CMR INSTITUTE OF TECHNOLOGY	USN										

Internal Assesment Test – III

Sub:	Transformers & Generators							Code:	18EE33
Date:	11/122020	Duration:	90 mins	Max Marks:	50	Sem:	3(B)	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1	Derive the Expression for the EMF generated in an Alternator with the help of Winding factors.	[10]	CO3	L2
	OR			
2	A 3 Phase, 8 Pole, Star connected alternator has the armature coils short chorded by one slot. The coil span is 165^0 electrical. The alternator is driven at the speed of 750 rpm. If there are 12 conductors per slot and flux per pole is 50 mwb, calculate the induced line and phase voltages.	[10]	CO4	L3
3	A 3phase, 16 pole synchronous generator has a resultant air gap flux of 0.06 Wb per pole. The flux is distributed sinusoidally over the pole. The stator has two slots per pole per phase and 4 conductors per slot are accommodated in two layers. The coil span is 150^0 electrical. Calculate the Line and Phase voltages induced when the machine runs at 375 rpm.	[10]	CO4	L2
	OR			
4	A 4-pole generator has a wave wound armature with 722 conductors and it delivers a full load. If the brush lead is 80, calculate the demagnetizing and cross magnetizing ampere turns per pole	[10]	CO3	L2
5	With the help of neat diagrams, explain the concept of Armature reaction in DC Generator.	[10]	CO2	L4
	OR			
6	Explain the concept of mechanical Rectification in DC Generator.	[10]	CO2	L3
7	Enumerate the various methods available for Voltage regulation. Explain Pessimistic Method of voltage regulation.	[10]	CO4	L4
	OR			
8	Explain Optimistic Method of finding Voltage regulation of an Alternator.	[10]	CO4	L2
9	The Open and Short Circuit test results of 3 phase, Star connected, 1000 KVA, 1905 V, 50 HZ Alternator has Armature reaction per phase is 0.2ohm. Draw the OC and SC Characteristics and voltage regulation by EMF and MMF methods.	[10]	CO5	L3

I_f in Amps	10	20	25	30	40	50
V_{oc} line volts	760	1500	1700	1905	2300	2600
Isc in Amps	--	220	--	335	--	--

	OR			
10	Explain the concept of Armature Reaction, Synchronous reactance and loading of Alternator with Phasor Diagrams.	[10]	CO4	L3

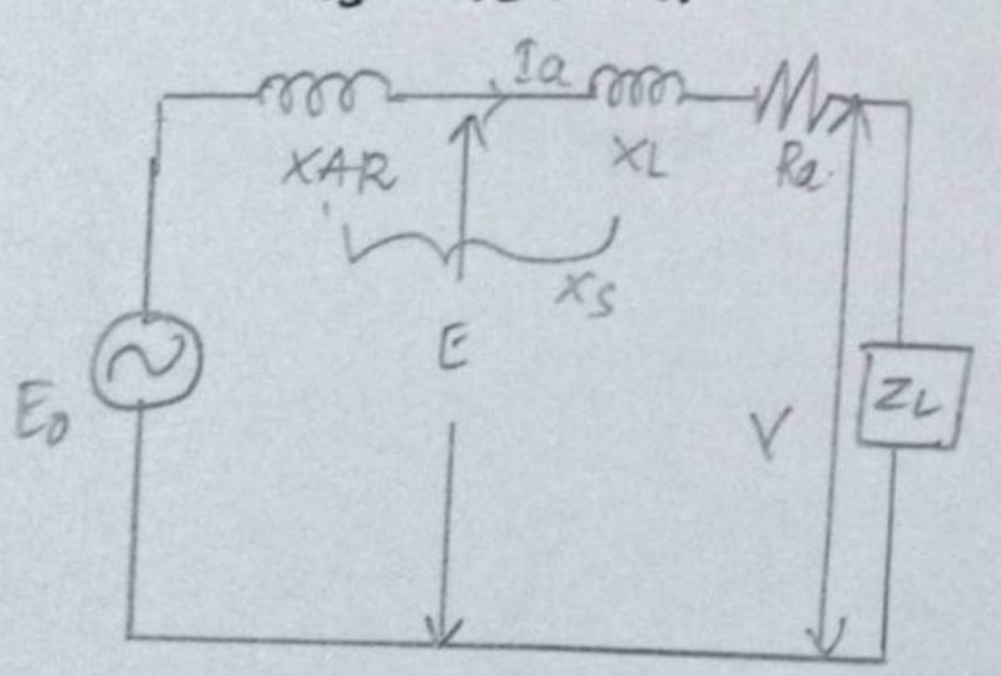
10. Explain the concept of armature reaction, synchronous reactance and loading of alternator with phasor diagram.

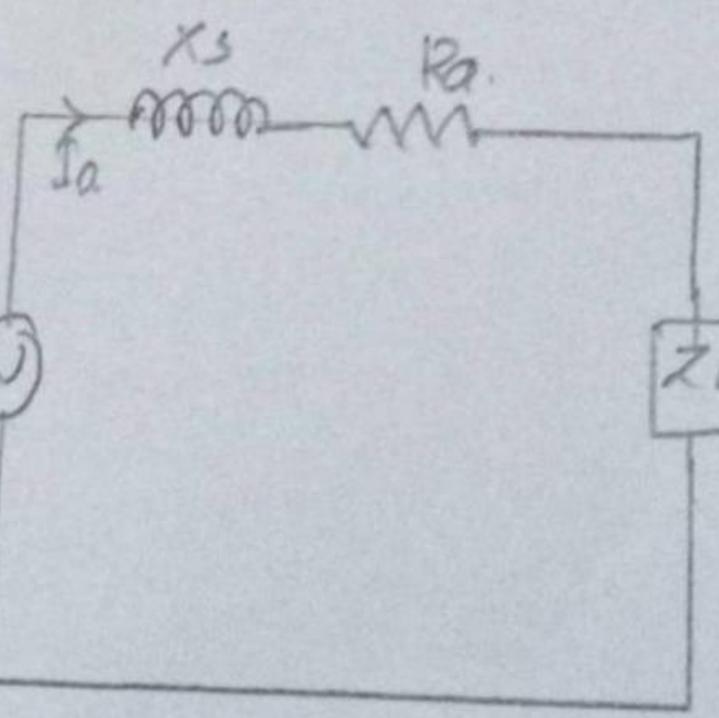
* The load is generally inductive and the effect of armature reaction is to reduce the generated voltage.
* Since armature reaction results in a voltage effect in a circuit caused by change in flux produced by current in same circuit, its effect is of nature of an inductive reactance.
* Armature reaction effect is accounted for assuming the presence of a fictitious reactance "X_{AR}" in armature winding.
* The quantity X_{AR} is called Reactance of armature reaction.
* The value of X_{AR} is such that $I_a X_{AR}$ represents the voltage drop due to armature reaction.

Synchronous Reactance (X_s)

The sum of armature leakage reactance (X_L) and reactance of armature reaction (X_{AR}) is called synchronous reactance (X_s)

$\therefore X_s = X_L + X_{AR}$



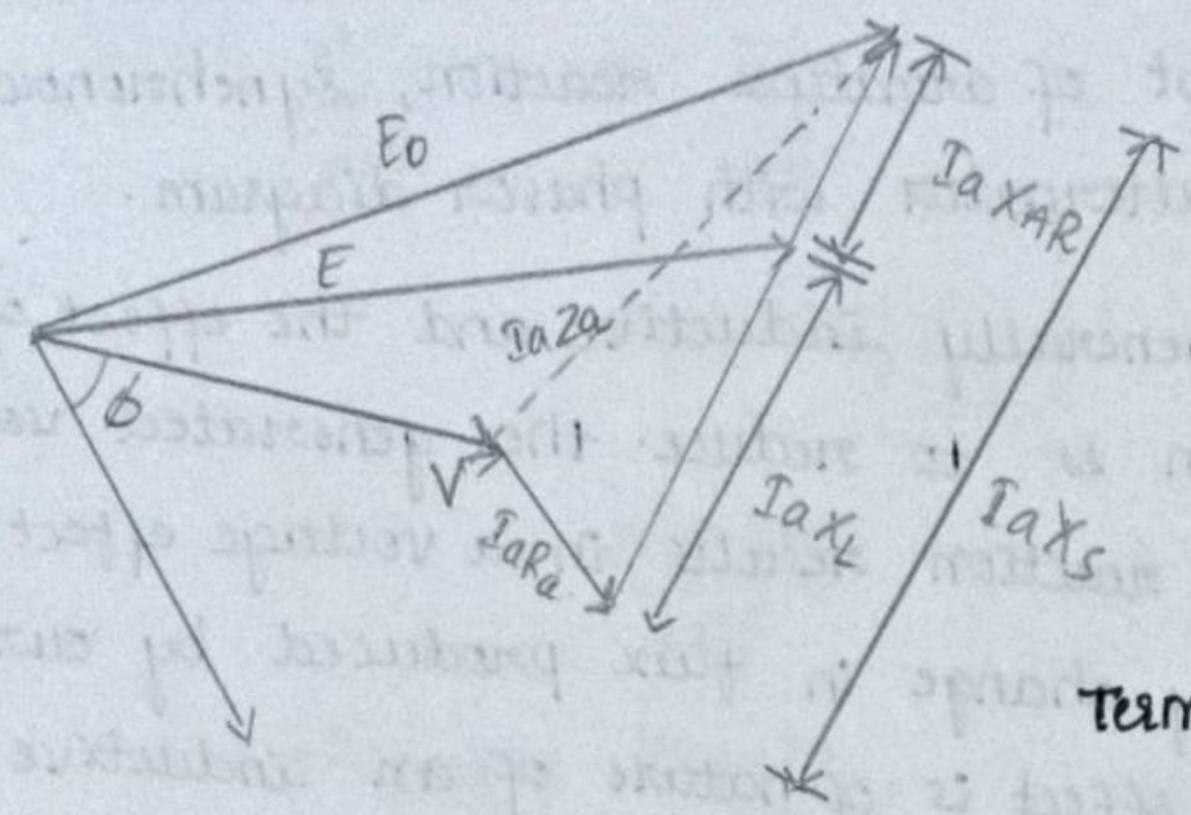


* The synchronous reactance is a fictitious reactance employed to account for voltage effects in armature

circuit produced by actual armature leakage reactance and the change in air-gap flux caused by armature reaction.

Synchronous impedance, $Z_s = R_a + jX_s$

Phasor diagram of a loaded alternator:



Terminal Voltage (V) - reference

→ The armature current Ia lags terminal voltage V by p.f angle ϕ

→ The phasor sum of V & drops IaRa and I_aX_L gives the load induced voltage E.

→ It is the induced e.m.f after allowing for armature reaction.

→ The phasor sum of E and I_aX_{AR} gives no load EMf Eo.

→ The phasor diagram for unity and leading pf is

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7. Enumerate the various methods available for voltage regulation. Explain pessimistic method of voltage regulation.

There are several methods of determining the voltage regulation of an alternator, by direct and indirect loading. These methods require only a small amount of power (Indirect) whereas loading directly requires high power comparitively.

1. Synchronous impedance (or) E.M.F method
2. Ampere-turn (or) M.M.F method.

The value of voltage regulation estimated by EMF method is always higher (or) poor than the actual value and hence this method is called "PESSIMISTIC METHOD".

Pessimistic Method of Voltage Regulation:

This method is also known as synchronous impedance method. Here the magnetic circuit is assumed to be unsaturated.

* In this method MMFs (fluxes) produced by rotor and stator are replaced by their equivalent emf and hence called emf method.
* To predetermine the regulation by this method,
  → Armature resistance/phase of alternator
  → Open circuit characteristic [O.C.C]
  → short circuit characteristic [S.C.C], of alternator are to be determined.

1. Armature resistance

Ra (Armature resistance) per phase is determined by using direct current and voltmeter-ammeter method - DC value.

2. Open circuit characteristic [O.C.C]

O.C.C of an alternator is curve between armature terminal voltage (phase value) on open circuit and field current when alternator is running at rated speed.

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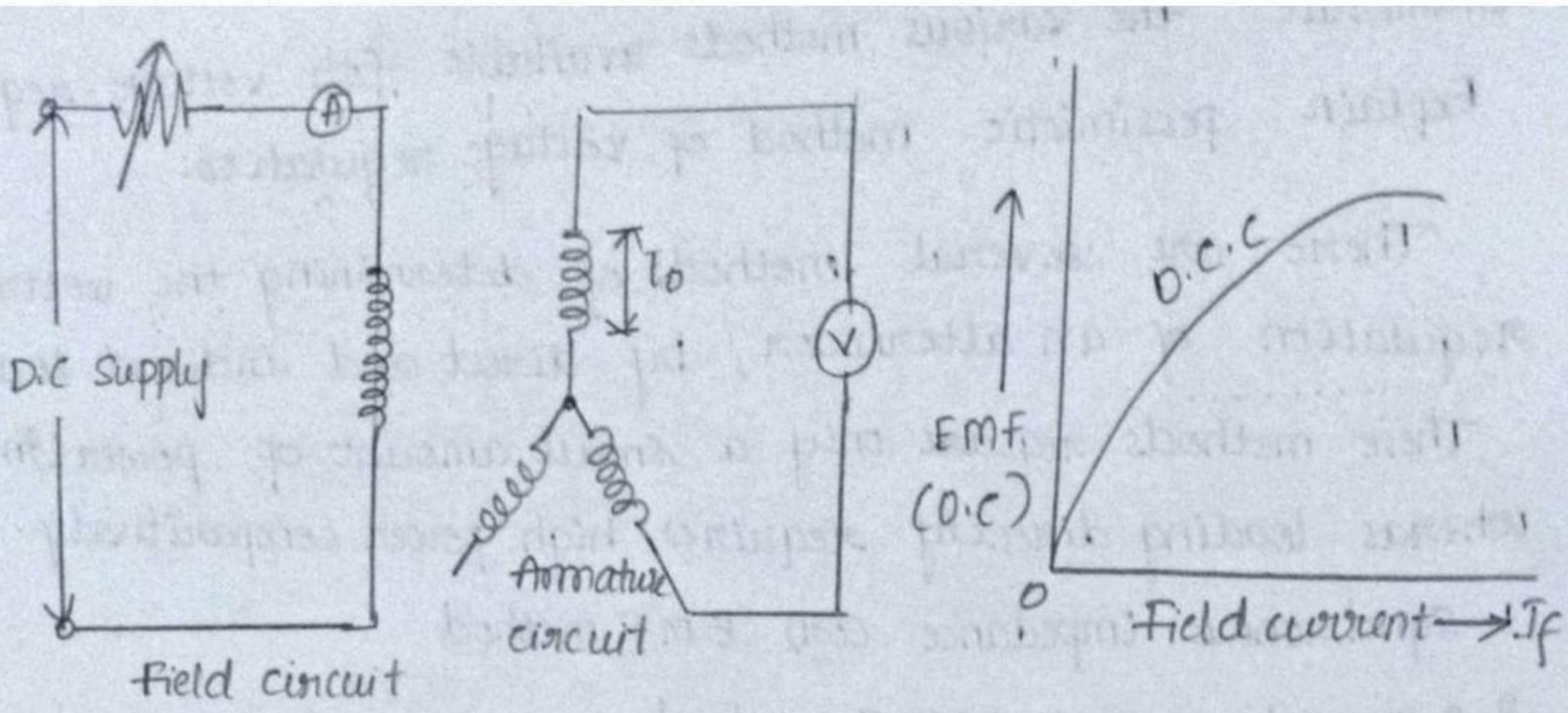
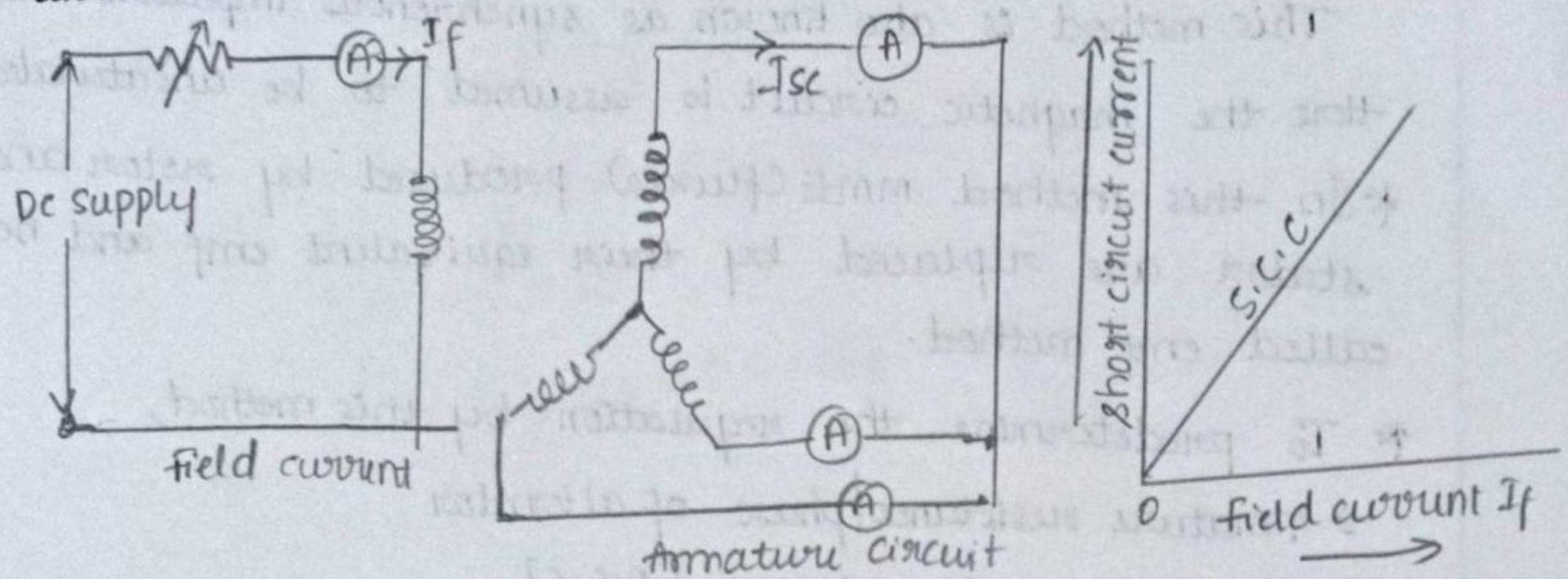


3. Short circuit characteristic [S.C.C].

In a S.C test, the alternator is run at rated speed and armature terminals are short-circuited through identical ammetis.

* The field current If gradually increases from zero until S.C. armature Isc is about twice its rated current.



* The open-circuit voltage corresponding to field current If is E_1. The S.C armature current corresponding to field current If is I_1

P.d = 0 & E_1 is being used to circulate I_1 against Z_s (synchronous impedance)

$$\therefore E_1 = I_1 Z_s$$

$$Z_s = \frac{E_1 (O.C)}{I_1 (S.C)}$$

E_1 is phase valued $\rightarrow I_1$

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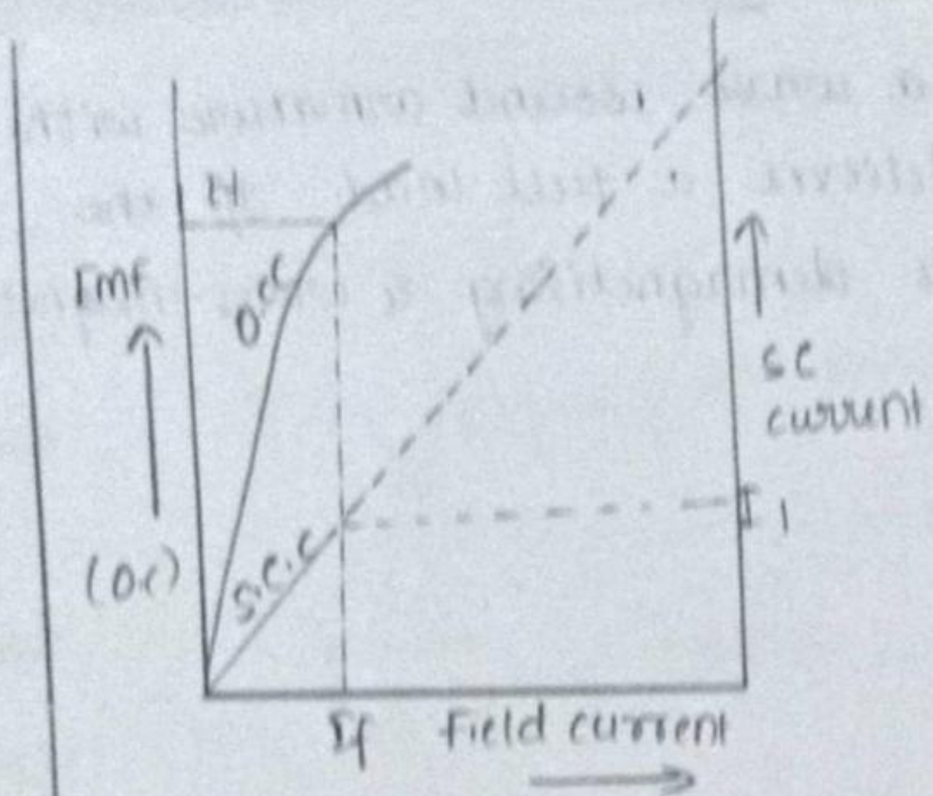

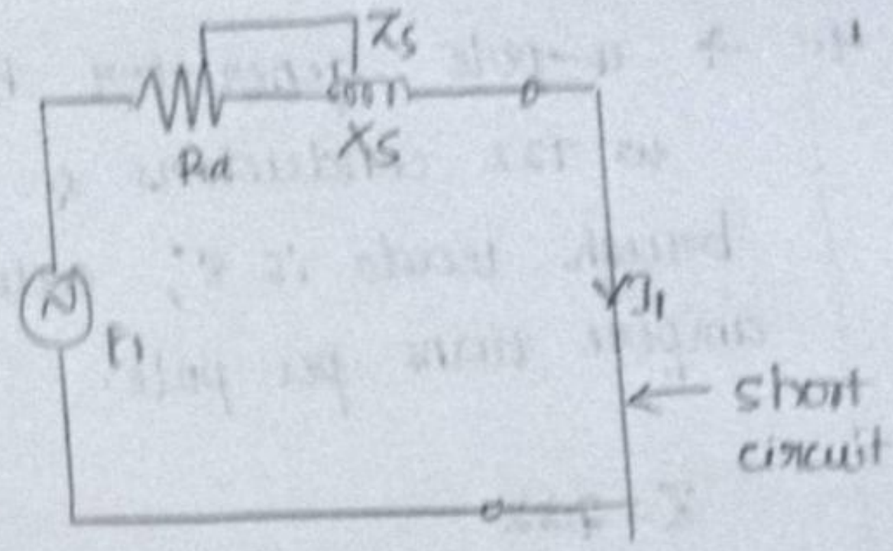

∴ Armature resistance can be found,

i.e Synchronous reactance $X_s = \sqrt{Z_s^2 - R_a^2}$.

→ The phasor diagram shows inductive load, load pf $\cos\phi$ lagging; current I_a - reference.

→ I_aR_a drop is in phase with I_a while I_aX_s drop leads I_a by 90°

→ Phasor sum of V, I_aR_a & I_aX_s gives no load e.mf E_0

$$E_0 = \sqrt{(OB)^2 + (BC)^2}$$

$$OB = V\cos\phi + I_aR_a$$

$$BC = V\sin\phi + I_aX_s$$

% Voltage regulation = $\frac{E_0 - V}{V} \times 100$.

$$\therefore E_0 = \sqrt{(V\cos\phi + I_aR_a)^2 + (V\sin\phi + I_aX_s)^2}$$

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1. Derive the expression for EMF generated in an alternator with the help of winding factors.

E.M.F Equation of an Alternator:

Let Z = No of conductors in series per phase.

P = Number of rotor poles

ϕ = Flux per pole in wb

N = Rotor speed in r.p.m

In one revolution, $(60/N_{sec})$ each stator conductor is cut by $P\phi$

$d\phi = P\phi$;

$dt = 60/N$

∴ Average e.m.f induced in one stator conductor

$$= \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60} \text{ Volts}$$

Since there are Z conductors in series per phase,

∴ Average e.m.f/phase $= \frac{P\phi N}{60} \times Z$

$$= \frac{P\phi Z}{60} \times \frac{120f}{P} \qquad \left\{\because N = \frac{120f}{P}\right\}$$

$$= 2f\phi Z \text{ Volts}$$

R.M.S value of e.m.f/phase = Avg value/phase x form factor.

$= 2f\phi Z \times 1.11 = 2.22 f\phi Z$ Volts

Erms/phase $= 2.22 f\phi Z$ volts

If k_p and k_d are pitch factor and distribution factor of armature winding, then

$E_{r.ms}$/phase $= 2.22\, k_p k_d f \phi Z$ volts
Erms/phase $= 4.44 k_p k_d f \phi T$ volts — Turns per phase.

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4. A 4-pole generator has a wave wound armature with 722 conductors & it delivers a full load. If the brush leads is 8°, calculate demagnetising & cross-magnetising ampere turns per pole.

$Z = 722$

$\theta m = 8°$

$Ia = 100$

$I = Ia/2 = \frac{100}{2} = 50A$

W.k.T $\frac{AT_d}{pole} = ZI \cdot \frac{\theta m}{360}$

$= 722 \times 50 \left[\frac{8}{360}\right]$

$= \frac{288,800}{360}$

$AT_a/pole = 802.22$

$AT_c/pole = ZI\left[\frac{1}{2p} - \frac{\theta m}{360}\right]$

$= 722 \times 50 \left[\frac{1}{2 \times 4} \frac{-8}{360}\right]$

$= 36,100 \left[\frac{1}{8} - \frac{8}{360}\right]$

$AT_c/pole = 4.625$

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5. With the help of neat diagram, explain the concept of armature reaction.

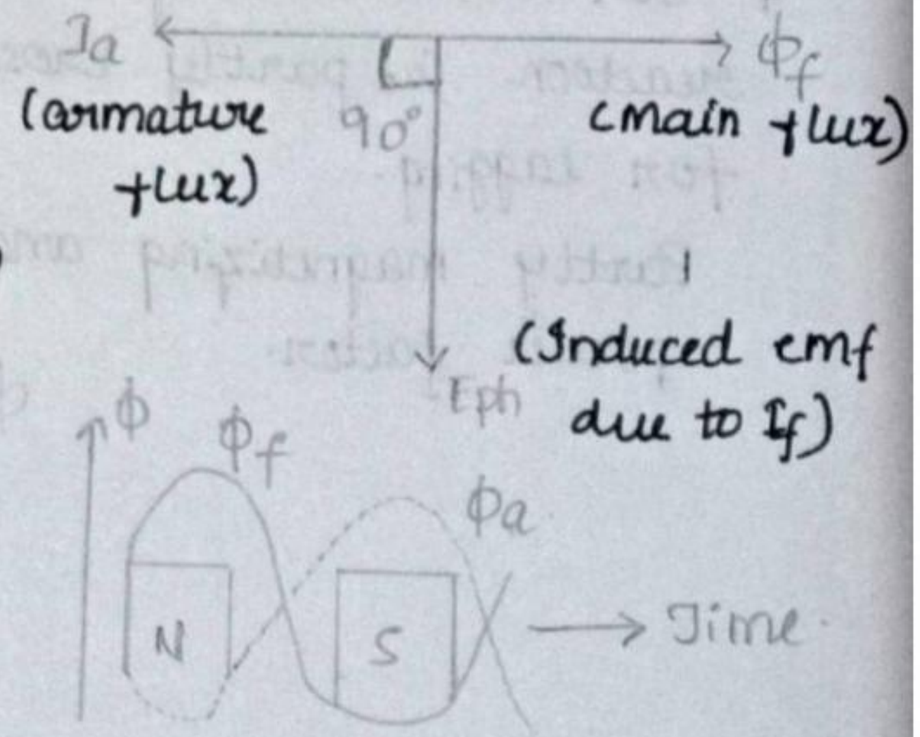
Armature Reaction:

The effect of armature flux on main flux affecting its value and distribution is called armature reaction.

* When an alternator is running at no-load, there will be no current flowing through the armature winding.
* The flux produced in the air-gap will be only due to the rotor-ampere turns.
* When the alternator is loaded, the three-phase currents will produce a total magnetic field in the air-gap, consequent the air-gap flux is changed from no-load condition.
* The flux induced in armature depends on magnitude of current and also on nature of power factor of load.

1. Zero lagging power factor load

* A purely inductive load give zero lagging power factor i.e current Iaph lags voltage Eph by exact 90°.
* Induced emf Eph lags main flux ϕ_f by 90°. ϕ_a is in phase with Ia.
* The armature flux is exactly opposite to main flux.
* This effect is called demagnetizing effect of armature reaction.



2. Unity power factor load.

* A purely resistive load will give unity power factor. Voltage Eph and current Iph are in phase with each other.

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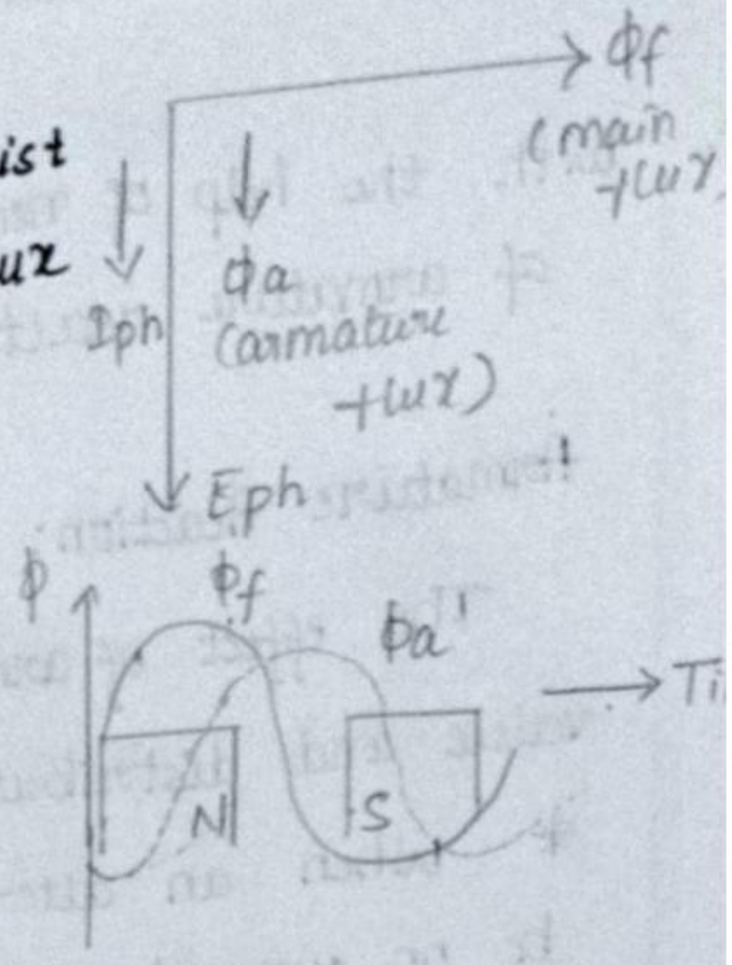
* From the phasor diagram, there exist 90° phase difference between armature flux and main flux.

* From graph, both fluxes oppose each other on left half of each pole while assist each other on right half of each pole

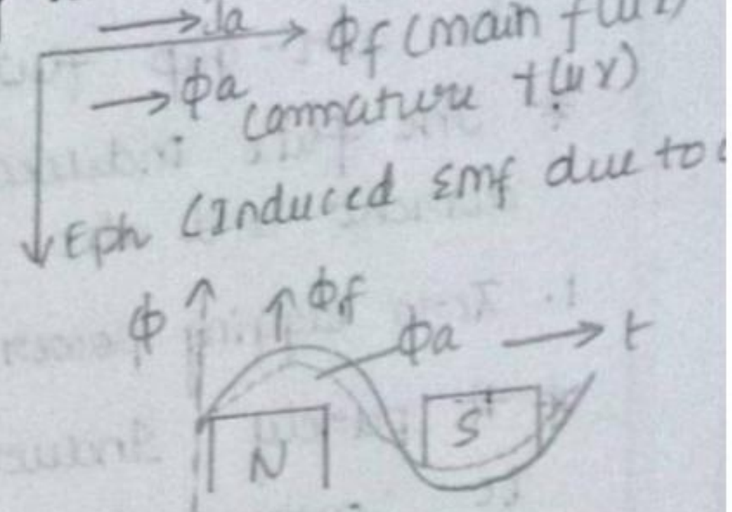
* Average flux in air gap remains constant but its distribution gets distorted.



3. Zero leading power factor load:

* A purely capacitive load will give zero leading power factor, voltage Eph lags current Iph by 90° (or) current Iph leads voltage Eph by 90°.

* From phasor diagram, Eph and Iph are in phase with each other thus the effect of armature reaction which assists main flux is called magnetizing effect.



* For loads having intermediate power factor, armature reaction is partly cross magnetizing and partly demagnetizing for lagging.

Partly magnetizing and partly cross magnetizing for leading power factor.

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6 Explain concept of mechanical rectification in D.C generators.

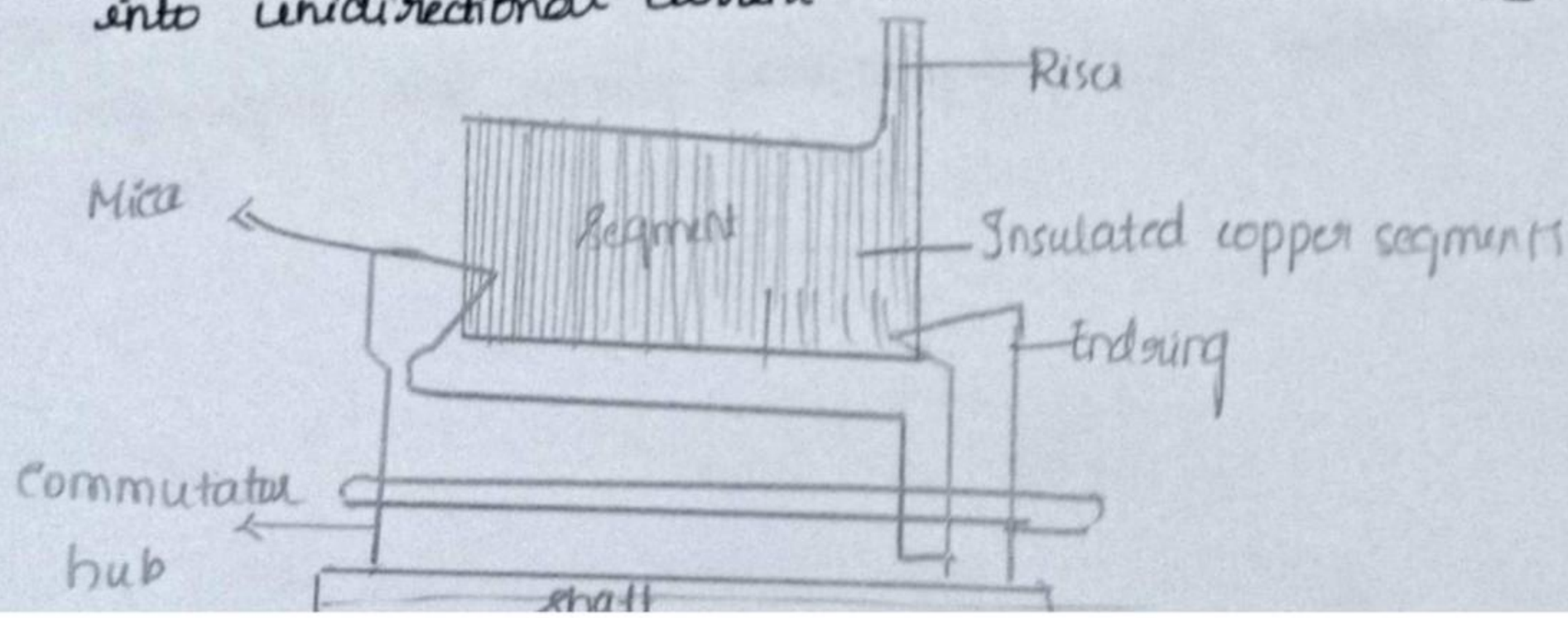
In D.C generators, the components are

→ field system
→ armature core
→ armature winding
→ commutator
→ brushes.

* A commutator is a "MECHANICAL RECTIFIER".

A commutator is a mechanical rectifier which converts alternating voltage generated in armature winding into direct voltage across brushes.

* The commutator is made of copper segments insulated from each other by mica sheets & mounted on the shaft of machine.
* The armature conductors are soldered to commutator segments in a suitable manner to give rise to armature winding.
* Each commutator segment is connected to armature conductor by means of a copper.
* The function of commutator is to facilitate collection of current from armatur conductors.
* It is mechanical rectification, as it converts the alternating current in induced in armature conductors into unidirectional current in external load current.



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