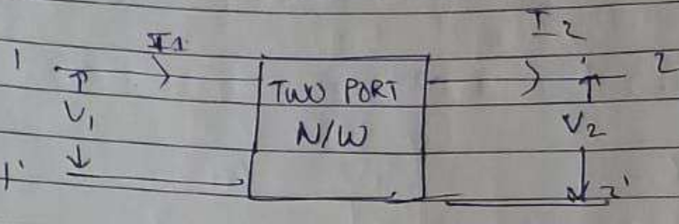
⇒ Two port Network

A two port network is a special case of multicode network.
Each code contains two terminals one for entry and other for exit.
From the defination of a port the current at Entry should be = current at exit.

⇒ Characterisation of 2 port network



Two port network with standard reference dirctions for voltages & currents

A two port network is illustrate in given fig. by analogy with the transmission network the port given as '1-1'' is called the input port 1 & the other '2-2'' is called the output port.

The port variables are the port current and port voltages

In a general way or general manner in n port network there will be 2n voltage & current variables.

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$$V_1 = Z_{11} I_1 + Z_{12} I_2 \longrightarrow (1)$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2 \longrightarrow (2)$$

From eqn (1) we have,

$$Z_{11} = \frac{V_1}{I_2}\Bigg]_{I_2=0} \longrightarrow (3)$$

Z_{11} is called Input impedance with the output port is open circuited.

$$Z_{12} = \frac{V_1}{I_2}\Bigg]_{I_1=0} \longrightarrow (4)$$

[Reverse transfer impedance with the input open circuited]

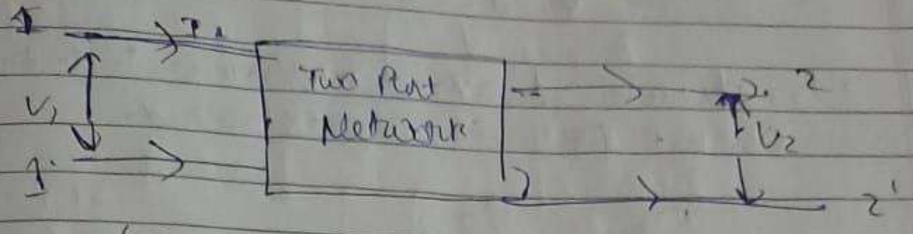
From eq(2) we have

$$Z_{21} = \frac{V_2}{I_1}\Bigg]_{I_2 0} \longrightarrow (5)$$

Z_{21} is called forward transfer impedance with the output ope circuited

$$Z_2 = \frac{V_2}{I_2}\Bigg]_{I_1=0}$$

Short circuited ~~a~~ impedence parameter



$$(I_1, I_2) = f(V_1, V_2)$$
$$[I] = [Y][V]$$

$$I_1 = Y_{11}V_1 + Y_{12}V_2 \quad -(7)$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2 \quad -(8)$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{12} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

From eq^n. (7) we have,

$$Y_{11} = \frac{I_1}{V_1}\Big]_{V_2=0} \longrightarrow (9)$$

Y_{11} is called the input ~~with the~~ admittance with ~~input~~ the output port short circuited.

$$Y_{12} = \frac{I_1}{V_2}\Big]_{V_1=0} \quad -(10)$$

Y_{12} is called the revers transfer admittance with the input port short-circuited.

From equation (8) we have

$$Y_{21} = \frac{I_2}{V_1}\Big]_{V_2=0} \longrightarrow (11)$$

Assignment

$(2n)!^2$ Not
$(n!)^2$

→ Two port network parameter -

(1) Open circuit ~~impedance~~ impedance (Z) parameter

(2) Short circuit admittance (Y) parameter.

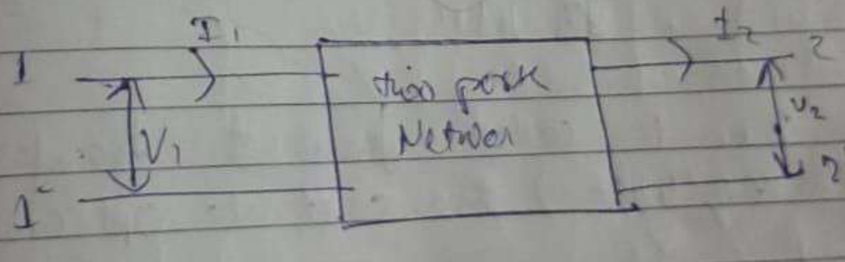
(3) Transmission parameter (A, B, C, D)

(4) Inverse transmission parameter (A', B', C', D')

(5) Hybrid Parameter (h)

(6) Inverse Hybrid Parameter (g)

→ Open circuit impedance (z) parameter



Charateristic eq: $(V_1, V_2) = f(I_1, I_2)$

$$[V] = [Z][I]$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$B = \frac{V_1}{-I_2}\Bigg]_{V_2=0} \longrightarrow (16)$$

B: reverse transfer impedance with the output port circuit.

From eq (14) we have

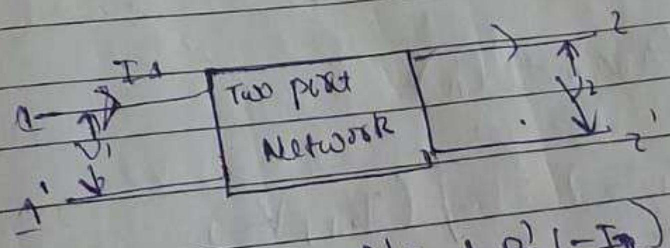
$$C = \frac{I_1}{V_2}\Bigg]_{I_2=0} \longrightarrow (17)$$

Reverse transfer ampedance with the output open circuit.

$$D = \frac{I_1}{-I_2}\Bigg]_{V_2=0} \longrightarrow (18)$$

output short circuit

* Inverse transmission parameters (A', B', C', D')



$$V_2 = A'V_1 + B'(-I_1) \longrightarrow (19)$$
$$I_2 = C'V_1 + D'(-I_1) \longrightarrow (20)$$

$$\begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} \begin{bmatrix} V_1 \\ -I_1 \end{bmatrix}$$

$$Y_{21} = \cancel{\frac{I_2}{V_1}}\Big]_{2=0} \longrightarrow (11)$$

Y_{21}: forward transfer admittance with the output port short circuited.

$$Y_{22} = \frac{I_2}{V_2}\Big]_{V_1=0} \longrightarrow 12$$

Y_{22} Output admittance with the ~~help~~ of input port short circuited

$$V_1 = AV_2 + B(-I_2) \rightarrow (13)$$

$$I_2 = CV_2 + D(-I_2) \;-\; (14)$$

$$\cancel{\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

From eq^n (13) we have

$$A = \frac{V_1}{V_2}\Big]_{I_2=0} \longrightarrow (15)$$

A : Reverse voltage gain with the output port open circuited.

Out

$$V_1 = h_{11} I_1 + h_{12} V_2 \longrightarrow (25)$$

$$I_2 = h_{21} I_1 + h_{22} V_2 \longrightarrow (26)$$

From eq. (25) we have

$$h_{11} = \frac{V_1}{I_1}\Big]_{V_2 = 0} \longrightarrow (27)$$

Input impedence with output short circuited

$$h_{12} = \frac{V_1}{V_2}\Big]_{I_1 = 0} \longrightarrow (28)$$

Reverse voltage gain with input open circuit

From eqn (26) we have,

$$h_{21} = \frac{I_2}{I_1}\Big]_{V_2 = 0}$$

(Forward current gain with output short circuit)

$$h_{22} = \frac{I_2}{V_2}\Big]_{I_1 = 0} \longrightarrow (30)$$

(Forwar current ompedence with open circuit)

Inverse Hybrid parameters (g)

$$(V_2, I_1) = f(I_2, V_1)$$

$$\begin{bmatrix} V_2 \\ I_1 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} I_2 \\ V_1 \end{bmatrix}$$

$$V_2 = g_{11} I_2 + g_{12} V_1 \longrightarrow (31)$$

$$I_1 = g_{21} I_2 + g_{22} V_1 \longrightarrow (32)$$

For eqn (31) we have,

$$g_{11} = \frac{V_2}{I_2}\Big]_{V_1=0} \longrightarrow (33)$$

$$g_{12} = \frac{V_2}{V_1}\Big]_{I_2=0} \longrightarrow (34)$$

For en.qn (32) we have

$$g_{21} = \frac{I_1}{I_2}\Big]_{V_1=0} \longrightarrow (3$$

$$g_{22} = \frac{I_1}{V_1}\Big]_{I_2=0} \longrightarrow (36)$$

From eq^n (19) we have,

$$A' = \left.\frac{V_2}{V_1}\right]_{I_1=0} \longrightarrow (21)$$

Forward voltage ration

$$B' = \left.\frac{V_2}{-I_1}\right]_{V_1=0} \longrightarrow (22)$$

Forward transfer impedance.

From eq^n (20) we have.

$$C' = \left.\frac{I_2}{V_1}\right]_{I_1=0} \longrightarrow (23)$$

Forward transfer ampidance

$$D' = \left.\frac{I_2}{-I_1}\right]_{V_1=0} \longrightarrow (24)$$

Forward current gain

(5) Hybrid Parameter (h)

$$(V_1, I_2) = f(I_1, V_2)$$

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

The original representation for z parameter is:-

$$V_1 = Z_{11} I_1 + I_2 Z_{12} \longrightarrow (1)$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2 \longrightarrow (2)$$

From eq (1) & (2)

$$\cancel{V_1 = Z_{11} I_1 +}$$

$$Z_{11} = \frac{V_1}{I_1}\bigg]_{I_2=0} \longrightarrow (3)$$

$$Z_{12} = \frac{V_1}{I_2}\bigg]_{I_1=0} \longrightarrow (4)$$

$$Z_{21} = \frac{V_1}{I_1}\bigg]_{I_2=0} \longrightarrow (5)$$

$$Z_{22} = \frac{V_2}{I_2}\bigg]_{I_1=0} \longrightarrow (6).$$

In order to determine the open circuit impedance parameters or z parameters we open the input core. and Excite output core with a known voltage source V_s so that $V_2 = V_s$ & $I_1 = 0$.
We determine I_2 & V_1 to obtain Z_{12} & Z

Then the output code is open circuited and the input code is exited with the same voltage source V_s

The circuit is analysed to determin I_1 V_2 so as to obtain Z_{11} & Z_{21}

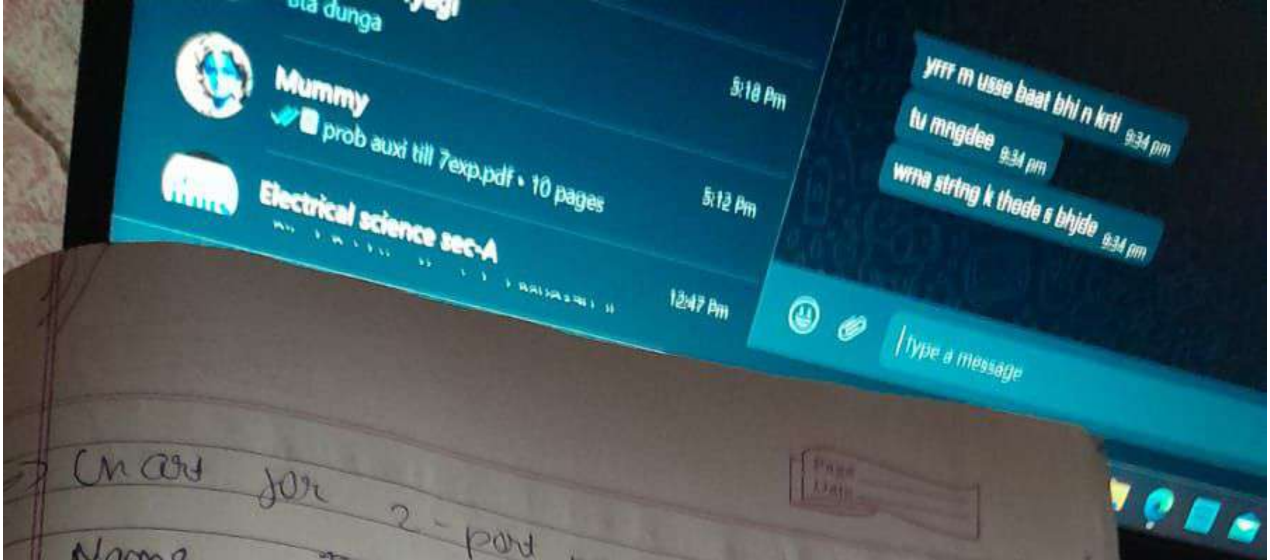
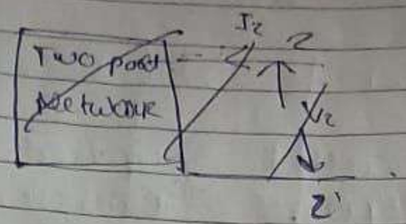
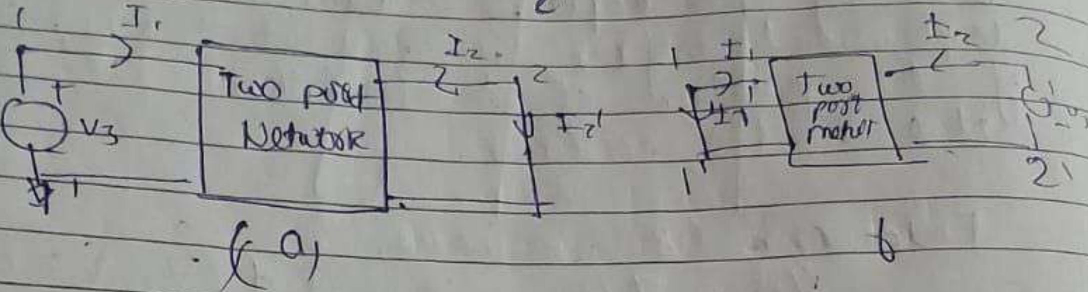


Chart for 2-port parameter

Name	Functions Express	In terms of	Equation
Z-parameter	V_1, V_2	I_1, I_2	$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$
Y-parameter	I_1, I_2	V_1, V_2	$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$
A, B, C, D parameter	V_1, I_1	V_2, I_2	$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$
A', B', C', D' parameters	$V_2\ I_2$	V_1, I_1	$\begin{bmatrix} V_2 \\ I_1 \end{bmatrix} = \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} \begin{bmatrix} V_1 \\ -I_1 \end{bmatrix}$
h-parameter	V_1, I_2	I_1, V_2	$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$
g-parameter	V_2, I_1	I_2, V_1	$\begin{bmatrix} V_2 \\ I_1 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} I_2 \\ V_1 \end{bmatrix}$

For determining reciprocity we consider the following network.





As in fig(a) we apply short circuit in the output side and apply voltage source V_s in Port. 1

Then,

$$V_s = V_1 \quad - (10)$$

$$V_2 = 0 \quad - (11)$$

$$I_2 = -I_2' \quad - (12)$$

Applying these 3 equations (10) (11) (12) on equation 1 & 2 we have

$$V_s = Z_{11} I_1 - Z_{12} I_2' \rightarrow (13)$$

$$0 = Z_{21} I_1 - Z_{22} I_2'$$

(13) & (14) gives

$V_s = I(Z_{11} + Z_{21}) I_1 + (Z_{12} - Z_{22})$

From equation (13) we have,

$$I_1 = \frac{V_s + Z_{12} I_2}{Z_{11}} \longrightarrow (15)$$

From eqn (14) we have,

$$I_1 = \frac{Z_{22}}{Z_{21}} I_2' \longrightarrow (16)$$

From eqn 15 & 16 we have

$$\frac{V_s + Z_{12} I_2}{Z_{11}} = \frac{Z_{22}}{Z_{21}} I_2'$$

$$V_s Z_{21} + Z_{12} Z_{21} I_2 = Z_{11} Z_{22} I_2'$$

$$(Z_{11} Z_{22} - Z_{12} Z_{21}) I_2' = V_s Z_{21}$$

$$I_2' = \frac{V_s Z_{21}}{(Z_{11} Z_{22} - Z_{12} Z_{21})} \quad - (17)$$

we apply short circuit on port
A voltage source V_s on port 2

$$V_2 = V_s \quad - (18)$$

$$V_1 = 0 \quad - (19)$$

$$I_1 = -I_1' \rightarrow (20)$$

Electrical science sec-A

12:47 Pm

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Eqⁿ (1) can be so written as

$$V_1 = (Z_{11} - Z_{12})I_1 + Z_{12}(I_1 + I_2) \quad -(7)$$

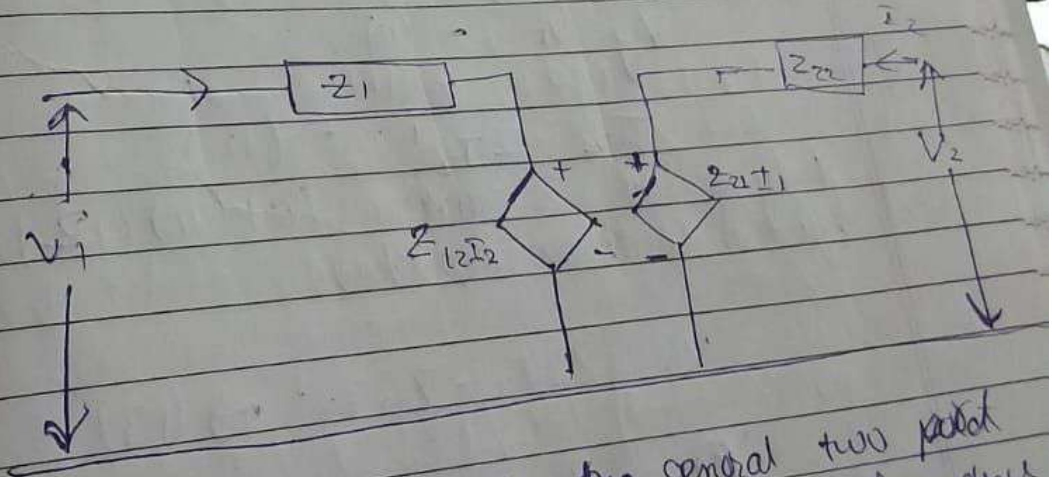
$$V_2 = (Z_{21} - Z_{22})I_1 + Z_{22}(I_1 + I_2) \quad -(8)$$

A network is called reciprocal if the ratio of the response transform to the excitation transform is invariant to interchange of the positions of the excitation and response in the network.

From eqⁿ (8) we have,

$$V_2 = (Z_{21} - Z_{12})I_1 + (Z_{22} - Z_{12})I_2 + Z_{12}(I_1 + I_2) \rightarrow (9)$$

The equivalent circuit representation for eqⁿ (1) & (2).



[two generator equivalent of the general two port network in terms of open circuit impedance parameters]

$$0 = -Z_{11} I' + Z_{12} I_2 \longrightarrow (21)$$

$$V_s = -Z_{21} I_1' + Z_{22} I_2 \longrightarrow (22)$$

From eq (21) we have,

$$I_2 = \frac{Z_{11}}{Z_{12}} I_1' \quad \text{—— (23)}$$

From eq (22) we have

$$I_2 = \frac{V_s + Z_{21} I_1'}{Z_{22}} \longrightarrow (24)$$

From eq (23) & (24) we have

$$\frac{Z_{11}}{Z_{12}} I_1' = \frac{V_s + Z_{21} I_1'}{Z_{22}}$$

Or $Z_{11} Z_{22} I_1' = Z_{12} V_s + Z_{12} Z_{21} I_1'$

Or $(Z_{11} Z_{22} - Z_{12} Z_{21}) I_1' = V_s \cdot Z_{12}$

$$I_1' = \frac{V_s \cdot Z_{12}}{(Z_{11} Z_{22} - Z_{12} Z_{21})} \longrightarrow (25)$$

=> Condition for reciprocity & symmetry of (Y) parameter.

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

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

$V_2 = 0$ (short circuiting)

$V_1 = V_s$

$I_2 = -I_2'$

Result

$\boxed{Y_{12} = Y_{21}}$ ← Reciprocity

$\boxed{Y_{11} = Y_{22}}$ ← Symmetry

Self Karore

=> Condition for reciprocity & symmetry of (ABCD) parameter.

Note:

$V_1, V_2 = f(I_1, I_2) \leftarrow Z$

$I_1, I_2 = f(V_1, V_2) \leftarrow Y$

$V_1, I_1 = f(V_2\ I_2) \leftarrow A, B, C, D$

$V_2\ I_2 = f(V_1, I_1) \leftarrow A', B', C', D'$

$V_1, I_2 = f(I_1, V_2) \leftarrow h$

$V_2, I_1 = f(I_2, V_1) \leftarrow g$

Eq of ABCD

$$V_1 = AV_2 - BI_2 \longrightarrow (1)$$
$$I_1 = CV_2 - DI_2 \longrightarrow (2)$$

For the network to be reciprocal we use the principal of reciprocity. We apply a voltage source V_S at ascending end with the receiver end shorted.

So, $V_1 = V_S$ — (3)

$V_2 = 0$ — (4)

$I_2 = -I_2'$ — (5)

$V_S = BI_2'$

$$\boxed{\frac{I_2'}{V_S} = \frac{1}{B}} \quad \text{— (6)}$$

Now we interchange the positions of excitation & response. So,

$V_1 = 0$ — (7)

$V_2 = V_S$ — (8)

$I_1 = -I_1'$ — (9)

Eq 7,8,9 apply in (1 & 2)

$$0 = AV_S - BI_2 \longrightarrow (10)$$
$$-I_1' = CV_S - DI_2 \longrightarrow (11)$$

Comparing I_1' & I_2' the condition for reciprocity become

$$\boxed{Z_{12} = Z_{21}}$$

similarly for condition of symmetry we apply voltage source V_s at port 1 with port 2 open circuited and find $\frac{V_s}{I_1}$

From eq (1) & (2)

$V_1 = V_s \rightarrow (26)$

$I_2 = 0 \rightarrow (27)$

Applying equation 26 & 27 on eq 1 &

$$\boxed{V_s = Z_{11} I_1} \longrightarrow (28)$$

$$\boxed{V_2 = Z_{21} I_1}$$

$$\boxed{\frac{V_s}{I_1} = Z_{11}} \rightarrow (29).$$

Now we apply V_s at port 2 & port (1) is open circuited.

$I_1 = 0 \rightarrow (30)$

$V_2 = V_s \rightarrow (31)$

$V_s = Z_{22} I_2$

$$\boxed{\frac{V_s}{I_2'} = Z_{22}} \rightarrow (32).$$

Condition of Symmetry $\boxed{Z_{11} = Z_{22}}$

→ Symmetry

The defination of symmetry for Z parameter can
as $Z_{11} = Z_{22}$ — (16)

$$Z_{11} = \frac{V_1}{I_1}\Big]_{I_2=0} = \frac{AV_1 - B}{CV_1 - DI} = \frac{A}{C} \rightarrow$$

$$Z_{22} = \frac{V_2}{I_2}\Big]_{I_1=0}$$

Interpolation and Approximation

UNIT - IV

Numerical solution of ordinary Differential Equations: Pica
Runge-Kutta's methods, Predictor-corrector methods: Eule
method.
Numerical Solution of Partial Differential equations: Parabol
Implementation to be done in C/C++

Textbook(s):

& David R. Kincaid, "Numerical Mathema

From eq^n (10) we have

$$I_2 = \frac{AVs}{B} \rightarrow (12)$$

from eq (11) we have,

$$DI_2 = CVs + I_1'$$

$$\therefore \quad I_2 = \frac{CVs + I_1'}{D} \rightarrow (13)$$

Equating eq 13 & 12

$$\frac{AVs}{B} = \frac{CVs + I_1'}{D}$$

or $ADVs = BCVs + BI_1'$

or $Vs(AD - BC) = BI_1'$

$$\boxed{\frac{I_1'}{Vs} = \frac{AD - BC}{B}} \quad - (14)$$

As per the defination of recipro[cal] the LHS of (6) & (14) should [be] identical

$$\frac{AD - BC}{} = 1$$

$$\begin{vmatrix} A & B \\ C & D \end{vmatrix} = 1 \rightarrow (1$$

Determinant

$F = \{q_1\}$

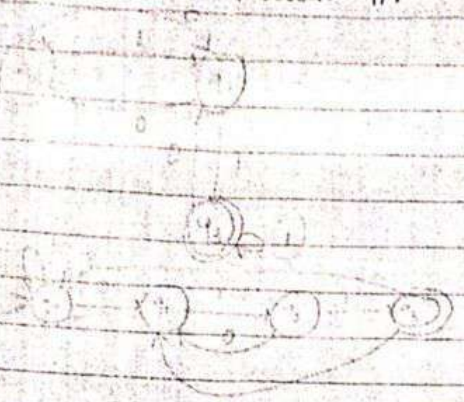
$q_0 = \{q_0\}$

$Q = \{q_0, q_1, q_2, q_3\}$

$\delta = Q \times \Sigma \rightarrow Q.$

Good Write

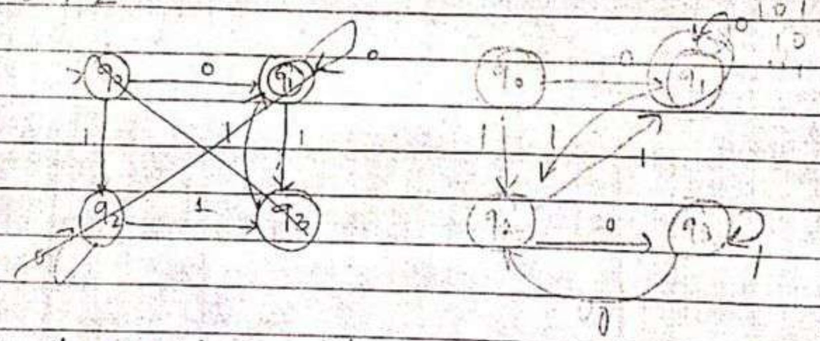
string should end with 11. 011|011



Q The set of all strings which when interpreted as binary integer is a multiply of 3.

q_1 q_2

q_0 0 1 2



Q The set of all strings which when interpreted as binary integer is a multiply of 5.

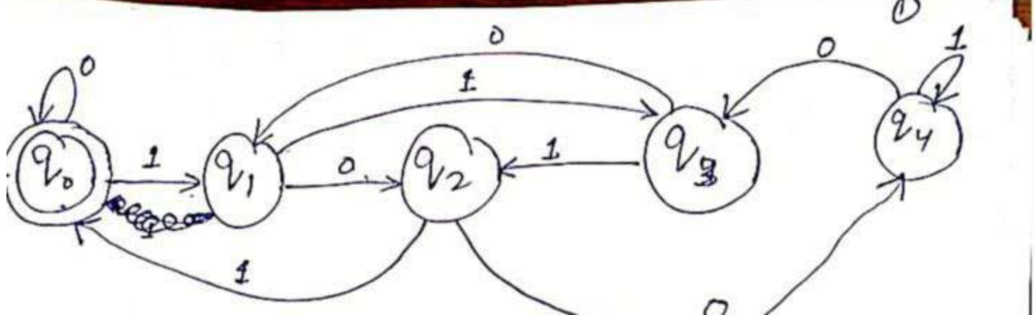
$n \% 5 = 0 \rightarrow q_0$ 0→0, 5→101, 10=1010, 15=1111

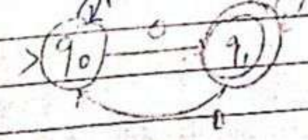
$n \% 5 = 1 \rightarrow q_1$ 1→1, 6→110, 11→1011 16=10000

$n \% 5 = 2 \rightarrow q_2$ 2=10

$n \% 5 = 3 \rightarrow q_3$ 3=11

$n \% 5 = 4 \rightarrow q_4$ 4=100





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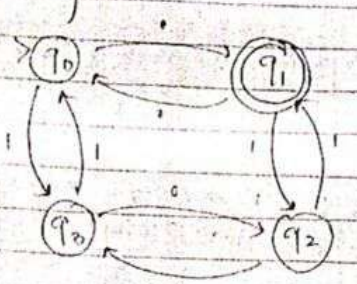
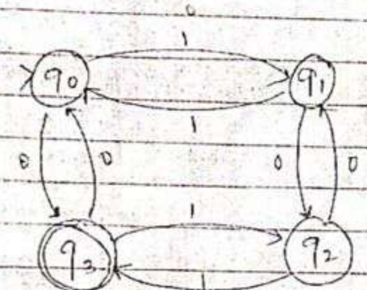
Ques Draw a DFA for all ~~strings~~ strings over {0,1} consisting odd no. of zeroes & even no. of '1'



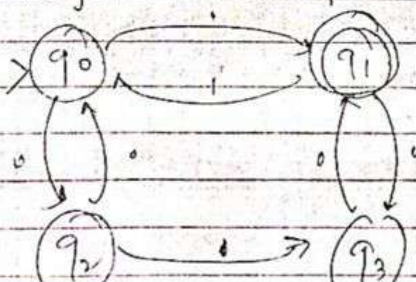
101
00111

11110

or



Ques Draw a DFA for all strings over {0,1} consisting even no. of '0' & odd no. of '1'.



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$M = \langle Q, F, q_0, \delta, \Sigma \rangle$

$\Sigma = \{0,1\}$

$F = \{q_1\}$

$q_0 = \{q_0\}$

$Q = \{q_0, q_1, q_2, q_3\}$

$\delta = Q \times \Sigma \to Q$.

Good Write

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String should end with 11. 011 | 011