Network Analysis

Network:

Combination (Series + Parallel) of Passive and active elements, Such as, R, L & C (Passive elements) and Voltage Current Sources, fixed or Controlled (active elements), is called a Network.

Networks are equivalent models of an actual equipment or a system (such as power system).

Analysis means to analyze or evaluate different parameters, e.g. i, v, P, Q, S, p.f under normal or abnormal condition, or we say, steady-state or Transient conditions.

Define R, L, C and equations Associated.

R → Resistor, → Resistance, → ohm → Ω

Conductors → Define, Low Resistance

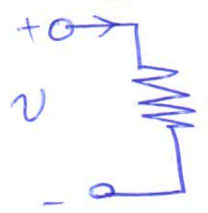
Insulator → Define, High Resistance

Both are important for each other.

Example of Conductors → Copper
→ Aluminium
→ Zn
→ Gold
→ Silver
→ Alloys,
→ Many other

Opposition to flow of Electrical current is called Resistance.

Element which opposes flow of Electric Current is called Resistor



$V = iR$

$R = \frac{V}{i}$ (ohm's law)

$P = I^2 R$

R → Constant By keeping temperature Constant.

$R_t = R_0(1 + \alpha t)$ Conductor

$R_t = R_0(1 - \alpha t)$ Insulator

$R_{eq} = R_1 + R_2$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

---

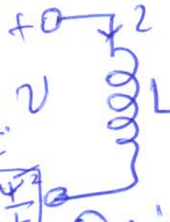
ideal $P = 0$

$E = \frac{1}{2} L i^2$ → Energy is stored in magnetic field

$\psi = Li$

$i = \frac{\psi}{L}$

$E = \frac{1}{2}\frac{\psi^2}{L}$



$Li = N\phi$

$L = \frac{N\phi}{i}$

$V = L\frac{di}{dt}$

$i = \frac{1}{L}\int_{-\infty}^{t} V \cdot dt$

$i = I_0 + \frac{1}{L}\int_0^t V \cdot dt$

Origin

$V = \frac{d\psi}{dt}$

$\psi = Li$

$V = \frac{d}{dt}(Li)$

$V = L\frac{di}{dt} + i\frac{dL}{dt}$

Faraday's Law

e.m.f induced is equal to rate of change of flux linkages.

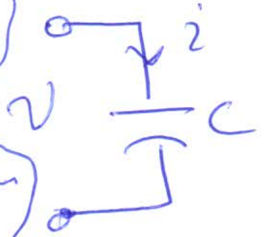
Element which opposes any change in current abruptly or instantaneously is called L.

$V = L\frac{di}{dt}$ for L = Constant

$L_{eq} = L_1 + L_2$

$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$

Element which opposes abrupt/instantaneous change in Voltage called capacitor



$$i = C\frac{dv}{dt}$$

$$i = C\frac{dv}{dt}.$$

$$v = \frac{1}{C}\int_{-\infty}^{t} i \cdot dt$$

$$v = V_0 + \frac{1}{C}\int_{0}^{t} i \cdot dt$$

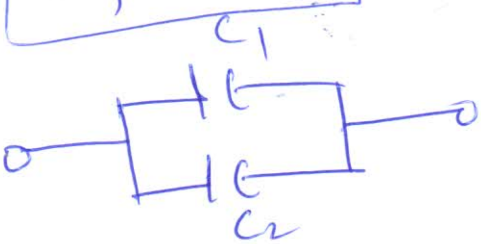
$i = \frac{dq}{dt}$ = rate of change of charge is current.

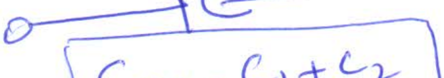
$$i = C\frac{dv}{dt} + v \cdot \frac{dc}{dt}.$$

$$i = C\frac{dv}{dt}$$

C = Constant

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}.$$





$$C_{eq} = C_1 + C_2$$

$P = 0$ (ideal)

$$E = \frac{1}{2}CV^2$$

$$q = CV$$

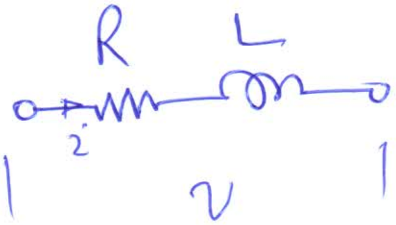
$$V = \frac{q}{C}.$$

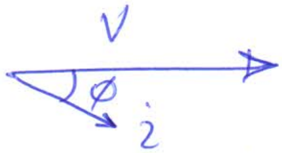
$$E = \frac{1}{2}\frac{q^2}{C}$$

Energy is stored in Electric field

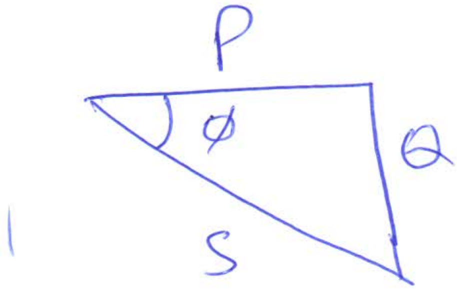
99% Load is Inductive.

(a) Single-phase load.





$\cos\phi$ = Power factor



MW ↑ KW ↑

$P = VI\cos\phi$ (Watts)

KVAR ↑

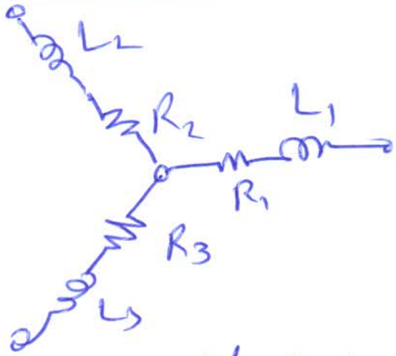
$Q = VI\sin\phi$ (VAR)

KVA ↑

$S = VI$ (VA)

Fan, Tube light, A-C, Induction motors, etc., etc.

(b) Three-phase load

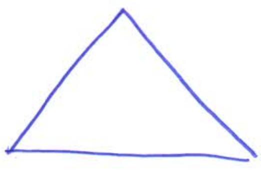


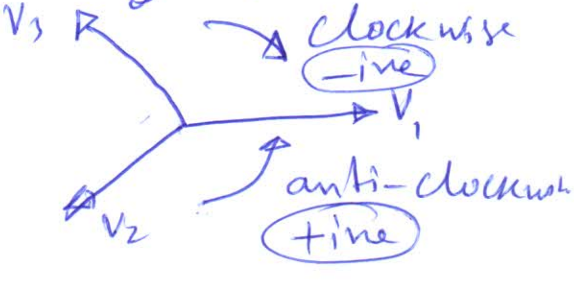
Balance ⇒ $I_1 = I_2 = I_3$

Un Balance ⇒ $I_1 \neq I_2 \neq I_3$

Y — Δ

Connections

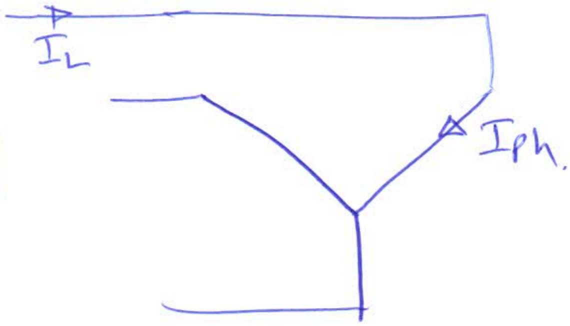


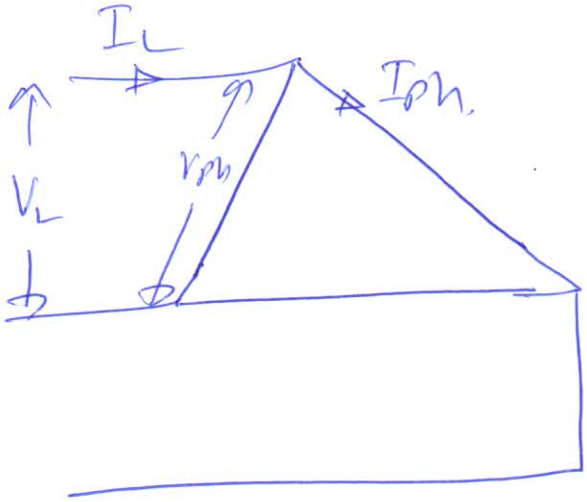


Y-Connection

$$I_{ph} = I_L$$

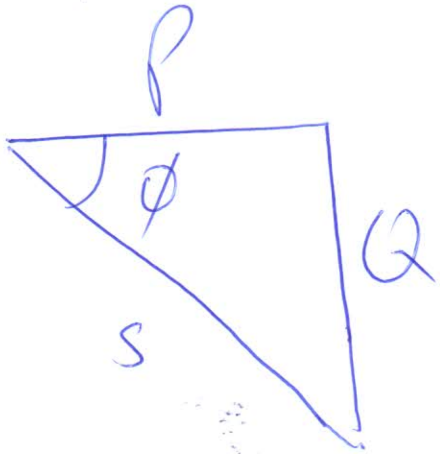
$$V_{ph} = \frac{V_L}{\sqrt{3}}$$





$$V_{ph} = V_L$$

$$I_{ph} = \frac{I_L}{\sqrt{3}}$$



$$P = \sqrt{3}\, V I \cos\phi$$

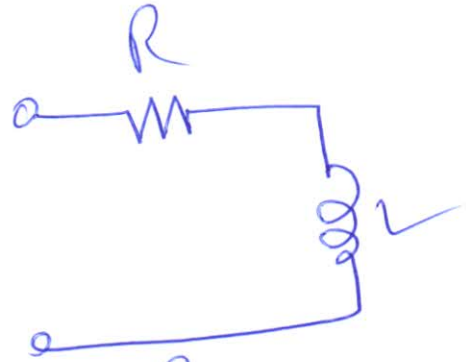
$$Q = \sqrt{3}\, V I \sin\phi$$

$$S = \sqrt{3}\, V I$$

$$P_T = P_A + P_B + P_C$$

First Order + 2nd order Differential Equations

First order Differential Equation

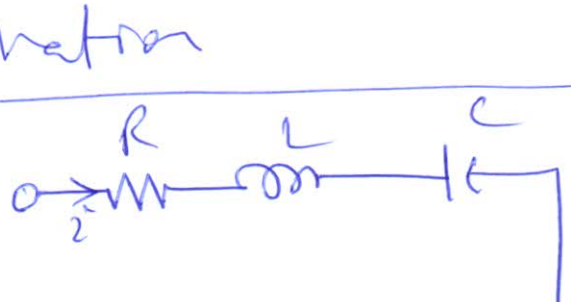


$$V = iR + L\frac{di}{dt}$$

$$V = iR + \frac{1}{C}\int_{-\infty}^{t} i \cdot dt$$

One Storage element
First order Differential Equation

Two Storage element
at Least 2nd order Differential Equation



$$V = iR + L\frac{di}{dt} + \frac{1}{C}\int_{-\infty}^{t} i \cdot dt$$

$$\frac{dV}{dt} = R\frac{di}{dt} + L\frac{d^2 i}{dt^2} + \frac{i}{C}$$

$$\frac{dV}{dt} = R\frac{di}{dt} + L\frac{d^2 i}{dt^2} + \frac{i}{C}$$