Saddle Bead Ferrites: Proximate RFI Suppressors

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Wireless suppression of radio frequency energy for board components is available through a new breed of ferrites.

Shielding with Ferrites

Ferrite shielding materials are now widely accepted as cost-effective, convenient solutions to radio frequency interference problems for many EMC practitioners in the electronics industry. Over the past two decades their use has grown and they are now one of the most popular compliance techniques for the attenuation of high frequency energy.

Originally, a simple cylindrical or box shape with a central hole for the passage of a cable was the common application form. In the last ten years, a split version of the shapes proved to be just as effective, and also offered convenient installation, mounting and cable routing options. These bisected ferrites, when clamped into position over a cable, act as a single unit electromagnetically. Further, they permit high levels of DC current carrying capability without saturation, compared to the solid ferrites of the same dimension, due to the presence of the technical air gap at the mating surfaces. Magnetically the gap is insignificant, while electrically it is a discontinuation.

The basic composition of ferrites is a combination of ferrous oxide (iron) and one or more other powdered metals – most often nickel, zinc, manganese and cobalt. An almost infinite variety of formulations are possible, but the wideband nature of these materials allow just a few primary combinations to service today's spectrum of frequency concerns, probably the single most important characteristic permitting the cost-effective universal application of just a few general-purpose commercially-available materials.

Performance Potential

The common measure of ferrite performance potential is permeability. This property expresses the ratio of the magnitude of magnetic induction to the magnetizing force, and is thereby associated with impedance damping effects of the discrete permeability of any particular formulation.

Generally speaking, engineers have come to rely on certain permeabilities as a signature of the performance of their interference solutions over a wide ranges of frequencies. Correct procedure particularly targets the frequency where the maximum attenuation is required, and also further presumes sufficient suppression from the same component at higher harmonics (Figure 1). With such a variable sensitivity to frequency when a ferrite is installed in a circuit, lower frequencies pass unimpeded and higher frequency energy couples with the ferrite at the points beyond the material's ferromagnetic resonance where a rapid increase in high frequency losses occur. Since energy is neither lost, nor gained, it is dissipated as imperceptible heat energy.

Saddle bead ferrites are essentially no different than the accepted fully circumferential geometries. They are just half of the physical shape profile, and depending on the application, frequencies and position in the circuit, 35%-40% of the impedance effect of the fully circumferential styles can be expected. In situations where other shielding methods are not practical, this new methodology proves to be very effective. They fit conveniently in most problem areas since space requirements are minimal (Figure 2). Mounting over, or actually attaching to, the component in close proximity (like a saddle on a horse) yields suppression characteristics that are more effective than component shielding enclosures which can capacitively couple and resonate (Figure 3).

Since the most effective way to con-

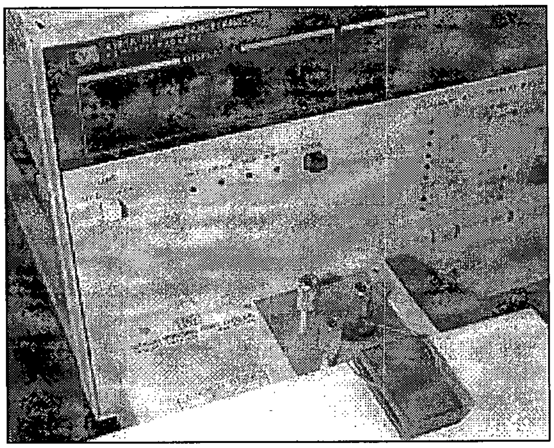


Figure 1. *Attenuation Tester with Fully Circumferential Bisected Ferrite over 25-ga Test Wire Exhibiting a Combined 270-ohm Resistance.*

*See advertisement on page 7

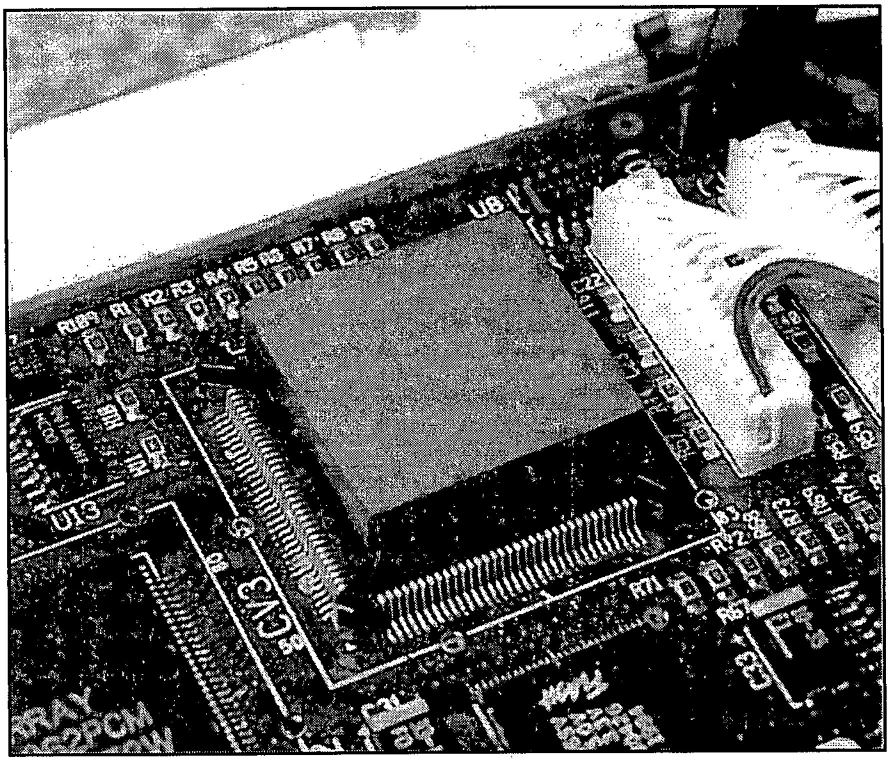


Figure 2. *Saddle Bead Ferrite.*

trol interference is at its source, the new bead concept now enables probably the closest integration of suppression known to date. Whether a radio frequency interference solution involves enclosure gasketing, on-board suppression components or shielded wiring, these methods are removed by distance, and by definition, are not at the source. As a result, the suppression methods must be more extensive and usually require multiple fixes using these traditional add-on components.

Engineering flexibility of the electronic package is always a consideration, and usually one in which inexpensive options are few. Ferrite suppression relies heavily on the effective magnetic path length of the radio frequency circuit versus the suppressor.

With solid or bisected ferrite beads, the length of travel through the bead can be increased by lengthening the bead itself or by looping the circuit through a number of times. The point of peak suppression rises dramatically using either method. Saddle beads exhibit the same characteristics and results can be manipulated by applying different geometries while usually satisfying any mechanical packaging considerations with ease.

Test Results

With such a new concept, it may be helpful to document an empirical comparison. Figure 4 shows test results of a ferrite suppressor with an increasing gap opening from 0° to 180°. The 180° gap position corresponds to the saddle bead design concept. In the case shown, twice as much suppression material surrounds the circuit at 0° gap than at 180° (Note 1). To simulate the same mass at 180°, two ferrite halves were stacked one upon the other resulting in the higher reading (Note 2). This approximates as true a comparison of the two geometries as may be of practical interest for such an evaluation.

The insertion loss can be modeled using the standard formula, which compares the circuit with the saddle bead installed to the original circuit without the saddle bead. The following example adds a saddle bead to a circuit with 100-ohm impedance at 100 MHz.

Insertion Loss (IL) (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

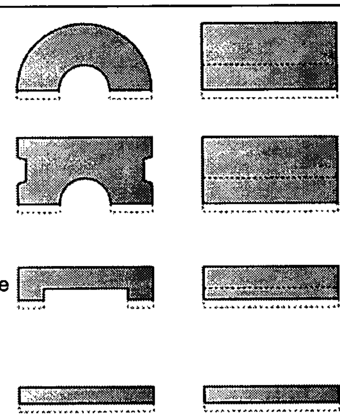
$$IL = 20 \log_{10} \frac{(70 + 100)}{(70)}$$

$$= 20 \log_{10} (2.428)$$

$$= 20 \times 0.38525$$

$$= 7.7 \text{ db}$$

Installation and mounting options include self-tack double adhesive tape, electronic RTV adhesives or even heat sink compounds. The latter will give an additional bonus of thermal dissipation



Type	End View	Side View	Applications
Half-toroid			
Half-sleeve			PC board mount over components and wiring
Rectangular plate			Direct mount on microprocessors in place of metal shielding.
Square plate			

Figure 3. *Common Profiles for Board and Direct Component Mounting.*

Ferrite Gap Opening (+ = test wire location)	Impedance (ohms) @ 100 MHz with 70-ohm test wire load	Net Impedance (ohms) @ 100 MHz without 70-ohm test wire load
0° bisected ferrite	270	200
30°	159	89
60°	126	56
90°	121	51
120°	119	49
150°	117	47
180° note 1 *(half mass saddle bead)*	114	44
180° note 2 *(same mass saddle bead)*	140	70

Figure 4. *Impedance Comparisons as Gap Opening Increases.*

for components which now use heat sinks or bridges for thermal management.

Testing is recommended to confirm expected results since positioning and component selection can vary the effective magnetic path, and therefore the resultant suppression effect. Mechanically, there are convenient shapes and sizes available for most applications. The primary consideration should be to introduce as much suppression material as practical along the length of any cable or wire circuit (12 to 25 mm); and in the case of board components, to cover as much of the top surface as practical.

Insertion loss device options are now effectively expanded with the saddle bead technique. After-the-fact tweaking is now easier, less costly; and, product time-to-market compliance delays can be decreased with reliable performance.

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