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ESE - 2018
MAINS EXAMINATION
Questions with Detailed Solutions

ELECTRICAL ENGINEERING

PAPER - I

All Queries related to ESE - 2018 Mains Solutions are to be sent to the following email address
*hyderabad@aceenggacademy.com | Contact Us : **040 - 23234418, 19, 20***

PAPER REVIEW

Paper was overall moderate, material science, measurements and mathematics had some questions from our test series. Networks questions are direct and easy. EMTL questions are direct previous years. Some one, who followed ACE test series, feels the paper really easy. Section-B is relatively tougher than section-A and the paper is lengthy.

SUBJECT WISE REVIEW

SUBJECT(S)	LEVEL	Marks
Engineering Mathematics	Easy	72
Electric Circuits and Fields	Easy	84
Basic Electronics Engineering	Hard	84
Electrical and Electronic Measurements	Moderate	72
Electrical Materials	Moderate	84
Computer Fundamentals	Hard	84

Subject Experts,

ACE Engineering Academy

SECTION – A

01. (a) Let A = $\begin{bmatrix} 5 & -2 & 0 \\ -2 & 6 & 2 \\ 0 & 2 & 7 \end{bmatrix}$ **and B = $A^3 - 2A^2 - 5A + 6I$,**

Where I is the identity matrix, then calculate the determinant of B. **(12M)**

Sol: Given, $A = \begin{bmatrix} 5 & -2 & 0 \\ -2 & 6 & 2 \\ 0 & 2 & 7 \end{bmatrix}$

Characteristic equation of A is $|A - \lambda I| = 0$

$$\Rightarrow \begin{bmatrix} 5-\lambda & -2 & 0 \\ -2 & 6-\lambda & 2 \\ 0 & 2 & 7-\lambda \end{bmatrix} = 0$$

By expanding

$\lambda^3 - 18\lambda^2 + 99\lambda - 162 = 0$

$\Rightarrow (\lambda - 3)(\lambda^2 - 15\lambda + 54) = 0$

$\Rightarrow (\lambda - 3)(\lambda - 9)(\lambda - 6) = 0$

Eigen values of A are 3, 9, 6.

For $B = A^3 - 2A^2 - 5A + 6I$ eigen values corresponding to

$3 \to 27 - 18 - 15 + 6 = 0$

$9 \to 729 - 162 - 45 + 6 = 528$

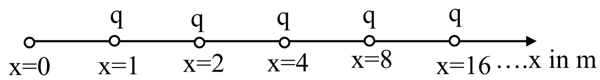
$6 \to 216 - 72 - 30 + 6 = 120$

We know that determinant of A matrix is equal to product of eigen values

$|B| = 0 \times 528 \times 120$

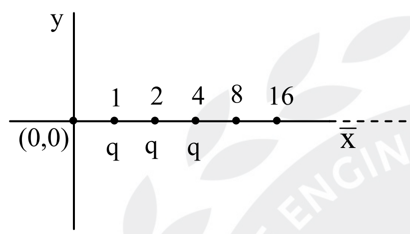
$= 0$

01. (b)



An infinite number of charges each equal to q Coulombs' are placed in a free space along the line at x = 1, x = 2, x = 4, x = 8, x = 16 and so on. Find the expression for potential and electric field intensity at point x = 0, due to these systems of charges. Assume that values of x are in metres. (12M)

Sol:



Resultant potential at the origin is

$$V_T = \frac{q}{4\pi\varepsilon_0}\sum_{i=1}^{\infty}\frac{1}{r} \quad \text{as this}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\underbrace{1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}......}_{G.P}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{a}{1-r}\right], \ r = \frac{1}{2}, \ a = 1$$

$$V_T = \frac{q}{4\pi\varepsilon_0}.\frac{1}{1-\frac{1}{2}}$$

$$\therefore \ V_T = \frac{q}{2\pi\varepsilon_0} \text{ Volt}$$

$$E_T = \frac{q}{4\pi\varepsilon_0}\sum_{i=1}^{\infty}\frac{1}{r_i^2} \Rightarrow \frac{q}{4\pi\varepsilon_0}\left[1+\frac{1}{4}+\frac{1}{16}+\frac{1}{64}+...\right](-\hat{a}_x)$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1-\frac{1}{4}}\right](-\hat{a}_x) = \frac{Q}{4\pi\varepsilon_0}\times\frac{4}{3} \ (-\hat{a}_x)$$

$$\therefore \ E_T = \frac{Q}{3\pi\varepsilon_0}(-\hat{a}_x) \text{ V/m}$$

01. (c) A Silicon diode that has an ohmic resistance of 0.5 Ω with reverse saturation current $I_0 = 10^{-12}$ A and η = 2.0, consumes 50 × 10^{-12} W extra power compared to ideal diode. Diode operating temperature is 350°K.

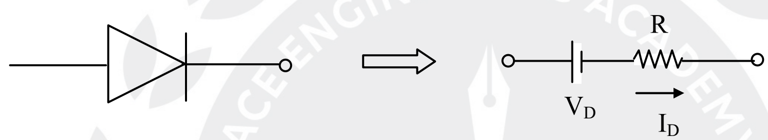
(i) Determine the fraction of the applied voltage that falls across the ohmic resistance.

(ii) Solve part (i), when diode current is 1A.

(iii) Compare results of part (i) & (ii) and draw conclusion. (8+2+2=12M)

Sol: Given that Ohmic resistance = 0.5 Ω

$$V_T = \frac{350}{11,600} = 30.1724 \text{ mV}$$



Power Consumption = $I_D V_D + I_D^2.R$

$$\Rightarrow \quad I_0 e^{V_D/\eta V_T}.V_D + \left(I_0 e^{V_D/\eta V_T}\right)^2 R = 50\times10^{-12}$$

$$I_0.V_D\ e^{V_D/\eta V_T}.I_0^2 e^{2V_D/\eta V_T}.R = 50\times10^{-12}$$

$$10^{-12}\left[V_D e^{V_D/\eta V_T} + 10^{-12} e^{2V_D/\eta V_T} R\right] = 50\times10^{-12}$$

$$\left[V_D e^{V_D/2\times30.17\times10^{-13}} + 10^{-12} e^{V_D/30.17\times10^{-3}} \times 0.5\right] = 50$$

$$\underbrace{V_D e^{16.57V_D} + 0.5\times10^{-12} e^{33.14} V_D}_{x} = 50$$

When $V_D = 0.30 \rightarrow x = 43.25$

$V_D = 0.305 \rightarrow x = 47.77$

$V_D = 0.307 \rightarrow x = 49.70$

$V_D = 0.3073 \rightarrow x = 50$

$\therefore \quad V_D = 0.3073$ V

Then $I_D = I_0 \left[e^{V_D/\eta V_T}\right]$

$= 10^{-12} [e^{0.3073/2\times30.172} \times 10^{-3}]$

= 162.78 pico amperes

(i) Voltage across ohmic resistance

(ii) When $I_D = 1$ A

Voltage across Diode is , $V_D = \eta V_T \ell n\left(\frac{1}{10^{-12}}\right)$

$$= 2 \times 30.1724 \times 10^{-3}\ \ell n\left(\frac{1}{10^{-12}}\right)$$

$$= 2 \times 30.1724 \times 10^{-3}\ \ell n\left(10^{12}\right)$$

$$= 1.6673\ V$$

$V_R = I_D R = 0.5$ V

(iii) In Part (i) ⇒ $I_D = 162.78 \times 10^{-12}$ A, $V_D = 0.3073$ V

Part (ii) ⇒ $I_D = 1$ A, $V_D = 1.6673$ V

In part (i) power consumes ⇒ 50×10^{-12} W

In part (ii) power consumes

$$= I_D V_D + I_D^2 R$$

$$= 1 \times 1.6673 + 0.5$$

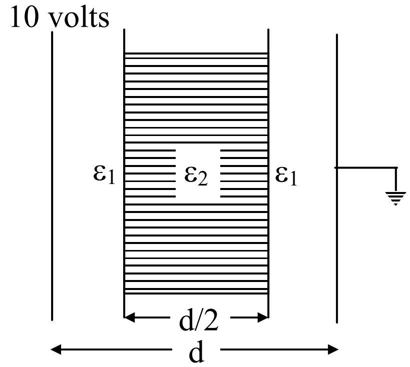
$$= 2.1673\ W$$

As diode current becomes 1 A, $V_D = 1.6673$ and power consumes 2.1673 W

⇒ For change in current of 162.78 PA to 1 A the voltage across diode changes from 0.3073 to 1.6673 V

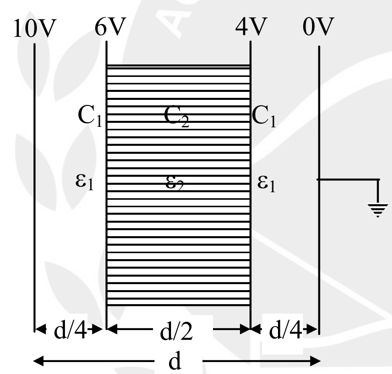
For a large change in current there is a small change in voltage. So diode is a logarithmic device (non linear device).

01. (d)



A parallel plate capacitor consisting of two dielectric materials is shown in figure. The middle dielectric slab is placed symmetrically with respect to the plates. If the potential difference between one of the plates and nearest surface of dielectric interface is 4 volts, determine $\frac{\varepsilon_1}{\varepsilon_2}$. Assume parallel plate capacitor has an electrode area of A m^2. (12M)

Sol:



In this all the three dielectrics are connected in series. So, the charge is same through the dielectrics, i.e., $Q_1 = Q_2$

Generally capacitance, $C = \frac{\varepsilon A}{d}$

$$C_1 = \frac{\varepsilon_0\varepsilon_1 \times A}{d/4} = \frac{4\varepsilon_0\varepsilon_1 \times A}{d}$$

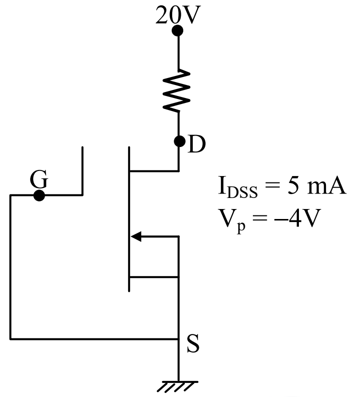
Similarly, $$C_2 = \frac{\varepsilon_0\varepsilon_2 A}{d/2} = \frac{2\varepsilon_0\varepsilon_2 A}{d}$$

$$C_1V_1 = C_2V_2$$

$$\frac{4\varepsilon_0\varepsilon_1 A}{d}\times 4 = \frac{2\varepsilon_0\varepsilon_2 A}{d}\times 2$$

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{1}{4}$$

01. (e)



Write the equation related to the drain current (I_D) and Gate to source voltage V_{GS} explaining all the parameters for

(i) Depletion type MOSFET

(ii) Enhancement type MOSFET

(iii) Determine V_{DS} for the circuit shown in the figure. **(4+4+4=12M)**

Sol: (i) Depletion type MOSFET

Case (i) Cutoff region:

$I_D = 0$ ….. (1)

In this case $V_{GS} = V_{GS(OFF)} = V_P$ …….. 1(a)

Case (ii) Saturation region:

$$I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_P}\right]^2$$ …….. (2) (Neglecting channel length modulation effect i.e $\lambda = 0$)

Where I_D is the total drain current in the device

I_{DSS} is the drain to source current with the gate shorted to the source.

V_{GS} is the reverse biased gate to source voltage, generally V_{GS} is negative for an N-channel MOSFET in Depletion Mode.

V_P is the pinch-off voltage: The maximum reverse biased gate to source voltage at which the channel becomes pinched-off or becomes very low and the current through the channel becomes almost zero is called pinch-off voltage.

NOTE: I_{DSS} is the device parameter, defined by manufacturer and is given by,

$I_{DSS} = \frac{1}{2}\mu_n C_{ox} V_{th}^2$ .... (3)

Where "$\mu_n C_{ox}$" is know as process transconductance parameter in which μ_n is the mobility of electron C_{ox} oxide capacitance and V_{th} is the threshold voltage.

(ii) Enhancement MOSFET:

Case (i) Cutoff Region:

$I_D = 0$ .... (1) in this case, $V_{GS} \le V_P$;

Case (ii) Saturation region:

$I_D = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{th})^2$ .... (2)

Where,

μ_n = mobility of electron

C_{ox} = Oxide capacitance $= \frac{\varepsilon_{ox}}{t_{ox}}$ (where ε_{ox} permitivity & silicon oxide t_{ox} is oxide thickness)

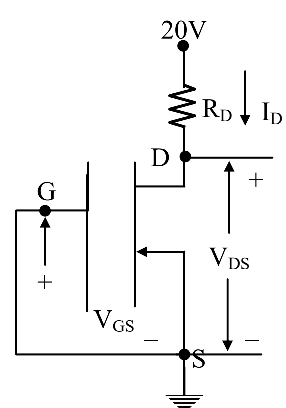
(**NOTE:** '$\mu_n C_{ox}$' is known as process trans conductance parameter)

W = channel width $\left[\text{Generally } \frac{W}{L} \text{ is known as aspect ratio of the MOSFET}\right]$

L = channel length

V_{GS} = applied gate to-source voltage. Generally V_{GS} is positive in Enhancement mode of an N-channel MOSFET.

V_{th} = Threshold voltage



(iii) Given $I_{DSS} = 5$ mA, $V_p = -4V$

Step (1) From the circuit,

$V_{GS} = 0V$

Step (2): consider shockly equation,

$$I_D = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2 = 5mA\left[1 - \frac{0}{-4V}\right] = 4mA$$

Step (3): KVL for output section,

$20V - I_D R_D - V_{DS} = 0$

$\Rightarrow \qquad V_{DS} = 20V - I_D R_D$

Let $R_D = 3k\Omega$

$\therefore \qquad V_{DS} = 20V - 5mA \times 3k\Omega = 5V$

02. (a) Show that in the interval (0, 1)

$$\cos \pi x = \frac{8}{\pi}\sum_{n=1}^{\infty}\frac{n}{4n^2-1}.\sin 2n\pi x$$ **(20M)**

Sol: $f(x) = \cos\pi x$

Half range sine series of f(x) in the interval (–1, 1)

$$f(x) = \sum_{n=1}^{\infty} b_n \sin n\pi x \quad \ldots\ldots\ldots..(1)$$

Where $b_n = 2\int_0^1 f(x)\sin n\pi x\, dx$

$$b_n = 2\int_0^1 \cos \pi x.\sin n\pi x..dx$$

$$b_n = \int_0^1 [\sin(n\pi x + \pi x) + \sin(n\pi x - \pi x)]dx$$

$$b_n = \left[\frac{-\cos(n+1)\pi x}{(n+1)\pi}\right]_0^1 + \left[\frac{-\cos(n-1)\pi x}{(n-1)\pi}\right]_0^1$$

$$b_n = \left[\frac{(-1)^n}{(n+1)\pi} + \frac{(-1)^n}{(n-1)\pi}\right] + \left[\frac{1}{(n+1)\pi} + \frac{1}{(n-1)\pi}\right]$$

$$= \frac{(-1)^n}{\pi}\left[\frac{2n}{n^2-1}\right] + \frac{1}{\pi}\left[\frac{2n}{n^2-1}\right] \text{ where } n = 1, 2, 3 \ldots\ldots\ldots$$

$$= \frac{2n}{(n^2-1)\pi}\left[(-1)^n + 1\right]$$

$$= \frac{4n}{(n^2-1)\pi} \qquad \text{if } n = \text{even}$$

$$= 0 \qquad \text{if } n = \text{odd}$$

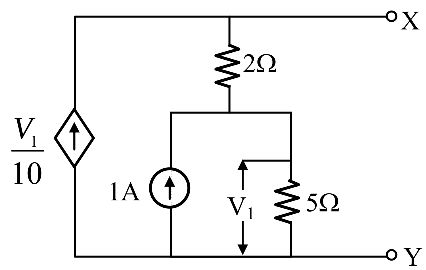
$$= \frac{4(2m)}{(4m^2 - 1)\pi} \text{..........(2)} \quad \text{where } m = 1, 2, 3......$$

Sub (2) in (1) then

$$f(x) = \sum_{m=1}^{\infty} \frac{8m}{(4m^2 - 1)\pi} \sin(2m\pi x)$$

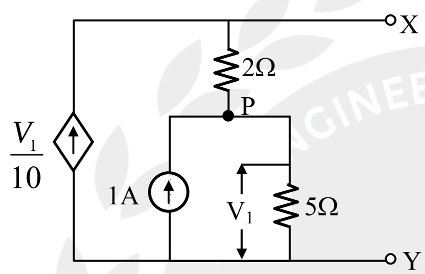
$$f(x) = \frac{8}{\pi} \sum_{n=1}^{\infty} \frac{n}{(4n^2 - 1)} \sin(2n\pi x) \quad (\because m \text{ is dummy variable})$$

02. (b)



Determine the value of Load Resistance R_L to be connected across terminals X-Y to receive maximum power. Also, obtain the value of this maximum power. (20M)

Sol:



Thevenin's voltage across the terminals X and $Y = V_{th} = V_{XY}$

At Node 'P', $\frac{V_1}{10} + 1 = \frac{V_1}{5}$

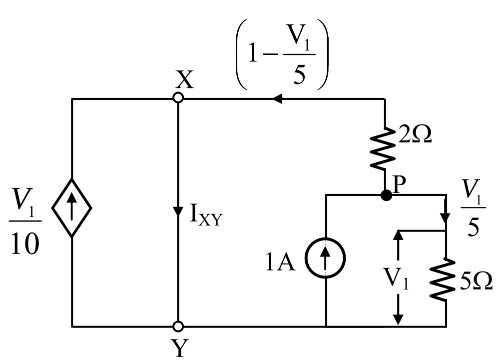
$\Rightarrow \quad 0.1V_1 = 1$

$\Rightarrow \quad V_1 = 10$

$V_{XY} = 2\left(\frac{V_1}{10}\right) + V_1$

$= 2\left(\frac{10}{10}\right) + 10 = 12\text{ V}$

Norton's Current across the terminals X and Y = $I_{SC} = I_{XY}$



$$I_{XY} = \frac{V_1}{10} + \left(1 - \frac{V_1}{5}\right) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$-V_1 + 2\left(1 - \frac{V_1}{5}\right) = 0 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

$$V_1 = 2 - \frac{2V_1}{5}$$

$$\frac{7V_1}{5} = 2$$

$$\Rightarrow V_1 = \frac{10}{7}$$

$$I_{XY} = \frac{V_1}{10} + \left(1 - \frac{V_1}{5}\right)$$

$$= \frac{10}{10\times 7} + \left(1 - \frac{10}{7}\times\frac{1}{5}\right)$$

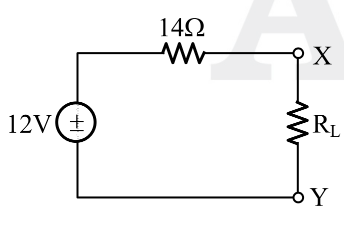
$$= \frac{1}{7} + \left(1 - \frac{2}{7}\right)$$

$$= 1 - \frac{1}{7} = \frac{6}{7}\text{ A}$$

Thevenin's equivalent resistance

$$R_{th} = \frac{V_{SC}}{I_{SC}} = R_{XY} = \frac{V_{XY}}{I_{XY}} = \frac{12}{6/7} = 14\ \Omega$$

Thevenin's equivalent circuit across terminals XY:

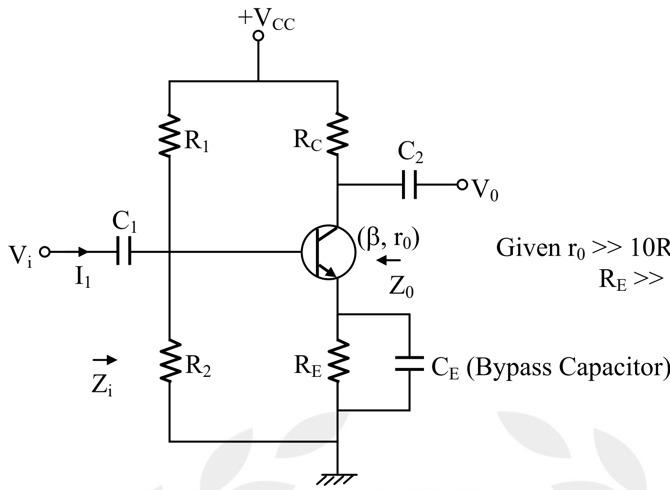


The value of load resistance connected across terminals for max power transfer

$R_{XY} = R_{th} = R_L = 14\ \Omega$

Maximum power deliver to the load $R_L = \dfrac{V_{XY}^2}{4R_{XY}} = \dfrac{12^2}{4\times 14} = \dfrac{144}{56} = 2.571$ W

02. (c)



Given $r_0 >> 10R_C$
$R_E >> r_e$

Obtain the expression for voltage gain to given circuit.

(i) With bypass capacitor.

(ii) Without bypass capacitor.

(iii) Calculate voltage gain in part (i) & part (ii), if R_1 = 90 kΩ, R_2 = 10 kΩ, R_E = 0.8 kΩ, β = 200, r_0 = 50 kΩ, R_C = 2.2 kΩ and V_{CC} = +15 V.

Compare both voltage gains and write conclusion in short. **(5+5+10=20M)**

Sol: **(i)** Given $r_0 >> 10R_c$

$R_E >> r_e$

with bypass capacitor:

Case (i):

Consider the AC model of the given circuit:

1. All DC sources = 0

2. $X_c = 0$

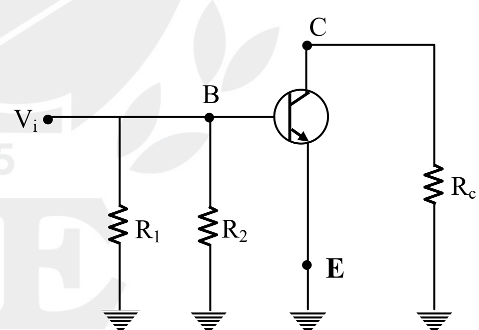


Fig. $2C_1$

Case (ii): small signal model of the amplifier shown in fig.$2C_1$

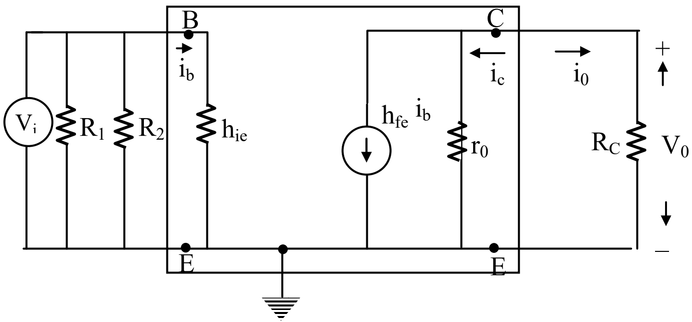


Fig. $2C_2$

NOTE: $h_{fe} = \beta$, $h_{ie} = \beta r_e$

$\because$ $r_0 >> 10R_c$ the above ckt can be simplified as:

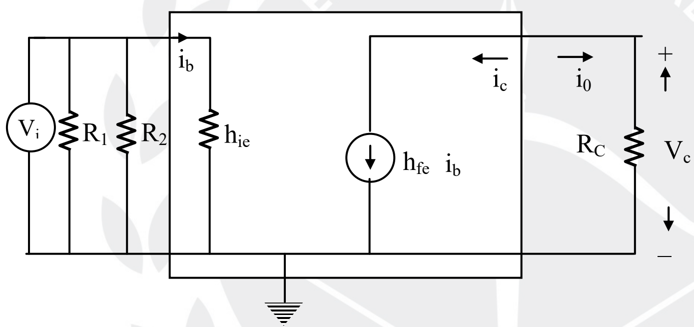


Fig. $2C_3$

Voltage Gain, $A_V = \dfrac{V_0}{V_i}$:

Step (1): From the circuit shown in fig:$2C_2$, $r_0 \parallel R_c \simeq R_c$ ……. (1) {$\therefore$ $r_0 >> 10\ R_c$] (as shown in fig. $2C_3$)

Step (2): From the circuit shown in fig $2C_3$, $V_0 = I_0 R_c = -h_{fe}\, i_b R_c = -\beta i_b R_c$ ……. (2)

Step (3): From the input section of the circuit shown in fig $2C_3$,

$$V_i = i_b h_{ie} = i_b \beta r_e \text{ …….. (3)}$$

$$\therefore A_V = \frac{V_0}{V_i} = \frac{-\beta i_b R_c}{i_b \beta r_e} = \frac{-R_c}{r_e} = \frac{-R_c}{r_e} = -g_m R_c \text{ …… (4)} \qquad \left[\because \frac{1}{r_e} = g_m\right]$$

$$= \frac{-h_{fe} R_c}{h_{ie}} \text{ …… (5)} \qquad \because \; g_m = \frac{h_{fe}}{h_{ie}}$$

(ii) Without bypass capacitor.

Consider the ckt given, without C_E : AC model $\begin{bmatrix} 1.\text{ let the DC source} = 0 \\ 2.\ X_c = 0 \end{bmatrix}$

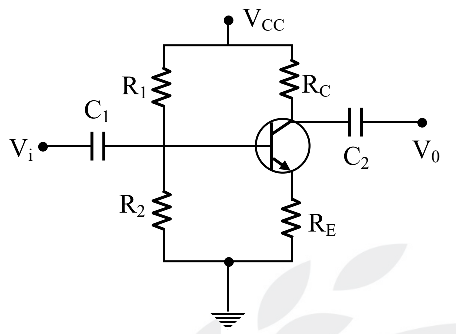


Fig.2C4

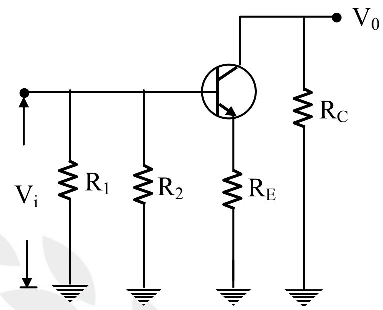


Fig.2C5

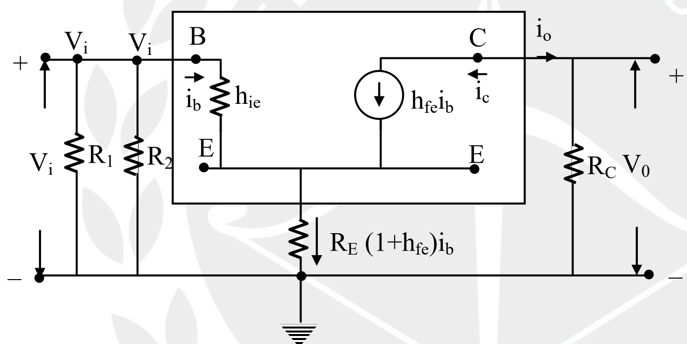


Fig.2C6 small –signal model

Step (1): $V_0 = I_0R_c = -\,h_{fe}\,i_bR_c$ …….. (1)

Step (2): KVL for input loop:

$V_i - i_bh_{ie} - (1+h_{fe})\,i_bR_E = 0$ ……… (2)

$V_i = i_b\,[\,h_{ie} + (1+h_{fe})\,R_E]$………… (3)

Step (3): Voltage gain, $A_v = \dfrac{V_0}{V_i} = \dfrac{-h_{fe}i_bR_c}{i_b[h_{ie} + (1+h_{fe})R_E]}$ …… (4)

$= \dfrac{-\beta R_c}{\beta r_e + (1+\beta)R_E}$ …… (5) $\begin{bmatrix} \because h_{fe} = \beta \\ h_{ie} = \beta r_e \end{bmatrix}$

$\therefore\ A_V = \dfrac{-\beta R_c}{(1+\beta)R_E}$ …… (6) $\begin{bmatrix} \because R_E >> r_e \text{given} \\ \Rightarrow (1+\beta)R_E >> \beta r_e \end{bmatrix}$

NOTE: If β is large, $A_V = \dfrac{-R_c}{R_E}$ ….. (7)

(iii) Given $R_1 = 90k\Omega$, $R_2 = 10k\Omega$, $R_E = 0.8k\Omega$, $\beta = 200$, $r_0 = 50\ k\Omega$, $R_c = 2.2\ k\Omega$ and $V_{cc} = 15V$

Part (i): CE amplifier with bypass capacitor:

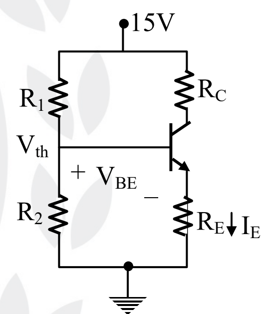
$$A_V = \frac{-h_{fe}(R_c \parallel r_0)}{h_{ie}} = -g_m(R_c \parallel r_0) \ldots\ldots (1) \left[\because \frac{h_{fe}}{h_{ie}} = g_m\right]$$

Case (i): Consider the DC model of the given circuit:

1. All AC source = 0
2. $X_c = \infty$

Step (1):

$$V_{th} = \frac{R_2(V_{cc})}{R_1 + R_2} = \frac{10k(15V)}{90k + 10k} = 1.5V = V_B \ldots\ldots (1) \ [\because \beta \text{ is large}]$$



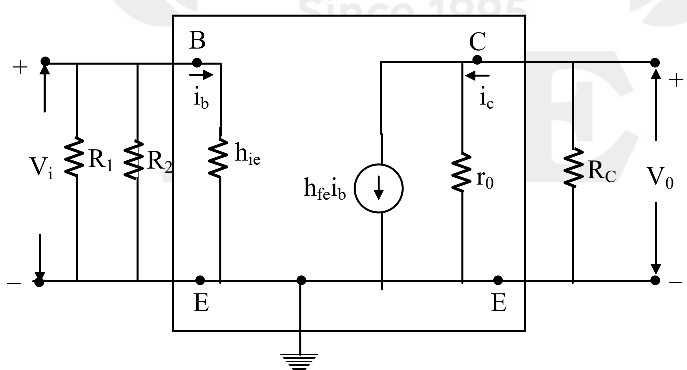
Step (2) : KVL for B-E loop of B.J.T:

$$V_{th} - V_{BE} - I_E R_E = 0 \ldots\ldots (2)$$

$$\Rightarrow I_E = \frac{V_{Th} - V_{BE}}{R_E} = \frac{1.5V - 0.7V}{0.8k\Omega} = 1mA \ldots\ldots (3)$$

$$\therefore g_m = \frac{1}{r_e} = \frac{I_E}{V_T} = \frac{1mA}{26mV} = 0.03846 \text{ mho} \ldots\ldots.. (4)$$

Case (ii): Consider the small signal model



Step (i):

$$V_0 = -h_{fe} i_b (r_o \parallel R_c) \ldots.. (1)$$

$$V_i = i_b\, h_{ie} \ldots\ldots (2)$$

Step (ii):

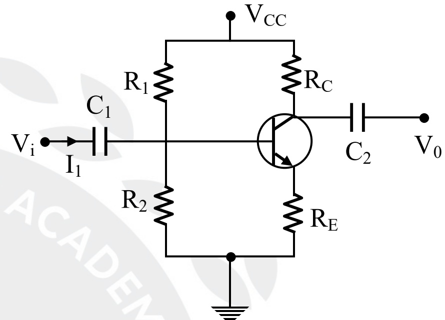
$$A_V = \frac{V_0}{V_i} = \frac{-h_{fe} i_b (r_o \| R_c)}{i_b} \quad ..... (3)$$

$$= \frac{-h_{fe}(r_o \| R_c)}{h_{ie}} \quad ...... (4)$$

$$= -g_m (r_0 \| R_c) ...... (5)$$

$$= -0.03846\ \mho\ [50k \| 2.2k] .... (6)$$

$\therefore A_v = -81.045977 ..... (7)$



Part(ii) CE Amplifier without CE:

Case (i) : same as part(i)

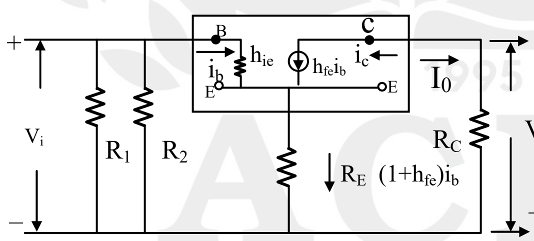
$$I_E = 1mA ...... (1)$$

$$\Rightarrow r_e = \frac{V_T}{I_E} = \frac{26mV}{1mA} = 26\Omega .... (2)$$

Approximate Approach:

Case (ii) given $r_o 50k$ & $R_c = 2.2.k$

$\because r_0 >> R_c$ (i.e $r_0 >> 10R_c$), the simplified small -signal model can be shown as follows



Step(1): $V_0 = I_0 R_C = -h_{fe} i_b R_c$ .... (1)

Step(2) : KVL for input loop

$$V_i - i_b h_{ie} - i_b (1+h_{fe}) R_E = 0 ....(2)$$

$$\Rightarrow V_i = i_b [h_{ie} + (1+h_{fe}) R_E] ....(3)$$

Step(3):

$$A_V = \frac{V_0}{V_i} = \frac{-h_{fe} i_b R_c}{i_b [h_{ie} + (1+h_{fe}) R_E]} ....(4)$$

$$= \frac{-\beta R_c}{\beta r_e + (1+\beta)R_E} \quad ....(5)$$

$$= \frac{-200 \times 2.2k}{200 \times 26\Omega + 201 \times 0.8k} \quad ....(6)$$

$$= -\frac{440}{166} \quad ....(7)$$

$$\therefore A_V = -2.65 \quad ....(8)$$

Comparison:

Case (i): $A_V = -81.045977$ [with by pass capacitor]

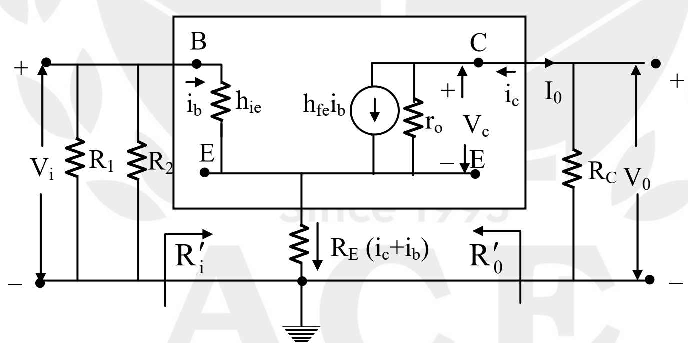
Case (ii): $A_V = -2.65$ [without by pass capacitor]

NOTE: In a CE amplifier, if the bypass capacitor is open, the voltage gain, A_V decreases, because the unbypassed R_E causes negative feed back.

This problem can be solved more accurately with the following approach:

Accurate Approach:

Case (ii): Small –signal model



$$\text{Step (1): } R'_i = h_{ie} + \left[\frac{(1+h_{fe}) + \frac{R_c}{r_0}}{1 + \left(\frac{R_c + R_E}{r_0}\right)}\right] R_E \; .... (1)$$

$$= \beta r_e + \left[\frac{(1+\beta) + \frac{R_c}{r_0}}{1 + \left(\frac{R_C + R_E}{r_0}\right)}\right] R_E \; .... (2)$$

$$\because \frac{R_C}{r_0} = \frac{2.2k}{50k} = 0.044 << (1+\beta),$$

$$R_i' = \beta r_e + \left[\frac{(1+\beta)}{1+\left(\frac{R_C + R_E}{r_0}\right)}\right] R_E \ldots\ldots (3)$$

$$\therefore r_0 > 10(R_C + R_E), \frac{R_C + R_E}{r_0} << 1 \ldots\ldots (4)$$

$$R_i' = \beta r_e + (1+\beta) R_E \ldots\ldots\ldots (5)$$

$$\therefore V_i = i_b R_i' = i_b[\beta r_e + (1+\beta) R_E] \ldots\ldots (6)$$

Step (2): $R_0' = r_0 + \dfrac{h_{fe} r_0 + h_{ie}}{1 + \dfrac{h_{ie}}{R_E}} \ldots\ldots (7)$

$$= r_0 + \frac{\beta r_0 + \beta r_e}{1 + \frac{\beta r_e}{R_E}} \ldots\ldots\ldots (8)$$

$$= r_0 + \frac{\beta r_0}{1 + \frac{\beta r_e}{R_E}} \ldots\ldots (9)\ [\therefore r_0 >> r_e]$$

$$= r_0 \left[1 + \frac{\beta}{1 + \frac{\beta r_e}{R_E}}\right] \ldots\ldots\ldots (10)$$

$$= r_0 \left[1 + \frac{200}{1 + \frac{5.2}{0.8}}\right] \ldots\ldots (11)$$

$$= r_0 \left[1 + \frac{200}{6.5}\right] \ldots\ldots (12)$$

$$\therefore R_0' = 31.77 r_0 \ldots\ldots (13)$$

Step (3) : $V_0 = -i_C R_C' \parallel R_C = -i_C R_C \parallel 31.77 r_0 \ldots\ldots\ldots (14)$

$= -i_C R_C$ …… (15) [$\because 31.77 r_0 >> R_C$]

$= - h_{fe}\, i_b\, R_C$……. (16)

Step (4): $A_V = \dfrac{V_0}{V_i} = \dfrac{-h_{fe} i_b R_c}{i_b(\beta r_e + (1+\beta)R_E} = \dfrac{-\beta R_C}{\beta r_e + (1+\beta)R_E}$ …… (17)

$= \dfrac{200 \times 2.2k}{200 \times 26.2 + 201 \times 0.8k}$ …….. (18)

$\therefore\ A_V = \dfrac{-440}{166} = -2.65$ …….. (19)

03. (a) Evaluate $\oint_C \dfrac{z^2 + 4z + 8}{\left(z - \frac{1}{2}\right)^2 (z^2 + 2z + 5)} dz$ where C is the contour |z + 1 – i| = 2 in anti-clockwise sense. (20M)

Sol: $\oint_C \dfrac{Z^2 + 4Z + 8}{\left(Z - \frac{1}{2}\right)^2 (Z^2 + 2Z + 5)}$, $|Z + 1 - i| = 2$

Case (1):

For $Z_1 = \dfrac{1}{2}, \Rightarrow 1\dfrac{1}{2} + 1 - i1 = 1.8 < 2$

$\therefore$ $Z_1 = \dfrac{1}{2}$ lies inside the contour

$$\oint_C \frac{f(Z)}{(Z-a)^n} = \frac{2\pi i}{(n-1)!} \underset{Z\to a}{Lt}\, f^{\,n-1}(Z)$$

$\therefore$ For $Z = \dfrac{1}{2}$

$$f(Z) = \frac{Z^2 + 4Z + 8}{Z^2 + 2Z + 5}$$

$$\oint_C \frac{\frac{Z^2 + 4Z + 8}{Z^2 + 2Z + 5}}{\left(Z - \frac{1}{2}\right)^2} = \frac{2\pi i}{(2-1)!} \underset{Z\to\frac{1}{2}}{Lt}\, f^{\,2-1}(Z)$$

$$= 2\pi i \underset{Z\to\frac{1}{2}}{Lt} f'(Z)$$

$$= 2\pi i \times \underset{Z\to\frac{1}{2}}{Lt} \frac{(Z^2+2Z+5)(2Z+4)-(Z^2+4Z+8)(2Z+2)}{Z^2+2Z+5)^2}$$

$$= 2\pi i \times \underset{Z\to\frac{1}{2}}{Lt} \frac{-2Z^2-6Z+4}{(Z^2+2Z+5)^2}$$

$$= 2\pi i \times \frac{-2\times\frac{1}{4}-6\times\frac{1}{2}+4}{\left(\frac{1}{4}+2\times\frac{1}{2}+5\right)^2}$$

$$= 2\pi i \times \left(\frac{0.5}{39.0625}\right) = 0.08i$$

Case (2):

$Z^2 + 2Z + 5 = (Z + 1+ 2i)(Z + 1 - 2i)$

$Z_2 = -1 -2i \Rightarrow |1 -2i + 1-i| = 3 > 2$

$\therefore$ $Z_2 = - 1-2i$ lies outside the contour

$Z_3 = -1 + 2i, \Rightarrow |-1 + 2i + 1 - i| = 1 < 2$

$\therefore$ Lies inside the contour.

For $Z_3 = -1 + 2i$

$$= 2\pi i \underset{Z\to(-1+2i)}{Lt} \times \frac{Z^2+4Z+8}{\left(Z-\frac{1}{2}\right)^2(Z+1+2i)(Z+1-2i)} \times (Z+1-2i)$$

$$= 2\pi i \times \frac{(-1+2i)^2+4(-1+2i)+8}{\left(-1+2i-\frac{1}{2}\right)^2(-1+2i+1+2i)}$$

$$= 2\pi i \times \left[\frac{1-4-4i+8i-4+8}{\left(-4+\frac{9}{4}-6i\right)(4i)}\right]$$

$$= 2\pi i \times \left[\frac{1-4i}{-7i+24}\right] \times \frac{24+7i}{24+7i}$$

$$= 2\pi i \times \left(\frac{-4+103i}{625}\right)$$

$$= -0.04i - 1.035$$

For, $Z_2 = -1 - 2i$, $\Rightarrow$ The contour integral is zero

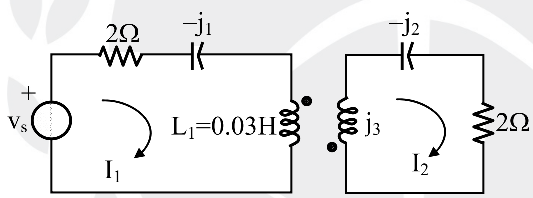
$$\therefore \oint \frac{Z^2+4Z+8}{\left(Z-\frac{1}{2}\right)^2 (Z^2+2Z+5)} = Z_1 + Z_2 + Z_3$$

$$= 0.08i + 0 - 0.04i - 1.035$$

$$= 0.04i - 1.035$$

Model Questions asked in ACE ESE mains 2018 Test Series Mock-1, Q5(c).

03. (b)

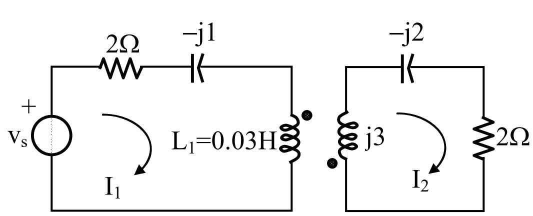


For the network shown, $v_S = 24\sqrt{2}\sin 100t$, coefficient of coupling $k = \frac{1}{3}$ between two coupled coils.

(i) Write loop equations in vector-matrix for currents I_1 & I_2.

(ii) Obtain the impedance seen by the source v_S and the power factor of the source. (20M)

Sol:



The supply voltage $V_S = 24\sqrt{2}\sin 100t$,

$V_{S(rms)} = 24\angle 0°$ v, ω = 100 rad/sec

Coefficient of coupling k = 1/3

$L_1 = 0.03$ H

$X_{L1} = j\omega L_1 = j(100)(0.03) = j3\ \Omega$

Mutual inductance, $M = K\sqrt{L_1 L_2}$

$\Rightarrow X_M = K\sqrt{X_{L1}X_{L2}}$

$$= \frac{1}{3}\sqrt{(j3)(j3)} = j1\ \Omega$$

Apply KVL to 1st loop

$$-V_S + 2I_1 + (j3 - j1)I_1 + (j1)I_2 = 0$$

$$V_S = (2 + 2j)I_1 + (j1)I_2 \text{ ………. (1)}$$

KVL to 2nd loop

$$(2 + j3 - j2)I_2 + (j1)I_1 = 0$$

$$(j1)I_1 + (2+j1)I_2 = 0 \text{ ………… (2)}$$

(i) Writing the loop equations I_1 and I_2 in matrix form

$$\begin{bmatrix} 24\angle 0° \\ 0 \end{bmatrix} = \begin{bmatrix} 2+2j & j1 \\ j1 & 2+j1 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

(ii) From the equation (2)

$(j1)I_1 + (2+j1)I_2 = 0$

$$\Rightarrow I_2 = \frac{-(j1)}{(2+j1)}I_1$$

Sub in (1) equation

$V_S = (2+2j)I_1 + (j1)I_2$

$$= (2+2j)I_1 + (j1)\times\frac{-(j1)}{(2+j1)}I_1$$

$$V_S = I_1\left(2+2j+\frac{1}{2+j}\right)$$

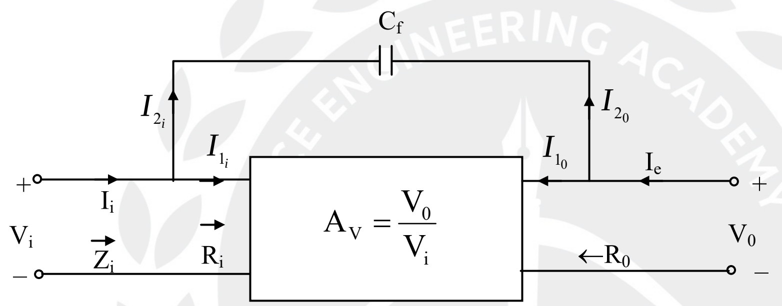
$$\frac{V_S}{I_1} = \frac{(2+2j)(2+j)+1}{2+j} = \frac{4+6j-2+1}{2+j}$$

$$= \frac{3+6j}{2+j} = 3\angle 36.86°\ \Omega$$

Impedance seen by the source $V_S = 3\angle 36.86°\Omega$

Power factor of the source = cos36.86° = 0.8 leading

03. (c)



(i) Explain Miller effect capacitance in brief

(ii) For the given circuit, prove that

(A) Miller effect input capacitance

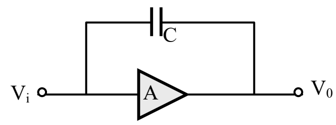
$$C_{M_i} = (1-A_v)C_f$$

(4+16=20M)

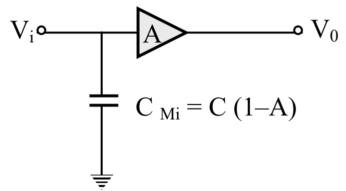
(B) Miller effect output capacitance

$$C_{M_o} = \left(1-\frac{1}{A_v}\right)C_f$$

Sol: **(i)** Miller effect capacitance:

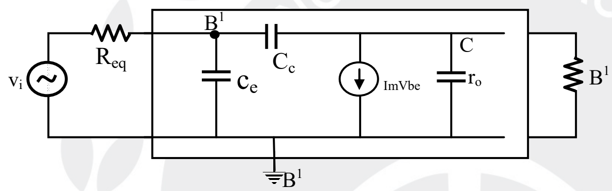


Consider a capacitor 'C' is placed between input and output sections of an amplifier having a gain of 'A' as shown above. Then its value is multiplied by a factor of (1–A) to obtain the equivalent capacitance at the input side as shown in fig. The multiplication of a capacitor, C by a factor (1–A) is referred to as Miller effect or Miller multiplication



NOTE: The Miller effect capacitance cause significant effect on the high frequency response of BJT and FET amplifiers.

Consider the small signal model of a CE amplifier at High Frequencies



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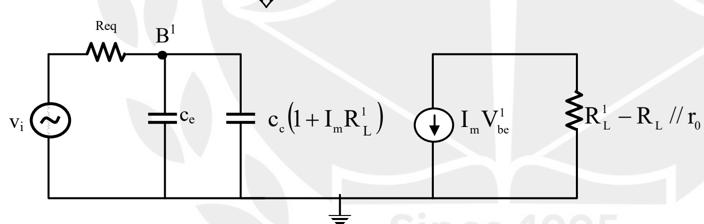


The upper 3 dB frequency of the amplifier shown in fig , is given by

$$f_H = \frac{1}{2\pi r'_{be}\left[c_e + c_c\left(1 + g_m R_L^1\right)\right]}$$

Conclusion: Due to the miller effect capacitor $C_e\left(1 + g_m R'_L\right)$, the upper 3-db frequency in CE amplifier is highly reduced.

(ii) Step(1): KVL from input to output

$$V_i - I_{2i}\frac{1}{sc_f} - V_0 = 0$$

$$\Rightarrow I_{2i}.\frac{1}{sc_f} = v_i - V_0$$

$$= V_i\left[1-\frac{V_0}{V_i}\right]$$

$$= V_i\,[1-A_V]$$

$$\Rightarrow \quad I_{2_i} = \frac{V_i[1-A_V]}{\left(\frac{1}{sc_f}\right)}$$

$$\Rightarrow \quad \frac{V_i}{I_{2i}} = \frac{1}{j\omega c_f(1-A_V)} = \frac{1}{j\omega C_{Mi}}$$

$$\therefore C_{M_i} = \text{Miller effect input capacitance} = C_f[1-A_v]$$

Step: (2): KVL from output to input

$$V_0 - I_{2_0}\frac{1}{sc_f} - V_i = 0$$

$$\Rightarrow I_{2_0}\frac{1}{sc_f} = V_0 - V_i$$

$$= V_0\left[1-\frac{V_i}{V_o}\right]$$

$$= V_0\left[1-\frac{1}{A_v}\right]$$

$$\Rightarrow \frac{V_0}{I_{2_0}} = \frac{1}{j\omega c_f\left(1-\frac{1}{A_V}\right)} == \frac{1}{j\omega c_{M_o}}$$

$$\therefore C_{M_0} = \text{Miller effect output capacitance} = C_f\left(1-\frac{1}{A_v}\right)$$

04. (a) Let the probability density function of a random variable X be given as:

$$f(x) = \frac{5}{3}e^{-5x}u(x) + \beta e^{2x}u(-x)$$

Where β is a constant and u(x) is the unit step function. Calculate:

(i) The value of β

(ii) Mean of X

(iii) Variance of X **(3+7+10 M)**

Sol: Given,

Probability density function, $f(x) = \frac{5}{3}e^{-5x}u(x) + \beta e^{2x}u(-x)$

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

$$\int_{-\infty}^{0} \beta.e^{2x}dx + \int_{0}^{\infty} \frac{5}{3}.e^{-5x}\,dx = 1$$

$$\frac{\beta}{2}\left[e^{2x}\right]_{-\infty}^{0} + \frac{5}{3}\times\frac{1}{(-5)}\left[e^{-5x}\right]_{0}^{\infty} = 1$$

$$\frac{\beta}{2}\left[e^{2\times 0} - e^{2\times(-\infty)}\right] - \frac{1}{3}\left[e^{-5\times\infty} - e^{-5\times 0}\right] = 1$$

$$\frac{\beta}{2}[1-0] - \frac{1}{3}[0-1] = 1$$

$$\frac{\beta}{2} + \frac{1}{3} = 1$$

(i) $\frac{\beta}{2} = \frac{2}{3} \Rightarrow \beta = \frac{4}{3}$

$\therefore$ f(x) = $\frac{5}{3}e^{-5x}\,4(x) + \frac{4}{3}e^{2x}\,4(-x)$

(ii) Mean of X, = $\int_{-\infty}^{0} x\times\frac{4}{3}e^{2x}dx + \int_{0}^{\infty} x\times\frac{5}{3}e^{-5x}dx$

$$E(x) = \int_{-\infty}^{0} x\times\frac{4}{3}e^{2x}dx + \int_{0}^{\infty} x\times\frac{5}{3}e^{-5x}dx$$

$$= \frac{4}{3}\left[x.\frac{e^{2x}}{2} - 1\times\frac{e^{2x}}{4}\right]_{-\infty}^{0} + \frac{5}{3}\left[x.\frac{e^{-5x}}{(-5)} - 1\times\frac{e^{-5x}}{(25)}\right]_{0}^{\infty}$$

$$= \frac{4}{3}\left[\left(0-\frac{1}{4}\right)-(0-0)\right] + \frac{5}{3}\left[(0-0)-\left(0-\frac{1}{25}\right)\right]$$

$$E(x) = -\frac{1}{3} + \frac{1}{15} = -0.2666$$

Variance, $V(x) = E(x^2) - [E(x)]^2$

$$\therefore\ E(x^2) = \int_{-\infty}^{\infty} x^2 \times f(x)dx$$

$$= \int_{-\infty}^{0} x^2 \times \frac{4}{3}e^{2x}dx + \int_{0}^{\infty} x^2 \times \frac{5}{3}e^{-5x}dx$$

$$= \frac{4}{3}\left[x^2.\frac{e^{2x}}{2} - (2x)\times\frac{e^{2x}}{4} + 2\times\frac{e^{2x}}{8}\right]_{-\infty}^{0} + \frac{5}{3}\left[x^2.\frac{e^{-5x}}{(-5)} - (2x)\frac{e^{-5x}}{(25)} + 2\times\frac{e^{-5x}}{(-125)}\right]_{0}^{\infty}$$

$$= \frac{4}{3}\left[\left(0-0-\frac{2}{8}\right)-(0-0-0)\right] + \frac{5}{3}\left[(0-0-0)-\left(0-0-\frac{2}{125}\right)\right]$$

$$= \frac{4}{3}\times\left(\frac{1}{4}\right) + \frac{5}{3}\times\left(\frac{2}{125}\right)$$

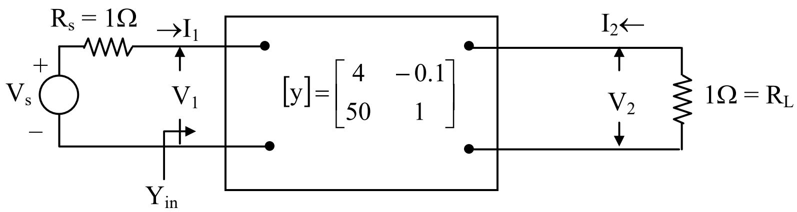
$$= \frac{1}{3} + \frac{2}{75}$$

$$= 0.36$$

$\therefore$ Variance = 0.36 – (–0.2666)^2

= 0.2889

04. (b)

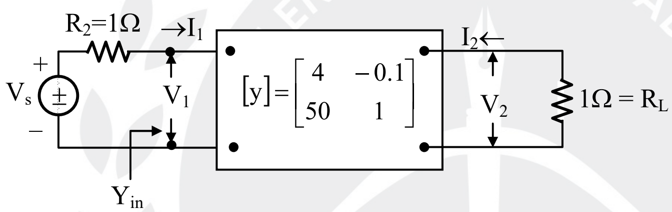


For the two port network shown, the y-parameter matrix is given.

(i) Obtain the input admittance Y_{in} as shown in the figure.

(ii) Obtain voltage gain $\frac{V_2}{V_s}$ **(20M)**

Sol:



The Y parameters of two port network given by

$I_1 = Y_{11}V_1 + Y_{12}V_2$

$I_2 = Y_{21}V_1 + Y_{22}V_2$

The Y parameters

$$[Y]=\begin{bmatrix} 4 & -0.1 \\ 50 & 1 \end{bmatrix}$$

$\Rightarrow I_1 = 4V_1 - 0.1V_2$ ………… (1)

$\Rightarrow I_2 = 50V_1 + V_2$ ………… (2)

The load voltage across R_L,

$\Rightarrow V_2 = (-I_2)(1) = -I_2$ ………… (3)

Applying KVL to the input side

$-V_S + (1)(I_1) + V_1 = 0$

$\Rightarrow V_S = V_1 + I_1$ ………… (4)

Substitute (3) in equation (1) and (2)

$I_1 = 4V_1 + 0.1I_2$ ………… (5)

$I_2 = 50V_1 - I_2$

$\Rightarrow I_2 = 25V_1$ ………… (6)

Substitute (6) in equation (5)

$I_1 = 4V_1 + 2.5V_1 = 6.5V_1$

$$\Rightarrow \frac{I_1}{V_1} = 6.5 \text{ mho} = Y_{in}$$

Input admittance $Y_{in} = 6.5$ mho

(ii) From equation (4)

$V_S = V_1 + I_1$

As $I_1 = 6.5\,V_1$

$\Rightarrow V_S = 7.5\,V_1$

From equation (6) $I_2 = 25\,V_1$

$$V_S = 7.5 \times \frac{I_2}{25}$$

$$V_S = \frac{75}{250} I_2$$

From (3) equation $V_2 = -I_2$

$$\Rightarrow \frac{V_2}{V_S} = \frac{-I_2}{\frac{75}{250} I_2}$$

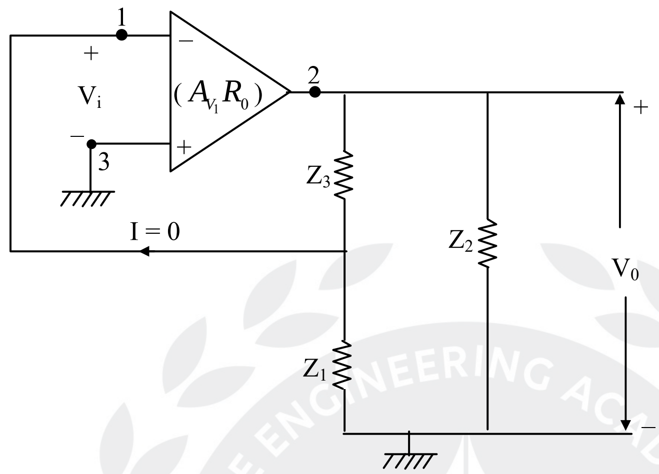
$$= \frac{-250}{75}$$

$$\frac{V_2}{V_S} = -3.33$$

Voltage gain $= \frac{V_2}{V_S} = -3.33$

04. (c) (i) State whether the given statement is true or false for practical oscillators with reasons. "Loop' gain is generally made slightly larger than unity".

(ii) In a general form of oscillator circuit given in figure.



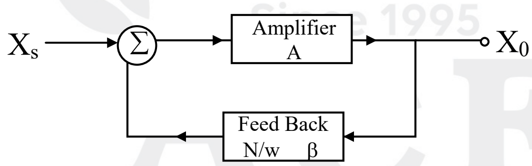
Given impedance Z_1, Z_2 and Z_3 are purely reactive.

Prove that if Z_1 and Z_2 are capacitors then Z_3 must be an inductor and vice versa.

(5+15 M)

Sol: (i) "The given statement is TRUE for practical oscillators"

Consider the basic structure of a sinusoidal oscillator i.e. an amplifier with positive feed back as shown in fig.

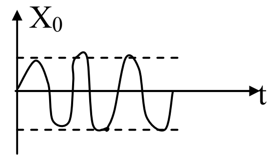


The overall gain of the amplifier with positive feedback, A_f is given by $A_f = \dfrac{A}{1 - A\beta}$ ...... (1)

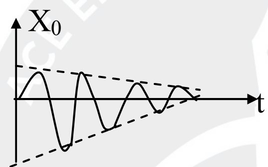
Criterion for oscillations: At a specific frequency, f_o, if the loop gain, $A\beta$ is equal to unity (i.e. $A\beta=1$), from eq(1), A_f will be infinite. That is at that frequency, f_o, the circuit will have a finite output for zero input signal. Such a circuit is called as an oscillator. This condition, loop gain $A\beta = 1$ is called as Barkhausen criterion.

But the Barkhausen Criterion i.e $A\beta=1$ guarantees sustained oscillations in a mathematical sense only. The gain, A of any physical system is a function of the device parameters and it is well known that the device parameters are temperature sensitive. Therefore the gain, A cannot be maintained as constant for a long time.

Case(i): Assume that with careful design, Aβ is maintained at unity in oscillator, so that sustained oscillations are obtained as shown:



Case(ii): Assume that the sudden change in temperature reduces the gain of the system and leads to Aβ, loop gain to fall below unity i.e $A\beta<1$, which will cause under damped oscillations and over period of time oscillations may be vanished as shown.



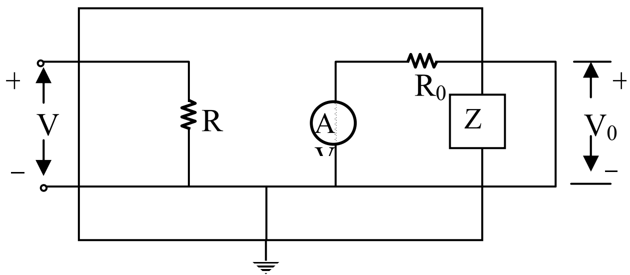
Under the circumstances we need a mechanism for forcing Aβ to remain equal to unity at the desired amplitude of output. This task is accomplished by providing a nonlinear circuit for gain control.

Basically the function of the gain - control mechanism is as follows: First, to ensure that oscillations will start, the circuit is designed such that, the loop gain Aβ is kept at slightly greater then unity this is corresponds to designing the circuit, so that the poles are in the right half of the 'S" plane. Thus, when the oscillations are initiated, the amplitude of oscillations will increases. When the amplitude reaches to the desired level, the non-linear network comes into action and causes the loop gain to be reduced to exactly unity. That is the poles will be pulled back to the jω axis. This action will cause the circuit to sustain oscillations at this desired amplitude.

(ii) Step: (1) from the ckt, $V_f = \dfrac{Z_1 V_0}{Z_1 + Z_3}$

$$\Rightarrow \frac{V_f}{V_o} = \beta = \frac{Z_1}{Z_1 + Z_3}$$

Step (2): $Z_L = (Z_1 + Z_3)//Z_2$



Step (3): $V_0 = \dfrac{Z_L A V_i}{Z_L + R_0}$ Where A is open loop gain of OP-AMP

$$\Rightarrow \frac{V_0}{V_i} = A_V = A\frac{Z_L}{Z_L + R_0}$$

Step (4): According to Barkhausen criterion, $A_V\beta = 1$

$$\Rightarrow \qquad A_V\beta = A\left[\frac{Z_L}{Z_L + R_0}\right]\left[\frac{Z_1}{Z_1 + Z_3}\right] = 1$$

$$\Rightarrow \qquad A\left[\frac{\dfrac{[z_1 + Z_3]Z_2}{Z_1 + Z_2 + Z_3}}{\dfrac{(Z_1 + Z_3)2}{Z_1 + Z_2 + Z_3} + R_0}\right]\left[\frac{Z_1}{Z_1 + Z_3}\right] = 1$$

$$\Rightarrow A\left[\frac{\dfrac{(Z_1 + Z_3)Z_2}{Z_1 + Z_2 + Z_3}}{\dfrac{(Z_1 + Z_3)Z_2 + R_0(Z_1 + Z_2 + Z_3)}{Z_1 + Z_2 + Z_3}}\right]\left[\frac{Z_1}{Z_1 + Z_3}\right] = 1$$

$$\Rightarrow \frac{AZ_1Z_2}{(Z_1+Z_3)Z_2 + R_0(Z_1+Z_2+Z_3)} = 1$$

Step: (5) Let $Z_1= jx_1$, $Z_2= jx_2$ & $Z_3=jx_3$

$$\Rightarrow \frac{-Ax_1x_2}{j(x_1+x_3)jx_2 + jR_0(x_1+x_2+x_3)} = 1$$

$$\Rightarrow \frac{-Ax_1x_2}{-(x_1+x_3)x_2 + jR_o(x_1+x_2+x_3)} = 1 \quad \text{......... (1)}$$

Case(i): General equation for frequency of oscillation in LC oscillators:

NOTE: Since gain of amplifier is a real value and log gain, Aβ is also a real value, the imaginary part in equation (β) is should be zero.

i.e $X_1+ X_2+ X_3= 0$ -------- (2)

Case (ii): condition for sustained oscillations:

consider the real part in equation (1)

$$\Rightarrow \frac{Ax_1x_2}{(x_1+x_3)x_2} = 1$$

$$\Rightarrow \frac{Ax_1x_2}{(-x_2)x_2} = 1$$

$$\therefore A = \frac{-x_2}{x_1}$$

NOTE:

(1) If Z_1 and Z_2 are capacitors, to satisfy equation (2) & to maintain a phase shift of 180° in the feedback net work, Z_3 should be an inductor.

(2) If Z_1 and Z_2 are inductors, again to satisfy equation (2) and to establish 180° phase shift in the feed back Z_3 should be a capacitor.

SECTION - B

05. (a) Mention the type of Bravais space lattice, relationship of crystal axial lengths (x,y,z) and relationship of interaxial angles (α, β , γ) in the following order of the crystal system.

(i) Triclinic

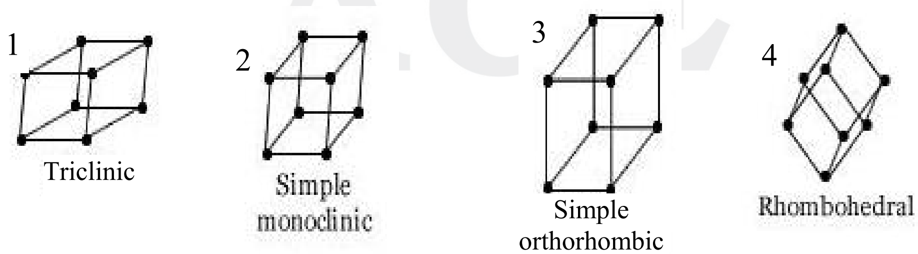
(ii) Monoclinic

(iii) Orthorhombic and

(iv) Trigonal **(12M)**

Sol:

Crystal structure	**Lattice Parameters**
1. Triclinic	$a \neq b \neq c$ $\alpha \neq \beta \neq \gamma \neq 90°$
2. Monoclinic	$a \neq b \neq c$ $\alpha = \beta = 90°, \gamma \neq 90°$
3. Orthorhombic	$a \neq b \neq c$ $\alpha = \beta = \gamma = 90°$
4. Rhombohedral (trigonal)	$a = b = c$ $\alpha = \beta = 90, \gamma \neq 90°$



Same Questions asked in ACE ESE mains 2018 Test Series Mock-1, Q8(a)(i)

05. (b) A standard cell of 1.0185 V used with a simple potentiometer balances at 50 cm Calculate.

(i) The emf of cell which balances at 72 cm

(ii) The percentage error in voltmeter which balances at 64.5 cm when reading 1.33 V

(iii) Percentage error in an ammeter that reads 0.43 A and balance is obtained at 43.2 cm with Pd across a 2Ω resistor in the ammeter circuit. (12M)

Sol: EMF of standard coil = 1.0185V

Voltage drop per cm length of potentiometer wire, $v = \frac{1.0185}{50} = 0.02037 V/cm$

(i) The emf of a coil which balances at 72 cm,

$= V/cm \times length$

$= 0.02037 \times 72 = 1.46664\ V$

(ii) The P.D which balances at 64.5 cm is

$= 0.02037\ V/cm \times 64.5\ cm$

$= 1.313865\ V$

Voltmeter reading = 1.33V

$$\%\,error = \frac{1.33 - 1.313865}{1.313865} \times 10$$

$= 1.228\% \simeq 1.23\%$ high

(iii) The P.D which balances at 43.2 cm

$= 0.02037\ V/cm \times 43.2\ cm$

$= 0.879984\ V$

Current through 2Ω resistor

$$I = \frac{0.879984}{2} = 0.4399 A$$

$$\%\ error = \frac{0.43 - 0.4399}{0.4399} \times 100$$

$= -2.26\ \%$ Low

05.(c) (i) Write down algorithm in Pseudocode for sorting an array in descending order. Specify the name of the algorithm you have used. (6M)

(ii) Write a program segment in any higher level language for Linear search problem. (Specify which language you are using) (6M)

Sol: (i)

```
void sort (array [ ], n) //size of array is n
{
    for i=1 to n, step by 1
    {
        for j= 0 to n–i –1
        {
            if (Array [j] < Array [j+1])
            {
                temp = Array [j];
                Array[j] = Array[j+1];
                Array [j+1] = temp;
            }
        }
}
```

The algorithm used is: Bubble sort

Array is having index: 0 to n–1

Array size: n

(ii) Linear search:

Programming language used is C-language

```
int linear_search (Array [ ], item, n)
{
   /* item is the element which is to be searched, n is number of elements in the array, array
      has indexed 0 to n–1 */
    int i;
```

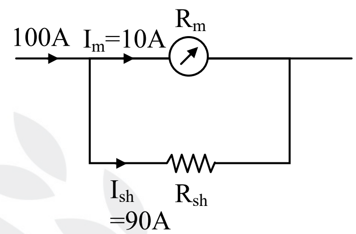
```
        for (i = 0; i < n; i++)
            {
            if (Array [i] = = item)
            {
                    return i;          /* for successful search return index of elements*/
            }
    }
                    return –1;         /* for unsuccessful search return –1 */
    }
```

05. (d) A non-inductive shunt is used to increase the range of a 10 A moving iron ammeter to 100 A. the impedance of the instrument including the leads is $(0.06+j4.71 \times 10^{-3})$ Ω. If the combination is correct on a dc circuit, find the error on ac circuit. (12M)

Sol: Impedance of instrument $(Z_m) = R_m + jX_m = (0.06 + j4.71 \times 10^{-3})\Omega$

DC Measurement:

$$m = \frac{\text{New range}}{\text{Old range}} = \frac{100}{10} = 10$$

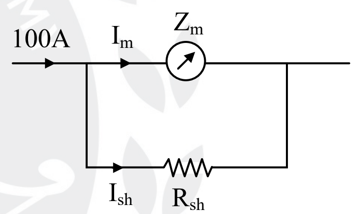


$\therefore$ m = 10

$$R_{sh} = \frac{R_m}{m-1} = \frac{0.06}{10-1} = \frac{0.06}{9}\Omega$$

AC measurement:

$$I_m Z_m = I_{sh} \times R_{sh}$$



$$(100 - I_{sh}) \times \sqrt{(0.06)^2 + (4.71\times10^{-3})^2} = I_{sh} \times \frac{0.06}{9}$$

$$(100 - I_{sh}) \times 60.1845 \times 10^{-3} = I_{sh} \times \frac{0.06}{9}$$

$$\Rightarrow \quad I_{sh} = \frac{6.01845}{\left(\frac{0.06}{9} + 60.1845\times10^{-3}\right)} = 90.0275 \text{ A}$$

$\therefore I_m = 100 - I_{sh} = 100 - 90.0275$

$I_m = 9.9725$ A

$$\therefore \%\text{Error} = \frac{I_m - I_T}{I_T} \times 100$$

$$= \frac{(9.9725)-(10)}{(10)} \times 100$$

%Error = – 0.275%

Model Questions asked in ACE ESE mains 2018 Test Series Mock-1, Q7(b)

05.(e) (i) Explain the electrochemical breakdown in insulators and discuss any two factors that accelerates the breakdown. (8M)

(ii) A magnetic material having almost a square hysteresis loop has a coercivity of 50 A/m and a remanence of 0.5 T. If this material is used in a toroidal inductor of mean diameter 1.6 cm, with a cross-sectional area of 0.25×10^{-4} m^2, calculate the power loss at a frequency of 50 Hz when the material is driven around one complete hysteresis cycle. (4M)

Sol: Electro-chemical deterioration is due to the presence and mobility of ions in the insulation, which are responsible for leakage current and energy loss in the material. In most of the cases the final breakdown resulting from electro-chemical deterioration is thermal breakdown.

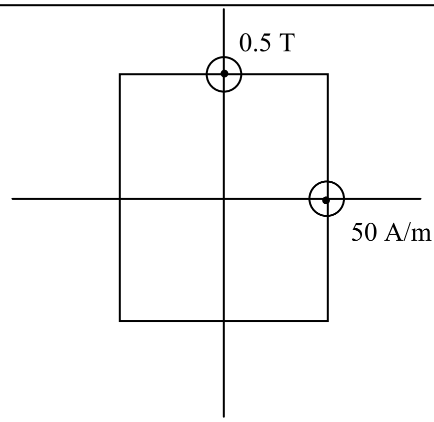
Almost all insulating materials have free ions, which are responsible for leakage current in the presence of electric field. Such ions after reaching the electrodes reduce their charge and may also attack the electrode metal evolving some gas, or some other substance may be deposited on to the electrodes. Such type of activities of the ions are chemically or electrically harmful and many times lead to rapid failure of insulation. The rate of electro-chemical deterioration is determined by the magnitude of leakage current and other factors like concentration of ions in the insulations, temperature, and whether the material is polar one or not. To avoid electro-chemical deterioration:

(i) The impurities should be avoided in the insulating materials

(ii) It should not be operated at elevated temperature

(iii) Care should be taken to avoid contamination in polar materials, which otherwise, will result in high leakage currents.

(ii)



Hysteresis losses = 100 × 1 = 100 J/m^3

Volume = (πd) × cross sectional area

$= \pi \times 1.6 \times 10^{-2} \times 0.25 \times 10^{-14}$

$= 1.256 \times 10^{-6}$ m^3

Hysteresis losses = $100 \times 1.256 \times 10^{-6}$

For one cycle $= 125.6 \times 10^{-6}$ Joule

For 50 cycles = $50 \times 125.6 \times 10^{-6} = 62.8 \times 10^{-4}$ joules

06. (a) (i) Explain electrical resistivity of metals in terms of thermal and residual components. Also draw the schematic variation of them with respect to temperature. (8M)

(ii) Write the relation between magnetic susceptibility and temperature according to Curie Law, Curie-Weiss Law and Neel Law. Sketch the variation of reciprocal of susceptibility with temperature as per the above laws. (6M)

(iii) What are the ferrites? Mention 3 disadvantages. State the reason, why ferrites are suitable for high frequency operation. (6M)

Sol: (i) The thermal component ρ_T; which arises from the lattice vibrations, and the residual resistivity ρ_r, caused by impurities and structural imperfections. The latter is independent of temperature. The total resistivity is given by

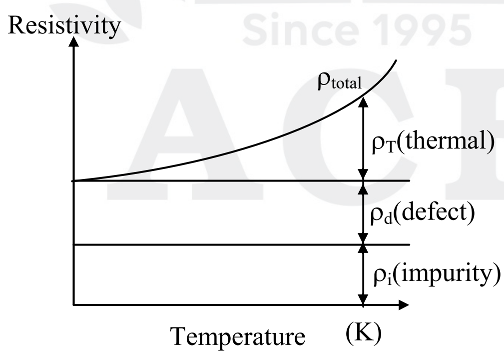
$$\rho = \rho_T + \rho_r \quad \ldots\ldots\ldots\ldots(1) \quad \text{(Matthiessen's rule)}$$

Temperature: The electrical resistance of most metals increases with increase in temperature**.** At temperatures above the so called Debye temperature, the thermal component of resistivity of conductors is approximately linear.

$$\rho \approx \rho_0\,[1 + \alpha\,(T - T_{RT}) + \ldots..]$$

Where ρ_0 is room temperature (T_{RT}) resistivity

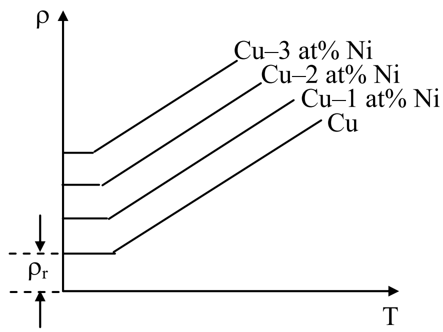
α is about 0.004 per °C



Alloying: A solid solution has a less regular structure than a pure metal. Consequently, the electrical conductivity of a solid solution alloy drops off rapidly with increased alloy content.

$\rho_{alloy} = \rho_{copper} + S\rho_i$ μ-ohm-cm

Where S = Atomic percentage of added impurity ρi = Increases in resistivity for one atomic percent addition of impurity.



Cold Work: Mechanical distortion of the crystal structure decreases the conductivity of a metal because the localized strains interfere with electron movement. Thus, hard drawn copper wire has a lower conductivity than annealed copper. Subsequent annealing restores the electrical conductivity by establishing greater regularity in the crystal lattice.

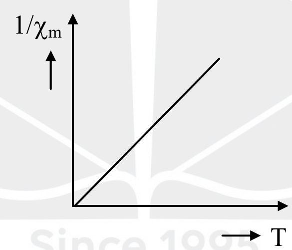
Age Hardening: Age hardening increases the resistivity of an alloy.

(ii) The relation between magnetic susceptibility and temperature

(a) Curie Law:

$$\chi_m = \frac{C}{T}$$

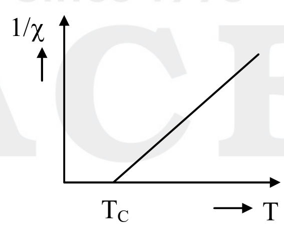
Ex: oxygen



(b) Curie-Weiss Law:

$$\chi_m = \frac{C}{T-\theta}$$

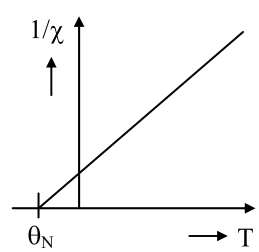
Ex: Fe, Co, Ni



(c) Neel's Law:

$$\chi = \frac{C}{T+\theta_N}$$

Ex: Cr, Mno



(iii) Ferrite Composition: Ferrites are the important class of magnetic materials containing iron oxide and metal oxides in different ratio depending upon their type. On the basis of their crystal structure, ferrites are of three types namely spinel ferrite, garnet and hexagonal ferrite.

There are 3 types of Ferrites:

(a) Spinel Ferrite: A spinel ferrite is a ferromagnetic material, containing mostly iron oxide which is derived from magnetic ($Fe^{2+}O,\ Fe_2^{2+}O_3$) represented by the formula $M^{2+}\ Fe_2^{2+}O_4$. M is a divalent metal iron like cobalt (Co), nickel (Ni), copper (Cu), manganese (Mg), zinc (Zn), cadmium (Cd) etc. Trivalent Fe^{3+} ions can be replaced by trivalent metal ions like Al^{3+} , Cr^{3+}, Ga^{3+} etc. In all cases the ionic radii of the substituting ion should be between 0.5 to 1.0 A.

(b) Garnet Ferrite: The second type of ferrite is a garnet having cubic structure with general formula $R_2^{3+}Fe_5^{3+}O_{12}$ where R is a rate earth ion (like dysprosium (Dy^{3+}), gadolium (Gd^{3+}), samarium (Sm^{3+}) etc or yttrium (Y^{3+}). Fe^{3+} can be replaced by trivalent metal ions like Al, Cr, etc.

(c) Magneto-plumbite Ferrite: Magneto-plumbite is having a hexagonal structure and are represented by the formula $MFe_{12}O_{19}$ where M is a divalent metal ion with large ionic radius like Ba^{2+}, Sr^{2+}, Pb^{2+}.

Disadvantages:

1. More porocity

2. High brittle.

3. More cost of production.

The ferries are used for high frequency applications

(1) High initial permeability

(2) High Remanance.

06. (b) (i) Prove that the most probable value is the mean value (6M)

(ii) What is an RS-232 interface? How many signals it can handle? How many wires are sufficient for operation? (6M)

(iii) What is creeping in energy meters? State the reasons for the same and how it is avoided. (8M)

Sol: (i) Most probable value is mean value:

1. Mean is calculated based upon all the observations in the data.

2. It is amenable to algebraic treatment. The mean of the composite series interms of the means and the sizes of the component series is given by

$$\overline{x} = \frac{\sum_{i=1}^{n} n_i \overline{x}}{\sum_{i=1}^{n} n_i}$$

3. Of all the averages arithmetic mean is affected least by fluctuations of sampling. So that arithmetic mean is a stable average.

4. Sum of deviations of the given values from their mean is always zero.

i.e., $\left(\sum_{i=1}^{n} f_i (x_i - \overline{x}) = 0\right)$

5. The expected value (mean) is a weighted average of all the possible values of the random variable.

$$\overline{x} = E(x) = \sum_{0}^{n} x.p(x) = \int_{-\infty}^{\infty} x.f(x)dx$$

$$\sum_{x=0}^{n} p(x) = 1$$

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

Thus we see that arithmetic mean satisfies all the properties laid down by prof. Yule for an ideal average.

(ii) RS-232 interface is standard for the interchange of serial binary data between a DTE (data terminal equipment) such as a computer terminal and a dce (data communication equipment).

The original standard uses 25 wires to connect the two devices.

However, in reality only three of these wires are sufficient.

(iii) In some meters, a slow but continuous rotation is obtained even when there is no current flowing through the current coil and only pressure coil is energized. This is called creeping.

Causes:

- Main reason is Over voltages and over static friction compensation
- Excessive lubrications, vibrations, stray magnetic field of Instrument.

Creep error compensation :

(i) To eliminate the creeping error, two diametrically opposite holes are drilled in the disc ; the disc will come to rest with one of the holes under the edge of a pole of the shunt magnet.

(ii) A small piece of iron is attached to the edge of the disc. The force of attraction exerted by the brake magnet on the iron piece is sufficient to prevent creeping of disc.

Same Questions asked in ACE ESE mains 2018 Test Series Test-3, Q3(a), Test-9, Q7(a)

06. (c) (i) Can we use Semiconductor Memory for secondary storage ? Justify your answer. (5M)

(ii) What exactly is the role of Control Unit in CPU ? How is it different from that of a Arithmetic Logic Unit? (6M)

(iii) How exactly is an array stored in main memory? Illustrate with the help of storage of a matrix. What will be the exact address of element A (3, 7) of an 8 × 9 array A assuming that location of the first element is d. (9M)

Sol: (i) Yes semiconductor memory can be used as secondary storage.

Now a days most of the Hard disks (Removable) are designed with semiconductor memories with flash technology and pendrive is also used for secondary storage (pendrive uses flash technology).

Flash memory is widely used in advanced cell phones and digital computers.

Merit: semiconductor secondary storage memory is faster than other secondary storage memories.

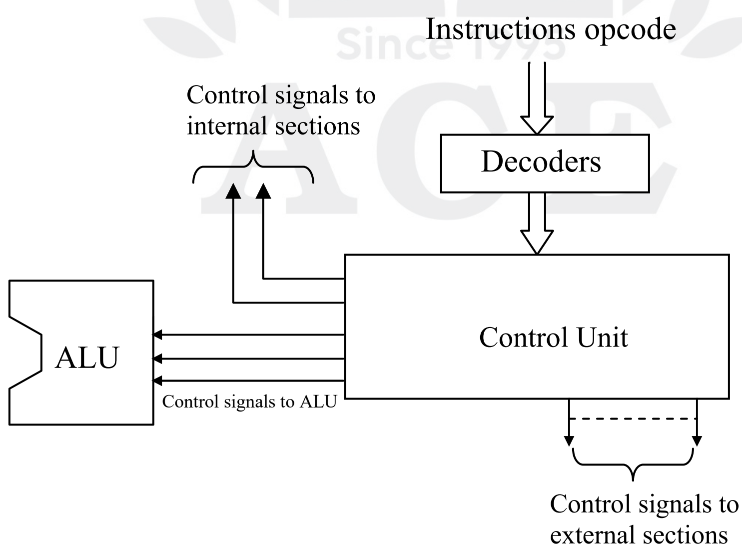
Demerit: These are more costlier than other secondary storage.

Note: Example for other secondary memories are magnetic hard disk and CD & DVD.

(ii)

- Control unit is the hardware inside a CPU for coordinating & controlling the activities of various sub sections within the CPU and other devices connected to the system bus.
- When an instruction is fetched from code memory, its opcode part will be decoded by decoder which produces timing information and control information. The timing information is about further clock cycles required for completing operation & control information is about type of operation to be performed.

  The outputs of the decoder will be given to control unit. Then the role of the control unit begins where it generates required control signals to internal sections and external units of CPU. And, inturn operation specified in the opcode will be performed, ALU operation is different from control unit.
- The ALU (Arithmetic Logic Unit) performs various Arithmetic (like addition, subtraction etc). and logical (like AND, OR etc) operations.
- Control unit generates control signals to ALU to decide the type of operation.



(iii) Array:

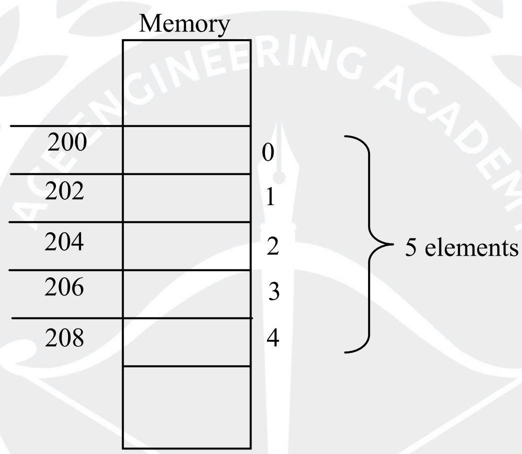
An array is stored in memory on consecutive memory locations

If array is 2-D array: then array storage has 2 types of schemes: Row major order, and column major order.

1-D array storage:

Array [5]

Suppose each element takes 2 memory locations and base address is 200.



2-D array:

Array [2] [3]

Number of rows = 2

Number of columns = 3

$$\begin{bmatrix} A_{00} & A_{01} & A_{02} \\ A_{10} & A_{11} & A_{22} \end{bmatrix}$$

Row Major order:

Elements are stored row-wise.

Base address=200, element size = 2

200	202	204	206	208	210
A_{00}	A_{01}	A_{02}	A_{10}	A_{11}	A_{22}
0	1	2	3	4	5

relative positions of elements

Column major order:

Elements are stored column-wise

200	202	204	206	208	210
A_{00}	A_{10}	A_{01}	A_{11}	A_{02}	A_{22}
0	1	2	3	4	5

For the given details:

Array size = 8×9 = m×n

Number of rows (m) = 8

Number of columns (n) = 9

Assuming element size = w

Starting address of array given = d

Starting index = 0

For row major order:

Address (A [i, j]) = Base + w * [i * n + j]

Address (A[3,7]) = d+w* [3 * 9 + 7] = d+34w

For column Major order:

Address (A[i,j])= Base+ w* [j * m + i]

Address (A[3, 7]) = d + w * [7 * 7 + 3]

= d+52w

07. (a) (i) Supporting with suitable figures, define initial permeability and maximum permeability. Mention the approximate range of values for iron. Mention one importance each of initial and maximum permeabilities. (8M)

(ii) Specific gravity of a ceramic is 3.2 g/cm^3. Calculate the percentage apparent porosity and percentage true porosity with the following data:

Ceramic when weighed dry = 360 g

Ceramic when weighed after soaking in water = 385 g

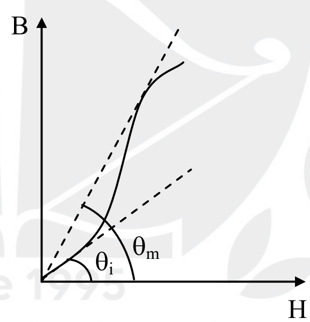
Ceramic weighed while suspended in water = 224 g (6M)

(iii) What is photo-conductivity? Discuss the factors that are to be considered for the selection of photo-conduction material. (6M)

Sol: (i) The initial permeability is the limiting value of the core materials permeability at the origin of the magnetization.

$$\mu_i = \frac{1}{\mu_0}\lim_{H\to 0}\frac{B}{H}$$

Initial permeability $\mu_I = \tan\theta_1$



Maximum permeability (μ_{max}): The maximum permeability is the value at the core material permeability at high magnetization.

$\mu_{max} = \tan\theta_{max}$

→ The initial permeability of iron is (μ_i) = 1150

→ The maximum permeability of iron is (μ_{max}) = 61,000

→ Initial permeability describe the relative permeability of a material of low values of B. The maximum value for permeability is frequently a factor of between 2 and 5 or more above its initial value.

(ii) Given data,

Specific gravity of ceramic = 3.2 g/cm^3 = ρ

Ceramic when weighted dry = 360g = W_d

Ceramic when weighed after soaking in water = 385g = W_W

Ceramic weighed while suspended in water 224g = W_S

(1) Percentage apparent porosity = $\dfrac{(\text{soaked water} - \text{Dry water})}{(\text{soaked water} - \text{suspended water})} \times 100$

$$= \frac{385-360}{385-224} \times 100$$

$$= 15.52\%$$

(2) Percentage of true porosity = $\left[1 - \left(\dfrac{\text{Apparent specific Gravity}}{\text{True specific Gravity}}\right)\right] \times 100$

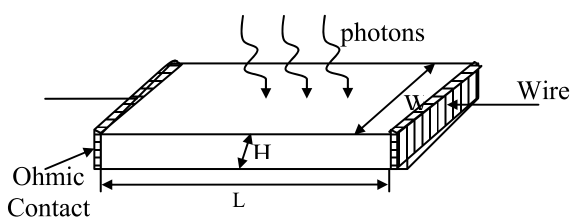
$$= \left(1 - \frac{B}{\rho}\right) \times 100$$

$$B = \frac{W_d}{W_W - W_S} = \frac{360}{385-224} = 2.24$$

% of true porosity = $\left(1 - \dfrac{2.24}{3.2}\right) \times 100 = 30\%$

(iii) Photoconductivity

- Illumination of an insulating crystal by photons of energy equal to or greater than the band gap E_g usually excites electrons from the valence band to the conduction band. It makes available the free electrons in the conduction band and the free holes in the valence band, both of which contribute to the electric current under the influence of an external electric field. *This phenomenon is called photoconductivity and is used in light meters (in cameras) and solid state infrared detectors*



Consider semiconducting slab placed in dark. Since a very small current flows in dark, the dark conductivity is

$$\sigma_d = ne\mu_e + pe\mu_h \approx 0$$

Where n and p are free electron and hole concentrations, μ_e and μ_h are the electron and hole mobilities, and e is the electron charge. When the electromagnetic radiation of an appropriate frequency is allowed to fall on the semiconductor slab, the electrical conductivity increases, the change in the conductivity (assuming $\Delta n = \Delta p$) is given by

$$\Delta\sigma = \sigma - \sigma_d = \Delta n\, e(\mu_e + \mu_h)$$

$$\frac{\Delta\sigma}{\sigma_d} = \frac{\Delta ne(\mu_e + \mu_h)}{\sigma_d}$$

If "τ" is the carrier lifetime and *f* is the rate of their generation (i.e. number of electron-hole pairs produced per second by the absorbed photons), then the average photo induced concentration is given by

$$\Delta n = f\,\tau$$

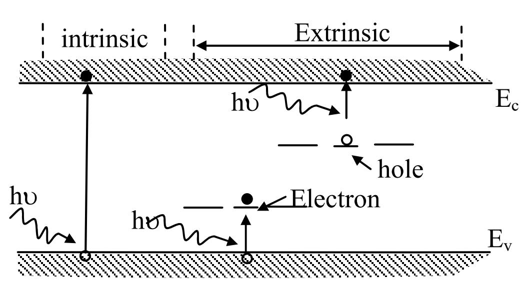
Where $\Delta n = 10^{20} m^{-3}$ for germanium

In a practical device, the sensitivity is expressed as a gain G.

If 't' is the transit time of the carriers between the electrodes then

$$G = \frac{\tau}{t}$$

Thus, photoconductivity is large when the lifetime is large. A pure material is generally found to have low τ ($\approx 10^{-6}$s) due to the greater probability of electron hole recombination and hence is relatively insensitive. However a careful doping can suppress recombination and hence increase τ and sensitivity.



In CdS careful doping of iodine increases τ to 10^{-3} sec.

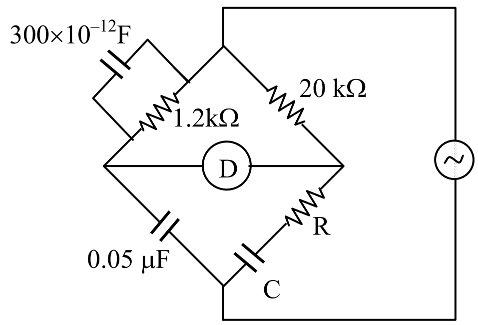
Iodine substituting for sulphur acts as donor.

Cd^{2+} vacancies act as efficient hole traps. During photoexcitation, holes are readily trapped and electron have much less chance of recombination and hence average lifetime is increased

CdS and CdTe single crystals are widely used as photoconductors because of their high sensitivity and response to visible light wavelengths.

Model Questions asked in ACE ESE mains 2018 Test Series Test-8, Q4(a)(i).

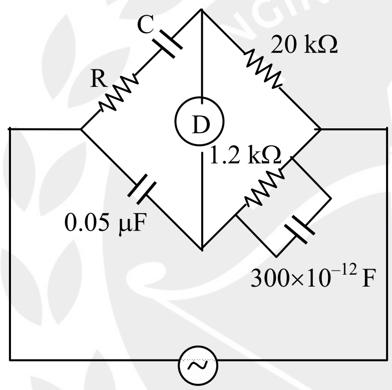
07. (b)



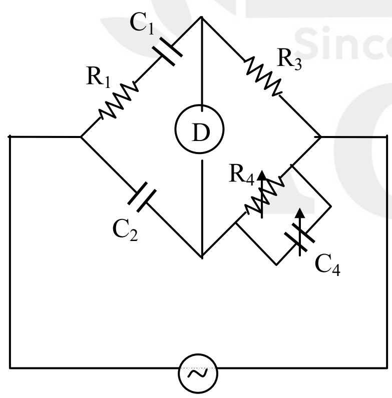
For the bridge circuit shown determine the values of R and C. Derive the formula used.

(20M)

Sol: Given bridge can be redrawn as



$\therefore$ Given bridge is Schering bridge.



Under bridge balanced condition

$Z_1 Z_4 = Z_2 Z_3$

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

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

$$j\omega R_1 R_4 C_2 + \frac{C_2 R_4}{C_1} = R_3 + j\omega C_4 R_4 R_3$$

Equating real parts,

$$\omega C_2 R / 4R_1 = \omega C_4 R_3 R_4$$

$$R_1 = \frac{C_4 R_3}{C_2}$$

$\therefore$ From the given data, we can write

$R_1 = R$, $C_1 = C$, $R_3 = 20\ k\Omega$, $C_2 = 0.05\ \mu F$

$R_4 = 1.2\ k\Omega$, $C_4 = 300 \times 10^{-12}$ F

By substituting in the above equations.

We get, $C = \dfrac{0.05 \times 10^{-6} \times 1.2 \times 10^3}{20 \times 10^3}$

C = 3 nF

$$R = \frac{300 \times 10^{-12} \times 20 \times 10^3}{0.05 \times 10^{-6}} = 12 \times 10^{-6} \times 10^3 \times 10^4$$

$R = 120\Omega$

Model Questions asked in ACE ESE mains 2018 Test Series Test-3, Q6(a)

07. (c) (i) How is Division exactly done by ALU? (7M)

(ii) Prove with illustration that NAND is a "Universal Gate". (6M)

(iii) How will you implement a two-way switch using minimum number of logic gates? (7M)

Sol: (i) Integer Division

Division is implemented using computer specific methods. Division can be implemented on computer systems by repeatedly subtracting the divisor from the dividend and counting the number of times that the divisor can be subtracted from the dividend before the dividend becomes smaller than the divisor. For example, 15 can be divided by 5 by subtracting 5 repeatedly from 15, getting 10, 5 and 0 as intermediate result. The quotient, 3, is the number of subtractions that had to be performed before the intermediate result became less than the dividend. Below shown an exemplary division steps for 15 ÷ 5.

```
          0b0101
    ob11)0b1111
           00
         ------
           1111
           11
         ------
           0011
            00
         ------
             11
             11
         ------
           0b00
```

An Example of Division steps for 15 ÷ 5

Restoring Algorithm

The following algorithm, called the restoring algorithm for a division, can be used. Assume that X register has k-bit dividend and Y has the k-bit divisor. Assume a sign bit S has the sign.

1. Start: Load 0 into accumulator k-bit A and dividend X is loaded into the k-bit quotient register MQ.
2. Step A: Shift 2k-bit registers pair A- MQ left.
3. Step B: Subtract the divisor Y from A.
4. Step C: If sign of A (msb) = 1, then reset MQ_0 (lsb) = 0 else set = 1

5. Step D: If MQ_0=0 add Y (restore the effect of earlier subtraction).
6. Steps A to D repeat again till the total number of cyclic operations = k.
7. At the end, A has the remainder and MQ has the quotient.

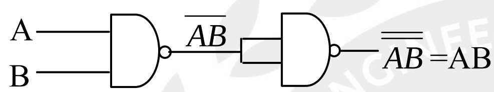
Step	S-flag*	First Register for A	Second Register for MQ	Action Taken	Number of operations (instructions)
Start	0	0b 0000	0b 0000	Clear S, A, MQ	3 for clearing C, A and M
	0	0b 0001	0b 1110	Load dividend X (lower k bits) between MQ_{k-1} and MQ_0 and dividend higher bits in A	2 for loading A and MQ
Step 0A	0	0011	1100	Shift left S-A-M	2
Step 0B	0	0000	1100	Subtract Y from S-A, result in S-A	1
Step 0C	0	0000	1101	MQ_0 = 1 as S = 0	1
Step 0D	0	0000	1101	Skip restore by adding as S = 0	1 (test S)
Step 1A	0	0001	1010	Shift left S-A-M	2
Step 1B	1	1110	1010	Subtract Y from S-A, result in S-A	1
Step 1C	1	1110	1010	MQ_0 = 0 as S = 1	1
Step 1D	0	0001	1010	Add Y into S-A to restore as S= 1	1
Step 2A	0	0011	0100	Shift left S-A-M	2
Step 2B	0	0000	0100	Subtract Y from S-A, result in S-A	1
Step 2C	0	0000	0101	MQ_0 = 1 as S = 0	1
Step 2D	0	0000	0101	Skip restore as S = 0	1(test S)
Step 3A	0	0000	1010	Shift left S-A-M	2
Step 3B	1	1101	1010	Subtract Y from S-A, result in S-A	1
Step 3C	1	1101	1010	MQ_0 = 0 as S = 1	1
Step 3D	0	0000	1010	Add Y into S–A to restore as S = 1	1
Answer	0	Remainder = 0		Quotient Decimal 10	Total 25

* after the left shift from msb of A.

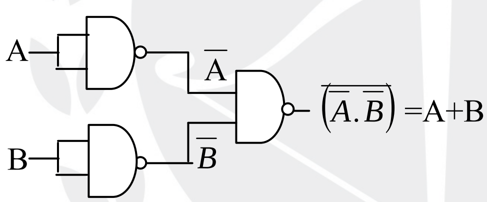
(ii) If it is possible to implement any logic function using only the basic gates, then the gate is called universal.

To implement any logic function the basic function required is OR, AND and NOT gates. If it is possible to implement there three basic gates using only the gates then it is possible implement any logic function.

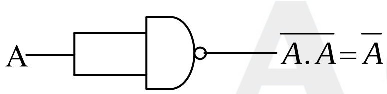
(1) Realization of AND gate using NAND gate:



(2) Realization of OR gate using NAND gate:

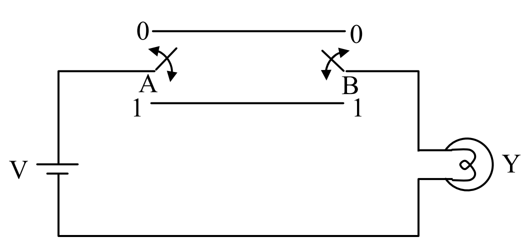


(3) Realization of NOT gate using NAND gate:



∴ NAND gate is universal gate

(iii)

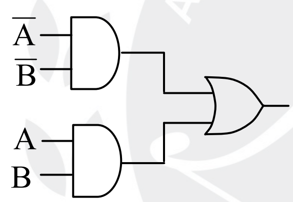


To switch on bulb A = 0 and B = 0 (or) A = 1 and B = 1.

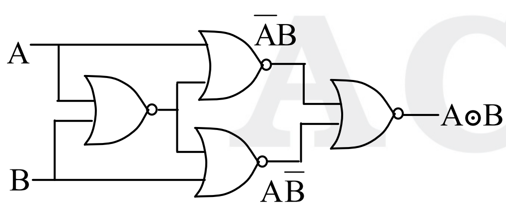
To switch it OFF the bulb A = 0 and B = 1 (or) A = 1 and B = 0

A	B	$(Y = \overline{A}\,\overline{B} + AB)$ $= A \odot B$
0	0	1
0	1	0
1	0	0
1	1	1

Using AND-OR:



Using NOR-NOR:



08.(a) (i) Explain the Top-Bottom and Bottom-Up approach to produce the nanostructure. Name the methods used in each case to produce nanomaterial. (8M)

(ii) The current measured in a superconducting ring by 0.01% accuracy meter after one year shows no decay of current. If there are 10^{28} electrons/m^3, calculate the conductivity. How may times larger is this conductivity than that of copper of resistivity 1.724×10^{-8} Ωm. (8M)

(iii) Addition of 0.25 atomic percent nickel and 0.4 atomic percent silver into copper at 298 K increases the resistivity by 0.012 μΩcm and 0.016 μΩm respectively. If the resistivity of copper is 0.015 μΩm at 298 K, determine the conductivity of the resulting alloy. (4M)

Sol:

(i) Top down Approach:

- Top down approach refers to slicing or successive cutting of a bulk material to get nano sized particle.
- *Attrition or Milling* is a typical top down method in making nano particles
- The nanomaterials are derived form a bulk substrate and obtained by progressive removal of material, until the desired nanomaterial is obtained.
- This approach leads to the bulk production of nano material. Regardless of the defects produced by top down approach, they will continue to play an important role in the synthesis of nano structures.

Ex: (1) photo lithography

(2) Scanning lithography

(3) E- beam lithography

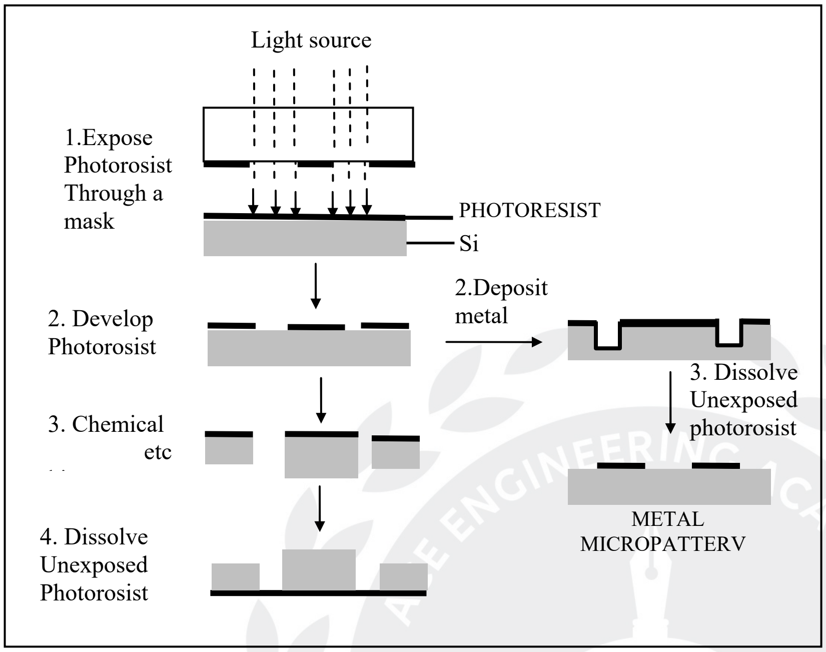
Photo Lithography:

This technique follows the principle of transferring an image from a mask to a receiving substrate.

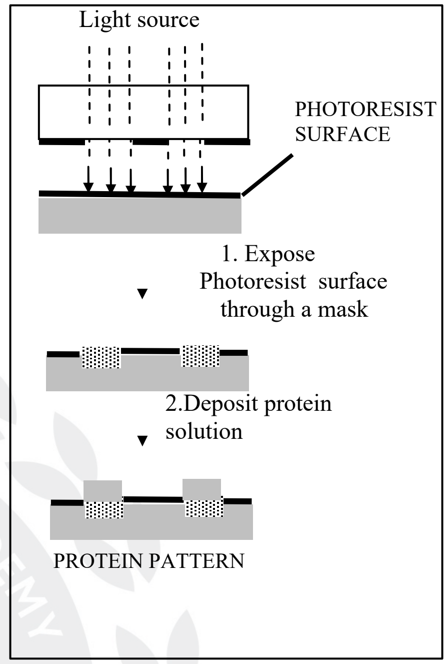
A typical lithographic process consists of three successive steps:

- Coating a substrate (Si wafer or glass) with a sensitive polymer layer (called resist)
- Exposing the resist to light, electrons or ion beams
- Developing the resist image with a suitable chemical(developer), which reveals a positive or negative image on the substrate depending on the type of resist used.(i.e. positive tone or negative tone resist).

(1) PHOTO LITHOGRAPHY



(2) PHOTOLIEOGRAPHY IN BIOPATTERNING



Problems associated with top down approach:

- The biggest problem with top down approach is the imperfection of surface structure and significant crystallographic damage to the processed patterns. Due to these imperfections design and fabrication of devices is difficult.
- The top down approach introduces internal stress, in addition to surface defects and contaminations

Bottom up Approach:

- Bottom up approach refers to the build up of a material from the bottom; atom by atom, molecule by molecule or cluster by cluster.
- The *colloidal dispersion* is a good example of bottom up approach in the synthesis of nano particles.
- This method is not a new concept. All the living beings in nature observe growth by this approach only and also it has been in industrial use for over a century.
  Ex: The production of salt and nitrate in chemical industry.
- Bottom up approach gives a better chance to obtain nano structures with less defects, more homogeneous chemical composition.
- Bottom up methods can be divided into gas-phase and liquid-phase methods.

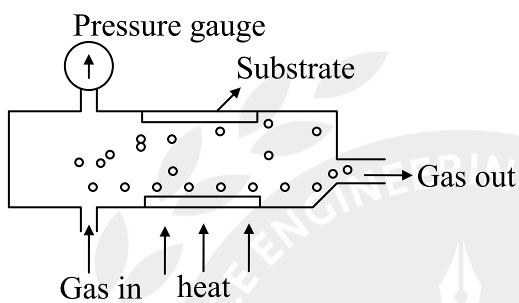
Gas-phase methods:

Plasma arcing and chemical vapour deposition

Liquid phase methods:

Sol-gel synthesis, molecular self-assembly

Chemical vapour deposition:



The material to be deposited is first heated to its gas form and then allowed to deposit as a solid on a surface.

- The method is normally performed under vacuum.
- The deposition can be direct or through a chemical reaction so that the material deposited is different from the one volatilized.
- This process is routinely used to make nanopowders of oxides and carbides of metals if carbon or oxygen are present with the metal.
- The method can also be used to generate nanopowders of pure metals, although not so easily.
- Chemical vapour deposition is often used to deposit a material on a flat surface.
- When a surface is exposed to a chemical vapour, the first layer of atoms or molecules that deposit on the surface can act as a template on which material can grow.

Model Questions asked in ACE ESE mains 2018 Test Series Test-7, Q4(c).

(ii) Given data,

$n = 10^{28}$ elec/m^3

$e = 1.6 \times 10^{-19}$

$\rho = 1.724 \times 10^{-8}\ \Omega$m

Let us assume that the super conducting ring relaxation time (t) = 3.15×10^{11} sec

Electrical conductivity (σ) = $\dfrac{ne^2t}{m}$

$$= \frac{10^{28} \times \left(1.6\times10^{-19}\right)^2 \times 3.15\times10^{11}}{9.1\times10^{-31}}$$

$= 0.883 \times 10^{32}$ n-m^{-1}

Electrical conductivity of copper (σ) = $\dfrac{1}{\rho} = \dfrac{1}{1.724\times10^{-8}}$

$= 0.58 \times 10^{8}$ n-m^{-1}

The electrical conductivity of super conducting ring is 1.5278×10^{24} larger than copper.

(iii) Given data,

Host material = cu

$\rho_{cu} = 0.015\ \mu\Omega$ km

Impurity materials are Ni & Ag

Atomic percent of Ni added to cu is (S_{Ni}) = 0.25

Atomic percent of Ag added to cu is (S_{cu}) = 0.4

Increase in resistivity of Ni (ρ_{Ni}) = 0.012 μΩ m

Increase in resistivity of Ag (ρ_{Ag}) = 0.016 μΩ

$\rho_{alloy} = \rho_{cu} + S_{Ni}\,\rho_{Ni} + S_{Ag}\,\rho_{Ag}$

$= 0.015 + 0.25(0.012) + 0.4(0.016)$

$= 0.0244\ \mu\Omega$m

08. (b) The power consumed by a single phase 11 kV load taking 100 A at 0.5 power factor lagging is measured on a dynamometer wattmeter used in conjunction with potential transformer (PT) and current transformer (CT). Determine the reading of the wattmeter considering the following data:

Nominal ratio of PT and CT are 100: 1 and 20: 1

Ratio error of PT and CT are +0.8% and –0.2%

Phase angle errors of PT and CT are +42 minutes and +90 minutes.

Phase angle of the pressure coil due to its inductance is 30 minutes. (20M)

Sol: Phase angle of pressure coil circuit (β) = 30′

Phase angle of load = $\cos^{-1}(0.5) = 60°$

Where

V = voltage across the load = 11 kV

I = load current = 100A

ϕ = Phase angle between current and voltage = 60°

α = phase angle bandwidth

Currents in the current and pressure coils of watt meter

V_s = voltage across secondary of the potential transformer.

I_s = secondary current of current transformer.

I_p = current in the wattmeter pressure coil.

β = angle by which I_s lags V_s on account of inductance of pressure coil = 30′ = 1/2°

δ = Phase angle of potential transformer = 45′= $\frac{3}{4}^{\circ}$

θ = phase angle of current transformer = 90′ = $1\frac{1}{2}^{\circ}$

Phase angle between pressure coil current I_P and current I_s of wattmeter current coil

$\alpha = \phi - \theta - \beta - \delta$

$$= 60° - \frac{3°}{2} - \frac{1°}{2} - \frac{3°}{4}$$

$= 57.25°$

$$\text{Correction factor} = k = \frac{\cos\phi}{\cos\beta.\cos\alpha}$$

$$= \frac{\cos 60°}{\cos(0.5°) \times \cos(57.25)}$$

$= 0.924$

$$\text{Percentage ratio error} = \frac{k_n - R}{R} \times 100$$

$$\text{Actual ratio } R = \frac{k_n \times 100}{(100 + \text{percentage ratio error})}$$

$$\text{Actual ratio of C.T} = \frac{20 \times 100}{(100 - 0.2)}$$

$= 20.04$

$$\text{Actual ratio of P.T} = \frac{100 \times 100}{(100 + 0.8)}$$

$= 99.2$

Power of lead

= k × actual ratio of P.T × actual ratio of C.T × wattmeter × wattmeter reading

(2) power of lead = 11kV ×0.5 ×100

= 0.924 × 20.4 ×99.2×wattmeter reading

(3) Wattmeter reading

= 294.18 Watts

08.(c) (i) Is the use of Virtual Memory advisable for Real Time Systems? Justify briefly your answer (7M)

(ii) Compare briefly and precisely the LINUX OS with Windows-NT OS. (5M)

(iii) For File Management how does a DBMS help? (8M)

Sol:

(i) Generally speaking, RTOS and VM are mutually exclusive. The RT in RTOS stands for "Real Time", meaning that the OS has a quick (and deterministic) task swap time and IRQ latency. You can't really have that when some of your memory is located in Flash/SSD/HD and might have to be swapped into main memory.

(ii)

Topics	Linux	Windows
Price	The Linux kernel, and the GNU utilities and libraries which accompany it in most distributions, are entirely free and open source. You can download and install GNU/Linux distributions without purchase. Some companies offer paid support for their Linux distributions, but the underlying software is still free to download and install.	Microsoft Windows usually costs between $99.00 and $199.00 USD for each licensed copy. However, Windows 10 is being offered as a free upgrade to current owners of Windows 7 or Windows 8.1.

Ease of use	GNU/Linux operating systems have a steeper learning curve for the average user. They frequently require a deeper understanding of the underlying system to perform day-to-day functions. Additionally, troubleshooting technical issues can be a more intimidating and complicated process than on Windows. However, some distributions such as Ubuntu and Linux Mint are designed specifically to ease the transition from Windows to a Linux environment.	Windows is one of the easiest desktop operating systems to use. One of its primary design characteristics is user friendliness and simplicity of basic system tasks. Its ease lack of difficulty is considered a positive by users who want their system to just work. However, more proficient users may be frustrated by oversimplification of system tasks at the expense of fine-grained control over the system itself.
Reliability	Linux is notoriously reliable and secure. It has a strong focus on process management, system security, and uptime.	Although Microsoft Windows has made great improvements in reliability in recent years, it's considered less reliable than Linux. Many of the sacrifices it makes in the name of user-friendliness can lead to security vulnerabilities and system instability.

Software	There thousands of programs available for Linux, and many are available as easy-to-install software packages — all for free. Also, many Windows programs can be run on Linux using compatibility layers such as WINE. Linux supports a wider array of free software than Windows.	Windows commands the highest number of desktop users, and therefore the largest selection of commercial software. It also has the largest selection of video games by a wide margin.
Hardware	Fifteen years ago, Linux struggled to support new hardware. Manufacturers often considered Linux support a secondary concern (if they considered supporting it at all). Furthermore, device drivers for Linux were created only by enthusiasts who devoted their own time and resources to making Linux compatible with new hardware. Since then, the Linux user base has grown exponentially. Today, the majority of hardware manufacturers give Linux support the same priority as Microsoft Windows.	Windows has a massive user base, so it would be madness for a consumer hardware manufacturer not to support Windows. As a Windows user, you can rest assured that your operating system is compatible with any hardware you might buy.

Security	Linux is a highly secure operating system. Although attack vectors are still discovered, its source code is open and available for any user to review, which makes it easier to identify and repair vulnerabilities.	Microsoft has made great security improvements over the years. But as the operating system with the largest user base, especially among novice computer users, it is the primary target for malicious coders. As a result, of all major operating systems, Microsoft Windows is the most likely to be the victim of viruses and malware.
Support	There is a massive amount of online support available for Linux, including here on Computer Hope.	Microsoft Windows offers integrated and online help systems, and there are thousands of informative books about Windows available for every skill level.

(ii) A Database Management System (DBMS) is a combination of computer software, hardware, and information designed to electronically manipulate data via computer processing. Two types of database management systems are DBMS's and FMS's. In simple terms, a File Management System (FMS) is a Database Management System that allows access to single files or tables at a time. FMS's accommodate flat files that have no relation to other files. The FMS was the predecessor for the Database Management System (DBMS), which allows access to multiple files or tables at a time. Below are some of the problems in FMS which was resolved in DBMS.

1) <u>Data Redundancy and Inconsistency</u>:-

The Redundancy leads to higher storage and access cost. In addition it may leads to data inconsistency i.e., The various copies of same data may no longer agree.

2) **Difficulty in accessing data**:-

File System requires to have an application program for each request i.e., more responsive data retrival systems are required for general views.

3) **Data Isolation**:-

Because data are scattered in various files and may be in different formats. Writing new application program s to retrieve the appropriate data is difficult.

4) **Integrity problems:-**

The data values stored in the database must satisfy certain types of consistency constraints.

Eg: The balance amount of customer may never fall below a prescribed amount [say Rs 500]

5) **Atomicity problems:-**

In many applications if a failure occurs the data be restored to the consistent state the existed prior to the failure i.e it must happen in its entirety (or) not at all. It is difficult to ensure atomicity in a file processing system.

6) **Concurrent access anamolies:-**

For the overall performance of the system and faster response many systems allow multiple users to update the data simultaneously in such an environment, iteration of concurrent updates may result in inconsistence in data.

CONCLUSION:-

These difficulties and many others prompted the development of database system over the file management system.

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24	E&T	Tausif Ahmad
25	E&T	Bharti Kumari
25	EE	Faiyaz Hussain
25	ME	Rishi Prakash
26	E&T	Vikash Jangid
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27	CE	Danish Khan
28	E&T	Mukesh Khokhar
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28	ME	Suhas M
29	EE	Jain Chanakya
30	E&T	G.V.V.S.D.E P.K. Yadav
30	EE	Ginige naveen
31	ME	Umakanth
32	CE	Ankur Mani Tripathi
32	E&T	Gnaneswar K
32	EE	Ajita Mohanty
33	EE	ANKIT SHARMA
33	CE	Amarnath Reddy
34	E&T	Satpal
34	EE	Ravindra Singh
35	EE	Vishal Bajaj
36	EE	Prasanth shekar
37	CE	Ajay Narwal
37	E&T	Ranjeet Kumar
37	EE	HIMANSHI GUPTA
38	E&T	Rajesh Kumar
38	EE	M Raquib Anjum
39	E&T	Akshaya Kumar
39	EE	Ashish Kumar
39	ME	Amit
40	ME	Ujjwal

TOTAL SELECTIONS	196	CE	86	ME	44	EE	36	E&T	30