· Try to avoid calculation mistake

· Improve presentation

MADE EASY

Leading Institute for ESE, GATE & PSUs

ESE 2026 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Electrical Engineering

Test-7 : Computer Fundamentals + Elec. & Electro. Measurements + Power Electronics & Drives-1 + Engineering Mathematics-1 + B.E.E.-2 + Analog Electronics-2 + Electrical Materials-2

Name : ....

Roll No :

Test Centres			Student's Signature
Delhi ☑	Bhopal ☐	Jaipur ☐	
Pune ☐	Hyderabad ☐		

Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. There are Eight questions divided in TWO sections.
3. Candidate has to attempt FIVE questions in all in English only.
4. Question no. 1 and 5 are compulsory and out of the remaining THREE are to be attempted choosing at least ONE question from each section.
5. Use only black/blue pen.
6. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
7. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
8. There are few rough work sheets at the end of this booklet. Strike off these pages after completion of the examination.

FOR OFFICE USE	
Question No.	Marks Obtained
Section-A	
Q.1	27
Q.2	
Q.3	
Q.4	26
Section-B	
Q.5	48
Q.6	
Q.7	43
Q.8	36
Total Marks Obtained	180

Signature of Evaluator: Sourabh kumar

Cross Checked by: ....

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.

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.

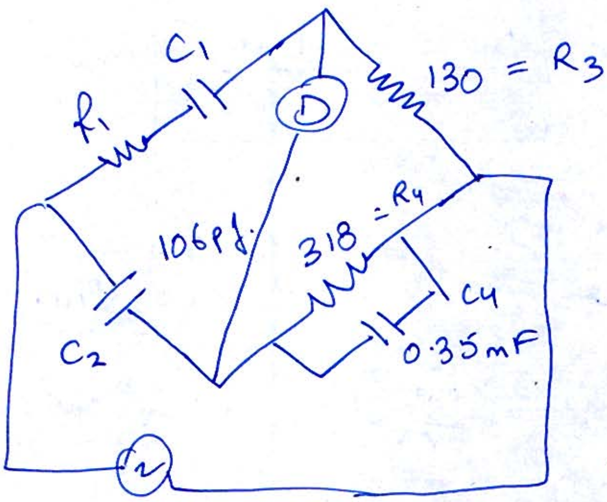
0, 4, 8, 20, 24, 36, 44, 12, 68, 72, 80, 84, 28, 32, 88, 92

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]

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]



Schering bridge

Now for balancing the eqn's are.

$$\boxed{Z_1 Z_4 = Z_2 \times Z_3}$$

$Z_1 = R_1 + \frac{1}{j\omega C_1}$ $\quad Z_2 = -\frac{j}{\omega C_2}$

$\frac{R_4 \times \frac{1}{j\omega C_4}}{R_4 + \frac{1}{j\omega C_4}}$

$Z_3 = R_3 = 130\Omega$ $\quad Z_4 = \frac{R_4}{j\omega C_4 R_4 + 1}$

$$\left(R_1 + \frac{1}{j\omega C_1}\right)\frac{R_4}{(j\omega C_4 R_4 + 1)} = -\frac{j}{\omega C_2} \times R_3$$

$$\frac{(R_1\omega j C_1 + 1)\, R_4\, (1 - j\omega C_4 R_4)}{j\omega C_1 (1 + \omega^2 C_4^2 R_4^2)} = -\frac{jR_3}{\omega C_2}$$

$$(R_4 R_1 \omega j C_1 + R_4)(1 - j\omega C_4 R_4) = \frac{R_3 \omega C_1 (1 + \omega^2 C_4^2 R_4^2)}{\omega C_2}$$

$$R_4 R_1 \omega j C_1 + \omega^2 R_4^2 R_1 C_1 C_4 + R_4 - j\omega C_4 R_4^2 = \frac{R_3 C_1 (1 + \omega^2 C_4^2 R_4^2)}{C_2}$$

on Comparing img & Real terms.

$j(R_4 R_1 \omega C_1 - \omega R_4^2 C_4) = 0$

$\omega^2 R_4^2 R_1 C_1 C_4 + R_4 = \frac{R_3 C_1}{C_2}(1 + \omega^2 C_4^2 R_4^2)$

$R_1 \omega C_1 R_4 = R_4^2 \omega C_4$ $\boxed{R_1 = \frac{R_4 C_4}{C_1}}$

$R_1 = \frac{318 \times 0.35 \times 10^{-3}}{C_1}$ Now finding C_1 value

$\omega^2 R_4^2 \frac{R_4 C_4}{C_1} \times C_1 C_4 + R_4 = \frac{R_3 C_1}{C_2} + \omega^2 C_4^2 R_4^2 \times \frac{R_3 C_1}{C_2}$

~~$\omega^2 R_4^3 C_4^2 + R_4 = C_1 \left(\frac{R_3}{R_2} + \right.$~~

$\frac{(\omega^2 R_4^3 C_4^2 + R_4) \times C_2}{R_3(1 + \omega^2 C_4^2 R_4^2)} = C_1$

$\frac{R_4(1 + \omega^2 R_4^2 C_4^2) \times C_2}{R_3(1 + \omega^2 C_4^2 R_4^2)} = C_1$

$\boxed{C_1 = \frac{R_4 C_2}{R_3}}$ $\boxed{R_1 = \frac{R_4 C_4}{C_1}}$

putting values

$C_1 = \frac{318 \times 106 \times 10^{-12}}{130} \Rightarrow \boxed{259.29 \text{ pF} = C_1}$

$R_1 = \frac{318 \times 0.35 \times 10^{-3}}{259.29 \times 10^{-12}} \Rightarrow \boxed{R_1 = 429.24 \text{ M}\Omega}$

$P.f = \cos\varphi$ $\varphi = \tan^{-1} \frac{10^6}{314 \times 259.29 \times 429.24}$

$\varphi = 1.638$

$\boxed{P.f = \cos 1.638 = 0.999}$ $\boxed{R_1 = 429.24 \text{ M}\Omega}$ $\boxed{C_1 = 259.29 \text{ pF}}$

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Try to avoid over writing

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]

32 bit precision

format ⇒

M	Biased exponent	Mantisa.
1 bit	11 bit	20 bit

11

Now making in format.

⇒ $1.11111\ldots\ 2^{+29}$

Now finding ⇒ B.E

Biased exponent = A.E + Bias

A.E ⇒ +29.

Bias = $2^{n-1} - 1 = 2^{11-1} - 1$ ⇒ here n = 11

$= 2^{10} - 1 = 1023$

B.E = 1023 + 29 = 1052

Now finding 1052 in binary.

2	1052	0
2	526	0
2	263	1
2	131	1
2	65	1
2	32	0
2	16	0
2	8	0
2	4	0
2	2	0
	1	

⇒ 10000011100 = B.E

Now sign = +ve as MSB bit is 0 not 1.

M	B.E	Mantisa.
0	10000011100	11110011011010000000

4

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]

to increase the voltmeter range we have to put series resistance with it i.e R_s.

$R_s = R_m (m-1)$ where m is magnify voltage.

$m = \frac{300}{100} = 3$.

$R_s = 2000(3-1)$ & R_m is voltmeter resistance

$= 2 \times 2000$

$R_s = 4000\,\Omega$ $\boxed{R_s = 4000\,\Omega}$ *

Now to read both ac & dc without error.

the time constant of (50 Hz) both the coil should be equal.

$\tau = \frac{L}{R} = \frac{L_m}{R_m} = \frac{L_s}{R_s}$.

$\frac{0.6}{2000} = \frac{L_s}{4000}$ $\boxed{L_s = 1.2\text{ H}}$ *

we have to put inductor of 1.2 H in series with R_s.

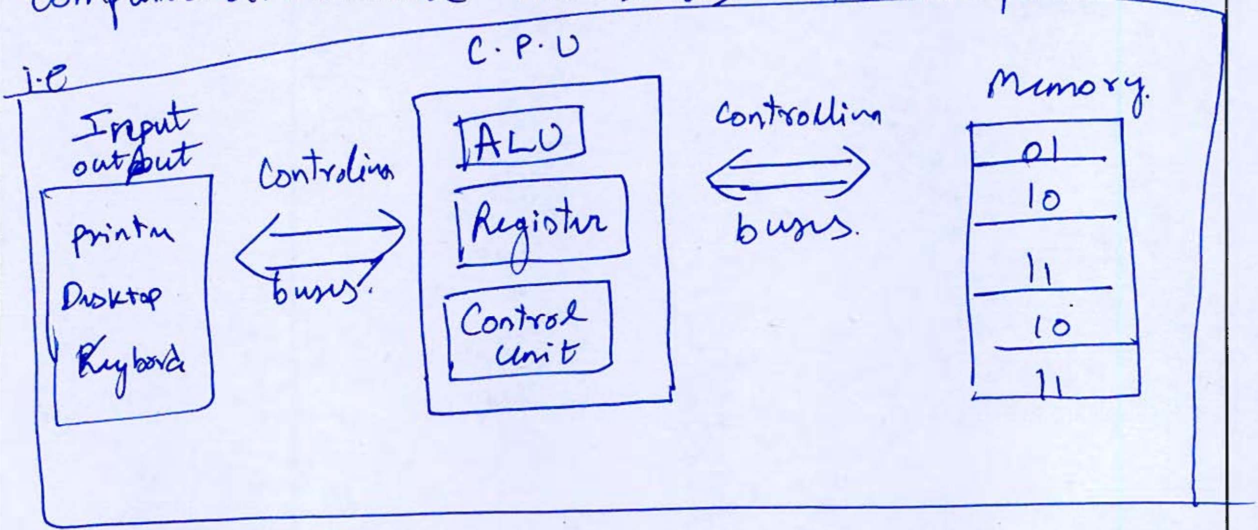
5

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

[12 marks]

Computer architecture means its internal parts.

i.e



in computer architecture the system includes →

① C.P.U (Central processing unit) ② I/p & o/p device.

③ memory.

(i) C.P.U it contains mainly 3 units.

(a) ALU Arthmatic logical unit.
it performs all the calculations of the system through hardwired chip.

(b) Register - These are Registers which is used by the C.P.U to take out the desired o/p.
ex - Accumulator → stores ALU i/p & o/p data.
- Program Counter (PC) → holds the address of the next instruction.
- [IR] instruction register → holds the op code of the data in processing.
- MAR & MDR & lot more.

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(c) Control unit - It is mother of all the system present inside the C.P.U it controls all the Arthmatic calculation & data transfer b/w the I/o devices & memory.

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?

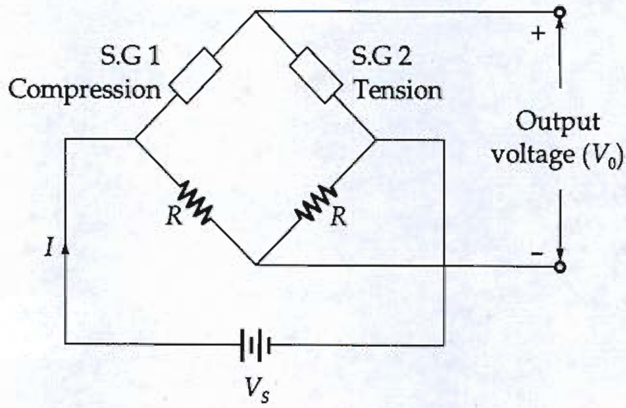
What are different types of ROM used in computer, enumerate and explain briefly?

[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]

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]

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

[8 marks]

Do not write in this margin

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

[12 marks]

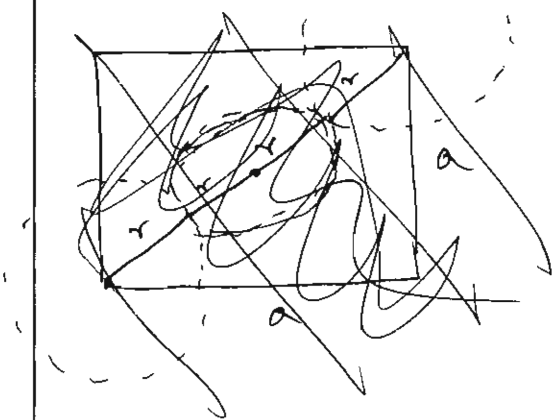
Do not write in this margin

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]



it ,

Not attempted

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

[5 marks]

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

[10 marks]

~~there~~ we can transfer data in many modes.

i.e with the Help of DMA controller.

it has 3 modes to transfer the data.

(i) cycle stealing mode.

(ii) Burst mode.

2

In complete Solution

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]

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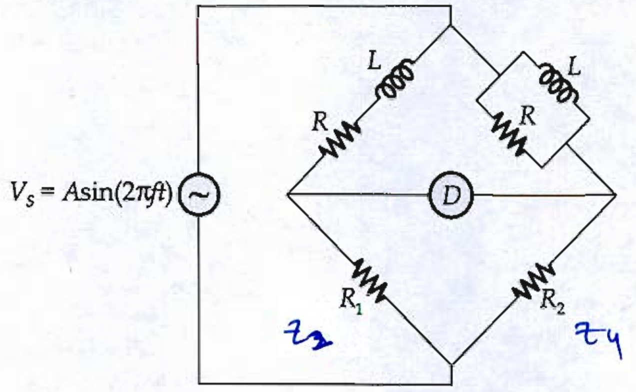
Q.4 (b) (i) Explain briefly the term "Multi Threading" in context to operating system. Give few advantages of multi-threading. How multi-threading is different from multitasking?

[10 marks]

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]

to blance $Z_1 Z_4 = Z_2 \times Z_3$

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

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

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

on comparing Real & imp.

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

$$R_2 R^2 + R_2 \omega^2 L^2 = \omega^2 L^2 R_1$$

$$\omega^2 (L^2 R_1 - R_2 L^2) = R_2 R^2$$

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

$$\omega = \frac{R}{L} \sqrt{\frac{R_2}{R_1 - R_2}}$$

$$\omega = \frac{300}{30\times10^{-3}}\sqrt{\frac{500}{1000-500}}$$

$$= \frac{300 \times 1000}{30} = 10\ \text{K rad/sec}$$

$$f = \frac{10 \times 1000}{2\pi}$$

$$\boxed{f = 1.592\ \text{KHz}}$$

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Good Approach

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]

Sources of errors in electrodynamometer.

① T/w = Torque to weight is very low in the the meter because of the air coiled the flux produce is also low.

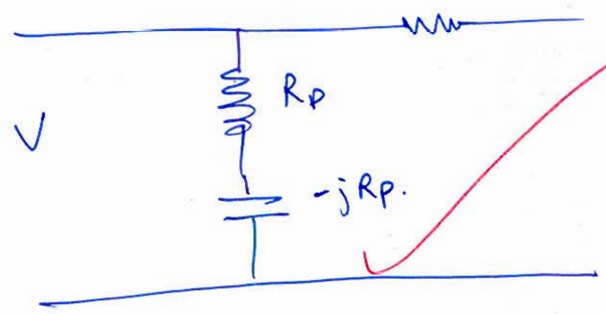
② Eddy current → all the metals are placed little away to reduce Eddy loss. it can create error in reading.

③ Temperature due to this fixed coil resistance can increase & hence can cause error.

④ External magnetic field → as the meter field is very small external magnetic field can also create error in reading.

$X_C = R_P$.

$P = P_2 + P_1$ $\quad Q = \sqrt{3}(P_2 - P_1)$



$$I_p = \frac{V}{R_p - jR_p} \qquad Z = R_p$$

$$I_p = \frac{\sqrt{2} V \sin\omega t}{Z} \qquad I_C = \sqrt{2} V \sin(\omega t - \varphi).$$

$$= \frac{\sqrt{2} V \sin\omega t}{\sqrt{2} R_p \angle 45.} \qquad V = \frac{I}{Z} \qquad \cos\beta.$$

$$|V| = \frac{I_p Z}{\sqrt{2}} = \qquad = \frac{I_p.}{\sqrt{2} R_p \angle -45.}$$

$$I_C = \qquad |V|_p = \frac{I_p}{\sqrt{2} R_P} \angle 45.$$

$$I_c = I \angle -\varphi.$$

$$\text{Wattmeter reading} = V_p \times I \cos(45 + \varphi)$$

$$= P_2. = \frac{I_p}{\sqrt{2} R_p} \cos(45 + \varphi$$

$$P_1 = V_p \times I \cos\varphi.$$

$$\frac{2P_2}{P_1} = \frac{2 \times \frac{1}{\sqrt{2}} \cos(45 + \varphi)}{\cos\varphi.}$$

15

$$1 - \frac{\sqrt{2}\cos(45+\varphi)}{\cos\varphi} = 1 - \frac{2P_2}{P_1}$$

$$\frac{\cos\varphi - (\sqrt{2}(\cos 45 \sin 45 + \sin\varphi \cos\varphi)}{\cos\varphi}$$

$$= \frac{\cos\varphi - \frac{1}{\sqrt{2}} - \sqrt{2}\sin\varphi\cos\varphi}{\cos\varphi.}$$

Ans *

$$1 - \tan\varphi = \frac{2P_2}{P_1}$$

$$\boxed{\tan\varphi = 1 - \frac{2P_2}{P_1}}$$

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]

Hermitian matrix is given by $(\bar{A}^T) = A$

taking conjugate.

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

taking transpose $(\bar{A})^T = \begin{bmatrix} 2 & 3+4i \\ 3+4i & 2 \end{bmatrix}$ —— ①

hence proved $(\bar{A})^T = A$ * it is a hermition matrix.

finding eigen values. $(A - \lambda I) = 0$

$$\begin{vmatrix} 2-\lambda & 3+4i \\ 3-4i & 2-\lambda \end{vmatrix} = 0 \qquad (2-\lambda)^2 - [3^2 + 4^2] = 0$$

$4 - 25 = -21$

$$(2-\lambda)^2 - 25 = 0$$

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

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

eigen values $\lambda_1 = 7$ $\quad \lambda_2 = -3$

Now find eigen vector. $(A - \lambda I)x = 0$

① $\lambda_1 = 7$

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

$-5x_1 + (3+4i)x_2 = 0$

$$5x_1 = (3+4i)x_2.$$

$$\frac{x_1}{x_2} = \begin{bmatrix} 3+4i \\ 5 \end{bmatrix} = X_1 \quad \text{— (2)}$$

Now taking $\lambda_2 = -3$

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

$$5x_1 + (3+4i)x_2 = 0$$

$$5x_1 = -(3+4i)x_2 \qquad \frac{x_1}{x_2} = \frac{-(3+4i)}{5}$$

$$X_2 = \begin{bmatrix} -(3+4i) \\ 5 \end{bmatrix}.$$

Now eigen values $\Rightarrow \lambda_1 = 7 \qquad \lambda_2 = -3$

eigen vector corresponds to eigen values $X_1 = \begin{bmatrix} 3+4i \\ 5 \end{bmatrix} \quad X_2 = \begin{bmatrix} -(3+4i) \\ 5 \end{bmatrix}$

Good Approach

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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]

Nano materials

(1) It is defined as the materials which have atleast one dimension less than 10^{-9} nm (=) 10nm.

(2) As the size decreases the ratio of surface area to volume increases.

(3) As the surface area of material it becomes more reactive & changes its properties at that small length this ~~thi~~ is the main reason in their nature at nano scale => the no. of reactive sites increases in the material.

(4) There are two approches from which we can produce the nano material from normal materials.

(i) Top down approach.

(ii) bottom up approach.

buckminiter fluorene

- it is invented by the scitinst name Dr. Buckminister & the name of the substance is on the inventer.

- it is ball shaped substance made with C_{60} carbon atoms. all the carbon atoms are joined in the

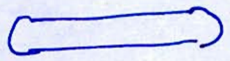
Hexagonal ring (sphere) structure.

- it is very hard material used in industrical application.

- There are many application of nano materials

(i) Quantam Dot -

it is 0 dimension object which is used to emit the electromagnetic radiation of certain freq.

(ii) Carban Nano tube 

it is low density, high strength object used to hold the essential things.

- it is made up of nano tube in middle & at ends it have half C-60 sphere of Buckminister.

(iii) It is used in medicines for ex.

nano materials liquid is to detect the cancer.

(iv)

7

Go through the made easy solection

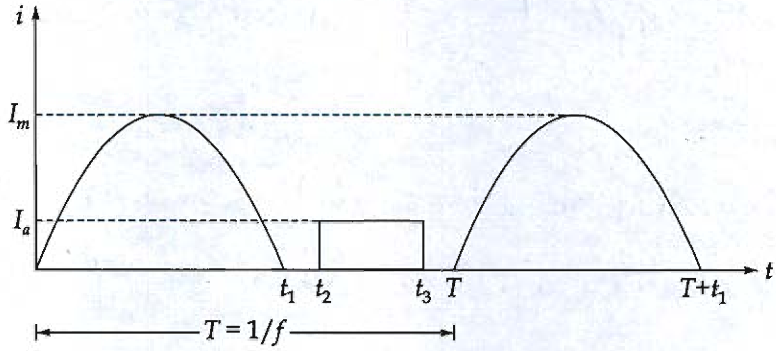
Q.5 (c) The current passing through a diode is shown in waveform.

Determine :

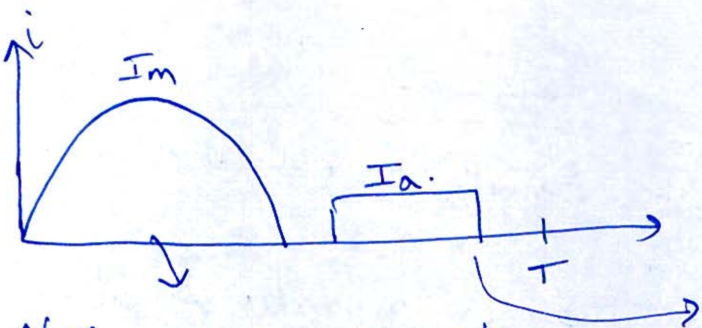
(i) rms current;

(ii) average diode current

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



[12 marks]



$I_a = I_2.$

Now $I_1 = I_m \sin \omega t.$

$$I_{rms} = \left[\frac{1}{T} \int_0^{t_1} (I_m \sin t)^2 + \int_{t_2}^{t_3} (I_a)^2 \right]^{1/2}.$$

$$= \left[\frac{1}{T} \int_0^{t_1} I_m^2 \sin^2 t + I_a^2 (t_3 - t_2) \right]^{1/2}$$

$$\left[\frac{1}{T} \left[\int_0^{t_1} I_m^2 \left(\frac{1 - \cos 2t}{2} \right] + I_a^2 (t_3 - t_2) \right]^{1/2}$$

$$\int_0^{t_1} \frac{I_m^2}{2} - \frac{I_m^2 \cos 2t}{2} + \quad ''$$

$$= \frac{1}{T}\left[\frac{I_m^2}{2}(t_1) - \frac{I_m^2}{4}\left(\sin 2t\right]_0^{t_1} + I_a^2(t_3 - t_2)\right]^{1/2}$$

$$= \frac{1}{T}\left\{ \frac{450^2 \times 100 \times 10^{-6}}{2} - \frac{450^2}{4}\sin\left(2\times 100\times 10^{-6} \times \frac{180}{\pi}\right) + (150)^2(500 - 350)\times 10^{-6}\right]$$

$$\frac{1}{T} = \left[10.125 - 10.125\right] + 150^2(500 - 350)\times 10^{-6}$$

$$\left(\frac{1}{T}\left[0 + 3.375\right]\right)^{1/2}$$

$$= (250 \times 3.375)^{1/2}$$

$$\boxed{I_{rms} = 29.04\ A}$$

$$I_{avg} = \frac{1}{T}\int_0^{t_1} I_m \sin t + \int_{t_2}^{t_3} I_a.$$

$$= 250\left\{\left(450 \times \sin\left(100\times 10^{-6} \times \frac{180}{\pi}\right) + 150(t_3 - t_2)\right]\right)$$

$$= 250(0.045 + 0.0225)$$

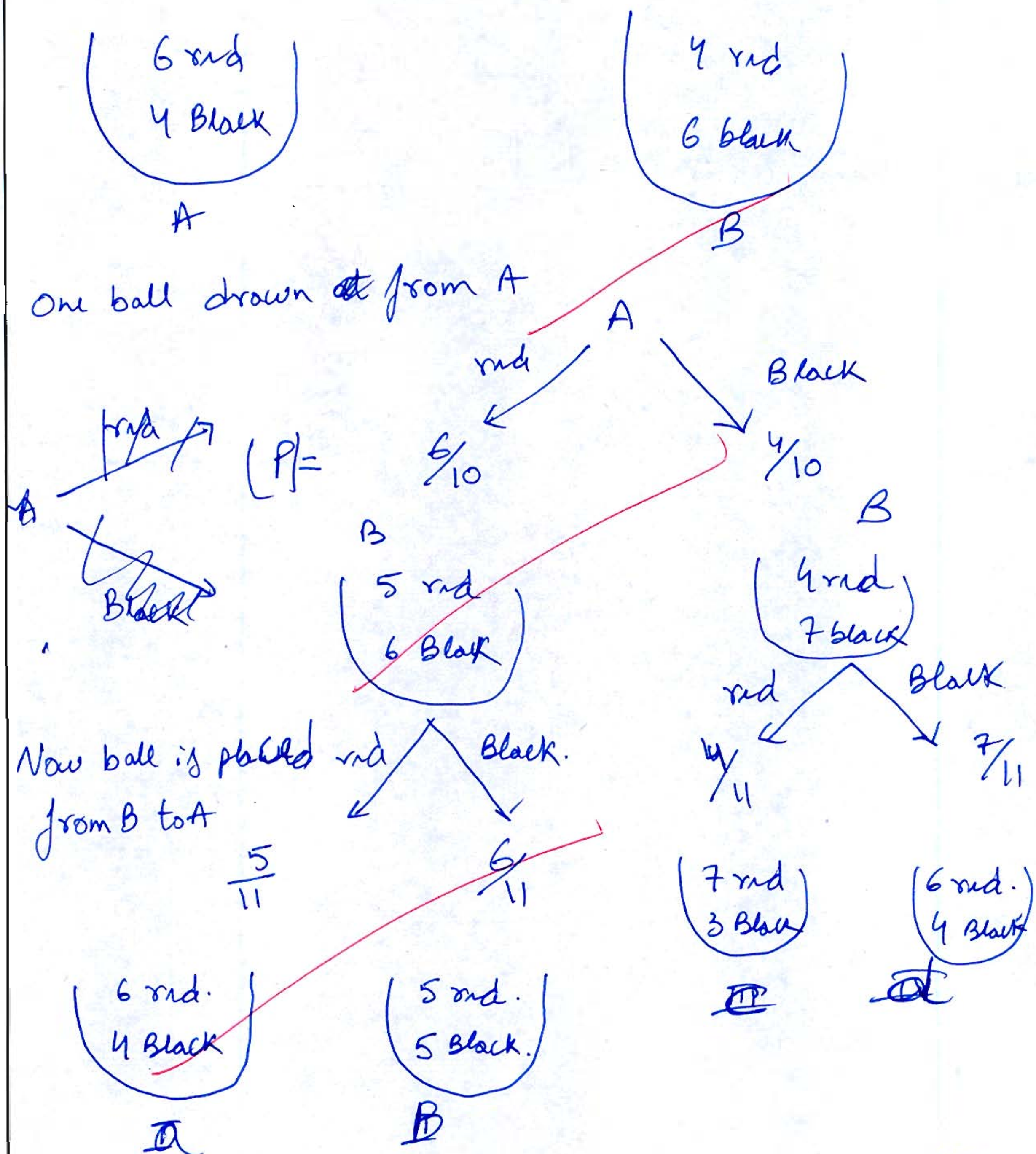
$$\boxed{I_{avg} = 16.875\ A}$$

8

Wrong Value calculated

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]



There are the 4 conditions possible for now to obtain red from the A in 3rd trial.

$$P(I) = \frac{6}{10}\left[\frac{5}{11}\times\frac{6}{10} + \frac{6}{11}\times\frac{5}{10}\right] = \frac{6}{10}\times\frac{60}{110} \quad (1)$$

$$P(II) = \frac{4}{10}\left[\frac{4}{11}\times\frac{7}{10} + \frac{7}{11}\times\frac{6}{10}\right] = \frac{70}{110}\times\frac{4}{10} \quad (2)$$

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from ① & ②

$$\frac{6}{10} \times \frac{60}{110} + \frac{70 \times 4}{110 \times 10}$$

P(red) from urn A = **P = 0.581**

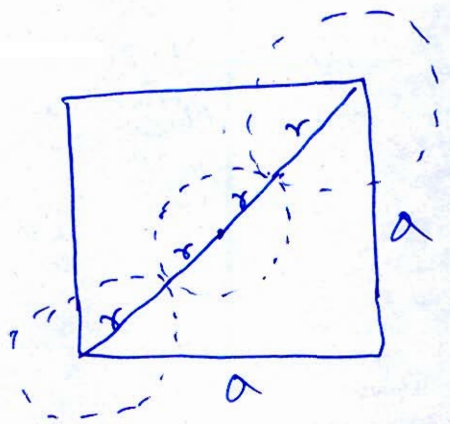
11

Good Approach

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

[12 marks]

FCC ⇒ Face cubic center crystal structure.



⇒ in this at face a atom is present.

Now using Pythagoras theorem.

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

$2a^2 = 16r^2$

$\sqrt{2}a = 4r$

$r = \frac{\sqrt{2}}{4}a$ radious of atom.

effective no. of atom = $8 \times \frac{1}{8} + 2 \times 1 + \frac{1}{8} \times 8$

$= 4$

atom packing = $\frac{n \times \text{No. of area/volume occupied by atom}}{\text{volume/area of cube}}$

$= \frac{4 \times \frac{4}{3}\pi r^3}{a^3}$ $\quad [\; a = 2\sqrt{2}r$

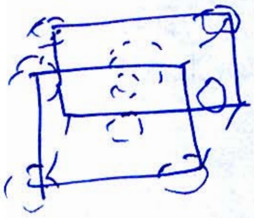
$= \frac{4 \times 4 \pi \times r^3}{3 (2\sqrt{2})^3 \times r^3} = 0.74$

atom packing factor % = 74%

11

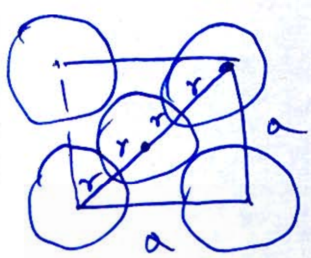
Good Approach

=> atom in FCC is arranged in the figure.



=> at all corners there are atoms present.

=> $\not$ all 6 faces there is face atom thats why it is called as face centred.



=> 1 face of the cubic crystall in FCC.

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]

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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]

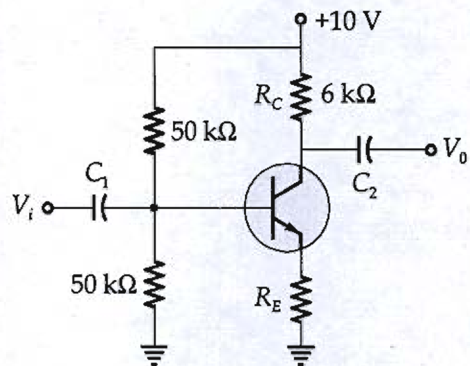
Q.6 (c) **(i)** Find the eigen values and eigen vectors of matrix

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

(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.

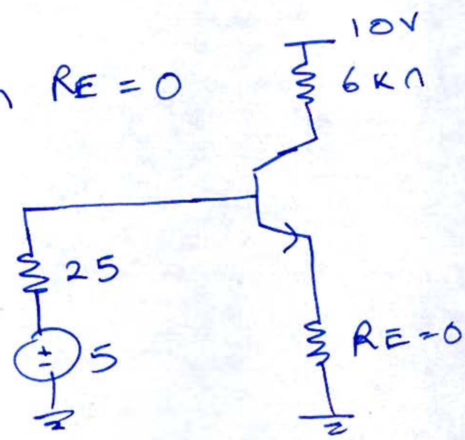
[12 + 8 marks]

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]

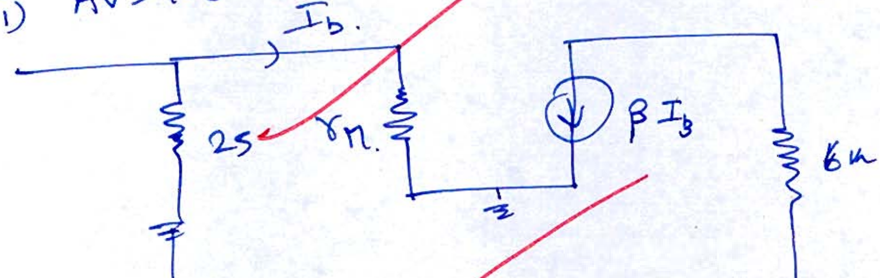
When $RE = 0$



$5 - 0.7 -$

AC analysis making π model

(i) $AV = 100$

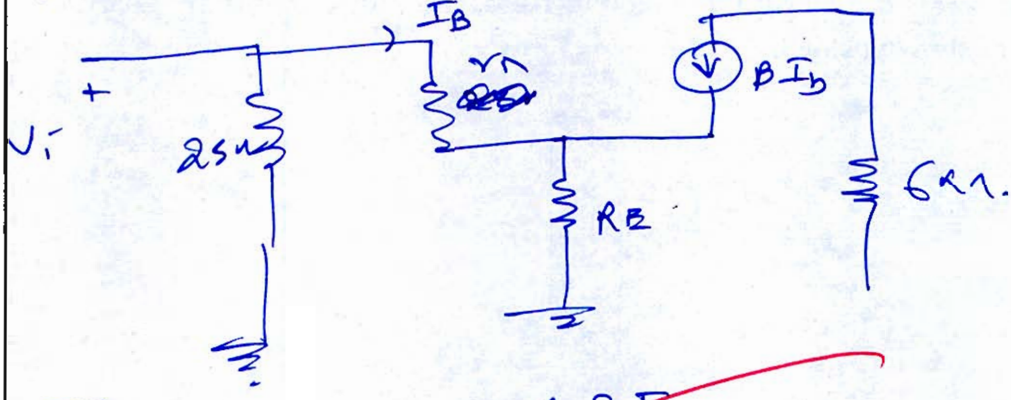


$$Av = 200 = \frac{-6\,\beta I_b}{r_\pi I_b} = \frac{-6\beta}{r_\pi}$$

$$200 = -6\frac{\beta}{r_\pi}$$

$$\boxed{\frac{\beta}{r_\pi} = \frac{-200}{6}}$$

Now with R_E-



$$A_v = \frac{-6\beta I_b}{I_B r_\pi + R_E(1+\beta) I_b}$$

$$= \frac{-6\beta}{r_\pi + R_E(1+\beta)}$$

$R_E(1+\beta) >> r_\pi$ & $1+\beta \simeq \beta$.

$$|200| = \left| -\frac{6\beta}{R_E \beta} \right| \qquad \frac{6}{R_E} = 200$$

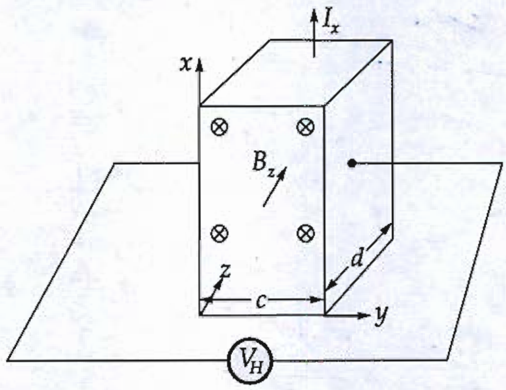
$$R_E = \frac{6\ k\Omega}{200}$$

$$\boxed{R_E = 30\ \Omega}$$ Ans

5

Wrong Value calculated

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]

Hall effect

In an conductor flowing a current 'I' when placed in magnetic field 'B' which is ⊥ to the direction of current a voltage is or Emf is endued in the conductor such that is is ⊥ to both 'I' & 'B' direction.

As $V = R_H \frac{(B \times I)}{t}$ when B = magnetic field density

I = current

t = thickness.

$R_H = \frac{1}{ne}$

here in case (i) $B \to -\hat{a}_z$ $V \to -\hat{a}_y$ (Electric field)

$I \to +\hat{a}_x$.

$-\hat{a}_z \times +\hat{a}_x = -\hat{a}_y$

Voltage induced $= -\hat{a}_y$.

Now as direction of B is $+\hat{a}_z$

$V \propto \hat{a}_z \times I$ $\quad V \rightarrow -\hat{a}_y$

Now the direct $\quad B \rightarrow +\hat{a}_z$.

$-V\hat{a}_y \propto B\hat{a}_z \times I\hat{a}_?$

Now the direction of current will be reversed i.e now current will be flow in $-\hat{a}_x$ (-ve x axis).

Hall coefficient $R_H = \frac{1}{ne}$ [n = no. of atoms per unit volume, e = charge.

$\sigma = ne\mu$

↑ conductivity given by

When $ne = \frac{1}{R_H}$.

$$\boxed{\mu = \sigma \times R_H}$$

9

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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]

$\alpha = \frac{\pi}{4}$ $\quad V_{mL} = 400 \times \sqrt{2}$ $\quad I_0 = 10$

$V_{0\,DC} = 360$

$L_s = ?$ $\quad \mu = ?$

As we know $V_0 = \frac{3 V_{mL}}{\pi} \cos\alpha - \Delta V_0$

$\Delta V_0 = 6 \times I \times f \times l$

decrease in O/p Voltage due to L_s

$$360 = \frac{3 \times 400 \times \sqrt{2}}{\pi} \cos\frac{\pi}{4} - \Delta V_0.$$

$$\Delta V_0 = 22.165 = 6 \times I \times f \times l$$

$$\frac{22.165}{6 \times 10 \times 50 \times 1} = L_s$$

*

$$\boxed{L_s = 7.388 \text{ mH}}$$

$$V_0 = \frac{V_{d0}}{2}\left(\cos\alpha + \cos(\alpha+\mu)\right)$$

O/P voltage

where $V_{d0} = \frac{3 V_{mL}}{\pi}.$

$$360 = \frac{3 \times 400 \times \sqrt{2}}{2 \times \pi}\left(\cos 45 + \cos(45+\mu)\right)$$

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$0.625 = \cos(45 + \psi)$

$\psi = 6.311^{\circ}$

$L_s = 7.388\,mH$

11

Good Approach

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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]

$H = 500$ field intensity.

$\phi = 2.4 \times 10^{-5}$ $\quad A = 0.2\ cm^2$.

$B = \frac{\phi}{A}$ $\Leftarrow$ $\phi = B \times A$

$B = \frac{2.4 \times 10^{-5}}{0.2 \times 10^{-4}}$

Magnetic density

$B = 1.2\ T$

$B = \mu_0 \mu_r H$.

$\mu_r = \frac{1.2}{4\pi \times 10^{-7} \times 500}$

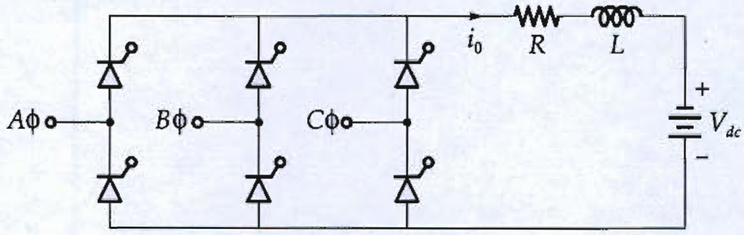
* $\mu_r = 1910.82$

$\chi = (\mu_r - 1) \Rightarrow$ $1909.82 = \chi_e$ *

7

Good Approach

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]

$\alpha = 120°$ $\quad V_{mL} = 4160 \times \sqrt{2}$

$V_{dc} = 3000 \quad R = 2\ \Omega$

As the o/p or load current is constant we consider it as a 3-φ full wave converter.

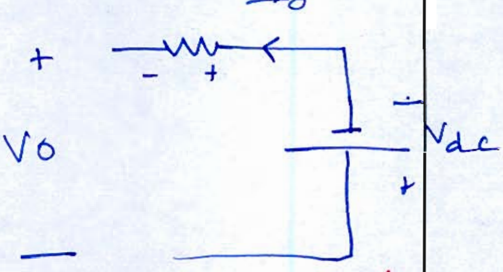
$$V_0 = \frac{3 V_{mL}}{\pi} \cos\alpha.$$

$$= \frac{3 \times 4160 \times \sqrt{2}}{\pi} \cos 120°$$

$$V_0 = -2810.41$$

5

KVL in output loop



$V_{dc} + V_0 = I_0 (R).$

$-(V_0 + V_d) - I_0 R = 0$

$$I_0 = \frac{3000 - 2810.41}{2}$$

$$I_0 = 94.79\ A$$

Incomplete Solution

$V = L\frac{di}{dt}$.

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]

$$H_0 = H_c\left[1 - \left(\frac{T_0}{T_c}\right)^2\right] \quad \text{--- (1)}$$

0.176 T ⟶ $T_0 = 14K$

0.528 T ⟶ $T_0 = 13K$

putting in eqⁿ —(1)

$$\frac{0.176}{0.528} = \frac{\left(1 - \left(\frac{14}{T_c}\right)^2\right)}{\left(1 - \left(\frac{13}{T}\right)^2\right]}$$

$$0.333\left(1 - \left(\frac{13}{T}\right)^2\right] = \left[1 - \left(\frac{14}{T}\right)^2\right]$$

$$0.333 - 0.333\left(\frac{13}{T}\right)^2 = 1 - \left(\frac{14}{T}\right)^2$$

$$\left(\frac{14}{T}\right)^2 - 0.333 \times \frac{(13)^2}{T^2} = 1 - 0.333$$

$$\frac{139.723}{T^2} = 0.666$$

$$\boxed{T_c = 14.48\ K^0}$$

find critical field H_c.

$$0.176 = H_c\left(1 - \left(\frac{14}{14.48}\right)^2\right]$$

$$\boxed{H_c = 6.976\ T}$$

Critical field at 0°K required

at 0K

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

$$H = H_c = 6.976\ T$$

$$T_c = 14.48\ K$$

Ans

at 4.2K

$$H = 6.976\left(1 - \left(\frac{4.2}{14.48}\right)^2\right)$$

$$H = 6.389\ T$$

$$T_c = 14.48\ K$$

Ans

6

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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

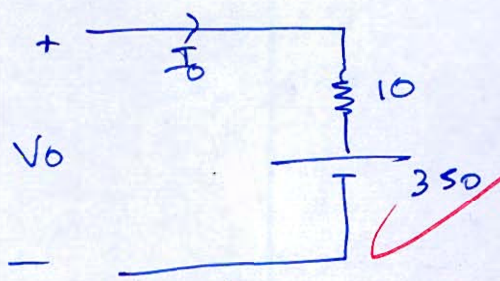
(i) firing angle of 30°.

(ii) firing advance angle of 60°.

[20 marks]

(i) $\alpha = 30°$ $V_{mL} = 400 \times \sqrt{2}$ $R = 10$

$E = 350$



3-φ full converter

Continious conduction I_o = constant

O/p side

$V_o = \frac{3 V_{mL}}{\pi} \cos\alpha$

$V_o = \frac{3 \times 400 \times \sqrt{2}}{\pi} \cos 30$

$V_o = 468.05$ V

$I_o = 11.80$ A $= \frac{V - E}{R}$

Power diliver to load $= I_{or}^2 \times R + I_o \times E_o$

$= 11.8^2 \times 10 + 350 \times 11.8$

* $P = 5522.4$ W Ans

$pf = \frac{3}{\pi} \cos\alpha$ | $\cos\phi = \frac{I_o \times \frac{3 V_m}{\pi} \cos\alpha}{\frac{V_m}{\sqrt{2}} \times I_{s}}$

$= \frac{3}{\pi} \cos\alpha.$

$= \frac{3}{\pi} \cos 30$ * $= 0.827 = \cos\phi$ Ans for (ii) $\alpha = 120$ $\alpha = 180 - 60$

Now it is inverter mode

$$V_o = \frac{3 V_{mL}}{\pi} \cos\alpha = \frac{3 \times 400 \times \sqrt{2}}{3.14} \cos 120$$

$$= -270.23\ V.$$

Battery E delivering power. KVL at o/p.

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

$$I_o = \frac{350 - 270.23}{10}$$

$$I_o = 7.97\ A$$

Power delivered to load $= V_o I_o$

$= -270.23 \times 7.97$

Ans $P_{delivered} = -2155.57\ W$

$$\cos\phi = \frac{V_o I_o}{\sqrt{3} \times V_{sr} I_{sr}} = \frac{\frac{3 V_{mL}}{\pi} \cos\alpha\, I_o}{\sqrt{3} \times \frac{V_{mL}}{\sqrt{2}} \times \sqrt{\frac{2}{3}} I_o}$$

18

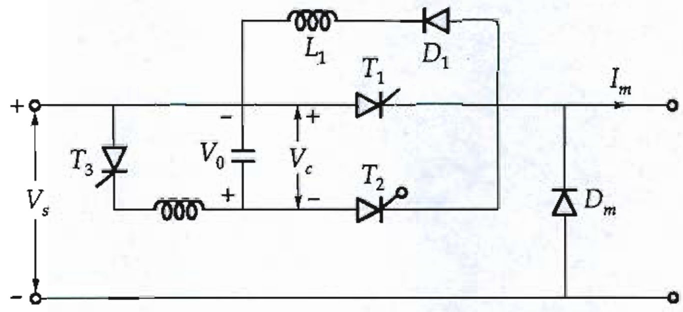
$$p.f = \frac{3}{\pi} \cos\alpha$$

$$= \frac{3}{\pi} \cos 120$$

Ans $p.f = -0.477$

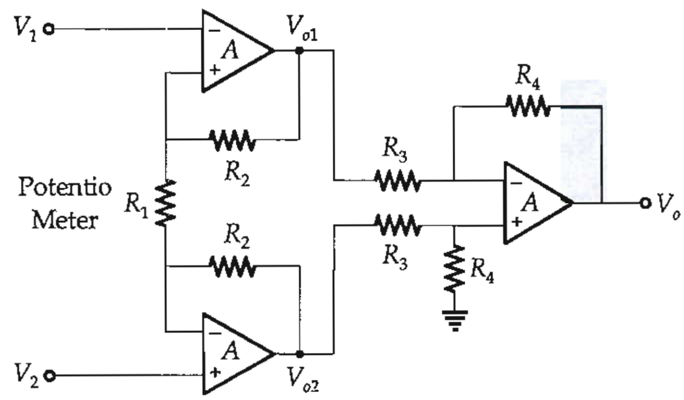
$P = -2155.57\ W$

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]

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]

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:

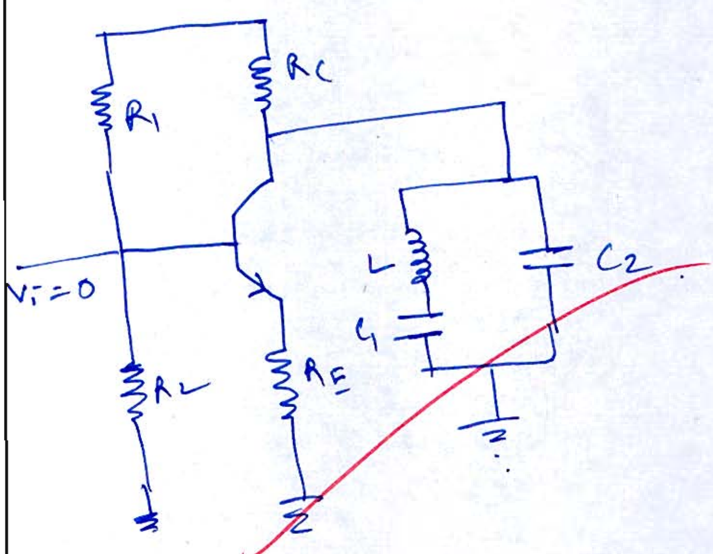
(i) Colpitt oscillator.

(ii) Clapp oscillator.

[20 marks]

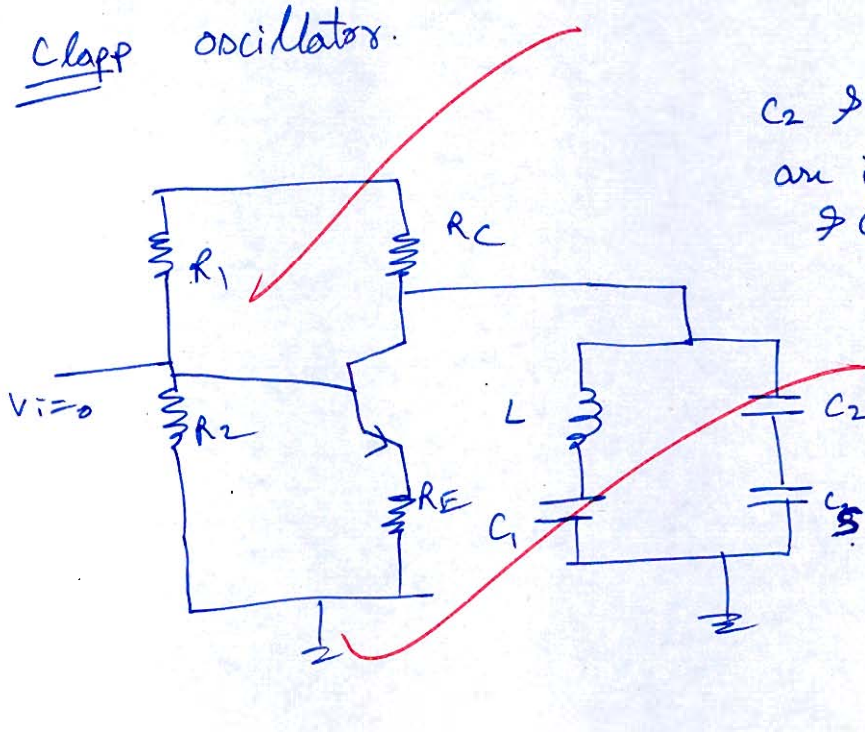
Colpitt· oscillator:

C_1 & C_2 are in parallel.



Clapp oscillator.

C_2 & C_3 are in series. & C_1 in ||.



the advantage of clapp over colpitt oscillator

① In clapp we have 3 capacitors connected we can easily change the freq.

② freq range is very much large as compare to colpitt oscillator

Now freq.

for colpitt

$$f = \frac{1}{2\pi\sqrt{C_c L}}$$

$$C_c = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{150 \times 150}{300} = 75\,pF$$

$$f = \frac{1}{2\pi\sqrt{75 \times 10^{-12} \times 50 \times 10^{-6}}}$$

$$\boxed{f = 2.6\,MHz}$$ Ans ①

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Good Approach

for Clapp $C_c =$

$$C_c = C_2 \parallel C_S \parallel C_1$$

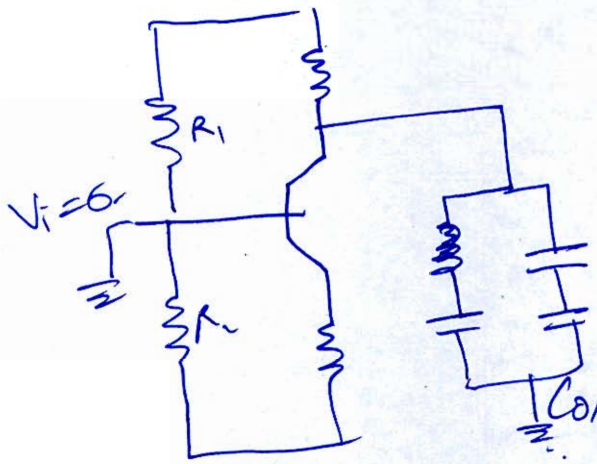
$$= \frac{75 \times 10}{85} \qquad C_c = 8.823\,pF$$

$$f = \frac{1}{2\pi\sqrt{8.823 \times 10^{-12} \times 50 \times 10^{-6}}}$$

$$\boxed{f = 7.581\,MHz}$$ Ans

OOOO

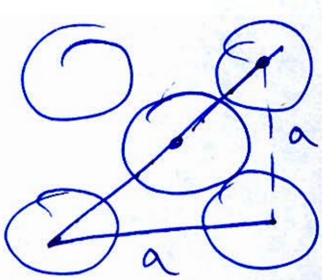
Space for Rough Work

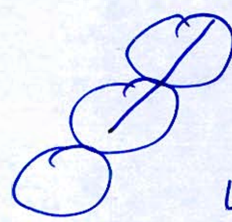


$\cos 2t = 1 - 2\sin^2 t.$

$2\sin^2 t = 1 - \cos 2t$

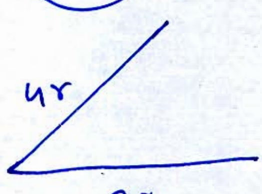
$\sin^2 t = \frac{1-\cos 2t}{2}$





$r = \frac{a}{2}$ $r = \frac{\sqrt{3}}{4}a$

$4r$ $r = \frac{\sqrt{2}}{4}a.$



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

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

$2a^2 = 16r^2$ $2a^2 = 16r^2$ $\sqrt{2}a = 4r.$

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

$$\frac{I_0 \times \frac{3V_{mL}}{\pi} \cos\alpha}{\sqrt{3}\frac{V_{mL}}{\sqrt{2}} \times \sqrt{\frac{2}{3}} I_0}$$

$\frac{3}{\pi}\cos\alpha.$