Experiment No:3 **Date:**

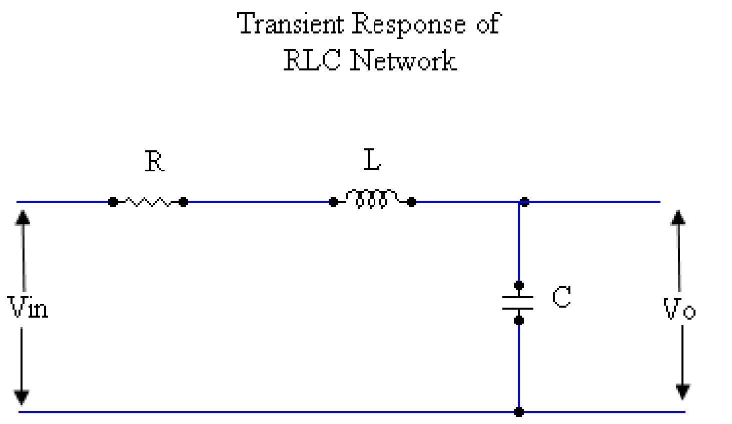
Aim:

To determine transient response of RLC network

Apparatus:

RLC network kit, patch cords, connecting wires etc.

Diagram:



Theory:

When system is given an excitation (I/p), there is a response (O/p). this response varies with time, and is called the time response Time response is divided in two parts:

1.Transient Response:

It is the part of response that goes to zero as a the time increases.

2. Steady State Response:

That part of the response that remain after the transients have died out.

Order of The System:

It is the highest power in the characteristics equation of the system.

For example:

$$S^2 + 2S + 1 = 0$$

Hence order of the system is two.

Consider the R, L, C network as shown in fig.

Using Kirchoffs voltage law,

$$Vi(s) = [\ R + LS + 1/CS]\ I(s)$$

And $Vo(s) = I(s) / 1/CS$

Therefore transfer function.

$$\frac{Vo(s)}{Vi(s)} = \frac{1/LC}{S^2 + S\ R/L + 1/LC}$$

If we compare the equation with standard form of characteristics equation of second order system i.e.

$$S^2 + 2\rho\ \omega n\ S + \omega n^2 = 0$$

Then

ωn = undamped natural frequency $= \sqrt{LC}$

ρ = damping ratio $= (R/2) * \sqrt{C/L}$

and ωd = Damped natural frequency $= \omega n \sqrt{1-\rho^2}$

The roots of the charecterstic equation $S^2 + 2\rho\ \omega n\ S + \omega n^2 = 0$ are

$$S1,S2 = -\rho\ \omega n + \omega n \sqrt{\rho^2 - 1}$$

Case 1:

For $0 < \rho < 1$;

The roots S1 & S2 are complex conjugate pair with –ve real part, and

$$Vo(t) = C(t) = 1 - (e^{-\rho Wnt} / \sqrt{1-\rho^2}) * \sin(\omega\ dt + \Phi)$$

where

$$\omega d = \omega n \sqrt{1-\rho^2} \quad \& \ \Phi = \text{Cos}^{-1} \rho$$

Case II:

For $\rho = 1$;

The roots S1 & S2 are real , -ve & equal and,

$$Vo(t) = 1 - e^{-Wnt} (1 + \omega nt)$$

Case III :-

For $\rho > 1$;

The roots S1 & S2 are real , -ve & equal and,

$Vo(t) = 1 + B\ e^{-S1t} + D\ e^{-S2t}$ where B,D ---- constants. and

$$S1,S2 = -\rho\omega n + \omega n \sqrt{\rho^2 - 1}$$

For

Case I :

i.e.$0< \rho <1$ is called as under damped.

Case II

i.e. $\rho =1$ is called as critically damped.

Case III

i.e. $\rho >1$ is called as over damped.

<u>Time Response Specification:</u>

1. Delay time (td):

It is the time required for the response to reach 50% of final value in first attempt.

2. Rise time (tr):

It is the time required for the response to rise from 10% to 90 % of the final value of the over damped system & 0 to 100% value of under damped system.

3. Peak time (tp):

It is the time required for the response to reach the peak of the response or the peak overshoot.

4. Peak overshoot (MP):

It indicate the normalized difference between the time response peak & steady state output.

It is defined as peak percent overshoot

$$\% M_p = \frac{C(t_p) - C(\omega)}{C(\omega)} * 100$$

Where $C(t_p)$ is o/p at $t = t_p$ and $C(\omega)$ is steady state output.

5. Settling time (ts):

It is the time required for the response to reach & stay within a specific tolerance band of its final value.

6. Steady State Error:

It indicates the error between the actual o/p & desired o/p as t tends to infinity.

Procedure:

1. Make connection as shown in fig.
2. Adjust max. O/p voltage of repeated step I/p generator.
3. Make power on to the unit.
4. Connect CRO at the O/p & adjust CRO to get stable pattern on CRO.
5. Vary R by pot meter & for a given set of values of R,L,C. Study the transient response as observed on CRO.
6. Plot the same response on graph paper .
7. Study the pattern by using another set of L & C or by varying R.
8. Each time note the values of R,L,& C

Observation Table:

SR.NO.	R/ohm	L/mH	C/μF	$\rho = R/2\sqrt{C/L}$	$\omega n = 1/\sqrt{LC}$	$\omega d=\omega n\sqrt{1-\rho}$
Set 1 $0< \rho<1$						
Set 2 P =1						
Set 3 P = 1						

Calculation:

1. Mp = $e^{-\Pi\ \rho\ \sqrt{1-\rho 2}}$ *100 % =

2. tr = $\dfrac{-\Pi-\Phi}{\omega d}$

3.Damping angle = Φ = $\text{Cos}^{-1}\ \rho$

4. $t_p = \dfrac{\Pi}{\omega d}$

5. $t_s = \dfrac{4}{\rho\omega n} =$ for 2% tolerance

Result :

	MP calculated	MP observed
SET 1		
SET 1I		
SET 1II		

Conclusion: