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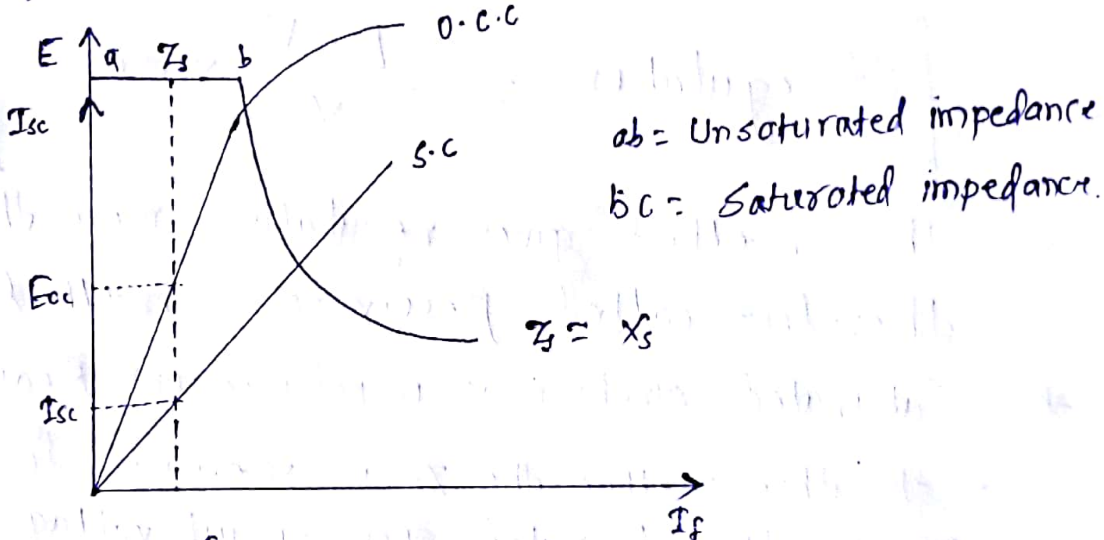
Voltage Regulation methods

(i) Synchronous impedance method / EMF
(ii) Rothert's Ampere-Turns method / MMF method.
(iii) Zero power factor method / Potier method.
(iv) American Standards Association method.

(i) EMF method:

In this method drop due to armature reaction is considered as drop due to additional leakage reactance, means entire drop is considered as drop due to Leakage reactance is voltage phenomenon, can be represented by EMF vector. That is why it is called emf method.



fig

→ Synchronous impedance $Z_s = \frac{\text{O.C voltage}}{\text{S.C current}}$ when field current is same for both O.C voltage & S.C current.

$$Z_s = \frac{E_{oc}}{I_{sc}} \quad (\text{If } I_f \text{ is same for } E_{oc} \,\&\, I_{sc})$$

→ In this method the Z_s is measured for the field current where the field poles are unsaturated. Means the Z_s measured by this method is belongs to unsaturated position which more than the actual synchronous impedance.

Z_s (Unsaturated) > Z_s (saturated)

Z_s (unsaturated) > Z_s (actual)

Regulation $\propto Z_s$

Regulation (S.I.M) > Regulation (Actual)

$$Z_s \text{ (S.I.M)} = \frac{E_{oc}}{I_{sc}} \quad (I_f \text{ is at } I_{sc} = I_{rated})$$

$$X_s = \sqrt{Z_s^2 - R_a^2}$$

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

$$\boxed{\text{Regulation} = \frac{E - V}{V} \times 100}$$ ***

→ This method gives regulation more than actual value, therefore called pessimistic method.

* Saturated synchronous impedance (or) Reactance method.

→ In this method the Z_s is measured for the field current corresponding to rated open circuit voltage.

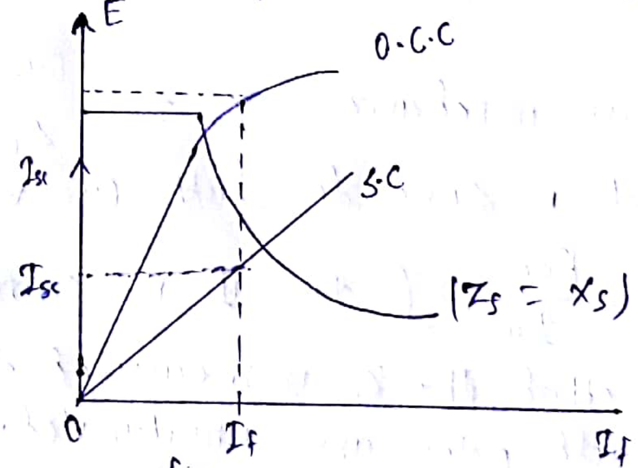
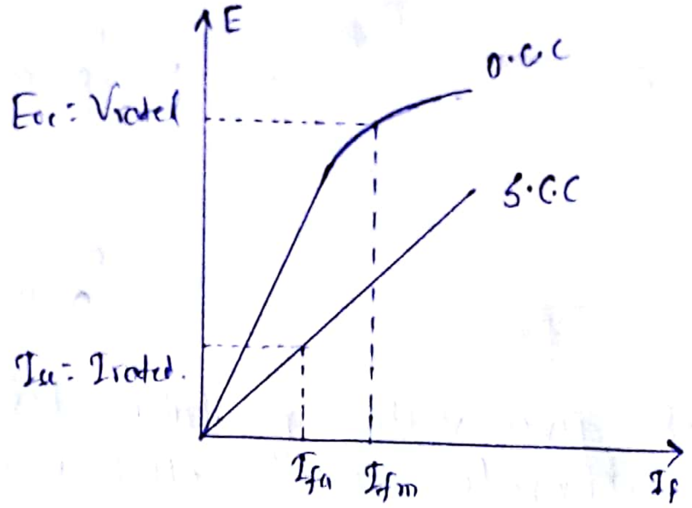


fig.
(determination of saturated synchronous impedance of an alternator)

→ Regulation by saturated synchronous impedance method is less than by emf method.

(ii) MMF method:-

In this method the drop due to leakage reactance is considered as the drop due to additional armature reaction, means entire drop is considered as drop due to armature reaction. Since armature reaction. Since armature reaction is a flux phenomena it can be represented with flux vector or field current vector or mmf vector. That's reason this method is called mmf method. This method requires O.C. and S.C characteristics.



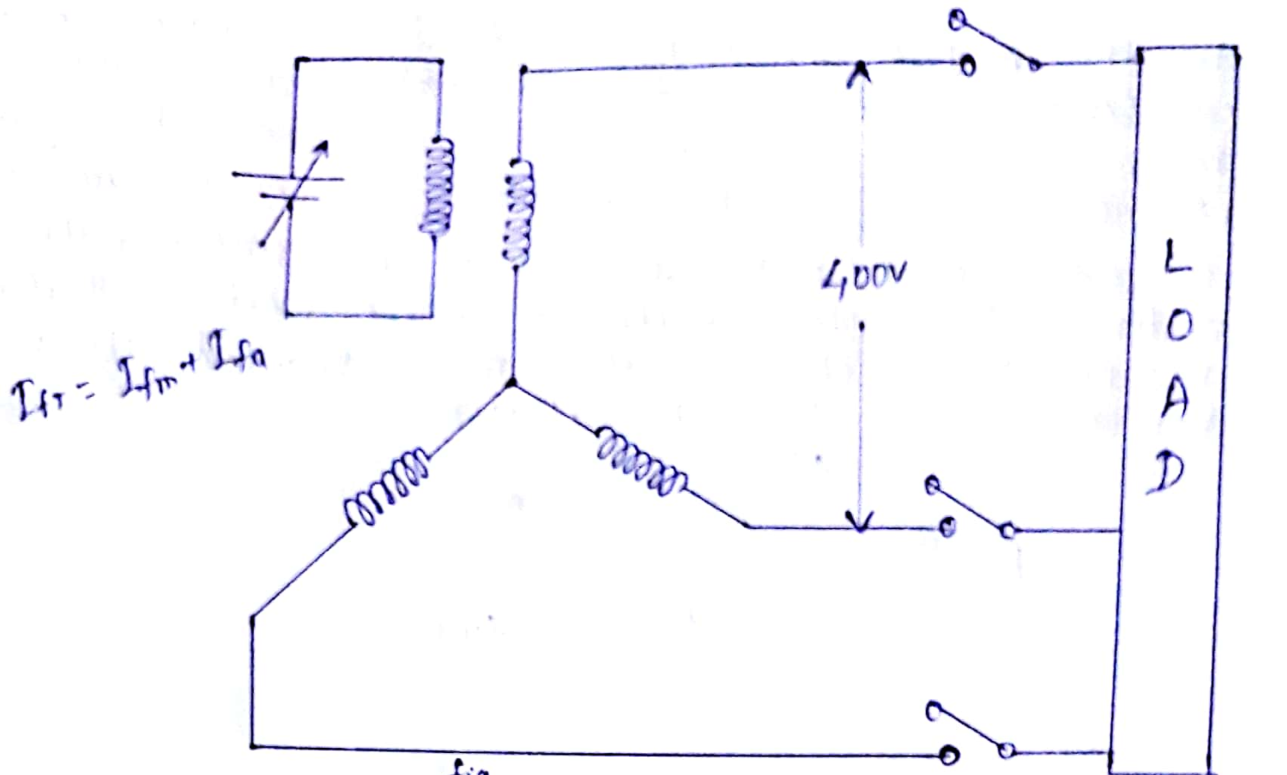
→ I_{fm} is the main field current require to generate rated voltage under open circuit condition.

→ I_{fa} is the main field current required to produce. rated armature current under S.C condition.

If the alternator is supplying full load, then total field current is the vector sum of its two components I_{fa} and I_{fm}. This depends on the power factor of the load. The resultant field current is denoted as I_{fr}. Let us consider the various power factors and the resultant I_{fr}.

* Measure E_0 corresponding to I_{fr} form O.C.C.

$$\text{Regulation} = \frac{E_0 - V}{V} \times 100\%$$



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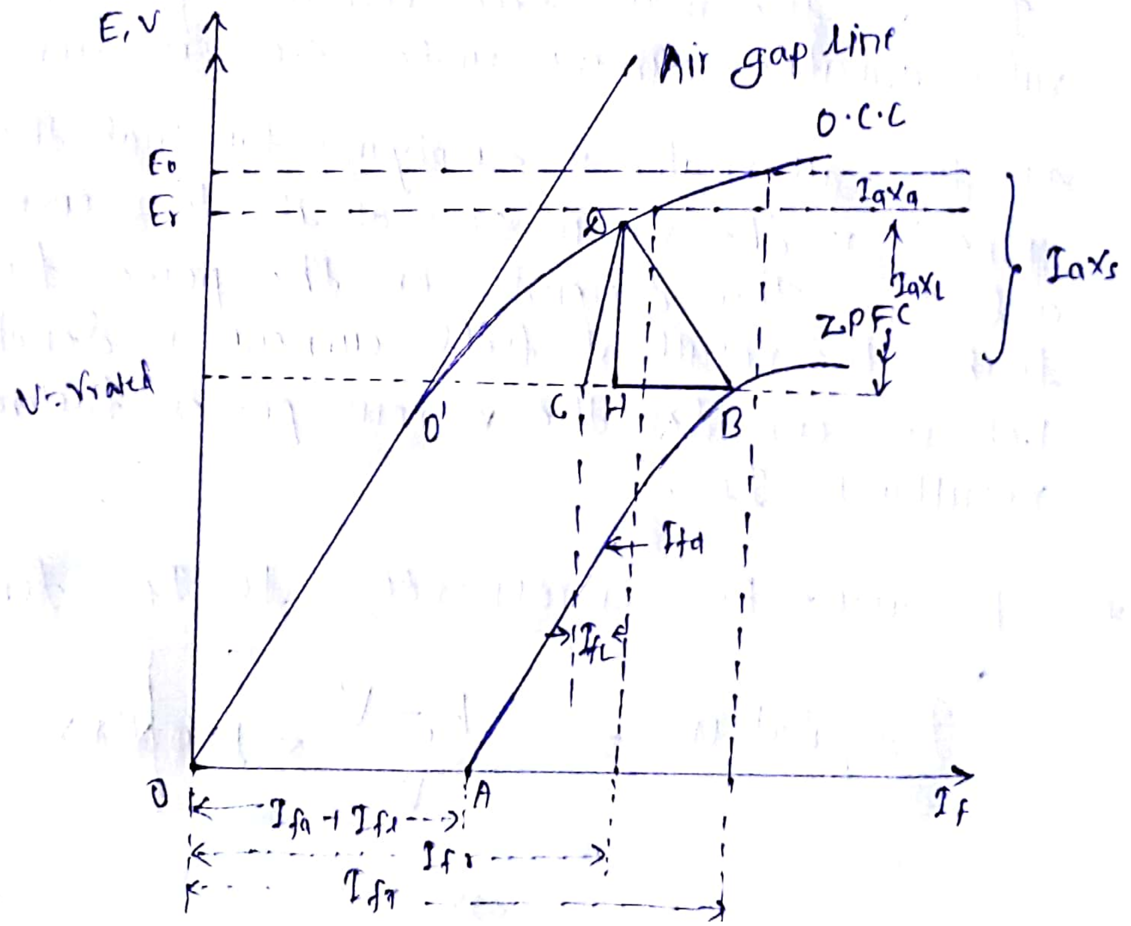
* This method gives voltage regulation less than the actual value. Therefore this method is called optimistic method.

(iii) Zero power factor method.



→ In this method the drop due to armature reaction and Leakage reactance are considered separately. Drop due to Leakage reactance is represented with voltage vector (emf vector). Drop due to armature reaction is represented with field current vector. This method gives the voltage regulation near to actual value, therefor this is accurate method. This method requires O.C.C and ZPF.C.

→ Draw OCC, ZPFC and Air gap line.

→ At V = Vrated draw a Horizontal line on the ZPFC to meet at point B.

→ Draw BC = OA,

→ Draw CD parallel to air gap line.

→ Join BD.

→ Draw DH perpendicular to BC.

→ The right angle triangle BHD is called ~~Potier~~ Potier triangle.

→ Base of the potier triangle BH = I_{fa} is the field current to compensate the drop due to armature reaction.

→ Height of the potier triangle DH = $I_a X_L$ is the drop due to Leakage reactance.

→ The base of the triangle CH = I_{fL} is the field current to compensate the drop due to leakage reactance.

→ With $I_a X_L$ = DH, calculate.

Air gap voltage (resultant)

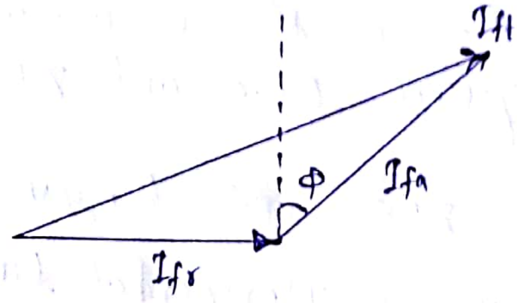
$$E_r = V + I_a R_a + j I_a X_L.$$

$$= \sqrt{(V\cos\phi + I_a R_a)^2 + (V\sin\phi \pm I_a X_L)^2}$$

→ After finding E_r, measure field current I_{fr} corresponding to E_r from O.C.C.

Add I_{fa} to I_{fr}

$$\therefore I_{fa} + I_{fr} = I_{ft}$$



→ Measure E_0 corresponding to I_{ft} from O.C.C.

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$$\therefore \text{Regulation} = \frac{E_0 - V}{V} \times 100$$

(IV) American Standards Association Method (ASA method)

* In this method, the drop due to saturation is also considered. therefore this is the most accurate method.
* American standard association (ASA) method is combination of ZPF & MMF methods.
* Regulation in ASA method is more than ZPF methods, since drop due to saturation is extra in ASA method.

Note:- Voltage regulation in descending order is

EMF method > Saturated synchronous

Impedance method > ASA > ZPF > MMF