Analog Instrument

① Based on quantity To be measured

V → (V) meter
I → (A) meter
P = VI ⇒ (W) meter

$$\text{Energy} = \int_0^t V(t)\,i(t)\,dt \Rightarrow \text{E.M.}$$

$Pf = \cos\phi \equiv$ Pf meter

② Based on working principle

→ Magnetic field effect
→ Electrostatic field effect
→ Electromagnetic Ind. effect
→ Thermal (or) heating effect

③ Based on Representation

① Indicating Type Inst. (No storage) — Only display

Ex PMMC → (A), (V)
EMMC (A), (V), (W)
MI − (A), (V)
EC − (V)
Ohmmeter, megger
P.f. meter

② Recording Type

→ Magnetic Tape
→ Cockpit voice (CVR)
→ Seismograph
→ ECG

③ Integrating Type Instrument

AC
- 1ϕ, EM ⇒ domestic
- 2ϕ, EM ⇒ Industrial

DC
- ampere hour meter

④ Null Deflection

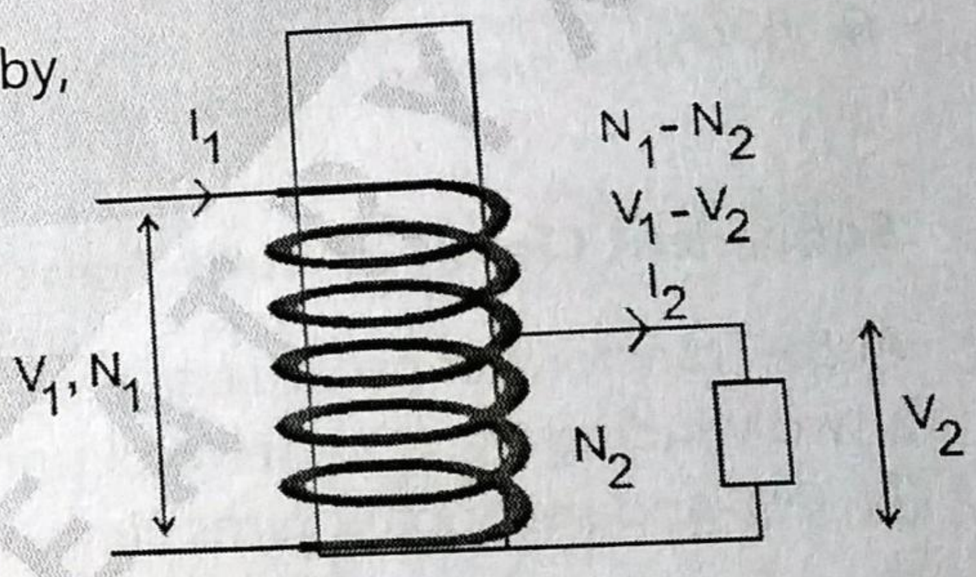
Ex Potentiometer
Galvanometer

Auto-Transformer

- It is used for Step-up and Step-down applications and here the primary and secondary windings are not isolated but rather some part of winding is common between the two. The schematic arrangement of windings of an auto-transformer is shown in the figure below,

The transformation ratio in an Auto Transformer is given by,

$$k = \frac{\text{Low Voltage}}{\text{High Voltage}}$$



In the schematic shown primary has N1 turns and Secondary has N2 turns and secondary turns are Common between primary and secondary windings.

Advantages of Auto Transformer over Two Winding Transformer

- Auto Transformer requires less volume of core material.
- No insulation is required between windings as the windings have common part.
- Size, weight and cost of Transformer are less due to common region in primary and secondary.
- Requires less volume of core and Cu-materials, so that iron and Cu loss are less, so efficiency is more.
- Auto Transformer has less leakage flux and leakage reactance as both windings are wound on same leg of transformer.

Comparison of Auto Transformer with Two Winding Transformer

The power in the uncommon part of the winding will be the power transferred through induction.

$(KVA)_{induction} = (V_1 - V_2)I_1$

$Input KVA = V_1 I_1$

$$\frac{(KVA)_{induction}}{(KVA)_{input}} = \frac{V_1 - V_2}{V_1} = 1 - \frac{V_2}{V_1} = \left(1 - \frac{LV}{HV}\right) = 1 - k$$

1. $(KVA)_{induction} = (1-k) \times input KVA$
2. $(KVA)_{conduction} = k \times input KVA$
3. $\left(\text{weight of copper}\right)_{Auto} = (1\text{-}k) \times (\text{weight of copper})_{2wdg}$
4. % full load losses in Auto Transformer = (1-k)× (% losses in 2 winding Transformer)
5. % voltage drop in Auto Transformer = (1-k)× (%voltage drop in 2winding Transformer)
6. $(KVA)_{Auto-Transformer} = \frac{1}{(1-k)}(KVA)_{2-winding}$