Transformers

Session 2c of "Basic Electricity"
A Fairfield University E-Course
Powered by LearnLinc

Basic Electricity

Two Sections

- Electron Flow and Resistance
  - 5 on-line sessions
  - Lab
- Inductance and Capacitance
  - 5 on-line sessions
  - Lab

Mastery Test, Part 1

Basic Electricity (Continued)

- Text: "Electricity One-Seven," Harry Mileaf, Prentice-Hall, 1996, ISBN 0-13-889585-6 (Covers several Modules and more)
- References:
  - "Digital Mini Test: Principles of Electricity Lessons One and Two," SNET Home Study Coordinator, (203) 771-5400
  - Electronics Tutorial (Thanks to Alex Pounds)
  - Electronics Tutorial (Thanks to Mark Sokos)
  - Basic Math Tutorial (Thanks to George Mason University)
  - Vector Math Tutorial (Thanks to California Polytec at atom.physics.calpoly.edu)

Section 2:
AC, Inductors and Capacitors

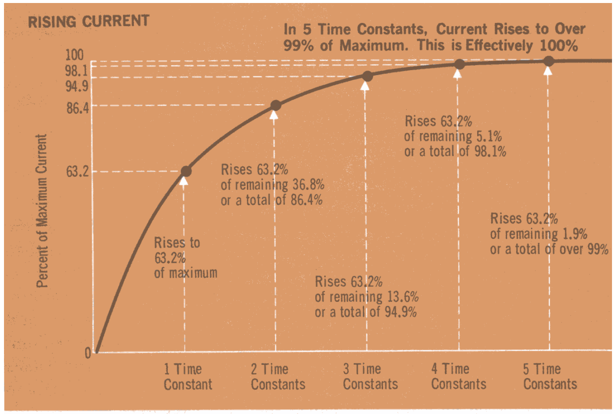
- 0BJECTIVES: This section introduces AC voltage / current and additional circuit components (inductors, transformers and capacitors).

Section 2 Schedule:

Session 2a	– 03/27	Alternating Current & Sine Waves	Text 3.1 – 3.41
Vector Math	– 04/01	Sine Waves, Magnitude, Phase and Vectors	Text 4.1 – 4.24
Session 2b (Fri. Q&A session)	– 04/03	Inductors and Circuits	Text 3.42 – 3.73
Session 2c	**– 04/08**	**Transformers**	**Text 3.74 – 3.100**
Session 2d (lab - 04/13, Sat.)	– 04/10	Capacitors	Text 3.101 – 3.135
Session 2e	– 04/15	More Capacitors	Text 3.135 – 3.148
Session 2f	– 04/22	Review (Discuss Quiz_2)	

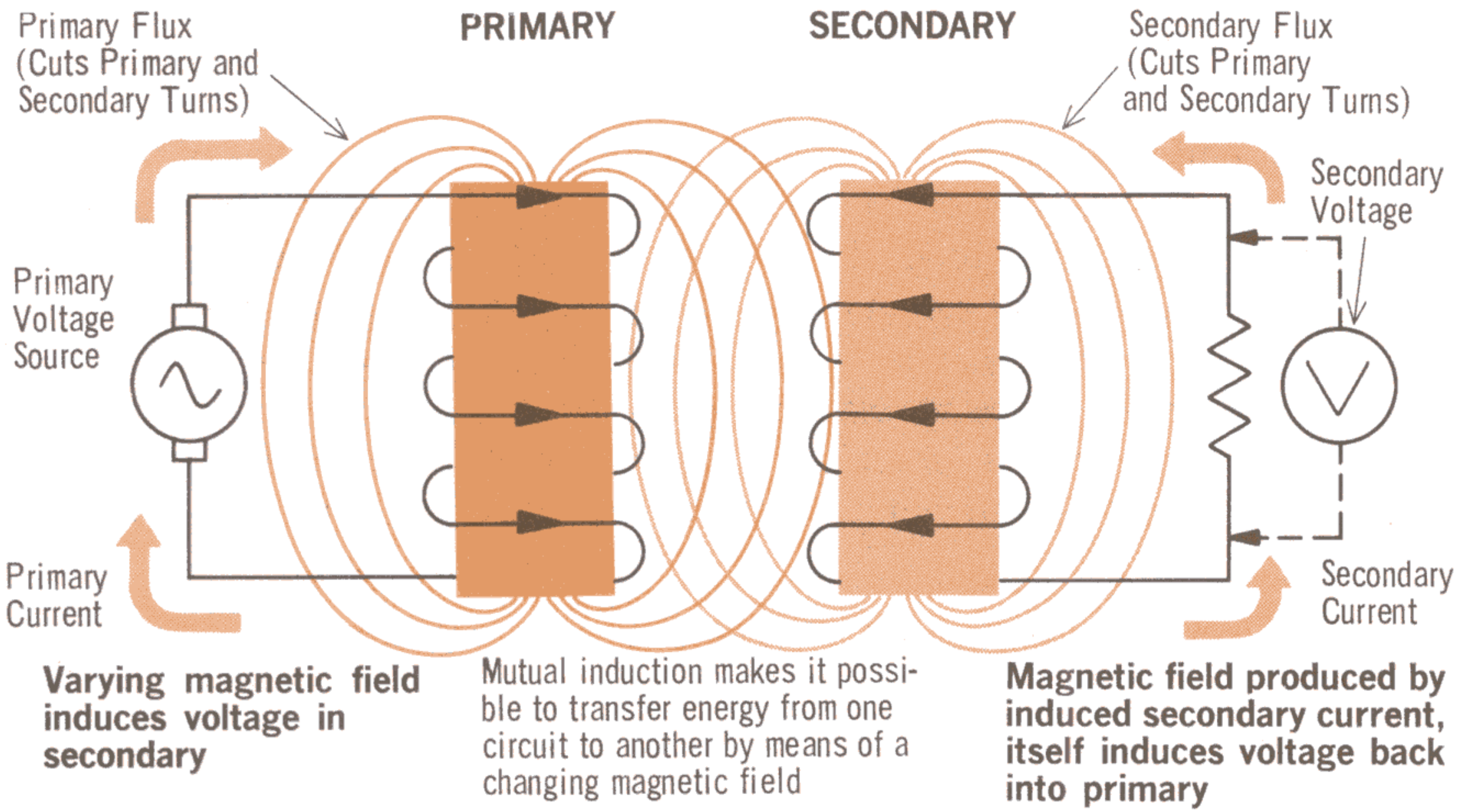
Inductor Session Review

- Inductors resist changes in their current with their “Reactance”
- Coiling a wire increases its inductance
- Time constant: $\tau = L/R$
- Inductor current “lags” the voltage 90° (Eli the ice man)
- Inductor Reactance ($X_L = 2\pi f L$) determines the current magnitude ($|I| = |V| / X_L$)
- Series and Parallel Inductors



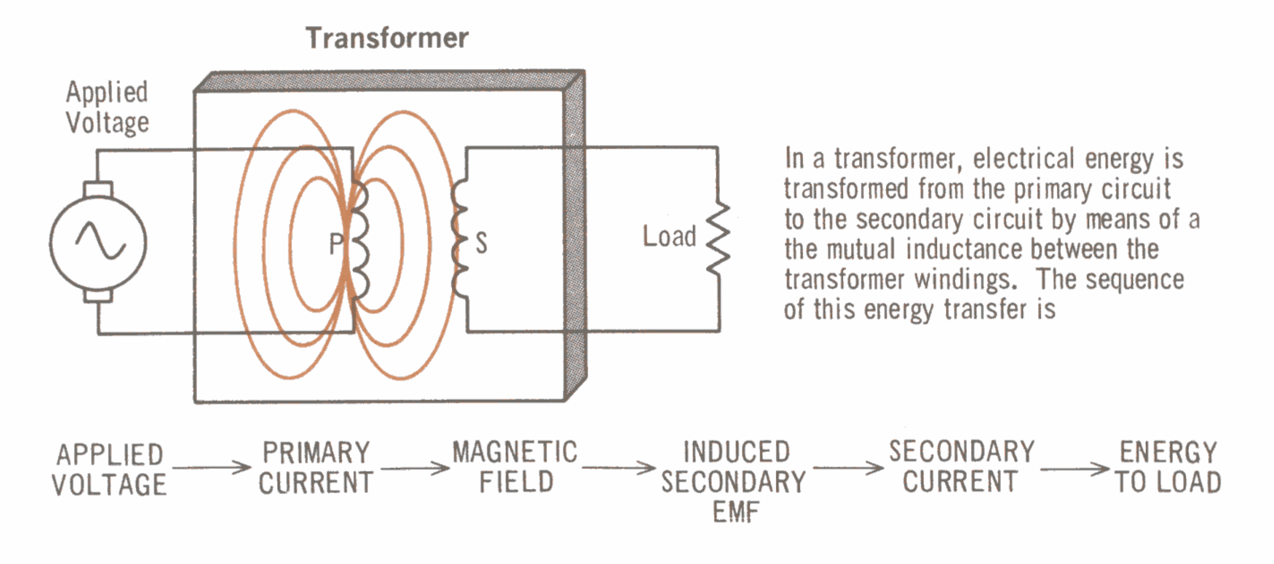
In each time constant, the current increases to a value 63.2% closer to its maximum value

Mutual Inductance



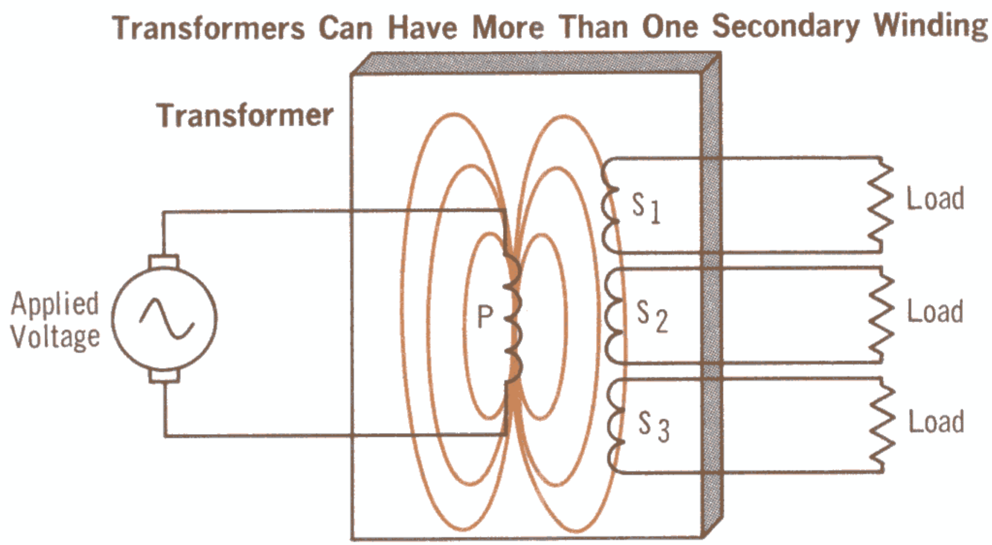
The Transformer

- Electrical energy is coupled from the "Primary" to the "Secondary"
- Provides "Isolation" (separate grounds)



Multiple Secondary Windings

- Divide power among several loads

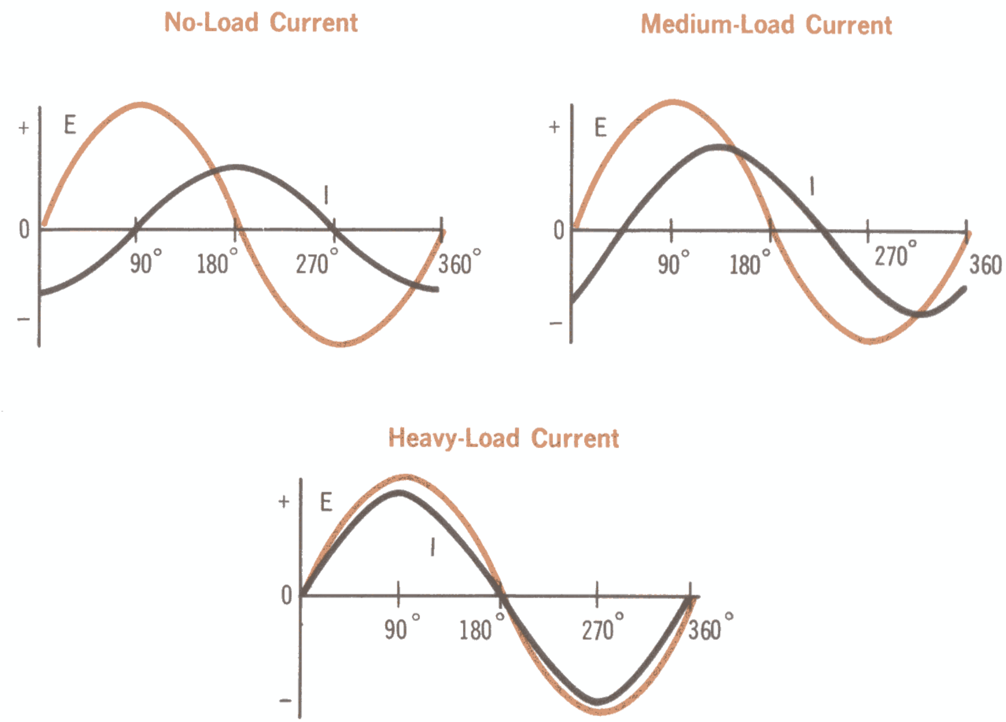


Coupling Coefficient (k)

- Perfect coupling: all flux goes through both coils (k=1)
- Normally k < 1
  $M = k \sqrt{L_1 * L_2}$
  (M is the Mutual Inductance)

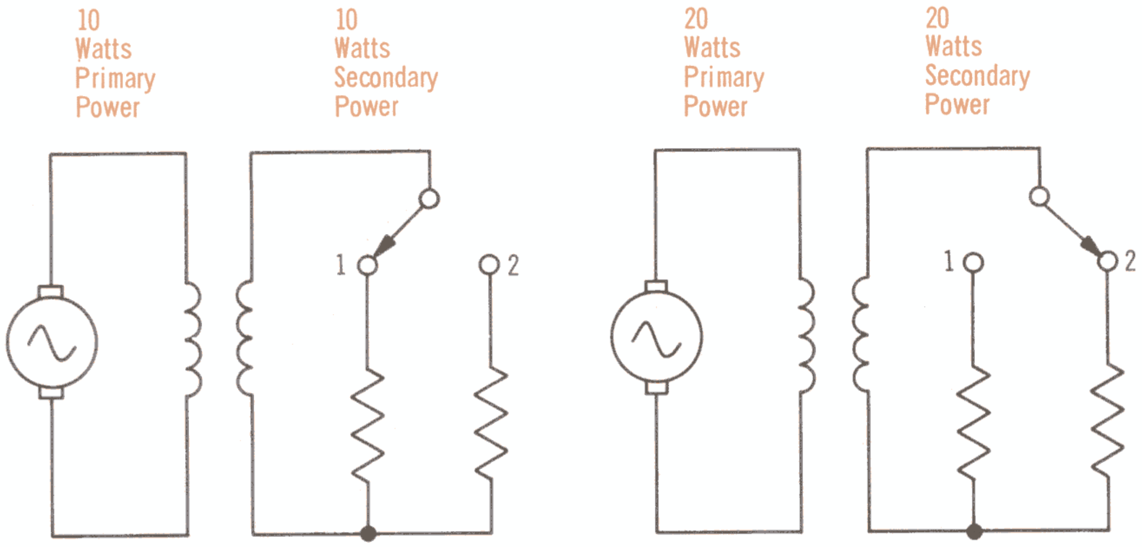
Phase Relationships

- Low power
  - Inductive load
- High power
  - Resistive load



Transformers and Power

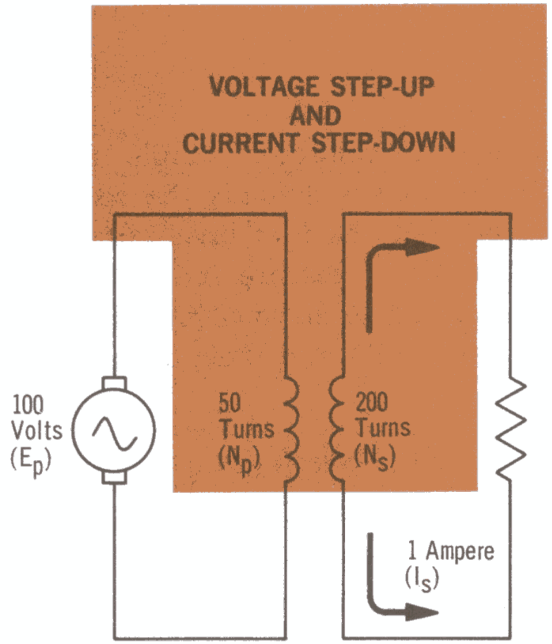
- Conservation of power



In an ideal transformer, the power in the primary circuit equals the power in the secondary circuit

Turns Ratio:
Step Up

- $Vs = Vp * (Ns/Np)$
- $Is = Ip / (Ns/Np)$



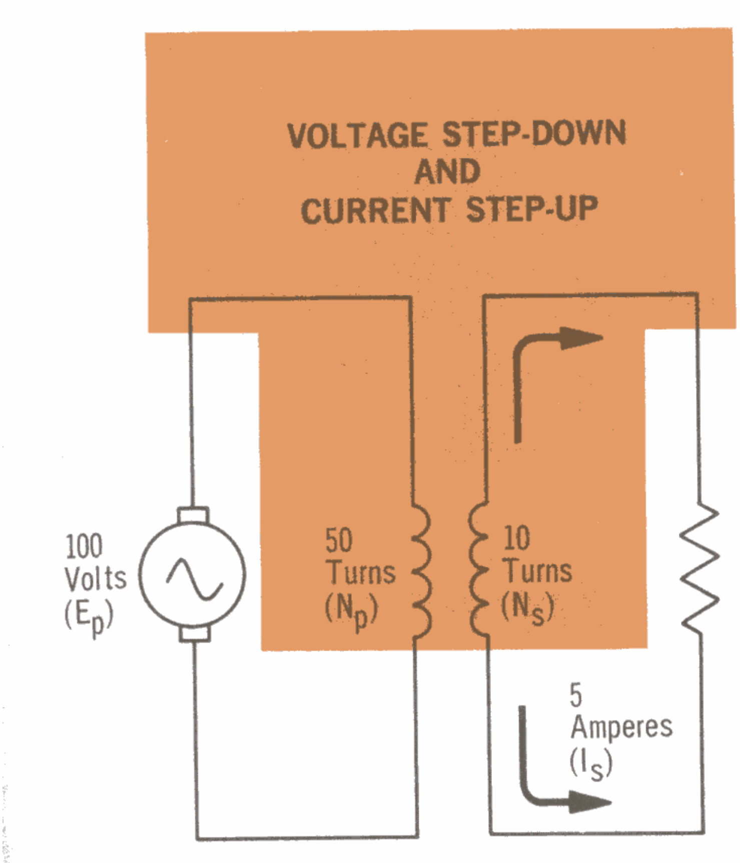
$I_p = I_s (N_s/N_p) = 1 \times (200/50) = 4$ amperes

$E_s = E_p (N_s/N_p) = 100 \times (200/50) = 400$ volts

$P_p = E_p \times I_p = 100 \times 4 = 400$ watts

$P_s = E_s \times I_s = 400 \times 1 = 400$ watts

Turns Ratio:
Step Down



$I_p = I_S\ (N_S/N_p) = 5 \times (10/50) = 1$ ampere

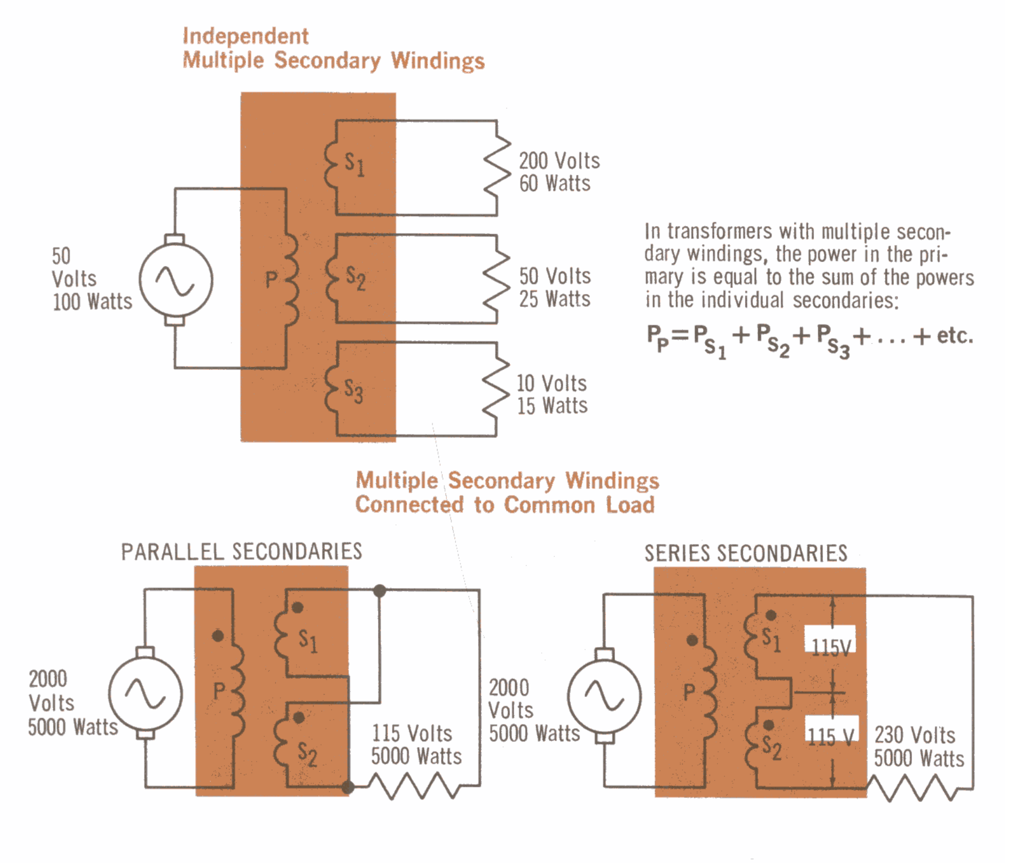
$E_S = E_p\ (N_S/N_p) = 100 \times (10/50) = 20$ volts

$P_p = E_p \times I_p = 100 \times 1 = 100$ watts

$P_S = E_S \times I_S = 20 \times 5 = 100$ watts

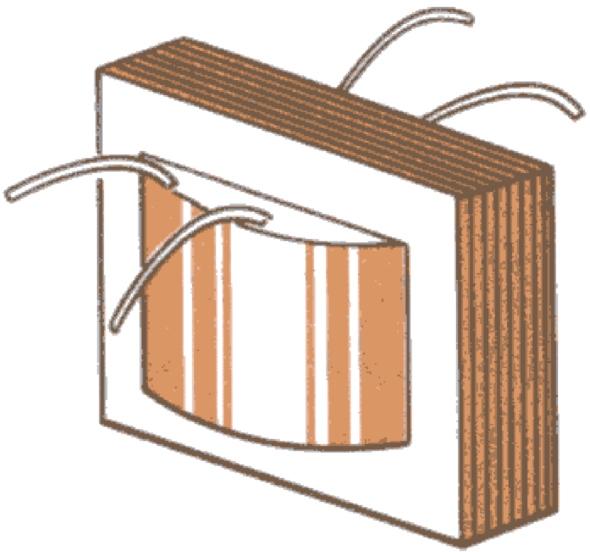
Multiple Secondary Windings (again)

- Provide multiple voltages
  - Total power conserved
- Windings in parallel
  - add current
- Windings in series
  - add voltage



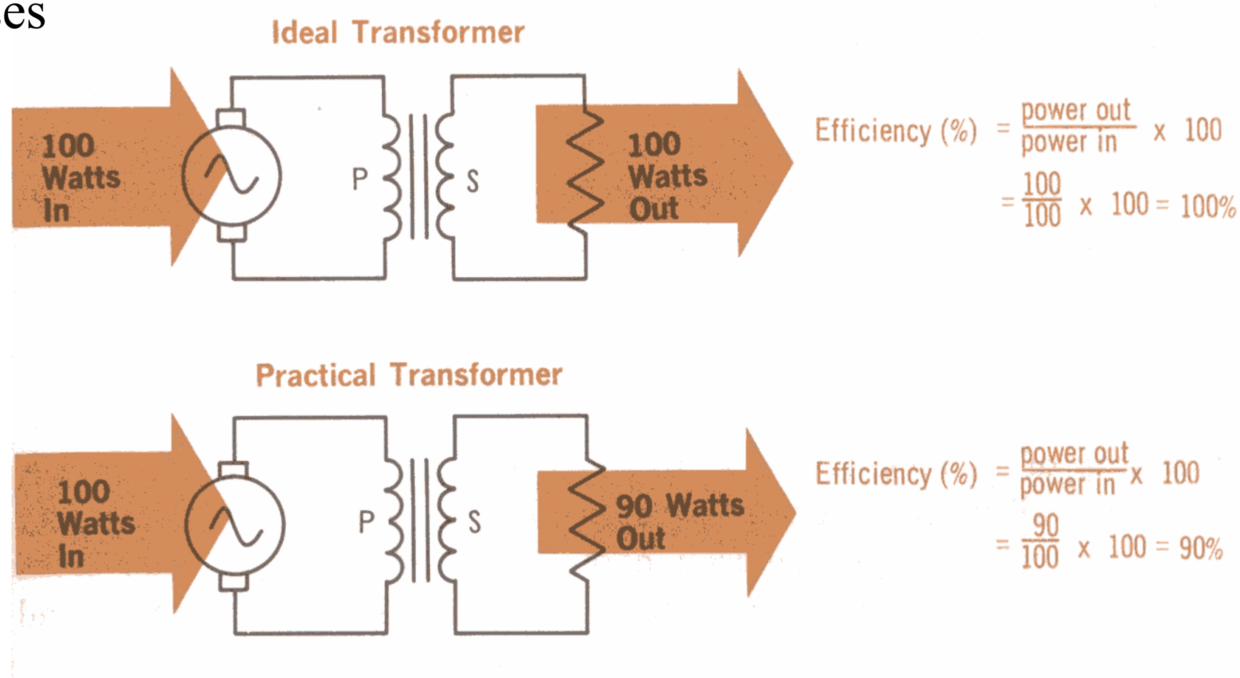
Real Transformers

- An "Iron Core" Transformer
  - Low frequency use
  - Power supplies
  - Home doorbell



Transformer Losses

- Conductor resistance
- Eddy currents
- Magnetic losses
  - Hysteresis
  - Saturation



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