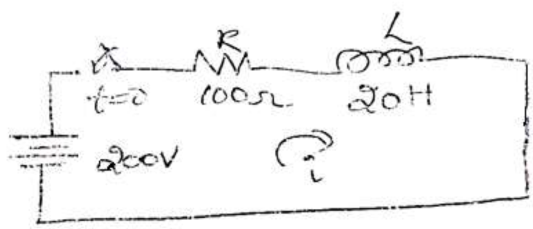
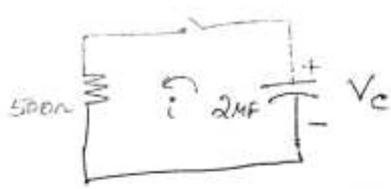
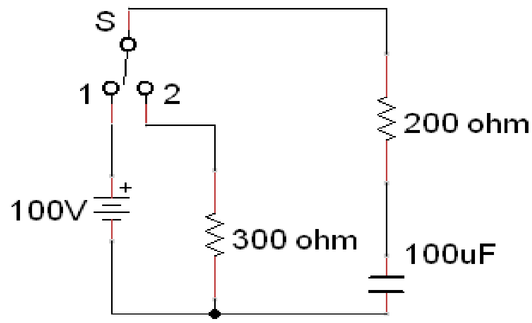
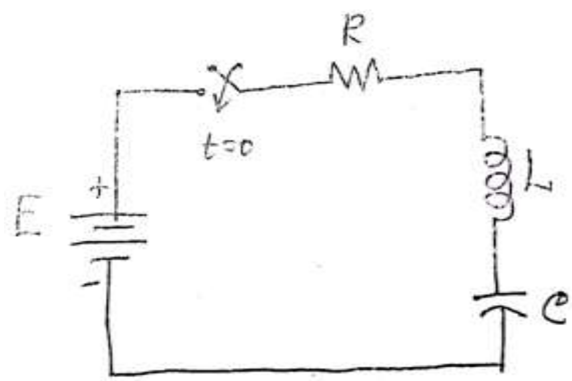
UNIT IV – TRANSIENT ANALYSIS AND TWO PORT NETWORKS				
PART – A (2 Mark Questions With Key)				
S.No	**Questions**	**Mark**	**COs**	**BTL**
1	**What is meant by transient analysis?**		4	K2
	The study of switching condition in circuit is called as transient analysis.	2		
2	**Define transient state.**	2	4	K2
	The state or condition of the circuit from the instant of switching to attainment of steady state is called as transient or transient state.			
3	**Define transient period.**	2	4	K2
	Transient period is defined as the time taken for the current to reach its final or steady state value from its initial values.			
4	**Define transient response.**	2	4	K2
	The current and voltage of the circuit elements during transient period is called as transient response.			
5	**Define natural response**	2	4	K2
	The response of the circuit due to stored energy alone (without any external source) is known as source free response or natural response.			
6	**Define forced response.**	2	4	K2
	The response of the circuit due to external source is called forced response.			
7	**List the applications of transient analysis.**	2	4	K2
	Transient analysis is used in (i) Analysis of switching conditions in circuit breakers, relays, generators and various types of load. (ii) Analysis of faulty conditions in electrical devices (iii) Analysis of switching conditions in analog and digital electronic devices			
8	**Give the advantages of Laplace transform method.**	2	4	K2
	(i) Differential equations are converted into simple algebraic equations (ii) Solution of algebraic equations are simple compared to solution of differential equations (iii) It simplifies operations (iv) Arbitrary constants need not to be determined separately.			
9	**When a circuit said to be in steady state?**	2	4	K2
	A circuit is said to be in steady state, when it has constant sources and the currents and voltages do not change with time.			
10	**What is time constant for RL circuit supplied by dc supply?**	2	4	K2
	Time constant of a function $\frac{V}{R}e^{-\left(\frac{R}{L}\right)t}$ is the rate at which the exponent e is unity, where e is the base of the natural logarithms. The term $\frac{L}{R}$ is called as the time constant and is denoted by 'τ'. $\tau = \frac{L}{R}$			
11	**What is time constant for RC circuit supplied by dc supply?**	2	4	K2
	Time constant of a function $\frac{V}{R}e^{-\left(\frac{1}{RC}\right)t}$ is the rate at which the exponent e is unity, where e is the base of the natural logarithms. The term RC is called as the time constant and is denoted by 'τ'. $\tau = RC$			
12	**What is meant by two port network?**	2	3	K2

	A two-port network is an electrical network with two pairs of terminals to connect to external circuits. It is a four-terminal circuit in which the terminals are paired to form an input port and an output port.			
13	**What are impedance parameters?**	2	3	K2
	Impedance or open circuit parameters are obtained by giving excitation at input port and output port is open circuited. Z_{11}, Z_{12}, Z_{21} and Z_{22} are called Impedance parameters.			
14	**What are admittance parameters?**	2	3	K2
	Admittance or short circuit parameters are obtained by giving excitation at input port and output port is short circuited. Y_{11}, Y_{12}, Y_{21} and Y_{22} are called admittance parameters.			
15	**What are hybrid parameters?**	2	3	K2
	Hybrid or h parameters are defined in terms of a mixture of port variables. These are referred as hybrid because, here Z parameters, Y parameters, voltage ratio, current ratio, all are used to represent the relation between voltage and current in a two port network. h_{11}, h_{12}, h_{21} and h_{22} are called hybrid parameters.			

PART – B (12 Mark Questions with Key)

S.No	Questions	Mark	COs	BTL
1	**A series RL circuit wit R=100Ω and L=20 as a dc voltage of 200V applied throuh a switc at t=0. Find (a) the equation for the transient current and voltage across elements (b) the current at t=0.5 sec (c) the current at t=0.5 sec (d) time at which $e_R=e_L$**	12	4	K3
	(i) $i(t)=2(1-e^{-5t})$ $e_R=200(1-e^{-5t})$ $e_L=200(e^{-5t})$ (ii) i(t=0.5s)=**1.836 A** (iii) i(t=1s)=**1.987 A** (iv) t= **0.1386 seconds**  	4×3 =12		
2	**A capacitor of 2µF with an initial charge Qo=200×10-6 C, is connected across the terminals of a 500Ω resistor at t=0. Calculate the time in which the transient voltage across the resistor drops from 60V to 20V.**	12	4	K3
	Vo=Qo/C= 100 V $i(t)=0.2(e^{-10^3 t})$ $e_R=100e^{-1000t}$ e_R= 60 V at t=t_1 $60V=100e^{-1000t1}$ -- (i) e_R= 20 V at t=t_2 $20V=100e^{-1000t2}$ --(2) By taking (1)/(2) and solving, t_2-t_1= **1.0986 seconds**  	4 4 4		
3	**For the circuit given the switch 'S' is in position 1 till steady state conditions are reached and then moved to 2. Find the energy dissipated in the two resistors. Show that this is equal to the energy stored in the capacitor before moving the switch.**	12	4	K4

				
	$i(t) = 0.2(e^{-20\,t})$	4		
	Energy dissipated in resistors = $\int_0^{\infty} i^2 R dt = 0.5\, joules$	4		
	Energy stored in capacitor= $\frac{1}{2} CE^2 = 0.5\, joules$	4		
4	**Derive the transient equation of series RLC circuit having DC excitation and show the response.**	12	4	K4
	 KVL Assume no initial charge on the capacitor $E = Ri + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$ L.T $\frac{E}{s} = R\,I(s) + L[sI(s) - i(0)] + \frac{1}{C}$ $i(0) = 0$	3		

$$\therefore \frac{E}{s} = I(s)\left(R + Ls + \frac{1}{Cs}\right)$$

$$I(s) = \frac{E}{s\left(R + Ls + \frac{1}{Cs}\right)}$$

$$= \frac{E}{Rs + Ls^2 + \frac{1}{C}}$$

$$= \frac{E}{L\left(s^2 + \frac{R}{L}s + \frac{1}{LC}\right)}$$

$$I(s) = \frac{E/L}{s^2 + \frac{R}{L}s + \frac{1}{LC}} \quad \text{—— (1)}$$

The roots of the denominator are

$$= -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

$$= \alpha \pm \beta$$

$$\alpha = -\frac{R}{2L} \; ; \; \beta = \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

Looking at the discriminant, there are 3 possibilities

case(i) Discriminant positive (3)
case(ii) Discriminant zero (3)
case(iii) Discriminant negative (3)

Case (i) Discriminant positive.

$$\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$$

$$\beta = \left(\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}\right)^{1/2}$$

$\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}$ is positive

then roots are real & distinct

∴ denominator has roots $(\alpha+\beta)$ & $(\alpha-\beta)$

Eqn (1) ⇒

$$I(s) = \frac{K_1}{s-(\alpha+\beta)} + \frac{K_2}{s-(\alpha-\beta)}$$

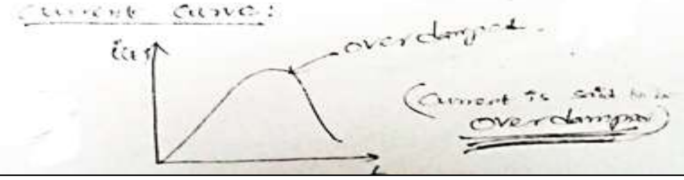
$$\therefore \quad i(t) = K_1 e^{(\alpha+\beta)t} + K_2 e^{(\alpha-\beta)t}$$

$$= K_1 e^{\alpha t} \cdot e^{\beta t} + K_2 e^{\alpha t} \cdot e^{-\beta t}$$

$$= e^{\alpha t}\left(K_1 e^{\beta t} + K_2 e^{-\beta t}\right)$$

$$\boxed{i(t) = e^{\alpha t}\left(K_1 e^{\beta t} + K_2 e^{-\beta t}\right)}$$

Current curve:



Discriminant Zero

$$\left(\frac{R}{2L}\right)^2 = \frac{1}{LC} \qquad \left(\frac{R}{2L}\right)^2 - \frac{1}{LC} = 0$$

∴ two roots are equal. (α, α) $(s-\alpha)(s-\alpha)$

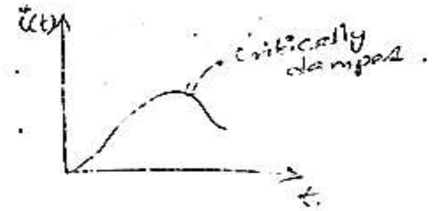
$$I(s) = \frac{k_1}{(s-\alpha)^2} + \frac{k_2}{(s-\alpha)}$$

L^{-1}

$$i(t) = k_1 \cdot t \cdot e^{\alpha t} + k_2 \cdot e^{\alpha t}$$

$$\boxed{i(t) = e^{\alpha t}\left(k_1 t + k_2\right)}$$

Current Curve:



Case (iii) Discriminant Negative

$$\left(\frac{R}{2L}\right)^2 < \frac{1}{LC} \qquad \Leftarrow \left(\frac{R}{2L}\right)^2 - \frac{1}{LC} \text{ is negative}$$

∴ roots then become complex conjugate.

Here, $\beta = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$

roots are, $(\alpha + j\beta)$ & $(\alpha - j\beta)$

$$I(s) = \frac{k_1}{s-(\alpha+j\beta)} + \frac{k_2}{s-(\alpha-j\beta)}$$

L^{-1}

$$i(t) = k_1 e^{(\alpha+j\beta)t} + k_2 e^{(\alpha-j\beta)t}$$

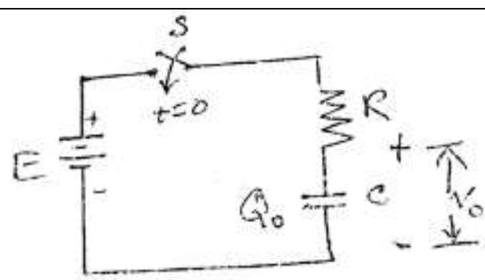
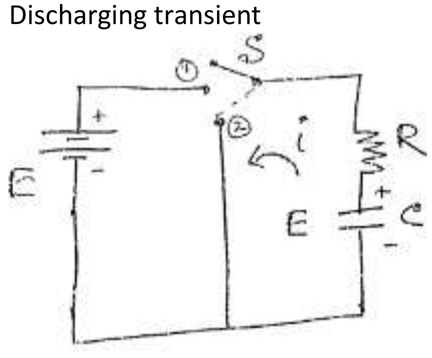
$$= k_1 \cdot e^{\alpha t} \cdot e^{j\beta t} + k_2 \cdot e^{\alpha t} \cdot e^{-j\beta t}$$

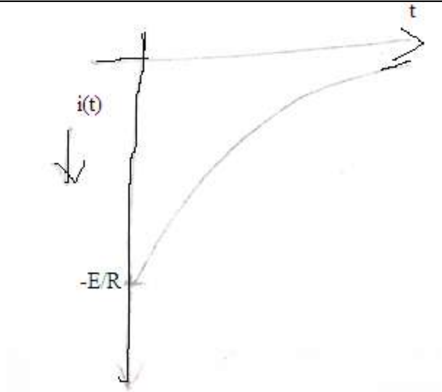
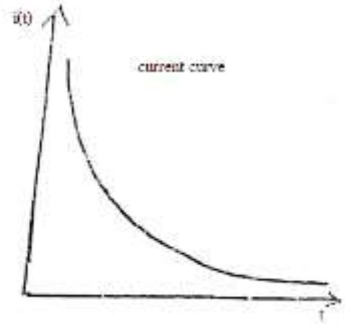
$$i(t) = e^{\alpha t}\left(k_1 e^{j\beta t} + k_2 e^{-j\beta t}\right)$$

k_1 & k_2 are complex & are also conjugate One another

$$\therefore \boxed{k_2 = k_1^*} \quad \text{or} \quad k_1 = k_2^*$$

$$\therefore \boxed{i(t) = e^{\alpha t}\left(A \cos\beta t + B \sin\beta t\right)}$$

	Case (iii) Discriminant Negative $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$ ← $\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}$ is negative ∴ roots then become complex conjugate. then, $\beta = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$ roots are, $(\alpha + j\beta)$ & $(\alpha - j\beta)$ $I(s) = \frac{K_1}{s-(\alpha+j\beta)} + \frac{K_2}{s-(\alpha-j\beta)}$ L^{-1}: $i(t) = K_1 e^{(\alpha+j\beta)t} + K_2 e^{(\alpha-j\beta)t}$ $= K_1 \cdot e^{\alpha t} \cdot e^{j\beta t} + K_2 \cdot e^{\alpha t} \cdot e^{-j\beta t}$ $i(t) = e^{\alpha t}\left(K_1 e^{j\beta t} + K_2 e^{-j\beta t}\right)$ K_1 & K_2 are complex & are also conjugate one another ∴ $K_2 = K_1^*$ or $K_1 = K_2^*$ ∴ $i(t) = e^{\alpha t}(A\cos\beta t + B\sin\beta t)$			
5	**Derive the transient equation of series RC circuit having DC excitation and show the response.**	12	4	K3
	(a) charging transient $i(t) = \frac{E}{R} e^{\frac{-1}{RC}t}$ $e_R = E e^{\frac{-1}{RC}t}$ $e_C = E(1 - e^{\frac{-1}{RC}t})$  Energy stored in capacitor= $\frac{1}{2}CE^2$ (b) Discharging transient 	3 3 3		

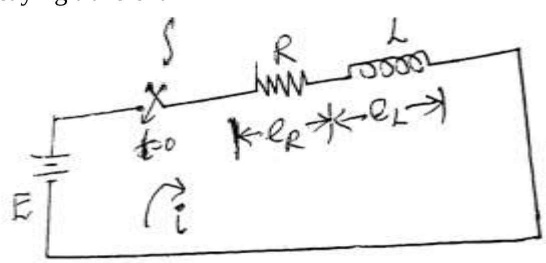
	 $i(t) = -\frac{E}{R} e^{\frac{-1}{RC}t}$	3		
6	**Briefly explain about two port network (i) Z Parameters (ii) Y-parameters (iii) h-parameters**	12	3	K3
	Z Parameters + Y-parameters + h-parameters Z-parameter matrix is given by: $\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}$ where $Z_{11} = \frac{V_1}{I_1}\Big\vert_{I_2=0} \qquad Z_{12} = \frac{V_1}{I_2}\Big\vert_{I_1=0}$ $Z_{21} = \frac{V_2}{I_1}\Big\vert_{I_2=0} \qquad Z_{22} = \frac{V_2}{I_2}\Big\vert_{I_1=0}$ Y-parameter matrix is given by $\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$ where $Y_{11} = \frac{I_1}{V_1}\Big\vert_{V_2=0} \qquad Y_{12} = \frac{I_1}{V_2}\Big\vert_{V_1=0}$ $Y_{21} = \frac{I_2}{V_1}\Big\vert_{V_2=0} \qquad Y_{22} = \frac{I_2}{V_2}\Big\vert_{V_1=0}$	4+4+4 =12		

	h-parameter matrix is given by $$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$ where $$h_{11} \stackrel{\text{def}}{=} \left.\frac{V_1}{I_1}\right\|_{V_2=0} \qquad h_{12} \stackrel{\text{def}}{=} \left.\frac{V_1}{V_2}\right\|_{I_1=0}$$ $$h_{21} \stackrel{\text{def}}{=} \left.\frac{I_2}{I_1}\right\|_{V_2=0} \qquad h_{22} \stackrel{\text{def}}{=} \left.\frac{I_2}{V_2}\right\|_{I_1=0}$$			

PART – C (20 Mark Questions with Key)

S.No	Questions	Mark	COs	BTL
1	**Derive the transient equation of series RL circuit having DC excitation and show the response.**	20	4	K3
	(a) Rise of current + (b) RL Decaying transient	10+10		

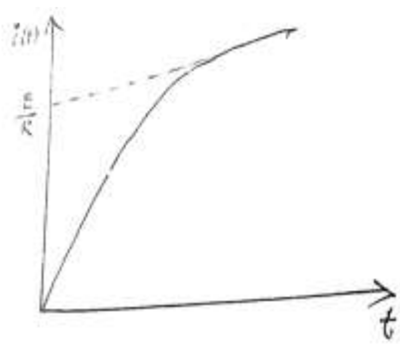
(a) Rise of current



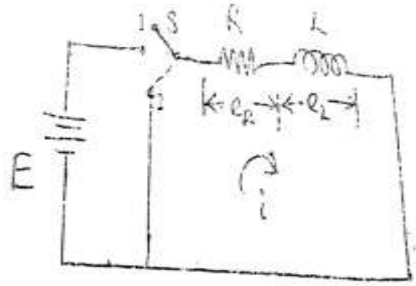
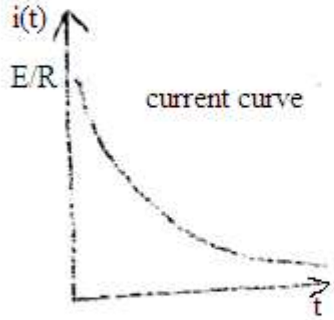
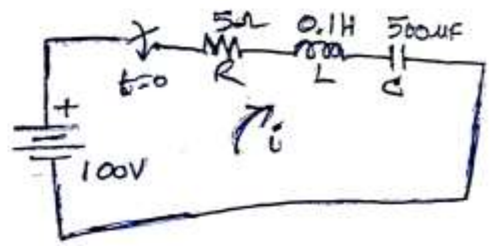
$$i(t) = \frac{E}{R}(1 - e^{-\frac{R}{L}t})$$

$$e_R = E(1 - e^{\frac{-R}{L}t})$$

$$e_L = e_R = Ee^{\frac{-R}{L}t}$$



(b) RL Decaying transient

	  $i(t)=\frac{E}{R}(e^{-\frac{R}{L}t})$			
		5+5		
2	**A series RLC circuit wit R=5Ω, L=0.1 and C=500µF as a dc voltage of 100 V applied at t=0 through a switch. Find the resulting current transient.**	20	4	K3
	$I(s)=\frac{1000}{S^2+50S+2\times10^4}$ A= 3.592 B= -3.592 $i(t)=1.796e^{-25\,t}(Sin139.2t)$  	7 5 8		