HOW TO select a FerriShield Ferrite for your application

1 Choose a ferrite material

FerriShield ferrites are offered in (4) unique formulations. The chart below offers an overview of typical material properties and catalog page references.

Ferrite	Performance	Catalog Pages
28 Material- Most Popular Wideband	10MHz-1GHz (250MHz peak)	10 to 21
33 Material- Low-Frequency Ferrite	1MHz-60MHz (30MHz peak)	22 to 23
25 Material- High-Frequency Ferrite	1MHz-1.2GHz (700MHz peak)	24 to 25
20 Material- Bluetooth/Microwave	2.45GHz peak	26 to 27

For detailed Attenuation and Material Properties see page 32 and 33

2 Select a mounting option

Each section of this catalog features multiple mounting options for bisected and solid bead ferrites. FerriShield Ferrites are recognized for their ease of installation and reliable performance over time.

3 Select the inside diameter of your ferrite

FerriShield Ferrites are designed to fit tight against the cable or wiring bundle that requires shielding. Ideally, you should select a ferrite with an inside diameter that is slightly less (+/- .04”) than the outside diameter of your cable.

For quick reference, all part numbers in this catalog have an accompanying technical drawing and specifications chart that illustrates dimensions and impedance for the selected ferrite.

For a more detailed technical explanation see page 33.

Helpful Tips and Insider Hints

- Ferrite performance typically increases as ferrite volume increases. The larger the ferrite mass, the better the RF attenuation.
- Smaller cables can be looped through larger ferrites to increase performance. Impedance increase by the square of the number of loops. For example, by looping a cable through a ferrite 2 times (2^2), impedance increases by a factor of 4.

  For a detailed explanation see page 6- Electromagnetic Characteristics

- Ferrite installation guidelines and recommendations are shown on page 35
- Attenuation properties by part number can be referenced on page 32
- Maximum recommend cable size by part number can be found on page 33

Product Profile

Ferrite shielding materials are widely accepted as providing the simplest, most convenient and most cost-effective solution for radio frequency interference problems in cables and connectors. Further, they accomplish both RF attenuation and suppression of unwanted high frequency oscillations with no loss in dc or low frequency signal strength.

The basic composition of ferrite materials is a combination of ferrous oxide and one or more other powdered metals - most often manganese, zinc, cobalt or nickel. An extensive selection of shapes and sizes is already available, and custom geometries may be manufactured for special situations.

There are infinite varieties of formulas and performance levels possible. Each discrete ferrite formulation results in a stoichiometric ratio which is its performance characteristic signature regarding electrical, magnetic and mechanical relationships. The most common expression of ferrites' performance capabilities is in terms of their permeability (μ). This property expresses the ratio of the magnitude of magnetic induction to magnetizing force. The materials are normally categorized according to initial permeability (μ_i).

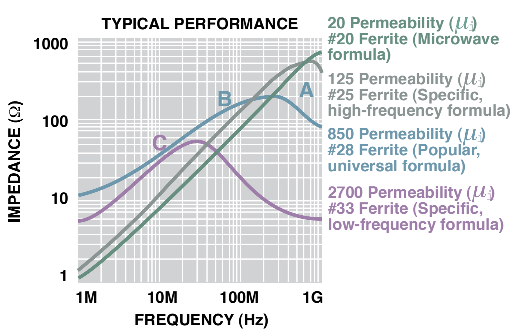


fig. 1 Typical attenuation profiles

FerriShield has developed four principal formulations which together serve the common spectrum of today's RFI needs. For frequencies from 10 MHz to 1 GHz, #28 formulation is recommended, especially when higher frequency harmonics are a consideration. For frequencies typified by microprocessor speeds in excess of 100MHz and harmonics peak interference at nominally 700MHz, #25 formulation is designed to cover this range with even some effect beyond that. For frequencies from 1 MHz to 30 MHz, #33 material offers a concentration of impedance in that range with a decreasing effect above 30 MHz. For microwave frequencies relating to Bluetooth™ 2.45GHz operations, the #20 material is available. See figure 1 above.

Electromagnetic Characteristics

Stated most simply, the operative characteristic which makes ferrites effective in RFI/EMI suppression is their variable sensitivity to frequency. With a ferrite installed as a suppressor, lower frequencies will pass with no significant loss. But above the frequency where (tan δ/μ) climbs sharply (see figure 1), the signal couples with the ferrite to create an impedance which is quite high compared with the rest of the circuit. The offending RFI is thus immediately and consistently blocked out by way of impedance damping of the unwanted high frequency signals. It is this greater resistive impedance which allows the basically passive, apparently simple material to suppress multiple signals in a variety of application situations.

fig. 2
Impedance comparison vs. cubic volume.

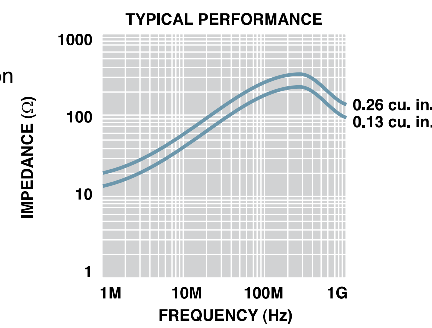
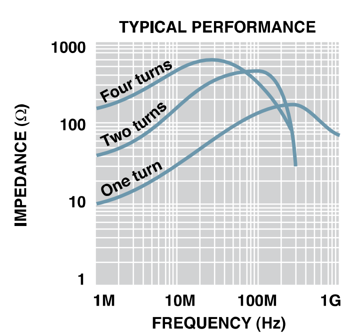


fig. 3
Two turn loop through ferrite increases effective magnetic path. Impedance increases by the square of the number of turns (N^2).

fig. 4
Increased impedance; multiple turns (N^2) vs. one turn through ferrite; i.e., 2 turns (2^2) = 4 times impedance





Organizing the Engineering Model

To understand the various practical modeling techniques employed with ferrite, it is best to prepare a properly engineered calculation of expected results. An empirical trial and error method may leave the circuit close to borderline performance without adequate safety margins. As indicated previously, a wide range of formulations is possible. The major application factors to be used when defining a specific ferrite solution for a particular interference problem include the following:

- Frequency where maximum attenuation is required.
- Amount of attenuation needed.
- Ferrite permeability formulation characteristics as they relate to the frequency range in question (i.e., initial permeability)
- Ferrite formulation consistency (i.e., expected range of variation in attenuation performance)
- Installation environment and mechanical attachment requirements.

The frequency range requiring attenuation must be matched to the performance of a given ferrite composition (figure 1 on previous page). The optimum profile would be a ferrite in which the highest attenuation level coincides with the disruptive frequency (A). That same ferrite could be used even if the frequency falls in a lower area of its impedance curve (B) but there would be correspondingly reduced attenuation. Conversely, a different ferrite formulation could be employed in the same frequency situation with the intent of using a lower part of its performance curve (C). Space and weight considerations are not normally a concern since good quality ferrites provide high performance per a given cubic volume.

The modeling procedure to calculate impedance characteristics of the source and load coupled with the ferrite suppressor is developed as follows:

$$\text{Insertion Loss (dB)} = 20 \log_{10} \frac{(Z_A + Z_B + Z_F)}{(Z_A + Z_B)}$$

Where:

Insertion Loss = A measure of the effectiveness of a filter, expressed in decibels, is described as the ratio of voltages with, and without, the filter in the circuit.

Z_A = Source Impedance
Z_B = Load Impedance
Z_F = Ferrite Impedance

If the circuit impedance ($Z_A + Z_B$) is 50 ohms and the ferrite impedance is 250 ohms, then the insertion loss will be:

$20 \text{ Log}_{10} (50+250)/50 = 15.56 \text{ dB}$

Even though the same unit of ferrite is used, the attenuation provided by a ferrite suppressor can differ somewhat as the original circuit impedance varies. The ferrite is more effective when the circuit impedance is low. For example, by using the same 250 ohm ferrite in a 75 ohm circuit, the result will be:

$$20 \text{ Log}_{10} (75 + 250)/75 = 12.7 \text{ dB}$$

With a high circuit impedance, it may be possible to increase the number of turns or passes through the ferrite (figures 3 and 4), or to use a larger amount of ferrite (cubic volume) in the circuit in order to achieve the same level of insertion loss (fig. 2). By increasing the number of turns (passes) through the ferrite opening, the "effective magnetic path" is increased – impedance then increases by the square of the number of turns (N^2) ; i.e., two turns (2^2) = 4 times the impedance. When additional ferrite volume is added, impedance increases on almost a direct percentage basis; i.e., a 100 percent increase in volume will provide about 100 percent increase in impedance (figure 2) in most situations according to certain prescribed dimensional ratios.

An alternative modeling procedure may also be structured in reverse by solving for a desired insertion loss goal. The result yields an impedance requirement. This can be matched to known performance profiles of existing ferrite configurations in the geometric style best suited for mechanical and packaging requirements.

As an example, a 15dB insertion loss is required for a flat ribbon cable at 100 MHz. Using the formula:

$$\text{Insertion Loss (dB)} = 20 \log_{10} \frac{(Z_A + Z_B + Z_F)}{(Z_A + Z_B)}$$

Where: IL = 15 dB
Z_A = 25 ohms
Z_B = 25 ohms
Z_F = Unknown ferrite impedance (solve for this value)

$$15\text{dB} = 20 \text{ Log}_{10} \left(\frac{50 + Z_F}{25 + 25} \right)$$

$$0.75 = \text{Log}_{10} \left(\frac{50 + Z_F}{50} \right)$$

$$5.625 = \frac{50 + Z_F}{50}$$

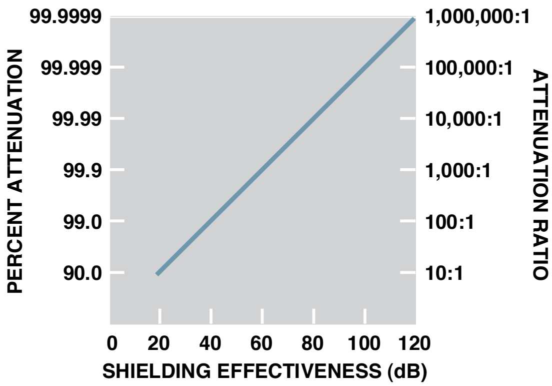
$$Z_F = 231.25 \text{ ohms}$$

Next, refer to the Attenuation Properties on page 36. The flat ribbon cable style part that closely matches is #28B2480 with a 250½ impedance at 100 MHz.

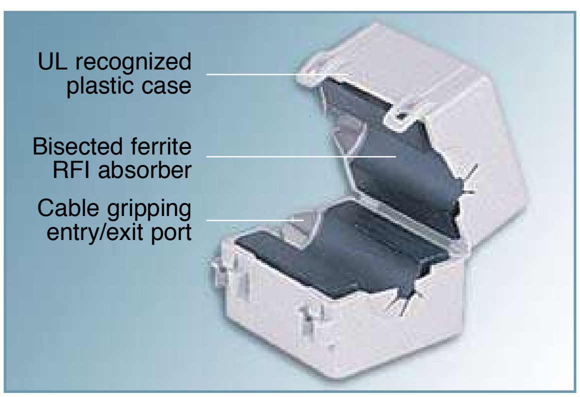
Once the ferrite suppressor is installed in the circuit, results should be confirmed by testing. Although these ferrites are "linear," the term is relative to the common operating range of temperatures. The permeability is different at every degree of temperature. The published initial permeability (μ_i) nomenclature applies to standard temperature, 59°F (15°C) only. There are only minor impedance differences, however, throughout normal operational ranges and up to 180° F (82°C). See Material Properties on page 33.

Controlling RFI/EMI

Any device used to block an RFI signal between its source and a receiver is an electromagnetic interference (EMI) shield.



The measure of this ability to attenuate RFI is Shielding Effectiveness, SE, which is expressed in decibels, dB, the ratio of field strength on one side of the shield to the other side. The figure above shows the relationship between shielding effectiveness (in dB), the amount of attenuation, and attenuation percentage.



Typical FerriShield RFI suppressor.

Design Support

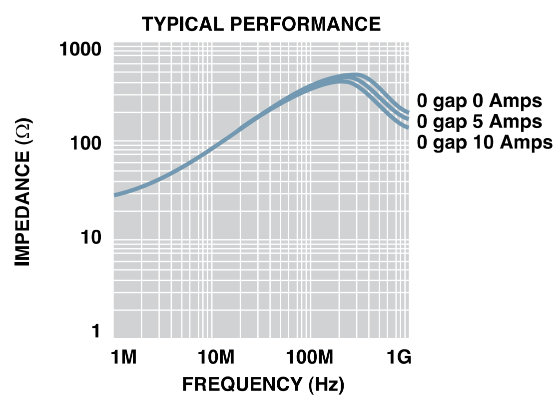
Engineering assistance is always available. We will be pleased to help with applications, cross-referencing or complete insertion loss calculations when a custom suppressor is required.

FerriShield Advantages

I/O cable with RFI suppressor.

The concept of bisected ferrites has been developed to address a number of industry needs in the area of Electromagnetic Compatibility, EMC.

- engineering adaptability
- risk-free engineering:
  - tight tolerance performance
  - easy to upgrade attenuation by changing size or number of turns.
- easy retrofitting
- convenient installation
- integral mounting features
- cost-effectiveness
- extended resistance to core saturation under Direct Current loads.
- consistent performance



Gap effect of ferrite subjected to direct current.

The technical air gap in bisected ferrites actually extends current carrying capability with only an imperceptible reduction in impedance versus solid ferrites of the same size. The gap is magnetically insignificant while it is electrically significant as a discontinuation, thereby accommodating more current.

For attenuation properties by frequency, see page 32

Installation is simple

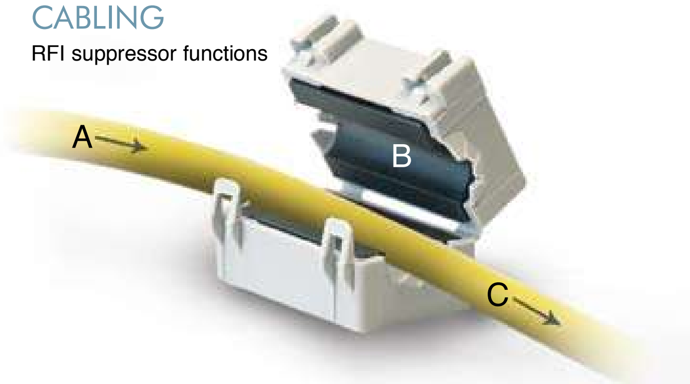
Just snap over circuit wiring to be controlled - even after wiring has been terminated Radio interference sources usually radiate their RFI power at frequencies above 30 MHz by way of the main cabling, which acts as an antenna.

Anywhere There is an Antenna-Like Structure

Electronic cabling and wires, by virtue of their length-to-width ratios, are perfect natural antennas. In the presence of high speed microprocessor signals, cables will conduct, radiate and/or receive unwanted high frequency interfering signals. Control of radio frequency interference can be assured by proper placement of an insertion loss device, such as a ferrite suppressor.

CABLING

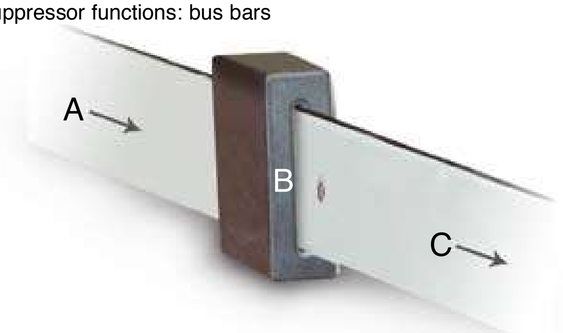
RFI suppressor functions



A. Data signals and high frequency interference signals absorbed and conducted
B. All high frequency interference absorbed by ferrite suppressor and thermally dissipated
C. Low frequency data signals pass unimpeded

BUS BARS

RFI suppressor functions: bus bars



A. Power distribution and high frequency interference signals absorbed and conducted
B. All high frequency interference absorbed by ferrite suppressor and thermally dissipated
C. Power distribution characteristics pass unimpeded

Application Points

FerriShield installation locations.

Advantages

Compared to other alternatives, ferrites' high resistivity per cubic volume stands out as the most important advantage. Prior to the development of bisected ferrites, suppression engineering was restricted to the costly addition of filters, cable shielding, and less versatile solid core (not bisected) ferrites. While these methods offer a degree of suppression, they are often awkward to install and, in many cases, are not completely effective. Bisected ferrites have a concentrated, homogeneous magnetic structure with high permeability. They are consistently stable versus time and temperature, and provide RF suppression without high eddy current losses.

For attenuation properties by frequency, see page 32