ch-5 Instrument transformers Dt-28-06-21

current transformer (CT) :-

Defn - A current transformer is a device that is used for the transformation of current from a higher value into a proportionate current to lower value.

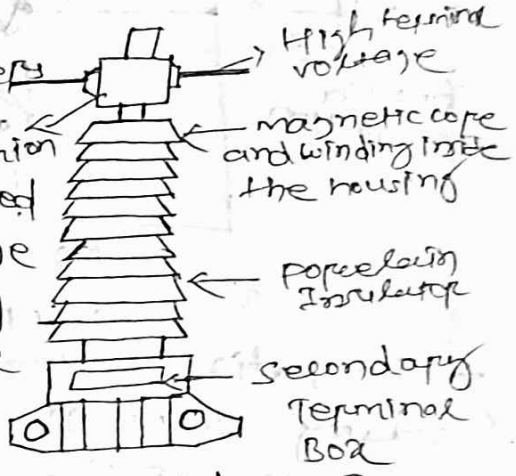
→ It transforms the high voltage current into the high voltage current into the low voltage current due to which the heavy currents flows through the transmission lines is safely monitored by the ammeter.

→ The current transformer is used with the AC instrument, meters or control apparatus where the current to be measured is of such magnitude that the meter or instrument coil cannot conveniently be made of sufficient current carrying capacity.

→ The current transformer is shown in the Fig. below.

→ The primary and secondary current of the current transformers are proportional to each other.

→ The current transformer is used for measuring the high ~~high~~ voltage current because of the difficulty of inadequate insulation in the meter itself.



→ The current transformer is (current transformer) used in meters for measuring the current up to 100 amperes.

construction of current Transformer :-

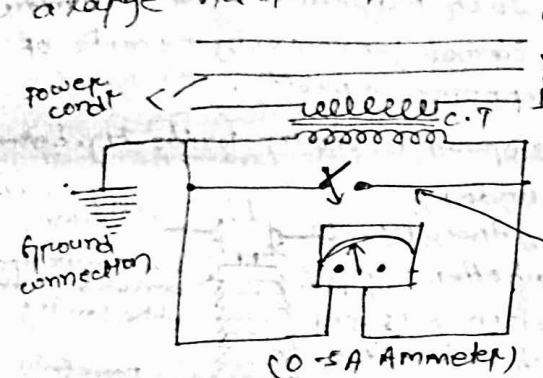
→ The core of the current transformer is built up with lamination of silicon steel.

→ For getting a high degree of accuracy the permalloy or mumetal is used for the making cores.

→ The primary windings of the current transformer carry the current which is to be measured, and it is connected to the main ckt.

→ The transformers carry the current which

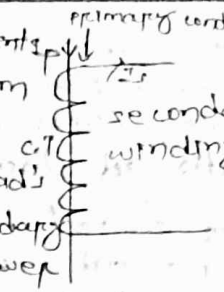
is to be measured, and it is connected to the main ckt.
→ The secondary windings of the transformer carries the current proportional to the current to be measured, and it is connected to the current windings of the meters or the instruments.
→ The primary and the secondary windings are insulated from the cores and each other.
→ The primary winding is a single turn winding (also called a bar primary) and carries the full load current.
→ The secondary winding of the transformer has a large no. of turns.



(current transformer)

→ The ratio of the primary current and the secondary current is known as current transformation ratio of the ckt.
→ The current ratio of the transformer is usually high.
→ The secondary current ratings are of the order of 5A, 1A and 0.1A.
→ The current primary ratings vary from 10A to 3000A or more.
→ The symbolic representation of the current transformer is shown in the figure below.

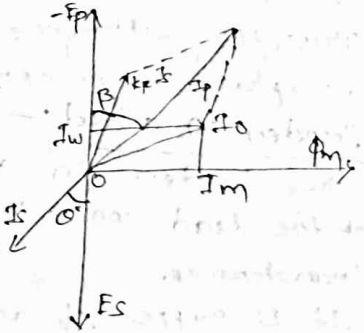
→ The working principle of the current transformer is slightly different from the power transformer.
→ In a current transformer, the load's impedance or burden on the secondary has slightly differed from the power transformers.
→ Thus, the current transformer operates on secondary ckt conditions.



phasor diagram of current Transformer:—

→ The phasor diagram of the current transformer is shown in the figure below.
→ The main flux is taken as a reference.
→ The primary and secondary induced voltages are lagging behind the main flux by 90°.
→ The magnitude of the primary and secondary voltages depends on the no. of turns on the winding.
→ The excitation current induces by the components of magnetising and working current.

where, I_s = secondary current
E_s - secondary induced voltage
I_p = primary current.
E_p - primary induced voltage
K_t = Turn ratio, no. of secondary turn/no of primary turn
I_0 = excitation current.
I_m = magnetising current
I_w = working component
ϕ_s = main flux



→ The secondary current lags behind the secondary induced voltage by an angle θ°.
→ The secondary current relocates to the primary side by reversing the secondary current and multiply by the turn ratio.

→ The currents flocas thpough the primary is the sum of the exciting current Io and the product of the turn ratio and secondary current KtIs.

Ratio and phase angle Errors of CTs:-

→ The current transformer has two errors- ratio error and a phase angle error.

Current Ratio Errors:-

The current transformer is mainly due to the energy component of excitation current and is given as, Ratio Error = $\frac{K_t I_s - I_p}{I_p}$

Where Ip is the primary current. Kt is the turns ratio and Is the secondary current.

phase Angle Error:-

In an ideal current transformer the vector angle bet^n the primary and reversed secondary current is zero.

→ But in an actual current transformer, there is a phase difference bet^n the primary and the secondary current because the primary current has also supplied the component of exciting current.

→ Thus, the difference bet^n the two phases is termed as a phase angle error.

Burden on a load:-

→ The burden of a current transformer is the value of the load connected across the secondary transformer

→ It is expressed as the output in voltamperes (VA)

→ The rated burden is the value of the burden on the nameplate of the CT.

→ The rated burden is the product of the voltage and current on the secondary when the CT supplies the instrument or relay with its rated value of current.

Applications of current Transformers:-

→ These transformers are used to measure electric power in power houses, industries, grid stations, control rooms in industries for metering metering of analysing the flow of current in the ckt and also for protection purposes.

potential Transformer (PT):-

→ Defn - The potential transformer may be defined as an instrument transformer used for the transformation of voltage from a higher value to lower value.

→ This transformer stepdown the voltage to a safe limit value which can be easily measured by the ordinary low voltage instrument like a voltmeter, wattmeter and watt-hours meters, etc.

Construction of potential Transformer:-

→ The PT is made with high-quality core operating at low flux density so that the magnetising current is small.

→ The terminal of the transformer should be designed so that the variation of the voltage ratio with load is minimum and the phase shift bet^n the input and output voltage is also minimum.

→ The primary winding has a large no. of turns, and the secondary winding has a much small no. of turns.

→ For reducing the leakage reactance, the co-axial winding is used in the potential transformer.

→ The insulation cost is also reduced by dividing the primary winding into the sections which reduce the insulation bet^n the layers.

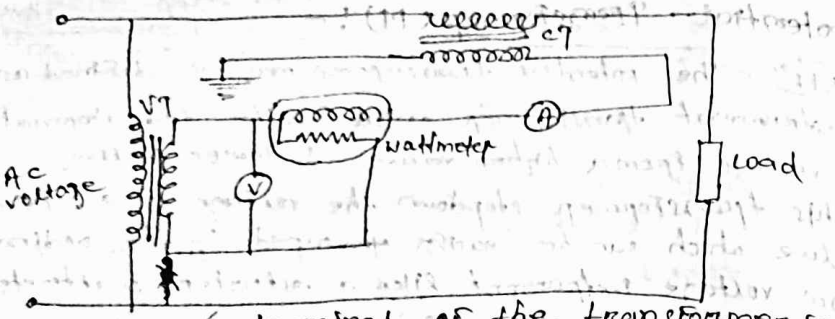
Connection of potential Transformer:-

→ The PT is connected in parallel with the ckt.

→ The primary windings of the PT are directly connected to the powerckt whose voltage is to be measured

→ The secondary terminals of the PT are connected to the measuring instrument like the voltmeter, wattmeter etc.

→ The secondary windings of the potential transformer are magnetically coupled through the magnetic ckt of the primary windings.



→ The primary terminal of the transformer is rated for 400V to several thousand volts, and the secondary terminal is always rated for 400V.

→ The ratio of the primary voltage to the secondary voltage is termed as transformation ratio or turns ratio.

Ratio and phase angle Errors of potential transformer

→ In an ideal PT, the primary and the secondary voltage is exactly proportional to the primary voltage and exactly in phase opposition.

→ But this cannot be achieved practically due to the primary and secondary voltage drops.

∴ Thus, both the primary and secondary voltage is introduced in the system.

Voltage Ratio error:- The voltage ratio error is expressed in regarding measured voltage, and it is given by the formula,

$$\text{Ratio error} = \frac{K_t V_s - V_p}{V_p}$$

where, K_t is the nominal ratio, i.e. the ratio of the rated primary voltage and the rated secondary voltage.

Phase Angle Error:- The phase angle error is the error between the secondary terminal voltage which is exactly in phase opposition with the primary terminal voltage.

→ The increases in the no. of instruments in the relay connected to the secondary of the PT will increase the errors in the potential transformers.

Burden of a potential transformer:-

→ The burden is the total external volt-amp loading the secondary at rated secondary voltage.

→ The rated burden of a PT is a VA burden which must not be exceeded if the transformer is to operate with its rated accuracy.

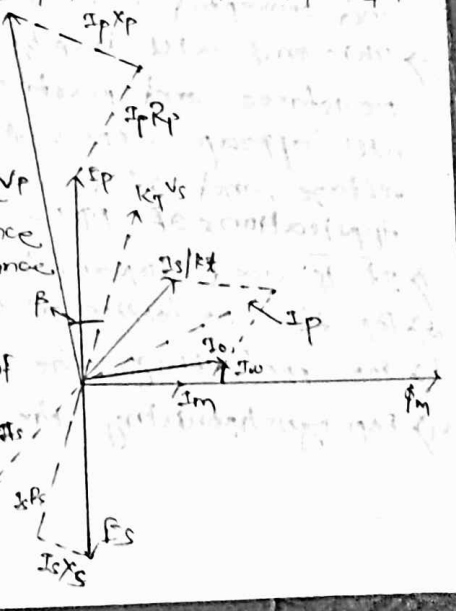
→ The rated burden is indicated on the name plate.

→ The limiting or maximum burden is greatest VA load at which the PT will operate continuously without overheating its winding beyond the permissible limits.

→ This burden is several times greater than the rated burden.

Phasor Diagram of a potential transformer:-

→ The phasor diagram of the potential transformer is shown in fig.



where, I_s = secondary current
E_s = secondary induced emf
V_s = secondary terminal voltage V_p
R_s = secondary winding resistance
X_s = secondary winding reactance
I_p = primary current
E_p = primarily induced emf
V_p = primary terminal voltage.
R_p = primary winding resistance

X_p = primary winding reactance.
K_t = Turn Ratio
I_0 = excitation current
I_m = Magnetising component of I_0
I_w = core loss component OF I_0
ϕ_m = main flux
β = phase angle error.

→ The main flux is taken as a reference. In the current transformer, the primary current is the vector sum of the excitation current I_0 and the current equal to the reversal secondary current Is multiplied by the ratio of $1/K_t$.

→ The V_p is the voltage applied to the primary terminal of the PT.

→ The voltage drops due to resistance and reactance of primary winding due to primary current is given by $I_p X_p$ and $I_p R_p$.

→ When the voltage drop substracts from the primary voltage of the PT, the primary induced emf will appear across the terminals.

→ This primary emf of the transformer will transform into secondary winding by mutual induction and converted into secondary induced emf E_s.

→ This emf will drop by the secondary winding resistance and reactance, and the resultant voltage will appear across the secondary terminal voltage, and it is denoted by V_s.

Applications OF PT :-

1) It is used for metering purpose.
2) For the protection of the feeders.
3) For protecting the impedance of the generators
4) For synchronising the generators and feeders.