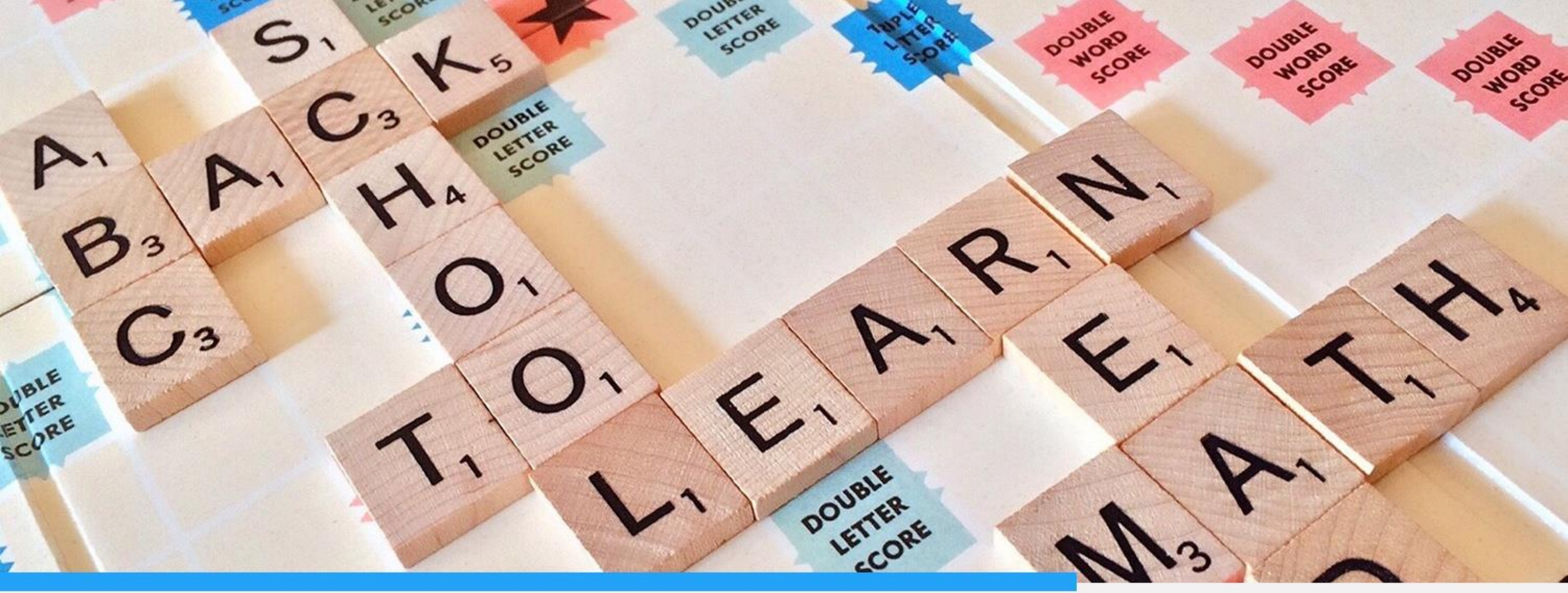


TRANSFORMERS

1. A transformer is a static piece of apparatus by means of which electric power of one circuit is transformed to electric power in another circuit.

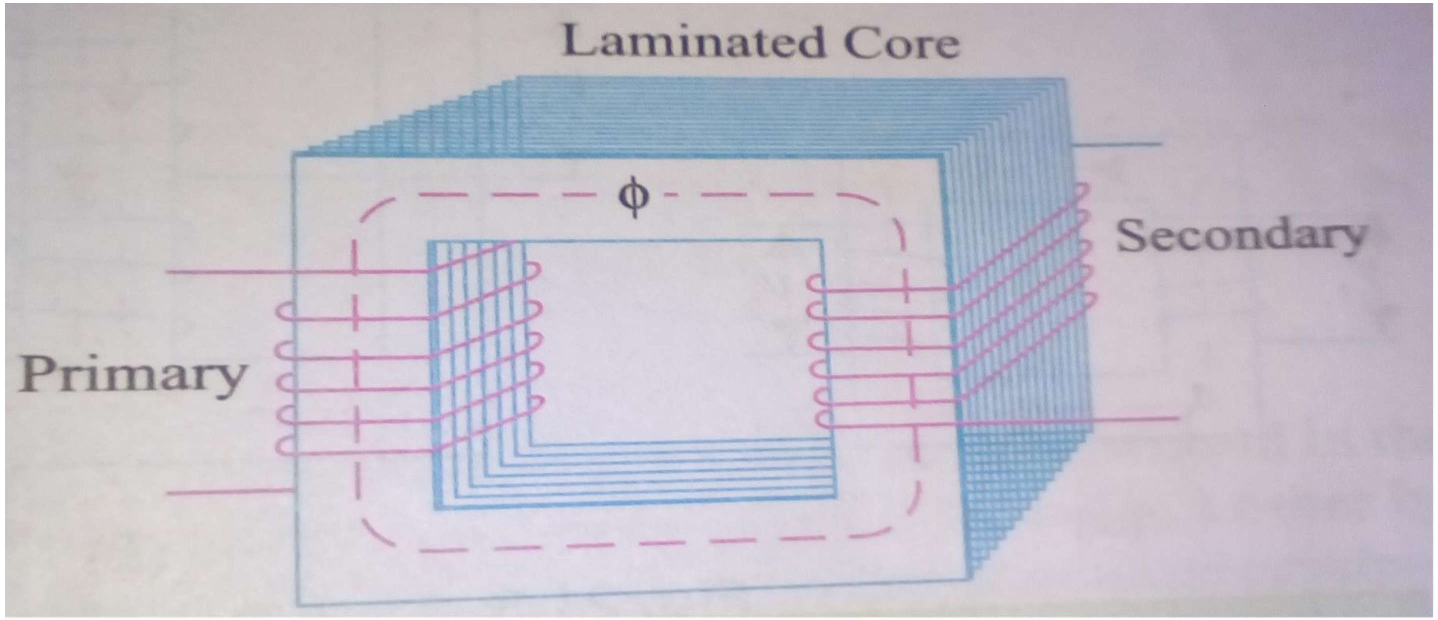
2. Transformers are rated in volt-amperes (VA)

3. The physical basis of a transformer is **mutual inductance.**

4. If two coils of wire are brought into close proximity with each other so the magnetic field from one links with the other,

5. A voltage will be generated in the second coil as a result. This is called **mutual inductance**

1. The first coil, in which electrical energy is feed from a.c. supply mains is called primary winding.
2. Other from which energy is drawn out is called secondary winding.



TURNS RATIO

The turns ratio of secondary voltage to primary voltage is known as transformation ratio or turns ratio. When voltage is applied in the transformer then magnetic flux is set up in the coil

$$\Phi = \Phi_m \sin \omega t = \Phi_m \sin 2\pi f t$$

Emf induced (rms value) can be calculated by

$$\boxed{E = 4.44\, f N \Phi_m}$$

- Let the N_2 , N_1 be the turns in primary and secondary whereas E_1 and E_2 rms value of primary and secondary emf so

$$E_1 = 4.44\, f N_1 \Phi_m$$

and $$E_2 = 4.44\, f N_2 \Phi_m$$

Then, the *transformation ratio* or *turns-ratio* can be expressed as

$$K = \frac{V_2}{V_1} = \frac{E_2}{E_1} = \frac{N_2}{N_1}$$

- By l
- Step up-transformer : $N_2 > N_1$ then $V_2 > V_1$
- Step down-transformer : $N_1 > N_2$ then $V_1 > V_2$

`

the power (VA) in the secondary must equal the power (VA) in the primary. This can be expressed as:

$$E_1 I_1 = E_2 I_2$$

The current is inversely proportional to the turns ratio. This can be expressed as:

$$\frac{I_2}{I_1} = \frac{N_1}{N_2} = \frac{1}{K}$$

The impedance ratio is equal to the turns ratio squared. This is expressed as:

$$\frac{Z_P}{Z_S} = \left(\frac{N_P}{N_S}\right)^2$$

Auto Transformer

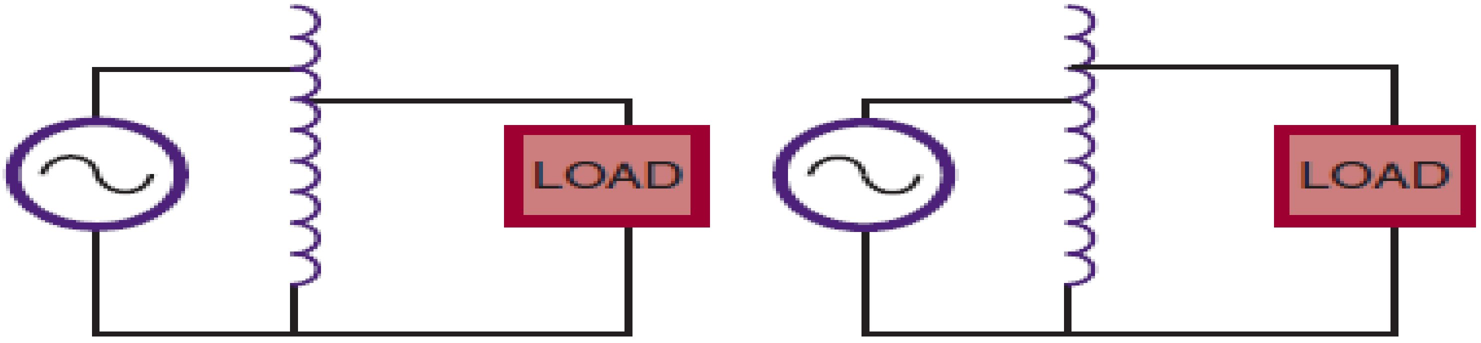
1. An autotransformer is a device used to step up or step down applied voltage.

2. It is a special type of transformer in which the primary and secondary windings are both part of the same core.

Figure 18–8A shows an autotransformer

FIGURE 18–8

An autotransformer is a special type of transformer used to step up or step down the voltage.



(A) STEPPING DOWN A VOLTAGE

(B) STEPPING UP A VOLTAGE

FIGURE 18–9

A variable autotransformer.

TRANSFORMERS HAVE MANY APPLICATIONS

1. **Stepping up voltage**

   When a transformer is used to "increase" the voltage on its secondary winding with respect to the primary.

2. **Stepping down voltage**

   When it is used to "decrease" the voltage on the secondary winding with respect to the primary.

EXAMPLE: A transformer has 400 turns on the primary and 1200 turns on the secondary. If 120 volts of AC current are applied across the primary, what voltage is induced into the secondary?

A transformer has a primary to secondary 10:1 turns ratio. If the primary has a current of 100 milliamperes, how much current flows in the secondary?

A transformer has a primary to secondary 20:7 turns ratio. If the primary has a current of 55 milli amperes, how much current flows in the secondary?

P = true power $\quad P = I^2R \quad P = \dfrac{E^2}{R}$

Measured in units of ***Watts***

Q = reactive power $\quad Q = I^2X \quad Q = \dfrac{E^2}{X}$

Measured in units of ***Volt-Amps-Reactive (VAR)***

S = apparent power $\quad S = I^2Z \quad S = \dfrac{E^2}{Z} \quad S = IE$

Measured in units of ***Volt-Amps (VA)***

Power and Power Factor

Instantaneous power P=v*i

v= $V_m$sin (wt) and i=I_m sin(wt-theta)

Average Power

V and I are the rms valu

$$P = VI\cos\theta$$

Power Factor (pf)

$$pf = \cos\theta$$

Average Power in Purely Resistive Circuit

$$P_{\mathrm{T}} = VI\cos\theta = VI\cos 0 = VI$$

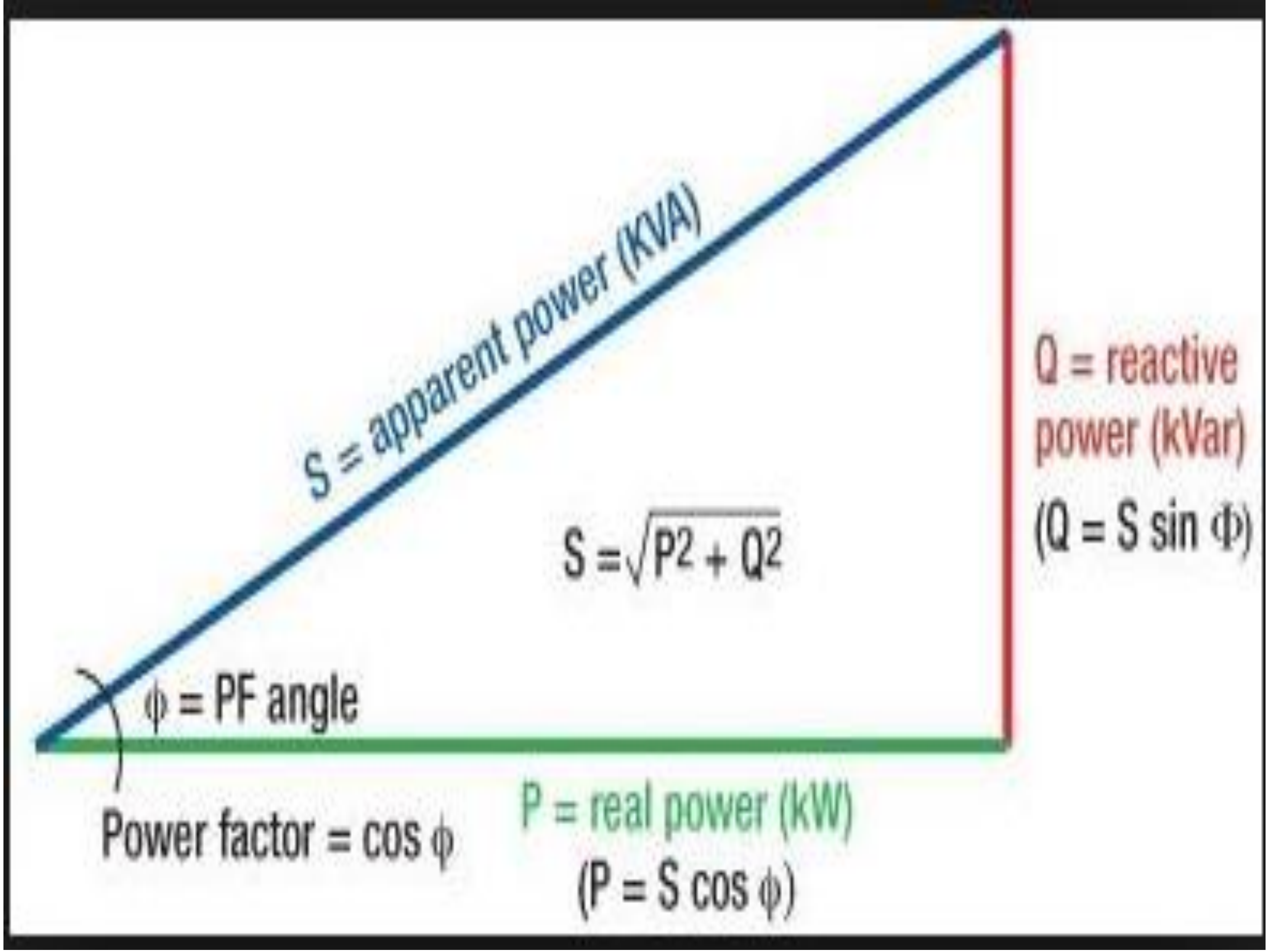
$$pf = \cos\theta = \cos 0^{\circ} = 1$$

Average Power in Purely Capacitive Circuit

P=VIcos(+90^0)=0 {I leads the voltage by 90^0}

Average Power in Purely Inductive Circuit

P=VIcos(-90^0)=0 {I lags the voltage by 90^0}


S = apparent power (KVA)
Q = reactive power (kVar)
(Q = S sin Φ)
S = $\sqrt{P^2 + Q^2}$
φ = PF angle
Power factor = cos φ
P = real power (kW)
(P = S cos φ)

Power Factor

- The ratio between Active Power and Apparent Power in volts-amperes is called power factor.

- Cosθ = Active Power ÷ Apparent Power
- Cosθ = P ÷ S
- Cosθ = kW ÷ kVA

mcq

- The Norton current is the_______
  a) Short circuit current
  b) Open circuit current
  c) Both open circuit and short circuit current
  d) Neither open circuit nor short circuit current

- Norton resistance is found by?
  a) Shorting all voltage sources
  b) Opening all current sources
  c) Shorting all voltage sources and opening all current sources
  d) Opening all voltage sources and shorting all current sources

Transformer on DC

- AC produces varying magnetic flux. Whereas a DC does not. So they won't be any linking magnetic flux from primary to secondary and thus there won't be any induced emf. So we would not get a dc output

Instrument Transformers

What is an Instrument Transformer ?:

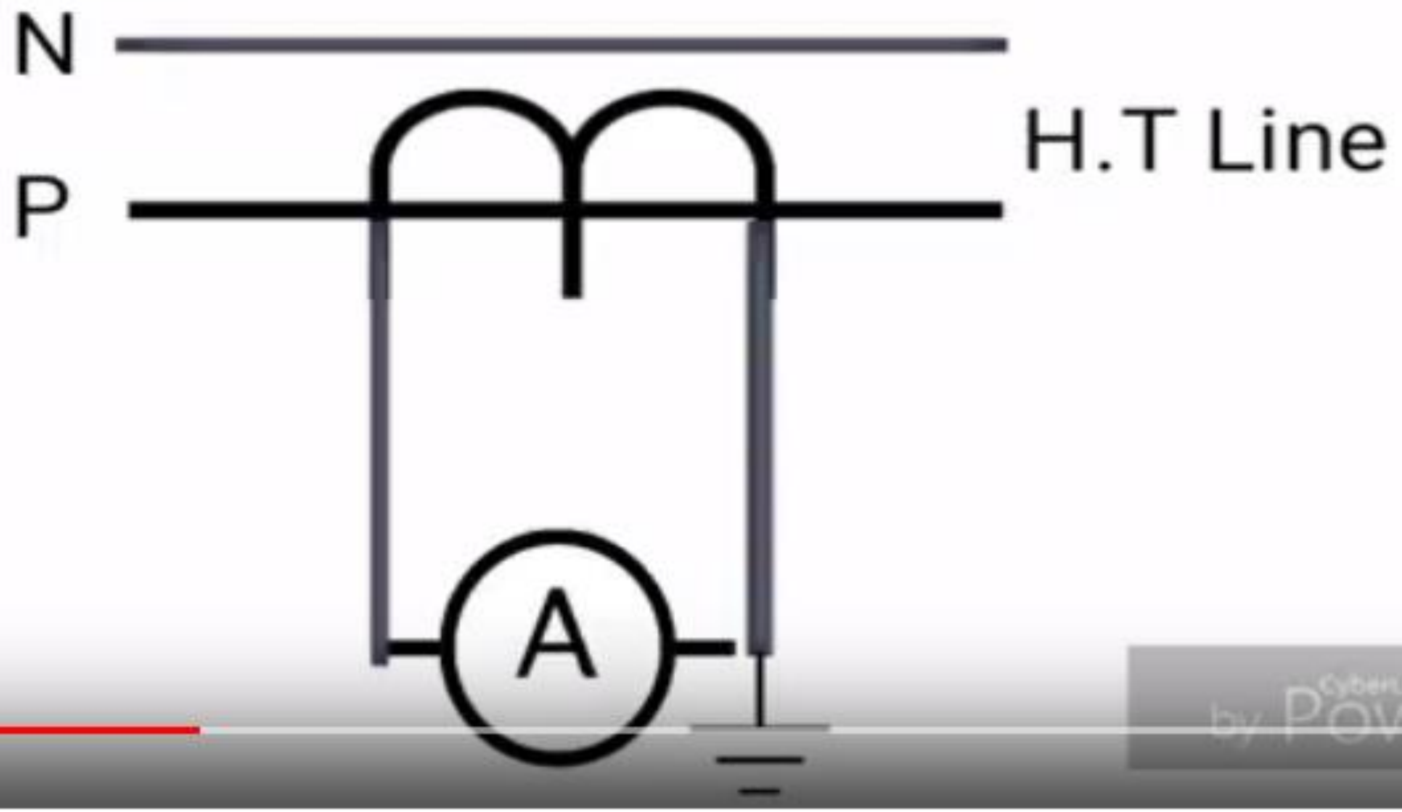
- It is a transformer that is used in conjunction with any measuring instrument (i.e., Ammeter, Voltmeter, Wattmeter,

- It utilizes the current-transformation and voltage transformation properties to measure high ac current and voltage.

- Current transformers are generally used to **measure currents of high magnitude**.
- Potential transformers are also known as **voltage transformers** . Used to measure high value of voltage.

Current Transformer (C.T)

The current Transformer is used for measuring the heavy current.



- The **Current Transformer** (**C.T.**), *Current transformers* reduce high currents to a much lower value and provide a convenient way of safely monitoring the actual electrical current flowing in an AC transmission line using a standard ammeter.

$$\boxed{T.R. = n = \frac{N_P}{N_S} = \frac{I_S}{I_P}}$$

from which we get:

$$\text{secondary current, } I_S = I_P\left(\frac{N_P}{N_S}\right)$$

We are aware with winding primary and secondary and output current so we can calculate input current using formula.

The primary of a 50-Hz step-down transformer has 480 turns and is fed from 6400 V supply. Find (*a*) the peak value of the flux produced in the core, and (*b*) the voltage across the secondary winding if it has 20 turns.

Solution

(*a*) Using Eq. 13.3, we get

$$\Phi_m = \frac{E}{4.44\, f N_1} = \frac{6400}{4.44 \times 50 \times 480} = 0.06 \text{ Wb} = \mathbf{60\ mWb}$$

(*b*) The voltage induced in the secondary winding is given as

$$E = 4.44\, f N_2\, \Phi_m = 4.44 \times 50 \times 20 \times 0.06 = \mathbf{266.4V}$$