- Name-plate on transformer
↑
Rating of the transformer
↓

50 KVA, 2400/240 V, 50 Hz (1-ϕ transformer)

50 KVA ↑ Power output

2400/240 V → voltages of primary & secondary
↑
Depends on the purpose

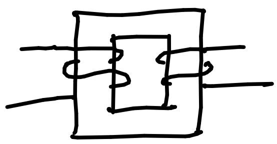
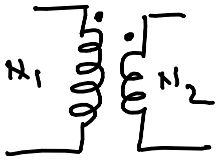
50 Hz ↑ operating frequency.

For step-down purpose
- primary 2400 V (to supply)
- Secondary 240 (out/ for load)

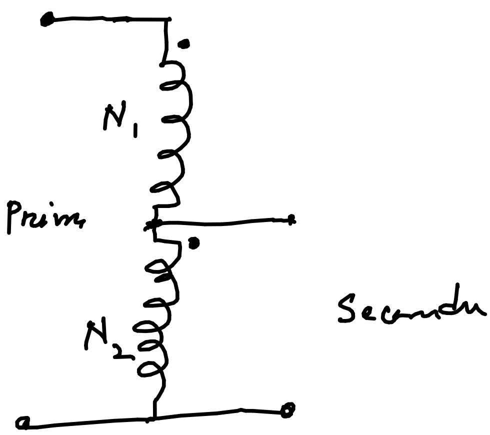
step-up purpose
- primary 240 V
- secondary 2400 V

The rated primary current $= \frac{50000}{2400} = 20.83\,A$

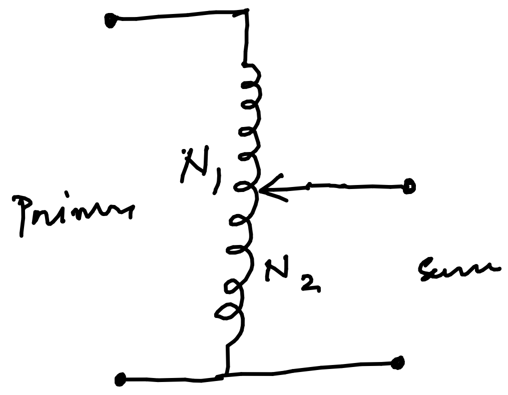
Secondary current $= \frac{50000}{240} = 208.3\,A$

- 
→


Two-winding transformer



Autotransformer



auto-transformer
or (variac)

- Regulate output voltage
- The difference between two-winding transformer & auto-transformer is that the windings in an auto-transformer are not electrically isolated.

- Some portion of the winding in auto-transformer is common to both primary & secondary.

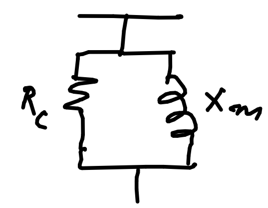
Transformer tests

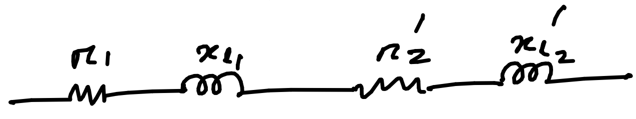
Open-circuit test

Short circuit test

to compute the various parameters of transformer

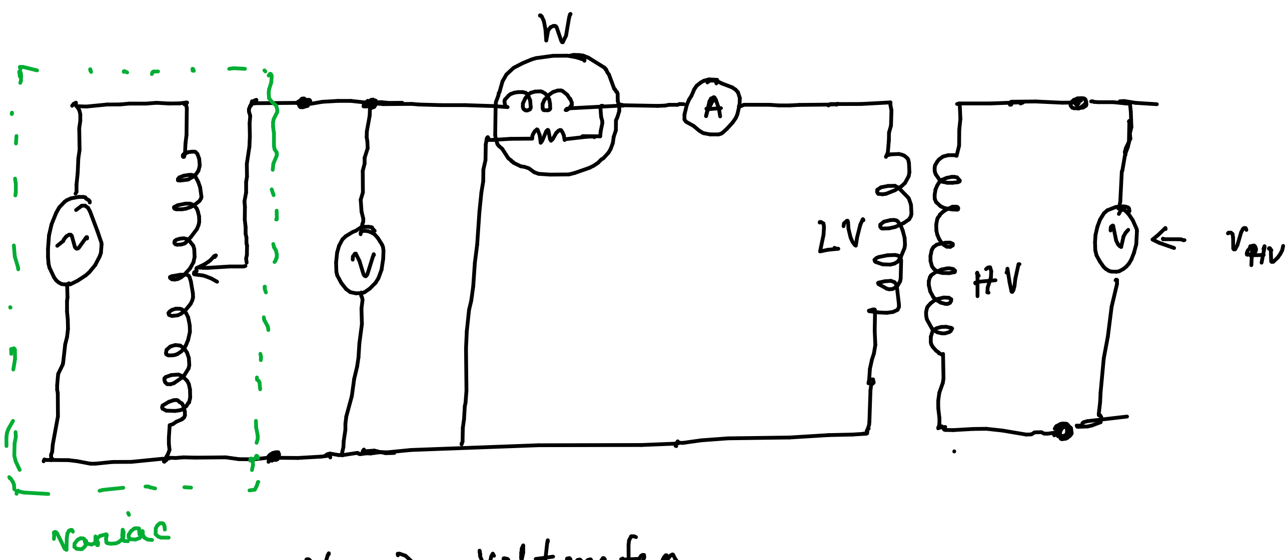
→ Core-loss





All these parameters can be computed.

- Open Circuit test (No-load test)

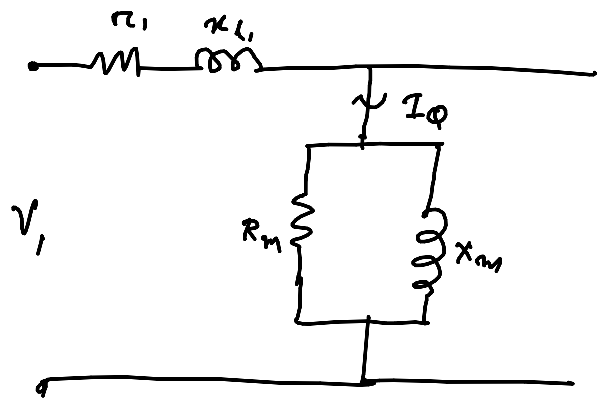


$V \rightarrow$ Voltmeter

$A \rightarrow$ Ammeter

$W \rightarrow$ Wattmeter

- Apply rated voltage to the LV (low voltage) side of transformer.



Only a small amount of current will flow in primary side just to establish flux in the core.

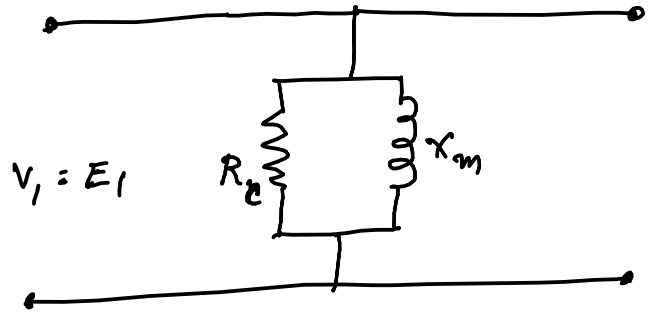
Since the current is very low

Neglect the drop in leakage impedance

$\Downarrow$

$V_1 = E_1$

The equivalent ckt



The measured quantities

- V_{oc} (voltmeter reading)
- I_{oc} (Ammeter reading)
- P_{oc} (Wattmeter reading)

$$Z_{oc} \approx \frac{R_c (jX_m)}{R_c + jX_m}$$

$$\boxed{R_c = \frac{V_{oc}^2}{P_{oc}}} \qquad \boxed{|Z_{oc}| = \frac{V_{oc}}{I_{oc}}}$$

$$|Z_{oc}| = \frac{|jR_c X_m|}{|R + jX_m|}$$

$$= \frac{R_c X_m}{\sqrt{R^2 + X_m^2}}$$

$$\Rightarrow \frac{1}{|Z_{oc}|^2} = \frac{R_c^2}{R_c^2 X_m^2} + \frac{X_m^2}{R_c^2 X_m^2} = \frac{1}{X_m^2} + \frac{1}{R_c^2}$$

$$\Rightarrow \frac{1}{X_m^2} = \frac{1}{|Z_{oc}|^2} - \frac{1}{R_c^2}$$

$$\boxed{\Rightarrow X_m = \frac{1}{\sqrt{1/|Z_{oc}|^2 - 1/R_{oc}^2}}}$$

$V_1 = E_1 \qquad E_2 = V_2$

From open circuit test

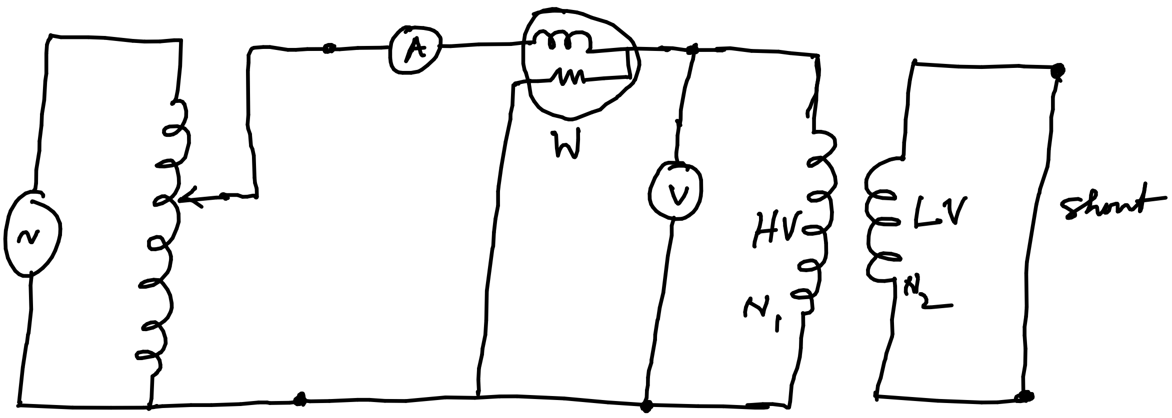
→ Core loss in transformer (by wattmeter reading)

→ The shunt branch parameters
(X_m & R_c in equivalent ckt)

→ $$\frac{E_1}{E_2} = \frac{\text{Voltmeter reading at LV side}}{\text{Voltmeter reading at HV side}} = \frac{N_1}{N_2}$$

50 kVA
220/220

- <u>Short circuit test</u>



- Apply a regulate voltage thr. variac s.t.
  the rated current in HV will flow.

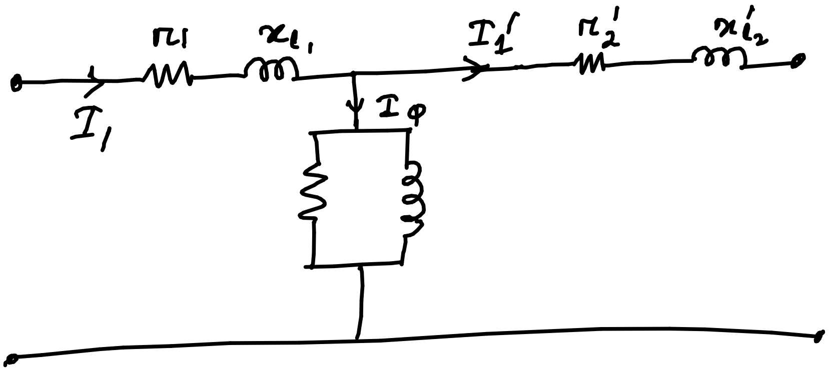
  ↓

  The mmf needs to be balanced.

  $$I_1' N_1 = I_2 N_2$$

  ⇓

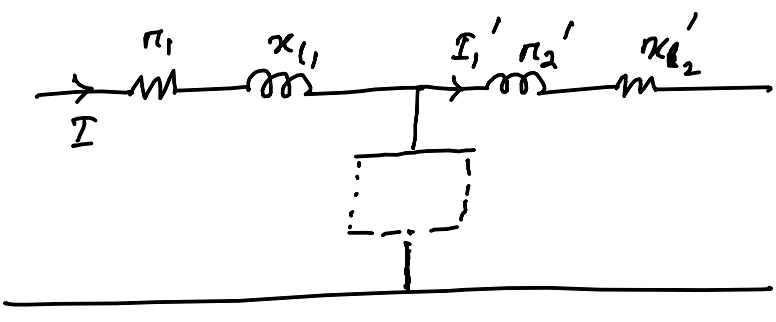
  The rated current will also flow in LV side.



- Since the secondary is short, the load component of primary current I_1' is very high in comparison the the magnetizing component of current I_φ

↓

Hence I_φ can be neglected from the equivalent ckt → $I_1 \cong I_1'$



$$Z_{sc} \approx \underbrace{r_1 + r_2'}_{R_{eq}} + j\,(\underbrace{x_{l_1} + x_{l_2}'}_{X_{eq}})$$

$$Z_{sc} = R_{eq} + j\,X_{eq}$$

Measured quantities :

- I_{sc} (Ameter reading)
- V_{sc} (Voltmeter reading)
- P_{sc} (Wattmeter reading)

$$\boxed{|Z_{sc}| = \frac{V_{sc}}{I_{sc}}} \qquad \boxed{R_{eq} = \frac{P_{sc}}{I_{sc}^2}}$$

$$\boxed{x_{eq} = \sqrt{|Z_{sc}|^2 - |R_{sc}|^2}}$$ (Since $Z_{sc} = R_{eq} + jx_{eq}$)

- For short - circuit tests

↳ $\left.\begin{aligned} R_{eq} &= R_1 + R_2' \\ x_{eq} &= x_1 + x_{e_2}' \end{aligned}\right\}$

↳ I^2R loss (Ohemic loss)

The reading of Wattmeter give Ohemic loss

- The open ckt test → Core - loss (in core)
- The short ckt test → Ohmic - loss (in the winding)

- The efficiency of transformer (in terms of percentage)

$$\eta = \left(\frac{P_{out}}{P_{input}}\right) \times 100$$

$$= \left(\frac{P_{input} - P_{Losses}}{P_{input}}\right) \times 100$$