Expt. No. 08	Calculation of Secondary turns and Current in a transformer

AIM:

To calculate the secondary turns and current in a single phase transformer.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Single phase transformer	230/115 V	1
2.	Auto transformer	0-300V AC	1
3.	Voltmeter	0-300V AC	2
	Ammeter	0-10A AC	1
4.	Connecting wires	-	As required
5.	Single phase AC power supply	-	-

THEORY:

It is essential to know the relative polarity at any instant of primary and secondary terminals for making correct connections. When the two transformers are to be connected in parallel to share the load on the system. The marking is correct if voltage V3 is less than V1, such a polarity is termed as subtractive polarity. The standard practice is to have subtractive polarity because it reduces the voltage stress between adjacent loads. In case V3 > V1, the EMF induced in primary and secondary have additive relation and transformer is said to have additive polarity

NAME PLATE DETAILS:

- KVA Rating :
- Rated H.V side Voltage :
- Rated H.V side Current :
- Rated L.V side Voltage :
- Rated L.V side Current :

FUSE RATING CALCULATIONS:

The required fuse ratings for O.C. are 20 % of rated current on L.V side

= (20/100) x Rated current on L.V. Side

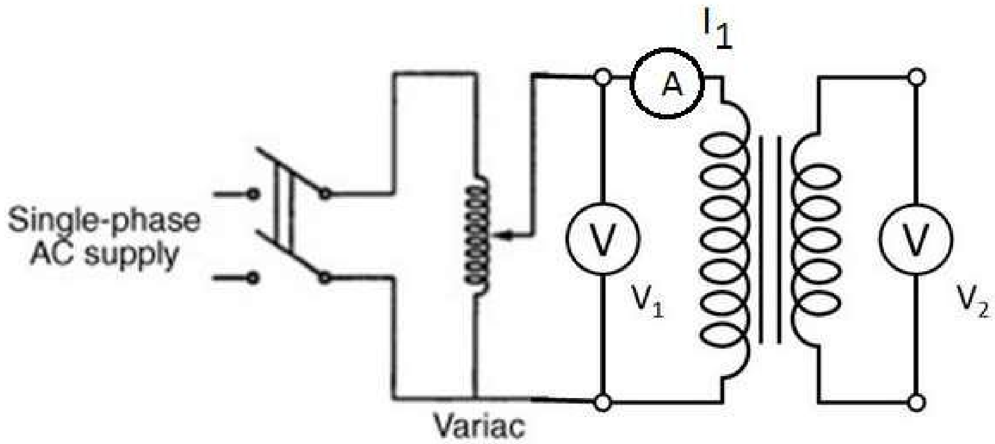
=

The required fuse ratings for S.C. are 120 % of rated current on H.V side

= (120/100) x Rated current on H.V. Side

=

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as shown in the diagram.
2. Switch on the a.c. supply.
3. Record voltage V1 across primary and V2 across various tappings of secondary.
4. If V1>V2 then transformer is step down.
5. If V2> V1 then transformer is step up.
6. Switch off a.c. supply

TABULAR COLUMN:

S.NO	Primary Voltage (V1) in volts	Secondary voltage (V2) in volts	Primary Current (I1) in amps	Turn ratio (k=V1/V2)	Secondary current, I2=I1/k

Marks Obtained:

Theoretical Calculations	20	
Observation	20	
Execution of practice examples	30	
Viva	10	
Record	20	
Total Score	100	
Date of experiment		
Date of record submission		Faculty signature

RESULT:

Thus the transformation ratio and the secondary current are measured for a given single phase transformer.

Expt. No. 9	Load Test on a single phase transformer

AIM:

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

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	Upf Upf	1 1
4	Auto Transformer	1ϕ, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

PRECAUTIONS:

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

NAME PLATE DETAILS:

- KVA Rating :
- Rated H.V side Voltage :
- Rated H.V side Current :
- Rated L.V side Voltage :
- Rated L.V side Current :

FUSE RATING CALCULATIONS:

The required fuse ratings for O.C. are 20 % of rated current on L.V side

= (20/100) x Rated current on L.V. Side

=

The required fuse ratings for S.C. are 120 % of rated current on H.V side

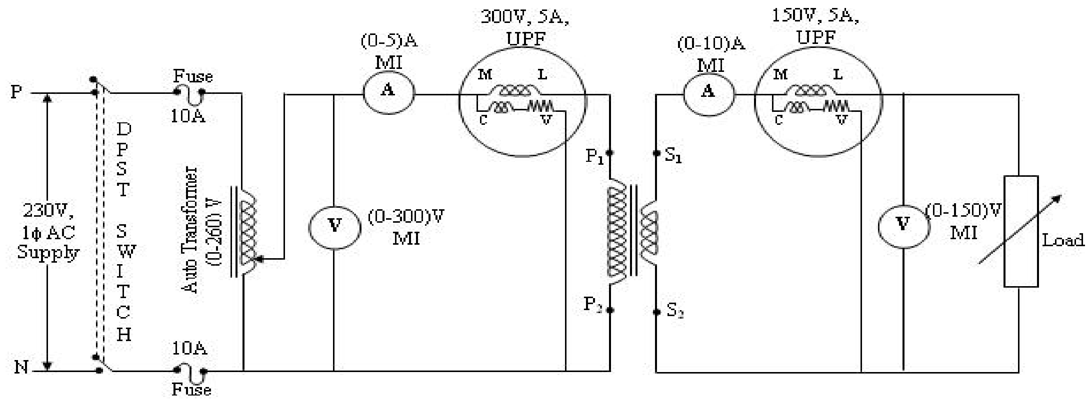
= (120/100) x Rated current on H.V. Side

=

PROCEDURE:

1. Connections are made as per the circuit diagram.
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 side 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:



FUSE RATING:

125% of rated current

$$\frac{125 \times 5}{100} = 6.25A$$

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :	230V	115V
Rated Current :	5A	10 A
Rated Power :	1KVA	1KVA

TABULAR COLUMN:

S.No.	Load	Primary			Secondary			Input Power W_1 x MF	Output Power W_2 x MF	Efficiency η %	% Regulation
		V_1 (Volts)	I_1 (Amps)	W_1 (Watts)	V_2 (Volts)	I_2 (Amps)	W_2 (Watts)				

FORMULAE:

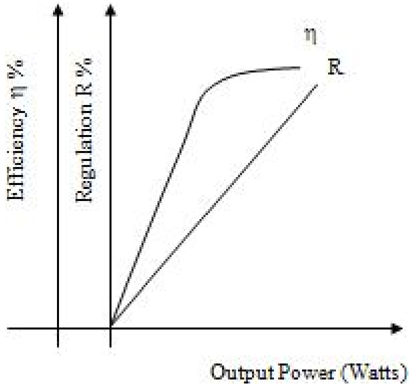
Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

$$\text{Efficiency } \eta \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

$$\text{Regulation R \%} = \frac{V_{NL} - V_{FL}\,(\text{Secondary})}{V_{NL}} \times 100\%$$

MODEL GRAPHS:



Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		
Date of record submission		**Faculty signature**

RESULT:

Thus the load test on single phase transformer is conducted.

Expt. No. 10	OC and SC test on single phase transformer

AIM:

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

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	Upf Upf	1 1
4	Auto Transformer	1ϕ, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

PRECAUTIONS:

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

NAME PLATE DETAILS:

- KVA Rating :
- Rated H.V side Voltage :
- Rated H.V side Current :
- Rated L.V side Voltage :
- Rated L.V side Current :

FUSE RATING CALCULATIONS:

The required fuse ratings for O.C. are 20 % of rated current on L.V side

= (20/100) x Rated current on L.V. Side

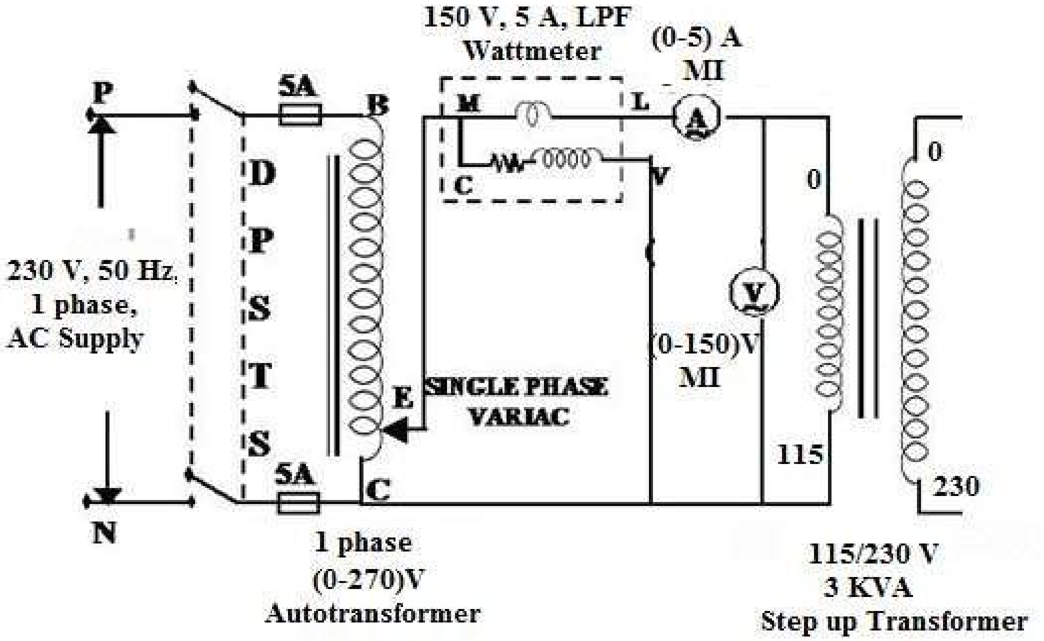
=

The required fuse ratings for S.C. are 120 % of rated current on H.V side

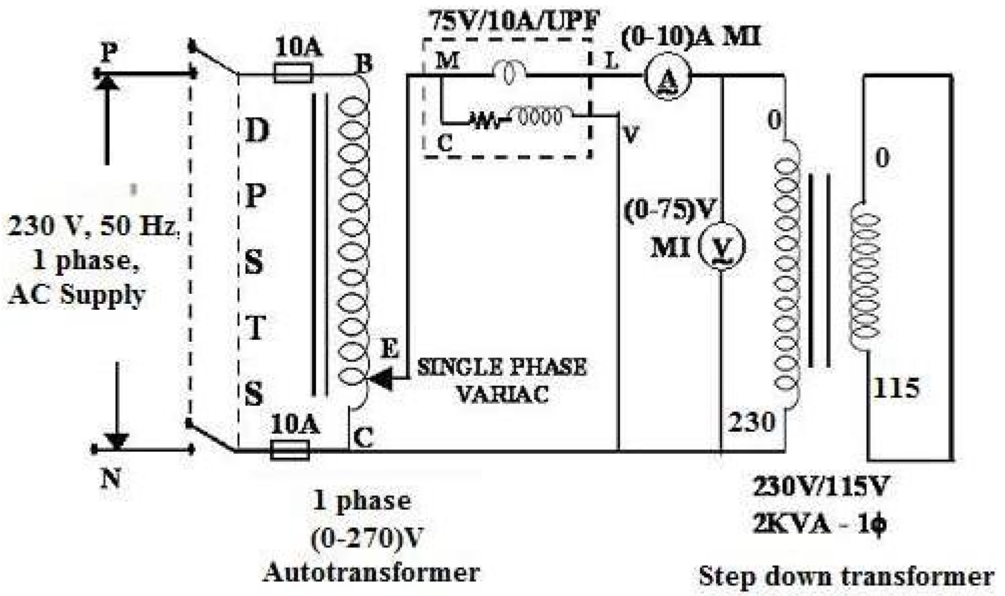
= (120/100) x Rated current on H.V. Side

=

OPEN CIRCUIT TEST



SHORT CIRCUIT TEST



PROCEDURE:

I) O.C. TEST:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the H.V. winding open and the autotransformer in its minimum position the main supply is switched ON.

3. By slowly and carefully adjusting the autotransformer, the rated voltage (115V) is applied to L.V. winding of the transformer.
4. Under this condition the ammeter (Io), Voltmeter (Vo) and Wattmeter (Wo) readings a noted down.
5. After the experiment is completed, the autotransformer is slowly brought back to minimum position and then the main supply is switched OFF.

II) S.C. TEST:

1. The circuit connections are made as per the circuit diagram.
2. Short circuiting the LV winding and keeping the autotransformer in its minimum position, the main supply is switched ON.
3. By slowly and carefully adjusting the autotransformer the rated current (which is calculated as H.V current.= KVA Rating *1000 / H.V. is circulated through the H.V. winding.
4. Under this condition, the ammeter (ISC), the voltmeter (VSC) and the Wattmeter (WSC) readings are noted down.
5. After the experiment is completed, the autotransformer is brought back to its minimum position and main supply is switched OFF.

TABULATION:

TEST	VOLTAGE(V)	CURRENT(A)	POWER(W)
O.C TEST (On L.V side)	Vo =	Io =	Wo =
S.C. TEST (On H.V side)	Vsc =	Isc =	Wsc=

MODEL CALCULATIONS:

1. To obtain the equivatent circuit parameters w.r.t. H.V side

i). From the O.C test the; constant loss Iron loss is noted

$W_c = W_o =$ _________watts.

ii). From the S.C test full load copper loss is noted

$W_{cu} = W_{sc}$ = __________watts.

For a transformer, the equivalent circuit parameters can be determined ether w.r.t H.V side or L.V side. If the parameters are estimated on the H.V side ;the resulting equivalent circuit is called H.V side equivalent circuit of the transformer.

From the O.C test Ro and Xo are calculated using the following expressions,

R_o (L.V) $=V_o / I_w =$ Ohms

X_o (L,V) $=V_o / I_m =$ Ohms

Where $I_W = I_o \text{Cos}\theta =$

$I_\mu = I_o \text{Sin}\theta =$ and

$\theta = \text{Cos}^{-1}[Wo/VoIo] =$

Since these values are calculated w.r.t L. V side (because O.C test is conducted on the I.V side), the equivalent values of 'R_o' and 'X_o' as referred to H.V side are determined as

$Ro(H.V) = Ro\ (L.V) / K^2 =$ &

$Xo(H.V) = Xo\ (L.V) / K^2 =$

Where K= (secondary voltage) / (primary voltage)

= 115/230 for a step down operation.

= 230/115 for a step up operation.

Since we are assuming a step down operation k = 115 / 230 = 0.5.

$R_T\ (H.V) = W_{sc}/I_{sc}^2 =$

$Z_T\ (H.V) = V_{sc}/I_{sc} =$

$X_T\ (H.V) = [Z_T^2\ (H.V) - R_T^2\ (H.V)]^{1/2} =$

R_T (H.V) and X_T (H.V) are the total equivalent resistance and reactance of the transformer as referred to the H.V side whose values are calculated from the S.C test. Now the H.V side equivalent circuit is drawn

2. To Predetermine The Efficiency:

The percentage efficiency is then predetermined for different load conditions for a specified load power factor using the expression,

$$\% \text{ Efficiency} = \frac{X*KVA * \cos\phi * 1000}{(X* KVA * \cos\phi * 1000) + W_o + X^2 W_{F.L}}$$

When X is the fraction ;of the full load which is 0.25 for 25% load, 0.5 for 50% load, 0.75 for 75% load, 1.0 for full load and 1.25 for 125% load and Cosϕ is the load p.f (usually assumed as 0.8 lag) The efficiency valued so calculated are entered in the tabular column as shown. A graph is plotted between percentage efficiency and the output as shown in model graph

TABULATION:

% Of load X	**Power factor cos ϕ**	**sin ϕ**	**Power factor cos ϕ**	**sin ϕ**
	0.8	**1.0**	**0.8**	**1.0**
0.25				
0.5				
0.75				
1.0				

% Of load X	**Output power = X*KVA*cosϕ*100 (watts)**		**Copper loss = $X^2 w_{sc}$(f.l) (watts)**	**Total loss = W_c+ copper loss (watts)**	**Input power = O/p power + losses (watts)**		**Efficiency% = [(o/p)/(i/p)] x 100 (watts)**	
	pf 0.8	pf 1.0			0.8	1.0	0.8	1.0
0.25								
0.5								
0.75								
1.0								

3. To pre-determine the Percentage Regulation:

The regulation on full load for different leading and lagging power factors are predetermined by formula,

$$\% \text{ Regulation} = \frac{[\, I\,(H.V) * R_T\,(H.V) \cos\phi \,] + [\, I\,(H.V) * X_T\,(H.V) \sin\phi \,] * 100}{V\,(H.V)}$$

$$\% \text{ Regulation} = \frac{[\, I\,(H.V) * R_T\,(H.V) \cos\phi \,] - [\, I\,(H.V) * X_T\,(H.V) \sin\phi \,] * 100}{V\,(H.V)}$$

Where + for lagging power factor, - for leading power factor.

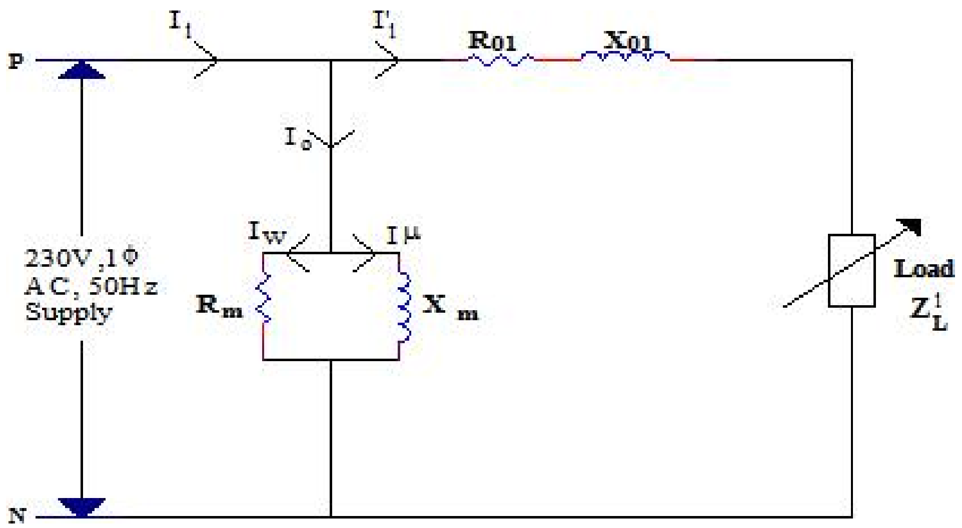
LH.V = Rated current on H.V side, VH.V = Rated voltage on H.V side. By assuming different leading and lagging power factor such as 0.2, 0.4, 0.6, 0.8 and 1.0 the regulation of the transformer for full load are determined and tabulated as shown below.

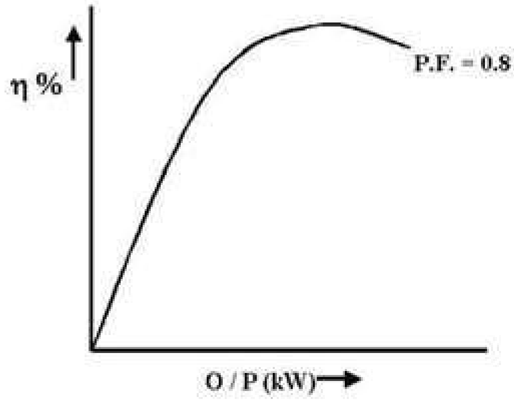
TABULATION:

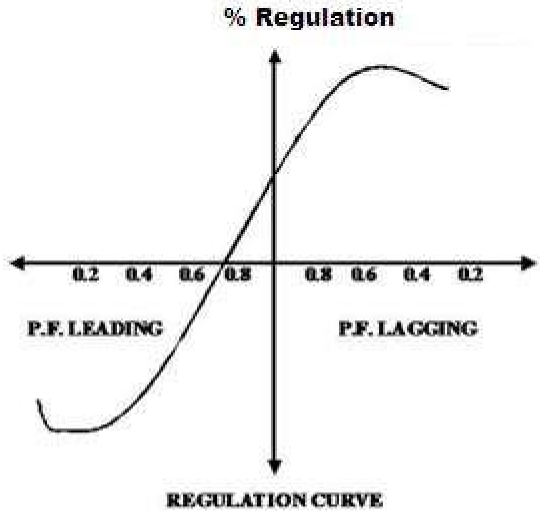
POWER FACTOR	% Regulation	% Regulation
	For lagging power factor	For leading power factor
0.2		
0.4		
0.6		
0.8		
1.0		

Now a graph is plotted between the percentage regulation and P.F as shown in figure which is known as the regulation graph.

EQUIVALENT CIRCUIT DIAGRAM:







Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		
Date of record submission		**Faculty signature**

RESULT:

Thus the O.C and S.C tests are conducted on the single phase transformer and the efficiency and regulation graphs and also the equivalent circuit as referred to H.V side is drawn.

Expt. No. 11	Load Test on a Single Phase Induction Motor

AIM:

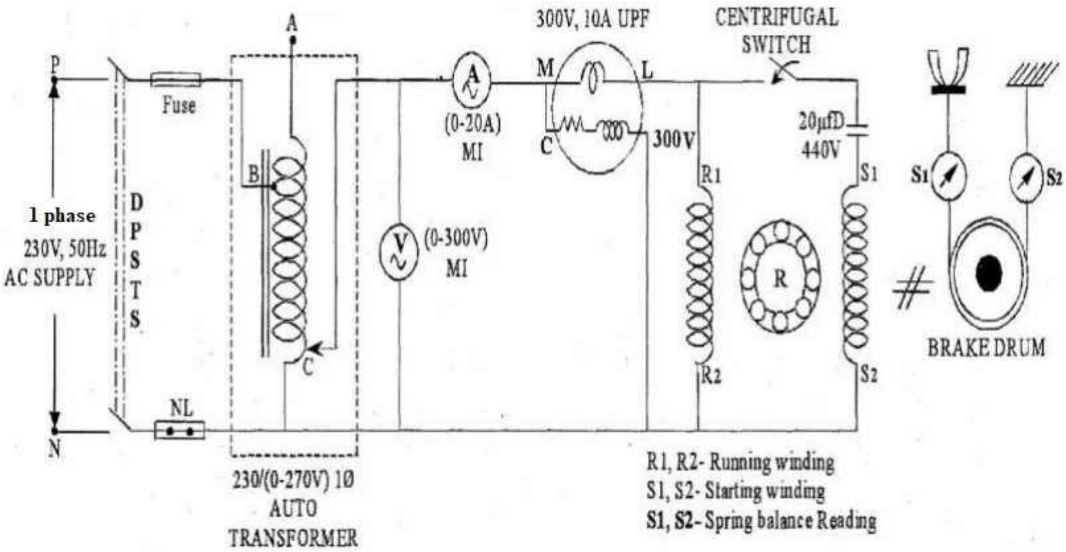
To conduct load test on single phase induction motor to plot the following performance characteristics

1) Output power vs Efficiency
2) Output power vs speed
3) Output power vs % slip
4) Output power vs Torque
5) Output power vs Line current

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MI	1
2	Voltmeter	(0-300) V	MI	1
3	Wattmeter	(300V, 10 A)	Upf	1
4	Auto Transformer	1ϕ, (0-270)V	-	1
5	Connecting Wires	2.5sq.mm	Copper	Few

CIRCUIT DIAGRAM



NAME PLATE DETAILS:

FUSE RATING CALCULATIONS:

For the load test the required fuse ratings are 120% of motor rated current

Fuse Rating Current = (125/100) x Rated Current

=

PRECAUTIONS: (NOT TO BE INCLUDED IN THE RECORD)

1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Check the position of the rheostat as specified.
3. The load on motor must be released initially.
4. Fuse calculations: For load test the required fuse ratings are 120% of the rated current of the motor.
5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge.

PROCEDURE:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the motor field rheostat in its minimum position and the starter in its OFF position the main supply is switched ON to the circuit.
3. The motor is started using the three point starter by slowly and carefully moving the starter handle from it's OFF to ON position.
4. The motor is brought to its rated speed by gradually adjusting the field rheostat and checked with the help of a tachometer.
5. Under this no load condition one set of readings namely, applied voltage (V_L), line current (I_L), the two spring balance readings (S1 and S2) and motor speed (N) are noted down in the tabular columns.
6. The load on the motor is increased in steps gradually and at each step, all the meter readings and the motor speed are recorded in the tabular column. The above procedure is repeated until the motor is loaded to 120% of its rated current.
7. After the experiment is completed, the load on motor is gradually decreased to minimum and the rheostat is brought back to its original position and then the main supply is switched OFF.
8. Plot the performance characteristics

TABULAR COLUMN:

Sl No:	Line voltage V_L (V)	Line current I_L (A)	Input power Pin (W)	Spring Balance			Torque (N)	Speed N (rpm)	Output power Pout (W)	η (%)	% S
				S1 (Kg)	S2 (Kg)	S1~S2 (Kg)					
1.											
2.											
3.											
4.											
5.											

MODEL CALCULATIONS:

The **circumference of the brake drum** is measured and the radius of the drum is calculated using the expression

r=C/2π = ___________________(m)

R=r + t/2 = ___________________(m)

r - Radius of the Brake drum (m)

c – Circumference of the Brake Drum (m)

R – Effective Radius (m)

t – Thickness of the belt.

The **torque** developed by the motor is given by

T= (S1~S2) * R * 9.81 = ___________________(Nm).

The **output power** of the motor is

Pout = 2πNT/60 = ___________________(W).

The **efficiency** of the motor

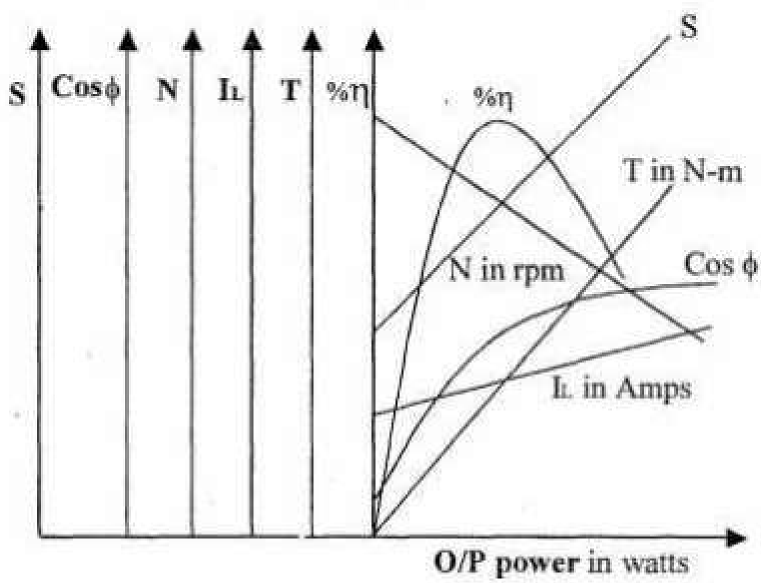
η = (Pout / Pin) * 100 = ________________________

The **%slip** of the motor

% s = (Ns-N / Ns) * 100 = ________________________

Ns – Synchronous speed = (120 * f) /P = ___________________(rpm).

MODEL GRAPH:



Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		
Date of record submission		**Faculty signature**

RESULT:

Thus the load test on single phase Induction motor is conducted and their performance characteristics are plotted.

Expt. No. 12	Three phase Power measurement using Two Wattmeter method

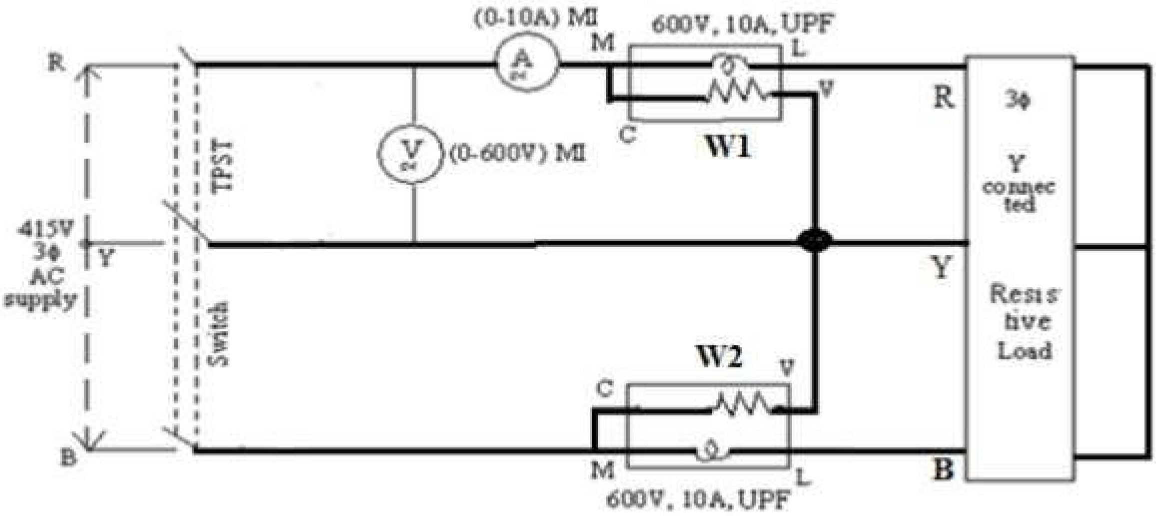
AIM:

To measure the power in three phase balanced star connected load using two wattmeter method.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A	MI	1
2	Voltmeter	(0-600) V	MI	1
3	Wattmeter	(600V, 10A)	Lpf	2
4	Auto Transformer	3ϕ, (0-600)V	-	1
5	Lamp load	-	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

CIRCUIT DIAGRAM



PROCEDURE:

1. Make the connections as per the circuit diagram shown in Fig 5.1.
2. Switch ON 3 phase AC supply.
3. Apply load and measure the values of wattmeters, ammeter and voltmeter.
4. Switch OFF all the loads and supply.

TABULAR COLUMN:

Sl No.	Line voltage V_L (V)	Line current I_L (A)	Wattmeter (W1)	Wattmeter (W2)	W= W1 + W2	Calculated power (W)

MODEL CALCULATIONS:

1. Total Power, P = W1 + W2 Watts.
2. Power Factor Cos Ø = Cos [tan-1{ √3 (W1 – W2) / (W1 + W2) }]
3. Calculated Power =√3 VL*IL*Cosϕ

Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		**Faculty signature**
Date of record submission		

RESULT:

Thus, the power in three phase balanced star connected load using two wattmeter method is measured and calculated.

Expt. No. 13	**Energy consumption measurement using a Single Phase Energy Meter**

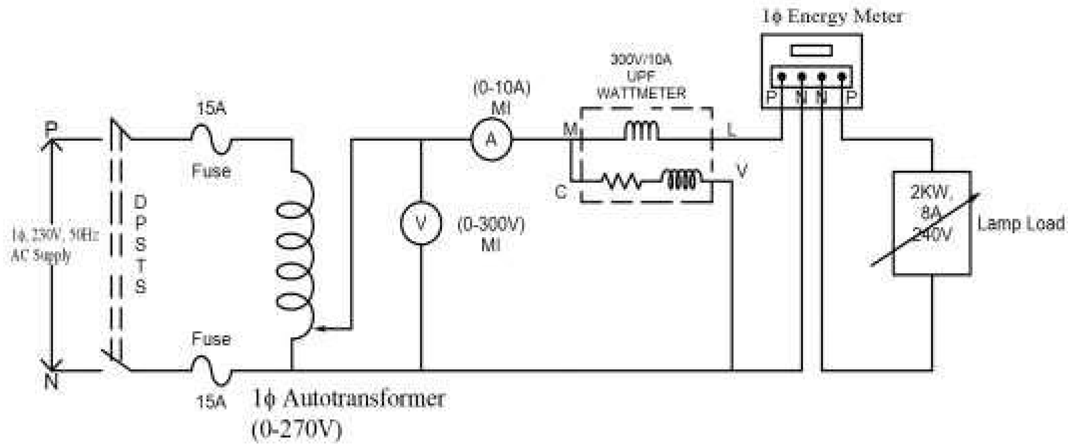
AIM:

To measure the energy consumption using single phase energy meter.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MI	1
2	Voltmeter	(0-300) V	MI	1
3	Auto Transformer	1ϕ, (0-270)V	-	1
4	Lamp load	-	-	1
5	Connecting Wires	2.5sq.mm	Copper	Few

CIRCUIT DIAGRAM



PROCEDURE:

1. Connect the circuit as shown in circuit diagram.
2. Connect the load rheostat 10 Ω/12A in series with load.
3. Keep the variac in minimum output voltage position.
4. Keep the load in maximum position.
5. Adjust the variac output equal to the rated voltage of energy meter.
6. Adjust the load till rated current of energy meter passes through it.
7. Note down the voltmeter and ammeter readings.
8. Note down the time taken for 2 revolutions of disc in the energy meter.
9. Switch off the supply.
10. Repeat the above steps for different currents.

TABULAR COLUMN:

Sl No.	Line voltage V_L (V)	Line current I_L (A)	Time taken for 2 revolutions (sec)	No.of revolutions (n)	Calculated Energy (Whr)	Measured Energy (Whr)

MODEL CALCULATIONS:

1. Calculated energy consumed during 'n' revolutions Wa = V*I*t / 3600 = (watt-hour)
   where V= Voltage (V)
   I= Current (A)
   t = Time (S)
2. Measured Energy by energy meter WR = n / meter constant

Marks Obtained:

Theoretical Calculations	20	
Observation	20	
Execution of practice examples	30	
Viva	10	
Record	20	
Total Score	100	
Date of experiment		
Date of record submission		Faculty signature

RESULT:

Thus the energy consumption using single phase energy meter is measured.

Expt No 14 Load Test on DC shunt Motor

AIM:

- To conduct load test on DC shunt motor and to determine the efficiency using mechanical loading arrangement
- To Draw the following characteristics curves
- Torque Vs Armature current (electrical characteristics)
- Speed Vs Armature current
- Speed Vs Torque (Mechanical characteristics)
- Performance curve

Apparatus Required:

Sl. No.	Name	Specification	Quantity
1	DC shunt motor with spring balance load	2 HP, 1440 rpm, 230V, 18.1A	1 no.
2	Voltmeter	(0-300) V, PMMC	1 no.
3	Ammeter	(0-20) A, PMMC	1 no.
4	Rheostat	1250 Ω, 0.8A	1 nos.
5	Tachometer	Digital Type	1 no.
6	Connecting wires	PVC Insulated copper	as per required

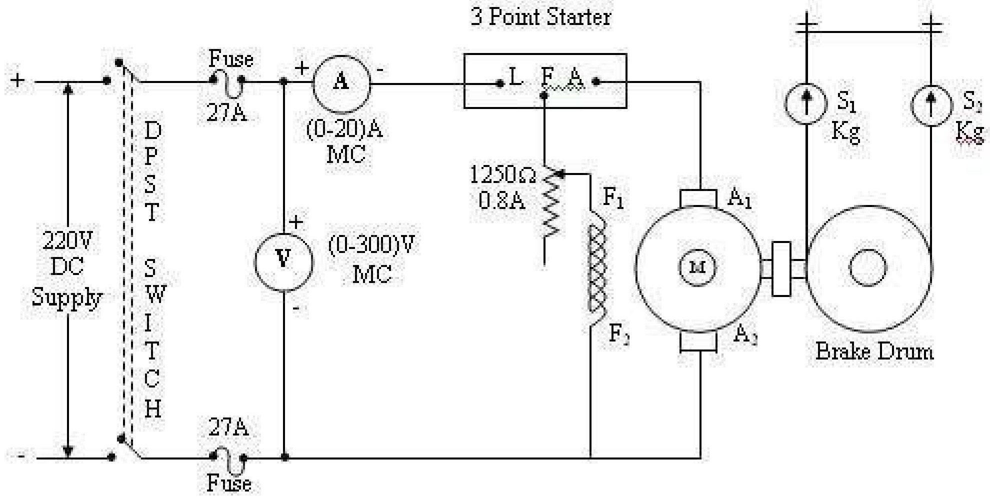
PRECAUTIONS:

- DC shunt motor should be started and stopped under no load condition.
- Field rheostat should be kept in the minimum position.
- Brake drum should be cooled with water when it is under load.

PROCEDURE:

- Connections are made as per the circuit diagram
- After checking the no load condition and minimum field rheostat position starter resistance is gradually removed.
- The motor is brought to its rated speed by adjusting the field rheostat.
- Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.
- The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted(Take readings up to rated current of the machine).
- The motor is then brought to no load condition and field rheostat to minimum position,then switch off the supply.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3.5KW
Rated Speed : 1500 RPM

FORMULAE USED:

- Torque (T) = 9.81 (S1-S2). r

Where, S_1, S_2→ Spring balance readings in kg

r→ Radius of brake drum in m

9.81→Constant to convert kg to Newton

2. Output Power (P_{out})= 2πNT/60

Where N= Speed in rpm

3. In put power (P_{in}) = $V_L.I_L$ Watts

V_L=Input voltage in volts

I_L=Input current in Amps

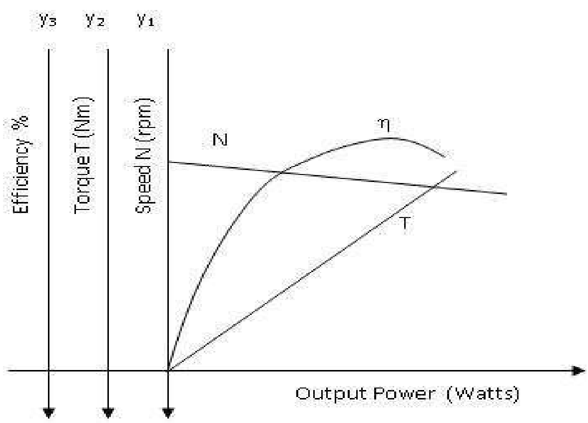
4. % Efficiency =(P_{out}/P_{in})*100

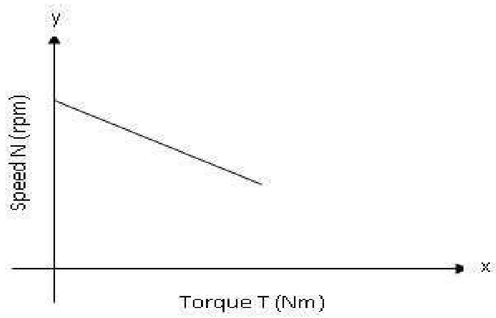
Observation Table: –

Radius of the Brake drum in meter =...........

Sl. No.	Input Voltage (V) in Volts.	Armature Current (I) in Amps.	Speed (N) in RPM	W_1 in Kg	W_2 in Kg	W=(W_2-W_1) in Kg	Torque (T) in N-m	Output Power (P_o) in watts	Input Power (P_i) in watts	% Efficiency
1										
2										
3										
4										
5										
6										

Model Graph:





Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		
Date of record submission		**Faculty signature**

Result:

Thus, Load Test on DC shunt Motor is experimentally verified.