Bisected Ferrite Suppressors

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INTRODUCTION

Bisected ferrite components have become an increasingly popular choice among the arsenal of weapons available in the continuing battle against EMI. In the process, electronic engineers have noted a particularly useful feature of bisected ferrites; not only do they offer a new level of convenience and cost-effectiveness for taming unwanted signals, but they also yield higher RF attenuation performance due to the slight intrinsic air gap at the mating surfaces under dc loads. This air gap also prevents core saturation when dc current is applied.

While ferrites made of high permeability materials have been used in impedance applications for many years, incorporation of the design concept featuring mating halves has been more recent. Initially, solid tube-like sections known as beads were the most common configuration for EMI control. The concept of bisected ferrites evolved subsequently to address a number of industry needs, including cost-effectiveness, convenience and engineering adaptability.

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ENGINEERING CONSIDERATIONS

Production Environment. Solid, one-piece ferrites require installation within circuits or devices before final assembly, since they cannot be installed with connectors or other terminations already in place. Further, a solid bead frequently requires additional positioning and attachment by various methods, such as shrink wrapping, overmolding or external cable ties.

By contrast, bisected ferrite assemblies can be applied at any time in the manufacturing process. When the bisected configuration is supplied in an integral mounting device, such as a hinged clamp, it can simply be snapped into place (Figure 1). Such assemblies usually provide a built-in method of maintaining a set position. Usually, this is in the form of a gripping mechanism on the case which locks onto a cable, an adhesive mounting surface, a snap-in mounting post, or a provision for a hardware mount such as a push rivet or screw (Figure 2). Both installation and affixing can be easily accomplished in seconds.

Cost-Effectiveness. Bisected ferrite assemblies should be considered as alternatives to filters, shielded cables and connectors, and extensive onboard suppression, for reasons of component cost, engineering cost and convenience.

In addition, just one properly placed ferrite can meet the suppression needs for most cables, which have innate antenna-like characteristics. Today's ferrite technology has produced a gamut of general purpose formulations which accommodate most common industry requirements. Consequently, a minimum of engineering is required to specify unilateral coverage for a wide range of frequencies where, by contrast, a number of different, specific filters might be required.

Easy Retrofit. Running changes and fine tuning of systems can be accommodated most easily

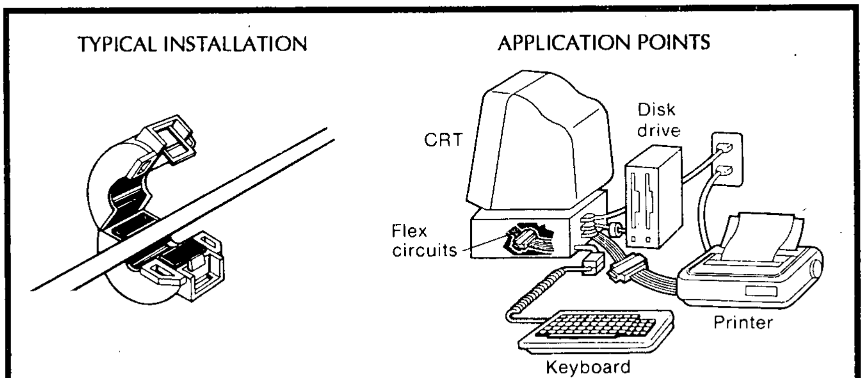

FIGURE 1. Application Points and Typical Installation of Ferrite Suppressors.

*See Advertisement on Pages 6&7.

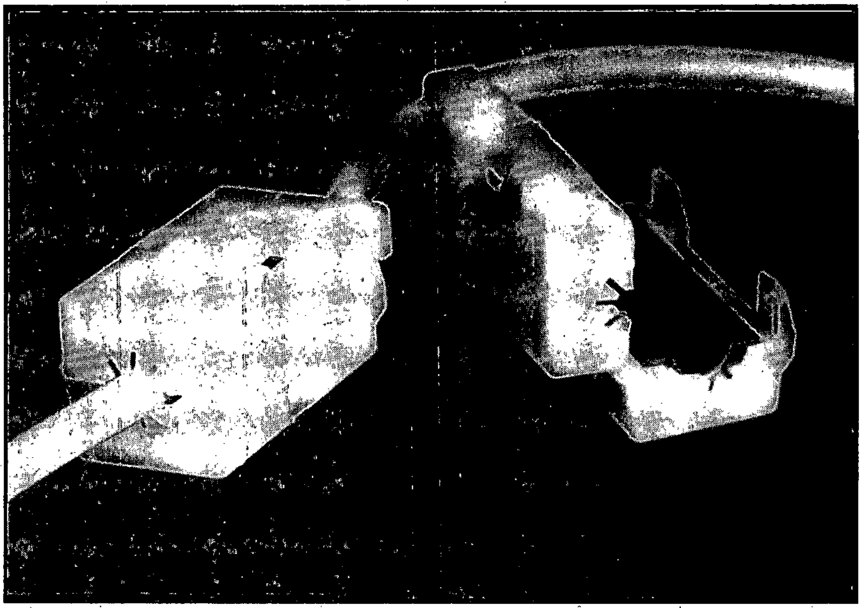

FIGURE 2. *Bisected Ferrite Assembly with Cable Grip-lock.*

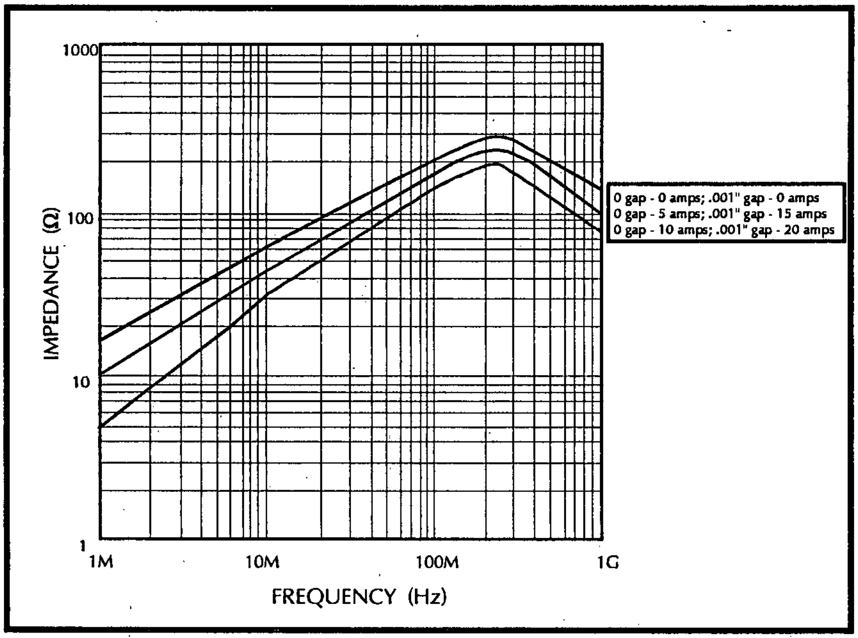

FIGURE 3. *Gap Effect of Ferrites Subjected to Direct Current.*

with split ferrite configurations. In situations where, due to a design change, revision of an entire circuit or cable subassembly is necessary to increase effective shielding, bisected ferrites can be installed as a single add-on component at any time a change, problem or need is encountered. This retrofit characteristic also facilitates field solutions for problems encountered in the end-use environment.

OEM engineering for such retrofit applications is straightforward, either through simple modeling techniques (described below), or even less demanding empirical methods.

Engineering without Risk. The impedance provided by ferrites is closely related to the cubic volume of the material in the suppressor; nearly a direct correspondence exists between a size increase and the resulting impedance increase. Therefore, if discrepancies are encountered which differ from preassembly test results, or if certain operational modes are found to require better shielding effectiveness, split ferrite assemblies facilitate either substitution of a larger size, or addition of a second suppressor, and thus shift attenuation results away from borderline situations and into a more comfortable performance margin.

Extended Resistance to Core Saturation under Direct Current Loading. One previously overlooked advantage is the resistance of split ferrite suppressors to the saturation effect of direct current in a circuit. The air gap in bisected ferrites actually extends their current-carrying capability with only a minor reduction in impedance, compared with solid ferrite cross-sections of the same volume and formulation. For applications where lines carrying high currents are a factor, a significant reduction in attenuation can be expected due to saturation, unless the ferrite core has a gap. With split cores, however, more current can be accommodated without disruptive saturation while the mating halves still form a complete magnetic field; the gap is electrically significant as a discontinuation, but magnetically insignificant (Figure 3).

SUPPRESSION WITH FERRITES

By way of their frequency sensitivity characteristics, ferrites introduce an impedance to a circuit. They are formulated to allow passage of the desired low frequency currents which follow the conductor, while high frequency energy couples with the ferrite and is selectively dissipated. The insertion loss occurs in a compound manner as two major factors form a vector interaction with the circuit: an inductive reactance at low frequencies and a resistivity at higher frequencies. Unwanted energy is absorbed at an increasing rate as the ferromagnetic resonance of the material is approached. This is the point where the permeability of the material decreases and significant signal loss occurs. High frequency energy is dispersed thermally from the core.

Circuits can be reliably tuned by selecting an appropriate ferrite formula and mass of material. Formulations are ceramic compounds consisting principally of iron oxide and one or more other metals such as zinc, cobalt, and nickel. While it is possible to formulate a perfect composition for each and every application, it is not practical. Accordingly, general purpose formulations are available which serve the EMI frequency range with insignificant compromises or trade-offs. To engineer a solution, the following steps are suggested:

1. Identify the highest frequency where maximum attenuation must occur.
2. Match a ferrite permeability formulation RF performance profile to that frequency range, i.e., the highest attenuation characteristics should closely coincide with the undesired frequency (Figure 4).
3. Determine the amount of attenuation desired.
4. Assure consistency according to the expected range of variation in attenuation performance due to formulation and manufacturing reliability. Also, environmental factors such as elevated temperatures and direct current loading effects should be considered.
5. Consider the mechanical installation environment, i.e., size and attachment methods.

An insertion loss model, illustrated in Figure 5, measures the effectiveness of a filter or suppressor by describing the ratio of voltages with and without the filter in the circuit according to the following formula:

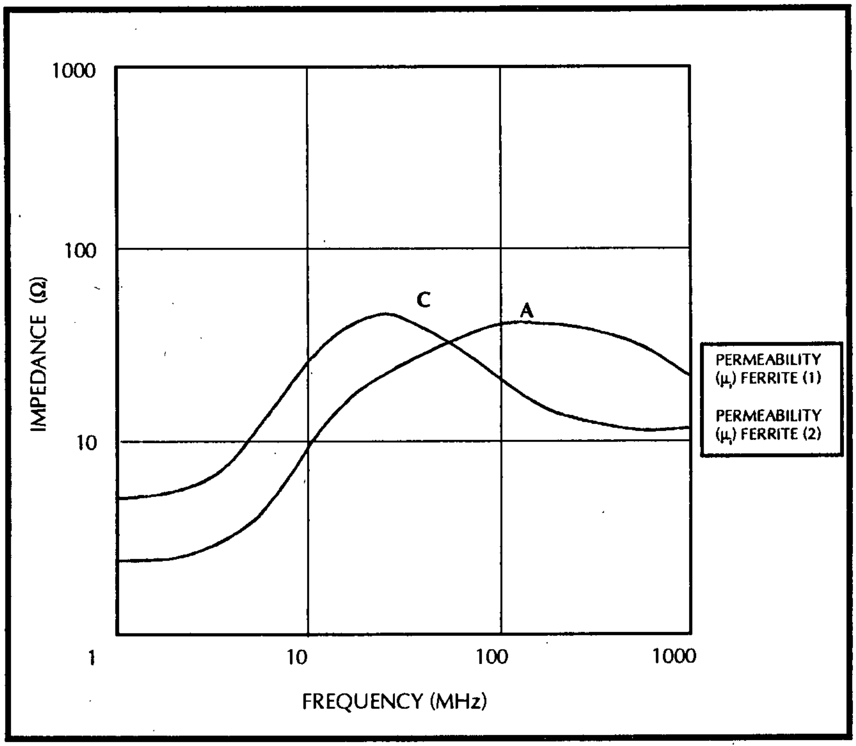

FIGURE 4. *Typical Attenuation Profiles of Two General Purpose Ferrite Formulations for EMI Frequency Range.*

Insertion Loss (dB) =

$$20 \log_{10} \frac{(Z_A + Z_B + Z_F)}{(Z_A + Z_B)}$$

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

As an example, in the case where a 15 dB insertion loss is required at 100 MHz when the source and load are 50 ohms, the required ferrite performance can be calculated as follows:

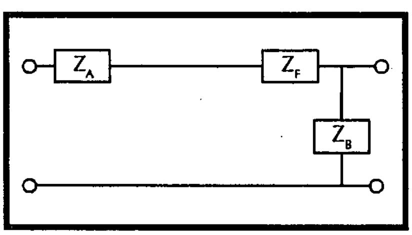

FIGURE 5. *Insertion Loss Model.*

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

$$0.75 = \log_{10} \left(\frac{50 + Z_F}{50} \right)$$

$$5.625 = \left(\frac{50 + Z_F}{50} \right)$$

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

Next, known attenuation profiles of ferrite configurations suited for the application are consulted and one which has 231.25 ohms or more at 100 MHz is specified (Figure 6).

Once the ferrite suppressor is installed in the circuit, results should be confirmed by testing. Although today's formulations 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 measurements taken at a standard temperature (59°F) only. There are only minor impedance differences, however, throughout normal operational ranges and up to 180°F. Therefore, in most calculations, this factor is not considered, although it is important to remember from the standpoint of sound and comprehensive engineering practice.

The packaging of bisected ferrites is the key to their versatility. Supplied in plastic cases, they can be closed around a circuit, cable or bundle with a hinge-action and clamped into permanent position. Variations include running a double loop through the same opening, especially on round wires or cables where space permits. This allows for some increased impedance at lower frequencies,

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and thus for fine tuning of the application. In addition, after circuitry is in place, another alternative is to use a single ferrite with a large enough inside diameter to allow assembly to an entire bundle of cabling. This is very effective since the suppression occurs somewhat independently with each circuit as needed, or with the entire group of circuits at one time (Figure 7).

A recent FCC ruling allows the use of ferrite suppressors in lieu of specific I/O video cables for monitors. This offers a unique cost savings to computer system manufacturers, since it eliminates the unnecessary shielded cabling which was previously required. Instead, a ferrite suppressor may be provided for installation when the system is assembled by the customer. All that is required is a set of instructions at the time of installation, to be followed when configuring the system.

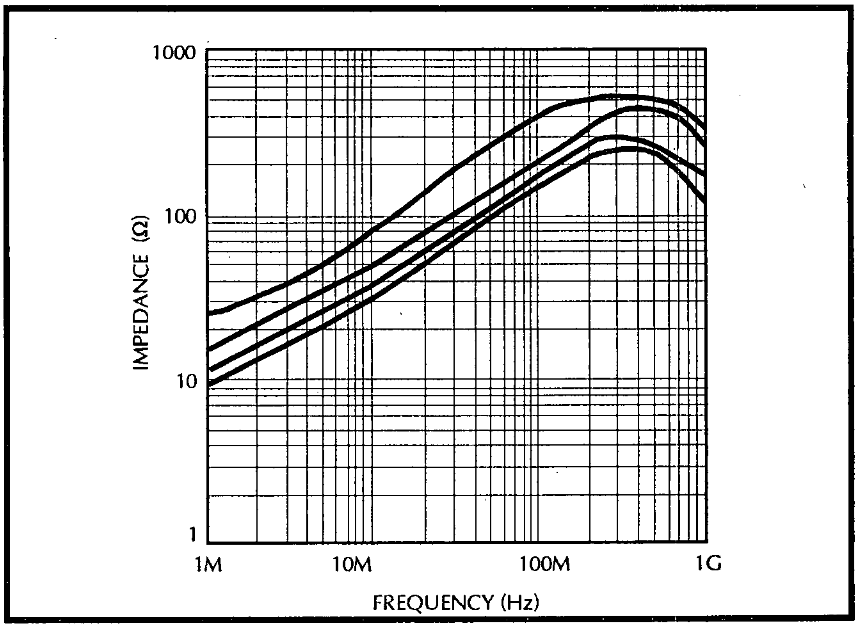

FIGURE 6. *Range of Specific Impedance Properties of Ferrites.*

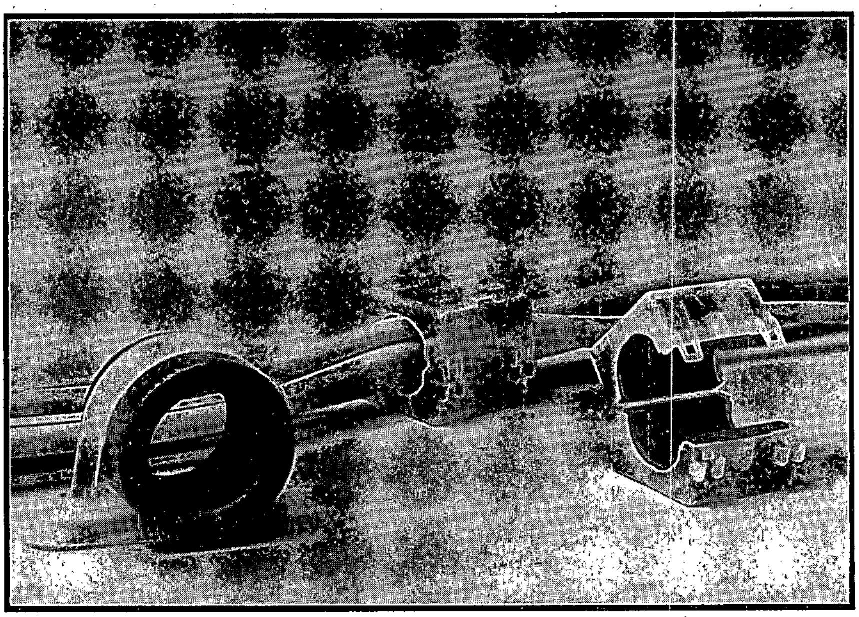

FIGURE 7. *Large Diameter Ferrites.*

CONCLUSION

Overall, ferrite suppressors offer reliability, consistency and flexibility, while minimizing space requirements. Existing formulations and geometries are high in resistivity and can be considered a primary suppression method as frequencies increase and computer devices decrease in size. Split geometries contribute added advantages in cost, installation, performance and resistance to dc saturation.

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