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UNIT-2

DC & AC Circuits :- Electrical circuit elements (R,L,C)-Kirchhoff's laws - series and parallel connection of resistances with DC excitation - Superposition theorem - Representation of sinusoidal waveforms - peak & RMS values - phasor representation - Real power - Reactive power - Apparent power - PF - Analysis of 1-ϕ AC RL, RC, RLC series ckts - Resonance.

Introduction :-

Voltage :- The work done for moving the charge from one point to another point is called voltage.

$$\text{Voltage (V)} = \frac{W}{Q} = \frac{dw}{dq} = V \text{ (volts)}$$

Current :- The rate of transfer of charge is known as current. It represent by 'I'.

$$I = \frac{Q}{t} = \frac{dq}{dt}$$ units :- Ampere (or) coulomb/sec

Power :- The rate of work done is known as Power

$$P = \frac{\text{workdone}}{\text{time}} = \frac{dw}{dt} = \frac{dw}{dq} * \frac{dq}{dt} = V * i = P$$

$$\boxed{P = i^2R = \frac{V^2}{R}}$$ units :- watt

Energy :- The capacity to do work is called energy.

$$w = P * t$$
$$= V * i * t$$
$$= i^2Rt$$ units :- Joules (or) watt-hour
$$= \frac{V^2}{R}t$$

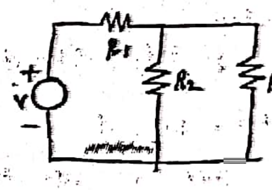
Circuit :- It is the conducting path through an electrical current flows in a closed loop is known as circuit.

circuit are classified into two types

① active circuits

② Passive circuits.

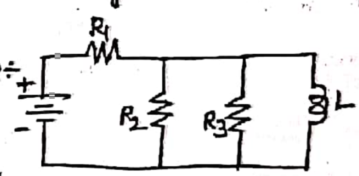
Eg :-



① active circuit :-

It is one which contains active element like voltage source (or) current source (or) with passive element.

Eg :-



② Passive circuit :-

* Passive circuit is one which contains passive element only i.e called passive circuit. It does not contain any source of emf.

Non Linear Circuit:-

* A circuit is whose Parameters change with Voltage (or) Current is known as nonlinear Circuit.

Unilateral Circuit:-

* it is one whose Properties change with direction of its operation is known as unilateral circuit.

Eg:- diode, Rectifier, amplifier.

bilateral circuit:-

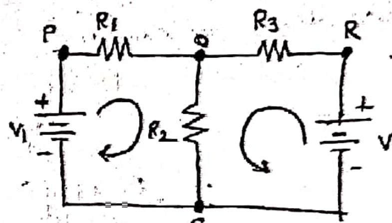
* it is one whose characteristics does not change in the direction of its operation

Eg:- Transmission line, Passive networks, Resonance circuits.

Node:- it is the Point which is Connect two (or) more elements in the circuit

Junction:-

* it is also the point which is connected to two (or) more elements in the circuit they flow current divisions.



Eg:- Q, S

Nodes:- P, Q, R, S

* branch:- it is the Part of the network (or) circuit it lies in b/w two Junctions

Eg:- P, Q, S, Q, R, S

* Loop:- it is nothing but closed path of the circuit

Eg:- P, Q, S, QRS, PQRS

* Mesh:- it is a elementary form of loop they don't further step of divisions

Eg:- PQS, QRS

Basic circuit Components:-

Resistance:- it is an element which opposes the flow of current is known as resistance. It is represent by 'R'.

units:- ohms (Ω)

The element which exhibits resistance property is known as resistor.

$$\boxed{\therefore R = \frac{\rho l}{a}}$$

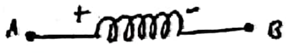
l = Length of element

a = Cross sectional area of the element

ρ = resistivity Constant (or) Specific resistivity

Inductance:-

The inductance is the Property which opposes sudden change of Current is Called Inductance



units:- Henry (H)

$$\boxed{\text{Inductance } (L) = \frac{\text{rate of change of flux linkages}}{\text{Current flow of elements}} = \frac{\psi}{I} = \frac{N\phi}{I}}$$

Voltage drop across the inductor:

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

$$di = \frac{1}{L} V\,dt$$

Integral (i) with respect to time.

$$\int_0^t di = \frac{1}{L}\int_0^t V\,dt$$

$$[i]_0^t = \frac{1}{L}\int V\,dt$$

$$i(t) - i(0) = \frac{1}{L}\int V\,dt$$

$$i(t) = \frac{1}{L}\int V\,dt + i(0)$$

Power observed in inductance:-

$$P = VI$$

$$= L\frac{di}{dt}[i]$$

$$\boxed{P = Li\frac{di}{dt}}$$

Energy stored in inductance:-

$$E = \omega = Vit$$

$$d\omega = Vi\,dt$$

$$d\omega = Li\frac{di}{dt}$$

$$\int_0^{\omega} d\omega = \int_0^{i} Li\frac{di}{dt}\,dt$$

$$\omega - \omega(0) = L\int_0^i i\,di$$

$$= \left[L\frac{i^2}{2}\right] - i(0)$$

$$\boxed{\omega = \frac{1}{2}Li^2}$$

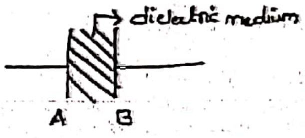
Properties of inductance:-

* it opposes the sudden change of current
* it acts as a short circuit i.e $V=0$
* if dc current passed through it $\frac{di}{dt}=0$
* The current through the inductor depends on the initial values of current $\therefore I_F = 0$
* It stores energy in magnetic field

Capacitance:-

It is the Material which opposes the sudden change of Voltages is known as Capacitance.

Units:- farad.



$$C = \frac{\text{charge}}{\text{Voltage}} = \frac{Q}{V}$$

Charge(Q) = Voltage × Capacitance.

$$Q = CV$$

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

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

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

$$i\,dt = C\,dv$$

$$\frac{1}{C} i\,dt = dv$$

$$\int_0^t \frac{1}{C} i\,dt = \int_0^t 1\,dv$$

$$\frac{1}{C}\int_0^t i\,dt = V(t) - V(0)$$

$$\boxed{\frac{1}{C}\int_0^t i\,dt + V(0) = V(t)}$$

$$P = VI$$

$$= V \cdot C\frac{dv}{dt} \Rightarrow \text{from } i = C\frac{dv}{dt}$$

$$E = P * t$$

$$dw = P\,dt$$

$$dw = VC\frac{dv}{dt} * dt$$

$$dw = VC\,dv$$

$$\int_0^w dw = C\int_0^V V\,dv$$

$$\boxed{w = \frac{CV^2}{2}}$$

Properties of Capacitance:-

* it opposes the sudden change of voltage.
* it acts as a open circuit for dc voltage.
* it stores the energy in electrical field.

Ohms Law:-

"The current flowing through the electric circuit is directly proportional to the Potential difference across the circuit and inversely Proportional to the resistance of the circuit provided the temperature remains Constant."

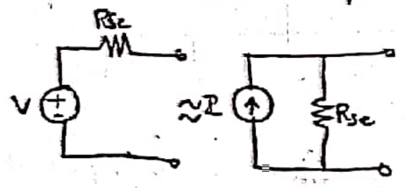
The internal resistance $R_{se} = R_{sb}$

$$V = I * R_{sb} = I * R_{se}$$

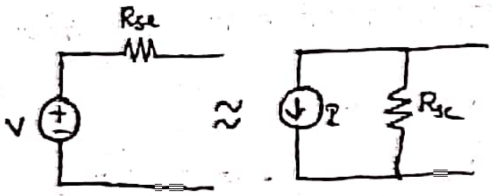
$$I = \frac{V}{R_{sb}}$$

$$I = \frac{V}{R_{se}}$$

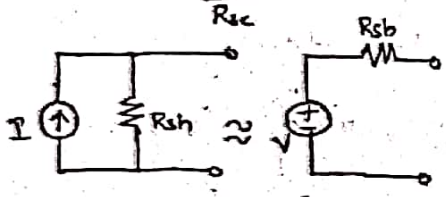
* If voltage source is connected to current source then current source $I = \frac{V}{R_{se}}$ with parallel internal resistance equal to R_{se}!



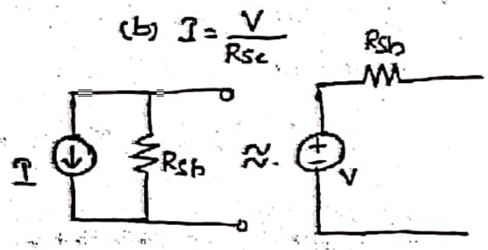
(a) $I = \frac{V}{R_{se}}$



(b) $I = \frac{V}{R_{se}}$



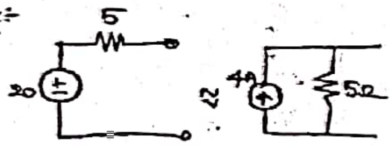
© $V = I * R_{sh}$



(d) $V = I * R_{sh}$

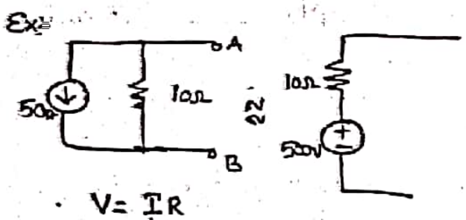
* If current source is converted to voltage source, then voltage source $V = IR_{sh}$ with series internal resistance equal to R_{sh}.

Ex:-



$$I = \frac{V}{R} = \frac{20}{5} = 4A$$

Ex:-



$V = IR$
$= 50 \times 10$
$= 500V$

Kirchhoff's Laws:-

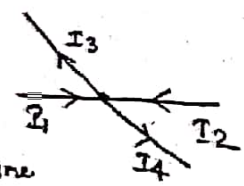
Kirchhoff Current law:- (KCL)

The total current flowing towards a junction point is equal to the total current flowing away from that junction point.

(or)

The algebraic sum of all the current meeting at a junction point is always zero.

ΣI at junction point $= 0$.



Consider a junction point in a complex network as shown at the junction point $I_1 = 2A$, $I_2 = 4$, & $I_3 = 1A$ then the determine I_4. total current entering is $2+4=6$ leaving $1+I_4$. $I_4 = 5A$

Sign Convention:- Current flowing towards a junction point are assumed to be positive while current away from a junction point assumed to be negative.

apply KCL = $I_1+I_2-I_3-I_4=0$ i.e $I_1+I_2=I_3+I_4$

Kirchhoff voltage law (KVL):-

"In any network, the algebraic sum of the voltage drops across the circuit elements of any closed path is equal to the algebraic sum of emf in the path."

In otherwords, the algebraic sum of (or) all the branch voltage around any closed path (or) closed loop is always zero.

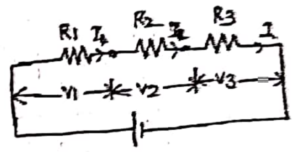
$$\therefore \sum E+\sum V=0 \text{ (or) } \sum E+\sum IR=0$$

* The law states that if one starts at a certain point of a closed path and goes on tracing and noting all the potential changes in any one particular direction till the starting point is reached again, he must be at the same potential with which he started tracing a closed path.
* Sum of all the potential rises must be equal to sum of all the potential drop while tracing any closed path of the circuit. The total change in potential along a closed path is always zero.

Series parallel circuit:-

Series circuit:-

Resistors are in series:-



$V=V_1+V_2+V_3$

according ohm's law

$V_1=IR_1,\ V_2=IR_2,\ V_3=IR_3$

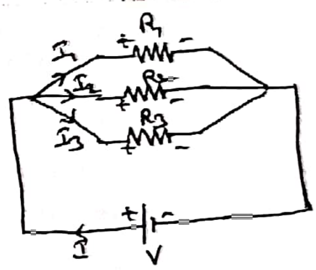
Current through all of them same i.e I. $V=IR_1+IR_2+IR_3$

$=I(R_1+R_2+R_3)$

$V=IR_{eq}$

R_{eq} total equivalent resistance of series circuit is sum of resistors connected in series $\boxed{R=R_1+R_2+R_3 \ldots\ldots +R_n}$

Resistors in parallel:-



In parallel circuits voltage will remain constant

$V_1=I_1R_1,\ V_2=I_2R_2\ \ V_3=I_3R_3;\ V=V_1=V_2=V_3$

$I_1=\frac{V}{R_1},\ I_2=\frac{V}{R_2},\ I_3=\frac{V}{R_3}$

$I=I_1+I_2+I_3=\frac{V}{R_1}+\frac{V}{R_2}+\frac{V}{R_3}=V\left[\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right]$

As $V=IR_{eq} \Rightarrow I=\frac{V}{R_{eq}}$

Comparing the above 2 eqns $\Rightarrow \boxed{\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$