ELECTRICAL MACHINES-II LABORATORY

M A N U A L

EEE

DEPARTMENT OF ELECRICAL & ELECTRONICS ENGINEERING

BALAJI INSTITUTE OF TECHNOLOGY AND SCIENCE

NARSAMPET, WARANGAL.

Vision and Mission of EEE Department

Vision:

To nurture excellence in the field of Electrical & Electronics Engineering by imparting core values to the learners and to mould the institution into a centre of academic excellence and advanced research.

Mission:

M1: To impart students with high technical knowledge to make globally adept to the new Technologies

M2: To create, disseminate and integrate knowledge of engineering, science and technology that expands the electrical engineering knowledge base towards research

M3: To provide the students with a platform for developing new products and systems that can help industry and society as a whole.

Program Outcomes

PO1	**Engineering knowledge:** Apply the knowledge of basic sciences and fundamental engineering concepts in solving engineering problems.
PO 2	**Problem analysis:** Identify and define engineering problems, conduct experiments and investigate to analyze and interpret data to arrive at substantial conclusions.
PO 3	**Design/development of solutions:** Propose an appropriate solution for engineering problems complying with functional constraints such as economic, environmental, societal, ethical, safety and sustainability.
PO 4	**Conduct investigations of complex problems:** Perform investigations, design and conduct experiments, analyze and interpret the results to provide valid conclusions.
PO 5	**Modern tool usage:** Select/ develop and apply appropriate techniques and IT tools for the design and analysis of the systems.
PO 6	**The engineer and society:** Give reasoning and assess societal, health, legal and cultural issues with competency in professional engineering practice.
PO 7	**Environment and sustainability:** Demonstrate professional skills and contextual reasoning to assess environmental/ societal issues for sustainable development.
PO 8	**Ethics:** An ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary situations.
PO 10	**Communication:** An ability to communicate effectively.
PO 11	**Project management and finance:** Demonstrate apply engineering and management principles in their own / team projects in multi-disciplinary environment.
PO 12	**Life-long learning:** An ability to do the needs of current technological trends at electrical industry by bridging the gap between academic and industry.

Program Specific Outcomes

PSO1	Apply fundamental knowledge to identify, analyze diverse problems associated with electrical and electronic circuits, power electronics drives and power systems.
PSO2	Understand the current technological developments in Electrical & Electronics Engineering and develop the innovative products/software to cater to the needs of society & Industry.

Program Educational Objectives

PEO1	To prepare students with solid foundation in Mathematics, Sciences and Basic Engineering to cover multi-disciplinary subjects enabling them to comprehend, analyze Electrical & Electronics Engineering problems and develop solutions.
PEO2	To design and develop an electrical system component or process to meet the needs of society and industry with in realistic constraints.
PEO3	To prepare students with technical competence to use advance techniques, skills and modern engineering tools that allow them to work effectively as electrical and electronics engineer.

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Exp .No	Name of the Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Oc & Sc Tests On Single Phase Transformer	PO1, PO9	PSO1
2	Sumpner's Test On A Pair Of Single Phase Transformer	PO1, PO9	PSO1
3	Scott Connection Of Transformers.	PO1, PO9	PSO1
4	Noload & Blocked Rotor Test On Three Phase Induction Motor	PO1, PO9	PSO1
5	Regulation Of A Three Phase Alternator By Synchronous Impedance & Mmf Methods	PO1, PO9	PSO1
6	V & Inverted V Of A Three Phase Synchronous Motor	PO1, PO9	PSO1
7	Equivalent Circuit Of A Single Phase Induction Motor	PO1, PO9	PSO1
8	Determination Of Xd & Xq Of A Salient Pole Synchronous Machine.	PO1, PO9	PSO1
9	Brake Test On Three Phase Induction Motor	PO1, PO9	PSO1
10	Regulation Of A Three Phase Alternator By Zpf & Asa Methods	PO1, PO9	PSO1
11	Efficiency Of A Three Phase Alternator	PO1, PO9	PSO1
12	Seperation Of Core Losses Of A Single Phase Transformer	PO1, PO9	PSO1

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PREFACE

This Laboratory book in Electrical Measurements has been revised in order to be up to date with Curriculum changes, laboratory equipment upgrading and the latest circuit simulation.

Every effort has been made to correct all the known errors, but nobody is perfect, if you find any additional errors or anything else you think is an error, please contact the HOD/EEE at mallik95_eee@yahoo.com

The Authors thanked all the staff members from the department for their valuable Suggestion and contribution.

The author would welcome the advice and suggestions leading to the improvement of the book.

The Authors,

Department of EEE.

Safety Rules and operating Procedures	**I**
Laboratory Safety information	**II**
Guidelines for Laboratory Notebook	**III**
Troubleshooting Hints	**IV**

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. 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)

21. 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. Moving iron meters are cheaper and more rugged compared to moving coil 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.

22. Some students have been found to damage meters by mishandling in the following ways:

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

STUDENTS ARE STRICTLY WARNED THAT FULL COST OF THE METER WILL BE RECOVERED FROM THE INDIVIDUAL WHO HAS DAMAGED IT IN SUCH A MANNER.

Copy these rules in your Lab Record. Observe these yourself and help your friends to observe.

I have read and understand these rules and procedures. I agree to abide by these rules and procedures at all times while using these facilities. I understand that failure to follow these rules and procedures will result in my immediate dismissal from the laboratory and additional disciplinary action may be taken.

Signature Date Lab

GUIDELINES FOR LABORATORY NOTEBOOK

The laboratory notebook is a record of all work pertaining to the experiment. This record should be sufficiently complete so that you or anyone else of similar technical background can duplicate the experiment and data by simply following your laboratory notebook. Record everything directly into the notebook during the experiment. Do not use scratch paper for recording data. Do not trust your memory to fill in the details at a later time.

Organization in your notebook is important. Descriptive headings should be used to separate and identify the various parts of the experiment. Record data in chronological order. A neat, organized and complete record of an experiment is just as important as the experimental work.

1. Heading:
The experiment identification (number) should be at the top of each page.Your name and date should be at the top of the first page of each day's experimental work.

2. Object:
A brief but complete statement of what you intend to find out or verify in the experiment should be at the beginning of each experiment

3. Diagram:
A circuit diagram should be drawn and labeled so that the actual experiment circuitry could be easily duplicated at any time in the future. Be especially careful to record all circuit changes made during the experiment.

4. Equipment List:
List those items of equipment which have a direct effect on the accuracy of the data. It may be necessary later to locate specific items of equipment for rechecks if discrepancies develop in the results.

5. Procedure:
In general, lengthy explanations of procedures are unnecessary. Be brief. Short commentaries alongside the corresponding data may be used. Keep in mind the fact that the experiment must be reproducible from the information given in your notebook.

6. Data:
Think carefully about what data is required and prepare suitable data tables. Record instrument readings directly. Do not use calculated results in place of direct data; however, calculated results may be recorded in the same table with the direct data. Data tables should be clearly identified and each data column labeled and headed by the proper units of measure.

7. Calculations:
Not always necessary but equations and sample calculations are often given to illustrate the treatment of the experimental data in obtaining the results.

8. Graphs:
Graphs are used to present large amounts of data in a concise visual form. Data to be presented in graphical form should be plotted in the laboratory so that any questionable data points can be checked while the experiment is still set up. The grid lines in the notebook can be used for most graphs. If special graph paper

is required, affix the graph permanently into the notebook. Give all graphs a short descriptive title. Label and scale the axes. Use units of measure. Label each curve if more than one on a graph.

9. Results:

The results should be presented in a form which makes the interpretation easy. Large amounts of numerical results are generally presented in graphical form. Tables are generally used for small amounts of results. Theoretical and experimental results should be on the same graph or arrange in the same table in a way for easy correlation of these results.

10. Conclusion:

This is your interpretation of the results of the experiment as an engineer. Be brief and specific. Give reasons for important discrepancies.

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 1 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.

ELECTRICAL MACHINES LAB - II

LIST OF EXPERIMENTS

1. OC & SC TESTS ON SINGLE PHASE TRANSFORMER
2. SUMPNER'S TEST ON A PAIR OF SINGLE PHASE TRANSFORMER
3. SCOTT CONNECTION OF TRANSFORMERS.
4. NOLOAD & BLOCKED ROTOR TEST ON THREE PHASE INDUCTION MOTOR
5. REGULATION OF A THREE PHASE ALTERNATOR BY SYNCHRONOUS IMPEDANCE & MMF METHODS
6. V & INVERTED V OF A THREE PHASE SYNCHRONOUS MOTOR
7. EQUIVALENT CIRCUIT OF A SINGLE PHASE INDUCTION MOTOR
8. DETERMINATION OF Xd & Xq OF A SALIENT POLE SYNCHRONOUS MACHINE.
9. BRAKE TEST ON THREE PHASE INDUCTION MOTOR
10. REGULATION OF A THREE PHASE ALTERNATOR BY ZPF & ASA METHODS
11. EFFICIENCY OF A THREE PHASE ALTERNATOR
12. SEPERATION OF CORE LOSSES OF A SINGLE PHASE TRANSFORMER

OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

Aim: To perform open circuit and short circuit test on a single phase transformer and to pre-determine the efficiency, regulation and equivalent circuit of the transformer.

Apparatus required:

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-30)V	1 no 1 no
2	Ammeter	MI	(0-1)A (0-10)A	1 no 1 no
3	Wattmeter	Dynamo type	(0-300)V LPF (0-2.5)A	1 no
4	Wattmeter	Dynamo type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	*****	Required

Transformer Specifications:

Transformer Rating :(in KVA) ________________________

Winding Details:

LV (in Volts): _____________________________ LV side current:_________________________

HV (in Volts): _____________________________ HV side Current:________________________

Type (Shell/Core):___________________________

Auto transformer Specifications:

Input Voltage (in Volts):__________________________

Output Voltage (in Volts): ________________________

Frequency (in Hz):________________________ Current rating (in Amp):_____________________

Theory:

OPEN CIRCUIT TEST :

Procedure:

1. Connections are made as per the circuit diagram.
2. Ensure that variac is set to zero output voltage position before starting the experiment.
3. Switch ON the supply. Now apply the rated voltage to the Primary winding by using Variac.
4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.
5. Then Variac is set to zero output position and switch OFF the supply.
6. Calculate $\mathbf{R_o}$ and $\mathbf{X_o}$ from the readings.

Calculations for OC test:

$$V_0 I_0 \cos\phi_0 = W_0$$

$$\cos\phi_0 = \frac{W_0}{V_0 I_0}$$

$$I_u = I_0 \sin\phi_0$$

$$I_w = I_0 \cos\phi_0$$

$$X_0 = \frac{V_0}{I_u} = \frac{V_0}{I_0 \sin\phi_0}$$

$$R_0 = \frac{V_0}{I_w} = \frac{V_0}{I_0 \cos\phi_0}$$

SHORT CIRCUIT TEST:

Procedure:

1. Connections are made as per the circuit diagram.
2. Ensure that variac is set to zero output voltage position before starting the experiment.
3. Switch ON the supply. Now apply the rated Current to the Primary winding by using Variac.
4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.
5. Then Variac is set to zero output position and switch OFF the supply.
6. Calculate $\mathbf{R_{o1}}$ and $\mathbf{X_{o1}}$ from the readings.

Calculations for SC test:

$$Z_{sc} = Z_{01} = \frac{V_{sc}}{I_{sc}}$$

$$W_{sc} = I_{sc}^2 * R_{01}$$

$$R_{01} = \frac{W_{sc}}{I_{sc}^2}$$

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$$

Let

V_o2 = Secondary terminal voltage at No- Load

V2 = Secondary terminal voltage on Full Load

$$\% \text{ Regulation} = \frac{V_{o2} - V_2}{V_{o2}} * 100$$

$$\% \text{ Regulation (lead, lag \& unity)} = \frac{I_1 R_{01} \cos\phi_o \pm I_1 X_{01} \sin\phi_o}{V_1} * 100$$

.

Tabular column For OC test

Sl no.	Voltmeter reading (V_o)	Ammeter reading (I_o)	Wattmeter reading W_o	R_o	X_o	Cos ϕ_o

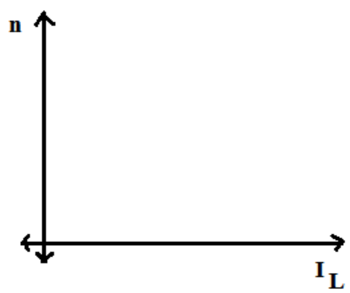
Tabular column For SC test

Sl no.	Voltmeter reading (V_{SC})	Ammeter reading (I_{SC})	Wattmeter reading W_{SC}	R_{o1}	Z_{o1}	X_{o1}

Equivalent Circuit Diagram

Graph:

Load Current Vs Efficiency



$$\text{efficiency} = \frac{\text{output}}{\text{input}} * 100$$

Calculate efficiencies at Full load, half load, ¾ load & ¼ loads.

Result:

SCOTT CONNECTION OF TRANSFORMERS

Aim: To perform the Scott connection of transformer from three phase to two phase connection.

Apparatus required:

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-600)V	3 no 1 no
2	Ammeter	MI	(0-1)A	1 no
3	Connecting Wires	*****	*****	Required

Transformer Specifications:
MAIN Transformer
Transformer Rating :(in KVA) ________________________
Winding Details:
LV (in Volts): ____________________________ LV side current:________________________
HV (in Volts): ____________________________ HV side Current:_______________________
Type(Shell/Core):__________________________
Tappings: _________________________________

TEASER Transformer
Transformer Rating :(in KVA) ________________________
Winding Details:
LV (in Volts): ____________________________ LV side current:________________________
HV (in Volts): ____________________________ HV side Current:_______________________
Type(Shell/Core):__________________________
Tappings: _________________________________

3 - ϕ Auto transformer Specifications:
Input Voltage (in Volts):_________________________
Output Voltage (in Volts): _______________________
Frequency (in Hz):_______________________ Current rating (in Amp):____________________

Theory:

Procedure:

1. Connections are made as per the circuit diagram
2. Ensure that output voltage of the variac is set in zero position before starting the experiment.
3. Switch ON the supply.
4. The output voltage of the variac is gradually increased in steps upto rated voltage of single phase MAIN transformer and readings are correspondingly taken in steps.
5. Enter the readings in tabular column.
6. After observations, the variac is brought to zero position and switch OFF the supply.

Calculation:

Prove

$$V_{2TM} = \sqrt{V_{2T}^2 + V_{2M}^2}$$

Tabular Column:

Sl no.	Voltmeter reading V_1	Ammeter reading I_1	Voltmeter reading V_{2T}	Voltmeter reading V_{2M}	Voltmeter reading V_{2TM}	Theoretical calculation $V_{2TM} = \sqrt{(V^2_{2T} + V^2_{2M})}$

Result:

SUMPNERS TEST

Aim: to determine the efficiency and losses of a given transformer accurately under full load condition.

Apparatus required:

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-60)V (0-600)V	1 no 1 no 1 no
2	Ammeter	MI	(0-2)A (0-10)A	1 no 1 no
3	Wattmeter	Dynamo type	(0-300)V LPF (0-2.5)A	1 no
4	Wattmeter	Dynamo type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	*****	Required

Transformer Specifications:

Two identical 1- ϕ Transformers

Transformer Rating :(in KVA) ________________________

Winding Details:

LV (in Volts): ____________________________ LV side current:________________________

HV (in Volts): ____________________________ HV side Current:_______________________

Type(Shell/Core):__________________________

1 - ϕ Auto transformer Specifications:

Input Voltage (in Volts):_________________________

Output Voltage (in Volts): _______________________

Frequency(in Hz):_______________________ Current rating (in Amp):____________________

Theory:

Procedure:

1. Make the connections as per the circuit diagram.
2. The secondary winding terminals of the two transformers are connected in series with polarities in phase opposition which can checked by means of a voltmeter.

3. Before starting the experiment, check the variacs are in minimum output voltage position.
4. Close the first DPST-1 switch and switch ON the supply.
5. Increase the variac slowly, and apply rated voltage to the primary windings of 1- ϕ transformers and check the voltmeter reading connected across the secondary terminals.
6. If the voltmeter reading is Zero, continue with step 8.
7. If the voltmeter reading is not zero, interchange the secondary terminals.
8. Now close the DPST-2 switch and vary the variac-2 slowly till rated current flows in the two series-connected secondaries.
9. Note down the readings of V_1,V_2, I_1, I_2, W_1, and W_2 and enter them in a tabular column.
10. $W_1 = 2P_c$, $W_2 = 2P_{sc}$. Losses of each transformer = $(W_1+W_2)/2$
11. Now the Variacs are brought to zero voltage position and open DPST switches.

Precautions:

1. Initially Autotransformers are kept in minimum position
2. DPST-1, DPST-2, and SPST are kept in open position.
3. Check the polarities of transformer.

Tabular column:

Sl no.	**Voltmeter reading V_1**	**Voltmeter reading V_2**	**Ammeter reading I_1**	**Ammeter reading I_1**	**Wattmeter Reading W_1**	**Wattmeter Reading W_2**	**Transformer losses = $(W_1+W_2)/2$**	**η = op/(op+loss)**

Result:

EQUIVALENT CIRCUIT OF A SIGLE PHASE INDUCTION MOTOR

Aim: to determine the equivalent circuit parameters of a single phase induction motor by performing the no- load and blocked rotor tests.

Appparatus required:

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Dynamotype	(0-300)V LPF (0-10)A	1 no
4	Wattmeter	Dynamotype	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	*****	Required

1 - ϕ induction motor specifications:

Name plate details

Sl. no.	quantity	
1	rated power	
2	Rated voltage	
3	Current	
4	Speed(RPM)	
5	Cos ϕ (pf)	
6	Frequency	
7	rotor	Squirrel cage

Theory:

Procedure:

NO LOAD TEST:

1. The circuit connections are made as per the circuit diagram.
2. Be sure that variac (auto transformer) is set to zero output voltage position before starting the experiment.
3. Now switch ON the supply and close the DPST switch.
4. The variac is varied slowly, until rated voltage is applied to motor and rated speed is obtained.
5. Take the readings of Ammeter, Voltmeter and wattmeter in a tabular column.
6. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.

BLOCKED ROTOR TEST

1. To conduct blocked rotor test, necessary meters are connected to suit the full load conditions of the motor.
2. Connections are made as per the circuit diagram.
3. Before starting the experiment variac (auto transformer) is set to zero output voltage position.
4. The rotor (shaft) of the motor is held tight with the rope around the brake drum.
5. Switch ON the supply, and variac is gradually varied till the rated current flows in the induction motor.
6. Readings of Voltmeter, Ammeter, and wattmeter are noted in a tabular column.
7. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.
8. Loosen the rope after the experiment is done.

CALCULATION FOR NO-LOAD TEST:

$$V_0 I_0 \cos\phi_0 = W_0$$

$$\cos\phi_0 = \frac{W_0}{V_0 I_0}$$

$$Z_0 = \frac{V_0}{I_0}$$

$$X_0 = Z_0 \sin\phi_0$$

$$X_0 = X_1 + \frac{1}{2}(X_2 + X_m)$$

$$X_m = 2(X_0 - X_1) - X_2$$

CALCULATION FOR BLOCKED ROTOR TEST

$$Z_{sc} = \frac{V_{sc}}{I_{sc}}$$

$$R_{sc} = \frac{W_{sc}}{I_{sc}^2}$$

r_1 is the DC resistance of stator of motor

$$r_2 = R_{sc} - r_1$$

$$x_1 + x_2 = X_{sc}$$

since leakage reactance can't be seperated out , it is common practice to to assume $x_1 = x_2$

$$x_1 = x_2 = \frac{X_{sc}}{2} = X_{sc} = \frac{1}{2}\sqrt{Z_{sc}^2 - R_{sc}^2}$$

Tabular column for NO-Load Test

Sl no.	Voltmeter reading V_0	Ammeter reading I_0	Wattmeter reading W_0

Tabular column for Blocked Rotor Test

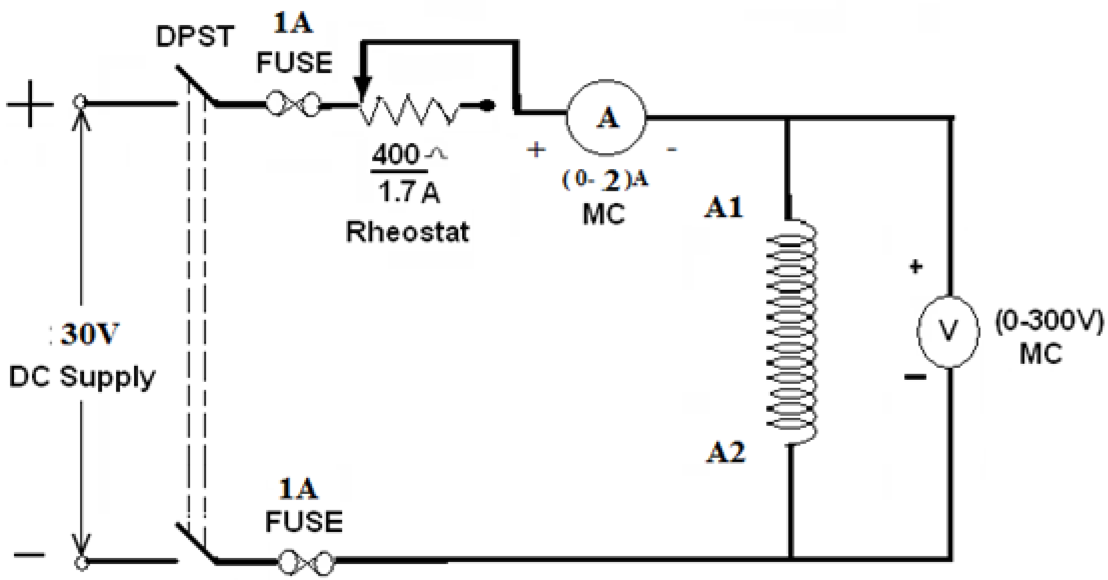
Sl no.	Voltmeter reading V_{sc}	Ammeter reading I_{sc}	Wattmeter reading W_{sc}

Procedure:

1. Connections are made as per the circuit diagram.
2. Initially rheostat is set at maximum resistance position.

3. Switch ON the supply, and vary the rheostat gradually and note down the readings of ammeter and voltmeter
4. For the corresponding values, average of r1 is taken.

Circuit diagram for measurement of R_1



Tabular Column of stator winding resistance r_1

Sl no.	Voltmeter reading V	Ammeter reading I	Resistance R

Comments:

1. Since IM is not self starting Machine, it is started by placing an auxiliary winding in the circuit.
2. Here no-load test is similar to open circuiting the load terminals and blocking the rotor is similar to conducting short circuit on the IM.

Result:

Thus the equivalent circuit parameters of single phase Induction Motor are determined by performing No-Load and Blocked rotor test on it.

SYNCHRONOUS IMPEDENCE METHOD

Aim: To find the regulation of a 3 - ϕ alternator by using synchronous impedance method.

Apparatus required:

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300/600)V	1 no
2	Ammeter	MI	(0-5/10)A	1 no
3	Ammeter	MI	(0-2.5/5)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A 145Ω /2A	1 no 2 no
4	Tachometer	Digital	*****	1 no

5	Connecting Wires	*****	*****	Required

Name plate details:

DC Motor(prime mover)	**3- ϕ Alternator**
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current :
Field current::	

Theory:

Procedure:

OPEN CIRCUIT TEST:

1. Make the connections as per the circuit diagram.
2. Before starting the experiment, the potential divider network in the alternator field circuit and field regulator rheostat of motor circuit is set minimum resistance position.
3. Switch ON the supply and close the DPST switch. The DC motor is started by moving starter handle.
4. Adjust the field rheostat of DC motor to attain rated speed (equal to synchronous speed of alternator)
5. By decreasing the field resistance of Alternator, the excitation current of alternator is increased gradually in steps.
6. Note the readings of field current, and its corresponding armature voltage in a tabular column.
7. The voltage readings are taken upto and 10% beyond the rated voltage of the machine.

SHORT CIRCUIT TEST:

1. For Short circuit test, before starting the experiment the potential divider is brought back to zero output position, i.e., resistance should be zero in value.
2. Now close the TPST switch.
3. The excitation of alternator is gradually increased in steps until rated current flows in the machine and note down the readings of excitation current and load current (short circuit current)
4. Switch OFF the supply.

Procedure to find Armature resistance of alternator:

1. Connections are made as per the circuit diagram.
2. Switch ON the supply. By varying the rheostat, take different readings of ammeter and voltmeter in a tabular column.
3. From the above readings, average resistance Ra of a armature is found out.

Procedure to find synchronous impedance from OC and SC tests.

1. Plot open circuit voltage, short circuit current verses field current on a graph sheet.
2. From the graph, the synchronous impedance for the rated value of excitation is calculated.
3. The excitation emf is calculated at full load current which is equal to the terminal voltage at No load.
4. The voltage regulation is calculated at rated terminal voltage.

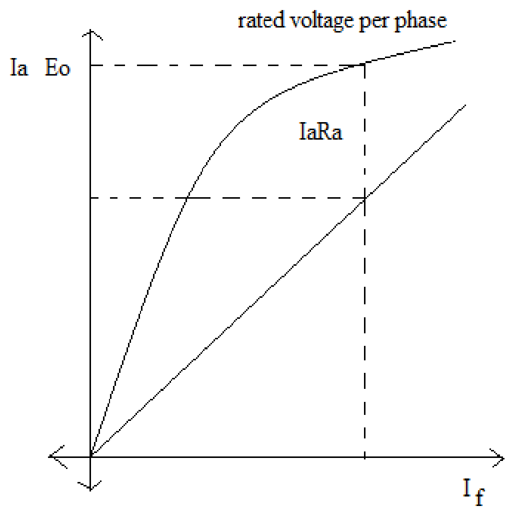
Result:

The synchronous impedance of the given alternator is calculated by conducting open circuit and SC test and voltage regulation of the given alternator is calculated at different power factors.

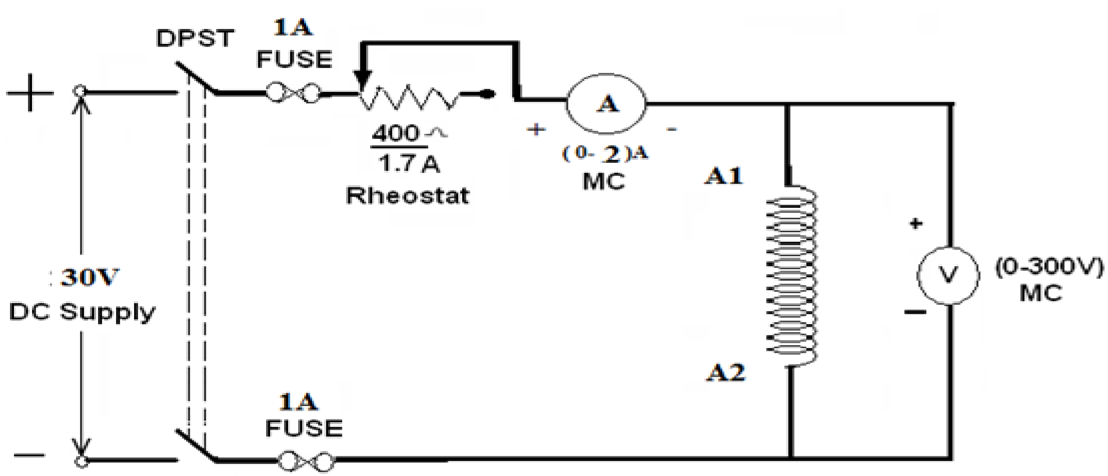
Tabular column:

Sl no.	OC test		Sl no.	S.C. test	
	Field current in Amp.(I f)	OC voltage per phase (Vo)		Field current I_f(Amp.)	SC current I_{sc} Amp.

Ideal graph:



Connection diagram to find Ra



Tabular column:

Sl no.	Armature current I(amp)	Armature voltage Va (volts)	R_{dc}=V / I

Theoretical calculation:

EFFICIENCY OF 3- ϕ ALTERNATOR

Aim: to determine the efficiency of 3- ϕ Alternator.

Apparatus Required:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-600)V	1 no 1 no
2	Ammeter	MC	(0-20)A (0-2.5)A	1 no 1 no
3		MI	(0-10)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A 145Ω /2A	1 no 2 no
4	Tachometer	Digital	*****	1 no
5	Wattmeter	Electro dynamo meter type	10A/600V UPF	2 no
6	Connecting Wires	*****	*****	Required

Name plate details:

DC Motor(prime mover)	3- ϕ Alternator
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current :
Field current::	

Theory:

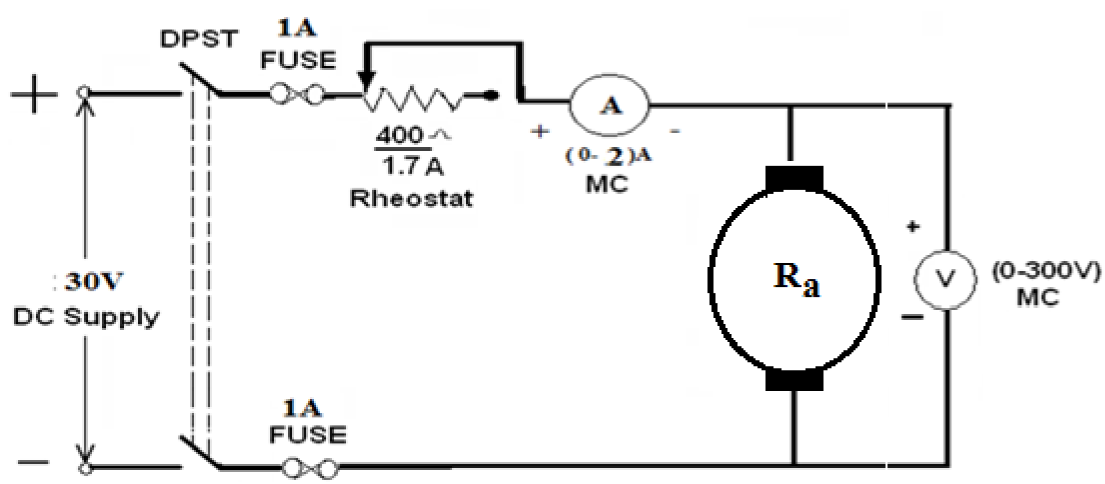
Procedure:

1. Connections are made as per the circuit diagram.
2. Ensure that TPST switch is opened before starting the experiment.
3. The motor is started with the help of 3-point starter.
4. The speed is set to 1500 RPM by varying rheostat.
5. The readings of voltmeter, ammeter are noted down in a tabular column.
6. The field rheostat of alternator is varied till the rated voltage is obtained in the alternator.
7. TPST switch is closed. Now 3- ϕ load is gradually applied and readings of meters are noted down till rated current flows in the ammeter.

Observation table:

Sl no.	V_1 (volts)	I_1 (Ampere)	I_{sh} (Amp.)	V_L (volts)	I_L (volts)	W_1 (watt)	W_2 (watt)	% η

Circuit diagram for determining the armature resistance of DC motor.



Observation table:

Sl no.	Armature current I(amp)	Armature voltage Va (volts)	R_{dc}=V / I

Procedure:

1. Connections are made as per the circuit diagram.
2. Switch ON the supply. By varying the rheostat, take different readings of ammeter and voltmeter in a tabular column.
3. From the above readings, average resistance Ra of a armature is found out.

Calculations:

$$\text{Alternator efficiency} = \frac{\textbf{output of alternator}}{\textbf{input of alternator}}$$

Output of alternator = (W_1+W_2) watt

Input of alternator = Mechanical output of DC motor.

Mechanical output of DC motor = Electrical input to motor – iron loss – $I^2_a R_a$ - $I^2_{sh} R_{sh}$ – frictional and windage losses

At No-Load:

The input to the DC motor $V_o I_o = I^2_{ao} R_a + I^2_{sh} R_{sh}$ + Frictional and windage loss of motor + iron loss of motor +friction and windage loss of alternator.

Neglecting friction and windage losses of alternator,

$V_o I_o = I^2_{ao} R_a + I^2_{sh} R_{sh}$ + Frictional and windage loss of motor + Iron loss of motor

Core losses = $V_o I_o - (I^2_{ao} R_a + I^2_{sh} R_{sh})$

Input to alternator = output of the motor = $V_1 I_1$ – (Core losses + $I^2_a R_a + I^2_{sh} R_{sh}$)

I_a is Varying if the load on the alternator is varying.

$I_a = I_1 - I_{sh}$

% efficiency =(o/p of alternator / i/p of alternator)*100

Result: The efficiency of the 3- ϕ alternator is determined.

NO LOAD AND BLOCKED ROTOR TEST ON A 3- ϕ INDUCTION MOTOR

Aim: to determine the equivalent circuit of a 3- ϕ induction motor and calculate various parameters of induction motor with the hlp of circle diagram.

Apparatus Required:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

Name plate details:

Power rating	
Voltage	
Current	
Speed(RPM)	
Frequency	
PF	

3- ϕ Auto transformer Details:

Input Voltage: __________________(Volt) Output Voltage: __________________(Volt)
Current:______________________(Amp.)

Theory:

Procedure:

NO LOAD TEST:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter.
5. Bring back the variac to zero output voltage position and switch OFF the supply.

BLOCKED ROTOR TEST:

1. Connections are as per the circuit diagram.
2. The rotor is blocked by tightening the belt.
3. A small voltage is applied using 3- ϕ variac to the stator so that a rated current current flows in the induction motor.
4. Note down the readings of Voltmeter, Ammeter and Wattmeter in a tabular column.
5. Bring back the variac to zero output voltage position and switch OFF the supply.

Tabular column:

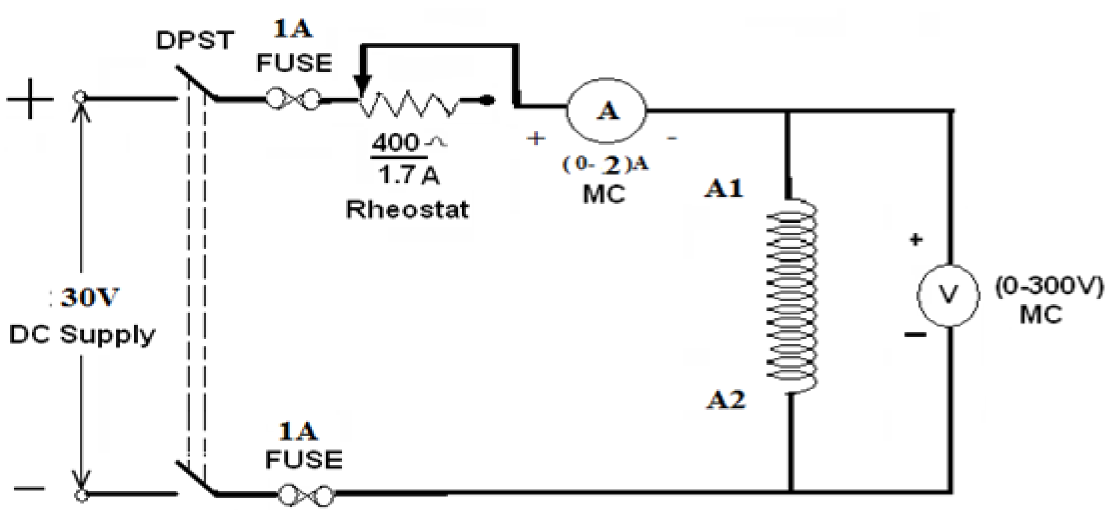
NO LOAD TEST:

Sl no.	Voltmeter reading V_{nl}	Ammeter reading I_{nl}	Wattmeter reading		W_{nl} (P_{nl}) W_1+W_2
			W_1	W_2	

BLOCKED ROTOR TEST

Sl no.	Voltmeter reading V_{br}	Ammeter reading I_{br}	Wattmeter reading		W_{br} (P_{br}) W_1+W_2
			W_1	W_2	

Measurement of stator winding resistance (r_1):
Circuit diagram:



Tabular column:

S no.	Voltage (v)	Ammeter (I)	Resistance (R)

Procedure to find r_1

1. Connections are made as per the circuit diagram
2. Switch ON the supply. By varying the rheostat, take different readings of ammeter and voltmeter in a tabular column.
3. From the above readings, average resistance r_1 of a stator is found

Calculations:

FOR NO-LOAD TEST:

The rated V_{nl} I_{nl} and power P_{nl} are all per phase values for No-Load test.

$$Z_{nl} = \frac{V_{nl}}{I_{nl}}$$

$$R_{nl} = \frac{P_{nl}}{I_{nl}^2}$$

$$X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2}$$

$$\cos \phi_o = \frac{P_{nl}}{V_{nl} I_{nl}}$$

BLOCKED ROTOR TEST:

The rated V_{br} , I_{br} and power P_{br} are all per phase values for Blocked rotor test.

Since $X_m >> X_2$

$X_{br} = X_1 + X_2$

For squirrel cage induction motor, total leakage reactance $X_{br}(= X_1 + X_2)$ can be distributed between stator and rotor as per the following table:

Sl no	Class of motor	Fraction of X_{br}	
		X_1	X_2
1	Class A	0.5	0.5
2	Class B	0.4	0.6
3	Class C	0.3	0.7
4	Class D	0.5	0.5

$$Z_{br} = \frac{V_{br}}{I_{br}}$$

$$R_{br} = \frac{P_{br}}{I_{br}^2}$$

$$X_{br} = \sqrt{Z_{br}^2 - R_{br}^2}$$

$$\cos\phi_{sc} = \frac{P_{br}}{V_{br} I_{br}}$$

$$X_m = X_{nl} - X_1$$

$$r_2 = \left(R_{br} - r_1\right)\left(\frac{X_2}{X_m}\right)^2$$

$$I_{sc} = I_{br}\left(\frac{V_1}{V_{br}}\right)$$

With the test data obtained, draw the circle diagram and calculate line current, power factor, slip, torque, and efficiency at Full load. Stator and rotor ohmic losses at standstill are assumed equal.

Result:

Thus various parameters of three phase induction motor with the help of circle diagram are determined.

BRAKE TEST ON 3- ϕ SQUIRREL CAGE INDUCTION MOTOR

Aim: To determine the efficiency of 3- ϕ induction motor by performing load test. To obtain the performance curves for the same.

Apparatus Required:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

Name plate details:

Power rating	
Voltage	
Current	
Speed(RPM)	
Frequency	
PF	

3- ϕ Auto transformer Details:

Input Voltage: __________________(Volt) Output Voltage: __________________(Volt)
Current:________________________(Amp.) Freq.:____________________________(Hz)

Theory:

Procedure:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter at no-load.
5. Now the increase the mechanical load by tightening the belt around the brake drum gradually in steps.
6. Note down the various meters readings at different values of load till the ammeter shows the rated current.
7. Reduce the load on the motor finally, and switch OFF the supply.

Calculations:

Input power = $W_1 + W_2$

Output power = $(2 \prod N T) / 60$

N =Speed of the motor in RPM

$T = 9.81 (S_1 - S_2) R$ N-m

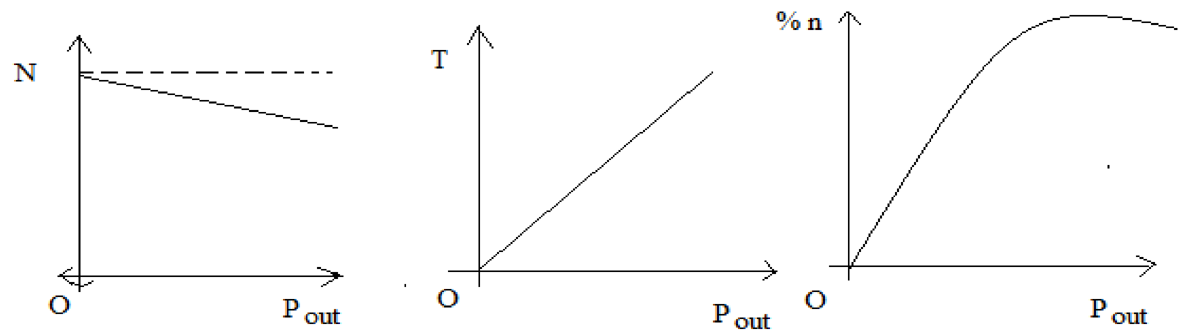
S = load in Kg.

R = radius of the pulley in meters (_______) Mt.

Power factor = $\text{Cos} [\tan^{-1}(\frac{\sqrt{3}(W1-W2)}{W1+W2})]$

Ideal graphs:

1. Speed or slip Vs output power
2. Torque Vs output power
3. % efficiency Vs output power



Tabular Column:

Sl no	Voltage (V_L)	Current I_L	Load		Speed	W_1	W_2	i/p power W_1+W_2	Torque T	O/P power	%η	PF
			S_1	S_2								

Result:

The efficiency of three phase induction motor is determined by conducting a brake test on it.

DETERMINATION OF X_d AND X_q OF SALIENT POLE SYNCHRONOUS MOTOR

Aim: To determine the direct axis reactance X_d and quadrature axis reactance X_q by conducting a slip test on a salient pole synchronous machine.

Apparatus required:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-5)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

DC Motor (prime mover)	3- ϕ Alternator
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current :
Field current::	

3- ϕ Auto transformer Details:

Input Voltage: ___________________(Volt) Output Voltage: ___________________(Volt)
Current:______________________(Amp.) Freq: ____________________________(Hz)

Theory:

Procedure:

1. Connections are made as per the circuit diagram.
2. Initially set field regulator, 3-ϕ variac at minimum position and TPST switch open.
3. The DC motor is started slowly by sliding starter handle and it is run at a speed slightly less than the synchronous speed of the alternator.
4. Close the TPST switch.
5. With field winding left open, a positive sequence balanced voltages of reduced magnitude (around 25% of rated Value) and of rated frequency are impressed across the armature terminals.
6. The prime mover (DC motor) speed is adjusted till ammeter and voltmeters pointers swing slowly between maximum and minimum positions.
7. Under this condition , readings of maximum and minimum values of both ammeter and voltmeter are recorded

Calculations:

$$X_d = \frac{\text{maximum armature terminal voltage per phase}}{\text{minimum armature armature current per phase}}$$

$$X_q = \frac{\text{minimum armature terminal voltage per phase}}{\text{maximum armature current per phase}}$$

Note:

1. When performing this test, the slip should be made as small as possible.
2. During Slip test, it is observed that swing of the ammeter pointer is very wide, whereas the voltmeter has only small swing.

Tabular column:

Sl no.	Speed	Vmax (V_L)	Vmin (V_L)	Imax (I_L)	Imin (I_L)	X_d	X_q

Result: Hence Xd and Xq are calculated by conducting slip test on Salient pole machine.

‘V’ AND ‘INVERTED V’ CURVES OF SYNCHRONOUS MOTOR

Aim: To plot the ‘v’ and ‘inverted v’ curves of synchronous motor.

Apparatus Required:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MC MI	(0-2.5)A (0-10)A	1 no 1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	*****	1 no
5	Wattmeter	Electrodynamometer	10A, 600V UPF 10A , 600V LPF	1 no 1 no
6	Connecting Wires	*****	*****	Required

Name plate details

3- ϕ Synchronous motor	
Power Rating:	
PF	
Line voltage:	
Speed	
Freq.	
Rated Current :	
Field current (I_f)	
Field Voltage (V_f)	

3- ϕ Auto transformer details

Input voltage: ______________________(Volt) Output Voltage : ___________________(Volt)

Freq. :_______________________________(Hz) Current: __________________________(Amp)

Theory:

Procedure:

1. Connections are made as per the circuit diagram.
2. Opening the SPST switch connected across the field DC supply is given to the field and field current is adjusted to 0.3A (20% of rated field current)
3. The DC supply to the field is removed and SPST switch is connected across the field by closing the switch
4. As 3- ϕ , 440V, 50Hz AC supply is applied to 3- ϕ dimmer stator keeping it in minimum output position, keeping it prior to that motor is kept in no load state.
5. Gradually supply voltage to synchronous motor is increased and then motor starts running as squirrel cage induction motor. The direction of rotation is observed. if it is not proper then supply phase sequence is altered.
6. Observing I_a, the voltage is gradually increased. It will reach a high value and suddenly falls to a low value.
7. At that instant, open SPST switch connected across the field. The DC supply is then given to the field. Then the motor is pulled into synchronism and motor now works as a synchronous motor.
8. Gradually the supply voltage to stator is increased by observing the armature current. If I_a, increases above the rated value then increase If such that I_a will be within limits and thus full rated supply voltage is gradually given to the motor. Now motor will work as synchronous motor with full rated voltage.
9. By varying If in steps, armature currents are recorded at no-load.
10. By applying half of full load on motor, If and I_a are recorded again. The same experiment is repeated at $3/4^{th}$ load, full load and corresponding readings are recorded.
11. Completely removing the load on motor, the 3- ϕ supply to stator and then the DC supply to the field are switched OFF

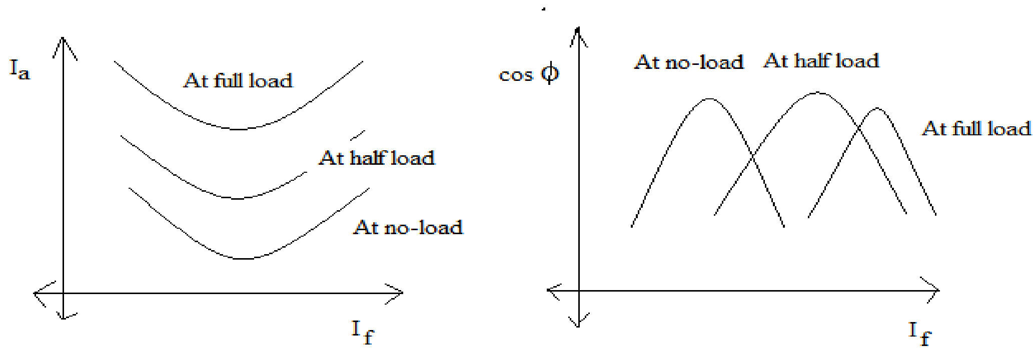
Observation table:

Sl no.	Supply voltage	Wattmeter W1	Wattmeter W2	Field current If(Amp)	Armature current I_a(Amp)	Cos ϕ

Calculations:

Power factor = $\cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W1-W2)}{W1+W2}\right)\right]$

Ideal graphs:



Result:

SEPARATION OF NO LOAD LOSSES IN 1-Φ TRANSFORMER

Aim: To separation the Eddy current loss and Hysteresis loss from the iron loss of 1-Φ transformer.

Apparatus Required:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MC	(0-2.5)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A 145Ω /2A	1 no 2 no
4	Tachometer	Digital	*****	1 no
5	Wattmeter	Electro dynamo meter type	10A/600V LPF	1 no
6	Connecting Wires	*****	*****	Required

Name plate details:

DC Motor(prime mover)	3- ϕ Alternator
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current :
Field current::	

Transformer Specifications:

Transformer Rating :(in KVA) ________________________

Winding Details:

LV (in Volts): _____________________________ LV side current:________________________

HV (in Volts): _____________________________ HV side Current:_______________________

Type (Shell/Core):___________________________

Theory

Procedure:

1. Make the circuit connections as per the circuit diagram.
2. The prime mover is started with the help of 3-point starter and it is made to run at rated speed.
3. By varying alternators field rheostat gradually, the rated primary voltage is applied to transformer.
4. By adjusting the speed of prime mover the required frequency, is obtained and corresponding reading are noted.
5. The experiment is repeated for different frequency and corresponding readings are tabulated.
6. The prime mover is switched off using the DPIC switch after bringing all the rheostats to initial position
7. From the tabulated readings the iron loss is separated from eddy current loss and hysteresis loss by using respective formulae.

Tabular form:

Separation of No load losses in single phase Transformer:

Multiplication factor=

S.No	Speed of the prime mover **N**(rpm)	Supply frequency **(f)**Hz	Primary voltage **(V)**volts	Wattmeter readings(w)		Iron or core loss (Wi)watts	Wi/f
				Observed (watts)	Actual (watts)		

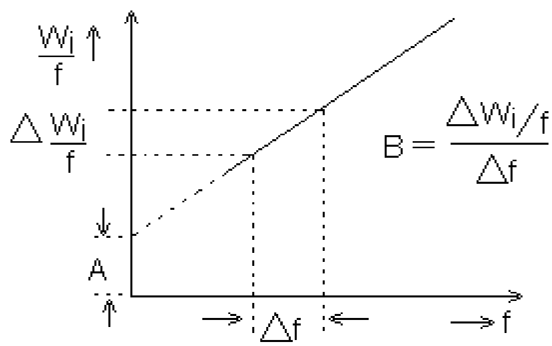
Calculation:

1. Frequency**$(f)=PN_s/120$**
   Where P-number of poles; N_s-Synchronous speed in rpm

2. Hysteresis loss**$(W_h)=Af$**
3. Eddy current loss**$(W_e)=Bf^2$**
4. Iron loss or core loss**$(W_i)= W_e + W_h$**

Model Graph:

The graph drawn as frequency Vs(W_i/f)

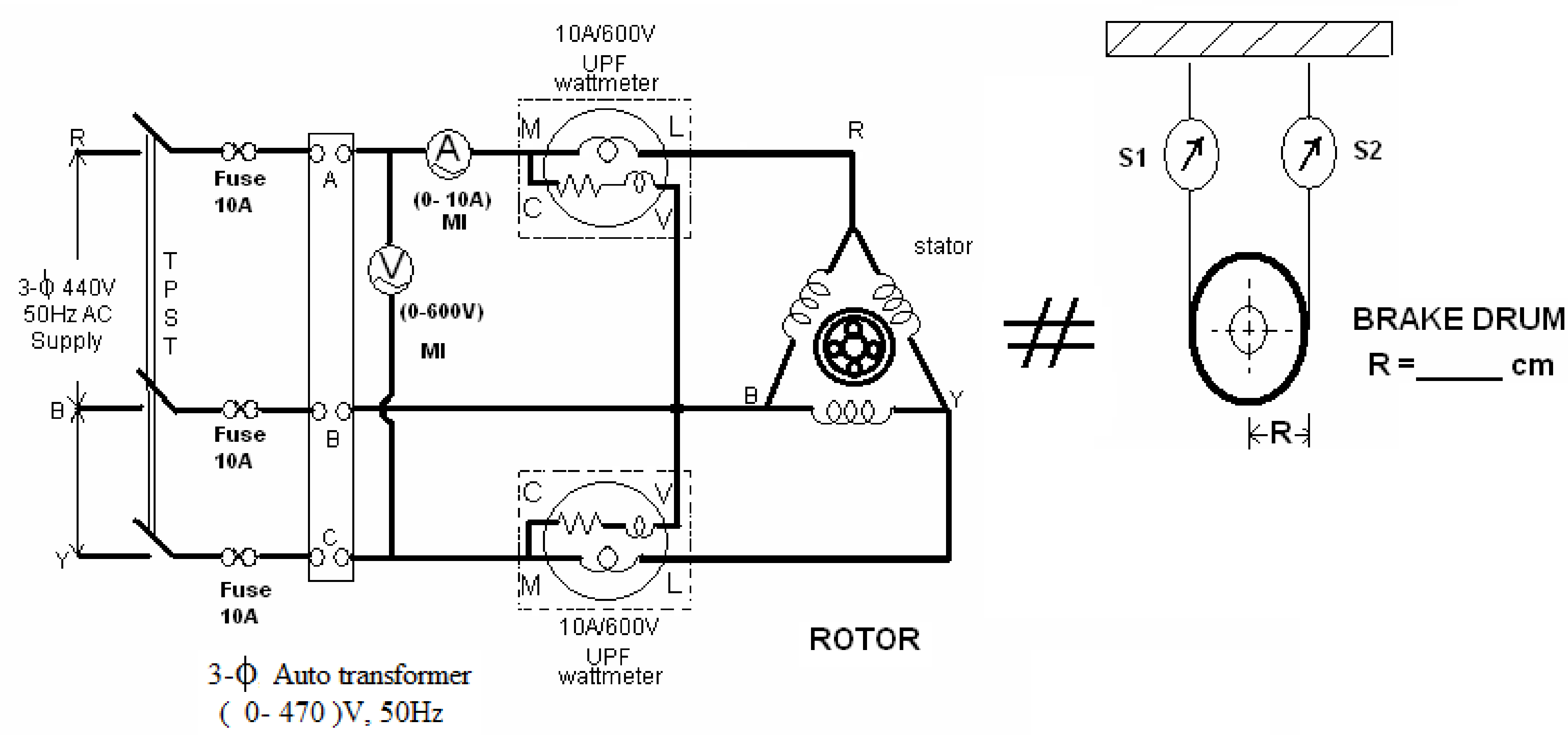


Precautions:

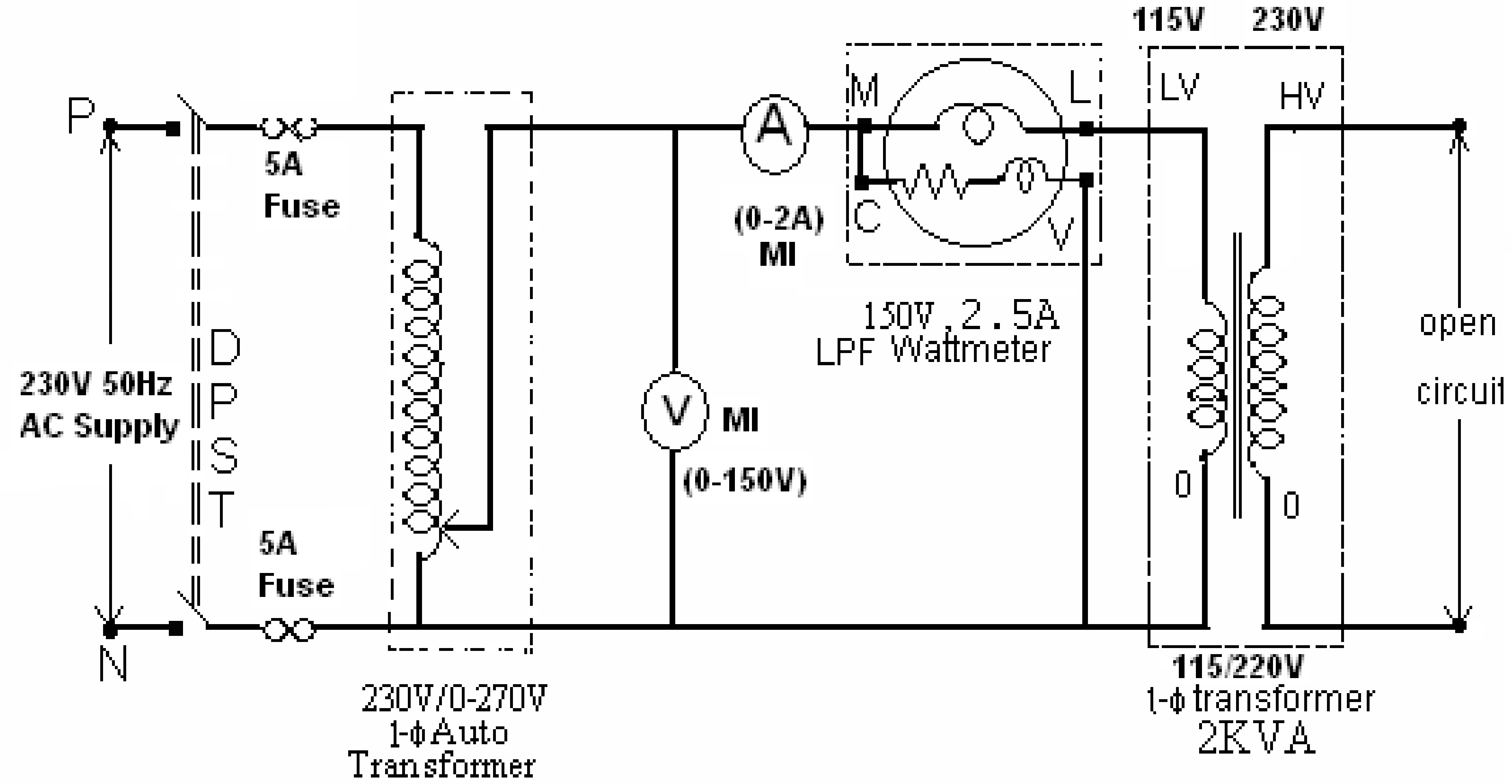
1. The motor field rheostat should be kept at minimum resistance position.
2. The alternator field rheostat should be kept maximum resistance position.
3. The motor should be run in anticlockwise direction.
4. Avoid loose connections.
5. Take the readings with any parallax error.

Result:

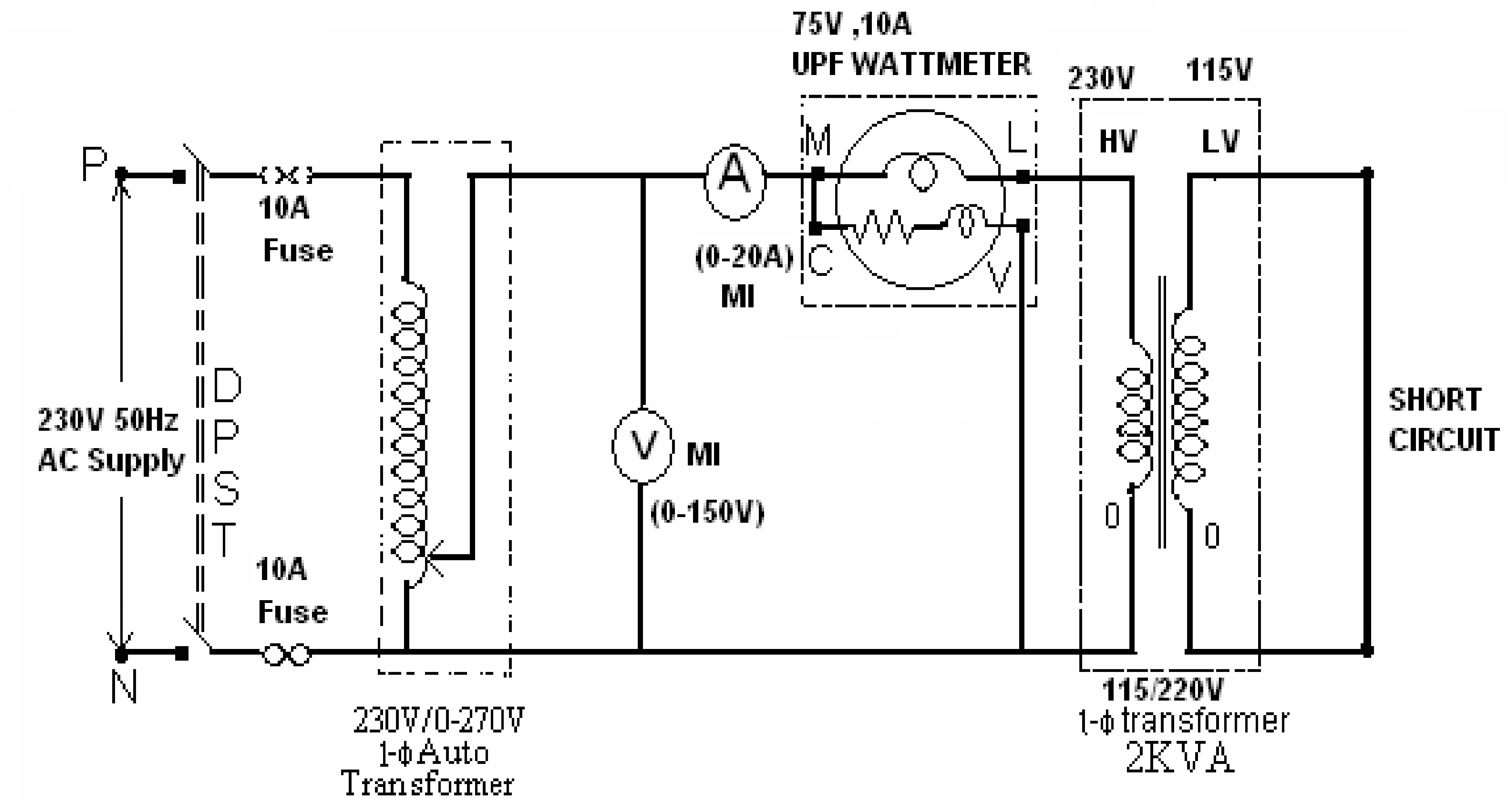
TITLE: BRAKE TEST ON 3-Φ INDUCTION MOTOR
CIRCUIT DIAGRAM



TITLE: OC TEST ON 1-Φ TRANSFORMER
CIRCUIT DIAGRAM

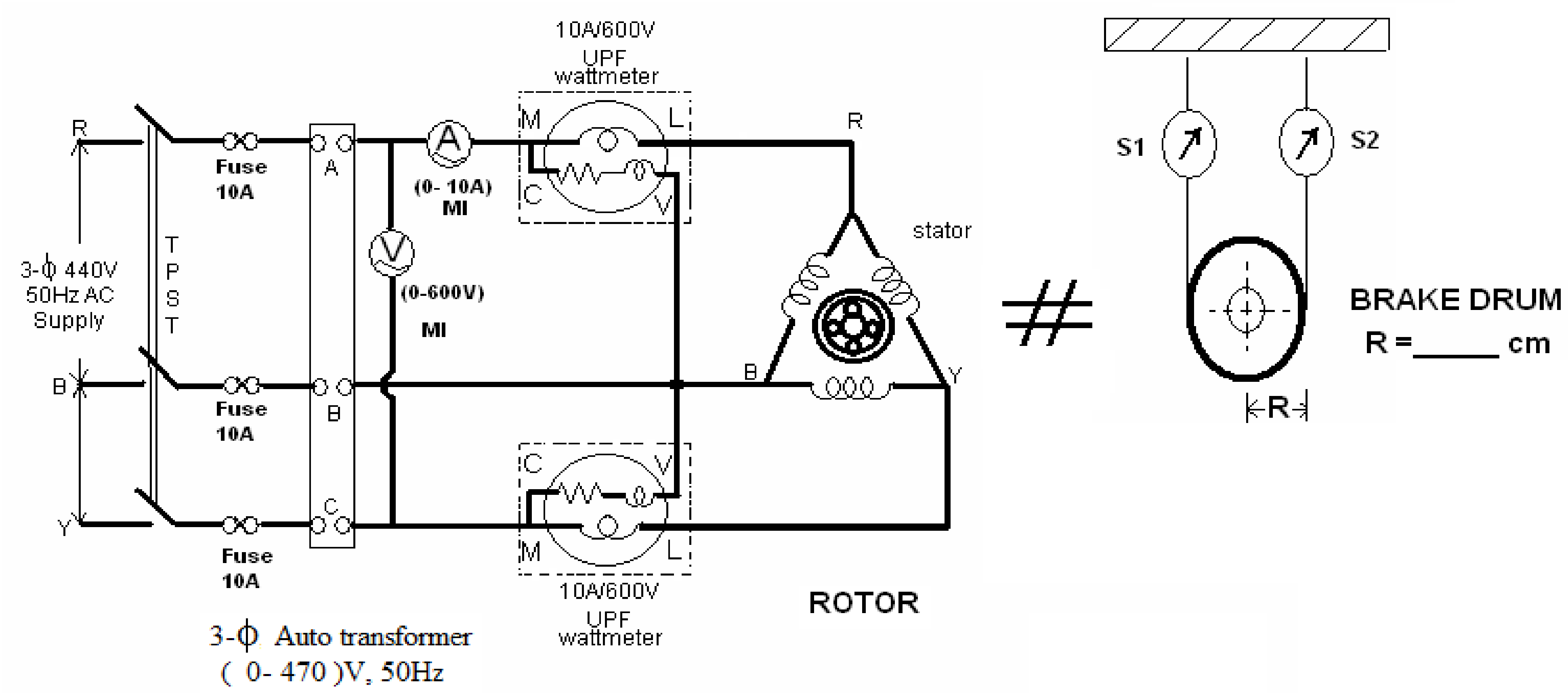


TITLE: SC TEST ON 1-Φ TRANSFORMER
CIRCUIT DIAGRAM

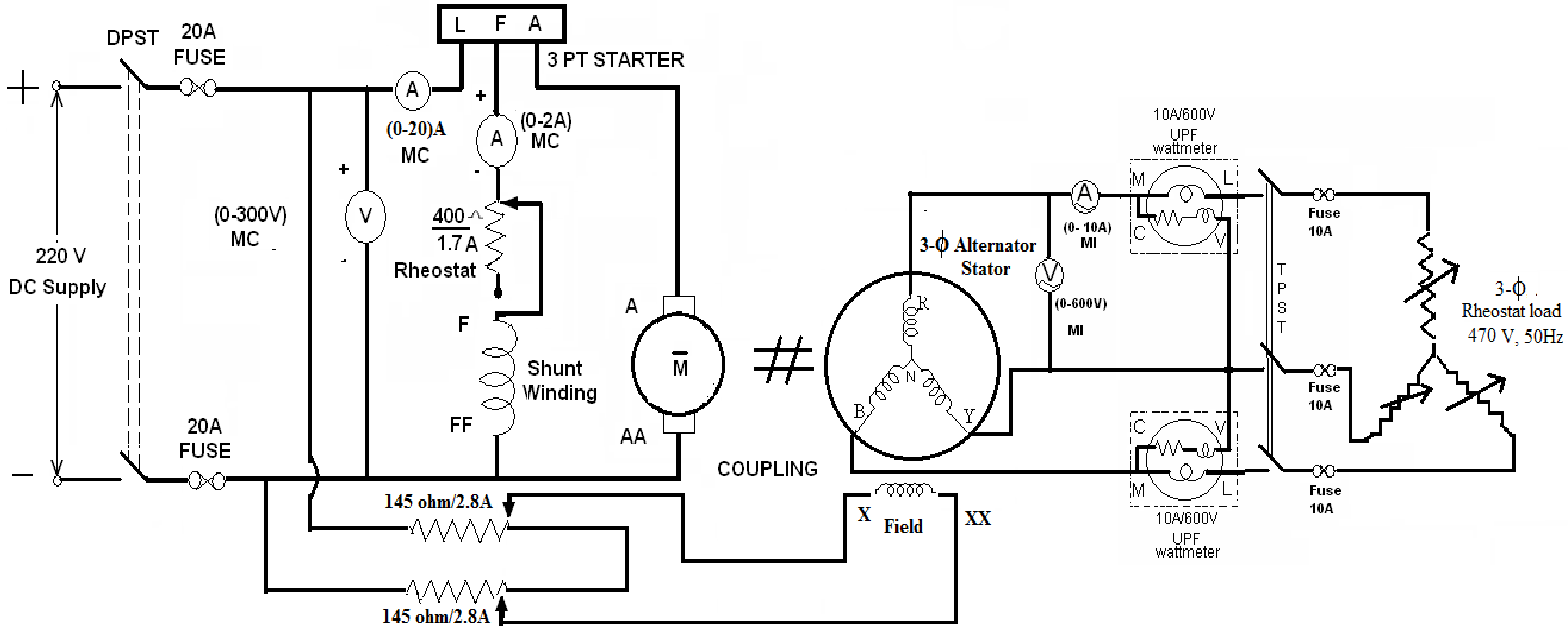


TITLE: NO-LOAD & BLOCKED ROTOR TEST ON 3-Φ INDUCTION MOTOR

CIRCUIT DIAGRAM

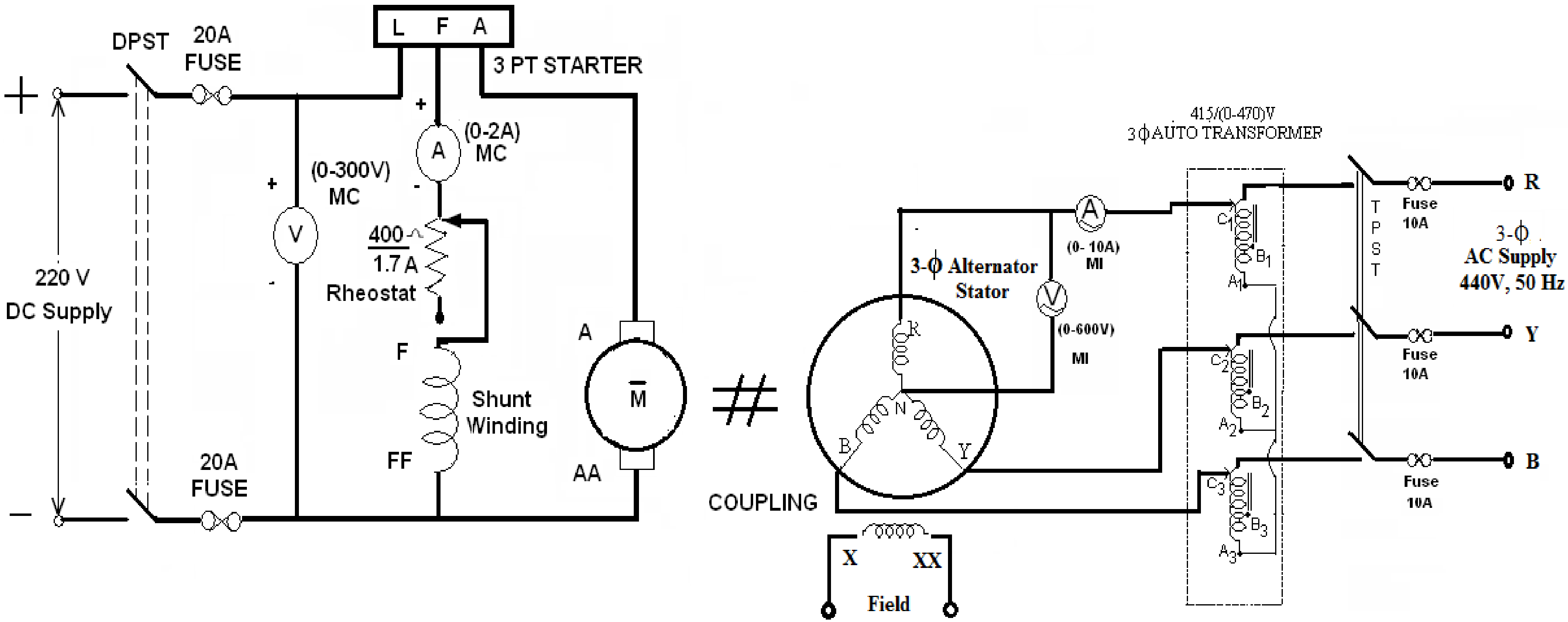


TITLE: EFFICIENCY OF 3-Φ ALTERNATOR
CIRCUIT DIAGRAM

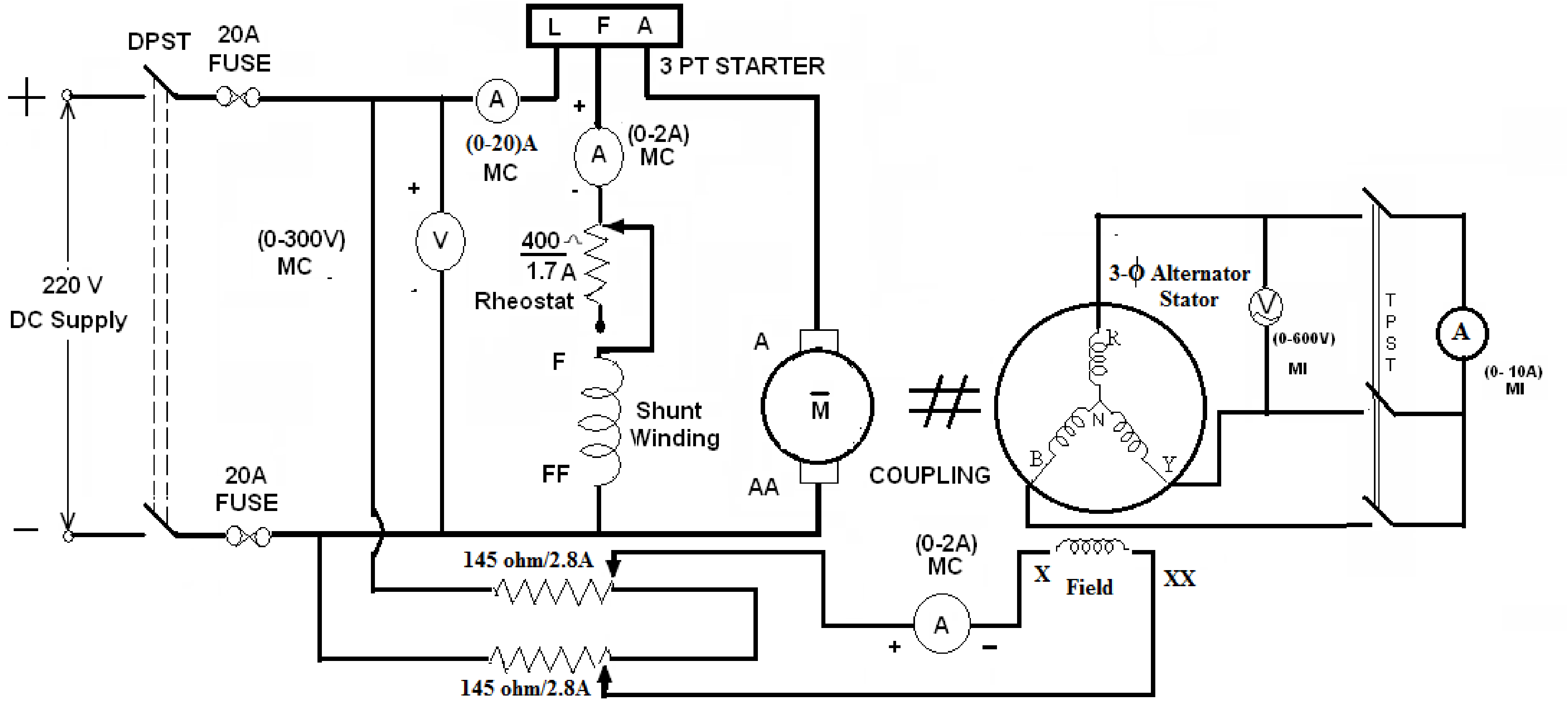


TITLE: DETERMINATION OF X_d & X_q ON 3-Φ SALIENT POLE MACHINE

CIRCUIT DIAGRAM

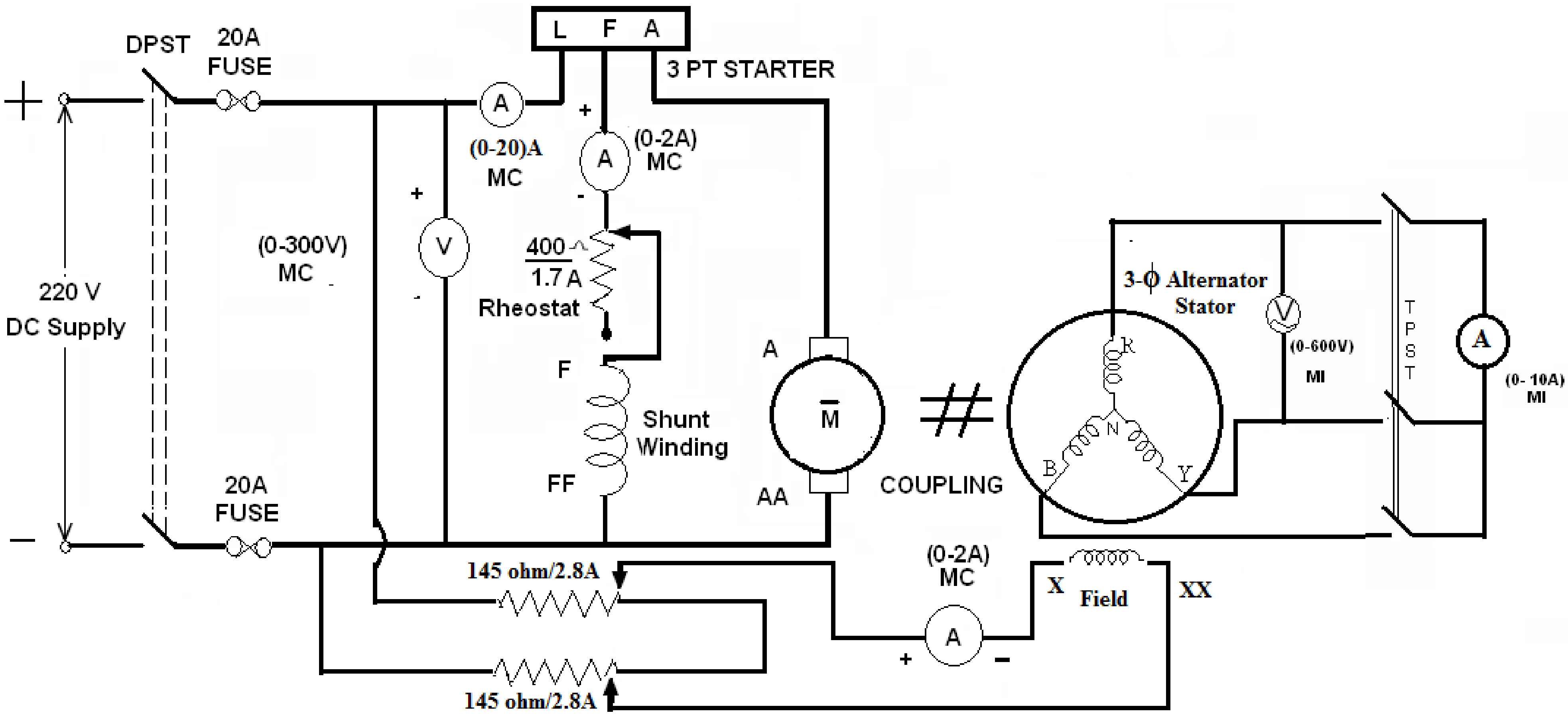


TITLE: DETERMINATION OF REGULATION ON 3-Φ ALTERNATOR (SYNC. IMP. & MMF)
CIRCUIT DIAGRAM



TITLE: DETERMINATION OF REGULATION ON 3-Φ ALTERNATOR (ZPF & ASA METHODS)

CIRCUIT DIAGRAM



TITLE: SCOTT CONNECTION
CIRCUIT DIAGRAM

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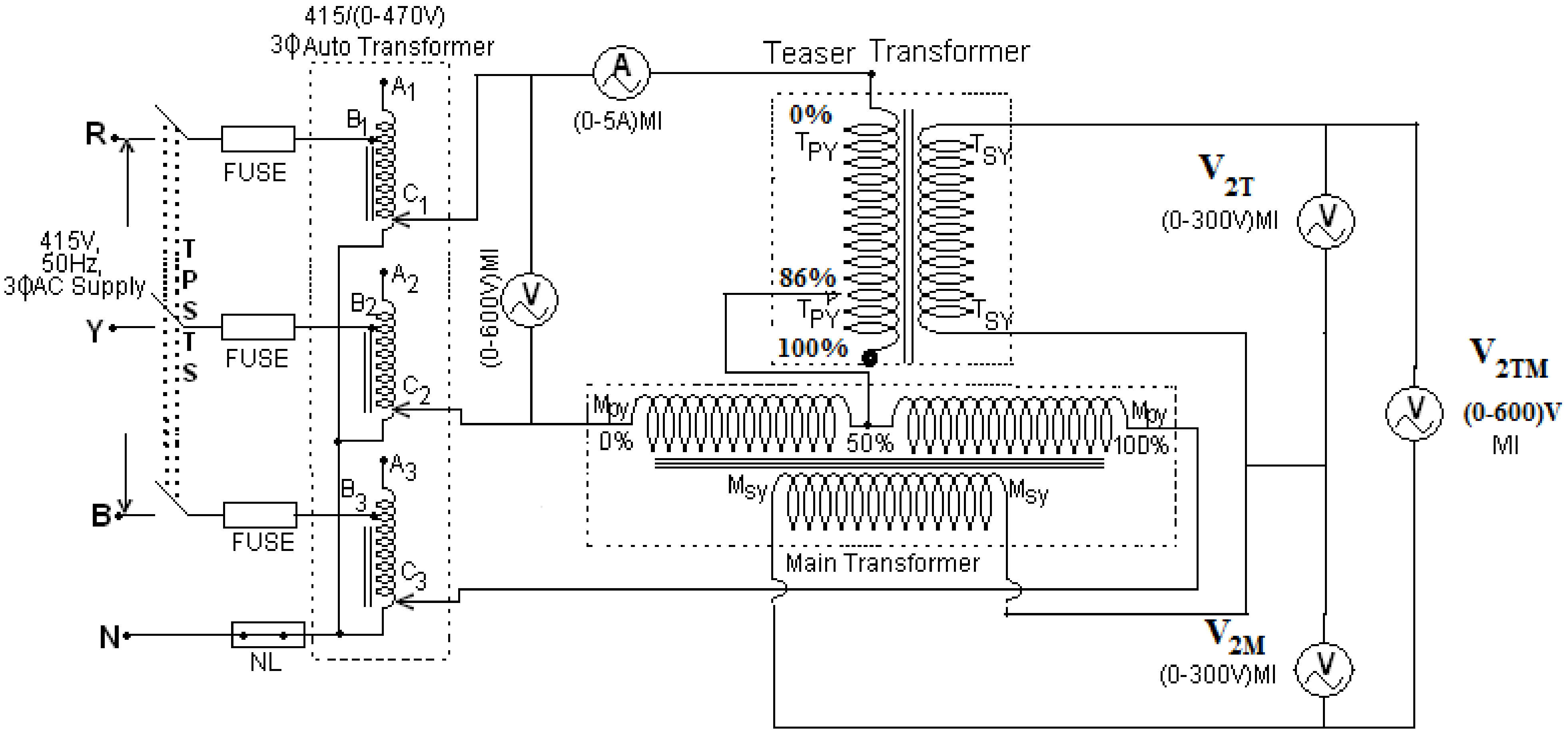
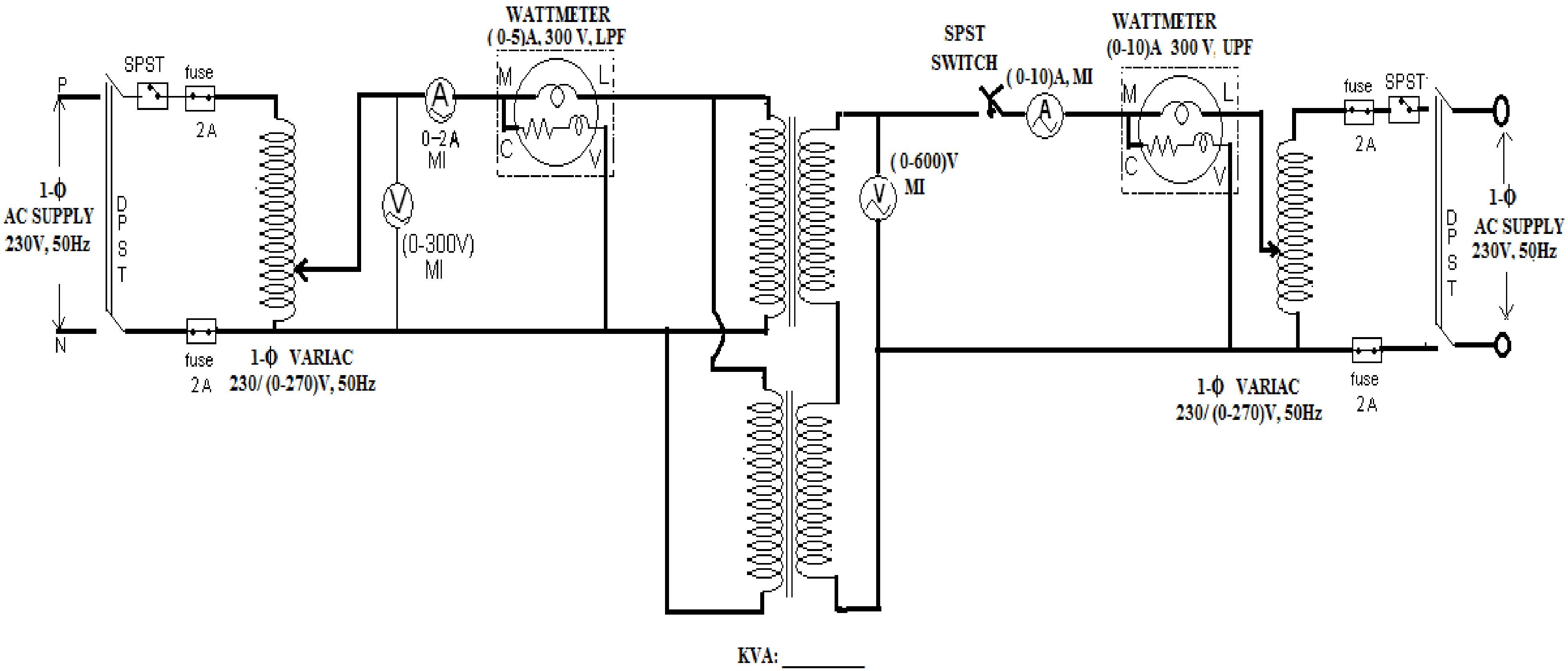
c



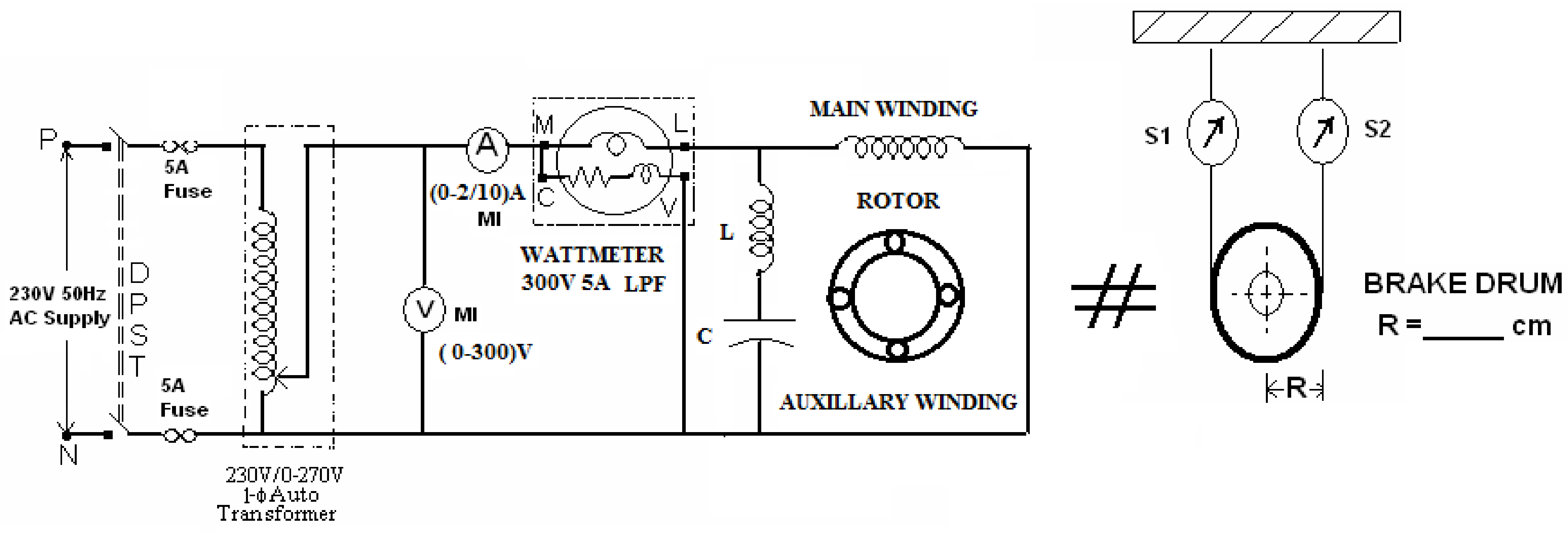
TITLE: SUMPERNER'S TEST

CIRCUIT DIAGRAM

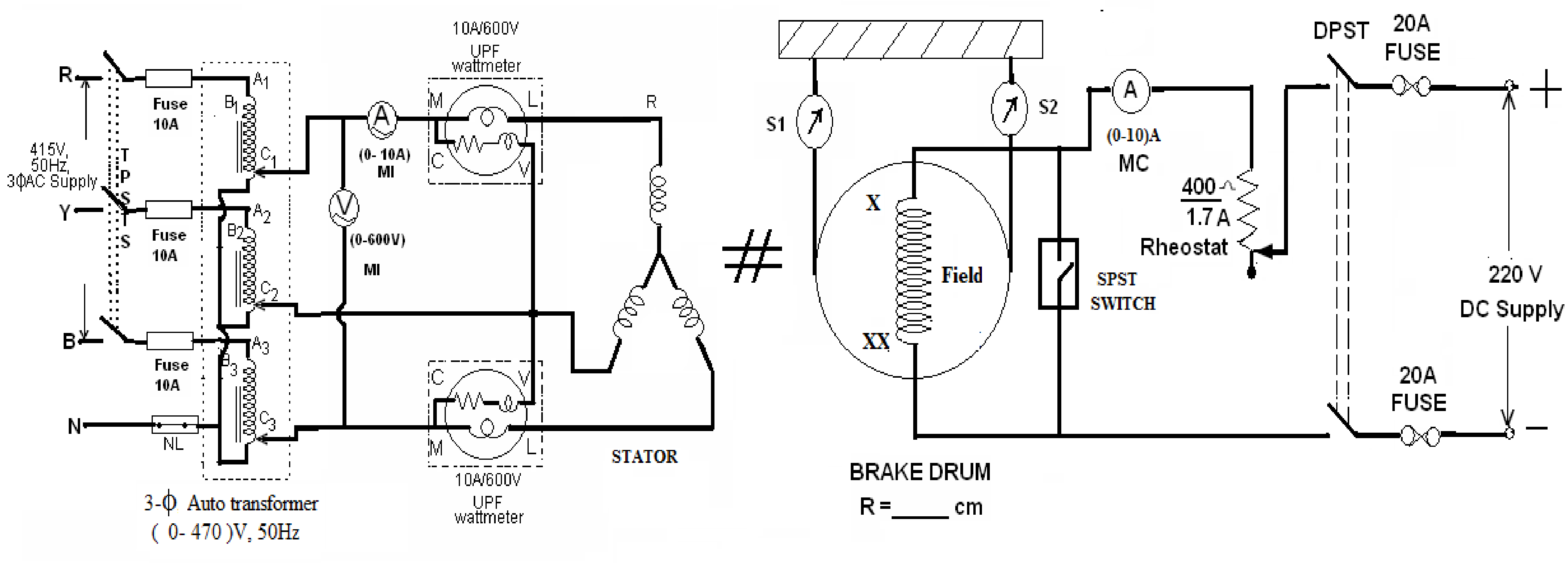


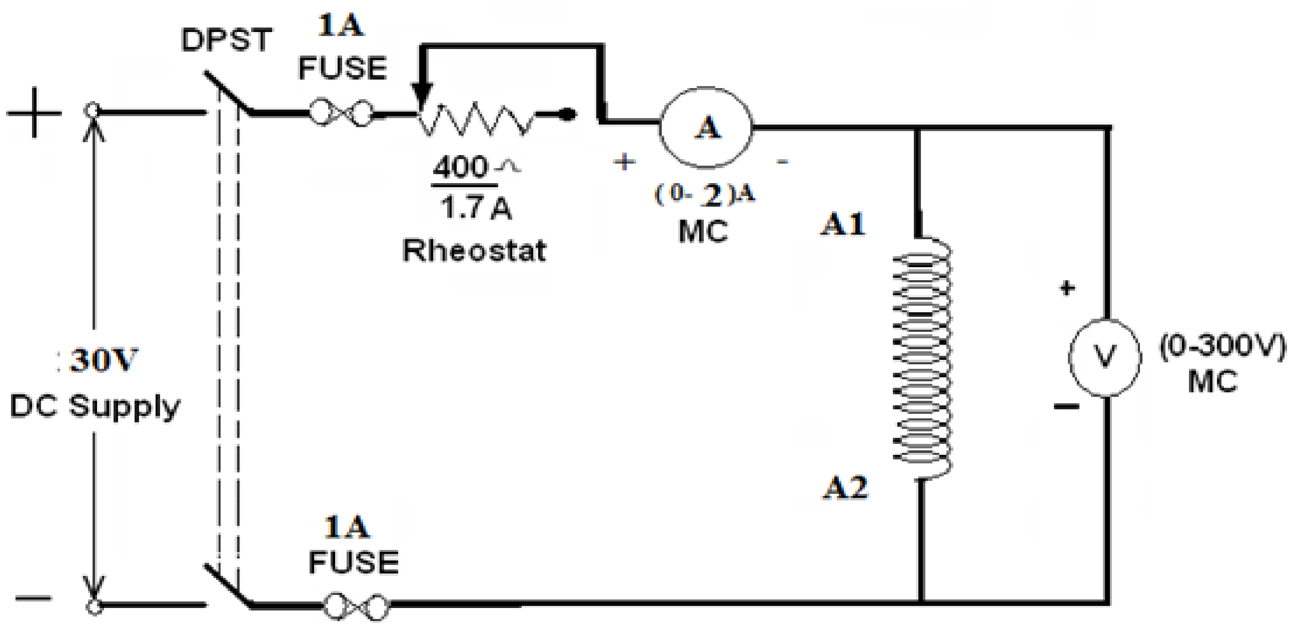
TITLE: EQUIVALENT CIRCUIT OF 1-ϕ INDUCTION MOTOR

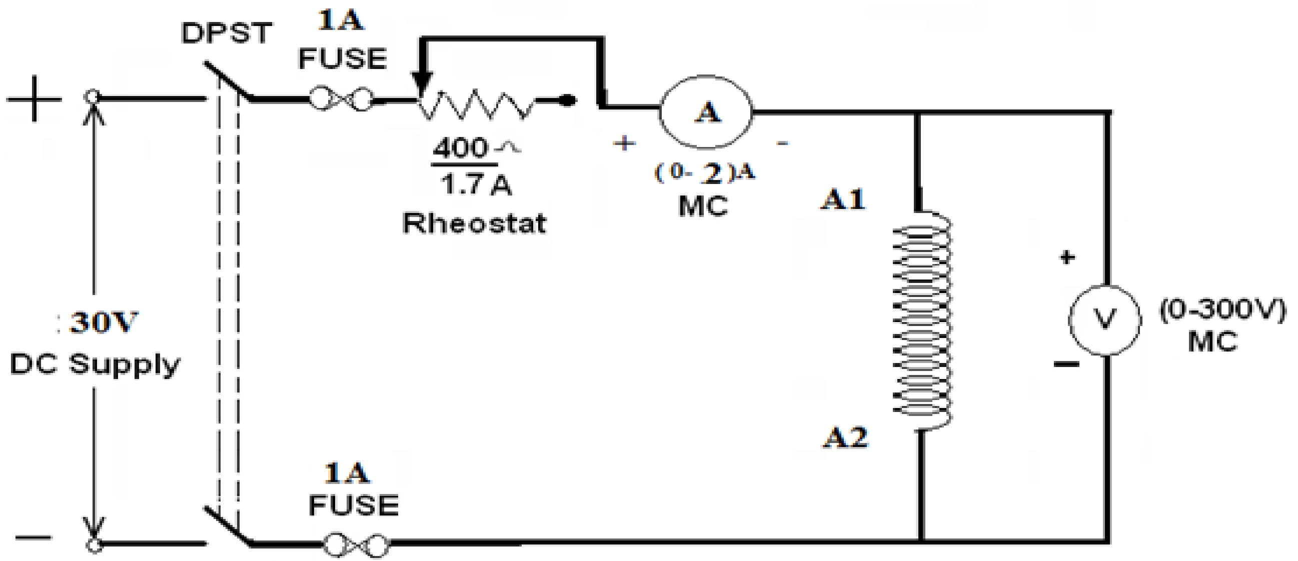
CIRCUIT DIAGRAM



TITLE: V & INV V CURVES OF 3-ϕ SYNCHRONOUS MOTOR
CIRCUIT DIAGRAM




DPST
1A
FUSE
400
1.7 A
Rheostat
A
+
-
(0- 2)A
MC
A1
A2
+
V
(0-300V)
MC
30V
DC Supply
1A
FUSE


DPST
1A
FUSE
400
1.7 A
Rheostat
A
+
-
(0- 2)A
MC
A1
A2
+
V
(0-300V)
MC
30V
DC Supply
1A
FUSE

TITLE: SEPERATION OF LOSSES IN A 1-ϕ TRANSFORMER
CIRCUIT DIAGRAM