Try to avoid over writing

Try to avoid calculation mistake

IMPORTANT INSTRUCTIONS

CANDIDATES SHOULD READ THE UNDERMENTIONED INSTRUCTIONS CAREFULLY. VIOLATION OF ANY OF THE INSTRUCTIONS MAY LEAD TO PENALTY.

DONT'S

1. Do not write your name or registration number anywhere inside this Question-cum-Answer Booklet (QCAB).
2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
3. Do not tear off any leaves from your QCAB, if you find any page missing do not fail to notify the supervisor/invigilator.
4. Do not leave behind your QCAB on your table unattended, it should be handed over to the invigilator after conclusion of the exam.

DO'S

1. Read the Instructions on the cover page and strictly follow them.
2. Write your registration number and other particulars, in the space provided on the cover of QCAB.
3. Write legibly and neatly.
4. For rough notes or calculation, the last two blank pages of this booklet should be used. The rough notes should be crossed through afterwards.
5. If you wish to cancel any work, draw your pen through it or write "Cancelled" across it, otherwise it may be evaluated.
6. Handover your QCAB personally to the invigilator before leaving the examination hall.

180

Improve presentation

Section A : Computer Fundamentals + Electrical & Electronic Measurements

Q.1 (a) Assume that a main memory with only 4 pages, each of 16 bytes, is initially empty. The CPU generates the following sequence of virtual addresses and uses the Least Recently Used (LRU) page replacement policy.

0, 4, 8, 20, 24, 36, 44, 12, 68, 72, 80, 84, 28, 32, 88, 92

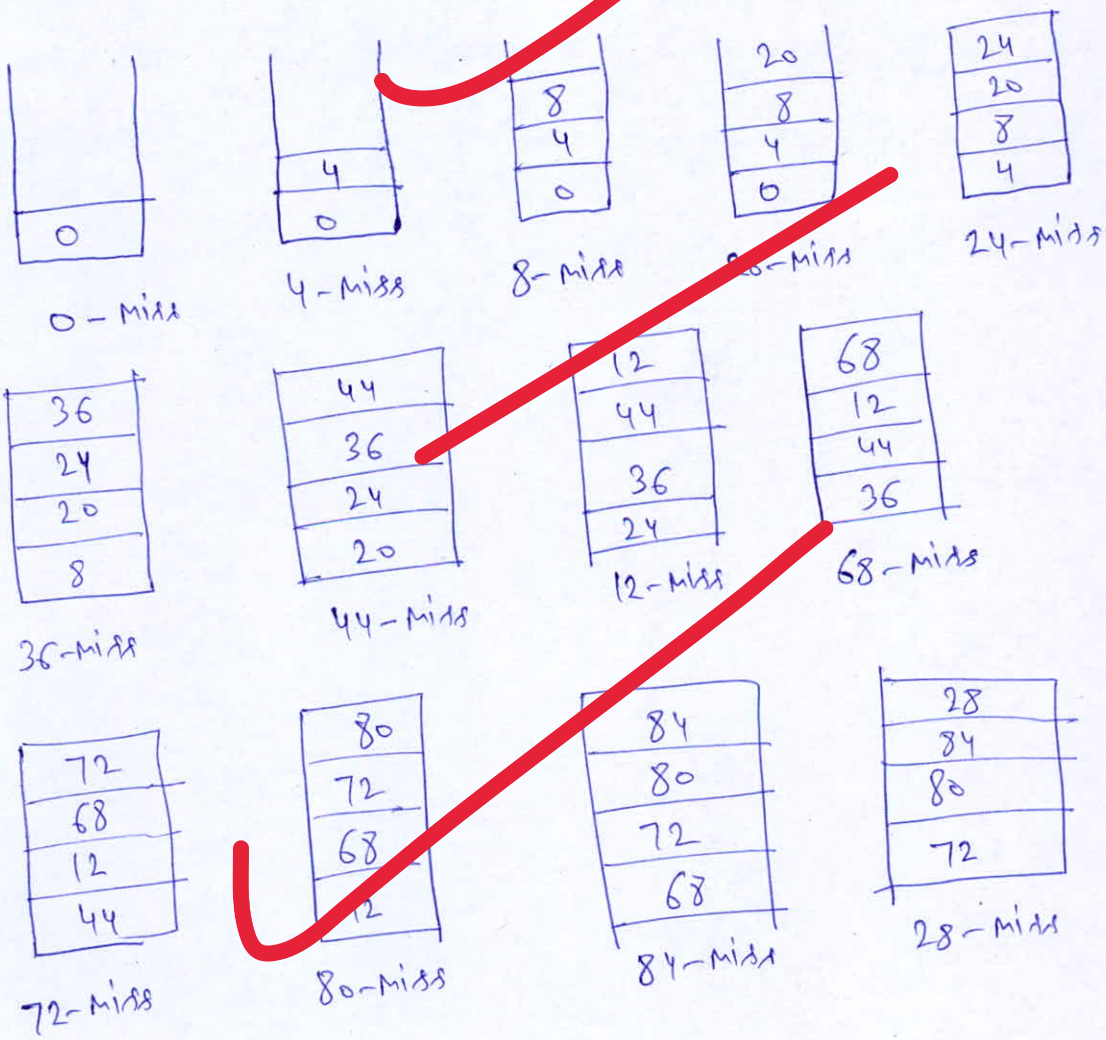
How many page faults does this sequence cause? What are the page numbers of the pages present in the main memory at the end of the sequence?

[12 marks]

Given :- 0, 4, 8, 20, 24, 36, 44, 12, 68, 72, 80, 84, 28, 32, 88, 92

Find :- Page faults

Solution :-



32
28
84
80

32- Miss

88
32
28
84

88- miss

92
88
32
28

92- Miss

Total Page faults = 6

~~Pages at the end~~

Page number at the end ⇒

92
88
32
28

Go through the made easy solution

Do not write in this margin

Q.1 (b) In a test on a Bakelite sample at 20 kV, 50 Hz by schering bridge, having a standard capacitor of 106 pF, balance was obtained with a capacitance of 0.35 mF in parallel with a non-inductive resistance of 318 Ω, the non-inductive resistance in the remaining arm of the bridge is 130 Ω. Calculate the power factor and equivalent series resistance of the capacitor. Also derive the balance condition of the bridge.

[12 marks]

Given data :- $C_3 = 106\,pF$, $C_4 = 0.35\,mF$

$R_4 = 318\,\Omega$, $R_2 = 130\,\Omega$

Find :- Power factor, R_1, C_1

Solution :-

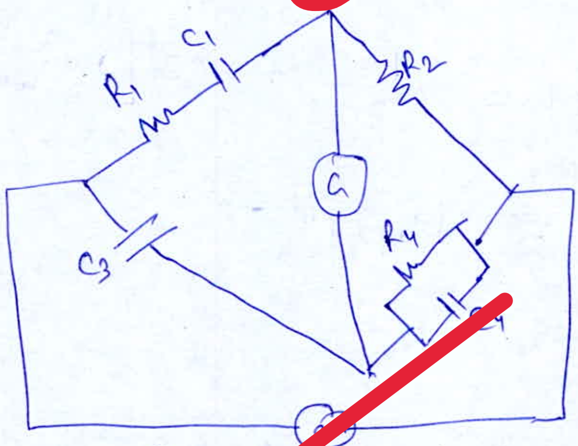


fig :- Schering bridge

As we know, At balance,

$$Z_1 Z_4 = Z_2 Z_3$$

then,

$$\left(R_1 + \frac{1}{j\omega C_1}\right)\left(\frac{R_4/j\omega C_4}{R_4 + \frac{1}{j\omega C_4}}\right) = \frac{R_2}{j\omega C_3}$$

$$\left(R_1 + \frac{1}{j\omega C_1}\right)\left(\frac{R_4}{1 + j\omega C_4 R_4}\right) = \frac{R_2}{j\omega C_3}$$

$$\left(R_1 - \frac{j}{\omega C_1}\right) R_4 = \frac{R_2 (1 + j\omega C_4 R_4)}{j\omega C_3}$$

$$j\omega C_3 \cdot R_4 \left(R_1 - \frac{j}{\omega C_1}\right) = R_2 + j\omega R_2 C_4 R_4$$

$$j\omega R_1 C_3 R_4 + \frac{C_3 R_4}{C_1} = R_2 + j\omega R_2 C_4 R_4$$

On comparing imaginary parts both sides

$$\omega R_1 C_3 R_4 = \omega R_2 C_4 R_4$$

$$R_1 = \frac{R_2 C_4}{C_3} \Rightarrow R_1 = \frac{130 \times 0.35 \times 10^{-6}}{106 \times 10^{-12}}$$

$$R_1 = 429.24\ M\Omega \quad \text{--- (1)}$$

And on comparing real parts both sides

$$\frac{C_3 R_4}{C_1} = R_2 \Rightarrow C_1 = \frac{C_3 R_4}{R_2}$$

$$C_1 = \frac{106 \times 10^{-12} \times 318}{130} \Rightarrow C_1 = 259.29\ pF \quad \text{--- (2)}$$

Power factor $\cos\phi = \frac{R_1}{Z_1} = \cos\left[\tan^{-1}\frac{1}{\omega R_1 C_1}\right]$

~~$R_1 = 429.24\ M\Omega$~~

~~$Z_1 = |R_1 + jX_{C1}| = \sqrt{429.24}$~~

$$\phi = \tan^{-1}\frac{1}{\omega R_1 C_1}$$

$$\phi = \tan^{-1}\left[\frac{1}{100\pi \times 429.24 \times 10^{6} \times 259.29 \times 10^{-12}}\right]$$

$$\phi = \tan^{-1}\frac{1}{34.965}$$

$$\phi = 1.638^\circ$$

$$\boxed{\cos\phi = 0.99}$$

$$\boxed{\begin{aligned} R_1 &= 429.24\ M\Omega \\ C_1 &= 259.24\ pF \\ \cos\phi &= 0.99 \end{aligned}}$$

10

Good approach

Do not write in this margin

Q.1 (c) Given the following binary number in 32-bit (single precision) IEEE-754 format:

00111110011011010000000000000000

Determine the decimal value closest to this floating-point number.

[12 marks]

Given :- 00111110011011010000000000

Find :- Decimal value

Solution :- As we know, 32-bit IEEE format

S	BE	M
1bit	8bit	23 bit

∵ MSB bit is '0', it means S = 0

Now, BE = 01111100 = 124

Bias = $2^{n-1} - 1 = 2^{8-1} - 1 = 127$

∵ BE = AE + Bias

~~BE~~ AE = BE − Bias

AE = 124 − 127 = −3

∵ AE is negative, on taking 2's complement,

00000011 ⟶ 11111101

AE =

Mantissa :- 110110100

1.M

5

Incomplete solution

Do not write in this margin

Q.1 (d) A moving iron voltmeter designed to read up to 100 V has resistance of 2000 Ω and inductance of 0.6 H. How it can be modified to read up to 300 V? How the modified voltmeter can be made to read without error on both dc and 50 Hz ac?

[12 marks]

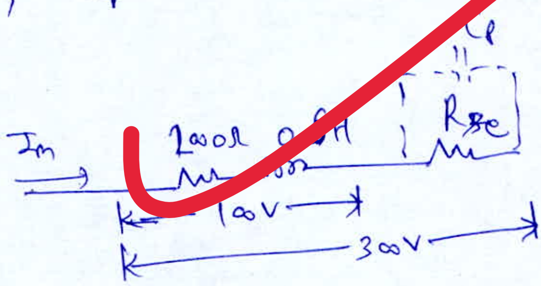
Given data: $V_M = 100\,V$, $R_M = 2000\,\Omega$

$L_M = 0.6\,H$, $V_2 = 300\,V$

$f = 50\,Hz$

Find:- R_{se}, C_p

Solution:-



$$V_M = I_m\sqrt{R_M^2 + (\omega L_M)^2} \quad \text{--- (1)}$$

$$V_2 = I_m\sqrt{(R_M+R_{se})^2 + (\omega L_M)^2} \quad \text{--- (2)}$$

Divide equation (2) by (1)

$$\frac{V_2}{V_M} = \frac{\sqrt{(R_M+R_{se})^2 + (\omega L_M)^2}}{\sqrt{R_M^2 + (\omega L_M)^2}}$$

$$(3)^2 = \frac{(2000 + R_{se})^2 + (100\pi \times 0.6)^2}{(2000)^2 + (60\pi)^2}$$

$$9\left[4000000 + 3600\pi^2\right] = (2000 + R_{se})^2 + \left[3600\pi^2\right]$$

$$36\times 10^6 + (35530.57\times 9) - 35530.57 = (2000 + R_{se})^2$$

$$\boxed{R_{se} = 4023.64\,\Omega}$$

For the same instrument, if it wants to read dc and 50Hz AC error free, we have to connect a capacitor (C_p) in parallel with R_{se}, whose value is

~~$C_p = \frac{0.47}{R_{se}}$~~

$C_p = \frac{L_m}{R_m R_e}$

$C_p = \frac{0.6}{2000 \times 4023.64}$

$\boxed{C_p = 7.456 \times 10^{-8} F}$

7

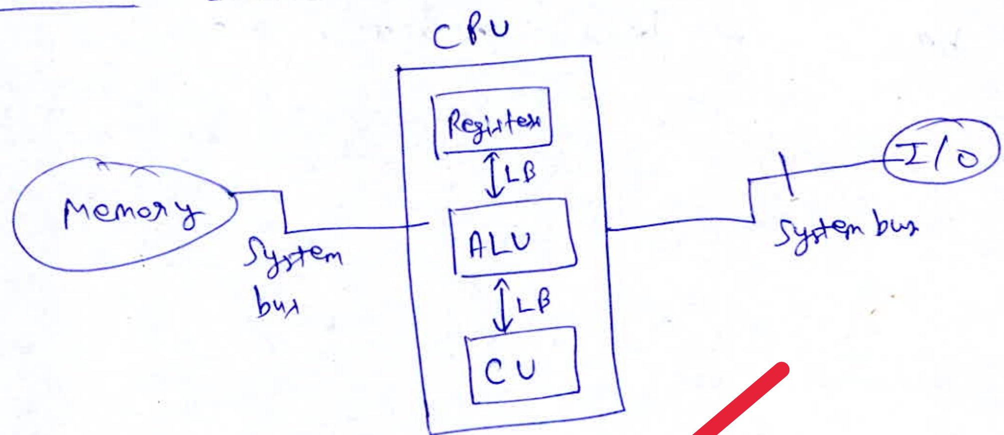
Wrong value calculated

Q.1 (e) What does "computer architecture" term means in regards to computing system? Enumerate properties of reduced instruction set computer architecture.

[12 marks]

Solution:-

Computer Architecture :-



CU → Control unit
ALU → Arithmatic and Logical unit
LB → Local Buss

Computer Architecture is Von-Neumann architecture in which instruction and data is stored into ROM and application program is ~~exeuted~~ executed into RAM.

Properties of Reduced instruction set Computer :-

→ It has fixed length instruction.
→ It has less addressing modes
→ It Carries more registers.
→ Cycle per instruction is equal to one.
→ It follows successfull pipelining concept.
→ They are Super Computers.

→ They are used in real time application.

→ Eg:- Motorola.

→ They have less instruction set.

Elaborate it more

Q.2 (a) Explain file access method and file allocation method with diagram.

[20 marks]

Q.2 (b) (i) Explain briefly the terms: Translator software, assembler, compiler and interpreter. Differentiate between a compiler and an interpreter.

[10 marks]

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Q.2 (b) (ii) Explain how ROM is related to BIOS in relation to operation of computer. What are steps performed by BIOS, when computer is turned-on?

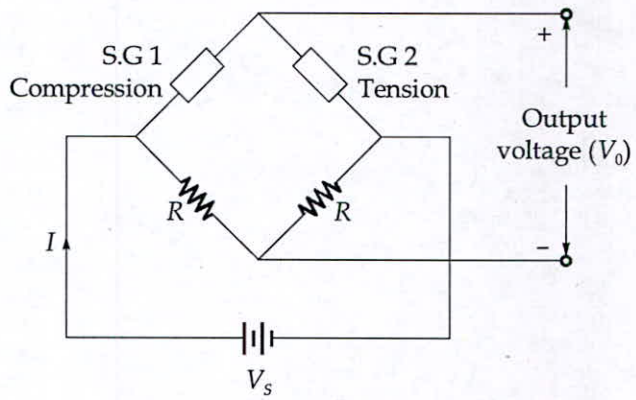
What are different types of ROM used in computer, enumerate and explain briefly?

[10 marks]

Q.2 (c) **(i)** Draw the circuit of Anderson bridge. Derive the null conditions and represent with help of phasor diagram. Show that Maxwell bridge is the special case of this bridge.

[10 marks]

Q.2 (c) **(ii)** A bridge circuit shown in the figure, has two fixed resistors and two strain gauges all of which have a value of 120 Ω each. The gauge factor is 2 and strain applied to twin strain gauges, one in tension and the other in compression is 150×10^{-6} respectively



If the battery current (I) is 100 mA, determine:

1. Open circuit output voltage (V_0) of the bridge.
2. The sensitivity of the bridge circuit in millivolt per unit microstrain.
3. If the galvanometer connected to output terminals read 1 mV per scale division and if 1/10th of a division can be read with confidence, determine the resolution.

[10 marks]

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Q.3 (a) **(i)** Mention the advantages and disadvantages of a LVDT.

(ii) The output of an LVDT is connected to a 5 V voltmeter through an amplifier whose amplification factor is 250. An output of 2 mV appears across the terminals of LVDT when the core moves through a distance of 0.5 mm. Calculate the sensitivity of the LVDT and that of the whole setup. The millivoltmeter has 100 divisions. The scale can be read to $1/5^{th}$ of a division. Determine the resolution of the instrument.

[10 + 10 marks]

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Do not write in this margin

Q.3 (b) (i) Explain "Demand paging" in detail.

[8 marks]

Q.3 (b) (ii) What is "peer-to-peer" computing? Explain its models.

[12 marks]

Q.3 (c) **(i)** A potential transformer has a turn ratio 1000/100 V and following parameters :
Primary resistance : 96 Ω, Secondary resistance = 0.88 Ω
Primary reactance : 67.2 Ω, Total equivalent reactance = 115 Ω
No load current is 0.03 A at 0.4 power factor lagging.

Calculate :

1. Phase angle error at no load.

2. Burden in VA at unity power factor at which phase angle will be zero.

[15 marks]

Q.3 (c) (ii) Briefly explain the elements of an analog data acquisition system.

[5 marks]

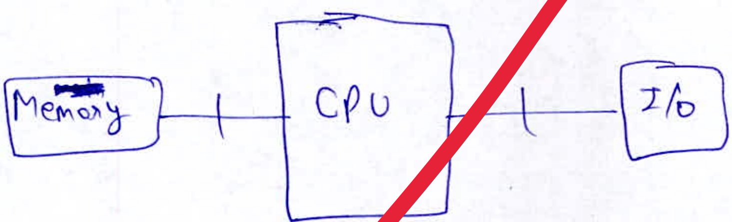
Q.4 (a) (i) What is input-output interface? Explain the different modes of data transfer with example.

[10 marks]

Solution:- Input - output interface:- ~~Input~~ Input output devices are peripheral device, which are connected through CPU. CPU gives signal to IO devices to perform task, after completing task, it acknowledges the CPU.

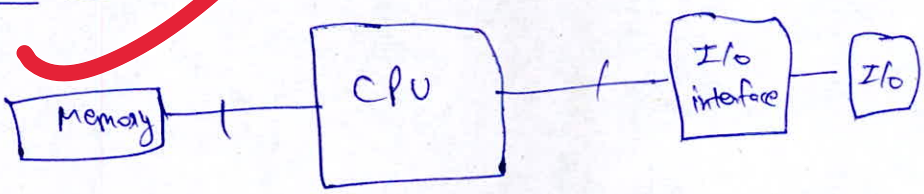
Modes of transfer:-

(i) Programmed I/O :-



In this interface, CPU takes responsibility and programs Input output devices. This is not a good mode of transfer, since CPU will remain busy with I/O device till completion of I/O task.

(ii) I/O interface Chip:-



In this mode, I/O interface will be there in between

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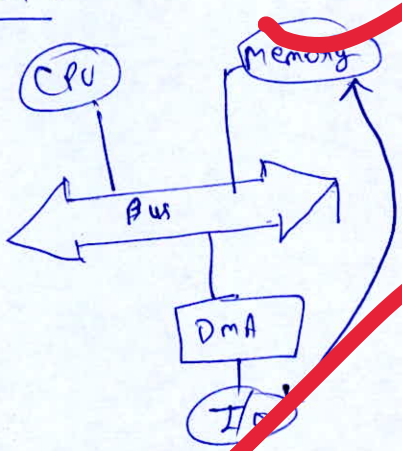
CPU and I/o device. CPU Can do another work in between, while I/o will perform their task.

(iii) DMA Controller :-



In this mode; DMA controller Controls the bus and Copy the I/o program into memory. Later, CPU will read it from memory.

7

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Q.4 (a) (ii) Write a C-program that takes a 4 × 4 matrix as input and gives transpose of input matrix as output.

[10 marks]

Solution:-

```
# include <stdio.h>
int main (   )
{ int   A[16]
```

Incomplete solution

Do not write in this margin

Q.4 (b) **(i)** Explain briefly the term "Multi Threading" in context to operating system. Give few advantages of multi-threading. How multi-threading is different from multitasking?

[10 marks]

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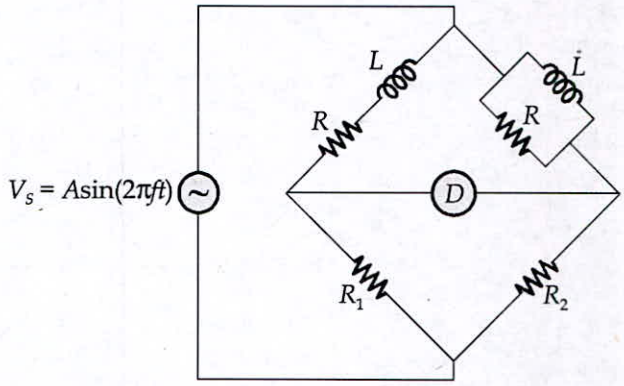
Q.4 (b) **(ii)** Consider an AC bridge shown in the figure with $R = 300\ \Omega$, $R_1 = 1000\ \Omega$, $R_2 = 500\ \Omega$, $L = 30$ mH and a detector D. At the bridge balance condition, find the frequency of the excitation source V_S.



[10 marks]

Given :- $R = 300\ \Omega$, $R_1 = 1000\ \Omega$, $R_2 = 500\ \Omega$

$L = 30\,mH$

Find :- frequency of V_s

Solution :- At balance,

$$Z_1 Z_4 = Z_2 Z_3$$

it means, $(R + j\omega L) R_2 = R_1 (R \| j\omega L)$

$$(R + j\omega L) R_2 = R_1 \left(\frac{j\omega L R}{R + j\omega L} \right)$$

$$(R + j\omega L)^2 = (j\omega L R) \frac{R_1}{R_2}$$

$$R^2 + (j\omega L)^2 + 2Rj\omega L = (j\omega L R) \frac{R_1}{R_2}$$

$$R^2 - \omega^2 L^2 + 2Rj\omega L = (j\omega L R) \frac{R_1}{R_2}$$

On comparing imaginary parts both side

$$2R\omega L = \frac{\omega L R R_1}{R_2}$$

$$\boxed{2' = \frac{R_1}{R_2}} \text{ — (1)}$$

Also on comparing real parts both sides

$$R^2 \; w^2 L^2 = R$$

$$\boxed{w = \frac{R}{L}} \text{ — (2)}$$

$$w = \frac{300}{30\times10^{-3}}$$

$$w = 10\times10^{3}$$

$w = 10^4$ rad/sec.

$$f = \frac{10^4}{2\pi}$$

$$\boxed{f = 1591.55 \text{ Hz}}$$

8

Good approach

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Q.4 (c) What are the sources of errors in an electrodynamometer type wattmeter? A dynamometer type wattmeter connected normally to read power in a single phase circuit. Indicating value P_1, a second reading P_2 is obtained when a capacitor of reactance equal to the pressure coil resistance is connected in series with the pressure coil. Show that the phase angle of the load can be obtained from the expression, $\tan\phi = 1 - \frac{2P_2}{P_1}$.

[20 marks]

Solution:- Errors in electro dynamometer type wattmeter:-

→ Error's due to pressure coil inductance

→ Errors due to low power factor.

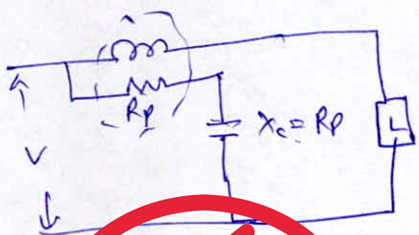
→ Error's due to series coil resistance.

→ Error due to pressure coil drop.

→ Error due to ageing of components

In electrodynamometer wattmeter,

$$T_d = \frac{P_T}{R_P} \frac{dM}{d\theta}$$ [if pressure coil inductance is zero]



$$P_1 = I_1 I_2 \cos\phi$$

$\because$ $X_C = R_P$

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

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

Net impedance in pressure coil,

$$Z_P = \sqrt{R_P^2 + R_P^2}$$

$$Z_P = \sqrt{2}\, R_P$$

5

Incomplete solution

Do not write in this margin

Section B : Power Electronics & Drives-1 + Engineering Mathematics-1 + B.E.E.-2 + Analog Electronics-2 + Electrical Materials-2

Q.5 (a) Show that matrix, $A = \begin{bmatrix} 2 & 3+4i \\ 3-4i & 2 \end{bmatrix}$ is a Hermitian matrix. Find its eigen values and eigen vectors.

[12 marks]

Solution:-

$$A = \begin{bmatrix} 2 & 3+4i \\ 3-4i & 2 \end{bmatrix}$$

$$A^\theta = \begin{bmatrix} 2 & 3+4i \\ 3-4i & 2 \end{bmatrix}$$

$\because$ Hermition matrix follows $A^\theta = A$, which is also being followed by given matrix, it mean given matrix is a Hermition Metrix.

Calculation of Eigen Values,

$$[A - \lambda I] = \begin{bmatrix} 2-\lambda & 3+4i \\ 3-4i & 2-\lambda \end{bmatrix}$$

$$|A - \lambda I| = 0$$

$$\boxed{\cancel{(2-\lambda)^2 [(3+4i)(3-4i)] = 0} \quad \cancel{(\lambda-2)^2 (9+16) = 0} \quad \cancel{(\lambda-2)^2 = 0} \quad \boxed{\lambda = 2, 2}}$$

$$(2-\lambda)^2 - (9+16) = 0$$

$$4 + \lambda^2 - 4\lambda - 25 = 0$$

$$\lambda^2 - 4\lambda - 21 = 0$$

$$\boxed{\lambda = 7, -3}$$

Calculation of Eigen vectors :-

Eigen vector corresponding to $\lambda = 7$

$[A - 7I] X_1 = 0$

$$\begin{bmatrix} -5 & 3+4i \\ 3-4i & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$-5x_1 + 3x_2 + 4ix_2 = 0$ — ①

$+3x_1 - 4x_1 i - 5x_2 = 0$ — ②

from equation ①

$x_1 = \frac{(3+4i)x_2}{5}$ — ③

Substitute equation ③ in ②

$\frac{(3-4i)(3+4i)x_2}{5} = 5x_2$

$\cancel{25 x_2 = 0}$

$x_2 = 0$

$x_1 = 0$

$X_1 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

Eigen vector corresponding to $\lambda = -3$

$[A + 3I] X_2 = 0$

$$\begin{bmatrix} 5 & 3+4i \\ 3-4i & 5 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$5y_1 + (3+4i)y_2 = 0$

$(3-4i)y_1 + 5y_2 = 0$

$y_2 = \frac{(3-4i)y_1}{-5}$

$5y_1 + (3+4i)y_2 = 0$

$5y_1 - \frac{(3+4i)(3-4i)}{5} y_1 = 0 \Rightarrow y_1 = 0$

$y_2 = 0$

$X_2 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

7

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Q.5 (b) How nano materials differ from normal materials in their characteristics? State the reasons behind change in their nature at nano-scale. What is buckminister fluorene? Give important application of this nano material.

[12 marks]

Solution :- Nano materials :-

Their size varies from 1nm to 100 nm and at least one - dimension should be in nano range.

At such a small size surface to volume ratio increases and more atoms will get ~~chang~~ chance to exhibit their performance.

At such a small size electrical, mechanical, magnetic and optical characteristic differs than the bulk material (same material).

→ Buckministe fluorene (C_{60}) is a allotrope of Carbon. It has 20- hexa and 12- Penta structure. It is generally used in CNT (Carbon nano tube) as an hemisphere at both the corners.

Application of Nano Materials :-

→ To change electrical characteristic of material.

→ Used in Medical science.

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→ Useful in Quantum physics.

→ Used in optical experiments

→ Used as magnetic materials

→ Used in industries [like steel etc].

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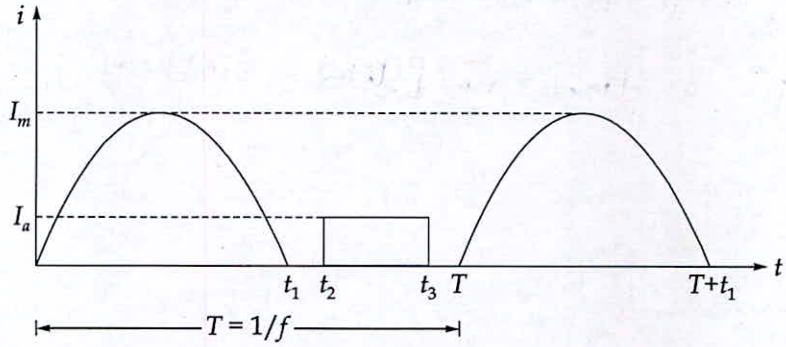
Q.5 (c) The current passing through a diode is shown in waveform.

Determine :

(i) rms current;

(ii) average diode current

if $t_1 = 100\ \mu s$, $t_2 = 350\ \mu s$, $t_3 = 500\ \mu s$, $f = 250$ Hz, $f_s = 5$ kHz, $I_m = 450$ A and $I_a = 150$ A.



[12 marks]

Q.5 (d) Urn *A* contains 6 red and 4 black balls and Urn *B* contains 4 red and 6 black balls. One ball is drawn at random from Urn A and placed in Urn *B*. Then one ball is drawn at random from Urn *B* and place in Urn *A*. If one ball is now drawn at random from Urn *A*, find the probability that it is red.

[12 marks]

Solution:

$$\boxed{\begin{matrix}6R\\4B\end{matrix}}_{A} \qquad \boxed{\begin{matrix}4R\\6B\end{matrix}}_{B}$$

$\cancel{P_A(R) = P_A(B)}$

$$P(R) = P_A(R)\,P_B(R)\,P_A(R) + P_A(R)\,P_B(B)\,P_A(R) + P_A(B)\,P_B(R)\,P_A(R) + P_A(B) * P_B(B)\,P_A(R)$$

$$P(R) = \frac{6}{10}\times\frac{5}{11}\times\frac{6}{10} + \frac{6}{10}\times\frac{6}{11}\times\frac{5}{10} + \frac{4}{10}\times\frac{4}{11}\times\frac{7}{10} + \frac{4}{10}\times\frac{7}{11}\times\frac{6}{10}$$

$$P(R) = \frac{1}{1100}\left[180 + 180 + 112 + 168\right]$$

$$P(R) = \frac{640}{1100}$$

$$\boxed{P(R) = \frac{32}{55} \text{ or } 0.581}$$

11

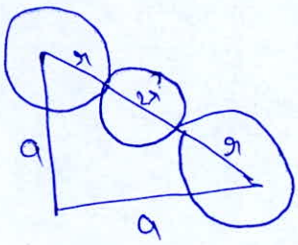
Good approach

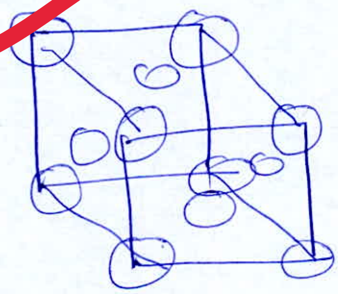
Q.5 (e) How are the atoms arranged in FCC crystal structure? Derive atomic packing factor of FCC materials.

[12 marks]

Solution: FCC crystal Structure:- Atoms are arranged in each corner and at each face, so total number of atoms per FCC structure.

$$n = \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$$





$$a^2 + a^2 = (4r)^2$$

$$2a^2 = (4r)^2$$

$$\boxed{4r = \sqrt{2}a}$$

$$\text{Atomic Packing density} = \frac{n \times \text{Volume of one atom}}{\text{Volume of cube}}$$

$\because$ Cube has dimension $= a$

Volume $= a^3$

$$APF = \frac{n \times \frac{4}{3}\pi r^3}{a^3}$$

$$= \frac{4 \times \frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{2}}\right)^3}$$

$$= \frac{\frac{16}{3}\pi r^3}{\frac{64}{2\sqrt{2}}a^3}$$

APF = 0.74

$\boxed{APF = 74\%}$

Good approach

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Q.6 (a) A 1-ϕ semi converter is connected to 240 V, 50 Hz supply. The load current I_0 can be assumed to be continuous and ripple free. Calculate the harmonic factor of input current for $\alpha = \frac{\pi}{2}$ rad. Derive all the relevant formulae used using Fourier series analysis. Also obtain the expression for rms value of supply current and rms value of fundamental current in term of I_0 and α.

[20 marks]

Solution:-

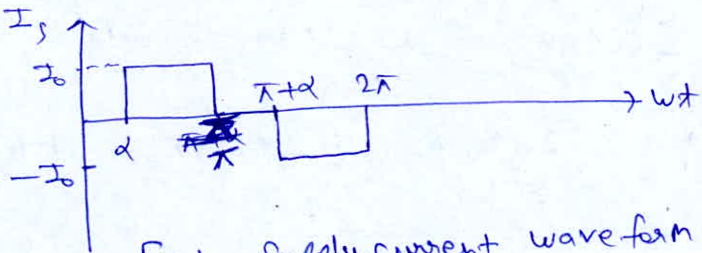


Fig:- Supply current waveform.

Supply current or Input current Fourier series Analysis :-

$$i_s = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n \cos n\omega t + b_n \sin n\omega t)$$

$$a_0 = \frac{2}{2\pi}\left[\int_0^{2\pi} i(s)\, d(\omega t)\right]$$

$$a_0 = \frac{1}{\pi}\left[\int_\alpha^{\pi} I_0\, d(\omega t) + \int_{\pi+\alpha}^{2\pi} -I_0\, d(\omega t)\right]$$

$$\boxed{a_0 = 0}$$

$$a_n = \frac{1}{\pi}\int_0^{2\pi} i(s) \cos n\omega t\, d(\omega t)$$

$$a_n = \frac{1}{\pi}\left[\int_\alpha^{\pi} I_0 \cos n\omega t\, d(\omega t) + \int_{\pi+\alpha}^{2\pi} -I_0 \cos n\omega t\, d(\omega t)\right]$$

$$a_n = \frac{I_0}{n\pi}\left[\left[\sin n\omega t\right]_\alpha^{\pi} - \left[\sin n\omega t\right]_{\pi+\alpha}^{2\pi}\right]$$

$$a_n = \frac{I_0}{n\pi}\left[\sin n\pi - \sin n\alpha - \sin 2n\pi + \sin n(\pi+\alpha)\right]$$

$$a_n = \frac{I_0}{n\pi}\left[-2\sin n\alpha\right] \Rightarrow \boxed{a_n = \frac{-I_0 2}{n\pi}\sin n\alpha}$$

Do not write in this margin

$$b_n = \frac{1}{\pi}\left[\int_{\alpha}^{\pi} I_0 \sin n\omega t \, d(\omega t) + \int_{\pi+\alpha}^{2\pi} -I_0 \sin n\omega t \, d(\omega t)\right]$$

$$b_n = \frac{I_0}{n\pi}\left[\left(-\cos n\omega t\right)_{\alpha}^{\pi} - \left(-\cos n\omega t\right)_{\pi+\alpha}^{2\pi}\right]$$

$$b_n = \frac{I_0}{n\pi}\left[\cos n\alpha - \cos n\pi - \cos n(\pi+\alpha) + \cos 2\pi n\right]$$

$$\cancel{b_n} = \cancel{\frac{2 I_0 \cos n\alpha}{n\pi}} \quad \boxed{b_n = \frac{I_0}{n\pi}\left[2\cos n\alpha - \cos n\pi + \cos 2n\pi\right]}$$

$$C_n = \sqrt{a_n^2 + b_n^2}$$

$$\hat{I}_s = \sqrt{\left(\frac{2I_0}{n\pi}\right)^2 + \left[\frac{I_0}{n\pi}\left(2\cos n\alpha - \cos n\pi + \cos 2n\pi\right)\right]^2}$$

$$\hat{I}_s = \sqrt{\left(\frac{2I_0}{n\pi}\right)^2 + \left[\frac{2I_0}{n\pi}\left(\cos n\alpha + 1\right)\right]^2} \quad [n = 1, 3, 5 \ldots]$$

$$\hat{I}_s = \sqrt{\left(\frac{2I_0}{n\pi}\right)^2 + \left(\frac{2I_0}{n\pi}\cos n\alpha\right)^2 + \left(\frac{2I_0}{n\pi}\right)^2 + 2\left(\frac{2I_0}{n\pi}\right)\left(\cos n\alpha + 1\right)}$$

→ on solving, we will get,

$$\hat{I}_s = \frac{4I_0}{n\pi}\cos\left(\frac{\pi}{2} - \alpha\right)$$

$$I_s = \frac{4I_0}{n\pi}\sin n\alpha \, \sin n\omega t$$

$$I_{s1rms} = \frac{2\sqrt{2} I_0}{\pi}\sin\alpha \quad \text{—— (1)}$$

$$I_{sr} = \left(\frac{\pi-\alpha}{\pi}\right)^{1/2} I_0 \quad \text{—— (2)}$$

then, $g = \frac{I_{s1}}{I_{sr}}$

$$g = \frac{\frac{2\sqrt{2}I_o}{\pi}}{I_o\left(\frac{\pi-\alpha}{\pi}\right)^{1/2}} \quad — (3)$$

$$THD = \sqrt{\frac{1}{g^2} - 1} \quad — (4)$$

for $\alpha = \frac{\pi}{2}$

$$g = \frac{\frac{2\sqrt{2}}{\pi}}{\frac{1}{\sqrt{2}}} = \frac{4}{\pi}$$

12

Q.6 (b) **(i)** Find the solution of differential equation

$$x^2\frac{d^2y}{dx^2} - 2y = x^2 + \frac{1}{x}$$

(ii) Find the area common to the parabola $y^2 = ax$ and the circle $x^2 + y^2 = 4ax$.

[10 + 10 marks]

Solution:- (i) $x^2\frac{d^2y}{dx^2} - 2y = x^2 + \frac{1}{x}$ —— ①

$$\frac{d^2y}{dx^2} - \frac{2}{x^2}y = 1 + \frac{1}{x^3}$$

Substitute $x = e^t$, $\frac{d^2y}{dx^2} = \theta(\theta-1)$, $\frac{dy}{dx} = \theta$

where, $\theta = \frac{d}{dt}$

then, by equation ①

$$\theta(\theta-1) - 2 = e^{2t} + e^{-t}$$

$$\theta^2 - \theta - 2 = e^{2t} + e^{-2t}$$

Solution of this equation $Y = Y_{CF} + Y_{PI}$ —— ②

Calculation of Y_{CF},

$$\theta^2 - \theta - 2 = 0$$

$$\theta = 2, -1$$

$$Y_{CF} = C_1 e^{2t} + C_2 e^{-t}$$ —— ③

Calcution of Y_{PI},

$$Y_{PI} = \frac{1}{\theta^2 - \theta - 2}\left[e^{2t} + e^{-t}\right]$$

$$Y_{PI} = \frac{1}{\theta^2-\theta-2}e^{2t} + \frac{1}{\theta^2-\theta-2}e^{-t}$$

~~$Y_{PI} = \frac{t}{2\theta-1}e^{2t} + \frac{e^{-t}}{(-1)^2-(-1)-2}$~~

$$Y_{PI} = \frac{t}{2\theta-1}e^{2t} + \frac{1}{2\theta-1}e^{-t}$$

$$y_{PI} = \frac{t}{3}e^{2t} - \frac{1}{3}e^{-t} \quad \text{--- (4)}$$

Substitute equation (3) and (4) in (2)

$$y = c_1 e^{2t} + c_2 e^{-t} + \frac{t}{3}e^{2t} - \frac{1}{3}e^{-t}$$

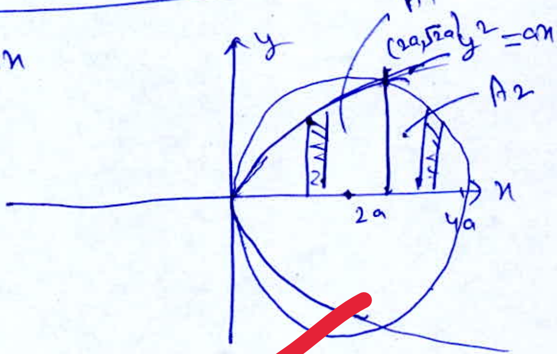
Substitute $t = \ln x$

$$y = c_1 e^{2\ln x} + c_2 e^{-\ln x} + \frac{\ln x}{3} e^{2\ln x} - \frac{1}{3} e^{-\ln x}$$

$$\boxed{y = c_1 x^2 + \frac{c_2}{x} + \frac{\ln x}{3}\cdot x^2 - \frac{1}{3x}}$$

Good approach

(ii) $y^2 = ax, \quad x^2 + y^2 = 4ax$



$$x^2 + y^2 - 4ax = 0$$

$$x^2 + y^2 - 4ax + 4a^2 - 4a^2 = 0$$

$$(x-2a)^2 + y^2 = (2a)^2$$

$x^2 + y^2 = 4ax$

Put $y^2 = ax$

$x^2 + ax = 3ax$ [sic]

$x^2 = 2ax$

$x = 2a$

and $y^2 = 2a^2$

$y = \sqrt{2}a$

$$A_1 = \int_{x=0}^{2a} \int_{y=0}^{\sqrt{ax}} dy\, dx$$

$$A_2 = \int_{x=2a}^{4a} \int_{y=0}^{\sqrt{4ax - x^2}} dy\, dx$$

Total area will be twice of $(A_1 + A_2)$

$$A_1 = \int_{x=0}^{2a} \sqrt{ax}\, dx \Rightarrow A_1 = \int_{x=0}^{2a} \sqrt{ax}\, dx$$

let $ax = t^2$

$a = \frac{2t\,dt}{dx}$

$dx = \frac{2t\,dt}{a}$

then, $A_1 = \int_{t=\sqrt{a}}^{\sqrt{2}a} \frac{2t^2}{a} dt = \frac{2}{3a}\left[t^3\right]_{\sqrt{a}}^{\sqrt{2}a}$

$$A_1 = \frac{2}{3a}\left[2\sqrt{2}a^3 - a^{3/2}\right]$$

$$A_2 = \int_{x=2a}^{4a} \int_{y=0}^{\sqrt{4ax-x^2}} dy\, dx$$

$$A_2 = \int_{x=2a}^{4a} \sqrt{4ax-x^2}\, dx$$

$\sqrt{4ax-x^2} = t^2 \Rightarrow 4ax - x^2 = t$

$4a - 2x = dt$

4

4

Incomplete solution

Q.6 (c) **(i)** Find the eigen values and eigen vectors of matrix

$$A = \begin{bmatrix} 3 & 1 & 4 \\ 0 & 2 & 6 \\ 0 & 0 & 5 \end{bmatrix}$$

(ii) A paramagnetic substance contains 6.5×10^{25} atoms per m^3 and the magnetic moment of each atom is one Bohr magneton. Find the susceptibility at 300 K temperature.

[12 + 8 marks]

Solution: (i) $A = \begin{bmatrix} 3 & 1 & 4 \\ 0 & 2 & 6 \\ 0 & 0 & 5 \end{bmatrix}$

Characteristic matrix = $A - \lambda I$

$$A - \lambda I = \begin{bmatrix} 3-\lambda & 1 & 4 \\ 0 & 2-\lambda & 6 \\ 0 & 0 & 5-\lambda \end{bmatrix}$$

$\because |A - \lambda I| = 0$ [will given eigen values]

$|A - \lambda I| = (3-\lambda)\left[(2-\lambda)(5-\lambda) - 0\right] = 0$

$(3-\lambda)(10 + \lambda^2 - 5\lambda - 2\lambda) = 0$

$(3-\lambda)(\lambda^2 - 7\lambda + 10)$

$-(\lambda-3)(\lambda-5)(\lambda-2) = 0$

$\boxed{\lambda = 2, 3, 5}$

Eigen vector corresponding to $\lambda = 2$

$[A - 2I]X_1 = 0$

$$\begin{bmatrix} 1 & 1 & 4 \\ 0 & 0 & 6 \\ 0 & 0 & 3 \end{bmatrix}\begin{bmatrix} x_1 \\ y_1 \\ z_1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$x_1 + y_1 + 4z_1 = 0$, Eigenvector $X_1 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$

$y_1 = 0$

$z_1 = 0$

$x_1 = 0$

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Eigen vector corresponding to $\lambda = 3$

$$\begin{bmatrix} 0 & 1 & 4 \\ 0 & -1 & 6 \\ 0 & 0 & 2 \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ z_2 \end{bmatrix} = 0$$

$z_2 = 0$

$-y_2 + 6z_2 = 0$

$y_2 = 0$

Eigenvector $X_2 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$

Eigen vector corresponding to $\lambda = 5$

$$\begin{bmatrix} -2 & 1 & 4 \\ 0 & -3 & 6 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_3 \\ y_3 \\ z_3 \end{bmatrix} = 0$$

$-2x_3 + y_3 + 4z_3 = 0$

$-3y_3 + 6z_3 = 0$

So, $z_3 = K$

$\therefore y_3 = 2K$

$-2x_3 = -2K - 4K$

$x_3 = 3K$

Eigen vector $X_3 = \begin{bmatrix} 3K \\ 2K \\ K \end{bmatrix}$

(ii) Given data:- $n = 6.5 \times 10^{25} \frac{atoms}{m^3}$

$P_m = 1 \mu_B$

Find:- χ

Solution:- $\because \chi = \frac{N P_m^2 \mu_0}{3KT}$

$$\chi = \frac{6.5 \times 10^{25} \times 9.24 \times 9.24 \times 10^{-28} \times 4\pi \times 10^{-7}}{3 \times 1.38 \times 10^{-23} \times 300}$$

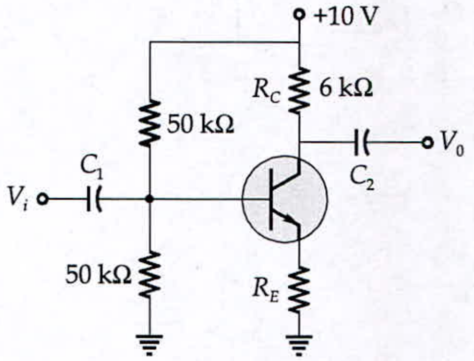
$$\delta = \frac{6973.76 \times 10^{-10}}{1242 \times 10^{-23}}$$

$$\boxed{\delta = 5.615 \times 10^{13}}$$

7

Go through the made easy solution

Q.7 (a) (i) Common emitter (CE) amplifier shown in figure has voltage gain of 200 when $R_E = 0$. Stability is brought through negative feedback by adding resistor R_E. Calculate the value of resistor R_E using feedback concepts so that final voltage gain (A_{FB}) is equal to 100.



[10 marks]

Solution:-

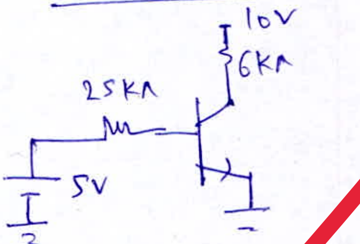
Given data:- $A = 200$

$A_{FB} = 100$

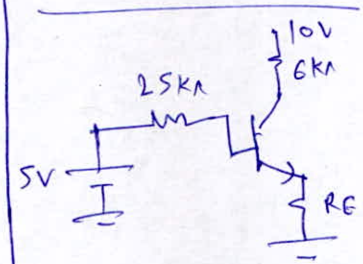
Find:- R_E

DC analysis:-

when $R_E = 0$

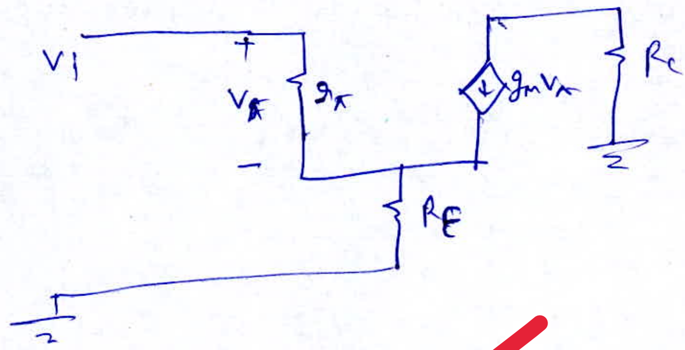


when $R_E = 0$



$I_B = \frac{5-0.7}{25}$

$I_B = 0.172\,mA$



$\because$ $A_{FB} = \dfrac{A}{1+A\beta}$

$100 = \dfrac{200}{1+200\beta}$

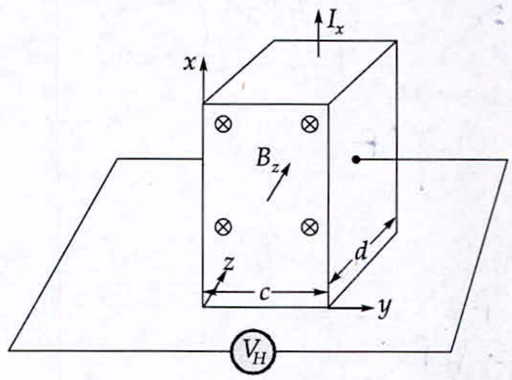
$1+200\beta = 2$

$\beta = \dfrac{1}{200}$

$\boxed{\beta = 0.005}$

5

Q.7 (a) **(ii)** What is Hall effect? For a parallelepiped specimen having one corner situated at origin and externally applied electric field causing current in positive x-direction as shown below :



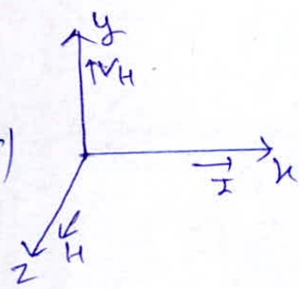
State what happens when magnetic field B_z is applied in positive z-direction in reference to Hall voltage. Determine electron mobility relation using Hall coefficient and conductivity (σ).

[10 marks]

Solution: Hall Effect :- When in a specimen, electric current and magnetic field is applied in perpendicular direction, then, there will be generation of Hall Voltage in perpendicular to both ~~apply~~ applied magnetic field and current.

$\because$ Current is in x- direction.
$\therefore$ magnetic field is in z- direction
then, Hall voltage will be generated in y- direction.

$\because$ At balance,



Electric field(F) = Magnetic field(F)

Electric field force $= q E_H$

Magnetic field force $= q V_d B$

then, $qE_H = qV_d B$

$$E_H = V_d B \quad \text{--- (1)}$$

$\because J = neV_d$

$$V_d = \frac{J}{ne} \quad \text{--- (2)}$$

Substitute equation (2) in (1)

$$E_H = \frac{JB}{ne} \quad \text{--- (3)}$$

Multiply and divide 'μ' (mobility)

$$E_H = \frac{JB\mu}{ne\mu}$$

$$E_H = \frac{JB\mu}{\sigma} \quad \text{--- (4)}$$

from equation (3)

$$E_H = \frac{JB}{ne}$$

$$\frac{V_H}{d} = \frac{JB}{ne} \Rightarrow V_H = \frac{JdB}{ne}$$

$\because J = \sigma E$

$$V_H = \frac{\sigma E d B}{ne}$$

$$\boxed{V_H = \sigma R_H E d B}$$

$\boxed{\text{where, } R_H = \frac{1}{ne}}$

9

Good approach

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Q.7 (b) **(i)** A three-phase fully-controlled bridge converter is connected to three-phase a.c. supply of 400 V, 50 Hz and operates with a firing angle $\alpha = \frac{\pi}{4}$. The load current is maintained constant at 10 A and the load voltage is 360 V. Find source inductance, L_S and overlap angle μ.

[12 marks]

Given data:- 3ϕ, $400V$, $50Hz$, $\alpha = \frac{\pi}{4}$

$I_o = 10A$, $V_o = 360V$

Find:- L_s and μ

Solution:- In 3ϕ fully controlled bridge,

$$\Delta V_{do} = \frac{3V_{ml}}{2\pi}\left[\cos\alpha - \cos(\alpha+\mu)\right] = 6fL_sI_o \quad \text{—— (1)}$$

and

$$V_o = \frac{3V_{ml}}{2\pi}\left[\cos\alpha + \cos(\alpha+\mu)\right] \quad \text{—— (2)}$$

then,

$$360 = \frac{3\times 400\sqrt{2}}{2\pi}\left[\cos\frac{\pi}{4} + \cos(\alpha+\mu)\right]$$

$$\cos\left(\frac{\pi}{4}+\mu\right) = 0.625$$

$$\boxed{\mu = 6.262}$$

from equation (1)

$$\frac{3V_{ml}}{2\pi}\left[\cos\alpha - \cos(\alpha+\mu)\right] = 6fL_sI_o$$

$$\frac{1200\sqrt{2}}{2\pi}\left[0.7071 - 0.6257\right] = 6\times 50\times L_s\times 10$$

$$\boxed{L_s = 7.3285\ mH}$$

Good approach

Do not write in this margin

Q.7 (b) **(ii)** A magnetizing field of 500 Am^{-1} produces a magnetic flux of 2.4×10^{-5} weber in an atom bar of 0.2 cm^2 cross-sectional area. Compute the permeability and susceptibility of the bar.

[8 marks]

Given data :- $H = 500\ Am^{-1}$

Area $= 0.2\ cm^2$

$\phi = 2.4 \times 10^{-5}\ Wb$

find :- μ, χ

Solution :- $\because$ flux density $B = \frac{\phi}{A}$

$$B = \frac{2.4 \times 10^{-5}}{0.2 \times 10^{-4}} \Rightarrow B = 1.2 \frac{wb}{m^2}$$

$\because$ $B = \mu H$

$$\mu = \frac{1.2}{500} \Rightarrow \boxed{\mu = 2.4 \times 10^{-3}}$$

$\because$ $\chi = \mu_r - 1$

$\because$ $\mu = \mu_0 \mu_r = 2.4 \times 10^{-3}$

$$\mu_r = \frac{2.4 \times 10^{-3}}{4\pi \times 10^{-7}} = 1909.86$$

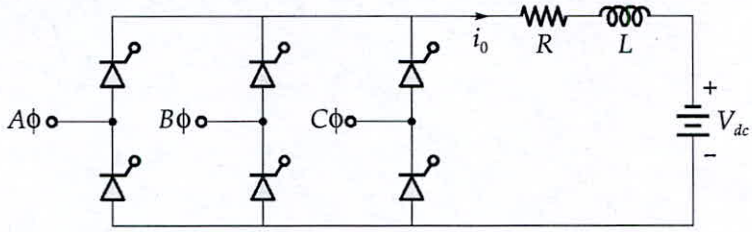
then, $\boxed{\chi = 1908.86}$

8

Good approach

Do not write in this margin

Q.7 (c) **(i)** The six pulse converter shown in figure has a delay angle $\alpha = 120°$. The three-phase ac system is 4160 V rms line to line. The dc source is 3000 V, $R = 2\ \Omega$ and L is large enough to consider the current to be purely dc. Determine the power transferred to the ac source from the dc source and the value of L such that the peak to peak variation in load current is 10 percent of the average load current.



[12 marks]

Solution:-

Given data:- $\alpha = 120°$, $V_{line} = 4160\text{ V}$

$V_{dc} = 3000\text{ V}$, $R = 2\ \Omega$

Find:- Power transferred by dc source.

Solution:-

$$V_{oavg} = \frac{3V_{ml}}{\pi}\cos\alpha$$

$$V_{oavg} = -2808.98\text{ V}$$

$$\because\ V_o = -E + I_o R$$

$$\frac{-2808.98 + 3000}{2} = I_o$$

$$I_o = 95.506\text{ A}$$

Power transferred by dc source,

$$I_o E = V_o I_o - I_{or}^2 R$$

6

Incomplete solution

Do not write in this margin

Q.7 (c) **(ii)** For a specimen of V_3Ga, the critical fields are respectively 0.176 T and 0.528 T for 14 K and 13 K represents. Calculate the transmission temperatures and critical fields at 0 K and 4.2 K.

[8 marks]

Given data :- $H_{c1} = 0.176\,T$, $T_1 = 14\,K$

$H_{c2} = 0.528\,T$, $T_2 = 13\,K$

Find :- T_c, H_{co}, H_c at 4.2 K

Solution :- As we know,

$$H_c = H_{co}\left[1-\left(\frac{T}{T_c}\right)^2\right]$$

$$H_{c1} = H_{co}\left[1-\left(\frac{T_1}{T_c}\right)^2\right] \quad \text{--- (1)}$$

$$H_{c2} = H_{co}\left[1-\left(\frac{T_2}{T_c}\right)^2\right] \quad \text{--- (2)}$$

Divide equation (1) by (2)

$$\frac{H_{c1}}{H_{c2}} = \frac{\left[1-\left(\frac{T_1}{T_c}\right)^2\right]}{\left[1-\left(\frac{T_2}{T_c}\right)^2\right]}$$

$$\frac{0.176}{0.528} = \frac{[T_c^2 - 14^2]}{[T_c^2 - 13^2]}$$

$$0.176\,T_c^2 - 29.744 = 0.528\,T_c^2 - 103.488$$

$$0.352\,T_c^2 = 73.744$$

$$\boxed{T_c = 14.474\,K}$$

Now, from equation (1)

$$0.176 = H_{co}\left[1-\left(\frac{14}{14.474}\right)^2\right]$$

$$\boxed{H_{co} = 2.7318\,T}$$

At T= 4.2 K

~~From equation 1~~

$$H_c = 2.731\left[1-\left(\frac{4.2}{14.474}\right)^2\right]$$

$$\boxed{H_c = 2.5\ T}$$

$$\boxed{\begin{aligned} T_c &= 14.474\ K \\ H_{c_0} &= 2.7318\ T \\ H_{c_{4.2}} &= 2.5\ T \end{aligned}}$$

6

Good approach

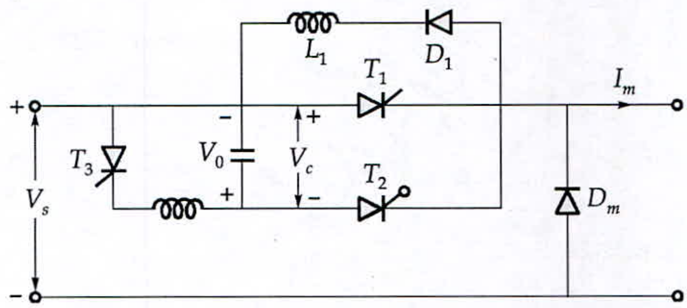
Q.8 (a) A 3-phase full converter, fed from 3-phase, 400 V, 50 Hz source is connected to a load having a series $R = 10\ \Omega$, $E = 350$ V and a large inductance so that the output current is ripple free. Calculate the power delivered to the load and input power factor for

(i) firing angle of 30°.

(ii) firing advance angle of 60°.

[20 marks]

Q.8 (b) **(i)** Consider the commutation circuit as shown in figure. It has capacitance $C = 20\ \mu F$ and recharging inductor $L_1 = 25\ \mu H$. The initial capacitor voltage is equal to the input voltage, $V_o = V_s = 200$ V. If the load current, I_m varies between 50 A and 200 A, determine the variations of the circuit turn-off time. Also comment upon the result.



[10 marks]

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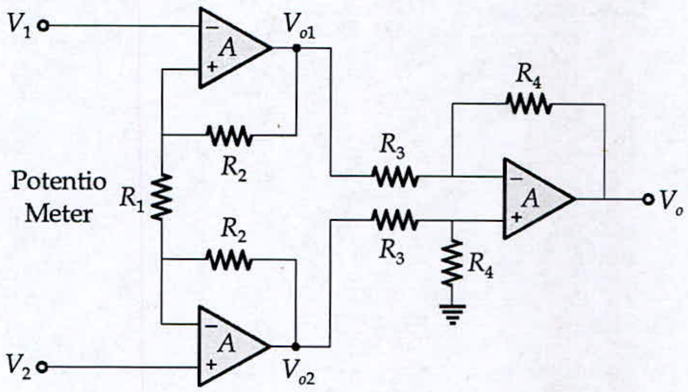
Q.8 (b) **(ii)** Design an instrument amplifier to have a variable differential gain in range 5 to 200. Use a 50 kΩ potentiometer.



[10 marks]

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Q.8 (c) Explain with circuit diagram the advantages of clapp oscillator over colpitt oscillator. If in the circuits $C_1 = C_2 = 150$ pF and $L_3 = 50$ μH and the value of additional capacitor used in clapp oscillator $C_S = 10$ pF. Find the frequency of oscillations for:

(i) Colpitt oscillator.

(ii) Clapp oscillator.

[20 marks]

$(x - \sqrt{2a})^2$

$(x \mp 2a)^2$

$x^2 + 2a - 2$

$x^2 + 4a^2 \mp 2ax$

$2a = 4a$

$x - \sqrt{2}\sqrt{a}$

$x^2 + 2a$

$(x - 2a)^2$

$x^2 + 4a^2 - 4ax$

$$\frac{\sin\phi}{\cos\phi} = \frac{P_1 - 2P_2}{P_1}$$

4
8
16
32
64

$\cos\phi$

$\cos\phi \; \cos(\alpha - \beta)$

Space for Rough Work

$x_2 = K$

$H_c = H_{c0}\left[1 - \frac{T}{}\right.$

$y_2 + 4z_2$

$e^t \quad \frac{dx}{d}$

$B = \Phi A$

$\Phi = BA$

$B = \frac{wb}{m^2} / T$

Cos2hr

$+4$

$-$

$B = \frac{\Phi}{A}$

$+1$

$\frac{IA}{2R}$

$\frac{1}{wc}$

$\frac{V_c}{V_R} =$

$\cos n\alpha + 1$

$J = \frac{\Im}{r}$

$\frac{a_m}{h}$

$\Phi = BA$

$\frac{I_c}{I_R} =$

$B = \Phi A$

w

$wR \quad B = \frac{\Phi}{A}$

$+1^2$

$\tan\phi = \frac{wL}{R}$

$\frac{4I_0}{n\pi}$ sin nd sin wt

μE

$\frac{1}{wRC} \quad B = T$

$\frac{ne V_d B}{ne}$

1 8 24
28

$\frac{4I_0}{n\pi} \cos\left(\frac{\pi}{2} - d\right)$

$\frac{-2I}{n\pi}$

sin d

1 7 23

$x^2 d^2$

$B = \frac{\Phi}{A}$

64

$x = e^t$

$V_H = V_d B d$

$\frac{d}{dt} = \theta$

$V_H = \mu E B d$

1 11 52

B

1 7 24

$\theta(\theta - 1) - 2\theta$

$V_H = \frac{J}{ne} B d$

$= e^{2t} + e^t$

θ

σE

2^{n-1}

θ

$B n$

R_n

σ

$x^3 \frac{d^2y}{dx^2}$

2^{8-1}

27

$ne\mu$

$\sigma_H = \mu E B$

$1 + 1$