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Coupled Magnetic Probes Compare EMI Absorber Materials

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This article decribes the procedures and results of lab experiments comparing the relative attenuation performance of two different EMI absorber materials

With engineers facing ever-increasing regulatory compliance concerns, they often employ various types of EMI absorber materials that have come to market. Material selection is important to achieve regulatory compliance and system performance. Surface currents resulting from incident magnetic fields cause re-radiation of H-fields and often need to be reduced to meet regulatory goals. Unwanted surface currents can also interfere with other circuitry, preventing proper system operation.

Most absorber materials employ some form of magnetic material such as carbonyl iron or ferrite powder in an organic binder. These materials are usually supplied in thin, flexible form, sometimes with an adhesive backing, for easy application. At higher frequencies, eddy currents within the magnetic particles attenuate H-fields that arise from nearby circuitry or radiating structures.

A simple surface current reduction test fixture (SCRF) is presented which allows comparison of absorber materials at radio frequencies. Absorber-induced changes in probe-to-probe isolation are used to compare absorber materials. The fixture may help narrow the material selection down to the best one or two for problem EMI frequencies.

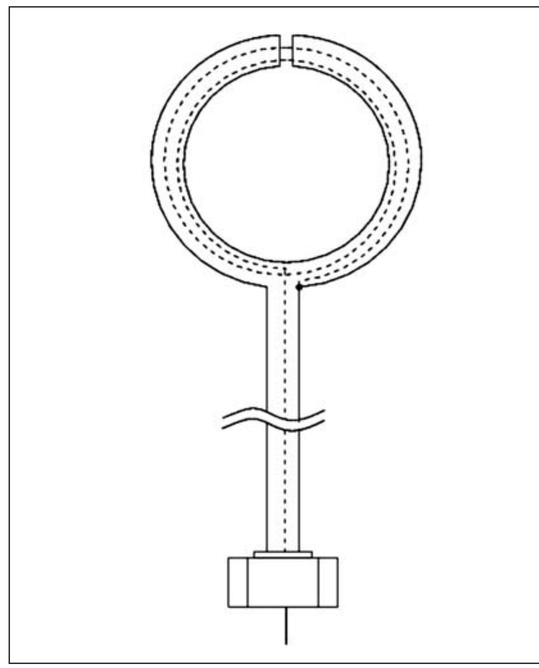

Figure 1 · Schematic view of the H-field test probe. Copper tape and RG-174 coax were used for its construction.

H-Field Probe Description

The SCRF consists of two electrostatically shielded H-Field probes (Figure 1). The probes are oriented at right angles to each other. One probe is connected to a swept RF source, the other to a swept receiver. The probes are carefully positioned such that minimum coupling (maximum insertion loss) between probes is attained. A high degree of isolation (70 dB or greater) is desired over the range of interest, so that maximum sensitivity can be obtained. The probe shown in Fig. 1 was used over the RF range of 3 to 600 MHz.

A piece of conductive material similar to the absorber mounting surface is placed adjacent to both magnetic probes, causing surface currents and re-radiation from the source probe into the receiving probe. An increase in measured coupling occured when a conductive plate was inserted between the isolated probes. Covering the conductive sheet with a sample of an EMI absorber material caused a measurable decrease in re-radiation. This change in re-radiation (change in fixture insertion loss) was used to compare absorber material performance.

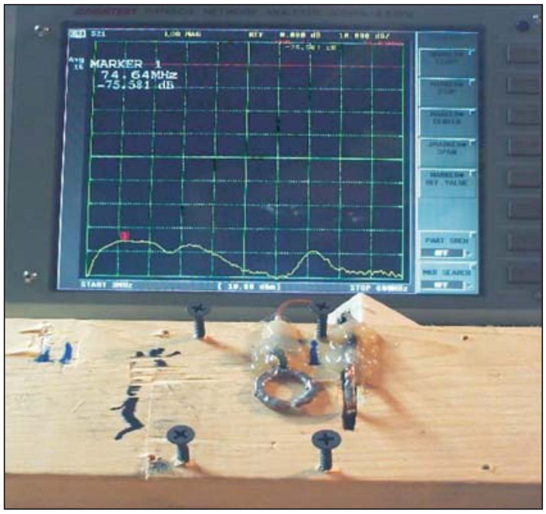

Figure 2 · View of twin-probe fixture, after tuning (adjusting probe positions) for maximum isolation between probes from 3 to 600 MHz.

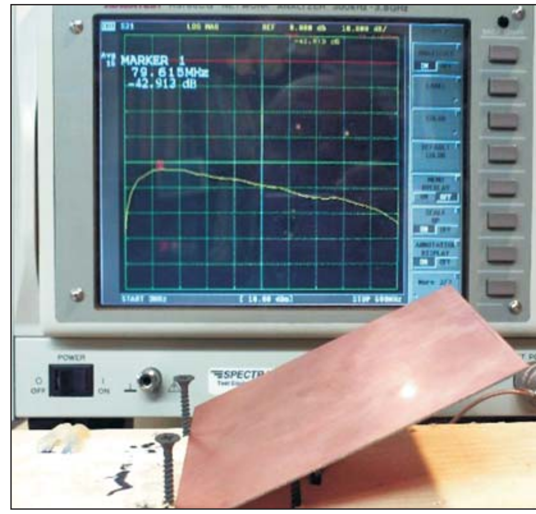

Figure 3 · Insertion loss between the twin magnetic probes with a copper reflective surface and no absorber material from 3 to 600 MHz.

The shielded magnetic probe was designed to be insensitive to electric fields. Since most absorber materials operate on H-field radiation, the absence of E-field response is important. E-fields would bypass the absorber material and render the test fixture insensitive to H-field characteristics.

Test Fixture Construction

The probe that was built is shown in the diagram of Fig. 1. The probe consisted of 2 turns of #24 AWG solid PTFE insulated wire wound on a 15 mm mandrel. The configuration was chosen for the desired frequency range. Larger diameter probes with more turns are more sensitive at the expense of a lower maximum usable frequency.

One end of the probe was soldered to the inner conductor of a coaxial line, the other end to the coax shield. Copper tape was wound over the probe, to completely cover the probe, except for a small (2 mm) gap opposite the coax attachment point. If this gap is not provided, the probe is effectively shorted and shielded to both H and E fields and is useless. Liberal use of solder connected the tape to the coax shield and each tape turn to the next. Two identical shielded probes must be constructed. The probe pictured in Fig. 1 was used from 3 to 600 MHz. Probes from commercial sources are also available, and should be usable.

Regardless of the probe "build or buy" choice, the probes must be carefully aligned at right angles as shown in Figure 2 to achieve minimum coupling. A simple block of wood or plastic makes a convenient support. One probe was connected to a swept RF source; the other to a tracking receiver. While a vector network analyzer was used in the lab, a spectrum analyzer/tracking generator will function well as long as at least 70 dB of isolation can be obtained between the tracking generator and spectrum analyzer ports.

The probes must be mounted on a dielectric block such as wood or plastic. The fixturing can be as simple as a wood block, using screws for sample holders as shown in Fig. 2.

The most difficult part of construction is probe alignment for minimum coupling. The first probe is solidly adhered to the support. The second probe must then be carefully aligned in two dimensions to minimize coupling. A suitable technique is the use of high temperature, quick set hot melt glue which is applied only after the approximate probe position is established. Then the probe is adjusted by hand to the precise position to achieve minimum coupling as the glue sets. 80 dB of isolation was achieved over a two-decade frequency range after about 1 hour of careful trial-and-error tweaking using the hot melt method. The use of one or more clamp-on ferrite beads to reduce radiation from the coaxial test fixture cables may be helpful in achieving maximum isolation over a wider bandwidth.

For best results, the distance between the probes at their closest point should be between 1/2 and 1 probe diameter.

Once the fixture is complete and adjusted for maximum isolation, a metallic sheet of material similar to the intended absorber mounting surface is brought into the proximity of both probes, as shown in Figure 3. The conductive plate is positioned for best coupling. A decrease in isolation of 20 dB or more was noted in the unit assembled by the authors. A simple mounting arrangement was constructed to achieve a repeatable position for testing.

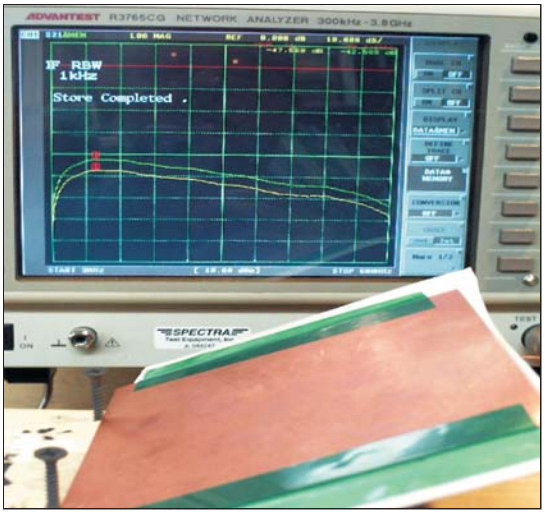

Figure 4 · Increased probe-probe insertion loss due to absorber material A, 3-600 MHz. Absorber material is taped to a sheet of copper, and is downward-facing.

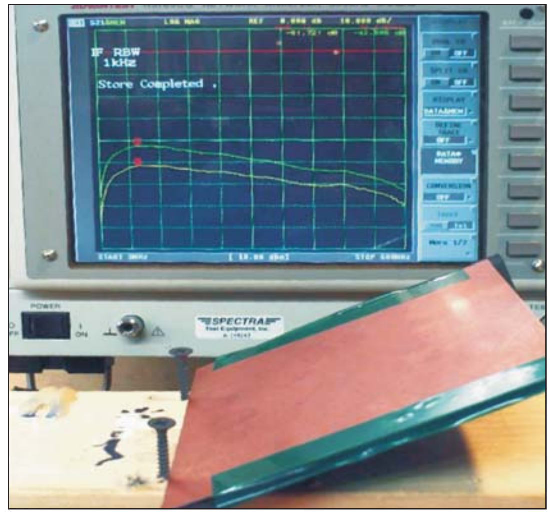

Figure 5 · Increased probe-probe insertion loss due to absorber material B, 3-600 MHz. The upper trace is the reference response with no absorber.

Measurements were made at RF from in this range. Material B exhibited insertion loss that was 2.5 dB greater than material A.

While the surface current reduction numbers generated are not absolute measurements of expected EMI reduction, the fixture allows materials having the best absorption characteristics for a frequency range of interest to be identified.

Test Procedure

A sample of test material was taped to the metallic sheet and placed in the holder on the SCRF. The coupled signal level was directly measured by the receiver and compared with the saved reference trace of the coupled signal on the metallic sheet without absorber.

While a vector network analyzer (VNA) is ideal to provide the swept RF source and receiver, a scalar network analyzer that covers the frequency range of interest is also a good solution. Lacking these pieces of test equipment, absorber comparisons can be made with a lower cost spectrum analyzer and tracking generator. All three instruments will allow swept measurements over the bandwidth of the H-Field probes. If noise is a problem at only a few frequencies, a signal generator and any test receiver can be used if swept equipment is not available.

Test Results

Samples of various EMI absorber materials from two sources [1, 2] were compared in the Surface Current Reduction Fixture. The metallic surface chosen was copper clad FR-4 PCB stock. The size of the PCB stock was 10 probe diameters on each side. A copper-clad surface was oriented toward the probes.

Figure 4 shows the attenuation of material A in the SCRF relative to the attenuation from a copper clad FR-4 surface with no absorber present. The upper trace is a reference trace (no absorber), while the lower trace shows the added loss due to the absorber under test. The added isolation was 7.5 dB.

Using the same test conditions as Fig. 4, the measurement of material B, shown in Figure 5, had 10 dB of attenuation over a frequency range of 3 to 600 MHz, which is 2.5 dB greater than the 7.5 dB attenuation in Figure 4. Again, the upper trace is a reference trace containing no absorber.

Conclusion

A simple Surface Current Reduction test Fixture (SCRF) was devised to compare relative absorption characteristics of different EMI absorber materials in a lab environment. Comparisons of insertion loss between two isolated H-field probes were used to compare two absorber materials from 3 to 600 MHz.

References

1. Brigitflex Inc., www.brigitflex.com

2. ARC Technologies Inc., www.arc-tech.com

Author Information

David Pacholak (BSEE Oakland University 1976) has headed Creative Electronics Consultants since 1983. In addition to providing EMI Compliance services to Industry, he has participated in Government programs and served as a product development consultant in the power conversion, pulse power, induction heating, RF and high voltage areas. Mr. Pacholok can be reached by e-mail at: cec@dls.net or by phone at 847-809-2786 or 847-428-5676.

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