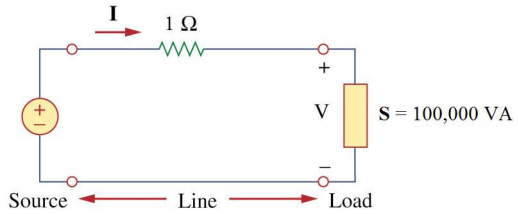
Lesson 25: Transformers

Transmission of power

Consider the problem of transmitting 100,000 VA over a power line with resistance R=1 Ω using either a line voltage of 1,000 or 100,000 V_{rms}.

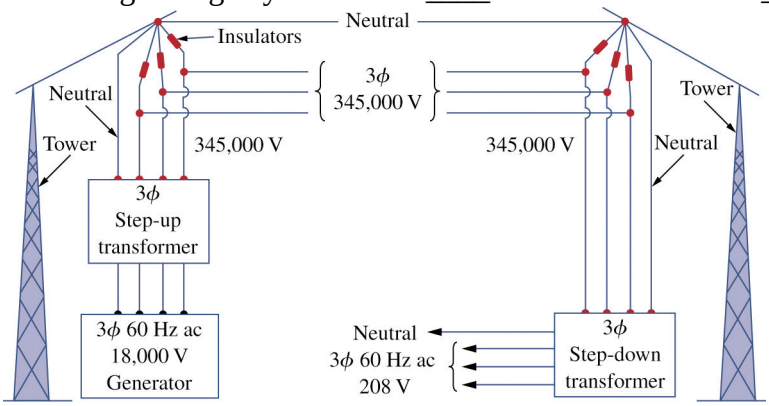
Which results in less power loss in the line?



Efficient transmission of power requires minimizing losses suffered during transit.

Line voltage (V)	Line current (I)	Loss on power lines
1,000 V		P_{loss}=
10,000 V		P_{loss}=

Increasing voltage by a factor of ____ results in a factor of ____ reduction in power loss.

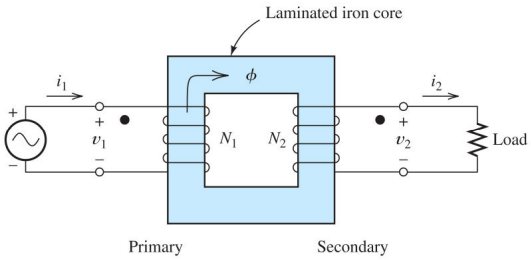


Transformation of voltage

What makes is possible to efficiently convert 345,000 V down to 208 V?
Is this possible using DC?

Transformers

A transformer consists of two or more windings coupled by mutual _____ ϕ.
Alternating current (i_1, i_2) result in a time-varying magnetic flux ϕ.
According to Faraday's law, a time-varying magnetic flux results in a _____ given



$$v_1 = N_1 \frac{d\phi}{dt}$$

$$v_2 = N_2 \frac{d\phi}{dt}$$

Ideal transformer

For an ideal transformer, we assume

- All of the _____ is contained in the core.
- No _____ in the transformer.

Given that the flux is the identical in both windings, we can see that

If $v_1 = N_1 \frac{d\phi}{dt}$ and $v_2 = N_2 \frac{d\phi}{dt}$,

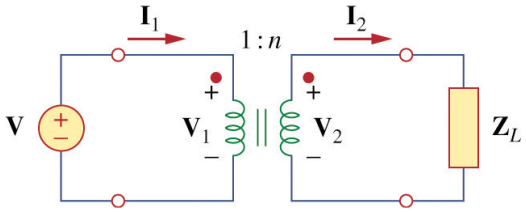
then $\frac{v_2}{v_1} = \frac{\mathbf{V}_2}{\mathbf{V}_1} =$

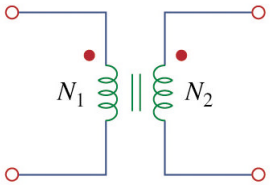
where n is the _____.

Turns ratio *n*

The turns ratio or transformation ratio of the number of _____ N_2 to N_1, and thus the voltages V_2 to V_1.

$$\frac{\mathbf{V}_2}{\mathbf{V}_1} = \frac{N_2}{N_1} = n$$





Transformer currents

Given that an ideal transformer has no power losses, $v_1 i_1 = v_2 i_2$, thus $\frac{\mathbf{I}_2}{\mathbf{I}_1} =$

Transformer categories

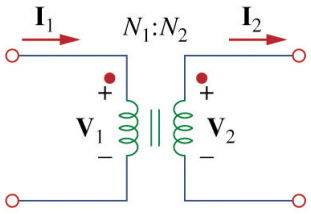
The turns ratio determines the transformer type

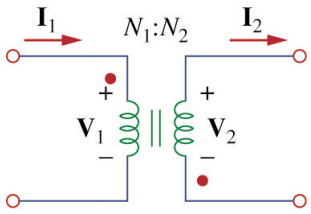
- When n = 1, the transformer is generally called an _____ transformer.
- When n > 1, we have a _____ transformer.
- When n < 1, we have a _____ transformer.

Transforms are usually specified as V_1/V_2 (rms) for example 2400/120 V.

Transformer polarities

The polarity of transformer currents and voltages are determined the dot indicated on the coils.





Complex power

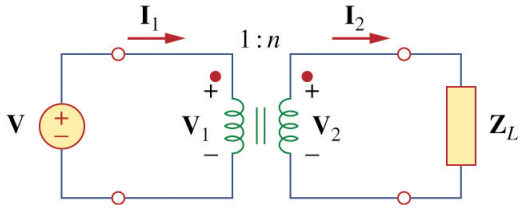
Applying conservation of power, the complex power delivered to the primary winding must also be delivered to the secondary.

$$\mathbf{S}_1 = \mathbf{V}_1\mathbf{I}_1^* =$$

Reflected impedance

The input impedance is also called the _____ impedance and is often used in impedance matching.

$\mathbf{Z}_{in} =$



Example Problem 1

An ideal transformer is rated at 2400/120 V, 9.6 kVA and has 50 turns on the secondary side. Calculate

a. the turns ratio

b. the number of turns on the primary side

c. the current ratings for the primary and secondary windings

Example Problem 2

For the ideal transformer below find

a. the source current I_1
b. the output voltage V_o
c. the complex power supplied by the source