EMI Suppression Ferrites

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Agenda

- What is Ferrite?
- Ferrite Application Areas
- Terminology
- Suppression Ferrites
  - How they work
  - Material Comparison
  - Design considerations
- Selecting the right Ferrite

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What Is Ferrite?

- Ferrite is a soft magnetic material formed by pressing and firing various metal oxides (primarily iron) into a ceramic material.
- A ‘Soft’ magnetic material is one that can be both easily magnetized and demagnetized.
- Two basic compositions: MnZn and NiZn
- Many different grades exist under these two basic types by way of altering the concentrations, adding or subtracting trace additives, and changing the processing parameters
Why Ferrites?

- Losses are proportional to Frequency
  - Hysteresis Losses (Magnetization)
  - Eddy Current Losses
Speak the language

- Permeability $B = \mu H$
  - Initial (10kHz low $B$)
  - Incremental ($\mu_i$ vs DC bias)
  - Amplitude ($\mu_i$ vs $B$)
  - Effective ($\mu_i$ with air gap)
  - Complex ($\mu'$, $\mu''$ over frequency)
- Saturation
- Curie Temperature
- Power Loss Density
Suppression Ferrites

- **Strengths**
  - Lossy Core Material
  - Resistive / dissipative

- **Trade Offs**
  - Limited frequency band
  - DC Bias Concerns

![IEEE Accepted Schematic Symbol for a Ferrite Suppression Device](image-url)
How do they work?

Series Model of a Ferrite Bead

\[ L_S \quad R_S \]

A ‘perfect’ inductor in series with a resistor. Each has an impedance.

Complex Permeability Curve
Total Impedance

\[ \tan \delta = \frac{R_s}{\omega L_s} = \frac{\mu''}{\mu'} \]

\[ Z = j\omega L_0(\mu' - j\mu'') \]

2773009112 Bead On Lead (1 turn)
Application Areas of One Material

61 Material Permability vs Frequency

- Power
- Inductive
- Suppressive

Frequency (Hz)

µ'
µ''
Design Considerations

Graph showing relative performance with dimensions and dimensions.
EMI Suppression materials have limited frequency bands where they operate most effectively. Material should be chosen as a function of the problematic frequencies.

Material Comparison for Cable Cores

26–540002 size 14.3OD x 6.35ID x 28.6Length (mm)
The Effect of Turns on Impedance

2643540002 Cable Bead

Graph showing the impedance (Z(Ω)) as a function of frequency (Hz) for different numbers of turns (N), with N=3, N=2, and N=1. The chart indicates a peak impedance at a certain frequency for each turn count, with N=3 showing the highest peak.
Differential Mode vs Common Mode

Common Mode Currents

Current goes out and comes back through the suppression device.

Differential Mode Currents

Current travels only one way through the suppression device.
Material Comparison w/ DC Bias

27-009112
IMPEDANCE vs. FREQUENCY WITH DC BIAS

Differential Mode Operation
Selecting the Correct Ferrite Core

- Know the source and mode
  - Differential or Common Mode
- Know / Estimate the frequencies of concern
  - Best Material Selection
- How much attenuation is required?
  - Requires impedance of the source and load
- DC Currents
- Form factor needed
  - Cable, bead, PC mount, etc.
Summary

1. Ferrites add impedance to a circuit by imparting their reactive and resistive properties through magnetic coupling.

2. Different ferrite compositions/grades are suited different bands of noise and different applications.

3. Having a complete picture of the application and attenuation required will aid in selecting the best solution.
Thank you!

Please check out our website at www.Fair-Rite.com

• Material and part data
• Technical papers and references
  • Design tools
• Videos and presentations
• Technical forums and ask the advisor