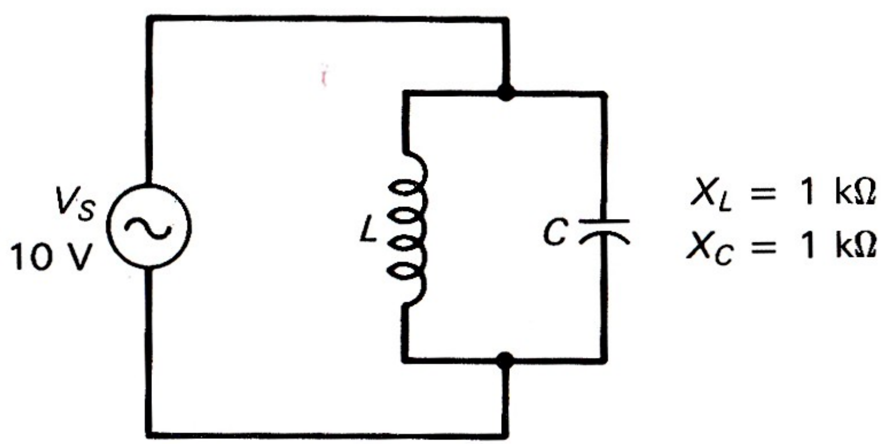
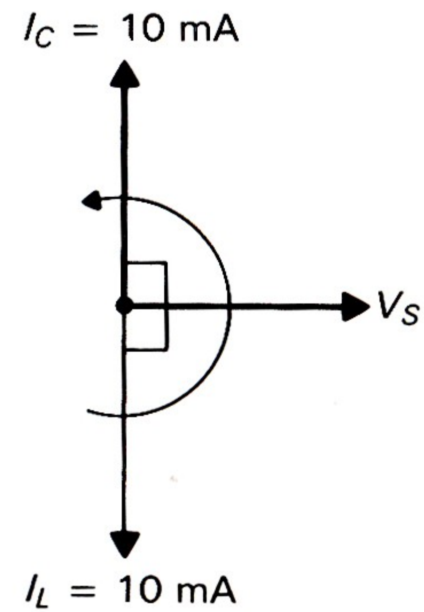
The New England Radio Discussion Society's "Electronics for Amateur Radio operators" course

"Getting down to nuts and volts"

Phase Two, PPT5
November 2016

Quick review: L and C in parallel



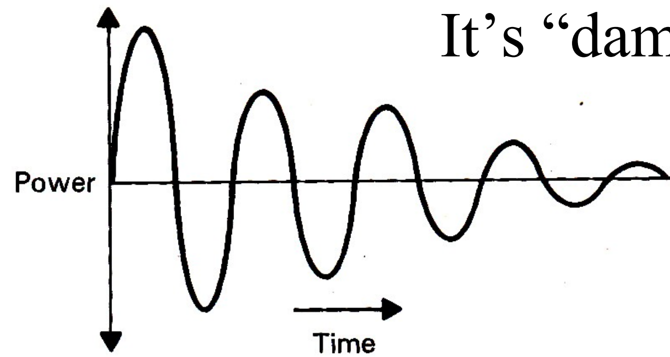


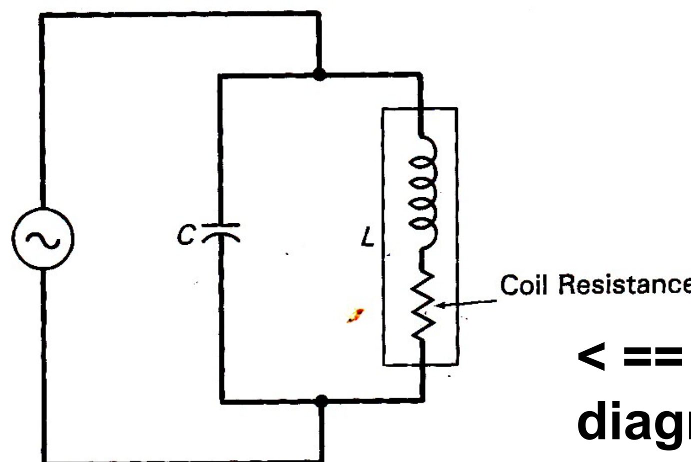
REVIEW: DC resistance is in the coil windings.

That R causes power to be dissipated.

For its part, the capacitor has *almost* no loss.

It's "damped"





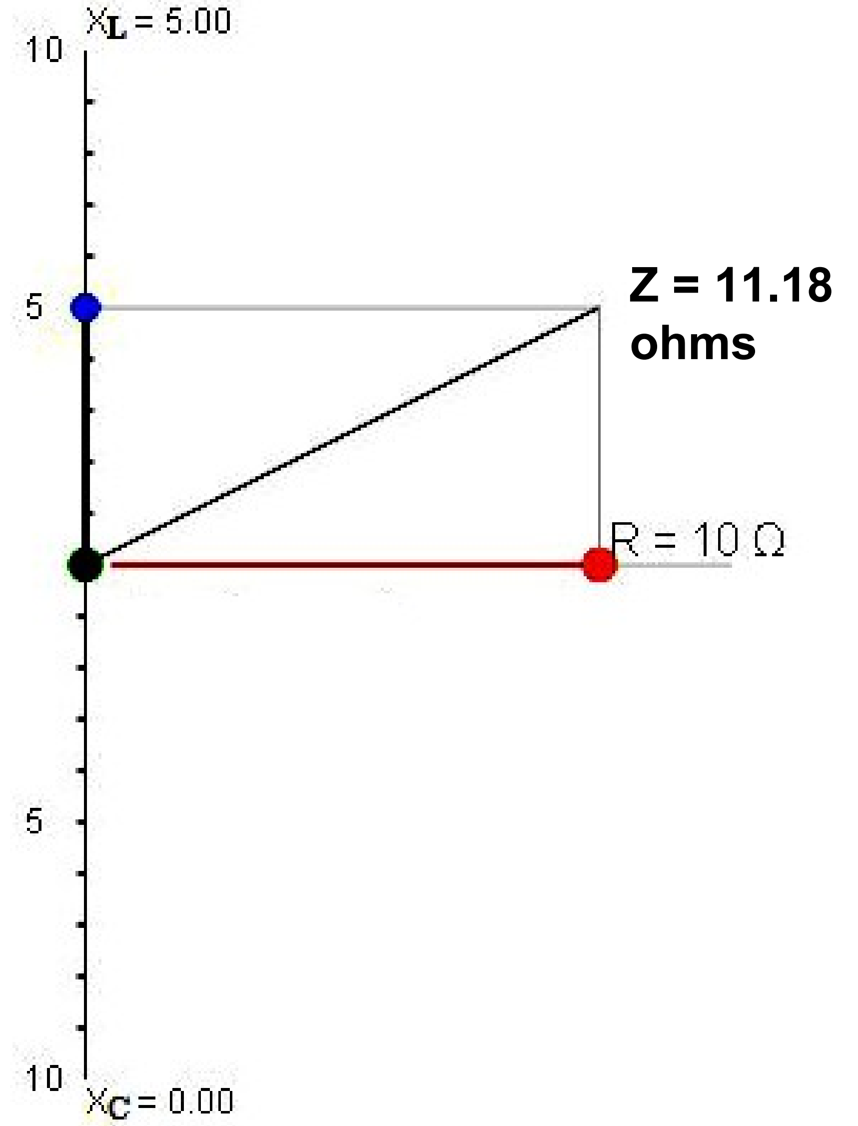
< == Equivalent diagram for the inductor

REVIEW: ***Impedance*** **(Z) is the** ***vector sum*** **of R and** ***reactance*** **(X), derived from the Pythagorean theorem.**

$$C = \sqrt{A^2 + B^2}$$

$$\text{Impedance, } Z = \sqrt{R^2 + X^2}$$

REVIEW: The vector diagram



REVIEW: The cosine of theta is *power factor*, which indicates dissipated power.

The COS of zero is 1.

The COS of 90 is zero!

In our AC circuits, the power factor is the ratio of the real power that's used to do work, and the *apparent power* that's supplied to a circuit.

When all the power is reactive power with no real power the power factor is 0.

When all the power is real power with no reactive power the power factor is 1.

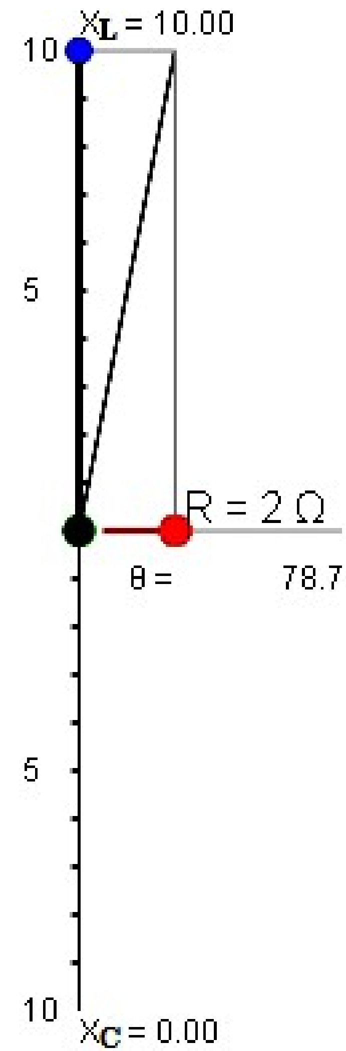
REVIEW:

X_L is 10 ohms, and the coil's internal resistance is 2 ohms.

The resultant, Z, is 10.2 ohms of impedance.

The angle is almost 79 degrees. The cosine of theta approaches zero, indicating that there's little power, or heat or light energy, dissipated in this highly inductive circuit.

Z = 10.2 ohms

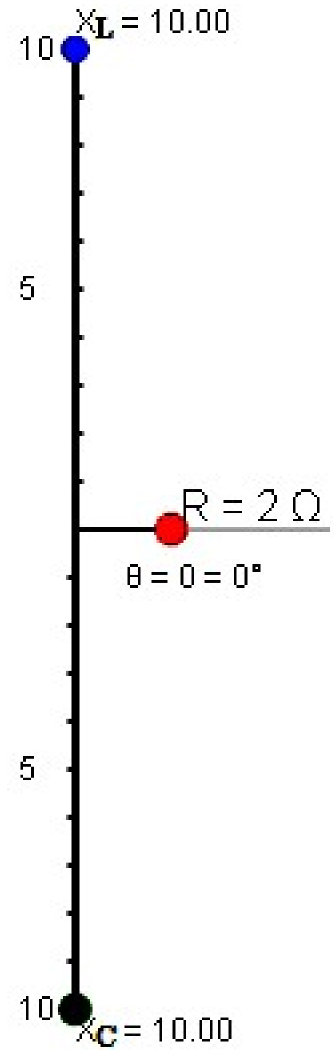


REVIEW: This is an LC circuit.

X_C is equal and opposite to its inductive reactance X_L. Both are 10 ohms.

The 10-ohm reactances cancel, as they're equal and opposite, the current and voltage is in phase, and the resultant, Z, is comprised of resistance only.

The power factor is the cosine of theta, or 1. The circuit dissipates power in the resistive portion only.

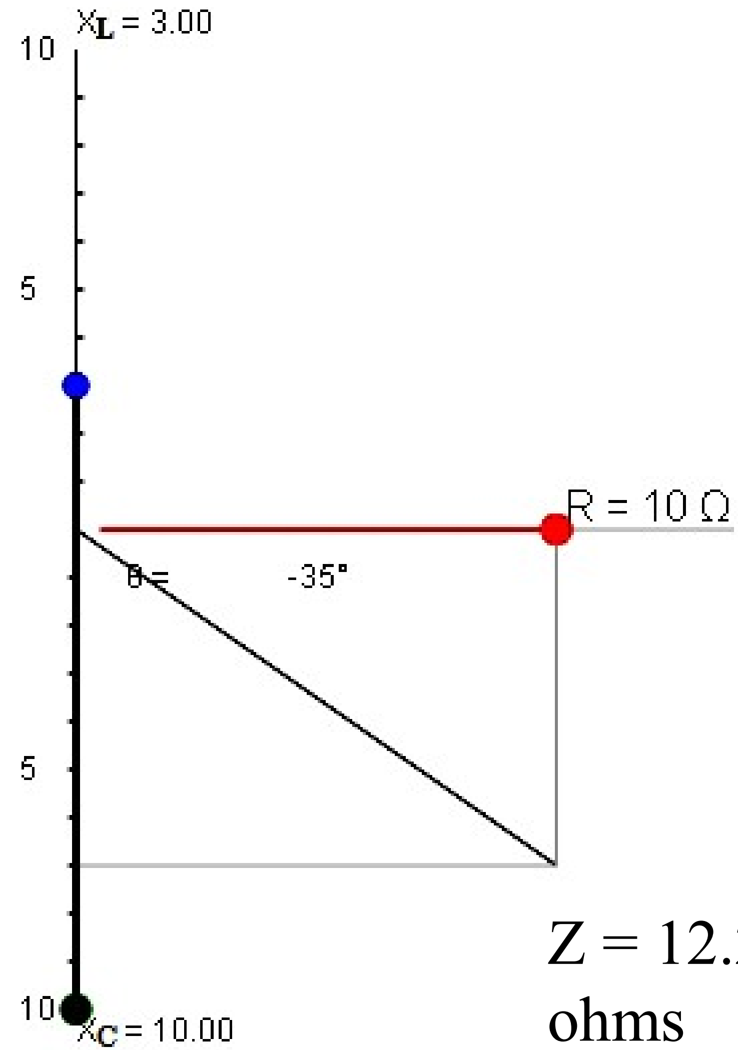


REVIEW:

Here X_C is greater than X_L. X_C is 10 ohms and X_L is 3 ohms.

The capacitive circuit exhibits 12.21 ohms of impedance, and the impedance (Z) is capacitive.

The power factor, PF, is 0.81, which is substantial, due to R.

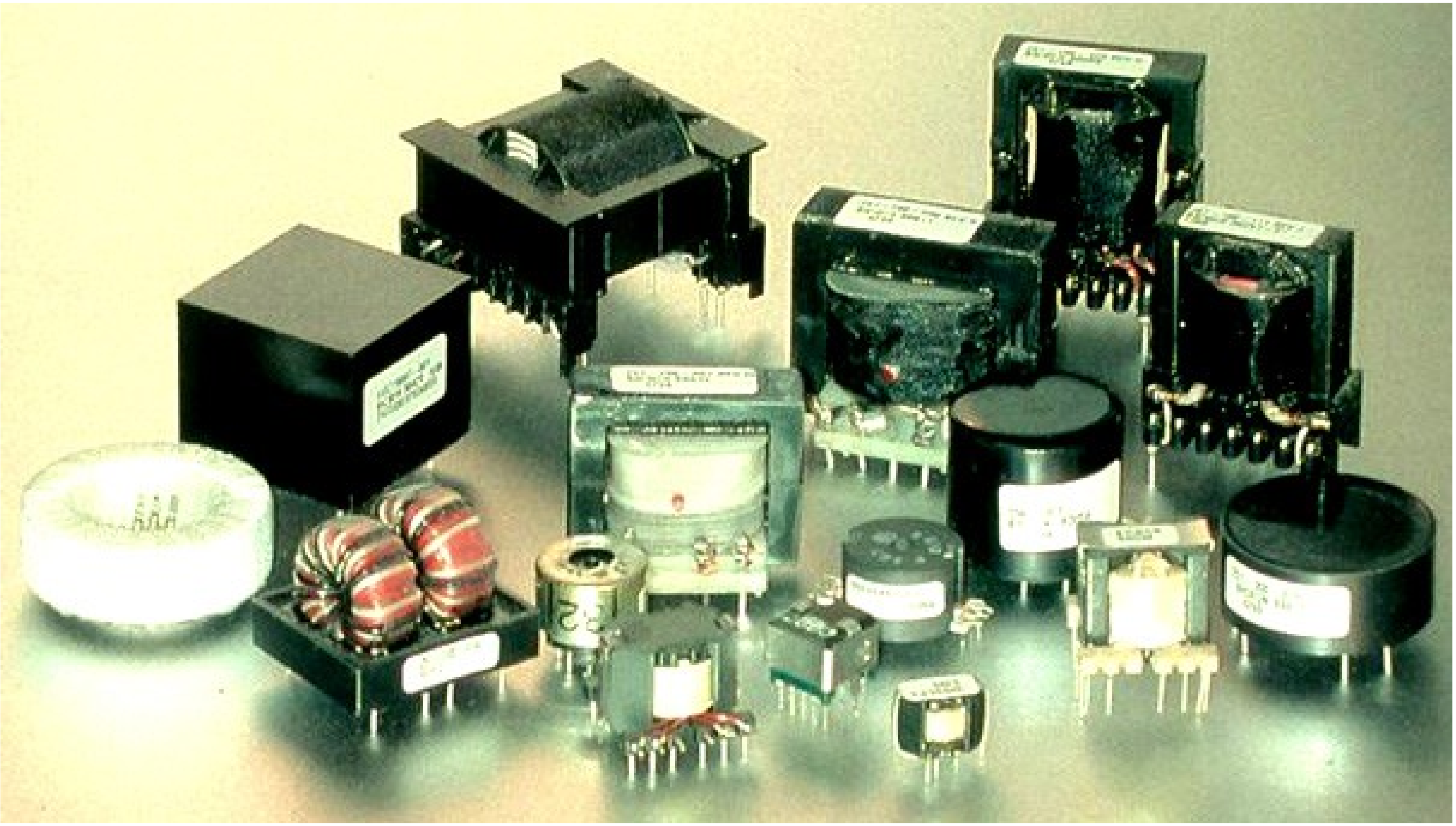


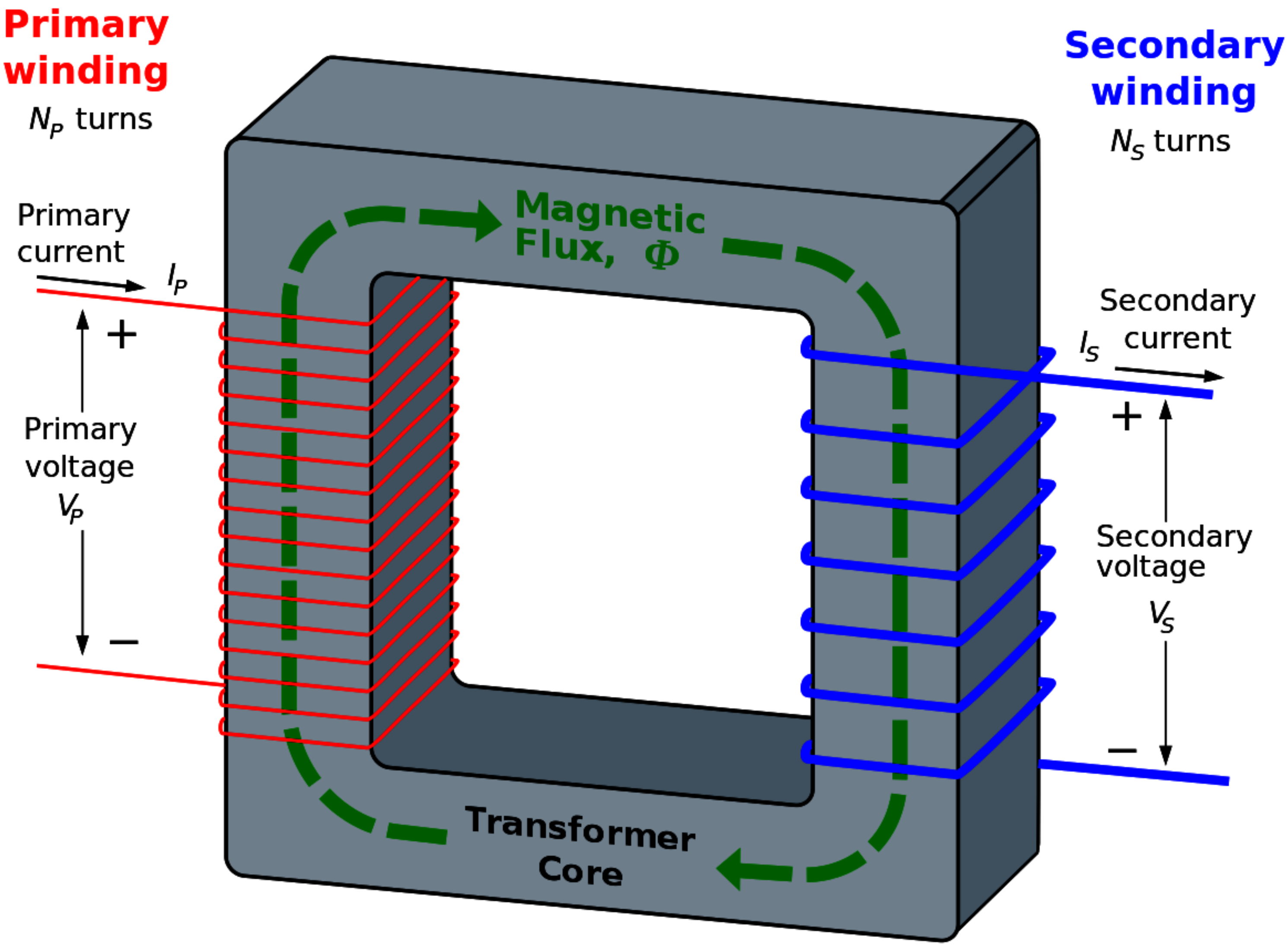
Z = 12.21 ohms

Transformers?

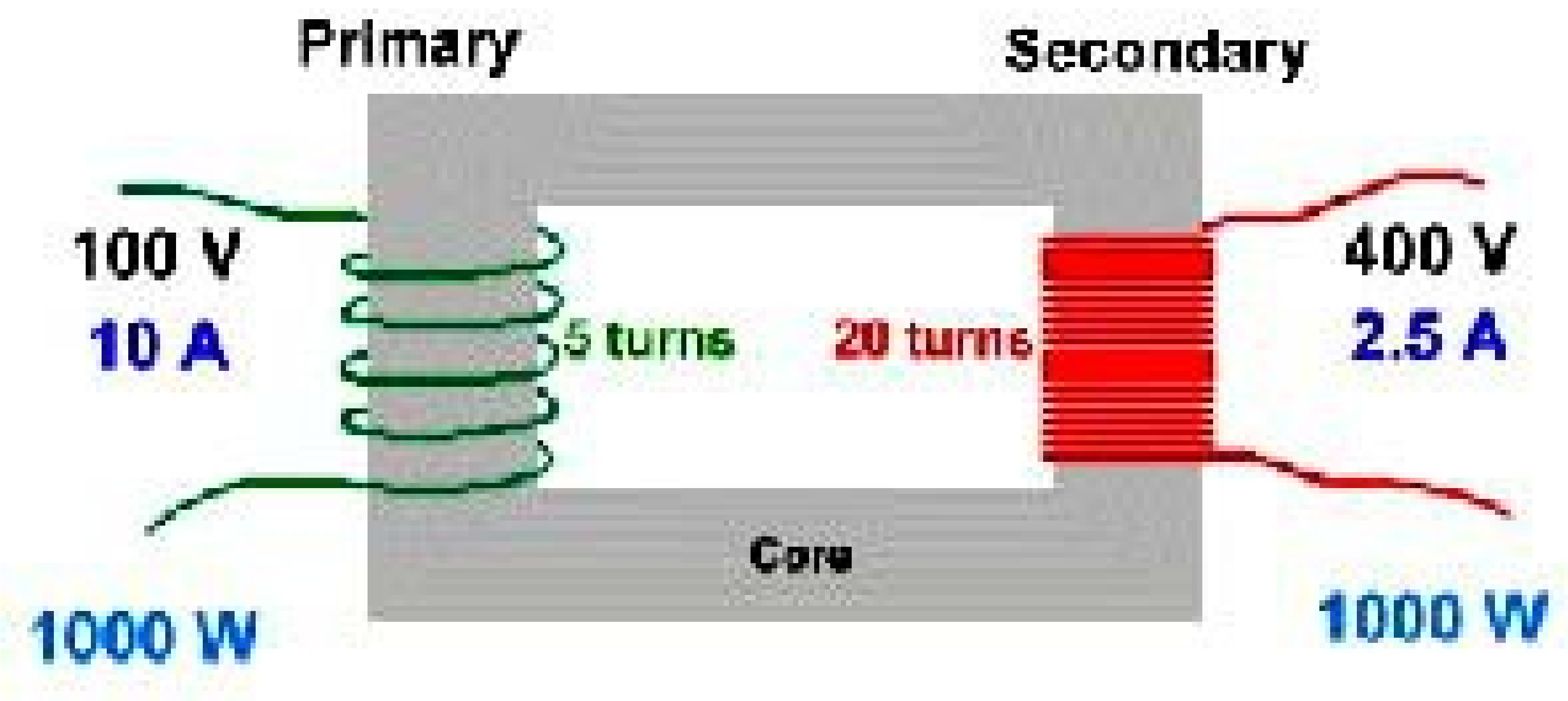
No!

Transformers?
Yes!



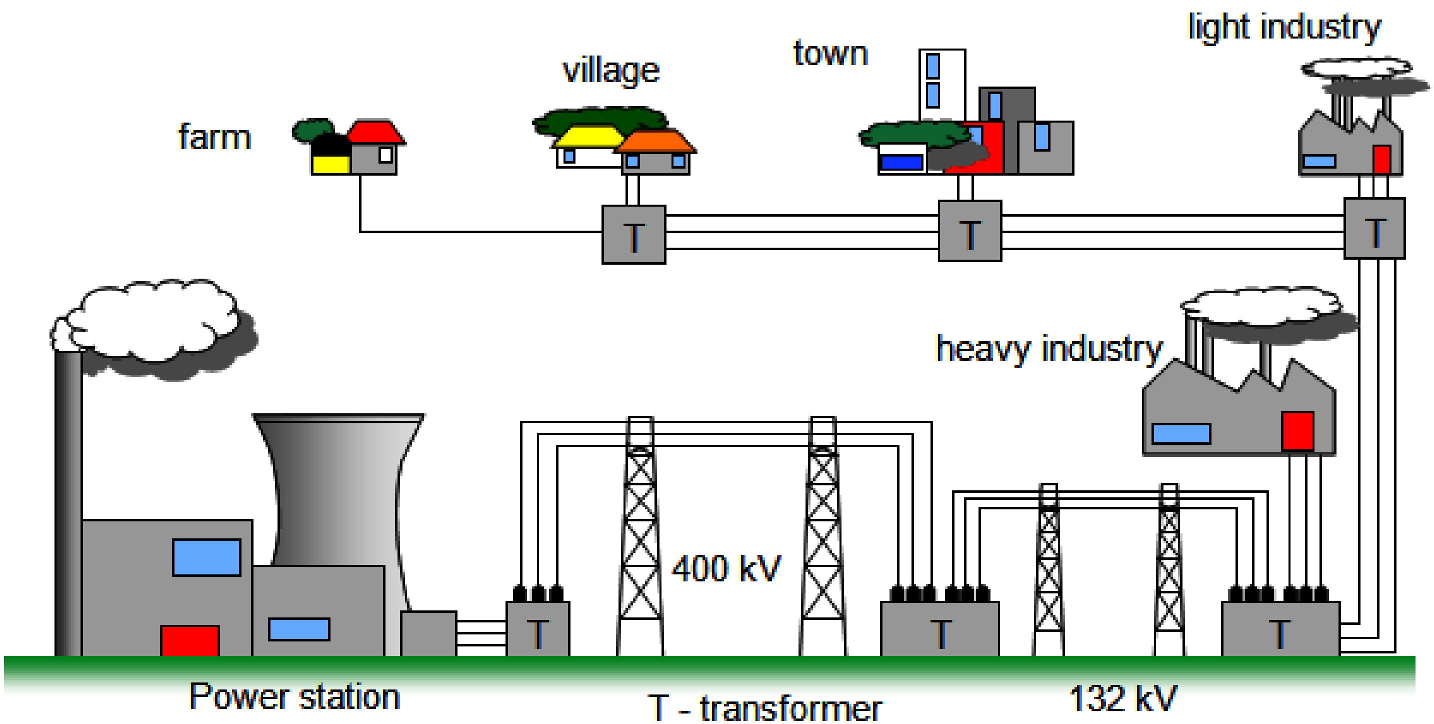

Primary winding
N_P turns
Secondary winding
N_S turns
Primary current
I_P
Magnetic Flux, Φ
+
Primary voltage
V_P
−
Secondary current
I_S
+
Secondary voltage
V_S
−
Transformer Core

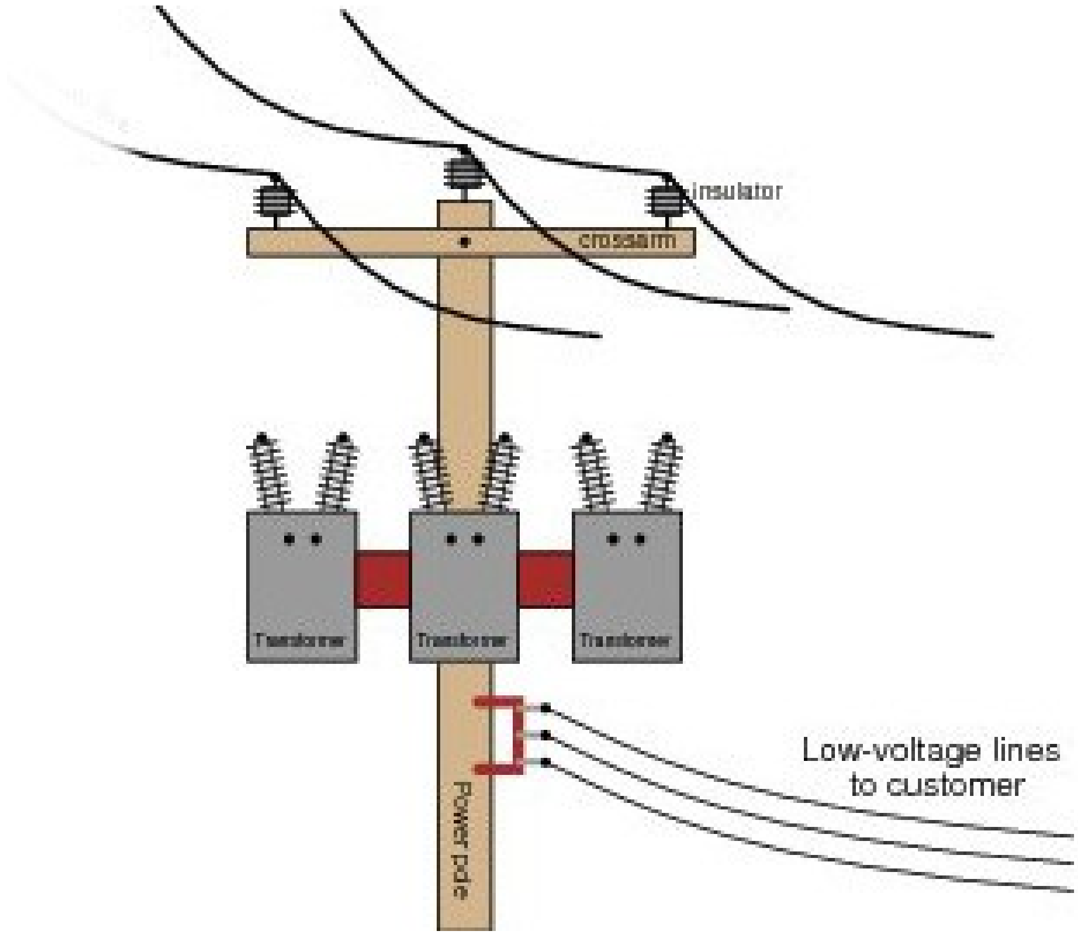
This is a “step-up” transformer (XFMR). If the primary and secondary windings were used in reverse, it could be considered a “step-down” transformer.



Transformers are used in AC circuits to step-up and to step-down voltages.

In this example the power station delivers 400,000 volts for long distance transmission, which is later stepped down to 132 kV and to 220V.





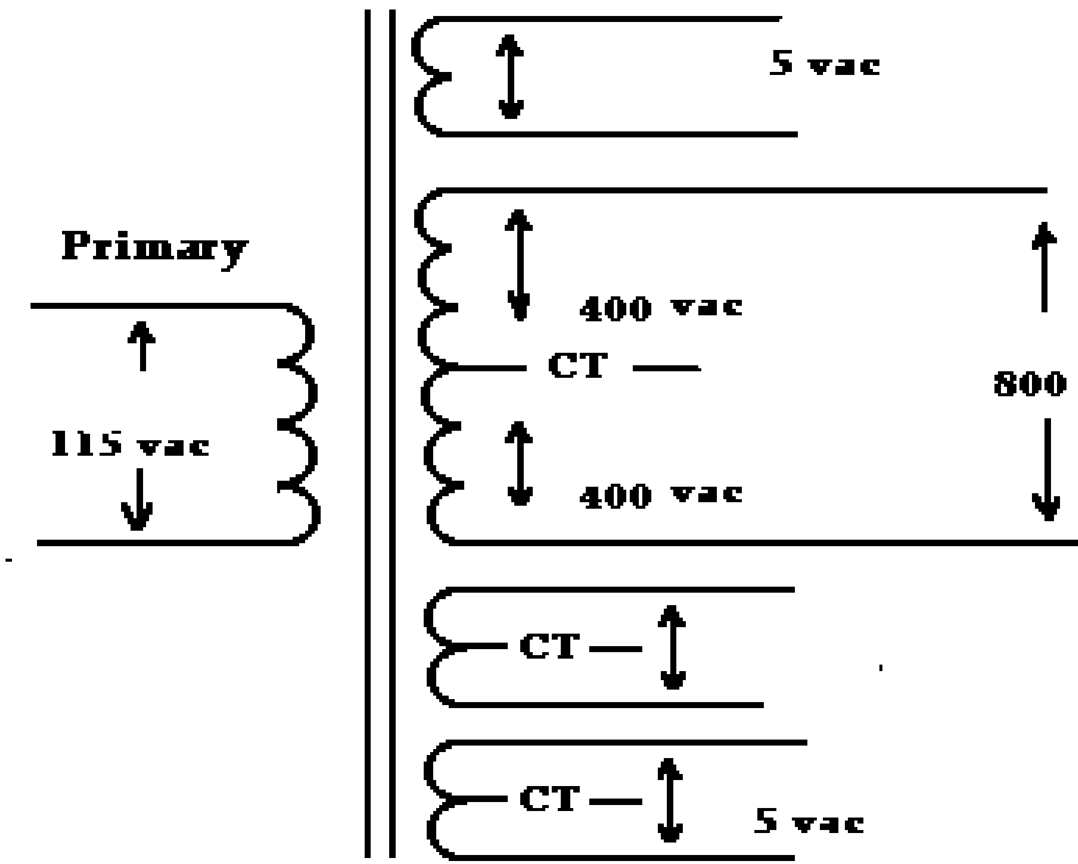
Step-down transformers are used on power poles near your QTH.

They're sometimes called *pole pigs*.

Hams have actually used these as power transformers in big RF amplifier power supplies.

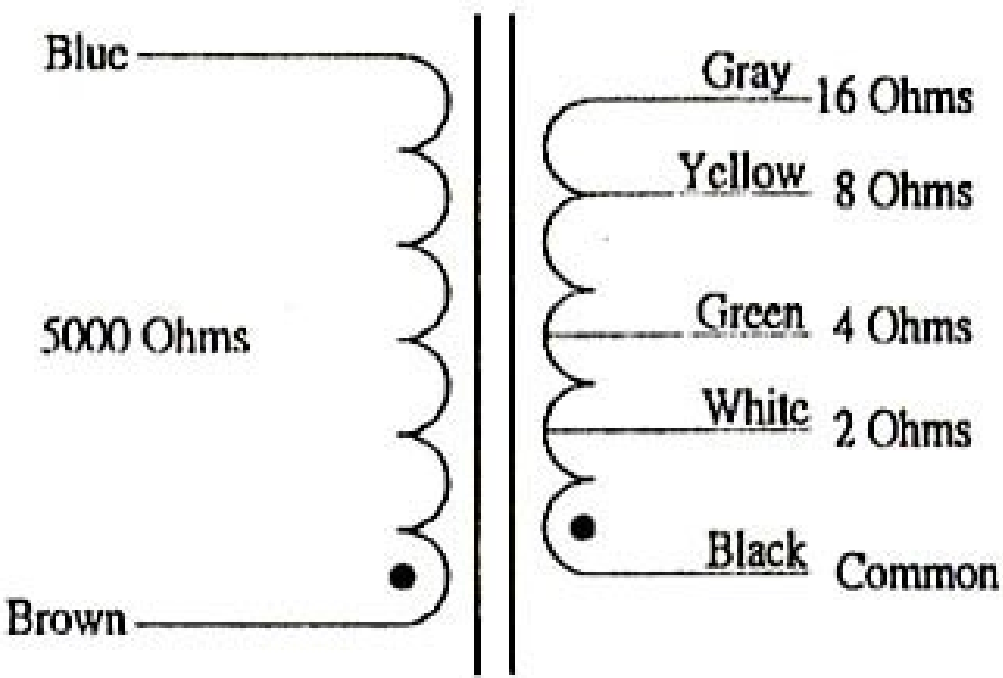
< == *Danger!*

This typical xfmr schematic, used in a ham radio transmitter, has four secondary windings. Three are center-tapped.



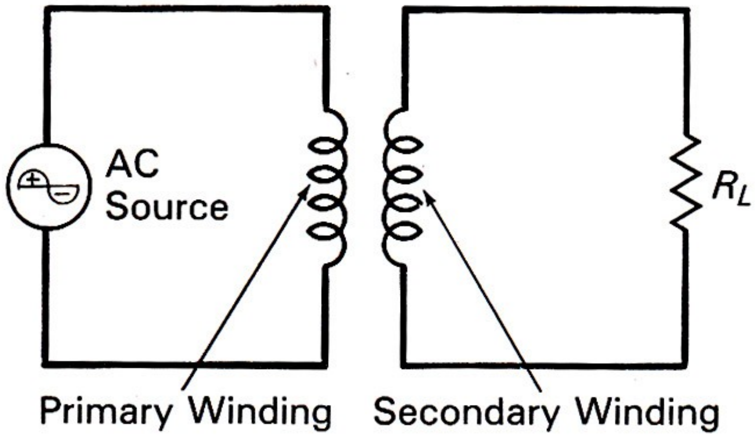
Transformers can also be used to match impedance.

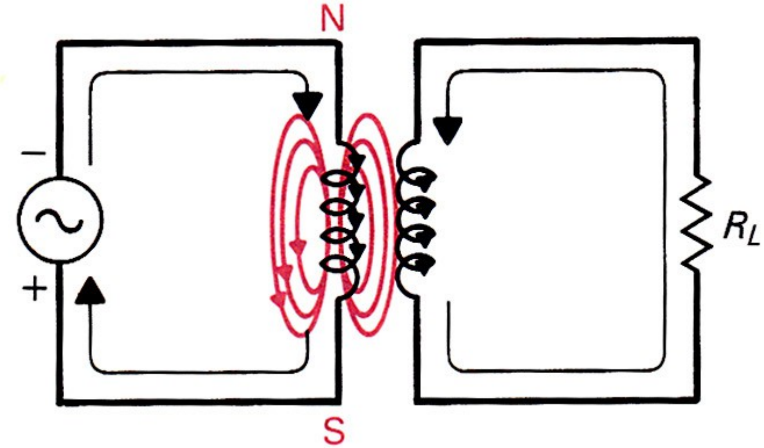
This transformer schematic matches an audio amplifier to a variety of loudspeaker impedances.

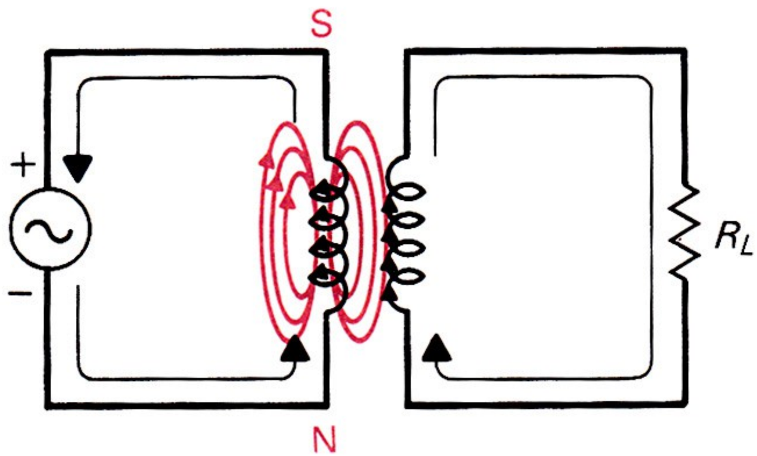


Transformers work on the principle of *mutual induction*.

Simply put, if the current in a primary changes, the magnetic flux in the core changes, and the flux that's linked to the secondary changes.







The AC current in the primary sets up an AC current in the secondary load. The *turns ratio* is the ratio between the number of turns in the primary and the number in the secondary.

The ratio of the secondary voltage to the primary voltage is equal to the *turns ratio*.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Then multiply both sides by V_p .....

The re-arranged equation lets you determine the secondary voltage if you know the primary voltage and the turns ratio.

$$V_s = \frac{N_s}{N_p} \times V_p$$

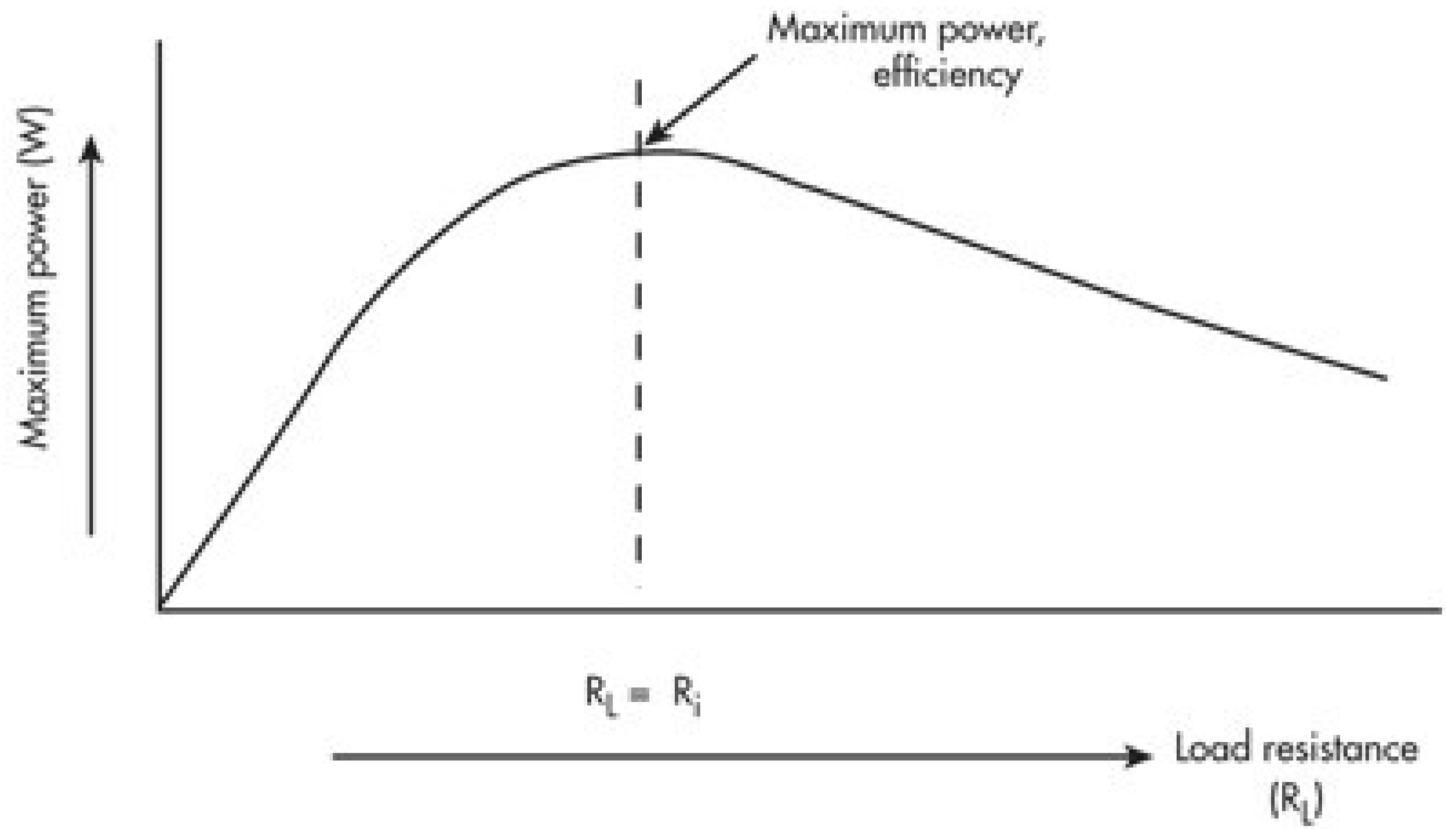
The turns ratio also relates to impedance.

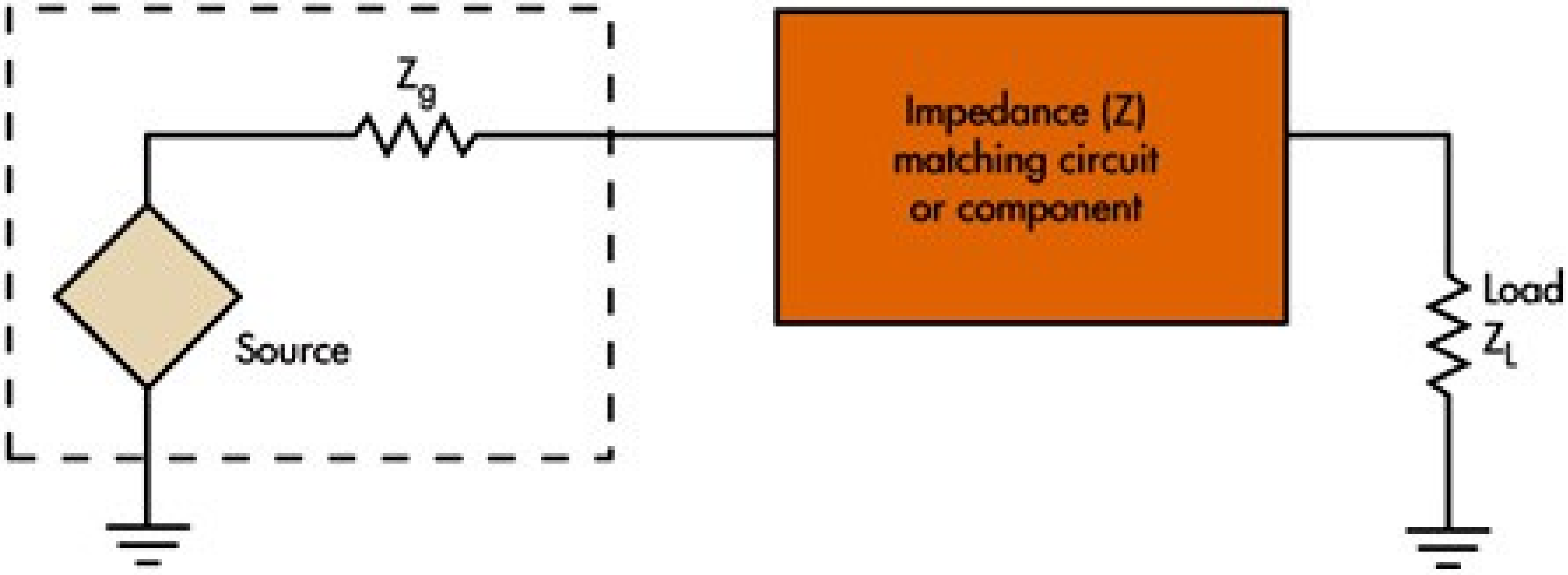
Impedance matching **is a prime function of many transformers.**

$$\text{turns ratio} = \sqrt{\frac{Z_L}{Z_S}}$$

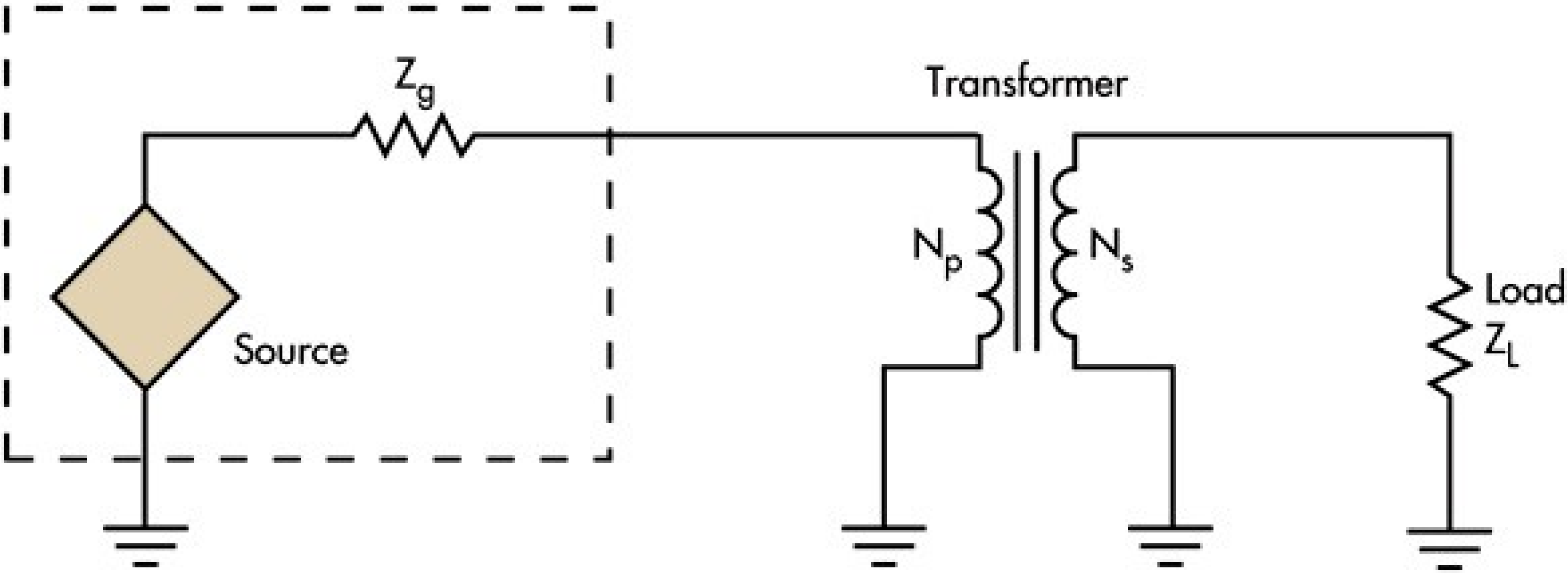
so, $(N_p/N_s)^2 = Z \text{ ratio}$

We know impedance matching is used to match amplifiers to loudspeakers, microphones to rigs, rigs to antennas, etc.





Maximum power transfer occurs when the load is matched to the source.

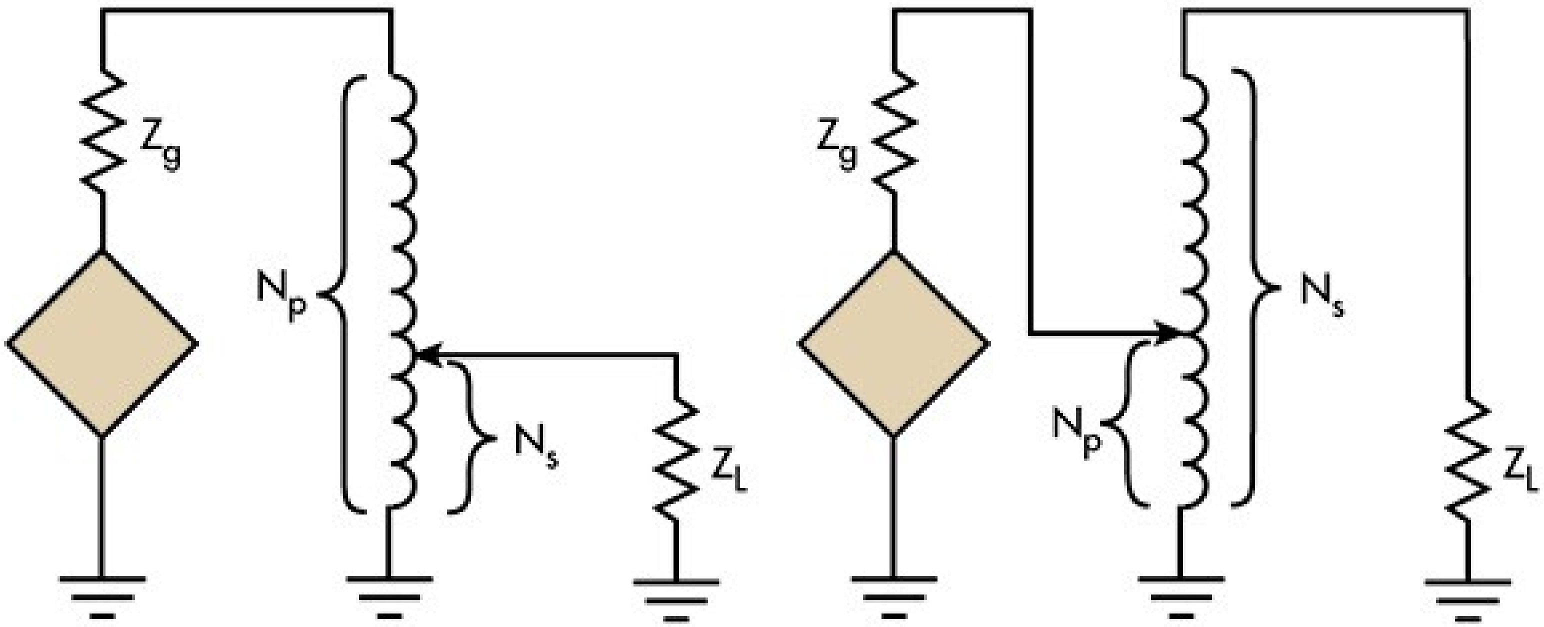


$$Z_s/Z_p = (N_s/N_p)2$$

or:

$$N_s/N_p = \sqrt{(Z_s/Z_p)}$$

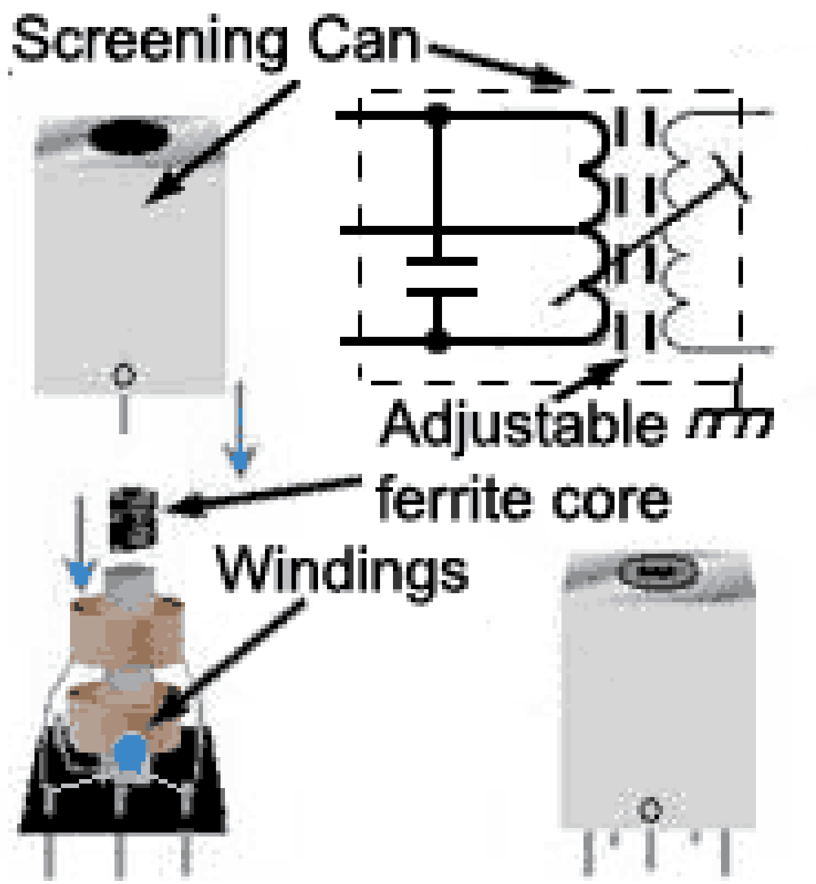
Enter the auto-transformer!



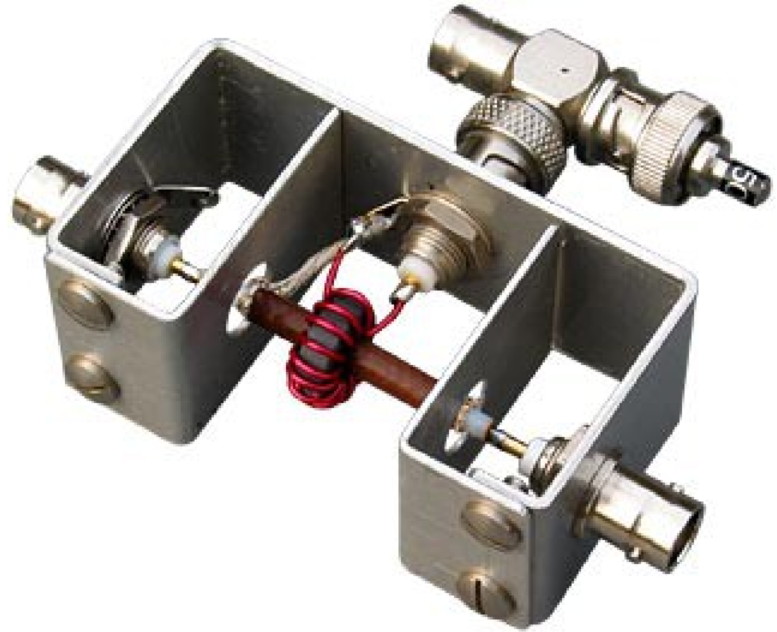
Auto-transformers are also be used to step-up or step-down voltages.

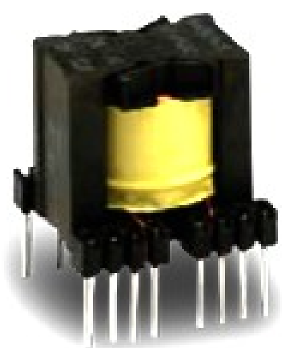
Trade names for auto-transformers have become generic, i.e. variacs, powerstats, etc.

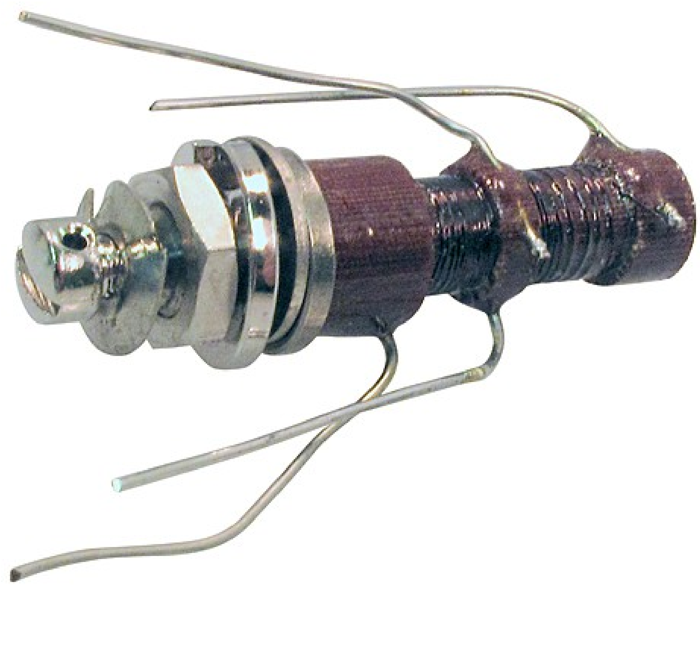
Much smaller transformers can be used to couple and match signals in *small-signal* RF circuits.



This is an example of an intermediate frequency (IF) xfmr, and it's tuned and adjustable.







If the secondary voltage is stepped up, the secondary current goes down.

If the secondary voltage is stepped down, the secondary current goes up.

You can't transform more power than you put in!

There are also small losses in transformers due to the resistance of the windings, magnetic (hysteresis) losses in the core material, eddy currents, and magnetic leakage.

Transformers are VERY efficient – but they're not perfect.

In conclusion ...

More to come ...

73,
AI2Q, Alex