Ultra Short Notes (Network) — Shashank Dabral (EE)

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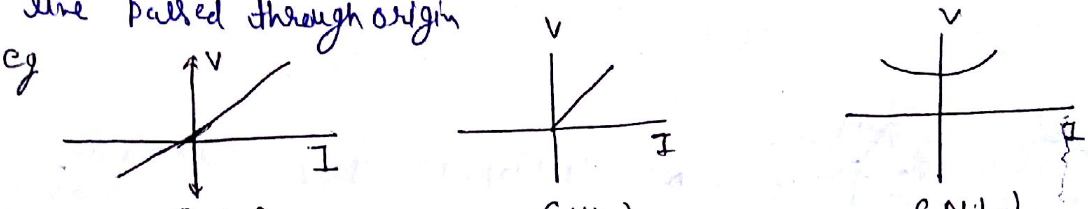
Lec-1 → **Classification of element**

(i) Linear and Non linear element → V-I charateristic show only one eq of straight line passed through origin

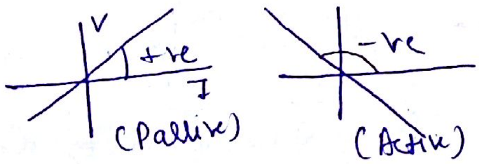
eg



(L) (NL) (N.L)

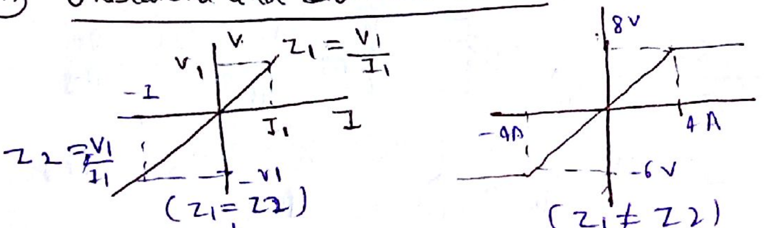
(ii) Active and Passive element → Active - delivers power to ckt → Voltage, Current, Source;
Passive — otherwise → R, L, C (R ≥, L, C ≥ 0)

- 1 or 3rd quad → +ve slope → Passive
- 2 or 4th quad → -ve slope → Active
- 1 or 4th → Active
- 2 or 3rd quad → Active



(Passive) (Active)

(iii) Unilateral and Bilateral element → Bilateral – R, L, C   Unilateral → Diode

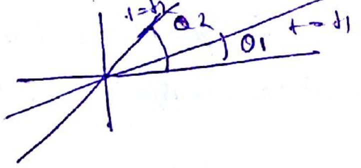


$(Z_1 = Z_2)$ → Bilateral $(Z_1 \neq Z_2)$ (Unilateral)

linear element ⇒ Bilateral

Bilateral ≠ linear

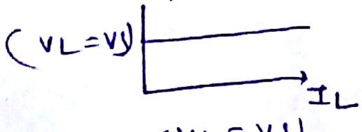
(iv) Time Variant and Time Unvariant → V-I charatestic change w.r.to time → time variant
V-I " Remain same – time invariant



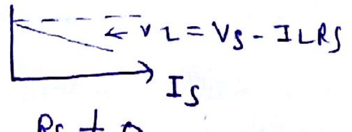
Lec-2 **Independent Sources**

Voltage Sources
- ideal Voltage source (Load voltage independent of Load current)
- Practical Source Voltage → $f(I_L) = V_L$

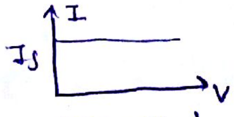
Current Source
- ideal Current Source → Load current independent of Load Volta
- Practical current Source → $f(V_L) = I_L$



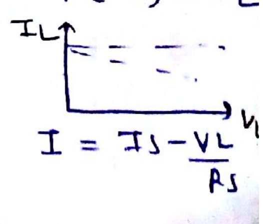
$(V_L = V_S)$ $R_{int} = 0$



$R_S \neq 0$ $(I \uparrow \to V_L \uparrow)$

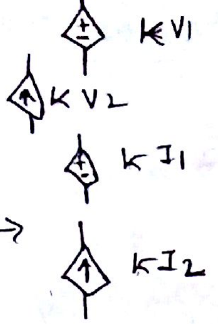


$(I_S = I_L)$



$V_L \uparrow \; I_L \downarrow$

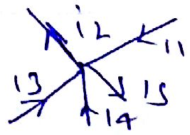
(2) Dependent Source →
- VCVS → kV_1
- VCCS → kV_2
- CCVS → kI_1
- CCCS → kI_2



- The Voltage / current of dependent source depends on other ckt parameter.

lec-3 ↓

KCL →

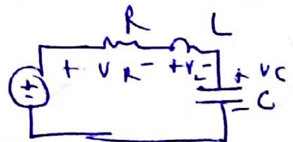


→ $i_1 + i_3 + i_4 = i_5 + i_2$ — Sum of incoming current = Sum of outgoing current

$$\frac{dq_1}{dt} + \frac{dq_3}{dt} + \frac{dq_4}{dt} = \frac{dq_5}{dt} + \frac{dq_2}{dt}$$

→ Follow of Law Conservation of charge

KVL →

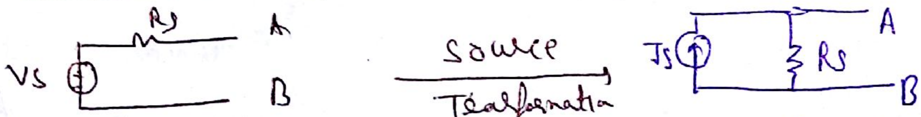


$= V = V_R + V_L + V_C$ $= \frac{dw}{dq} = \frac{dw_R}{dq} + \frac{dw_L}{dq} + \frac{dw_C}{dq}$

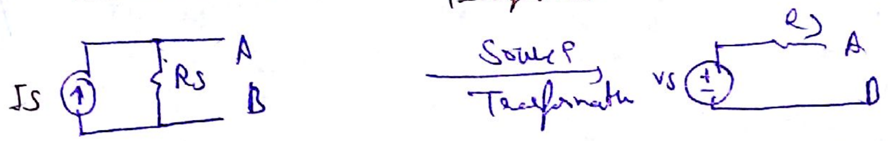
$$\boxed{W = W_R + W_L + W_C}$$

Follow of Law of energy Conservation.

Source transformation ↓

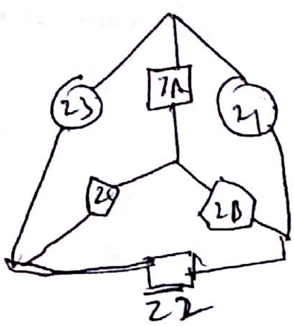


$I_S = \frac{V_S}{R_S}$



$V_S = I_S R_S$

Star delta transformation ↓



Star–Delta → Given – Z_A, Z_B, Z_C
To find – Z_1, Z_2, Z_3

$$Z_1 = (Z_A + Z_B) + \frac{Z_A Z_B}{Z_C},$$

$$Z_2 = (Z_C + Z_B) + \frac{Z_C Z_B}{Z_A}$$

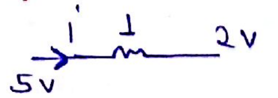
$$Z_3 = (Z_A + Z_C) + \frac{Z_A Z_C}{Z_B}$$

Delta to Star ↓

Given Z_1, Z_2, Z_3, To find $= Z_A, Z_B, Z_C$

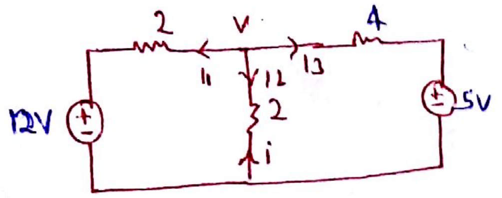
$$Z_A = \frac{\text{Product of known}}{\text{Total sum}} = \frac{Z_1 Z_3}{Z_1 + Z_2 + Z_3} \qquad Z_B = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z_3} \qquad Z_C = \frac{Z_2 Z_3}{Z_1 + Z_2 + Z_3}$$

Nodel Analysis →



$\frac{5-2}{1} = +3A \quad \alpha \left\{ \frac{HP-LP}{R} \right\}$

$= \frac{-2-(-5V)}{1} = +3A$

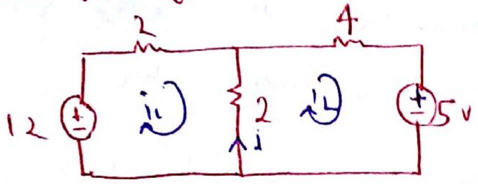


→ $\frac{V-12}{2} + \frac{V-0}{2} + \frac{V-5}{4} = 0$

$V = 29/5\,V, \quad i_2 = \frac{V-0}{2} = 29/10 = 2.9A$

$i' = +i_2 = -2.9A$

Mesh Analysis ↓



$2i_1 + 2(i_1 - i_2) = 12$

$4i_1 - 2i_2 = 12$ — (1) — Mesh 1

Mesh$_2$ → $4i_2 + 5 + 2(i_2 - i_1) = 0$

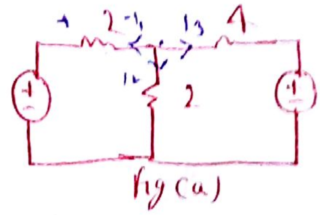
$-2i_1 + 6i_2 = -5$ — (2)

$i_1 = 3.1 \quad i_2 = 0.2 \quad i_1 = (i_2 - i_1) = 2.9A$

Tellegen's Theorem ↓

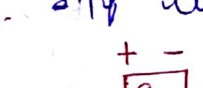
In any N/W the algebric sum of Power at any instant is equal = 0

$\boxed{P_{delivered} = P_{absorbed}}$



(*) – If current enter from +ve and Leaves from −ve terminal then that element is absorbing Power

(*) – If current enter from −ve and Leaves from +ve then element is delivered Power.



absorbing Power

delivering Power

For fig (a)

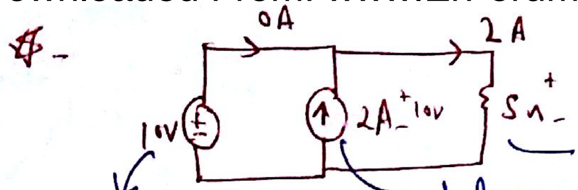
$V = 29/5\,V. = \underline{5.8V}$

$i_1 = \frac{12-5.8}{2} = 3.1 \quad i_2 = 2.9A \quad i_3 = 0.2A$

2Ω, 2Ω, 4Ω & 5V – absorbed Power $= (P_{2\Omega} + P_{2\Omega} + P_{4\Omega} + P_{5\Omega}) = 37.2\,W$

12V – delivered Power = $P_{12V} = 12 \times 3.1 = \underline{37.2\,W}$

4 -

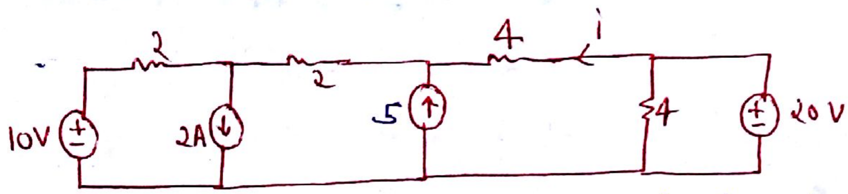


absorbing

delivers

X (Neither Absorbed Nor delivers) $(I = 0)$

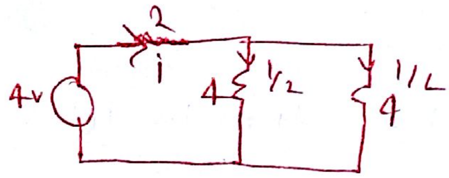
Lec-6 → N/w theorem



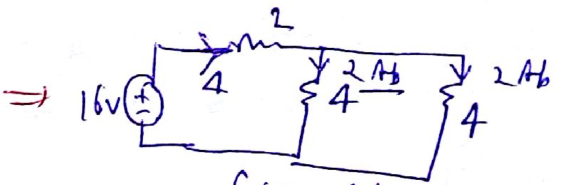
Superposition – Responce in a particular branch in the algebric sum of individual Responce calculated by treating one independ source at a time

(linear N/w)

Homogenity – in Linear N/w → excitation × K ⇒ Responce in each branch × K

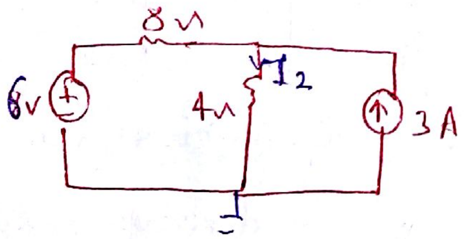


⇒

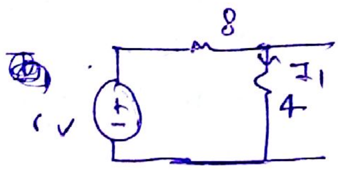


$(K = 4)$

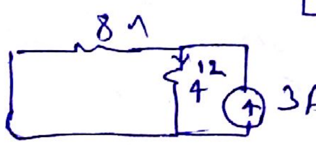
Superposition theorem
- → Ideal voltage source = S.C
- → Ideal current source = O.C
- → Dependent source = Leave it



→

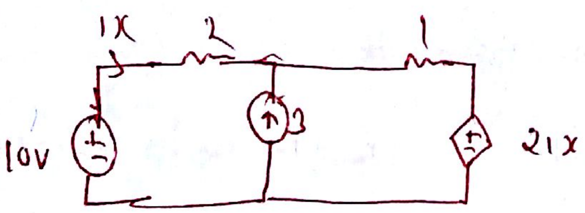


$I_1 = \frac{6}{12} = 0.5A$



$= i_2 = 3 \times \frac{8}{12} = 2A$

$I = I_1 + I_2 = 2 + 0.5 = 2.5A$



find I_x = ?

⇒ $5 i_{x_1} = 10$

$i_{x_1} = 2A$

⇒ $\frac{V}{2} - 3 + \frac{V - 2V}{1} = 0$

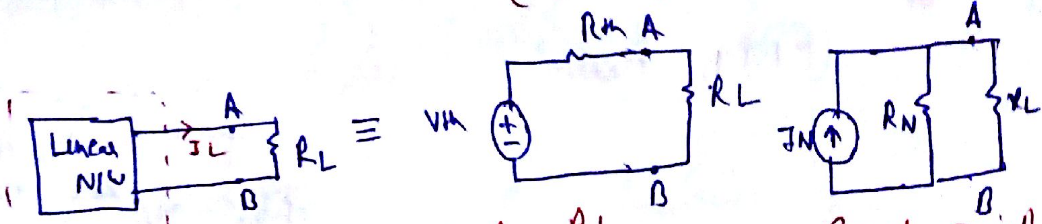
$-1x_2 = V/2$

$-1x_2 = 0.6A$

$x = 2 - 0.6 = 1.4A$

Lec 07

Thevenin Theorem → and Norton theorem



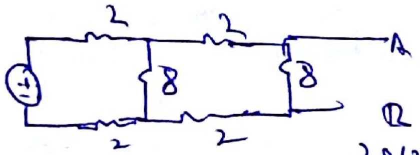
Vth = O·C Voltage Measure b/w AB By Remo RL

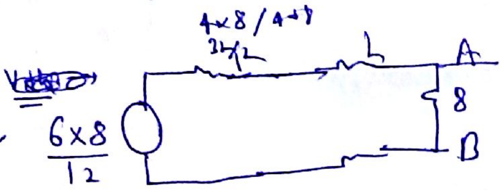
Rth = Req ≐ {V·S → S·C, C·S → O·C} ; $\left\{\frac{Vth}{Isc}\right\}$

IN ⇒ {S·C terminal AB find IN} ; $\left\{\frac{Vth}{Rth}\right\}$ {RN = Rth}

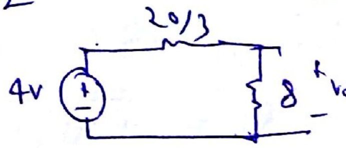
Method to find Thevenin equivalent

Case-1 – all independent source →



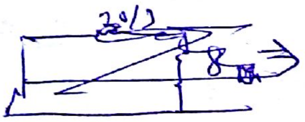


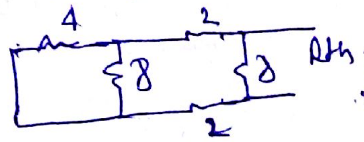
$\frac{6\times8}{12}$



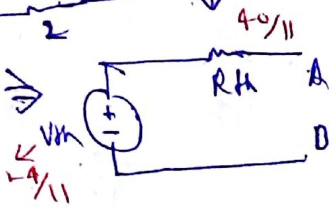
$Vth \to 4\left(\frac{8}{20/3+8}\right) = 24/11$ volt

Rth →



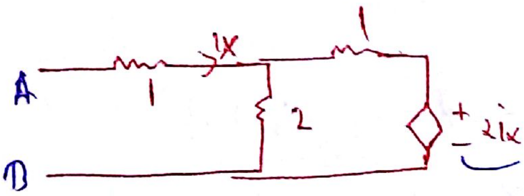


$\left(\frac{32}{12}+4\right) \| 8 = 40/11\ \Omega$ ⇒

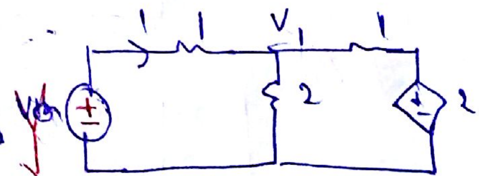


$IN = \frac{24/\cancel{11}}{40/\cancel{11}} = 0.6\ Ab$

Case 3 →



dependent source



$-I + \frac{V_1}{2} + \frac{V_1 - 2i_a}{1} = 0$

$\frac{V_1}{2} = I$; $i = \frac{V - V_1}{1} \to V_1 = V - i$

$\frac{V - i}{2} = I$

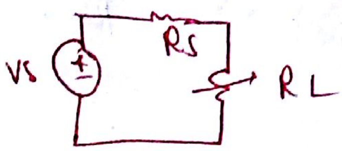
$\frac{V}{2} = \frac{3I}{2}$; $V/I = 3 = Rth\ \Omega$

Lec 8 –

(MPTT) – Maximum Power Xfer theorem → ① when Load is variable
② choose Min, internal impedance – otherwise
③ → for Linear, Active, Passive, N/W

Applicable

Case 1



$RL \rightarrow$ $I = \frac{V_S}{R_S + R_L}$ $P = I^2 R_L \Rightarrow \frac{V_S^2}{(R_S + R_L)^2} \times R_L$

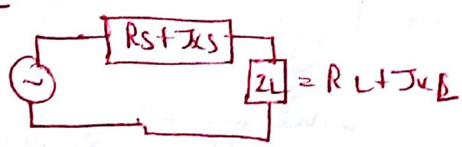
(Rs – fixed
(RL – variable)

$\frac{dP_L}{dR_L} = 0 \rightarrow$ $\boxed{R_L = R_S} \rightarrow$ Maximum Power xfer to Load

$$\boxed{P_L = \frac{V_S^2}{4R_L}}$$

$$\boxed{\eta = 50\%}$$

Case-2 →



(2(a)) → RL → variable XL – fixed

$$\boxed{R_L = \sqrt{R_S^2 + (X_S + X_L)^2}}$$

$\% \eta < 50\%$

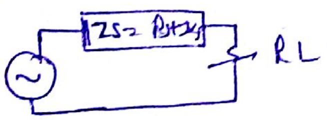
2(b) – RL – fixed XL – Variable

$$\boxed{X_L = -X_S}$$

2(C) – RL, XL → Variable]

$$\boxed{Z_L = R_S - jX_S = Z_S^*}$$

Case-3 →



$$R_L = \sqrt{R_S^2 + (X_S)^2}$$

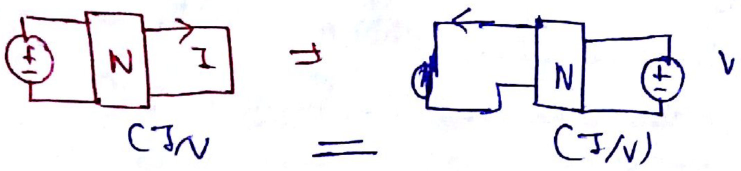
##

If only RL is variable → $R_L = \lvert \text{Constant} \rvert$ If XL is variable only – $X_L = -X_S$ If RL and XL both variable $\left.\begin{array}{l} R_L = R_S \\ X_L = -X_S \end{array}\right\} Z_L = Z_S^*$

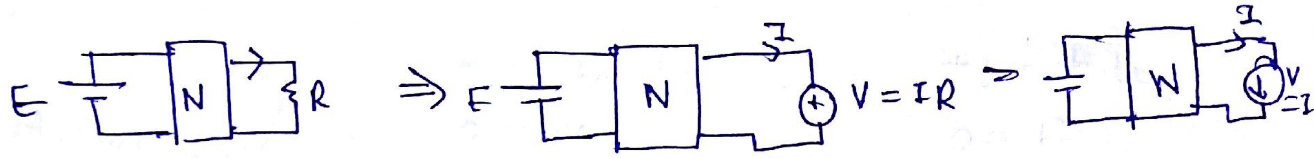
Lec-5 —

Reciprocity theorem

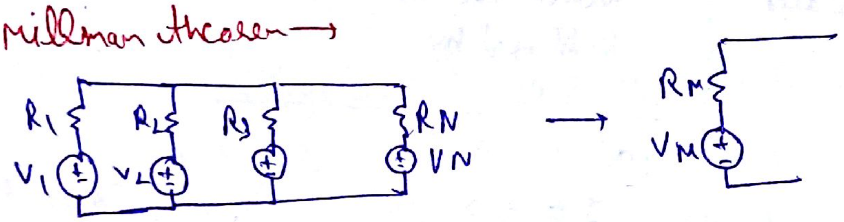
(L, P, B) → Responce to excitation Ratio → Constant → I/P and O/P terminal interchanged)



Substitution Theorem



Millman theorem →



$$V_M = \frac{V_1 G_1 \pm V_2 G_2 \pm V_3 G_3 \pm \cdots \pm V_N G_N}{G_1 + G_2 + \cdots + G_N}$$

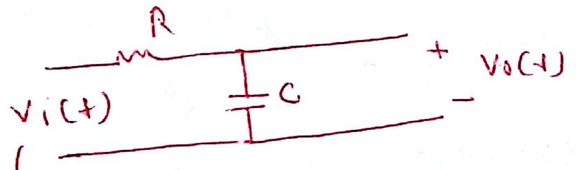
$$R_M = \frac{1}{G_1 + G_2 + G_3 + \cdots + G_N}$$

* — Check the polarity of voltage source while adding

Lec-11

Steady State Response

$x(t) \longrightarrow$ LTI $\longrightarrow y(t)$ < Transient / Steady state



↓ Vinput

$v_i(t) = A_i \sin(\omega_0 t + \phi_i) \longrightarrow$ H(s) $\longrightarrow v_o(t) = A_i A_o \sin(\omega t + \phi_i + \phi_o)$

$$H(s) = \frac{V_o(s)}{V_i(s)}$$

$A_o = |H(j\omega)|$ at $\omega = \omega_0$

$\phi_o = \angle H(j\omega)$ at $\omega = \omega_0$

$$\boxed{V_o(s) = H(s) * V_i(s)}$$

Lec-12

$i(t) = I_0 (1 - e^{-t/\tau})$ → Charging of inductor

$i(t) = I_0 e^{-t/\tau}$ → Discharging of inductor

$V_c(t) = V_0 (1 - e^{-t/\tau})$ → charging of capacitor

$V_c(t) = V_0 e^{-t/\tau}$ → Discharging of capacitor

Behaviour of L, C element at $t = 0^+$ and $t = \infty$

at $t = 0^+$	at $t = \infty$	
$I_L = 0$ Inductor can be replaced by open ckt	$V_L = 0$ Inductor can be replaced by S-C	— Inductor
$V_c = 0$ Capacitor act as S.C	$I_c = 0$ Capacitor act as open ckt	— Capacitor
at $t = 0^-$ and $t = 0^+$ $\boxed{I_L(0^-) = I_L(0^+)}$	at $t = 0^-$ and $t = 0^+$ $\boxed{V_c(0^-) = V_c(0^+)}$	— Practical value
for $t \geq 0$ Inductor $\xrightarrow{\text{Replace}}$ inductor parallel with current source	for $t \geq 0$ Capacitor $\xrightarrow{\text{Replace}}$ Capacitor in series with voltage source	

Lec-13

DC Transient

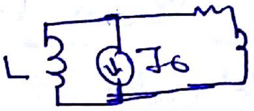
- Source free ckt
  - RL ckt
  - RC ckt
  - RLC ckt
- With Source: Initial $t = 0^+$ and final $t = \infty$
- With source Responses for $0 \leq t \leq \infty$ conditions

DC transient (Source free RL N/W)

(1) at $t = 0^-$
N/W – Steady state – (Inductor – S.C)

(2) at $t = 0$ → Source disconnected
Inductor $\xrightarrow{\text{Replace}}$ Current source ($I_L 0^- = I_L 0^+$)

(3) At $t \geq 0$
$i(t) = I_0 e^{-t/\tau}$



– equivalent ckt

$\boxed{\tau = \frac{L_{eq}}{R_{th}}}$

(14) DC transient (Source free RC ckt)

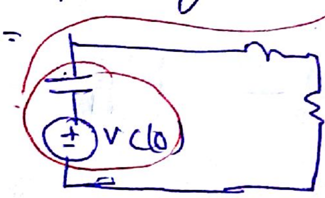
(i) – at $t = 0^-$ → N/W – Steady state → (Capacitor – O.C)

(ii) at $t = 0$ → Source disconnected
Capacitor $\xrightarrow{\text{Replace}}$ Voltage source ($V_C 0^+ = V_C 0^-$)

(iii) $V_C(t) = V_0 e^{-t/\tau}$ $\tau = RC$

Replace Capacitor by → equivalent ckt to find $V_C(t)$.

~~Vc(t)~~ =



(15) – With Source

(1) initial $t = 0^+$ and final $t = \infty$

→ Steady state
- Inductor – S.C
- Capacitor – O.C

→ $I_L(0^-) = I_L(0^+) = 0$ (Inductor – O.C)

→ $I_L(0^-) = I_L(0^+) \neq 0$ (Inductor → Current Source)

→ $V_C(0^-) = V_C(0^+) = 0$ (Capacitor – S.C)

→ $V_C(0^-) = V_C(0^+) \neq 0$ (Capacitor – Voltage Source)

(3) With source Responsed for $0 \le t \le \infty$ Condition →

⊙ → If N/W contain several source, several resistor, several inductor then $\boxed{I_L(t) = I_L(\infty) + [I_L(0) - I_L(\infty)]\, e^{-t/\tau}}$ $0 \le t \le \infty$

⊙ → If above case – if ~~cap~~ inductor, is Replaced by Capacitor

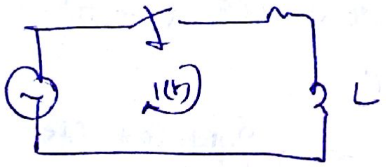
$$\boxed{V_C(t) = V_C(\infty) + [V_C(0) - V_C(\infty)]\, e^{-t/\tau}} \quad 0 \le t \le \infty$$

⊙ RL, RC – not separable → Laplace transform approach is used

Lec-17 →

AC transient ↓

RL Ckt



$$i(t) = k e^{-t/\tau} + I_{sc}(t)$$

Phasor Approach — Laplace approach

$$v(t) = V_m \sin(\omega t + \theta) \longrightarrow \boxed{\frac{1}{R+LS}} \longrightarrow V_o(t) = V_m A_0 \sin(\omega t + \phi + \phi_0)$$

$$i(t) = k e^{-t/\tau} + \frac{V_m}{\sqrt{R^2 + \omega^2 L^2}} \sin\left(\omega t + \phi - \tan^{-1}\frac{\omega L}{R}\right)$$

$$\boxed{\phi = \tan^{-1}\frac{\omega L}{R}} \rightarrow \text{Transient free state}$$

at $t = t_0$

$$\boxed{(\omega t_0 + \phi) = \tan^{-1}\frac{\omega L}{R}} \quad \text{or} \quad (\omega t + \phi) = \tan^{-1}\left(\frac{\omega L}{R}\right) + \frac{\pi}{2}$$

(Sine function) Cosine fun

(i) RC Ckt →

$$v(t) \text{ — } V_m \sin(\omega t + \phi) \longrightarrow \boxed{\frac{1}{1+SCR}} \longrightarrow V_o(t) = V_m A_0 \sin(\omega t + \phi + \phi_0)$$

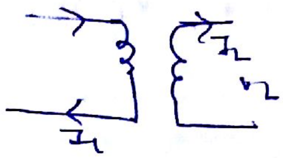
$$\boxed{\phi = \tan^{-1} \omega RC} \text{ — Transient free RC ckt}$$

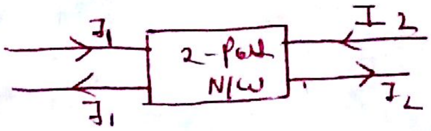
$$\boxed{(\omega t + \phi)_{t=t_0} = \tan^{-1} \omega RC}$$

$$\boxed{(\omega t + \phi)_{t=t_0} = \tan^{-1} \omega RC + \pi/2}$$

(ii) RLC Ckt → no Transient free Condition

→ Two Port N/w





(1) Z - parameter (Z) - (O.C Parameter)

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

V_1, V_2 - Dependent
I_1, I_2 - Independent

Symmetrical = $Z_{11} = Z_{22}$
Reciprocal = $Z_{12} = Z_{21}$

(2) Y Parameter (Short Ckt Parameter)

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

Symmetrical : $y_{11} = y_{22}$
Reciprocal : $y_{12} = y_{21}$

(3) ABCD Parameter (T Parameter)

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

Symmetrical $A = D$
Reciprocal $AD - BC = 1$

(4) T' Parameter

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

Symmetrical = $A' = D'$
Reciprocal = $A'D' - B'C' = 1$

(5) h-Parameter

$$\begin{pmatrix} V_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ V_2 \end{pmatrix} \rightarrow$$

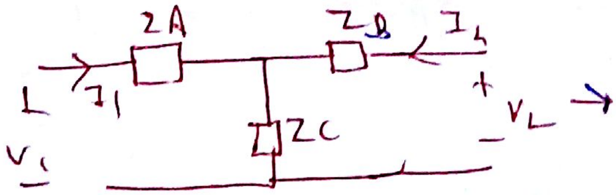
Symmetrical → $h_{11}h_{22} - h_{12}h_{21} = 1$
Reciprocal = $h_{12} = -h_{21}$

(6) (g - Parameter)

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

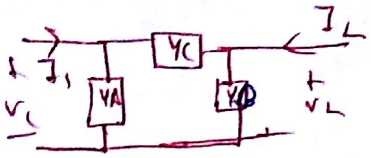
Symmetrical = $g_{11}g_{22} - g_{12}g_{21} = 1$
Reciprocal → $g_{12} = -g_{21}$

Z Parameter of T N/W



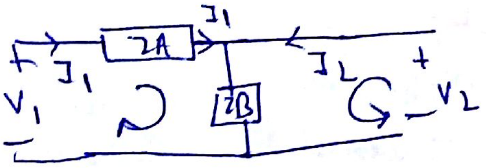
$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} (Z_A + Z_C) & Z_C \\ Z_C & (Z_B + Z_C) \end{bmatrix}$$

Y Parameter of π-N/W ↓



$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} YA+YC & -YC \\ -YC & YB+YC \end{bmatrix}$$

T Parameter of Inverted L →

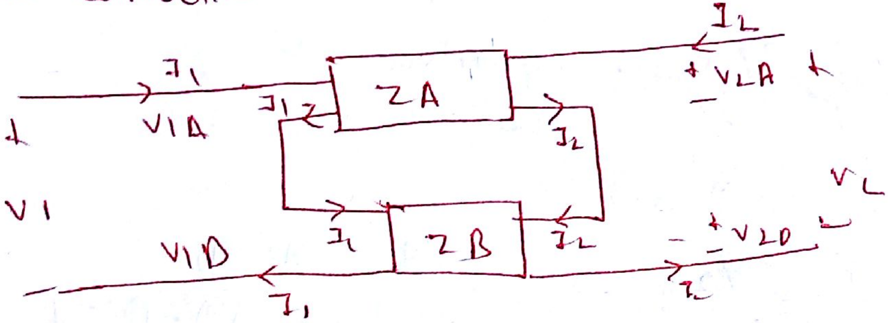


$$\Rightarrow \quad A = \left(\frac{ZA+ZB}{ZB}\right) \qquad B = -ZA$$

$$C = 1/Z_B \qquad D = 1$$

(Lec-9)

(i) Series Connection –



$$\begin{pmatrix} V_1A \\ V_2A \end{pmatrix} = (ZA)\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} \quad \text{— (i)}$$

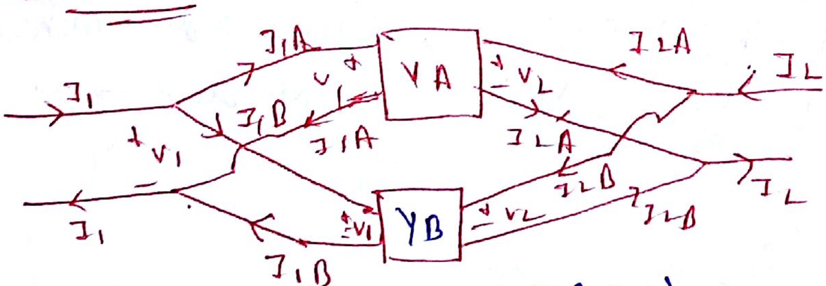
$V_1 = V_1A + V_1B$

$V_2 = V_2A + V_2B$

$$\begin{pmatrix} V_1B \\ V_2B \end{pmatrix} = (ZB)\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} \quad \text{— (ii)}$$

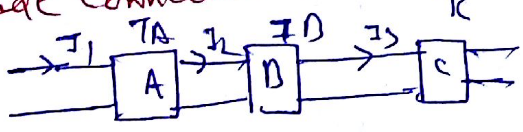
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = (ZA+ZB)\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} \qquad \boxed{Z_{eq} = ZA+ZB}$$

(ii) Parallel Connection →



$$\begin{matrix} I_1 \\ I_2 \end{matrix} = [YA+YB]\begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$$

(iii) Cascade Connection →



$$T_{rel} = (TA)(TB)(Tc)$$

AC Analysis]

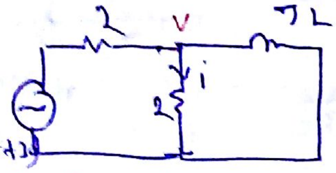
Lec 20

$20\angle 30$

{take RMS value if when nothing is mention}

$$I = \frac{20\angle 30}{2+2j} = \frac{10}{\sqrt{2}}\angle -15 \leftarrow \text{RMS value}$$

$$I_{max} = \sqrt{2} I_{rm} = \sqrt{2} \times \frac{10}{\sqrt{2}}\angle -15 = 10\angle -15$$



$v_1 = 20\cos(100t+30)$

(Method -1)

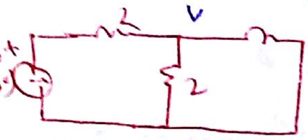
$$V_i = 20\cos(100t+30)$$

$$\frac{V - 20\angle 30}{2} + \frac{V}{2} + \frac{V}{2j} = 0$$

$$V = 4\sqrt{5}\angle 56.56$$

or

$$I_1 = \frac{V}{2} = 2\sqrt{5}\angle 56.56 = 2\sqrt{5}\cos(100t + 56.56)$$



$20\cos(100t+30)$

Take RMS value

(Method-2)

$$\frac{V - \frac{20}{\sqrt{2}}\angle 30}{2} + \frac{V}{2} + \frac{V}{2j} = 0$$

$$\underbrace{V = 2\sqrt{10}\angle 56.56}_{rm} \qquad i_{rm} = \sqrt{10}\angle 56.56$$

$$i_{max} = i_{rm} \times \sqrt{2} = \sqrt{20}\angle 56.56 = 2\sqrt{5}\angle 56.56$$

$(a+bi) \rightarrow A\angle\theta \rightarrow A = \sqrt{a^2+b^2} \quad \theta = \tan^{-1} b/a$

$A\angle\theta \rightarrow (a+bi) \rightarrow a = A\cos\theta \quad b = A\sin\theta$

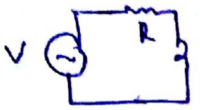
(Polar - Rectangular Conversion)

Bullated point

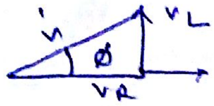
- when nothing is given about excitation then always taken that value as RMS value
- when only sinusoidal excitation is given then taken sine as Ref.
- when only cosinusoidal " " " " cos as Ref.
- when both sine, cosine excitation have same freq is given then taken anyone as Ref. and make other as same Ref.
- when both sine and cosine excitation having diff. freq is given then only superposition theorem can be applicable.

Lec-21 —

Series RL Ckt —

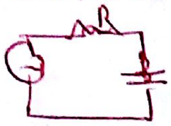


$\rightarrow$ $V_R = IR$, $V_L = I\omega L$ $\quad \tan\phi = \frac{V_L}{V_R} \Rightarrow \phi = \tan^{-1}\frac{V_L}{V_R} = \tan^{-1}\frac{X_L}{R}$



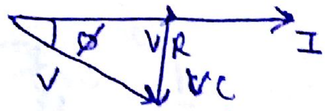
$\rightarrow$ (Lag p.f)

Series RC Ckt



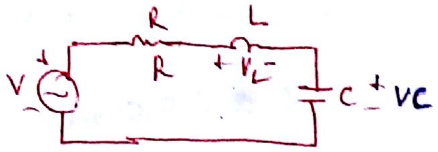
— $V_R = IR$, $V_C = \frac{I}{j\omega C} = \left|\frac{I\phi}{\omega C}\right| \angle -90$

$\phi = \tan^{-1}\frac{V_C}{V_R} = \tan^{-1}\frac{1}{\omega RC}$



(Leading p.f) an

Series RLC Ckt $\rightarrow$



$V_L > V_C \rightarrow$ Lag $\rightarrow \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ — pf

$V_C > V_L$ — Lead — $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$ — p.f

$V_L = V_C \rightarrow \quad \phi = 0$ — (Resonance Condition) ($X_L = X_C$)

Parallel RL Ckt $\rightarrow$ $\quad \cos\phi = \frac{I_R}{I} \quad \phi = \tan^{-1}\left(\frac{I_L}{I_R}\right)$ — (Lag)

Parallel RC Ckt — $\phi = \tan^{-1}\left(\frac{I_C}{I_R}\right) \rightarrow$ Leading pf

Parallel RLC Ckt — $I_L = \left|\frac{V}{\omega L}\right| \angle 90 \quad I_C \left|V\omega C\right| \angle +90$ — (Lead $I_C > I_L$, Lag — I)

$\phi = \tan^{-1}\left(\frac{I_C - I_L}{I_R}\right)$ (Lead) or $\phi = \tan^{-1}\left(\frac{I_L - I_C}{I_R}\right)$ Lag $\quad I_L = I_C$ Resonance

Power $\Rightarrow$

$P(t) = V_m I_m \cos(\theta_v - \theta_i)$ — p.f

$\boxed{S = V_m I_m^*}$

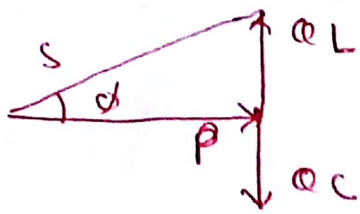
P_{avg} — $V_m I_m \cos(\theta_v - \theta_i)$ — Active Power

$Q_{avg} \rightarrow V_m I_m \sin(\theta_v - \theta_i)$ — Reactive Power

R Load — $\theta_v = \theta_i$. $Q = 0$

L Load $\rightarrow$ $\theta_i = -90$ $\quad Q = V_m I_m > 0$

C Load = $\theta_i = +90$ $\quad Q = -V_m I_m < 0$



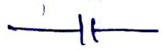
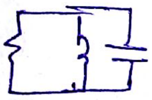
$\cos\phi = \frac{\text{Useful Power}}{\text{Net Power}} =$

Resonance

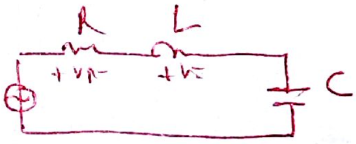
Quality fact $Q = 2\pi \times \dfrac{\text{Max energy stole}}{\text{energy dissipated in 1 cycle}} = \dfrac{\text{Reactive Power}}{\text{active Power}}$

R L —→ $\boxed{Q = \dfrac{X_L}{R} = \dfrac{\omega L}{R}}$

Dissipation factor (D) $= 1/Q$

S.No	Type	Quality factor
1	 R	$Q = 0$
2		$Q = \infty$
3		$Q = \infty$
4		$Q = \omega L/R$
5		$Q = \dfrac{1}{\omega CR}$
5		$Q = \dfrac{\omega L}{R} = \dfrac{1}{\omega CR} = \dfrac{1}{R}\sqrt{L/C}$
5		$Q = R/X_L = R/\omega L$
6	 R, C	$Q = \omega CR$
7		$Q = R\sqrt{C/L}$

Series Resonance →



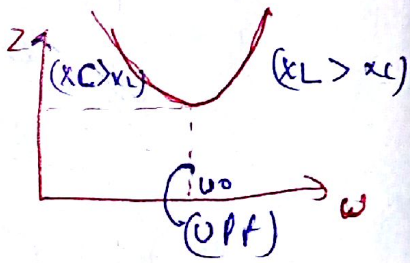
$f_0 = \dfrac{1}{2\pi\sqrt{LC}}$

$I = \text{Max} = \dfrac{V}{Z} = \dfrac{V}{R}$

$V_R = V$

$V_L = JQV$

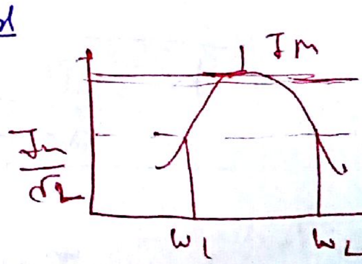
$V_C = -JQV$



(Bandwidth) → BW↓ no of chanel ↑

$P \geq \frac{1}{2} P_{max}$ → good signal

$(BW = \omega_2 - \omega_1)$



Cut off freq

$\omega_1 = \dfrac{-R}{2L} + \sqrt{(R/2L)^2 + 1/LC}$

$\omega_2 = R/2L + \sqrt{(R/2L)^2 + 1/LC}$

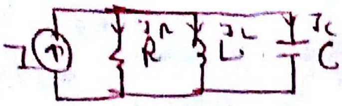
$BW = R/L$

$f_2 - f_1 = R/2\pi L$

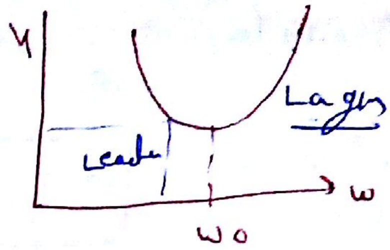
$\boxed{Q = \dfrac{\omega_0}{BW}}$

1/Area Cont

Parallel Resonance



$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$



BW ⇒ $f \geq Q\ 2\ P_{max}$ – good stud

find cut off freq

$$\omega_1 = \frac{-1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + 1/LC}$$

$$\omega_2 = 1/2RC + \sqrt{\left(\frac{1}{2RC}\right)^2 + 1/LC}$$

$$\omega_0 = \sqrt{\omega_1 \omega_2}$$

$$BW = \omega_2 - \omega_1 = 1/RC = \frac{\omega_0}{Q_0} = \frac{1}{\text{tir Cost}}$$

Lec-25

Magnetically Coupled ckt →

Case-1 →

$$v_1 = L_1\frac{di_1}{dt} + M\frac{di_2}{dt} \qquad V_2 = L_2\frac{di_2}{dt} + M\frac{di_1}{dt}$$

Case 2 →

$$v_1 = L_1\frac{di_1}{dt} - M\frac{di_2}{dt} \qquad V_2 = L_2\frac{di_2}{dt} - M\frac{di_1}{dt}$$

Coupling Coefficient →

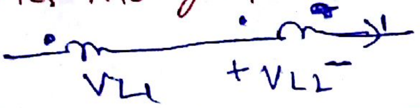
$$E = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 + M i_1 i_2$$

$$\boxed{K = \frac{M}{\sqrt{L_1 L_2}}}$$

$K = 0$ – $M = 0$ → Isolated coil

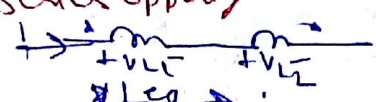
$K = 1$ – $M = \sqrt{L_1 L_2}$ – Tightly Coupled

Series Aiding →



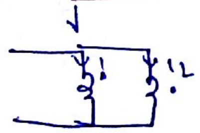
$$\boxed{L_{eq} = L_1 + L_2 + 2M}$$

Series opposing



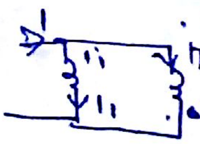
$$\boxed{L_{eq} = L_1 + L_2 - 2M}$$

Parallel adding



$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$

Parallel opposing



$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$