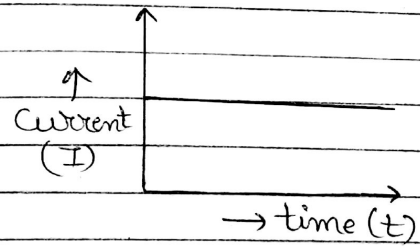
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UNIT-1

APPLICATION & ADVANTAGES of ELECTRICITY

① DIRECT CURRENT (DC)

- It flows in only one direction.
- It may or may not have constant value.

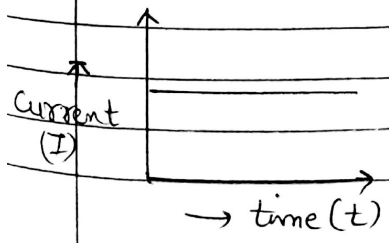


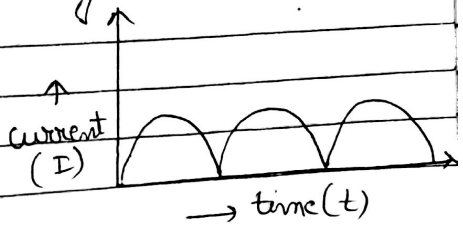
Graph show: Direct current (DC).

TYPES OF DC

① Steady DC
② Pulsating DC

① STEADY DC	PULSATING DC
- A direct current that has constant magnitude (value).	A direct current which change its magnitude (value) with time but flows in only one direction



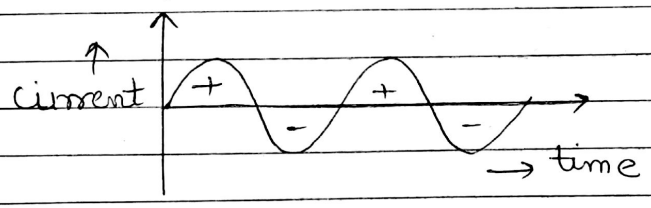


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- Example of DC Source
  Cells.
  Batteries
  DC generators

- DC circuit
  A circuit in which DC current flows is called DC circuit.

(2) ALTERNATING CURRENT (AC)
An AC current changes its direction periodically with time.

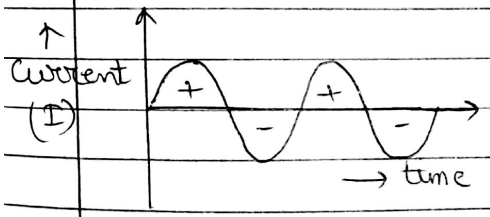
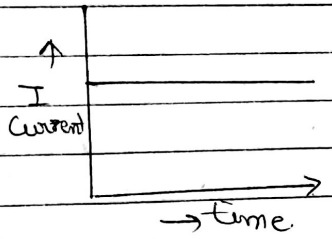


Example of AC source
(a) - A.C Generator
(b) - Oscillator

AC circuit
A circuit in which AC current flows is called AC circuit.

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Difference Between AC & DC

	Alternating Current	Direct current
①	It changes its direction periodically	① It flows in only one direction
②	The magnitude (value) of AC varies with time	② The magnitude of steady DC does not change.
③	It can be Step-up or step-down easily	③ It cannot be done with DC.
④	Waveshape of AC 	④ waveshape of DC 
⑤	It can be easily transmitted from one place to another.	⑤ High voltage DC cannot be transmitt from one place to another.
⑥	Frequency of AC is 50 H_z in India	⑥ Frequency of DC is 0 H_z

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⑦ Skin Effect is present in AC system	⑦ No skin Effect in DC system.
⑧ AC power can be generated at 11 kV or 33 kV	⑧ High voltage DC power cannot be generated.
⑨ Voltage Drop is more in AC system	⑨ Voltage Drop in DC system is less than the AC system.
⑩ At high voltage, Corona loss is large in AC system.	⑩ Corona loss is less in DC system.

Various Uses of Electricity

Electricity → A form of energy which make flow of electrons in a circuit.

Various Uses of Electricity

① LIGHTING

Electric energy is converted into light energy by use of lamps, LED, tubelight etc

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Used :- Houses, Industries, offices, street light etc

② HEATING.
It is used in the form of heaters, Room heaters, ovens, geysers, Boilers, etc.

③ RUNNIG OF MOTORS.
- Electricity used to run motors of cooler, water cooler, washing machine, industry motors, etc.

④ Welding.
Metals welding can be done with the help of electricity.

⑤ Charging of Battery.
- Secondary Battery can be charged by electricity.

⑥ In Sound system
Radio, CD players, Tape Recorder can be used to run by electricity.

⑦ Electroplating
A process of placing a thin layer of metal (like gold) on the other

metal (like silver). This process requires electricity to work.

⑨ Telephone / Mobile Phone
They also work on the electricity

⑩ Electric Traction
They also work on electricity.

Advantages of electricity over forms of Energy

ENERGY :- Potential to do a work is called energy.

- Energy can neither be created nor be destroyed but can be converted from one form to another form.

Different Types of Energy are
1. Mechanical Energy
2. Heat Energy
3. Light Energy
4. Electric Energy
5. chemical Energy
6. wind Energy
7. Solar Energy

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Advantages of Electrical Energy over other different energy.

Or

Electrical Energy is better than other energy because

1. It is clean & cheap
2. It can be easily Controlled
3. It can be transmitted from one place to another
4. It has no noise.
5. It has high Efficiency.
6. It has zero pollution
7. It is safe to Use.
8. It can be converted from one form to another.

ADVANTAGES OF AC OVER DC

1. AC can be step-up or step-down easily by using transformer
2. The power generated in 3-phase alternator is 3 times the power generated in dc generator.
3. High voltage ac power can be easily generated than dc.

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④ The conductor material required is less for transmission of AC power than the DC power in 2-wire transmission system.

⑤ In 3-phase, 4-wire system, two different voltage (230V, 440V) can be produced easily in AC system than the DC system.

⑥ AC motors are smaller in size, cheaper, require less maintenance, simple in construction. than the DC motors.

ADVANTAGES of DC over AC

① For Battery charging, Electrolysis, and electroplating require only DC current.

② DC motors are better (good) for speed controls over wide range than the ac motors.

③ In ac transmission line, if there is no load at Receiving end, then current flows but in dc lines

if there is no load at receiving end, then no current flows.

④ AC current flowing ~~the~~ in ac line produce alternating FLUX, it cause problem in telephone line. This is not a problem in DC line.

Or

No flux produced in DC lines.

⑤ In DC lines, there are no skin effect problem, eddy current losses, dielectric loss but all losses present in ac lines..

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UNIT- 2

Quantities of Electricity & Power-factor

Electricity

A form of energy which produce flow of current through a circuit.

- It can be easily generated into different form of energy

MODERN ELECTRON THEORY

Every material (solid, liquid, gas) is made up of tiny particles called molecule. A molecule is made up of ATOM.

- An Atom has two parts:
  1. Nucleus
  2. Electrons

① NUCLEUS

- It is the central part of an atom.
- It CONTAIN → (i) Neutrons
  → (ii) Protons

(i) Neutrons:- They have no charge

(ii) PROTONS

- They have positive charge

Charge of Protons = 1.602×10^{-19} Coulomb.

Charge of Proton = 1.602×10^{-19} coulomb

Atomic Mass = No. of Protons + No. of Neutrons

(iii) Electrons.

- They have negative charge
- They move around the nucleus but in different shells.
- There are different shells like K, L, M, N -- shells

Charge of electons = -1.602×10^{-19} Coulom

Atomic Number = No. of Protons the electrons in an atom

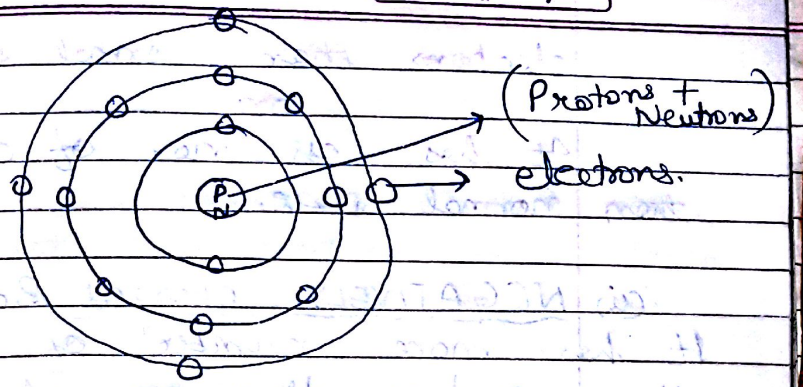
For Example :- SILICON →

It has the Atomic No = 14

electronic Configuration = 2, 8, 4

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Atomic Structure of silicon Atom

- Silicon has → 14 electrons present
  first shell (K) → 2 electrons
  2nd " (L) → 8 electrons
  3rd " (M) → 4 electrons

- Silicon has → 14 protons present

- An atom is electrically Neutral because the no of protons = no. of electrons present.

Nature of Electricity

① CHARGE

A charge body have more or less no. of electrons than its normal state.

POSITIVELY charged Body.
It has more number of protons than

electrons than normal state.

or

It has less no. of electrons than normal state.

(ii) NEGATIVELY charged Body

It has more number of electrons than protons than normal state.

UNIT of charge → COULOMB (C).

Charge of 1 electron = -1.602×10^{-19} C

1 coulomb = $\frac{1}{1.602 \times 10^{-19}}$

= 6.28×10^{18} electrons

- Similar charge Repel each other.
- Opposite charge attract each other.

② VOLTAGE

It is the electric pressure which make electric current to flow through a circuit.

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SOURCE OF VOLTAGE

Batteries, Generator

NOTE :- In Electrical circuit, when voltage is applied than electric current flow through circuit.

UNIT → VOLTS (V)

NOTE - Voltage is measured in Parallel in the circuit
→ It is measured by voltmeter

$$1 \text{ volt} = \frac{1 \text{ Joules}}{1 \text{ coulomb}}$$

One volt is the electric pressure, which makes one ampere of current to flow through one ohm resistance.

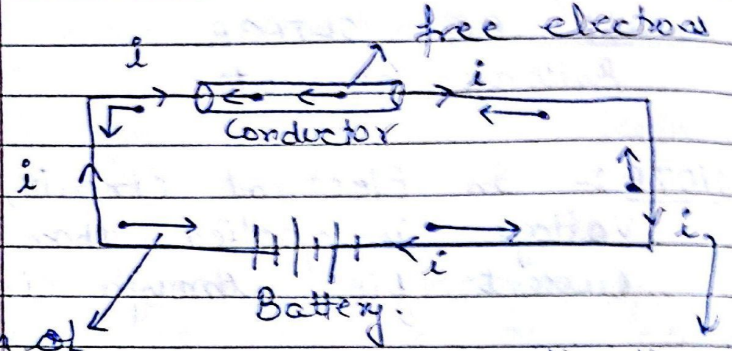
(3) CURRENT.

The flow of electrons in the circuit is called current.

OR

When voltage is applied through circuit, then free electrons flow from conductor towards +ve terminal of battery & Produce current.

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NOTE - current direction is opposite to the flow of electrons

UNIT of current

AMPERE (A).

$$1 \text{ Ampere} = \frac{\text{Coulomb}}{\text{Second}}$$

one Ampere current is said to flow in the ~~circuit~~ conductor, if one coulomb of charge flows in 1 second.

- Ammeter is used to measure current
- Ammeter is connected in series in the circuit.

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RESISTANCE

The opposition offered by a material to the flow of current is called Resistance.

UNIT → OHM (Ω)

- It can be measured by multimeter.

FACTORS ON WHICH RESISTANCE DEPEND

① Resistance is directly proportional to length of conductor.

$$R \propto l$$

Resistance ∝ length of conductor

② Resistance is Inversely proportional to area of cross-section.

$$R \propto \frac{1}{A}$$

Resistance ∝ $\frac{1}{\text{(Area of cross-Section of Conductor}}$

③ Resistance depends upon nature of conductor

example → Gold has low Resistance
→ Iron has high Resistance as compare to Gold.

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④ It depends upon temperature of conductor.

∴ $\boxed{\text{Resistance}, R = \rho \frac{l}{a}}$

where, ρ = Resistivity of conductor
l = length of conductor
a = area of cross-section of conductor

RESISTIVITY (Specific / Specific Resistance)

The resistance offered by wire of one metre length & area equal to one-square metre is called specific resistance / resistivity.

- It is denoted by ρ (pronounced by Rho)
- Unit → Ohm-m (Ω-m).

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ELECTRICAL ENERGY

The total amount of work done in an electrical circuit in a given time is called Electrical energy.

Work done / Electrical Energy = $V \cdot Q$

$= V \cdot It$ $(Q = I \cdot t)$

$= (IR) \cdot It$ $(V = IR)$

$= I^2 R \cdot t$

or

Electrical Energy $= \frac{V^2}{R} \cdot t$ $\left(I = \frac{V}{R}\right)$

Note:

$V = IR$ (ohm's law)

$I = \frac{V}{R}$

Charge $(Q) = I \cdot t$

= current x time

Where

V = Potential difference (voltage) in Volts

I = current (in Amperes)

t = Time (in seconds)

R = Resistance (in ohms).

UNIT →

JOULE / or Watt-Sec

1 Joule = 1 volt x 1 amp x 1 sec

One joule is equal to, if 1 coulomb of current passes in the circuit for 1 second when 1 volt of potential difference (voltage) is applied across it

NOTE :- BOT (Board of Trade)

The commercial unit of electrical energy is B.O.T (Board of Trade) Unit
$1\ Kwh = 36 \times 10^5$ Joules.
The domestic consumers are charged on the basis of BOT Unit charges

Que :- An 100 W electric lamp work for 10 hours. How much energy is consumed.

Sol :- Energy Consumed = (V . I . t) watt

= 100 watt × 10 hour

$= \frac{100 \times 10}{1000}$ Units

= 1 Unit (is Consumed)

given ⇒ 100 watt = Voltage × Current
t = 10 hours

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ELECTRICAL POWER

The Rate at which electrical energy is consumed in electrical circuit is called electrical Power.

OR.

The Rate of doing work in electrical circuit is called electrical Power.

$$\therefore \text{Electrical Power} = \frac{\text{Work done in Electrical circuit}}{\text{time}}$$

$$\text{Power}(P) = \frac{V \cdot I \cdot t}{t}$$

$$= V \cdot I = \frac{I^2 R \cdot t}{t} = I^2 R$$

$$\text{or} \quad \text{Power}(P) = \frac{V^2}{R}$$

$$\Rightarrow \boxed{\text{Power} = I^2 R = \frac{V^2}{R}}$$

UNIT :- Watt

$$\boxed{1 \text{ watt} = 1 \text{ ampere} \times 1 \text{volt}}$$

One Watt power is consumed, if one ampere current flows through circuit, if one volt potential difference (voltage) is applied across the circuit.

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Electrical Power is of 3 types :-

1. Actual or Real or True Power
2. Apparent Power
3. Reactive Power

① Actual / Real / True Power

It is the product of applied voltage, current & power-factor of the circuit.

Actual Power =
= Voltage x Current x Power factor of circuit

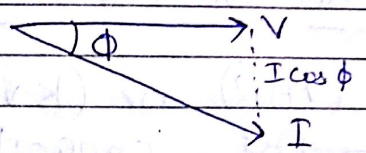
Actual Power = $V \cdot I \cdot \cos\phi$
V = voltage (in Volts)
I = current (in Ampere)
$\cos\phi$ = Power factor (P.F)

Case : 1 **when $\phi = 0^\circ$**
→ then $\cos\phi = \cos 0^\circ$
$= 1$
Actual Power = $V \cdot I \cdot \cos 0^\circ$
$= V \cdot I \ (1)$
$= V \cdot I$ (maximum)

Case : 2 **when $\phi = 90^\circ$**

→ then $\cos\phi = \cos 90^\circ = 0$ (zero)
Actual Power = V. I. cos 90°
= V. I (0)
= 0 (minimum).

	Actual Power Value	phase difference (Angle) between Voltage & current
1→	Maximum Value = 1	0° (zero degree)
2	Minimum Value = 0	90° (Ninety degree)



Actual Power Expressed in Watts (W) or Kilo-Watts (kW).

$$1\,kW = 1000\,W$$

Example:- Bulbs, Incandescent lamp, Heater are Rated in watts.

(ii) **Apparent Power**

It is the product of voltage & current.

Apparent Power = V. I

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Note:→ When Power - factor = Unity
Apparent Power = Actual Power

Apparent Power Expressed in
Volt Ampere or Killo - Volt ampere
(VA) or (KVA)

Example → Motors, Generators, Transformers are Rated in KVA.

③ REACTIVE POWER :-

The product of voltage, current & and sine of angle between voltage & current is called Reactive Power.

$$\text{Reactive Power} = V \cdot I \cdot \sin\phi$$

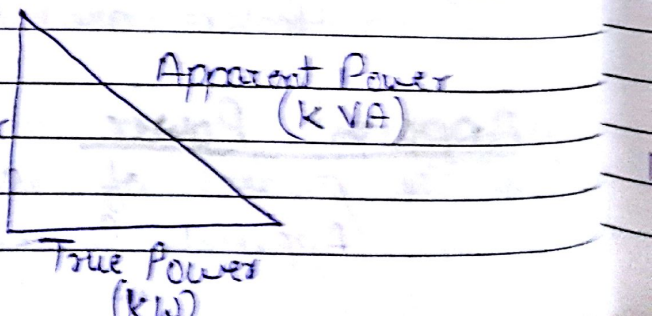
UNIT → (VAR) or (KVAR)

Example → All capacitors are Rated in (VAR).

Relation Between Actual, Apparent, Reactive Power

Imp ↳

$$KVAR = \sqrt{(KVA)^2 - (KW)^2}$$



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POWER FACTOR

The power factor ($\cos\phi$) of a circuit can be defined in the following ways.

① Power factor = $\cos\phi$
= Cosine of angle between V & I.

② Power factor = $\frac{R}{Z}$ = $\frac{\text{Resistance}}{\text{Impedance}}$

③ Power factor = $\frac{EI\cos\phi}{EI}$ = $\frac{\text{True Power}}{\text{Apparent Power}}$
$\left(= \frac{V \cdot I \cos\phi}{V \cdot I}\right)$

For Example.

Electronic Components	Value of Power factor
① Resistor	→ Voltage & current are in Phase. → therefore ∴ $\cos\phi = \cos 0^\circ = 1$ (one) → therefore Power factor = 1 (maximum)
② Inductor or Capacitor	→ Angle between Voltage & current = 90° → ∴ $\cos\phi = \cos 90^\circ$ = Zero (0). → Power factor (P.f) = 0 (minimum) power consumed by pure inductor or Capacitor = Zero.

Note → Power factor (P.f) can never have a value greater than 1.

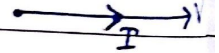
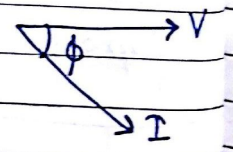
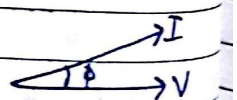
Imp → Maximum Value of P.f = 1

	Power factor (P.f)	Value
①	In AC	V.I cos ϕ
②	In DC	V.I

In DC → power factor is always Unity.

POWER FACTOR can be of 3 type.

① Unity Power factor
② Leading Power "
③ Lagging Power "

Power factor	Type of Load	Example	Angle Between Voltage & Current	Vector Diagram
Unity Power factor	Resistive Loads.	Lamp, Heater	Voltage & current are in Phase	
Lagging Power factor	Inductive Loads	Transformer, Motor	Current lags Voltage by angle ϕ.	
Leading Power factor	Capacitive Loads.	Capacitor Bank	Current lead Voltage by angle ϕ	

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① UNITY Power factor

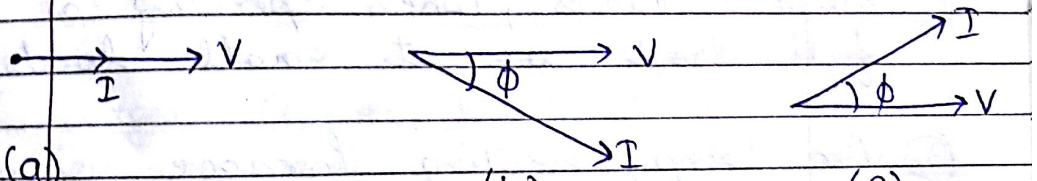
- It occurs in case of Resistive loads.
- Example → Lamp, Heater etc.
- It has Voltage & current are in phase.

② LAGGING Power factor

- It occurs in case of Inductive loads.
- Example – Transformer, Motor etc
- current lags voltage by angle ϕ.

③ Leading Power factor

- It occurs in case of Capacitive loads.
- Example → Capacitor Bank
- Current leads voltage by angle ϕ.



(a) (Unity Power factor)

(b) (lagging Power factor)

(c) (Leading Power factor)

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CAUSES OF LOW POWER FACTOR

① Power factor of Inductive load have lagging power factor.
→ Example - Transformer, Generator, Chokes.

→ At normal load, the magnetising current does not affect
→ At low loads or light loads, the magnetising effects & lower power factor

② In Industries, generally Inductive motors used with Inductive loads & they have low power factor.
Power factor of Induction motors varies, when operating at full load or at small loads.

③ Arc lamp, heating furnace operate at a low power factor (lagging power factor).

DISADVANTAGE OF LOW POWER FACTOR

Power Consumed (P) = $V \cdot I \cos\phi$

$$I = \frac{P}{V \cdot \cos\phi}$$

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→ Current is Inversely Proportional to power factor

Power factor	Current
Low	High
High	Low

Imp → lower the Power factor & the higher current has following advantages.

① LARGER CONDUCTOR SIZE
To transmit fixed voltage at low Power factor, the conductor size will be large to carry high current & hence Cost is large.

② Larger Copper losses
Due to more current carried by Conductor, I^2R losses increases & ∴ efficiency decreases.

③ Poorer Voltage Regulation
Low Power factor & high current in transmission lines have high voltage drop & ∴ Poor Voltage regulation.

④ Large KVA Rating of Equipment

- Electrical machines are Rated in KVA or in Apparent Power
  - Example → Alternators, Transformers

$$KVA = \frac{KW}{\cos\phi}$$

or

$$\text{Rating (KVA)} \propto \frac{1}{\text{Power factor}}$$

Rating of Equipment is inversely proportional to Power-factor.

Note →

Power factor	KVA Rating
Low	High

For the same load at low Power factor, KVA rating increased → ∴ the size & cost of equipment also increase.

(5) POOR Efficiency

$$\text{Efficiency } (\eta) = \frac{\text{Output}}{\text{Output + losses}}$$

→ Losses will be higher at low Power factor.

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ADVANTAGES OF IMPROVED POWER FACTOR :-

- When Power factor Increases, the current decreases in the circuit.

- It has following advantages.

1. Smaller Conductor size
2. Lower Copper losses.
3. Low Voltage Drop
4. Better Efficiency,
5. Smaller KVA Rating equipment are needed.

INSTRUMENTS USED FOR MEASUREMENT

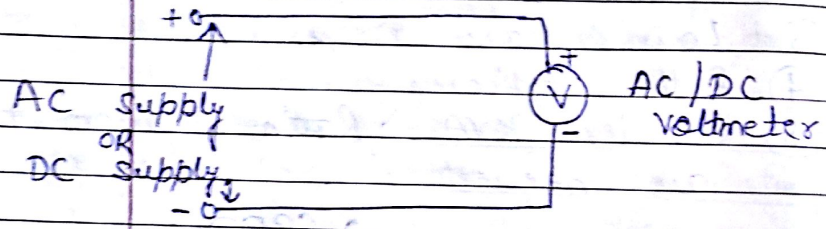
	Quantities to be measured	Name of the Instrument
1	Voltage	Voltmeter
2	Current	Ammeter
3	Power	Wattmeter
4	Energy	Energy Meter
5	Power factor	Power factor Me

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① VOLTAGE :-

→ It is measured by Voltmeter
↳ Voltmeter is connected in parallel with supply because it has high Resistance.

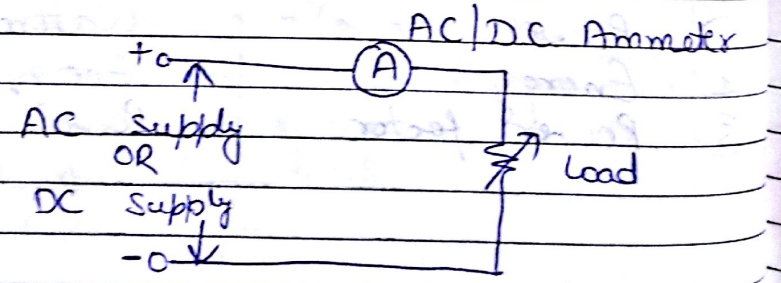
Units → Volts.



Connections of Voltmeter

② CURRENT :-

→ It is measured by Ammeter
↳ Ammeter is connected in SERIES with supply because it has Low Resistance.



Connections of Ammeter

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③ POWER :-

→ Power is measured by Wattmeter

A wattmeter has 2 coils.

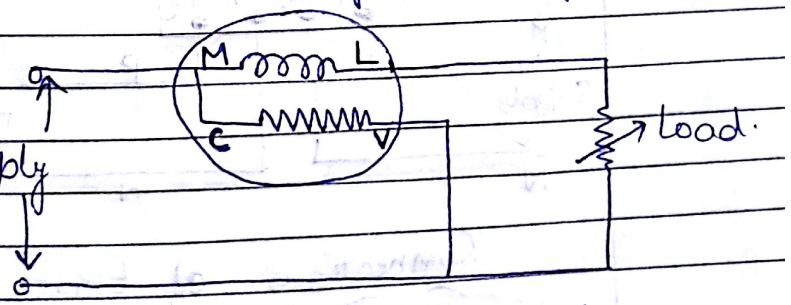
① Current coil (ML)
② Voltage Coil (C V).

① Current coil (M L)

→ It is Connected in series with load.
→ It is made up of thick wire with few no. of turns
→ It has low Resistance
→ It measure current flowing through it.

② Voltage Coil (CV)

→ It is Connected in Parallel with supply
→ Terminal M & C are short circuited
→ It is made up of thin wire having large no. of turns.
→ It has high Resistance.
→ It measure Voltage flowing through i



Connections of wattmeter.

UNIT → Watts.

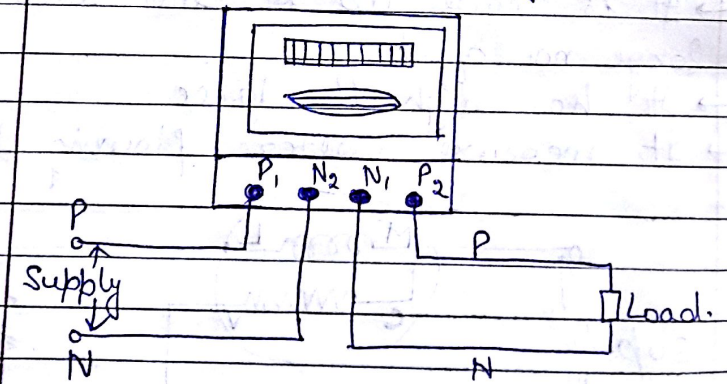
NOTE → For AC, Supply Power = VI cosϕ
DC Supply Power = VI

(4) ENERGY METER :-

→ It is used to measure energy consumed in electrical circuit.
→ It measure in KWH (Kilo-Watt-Hour)

⇒ In single-ϕ (phase) energy meter
→ There are four Terminals.
→ Two terminals for supply & other two terminals for load.

Example :- Induction Type Energy Meter used in AC supply.



Connections of Energy meter

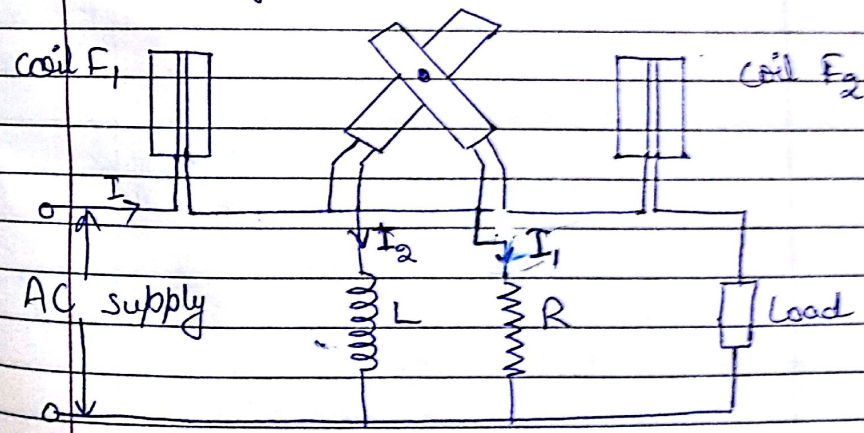
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⑤ POWER FACTOR :-

- Power factor ($\cos\phi$)
  - It is measured by Power factor meter.
  - This instrument has fixed (stationary) coil divided into 2 sections F_1 & F_2
  - This coil connected in series with supply line, it carries load current

- MOVING ELEMENT
  - It has 2 coils on the same shaft at right angle to each other.
  - Moving coil rotate in magnetic field.
  - Movement of coil depends upon Voltage & current



POWER FACTOR METER

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Connections of Voltmeter, Ammeter, Power factor meter, Energy meter :-

