<u>Electrical Engineering Department</u>
<u>Network Lab.</u>

Part:-1

<u>Determination of different parameters of 2-port networks and verification of their interrelation ships.</u>

<u>Objective</u>: - To determine Y,Z and ABCD parameters of single and cascaded two Port networks experimentally and verify their interrelation ships.

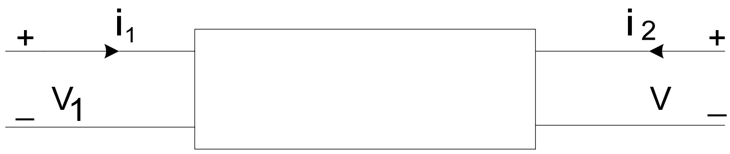

Fig.-1

Theory:

Consider a passive 2-port (4-terminal) network as shown Fig-1.

The voltage V_1 , V_2 and current I_1 , I_2 can be related in terms of the Z-parameters as shown below.

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \qquad \text{------------} \quad (1)$$

Where
$$\left.\begin{aligned} Z_{11} &= \left.\frac{V_1}{I_1}\right|_{I_2 = 0} & \qquad Z_{12} &= \left.\frac{V_1}{I_2}\right|_{I_1 = 0} \\ Z_{21} &= \left.\frac{V_2}{I_1}\right|_{I_2 = 0} & \qquad Z_{22} &= \left.\frac{V_2}{I_2}\right|_{I_1 = 0} \end{aligned}\right\} \text{-------------} \ (2)$$

Similarly, one may express the currents I_1, I_2 in terms of the voltages V_1, V_2 using the $Y-$ parameters as,

$$\begin{bmatrix} I_1 \\ \\ \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ & \end{bmatrix} \begin{bmatrix} V_1 \\ \\ \end{bmatrix} \qquad \text{-------------------} \ (3)$$

$I_2 \qquad Y_{21} \quad Y_{22} \qquad V_2$

$$\left.\begin{aligned} &\text{Where } Y_{11} = \frac{I_1}{V_1}\bigg|_{V_2 = 0} && Y_{12} = \frac{I_1}{V_2}\bigg|_{V_1 = 0} \\ &Z_{21} = \frac{I_2}{V_1}\bigg|_{V_2 = 0} && Y_{22} = \frac{I_2}{V_2}\bigg|_{V_1 = 0} \end{aligned}\right\} \text{-----------} \quad (4)$$

Lastly, we may represent the voltages and current of port 1 in terms of those of port 2 as follows.

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

$$= T.\begin{bmatrix} V_2 \\ -I_2 \end{bmatrix} \qquad \text{----------------} \ (5)$$

Where, the elements of the transmission matrix T, are given as,

$$\left.\begin{aligned} &A = \frac{V_1}{V_2}\bigg|_{I_2 = 0} && -B = \frac{V_1}{I_2}\bigg|_{V_2 = 0} \\ &C = \frac{I_1}{V_2}\bigg|_{I_2 = 0} && -D = \frac{I_1}{I_2}\bigg|_{V_2 = 0} \end{aligned}\right\} \text{--------------} \quad (6)$$

If two networks *M* and *N* are connected in cascade (as shown in Fig. 2). Then the transmission matrix of the overall network is given as.

$$T = T_{M.}T_N \qquad \text{-------------------} \quad (7)$$

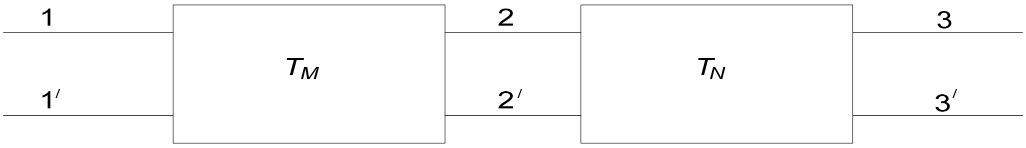

Fig. - 1

Fig-2

Procedure :

(1). Perform the open circuit and short circuit tests on the two 2-port networks *M* and *N* separately as given below:

(i). Apply a voltage +12 V DC across terminals 1-1' of network and measure the voltage V_2 and currents I_1 and I_2 with terminals 2-2" under open circuit and short circuit conditions. (Note the polarities carefully).

(ii Repeat the same from the other end 2-2" with terminals 1-1' kept open and short, respectively.

(iii) Calculate the two networks in cascade as shown in Fig. 2 and once again determine the parameters for the combined network.

(2). Connect the two networks in cascade as shown in Fig. 2 and once again determine the parameters for the combined network.

(3). Measure the values of the circuit elements.

Report :

(i) Verify the theoretical relationships relations between Y, Z and $ABCD$ parameters.
(ii) Verify equation (7)
(iii) Establish the relationship $AD - BC = 1$
(iv) Obtain the theoretical values of the parameters from the values of the circuit element measured experimentally and compare with values of the parameters obtained experimentally.
(v) Comment on discrepancies, if any.

Electrical Engineering Department

Network Lab.

Part:-2

Determination of transient response of an R-L-C network with intial conditions

Objective: - To determine the transient response of an R-L-C network in terms of the parameters $\sigma, \xi, \omega, \omega_n$ and initial conditions $i_L(0-), v_C(0-)$

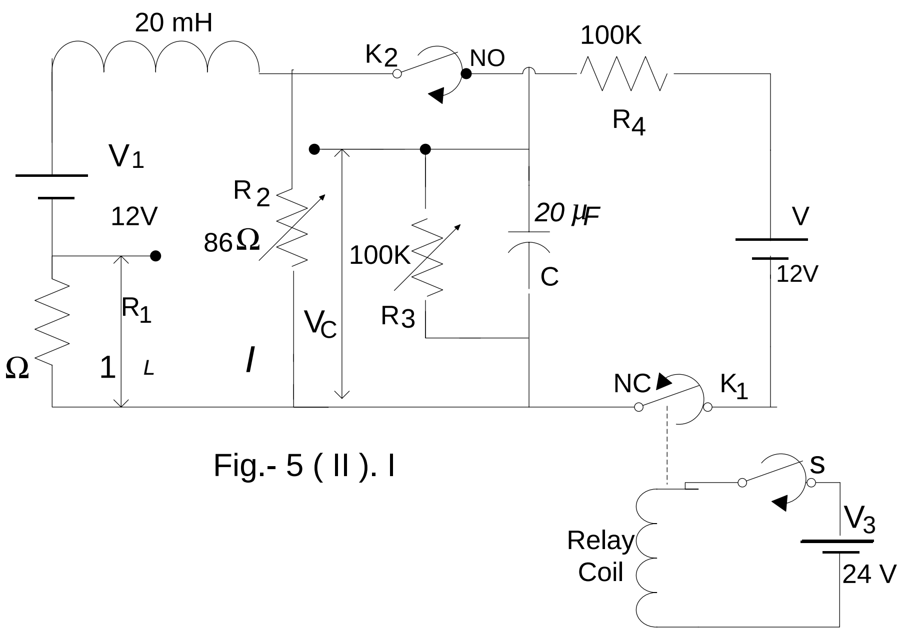

Fig.- 5 (II). I

Procedure:

1. Make the connections as shown in the Fig. 5(II).1. without energizing any one of the voltage sources.

2. Switch on the voltage source V 1=12 V. Adjust the resistances R3 and R4 (in the range of 100K) to set an initial voltage $V_C(0)$ across the capacitor $C = 20\mu F$. Capture the transient by connecting an oscilloscope probe across the capacitor and by triggering at the rising edge of the waveform in "single shot" mode. Note the time constant of the transient.

3. Switch on the voltage source $V_2 = 12V$ and adjust the current in the inductor $L = 20mH$ by changing R_2 to some value less than 0.75 A. The voltage drop across the shunt resistance

$R_1 = 1\Omega$ can be used to record the transient in the inductor current. Capture the transient in a digital oscilloscope by triggering in an identical manner as was done in step 2. Note the time constant of the transient.

4. Turn on the switch S to energize the relay. It disconnects the contacts K_1 and connects K_2 almost simultaneously (circuit time contant is higher than the turn on/off time of the relay contacts).The equivalent circuit is shown in Fig. 5(II).2.

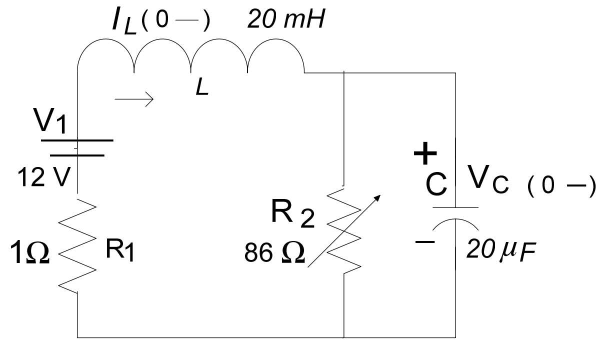

Fig.- 5 (II).2

5. Capture the voltage across the capacitor in the digital oscilloscope using single shot mode. Measure the maximum overshoot, frequency of oscillation, time constant, initial and final values of the capacitor voltage and sketch the waveform in a tracing sheet.

6. Similarly capture and record the transient in the inductor current (measured by the voltage drop across the shunt).

7. Conduct the experiment with different combinations of $i_{L.}(0)(=0.1A, 0.6A)$, $v_C(0)(=2.5V, 5V)$ and $C(=20\mu F, 40\mu F)$ (2 variations in each variable). Note that $R_2 = \dfrac{V_1}{i_L(0-)}$ will change for each setting of $i_L(0)$.

__Report:__

8. (a) Refer to the equivalent circuit shown in Fig. 5 (II). 2. Use KCL and KVL to formulate the differential equation involving capacitor voltage as $V_1 = LC\dfrac{d^2 v_C(t)}{dt^2} + \dfrac{L}{R}\dfrac{dv_c(t)}{dt} + v_C(t)$

   Determine the initial conditions $v_C(0-)$ and $v_C^{/}(0-)$

   (b) Also do the same for the inductor current $i_{1.}$

(c) Use Laplace transformation to analytically determine the complete solution for the voltage $v_C(t)$ and identify the steady state v_{CSS} and transient portions of the solution v_{ctr}.

In the process, the characteristics equation of the network in the form: $s^2 + (2\sigma)s + \omega_n^2 = 0$. The roots of the characteristic equation are $s_{1,} s_2 = -\sigma \pm \sqrt{\sigma^2 - \omega_n^2}$. The general solution corresponding to those roots is

$$v_c(t) = K_1 e^{(-\sigma+\sqrt{\sigma^2-\omega_n^2})t} + K_2 e^{(-\sigma-\sqrt{\sigma^2}-\omega_n^2)t}$$

A new parameter ξ can be defined as $\xi = \dfrac{\sigma}{\omega_n}$, that physically quantifies the damping of the network. There are three different forms for the roots:

Case 1 : $\xi > 1$, the roots are real and unequal

Case 2 : ξ =1, the roots are real and repeated

Case 3 : ξ < 1, the roots are complex and conjugates

Note that roots on the imaginary axis correspond to oscillatory response (zero damping), roots in the complex plane correspond to damped oscillation and that roots on the negative real axis correspond to the critically damped case (ξ =1) or to an over damped form. When the roots are complex conjugate the solution is of the form

$$v_C(t) = K_1 e^{-(\sigma)t} \text{Cos } (\omega)t + K_2 e^{(-\sigma)t} \text{Sin } (\omega)t$$

$$= K_1 e^{-(\xi\omega_n)t} \text{Cos} (\omega_n\sqrt{1-\xi^2})t + K_2 e^{-(\xi\omega_n)t} \text{Sin } (\omega_n\sqrt{1-\xi^2})t$$

Where, the physical interpretations of the parameters are: ω is natural frequency , ω_n is the undamped natural frequency and the time constant is $\dfrac{1}{\sigma}$.

(d) Find the parameters and constants: $\sigma, \omega, \omega_n, \xi, K_1, K_2$ and v_c (max).

(e) Also find the complete solution for the inductor current i_L and identify the steady state and transient portions of the solution. Note that the characteristic equation is the same and therefore find only $K_{3,} K_4$ and i_L (max).

9. From the experimental results obtained in step 7 identify the steady state and transient portions of the solution. Determine / estimate the parameters $\sigma, \omega, \omega_n, \xi, K_1, K_2$ and v_C (max). Compare these values with the analytical

results obtained in step 9.

10. Find the transform domain network of the circuit shown in Fig. 5(II).2 and determine input impedance $Z_i(s)$ and the output impedance $Z_0(s)$.

11. From the transform domain network find the complete solutions by applying the principal of superposition that is, you should treat initial conditions as independent voltage and current sources and find out the solution due to each source separately and then add to find complete solution.

12. In the transformer domain network apply Thevenin's theorem to determine the current through the inductor L. The initisal values are $I_L(0-) = 0.1A$ and $V_C(0-) = 5V$ and $L = 20mH$ and $C = 20\mu F$.

13. Explain the differences (if any) between the analytical and experimental results.