

**COMBINED FIRST AND SECOND SEMESTER B.TECH (ENGINEERING) DEGREE
EXAMINATION
EN14107 – BASICS OF ELECTRICAL ELECTRONICS AND COMMUNICATION
ENGINEERING
Section I (Basics of Electrical Engineering)**

Part A

Answer any 4 questions

- 1) State and explain Faraday's laws of electromagnetic induction
- 2) State and explain Kirchoff's laws
- 3) Derive the e.m.f. equation of a transformer.
- 4) Explain the principle of operation of induction motor
- 5) What is an ideal transformer explain about it.

Part B

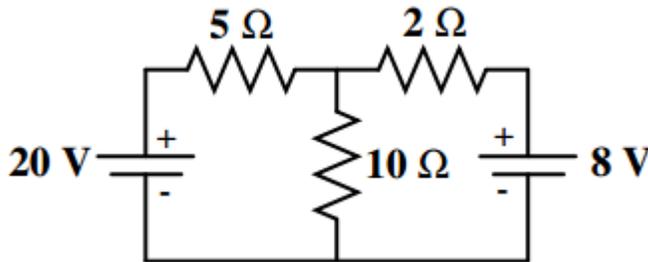
- 6) i) Explain construction details of d.c. generator (10 Marks)
ii) Derive an expression for emf equation for dc generator (5Marks)

OR

- 7) i) Explain the construction and principle of operation single-phase transformer (10 Marks)
ii) Explain about the basic structure of a.c. power system. (5Marks)

- 8) i) Define the terms
(i) time period
(ii) rms value
(iii) average value
(iv) form factor
(v) peak factor in an ac circuit (10 Marks)

- ii) Using Kirchoff's law, find the current through 10Ω resistor.



(5Marks)

OR

- 9) i) Explain about three phase system (10 Marks)
ii) Compare electric and magnetic circuits (5 marks)

ANSWERS

PART A

1)) Faraday's laws of electromagnetic induction state:

- (i) 'An induced e.m.f. is set up whenever the magnetic field linking that circuit changes.'
- (ii) 'The magnitude of the induced e.m.f. in any circuit is proportional to the rate of change of the magnetic flux linking the circuit.'

2) Kirchhoff's Current Law (KCL): KCL states that at any node (junction) in a circuit the algebraic sum of currents entering and leaving a node at any instant of time must be equal to zero. Here currents entering(+ve sign) and currents leaving (-ve sign) the node must be assigned opposite algebraic signs

Kirchhoff's Voltage Law (KVL): It states that in a closed circuit, the algebraic sum of all source voltages must be equal to the algebraic sum of all the voltage drops.

3) The magnetic flux set up in the core of a transformer when an alternating voltage is applied to its primary winding is also alternating and is sinusoidal. Let ϕ_m be the maximum value of the flux and f be the frequency of the supply. The time for 1 cycle of the alternating flux is the periodic time T , where $T = 1/f$ seconds. The flux rises sinusoidally from zero to its maximum value in $1/4$ cycle, and the time for 1 cycle is $1/4f$ seconds.

Hence the average rate of change of flux = $4 f \phi_m$ Wb/s, and since 1 Wb/s = 1 volt, the average e.m.f. induced in each turn = $4 f \phi_m$ volts.

As the flux varies sinusoidally, then a sinusoidal e.m.f. will be induced in each turn of both primary and secondary windings.

For a sine wave, form factor = 1.11

$$\begin{aligned} \text{rms value} &= \text{form factor} \times \text{average value} \\ &= 1.11 \times \text{average value} \end{aligned}$$

Thus rms e.m.f. induced in each turn
= $1.11 \times 4 f \phi_m$ volts = $4.44 f \phi_m$ volts

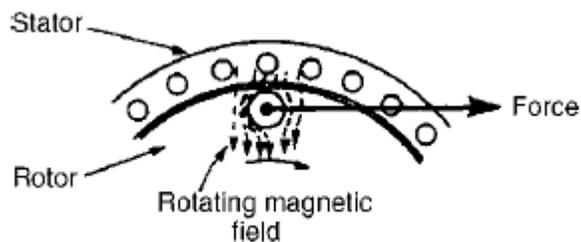
Therefore, rms value of e.m.f. induced in primary,

$$E1 = 4.44 f \phi_m N1 \text{ volts}$$

and rms value of e.m.f. induced in secondary,

$$E2 = 4.44 f \phi_m N2 \text{ volts}$$

4) When a three-phase supply is connected to the stator windings, a rotating magnetic field is produced. As the magnetic flux cuts a bar on the rotor, an e.m.f. is induced in it and since it is joined, via the end conducting rings, to another bar one pole pitch away, a current flows in the bars. The magnetic field associated with this current flowing in the bars interacts with the rotating magnetic field and a force is produced, tending to turn the rotor in the same direction as the rotating magnetic field,



5) Ideal transformer

- 1) No winding resistance
- 2) No leakage flux
- 3) No hysteresis and eddy current loss
- 4) Input VA = Output VA

PART B

6)

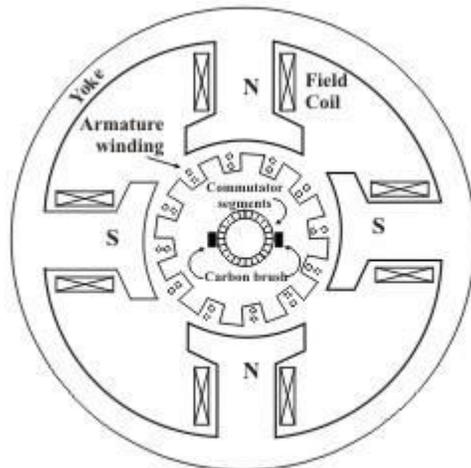


Figure 35.1: Sectional diagram of a D, C machine

The major parts can be identified as,

1. Body
2. Poles
3. Armature
4. Commutator and brush gear
5. Commutating poles
6. Compensating winding
7. Other mechanical parts

Body The body constitutes the outer shell within which all the other parts are housed. This will be closed at both the ends by two end covers which also support the bearings required to facilitate the rotation of the rotor and the shaft.

Main poles Solid poles of fabricated steel with separate/integral pole shoes are fastened to the frame by means of bolts. Pole shoes are generally laminated. Sometimes pole body and pole shoe are formed from the same laminations.

Inter-poles These are small additional poles located in between the main poles. These can be solid, or laminated just as the main poles. These are also fastened to the yoke by bolts. Sometimes the yoke may be slotted to receive these poles.

Armature The armature is where the moving conductors are located. The armature is constructed by stacking laminated sheets of silicon steel. Thickness of these lamination is kept low to reduce eddy current losses.

Field windings In the case of wound field machines (as against permanent magnet excited machines) the field winding takes the form of a concentric coil wound around the main poles. These carry the excitation current and produce the main field in the machine. Thus the poles are created electromagnetically.

Brush and brush holders Brushes rest on the surface of the commutator. Normally electro-graphite is used as brush material. The actual composition of the brush depends on the peripheral speed of the commutator and the working voltage. The hardness of the graphite brush is selected to be lower than that of the commutator.

Bearings Small machines employ ball bearings at both ends. For larger machines roller bearings are used especially at the driving end.

ii) Let Z = number of armature conductors,

Φ = useful flux per pole, in webers

p = number of **pairs** of poles

and n = armature speed in rev/s

The e.m.f. generated by the armature is equal to the e.m.f. generated by one of the parallel paths. Each conductor passes $2p$ poles per revolution and thus cuts $2p \Phi n$ webers of magnetic flux per revolution. Hence flux cut by one conductor per second = $2p \Phi n$ Wb and so the average e.m.f. E generated per conductor is given by: $E = 2pn \Phi$

Let c = number of parallel paths through the winding between positive and negative brushes

$c = 2$ for a wave winding

$c = 2p$ for a lap winding

The number of conductors in series in each path = Z/c

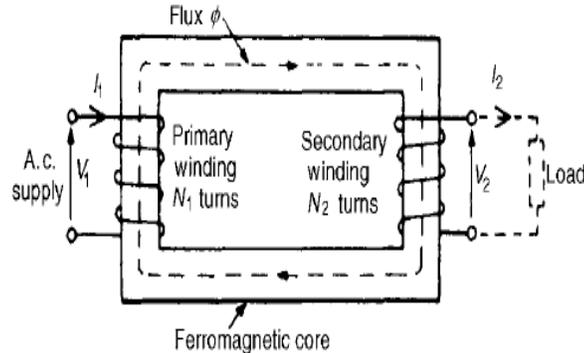
The total e.m.f. between brushes

= (average e.m.f./conductor)(number of conductors in series per path) = $2pn \Phi Z/c$

generated e.m.f., $E = 2pn \Phi n Z/c$ volts

7) i) A transformer is a device which uses the phenomenon of mutual induction to change the values of alternating voltages and currents. A transformer consisting of two electrical circuits linked by a

commferromagnetic core. One coil is termed the **primary winding** which is connected to the supply of electricity, and the other the **secondary winding**, which may be connected to a load.

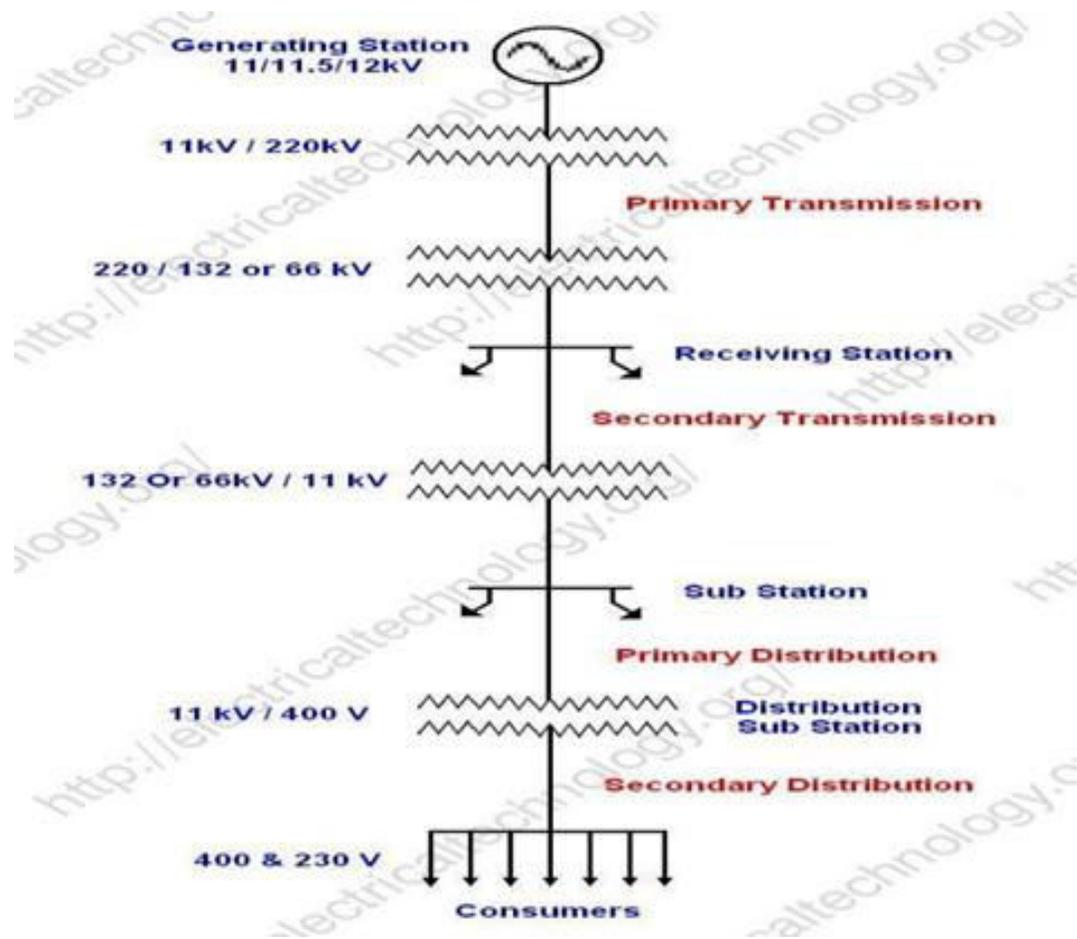


Transformer principle of operation

When the secondary is an open-circuit and an alternating voltage V_1 is applied to the primary winding, a small current called the no-load current I_0 — flows, which sets up a magnetic flux in the core. This alternating flux links with both primary and secondary coils and induces in them e.m.f.'s of E_1 and E_2 respectively by mutual induction. The induced e.m.f. E in a coil of N turns is given by

$E = -N d\phi/dt$ volts where $d\phi/dt$ is the rate of change of flux. In an ideal transformer, the rate of change of flux is the same for both primary and secondary and thus $E_1/N_1 = E_2/N_2$, i.e. **the induced e.m.f. per turn is constant**. Assuming no losses, $E_1 = V_1$ and $E_2 = V_2$. Hence $V_1/N_1 = V_2/N_2$ or $V_1/V_2 = N_1/N_2$. V_1/V_2 is called the **voltage ratio** and N_1/N_2 the **turns ratio**, or the '**transformation ratio**' of the transformer. If N_2 is less than N_1 then V_2 is less than V_1 and the device is termed a **step-down transformer**. If N_2 is greater than N_1 then V_2 is greater than V_1 and the device is termed a **step-up transformer**. When a load is connected across the secondary winding, a current I_2 flows. In an ideal transformer losses are neglected and a transformer is considered to be 100% efficient. Hence input power=output power, or $V_1 I_1 = V_2 I_2$, i.e. in an ideal transformer, the **primary and secondary volt-amperes are equal**.

ii)



8) i) **peak value**-it is the maximum value of the wave either during positive half cycle or during negative half cycle

ii)**Average value**:- it is the dc value of a wave .In general average value of a wave form $x(t)$ can be represented as $x_{avg} = \frac{1}{T} \int_0^T x(t) dt$. Where T is the time period of the signal.

iii)**RMS value**:-Root Mean Square value.It is the capability of a sine wave in terms of heating power

iv) **Form factor**:-

$$FF = \text{RMS value} / \text{Average value}$$

For a sin wave form factor is 1.11

v)**Time period**:-It is the time taken to complete one cycle

$$\text{ii) } 20 = 5I_1 + 10(I_1 + I_2)$$

$$8 = 2 I_2 + 10(I_1 + I_2)$$

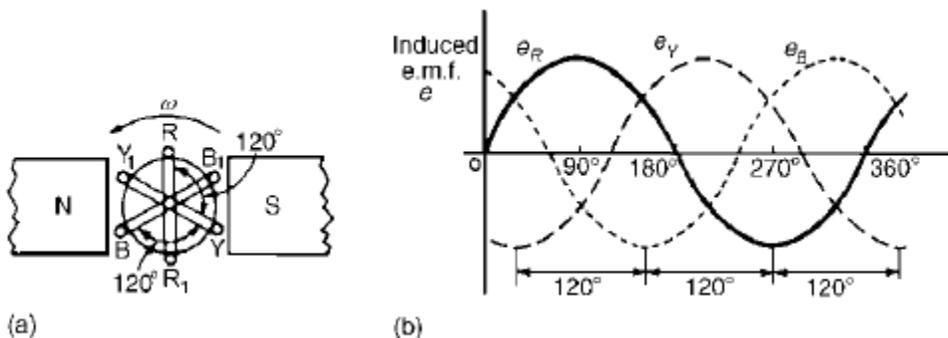
$$20 = 15 I_1 + 10 I_2 \dots\dots\dots(1)$$

$$8 = 10 I_1 + 12 I_2 \dots\dots\dots(2)$$

On solving the equation 1 & 2 we will get the value of I_1 & I_2 .

Current through 10Ω resistor is $(I_1 + I_2)$

9) i) **A three-phase supply** is generated when three coils are placed 120° apart and the whole rotated in a uniform magnetic field . The result is three independent supplies of equal voltages which are each displaced by 120° from each other



A three-phase a.c. supply is carried by three conductors, called '**lines**' which are coloured red, yellow and blue. The currents in these conductors are known as line currents (I_L) and the p.d.'s between them are

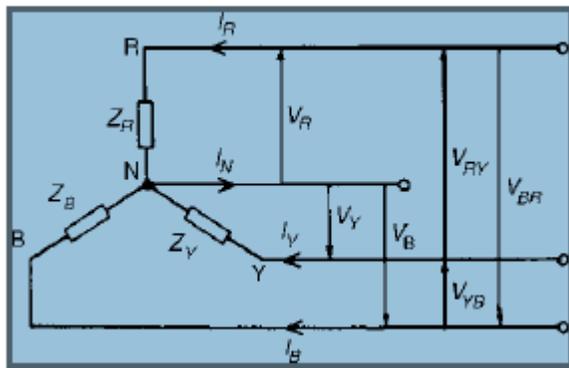
known as line voltages (V_L). A fourth conductor, called the **neutral** (coloured black, and connected through protective devices to earth) is often used with a three-phase supply. To reduce the number of wires it is usual to interconnect

the three phases. There are two ways in which this can be done, these being:

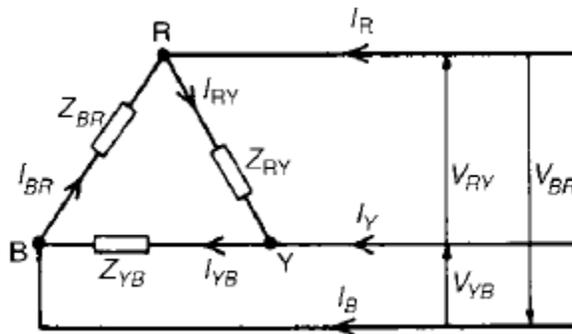
- (a) a **star connection**, and (b) a **delta, or mesh, connection**.

Star connection

A **star-connected load** is shown in Figure 19.3 where the three line conductors are each connected to a load and the outlets from the loads are joined together at N to form what is termed the **neutral point** or the **star point**.



Delta connection



ii)

Electrical circuit	Magnetic circuit
e.m.f. E (V)	mmf F_m (A)
current I (A)	flux Φ (Wb)
resistance R (Ω)	reluctance S (H^{-1})
$I = \frac{E}{R}$	$\Phi = \frac{\text{mmf}}{S}$
$R = \frac{\rho l}{A}$	$S = \frac{l}{\mu_0 \mu_r A}$