SREE VIDYANIKETHAN ENGINEERING COLLE
(An autonomous institution affiliated to JNTUA, Anantapuramu)
SreeSainath Nagar, Tirupati – 517 102.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Lab Manual

TRANSFORMERS AND INDUCTION MACHINES LAB (16BT40232)

(II B. Tech., II-Semester, EEE)

Prepared by
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16BT40232: TRANSFORMERS AND INDUCTION MACHINES LAB

CONTENTS

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Vision

To be one of the Nation's premier Engineering Colleges by achieving the highest order of excellence in Teaching and Research.

Mission

Through multidimensional excellence, we value intellectual curiosity, pursuit of knowledge building and dissemination, academic freedom and integrity to enable the students to realize their potential. We promote technical mastery of Progressive Technologies, understanding their ramifications in the future society and nurture the next generation of skilled professionals to compete in an increasingly complex world, which requires practical and critical understanding of all aspects.

Vision

To become the Nation's premiere centre of excellence in electrical engineering through teaching, training, research and innovation to create competent engineering professionals with values and ethics.

Mission

- Department of Electrical Engineering strives to create human resources in Electrical Engineering to contribute to the nation development and improve the quality of life.
- Imparting Knowledge through implementing modern curriculum, academic flexibility and learner centric teaching methods in Electrical Engineering.
- Inspiring students for aptitude to research and innovation by exposing them to industry and societal needs to creating solutions for contemporary problems.
- Honing technical and soft skills for enhanced learning outcomes and employability of students with diverse background through comprehensive training methodologies.
- Inculcate values and ethics among students for a holistic engineering professional practice.

Department of Electrical and Electronics Engineering

B.Tech. (Electrical and Electronics Engineering)

Program Educational Objectives:

Within few years of graduation, graduates will

PEO1. Have enrolled in academic program in the disciplines of electrical engineering and multidisciplinary areas.

PEO2. Become entrepreneurs or be employed as productive and valued engineers in reputed industries.

PEO3. Engage in lifelong learning, career enhancement and adopt to changing professional and societal needs.

Program Outcomes:

On successful completion of the program, engineering graduates will be able to:

PO1. Apply the knowledge of mathematics, science, engineering fundamentals, and concepts of engineering to the solution of complex engineering problems. **(Engineering knowledge)**

PO2. Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. **(Problem analysis)**

PO3. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. **(Design/development of solutions)**

PO4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. **(Conduct investigations of complex problems)**

PO5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. **(Modern tool usage)**

PO6. Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. **(The engineer and society)**

PO7. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development. **(Environment and sustainability)**

PO8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. **(Ethics)**

PO9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. **(Individual and team work)**

PO10. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. **(Communication)**

PO11. Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. **(Project management and finance)**

PO12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. **(Life-long learning)**

Program Specific Outcomes:

On successful completion of the program, engineering graduates will

PSO1. Demonstrate knowledge of Electrical and Electronic circuits, Electrical Machines, Power Systems, Control Systems, and Power Electronics for solving problems in electrical and electronics engineering.

PSO2. Analyze, design, test and maintain electrical systems to meet the specific needs of the Industry and society.

PSO3. Conduct investigations to address complex engineering problems in the areas of Electrical Machines, Power Systems, Control Systems and Power Electronics.

PSO4. Apply appropriate techniques, resources and modern tools to provide solutions for problems related to electrical and electronics engineering.

II B.Tech. - II Semester
(16BT40232)TRANSFORMERS AND INDUCTION MACHINES LAB

L	T	P	C
-	-	3	2

ASSESSMENT:

DAY-TO-DAY EVALUATION	INTERNAL MARKS	EXTERNAL MARKS	TOTAL
30MARKS	50 MARKS	50 MARKS	100 MARKS

PREREQUISITES: Course on DC Machines Lab

COURSE DESCRIPTION: Construction, types, operation and applications of transformers and induction machines; Performance evaluation of transformers and induction machines.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. demonstrate knowledge on
- construction, operation of various types of transformers and induction machines.
- starting and speed control of induction machines.
- testing of transformers and induction machines.
- parallel operation of transformers.
- characteristics of transformers and induction machines.

CO2. analyze the performance of transformers and induction motors for various operating conditions.

CO3. design the circuit with suitable accessories / controllers for desired operation of Transformers and Induction motors.

CO4. interpret and synthesize the data obtained from experimentation on transformers & induction machines and provide valid conclusions.

CO5. select and apply appropriate technique for testing and control of transformers & induction machines used in domestic and industrial applications.

CO6. apply the conceptual knowledge of Transformers and Induction motors in relevance to industry and society.

CO7. commit to ethical principles and standards while exercising the practical investigations on Transformers and Induction motors.

CO8. work individually or in a group while exercising practical investigations in the field of Transformers and Induction motors.

CO9. communicate effectively in verbal and written form in relevance to Transformers and Induction motors.

DETAILED SYLLABUS:

PART-A:

1. Construction of transformers
2. Construction of three phase induction motors.

PART-B: Any EIGHT experiments are to be conducted from the following

1. OC and SC tests on single phase transformer.

2. Separation of core losses of a single phase transformer.
3. Load test on single phase transformer.
4. Sumpner's test on a pair of single phase transformers.
5. Parallel operation of single phase transformers.
6. Scott connection of transformers.
7. Brake test on three phase induction motor.
8. Separation of no-load losses of three phase induction motor.
9. No-load and blocked rotor tests on three phase induction motor.

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CO – PO MAPPING

II B. Tech. – II Semester

(16BT40232)TRANSFORMERS AND INDUCTION MACHINES LAB

(EEE)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	--	--	3	2

Course Outcomes	Program Outcomes												Program Specific Outcomes			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	H												H			
CO2	M	H											M	H		
CO3	L	M	H											H		
CO4		L	M	H										M		
CO5			L	M	H										H	M
CO6				L	M	H			L						M	H
CO7						M		H	M							
CO8								M	H	L						
CO9								L		H						

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Department of Electrical and Electronics Engineering

RUBRICS FOR TRANSFORMERS AND MACHINES LAB (16BT40232)

Course Outcome On successful completion of the course, students will be able to		Poor (0 - 1) Mark	Average (2 - 3) Marks	Excellent (4) Marks
CO1	Demonstrate knowledge on • construction, operation of various types of transformers and induction machines. • starting and speed control of induction machines. • testing of transformers and induction machines. • parallel operation of transformers. • characteristics of transformers and induction machines.	Unable to demonstrate knowledge on transformers and induction machines for various operating conditions.	Able to demonstrate knowledge on transformers and induction machine for various operating conditions up to some extent.	Able to demonstrate knowledge transformers and induction machine for various operating conditions.
CO2	Analyze the performance of synchronous and fractional kW machines for various operating conditions.	Unable to analyse the performance of transformers and induction machine	Able to analyse the performance of transformers and induction machines up to some extent.	Able to analyse the performance of transformers and induction machines
CO3	Design the circuit with suitable accessories / controllers for desired operating conditions of synchronous and fractional kW machines.	Unable to design the experimental circuit.	Able to design some parameters of the circuit.	Able to design the experimental circuit based on loading and rating of transformers and induction machines
		Poor (0)	**Average (1-2)**	**Excellent (3)**
CO4	Interpret and synthesize the data obtained from experimentation on synchronous and fractional kW machines to provide valid conclusions.	Unable to interpret and synthesize the data obtained from experimentation on transformers and induction machines	Able to interpret and synthesize the data obtained from experimentation on transformers and induction machines to some extent.	Able to interpret and synthesize the data obtained from experimentation on transformers and induction machines
CO5	Select and apply appropriate technique for testing and control of synchronous and fractional	Unable to select and apply appropriate technique for testing	Able to select and apply appropriate technique for testing	Able to select and apply appropriate technique for testing

	kW machines for domestic and industrial applications.	and control of transformers and induction machines.	and control of transformers and induction machines to some extent.	and control of transformers and induction machines.
		Poor (0)	**Average (1-2)**	**Excellent (3)**
CO6	**Apply the conceptual knowledge of synchronous and fractional kW machines in relevance to domestic and industrial needs.**	Unable to apply the conceptual knowledge of transformers and induction machines in relevance to industry and society.	Able to apply the conceptual knowledge of transformers and induction machines in relevance to industry and societyto some extent.	Able to apply the conceptual knowledge of transformers and induction machines in relevance to industry and society.
CO7	**Follow ethical principles and standards while exercising the practical investigations on synchronous and fractional kW machines**	Unable to follow ethical principles and standards.	Able to follow ethical principles and standards to some extent.	Able to follow ethical principles and standards.
CO8	**Work individually or in a group while exercising practical investigations in the field of synchronous and fractional kW machines.**	Unable to work individually or in a group	Occasionally work individually or in a group	Able to work and execute the problem individually as well as in a group.
CO9	**Communicate effectively in verbal and written form in relevance to synchronous and fractional kW machines.**	Unable to communicate effectively in verbal and written form in relevance to transformers and induction machines.	Able to communicate effectively in verbal and written form in relevance to transformers and induction machines to some extent.	Able to communicate effectively in verbal and written form in relevance to transformers and induction machines

Faculty In-charge

Chairman, BoS&
HOD, EEE

II B. Tech., II-Semester, EEE

	L	T	P	C
16BT40232: TRANSFORMERS AND INDUCTION MACHINES LAB	-	-	3	2

CO ASSESMENT

DAY-TO-DAY EVALUATION: (30 Marks)

CO	Assessment Parameter	Total Marks: 30
CO1	Identify various of parts of transformers and AC machines	**4M**
CO2	Analyze the performance of transformers and AC machines	**4M**
CO3	Design the circuit based on loading and rating of the AC machine.	**4M**
CO4	Demonstrate skills in • Obtaining the various characteristics of transformers and AC machines. • Determining the performance characteristics of transformers and AC machines. • Determining and separation of losses in transformers and AC machines.	**4M**
CO5	Function effectively as individual and as member in a team	**4M**
CO6	Communicate effectively both oral and written	**10M**

INTERNAL EXAM EVALUATION: (20 Marks)

Each student has to conduct a suitable experiment for the task assigned to him/her individually similar to end semester external examination. The performance of the student will be evaluated as follows:

CO	Assessment Parameter	Total Marks: 20
CO1	Identify various parts of DC machine and different starters	**2M**
CO2	Analyze the performance of transformers and AC machines	**4M**
CO3	Design the circuit based on loading and rating of the AC machine.	**4M**
CO4	Demonstrate skills in • Obtaining the various characteristics of transformers and AC machines. • Determining the performance characteristics of transformers and AC machines. • Determining and separation of losses in transformers and AC machines.	**4M**
CO5	Function effectively as individual and as member in a team	**2M**
CO6	Communicate effectively both oral and written	**4M**

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Department of Electrical and Electronics Engineering

Year & Semester	**II B.Tech. II Semester**	Roll No :										
Name of the Laboratory	**Transformers and Induction Machines Lab**	Course Code	**16BT50232**									

DAY-TO-DAY EVALUATION: 30 Marks

S.No	Experiment Name	CO1 KNOWLEDGE 4 M	CO2 ANALYSIS 4 M	CO3 DESIGN 4 M	CO4 PROBLEM SOLVING 3 M	CO5 TOOLS & TECH 3 M	CO6 ENG & SOCIETY 3 M	CO7 ETHICS 3 M	CO8 TEAM WORK 3 M	CO9 RECORD 3 M	TOTAL 30 M	Signature of the Faculty
1	Construction of transformers											
2	Construction of three phase induction motors											
3	OC and SC tests on single phase transformer											
4	Separation of core losses of a single phase transformer											
5	Sumpner's test on a pair of single phase transformers											
6	Parallel operation of single phase transformers											
7	Scott connection of transformers											
8	Brake test on three phase induction motor											
9	No-load & blocked rotor tests on three phase induction motor											
10	Speed control three phase induction motor											

Faculty in-charge

II B. Tech., II-Semester, EEE
16BT40232: TRANSFORMERS AND INDUCTION MACHINES LAB

List of Equipment Needed

S.No	Name of the Equipment	Rating
1.	Transformer	1-Ø, 2 KVA, 120 V/230 V. 1-Ø, 3 KVA, (0-50-86.6-100)% TAPPINGS, 230V/415V.
2.	Induction motor	7.5 HP, 3-Ø, 415V. 0.5 HP, 1-Ø, 240V.
3.	M-G Set	DC Shunt Motor -7.5 HP, 220 V, Alternator -5 KVA, 3-Ø, 415V.
4.	1-ø variac	230 V/(0-270) V.
5.	3-ø variac	415 V/(0-470) V.
6.	Rectifier	(0-220) V, 100 A.
7.	Resistive load or lamp load	7 KW, 230V.
8.	Panel board	--

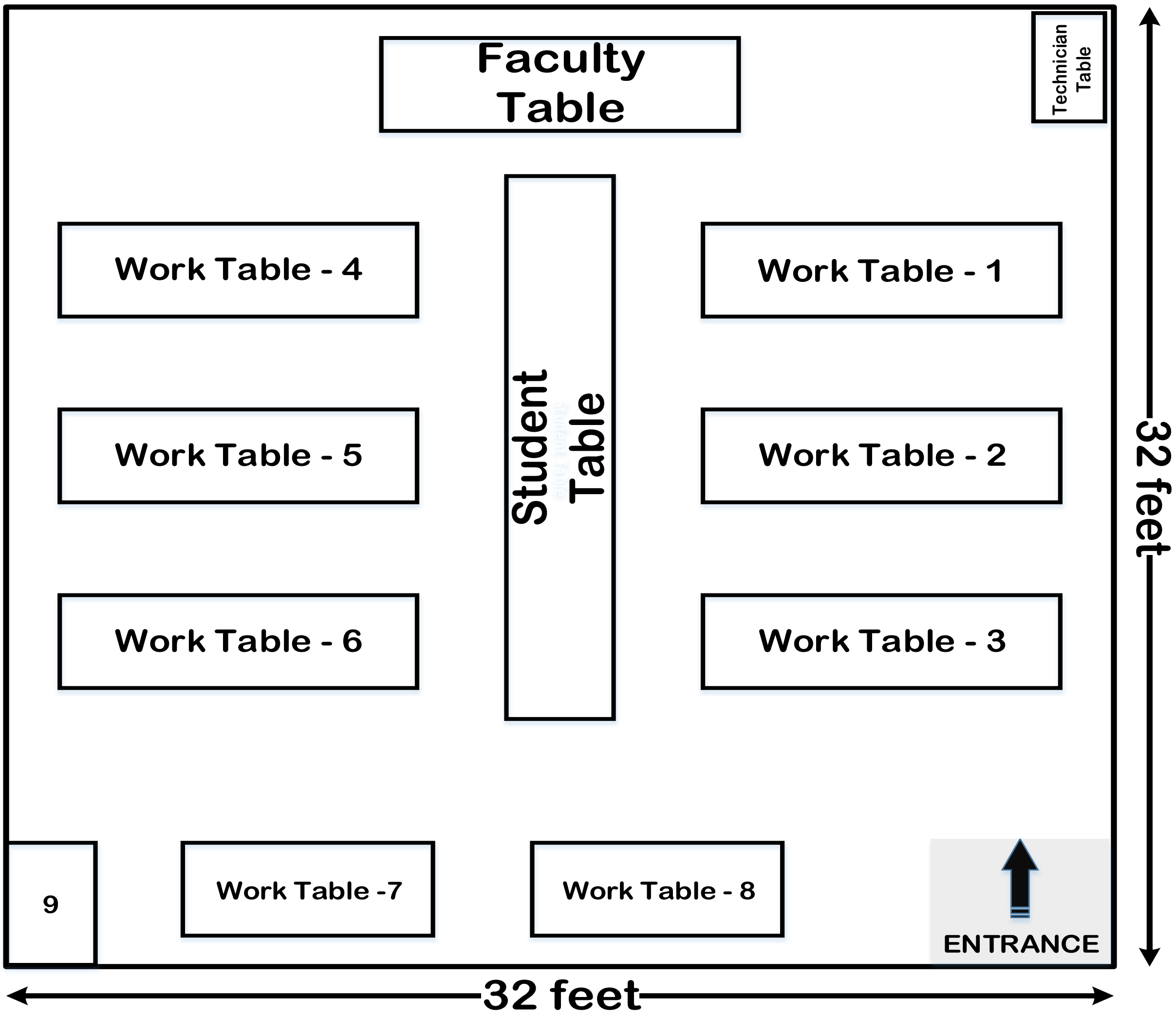
GENERAL INSTRUCTIONS

1. Shirts should be tucked in.
2. Perform only appropriate experiments and be sure that you understand the procedures involved before you begin.
3. Girl students should wear apron.
4. Supply to test table should be obtained only through the lab technician.
5. Energize the circuit only after getting approval from the faculty-in-charge.
6. Students who are not appropriately attired will not be allowed to perform experiments.
7. No horse-play before, during or after the lab.
8. Be familiar with emergency procedures & know the location of emergency equipment. First aid kit for minor injuries is with the lab technician.
9. Do not modify equipment settings unless instructed by lab handout or lab instructor.
10. Unauthorized experiments and working in the laboratory outside the class hours without permission are strictly prohibited.
11. Keep bags in designated areas.
12. If you feel unwell or dizzy while doing the experiment, stop immediately, sit down and notify the instructor.

SAFETY PRECAUTIONS

1. Wearing shoes is compulsory.
2. Do not use extension cords for permanent wiring.
3. Electrical cords on equipment must be in good condition.
4. Cables used must be appropriate to their loading. Avoid contact with water.
5. Do not tamper with or touch any equipment not specifically related to the current experiment.
6. Do not allow chains / ornaments to hang.
7. Do not lean over rotating machinery.
8. Do not operate any other machine not related to your experiment.
9. Follow precautions where ever necessary as indicated in the lab manual.
10. Do not touch any live part in the circuit while Experiment is ON.

AC Machines Lab Layout



1	Induction Motor – DC Compound Motor – Smooth Cylindrical Alternator
2	Induction Motor – DC Compound Motor – Smooth Cylindrical Alternator
3	Induction Motor – DC Compound Motor – Smooth Cylindrical Alternator
4	Slip Ring Induction Motor – DC Compound Motor – Salient Pole Alternator
5	Slip Ring Induction Motor – DC Compound Motor – Salient Pole Alternator
6	Slip Ring Induction Motor – DC Compound Motor – Salient Pole Alternator
7	Universal Motor
8	Single Phase Induction Motor
9	Meter Stack

Total cost of the equipment : Rs. 32,58,302.92/-

Area of the Laboratory : 95.13 Sq.mts

Name of the Lab in-charge : Mr. A. Muni Sankar

Name of the Technician : Mr. Sk. Azeez

1. CONSTRUCTION OF TRANSFORMERS

AIM:

To study about the constructional details of transformers.

Construction:

Basically a transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core.

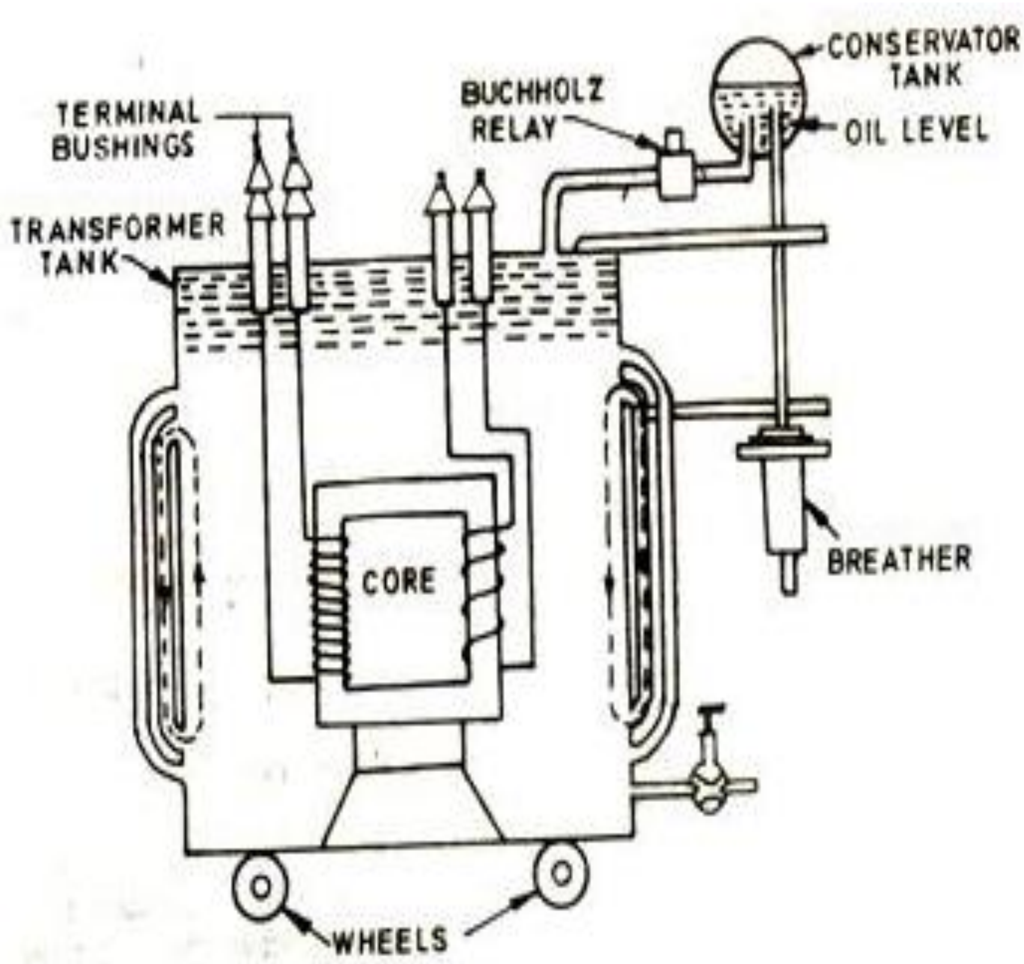


Fig 1.1: Detailed construction of transformer

A transformer may also consist of a container for winding and core assembly (called as tank), suitable bushings to take over the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. The figure at left illustrates the basic construction of a transformer.

Transformer laminated steel sheet shapes in all types of transformers, core is constructed by assembling (stacking) laminated sheets of steel, with minimum air-gap between them (to achieve continuous magnetic path).

The steel used is having high silicon content and sometimes heat treated, to provide high permeability and low hysteresis loss. Laminated sheets of steel are used to reduce eddy current loss. The sheets are cut in the shape as E, I and L.

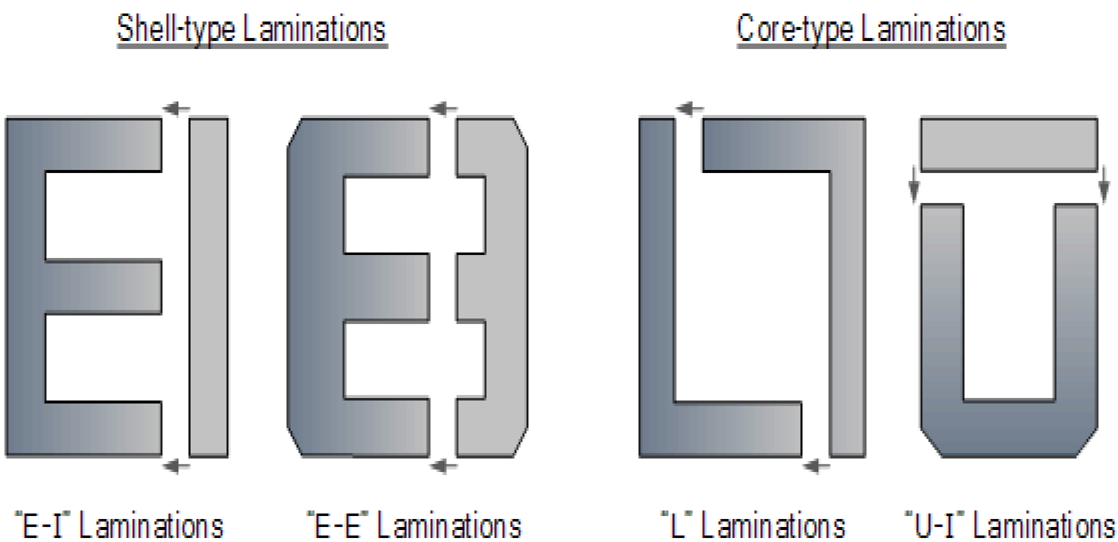


Fig 1.2 Different types of laminations

To avoid high reluctance at joints, laminations are stacked by alternating the sides of joint. That is, if joints of first sheet assembly are at front face, the joints of following assemble are kept at back face.

CORE

The core acts as support to the winding in the transformer. It also provides a low reluctance path to the flow of magnetic flux. It is made of laminated soft iron core in order to reduce eddy current loss and Hysteresis loss. The composition of a transformer core depends on such as factors voltage, current, and frequency.

The diameter of the transformer core is directly proportional to copper loss and is inversely proportional to iron loss. If the diameter of the core is decreased, the weight of the steel in the core is reduced, which leads to less core loss of the transformer and the copper loss increase. When the diameter of the core is increased, the vise-versa occurs.

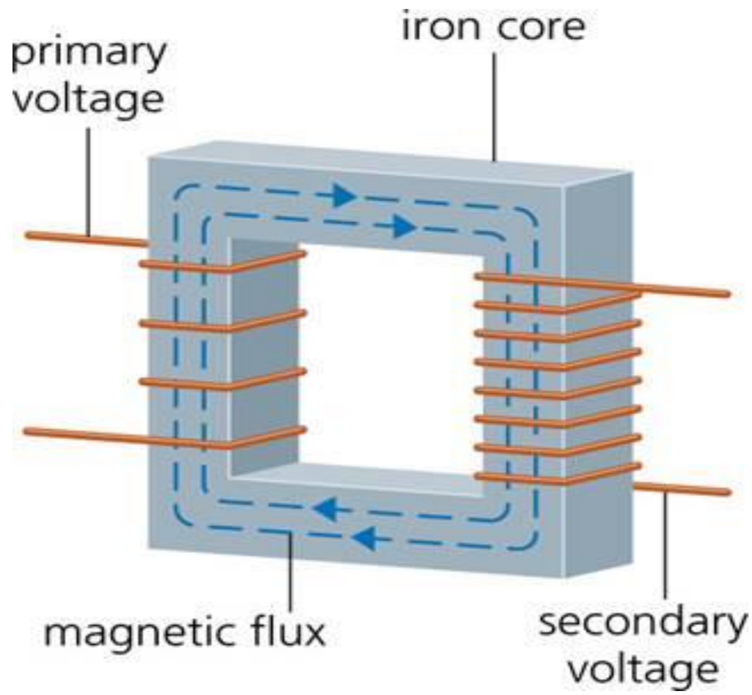


Fig 1.3: Main parts of transformer

WINDING

Two sets of winding are made over the transformer core and are insulated from each other. Winding consists of several turns of copper conductors bundled together, and connected in series. Winding can be classified in two different ways:

1) Based on the input and output supply
2) Based on the voltage range

Within the input/output supply classification, winding are further categorized:

Primary winding - These are the winding to which the input voltage is applied.

Secondary winding - These are the winding to which the output voltage is applied.

Within the voltage range classification, winding are further categorized:

- High voltage winding - It is made of copper conductor. The number of turns made shall be the multiple of the number of turns in the low voltage winding. The conductor used will be thinner than that of the low voltage winding.
- Low voltage winding - It consists of fewer number of turns than the high voltage winding. It is made of thick copper conductors. This is because the current in the low voltage winding is higher than that of high voltage winding.

Input supply to the transformers can be applied from either low voltage (LV) or high voltage (HV) winding based on the requirement.

CONSERVATOR

The conservator conserves the transformer oil. It is an airtight, metallic, cylindrical drum that is fitted above the transformer. The conservator tank is vented to the atmosphere at the top, and the normal oil level is approximately in the middle of the conservator to allow the oil to expand and contract as the temperature varies. The conservator is connected to the main tank inside the transformer, which is completely filled with transformer oil through a pipeline.

BREATHER

The breather controls the moisture level in the transformer. Moisture can arise when temperature variations cause expansion and contraction of the insulating oil, which then causes the pressure to change inside the conservator. Pressure changes are balanced by a flow of atmospheric air in and out of the conservator, which is how moisture can enter the system. If the insulating oil encounters moisture, it can affect the paper insulation or may even lead to internal faults. Therefore, it is necessary that the air entering the tank is moisture-free.

The transformer's breather is a cylindrical container that is filled with silica gel. When the atmospheric air passes through the silica gel of the breather, the air's moisture is absorbed by the silica crystals. The breather acts like an air filter for the transformer and controls the moisture level inside a transformer. It is connected to the end of breather pipe.

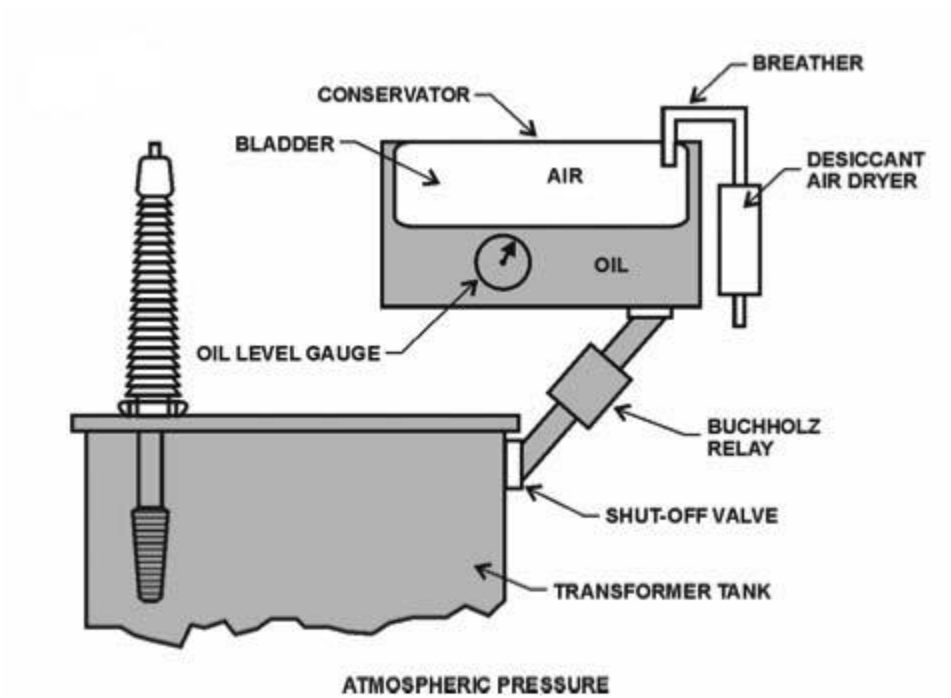


Fig 1.4: Conservator arrangement

TAP CHANGER

The output voltage of transformer varies according to its input voltage and the load. During loaded conditions, the voltage on the output terminal decreases, whereas during off-load conditions the output voltage increases. In order to balance the voltage variations, tap changers are used. Tap changers can be either on-load tap changers or off-load tap changers. In an on-load tap changer, the tapping can be changed without isolating the transformer from the supply. In an off-load tap changer, it is done after disconnecting the transformer. Automatic tap changers are also available.

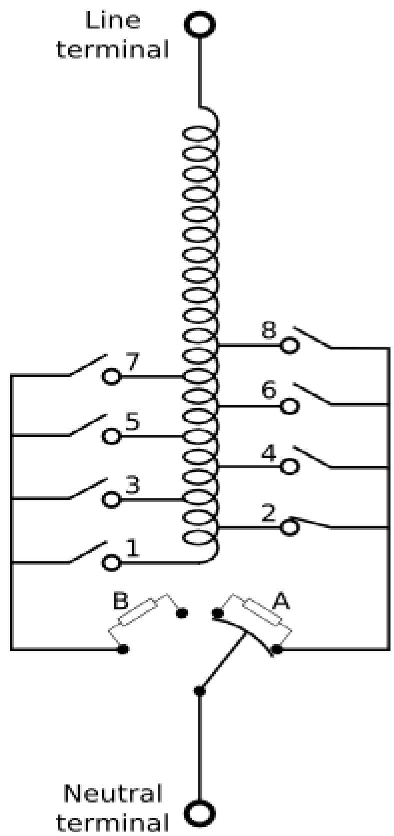


Fig 1.5: Schematic arrangement of tap changer

COOLING TUBES

Cooling tubes are used to cool the transformer oil. The transformer oil is circulated through the cooling tubes. The circulation of the oil may either be natural or forced. In natural circulation, when the temperature of the oil raises the hot oil naturally rises to the top and the cold oil sinks downward. Thus the oil naturally circulates through the tubes. In forced circulation, an external pump is used to circulate the oil.

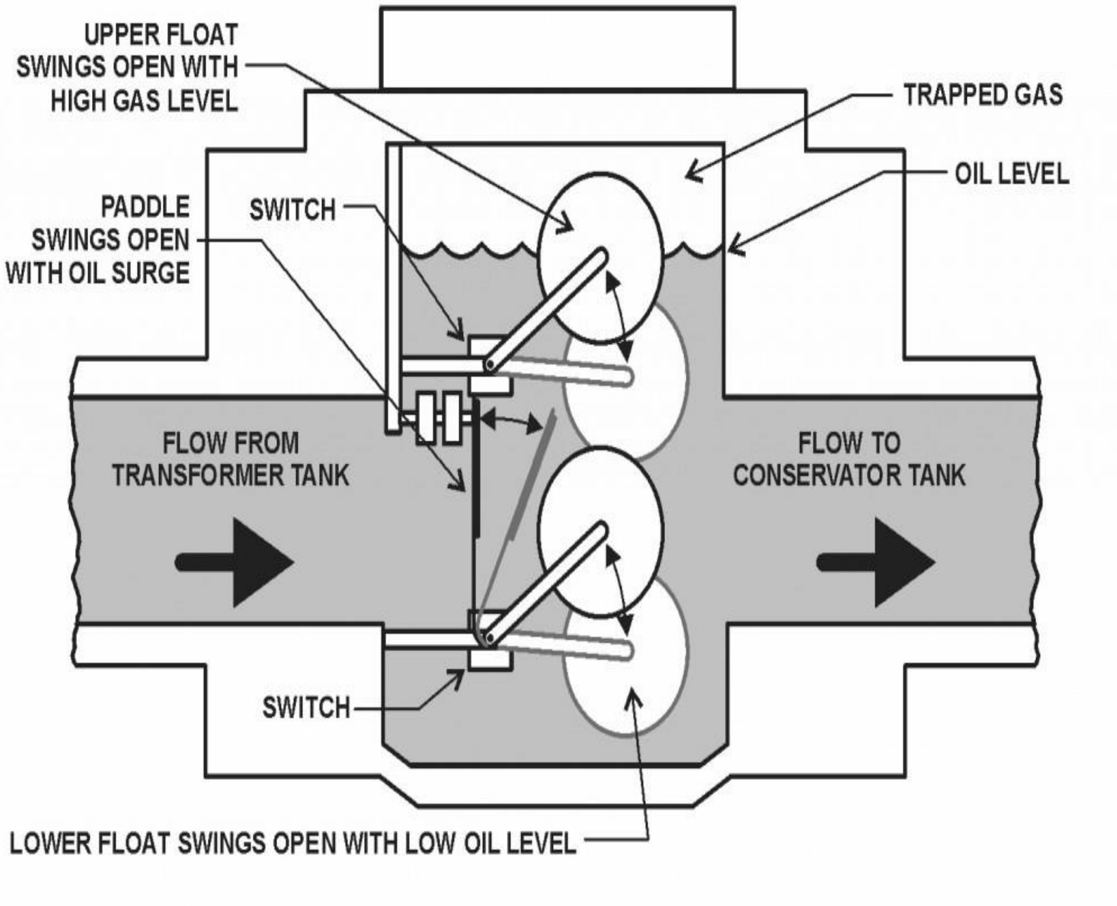


Fig 1.6 Schematic diagram of Buchholz relay

BUCHHOLZ RELAY

The Buchholz Relay is a protective device container housed over the connecting pipe from the main tank to the conservator tank. It is used to sense the faults occurring inside the transformer.

It is a simple relay that is operated by the gases emitted during the decomposition of transformer oil during internal faults. It helps in sensing and protecting the transformer from internal faults.

EXPLOSION VENT

The explosion vent is used to expel boiling oil in the transformer during heavy internal faults in order to avoid the explosion of the transformer. During heavy faults, the oil rushes out of the vent. The level of the explosion vent is normally maintained above the level of the conservatory tank.

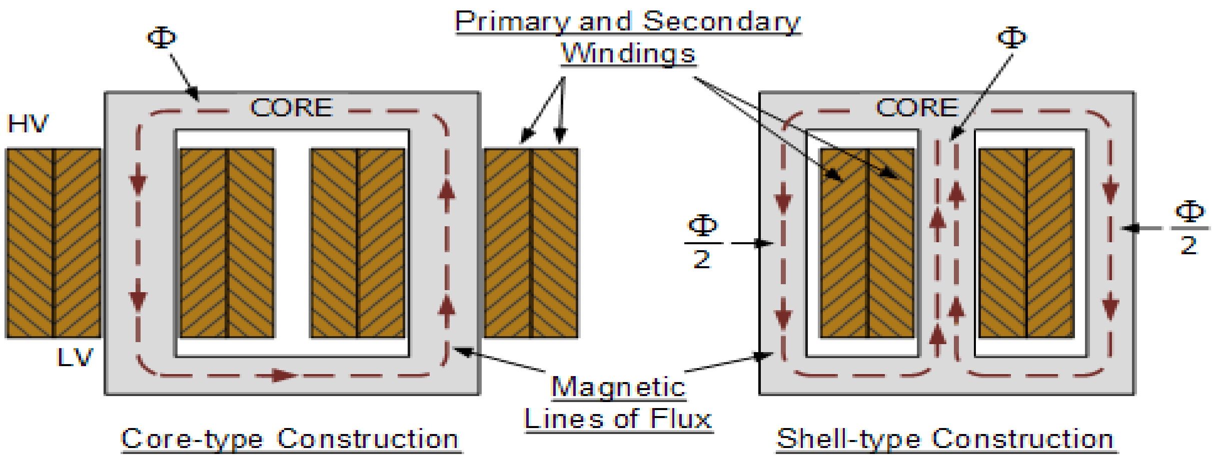


Fig 1.7: Types of cross sections of core in a transformer

TYPES OF TRANSFORMERS:

Transformers can be classified on different basis, like types of construction, types of cooling etc.

(A) On the basis of construction, transformers can be classified into two types as;

- Core type transformer and
- Shell type transformer, which are described below.

Core type and shell type transformer:

- Core Type Transformer: In core type transformer, windings are cylindrical former wound, mounted on the core limbs as shown in the fig1.7 above. The cylindrical coils have different layers and each layer is insulated from each other. Materials like paper, cloth or mica can be used for insulation. Low voltage windings are placed nearer to the core, as they are easier to insulate.
- Shell Type Transformer: The coils are former wound and mounted in layers stacked with insulation between them. A shell type transformer may have simple rectangular form (as shown in above fig 1.7), or it may have a distributed form.

(B) On the basis of their purpose

- Step up transformer: Voltage increases (with subsequent decrease in current) at secondary.
- Step down transformer: Voltage decreases (with subsequent increase in current) at secondary.

(C) On the basis of type of supply

- Single phase transformer

- Three phase transformer

(D) On the basis of their use

- Power transformer: Used in transmission network and high rated transformer.
- Distribution transformer: Used in distribution network, comparatively lower rating than that of power transformers.
- Instrument transformer: Used in relay and protection purpose in different instruments in industries.
    - Current transformer (CT)
    - Potential transformer (PT)

(E) On the basis of cooling employed

- Oil-filled self-cooled type
- Oil-filled water cooled type
- Air blast type (air cooled)

RESULT:

2. CONSTRUCTION OF 3-PHASE INDUCTION MOTOR

AIM:

To study about the constructional details of 3-phase induction motor.

CONSTRUCTION:

The three phase induction motor is the most widely used electrical motor. Almost 80% of the mechanical power used by industries is provided by **three phase induction motors** because of its simple and rugged construction, low cost, good operating characteristics, the absence of commutator and good speed regulation. In three phase induction motor, the power is transferred from stator to rotor winding through induction. The induction motor is also called a synchronous motor as it runs at a speed other than the synchronous speed.

Like any other electrical motor induction motor also have two main parts namely rotor and stator.

1. **Stator:** As its name indicates stator is a stationary part of induction motor. A stator winding is placed in the stator of induction motor and the three phase supply is given to it.
2. **Rotor:** The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft.

Depending upon the type of rotor construction used the **three phase induction motor** are classified as:

- ❖ Squirrel cage induction motor,
- ❖ Slip ring induction motor or wound induction motor or phase wound induction motor.

The other parts, which are required to complete the induction motor, are:

1. Shaft for transmitting the torque to the load. This shaft is made up of steel.
2. Bearings for supporting the rotating shaft.
3. One of the problems with electrical motor is the production of heat during its rotation. To overcome this problem, we need a fan for cooling.
4. For receiving external electrical connection Terminal box is needed.
5. There is a small distance between rotor and stator which usually varies from 0.4 mm to 4 mm. Such a distance is called air gap.

Stator of Three Phase Induction Motor:

The stator of the three-phase induction motor consists of three main parts:

1. Stator frame,
2. Stator core,
3. Stator winding or field winding.

Stator Frame:

It is the outer part of the three phase induction motor. Its main function is to support the stator core and the field winding. It acts as a covering, and it provides protection and mechanical strength to all the inner parts of the induction motor.

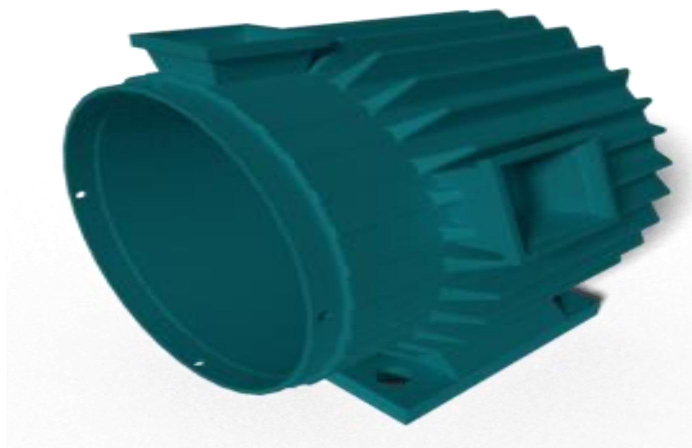


Fig 2.1: stator frame

The frame is either made up of die-cast or fabricated steel. The frame of three phase induction motor should be strong and rigid as the air gap length of three phase induction motor is very small. Otherwise, the rotor will not remain concentric with the stator, which will give rise to an unbalanced magnetic pull.

Stator Core:

The main function of the stator core is to carry the alternating flux. In order to reduce the eddy current loss, the stator core is laminated.

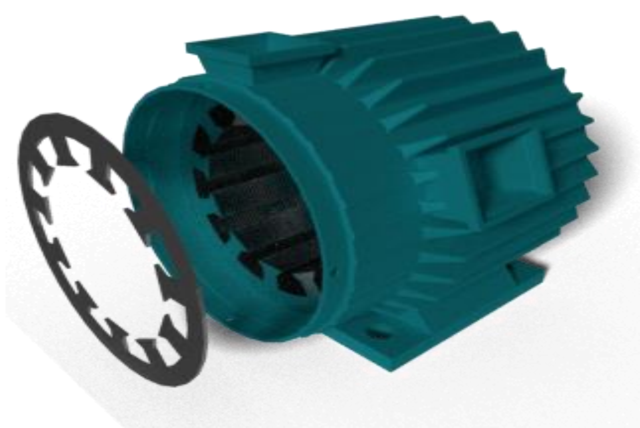


Fig 2.2: stator core and laminations

These laminated types of structure are made up of stamping which is about 0.4 to 0.5 mm thick. All the stamping are stamped together to form stator core, which is then housed in stator frame. The stamping is made up of silicon steel, which helps to reduce the hysteresis loss occurring in the motor.

Stator Winding or Field Winding

The slots on the periphery of the stator core of the three-phase induction motor carry three phase windings. We apply three phase ac supply to this three-phase winding. The three phases of the winding are connected either in star or delta depending upon which type of starting method we use. We start the squirrel cage motor mostly with star-delta stater and hence the stator of squirrel cage motor is delta connected.

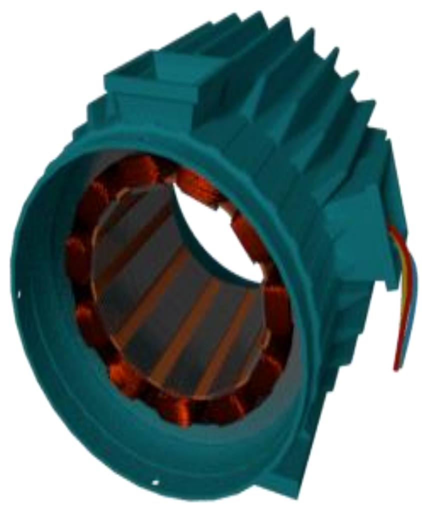


Fig 2.3: stator winding

We start the slip ring three-phase induction motor by inserting resistances so; the stator winding of slip ring induction motor can be connected either in star or delta. The winding wound on the stator of three phase induction motor is also called field winding, and when this winding is excited by three phase ac supply, it produces a rotating magnetic field.

Types of Three Phase Induction Motor

1. *Squirrel Cage Three Phase Induction Motor*

The rotor of the squirrel cage three phase induction motor is cylindrical and have slots on its periphery. The slots are not made parallel to each other but are bit skewed as the skewing prevents magnetic locking of stator and rotor teeth and makes the working of the motor more smooth and quieter.

The squirrel cage rotor consists of aluminum, brass or copper bars (copper bras rotor is shown in the figure beside). These aluminum, brass or copper bars are called rotor conductors and are placed in the slots on the periphery of the rotor.

The rotor conductors are permanently shorted by the copper, or aluminum rings called the end rings. To provide mechanical strength, these rotor conductors are braced to the end ring and hence form a complete closed circuit resembling like a cage and hence got its name as squirrel cage induction motor.

The squirrel cage rotor winding is made symmetrical. As end rings permanently short the bars, the rotor resistance is quite small, and it is not possible to add external resistance as the bars get permanently shorted. The absence of slip ring and brushes make the construction of Squirrel cage three-phase induction motor very simple and robust and hence widely used three phase induction motor.

These motors have the advantage of adopting any number of pole pairs. The below diagram shows a squirrel cage induction rotor having aluminum bars short circuit by aluminum end rings.

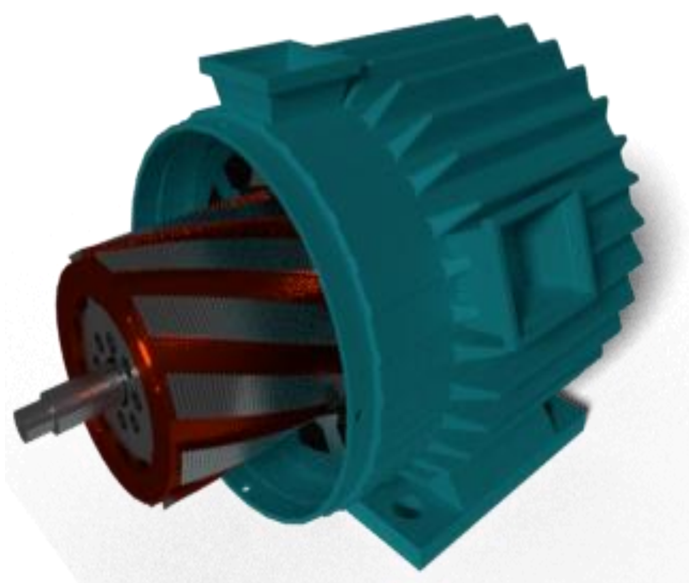


Fig 2.4: squirrel cage induction motor

Advantages of Squirrel Cage Induction Rotor

1. Its construction is very simple and rugged.
2. As there are no brushes and slip ring, these motors requires less maintenance.

Applications of Squirrel Cage Induction Rotor

We use the squirrel cage induction motors in:
- lathes,
- drilling machine,
- fan,
- blowers
- printing machines, etc

2. Slip Ring or Wound Rotor Three Phase Induction Motor

In this type of three phase induction motor the rotor is wound for the same number of poles as that of the stator, but it has less number of slots and has fewer turns per phase of a heavier conductor. The rotor also carries star or delta winding similar to that of the stator winding. The rotor consists of numbers of slots and rotor winding are placed inside these slots. The three end terminals are connected together to form a star connection. As its name indicates, three phase slip ring induction motor consists of slip rings connected on the same shaft as that of the rotor. The three ends of three-phase windings are permanently connected to these slip rings.

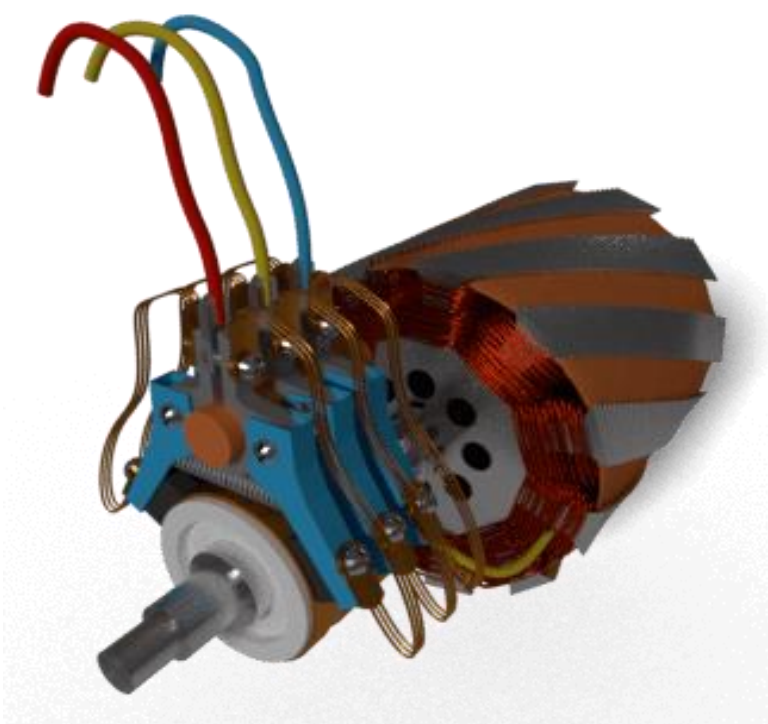


Fig 2.5: Slip ring induction motor

The external resistance can be easily connected through the brushes and slip rings and hence used for speed controlling and improving the starting torque of three phase induction motor. The brushes are used to carry current to and from the rotor winding. These brushes are further connected to three phase star connected resistances.

At starting, the resistance is connected to the rotor circuit and is gradually cut out as the rotor pick up its speed. When the motor is running the slip rings are shorted by connecting a metal collar, which connects all slip ring together, and the brushes are also removed. This reduces the wear and tear of the brushes. Due to the presence of slip rings and brushes the rotor construction becomes somewhat complicated therefore it is less used as compare to squirrel cage induction motor.

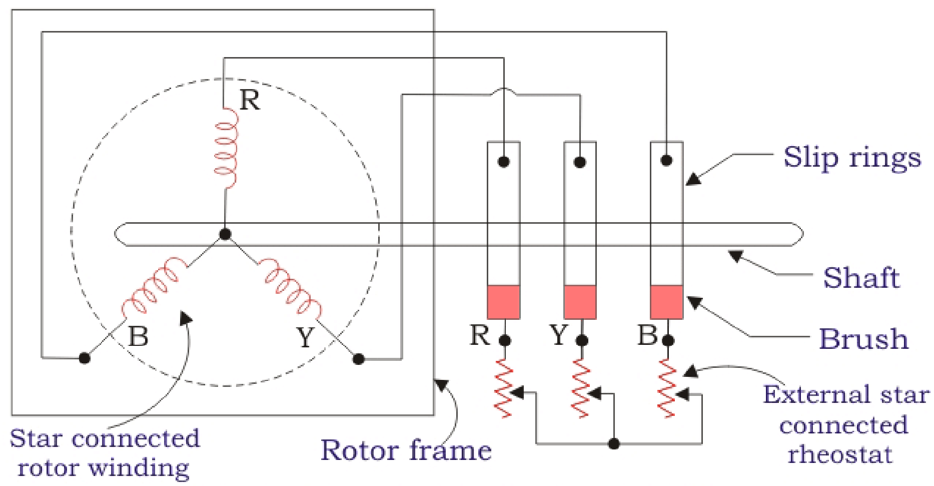


Fig 2.6: Schematic diagram of slip ring induction motor

Advantages of Slip Ring Induction Motor

1. It has high starting torque and low starting current.
2. Possibility of adding additional resistance to control speed.

Application of Slip Ring Induction Motor

Slip ring induction motors are used where high starting torque is required i.e., in:

hoists,

cranes,

elevator etc.

RESULT:

3. OC & SC TESTS ON SINGLE PHASE TRANSFORMER

AIM:

(a) To predetermine the efficiency and regulation of single phase transformer by conducting no-load test (or) open circuit test and short circuit test.

(b) To draw the equivalent circuit of single phase transformer referred to LV side as well as HV side.

APPARATUS REQUIRED:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAM:

Open Circuit Test:

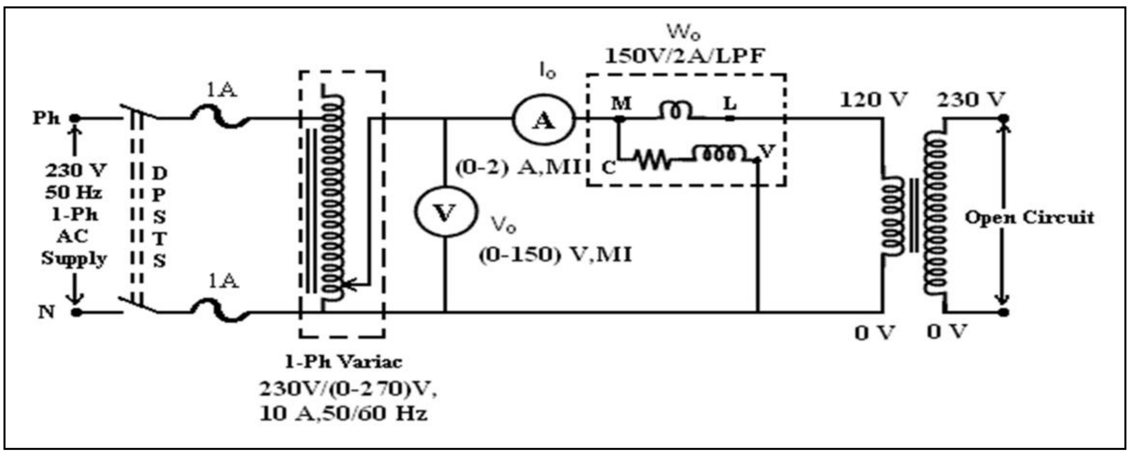


Fig 3.1: Circuit for open circuit test

Name Plate Details:

KVA rating :

LV Side Voltage :

HV Side Voltage :

Frequency :

Number of Phases :

Type of Construction :

Short Circuit:

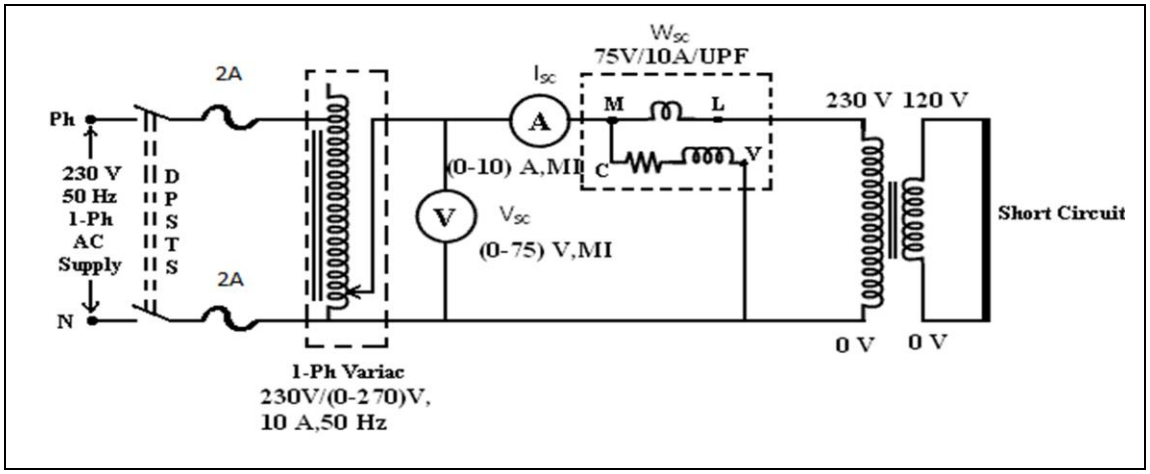


Fig 3.2: Circuit diagram for short circuit test

OBSERVATIONS:

OC Test:

V_o^1 (V)	I_o^1 (A)	Wo = W x M.F (W)

SC Test:

V_{SC} (V)	I_{SC} (A)	W_{SC} = W x M.F (W)

Where

M. F. = Multiplication factor = $\frac{VI\cos\phi}{FSD}$

FSD = Full scale divisions

PRECAUTIONS:

1. Avoid loose and wrong connections.
2. All knife switches should be open initially.
3. Single phase variac should be at minimum potential position initially.
4. Readings are taken without parallax error.

PROCEDURE:

For OC Test:

1. Connect the circuit as per fig 3.1.
2. Observe all precautions and close the DPST Switch.
3. Apply the rated voltage by increasing variac output gradually.

4. Note down the readings of all the meters.

For SC Test:

1. Connect the circuit as per fig 3.2.
2. Observe all precautions and close the DPST Switch.
3. Apply the rated current by increasing variac output gradually.
4. Note down the readings of all the meters.

MODEL CALCULATIONS:

Let the transformer be the step-down transformer

Primary is H. V. side.   Secondary is L. V. side

K = $\frac{V_2}{V_1}$ = Transformation ratio.

OC TEST CALCULATIONS:

$\cos\phi_0 = W_o/(V_o^1 I_o^1)$

$\sin^2\phi_0 = (1- \cos\phi_0^2)$

$\sin\phi_0 =$

$I_w^1 = I_0^1 \cos\phi_0$

$I_\mu^1 = I_0^1 \sin\phi_0$

$R^1_0 = V_0^1/I_w^1$

$X^1_{0=} V_0^1/I_\mu^1$

$R_0 = R^1_0/K^2$

$X_0 = X^1_0/K^2$

$I_0 = I_0^1 * K$

$I_W = I_w^1 * K$

$I_\mu = I_\mu^1 * K$

SC TEST CALCULATIONS:

$R_{01} = W_{sc}/I^2_{SC}$

$Z_{01} = V_{SC}/I_{SC}$

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

$$R_{02} = K^2 R_{01} =$$

$$X_{02} = K^2 X_{01}$$

$$Z_{02} = K^2 Z_{01}$$

CALCULATIONS TO FIND EFFICIENCY:

For reading 1:- 10% of full load and at Unity Power factor

Copper losses = W_{sc} x (10% of Full Load)^2

where W_{SC} = full – load cupper losses

Constant losses = W_0

Output = 10% of kVA x cos ϕ

Input = output + Cu. Loss + constant loss=

$$\%\ efficiency = \frac{Output}{Input}\ x\ 100 =$$

CALCULATIONS TO FIND REGULATION:

For reading 1: for full load 0.1 pf lag

$$\%\ \mathrm{Re}\,gulation = \frac{I_2\ R_{02}\ \cos\phi\ \pm\ I_2\ X_{02}\ \sin\phi}{V_2}\ x\ 100$$

$=$

'+' for lagging power factors

'-' for leading power factors

Efficiency at different loads and P.f's:

cos ϕ_2 = 0.707 Lag

S.No.	Load	Cu. loss (W)	Output (W)	Input (W)	%η

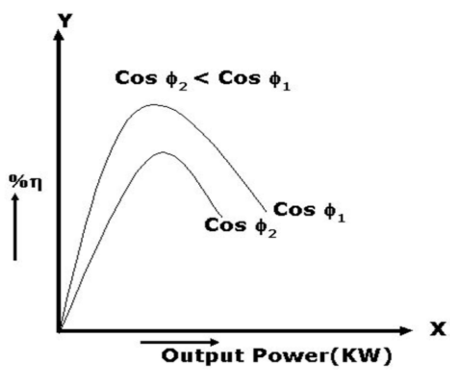
cos ϕ_1 = Unity pf

S.No	Load	Cu. loss (W)	Output (W)	Input (W)	%η

Regulation at different power factors:

Lagging Pf			Leading Pf		
S.No.	P.F.	% Reg.	S.No.	P. F.	% Reg.

MODEL GRAPHS:



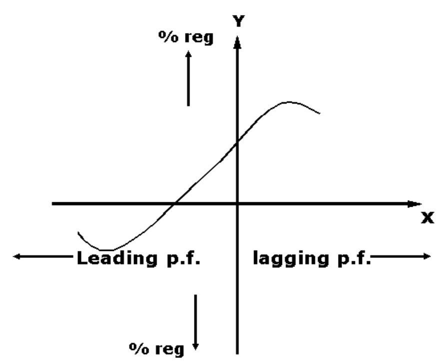


Fig 3.3: Plot of % efficiency Vs output

Fig 3.4: Plot of % regulation Vs power factor

EQUIVALENT CIRCUIT:

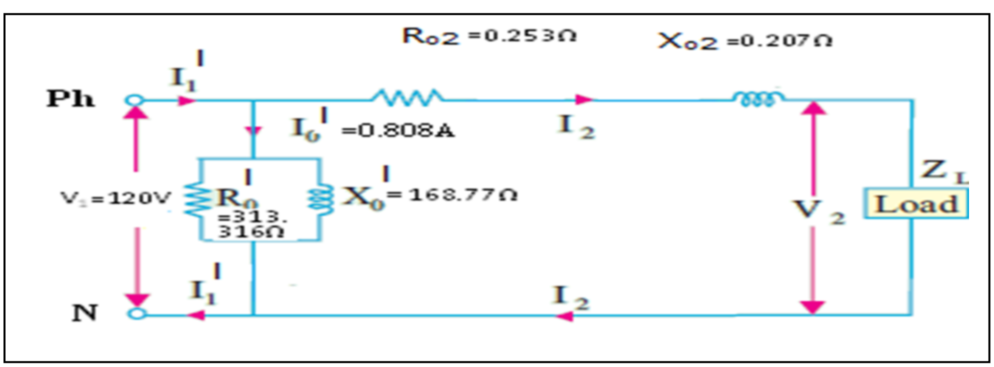


Fig 3.5: Equivalent circuit referred to LV side

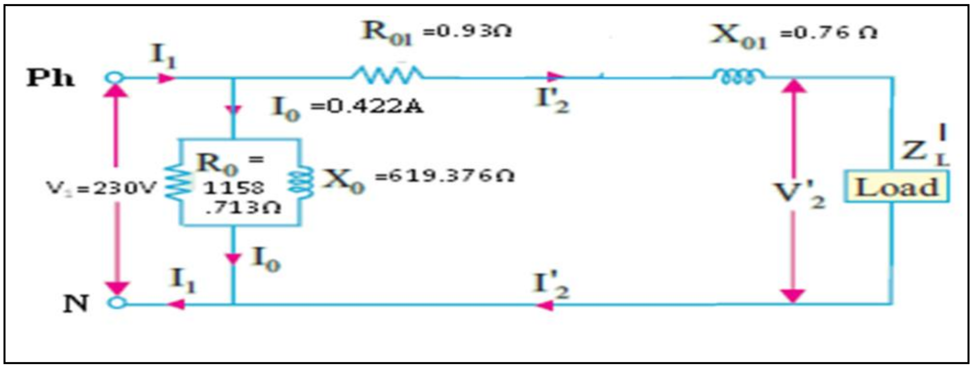


Fig 3.6: Equivalent circuit referred to HV side

Result:

4. SEPARATION OF CORE LOSSES OF A SINGLE PHASE TRANSFORMER

AIM:

To separate the core losses of a given single phase transformer by conducting no-load test on it at different frequencies provided v/f is constant.

APPARATUS:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAM:

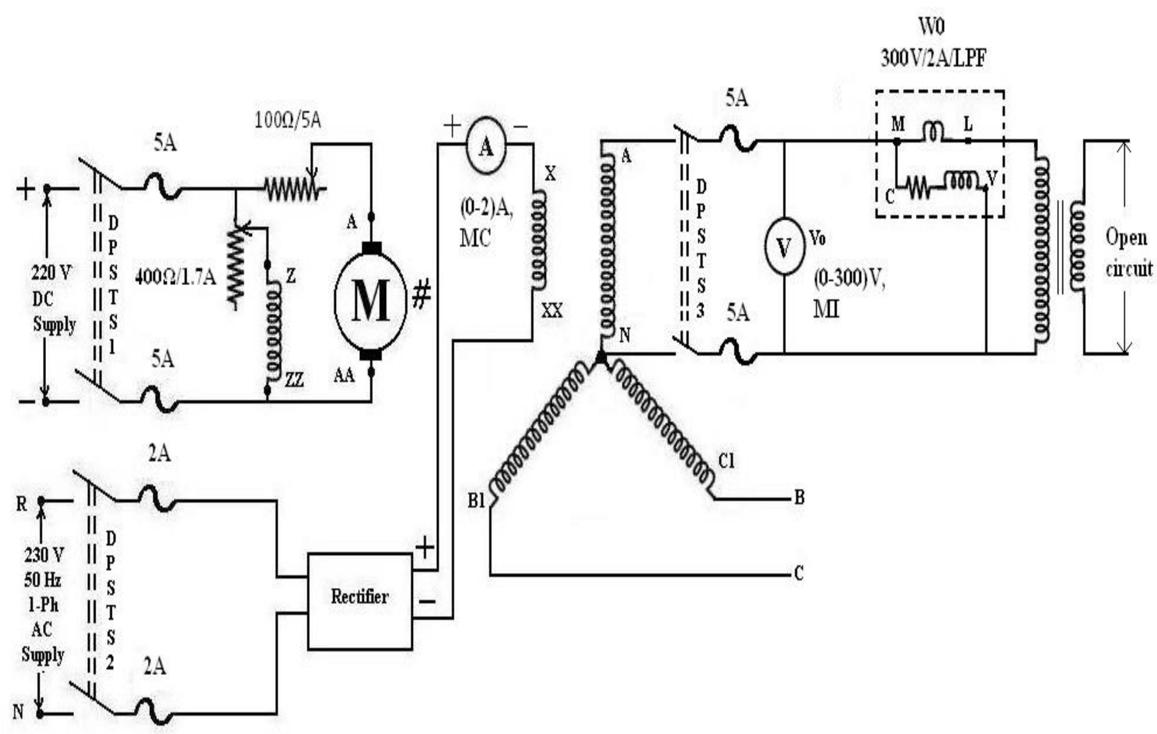


Fig 4.1: Circuit diagram for separation of core losses

NAME PLATE DETAILS:

a) Motor and alternator:

PARAMETER	MOTOR	ALTERNATOR
Power		
Voltage		
Current		
Type		
Speed		

Excitation Voltage
Excitation Current

b) Transformer:

KVA rating	:
LV Side Voltage	:
HV Side Voltage	:
Frequency	:
Number of Phases	:
Type	:

PRECAUTIONS:

1. Avoid loose connections and wrong connections.
2. All knife switches should be open initially.
3. Readings are to be taken without any parallax error.
4. Initially field rheostat should be in minimum resistance position and armature rheostat should be in maximum resistance position.
5. Rectifier output should be in minimum voltage position initially.

PROCEDURE:

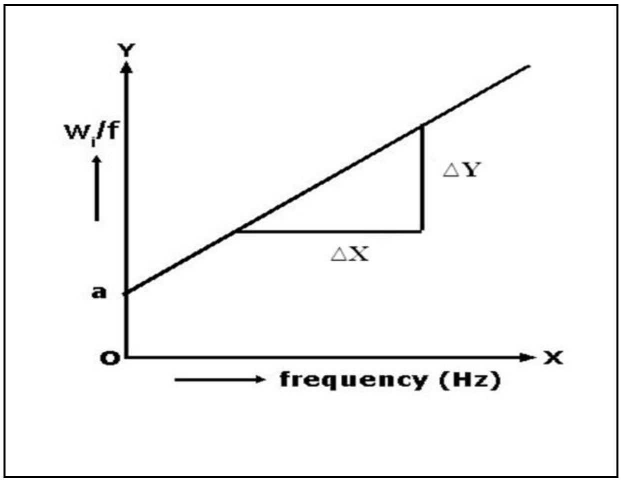
1. Make the connections as per the fig 4.1.
2. Observe all precautions and close the DPST Switch1.
3. Vary the armature rheostat and then field rheostat (if required) so that motor runs at rated speed of alternator.
4. Close the DPST Switches 2&3 and vary rectifier output up to voltmeter shows rated voltage.
5. Take down all meter readings.
6. Decrease the motor speed by varying armature rheostat in steps up to 50% of rated speed and in each step note down all meter readings.

MODEL CALCULATIONS:

$$P = \frac{120 f}{N} \qquad N_1 = \frac{120 f_1}{P} \qquad \frac{V}{f} = \frac{rated\ voltage}{rated\ \ frequency}$$

where, f = rated frequency,
f_1 = selected frequency,
N = rated speed,
N_1 = speed corresponding to f_1

Let $W_h = Af$; $W_C = Bf^2$;
$W_i = W_h + W_e = Af + Bf^2$
$W_i/f = A + B \times f$
A → Oa from graph
B → Y/x



OBSERVATIONS:

S. No.	Speed in rpm	Frequency in Hz	Voltage in volts	E/f	W_i=W X Mf (Watts)	W_i/f ratio

S.No.	Frequency (Hz)	Hysteresis Loss (Watts)	Eddy current Losses (Watts)	Total Losses (Watts)

RESULT:

5. LOAD TEST ON A SINGLE PHASE TRANSFORMER

AIM:

To conduct load test on single phase transformer and to find efficiency and percentage voltage regulation of it.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity

NAME PLATE DETAILS:

KVA rating :
LV Side Voltage :
HV Side Voltage :
Frequency :
Number of Phases :
Type of Construction :

PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

PROCEDURE:

1. Connections are made as per the Fig 5.1.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary sides are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on

both primary and secondary sides are noted.

5. Again no load condition is obtained and DPST switch is opened.

CIRCUIT DIAGRAM:

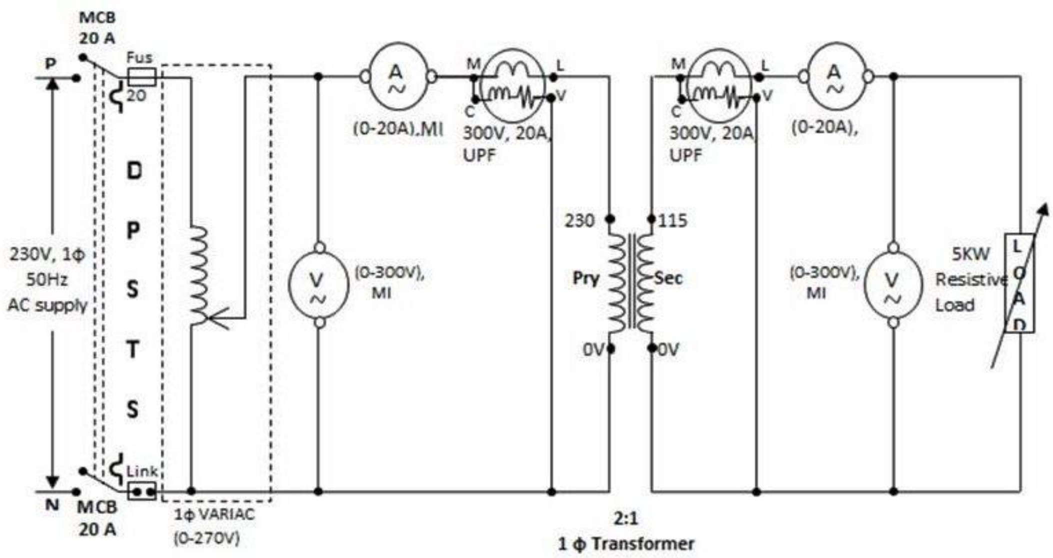


Fig 5.1: Circuit diagram for load test

TABULAR COLUMN:

S.No.	Input Voltage (v1)	Input Power W1 x MF	Output Voltage (v2)	Output current (I2)	Output Power W2 x MF	% Efficiency	% Regulation

FORMULAE:

Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplicationfactor

$$\% \ efficiency = \frac{output\ power\ in\ watts}{Input\ power\ in\ watts}\ X\ 100$$

$$\% \operatorname{Re} gulation = \frac{Noloadvoltage - loadvoltage}{noloadvoltage}\ x\,100$$

MODEL CALCULATIONS:

For 3rd reading:

Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

$$\% \ efficiency = \frac{output\ power\ in\ watts}{Input\ power\ in\ watts}\ X\ 100$$

$$\% \operatorname{Re} gulation = \frac{Noloadvoltage - loadvoltage}{noloadvoltage}\ x\,100$$

MODEL GRAPH:

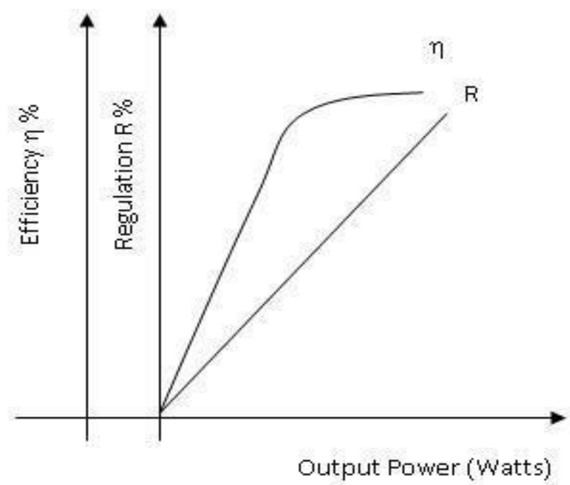


Fig 5.2: Efficiency and regulation characteristics

RESULT:

6. SUMPNER'S TEST ON A PAIR OF SINGLE PHASE TRANSFORMERS

AIM:

To find out the iron loss, copper loss and the efficiency of each transformer by conducting Sumpner's test on two identical single phase transformers.

APPARATUS REQUIRED:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAM:

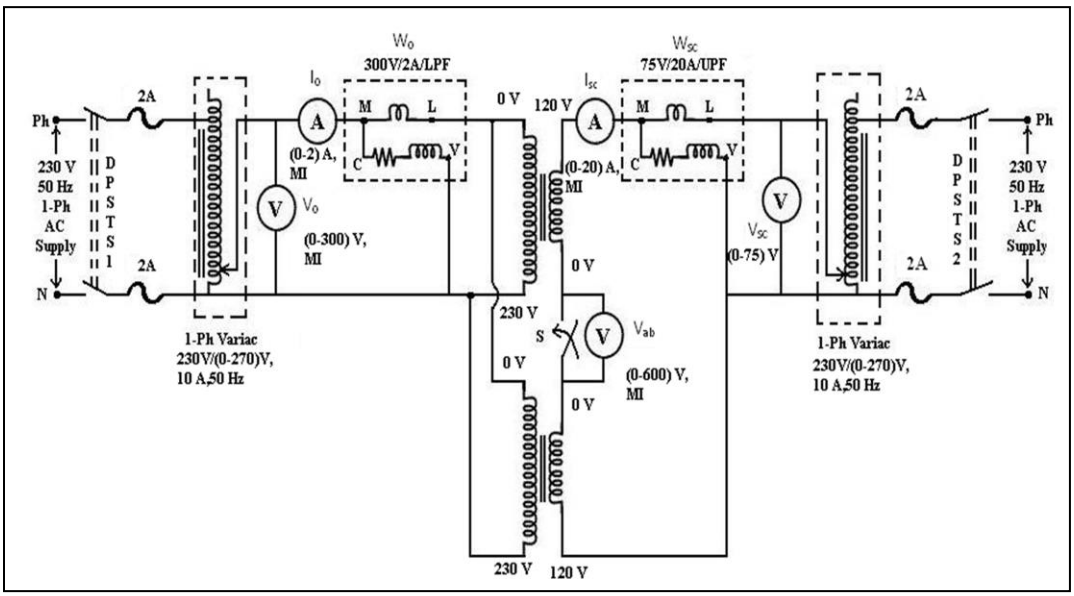


Fig 6.1: Circuit diagram for sumpner's test

NAME PLATE DETAILS:

KVA rating :

LV Side Voltage :

HV Side Voltage :

Frequency :

Number of Phases :

Type of Construction :

PRECAUTIONS:

1. Avoid loose connections and wrong connections.
2. All knife switches should be open initially.
3. Readings are to be taken without any parallax error.
4. 1-Ø variac must be in minimum output position initially.

PROCEDURE:

1. Connect the circuit as per the fig 6.1.
2. Observe all precautions and close the DPST Switch1.
3. Vary the variac till the rated voltage is present in the primaries of transformer.
4. Note down the Wattmeter (W_0) reading, Voltmeter (V_0) reading and ammeter (I_0) reading.
5. Close the SPST switch when voltage V_{ab} = 0 (see circuit diagram).
6. Observe all precautions and close the DPST Switch2. Now vary the corresponding Variac up to rated current of transformers.
7. Note down the Wattmeter (W_{sc}) reading, Voltmeter (V_{sc}) reading and ammeter (I_{sc}) reading.

MODEL CALCULATIONS:

Losses in each transformer = $\frac{w_0 + w_{sc}}{2}$

%η combined = $\frac{V_{sc} I_{sc}}{V_{sc} I_{sc} + w_0 + w_{sc}} x\, 100 =$

For reading 3:

For Pf=Unity

Load=30 %

I_{SC}= $W_{I=}$ W_{Cu}

I_{SC}=17.4Xload=

W_{Cu}= W_{Cu}/2 X $(load)^2$=

W_I= W_i/2=

Output =KVAXCosφX0.3

Input = Output + Losses

Efficiency=Output/Input X 100

MODEL GRAPH:

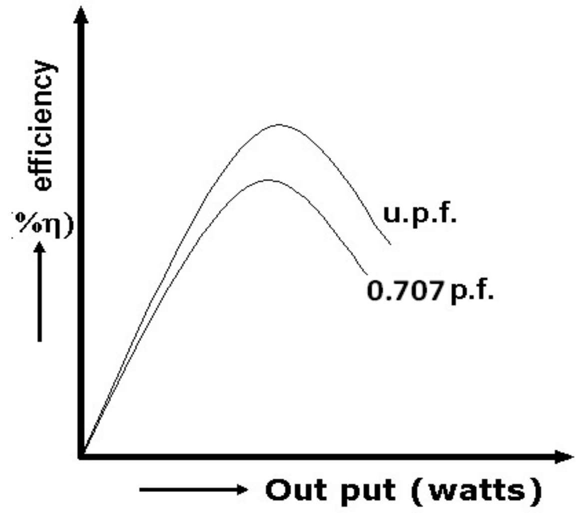


Fig 6.2: Efficiency characteristics at different Power Factors

OBSERVATION:

V_0 (V)	I_0 (A)	W_0 (W)

V_{sc} (V)	I_{sc} (A)	W_{sc} (W)

For CosΦ =Unity

% of load	V_0 (V)	I_0 (A)	I_{sc} (A)	W_i (W)	W_{cu} (W)	W_i /2 (W)	W_{cu} /2 (W)	Total Loss (W)	Input (W)	Output (W)	%η

For CosΦ =0.707

% of load	V_0 (V)	I_0 (A)	I_{sc} (A)	W_i (W)	W_{cu} (W)	W_i /2 (W)	W_{cu} /2 (W)	Total Loss (W)	Input (W)	Output (W)	%η

RESULT:

7. PARALLEL OPERATION OF TWO SINGLE PHASE TRANSFORMERS

AIM:

To connect two single phase transformers in parallel and to study how they share a common load.

APPARATUS:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAM:

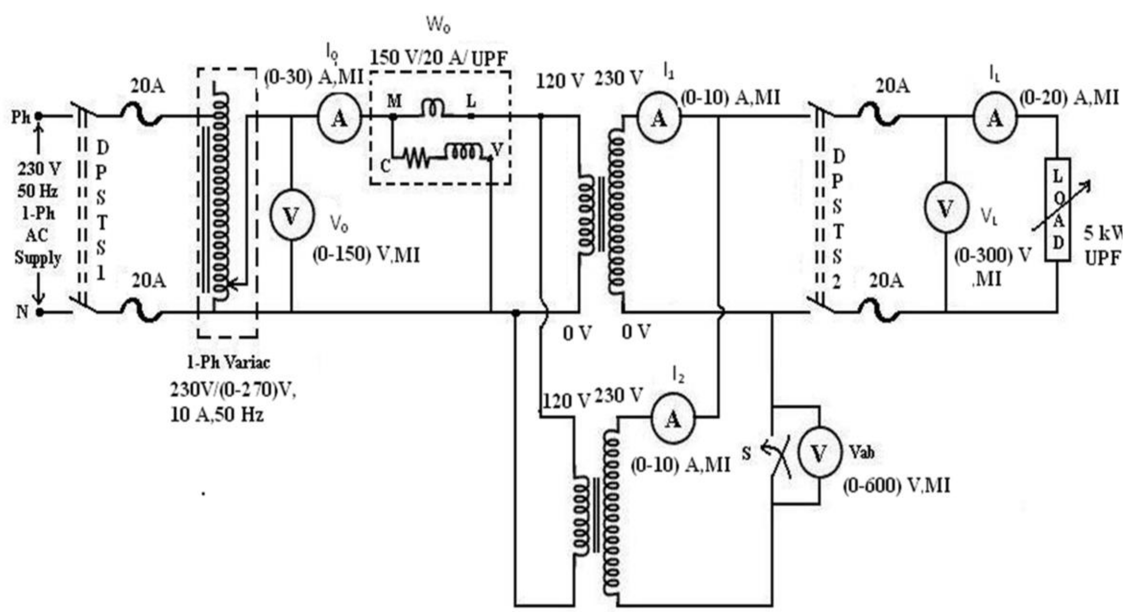


Fig 7.1: Circuit diagram for parallel operation

NAME PLATE DETAILS:

KVA rating :

LV Side Voltage :

HV Side Voltage :

Frequency :
Number of Phases :
Type of Construction :

PRECAUTIONS:

1. Keep all knife switches open initially.
2. Initially load should be off position.
3. Single phase variac should be minimum potential position initially.
4. Take meter readings without parallax error.

PROCEDURE:

1. Make the connections as per the fig 7.1.
2. Observe the precautions and close DPST Switch 1.
3. Vary the variac up to rated lv voltage of transformers. Observe the reading of voltmeter 'Vab', If Vab is zero close the SPST switch. Otherwise inter change secondary terminals of either transformer 1or 2**.**
4. Close the DPST switch 2 after reading of voltmeter, Vab is zero and note down the readings of all meters.
5. Vary the load in steps up to rated current and note down all meters reading in each step.

TABULAR COLUMN:

S.No.	Vo(V)	Io(A)	Wo(W)	V_L (V)	I_1 (A)	I_2 (A)	I_L (A)	% η	%Reg.

MODEL GRAPH:

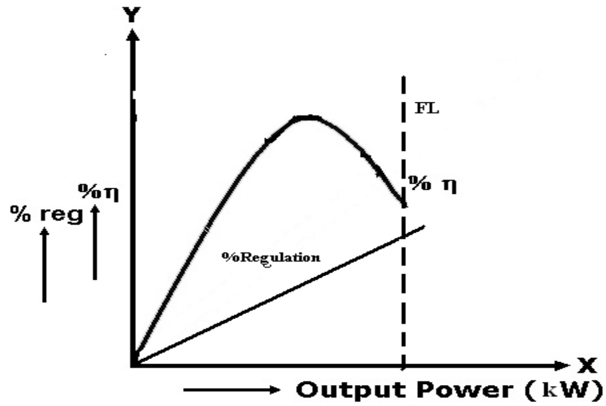


Fig 7.2: Efficiency and regulation characteristics

MODEL CALCULATIONS:

Reading No.:

$$\% efficiency(\% \eta) = \frac{Output\ in\ watts}{Input\ in\ watts}\ x\ 100$$

$$= ((V_L * I_L)/WoX100$$

$$\% \mathrm{Re}\,gulation = \frac{Noloadvoltage - loadvoltage}{noloadvoltage}\ x\ 100$$

RESULT:

8. SCOTT CONNECTION OF TRANSFORMERS

AIM:

To convert the given 3ϕ supply into 2ϕ supply using Scott connection of transformers and to find the efficiency of conversion.

APPARATUS REQUIRED:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAM:

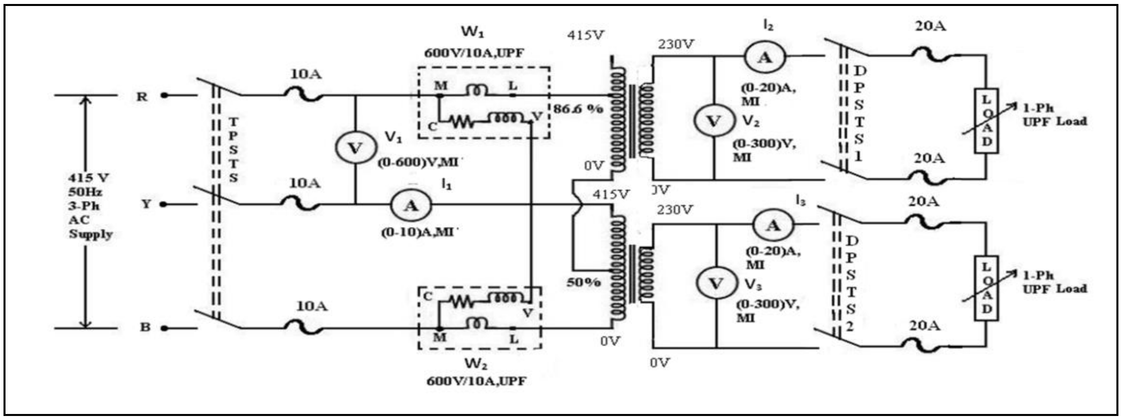


Fig 8.1: Circuit diagram for scott connection

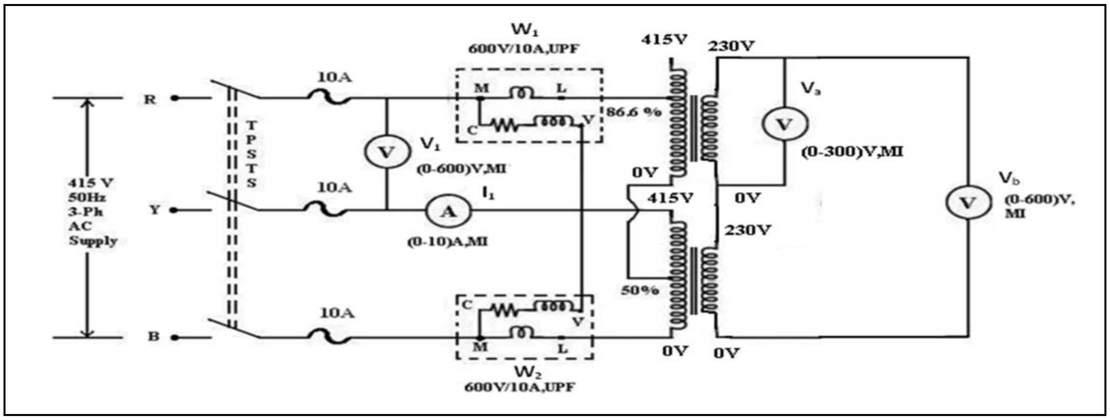


Fig 8.2: Circuit diagram for finding phase relation

NAME PLATE DETAILS:

a) Main Transformer:

KVA rating :
LV Side Voltage :
HV Side Voltage :
Frequency :
Number of Phases :
Type of Construction :

b) Teaser Transformer:

KVA rating :
LV Side Voltage :
HV Side Voltage :
Frequency :
Number of Phases :
Type of Construction :

PRECAUTIONS:

1. Connections must be tight and avoid wrong connections.
2. Readings are to be taken without any parallax error.
3. Initially all the knife switches should be in OPEN position.

PROCEDURE:

1. Connect the circuit diagram as shown in fig 8.1.
2. Close the TPST Switch. Note down the readings of all meters.
3. Close the DPST Switches 1&2 and vary both the loads in steps up to rated load and note down the readings of all meters in each step. Open the TPST Switch.
4. Connect the circuit diagram as shown in fig 8.2 to verify the phase relationship of the two phase voltages.
5. Close the TPST Switch and note down all meter readings in secondary side.

TABULATION

a) **for Scott connection:**

S.No.	V_1 (V)	I_1 (A)	W_1 (W)	W_2 (W)	V_2 (V)	I_2 (A)	V_3 (V)	I_3 (A)	Input (kW)	Output (kW)	%η

b) **for phase relation:**

V_a (V)	V_b (V)

MODEL CALCULATIONS:

For reading 2:

Input Power = $(W_1 + W_2)/1000$

Output Power = $(V_2 I_2 + V_3 I_3)/1000$

% efficiency = Output/Input*100

To Calculate Phase Relationship:

$(V_b)^2 = (V_a)^2 + (V_a)^2 + 2(V_a)(V_a)\cos(\Phi)$

MODEL GRAPH:

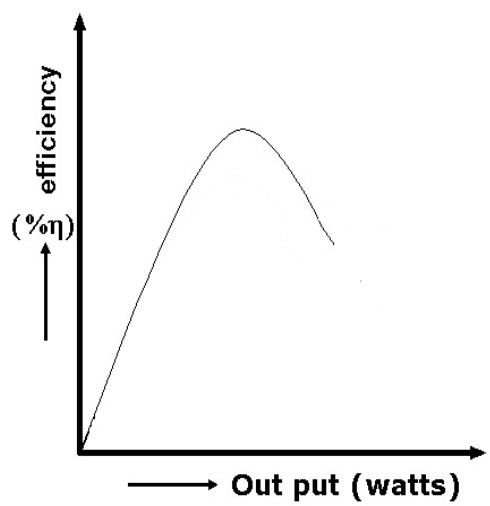


Fig 8.3: Efficiency characteristics

RESULT:

9. BRAKE TEST ON THREE PHASE INDUCTION MOTOR

AIM:

To conduct brake test on the given 3 phase induction motor and to plot its performance characteristics.

APPARATUS REQUIRED:

S.No.	Apparatus	Type	Range	Quantity

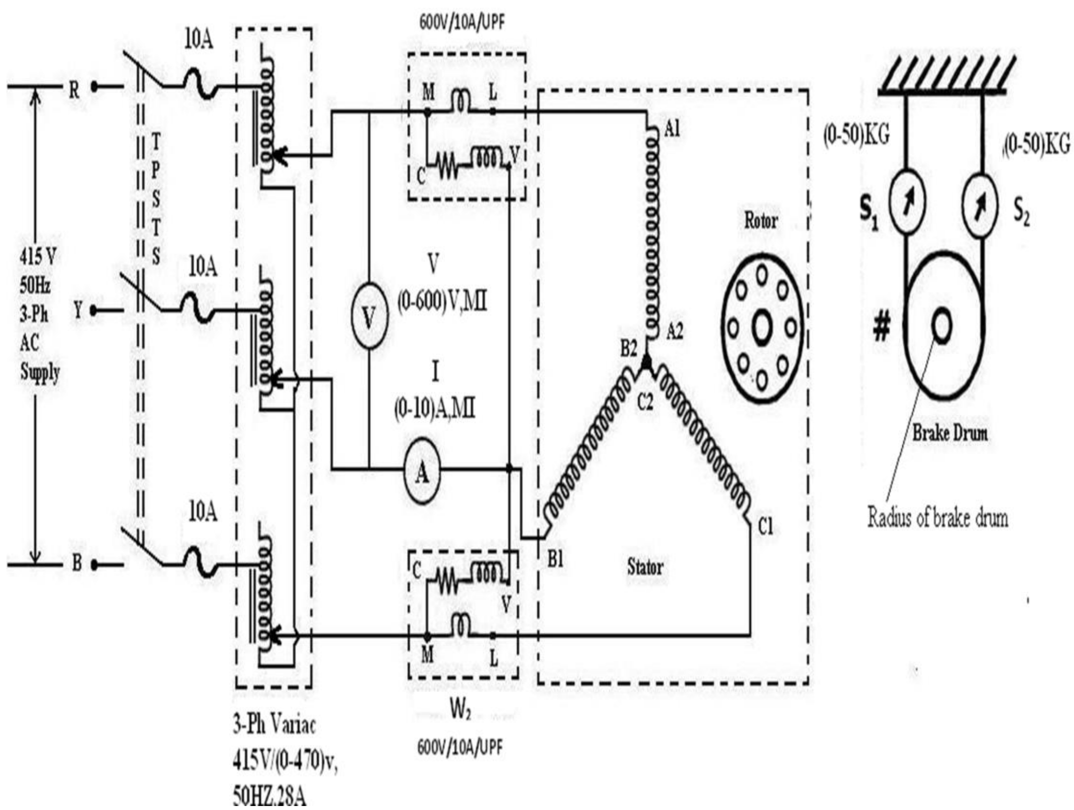


Fig 9.1: Circuit diagram for brake test

NAME PLATE DETAILS:

Power :

Voltage :

Current :

Speed :

Connection :

PRECAUTIONS:

1. Avoid loose connections and wrong connections.
2. All knife switches should be open initially.
3. Readings are to be taken without any parallax error.
4. 3-Ph Variac should be in minimum output position initially.
5. There should be no load on the motor initially.
6. Circulate water in the brake drum during operation.

PROCEDURE:

1. Connect the circuit as per the Fig 9.1.
2. Observe all precautions and close the TPST Switch.
3. Apply the rated voltage to the stator windings of 3-ϕ induction motor with the help of 3 phase variac transformer.
4. Note down the readings of all meters.
5. Load the induction motor in steps using the brake-drum arrangement. At each step note down the readings of all meters.

OBSERVATIONS:

S.No	V (v)	I (A)	W_1 (W)	W_2 (W)	S_1 (Kg)	S_2 (Kg)	% Slip	T_{sh} (N-m)	Output (W)	Input (W)	%η

MODEL CALCULATIONS:

for reading No 2:

Input power drawn by the motor W = ($W_1 \pm W_2$

Shaft Torque, T_{sh} = 9.81 ($S_1 \sim S_2$) R

r → Radius of drum in mts.=______ m

Output power in watts = $\frac{2\pi N\ T_{sh}}{60} =$

$$\%\ efficiency = \frac{output\ power\ in\ watts}{Input\ power\ in\ watts}\ X\ 100$$

$$\%\ slip\ = \frac{N_s - N}{N_s}\ X\ 100 = \quad \left[where\ N_s\ = \frac{120\ X\ f}{p} \right] = 1500 rpm$$

Power factor of the induction motor $\cos\phi\ = \frac{W}{\sqrt{3}\ V_L\ I_L} =$

MODEL GRAPH:

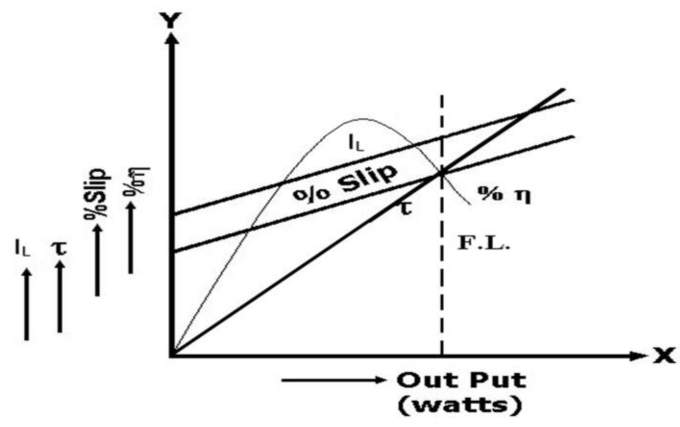


Fig 9.2: Performance characteristics of induction motor

RESULT:

10. SEPERATION OF NO-LOAD LOSSES OF THREE PHASE INDUCTION MOTOR

AIM:

To separate no-load loss of a 3-phase squirrel cage Induction motor as core loss, mechanical loss and stator copper loss.

APPARATUS:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAMS:

a) **No-load test:**

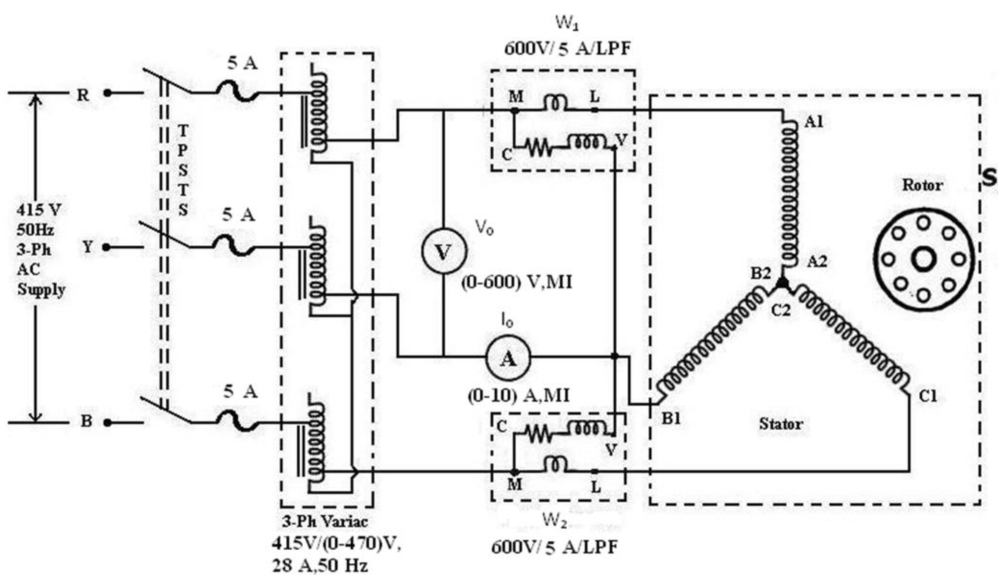


Fig 10.1: Circuit Diagram for no-load test

b) stator resistance test:

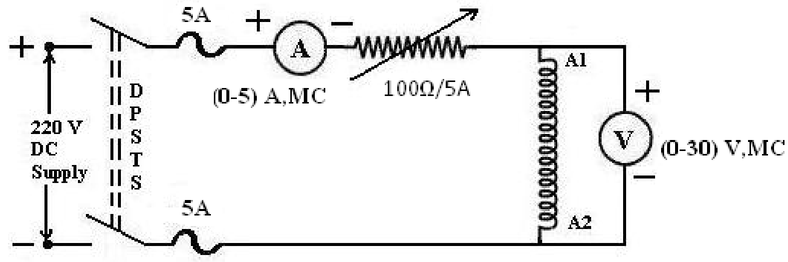


Fig 10.2: Circuit diagram for finding stator resistance

NAME PLATE DETAILS:

Power :

Voltage :

Current :

Speed :

Connection :

PRECAUTIONS:

1. Avoid loose connections and wrong connections.
2. All knife switches should be open initially.
3. Readings are to be taken without any parallax error.
4. 3-Ph Variac should be in minimum output position initially.

PROCEDURE:

a) No-load test:

1. Connect the circuit as per the fig 10.1.
2. Observe all precautions and close the TPST Switch.
3. Apply the rated voltage to the stator windings of 3-ϕ induction motor with the help of 3 phase variac transformer.
4. Note down the readings of wattmeter, ammeter and voltmeter on no-load.
5. Reduce the voltage gradually in steps up to motor speed becomes very low or zero and take down all meter readings in each step.

b) stator resistance test:

1. Connect the circuit as per the fig 10.2.
2. Observe all precautions and close the DPST Switch.

3. Note down the readings of all the meters.
4. Vary the rheostat in steps and note down both voltmeter and ammeter readings in each step.

OBSERVATIONS:

For no-load test:

S.No.	Io (A)	Vo (V)	W_1 (W)	W_2 (W)	W_1+W_2 (W)	Stator Cu loss (W)	Constant loss per phase (W)	Core loss per phase (W)	Speed (rpm)

Io = No load Current

Vo = No load voltage

W_1, W_2 = Wattmeter readings

$W_1 + W_2$ = Total no load input power

For stator resistance test:

S.NO	Armature Current (I) (amps)	Armature Voltage (V) (volts)	Armature Resistance R_{dc} = V/I (ohm)
Average Resistance, R_{dc}=			

Effective resistance per phase, $R_a=1.5*R_{dc}$

MODEL CALCULATIONS:

For reading no.4:

1. Input Power $W = (W_1 + W_2)$ watts W
2. Stator cu loss = $3I_o^2R_a$ watts =
3. Constant loss / phase ,Wc = $(W - 3I_o^2R_a)/3$ watts
4. Core loss/phase ,Wi = (Constant loss/phase ,Wc)– (Mechanical loss, Wm)

Here the mechanical loss, Wm will be the distance from the origin to the point at where the constant loss/phase Vs voltage curve cuts the y axis.

MODEL GRAPH:

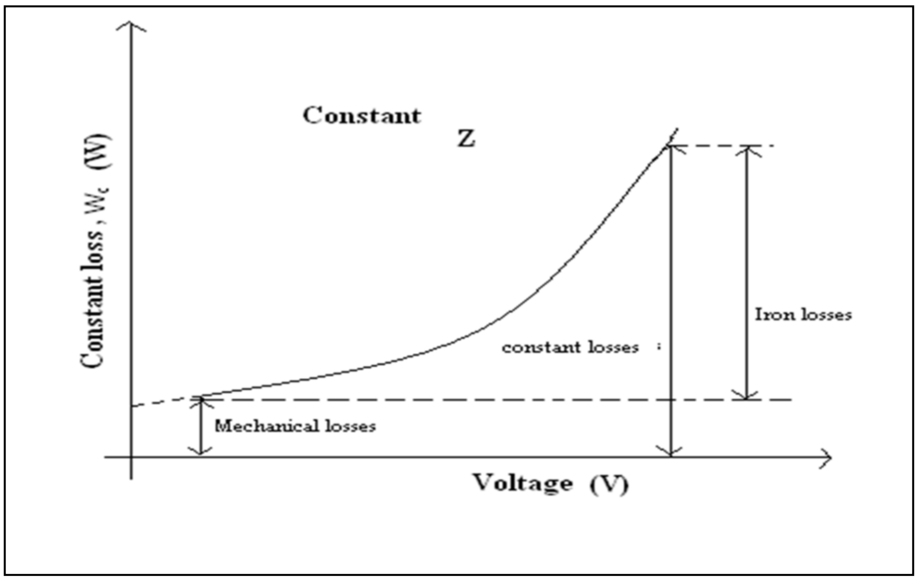


Fig 10.3: The graph drawn between constant loss and input voltage

RESULT:

11. NO LOAD AND BLOCKED ROTOR TESTS ON A 3 PHASE INDUCTION MOTOR

AIM:

To draw the equivalent circuit of a given 3 phase induction motor and construct the circle diagram by conducting No-load, blocked rotor and stator resistance tests.

APPARATUS REQUIRED:

S.No.	Apparatus	Type	Range	Quantity

CIRCUIT DIAGRAMS:

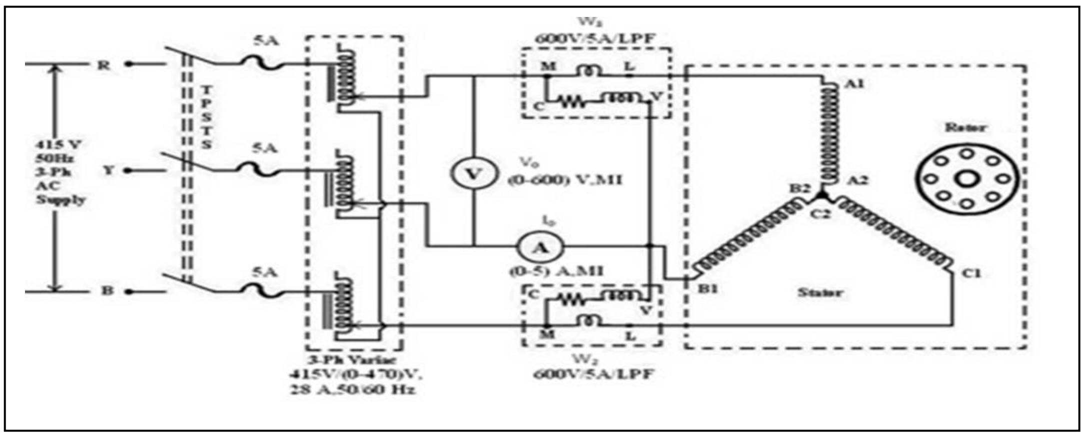


Fig 11.1: Circuit diagram for no-load test

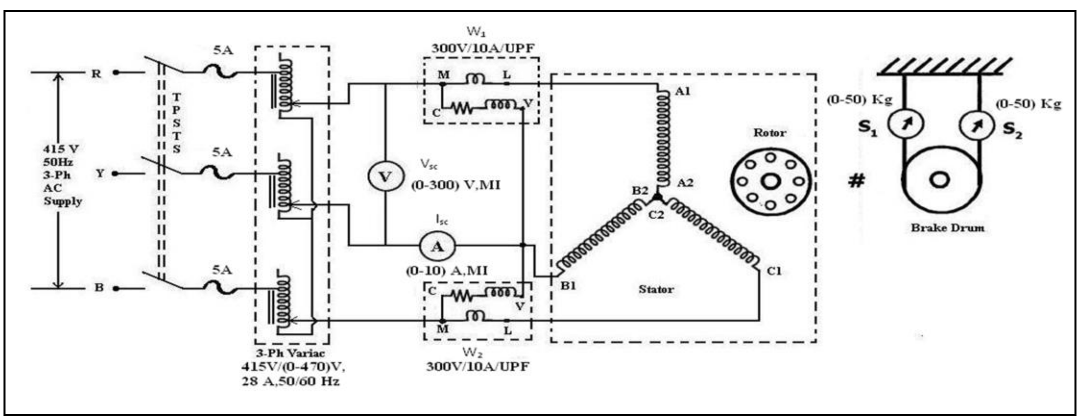


Fig 11.2: Circuit diagram for blocked rotor test

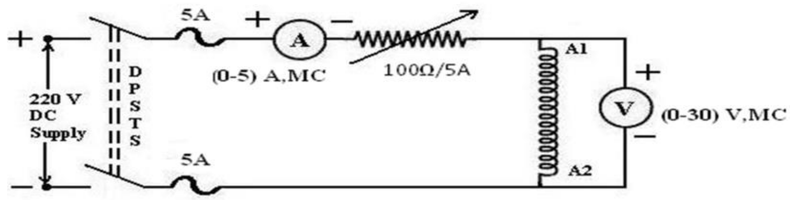


Fig 11.3: Circuit diagram for finding stator resistance

NAME PLATE DETAILS:

Power	:
Voltage	:
Current	:
Speed	:
Connection	:

PRECAUTIONS:

1. Avoid loose and wrong connections.
2. All knife switches should be open initially.
3. Three phase variac should be at minimum potential position initially.
4. There should be no load on the motor initially for no-load test.
5. Rotor should be blocked initially for blocked rotor test.
6. Readings should be noted without parallax errors.

PROCEDURE:

No-load test:

1. Connect the circuit as per fig 11.1.
2. Observe all precautions and close the TPST Switch.
3. Apply the rated voltage by increasing variac output gradually.
4. Note down the readings of all the meters.

Blocked rotor test:

1. Connect the circuit as per fig 11.2.
2. Observe all precautions and close the TPST Switch.
3. Apply the rated current by increasing variac output gradually.
4. Note down the readings of all the meters.

Measurement of Stator resistance:

1. Connect the circuit as per the fig 11.3.
2. Observe all precautions and close the DPST Switch.
3. Note down the readings of all the meters.
4. Vary the rheostat in steps and note down both voltmeter and ammeter readings in each step.

OBSERVATION:

For no-load test:

Speed:_______RPM

S.No.	V_o (V)	I_o (A)	Wo = W x M.F (w)	
			W1	W2

For blocked rotor test:

Speed=_________RPM.

S.No.	V_{SC} (V)	I_{SC} (A)	W_{SC} = W x M.F (w)	
			W1	W2

For stator resistance test:

S.No.	Voltage (V)	Current(I)	Resistance(Ω)	
				Rdc=____ Ω. Rac=1.6Rdc
Average				

MODEL CALCULATIONS:

List of formulae:

$$G_0 = \frac{W_0}{3V^2} \qquad Y_0 = \frac{I_0}{V} \qquad B_0 = \sqrt{Y_0^2 - G_0^2}$$

$Z_{01} = V_{SC}/I_{sc}$

$R_{01}= W_{SC}/(3* I_{SC}^{2})$

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

$I\mu = I_o \cos\varphi$

$I_W = I_o \sin\varphi$

For circle diagram:

$$\cos\varphi_0 = \frac{W_0}{\sqrt{3}\,V_0\,I_0} \qquad , \varphi_0 = \cos^{-1}\left(\frac{W_0}{\sqrt{3}\,V_0\,I_0}\right)$$

$$\cos\varphi_{SC} = \frac{W_{SC}}{\sqrt{3}\,V_{SC}\,I_{SC}} \qquad \sin\theta_{SC} = \cos^{-1}\left(\frac{W_{SC}}{\sqrt{3}\,V_{SC}\,I_{SC}}\right) \qquad , I_{SN} = I_{SC}\left(\frac{V_0}{V_{SC}}\right)$$

$$W_{SN} = W_{SC}\left(\frac{I_{SN}}{I_{SC}}\right)$$

$R_1 = Rac = 4.61\Omega$

Power scale: current scale:

Stator copper loss=3 $I_{SN}{}^{2}R_1$=.

Rotor copper loss=W_{SN}-3 $I_{SN}{}^{2}R_1$

From Graph:

Fixed Losses =JK X Power scale

Motor Input=LK X Power scale

Mechanical output= ML X Power scale

Torque at full load input= NL X Power scale

Slip= $\frac{MN}{NL}$ =

%efficiency=$\frac{ML}{LK} = \frac{4}{5}$

Speed at full load torque=$N_s(1-s)$

Starting torque input= AE X Power scale

Maximum output= uv X Power scale

Maximum torque input= RS X Power scale

Maximum input =CQ X Power scale

$R_1^1 = R_{01} - R_{ac}$

$R_2^1 = R_1^1\left(\frac{1}{S} - 1\right).$

CIRCLE DIAGRAM:

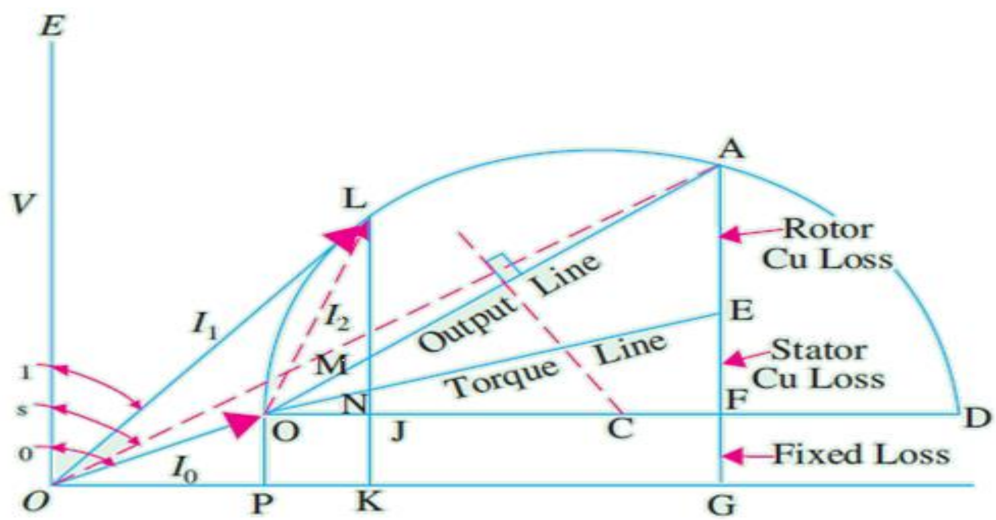


Fig 11.4: Circle diagram

EQUIVALENT CIRCUIT:

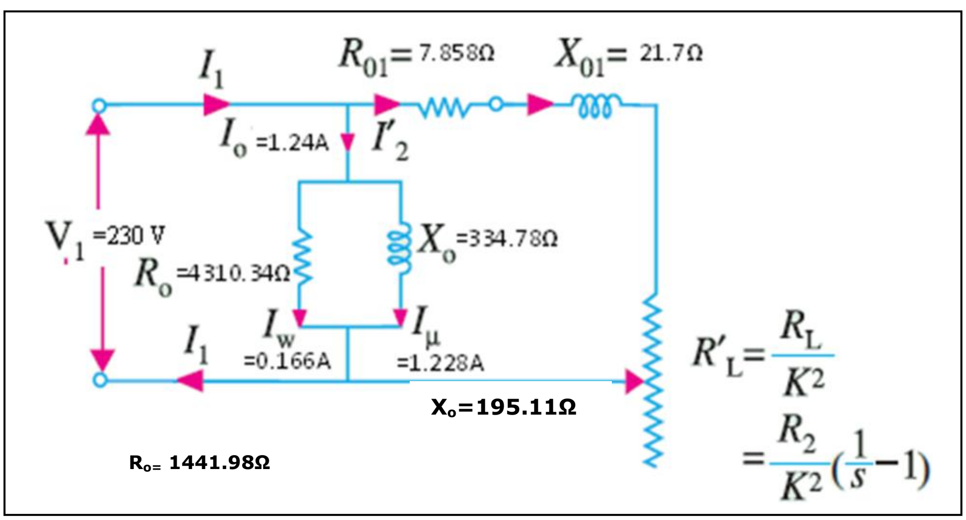


Fig 11.5: Equivalent diagram

RESULT: