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ESE 2020 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Electrical Engineering

Test-3 : Power Systems

Electrical Circuits-1 + Microprocessors-1

Digital Electronics-2 + Control Systems-2

Name : ....

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Student's Signature

Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. Answer must be written in English only.
3. Use only black/blue pen.
4. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
5. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
6. Last two pages of this booklet are provided for rough work. Strike off these two pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	
Q.2	
Q.3	
Q.4	
Section-B	
Q.5	
Q.6	
Q.7	
Q.8	
Total Marks Obtained	

Signature of Evaluator .... Cross Checked by ....

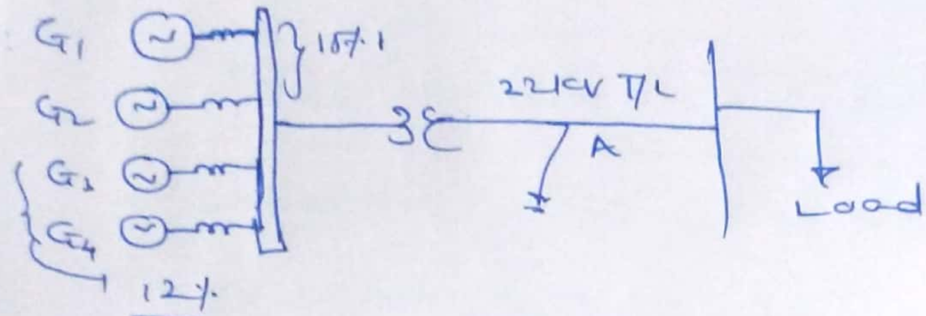
Q1) a) A power plant has four generators feeding a common bus with following rating

G_1 & G_2 : 20 MVA, 15 % reactance each

G_3 & G_4 : 15 MVA, 12 % reactance each

A 15 MVA transformer steps up the voltage and feeds a 22 kV transmission line. Determine the safe minimum reactance of transformer such that the fault level on the secondary bus of the transformer may not exceed 150 MVA, Base MVA = 20 MVA.

Soln.



→ let us consider Base MVA = 20 MVA

∴ For G_1 & G_2, reactances are 15 %

For G_3 & G_4, reactances will be $12 \times \frac{20}{15}$ % = 16 %

→ If fault occurs at point A location the fault level may not exceed 150 MVA.

→ As we know that

$$\text{Short ckt MVA} = \frac{V_{pf}^{(o)}}{Z_{eq}} \times (\text{MVA})_{Base}$$

substituting given values we get

$$150 \geq \frac{1}{Z_{eq}} \times 20$$

$$\therefore \boxed{Z_{eq} \leq \frac{20}{150} \text{ pu}} \rightarrow (1)$$

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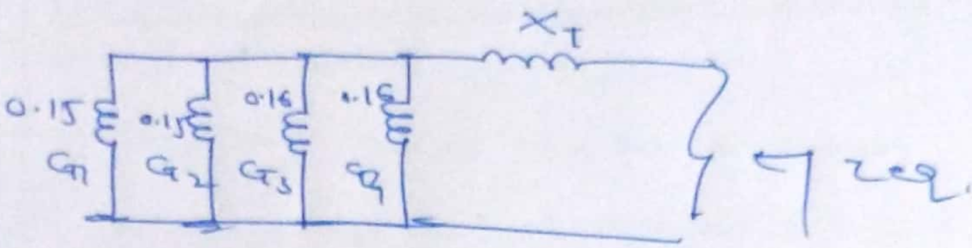
→ let us find Z_{eq} across fault point



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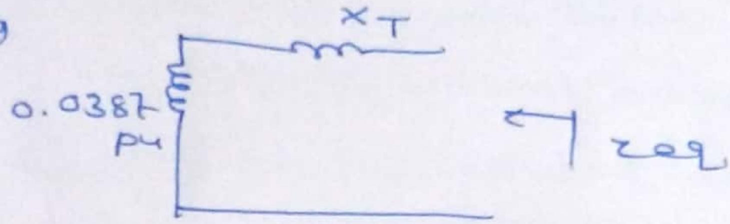

$$\therefore \boxed{Z_{eq} = 0.0387 + X_T \quad pu} \quad \text{(2)}$$

substituting eqn (2) in eqn (1) we get

$$(0.0387 + X_T) \le \frac{20}{150}$$

$$\therefore X_T \le 0.0946 \text{ pu.}$$

∴ The safe minimum reactance of T/F is $\underline{0.0946 \text{ pu}} = 0.0946 \times \frac{(22)^2}{20}$

$$= \underline{\underline{2.289\,\Omega}}.$$

Q.1 (b) In a 132 kV system, the inductance and capacitance per phase up to the location of the circuit breaker is 10 H and 0.02 μF respectively. If the circuit breaker interrupts to a magnetizing current of 20 A (instantaneous), current chopping occurs. Determine the voltage (in rms) which will appear across the contacts of the circuit breaker. Also calculate the value of the resistance which would be connected across the contacts to eliminate the transient restriking voltage.

[12 marks]

→ Given:- In a 132 kV system

inductance upto Location of C.B = 10H

capacitance upto Location of C-B = 0.02μF

Magnetizing current = 20A

To find :- (i) The voltage (in rms) which will appear across the C.B.

(ii) The value of resistance

Soln.:

As we know that

Energy delivered by L = Energy stored by C

$\therefore \frac{1}{2}Li^2 = \frac{1}{2}CV^2$

$\therefore V = i\sqrt{\frac{L}{C}}$

(a) Voltage appearing across the C.B contacts after current interruption is

$$V = 20\sqrt{\frac{10}{0.02\times10^{-6}}}\ V$$

$$\boxed{V = 447.213\ kV}$$

$$V_{rms} = \frac{447.213}{\sqrt{2}} = 316.227\ kV$$

(ii) The value of Resistance which would be connected across the contacts to eliminate the transient restriking voltage.

$$R = \frac{1}{2}\sqrt{\frac{L}{C}} = \frac{1}{2}\sqrt{\frac{10}{0.02\times10^{-6}}}$$

$$\boxed{R = 11.18\ k\Omega}$$

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Do not write in this margin

Q.1 (c) (i) A 400 MVA synchronous machine has $H_1 = 4.6$ MJ/MVA and 1200 MVA machine has $H_2 = 3.0$ MJ/MVA. The two machines operate in parallel in a power plant. Find out H_{eq}, relative to a 100 MVA base.

(ii) Write down the methods of improving the transient stabilty limit of a power system.

[8 + 4 = 12 marks]

→ (i) Given:-

Machine ①:- $G_1 = 400$ MVA,
$H_1 = 4.6$ MJ/MVA

Machine ②:- $G_2 = 1200$ MVA
$H_2 = 3.0$ MJ/MVA

To find:- H_{eq} relative to 100 MVA base

Soln:

Let us first of all find out total kinetic energy present in system

$\therefore (K.E.)_T = G_1 H_1 + G_2 H_2$

substituting given values we get

$(K.E.)_T = 400 \times 4.6 + 1200 \times 3$

$= 5440$ MJ

As we know that

$(K.E.)_T = G_{eq} \cdot H_{eq}$

$5440 = 100 \cdot H_{eq}$

$\therefore H_{eq} = \frac{5440}{100}$ MJ/MVA

$\therefore \boxed{H_{eq} = 54.40 \text{ MJ/MVA}}$

$\therefore$ The H_{eq} relative to 100 MVA Base is
$H_{eq} = 54.40$ MJ/MVA

② Methods of improving the transient stability limit of a power system

→ $$M\frac{d^2\delta}{dt^2} = P_m - P_{max}\sin\delta = P_m - \left|\frac{V_s V_R}{X_L}\right|\sin\delta$$

→ P_e is controlled by controlling voltage and line reactance using series capacitance, double ckt line & bundle conductor for improvement of system stability

→ Fast acting governing valve controls P_m Fast operating excitation controls generator voltage

→ By using dynamic breaking [Resistance switching] during fault condition the difference of P_m & P_e is reduced

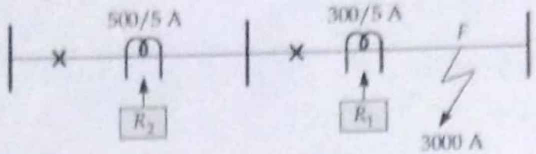
→ Single pole switching

→ Generator with neutral resistance.

→ FACT devices, SVCs & compensators

→ HVDC line along with HVAC line improve the stability.

Q.1 (d) Two relays R_1 and R_2 are connected in two sections to a feeder as shown in figure below.



Relay R_1 : CT ratio = 300/5, P_s = 50%, TMS = 0.3

Relay R_2 : CT ratio = 500/5, P_s = 75%

PSM	2	4	5	8	12	20
Operating time in seconds	10	5	4.7	3	2.8	2.4

A fault at '*F*' results in a fault current of 3000 A. Find TMS of R_2 to give time grading margin of 0.5 sec between the relays.

[12 marks]

Sol^n.

Here fault current in relay R_1 is

$\therefore \quad I_{R_1} = \frac{3000}{300} \times 5 = 50\text{ A}$

Now,

Relay operating current = current setting × Rated secondary current of CT.

$= \frac{50}{100} \times 5$

$= 2.5\text{ A}.$

$PSM = \frac{I_{R_1}}{\text{Relay operating current}} = \frac{50}{2.5} = 20$

Since, operating time corresponding to a PSM of 20 = 2.4 sec

$\therefore$ Actual operating time of Relay R_1 (t_{R_1})

$= (TMS)_1 \times 2.4 = 0.3 \times 2.4 = 0.72\text{ sec}$

Fault current in relay R_2 is

$$(I_{R_2}) = \frac{3000}{500} \times 5 = 30\ A.$$

$$\text{PSM of this current} = \frac{I_{R_2}}{\text{Relay operating current}}$$

$$= \frac{30\ A}{C.S. \times \text{Rated secondary current of C.T.}}$$

$$= \frac{30}{0.75 \times 5}$$

$\therefore$ PSM $= 8$

Since operating time corresponding to a PSM of 8 is 3 sec and as the relay R_2 should operate 0.5 sec after the operation of relay R_1 therefore operating time of relay R_2 is

$$t_{R_2} = 0.72 + 0.5 = \cancel{3\ sec}\ 1.22\ sec$$

Also. TMS for relay R_2

$$\cancel{R_2} = \frac{1.22}{3} = 0.406$$

$\therefore$ TMS for relay R_2 is 0.406

Q.1 (e) (i) A 100 MVA, two-pole, 50 Hz generator has a moment of inertia 40×10^3 kg-m². What is the energy stored in the rotor at the rated speed? What is the corresponding angular momentum? Determine the inertia constant H?

(ii) The inertia constant for a 60 Hz, 100 MVA generator is 5.5 MJ/MVA. Determine the acceleration (in °/s²) imparted to the rotor if the input to generator is suddenly increased by 30 MVA.

[8 + 4 = 12 marks]

→ Given (I): MVA rating = 100 MVA

Moment of Inertia (J) = 40×10^3 kg-m²

To find:- (i) $(K.E.)_T$

(ii) Angular momentum

(iii) Inertia constant (H)

Solⁿ:-

→ Energy stored in rotor at rated speed $= \frac{1}{2} J \omega^2$

$= \frac{1}{2} \times J \times (2\pi f)^2$

$(K.E.)_T = \frac{1}{2} \times 40 \times 10^3 \times (2\pi \times 50)^2$

$\therefore \boxed{(K.E.)_T = 1973.92 \text{ MJ}}$

→ Angular momentum $= J\omega$

$= 40 \times 10^3 \times 2\pi \times 50$

$= 12.5663$ M kg-m²/sec

$\therefore \boxed{\text{Angular momentum} = 12.5663 \text{ M kg-m}^2/\text{sec}}$

→ Inertia constant $H = \frac{(K.E.)_T}{MVA}$

$\therefore H = \frac{1973.92 \text{ MJ}}{100 \text{ MVA}}$

$\therefore \boxed{H = 19.7392 \text{ MJ/MVA}}$

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(ii) Given:- $H = 5.5\,MJ/MVA$
$G = 100\,MVA$, $\Delta P = 30\,MVA$
$f = 60\,Hz$

To find:- Accelaration (in Degree/s²)

Soln.

According to swing equation

$$M\frac{d^2\delta}{dt^2} = P_m - P_e$$

$$\frac{GH}{180\cdot f}\frac{d^2\delta}{dt^2} = P_m - P_e \quad \text{--- (1)}$$

As it is given that Generator input is suddenly increased by 30 MVA & substituting given value in eqn (1), we get

$$\frac{d^2\delta}{dt^2} = \frac{\Delta P_m \times 180 \times f}{G \times H}$$

$$= \frac{30 \times 180 \times 60}{100 \times 5.5}$$

$$\boxed{\frac{d^2\delta}{dt^2} = 589.09 \text{ degree}/s^2}$$

∴ The accelaration (in °/s²) imparted due to the rotor if the i/p to generator is suddenly increased by 30 MVA is 589.09 degree/s²

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Q.4 (a) A 60 Hz, 4-pole turbogenerator rated 100 MVA, 13.8 kV has an inertia constant of 10 MJ/MVA:

(i) Find the stored energy in the rotor at synchronous speed.

(ii) If the input to the generator is suddenly raised to 60 MW for an electrical load of 50 MW, find rotor acceleration in rpm/sec.

(iii) If the rotor acceleration calculated in part (ii) is maintained for 12 cycles, find the change in torque angle and rotor speed in rpm at the end of this period.

[20 marks]

→ Given :- 4 pole, 60 Hz, $S_{M/C} = 100\,MVA$.

$H = 10\,MJ/MVA$

(i) Stored kinetic energy in rotor at synchronous speed

$KE = H \cdot S_{M/C} = 100 \times 10 = 1000\,MJ$

$\therefore \boxed{KE = 1000\,MJ}$

(ii) By using swing equation

$$\frac{2H}{S}\frac{d^2\delta}{dt^2} = P_m - P_e = P_a$$

P_m - Initial mechanical input

P_e - Electrical developed power

P_a - Accelerating power

$$M = \frac{H \cdot S}{\pi \cdot f} = \frac{1000\,MJ}{\pi \times 50} = 6.366\ MJ\text{-sec/elec rad}$$

$P_a = 60 - 50 = 10\,MW$

$$\therefore \frac{d^2\delta}{dt^2} = \frac{P_a}{M}$$

$$= \frac{10\,MW}{6.366\,MJ\text{-sec/elec rad}}$$

$$\frac{d^2\delta}{dt^2} = \frac{10}{6.366} = 1.57 \text{ rad/sec}$$

$$\boxed{N = \frac{60}{2\pi}(\omega) \times \frac{2}{P}}$$

$$\alpha = \frac{d^2\delta}{dt^2} = \frac{60}{2\pi} \times 1.57 \times \frac{2}{4} = 7.5 \text{ rpm/sec}$$

$$\therefore \boxed{\alpha = 7.5 \text{ RPM/sec}}$$

(iii) Accelorotion is constant for a 12 cycl

$$12T = 12 \times \frac{1}{60} = 0.2 \text{ sec.}$$

New load angle $\rightarrow \delta = \delta_0 + \Delta\delta$

change in angle $\Rightarrow \Delta\delta = \frac{1}{2}\alpha t^2$

$$\Delta\delta = \frac{1}{2} \times 1.57 \times (0.2)^2$$

$$\therefore \boxed{\Delta\delta = 0.0314 \text{ rad}}$$

$\therefore$ The change in torque angle is

0.0314 rad.

(iii) New speed of rotor

$$N = N_o + \Delta N \quad \rightarrow (1)$$

$N_o \rightarrow$ Initial rotating synchronous speed of rotor

$$N_o = \frac{120f}{P} = \frac{120 \times 60}{4} = \underline{\underline{1800\ rpm}}$$

$$\Delta N = \alpha t = \cancel{1.57}\ 7.5 \times 0.2$$

$$\boxed{\Delta N = 1.5\ rpm}$$

Substituting this value in eq^n (1) we get

$$N = 1800 + 1.5$$

$$\boxed{N = 1801.5\ rpm}$$

∴ The rotor speed in rpm at the end of this period is

$$\boxed{N = 1801.5\ rpm}$$

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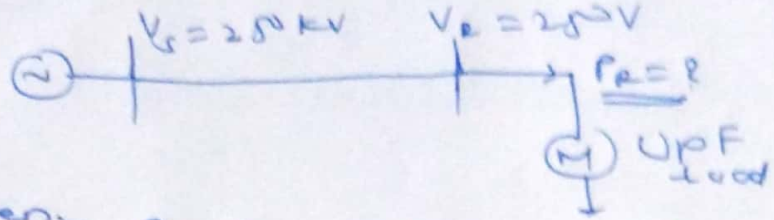
Q.4 (b) A 250 kV transmission line has line constants as shown below:

$$A = 0.80\angle 2^\circ \quad \text{and} \quad B = 190\angle 78^\circ\ \Omega$$

If the voltage at receiving and sending end is maintained at 250 kV, then determine power which can be received at unity power factor. What value of compensation will be required for a load of 180 MW at unity power factor with the same voltage profile?

[20 marks]



Given: $A = 0.8\angle 2 = |A|\angle\alpha$

$B = 190\angle 78^\circ = |B|\angle\beta$

To find: P_R

Sol^n:- As the load operating at receiving end is at unity power factor.

$\therefore$ $\underline{Q_R = 0}$

As we know that

$$Q_R = \left|\frac{V_S V_R}{B}\right| \sin(\beta-\delta) - \frac{|A||V_R|^2}{|B|}\sin(\beta-\alpha)$$

Substituting given values we get ($V_s = V_R$)

$$Q_R = \left|\frac{(V_R)^2}{B}\right| \sin(\beta-\delta) - \left|\frac{AV_R^2}{B}\right|\sin(\beta-\alpha) = 0$$

$$\frac{\cancel{V_R^2}}{\cancel{B}}\sin(\beta-\delta) = \frac{A\cancel{V_R^2}}{\cancel{B}}\sin(\beta-\alpha)$$

$$\sin(78-\delta) = 0.8\sin(78-2)$$

$$\delta = 78 - \sin^{-1}(0.8\sin 76)$$

$$\therefore \boxed{\delta = 27.082^\circ}$$

As we know that

$$P_R = \left|\frac{V_S V_R}{B}\right| \cos(\beta-\delta) - \left|\frac{A V_R^2}{B}\right| \cos(\beta-\alpha)$$

$$= \left|\frac{(250)^2}{190}\right| \cos(78^\circ - 27.08) - \left|\frac{0.8\times(250)^2}{190}\right| \cdot \cos(78^\circ - 2^\circ)$$

→ substituting given values

$$\boxed{P_R = 143.70 \text{ MW}}$$

∴ The power which can be received at unity power factor is 143.70 MW

(2) As from above value of P_R given value of $P_R = 180$ MW is more due to which power factor will change but we will have maintain constant. For that we will have to inject reactive power.

→ First of all we will find δ.

$$P_R = \left|\frac{V_S V_R}{B}\right| \cos(\beta-\delta) - \left|\frac{A V_R^2}{B}\right| \cos(\beta-\alpha)$$

$$180 = \frac{(250)^2}{190} \cos(78-\delta) - \frac{0.8\times 250^2}{190} \cos(76^\circ)$$

$$\therefore \frac{(250)^2}{190} \cos(78-\delta) = 243.66$$

$$\therefore \boxed{\delta = 35.794^\circ}$$

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Now let us find Q_R at this δ

$$Q_R = \left|\frac{V_S V_R}{B}\right| \sin(\beta-\delta) - \left|\frac{A V_R^2}{B}\right| \sin(\beta-\alpha)$$

$$Q_R = \frac{(250)^2}{190}\sin(76-35.79) - \frac{0.8\times 250^2}{190}\sin 76^\circ$$

$$\therefore \boxed{Q_R = -34.355 \text{ MVAR}}$$

→ So to maintain constant unity power factor we have to inject 34.358 MVAR reactive power into system through shunt capacitor

$$\boxed{Q_{\text{injected}} = 34.358 \text{ MVAR}}$$

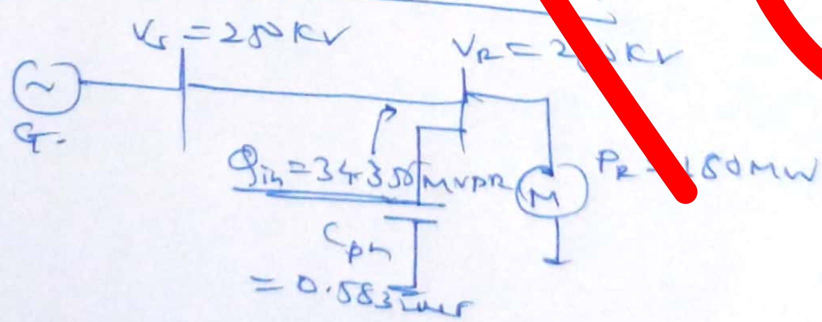
→ $Q_c = 34.358$ $Q_{cph} = \frac{34.358}{3} = 11.45$ MVAR

$$\frac{V^2}{X_c} = 11.45 \text{ MVAR}$$

$$V^2\omega C = 11.45 \text{ MVAR}$$

$$C_{ph} = \frac{11.45}{(250)^2 \times 2\pi \times 50}$$

$$\therefore \boxed{C_{ph} = 0.5832\ \mu F}$$



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Q.4 (c) A 3-ϕ, 50 Hz transmission line of length of 100 km is delivering 20 MW at 0.9 p.f. lagging at 110 kV. The resistance and reactance of the line per phase per km are 0.2 and 0.4 Ω respectively, while capacitance admittance is 2.5×10^{-6} Siemen/km/phase.

Determine:

(i) the current and voltage at sending end

(ii) efficiency of transmission

Using nominal T-method, also obtain equivalent T-model and phasor diagram.

[20 marks]

→ Soln:

$$Z = R + j\omega L = (0.2 + j0.4) \times 100$$

$$\therefore \boxed{Z = 20 + j40 \ \Omega/ph} = 44.721 \angle 63.434^\circ$$

$$\boxed{Y = 2.5 \times 10^{-6} \times 100 = j2.5 \times 10^{-4} \text{ Siemen/ph}}$$

As here we have to use nominal T-method

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 + \frac{YZ}{2} & Z\left(1 + \frac{YZ}{2}\right) \\ Y & 1 + \frac{YZ}{2} \end{bmatrix}$$

→ $A = 1 + \frac{YZ}{2} = 1 + \frac{(20 + j40)(j2.5 \times 10^{-4})}{2}$

$$\therefore \boxed{A = 0.995 \angle 0.143^\circ}$$

→ $B = Z\left(1 + \frac{YZ}{2}\right) = 44.721 \angle 63.434^\circ \times 0.995 \angle 0.143^\circ$

$$\boxed{B = 44.497 \angle 63.434^\circ}$$

$C = Y = 2.5 \times 10^{-4} \angle 90^\circ$

$D = 1 + \frac{YZ}{2} = 0.995 \angle 0.143^\circ$

$V_S = A V_R + B I_R$ —① , $I_S = C V_R + D I_R$ —②

$\cancel{= 0.995 \angle 0.143^\circ \times}$

$V_R = \frac{110}{\sqrt{3}} = 63.508\ kV$

$I_R = \frac{P_R}{\sqrt{3} \times V_L \times 0.9} = \frac{104.972}{0.9} \angle -25.841^\circ = 116.635^\circ \angle -25.841 A$

Substituting values in eqn ① & ②

$V_S = 0.995 \angle 0.143^\circ \times 63.508 \angle 0^\circ\ kV + 44.497 \angle 63.435^\circ \times \frac{104.972}{0.9} \angle -25.841$

$\boxed{V_{S_{ph}} = \cancel{66.958 \angle 2.574^\circ}\ kV}$

$\boxed{V_{ph}\ 67.384 \angle 2.827^\circ\ kV}$

$I_S = 2.5 \times 10^{-4} \angle 90^\circ \times 63.508\ kV + 0.995 \angle 0.143 \times \frac{104.972}{0.9} \angle -25.841$

$\boxed{I_S = \cancel{98.605 \angle -17.35^\circ}\ A}$

$\boxed{I_S = 11[illegible].1 \angle -18.231\ A}$

$P_S = 3 V_{ph} I_{ph} \cos\phi$

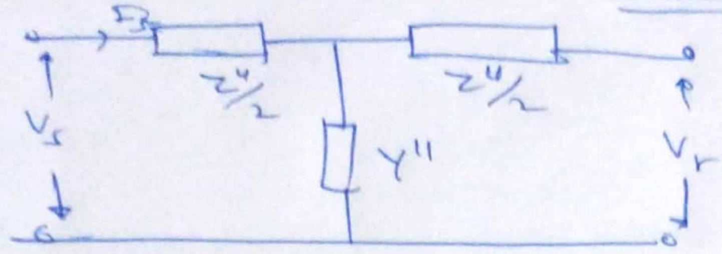
$P_S = 3 \times 66.956 \times 98.605 \times 10^3 \cos(19.924)$

$\boxed{P_S = \cancel{18.621\ MW}} = 20.77\ MW$

$\text{efficiency} = \frac{P_R}{P_S} \times 100 = \frac{20}{20.77} \times 100$

$\boxed{\text{efficiency} = 96.29\ \%}$

→ Equivalent T-model $\quad \boxed{r = \sqrt{ZY} = 0.1057}$



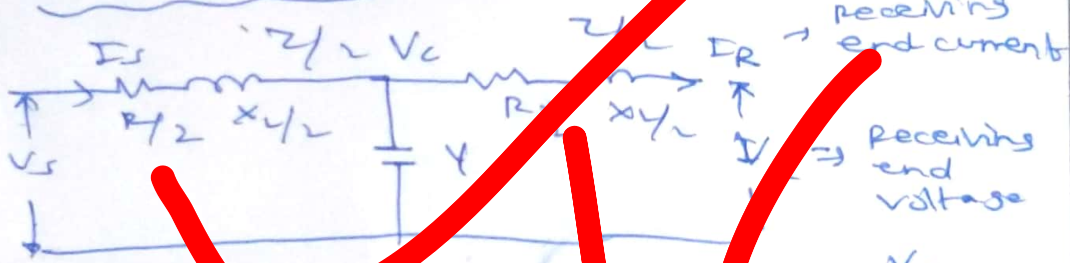
$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} 1 + \frac{Y''Z''}{2} & Z''\left(1 + \frac{Z''Y''}{2}\right) \\ Y'' & 1 + \frac{Y''Z''}{2} \end{bmatrix} \begin{bmatrix} V_r \\ I_r \end{bmatrix}$$

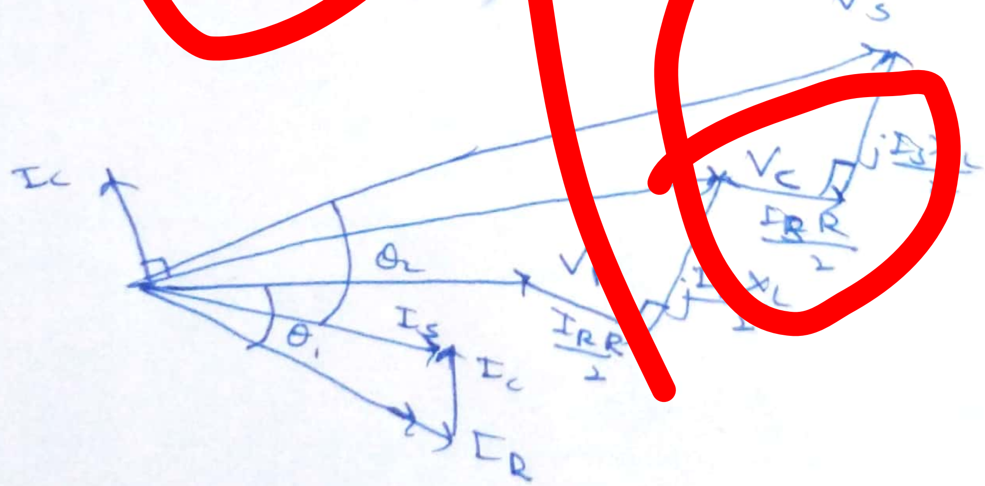
$$\frac{Z''}{2} = \frac{Z}{2} \frac{\tanh(rl/2)}{(rl/2)} = 4.230\angle 63.435^\circ$$

$$Y'' = Y \frac{\sinh rl}{rl} = \frac{2.5\times10^{-4}\angle 90^\circ \sinh(0.1057\times100)}{0.1057\times100}$$

$$\boxed{Y'' = 4.3386\times10^{-6}\angle 90^\circ}$$

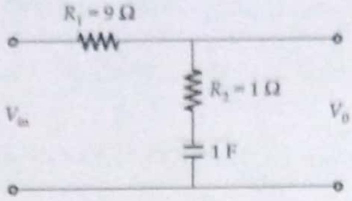
phasor diagram





Section B : Power Systems + Electrical Circuits-1 + Microprocessors-1 + Digital Electronics-2 + Control Systems-2

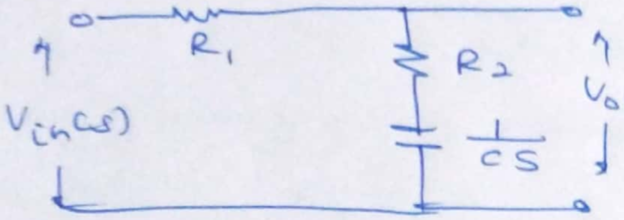
Q.5 (a) For the network shown in the figure below:



Find the frequency (in rad/sec) at which the maximum phase lag occurs?

[12 marks]

→ First of all let us find our transfer function of the system.



converting above ckt into Laplace domain

→ Applying voltage division rule, we get

$$V_o(s) = \frac{R_2 + \frac{1}{CS}}{R_1 + R_2 + \frac{1}{CS}} \times V_{in}(s)$$

$$\therefore \frac{V_o(s)}{V_{in}(s)} = \frac{1 + R_2 CS}{1 + (R_1+R_2)CS} = \frac{R_2 C\left[S + \frac{1}{R_2 C}\right]}{(R_1+R_2)C\left[S + \frac{1}{(R_1+R_2)C}\right]}$$

$$\therefore \frac{V_o(s)}{V_{in}(s)} = \left(\frac{R_1}{\text{[illegible]}}\right)\left(\frac{S + \frac{1}{R_2 C}}{S + \frac{1}{(R_1+R_2)C}}\right)$$

$$\therefore \boxed{T.F = \left(\frac{R_1}{R_2+R_2}\right)\left[\frac{S + \frac{1}{R_2 C}}{S + \frac{1}{(R_1+R_2)C}}\right]}$$

→ As we know that the frequency at which the maximum phase lag occurs is given by ~~ω_{max}~~

$$\omega^2 = \text{product of locations of poles \& zeroes}$$

$$\therefore \omega^2 = \frac{1}{R_2 C} \times \frac{1}{(R_1 + R_2) C}$$

$$\therefore \omega = \sqrt{\frac{1}{R_2 (R_1 + R_2) C^2}}$$

substituting given values

$R_1 = 9\Omega$, $R_2 = 1\Omega$, $C =$ [illegible] F we get

$$\omega = \frac{1}{\sqrt{1 \times 10 \times 1}}$$

$$\boxed{\omega = 0.316 \text{ rad/sec}}$$

∴ The frequency at which the maximum phase lag occurs = 0.316 rad/sec

Q.5 (b) Design and implement a mod-10 asynchronous up counter using T-flip-flops.

[12 marks]

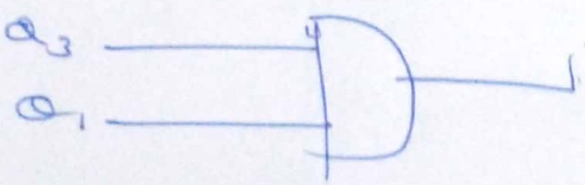
→ To implement Mod-10 counter, At 10th counter All Flip Flops should be reset.

→ For implementation of Mod-10 counter we will require 4 Flip-flops.

→ Truth Table.

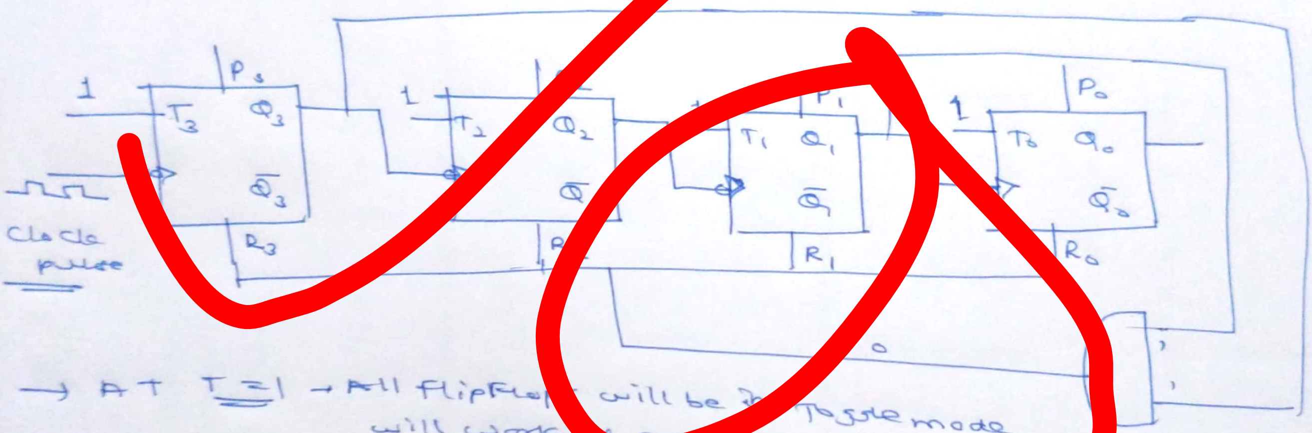
	Q_3	Q_2	Q_1	Q_0	
0	0	0	0	0	Mod 10 Counter
1	0	0	0	1	
2	0	0	1	0	
3	0	0	1	[illegible]	
4	0	1	0	0	
5	0	1	0	1	
6	0	1	1	0	
7	0	1	1	1	
[illegible]	1	0	0	0	
9	1	0	0	1	
10	1	0	1	0	→ At this count all FF should be reset

→ Logic ckt



To words all resets of FFs.

Design   MOD 10 Asynchronous up counter



→ AT $T=1$ → All flipflop will be in Toggle mode
will work as counter.

→ output of one F-F is given to input of other flip-flop
→ Asynchronous.

→ Negative edge triggering with Q connected to F-F.
→ Up counter

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Q.5 (c) Find the solution of state equation, state transition matrix and output of the system having state model is as given below and taking input as unit step.

$$x' = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u \text{ and } y = [1 \quad 1]\, x$$

and $x(0) = [1 \quad 0]^T$

[12 marks]

→ Comparing above equation with following state equations

$\dot{x}' = Ax + BU, \quad y = Cx + DU$

we get

$A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}, \quad B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, \quad C = [1 \quad 1]$

→ let us find state transision matrix

$[SI - A]^{*} = \begin{bmatrix} S-1 & 0 \\ -1 & S-1 \end{bmatrix}$

$[SI - A]^{-1} = \dfrac{\begin{bmatrix} S-1 & 0 \\ 1 & S-1 \end{bmatrix}}{(S-1)^2} \rightarrow ①$

State transition matrix $= \phi(t)$

$= L^{-1}(SI - A)^{-1}$

$= L^{-1} \begin{bmatrix} \frac{1}{S-1} & 0 \\ \frac{1}{(S-1)^2} & \frac{1}{(S-1)} \end{bmatrix}$

$\phi(t) = \begin{bmatrix} e^t u(t) & 0 \\ te^t u(t) & e^t u(t) \end{bmatrix}$

→ As we know that

$x' = Ax + BU$ —① $y = Cx + DU$ —②

Taking Laplace Transform on eqⁿ —①

$sX(s) - x(0) = AX(s) + BU(s)$

$X(s) = [sI - A]^{-1} B\,U(s) + [sI - A]^{-1} x(0)$

Substituting value from eqⁿ ① we get

$$X(s) = \underset{2\times 2}{\begin{bmatrix} \frac{1}{s-1} & 0 \\ \frac{1}{(s-1)^2} & \frac{1}{s-1} \end{bmatrix}} \underset{2\times 1}{\begin{bmatrix} 1 \\ 1 \end{bmatrix}} U(s) + \begin{bmatrix} \frac{1}{s-1} & 0 \\ \frac{1}{(s-1)^2} & \frac{1}{(s-1)} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$X(s) = \underset{2\times 1}{\begin{bmatrix} \frac{1}{s-1} \\ \frac{1}{(s-1)^2} + \frac{1}{(s-1)} \end{bmatrix}} \begin{bmatrix} \frac{1}{s} \end{bmatrix} \underset{1\times 1}{\cancel{0}} + \begin{bmatrix} \frac{1}{s-1} \\ \frac{1}{(s-1)^2} \end{bmatrix}$$

$$X(s) = \begin{bmatrix} \frac{1}{s}\frac{1}{(s-1)} + \frac{1}{(s-1)} \\ \frac{1}{s}\left(\frac{1}{(s-1)^2} + \frac{1}{(s-1)}\right) + \frac{1}{(s-1)^2} \end{bmatrix}$$

Taking Inverse Laplace Transform we get

$$x(t) = \begin{bmatrix} (e^t - 1)u(t) + e^t u(t) \\ 2te^t u(t) \end{bmatrix}$$

$y(s) = [1 \quad 1]\, X(s)$

$y(s) = \frac{1}{s}\frac{1}{(s-1)} + \frac{1}{(s-1)} + \frac{1}{s(s-1)^2} + \frac{1}{s(s-1)} + \frac{1}{(s-1)^2}$

Taking inverse Laplace Transform we get

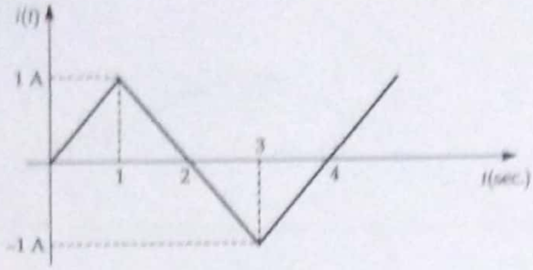
$y(t) = e^t u(t) - u(t) + e^t u(t) + u(t) + e^t u(t)$
$+ te^t u(t) + e^t u(t) - u(t)$
$+ te^t u(t)$

$\boxed{y(t) = (2e^t + 2te^t - 1)\,u(t)}$

Q.5 (d) A current source, having waveform shown below is connected across the terminals of an inductor of 10 mH.

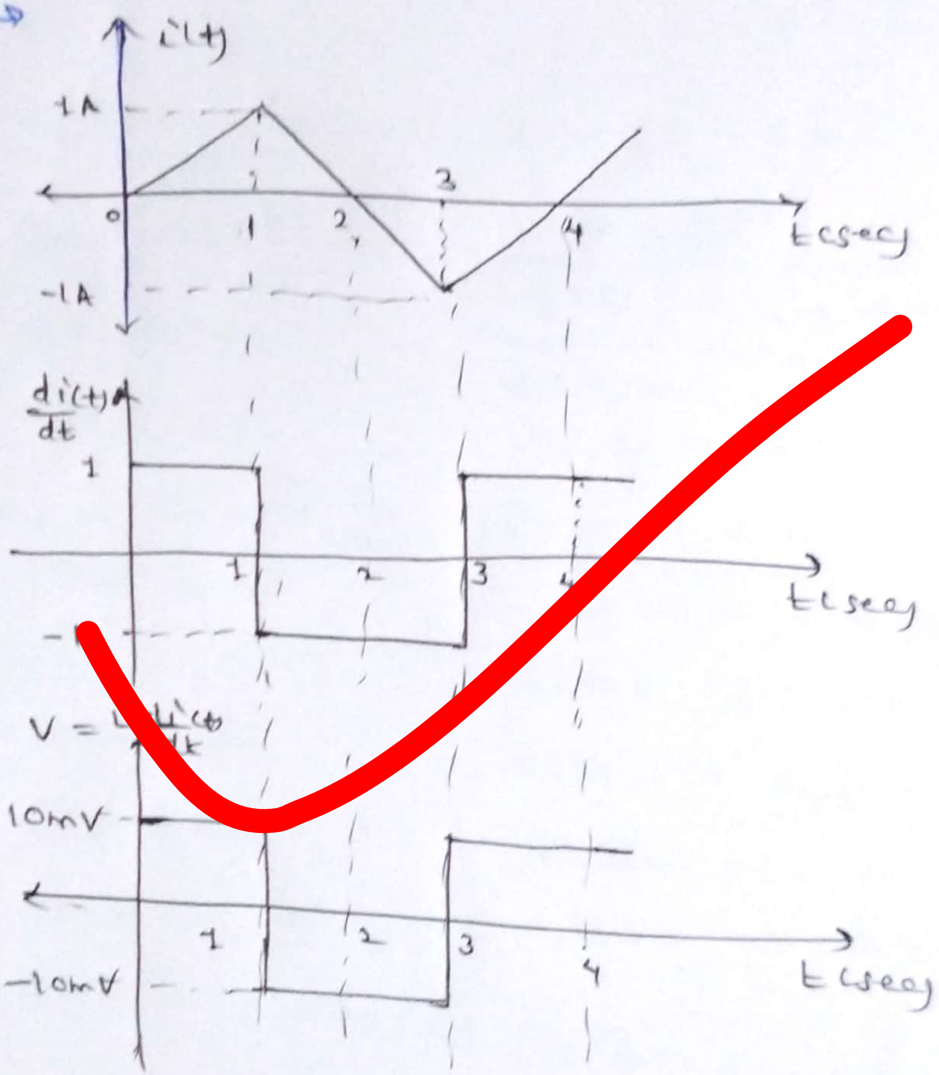
Draw: (i) The voltage waveform and

(ii) The charge waveform through the device.



Assume the initial conditions through the inductor to be zero.

[12 marks]

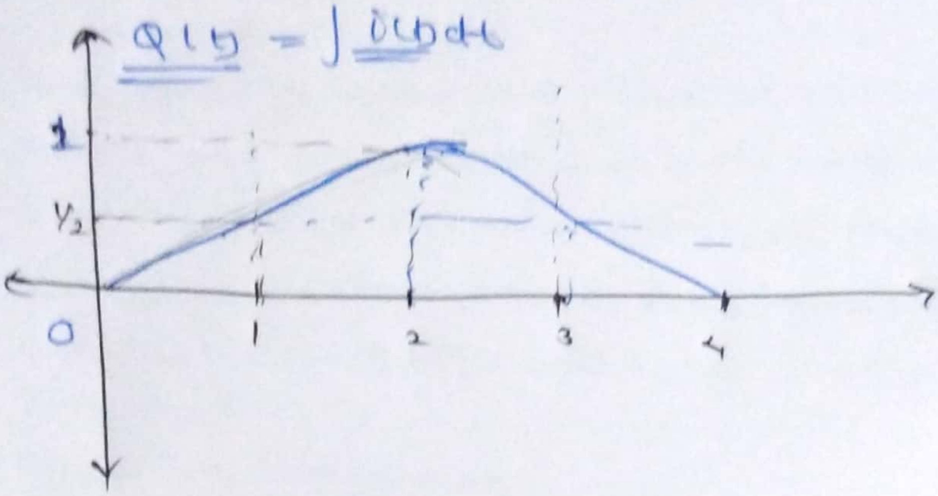


As we know that In case of inductor

$$V_L = L\frac{di}{dt}$$

→ (2). The charge $(Q) = \int i\,dt$

$Q(t) = \int i(t)\,dt$



→ (1) $0 < t < 1$

$q(t) = \int i\,dt$

$q = \int t\,dt$

$q(t) = \frac{t^2}{2} + c$

As initial cond's are zero

$\boxed{q(t) = \frac{t^2}{2} c}$

$\boxed{q(1) = \frac{1}{2} c}$

(2) $1 < t < 3$

$q(t) = \int i(t)\,dt$

$q(t) = \int (-t+2)\,dt$

$q(t) = -\frac{t^2}{2} + 2t + c$

At $t = 1$ $q(1) = 1/2$

$\therefore \frac{1}{2} = -\frac{1}{2} + 2 + c$

$\therefore c = -1$

$\therefore \boxed{q(t) = -\frac{t^2}{2} + 2t - 1}$

$q(2) = 1\ c$

$q(3) = 0.5\ c$

(3) $3 < t < 4$

$q(t) = \int i(t)\,dt$

$q(t) = \int (t-4)\,dt$

$q(t) = \frac{t^2}{2} - 4t + c$

$q(3) = 0.5\ c$

$\therefore 0.5 = 4.5 - 12 + c$

$c = 8$

$\boxed{q(t) = \frac{t^2}{2} - 4t + 8}$

$\boxed{q(4) = 0\ c}$

Q.5 (e) Write about the flag register in 8085 microprocessor. [12 marks]

→ The flag register is a special purpose register.

→ Depending upon the value of result after any arithmetic & logical operation the flag bits become set (1) or reset (0)

→ In 8085 microprocessor, flag register consists of 8 bits and only 5 of them are useful

→ The five flags are

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
S	Z	×	AC	×	P	×	CY

① Sign flag (S) :-

After any operation, if the MSB (B(7)) of the result is 1, it indicates the number is negative and the sign bit becomes set i.e. 1. If the MSB is 0, it indicates the number is positive and the sign flag becomes reset i.e. 0

From 00H to 7F, sign flag is 0

From 80H to FF, sign flag is 1

② Zero flag (Z)

After any arithmetical or logical operation if the result is 0 (00)H, the zero flag becomes set i.e. 1. otherwise it becomes reset i.e. 0

i.e. for 00H - zero flag is 1
from 01H to FFH, - zero flag is 0

→ zero flag = 1 - zero result
0 - non-zero result

③ Auxiliary carry flag (AC)

→ This flag is used in BCD number system
→ If after any arithmetic or logical operation B(3) generates any carry and passes onto B(4) this flag becomes set. i.e. 1. otherwise it becomes reset i.e. 0.
→ This is the only flag register which is not accessible by programmer

④ Parity flag (P)

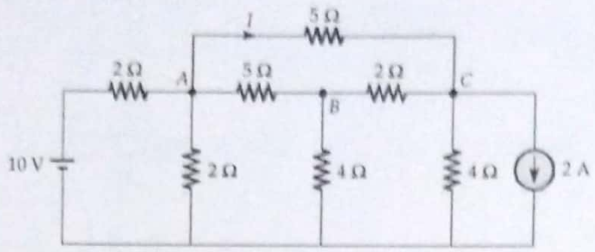
→ If after any arithmetic or logical operation the result has even parity, an even number of 1 bits, the parity register becomes set i.e. 1, otherwise it becomes reset i.e. 0
→ 1 → Accumulator has even number of 1 bits
0 → accumulator has odd number of 1 bits

⑤ Carry flag (CY)

→ Carry is generated when performing 'n' bit operations and the result is more than 'n' bits then this flag becomes set i.e. 1 otherwise it becomes reset i.e. 0
→ Carry flag is also called borrow flag

Q.6 (a) (i) A constant voltage at a frequency of 1 MHz is applied to an inductor in series with a variable capacitor. When the capacitor is set to 500 pF, the current has its maximum value while, it is reduced to one-half when the capacitance is 600 pF. Find resistance, inductance and Q-factor of inductor.

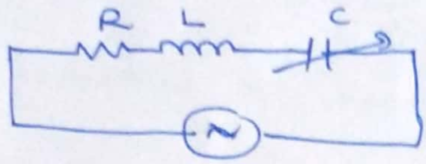
(ii) Calculate the current flowing in 5 Ω branch AC of the circuit shown in figure using nodal analysis.



[10 + 10 = 20 marks]

Solⁿ

(i)



V, 1MHz freq.

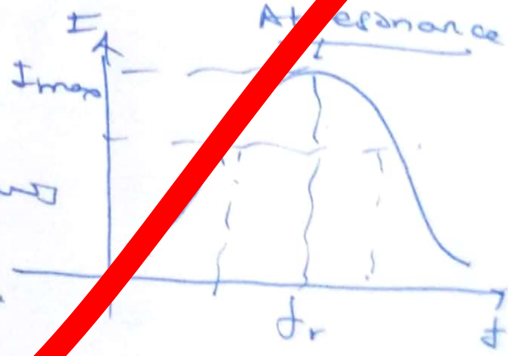
when $C = 500pF \rightarrow I = I_{max}$.

$C = 600pF \rightarrow I = \frac{I_{max}}{2}$

To find :- 1), R, L & Q_{coil}

Solⁿ :-

As we know that At resonance, the maximum current flows through the ckt & impedance is resistive.



$Z_{in} = R$, $X_L = X_C$ ← At resonance

so here At f = 1 MHz, $I = I_{max}$

$\therefore X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C}$

$\therefore \boxed{L = \frac{1}{\omega^2 C}}$

$$\therefore L = \frac{1}{(2\pi f)^2 \times C} = \frac{1}{(2\pi \times 1\times10^6)^2 \times 500\times10^{-12}}$$

$$\therefore L = \frac{1}{4\pi^2 \times 500} = 50.66\,\mu H$$

$$\therefore \boxed{L = 50.66\,\mu H} \rightarrow ①$$

→ At $\frac{I_{max}}{2} = I$, $C = 600\,pF$

$$\therefore |Z| = \frac{|V|}{|I|} = \frac{|V|}{\frac{I_{max}}{2}} = 2\frac{|V|}{I_{max}} = 2R$$

As we know that At resonance $\boxed{\frac{|V|}{I_{max}} = R}$

$$\therefore 2R = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\therefore 4R^2 = R^2 + (X_L - X_C)^2$$ → Taking square on both sides

$$\therefore R = \frac{(X_L - X_C)}{\sqrt{3}} = \frac{\left(\omega L - \frac{1}{\omega C}\right)}{\sqrt{3}}$$

$$\therefore R = \frac{\left(2\pi f \times 50.66\mu - \frac{1}{2\pi f \times 600\times10^{-12}}\right)}{\sqrt{3}}$$

$$\therefore \boxed{R = 30.627} \rightarrow ②$$

→ $Q_{coil} = \frac{\omega L}{R} = \frac{2\pi f \times L}{R}$

$$\therefore Q_{coil} = \frac{2\pi \times \cancel{10^6} \times 50.66\times\cancel{10^{-6}}}{30.627}$$ → substitution from eqⁿ ② & eqⁿ ①

$$\therefore \boxed{Q_{coil} = 10.392}$$

(2)

Applying KCL At node A, we get

$$\therefore \frac{V_A - 10}{2} + \frac{V_A}{2} + \frac{V_A - V_B}{5} + \frac{V_A - V_C}{5} = 0$$

$$\therefore \boxed{V_A(1.4) + (-0.2)V_B + (-0.2)V_C = 5} \rightarrow (1)$$

Applying KCL at node B, we get

$$\therefore \frac{V_B - V_A}{5} + \frac{V_B}{4} + \frac{V_B - V_C}{2} = 0$$

$$\boxed{(-0.2)V_A + (0.95)V_B + (-0.5)V_C = 0} \rightarrow (2)$$

Applying KCL at node C, we get

$$\frac{V_C - V_B}{2} + \frac{V_C}{4} + \frac{V_C - V_A}{5} + 2 = 0$$

$$\boxed{V_A(-0.2) + (-0.5)V_B + (0.95)V_C = -2} \rightarrow (3)$$

solving eq^n's (1), (2) & (3) we get

$V_A = 3.363\ V$

$V_B = -0.0376\ V$

$V_C = -1.416\ V$

we can find out value of I

$$I = \frac{V_A - V_C}{5} = \frac{3.363 + (1.416)}{5}$$

$$\therefore \boxed{I = 0.9558\ A}$$

$\therefore$ The value of current flowing in 5Ω branch AC of the circuit shown is 0.9558 A

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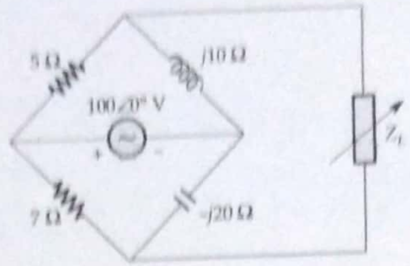
Q.6 (b) Find the value of Z_L for maximum power transfer in the network shown and find maximum power.

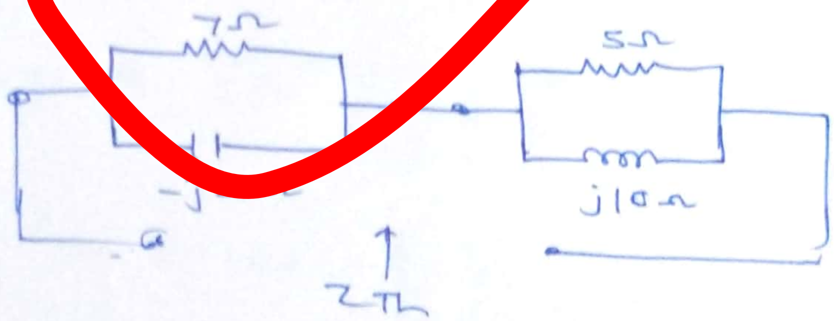


[20 marks]

→ for finding out the value of Z_L we will apply thevenin's theorem for above ckt.

→ According to thevenin's theorem we can replace a network by its equivalent Z_{th} & V_{th}. where Z_{th} is thevenin's ~~Resistance~~ Impedance, can be found out by deactivating sources. & V_{Th} can be found out by find voltage across load terminals

→ ① Let us find Z_{Th}



$$\therefore Z_{Th} = \frac{7\times(-j20)}{7-j20} + \frac{5\times j10}{5+j10}$$

$$\therefore Z_{Th} = \frac{(-140j)(7+j20)}{45+400} + \frac{j50(5-j10)}{25+100}$$

$$Z_{Th} = \frac{2800 - 980j}{449} + \frac{500 + j250}{125}$$

$$Z_{Th} = 10.236 - j0.1826 = 10.237\angle -1.022^\circ$$

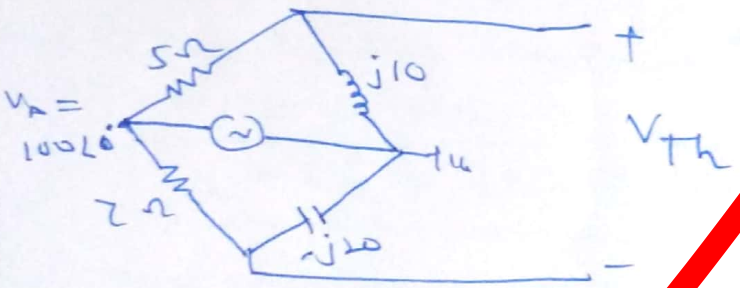
$$\therefore \boxed{Z_{Th} = 10.237\angle -1.022^\circ\ \Omega}$$

$\therefore$ The value of Z_L for maximum power transfer in the network shown is

$$Z_L = \boxed{Z^*_{Th} = 10.237\angle +1.022^\circ\ \Omega}$$

(1) Let us find maximum power

(i) Let us find V_{th}



$$V_{Th} = \frac{V_A \times j10}{5+j10} - \frac{V_A \times (-j20)}{7-j20}$$

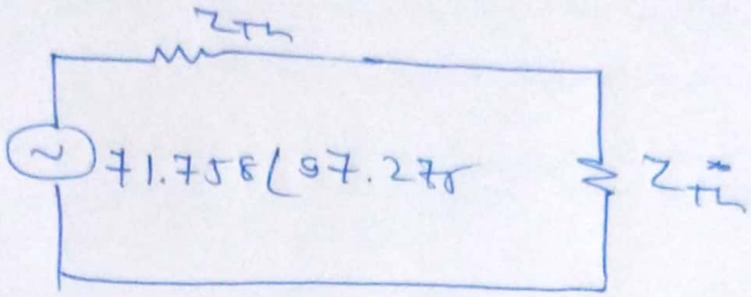
$$\therefore V_{th} = 100\angle 0 \left[\frac{j10}{5+j10} + \frac{j20}{7-j20}\right]$$

$$\therefore \boxed{V_{Th} = 71.758\angle 97.275\ V}$$

$$\boxed{V_{Th} = -9.086 + j71.1804\ V}$$

→ let us draw thevenin ckt.

For maximum power transfer $Z_L = Z_{th}^*$



$$\therefore \quad P_{Lmax} = \frac{V^2}{4R_{Th}} = \frac{(71.758)^2}{4 \times 10.236}$$

$$\therefore \quad \boxed{P_{Lmax} = 125.7622}$$

→ ∴ The Z_L for maximum power transfer in N/W is

$$\boxed{Z_L = Z_{Th}^* = 10.237\angle 1.0\ldots}$$

→ The maximum power is

$$\boxed{P_{Lmax} = 125.7622\,W}$$

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Q.6 (c) Design and implement a BCD counter using J-K flip-flops.

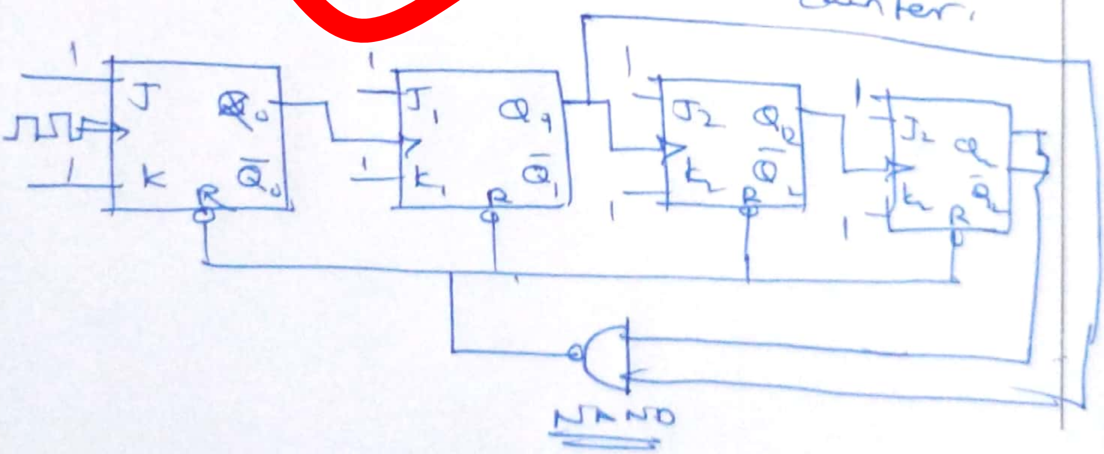
[20 marks]

→ Here it is not mentioned whether the counter is synchronous or Asynchronous so we will design both counters

→ ① Asynchronous BCD counter using JK-FF.

Input pulses	Q_3	Q_2	Q_1	Q_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	0		0	0 ← Reset

Design: $J = K = 1$ → Toggle mode - will work as counter.



② Synchronous BCD counter using JK FF

Truth Table → 4 FF will be required
mod 10 counter

Counter state

Present state				Next state			
Q_3	Q_2	Q_1	Q_0	Q_3^+	Q_2^+	Q_1^+	Q_0^+
0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	1	1
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	0
1	0	0	0	1	0	0	1
1	0	0	1	0	0	0	0

Excitation Table of JK Flip Flop

Q	Q^+	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

J_0	K_0	J_1	K_1	J_2	K_2	J_3	K_3
1	X	0	X	0	X	[illegible]	X
X	1	1	X	0	X	0	X
1	X	X	0	0	[illegible]	0	X
X	1	X	1	1	X	0	X
1	X	0	X	[illegible]	0	0	X
X	1	1	X	X	0	0	X
1	X	X	0	X	0	0	X
X	1	X	1	X	1	1	X
1	X	0	X	0	X	X	0
X	1	0	X	0	X	X	1

Kmaps

Q_3Q_2 / Q_1Q_0 — $\boxed{J_0 = 1}$

1	1	x	1
x	x	x	x
x	x	x	x
1	1	x	x

Q_3Q_2 / Q_1Q_0 — $\boxed{K_0 = 1}$

x	x	x	x
1	1	x	1
1	1	x	x
x	x	x	x

Q_3Q_2 / Q_1Q_0 — $\boxed{J_1 = Q_0Q_3}$

0	0	x	0
1	1	x	0
x	x	x	x
x	x	x	x

Q_3Q_2 / Q_1Q_0 — $\boxed{K_1 = Q_0}$

x	x	x	x
x	x	x	x
1	x	x	x
x	0	x	x

Q_3Q_2 / Q_1Q_0 — $\boxed{J_2 = Q_0Q_1}$

0	x	x	0
0	x	x	0
1	x	x	x
0	x	x	x

Q_3Q_2 / Q_1Q_0 — $\boxed{K_2 = Q_0Q_1}$

x	0	x	x
x	0	x	x
x	1	x	x
x	0	x	x

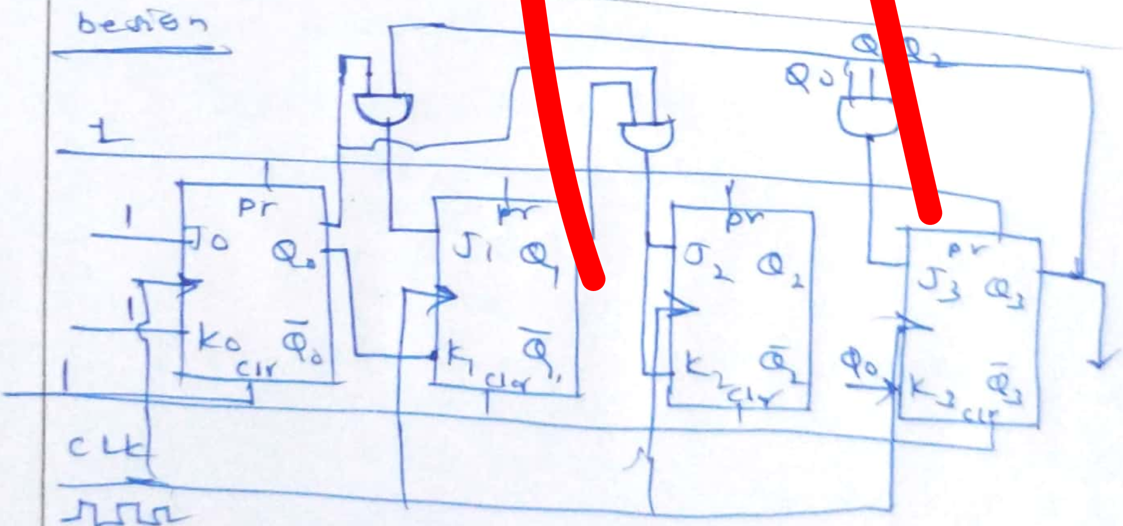
Q_3Q_2 / Q_1Q_0 — $J_3 = Q_0Q_1Q_2$

0	0	[illegible]	x
[illegible]	[illegible]	x	x
0	1	x	x
0	0	x	x

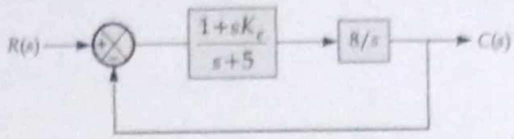
Q_3Q_2 / Q_1Q_0 — $\boxed{K_3 = Q_0}$

x	x	x	[illegible]
x	x	x	[illegible]
[illegible]	x	x	x
x	x	1	x

Design



Q.8 (a) Consider the block diagram shown below which employs proportional plus error rate control mechanism. Determine the value of error rate constant K_e, so that the damping ratio of the system is 0.90.



What will be the value of settling time and maximum overshoot? If the input provided is unit ramp signal then calculate the value of steady error.

[20 marks]

→ Sol^n:- ① let us find value of K_e.

open loop T/F function = $G(s)H(s)$

$$= \left(\frac{1+sK_e}{s+5}\right)\left(\frac{8}{s}\right)$$

characteristic equation = $1+G(s)H(s)=0$

$$1+\frac{8(1+sK_e)}{s(s+5)}=0$$

$\therefore\ s^2+5s+8+8sK_e=0$

$\therefore\ s^2+(5+8K_e)s+8=0$

Comparing above eq^n with $s^2+2\xi\omega_n s+\omega_n^2=0$ we get

$$\omega_n^2=8\ ,\quad 2\xi\omega_n=5+8K_e$$

$\therefore\ \boxed{\omega_n=\sqrt{8}\ \text{rad/s}}$ $\quad 2\times\xi\times\sqrt{8}=5+8K_e$

→ As $\xi=0.9$ (given)

$\therefore\ 2\times0.9\times\sqrt{8}=5+8K_e$

$5.0911=5+8K_e$

$\therefore\ \boxed{K_e=0.0113}$

$\therefore$ The value of error rate constant K_e is

$\therefore\ \boxed{K_e=0.0113}$

② As we know that
settling time of 2% error band $= \frac{4}{\xi\omega_n}$

$\therefore$ settling time $= \frac{4}{0.9 \times \sqrt{8}}$ → substituting from eqⁿ ①

$\therefore$ $\boxed{\text{settling time} = 1.571 \text{ sec}}$

→ Maximum overshoot

% Maximum overshoot $= e^{-\pi\xi/\sqrt{1-\xi^2}}$

$= e^{\frac{-\pi \times 0.9}{\sqrt{1-0.9^2}}}$

$= 0.1523\ \%$

$\therefore$ $\boxed{\text{Maximum overshoot} = 0.1523\ \%}$

③ If input signal is ramp signal
i.e. $R(t) = t\,u(t) \Rightarrow \boxed{\frac{1}{s^2} = R(s)}$

As we know that

$e_{ss} = \lim_{s \to 0} \frac{sR(s)}{1 + G(s)H(s)}$

$e_{ss} = \lim_{s \to 0} \frac{s \times \frac{1}{s^2}}{1 + \left(\frac{1+sk_e}{s+5}\right)\frac{8}{s}}$

$e_{ss} = \lim_{s \to 0} \frac{1}{s + \frac{8(1+sk_e)}{(s+5)}}$

$\boxed{e_{ss} = \frac{5}{8} = 0.625}$

Thus the value of steady state error

= 0.625.

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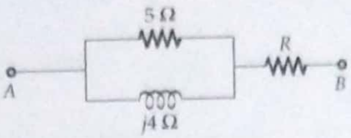
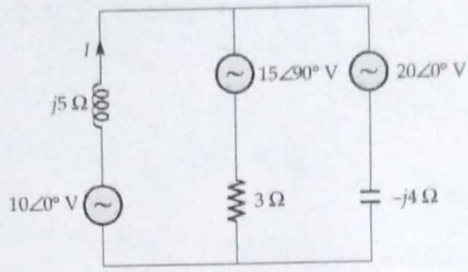
Q.8 (b) (i) If a voltage of 150 V applied between terminals *A* and *B* produces a current of 32 A for the circuit shown below. Calculate the value of resistance *R* and power factor of the circuit.

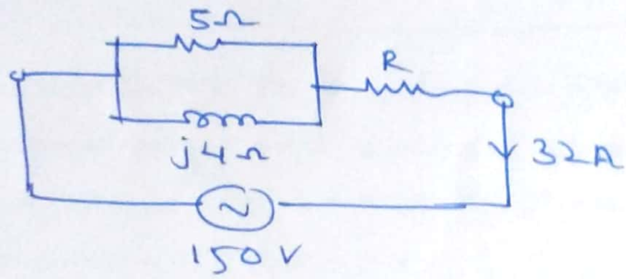


(ii) Find current *I* through *j*5 Ω branch using superposition theorem for the network shown below.



[10 + 10 = 20 marks]

→ (i)



$$\rightarrow Z_{AB} = \frac{5 \times j4}{5+j4} + R$$

$$Z_{AB} = \frac{20j}{5+j4} + R$$

$$Z_{AB} = \frac{20j(5-j4)}{25+16} + R = \frac{80}{41} + \frac{j100}{41} + R$$

$$\boxed{Z_{AB} = \left(\frac{80}{41} + R\right) + j\left(\frac{100}{41}\right)} \quad \text{—③}$$

$$|Z_{AB}| = \sqrt{\left(\frac{80}{41} + R\right)^2 + \left(\frac{100}{41}\right)^2} \quad \text{—①}$$

from given information

$$|Z_{AB}| = \frac{|V|}{|I|} = \frac{150}{32} \quad \text{—②}$$

→ on comparing eq ① & ② we get

$$\left(\frac{150}{32}\right)^2 = \left(\frac{80}{41}+R\right)^2+\left(\frac{100}{41}\right)^2$$

Solving above eqn we get $\boxed{R = 2.051\,\Omega}$

∴ The value of resistance $R = 2.051\,\Omega$

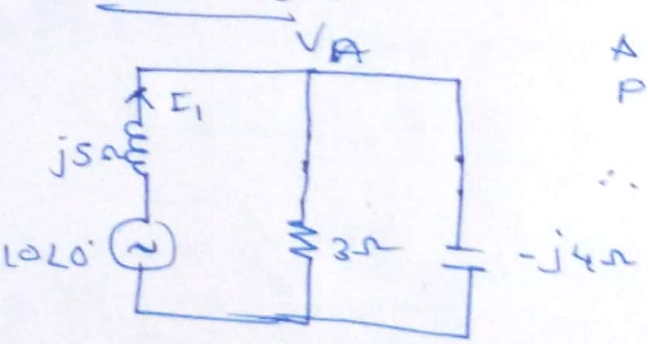
→ $p.f. = \cos\left(\tan^{-1}\frac{\left(\frac{80}{41}+2.051\right)}{\left(\frac{100}{41}\right)}\right)$

∴ $PF = \cos(58.645) = 0.5203$ lag.

∴ The power factor of circuit is 0.5203 lag

(ii) According to Superposition theorem Activate only one source at a time & replace other vtg source by short ckt & current source by open ckt & find response due to it. And at last add all the responses to get resultant output.

① case (i) :-



Apply KCL at point A

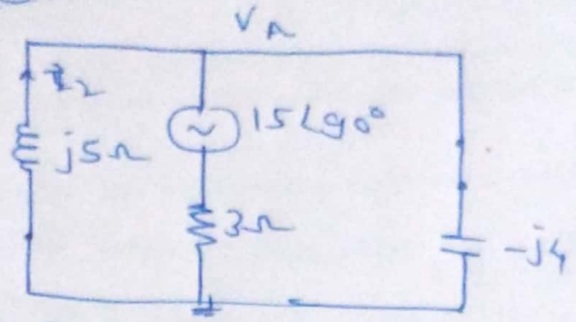
$$\therefore \frac{V_A - 10\angle 0}{j5}+\frac{V_A}{3}+\frac{V_A}{-j4} = 0$$

$$\therefore V_A = \left(\frac{10}{j5}\right)\Big/\left(\frac{1}{j5}+\frac{1}{3}+\frac{1}{-j4}\right) = 5.933\angle -98.53\,V$$

$$\therefore I_1 = \frac{10\angle 0 - 5.933\angle -98.53}{j5} = 2.472\angle -61.66$$

$$\therefore \boxed{I_1 = 2.472\angle -61.66^\circ A} \rightarrow ①$$

Case ②..



Applying KCL, at point A we get

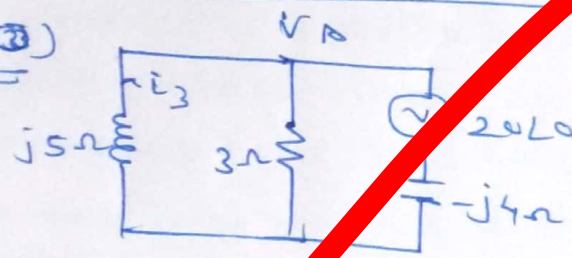
$$\frac{V_A}{j5} + \frac{V_A - 15\angle 90°}{3} + \frac{V_A}{-j4} = 0$$

$$\therefore V_A = \left(\frac{15\angle 90°}{3}\right) \Big/ \left(\frac{1}{j5} + \frac{1}{3} + \frac{1}{-j4}\right)$$

$$\therefore \boxed{V_A = 14.834\angle 81.469°\ V}$$

$$\therefore \boxed{I_2 = \frac{0 - V_A}{j5} = 2.966\angle 171.46°\ A} \quad \text{—②}$$

Case ③)



Applying KCL at point A we get

$$\frac{V_A}{j5} + \frac{V_A}{3} + \frac{V - 20\angle 0}{-j4} = 0$$

$$\therefore V_A = (20\angle 0/-j4) \Big/ \left(\frac{1}{j5} + \frac{1}{3} + \frac{1}{-j4}\right)$$

$$\therefore \boxed{V_A = 14.834\angle 81.468°\ V}$$

$$\boxed{I_3 = \frac{0 - V_A}{j5} = 2.966\angle 171.46°\ A} \quad ③$$

Adding eqⁿ ①, ② & ③ we get

$$\boxed{I = I_1 + I_2 + I_3 = 4.869\angle -164.572°\ A}$$

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Do not write in this margin

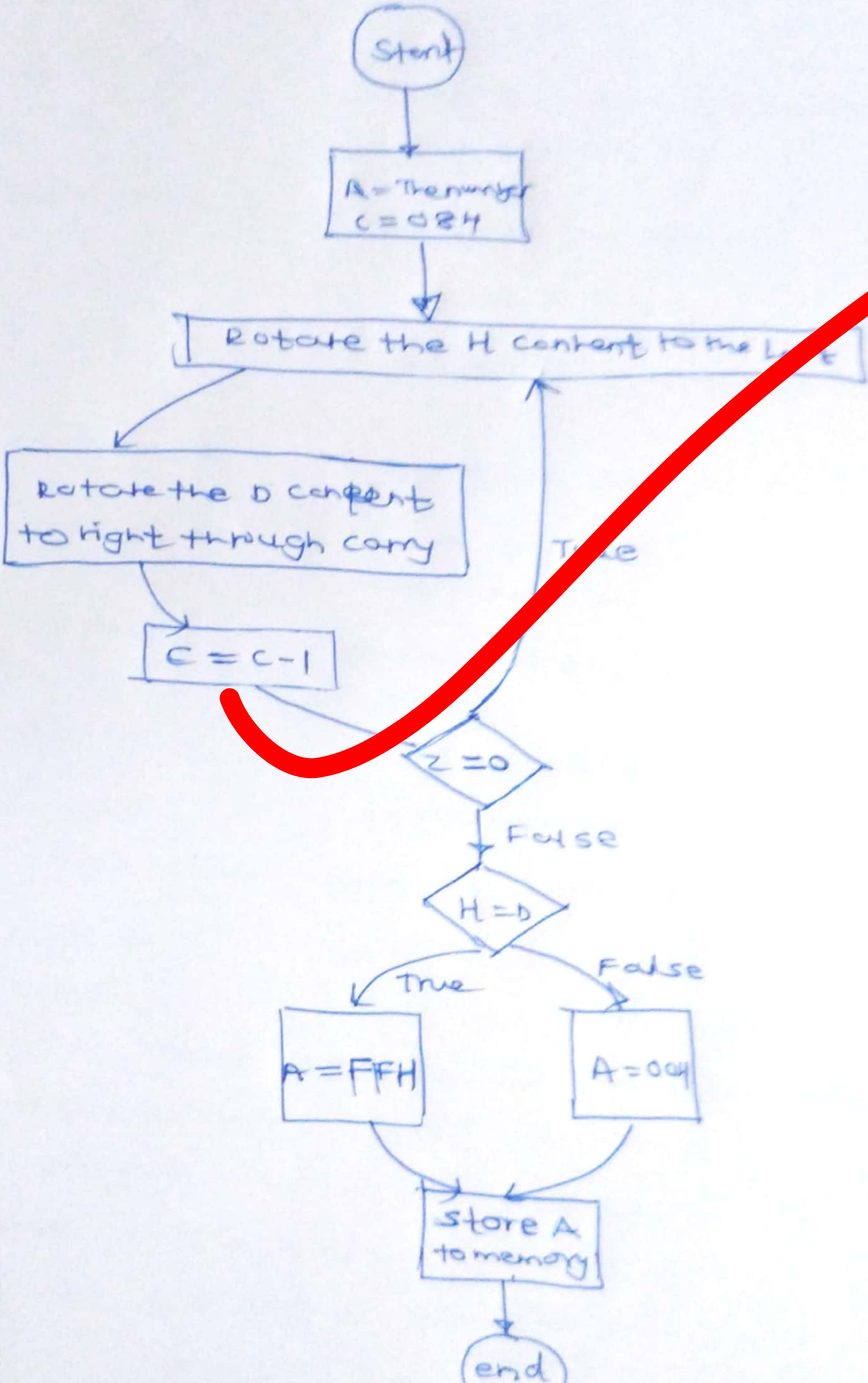
Q.8 (c) Write an 8085 assembly language program to check whether the 8-bit number at location, D200H is palindrome or not, write comments for each instruction of program? [20 marks]

→ In this program, we are taking the number from location D200H. The program will return 00H if the number is not palindrome otherwise it will return FFH

→ let the input is 18H so the binary value is (0001, 1000) this is a palindrome The number 52H (01010010) it is not a palindrome.

→ In this problem, we are taking the first number into Accumulator, then shifting it to the left; when it is left shifted the MSB will be placed at LSB and also in the carry flag. This carry flag is inserted into the D register by right shifting. Thus the bit pattern will be reversed now by the using the value of actual number & the reversed number we can determine it is palindrome or not.

Flow diagram



Program:-

	LDA 2100H	Load the number into A
	MOV H, A	Move content of Accumulator to Register H
	~~MOV~~ MVI C, 08 H	Initialize counter
Loop	MOV A, H	Load H to Acc
	RLC	Rotate left without carry
	MOV H, A	Get back Acc to H
	MOV A, D	Load D content to accumulator
	RAR	Rotate Right through carry
	MOV D, A	Get back Acc to D
	DCR	Decrease C
	JNZ Loop	Jump to Loop if C = 0
	MOV A, H	Load H data to A
	CMP D	Compare D with Accumulator
	JZ TRUE	If both are same it is palindrome
	MVI A, 00H	Load 00H into A
	JMP Exit	Jump to Exit
TRUE	MVI A, FFH	Load FFH into A
EXIT	STA 8050H	Store the result at memory location 8050H
	HLT	Terminate the program

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