Meerut Institute of Engineering and Technology, Meerut

CO -wise Assignment (5 Question/Student-As Per Allocation)

Subject Code : BEE101/201			Subject Name : Fundamental of Electrical Engineering	Taught in :	First Year
CO No.	**Topic**	**Q. No.**	**Question (Statement) - appeared in AKTU End Sem Exams**	**Year and Sem (Odd / Even)**	**Marks**
4	E.M.F equation of D.C Gernrator	36	What is back E.M.F and it's significance in dc motor?	2020-21(ODD)	2
		37	Derive the E.M.F. equation of D.C. Generator. An 8 pole lap wound dc generator has 450 armature turns. It operates at 0.02 Wb flux per pole and runs at 1000 r.p.m. at no load. Find the emf induced by it.	2018-19 (ODD)	10
	Application of D.C motor	38	What are the applications of dc series and shunt motor?	2019-20 (ODD)	2
	Torque equation of D.C Motor	39	Derive the expression of torque for dc motor. Also discuss the applications of it.	2021-22(EVEN),2019-20 (ODD)	10
	Slip, rotor current frequency and field speed of three phase induction motor	40	A 4 pole, 3 phase, 50 Hz star connected induction motor has a full load slip of 4%.Calculate full load speed of the motor.	2019-20 (even)	2
		41	What is the relation between frequencies of stator & rotor currents? A 3-phase, 50Hz induction motor has 6 poles and operates with a slip of 5% at a certain load. Determine (i) The speed of rotor with respect to the stator. (ii) The frequency of the rotor current. (iii) The speed of the rotor magnetic field with respect to the stator.	2018-19 (ODD)	10
	Torque-slip characterictics of three phase induction motor	42	Draw the slip-torque characteristics of three phase induction motor. A 3-phase, 50 Hz induction motor has 6 poles and operates with a slip of 5 % at a certain load. Determine (i) the speed of the rotor with respect to the stator (ii) the frequency of rotor current (iii) the speed of the rotor magnetic field with respect to rotor.	2019-20 (ODD)	10
	Types of single phase induction motor	43	Why Single Phase induction motor is not self starting. What are different methods to make self starting. Explain one of them.	2020-21(ODD),19-20,18-19,16-17,14-15,13-14	10

Qus ⇒ Derive the emf equation of DC generator

E.M.F Equation of DC generator ⇒

(2018-19, 2017-18, 2013-14)

Let P = No of poles

ϕ = Flux produced by each pole in wb.

N = Speed of armature in r.p.m.

Z = Total No of Armature Conductors

A = No of parallel paths

$A = P$ for lap winding

$A = 2$ for wave winding

Now the average value of e.m.f induced in each armature conductor is,

$$e = \text{Rate of cutting the flux} = d\phi / dt$$

Now consider one revolution of conductor. In one revolution conductor will cut total flux produced by all the poles i.e $\phi \times P$. While time required to complete one revolution is 60/N seconds as speed is N r.p.m.

$$e = \frac{\phi P}{60/N} = \frac{\phi N P}{60}$$

This is the e.m.f. induced in one conductor. Now we have Z No of conductors with of parallel path. So we have total Z/A conductors in series in each parallel path.

$\therefore$ Total e.m.f. induced

$$E_g = \frac{\phi N P}{60} \cdot \frac{Z}{A} \quad \text{or} \quad \boxed{E_g = \frac{\phi Z N P}{60 A}}$$

Qus ⇒ An 8 Pole lap wound DC generator has 450 armature turns. It operates at 0.02 Wb flux per pole and runs at 1000 r.p.m at no load. find the e.m.f induced by it. (2018-19)

Solution ⇒ Given $P = 8$, $A = 8$, No of turns $= 450$

$\phi = 0.02$ Wb, $N = 1000$ r.p.m

Now No of conductors = 2X no of turns

$$\therefore Z = 2 \times 450$$
$$= 900$$

$$\text{Now } E_g = \frac{\phi N Z P}{60 A} = \frac{0.02 \times 900 \times 1000 \times 8}{60 \times 8}$$

$$\boxed{E_g = 300 \text{ Volt}} \quad \text{Ans}$$

Qus ⇒ Discuss various types of DC generator.

Types of DC generator ⇒ Depending upon the method of excitation used, the DC generator are classified as.

1. Separately excited generator → Separate DC supply is used to excite the field winding.

Ques ⇒ What is back emf ? What is the significance of back emf ? (2016-17, 15-16, 14-15, 13-14)

Back emf ⇒ * In DC motor, after motoring action, armature starts rotating and armature conductor cuts the main flux.

* So, there exist a generating action also. Due to which an emf gets induced into the armature conductors.
* This induced emf always opposes the supply voltage (lenz's law). It is called back emf.
* So according to emf equation back emf is given by

$$\boxed{E_b = \frac{\phi Z N P}{60 A}}$$

Significance of Back E.M.F ⇒ The symbolic representation of motor and back e.m.f is shown in fig.

We can write

$$-V + I_a R_a + E_b = 0$$

or $V = E_b - I_a R_a$

or $I_a = \boxed{\frac{V - E_b}{R_a}}$

Due to presence of back e.m.f DC motor becomes a self regulating machine i.e motor adjust itself to draw the armature current which is enough to supply the load demand.

As $E_b \propto N$

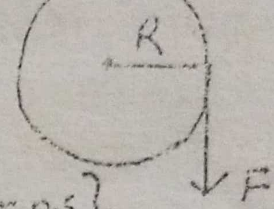
So when load increase ↑, motor speed N decrease ↓ and due to this E_b ↓. Now the difference $(V - E_b)$ increase ↑

Therefore I_a increases ↑.

Ques ⇒ Derive the torque equation of DC motor. (2019-20, 14-15) (2016-17)

Ans ⇒ Torque equation ⇒

Let a wheel having radius R meter.
Circumferential force = F Newton
Speed of rotation of wheel = N r.p.m



Now

$$\omega = 2\pi n = \frac{2\pi N}{60} \quad \{\text{where } n = \text{speed in r.p.s}\}$$

Now the work done is given by

W = F × distance travelled in one revolution = F×2πR

And

$$\text{Power developed, } P = \frac{\text{Workdone}}{\text{Time}} = \frac{F \times 2\pi R}{\left(\frac{60}{N}\right)}$$

$$P = F \times R \cdot \left(\frac{2\pi N}{60}\right)$$

$$\therefore \boxed{P = T \cdot \omega} \quad \left\{\text{where } \omega = \frac{2\pi N}{60}\right\}$$

Now the gross mechanical power developed by the armature is

$$\boxed{P = E_b \cdot I_a}$$

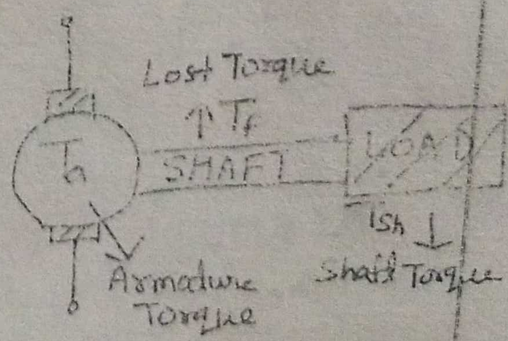
$$\therefore E_b \cdot I_a = T_a \cdot \frac{2\pi N}{60}$$

$$\frac{NP\phi Z}{60A} \cdot I_a = T_a \cdot \frac{2\pi N}{60} \quad \left\{\because E_b = \frac{NP\phi Z}{60A}\right\}$$

$$\boxed{T_a = \frac{1}{2\pi} \cdot \frac{I_a \cdot P\phi Z}{A}} \quad \text{OR} \quad \boxed{T_a = 0.159 \frac{I_a P\phi Z}{A}}$$

$$\boxed{T_a \propto \phi \cdot I_a}$$

$$\boxed{T_a = T_f + T_{sh}}$$

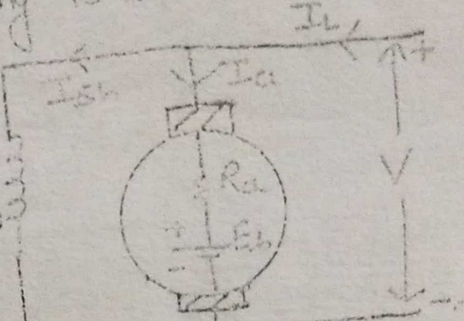


Imp.

Q. What are the different types of DC motor? (2016-17, 14-15)

Types of DC motor ⇒

① DC shunt Motor ⇒ Similar to DC shunt generator, here also field winding is connected across the armature.



From the fig. 8

$I_L = I_a + I_{sh}$

OR $\boxed{I_a = I_L - I_{sh}}$ also $\boxed{I_{sh} = \frac{V}{R_{sh}}}$

And apply K.V.L

$-V + I_a R_a + E_b + 2V_b = 0$. Where V_b = Voltage drop across each brush

$\therefore \boxed{E_b = V - I_a R_a - 2V_b}$

or $\boxed{E_b = V - I_a R_a}$ {Neglecting brush voltage drop}

And power developed in armature

$\boxed{P_a = E_b I_a}$

② DC Series Motor ⇒ Here field winding is connected in series with armature.

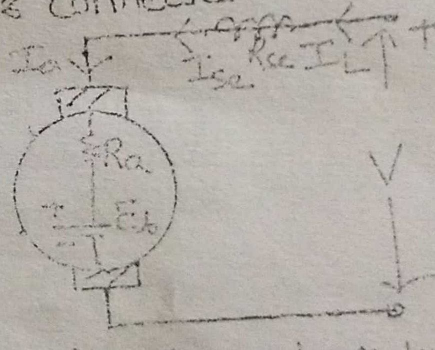


Fig 9: DC series motor

So from fig 9 $I_a = I_L = I_{se}$

and $-V + I_{se}R_{se} + I_a R_a + E_b + 2V_b = 0$

or $\boxed{E_b = V - I_a (R_a + R_{se}) - 2V_b}$

Where V_b = brush drop across each brush

$\boxed{E_b = V - I_a (R_a + R_{se})}$

Here $\phi \propto I_{se} \propto I_a$

So $T \propto \phi I_a$ or $\boxed{T \propto I_a^2}$

So very high torque is available. this is why it is used for heavy loads

Now Armature Power $\boxed{P_a = E_b I_a}$

It is similar to speed - Armature current characteristics.

Qus ⇒ Write down the applications of DC series & shunt motor

(2020-21, 19-20, 18-19, 17-18, 15-16)

Ans ⇒ Series Motor ⇒ ① Crane
② Hoists
③ Elevators
④ Trolley's
⑤ Conveyors
⑥ Electric locomotive

Shunt Motor ⇒ ① Fans and blowers
② Centrifugal pumps
③ Lathe machines
④ Machine tools
⑤ Milling Machines
⑥ Drilling Machines

V.Imp.

Ques ⇒ A 3-phase 4 pole induction motor is supplied from 3-phase 50 Hz supply. calculate : (a) N_s (b) Rotor speed when slip is 4%. (c) Rotor frequency when rotor runs at 60 rpm. (2013-14 Even)

Solution ⇒ Given $P = 4$, $f = 50 Hz$, $s = 4\%$.

(1) Now $N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 rpm$

$$\boxed{N_s = 1500 rpm}$$

(2) $N_r = N_s (1-s)$

$1500 (1-0.04)$

$$\boxed{N_r = 1440 rpm}$$

(3) $N_r = 60 rpm$

$\therefore s = \frac{N_s - N_r}{N_s} = \frac{1500-600}{1500}$

$= 0.96$

$\therefore$ rotor frequency

$f_r = sf$

0.96×50

$$\therefore \boxed{f_r = 48 Hz}$$

Imp.

Ques ⇒ How to reverse of rotation of 3-ϕ Im (Induction-motor). (2018-19)

Ans ⇒ By interchanging any two terminals of stator winding which is connected to 3ϕ AC supply, the direction of RMF get reversed. Due to this the direction of rotation of 3-ϕ induction motor gets reversed.

Ques ⇒ What is the relation between frequency of stator & rotor currents? A 3-phase, 50Hz induction motor has 6 poles and operates with a slip of 5% at a certain load. Determine (i) The speed of rotor with respect to the stator. (ii) The frequency of the rotor current. (iii) The speed of the rotor magnetic field with respect to the stator. (2018-19 odd)

Ans ⇒ $\boxed{F_r = sf}$

Given, $f = 50Hz$, $P = 6$, $s = 5\% = 0.05$

Now $N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000$ rpm

And $N_r = N_s(1-s) = 1000(1-0.05) = 950$ r.p.m

Now ① Speed of rotor w.r.t stator ⇒ $N_r - 0 = 950$ rpm

② $F_r = Sf = 0.05 \times 50 = \boxed{F_r = 2.5\ Hz}$

③ Speed of rotor magnetic field with respect to stator $= N_s - 0 = 1000$ r.p.m. Ans

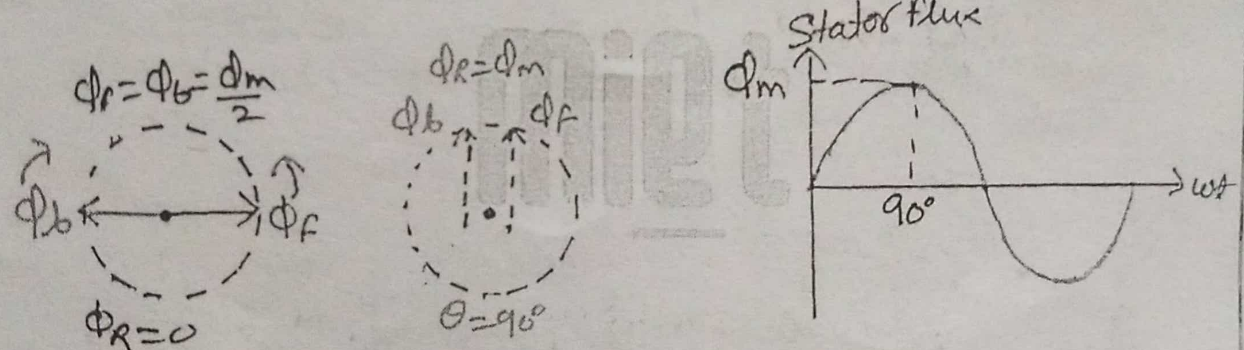
SINGLE PHASE INDUCTION MOTOR

Imp.

Ques ⇒ With the help of double revolving field theory explain that single phase induction motor is not self-starting. List the various methods of starting. (2020-21, 19-20, 18-19, 16-17, 14-15, 13-14)

Ans ⇒ Double revolving field theory ⇒ According to this theory, any alternating quantity can be resolved into two rotating components which rotate in opposite direction with same speed (N_s) and each having magnitude as half of the maximum magnitude of alternating quantity.

Where $$\boxed{N_s = \frac{120f}{P}}$$



⇒ In case of single phase induction motor, when 1-ϕ AC supply is given to stator winding, it produces an alternating magnetic field having maximum magnitude of ϕ_m.

⇒ Now according to double revolving field theory, this alternating flux can be imagined as of two rotating fluxes each having magnitude $\phi_m/2$ and rotates in opposite direction with a speed N_s.

⇒ Let ϕ_f is the forward component rotating anticlockwise direction and ϕ_b is backward component rotating in anti-clock wise direction.

⇒ Now, as we have two rotating fluxes ϕ_f & ϕ_b. Hence get cut by rotor. Due to this an emf induced in the rotor which circulate rotor current.

⇒ Now we know that every current carrying conductor will experiance a force if it is placed in magnetic field.

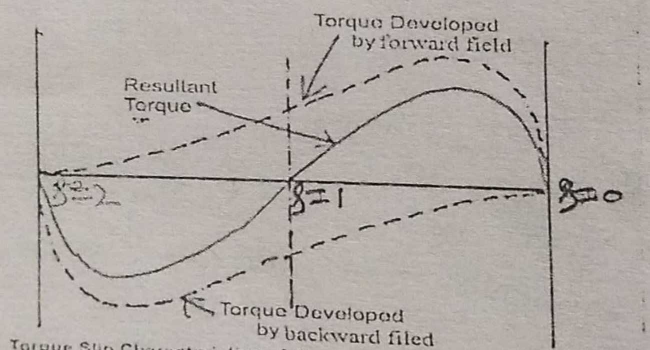
⇒ So due to ϕ_f rotor will experience a torque in anti-clockwise direction and due to ϕ_b it will experience some amount of torque in clockwise

⇒ Thus the net torque experienced by the rotor is zero at start and hence the single phase IM is not self stator.

Torque slip characteristics ⇒

⇒ The two torque which are opposite to each other and their resultat can be shown effectively with the help of torque slip characteristics.

Ques ⇒



Torque Slip Characteristics of Single Phase Induction Motor

V. Imp.

Ques ⇒ List the various methods of starting/types of 1-ϕ induction motor. (2018-19, 16-17, 14-15, 13-14)

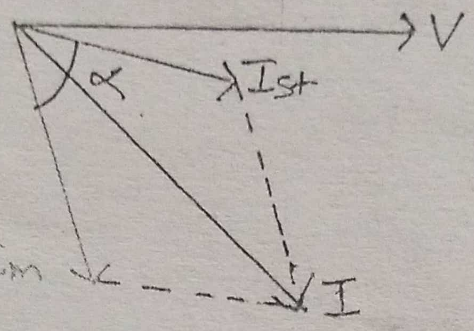
⇒ As we have see that 1-ϕ induction motor have zero starting torque. So it is not self starting.

So at start if rotor get some brush in direction then it will start rotation.

⇒ So, to produce starting torque we need atleast two fluxes having some phase difference between them.

$$\boxed{T_{st} \propto I_a \sin\alpha}$$

$$\boxed{I_{st} = I_a}$$



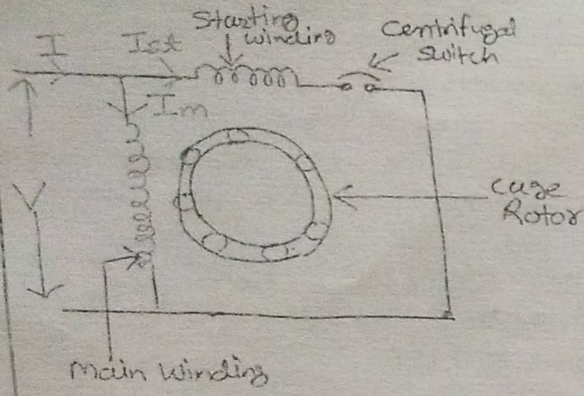
⇒ So attempt is made in single phase induction motor. To produce additional flux along with the stator flux, which must have certain phase difference between them. for this we use phase splitting technique.

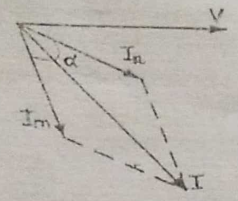
So according to the method applied 1-φ induction motor are divided in to following types.

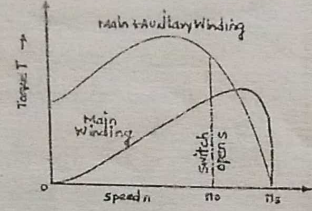
1. Split phase induction motor
2. Capacitor start induction motor (2013-14)
3. Capacitor start capacitor run induction motor
4. Shaded pole induction motor.

1. Split Phase induction motor ⇒ * This type of motor has single phase stator winding called main winding and one more winding called auxiliary winding or starting winding.

* The starting winding is highly resistive while the main winding is highly inductive.







Let I_m = Current in main winding
I_{st} = Current in starting winding

* Now from phasor diagram, we have two current I_m & I_{st} and there exits a phase difference α b/n them

And $\boxed{I_{st} \propto I_a \sin\alpha}$

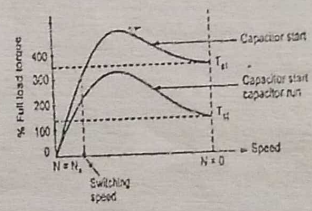
* So due to this starting torque is produced and motor runs in one particular direction.
* The auxiliary winding has a centrifugal switch in series with it. So when motor gain speed up to 70 to 80% of synchronous speed, centrifugal switch gets open and starting winding is disconnected.

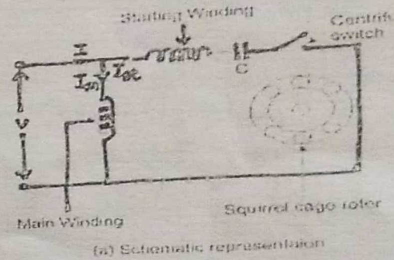
V. Imp.

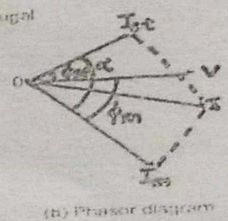
② Capacitor start induction motor ⇒ * It is similar to the resistance split phase capacitor in series

The only difference is, there is capacitor in series with auxilary winding.

* As capacitor draws a leading current. So due to this angle between I_m and I_{st} (α) increases.
Hence torque also increases.

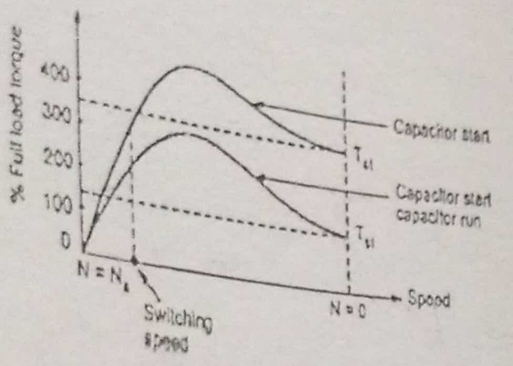


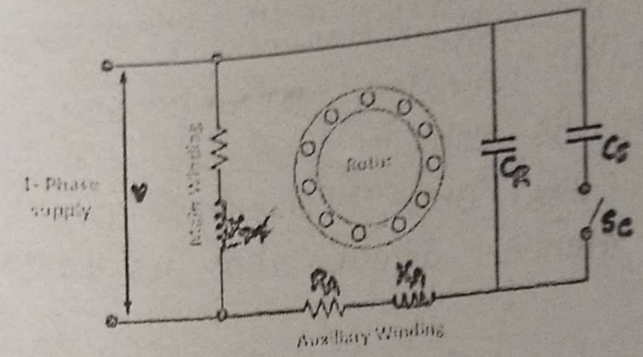




③ Capacitor start - capacitor run induction motor ⇒

* It is similar to capacitor start induction motor. The only difference is here capacitor remains in the ckt during running condition. this will improved the P.f of motor.
* In some motors two different - 2 capacitor are use for starting & running.
* The starting capacitor along with starting winding is disconnected with the help of centrifugal switch when motor gain 70 to 80%. speed.





(2020-21, 14-15).

Applications ⇒ Fans, Blowers, Compressors, grinders, retrigerators, AC etc.

SYNCHRONOUS MOTOR

Imp.

Ques ⇒ Explain the principle of operation of 3-φ synchronous motor. (2020-21, 19-20, 18-19, 17-18, 16-17, 14-15, 13-14)

Ans ⇒ Working principle of synchronous motor :—

Synchronous motor works on the principle of magnetic locking. When two magnets are brought together, opposite poles attract each other, and the magnetically locked.

* ... of the magnet is rotated the other ... in same direction, with the