Chapter # 16
Alternating Current
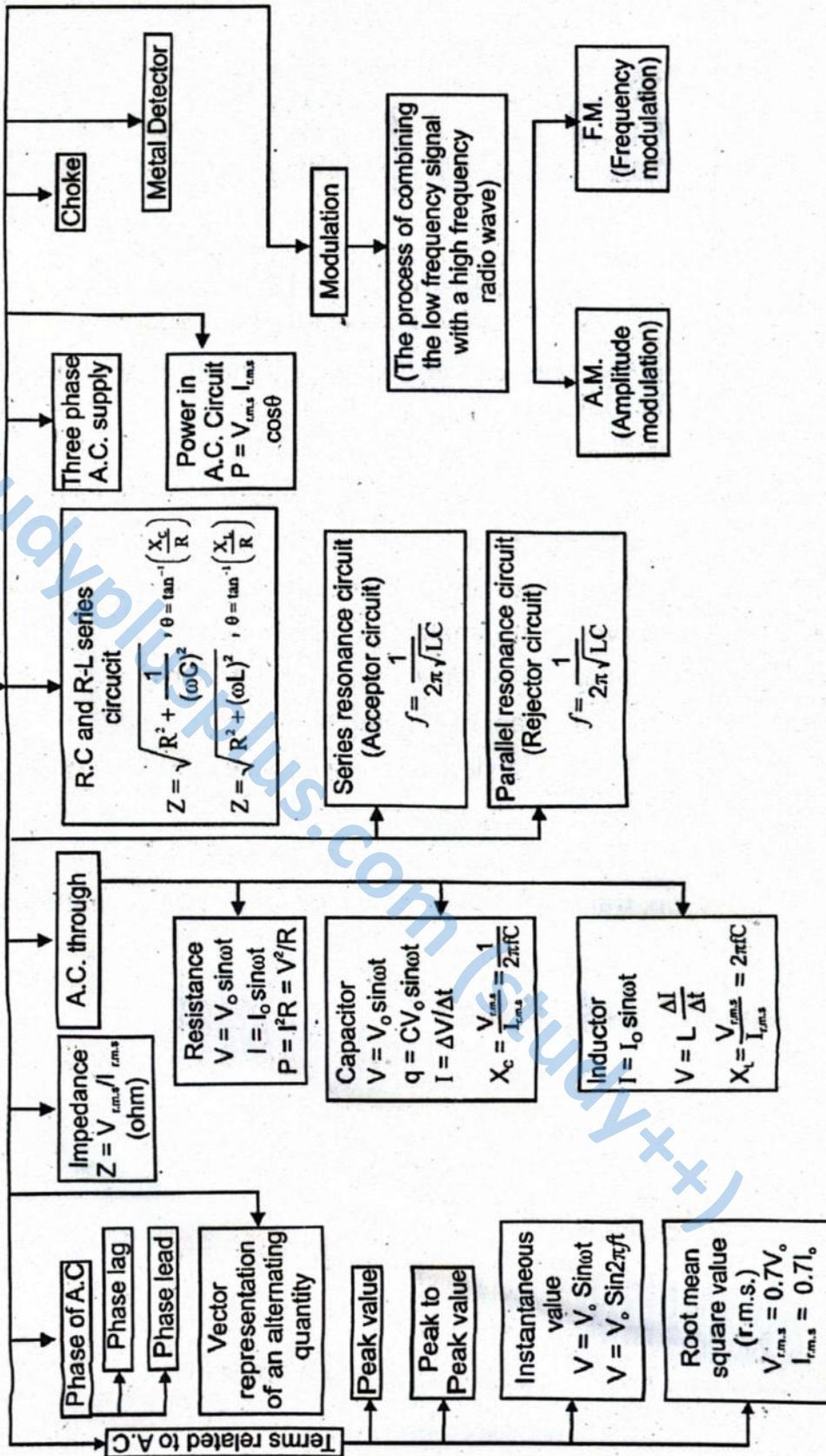
Learning Objectives

- Understand and describe time period, frequency, the peak and root mean square values of an alternating current and voltage.

- Know and use the relationship for the sinusoidal wave.

- Understand the flow of A.C. through resistors, capacitors and inductors.

- Understand how phase lags and leads in the circuit.

- Apply the knowledge to calculate the reactances of capacitors and inductors.

- Describe impedance as vector summation of resistance.

- Know and use the formulae of A.C. power to solve the problems.

- Understand the function of resonant circuits.

- Appreciate the principle of metal detectors used for security checks.

- Describe the three phase A.C. supply.

- Become familiar with electromagnetic spectrum (ranging from radio waves to γ rays).

- Know the production, transmission and reception of electromagnetic waves.

CONCEPT MAP

ALTERNATING CURRENT (A.C.)

The current that is produced by a voltage source whose polarity keeps on reversing with time is called A.C.

Choke

Metal Detector

Modulation

The process of combining the low frequency signal with a high frequency radio wave

F.M. (Frequency modulation)

A.M. (Amplitude modulation)

Three phase A.C. supply

Power in A.C. Circuit $P = V_{r.m.s} \, I_{r.m.s} \cos\theta$

R.C and R-L series circucit

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

$$Z = \sqrt{R^2 + (\omega L)^2}, \quad \theta = \tan^{-1}\left(\frac{X_L}{R}\right)$$

Series resonance circuit (Acceptor circuit) $f = \frac{1}{2\pi\sqrt{LC}}$

Parallel resonance circuit (Rejector circuit) $f = \frac{1}{2\pi\sqrt{LC}}$

A.C. through

Resistance
$V = V_o \sin\omega t$
$I = I_o \sin\omega t$
$P = I^2 R = V^2/R$

Capacitor
$V = V_o \sin\omega t$
$q = CV_o \sin\omega t$
$I = \Delta V/\Delta t$
$X_c = \frac{V_{r.m.s}}{I_{r.m.s}} = \frac{1}{2\pi f C}$

Inductor
$I = I_o \sin\omega t$
$V = L \frac{\Delta I}{\Delta t}$
$X_L = \frac{V_{r.m.s}}{I_{r.m.s}} = 2\pi f C$

Impedance $Z = V_{r.m.s}/I_{r.m.s}$ (ohm)

Phase of A.C

Phase lag

Phase lead

Vector representation of an alternating quantity

Peak value

Peak to Peak value

Instantaneous value
$V = V_o \sin\omega t$
$V = V_o \sin 2\pi f t$

Root mean square value (r.m.s.)
$V_{r.m.s} = 0.7 V_o$
$I_{r.m.s} = 0.7 I_o$

Terms related to A.C

A.C. generator generates the A.C current/ voltage.

The basic reason for the world wide use of A.C is that it can be transmitted to long distances easily and at a very low cost.

Q.1 What is alternating current? Show that the output voltage of A.C. generator varies sinusoidally with time.

Ans.

ALTERNATING CURRENT

The current which changes its magnitude continuously and direction periodically is called alternating current.

<center>OR</center>

Alternating current is that which is produced by a voltage source whose polarity keeps on reversing with time.

Explanation

In fig 1(a), the terminal A of the source is positive with respect to terminal B and its remains so during a time interval 0 to $\frac{T}{2}$.

At $t = \frac{T}{2}$, the terminals change their polarity. In fig 1(b), the terminal B of the source is positive with respect to terminal A and its remains so during a time interval $\frac{T}{2}$ to T, after which terminal A again become positive with respect to B and the next cycle starts.

So during $0 - \frac{T}{2}$, it flows in one direction and during the interval $\frac{T}{2} - T$ in opposite direction.

(a)

(b)

Time Period

The time interval T during which the voltage source changes its polarity once is known as *period of the alternating current or voltage.*

Frequency

The number of cycles completed in one second is called the *frequency of alternating current signal.*
The frequency of A.C used in Pakistan is 50 Hz.

$$f = \frac{1}{T}$$

> **For Your Information**
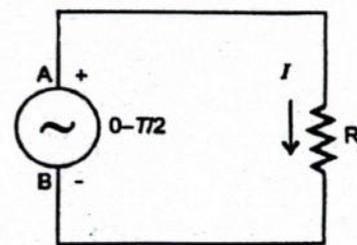> Current changes its polarity once in a cycle.

Source of A.C

The *most common* source of alternating voltage is an A.C. generator. The output V of this A.C generator at any instant is given by
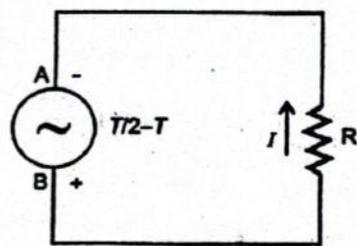
$$V = V_o \sin\left(\frac{2\pi}{T}\right) t$$

Where T is the period of the rotation of the coil and is equal to the period of A.C.

(i) When $t = 0$

$$V = V_o \sin\left(\frac{2\pi}{T}\right)(0)$$

$$V = V_o \sin 0$$
$$V = 0$$

(ii) When $t = T/4$

$$V = V_o \sin\left(\frac{2\pi}{T}\right)\left[\frac{T}{4}\right]$$
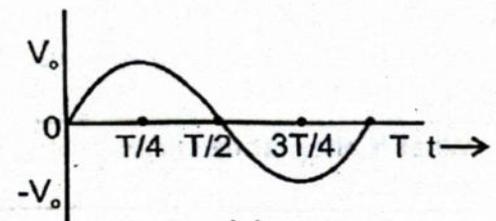
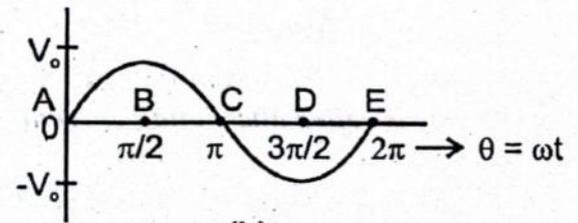$$V = V_o \sin\left(\frac{\pi}{2}\right)$$

$$V = V_o$$

(iii) When $t = T/2$

$$V = V_o \sin\left(\frac{2\pi}{T}\right)\left[\frac{T}{2}\right]$$

$$V = V_o \sin(\pi)$$

$$V = 0$$

(iv) When $t = 3T/4$

$$V = V_o \sin\left(\frac{2\pi}{T}\right)\left[\frac{3T}{4}\right]$$

$$V = V_o \sin\left(\frac{3\pi}{2}\right)$$

$$V = -V_o$$

(v) When $t = T$

$$V = V_o \sin\left(\frac{2\pi}{T}\right)(T)$$

$$V = V_o \sin(2\pi)$$

$$V = 0$$

(a)

(b)

Waveform

Figure 2 (a, b) shows the variation of V with t and θ. This graph between voltage and time is known as waveform of alternating voltage. It can be seen that it is a sine curve. So the alternating signal is also known as *sinusoidal signal*.

Q.2   Discuss the characteristics of alternating voltage.

Ans.

(1) INSTANTANEOUS VALUE

The value of voltage or current that exists in a circuit at any instant of time t measured from some reference point is known as its *instantaneous value.*

It can have any value in between plus maximum value $+V_o$ and negative maximum value $-V_o$ and it is denoted by V. Mathematically,

$$V = V_o \sin\theta$$

$$V = V_o \sin\omega t$$

$$V = V_o \sin\left(\frac{2\pi}{T}\right)t$$

$$V = V_o \sin(2\pi f)t$$

(2) Peak value

The highest value reached by the voltage or current in one cycle is called its *peak value*.

It is represented by V_0.

(3) Peak to Peak value

The sum of the positive and negative peak values usually known as *p-p value*. The p-p value of voltage waveform is $2V_0$.

(4) Root Mean Square (rms) Value

The effective value of a.c over a complete cycle is called *root mean square value*.

If we connect an ordinary D.C. ammeter to measure alternating current, it would measure its value as averaged over a cycle.

For an alternating signal, the average value of current or voltage is zero over a cycle, but the power delivered for a cycle is not zero because power is $P = I^2R$. Therefore, the average of the square of current or voltage will not be zero. Actually it is measured by its rms value. The root mean square value is the square root of average value of V^2 or I^2 which are positive even for the negative values of V or I.

As the graph of V^2 is symmetrical about $\frac{1}{2}V_0^2$, so the mean or average value of V^2 is, therefore, $\frac{V_0^2}{2}$. So rms value V_0^2

is obtained by taking the square root of $\frac{V_0^2}{2}$, therefore,

$$V_{rms} = \sqrt{\frac{V_0^2}{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$V_{rms} = 0.707 V_0$$

Similarly,

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$I_{rms} = 0.707 I_0$$

Most of the alternating current and voltage meter is calibrated to read the rms value. So the effective value of alternating current signal is called as root mean square value of A.C signal.

Fig. 16.3

Q.3 What do you mean by phase angle? Explain please lag and phase lead. How can you represent alternating voltage and current by phasor (vector) diagram?

Ans.

ALTERNATING CURRENT
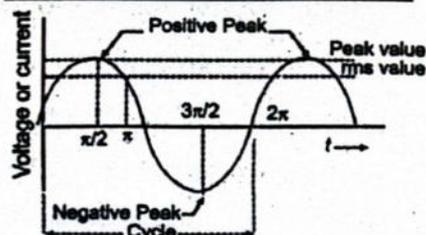
Phase of A.C

As the instantaneous value of voltage can be expressed as,

$$V = V_0 \sin \omega t$$

or

$$V = V_0 \sin \theta$$

The angle θ describes the instantaneous value of alternating voltage or current is known as its phase. So,
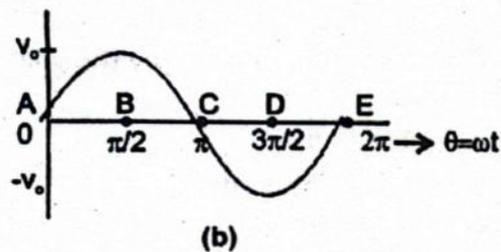
when $\theta = 0°$ then $V = V_o \sin 0° = 0$

when $\theta = 90°$ then $V = V_o \sin 90° = V_o$

when $\theta = 180°$ then $V = V_o \sin 180° = 0$

when $\theta = 270°$ then $V = V_o \sin 270° = -V_o$

when $\theta = 360°$ then $V = V_o \sin 360° = 0$

The wave form of voltage verses θ is shown in figure.


(b)

Phase Lag And Phase Lead:

The phase difference between two alternating quantities is more important than their absolute phases.

Fig (1) shows two waveforms 1 and 2. The phase angles of waveforms 1 and 2. The phase angles of waveform 1 at the points A, B, C, D and E has been shown above the axis and those of waveform 2 below the axis. At the point B, the phase of 1 is $\pi/2$ and that 2 is 0 it can be seen that at each point the phase of waveform 2 is less than the phase of waveform 1 by an angle of $\pi/2$. It means that at each instant, the phase of A.C. 2 is less than the phase of A.C. 1 by $\pi/2$.
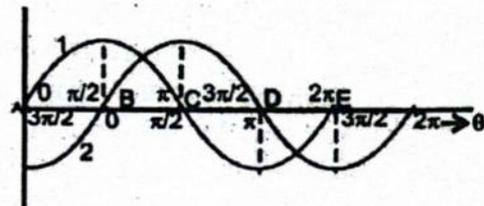
Similarly it can be seen in fig (2) that the phase at a point of the waveform of A.C. 2 is greater than that of waveform 1 by an angle $\pi/2$. In this case, it is said that A.C. 2 leading the A.C. 1 by $\pi/2$. It means that at each instant, the phase of A.C. 2 is greater than that of 1 by $\pi/2$.
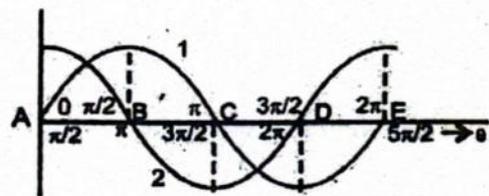
Vector Representation of an Alternating Quantity

Phasor or vector representation for alternating quantities is basically used to show the phase differences between alternating quantities although these quantities are not vectors.

Sinusoidally alternating voltage or current can be graphically represented by a counter clockwise rotating vector provided it satisfies the following conditions.

(i)   Its length on a certain scale represents the peak or rms value of the alternating quantity.

(ii)   It is in the horizontal position at any instant when the alternating quantity is zero and is increasing positively.

(iii)   The angular frequency of the rotating vector is the same as the angular frequency ω of the alternating quantity.

Fig (1) shows the sinusoidal voltage waveform leading an alternating current waveform by $\pi/2$. The same fact has been shown vectorically in fig (2). Here vector OI represents the peak or rms value of the current which is taken as reference quantity.

Similarly OV represents the rms or peak value of the alternating voltage which is leading the current by $\pi/2$.

(a)

(b)

Both vectors are supposed to be rotating in the counter clockwise direction at angular frequency ω of the two alternating quantities. Figure (b) shows the position of voltage and current at t = 0.
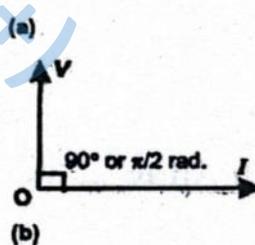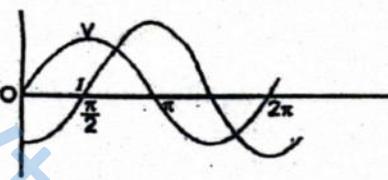
1. The most common source of A. C is: (Swl 2015, Lhr 2014 G I)
   (A) Motor　　(B) Battery　　(C) generator　　(D) Solar cell

2. The waveform of alternating voltage is a: (Bwp 2015, Mtn 2015 G – I)
   (A) Cotangent curve　　(B) Cosine Curve　　(C) Tangent Curve　　(D) Sine Curve

3. Main reason for worldwide use of A.C is: (Mtn 2015 G – II, Lhr 2015)
   (A) It is cheaper　　(B) Transmitted to long distance
   (C) Both A and B　　(D) Reaches in short time

4. Average value of current and voltage over a complete cycle is (Lhr 2016, D. G. Khan 2015 G – II)
   (A) Positive　　(B) Negative　　(C) Zero　　(D) Infinite

5. The frequency of A.C. source used in Pakistan is: (Mirpur, Lhr 2016, Lhr 2015 G-II, Swl 2014)
   (A) 50 Hz　　(B) 60 Hz　　(C) 45 Hz　　(D) 70 Hz

6. The highest value reached by the voltage or current in one cycle is called: (Mirpur 2016, 2013, Grw 2013 G I)
   (A) Peak to Peak value　　(B) Peak value
   (C) Instantaneous value　　(D) Root mean square value

7. The frequency of A.C used in Pakistan is _____ . (Fed 2013, Rwp 2014)
   (A) 50 CPS　　(B) 60 CPS　　(C) 100 CPS　　(D) 120 CPS

8. If I_0 is the peak value of an AC supply, then its rms value is given as $I_{rms} =$ ____ (Lhr 12 G-II, Grw 12, Fed 11,12, Fsd 17)
   (A) $\frac{I_0}{\sqrt{2}}$　　(B) $\frac{I_0}{0.707}$　　(C) $\sqrt{2}\,I_0$　　(D) $\frac{I_0}{2}$

9. Root mean square value of voltate is given by: (Rwp 2014, 15, Grw 2015, 2018)
   (A) $V_{rms} = 2V_0$　　(B) $V_{rms} = \sqrt{2V_0}$　　(C) $V_{rms} = \frac{V_0}{\sqrt{2}}$　　(D) $V_{rms} = \frac{V_0}{\sqrt{2}}$

10. The phase angle at +ve (positive) peak is (Mtn 2018, Sgd 2017 G I, Grw 2016)
    (A) $\frac{\pi}{2}$　　(B) π　　(C) $\frac{3\pi}{2}$　　(D) 2π

11. During each cycle AC voltage reaches a peak value (Fsd 2017, 2018, Azad Kashmir 2017, Sgd 2016 Group II)
    (A) Once　　(B) Twice　　(C) Thrice　　(D) Four times

12. The sum of positive and negative peak value is called (Mirpur 2015, Grw 2016)
    (A) R.M.S Value　　(B) P – P Value　　(C) Peak Value　　(D) Average Value

13. The peak value of A.C source is 20 A, then its rms value will be: (Grw 2015)
    (A) 14.1 A　　(B) 10 A　　(C) 20 A　　(D) 28.2 A

14. The value of peak to peak voltage is: (Lhr 2017 G I)
    (A) V_0　　(B) $-V_0$　　(C) $\sqrt{2}V_0$　　(D) $2V_0$

15. The output voltage of an A.C generator at time $t = \frac{T}{4}$ is given by:- (Mtn 2017 G II)
    (A) $V = -V_0$　　(B) $V = V_0$　　(C) $V = 0$　　(D) $V = \frac{V_0}{4}$

16. The r.m.s value of the current when $I_0 = 2A$ is given by: (Federal 2017)
    (A) $\sqrt{2}A$　　(B) $2\sqrt{2}A$　　(C) $4\sqrt{2}A$　　(D) $\frac{1}{\sqrt{2}}A$

17. An A.C. voltmeter reads 220 V, its peak value will be: (Bwp 2017, Sgd GI 2018)
    (A) 255 V　　(B) 311.12 V　　(C) 300 V　　(D) 200 V

ANSWER KEY'S

1.	C	2.	D	3.	C	4.	C	5.	A	6.	B	7.	A	8.	A	9.	C	10.	A
11.	B	12.	B	13.	A	14.	D	15.	B	16.	A	17.	B						

Q.4 Describe the types of A.C. circuit?

Ans.

A.C. CIRCUITS

The basic circuit element in a D.C. circuit is a resistor (R) which controls the current or voltage and the relationship between them is given by Ohm's law that is V = IR.

> **Do you know?**
> For phasor vector algebra should be applied

In A.C. circuits, in addition to resistor R, two new circuit elements namely INDUCTOR (L), and CAPACITOR (C) become relevant. The *current and voltages* in A.C. circuits are controlled by three *elements* R, L and C. We would study the *response* of an A.C. circuit when it is excited by an alternating voltage.

Q.5   Describe the effect of resistance in an A.C. circuit?

Ans.

A.C. THROUGH A RESISTOR

Consider a resistor of resistance R is connected with an alternating voltage source as shown in fig(a). At any time t, the alternating voltage across the terminals of the resistor is given by

$$V = V_0 \sin\omega t \qquad (1)$$

Where V_0 is the peak value of the alternating voltage and ω is the angular frequency. The alternating current I flowing through the circuit is given by ohm's law,

$$I = \frac{V}{R}$$

Putting the value of V from equation (1).

$$I = \frac{V_0}{R} \sin \omega t$$

But $I_0 = \frac{V_0}{R}$ is the peak value of current

So

$$I = I_0 \sin\omega t \qquad (2)$$

A comparison of equation (1) and (2) shows that the instantaneous values of voltage and current are the sine functions which vary with time are in phase in resistive circuit. They reach their minimum and maximum values at the same time. Thus V and I are said to be in phase. This behaviour is shown graphically in fig(b) and vectorically in fig(c). They are drawn parallel because there is no phase difference between them.

The opposition to A.C, which a circuit offers is the called resistance $R = \frac{V}{I}$

The instantaneous power in the resistance is given by

$$P = I^2 R = VI = \frac{V^2}{R}$$

P is in watts, V is in volts, I is in ampere and R is in ohms.
Equation for power holds only when the current and voltage are in phase.

(a)

(b)

(c)

Q.6   Describe the effect of capacitor in an A.C. circuit?
FEDERAL – 2017, Lhr 2016 G II, Grw 2017, Mtn 2016 G I

Ans.

A.C. THROUGH A CAPACITOR

Alternating current can flow through a resistor but it is not clear that how it can flow through a capacitor. In fig(a), a low power bulb is connected in series with a 1μF capacitor to alternating voltage source through a switch S. When the switch is closed, the bulb lights up which shows that the current is flowing through the capacitor.

Direct current can not flow through a capacitor continuously because the plates of the capacitor are separated by an insulating medium.
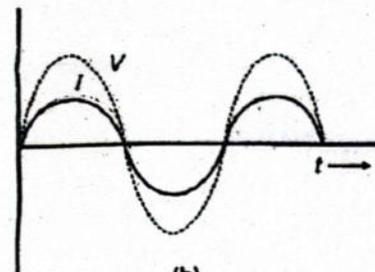
An alternating current flows in the circuit as the plates are being continuously charged and discharged and changed the other way round by the alternating voltage.
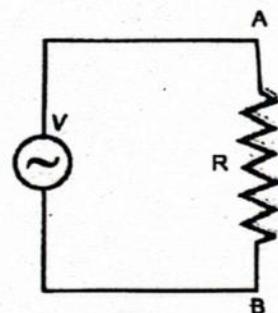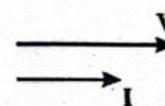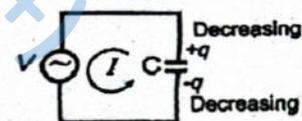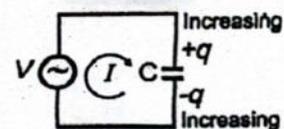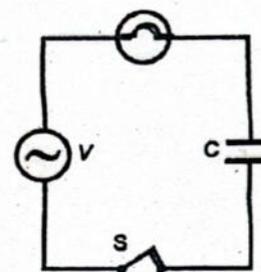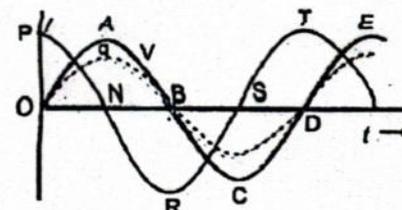

(a)

(b)

The relation between the charge q on a capacitor and the voltage V across its plates is q = CV holds at every instant.

As $\qquad$ $V = V_o \sin \omega t$ _____(1)

And

$$q = CV$$
$$q = CV_o \sin \omega t \qquad\qquad (2)$$

Since C and V_o are constants, therefore, q will vary in the same way as applied voltage V. i.e V and q are in phase, shown in fig(b).

We know that,

$$I = \frac{\Delta q}{\Delta t} \qquad\qquad (3)$$

Thus slope of q–t graph represents the current.

The voltage and charge curves are drawn in fig (b). At point O, when q = 0, the slope is maximum, so I is maximum. From O to A, slope of q–t curves decreases to zero. So I become zero at N. From A to B the slope of the curve is negative and so I is negative from N to R.
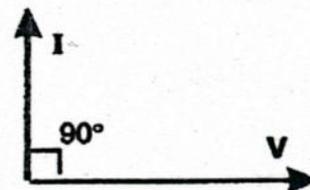
(c)

In this way the curve PNRST give the variation of current. Referring to fig. (b), it can be seen that the phase at O is zero and the phase at the upper at maximum is $\frac{\pi}{2}$. So in fig. (b), the phase of V at O is zero while the current at this point is maximum so its phase is $\frac{\pi}{2}$. This shows that the current is leading the applied voltage by $\frac{\pi}{2}$. Now consider the points A and N. Thus again the phase of alternating voltage at A is $\frac{\pi}{2}$, but the phase of current at N is π. Again the current is leading the voltage by $\frac{\pi}{2}$. Similarly by comparing the phases at the pair (B, R), (C, S) and (D, T) it can be seen that at all these points the current leads the voltage by $\frac{\pi}{2}$. This is vectorically shown in fig. (c)

The opposition offered by a capacitor to the flow of A.C. is called capacitive reactance.

It is represented by X_c. It value is given by,

$$X_c = \frac{V_{rms}}{I_{rms}}$$

Where V_{rms} is the rms value of alternating voltage across the capacitor and I_{rms} is the rms value of current passing through the capacitor.

The unit of reactance is ohm. The reactance X_c depends upon frequency and capacitance C and is given by,

$$X_c = \frac{1}{\omega C}$$

$$X_c = \frac{1}{2\pi f C}$$

So the reactance increases with the decrease in frequency of A.C. and reactance decrease with the increase in frequency through the same capacitor.

Ans.

A.C. THROUGH AN INDUCTOR

An inductor is usually in the form of a coil or a solenoid wound from a thick wire so that it has a large self inductance and has a negligible resistance. When an alternating source of voltage is applied across an inductor. It must opposes the flow of A.C. which is continuously changing.

Consider an alternating voltage V is applied across an inductor L as shown in fig(a). An inductor is in the form of a coil or a solenoid wound from a thick wire so that it has a large value of self inductance and has a negligible resistance. We know that self inductance opposes any change of current flowing through an inductor. The changing current (alternating) sets up a back emf in the coil of magnitude,

$$\varepsilon_L = L\frac{\Delta I}{\Delta t}$$

Where L is the inductance of the coil, while the alternating current may be expressed as

$$I = I_o \sin \omega t \underline{\hspace{3cm}}(1)$$

The resistance of the coil is negligible then the applied voltage must be equal to the back emf.

$$V = L\frac{\Delta I}{\Delta t}\underline{\hspace{3cm}}(2)$$

Since L is constant, so V is proportional to $\Delta I/\Delta t$ *which is the slope of i–t*

graph. Fig(b) shows how the current I varies with time.
At point O, the value of the slope is maximum, so the maximum value of V equal to V_o occurs at O and the slope of I-t graph decreases to zero so the voltage decreases from V_o to zero at Q.

From A to B, the slope of I-t graph is negative, so the voltage curve goes from Q to R. In this way, voltage is represented by curve PQRST corresponding to current curve OABCD. Let us compare the phases at the pair of points (O, P), (A, Q), (B, R), (C, S) and (D, T).

It can be seen that at all these points the current lags behind the applied voltage by 90° or the applied voltage leads the current by 90°. This can be shown by vector diagram(c).

*The resistance offered by the inductor in the flow of A.C. is known as **inductive reactance**.* The inductive reactance is given by,

$$X_L = \frac{V_{rms}}{I_{rms}}$$

So V_{rms} and I_{rms} are the root mean square speed of voltage and current.

$$X_L = \omega L$$
$$X_L = 2\pi f L$$

The reactance of the coil depends upon the frequency of the A.C and inductance L. It is directly proportional to both f and L.
Where L is in henry, f is in hertz and X_L is in ohm. It is to be noted that inductance and capacitance behave oppositely as a function of frequency.
Referring to figure (b), it can be seen that no power is dissipated in a pure inductor. In first quarter of cycle both V and I are positive so power is positive,

(a)

(b)
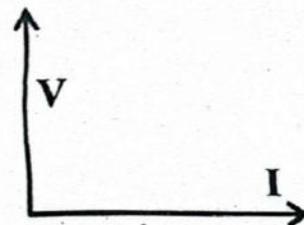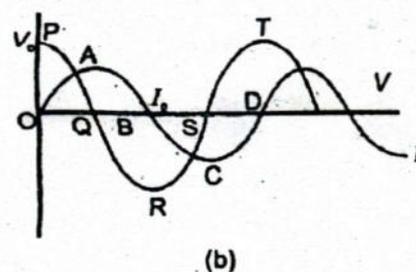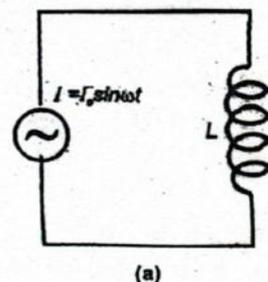
Do You Know?

Inductors are made in many sizes to perform a wide variety of functions in business and industry.

which mean that energy is supplied to inductor. In second quarter, I is positive but V is negative, so power is negative which implies that energy is returned by the inductor. Again in third quarter, it receives energy but return the same amount in the fourth quarter. So there is no net change in a complete cycle. Since and inductor coil does not consume energy, the coil is often employed for control A.C. without consumption of energy. Such an inductance coil is known as choke.

MCQ's From Past Board Papers

1. Power dissipated in pure inductor is: (Lhr 2017 G I, Sgd 2017 G II) (Swl 2015, Lhr 2016, Fsd 2015, Rwp 2011, 13)
   (A) Large   (B) Small   (C) Infinite   (D) Zero

2. Direct current cannot flow through: (Sgd 2015 G – I, Grw 2011, 15)
   (A) Resistor   (B) Capacitor   (G) Inductor   (D) Voltmeter

3. Pure choke consumes: (Lhr 2011, 12 G II)
   (A) Minimum power   (B) Maximum power   (C) No power   (D) Average power

4. Capacitive reactance X_c = (Fsd 2015, Sgd 2015 G-I, 2016, AJK 2017)
   (A) $2\pi fC$ (B) $\dfrac{1}{2\pi fC}$ (C) $4\pi fC$ (D) $\dfrac{1}{4\pi fC}$

5. Phase difference between V and I of an A.C through resistor is: (Lhr 15,16 G-I, Bwp 14, Mtn 2015 G-I, Grw 2013)
   (A) Zero degree   (B) 90°   (C) 180   (D) 270°

6. Choke consumes extremely small: (Lhr 2014, 15 G – I)
   (A) Current   (B) Charge   (C) Power   (D) Potential

7. At what frequency will an inductor of 1.0 H have a reactance of 500 Ω? (Bwp 2017 G II) (Fed 2011)
   (A) 50 Hz   (B) 80 Hz   (C) 500 Hz   (D) 1000 Hz

8. The device which allows only the continuous flow of an A.C., through a circuit is: (Fsd 2018, Lhr 2013, 15)
   (A) Capacitor   (B) Inductor   (C) D.C. motor   (D) Battery

9. At high frequency, the current through a capacitor of A.C. circuit will be: (Lhr 2013, Grw 15)
   (A) Large   (B) Small   (C) infinite   (D) Zero

10. The basic circuit element in DC circuit which controls current: (Swl 16, 2018, Grw 14 Lhr 14 G I)
    (A) Resistor only   (B) Capacitor only   (C) Inductor only   (D) All of these

11. The capacitive reactance to pure D.C. is: (D.G.Khan 2017, Bwp 2014, Lhr 2014 G II)
    (A) Zero   (B) Infinite   (C) Variable   (D) Equal to inductive reactance

12. Resistance of pure choke is: (Mtn 2014, D.G.Khan 2015, Fsd 2014)
    (A) Zero   (B) Large   (C) Very small   (D) infinite

13. Inducitive reactance of an inductor is: (D.G.Khan 2016, Sgd 2014, Fsd 2015, Rwp 2014)
    (A) $X_L = \pi f L$ (B) $X_L = 4\pi f L$ (C) $X_L = 2\pi f L$ (D) $X_L = 2\pi L$

14. Capacitor will have a large reactance at: (Mtn 2011, 13, Bwp 2012, 2017, Swl 2014, 2016)
    (A) Low frequency   (B) High frequency   (C) Zero frequency   (D) Negative frequency

15. In capacitor: (Swl 2014, Mtn 2013)
    (A) Current leads voltage by $\dfrac{\pi}{2}$ (B) Voltage leads voltage by $\dfrac{\pi}{2}$
    (C) Current leads the voltage by π (D) Both are in phase

16. Power dissipation in a pure inductive or in a pure capacitance circuit is: (Lhr 2011 G – II, 2012)
    (A) Infinite   (B) Zero   (C) Minimum   (D) Maximum

17. In case of capacitor, the unit of reactance is: (AJK 2018, Swl 2018, Lhr 2016 Group I)
    (A) ohm   (B) mho   (C) farad   (D) henry

18. The phase difference between current and voltage in an Inductive circuit is (Lhr 2015, Bwp 2016, Sgd 2016 Group I)
    (A) Zero   (B) 90°   (C) 180°   (D) 45°

19. 100 μF capacitor is connected to an AC-voltage of 24 V and frequency 50 Hz. The reactance of the capacitor is (Sgd 2016 Group II)
    (A) 30.8 Ω   (B) 31.8 Ω   (C) 34.8 Ω   (D) 40 Ω

20. The slope of q – t curve at any instant of time gives: (Bwp 2017 G II) (Bwp 2016)
    (A) Current   (B) Voltage   (C) Charge   (D) Both A and B

21. In alternating current, Inductors behave like (Sgd 2015 Group I)
    (A) Semi conductors   (B) Inductors   (C) Resistors   (D) Insulators

22. The reactance of an Inductor at 50 Hz is 10Ω its reactance at 100 Hz becomes (Sgd 15 Group II)
    (A) 20 Ω   (B) 5 Ω   (C) 2.5 Ω   (D) 1 Ω

23. Which consumes small power? (D.G.Khan 2017 G I)
    (A) Inductor   (B) Resistor   (C) Motor   (D) All of them
24. A device which opposes the flow of A.C only is (D.G.Khan 2017 G II)
    (A) resistor   (B) capacitor   (C) inductor   (D) None
25. In pure capacitor AC circuit, the current I and q are (Sgd 2017 G I)
    (A) In phase   (B) Out of phase   (C) Parallel to each other (D) None of above
26. X_L is low for low frequency f, but X_c is (Sgd 2017 G II)
    (A) Zero   (B) low   (C) High   (D) Same as X_L
27. If the frequency of AC supplied is doubled then the capacitor reactance becomes (Bwp 2018, Sahiwal 2017)
    (A) half   (B) two times   (C) four times   (D) one fourth
28. If the capacitive reactance of AC circuit is made four times then the frequency of the circuit becomes: (Federal 2017)
    (A) Twice   (B) One half   (C) Four times   (D) One forth
29. The device which allows only the flow of D.C. is: (Bwp GII 2018)
    (A) Capacitor   (B) Transformer (C) Inductor   (D) Generator
30. The inductive reactance of a coil is directly proportional to: (Bwp GII 2018)
    (A) Inductance   (B) Resistance   (C) Frequency of A.C. (D) Both Frequency of A.C
31. Choke consumes extremely small (D.G.Khan GII 2018)
    (A) Current   (B) Charge   (C) Power   (D) Potential

ANSWER KEY'S

1.	D	2.	B	3.	C	4.	B	5.	A	6.	C	7.	B	8.	A	9.	A	10.	A
11.	B	12.	A	13.	C	14.	A	15.	A	16.	B	17.	A	18.	B	19.	B	20.	A
21.	C	22.	A	23.	A	24.	C	25.	B	26.	C	27.	A	28.	D	29.	C	30.	C
31.	C																		

Q.8 Write a short note on impedance?

Ans.

IMPEDANCE

The combined effect of resistance and reactances (capacitive and inductive) in an alternating current circuit is known as impedance.

> **For Your Information**
> Reciprocal of impedance is called admittance $Y = \dfrac{1}{Z}(ohm)^{-1}$ or siemen.

As the resistance R offers opposition to the flow of current and inductance L or a capacitance C also offer opposition to the flow of A.C. Their combined effect is known as impedance and it is denoted by Z.

Impedance is the measure by the ratio of rms value of the applied voltage to the rms value of resulting A.C.

Thus,
$$Z = \frac{V_{rms}}{I_{rms}}$$

Impedance is expressed in ohms.

Q.9 Describe the A.C. through a R-C series circuit?

D.G.Khan 16 G I, FSD 16, GRW 10, Federal 16, MIRPUR 17

Ans.

A.C. THROUGH R-C SERIES CIRCUIT

Consider a resistance R and capacitor C connected in series to a source of alternating voltage as shown in fig(a).

When an alternating voltage is applied then the same current I_{rms} would flow through each of them because R and C are in series. The voltage across R is

$$V_R = I_{rms}R$$

and voltage across the capacitor is
$$V_C = I_{rms}X_C$$
$$V_C = \frac{I_{rms}}{\omega C} \qquad \left[\text{since } X_C = \frac{1}{\omega C} \right]$$

As V_{rms} and I_{rms} are in phase in case of resistor while for capacitor the voltage lags the current by 90°, so the line representing the $I_{rms}X_C$ is drawn at right angles to the current line as shown in fig(b).

The resultant voltage V_{rms} is obtained as,

$$V_{rms} = \sqrt{V_R^2 + V_C^2}$$

$$V_{rms} = \sqrt{(I_{rms}R)^2 + (I_{rms}X_c)^2}$$

$$V_{rms} = \sqrt{I_{rms}^2[R^2 + (\tfrac{1}{\omega C})^2]}$$

$$V_{rms} = I_{rms}\sqrt{(R)^2 + (\tfrac{1}{\omega C})^2} \qquad [\text{Since } X_c = \frac{1}{\omega C}]$$

(a)

So the impedance becomes,

$$Z = \frac{V_{rms}}{I_{rms}}$$

$$Z = \frac{I_{rms}\sqrt{(R)^2 + (\tfrac{1}{\omega C})^2}}{I_{rms}}$$

$$Z = \sqrt{(R)^2 + (\tfrac{1}{\omega C})^2}$$

(b)

Thus from fig(b) the current leads the applied voltage by an angle θ such that,

$$\tan\theta = \frac{V_c}{V_R}$$

$$\tan\theta = \frac{I_{rms}/\omega C}{I_{rms}R}$$

$$\tan\theta = \frac{1}{\omega CR}$$

$$\theta = \tan^{-1}\left(\frac{1}{\omega CR}\right)$$

(c)

We can find the impedance of R-C series circuit by vector addition. The resistance R is represented by a horizontal line in the direction of current.
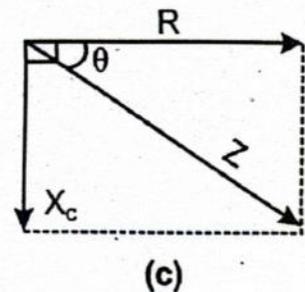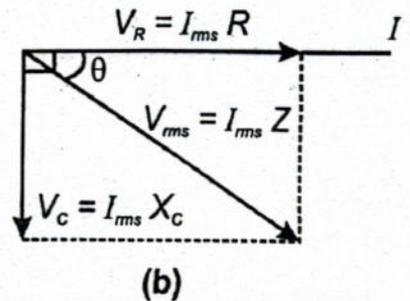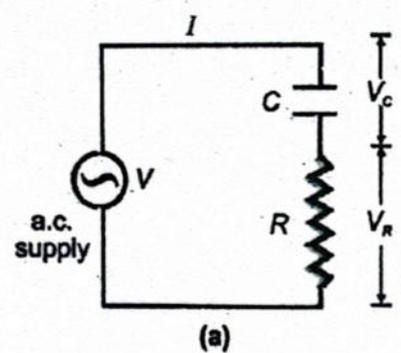
The reactance X_C is shown by a line lagging the R by 90° as shown in fig(c). Thus the impedance Z is the vector sum of resistance and reactance.

The angle which the line representing the impedance Z makes with R gives the phase difference between the voltage and current. The current is leading the voltage across the capacitor by angle

$$\tan\theta = \frac{X_c}{R}$$

$$\tan\theta = \frac{\tfrac{1}{\omega C}}{R}$$

$$\theta = \tan^{-1}\left(\frac{1}{\omega CR}\right)$$

Q.10 Describe the A.C. through a R-L series circuit? *SGD 16 G I, FSD 2015, D.G.KHAN 2016 G II*

Ans.

A.C. THROUGH R-L SERIES CIRCUIT

Consider a resistance R and inductor L are connected in series to a source of alternating voltage as shown in fig(a).

When an alternating voltage is applied then the same current I_{rms} would flow through each of them because R and C are in series. The voltage across R is $V_R = I_{rms}R$ and voltage across the inductor is $V_L = I_{rms}X_L$.

As V_{rms} and I_{rms} are in phase in case of resistor while for inductor the voltage leads the current by $90°$, so the line representing the $I_{rms}X_L$ is drawn at right angles to the current line as shown in fig(b).

The resultant voltage is obtained as,

$$V_{rms} = \sqrt{V_R^2 + V_L^2}$$

$$V_{rms} = \sqrt{(I_{rms}R)^2 + (I_{rms}X_L)^2}$$

$$V_{rms} = \sqrt{I_{rms}^2[R^2 + (\omega L)^2]} \qquad [\text{since } X_L = \omega L]$$

$$V_{rms} = I_{rms}\sqrt{(R)^2 + (\omega L)^2}$$

(a)

So the impedance becomes,

$$Z = \frac{V_{rms}}{I_{rms}}$$

$$Z = \frac{I_{rms}\sqrt{(R)^2 + (\omega L)^2}}{I_{rms}}$$

$$Z = \sqrt{R^2 + (\omega L)^2}$$

Thus from fig(b) the current lags the applied voltage by an angle θ such that,

$$\tan\theta = \frac{V_L}{V_R}$$

$$\tan\theta = \frac{I_{rms}\omega L}{I_{rms}R}$$

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

(b)

We can find the impedance of R-L series circuit by vector addition. The resistance R is represented by a horizontal line in the direction of current.
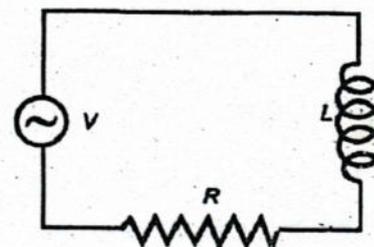
The reactance X_L is shown by a line leading the R by $90°$ as shown in fig(c). Thus the impedance Z is the vector sum of resistance and reactance.

The angle which the line representing the impedance Z makes with R gives the phase difference between the voltage and current. The current is lagging the voltage across the inductor by angle

$$\tan\theta = \frac{X_L}{R}$$

$$\tan\theta = \frac{\omega L}{R}$$

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$
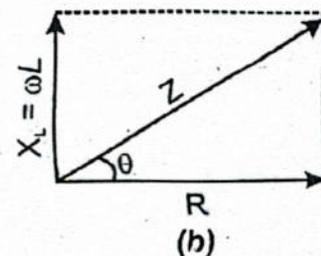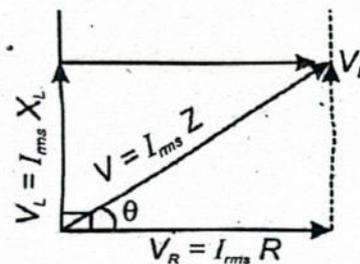
MCQ's From Past Board Papers

1. The combination effect of resistance and reactance is known as: (Mirpur 2013, Bwp 2011, Rwp 2015, Mtn 2015 G-II)
   (A) Inductance   (B) Conductance   (C) Resistance   (D) Impedance

2. S.I. unit of impedance is: (Swl 2018, Lhr 2010, 11, 15)
   (A) Henry   (B) Hertz   (C) Ampere   (D) Ohm

3. The impedance of R–C series A.C. circuit is given by Z = _____ (Bwp 2014, Grw 2014, 15)

(A) $\sqrt{R^2 - (\omega C)^2}$ (B) $R^2 + (\omega C)^2$ (C) $\sqrt{R^2 + (\omega C)^2}$ (D) $\sqrt{R^2 + \frac{1}{(\omega C)^2}}$

4. The A.C. circuit in which current and voltage are is phase the power factor is (Grw 2014)

(A) Zero   (B) 1   (C) 0.5   (D) infinity

5. Which phase diagram is true of RL-Series circuit? (Federal 2013, 15)

(A)   (B)   (C)   (D)
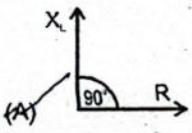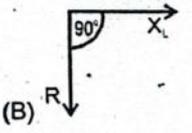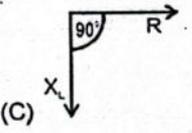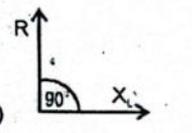
6. Impendance is denoted by (Mir-II-13, 15)

(A) A   (B) Z   (C) P   (D) Q

7. Which phase diagram is true for RC-series circuit? (Fed 2014)
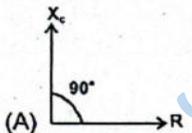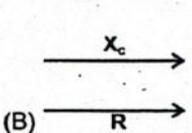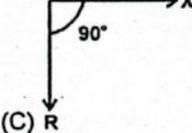
(A)   (B)   (C)   (D)
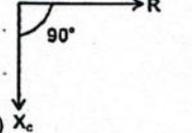
8. For R – L series circuit, the voltage leads the current by phase angle of: (D.G.Khan 2015, Mir-II-13, 15, Swl 2014)

(A) $\tan^{-1}(\omega L/R)$ (B) $\tan^{-1}(\omega C/R)$ (C) $\tan^{-1}(1/\omega CR)$ (D) $\tan^{-1}(\omega/RC)$

9. The power factor of RL-series circuit is: (Lhr 2016 Group II)

(A) 0   (B) 1   (C) Less than 1   (D) More than 1

10. The impedance Z can be expressed as:- (Lhr 2018, Mtn 2016 Group II)

(A) $Z = \frac{V_{rms}}{I_{rms}}$ (B) $Z = \frac{I_{rms}}{V_{rms}}$ (C) $Z = I + V$ (D) $Z = I - V$

11. When 10V are applied to an A.C. circuit, the current flowing in it is 100 mA, its impedance is: (Lhr 17 G II, Rwp 17)

(A) 50Ω (B) 75Ω (C) 100Ω (D) 90Ω

12. If L and R represent inductance and resistance respectively, then the dimensions of $\frac{L}{R}$ will be: (Fed 2017)

(A) $[M^0L^0T^{-1}]$ (B) $[M^0L^0T^{-2}]$ (C) $[M^0L^{-1}T^{-2}]$ (D) $[M^0L^0T]$

ANSWER KEY'S

1.	D	2.	D	3.	D	4.	B	5.	A	6.	B	7.	D	8.	A	9.	C	10.	A
11.	C	12.	D																

Q.11 Discuss the power dissipation in A.C. circuit?

Ans.

POWER IN A.C. CIRCUIT

The expression for power is $P = V_{rms} I_{rms}$ holds only when V_{rms} and I_{rms} are in phase and the circuit is pure resistive. We know that the power dissipation in a pure inductive or in a pure capacitance circuit is zero. In these cases the current lags or leads the applied voltage by 90° and the component of applied voltage vector V along current I is zero.

In A.C. circuit the phase difference between applied voltage V and the current I_{rms} is θ.

The component of V along current I_{rms} is $V_{rms} \cos\theta$. Actually it is the component of voltage vector which is in phase with current. So the power dissipated in A.C. circuit is

$$P = I_{rms}(V_{rms}\cos\theta) = I_{rms}V_{rms}\cos\theta$$

The factor $\cos\theta$ is known as power factor.

> **For Your Information**
>
> For a pure capacitor or a pure inductor, the net power loss over the complete sycle is zero and the current then called as watt-less current.
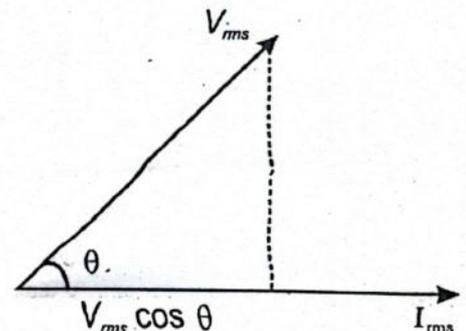
Q.12 Derive the expression for resonance frequency in R-L-C series circuit (Acceptor circuit). Also give the properties of the series resonance?

Ans.

(a)

(b)

(c)

SERIES RESONANCE CIRCUIT (ACCEPTOR CIRCUIT)

Consider an RLC series circuit in which a resistance R, inductance L and capacitance C are connected in series to a source of alternating voltage as shown in fig (a).

The impedance diagram of the circuit is shown in fig (b). where

- Resistance = R

- Capacitive reactance = $X_C = \dfrac{1}{\omega C}$

- Inductive reactance = $X_L = \omega L$

X_L and X_C are opposite in direction. ($\theta = 180°$)

At high frequency:

The value of X_L is greater than X_C. So the inductance dominates and circuit behaves as R-L circuit.

At low frequency:

The value of X_C is greater than X_L. So the capacitance dominates and circuit behaves as R-C circuit.

> **For Your Information**
> At resonance, series resonance circuit will accept (draw) the maximum current so it is also called acceptor circuit.

In between these frequencies there will be a certain value of frequency ω_r at which $X_L = X_C$. This is called the condition of resonance and at this particular value of frequency is called resonance frequency.

Thus at resonance frequency the inductive reactance being equal and opposite to the capacitor reactance, If so, they cancel each other and the impedance diagram is (c), which is only resistive R.

$$As \quad X_L = X_C$$

$$\omega_r L = \frac{1}{\omega_r C}$$

$$\omega_r^2 = \frac{1}{LC}$$

$$\omega_r = \frac{1}{\sqrt{LC}}$$

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

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

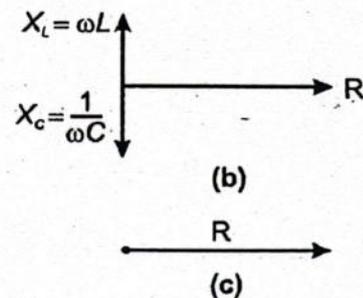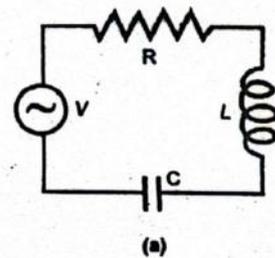This frequency is known as resonance frequency.

Properties of the series resonance circuit:

(i) The resonance frequency is given by
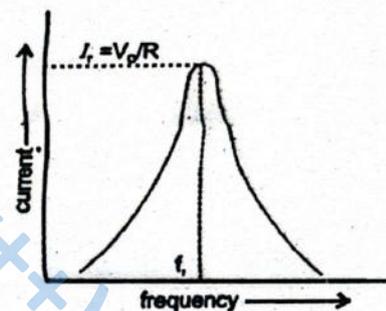
$$f_r = \frac{1}{2\pi \sqrt{LC}}$$

(ii) The impedance of the circuit at resonance is resistive so the current and voltage are in phase and the power factor is $\cos \theta$ is 1.

(iii) The impedance of the circuit is minimum at resonance frequency and it is equal to R.

(iv) If the amplitude of the source voltage V_o is constant, the current is a maximum at the resonance frequency and its value is V_o/R. The variation of current with the frequency is shown in figure.

(v) At resonance, V_L the voltage drop across inductance and V_c the voltage drop across capacitance may be much larger than the source voltage.

MCQ's From Past Board Papers

1. Resonating frequency of RLC series circuit is $f_r =$ _____.

   (D.G.Khan 2014, Lhr –12 G II, Rwp 2015) (Sgd 2014, Grw 2012, 2014, Lhr 2015)

   (A) $\frac{2\pi}{\sqrt{LC}}$ (B) $\frac{1}{2\pi}\sqrt{LC}$ (C) $\frac{1}{2\pi\sqrt{LC}}$ (D) $2\pi\sqrt{LC}$

2. At high frequency, RLC series circuit shows that behavior of: (Bwp 14, Mtn 11, Grw 13 G II)
   (A) RC circuit   (B) RL circuit   (C) Pure capacitive circuit   (D) Pure RLC circuit

3. At resonance RLC series circuit shows the behavior of: (Lhr 2014, Grw 2013 G II)
   (A) Pure resistive circuit   (B) pure capacitive circuit   (C) pure inductive circuit   (D) pure RLC circuit

4. At resonance frequency, the impedance of RLC series circuit is:

   (Rwp 2011, Lhr 2014 G I, Fsd 2014, Sgd 2015) (Lhr 2017 G II) (Mtn 2016 Group I, Fsd 2015)

   (A) Zero   (B) Minimum   (C) Maximum   (D) Moderate

5. The impedance of RLC series circuit at resonance is given by: (Mirpur 16, Bwp 11, 14 Lhr 2014 G II, Mirpur 09, 2015)
   (A) $Z = \sqrt{R^2 + (X_L - X_c)^2}$ (B) $Z = \sqrt{R^2 + X_L^2}$ (C) $Z = R$ (D) $Z = \sqrt{R^2 + X_c^2}$

6. In RLC series circuit at resonance the phase difference between capacitor and inductor reactances is: (Rwp16, Grw17)
   (A) $90°$ (B) $270°$ (C) $0°$ (D) $180°$

7. In R-L-C Circuit, the energy is dissipated in:-   (Mtn 2016 Group I)
   (A) R only   (B) R and L   (C) R and C   (D) R, L and C

8. In RLC series circuit, the condition for resonance is   (D.G.Khan 2017 G II)
   (A) $X_L < X_c$ (B) $X_L > X_c$ (C) $Z < X_c$ (D) $X_L = X_c$

9. At resonance in RLC series circuit, phase difference between voltage and current in: (Sgd GII 2018)
   (A) $0°$ (B) $90°$ (C) $120°$ (D) $180°$

10. The unit of $\sqrt{LC}$ is: (Lhr GI 2018)
    (A) Second   (B) Ampere   (C) Hertz   (D) Farad

ANSWER KEY'S

1.	C	2.	B	3.	A	4.	B	5.	C	6.	D	7.	D	8.	D	9.	A	10.	A

Q.13 Derive the expression for resonance frequency in L-C parallel circuit (Rejecter circuit). Also give the properties of the series resonance?   GRW 14, fsd 16, Lhr 15 G II, Bwp 15

Ans.

PARALLEL RESONANCE CIRCUIT (REJECTER CIRCUIT)

Figure shows a L-C parallel circuit. It is excited by an alternating source of voltage whose frequency could be varied. The inductance coil L has a resistance r which is negligibly small. The capacitor draws a leading current, whereas the coil draws a lagging current. The circuit resonates at a frequency $\omega = \omega_r$ which makes $X_L = X_c$, so that the two branch-currents are equal but opposite.

Hence they cancel out with the result that the current drawn from the supply is zero. In actual practice, the current is not zero but has a minimum value due to small resistance r of the coil.

Properties of the parallel resonance circuit

(i) Resonance frequency is
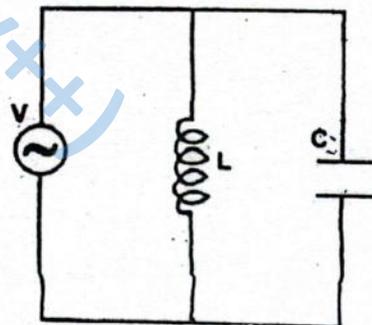
$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

(ii) At resonance frequency, the circuit impedance is maximum and it is a resistive.

(iii) At the resonance the current is minimum and it is in phase with the applied voltage. So the power factor is one. The variation of current with frequency is shown in fig(b).

(iv) At resonance, the branch currents I_L and I_C may each be larger than the source current I_r.
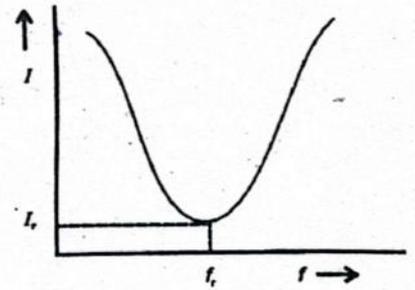
Q.14   Write a note on three phase A.C. supply?

Ans.

THREE PHASE A.C. SUPPLY

One Phase AC supply:

In one phase AC. Generator there is a coil with a pair of slip rings. An alternating voltage is generated across the *slip rings when the coil rotates in a magnetic field.*

Three Phase AC supply:

In a three phase AC. Generator there are three coils inclined at 120° to each other, each connected to its own pair of slip rings Three alternating voltages are generated across its own pair of slip rings when this combination of three coils rotate in the magnetic field.
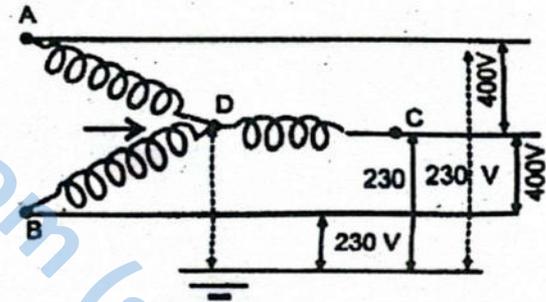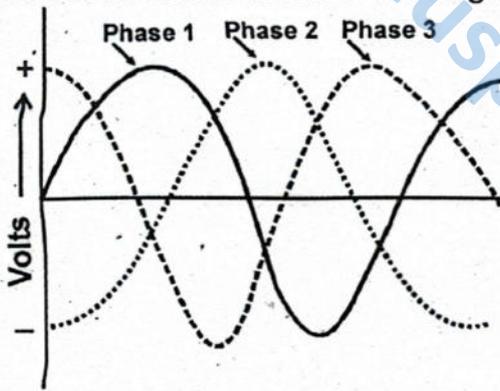
Explanation:

The phase difference between these voltages is 120°.

1.   When voltage across the first pair of slip rings is zero it will have a phase of 0°.
2.   Then voltage across the second pair of slip rings would not be zero but it will have a phase of 120°.
3.   Similarly at this instant the voltage generated across the third pair will have a phase 240°

This is shown in figure has four terminal A,B,C and D. The starting point of all the three coils has a common junction D, which is earthed to the shaft of the generator and the other three ends of the coils are connected to three ends of the coils are connected to three separate terminal (A, B and C) on the machine. The voltage across each of lines connected to terminal A, B, C and the neutral line is 230 V. Because of 120° phase shift the voltage across any two lines is about 400 V.

Advantages:

The main advantage of a three phase supply is that the total load is divided in three parts so that none of the line is over loaded. If heavy load (consisting of a number of air conditioners and motors etc.) is supplied power from a single phase supply, its voltage is likely to drop at full load.

The three phase supply gives 400V which can be used to operate some special appliances that require 400 V for their working.

Ans.

METAL DETECTORS

Principle:

Coil and a capacitor are electrical components together can produce oscillations of current. In LC circuit energy oscillates between a capacitor and an inductor. This inductance of the inductor varies in the presence of metal that changes the frequency of the oscillator. The difference of two frequencies creates beat notes. This can be heard with the help of speaker. That tells about the presence of metal.

Fig. 16.19
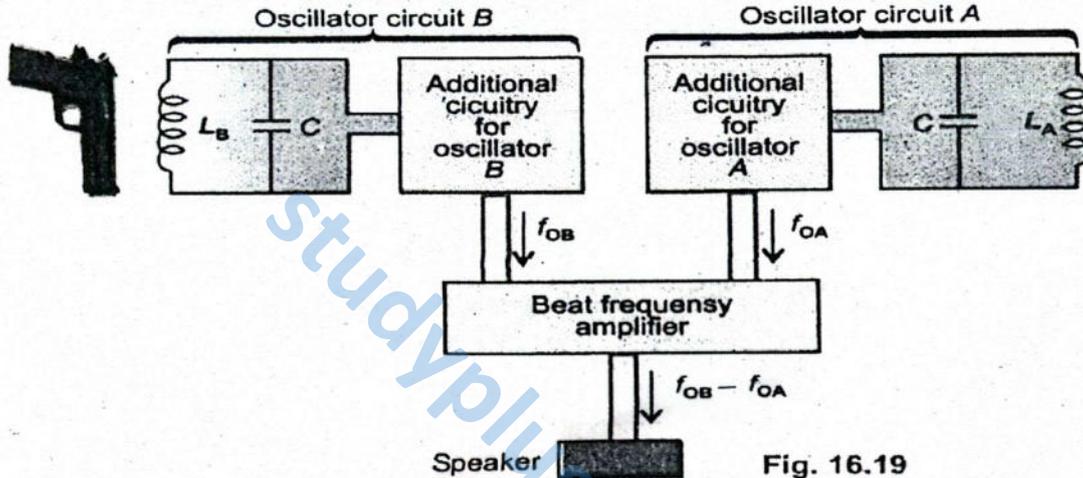
Explanation:

LC circuit is called an electrical oscillator.

Two similar oscillators A and B are used in metal detector device. In the absence of metal object, the inductances X_C and X_L are the same, The resonance frequency of the two circuits is also same. When the inductor of circuit B comes near a metal object, its inductance L decreases so the frequency of Oscillator B will increase. The difference of frequencies creates a beat note. This is heard in the attached speaker that indicates the presence of metal.

Applications:

(i)   Metal detectors are used for various security checks.
(ii)   Metal detectors are used to locate buried metal objects.

Do You Know?

A metal detector is used to locate buried metal objects and for security checks.

MCQ's From Past Board Papers

1. In tuning circuit if capacitance is doubled and inductance is halved then its resonance frequency   (Sgd 2015 G – II)
    (A) Doubled   (B) Halved   (C) Remain the same   (D) Increases to 4 times
2. In three phase voltage across any two live lines is about: (Mtn 2014, 15 Bwp 2015)
    (A) 220 V   (B) 230 V   (C) 400 V   (D) 430 V
3. In three phase A.C supply coils are inclined at an angle of
            (Lhr 2014, Grw 2015, D. G. Khan 2015 G I, Fsd 2015, D.G.Khan 2015 Group I) (Mtn 2017 G I, Bwp 2018)
    (A) 0°   (B) 90°   (C) 120°   (D) 180°
4. Power factor is equal to: (Fsd 2016)
    (A) sin θ   (B) tan θ   (C) sec θ   (D) cos θ
5. Choke consumes extremely small: (Lhr 2015 Group I)
    (A) Current   (B) Charge   (C) Power   (D) Potential
6. The expression P = VI holds only when current and voltage are:-   (Mtn 2017 G II)
    (A) In phase   (B) Out of phase   (C) At right angle to each other   (D) At angle of 120°
7. When an inductor comes close to a metallic object, its inductance is: (D.G.Khan 2017 G I)
    (A) Decreased   (B) Increased   (C) Becomes half   (D) Becomes 4 times

8. Metal detector consist of   (Sahiwal 2017)
   (A) L.C circuit   (B) R.L circuit   (C) R.C circuit   (D) RLC.series circuit
9. In three phase A.C. supply, if first coil has phase 0°, then the other two coils will have phases:
   (Mtn GI 2018) (Mtn GII 2018)
   (A) 0° and 120°   (B) 120° and 240°   (C) 240° and 360°   (D) 0° and 360°
10. Metal detector consists of   (D.G.Khan GII 2018) (Rwp 2018)
   (A) L.C circuit   (B) R.L circuit   (C) R.C circuit   (D) R.L.C series circuit
11. In resonance circuit at resonance, the phase difference between current and voltage is _____.   (Fed 2012)
   (A) 90°   (B) 180°   (C) 0°   (D) 360°

ANSWER KEY'S

1.	C	2.	C	3.	C	4.	D	5.	C	6.	A	7.	A	8.	A	9.	B	10.	A
11.	C																		

Q.16 Write a brief note on choke?

Ans.

CHOKE

Choke is a coil which consists of thick copper wire wound closely in a large number of turns over a soft iron laminated cores. This makes the inductance L of the coil quite large whereas its resistance R is very small. Thus it consumes very small power. It is used in A.C. circuits to limit the current with very small wastage of energy as compared to a resistance or a rheostat.

Q.17 Describe a brief note on electromagnetic waves?   Sgd 15, G I, Swl 2016, Mtn 15

Ans.

ELECTROMAGNETIC WAVES

In 1864 British physicist Maxwell formulated a set of equations known as Maxwell's equations which explained the various electromagnetic phenomena.

According to these equations, a changing magnetic flux creates an electric field and changing electric flux creates a magnetic field.

Each field generates the other and the whole package of electric and magnetic fields will move in the direction of its propagation through space. Such moving electric and magnetic fields are known as electromagnetic waves. They require no medium for their propagation. *Consider* a region of space as shown in fig. Suppose a change of magnetic flux is taking place through AB. This changing magnetic flux will set up a changing electric flux in the surrounding regionCD, due to which a magnetic field would be set up in the space surrounding CD. Thus each field generates the other and both fields will move along propelling itself through space.

> **For Your Information**
> Speed of all electromagnetic waves in vacuum
> $$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}} = 3 \times 10^8 \text{ m/sec}$$

Such moving electric and magnetic fields are known as electromagnetic waves. The electric field and magnetic field are perpendicular to each other. The direction of propagation of waves is perpendicular to electric and magnetic field as shown in fig(b).

The speed of electromagnetic waves can be determined by using the formula $c = f\lambda$. In free space, the speed of electromagnetic waves is 3×10^8 m/sec. The range of electromagnetic waves varies from radio waves to gamma rays.

Fig 16.20

From Antenna →

E

B

Direction of Propagation →

visible spectrum

Radiowaves					Infra red radiation	Ultraviolet radiation	X-rays	Gamma rays
Emergency and defence radio	AM radio	TV and FM radio	Microwave and radar					

Frequency (Hertz)										
10^4	10^6	10^8	10^{10}	10^{12}	10^{14}	10^{16}	10^{18}	10^{20}	10^{22}	

Wavelength (metres)										
10^6	10^4	10^2	10^0	10^{-2}	10^{-4}	10^{-6}	10^{-8}	10^{-10}	10^{-12}	10^{-14}

The electromagnetic spectrum

Q.18 Describe the principle of generation, transmission and reception of electromagnetic waves?

Lhr 2015, Grw 2011, 14, Mtn 2015 D.G.Khan 2015 G II

Ans.

PRINCIPLE OF GENERATION, TRANSMISSION AND RECEPTION OF ELECTROMAGNETIC WAVES

Generation:

The electromagnetic waves are generated when electric or magnetic flux is changing through a certain region of space.

An electric charge at rest gives rise to a coulomb's field which does not radiate electromagnetic waves in space because no change of flux takes place in this type of field.

A charge moving with constant velocity is equivalent to a steady current which generates a constant magnetic field in the surrounding space, but such a field also does not radiate out electromagnetic waves because no changes of magnetic flux are involved.

When we accelerate the electrical charges, electromagnetic waves are generated because of the changes of magnetic flux are involved.

Tit-Bits

Shake an electrically charged object to and fro, and you produce electromagnet waves.

Transmission:

A radio transmitting antenna is a good example of generating the electromagnetic waves by acceleration of charges.

The piece of wire along which charges are made to accelerate is known as transmitting antenna. It is charged by an alternating source of potential of frequency f and time period T. As the charging potential alternates, the charge on the antenna also constantly reverses. This changing electric flux sets up electromagnetic waves which propagate out in space away from the antenna. The frequency with which the fields alternate is always equal to the frequency of the source generating them.

Thus radio waves are produced. In free space these waves travel with the speed of light.

Transmitting antenna

Reception:

When radio waves fall on a piece of wire, the electrons in the wire move under the action of the oscillating magnetic field. It produces an emf or voltage across the wire. The frequency of this emf or voltage is the same as that of the wave intercepting the wire. The wire receiving the wave is known as receiving antenna.

The voltage of one particular frequency can be picked up by the connecting an inductance L and a variable capacitor C in parallel with tone end of the receiving antenna. As the electric field of the wave is very weak at a distance of many *kilometres* from the transmitter, the voltage that appears across the antenna is very small.

Each transmitter propagates radio waves of one particular frequency.

So when a number of transmitting stations operates simultaneously, we have a number of radio waves of different frequencies in space. Thus the voltage that appears across receiving antenna placed in space is usually due to the radio waves *of large number of frequencies*. The voltage of one particular frequency can be picked up by connecting an inductor and a variable capacitor in parallel with one end of receiving antenna.

We adjust the value of the capacitor so that the natural frequency of LC circuit is the same as that of the transmitting station that produces a resonance. The LC circuit gives a large response to that radio wave to which it is tuned.

In our radio receiver set when we change stations we actually adjust the value of the capacitance.
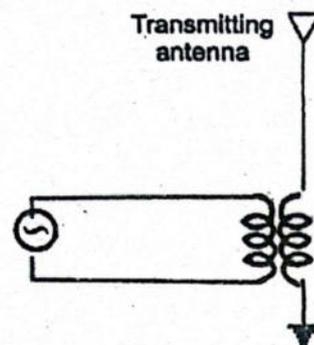
Do You Know?
When electrons in the transmitting antenna vibrate 94,000 times each second, they produced radio waves having frequency 94 kHz.
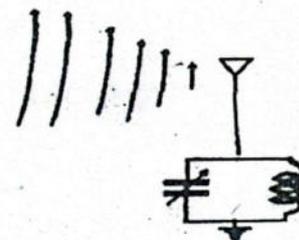
Q.19 Define and explain the modulation?

Ans.

MODULATION

Speech and music are transmitted hundreds of kilometers away by a radio transmitter. The picture taken by TV camera is sent many kilometers away to viewers. In all these cases, the carrier of speech or picture is a high frequency radio wave. The information is superposed on the radio wave. It is carried along with it to the destination.

Modulation is the process of combining the low frequency signal with a high frequency radio wave. The resultant wave is called *modulated carrier wave.*

The high frequency radio wave in modulation is called *carrier wave.*
The low frequency signal in modulation is known as *modulation signal.*

For Your Information
Sound — Microphone amplifier — Audio signal — Modulated carrier waves — to the transmitter — Carrier waves — Amplitude modulation
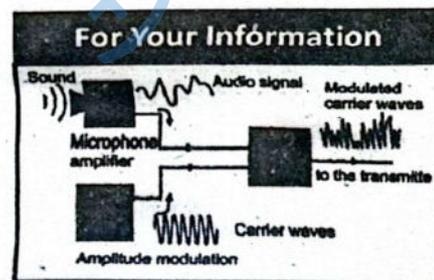
Types of Modulation

Modulation is achieved by changing the amplitude or the frequency of the carrier wave in accordance with the modulating signal. There are two types of modulations.

- Amplitude Modulation A.M
- Frequency Modulation F.M

Amplitude Modulation:

In this type of modulation the amplitude of the carrier wave is increased or decreased as the amplitude of the superposing modulating signal increases and decreases.

Fig (a) represents a high frequency carrier wave of constant amplitude and frequency.

Fig (b) represents a low or audio frequency signal of the sine waveform.

Fig (c) shows the result obtained by modulating the carrier waves with modulating wave.

The A.M transmission frequencies range from **540kHz to 1600kHz.**

Advantage:

They are batter to transmit the signal for large ranges.

Disadvantage:

AM radio waves have low quality transmission of sound.

(a) carrier wave
(b) audio signal
(c) amplitude modulated wave

Frequency Modulation:

In this type of modulation the frequency of the carrier wave is increased or decreased as the modulating signal amplitude increases or decreases but the carrier wave amplitude remains constant.

The frequency of the modulated carrier wave is highest (point H) when the signal amplitude is at its maximum positive value.

The frequency of the modulated carrier wave is lowest (point L) when signal amplitude has maximum negative value.

When the signal amplitude is zero, the carrier frequency is at its normal frequency f_o.

The F.M. transmission frequencies range from **88MHz to 108MHz.**

Advantage:

FM radio waves are affected less by electrical interference than AM waves. They provide a higher quality transmission of sound.

Disadvantage:

They are less able to travel around obstacles such as hill and are high buildings FM radio waves are affected less by electrical.

(a) carrier wave
(b)
(c) frequency modulated wave
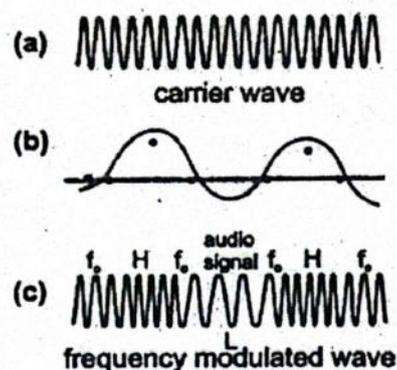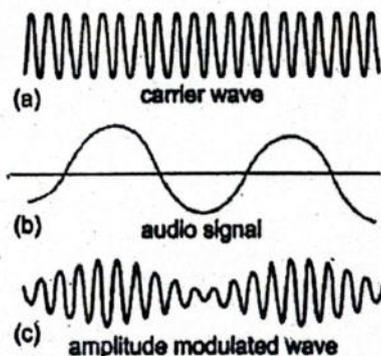
MCQ's From Past Board Papers

1. When we accelerate the charges, which type of waves are produced **(D. G. Khan 2015 G – I)**
   (A) Mechanical waves   (B) Travelling waves   (C) Stationary waves   (D) electromagnetic wave

2. The velocity of an oscillating charge as it moves to and fro along a wire is: **(Lhr 2015 G – I, Fsd 2013, 15)**
   (A) Changing   (B) Constant   (C) Infinite   (D) Zero

3. Electromagnetic waves do not transport _____.   **(Fed 2012)**
   (A) Energy   (B) Momentum   (C) Charge   (D) Information

4. The process of combining the low frequency signal with high frequency carrier waves is called ____. (Fed 2014)
   (A) Wave transmission   (B) Modulation   (C) Resonance   (D) Beats

5. In modulation, low frequency signal is known as: (Mtn 17 G I, Lhr 2012 G II, Lhr 2015, Bwp 2015, Grw 2014)
   (A) Loaded signal   (B) Fluctuated signal   (C) Harmonic signal   (D) Modulation signal

6. The A.M. transmission frequencies range from: (Fsd 2016, Sgd 2014, Mtn 2013)
   (A) 540 KHz to 1000 kHz   (B) 540 KHz to 1600 kHz   (C) 520 KHz to 1600 kHz   (D) 540 KHz to 1400 kHz

7. Which one of the following is the velocity of carrier wave: (Mirpur 2009, 11)
   (A) $3 \times 10^6 \, ms^{-1}$ (B) $3 \times 10^8 \, ms^{-1}$ (C) $3 \times 10^9 \, ms^{-1}$ (D) $3 \times 10^{10} \, ms^{-1}$

8. Which one is in the order of decreasing frequency?   (Mirpur 2014, Grw 2011)
   (A) X-rays, radio waves, infrared rays   (B) Ultraviolet rays, visible light, radio waves
   (C) Infrared rays, visible light, x-rays   (D) Yellow, green, red

9. The net reactance of a circuit is zero. The circuit may consist of   (Rwp 2015, Swl 2014, Grw 2010)
   (A) An inductor only   (B) A capacitor only   (C) Both inductor and capacitor   (D) None of these

10. Which one of the following requires a material medium for their propagation?   (Lhr 2015, Grw 2013 G I)
    (A) Heat waves   (B) X–rays   (C) Sound waves   (D) Ultraviolet rays

11. The range of F.M transmission frequencies is from:-   (Grw 2017, Rwp 2017, Mtn 2016 Group I, D.G.Khan 2016 Group I)
    (A) 540 KHz to 1600 Khz   (B) 88 KHz to 108 KHz   (C) 88MHz to 108 MHz   (D) 540 MHz to 1600 MHz

12. High frequency radio wave is called as:-   (Lhr 2018, Mtn 2016 Group II)
    (A) Fluctuative wave   (B) Carrier wave   (C) Matter wave   (D) Mechanical wave

13. Electromagnetic waves emitted from radio antenna are: (Mirpur 2014, Sgd 2011, Rwp 2015)
    (A) Stationary   (B) Longitudnal   (C) Transverse   (D) Both A & B

14. Electrons vibrating 94.000 times each second will produce radio waves of frequency   (Rwp 2016)
    (A) 94 Hz   (B) 940Hz   (C) 940KHz   (D) 94KHz

15. In frequency modulation, which factor is changed?   (Rwp 2018)
    (A) Amplitude of carrier waves   (B) Frequency of carrier wave
    (C) Amplitude f signal   (D) Frequency of signal

16. A changing electric flux creates   (Mtn 2015, D.G.Khan 2016 Group II)
    (A) Electric field   (B) gravitational field   (C) magnetic field   (D) electric charge

ANSWER KEY'S

1.	D	2.	A	3.	C	4.	B	5.	D	6.	B	7.	B	8.	B	9.	C	10.	C
11.	C	12.	B	13.	C	14.	A	15.	A	16.	C								

IMPORTANT SHORT QUESTIONS FOR BOARD EXAMS

1. Where two properties of RLC series circuit.   (Fsd 2015)

Ans. Properties of the series resonance circuit:

(i) The resonance frequency is given by

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

(ii) The impedance of the circuit at resonance is resistive so the current and voltage are in phase and the power factor is $\cos\theta$ is 1.

(iii) The impedance of the circuit is minimum at resonance frequency and it is equal to R.

(iv) If the amplitude of the source voltage V_o is constant, the current is a maximum at the resonance frequency and its value is V_o/R. The variation of current with the frequency is shown in figure.

(v) At resonance, V_L the voltage drop across inductance and V_c the voltage drop across capacitance may be much larger than the source voltage.

2. Show that $\frac{L}{R}$ has the unit of time (sec).

Ans. As $\varepsilon = L\frac{\Delta I}{\Delta t}$

$\Rightarrow \quad L = \frac{\varepsilon \Delta t}{\Delta I}$

So SI unit of L is $\frac{Vs}{A}$

And $\quad R = \frac{V}{I}$

So unit of R is $\frac{V}{A}$

Hence Unit of $\frac{L}{R}$ becomes

$$\frac{L}{R} = \frac{Vs/A}{V/A}$$

$$= \frac{VsA}{AV}$$

$$= s$$

3. What is the average value of alternating voltage over a complete cycle?

Ans. The average value of alternating voltage over a complete cycle is zero

$$<V> = \frac{V_o + (-V_o)}{2} = 0$$
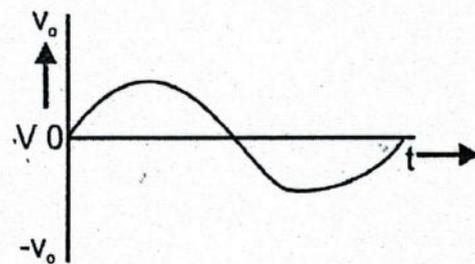
4. What do mean by root mean square value of voltage?

Ans. The root mean square value it is the effective value of A.C. It produces the same heating effect in a resistor as produces by same amount of d.c.

The root mean square value (effective value) is obtained by taking the square root of $\frac{V_o^2}{2}$, therefore

$$V_{rms} = \sqrt{\frac{V_0^2}{2}} = \frac{V_o}{\sqrt{2}} = 0.707V_o,$$

Similarly $\qquad I_{rms} = 0.707I_o$

5. Show that resonance frequency is given as $\qquad f_r = \frac{1}{2\pi\sqrt{LC}}$

Ans. Resonacne frequency

As condition for resonance is given by $\quad X_L = X_c$

where $X_L = \omega L$ and $X_c = \frac{1}{\omega c}$.

Thus

$$\omega_r L = \frac{1}{\omega_r c},$$

or

$$\omega_r^2 = \frac{1}{LC},$$

$$\omega_r = \frac{1}{\sqrt{LC}}, \qquad \text{but } \omega_r = 2\pi f_r$$

Thus

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

Or

$$f_r = \frac{1}{2\pi\sqrt{LC}} \qquad \text{Hence proved}$$

---

6. **Give some properties of electromagnetic waves?**

Ans. Some properties of em waves are as follows

Properties

(i) They are produced by oscillating electric and magnetic fields.

(ii) They don't required any medium for their propagation.

(iii) They travel in vacuum with speed $3 \times 10^8 \text{ ms}^{-1}$ (i.e. speed of light)

(iv) The formula for speed of electromagnetic wave is $c = f\lambda$

❀ ❀ ❀ ❀ ❀

FORMULAE

1	Relation between frequency and time period of AC	$f = \dfrac{1}{T}$	$f \times T = 1$	
2	Instantaneous value of AC voltage	$V = V_o \sin \dfrac{2\pi}{T} t$	$V = V_o \sin \omega t$	$V = V_o \sin 2\pi f t$
3	Instantaneous value of AC current	$I = I_o \sin \dfrac{2\pi}{T} t$	$I = I_o \sin \omega t$	$I = I_o \sin 2\pi f t$
4	Root mean square value of AC voltage	$V_{rms} = \dfrac{V_o}{\sqrt{2}}$	$V_{rms} = 0.707 V_o$	
5	Root mean square value of AC current	$I_{rms} = \dfrac{I_o}{\sqrt{2}}$	$I_{rms} = 0.707 I_o$	
6	Instantaneous power in pure resistive circuit	$P = VI$	$P = I^2 R$	$P = \dfrac{V^2}{R}$
7	Charge on capacitor on any instant	$q = CV$	$q = CV_o \sin \omega t$	
8	Reactance of a capacitor	$X_C = \dfrac{V_{rms}}{I_{rms}}$	$X_C = \dfrac{1}{\omega C}$	$X_C = \dfrac{1}{2\pi f C}$
9	Reactance of an inductor	$X_L = \dfrac{V_{rms}}{I_{rms}}$	$X_L = \omega L$	$X_L = 2\pi f L$
10	Impedance	$Z = \dfrac{V_{rms}}{I_{rms}}$		
11	Impedance of RC-circuit	$Z = \sqrt{R^2 + X_C^2}$	$Z = \sqrt{R^2 + \left(\dfrac{1}{\omega C}\right)^2}$	$Z = \sqrt{R^2 + \left(\dfrac{1}{2\pi f C}\right)^2}$
12	Impedance of RL-circuit	$Z = \sqrt{R^2 + X_L^2}$	$Z = \sqrt{R^2 + (\omega L)^2}$	$Z = \sqrt{R^2 + (2\pi f L)^2}$
13	Phase difference (θ) between voltage and current for RC-circuit	$\theta = \tan^{-1}\dfrac{X_C}{R}$	$\theta = \tan^{-1}\dfrac{1}{\omega CR}$	$\theta = \tan^{-1}\dfrac{1}{2\pi f CR}$

14	Phase difference (θ) between voltage and current for RL-circuit	$\theta = \tan^{-1}\dfrac{X_L}{R}$	$\theta = \tan^{-1}\dfrac{\omega L}{R}$	$\theta = \tan^{-1}\dfrac{2\pi f L}{R}$
15	Power in AC circuits, when current and voltage are in phase	$P = V_{rms} I_{rms}$		
16	Power dissipated in AC circuits	$P = V_{rms} I_{rms} \cos\theta$		
17	Resonance frequency in RLC-series AC-circuit	$\omega_r = \dfrac{1}{\sqrt{LC}}$	$f_r = \dfrac{1}{2\pi\sqrt{LC}}$	
18	Resonance frequency in LC-parallel AC-circuit	$\omega_r = \dfrac{1}{\sqrt{LC}}$	$f_r = \dfrac{1}{2\pi\sqrt{LC}}$	

UNITS

1	Reactance	VA^{-1}	Ω	
2	Impedance	VA^{-1}	Ω	

SOLVED EXAMPLES

Example 16.1:

An A.C. voltmeter reads 250 V. What is its peak and instantaneous values if the frequency of alternating voltage is 50 Hz?

Given data:

rms value of alternating voltage = V_{rms} = 250 V

Frequency of alternating voltage = f = 50 Hz

To find:

(i) Peak value of alternating voltage = V_o = ?

(ii) Instantaneous value of alternating voltage = V = ?

Calculations:

(i) Using the relation

$$V_{rms} = \frac{V_o}{\sqrt{2}}$$

or $V_o = \sqrt{2} V_{rms}$

Putting the values, we get

$V_o = 1.414 \times 250$

$$\boxed{V_0 = 353.5 \text{ V}}$$

(ii) For instantaneous value of alternating voltage using the relation

$$V = V_0 \sin \omega t$$

or $\quad V = V_0 \sin(2\pi f)t \qquad$ As $\omega = 2\pi f$

Putting the values, we get

$$V = (353.5) \sin 2\pi(50)t$$

$$\boxed{V = 353.5 \sin(100\pi t)\text{V}}$$

Example 16.2:

A 100 μF capacitor is connected to an alternating voltage of 24 V and frequency 50 Hz. Calculate:

(a) The reactance of the capacitor, and

(b) The current in the circuit

Given data:

Capacitance of capacitor = C = 100 μF = 100×10^{-6} F

Alternating voltage = V = 24 V

Frequency = f = 5 Hz

To find:

(a) Reactance of capacitor = X_C = ?

(b) Current in the circuit = I = ?

Calculations:

(a) The reactance of the capacitor is given by

$$X_C = \frac{1}{\omega C}$$

or $\quad X_C = \dfrac{1}{2\pi f C}$

Putting the values, we get

$$X_C = \frac{1}{2 \times 3.14 \times 50 \times 100 \times 10^{-6}}$$

$$X_C = \frac{1000}{31.4}$$

$$\boxed{X_C = 31.8 \ \Omega}$$

(b) Now using the relation

$$X_C = \frac{V}{I}$$

or $\quad I = \dfrac{V}{X_C}$

Putting the values, we get

$$I = \frac{24}{31.8}$$

$$\boxed{I = 0.75 \text{ A}}$$

Example 16.3:

When 10 V are *applied* to an A.C. circuit, the current flowing in it is 100 mA. Find its impedance.

Given data:

rms value of applied voltage = V = 10V

rms value of current = I = 100 mA = 100×10^{-3} A

To find:

Impedance = Z = ?

Calculations:

Using the relation

$$Z = \frac{V}{I}$$

Putting the values, we get

$$Z = \frac{10}{100 \times 10^{-3}}$$

$$\boxed{Z = 100 \; \Omega}$$

Example 16.4:

At what frequency will an inductor of 1.0 H have a reactance of 500 Ω?

Given data:

Inductance = L = 1.0 H

Reactance = X_L = 500 Ω

To find:

Frequency = f = ?

Calculations:

Using the relation

$$X_L = \omega L$$

or $X_L = (2\pi f)L$ As $\omega = 2\pi f$

or $f = \dfrac{X_L}{2\pi L}$

Putting the values, we get

$$f = \frac{500}{2 \times 3.14 \times 1}$$

$$\boxed{f = 80 \; Hz}$$

Example 16.5:

An iron core coil of 2.0 H and 50 Ω is placed in series with a resistance of 450 Ω. An A.C. supply of 100 V, 50 Hz is connected across the circuit. Find (i) the current flowing in the coil, (ii) phase angle between the current and voltage.

Given data:

Resistance = R = 50 Ω + 450 Ω = 500 Ω

(As resistance are connected in series)

Inductance = L = 2.0 H

Supply voltage = V = 100 V

Frequency = f = 50 Hz

To find:

(i)   Current in the coil = I = ?

(ii)   Phase angle = θ = ?

Calculations:

(i)   Using the relation

$$I = \frac{V}{Z} \qquad \text{......(1)}$$

But $Z = \sqrt{R^2 + (\omega L)^2}$

or $\quad Z = \sqrt{R^2 + (2\pi fL)^2}$

Putting the values, we get

$$Z = \sqrt{(500)^2 + (2 \times 3.14 \times 50 \times 2)^2}$$

$$Z = \sqrt{(500)^2 + (628)^2}$$

$$Z = 803 \ \Omega$$

Putting the values in equation (1), we get

$$I = \frac{100}{803}$$

$$I = 0.1245 \ A$$

or $\quad \boxed{I = 124.5 \ mA}$

(ii)   To find phase angle between the current and voltage using the relation

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

or $\quad \theta = \tan^{-1}\left(\frac{2\pi fL}{R}\right)$

Putting values, we get

$$\theta = \tan^{-1}\left(\frac{2 \times 3.14 \times 50 \times 2}{500}\right)$$

$$\theta = \tan^{-1}\left(\frac{628}{500}\right) = \tan^{-1}(1.256)$$

$$\boxed{\theta = 51.5^\circ}$$

Example 16.6:

A circuit consists of a capacitor of 2 µF and a resistance of 1000 Ω connected in series. An alternating voltage of 12 V and frequency 50 Hz is applied. Find (i) the current in the circuit, and (ii) the average power supplied.

Given data:

Capacitance = C = 2µF = 2×10^{-6} F
Resistance = R = 1000 Ω
Alternating voltage = V = 12V
Frequency = f = 50 Hz

To find:

(i)   Current in circuit = I = ?
(ii)   Average power supplied = P = ?

Calculations:

(i)   As we know

$$I = \frac{V}{Z} \qquad \ldots\ldots(1)$$

and   Z = Impedance = $\sqrt{R^2 + (X_c)^2}$

where $X_c = \dfrac{1}{\omega C}$

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2 \times 3.14 \times 50 \times 2 \times 10^{-6}}$$

$$X_c = 1592 \ \Omega$$

Thus

$$Z = \sqrt{(1000)^2 + (1592)^2}$$

$$Z = 1880 \ \Omega$$

Putting the values in equation (1), we get

$$I = \frac{12}{1880}$$

$$I = 0.0064 \ A = 6.4 \times 10^{-3} \ A$$

or $\boxed{I = 6.4 \ mA}$

(ii)   As phase difference is

$$\theta = \tan^{-1}\left(\frac{X_c}{R}\right)$$

$$\theta = \tan^{-1}\left(\frac{1592}{1000}\right)$$

$$\theta = \tan^{-1}(1.592)$$

$$\theta = 57.87°$$

Now, the average power is

$$P_{av} = VI \cos\theta$$

Putting the values, we get

$$P_{av} = 12 \times 0.0064 \times \cos 57.87°$$

$$P_{av} = 12 \times 0.0064 \times \cos 57.87°$$

$$P_{av} = 12 \times 0.0064 \times 0.532$$

$$\boxed{P_{av} = 0.04 \ W}$$

Example 16.7:

Find the capacitance required to construct a resonance circuit of frequency 1000 kHz with an inductor of 5 mH.

Given data:

Resonance frequency = f_r = 1000 KHz = 1000×10^3 Hz = 10^6 Hz

Inductance = L = 5 mH = 5×10^{-3} H

To find:

Capacitance = C = ?

Calculations:

Using the relation

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

Squaring both sides, we get

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

or
$$C = \frac{1}{4\pi^2 L f_r^2}$$

Putting the values, we get

$$C = \frac{1}{4 \times (3.14)^2 \times 5 \times 10^{-3} \times (10^6)^2}$$

$$C = \frac{1}{4 \times 9.86 \times 5 \times 10^{-3} \times 10^{12}}$$

$$C = 5.09 \times 10^{-12} \text{ F}$$

or $\boxed{C = 5.09 \text{ pF}}$

SHORT QUESTIONS OF THE EXERCISE

Write the short answer to the following questions:

16.1 A sinusoidal current has rms value of 10A. What is the maximum or peak value?

(Bwp 2014, Rwp 2015, Grw 2008, Lhr 2008,09, 14)

Ans. **Data**

$$I_{rms} = 10A$$
$$I_o = ?$$

Solution

$$I_{rms} = \frac{I_o}{\sqrt{2}}$$

OR

$$I_o = \sqrt{2} \, I_{rms}$$
$$I_o = \sqrt{2} \times 10$$
$$I_o = 14.14 \text{ A}$$

16.2 Name the device that will (a) permit of direct current but oppose the flow the alternating current (b) permit flow of alternating current but not the direct current.

(Grw 2018, Lhr 2018 G II, Bwp 2015, Mtn 2013)

Ans. a) The device that permits flow of direct current but opposes the flow of alternating current is _inductor._

$$X_L = 2\pi f L$$

For D.C $f = 0$ so $X_L = 0$ hence I is maximum

(b) The device that permits flow of A.C but apposes blocks the D.C is _capacitor._

$$X_C = \frac{1}{2\pi f C}$$

For D.C $f = 0$ so X_L become infinite hence I is zero.

16.3 How many times per second will an incandescent lamp reach maximum brilliance when connected to a 50 Hz source? (Mtn 2015, Grw 2008, 10, 12, Lhr 2009,10)

Ans. It reaches maximum brilliance _100_ times per second,

Reason

The lamp shows maximum brilliance when A.C reaches its peak value. As, A.C reaches its peak value (+ve and –ve) twice a cycle.

Therefore, A.C reaches its peak value in one second = 2 ×50 = 100 times / second.

Hence lamp reaches maximum brilliance 100 times per sec.

16.4	A circuit contains and iron-cored inductor, a switch and a D.C source arranged in series. The switch is closed and after an interval reopened. Explain why a spark jumps across the switch contacts?

Ans. **Reason**

When switch is reopened, the current in the circuit decreases form its maximum value to zero, this changing current produces an *emf* across the inductor which produces spark (heat and light) across the switch contacts.

16.5	How does doubling the frequency affect the reactance of (a) and inductor (b) a capacitor?
	(Grw 2015, Bwp 2016, Fsd 2011, Mirpur 2011)

Ans. (a) The reactance of inductor becomes *double.*

Explanation

As reactance of an inductor, $X_L = 2\pi fL$

If $f' = 2f$

Then $X_L' = 2\pi (2f) L$

$X_L' = 2(2\pi fL)$

$X_L' = 2X_L$

(b) The reactance of capacitor becomes *half.*

Explanation

As reactance of capacitor, $X_C = \dfrac{1}{2\pi fC}$

If $f' = 2f$, then

$X_C' = \dfrac{1}{2\pi(2f)C}$

$X_C' = \dfrac{1}{2} \left(\dfrac{1}{2\pi fC}\right)$

$$\boxed{X_C' = \dfrac{1}{2}X_C}$$

16.6	In a R-L circuit, will the current lag or lead the voltage? Illustrate your answer by a vector diagram.
	(Lhr 2014, Bwp 2018, DG khan 2017 G II)

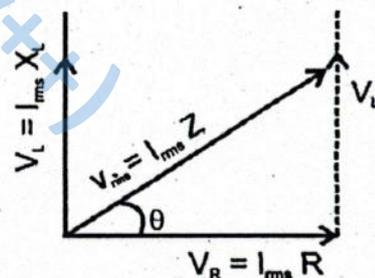**Ans.** In R-L- circuit the *current lags the voltage.*

Illustration

Consider the vector diagram of RL-circuit. It is clear from diagram that voltage lags the current by θ which is given by

$\theta = \tan^{-1}\left(\dfrac{V_L}{V_R}\right)$

$\theta = \tan^{-1}\left(\dfrac{I_{rms} X_L}{I_{rms} R}\right)$

$\theta = \tan^{-1}\left(\dfrac{X_L}{R}\right)$

16.7 A choke oil placed in series with an electric lamp in an A.C circuit causes the lamp to become dim. Why is it so? A variable capacitor added in series in this circuit may be adjusted until the lamp glows with normal brilliance. Explain, how this is possible?

Ans. **Why lamp becomes dim?**

(a) When the choke coil is connected in series with an electric lamp in L.C circuit, the impedance Z of circuit is increased,

$$Z=\sqrt{X_L^2+R^2}$$

so

$$I=\frac{V}{Z}$$

Therefore, the current is _reduced_. Hence the lamp becomes dim.

How glows with normal brilliance?

As reactances of capacitor (X_C) and inductor (X_L) **oppose** each other. Thus when the variable capacitor is connected in series with inductor and adjusted until $X_C = X_L$. Under this condition, they cancel each other's effect. So impedance becomes _minimum_ and current becomes maximum. Thus lamp glows with normal brilliance.

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

and $$I=\frac{V}{R}$$
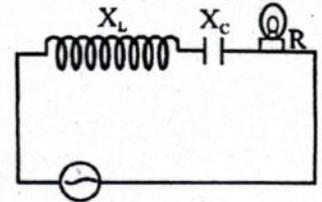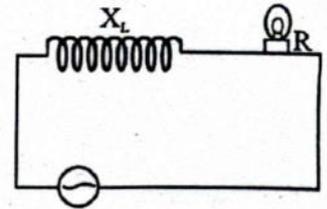
16.8 Explain the conditions under which electromagnetic was are produced form a source?

(Bwp 2009, 2015, Grw 2010, 15, Rwp 2009)

Ans. Electromagnetic waves are generated, when electric or magnetic flux is changing through a certain region of space. This is possible only when electrical charges are _accelerated_ by A.C source.

For example when electrons in the radio transmitting antenna vibrate, it produces a changing magnetic flux. This changing flux sets up electromagnetic waves which propagate in space away from antenna.

Transmitting antenna
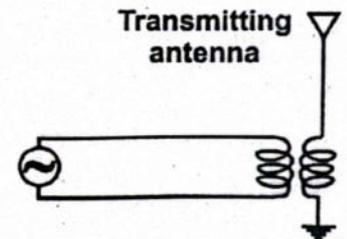
16.9 How the reception of a particular radio station is selected on your radio set?

(Grw 2009, Lhr 2011, Bwp 2008,09, DG khan 2009)

Ans. **Reception of a radio station**

A particular radio station is selected on our radio set by adjusting the natural frequency of LC-circuit (in our radio set) _equal_ to the frequency of particular transmitting station. This is done by adjusting the value of Capacitance or inductance which is given by

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Under this condition **resonance** is produced. The impedance of circuit is minimum and current is maximum. Hence a particular station is picked up.
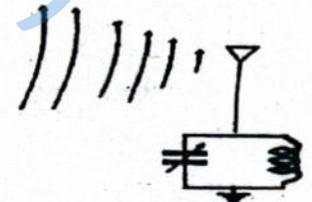
Ans. **Amplitude Modulation**

It is that type of modulation in which the **amplitude** of carrier wave is increased or decreased as the amplitude of superposing modulating signal increases or d...

Frequency Modulation
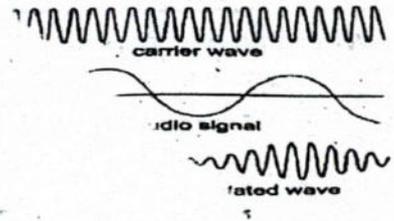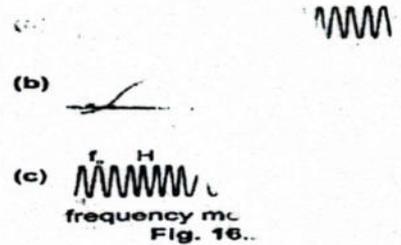
It is that type of modulation in which **frequency** of carrier wave is increased or decreased as the amplitude of superposing modulating signal increases or decreases but the amplitude of carrier wave remains constant.

(b)

(c) frequency m...
Fig. 16...

Exercise Problems

16.1 An alternating current is represented by the equation $I = 20 \sin 100\pi t$. Compute its frequency and the maximum and rms values of current.

Given data:

Alternating current $= I = 20 \sin 100\pi t$

To find:

(i) Frequency $= f = ?$

(ii) Maximum value of current $= I_o = ?$

(iii) rms value of current $= I_{rms} = ?$

Calculations:

(i) As instantaneous value of current is

$$I = I_o \sin 2\pi f t$$

or $I = I_o \sin 2 f \pi t$ ......(1)

and given values is

$$I = 20 \sin 100\pi t$$ ......(2)

Comparing eq. (1) and (2), we get

$$2f\pi t = 100\pi t$$

or $2f = 100$

	or	$f = 50 \text{ Hz}$
(ii)	Again comparing, we get
		$I_o = 20 \text{ A}$

(iii)   Now $I_{rms} = 0.7 \, I_o$

Putting the value of I_o, we get

$$I_{rms} = 0.7 \times 20$$

$$\boxed{I_{rms} = 14 \text{ A}}$$

16.2   **A sinusoidal A.C. has a maximum value of 15A. What are its rms values? If the time is recorded from the instant the current is zero and is becoming positive, what is the instantaneous value of the current after 1/300 s, given the frequency is 50 Hz.**

Given data:

Maximum (peak) value of current = I_o = 15A

Time = $t = \dfrac{1}{300}$ (sec)

Frequency = f = 50 Hz

To find:

(i)   rms value of current = I_{rms} = ?

(ii)   Instantaneous current = I = ?

Calculations:

(i)   As $I_{rms} = 0.707 \, I_o$

Putting the value of I_o, we get

$$I_{rms} = 0.707 \times 15$$

$$\boxed{I_{rms} = 10.6 \text{ A}}$$

(ii)   Now instantaneous value of current is

$$I = I_o \sin 2\pi ft$$

Putting the values, we get

$$I = 15 \times \sin 2\pi \times 50 \times \frac{1}{300}$$

$$I = 15 \times \sin \frac{\pi}{3}$$

$$I = 15 \times \sin 60^\circ$$

$$I = 15 \times 0.866$$

$$\boxed{I = 12.9 \text{ A}}$$

$$I \approx 13 \text{A}$$

16.3   **Find the value of the current and inductive reactance when A.C. voltage of 220 V at 50 Hz is passed through an inductor of 10 H.**

Given data:

A.C. Voltage = V = 220 V

Frequency = f = 50 Hz

Inductance = L = 10 H

To find:

(i)   Inductive reactance = X_L = ?

(ii)   Current = I = ?

Calculations:

(i)   As reactance is given by

$$X_L = \omega L \qquad (\because \omega = 2\pi f)$$
$$X_L = 2\pi f L$$

Putting the values, we get

$$X_L = 2 \times 3.14 \times 50 \times 10$$
$$\boxed{X_L = 3140 \ \Omega}$$

(ii)   Now as according to ohm's law

$$V = I X_L$$
$$\text{or} \quad I = \frac{V}{X_L}$$

Putting the values, we get

$$I = \frac{220}{3140}$$
$$\boxed{I = 0.07 \ A}$$

16.4   A circuit has an inductance of $1/\pi$ H and resistance of 2000 Ω. A 50 Hz A.C. is supplied to it. Calculate the reactance and impedance offered by the circuit.

Given data:

$$\text{Inductance} = L = \frac{1}{\pi} H$$
$$\text{Resistance} = R = 200 \ \Omega$$
$$\text{Frequency} = f = 50 \ H$$
$$\text{Voltage} = V = 220 \ V$$

To find:

(i).   Reactance = X_L = ?

(ii)   Impedance = Z = ?

Calculations:

(i)   For reactance

$$X_L = \omega L$$
$$\text{or} \quad X_L = 2\pi f L$$

Putting the values, we get

$$X_L = 2 \times \pi \times 50 \times \frac{1}{\pi}$$
$$\boxed{X_L = 100 \ \Omega}$$

(ii)   Now for impedance

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

Putting the values, we get

$$Z = \sqrt{(100)^2 + (2000)^2}$$
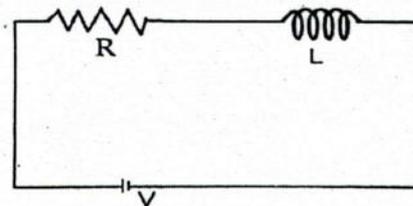$$= \sqrt{10000 + 4000000}$$
$$\boxed{Z = 2002.5 \ \Omega}$$

16.5 An inductor of pure inductance $3/\pi$ H is connected in series with a resistance of 40 Ω. Find (i) the peak value of the current (ii) the rms value, and (iii) the phase difference between the current and the applied voltage $V = 350 \sin(100\pi t)$.

Given data:

Inductance $= L = \dfrac{3}{\pi}$ H

Resistance $= R = 40\ \Omega$

Voltage $= V = 350 \sin(100\ \pi t)$

To find:

(i) Peak value of current $= I_o = ?$

(ii) rms value of current $= I_{rms} = ?$

(iii) Phase difference $= \theta = ?$

Calculations:

As

$$V = V_o \sin(2\pi ft)\ ......(1)$$

and given

$$V = 350 \sin(100\ \pi t)\qquad ......(2)$$

Comparing eq. (1) and (2), we get

$$V_o = 350 \text{ volts}$$

and

$$2f\pi t = 100\pi t$$
$$2f = 100$$
$$f = 50 \text{ Hz}$$

Now for impedance

$$Z = \sqrt{(R)^2 + (X_L)^2}$$
$$Z = \sqrt{(R)^2 + (\omega L)^2}$$
$$Z = \sqrt{(R)^2 + (2\pi fL)^2}$$

Putting the values, we get

$$Z = \sqrt{(40)^2 + \left(2\pi \times 50 \times \dfrac{3}{\pi}\right)^2}$$

$$Z = \sqrt{(40)^2 + (300)^2}$$
$$Z = \sqrt{1600 + 90000}$$
$$Z = 302.65\ \Omega$$

(i) Peak value of current, $I_o = \dfrac{V_o}{Z}$

Putting the values, we get

$$I_o = \frac{350}{302 \cdot 65}$$

$$\boxed{I_o = 1.16 \text{ A}}$$

(ii) Now I_{rms} is given by the formula

$$I_{rms} = 0.7 \, I_o$$

Putting the value of I_o, we get

$$I_{rms} = 0.7 \times 1.16$$

$$\boxed{I_{rms} = 0.81 \text{ A}}$$

(iii) Now phase difference is

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$\theta = \tan^{-1}\left(\frac{2\pi f L}{R}\right)$$

$$\theta = \tan^{-1}\left(\frac{2\pi \times 50 \times 3/\pi}{40}\right)$$

$$\theta = \tan^{-1}\left(\frac{300}{40}\right)$$

$$\theta = \tan^{-1}(7.5)$$

$$\boxed{\theta = 82.4^\circ}$$

16.6 A 10 mH, 20 Ω coil is connected across 240 V and 180/π Hz source. How much power does it dissipate?

Given data:

Inductance = L = 10 mH = 10×10^{-3} H

Resistance = R = 20 Ω

Voltage = V_{rms} = 240 V

Frequency = $f = \dfrac{180}{\pi}$ Hz

To find:

Power = P = ?

Calculations:

As $P = V_{rms} I_{rms}, \cos\theta$

First we have to calculate I_{rms} and θ

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

Where $X_L = \omega L$

$X_L = 2\pi f L$

$X_L = 2\pi \times \dfrac{180}{\pi} \times 10 \times 10^{-3}$

$X_L = 3.6$ Ω

Now $Z = \sqrt{(20)^2 + (3.6)^2}$

$$Z = \sqrt{400 + 12.96}$$
$$Z = \sqrt{412.96}$$
$$Z = 20.32\,\Omega$$

Thus, rms value of current is

$$I_{rms} = \frac{V_{rms}}{Z}$$

Putting the values, we get

$$I_{rms} = \frac{240}{20.32}$$
$$I_{rms} = 11.81\,A$$

In R-L series circuit

$$\theta = \tan^{-1}\left(\frac{X_L}{R}\right)$$
$$= \tan^{-1}\left(\frac{3.6}{20.3}\right)$$
$$= 10.2°$$

Now power dissipation is

$$P = V_{rms} \times I_{rms} \cos\theta$$

Putting the values, we get

$$P = 240 \times 11.81 \cos 10.2°$$
$$= 240 \times 11.81 \times 0.98$$
$$\boxed{P = 2778\ W}$$

16.7 Find the value of the current flowing through a capacitance 0.5 µF when connected to a source of 150 V at 50 Hz.

Given data:

Capacitance = C = 0.5 µF = 0.5×10^{-6} F

Voltage = V = 150 V

Frequency = f = 50 Hz

To find:

Current = I = ?

Calculations:

First we have to calculate the value of X_C

$$\text{As} \quad X_C = \frac{1}{\omega C}$$

$$\text{or} \quad X_C = \frac{1}{2\pi f C}$$

$$X_C = \frac{1}{2 \times 3.14 \times 50 \times 0.5 \times 10^{-6}}$$

$$X_C = \frac{10^6}{157}$$

$$X_C = 6369\,\Omega$$

Now

$$I = I_{rms} = \frac{V}{X_C}$$

Putting values, we get

$$I = \frac{150}{6369} \text{ A}$$
$$I = 0.0235$$
$$\boxed{I = 0.024 \text{ A}}$$

16.8 An alternating source of emf 12 V and frequency 50 Hz is applied to a capacitor of capacitance 3 μF in series with a resistor of resistance 1kΩ. Calculate the phase angle.

Given data:

Voltage = V = 12 volts

Frequency = f = 50 Hz

Capacitance = C = 3 μF = 3×10^{-6} F

Resistance = R = 1kΩ = 1×10^{3} Ω

To find:

Phase angle = θ = ?

Calculations:

$$\text{Phase angle} = \theta = \tan^{-1}\left(\frac{X_C}{R}\right)$$

and

$$X_C = \frac{1}{\omega c}$$
$$X_C = \frac{1}{2\pi f c}$$

Putting the values, we get

$$X_C = \frac{1}{2 \times 3.14 \times 50 \times 3 \times 10^{-6}}$$
$$X_C = 1060.89 \, \Omega$$

So $\theta = \tan^{-1}\left(\dfrac{X_C}{R}\right)$ becomes

$$\theta = \tan^{-1}\left(\frac{1060.89}{1 \times 10^{3}}\right)$$
$$\theta = \tan^{-1}(1.06)$$
$$\boxed{\theta = 46.7°}$$

16.9 What is the resonant frequency of a circuit which includes a coil of inductance 2.5 H and a capacitance 40 μF?

Given data:

Inductance = L = 2.5 H

Capacitance C = 40 μF = 40×10^{-6} F

To find:

Frequency = f_r = ?

Calculations:

As $f_r = \dfrac{1}{2\pi\sqrt{LC}}$

Putting the values, we get

$$f_r = \dfrac{1}{2\times 3.14\sqrt{2.5\times 40\times 10^{-6}}}$$

$$= \dfrac{1}{6.28\sqrt{100\times 10^{-6}}}$$

$$= \dfrac{10^3}{6.28\times\sqrt{10^{-4}}}$$

$$= \dfrac{1}{62.8\times 10^{-2}}$$

$$= \dfrac{100}{62.8}$$

$$\boxed{f_r = 15.9\ Hz}$$

16.10 An inductor of inductance 150 μH is connected in parallel with a variable capacitor whose capacitance can be changed from 500 pF to 20 pF. Calculate the maximum frequency and minimum frequency for which the circuit can be tuned.

Given data:

Inductance = L = 150 μH = 150×10^{-6} H

Maximum capacitance = C_{max} = 500 pF = 500×10^{-12} F

Minimum capacitance = C_{min} = 20 pF = 20×10^{-12} F

To find:

(i) Maximum frequency = f_{max} = ?

(ii) Minimum frequency = f_{min} = ?

Calculations:

As relation between frequency and capacitance is

$$f = \dfrac{1}{2\pi\sqrt{LC}}$$

Which shows that frequency and capacitance are inversely proportional, so frequency will be minimum when capacitance will be max. and vice versa.

(i) $f_{max} = \dfrac{1}{2\pi\sqrt{LC_{min}}}$

Putting the values, we get

$$f_{max} = \dfrac{1}{2\times 3.14\sqrt{150\times 10^{-6}\times 20\times 10^{-12}}}$$

$$f_{max} = \dfrac{1}{6.28\sqrt{150\times 20\times 10^{-18}}}$$

$$f_{max} = \dfrac{1}{6.28\sqrt{3000\times 10^{-18}}}$$

$$f_{max} = \frac{1}{6.28 \times 54.77 \times 10^{-9}}$$

$$f_{max} = 2.907 \times 10^6 \, Hz$$

$$\boxed{f_{max} = 2.91 \, MHz}$$

(ii)   Now

$$f_{min} = \frac{1}{2\pi\sqrt{LC_{max}}}$$

Putting the values, we get

$$f_{min} = \frac{1}{2 \times 3.14\sqrt{150 \times 10^{-6} \times 500 \times 10^{-12}}}$$

$$f_{min} = \frac{1}{6.28\sqrt{75000 \times 10^{-18}}}$$

$$f_{min} = \frac{1}{6.28 \times 273.86 \times 10^{-9}}$$

$$f_{min} = 0.58 \times 10^6 \, Hz$$

$$\boxed{f_{min} = 0.58 \, MHz}$$

MCQ's From Past Board Papers

1. In RLC series circuit $X_L = X_C$, which of following will be power factor
    (a) Zero   (b) 1   (c) 1 / 2   (d) Infinite

2. The value $\frac{R}{Z}$ is equal to

    (a) $\sin\theta$ (b) $\cos\theta$ (c) $\tan\theta$ (d) $\cot\theta$

3. The RLC series circuit at resonance frequency energy is dissipated across
    (a) R   (b) R and L   (c) R and C   (d) R, L and C

4. In an A.C circuit current leads voltage by phase $\pi/2$ then circuit is
    (a) Capacitive   (b) inductive   (c) Resistive   (d) RLC series

5. The A.C voltage is 210V, then its P − P value is

    (a) 420   (b) $420\sqrt{2}V$ (c) $\frac{420}{\sqrt{2}V}$ (d) $210\sqrt{2}V$

6. Dimensions of RC matches with that of
    (a) RL   (b) R/L   (c) L/C   (d) L/R

7. If E and B vectors of electromagnetic waves then propagation of wave is along
    (a) E   (b) B   (c) E x B   (d) None

8. In metal detector presence of metal near search coil B   Then
    (a) $L_A < L_B$ (b) $L_A > L_B$ (c) $L_A = L_B$ (d) None

9. Which of following electromagnetic waves has shortest wave length
    (a) Microwaves   (b) Ultra violet Waves   (c) Infrared   (d) Radio waves

10. An alternating voltage has peak value 14.14 V its rms value is
    (a) 20V   (b) 15V   (c) 12V   (d) 10V

IMPORTANT PREVIOUS BOARDS SHORT QUESTIONS

1. Define choke and write its advantage in A.C. circuits. *(Lhr GI 2018)*

2. A sinusoidal current has rms value of one example. *(Lhr GI 2018)*

3. In R-C series circuit, will the current lag or lead the voltage. Illustrate your answer by a vector diagram. *(Lhr GII 2018)*

4. Define A.C. current. Draw its waveform. *(Lhr GII 2018)*

5. Describe some advantages of a 3 - Phase A.C Supply. *(Bwp GI 2018) (Lhr GI 2018)*

6. Find the Capacitance required to construct a resonance circuit of frequency 1000 kHz with an inductor of 5 mH. *(Bwp GI 2018)*

7. How does doubling the frequency affect the reactance of: (a) An Inductor (b) A capacitor
(Rwp 2018) (Azad Kashmir 2018) (Sgd GII 2018) (Grw 2018) (D.G.Khan GII 2018) (Lhr GII 2018) (Bwp GII 2018)

8. What is meant by A.M. and F.M.? *(Mtn GI 2018) (Bwp GII 2018) (D.G.Khan GI 2018)*

9. Define Choke and Impedance. *(Bwp GII 2018)*

10. A sinusoidal current has rms value of 10A. What is the maximum or peak value?
(Rwp 2018) (Sgd GI 2018) (D.G.Khan GI 2018)

11. Define choke and electromagnetic waves. *(D.G.Khan GI 2018)*

12. An alternating current is represented by equation $I = 20 \sin 100\pi t$. Compare its frequency and rms value of current. *(D.G.Khan GII 2018)*

13. What do you mean by phase lag and phase lead? *(Fsd 2018) (Azad Kashmir 2018)*

14. Show that potential difference across LC is zero at resonating frequency in series LRC series circuit. *(Fsd 2018)*

15. Name the device that will:

    (a) permit the flow of direct current but oppose the flow of alternating current

    (b) permit the flow of alternating current but not direct current. *(Lhr GII 2018) (Fsd 2018)*

16. An A.C. voltmeter reads 250 V. What is its peak value? *(Grw 2018)*

17. A 100 μF capacitor is connected to an alternating voltage of 24 V and frequency 50 Hz. Calculate the current in the circuit. *(Grw 2018)*

18. Find the frequency of a inductor of 1.0 H having a reactance of 500Ω. *(Mtn GI 2018) (Mtn GII 2018)*

19. How many times per second will an incandescent lamp reach maximum brilliance when connected to a 50Hz source? *(Mtn GI 2018)*

20. Define Alternating current and Choke. *(Sgd GI 2018)*

21. Define impedance and resonant frequency, also write their formula. *(Sgd GII 2018) (Mtn GII 2018)*

22. How the reception of a particular radio station is selected on your radio set. *(Sgd GII 2018)*

23. Differentiate between peak value and peak to peak value. *(Swl 2018)*

24. What is meant by inductive and capacitive reactance? *(Swl 2018)*

25. A *circuit contains* an iron-cored inductor, a switch and a D.C source arranged in series. The switch is closed and after an interval reopened. Explain why a spark jumps across the switch contacts? *(Bwp GI 2018) (Swl 2018)*

26. Write two properties of *parallel resonance* circuit. *(Rwp 2018)*

27. Define impedance, draw impedance diagram or R-L series circuit. *(Azad Kashmir 2018)*

Q1. Define modulation, electromagnetic waves and in a R-L series circuit. Will the current lag or lead the voltage? Illustrate your answer by a vector diagram. **(D.G.Khan GI 2018) (Lhr GI 2018)**

Q2. Define impedance. Derive an expression for impedance and phase angle in R-C and R-L series circuit excited by A.C. voltage. **(Lhr GII 2018)**

Q3. A 10mH, 20Ω coil is connected across 240V and 180π Hz source. How much power does it dissipate? **(Bwp GI 2018)**

Q4. Explain the working of Series Resonance Circuit. Write down its any four properties. **(Bwp GII 2018)**

Q5. A 10 mH, 20Ω is connected across 240 V and $\frac{3}{\pi}$ Hz source. How much power does it dissipate? **(Bwp GII 2018)**

Q6. Draw the circuit diagram for R-L-C series resonating circuit. Discuss the behavior of this circuit for A.C and also write down its properties. **(D.G.Khan GII 2018)**

Q7. Find the value of the current and inductive reactance when AC voltage of 220V at *50Hz is* passed through an inductor of 10H. **(Fsd 2018)**

Q8. What is the resonant frequency of a circuit which includes a coil of inductance 2.5 H and a capacitance 40μ F? **(Mtn GI 2018) (Rwp 2018)**

Q9. Describe an R - L - C series circuit. Draw its impedance diagram and derive expression for its resonance frequency. Also write down its two properties. **(Mtn GII 2018) (Grw 2018)**

Q10. *Find the value of* current flowing through a capacitance 0.5 μF when connected to a source of 150 V at 50 Hz. **(Sgd GII 2018) (Azad Kashmir 2018)**

Q11. Define Choke. Explain R - C series circuits. **(Swl 2018)**

Q12. Write down the brief procedure to study the relation between current and capacitance when different capacitors are used in A.C circuit. **(Mtn GI 2018)**