(1) (a)

(i) ☐ A process scheduling algorithm favours those process that have used the least time in recent past because most of the computer consisting of single processing unit and memory of unit may have partition or the ~~sysy~~ system may consist of several memory unit or I/O devices. To having several memory unit it is comparatively cheaper than to have multiple processing unit. That is why algorithm favour I/O bound process, but not starve CPU bound process.

(ii) Any process, should start or terminate by the CPU burst. It is not possible to a process transition from waiting for an I/O operation to the terminated state. Because CPU should have status of all the process whether it is waited state or in terminated state. Termination in I/O operation waiting will ~~b~~ lead to discrimency of the process status record.

10

1 (b) Given that,

$\alpha = 0.2$

$[E_b/N_0]_{min} = 9.6\,dB.$

$L = 200\,dB.$

$G/T = 32\,dB/K$

$BW = 36\,MHz = 36\times10^6\,Hz.$

~~Carrier to noise ratio can be found by,~~

~~$C/N_0 =$~~

Bandwidth for a QPSK signal is given by

$$\frac{R_b \times (1+\alpha)}{\log_2 4} \leq BW \qquad [R_b = \text{data rate.}]$$

$$\Rightarrow R_{bmax} = \frac{(BW)}{(1+\alpha)}\log_2 4$$

$$R_{bmax} = \frac{36\times10^6}{(1+1.2)}\times 2$$

$$\boxed{R_{bmax} = 60\ Mbps.}$$

And we know, Carrier to noise ratio

$$[C/N_0]_{dB} = \left[\frac{E_b}{N_0}\right]_{dB} + 10\log[R_b]$$

$\Rightarrow$ ~~C~~

$$[EIRP] + [G/T] - [losses] - 10\log[BW] - 10\log[K] = [E_b/N_0] + 10\log[R_b]$$

$$\Rightarrow EIRP = \left[\frac{E_b}{N_0}\right] + 10\log R_b - [G/T] + [losses] + 10\log[BW] + 10\log[K]$$

$$= 9.6 + 10\log[60\times10^6] - 32 + 200 + 10\log[36\times10^6] + 10\log[1.38\times10^{-23}]$$

EIRP = 102·34 dB

1 (c)

Given

Sign	Exponent	Mantissa
(16−7−9)=0.	7 bit	9 bit

There is no sign field in the given floating point word

For exponent (7 bit)

$$\text{Bais} = 2^{7-1} - 1 = 63.$$

Maximum exponent BE = all 1's

$= 1111\ 111 = 127$

Actual exponent (max) $= 127 - 63 = 64$

Minimum based exponent = all 0's

$= 0000\ 000 = 0.$

Actual exponent $= 0 - 63 = -63.$

(i) For fraction Mantissa

Maximum mantissa (9 bit) = All 1's

$= 1\cdot 1111\ 1111\ 1$

$= (2 - 2^{-9})$

Minimum mantissa (9 bit) = All 0's

$= 1\cdot 0000\ 0000 = 2$

$= 1$

Therefore Range of fraction number

= from 1×10^{-63} to $(2-2^{-9}) \times 10^{64}$

(ii)

Integer Mantissa

For integer mantissa

Max Mantissa = all the 9 bits are 1

= 1 1111 1111

= $2^9 - 1 = 511$

Minimum Mantissa = all the 9 bits are 0

= 0 0000 0000

= 0.

Therefore Range of Integer mantissa number

from (0 to 511×2^{64}). which is much larger than fraction number range.

(1)(d)

Circuit Switching	Datagram Packet Switching	Virtual Circuit Switching
→ It is a Connection oriented service	→ It is a Connection less service	→ It is a Connection less service.
→ Dedicated transmission path required	→ No dedicated path required	→ No dedicated path required
→ Message are not stored	→ Packets are stored until delivery	→ Packets ~~may~~ stored until delivery
→ Continious transmission of data	→ transmission of packets	→ Transmission of packets
→ Resources are allocated before data transfer	→ No resources allocation required	→ No resource allocation required
→ The path is established for entire conversion	→ Routh establish for one packet	→ Routh establish for entire Conversation
→ Call setup delay: negligible transmission delay.	→ Packet transmission delay	→ Call setup delay, packet transmission delay.
→ Busy signal if call party busy	→ Sender may be notified of packet not delivered.	→ Sender notified of Connection denial.

→ Electromechanical or Computerized Switching nodes.	→ Small Switching nodes	→ Small Switching nodes.
→ Usally no speed or Code Conversion	→ Speed and Code Conversion	→ Speed and Code Conversion
→ Fixed bandwidth	→ Dynamic use of bandwidth	→ Dynamic use of bandwidth.
→ No Overhead bits after call setup	→ Overhead bit in each packet	→ Overhead bits in each packet

(1)
(e)

For operand forwarding technique.

CLK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Load	IF	ID	EX	MA	WB										
2. load		IF	ID	EX	MA	WB.									
MUL			IF	-	-	ID	EX	MA	WB						
DIV				IF	-	-	-	-	ID	EX	MA	WB			
SUB					IF	-	-	-	-	-	-	ID	EX	MA	WB

Required clock Cycle = 15

For without operand forwarding technique

Clock	1	2	3	4	5	6	7	8	9
Load1	IF	ID	EX	MA	WB				
Load2		IF	ID	EX	MA	WB			
MUL			IF	ID	EX	MA	WB		
DIV				IF	ID	EX	MA	WB	
SUB					IF	ID	EX	MA	WB

Therefore ~~Res~~ required clock cycle = 9.

Hence,

Save in clock cycle = 15 − 9 = 6.

(2)
(a)

Given that

Process	CPIs	A	B	C	D	Clock ~~cycle~~ rate
P_1		1	2	3	3	2.5 GHz
P_2		2	2	2	2	3 GHz.

(i)

~~For~~ Probability of ~~of~~ classes to occur is A - 10%, B - 20%, C - 50%, D - 20%.

Average CPI for P_1

$= CPI_A \times P(A) + CPI_B \times P(B) + CPI_C \times P(C) + CPI_D \cdot P(D)$

$= 1 \times 0.1 + 2 \times 0.2 + 3 \times 0.5 + 3 \times 0.2$

$= 2.6$ CPIs

Average CPI for P_2

$= CPI_A \times P(A) + CPI_B \times P(B) + CPI_C \times P(C) + CPI_D \times P(D)$

$= 2 \times 0.1 + 2 \times 0.2 + 2 \times 0.5 + 2 \times 0.2$

$= 2$ CPIs.

Time required to process 10^6 instruction by P_1

$T_{P_1} = CPI_{P_1} \times$ No of instruction $\times$ Clock pulse

$= 2.6 \times 10^6 \times \frac{1}{2.5 \times 10^9}$ sec.

$T_{P_1} = 1.04$ ms.

Time required to process 10^6 instruction by P_2

$T_{P_2} = CPI_{P_2} \times$ No of instruction $\times$ Clock pulse

$= 2 \times 10^6 \times \frac{1}{3 \times 10^9}$

$T_{P_2} = 0.667$ ms.

As, $T_{P_1} > T_{P_2}$, there fore

P_2 is faster than P_1.

Global CPIs for P_1 is 2·6 and for P_2 is 2 respectively.

(ii) Total clock required for P_1

$= CPI_{P_1} \times Instruction$

$= 2{\cdot}6 \times 10^6$

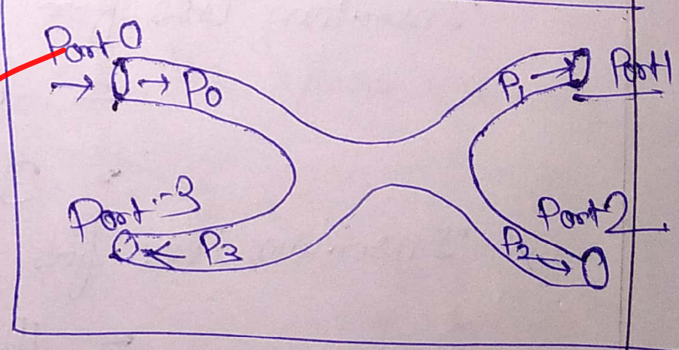
$= 2{\cdot}6 \times 10^6$ nos.

Total clock required for P_2

$= CPI_{P_2} \times Instruction$

$= 2 \times 10^6$ nos.

(2) (b) Given



$P_0 = 200\ \mu W.$

$P_1 = 90\ \mu W.$

$P_2 = 85\ \mu W.$

$P_3 = 6{\cdot}3\ mW.$

Coupling ratio

Coupling ratio for port-1

$$= \frac{P_1}{P_1+P_2} = \frac{90\times10^{-6}}{90\times10^{-6}+85\times10^{-6}}$$

$= 51.428\%$

Coupling ratio for port 2

$$= \frac{P_2}{P_1+P_2} = \frac{85\times10^{-6}}{90\times10^{-6}+85\times10^{-6}}$$

$= 48.57\%$

Excess loss

$$\text{Excess loss} = 10\log\left(\frac{P_0}{P_1+P_2}\right)$$

$$= 10\log\left(\frac{200\times10^{-6}}{90\times10^{-6}+85\times10^{-6}}\right)$$

$= 0.58$ dB.

Insertion loss

Insertion loss for port 1

$$= 10\log\left(\frac{P_0}{P_1}\right) = 10\log\left(\frac{200\times10^{-6}}{90\times10^{-6}}\right)$$

$= 3.468$ dB

Insertion loss for port 2

$$= 10\log\left(\frac{P_0}{P_2}\right) = 10\log\left(\frac{200\times10^{-6}}{85\times10^{-6}}\right)$$

$= 3.716$ dB

~~Insertion loss~~

Return loss

$$= 10 \log \left(\frac{P_3}{P_0}\right)$$

$$= 10 \log \left(\frac{6.3 \times 10^{-9}}{200 \times 10^{-6}}\right)$$

$$= -45.01 \text{ dB}$$

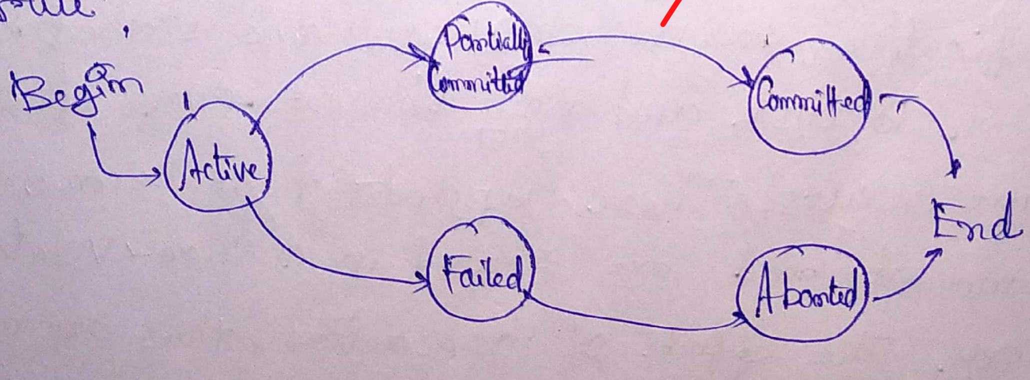
(2)
(c) (i) ACID ~~property~~ properties in Database

In order to maintain consistency in a database, before and after transaction, certain properties are followed. These are called ACID properties.

Atomicity

By this, we mean that either the entire transaction takes place at once or doesnot happen at all. There is no midway. i.e. transactions do not occur partially.

'Atomicity is also known as the 'all or nothing rule'.



Consistency

This means that integrity Constrains must be maintain so that the data base is consistent before and after the transaction. It refers to Correctness of a database.
Total amount before and after execution must be maintained.

Isolation

This property ensures that multiple transaction can occur concurrently without leading to inconsistency of database state. Transaction occur independently with out interference. This property ensures that the execution of transactions concurrently will result in a state that is equivalent to a state achieved these were executed serially in some order.

Durability

This property ensures that once the transaction has completed execution, the updates and modifications to the database are stored in and written to disk and they persist even if system failure occurs. These updates now become permanent and are stored in a non-volatile memory. The effects of transaction, thus are never lost.

(2) (c) (ii)

Given that,

$S_1 = W_2(a), W_1(a), W_3(c), R_1(a), R_3(b), W_2(b), R_3(c)$

T_1	T_2	T_3
	$W_2(a)$	
$W_1(a)$		
		$W_3(c)$
$R_1(a)$		
		$R_3(b)$
~~W_2~~	$W_2(b)$	
		$R_3(c)$

Initial Read

a: T_2
b: T_3
c: T_3

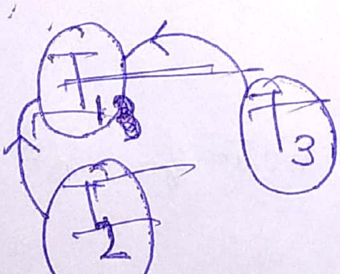
Updated Read

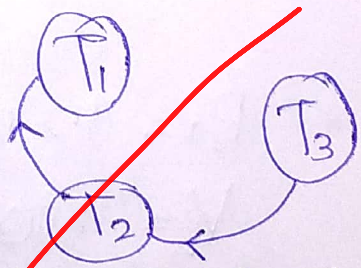
a: $T_2 \rightarrow T_1$
b: $T_3 \rightarrow T_2$
c: T_3

Final write

a: T_1
b: T_2
c: T_3

Therefore precedence diagram can be drawn as





As precedence diagram containing no cycle, then S_1 is conflict serializable and order of transaction ~~for~~ is

$T_3 \longrightarrow T_2 \longrightarrow T_1$

Given

S_2: $R_3(a)$, $R_1(b)$, $R_3(a)$, $W_2(b)$, $R_1(a)$, $R_2(a)$, $W_2(c)$, $R_3(c)$

Order of conflict
1. $R_1(b)$, $W_2(b)$
2. $W_2(b)$, $R_3(c)$

S_2: T_3 T_2 T_1 (As per S_1).

: $R_3(a)$, $R_3(a)$, $R_3(c)$., $W_2(b)$, $R_2(a)$, $W_2(c)$, $R_1(b)$, $R_1(a)$

Order change. Order changed

Therefore
Minimum 2 swaps required so that schedule S_2 has conflict serializability in the same order as that of S_1.

Section - B

(5)(b)

Given $R_a = 0.2\,\Omega$, Rating 55 kVA.

$V_L = 550$ V

Therefore $V_p = \frac{550}{\sqrt{3}}$ V.

And also, $V_{oc}|_{(I_f=10A)} = 450$ V

$I_{sc}|_{(I_f=10A)} = 200$ A,

(i) Synchronous Impedance

$$Z_s = \frac{\{V_{oc}|_{(I_f=10A)}\}_P}{I_{sc}|_{(I_f=10A)}}$$

$$Z_s = \frac{\frac{450}{\sqrt{3}}}{200}$$

$\Rightarrow$ $Z_s = 1.3\ \Omega$.

Therefore, Synchronous reactance

$$X_s = \sqrt{Z_s^2 - R_a^2}$$

$$= \sqrt{1.3^2 - 0.2^2}$$

$$X_s = 1.2835\ \Omega$$

~~(ii) Induce voltage at p.f 0.8 (lag)~~

~~$E_f = \sqrt{(V_p + R\cos\theta)^2 \pm V_p}$~~

~~$= \sqrt{(V_p\cos\theta + RI)^2}$~~

Rating $S = \sqrt{3}\, V_L I_L = 55\times10^3$

$\Rightarrow$ $I_L = \frac{55\times10^3}{\sqrt{3}\times 550}$

Armature Current: $I_a = I_L = 57.735$ A

Induce votage at p.f. 0.8 (lag).

Given $\cos\theta = 0.8$, $\sin\theta = \sqrt{1-0.8^2} = 0.6$

$$E_f = \sqrt{(V_p\cos\theta + R_a I_a) + (V_p\sin\theta + X_s I_a)^2}$$

$$= \sqrt{\left(\frac{550}{\sqrt{3}}\times0.8 + 0.2\times57.735\right)^2 + \left(\frac{550}{\sqrt{3}}\times0.6 + 1.2835\times57.735\right)^2}$$

$$E_f = 374.9154\ V$$

Hence
Full load regulation

$$Reg = \frac{E_f - V}{V} = \frac{374.915 - \frac{550}{\sqrt{3}}}{\frac{550}{\sqrt{3}}}$$

$$\boxed{Reg = 19.8745\ \%}$$

(5)
(C)

Given that
atomic weight of Pb = 207
Valency = 2
Electrochemical equivalent of hydrogen (ECE) $= 0.0140 \times 10^{-6}$ kg/C.

Therefore Electrochemical equivalent for Lead (pb) $= \frac{\text{Atomic weight}}{\text{Valency}} \times (ECE)_{H_2}$

$$= \frac{207}{2} \times 0.0140 \times 10^{-6} \text{ kg/c}$$

$$(ECE)_{pb} = 1.449 \times 10^{-6} \text{ kg/c}$$

Therefore atomic weight of PbO_2 $= (207 + 16 \times 2) = 239.$

Hence electrochemical Equivalent of PbO_2 $= \frac{\text{Atomic weight}}{\text{Valency}} \times (ECE)_{H_2}$

$$= \frac{239}{2} \times 0.014 \times 10^{-6}$$

$$(ECE)_{PbO_2} = 1.673 \times 10^{-6} \text{ kg/c}$$

The charge

One Ampere-hour

$= 1 \times 3600 \ C$

$= 3600 \ C.$

Therefore required weight for active material

Positive plate (PbO_2) Weight $= (ECE)_{PbO_2} \times$ charge

$= 1.673 \times 10^{-6} \times 3600 \ kg/A\text{-}Hr$

$= 6.0228 \times 10^{-3} \ kg/A\text{-}Hr$

Negative plate (Pb) Weight $= (ECE)_{PbO_2} \times$ charge

$= 1.449 \times 10^{-6} \times 3600 \ kg/A\text{-}Hr$

$= 5.2164 \times 10^{-3} \ kg/A\text{-}Hr$

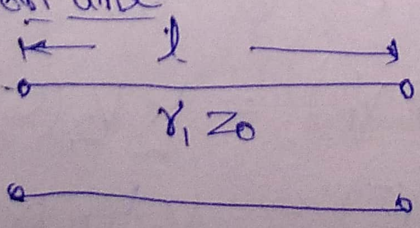
5 (d)

Standard equation of ABCD parameter

$V_1 = AV_2 - BI_2$ ——— (1)

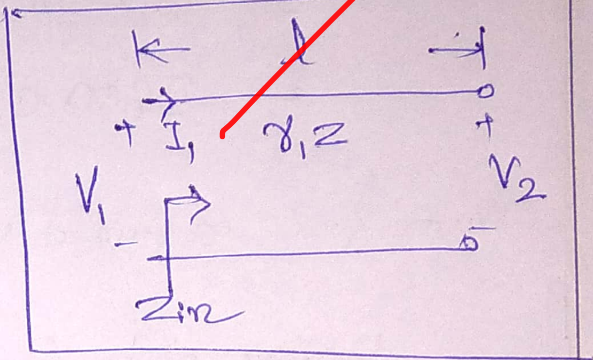
$I_1 = CV_2 - DI_2$ ——— (2)

Given transmission line



To find $A = \frac{V_1}{V_2}\Big|_{I_2=0}$ and $C = \frac{I_1}{V_2}\Big|_{I_2=0}$

Consider $I_2 = 0$ i.e. Output terminal is open circuited. $Z_L = \infty$



Input impedence is given by.

$$Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh \gamma l}{Z_0 + Z_L \tanh \gamma L}$$

$$\Rightarrow Z_{in} = Z_0 \frac{1 + \frac{Z_0}{Z_L} \tanh \gamma l}{\frac{Z_0}{Z_L} + \tanh \gamma l}$$

[∵ As $Z_L \to \infty$]

$Z_{in} = Z_0 \coth \gamma l$.

For transmission line, we know,

$$V_1^+ = \frac{1}{2}(V_1 + Z_0 I_1) \quad \text{——— (3)}$$

$$V_1^- = \frac{1}{2}(V_1 - Z_0 I_1) \quad \text{——— (4)}$$

And also,

$$V_1^+ = \frac{1}{2}(V_2 + Z_0 I_2) e^{\gamma l} \quad \text{——— (5)}$$

$$V_1^- = \frac{1}{2}(V_2 - Z_0 I_2) e^{-\gamma l} \quad \text{——— (6)}$$

By putting $I_2 = 0$ in eqn (5) and (6) we get,

$$V_1^+ = \frac{1}{2} V_2 e^{\gamma L} \quad \text{——— (7)}$$

$$V_1^- = \frac{1}{2} V_2 e^{-\gamma L} \quad \text{——— (8)}$$

By eqn (7) + eqn (8) we get,

$$(V_1^+ + V_1^-) = \frac{1}{2} V_2 (e^{\gamma l} + e^{-\gamma l})$$

$$(V_1^+ + V_1^-) = V_2 \cosh \gamma l \quad \text{——— (9)}$$

And, By eqn (7) − eqn (8) we get,

$$V_1^+ - V_1^- = \frac{1}{2}V_2\left(e^{+\gamma l} - e^{-\gamma l}\right)$$

$$\Rightarrow \quad V_1^+ - V_1^- = V_2 \sinh\gamma l \quad \text{—— (10)}$$

And also from, eqn (3) + eqn (4) we get,

$$V_1^+ + V_1^- = \frac{1}{2}V_1 + \frac{1}{2}V_1$$

$$\Rightarrow \quad V_1 = V_1^+ + V_1^- \quad \text{—— (11)}$$

And also from eqn (3) − eqn (4) we get,

$$V_1^+ - V_1^- = Z_0 I_1 \quad \text{—— (12)}$$

By using eqn (9) and (11) we get,

$$V_1 = V_2 \cosh\gamma l$$

$$\Rightarrow \boxed{A = \frac{V_1}{V_2}\Big|_{I_2=0} = \cosh\gamma l}$$

By using eqn (10) and eqn (12) we get,

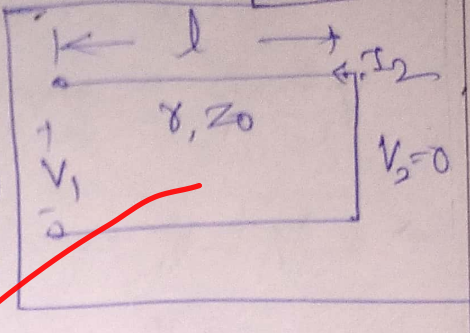
$$Z_0 I_1 = V_2 \sinh\gamma l$$

$$\Rightarrow \boxed{C = \frac{I_1}{V_2}\Big|_{I_2=0} = \frac{1}{Z_0}\sinh\gamma l}$$

Now to find $B = \frac{V_1}{-I_2}\Big|_{V_2=0}$ and $D = \frac{I_1}{-I_2}\Big|_{V_2=0}$

output terminal open circuited.

By putting $V_2 = 0$ in equation (5) and eqn (6) we get.



$$V_1^+ = \frac{1}{2} Z_0 I_2 e^{\gamma l} \quad \text{---} (13)$$

$$V_1^- = -\frac{1}{2} Z_0 I_2 e^{-\gamma l}. \quad \text{---} (14)$$

By eqn (13) + eqn (14) we get,

$$V_1^+ + V_1^- = \frac{1}{2} Z_0 I_2 \left[e^{\gamma l} - e^{-\gamma l}\right]$$

$$\Rightarrow V_1^+ + V_1^- = Z_0 I_2 \sinh \gamma l \quad \text{---} (15)$$

By eqn (13) − eqn (14) we get,

$$V_1^+ - V_1^- = \frac{1}{2} I_2 Z_0 \left[e^{\gamma l} + e^{-\gamma l}\right]$$

$$\Rightarrow V_1^+ - V_1^- = Z_0 I_2 \cos \gamma l \quad \text{---} (16)$$

By substituting the value of eqn (3) and (4) in eqn (15) we get,

$$\frac{1}{2}\left(V_1 + I_1 Z_0\right) + \frac{1}{2}\left(V_1 - I_1 Z_0\right) = Z_0 I_2 \sinh \gamma l$$

$$\Rightarrow \boxed{B = + \left.\frac{V_1}{-I_2}\right|_{V_2=0} = Z_0 \sinh \gamma l}$$

By substituting the value of eqn (3) and (4) in eqn (16) we get

$$\frac{1}{2}\left(V_1 + I_1 Z_0\right) - \frac{1}{2}\left(V_1 - I_1 Z_0\right) = Z_0 I_2 \cosh \gamma l$$

~~$I_1 Z_0 =$~~

$$\Rightarrow \boxed{D = \left.\frac{I_1}{-I_2}\right|_{V_2=0} = \cosh \gamma l}$$

Thus, ABCD parameter matrix for the lossy transmission line is

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cosh \gamma l & Z_0 \sinh \gamma l \\ \frac{1}{Z_0} \sinh \gamma l & \cosh \gamma l \end{bmatrix}$$

(5)(e)

Given $\alpha = \frac{2}{\eta_0} \sqrt{\frac{\pi f \mu/\sigma}{1-\left(\frac{f_c}{f}\right)^2}}$ ——— (1)

For maximum value of 'α' differentiating above equation w.r.t f and equate to zero, we get,

$$\frac{d\alpha}{df} = \frac{2}{\eta_0} \frac{1}{2\sqrt{\frac{\pi f \mu/\sigma}{1-(f_c/f)^2}}} \times \frac{\left[1-\left(\frac{f_c}{f}\right)^2\right]\frac{\pi\mu}{\sigma} - \frac{\pi f \mu}{\sigma}\left[-2f_c^2\left(-\frac{1}{f^2}\right)\right]}{\left[1-\left(\frac{f_c}{f}\right)^2\right]^2}$$

$$\Rightarrow 0 = \frac{2}{\eta_0} \frac{1}{2\sqrt{\frac{\pi f \mu/\sigma}{1-(f_c/f)^2}}} \times \frac{\frac{\pi\mu}{\sigma}\left[1-\left(\frac{f_c}{f}\right)^2 - \frac{2f_c^2}{f^2}\right]}{\left[1-\left(\frac{f_c}{f}\right)^2\right]^2}$$

$$\Rightarrow 1-3\left(\frac{f_c}{f}\right)^2 = 0$$

$$\Rightarrow \boxed{f = \sqrt{3}\, f_c}$$

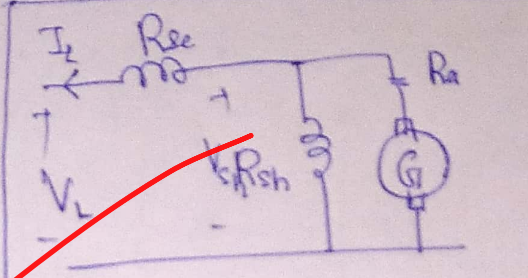
Hence, at $f = \sqrt{3} f_c$ the value of α will be minimum

(6)
(a)

Given that

$I_L = 100\,A$

$V_L = 220\,V$



Short-shunt generator.

$R_{sh} = 50\,\Omega$

$R_{se} = 0.025\,\Omega$

$R_a = 0.05\,\Omega$ $\quad V_{brush} = 2V$

$P_I = 1000\,W.$

(i) Voltage across shunt field

$$V_{sh} = V_L + R_{se} I_L$$

$$= 220 + 0.025 \times 100$$

$$V_{sh} = 222.5\,V$$

Current in the shunt field

$$I_{sh} = \frac{V_{sh}}{R_{sh}} = \frac{222.5}{50} = 4.45\,A.$$

Armature current

$$I_a = I_L + I_a = 100 + 4.45$$

$$I_a = 104.45\,A$$

Generated voltage

$$E_G = V_{sh} + I_a R_a + V_{brush}$$

$$= 222.5 + 104.45 \times 0.05 + 2$$

$$\boxed{E_G = 229.7225\,V}$$

(ii)
Total Copper loss

$= \text{series field loss} + \text{Shunt field loss} + \text{Armature loss}$

$= I_L^2 R_{se} + I_{sh}^2 R_{sh} + I_a^2 R_a$

$= 100^2 \times 0.025 + 4.45^2 \times 50 + (104.45)^2 \times 0.05$

$$P_{cu} = 1785.62\ W$$

(iii)

Output of the prime movers

$P_{in} = \text{Electrical Output power} + \text{Iron loss} + \text{Copper loss}$

$= V_L I_L + P_I + P_{cu}$

$= 220 \times 100 + 1000 + 1785.62\ W$

$P_{in} = 24785.62\ W$

$$P_{in} = 24.78562\ kW$$

(iv)

Generator efficiency

$$\eta = \frac{P_o}{P_{in}} \times 100\%$$

$$= \frac{V_L I_L}{P_{in}} \times 100\%$$

$$= \frac{220 \times 1000}{24785.62} \times 100\%$$

$$\eta = 88.76\%$$

(6) (b) (i) Given, $U(\theta,\phi) = \sin^2 2\theta, \quad 0<\theta<\pi, 0<\phi<2\pi$

$$P_{rad} = \int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi} U(\theta,\phi)\sin\theta\, d\theta\, d\phi$$

$$= \int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi} \sin^2 2\theta \sin\theta\, d\theta\, d\phi$$

$$= \int_{\theta=0}^{\pi} 4\sin^2\theta(1-\sin^2\theta)\sin\theta . d\theta \int_{\phi=0}^{2\pi} d\phi$$

$$= \int_{0}^{\pi} 4\cos^2\theta(1-\cos^2\theta)[-d(\cos\theta)] \times \int_{\phi=0}^{2\pi} d\phi$$

$$= -\int_0^{\pi} 4(\cos^2\theta - \cos^4\theta)\, d(\cos\theta)\int_{\phi=0}^{2\pi} d\phi$$

$$= -4\left[\frac{\cos^3\theta}{3} - \frac{\cos^5\theta}{5}\right]_0^{\pi} \times 2\pi$$

$$= -4\left[\frac{-1-1}{3} - \frac{-1-1}{5}\right] \times 2\pi$$

$$U_{avg} = \frac{P_{rad}}{4\pi} = \frac{32\pi}{15\times 4\pi} = \frac{8}{15} \text{ W/sr}$$

$$U_{max} = \sin^2 2\theta\big|_{max} = 1 \text{ W/sr}$$

Directivity $D_0 = 4\pi \dfrac{U_{max}}{P_{rad}} = \dfrac{4\pi \times 1}{\frac{32\pi}{15}}$

$$D_0 = \frac{15}{8} = 1.875$$

(ii) Given,

$$U(\theta,\phi) = 4\,Cosec^2\theta. \quad \pi/3 < \theta < \pi/2 \,,\ 0 < \phi < \pi$$

P_{avg}

$$P_{rad} = \int_\theta\int_\phi U(\theta,\phi)\ Sin\theta\, d\theta\, d\phi$$

$$= \int_{\theta=\pi/3}^{\pi/2} 4\,Cosec^2\theta\ Sin\theta\, d\theta \int_{\phi=0}^{\pi} d\phi$$

$$= \int_{\theta=\pi/3}^{\pi/2} \frac{4}{Sin\theta}\, d\theta \int_0^{\pi} d\phi$$

$$= \int_{\pi/3}^{\pi/2} \frac{2\, d\theta}{Sin\theta/2\ Cos\theta/2} \int_0^{\pi} d\phi$$

$z = tan\theta/2$

$dz = \frac{1}{2} Sec^2\theta/2\, d\theta$

$2\, d(tan\theta/2) = s^2$

$$= 4 \cdot \int_{\pi/3}^{\pi/2} \frac{d(tan\theta/2)}{(tan\theta/2)} \int_0^{\pi} d\phi$$

$$= 4\pi \left[ln(tan\theta/2) \right]_{\pi/3}^{\pi/2}$$

$$P_{rad} = 1.9356\pi$$

$$U_{avg} = \frac{P_{rad}}{4\pi} = \frac{1.9356\pi}{4\pi}$$

$$\boxed{U_{avg} = 0.5493}\ W/sr$$

$$U_{max} = 4\,Cosec^2\theta \Big|_{max} = \frac{4}{Sin^2\theta}\Big|_{max}$$ where $\pi/3 < \theta < \pi/2$

$$= \frac{4}{Sin^2(\pi/3)} =$$

[∵ $Sin\theta = Min$, $U = max$]

$$\boxed{U_{max} = 5.333\ W/sr}$$

Directivity $D_0 = 4\pi \frac{U_{max}}{P_{rad}}$

$= 4\pi \times \frac{5.333}{1.9356\pi}$

$\boxed{D_0 = 11.02}$

(iii) Given, $U(\theta,\phi) = 2\sin^2\theta \sin^2\phi$, $0<\theta<\pi$, $0<\phi<\pi$

$P_{rad} = \int_\theta \int_\phi U(\theta,\phi) \sin\theta \, d\theta \, d\phi$

$= \int_{\theta=0}^{\pi} \sin^2\theta \sin\theta \, d\theta \int_{\phi=0}^{\pi} 2\sin^2\phi \, d\phi$

$= \int_0^{\pi} [1-\cos^2\theta][-d(\cos\theta)] \int (1-\cos 2\phi) \, d\phi$

$= -\left[\cos\theta - \frac{\cos^3\theta}{3}\right]_0^{\pi} \times \left[\phi - \frac{\sin 2\phi}{2}\right]_0^{\pi}$

$= -\left[(-1-1) - \frac{-1-1}{3}\right] \times \left[(\pi-0) - \frac{0-0}{2}\right]$

$= \frac{4\pi}{3}$ W.

$U_{avg} = \frac{P_{rad}}{4\pi} = \frac{\frac{4\pi}{3}}{4\pi} = 0.33$ W/Sr

$\boxed{U_{avg} = 0.333 \text{ W/Sr}}$

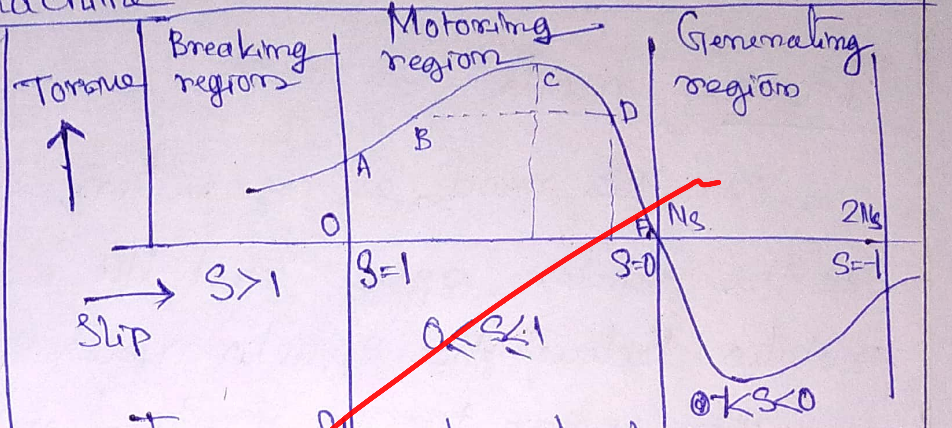
$U_{max} = 2\sin^2\theta \sin^2\phi \big|_{max} = 2\times1\times1 = 2$ W/Sr

Directivity $D_0 = 4\pi \frac{U_{max}}{P_{rad}} = 4\pi \times \frac{2}{\frac{4\pi}{3}} = 6$

$\boxed{D_0 = 6}$

6 (C)

Torque Slip-Characteristics of 3-ϕ induction machine



Torque-Slip characteristics.

The torque Slip - characteristics of 3-ϕ induction machine shown above. In which for $S>1$ induction machine works in breaking mode, and for $0 \leq S \leq 1$ works motor and for $-1 \leq S \leq 0$ works as generator

Braking Mode:-

In the breaking mode, the two leads or the polarity of supply voltage is changed so that the motor starts to rotate in the reverse direction and as a result the motor stops. This method of breaking is known as plugging. This method used when it is required to stop the motor with in a very short period of time. The kinetic energy stored in the revolving load is dissipated as heat. Also, motor is still receiving power from the stator which is also dissipated heat. So as a result of which motor develops enormous heat energy. For this stator is disconnected from the supply before motor enters the braking mode.

Motoring mode

In this mode of operation, supply is given to the stator sides and the motor always rotates below the synchronous speed. The induction motor torque varies from zero to full load torque as the slip varies, this slip varies from zero to one. It is zero at no load and one at stand still. From the curve it is seen that the torque is directly proportional to the slip.

That is, more is the slip, more will be torque produce and vice versa. The linear relationship simplifies the calculation of motor parameter to great extent.

Generating Mode

In this mode of operation induction motor runs above the synchronous speed and it should be driven by a prime mover. The stator winding is connected to a three phase supply in which it supplies electrical energy. Actually, in this case, the torque and slip both are negative so the motor receives mechanical energy and delivers electrical energy.

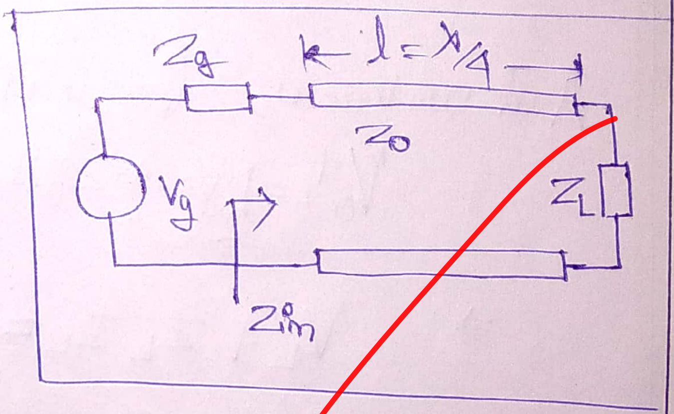
Induction motor is not much used as generator because it requires reactive power for its operation. That is, reactive power should be supplied from outside and if it runs below the synchronous speed by any means, it consumes electrical energy rather the giving it at the output. So, as far as possible, induction generators are generally avoided.

(8)
(a) Given that,

$Z_0 = 50\,\Omega$

$Z_g = 50\,\Omega$, $V_g = 10V$

$l = \frac{\lambda}{4}$, $Z_L = 50 - j50\,\Omega$



Input impedance of the given line (Lossless).

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}$$

$$= Z_0 \cdot \frac{Z_L + jZ_0 \tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}\right)}{Z_0 + jZ_L \tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}\right)} \quad \left[\because \beta = \frac{2\pi}{\lambda} \text{ and } l = \frac{\lambda}{2}\right]$$

$$= Z_0 \frac{\frac{Z_L}{\tan\pi/2} + jZ_0}{\frac{Z_0}{\tan\pi/2} + jZ_L} \quad [\because \tan\pi/2 = \infty]$$

$$Z_{in} = \frac{Z_0^2}{Z_L} = \frac{50^2}{(50 - j50)} = (25 + j25)$$

Therefore,

Current $I_0 = \frac{V_g}{Z_{in}+Z_g}$

$= \frac{10}{(25+j25)+50}$

$I_0 = 0.1265 \angle -18.43°$ ——— (1)

Votage $V_0 = \frac{V_g \, Z_{in}}{Z_{in}+Z_g} = \frac{10\times(25+j25)}{(25+j25)+50} = 4.472\angle 26.57°$ ——— (2)

(i) ~~Power that dissipated by the load~~

$P_L = I_0^2 Z_L$

$=$

And we know, for loss less line,

$V_0^+ = \frac{1}{2}(V_0 + Z_0 I_0) = \frac{1}{2}(V_L + Z_L I_L)e^{+j\beta l}$

$\Rightarrow V_L + Z_L I_L = (V_0 + Z_0 I_0)e^{-j\beta l}$

$V_L + Z_L I_L = (4.472\angle 26.57° + 50\times 0.1265\angle -18.43°)e^{-j\pi/2}$

$\Rightarrow$

$\Rightarrow V_L + (50-j50) I_L = 10\angle -90°$
$V_L + 70.7\angle -45° I_L = 10\angle -90°$ ——— (3) $[\beta l = \frac{2\pi}{\lambda}\times\frac{\lambda}{4}$, $\beta l = 90°]$

And also,

$V_0^- = \frac{1}{2}(V_0 - Z_0 I_0) = \frac{1}{2}(V_L - Z_L I_L)e^{-j\beta l}$

$\Rightarrow V_L - Z_L I_L = (4.472\angle 26.57° - 50\times 0.1265\angle -18.43°)e^{+j\pi/2}$

$V_L -$ ~~70.7∠1°~~ $70.7\angle -45° I_L = 4.472\angle -153.4°$ ——— (4)

By equation (3) and (4) we get

$$\begin{bmatrix} 1 & 70.7\angle 45^\circ \\ 1 & -70.7\angle 45^\circ \end{bmatrix} \begin{bmatrix} V_L \\ I_L \end{bmatrix} = \begin{bmatrix} 10\angle -90^\circ \\ 4.472\angle -153^\circ \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 1 & 70.7\angle 45^\circ \\ 1 & -70.7\angle 45^\circ \end{vmatrix} = 141.4\angle 135^\circ \neq 0$$

By using Cramer's rule.

$$V_L = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 10\angle -90^\circ & 70.7\angle -45^\circ \\ 4.472\angle -153^\circ & -70.7\angle -45^\circ \end{vmatrix}}{141.4\angle 135^\circ} = 6.34\angle -108.3^\circ$$

$$I_L = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 1 & 10\angle -90^\circ \\ 1 & 4.472\angle 153^\circ \end{vmatrix}}{141.4\angle 135^\circ} = 0.08947\angle -63.425$$

(i) Power dissipated by the load.

$$P_L = \frac{1}{2}|I_L|^2 |Z_L|$$

$$= \frac{1}{2} * (0.08947)^2 \left(\sqrt{50^2 + 50^2}\right)$$

$$\boxed{P_L = 0.2830 \text{ W}}$$

(ii) Voltage amplitude that appear at the load

$$\boxed{|V_L| = 6.34 \text{ V}}$$

(8) (b) (i) Advantages of distributed winding

In a concentrated winding, the coil sides of a given phase are concentrated in a single slot under a given pole. The individual coil voltage induced are in phase with each other.

The voltage may be added arithmetically for distributed winding induced in coil sides constituting a polar group are not in phase but differ by an angle equal to the angle equal to angular displacement β of the slots. The total voltage induced in any phase will be phasor sum of the individual coil voltage.

So, the distributed winding

→ Reduces harmonic emf and so waveform is improved

→ It also diminishes armature reaction

→ Even distributed conductors helps for better cooling

→ The core is fully utilized as the conductor are distributed over the slots on the armature periphery.

(ii) Given P = 8, 3-φ, f = 50Hz.

Slots per pole per phase m = 2

Conductors per slot = 4

Coil span = 180 - α = 120°

short pitch angle α = 180 - 120 = 60°.

Flux per pole = 74 mWb.

Total number of slots = ~~2×~~ m × P × 3(phase)

= 2 × 8 × 3

= 48

Slot angle $\gamma = \frac{180°}{\text{Slot/pole}} = \frac{180°}{\frac{48}{8}} = 30°$

Distribution factor

$$K_d = \frac{\sin \frac{m\gamma}{2}}{m \sin \gamma/2} = \frac{\sin \frac{2\times30°}{2}}{2\times\sin\frac{30°}{2}}$$

$K_d = 0.9659$

Pitch factor $K_p = \cos \alpha/2 = \cos\left(\frac{60°}{2}\right) = 0.866$

For double layer winding

~~no of Coils = No. of Slots = 48~~

~~Total turns = 2×48 = 96~~

~~Turns per phase = 48~~

Total number of conductor = (Conductors per Slot) × (No of Slot)

= 4 × 48

Total number of turns = $\frac{\text{No of Conductors}}{2}$

$= \frac{48 \times 4}{2}$

No of turns per phase $T_{ph} = \frac{48 \times 4}{2 \times 3} = 32$

Therefore

Induce phase votage (rms).

$E_{ph} = 4.44\, K_p K_d \phi f T_{ph}$

$= 4.44 \times 0.866 \times 0.9659 \times 74 \times 10^{-3} \times 50 \times 32$ V

$E_{ph_{rms}} = 439.729$ V

(8)
(C)

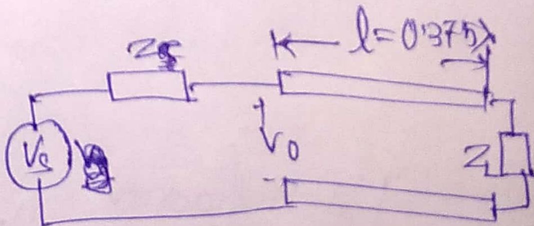
Given $V_s = 150V$ $\quad f = 0.3$ GHz.

$Z_s = 100\Omega$

$Z_0 = 100\Omega$

$l = 0.375\lambda$

$Z_L = 100 - j100\,\Omega$



$\beta l = \left(\frac{2\pi}{\lambda} \times 0.375\lambda\right) = \frac{3}{4}\pi = 135°$

Input input impedance for lossless line

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}$$

$$= 100 \frac{(100-j100) + j100 \tan(135^\circ)}{100 + j(100-j100)\tan(135^\circ)}$$

$$= (2+j) \times 100$$

$$Z_{in} = (200 + j100) \quad \text{—— (1)}$$

$$V_0 = \frac{V_s \times Z_{in}}{Z_s + Z_{in}} = \frac{150 \times (200+j100)}{100+(200+j100)}$$

$$V_0 = (105 + j15) \quad \text{—— (2)}$$

$$I_0 = \frac{V_s}{Z_s + Z_{in}} = \frac{150}{100+(200+j100)}$$

$$I_0 = \frac{9}{20} - j\frac{3}{20} \quad \text{—— (3)}$$

And we know for transmission line,

$$V_0^+ = \frac{1}{2}(V_0 + Z_0 I_0) = \frac{1}{2}(V_L + Z_L I_L) e^{j\beta l}$$

$$\Rightarrow (V_L + Z_L I_L) = (V_0 + Z_0 I_0) e^{-j\beta L}.$$

$$\Rightarrow V_L + (100-j100) I_L = \{(105+j15) + 100(\tfrac{9}{20} - j\tfrac{3}{20})\} e^{-j\frac{3\pi}{4}}$$

$$V_L + 141.4\angle{-45^\circ}\, I_L = 153\angle{-123.7^\circ} \quad \text{—— (4)}$$

And also for lossless transmission line

$$V_0^- = \frac{1}{2}(V_0 - Z_0 I_0) = \frac{1}{2}(V_L - Z_L I_L) e^{-j\beta l}$$

$$\rightarrow V_L - Z_L I_L = (V_0 - I_0 Z_0) e^{j\beta L}$$

$$V_L - (100 - j100) I_L = \left\{ (105 + j15) - \left(\frac{9}{50} - j\frac{13}{50}\right) \times 100 \right\} e^{+j\frac{3\pi}{4}}$$

$$\Rightarrow V_L - 141.4\angle{-45^\circ}\, I_L = 60\angle 135^\circ \qquad (5)$$

By eqn (4) − eqn (5) we get.

$$2 \times 141.4\angle{-45^\circ}\, I_L = 153\angle{-123.7^\circ} - 60\angle 135^\circ$$

Load Current.

$$\Rightarrow \boxed{I_L = 0.6186\angle{-59^\circ}}$$