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ESE – 2019 MAINS
OFFLINE TEST SERIES

ELECTRONICS & TELECOMMUNICATION ENGINEERING (E&T)

TEST – 11
SOLUTIONS

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01. (a)
Sol:

(i) Base transport factor $\alpha_T = \dfrac{I_{CP}}{I_{EP}} = 1 - \left(\dfrac{W^2}{2L_P^2}\right)$

The common emitter current gain is given by

$$\beta_0 = \frac{\alpha_0}{1-\alpha_0} = \frac{\gamma\alpha_T}{1-\gamma\alpha_T}$$

Since $\gamma = 1$, $\beta_0 = \dfrac{\alpha_T}{1-\alpha_T} = \dfrac{1-\left(\dfrac{W^2}{2L_P^2}\right)}{1-\left[1-\left(\dfrac{W^2}{2L_P^2}\right)\right]} = \left(\dfrac{2L_P^2}{W^2}\right) - 1$

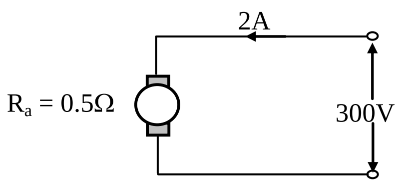
If $\dfrac{W}{L_P} << 1$, then $\beta_0 \cong \dfrac{2L_P^2}{W^2}$

(ii) $L_P = \sqrt{D_P \tau_P} = \sqrt{100 \times 3 \times 10^{-7}} = 5.477 \times 10^{-3}\text{cm} = 54.77\mu\text{m}$

Therefore, the common emitter current gain is

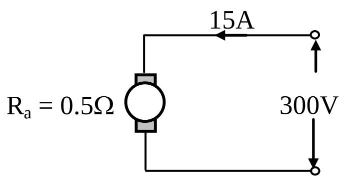
$$\beta_0 = \frac{2L_P^2}{W^2} = \frac{2(54.77 \times 10^{-4})^2}{\left(2 \times 10^{-4}\right)^2} = 1500$$

01. (b)
Sol:



No - load condition, N_1 = 900rpm

$E_{b1} = V - I_a R_a$
$= 300 - 2 \times 0.5$
$= 299$ V



Load condition,

$E_{b2} = V - I_a R_a$
$= 300 - 15 \times 0.5$
$= 292.5$ V

$\therefore \dfrac{N_2}{N_1} = \dfrac{E_{b2}}{E_{b1}}$

$\Rightarrow \dfrac{N_2}{900} = \dfrac{292.5}{299}$

$\Rightarrow N_2 = 880.43$ rpm

01. (c)

Sol: Given data:

$N = 2\times 10^{19}$ atoms/m^3

$\mu = 1.8 \times 10^{-27}$ C-m

$E = 10^5$ V / m ;

Find P and $\in_r$?

We have $P = N\mu$

$= 2 \times 10^{19} \times 1.8 \times 10^{-27}$

$= 3.6 \times 10^{-8}$ C/m^2

$\chi = \dfrac{P}{\in_0 E}$ and $\in_r = \chi+1$,

$$\chi = \frac{3.6\times10^{-8}}{8.85\times10^{-12}\times10^{5}} = 0.04$$

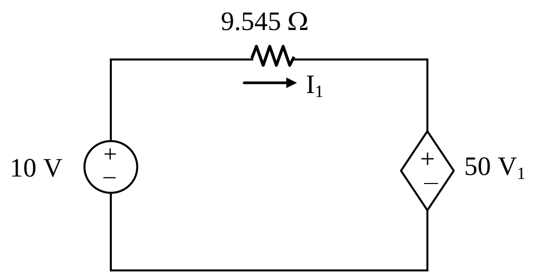
We get $\in_r = \chi + 1 = 1 + 0.04 = 1.04$

$\in_r = 1.04$

01. (d)

Sol: From the circuit $I_1 = I_4 = I_2 + I_3$ and $V_1 = 3I_1$

The 4 Ω and 7-Ω resistors are replaced by the equivalent



Resistance of magnitude $\dfrac{4\times7}{4+7} = \dfrac{28}{11} = 2.545\Omega$

$\therefore$ Total circuit resistance = 2.545 + 3+ 4

= 9.545 Ω

The circuit reduces as shown in applying KVL to the loop we get

$9.545I_1 + 50\,V_1 = 10$

$V_1 = 3I_1$

$9.545I_1 + 50\,(3I_1) = 10$

$9.545I_1 + 150\,I_1 = 10$

$$I_1 = \frac{10}{159.545} = 0.0626 \text{ A}$$

We have $I_2 + I_3 = I_1 = 0.0626$ A

$0 = 4I_2 - 7I_3$

$I_2 = 0.03986$ A; $I_3 = 0.02279$A

$V_1 = 3I_1 = 3 \times 0.0626 = 0.0188$ V

01. (e)

Sol:

(i) **(A)** The given oscillator is a Colpitts oscillator

(B) For Colpitts oscillator, the expression for frequency of oscillation is given as

$$\omega_{osc} = \frac{1}{\sqrt{LC_{eq}}}$$

$$C_{eq} = \frac{C_1C_2}{C_1 + C_2} \Rightarrow C_{eq} = \frac{2\times 2}{2+2} = 1\text{pF}$$

$$LC_{eq} = 100\times 10^{-6}\times 1\times 10^{-12}$$

$$\omega_{osc} = \frac{1}{\sqrt{LC_{eq}}} = \frac{1}{\sqrt{100\times 10^{-18}}} = \frac{10^9}{\sqrt{100}}$$

$$= \frac{1000\times 10^6}{\sqrt{100}} = 100 \text{ Mrad/s}$$

(ii) The output of integrator is

$$V_x = -\frac{1}{RC}\int V_0\,dt \text{ and}$$

$$V_0 = -2V_x$$

Then $V_x = \frac{2}{RC}\int V_x dt$

$$\frac{2}{RC}tV_x = V_x \Rightarrow t = \frac{RC}{2}$$

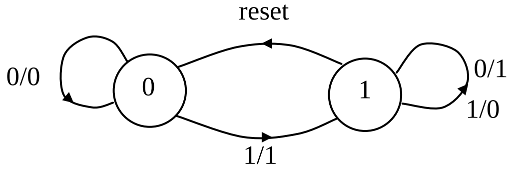
$$f = \frac{2}{RC}$$

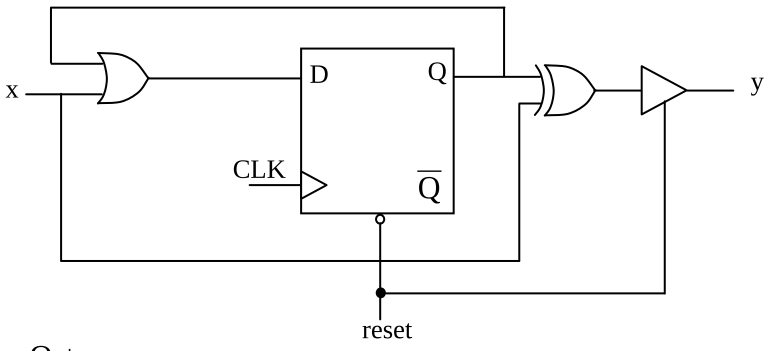
$$f = \frac{2}{10^5\times 10^{-9}} = 20\text{ kHz}$$

01. (f)

Sol: The output is 0 for all 0 inputs until the first 1 occurs, at that time the output is 1. Thereafter, the output is the complement of the input. The state diagram has two states. In state 0, output = input; in state 1, output = $\overline{\text{input}}$

Present state	X input	Next State	Output Y
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	0



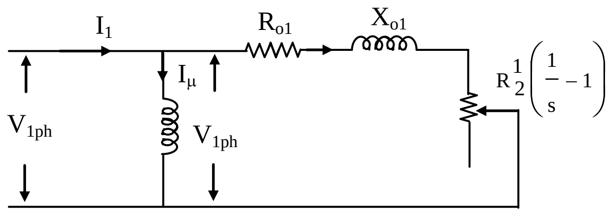


D = Q + x

$$y = Q\overline{x} + x\overline{Q} = Q \oplus x$$

02. (a)

Sol: The approximate equivalent circuit model of Induction motor is



$$X_{01} = X_1 + X_2^1$$

$$R_{01} = R_1 + R_2^1$$

$$R_2^1 + R_2^1\left(\frac{1}{s} - 1\right) = \frac{R_2^1}{s}$$

During starting slip = 1

$$I_r^1 = \frac{V_{1ph}}{\sqrt{\left(R_1 + \frac{R_2^1}{s}\right)^2 + \left(X_1 + X_2^1\right)^2}}$$

$$I_r' = \frac{\left(400\sqrt{3}\right)}{\sqrt{\left(1 + \frac{0.5}{1}\right)^2 + \left(1.2 + 1.2\right)^2}}$$

$I_r^1 = 81.6\text{A}$

Starting Torque

$$T_{st} = \frac{60}{2\pi N_S} \times 3\left(I_r^1\right)^2 \times \frac{R_2^1}{S}$$

$$T_{st} = \frac{60}{2\pi \times 1500} \times 3 \times (81.6)^2 \times \frac{0.5}{1} \qquad [\because N_S = 1500\text{rpm}]$$

T_{st} = 63.6 N-m

02. (b)

Sol:

(i) Operating Principle of Dynamometer type moving coil instrument.

The operating torque is produced by the reaction between the magnetic field of the fixed coils and the current through the moving coil. The torque is always positive regardless of the direction of the current, as with change in direction of the current in the moving coil the field of the fixed coils also changes its direction. To derive the expression for the torque we will consider the energy stored in the magnetic circuits. The total energy stored in the magnetic circuits is

$$W = \frac{i_1^2 L_1}{2} + \frac{i_2^2 L_2}{2} + i_1 i_2 M \text{ ………. (1)}$$

If the moving system rotates through a small angle dθ and the corresponding change in energy is dW then the work done in moving the system must be equal to the change in energy dW, i.e.,

$$dW = T_d d\theta$$

Where T_d is the deflecting torque.

$$T_d = \frac{dW}{d\theta} \text{ ………………. (2)}$$

From Eq. (1)

$$\frac{dW}{d\theta} = i_1 i_2 \frac{dM}{d\theta}$$

Since L_1 and L_2 are independent of θ

$$\therefore \quad T_d = I_1 I_2 \frac{dM}{d\theta} \text{ ………(3)}$$

In case of direct current

$$T_d = I_1 I_2 \frac{dM}{d\theta} \text{ ………… (4)}$$

In case of ammeters and voltmeters

$$I_1 = I_2 = I$$

$$T_d = I^2 \frac{dM}{d\theta} \text{ …………… (5)}$$

In case of steady-steady sinusoidal currents, if

$$i_1 = I_{m1}\sin\omega t$$

and $i_2 = I_{m2}\sin(\omega t - \phi)$

Then the average toque,

$$T_d = \frac{1}{\tau}\int_0^{\tau} i_1 i_2 \frac{dM}{d\theta} dt \qquad \left(\because \tau = \frac{2\pi}{\omega}\right)$$

(or) $$T_d = \frac{dM}{d\theta}\frac{1}{\tau}\int_0^{\tau} I_{m1} I_{m2} \sin\omega t \sin(\omega t - \phi) dt = \frac{I_{m1} I_{m2}}{2}\frac{dM}{d\theta}\cos\phi = I_1 I_2 \frac{dM}{d\theta}\cos\phi \text{ …….. (6)}$$

Where I_1 and I_2 are the rms values of currents.

In case of ammeters and voltmeters,

$$I_1 = I_2 = I \text{ and } \phi = 0$$

$$\therefore T_d = I^2 \frac{dM}{d\theta} \text{ ………… (7)}$$

By suitable design of coil sections and radii, it is practicable to obtain constancy of $\frac{dM}{d\theta}$ over the usual working range.

(ii) Dynamometer voltmeters

The dynamometer voltmeter is the most accurate form of voltmeter for measuring alternating voltages of moderate magnitude (about 50 – 500 V) at power frequency. The current through the moving coil is led by the ordinary control springs, since the current does not exceed 75 mA. The fixed and moving coils are connected in series with a high non-inductive resistance as shown in fig.

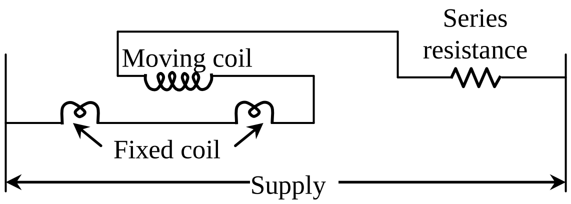


Fig. 1: Dynamometer voltmeter

The deflecting torque, $T_d = I^2 \frac{dM}{d\theta}$

But $\frac{dM}{d\theta}$ is constant over the usual working range, hence

$$T_d \propto K_1 I^2$$

If Z is the total impedance of the circuit shown in fig.

$$T_d = K_1 \frac{V^2}{Z^2} \quad \text{……….} \ (8)$$

Where V is the voltage to be measured.

As the control is by springs,

$$S\theta = K_1 \frac{V^2}{Z^2}$$

$$\theta = \frac{K_1 V^2}{SZ^2}$$

$$\theta = K_2 \frac{V^2}{Z^2} \qquad \left(K_2 = \frac{K_1}{S}\right) \ \text{……….} \ (9)$$

$$= KV^2 \text{…………..} \ (10)$$

Dynamometer Ammeters

For low range ammeters (about 0.2 A) the moving and fixed coils are connected in series as shown in fig. 2. The current carrying capacity of the control springs limits the use of ammeters of range higher than 0.2 A without a shunt. The arrangement of a higher range ammeter is shown in fig. 3.

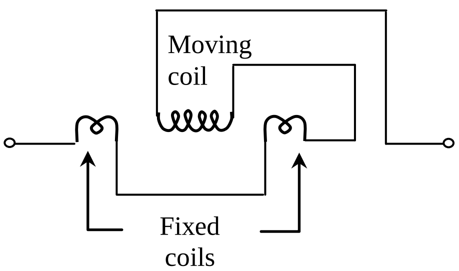


Fig. 2: Low range dynamometer ammeter

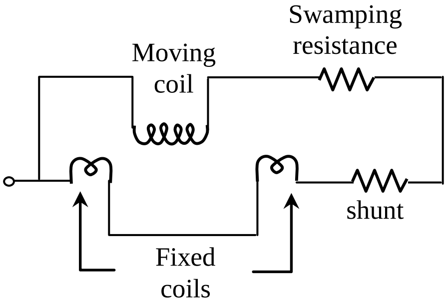


Fig. 3: High range dynamometer ammeter

In first case, as shown in fig. 2, the current I_1 and I_2 are same both I magnitude and phase. For the second arrangement (fig. 3) to satisfy the condition ϕ =0, it is essential that the time constants L/R of two parallel paths are equal,

For first case $I_1 = I_2 = I$ and $\phi = 0$

$$\therefore \ T_d = I^2 \frac{dM}{d\theta}$$

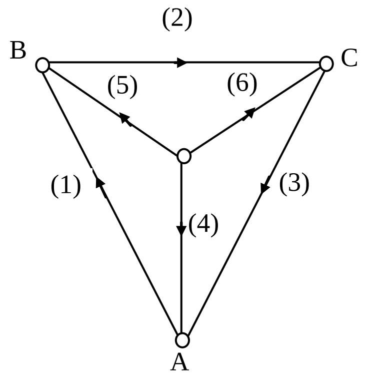
And $\theta = K^2 I^2$ ……….. (11)

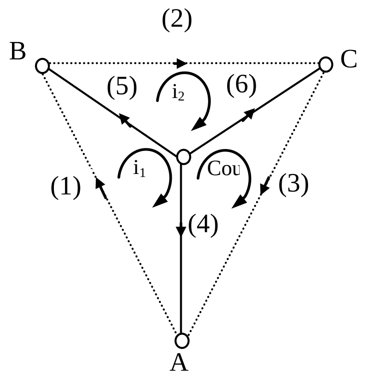
Where, $K' = \dfrac{dM/d\theta}{S}$

02. (c)

Sol:

(i) The directed graph of the above network is shown below





I_2

From the above figure, various f circuits formed by placing links in the tree are

f-circuit (1) : {1,5,4}

f-circuit (2) : {2,6,5}

f-circuit (3) : {3,4,6}

(ii) Based on these f circuits, the f circuit matrix or tieset matrix will be

$$
\begin{array}{ll}
\text{f – circuits} & \text{Branches} \\
& \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \\
B = \begin{array}{c} 1 \\ 2 \\ 3 \end{array} & \begin{bmatrix} 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & -1 & 0 & 1 \end{bmatrix}
\end{array}
$$

(iii) Since the given is resistive, the branch impedance matrix Z_b will be diagonal.
In this matrix all non-diagonal elements will be zero. The branch impedance matrix is shown below.

$$
Z_b = \begin{bmatrix} 5 & & & & & 0 \\ & 5 & & & & \\ & & 5 & & & \\ & & & 10 & & \\ & & & & 5 & \\ 0 & & & & & 10 \end{bmatrix}
$$

Since there are three loop currents I_1, I_2 and I_3, the loop current matrix I_L will be,

$$
I_L = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix}
$$

The network contains voltage source of 5 V in only branch 1. Hence the branch input voltage source matrix V_s will be as follows –

$$
V_s = \begin{bmatrix} 5 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}
$$

Since there are no current sources in the network, the branch input current source matrix I_s will be zero i.e.

$$I_s = 0$$

The mesh or loop or KVL or tieset equilibrium equations are given by equation 7.6.1 as

$$BZB^T I_L = B (V_s - Z_b I_S)$$

Since $I_s = 0$, the above equation will be,

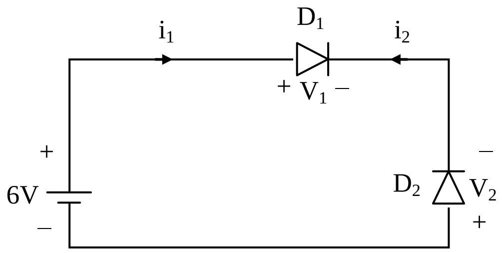
$$BZB^T I_L = B V_s$$

Putting the values for appropriate matrices in the above equation and on simplification we get,

$$\begin{bmatrix} 20 & -5 & -10 \\ -5 & 20 & -10 \\ -10 & -10 & 25 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 0 \end{bmatrix}$$

This is the required equilibrium equation in matrix form on solving the above matrix equation

03. (a)
Sol:
(i)



Analysis:
By looking at the circuit, we can simply say that diode 'D_1' is forward bias while 'D_2' is in reverse –biased.

Current through a forward biased diode $I_{D1} = I_{S1}\left(e^{V_1/\eta V_I} - 1\right)$

Current through a reverse biased diode, $I_{D_2} = I_{S_2}$

So, 20nA (which is saturation current of D_2) will flow through the circuit

$\Rightarrow$ 20nA = $I_{D_1} = i_1$

$\Rightarrow$ –20nA = $I_{D_2} = i_2$

From this ,

$i_1 = I_{D_1} = I_{S_1}\left(e^{V_1/\eta V_T} - 1\right) = 20\text{nA}$

$\Rightarrow$ 20nA = 1nA $\left(e^{V_1/2V_T} - 1\right)$

$\Rightarrow V_1 = 2V_T \ln(21)$

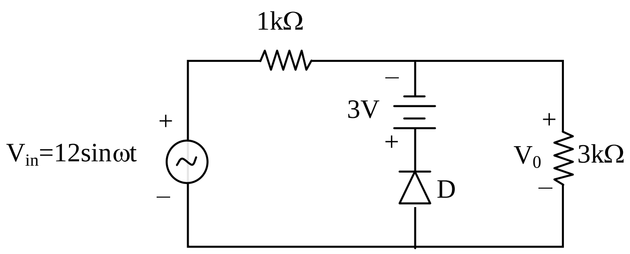
$= 2\times 0.025\times \ln(21)$

$= 0.152$V

$\Rightarrow 6 + V_2 = V_1$

$V_2 = -5.848$ V

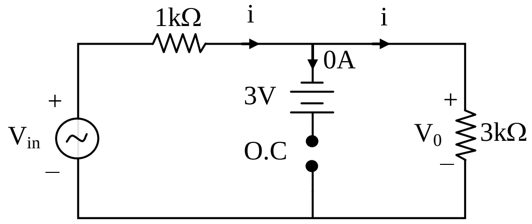
(ii)



Case 1: When $V_0 > -3$

i.e., $V_{in} > -4$

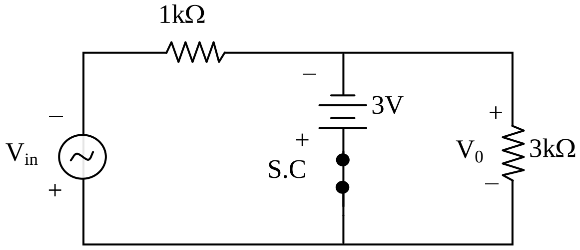
Diode (D_1) is in reverse-bias. So replace it with open circuit.



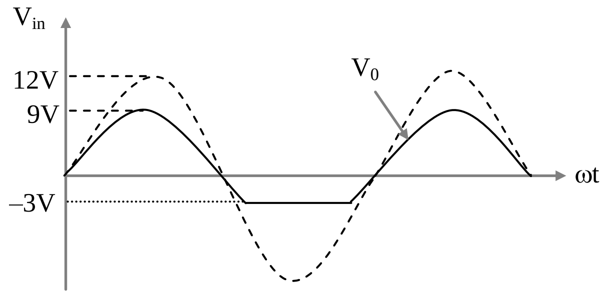
$$i = \frac{V_{in}}{(3k\Omega + 1k\Omega)} = \frac{12\sin\omega t}{(4k\Omega)} = 3\sin\omega t\ mA$$

$\therefore$ $V_0 = i \times 3k\Omega = 9\sin\omega t$ volts

Case 2: When $V_{in} < -4$, diode is in forward bias, so replace it with short circuit.



$V_0 = -3V$



$\therefore$ The given circuit is 'clipper (limiter)', the output voltage (V_0) is not allowed in fall below –3V

03. (b)

Sol: **Exact Analysis:**

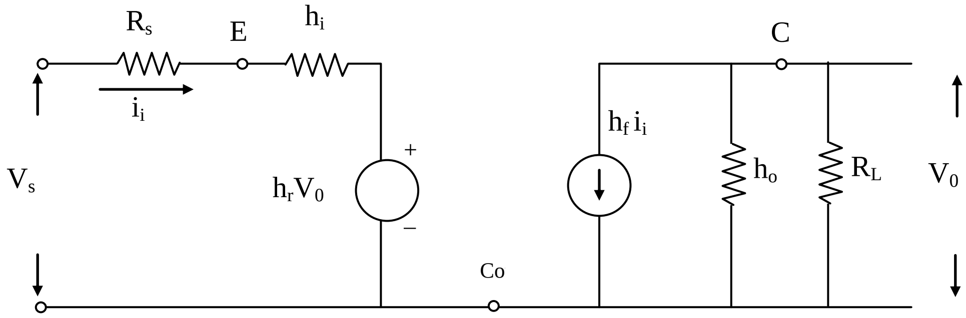


Figure: CB connection h parameter model

$$A_I = \frac{-h_{fb}}{1 + h_{ob}R_L} = \frac{-(-0.98)}{1 + (0.49 \times 10^{-6})(4 \times 10^{3})}$$

$\therefore$ $A_I \cong 0.98$

$R_i = h_{ib} + h_{rb} A_I R_L$

$= 21.6 + (2.9\times10^{-4})\ (0.98)\ (4\times10^3)$

$\therefore$ $R_i = 22.7\Omega$

$$A_V = A_I \frac{R_L}{R_i} = 0.98\times\frac{4\times10^3}{22.7}$$

$\therefore$ $A_v = 172.68$

$$Y_0 = h_{ob} - \frac{h_{fb}h_{rb}}{h_{ib}+R_s}$$

$Y_0 = 0.63\times10^{-6}\mho$

$\therefore$ $R_0 = 1/Y_0 = 1.58M\Omega$

$R'_0 = R_0||R_L = 3.98K\Omega$

Now, $A_{vs} = A_v \dfrac{R_i}{R_i + R_S} = 1.96$

Approx, solution:

$A_I = -h_{fb} = 0.98$

$R_i = h_{ib} = 21.6\Omega$

$$A_V = -h_{fb}\frac{R_L}{h_{ib}} = 0.98\times\frac{4K\Omega}{21.6}$$

$A_v = 181.48$

$R_0 \to \infty$ and $R_i' = 4K\Omega$

$$A_{vs} = 181.48\times\frac{21.6}{21.6+2K\Omega}$$

$A_{vs} = 1.94$

03. (c)

Sol:

(i) Addressing is the method of specifying the location of data in an instruction. The different types of addressing modes in 8085 are,

(1) Direct addressing mode: The data is stored in memory and 16 bit address of data, in memory location is stored is specified in the instruction.

Eg: LDA 4500
LHLD 4200

(2) Immediate addressing mode: The required data for processing is given next to the opcode, in the instruction itself.

Eg: MVI A, 55
CPI 64
ADI 0A

(3) Register addressing mode: The data placed in a register and the register name is given in the instruction to access the data.

Eg: MOV A, B
ADD B
SUB C

(4) Register indirect addressing mode: The data is stored in memory and the 16–bit address of the data location in memory is placed in a register pair. This register pair holding the 16-bit address is given in the instruction to access the data.
Eg: LXI H, 4250
MOV A, M

(5) Implied addressing mode: The data location & the operation to be performed is given in the instruction itself.
Eg: CMA, RAR, XCHG

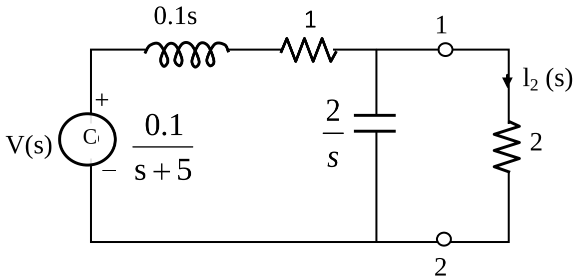
(ii) Interrupt is a signal sends by an external device special instruction executed in a program to the processor to stop the execution of the current process in the microprocessor and perform a particular task between the processor and the called device.
Interrupts are classified into 3 types.
(i) Interrupts are classified into software interrupts and hardware interrupts.
8085 has five hardware interrupts.
(a) TRAP
(b) RST 7.5
(c) RST 6.5
(d) RST 5.5
(e) INTR (address is supplied externally)
The software interrupts are
RST 0, RST 1, RST 2, RST 3, RST 4, RST 5, RST 6 & RST 7.

(ii) Interrupts are classified into vectored and non-vectored interrupts.
Vectored interrupt:
In vectored interrupt, the processor automatically branches to the specific address in response to an interrupt.
TRAP, RST 7.5, RST 6.5, RST 5.5 are vectored interrupts.

Non-vectored interrupt:
In non-vectored interrupts the interrupted device should give the address of the interrupt service routine [ISR]
INTR is a non-vectored interrupt. Hence when a device interrupts through INTR, it has to supply the address of ISR after receiving interrupt acknowledge signal.

(iii) Interrupts are classified as maskable and non-maskable interrupts.
TRAP is non-masking interrupts.
RST 7.5, RST 6.5, RST 5.5 are maskable interrupts

04. (a)
Sol: The Laplace equivalent network of the above circuit is shown bellows



The supply voltage v(t) to the network is

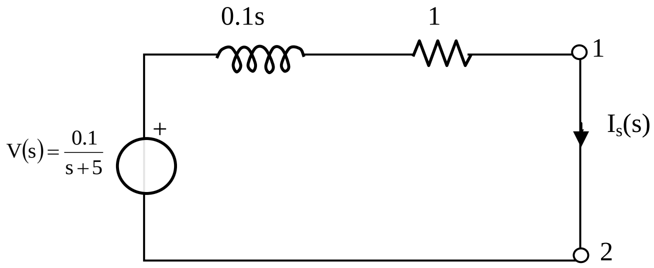
$V(t) = 0.1\, e^{-5t}$

Taking Laplace transform of above equation we get,

$V(s) = \dfrac{0.1}{s+5}$

The Norton equivalent current source is obtained by shorting terminals 1 and 2 and the evaluating this short circuit current.

The equivalent diagram is shown below in Figure



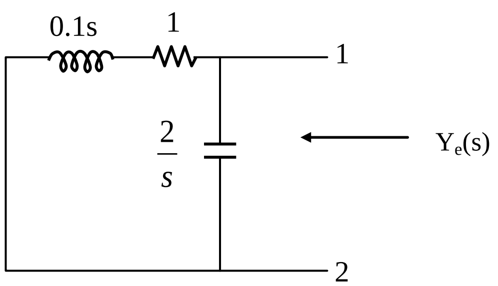
From above figure we can write

$$I_s(s) = \frac{V(s)}{0.1s+1} = \frac{0.1}{(0.1s+1)(s+5)}$$

$$\therefore\ I_s(s) = \frac{1}{(s+5)(s+10)}$$

Now the equivalent admittance of the circuit viewed from points 1 and 2 is obtained by shorting voltage source.

The equivalent network for this is shown below

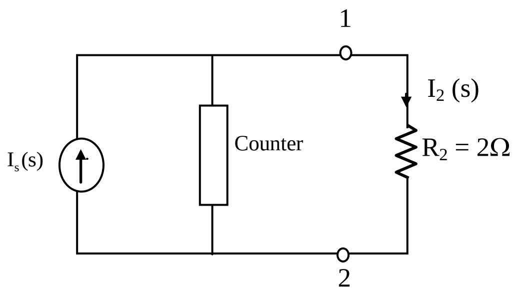


From the equivalent network we can obtain $Y_e(s)$ as,

$$Y_e(s) = \frac{1}{2/s} + \frac{1}{0.1s+1}$$

$$= \frac{0.5s^2 + 5s + 10}{s+10}$$

Thus the Norton equivalent network formed by I_s (s), Y_e (s) and R_2 is shown below



From the above figure it is clear that the voltage V(s) across resistance R_2 will be,

$$V(s) = \frac{I_s(s)}{Y_e(s) + \frac{1}{R_2}}$$

$\therefore$ Current I_2 (s) through resistance R_2 will be,

$$I_2(s) = \frac{V(s)}{R_2} = \frac{I_s(s)}{R_2\left[Y_e(s) + \frac{1}{R_2}\right]} = \frac{I_s(s)}{R_2 Y_e(s) + 1}$$

Putting values in above equation we get,

$$I_2(s) = \frac{\frac{1}{(s+5)(s+10)}}{2\left[\frac{0.5s^2 + 5s + 10}{s+10}\right] + 1}$$

$$= \frac{1}{(s+5)(s^2 + 11s + 30)} = \frac{1}{(s+5)\left[(s+5)^2 + s + 5\right]}$$

$$= \frac{1}{(s+5)^2 (s+6)}$$

Let us rearrange the above equation as,

$$I_2(s) = \frac{(s+6) - (s+5)}{(s+5)^2(s+6)} = \frac{1}{(s+5)^2} - \frac{1}{(s+5)(s+6)}$$

Again rearranging second term we get partial fraction expansion as follows

$$I_2(s) = \frac{1}{(s+5)^2} - \frac{1}{s+5} + \frac{1}{s+6}$$

Taking inverse Laplace transform we get.

$$i_2(t) = te^{-5t} - e^{-5t} + e^{-6t}$$

This is the current through resistance R_2

04. (b)

Sol: $\tau_p = \tau_n = 10^{-6}$, $D_n = 21\ cm^2/sec$ and $D_p = 10\ cm^2/sec$

(i) The saturation current calculation

We know , $L_P = \sqrt{D_P \tau_P}$

$$J_S = \frac{qD_P P_{no}}{L_P} + \frac{qD_n n_{Po}}{L_n} = qn_i^2\left(\frac{1}{N_D}\sqrt{\frac{D_P}{\tau_{P_o}}} + \frac{1}{N_A}\sqrt{\frac{D_n}{\tau_{n_o}}}\right)$$

$$= 1.6 \times 10^{-19} \times (9.65\times10^9)^2 \left(\frac{1}{10^{18}}\sqrt{\frac{10}{10^{-6}}} + \frac{1}{10^{16}}\sqrt{\frac{21}{10^{-6}}}\right)$$

$$= 6.87 \times 10^{-12}\ A/cm^2$$

Given that the cross–sectional area $A = 1.2 \times 10^{-5}\ cm^2$, we obtain

$I_s = A \times J_S = 1.2 \times 10^{-5} \times 6.87 \times 10^{-12} = 8.244 \times 10^{-17}$ A

(ii) The total current density is $I = I_S\left(e^{\frac{qV}{\eta KT}} - 1\right)$, Thus

$$I_{0.7V} = 8.244 \times 10^{-17}\left(e^{\frac{0.7}{0.0259\times2}} - 1\right)$$

$$= 8.244 \times 10^{-17} \times 1.2 \times 10^6 = 9.91 \times 10^{-11}\ A$$

$$L_{-0.7V} = 8.244 \times 10^{-17}\left(e^{\frac{-0.7}{0.0259\times2}} - 1\right)$$

$$= -8.244 \times 10^{-17}\ A$$

04. (c)

Sol:

(i) **Laser ablation:** Laser ablation has been extensively used for the preparation of nanoparticles and particulate films. In this process a laser beam is used as the primary excitation source of ablation for generating clusters directly from a solid sample in a wide variety of applications. The small dimensions of the particles and the possibility to form thick films make this method quite an efficient tool for the production of ceramic particles and coatings and also an ablation source for analytical applications such as the coupling to induced coupled plasma emission spectrometry, ICP, the formation of the nanoparticles has been explained following a liquefaction process which generates an aerosol, followed by the cooling/solidification of the droplets which results in the formation of fog. The general dynamics of both the aerosol and the fog favours the aggregation process and micrometer-sized fractal-like particles are formed. The laser spark atomizer can be used to produce highly mesoporous thick films and the porosity can be modified by the carrier gas flow rate. ZrO_2 and SnO_2 nanoparticulate thick films were also synthesized successfully using this process with quite identical microstructure. Synthesis of other materials such as lithium manganate, silicon and carbon has also been carried out by this technique.

(ii) The unusual properties of nano materials can be attributed to the following reasons: the number of atoms on the surface is comparable to the number of atoms at the lattice points. Therefore the properties are affected by the atoms at these locations. The other aspect is the Quantum Confinement effect; when the particles are of nano size, say, 100nm side cube, the presence of a few vacancies allows the crystal lattice to large relaxation. As a result, the optical, electronic and mechanical properties are affected significantly.

Some examples are given below:

(i) They are more ductile at elevated temperatures as compared to the coarse-grained ceramics.

(ii) Nanostructured semiconductors are known to show various non-linear optical properties.

(iii) Semiconductor Q-particles also show quantum confinement effects which may lead to special properties, like the luminescence in silicon powders; silicon - germanium quantum dots as infrared optoelectronic devices.

(iv) Cold welding properties combined with the ductility make them suitable for metal-metal bonding especially in the electronic industry.

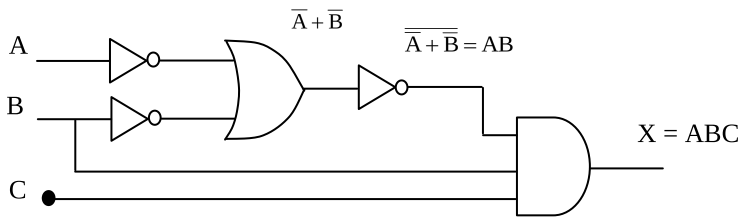
(v) Very small particles have special atomic structures with discrete electronic states, which give rise to special properties for high density information storage and magnetic refrigeration.

(vi) They have large surface to volume ratio. Further, in a nano wire, electrons are confined to one dimensional ballistic motion which gives rise to special electrical properties.

04. (d)

Sol:

(i)

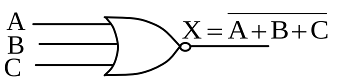


$$X = \left(\overline{\overline{A}+\overline{B}}\right)BC$$

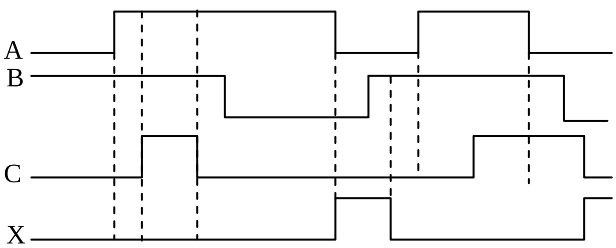
$$X = \left(\overline{\overline{AB}}\right)BC = ABC$$

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

(ii) (A)



For NOR gate output is 1 only when all inputs are 0



(B) With C = 1, output X = 0 for all times, because

$$X = \overline{A+B+C} = \overline{A+B+1} = \overline{1} = 0$$

05. (a)

Sol: Full load efficiency (η) at upf

$$= \frac{50\text{kVA} \times 1}{50\text{kVA} \times 1 + 500 + 600} \times 100 = 0.978 \times 100 = 97.8\ \%$$

The load for maximum efficiency

$$= \sqrt{\frac{500}{600}} \times \text{rated load}$$

$$= \sqrt{\frac{5}{6}} \times 50\text{kVA} \times 1$$

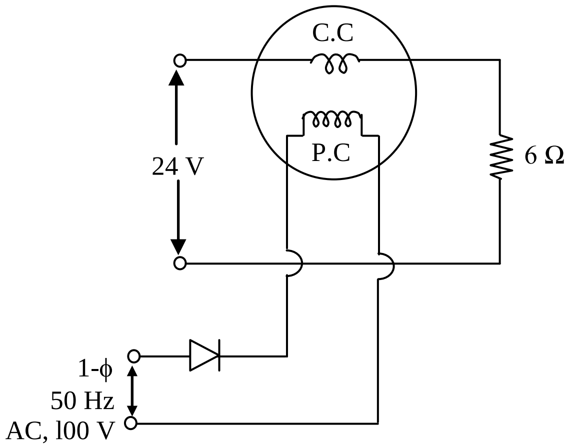
= 45.64 kVA × 1

= 45.64 kW

At maximum efficiency, the variable copper losses equal the constant core losses, each of them being equal to 500 W.

05. (b)

Sol:



Current through the current coil = $\frac{24}{6}$ = 4 A

$\therefore$ Reading of wattmeter = Average power over a cycle $= \frac{1}{2\pi}\left[\int_0^{2\pi} vi\, d\theta\right]$

$$\Rightarrow \frac{1}{2\pi}\left[\int_0^{\pi} \sqrt{2} \times 100 \sin\theta \times 4\, d\theta\right] = \frac{\sqrt{2} \times 100 \times 4}{2\pi}\left[\int_0^{\pi} \sin\theta\, d\theta\right] = \frac{\sqrt{2} \times 100 \times 4}{2\pi}\left[-\cos\theta\big|_0^{\pi}\right] = 180.06\ \text{W}.$$

05. (c)

Sol: Let assume V_m be the maximum amplitude of sinusoidal voltage = 24V

$I_D = \frac{24 - 12 - 0.6}{100}$

$\Rightarrow I_D = 114$ mA

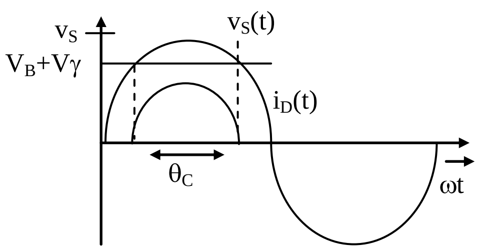


Fig: input voltage and diode current waveforms

Let θ_C be the angle of conduction of the diode

$V_s(t) = V_m \sin\theta = 24 \sin\theta$

Diode conducts when $V_s \geq V_B + V_\gamma$

i.e. $V_s > 12 + 0.6$ V

$24 \sin\theta = 12.6$

$\text{Sin}\,\theta = \dfrac{12.6}{24} \Rightarrow \theta = 31.66°$

But sin 90° = 1

From the above characteristics of diode current $\dfrac{\theta_C}{2} = 90^\circ - 31.6^\circ$

$\Rightarrow \theta_C = 116.66°$

$\therefore \%\,\theta_C = \dfrac{116.66}{360} \times 100\%$

$\Rightarrow \%\,\theta_C = 31.41\%$

05. (d)

Sol: Based on output states can be reduced as,

(abce) (g) (dh) f.

For x = 0, x = 1, the next states of b and e are d and c respectively. Hence state e can be reduced by considering state 'e' as state 'b'.

Similarly, For x = 0, x = 1, the next states of d and h are g and a respectively. Hence state h can be reduced by considering state 'h' as state 'd'.

So, (abc)(g)(d)(f)

Present state	Next state x = 0	Next state x = 1	Output x = 0	Output x = 1
a	f	b	0	0
b	d	c	0	0
c	f	b	0	0
d	g	a	1	0
f	f	b	1	1
g	g	d	0	1

For x = 0, x = 1, the next states of c and a are f and b respectively. Hence state c can be reduced by considering state 'c' as state 'a'.

$\Rightarrow$ (ab)(g)(d)(f)

Present state	Next state x = 0	Next state x = 1	Output x = 0	Output x = 1
a	f	b	0	0
b	d	a	0	0
d	g	a	1	0
f	f	b	1	1
g	g	d	0	1

05. (e)

Sol: Superconductivity:

The resistivity of some materials abruptly becomes zero below a specific critical temperature. It is called Superconductivity. It was first observed in pure mercury at the critical temperature of 4.2° K. Different materials have different critical temperatures.

(i) Effect of Magnetic Field:

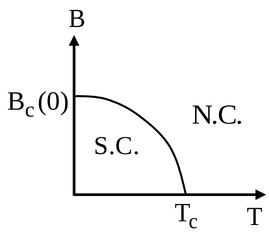
When the magnetic field is applied on a specimen in SC State ($T < T_C$) and it is increased gradually, at a specific field called critical magnetic field (B_C), it becomes a normal conductor. That is, magnetic field is capable of destroying superconductivity. This B_c depends on the temperature of the specimen below T_c as

$$B_C = B_C(0)\left[1-\left(\frac{T}{T_C}\right)^2\right]$$

At $T = T_c$, $B_c = 0$

and at T = 0 K

$B_c = B_c(0)$.



(ii) Effect of frequency:

- The superconducting metal offers zero resistance only for direct current of constant value.
- If the current is changing like in AC, an electric field is developed and some power is distributed.
- The superconductor contains two different types of electrons. Normal electrons and Super electrons which are responsible for superconductivity. Thus, the SC metal is like two parallel conductors one having a normal resistance and the other zero resistance.
- Super electrons, short circuit the normal electrons giving zero resistivity in DC current case.
- In AC current case, current is due to both super and normal electrons where some power dissipation is present.
- If the frequency of applied AC is high, super electrons behave like normal electrons and SC behave like normal metal.
- Electronic specific heat decreases exponentially

06. (a)

Sol:

(i) For a regulator circuit, V_{in} should be greater than V_Z (then only Zener diode operates in breakdown region)

$V_{in} > V_Z$, Since V_Z=12V, let us consider V_{in}= 24V (you can take any value which is more than 12)

When I_L = 0 A,

I_z is maximum

$$= \frac{V_{in} - V_z}{R} = 25.5\,\text{mA}$$

If R_L is removed from the circuit, then I_L = 0 A since, $I_{zmax} < I_{zm}$, therefore, I_L = 0 A is acceptable for minimum. i.e I_{min}= 0 Amp

I_L maximum occurs for $I_z = I_{zk}$ and given as $I_{L(max)} = I - I_{zk} = 25.5 - 1 = 24.5$ mA

$R_{(min)}$ for regulation = $\dfrac{12\text{V}}{24.5\text{mA}} = 490\Omega$

(ii) (A) Applying KVL around the gate-source loop yields

$V_G = V_{GSQ} + R_S I_{DQ} + V_{SS}$ -------- (1)

Solving (1) for I_{DQ} and equating the result to $I_{dss}\left(1+\frac{V_{GSQ}}{V_{P0}}\right)^2$

$$\frac{V_G - V_{GSQ} - V_{SS}}{R_S} = I_{dss}\left(1+\frac{V_{GSQ}}{V_{P0}}\right)^2 \text{ --------- (2)}$$

Rearranging (2) leads to the following quadratic in V_{GSQ}:

$$V_{GSQ}^2 + V_{p0}\frac{V_{p0}+2I_{dss}R_S}{I_{dss}R_S}V_{GSQ} + \frac{V_{p0}^2}{I_{dss}R_S}(I_{dss}R_S - V_G + V_{SS}) = 0 \text{ --------- (3)}$$

Substituting known values into (3) and solving for V_{GSQ} with the quadratic formula lead to

$$V_{GSQ}^2 + 3\frac{3+(2)(5\times10^{-3})(8\times10^{-3})}{(5\times10^{-3})(8\times10^{3})}V_{GSQ} + \frac{(3)^2}{(5\times10^{-3})(8\times10^{3})}[(5\times10^{-3})(8\times10^{3}) - 0 - 8] = 0$$

So that $V_{GSQ}^2 + 6.225V_{GSQ} + 7.2 = 0$ and V_{GSQ} = –4.69 V or –1.53 V.

Since V_{GSQ} = –4.69 V < $-V_{p0}$, this value must be considered extraneous as it will result in $i_D = 0$. Hence, V_{GSQ} = –1.53 V.

Now,

$$I_{DQ} = I_{dss}\left(1+\frac{V_{GSQ}}{V_{p0}}\right)^2 = 5\times10^{-3}\left(1+\frac{-1.53}{3}\right)^2 = 1.2\text{mA}$$

and, by KVL,

$V_0 = I_{DQ}R_S + V_{SS} = (1.2\times10^{-3})\,(8\times10^{3}) + (-8) = 1.6\text{V}$

(B) Substitution of known values into (3) leads to

$$V_{GSQ}^2 + 6.225\ V_{GSQ} + 4.95 = 0$$

Which, after elimination of the extraneous root, results in V_{GSQ} = –0.936 V.

Then, as in part (a),

$$I_{DQ} = I_{dss}\left(1+\frac{V_{GSQ}}{V_{p0}}\right)^2 = 5\times10^{-3}\left(1+\frac{-0.936}{4}\right)^2 = 2.37\text{ mA} \quad \text{and}$$

$V_0 = I_{DQ}R_S + V_{SS} = (2.37\times10^{-3})\,(8\times10^{3}) + (-8) = 10.96\text{ V}$

06. (b)

Sol:

(i) Loss of charge method: This method is specially suited for the measurement of a very high insulation resistance. The connections are shown in fig. 1. With the key K_1 closed and K_2 open, the capacitor is charged upto a suitable voltage. Then the capacitor is allowed to discharge through the unknown resistance X, by opening the key K_1 and closing K_2. The terminal voltage is being observed for a long time (in hours).

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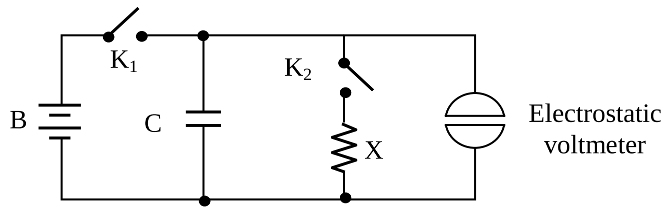


Fig. 1 Loss of charge method for measurement Of insulation resistance

Let V be the terminal voltage and Q be the charge (in coulomb) at time t. Then the current through the resistance X is

$$i = \frac{dQ}{dt} = -C\frac{dV}{dt}$$

Where C is the capacitance of the capacitor in farad.

But, $i = \dfrac{V}{X}$

$$\therefore \frac{V}{X} = -C\frac{dV}{dt}$$

Or $C\dfrac{dV}{dt} + \dfrac{V}{X} = 0$

$$\frac{dV}{V} = -\frac{1}{CX}dt$$

Or $\log_e V = -\dfrac{t}{CX} + \log_e K$

Where K is a constant

Let V = E, when t = 0

Then, K = E

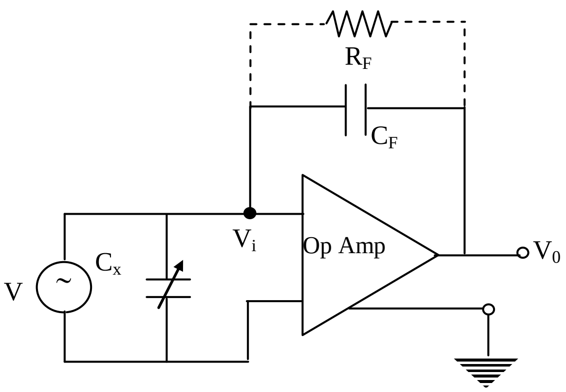
$$\therefore \log_e V = \log_e E - \frac{t}{CX}$$

Or $\dfrac{t}{CX} = \log_e \dfrac{E}{V}$

$$X = \frac{t}{C\log_e \frac{E}{V}} = \frac{0.4343t}{C\log_{10}\frac{E}{V}} \text{ ohm}$$

(ii) Charge Amplifier

In order to improve the low frequency response of the piezoelectric transducer we require a charged amplifier.



We know that

$$\frac{V_0}{V_i} = -\frac{C_x}{C_F} \;;\; V_0 = \left(\frac{-C_x}{C_F}\right).V_i \quad \text{---------(1)}$$

We know that $VI = \dfrac{q}{c_x}$ --------(2)

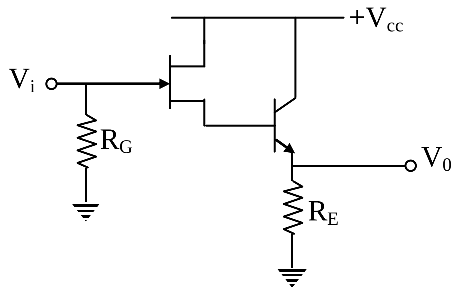
By putting the value of equation-2 in equation-1

We get $Vo = -\frac{C_x}{C_F}\times\frac{q}{C_x}=\frac{-q}{C_F}$ -------(3)

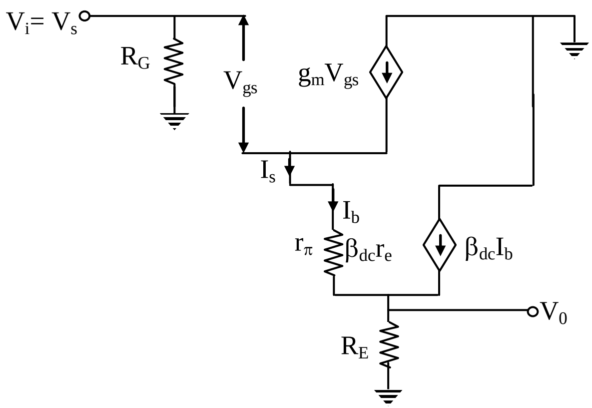
$$V_0 = -\frac{q}{C_f} = \frac{K_q.X_i}{C_F}$$

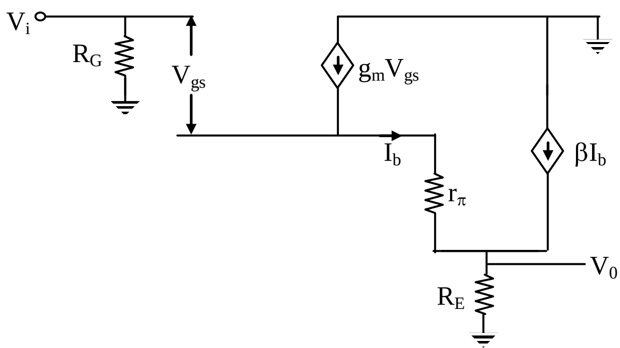
Equation-3 indicates output voltage V_0 is linearly related to input displacement xi. It also indicates that the output changes instantaneously with input without loss in the steady state response. But in practice, it is not so, this is because op-Amp doesn't have an '∞' input resistance though very high. The input resistance and the leakage resistance of CF, exhibit a steady changing of CF by the leakage current till the amplifier is saturated. In order to overcome this problem, a resistance RF is connected across capacitor CF in the feedback path. This presents a small leakage current to charge the capacitor heavily. The connection of RF is shown as dotted line.

06. (c)
Sol:



It is multistage cascading amplifier with source follower to emitter follower.





$V_i = V_{gs} + I_b r_\pi + (\beta+1)\, I_b \, . \, R_E$

$V_i = V_{gs} + g_m V_{gs} r_\pi + (\beta + 1)\, g_m\, V_{gs}\, R_E$ $\quad [\because I_b = g_m V_{gs}]$

$V_i = V_{gs}\,[1 + g_m r_\pi + (\beta+1)_{gm}\, R_E]$ ………. (1)

$V_0 = (\beta+1) I_b .\, R_E$

$\quad = (\beta+1) g_m V_{gs} .\, R_s$

$$\frac{V_0}{V_i} = \frac{(\beta+1) g_m V_g . R_E}{V_{gs}[1 + g_m r_\pi + (\beta+1) g_m R_E)}$$

$$A_V = \frac{(\beta+1) g_m R_E}{[1 + g_m r_\pi + (\beta+1) g_m R_E]}$$

Output resistance $R_0 = R_E \,||\, \left[\frac{V_0}{I_0}\right]$

$[\therefore V_i$ is short circuited$]$ $\quad [\because I_b = g_m V_{gs}]$

$I_0 = (\beta+1) I_b = (\beta + 1) g_m\, V_{gs}$

$V_0 = (1 + g_m r_\pi) V_{gs}$

$$\frac{V_0}{I_0} = \frac{1 + g_m r_\pi}{(\beta+1) g_m}$$

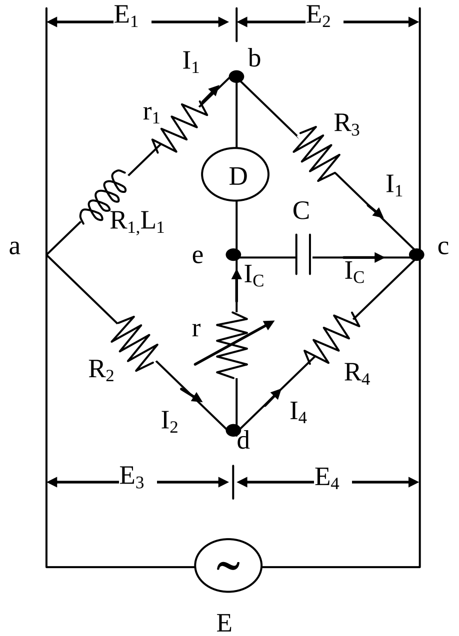
$\therefore$ Output resistance $R_0 = R_E \,||\, \left(\frac{V_0}{I_0}\right) = R_E \,||\, \left[\frac{1 + g_m r_\pi}{(\beta+1) g_m}\right]$

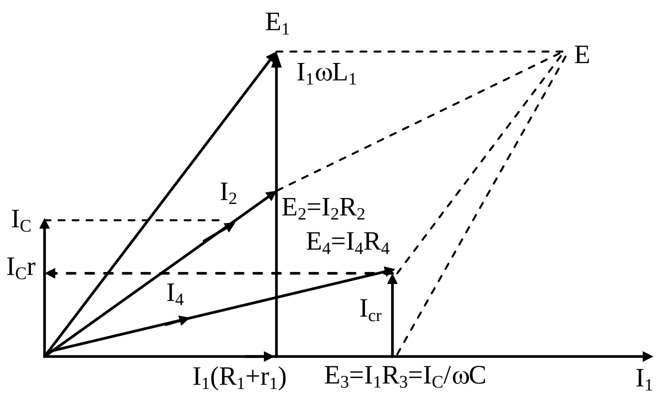
07. (a)

Sol: This bridge, in fact, is a modification of the Maxwell's inductance capacitance bridge. In this method, the self inductance is measured in terms of a standard capacitor.

This method is applicable for precise measurement of self inductance over a very wide range of values.

Figure below shows the connections and the phasor diagram of the bridge for balanced conditions.





L_1 = self inductance to be measured

R_1 = resistance of self inductor,

r_1 = resistance connected in series with self inductor

r, R_2, R_3, R_4 = known non inductance resistances,

and C = fixed standard capacitor.
At balance, $I_1 = I_3$ and $I_2 = I_c + I_4$

Now, $I_1R_3 = I_C \times \frac{1}{j\omega C}$

$\therefore I_C = I_1 j\omega CR_3$.

Writing the other balance equations

$I_1(r_1 + R_1 + j\omega L_1) = I_2R_2 + I_Cr$

And $I_C\left(r + \frac{1}{j\omega C}\right) = (I_2 - I_C)R_4$

Substituting the value of I_C in the above equations, we have

$I_1(r_1 + R_1 + j\omega I_1) = I_2R_2 + I_1 j\omega CR_3 r$

Or $I_1(r + R_1 + j\omega L_1 - j\omega CR_3 r) = I_2R_2$

And $j\omega CR_3I_1\left(r + \frac{1}{j\omega C}\right) = (I_2 - I_1 j\omega CR_3)R_4$

Or $I_1(j\omega CR_3 r + j\omega CR_3R_4 + R_3) = I_2R_4$

From equations (i) and (ii) we obtain

$I_1(r_1 + R_1 + j\omega L_1 - j\omega CR_3 r) = I_1\left(\frac{R_2R_3}{R_4} + \frac{j\omega CR_2R_3 r}{R_4} + j\omega CR_3R_2\right)$

Equating the real and the imaginary parts,

$R_1 = \frac{R_2R_3}{R_4} - r_1$ and $L_1 = C\frac{R_3}{R_4}\left[r(R_4 + R_2) + R_2R_4\right]$

An examination of balance equations reveals that to obtain easy convergence of balance alternate adjustments of r_1 and r should be done as they appear in only one of the two balance equations.

Advantages:

1. In case adjustments are carried out by manipulating control over r_1 and r, they become independent of each other. This is a marked superiority over sliding balance conditions met with low Q coils when measuring with Maxwell's bridge. A study of convergence conditions would reveal that it is much easier to obtain balance in the case of Anderson's bridge than in Maxwell's bridge for low Q-coils.
2. A fixed capacitor can be used instead of a variable capacitor as in the case of Maxwell's bridge
3. This bridge may be used for accurate determination of capacitance in terms of inductance.

07. (b)

Sol:

(i) Body centered cubic structure (B.C.C):

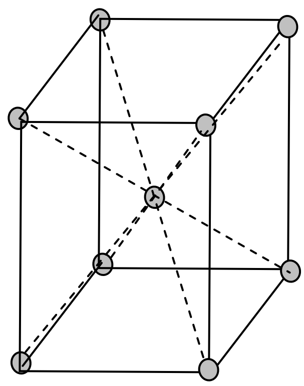


Figure shows the unit cell of B.C.C. structure. In this structure the eight corners of the cube are occupied by eight atoms and the centre of the cube is occupied by one atom. Metals that crystallize into B.C.C. structure are chromium, tungsten, iron, vanadium, molybdenum and sodium.

Number of atoms in the unit cell of B.C.C Structure:

In B.C.C. structure, the unit cell contains eight atoms at each corner of the cube and one atom in the centre of the cube. Since each corner atom is shared by eight surrounding cubes and the atom in the centre can not be shared by any other cube, the unit cell of the B.C.C. structure contains:

8 atoms at the corners $\times \frac{1}{8}$ = 1 atom

1 centre atom = 1 atom

$\therefore$ **Total = 2 atoms**

Therefore the unit cell of B.C.C. structure contains two atoms.

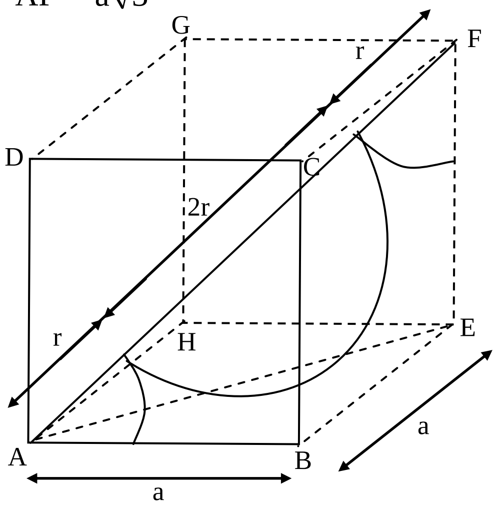
Atomic packing factor of B.C.C. structure:

From the figure

$(AE)^2 = (AB)^2 + (BE)^2 = a^2 + a^2 = 2a^2$

and $(AF)^2 = (AE)^2 + (EF)^2 = 2a^2 + a^2 = 3a^2$

$\Rightarrow$ AF = $a\sqrt{3}$



We have from the figure

AF = 4r

$\therefore\ 4r = a\sqrt{3}$

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

$\therefore$ The radius of the atom (sphere) in the B.C.C. structure is $\frac{a\sqrt{3}}{4}$. And the number of atoms in the unit cell of B.C.C. structure are two.

Volume of atoms in the unit cell = $\frac{2\times 4\pi r^3}{3}$

$$= \frac{8\pi}{3}\left(\frac{a\sqrt{3}}{4}\right)^3 = \frac{\pi a^3\sqrt{3}}{8}$$

Volume of unit cell = a^3

Atomic packing factor

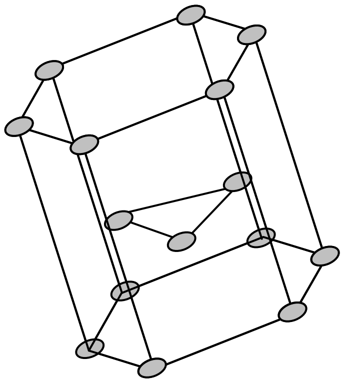
$$= \frac{\text{Volume of atoms in the unit cell}}{\text{Volume of unit cell}}$$

$$= \frac{\left(\frac{\pi a^3 \sqrt{3}}{8}\right)}{a^3}$$

$$= \frac{\pi\sqrt{3}}{8} = 0.68$$

(ii) Hexagonal close packed structure (H.C.P.):

Figure shows the unit cell of H.C.P. structure. The H.C.P. structure contains i) One atom at each corner of the hexagon ii) One atom at the centre of the two hexagonal faces and iii) Three atoms in the form of a triangle midway between the two basal planes. Metals that crystallize into H.C.P. structure are zinc, cadmium, beryllium, magnesium, titanium, zirconium etc.



Number of atoms in the unit cell of H.C.P. structure:

Since each corner atom of the hexagon is shared by six surrounding hexagons, the centre atom of the hexagon face is shared by two surrounding hexagons and the three middle layer atoms can not be shared by any other hexagons, the unit cell of the H.C.P. structure contains.

12 atoms at the concerns $\times \frac{1}{6}$ = 2 atoms

2 face centered atoms $\times \frac{1}{2}$ = 1 atom

3 middle layer atoms = 3 atoms

$\therefore$ Total = 6 atoms

Atomic packing factor of H.C.P. structure:

The volume of the unit cell can be found out by finding out the area of the basal plane and then multiplying this by its height.

The area of the basal plane is the area ABCDEFG. This area is six times the area of equilateral triangle ABC.

Area of triangle ABC = $\frac{1}{2}$(base) $\times$ (height) $= \frac{1}{2} \times a \times a \sin 60°$

$$= \frac{1}{2} a^2 \sin 60°$$

Total area of the basal plane

$$= 6\times\frac{1}{2}\times a^2 \sin 60^o$$

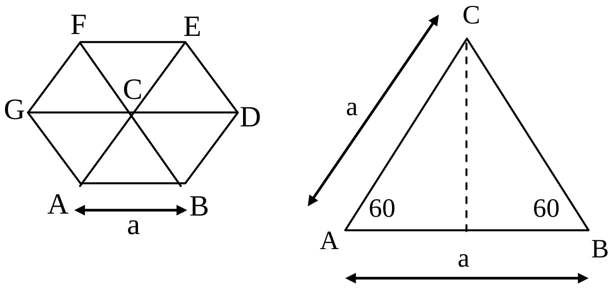
$$= 3\,a^2 \sin 60°$$

Volume of unit cell

= Area of basal plane × height

$$= 3\,a^2 \sin 60° \times h$$

For HCP structures, $a = 2r \Rightarrow r = \frac{a}{2}$



Also we know that the number of atoms in the unit cell of HCP structure are six.

Volume of atoms in the unit cell = $6\times\frac{4\pi r^3}{3}$

Atomic packing factor

$$= \frac{\text{Volume of atoms in the unit cell}}{\text{Volume of unit cell}} = \frac{6\times\frac{4\pi r^3}{3}}{3a^2 \sin 60^o \times h}$$

$$= \frac{6\times\frac{4\pi}{3}\left(\frac{a}{2}\right)^3}{3a^2 \sin 60^o \times h}$$

$$= \frac{\pi a}{3h \sin 60^o}$$

The h/a ratio for an ideal HCP crystal structure consisting of uniform spheres packed tightly together is 1.633.

Therefore, substituting h/a = 1.633

We get,

Atomic packing factor = 0.74

07. (c)

Sol: Separately excited DC motor.

$R_a = 0.5\,\Omega$ $V = 250$V,

$I_a = 20$A $N = 1500$rpm

To be found:

Torque developed for I_a=10A

Case (i):

Power developed(P_1) = $E_b I_a$

$E_{b1} = V - I_a R_a = 250 - 20 \times 0.5$

= 240V.

$\therefore \quad P_1 = 240 \times 20$
$= 4800W.$

But $T_1 = \dfrac{P_1}{\left(\dfrac{2\pi N}{60}\right)}$

$= \dfrac{4800 \times 60}{2\pi \times 1500}$

$= 30.55N\text{-m}.$

Case (ii)

Torque $T \propto \phi I_a$

For separately excited machine

ϕ = constant

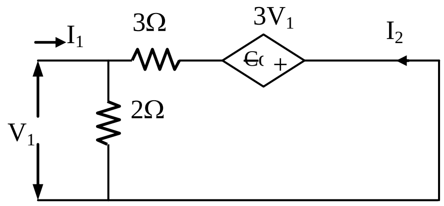
$\therefore \dfrac{T_2}{T_1} = \dfrac{I_{a2}}{I_{a1}}$

$T_2 = \dfrac{10}{20} \times 30.55$

$\Rightarrow T_2 = 15.28$ N-m

07. (d)

Sol: When $V_2 = 0$, the circuit is reduced as shown figure



Current through 1 Ω can be neglected $V_1 = 2\,(I_1 + I_2)$…… (1)

Applying KVL to loop

$3V_1 + 3I_2 + 2\,(I_1 + I_2) = 0$

$3V_1 + 3I_2 + V_1 = 0$ [from eq(1)]

$4V_1 = -\ 3I_2$

$\dfrac{I_2}{V_1} = Y_{21} = \dfrac{-4}{3}$ mho

$Y_{21} = \dfrac{-4}{3}$ mhos

From equation $I_2 = \dfrac{-4}{3} V_1$

Substitute the equation given above in Equation [eq (1)]

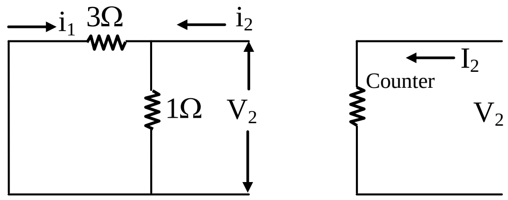
$$V_1 = 2I_1 + 2\left(\frac{-4}{3}\right)V_1$$

$$V_1 + \frac{8}{3}V_1 = 2I_1$$

$$\frac{11}{3}\ V_1 = 2I_1 \Rightarrow \frac{I_1}{V_1} = \frac{11}{6}$$

$$Y_{11} = \frac{11}{6}\ \text{mhos}$$

When $V_1 = 0$, the circuit is reduced as shown in Figure



$\therefore$ $V_1 = 0$, $3V_1$ will tend to zero and current across 2Ω is zero

$$V_2 = \frac{3}{4}I_2$$

$$\therefore\ Y_{22} = \frac{I_2}{V_2} = \frac{4}{3}$$

$$\therefore\ Y_{22} = \frac{4}{3}\ \text{mhos}$$

From fig, we can write

$$I_1 = -I_2 \times \frac{1}{3+1} = \frac{-I_2}{4}$$

$$\therefore\ I_1 = \frac{-1}{4}\left(\frac{4}{3}V_2\right)$$

$$I_1 = \frac{-1}{3}V_2$$

$$\therefore\ Y_{12} = \frac{I_1}{V_2} = \frac{-1}{3}$$

$$\therefore\ Y_{12} = \frac{-1}{3}\ \text{mhos}$$

$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} \frac{11}{6} & -\frac{1}{3} \\ -\frac{4}{3} & \frac{4}{3} \end{bmatrix}$$

08. (a)

Sol:

(i) $f_0 = 100$ Hz

$Z_1 = (10 + j8)$, $Z_2 = (10 - jX_c)\ \Omega$

$$Y_1 = \frac{1}{Z_1} = \frac{1}{10+8j} = 0.06 - j0.04\,\Omega$$

$$Y_z = \frac{1}{Z_2} = \frac{1}{10 - jX_c} = \frac{10 + jX_c}{10^2 + (X_c)^2}$$

$$= \frac{10}{100 + X_c^2} + \frac{jX_c}{100 + X_c^2}$$

$Y = Y_1 + Y_2$

$$= 0.06 + \frac{10}{100 + X_c^2} + j\left[\frac{X_c}{100 + X_c^2} - 0.04\right]$$

The condition for resonance is that the net suceptance should become equal to zero. That is,

$$\frac{X_c}{100 + X_c^2} - 0.04 = 0$$

$$\frac{X_c}{100 + X_c^2} = 0.04$$

$X_c = 4 + 0.04\ X_c^2$

$$0.04X_c^2 - X_c + 4 = 0$$

$$X_c = \frac{1 \pm \sqrt{(1)^2 - 4(0.04)(4)}}{2 \times 0.04}$$

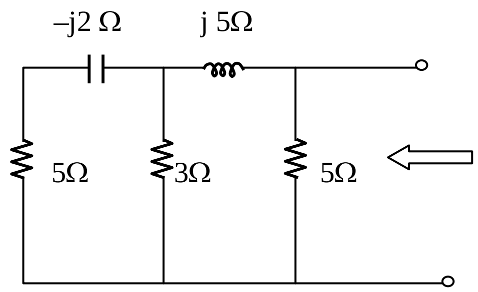
$$= \frac{1 \pm \sqrt{1 - 0.64}}{0.08} = 20\ \Omega$$

$$X_c = \frac{1}{2\pi f_c} \Rightarrow c = \frac{1}{2\pi f X_c}$$

$$\frac{1}{2\pi \times 100 \times 20} = 79.61\ \mu F$$

$C = 79.61\ \mu$F

(ii) Thevenin impedance can be found by network reduction for the network shown in Figure



$Z_1 = (5 - j2)||3 = \dfrac{(5 - j2)\times 3}{5 - j2 + 3} = (1.94 - j0.265)\Omega$

Z_1 in series with j5 impedance, add this two impedances to obtain

$Z_2 = 1.94 - j0.265 + j5$

$= (1.94 - j4.735)\Omega$

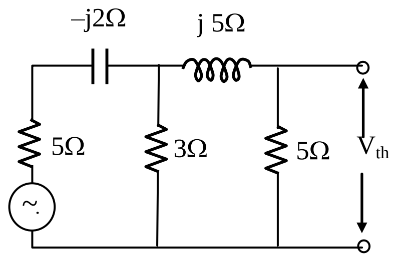
Z_{th} is now found by combining Z_2 and the 5Ω resistor

$$Z_{th} = \left(\frac{(1.94 - j4.735)\times 5}{1.94 - j4.735 + 5}\right)$$

$= 2.54 + j1.67$

$= 3.04 \angle 33.4°$

Consider the open circuit and solve for I_2 using the mesh current method for the network shown



$$I_2 = \frac{\begin{bmatrix} 8-j2 & 10\angle 30° \\ -3 & 0 \end{bmatrix}}{\begin{bmatrix} 8-j2 & -3 \\ -3 & 8+j5 \end{bmatrix}} = \frac{30\angle 30°}{09.25\angle 20.3°}$$

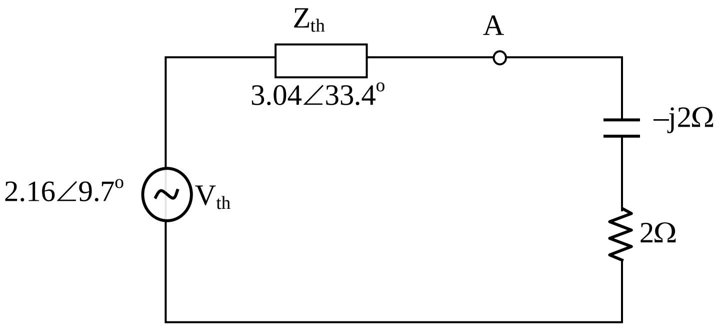
$= 0.433 \angle 9.7°$ A

The Open - Circuit voltage or V_{th} is the drop across the 5–Ω resistor

$V_{Th} = 5 \times I_2 = 5\times 0.433 \angle 9.7°$

$= 2.16 \angle 9.7°$ V

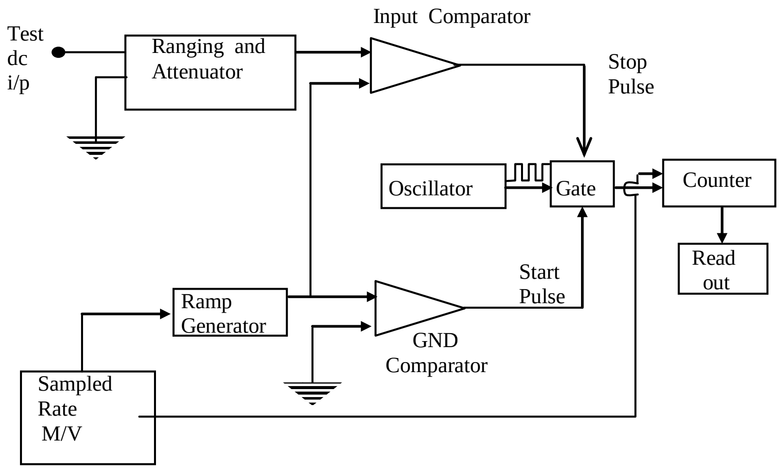
Connect the (2 – j2) Ω impedance to the Thevenin equivalent circuit as shown



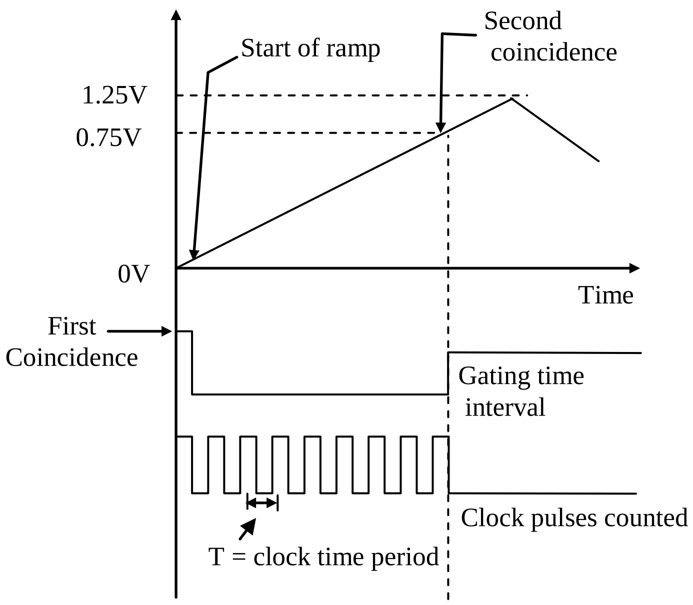
$$\text{Current, } I = \frac{V_{Th}}{Z_{Th} + 2 - j2} = \frac{2.16\angle 9.7°}{4.54 - 54 - j0.33} = 0.467\angle 13.87° A$$

08. (b)

Sol: The operating principle is to measure the time that a linear ramp takes to change the input level to the ground level, or vice-versa. This time period is measured with an electronic time-interval counter and the count is displayed as a number of digits on an indicating tube or display. The operating principle and block diagram of a ramp type DVM are shown in fig.



The ramp may be positive or negative; in this case a negative ramp has been selected.



N1 = Number clock cycles in 1.25 V

$$= \frac{125\ \text{m sec}}{1\ \mu\text{sec}} = 125000$$

1.25 V $\rightarrow$ 125000 counts

0.75 V $\rightarrow$ x counts

x = 75000 counts counted into register for an input of 0.75 V

Method 2:

Slope of ramp = m = $\dfrac{dV}{dt}$

$= \dfrac{1.25\,V}{125\,m\sec}$

$= 0.01\left(\dfrac{V}{m\sec}\right)$

$\Rightarrow$ 0.75 V corresponding time required

$= \dfrac{0.75}{0.01}$ msec

= 75 msec

Number of clock pulses counted = $\dfrac{75\,m\sec}{T}$

$= \dfrac{75\,m\sec}{1\mu\sec} = 75000$

08. (c)

Sol:

(i) Since the B-H curve is linear; the core flux waveform is the same as that of the excitation current.

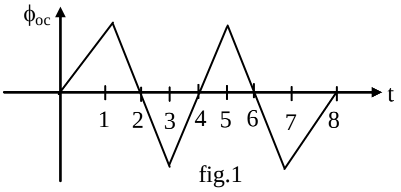


fig.1

(ii) The open circuited secondary terminal voltage. $e_2 = -N_2\dfrac{d\phi}{dt}$

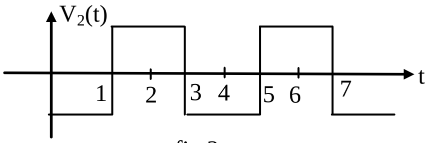


fig.2

(iii) The short circuited secondary current $i_2(t)$ is of pure inductive type, hence lags the voltage by 90^o.

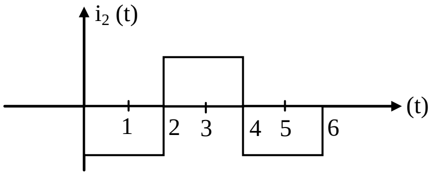


fig.3

(iv) The core flux ϕ_{sc}, with the secondary of transformer short circuited.

The transformer core flux wills always remains constant since the secondary amp-turns are balanced by additional primary amp-turns.