Summer – 2019 Examinations

Model Answers

Subject & Code: Electric Motors and Transformers (22418)

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1 Attempt any FIVE of the following: **10**

1 a) State any four parts of the D.C motor.

Ans:

Part of the D.C. Motor as follow:

(i) Armature core.
(ii) Armature winding.
(iii) Field winding.
(iv) Commutator.
(v) Brushes.
(vi) Yoke.
(vii) Pole core.
(viii) Pole shoe.

1 Mark for two parts (Any four) = 2 Marks

1 b) State the working principal of d.c. generator.

Ans:

- Working principle of DC generator is the principle of dynamically induced emf or electromagnetic induction.
- According to this principle, if flux is cut by a conductor, then emf is induced in conductor.
- In case of DC generator, when armature winding is rotated in magnetic field by the prime mover, the flux is cut by the armature winding and an emf is dynamically induced in the armature winding.

2 Marks

1 c) State principle operation of a transformer.

Ans:

Working Principle of a Transformer:

The transformer operates on the principle of mutual induction. 1 Mark

When ac supply is applied to primary, it circulates ac flux in core which is going to link with secondary. The changing flux linking with the secondary induces emf in secondary winding. 1 Mark

1 d) List various losses take place in a transformer.

Ans:

Various Losses in Transformer:

1) **Copper losses (P_{cu}):**

These are also known as Variable losses. The total power loss taking place in the winding resistances of a transformer is known as the copper loss. 1 Marks

Cu loss = Primary Cu loss + Secondary Cu loss

$P_{cu} = I_1^2R_1 + I_2^2R_2$

R_1 & R_2 are resistances of primary & secondary winding respectively.

2) **Iron losses (P_i):**

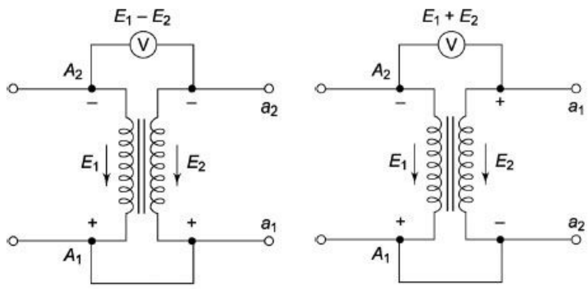
These are also known as Fixed losses. These are further divided into Eddy current loss and hysteresis loss. 1 Mark

i) Eddy current loss = $K_EB_m^2 f^2T^2$

where, K_E is eddy current constant, B_m is the maximum value of the flux density, f is the frequency of magnetic reversals; T is thickness of core in m.

ii) Hysteresis loss = $K_H B_m^{1.67} f V$
Where K_H is Hysteresis constant, B_m is the maximum flux density
f is the frequency of magnetic reversals and V is the volume of the core in m^3

1 e) Draw circuit diagram for polarity test on single-phase transformer.
Ans:
Circuit Diagram of Polarity test of Single-phase Transformer:



2 Marks

OR any equivalent diagram

1 f) Define current transformer.
Ans:
Current transformer: Current transformer is an instrument transformer which is used in conjunction with measuring instrument like ammeter for measurement of current. 2 Marks

1 g) State the function of the isolation transformer.
Ans:
Functions of Isolation Transformer: 2 Marks for two function
i) Disconnect the load equipment from supply ground:
ii) Reduction of voltage spikes
iii) It acts as a decoupling device.
iv) Protects loads from harmonic distortion.

2 Attempt any THREE of the following: 12

2 a) State function of following parts of D.C motor:
(i) Pole shoe
(ii) Commutator
(iii) Brushes
(iv) Yoke

Ans:
Function of Pole shoe in D.C Motor:.
i)Gives machanical support to field coil and reduce magnetic reluctance due to enlarged area. 1 Mark
ii)Distribute the flux uniformly in the air gap.
Function of commutator in D.C Motor:
i)It helps to produce an unidirectional current from the armature winding. 1 Mark

ii) It collects the current from armature conductors and passes it to the external load via brushes

Function of Brushes in D.C Motor:

i)Function of brush is to give current to the armature conductors through commutator segments. 1 Mark

ii) It makes moving contact with commutator to facilitate the contact between stationary and moving parts.

Function of Yoke in D.C Motor:

i) Provides mechanical support for poles. 1 Mark

ii) Acts as protecting cover for machine.

iii) Provides path for magnetic flux.

2 b) Explain the principal of working of three phase induction motor.

Ans:

- When the motor is excited with three-phase supply, three-phase stator winding produces a rotating magnetic field of constant magnitude which rotates at synchronous speed.
- This changing magnetic field is cut by the rotor conductors and induces emf in them according to the principle of Faraday's laws of electromagnetic induction. As these rotor conductors are shorted, the current starts to flow through these conductors. 4 Marks
- The current carrying rotor conductors are placed in magnetic field produced by stator. Consequently, mechanical force acts on rotor conductors. The sum of the mechanical forces on all the rotor conductors produces a torque, which tend to move the rotor in same direction as the rotating magnetic field.
- This rotor conductor's rotation can also be explained by Lenz's law, which tells that the induced currents in the conductors oppose the cause for its production. Here this opposition is rotating magnetic field. This results in the rotor starts rotating in the same direction as that of the rotating magnetic field produced by stator.

2 c) Draw a neat labeled sketch of three-point starter.

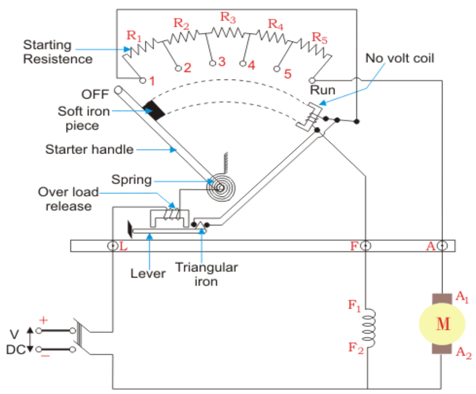
Ans:

Three Point Starter:

4 Marks for labeled sketch

3 Marks for partially labeled sketch

2 Marks for unlabeled sketch



Three Point Starter

2 d) Select or suggest any two applications for:
(i) D.C shunt motor
(ii) D.C series motor

Ans:

Applications of DC shunt motor: (2 Marks for any two applications)

DC shunt motors are fairly constant speed and medium starting torque motors, hence they are used in applications requiring constant speeds.

i) Lathe machine
ii) Drilling machines
iii) Grinders
iv) Blowers & fans
v) Compressors
vi) Centrifugal and reciprocating pumps
vii) Machine tools
viii) Milling machine

Applications of DC series motor:

DC series motors are variable speed and high starting torque motors, hence they are used in applications requiring variable speeds and high starting torque. (2 Marks for any two applications.)

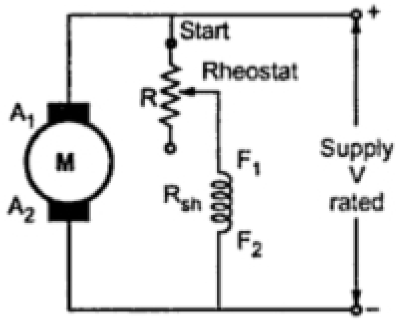
i) Electric tractions
ii) Cranes
iii) Elevators
iv) Air compressors
v) Vacuum cleaners
vi) Hair dryers

3 Attempt any THREE of the following: 12

3 a) Describe with suitable diagram speed control of DC shunt motor by field current control method.

Ans:

Speed control of DC shunt motor by field current control method:



2 Marks for circuit diagram

The back emf induced in the armature winding of DC motor is given by,

$$E_b = \frac{\emptyset ZN}{60}\frac{P}{A} \text{ volt}$$

Since Z, P, A are constants, $E_b \propto \phi N$

i.e $N \propto E_b/\phi$

Since $E_b \cong$ Supply voltage V, we can write N α $1/\phi$, thus the speed is inversely proportional to the flux.

In this flux control method, speed of the motor is inversely proportional to the flux. Thus, by decreasing flux the speed can be increased. To control the flux, here a rheostat is added in series with the field winding. When the rheostat is increased, the field current and so the magnetic flux decreases. This results in an increase in the speed of the motor. Since the speed is inversely proportional to the flux or field current, the graphical representation curve showing relationship between speed and field current is hyperbola. The field current is relatively small and hence I^2R loss in field winding is less, which makes this method quite efficient.

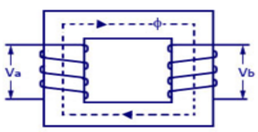
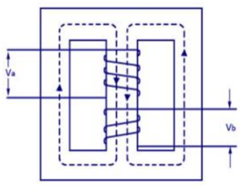
2 Marks for explanation

With zero value of rheostat, the motor runs at rated speed and when rheostat is increased, the field current decreases and speed increases. Thus this method controls the speed above normal or rated speed.

3 b) Compare core type and shell type transformer on any four parameters.

Ans:

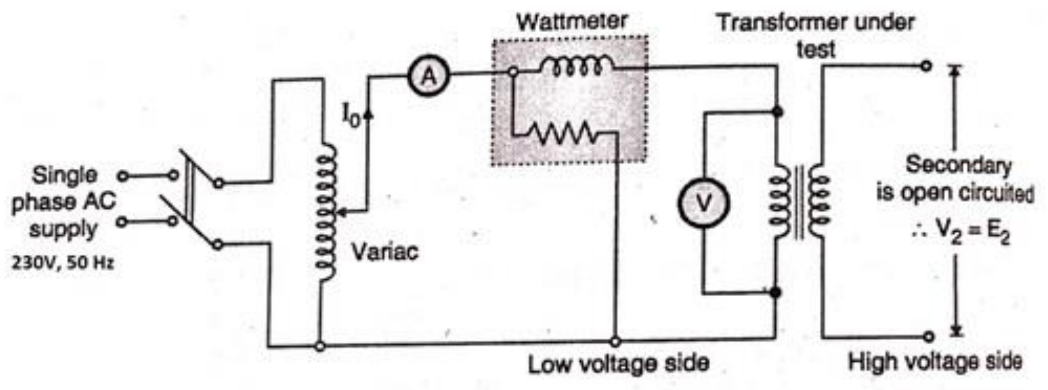
Comparision of Core Type and Shell Type Transformer:

Sr. No.	Core type	Shell type
1		
2	It has one window	It has two windows
3	It has one magnetic circuit.	It has two magnetic circuits.
4	Core surrounds the winding.	Winding surrounds the core
5	Average length of core is more.	Average length of core is less.
6	Area of cross section is less so more turns are required.	Area of cross section is more so less turns are required.
7	Better cooling for winding	Better cooling for core
8	Mechnical strength is less	Mechnical strength is high
9	Repair and maintenance is easy	Repair and maintenance is difficult
10	Application: Low current, high voltage	Application: High current, low voltage

1 Mark for each of any 4 parameters = 4 Marks

3 c) Draw a neat experimental set up to conduct OC test on a single phase transformer.

Ans:



Set up for the O.C. test

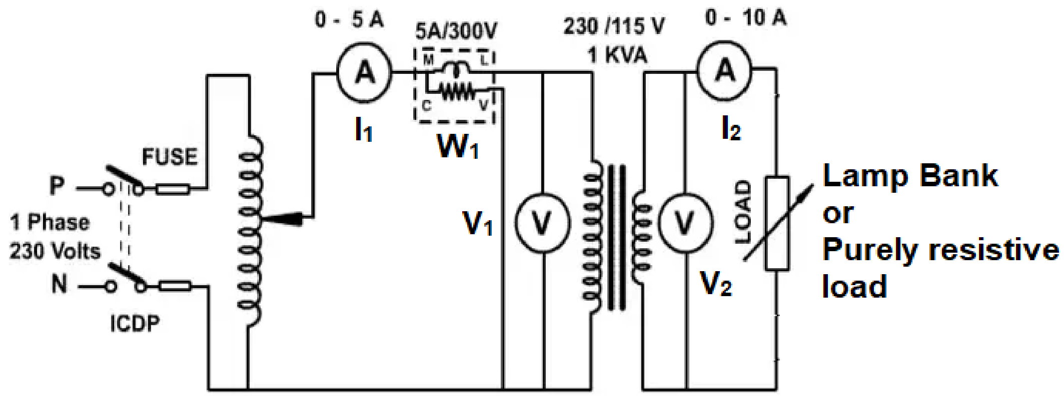
4 Marks for labeled diagram

3 Marks for partially diagram sketch

2 Marks for unlabeled diagram

3 d) Explain with circuit diagram, the direct loading tests on single phase transformer. How the efficiency and regulation at given load condition is determined?

Ans:



Direct loading test on Single-phase Transformer

2 Marks for circuit diagram

Direct loading test is conducted on small capacity transformers whose voltage and current ratings are within the limits of direct measurement. The transformer is directly connected to load and subjected to various load conditions just like its operation in the field.

Procedure to conduct Direct Loading Test:

i) Connect the circuit as shown in figure.
ii) Adjust primary voltage to its rated value and keep it constant throughout the experiment.
iii) Take first reading on No-load condition.
No-load supply voltage V_0 = Rated primary voltage V_1.
No-load primary current = I_0

1 Mark for procedure

No-load input Power = W_0 = Iron loss of transformer.= W_i
No-load secondary load voltage = E_2
No-load output power $W_2 = 0$

iv) Increase the load gradually from no load to full load and note down all the meter readings.

v) At any particular loading condition,
Secondary on-load voltage = V_2
Secondary on-load current = I_2
Input power = W_1
Output power = $W_2 = V_2 I_2$ (Load is purely resistive) — ½ Mark for each of efficiency and regulation = 1 Mark

Calculation of Efficiency:

$$\%\ \text{Efficiency} = (W_2 / W_1)\times 100$$

Calculation of Regulation:

$$\%\ \text{Regulation} = \{(E_2 - V_2) / E_2\}\times 100$$

4 Attempt any THREE of the following: **12**

4 a) State the criteria of selection of power transformer as per IS:10028 (part-I)

Ans:

Criteria of Selection of Power Transformer:

i) Ratings - The kVA ratings should comply with IS:10028 (Part I) -1985. The no-load secondary voltage should be 5 % more than nominal voltage to compensate the transformer regulation partly. The transformer requiring to be operated in parallel, the voltage ratio should be selected in accordance with guidelines given in 12.0.1 & 12.0.1.1 of IS : 10028 (Part l)-1985 — 1 Mark for each of any four criteria = 4 Marks

ii) Taps - On-Load tap changers on HV side should be specified, wherever system conditions warrant. In case of OLTC, total number of taps should be 16 in steps of 1.25 %. The standard range for off-circuit taps which are provided should be in range of $\pm$ 2.5 percent and $\pm$ 5 percent.

iii) Connection Symbol - The preferred connections for two winding transformers should be preferably connected in delta/star (Dyn) and star/star (YNyn). For higher voltage connections star/star (YNyn) or star/delta (YNd) may be preferred accordance with IS : 10028 (Part l)-1985.

iv) Impedance:

- The value of transformer impedance is decided by considering the secondary fault levels and the associated voltage dips. For deciding the precise value of transformer impedance, IS:2026(Part-I)-1977 is referred.
- If the transformer is to be operated in parallel, then the impedance be selected as per the guidelines given IS:10028(Part-II)-1981.

v) Termination Arrangement:

- The HV & LV terminals may be one of following three types depending upon on the method of installation:
  - Bare outside bushing
  - Cable boxes
  - Bus trunking

- The types of bushings that should be specified are:
  - Upto 33kV: Porcelain bushings
  - 66kV & above: Oil filled condenser type bushings.

vi) Cooling:

Sr. No.	Rating	Voltage class	Type of cooling
1	Upto 10MVA	Upto 66kV	ONAN
2	12.5 to 40MVA	Upto 132kV	ONAN(60%), ONAF(40%)
3	50 to 100MVA	Upto 220kV	ONAN(50%), ONAF(62.5%)
4	Above 100MVA	Upto 400kV	ONAN(50%), ONAF(62.5%)

4 b) List the condition for parallel operation of three phase transformer.

Ans:

Conditions For Parallel Operation of 3 Phase Transformer:

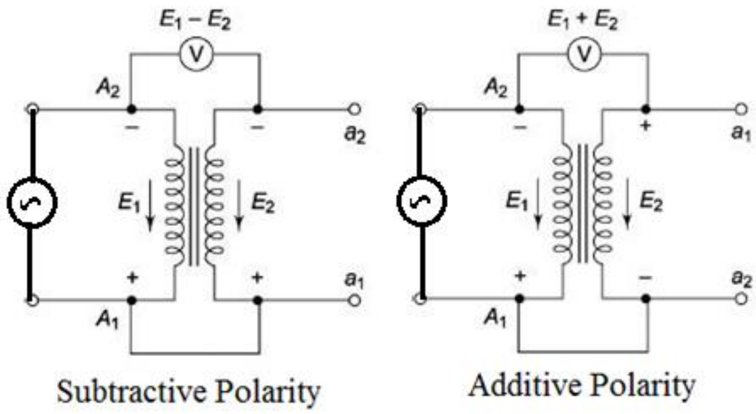
1) Voltage ratings of both the transformers must be identical.
2) Percentage / p.u. impedance should be equal in magnitude.
3) X / R ratio of the transformer winding should be equal.
4) Transformer connections w.r.t. polarity must be that identical polarity terminals of corresponding phases are connected together.
5) Phase displacement between primary & secondary line voltages of the transformers must be identical.
6) Phase sequence of both transformers must be same

1 Mark for each of any four conditions = 4 Marks

4 c) Explain the Polarity test of a transformer. Why it is necessary?

Ans:

Polarity test of single Phase transformer:



2 Marks for 2 circuit diagrams

Necessity: This test is conducted to identify the corresponding polarity terminals of the transformer HV and LV windings.

The primary winding (high-voltage winding) terminals of single-phase transformer are marked as A_1-A_2 and the secondary winding (low-voltage winding) terminals will be marked as a_1-a_2 after the polarity test. The transformer primary is connected to a low

2 Marks for explanation

voltage a.c. source with the connections of link and voltmeter made as shown in the figure. The reading of the voltmeter is noted.

This test is carried out on open circuit. Hence the primary applied voltage V_1 is equal to E_1 and the corresponding secondary voltage V_2 is E_2.

If the voltmeter reading appears to be $V = (E_1-E_2)$ then it is referred as subtractive polarity connection and the terminals so connected are of similar polarity. Therefore, the secondary terminal connected to A_1 is marked as a_1. The secondary terminal connected to A_2 through voltmeter is marked as a_2.

If voltmeter reading appears to be $V = E_1+E_2$, it is referred as additive polarity. The terminals connected to each other are of opposite polarity. Therefore, the secondary terminal connected to A_1 is marked as a_2 and the secondary terminal connected to A_2 through voltmeter is marked as a_1.

4 d) A 20 KVA, 2200/220V, 50 Hz transformer. The OC / SC test result are as follows
O.C. test: 220V, 4.2A, 148W (L.V. side)
S.C test: 86V ,10.5A, 360W (H.V. side)
Determine the regulation at 0.8 pf lagging at full load.

Ans:

$K = V_2/V_1 = 220/2200 = 0.1$

Full load primary current $I_{1\,F.L.} = (20x1000)/2200 = 9.09$ A — 1 Mark

From S.C.test:

$Z_{T1} = V_{SC}/I_{SC} = 86/10.5 = 8.19$ ohm — 1 Mark

$R_{T1} = W_{SC}/(I_{SC})^2 = 360/(10.5)^2 = 3.26$ ohm

$X_{T1} = \sqrt{(8.19^2-3.26^2)} = 7.51$ ohm — 1 Mark

% Regulation $= 100 \times I_{1FL}(R_{T1}\cos\varphi + X_{T1}\sin\varphi)/V_1$
$= 100 \times 9.09(3.26 \times 0.8 + 7.51 \times 0.6)/2200$ — 1 Mark
$= 2.94\%$

4 e) Describe the method for measurement of high voltage in a.c circuit using potential transformer.

Ans:

Measurement of high voltage a.c. circuit using Potential Transformer.

The potential transformer is used to measure high alternating voltage in a power system.

The primary of this transformer has very large turns while the secondary has few turns as shown in the figure. It is well designed step-down transformer. The stepped down voltage is measured with a low range a. c. voltmeter. — 3 Marks

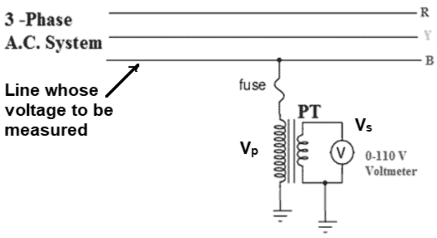
The primary of the potential transformer is connected across the high voltage line whose voltage is to be measured. A low range (0-110V) a.c. voltmeter is connected across the secondary. The line voltages(V_p) and a .c. voltmeter voltage (V_s) are related as:

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

$$\frac{V_P}{V_S} = \text{P. T. ratio}$$

Line voltage(V_p) = A.C. Voltmeter Reading × P. T. ratio

1 Mark



Potential Transformer (P.T.)

5 Attempt any TWO of the following: 12

5 a) A 4 pole, 220V shunt motor has 540 lap wound conductor. It takes 32 A from the supply mains and develops output power of 5.595 kW. The field winding takes 1A. The armature resistance is 0.09Ω and flux per pole is 30 mWb. Calculate:

i) The speed and

ii) The torque developed in N-m. — 1 Mark for losses

Ans:

Data Given:

Poles (P) = 4, Supply voltage V = 220V, Armature Resistance R_a = 0.09Ω

Output Power P_{out} = 5.595kW = 5595 W

Total no. of conductors = Z = 540, Lap winding: No. of parallel paths A = P = 4 — 1 Mark

Motor input current I_m = 32A, Flux per pole ϕ = 30 mWb

Field current I_f = 1A

∴ Armature current $I_a = I_m – I_f$ = 32 – 1 = 31A — 1 Mark

The voltage equation of motor is,

$V = E_b + I_aR_a$

The back emf is then, $E_b = V – I_aR_a$ = 220 – (31)(0.09) = 217.21V — 1 Mark

But $E_b = \frac{\phi ZN}{60}\frac{P}{A} = \frac{(30\times10^{-3})(540)N}{60}\frac{(4)}{(4)}$ = 217.21V

Therefore, **Speed N = 804.48 rpm** — 1 Mark

Output mechanical power developed $P_m = \frac{2\pi NT}{60} = \frac{2\pi(804.48)T}{60}$ — 1 Mark

Therefore, Torque developed = $\frac{60\,P_m}{2\pi(804.48)} = \frac{(60)(5595)}{2\pi(804.48)}$ — 1 Mark

T = 66.41 N-m

5 b) Give the specification of three phase transformer as per IS 1180 (Part-1).

Ans:

Specification of 3-phase transformer:

1) kVA rating of transformer
2) Voltage ratings for the primary and secondary voltages
3) HV and LV currents
4) Operating frequency of the transformer
5) % impedance of transformer

1 Mark for each of any six specification

6) Allowable temperature rise. s
7) Wiring instructions for HV and LV windings/terminal diagram = 6 Marks
8) Model number and serial number of the transformer
9) Weight of the transformer
10) Information related to the tap changer
11) Transformer vector group
12) Winding connection diagrams
13) Type of cooling
14) Insulation class
15) Name of the manufacturer
16) Weight of core
17) Weight of winding
18) Volume of oil in litres.

5 c) A 500 kVA, 3-phase, 50 Hz transformer has a voltage ratio (line voltages) of 33/11 kV and is delta/star connected. The resistance per phase are: high voltage 35Ω, low voltage 0.876Ω and iron loss is 3050W. Calculate the value of efficiency at full load.

Ans:

Data Given: 500kVA, 33/11kV, 3-phase, 50 Hz transformer

$R_1 = 35\Omega$ $R_2 = 0.876\Omega$ Iron loss $W_i = 3050W$

$\therefore \sqrt{3}V_{1L}I_{1L} = \sqrt{3}V_{2L}I_{2L} = 500kVA$

Primary (HV) line current $I_{1L} = \frac{500}{\sqrt{3}\times 33} = 8.75A$

Since HV side is connected in delta,

Primary (HV) phase current $I_{1ph} = \frac{I_{1L}}{\sqrt{3}} = \frac{8.75}{\sqrt{3}} = 5.052$ A 1 Mark

Secondary (LV) line current $I_{2L} = \frac{500}{\sqrt{3}\times 11} = 26.24A$

Since LV side is connected in star,

Secondary (LV) phase current $I_{2ph} = I_{2L} = 26.24A$ 1 Mark

Primary Copper (Cu) loss, $W_{1Cu} = 3(I_{1ph})^2R_1 = 3(5.052)^2(35) = 2679.884W$ 1 Mark

Secondary Copper (Cu) loss, $W_{2Cu} = 3(I_{2ph})^2R_2 = 3(26.24)^2(0.876) = 1809.48W$ 1 Mark

Total Copper (Cu) loss at full load = $W_{Cu} = W_{1Cu} + W_{2Cu} = 2679.884 + 1809.48$ 1 Mark

$= 4489.364W$

Assuming load pf as UNITY,

Full load output = P_{out} = 500KW = 500×10^3 W

% Efficiency at Full-load = $\eta_{FL} = \frac{Full-load\ output}{Full-load\ Output + Cu\ loss + Iron\ loss} \times 100$

$= \frac{500\times 10^3}{500\times 10^3 + 4489.36 + 3050} \times 100$

= 98.51% 1 Mark

6 Attempt any TWO of the following: 12

6 a) Find the all-day efficiency of 500kVA distribution transformer whose copper loss and iron loss at full load are 4.5kW and 3.5kW respectively. During a day of 24 hours, it is loaded as under:

No. of hrs.	Loading (KW)	Power Factor
06	400	0.8
10	300	0.75
04	100	0.8
04	0	-------

Ans:

The problem can be solved by using following steps:

Step-I : Convert the loading from kW to KVA
Step-II : Calculate copper losses at different KVA values
Step-III: Calculate iron losses in 24 hours & calculate Output energy
Step-IV: Calculate All day efficiency

No of Hrs	Load in KW	P.F.	Load in KVA= $\frac{Load\ in\ KW}{COS\emptyset}$	Copper Losses/hr = Losses at f.l. $\times\left(\frac{Actual\ KVA}{Rated\ KVA}\right)^2$	Total cu Losses in kwh	Total Iron losses
06	400	0.8	$\frac{400}{0.8} = 500$	$4.5\ kw \times \left(\frac{500}{500}\right)^2 = 4.5$ kw	4.5×6 hr = 27 kWh	3.5kW × 24hr
10	300	0.75	400	2.88	28.8	
04	100	0.8	125	0.281	1.125	
04	0	-	0	0	0	
Total					**56.925kwh**	**84kwh**

3 Marks

1 Mark

Total energy in 24 Hr = (6×400)+(10×300)+(4×100)+(4×0) = **5800kWh** 1 Mark

$$\text{Efficiency}_{\text{All day}} = \frac{\text{Output Energy in 24 hrs}}{\text{Output Energy in 24 Hrs + Losses in 24 Hrs}}$$

1 Mark

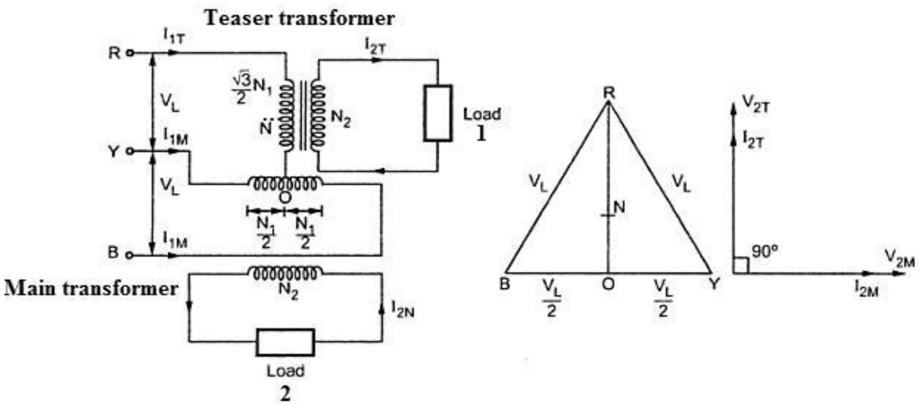
$$= \frac{5800}{5800 + 56.925 + 84} = \frac{5800}{5940.925} = 0.97627$$

$$\%\ \text{Efficiency}_{\text{All day}} = \mathbf{97.63}\ \%$$

6 b) Describe the method of converting three-phase to two-phase transformer by neat diagram. State any two applications.

Ans:

Three-phase to Two-phase Transformation (Scott Connection of Transformers):



2 Marks for diagram

Working:

i) Scott connection can be used for three-phase to two-phase conversion using two single-phase transformers.

ii) Scott connection for three-phase to two-phase conversion is as shown in figure.

iii) Point 'O' is exactly at midpoint of winding connected between phases Y & B.

iv) The no. of turns of primary winding will be $\frac{\sqrt{3}}{2}N_1$ for Teaser and N_1 for main transformer. The no. of secondary turns for both the transformers are N_2.

v) When three-phase supply is given to primary, two-phase emfs are induced in secondary windings as per turns ratio & mutual induction action.

vi) It is seen that the voltage appearing across the primary of main transformer is $V_{1M} = V_L$ i.e line voltage. The voltage induced in secondary of main transformer is V_{2M} which is related to V_{1M} by turns ratio N_1:N_2.

vii) From phasor diagram it is clear that the voltage appearing across the primary of Teaser transformer corresponds to phasor RO which is $\frac{\sqrt{3}}{2}$ times the line voltage V_L. Due to this limitation, the turns selected for primary of Teaser transformer are not N_1 but $\frac{\sqrt{3}}{2}N_1$. This makes the volts per turn in teaser transformer same as that in main transformer and results in voltage induced in secondary of teaser transformer same as that in main transformer, i.e $V_{2T} = V_{2M}$.
As seen from the phasor diagram, the output voltages to the two loads are identical.

2 Marks for description

Applications:

i) The Scott-T connection is used in an electric furnace installation where it is desired to operate two single-phase loads together and draw the balanced load from the three-phase supply.

ii) It is used to supply the single phase loads such as electric train which are so scheduled as to keep the load on the three phase system balanced as nearly as possible.

iii) The Scott-T connection is used to link a 3-phase system with a two–phase system with the flow of power in either direction.

1 Mark for each of any two applications = 2 Marks

6 c) A 250/125 V, 5 kVA single-phase transformer has primary resistance of 0.2 Ω and reactance of 0.75 Ω. The secondary resistance is 0.05 Ω and reactance of 0.2 Ω. Determine its regulation while supplying full load on 0.8 leading P.F.

Ans:

Data Given: 5 kVA, 250/125 V, 1-ϕ transformer.

$R_1 = 0.2\Omega$, $R_2 = 0.05\Omega$, $X_1 = 0.75\Omega$, $X_2 = 0.2\Omega$

Transformation ratio $k = V_2/V_1 = 125/250 = 0.5$

Equivalent resistance referred to secondary side of transformer is given by,

$R_{02} = R_2 + K^2R_1 = 0.05 + (0.5)^2(0.2) = 0.1\Omega$ 1 Mark

Equivalent reactance referred to secondary side of transformer is given by,

$X_{02} = X_2 + K^2X_1 = 0.2 + (0.5)^2(0.75) = 0.3875\Omega$ 1 Mark

Full-load secondary current is given by,

$I_2 = (kVA\times1000)/V_2 = (5\times1000)/125 = 40A$ 1 Mark

1 Mark

Power-factor = $\cos\phi_2 = 0.8$ leading $\therefore \phi_2 = 36.87°$

$\sin\phi_2 = 0.6$

Approximate voltage drop in equivalent impedance on secondary side of transformer for leading pf is given by, 1 Mark

V.D. = $I_2R_{02}\cos\phi_2 - I_2X_{02}\sin\phi_2 = 40\times0.1\times0.8 - 40\times0.3875\times0.6$

$= -6.1$ volt

% Voltage regulation = $\frac{V_{20}-V_2}{V_{20}}\times100 = \frac{V.D.}{V_{20}}\times100$

where, V_{20}= No-load secondary voltage = k V_1

V_2 = Secondary voltage on load 1 Mark

% Voltage regulation = $\frac{-6.1}{125}\times100 =$ **- 4.88%**