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 TEN of the following:	20

1 a) State Fleming's Right Hand Rule — 2 M

Ans: 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.

1 b) Why poles of dc machine are laminated? — 2 M

Ans: Poles of DC machines are laminated to reduce the eddy current losses in the poles.

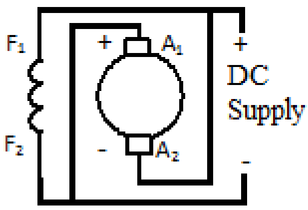
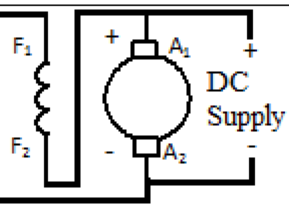
1 c) State the principle of operation of d.c. motor.

Ans: When a current carrying conductor is placed in a magnetic field, the conductor experiences the force. The magnitude of force is given by F = BIL newton — 2 M

where F – Force
B – maximum flux density
I – Current
L – Length of conductor

1 d) Give two methods to change direction of rotation of d.c. motor.

Ans:

(i) By reversing direction of only Armature current	(ii) By reversing the direction of only field current
	

1 M each

1 e) Name the d.c. motors suitable for:

(i) Cranes, (ii) Hoists, (iii) Paper machines, (iv) Punches

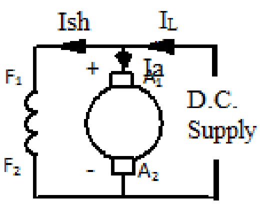
Ans:

(i) Cranes	D.C. Series motor.
(ii) Hoists	D.C. Series motor.
(iii) Paper machines	D.C. Shunt motor.
(iv) Punches	Cumulative compound motor

½ M each

1 f) Draw the neat connection diagram of dc shunt motor showing the direction of all currents.

Ans:



D.C. Shunt motor

2 M for correct diagram

1 M without direction of current

1 g) Define the transformation ratio in terms of current and voltage.

Ans : (i)Transformation Ratio = $\frac{\text{Primary Current}}{\text{Secondary Current}} = \frac{I1}{I2} = K$ — 1 M each

(ii) Transformation Ratio = $\frac{\text{Secondary Voltage}}{\text{Primary Voltage}} = \frac{V2}{V1} = K$

1 h) A 50 kVA transformer has 800W of copper loss on full load. Calculate its copper loss at 50% full load. — 2 M

Ans: Copper loss at any fraction ‘x’ of full load = x^2 Copper loss at full load

Copper loss at 50% FL = $(0.5)^2 * 800 = 200$ Watts.

1 i) Define commercial efficiency and all day efficiency of a transformer.

Ans:

(i)Commercial Efficiency : It is the ratio of output power in watts to the Input power in watts

OR

$$\text{Commercial Efficiency} = \frac{\text{Output in kW}}{\text{Input in kW}}$$

(ii)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. — 1 M each

OR

$$\text{All Day Efficiency} = \frac{\text{Output energy in kWh in 24 hrs}}{\text{Input energy in kWh in 24 hrs}}$$

1 j) Compare core type transformer and shell type transformer on following parameters:

(i) No. of windows, (ii) Type of winding used — 1 M for each parameter

Ans:

Parameter	**Core type**	**Shell type**
No. of windows	One	Two
Type of winding used	Cylindrical type	Sandwich type

1 k) Compare a bank of three single phase transformer with three phase transformer on the following points:

(i) No. of cores, (ii) Space occupied, (iii) Weight, (iv) If one of the phases is inoperative

Ans: — ½ M for each parameter

Parameter	Bank of 3 single phase transformer	Three phase transformer
(i)No. of cores	Three	One
(ii)Space occupied	More	Less
(iii)Weight	More	Less
(iv)If one of the phase is inoperative	Used as a reduced voltage open delta or V-V type transformer	Inoperative

1 l) State any two conditions for parallel operation of 3-phase transformer.

Ans: Conditions for Parallel operation of 3 ph transformer

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

1 M each (any two)

2 Attempt any FOUR of the followings 16

2 a) State at least one function and the material used for the following parts of dc generator: (i) Yoke, (ii) Field winding, (iii) Commutator, (iv) Brushes

Ans:

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 uniform 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 for generator & supply current in motors.	Carbon

½ M for function and ½ M for material of each part

2 b) A 4-pole generator having wave wound armature winding has 51 slots, each slot containing 20 conductors. What will be voltage generated in the machine when driven at 1500 rpm assuming the flux per pole to be 7.0 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

Z= 1020

EMF equation of Generator : $E_g = \frac{PZ\Phi N}{60A}$ Volts 2 M

E_g = 357 Volts. 2 M

2 c) What is back emf? Also explain its significance in DC motor.

Ans :

Back EMF: When a current carrying conductor is placed in a magnetic field it experiences a force; when it moves due to the force it (conductor) cuts the magnetic field due to which an emf is induced in it. According to Lenz's law the effect of induced emf is to oppose the cause of it. The armature current (hence the applied armature voltage) is opposed by the induced emf which is therefore called as Back emf. 2 M

SIGNIFICANCE OF BACK EMF IN D.C. MOTOR:-

Since the back e.m.f. opposes the applied voltage across the armature, the net voltage acting in the armature circuit is the difference between the two (i.e. $V-E_b$), this effective voltage which determines the value of armature current (I_a). 2 M

If R_a is the armature resistance, then from Ohm's law, $I_a = (V-E_b)/R_a$ amperes.

In the running condition, E_b is nearly equal to V. As the internal resistance of the armature of a d.c. motor being very low, it is the back e.m.f. which **mainly limits the armature current** in the running condition of the motor.

2 d) A 230V dc shunt motor has field resistance of 230 ohm and armature resistance of 0.25 ohm, running at 1500 rpm, taking 20A from the supply. When a resistance of 230 ohm is added in series with field circuit, the torque remains unchanged. Find speed and current taken at this condition.

Ans:

We know $\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{Ish_1}{Ish_2}$

$Ish_1 = 230V/230\Omega = 1A$

$Eb_1 = V - Ia_1R_a = 225.25V$ 1 M

Torque remains unchanged ------- Condition given

$Ta_1 = Ta_2$

$\Phi_1 Ia_1 = \Phi_2 Ia_2$

$Ia_2 = Ia_1 * (Ish_1 / Ish_2)$ assuming flux is directly proportional to the field current (saturation not reached).

$Ish_2 = (230V / (230+230)\ \Omega) = 0.5A$ 1 M

$Ia_2 = 38A$

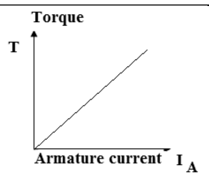
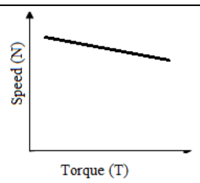
$Eb_2 = V - Ia_2R_a = 220.5V$ 1 M

Using above equation $N_2 = 2936.73$ RPM 1 M

2 e) Draw and explain the following characteristics of DC shunt motor:

(i) Torque vs Armature current, (ii) Speed vs Torque

Ans:

<table>
<tr><th>Torque Vs Armature current</th><th>Speed Vs Torque</th></tr>
<tr><td>
</td><td>
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1 M for each characteristic

$T_a \propto \phi . I_a$ Field current is constant Flux is also constant Therefore $T_a \propto I_a$ Hence the characteristic is straight line passing through zero.	-Curve obtained by plotting N and T for values of armature current - It may be seen that the speed falls somewhat as torque increases	1 M for each explanation

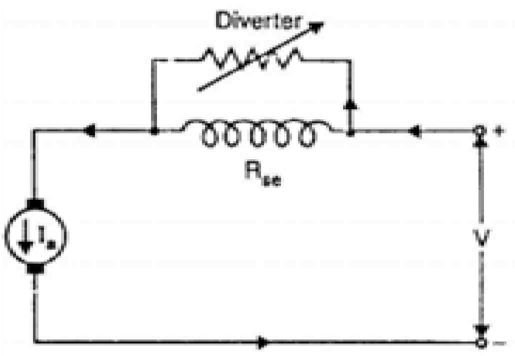
2 f) Explain with the help of neat diagram the following methods of speed control for DC series motor: (i) Field Diverter method, (ii) Tapped field method

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.

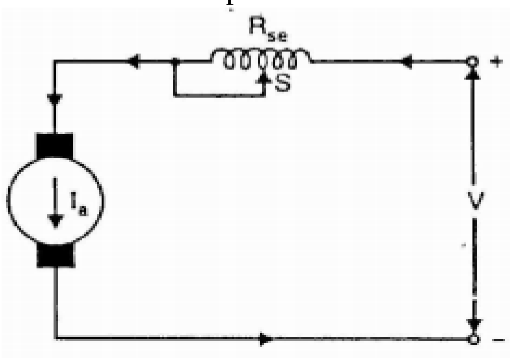
1 M for diagram
1 M for explanation



(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.

1 M for diagram
1 M for explanation



3 Attempt any FOUR of the followings 16

3 a) Derive the emf equation of a transformer.

Ans:

Emf equation of transformer:

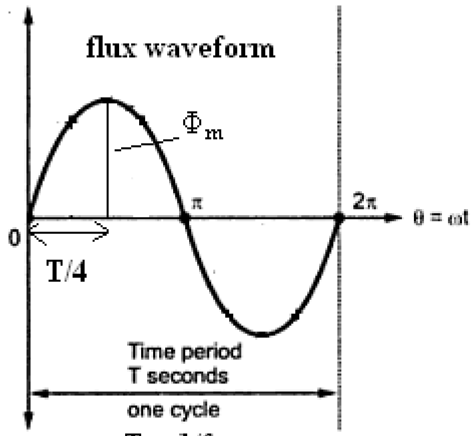
N_1 = No. of turns on primary winding

N_2 = No. of turns on secondary winding

Φ_m= maximum value of flux linking both the winding in Wb

F = Frequency of supply in Hz

1st method



T = 1/f 1 M

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 1 M

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

Form factor = (RMS value)/(Avg. value) = 1.11 1 M

R.M.S. emf induced in each turn = 1.11 x Avg. value = 1.11 x 4Φ_mf

= 4.44 Φm f volts

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 M

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

OR **2nd method** **OR**

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

According to Faraday's laws of electromagnetic induction

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

$= -\omega\Phi_m\cos(\omega t)$ 1 M

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

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

But $\omega = 2\pi f$

Max. value of emf /turn =$2\pi f\ \Phi_m$ 1 M

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

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

E_2= 4.44 $\Phi_m f\ N_2$ volts

3 b) 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.

The primary of the transformer is connected to 440V, 60 Hz supply.

Ans:

$E_1 = 4.44 B_m A f N_1$ volts

Substituting the values

$A = 5.55 \times 10^{-3} m^2$. — 2 M for area

Also $\frac{V_2}{V_1} = \frac{N_2}{N_1}$ — 2 M for emf

$V_2 = 1100$ Volts

3 c) Explain with neat diagram, 3-phase to 2-phase conversion (scott connection) of 3-phase transformer.

Ans:

Scott connection of transformers:

Used for three phase to two phase conversion when two phase loads such as furnaces/ electric traction of large ratings are to be used so that the large load gets distributed equally on the three phases to have balanced load condition.

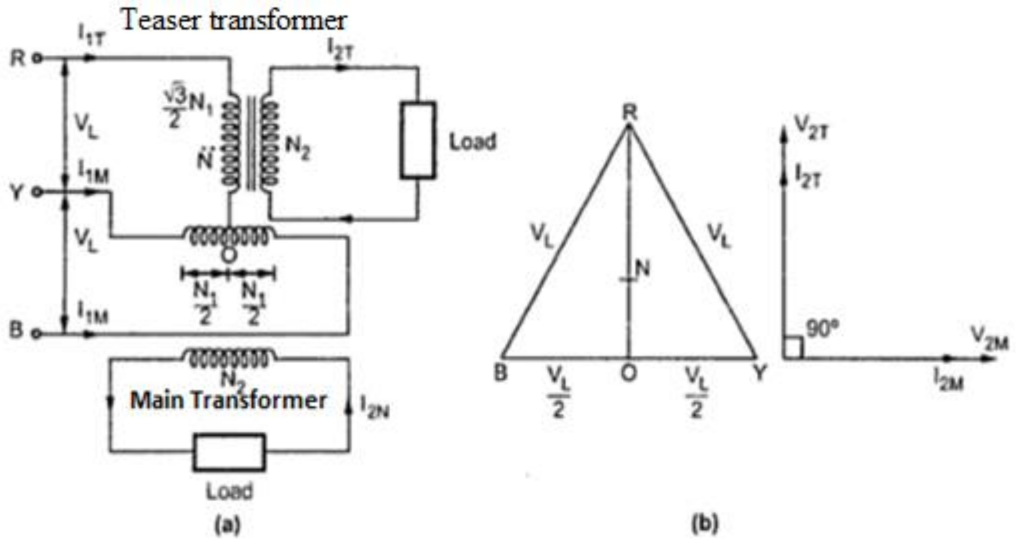


Figure (or equivalent) 2 Marks

-Can also be used for two phase to 3 phase transformation. Two transformers which have turns rated as shown are used.

-Teaser transformer primary has √3/ 2 times the turns of main primary. But volt per turn is same.

-The secondary's have same turns.

- The main transformation ratio is N_2/N_1 and that of teaser is 1.15 N_2/N_1 .

- If the Load is balanced on one side , It is balanced on other side also.

- Under balanced load condition, main transformer rating is 15 % greater than teaser.

2 Marks (description)

- The currents in either side of two halves of main primary are the vector sum of KI_{2M} and 0.58 KI_{2T}.

3 d) Explain why rating of transformer is in kVA and not in kW?

Ans:

1) The output of transformer is limited by heating due to the losses.
   Two types of losses in the transformer (i) Iron loss, (ii) Copper loss.
2) Iron loss depends on the transformer voltage (V). — 1 M for each
   Copper loss depends on transformer current (I).
3) As the losses depends on Voltage (V) and Current (I) and
4) Almost unaffected by load power factor.
   - Hence the transformer output is expressed in VA or kVA and not in kW.

3 e) State the different types of losses occurring in a transformer. Give their location and also suggest remedies to minimize these losses.

Ans :

Losses	Location	Remedies to minimize losses
(1) Copper loss	`Primary and Secondary windings of transformer.	By reducing the resistance of primary and secondary windings.
(2) Iron loss (a) Hysteresis loss	In the iron core of transformer	By selecting proper magnetic material for core such as silicon steel
(b) Eddy current loss		Using laminated core of transformer

Types – 1 M each (any two types)

½ M for location of each type

½ M for remedy of each

3 f) A 400/100V transformer takes a no load current of 5A at 0.2 lagging pf. Secondary winding supplies a load of 100A at 0.8 pf lagging. Find the primary input current.

Ans: $$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{100}{400} = \frac{1}{4}$$

$I_0 = 5A$, $\cos\Phi_0 = 0.2$ hence $\sin\Phi_0 = 0.98$

$I_2 = 100A$, $\cos\Phi_2 = 0.8$ hence $\sin\Phi_2 = 0.6$ — 1 M

Therefore for load component I'_1 of primary current corresponding to I_2,

$I'_1 N_1 = I_2 N_2$,

$I'_1 = 25A$ — 1 M

$I_1\cos\Phi_1 = I'_1\cos\Phi_2 + I_0\cos\Phi_0 = 21A$

$I_1\sin\Phi_1 = I'_1\sin\Phi_2 + I_0\sin\Phi_0 = 19.9A$ — 1 M

Primary input current $I_1 = \sqrt{[(I_1\sin\Phi_1)^2 + (I_1\cos\Phi_1)^2]} = 28.93A$ — 1 M

4 Attempt any FOUR of the followings — 16

4 a) A 25 kVA, 4000/200V, 50Hz transformer has R_1=3.45Ω, R_2= 0.009Ω, X_1=5.2Ω and X_2=0.051Ω. Calculate the equivalent resistance and reactance referred to (i) Primary, (ii) Secondary.

Ans:

$K = V_2/V_1 = 0.05$

(i)Equivalent resistance referred to primary side

$R_{01} = R_1 + R'_2 = R_1 + (R_2/K^2) = 7.05\ \Omega$ 1 M

$X_{01} = X_1 + X'_2 = X_1 + (X_2/K^2) = 25.6\ \Omega$ 1 M

(ii)Equivalent resistance referred to secondary side

$R_{02} = R_2 + R'_1 = R_2 + (R_1 * K^2) = 0.017625\ \Omega$ 1 M

$X_{02} = X_2 + X'_1 = X_2 + (X_1 * K^2) = 0.064\ \Omega$ 1 M

4 b) A 600kVA 1-phase transformer when working at unity pf has an efficiency of 92% at full load and also at half load. Determine its efficiency when it operates at unity pf and 60% of full load.

Ans : $\eta = \dfrac{(x)KVA(\cos\Phi)}{(x)KVA(\cos\Phi) + P_i + x^2 P_C}$

Assume all powers losses in kW

At Full load : x=1, η = 0.92, cos Φ = 1 ………… Data given

0.92Pi + 0.92Pcu = 48 ---------- Eq(1) ½ M

At half load : x=0.5, η = 0.92, cos Φ = 1 ………… Data given

0.92Pi + 0.23Pcu = 24 ---------- Eq(2) ½ M

Solving Eq (1) and (2)

Pcu = 34.782 kW = 34782.60 W 1 M

Pi = 17.39 kW = 17391.30 W 1 M

Therefore η at 60% full load at unity pf is

η = 92.32% 1 M

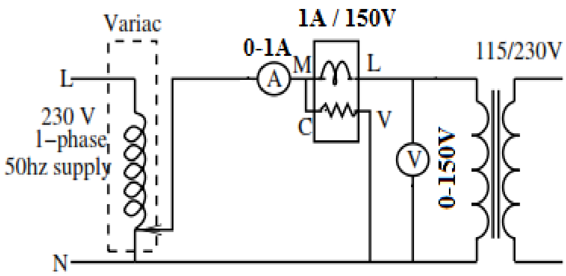
4 c) For 1 kVA, 230/115V, 50 Hz, 1-phase transformer, draw experimental setup to conduct open circuit test on it. Determine the range of instruments to be used for their OC test.

Ans : **Range of instruments :**

- Open circuit test conducted by keeping HV side open circuited.
- Voltmeter, wattmeter and ammeter are connected on LV side.
- **Voltmeter reads rated voltage hence Range of voltmeter is 0-150V**
- Ammeter reads no-load or exciting current.
- No-load or exciting current is 2% - 6% of Full load current
- $I_{FL(LV)}$ = 8.69A Ie = 0.52 A (6% of FL current).
- **Range of Ammeter is 0-1A.**
- **Range of Wattmeter is 1A / 150V.**

½ M for voltmeter range
1 M for ammeter range
½ M for wattmeter range

Experimental Setup :



Set up drawing - 2 M

4 d) A 5 kVA, 250/500V, 50 Hz 1-phase transformer gave following test results :
No load : 250V; 0.75A; 60 W (LV side)
Short circuit : 9V; 6A; 21.6 W (HV side)
Calculate the equivalent circuit components and insert them on the diagram.
Ans:

From OC test (LV side)

$Cos\Phi_0 = W_0 / (V_1 * I_0) = 0.32$ and $Sin\Phi_0 = 0.947$.

$Ic = I_O \cos \Phi_0 = 0.24$ A and $Im = I_O \sin \Phi_0 = 0.71$ A.

$\mathbf{R_0 = V_1 / I_c = 1041.67\ \Omega}$ 1 M

$\mathbf{X_0 = V_1 / I_m = 352.11\ \Omega}$

From SC test :

$R_2 = Wsc / I^2_{sc} = 0.6\ \Omega$

$Z_2 = Vsc / Isc = 1.5\ \Omega$

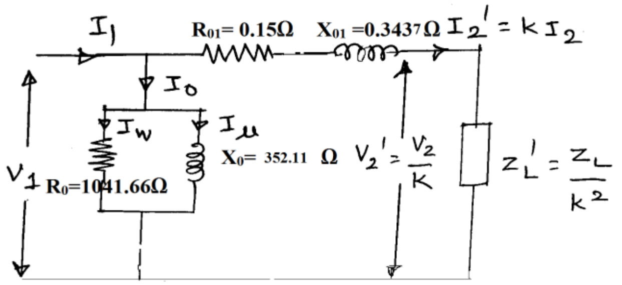
And $X_2 = \sqrt{[(Z_2)^2 - (R_2)^2]} = 1.375\ \Omega$

Transformation ratio K = 500/250 = 2, refer circuit to LV side, 1 M

$\mathbf{R_{01} = (R_2/K^2) = 0.15\ \Omega}$

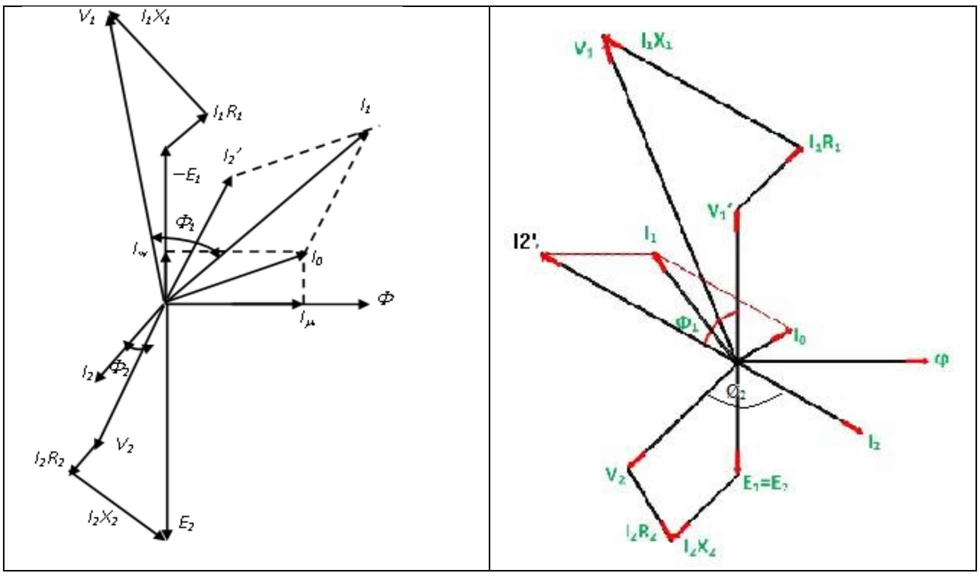
$\mathbf{X_{01} = (X_2/K^2) = 0.34375\Omega}$ 1 M

Equivalent Circuit :



Equivalent circuit – 1 M

4 e) Draw the complete phasor diagram of transformer at load of :
(i) 0.8 pf lagging; ($Ø_2 = -36.8^O$) (ii) 0.8 pf Leading. ($Ø_2 = +36.86^O$)
Ans:



2 M for lagging pf

2 M for leading pf

4 f) Derive the condition for maximum efficiency of transformer.

Ans : $\eta = \frac{V_2 I_2 (\cos\Phi_2)}{V_2 I_2 (\cos\Phi_2) + P_i + I_2^2 R_2}$ 1 M

- In above equation Pi is constant and V_2 is practically constant.
- At specified value of load p.f. $\cos\Phi_2$ the efficiency is maximum when $d\eta/dI_2 = 0$.

$$\frac{d\eta}{dI_2} = \frac{d}{dI_2}\left[\frac{V_2 I_2 (\cos\Phi_2)}{V_2 I_2 (\cos\Phi_2) + P_i + I_2^2 R_2}\right] = 0$$ 1 M

Solving the above equation 1 M

$P_i - I_2^2 R_2 = 0.$

$I_2^2 R_2 = P_i$ 1 M

Copper loss = Iron loss --------------- Condition for Maximum efficiency.

5 a) In 20 kVA, 1000/400 V, 1-ph, 50Hz transformer, iron and full load copper loss are 300 W & 500W respectively. Calculate the effiency at:

i) Full load and 0.8 pf lagging and
ii) Half load and unity p.f.

Ans: Given T/F rating 20 kVA, 1000/400V, 1ph, 50Hz.
F.L.Cu loss= 500W Iron Loss= 300W,
Total full load losses= 800W= 0.8kW

i) F.L. % η at 0.8pf lagging
= O/P * 100 / (O/P+ Total losses)
= kVA* p.f* 100 / (kVA* p.f+ Total losses) 1 Mark
= 20*0.8*100 /[(20*0.8)+ 0.800]
= 95.23 % 1Mark

ii) Half Load % η at unity p.f. (Half load Cu loss= ¼*500= 125W=0.125kW) 1 Mark
= O/P * 100 / (O/P+ Total losses)
= kVA* p.f* 100 / (kVA* p.f+ Total losses)
= 10*100 / (10+ 0.425) 1 Mark
= 95.9 %

5 b) The total full load loss of a 150kVA transformer is 4.5kW which is divided eually between iron and copper loss. The transformer is loaded as follows during the 24 hours of the day. Calculate the all day efficiency.

No.of hours	Loading
3 hours	Full load
4 hours	Half load
17 hours	No load

Assume pf to be unity throught the day.

Ans: Given 150kVA T.F Total loss= 4.5kW equally loaded
(Iron loss= 2.25kW Cu loss= 2.25kW)
Cu loss at F.L.= 2.25kW Cu loss at half load= (1/4 * 2.25) = 0.5628kW
Iron loss= 24 * 2.25= 54 kWh 1 Mark
F.L. Cu loss (energy) for 3 hours = 3*2.25 = 6.75kWh
H.L. Cu loss (energy) for 4 hours = 4* 0.5625 = 2.25kWh
Total Cu loss (energy) = 6.75+ 2.25 = 9.00 kWh 1Mark
O/P in kWh for 24hrs = (150*3+75*4+0)=750 kWh

$$\eta_{all\ day} = \frac{\text{Output in kWh*100}}{\text{Input in kWh}}$$ 1Mark

$$= \frac{750*100}{(750+63)}$$

$$= 92.25\ \%$$ 1Mark

5 c) Two single phase transformers A and B rated at 250 KVA each are operated in parallel on both sides. Percentage impedances for A and B are (1 + j6) ohm and (1.2 + j4.8) respectively. Compute the load shared by each when the total load is 500 KVA at 0.8 p.f. lagging.

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- $Z_A = 1 + j6 = 6.08\angle 80.53$, $Z_B = 1.2 + j4.8 = 4.94\angle 75.96$ 1 Mark
$Z_A + Z_B = 2.2 + j\,10.88 = 11.02\angle 78.48^o$. 1Mark
We know that,

$S_A = S * Z_B/(Z_A+Z_B)$
$= 500\angle -36.9^o * 0.45\angle -2.5^o$ 1 Mark
$= 225\angle -39.4^o$ kVA

$S_B = S * Z_A/(Z_A+Z_B)$
$= 500\angle -36.9^o * 0.55\angle 2.05^o$
$= 275\angle -34.85^o$ kVA 1 Mark

5 d) 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: 585-19627 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 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 (Dyn 11 or Dyn 1) is to be specified depending upon requirements of parallel operation.

1/2 mark for each(at least four)

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

OR

i) Tariff applicable to consumers covered.
ii) Standard sizes available to cover the loads specified.
iii) Easy availability of spares when needed.
iv) Distribution transformer must be such that it is loaded around 70 to 80 % of its rating.
v) Types of loads to be supplied (as motor loads, furnaces, single phase domestic, etc.)

½ mark each any four = 2 marks

ii) Selection Criteria for Power transformer:

i) 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 requiring to be operated in parallel, the voltage ratio should be selected in accordance with guidelines given in 12.0.1 & 12.0.1.1 of IS : 10028 (Part l)-1985 — ½ mark for each(at least four)

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

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

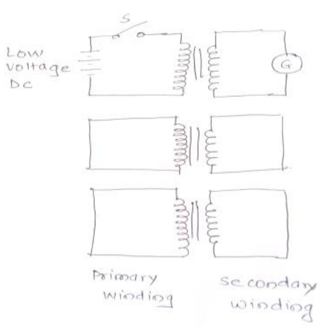
iv)Impedance – The transformer impedance is decided taking into consideration the secondary fauly levels and voltage dip. The typical values are given in table 3 of IS:2026.

iv)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.

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

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

Ans:



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

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

iii) Low voltage DC supply is given to primary winding. The galvanometer is connected to terminals of secondary winding which is not short circuited. — 2 mark

iv) The switch 'S' is connected as shown in fig. When switch is closed deflection of galvanometer is observed.
v) Similarly galvanometer is connected to other secondary terminals and procedure is repeated. The winding across which maximum deflection occurs is the secondary phase winding that corresponds to primary winding to which source is connected.
vi) The procedure is repeated for remaining primary windings.
vii) Phasing out test can be carried out by using AC voltage source also. Voltmeter is connected at secondary terminals to observe deflections. 1 mark
The purpose of this test is to check the respective phases of primary & secondary windings in 3-ph transformer

5 f) Identify the following vector group.
Dd0, Dy5, Yy6, Yz11

Ans:

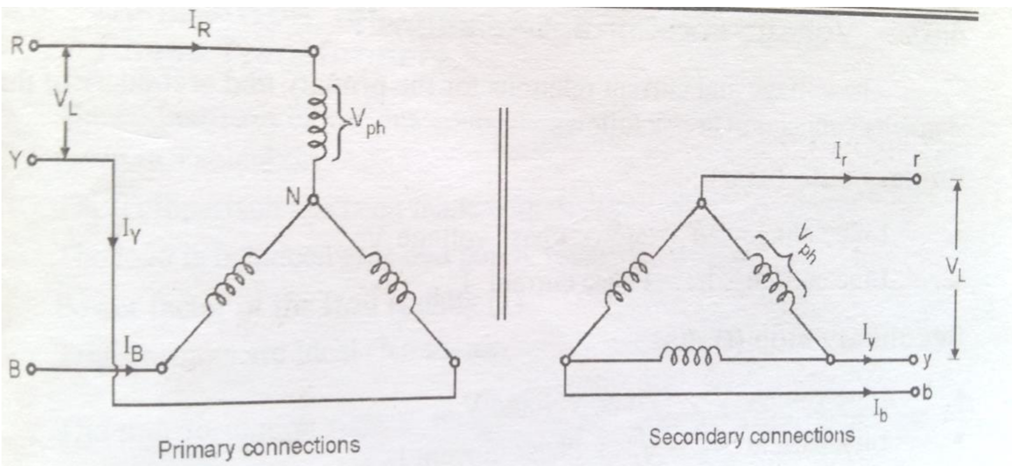
Dd0	Delta-Delta configuration with 0^0 phase shift between HV side phase voltage & LV side phase voltage.
Dy5	Delta-Star configuration with HV side phase voltage leading LV side phase voltage by 150^0 ($=5*30^0$)
Yy6	Star-Star configuration with HV side phase voltage leading LV side phase voltage by 180^0 ($=6*30^0$)
Yz11	Star-Zigzag configuration with HV side phase voltage lagging LV side phase voltage by 30^0.

1 Mark Each

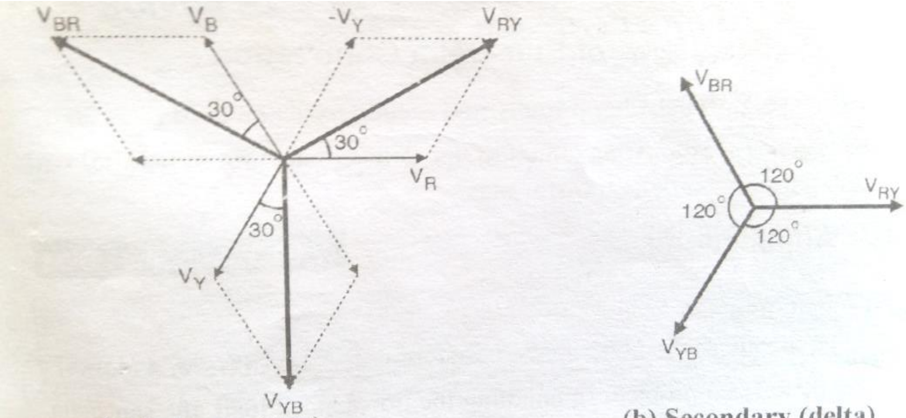
6 Attempt any FOUR of the following: 16

6 a) Draw the connection diagram and phasor diagram for Star-Delta, three phase transformer. Give any two advantages of this connection.

Ans:



1.5 mark



(a) Primary (star) (b) Secondary (delta)

1.5 mark

Advantages:

i) Due to secondary in delta, large unbalanced load can be properly handled.

ii) Due to primary in Star less No. of turns are required to be wound. This reduces cost and size.

iii) It is possible to reduce the third harmonic distortion by connecting primary neutral point to ground.

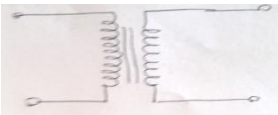
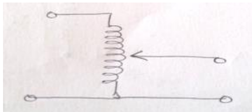
iv) Commonly used for step down transformer at receiving end sub-stations.

Any two ½ mark each

6 b) Compare two winding transformer with auto transformer on the following parameters.

i) Movable contact ii) Symbol
iii) Copper saving iv) Electrical Isolation
v) Cost vi) Efficiency
vii) Regulation vii) One application each

6 b) Ans:

Parameters	TWO- WINDING TRANSFORMER	AUTO TRANSFORMER
Movable contact	No movable contact	movable contact
Symbol		
Copper saving	None	Cu saving takes place
Electrical Isolation	Yes	No
Cost	More	Less
Efficiency	Less than Auto T/F	More than Two-winding T/F
Regulation	Poor than Auto T/F	Better
One application each	Main T/F, power supply, welding, Isolation T/F	Variac, Starting of motor, dimmerstat

½ Mark Each

6 c) Explain why should a current transformer is never operated with an open secondary

Ans:
i)The secondary winding of C.T. has a large no. of turns of thin wire.

ii) The secondary winding of C.T. should never be open circuited, otherwise there will be no secondary mmf. 1 mark

iii)These secondary mmf oppose primary mmf and as there is no secondary mmf the opposition is zero. Primary mmf will produce a large flux in core.

iv)It would produce high eddy current and hystresis losses. 1 mark

v) It would increase the temperature of the core which may result in damage of insulation & core. 1 mark

vi) High voltage will be induced in open circuited secondary and this may be dangerous to the equipment and personnel. 1 mark

6 d) Describe the method of measurement of high voltage in an a.c. circuit using potential transformer.

Ans:
Use of PT:

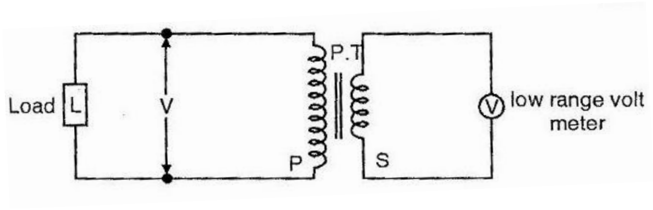


Diagram 2 Mark

- "V" is the voltage to be measured which is very high.
- Use to read high voltages on low range voltmeters.
- PT is two winding step down transformer.

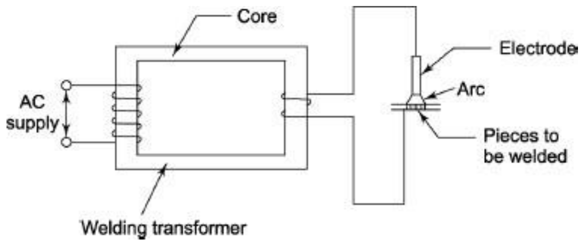
The actual value of high voltage under measurement

= Reading of low range meter *nominal ratio of P.T.

Description 2 Mark

6 e) Draw a neat diagram of welding transformer. Also state any two special features of welding transformer.

Ans:



2 Marks

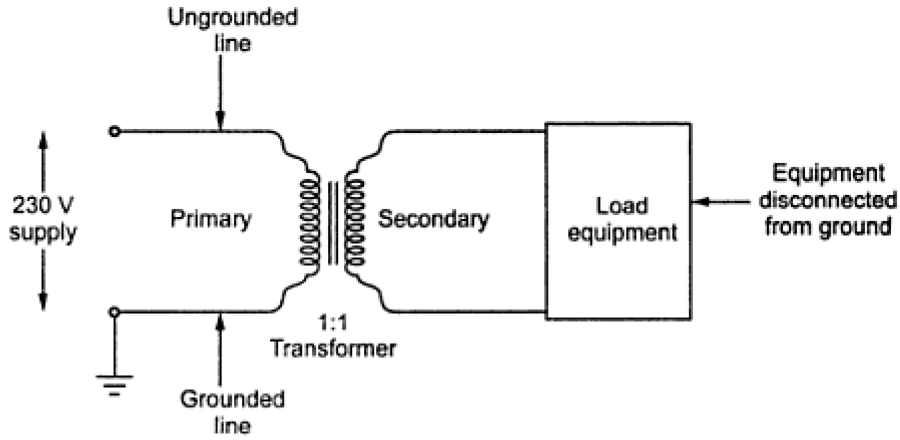
Special features of welding transformer:

- 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.
- Having large primary turns and less secondary turns.
- The secondary current is quite high.
- The secondary has several taps for adjusting the secondary voltage to control the welding current.
- The transformer is normally large in size compared to other step down transformers as the windings are of a much larger gauge.
- Common ratings:
- Primary voltage – 230 V, 415 V
- Secondary voltage – 40 to 60 V
- Secondary current – 200 to 600 A

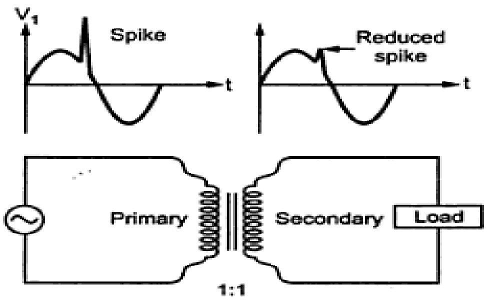
1/2 Mark each (any Four)

6 f) Explain two functions of isolation transformer.

Ans:
i) Disconnect the load equipment from supply ground:
Sometimes it is essential to disconnect the load equipment such as the cathode ray oscilloscope (CRO) from the supply ground. 2 mark
Sensitive and costly equipment are needed to be disconnected from supply ground to protect from noisy ground connection.



ii) Reduction of voltage spikes
Voltage spikes are short duration high amplitudes pulses which get superimposed on the ac supply.
These are dangerous to delicate equipments. 2 mark
Isolation transformer reduces the amplitude of spike.



The load is sensitive equipment