B.Tech.

First Semester Examination, December-2010

Electrical Technology (EE-101-F)

Note : Attempt any one question from each Section B, C, D & E. Section A is compulsory.

Section-A

Q. 1. (a) Define Ohm's Law.

Ans. Ohm's Law : The current flowing through the electric circuit is directly proportional to the potential difference across the circuit and inversely proportional to the resistance of the circuit, provided the temperature remains constant.

$$I \propto \frac{V}{R}.$$

Q. 1. (b) State Milman's theorem.

Ans. Milman's Theorem : It states that given a convex polygon, one only needs the corners of the polygon to recover the polygon shape. The statement of the theorem is false if the polygon is not convex.

Q. 1. (c) Define phase and phase angle.

Ans. The phase of an alternating quantity at any instant is the angle (ϕ) travelled by the phasor representing that alternating quantity upto the instant of consideration, measured from the reference.

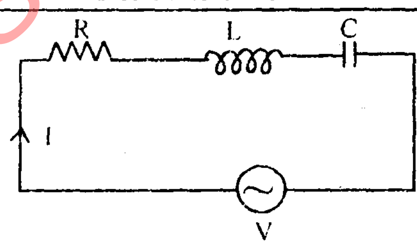
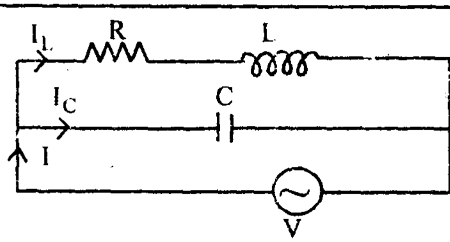
Q. 1. (d) Differentiate between balanced and unbalanced circuit.

Ans. Balanced Circuit : A circuit whose two sides are electrically alike and symmetrical with respect to a common reference point, usually ground. An electric circuit that has been adjusted to neutralize the mutual induction of an adjacent circuit.

Unbalanced Circuit : A circuit having input or output connects one of its signal conductors to ground and has a non-zero impedance at the other signal conductor.

Q. 1. (e) Differentiate between series and parallel resonance.

Ans.

Parameter	Series Resonance	Parallel Resonance
1. Circuit		
2. Impedance	Minimum Z = R	Dynamic but maximum $Z_D = \frac{L}{RC}$
3. Nature	Acceptor	Rejector

4. Current	Maximum $I = \frac{V}{R}$	Minimum $I = \frac{V}{Z_D}$
5. Power factor	Unity	Unity

Q. 1. (f) Define efficiency of transformer.

Ans. Efficiency is a function of transformer's power losses but its' easy to loss sight of what transformer efficiency means in the real world.

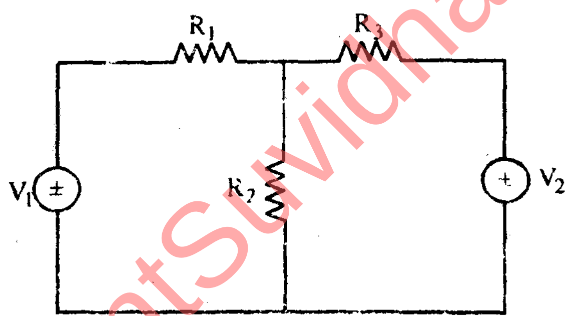
Q. 1. (g) What is the principle of moving coil type instruments?

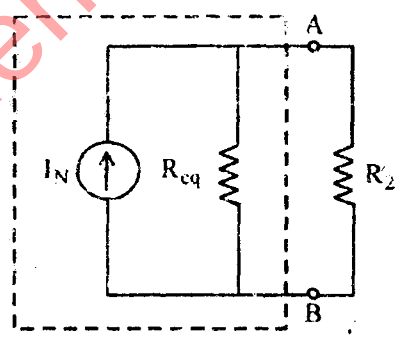
Ans. The moving coil instrument is worked on a principle of D'Arsonval principle. The amount of force experienced by the coil is proportional to the current passing through the coil.

Section-B

Q. 2. (a) State and explain Nortons Theorem.

Ans. Norton's theorem states that it is possible to simply and linear circuit, no matter how complex, to an equivalent circuit with just a single current source and parallel resistance connected to a load.





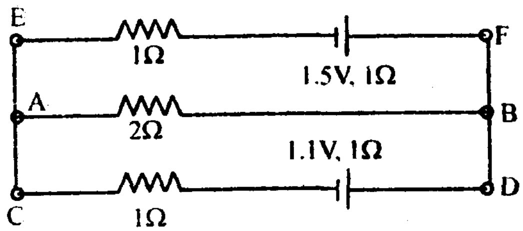
Norton's Equivalent Circuit

According to this theorem network can be replaced by a current source I_N with equivalent resistance R_{eq} parallel with it across the load terminals.

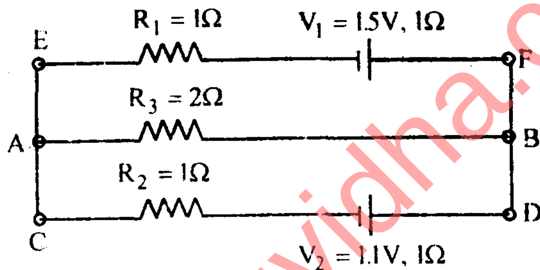
$$I_N = \frac{V_{TH}}{R_{eq}}$$

$$V_{TH} = I_N \times R_{eq}.$$

Q. 2. (b) Find the current flowing through 2Ω resistance by applying superposition theorem as shown in fig.



Ans.



Open circuit voltage

$$= V_2 - \frac{V_1 R_3}{R_1 + R_3}$$

$$= 1.1 - \frac{1.5 \times 2}{1+1}$$

$$V_2 = 0.4V$$

Norton resistance, $$R_N = \frac{R_1 R_3}{R_1 + R_3}$$

$$= \frac{1 \times 1}{1+1}$$

$$= 0.5\Omega$$

Norton current, $$I_N = \frac{V_2}{R_N}$$

$$= \frac{0.4}{0.5}$$

$$= 0.8A$$

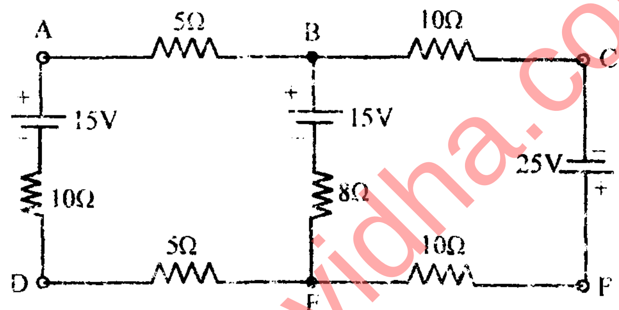
Finally calculated current, I_2

$$I_2 = \frac{I_N R_N}{R_N + R_2}$$

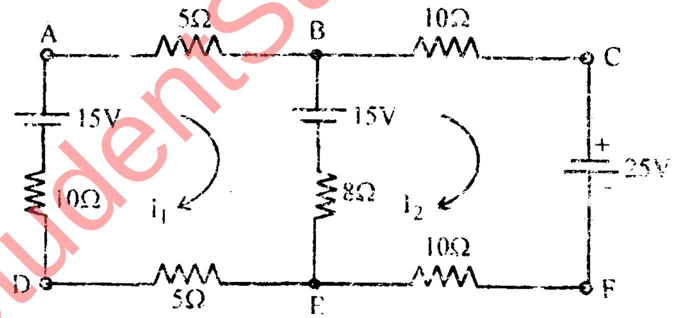
$$= \frac{0.8 \times 0.5}{0.5 + 1}$$

$$I_2 = 0.266A$$

Q. 3. (a) Find the current in the 8Ω resistor in the circuit shown in fig. (Using Loop analysis method).



Ans. Find the current in the 8Ω resistor in the circuit.



In loop ABEDA

Using KVL,

$$5I_1 + 15 + 8(I_1 - I_2) + 5I_1 + 10I_1 - 15 = 0$$

$$28I_1 - 8I_2 = 0$$

In loop BCFEB

Using KVL

$$10I_2 + 25 + 10I_2 + 8(I_2 - I_1) - 15 = 0$$

$$28I_2 - 8I_1 = -10$$

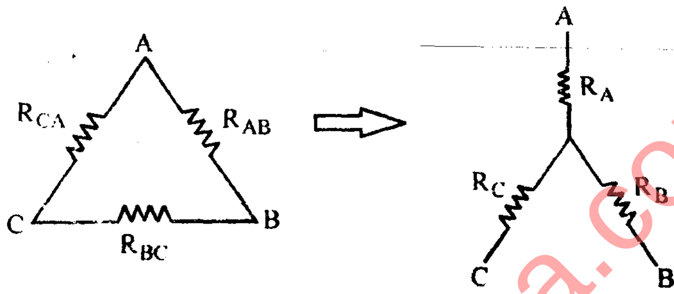
$$I_1 = 0.1A$$

$$I_2 = 0.38A$$

Current is 8Ω resistance $= 17.24A$

Q. 3. (b) Derive expression for converting star circuit to Delta circuit and vice-versa.

Ans. Delta circuit to star circuit.



Two network are electrically equivalent. For delta network,

Resistance between A and B $= R_{AB} \| (R_{BC} + R_{CA})$

$$= \frac{R_{AB} \times (R_{BC} + R_{CA})}{R_{AB} + R_{BC} + R_{CA}} \quad ...(1)$$

For star network

Resistance between A and B $= R_A + R_B$ ...(2)

From equations (1) and (2)

$$R_A + R_B = \frac{R_{AB}(R_{BC} + R_{CA})}{R_{AB} + R_{BC} + R_{CA}} \quad ...(3)$$

Similarly,

$$R_B + R_C = \frac{R_{BC}(R_{CA} + R_{AB})}{R_{AB} + R_{BC} + R_{CA}} \quad ...(4)$$

$$R_C + R_A = \frac{R_{CA}(R_{AB} + R_{BC})}{R_{AB} + R_{BC} + R_{CA}} \quad ...(5)$$

Subtracting equations (4) from (3) and adding the result to equation (5), we get

$$R_A = \frac{R_{AB} \cdot R_{CA}}{R_{AB} + R_B + R_{CA}}$$

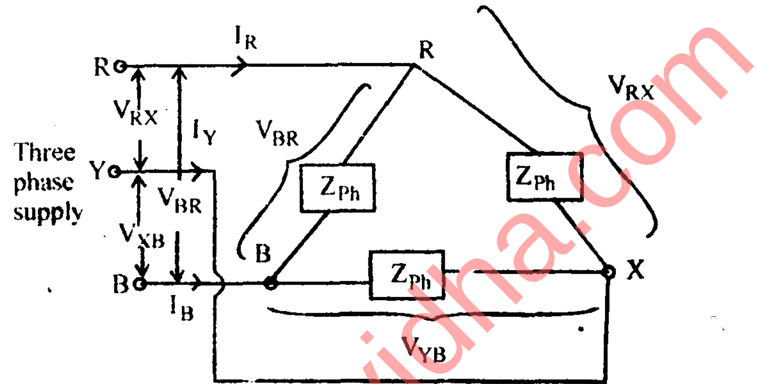
$$R_B = \frac{R_{BC} \cdot R_{AB}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_C = \frac{R_{BC} + R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

Section-C

Q. 4. (a) Derive relation between I_L and I_{ph}, V_L and V_{ph} in case of delta connected $3-\phi$ circuit.

Ans.



Line voltage, $V_L = V_{RY} = V_{YB} = V_{BR}$

Line current, $I_L = I_R = I_Y = I_B$

Phase voltage, $V_{Ph} = V_{RY} = V_{YB} = V_{BR}$

Phase currents, $I_{Ph} = I_{RY} = I_{YB} = I_{BR}$

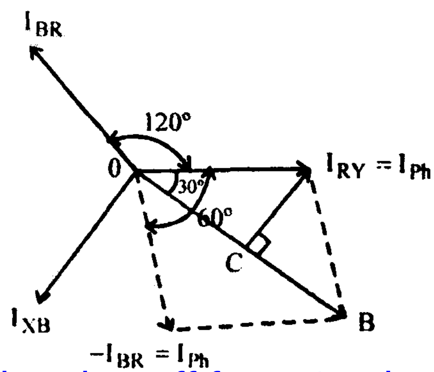
$$\bar{I}_R + \bar{I}_{BR} = \bar{I}_{RY}$$

$$\bar{I}_R = \bar{I}_{RX} - \bar{I}_{BR}$$

Apply KCL at node Y and B

$$\bar{I}_Y = \bar{I}_{YB} - \bar{I}_{RY}$$

$$\bar{I}_B = \bar{I}_{BR} - \bar{I}_{YB}$$



$$\angle BOA = 30°$$

And $$OC = CB = \frac{I_L}{2}$$

From triangle OAB,

$$\cos 30° = \frac{OC}{OA} = \frac{I_R/2}{I_{RY}}$$

$$\frac{\sqrt{3}}{2} = \frac{I_L/2}{I_{Ph}}$$

$$\boxed{I_L = \sqrt{3} I_{Ph}}$$

Q. 4. (b) Explain how 3ϕ power can be measured by two wattmeter method for a balanced load.

Ans. In case of balanced load, the pf. can be calculated from W_1 and W_2 readings.

$$W_1 = V_L I_L \cos(30 - \phi)$$

$$W_2 = V_L I_L \cos(30 + \phi)$$

$$W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi \qquad ...(1)$$

$$W_1 - W_2 = V_L I_L [\cos(30 - \phi) - \cos(30 + \phi)]$$

$$= V_L I_L [\cos 30 \cos\phi + \sin 30 \sin\phi - \cos 30\phi + \sin 30 \sin\phi]$$

$$= V_L I_L [2 \sin 30 \sin\phi]$$

$$= V_L I_L \left[2 \times \frac{1}{2} \times \sin\phi\right]$$

$$W_1 - W_2 = V_L I_L \sin\phi \qquad ...(2)$$

Take ratio of equations (1) and (2)

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{V_L I_L \sin\phi}{\sqrt{3} V_L I_L \cos\theta} = \frac{\tan\phi}{\sqrt{3}}$$

$$\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)}$$

$$\phi = \tan^{-1}\left[\frac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)}\right]$$

$$P.F.\ \cos\phi = \cos\left\{\tan^{-1}\left[\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right]\right\}$$

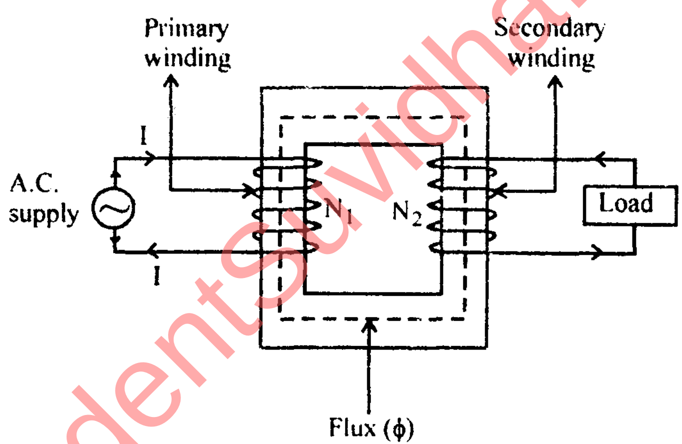
Q. 5. Explain basic principle, construction and working of transformer. Also explain O.C. and S.C. tests.

Ans. Working Principle : It is based on the principle of electromagnetic induction such that when the voltage is provided with an AC source than due to the presence of the coil which is showing electromagnetic properties then the AC current flowing will shown variable voltage which produces a changing flux in the secondary coil.

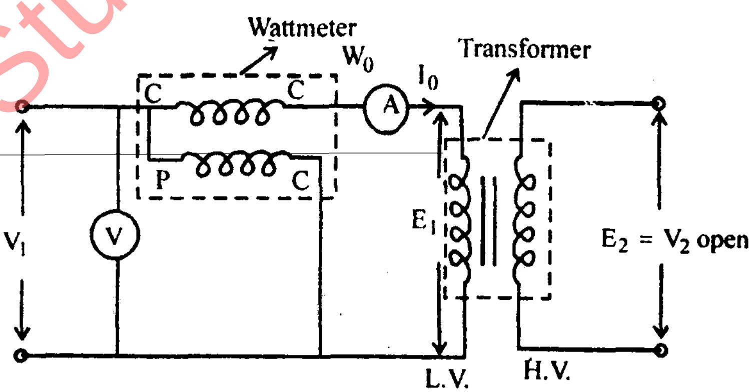
As the current flowing through the primary coils, it links with the secondary coils and produced the electromotive force in the secondary coil such that frequency remains constant and through secondary coils provided to deliver current to external loads.

Construction :

It consists of soft iron core or the silicon steel core and two windings attached to it.



Open Circuit Test :



$$P_i = W_0 = V_1 I_0 \cos\phi_0$$

$$I_w = I_0 \cos\phi_0$$

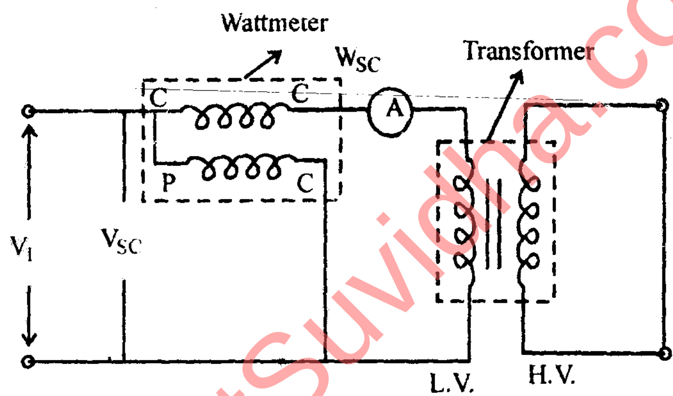
$$I_m = I_0 \sin\phi_0$$

$$I_0 = \sqrt{I_w^2 + I_m^2}$$

$$\boxed{R_0 = \frac{V_1}{I_w}\Omega}$$

$$\boxed{X_0 = \frac{V_1}{I_m}\Omega}$$

Short Circuited Test :



$$\boxed{W_{sc} = (P_{cu})_{F.L.} = V_{sc} I_{sc} \cos\phi_{sc}}$$

$$P_{cu} = W_{sc} = I_{sc}^2 R_{1e}$$

$$\boxed{R_{1e} = \frac{W_{sc}}{I_{sc}^2}\Omega}$$

$$Z_{1e} = \frac{V_{sc}}{I_{sc}} = \sqrt{R_{1e}^2 + X_{1e}^2}$$

$$\boxed{X_{1e} = \sqrt{Z_{1e}^2 - R_{1e}^2}\,\Omega}$$

Section-D

Q. 6. (a) Write comparison between DC machine and Induction motor.

Ans. Synchronous and induction machines both produce torque through the interaction of a rotor magnetic field and a stator magnetic field. The differences between the two types of machines arise because of the differences in the way the rotor magnetic field is generated.

DC machines have a stationary (relative to the rotor) magnetic field on the rotor. This field can be generated either by permanent magnets or by a field winding powered through slip rings. The interaction of this field with the rotating field on the stator creates torque and causes the motor to rotate. A synchronous motor always rotates at some multiple, determined by the number of poles, of the line frequency. If a synchronous motor loses lock with the line frequency, e.g., by torque overload, it will stall. A synchronous motor cannot start by itself on a fixed frequency AC source. It either needs to be fed a variable frequency source, or it needs to be brought up to speed by an auxiliary motor, sometimes called a pony motor, so that it can generate torque. Synchronous machines usually require some form of control to keep the rotor speed locked to the line frequency.

Induction machines have a rotating (relative to the rotor) magnetic field on the rotor. In a squirrel cage motor, this field is created because the motion of the stator field relative to the shorted rotor cage induces currents in the rotor. These currents generate the rotor field, which interacts with the stator field to create torque. A wound-rotor induction machine has rotor windings similar to a synchronous machine, in which currents are induced by the rotating stator field. Induction motors always rotate in some narrow speed range that is less than synchronous speed. This speed difference, which is necessary to generate the rotor field, is called the "slip." Low slip machines, which turn at very near synchronous speed, are more efficient than high slip machines, but have lower starting torque. Induction machines can produce some torque at zero speed, so they are capable of starting themselves if the load torque is low enough at zero speed. The torque-speed characteristic of induction machines at rated speed has a negative slope (as speed decreases, torque increases). As a result induction machines do not require controls to operate–the feedback mechanism is built into the machine.

The winding resistance a wound-rotor induction machine can be varied by connecting resistors to the rotor windings via the slip rings. This allows the torque-speed characteristics of the wound-rotor machine to be varied as needed (e.g., high resistance (=high slip) for high starting torque and then low resistance (= low slip) for high efficiency at rated speed).

The absence of a rotor winding makes squirrel cage induction machines significantly cheaper to manufacture than synchronous machines (or wound-rotor induction machines). Squirrel cage machines are extremely rugged because of the lack of a wound rotor (the cage is usually cast right into the rotor laminations), and the lack of slip rings makes them more suitable for explosive environments because there is no arcing mechanism. The circulating currents in an induction machine rotor lead to resistive losses that make induction machines less efficient that synchronous machines.

DC Machines :

(i) Wound-rotor or permanent magnet to generate the rotor magnetic field.

(ii) Rotor magnetic field is stationary with respect to the rotor.

(iii) Always turn at synchronous speed.

(iv) Require some form of control to operate.

(v) More expensive to produce than squirrel cage induction machines.

(vi) Not self-starting.

(v) More efficient than induction machines.

Induction Machines :

(i) Wound-rotor or squirrel cage to generate the rotor magnetic field.

(ii) Rotor magnetic field rotates with respect to the rotor.

(iii) Always turn at less than synchronous speed.

(iv) Do not require control.

(v) Much cheaper to produce (true for squirrel cage machines).

(vi) Self-starting.

(vii) Less efficient than synchronous machines.

(viii) More suitable for explosive environments.

(ix) No maintenance (for squirrel cage machines).

Q. 6. (b) Explain working principle, construction and applications of DC machine.

Ans. An electric motor converts electrical energy into mechanical energy. Most electric mohm, operate through interacting magnetic fields and current-carrying conductors to generate force, although a few use electrostatic forces. The reverse process, producing electrical energy from mechanical energy, is done by generators such as an alternator or a dynamo. Many types of electric motors can be run as generators and vice versa. For example a starter/generator for a gas turbine, or traction motors used on vehicles, often perform both tasks. Electric motors and generators are commonly referred to as electric machines.

Electric motors are found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools and disk drives. They may be powered by direct current (e.g., a battery powered portable device or motor vehicle), or by alternating current from a central electrical distribution grid. The smallest motors may be found in electric wristwatches. Medium-size motors of highly standardized dimensions and characteristics provide convenient mechanical power for industrial uses. The very largest electric motors are used for propulsion of ships, pipeline compressors and water pumps with ratings in the millions of watts. Electric motors may be classified by the source of electric power, by their Internal construction, by their application, or by the type of motion they give.

The physical principle of production of mechanical force by the interactions of an electric current and a magnetic field was known as early as 1821. Electric motors of increasing efficiency were constructed throughout the 19th century, but commercial exploitation of electric motors on a large scale required efficient electrical generators and electrical distribution networks.

Some devices, such as magnetic solenoids and loudspeakers, although they generate some mechanical power, are not generally referred to as electric motors and are usually termed actuators and transducers, respectively.

The Principle : The conversion of electrical energy into mechanical energy by a electromagnetic means was demonstrated by the British scientist Michael Faraday in 1821. A free-hanging wire was dipped into a pool of mercury, on which a permanent magnet was placed. When a current was passed through the wire, the wire rotated around the magnet, showing that the current gave rise to a close circular magnetic field around the wire. This motor is often demonstrated in school physics classes, but brine (salt water) is sometimes used in place of the toxic mercury. This is the simplest form of a class of devices called homo polar motors. A later refinement is the Barlow's wheel. These were demonstration devices only, unsuited to practical applications due to their primitive construction.

Q. 7. Write a short note on :

(a) Moving Iron type Instruments

(b) Energy meter.

Ans. (a) Moving Iron Type Instruments :

An ammeter is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name. Instruments used to measure smaller currents, in the milliampere or microampere range, are designated as milliammeters or microammeters.

The D'Arsonval galvanometer is a moving coil ammeter. It uses magnetic deflection, where current passing through a coil causes the coil to move in a magnetic field. The voltage drop across the coil is kept to a minimum to minimize resistance across the ammeter in any circuit into which it is inserted. The modern form of this instrument was developed by Edward Weston, and uses two spiral springs to provide the restoring force. By maintaining a uniform air gap between the iron core of the instrument and the poles of its permanent magnet, the instrument has good linearity and accuracy. Basic meter movements can have full-scale deflection for currents from about 25 microamperes to 10 milliamperes and have linear scales.

Moving iron ammeters use a piece of iron which moves when acted upon by the electromagnetic force of a fixed coil of wire. This type of meter responds to both direct and alternating currents (as opposed to the moving coil ammeter, which works on direct current only). The iron element consists of a moving vane attached to a pointer, and a fixed vane, surrounded by a coil. As alternating or direct current flows through the coil and induces a magnetic field in both vanes, the vanes repel each other and the moving vane deflects against the restoring force provided .by tine helical springs. The non-linear scale of these meters makes them unpopular.

An electrodynamic movement uses an electromagnet instead of the permanent magnet of the d'Arsonval movement. This instrument can respond to both alternating and direct current.

In a hot-wire ammeter, a current passes through a wire which expands as it heats. Although these instruments have slow response time and low accuracy, they were sometimes used in measuring radio-frequency current.

Digital ammeter designs use an analog to digital converter (ADC) to measure the voltage across the shunt resistor: the digital display is calibrated to read the current through the shunt.

There is also a whole range of devices referred to as integrating ammeters. In these ammeters the amount of current is summed over time giving as a result the product of current and time, which is proportional to the energy transferred with that current. These can be used for energy meters (watt-hour maters) or for estimating the charge of battery or capacitor.

(b) Energy Meter : An instrument which measures electrical energy is called energymeter or watthour meter. It is an integrating type instrument. When induction watthour meter is connected in the circuit to measure electrical energy.

It works on the principle of induction i.e., on the production of eddy currents in the moving system by alternating fluxes. In energymeter there is no controlling torque and thus due to driving torque only a continuous rotation of the disc is produced.

Section-E

Q. 8. (a) State and explain series resonance.

Ans. As X_L and X_C are the functions of frequency f. When f is varied both X_L and X_C also get varied. At a certain frequency, X_L becomes equal to X_C. Such a condition when $X_L = X_C$ for certain frequency is called series resonance.

Let f_r be the resonant frequency in Hz at which

$$X_L = X_C$$

$$2\pi f_0 L = \frac{1}{2\pi f_0 C}$$

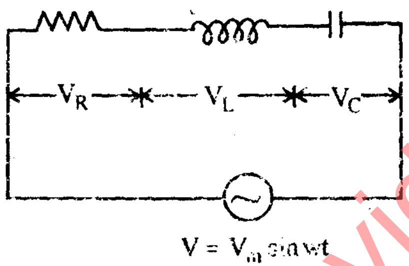
$$(f_r)^2 = \frac{1}{4\pi^2 LC}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}\,\text{Hz}$$

$$\boxed{W_r = \frac{1}{\sqrt{LC}}\ \text{rad/sec.}}$$

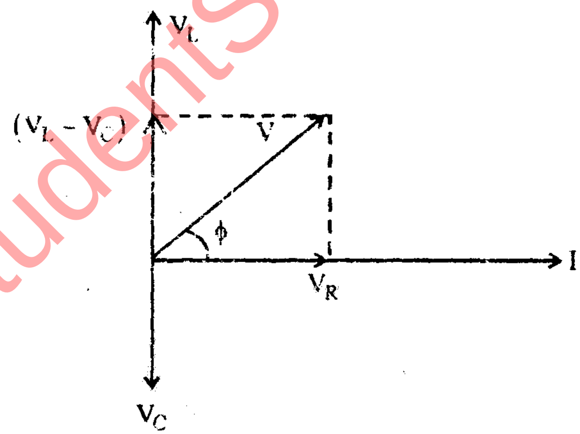
Q. 8. (b) Derive an expression for impedance, current and phase angle for R, L, C series circuit with phasor diagram.

Ans.



$V = V_R + V_L + V_C$

Case I : $X_L > X_C$ circuit has inductive nature.



Phase Diagram

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

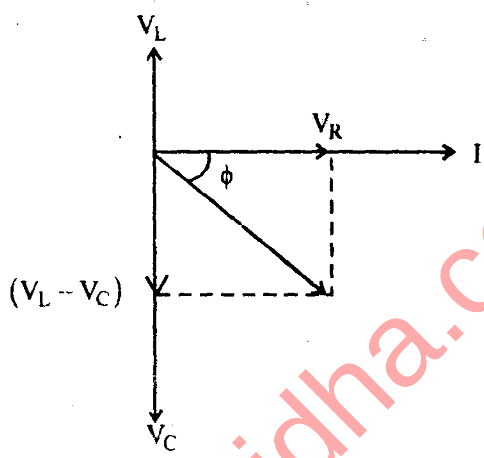
$$= \sqrt{(I_R)^2 + (IX_L - IX_C)^2}$$

$$V = I\sqrt{R^2 + (X_2 - X_C)^2}$$

$$V = IZ$$

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

Case II : $X_L < X_C$



Phasor Diagram

$$V = \sqrt{(V_R)^2 + (V_C - V_L)^2}$$

$$= \sqrt{(IR)^2 + (IX_C - IX_L)^2}$$

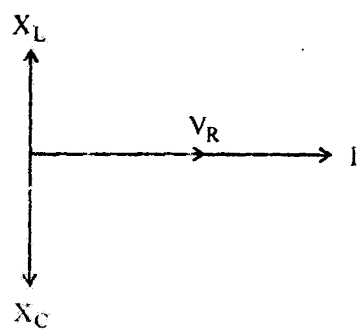
$$V = IZ$$

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

Case III :

$$X_L = X_C$$

$$Z = R$$



Q. 9. (a) Prove that the average power in an ac circuit is equal to $VI\cos\phi$.

Ans.

$$i = I_m \sin(wt - \phi)$$

$$P = VI$$

$$P = V_m \sin wt + I_m \sin(wt - \phi)$$

$$= V_m I_m \left[\frac{\cos\phi - \cos(2wt - \phi)}{2}\right]$$

$$= \frac{V_m I_m \cos\phi}{2} - \frac{V_m I_m \cos(2wt - \phi)}{2}$$

$$P_{av} = \frac{V_m I_m}{2}\cos\phi$$

$$P_{av} = \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}\cos\phi$$

$$P_{av} = V_{rms} \times I_{rms} \times \cos\phi$$

$$\boxed{P = VI\cos\phi}$$

Q. 9. (b) Differentiate between :

(i) Active and reactive power

(ii) Crest and peak factor.

Ans. (i) Active and Reactive Power :

Active power is nothing but the actual power (kW) or Real Power consumed by load. If we are not maintaining the power factor at the appreciable value that is if $\cos\phi$ is decreasing then $\sin\theta$ is increased that is $VI\sin\theta$ is reactive power.

Active power $= P = VI\cos\theta$ (watt)

Reactive power, $Q = VI\sin\phi$ (VAR)

(ii) Crest and Peak Factor :

The peak factor of an alternating quantity is defined as the ratio of maximum value to the r.m.s. value.

Peak factor, $K_P = \frac{\text{Maximum value}}{\text{r.m.s. value}}$

The peak factor for sinusoidally varying alternating currents and voltages can be obtained as

$$K_P = \frac{I_m}{0.707 I_m} = 1.414 \text{ for sinusoidal waveform}$$