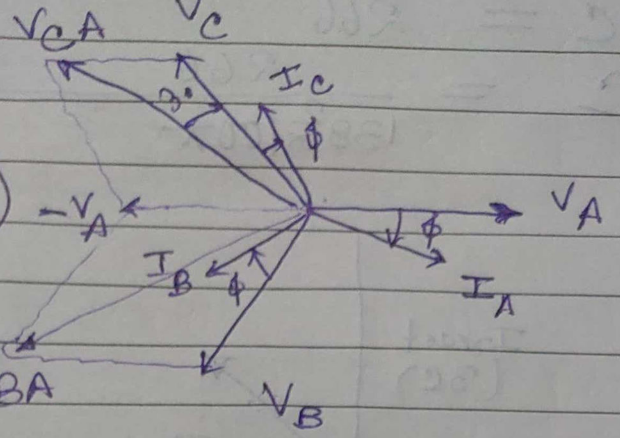
DATE 1/ / (1)

1.



$Z = 5\angle \tan^{-1}(3/4)$
$= 5\angle 36.869$

$W_1 = V_{CA} I_C \cos(30+\phi)$

$I_C = \dfrac{200}{\sqrt{3}\times 5} = 23.094$

$W_1 = 200 \times 23.094 \cos(30 + 36.869) = 1.814\,KW$

$W_2 = V_{BA} I_B \cos(30-\phi)$
$= 200 \times 23.094 \cos 6.869 = 4.585\,KW$

Reactive Power $= \sqrt{3} \times 200 \times 23.094 \sin(36.869)$
$= 4.799$ KVar.

2. → If the above phase conversion is followed then $W_1 = 0$ when $\phi = 60°$, i.e. power factor is 0.5 lagging.

3. At first case $P_1 = 1\,KW$; $\sin\phi = \sqrt{1-0.8^2} = 0.6$

$VI = \dfrac{1\,KW}{0.8} = 1.25$

$Q_1 = VI\sin\phi = 0.75$ kVar

Now in second case $\cos\phi = 0.9$; $\sin\phi = 0.4358$

$Q_{1\,new} = \dfrac{1}{0.9} \times 0.435 = 0.484$ KVAr

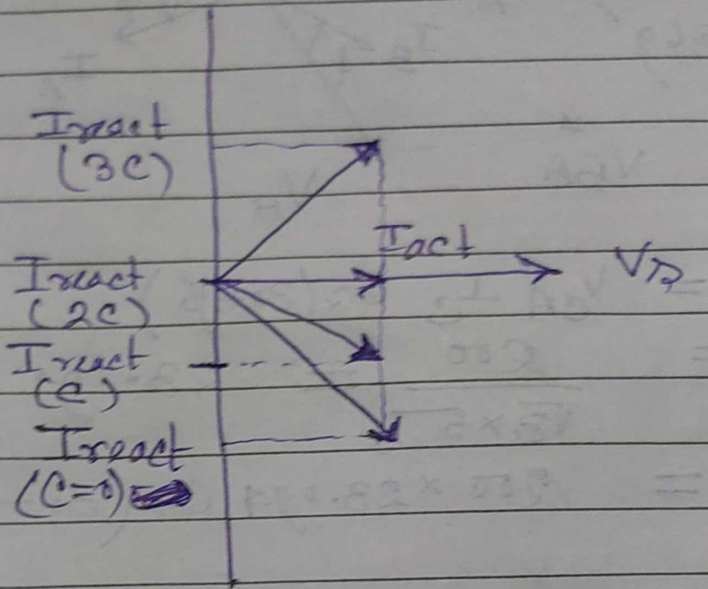
$$Q_{cap} = V^2 \times \omega C$$

(2)

$$V^2 \times 2\pi f \times C = 266$$

$$C = \frac{266}{133^2 \times 100\pi} = 47.86\ \mu F$$

4.

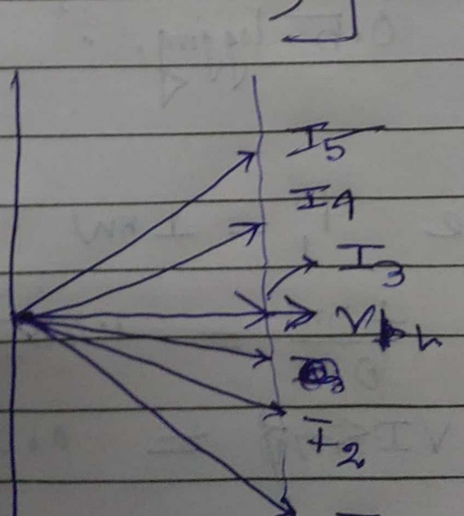


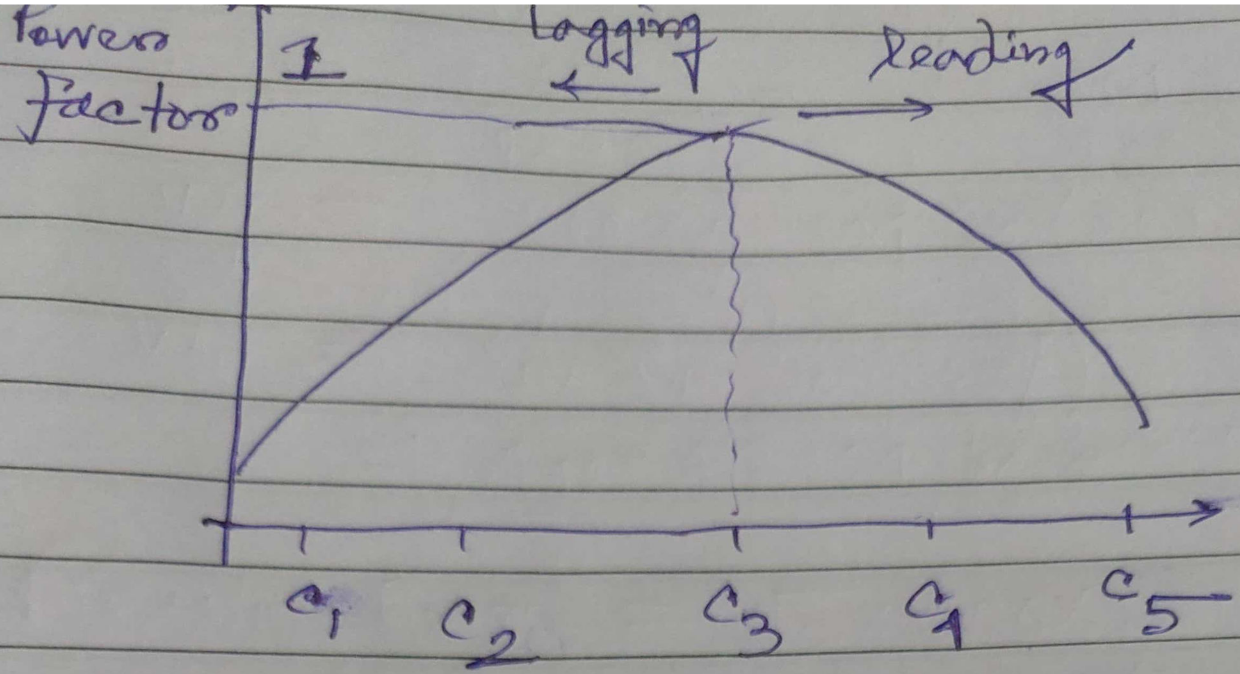
5. Active Power = Average Power

$$P = \frac{1}{2\pi}\int_0^{2\pi} v(t)\cdot i(t) \rightarrow$$ average of two sin terms with different ω is zero.

$$= \frac{1}{2}\left[V_1 I_1 \cos(\phi_1) + V_3 I_3 \cos(\phi_3)\right]$$

6. i)




Power factor
1
Lagging
Leading
C1
C2
C3
C4
C5

Quiz 2

PAGE No.
DATE / /

1. $\frac{E_1}{N_1} = \frac{E_2}{N_2} = 11$; $B_m = 1.2\ wb/m^2$

$4.44\ N_1 \phi_m f = E_1$

$\phi_m = \frac{11}{4.44 \times 50} = 0.0495$

$A_c = 0.04129\ m^2 = 412\ cm^2$

2. It can't be, because the load is inductive hence $E_2 - V_2 = I_2 r_{e_2} \cos\phi + I_2 x_{e_2} \sin\phi$ = is positive. $E_2 > V_2$

3. At Leading Power Factor $E_2 - V_2 = 0$

$\Rightarrow I_2 r_{e_2} \cos\phi - I_2 x_{e_2} \sin\phi = 0$

$\tan\phi = \frac{r_{e_2}}{x_{e_2}}$ $\quad Z_{e_2} = \sqrt{r_{e_2}^2 + x_{e_2}^2}$

$\cos\phi = \frac{x_{e_2}}{Z_{e_2}}$

4. At unity pf.

during

hence $E_2 - V_2 = I_2 r_{e_2} \cos\phi + I_2 x_{e_2} \sin\phi$ = is positive. $\therefore E_2 > V_2$

3. At Leading Power Factor $E_2 - V_2 = 0$

$\Rightarrow I_2 r_{e_2} \cos\phi - I_2 x_{e_2} \sin\phi = 0$

$$\tan\phi = \frac{r_{e_2}}{x_{e_2}} \qquad Z_{e_2} = \sqrt{r_{e_2}^2 + x_{e_2}^2}$$

$$\cos\phi = \frac{x_{e_2}}{Z_{e_2}}$$

4. At unity p.f.

5. If Ammeter put at LV side during short circuit test, then it has to bear full rated current therefore ammeter rating has to be very high.

6. At V_{13}, during the instant when peak voltage is applied to core, it gets saturated and a saturated core behaves like an air gap (almost 0 inductance) $\therefore$ the current is almost upf and during peak high current is drawn for magnetization.

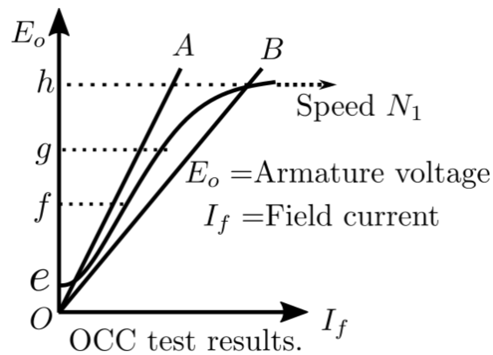
7. $\rightarrow$ V/f = Constant $\Rightarrow \phi$ constant $\therefore$

$$V = \frac{110 \times 50}{60} = 91.7\,V$$

Power Engineering Lab (EE 240)

IIT Bombay

Quiz 3

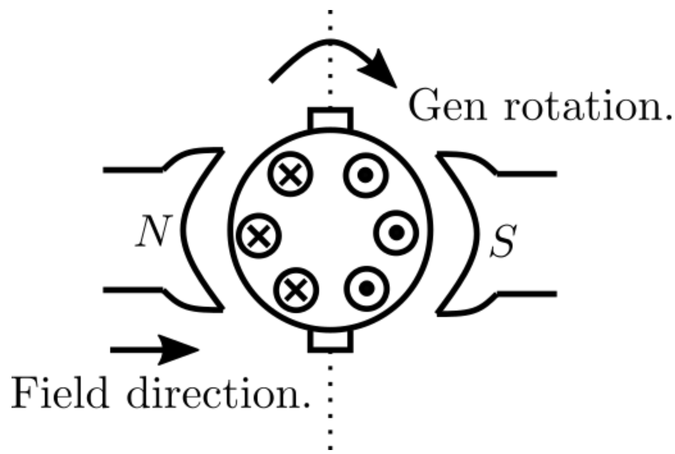


1. The OCC test results of a DC self-excited generator is shown above. Field resistance of the generator is variable and the slope of "OA" and "OB" defines the different resistances of the field winding. Answer the following:
   (i) What is the armature voltage of the generator when the field resistance is defined by the slope of OA? **Ans: Oe**
   (ii) What modification in the circuit could be done so that for same speed the armature voltage attains the magnitude of "Oh"? **Ans: Resistance of field has to be decreased so that the slope OA shifts to slope OB.**
   (iii) What is the contribution of residual flux in this voltage build up process? **Ans: At the beginning residual flux generates a small emf and that emf energizes the field. If the field and the residual flux are additive in nature, then only the overall flux can cause the rise in armature voltage.**

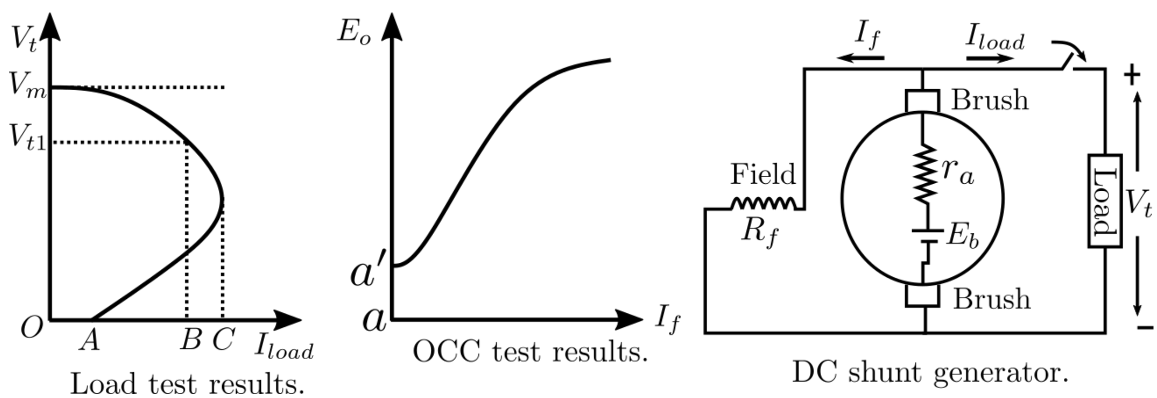
2. For a separately excited dc motor operating at rated load, what will be the angular velocity between the armature flux and the field flux? **Ans: Armature and field flux has to be stationary wrt each other for a stable operation.**

3. The armature of a 4 pole DC generator is rotating at a speed of 1000 R.P.M. What will be the frequency of the armature induced emf? How this voltage gets converted to dc voltage?
   Ans: f = N_R*P/120.

4. The direction of field and the direction of rotation of a separately excited dc generator is shown below. Show the direction of armature current induced in the armature conductors (Dot and cross convention.) **Ans: Flemming's right hand rule, drawing is given below.**



5. A 200 V, 10 KW, separately excited dc generator has armature resistance of 0.2 Ω (including brush drops) and it is operating at its rated speed to supply rated power to a load that draws constant current. Calculate the power generated by the armature once the speed is reduced to half of the rated speed.
 Ans: E_b*I_a = 105*50



6. The graph above describes the load test results and OCC results of a self-excited dc generator. Answer the following:
   (i) Out of A, B and C, which one refers to the rated load current?
   (ii) What are the factors that cause the terminal voltage to fall from the value that it had during no load condition, with gradual increment of load?
   (iii) From the OCC curve, the voltage shown as aa' has the value of 2.2 volts. Armature resistance of the generator is 1.5 Ω and total brush drop is of 2 volts as shown in the figure above. Calculate the value of the current 'OA' as shown in the figure indicating load test results.
   ANS: At this point V_t = 0 and OA = (2.2-2)/1.5 = 0.133 amps

7. How does saturation of iron effectively helps the operation in case of self-excited generators?

5. $V_t = 200v$, $W_{out} = 10{,}000$ Watt

$I_{out} = 50$ A, $E_{b_1} = V_t + I_a R_a = 210v$

At constant current demand, speed is halved. (ϕ constant)

$\frac{E_{b2}}{E_{b1}} = \frac{1}{2} \Rightarrow E_{b2} = 105$

$P_{Arm} = 105 \times 50$

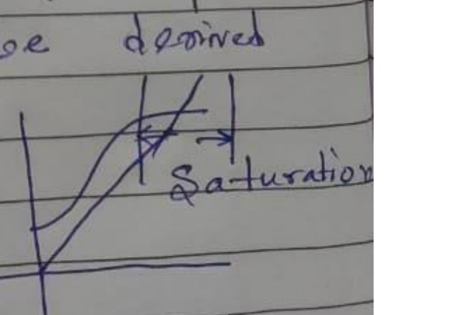
6. i) refers to rated current.

ii) $I_a R_a$ drop; Armature reaction → therefore net flux reduces and E_b drops and as E_b drops field current drops.

iii) At A point $V_t = 0$; (2.2-2)/1.5=0.133A

Ans: 0.133A

7. ii) When rated emf E_0 is generated iron slowly gets saturated and behaves like air gap and draws more current to generate same emf. If this had not happened, cumulative voltage build up would be infinite as can be derived from oc OCC curve.



EE240-Quiz 4 Solutions

1. The figure below shows a separately excited DC motor with the nameplate rating as follows: Armature rating: 220V, 10A, 1450rpm, ra=1 ohm Feild rating: 220V, 0.45A , Rf=490 ohm. In order to start the motor what should be the approximate value of Va and Vf? Explain.

Since, we prefer the motor to accelerate fast. we would require the maximum possible torque at start. But this torque should be a value such that the current does not exceed the ratings.

$T = K\phi I_a$

$\phi = \phi_{max}$.

$I = I_{a\,rated}$.

For $\phi = \phi_{max}$, $\boxed{V_F = 220V}$

At start, speed $= 0$ and $E_b = K\phi\underbrace{\omega}_{\omega = 0} = 0$.

$V_a = I_a R_a + E_b$.

$V_a = \underbrace{I_a}_{I_a = I_{a\,rated} = 10A} R_a$

$\boxed{V_a = 10 \times 1 = 10V}$

2. Armature and field winding of a separately excited DC motor is supplied with rated Voltages. The circuit is connected correctly yet the motor is not starting. What could be the reasons?

   Load torque>Motor torque, Field winding resistance is high, Loose Brush contact, Switched ON armature winding before filed winding which leads to higher armature current may damage motor

3. It is found that brushes are not making contact with the armature of the DC motor. How will this affect the performance of the motor?

   (3) As it is found that the brushes are not in contact with the armature of the DC motor hence the armature circuit is open i.e

   $$I_a = 0$$

   Since ~~B~~ armature current is zero hence torque is zero and the motor stops working.

Power Engineering Lab (EE 240)

IIT Bombay

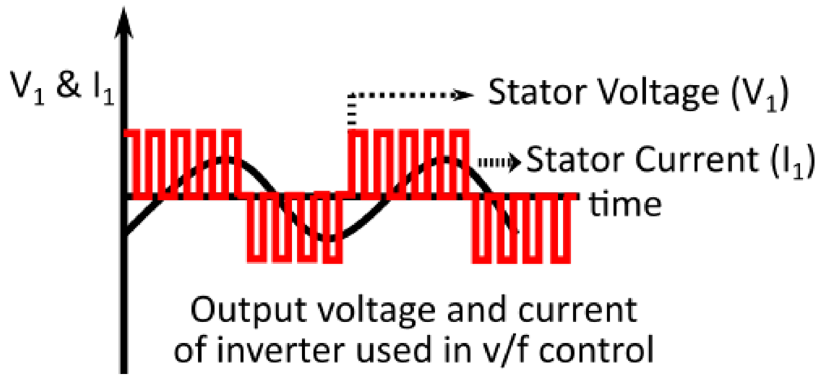
Quiz 5

1. A 3 phase 50 Hz induction motor has the synchronous speed of 1500 rpm and it is driving a balanced load with the rotor speed of 1470 rpm. Calculate the rotational speed of the rotor MMF with respect to the rotor and with respect to the stator. **Ans: slip = 0.02 and poles = 4. rotor mmf speed w.r.t rotor = (120 * (0.02*50))/4 = 30 rpm, speed w.r.t stator = 1500 r.p.m**

2. A 3 phase, 440 V, star connected squirrel cage induction motor has the starting torque of 60 N-m, when it is being started at its rated voltage, with a direct on line starter. Once the stator of the induction machine is connected through a Y connected auto-transformer, per phase voltage of 127 V is applied during the starting. What will be the value of the starting torque during this condition? **Ans: per phase voltage 254 V, Torque = 60 N-m, when per phase voltage is reduced to half, starting torque will be 0.25*60 = 15 N-m.**

3. From the video (posted in moodle) that explains the 'V/f' control of induction machine drive, it can be noticed that the output voltage of the inverter conprises of large number of pulses whose width is continuously changing, but the current flowing into the stator of the induction machine is of sinusoidal nature (explained in the figure below). Explain the reason behind this phenomenon. **Ans: Induction motor behaves like an R-L load to the inverter output voltage. Inductive nature of the load presents high impedance to the high frequency components of the voltage profile, so**

the stator current is predominantly of fundamental frequency and lagging in nature.



4. In the diagram depicted below, Fig. 1. Shows a machine which has slotted fins across its periphery, which is specially incorporated for the cooling purposes. Subsequently the machine showed in Fig. 2 does not require the fins as shown in the figure below.

Fig.1. Machine with Fins.

Fig.2. Machine without Fins.

One of these two machines is an induction machine and the other one is a dc machine. Point out which one is the induction machine and explain your answer. **Ans: Machine with slotted fins is the induction machine. The field across the airgap of the induction machine varies with time, which can initiate eddy current losses across the stator winding and that converts to**

heat energy. In dc machine the air gap flux is constant wrt time (varying in space). So eddy current based heating doesn't happen there.

5. Assume that a 3 phase, 4 pole, induction motor is developing same torque at 600 rpm when it is supplied by (a) V.V.V.F source, (b) reduced voltage at 50 Hz. In which case Torque/Amp is higher, justify your answer. Please note that V.V.V.F source is suitably adjusted so that motor speed is 600 rpm.

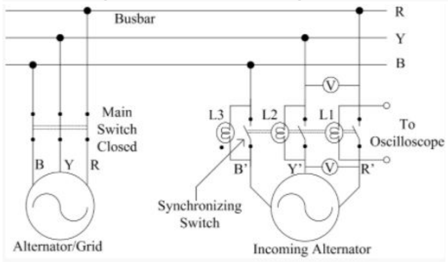
Ans: Torque/Amp is higher for V.V.V.F source as the flux stays constant in this method. With decreased voltage, to generate same torque, current requirement increases.

6. Why is the power factor of induction motor always lagging?

induction motor works on the principle of electromagnetic induction, in which the induced current always lag the voltage by 90 deg(pure inductor) in case of practical motor it is RL so the pf varies from 0 to 1 lagging.

EE-240 Quiz :6 solutions

1. What should be the worst-case voltage rating of the bulbs L1, L2, and L3 connected in between the incoming alternator and grid (440V,50Hz)?



2. While performing the experiment (synchronization using the dark lamp method), it was found that bulbs are flickering one after the other and not simultaneously. What could be the possible reason for it? And how can it be rectified?

3. There are Damper windings in Synchronous machines, which are similar to Squirrel cage in Induction machines. Why are they called Damper windings in Synchronous machines?

4. Why Synchronous motors are not self-starting?

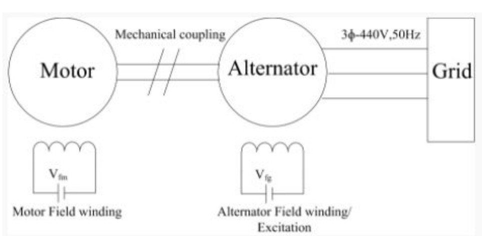
5. How much is the approximate installed Power Generation capacity in India and how much of it is Solar?

6. What is the maximum power rating of an alternator in MVA in India?

7. Consider the diagram as shown below and answer the questions related to it.

   i) What happens if we increase the field winding voltage (Vfg) of Alternator ?

   ii) What happens if we reduce the field winding voltage (Vfm) of Motor? Explain what is this analogous to in a thermal power plant.



8. How much is the approximate power demand of IIT Bombay? At what voltage level do we receive power from the grid?

Solutions

1.In the worst case, phase diffrence between the two-phase voltages would be 180°. The voltage that appears across the lamp will be ((440*√2)/√3 -(-440*√2)/√3)) = (2*440*√2)/√3

2. due to incorrect phase sequence correct the phase sequence until all bulbs glow bright and dark simultaneously by switching any two terminals

3. Damper windings damp the increase or decrease in speed and makes the rotor to rotate at synchronous speed. Damper winding provides induction motor action during disturbance

4. Due to the **inertia of the rotor** it cannot instantly catch\follow the synchronously rotating magnetic field. Or since rotor is stationery at starting and air gap field is rotating at synchronous speed so net torque on rotor is zero (torque is proportional to angle between rotor and stator magnetic field, which is varying sinusoidal)

5. Installed capacity: **Installed Capacity :3,79,130 MW (from Ministry of Power)**
Solar : **35,000MW(MNRE)** marks given to 30GW-40GW

6. 1000MVA

7. 1) When we increase Excitation E (E=4.44*f*N*Φ, as Φ increase,) of alternator δ can't change instantaneously so alternator will inject more power to grid but input power to alternator is constant. Now δ will decrease such that P=constant i.e. -Ef sinδ = constant, and Vt cosΦ = constant, and it will supply more reactive power for the same active power to the grid. in case of P is not constant, real power can be increased while maintaining the power factor.
Note: have a look on V-curve and inverted V curve for Alternator

2) When we reduce the field flux of motor it will increase speed, but speed is fixed by the alternator so back emf of motor will decrease and motor draw more current from source and it produces more toque and supply more power to alternator.
Note: - Motor is DC Motor; Em= k*ΦWm, P=Vmt(Vmt-Em)/Ra ; Vmt : motor terminal Voltage. It is analogous to increase steam input to turbine in a thermal power plant.

8. **22KV, 6-7 MW**