Soft Ferrite Advantages, Capabilities & Markets

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Soft Ferrite is the general term to a class of ceramic, electromagnetic

- They have a homogeneous cubic spinel crystalline structure

- Are composed of iron oxide with divalent metal oxides

- $MnZnFe_2O_4$ or $NiZnFe_2O_4$

Advantages of Soft Ferrite

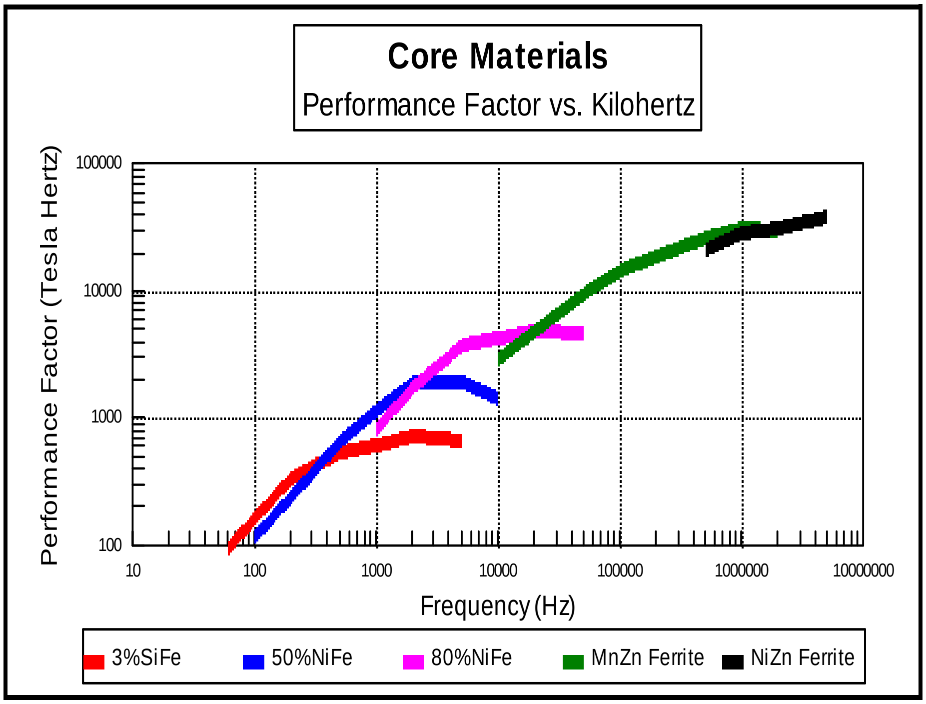
- High Resistivity = low eddy current loss = high usable frequency ranges

- High Magnetic Permeability = high induction in minimal space

- Versatility of core shapes = satisfies magnetic requirements in minimal space

- Light Density = light weight

- Low Cost Relative to Alternative Materials



NiZn Ferrite are best for > 2 MHz

MnZn Ferrite are best for 20 KHz to 2 MHz

80% NiFe is best for 2 KHz to 20 KHz

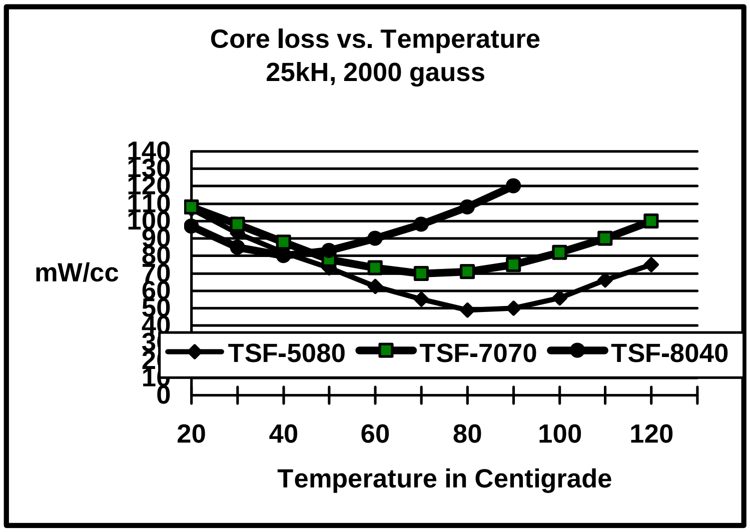
50% NiFe is best for 300 Hz to 2 KHz

3% SiFe is best < 300 Hz

Some Important Properties

		MnZn	NiZn
Volume Resistivity	ρ Ωcm	50 to 100	$1x10^5$ to $5x10^9$
Permeability	μ	1,000 to 15,000	10 to 1,000
Saturation Flux Density	Bm Gauss	3,000 to 5,000	2,000 to 3,500
Useful frequency Range	MHz	Up To 10	Up To 100
Density	G/cm^3	4.8	4.9

Core Loss - A measure of the efficiency of a material at high levels of magnetizing force. Dissipated energy in the form of heat.

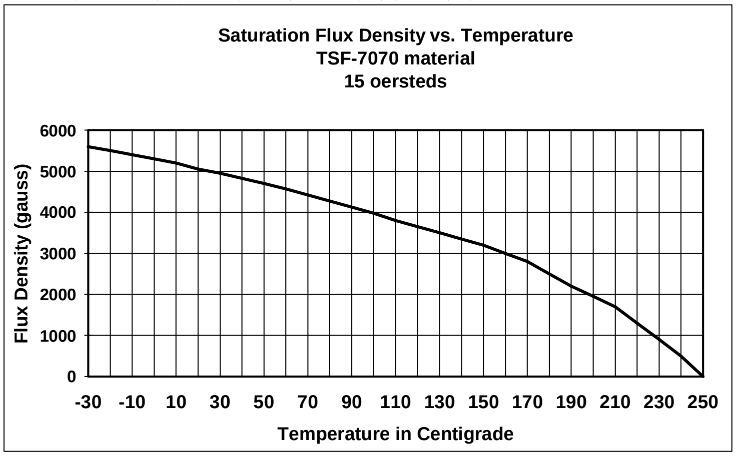


- Core size is often constrained by temperature rise that results from core loss

- A number of material grades have been designed so that their minimum core loss occurs at specific Temperatures.

Saturation Flux Density - The value of magnetic flux density at saturation. A materials maximum magnetic induction.

$B = (Erms)(10^8) / (4.44)(f)(N)(Ae)$



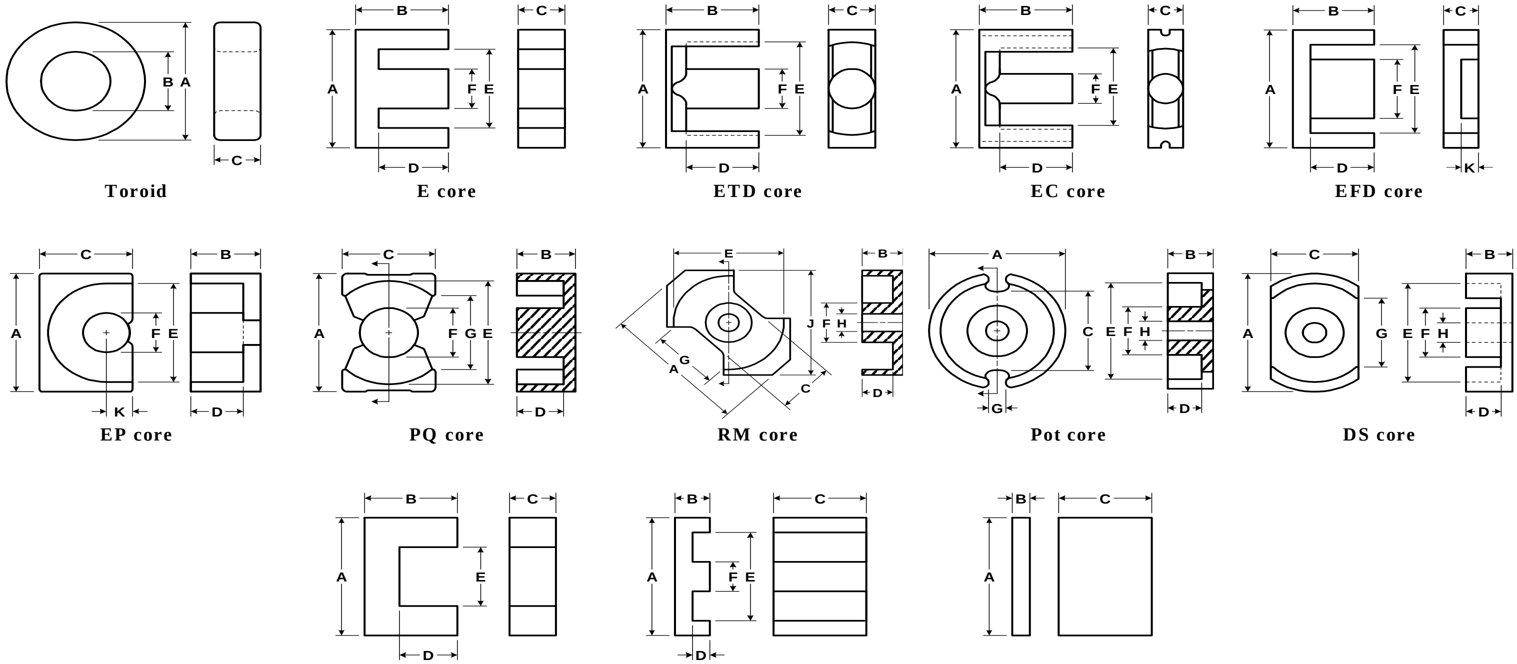
- Core size is often constrained by Saturation Flux Density
- Saturation Flux Density decreases with increasing temperature. Often a material's Saturation Flux Density is a constraint on the minimum core size.

f = frequency
N= turns
Ae = effective core area

Ferrite Material Constants	
Specific Heat	0.25 cal / g / °c
Thermal Conductivity	10 x 10^{-3} cal / sec / cm / °c
Coefficient of Linear Expansion	8 to 10 x 10^{-6} / °c
Compressive Strength	60 x 10^{3} lbs / in^{2}
Young's Modulus	18 x 10^{3} lbs / in^{2}
Hardness (Knoop)	650
Density	4.6 to 4.8 gm / cm^{3}

- **Ferrites are poor thermal conductors, are strong in compression but weak in tension**

Common Core Configurations



Toroid · E core · ETD core · EC core · EFD core

EP core · PQ core · RM core · Pot core · DS core

U core · Planar E core · Planar I core

Applications using Ferrites

- ## Inductors

  Inductance is the electrical circuit property that opposes change in current due to a magnetic field

- ## Transformers

  Devices that transform electric energy from one circuit to another by electromagnetic induction

- ## Noise Suppression

  Reduction of unwanted high frequency electrical disturbance

- ## Deflection Yokes for CRT & Video Displays

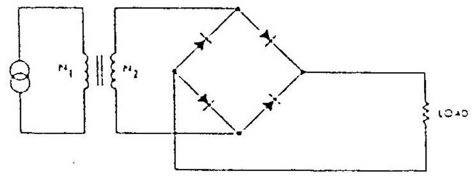
  Electromagnet for deflecting (directing) electron beams

Transformer Applications

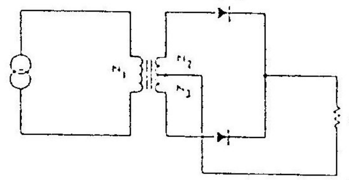
- Impedance Matching Transformer
- Isolation Transformer
- Current Transformer
- Voltage Transformer
- Wide Band Transformer
- Pulse Transformer
- Switching Power (Output/Inverter) Transformer
  - Flyback Transformer
  - Forward Transformer
  - Push-Pull Transformer
  - Half-Bridge Transformer
  - Full-Bridge Transformer

$Ap = WaAe = (P_t)(10^4)/(K_u\ K_f\ B_m\ f\ J)$

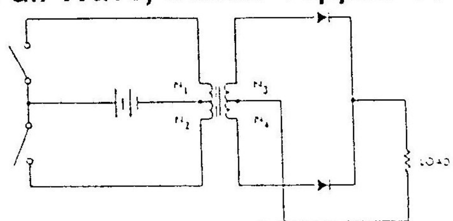
Full-Wave Bridge $P_t = P_o\ (1/\eta + 1)$



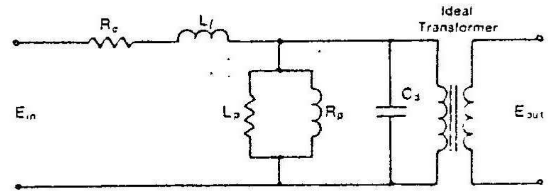
Full-Wave Center Tapped $P_t = P_0\ (1/\eta + \sqrt{2})$



Push-Pull, Full-Wave, Center-Tapped $P_t = P_0\ (\sqrt{2}/\eta + \sqrt{2})$



Equivalent Circuit of a Transformer

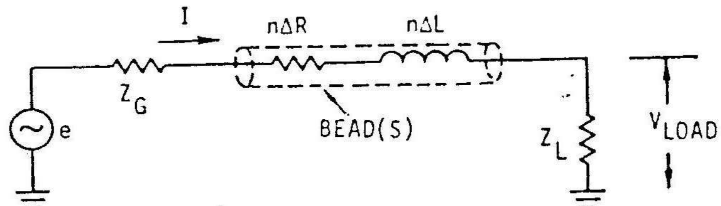


where R_c = Coil resistance
L_l = leakage reactance
L_p = parallel inductance of core
R_p = parallel resistance of core
C_d = winding capacitance

Equivalent Line & Load Circuit with Ferrite Bead

Insertion Loss = $Z_G + Z_L / (Z_G + Z_L + n\Delta Z_T)$

$\Delta Z_T = \Delta R + j\Delta XL$



Inductor Applications

- Filter Inductor
  - Common Mode Inductor
  - Differential Mode Inductor
- Power Inductor
  - Resonant Inductor
  - Boost Inductor
  - Output Choke Inductor

Inductance - Electrical property that opposes any change in current because of a magnetic field.

$L = ((.004)(\pi)(N^2)(Ae)(10^6)) / Le$ (in Henries)

- Material Permeability, core dimensions & number of turns all affect inductance and therefor affect component size

  Ae = effective cross sectional area

  Le = effective magnetic path length

  N = turns on coil.

Telecommunications Markets

- System Networks
- Integrated System Digital Networks (ISDN)
- Modems
- Cell Phones & Pagers

Power Supply Markets

- Computers (Notebook to Mainframe)
- Medical Equipment
- Test Equipment

Fluorescent Lighting Ballast Markets

- Commercial, Industrial & Institutional Lighting
- Compact Florescent Lamps
- Controllable Lighting
- Emergency Lighting

Automotive Markets

- HID Head Lamps
- Neon Stop Lights
- Battery Chargers for Electric Vehicles
- Sensors

Consumer Electronics

- Conventional Television
- Digital & High Definition Television
- VCR
- Stereo & Radio