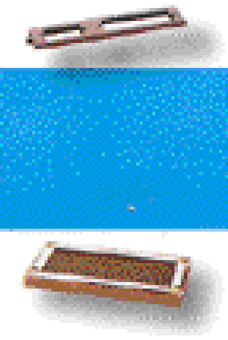
Laird Technologies

TECH NOTES

LAIRD TECHNOLOGIES



#105

SHIELDING DESIGN AND CALCULATION

By Ron Brewer

Shielding of electronic equipment is used as necessary to attenuate radiation from emitters and/or to attenuate radiation that may interfere with circuits that act as receptors of RF energy. Depending upon the application, these enclosures may be small PC board mounted boxes, equipment enclosures, or large scale building structures. In new equipment designs, shielding should be used in conjunction with or after circuit suppression, isolation, and desensitization measures have been implemented. For existing off-the-shelf items, shielding can frequently be used as a stand-alone solution to the interference problem. In any case, the shielding effectiveness depends upon the properties of the enclosure materials, the incident RF wave impedance, the number and configuration of discontinuities in the shield, and whether the enclosure contains the emitter or the receptor.

The following guidelines are recommended for shielded enclosure design:

- **Permeable materials should be used for low impedance magnetic fields.**
- **Enclosures containing emitters should be designed for maximum absorption loss of the emitted field.**
- **Enclosures containing receptors should be designed for maximum reflection loss of the received field.**
- **Discontinuities should be minimized and designed to maintain shielding effectiveness by proper seam treatment, and use of RF gaskets, vent/window screening, and shielded/filtered leads. Connectors must be regarded as discontinuities.**

Shielding effectiveness definitions and/or measurement values are normally expressed in decibels (dB) as a function of the logarithm of the ratio of incident and exit power densities (P) or of the incident and exit electric, magnetic, or plane wave field intensities (F):

$$SE(dB) = 10 \log (Pi/Pe) \text{ or } SE(dB) = 20 \log (Fi/Fe)$$

Shield material behavior can also be expressed in terms of the RF energy being dissipated or absorbed (A) within the material and the redirection of the energy reflected (R) from the shield boundaries. If the emitter is located external to the shield then redirecting the reflected RF energy away from the enclosure adds to the shielding effectiveness. If the enclosure contains the emitter the redirected reflected RF energy is always inside the enclosure and as a result, does not add fully to the overall shielding effectiveness.

Shielding effectiveness calculations for an enclosure containing an emitter are very simple since the absorption loss (A) provides most of the shield attenuation.

The attenuation for the enclosed emitter is approximated by the absorption loss:

[1] AdB = Absorption loss in dB

$$= 3.338\, t\, [(\mu\, \sigma\, F)]^{0.5}$$

Where:
- **t = thickness in mils**
- **μ = relative permeability**
- **σ = relative conductivity**
- **F = Frequency (MHz)**

Shielding effectiveness calculations for an enclosure containing a receptor are much more complex because both the absorption and reflection losses provide attenuation. The attenuation relationship for the emitter external to the shield can be generalized and approximated by:

[2] $$SEdB = AdB + BdB + R(\ )dB$$

Where:
- **A = Absorption loss in dB (same as above)**
- **B = Correction for multiple internal reflections. Insignificant if the absorption loss is greater than 10 dB.**
- **R( ) = Reflection loss resulting from the mismatch between the incident wave impedance and the shield material impedance.**

For nearby sources, the wave impedance varies with both the emitter impedance and the distance from the emitter to the shield material. The wave impedance of low impedance emitters (magnetic field) will be less than 377 ohms and will increase to that limiting value as distance increases. The wave impedance of high impedance emitters (electric field) will be greater than 377 ohms and will decrease to that limiting value as distance increases. When the separation distance has increased to $d = \lambda/2\pi$ or about 1/6 wavelength (plane wave region) the wave impedance becomes constant at 377 ohms regardless of the source impedance or separation distance.

→

charged potential first. Once the finger and its initial path deionizes, the main discharge is allowed to come from the rest of the body causing a long exponential decay. If the voltage level increases the voltage arc gap will also increase, creating a greater inductance. This increase of inductance will slow down the rise time and permit a more complete transfer of the charge without this extremely fast spike. If the speed of the finger approaching the object is slowed, the voltage will arc at a greater distance and the percursor will not develop, but the decay will still be maintained.

Simple field theory states that in the near field, low impedance (< 377 ohms), sources will radiate predominately magnetic fields, while high impedance sources (> 377) ohms) radiate predominately electric fields. Since furniture has a much lower resistance than the human body, it is understandable that the field developed will be predominately magnetic while the human discharge will be predominately electric. For direct discharges, it is this increased current along with the resultant magnetic field which create severe problems for high speed, high impedance logic families. For recessed areas, plastic barriers, and remote areas where a tremendous amount of voltage is needed to break the air gap the electric field created by the human discharge is more severe.