

Verify terminals identify components and calculate transformation ratio of single phase transformers

Objectives: At the end of this exercise you shall be able to

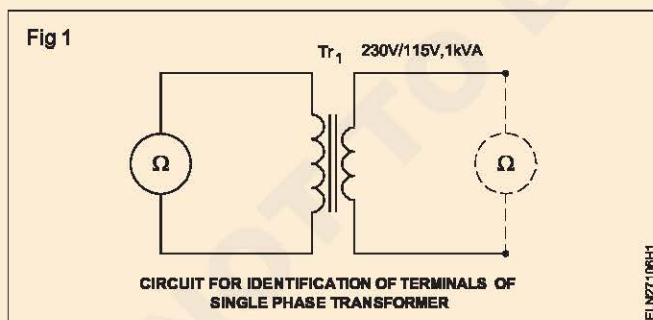
- read and interpret the details of the name-plate of single phase transformer
- identify H.T & L.T. winding
- determine transformation ratio (turns ratio) by the
 - voltmeter method
 - ammeter method.

Requirements	
<p>Tools/Instruments</p> <ul style="list-style-type: none"> • Voltmeter M.I. 0 - 250/300V - 2 Nos. • Ohmmeter (0 - 500 ohms) - 1 No. • Ammeter M.I. type (0 - 10 Amp) - 1 No. • Ameter M.I. 100 mA - 1 No. • Voltmeter M.C. 0-15V - 1 No. <p>Equipment/Machines</p> <ul style="list-style-type: none"> • D.C. supply 12 volts - 1 No. • Single phase transformer 115/230 volts, 1KVA - 1 No. • Auto-transformer (IP-240V) OP 0-270V, 5A - 1 No. 	<p>Materials</p> <ul style="list-style-type: none"> • Knife switch DPST 16A 250V - 1 No. • Push-button 6A, 250V - 1 No. • Connecting cables - as reqd.

PROCEDURE

TASK 1 : Identify terminals

- 1 Find out the corresponding terminals of two windings (H.T. & L.T) with ohmmeter as shown in Fig 1, by checking the continuity.



- 2 Determine HT and LT winding by measuring resistances with the ohmmeter.

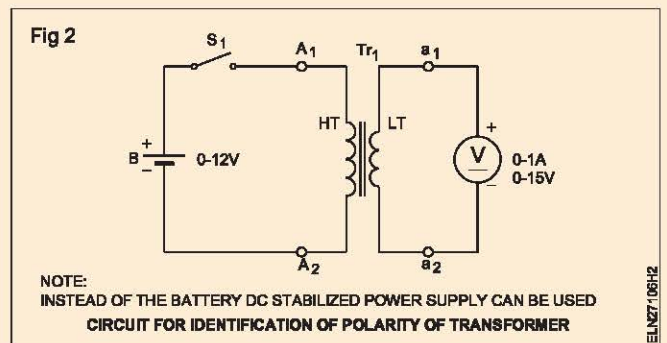
L.T. windings will have low resistance in the case of step down transformer.

Record resistance of both pairs.

1st pair _____ ohms. This is HT/LT winding.

2nd pair _____ ohms This is HT/LT winding.

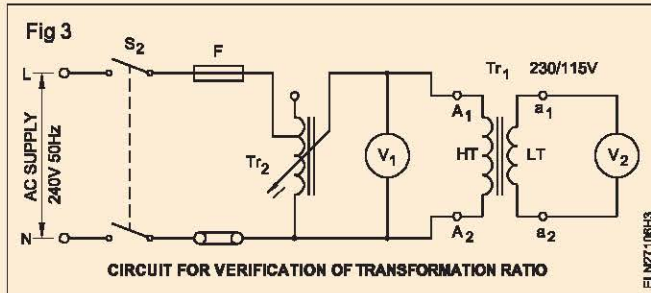
- 3 Connect DC supply to HT through push-button switch and connect the voltmeter to LT as shown in Fig 2.



- 4 Mark HT terminals as A_1 and A_2 . Mark at LT terminals as a_1 and a_2 .
- 5 Press the push-button switch. Observe the deflection of the pointer of the voltmeter. If the pointer deflects in the right direction, retain the markings made on terminals.
- 6 Change the voltmeter connections made to LT terminals and change the marking made on the LT terminals if the deflection is in the reverse direction. Now press the push-button switch once again and observe that the voltmeter deflects in right direction.

TASK 2 : Verification of transformation ratio (by voltmeter method)

- 1 Connect the auto-transformer and the voltmeters to the transformer as shown in Fig 3. Check and set the auto-transformer at zero volt output position.



- 2 Switch on 'S₂' and adjust the autotransformer to get the output voltage V₁ = 100 volts and read V₂ record the value in Table 1.

The output voltage of the auto-transformer should be adjusted to about 50% of the rating of the H.T. side.

- 3 Set the V₁ value for the values indicated in Table 1 and record the corresponding readings of V₂ in Table 1.

- 4 Calculate the transformation ratio from the measured V₁ & V₂ values.

Applying the formula -

$$\text{Transformation ratio} = \frac{V_2}{V_1}$$

Table 1

Sl. No.	V ₁	V ₂	Transformation ratio K=V ₂ /V ₁
1	100 Volts		
2	125 Volts		
3	150 Volts		
4	200 Volts		
5	225 Volts		

- 5 Compare the calculated transformation ratio with the marking of name plate.

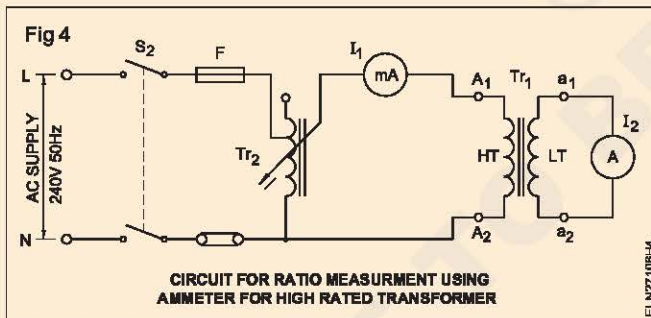
- 6 Transformation ratio calculated

from measurements =

from markings =

TASK 3 : Verification of transformation ratio (by ammeter method)

- 1 Connect the auto-ransformer output to the transformer H.T. winding through a milliammeter in the line as shown in Fig 4.



The current in the H.T. winding should be kept low, but should be large enough to be measured accurately with a milliammeter.

- 2 Connect the L.T. winding to the ammeter. The ammeter should carry the rated current of L.T. side.

Use the current transformer and ammeter if the secondary rating is very high.

- 3 Increase the voltage to give the required current in H.T. winding.

- 4 Read the L.T. current. Record in Table 2.

- 5 Change the H.T. current to different values and record the corresponding L.T. current.

Table 2

Sl. No.	I ₁	I ₂	Transformation ratio K=I ₁ /I ₂
1			
2			
3			
4			

- 6 Verify the transformation ratio with the markings on the name-plate and record your findings.

Perform open circuit and short circuit test to determine the efficiency of single phase transformer

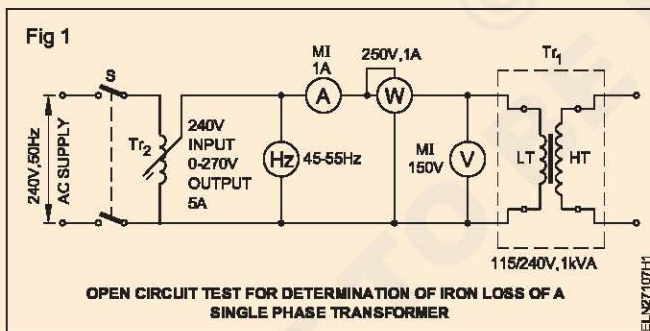
- Objectives:** At the end of this exercise you shall be able to
- conduct open circuit test to determine iron or core loss
 - conduct short circuit test to determine full load copper loss
 - determine efficiency of the transformer at different loads.

Requirements	
Tools/Instruments	Equipment/Machines
<ul style="list-style-type: none"> • Voltmeter M.I. 100V - 1 No. • Voltmeter M.I. 150V - 1 No. • Wattmeter 250V, 5A - 1250W - 1 No. • Ammeter M.I. 5A - 1 No. • Ammeter M.I. 15A - 1 No. • Frequency meter 45 to 55Hz. - 1 No. • Power factor meter 0.5 lag -1-0.5 lead 250V rating - 1 No. 	<ul style="list-style-type: none"> • Transformer 100/250V 1 kVA 50 Hz - 1 No. • Auto-transformer input 240V Voutput 0 to 270V, 5A - 1 No.
	Materials
	<ul style="list-style-type: none"> • Knife switch DPST 16A, 240V - 1 No. • Connecting cables - as reqd.

PROCEDURE

TASK 1 : Conduct open circuit test to determine iron or core loss

- 1 Identify the LT and HT windings of the given transformer.
- 2 Connect the Auto-transformer, frequency meter, ammeter, wattmeter. Voltmeter to the LT side of the transformer as shown in Fig 1.



Increase the voltage slowly up to (100%) of the rated value of the transformer L.T.

- 4 Check for the supply frequency is at rated value.
- 5 Observe the meters and record the readings in Table.
- 6 Repeat the above steps for 110% rated value of transformer voltage and record the readings in Table.

TABLE

Sl.No.	Rated	Voltage V	Current A	Total Iron loss W
1	100%			
2	110%			

Ensure that the auto-transformer is initially set at zero volt output position.

From the above data the No load loss is equal to iron loss. Since the copper loss is negligible.

- 3 Close the switch 'S'.

TASK 2 : Conduct short circuit test to determine full load copper loss of a transformer

Short circuit test

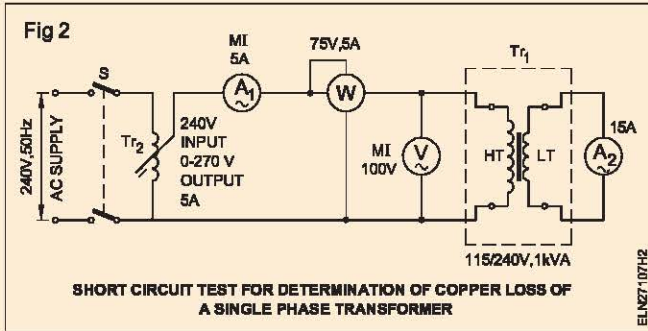
- 1 Connect the auto-transformer, ammeters, voltmeter and wattmeter in the HT side of the transformer as shown in Fig 2.

Ensure the auto-transformer is initially set at zero volt output position.

The secondary is short circuited by the ammeter.

- 2 Close the switch 'S'

- 3 Increase the voltage gradually to obtain full load current in the secondary winding of the transformer.
- 4 Observe the wattmeter and record the readings.
W = Copper loss (full load).



TASK 3 : Determine efficiency of transformer or different loads

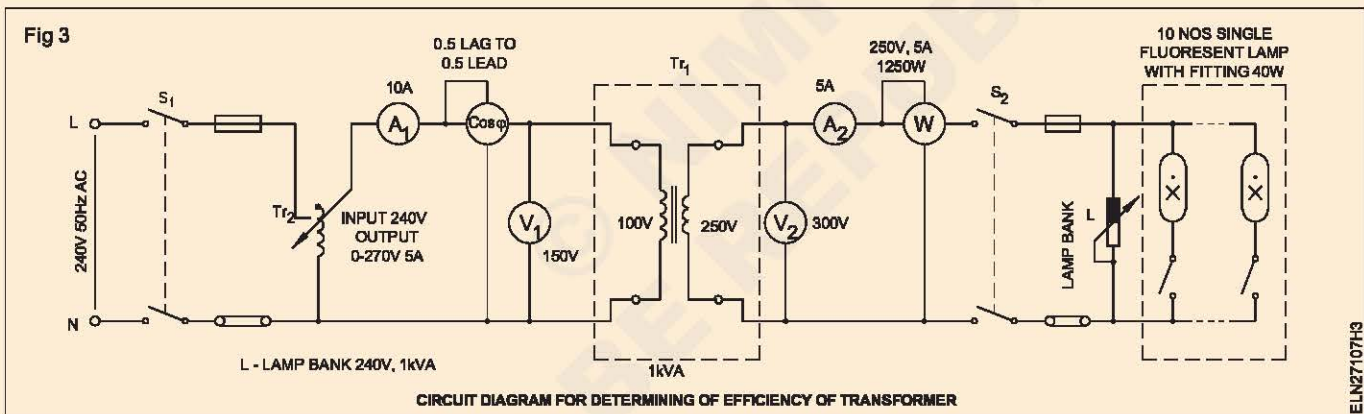
- 1 Prepare and draw the circuit diagram for the said task and get approved by your instructor.
- 2 Collect the equipments and materials and check their condition.
- 3 Connect the circuit as per the approved circuit diagram (Fig 3).

- 4 Close switch S_1 and gradually increase the output of the auto-transformer to reach the rated voltage.

Keep all the switches in the lamp bank in 'off' position.

- 5 Close switch S_2 and switch 'on' the incandescent lamps one by one till ammeter A_2 reads 25% of the load.
- 6 Adjust the auto-transformer Tr_2 if necessary to keep the primary voltage constant.

Keep the switches s_1 and s_2 open. Set the auto transformer for zero volt output.



- 7 Record the readings of the instruments in Table 1.
- 8 Increase the incandescent lamp load to 50% of the full load 75% of the full load and 100% of the full load and record the reading in each case.
- 9 Repeat the above steps by switching on the tube lights to get a power factor of about 0.9, 0.8 and 0.7 and record the readings in Table 2.
- 10 Switch 'OFF' supply after bringing the knob of the auto transformer to minimum (zero) position.

- 11 Calculate the efficiency using the formula

$$\text{Percentage efficiency} = \frac{\text{Output}}{\text{Input}} \times 100 \text{ OR}$$

$$\text{Percentage efficiency} = \frac{\text{Output}}{\text{Output} + \text{losses}} \times 100$$

$$= \frac{W}{W + W_1} \times 100$$

where W_1 = Iron loss + copper loss.

Table - 1
(Unity P.F)

Sl.No.	Load	V ₁	A ₁	P.F (Cos φ)	V ₂	A ₂	W	% Efficiency $= \frac{W}{V_1 A_1 \cos \phi} \times 100$
1	No load							
2	1/4th load							
3	1/2 load							
4	3/4 load							
5	Full load							

Table - 2
(Different P.Fs)

Sl.No.	Load	V ₁	A ₁	P.F (Cos φ)	V ₂	A ₂	W	% Efficiency $= \frac{W}{V_1 A_1 \cos \phi} \times 100$
1	No load							
2	1/4th load							
3	1/2 load							
4	3/4 load							
5	Full load							

12 Complete the tasks and get approved by your instructor and disconnect the circuit.

Conclusion

- 1 The relationship between load and efficiency _____
- 2 The relationship between power factor and efficiency _____
- 3 The efficiency will be maximum when _____

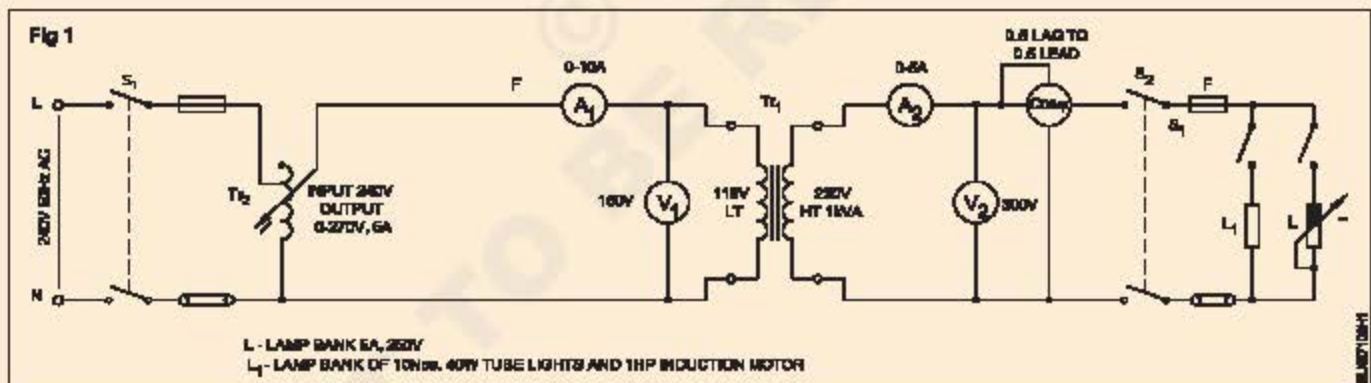
Determine voltage regulation of single phase transformer at different loads and power factors

Objectives: At the end of this exercise you shall be able to

- connect the transformer with suitable instruments to measure load and power factor
- calculate the regulation of single phase transformer from the readings of instruments in primary and secondary side.

Requirements	
Tools/Instruments	Materials
<ul style="list-style-type: none"> • Ammeter M.I.-0 to 5A, 0 to 10A each - 1 No. • Voltmeter M.I.-0 to 300 V, 0 to 150 V each - 1 No. • P.F. meter 0.5 lag - 1 - 0.5 lead 250 V rating - 1 No. 	<ul style="list-style-type: none"> • Connecting cable - as reqd. • 40 watts-tube light fitting - 10 Nos. • DPST switch 250V 16A - 2 Nos. • SPT switch 6 A - 2 Nos.
Equipment/Machines	
<ul style="list-style-type: none"> • Induciton motor with starter & loading arrangement 240V/50Hz 1 HP - 1 No. • Auto-transformer Input 40V Output 0 to 270 V, 5 amps - 1 No. • Single phase transformer 115/230V 1 kVA, 50 cycle air cooled - 1 No. • Lamp bank 5 A, 250V - 1 No. 	

PROCEDURE



- 1 Form the circuit as shown in Fig 1.
- 2 Note down the name-plate details of the transformer. (Table 2)

Check the auto-transformer T_2 is set at zero volts output position.

Table 1

Sl. No.	Load (Lamp)	Secondary Terminal Voltage V_s	Change of volts $V_o - V_s$	Regulation
1	No load V_o			
2	1/4 F.L.			
3	1/2 F.L.			
4	3/4 F.L.			
5	F.L.			

- 3 Switch on 'S₁' and adjust the voltage of primary to rated secondary voltage (V_o) of transformer.
- 4 Close the load switch S₂
- 5 Adjust the lamp load as indicated in Table 1 and record the secondary voltages at each load. (V_s)
- 6 Calculate % of regulation at different resistive loads.

$$\left(\% \text{ of regulation} = \frac{V_o - V_s}{V_s} \times 100 \right)$$

- 7 Put the inductive load with lamp bank (mixed load) so that the load power factor is lagging.

Perform series and parallel operation of two single phase transformers

Objectives: At the end of this exercise you shall be able to

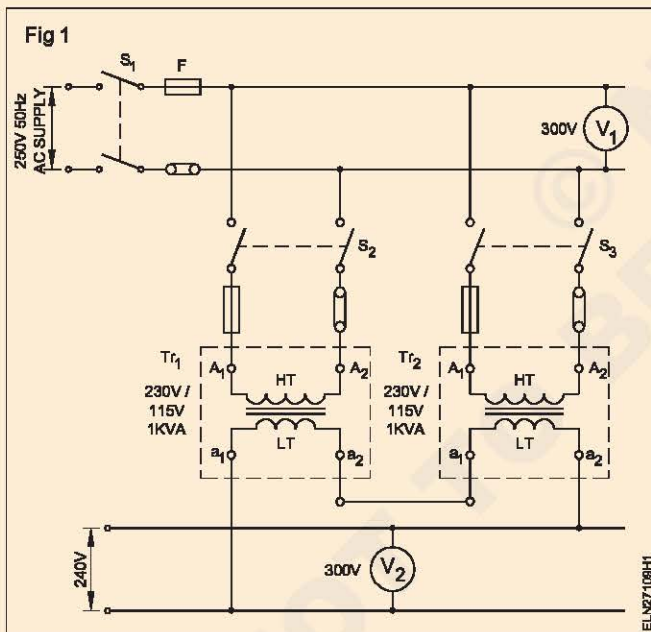
- connect two single phase transformers in parallel
- connect two single phase transformers secondary in series.

Requirements			
Tools/Instruments		Materials	
• Voltmeter MI, 150V	- 1 No.	• ICDP switch 16A 250V 50Hz	- 4 Nos.
• Voltmeter MI, 300V	- 2 Nos.	• Connecting cables	- as reqd.
Equipment/Machines			
• Single phase transformer 230/115, 1 KVA 50 H1.	- 2 Nos.		
• DC supply 12V/Battery 12V	- 1 No.		

PROCEDURE

TASK 1 : Connect the transformer secondary in series

1 Connect the transformer as per diagram. (Fig 1)



2 Close the switches S_1 , S_2 and S_3 .

3 Measure the primary voltage V_1 and secondary voltage V_2 and record in Table 1

Table 1

Transformer in series		
	Primary V_1	Secondary V_2
Tr ₁		
Tr ₂		

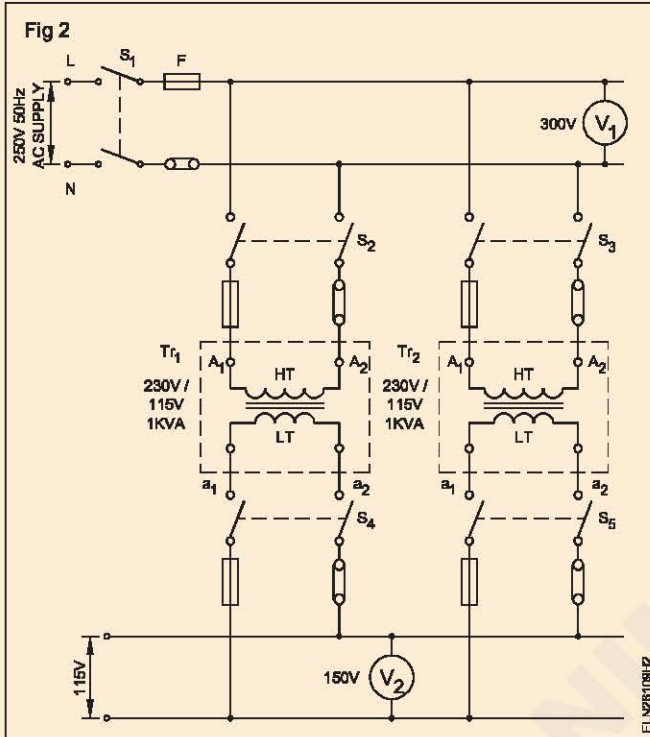
4 Disconnect the transformers by opening S_3 , S_2 and S_1 .

Table 2

Sl. No.	<input type="text"/>	Type of cooling	<input type="text"/>
KVA	<input type="text"/>	Frequency	<input type="text"/>
		Date of MFG	<input type="text"/>
AT NO LOAD VOLTS	HT	<input type="text"/>	
	LT	<input type="text"/>	
AT NO LOAD CURRENT	HT	<input type="text"/>	
	LT	<input type="text"/>	

TASK 2 : Connect the transformer in parallel

- 1 Read and record the name-plate details of both the transformers, Tr_1 & Tr_2 in table 2.
- 2 Determine the polarity of the two given transformers.
- 3 Connect the switches, transformers and meters as per diagram. (Fig 2)



- 4 Keep all the switches open.
- 5 Ensure that the transformers are identical for parallel connections.
- 6 Connect transformer Tr_1 to the bus bar closing the switches S_1 & S_2 . Measure the primary voltage V_1 and record in Table 3

Table 3

Transformer in parallel		
	Primary V_1	Secondary V_2
Tr_1		
Tr_2		

- 7 Check the secondary voltage of Tr_1 and record it table 2.
- 8 Close the switch S_3 and check the secondary voltage of the transformer Tr_2 and record. (Table 2)
- 9 Close the switch S_4 and S_5 and measure the secondary bus bar voltage and record in table 3.
- 10 Switch off all the switches and disconnect both the transformers.

CONCLUSIONS

- 11 The effect on secondary voltage of transformers when connected in series is

- 12 The effect on the secondary voltage of transformers when connected in parallel is

Verify the terminals and accessories of three phase transformer HT and LT side

Objectives: At the end of this exercise you shall be able to

- read and interpret the name plate details of a three phase transformer
- verify the terminals of HT and LT winding
- Identify the accessories of a three phase transformer.

Requirements			
Tools/Instruments		Equipment/Machines	
• DE Spanner Set 5mm to 20mm	- 1 Set	• 3 - Phase transformer 415/240V, 3 KVA	- 1 No.
• Insulated cutting pliers 200mm	- 1 No.	• 3 - Phase transformer Input 415 V Output 0-500 V, 3 kVA	- 1 No.
• Screw driver 200mm	- 1 No.		
• M.I.voltmeter 0-500 V	- 1 No.	Materials	
• Multimeter	- 1 No.	• Test lamp 40 W, 230 Volts	- 2 Nos.
		• Connecting leads	- as reqd.

PROCEDURE

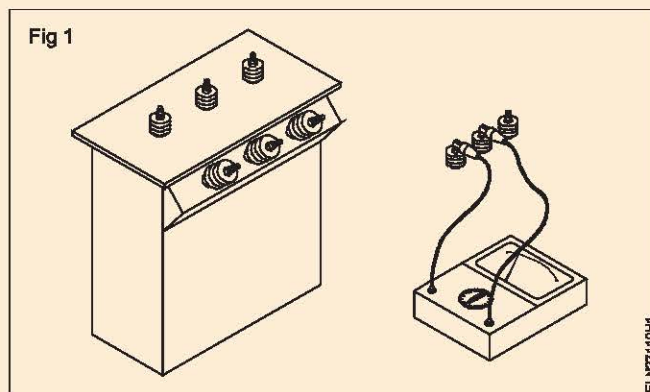
TASK 1 : Verify the terminals of three phase transformer

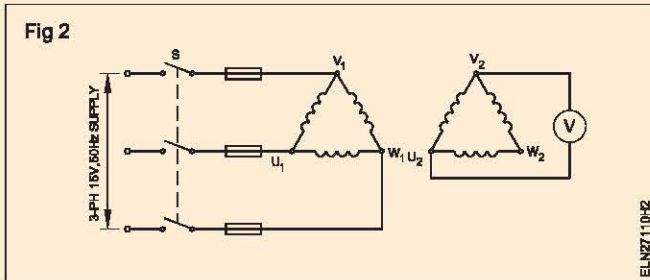
- 1 Note down the name plate details and enter in Table 1

Table 1

Name plate details			
SINo	: _____	Type of cooling	: _____
KVA	: _____	Mass of Coil	: _____
Volts HT	: _____	Total mass	: _____
LT	: _____	Date of MFG	: _____
Amps HT	: _____	Volume of oil	: _____
LT	: _____		
Frequency	: _____		

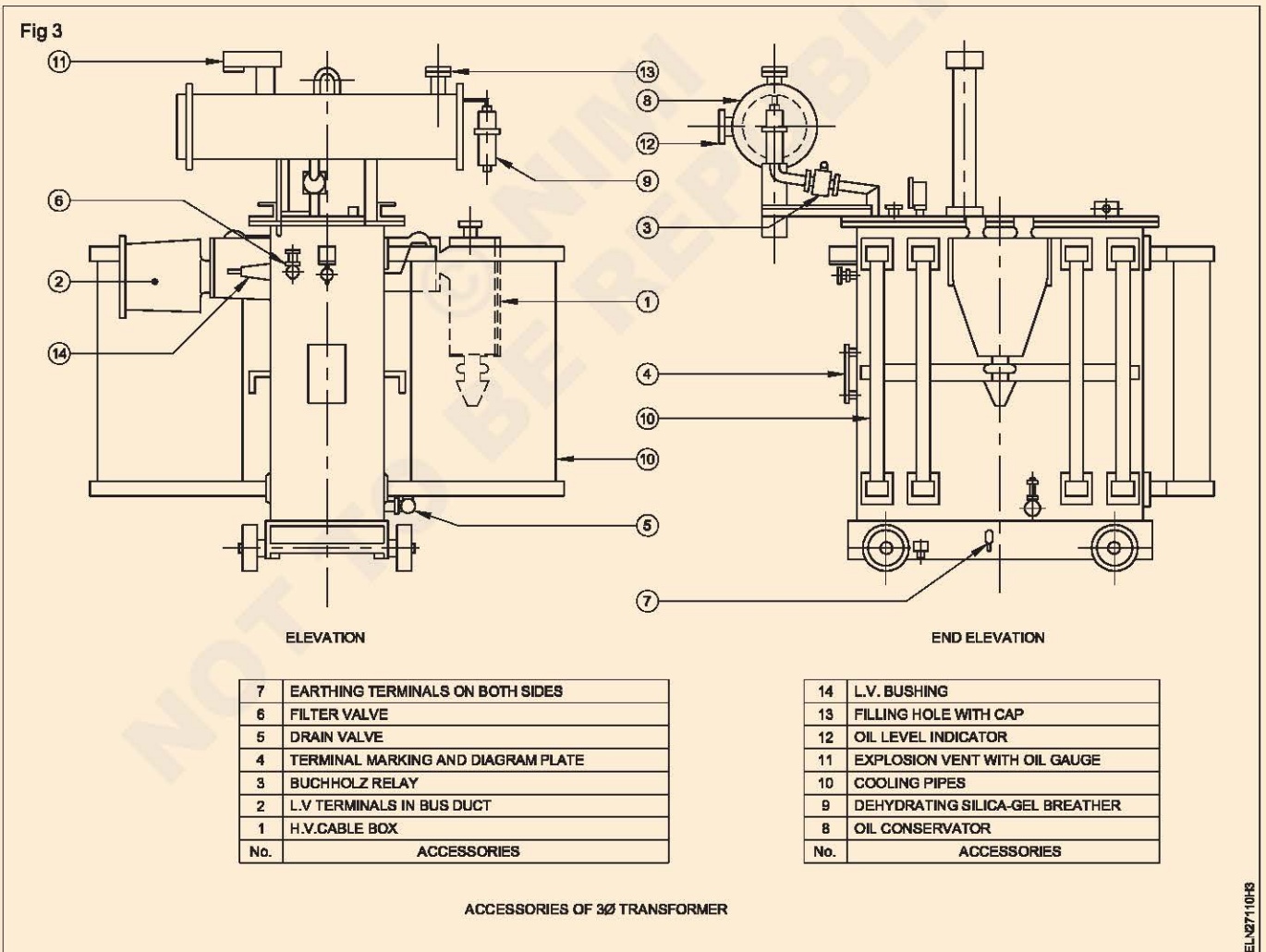
- 2 Check the continuity test using a multimeter to find out the two groups of terminals. (Fig 1)
- 3 Apply 15V 3 ϕ supply to U_1 , V_1 and W_1 by switching on switch 'S'.
- 4 Measure the voltage between V_2 and W_2 and between V_2 and U_2 . If the voltmeter shows less than 15 volts then those windings are LT winding. If the voltmeter shows more than 15 Volts then those windings are HT winding. (Fig 2)





TASK 2 : Identify the accessories of 3 phase tranformer

- 1 Get permission to enter the 11 KV transformer substation yard from the appropriate authority
- 2 Identify the following accessories of a 100KVA three phase transformer. (Fig 3 and 4)
 - a HV & LV Bushing
 - b Buchholz relay
 - c Conservator
 - d Breather
 - e Cooling pipes
 - f Explosion vent with oil gauge
 - g Earthing terminals
 - h Oil level indicator.



Perform 3 phase operation (i) delta - delta (ii) delta - star (iii) star-star (iv) star - delta by use of three single phase transformes

Objectives: At the end of this exercise you shall be able to

- connect three single phase transformers to 3-phase supply with different types of primary and secondary connection
- measure the primary and secondary line voltages in each type of connection
- determine the line voltage ratio and compare with the theoretical ratio values.

Requirements	
<p>Tools/Instruments</p> <ul style="list-style-type: none"> • Electrician tool kit - 1 No. • Voltmeter M.I. - 0 to 500V - 1 No. • Voltmeter M.I. - 0 to 300V - 1 No. <p>Equipment/Machines</p> <ul style="list-style-type: none"> • Single phase transformer 1 kVA 415/230 V 50Hz - 3 Nos. 	<p>Materials</p> <ul style="list-style-type: none"> • Connecting cables - as reqd. • ICTP switch 500V, 16A, - 2 Nos. • HRC fuses, 2 Amp - 3 Nos.

PROCEDURE

- 1 Connect the three single phase transformers and perform polarity test and voltage ratio test.

All the three transformers should have the same voltage ratio and same primary and secondary voltages.

Note down the voltage ratio of each transformer in the table.

- 2 Mark the terminals of the primary (HT) and secondary (LT) of each single phase transformer as follows.

The Terminal Marking are as per Standards

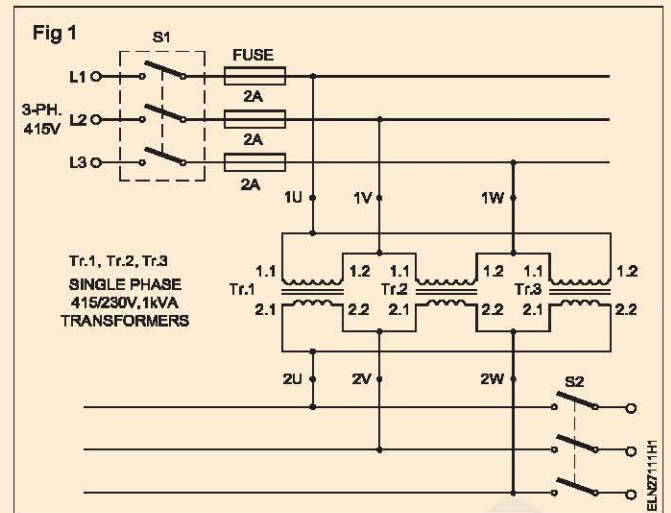
Terminals	Transformer 1	Transformer 2	Transformer 3
Primary (HT)	1U	1V	1W
	Starting Ending	Starting Ending	Starting Ending
	1.1 1.2	1.1 1.2	1.1 1.2
Secondary(LT)	2U	2V	2W
	Starting Ending	Starting Ending	Starting Ending
	2.1 2.2	2.1 2.2	2.1 2.2

TASK 1 : Connect the transformers as three phase delta-delta transformer

- 1 Connect the dissimilar ends of the primary together. i.e. (Fig 1)
 Connect 1.1. of Tr.1 with 1.2 of tr.3 and mark it as 1 U
 Connect 1.2. of Tr.1 with 1.1 of tr.2 and mark it as 1 V
 Connect 1.2. of Tr.1 with 1.1 of tr.3 and mark it as 1 W
- 2 Connect the dissimilar ends of the secondary windings. i.e.
 Connect 2.1. of Tr.1 with 2.2 of tr.3 and mark it as 2 U

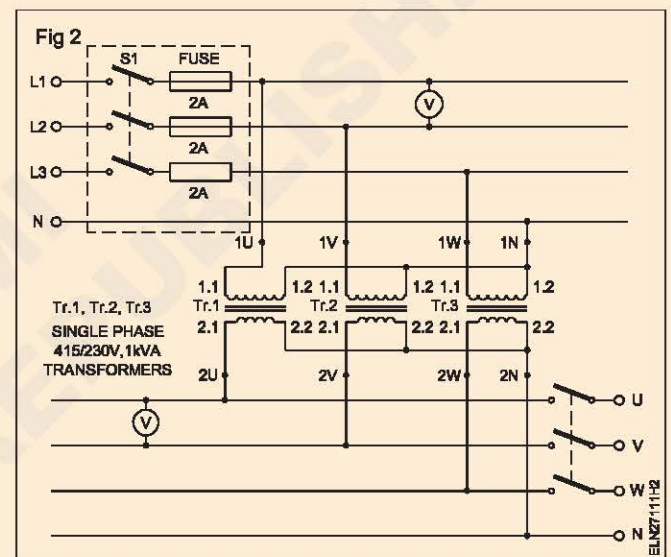
- Connect 2.2. of Tr.1 with 2.1 of tr.2 and mark it as 2 V
 Connect 2.2. of Tr.2 with 2.1 of tr.3 and mark it as 2 W
- 3 Connect 1U, 1V, 1W to ICTP switch S1.
- 4 Connect a voltmeter 0-500V across 1U and 1V.
- 5 Connect a voltmeter 0-300V across 2U and 2V.
- 6 Close the switch S1 and Note down the primary line voltage and secondary line voltage in tabular column under Delta-Delta connection.

- 7 Calculate the ratio of secondary line voltage and primary line voltage. Compare the values with Theoretical values.



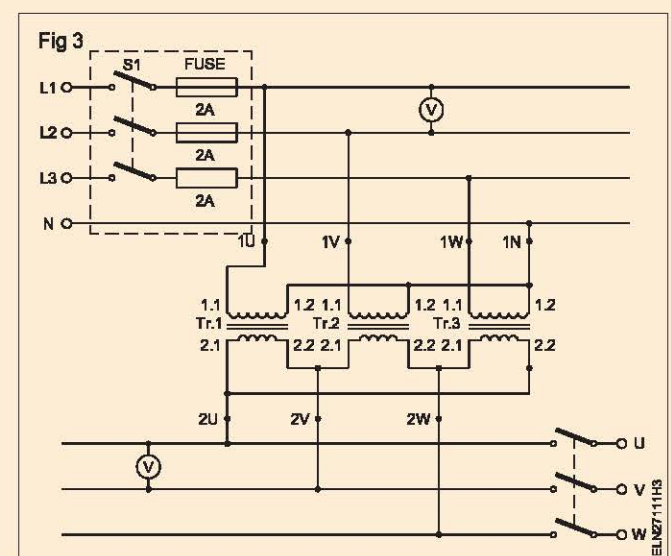
TASK 2 : Connect in star-star connection

- 1 Connect any three similar ends of primary winding together. Say connect 1.2 of Tr.1, 1.2 of Tr.2, 1.2 of Tr.3 together and mark the junction as 1N. (Fig 2)
- 2 Mark 1.1 of Tr.1 as 1U, 1.1 of Tr.2 as 1V and 1.1 of Tr.3 as 1W.
- 3 Connect any three similar ends of secondary winding together. Say connect 2.2 of Tr.1, 2.2 of Tr. 2, 2.2 of Tr.3 together and mark the junction as 2N as shown in circuit 2.
- 4 Mark 2.1 of Tr.1 as 2U, 2.1 if Tr.2 as 2V and 2.1 of Tr.3 as 2W.
- 5 Repeat the steps 3,4,5,6,7 of Task 1.



TASK 3 : Connect in star-delta connection

- 1 Connect three similar terminals of the primary windings together. Say connect 1.2 of Tr.1, 1.2 of Tr.2, 1.2 of Tr.3 and mark the junction as 1N. As shown in Fig 3.
- 2 Mark 1.1 of Tr.1 as 1U, 1.1 of Tr.2 as 1V and 1.1 of Tr.3 as 1W.
- 3 Connect the dissimilar terminals of the secondary windings.
Connect 2.1. of Tr.1 with 2.2 of tr.3 and mark it as 2 U
Connect 2.2. of Tr.1 with 2.1 of tr.2 and mark it as 2 V
Connect 2.2. of Tr.2 with 2.1 of tr.3 and mark it as 2 W
- 4 Repeat steps 3, 4, 5, 6, 7 of Task 1.



TASK 4 : To connect in delta-star connection

1 Connect the dissimilar terminals of the primary windings as follows. (Fig 4)

Connect 1.1. of Tr.1 with 1.2 of tr.3 and mark it as 1 U

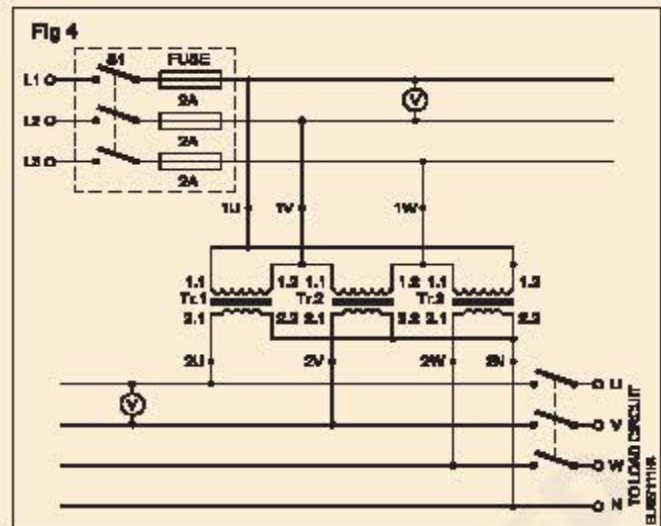
Connect 1.2. of Tr.1 with 1.1 of tr.2 and mark it as 1 V

Connect 1.2. of Tr.2 with 1.1 of tr.3 and mark it as 1 W.

2 Connect the three similar terminals of secondary windings together. Say connect 2.2 of Tr.1, 2.2 of Tr.2, 2.2 of Tr.3 and mark the junction as 2N as shown in Fig 4.

3 Mark 2.1 of Tr.1 as 2U, 2.1 of Tr.2 as 2V and 2.1 of Tr.3 as 2W.

4 Repeat steps 3,4,5,6,7 of Task 1.



Voltage ratio of each transformer K =.....

Tabular Column

Type of Connection	Primary Line Voltage	Secondary Line Voltage	Line Voltage Ratio (Theoretical)
			Line Voltage Ratio (Practical)
Delta - Delta			$= \frac{\text{Secondary Line Voltage}}{\text{Primary Line Voltage}}$
Star - Star			
Star - Star			
Delta - Star			

If a 3 single phase transformer is available with six secondary terminals brought out then follow the same procedure as given in above tasks with the following given terminal markings.

	Transformer Windings 1		Transformer Windings 2		Transformer Windings 3	
	Starting	Ending	Starting	Ending	Starting	Ending
Primary (HT)	1.1U	1.2U	1.1V	1.2V	1.1W	1.2W
Secondary (LT)	2.1U	2.2U	2.1V	2.2V	2.1W	2.2W

Perform testing of transformer oil

Objectives: At the end of this exercise you shall be able to

- **conduct field test on the transformer oil**
- **conduct crackle test on transformer oil**
- **conduct dielectric test on the transformer oil using standard test set.**



Scan the QR Code to view the video for this exercise

Requirements**Tools/Instruments**

- Glasstumbler - 1 No.
- Pipette - 1 No.
- 200mm dia. metal tube with one side closing - 1 No.
- Insulated piler - 1 No.
- 100 mm connector screwdriver - 1 No.
- Double end electrician knife - 1 No.

Equipments/Machines

- Standard transformer oil test kit with it's accessories - 1 No.
- Electric heater 1000 watts/250V - 1 No.

Materials

- Samples transformer oil (different samples) - as reqd.
- Distilled water - as reqd.

PROCEDURE**TASK 1 : Conduct field test**

- 1 Collect a glasstumbler, pipette, oil sample and distilled water on the work bench.
- 2 Fill the glass tumbler with the distilled water to 3/4th level.
- 3 Take a sample drop of transformer oil through a pipette and drop a single drop on the distilled water.
- 4 Observe, the field of the oil surface and record the field diameter and shape.

- a The shape of the oil drop
- b The dia for the field
- c Condition of oil good/bad.

If the shape of drops retained, the oil is good. If the shape is flattened and the drop occupies the area of diameter less than 18mm, the oil may be used. If it is more, it is not suitable and it has to be reconditioned.

TASK 2: Conduct Crackle test

- 1 Collect, steel tube, heater and a sample of transformer oil.
- 2 Heat the close end of steel tube.
- 3 Pour the oil sample into the tube.
- 4 Take the open end of the tube to the ear and hear the sound.

- 5 Record the sound heard.
 - a Sound heard
 - b The condition of the oil is ..

If the oil contains moisture, a sharp crackle sound will be heard. Dry oil will only sizzle.

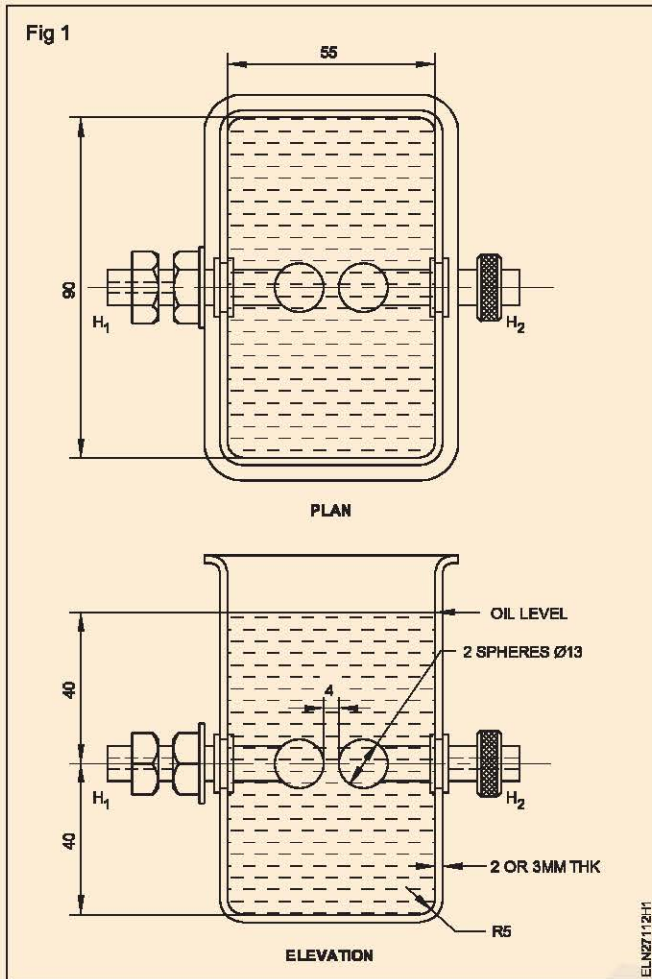
TASK 3 : To conduct dielectric test with oil testing kit

- 1 Examine the oil testing set and read the instructions given by the manufacturer. (Fig 1)
- 2 Take a sample of the transformer oil in a clean, transparent and dry glass bottle. If there is a drain valve take the sample from the drain valve.

If it is not possible to take the sample from the drain valve then the sample may be drawn by syphoning off from the conservator tank.

- 3 Take atleast three samples in three bottles from the transformer to conduct atleast three tests.
- 4 Clean the standard test cup by washing it with clean oil and adjust the gap of the electrodes in such a way that it should be of 4 mm.

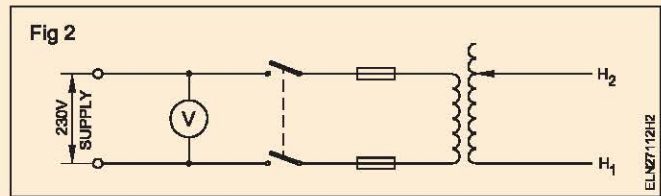
Measure the gap by the calibrated gauge, which is usually supplied with the equipment.



- 5 Fill the cup with a sample of oil to be tested 1 cm above the electrodes or the marked level on the cup.
- 6 Close the cup with a clean cover and allow 5 minutes for the oil to settle so that all air bubbles may disappear.
- 7 Make sure that the test area is clear of all the other persons.
- 8 Set voltage regulation at zero position.
- 9 Switch 'ON' the supply.
- 10 Raise the voltage gradually from zero so that the full voltage is reached within 20 to 30 seconds.

It is quite possible that a spark may occur at a very early stage i.e even 20 kV due to some extraneous matter like microscopic strands of cotton, dust etc. which have a tendency to get aligned along the strong electrostatic field in the spark gap. It may burn out and may not affect the test.

- 11 Raise the voltage until the final breakdown of the oil. The circuit breaker will get tripped. Simultaneously watch the voltmeter and note the readings of the breakdown voltage. (Fig 2)



After sparking the oil near the electrode will turn black in colour.

- 12 Repeat the steps 5 to 11 with oil in the second sample.

Note that the breakdown voltage of the first and second samples should be approximately equal.

- 13 Prepare the test for the third sample.
- 14 Conduct the test by increasing the test voltage up 40 KV.
- 15 Apply the test voltage for about one minute and observe that there is no sparking.

Note that good oil should withstand 40 kV for one minute.

Conclusion

Since the water is heavier than oil, it settles down at the bottom of the tank.

- 16 If the tested oil is in good condition, fill this oil in the transformer tank up to the oil level marked on the body of the transformer tank.

Practice on winding of small transformer

Objectives: At the end of this exercise you shall be able to

- dismantle the transformer cores
- measure and determine the size of winding wire for primary and secondary winding
- take the dimensions of a bobbin and prepare the bobbin from suitable materials
- wind the primary and secondary windings layer by layer
- stack the cores and fasten them
- terminate the winding end in a terminal board
- test the transformer for insulation, transformation ratio and performance
- design a transformer when power and voltage ratings are known.



Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

- Scissors 150 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Firmer chisel 20 mm - 1 No.
- Hammer ball pein 0.5 kg - 1 No.
- Iron soldering 25 W, 240V - 1 No.
- DE spanner 6 mm to 25 mm - 1 No.
- Mallet hardwood 0.5 kg - 1 No.
- Nylon mallet 5 cm dia. - 1 No.
- D.B. Knife 100 mm - 1 No.

Materials

- Super-enamelled copper wires - as reqd.
- Empire sleeves 1 mm, 2mm - 1 m each
- Air-dry varnish - 100 ml.
- Resin-core solder 16 SWG - 10 G
- Soldering paste - 5 g
- Smooth emery paper - 1 piece
- Fabric based fibre sheet and 6 mm thick - 3 mm
- Cotton cloth for cleaning - 500sq.cm
- Insulation papers - as reqd.

PROCEDURE

TASK 1 : Dismantling the transformer for rewinding

- 1 Note down the name plate details in Table 1.
- 2 Draw the end connection terminal marking of the transformer in your record.
- 3 De-solder the leads and remove the terminal strips if they are attached to the core.
- 4 Loosen the nuts of the core assembly and remove the screws if any.
- 5 Remove the clamps attached to the core.
- 6 Gently tap the transformer core with a nylon mallet so that the core gets loosened.
- 7 Remove the stampings starting from the centre of the core using Nylon /fibre knife.

In the case of hard stacked stamping, occasionally use a thinner to loosen the stamping.

Table 1

Transformer rating plate

No of Phases	Sl.No.....
V.A rating	Frequency
Primary voltage.....volt	Secondary voltage.....volt
Primary current.....amp	Secondary current.....amp
Manufacturer	

If a metal knife is used to remove the tight and sticky stampings, care should be taken not to damage the stampings. While stripping the core see that the stampings are taken out straight without bends.

8 Remove all the stampings and record the following in Table 2.

Table 2
Core details

Type of core
No. of stampings of shape..... No.....
No. of stamping of shape..... No.....

9 Wipe the bobbin and winding with a cloth.

10 Record the dimensions of the coil in Table 3 with and without insulation and prepare a template to check the winding's height and length.

Table 3
Size of the coil

Description	With insulation	Without insulation	Remarks
Coil height	..... cm	..... cm.	
Coil height	..... cm.	..... cm.	

11 Strip off the winding carefully. During the stripping process record all the particulars in Table 4.

12 Draw the schematic diagram of the primary and secondary sides of the transformer from the above findings in your record.

13 Clean the bobbin, write down the bobbin particulars in Table 5 for your guidance.

The same bobbin can be used if it is not damaged.

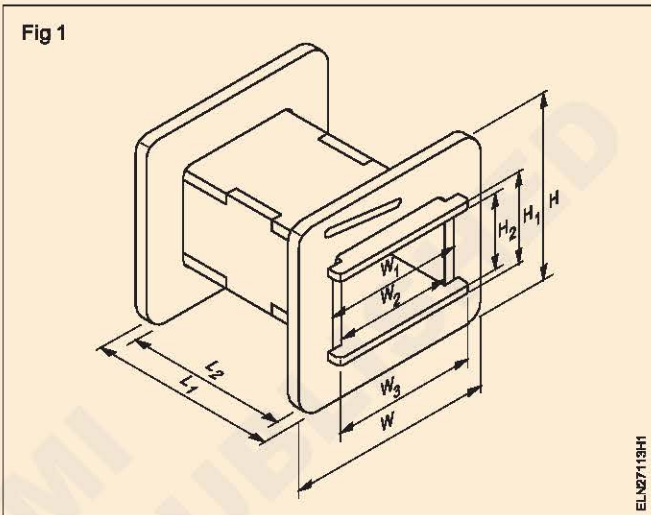


Table 4

Winding details

Total No. of winding/turns			
No. of layers			
No. of turns/layer			
Layer insulation Type Thickness .....mm.			
	With Insulation	Without Insulation	Wt. of the coil
Primary winding			
1 st Tapping, No. of turns diameter of wire	.....mm.	.....mm	.....g
2 nd Tapping, No. of turns ... diameter of wire	.....mm.	.....mm	.....g
3 rd Tapping, No. of turns ... diameter of wire	.....mm.	.....mm	.....g
Secondary winding			
Winding 1, No. of turns diameter of wire	.....mm.	.....mm	.....g
Winding 2, No. of turns ... diameter of wire	.....mm.	.....mm	.....g
Winding 3, No. of turns ... diameter of wire	.....mm.	.....mm	.....g
Coil insulation - type thickness .....mm.			
Connecting lead size			

Table 5
Bobbin details

1	Type of bobbin	.....Injection moulded/Built up
2	Bobbin material	.....Thickness .....mm.
3	Length of the bobbin	L.....mm, L_1.....mm, L_2.....mm.
4	Width of the bobbin	W.....mm, W_1.....mm, W_2.....mm, W_3.....mm.
5	Height of the bobbin	H .....mm, H_1.....mm, H_2 .....mm

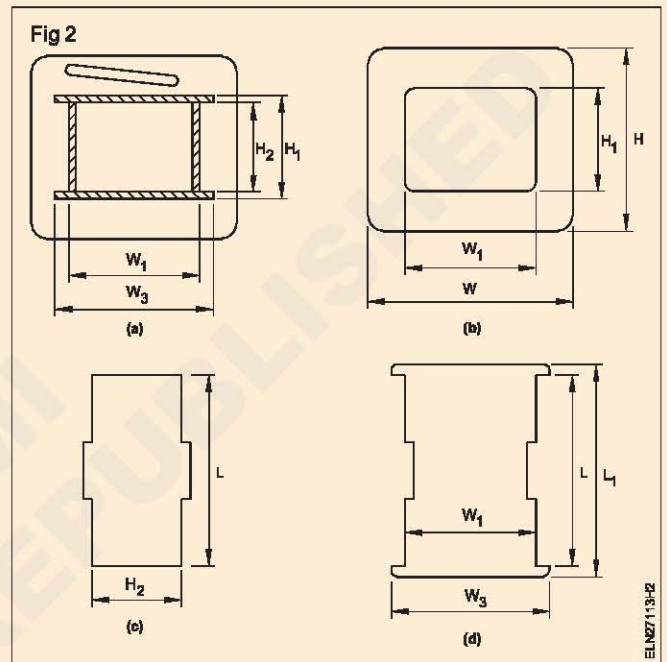
TASK 2 : Preparation of bobbin

- Referring to the data taken in Table 5 and as per Fig 1, prepare the bobbin parts from a hylam/fibre sheet of the same thickness. (Fig 2)

Bobbin parts of standard sizes are also available in the market which can be assembled to form the bobbin.

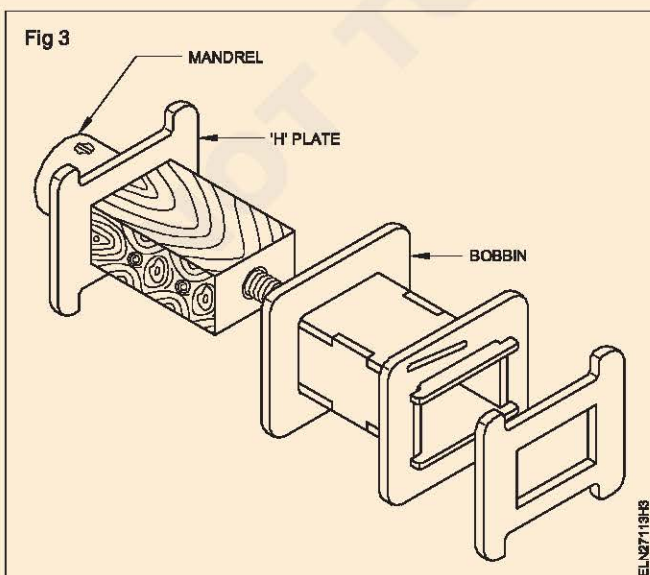
- Assemble the parts of the bobbin as shown in Fig 2 which is given for your guidance.
- Check the size of the assembled bobbin and verify it with the data taken and recorded in Table 5.

In the case of an injection moulded bobbin it can be purchased from the market assuming it is of standard size.



TASK 3 : Rewinding of transformer

- Prepare/select a suitable mandrel for the prepared bobbin as shown in Fig 3 depending upon the design of the winding machines.

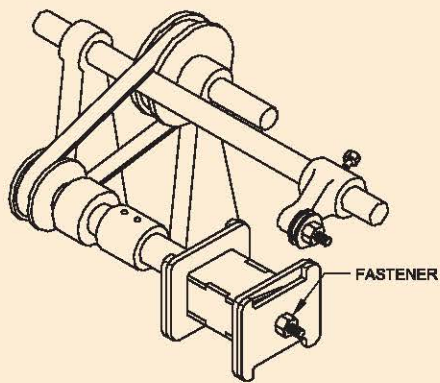


- Clamp the mandrel/wooden block in the winding machine.

See to it that while clamping the mandrel under no circumstances the work becomes loose during winding.

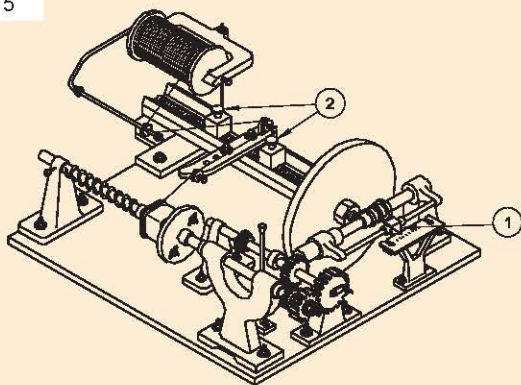
- Fit the bobbin tightly to the mandrel of the winding machine with the help of fasteners as the bobbin must turn along with the mandrel without play. (Fig 4).
- Adjust the feed of the winding machine to suit the selected winding wire size by friction drive or by changing the gear as shown in number 1 of Figs 5 and 6.
- Adjust the transverse feed of the winding machine guides such that the length of the inner side of the bobbin so as to maintain the length of the coil as in the original. Refer to number 2 of Figs 5 and 6. You may need several trials before final setting.
- Place one layer of paper or cloth as core insulation on the bobbin smoothly without crease.

Fig 4



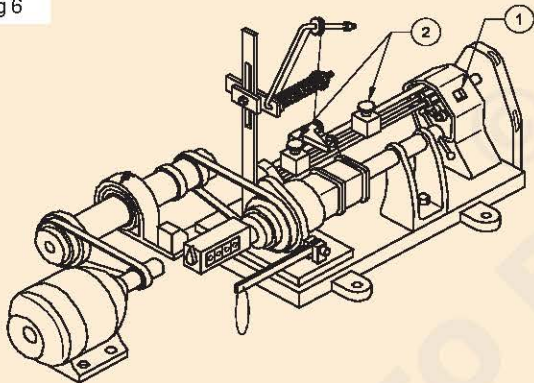
ELN2713H5

Fig 5



ELN2713H6

Fig 6



ELN2713H7

If the winding wire thickness is sufficiently large, soldering of connecting lead wire is not necessary.

- 7 Start the winding and complete at least one layer to check whether the coil length is well within the bobbin as in the original. If not, readjust the transverse feed.

Adjacent turns of the winding wire should not overlap or have a gap in between them. If incorrect, readjust the feed.

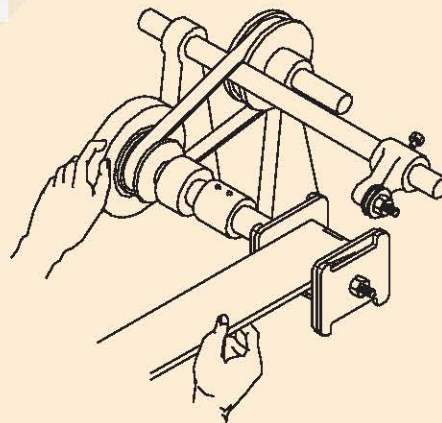
- 8 Start and continue the winding layer by layer providing the necessary in-between insulation and specified number of turns in each layer as per data taken in Table 4.
- 9 After the designated number of turns are wound, solder the end lead and take it out through the bobbin flange outlet.

If a coil has a number of taps of winding, never cut the wire. Instead fold the length into a long loop and carry the wire to continue the winding. The looped wire can then be bared and connected outside the coil.

- 10 After inspecting the primary winding, wrap the winding as shown in Fig 7 with sufficient insulation according to the data taken in Table 4.
- 11 Select a suitable secondary winding wire as shown in the data taken in Table 4 and proceed as in steps 4 to 7.
- 12 At the end of the winding, wrap and bind the insulation on the winding tightly.
- 13 Inspect the coil for proper termination of lead and check the size by using a template and data taken in Table 3.
- 14 Test the windings for continuity and short circuit.

If winding data is not available or a new transformer has to be designed and wound.

Fig 7



ELN2713H8

TASK 4 : Stacking of transformer cores (E & I)

- 1 Insert an 'E' lamination into the bobbin from both sides as shown in Fig 8a.
- 2 Place the right hand side (R.H.S.) laminations below the one inserted from the left hand side (L.H.S.).
- 3 Place an 'I' lamination to the free end of the L.H.S. 'E' piece as in Fig 8b.
Ensure that the slot in the 'I' is above the corresponding slot in the R.H.S. 'E' lamination.

Fig 8a

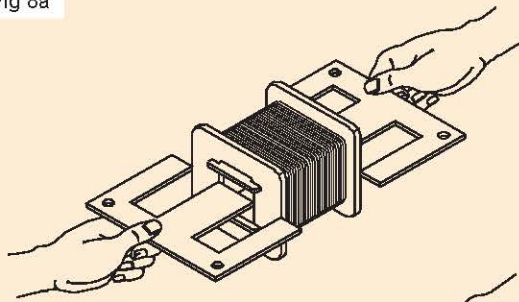
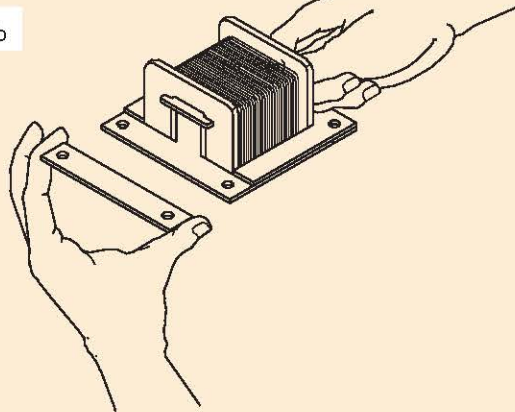


Fig 8b



ELN2713HA

The laminated assembly should be flush and lying flat.

- 4 Insert the second 'E' shaped laminations from the opposite side.

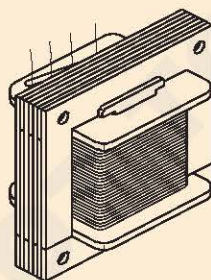
Ensure that it fits snugly against the bobbin.

- 5 Place an 'I' shaped lamination in position.

Ensure that it lies flat on the first "E" lamination.

- 6 Likewise insert the laminations alternately without any gap as shown in Fig 9.

Fig 9



ELN2713IB

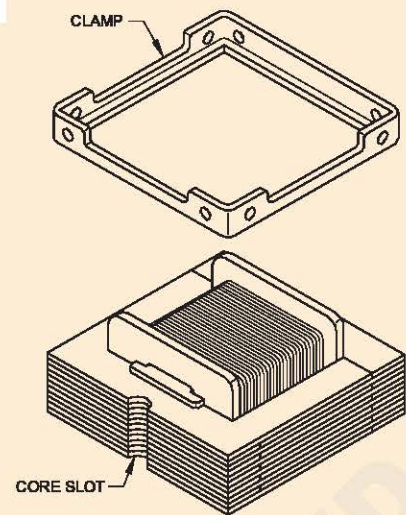
Ensure that when all of the specified quantity of laminations are inserted, the assembly has the right dimension, from loose laminations and correct interpolated laminations.

- 7 Fit both top and bottom clamp plates on the assembly as in the original. (Fig 10)

Pay particular attention to align the core slots in the laminations.

Ensure that the fixing bolts can be easily inserted.

Fig 10



ELN2713HC

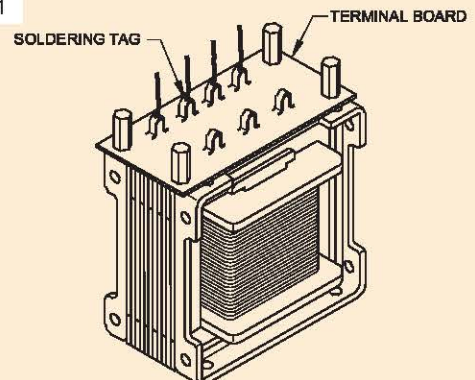
- 8 Push the fixing bolts through the clamp plates.
- 9 Use the specified fasteners and tighten the assembly.
- 10 Varnish the transformer by dipping in an air-dry varnish and drain it.
- 11 Fit the specified insulating sleeves over the lead-out wires.
- 12 Obtain the specified terminal board and pass each lead-out through the specified hole.

Ensure that all the sleeved leads are correctly positioned.

Check that all the sleeved leads terminate at each hole i.e. no bare leads should be visible in the terminal board.

- 13 Place the terminal board in position as shown in Fig 11.
- 14 Secure the terminal board with the specified studs.
- 15 Check that no leads have been trapped between the terminal board and the core.
- 16 Make the specified mechanical joint between each lead-out wire and its soldering tag.
- 17 Solder each joint and cut off the surplus wire ends as seen in Fig 11.

Fig 11



ELN2713HD

TASK 5 : Testing of transformer after winding

- 1 Test the primary and secondary windings for continuity with a megger.
- 2 Measure and record the primary and secondary winding resistance in Table 6.

Table 6

Transformer winding resistance

Primary	resistance	.....	ohm
Secondary 1	resistance	.....	ohm
Secondary 2	resistance	.....	ohm
Secondary 3	resistance	.....	ohm

- 3 Measure and record the insulation resistance, between windings and frame in Table 7.

Table 7

Insulation resistance between

Primary & secondary windings	.....	megohm
Secondary windings (in case of separate windings)	.....	megohm
Windings and frame	.....	megohm

- 4 Connect the primary winding of the transformer with the rated voltage. Keeping the secondary open, test the primary and the secondary voltage. Record the finding in Table 8.

Table 8

No-load measurement

Primary voltage	.....	volt
Secondary voltage		
1	.....	volt
2	.....	volt
3	.....	volt

- 5 Observe for vibration sound of the core. If it is abnormal, tighten the stampings, also check for tightness of the coil.
- 6 Connect the transformer with suitable load so that full load current passes through the secondary, and record the voltage and current at load in Table 9.

Table 9

Load measurement

Primary voltage	.....	volt
Primary current	.....	amp
Secondary voltage	.....	volt
Primary current	.....	amp

- 7 Keep the transformer on full load for eight hours continuously. Observe the change in temperature of the winding and core by touching. If the temperature raise is within the class of insulation, the transformer is O.K.



Practice of general maintenance of transformer

Objectives: At the end of this exercise you shall be able to

- carry out hourly maintenance of transformer
- carry out daily maintenance of transformer.

Requirements	
Tools/Instruments <ul style="list-style-type: none"> • Electrician tool kit 	Materials <ul style="list-style-type: none"> • Items required for reactivating silica gel. • Spare relief diaphragm.

Note: The instructor may take the trainees to the transformer yard and demonstrate the maintenance procedures.

PROCEDURE

TASK 1 : Carry hourly maintenance

- 1 Note down the secondary load current of the transformer read by the ammeter provided.
- 2 Check this value with the rated value as per name plate details.
- 3 If the load current is more than the rated value then reduce the load on transformer by the following sequence.
 - a Trip off the circuit breaker
 - b Switch off the load feeders which are not very essential
 - c Again charge and switch on the circuit breaker.
- 4 Record the values of primary line voltage and line current and secondary line voltage and line current and PF in Table 1.
- 5 Note down the oil temperature which is indicated by thermostat dial or thermometer in Table 1.

Table1

Maintenance chart for hourly maintenance of 3 ϕ transformer

Sl. No.	Date & Time	Primary Line Voltage		Secondary Line Voltage		Secondary Current		Power Factor	Oil Temp	Remarks
		Phases	Voltage (V)	Phases	Voltage (V)	Phases	Current in Amps			
1		1U - 1V		2U - 2V		2U				
2		1V - 1W		2V - 2W		2V				
3		1W - 1U		2W - 2U		2W				



TASK 2 : Carry out daily maintenance of transformer

- 1 Inspect the dehydrating breather, by following sequence.
 - a Check whether the air passages are clear, if not clean it
 - b Check the colour of the active agent i.e. silicagel
 - c If the silicagel is pink in colour, reactivate it in following sequence.
- 2 Collect the silica gel crystals in a shallow tray and bake them at 200°C.
- 3 When the crystals become blue in colour, fill the breather with reactivated blue crystals.

- 4 Inspect the oil level in the transformer.
- 5 Observe the conservator sight glass and check the oil level of the transformer.
- 6 If the oil level is low, top up the level through drain valve by filling clean transformer oil.
- 7 If the oil level drops appreciably over a short period, then check the tank for any oil leakage.
- 8 If there is a leak in the transformer tank, take suitable actions to prevent leakage by consulting the instructor.
- 9 Inspect the relief diaphragm.
- 10 Observe the explosion vent of the transformer and check the condition of relief diaphragm and record the observations in Table 2.
- 11 If it is cracked or broken replace it after isolating the primary supply to the transformer.

Table 2

Maintenance chart for daily maintenance of 3 ϕ oil cooled transformer

Date	Time	Oil level	Colour of Silicagel	Condition of relief diaphragm	Remarks action taken

Project Work

Objectives: The Trainees/P articipants shall be able to

- **select a project work of their choice**
- **prepare the list of materials required and collect them**
- **list out the tools required**
- **prepare a brief note on the project**
- **complete the project and submit the project report with all the details.**

Note: Instructor has to explain in detail regarding the project works to be carried out in the section. The trainees may be divided in groups according to the strength available in section and give all details how to prepare and finish the work with complete workmanship and accuracy.

- Step to start and follow the project work
- Motivate the group by emphasising the technical work involved and its future influences.
- Divide the work equally and make sure in yoke participating with full interest.
- Start the project work, test it stage by stage and complete it.
- Test the completed project job for its functionality and its utility.
- Prepare a project report containing its technical parameters, specification, material requirement and its cost, operational procedure, maintenance, utility and marketing etc.
- Indicate the scope of future expansion, easy conversion to other project for advanced version in the report.

- Get it checked with your instructor.
- The project should complete with all operational instructions and carry necessary procedure with switches, controls, labels, symbols etc.
- Safety devices has to be placed according to the project and its functions.
- Maintenance and repair instructions should be indicated clearly.

Note: Instructor has to evaluate the project work with all records and reports. Marks to be awarded for the project working, accuracy, workmanship, safety features and its work performance related to the viva questions.

Project work

- 1 Overload protection of electrical equipment.
- 2 Automatic control of street light/night lamp.
- 3 Fuse and power failure indicator using relays.
- 4 Door alarm/indicator.
- 5 Decorative light with electrical flasher.



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