PESIT Bangalore South Campus

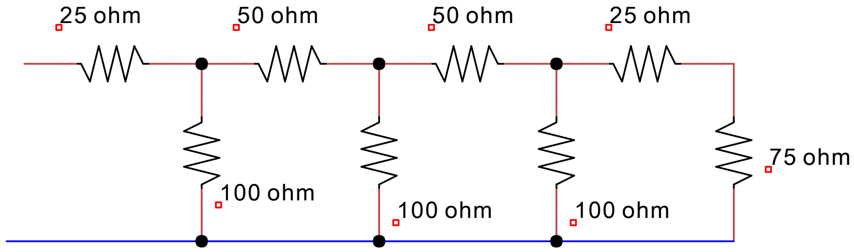
Hosur road, 1km before Electronic City, Bengaluru -100

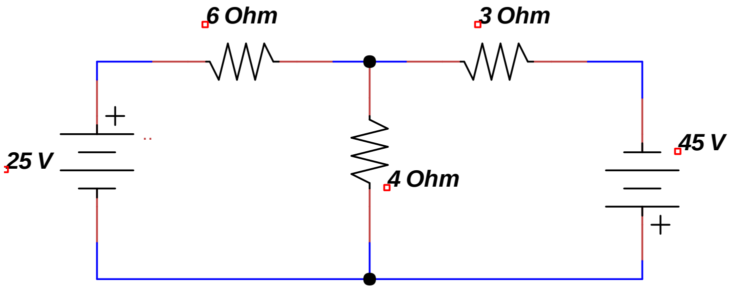
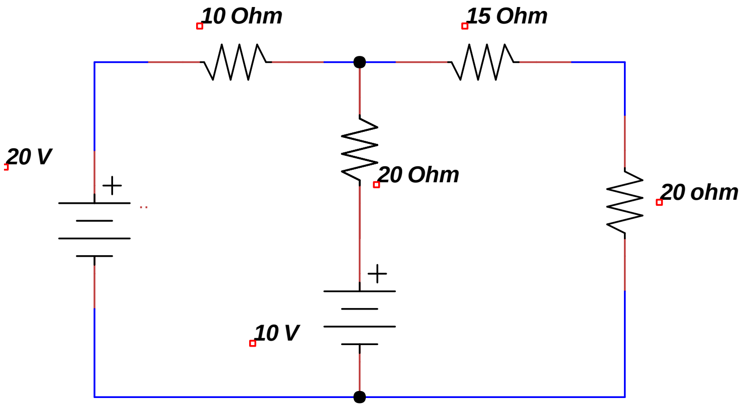
Department of Electronics & Communication Engineering

CONTINUOUS INTERNAL EVALUATION TEST -1

Date : 27/2/2018		**Marks:60**
Subject & Code : Basic Electrical Engineering , 17ELE25		**Section: A,B,C,D,E**
Name of faculty: Mrs. Dhanashree Bhate, Mr. Prashanth, Mr. Nagendra		**Time : 8:30 am – 11:30 a.m**

Note: Answer FIVE full questions choosing any ONE full question from each part.

		PART 1	
1	**a**	State and explain Ohm's Law and state its limitations	**6M**
	b	A domestic power load in a house comprises of 8 lamps of 100 W each, 3 fans 80 W each, refrigerator 373 W and a heater 1000 W. Calculate the total current taken from a 230V supply. Calculate energy consumed in a day, if on an average only a quarter of the above load persists all the time.	**6M**
2	**a**	State and explain (i) Kirchhoff's Voltage law (ii) Kirchhoff's Current law	**6M**
	b	What is the equivalent resistance of the ladder network shown in the figure below (i) With 75 Ω load resistor connected as shown (ii) with 75 Ω load resistor disconnected? 	**6M**
		PART 2	
3	**a**	Define Dynamically and Statically induced emf. Derive the expression for self inductance, $L = \mu 0 \mu r\ AN^2 / l$	**6M**
	b	Two identical 1000 turns coils X & Y lie in parallel plane such that 60 % of the flux produced by one links the other. A current of 5 A in coil X produces in it a flux of 5×10^{-5}wb. If a current in coil X changes from +6A to -6A in 0.01 sec. What is the EMF induced in coil Y. Calculate the self inductance of each coil and their mutual inductance.	**6M**
4	**a**	Derive expression for the coefficient of coupling between two coils and explain the conditions for tightly coupled coils & magnetically isolated coils.	**6M**
	b	Calculate the self inductance of an air cored solenoid having 25 cm mean diameter, $10 cm^2$ cross section which is uniformly wound with 1000 turns of wire. Also find the emf induced when a current increasing at the rate of 100 A/sec in windining.	**6M**
		PART 3	
5		Find the current flowing through all the resistances using KCL & KVL. Also find power consumed in all the resistances.	

			
6		Find the current flowing through all the resistances using KCL & KVL. Also find power consumed in all the resistances. 	
PART 4			
7		Define Instantaneous value , maximum value, RMS value and derive the relation between maximum value and RMS value	**12M**
8		Define phase difference, amplitude of an alternating quantity, average value and derive the relation between the average value and maximum value	**12M**
PART 5			
9		Prove that the power consumed in an inductor is zero	**12M**
10		Prove that the power consumed in a capacitor is zero	**12M**

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SCHEME AND SOLUTION
INTERNAL TEST-I

Subject & Code : Basic Electrical Engineering, 14ELE15
Name of faculty: Dhanashree Bhate   Semester: II   Section: A,B,C,D,E

Q.No		Marks

1.a State and explain Ohm's Law and State its limitations

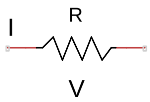
Ohm's law : This is the most fundamental law in electrical engineering. It states that the potential difference between two ends of a conductor is directly proportional to the current flowing through it , provided its temperature and other physical parameters remain unchanged .

That is $V \alpha I$

$V=IR$

2M

The constant of proportionality **R** is called ***resistance*** of the conductor. The unit is **ohm (Ω).**The unit ohm is defined as the resistance which permits a flow of one ampere of current when a potential difference of 1 V is applied to the resistance.



The resistance R depends on the followng factors

Length : If the length increases, the distance to be travelled by electrons increases, as the distance increases the electrons will be obstructed by more atoms and molecules present therefore resistance increases with the length.

ie $R \alpha$ length

Cross sectional area : If the crossectional area of conductor increases, the path for flow of electrons increases .Hence opposition offered decreases.

ie $R \alpha$ 1/crossectional area

$R \alpha L/A$

$\boxed{R = \rho L /A}$ where ρ is resistivity of the material

$\rho = RA /L$ unit is Ω-m

4M

Limitations :

1. This law cannot be applied to unilateral networks. A unilateral network has unilateral elements like diode, transistors, etc., which do not have same voltage current relation for both directions of current.
2. Ohm's law is also not applicable for non – linear elements.
   Non-linear elements are those which do not have current exactly proportional to the applied voltage, that means the resistance value of those elements changes for different values of voltage and current. Examples of non – linear elements are thyristor, electric arc, etc.

1.b A domestic power load in a house comprises of 8 lamps of 100 W each, 3 fans 80 W each, refrigerator 373 W and a heater 1000 W. Calculate the total current taken from a 230V supply. Calculate energy consumed in a day, if on an average only a quarter of the above load persists all the time.

Total power =P= 8x100 + 3X 80 + 373 + 1000
= 2413 watt
=2.413 k W

3M

V= 230 V and P= 2413 watt
Therefore I = P/V = 2423/ 230 =10.49 A

Energy consumed in a day = P X (time) = 2. 413 x (24) k W –hr
= 57.912 k Watt - hr

3M

Energy for ¼ th load is consumed per day = 57.912 k Watt – hr x (0.25)
Energy for ¼ th load is consumed per day = 14.478 k W- hr

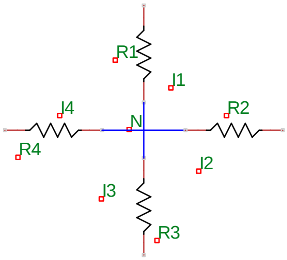
Q.2.a. State and explain (i) Kirchhoff's Voltage law (ii) Kirchhoff's Current law

Kirchhoff's Current Law :

Statement : Kirchhoff's current law states at any node or a juction the algebraic sum of the currents is zero.ΣI = 0.

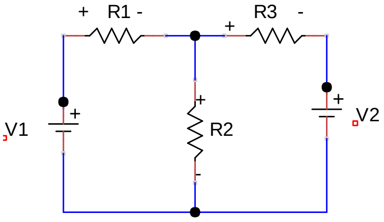
At node N if I1 & I2 are enterring the node and I3 & I4 are leaving from the node then I1+ I2-I3-I4 =0

3M



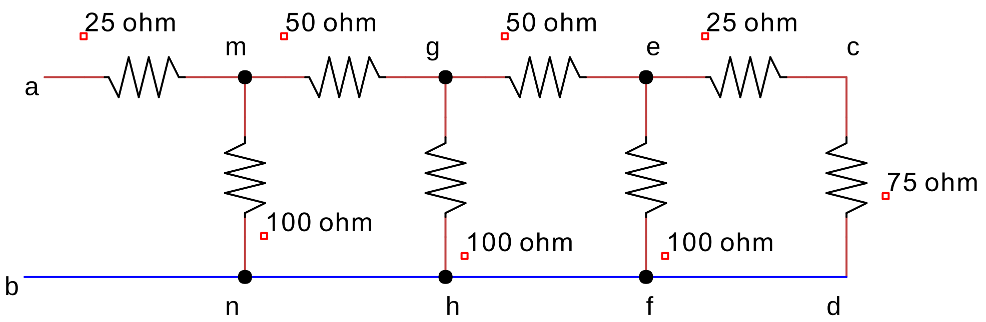
Kirchhoff's Voltage Law :

Statement : Kirchhoff's law states that in a closed loop or a mesh the algebraic sum of the voltages is eqaul to zero. It can be also stated as the sum of the voltage dropes in a closed mesh equal to the sum of the voltage gain in the circuit.



3M

Q.2 b. What is the equivalent resistance of the ladder network shown in the figure below (i) With 75 Ω load resistor connected as shown (ii) with 75 Ω load resistor disconnected?



Let us name the loads and solve

(i) With 75 Ω load resistor connected

Ref = 100 || (25+ 75) = 100 (100/200) = 50 Ω

Rgh = 100 || (50+ 50) = 50 Ω

Rmn = 100 || (50+ 50) = 50 Ω

Rab = (25+ 50) = 75 Ω **therefore the Req = 75 Ω** — 3M

(i) With 75 Ω load resistor disconnected

When the load of 75 Ω is disconnected, the output terminal c & d become open circuit. the 25 Ω has no effect as no current flows through that part of the circuit hence resistance to the right of nodes g and h — 3M

Rgh = 100 || (50+ 100) = 100 (150/250) = 60 Ω

resistance to the right of nodes m and n

Rmn = 100 || (50+ 60) = 100 (110/210) = 52.4 Ω

This resistance is in series with 25 Ω

therefore the Req = 25 +52.4 = 77.4 Ω

Q.3.a Define Dynamically and Statically induced emf. Derive the expression for self inductance, $L = \mu 0 \mu r\ AN^2 / l$

Emf can be induced in different ways

1. Dynamically induced emf
2. Statically induced emf

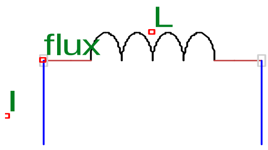
Dynamically induced emf

When a magnet is moved towards a coil of N number of turns , the flux linking the coil changes and by Faraday's first law an emf is induced in the coil. This emf is called dynamically induced emf — 2M

Statically induced emf

When an ac voltage is applied to the coil ,the flux linking with the coil changes with respect to the time. This is called Statically induced emf. There is no movement of — 2M both the coil and the magnet.

When current flowing through a coil changes, the flux linking with the coil also changes resulting in an emf called as self induced emf 2M



Consider a coil of N turns carrying a current of I A. Let @ be the flux.
Flux changes with respect to current in the coil and an emf is induced in the coil. This is called self induced emf and the phenomenon is called as coefficient of self induction. This induced emf opposes the change of current in the coil
Derivation:

$e \;\alpha\; di/dt$

$e = L\, di/dt$

$\mathbf{L = e / di/dt}$ 2M

But we know that

$\mathbf{E = N\, d\Phi / dt}$

Eqauting both the equations

$\mathbf{N\Phi = L\, I}$

$\mathbf{L = N\Phi / I}$

But flux $\mathbf{\Phi = NI / S}$ 2M

$\mathbf{L = N\, NI / S\, I}$

$\mathbf{L = N^2\, I / l / \mu 0 \mu r A}$

$\mathbf{L = \mu 0 \mu r A\, N^2 / l}$

Coefficient of self inductance (L)

Coefficient of self inductance L of a coil is defined to be 1 H when the current changes in the coil at the rate of 1A per second inducing an emf of 1V. Unit of self inductance is Henry (H). 2M

Q.3.b Two identical 1000 turns coils X & Y lie in parallel plane such that 60 % of the flux produced by one links the other. A current of 5 A in coil X produces in it a flux of 5 x 10^{-5}wb. If a current in coil X changes from +6A to -6A in 0.01 sec. What is the EMF induced in coil Y. Calculate the self inductance of each coil and their mutual inductance.

Nx = 1000 turns
Ny = 2000 turns
$\Phi xy = 0.6\, \Phi x$
Ia = 5A , $\Phi = 5 \times 10^{-5}$wb
dIx = 12 A, dt = 0.01sec

Solution : — 2M

$Lx = Nx\ \Phi x / I x$

$= 1000(5 \times 10^{-5}) / 5$

$Lx = 0.01$ H

Lx = Ly = 0.01 H (as the coils are identical) — 2M

$M = Ny\ \Phi xy / Ix$

$= 1000(0.6 \times 5 \times 10^{-5}) / 5$

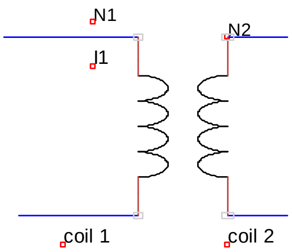
M = 0.006 H = 6 μH — 2M

Mutually induced emf ey = M dIx/ dt

= 0.006 (12) / 0.01

Mutually induced emf ey = 7.2 V

Q.4.a Derive expression for the coefficient of coupling between two coils and explain the conditions for tightly coupled coils & magnetically isolated coils.



Let I_1 -------current in coil 1

I_2 --------current in coil2

Φ_1 -------- flux due to I_1

Φ_{11}-----------flux linking with coil1

Φ_{12}-----------flux linking with coil2

The total flux is vector summation of both the linking flux

$\Phi_1 = \Phi_{11} + \Phi_{12}$

Coefficient of coupling K is defined as the ratio of mutual flux to the mutal flux. In this case the toatal flux is Φ_1 and the mutual flux is Φ_{12}. — 2M

K = Mutual flux / total flux

$K = \Phi_{12}/\Phi_1 < 1$

K tells us how closely the coils are coupled

The coefficient of mutual induction is defined as

$M = N_2\ \Phi_{12} / I_1$

& $K = \Phi_{12}/\Phi_1$

we get $M = N_2\ K\ \Phi_1 / I_1$

similarly if the voltge source V_2 is connected to coil 2 then I_2 is the current coil 2 and let Φ_2 be the flux.

	But $\Phi_2 = \Phi_{21} + \Phi_{22}$ $K = \Phi_{21}/\Phi_2$ $\Phi_{21} = K\Phi_2$ $M = N1\Phi_{21} / I_2$ $M = N1\ K\ \Phi_2 / I_2$ Multipling eq 2.7 & 2.8 $M.\ M = (N_2\ K\ \Phi_1 / I_1)\ (N1\ K\ \Phi_2 / I_2)$ $M^2 = K^2\ (N1\ \Phi_1 / I_1)\ (N_2\ K\ \Phi_2 / I_2)$ $M^2 = K^2\ L_1\ L_2$ $K = M / \sqrt{L_1\ L_2}$	2M
	The value of K tells us how closely the coils are coupled . If K = 0 then mutual flux is zero and there is no coupling between the coils. So coils are said to be magnetically isolated . If $K \approx 1$ but $K \neq 1$ then mutual flux is nearlly equal to total flux. So coils are said to be tightly coupled	2M
Q.4 b	Calculate the self inductance of an air cored solenoid having 25 cm mean diameter, $10cm^2$ cross section which is uniformly wound with 1000 turns of wire. Also find the emf induced when a current increasing at the rate of 100 A/sec in windinding. L = ? Length $l = \pi\ (25x10^{-2})$ $A= 10\ cm^2$ N= 1000 turns E =? When di/dt = 100 A/s $L = \mu 0\ \mu r\ A\ N^2 / l$ $= 4 \times \pi \times 10^{-7} \times 1 \times 10 \times 10^{-4} \times 1000^2 / (\pi \times 25 \times 10^{-2})$ L = 0.0016 H	4M
	E = L di/dt = 0.0016 x 100 E= 0.16 V	2M

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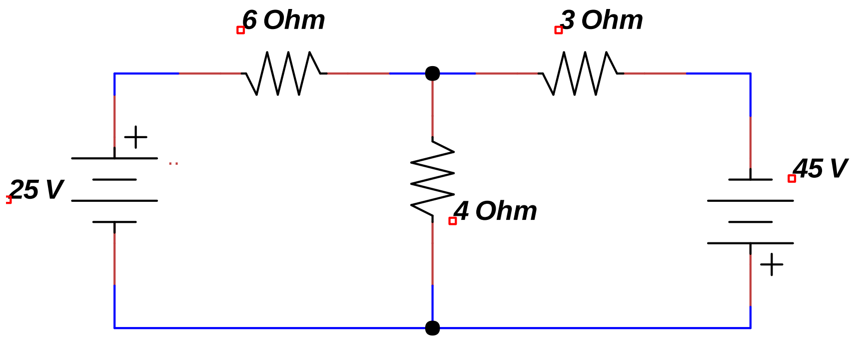
Q.5

Find the current flowing through all the resistances using KCL & KVL. Also find power consumed in all the resistances.



Assuming loop current in clockwise direction I_1 in loop 1 ,And I_2 in loop2

Loop 1

$25 - 6\ I_1 - 4\ (\ I_1 - I_2\ ) = 0$

$-10\ I_1 + 4\ I_2 + 25 = 0$ --------- eq 1

3M

Loop 2

$-3\ I_2\ + 45 - 4\ (I_2 - I_1) = 0$

$4\ I_1 - 7\ I_2 + 45 = 0$ ----------eq 2

3M

Solving eq 1 & 2

$I_1 = 6.57$ A ,

$I_2 = 10.18$ A

3M

Power consumed in 6Ω P1 = $(6.57)^2\ (6) = 258.98$ watt

Power consumed in 3Ω P2 = $(10.18)^2\ (3) = 310.89$ watt

Power consumed in 6Ω P1 = $(3.61)^2\ (4) = 52.12$ watt

3M

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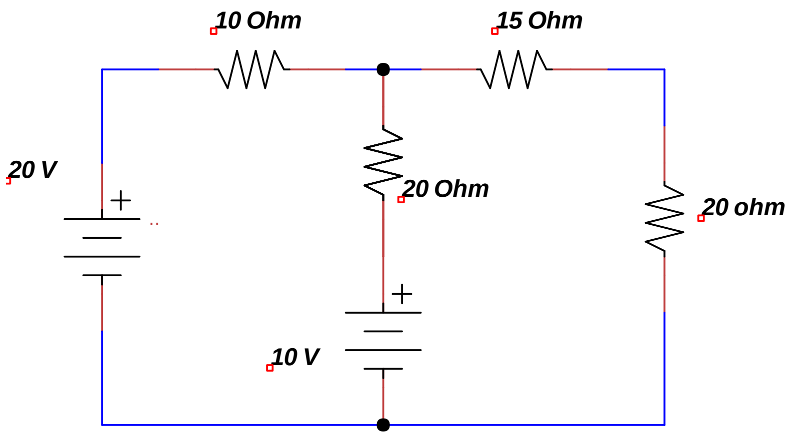
Q.6

Find the current flowing through all the resistances using KCL & KVL. Also find power consumed in all the resistances.



Assuming loop current in clockwise direction I_1 in loop 1 ,And I_2 in loop2

Loop 1

$20 - 10\ I_1 - 20\ (I_1 - I_2) - 10 = 0$

$30\ I_1 - 20\ I_2 - 10 = 0$ --------- eq 1 — 3M

Loop 2

$-35\ I_2 + 10 - 20\ (I_2 - I_1) = 0$

$-20\ I_1 + 55\ I_2 - 30 = 0$ ---------- eq 2 — 3M

Solving eq 1 & 2

$I_1 = 0.6$ A

$I_2 = 0.4$ A — 3M

Power consumed in 10Ω P1 = $(0.6)^2 (10) = 3.6$ watt

Power consumed in 15Ω P2 = $(0.4)^2 (15) = 2.4$ watt

Power consumed in 20Ω (middle arm) P3 = $(0.6\text{-}0.4)^2 (20) = 0.8$ watt — 3M

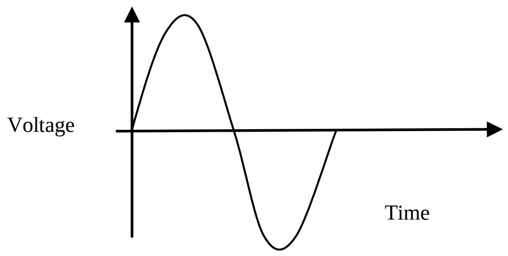
Power consumed in 20Ω P4 = $(0.4)^2 (20) = 3.2$ watt

Q.7 Define Instantaneous value , maximum value, RMS value and derive the relation between maximum value and RMS value

Instantaneous value:
The magnitude of an alternating quantity at any instant of time is called instantaneous value and denoted by v,i,p — 2M

Maximum value :
The maximum value attained by an alternating quantity in every cycle is called the amplitude. The amplitude of voltage or current is denoted by Vm or Im — 2M

RMS or effective value: RMS value of an alternating current is defined to be equal to that DC current which produces the same amount of heat as produced by the alternating current when passed through the same resistance for the same time . — 2M



Consider a sinusoidal waveform having equation E =Em sin (θ) — 4M

The RMS value can be defined as Erms = $\frac{1}{2\pi}\sqrt{\int_0^{2\pi} Em^2 sin^2(\theta)d\theta}$

$$=\frac{1}{2\pi}\ (Em^2)\sqrt{\int_0^{2\pi} sin^2(\theta)d\theta}$$

$$=\frac{1}{4\pi}\ (Em^2)\sqrt{\int_0^{2\pi(}1-\cos 2\theta\ )d\ \theta}$$ — 2M

Solving the above equation

$$\mathbf{E_{RMS} = E_m / \sqrt{2}}$$

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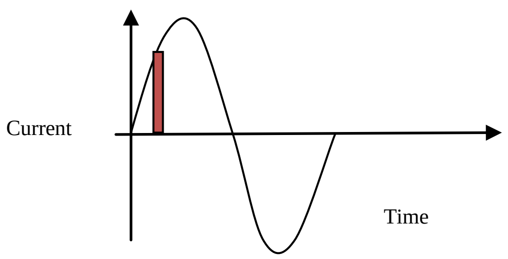
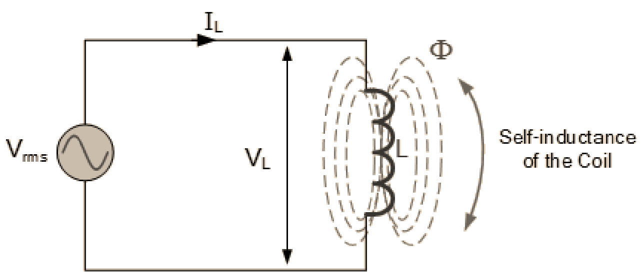
Q.8	Define phase difference, amplitude of an alternating quantity, average value and derive the relation between the average value and maximum value	
	Phase difference: It is the difference in phase angle between two alternating quantities	2M
	Amplitude: The maximum value attained by an alternating quantity in every cycle is called the amplitude. The amplitude of voltage or current is denoted by Vm or Im	2M
	Average or mean value: Average value of an alternating current is defined to be that DC current , which transfers the same amount of charge as transferred by the alternating current across the same circuit and in the same time	2M
	Let consider a current with equation $i = im \sin(\theta)$ Let a strip of width dθ and the mid ordinate value of voltage be i considered  	4M
	The area of the strip = i. dθ The average of the half cycle can be written as $=1/\pi \int_0^{\pi} i \, . d\theta$ $= 1/\pi \int_0^{\pi} im \sin(\theta)\, d\theta$ Iavg = $1/\pi$ (Vm) (cos θ)$_0{}^{\pi}$ I avg = 2 Vm /π	2M

Q.9 Prove that the power consumed in an inductor is zero

Consider a circuit with a pure inductor connected to an AC source



Consider a circuit with an inductor L connected across a source of $V = Vm \sin(\omega t)$. **2M**

Let I_L be the current flowing through the circuit.

But we know that

$I_L = 1/L \int V\, dt$

$= 1/L \int Vm \sin(\omega t)\, dt$

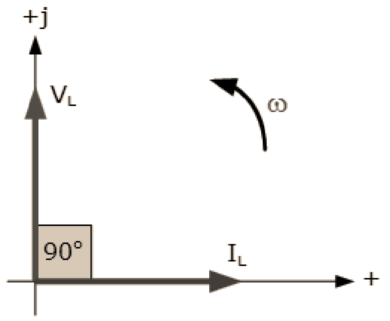
$= Vm\ (-\cos(\omega t) / \omega L$

But $X_L = \omega L$ is called inductive reactance of the coil

$I_L = Im \sin(\omega t - \pi/2)$ ------------------eq2

Where $Im = Vm / X_L$ **2M**

Therefore from equation 1 & 2 we can say that the current lags the applied voltage by $\pi/2$ **2M**



$$Pavg = \frac{1}{2\pi} \int_0^{2\pi} p\, d\omega t$$ **2M**

$$= \frac{1}{2\pi} \int_0^{2\pi} v.i\, d\omega t$$

$$= \frac{1}{2\pi} \int_0^{2\pi} Vm\, Sin\,(\omega t)\ (-Im \cos(\omega t))\, d\omega t$$

$$= -\frac{Vm\, Im}{2\pi} \int_0^{2\pi} Sin\,(\omega t) \cos(\omega t)\, d\omega t$$ **2M**

$$= -\frac{Vm\,Im}{2\pi}\int_0^{2\pi} Sin\frac{(2\omega t)}{2}\ d\omega t$$

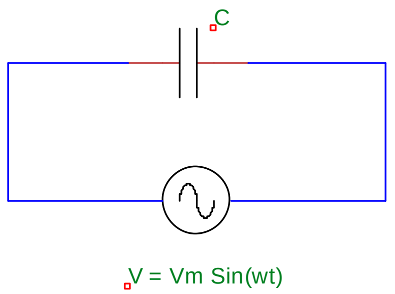
$$= \frac{Vm\,Im}{2\pi}[\ 0\ ]$$

Hence it is proved that the power consumed in an inductor is zero.

Pavg = 0

Power Waveform--- 2M

Q.10 Prove that the power consumed in a capacitor is zero



Consider a circuit with a capacitor C connected across a source of V= Vm sin (ωt).
Let i be the current flowing through the circuit.
We know that charge q = CV 2M

Current $i = \frac{dq}{dt}$

$$i = \frac{dCV}{dt}$$

$$i = \frac{d(CVm \sin \omega t)}{dt}$$

$$i = C\,Vm\ \frac{d(\sin \omega t)}{dt}$$ 2M

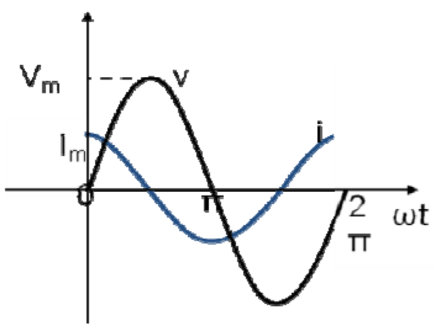
$$i = (\ Vm / \omega C\ )\ \ (\cos(\omega t))$$

$$i = (\ Vm / Xc\ )\ \sin(\omega t + \pi/2)$$

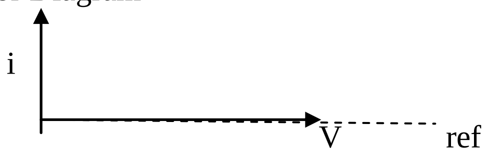
$$i = Im\ \sin(\omega t + \pi/2)$$

From the above equation we can say that the current leads the applied voltage by π/2

Waveforms 2M



Vector Diagram



2M

$$Pavg = \frac{1}{2\pi} \int_0^{2\pi} p \, d\omega t$$

$$= \frac{1}{2\pi} \int_0^{2\pi} v.i \, d\omega t$$

2M

$$= \frac{1}{2\pi} \int_0^{2\pi} Vm \, Sin\,(\omega t) \; Im \, Cos\,(\omega t) d\omega t$$

$$= \frac{Vm\, Im}{2\pi} \int_0^{2\pi} Sin\,(\omega t)\, Cos\,(\omega t) d\omega t$$

$$= \frac{Vm\, Im}{2\pi} \int_0^{2\pi} Sin \frac{(2\omega t)}{2} \; d\omega t$$

$$= \frac{Vm\, Im}{2\pi} [\,0\,]$$

Pavg = 0

Hence it is proved that the power consumed in a capacitor is zero

Power Waveform-- 2M
