
Soft Ferrite Advantages, Capabilities & Markets

1997 Soft Ferrite Users Conference

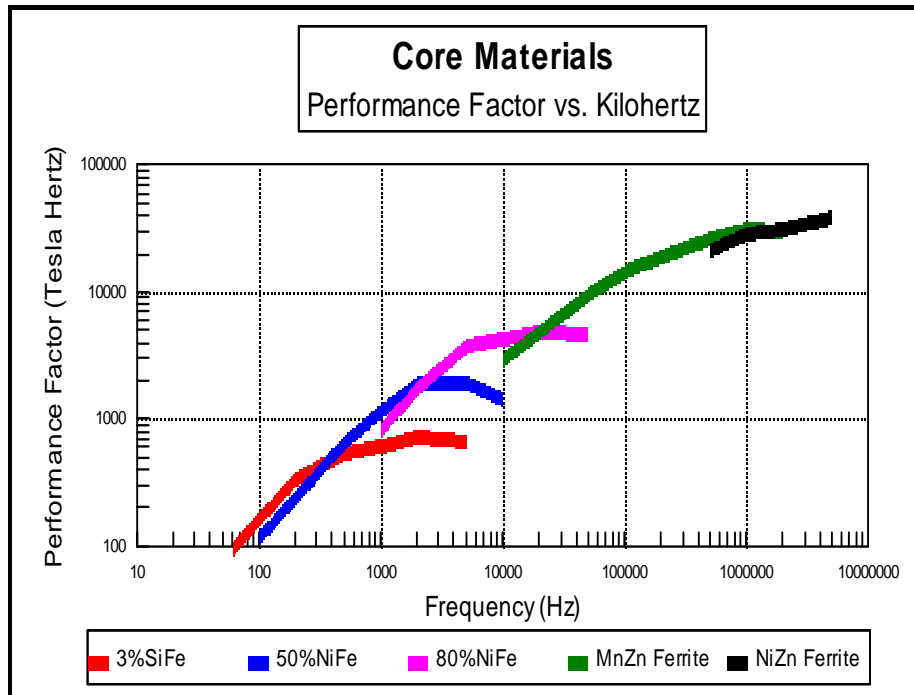
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Soft Ferrite is the general term to a class of ceramic, electromagnetic

- v They have a homogeneous cubic spinel crystalline structure
- v Are composed of iron oxide with divalent metal oxides
- v $\text{MnZnFe}_2\text{O}_4$ or $\text{NiZnFe}_2\text{O}_4$

Advantages of Soft Ferrite

- v High Resistivity = low eddy current loss = high usable frequency ranges
- v High Magnetic Permeability = high induction in minimal space
- v Versatility of core shapes = satisfies magnetic requirements in minimal space
- v Light Density = light weight
- v 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

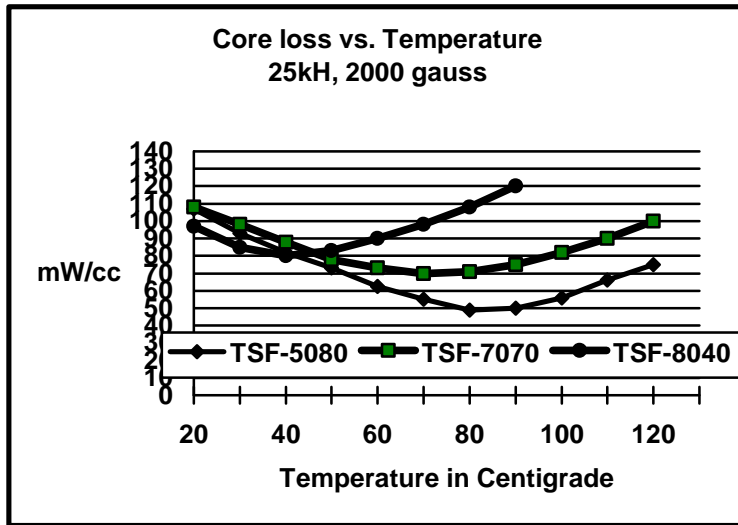
50% NiFe is best for 300 Hz to 2 KHz

3% SiFe is best < 300 Hz

Some Important Properties

		MnZn	NiZn
Volume Resistivity	ρ Ωcm	50 to 100	1×10^5 to 5×10^9
Permeability	μ	1,000 to 15,000	10 to 1,000
Saturation Flux Density	B_m 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

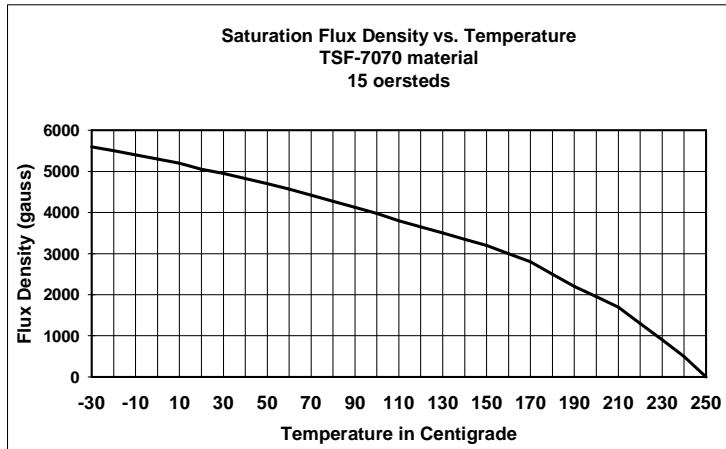
**Core Loss - A measure of the efficiency of a material at high levels of magnetizing force.
Dissipated energy in the form of heat.**



- 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.

$$B = (E_{rms})(10^8) / (4.44)(f)(N)(A_e)$$



- 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

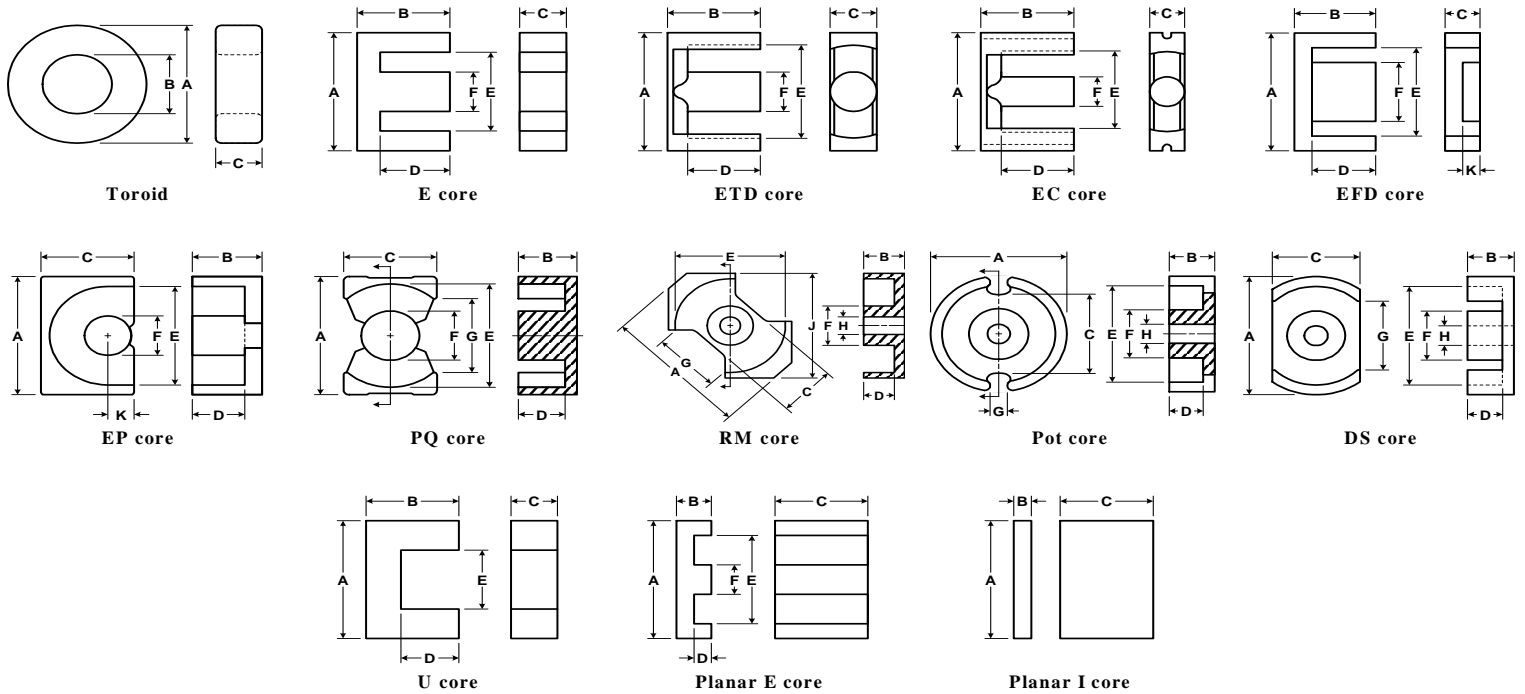
N= turns

A_e = 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 10³ lbs / in²
Young's Modulus	18 x 10³ lbs / in²
Hardness (Knoop)	650
Density	4.6 to 4.8 gm / cm³

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

Common Core Configurations



Applications using Ferrites

- v **Inductors**

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

- v **Transformers**

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

- v **Noise Suppression**

Reduction of unwanted high frequency electrical disturbance

- v **Deflection Yokes for CRT & Video Displays**

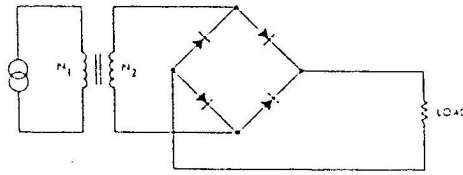
Electromagnet for deflecting (directing) electron beams

Transformer Applications

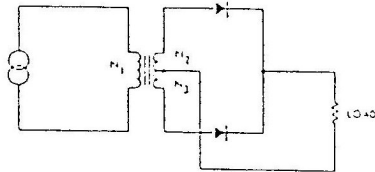
- v Impedance Matching Transformer
- v Isolation Transformer
- v Current Transformer
- v Voltage Transformer
- v Wide Band Transformer
- v Pulse Transformer
- v Switching Power (Output/Inverter) Transformer
 - v Flyback Transformer
 - v Forward Transformer
 - v Push-Pull Transformer
 - v Half-Bridge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

$$A_p = W a A_e = (P_t)(10^4)/(K_u K_f B_m f J)$$

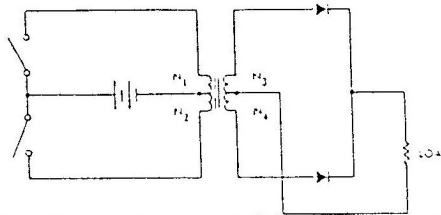
$$\text{Full-Wave Bridge } P_t = P_o (1/\eta + 1)$$



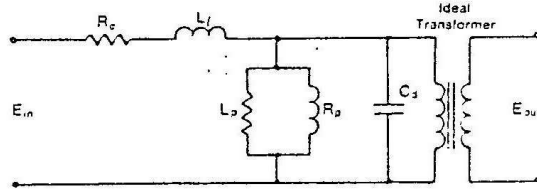
$$\text{Full-Wave Center Tapped } P_t = P_o (1/\eta + \sqrt{2})$$



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



Equivalent Circuit of a Transformer

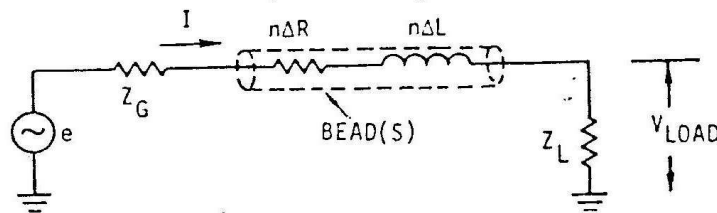


where R_c = Coil resistance
 L_l = leakage reactance
 L_p = parallel inductance of core
 R_p = parallel resistance of core
 C_d = winding capacitance

Equivalent Line & Load Circuit with Ferrite Bead

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

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



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.

$$L = \left(\frac{.004}{10^6} \right) (\mu) (N^2) (A_e) / L_e \text{ (in Henries)}$$

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

A_e = effective cross sectional area

L_e = effective magnetic path length

N = turns on coil.

Telecommunications Markets

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

Power Supply Markets

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

Fluorescent Lighting Ballast Markets

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

Automotive Markets

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

Consumer Electronics

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