Experiment - 5

Aim : Interconnection of a T network and a pie network in cascade form and determination of ABCD Parameters and verification of results.

Apparatus and Auxiliaries: D.C. power supply (0-12V), Carbon Resistors of 1K - 6K, Panel type DC voltmeter (0 - 20V), Pannel type DC Ammeter (0 - 25 mA), connecting wires or patch cords.

Theory :

→ When input voltage and current are expressed in terms of output voltage and load current, the parameters are known as Transmission Parameters

→ ABCD parameters are same as transmission parameters and for any resissive network, there values are always positive.

→ When two or more than 2 networks are connected in cascade, their T-parameter matrices get multiplied.

CASCADE : output of first subsystem acts as input for the second.

Interconnection constraints

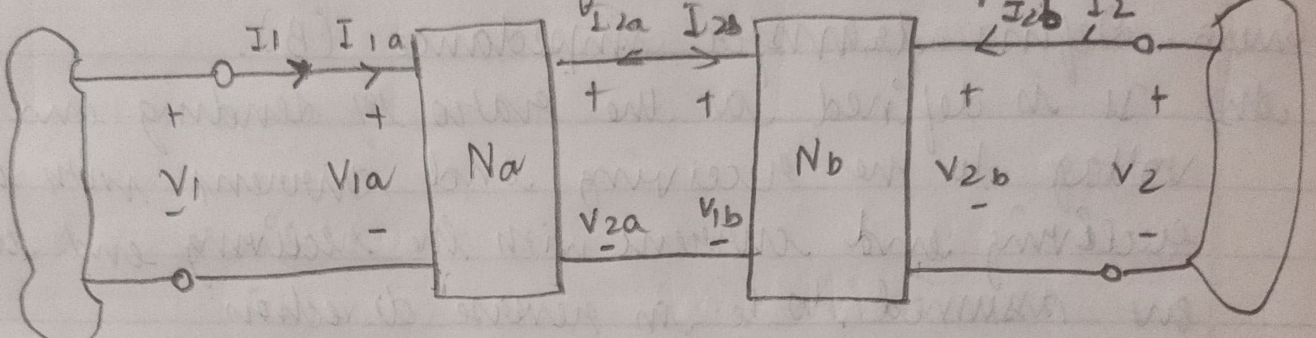
$I_{2a} = -I_{1b}$ $\quad V_{2a} = V_{1b}$

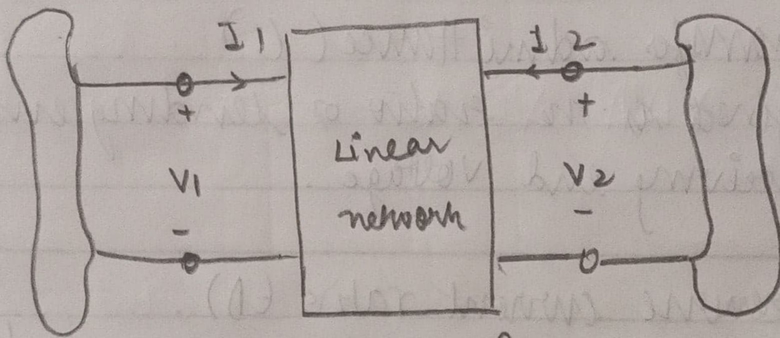
$V_1 = V_{1a}$ $\quad V_2 = V_{2b}$

$I_1 = I_{1a}$ $\quad I_2 = I_{2b}$

Aim: Interconnection of a T-network and a π-network in cascade form and determination of ABCD parameters and verification of results

Cascade connection using transmission parameters





$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

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

$$\begin{bmatrix} V_{1a} \\ I_{1a} \end{bmatrix} = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} V_{2a} \\ -I_{2a} \end{bmatrix}$$

$$\begin{bmatrix} V_{1b} \\ I_{1b} \end{bmatrix} = \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} \begin{bmatrix} V_{2b} \\ -I_{2b} \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

Permissibility of cascade interconnection :

→ Both 3 terminal, and 4 terminal two port networks can be connected in cascade without any problem or complication

→ Always the output port of first network is connected to the input port of the second network and so on.

Appeication of Cascade Interconnection :

→ Transmission line utilizes the concept of cascade connection by treating a long line as a cascaded network of short lines

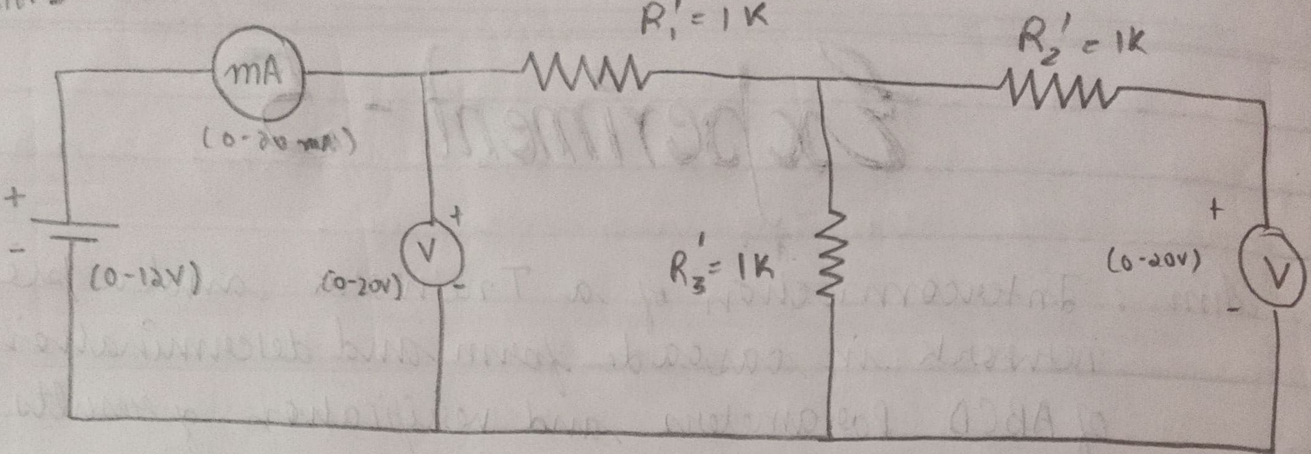
→ Cascade amplifiers, used in analog circuits also based on the concept of cascade connection where the output of first stage of amplifier becomes the second stage and so on. It results in magnification of voltage gain, and current gain, etc.

Procedure :

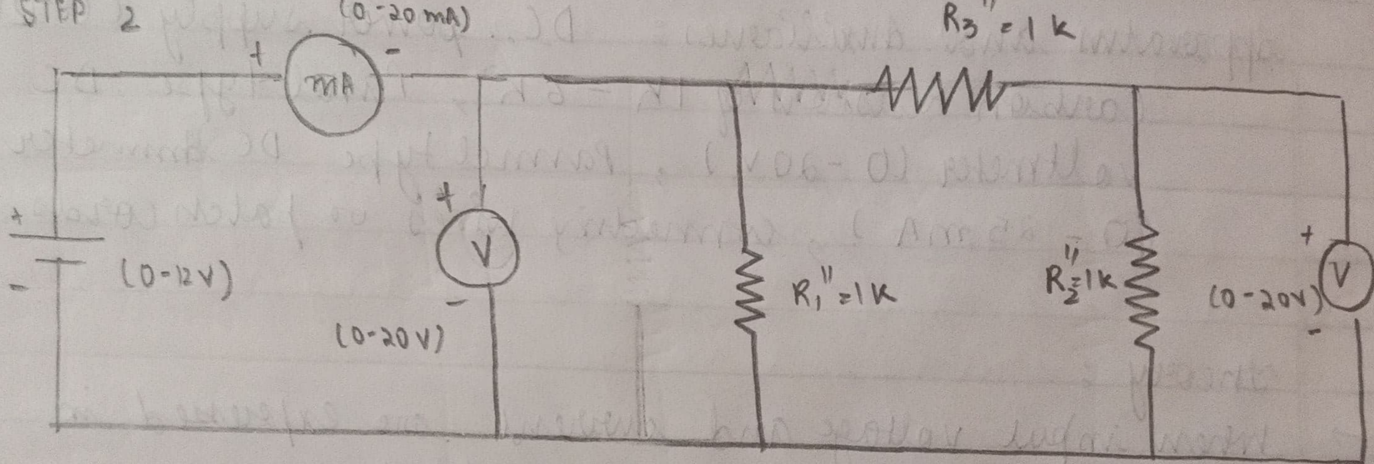
connect the circuit as shown in step 1, step 2, step 3, step 4, step 5 and step 6.

CASCADE CONNECTION OF NETWORKS

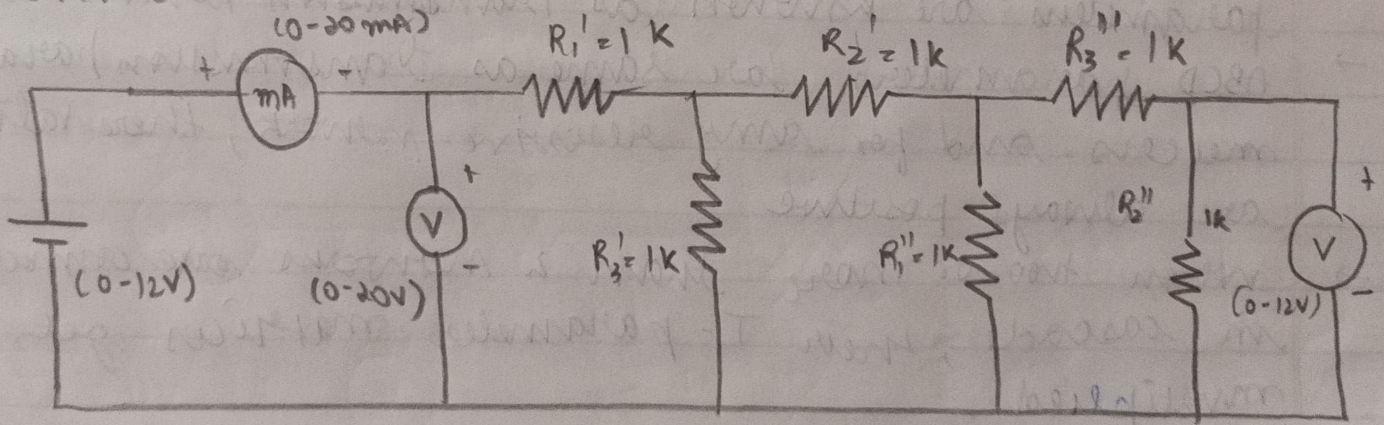
STEP 1



STEP 2



STEP 3

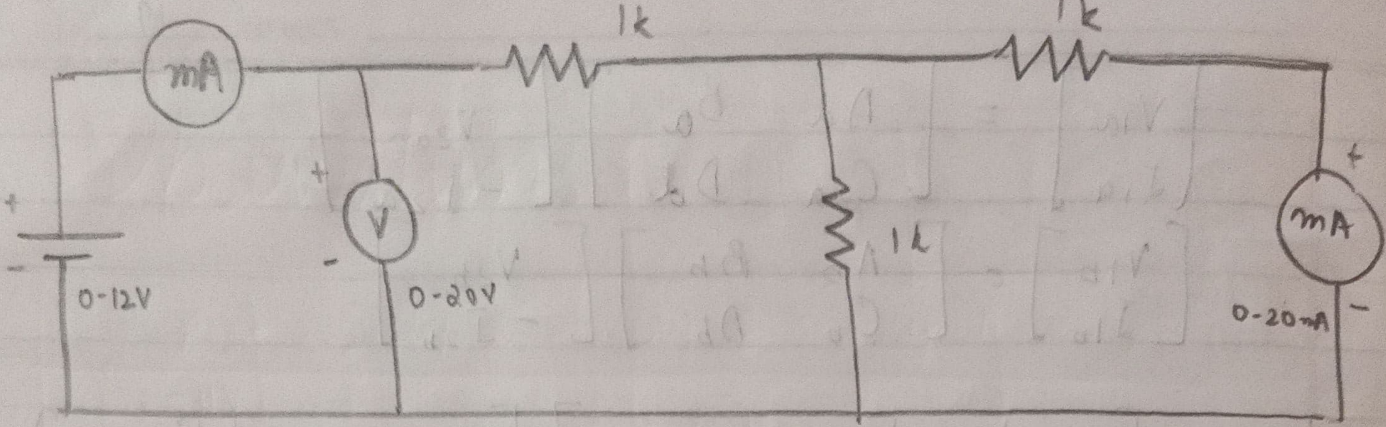


$V_1 = V_{1a} = 11V$

$I_1 = I_{1a} = 6mA$

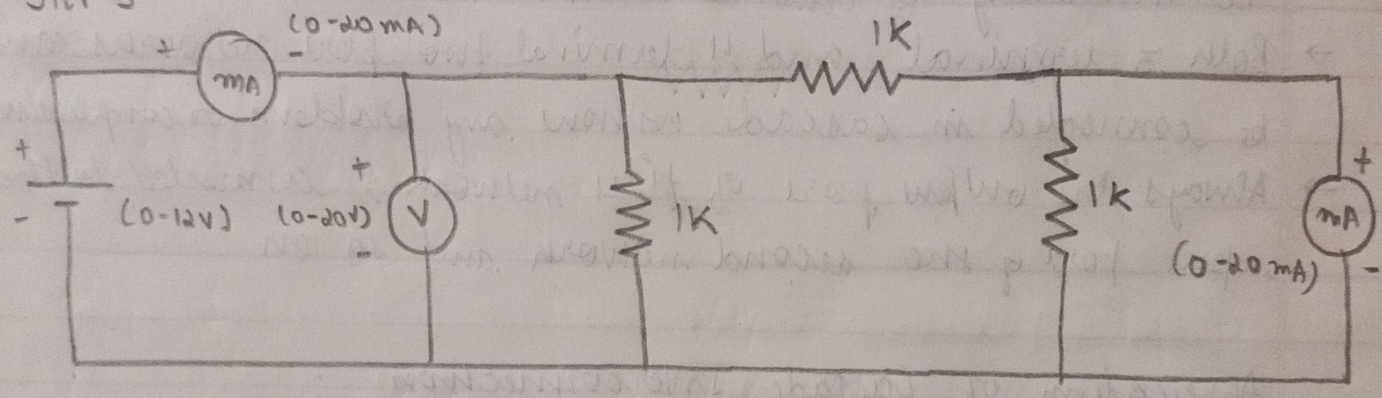
$V_2 = V_{2b} = 1V$

STEP 4.



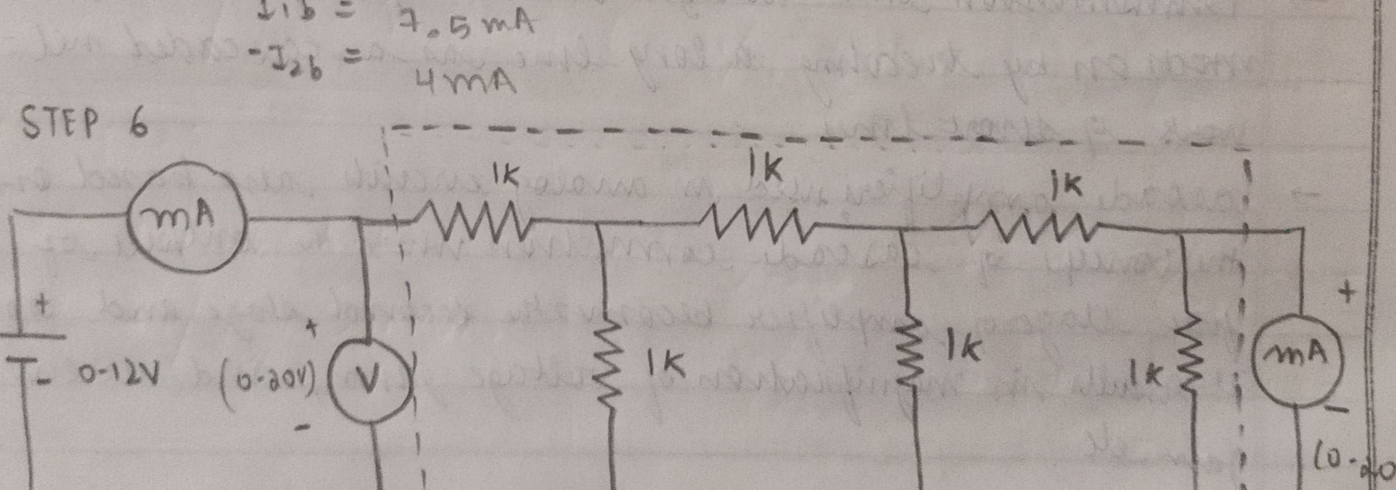
$V_{1a} = 12V$
$I_{1a} = 7.5mA$
$-I_{2a} = 4mA$

STEP 5



$V_{1b} = 12V$
$I_{1b} = 7.5mA$
$-I_{2b} = 4mA$

STEP 6



→ Interconnect again in cascade

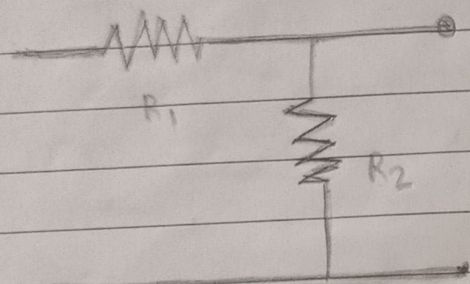
Result :

$$[T] = \begin{bmatrix} 13.84 & 8.548 \\ 7.81 & 4.92 \end{bmatrix}$$

$AD - BC = 1.33 \approx 1$

Hence, verified

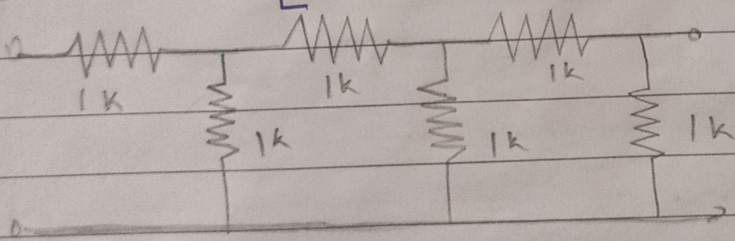
Theoretical Verification :



$$\Rightarrow [T_a] = \begin{bmatrix} 1+\frac{R_1}{R_2} & R_1 \\ \frac{1}{R_2} & 1 \end{bmatrix}$$

as $R_1 = 1k$ $R_2 = 1k$

$$[T_a] = \begin{bmatrix} 2 & 1000\Omega \\ 1\times10^{-3}\mho & 1 \end{bmatrix} \text{ or } \begin{bmatrix} 2 & 1k \\ 1m\mho & 1 \end{bmatrix}$$



Three such networks in cascade

$$[T] = [T_a][T_b][T_c] = \begin{bmatrix} 2 & 1k \\ 1m\mho & 1 \end{bmatrix}\begin{bmatrix} 2 & 1k \\ 1m\mho & 1 \end{bmatrix}\begin{bmatrix} 2 & 1k \\ 1m\mho & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 & 1k \\ 1m\mho & 1 \end{bmatrix}\begin{bmatrix} 5 & 3k \\ 3m\mho & 2 \end{bmatrix} = \begin{bmatrix} 13 & 2k \\ 1m\mho & 5 \end{bmatrix} \text{ Ans}$$

Sources of Error :

1. Parallax error in taking readings.
2. Zero error of instruments
3. The resistance of connecting wire (lead also)

Observations:

Step 1	Step 2	Step 3	Step 4	Step5	Step 6
$V_{1a} = 11V$ $I_{1a} = 5mA$ $V_{2a} = 5V$	$V_{1b} = 11V$ $I_{1b} = 15mA$ $V_{2b} = 5V$	$V_2 = V_{2b} = 1V$ $V_1 = V_{1a} = 11V$ $I_1 = I_{1a} = 6mA$	$V_{1a} = 12V$ $I_{1a} = 7.5mA$ $-I_{2a} = 4mA$	$V_{1b} = 12V$ $I_{1b} = 22.5 mA$ $-I_{2b} = 11mA$	$V_1 = V_{1a} = 12V$ $I_1 = I_{1a} = 7mA$ $-I_2 = -I_{2a} = 1.5mA$

Calculations:

Step 1: $A_a = V_{1a}/V_{2a} = 2.2$ $C_a = I_{1a}/V_{2a} = 1\ mMho$	**Step 3:** $A = V_1/V_2 = 11$ $C = I_1/V_1 = 6\ mMho$	**Step 5.** $B_b = V_{1b}/-I_{2b} = 1.09k\Omega$ $D_b = I_{1b}/-I_{2b} = 2.045$
Step 2: $A_b = V_{1b}/V_{2b} = 2.2$ $C_b = I_{1b}/V_{2b} = 3\ mMho$	**Step 4.** $B_a = V_{1a}/-I_{2a} = 3k\Omega$ $D_a = I_{1a}/-I_{2a} = 1.875$	**Step 6.** $B = V_1/-I_2 = 8k\Omega$ $D = I_1/-I_2 = 4.67$

4. The internal resistance of the supply.
5. High "least count" of the instruments

Precautions :

1. Never connect ammeter directly across the supply (even by mistake else it will get damaged and you would be fined)
2. Keep the pot of the power supply at zero position initially and gradually increase the voltage.
3. Connecting wires must be properly connected (because current cannot flow through air gap).
4. Dont pull the connecting cords, as it would get damaged.

VIVA - VOICE

Ques1. Why are chain parameters (ABCD) known as transmission parameters?

Ans A, B, C, D are the constants also known as transmission parameters or chain parameter. These are used for the analysis of electric network. It is used for determining performance of input, output voltage and current of transmission network.

Ques2. What is difference between transmission and inverse transmission parameter?

Ans Transmission and inverse transmission parameter are duals for each other. The quantities V_2 and

Result

$$[T] = T_A \times T_B = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \times \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix}$$

$$= \begin{bmatrix} 2.2 & 3 \\ 1 & 1.87 \end{bmatrix} \begin{bmatrix} 2.2 & 1.09 \\ 3 & 2.05 \end{bmatrix}$$

$$= \begin{bmatrix} 13.84 & 8.548 \\ 7.81 & 4.92 \end{bmatrix}$$

$$AD - BC = (13.84 \times 4.92) - (8.548 \times 7.81)$$

$$= 68.0928 - 66.75988$$

$$= 1.33$$

$$\approx 1$$

I_2 are expressed in terms of V_1 and I_1 in inverse transmission parameter. The resulting parameter (A', B', C', D') are inverse transmission parameter.

$$V_2 = A_1' V_1 + B'(-I_1)$$

$$I_2 = C' V_1 + D'(-I_1)$$

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

$$A' = \frac{V_2}{V_1}, \quad I_1 = 0$$

$$C' = \frac{I_2}{V_1}, \quad I_1 = 0$$

forward voltage ratio with sending end open circuited

transfer admittance with sending end open circuited.

Ans 3. How do we convert T-parameter to Z-parameter and T to T' parameter?

Ans: Two-port network in T-parameter and Z-parameter are:

T- PARAMETER

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

Z- PARAMETER

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

Hence, modified equation becomes

$$V_2 = Z_{12} I_2 = Z_{21} I_1$$

$$I_1 = \left(\frac{1}{Z_{21}}\right) V_2 = \left(\frac{Z_{12}}{Z_{21}}\right) I_2$$

$$I_1 = CV_2 - DI_2$$

$$\boxed{C = \frac{1}{Z_{21}}} \quad \boxed{D = \frac{Z_{12}}{Z_{21}}}$$

$$V_1 = AV_2 - BI_2 = \left(\frac{Z_{11}}{Z_{22}}\right)V_2 - \left(\frac{Z_{11}Z_{22} - Z_{12}Z_{21}}{Z_{21}}\right)I_2$$

$$\Rightarrow \boxed{A = \frac{Z_{11}}{Z_{21}}}$$

$$\boxed{B = \frac{Z_{11}Z_{22} - Z_{12}Z_{21}}{Z_{21}}}$$

T-parameter matrix : $\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} Z_{11}/Z_{21} & \frac{(Z_{11}Z_{22} - Z_{12}Z_{21})}{Z_{21}} \\ 1/Z_{21} & Z_{22}/Z_{21} \end{bmatrix}$

Ans 4. Write down symmetry condition of t to T' parameter

Ans $\frac{V_s}{I_1} = \frac{V_s}{I_2}$ $\quad \frac{A}{C} = \frac{D}{C} \Rightarrow A = D$

Ans 5. Write down reciprocity condition of T and T' parameter

$\frac{V_s}{I_1'} = \frac{V_s}{I_2'}$ $\quad \frac{B}{AD - BC} = B$

$\Rightarrow AD - BC = 1$

Ans 6 What are the application of ABCD parameter in :

i) Electrical power system

They are a part of power system dealing in transmission of electrical power from one place to another.

ii) Communication system

ii) They are used for determining the performance of input output voltage and current transmission networks in communication system.

iii) Electronic circuit.
They provide link between the supply and receiving end voltages and current, considering the circuit elements to be linear in nature

Ques 7. Does the equivalent circuit to T parameter exists? why?

Ans No, the equivalent circuit of T parameter doesn't exists because both the equations of T-parameter are for one port only. So, this specific need calls for expressing V_1, I_1 in terms of V_2, I_2 but there exists no equivalent circuit

Ques 8. Why is transmission line simplified into a 2-port network?

Ans. A 2-port network specifies the understanding and calculations. Hence, transmission lines are simplified in 2-port networks.