22418

21819

3 Hours / 70 Marks

Seat No. | | | | | | | | |

Instructions – (1) All Questions are *Compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any FIVE of the following: 10

a) State any four parts of the d.c motor.

b) State the working principle of d.c generator.

c) State principle operation of a transformer.

d) List the various losses take place in transformer.

e) Draw circuit diagram for polarity test on single-phase transformer.

f) Define current transformer.

g) State the function of the isolation transformer.

Marks

2. Attempt any THREE of the following: 12

a) State functions of the following parts of d.c motor:

(i) Pole shoe

(ii) Commutator

(iii) Brushes and

(iv) Yoke.

b) Explain the principle of working of an three phase induction motor.

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

d) Select or suggest any two applications for:

(i) D.C shunt motor

(ii) D.C series motor

3. Attempt any THREE of the following: 12

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

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

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

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

Marks

4. Attempt any THREE of the following: 12

a) State the criteria of selection of power transformer as per IS:10028 (Part–I).

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

c) Explain polarity test of a transformer. Why it is necessary?

d) A 20 KVA, 2200/220V, 50 Hz transformer. The O.C/S.C test result are as follows:

O.C.test : 220V, 4.2 A, 148 W (*l*. v. side),

S.C. test : 86V, 10.5 A, 360 W (h. v. side).

Determine the regulation at 08 P.F lagging at full load.

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

5. Attempt any TWO of the following: 12

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

(i) the speed and

(ii) the torque developed in N-M.

b) Give the specification of three phase transformer as per IS : 1180 (Port I).

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

Marks

6. Attempt any TWO of the following: 12

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

No of hours	Loading in KW	Power factor
6	400	0.8
10	300	0.75
4	100	0.8
4	0	-

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

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.

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC-27001-2013 Certified)

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.

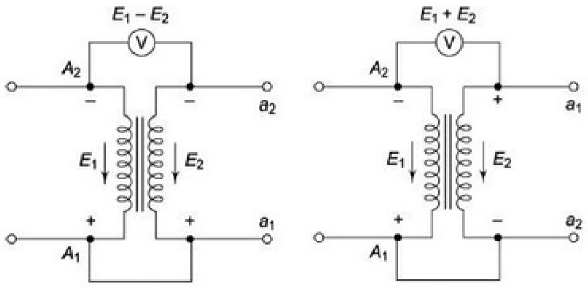
ii) Hysteresis loss = $K_H B_m^{1.67} f V$

Where KH is Hysteresis constant, Bm 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:



Subtractive Polarity   Additive Polarity

OR any equivalent diagram

2 Marks

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:

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 Marks for two function

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.

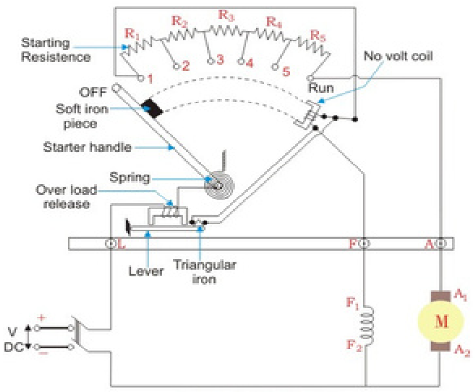
Ans:

- 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:



Three Point Starter

4 Marks for labeled sketch

3 Marks for partially labeled sketch

2 Marks for unlabeled sketch

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:

2 Marks for any two applications.

DC series motors are variable speed and high starting torque motors, hence they are used in applications requiring variable speeds and high starting torque.

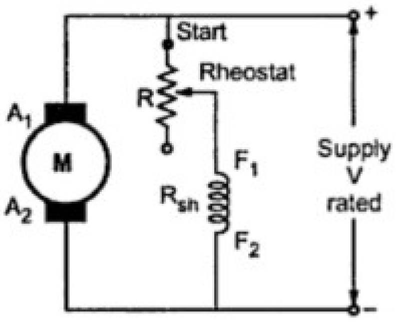
i) Electric tractions
ii) Cranes
iii) Elevators
iv) Air compressors
v) Vacuum cleaners
vi) Hair dryers

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,

——_

Since Z, P, A are constants, Eb ▯▯ N

i.e N ▯ Eb/▯

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

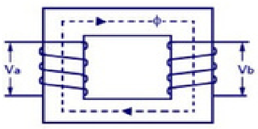
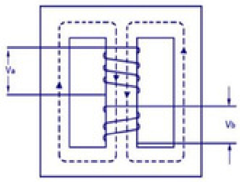
In this flux control method, speed of the motor is inversely proportional to the flux. Thus, by decreasing flux the speed can be increased. To control the flux, here a rheostat is added in series with the field winding. When the rheostat is increased, the field current and so the magnetic flux decreases. 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 IR 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:

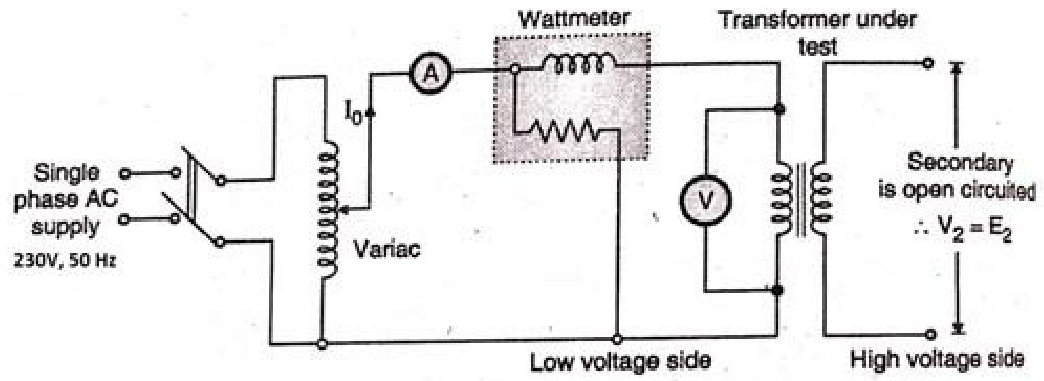
Comparision of Core Type and Shell Type Transformer:

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

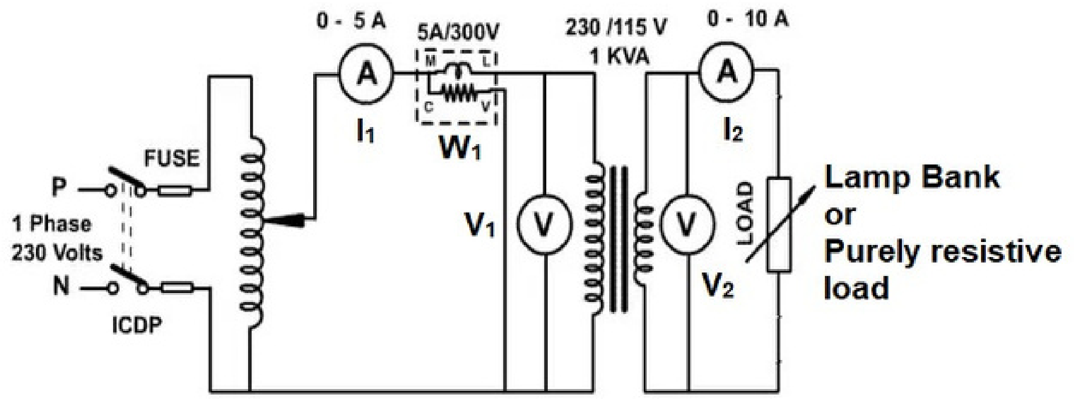
4 Marks for labeled diagram

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 V0 = Rated primary voltage V1.
No-load primary current = I0

1 Mark for procedure

No-load input Power = W0 = Iron loss of transformer.= Wi
No-load secondary load voltage = E2
No-load output power W2 = 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 = V2
Secondary on-load current = I2
Input power = W1
Output power = W2 = V2 I2 (Load is purely resistive)

Calculation of Efficiency:

% Efficiency = (W2 /W1)×100

Calculation of Regulation:

% Regulation = {(E2 – V2) / E2 }×100

½ Mark for each of efficiency and regulation = 1 Mark

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 + 2.5 percent and + 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 as:
  - 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 3 4	12.5 to 40MVA 50 to 100MVA Above 100MVA	Upto 132kV Upto 220kV Upto 400kV	ONAN(60%), ONAF(40%)
			ONAN(50%), ONAF(62.5%)
			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:

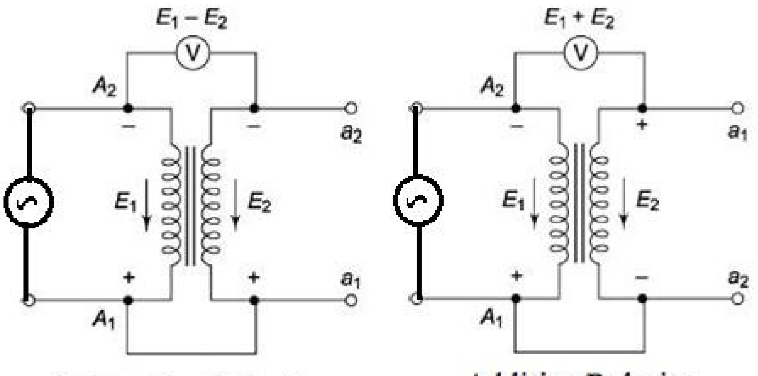
1) Voltage ratings of both the transformers must be identical.
2) Percentage / p.u. impedance should be equal in magnitude.
3) X / R ratio of the transformer winding should be equal.
4) Transformer connections w.r.t. polarity must be that identical polarity terminals of corresponding phases are connected 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:



Subtractive Polarity   Additive Polarity

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 A1−A2 and the secondary winding (low-voltage winding) terminals will be marked as a1−a2 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 V1 is equal to E1 and the corresponding secondary voltage V2 is E2.

If the voltmeter reading appears to be V = (E1-E2) then it is referred as subtractive polarity connection and the terminals so connected are of similar polarity. Therefore, the secondary terminal connected to A1 is marked as a1. The secondary terminal connected to A2 through voltmeter is marked as a2.

If voltmeter reading appears to be V = E1+E2, it is referred as additive polarity. The terminals connected to each other are of opposite polarity. Therefore, the secondary terminal connected to A1 is marked as a2 and the secondary terminal connected to A2 through voltmeter is marked as a1.

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 $I_{1\,F.L.} = (20 \times 1000)/2200 = 9.09$ 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 = $100 \times I_{1FL}(R_{T1}\cos\varphi + X_{T1}\sin\varphi)/V_1$ — 1 Mark

$= 100 \times 9.09(3.26 \times 0.8 + 7.51 \times 0.6)/2200$

$= 2.94\%$

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

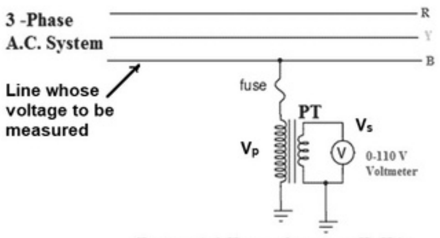
The primary of the potential transformer is connected across the high voltage line whose voltage is to be measured. A low range (0-110V) a.c. voltmeter is connected across the secondary. The line voltages(Vp) and a .c. voltmeter voltage (Vs) are related as:

— = —

— P. T. ratio

Line voltage(Vp) = 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.

Ans:

Data Given:

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

Output Power Pout = 5.595kW = 5595 W

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

Motor input current Im = 32A, Flux per pole = 30 mWb — 1 Mark

Field current If = 1A

Armature current Ia = Im – If = 32 – 1 = 31A — 1 Mark

The voltage equation of motor is,

V = Eb + IaRa

The back emf is then, Eb = V – IaRa = 220 – (31)(0.09) = 217.21V — 1 Mark

But Eb = — = 217.21V

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

Output mechanical power developed Pm = — 1 Mark

Therefore, Torque developed = — 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 $W_i = 3050W$

√ √

Primary (HV) line current √

Since HV side is connected in delta,

Primary (HV) phase current I_{1ph} = = √ = 5.052 A 1 Mark

Secondary (LV) line current √

Since LV side is connected in star,

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

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

Secondary Copper (Cu) loss, $W_{2Cu} = 3(I_{2ph}^2)R_2 = 3(26.24^2)(0.876) = 1809.48W$ 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 = Pout = 500KW = 500×10^3 W

% Efficiency at Full-load = η_{FL} =

= 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=	Copper Losses/hr = Losses at f.l. ×( )	Total cu Losses in kwh	Total Iron losses
06	400	0.8	= 500	( )= 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

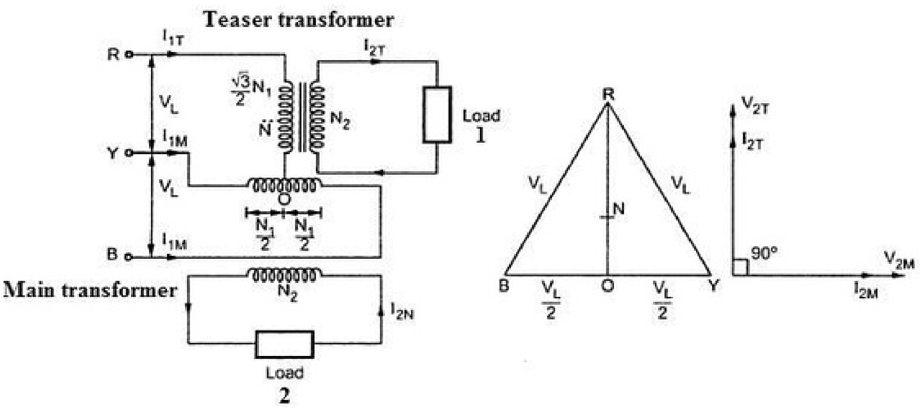
1 Mark

%

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 $\frac{\sqrt{3}}{2}$N1 for Teaser and N1 for main transformer. The no. of secondary turns for both the transformers are N2.

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 V1M = VL i.e line voltage. The voltage induced in secondary of main transformer is V2M which is related to V1M by turns ratio N1:N2.

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 VL. Due to this limitation, the turns selected for primary of Teaser transformer are not N1 but $\frac{\sqrt{3}}{2}$N1. 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 V2T = V2M. 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. = $I_2R_{02}\cos\phi_2 - I_2X_{02}\sin\phi_2$ = 40×0.1×0.8 - 40×0.3875×0.6

= - 6.1 volt

% Voltage regulation = $\frac{\quad}{\quad}$×100 = $\frac{\quad}{\quad}$×100

where, = No-load secondary voltage = k V_1

V_2 = Secondary voltage on load 1 Mark

% Voltage regulation = $\frac{\quad}{\quad}$×100 = **- 4.88%**

22418

11920

3 Hours / 70 Marks

Seat No. | | | | | | | | |

Instructions – (1) All Questions are *Compulsory.*

(2) Illustrate your answers with neat sketches wherever necessary.

(3) Figures to the right indicate full marks.

(4) Assume suitable data, if necessary.

(5) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any FIVE of the following: 10

a) State Fleming's right hand rule.

b) State working principal of DC generator.

c) ''DC series motor should never be started at no load''. Justify.

d) State why a transformer always have a efficiency of more than 90%.

e) Give the specification of three phase transformer as per IS 1180 (part 1) 1989 (any four)

f) State two applications of isolation transformer.

g) List two special features of welding transformer.

Marks

2. Attempt any THREE of the following: 12

a) Explain the working principal of Induction motor.

b) State at least one function and material used for the following parts of DC motor.

c) A 3300 / 250V, 50Hz single phase transformer is built on a core having an effective cross sectional area of 125 cm2 and 70 turns on the low voltage winding.

Calculate:

(i) the value of max flux density.

(ii) number of turns on the high voltage windings.

d) Draw the equivalent circuit of transformer refered to the primary state the meaning of each term related to equivalent circuit.

3. Attempt any THREE of the following: 12

a) Explain the necessity of starter for DC motor. State various types of DC motor starter.

b) Derive the emf equation of a transformer.

c) A single phase transformer has 300 turns on its primary side and 750 turns on its secondary side, the maximum flux density in the cone is 1 wb/m2. Calculate:

(i) the net cross sectional area of the cone.

(ii) the emf induced in the secondary side

d) Compare cone type and shell type transformer.

Marks

4. Attempt any THREE of the following: 12

a) Give any four selection criteria for :

(i) Distribution transformer

(ii) Power transformer

b) With the help of neat diagram, describe the procedure to carry out phasing out test on 3 phase transformer. Also state the purpose of conducting this test on 3-phase transformer.

c) Explain with the neat circuit diagram only the scott connection scheme for conversion of three phase supply to two phase supply. Name one application of the same.

d) In 20kVA, 1000/400V, 1 f 50Hz transformer iron and full load copper losses are 300 W and 500 W respectively. Calculate its efficiency at 3/4 full load at unity power factor.

e) Explain with circuit diagram use of potential transformer to measure 33kV.

5. Attempt any TWO of the following: 12

a) A 250V, shunt motor on no load runs at 1000 rpm and takes 5A. The total armature and shunt field resistance are respectively 0.2W and 250W. Calculate the speed when loaded and taking a current of 50A, if armature reaction weaken on the field by 3%.

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

c) A 500kVA distribution transformer having copper and iron losses of 5kW and 3kW respectively on full load. The transformer is loaded as shown below:

Loading (kW)	Power Factor (Lag)	No. of hours
400	0.8	06
300	0.75	12
100	0.8	03
No load	-	03

Calculate the all day efficiency.

Marks

6. Attempt any TWO of the following: 12

a) Explain with the help of neat diagram the following methods of speed control for DC series motor.

(i) Field diverter method.

(ii) Tapped field method.

b) Explain with the help of neat diagram working of 3 phase autotransformer. Write any two application.

c) Explain the effects of Harmonics on the transformer.

Winter – 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.

Winter – 2019 Examinations
Model Answers
Subject & Code: Electric Motors and Transformers (22418)

1 Attempt any FIVE of the following: 10

1 a) State Fleming"s Right Hand Rule.

Ans:
Fleming's Right Hand Rule:
Stretch out the first three fingers of your right hand such that they are mutually perpendicular to each other. If first finger indicates direction of magnetic field, thumb indicates direction of motion of conductor with respect to magnetic field, then the middle finger will indicate the direction of induced EMF / current. 2 Marks

1 b) State the working principle of DC generator.

Ans:
Working principle of DC generator:
- Working principle of DC generator is the principle of dynamically induced emf or electromagnetic induction. 2 Marks
- According to this principle, when flux is cut by a conductor, an emf is induced in the 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 it.

1 c) "DC series motor should never be started at no load". Justify.

Ans:
"DC series motor should never be started at no load"- Justification
- At no load, the field current (which is also the armature current) is very small and hence the useful air-gap field flux is also very small. 2 Marks
- As —— the speed rises excessively high / dangerous values and it is mechanically very harmful for machine.
- At high speeds, due to centrifugal forces of the rotating parts, they may damage the machine.

Hence DC series motor should never be started at no-load.

1 d) State why a transformer always have an efficiency of more than 90%.

Ans:
As transformer is static device with no moving parts, the losses due to friction & windage are completely absent. Hence transformer has efficiency of more than 90%. 2 Marks

1 e) Give the specification of three phase transformer as per IS 1180 (Part-1) 1989 (any four).

Ans:
Specification of 3-phase transformer as per IS 1180 (Part-1) 1989:
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

½ Mark for each of any four specification = 2 Marks

6) Allowable temperature rise.
7) Wiring instructions for HV and LV windings/terminal diagram
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.

1 f) State two applications of isolation transformer.

Ans:

Applications of isolation transformer:

i) Isolates the load equipment from supply ground:
ii) Reduction of voltage spikes
iii) It acts as a decoupling device.
iv) Protects loads from harmonic distortion.

1 Mark for each of any two applications = 2 Marks

1 g) List two special feature of welding transformer.

Ans:

Special features of welding transformer:

i) It is a step down transformer that reduces the source voltage to a voltage desired according to the demands of the welding process.
ii) Having large primary turns and less secondary turns.
iii) The secondary current is quite high.
iv) The secondary has several taps for adjusting the secondary voltage to control the welding current.
v) The transformer is normally large in size compared to other step down transformers as the windings are of a much larger gauge.
vi) Common ratings:
   i) Primary voltage – 230 V, 415 V
   ii) Secondary voltage – 40 to 60 V
   iii) Secondary current – 200 to 600 A

1 Mark for each of any two features = 2 Marks

2 Attempt any THREE of the following: 12

2 a) Explain the working principle of induction motor.

Ans:

Working principle of induction motor:

- When the motor is excited with three-phase supply, three-phase stator winding carries three-phase currents & produces a rotating magnetic field of constant magnitude and rotates at synchronous speed.
- This changing magnetic field is cut by the rotor conductors and induces emf in

them according to Faraday"s laws of electromagnetic induction. As these rotor conductors are shorted, the current starts to flow through these conductors.

- These current carrying rotor conductors are now in the rotating 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 the same direction as the rotating magnetic field.

4 Marks for step-wise answer

2 b) State at least one function and the material used for the following parts of DC Motor.

Ans:
NOTE: Since the parts are not given in question, the marks may please be allotted for any TWO parts

Part	Function	Material
Yoke	-Provides mechanical support for poles -Acts as protecting cover for machine -Provides path for magnetic flux	Cast Iron OR Cast Steel
Field Winding	-Produce magnetic field in which armature rotates	Copper
Commutator	-Converts AC from armature to DC for generator -Converts DC to AC for motor armature.	Copper segments insulated from each other by mica
Brushes	-To collect current from armature winding of generator & supply current to armature winding of motor.	Carbon
Pole shoe	To spread the flux in air gap.	Cast Iron OR Cast Steel
Pole core	Provides mechanical support to field winding.	Cast Iron OR Cast Steel

1 Mark for function and 1 Mark for material of each of any two parts = 4 Marks

2 c) A 3300/250V, 50Hz single phase transformer is built on a core having an effective cross sectional area of 125 cm^2 and 70 turns on the low voltage winding.
Calculate:
i) The value of max. flux density.
ii) Number of turns on high voltage windings.

Ans:
Given Data:
Cross sectional Area, $A = 125 cm^2 = 125 \times 10^{-4} m^2$
Frequency f =50Hz, N2 = 70, E1 = 3300, E2 = 250.
To Find Bm, N1
E2= 4.44 Φmf N2 volt

1 Mark

Maximum Flux Density = Bm= = $0.016087 / (125 \times 10^{-4})$

Bm = 1.2869 Wb/m^2

1 Mark

1 Mark

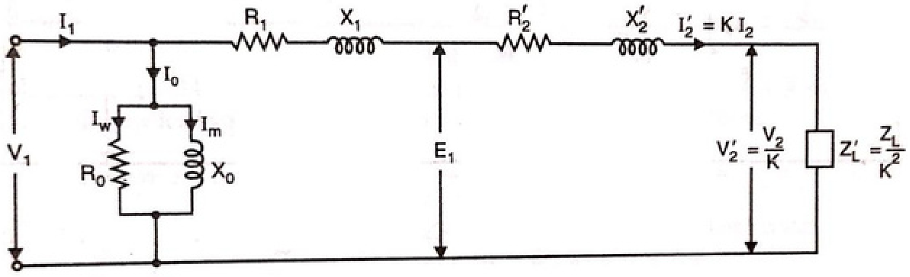
1 Mark

N1= 924 turns

2 d) Draw the equivalent circuit of transformer referred to primary. State the meaning of each term related to equivalent circuit.

Ans:

Equivalent Circuit Diagram of Transformer Referred to Primary:



2 Marks for Equivalent circuit

V1 -Primary Input voltage
I1 - Input Current
I0- Exciting current/ No load current
Im- Magnetizing component of no load current
Iw-Working component of no load current
R0- Core loss resistance
X0- magnetizing reactance
R1 -Primary winding resistance
X1 - Primary winding reactance
E1 –Induced emf in Primary winding
R2′ - Secondary winding resistance referred to primary
X2′- Secondary winding reactance referred to primary
I2-Secondary winding current
I2′– Primary equivalent of secondary current
K- Transformation ratio
V2- Secondary terminal voltage
V2′- Primary equivalent of secondary terminal voltage
ZL– Load impedance
ZL ′- Primary equivalent of load impedance

2 Marks for terminology

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

3 a) Explain the necessity of starter for D.C. motor. State various types of D.C. motor starter.

Ans:

Necessity of Starter for D.C. Motor:

Armature current is given by equation Ia = (V−Eb)/Ra

i) If the motor is at standstill or rest, back emf Eb is zero (as Eb= ZNP/(60A), at start speed N is zero). This causes starting current Ia = V/Ra,which is large as armature resistance is usually low. This large starting current may damage armature winding due to heavy heating. 3 Marks

ii) Hence to limit the very high starting current, the starter is required.

iii) Once motor picks up the speed, the back emf Eb is induced in armature winding and armature current is limited to safe value. So starter is not required under running condition.

Types of D.C. motor starters:

i) Two point starter 1 Mark
ii)Three point starter
iii) Four point starter

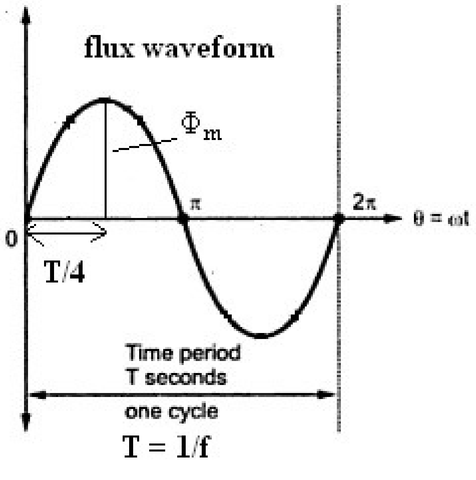
3 b) Derive the emf equation of a transformer.

Ans:

Emf equation of transformer:

N1 = No. of turns on primary winding
N2 = No. of turns on secondary winding
m= Maximum value of flux linking both the windings in Wb
f = Frequency of supply in Hz

1st method



1 Mark

Maximum value of flux is reached in time t = 1/ 4f

Avg. rate of change of flux = m/t = m/(1/ 4f) = 4 mf Wb/sec

From faraday"s laws of electromagnetic induction

Avg. emf induced in each turn = Avg. rate of change of flux = 4 mf volt

Form factor = (RMS value)/(Avg. value) = 1.11for sinusoidal voltage

R.M.S. emf induced in each turn = 1.11 x Avg. value = 1.11 x 4 mf
= 4.44 m f volt 1 Mark

R.M.S. emf induced in primary winding = (RMS emf / turn) x N1 1 Mark

E1 = 4.44 mf N1 volts — 1 Mark

Similarly, E2 = 4.44 mf N2 volts

OR

2nd method:

= m sin ωt

According to Faraday"s laws of electromagnetic induction

Instantaneous value of emf/ turn = - d /dt = -d /dt (m sin ωt) — 1 Mark
= -ω mcosωt
= ω msin (ωt – π/2) volts

Maximum value of emf/turn = ω m — 1 Mark
But ω = 2πf

Max. value of emf /turn =2πf m

RMS value of emf /turn = 0.707 x 2πf m= 4.44 mf volts — 1 Mark

RMS value of emf in primary winding E1 = 4.44 m f N1 volts — 1 Mark
E2= 4.44 mf N2 volts

3 c) A single phase transformer has 300 turns on its primary side and 750 turns on its secondary side, the maximum flux density in the core is 1Wb/m^2, calculate:
(i) The net cross sectional area of the core,
(ii) The emf induced in the secondary side.

Ans:

(NOTE: The data regarding the supply voltage is not given. Assuming the primary of the transformer is connected to 230V, 50 Hz supply)

Given: N1 = 300, N2 = 750, Bm = 1 Wb/m^2

Assumption: E1 = 230V f = 50 Hz

(i) The net cross sectional area of the core,
E1 = 4.44Bm A f N1 volt — 1 Mark

A = 3.453 x 10^{-3} m^2 — 1 Mark

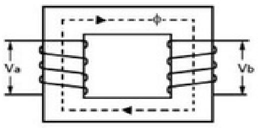
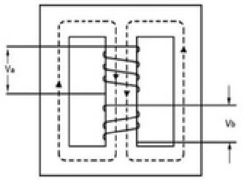
(i) The emf induced in the secondary side.
E2 /E1 = N2 /N1 — 1 Mark
E2 /230 = 750/300
E2 = 575 volt — 1 Mark

(NOTE: Examiners are requested to award the marks for the procedure followed by the student for any assumed data)

3 d) Compare core type and shell type transformer.

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	Winding surrounds the core.	Core surrounds the winding.
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

Each point 1 Mark (any four points) = 4 Marks

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

4 a) Give any four selection criteria for :
- i) Distribution transformer
- ii) Power transformer

Ans:

Selection Criteria for Distribution Transformer:

i) **Ratings -** The kVA ratings should comply with IS:2026 (Part l)-1977*. The no-load secondary voltage should be 433 volts for transformers to be used in 415 V system. Voltage should be normally in accordance with IS:585-1962 except for special reasons when other values may be used.

1 Mark for each of any two criteria = 2 Marks

ii) **Taps** -The transformers of these ratings are normally provided with off-circuit taps on HV side except in special cases when on-load tap changers are specified. The standard range for off-circuit taps which are provided on HV side should be of 2.5 percent and of 5.0 percent. In case of on-load tap changers, the taps may be in steps of 1.25 percent with 16 steps. The positive and negative taps shall be specified to suit the system conditions in which the transformer is to be operated.

iii) **Connection Symbol -** The two winding transformers should be preferably connected in delta/star in accordance with IS:2026 (Part 4)-1977s. The exact connection symbol (Dyn11or Dyn1) is to be specified depending upon requirements of parallel operation.

iv) **Impedance** - Consideration shall be given in the selection of impedance for the standard available rating of the switchgear on the secondary side and associated voltage drops.

v) **Termination Arrangement** - The HV and LV terminals may be bare outdoor bushings, cable boxes or bus trunking depending upon the method of installation. Wherever compound filled cable boxes are used, it is preferable to specify disconnecting chamber between transformer terminals and cable box to facilitate disconnection of transformer terminals without disturbing the cable connections (see also IS:9147-1979). In case of extruded insulation cables with connections in air, a separate disconnecting chamber is not necessary.

vi) **Cooling** - The transformers covered in this group are generally ONAN, AN

Selection Criteria for Power Transformer:

1) **Ratings -** The kVA ratings should comply with IS:10028 (Part l)-1985. The no-load secondary voltage should be 5 % more than nominal voltage to compensate the transformer regulation partly. The transformer required 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 two criteria = 2 Marks

2) **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 + 2.5 percent and + 5 percent.

3) **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.

4) **Impedance** -The transformer impedance is decided taking into consideration the secondary fault levels and voltage dip. The typical values are given in table 3 of IS:2026.

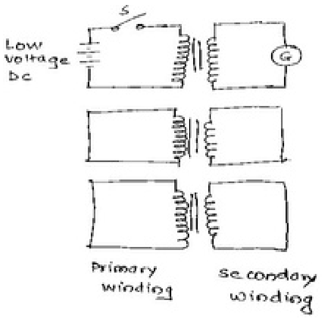
5) **Termination Arrangement** - The HV and LV terminals may be bare outdoor bushings, cable boxes or bus trunking depending upon the method of installation. Wherever compound filled cable boxes are used, it is preferable to specify disconnecting chamber between transformer terminals and cable box to facilitate disconnection of transformer terminals without disturbing the cable connections (see also IS:9147-1979). In case of extruded insulation cables with connections in air, a separate disconnecting chamber is not necessary.

6) **Cooling** - The transformers covered in this group are generally ONAN, ONAN/ONAF, ONAN/ONAF/OFAF.

4 b) With the help of neat diagram, describe the procedure to carry out phasing out test on a

3-phase transformer. Also state the purpose of conducting this test on 3 phase transformer.

Ans:



i) This test is carried out on 3-ph transformer to identify primary & secondary winding belonging to the same phase. 1 Mark for circuit diagram

ii) As shown in fig above all primary & secondary phases are short circuited except the phases to be checked.

iii) Low voltage DC supply is given to primary winding. The galvanometer is connected to terminals of secondary winding which is not short-circuited. 2 Marks for steps of procedure

iv) The switch „S" is connected as shown in fig. When switch is closed, deflection of galvanometer is observed.

v) Similarly galvanometer is connected to other secondary terminals and procedure is repeated. The winding across which maximum deflection occurs is the secondary phase winding that corresponds to primary winding to which source is connected.

vi) The procedure is repeated for remaining primary windings.

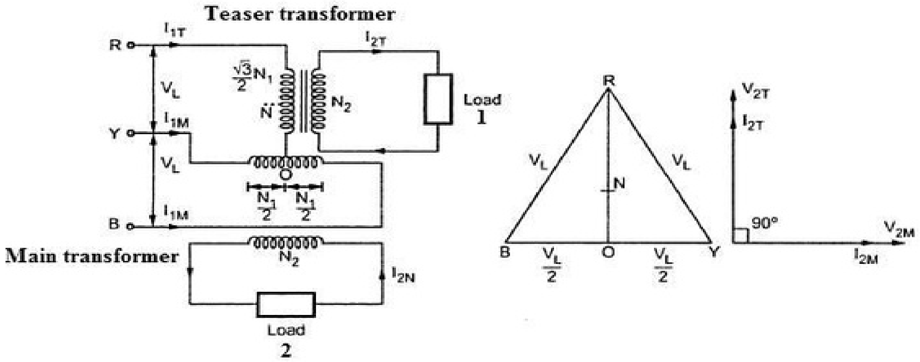
vii) Phasing out test can be carried out by using AC voltage source also. Voltmeter is connected at secondary terminals to observe deflections. 1 Mark for purpose

The purpose of this test is to check the respective phases of primary & secondary windings in 3-ph transformer.

4 c) Explain with the neat circuit diagram only the scott connection scheme for conversion of three phase supply to two phase supply. Name one application of the same.

Ans:

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



1 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. 2 Marks for explanation

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

iv) The no. of turns of primary winding will be √—N1for Teaser and N1 for main transformer. The no. of secondary turns for both the transformers are N2.

v) When three-phase supply is given to primary, two-phase emfsare 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 V1M = VLi.e line voltage. The voltage induced in secondary of main transformer is V2M which is related to V1M by turns ratio N1:N2.

vii) From phasor diagram it is clear that the voltage appearing across the primary of Teaser transformer corresponds to phasor RO which is √‾ times the line voltage VL. Due to this limitation, the turns selected for primary of Teaser transformer are not N1 but √‾ . 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 V2T = V2M.
As seen from the phasor diagram, the output voltages to the two loads are identical.

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 any one application

4 d) In 20 kVA, 1000/400 V, 1-ph, 50Hz transformer, iron and full load copper losses are 300 W & 500W respectively. Calculate the efficiency at ¾ full load at unity power factor.

Ans:

Given Data:

T/F rating 20 kVA, 1000/400V, 1ph, 50Hz.

F.L.Cu loss = 500W Iron Loss = 300W,

For ¾ full-load, x = ¾

Cu loss= $(x)^2$ x Full-load Cu loss = $(¾)^2$ x 500 = 281.25W=0.28125kW 1 Mark

T/F Output = 3/4 x 20 =15kVA 1 Mark

Total losses at ¾ full-load = 300+281.25=581.25=0.58125 kW 1 Mark

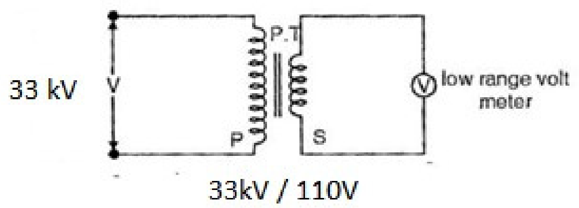
% η at unity pf and ¾ full-load = ――――

= ――――

% η = 96.27 % 1 Mark

4 e) Explain with circuit diagram use of potential transformer to measure 33kV.

Ans:



2 Marks for circuit diagram

Circuit Diagram of PT:

i) Higher voltage '33kV' is the voltage to be measured
ii) Primary of PT is connected across this voltage
iii) PT is step down transformer
iv) Due to PT, voltage across voltmeter gets reduced by a factor equal to the turns ratio of PT. Hence low range voltmeter is used to measure voltage.
v) The secondary voltage is given by,
V2= V1 x (N2/N1)

2 Marks for explanation

The secondary voltage of PT is standardized to 110V. The ratio of PT required for this measurement is (33000/110) = 300:1

5 **Attempt any TWO of the following:** A 250V shunt motor on no load runs at 1000 **12**

5 a) rpm and takes 5 A. The total armature and shunt field resistance are respectively 0.2Ω and 250Ω. Calculate the speed when loaded and taking a current of 50A, if armature reaction weaken on field by 3%.

Ans:

Motor I/P current , IL1 = 5A at no-load

Field current , If1 = (Applied voltage/Field resistance)
= 250/250
= 1A

1 Mark

Armature current Ia1 = Motor I/P current - Field current
= 5-1= 4A

At a load current of 50A, the armature reaction weakens the field by 3 %,
The back emf E= KØ *N*, where K is proportionality constant and E = V-*IaRa*

1 Mark

The armature current on load is given by,

1 Mark

Due to armature reaction, the field is weakened by 3%,
and

1 Mark

1 Mark

1 Mark

5 b) List the Conditions 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) Phase sequence of both must be same.
3) Transformer connections must be carried out polarity wise.
4) Vector group of both the transformers must be same.
5) Percentage / p.u. impedances should be equal in magnitude.
6) X/R ratio of the transformer windings should be equal.

1 Mark for each of any six conditions = 6 Marks

5 c) A 500kVA, distribution transformer having copper and iron losses of 5kW and 3kW respectively on full load. The transformer is loaded as shown below:

Loading (KW)	Power Factor (lag)	No. of hrs.
400	0.8	06
300	0.75	12
100	0.8	03
No load	-------	03

Calculate the all day efficiency.

Ans:

The problem can be solved by using following steps:

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

No of Hrs	Load in KW	P.F.	Output energy in kWh=	Load in KVA=	Copper Losses/hr = Losses at F.L. ×( )	Total cu Losses in kwh	Total Iron losses
06	400	0.8	2400	—=500	(—) = 5 kw	5 6hr = 30 kWh	3kW× 24hr
12	300	0.75	3600	—=400	(—) = 3.2 kw	38.4	
03	100	0.8	300	—=125	(—) = 0.3125kw	0.9375	

1 Mark for each row calculations = 4 Marks

03	0	-	-		0	0	
Total			**6300kwh**			**69.337kwh**	**72kwh**

1 Mark

1 Mark

%

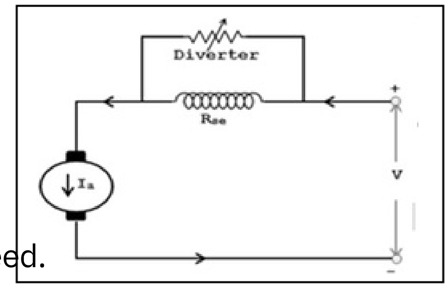
6 Attempt any TWO of the following: 12

6 a) Explain with the help of neat diagram, the following methods of speed control for DC series motor.
i) Field diverter method.
ii) Tapped field method.

Ans:

i) Field diverter method:

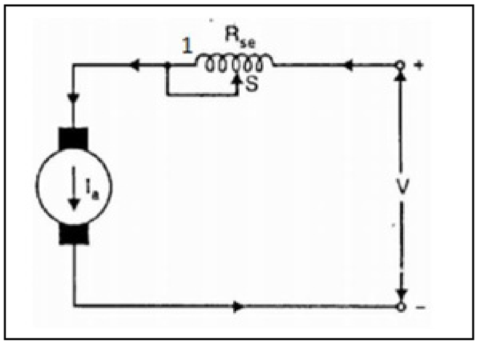
- Resistance connected in parallel with field winding.
- By adjusting this resistance current can by diverted from field winding.
- Thus field current decreases and the speed can be increased above rated speed.



3 Marks

ii) Tapped field method :

- Selector switch is moved from position 1 onwards.
- The number of field turns decreases which decrease mmf.
- Hence the speed increases above the rated speed.



3 Marks

6 b) Explain with the help of neat diagram working of 3 phase autotransformer. Write any two application.

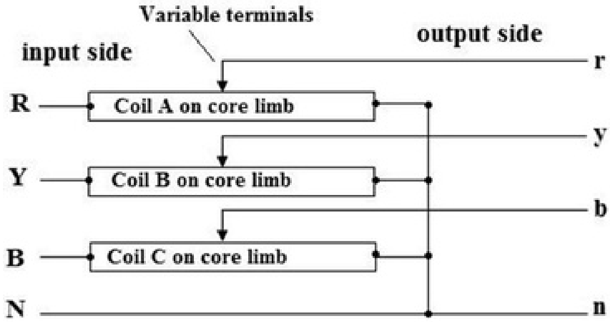
Ans:

Working of three phase autotransformer:

- Working principle of Auto-transformer is based on self-induction.
- When three-phase ac supply is given to star connected three windings, flux is produced and gets linked with each phase winding. The emf is induced in it according to self-induction. 3 Marks
- As only one winding per phase is available, part of it acts as secondary between

variable terminal and neutral.

- Depending upon the position of variable terminal, we get variable AC voltage at the output.



2 Marks

Applications:

1) It is used as power transformer in transmission system for 110kV, 132kV and 220kV voltage levels
2) It is used as autotransformer starter for starting high capacity motors.

1 Mark for two applications

6 c) Explain the effect of Harmonics on the Transformer.

Ans:

Effect of Harmonics on the Transformer:

1. Core loss: Harmonic voltage increases the hysteresis and eddy current losses in the lamination. The amount of the core loss depends on harmonic present in supply voltage.

2. Copper loss: Harmonic current increases copper loss. The loss mainly depends on the harmonics present in the load and effective ac resistance of the winding. Copper loss increase temperature and create hot spots in that transformer. The effect is prominent in the case of converter transformers. These transformers do not benefit from the presence of filters as filter are normally connected on the AC. system side.

2 Marks for each of any three effects = 6 Marks

3. Stress: Voltage harmonics increase stresses of the insulation,

4. Core vibration: Current and voltage harmonics increase small core vibrations.

5. Saturation problem: Sometimes additional harmonic voltage causes core saturation.