Vidyalankar

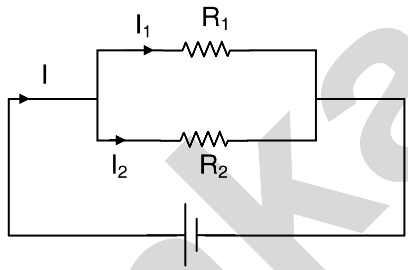
F.E. Sem. I

Basic Electrical Engineering (B.E.E.)

List of Formulae

Module -1 D.C. circuits

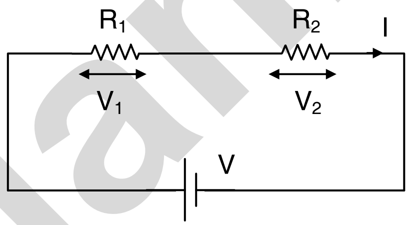
- $v = IR$ (ohm's law)
- Current divider rule (CDR)
  Applied to parallel circuit only



$$I_1 = \frac{IR_2}{R_1 + R_2}$$

$$I_2 = \frac{IR_1}{R_1 + R_2}$$

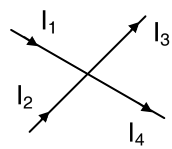
- **Voltage divider rule (VDR)**
  Applied to series circuit only



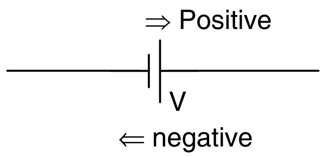
$$V_1 = \frac{VR_1}{R_1 + R_2}$$

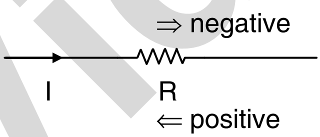
$$V_2 = \frac{VR_2}{R_1 + R_2}$$

- Kirchhoff's current law (KCL)
  $\sum$ Incoming current $= \sum$ outgoing current
  $I_1 + I_2 = I_3 + I_4$



- Kirchhoff's voltage law (KVL)
  Over all voltage drop in a loop is equals 0.
  Notations followed.
  Induction of current





- **MESH Analysis**
  mesh is undivided load
  steps:
  (i) Identify meshes
  (ii) Assume clockwise current
  (iii) Apply KVL in each mesh
  (iv) Solve the above equations to get answer.

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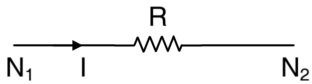
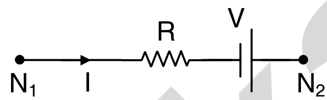
- **Nodal Analysis**
  Node is a junction where current gets split.
  Steps
  (i) Identify Nodes
  (ii) At each node assume outgoing current
  (iii) Express current as potential difference upon resistance which can be one of following.

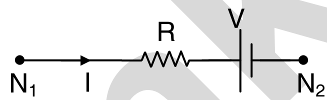
$$I = \frac{N_1 - N_2}{R}$$



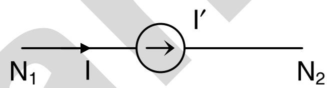
$$I = \frac{N_1 - N_2 + V}{R}$$



$$I = \frac{N_1 - N_2 - V}{R}$$



$$I = I'$$

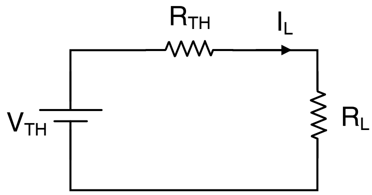


Superposition Theorem
This can be applied wherever we have more than one sources.
Steps :
1) Consider one source at a time
2) De-imergine the sources ∠ replace the sources with its internal resistance if gain. It not green voltage source is replaced with short circuit and current source is replaced with open circuit.
3) Find out the current through required resistance using any mechanism like KVL, KCL, mesh or nodal.
4) Repeat above steps for all other sources.
5) Current through required resistance is algebraic sum of individual current due to individual source. (If current are in same direction then addition else subtraction.)

Thevenin Theorem
1) It involves two steps

   step 1 $I_L = \frac{V_{TH}}{R_{TH} + R_L}$

   R_{TH}



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Steps :
Step 1

1) De-imergine the sources (replace the source with internal resistance if given. If not given voltage source is replaced with short circuit and current source is replaced with open circuit.)
2) Replace the substance through which current is required by open circuit name the end points as A and B.
3) Find R_{AB} which is R_{TH}

Step 2
V_{TH} same as maximum power the open

Maximum Power

$$P_{max} = \frac{{V_{TH}}^2}{4R_{TH}}$$

STEP to calculate R_{TH} same as in Thevenin refer thevenin.

STEP TO calculate V_{TH} (same in THEVENIN 8 MAXIMUM power).

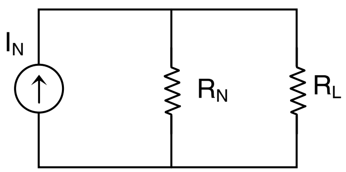
– Replace the resistance through which we want current with open circuit. Name the endpoints as A and B.
– Find a path from B to A and across the path add all the voltages as per KVL notation to get the answer which is $V_{AB} = V_{TH}$

NORTON Theorem

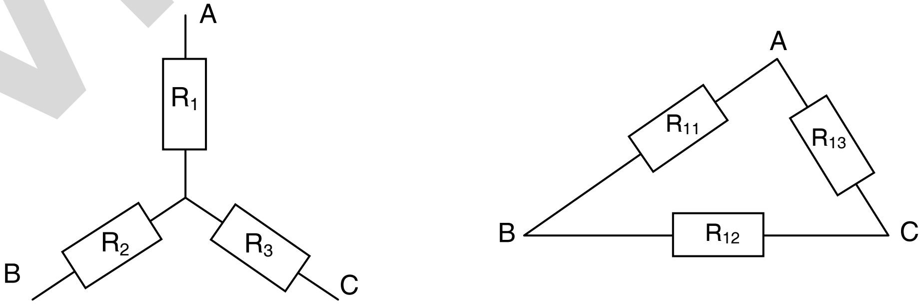
Step 1 : find $R_N \Rightarrow$ Step is same as R_{TH}
Step 2 : Find I_N

- Replace the resistance through which we want current with short circuit find the current through the replaced short circuit which is I_N.

Step 3 : $I_L = \frac{I_N R_N}{R_N + R_L}$



STAR TO DELTA



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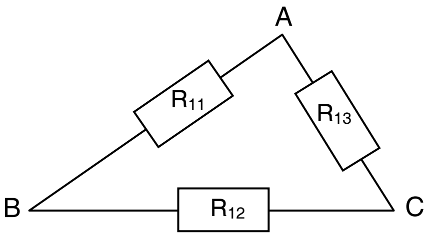
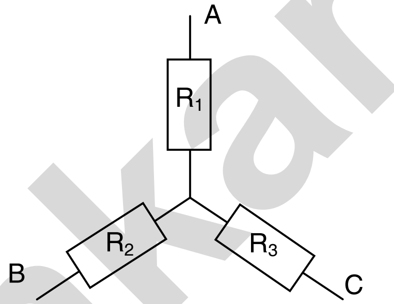
$$R_{11} = R_1 + R_2 + \frac{R_1R_2}{R_3}$$

$$R_{12} = R_2 + R_3 + \frac{R_2R_3}{R_1}$$

$$R_{13} = R_1 + R_3 + \frac{R_1R_3}{R_2}$$

DELTA TO STAR



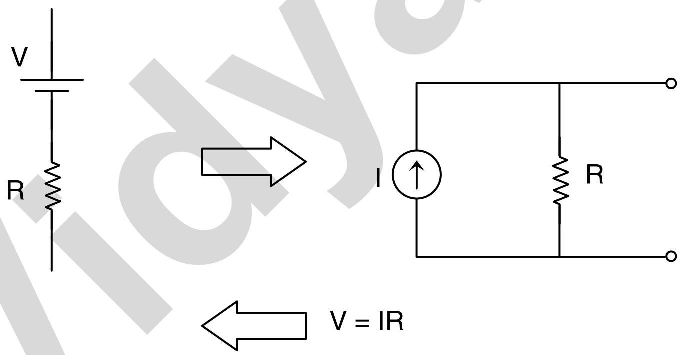


$$R_1 = \frac{R_{11}R_{13}}{R_{11} + R_{12} + R_{13}}$$

$$R_2 = \frac{R_{11}R_{12}}{R_{11} + R_{12} + R_{13}}$$

$$R_3 = \frac{R_{12}R_{13}}{R_{11} + R_{12} + R_{13}}$$

SOURCE Transformation



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Module -2 A.C. Circuits

- **Graph Theory**

Average value = $\frac{1}{b-a}\int_a^b f(\theta)d\theta$

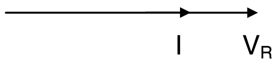
For symmetric signal – half cycle
For asymmetric signal – full cycle

RMS Value = $\sqrt{\frac{1}{b-a}\int_a^b f^2(\theta)\,d\theta}$

for RMS always full cycle.

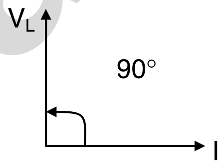
- **RLC**

For pure R.
→ Voltage and current are in phase.
$\phi = 0$



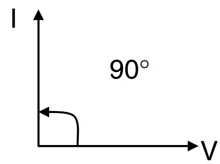
⇒ power factor = cos ϕ = 1
For pure L ⇒ $X_L = 2\pi fL$.
⇒ Voltage leads current by 90°, ϕ = 90

Power factor cosϕ = ∞



For pure C.

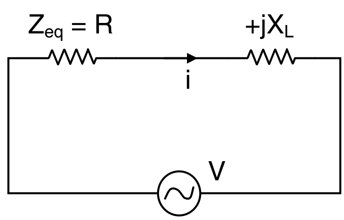
$X_C = \frac{1}{2\pi fC}$



Current leads voltage by 90°
power factor = cos 90 = ∞
RL circuit (also known as chake cail)

$Z_{eq} = R + j\,X_L$

$i = \frac{V}{Z_{eq}}$



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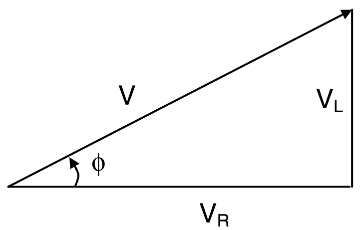
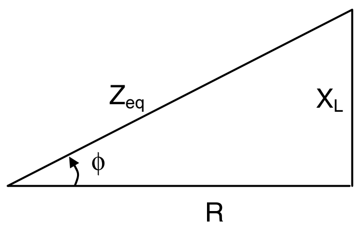
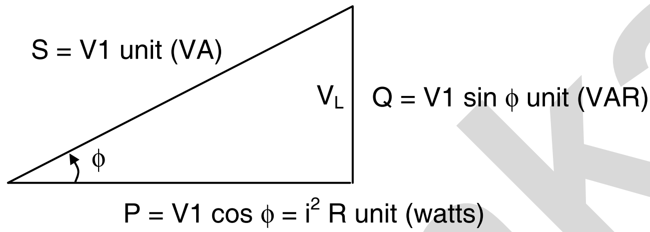
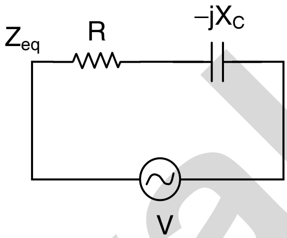


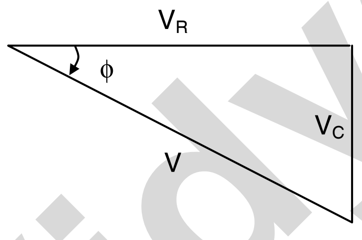


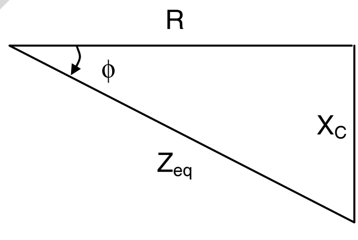


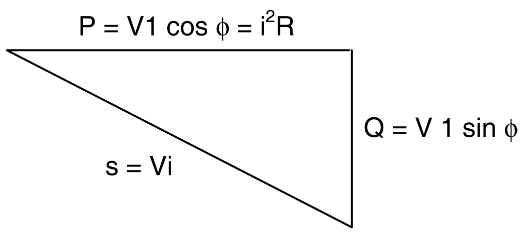
RC Series Circuit

$Z_{eq} = R - jX_C$









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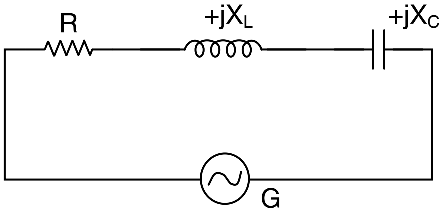
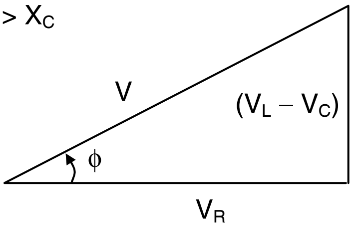
RLC series

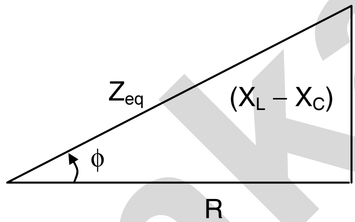


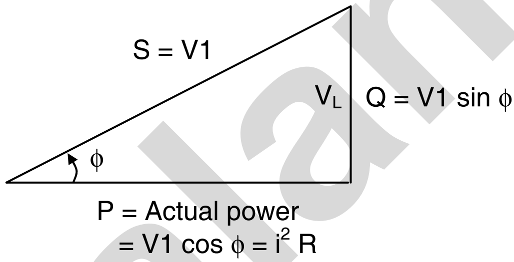
Zeq $= R + j(X_L - X_C)$

Two cases rust

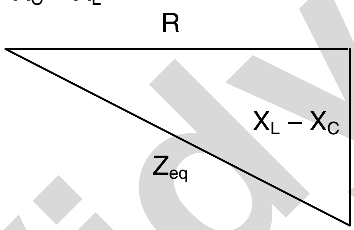
(1) $X_L > X_C$

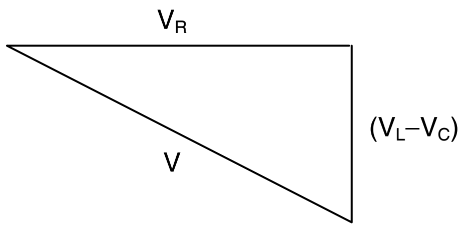


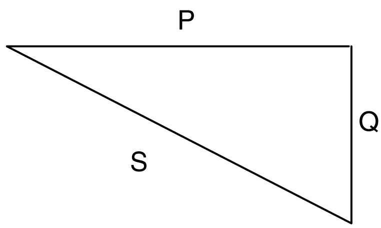




2) $X_C > X_L$







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Series resonance

$Z_{eq} = R$

$X_L = X_C$

$F_\mu = \frac{1}{2\pi}\sqrt{LC}\ \text{Hz}$

Current maximum
impedance maximum

$$f_2 = \left(f_r + \frac{R}{4\pi L}\right)\text{Hz}$$

$$f_1 = \left(f_r - \frac{R}{4\pi L}\right)\text{Hz}$$

Band width $= f_2 - f_1$

$$= \frac{R}{2\pi L}$$

$\phi = 0$

$\cos\phi = 1$

Quality factor

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

$$Q = \frac{rf}{BW}$$

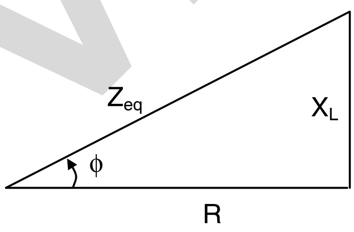
Parallel circuit

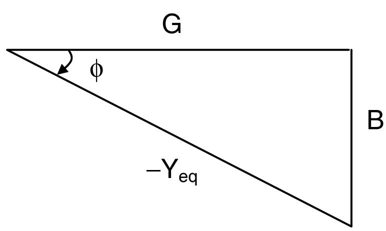
Admittance $\Rightarrow Y_{eq} = \frac{1}{Z_{eq}}$ $\Rightarrow$ Impedance

conductance $G = \frac{1}{R}$ $\Rightarrow$ resistance

Admittance $\Rightarrow B = \frac{1}{X}$ $\Rightarrow$ unductance or capacitance

For RL
Impedance triangle





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Parallel resonance

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

Impedance is maximum
current is minimum

$$Z^2_{cail} = \frac{L}{C}$$

$$Z_{eq} = \frac{L}{CR}$$

$\phi = 0$

$\cos\phi = 1$

Module -3 Three phase circuits

For 3ϕ

$V_1 = V_m \sin wt$

$V_2 = V_m \sin (wt + 120^\circ)$

$V_3 = V_m \sin (wt + 240^\circ)$

For STAR

V_L = line voltage I_L = line current

V_{Ph} = Phase voltage   Iph = Phase current

$V_L = \sqrt{3}\, Vph$

$I_L = Iph$ In both cases

For DELTA

$V_L = Vph$ $Zph = \frac{Vph}{ph}$

$V_L = \sqrt{3}\, Iph$

Power in 3ϕ

P = Active power = $\sqrt{3}\ V_L I_L \cos Q$

Q = Reactive power = $\sqrt{3}\ V_L I_L \sin\phi$

S = $\sqrt{3}\ V_L I_L$ = Apparent Power.

Power data = 3 Power star

Z_{delta} = 3Z star

For two watt meters

$W_1 + W_2 = V_L I_L \cos\phi$

$W_1 - W_2 = V_L I_L \sin\phi$

$$\tan\phi = \sqrt{3}\ \frac{(W_1 - W_2)}{(W_1 + W_2)}$$

Active power = input power

$$\text{Efficiency} = \frac{o/p}{i/p}$$

Module -4 Single phase transformer

$$K = \frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_1}$$

Transformation ratio

$\frac{1}{K}$ = turns ratio

$E_2 = 4.44\ f\ N_2 \phi\ m$

$E_1 = 4.44\ f\ N_1 \phi\ m$

$W_u = I_1^2 R_1 + I_2^2 R_2$

$= I_1^2 R_{01}$

$= I_2^2 R_{02}$

R_1 = Primary resistance

R_2 = Secondary resistance

R_1^1 = Primary resistance with respect secondary = $\frac{R_1}{K^2}$

R_2^1 = Secondary resistance with respect Primary = $K^2 R_1$

X_1 = Primary leakage reactance

X_2 = Secondary leakage reactance

X_1^1 = Primary leakage reactance with secondary = $\frac{X_1}{K^2}$

X_2^1 = Secondary leakage reactance with respect to primary = $K^2 X_2$

R_{01} = Total resistance w.r.t. Primary

R_{02} = Total resistance w.r.t. Secondary

X_{01} = Total reactance w.r.t. Primary

X_{02} = Total reactance w.r.t. Secondary

Z_{01} = Total impedance.w.r.t. Primary

Z_{02} = Total impedance.w.r.t. Secondary

I_0 =	I_u +	I_w
I	L	L
No. Load Current	Magnetizing Current	Coil loss Current

$I_w = I_0 \cos\phi$

$I_u = I_0 \sin\phi$

$R_0 = \frac{V_1}{I_W}$

$X_0 = \frac{V_1}{I_u}$

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$$KVA = \frac{E_1 I_1 F_L}{1000} = \frac{E_2 I_2 F_L}{1000}$$

$$\% \text{ Efficiency} = \frac{(x \times KVAFL \times Pf) \times 100}{(X \times KVA\,FL \times Pf)\,W_i \ + x^2\ W_w FL}$$

$$\eta \max = W_i = W_w$$

$$x = \sqrt{\frac{W_i}{W_w FL}}$$

$$\% \ \eta\max = \frac{(x + KVA\,FL \times Pf) \times 100}{(x \times KVA\,FL \times Pf) + 2W_i}$$

Current at any load

x = x current full load

$KVA_{n\ max}$ = η KVAFL

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