Chapter = 16

ALTERNATING CURRENT

Alternating Current: "Such a current whose polarity keeps on reversing with time is called alternating current".
Why AC is widely used? It is widely used because it can be transmitted to long distance easily and at a very low rate.
Main common source of AC voltage: AC generator is most common source of AC voltage
Time period of AC: The time interval T during which the voltage source change its polarity once is called time period
Frequency of AC: The number of cycles completed in one second is called frequency of AC. f=1/T SI unit of frequency is Hz. The frequency of AC in Pakistan is 50 Hz.
Instantaneous value of AC: The value of AC current or voltage that exists in circuit at any instant of time t is called instantaneous value. $V = V_o \sin(2\pi ft)$.
Peak value of AC: The highest value reached by the voltage or current in one cycle is called peak value.
Peak to peak value: Sum of positive and negative peak values is called p-p value p-p value of voltage is 2Vo.
Root mean square (RMS) value: The effective value of AC over complete cycle **OR** square root of average values of V^2 and I^2 is called rms value.

$$V^2{}_{rms} = \frac{0^2 + V_o{}^2}{2} \Rightarrow V^2{}_{rms} = \frac{V_o{}^2}{2} \Rightarrow V_{rms} = \frac{V_o}{\sqrt{2}} \Rightarrow V_{rms} = 0.707V_o$$

$$I^2{}_{rms} = \frac{0^2 + I_o{}^2}{2} \Rightarrow I^2{}_{rms} = \frac{I_o{}^2}{2} \Rightarrow I_{rms} = \frac{I_o}{\sqrt{2}} \Rightarrow I_{rms} = 0.707I_o$$

Most of the meters measured Rms values of current and voltage. Average value of current or voltage over a cycle is zero.AC changes its polarity one time in one cycle.

Phase of AC: The angle which specifies the instantaneous value of alternating voltage or current is called phase. The formula for this $V = V_o \sin\theta = V_o \sin(\omega t)$.

Phase lag and phase lead: "The phase difference b/w two alternating quantities is called phase lag or phase lead".

Vector representation of Alternating quantity: Alternating voltage or current can be graphically represented by counter clock rotating vector and satisfies following conditions

1. Its length on scale show peak value of quantity
2. When the alternating quantity is zero, it is in horizontal position.
3. Angular frequency of rotating vector is same as angular frequency of alternating quantity.

What are the basic elements of AC& DC circuits?

Basic element of DC circuit: Resistor is the basic element of DC circuit.
Basic elements of AC circuit: There are three components of AC circuits.

i. Resistor R
ii. Inductor L
iii. Capacitor C

Multiple choice questions

1	A sinusoidal current has rms value of 10A, its maximum value	7.7A	10 A	**14.14A**	20A
2	The average value of AC over one period with peak value Vo is	$V_o/\sqrt{2}$	V_o	$\sqrt{2}Vo$	**Zero**
3	The rms value of AC supply is 220V its peak value Vo is	150V	**311V**	110V	440V
4	The frequency of AC in Pakistan is	30Hz	40Hz	**50Hz**	60Hz
5	The highest value reached by the voltage or current in one cycle is called	Peak to peak value	**Peak value**	Instantaneous value	Root mean square value
6	If Io is the peak value of an AC supply then rms value is given as Irms=?	**$Io/\sqrt{2}$**	Io/0.707	$\sqrt{2}\,Io$	Io/2
7	The basic circuit element in AC circuit which controls the current	Resistor only	Capacitor only	Inductor only	**All of these**
8	If Vrms=$10\sqrt{2}$ V the peak value Vo=?	10 V	**20V**	40V	$10/\sqrt{2}$
9	The peak value of AC source is 20A, then rms value will be	**14.2 A**	10 A	20 A	28.2 A
1	The phase of AC at positive	**π/2**	π/3	2π	Π

0	peak from origin				
11	AC changes its polarity in once cycle	**<u>Once</u>**	Twice	Thrice	Four time
12	All voltmeters and ammeters measures	**<u>Rms value</u>**	Peak value	Average value	None
13	Main reason for the worldwide use of Ac is that it can be transmitted to	Short distance at very low cost	Long distance at very high cost	Short distance at very high cost	**<u>Long distance at very low cost</u>**
14	Peak to peak value of an alternating voltage is	0	Vo	Vo/2	**<u>2Vo</u>**
15	An AC varies as a function of	Displace ment	Current	Voltage	**<u>Time</u>**
16	The peak value of alternating current is $5\sqrt{2}$ A. the mean square value of current will	**<u>5A</u>**	2.5A	25 A	$10\sqrt{2}$ A
17	The device which permit flow of DC but not AC	**<u>Inductor</u>**	Capacitor	Both A&B	None
18	The sum of positive and negative peak values of ac	**<u>P-P value</u>**	Peak value	Rms value	Instantan eous value
19	Most common source of AC voltage is	**<u>Ac generat or</u>**	Motor	Transfor mer	Battery

AC through Resistor

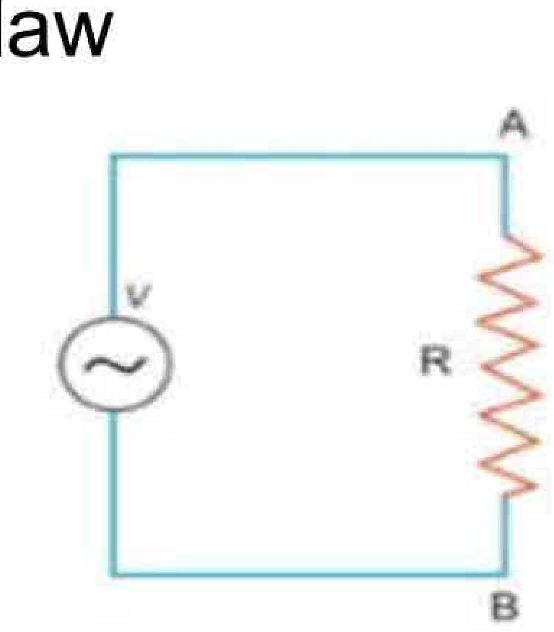
Consider a resistor of resistance R connected with an alternating voltage source as shown in fig.

<u>Instantaneous voltage</u>: At any instant of time the potential difference across the terminals

Of resistors is given by $V=V_o\sin\omega t$ where V_O is the peak value of alternating voltage

<u>Instantaneous current:</u> This is given by the relation by using Ohm's law

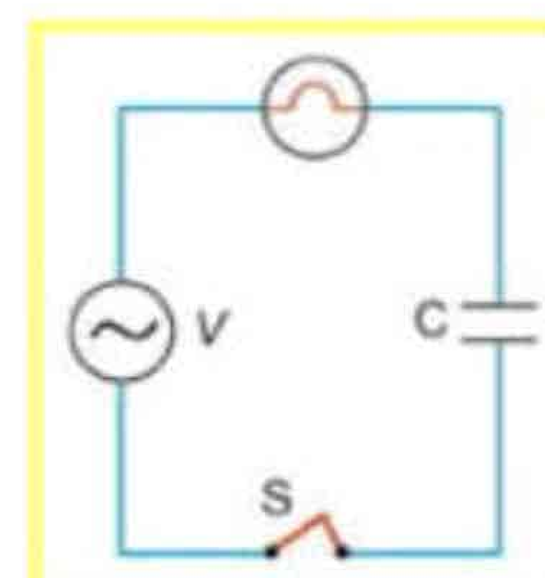
$$I=\frac{V}{R}=\frac{V_o\sin\omega i}{R}=I_o\sin\omega in \quad \text{As} \quad I_o=\frac{V_o}{R},\ I_o=\text{peak value of current},$$



Resistance: The measure of opposition of to flow of current is called resistance, R=V/I, its unit is ohm.
Electrical power: The electrical power supplied by the source or power dissipated in resistor is given as
$P=VI=(IR)I=I^2R$ or $P=V^2/R$. SI unit power is watt.

Explain the behavior of AC through capacitor?

Let us consider a capacitor of capacitance C is connected in series with voltage source, alternating current flows in circuit and plates are continuously charged and discharged.
Charge: At any instant of time charged stored in capacitor due to voltage V is q=CV
Also we know that $V=V_o\sin\omega t$, so charge $q=CV_o\sin\omega t$,
q and V are sine function and inn phase.
Electric current: As the rate off flow of charge is equal to current whihich is $I=\frac{\Delta q}{\Delta t}$.So at any instant the slope of q-t curve represent electric current.
When slope of q-t curve is maximum it means current is maximum across capacitor.
Phase: In AC through capacitor current is leading the voltage by 90° or π/2.
Reactance: The measure of opposition offered by capacitor to flow of AC is called reactance of capacitor.



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

$$Xc=\frac{V_{rms}}{CV_{rms}\omega}=\frac{1}{\omega C}$$

$$Xc=\frac{1}{2\pi\pi C}\Rightarrow Xc\propto\frac{1}{f}\text{, this is the relation of reactance, SI unit of reactance is ohm.}$$

Reactance depends upon **frequency**, when frequency is large reactance will be small and vice versa.

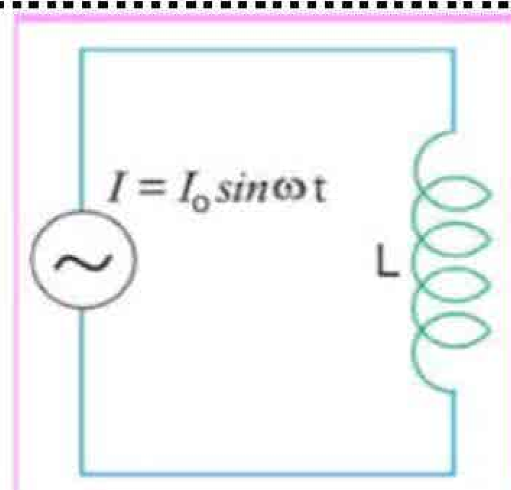
$$\therefore I=\frac{\Delta q}{\Delta t}=\frac{\Delta CV}{\Delta t}=\frac{\Delta CVo\sin\omega t}{\Delta t}=\frac{\Delta}{\Delta t}(CV_o\sin\omega t)=CV_o(\omega\cos\omega t)=CV_o\omega\quad\text{, as }\cos\omega t=1$$

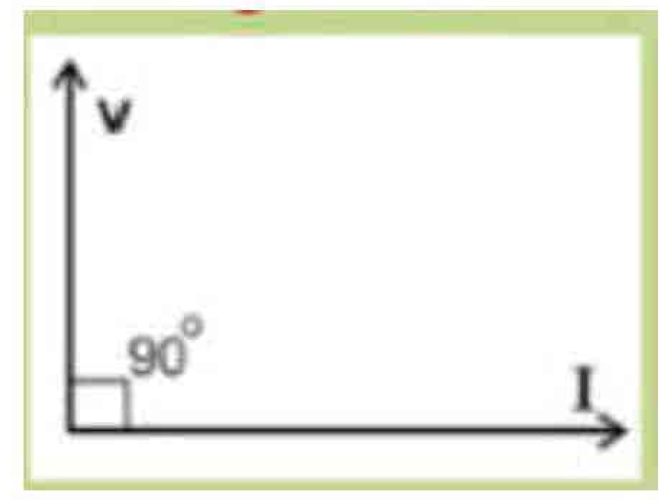
Explain the behavior of AC through Inductor?

"**A coil or solenoid wound form a thick wire having large of self-inductance and negligible resistance is called inductor**".
Flow of AC through inductor: Let us consider an inductor which is connected with alternating voltage source, As the self-inductance of coil oppose the change of current, so inductor must oppose the flow of AC which is continuously changing.
Electric current: current flowing through inductor is $I=I_o\sin\omega t=I_o\sin(2\pi f)t$.
Voltage: If L is the inductance of coil, the changing current setup a back emf in coil which is
$\varepsilon_L=L\frac{\Delta I}{\Delta t}$. To maintain the current,
Applied voltage must be equal to back emf so applied voltage $V=L\frac{\Delta I}{\Delta t}$, so $V\propto\frac{\Delta I}{\Delta t}$, thus slope of I-t curve at any instant of time gives the value of voltage. It means when slope of I-t curve is maximum V is maximum.

Phase: In AC through inductor voltage is leading the current by 90° or π/2.

Inductive Reactance: "The measure of opposition offered by inductance coil to flow of AC is called inductive reactance".





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

$$X_L = \frac{LI_{rms}\omega}{I_{rms}} = \omega L$$

$X_L = 2\pi f L \Rightarrow X_L \propto f$, this is the relation of reactance, SI unit of inductive reactance is ohm.

Inductive Reactance depends upon **frequency**, when frequency is large inductive reactance is large.

Power in inductor: No power is dissipated in inductor, so inductor does not consume energy.

$$\therefore V = L\frac{\Delta I}{\Delta t} = L\frac{\Delta I_o \sin\omega t}{\Delta t} = \frac{\Delta LI_o \sin\omega t}{\Delta t} = \frac{\Delta}{\Delta t}(LI_o \sin\omega t) = LI_o(\omega\cos\omega t) = LI_o\omega \quad \text{, as } \cos\omega t = 1$$

Multiple choice questions

1	In inductor the voltage	Leads the current 90°	**Lags current by 90°**	Is in phase with current	Changes independently
2	The net reactance of a dc circuit is zero the circuit may consist of	**An inductor only**	A capacitor only	Both inductor and capacitor	None of these
3	The phase angle between the voltage and current AC through a resistor is	**0**	45	180	270
4	Power dissipation in a pure inductive or in a pure capacitance circuit is	Infinite	**Zero**	Minimum	Maximum
5	A capacitor is perfect insulator for	AC	**DC**	Both A&B	None
6	In pure resistive AC circuit, instantaneous value of voltage or current	Current lags behind voltage	Current leads voltage by 90	**Both are in phase**	Voltage leads current by 90
7	At high frequency, the current through a capacitor of AC circuit will be	**Large**	Small	Infinite	Zero
8	The capacitive reactance to	Zero	**Infinite**	Variable	Equal to

9)	pure DC is				reactance
10)	If frequency of AC supply is doubled then reactance of capacitor is	**Half**	Two times	Four times	One fourth
11)	The inductive reactance is	X_L=Wc	**$X_L=\omega L$**	Xc=1/Wc	XL=1/WL
12)	The reactance of an inductor at 50Hz is 10Ω its reactance at 100Hz becomes	**20 ohm**	5 ohm	2.5 ohm	1 ohm
13)	In AC inductor behave like	Semiconductor	Inductors	Resistor	**Insulator**
14)	DC cannot flow through	Resistor	**Capacitor**	Inductor	Voltmeter
15)	Capacitive reactance Xc=?	X_L=Wc	X_L=WL	**Xc=1/Wc**	XL=1/WL
16)	In pure inductive AC circuit the current	**Lags behind voltage 90**	Lead the voltage by 90	In phase with voltage	Lead the voltage 270
17)	In pure capacitive circuit current and charge are	In phase	**Out of phase**	Parallel to each other	None
18)	X_L is low for low frequency but Xc is	Low	**High**	Zero	None
19)	Inductive reactance is directly proportional to	Frequency	Resistance	Inductance	**Both A&C**
20)	SI unit of reactance is	Joule	Ampere	Volt	**Ohm**
21)	At high frequency, the value of reactance of capacitor will	large	Infinite	Zero	**Small**
22)	In RL series circuit, phase angle is given by	$\theta = \tan^{-1}(\frac{L}{R})$	$\theta = \tan^{-1}(LR)$	$\theta = \tan^{-1}(R/L)$	**$\theta = \tan^{-1}(\frac{\omega L}{R})$**
23)	Slope of q-t curve at any instant of time give	Voltage	Charge	Resistance	Current

What is Impedance. Write its formula and unit.

<u>Definition</u>: "The combined effect of resistance and reactance's in AC circuit is called impedance". Its formula is $Z = \frac{V_{rms}}{I_{rms}}$. The unit of impedance is **ohm**.

<u>Admittance</u>: Reciprocal of impedance is called Admittance. Y=1/Z, unit of admittance is Ω^{-1}

Write a note on RC and RL Series Circuit.

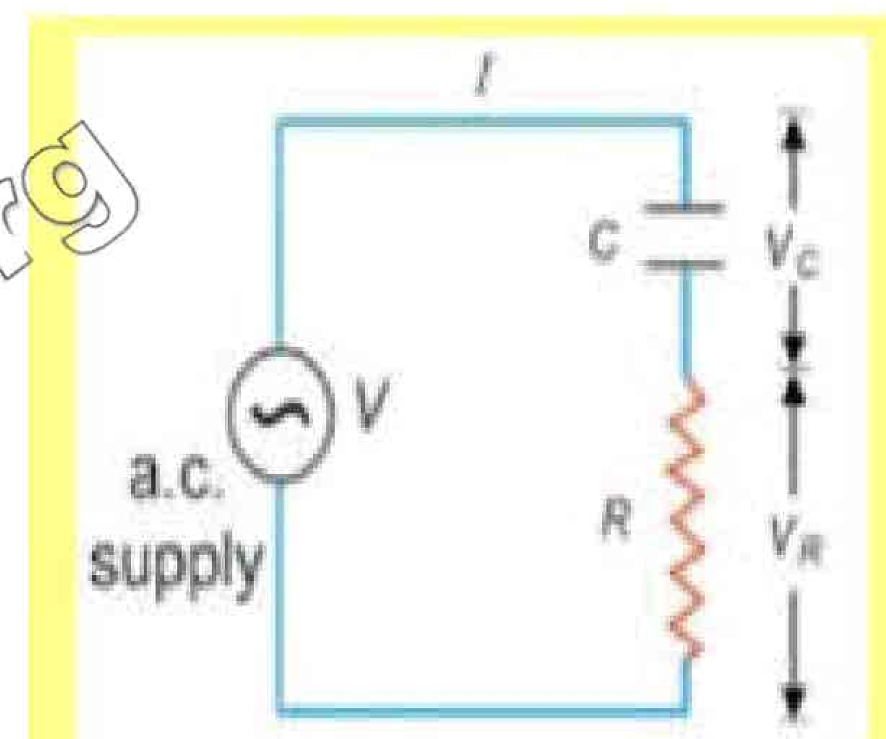
<u>RC series circuit</u>:"<u>A circuit in which resistor and a capacitor are connected in series combination across an alternating voltage is called RC series circuit</u>".
Consider a circuit in which resistor R and capacitor C in series with voltage source, if I is the value of current then potential difference across resistance is V_R=IR, but potential difference across the capacitor will be $V_c=IX_c$.
<u>Impedance</u>: Impedance can be calculated by using the formula

$$V_{rms} = \sqrt{V_R{}^2 + Vc^2} = \sqrt{(I_{rms}R)^2 + (\frac{I_{rms}}{\omega C})^2}$$

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

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

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

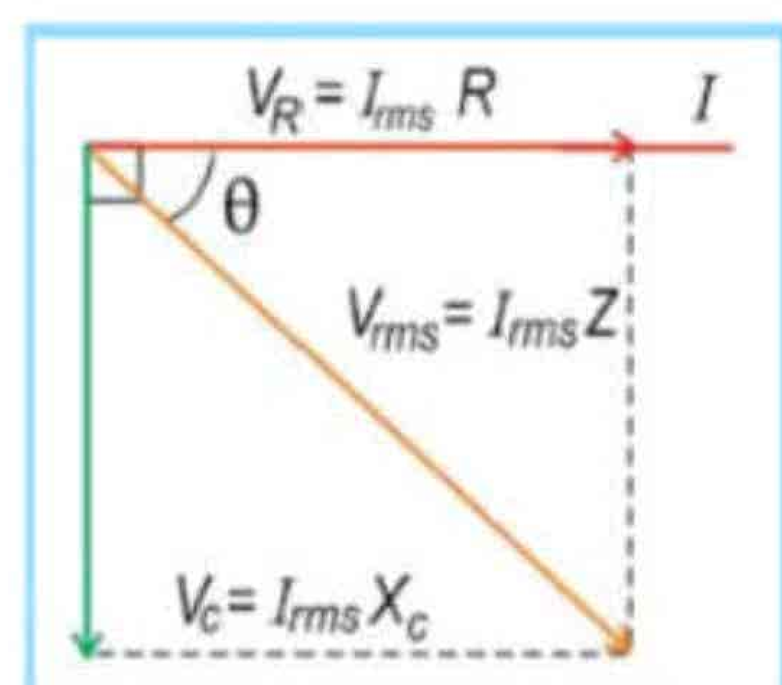


Which is required relation for the impedance of RC circuit as shown in fig.
<u>Phase</u>: voltage and current are not in phase, Current leads the applied voltage 90° or π/2.

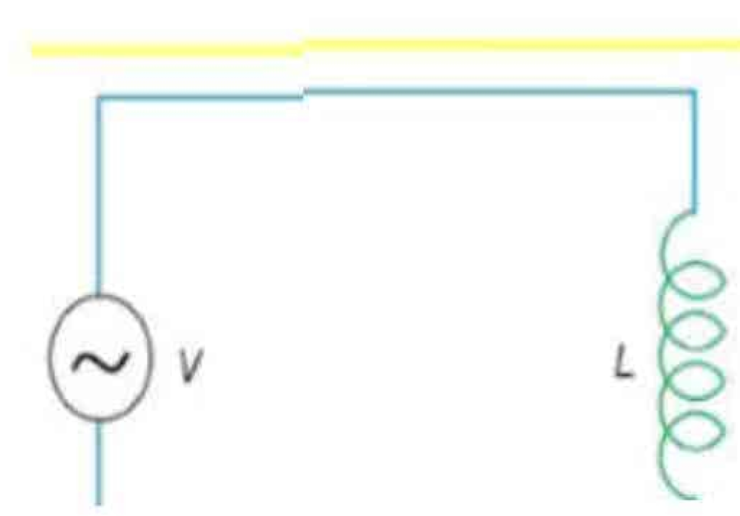
$$Tan\theta = \frac{Xc}{R}$$

$$\theta = Tan^{-1}\left(\frac{Xc}{R}\right) = Tan^{-1}\left(\frac{1/\omega C}{R}\right)$$

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



<u>RL series circuit</u>:"<u>A circuit in which resistor and an inductor are connected in series combination across an alternating voltage source is called RL series circuit</u>".
Consider a circuit in which resistor R and inductor L in series with voltage source, if I is the value of current then potential difference across resistance is V_R=IR, but potential difference across the capacitor will be $V_L=IX_L$.
<u>Impedance</u>: Impedance can be calculated by using the formula



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

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

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

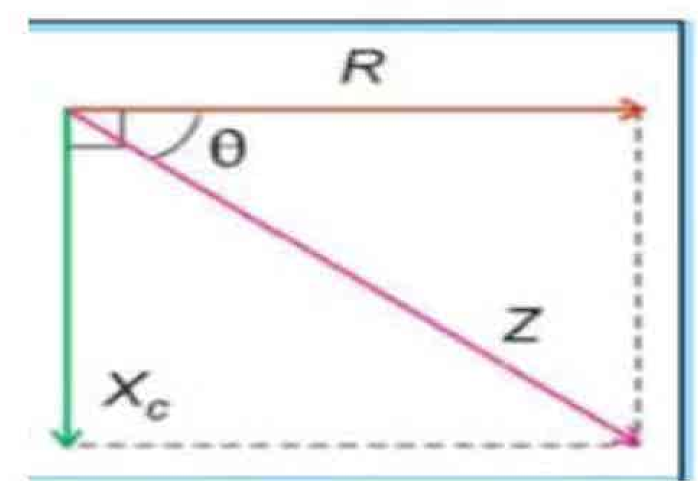
$$Z=\sqrt{(R)^2+(\omega L)^2}$$

Phase: voltage and current are not in phase, voltage leads the current by 90° or π/2.

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

$$\theta=Tan^{-1}\left(\frac{X_L}{R}\right)=Tan^{-1}\left(\frac{X_L}{R}\right)$$

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



What is Power in AC circuit?

Power in AC circuit: The formula for power $P=V_{rms}I_{rms}$, this relation is true when resistive the voltage V and current I are in phase. The power dissipation in pure inductive or in a pure capacitive circuit is zero, if the phase difference b/w applied voltage V and current I is Θ, so power dissipation in AC circuit is $P=V_{rms}I_{rms}Cos\Theta$, CosΘ is power factor.
For pure capacitor or inductor phase is Θ=90°, $P=V_{rms}I_{rms}Cos90°=0$
Power factor: The ratio of consumed power to applied power is called power factor.

What is Series Resonant circuit/RLC series circuit? Derive formula for resonance frequency and write its properties.

RLC/Series resonant circuit:"Such a circuit in resistor R, capacitor C and inductor L are connected in series with alternating voltage source is called RLC series or resonant circuit".

Explanation: Let us consider RLC series circuit connected with voltage source in which Resistance R, capacitive reactance Xc=1/ωC and inductive Reactance X_L=ωL. As X_L and Xc are opposite in direction.
At high frequency X_L>> Xc, so behave as RL circuit, at low frequency Xc >> X_L so behave as RC circuit.

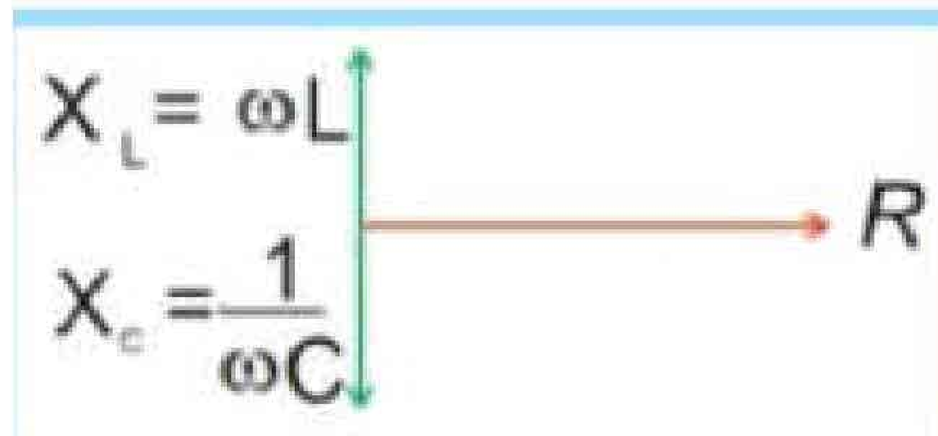
Resonance frequency: The frequency at $X_L=X_c$ across the circuit and maximum current flow through it called resonance frequency. Its formula is $f_r=\frac{1}{2\pi\sqrt{LC}}$.

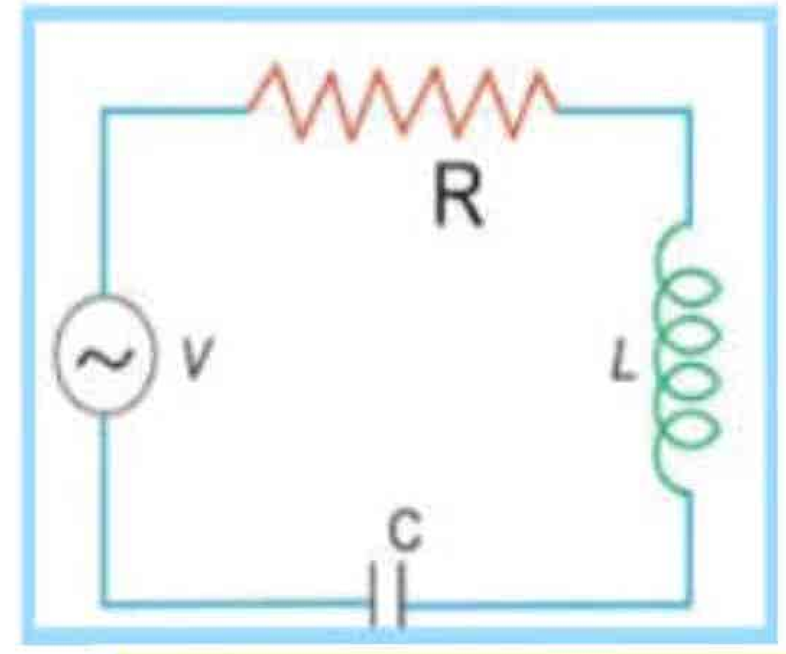
$X_L = X_c$

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

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

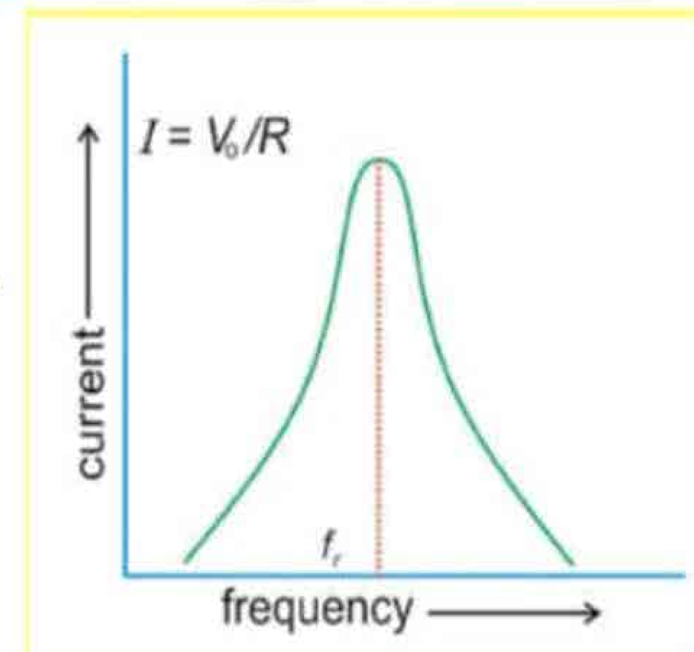
$\omega = \frac{1}{\sqrt{LC}}$ As $\omega = 2\pi f$





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

$f_r = \frac{1}{2\pi\sqrt{LC}}$, This is the formula for resonance frequency



Properties of Series Resonant circuit

1. The resonance frequency is given by $f_r = \frac{1}{2\pi\sqrt{LC}}$.
2. The impedance of circuit at resonance is resistive so voltage and current are in phase and power factor is 1.
3. The impedance of circuit is minimum at resonance and is equal to R.
4. If source voltage V_o is constant, the current is a maximum at resonance I=Vo/R.
5. At resonance, voltage drop across inductance and capacitance may be larger than source voltage.

It is called acceptor circuit because this circuit accept the maximum flow of current due to minimum impedance.

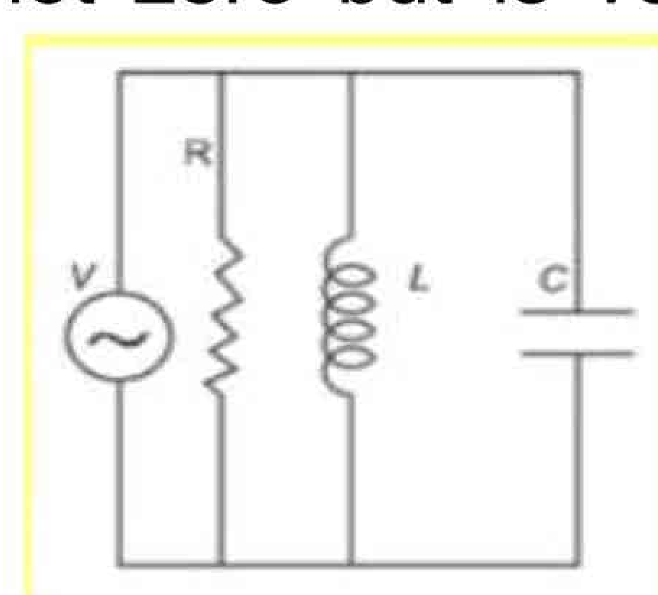
What is Parallel Resonance circuit/LC parallel circuit. Write its properties.

LC/parallel resonant circuit: "Such a circuit in which inductor is connected parallel with capacitor then it is called parallel resonant circuit".

Let us consider LC parallel circuit in which inductance coil L and negligible resistance r. at resonance frequency X_L=X_c

Current drawn from the source is zero. Practically current is not zero but is very small due to small resistance r of coil.

Properties of Parallel resonant circuit



1. The resonance frequency is given by $f_r = \frac{1}{2\pi\sqrt{LC}}$.
2. At resonance frequency the circuit impedance is maximum whose value is L/CR.
3. At resonance the current is minimum and in phase with applied voltage so power factor is one.
4. At resonance branch current I_L and Ic may be larger than the source current Ir.

It is called rejecter circuit because it rejects the maximum flow of current due to maximum impedance.

PRACTICE MCQS

1	The power dissipated in AC circuit is given by $P=I_{rms}V_{rms}\cos\Theta$, in relation $\cos\Theta$ is called	Phase factor	Gain factor	Loss factor	**Power factor**
2	Impedance Z can be expressed by	**$Z= V_{rms}/I_{rms}$**	$Z=V_{rms}I_{rms}$	Z=RI	None
3	In RLC series circuit the true condition for resonance takes place when	**$X_L=X_C$**	$X_L>X_C$	$X_L<X_C$	None of these
4	SI unit of impedance is	Henry	Hertz	Ampere	**Ohm**
5	In RLC series circuit the current at resonance frequency will	Minimum	Zero	**Maximum**	Infinite
6	The formula for resonance frequency is fr=	$\frac{1}{T}$	**$\frac{1}{2\pi\sqrt{LC}}$**	$\frac{1}{2\pi\sqrt{C}}$	None of these
7	At resonance RLC series circuit shows the behavior of	**Pure resistive**	Pure inductive circuit	Pure capacitive circuit	Pure RLC circuit
8	The impedance of RC series AC circuit is given by Z=?	$\sqrt{R^2-(wC)^2}$	$R^2+(wC)^2$	$\sqrt{R^2+(wC)^2}$	**$\sqrt{R^2+(\frac{1}{wC})^2}$**
9	The total reactance of a series RLC circuit at resonance is	**Equal to R**	Zero	Infinity	1
10	At higher frequencies, which of the following plays a dominant role in RLC	Resistor	**Inductor**	Capacitor	Transistor

	series circuit				
11	At resonance frequency, the impedance of RLC series circuit is	Zero	**Minimum**	Maximum	Moderate
12	The impedance of RLC series circuit at resonance is given as	$\sqrt{R^2+(X_L-Xc)^2}$	$\sqrt{R^2+X_L^2}$	**Z=R**	$\sqrt{R^2+X_c^2}$
13	Power factor of an AC series circuit is	Always greater than one	Always less than one	**Always equal to one**	Zero
14	EM waves have frequency of range of	10^4 Hz	10^5 Hz	**10^6 Hz**	10^2 Hz
15	Resistance of choke is	Zero	**Very small**	Large	Infinite
16	At resonance the value of current in RLC series circuit is equal to	**Vo/R**	VoR	I/2	Zero
17	Which one is most energetic	**Gamma rays**	X-rays	UV rays	Visible light
18	In tunning a circuit if capacitance is doubled and inductance is halved then frequency	Doubled	Halved	**Remain same**	Increase 4 times
19	Reciprocal of impedance is called	Resistance	Deflection	**admittance**	Coherence
20	The unit of $\sqrt{LC}$ is	**Second**	Ampere	Hertz	Farad
21	With increase in frequency of an AC supply, the impedance of RLC series circuit	Decrease	Increase	Remains same	**1st decrease becomes min than increase**

22	The unit of ωL/R in RLC series circuit is	Ohm	Volt	Henry	**Unitless**
23	When 10V are applied to AC circuit, current flowing in it 100 mA, its impedance	10 ohm	1000 ohm	**100 ohm**	1 ohm
24	In AC circuit, R is connected in series with inductance L, if the Phase angle b/w voltage and current is 45, inductive reactance will be	R/2	2R	**R**	R/4
25	The capacitance required to construct a resonance circuit of frequency 1000 KHz with inductor 5mH is	**5.09PF**	5.09μF	5.09mF	5.09KF
26	In RL series circuit the phase angle is	$\underline{\theta = Tan^{-1}\left(\frac{\omega L}{R}\right)}$	$\theta = Tan^{-1}\left(\frac{\omega}{R}\right)$	$\theta = Tan^{-1}\left(\frac{1}{\omega CR}\right)$	None
27	The dimension of L/R is	**[T]**	[ML]	[LT]	None
28	At resonance, the behavior of RLC series circuit is	**Resistive**	Capacitive	Inductive	All of these

What is Three phase AC supply? Write is construction and working with advantages.

Three phase AC supply: “In In three phase AC generator therethere are three coils inclined at 120° to each other, , eaeach connected to its own pair of slip p rings and three alternating voltages are generateerated across its own pair of slip rings s when coil rotate in field”.
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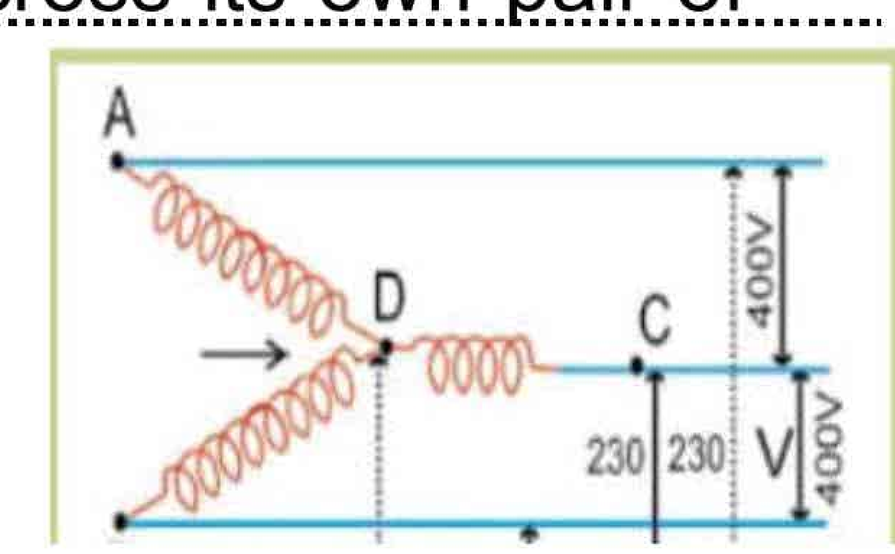


Advantages of Three phase AC supply: There are following advantages

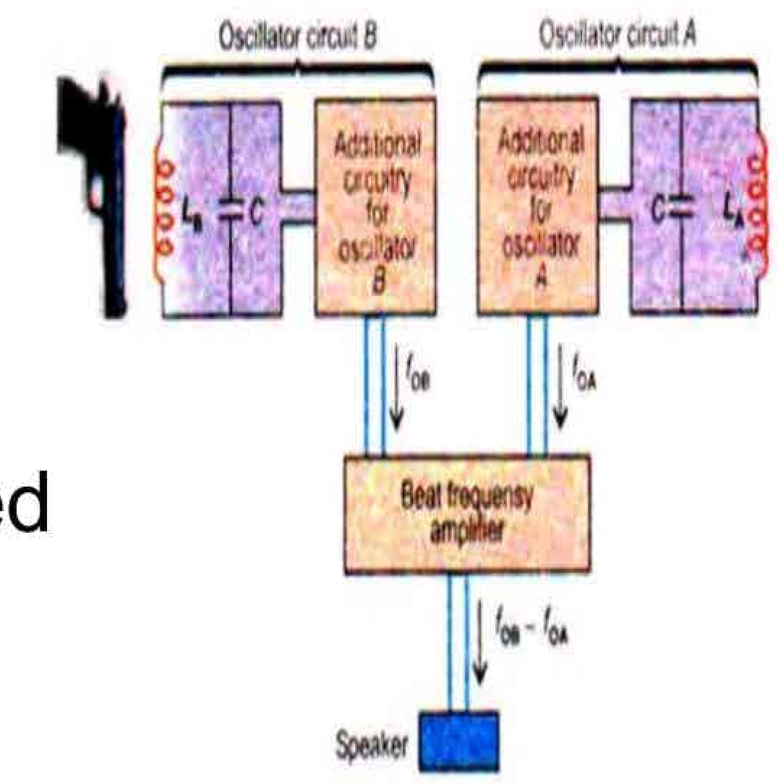
i. Total load is divided into three parts and none of line is overloaded.
ii. Some special devices operate at 400 V so this supply provides 400V to those Devices.

What is Principle of Metal detector and uses.

Metal detector: Metal detector consists of two oscillators A and B having inductances L_A and L_B, the inductances varies in the presence of metal that change the frequency of oscillator, the difference of frequencies creates beat notes which can be heard with help of speaker that tells about the presence of metal. This is shown in figure below.

Uses of metal detector: There are following uses of metal detector

i. The detectors are used at security checks
ii. They are used to detect buried metal objects.



What is Choke? Write its uses.

Choke: Such a coil which consists of thick copper wire wound Closely in Large no of turns over soft iron laminated core is called Choke. Its inductance is very large and R is very small.

Uses: It is used to control or limits the current with very small Wastage of energy.

Explain Principle, Generation, Transmission And Reception Of Electromagnetic Waves

Electromagnetic waves: "The waves which require no medium for transmission and rapidly propagate through vacuum are called electromagnetic waves".

Maxwell equations: In 1864 James Clark Maxwell formulated a set of equations which explained the various electromagnetic phenomenons are called Maxwell equations.

- According to Maxwell equation, a changing magnetic flux creates electric field and changing electric flux produces magnetic field. It means each field generates the other fields and both the fields' moves in a direction of its propagation through space and waves produced are called electromagnetic field.
- Speed of EM waves is equal to speed of light in vacuum $3*10^8$ m/s.
- EM waves are periodic. EM spectrum starts from low frequency Radio waves and end on high frequency Gamma rays.

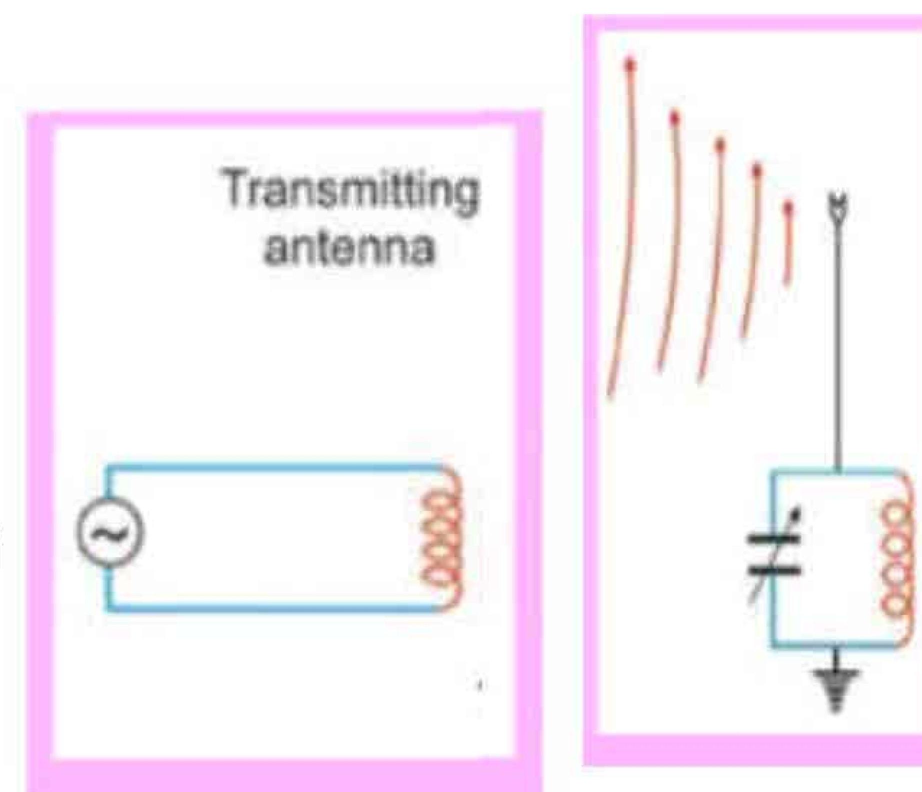
Principle: According to Maxwell equation, a changing magnetic flux creates electric field and changing electric flux produces magnetic field. It means each field generates the other fields and both the fields' moves in a direction of its propagation through space and waves produced are called electromagnetic field.

Generation: The electromagnetic waves are generated when electric or magnetic flux is changing through a region of space, it means when we accelerate the electrical charges radiate electromagnetic waves.

Transmission: The piece of wire along the charges is made to accelerate is called transmitting antenna. A radio transmitting antenna is a good example of generating the electromagnetic waves by accelerating charges. It is charged by alternating source of potential V frequency f, the frequency with which the field alternate is always equal to the frequency of source generating them in free space with the speed of light.

Reception: The voltage of one particular frequency can be picked up by connecting an inductor L and variable capacitor C in parallel with one end of receiving antenna as shown in fig. In order to pick the required signal capacitance of capacitor is so adjusted that natural frequency of LC circuit is same as that of required transmitting station. At this frequency the circuit will resonate under the driving action of antenna. So, LC circuit will build up a large response to radio waves to which it is tuned.

What is Modulation and carrier wave?



Modulation: The process of combining the low frequency Signal with a high frequency is called modulation.

Carrier wave: The high frequency radio wave in modulation Is Called carrier wave.

Modulation signal: Low frequency signal in modulation is Called modulation signal.

What is Difference b/w A.M and F.M?

Amplitude modulation (A.M)	**Frequency modulation (F.M)**
In this type of modulation, the amplitude of the carrier wave is increased or decreased as the amplitude of the superposing modulating signal increases or decreases	In this type of modulation, the frequency of the carrier wave is increased or decreased as the amplitude of the superposing modulating signal increases or decreases. But the carrier wave amplitude remains constant.
The range of A.M is **540 KHz to 1600 KHz**	The range of F.M is **88 MHz to 108 MHz**
Advantage of A.Mis better to transmit the signal for large range.	F.M are less affected by electrical interference then A.M and it provide higher quality transmission of sound
Disadvantage of A.Mhave low quality transmission of sound	They are less able to travel around obstacles such as hills and high building.

Multiple choice questions

1	Pure choke consumes	Minimum power	Maximum power	**No power**	Average power

2	In a choke of inductance L and resistance R	**L is large and R is small**	L is small and R is large	Both L and R are large	Both L and R are small
3	Power dissipated in pure inductor and pure capacitor is	Large	Small	Infinite	**Zero**
4	In three phase AC supply the phase difference between each pair of coil is	45°	**120°**	90°	180°
5	Electromagnetic waves emitted from an antenna are	**Transverse**	Longitudinal	Stationary	All of these
6	Three phase AC supply uses	No terminals	Two terminals	**Four terminals**	Six terminals
7	The velocity of an oscillating charge as it moves to and fro along wire is	**Changing**	Constant	Infinite	Zero
8	Metal detector consist of circuit	**LC**	RL	RC	RLC
9	Shake an electrically charged object to and fro and produce	Mechanical waves	Transverse waves	Longitudinal waves	**EM waves**
10	When electrons in the transmitting antenna vibrate 94000 times then produce radio wave of	94 Hz	940 KHz	**94 KHz**	94 MHz
11	Which one is in the order of increasing frequency?	X-rays,. Radio waves, infrared waves	UV rays, visible light , X-rays	Yellow, green, red	**Infrared rays, visible light, X-rays**
12	In three phase AC supply, phase difference between	45°	**240°**	90°	180°

	first and third coil is				
13	Resistance of choke is	Zero	**Very small**	Large	Infinite
14	The process of combining low frequency signal with high frequency radio wave is called as	**Modulation**	Amplification	Demodulation	Resonance
15	The range of A.M is	**540 KHz to 1600 KHz**	54 KHz to 1600 KHz	50 KHz to 1600 KHz	5 MHz to 1600 KHz
16	The range of F.M is	540 KHz to 1600 KHz	88 KHz to 108 KHz	50 KHz to 1600 KHz	**88 MHz to 108 MHz**

EXERCISE SHORT QUESTIONS

1. **A sinusoidal current has r.m.s value of 10A. What is the maximum or peak value?

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

$Irms = \frac{I_o}{\sqrt{2}}, \qquad I_o = \sqrt{2} I_{rms}$

$I_o = 1.41(10) = 14.14A$

maximum current $= 14.14$ A

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

a) An inductor (choke) is a device which permits flow of direct current but opposes the flow of alternating current

b) A capacitor is a device which permits flow of alternating current but not the direct current

3. ****How many times per second will an incandescent lamp reach maximum brilliance when connected to a 50 Hz source?**

It reaches the maximum brilliance 100 times per second.

The brilliance of the lamp will become maximum twice in one AC cycle because the current also becomes maximum two times in a cycle so

Maximum brilliance shown by lamp=2f=2*50=100 Hz

4. 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?

When switch is reopened, the current in circuit decreased from its maximum value to zero, this changing current produce an emf across the inductor which produce spark across the switch contacts.

5. How does doubling the frequency affect the reactance of (a) an inductor (b) a capacitor?**

a) The reactance of inductor becomes double

$X_L = \omega L = 2\pi f L$
$X'_L = 2\pi(2f)L$
$X'_L = 2(2\pi f L)$
$X'_L = 2X_L$

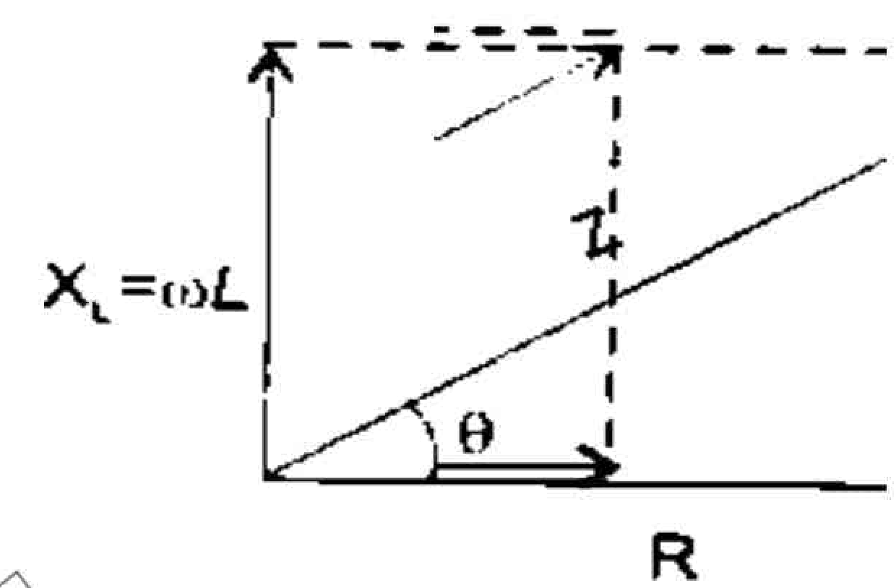
b)The reactance of capacitor becomes half

$Xc = \frac{1}{\omega C} = \frac{1}{2\pi f C}$
$X'_c = \frac{1}{2\pi(2f)C}$
$X'_c = \frac{1}{2}X_c$

6.In a R – L circuit, will the current lag or lend the voltage? Illustrate your answer by a vector diagram.**

In R-L circuit current lags the voltage by an angle θ

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



7. **A choke coil 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?**

a)When the choke coil is connected in series with an electric lamp in L.C circuit, the impedance Z of circuit is increased so current is reduce and lamp becomes dim.

b)At resonance X_L=Xc, impedance becomes minimum and current becomes maximum and lamp glows with normal brilliance.

8.** **Explain the conditions under which electromagnetic waves are produced from a source?**

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 AC source. For example when electrons in the radio transmitting antenna vibrate it produce changing flux which setup electromagnetic waves propagated in space from antenna.

9.How the reception of a particular radio station is selected on your radio set?**

A particular radio station can be selected on a radio set by tuning it. When the frequency of the LC oscillator in the radio set is equal to the frequency of the radio wave from a particular radio station, a resonance is produced. The current of this signal becomes maximum and can detected and amplified $f_r = \frac{1}{2\pi\sqrt{LC}}$.

10. What is meant by A.M. and F.M.?**

Amplitude modulation (A.M)

In this type of modulation, the amplitude of the carrier wave is increased or

Frequency modulation (F.M)

In this type of modulation, the frequency of the carrier wave is increased or

decreased as the amplitude of the superposing modulating signal increases or decreases	decreased as the amplitude of the superposing modulating signal increases or decreases. But the carrier wave amplitude remains constant.
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NUMERICALS

16.1: An alternating current is represented by the equation I=20sin100π t. Compute its frequency and the maximum and r.m.s values of current.

solution : Given Equation, $I = 20\text{Sin}100\pi\, t$ compare with general equation $I = I_o \text{Sin} 2\pi f\, t$

$I_o = 20A \quad 2\pi f = 100\pi \Rightarrow f = 50\text{Hz}, \quad I_{rms} = I_o/\sqrt{2} = 20/\sqrt{2} = 14A$

16.2: A sinusoidal A.C. has a maximum value of 15A. What are its r.m.s 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 1/300s, given the frequency is 50Hz.

Given Data : $I_o = 15A, t = 1/300\text{ sec}, f = 50\text{Hz}, I_{rms} = ?\; I = ?$

sol : $I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{15}{\sqrt{2}} = 10.6A \quad I = I_o \sin 2\pi f t = 15 \sin 2\pi(50)(1/300) = 15 \sin(\pi/3) = 12.96A$

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

Given Data : $V = 220V, f = 50\text{ Hz}, L = 10\text{ H}, I = ?\; X_L = ?$

$X_L = \omega L = 2\pi f L = 2 * 3.14 * 50 * 10 = 3140\text{ohm}, \quad I = \frac{V}{X_L} = \frac{220}{3140} = 0.07\text{ ampere}$

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

Given Data : $L = \frac{1}{\pi}H,\; R = 2000\,\Omega,\; f = 50\text{Hz}, X_L = ?\; Z = ?$

$X_L = \omega L = 2\pi f L = 2 * \pi * 50 * 1/\pi = 100\text{ ohm}$

$Z = \sqrt{R^2 + X_L{}^2} = \sqrt{2000^2 + 100^2} = 2002.5\text{ ohm}$

16.5: An inductor of 3/π H is connected in series with a resistance of 40Ω. Find (i) the peak value of the current (ii) the r.m.s value, and (iii) the phase difference between the current and the applied voltage V=350sin(100π t).

$$\text{Given Data}: L = 3/\pi\ H, R = 40\ \text{ohm}, V = 350\sin(100\pi t), I_o = ?\ I_{rms} = ?\ \theta = ?$$

$$\text{comparing voltage by orignal eq}, V = V_o\sin(2\pi f)t,\ V_o = 350V,\ f = 50Hz$$

$$A = \sqrt{R^2 + X_L^{\ 2}} = \sqrt{R^2 + (2\pi fL)^2} = \sqrt{40^2 + (2*3.14*50)^2} = 302.65\ \text{ohm}$$

$$I_o = \frac{V_o}{Z} = \frac{350}{302.65} = 1.16A,\quad I_{rms} = 0.707\,I_o = 0.707*1.16 = 0.81A$$

$$\theta = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{2\pi fL}{R}\right) = \tan^{-1}\left(\frac{2*3.14*50*3/3.14}{R}\right) = 82.4^o$$

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

$$\text{Given Data}: L = 10mH = 10*10^{-3} H, R = 20\ \text{ohm}, Vrms = 240\ V, f = 180/\pi\ Hz\ P = ?\ P = V_{rms}I_{rms}\cos\theta - - - (1)$$

$$X_L = \omega L = 2\pi f L = 2\pi*180/\pi*10*10^{-3} = 3.6\ \text{ohm}\quad Z = \sqrt{R^2 + X_L^{\ 2}} = \sqrt{20^2 + 3.6^2} = 20.32\text{ohm}$$

$$I_{rms} = \frac{240}{20.32} = 11.81A \quad \theta = \tan^{-1}(X_L/R) = \tan^{-1}(3.6/20.32) = 10.2^o \ \text{putting in (1)}$$

$$P = 240*11.81\,\text{Cos}10.2^o = 2778\ W$$

16.7: Find the value of the current flowing through a capacitance $0.5\mu F$ when connected to a source of 150V at 50Hz.

$$\text{Given Data}: C = 0.5\mu.F = 0.5*10^{-6} F, V = 150\ V, f = 50\ Hz,\ I = ?\ \text{As circuit is capacitive so}\ I = V/Xc$$

$$Xc = \frac{1}{\omega C} = \frac{1}{2\pi\pi f} = \frac{1}{2*3.14*50*0.5*10^{-6}} = 6369.4\ \text{ohm}\quad I = V/X_c = 150/6369.4 = 0.02A$$

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

$$\text{Given Data}: V = 12V, f = 50Hz, C = 3*10^{-6} F, R = 1\ \text{ohm}\quad \theta = ?$$

$$\theta = \tan^{-1}\frac{(Xc)}{R} = \tan^{-1}\frac{1}{2\pi f\ CR} = \tan^{-1}\frac{1}{2*3.14*50*3*10^{-6}*1} = 46.7^o$$

16.9: What is the resonant frequency of a circuit, which includes a coil of inductance 2.5H and a capacitance $40\mu F$?

$$\text{Given dAta}: L = 2.5\ H,\quad C = 40\mu F = 40*10^{-6} F\quad f_r = ?$$

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2*3.14\sqrt{2.5*40*10^{-6}}} = 15.9Hz$$

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

$$\text{Given Data}: L = 150\mu H = 150*10^{-6} H, C_1 = 500PF = 500*10^{-12} F, C_2 = 20PF = 20*10^{-12} F$$

$$f_{min} = \frac{1}{2\pi\sqrt{LC_1}} = \frac{1}{2*3.14\sqrt{150*10^{-6}*500*10^{-12}}} = 2.91*10^6\ Hz = 2.91MHz$$

$$f_{max} = \frac{1}{2\pi\sqrt{LC_2}} = \frac{1}{2*3.14\sqrt{150*10^{-6}*20*10^{-12}}} = 0.58*10^6\ Hz = 0.58MHz$$

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