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 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 *TEN* of the following: 20

1 a) State Fleming's right hand rule.

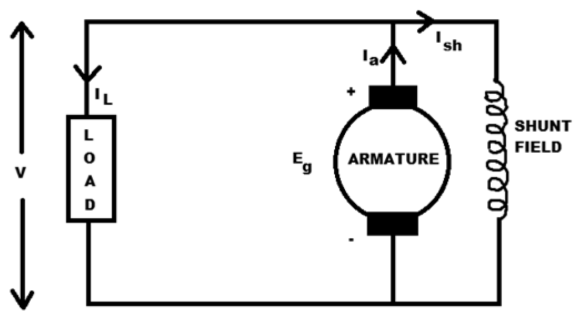
1 a) Ans:

FLEMING'S RIGHT HAND RULE :-

Stretch 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 indicate the direction of EMF / current. 2 Marks

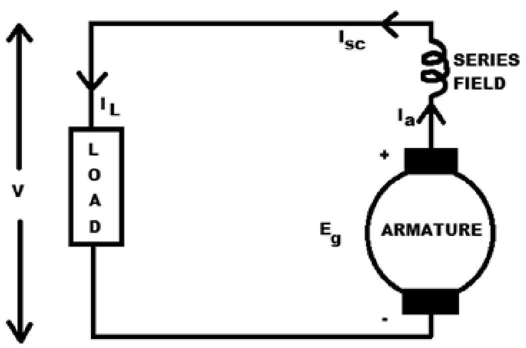
1 b) Draw connection circuit diagram of (i) DC shunt generator & (ii) DC series generator

1 b) Ans:



Shunt Wound Generator

1 mark



Series Wound Generator

1 mark

1 c) Write voltage equation & power equation of DC motor

1 c) Ans:

Voltage equation: Any one

1) $V = E_B + I_A.R_A$ for DC shunt motor. voltage

(V = applied voltage (Volts), E_B = back emf generated (volts), I_A = armature current (Amperes), R_A = armature winding resistance in ohms. — equation 1 mark

2) $V = E_B + I_A(R_A + R_S)$ for DC series motor. (R_S = series winding resistance in ohms).

Power equation:

1) $VI = E_B I_A + (I_A)^2 R_A + (I_{SH})^2 R_{SH}$ for DC shunt motor.

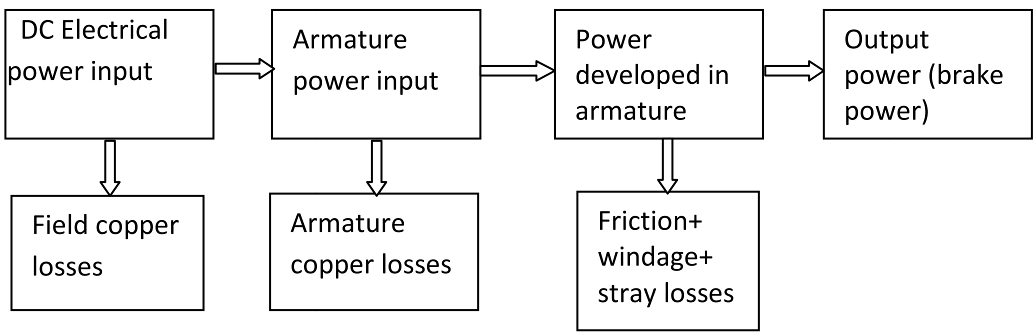
(V = applied voltage (Volts), I = current drawn by motor from supply, E_B = back emf generated (volts), I_A & I_{SH} = armature & shunt field currents respectively (Amperes), R_A & R_{SH} = armature & shunt field winding resistances respectively (ohms). — Any one power equation 1 mark

2) $VI = E_B I + I^2(R_A + R_S)$ for DC series motor. (R_S = series winding resistance in ohms).

(some students may give the relevant equations for the compound motors for which they should be awarded marks)

1 d) Draw power stages block diagram of dc motor

1 d) Power stages block diagram of DC motor.



Fully correct 2 marks, partial marks for partially correct. (OR equivalent figure)

1 e) A 4 pole dc generator having wave wound armature winding has total 1020 conductors. Determine the emf generated when driven at 1500 RPM assuming flux per pole to be 7.0 mWb.

1 e) Ans: Given P = 4, Ø = 7.0mWb, Z = 1020, A = 2, N =1500 RPM.

We know,

$$E = (P \text{Ø} Z N)/(60 A) \text{ V.}$$ 1mark

Substituting the given data,

$E = (4 \times 7.0 \times 10^{-3} \times 1020 \times 1500) / (60 \times 2)$

$E = 357$ V — 1mark

1 f) A dc series motor takes 40 A at 220 V and runs at 800 RPM. If the armature and field resistance are 0.2 ohm and 0.1 ohm respectively, find the torque developed by the armature.

1 f) Ans:
Armature torque (Nm) = [power developed by armature (W)] / [speed (rad/sec)]

$= E_B I_A/\omega$ Or $[9.55 E_B I_A]/N$ — 1 mark

$= [V - I_A (R_A + R_{SE})]I_A /(2\pi N/60)$

$= [220 - 40(0.2 + 0.1)]40/(2\pi \times 800/60)$

= 99.3 Nm. — 1 mark

1 g) Define voltage transformation ratio & turns ratio for single phase transformer.

1 g) Ans:

Voltage transformation ratio= (secondary terminal voltage/ primary terminal voltage) — 1 mark

Turns ratio = (secondary number of turns) / (primary number of turns). — 1 mark

1 h) State principle of operation of transformer.

1 h) Ans:

The transformer operates on the principle of mutual induction, wherein the flux produced by one coil current (primary winding) produces emf in another coil (secondary winding) thus transferring the voltage/current from one coil to another without any conductive connection. This is used to transfer electrical power from one circuit to another. — 2 marks

1 i) A 3 kVA 220/110 V transformer has 500 turns on its primary. Find its transformation ratio and secondary turns.

1 i) Ans:

Transformation ratio $K = V_2/V_1 = 110/220 = ½$. — 1 mark

Secondary turns $= K. N_1 = (½) \times 500 = 250$ turns. — 1 mark

1 j) List characteristics of an ideal transformer.

1 j) Ans:

Characteristics of Ideal transformer:

1) No losses (iron and copper), hence no temperature rise. — ½ mark each any four = 2 marks
2) Zero winding resistance and leakage reactance (zero impedance).
3) No voltage drop i.e. $E_1 = V_1$, $E_2 = V_2$.
4) No magnetic leakage.
5) Efficiency 100 %.
6) Regulation 0 %.

OR

1) Zero core power loss [core (hysteresis & eddy current) losses]
2) No ohmic résistance of primary and secondary windings.
3) Zero copper losses [I^2R losses]
4) Zero magnetic leakage (coefficient of coupling between primary and secondary windings is unity).

1 k) State any two advantages of three phase transformer over bank of single phase transformers.

1 k) Ans:

Advantages of three phase transformer over bank of single phase transformers:

For identical magnitudes of power transformation, — 1 mark each any two = 2 marks

i) Saving in copper conductor.
ii) Saving in electromagnetic core material.
iii) Compact arrangement (Lower space required)
iv) Saving in dielectric material such as insulating oil.
v) Saving in overall cost.
vi) Higher efficiency.

1 l) State the conditions for parallel operation of three phase transformer.

1 l) Ans:

Conditions for Parallel operation of 3 ph transformer

1) Voltage ratings of both the transformers must be identical. — ½ mark each (any four)
2) Percentage / p.u. impedance should be equal in magnitude.
3) X / R ratio of the transformer winding should be equal.
4) Transformer polarity wise connections must be carried out.
5) Phase displacement between primary & secondary voltages must be same.
6) Phase sequence of both must be same.

2 Attempt any FOUR of the following: 16

2 a) Study the following figure shown in figure no 1.

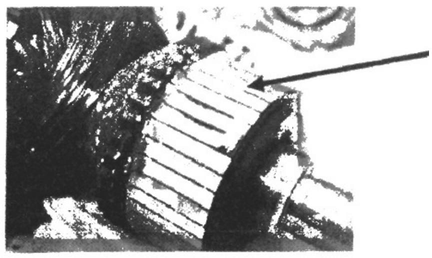


Fig. No. 1

(i) Identify the part of DC machine.

(ii) Name the material used for it.

(iii) State the use of the above part in case of DC motor & generator.

2 a) Ans:

(i) Commutator. 1 mark

(ii) Segmented copper wedges with mica insulation between them. 1 mark

(iii) In DC motor it is used to convert the external current (dc) supplied to the armature in such a manner that armature conductors coming under particular poles have current in same direction to produce unidirectional torque (with the help of stationary brushes) 1 mark

In DC generator it is used to obtain (through stationary brushes) direct quantities by converting the alternating quantities (emf or current) produced in the armature. 1 mark

2 b) Derive emf equation of DC generator

2 b) Ans: 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 (driven) of generator in RPM.

By Faraday's Laws of electromagnetic induction

Induced emf in each conductor 'e_c' = d Ø/dt. 1 mark

In this case 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) V 1 mark

$$= \frac{P\,Ø}{\frac{60}{N}} = \frac{P\,Ø\,N}{60}\,V$$ 1 mark

For Z conductors the total emf will be

$$Ez = Z\frac{P\,Ø\,N}{60}\,V$$

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' = E_Z/A = $(P\,Ø\,Z\,N)/(60\,A)$ V. 1 mark

2 c) A DC series motor operates at 800 RPM with a line current of 100 A from 230 V mains. Its armature circuit resistance is 0.15 Ohm & its field resistance 0.1 ohm. Find the speed at which the motor runs at a line current of 25 A, assuming that the flux at this current is 45 % of the flux at 100 A.

2 c) Ans:

For DC series motor:

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\Phi_1}{\Phi_2} \quad \text{--------------------(I)}$$ 1 mark

$\Phi_2 = 0.45\,\Phi_1$

$E_{B1} = V - I_{A1}(R_A + R_{SE}) = 230 - 100(0.15 + 0.1) = 205$ V 1 mark

$E_{B2} = V - I_{A2}(R_A + R_{SE}) = 230 – 25(0.15 + 0.1) = 223.75$ V. 1 mark

Using (I),

N_2 = (223.75/205) x (1/0.45) x 800 = 1940 RPM. 1 mark

2 d) A dc series motor takes 40 A at 220 V and runs at 800 RPM. If the armature and field resistance are 0.2 ohm and 0.1 ohm respectively & the iron and friction losses are 0.5 kW. Find the armature torque and efficiency of the motor.

2 d) Ans:

Armature torque (Nm) = [power developed by armature (W)] / [speed (rad/sec)]

$= E_B I_A/\omega$ Or $[9.55\, E_B I_A]/N$

$= [V - I_A(R_A + R_{SE})]I_A/(2\pi N/60)$

$= [220 – 40(0.2 + 0.1)]40/(2\pi \times 800/60)$

= 99.3 Nm. 1 Mark

Copper losses in armature & series field resistance = $I^2(R_A + R_{SE})$

$= 40^2(0.2 + 0.1) = 480$ W.

Total losses

=(Copper losses in armature & series field resistance + iron losses + friction losses)

= 480 + 500 = 980 W. 1 Mark

Motor power input = V I = 220 x 40 = 8800 W.

Motor output = input – losses = 8800 – 980 = 7820 W 1 Mark

% η = (Motor output) /(Motor power input) x 100

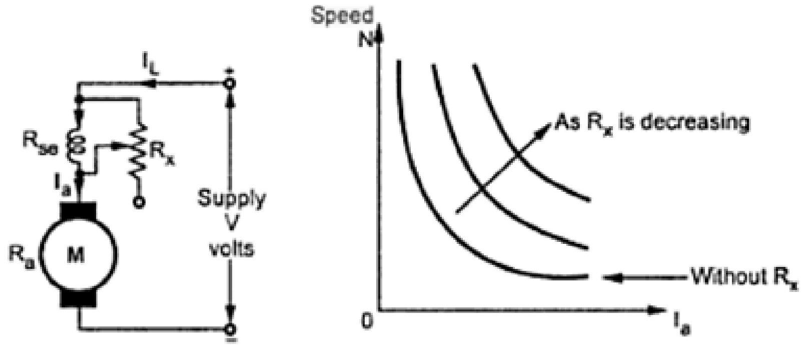
= 88.86 % 1 Mark

2 e) Describe the flux control speed control method of Dc series motor with neat diagram.

2 e) Ans:

I) Flux control methods: N α (1/Ø) α (1/I_F) before saturation

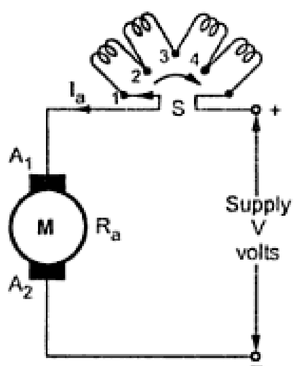
i) Field diverter method: by adjusting R_X field current is controlled, flux is controlled and speed is controlled above rated value as shown in graph



(a) Field diverter (b) Speed-current characteristics

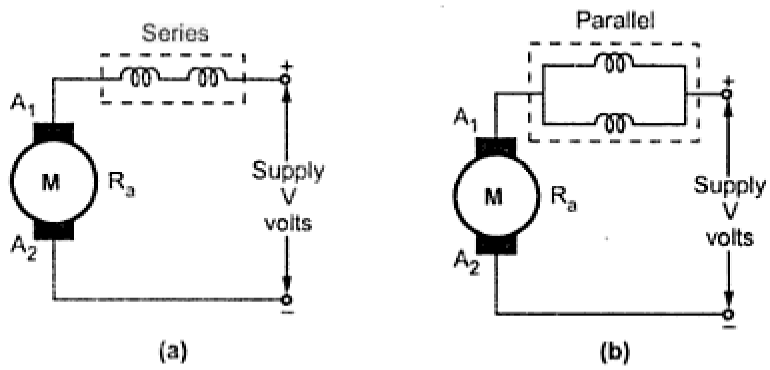
Any one method: diagram =2 marks & description = 2 marks total = 4 marks

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. Used in electric traction



iii) For same torque 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. In parallel grouping higher speeds can be obtained.

Series parallel connection of field:



2 f) Describe the reason of using dc series motor for electric trains.

2 f) Ans:

Electric trains require an inverse torque speed characteristics for proper operation. That is a higher torque is required at start (when speed is nil or low) and as the train picks up speed the torque needed to maintain motion is low as inertia is high. 1 mark

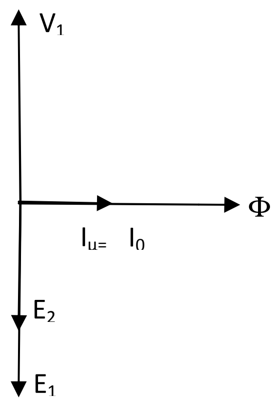
The dc series motor has inverse type output torque speed characteristics suitable for the applications where the torque required by connected loads is high at start and then diminishes to lower values as the speed increases. 1 mark

As the load torque speed requirements of the trains and the output torque – speed characteristics of DC series motors match, these motors are suitable for electric trains 2 mark

3 Attempt any FOUR of the following: 16

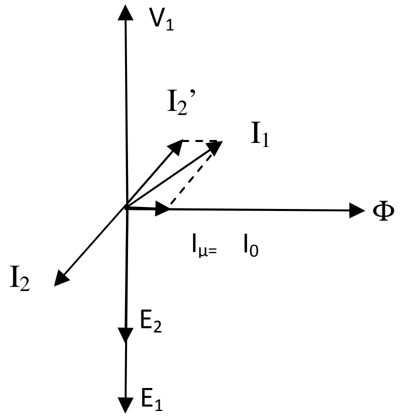
3 a) Draw the phasor diagram for
- i) Ideal transformer
- ii) Practical transformer on no load and on load.

3 a) Ans:
- i) Ideal transformer
  - a) On no load:



1 mark

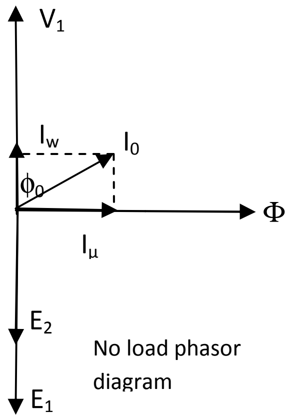
b) On load:



1 mark

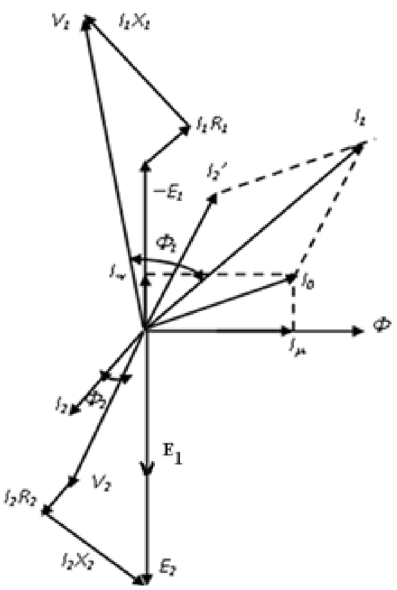
ii) Practical transformer

a) On no load:



1 mark

b) On load:



1 mark

3 b) 'Performance of a transformer is analyzed on all day efficiency". Justify the statement.

3 b) Ans:

- The distribution transformers are energized for 24 hours of the day. 1 mark
- The constant losses occur continuously and the copper (load dependent) losses occur varyingly with respect to the load for different times of the day. 1 mark
- Thus varying powers are drawn due to which the efficiency varies drastically over the whole day. 1 mark
- Thus the performance of the transformers need to be judged in terms of the energy efficiency (or in terms of the energy it supplies) rather than the commercial (power) efficiency. 1 mark

3 c) State types of cooling used in distribution transformers

3 c) Ans:
The distribution transformers are generally cooled by AN, ANAN and ONAN methods. 1 mark

In the AN or ANAN type of cooling the air cools the transformer by its natural flow around the transformer body parts. 1 mark

In the ONAN type the oil in the transformer tank circulates vertically between the top & bottom sections by virtue of hot oil moving upwards then side wards to cool and then move down wards as it becomes heavy on cooling. The cooling occurs in the tubes/fins. The external surfaces of the cooling tubes/fins are cooled by natural air circulation. 2 marks

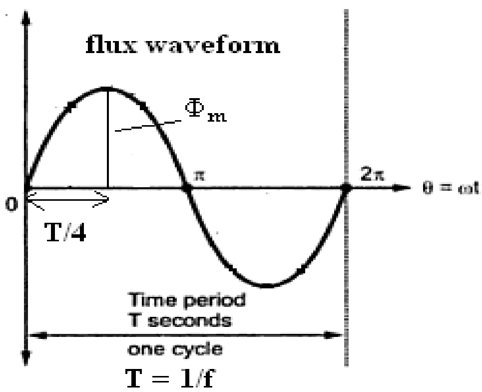
3 d) Derive the emf equation of a transformer.

3 d) 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 winding in Wb
f = Frequency of supply in Hz
1^{st} method

1 mark



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

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

From faraday's laws of electromagnetic induction

Avg. emf induced in each turn = Avg. rate of change of flux $= 4\Phi_m f$

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 1 mark

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

OR II[nd] method OR

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

According to Faraday's laws of electromagnetic induction

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

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

$= \omega\Phi_m \sin(\omega t - \pi/2)$ volts 1 mark

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

But $\omega = 2\pi f$ 1 mark

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

$E_2 = 4.44\ \Phi_m f\ N_2$ volt 1 mark

3 e) From the following fig no 2 of transformer

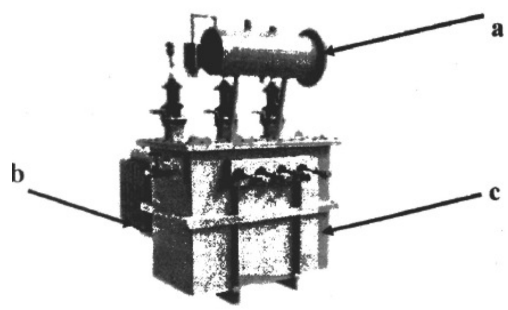


Fig. No. 2

(i) Name part 'a'
(ii) State application of part 'b'
(iii) State material used for part 'c'
(iv) Name the type of transformer from connections.

3 e) Ans:

(i) Conservator tank. 1 mark

(ii) Cooling tube or fins for insulating/dielectric oil to move from top to bottom as it cools. Hence used for cooling of transformer. 1 mark

(iii) MS (mild steel) for the tank in which the core, windings… assembly is placed. 1 mark

(iv) As it is having three bigger insulators on one side (HV) and four smaller ones on the other side (LV) with ONAN (due to cooling fins with oil in them exposed to natural air) cooling it is a distribution transformer. 1 mark

3 f) The maximum flux density in the core of a 250V/3000V 50 Hz 1-phase transformer is 1.2 Wb/m^2. If the emf per turn is 8 V, determine area of the core, primary & secondary turns.

3 f) Ans:

$E = 4.44\ \Phi_m\ f\ N$ (V)

Voltage per turn = $e_t = E/N = 1/(4.44\ \Phi_m\ f)$.

Given $e_t = 8$ volts,

$\Phi_m = e_t / (4.44\ f) = 8 / (4.44 \times 50) = 0.036$ webers. 1 mark

Area of core = $A = \Phi_m / B_m = 0.036/1.2 = 0.03\ m^2$.

1 mark

$E_1 \doteqdot V_1 = 250$ V, & $E_2 \doteqdot V_2 = 3000$ V.

Primary turns $N_1 = E_1 / (4.44\ \Phi_m\ f) \doteqdot 250/(4.44 \times 0.036 \times 50) = 32$ turns.

1 mark

Secondary turns $N_2 = E_2 / (4.44\ \Phi_m\ f) \doteqdot 3000/(4.44 \times 0.036 \times 50) = 375$ turns.

1 mark

4 Attempt any FOUR of the following: 16

4 a) A 30 kVA 2400/120 V , 50 Hz transformer has a high voltage winding resistance of 0.1 ohm and leakage reactance of 0.22 ohms. The low voltage resistance is 0.035 ohm and the leakagew reactance is 0.012 ohm. Find the equivalent winding resistance, reactance and impedance referred to LV side.

4 a) Ans:

$R_1' = R_1 \times K^2$ and $X_1' = X_1 \times K^2$

$R_{02} = R_2 + R_1' = R_2 + R_1 \times K^2$

$X_{02} = X_2 + X_1' = X_2 + X_1 \times K^2$

$Z_{02} = \sqrt{(R_{02}^2 + X_{02}^2)}$ 1 Mark

$K = 120/2400 = 1/20.$

$R_{02} = 0.035 + 0.1 \times [1/20]^2 = 0.03525$ ohm 1 Mark

$X_{02} = 0.012 + 0.22 \times [1/20]^2 = 0.01255$ ohm 1 Mark

$Z_{02} = \sqrt{(0.03525^2 + 0.01255^2)} = 0.0374$ ohm 1 Mark

4 b) "Transformers are rated in kVA instead of kW", Justify

4 b) Ans:

The capacity of a transformer is decided by the rated voltage and rated current it can safely handle without over heating or damage. 1 mark

Also output power of transformer is given by P= VICosØ, for different types of load i.e (resistive, capacitive, inductive) cosØ changes so, for same voltage and current output powers will different, as the transformer is designed to operate at particular voltage and current levels and it is not designed to deliver particular real power hence its rating is in kVA. 1 mark, 2 marks

OR

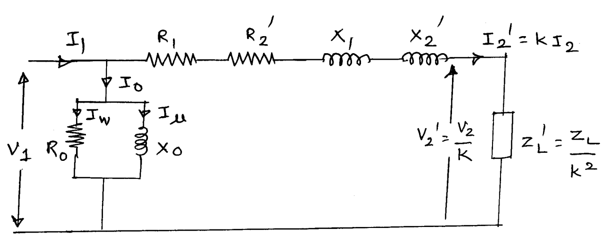
As copper loss of a transformer depends on current and iron loss on voltage, 1 mark

Hence total transformer loss depends on volt-ampere and not on phase angle between voltage and current ie. It is independent of load power factor. 1 mark

That is why rating of transformer is in kVA. 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 over heating and abnormal operation. Hence to avoid this the transformer is specified by VA rating 1 mark, 1 mark

4 c) Derive the equivalent circuit of transformer referred to primary.

4 c) Approximate equivalent circuit referred to Primary: Labeled Diagram 2 Marks, Partial diagram 1 mark



$R_o = V_1 / I_w$ and $X_o = V_1 / I_\mu$

$K = E_2 / E_1 = N_2 / N_1 = V_2 / V_1$

$V_2' = V_2 / K$

$I_2' = K\, I_2$

$R_2' = R_2 / K^2$ and $X_2' = X_2 / K^2$

$R_{01} = R_1 + R_2' = R_1 + R_2 / K^2$ — R_{01} _ 1 mark

$X_{01} = X_1 + X_2' = X_1 + X_2 / K^2$ — X_{01} _1 mark

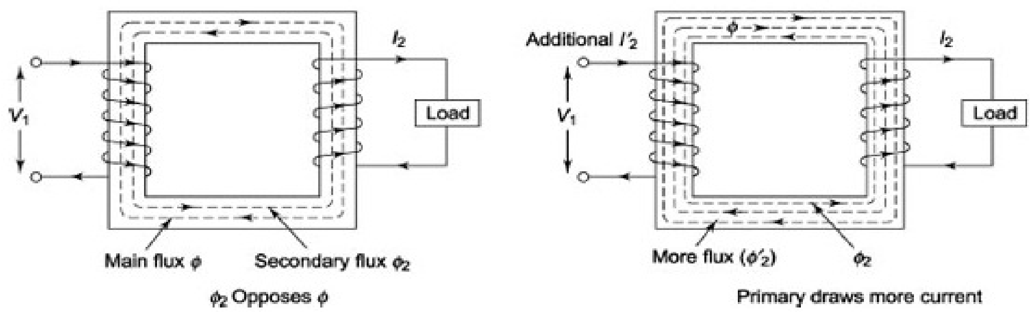
4 d) A 20 kVA, 2200/220 V, 50 Hz transformer is carried out with OC/SC tests. The results are
OC test: 220 V, 4.2 A, 148 W.
SC test: 86 V, 10.5 A, 360 W.
Determine regulation at 0.8 pf lag and at full load. Also calculate pf at SC.

4 d) Ans:
$K = V_2/V_1 = 220/2200 = 0.1$
Full load primary current $I_{1\ F.L.} = (20x1000)/2200 = 9.09$ A — 1 mark
From S.C.test $Z_{T1} = V_{SC}/I_{SC} = 86/10.5 = 8.19$ ohm
$R_{T1} = P_{SC}/(I_{SC})^2 = 360/(10.5)^2 = 3.26$ ohm
$X_{T1} = \sqrt{(8.19^2 - 3.26^2)} = 7.51$ ohm — 1 mark
% regulation $= 100 \times I_{1FL} (R_{T1}\cos\Phi + X_{T1}\sin\Phi) / V_1$
$= 100 \times 9.09(3.26 \times 0.8 + 7.51 \times 0.6)/2200$
$= 2.94\%$ — 1 mark

Pf at SC is $= R_{T1}/ Z_{T1} = 3.26/8.19 = 0.398$ lag — 1 mark
(students may also calculate by $W_{SC}/(V_{SC}\ I_{SC}) = 360/(86 \times 10.5) = 0.398$ lag

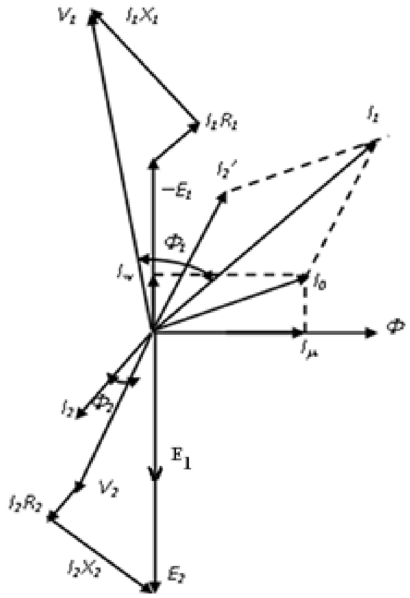
4 e) Describe the working of transformer on load with the help of phasor diagram considering lagging (inductive) load.

4 e) Ans:



For inductive load:
When transformer is loaded current I_2 flows through secondary
With inductive load it lags behind V_2
I_2 sets up Φ_2, opposes main flux Φ and weakens it.
E_1 reduces, more primary current flows $= I_o + I_2'$

Sets up Φ_2' which opposes Φ_2, $\Phi_2' = \Phi_2$, $I_2' = k I_2$ — 2 mark
Neglecting I_o, $I_2' = I_1$



Phasor diag 2 marks

4 f) State advantages of parallel operation of transformers.

4 f) Ans:

Advantages of parallel operation of transformers:

i) Reliability of the supply system enhances. — 1 mark for each

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.

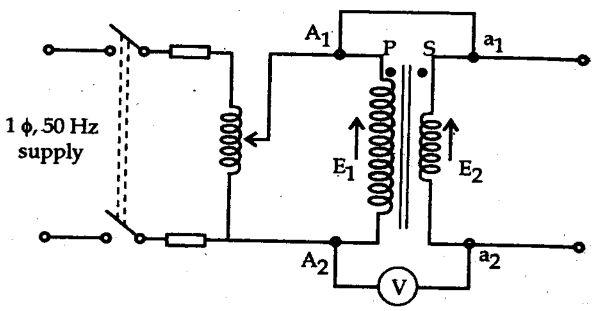
(Any related advantages should be considered)

5 Attempt any FOUR of the following: 16

5 a) Describe polarity test on transformer with neat diagram.

5 a) Ans:

Polarity test is conducted to determine the relative polarity of the mutually inductive windings of a transformer (primary, secondary and tertiary).



2 mark

- transformer is connected to a single phase AC supply.
- The primary terminals are A_1 and A_2 while secondary terminals are a_1 and a_2.
- Let A_1 and a_1 are shorted and a voltmeter is connected between A_2 and a_2.
- If voltmeter reading is $V = E_1 - E_2$ (subtractive), then marked polarities are correct. 2 mark
- If voltmeter reading is $V = E_1 + E_2$ (additive) , then marked polarities are not correct. One of them should be reversed.

The polarity marking shown above is used for transformers, i.e.
Identical alphabets with identical suffixes are shown for similar polarity, with capital letters for HV and small case letters for LV.
Eg. A_1 (HV side) has same polarity as a_1 (LV side).

5 b) A 100KVA lighting transformer has a full load loss of 3kW, the losses being equally divided between iron and copper loss. During a day, the transformer operates on full load for 3 hrs, one half load for 4 hrs, the output being negligible for the remainder of the day. Calculate all day efficiency.

5 b) Ans: As it is lighting transformer power factor considered as unity.
Losses are equally divided, hence
Iron loss + Cu loss = 3kW
Iron loss for 24 hours= 1.5 x 24= 36 kWh 1 mark
F.L.Cu loss= 1.5 kW
Energy losses in Cu for 3 hours of FL = 1.5 x 3 = 4.5 kWh 1 mark
Half load Cu loss= (1.5/4) kW.
Energy losses in Cu for 4 hours at half load= (1.5 x 4)/4=1.5 kWh 1mark
Total 24 hr energy losses= Iron loss + Cu loss= 36 + 4.5 + 1.5= 42 kWh
Total output= (100 x 3) + (50 x 4) = 500 kWh
$\eta_{\text{all day}}$= (500 x 100)/(500 + 42) = 92.26% 1 mark

5 c) Two single phase transformers of 250 KVA each are operated on parallel (both side). Their % drops are (1 + j6) ohm and (1.2 + j4.8) ohm. The load connected across the bus bar is 500 KVA at 0.8 p.f. lag. Calculate load shared by each transformer.

5 c) Ans:
As given machines are having equal kVA ratings we may assume the given impedances to be in % or Ohmic values (any one)
Given- $Z_A = 1 + j6 = 6.08\angle 80.53\ \Omega$, $Z_B = 1.2 + j4.8 = 4.94\angle 75.96\ \Omega$
$Z_A + Z_B = 2.2 + j\,10.8 = 11.02\angle 78.48^o\ \Omega$.
We know that,
$S_A = S * Z_B/(Z_A+Z_B)$ 1 Mark
$= 224.45\angle -39.4°$ kVA 1Mark

$S_B = S * Z_A/(Z_A+Z_B)$ 1 Mark
$= 275.86\angle -34.82°$ kVA 1 Mark

5 d) List any four parts of 3 phase transformer and state function of each part.

5 d) Ans:

1) 3 limbed core: facilitates placement of respective phase windings (primary and secondary), path of low reluctance for the magnetizing flux.
2) 3 phase windings: facilitates production of emf due to common flux linking the windings for transferring electrical energy from primary to secondary circuit.
3) HT/LT Bushings: provide insulated support and connection means for the respective phase terminals
4) Buchholz Relay: gives the alarm signals in case of incipient faults and trip signal in case of severe explosive winding faults.
5) Conservator: provides through breather scope for expansion and contraction of insulating oil in the transformer tank due to heating/cooling, thus preventing the buildup of high pressure in the tank.
6) Cooling Tubes: provide interface or path for the hot oil to cool by natural or forced circulation.
7) Breather: absorbs the moisture in the air being drawn inside the conservator tank at the oil surface when the oil level falls due to cooling of the oil. Thus the oil remains above acceptable levels of purity for a longer time.

Any four 1 mark each = 4 marks.

5 e) State the criteria for selection of distribution transformer as per IS 10028 (part I): 1985

5 e) Selection Criteria for distribution transformer: as per IS 10028 part I of 1985

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: 585-19627 except for special reasons when other values may be used.

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 ± 2.5 percent and ± 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 (Dyn 11 or Dyn 1) is to be specified depending upon requirements of parallel operation.

1 Marks Each (any four criteria)

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 and ANAN.

5 f) Compare distribution transformer and power transformer on basis of connection, rating, cost and maintenance.

5 f) Ans:

1 Mark Each

Parameters	DISTRIBUTION TRANSFORMER	POWER TRANSFORMER
Connection	Secondary star connected with neutral provided.	Neutral not always required. (other connections used)
Rating	Lower	Higher
Cost	Low	High
Maintenance	Carried out somewhat irregularly. Less cost.	Carried out more regularly. More cost.

6 Attempt any FOUR of the following: 16

6 a) Why phasing out test & polarity test are carried out on three phase transformers.

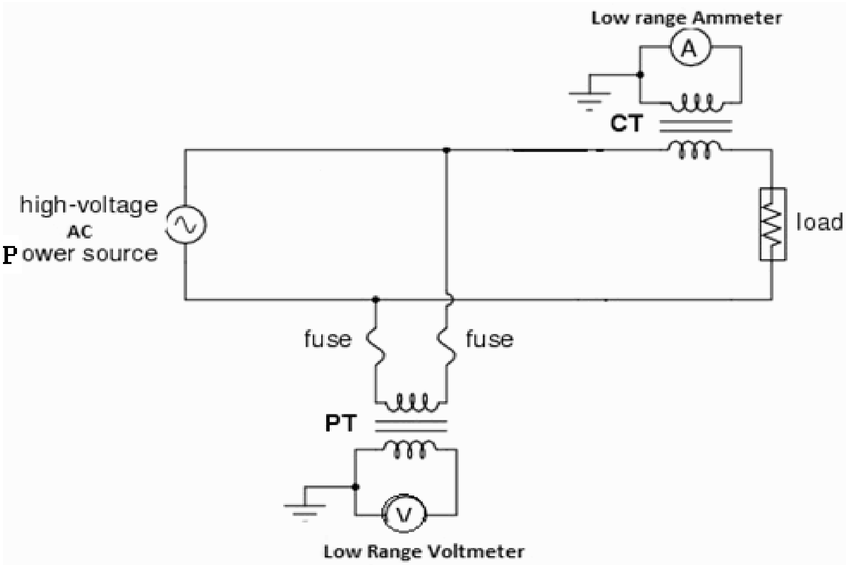
6 a) Ans:

Aim of conducting phasing out test is to identify the windings (primary and secondary of corresponding phase) placed on each core limb of the three phase transformer. 2 marks

Aim of conducting the polarity test is to identify the terminals of identical polarity of the primary and secondary windings of each phase of the transformer. 2 marks

6 b) Draw circuit diagram of connected CT and PT in the power circuit.

6 b) Circuit diagram for P.T and C.T.:



2 marks for C. T. connection

2 marks for P. T. connection

6 c) Describe the features of isolation transformer.

6 c) Ans:

1) This Transformer has a ratio of 1:1. The primary and secondary windings isolate & protect secondary circuits.
2) Special insulation is provided between primary & secondary.
3) It blocks transmission of the DC component in signals from one circuit to the other, but allow AC components in signals to pass.
4) It reduces the voltage spike greatly that gets applied on the primary before getting transformed to the secondary side thus protecting the loads.
5) As neutral on primary side is grounded sometimes with ungrounded secondary side the load is removed from ground to avoid accidents.
6) Grounding of equipment can cause ground loop interference & noise in connected systems, hence ungrounded secondary avoids such interferences.
7) Most suited for power supplies of sensitive equipment such as computers, medical devices, or laboratory instruments by using electrostatic shield.

1 mark each any four = 4 marks.

6 d) List the advantages of instrument transformers

6 d) Ans:

1) Measuring higher or directly unsafe values of current, voltage, power and energy safely.
2) Operating many types of relays of protection systems and pilot lights.
3) Their use results in use of safe low/normal range instruments as ammeters, voltmeters, wattmeters & energy meters.
4) The rating of the low range meter can be fixed irrespective of the high value of the parameter to be measured.
5) Several instruments can be fed economically from a single instrument

1 mark each any four = 4 marks.

transformer of relevant capacity.

6) Costs of measuring instruments get reduced.
7) Multi-core CTs are used for measurement & protection purpose.

6 e) Describe working of welding transformer.

6 e)

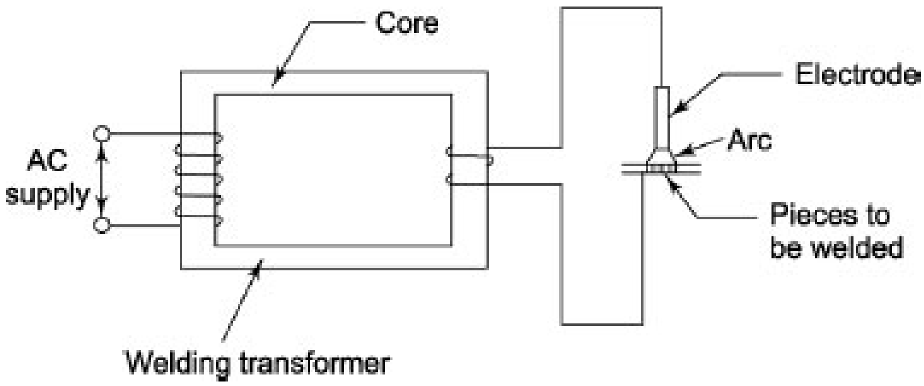


Fig 2 marks

Ans:

Working 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) Winding used is highly reactive or a separate reactor winding is added in series with the secondary winding.

iii) Having large & thin primary turns and low number but thick secondary turns.

Working 2 marks

iv) The secondary current is quite high. One end of secondary is connected to welding electrode while other end to the pieces to be welded.

v) Due to the contact resistance 'R' between the electrode and pieces to be welded a very high current flows creating high heat by I^2R that melts the tip of the electrode. The melted tip flows/fills the gap between the pieces to be welded creating a solid weld on cooling.

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

vii) 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:

Primary voltage – 230 V, 415 V
Secondary voltage – 40 to 60 V
Secondary current – 200 to 600 A

6 f) Compare single phase autotransformer with two winding transformer on basis of construction, copper loss, cost and weight.

6 f) Ans:

Point	Two winding transformer	Auto transformer
Construction	Different primary & secondary winding = 2 windings	Primary & secondary turns in same winding = 1 winding only.
Copper losses	More as more copper conductor used.	Lower
Cost	More costly for same capacity	Less cost
Weight	More due to more copper (2 windings) & core (larger window area).	Less due to less copper & core.

1 Mark each