MAGNETIC SHIELDING: A RUDIMENTARY SYNOPSIS

FIRST THERE WAS MAGNETIC INTERFERENCE

In the beginning there was earth's field.

The pervasive earth's magnetic field can be a detrimental factor in achieving accurate results from some experiments, research, and testing. Equipment operation can also be adversely affected.

Structural steels and an abundance of other man-made ferromagnetic objects contribute to undesirable environmental magnetic conditions.

Modern building construction, with its lower ceilings and increased number of reinforced steel beams, has created magnetic problems. The lower ceilings bring steel beams closer to sensitive equipment, thereby presenting magnetic fields that affect performance. Laboratory researchers and production technicians frequently mull over the cause of interference, especially when they had no such problem with the same equipment or identical equipment at a previous location.

THEN CAME ELECTROMAGNETIC INTERFERENCE

Electromagnetic interference can originate from various sources. These sources include components such as motors, transformers, solenoids, coils, electromagnets, high-current cables, power generating equipment, and a variety of mobile or nearby radiating electronic and electrical gear.

A NEED FOR MAGNETIC SHIELDING

Magnetic shielding is a properly selected metal alloy placed around or adjacent to a circuit component to suppress radiated magnetic fields interfering with other nearby components, or vice versa. To assure optimum performance, stray magnetic fields must be directed around critical electronic components as a rock in a river diverts running water. This is accomplished by a magnetic shield of high permeability (indicative of the ability of a material to conduct magnetic flux) which provides a low reluctance path guiding the magnetic flux around the critical area.

More and more, engineers are learning the necessity of using magnetic shielding to achieve the performance desired from components and systems. Denser packaging has incited much of the recent interest in magnetic shields. With components positioned ever closer together, and radiating components affecting adjacent components, increased electromagnetic interference frequently occurs.

To shield out a magnetic field, its source or sources must first be determined. Usually, this is not difficult, but sometimes the source seems to elude discovery. For example, interfering magnetic fields are several times greater in modern, low-ceilinged concrete structures than in older, higher-ceilinged buildings of different construction. This can be immensely perplexing until the realization dawns that numerous reinforcing steel beams are incorporated into concrete construction, and that low ceilings bring the resulting steel beams' extraneous magnetic interference much closer to sensitive equipment than in higher-ceilinged rooms of different construction.

Electromagnetic components within the same housing must be investigated as a prime source of interference. Also, other equipment in close proximity must be considered as a possible source.

Multiple sources of interference are often present and must be evaluated.

Once the unwelcome field's source is discovered, consideration is given whether to shield the source or the affected components. When it is practical to do so, it is preferable to shield the affected component or components, rather than the offending source.

Other factors to consider in specifying the optimum shield are the strength of the field, the number of shielding layers required, whether to use a high or low permeability alloy or a combination thereof, the shape of the shield and the accessibility of the component to be shielded. It is vital that the shielding alloys selected do not saturate when properly used, do not suffer excessive permeability loss from shock, display minimum retentivity, and exhibit relatively stable permeability characteristics after final anneal, avoiding the expense and inconvenience of regularly repeated annealings.

For lighter fields, a single layer shield can suffice. Two or more layers must be used for stronger fields. The shielding material which best matches a particular application should be chosen after analyzing the field. Among the major factors considered are permeability, saturation, shock sensitivity, and proper annealing after fabrication.

After the magnetic requirements have been established there remains the annealing, the mechanicals, and the aesthetics.

Shield shapes may range from simple to quite complex. In complex applications, shields are tailored to fit exactly and can consist of many unusual configurations.

Cylindrical, conical, and box-shaped configurations constitute the most common shielding enclosures. The cylindrical design is best for scan converter and photomultiplier tubes, degaussed rock transports, isolation chambers, storage tubes, motors, meters, and tiny vacuum tubes. Cathode ray tube shields usually are conical. The box-shaped shields are suited for video recorder head assemblies, magnetic tape containers, transformers, aircraft weather radar, power supplies, and reactors.

The most effective magnetic shielding enclosures are designed and fabricated to meet specific requirements.

Magnetic field interference usually is discovered when the completed assembly is tested. Shielding becomes imperative but not enough space has been allowed by the designer. Jamming some shielding into the inadequate area helps but doesn't produce the full performance desired.

In accordance with the time-tested "ounce of prevention," the shield should be incorporated at the equipment manufacturing stage whenever possible. CRTs are a good example. Retrofitting the optimum shield is often expensive and sometimes impossible if the designer hasn't allowed sufficient space. If the shield is designed into the assembly at the very beginning, optimum shielding is easily attained.

AN OUNCE OF DESIGN IS WORTH A POUND OF RETROFIT

Magnetic shielding techniques are most valuable and more economical in the design and prototype stages.

Without magnetic shielding much of today's sophisticated electronic gear would be larger, less efficient and in some magnetic environments, impossible to function at all. As components are made more sensitive and packaging denser, susceptibility to electromagnetic interaction increases dramatically even in the best engineered layouts.

As a final consideration, assistance with shielding problems is available from experienced reputable manufacturers of magnetic shielding.

This article was prepared by Lester Dant, Vice President, Ad-Vance Magnetics, Inc., Rochester IN, and is published with permission.

NOMOGRAPHS OF MAGNETIC SHIELDING EFFECTIVENESS

Shielding effectiveness (SE) describes the ability of a given material to act as a shield against incident magnetic fields. It is composed of three factors: reflection losses (R), absorption losses (A) and secondary reflection losses (B). These factors can be calculated separately and added as follows.

$$SE = R + A + B \text{ (dB)}$$

The R and A can be determined by using one nomograph each; however, the B is complex and requires both a nomograph and a graph.

ABSORPTION LOSSES

Absorption losses (A) are a function of the physical characteristics of the shield and are independent of the type of source field. For a given thickness, magnetic material (steel) provides higher absorption losses than non-magnetic material (copper). When reflection losses are low, thicker, high-permeability materials are employed to increase shielding effectiveness. The nomograph in Figure 1 is used to determine A.

REFLECTION LOSSES

The computation of reflection losses can be greatly simplified by considering shielding effectiveness for incident electric fields as a separate problem from that of magnetic fields or plane waves. The nomograph in Figure 2 solves the equation for R.

SECONDARY REFLECTION LOSSES

When absorption losses are very low (less than 6 dB), the magnetic shielding effectiveness due to reflection losses changes. The B can be found by using Figure 3.

PERMEABILITY INFLUENCES SHIELDING EFFECTIVENESS

Magnetic shielding effectiveness calculations are highly dependent on the permeability (μ) of the shield. It has long been thought that permeability decreased at higher frequencies, and that saturation due to exposure to high-intensity magnetic fields also produced a loss of shield permeability.

This is not entirely true. The more common building metals (i.e., cold-rolled steel, galvanized steel, hot-rolled steel) do not change permeability with frequency, and show only one to 3 dB variation in SE when exposed to high intensity fields (2 Oersteds). Higher permeability materials show both a change of permeability with frequency and a 5 to 8 dB saturation loss in 2 Oersted fields.