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

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. • 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.	2 Marks
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. • As $Speed\ N \propto \frac{1}{flux}$ 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.	2 Marks
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 <u>THREE</u> 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 $f = 50Hz$, $N_2 = 70$, $E_1 = 3300$, $E_2 = 250$.

To Find B_m, N_1

$E_2 = 4.44\ \Phi_m f\ N_2$ volt

$$\therefore \Phi m = \frac{E_2}{4.44 \times f \times N_2} = \frac{250}{4.44 \times 50 \times 70}$$

$$\therefore \mathbf{\Phi m = 0.016087\ Wb}$$ 1 Mark

Maximum Flux Density = $B_m = \Phi m / A = 0.016087 / (125 \times 10^{-4})$ 1 Mark

$$\mathbf{B_m = 1.2869\ Wb/m^2}$$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$ 1 Mark

$\therefore N_1 = \frac{E_1 N_2}{E_2}$

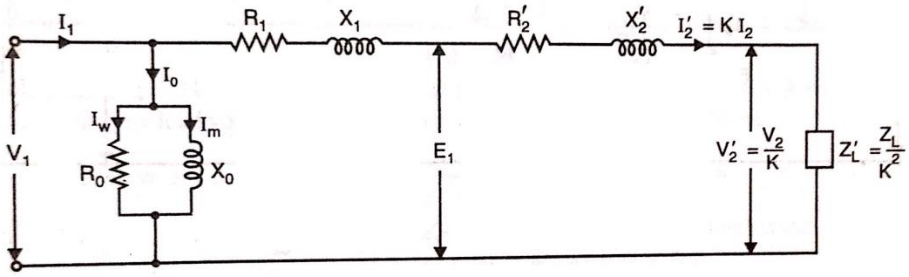
$\therefore N_1 = \frac{3300\ X\ 70}{250} = 924$ 1 Mark

N_1= 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

V_1 -Primary Input voltage
I_1 - Input Current
I_0- Exciting current/ No load current
I_m- Magnetizing component of no load current
I_w-Working component of no load current
R_0- Core loss resistance
X_0- magnetizing reactance
R_1 -Primary winding resistance
X_1 - Primary winding reactance
E_1 –Induced emf in Primary winding
R_2' - Secondary winding resistance referred to primary
X_2'- Secondary winding reactance referred to primary
I_2-Secondary winding current
I_2'– Primary equivalent of secondary current
K- Transformation ratio
V_2- Secondary terminal voltage
V_2'- Primary equivalent of secondary terminal voltage
Z_L– Load impedance
Z_L'- 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 = $(V-E_b)/Ra$

i) If the motor is at standstill or rest, back emf E_b is zero (as E_b= ΦZNP/(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 E_b 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:

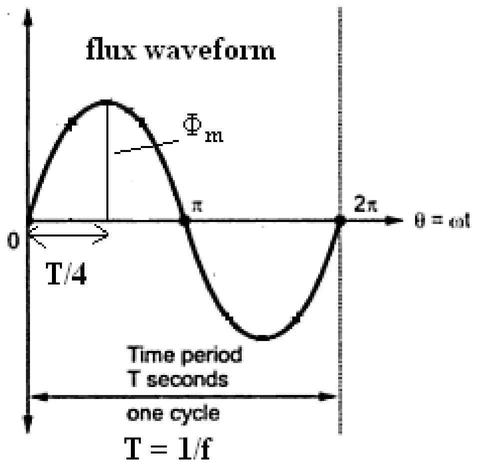
N_1 = No. of turns on primary winding

N_2 = No. of turns on secondary winding

Φ_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 = Φ_m/t = Φ_m/(1/ 4f) = 4Φ_mf Wb/sec

From faraday's laws of electromagnetic induction

Avg. emf induced in each turn = Avg. rate of change of flux = 4Φ_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 4Φ_mf

= 4.44 Φm f volt 1 Mark

R.M.S. emf induced in primary winding = (RMS emf / turn) x N_1 1 Mark

$E_1 = 4.44\ \Phi_m f\ N_1$ volts 1 Mark

Similarly, $E_2 = 4.44\ \Phi_m f\ N_2$ volts

OR

2nd method:

$\Phi = \Phi_m \sin \omega t$

According to Faraday's laws of electromagnetic induction

Instantaneous value of emf/ turn = $-\ d\Phi/dt = -d/dt\ (\Phi_m \sin \omega t)$ 1 Mark

$= -\omega\Phi_m \cos\omega t$

$= \omega\Phi_m \sin(\omega t - \pi/2)$ volts

Maximum value of emf/turn = $\omega\Phi_m$ 1 Mark

But $\omega = 2\pi f$

Max. value of emf /turn $= 2\pi f\ \Phi_m$

RMS value of emf /turn = $0.707 \times 2\pi f\ \Phi_m = 4.44\Phi_m f$ volts 1 Mark

RMS value of emf in primary winding $E_1 = 4.44\Phi_m\ f\ N_1$ volts 1 Mark

$E_2 = 4.44\ \Phi_m f\ N_2$ 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 $1 Wb/m^2$, 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: $N_1 = 300$, $N_2 = 750$, $Bm = 1\ Wb/m^2$

Assumption: $E_1 = 230V$ f = 50 Hz

(i) The net cross sectional area of the core,

$E_1 = 4.44 B_m\ A\ f\ N_1$ volt 1 Mark

$$\therefore A = \frac{E_1}{4.44 B_m f N_1} = \frac{230}{4.44 \times 1 \times 50 \times 300}$$ 1 Mark

$$\mathbf{A = 3.453 \times 10^{-3}\ m^2}$$

(i) The emf induced in the secondary side.

$E_2/E_1 = N_2/N_1$ 1 Mark

$E_2/230 = 750/300$

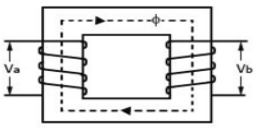
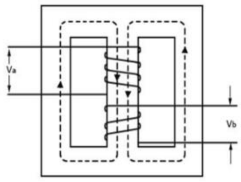
$\mathbf{E_2 = 575}$ **volt** 1 Mark

(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 <u>THREE</u> 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.

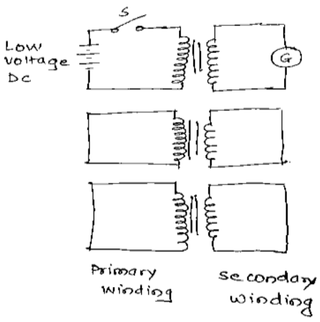
5) **Termination Arrangement** - The HV and LV terminals may be bare outdoor bushings, cable boxes or bus trunking depending upon the method of installation. Wherever compound filled cable boxes are used, it is preferable to specify disconnecting chamber between transformer terminals and cable box to 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.

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

1 Mark for circuit diagram

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.

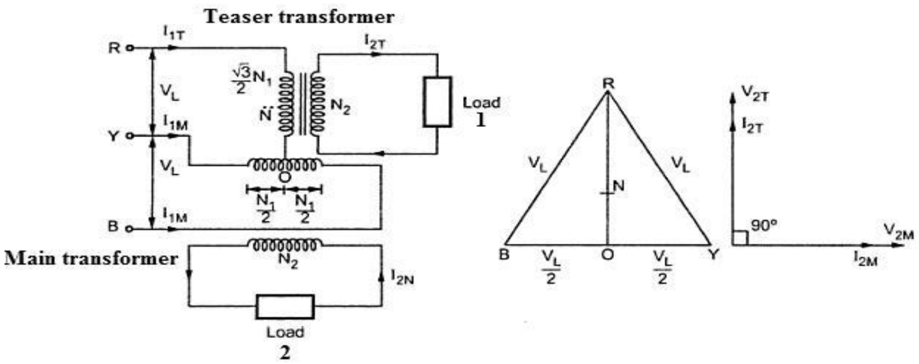
The purpose of this test is to check the respective phases of primary & secondary windings in 3-ph transformer.

1 Mark for purpose

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 $\frac{\sqrt{3}}{2}N_1$ 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 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 $V_{1M} = V_L$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.

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

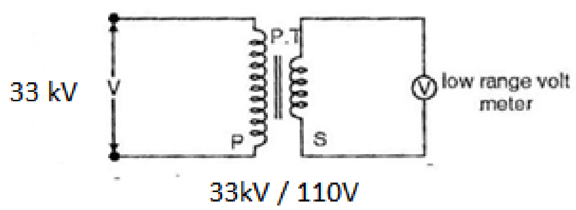
% η at unity pf and ¾ full-load = $\frac{\text{Output}\times\text{p.f}\times 100}{\text{output}\times\text{p.f}+\text{Losses}}$ — 1 Mark

$$= \frac{15 \times 1 \times 100}{15\times1+0.58125} = 96.27\%$$

% 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,
$V_2 = V_1 \times (N_2/N_1)$

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: 12

5 a) A 250V shunt motor on no load runs at 1000 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 , I_{L1} = 5A at no-load

Field current , I_{f1} = (Applied voltage/Field resistance)
= 250/250
= 1A 1 Mark

Armature current I_{a1} = 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-I_aR_a

$$\frac{E_1}{E_2} = \frac{\emptyset_1 N_1}{\emptyset_2 N_2}$$

$$N_2 = \frac{\emptyset_1 N_1 E_2}{\emptyset_2 E_1}$$ 1 Mark

The armature current on load is given by,

$$I_{a2} = I_{L2} - I_{f2}$$
$$= 50 - 1 = 49A$$ 1 Mark

Due to armature reaction, the field is weakened by 3%, 1 Mark

$\therefore\ \emptyset_1 = 1$ and $\emptyset_2 = 0.97$ 1 Mark

$$\therefore N_2 = \frac{(1)(1000)(V - I_{a2}R_a)}{(0.97)(V - I_{a1}R_a)}$$

$$\therefore \mathrm{N_2} = \frac{(1)(1000)[250 - 49 \times 0.2]}{(0.97)[250 - 4 \times 0.2]}$$

$$\therefore \mathrm{N_2} = \frac{240200}{241.724}$$ 1 Mark

$$\therefore \mathrm{N_2} = 993.69 \text{ rpm}$$

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= $load\ in\ KW \times No.of\ hrs$	Load in KVA= $\frac{LoadinKW}{COS\emptyset}$	Copper Losses/hr = Losses at F.L. $\times\left(\frac{ActualKVA}{RatedKVA}\right)^2$	Total cu Losses in kwh	Total Iron losses
06	400	0.8	2400	$\frac{400}{0.8}$=500	$5\ kw \times \left(\frac{500}{500}\right)^2$ = 5 kw	5×6hr = 30 kWh	3kW× 24hr
12	300	0.75	3600	$\frac{300}{0.75}$=400	$5\ kw \times \left(\frac{400}{500}\right)^2$ = 3.2 kw	38.4	
03	100	0.8	300	$\frac{100}{0.8}$=125	$5\ kw \times \left(\frac{125}{500}\right)^2$ = 0.3125kw	0.9375	

1 Mark for each row calculations = 4 Marks

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

$$\text{Efficiency}_{\text{Allday}} = \frac{\text{Output Energy in 24 hrs}}{\text{Output Energy in 24 Hrs + Losses in 24 Hrs}}$$ 1 Mark

$$= \frac{6300}{6300 + 69.337 + 72} = \frac{6300}{6441.337} = 0.978$$

$$\%\ \text{Efficiency}_{\text{Allday}} = \mathbf{97.8}\ \%$$ 1 Mark

6 Attempt any TWO of the following: **12**

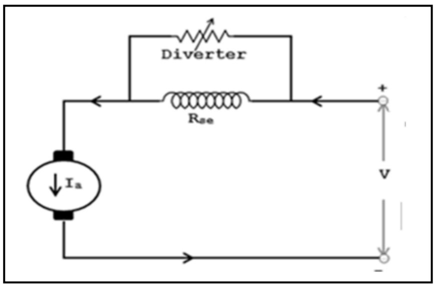
6 a) Explain with the help of neat diagram, the following methods of speed control for DC series motor.

i) Field diverter method.
ii) Tapped field method.

Ans:

i) Field diverter method:

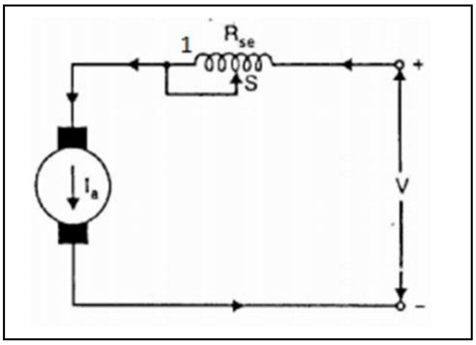
- Resistance connected in parallel with field winding.
- By adjusting this resistance current can by diverted from field winding.
- Thus field current decreases and the speed can be increased above rated speed.



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.

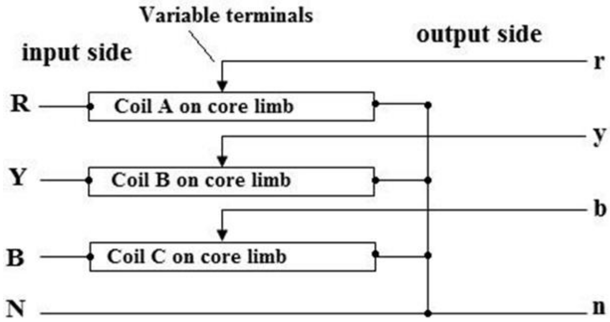
Ans:

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 Marks for each of any three effects = 6 Marks

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.

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.