Sub:	Introduction to Electrical Engineering							Code:	BESCK104B
Date:	/ /2023	Duration:	90mins	Max Marks:	50	Sem:	1st sem	Branch:	Chemistry cycle

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1.a	In a series RLC, circuit R = 100 Ω, L = 0.15 H, and C = 25 µF. If the source voltage and frequency are 220 V and 50 Hz, respectively.Calculate (i) impedance (ii)Power (iii)Power factor (iv)current	4	CO2	L3
1. b	With the help of phasor diagram, show that the current drawn by the R-C series circuit, leads the applied voltage by an angle Ø with respect to voltage.	6	CO2	L1
2	With a neat diagram, explain the constructional details of DC generator.	10	CO3	L2
3.a	A long shunt compound generator has an armature, series field and shunt field resistances of 0.04 Ω, 0.03 Ω and 200 Ω respectively. It supplies a load current of 180 A at 400 V. Calculate the Generated e.m.f. Assume the contact drop per brush is 1 V.	6	CO3	L3
3.b	Explain the function of following parts of DC machine.(i) Commutator (ii)Pole shoe	4	CO3	L2
4.a	With usual notations derive an emf equation of D.C. generator.	4	CO3	L3

P.T.O

4.b	A 4 pole short shunt compound generator has armature, shunt field and series field resistances of 0.4 ohms,160 ohms and 0.2 ohms respectively.The armature is lap connected with 440 v conductors and is driven at 600rpm. Calculate the flux per pole when the machine is delivering 120 Amperes at 400v.	6	CO3	L3
5	Discuss the classification of different types of DC generators. What is the relation between induced emf and terminal voltage?	10	CO3	L2
6.a	Three coils having resistance of 10Ω and inductance of 0.02H are connected in star across 440V, 50Hz three phase supply. Calculate the line current, power factor and total power consumed.	6	CO3	L2
6.b	Differentiate between star and delta connection.	4	CO3	L1
7	What is phase sequence? Explain how 3-phase waveform is generated and also what are the limitations of 1-phase supply? Discuss about advantages of 3-phase supply.	10	CO2	L2

CCI **CI** **HOD**

BEE_IAT II_ Solution

1.a In a series RLC, circuit R = 100 Ω, L = 0.15 H, and C = 25 µF. If the source voltage and frequency are 220 V and 50 Hz, respectively. Calculate (i) impedance (ii)Power (iii)Power factor (iv)current

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Given

$R = 100\,\Omega$

$C = 25\,\mu F \quad X_C = \frac{1}{C\omega} = \frac{1}{25\times10^{-6}\times2\times\pi\times50}$

$= 127.39\,\Omega$

$L = 0.15\,H \quad X_L = L\omega = 0.15\times2\times\pi\times50$

$= 47.1\,\Omega$

$$Z = \sqrt{100^2 + (X_L - X_C)^2}$$

$$Z = 100 - j\,80.29 = 128.24\,\angle{-38.76}\,\Omega$$

$$I = \frac{V}{Z} = \frac{220}{128.24\,\angle{-38.76}} = 1.72\,\angle 38.76\,A$$

$$P = VI\cos\phi$$

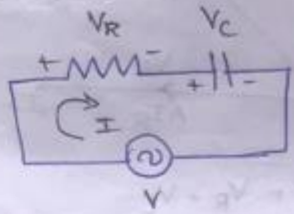
$$Pf = \cos\phi = \frac{R}{Z} = \frac{100}{128.24\,\angle{-38.76}} = 0.78\,\angle 38.76$$

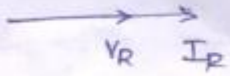
leading

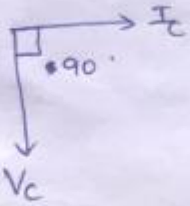
1.b With the help of phasor diagram, show that the current drawn by the R-C series circuit, leads the applied voltage by an angle Ø with respect to voltage.

Series RC circuit

$V = V_R + V_C$

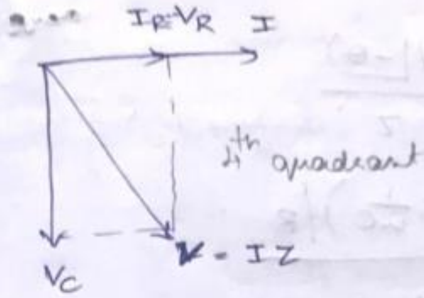






$V_C = -jIX_C$

$V = V_R + V_C = IR - jIX_C$

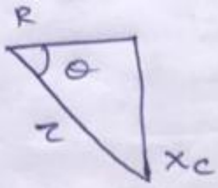


X_C - capacitive reactance

$V = I(R - jX_C)$

$\frac{V}{I} = R - jX_C = Z = Z\angle\theta$

$Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$ $\theta = \tan^{-1} \frac{-X_C}{R}$



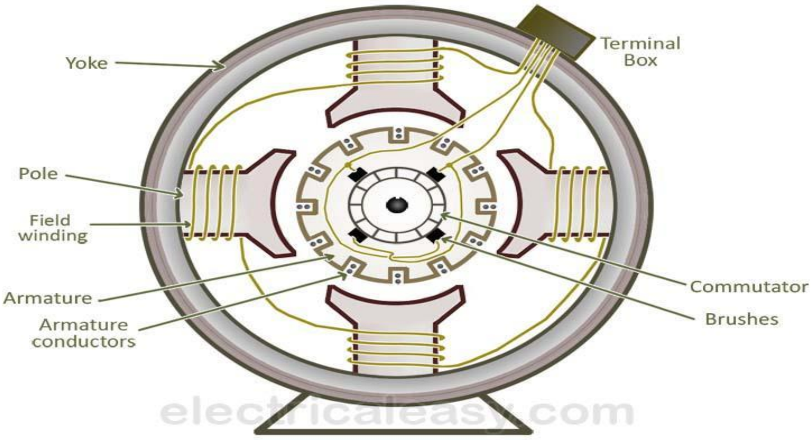
$i = \frac{V_m \sin(\omega t + \theta)}{\sqrt{R^2 + \frac{1}{(\omega C)^2}}}$ $\theta = \tan^{-1} \frac{1}{\omega CR}$

Q.2 With a neat diagram, explain the constructional details of DC generator.
(Explanation of each part-2 marks)

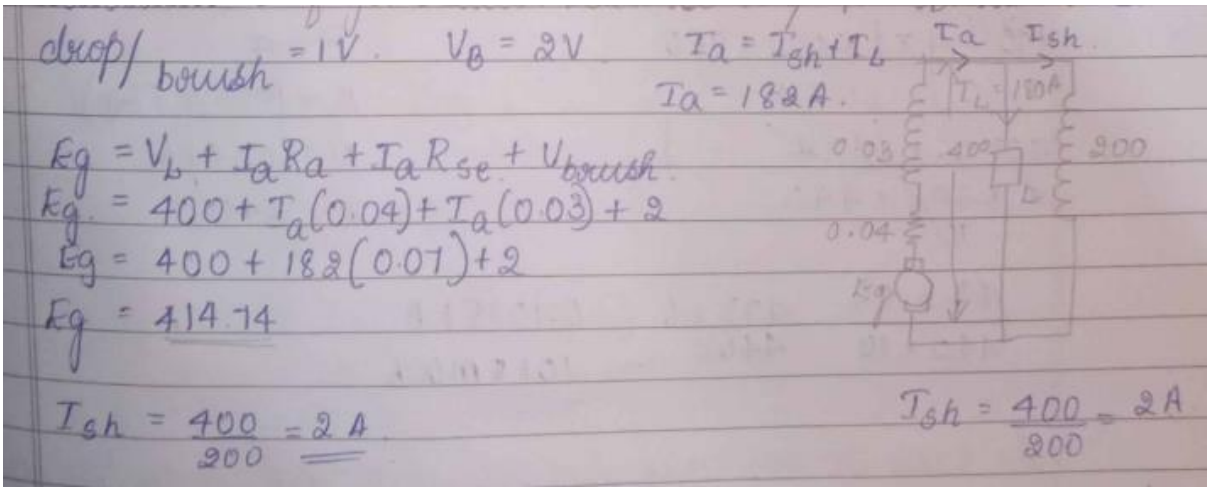
Main components

1. Field system
2. Armature core
3. Armature winding
4. Commutator
5. Brushes

6. Shaft & Bearings



3.a A long shunt compound generator has an armature, series field and shunt field resistances of 0.04 Ω, 0.03 Ω and 200 Ω respectively. It supplies a load current of 180 A at 400 V. Calculate the Generated e.m.f. Assume the contact drop per brush is 1 V.



drop/brush = 1V. $V_B = 2V$

$I_a = I_{sh} + I_L$

$I_a = 182A$.

$E_g = V_L + I_a R_a + I_a R_{se} + V_{brush}$

$E_g = 400 + I_a(0.04) + I_a(0.03) + 2$

$E_g = 400 + 182(0.07) + 2$

$E_g = 414.74$

$I_{sh} = \frac{400}{200} = 2A$

3.b Explain the function of following parts of DC machine.(i) Commutator (ii)Pole shoe

Commutator

- The function of the commutator is to convert alternating current induced in the armature to direct current
- The commutator is made up of copper segments insulated from each other by mica sheets

Pole shoes

- It supports the field winding
- It spreads out the flux uniformly in the air gap
- It reduces the reluctance of the magnetic path

4.a With usual notations derive an emf equation of D.C. generator.

Emf equation of generator

Notations for equations

ϕ= flux/pole in Wb

Z = total number of armature conductors

P = number of poles

A = number of parallel paths = 2 ... for wave winding

= P ... for lap winding

N = speed of armature in r.p.m

Eg = e.m.f of the generator = e.m.f /parallel path

Derivation of equation

Flux cut by one conductor in one revolution of the armature,

$$d\Phi = P\Phi \text{ webers}$$

Time taken to complete one revolution,

$$dt = 60/N \text{ second}$$

e.m.f generated/conductor $= d\Phi/dt = p\Phi N/60$ volts

Emf of generated,

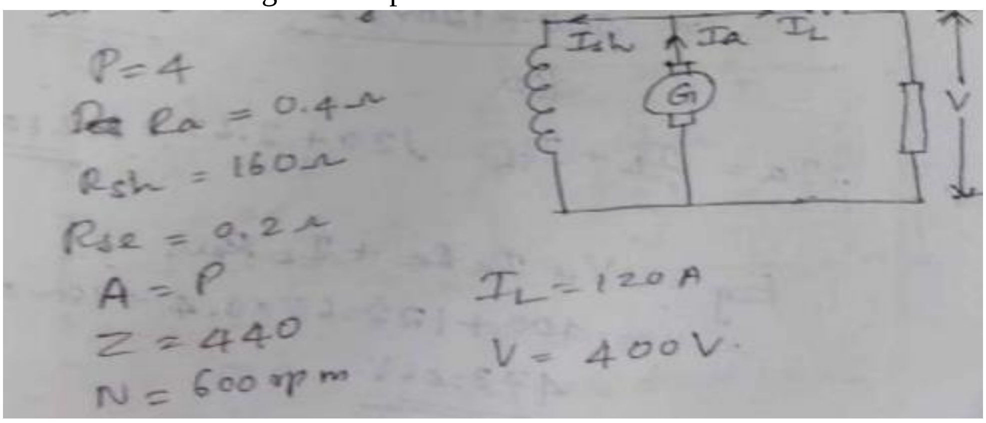
$E_{g=emf}$ per parallel

=(emf/conductor)*no, of conductor in series per parallel path

$= P\Phi NZ/60A$

therefore $E_{g=} P\Phi NZ/60A$

4.b A 4 pole short shunt compound generator has armature, shunt field and series field resistances of 0.4 ohms,160 ohms and 0.2 ohms respectively.The armature is lap connected with 440 conductors and is driven at 600rpm. Calculate the flux per pole when the machine is delivering 120 Amperes at 400v.



$$E_g = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$$

$$V = E_g - I_a R_a - I_L [R_{se}]$$

$$= E_g - I_a R_a - I_L R_{se}$$

$$\therefore E_g = V + I_a R_a + I_L R_{se}$$

$$I_a = I_L + I_{sh}$$

$$I_{sh} = \frac{V + I_L R_{se}}{R_{sh}}$$

$$= \frac{400 + 120 \times 0.2}{160} = \underline{2.65A}$$

$$\therefore I_a = I_L + I_{sh} = 120 + 2.65 = \underline{122.65A}$$

$$\therefore E_g = V + I_a R_a + I_L R_{se}$$

$$= 400 + 122.65 \times 0.4 + 120 \times 0.2$$

$$= \underline{473.06V}$$

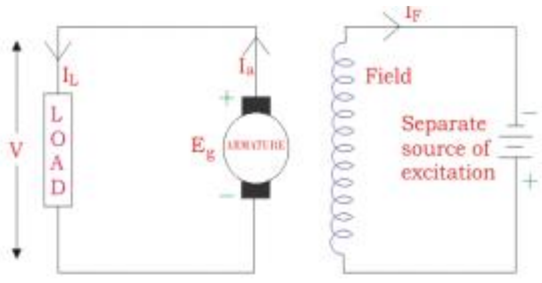
5. Discuss the classification of different types of DC generators. What is the relation between induced emf and terminal voltage?

7(b) Generally **DC Generators** are classified according to the ways of excitation of their fields.
There are three methods of excitation. Field coils excited by permanent magnets – **Permanent magnet DC generators.**

- Field coils excited by some external source – **Separately excited DC generators.**
- Field coils excited by the generator itself – **Self excited DC generators.**

Separately Excited DC Generators

- These are the generators whose field magnets are energized by some external DC source such as battery.
  A circuit diagram of separately excited DC generator is shown in figure.
  I_a = Armature current
  I_L = Load current
  V = Terminal voltage
  E_g = Generated emf



Separately Excited DC Generator

Voltage drop in the armature = Ia Ra
Let Ia = IL = I
Voltage across the load, V = IRa
Power generated, Pg = Eg I
Power delivered to the external load,
PL = V I

According to the position of the field coils the self – excited DC Generators may be classified as :

- Series wound generators
- Shunt wound generators
- Compound wound generators

Series Wound Generator

Let R_{sc} = Series winding resistance

I_{sc} = Current flowing through the series field

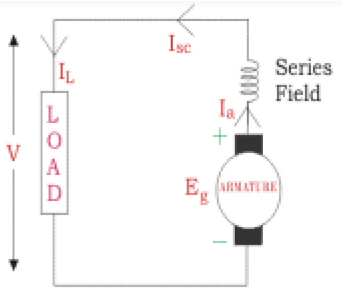
R_a = Armature resistance

I_a = Armature current

I_L = Load current

V = Terminal voltage

E_g = Generated emf



Series Wound Generator

- Here Ia = Isc = IL = I
- Voltage across the load, V = Eg – Ia(Ra + Rsc) – Brush drop
- Power generated, Pg = Eg Ia
- Power delivered, PL = V I

Shunt wound Generator

Let, R_{sh} = Shunt winding resistance

I_{sh} = Current flowing through the shunt field

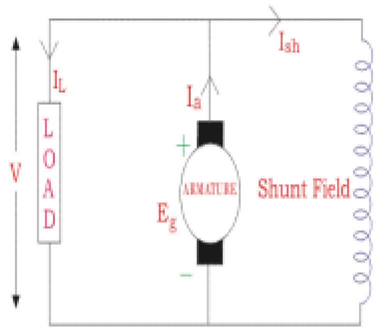
R_a = Armature resistance

I_a = Armature current

I_L = Load current

V = Terminal voltage

E_g = Generated emf



Shunt Wound Generator

Here Ia = Ish + IL

Ish = V / Rsh

Voltage across the load,

V= Eg – Ia Ra – Brush drop

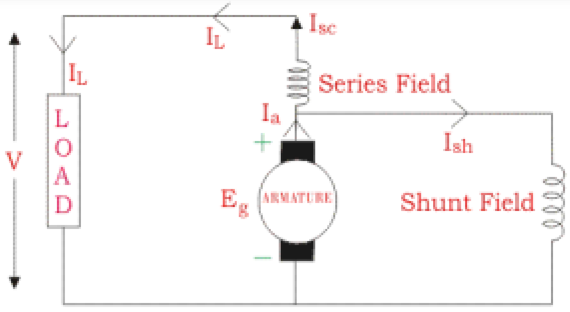
Power generated, Pg = Eg Ia

Power delivered to the load, PL = V I_L

Compound Wound Generators

Short Shunt Compound Wound DC Generators

These are the generators in which only shunt field winding is in parallel with the armature winding

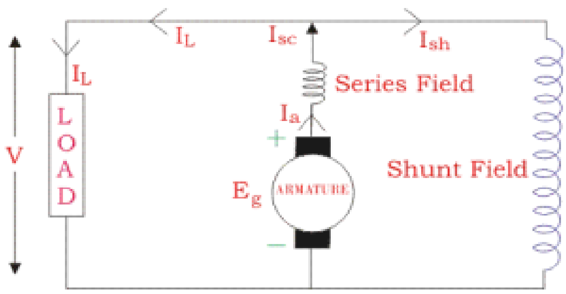


Short Shunt Compound Wound Generator

$Isc = I_L$
$Ish = (V + Isc\ Rsc) / Rsh$
$Ia = Ish + I_L$
$V = Eg – Ia\ Ra – Isc\ Rsc – \text{Brush drop}$
$Pg = Eg\ Ia$
$PL = V\ I_L$

Long Shunt Compound Wound DC Generator

The generators in which shunt field winding is in parallel with both series field and armature winding as shown in figure.



Long Shunt Compound Wound Generator

$Ish = V / Rsh$
$Isc = I_L + Ish$
$V = Eg – Ia\ Ra – Isc\ Rsc – \text{Brush drop}$
$Pg = Eg\ Ia$
$PL = V\ I_L$

6.a Three coils having resistance of 10Ω and inductance of 0.02H are connected in star across 440V, 50Hz three phase supply. Calculate the line current, power factor and total power consumed.

Given $R = 10\,\Omega$, $L = 0.02H$, Y Connected

$V_L = 440V$ $f = 50Hz$, 3ϕ.

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254.03V$$

$$Z_{ph} = R + jX_L = 10 + j(0.02 \times 2\pi \times 50)$$

$$= 11.81 \angle 32.13\,\Omega$$

$$I_{ph} = V_{ph}/Z_{ph} = \frac{254.03}{11.81 \angle 32.13}$$

$$= 21.57 \angle -32.13\,A$$

In Y Connected system $I_L = I_{ph}$

$$P = \sqrt{3}\, V_L I_L \cos\phi = \sqrt{3} \times 440 \times 21.57 \cos(32.13)$$

$$= 13.882\,kW$$

6.b Differentiate between star and delta connection.

Star (Y)	Δ - Connection
→ $V_L = \sqrt{3}\, V_{ph}$ $I_L = I_{ph}$	→ $I_L = \sqrt{3}\, I_{ph}$ $V_L = V_{ph}$
→ Neutral wire available	→ Neutral wire not available.
→ 3ϕ 4 wire S/m possible	→ 3ϕ 4 wire S/m - not possible.
→ Both domestic & industrial loads can be handled	→ only Industrial load
→ Protection through Neutral wire	→ Neutral wire absent. Protective devices cannot be used.

7. What is phase sequence? Explain how 3-phase waveform is generated and also what are the limitations of 1-phase supply? Discuss about advantages of 3-phase supply.

Phase rotation, or phase sequence, is the order in which the voltage waveforms of a polyphase AC source reach their respective peaks. For a three-phase system, there are only two possible phase sequences: 1-2-3 and 3-2-1, corresponding to the two possible directions of alternator rotation.

→ 1-ϕ AC Voltage generated by using a single turn alternator.

→ No. of turns connected in series to form one winding armature

→ Poly phase systems – Armature winding is divided into No. of phase required.

2 windings - 2ϕ 3 windings - 3ϕ

→ No. of independent voltage is the same as number of phases of armature winding.

→ Various phases are arranged such a way that frequency & magnitude remain same but will have phase difference between them.

$$\text{Phase difference} = \frac{360}{\text{No. of phases}}$$

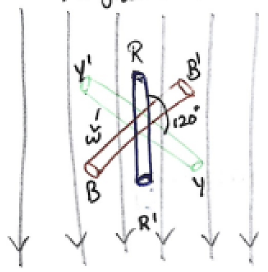
for 2ϕ S/m: $\frac{360}{2} = 180^\circ$

for 3ϕ: $\frac{360}{3} = 120^\circ$

Generation

In general the 3ϕ system is named as RYB (Red, Yellow, Blue).

The fig. below illustrates principle of generation of 3ϕ voltage s/m.



The 3 coils wound on rotor has a displacement of 120° from one another.

The rotor is rotated anti clockwise in a uniform magnetic field with a uniform angular speed ω.

A sinusoidal emf is generated in each coil.

Because of the space displacement of the coils, after 1/3 cycle of rotation coil YY' occupies the same position as RR' coil did.

∴ The emf of coil YY' lags behind the emf of coil RR' by 120°. Similarly BB' lags YY' by 120° hence RR' by 240°.

∴ If all three coils are identical then we get emf. of same amplitude and frequency but time displaced by 120°.

For generating emf in a coil we need relative motion between coil & magnetic field.

So we can either rotate coil keep field constant

or

rotate field and keep coil constant.

In either way we can generate emf.

Generally coils are wound on stator with 120° phase displacement and field on rotor.

The emfs generated are

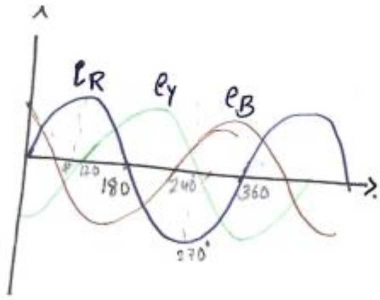
The emfs generated are

$$e_R = E_m \sin\omega t$$

$$e_y = E_m \sin(\omega t - 120)$$

$$e_B = E_m \sin(\omega t - 240) \quad \text{or} \quad E_m \sin(\omega t + 120)$$

$$e_R + e_y + e_B = 0$$



Depending on the interconnection of 3phase winding: 3ϕ system is divided in two category

1. Star
2. Delta.

Limitation :->

The biggest disadvantage of 3-ϕ system is that it cannot handle the overload; It might damage the equipment.

chances of repairing the instrument is higher. Bcoz cost of individual components are expensive.

Advantages of 3-Phase system.

1. Three phase transmission lines require much less conductor material

2. Phasor sum of currents in all phases is zero. So, saving of material as we need not provide neutral conductor or if we provide also it is single neutral with conductor of smaller size.

3. For a given frame size, a 3-phase machine gives a higher output than a single-phase machine.

4. Power in single phase system develops pulsating torque. While 3ϕ is almost constant.

5. The 3ϕ supply system can supply both domestic and commercial load.

6. Voltage regulation is better in 3ϕ than 1ϕ system.

7. Output of 3ϕ machine is higher compared to 1ϕ.

8. 3ϕ supply produces rotating magnetic field this makes IM self starting.

9. 3ϕ system is more efficient.