Winter – 2017 Examinations
Model Answer **Subject Code: 17415 (DMT)**

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 should assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

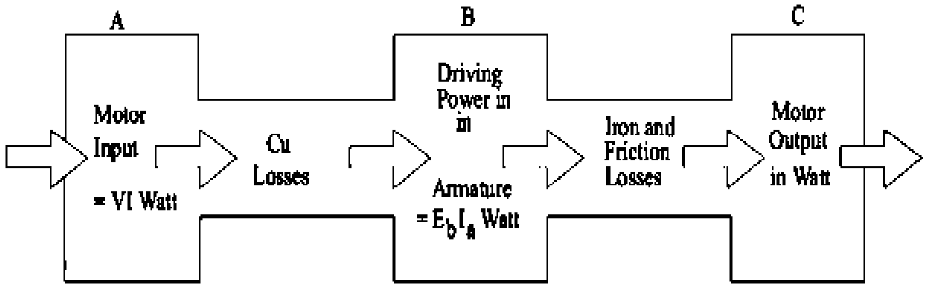
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.

5) Credits to 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 (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment 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 <u>TEN</u> of the following:**	20
1 a)	State significance of back emf **Ans:** **Significance of back emf:** Armature current, Ia = (V−Eb)/Ra i) If the motor is at standstill or rest Eb is zero. This causes large current flow through armature, which produce high starting torque. ii) When motor takes speed, the back emf increases, causes armature current to decrease hence decrease in torque. iii) It follows therefore that back emf in DC motor regulates the flow of armature current i.e. it automatically changes the armature current to meet load requirements.	2 Marks for explanation
1 b)	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 , *align* first finger in direction of magnetic field, thumb in direction of relative motion of conductor with respect to field *then* the middle finger will give the direction of EMF / current.	2 Marks for statement
1 c)	**List the types of DC generator.** **Ans:** **Types of DC generators:** 1) Separately excited DC generator 2) Self excited DC generator (i) DC series generator (ii) DC shunt generator (iii) Compound generator – short shunt, long shunt (cumulative or differential)	2 Marks
1 d)	**State the condition for maximum efficiency of a DC motor.** **Ans:** **Condition for maximum efficiency of a DC motor:** Variable loss = Constant loss OR Copper loss = Iron loss	2 Marks
1 e)	Draw the block diagram showing power stages of DC motor. **Ans:** **Block diagram showing power stages of DC motor:**	



2 Marks

1 f) Define armature torque and shaft torque of DC motor.

Ans:

Armature torque (Ta): When armature conductors of a DC motor carry current in the presence of stator field flux, a mechanical torque is developed between the armature and the stator.

Shaft torque (Tsh): In case of DC motors, the actual torque available at the shaft for doing useful mechanical work is known as Shaft Torque**.** It is so called because it is available on the shaft of the motor.

1 Mark for each definition

1 g) Define all day efficiency of transformer.

Ans:

All day efficiency: It is the ratio of output energy in kWh to the input energy in kWh in the 24 hours of the day.

OR

All day efficiency = Output energy in kWh in 24 Hrs/ Input energy in kWh in 24 Hrs.

2 Marks

1 h) A 100 KVA transformer has iron loss 3 kW on full load. Calculate its iron loss at 50 % of full load.

Ans:

Iron loss at 50% of full load = 3 kW

2 Marks

1 i) A 1 phase transformer has 500 primary and 1200 secondary turns. Calculate transformation ratio.

Ans:

Turns ratio $= \frac{N_2}{N_1} = \frac{1200}{500} = 2.4$ = Transformation ratio

2 Marks

1 j) State any four properties of ideal transformer.

Ans:

Properties of Ideal transformer:

1) No losses (iron and copper), hence no temperature rise.
2) Zero winding resistance and leakage reactance
3) No voltage drop.
4) No magnetic leakage.
5) Efficiency 100 %.
6) Regulation 0 %.

½ mark for each of any four

1 k) State the different types of (any four) cooling system used for 3 phase transformer.

Ans:

Different types of cooling system used for 3 phase transformer:

- Air Natural (AN)
- Air Forced (AF)
- Oil Natural Air Natural (ONAN)
- Oil Natural Air Forced (ONAF)
- Oil Forced Air Natural (OFAN)
- Oil Forced Air Forced (OFAF)
- Oil Natural Water Forced (ONWF)
- Oil Forced Water Forced (OFWF)

½ mark for each of any four

1 l) State conditions for parallel operation of 3 phase transformer (any four).

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 polarity wise connections must be carried out.
4) Percentage / p.u. impedances should be equal in magnitude.
5) X/R ratio of the transformer windings should be equal.

½ mark for each of any four

2 **Attempt any <u>FOUR</u> of the following:** 16

2 a) Derive the E.M.F. equation of D.C. Generator?

Ans:

Let P = no of poles,
Ø = average flux per pole (Wb),
Z = total no of armature conductors.
A = number of parallel paths of armature winding,
N = speed of generator in RPM.
E_g = emf of generator

1 Mark

By Faraday's Laws of electromagnetic induction

Induced emf in each conductor $e_c = \frac{d\emptyset}{dt}$

Here, the flux cut by one armature conductor in one revolution = P Ø.

The time for one revolution = (60/N) sec.

Hence e_c = (flux cut in one revolution)/(time for one revolution) volt

$$= \frac{P\,\emptyset}{\frac{60}{N}} = \frac{P\,\emptyset\,N}{60} \quad volt$$

1 Mark

For Z conductors the total emf will be

$$Ez = Z\frac{P\,\emptyset\,N}{60} \quad volt$$

1 Mark

Depending on the number of identical parallel paths the conductors get divided into those many paths (depending on the armature winding type as wave and lap winding)

Hence induced emf $E_g = E_Z/A = \frac{\emptyset Z N}{60}\frac{P}{A}$ volts

A= P (lap winding) A= 2 (wave winding)

1 Mark

2b) A 4 pole generator having wave wound armature winding has 51 slots, each slot containing 20 conductors. What will be the voltage generated in machine when driven at 1500rpm assuming flux per pole ~~tube~~ 7 mWb?

Ans:

Given : P=4, A=2 (for wave winding), No. of slots = 51,
Conductors/Slot = 20, N=1500 rpm, Ø = 7 mWb = 7 x 10^{-3} Wb

Z= Total number of conductors = No. of Slots x Conductor / slot = 51×20 — 1 Mark

∴ Z= 1020

EMF equation of Generator : Eg= (ΦZNP/60A) — 1 Mark

$$E_g = \frac{0.007 \times 1020 \times 1500 \times 4}{60 \times 2} = 357\ volts$$ 2 Marks

2c) Explain the necessity of starter for D.C. motor. List the types of D.C. motor starter.

Ans:

Necessity of starter for D.C. motor

Armature current, is given by equation Ia=(V−Eb)/Ra — 2 Marks

i) If the motor is at standstill or rest, back emf Eb is zero (as Eb=ΦZNP/60A, at start speed N is zero). This causes large starting current which flows through armature winding and may damage it.

ii) Hence to limit the very high starting current the starters are required.

Types of D.C. motor starters:

i) Three point starter

ii) Four point starter — 2 Marks

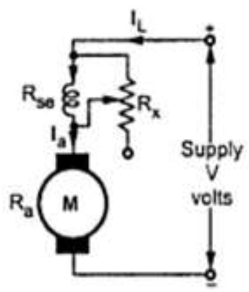
2d) Explain with suitable diagram flux control method for speed control of DC series motor?

Ans:

Flux control method for speed control of DC series motor:

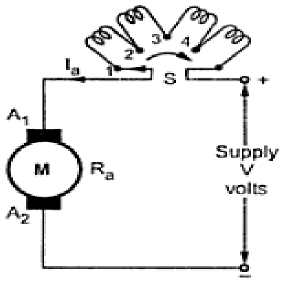
There are generally four methods of flux control used for speed control of DC series motor.

i) Field diverter method: By adjusting R_X field current is controlled, Hence flux is controlled and speed is controlled above rated value.

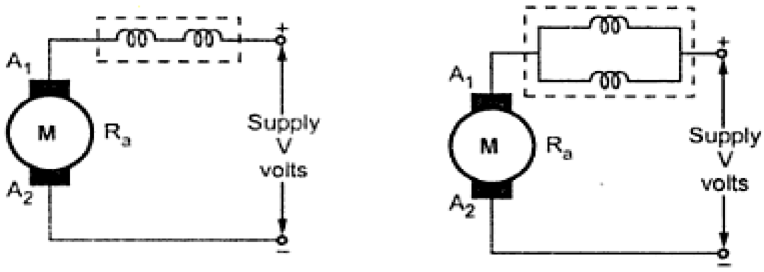


Explanation of any one method with diagram = 4 Marks

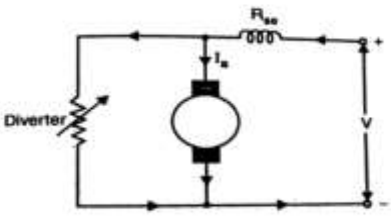
ii) Tapped field method: As selector switch is moved from position 1 onwards the number of field turns decreases which decreases MMF, hence speed increases above rated value.



iii) Paralleling field coils: If field coil is arranged in series or parallel, MMF of coil changes, hence flux produced also changes and speed can be controlled. Some fixed speeds can only be obtained with this method. In parallel grouping of fields higher speeds can also be obtained.



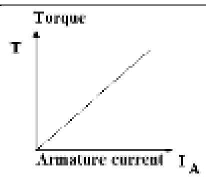
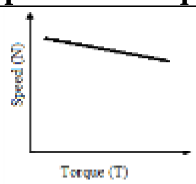
iv) Armature Diverter method: Resistance is connected in parallel with armature winding called as armature diverter .This diverter resistance shunts some of the line current, thus reducing armature current. Now for a given load if armature current decreased, the flux must increase and hence speed is decreased than the rated speed.



2 e) Draw Torque versus Armature current and speed versus torque characteristics of D.C. shunt motor.

Ans:

Torque versus Armature current and speed versus torque characteristics of D.C. shunt motor:

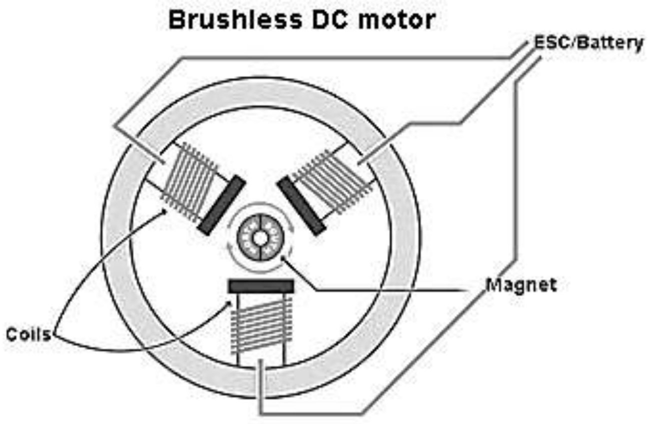
Torque Vs Armature current	Speed Vs Torque
	

2 Marks each

2 f) Explain working of Brushless D.C. motor with neat sketch.

Ans:

Working of Brushless D.C. motor:



2 Marks for diagram

Working of BLDC motor:

In case BLDC motor, the current carrying conductor is stationary while the permanent magnet rotor moves. When the stator coils are electrically switched by a supply source, it becomes electromagnet and starts producing the uniform field in the air gap. Though the source of supply is DC, switching makes to generate an AC voltage waveform with trapezoidal shape. Due to the force of interaction between electromagnet stator and permanent magnet rotor, the rotor continues to rotate.

2 Marks for working

3 **Attempt any FOUR of the following**: 16

3 a) Derive E.M.F. equation of transformer.

Ans:

Emf equation of transformer:

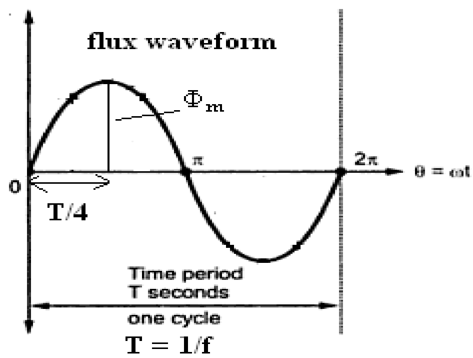
Let N_1 = No. of turns on primary winding

N_2 = No. of turns on secondary winding

Φ_m = maximum flux in core in Wb = $B_m \times A$

f = Frequency of supply in Hz

<u>1st method</u>



1 Mark

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

Av. rate of change of flux $= \Phi_m/t = \Phi_m/(1/4f) = 4\Phi_m f$ Wb/sec From

1 Mark

faraday's laws of electromagnetic induction,

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

$= 4\Phi_m f$ Wb/sec or volt

Form factor = (RMS value)/(Avg. value) = 1.11

R.M.S. emf induced in each turn = 1.11 x Avg. value

$= 1.11 \times 4\Phi_m f$

$= 4.44\ \Phi_m\ f$ volts — 1 Mark

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

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

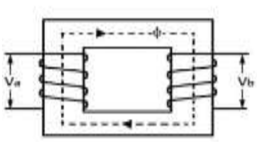
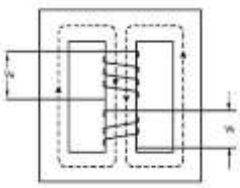
Similarly, $E_2 = 4.44\ \Phi_m f\ N_2$ volts — 1 Mark

OR Equivalent Derivation.

3b) 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

3c) Compare distribution transformer and power transformer on any four points.

Ans:

Comparision of distribution transformer and power transformer:

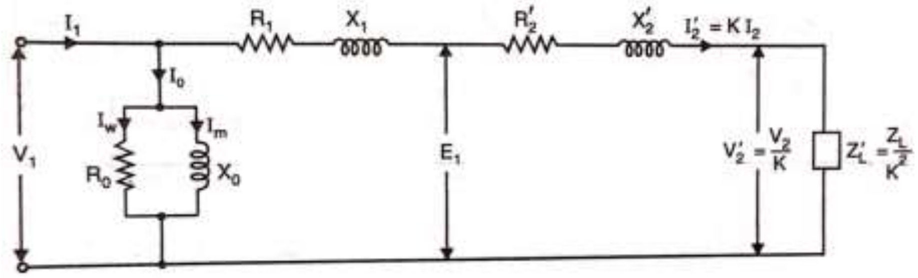
Parameters	Distribution Transformer	Power Transformer
Typical Voltages	11kV,6.6kV, 3.3kV, 440V, 230V	400kV, 220kV, 110kV,66kV,33kV
Power Rating	Lower (< 1MVA)	Higher (> 1MVA)
Size	Small	Big
Load	50-70% of full load	Full load
Insulation Level	Low	High
Installation	Pole mounted/ Plinth Mounted.	Compulsory Plinth Mounted
Maximum efficiency	Obtained near 50% of full load	Obtained near 100% of full load
Type of efficiency	All day efficiency needs to be defined	Only power efficiency is sufficient

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

3d) Draw the equivalent circuit of transformer referred to primary. State the meaning of each term.

Ans:

Equivalent diagram referred to primary:



2 Marks Equivalent Diagram

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

2 Marks for terminology

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

3 e) A 10 KVA , single phase , 50 Hz, 500/250V transformer have following results-
O.C. Test (L.V. Side) : 250V, 3A, 200W
S.C. Test (H. V. Side) : 15V, 30A, 300W
Calculate efficiency and regulation at full load 0.8 P.F. lagging.
(NOTE: In short circuit test, full load current must be circulated but here the full load current is $10\times10^3/500 = 20A$ and the current circulated in short circuit test is 30A. The Cu loss in SC test is 300W, which is not the Cu loss at full load)
Ans:

$$Z_{1T} = \frac{V_{sc}}{I_{sc}} = \frac{15}{30} = 0.5\ \Omega$$

$$R_{1T} = \frac{W_{sc}}{{I_{sc}}^2} = \frac{300}{30^2} = 0.333\ \Omega$$ 1 Mark

$$X_{1T} = \sqrt{{Z_{1T}}^2 - {R_{1T}}^2} = \sqrt{0.5^2 - 0.33^2} = 0.375\ \Omega$$

To find efficiency:
$P_i = 200W$ $P_{cu} = 300W$ **(Assuming this as Full load Cu loss)**
(NOTE: If somebody computes full-load Cu loss considering 20A as full-load current, the marks should be allotted)
Total losses = 500W

$$Efficiency = \frac{F.L.output \times cos\emptyset}{F.L.output \times cos\emptyset + Losses} = \frac{10000\times0.8}{10000\times0.8+500} = \frac{8000}{8500}$$ 1 Mark

$$= 0.9411 \text{ or } 94.11\%$$

Regulation
Total approximate voltage drop as referred to primary is 1 Mark

$$= I_1(R_{1T}cos\emptyset + X_{1T}\,sin\emptyset)$$

$$I_1 = \frac{VA}{V_1} = \frac{10000}{500} = 20\text{ A}$$

Voltage drop= $20[(0.333\times0.8) + (0.375\times0.6)] = 9.82\ volts$

$$Voltage\ Regulation = \frac{Voltage\ drop}{No\ load\ Voltage} = \frac{9.82}{500}$$

$$= 0.01964 \quad or \quad 1.964\%$$ 1 Mark

3 f) Find 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 day of 24 hrs it is loaded as under:

No of Hrs	Load in KW	P.F.
6	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. × $\left(\frac{Actual\ KVA}{Rated\ KVA}\right)^2$	Total cu Losses in kwh	Total Iron losses
6	400	0.8	$\frac{400}{0.8}$ = 500	4.5 kw × $\left(\frac{500}{500}\right)^2$ = 4.5 kw	4.5×6hr = 27kWh	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**

1 Mark for Each step= 4 Marks

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

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

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

$$\%\ Efficiency_{All\ day} = 97.62\ \%$$

4 **Attempt any <u>FOUR</u> of the following**: **16**

4 a) A 500 KVA transformer has 2500 watt iron losses and 7500 watts copper losses at full load. Calculate it’s efficiency at full load unity p.f and 0.8 p.f. lagging.

Ans:

$$Efficiency_{FL} = \frac{Rated\ output \times cos\emptyset}{Rated\ output \times cos\emptyset + Cu.Losses + Iron\ Losses}$$

Case I:- cos∅=1

$$Efficiency_{unity\ pf} = \frac{500 \times 10^3 \times 1}{500 \times 10^3 \times 1 + 7500 + 2500}$$

1 Mark

$$= \frac{500000}{510000} = 0.9803$$

$$\%Efficiency_{unity\ pf} = 98.03\%$$

1 Mark

Case II:- cos∅=0.8

$$Efficiency_{0.8\ pf} = \frac{500 \times 10^3 \times 0.8}{500 \times 10^3 \times 0.8 + 2500 + 7500}$$

1 Mark

$$= \frac{400000}{410000} = 0.9756$$

1 Mark

$$\%Efficiency_{0.8\ pf} = 97.56\%$$

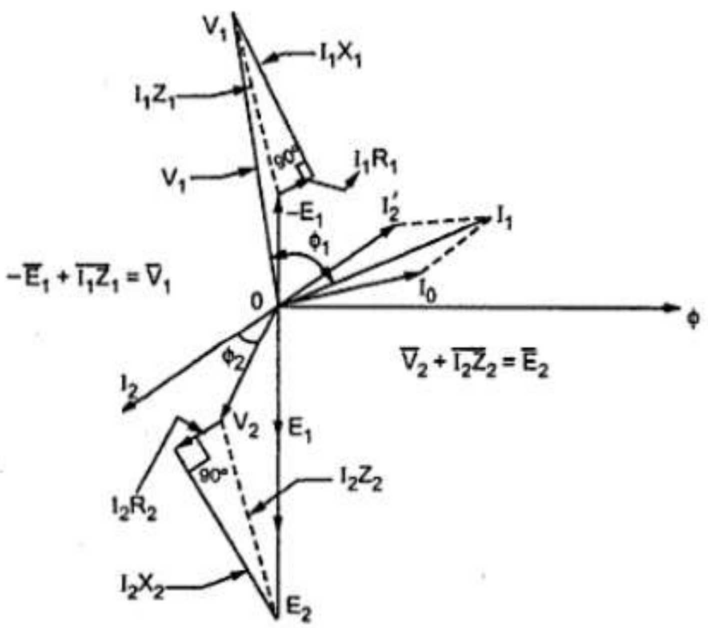
4 b) Draw complete phasor diagram of transformer for lagging p.f. load condition.

Ans:

Phasor diagram of transformer for lagging p.f. load condition:

2 Marks Phasor diagram

2 Mark Notations



For Lagging pf condition

4 c) List Various losses in transformer and explain the places at which they occur and methods to minimize these losses.

Ans:

Various Losses in Transformer:

Sr. No.	Losses in Transformer	Places at which the losses occur	Methods to minimize the losses
1	Copper Losses	Windings of transformer	By using purest conducting material for winding so as to reduce its resistance.
2	Iron Losses or Core Losses i) Eddy Current losses ii) Hysteresis Losses	Core of the transformer	i) Using laminated core.(Minimizing thickness of core) ii) Using special magnetic materials like Silicon Steel having small hysteresis loop area

2 marks Losses

1 mark Places

1 Mark Method to minimize

4 d) State the advantages of parallel operation of transformer.

Ans:

Advantages of parallel operation of transformers:

i) Reliability of the supply system enhances.
ii) Highly varying load demands can be fulfilled.
iii) Loading only the relevant capacity transformer to operate at high efficiency.
iv) Overloading of transformers is avoided and hence of life of transformer increases.

(Any related advantages should be considered)

1 Marks for each of any four advantages = 4 Marks

4 e) Two 1 phase Transformers A and B rated at 250 KVA each are operated in parallel on both side. Percentage impedances for A and B are (1+j6) and (1.2+j4.8) respectively. Compute the load shared by each when the total load is 500 KVA at 0.8 pf lagging.

Ans :

$Z_A = (1 + j6) = 6.082 \angle 80.537°$ 1 Mark

$Z_B = (1.2 + j4.8) = 4.947 \angle 75.963°$

$Z_A + Z_B = 2.2 + j10.8 = 11.021 \angle 78.486°$

Now , a load of 500KVA, 0.8 lagging is shared by both the transformers

$$S = 500 \angle -36.86° \text{ KVA}$$

Load shared by transformer A 2 Mark Calculation

$$S_A = \frac{Z_B}{Z_A + Z_B} = 500\angle -36.86° \times \frac{6.082 \angle 80.537°}{11.021 \angle 78.486°}$$

$$S_A = 224.10 \angle -39.382° \text{KVA}$$

$$\cos(-39.382°) = 0.77 \text{ (lag)}$$

i.e A load of 224.10 KVA at pf of 0.77(lag) is shared by transformer A

Load shared by transformer B

$$S_B = \frac{Z_A}{Z_A + Z_B} = 500\angle -36.86° \times \frac{4.947 \angle 75.963°}{11.021 \angle 78.486°}$$ 1 Mark result

$$S_B = 275.91 \angle -34.809^{\circ} \text{KVA}$$

$$\cos(-34.809^{\circ}) = 0.82 \text{ (lag)}$$

i.e A load of 275.91 KVA at pf of 0.82 (lag) is shared by transformer B

4 f) Explain with neat sketch polarity test of 1ϕ transformer.

Ans:

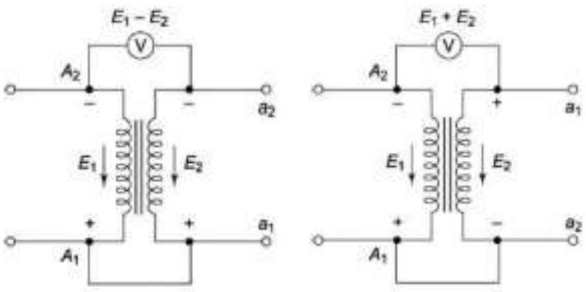
Polarity test of single Phase transformer:

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 voltage a.c. source with the connections of link and voltmeter made as shown in the figure. The reading of the voltmeter is noted. 2 Marks Explanation

If the voltmeter reading appears to be $V = (E_1 - E_2)$ then it is referred as subtractive polarity. The terminals connected to each other 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.



Subtractive Polarity Additive Polarity

2 Marks diagram

5 **Attempt any FOUR of the following** 16

5 a) State why transformer rating is in KVA.

Ans:

Transformer rating is in KVA:

The copper loss of transformer depends on the current and the iron loss depends on the voltage. Hence total transformer losses depend on volt-amperes and not on phase angle between voltage and current. The losses are independent of load power factor. If transformer is operated beyond the permissible values of voltage and current, the losses exceed the limit and 4 Marks for correct answer

due to large heat the transformer get damaged. Thus to avoid this, the losses are restricted by imposing the limits on the operating voltage and current. That is why rating of transformer is in VA or kVA or MVA.
The heating occurs due these losses. The cooling system is designed for specified heating due to the rated values of voltage and current. Any value above the rated may lead to overheating and abnormal operation. Hence to avoid this, the transformer is specified by VA rating.

5b) State the advantages of amorphous core type distribution transformer.
Ans:
Advantages of amorphous core type distribution transformer:

1) Increases efficiency of transformer as constant losses are reduced by 75 % compared to conventional transformers.
2) The material has high electrical resistivity hence low core losses.
3) Amorphous material has lower hysteresis losses, hence less energy wasted in magnetizing & demagnetizing the core during each cycle of supply current.
4) Amorphous metal have very thin laminations, which result is lower the eddy current losses.
5) Reduced magnetizing current.
6) Better overload capacity.
7) High Reliability.
8) Excellent short circuit capacity.
9) Less maintenance cost.

1 Mark for each of any 4 advantages = 4 Marks

5c) "OC test is performed on HV winding and SC test is performed on LV winding of transformer". Justify.
(NOTE: The question is wrong. It should be like this:
"OC test is performed on LV winding and SC test is performed on HV winding of transformer". Justify.)

Ans:
Open Circuit Test:
OC test is conducted to determine mainly the constant or iron losses at rated voltage.
Open circuit test is conducted on L.V. side (HV open) to overcome the following difficulties:

i) Meters required of high range will be needed when it is conducted on HV side. However, if the test is conducted on LV side, low range meter can be used without loss of accuracy.
ii) For testing, high voltage supply is required, which may not be available.
iii) Working with H. V. is unsafe.

2 Marks for OC test justification

Hence O.C. test is conducted on LV side by keeping HV open circuited.

Short Circuit Test:
SC test is conducted to determine the variable or copper losses at the rated or full load current.
S. C. test is carried on HV side (LV short circuited) to overcome the

following difficulties:

i) As full load current of LV side is very large, autotransformer capable of handling this current may not be readily available to supply the current.
ii) High range ammeters (usually not available) will be needed when the test is conducted on LV side. However, if the test is conducted on HV side, low range ammeters can be used.
iii) Working with higher current is unsafe.

2 Marks for SC test justification

Hence S.C. test is conducted on HV by keeping LV short circuited.

5 d) Explain with neat sketch the procedure of conducting phasing out test on 3 phase transformer.

Ans:

Procedure of Phasing out test on 3 phase transformer:

-Short primary & secondary windings of other phases except the one under test.

-Connect voltmeter to concerned secondary winding.

-A small DC current is circulated through the primary winding through switch.

-Now with the help of switch interrupt the DC supply instantly & repeatedly.

-If voltmeter indicator deflects then it indicates the two windings under test are belonging to the same phase.

-If not deflected then two windings are not belong to same phase.

-Repeat the procedure by connecting voltmeter to secondary side to next secondary winding till voltmeter gives deflection.

-In this way we can search the phasing out.

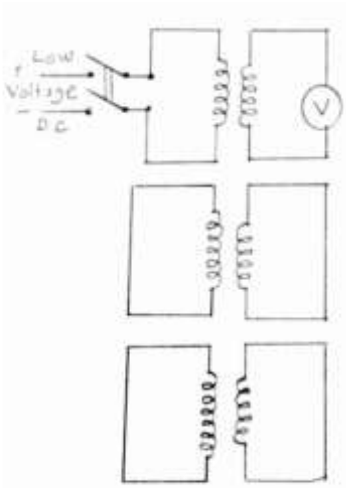
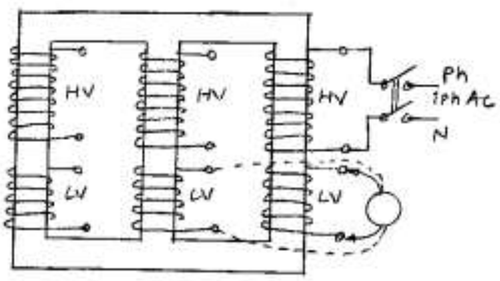


Diagram 2 Marks and Procedure 2 Marks= 4 Marks

OR

-This test is carried to find out the corresponding HV and LV phase winding.

-The circuit diagram is as shown in figure. Here normal ac voltage is applied to one of the HV or LV windings. In this case to HV winding and the voltages across all three LV windings are measured.



-The winding across which voltage is much more compared to other two windings represents the secondary of the winding to which supply is connected.

-The test is repeated for finding out remaining concerned secondary winding.

5 e) State criteria for selection of distribution transformer.

Ans:-

Selection Criteria for distribution transformer:

i) kVA Rating
ii) Required Tappings
iii) Vector group.
iv) Winding Impedances
v) Termination Arrangement.
vi) Cooling system
vii) Nature of load
viii) Ambient/ Environment conditions
ix) Voltage ratings
x) Nature of service required
xi) Tariff applicable etc.

½ mark for each of any eight points = 4 Marks

5 f) Explain construction and working of three phase auto transformer.

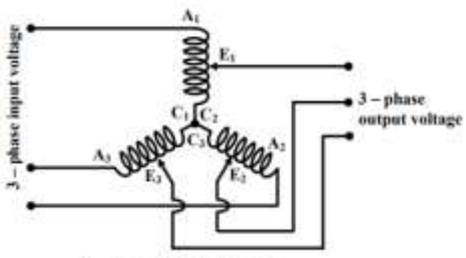
Ans:-

Construction and working of three phase auto transformer:

Construction:

- The coils connected in star are placed on electromagnetic cores, each phase of auto-transformer consists of a single continuous winding common to primary and secondary circuit.
- The limbs (electromagnetic cores) are made of laminations (sheet steel with silicon).
- The output terminal connections are gang operated to get identical tapings on all phases and are brought out on the insulated plate. The variable voltage can be obtained by tapings to which the output terminals are connected as required.
- As only one winding per phase is available, part of it acts as secondary between variable terminal and neutral.

1 Mark



3 – phase autotransformer

2 Marks

Working:

- Working principle is based on self-induction.
- When three-phase ac supply is given to star connected primary winding, according to number of secondary turns the input voltage is transferred to secondary winding.
- Depending upon the position of variable terminal, we get variable AC voltage at the output.

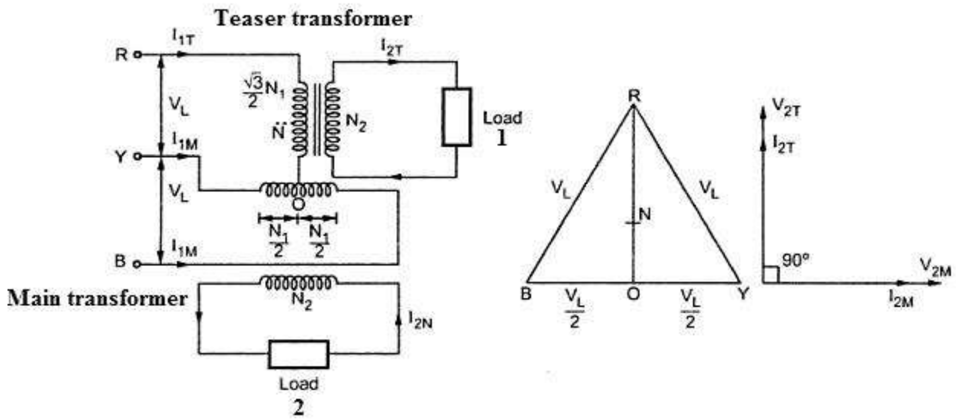
1 Mark

6 **Attempt any FOUR of the following** **16**

6 a) Describe the method of converting three phase to two phase transformer by neat diagram.

Ans:

Scott connection of transformers:



2 Marks

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 midway on V_{YB}.

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 $N_1:N_2$. 2 Marks

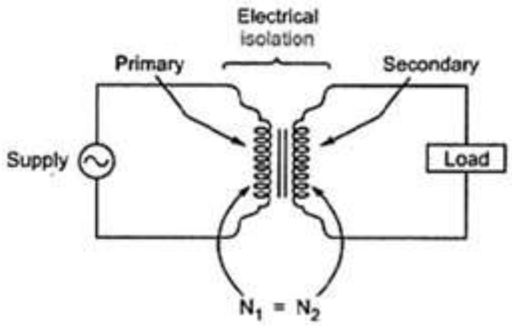
vii) From phasor diagram it is clear that the voltage appearing across the primary of Teaser transformer corresponds to phasor RO which is $\frac{\sqrt{3}}{2}$ times the line voltage V_L. Due to this limitation, the turns selected for primary of Teaser transformer are not N_1 but $\frac{\sqrt{3}}{2}N_1$. 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 $V_{2T} = V_{2M}$.

viii) As seen from the phasor diagram the output voltages to the two loads are identical .

6 b) Describe working of isolation transformer.

Ans:

Working of isolation transformer:



1 Mark

i) Isolation transformers are specially designed transformers for providing electrical isolation between the power source and the powered devices having same number of primary as well as secondary turns. Hence same voltage is transferred from primary to secondary.

ii) When supply is given to primary it causes primary current to flow in primary winding and inducing ac fluxes in core. The secondary winding is wound on common magnetic core, hence these ac fluxes are linked with it. Now secondary emf is induced according mutual induction action and secondary current flows through load if connected.

iii) Unwanted voltage spikes, transients are prevented by isolations transformer from reaching to delicate and costly sensitive load/equipment.

3 Marks

6c) Compare single phase auto transformer and two winding transformer on basis of no. of winding, copper loss, vtg regulation and cost.

Ans:

Comparision of single phase auto transformer and two winding transformer:

Parameter	**Single phase auto transformer**	**Two winding transformer**
No. of winding	Single winding.	Two windings.
Copper losses	Less	Comparatively More
Voltage regulation	Better	Poor than auto T/F
Cost	Less	More

1 mark for each point= 4 Marks

6d) List the special features of welding transformer.

Ans:

Special features of welding transformer:

i) It is a step down transformer that reduces the voltage from the source voltage to a voltage desired according to the demands of the welding process.

ii) Having large number of primary turns and less number of

1 Mark each of any four

secondary turns. The secondary current is very high.

iii) The secondary has several taps for adjusting the secondary voltage to control the welding current.

iv) The transformer is normally large in size compared to other step down transformers as the windings are of a much larger gauge.

v) A winding used for the welding transformer is highly reactive or a separate reactor may be added in series with the secondary winding.

vi) Common ratings:

Primary voltage – 230 V, 415 V

Secondary voltage – 40 to 60 V

Secondary current – 200 to 600 A

6 e) Explain construction and working of potential transformer.

Ans:

Construction and working of potential transformer:

Construction:

i) It is basically step down transformer. These are made with high quality iron core operating at very low flux densities so that the magnetizing current may be very small. 2 Marks

ii) No. of primary turns are more than secondary turns.

iii) It is wound on common magnetic core made up of silicon steel stamping.

iv) The secondary must grounded for safety.

v) PT secondary is commonly designed for an output of 110V.

Working:

i) Primary winding is connected to high voltage and secondary to low range voltmeter. The transfer of primary voltage to secondary voltage is done according to transformer action.

ii) The secondary voltage across voltmeter is given by

$$V_2 = \frac{N_2}{N_1} \times V_1$$

2 Marks

$V_2 =$ Voltmeter reading

iii) So if the ratio ($\frac{N_2}{N_1}$) is known and V_2 is measured then we can obtain the voltage V_1 accurately.

6 f) Give the specification of 3 phase distribution transformer as per IS: 1180(Part-I)-1989

Ans:

Specification of 3 phase distribution transformer as per IS:1180(PartI)-1989:

1) Continuous rated capacity
2) System voltage (max.)
3) Rated voltage HV
4) Rated voltage LV
5) Line current HV
6) Line current LV
7) Frequency
8) No. of Phases
9) Connection HV

Any 8 points each ½ mark= 4 Marks

10) Connection LV
11) Vector group
12) Type of cooling
13) Noise level at rated voltage and frequency
14) Permissible temperature rise over ambient
15) Minimum clearances in air of bushing terminals with connectors fitted. etc.