**Direct current (DC)**

Direct current (DC) describes the flow of charge (positive ion or negative ion or electron)that always **flows only in one direction with time.**

**Direct current of positive value and negative value are shown in Fig.1 (a) and (b). Fig.1 (c) and (d) represent direct positive or negative voltages.**

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| **Fig.4: Direct (a) Positive Current (b) Negative Current**  **Direct (c) Positive Voltage (b) Negative Voltage** |

DC can be generated in a number of ways:

* Batteries provide DC, which is generated from a chemical reaction inside of the battery
* An AC generator equipped with a device called a “commutator” can produce direct current
* An electronic circuit called a “rectifier” can convert AC into DC.

**Alternating Current (AC)**

Alternating Current (AC) describes the flow of charge (positive ion or negative ion or electron) that changes direction periodically.

Due to flow of current, the voltage level also periodically changes direction along with the current.

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| Fig.1: (a) Alternating Voltage (b) Alternating Current |

 = maximum value or peak value.

 = Peak-to-peak value

 = Time period of one cycle

**Generation of Alternating Current (AC):**

AC can be produced using a device called an alternator or an ac generator. This device is a special type of electrical generator designed to produce alternating current.

An ac generator consists of a magnet (NS) and a loop of wire (X) which rotates in the magnetic field of the magnet as shown in Fig.2 (a). As the wire rotates in the magnetic field, the changing strength of the magnetic field through the wire produces a force which drives the electric charges around the wire. The force initially generates an electric current in one direction along the wire. Then as the loop rotates through 180 degrees the force reverses to give an electric current in the opposite direction along the wire.

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| Fig. 2: (a) AC Generator (b) Generation of sine wave form (c) Showing angle of rotation |

Every time the loop rotates through 180 degrees the direction of the force and therefore the current changes. The changing direction of the force after every 180 degrees of rotation gives the alternating current. As well as having the magnet and wire an electric generator also has slip rings which make sure that the ends of the wire are always connected to the same side of the electric circuit. This makes sure that the direction of the current changes every half revolution of the wire.

The Fig.2 (b) shows how the force that produces the current in the wire varies as the loop of wire rotates through the magnetic field. The force is given a special name called the "electromotive force" or e.m.f. It is measured in Volts.

**Describing a Sine Wave:**

We often want to describe an AC waveform in mathematical terms. AC voltage is commonly represented by sine wave.



or 

where

 = voltage as a function of time  means voltage at any time . This means

that voltage changes as time changes

 = maximum value of voltage or amplitude

 = angular frequency

 

 = frequency (Hz/sec)

 = describes the phase of the sine wave means how much the waveform is shifted

with respect to time

For current, above two equations (1) and (2) are:



or 

Phase is often given as a number between  and  and measured in degrees. Because of the periodic nature of the sine wave, if the wave form is shifted by it becomes the same waveform again, as if it was shifted by(Fig.2c). For simplicity, we will assume that phase is

**Average value of AC during half cycle of time****:**

Mean or average value of alternating current is defined as that **direct current** or steady state current which sends the same charge through a circuit in the same time as is sent by AC in half of its cycle.

From equation (3) if phase:



In an infinitesimally small time, an ac currentcan be considered approximately constant and the charge sent during this time by this current is given by

 

If total charge sent by ac in half cycle (i.e. in time ) then



|  |
| --- |
|  |
| Fig.3: (a) Alternating Current (AC) (sinusoidal) (b) Direct Current (DC) |

Again, if  be the dc current which sends the same charge  during the same equal time, then:



Now from equations (8), (7), and (5) we get



Therefore, 













**Average value of AC during one full cycle of time period****:**

Let total charge sent during one full cycle of ac of time period then we can write:



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|  |
| Fig.3: (a) Alternating Current (AC) (sinusoidal) (b) Direct Current (DC) |

Again if the same above equal charge is sent by a direct current during equal time duration of one full ac signal then we express:



Now using equations (5), (12) and (13):



We can also write:























**Root mean square (RMS) value of AC current:**

Root mean square value or effective value or virtual value of ac is defined as that dc or steady state current which when passed through any resistance  for any given time would produce the same amount of heat as is produced by ac when passed through the same resistance for the same time.

If we consider a current  is allowed to flow through a resistance  in an infinitely small time then heat will be produced during this time is given by



Now if total heat produced during period  of ac is



Again if  amount of dc current which produces the same heat during the same time  in the same resistance, then



Now from equations (15), (16) and (5) we get







**Form Factor:**

It is defined as the ratio of the RMS value to the Average value.

