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Maximum Power Transfer Theorm:-

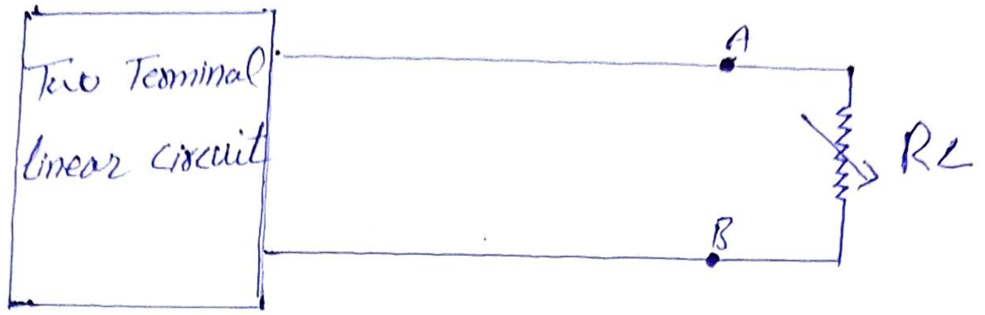
It states that the DC voltage source will deliver maximum power to variable load resistor only when the load resistence is equal to the source resistence.

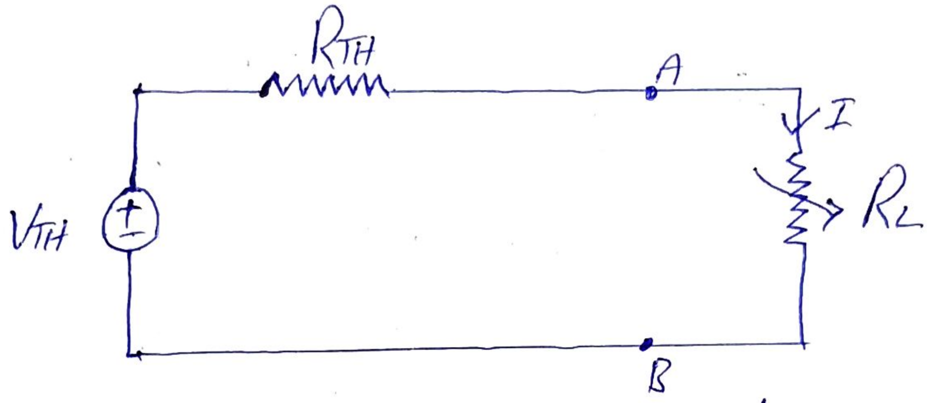
Similarly, Maximum power transfer theorm states that AC source of voltage, will deliver maximum power to variable complex load only when the load impedence is equal to the complex conjugate of source impedence.

Proof of Maximum Power Transfer Theorm:-

Replace any two terminal linear network or circuit to the left side of variable load resistor having resistence of R_L ohms with a Thevenin's equivalent circuit. we know that Thevenin's equivalent circuit resembles a practicle voltage source.

This concept is illustrated below.





The ammoun of power dissipated across the load resistor is

$$P_L = I^2 R_L$$

substitute $I = \dfrac{V_{th}}{R_{TH} + R_L}$ in above equation

$$P_L = \left(\frac{V_{TH}}{R_{TH} + R_L}\right)^2 R_L$$

$$P_L = \left(\frac{V_{TH}^2}{(R_{TH}+R_L)^2}\right) \times R_L$$

$$\Rightarrow P_L = V_{TH}^2 \left\{\frac{R_L}{(R_{TH} + R_L)^2}\right\}$$

Equation #01

Condition for maximum powe transfer

For maximum or minimum, first doriative will be zero, so, differentiative Equation #1 with respect to R_i & make it equal to zero

$$\frac{dP_L}{dR_L}$$

$$= V_{TH}^2$$

$$\left\{ \frac{(R_{TH}+R_L)^2 \times 1 - R_L \times 2\,(R_{TH}+R_L)}{(R_{TH}+R_L)^4} \right\} = 0$$

$$\Rightarrow \quad (R_{TH}+R_L)^2 - 2R_L(R_{TH}+R_L) = 0$$

$$\Rightarrow \quad (R_{TH}+R_L)(R_{TH}+R_L-2R_L) = 0$$

$$\Rightarrow \quad (R_{TH}-R_L) = 0$$

$$\Rightarrow \quad R_{TH} = R_L \text{ OR } R_L = R_{TH}$$

Therefor, the condition for maximum power dissipation accross the load is $R_L = R_{TH}$

That means, if the value of load resistence is equal to the value of source resistence i.e, Thevenin's resistence, then the power dissipated across the load will be of maximum value.

The value of maximum power transfer substitute $R_L = R_{TH}$ & $P_L = P_{L,Max}$ in eq # 1

$$P_{L,max} = V_{TH}^2 \left\{ \frac{R_{TH}}{(R_{TH} + R_{TH})^2} \right\}$$

$$P_{L,Max} = V_{TH}^2 \left\{ \frac{R_{TH}}{4R_{TH}^2} \right\}$$

$$\Rightarrow P_{L,max} = \frac{V_{th}^2}{4R_{TH}}.$$

$$\Rightarrow P_{L,Max} = \frac{V_{TH}^2}{4R_L}, \text{ since } R_L = R_{TH}$$

Therefore, the maximum ammount of power transferred to the load is

$$\cancel{P_{L,Max}} \; P_{L,Max} = \frac{V_{TH}^2}{4R_L} = \frac{V_{TH}^2}{4R_{TH}}$$

Efficiency of Maximum Power Transfer :-

we can calculate the efficiency of maximum power transfer η_{Max} using following formula.

$$\eta_{Max} = \frac{P_{L\,Max}}{P_s} \quad \text{—— Eq \# 02}$$

where,

* $P_{L,Max}$ is the maximum ammount of power transferred to the load.

* P_s is the ammount of power generated by the Source is

The ammount of power generated by the source is $P_s = I^2 R_{TH} + I^2 R_L$

$\Rightarrow P_s = 2I^2 R_{TH}$, since $R_L = R_{TH}$

substitute $I = \frac{V_{TH}}{2R_{TH}}$ in the above equation

$$P_s = 2\left(\frac{V_{TH}}{2R_{TH}}\right)^2 R_{TH}$$

$$\Rightarrow P_s = 2\left(\frac{V_{TH}^2}{4R_{TH}^2}\right) R_{TH}$$

$$\Rightarrow P_s = \frac{V_{TH}^2}{2R_{TH}}$$

Substitute the value of $P_{L,Max}$ & P_s in eq #2

$$\boxed{\eta_{Max} = \frac{\left(\frac{V_{TH}^2}{4R_{TH}}\right)}{\left(\frac{V_{TH}^2}{2R_{TH}}\right)}}$$

$$\Rightarrow \eta_{Max} = \frac{1}{2}$$

Represent in percentage the efficency of Maximum power Transfer $\quad \% \eta_{Max} = \eta_{Max} \times 100\%$

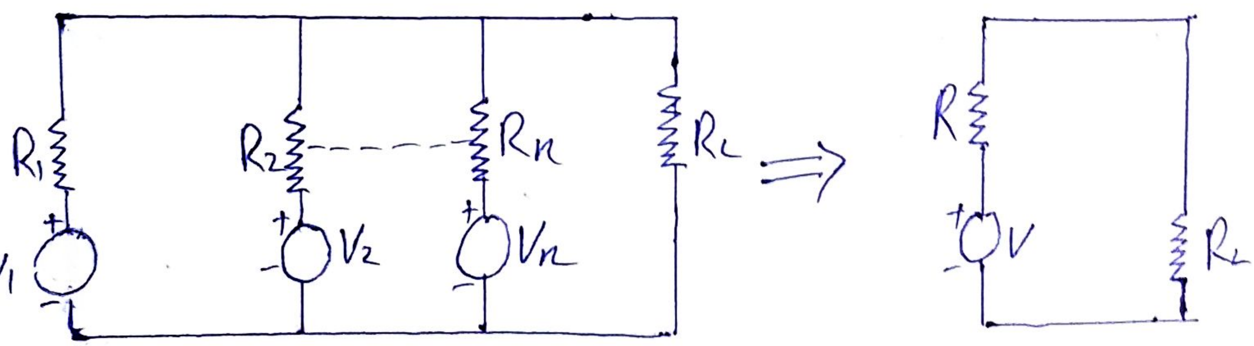
$$= 1/2 \times 100\%$$

$$\boxed{\% \eta_{Max} = 50\%}$$

Millman's Theorm:-

The Millmon's Theorem states that, when a number of voltage source ($V_1, V_2, V_3 ---- V_n$) are in parallel having internal resistence ($R_1, R_2, R_3 --- R_n$) respectively, the arrangement can replace by a single equivalent voltage source V in series with an equivalent series resistence R. In other words; it determines the voltage accross the parallel branches of the circuit, which have more than one voltage sources,
i.e Reduce the complexity of electrical circuit

This Theorem is given by jacob Millmon. The utility of Millman's Theorem is that. the number of parallel voltage sources can be reduced to one equivalent source. It is applicable only to solve the parallel branch with one resistence connected to one voltage source or current source. it is also used in solving network having an unbalanced bridge circuit.



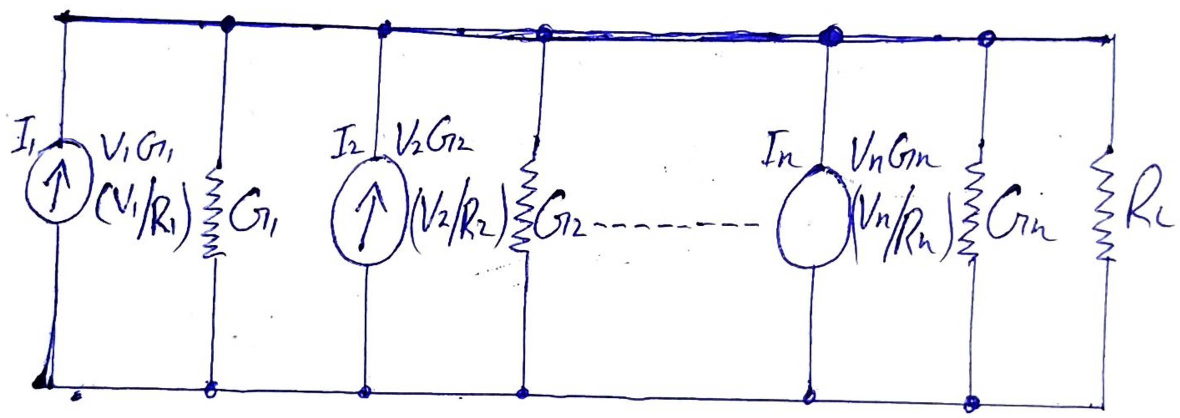
As per Millmon's Theorem

$$V = \frac{\pm V_1 G_1 \pm V_2 G_2 \pm \cdots\cdots \pm V_n G_n}{G_1 + G_2 + \cdots\cdots + G_n} \quad \text{and}$$

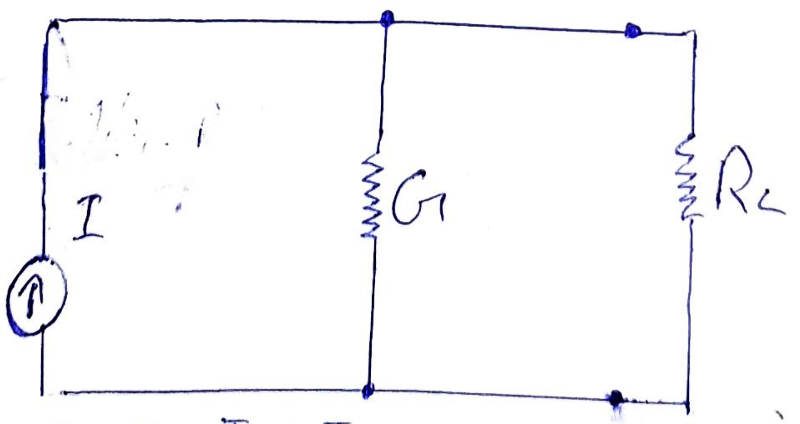
$$R = \frac{1}{G} = \frac{1}{G_1 + G_2 + \cdots\cdots + G_n}$$

Explaination of Millmon's Theorem:-

Assuming a DC network of numerous parallel voltage sources with internal resistences supplying power to a load resistence R_L as shown.



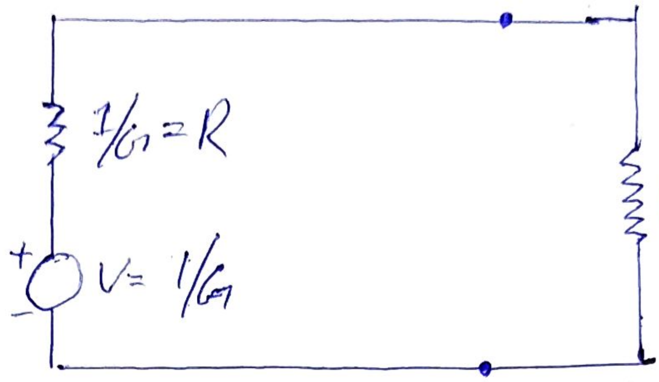
Let I represent the resultent current of the Parallel current sources while G the equivalent conductance as shown



$I = I_1 + I_2 + I_3 + \cdots\cdots$ &

$G = G_1 + G_2 + G_3 + \cdots\cdots$

Next, the resulting current source is converted to an equivalent voltage source as shown:



Thus

$$V = \frac{I}{G} = \frac{\pm I_1 \pm I_2 \pm \text{------} \pm I_n}{G_1 + G_2 + \text{----} + G_n}$$

Positive (+) & negative (-) sign appeared to include the cases where the source may not be supplying current in the same direction

Also,

$$R = \frac{1}{G} = \frac{1}{G_1 + G_2 + \text{----} + G_n}$$

And as we know.

$I = V/R$ & we can also write $R = 1/G$ as

$G = 1/R$

So the equation can be written as

$$V = \frac{\pm \frac{V_1}{R_1} \pm \frac{V_2}{R_2} \pm \text{-----} \pm \frac{V_n}{R_n}}{\frac{1}{R_1} + \frac{1}{R_2} + \text{-----} + \frac{1}{R_n}}$$

where R is the equivalent Resistence connected to the equivalent voltage source in series.

Thus, the final equation is become

$$V = \frac{\pm V_1 G_1 \pm V_2 G_2 \pm ----- V_n G_n}{G_1 + G_2 + ------ + G_n}$$

$$V = \frac{\sum_{K=1}^{n} V_K G_K}{\sum_{K=1}^{n} G_K} \quad \& \quad G_K = \frac{1}{R_K}$$

Steps for Solving Millman's Theorem:-

Following steps are used to solve the network by Millman's Theorem

Step#1 obtain the conductence (G_1, G_2) of each voltage source (V_1, V_2---).

Step#02 Find the value of equivalent conductence G by removing the load from the network

Step#03 Now, apply Millman's Theorem to find the equivalent voltage source V by the equation below

$$V = \frac{\pm V_1 G_1 \pm V_2 G_2 \pm ------ \pm V_n G_n}{G_1 + G_2 + --- + G_n}$$

Step# 04 Determine the equivalent series resistence (R) with the equivalent voltage source (V) by the equation

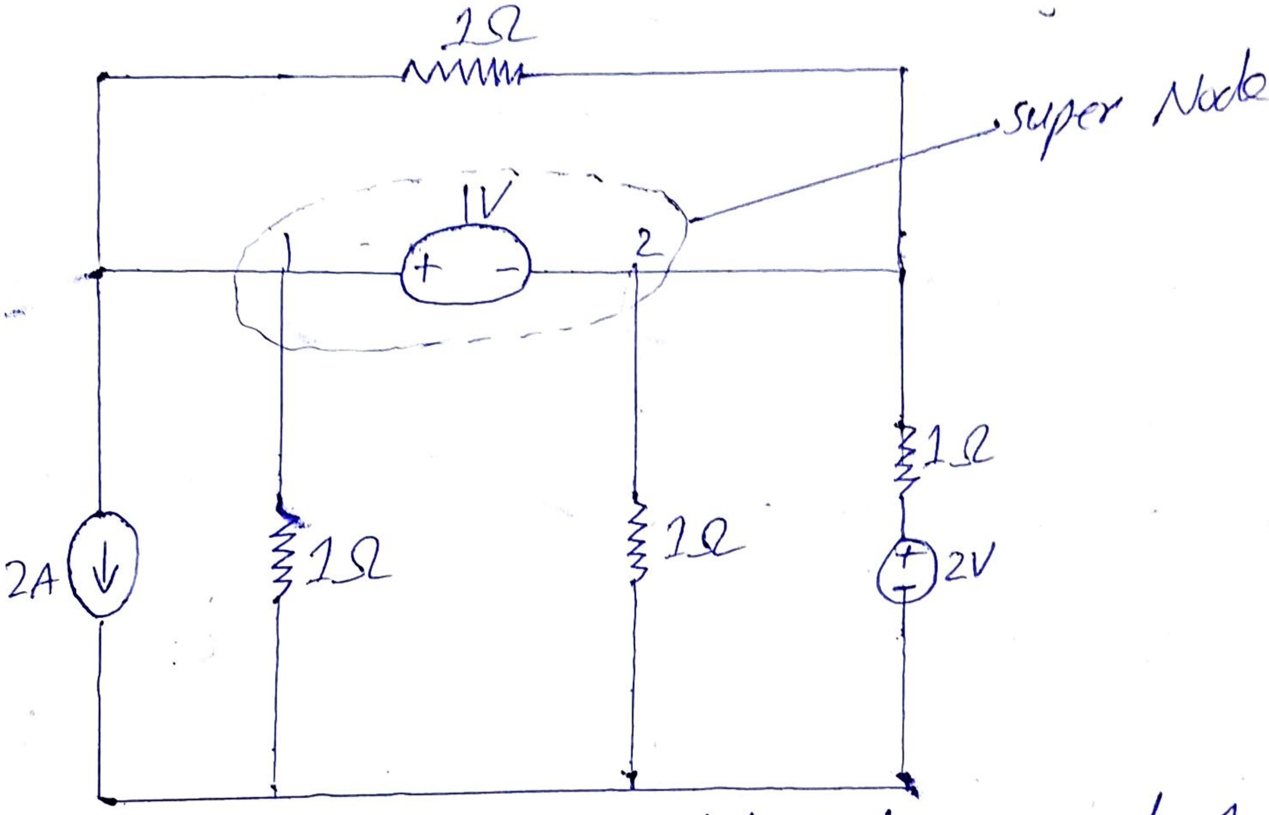
$$R = \frac{1}{G}$$

Step# 05 Find the current I_L flowing in the circuit across the load resistence R_L by the equation

$$I_L = \frac{V}{R + R_L}$$

Supernode

The two nonreference nodes from supernode if the voltage source (dependent or independent) is connected between two nonreference nodes. The figure is shown below:



* 1V Voltage source is connected between nodes 1 & 2 So node 1 & node 2 forms supernode

Procedure For Applying Nodel Analysis:

① Identify the total number of Nodes

② one node selected as reference node it is assigned to have ground potential (zero) & remaining nodes called as nonrefference node & we assign voltage designation to nonrefference nodes, And at least check for supernode

(3) Develop the KCL equations for each nonrefference node

(4) Solve the equations to find the unknown node voltage

* Note: Apply both KCL & KVL to determine the node voltage.

RMS Value:-

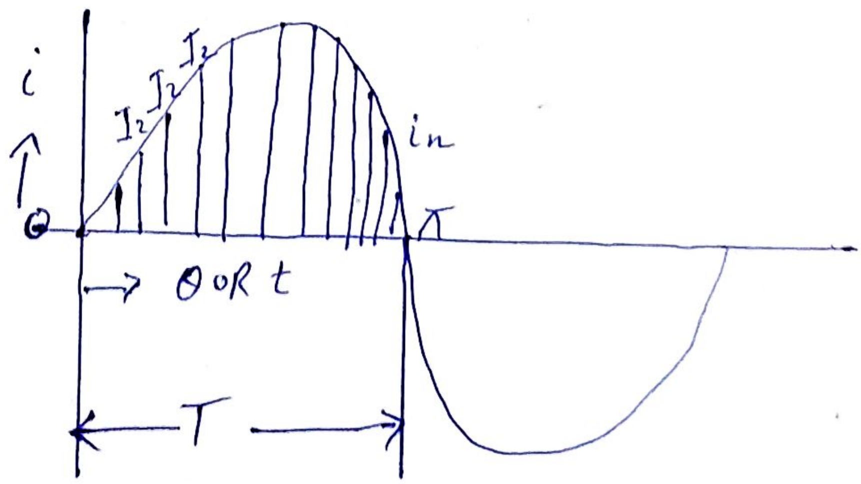
Definition:-

The square root of means of squares of instantaneous values.

OR

That steady current which, when flow through a resistor of known resistence for a given period of time than as a result the same quantity of heat is produced by an alternating current when flows through the same resistor for same period of time is called RMS or effective value of alternating current.

Let I be the alternating current flowing through a resistor R for time t seconds which produce the same ammount of heat as produced by direct current (Ieff) so that each interval is of t/n second as shown



Let $i_1, i_2, i_3 ---- i_n$ be the mid ordinates

Then heat produced in

First interval $\frac{i_1^2 Rt}{Jn}$ calories

2nd interval $\frac{i_2^2 Rt}{Jn}$ calories

3rd interval $\frac{i_3^2 Rt}{Jn}$ calories

n^{th} interval $\frac{i_n^2 Rt}{Jn}$ calories

Total heat produced $= \frac{Rt}{J}\left(\frac{i_1^2 + i_2^2 + i_3^2 + --- + i_n^2}{n}\right)$ calories --- ①

Since Ieff is considered as the effective value of this current, then the total heat produced by this current will be

$\frac{i_{eff}^2 Rt}{J}$ calories ----- (2)

Now equating equation ① & ② we will get

$$i_{eff}^2 Rt = \frac{Rt}{J}\left(\frac{i_1^2 + i_2^2 + i_3^2 + ----- i_n^2}{n}\right) \text{ OR}$$

$$I_{eff} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + ---- + i_n^2}{n}}$$

$$I_{eff} = \sqrt{\text{mean of squares of instantaneous value}}$$

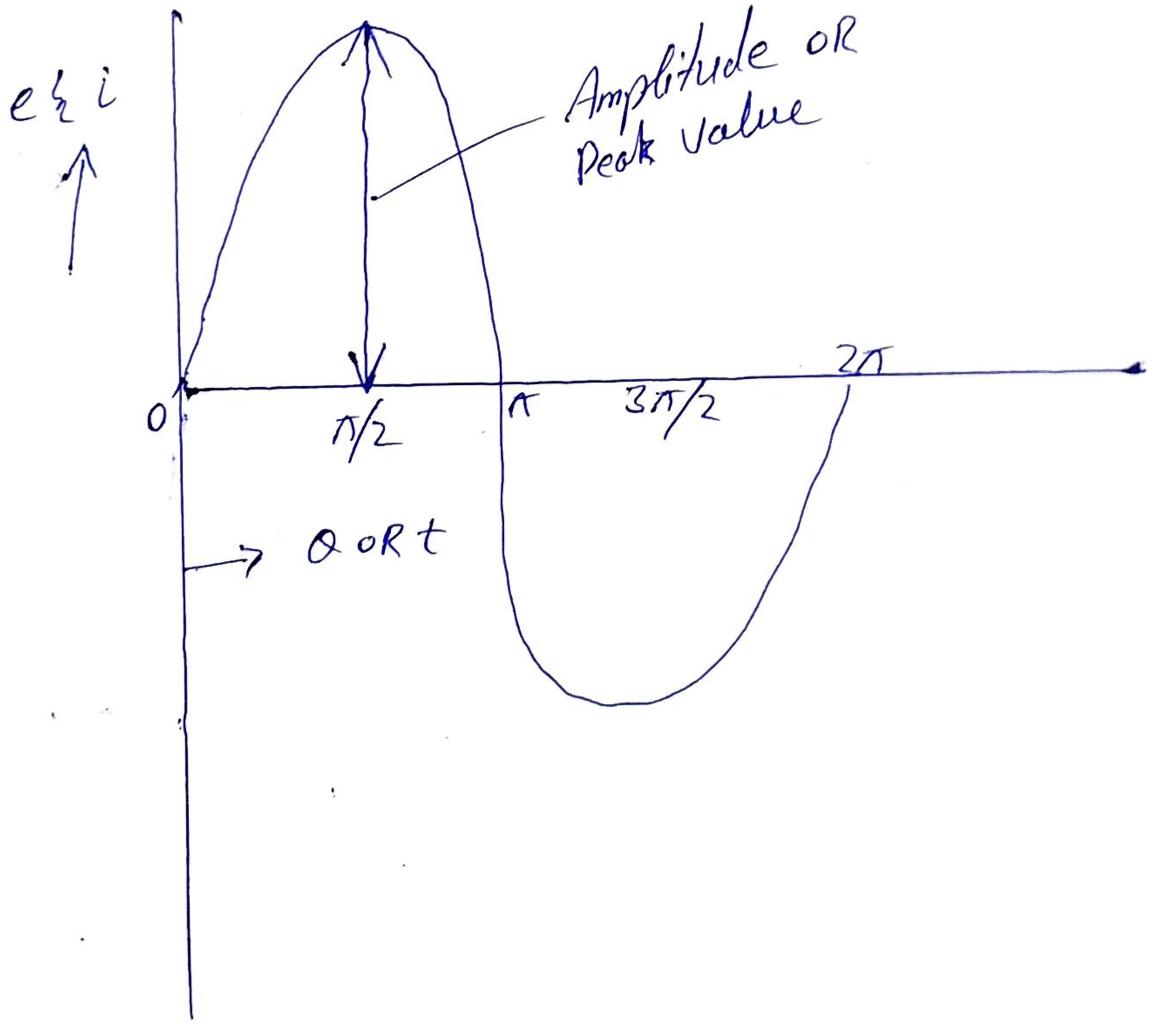
Ieff = Square root of mean of squares of instantaneous values = RMS Values.

Root Mean Square is the actual value of an alternating quantity which tells us an energy transfer capability of AC Source

* The Ammeter records the RMS Value of Alternating current & voltmeter record the root mean square (RMS) Value of an alternating voltage. The domastic single-phase AC supply is 230 V 50Hz where 230V is the RMS Value of alternating voltage.

Peak Value:-

Definition:- The maximum value attained by an alternating quantity during one cycle is called its peak value. It is also known as the maximum value or amplitude or crest value. The sinusoidal alternating quantity obtains its peak value at 90 degrees as shown in figure:



i) Active Elements :-

The electronic components which supply energy to a circuit.

* These devices produces energy in form of Voltage or current
* There capable of providing power gain
* They require an external source for the operation
* These components are energy donar
* Examples are Diode, Transistor, SCR, Integrated-circuits, Voltage source, current sources etc

(ii) Passive Elements:-

The electronics component which utilize power or energy in circuit.

* Devices which store energy in form of voltage or current.
* They are incapable of providing power gain
* passive components cannot control the flow of current.
* These components do not require any external source for the operation & These are energy acceptor.
* Example : Resistor, Capacitor, inductor etc