FE REVIEW

TRANSFORMERS

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The Ideal Transformer

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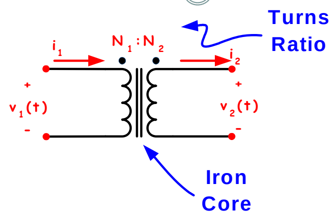

Note:
Power in the primary
Is equal to the power
In the secondary.

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The Ideal Transformer

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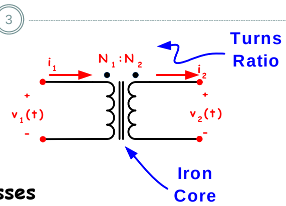
$$voltage \Rightarrow \frac{v_2}{v_1} = \frac{N_2}{N_1}$$

$$current \Rightarrow \frac{i_2}{i_1} = \frac{N_1}{N_2}$$



Used to reduce I^2*R losses

Power is conserved

If Voltage is stepped up ⇔ Current steps down

If Voltage is stepped down ⇔ Current steps up

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Turns Ratio

In these notes the primary and the secondary are quite often obscured by using the **N1** and **N2** variables for the identification of **primary** and **secondary**. **This is because normally, a transformer can be reversed such that what was the primary is now the secondary and vice versa.**

Turns Ratio

While this has its uses, note that when a transformers "Turns Ratio" is identified, it is with the mindset of one set of coils always being the Primary side. So, we need to define the term "Turns Ratio" mathematically as:

$$Turns\ \ Ratio = a = \frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

Reflecting Resistance into Primary

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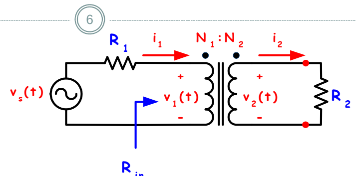

We know $\frac{v_2}{v_1} = \frac{N_2}{N_1}$ **and** $\frac{i_2}{i_1} = \frac{N_1}{N_2}$

Since $R_{in} = \frac{V_1}{i_1}$ **we work some math magic**

and we get: $R_{in} = \left(\frac{N_1}{N_2}\right)^2 R_2$

Example continued on the next slide.

Impedance Reflection Example

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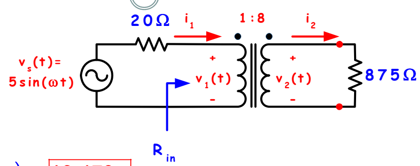

$$R_{in} = \left(\frac{1}{8}\right)^2 (875\Omega) = \boxed{13.672\Omega}$$

$$v_1 = \frac{v_s R_{in}}{R_{in} + 20\Omega} = \frac{(5\sin\omega t)\,13.672\Omega}{13.672\Omega + 20\Omega} = \boxed{2.03\sin\omega t}$$

$$i_1 = \frac{v_1}{R_{in}} = \frac{2.03\sin\omega t}{13.672\Omega} = \boxed{148.491\text{mA}\sin\omega t}$$

Impedance Reflection Example

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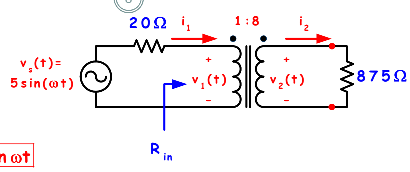

$$R_{in} = \boxed{13.672\Omega}$$

$$v_1 = \boxed{2.03\sin\omega t}$$

$$i_1 = \boxed{148.491\text{mA}\sin\omega t}$$

Remember that $v_2/v_1 = N_2/N_1$ so $v_2 = \frac{N_2(v_1)}{N_1} = \frac{8(v_1)}{1}$

$$v_2 = 8v_1 = 8(2.03\sin\omega t) = \boxed{16.24\sin\omega t}$$

$$i_2 = \frac{v_2}{R_2} = \frac{16.24\sin\omega t}{875\Omega} = \boxed{18.56\text{mA}\sin\omega t}$$

Impedance Matching

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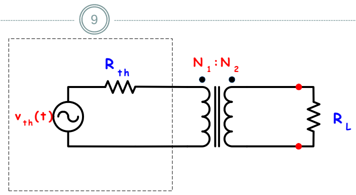

$$\left(\frac{N_1}{N_2}\right)^2 R_L = R_{th}$$

$$\frac{N_1}{N_2} = \sqrt{\frac{R_{th}}{R_L}}$$

Example

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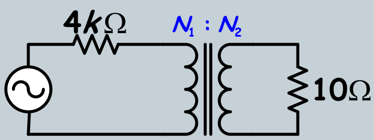
What is the required turns ratio for maximum power transfer in the circuit below?

a) 1:20
b) 1:40
c) 20:1
d) 40:1



Example continued on the next slide.

Example (continued)

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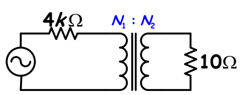
In order to have maximum power transfer, it is necessary to have the value which the load reflects into the primary to be equal to **R Thevenin**. In this case, that would be **4k ohms**.



$$4k\Omega = \left(\frac{N_1}{N_2}\right)^2 (10\Omega)$$

$$\frac{N_1}{N_2} = \sqrt{400} = 20$$

$$Ans = (C) = 20 : 1$$

Example

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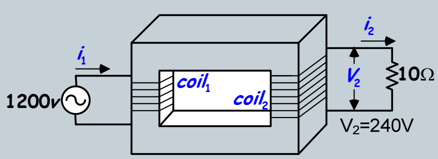
In the transformer below with the indicated voltages, if coil 1 has **500 turns**, **how many turns does coil 2 have?**



Example continued on the next slide.

Example (continued)

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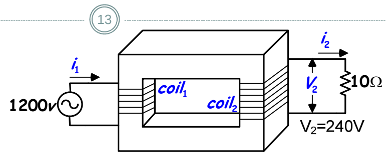

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

$$\frac{240}{1200} = \frac{N_2}{500}$$

$$N_2 = \frac{240(500)}{1200} = 100 \text{ turns}$$

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Example

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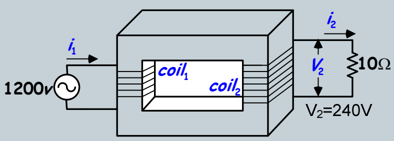
If the turns ratio of the transformer is **5**, what is **the current thru Coil 1**?



Example continued on the next slide.

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Example (continued)

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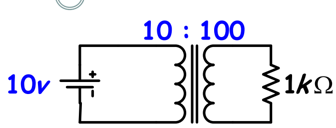
What is the value of the power dissipated by the 1k ohm resistor?



Since a transformer does not pass DC, there is 0 watts Of power dissipated in the secondary.

ALMOST ALWAYS ON TEST IN SOME FORM

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Example

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A step-down transformer consists of 200 primary turns and 40 secondary turns. The primary voltage is 550v. If the load is 4.2 ohms, find the secondary voltage, the primary current, and the secondary current.

Example continued on the next slide.

Example

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$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow V_s = \frac{40}{200}(550v) = \boxed{110V}$$

$$R_{reflected} = \left(\frac{N_p}{N_s}\right)^2 4.2\Omega = \left(\frac{200}{40}\right)^2 4.2\Omega$$

$$= 25(4.2\Omega) = 105\Omega$$

$$I_p = \frac{550v}{105\Omega} = \boxed{5.238A}$$

$$I_s = \frac{V_s}{R_L} = \frac{110v}{4.2\Omega} = \boxed{26.19A}$$