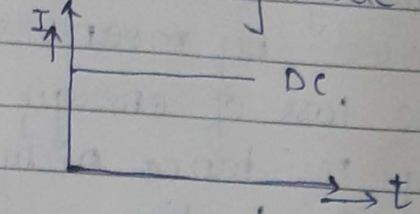
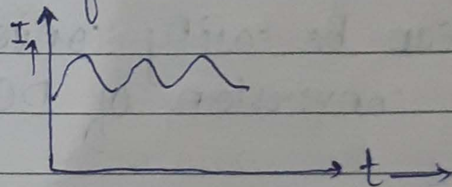
* AC - Fundamentals *

* Types of current :

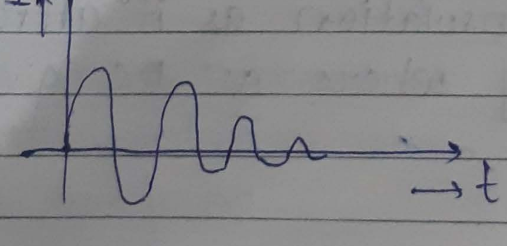
(1) D.C (Direct Current)
The current which always flows in one direction with constant magnitude is known as direct current.



(2) Fluctuating current
In current generated by devices like rectifier, it is observed that direction of current remains constant but magnitude has ~~so~~ small periodic variations with time, such type of current is known as fluctuating current.



(3) AC (Alternating Current)
The current which changes its direction & magnitu periodically at regular intervals of time in a circuit is known as alternating current.



AC is more dangerous because AC gives attractive shock whereas DC gives repelling shocks.

* **Advantages of AC over DC:**

1. The alternating voltage or current can be increased or decreased by means of transformer without appreciable loss of energy whereas DC can be changed by resistance only resulting in loss of energy due to heating.

2. In AC, wide range of voltage or current is available with the help of transformer.

3. The generation of AC is cheaper than that of DC.

4. AC can be easily converted into DC by rectifier but conversion of DC into AC is costlier.

5. AC motors are cheaper and simpler in construction compared to DC motors.

* **Disadvantages of AC over DC:**

1. AC is comparatively more dangerous to use during faculty insulation as it attract persons to touch AC supply where as DC gives expelling shock.

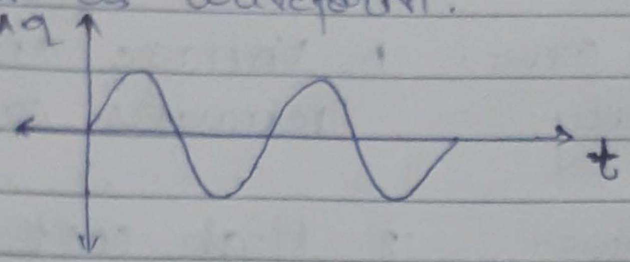
(2) For certain purpose such as electronic circuits, computers etc where only DC is required AC cannot be used directly.

→ Comparison of AC with DC :

AC	DC
1. In AC voltage & current changes periodically.	1. Voltage and current remains constant.
2. Low cost of power generation.	2. High cost of power generation.
3. Cost of transmitting AC power can be reduced by using step up transformer.	3. No such provision can be made.
4. AC can be converted to DC by using rectifier also known as converter	4. DC can be converted to AC by using choppers also known as invertor
5. AC cannot be used directly for electronic circuits, etc.	5. DC can be used directly for such operations
6 AC motors are more robust and durable.	6. DC motors are less durable.
7. AC attracts a person so faulty insulation are more dangerous.	7. DC gives repelling shoc to a person so faulty insulation of DC are less dangerous.

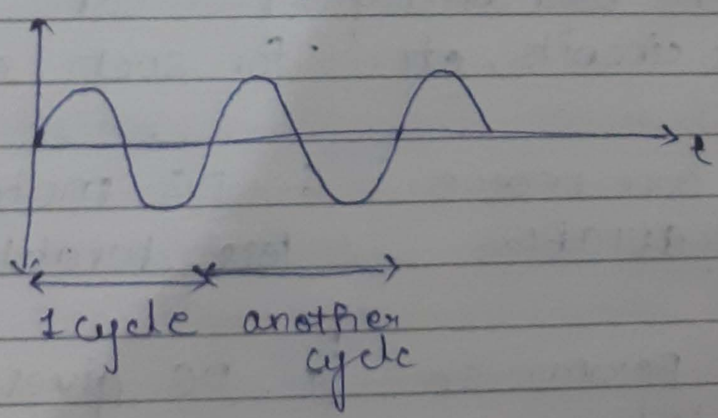
-* Definitions :

→ Waveforms : ~~The~~
The shape of the curve obtained by plotting instantaneous values of alternating quantity along y-axis and time along x-axis is known as waveform.



→ Instantaneous value :
The value of alternating quantity at any instant is known as its instantaneous value. It is represented by small english letters like (v, i, e, p).

→ Cycle :
One complete set of positive and negative values of an alternating quantities is known as cycle.



Date
Page

→ Amplitude :

The max. value positive or negative of an alternating quantity is known as its amplitude.

→ Time Period :

Time taken by alternating quantity to complete 1 cycle is known as time-period T. It is given by $T = 1/f$.

→ Frequency :

→ The number of cycles completed by an alternating quantity per second is known as frequency.

→ In 2 pole alternator,
1 cycle of alternating current is generated in 1 revolution.
In 4 pole alternator,
2 cycles are produce, in each revolution

$$\therefore f = \frac{P \times N}{120}$$

where P = ~~speed~~ no. of poles of an alternato
and N = speed of alternator in rpm.

Standard frequency of generation in India is 50 Hz and in USA it is 60 Hz.

Date
Page

Angular frequency:

Angular frequency of an alternating ~~frequency~~ quantity is given by $\omega = 2\pi f$.

Phase:

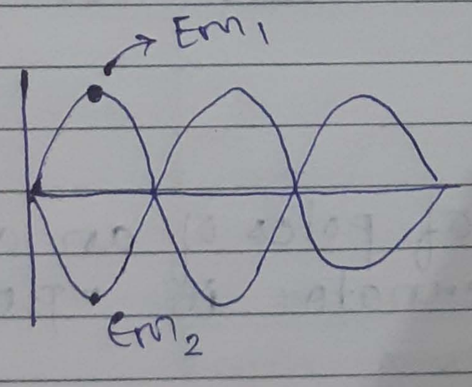
It is defined as fractional part of cycle through which alternating quantity has advanced from origin.

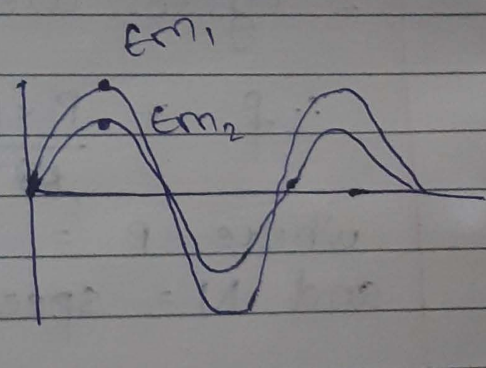
Phase angle:

It is defined as phase measured in terms of angle. The phase angle at any instant t is given by ωt.

Phase difference:

The phase difference b/w 2 alternating quantities having same frequency is the differences of phases at max. or 0 or min value of 2 alternating quantites.





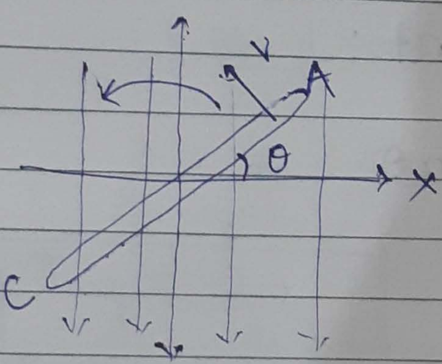
Out of phase

In phase

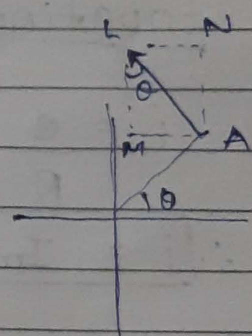
→ Two alternating quantities are called In phase when they attain max value or 0 values at same time.

→ Two alternating quantities are called Out of phase when 1 alternating quantity attains max. value and another ~~qua~~ alternating quantity attains min value at the same instant.

* Equation of Alternating Voltage:



l = length
b = width



$\therefore AM = v \sin\theta$

$e = Blv \sin\theta$ (for 1 half) i.e 0 to 2π

$v = \cancel{2}\pi f \left(\frac{b}{\cancel{2}}\right)$

$v = \pi f b$

Total emf for 1 cycle : $e = 2Blv \sin\theta$

$\therefore e = N \cdot 2Blv \cdot \sin\theta$

$\therefore e = N\, 2Bl \cdot b f \pi \sin\theta$

$\therefore e = 2NBAf\pi \sin\theta$ —— (1) $(\because A = l \times b)$

at $\theta = 90^\circ$, $e = e_{max}$ i.e E_m

$\therefore E_m = 2NBAf \cdot \pi$ —— (2)

Rectangular coil AC having n turns rotating in uniform magnetic field with constant angular velocity in anti-clockwise direction.

l = length of coil
b = width of coil
v = peripheral velocity of coil
f = frequency
B = flux density of magnetic field.

Hence, from eq^n 1 and 2:

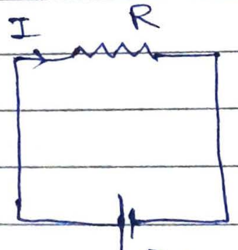
$$\boxed{e = E_m \sin\theta}$$

* <u>Equation of Current</u>:

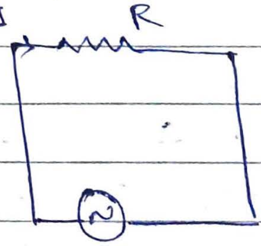
$$i = \frac{e}{R} = \frac{E_m \sin\theta}{R}$$

$$\therefore \boxed{i = I_m \sin\theta}$$

* <u>Average Value or Mean Value</u>:



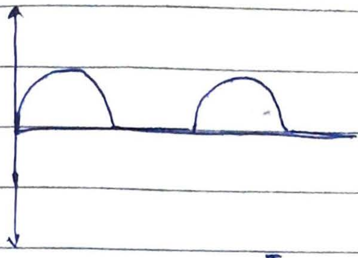
DC



AC

The DC current which flows through a circuit for a given time transfer same charge as transferred by alternating current when flows through same circuit for same time is called average value of alternating current.

→ For halfwave rectifier :



$$I_{avg} = \frac{1}{2\pi}\int_0^{\pi} i\,d\theta$$

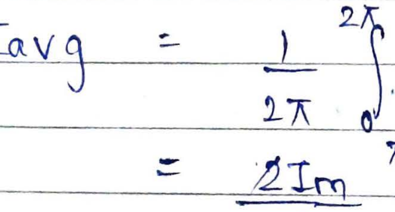
$$= \frac{1}{2\pi}\int_0^{\pi} I_m \sin\theta\,d\theta$$

$$= \frac{I_m}{2\pi}\left[-\cos\theta\right]_0^{\pi}$$

$$= \frac{I_m}{\cancel{2}\pi}(\cancel{2})$$

$$\boxed{I_{avg} = \frac{I_m}{\pi}}$$

→ For fullwave rectifier / (Sinosoidal Alternating Current)



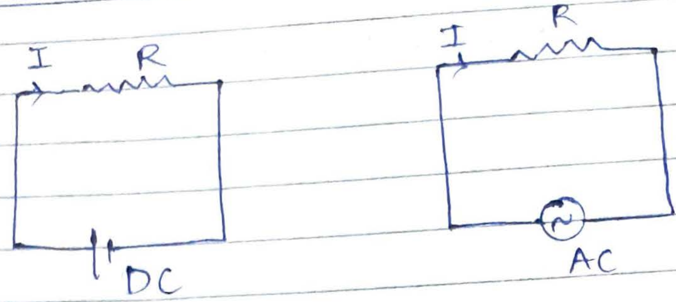
$$I_{avg} = \frac{1}{2\pi}\int_0^{2\pi} I_m \sin\theta\,d\theta$$

$$= \frac{2I_m}{\cancel{2}\pi}\int_0^{\pi} \sin\theta\,d\theta$$

$$= \frac{I_m}{\pi}\left[-\cos\theta\right]_0^{\pi}$$

$$\boxed{I_{avg} = \frac{2I_m}{\pi}}$$

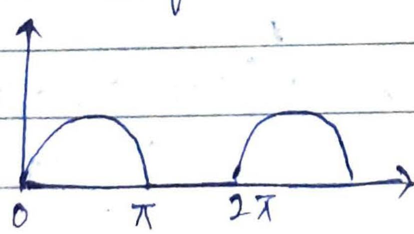
* Rms. Value or Effective Value :



The DC current when flows through a given circuit for a given time produces same amount of heat produced by alternating current when flows through same circuit for same time is known as effective value or rms value of alternating current.

$$I_{rms} = \sqrt{(\text{mean of } i)^2}$$

→ For halfwave :

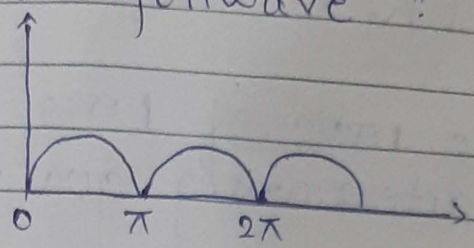


$$\therefore \quad I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} I_m^2 \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{2.2\pi}\int_0^{\pi} 1 - \cos 2\theta \, d\theta}$$

$$= \frac{I_m}{2}$$

→ For fullwave :



$$\therefore I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} I_m^2 \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\int_0^{\pi} 1 - \cos 2\theta \, d\theta}$$

$$= \frac{I_m}{\sqrt{2}}$$

Q: Why RMS value is more imp. than avg value?

→ The instantaneous value of alternating current is continuously changing w.r.t time. So, to consider its effective value, avg value is found.

- This avg. value does not give the correct idea when heating effect is considered.
- The rms value is based on equivalent heat produced by direct current flowing through given circuit or given time produce same heating effect as produced by alternating current flowing through same circuit for same time.

So, rms value is more imp. than avg valu

* Form Factor : (K_f)

It is defined as the ratio of rms value to avg. value of an alternating quantity.

$$K_f = \frac{\text{rms value of alternating quantity}}{\text{avg value of alternating quantity}}$$

→ Calculate K_f for sinosoidal alternating current :

$$K_f = \frac{I_m/\sqrt{2}}{2I_m/\pi} = \frac{\cancel{I_m}}{\sqrt{2}} \times \frac{\pi}{2\cancel{I_m}} = \frac{\pi}{2\sqrt{2}}$$

$$\therefore \boxed{K_f = 1.11}$$

(If not mentioned, consider fullwave case for value of rms & avg.)

* Peak Factor (K_p) :

It is defined as ratio of max. value to rms value of an alternating quantity.

$$K_p = \frac{\text{max. value of alternating quantity}}{\text{rms value of alternating quantity}}$$

$$= \frac{I_m}{I_m/\sqrt{2}} = \sqrt{2}$$

$$\boxed{K_p = 1.414}$$

Date
Page

Q: An alternating emf is represented by $e = 200 \sin 2\pi 50t$. Find:
1) max. value
2) f
3) T
4) angular frequency

1) max value (E_m) = 200 V
2) $f = 50$ Hz
3) $T = 0.02$ s
4) $\omega = 314$ rad/sec

Q: Rms value of alternating current is 30 A, and its frequency is 25 Hz. Write its equation to find Instantaneous value. Also calculate: 1) avg value
2) time period.

$I_{rms} = 30 = \frac{I_m}{\sqrt{2}}$ $\therefore I_m = 30\sqrt{2}$
$= 42.43$ A

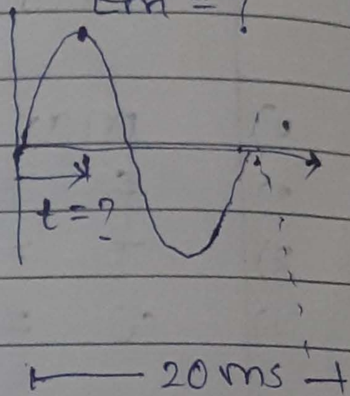
$\therefore i = 30\sqrt{2} \sin 50\pi t$
$i = 42.43 \sin 50\pi t$

$I_{avg} = \frac{2 \times 42.43}{3.14} = 27.02$ A

$T = 1/f = 0.04$ s

Date
Page

Q: A sinosoidal voltage has value of 100 V at 2.5 ms and it takes time of 20 ms to complete 1 cycle. Find max. value and time to reach max. value for the first time after 0.



$e = 100 \text{ V}$ at $t = 2.5$ ms

$T = 20$ ms $\Rightarrow f = 50$ Hz

$e = E_m \sin \omega t$

$e = E_m \sin 2\pi f t$

$100 = E_m \sin\left(\frac{100\pi \times 2.5}{1000}\right)$

$100 = E_m \sin\left(\frac{\pi}{4}\right)$

$\therefore E_m = 100\sqrt{2}$

$\boxed{E_m = 141.4 \text{ V}}$

$t = ?$ $\quad e = E_m$

$e = E_m \sin(2\pi f t)$

$141.4 = 141.4 \sin(100\pi t)$

$100\cancel{\pi} t = \frac{\cancel{\pi}}{2}$

$t = \frac{1000 \times 10^{-3}}{200} = \underline{\underline{5 \text{ ms}}}$