DIGITAL EDUCATION
MARTCOST

ELECTRONICS ENGINEERING DEPARTMENT

Network

Hand Notes For Electronics Engineering Department

HAND NOTES

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Network Theory

May 30, 2007.

1. Basics
2. Theorems
3. L.T.
4. Transients < dc, ac
5. Ac Analysis

Ref:

1. Network Analysis – Van valkenburg
✓2. Engg. circuit analysis – Hayt & kemmerly
3. previous papers : GK pub.

(i). GATE < EE, EC, INSTRUMENTAL (1990 – 2007)

UPSC

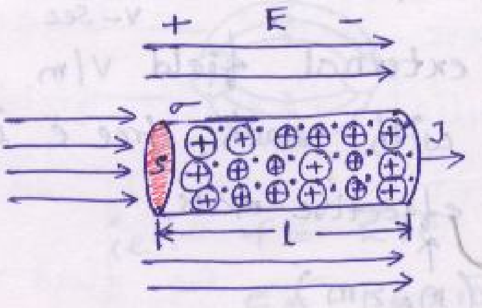
(ii). IES < EE, EC

(1994 – 2006)

(iii). IAS – Prelims – EE (Raj kamal text book
cengage koli)

Basics.

→ The mechanism of energy flow through the conductor and ohm's law:-



⊕ ⇒ Ag^{+} ion, immobile, Larger in size ie 10^3 times than $\bar{e}$.

• ⇒ free e^-

→ $Ag^{+1} \longrightarrow +1$

$Cu^{+2} \longrightarrow +2$

$Au^{+2} \longrightarrow +2$

$Al^{+3} \longrightarrow +3$

→ The mobility of free ē's in a Ag, is several times to that of other conductors so its conductivity is very high.

→ Generally in any conductor, there are 10^{18} to 10^{23} atoms per unit volume (ie per unit cube) and hence there are 10^{18} to 10^{23} free ē's per unit volume in a Ag conductor. ie every conductor is a very rich of free ē's.

→ In the presence of external field different free e^- will under go diff. forces [due to a large no. of free ē's] and hence they will move with diff. velocity. But only one velocity is defined, so called drift velocity. It is an avg. velocity of all the free ē's within a conductor. and is given by $v_d = \mu E$ m/s.

μ = mobility of free ē's $\frac{m^2}{V\text{-}Sec}$

E – Applied external field V/m

→ The K.E. associated with each free ē is

$KE = \frac{1}{2} m_e v_d^2$ J

$m = 9.11 \times 10^{-31}$ kg $\quad (\overset{\overset{\text{effective mass}}{\uparrow}}{m_e} > m)$

m_e is the mass of free ē while it is in a motion.

The first Half of the Ohm's experiment when the conductor not carrying electrical energy $E=0$:-

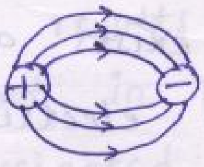
→ when $E=0 \Rightarrow v_d = 0 \Rightarrow K.E. = 0$

ie all the free $\bar{e}$ are in the rest.

→ since the conductor is operating at room temp. (27°C or 300°K), diff. free $\bar{e}$s will acquire diff. thermal energies [due to a Large no. of free $\bar{e}$] and hence they will move in diff. directions in a random manner the net flow of $\bar{e}$ motion in any direction zero, ie the charge motion is zero and the i is zero and also the current density [J] is zero.

ie when $E=0$, then $J=0$.

Second Half of Ohm's experiment, when the conductor is carrying electrical energy $[E \neq 0]$:-



when the conductor is subjected to an axial electric field, the force will be exerted on every free $\bar{e}$.

ie. $\vec{F} = \vec{E}.e$ N

$e = -1.6 \times 10^{-19}$ C

Since 'e' is -ve, there exists the direction of force is in opposite to that of E. and hence there exists a net $\bar{e}$ motion ie the charge motion in the direction opposite so that of 'E'.

The magnitude of charge is given by

$q = ne$ c , n = no. of free $\bar{e}$ s crossing a reference cs area, a variable quantity due a large no. of free $\bar{e}$.

$e = -1.6 \times 10^{-19}$ c

→ The time rate of flow of electric charges is nothing but the electric i ie

$$i = \frac{dq}{dt} \text{ A}$$

Since q is -ve, the conventional current direction is opposite that of the charge motion ie $\bar{e}$ motion [ie in the dire. of 'E']

The current per unit cs area is nothing but the current density resulted within a conductor

$$\text{ie} \quad J = \frac{i}{s} \text{ A/m}^2$$

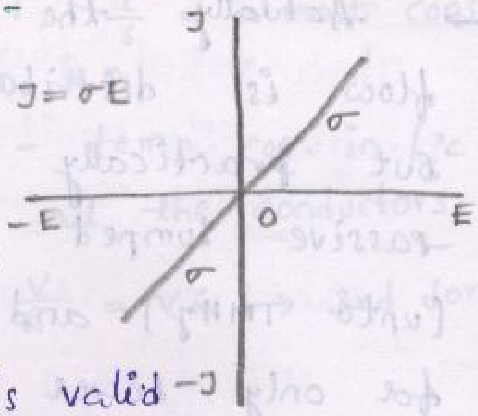
Since 's' is a scalar, the dire. of 'J' is in the dire. of 'i', ie [in the dire. of E.

Acc. to. Ohm, there exists a linear relation b/w the applied electric field and resulting current density by $J \propto E$

$J = \sigma E$ → Ohm's law in the field theory form.

σ → Conductivity of the conductor.

J – E characteristics :-



At the origin $E = 0 \Rightarrow J = 0$ and σ is not equal to zero.

Limitation:-

The ohm's law is valid only when proportionality const. σ is const. ie the temp. is kept constant condition.

At the const. E, as temp. increases from room temp. there exists an increase in collisions among the free $\bar{e}$'s and hence the mobility falls, so the conductivity decreases. [Here the collisions b/w the free $\bar{e}$'s and +ve ions are assumed to be const., since E is kept constant.].

At a const. TEMP. as 'E' increases there exists an increase in collisions b/w the free $\bar{e}$s and the +ve ions [larger in size], which results the fall lost in v_d and hence the lost in K.E. This losted energy will be dissipated in the form of heat, which results the volt. drop across the conductor. [Here the collisions amount, the free e^-s are assumed to be const, since the temp. is kept const.

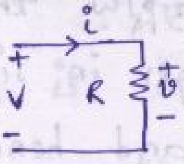
→ Actually the opposition for the energy flow is distributive through the conductor. But practically this is approximated into passive lumped R, L, C's for lower freq.s [upto 1MHz] and hence n/w theory valid for only lower freq.s.

At higher freq.s we can't derive the lumped elements so no lumped electric n/w, so no n/w theory ie field theory is applicable.

field theory approach of solving the distributive electric n/w's are valid for all freq.s starting from zero [DC].

So the currents through all the 3 passive lumped elements will always flows from +ve to −ve terminals.

Resistance R :-



→ Since $J = \sigma E$

$\Rightarrow \frac{i}{s} = \sigma\left(\frac{v}{l}\right)$

$\Rightarrow v = \left(\frac{l}{\sigma s}\right) i$

$\Rightarrow v = Ri$ → Ohm's law in ckt ckt theory form

$\therefore R = \frac{l}{\sigma s}$

Limitation :

The Ohm's law is valid when R is kept const ie temp. is kept const.