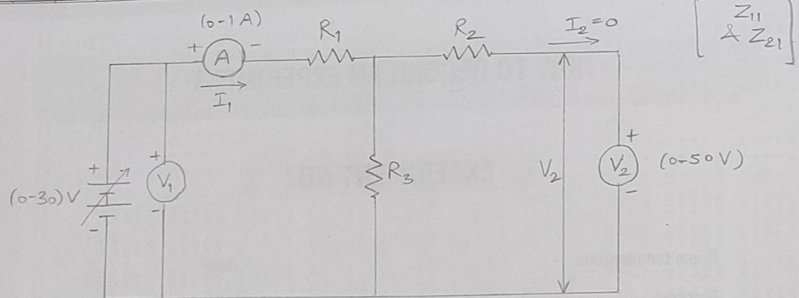
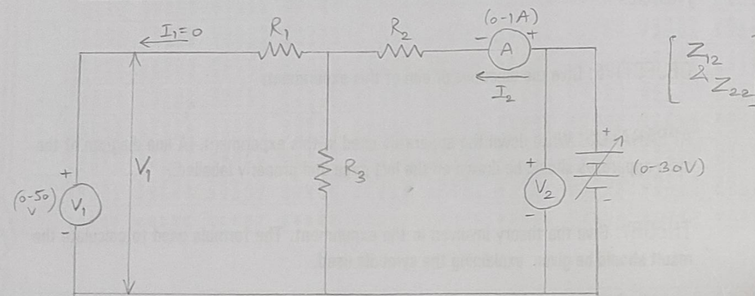
$\begin{bmatrix} Z_{11} \\ \& Z_{21} \end{bmatrix}$



$\begin{bmatrix} Z_{12} \\ \& Z_{22} \end{bmatrix}$



Observations :

When O/P is open ckt. $I_2 = 0$					When I/P is open ckt. $I_1 = 0$				
V_1 (V)	V_2 (V)	I_1 (mA)	$Z_{11} = \frac{V_1}{I_1}$ (Ω)	$Z_{21} = \frac{V_2}{I_1}$	V_1 (V)	V_2 (V)	I_2 (mA)	$Z_{12} = \frac{V_1}{I_2}$ (Ω)	$Z_{22} = \frac{V_2}{I_2}$ (Ω)
5	2.5	2	2.5	1.25	2.5	5	2	1.25	2.5
10	4.5	5	2	0.9	4.5	10	5	0.9	2
12.5	5.5	6	2.083	0.916	6.0	12.5	6	0.916	2.083

$$Z = \begin{bmatrix} 2.194 & 1.022 \\ 1.022 & 2.194 \end{bmatrix}$$

Date 30-1-24

Expt. No. 1

Page No. 1

Experiment -1

* **AIM :** To calculate and verify 'Z' & 'Y' parameters of two-port network.

* **Apparatus Required :** power supply, bread board, three resistances, connecting leads, voltmeter, ammeter, etc.

* **'Z' Parameters :**

•) **Brief theory:** In Z parameters of a two-port, the input & output voltages V_1 & V_2 can be expressed in terms of input & output currents I_1 & I_2. Out of four variables (V_1, V_2, I_1, I_2), V_1 & V_2 are dependent variables and I_1 & I_2 are independent.

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

Here, Z_{11} & Z_{22} are input & output driving point impedances while Z_{12} & Z_{21} are reverse & forward transfer impedances.

•) **Procedure :**

1. Connect the variable voltage to port 1 & keep port 2 open circuit i.e. $I_2 = 0$ as shown in figure. Set diff. voltages on V_1 and measure V_1, V_2 and I_1 for each setting and tabulate Z_{11} & Z_{21}.
2. Connect the variable voltage to port 2 & keep port 1 open circuit i.e. $I_1 = 0$ as shown in figure. Set diff.

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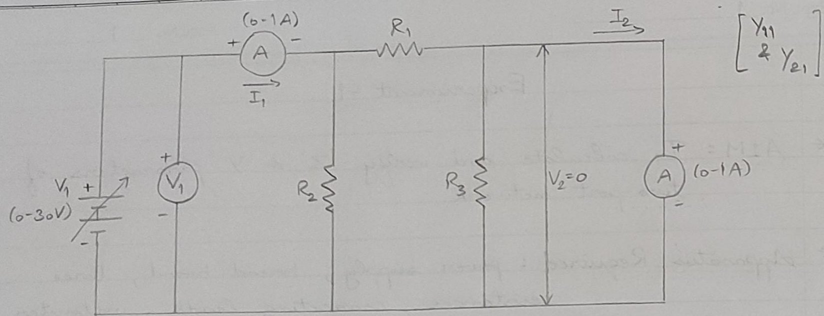
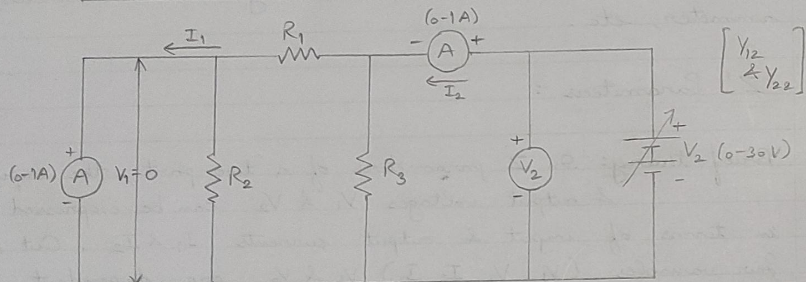




Observations:

When O/P is open ckt. $V_2=0$					When I/P is open ckt. $V_1=0$				
V_1 (V)	I_1 (mA)	I_2 (mA)	$Y_{11}=I_1/V_1$ (℧)	$Y_{21}=I_2/V_1$ (℧)	V_2 (V)	I_1 (mA)	I_2 (mA)	$Y_{12}=I_1/V_2$ (℧)	$Y_{22}=I_2/V_2$ (℧)
5	12	5	2.4	1	5	5	11	1	2.2
10	24	11	2.4	1.1	10	11	22	1.1	2.2
12.5	30	14	2.4	1.12	12.5	14	27	1.12	2.16

$$Z = \begin{bmatrix} 2.4 & 1.073 \\ 1.073 & 2.1867 \end{bmatrix}$$

voltages at V_2 and measure V_2, V_1, I_2 for each setting and tabulate Z_{12} & Z_{22}.

* 'Y' Parameters :

• **Brief Theory:** In Y-parameters of a two port, the input & output currents I_1 & I_2 can be expressed in terms of input & output voltages V_1 & V_2. Out of 4 variables (I_1, I_2, V_1, V_2), I_1 & I_2 are dependent and V_1 & V_2 are independent.

$$I_1 = Y_{11} V_1 + Y_{12} V_2 \quad \text{—(1)}$$

$$I_2 = Y_{21} V_1 + Y_{22} V_2 \quad \text{—(2)}$$

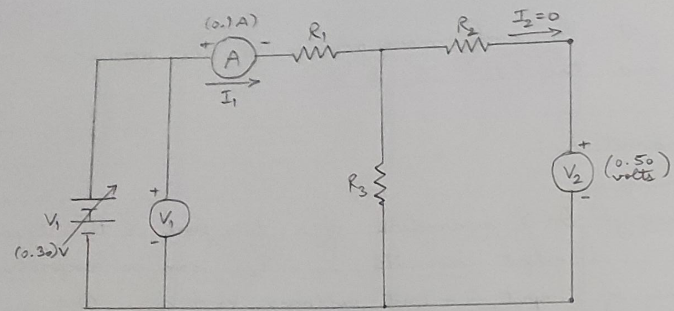
Here, Y_{11} & Y_{22} are the input & output driving point admittances while Y_{12} & Y_{21} are the reverse & forward transfer admittances.

• **Procedure :**

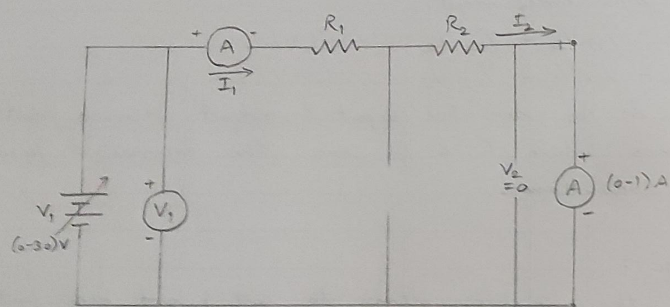
1. Connect the variable voltage to port 1 and keep port 2 short i.e. $V_2=0$. Set diff. voltages on V_1 & measure V_1, I_2 and I_1 for each setting and tabulate Y_{11} & Y_{21}.
2. Connect the variable voltage to port 2 and keep port 1 short i.e. $V_1=0$. Set diff voltages on V_2 & measure V_2, I_1, I_2 for each setting and tabulate Y_{12} & Y_{22}.

* Result : The Z & Y parameters of the two port network has been calculated and verified.

Teacher's Signature



Circuit for determining A & C.



Circuit for determining B & D.

Date 13-2-24

Expt. No. 2

Page No. 3

Experiment - 2

* **AIM:** To calculate and verify 'ABCD' parameters of two-port network.

* **Apparatus required:** power supply, bread board, resistances, connecting leads, voltmeter, ammeter etc.

* **Theory:** ABCD parameters are widely used in analysis of power transmission engineering where they are termed as "Circuit Parameters". ABCD parameters are also known as "Transmission Parameters". In these parameters, the voltage & current at the sending end terminals can be expressed in terms of voltage & current at the receiving end. Thus,

$$V_1 = AV_2 + B(-I_2)$$
$$I_1 = CV_2 + D(-I_2)$$

Here, "A" is called reverse voltage ratio, "B" is called transfer impedance, "C" is called transfer admittance & "D" is called reverse current ratio.

* **Procedure:**

1. Connect the variable voltage to port 1 and keep the port 2 open circuit i.e. $I_2 = 0$ as shown. Set different voltages on V_1 & measure V_1, V_2, I_1 for each setting and tabulate A&C.
2. Connect the variable voltage to port 1 and keep port 2 short circuit i.e. $V_2 = 0$. Set diff. voltages at V_1 & measure V_2, I_2, I_1 for each setting and tabulate B & D.

Teacher's Signature

* Observations Table:

When O/P is open ckt. $I_2 = 0$					When O/P is short ckt. $V_2 = 0$				
$V_1 (V)$	$V_2 (V)$	I_1 (mA)	$A = V_1/V_2$	$C = I_1/V_2$ (℧)	$V_1 (V)$	I_1 (mA)	I_2 (mA)	$B = V_1/I_2$ (Ω)	$D = I_1/I_2$
5	2	4	2.5	2	5	3	1	-5	-3
10	4.5	5	2.22	1.11	10	6	2	-5	-3
12.5	5.5	6	2.27	1.091	12.5	8	3	-4.167	-2.667

A = 2.33

B = -4.722

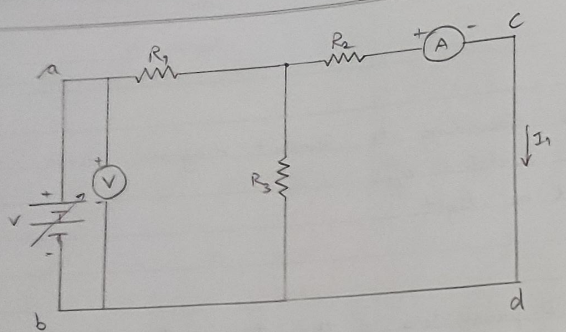
C = 1.4003

D = 2.889

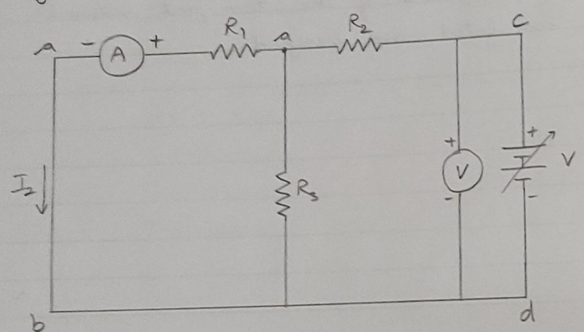
* Precautions:

1. Make connections according to circuit diagram. Power supply should be switched off.
2. Connections should be tight.

* Result: The ABCD-parameters of the two-port network has been calculated and verified.



Circuit for finding current I_1.



Circuit for finding current I_2.

* Observations Table :

Input voltage V (volts)	I_1 (mA)	I_2 (mA)	Error $I_1 - I_2$ (mA)
5	1	1	0
10	3	3	0
12.5	4	4	0

Experiment - 3

* **AIM** : To verify Reciprocity theorem.

* **Apparatus Required** : power supply, bread board, Three resistances, connecting leads, voltmeter, ammeter, etc.

* **Theory** : In any bilateral network, if a source of emf E in any branch produces a current I in any other branch, then the same emf E acting in the second branch would produce same current I in first branch.

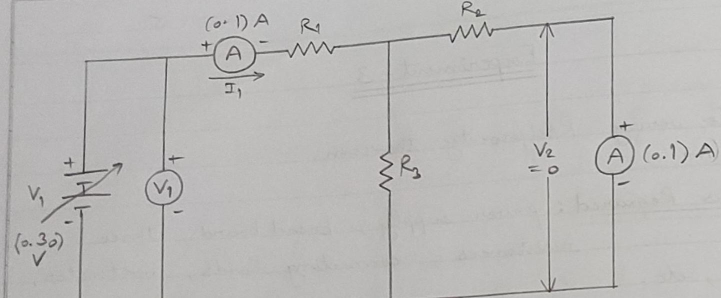
* **Procedure** :

1. Connect the circuit as shown in figure.
2. Apply some voltage V.
3. Note down the ammeter reading as "I_1".
4. Inter change ammeter and voltage source and read the ammeter reading as "I_2".
5. Repeat the above procedure for different values or V and tabulate the values.
6. I_1 should be equal to I_2.

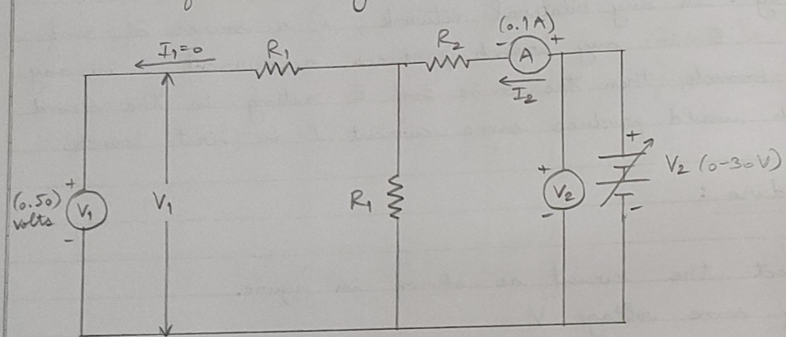
* **Precautions** : 1. Connect circuit elements as shown.
2. Avoid loose connections.
3. Take readings carefully & accurately.
4. Do not tamper the circuit elements.

* **Result** : $I_1 = I_2$

Teacher's Signature



Circuit for determining h_{11} & h_{21}.



Circuit for determining h_{12} & h_{22}.

Date 20-2-24

Expt. No. 4 Page No. 6

Experiment – 4

* **AIM:** To calculate and verify 'h' parameters of 2 port network.

* **Apparatus Required:** power supply, breadboard, 5 resistances, connecting leads, multimeter.

* **Theory:** In 'h' parameters of a two port network, voltage of input port & current of output port are expressed in terms of current of input port and voltage of output ~~p~~ port. Due to this reason, these parameters are called 'hybrid' parameters i.e. out of four variables (V_1, V_2, I_1, I_2) V_1 & I_2 are dependent while V_2 & I_1 are independent. Thus,

$$V_1 = h_{11} I_1 + h_{12} V_2$$
$$I_2 = h_{21} I_1 + h_{22} V_2$$

h_{11} & h_{22} are input impedance & output ~~abundance~~ admittance.
h_{21} & h_{12} are forward current gain & reverse voltage gain.

* **Procedure:**

1. Connect the variable voltage to port 1 & keep port 2 short circuit i.e. $V_2=0$. Set different voltages on V_1 & measure V_1, I_2, I_1 for each setting and tabulate h_{11} & h_{21}.
2. Connect the variable voltage to port 2 & keep port 1 open circuit i.e. $I_1=0$. Set different voltages on V_2 & measure V_1, V_2, I_2 for each setting and tabulate h_{12} & h_{22}.

Teacher's Signature ____________

* Observations Table:

When O/P is short ckt. $V_2 = 0$					When I/P is open ckt. $I_1 = 0$				
V_1 (V)	I_1 (mA)	I_2 (mA)	$h_{11} = V_1/I_1$ (Ω)	$h_{21} = I_2/I_1$	V_2 (V)	I_2 (mA)	V_1 (V)	$h_{12} = V_1/V_2$	$h_{22} = I_2$
5	3	2	1.667	0.667	5	2	1.5	0.3	0.4
10	7	3	1.428	0.4281	10	5	3.5	0.35	0.5
12.5	9	4	1.389	0.444	12.5	7	5	0.4	0.56

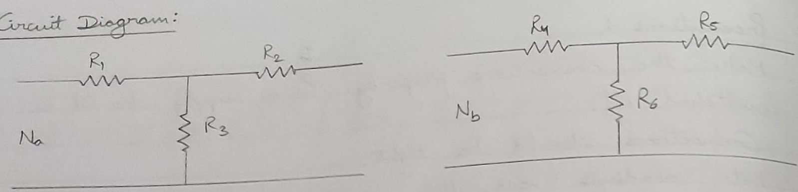
$$h = \begin{bmatrix} 1.494 & 0.35 \\ 0.513 & 0.4367 \end{bmatrix}$$

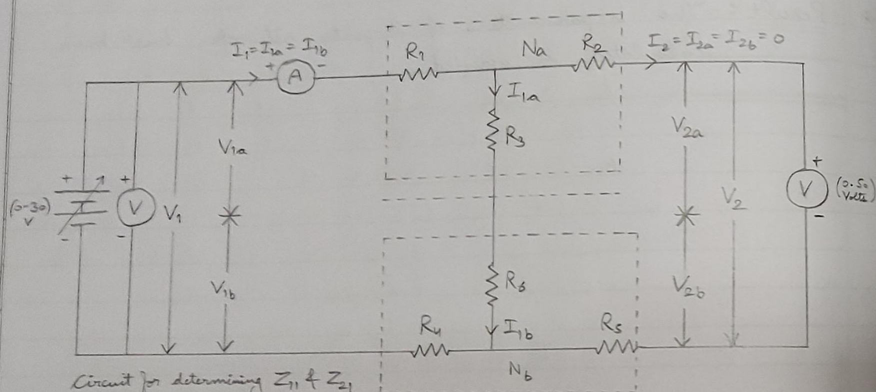
* Precautions :

1. Make the connections properly. Power supply should be switched off.
2. Connections should be tight.
3. Note readings carefully.

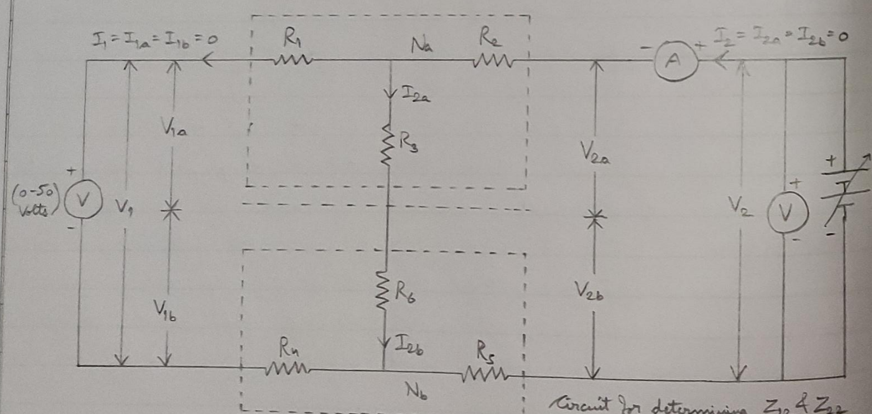
* Result : The h-parameters of 2-port network has been calculated & verified.

Circuit Diagram:





Circuit for determining Z_{11} & Z_{21}



Circuit for determining Z_{12} & Z_{22}

Experiment - 5

* **AIM:** To determine the equivalent parameters of series connection of two port network.

* **Apparatus Required:** power supply, bread board, resistances, connecting leads, multimeter etc.

* **Theory:** Two 2-port networks are said to be connected in series if the corresponding ports are connected in series.

Let N_a be described by Z_a parameters, N_b by Z_b and the overall two port network N by Z parameters. Before the networks are interconnected, the relationship between voltages and currents for N are given by:

$$\begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix} = \begin{bmatrix} Z_{11a} & Z_{12a} \\ Z_{21a} & Z_{22a} \end{bmatrix} \begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix}$$

Similarly for the network N_b,

$$\begin{bmatrix} V_{1b} \\ V_{2b} \end{bmatrix} = \begin{bmatrix} Z_{11b} & Z_{12b} \\ Z_{21b} & Z_{22b} \end{bmatrix} \begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix}$$

In matrix form we can write,

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11a} + Z_{11b} & Z_{12a} + Z_{12b} \\ Z_{21a} + Z_{21b} & Z_{22a} + Z_{22b} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

Observation Tables:

• When O/P is open circuit

V_2 (V)	V_1 (V)	V_{1a} (V)	V_{1b} (V)	V_{2a} (V)	V_{2b} (V)	$I_1 = I_{1a} = I_{1b}$ (mA)	$Z_{11a} = \frac{V_{1a}}{I_{1a}}$ (Ω)	$Z_{11b} = \frac{V_{1b}}{I_{1b}}$ (Ω)	$Z_{21a} = \frac{V_{2a}}{I_{1a}}$ (Ω)	$Z_{21b} = \frac{V_{2b}}{I_{1b}}$ (Ω)	$Z_{11} = V_1/I_1$ (Ω)	$Z_{21} = V_2/I_1$ (Ω)
2.5	5	2.5	2.5	1.25	1.25	1	2.5	2.5	1.25	1.25	5	2.5
4.5	10	5	5	2.25	2.25	2.5	2	2	0.9	0.9	4	1.8
6	12.5	6.25	6.25	3	3	3	2.083	2.0837	0.916	1.084	4.1607	2

• When I/P is open circuit

V_2 (V)	V_1 (V)	V_{1a} (V)	V_{1b} (V)	V_{2a} (V)	V_{2b} (V)	$I_2 = I_{2a} = I_{2b}$ (mA)	$Z_{22a} = \frac{V_{2a}}{I_{2a}}$ (Ω)	$Z_{22b} = \frac{V_{2b}}{I_{2b}}$ (Ω)	$Z_{12a} = \frac{V_{1a}}{I_{2a}}$ (Ω)	$Z_{12b} = \frac{V_{1b}}{I_{2b}}$ (Ω)	$Z_{12} = V_1/I_2$ (Ω)	$Z_{22} = V_2/I_2$ (Ω)
5	2.5	1.25	1.25	2.5	2.5	1	2.5	2.5	1.25	1.25	2.5	5
10	9.5	2.25	2.25	5	5	2.5	2	2	0.9	0.9	1.8	4
12.5	5.5	2.75	2.75	6.25	6.25	3	2.083	2.0837	0.9167	0.9167	1.833	4.1667

$$Z = \begin{bmatrix} 4.3889 & 2.0443 \\ 2.1 & 4.3889 \end{bmatrix}$$

For the overall network N,

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

Thus, the matrix of the two 2-port networks connected in series-series is equal to the sum of the z matrices of the individual networks,

$$[Z] = [Z_a] + [Z_b]$$

This result may be generalised for any number of 2-port networks connected in series. The overall z ~~network~~ matrix for the series-series connected 2-port networks is the sum of z matrices of the individual networks.

* **Procedure :**

1. Connect the circuit and switch 'ON' the experiment board.
2. Open the output port & excite input port with a known voltage source V_s so that $V_1 = V_s$ and $I_2 = 0$. We determine $V_2, V_{1a}, V_{1b}, V_{2a}, V_{2b}, I_1$ to obtain $Z_{11}, Z_{11a}, Z_{11b}, Z_{21}, Z_{21a}, Z_{21b}$.
3. Input port is open circuited and output port is excited with the same voltage source V_s so that $V_2 = V_s$ & $I_1 = 0$. We determine $V_1, V_{1a}, V_{1b}, V_{2a}, V_{2b}, I_2$ to obtain $Z_{22}, Z_{22a}, Z_{22b}, Z_{12}, Z_{12a}, Z_{12b}$.
4. Switch OFF the supply after taking the readings.

* Precautions :

1. Make the connections according to the circuit diagram. Power supply should be switched off.
2. Connections should be tight.
3. Note the readings carefully.

* Result :

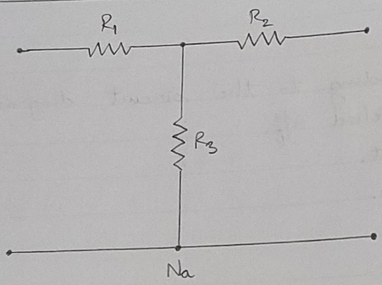
$Z_{11} = Z_{11a} + Z_{11b}$

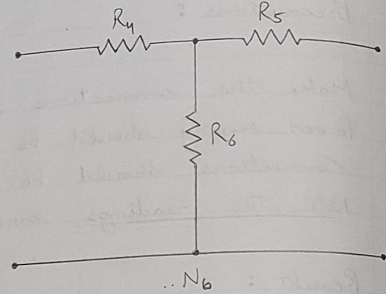
$Z_{22} = Z_{22a} + Z_{22b}$

$Z_{12} = Z_{12a} + Z_{12b}$

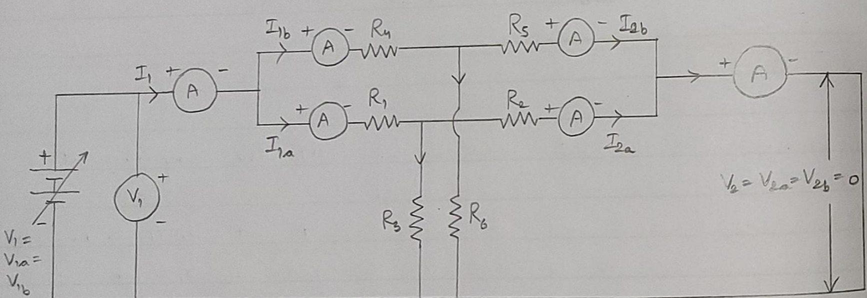
$Z_{21} = Z_{21a} + Z_{21b}$

Circuit Diagram :

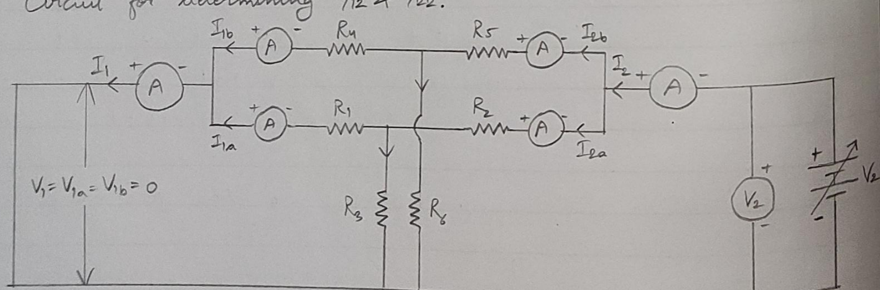




Circuit for determining Y_{11} & Y_{21}.



Circuit for determining Y_{12} & Y_{22}.



Experiment - 6

* AIM : To determine equivalent parameters of parallel connection of two-port network.

* Apparatus Required : power supply, bread board, 6 resistances, connecting leads, voltmeter, ammeter, etc.

* Theory : The method of interconnecting two 2-port networks shown in figure is called a parallel-parallel connection of two ports because the corresponding ports of each network are connected in parallel. Let us find the parameters of the overall 2-port network N. Before the networks are interconnected, the network N_a satisfies

$$\begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix} = \begin{bmatrix} y_{11a} & y_{12a} \\ y_{21a} & y_{22a} \end{bmatrix} \begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix}$$

Similarly, for the network N_b

$$\begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix} = \begin{bmatrix} y_{11b} & y_{12b} \\ y_{21b} & y_{22b} \end{bmatrix} \begin{bmatrix} V_{1b} \\ V_{2b} \end{bmatrix}$$

In order to connect two networks N_a & N_b in parallel, they must satisfy certain conditions. One test is performed at the output end and the other at the input end.

In matrix form we can write

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix} = \begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix}$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11a} + y_{11b} & y_{12a} + y_{12b} \\ y_{21a} + y_{21b} & y_{22a} + y_{22b} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

For the overall network N,

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

Teacher's Signature

Observations Tables :

•) Output port short circuited, $V_2 = 0$

$V_1 = V_{1b} = V_{1a}$ (V)	I_1 (mA)	I_2 (mA)	$Y_{11} = I_1/V_1$ (℧)	$Y_{21} = \frac{I_2}{V_1}$ (℧)
5	23.5	10	4.7	2
10	48	22	4.8	2.2
12.5	~60	27.5	4.8	2.2

•) Input port short circuited, $V_1 = 0$

$V_2 = V_{2b} = V_{2a}$ (V)	I_1 (mA)	I_2 (mA)	$Y_{22} = I_2/V_2$ (℧)	$Y_{12} = I_1/V_2$ (℧)
5	11	22	4.4	2.2
10	22	43	4.3	2.2
12.5	28	~54	4.32	2.24

$$Y_a = Y_b = \begin{bmatrix} 2.4 & 1.073 \\ 1.073 & 2.1867 \end{bmatrix}$$

$$[Y_c] = [Y_a] + [Y_b]$$

$$Y_c = \begin{bmatrix} 4.7667 & 2.2133 \\ 2.1333 & 4.34 \end{bmatrix}$$

Thus, the y matrix of the two 2-port networks connected in series-series is equal to the sum of the y matrices of the individual networks,

$$[y] = [y_a] + [y_b]$$

This result may be generalised for any no of 2-port networks connected in parallel.

* Procedure :

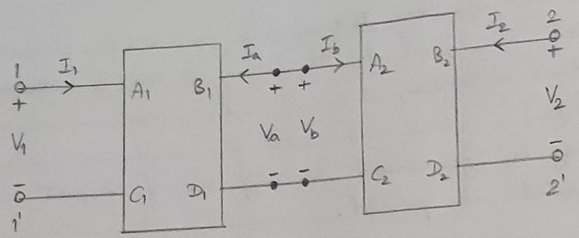
1. Connect the circuit as shown and switch 'ON' the experiment board.
2. Short the output port & excite input port with a known voltage source V_s ~~so~~ that $V_1 = V_s$ & $V_2 = 0$. We determine ~~to~~ $V_1, V_{1a}, V_{1b}, I_{2a}, I_{2b}, I_2, I_1$ to obtain $Y_{11}, Y_{11a}, Y_{11b}, Y_{21}, Y_{21a}, Y_{21b}$.
3. Input port is short circuited & output port is excited with the same voltage source V_s ~~so~~ that $V_2 = V_s$ & $I_1 = 0$. We determine $I_{1a}, I_{1b}, I_{2a}, I_{2b}, I_1, I_2, V_2$ to obtain $Y_{22}, Y_{22a}, Y_{22b}, Y_{12}, Y_{12a}, Y_{12b}$.
4. Switch OFF the supply after taking the readings.

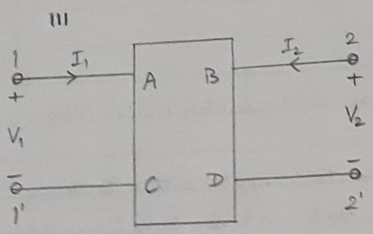
* Precautions :

1. Make connections according to ~~ckt~~ ckt. diagram. Power supply should be switched off.
2. Connections should be tight.
3. Note the readings carefully.

*** Result :** The Y-parameters of parallel connection of 2-port network has been determined.

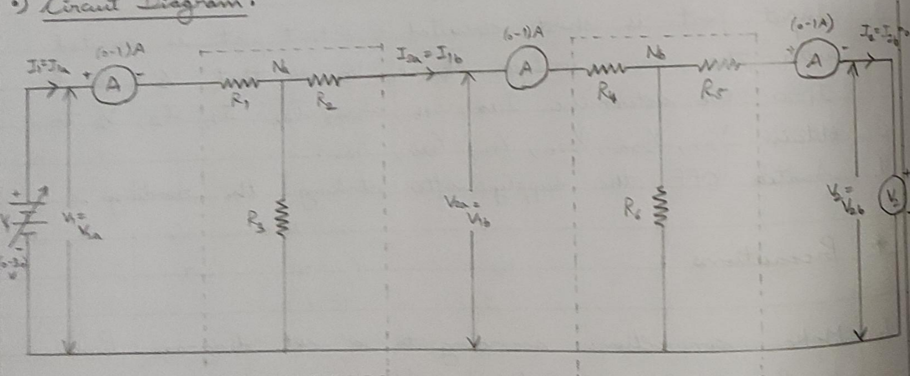
Teacher's Signature ______





Two cascaded networks and their equivalent network.

•) Circuit Diagram:



Circuit for determining A & C

Experiment -7

* **AIM**: To determine the 'ABCD' parameters of the cascade connection of two-port network.

* **Apparatus Required**: power supply, breadboard, resistances, connecting leads, multimeter, etc.

* **Theory**: Two networks are said to be connected in cascade if the output port ~~of~~ of one ~~of~~ is the input port of the second as shown in fig.

The overall parameters for several two-port networks connected in cascade may conveniently be found using ABCD parameters. Figure shows two cascaded networks and their equivalent network. For the first network,

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V_a \\ -I_a \end{bmatrix}$$

For the second network,

$$\begin{bmatrix} V_b \\ I_b \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

For the equivalent network,

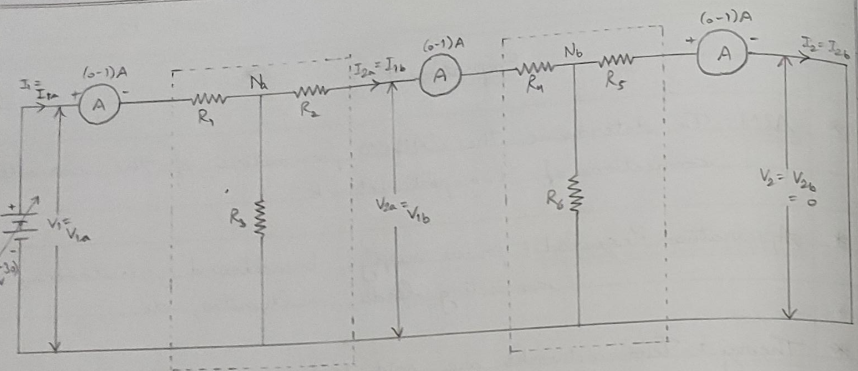
$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

From figure, $\begin{bmatrix} V_a \\ -I_a \end{bmatrix} = \begin{bmatrix} V_b \\ I_b \end{bmatrix}$

Combination of above three equations gives

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

Thus,



Circuit for determining B & D

•) Observation Tables :

• When O/P is open ckt.

$V_1 = V_{1a}$ (V)	$V_2 = V_{2b}$ (V)	$V_{1b} = V_{2a}$ (V)	$I_1 = I_{1a}$ (mA)	$I_{2a} = I_{1b}$ (mA)	$A = V_1/V_2$	$A_1 = V_{1a}/V_{2a}$	$A_2 = V_{1b}/V_{2b}$	$C = I_1/V_2$ (℧)	$C_1 = I_{1a}/V_{2a}$ (℧)	$C_2 = I_{1b}/V_{2b}$ (℧)

• When O/P is short ckt.

$V_1 = V_{1a}$ (V)	$V_{1b} = V_{2a}$ (V)	$I_1 = I_{1a}$ (mA)	$I_{2a} = I_{1b}$ (mA)	$I_2 = I_{2b}$ (mA)	$B = V_1/I_2$ (Ω)	$B_1 = V_{1a}/I_{2a}$ (Ω)	$B_2 = V_{1b}/I_{2b}$ (Ω)	$D = I_1/I_2$	$D_1 = I_{1a}/I_{2a}$	$D_2 = I_{1b}/I_{2b}$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}$$

Thus, the overall ABCD matrix for 2 cascaded networks is equal to the product of ABCD matrices of the individual networks taken in order. The result may be extended to any no. of cascaded networks.

* Procedure :

1. Connect the circuit as shown in fig. and switch ON the experiment board.
2. Open the output port & excite input port with a known voltage source V_s so that $V_1 = V_s$ and $I_2 = 0$. We determine to $V_2 (V_{2b})$, $V_1 (V_{1a})$, $V_{1b} (V_{2a})$, $I_1 (I_{1a})$, $I_{2a} (I_{1b})$ to obtain A, A_1, A_2, C, C_1 & C_2 as shown in fig.
3. Input port is excited with the same voltage source V_s so that $V_1 = V_s$ & output port short circuited & $V_2 = 0$. We determine $V_1 (V_{1a})$, $V_{1b} (V_{2a})$, $I_1 (I_{1a})$, $I_{2a} (I_{1b})$, $I_2 (I_{2b})$ to obtain B, B_1, B_2, D, D_1, D_2 as shown in fig.
4. Switch OFF the supply after taking the readings.

* Precautions :

1. Make the connections according to the circuit diagram. Power supply should be switched off.
2. Connections should be tight.
3. Note the readings carefully.

* Result :

$A = A_1 A_2 + B_1 C_2$

$B = A_1 B_2 + B_1 D_2$

$C = C_1 A_2 + D_1 C_2$

$D = C_1 B_2 + D_1 D_2$