

3.1 Current transformers and their applications in protection schemes:

➤ Instrument transformers—

i.e. current transformer and voltage transformers insulate secondary circuits from Primary (power) circuit and provide quantities which are proportional to those in primary.

- These quantities are used for metering and relaying circuits. Current and voltage transformers are regarded as constituting part of the protection system and must be carefully matched with the protective relay.
- Measuring current transformers for metering are required to accurately perform its function over normal range of load currents, whereas protective current transformers is required to provide sufficiently accurate secondary current to provide satisfactory protection over a wider range of fault current from a fraction of full load to many times of full load.
- Therefore separate type of current transformer is used for measuring and protection. In case of voltage transformers same transformers can serve both the purposes.
- Protective relays in a.c. power systems are connected in the secondary circuit of current transformers and potential transformers. In current transformers, primary current is not controlled by condition of the secondary circuit.
- Hence primary current is dominant in the operation of current transformers.

Instrument transformers are further classified into two groups:

- Protective instrument transformers used in association with relays, trip coils, pilot wires etc.
- Measuring instrument transformers – used in conjunction with ammeter, wattmeter etc.

Latest version of following Standards may be referred for complete information.

A. Current Transformer

- i) IS:2705(4 parts)— Current Transformer
- ii) IEC185 Current Transformer— International Electro- technical

Commission

- iii) IS 4201 – Application Guide for current transformers
- iv) IEC-60044-1- Current transformers

Current Transformer

- Primary requirement is that current ratio must be constant. Primary windings are connected in series with load and carries load current to be measured. The winding is connected to the relay or metering unit.
- Secondary current for relay together with load resistance and winding impedance constitute the burden of the transformer.

Primary current contains two components.

- a) Secondary current which is transformed and is in inverse ratio of the turns ratio.
- b) Exciting current to magnetize the core and supply eddy and hysteresis losses and is not transformed. Amount of exciting current depends upon core material and burden requirement.

The ratio error is given by the following expression.

$$\% \text{ error} = \frac{K_a I_s - I_p \times 100}{I_p}$$

K_a = Rated transformation ratio
 I_s = Actual secondary current
 I_p = Actual primary current

- ❖ As the relay time has reduced to the order of a few milli-seconds in modern protective relays, the transient behavior of current transformers and voltage transformers needs more attention. In order to prevent saturation of current transformer cores during sub-transient currents, larger cores and air gaps are introduced in CT's for fast protective relays.
- ❖ The standard specifications given by IEC, IEEE and IS cover several aspects about current transformers such as general requirements, specifications, testing, applications, terms and definitions.

- ❖ The major criterion of the selection of the current transformer ratio almost invariably is maximum load current.
- ❖ In other words, the current transformer secondary current at maximum load currents, should not exceed the continuous current rating of the applied relay. This is particularly applicable to phase type relays where load current flows through the relays.
- ❖ This criterion applies indirectly to the ground relays even though they do not receive current because they are generally connected to the same set of current transformers as the phase relays.
- ❖ Since the ratio has been set on the basis of load current of the phase relays, this ratio would then apply to the ground relay.
- ❖ The current transformer ratio is selected to provide around 5 amperes or 1 amp. (in switchyard) secondary for the maximum load current. Where delta-connected CT's are used, the $\sqrt{3}$ factors should not be overlooked.

Application of Protective Current Transformers

General shape of exciting characteristics for cold rolled silicon steel material (cross) generally used for protection CTs is shown in the below figure

- Working range of a protective transformer extends from ankle point to knee point and beyond (full range).
- Metering current transformer normally operates in the region of ankle point about 10% to 120% full load. High permeability with low saturation level material is used for metering CTs. CT saturates above this range and protects the meters.
- The determination of the rating of a protective CT is dependant on its application and consequently the following parameters are worked out: rated burden, rated accuracy limit factor and accuracy class.
- For balanced protection system and distance protection special class current transformers designated class

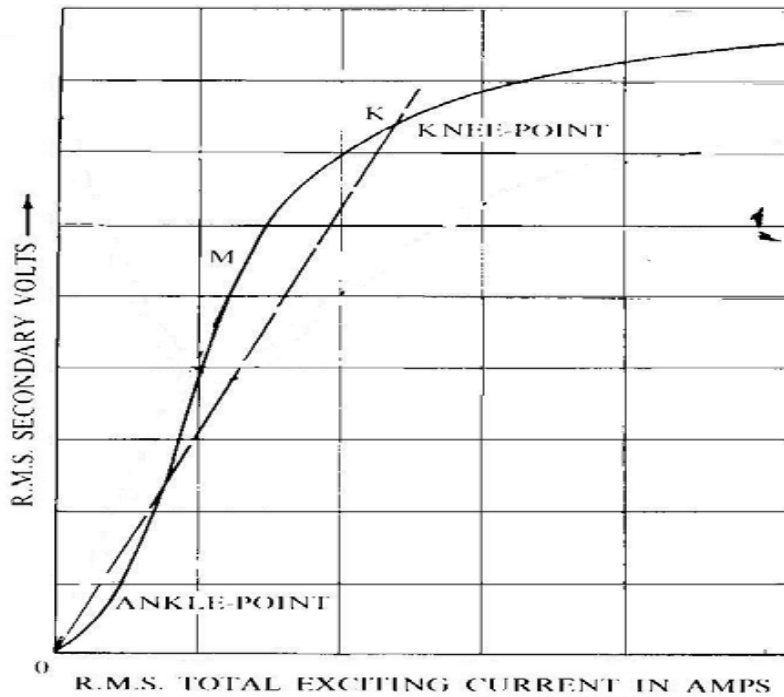


Figure:3.1.1 Exciting Curve for Current Transfer

[Source: "Power System Protection and Switchgear" by B.Rabindranath and N.Chander, Page: 212]

PS are used and needs in addition following parameters to be specified.

- a) Rated knee point voltage
 - b) Secondary winding resistance
 - c) Maximum exciting current at rated knee point voltage
- Current transformers are generally used to measure currents of high magnitude. These transformers step down the current to be measured, so that it can be measured with a normal range ammeter.
 - A Current transformer has only one or very few number of primary turns. The primary winding may be just a conductor or a bus bar placed in a hollow core (as shown in the figure).
 - The secondary winding has large number turns accurately wound for a specific turns ratio.

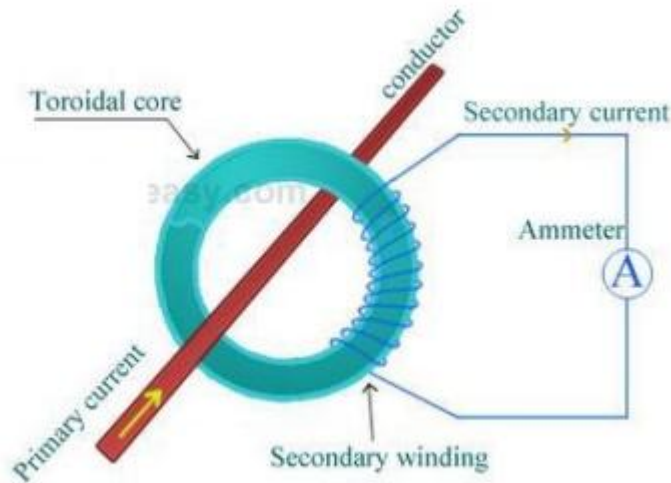


Figure 3.1.2 : Current Transformer

[Source: "Power System Protection and Switchgear" by B.Rabindranath and N.Chander, Page: 222]

- Thus the current transformer steps up (increases) the voltage while stepping down (lowering) the current. Now, the secondary current is measured with the help of an AC ammeter. The turns ratio of a transformer is $N_P / N_S = I_S / I_P$
- UPS systems
- Transfer switches
- Motor-generator sets
- Commercial sub-metering,
- CT's in one package for 3-phase metering
- Accurate measuring for metering/WATT/VAR
- Current sensing, recording, monitoring & control
- Control panels and drives
- Standard CT used as measuring standard for comparison
- Winding temperature indicator (WTI) for power transformers
- Summation current transformers.