National Institute of Technology, Durgapur
Department of Electrical Engineering
Electrical Measurement Laboratory Manual

<u>Experiment No. 7</u>

Measurement of Power Using CT & PT

Objectives:

1. To study the working of current transformer and potential transformer.
2. To connect instrument transformers in electrical circuits for measurement of current, voltage and power.

Apparatus Used:

Sl. No.	Name of the equipments	Range
1	Current Transformer	
2	Potential Transformer	
3	M.I type Ammeter	
4	M.I type Ammeter	
5	Dynamometer type Wattmeter	
6	Loading arrangement	

Theory:

In de circuits, large currents can be measured with the help of low range ammeters with appropriate shunts. For measuring high voltages, low range voltmeters are used in conjunctions with a high series resistance. Same methods cannot be used with ac circuits because of the presence if inductance and capacitance in the circuit. For this purpose specially designed accurate ratio instrument transformers are used in conjunction with standard low range ac instruments. These instrument transformers are of two types (i) current transformers for measuring large alternating currents and(ii) potential transformers for measuring high alternating voltages.

Instrument Transformers are employed in conjunction with standard low range AC instruments to reduce the line current or supply voltage to a value small enough to be easily measured with meters of moderate size and capacity. Operating personnel coming in contact with the instruments are not subjected to high voltage and current lines. The instrument transformers are widely used in protection circuits of power system for the operation of over-current, under voltage, earth-fault and various others relays. They provide a single range instrument to cover a large current or voltage range (normal ranges: 0-5A, 0-110V) but cannot be used for DC measurements. Just as a shunt extends the range of a DC ammeter so does the **current transformer (CT)** perform the same function in AC circuits. Thus, a high magnitude alternating current can be easily measured by a combination of a current transformer and a low range ammeter. The primary of a current transformer (CT) consists of a few turns of thick cross-section connected in series with the high current line. Very often the primary is just one turn formed by taking the line conductor through the secondary winding. The secondary winding consists of a large number of turns of fine wire designed for either 1A or 5A rating. Thus, a current transformer is a step-up transformer. The current transformer has the secondary effectively short-circuited through the low impedance of the ammeter. A **Potential Transformer (PT)** on the other hand is a step down transformer used along with a low range voltmeter for measuring high voltage. The primary is connected across the high voltage supply and the secondary to the voltmeter or potential coil of the wattmeter. Since, the voltmeter (or potential coil) impedance is very high, the secondary current is very small and the potential transformer (PT) behaves as an ordinary two winding transformer operating on no-load. Potential transformer (PT) secondary is commonly designed for an output of 110Volt.

Calibration of Current Transformer (CT)

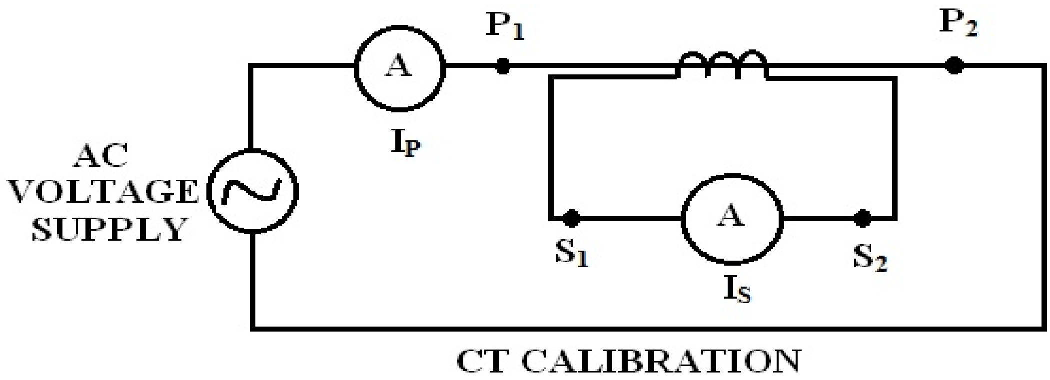

Fig. Potential Transformer (PT) Calibration

Calibration of Potential Transformer (PT)

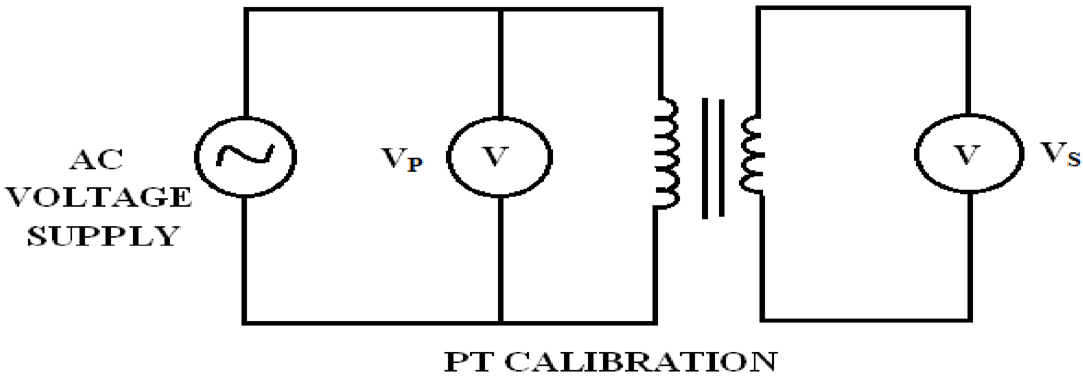

Fig. Potential Transformer (PT) Calibration

Current Transformer (CT)

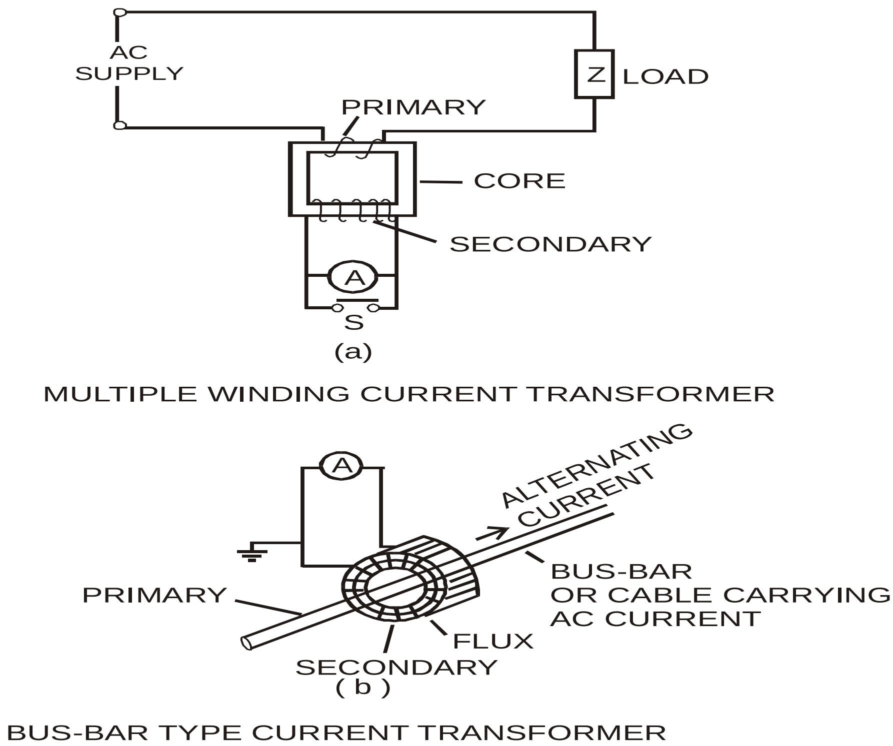

Fig. Different types of current transformers

These transformers are used with low-range ammeters to measure currents in high voltage alternating current circuits where it is practically not possible to connect instruments and meters directly to the lines. In addition to insulating from high voltage, they step down the current in a known ratio. The current transformer has a primary coil of one, two or more turns of thick wire connected in series with the line whose current is to be measured as shown in the above figure. The secondary side consists of a large number of turns of fine wire and is connected across the ammeter terminals (usually of 5 ampere or I ampere range).

The current transformer is basically a step-up transformer and obviously the current in the secondary winding will be less than that in the primary winding. Thus a current transformer having primary to secondary voltage transformation ratio of 1: 20 will have a current transformation ratio of 100:5 (or 20:1). Hence if we know the current transformation ratio (I_1 /I_2) then line current is obtained by multiplying the ammeter reading i.e. I_2 by the ratio I_1 / I_2. Clip-on or clamp-on type current transformers are also very common. In such clamp-on meters, the core of the transformer is so arranged that it can be opened out at hinged section by pressing a handle. When the core is thus opened, it permits the admission of heavy current carrying bus bars or conductor in between the core. When core is tightly closed, the current carrying conductor or feeder acts as a single turn primary whereas the secondary is connected across the standard ammeter mounted between the handle and the arm. A typical clamp-on meter is shown in Figure below.

It should be noted that, since the ammeter resistance is very low, the CT normally works as short circuited. In case, the ammeter has to be removed on an energized CT, the terminals must be short circuited by short circuited by switch S (Refer Figure above) otherwise in the absence of opposing secondary ampere-turns, the primary current will produce a very high flux in the core which will result into increased iron losses. and abnormally high voltage across the open secondary terminals which may become dangerous for the operating personnel. In case of a two-winding conventional transformer, the primary current is determined by the primary current because secondary is shot circuited through a very small impedance of an ammeter. Hence, as a precaution, secondary of an energized CT should never be left open under any circumstances.

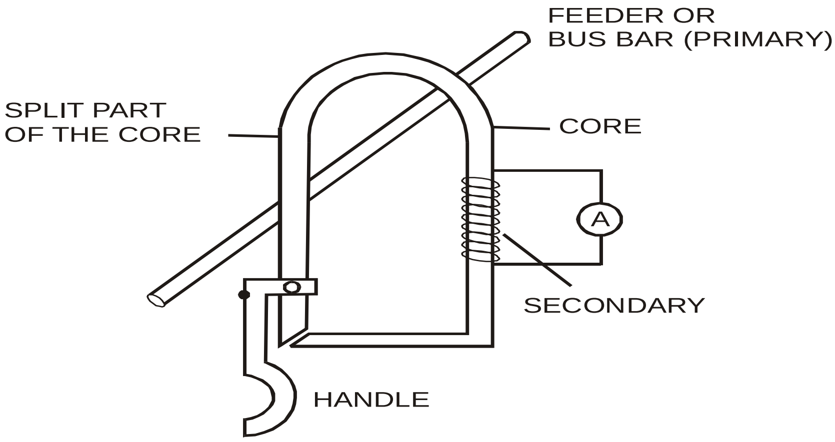

Fig. Clamp-on meter

Potential Transformer (PT)

These transformers are step-down transformers with known transformation ratio. PTs are used in conjunction with low rang voltmeters (usually 110 V) whose defection. when divided by voltage transformation ratio gives the true voltage on the high voltage side. In general, they are of shell type and do not differ much from the ordinary two-winding transformers except that their power rating is extremely small. For voltage higher than 11 kV.they are generally oil immersed. Since secondary load is either an instrument, a relay or a pilot lamp, the rating of PTs is 40 to 100 w. For safety.the secondary should be completely insulated from the high voltage primary and should be earthed. Fig. shows the connection of such a transformer.

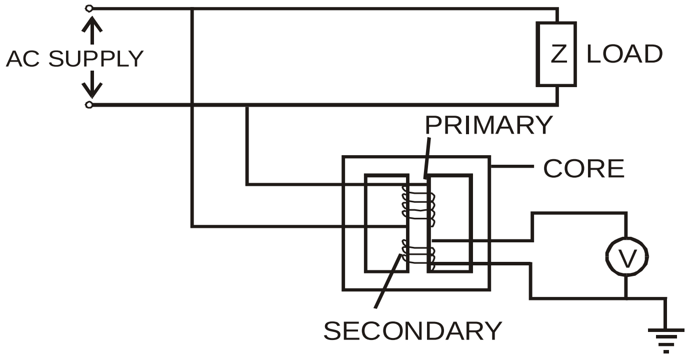

Fig. Potential transformer connection

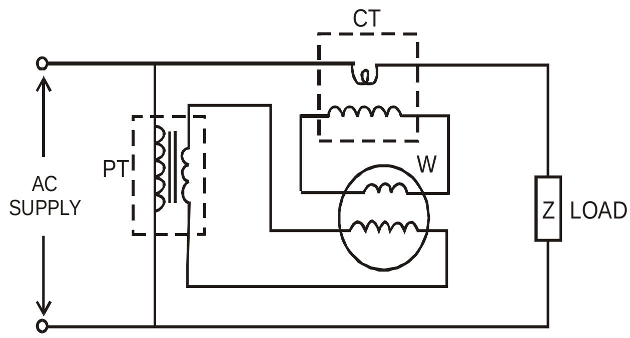

Fig. The connections of instrument transformers with a wattmeter

The figure shows the connections of instrument transformer with a wattmeter. Such connections will be useful for measurement of power in a circuit having such currents and voltages which are not practically possible to apply to a wattmeter current and potential coils. The wattmeter reading is to be multiplied by the current transformation ratio of CT and voltage transformation ratio of the potential transformer respectively. If k_p and k_c are the transformation rations of PT and CT respectively, then power in the load is given by $k_p.k_{e.}$ W where W is the wattmeter reading.

Procedure:

Measurement of Current using CT

1. Make connections as shown in Figure. Note the current transformation ratio mentioned on the CT name plate.
2. Switch on the supply and adjust load to a suitable value. Note I_1 and $I_{2.}$ Change load and take several readings of I_1 and I_2 and record them.
3. Calculate current transformation ratio of the CT and record against each set of observation.

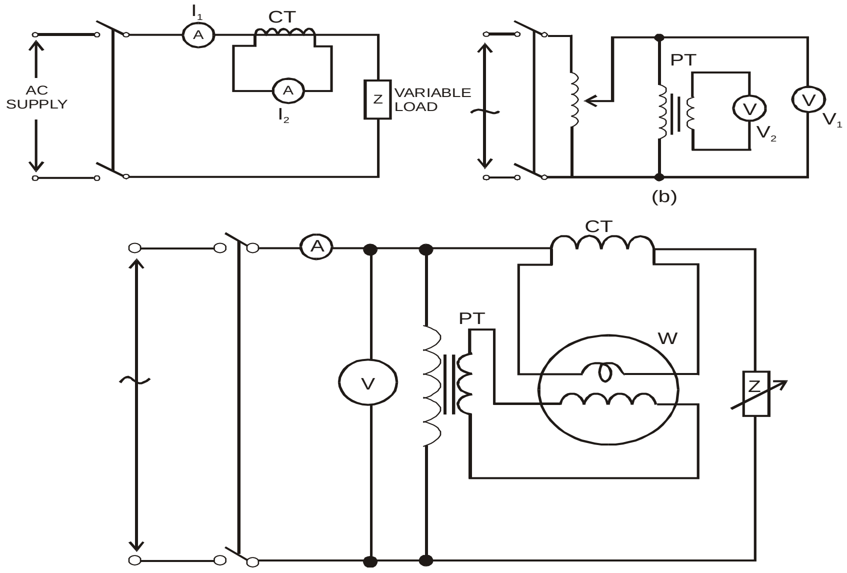

Fig. Circuit diagram for measurement (a) Current (b) Voltage and
(c) Power using CT and PT.

Fig. Circuit diagram for measurement (a) Current (b) Voltage and (c) Power using CT and PT.

Measurement of voltage using PT

1. Make connections as shown in Figure. Note the voltage transformation ratio of the PT from its name plate.
2. Switch on the supply and adjust input voltage to an appropriate value. Note V_1 and V_2. Change the primary voltage and take several observations of V_1 and $V_{2.}$
3. Calculate voltage transformation ratio of the PT and record against each set of observation.

Measurement of Power using CT and PT

1. Make connections as shown in Figure. Note current transformation ratio of CT and voltage transformation ratio of PT.
2. Switch on the supply and adjust load such that the wattmeter shows some reading. Record ammeter, voltmeter and wattmeter readings.
3. Take several observations by changing the load and record in the observation table.
4. Calculate total power consumed by the load by multiplying the wattmeter observations with transformation rations of CT and PT.

Observations and Results:

Measurement of Current

Sl. No.	CT Nominal transformation ratio K_o	Primary Current, I_P(amp)	Secondary Current I_S(amp)	Actual Ratio $K_{CT}=I_P / I_S$	Ratio Error $[(K_o-K_{CT})/K_{CT}]$ x100

Measurement of Voltage

Sl.No.	PT Nominal transformation ratio K_o	Primary voltage V_P, (volt)	Secondary voltage V_S (volt)	Actual Ratio $K_{PT}=V_P / V_S$	Ratio Error $[(K_o-K_{PT})/K_{PT}]$x 100

Measurement of Power

Sl. No	CT secondary Current I_s	PT Secondary Voltage V_s	Actual CT ratio $K_{CT}= I_P / I_S$	Actual PT ratio $K_{PT}= V_P / V_S$	Wattmeter reading W_m	True power $W_t=(V_sI_s)$ x K_{CT} x K_{PT}	% Error [(Wm-Wt)/Wt]*100

RESULTS:

Draw the followings:

1. Characteristics Curve between Ratio Error Vs Current for CT
2. Characteristics Curve between Ratio Error Vs Voltage for PT
3. Characteristics Curve between % Power Error Vs Measured Nominal Power

Suggested Reading:

1. Electrical Measurement & Measuring Instrument by E.W.Golding