Q2a State and explain Faraday's laws of Electromagnetic Induction.

Answer:

Faradays laws of Electromagnetic Induction

Faradays first law states, whenever the magnetic flux associated or linked with a closed circuit is changed, or alternatively, when a conductor cuts or is cut by the magnetic flux, an emf is induced in the circuit resulting in an induced current. The emf is induced so long as the magnetic flux changes.

Faradays second law states that the magnitude of the induced emf generated in a coil is directly proportional to the rate of change of magnetic flux.

The change of flux in the faradays law can be produced in two different ways:

i. By the motion of the conductor or the coil in a magnetic field, i.e the magnetic field is stationary and the moving conductor cut across it. The emf generated in this way is normally called dynamically induced emf.

ii. By changing the current in a circuit, thereby changing the flux linked with the stationary conductor i.e the conductors or coils remain stationary and the flux linking these conductors is changed. The emf is termed as statically induced emf. Statically induced emf can be further sub divided into

a. Self induced emf

b. Mutually induced emf

Q2b Give comparison of electric and magnetic circuit on the basis of similarities and dissimilarities.

Answer:

	Electric circuits	**Magnetic circuits**
	Similarities in electric and magnetic circuits	
(i)	Current flows in the circuit	Flux is assumed to flow
(ii)	The path of current is called electric circuit.	Path of flux is called magnetic circuit.
(iii)	Current flows due to e.m.f.	Flux flows due to m.m.f.
(iv)	Flow of current is restricted by resistance of the circuit.	Flow of flux is restricted by reluctance of the circuit.
(v)	Current = e.m.f./resistance	Flux = m.m.f./reluctance
(vi)	resistance $R = l/\sigma A$	Reluctance $S = l/\mu A$
	Dissimilarities in electric & magnetic circuits	
(i)	Current actually flows in the circuit	Flux does not flow, it is only assumed to flow for finding out certain magnetic effects.
(ii)	Energy is needed till the current flows	Energy is needed only to create the magnetic flux
(iii)	Resistance of the circuit is independent of the current.	Reluctance of the circuit changes with the magnetic flux.

Q3a Give the relationship between the phase values and line values of current and voltage in Star connected circuits. Three 10Ω resistors are connected in a star across 440 V, 3 - phase lines. Calculate the line and phase currents and the power taken from the mains.

Answer:

In the case of a star connected circuit

$V_L = \sqrt{3}\ V_{Ph}$

$I_L = I_{Ph}$

Where V_L = Line Voltage

V_{Ph} = Phase Voltage

I_L = Line Current

I_{Ph} = Phase Current

For star connection $V_{Ph} = 440 / \sqrt{3}$ = **254.03V**

$_{Ph}$ = 254.03/10 = 25.40 A

$I_L = I_{Ph}$ = **25.40 amp**.

Power = $\sqrt{3}\ V_L\ I_L \cos\varphi = \sqrt{3} \times 440 \times 25.4 \times 1$ = **19357.40 W**

Q3b Define the following A.C quantities

(i) R.M.S value of alternating current.

(ii) Instantaneous value of alternating current.

(iii) Average value or mean value of alternating current

(iv) Amplitude

Answer:

i) RMS value of alternating current

R.M.S. value i.e. Root mean square value of alternating current is defined as that steady current which when flows through a known resistance for a given time produces the same amount of heat as when the alternating current is flowing through the same resistance for the same time.

ii) Instantaneous value of alternating currents.

The value of alternating current or voltage at any particular instant is called its 'Instantaneous Value' and is represented by small italic letter 'i' or 'e' respectively

iii) Average value or mean value of Alternating Current

The average or mean value of Alternating current is equal to the value of direct current, which transfer across any circuit the same charged as is transferred by that alternating current during a given time.It may also be defined as "The arithmetic average of all the instantaneous value considered on alternating quantity over one complete cycle is called average or mean value.

iv) Amplitude

The maximum (positive or negative) attend by an alternating quantity in one cycle is called its amplitude or peak value or maximum value and is denoted by E_m or I_m respectively

Q4a Derive E.M.F equation of D.C Generator

Answer:

EMF equation of DC Generator. The average emf generated by the armature of a dc generator (voltage across the brushes of different polarity) is equal to the sum of the emfs of all the conductors connected in series in one parallel path. If the total conductor on the armature of a dc machine is Z, then the number of conductors connected in series in one parallel path will be Z/A. where A is the number of parallel paths in the armature winding.

Hence the emf generated by one parallel path,

E_g = Average emf per conductor x Z/A

= e_{av} x Z / A

And the emf generated by the armature = emf generated by one of the parallel paths of the armature winding

= e_{av} x Z / A---------- (1)

Also, the average emf generated by one conductor = flux cut per second (according to faradays second law of induction)

If Φ is the air gap flux per pole in webers and P the total number of poles in the machine , then the total flux cut by one conductor in completing one revolution of armature = P Φ

Flux cut by one conductor per second = P Φ x(N/ 60)

Where N is the speed of the machine in rpm

Hence emf generated by one conductor of the armature = (P Φ N / 60) x V -----(2)

Combining (1) and (2), emf generated by the armature of a dc machine,

E_g = (P Φ N / 60) x (Z / A) = (P Φ N Z / 60 A) x (V)------------(3)

For a lap wound armature, the number of parallel paths in the armature winding is equal to the number of poles in the machine. Hence emf generated for lap wound armature

= (P Φ N Z / 60 P) = (Φ N Z / 60) x V -------------- (4)

For a wave wound armature, the number of parallel paths in the armature winding is equal to two, irrespective of the number of poles in the machine.

Thus emf generated for wave wound machines

= (P Φ N Z / 60 x 2) = (P Φ N Z / 120) x V ----------- (5)

The expressions given for the induced emf in eqns (3, 4 and 5) hold equally for generators and motors, because it is quite immaterial whether the motion of the armature is due to the mechanical prime mover or due to action of machine as a dc motor.

In the case of a dc motor, however, the emf so induced is known as back emf , because the induced emf acts in a direction opposite to the applied voltage.

Hence back emf for dc motor = $(P\ \Phi\ N\ Z\ /\ 60\ A) \times V$

Q4b What are the different types of d.c .motors and give the application each?

Answer:

Different type of DC motors and their applications are as follows:-

1. **Shunt motors:** Shunt motor is a fairly constant speed motor though its starting torque is not very high. Hence it is suitable for constant speed drive which do not require very high starting torque such as pumps, blowers, fan, lathe machines, tools' belt or chain conveyor etc.
2. **Service motors:** This motor develops a high starting torque & its sped is inversely proportional to the loading conditions i.e. when lightly loaded, the speed is high and when heavily loaded, it is low. Therefore, motor is used in lifts, cranes, traction work, coal loader and coal cutter in coal mines etc.

3. Compound motors: This motor has a variable speed and high starting torque. It can also run at NIL loads without any danger. This motor will therefore find its application in loads having high inertia load or requiring high intermittent torque such as elevators, conveyor, rolling mill, planes, presses, shears and puches, coal cutter and winding machines etc.

Q4c A 250 V dc shunt motor takes 30 A current while running at full load. The resistance of motor armature and field winding are 0.1Ω and 200Ω respectively. Determine the back emf generated in the motor. When it runs on full load.

Answer:

Shunt Field current , $I_{Sh} = V/ R_{Sh} = 250/200 = 1.25A$
Armature Current $I_a = I_L - I_{Sh} = 30-1.25 = 28.75$ A

Back emf on full load , $E_b = V - I_a R_a$

$$= 250 - 28.75 \times 0.1 = 247.125 \text{ V}$$

Q5a Explain the principle of operation of three-phase induction motor

Answer:

Principle of operation of 3-phase Induction motor

When the three phase winding of the stator of the 3 phase induction motor is connected to the three phase supply, then the three phase current in stator winding produces a rotating magnetic field or flux which rotates round the stator at synchronous speed (Ns). This rotating flux passes through the air gap and cuts the rotor conductors (which are yet stationary). Due to relative velocity between the rotating flux and stationary rotors, emf induced in the rotor conductor, the frequency of induced emf is the same as the supply frequency, when the rotor is stationary. Since the rotor conductor circuit is closed, so induced emf produces rotor current, which starts flowing in the rotor conductors, consequently a torque is developed. Accordingly to Lenz's law, under the influence of this torque, the rotor starts rotating in the same direction as the rotating magnetic field.

Since the directions of rotation of rotor as well as the rotating magnetic field are the same, so the relative velocity, between the two decreases. A decrease in relative velocity however decreases the induced EMF, rotor current, and the torque also. But the rotor continues to accelerate and gain speed, till the developed torque equals losses torque. When the equilibrium condition is reached, the motor runs at nearly synchronous speed. Since the losses in an induction motor are small. So on no load condition, the motor runs almost at synchronous speed.

Q5b The secondary of a 750 KVA, 11000/ 400 V, 50 Hz transformer has 160 turns

Determine:

(i) primary number of turns

(ii) primary and secondary full load current neglecting losses. If the area of cross section of the core is 100 cm2, then

(iii) Find the flux density in the core?

Answer:

$N_1 / N_2 = V_2 / V_1$ □where N2 and N1 are the number of turns on the secondary and primary windings.

$N_1 = V_1 N_2 / V_2 = (11000 \times 160) / 400 = 4400$ turns.

N_1 = 4400 turns.

$I_1 V_1 = 750 \times 1000$

$I_1 = (750 \times 1000) / V_1 = (750 \times 1000) / 11000$ A

I_1 = 68.182 A

$I_2 V_2 = 750 \times 1000$

$I_2 = (750 \times 1000) / V_2 = (750 \times 1000) / 400$ A

I_2 = 1875 A

$E_1 = 4.44 \times \varphi_{max} \times f N_1$ volts

$\varphi_{max} = 11000 / (4.44 \times 50 \times 4400)$

= 0.01126 Wb.

Therefore $B_{max} = 0.01126 / 100 \times 10^{-4} = 1.126$ Wb/m^2

B_{max} = 1.126 Wb/m^2

Q6a Explain the energy bands in solids? Also classify the materials based on the energy band diagram and explain briefly.

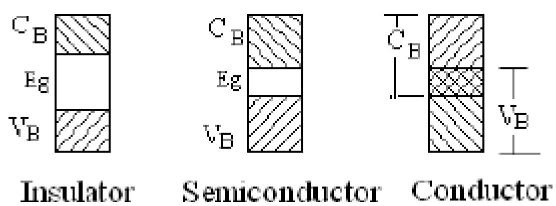
Answer:

There are as many energy bands in a solid as there are energy levels in the parent atoms.

Most electrical properties of importance to engineers and scientists are related to the upper band of energy levels and to be specific the upper two called the conduction band and the valance band. The valence band contains energies of the same level as those of valence electrons. Electrons in this band are in effect attached to individual atoms and therefore not free to move about. The conduction band energies are high enough so that electrons attaining these levels of energy are loosely attached to individual atoms or practically free such that they could easily move under the influence of an electric field. Electrons in the valence band can leave their band to join the conduction band if given sufficient energy to jump the forbidden energy band (energy gap , Eg) . The size of Eg is a prime factor in determining whether a solid is a conductor, an insulator, or a semiconductor.

Classification of materials based on energy bands

With reference to different band structures shown in fig. below we can broadly divide solid into conductors, semiconductors, and insulators. Conductors contain a large number of electrons in the conduction band at room temperature. No energy gaps exist and the valence and conduction bands overlap.



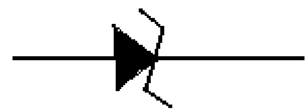
Insulator is a material in which the energy gap is so large that practically no electron can be given enough energy to jump this gap. These materials might conduct little electricity if their temperatures are raised to very high values enabling a number of electrons to join the conduction band. A semiconductor is a solid with a energy gap small enough for electron to cross easily from the valence band to the conduction band. At room temperature sufficient energy is available for a valence electrons to bridge the energy gap to the conduction band, thus the material sustains some electric current.

The energy distribution of electrons in a solid are governed by the laws of Fermi – Dirac statistics. The Fermi level is such that at any temperature, the number of electrons with greater energy than the Fermi energy is equal to the number of unoccupied energy levels lower than this. In conductors, the Fermi level is situated in a permitted band (since the valence band and conduction band overlap with no energy gap.). In insulators, it lies in the centre of the large energy gap while in semiconductors it lies in the relatively small energy gap.

Q6b What is zener diode? Explain its main features.

Answer:

Zener diode: When the reverse bias on a crystal diode is increased, a critical voltage, called brake down voltage is reached where the reverse current increases sharply to a high value. The explanation of this breakdown of the junction was first given by American scientist Zener. Therefore, the breakdown voltage is called zener voltage and the sudden increase in current is known as zener current. A properly doped crystal diode which has a sharp breakdown voltage is known as a zener diode.The zener diode is represented as:



Main features of zener diode:

(i.) A zener diode is like an ordinary diode except that it is properly doped so as to have a Sharp breakdown voltage.

(ii.) A zener diode is always reverse connected I.e. it is always reverse biased.

(iii.) A zener diode has sharp breakdown voltage, called zener voltage.

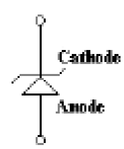
(iv.) When forward biased, its characteristics are just those of ordinary diode.

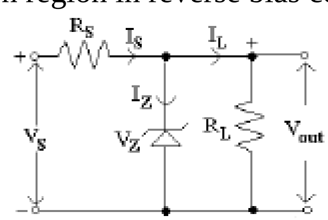
(v.) The zener diode is not immediately burned just because it has entered the breakdown reason.

Q7a Explain Zener diode voltage regulation circuit with no load?

Answer:

Zener diode also sometimes called the breakdown diode is a P-N junction diode specially designed for operation in the breakdown region in reverse bias condition.





Zener diode symbol Zener diode used as a Voltage regulator

Voltage regulation is a measure of a circuit‘s ability to maintain a constant output voltage even when either input voltage or load current varies.

A resistor RS is necessary to limit the reverse current through the diode to a safer value. The voltage source VS and resistor RS are selected that the diode operates in the breakdown region. The diode voltage in this region which is also the voltage across the load RL is called Zener Voltage VZ and the diode current is called the Zener current IZ.

As long as voltage across the load resistor RL is less than the breakdown voltage VZ the zener diode does conduct. The resistors RS and RL constitute a potential divider across VS. At an increased supply voltage VS the voltage drop across load resistor becomes greater than the zener breakdown voltage. It then operates in the breakdown region. The series resistor RS limits the zener current IZ from exceeding its rated maximum value because zener current is given as

$$IZ = (V_S - V_Z) / R_S$$

$$\text{so } IS = IZ + IL$$

When zener diode operates in its breakdown region the voltage across it VZ remains fairly constant even though the current IZ flowing through it may vary considerably.

Q7b What are clipping and clamping circuits? Explain any two functions of clipping circuits.

Answer:

Clipping circuit:

The circuit with which the waveform is shaped by removing (or clipping) a portion of the applied wave is known as a clipping circuit. Clippers find extensive use in radar, digital and other electronic systems.

Clamping circuits:

A circuit that places either the positive or negative peak of a signal at a desired d.c. level is known as clamping circuit. A clamping circuit essentially adds a d.c. component to the signal. The clamping circuit does not change the peak to peak or r.m.s. value of the waveform.

A clamping circuit changes the peak and average values of a waveform.

Functions of clipping circuits:

(i.) Changing the shape of waveform.

Clippers can alter the shape of a waveform. For example, a clipper can be used to convert a sine wave into a rectangular wave, square wave etc. They can limit either the negative or positive alternation or both alternations of an a.c. voltage.

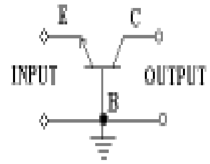
(ii.) Circuit transient protection.

Transients can cause considerable damage to many type of circuits for example a digital circuit. In that case a clipper diode can be used to prevent the transient for reaching that circuit.

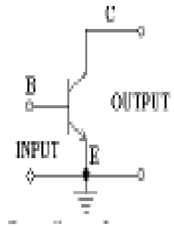
Q8a Give a table of comparisons between CE and CB configuration with regard to the important parameters

Answer:

(1) Common – Base configuration – In common base configuration, input is connected between emitter base and output is taken across collector and base.



(2) Common – Emitter configuration – In common emitter configuration, input is connected between emitter base and output is taken across collector and emitter. This emitter is common to both input and output circuits.



COMMON BASE	COMMON EMITTER
Low input impedance(@100_)	Medium input impedance (@800_)
Very high output impedance (@500K_)	Output impedance high (@50K_)
Current gain less than unity.	High current gain.
Voltage gain @150	Voltage gain @800
Very small leakage current.	Very large leakage current

Q8b What are the different methods of transistor biasing? Mention the steps that are taken to design the transistor biasing circuits.

Answer:

Different methods of transistor biasing. The following are the most commonly used methods of obtaining transistor biasing.
(i.) Base resistor method.
(ii.) Biasing with feedback resistor.
(iii.) Voltage- divider bias.
In all these methods the same basic principle is employed i.e. required value of base current is obtained from signal source voltage in the zero signal conditions.
Following steps are taken to design transistor biasing circuits.

Step 1: It is a common practice to take R_E = 500 - 1000 Ω.Greater the value of R_E better is the stabilization. However, if R_E is very large, higher voltage drop across it leaves reduced voltage drop across the collector load. Consequently, the output is decreased. Therefore, a compromise has to be made in the selection of the value of $R_{E.}$

Step 2: the zero signal current I_C is chosen according to the signal swing. However, in the initial stages of most transistor amplifiers, zero signal I_C = 1mA is sufficient. The major advantages of selecting This value are :
(i.) The output impedance of a transistor is very high at 1 mA. This increases the voltage gain.
(ii.) there is little danger of overheating as 1 mA is quite a small collector current.

Step 3: The values of resistances R_1 and R_2 are so selected that current I_1 flowing through R_1 and R_2 is at least 10 times I_B i.e. $I_1 \geq 10\ I_B$. when this condition is satisfied, good stabilization is achieved.

Step 4: The zero signal I_C should be a little more than the maximum collector current swing due to signal. It is important to note this point. Selecting zero signal I_C below this value may cut off a part of negative half cycle of a signal. On the other hand, selecting a value much above this value may unnecessarily overheat the transistor, resulting in wastage of battery power. Moreover, a higher zero signal I_C will reduce the value of R_C , resulting in reduced voltage gain.

Q9a List out the advantages of negative voltage feedback in amplifiers? Explain in any three them.

Answer:

Advantages of negative voltage feedback:

The following are the advantages of negative voltage feedback in amplifiers.

(i) Gain stability:

An important advantage of negative voltage feedback is that the resultant gain of the amplifier can be made independent of transistor parameters or the supply voltage variation.

$$A_{vf} = A_v / 1 + A_v m_v$$

For negative feedback in an amplifier to an effective, the designer deliberately makes the product $A_v m_v$ much greater than unity. Therefore in the above relation, 1 can be neglected as compared to

(ii) $A_v m_v$ and the expression becomes:

$$A_{vf} = A_v / A_v m_v$$
$$= 1 / m_v$$

(iii) It may be seen that the gain now depends only upon feedback fraction m_v I.e., on the characteristics of feedback circuits.

Reduces non-linear distortion.

(iv) A large signal stage has non-linear distortion because its voltage gain changes at various points in the cycle. The negative voltage feedback reduces the non linear distortion in large signal amplifiers.

Improves frequency response.

(v) As feedback is usually obtained through a resistive network, therefore, voltage gain of the amplifier is independent of signal frequency. The result is that voltage gain of the amplifier will be substantially constant over a wide range of signal frequency.

Increases circuit stability.

The output of an ordinary amplifier is easily changed due to variations in ambient temperature, frequency and signal amplitude. This changes the gain of the amplifier, resulting in distortion. However, by applying negative voltage feedback, voltage gain of the amplifier is stabilized or accurately fixed in value.

Increases input impedance and decreases output impedance.

The negative voltage feedback increases the input impedance and decreases the output impedance of amplifier. Such a change is profitable in practice as the amplifier can then serve the purpose of impedance matching.

Q9b Draw the circuit of BJT Colpitts Oscillator and explain its operation.

Answer: Page Number 674 of Text Book II

Text Book

1. V.N. Mittle & Arvind Mittal, 'Basic Electrical Engineering', Tata McGraw Hill Publishing Company Limited, 2nd Edition, 2006.

2. Electronic Devices & Circuits, David A Bell, 4th Edition, PHI-2006