MADE EASY

ELECTRICAL ENGINEERING

NETWORK THEORY

BY-Y.NARESH SIR

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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NAS [NETWORK ANALYSIS SYSTEM]

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Topic :

1.) Basics
2.) Steady state analysis
3.) Theorems
4.) Transients And steady state Analysis
5.) Two - Port n/w
6.) Magnetic coupled ckt
7.) Graph theory
8.) Passive filters.

<u>Network Synthesis</u> : It's consists of finding new ckt which provides a desirable response to a given I/p excitation.

<u>Network Analysis</u> : It involves the calⁿ of the response of a known ckt to a given I/p.

I/P → [Known ckt] → ? → Response
I, V, P, & W

Circuit variables :

1.) <u>current</u> - The net out flow of e⊖ / charges across any cross section of a conductor is known as CURRENT.

$i(t) = \frac{dq}{dt}$ (or) $I = \frac{Q}{t}$ $\frac{C}{S}$ (or) Amphere

$i(t) = \frac{dq}{dt}$ → Instantaneous (or) dynamic

$I = \frac{Q}{t}$ → Steady state

$$i(t) = \frac{dq}{dt}$$

$$\frac{dq}{dt} = i(t)$$

$$q = \int_{-\infty}^{t} i(t)\,dt$$

$$q = \int_{-\infty}^{0} i(t)\,dt + \int_{0}^{t} i(t)\,dt$$

$$\boxed{q = q(0) + \int_{0}^{t} i(t)\,dt}$$

$q(0)$ → Initial charge

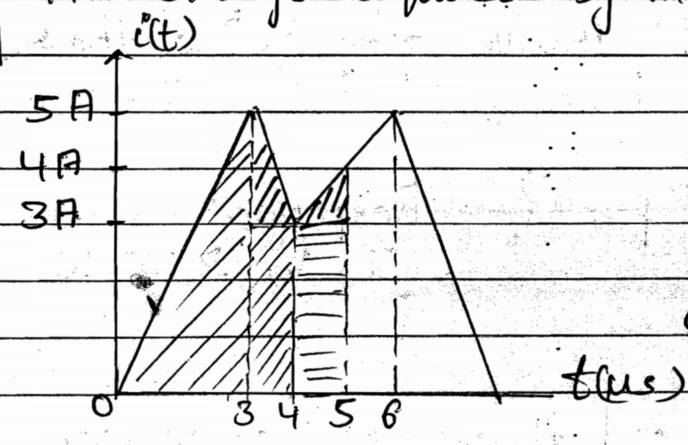
$\int_0^t i(t)\,dt$ → current is varying w.r.t time.

$$I = \frac{Q}{t}$$

$\boxed{Q = I \cdot t}$ colombs

Ques| The current through the capacitor. Determine the charge acquired by the capacitor up to 5 μs.

Ans|



$$q = q(0) + \int_{0}^{5} i(t)\,dt \quad (q(0) = 0)$$

$$q = \int_{0}^{3} i(t)\,dt + \int_{3}^{4} i(t)\,dt + \int_{4}^{5} i(t)\,dt$$

$$= \frac{1}{2} \times 3 \times 5 + \frac{1}{2} \times 1 \times 2 + 1 \times 3 + \frac{1}{2} \times 1 \times 1 + 1 \times 3$$

$$= 7.5 + 1 + 3 + 0.5 + 3$$

$$q = 15\ \mu C.$$

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2) Vltg / Electro motive force / Potential:

The workdone to move a unit +ve charge from infinity to some reference pt is known as Electro motive force (or) Vltg (or) potential.

$V = \frac{dw}{dq}$ (or) $V = \frac{w}{Q}$ energy per unit charge J/C (or)

E ⟶ Electric field intensity

$$\vec{E} = -\nabla V \text{ (or) } E = \frac{V}{l}$$

⇒ Electric field is negative potential gradient.

3) Power: The rate of change of Energy.

$P = \frac{dw}{dt}$ (or) $P = \frac{w}{t}$ $\frac{J}{s}$ (or) watts

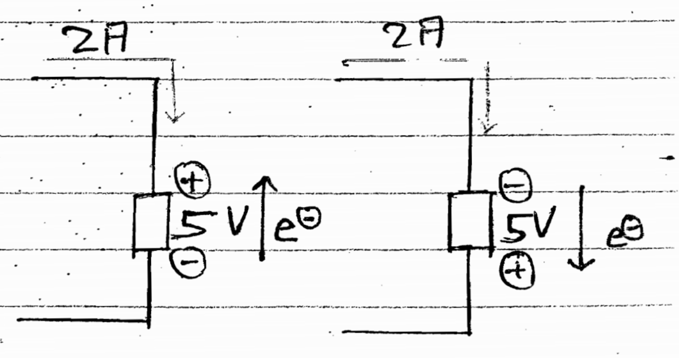
$P = \frac{dw}{dq} \cdot \frac{dq}{dt}$

$$P = V \cdot i$$

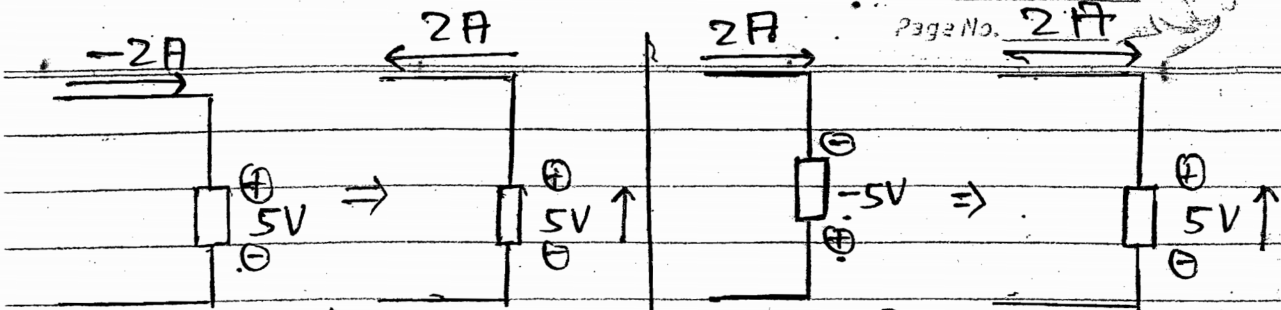
$$P = V \cdot I$$

Power

- generated (or) delivered
- absorbed (or) consumed



⇒ Power absorbed ⇒ Power delivered



Power Delivered | Power absorbed

Power delivered = - Power absorbed.

4.) **Energy**: capacity to do the work.

$P = \frac{dw}{dt}$ (or) $P = \frac{w}{t}$

$\frac{dw}{dt} = P$

$w = P \cdot t$

$\boxed{w = \int v \cdot i \cdot dt}$ Joules

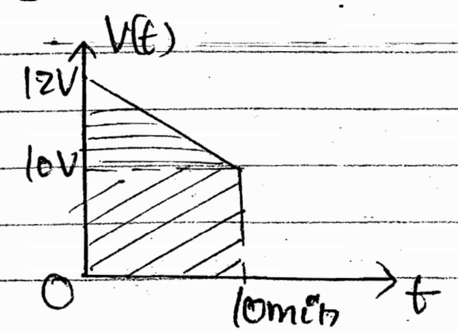
$v \cdot i$ → varying w.r.t time

$\boxed{w = V \cdot I \cdot t}$ Joules.

$V \cdot I$ → constant

Ques) A fully charged mobile phone with a 12V battery is good for 10 min talk time. Assume that during the talk time, the battery delivers a constant current of 2A & it vltg drops linearly from 12V to 10V. How much energy does the battery delivere during this talk time?

Ans



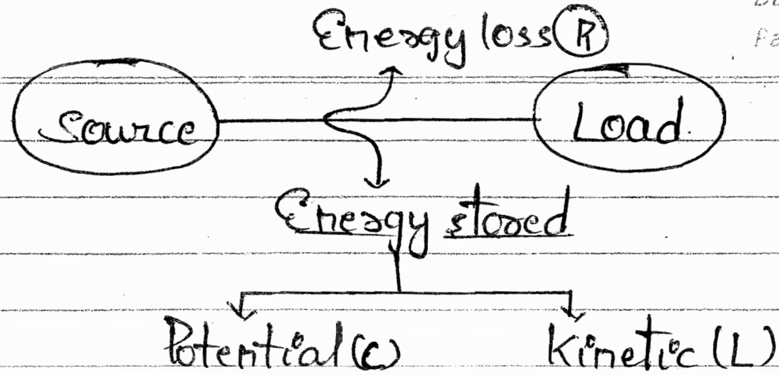
$w = \int v i \, dt$

$w = (10 \times 60 \times 10) + \frac{1}{2} \times 10 \times 60 \times 2$

$\int v dt = 6600 \; V\text{-}s$

$w = i \int v dt = 2 \times 6600 = 13.2 \, KJ$

Circuit Elements :



$W = \frac{1}{2} C V^2$ $\quad$ $W = \frac{1}{2} L I^2$

1) Resistance : $\quad V = IR$

$I = \frac{V}{R}$ $\quad$ $V \propto I$

$J = \sigma E$ $\longrightarrow$ $\frac{I}{a} = \frac{1}{\rho} \cdot \frac{V}{l}$

J → current density (A/m^2) $\quad$ $I = \frac{1}{\rho} \frac{Va}{l}$

E → Electric field (E)

$J \propto E$ (Temp. constant) $\quad$ $I = \frac{V}{R}$

$\vec{J} = \sigma . \vec{E}$ ('σ' is prop. constant)

Ohm's law : At constnt tempr the current density (J ∝ Electric field intensity (E) is k as Pt form of ohm's law.

(or)

At Constnt tempr the current through a con to the potential diffn b/w two ends

$R = \frac{V}{I}$ Volt / Amp (or) ohm (Ω)

Observation : Resistance doesn't depen rent then current.

If resistance is independent of vltg or it is said to be linear.

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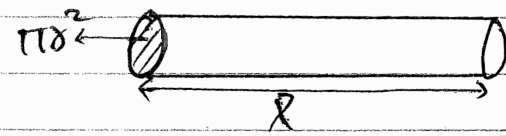
Resistance depend upon

1.) Type of material
2.) Length
3.) cross-sectional Area
4.) Temprature

$R \propto \frac{l}{a}$



$R = \rho . \frac{l}{a}$

Area = 2πrl

C. Area = $\pi r^2 = \pi . \frac{d^2}{4}$

$$\boxed{\rho = \frac{Ra}{l}}$$

ρ : Specific Resistance
(or)
Resistivity

Units — ohm-m

	R	T	
Conductors	↑	↑	→ +ve Temp. cofficient
Semi & Insulators	↓	↑	→ -Ve Tempn coefficient

$$R_1 = R_0 [1 + \alpha(t_1 - t_0)]$$
$$\rho_1 = \rho_0 [1 + \alpha(\rho_1 - \rho_0)]$$

α : Temp coefficient
unit : 1/°C

...ood conductors, an ↑es in tempn will result ... ↑es in the resis'nce level. Consequently, ... have a +ve tempn coefficient.

...onductor & insulator, an ↑es in tempn will ... ↓es in the resis'ce level. Consequently, ...r & insulators has -ve tempn coefficient.

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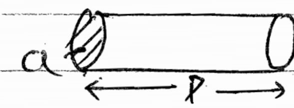
Ques| Cond^n length 'l', Uniform C.S.A 'a' & its 'R'. If length of the cond^n is uniformly stretched to '2l' then the new value of resistance?

sol^n| $R = \frac{\rho l}{a}$, $R_2 = \rho_2 \frac{l_2}{a_2}$



$$R_2 = \frac{\rho \cdot (2l)}{a/2}$$

$$\boxed{R_2 = 4R}$$

Volume 1 = Volume 2

$a \cdot l = a_2 \cdot l_2$

$a \cdot l = a_2 \frac{l}{2}$

$$\boxed{a_2 = \frac{a}{2}}$$

Observation :-

Res^ce depends upon type of material & dimensions but resistivity only depends upon type of material.

Power absorbed by Resistance :-

$P = V \cdot I$

$P = IR \cdot I$

$\boxed{P = I^2 R}$ watts

↳ Current through resistance

$P = V \cdot I$

$P = \frac{V \cdot V}{R} = \frac{V^2}{R}$

$\boxed{P = \frac{V^2}{R}}$

↳ Voltage across Resistance.

Energy absorbed by the Resistance :-

$W = P \cdot t$

$W = \frac{V^2}{R} \cdot t$

$W = I^2 R t$

$H = I^2 R t$ Joules

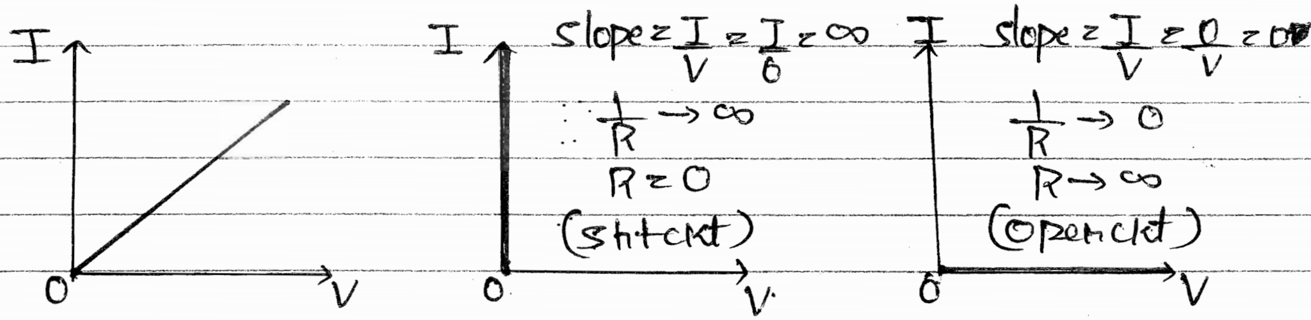
$W = \int \frac{V^2}{R} dt$

(or)

$W = \int i^2 R \, dt$ Joules

DELTA Notebook

Applications : Heater, Iron box, starters, filters, potentio-meters



slope $= \frac{I}{V} = \frac{I}{0} = \infty$

$\therefore \frac{1}{R} \to \infty$

$R = 0$

(sh t ckt)

slope $= \frac{I}{V} = \frac{0}{V} = 0$

$\frac{1}{R} \to 0$

$R \to \infty$

(open ckt)

slope $= \frac{I}{V} = \frac{1}{R}$

(Linear)

$V = 0$
$I = I$
$R = 0$

→ Non-linear
Ohm's law is not applicable
→ use KCL

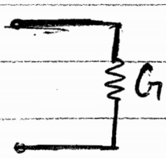
→ Non linear
→ Ohm's law not applicable
→ use KVL
→ open ckt

Limitations of ohm's law : Ohm's law is only applicable to linear elements & that to temp is constant.

Ex : Ohm's law is not applicable to
- semiconductor
- electrolytes
- gaseous
- Iron box.

Conductance (G) : Reciprocal of resistance is known as conductance (G)

$G = \frac{1}{R} = \frac{I}{V}$ A/V (or) MHO (or) siemens (℧)



→ Reciprocal of Resistivity is known as conductivity (σ)

$\sigma = \frac{1}{\rho} = \frac{l}{RA}$ siemens/m