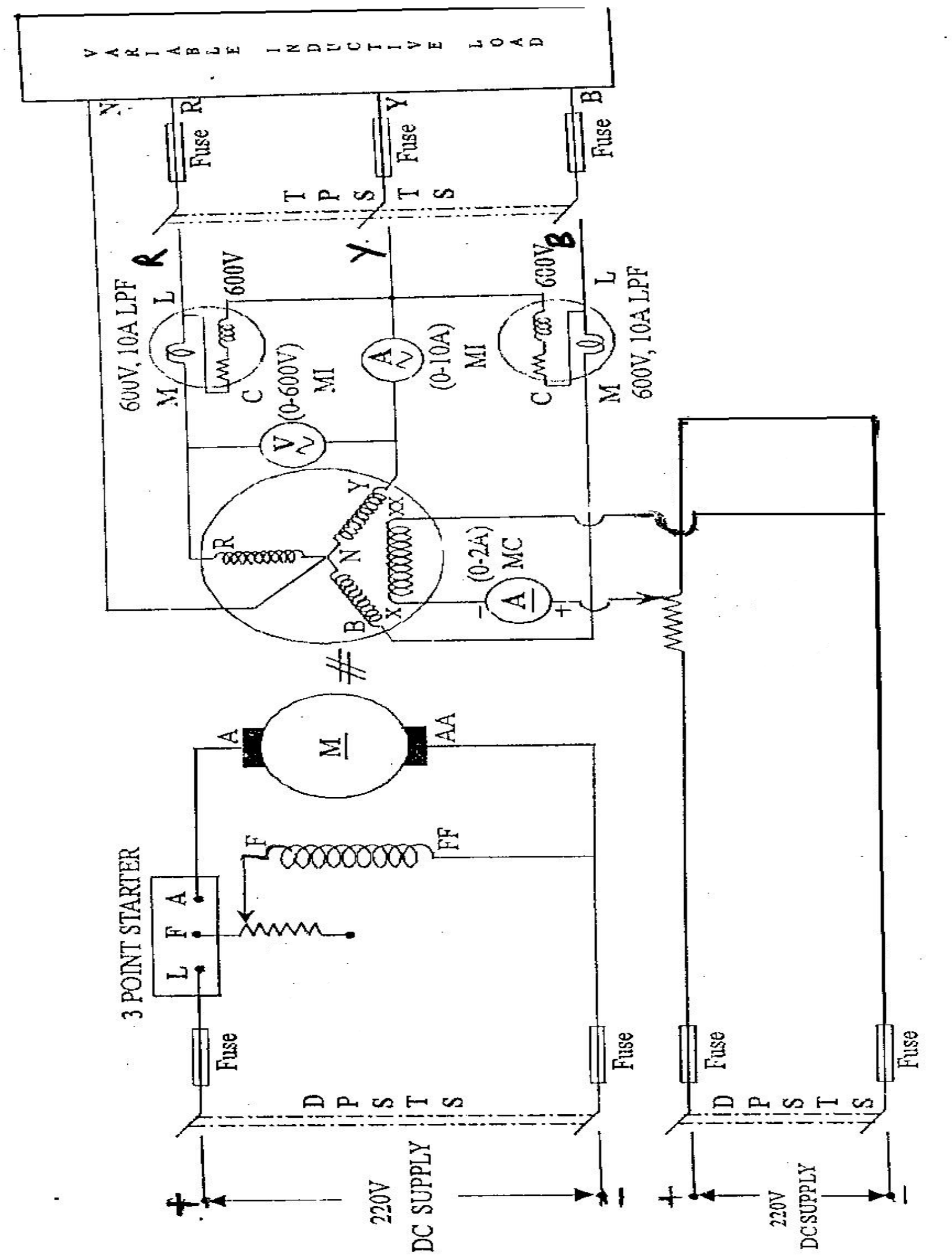
S.No.	Field Current (I_f)	Short Circuit Current (120% to 150% of rated current) (I_{SC})
	Amps	Amps

REGULATION OF 3-PHASE ALTERNATOR BY EMF

EMF METHOD:

SL.NO.	Power factor	Eph (V)		% Regulation	
		Lag	Lead	Lag	Lead

DETERMINE THE VOLTAGE REGULATION OF AN ALTERNATOR BY ZERO POWER FACTOR (ZPF) OR POTIER TRIANGLE METHOD



CIRCUIT DIAGRAM

FORMULAE USED:

$$\text{Percentage regulation} = \frac{Eo - V}{V} \times 100$$

PRECAUTION:

(i) The motor field rheostat should be kept in the minimum resistance position.
(ii) The Alternator field potential divider should be in the position of minimum potential.
(iii) Initially all switches are in open position.

PROCEDURE FOR POTIER TRIANGLE METHOD:

1. Note down the complete nameplate details of motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch on the supply by closing the DPST main switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat.
5. Conduct an Open Circuit Test by varying the Potential Divider for various values of Field current and tabulate the corresponding Open circuit voltage readings.
6. Conduct a Short Circuit Test by closing the TPST knife switch and adjust the potential divider the set the rated Armature current, tabulate the corresponding Field current.
7. Conduct a ZPF test by adjusting the potential divider for full load current passing through either an inductive or capacitive load with zero power and tabulate the readings.
8. Conduct a Stator Resistance Test by giving connection as per the circuit diagram and tabulate the voltage and Current readings for various resistive loads.

RESULT:

Thus the regulation of 3-phase alternator has been predetermined by the Potier triangle methods.

VIVA QUESTIONS:

1. What is meant by ZPF Test?

2. What is Potier reactance? How is it determined by Potier triangle?

3. What is meant by armature reaction reactance?

4. What is the significance of the ASA modification of MMF method?

5. What is air gap line in Potier method?

AIM OF THE EXPERIMENT

Experiment No. 09

Measurement of Sub-transient and Transient reactance of a Salient Pole Alternator.

Apparatus Required:

Sl. No.	Instrument	Type	Range	Quantity
1.	Voltmeter	AC	0 -300-600V	01No.
2.	Ammeter	AC	0-5A	02 Nos.
3.	Ammeter	DC	0-2A	01Nos.
4.	Voltmeter	DC	0 -150-300V	01No.
5.	Tachometer	Digital	0-9999 rpm	01No
6.	Resistor		0.1Ω/10A	01No
7.	Connecting wire		1.5mm²	10 mtr.
8.	Cutting Plier/Wire Stripper			01 No
9.	DSO-60MHz	Digital		01 No.

Machine Specification :

Sl. No.	Machine	Range	Quantity
1.	DC Shunt Motor	5HP,220V DC, 1500 rpm	01 No
2.	Alternator (Salient Pole type)	3KVA, 3-Phase, 415V AC,	01 No

THEORY

This theory is related to behavior of an Alternator under transient conditions. In purely inductive closed circuit the total flux linkages cannot change suddenly at the time of any disturbance. Now if all the three phases of an unloaded alternator with normal excitation are suddenly short circuited, there will be short circuit current flowing in the armature. As the resistance is assumed to be zero this current lag behind the excitation voltage by 90 ° and the mmf produced by this current will be in d- axis and the first conclusion is that , this current will be affected by d axis parameters xd, xd' and xd'' only.

Further there will be demagnetizing effect of this current but as the flux linkages with field can not change the effect of demagnetizing, armature mmf must be counter balanced by a proportional increase in the field current. This additional induced component of field current gives rise to greater excitation , under transient state and results in more short circuit current at this time than the steady state short circuit .

If field poles are provided with damper bars, then at this instant three phase short circuit the demagnetizing armature mmf, induces current in damper bars which in turn produces field in the same direction as main field and hence at this instant the excitation further increases in short circuit armature current . This is for a very short duration. Normally 5 to 4 cycles and this period is knows as sub-transient period. Since the field voltages are constant, there is no additional voltage to sustain these increased excitation during sub transient period or transient period. Consequently the effect of increased field current decrease with a time constant determined by the field and armature circuit parameter and accordingly the short circuit armature current also decays with the same time constant.
Fig. shows a symmetrical waveform for a armature short circuit for one phase of three phase alternator. The DC component is taken to be zero for this phase.

The reactance's offered by the machine during sub transient periods are known as sub transient reactance. In direct axis it is xd" and in quadrature axis it is xq"

PROCEDURE:

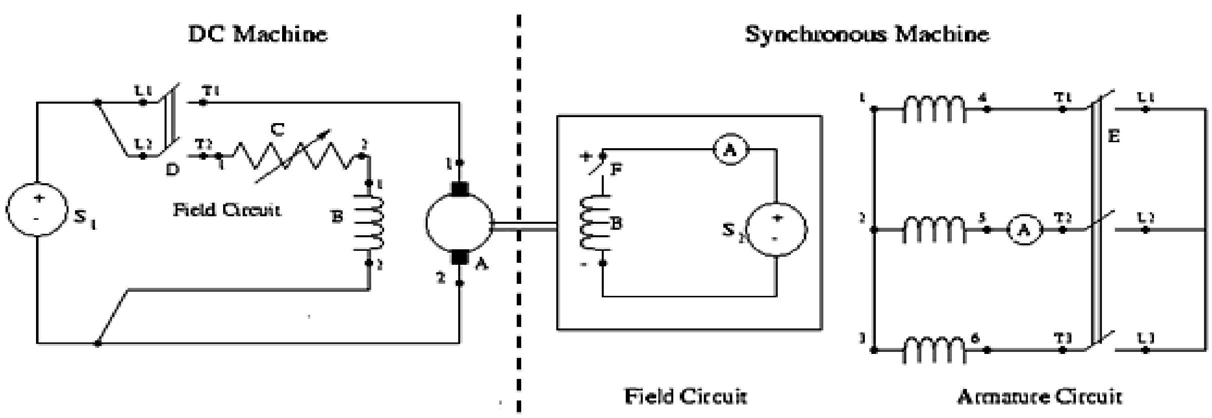
1) Make the connections as shown in the circuit diagram
(similar to short circuit test)

2) Initially disconnect the DSO from the circuit and do the short circuit test and note down the field current & armature current.

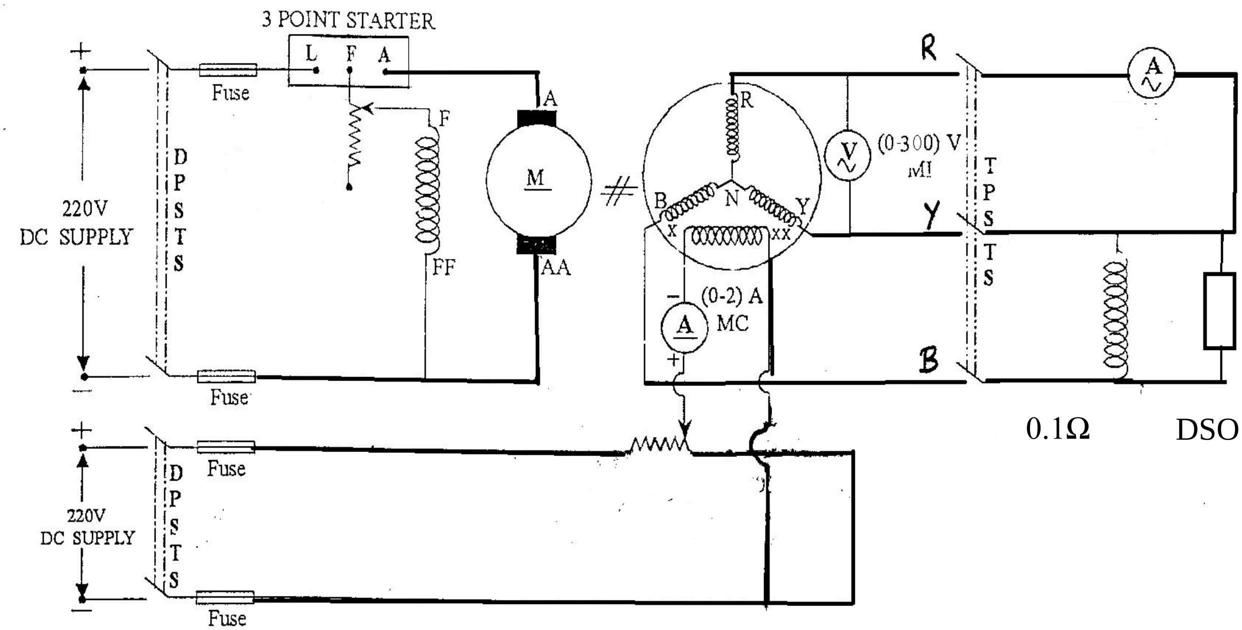
3) Now switch off the knife blade switch and connect the DSO.

4) Again suddenly switch ON & OFF the knife blade switch and take the reading from DSO.

Circuit Diagram of Short Circuit Test:



Circuit Diagram



DISCUSSION AND QUESTIONS

1) In this experiment why 1 phase supply is used and not three phase?
2) What is the purpose of damper winding in synchronous machines?
3) Generally whether Xd" > Xq" or Xd"< Xq" and why.
4) What is the frequency of rotor induced emf in this test and why?
5) What is meant by Xd" and Xq"?
6) Out of Xq, Xq', Xq" which one is minimum? Why?
7) Out of Xd, Xd', Xd" which one is minimum ? Why?
8) What is hunting of synchronous machine?
9) What happen if there is sudden short circuit on the alternator?
10) What do meant by transient stability?

AIM OF THE EXPERIMENT

Experiment No. 08

Measurement of direct and quadrature axis reactance of a Salient Pole Synchronous machine.

Apparatus Required:

Sl. No.	Instrument	Type	Range	Quantity
1.	Voltmeter	AC	0 -300-600V	01 No.
2.	Voltmeter	AC	0 -150-300V	01 No.
3.	Voltmeter	DC	0 -150-300V	01 No.
4.	Ammeter	AC	0-5A	02 Nos.
5.	Ammeter	DC	0-2A	01 Nos.
6.	Wattmeter	UPF	0 -300/600V 2.5/5A	01 No.
7.	Tachometer	Digital	0-9999 rpm	01 No
8.	Variac		3-phase, 8A	01 No
9.	Variac		1-phase, 10A	01 No
10.	Connecting wire		$2.5/1.5mm^2$	10 mtr.
11.	Cutting Plier/Wire Stripper			01 No

Machine Specification :

Sl. No.	Machine	Range	Quantity
1.	DC Shunt Motor	5HP,220V DC, 1500 rpm	01 No
2.	Alternator (Salient Pole type)	3KVA, 3-Phase, 415V AC,	01 No

THEORY:

The synchronous Machine reactance classified into three namely, positive-sequence, negative-sequence reactance and zero-sequence reactance. A synchronous machine has only one negative sequence reactance (X_2) and one zero-Sequence Reactance (X_0). But, it has several positive sequence reactance, these are Direct axis synchronous reactance, Quadrature-axis reactance, Direct axis transient Reactance, Quadrature-axis transient Reactance, Direct axis sub transient Reactance, Quadrature axis sub transient Reactance.

The armature reactance varies from Xq to Xd periodically.

Xd - is the synchronous reactance of armature coil offered to the flow of direct axis current.
Xq – is the synchronous reactance of armature coil offered to the flow of quadrature axis current.

When voltage induced in the field winding is zero, armature current is minimum and the terminal voltage is maximum. At this instant direct axis coincides with armature mmf and corresponding reactance is Xd is given by

$$X_d = \frac{\text{Maximum value of armature voltage / phase}}{\text{Minimum value of armature current / phase}}$$

Similarly when the voltage induced in the field winding is maximum (positive or negative) armature current is maximum and terminal voltage is minimum. At this instant quadrature axis coincides with armature mmf and corresponding reactance is Xq is given by

$$X_q = \frac{\text{Minimum value of armature voltage / phase}}{\text{Maximum value of armature current / phase}}$$

If the readings of maximum and minimum armature current and voltage are taken Xd and Xq can be determined. The readings can not be taken at higher armature current to avoid synchronization.

Positive Sequence Reactance

PROCEDURE :

(1) Connect the circuit as shown. Set the variac output to zero.

(2) Put on the DC supply and run the DC motor of a speed close to the synchronous speed of alternator but less than synchronous speed.

(3) Put on the 3-Phase ac-supply and increase the Variac output upto 5V and observe the variations in the voltmeter readings across stator and field winding. If voltmeter reading is very high across field winding then change the polarity of the input to the Variac and observe the reading once again. ***Only 1/4th of rated voltage of an alternator can be applied during positive sequence experiment.***

(4) Adjust the speed of complete dc motor further to get maximum swings in ammeter and voltmeter.

(5)Note maximum and minimum readings of voltage and current at stator winding.

(6)Take additional sets of reading by adjusting different variation outputs.

(7) Now adjust the dc motor speed to a value little higher than synchronous speed and take similar readings as above.

Tabulation :

For + ve Sequence

Sl.	V_{max}	V_{min}	I_{max}	I_{min}	Speed	X_d	X_q	Xq/Xd	Avg. Xq/Xd
01. 02. 03.					**(1495 to 1499)**				
01. 02. 03.					**(1500 to 1505)**				

$$X_d = \frac{\text{Max. voltmeter reading}}{\text{Min. ammeter reading}}$$

$$X_q = \frac{\text{Min. voltmeter reading}}{\text{Max. ammeter reading}}$$

RESULT :-

The ratio of Xq/ Xd is determined for a salient pole rotor type synchronous machine by slip test which is found to be ------------

DISCUSSION QUESTIONS:-

1) Why it is necessary to keep the field open while taking the reading during slip test.
2) Justify that the reactance obtained by O.C. & S.C test is Xd and not Xq.
3) Defined Xd and Xq.
4) What are the normal values of Xq/Xd for the two types of syn. Machines.
5) How will you recognize whether a given syn. machine is cylindrical rotor type or salient pole type.
6) Why this test is called slip test.
7) Why it is necessary to maintain the slip.
8) What are the main assumptions during this test.

Experiment No. 04 *Determination of Parameters of Synchronous Machine.*
Negative Sequence Reactance.
Zero Sequence Reactance.

Apparatus Required:

Sl. No.	Instrument	Type	Range	Quantity
1.	Voltmeter	AC	0 -300-600V	01 No.
2.	Voltmeter	AC	0 -150-300V	01 No.
3.	Voltmeter	DC	0 -150-300V	01 No.
4.	Ammeter	AC	0-5A	02 Nos.
5.	Ammeter	DC	0-2A	01 Nos.
6.	Wattmeter	UPF	0 -300/600V 2.5/5A	01 No.
7.	Tachometer	Digital	0-9999 rpm	01 No
8.	Variac		3-phase, 8A	01 No
9.	Variac		1-phase, 10A	01 No
10.	Connecting wire		2.5/1.5mm^2	10 mtr.
11.	Cutting Plier/Wire Stripper			01 No

Machine Specification:

Sl. No.	Machine	Range	Quantity
1.	DC Shunt Motor	5HP,220V DC, 1500 rpm	01 No
2.	Alternator (Salient Pole type)	3KVA, 3-Phase, 415V AC,	01 No

DETERMINATION OF NEGATIVE SEQUANCE AND ZERO SEQUENCE REACTANCE OF A SYNCHRONOUS GENERATOR

Negative Sequence Reactance

THEORY:-

When a synchronous generator is carrying an unbalanced load its operation may be analyzed by symmetrical components. In a synchronous machine the sequence current produce an armature reaction which is stationary with respect to reactance and is stationary with respect to field poles. The component currents therefore encounter exactly same as that by a balanced load as discussed. The negative sequence is produced and armature reaction which rotates around armature at synchronous speed in direction to that of field poles and therefore rotates part the field poles at synchronous speed. Inducing current in the field damper winding and rotor iron. The impendence encountered by the negative sequence is called the – ve sequence impedance of the generator. The zero sequence current produce flux in each phase but their combined armature reaction at the air gap is zero. The impedance encountered by their currents is therefore different from that encountered by + ve and –ve sequence components and is called zero sequence impedance of generator.

Negative Sequence Impendence:-

The –ve sequence impedance may be found by applying balanced –ve sequence voltage to the armature terminals. While the machine is drive by the prime mover at its rated synchronous speed with the field winding short circuited. The ratio of v/ph and Ia/ph gives –ve sequence Z/ph. The reading of the wattmeter gives I^2 R losses. This loss /ph divided by Iph required gives the –ve sequence R/ph from the impedance and reactance/ph. –ve sequence can be calculated.

Another method of measuring –ve sequence reactance is found to be connect the arm terminals. The machine is driven at synchronous speed and field current adjusted until rated current flows in the phases shorted through armature and current coil of wattmeter respectively.

PROCEDURE

For Negative Sequence Reactance:

(1) Make connection as shown in circuit diagram.
(2) Run DC motor with synchronous speed.
(3) Keeping the speed constant, vary the excitation and measure the voltmeter, ammeter and wattmeter reading.
(4) Take 3-4 readings for different excitation.
(5) The excitation should not be increased beyond the rated capacity of synchronous machine **i.e. 3.4 A.**

For - ve Sequence

Sl.	Power consumed in watt (P)	Line current (I_L)	Line voltage (V_L)	Z2	X_2
01.					
02.					
03.					

$$Z_2 = \frac{V}{\sqrt{3}I}$$

$$X_2 = Z_2 * \frac{P}{VI}$$

$$X_2 = \frac{V}{\sqrt{3}I} * \frac{P}{VI} = \frac{P}{\sqrt{3}I^2}$$

Zero Sequence Impedance

The sequence impedance may be determined by the connecting the armature windings of the three phase in series and then connecting them to the single phase source of power. If the machine is driven at synchronous speed with field winding shorted, then ZO=V/3I practically the same results will be obtained with rotor stationary.
If windings are connected in parallel, then

$$Z_0 = \frac{\text{Voltage applied to phase}}{\text{Current through each phase}} = \frac{V}{I/3} = \frac{3V}{I}$$

PROCEDURE

For Zero Sequence Reactance:

(1) Make connection as shown in circuit diagram.
(2) Set the dimmer stat output to zero volts and switch on the supply.
3) Gradually increase dimmer stat output and note the ammeter reading for suitable voltage applied.
4) Repeat reading for suitable voltage applied.
5) It should be kept in mind that the ammeter reading should not exceed the rated current capacity of the machine i.e. 3.4 A.

For Zero sequence

No. of Observation	Line voltage in volt (V_L)	Line current in amp	Power in watt	R_o in Ω	Z_0 in Ω	X_0 in Ω
01.						
02.						
03.						

$Z_0 = 3\ (V/I)$ ohm per phase

$R_0 = 3 \left(\frac{W}{I^2}\right)$

$X_0 = \sqrt{Z^2_0 - R^2_0}$

RESULT:-

The negative sequence reactance and zero sequence reactance of an alternator are found to be

X_2 =

X_0 =

DISCUSSION QUESTIONS :-

1. Define X_2 and X_0.
2. What are sequence currents?
3. What are the effects of Negative currents on the rotor (field) winding ?
4. What are the effects of zero sequence currents on the rotor (field) winding ?
5. Give the equivalent circuits of synchronous machine under the influence of the three Sequence currents.

Precaution :

1. All connections should be neat and tight.
2. The meters used should be of proper range.
3. The zero settings of the various instruments should be checked before switching the circuit on.
4. For positive phase sequence the rotor is stand still.
5. During the Negative phase sequence test the short circuit current should be kept low in order to avoid undue heating of the field system.

AIM OF THE EXPERIMENT

Experiment No. 07

Study of parallel operation of two Alternators.

APPARATUS REQUIRED:

Sl. No.	Instrument	Type	Range	Quantity
1.	Ammeter	AC	2.5/5A	06Nos
2.	Ammeter	AC	5/10A	03Nos
3.	Ammeter	DC	1/2A	04Nos.
4.	Voltmeter	DC	150/300V	04Nos.
5.	Voltmeter	AC	600V	02Nos
6.	Wattmeter	UPF	2.5/5A, 600V	02Nos.
7.	Frequency meter	Digital Display	0 -100Hz	02Nos.
8.	Resistive Load	Unbalance type	3ph, 6KW	01No
9.	Tachometer	Digital	9,999rpm	01No
10.	Rheostats	Variable, wire wound	750Ω, 1.2A	04Nos.
11.	Plier			01No
12.	Connecting wire		2.5mm²	10 mtr.

MACHINE SPECIFICATION :

Sl. No.	Machine	Range	Quantity
1.	DC Shunt Motor	5HP,220V DC, 1500 rpm	2 Nos
2.	Alternator with Shaft Extension	3KVA, 3-Phase, 415V AC,	2 Nos

SYNCHRONIZATION OF 3-PHASE ALTERNATORS

Introduction:

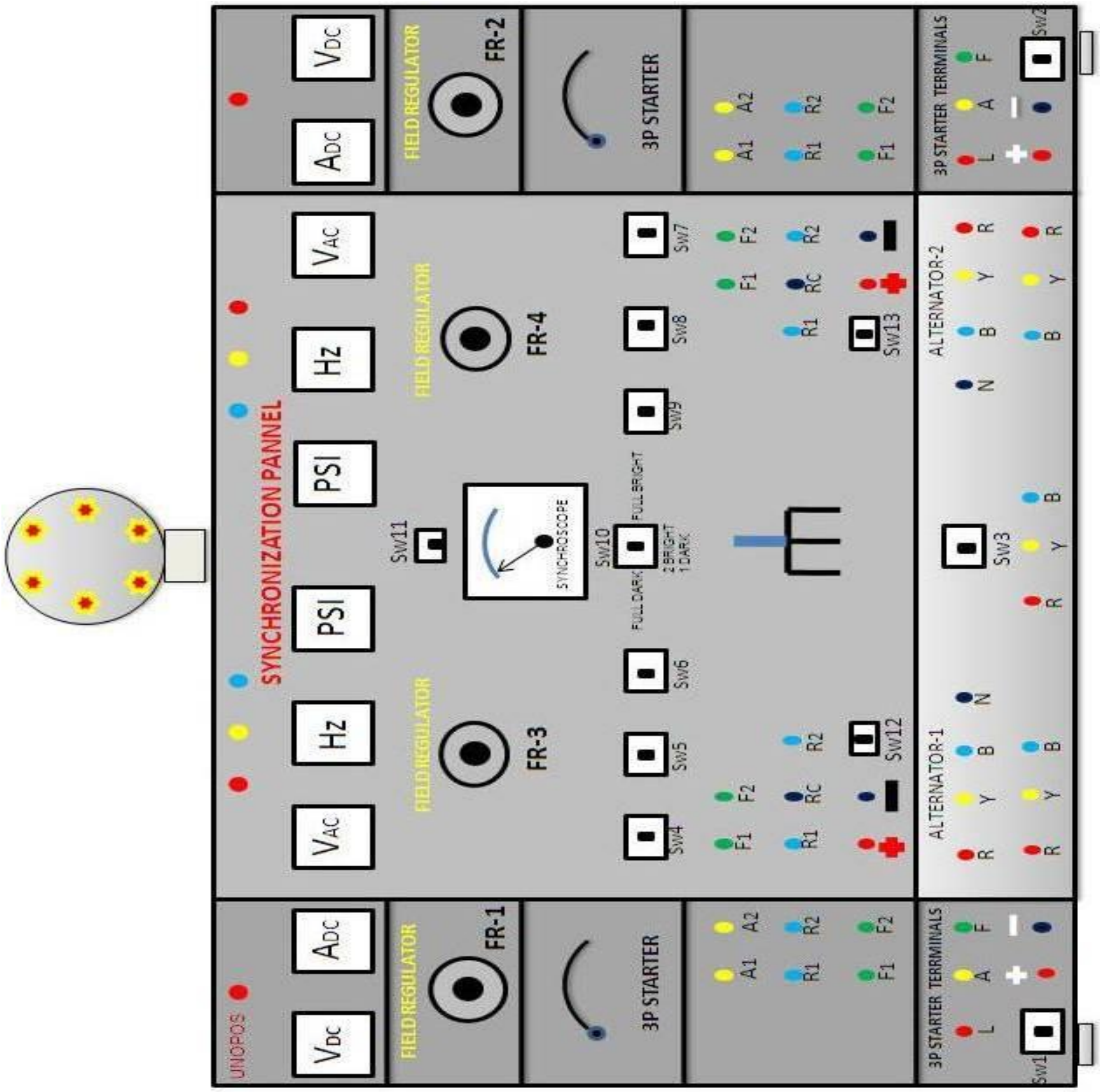
In most power stations it is necessary to supply power from several small units (alternators) than that from a large single unit. There are a number of good reasons for this practice. The reasons for this practice are given below:

1. Local or regional load may exceed the rating of the largest alternator available.
2. High efficiency of operation-the machines are inefficient on part loads and shutting down of one or more alternators allows the remaining machines supplying the load to operate on full load or near full load.
3. Increased reliability – in case of failure of one unit, the continuity of supply can be maintained by other units.
4. Repair of units is more economical and convenient.
5. Small cost of standby unit.
6. Load growth can be handled by additional units without disturbing the original installation.

The process of connecting an Alternator in Parallel with other alternator or with common bus–bars (bus–bar to which a number of alternators are connected) is called Synchronising.

Conditions for proper Synchronising of an Alternators:

1. The terminals Voltage of the incoming machine (Alternator-II) must be approximately equal to bus–bar (running Alternator-I) Voltage.
2. The Frequency of the incoming machine (Alternator-II) must be approximately equal to that of bus–bar (Alternator-I)
3. Phase sequence of the incoming Alternator must be the same (clockwise-direction) as that of the bus–bar (running Alternator-I).



PROCEDURE:

Before starting, keep all the Switches of the **Synchronization Panel** in **OFF** Condition. (Like Knife Blade Switch, Main ON/OFF Switches, Phase Sequence Indicator Switch, Voltmeter Selector Switch. Etc.) Keep the Central Switch (above the Knife Blade Switch) at position No.-1.

1. Connect Alternator –I / Infinite Bus Bar out put to the Synchronization Panel terminals R1, Y1, B1 (left side of the panel board) and Incoming-Alternator-II to the panel Terminals R2, Y2, B2 (right side of the panel board).
2. Connect the Infinite Bus Bar / Run the Alternator–I first.
3. Switch ON the incoming machine (Alternator –II)

4. Set the Alternators Out put to 415volts, while varying the Field Excitation (or field regulator) of the Alternators.
5. Switch ON both the Main Switch of the Panel board (L to R).
6. Switch ON both the Phase Sequence Indicator Switch and observe the phase sequence (clockwise direction) of both the Alternators and Switch OFF the Phase Sequence Indicator Switch immediately.
7. If any one / both of the Phase Sequence Indicator rotation is in Anticlockwise direction then interchange any two adjacent-terminals of Alternator.
8. Adjust the Frequency of both the Alternators so as to make them as nearly as possible equal to the same, while varying the Field Excitation (field regulator) of DC-Motors/Prime Mover.(Set the frequency at 50Hz).
9. Once the Voltage, Frequency and Phase Sequence of both the Alternators are equal, start the experiment as per the following steps.

I) Parallel Operation by Full Bright Lamp Method :

1. **Keep the Central Switch on Position No.-02**
2. The frequency of the machines to be adjusted until the rate of rise and fall of Lamps is quite slow and a Bright Period (Full Glow condition of the Lamps) of about four seconds is observed.
3. The Knife blade switch (Paralleling switch) may then be closed in the middle of the Bright Period.

PRECAUTION: Do not switch ON the Knife Blade Switch if bulbs are not in Full Glow Condition.

Do not keep the Phase Sequence Indicator in ON Position.

II) Parallel Operation by Dark Lamp Method :

1. **Keep the Central Switch on Position No.- 04**
2. The frequency of the machines to be adjusted until the rate of rise and fall of Lamps is quite slow and a DARK Period of about four seconds is observed.
3. The Knife blade switch (Paralleling switch) may then be closed in the middle of the Dark Period.

PRECAUTION: Do not switch ON the Knife Blade Switch if bulbs are not in Full Glow Condition.

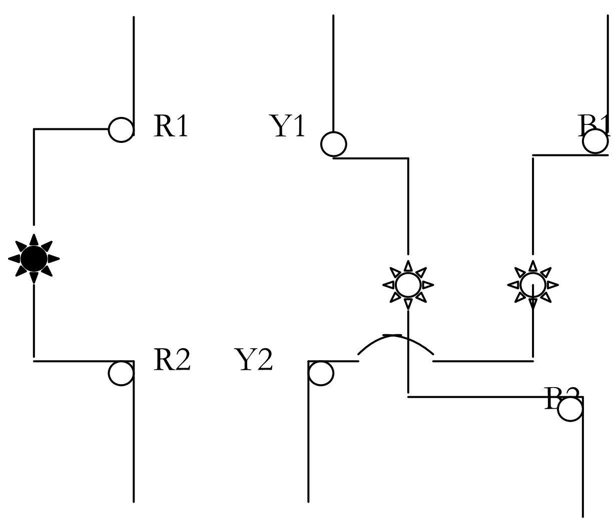
Do not keep the Phase Sequence Indicator in ON Position.

III) Parallel Operation by 2-Bright and 1-Dark Lamp Method:

1. **Keep the Central Switch on Position No.-03**
2. When Six Lamps are placed in a ring, a light wave traveling in Anti-clockwise direction indicates that the incoming machine (Alternator-II) is Slow and light wave traveling in Clockwise direction indicates that the incoming machine (Alternator-II) is Fast. So, by observing the sequences of brightness of the lamps (two in series per phase), it can be determined the incoming Alternator-II is Fast or Slow.
3. The Knife blade switch (Paralleling switch) may be closed when changes in light are very slow and at the instant one phase is DARK (i.e., four lamps are in their Bright Period and two lamps are in their Dark period.)

PRECAUTION: Do not switch ON the Knife Blade Switch if bulbs are not in Full Glow Condition.

Do not keep the Phase Sequence Indicator in ON Position.



The best method of Synchronizing Alternators is by means of Single-phase device known as Synchroscope.

The Synchroscope is an instrument for indicating difference of phase and frequency between two voltages. It is essentially a Split phase motor in which torque is developed if the frequencies of the two Voltages differ. Voltages from corresponding phases of incoming Alternator (Alternator –II) and Running Alternator (Alternator-I) are applied to the Synchroscope.

IV) Parallel Operation by Synchroscope Method

1. Keep the Central Switch on Position No.-1 (OFF-condition of all lamp methods)
2. Switch ON the Synchroscope Switch (Yellow in Colour)
3. If the incoming machine is running faster, pointer of the Synchroscope will move in clockwise direction and if incoming machine is running slower, pointer of the Synchroscope will move in anticlockwise direction. Depending upon the pointer movement adjust the Frequencies of both the Alternators, so as to make them as nearly as possible equal to the same, while varying the Field Regulator of the DC Motors.
4. Switch ON the Knife Blade Switch (Paralleling switch) just before the pointer reaches vertical position when traveling in the fast direction.
5. Switch OFF the Synchroscope Switch immediately after Synchronisation.

PRECAUTION: Do not switch ON the Knife Blade Switch if bulbs are not in Full Glow Condition.

Do not keep the Phase Sequence Indicator in ON Position.

Do not keep the Synchroscope in ON Position.

DISCUSSION QUESTIONS:-

1) What are the conditions of synchronization of two alternators?
2) What are the possible effects of wrong synchronization?
3) What are the different methods for synchronization?
4) Why a lamp pair is required in this experiment?
5) After synchronizing what is the effect of changing the excitation of the alternators.
6) Why the incoming m/c in parallel operation is operated at slightly higher speed then the synchronous speed during synchronization.
7) In parallel operation of generator, for which condition circulating current develop even no load on the machine.
8) What will happen, if synchronization takes place without proper phase sequence?

AIM OF THE EXPERIMENT

Experiment No. 05

Determination of Power Angle Characteristics of an Alternator.

APPARATUS REQUIRED:

Sl. No.	Instrument	Type	Range	Quantity
1.	Stroboscope	Digital	10,000 rpm	01No
2.	Ammeter	AC	5/10A	03Nos
3.	Ammeter	DC	20-0-20A	04Nos.
4.	Voltmeter	DC	300-0-300V	04Nos.
5.	Voltmeter	AC	600V	02Nos
6.	Wattmeter	Center zero UPF	1/2A, 600V	01No.
7.	Frequency meter	Digital Display	0 -100Hz	02Nos.
8.	Resistive Load	Unbalance type	3ph, 6KW	01No
9.	Brass Disc			01No
10.	Connecting wire		2.5mm²	10 mtr.

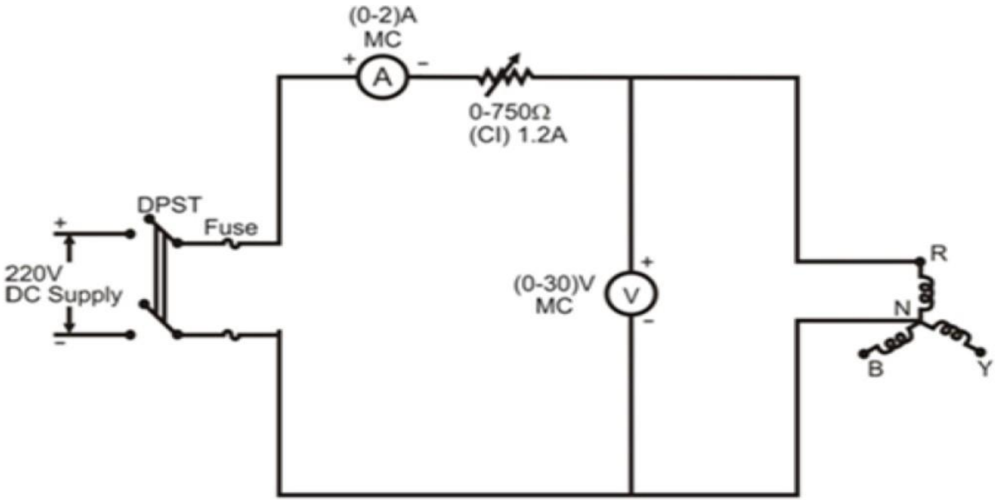
Machine Specification :

Sl. No.	Machine	Range	Quantity
1.	DC Shunt Motor	5HP,220V DC, 1500 rpm	1 No
2.	Alternator with Shaft Extension	3KVA, 3-Phase, 415V AC,	1 No

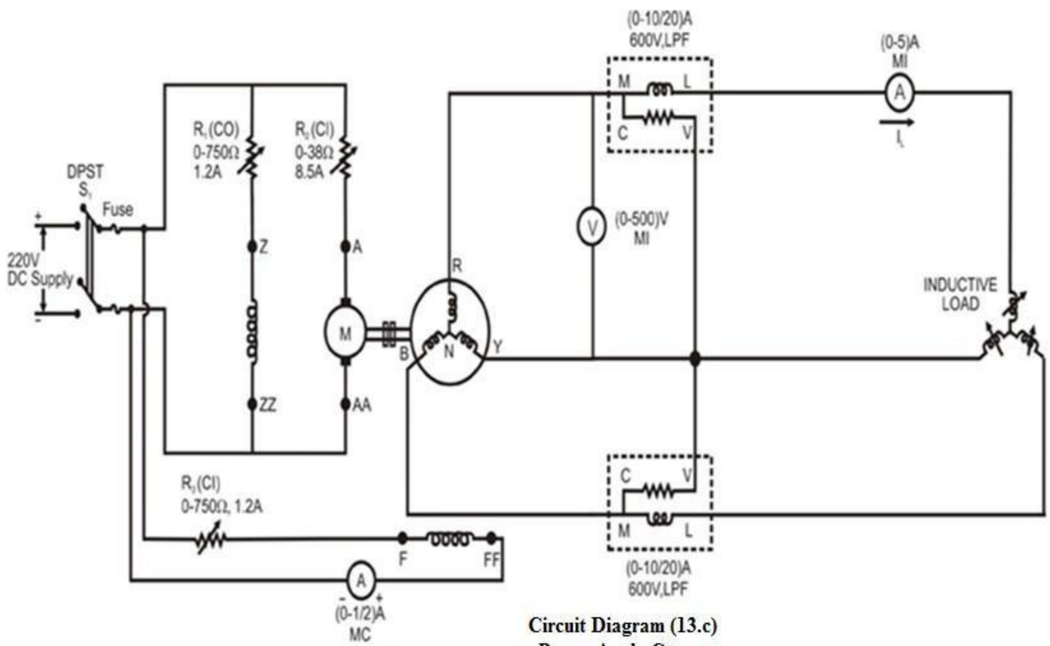
THEORY :

The arrangement between the starter and rotor poles is not an absolutely rigid one. As the load on the motor is increased, the rotor progressively tends to fall back in phase by some angle. The value of this load angle depends on the amount of load to be met by the motor, depends on the angle δ, where δ is called power angle or load angle.

CIRCUIT DIAGRAM:



Determination of Stator Resistance of Alternator (R_a)



Circuit Diagram (13.c)
Power Angle Curve

Procedure :

a. Open circuit test

1. Connections are made as shown in the circuit diagram 13.a

2. Keeping the rheostat R1 in the field circuit of motor in cut-out position, the rheostat R2 in the armature circuit of the motor and the rheostat R3 in the field of the alternator in cut-in positions and TPST (S2) in open position, the supply switch (S1)is closed

3. The motor is brought to synchronous speed by cutting out the rheostat R2 and then by cutting in the rheostat R1, if necessary.

4. By gradually cutting out the rheostat R3, the readings of ammeter (A1, 0-2A) and voltmeter (V) are noted down.

5. The above step is continued until voltmeter reads about 1.25 times the rated voltage of the alternator.

b. Short circuit test

1. The rheostat R3 is brought to its initial position (cut-in) and TPST (S2) is closed.

2. By gradually cutting out the rheostat R3, reading of the ammeter (A2, 0-10/20A) is adjusted to the rated current of the alternator and the corresponding field current (A1) is noted down.

3. All the rheostats are brought back to their respective initial positions, TPST switch(S2)and supply switch (S1) are opened.

Determination of Armature Resistance (R_a) by V-I Method

1. Connections are made as shown in the circuit diagram(.b)
2. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed,Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
3. The supply switch (S_1) is opened.

Power angle curve

1. Connections are made as shown in the circuit diagram (b)
2. Follow the procedure steps 2, 3 of procedure (a).
3. By gradually cutting out the rheostat R3, the alternator voltage is built-up to its ratedvoltage.
4. Apply load in steps & note down all meter readings (Excitation should be constant byadjusting the speed of the Motor).
5. Bring back the load to zero, reduce the excitation to a normal value and all rheostats arebrought back to respective initial positions & supply switch (S1) is opened.

Determination of Stator Resistance of Alternator (R_a)

Sl.No	V (Volts)	I (Ampere)	Resistance R_{DC} = V/I Ω	Resistance R_{AC} =1.5*R_{DC}

CALCULATION

EMF Method

1. Draw OCC and SCC for suitable scales as shown in model graph no (1).

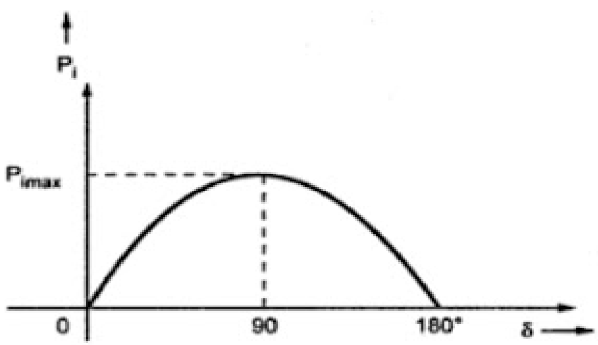
2. Mark a point A on the OCC corresponding to the rated voltage and draw a Perpendicularso that it cuts SCC line at a point B and X-axis at point C.

3. Corresponding to point A, E1 is the open circuit voltage per phase, and BC is the Shortcircuit current.

4. Therefore Synchronous impedance per phase Zs = E1/I1Ω (If Constant) Synchronous reactance per phase $X_s = \sqrt{Zs^2 - Ra^2}\ \Omega$

Sl. No.	If (Amps)	Ia (Amps)	W1 x K1 (Watt)	W2 x K2 (Watt)	N (rpm)	|V| (Volts)	|E| (Volts)	P = W1 + W2 (Watt)	δ Degree

Model Graph



CONCLUSION:

AIM OF THE EXPERIMENT

Experiment No. 02

Determination of the V and inverted V curves of a Synchronous Motor.

APPARATUS REQUIRED:

Sl. No.	Instrument	Type	Range	Quantity
1.	Tachometer	Digital	9,999rpm	01No
2.	Ammeter	AC	5/10A	02Nos
3.	Ammeter	DC	2A	01No.
4.	Voltmeter	DC	300V	01No.
5.	Voltmeter	AC	600V	02Nos
6.	Wattmeter	UPF	5/10A, 600V	02Nos.
7.	Frequency meter	Digital Display	0 -100Hz	01No.
8.	Connecting wire		$2.5mm^2$	10 mtr.

Sl. No.	Machine	Range	Quantity
1.	Synchronous Motor With Loading Arrangement	5HP, 415V AC, 1500 rpm	1 No

THEORY :-
If synchronous motor is connected to a 3- ph. Ac supply with its field winding excited the torque acting on rotor will be of pulsating nature &will change its direction every half revolution of field rotation . Hence the average torque is zero & motor does not start – while if the speed of the motor is brought very near the synchronous speed & then the field winding is excited , the torque acts is one direction for quite a long time &in this time , the motor is pulled into synchronism. To start the motor, thus , it is required to bring it near the synchronous speed &then excite the field . This can be achieved by two methods.

1) Run the motor by an auxiliary motor in a proper direction at the synchronous speed, then switch on the supply to its armature & excite the field . synchronous motor is pulled into synchronous the supply the auxiliary motor is then switched off the excitation can be adjusted to given required power factor.

2) A synchronous motor which is provided with damper winding can be started as an Induction motor .the field winding is kept open . A reduced voltage supply is given to the Armature'. This induces a voltage in damper bars & the motor starts running is an Induction motor . The supply voltage is now increased to its normal value. The Speed increases and is allowed to reach synchronous speed .At this speed, the field is excited which pulls the motor into synchronism at synchronous speed , there is no current in damper bars & hence no induction torque acts . In a synchronous motor, the rotor follows rotating magnetic field . If the direction of rotation is to be reversed. This can be achieved by changing the phase sequence of the voltage to the armature winding.

PROCEDURE:-

(1) Note down the name plate details of the motor.
(2) Connections are made as pr the circuit diagram.
(3) Connect as figure shown below.
(4) Keep the switch connected to the field circuit in position no.1
(5) Set the variac to minimum position & switch on the supply.
(6) When the motor speed is close to the synchronous speed change – over the switch to position '2'. The field winding is excited by varying the Variac knob, the machine runs at synchronous speed .
(7) Note down its speed (if run at its synchronous speed .
(8) By varying the field excitation note down the excitation current, armature current and the power factor for various values of excitation.
(9) The same process has to be repeated for loaded condition.
(10) Later the motor is switched OFF and the graph is drawn.

PRECAUTION:

(1) Field winding must be kept open
(2) The motor should be started without load .

OBSERVATIONS:-

[A] AT NO LOAD

Sl. No.	I_f	Power Factor (cos Ø)	I_a
1			
2			
3			
4			
5			

[B] AT LOAD

Sl. No.	I_f	Power Factor (Cos Ø)	I_a
1			
2			
3			
4			
5			

GRAPH:

Plot the curves between armature current (Ia) vs field current (If) and power factor (cosf) vs field current (If)

CONCLUSION:

1. The variation of armature current (line current) and its power factor due to field current variation at load and at no load are shown. The armature current is minimum when the PF is unity.
2. As load increases the V curve shifts upward and the inverted V curve shift towards right.

DISCUSSION :

1. With what condition synchronous motor can be used as a synchronous condenser**.**
2. What are the special applications of an over excited synchronous motor.
3. Explain the effect of change of excitation of a synchronous motor on its armature current.
4. Explain the effect of change of excitation of a synchronous motor on its power factor.
5. With the given excitation a synchronous motor draws a unity PF current . if the Mechanical load is increased what will be the power factor and current for the same excitation.
6. Why V curve shift upwards and inverted V curve shift right as the load increases.
7. Explain the effect of change of excitation of a synchronous generator on its armature current.
8. Explain the effect of change of excitation of a synchronous generator on its power factor.

AIM OF THE EXPERIMENT

Experiment No. 03

Speed control of a three phase induction motor using Variable Frequency Drive.

Apparatus Required:

Sl. No.	Instrument	Type	Range	Quantity
01	Voltmeter	AC		
02	Ammeter	AC		
03	VVF Drive			01No
04	Connecting wire		$1.5mm^2$	10 mtr.

Machine Specification :

Sl. No.	Machine	Range	Quantity
1.	Squirrel cage induction motor	2HP, 220V DC, 1500 rpm	1 No

THEORY:

VVVF stands for Variable Voltage Variable Frequency. VVVF Speed Control method is widely used method for Induction Motor. As we know that synchronous speed of machine is given as N_s (rpm) = 120f/P (1) where f is frequency and P is number of pole.

Thus if we can change the frequency f then it is possible to change the speed of induction motor. Now frequency of power supply can easily be varied using power electronics devices like inverter. The inverter converts DC power into AC power and feeds to induction motor. Inverter output may be either constant voltage variable frequency or variable voltage variable

frequency. Suppose inverter output is constant voltage but variable frequency. Thus we can write V = Constant but f = Variable. The relationship between voltage V and frequency f is well known and can be written as

V = 4.44fNØ .... (2)

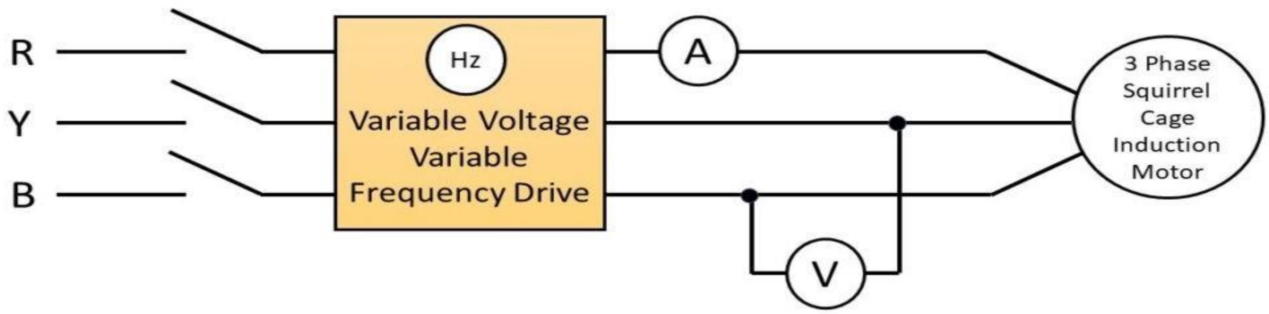
where N is number of turns per phase and Ø is resultant air gap flux.

Suppose we want to reduce the speed of induction motor. For this, obviously we will have to reduce the frequency f while keeping V constant as per (1). But from (2), $Ø = V / (4.44fN)$ (3)

Air gap flux Ø will increase which may cause machine core to saturate which is not desirable.

But from (3), it is possible to achieve constant flux Ø by maintaining (V/f) constant. This allows us to change voltage and frequency simultaneously to have speed control while maintaining constant air gap flux. This is the basic concept behind VVVF speed control of induction motor.

CIRCUIT DIAGRAM:



TABULATION:

Sl. No.	Line Voltage	Frequency	Speed
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

Observations:

1. **Draw the curve between speed and line voltage.**
2. **Draw the curve between speed and frequency.**

AIM OF THE EXPERIMENT

Experiment No. 06

Determination of parameter of a three phase induction motor .

To obtain the variation of no load power and current and blocked rotor power and current with changes in the applied voltage to the stator. 2. To determine the equivalent circuit parameters of an induction motor.

APPARATUS REQUIRED:

Sl. No.	Instrument	Type	Range	Quantity
01	Variac	Variable	1-Phase, 10A	01 No
02	Ammeter	AC	5A	02 Nos
03	Voltmeter	AC	150/300V	02 Nos
04	Connecting wire		$2.5mm^2$	10 mtr.

MACHINE SPECIFICATION :

Sl. No.	Machine	Range	Quantity
1.	Induction Run Motor	3HP, 415V AC, 1440 rpm, Drum brake loading arrangement	1 No

THEORY:

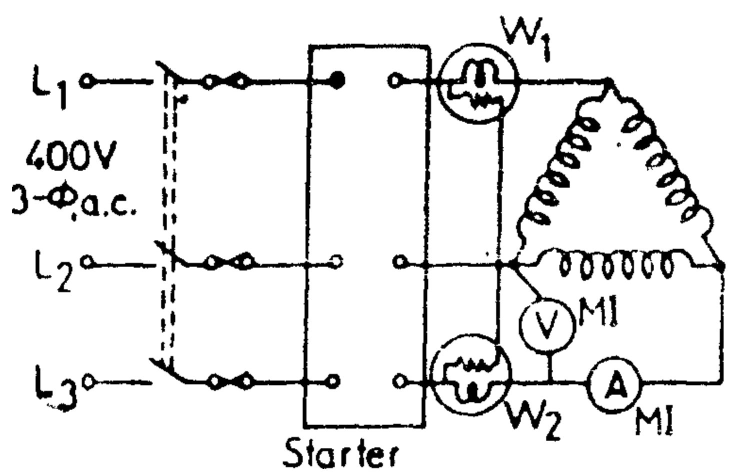
The no load test is similar to the open circuit test on a transformer. It is performed to obtain the magnetizing branch parameters (shunt parameters) in the induction machine equivalent circuit. In this test, the motor is allowed to run with no-load at the rated voltage of rated frequency across its terminals. Machine will rotate at almost synchronous speed, which makes slip nearly equal to zero. This causes the equivalent rotor impedance to be very large (theoretically infinite neglecting the frictional and rotational losses). Therefore, the rotor equivalent impedance can be considered to be an open circuit which reduces the equivalent circuit diagram of the induction machine (Fig. 1) to the circuit as shown in Fig. 2. Hence, the data obtained from this test will give information on the stator and the magnetizing branch. The connection circuit diagram of no load test is shown in Fig. 3. The no load parameters can be found from the voltmeter, ammeter, and wattmeter readings obtained when the machine is run at no load as shown below:

Readings Obtained: 1. Line to line voltage at stator terminals: V_o volts
2. Stator Phase Current : I_o amps
3. Per phase power drawn by the stator : W_o watts

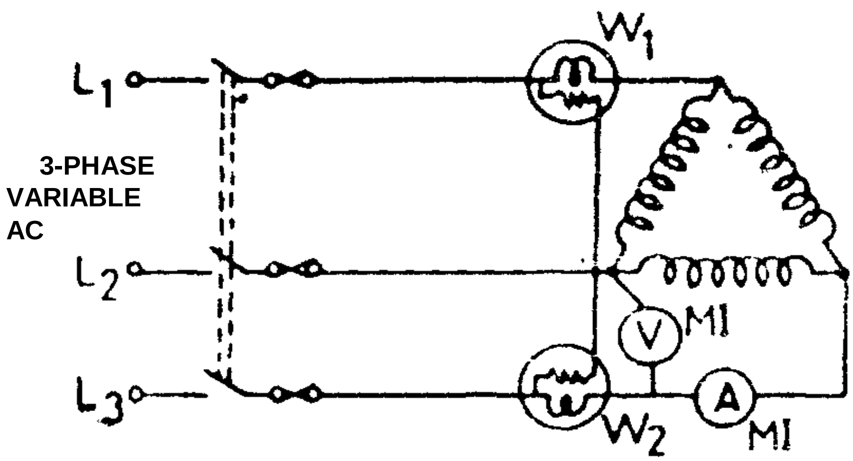
Blocked rotor test is similar to the short circuit test on a transformer. It is performed in the to calculate the series parameters of the induction machine i.e., its leakage impedances. The rotor is blocked to prevent rotation and balanced voltages are applied to the stator terminals at a frequency of 25 percent of the rated frequency at a voltage where the rated current is achieved. Under the reduced voltage condition and rated current, core loss and magnetizing component of the current are quite small percent of the total current.

CIRCUIT DIAGRAM:

FOR NO-LOAD TEST



FOR BLOCKED ROTOR TEST



PROCEDURE:

For blocked Rotor test

1. Connect the circuit as per the circuit diagram.
2. Make the Rotor rest by arranging Brake or Firction pulley.
3. Before switching make the variac at zero position.
4. Switch on the main supply.
5. Applied three-phase voltage to the stator main winding.
6. Increased the applied voltage gradually from zero so that Rated current flows in the main winding.
7. Note down the ammeter, voltmeter and wattmeter readings.
8. Measure d.c. resistance of main stator winding by ammeter-voltmeter method.
9. Multiply the obtained d.c. resistance by a Factor 1.1 to 1.3 so as to obtain effective a.c. resistance and note it down.

No Load Test

1. Connect the circuit as per the circuit diagram.
2. Before switching make the variac at zero position.
3. Switch on AC supply.
4. Applied three-phase voltage.
5. Measure the RPM of the Rotor.
6. Observe that, if the speed is 75% of the Rated speed then open the centrifugal switch.
7. After opening the switch increase voltage upto Rated condition and measure the speed.
8. Note down the ammeter wattmeter and voltmeter reading.

Tabulation:

Blocked Rotor Test

No. of observation	Voltmeter Reading (V_{sc}) in volt	Ammeter Reading (I_{sc}) in amp	Power (W_{sc}) In watts

No Load Test

No. of observation	Voltmeter Reading (V_0) in volt	Ammeter Reading (I_0) in amp	Power (W_0) In watts

Calculation:

<u>From blocked Rotor Test</u>

Equivalent impedance = $Z_{sc} = V_{sc}/I_{sc}$

Equivalent Resistance = $R_{sc} = r_2 + \left(\frac{r_1}{2}\right) 2 = \frac{W_{sc}}{I^2_{sc}}$

Resistance of main stator winding = r_1

$r_2 = R_{sc} - r_1$

$= \frac{W_{sc}}{I^2_{sc}} - r_1$

$X_{sc} = x_1 + \left(\frac{1}{2} x_2\right) X\ 2$

$= x_1 + x_2$

Since leakage reactance x_1 and x_2 can not be separated out so

$x_1 = x_2$

$x_1 = x_2 = \frac{1}{2} X_{sc}$

$x_1 = x_2 = \frac{1}{2} \sqrt{Z^2_{sc} - R^2_{sc}}$

<u>From No Load Test</u>

$\cos \theta 0 = \frac{W_0}{V_0 I_0}$

No load equivalent impedance $Z0 = \frac{V_0}{I_0}$

$X_0 = Z_0 \sqrt{1-\cos^2\theta_0}$

$= Z_0 \sin \theta_0$

$Z_0 = R_0 + Jx_0$

$= \left(r_1 + \frac{r_2}{2} \right) + J \left[x_1 + \frac{1}{2} (x_2 + x_m) \right]$

$Z_0 = R_0 + jx_0$

$X_1 + \frac{1}{2} (x_2 + x_m) = X_0$

(X_1 and X_2 known from blocked Rotor test)

Conclusion:

No load and blocked Rotor test was performed on the capacitor start Induction motor. The parameters were determined.