Ferrite Tile Absorbers

for EMC Test Chamber Applications

Introduction

Fair-Rite's tile absorbers provide an attractive alternative to traditional large, foam-type absorber materials for new anechoic chambers or for upgrading older rooms for radiated emission and immunity measurements. While ferrite tiles are a relatively recent development, they have come into use wherever high absorption (-15 to -25 dB at <100 MHz) and compact size (6mm vs 2400mm for foam absorbers) are required. There are now hundreds of installations worldwide in compact and 3/10 meter FCC certified chambers. Ferrites themselves are inherently immune to fire, humidity and chemicals providing a reliable and compact solution for attenuating plane wave reflections in shielded enclosures.

Theory of Operation

The basic physics of operation for any planar electromagnetic absorber involves fundamental concepts as shown in Figure 1. When an electromagnetic wave traveling through free-space encounters a different medium (at Z=0), the wave will be reflected, transmitted, and/or absorbed. It is of course, the magnitude of the reflected signal which is usually of interest in this application. For ferrite tiles, the thickness is tuned so that the relative phases of the reflected and exiting wave cancel to form a resonant condition. This resonant condition appears as a deep "null" in the return loss response. This resonance is also a function of the frequency dependent electrical properties of the ferrite material such as relative permeability (μ_r) and permittivity (ε_r) which interact to determine the reflection coefficient (Γ), impedance (Z) and return loss (RL) according to the following formulas:

$$Z_f = \sqrt{\frac{\mu_r}{\varepsilon_r}} \cdot \tanh\left[\left(\frac{j2\pi d}{\lambda}\right)\left(\sqrt{\mu_r \varepsilon_r}\right)\right] \quad \text{(ohm)}$$

$$\Gamma = \frac{Z_f - Z_0}{Z_f + Z_0}$$

$$RL = 20 \log_{10} (\Gamma) \quad \text{(dB)}$$

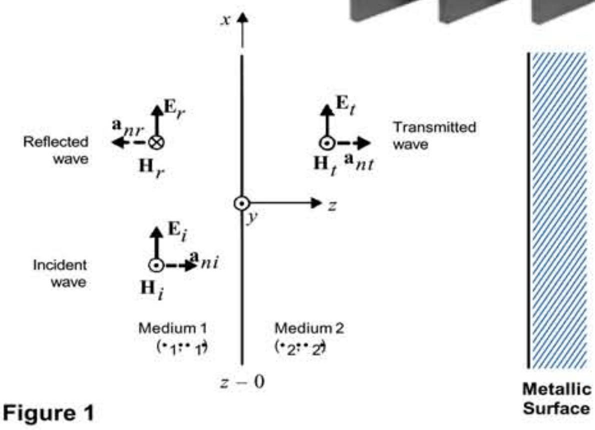

Figure 1

Where :

- μ_1 = relative permeability of medium 1 (air)
- ε_1 = relative permittivity of medium 1 (air)
- μ_2 = relative permeability of medium 2 (ferrite)
- ε_2 = relative permittivity of medium 2 (ferrite)
- Γ = reflection coefficient of metal backed ferrite tile
- Z_f = input impedance of metal backed ferrite tile
- Z_o = impedance of free space (air)
- E_i, H_i = components of incident plane wave
- E_r, H_r = reflected components of incident plane wave
- E_t, H_t = transmitted components of incident plane wave
- d = thickness of medium 2 (ferrite)

Increasing Bandwidth

For some chamber applications increased absorber bandwidth may be desired to comply with high frequency testing needs. One technique shown in Figure 2 increases the bandwidth of ferrite tile installations by mounting the tile over a dielectric spacer (typically wood) of appropriate thickness. When both tile and spacer thicknesses are optimized, the frequency response is shifted upward to improve return loss performance from 600-1500 MHz (see Figure 3). Of course, if increased bandwidth up to 20 GHz is desired, several absorber vendors provide completely engineered hybrid absorbers using specially designed pyramidal and wedge shaped dielectric absorbers matched to ferrite tiles.

Fair-Rite Products Corp.

Phone: (888) FAIR RITE / (845) 895-2055 • FAX: (888) FERRITE / (845) 895-2629 • www.fair-rite.com
(888) 324-7748 (888) 337 -7483 • E-Mail: ferrites@fair-rite.com
PO Box 288, One Commercial Row, Wallkill, NY 12589-0288

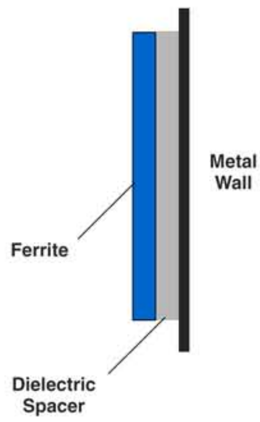

Figure 2

Typical Return Loss vs. Tile Thickness

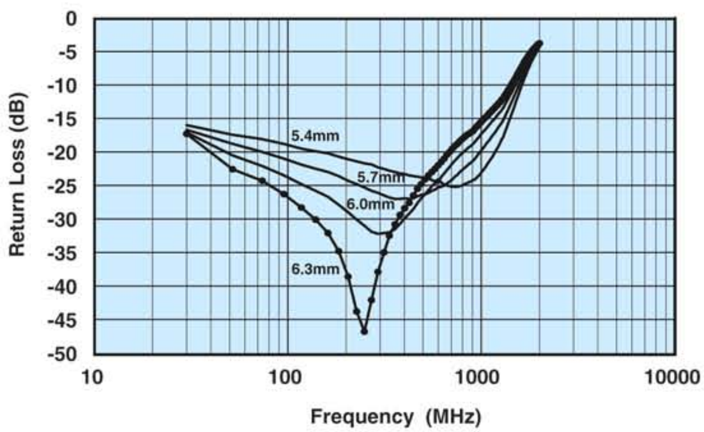

Figure 3

Spacer Thickness = **13mm**

Wide Angle Absorption

One of the most overlooked aspects of using any absorber is the rolloff of absorption with increasing angle of incidence. Most published absorber data contains only normal incidence return loss (dB) which is typically where the maximum absorption is obtained. Normal incidence is defined as plane wave radiation arriving perpendicular (0°) to the plane of the absorbing surface. The curves in Figure 4 were generated using equations described in IEEE document "Recommended Practice for RF Absorber Evaluation in the range 30 MHz to 5 GHz". Since the reflections occuring in anechoic chambers seldom illuminate absorber materials at 0°, it is important to consider the reflection angles generated by each chamber geometry and size for best results. For most chambers, the range of angles is in the 40-60° range, however it is usually desirable to operate at < 50°.

Return loss vs angle of incidence for TM polarization is shown in Figure 4. Return loss curves for TE polarization (not shown) are similar.

Wide-Angle Return Loss – TM Polarization

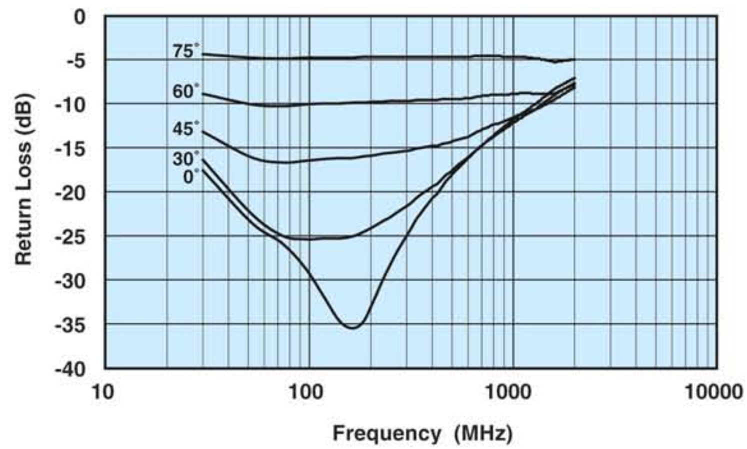

Figure 4

Precision Dimensions

Studies have shown that maximum low-frequency performance is obtained when tile to tile gaps are minimized. Fair-Rite precisely machines each of the six surfaces to ± **0.13mm** (.005") to ensure a tight tile to tile fit for easier installation with less cutting required. Figure 5 illustrates the effect of gaps on tile performance when installed with: no gap (**0mm**), **0.25mm** and **1.0mm**. It is critical to maintain contact between tiles for best results. The final results of the completed test chamber will also be degraded by other factors such as lights, gaps around door openings, and exposed metallic conduit.

Reflectivity vs. Tile – Tile Gap Size

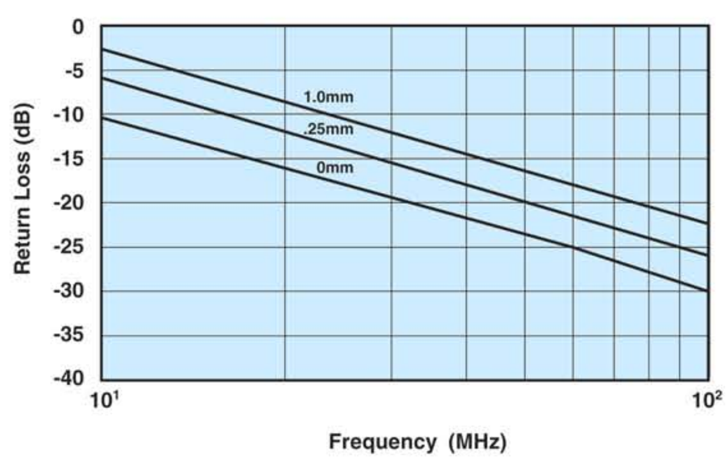

Figure 5

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