# B.Tech.

## Third Semester Examination

# Electrical Machines-I (EE-207-F)

**Note : Attempt any five questions. All questions carry equal marks.**

**Q. 1. (a) Define voltage regulation of a transformer and derive condition for maximum regulation.**

**Ans. Voltage Regulation and Condition for Maximum Regulation :** It is defined as the ratio of charge output voltage from no load to load to the no load voltage.

$$\text{Percentage Regulation} = \frac{E_2 - V_2}{E_2} \times 100$$

$E_2$ = No load terminal voltage

$V_2$ = Load termi nal voltage

$$= \frac{I_2 R_{02} \cos\phi \pm X_{02} \sin\phi}{\text{No load rated secondary voltage}}$$

Regulation will be maximum if $\frac{d}{d\phi}$ (regulation) $= 0$

$$\frac{d}{d\phi} \frac{I_2 R_{02} \cos\phi + I_2 X_{02} \sin\phi}{E_2} = 0$$

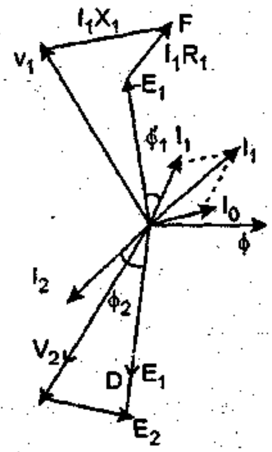
$$= \frac{-I_2 R_{02}}{E_2} \sin\phi + \frac{I_2 X_{02}}{E_2} = 0$$

$$\therefore \quad \tan\phi = \frac{X_{02}}{R_{02}}$$

**Q. 1. (b) Develop the phasor diagram of a single phase transformer under load condition. Assume lagging p. f. load.**

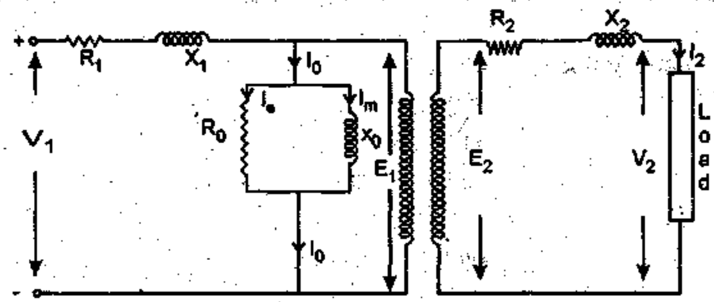
**Ans.** Phasor diagram of transformer on load condition and lagging power factor

Fig. shows phasor diagram of a transformer on Inductive load with various voltage drops in primary as well as secondary side.



**Q. 1. (c) Derive the equivalent circuit parameters of transformer from its equivalent circuit model.**

**Ans. Equivalent Circuit of Transformer and Parameters :**




Equivalent circuit is simply a circuit representation of the equations describing the performance of the device.

$R_1$ = Primary winding resistance

$R_2$ = Secondary winding resistance

$X_1$ = Primary winding reactance

$X_2$ = Secondary winding reactance

**From S.C. Test :** $R_{eq} = \frac{W_s}{I_s^2}$

$$R_{eq} = \frac{V_s}{I_s}$$

$$X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$$

**From O.C. Test :** $R_0 = \frac{V_i}{I_e} = \frac{V_1^2}{P_0}$

$$X_0 = \frac{V_1}{I_m} = \frac{V_1}{\sqrt{I_0^2 - I_e^2}}$$

**Q. 2. (a) Describe the tests on a 1-$\phi$ transformer that gives its ohmic losses & core losses.**

**Ans. Test on 1-$\phi$ Transformer :**

**(i) Polarity Test** : Polarity test is performed to determined the terminals having the same instantaneous polarity.

**(ii) Voltage Ratio Test :** This test is performed to determine the turn ratio of the transformer.

**(iii) Open Circuit Test :** The purpose of this test is to determine the core losses $P_i$ and no load current $I_0$ and thereby shunt branch parameter $R_0$, $X_0$ of the equivalent circuit.

**(iv) Short Circuit Test :** The purpose of this test is to determine full load copper losses and equivalent resistance.

**(v) Sumpner Back to Back Test :** This test is also used to calculate the efficiency and regulation of the transfomer.

**Q. 2. (b) A 40 KVA single phase transformer has iron losses of 800 W & Cu loss of 1140 W when supplying its full load at unity p.f. calculate the efficiency of transformer at v. p. f. full load & half load.**

**Ans.**

Input Power $= 40 \text{ KVA} \times 1.0 = 40 \text{ kW}$

Input Losses $= 800 \text{ W}$

Copper Losses $= 1140 \text{ watt}$

Output Power $= 40 \text{ kW} - 800 \text{ kW} - 1140 \text{ W}$

$= 38060 \text{ watt}$

$$\eta = \frac{\text{output}}{\text{input}} = \frac{38060}{40000} = 95.15\ \%$$

At half load

Iron Losses : 800 W

Copper Losses $= (1/2)^2\, 1140 = 285 \text{ watt}$

$\therefore$
$$\eta = \frac{\text{Input power} - \text{Copper Losses} - \text{Input Losses}}{\text{Input Poswer}}$$

$= 97.25\ \%$

**Q. 3. (a) Derive an expression for saving in conductor material in an auto transformer over a two winding transformer of equal rating.** **10**

**Ans. Auto Transformer Saving in Conductor Material :** The x section of conductor is proportional to the current to be carried and length of the conductor in a winding is proportional to the number of turns. Hence the weight of conductor material in the winding being proportional to the product of cross sectional area.

In an ordinary transformer the total weight of conductor material required is proportional to

$$(N_1 I_1 + N_2 I_2) \propto 2\, N_1 I_1 \text{ because } N_2 I_2 = N_1 I_1$$

The top section AC has $(N_1 - N_2)$ turus and carries a current $I_1$ and bottom section has turns $N_2$ and carries a current $I_2 - I_1$

$$\left[\left[N_1 - N_2\right] I_1 + N_2 \left[I_2 - I_1\right]\right] \text{or} \left[\left(N_1 - N_2\right) I_1 + N_2 I_2 - N_2 I_1\right] \text{or}$$

$$\left(N_1 - N_2\right) I_1 + N_1 I_1 - N_2 I_1] \text{ or } 2\left(N_1 - N_2\right) I$$

$$\frac{\text{So weight of conductor in auto transformer}}{\text{Weight of conductor in two winding transformer}} = \frac{2\left(N_1 - N_2\right)}{2\, N_1 I_1} = \frac{1 - N_2}{N_1}$$

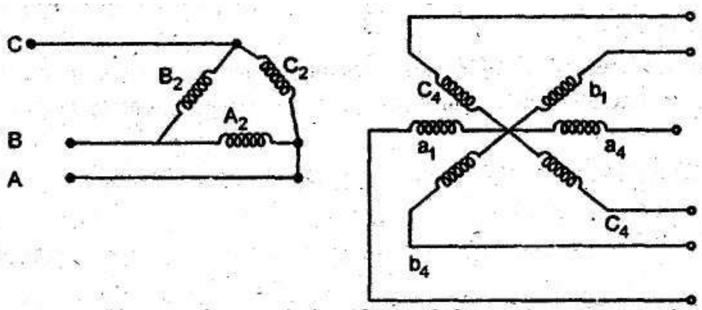
$= 1 - K$

Hence saving in conductor material required for winding affected by using an auto transformer

$= K \times$ Weight of conductor in two winding transformer

**Q. 3. (b) Describe two methods of conversion from three to six phases with suitable circuit & phaser diagram.**

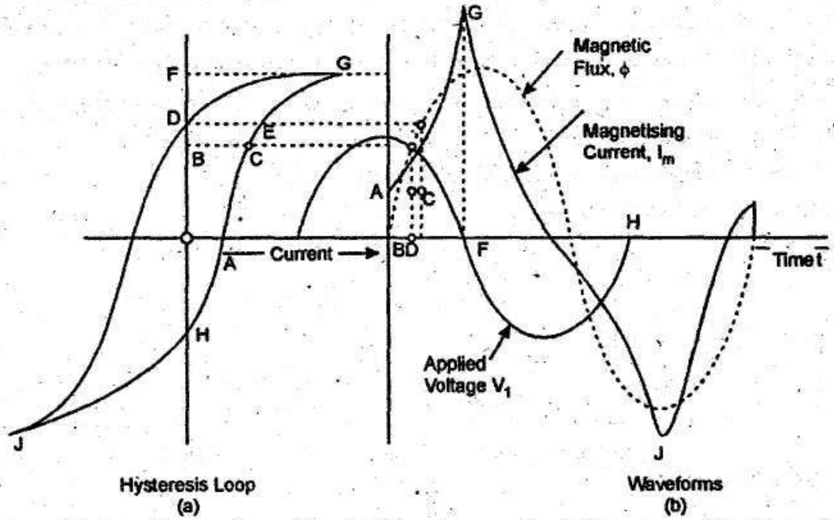
**Ans. Three Phase to Six Phase Conversion :** In three phase to six phase conversion each secondary phase is divided into two equal halves polarity cabelling as in fig. Six phase voltages are obtained by means




of two star in phase opposition each star being formed from three respective half winding. This connection is employed in rectifiers and thyristors circuit where a path for the D.C. current is needed.

**Q. 4. (a) Explain how the exciting current of a single phase trasformer contains harmonics even when supply voltage is a sine wave.** **10**

**Ans. Harmonics in Transformer :**




With a sinusoidal applied voltage $V_1$ of a transformer the induced e.m.f. in the primary $E_1$ which balance the applied voltage $V_1$ has to be sinusoidal since $C_1$ is proportionate to rate of charge of flux. The latter must be vary considerably with respect to time. But the no load current wave will be distorted owing to hysteresis loop.

The use of high flux density in core of power transformer, imposed by the requirement of an economical design and the reduction in size, result in high saturation level and the departure from rectilinearity of the flux current relation or B-H curve. Due to the saturation effect a sinusoidal flux and e.m.f. necessitance a pronounced third and less pronounced higher order harmonic component in the magnetizing current. If for any reason the third harmonic current is not permitted to flow i.e., when two magnetising current is sinusoidal the flux is flat tapped containing depressing third harmonic and as a consequence third harmonic voltage are present in the induced e.m.f..

**Q. 4. (b) What are distinguishing features of $\Delta + \Delta$ & $Y - \Delta$ 3-phase connections ? Compute their advantages & disadvantages.**

**Ans. Delta-Delta Connection :** This arrangement is generally used in system which carry large current on low voltage specially when continuity of service must be maintained even though one of the phase develop fault.

**Advantages :** (i) No phase displacement between primary and secondary.

(ii) There is no distortion of flux.

(iii) The corss-section of conductor is reduced because the phase current is $1/\sqrt{3}$ times of line current.

(iv) No difficulty in unbalancing of load.

**Disadvantages :**

(i) More insulation is required.

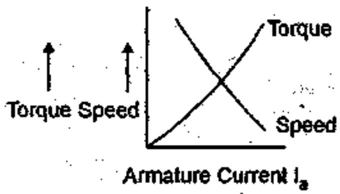
(ii) The absence of star point may be disadvantageous.

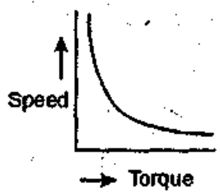
**Star-Delta Connection :** This type of transformer connection is used where it is necessary to step down the voltage i.e., at the end of transmission line. In this type of connection the neutral of the primary winding is earthed. In this system the voltage ratio is $1/\sqrt{3}$ of transformer turn ratio and a secondary have a phase shift of $\pm$ with respect to primary line voltage on the H.V. side the transformer insulation is only to 57.7% of line voltage and therefore some saving of cost of insulation.

**Q. 5. (a) Explain various characteristics D.C. motor.** **10**

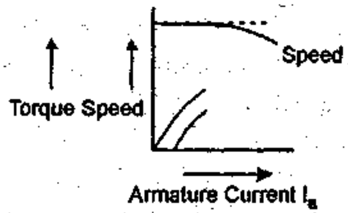
**Ans. Characteristic of D.C. Motor :**

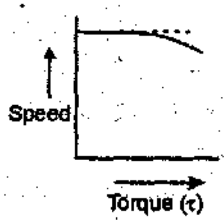
**Series Motor :**



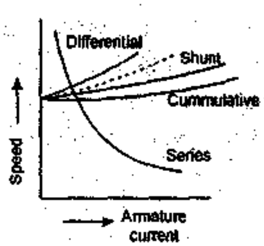



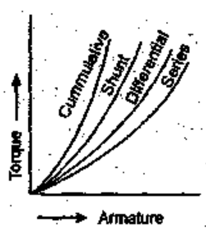

**Shunt Wound Motor :**




**Compound Motor :**



**Q. 5. (b) A 10 h. p; 230 V shunt motor takes an armature current of 6A from 230 V supply at no load & runs at 1200 r. p. m. armature resistance is 0.25 Ω. Determine the speed & torque when armature takes 36 A with same flux.** **10**

**Ans.** $E_{b_0} = V - I_{a_0} R_a = 230 - 6 \times 0.25 = 228.5$ Volt

$E_{b_1} = V - I_{a_L} R_a = 230 - 36 \times 0.25 = 194.25$ Volt

$$N_L = \frac{194.25}{228.5} \times 1200 = 1020 \text{ rpm}$$

$$T_f = \frac{194.25 \times 36 \times 60}{2 A \times 1020} = 65.50 \text{ Nm}$$

**Q. 6. (a) A 4-pole generator with wave wound alternator has 51 slots each having 48 conductor. Flux per pole is 7.5 m wb. At what speed must armature be driven to give an induced emf of 440 V.**

**Ans.** $\phi = 7.5 \times 10^{-3}$

$Z = 51 \times 48 = 2448$

$A = P = 4$

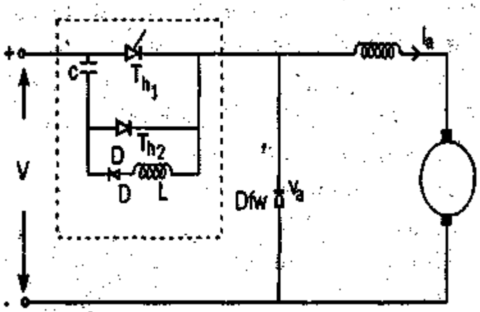
$E = 440$ V

$$\therefore \quad 400 = 7.5 \times 10^{-3} \times 2448 \times \frac{N}{60} \times \frac{2}{4}$$

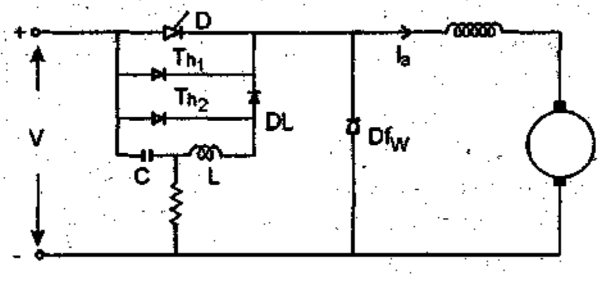
$$= 2614 \text{ rpm}$$

**Q. 6. (b) Explain emf commutation & reactance commutation.** **10**

**Ans. Voltage Commutation :** The circuit diagram of the voltage commutation is shown in figure, it consist of two thyristor. $T_{h_1}$ and $T_{h_2}$ diode D inductor L and capacitor C.




**Current Commutation :**



**Q. 7. What do you understand by demagnetizing and cross magnetizing effects of armature reaction in a d.c. machine ? How these effects are minimized ?** **20**

**Ans. Armature Reaction :** The effect of magnetic field set up by armature current on the distribution of flux under the main pole of DC machine is known as the armature reaction.

**Effect of Armature Reaction on D.C. Machine**

(i) The cross magnetising effect of armature reaction distort the field in air gap. There are two principle effect of the distortion of field namely (i) the creation of magnetic in interpolar region (ii) weakened field strength in air gap

(ii) The demagnetization effect of the armature reaction reduces the total flux per pole from its no load value to magnetizing saturation and reduction in flux depend upon the degree of magnetic saturation.

(iii) The effect of armature reaction on the main field flux are opposite sign for a generator and a motor because of the same direction of armature current under main pole the direction of rotation of armature for motor is opposite to that of generator.

**Q. 8. Write short notes on any three of the following :** **20**

**(i) 3 point starter of D. C. motor**

**(ii) Scott connection**

**(iii) Braking of D. C. motor**

**(iv) Parallel operation of 1-$\phi$ transformers.**

**Ans. (i) 3 Point Starter :** The three point starter with its electrical connection and protective device is shown. It consist of series starting resistance divided into several section and connected to brass stud. Brass all by which the connection to shunt field is made, no volt release and over load release. Since only three terminal are available for starter therefore it is known as the three point starter.

When the motor is at rest the starter arm is in the off position due to the action of strong spiral string S. For starting the motor the D.C. supply is switched ON by choosing the main switch keeping starter arm in off position. The starter arm is then turned clockwise to the first stud brass arc. As soon as it come in contact with first stud, whole of starting resistance R is inserted in series with the armature, the field winding is directly connected across the supply through the brass arc and holding coil is also exchange. As the starter arm is turned further the starting resistance is cut out of armature circuit. When the starting arm reaches the ON position it is held against the action of spiral string S by force of attraction between holding coil magnet and soft iron keeper attached to starter arm. The starter arm should not be held for an unduly long time in an intermediate position as it is likely to burn out the starting resistor.

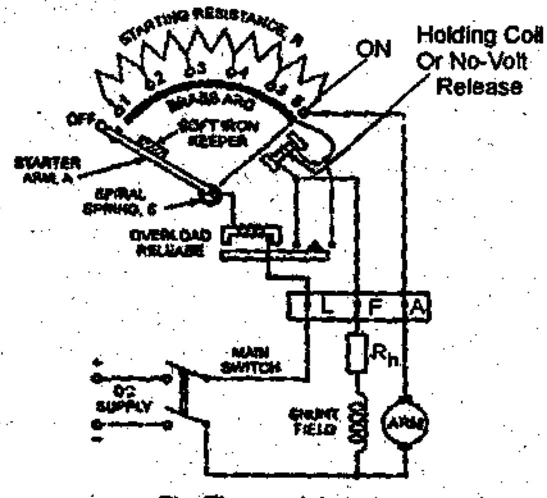



Fig. Three point starter

**(ii) Scott Connection :** Phase conversion from 3 phase to two phase is needed in special cases such as supplying 2 phase electric arc furnance.

The concept of 3/2 phase conversion follows from the voltage phasor diagram of balance $3\phi$ supply. If the point m midway on $V_{BC}$ could be located then $V_{AM}$ leads $V_{BC}$ by 90°. A two phase supply could thus be obtained by means of transformer are conncern across AM called the teaser transformer and the other connected across the line B and C since $V_{AM} = \left(\frac{\sqrt{3}}{2}\right) V_{BC}$ the transformer primaries must have $\sqrt{3}\ N_1/2$ and $N_1$ turns this would them equal voltage and turns in each transformer balance $2\phi$ supply then could easily obtained by having both secondary with equal number of turns $N_2$. The point M is

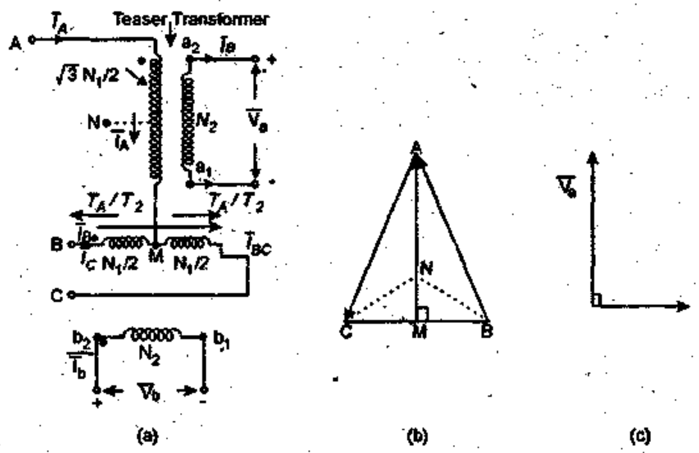



Fig.Scott Connection

located midday on primary of transformer and connection across the line B and C.

**Fig. Scott Connection (S/C in EM-I, may 2008. Ans. no. 3 (a))**

**(iii) Breaking of D. C. Motor :** If the load is removed from an electric motor and supply is to be disconnected. It will continue to run for some time due to inertia. The time elapsing before it stops will be especially long if the motor is massive and has run at high speed. It is essential however in many cases that the motor and its driven machine be stopped quickly.

There are three types of electric breaking viz. plugging, dynamic and regulative breaking.

**(a) Plugging or Counter Current Breaking :** This is the simplest type of breaking plugging or counter current breaking occurs when the motor winding are connected for reverse direction.

**(b) Dynamic (Rheostate) Breaking :** In this method of breaking the motor is disconnected from the supply and operated as generator driven by kinetic energy of rotating part of motor and its driven machine.

**(c) Regulative Breaking :** In regulative breaking mechanical energy is connected in the electrical energy, part of which is returned to the supply and rest is lost as heat in winding.

**(iv) Parallel Operation of 1-$\phi$ Transformer :** This is the arrangement in which the primaries of two or more transformer are energised from the same source and secondaries are connected to supply the same load.

**Necessity of Parallel Operation :**

(i) If the amount of power to be transformed is greater than that which can bes handled by one transformer it i.e., because to employ two or more unit in parallel.

(ii) To meet the additional demand in power system.

(iii) The cost of standby unit is reduced since spare transformer units are invariably required to ensure the continuity of service.

**Condition for Parallel Operation :**

(i) Polarities of transformer are the same .

(ii) The voltage rating of both primary and secondary are identical.

(iii) Per unit impedance of transformer are same.

(iv) Same phase displacement between primary and secondary.

(v) Same phase sequence of transformer.