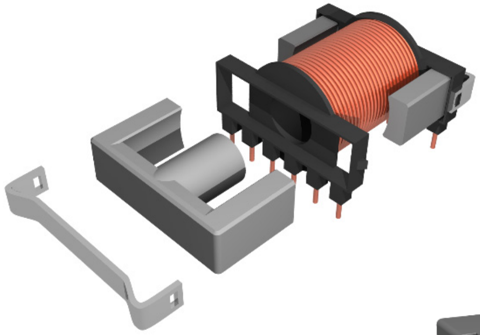
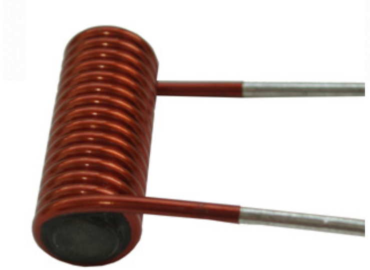
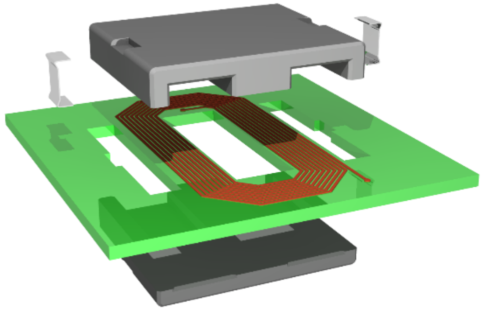
Part III: Magnetics

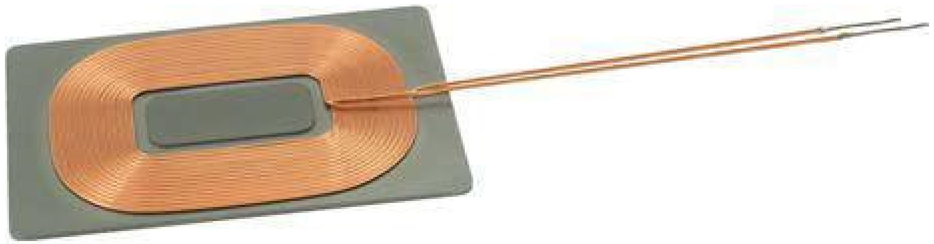
- Ch 10 Basic Magnetics Theory
- Ch 11 Inductor Design
- Ch 12 Transformer Design
  - Ch. 13-15 in 2nd edition

Some Inductor Examples

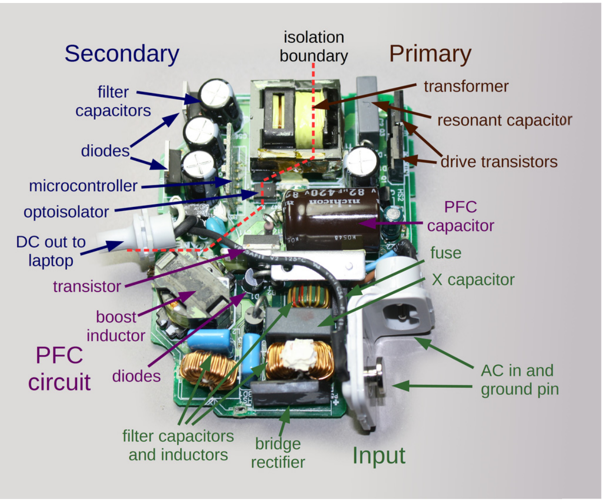


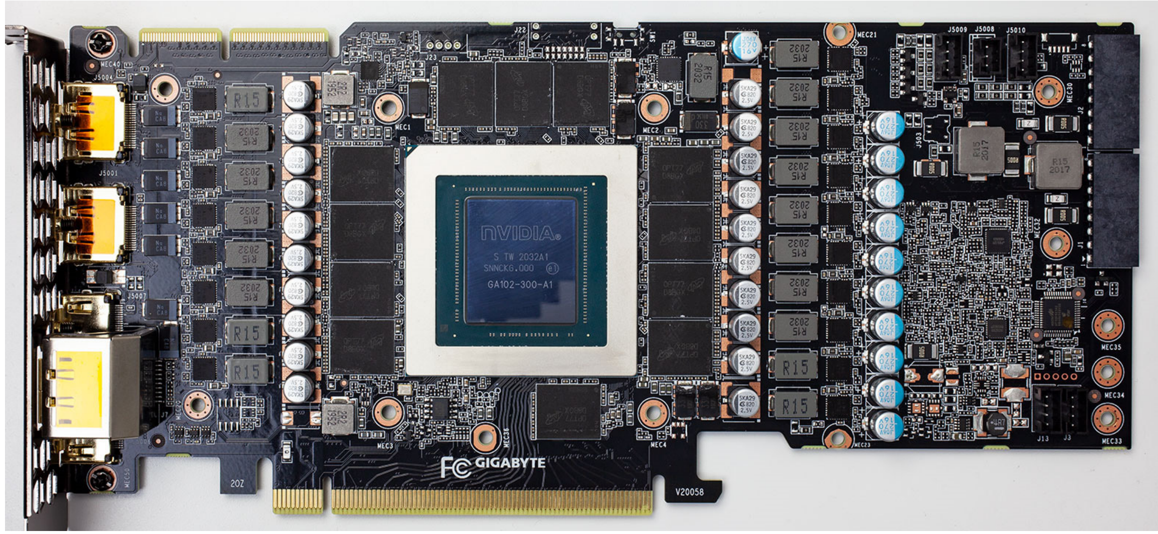


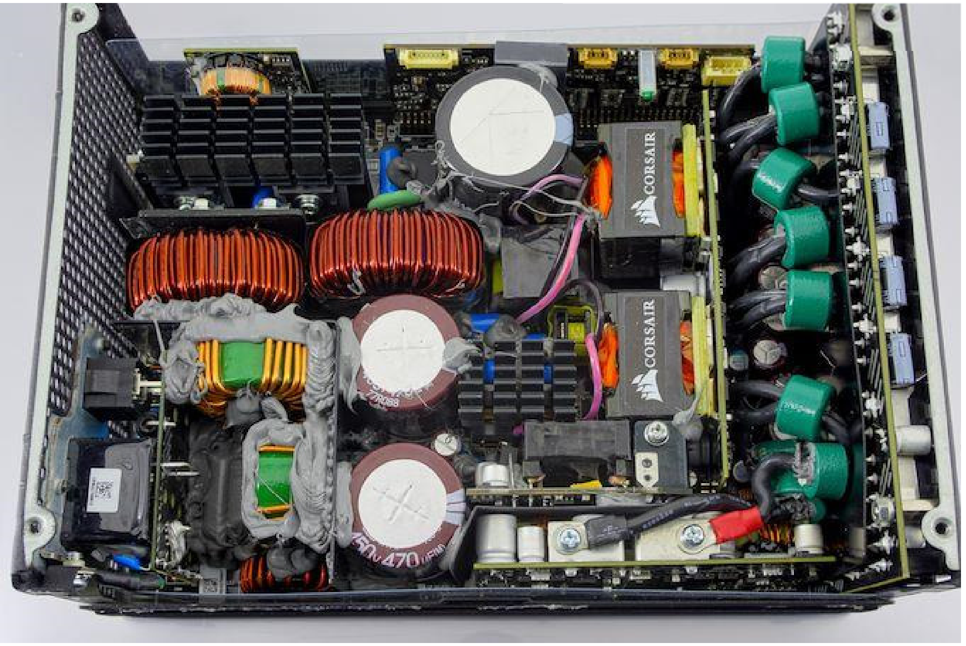


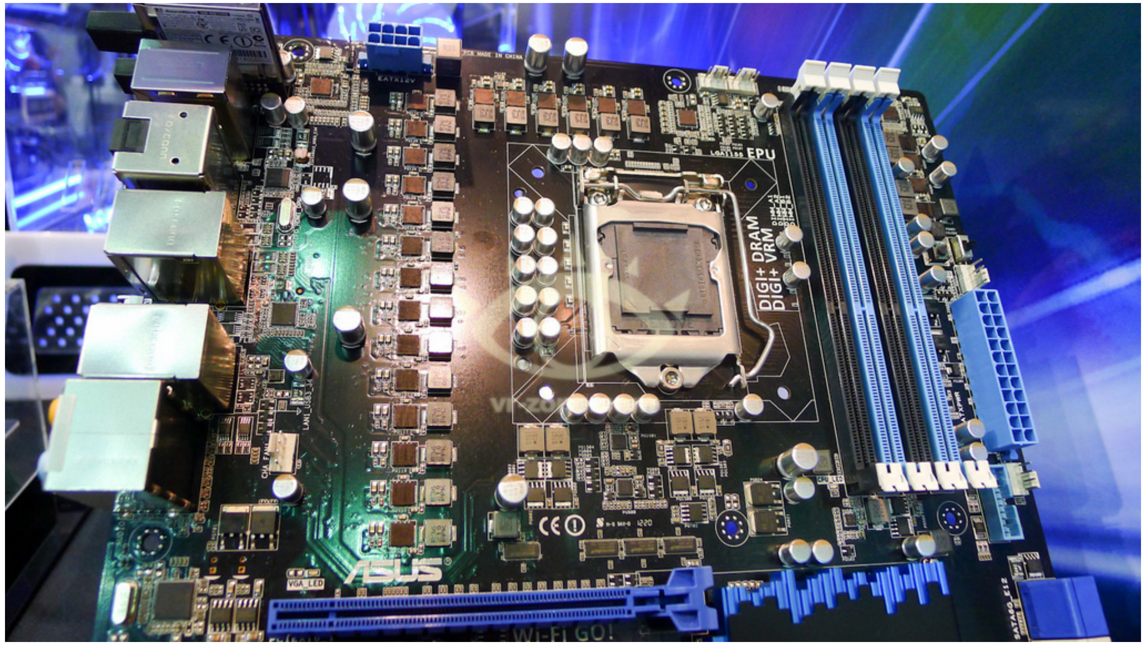


Example Power Converters

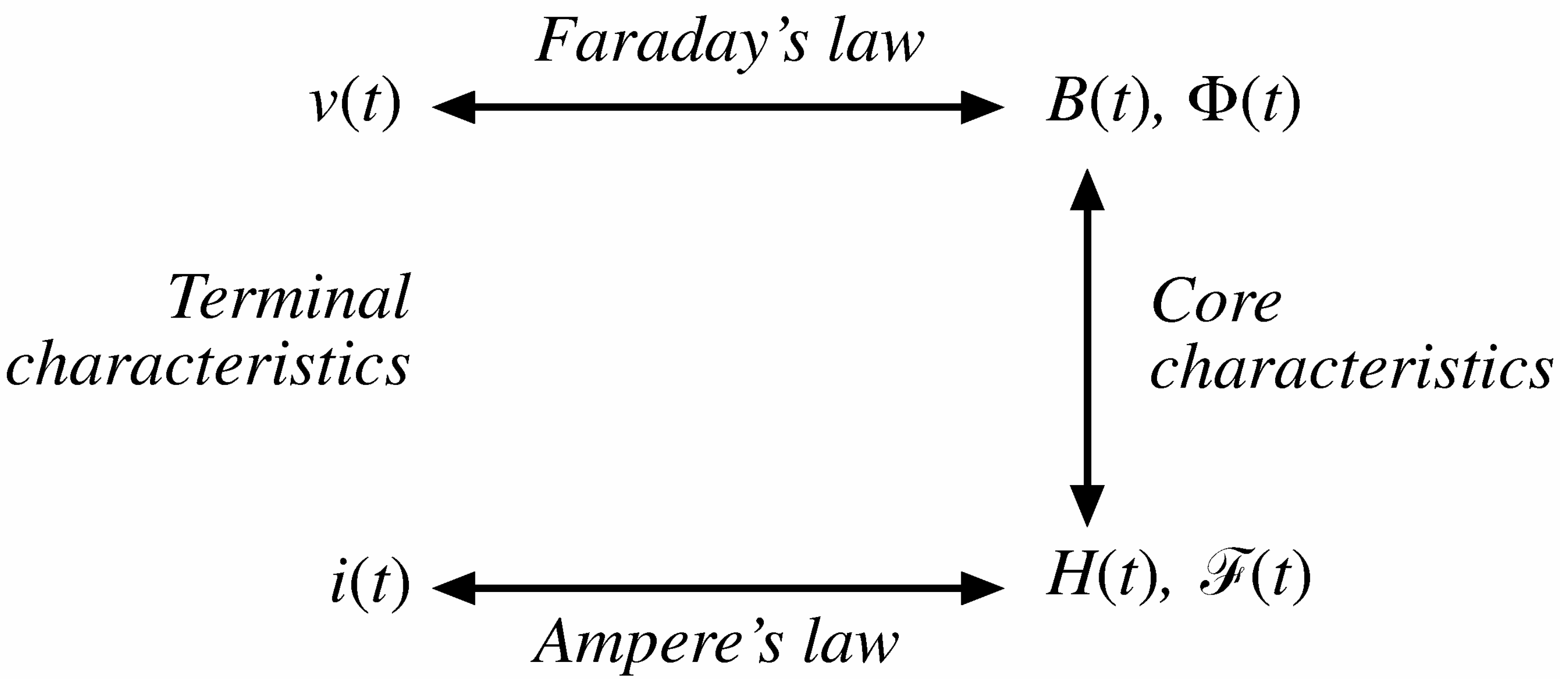








Basic Magnetics Relationships



Electric/Magnetic Duals

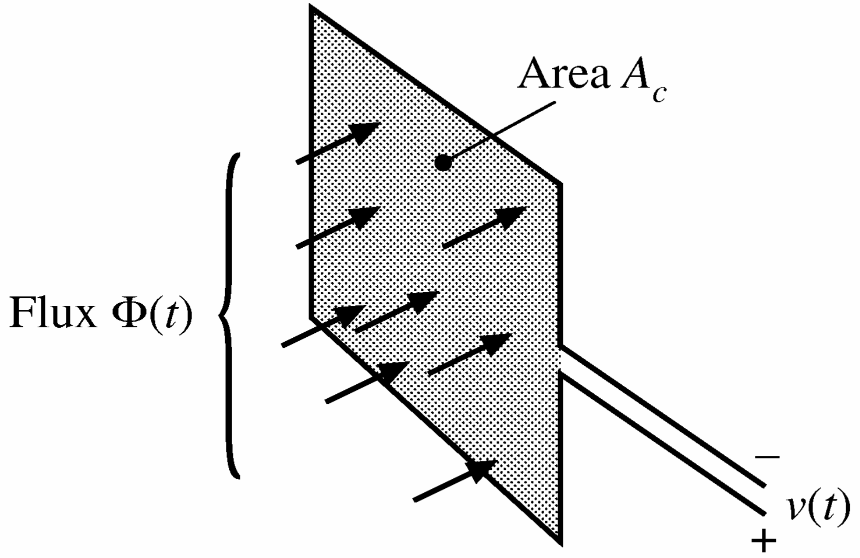
Faraday's Law

Voltage $v(t)$ is induced in a loop of wire by change in the total flux $\Phi(t)$ passing through the interior of the loop, according to

$$v(t) = \frac{d\Phi(t)}{dt}$$

For uniform flux distribution, $\Phi(t) = B(t)A_c$ and hence

$$v(t) = A_c \frac{dB(t)}{dt}$$

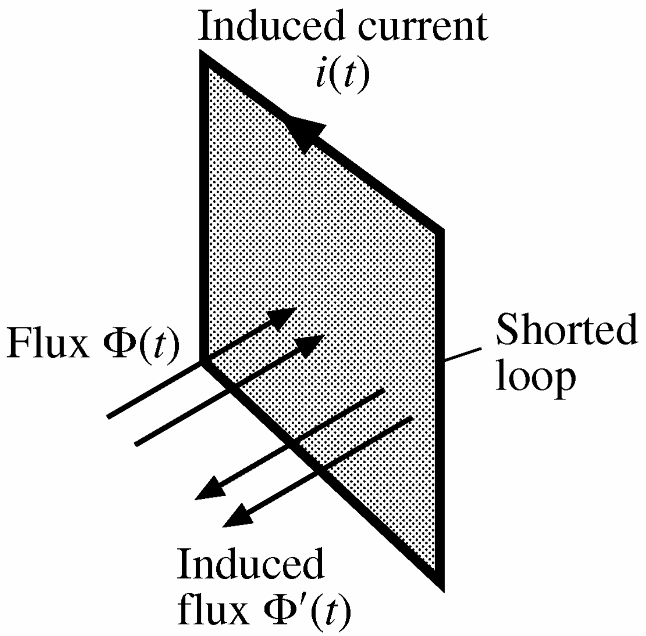


Lenz's Law

The voltage $v(t)$ induced by the changing flux $\Phi(t)$ is of the polarity that tends to drive a current through the loop to counteract the flux change.

Example: a shorted loop of wire

- Changing flux $\Phi(t)$ induces a voltage $v(t)$ around the loop
- This voltage, divided by the impedance of the loop conductor, leads to current $i(t)$
- This current induces a flux $\Phi'(t)$, which tends to oppose changes in $\Phi(t)$



Ampere's Law

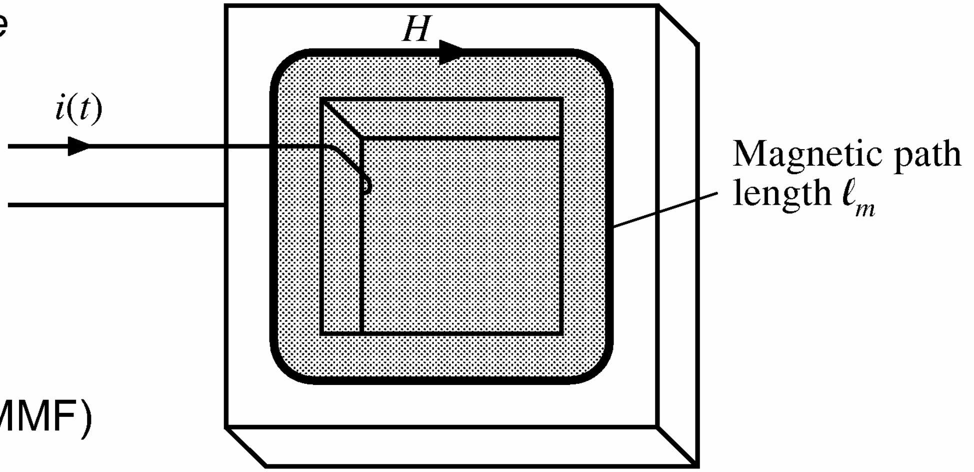
The net MMF around a closed path is equal to the total current passing through the interior of the path:

$$\oint_{closed\ path} \boldsymbol{H} \cdot d\boldsymbol{\ell} = \text{total current passing through interior of path}$$

Example: magnetic core. Wire carrying current $i(t)$ passes through core window.

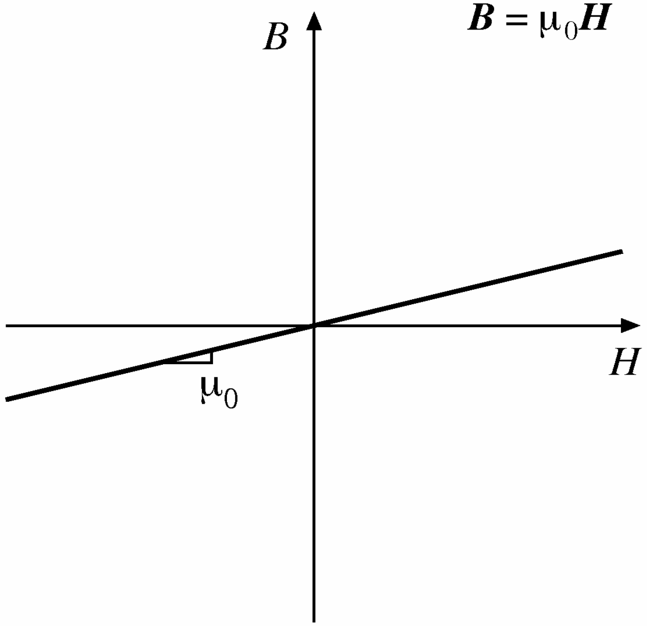
- Illustrated path follows magnetic flux lines around interior of core
- For uniform magnetic field strength $H(t)$, the integral (MMF) is $H(t)\ell_m$. So

$$\mathscr{F}(t) = H(t)\ell_m = i(t)$$



Core Material Characteristics

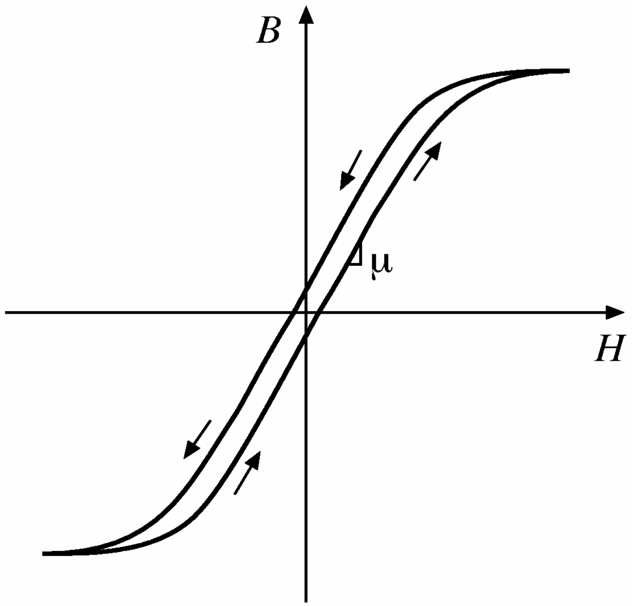
Free space



μ_0 = permeability of free space

= $4\pi \cdot 10^{-7}$ Henries per meter

A magnetic core material



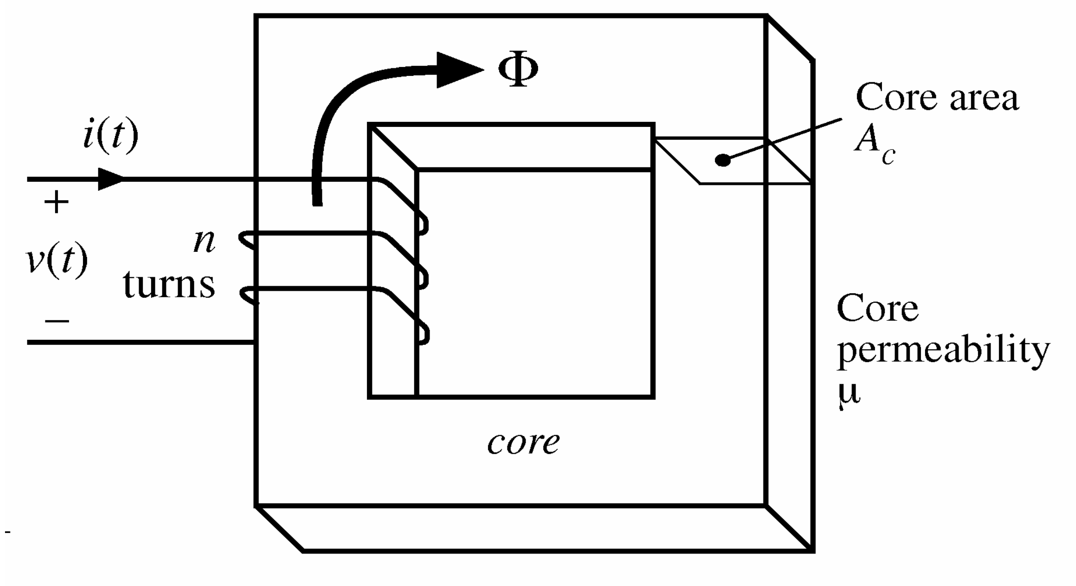
Highly nonlinear, with hysteresis and saturation

Units

Table 12.1. Units for magnetic quantities

quantity	*MKS*	*unrationalized cgs*	*conversions*
core material equation	$B = \mu_0 \mu_r H$	$B = \mu_r H$	
B	Tesla	Gauss	$1\text{T} = 10^4\text{G}$
H	Ampere / meter	Oersted	$1\text{A/m} = 4\pi \cdot 10^{-3}\ \text{Oe}$
Φ	Weber	Maxwell	$1\text{Wb} = 10^8\ \text{Mx}$ $1\text{T} = 1\text{Wb} / \text{m}^2$

Inductor Example



Magnetic Circuits