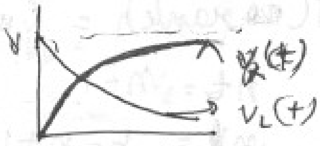
Network Theory

RLC circuits (for dc)

RL-series $V_R(t) = V\left[1-e^{-\frac{R}{L}t}\right]$



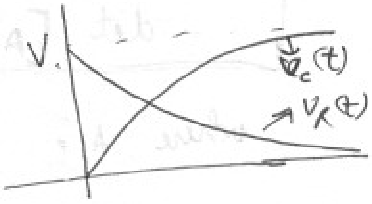
$V_L(t) = V\cdot e^{-\frac{R}{L}t}$

τ = time taken to reach $1-1/e \simeq 63.2\%$

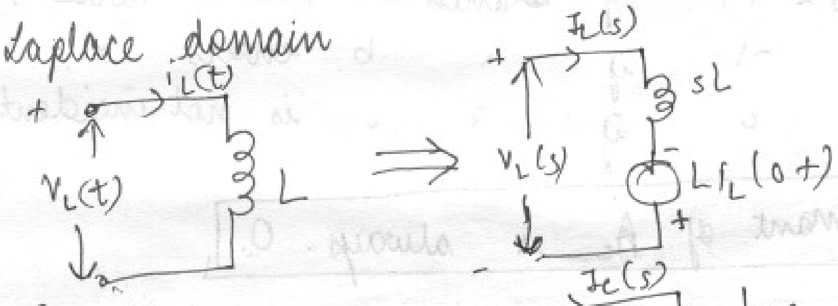
RC-series $i(t) = \frac{V}{R}\cdot e^{-t/RC}$

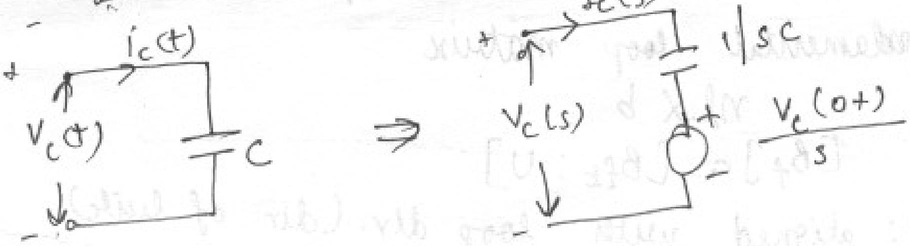
$V_R(t) = \frac{V}{\cancel{R}} e^{-t/RC}$

$V_C(t) = \frac{V}{\cancel{R}}\left[1-e^{-t/RC}\right]$



Laplace domain





RLC series circuit (for a.c. ckt)

Case I: $Q<1/2 \Rightarrow \frac{R^2}{4L^2} > \frac{1}{LC}$

overdamped

Case II: $Q=1/2 \Rightarrow \frac{R^2}{4L^2} = \frac{1}{LC}$

critically damped

Case III: $Q>1/2 \Rightarrow \frac{R^2}{4L^2} < \frac{1}{LC}$

underdamped

Graph

ρ(~~no~~ rank) = $(n-1)$

$n_t = n-1$ twigs (in tree)

$n_\ell = b-n+1$ links (not in tree)

* Total no. of possible trees of any graph = $\det[A \cdot A^T]$

where A = reduced incidence matrix

$(n_t \times b)$ $= [A_t : A_\ell]$

a_{nb} = +1 if branch b leaves node n

-1 if " b enters "

0 if " " is not incident on

* Determinant of A_c is always 0.

Fundamental loop matrix

$n_\ell \times b$

$[B_f] = [B_{ft} : U]$

1: aligned with loop dir. (dir. of link)

-1: not " " " "

0: not in loop

Fundamental cut-set matrix $(n_t \times b)$

Rank reduces by 1 by cutting graph into 2 parts

$[Q_f] = [U : Q_{f\ell}]$

q_{cb} = 1 : branch in cutset and orientations coincide

-1 : " " " " " opp.

0 : " not in "

orientation coincide (both arrows with common head/tail

Relationships

$\boxed{A B_f^T = 0}$ A orthogonal to B_f

$V_b = \begin{bmatrix} V_t \\ V_l \end{bmatrix}$

$B_{ft} = [-A_t^{-1} A_l]^T$

$I_b = \begin{bmatrix} I_t \\ I_l \end{bmatrix}$

$\boxed{\begin{matrix} A I_b = 0 \\ Q_f I_b = 0 \end{matrix}}$ KCL

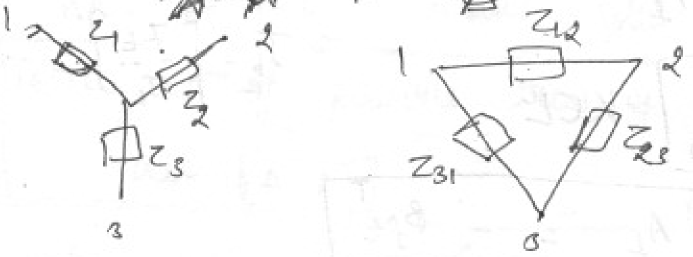
$\boxed{Q_{fl} = A_t^{-1} A_l = -B_{ft}^T}$

$\boxed{B_f V_b = 0}$ KVL

~~Star-Delta~~ ~~X-form~~ N/w Theorems

~~Sta~~ Star - Delta X-formation

~~$\star \to$~~ Δ



~~Y-Δ~~ $\Delta \to \star$

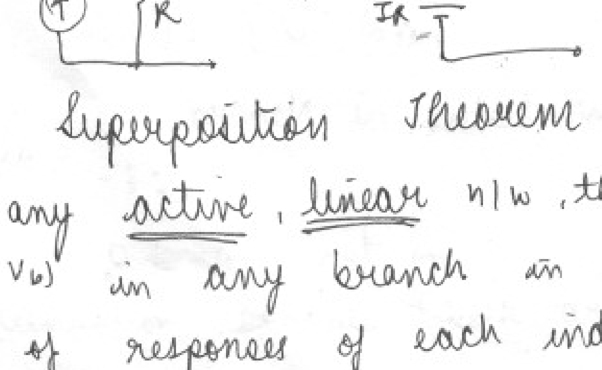
$$Z_1 = \frac{Z_{12}\,Z_{31}}{Z_{12} + Z_{23} + Z_{31}} \ \ldots$$

$\star \longrightarrow \Delta$

$$Z_{12} = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3} \ \ldots$$

NOTE: For equal resistances ~~While converting from delta to~~
$\Delta \to \star$ /3
$\star \to \Delta$ *3

Source X-fation



Superposition Theorem

"In any active, linear n/w, the overall response (I_b or V_b) in any branch in n/w equals the alg. sum of responses of each individual source considered separately with all other sources made inoperative."

It is combined prop. of additivity and homogeneity (scaling) of linear n/w

Limitations:

(i) Not applicable for only dependent sources

(ii) " " " non-linear elements eg diodes

(iii) " " " calculation of power

Reciprocity Theorem

"Ratio of excitation to response remains invar. in a reciprocal n/w with respect to an interchange b/w pts. of app^n of exc. and measurement of response".

$$E_1 / I_2 = E_2 / I_1$$

Limitations:

(i) Not applicable to n/w consisting of dependent source

(ii) " " " " " time-varying element

(iii) " " " " " non-linear elements

Thevenin's / Norton's

Calculate $Z_{th} = Z_N$

Case I: Only independent sources

Deactivate all sources, find eq. resist. looking back from the load terminal.

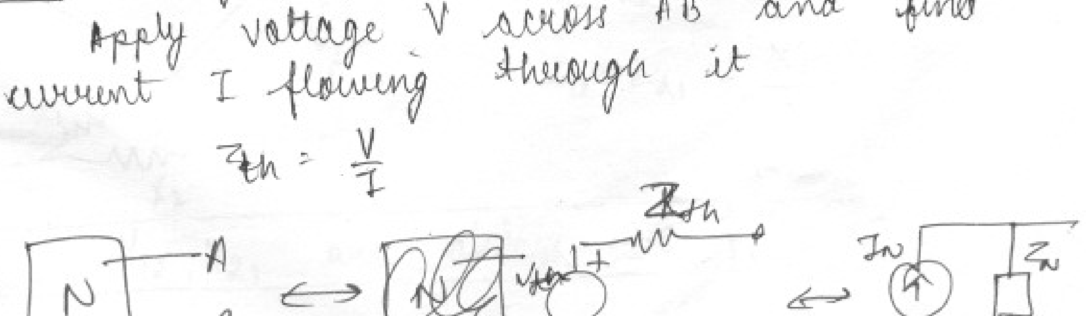
Case II: Both dependent and independent

$$Z_{th} = Z_N = \frac{V_{OC}}{I_{SC}}$$

Case III: Only dependent sources

Apply voltage V across AB and find current I flowing through it

$$Z_{th} = \frac{V}{I}$$



Limitation
Not applicable to circuits consisting of
1. unilateral elements e.g. diodes
2. non-linear " "
3. load series or || with controlled/dependent sources
4. magnetic coupling b/w load and any other ckt. element.

Max. Power X-fer Theorem

Max. power is obtained from circuit when load impedance equals complex conjugate of internal impedance of the circuit as seen from load terminals.

Various cases:

I DC $R_L = R_i$ (internal rest.)

II A.C.

$Z_L = \overline{Z_i}$

III A.C. X_L is fixed

$R_L^2 = R^2 * (X + X_L)^2$

IV A.C. $Z = R$, X_L is fixed

$R_L^2 = R^2 * X_L^2$

V A.C. like X-mer

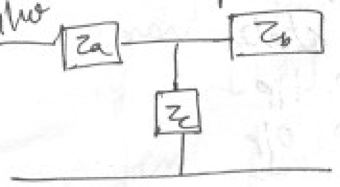
$|Z_L| = |Z|$

Two-port parameters

Set of parameters	Matrix eq.	Condition for reciprocity	for symmetry

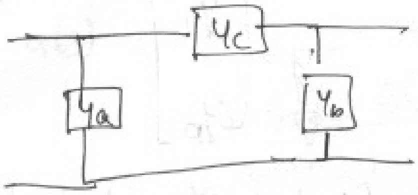
Some special configurations

T n/w

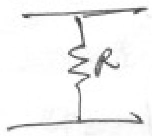
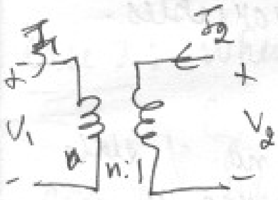


$$Z = \begin{bmatrix} Z_a + Z_c & Z_c \\ Z_c & Z_b + Z_c \end{bmatrix}$$

π n/w



$$Y = \begin{bmatrix} Y_a + Y_c & -Y_c \\ -Y_c & Y_b + Y_c \end{bmatrix}$$

	[Z]	[Y]	[T]	[h]
	* $\begin{bmatrix} R & R \\ R & R \end{bmatrix}$	–	$\begin{bmatrix} 1 & 0 \\ 1/R & 1 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 \\ -1 & 1/R \end{bmatrix}$
	–	* $\begin{bmatrix} 1/Z & -1/Z \\ -1/Z & 1/Z \end{bmatrix}$	$\begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$	$\begin{bmatrix} Z & 1 \\ -1 & 0 \end{bmatrix}$
			$\begin{bmatrix} n & 0 \\ 0 & 1/n \end{bmatrix}$