Transformer
Transformer:

Machine to transform levels of voltage and current but not power or volt-ampere.
From amperes’s law:

\[ \phi_m = \frac{N_1 i_m}{\text{reluctance}} \]

- Core
- Winding

\( N_1 = \) no. of turns of the coil
\( i_m = \) current in the coil

Direction of flux given by right hand thumb rule
From Faraday's law:

\[ v_1 = e_1 = N_1 \frac{d\phi_m}{dt} \]

Magnitude of core flux is determined by the induced voltage and hence applied voltage in case of an ideal transformer.

For an ideal transformer, \( i_m = 0 \)
Voltage induced in winding 2

Ideal transformer: Recluctance of core material is zero

\[ v_1 = e_1 = N_1 \frac{d\phi_m}{dt} \]

\[ v_2 = e_2 = N_2 \frac{d\phi_m}{dt} \]

Polarity of induced voltage is given by Lenz’s law: “dotted” terminals gets ‘similar polarity

\[ \frac{v_1}{v_2} = \frac{e_1}{e_2} = \frac{N_1}{N_2} \]
v_1 being the applied voltage remains same, but

\[ e_1 = N_1 \frac{d(\phi_m - \phi_2)}{dt} \]

Therefore, \( e_1 < v_1 \)

Hence a current \( i_1 \) flows from v1 to “dot” terminal of winding 1.
Flow of current \( i_1 \) in N_1 sets a flux \( \phi_1 \) in the core
Ideal Transformer on load

Steady state will reach when, $\phi_1 = \phi_2$

Therefore at steady state

$N_1 i_1 = N_2 i_2$

$\frac{i_1}{i_2} = \frac{N_2}{N_1}$
Ideal Transformer on load

Therefore,

\[
\frac{v_1}{v_2} = \frac{e_1}{e_2} = \frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{i_1}{i_2}
\]

Volt-amperes at both the sides are same

\[
v_1 i_1 = v_2 i_2 \quad \text{and} \quad e_1 i_1 = e_2 i_2
\]
Ideal Transformer on load

\[ i_1 = 0 \]

\[ Z = \frac{v_2}{i_2} = \frac{e_2}{i_2} \]

Impedance seen by winding-1,

Impedance seen by winding-2,

\[ Z' = i_1 = \frac{v_1}{\frac{N_1}{N_2}} \]

\[ = \left( \frac{N_1}{N_2} \right)^2 \frac{v_2}{i_2} = \left( \frac{N_1}{N_2} \right)^2 Z \]