ELECTROMAGNETIC RADIATION AND DISPLAY VISIBILITY

Life on our planet evolved under the constant bombardment of natural electromagnetic (EM) radiation. Now and then, when lightning flashed, volcanoes erupted, or dust storms choked us, we humans may have dimly realized that our atmosphere was "highly charged;" but for most of history, EM radiation was something we managed to ignore.

The situation changed less than 100 years ago with the pioneering work of Edison, Marconi and DeForest and the "Dawn of the Electronic Age." We became aware of static interference from natural atmospheric disturbances and, concurrently, we became a source of EM radiation through the emissions of our own electric and electronic devices.

As our dependence on these devices has grown, so has the volume of EM radiation in the atmosphere. Unfortunately, as our electronic equipment becomes increasingly sophisticated, it becomes increasingly susceptible to the ever-higher levels of EM interference. Countering undesirable EM radiation is, therefore, a major challenge for designers and users of modern electronic equipment.

Another aspect of the EM radiation problem involves controlling equipment emissions so that data cannot be intercepted and interpreted by unauthorized persons. The government's TEMPEST program provides guidelines for manufacturers of national security related electronic equipment in the employment of EM shielding techniques to control emission loss. Business and industry, seeking to protect confidential information regarding industrial processes or financing, have an equally critical interest in this technology.

There are two basic approaches to these related problems of EM interference and EM emission loss. We can either produce equipment that is intrinsically less sensitive to interference and that emits less radiation of its own, or we can devise methods for shielding our equipment. At the present state of the art, we can't adequately limit equipment sensitivity and reduce emissions without limiting the capabilities of the equipment as well. Since this trade-off is impractical in most applications, we are left with a search for more effective shielding techniques.

Our basic technique is to enclose sensitive equipment in a sealed, electromagnetically conductive box that attentuates radiation through reflection and absorption. Since EM radiation can enter or exit through any opening, we have EM-shielded seals, gaskets, wrapping tapes, conduits, panels and filters to protect the openings necessary for ventilation, maintenance access, power supply and data link. The largest opening in the box, the visual display through which the operator interacts with the machine, presents a special challenge. Shielding for the visual display must not only control EM radiation but also allow the operator clear, undistorted access to the information on the screen.

EM shielding for visual displays is accomplished by placing a shielded, transparent (see-through) panel between the display and the operator. These panels may be shielded by three different methods. The first involves the deposition of thin film conductive coatings on glass or plastic. The second method employs a conductive wire mesh screen, sandwiched between layers of glass or plastic. The third approach is simply a combination of the first two for increased shielding in a specific frequency range.

Thin film conductive coatings for visual displays are typically made from indium-tin oxide that is evaporated by heat in a vacuum chamber and deposited in optically precise layers of predetermined thickness onto a transparent glass or plastic surface. A silver epoxy bus is then applied to the coating around the perimeter of the panel and grounded to the conductive box that encloses the equipment.

Among the advantages of thin film conductive coatings are good electric field shielding over a specific narrow frequency range. The chief disadvantage is that the thin film materials that allow transparency have limited magnetic properties and offer little or no magnetic field shielding. (See Figure 1.)

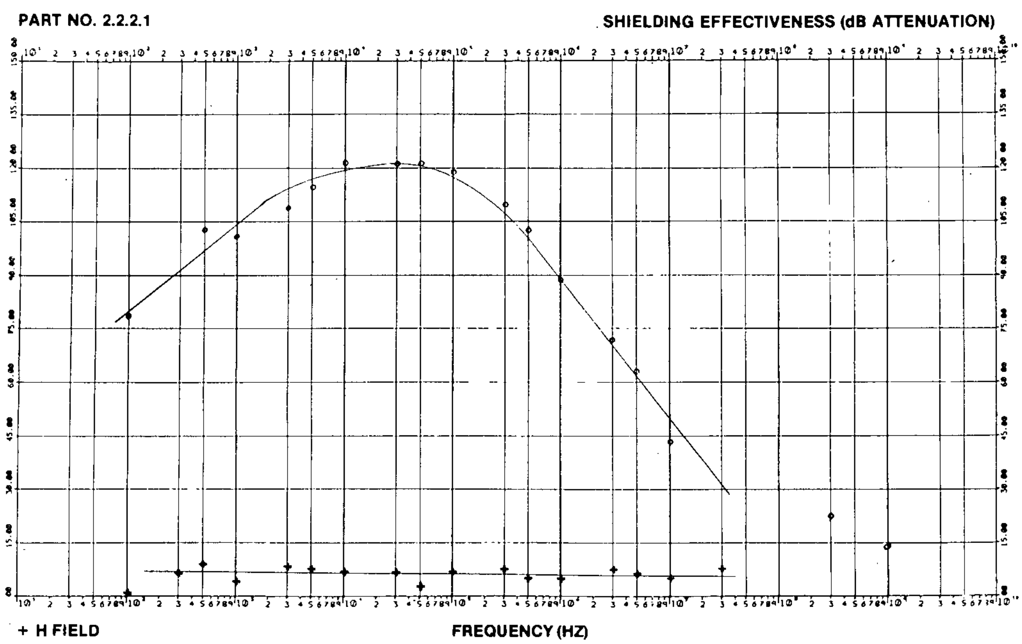

Figure 1.

Conductive wire screens provide the maximum EM interference suppression. Made of fine, highly conductive, silver-coated stainless steel wire that is internally bonded at each intersection and laminated between panels of glass or plastic, this type of shield is effective in shielding both electric and magnetic fields. These properties make it the best defense against electronic eavesdropping and a mandatory part of the TEMPEST program. (See Figure 2.)

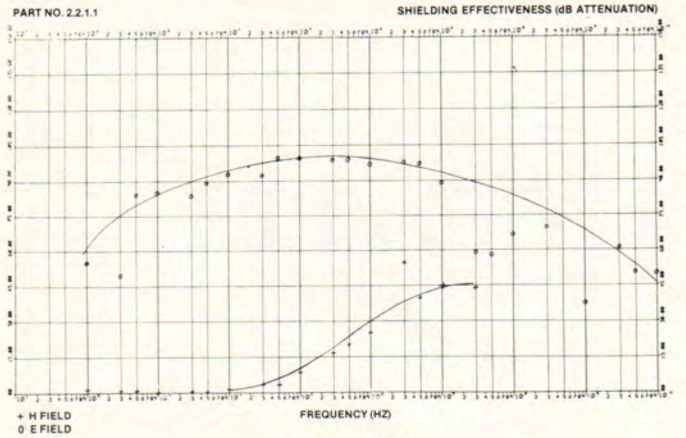

Figure 2.

As mentioned earlier, even greater electric field and magnetic field shielding may be obtained when thin film conductive coatings and conductive wire-mesh screens are used together. (See Figure 3.)

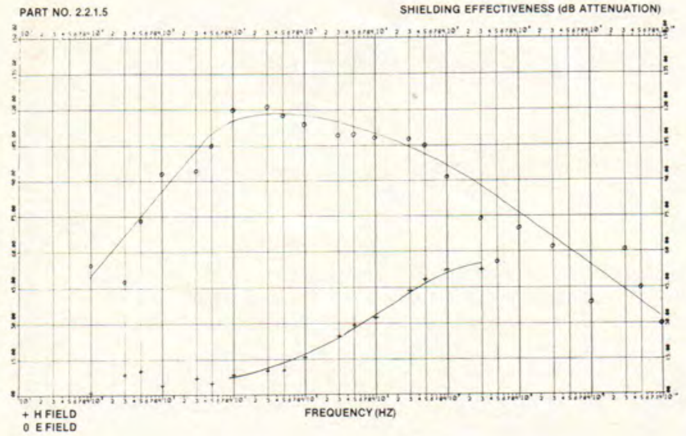

Figure 3.

Having solved the problems of EM interference and emission control, we must now address the sine qua non of visual displays: image clarity. Because eyestrain leads to fatigue and error, an investment in sophisticated electronic equipment is wasted if the visual display presents a diffused or distorted image.

Of the types of EM shielding discussed above, the combination of wire-mesh screen with plastic panels, whether or not etched to reduce glare, gives the poorest optical resolution. Whether the screen is sandwiched between the panels or fully encapsulated in the plastic, the juxtaposition of two types of diffusing materials results in moire patterns and distracting reflections.

The most satisfactory combination of optical resolution and high shielding performance is obtained when the conductive wire-mesh screen is laminated between optically matched glass panels. This type of shielding may be used with all types of displays, including cathode ray tubes (CRTs), gas plasma, electroluminiscent, light-emitting diodes (LEDs) and liquid-crystal displays (LCDs). With properly matched glass panels and the correct screen size, this technique provides excellent visual clarity even when used with high-resolution graphics CRTs with spot sizes of .010-inch diameter. Moreover, because the image remains free of distortion even when the shield is at some distance from the display, these flat-panel, glass-and-wire shields can be used to economic advantage with curved CRT displays. Other applications for this technology include windows for meter and line printers, shielded rooms and aircraft. (See Figure 4.)

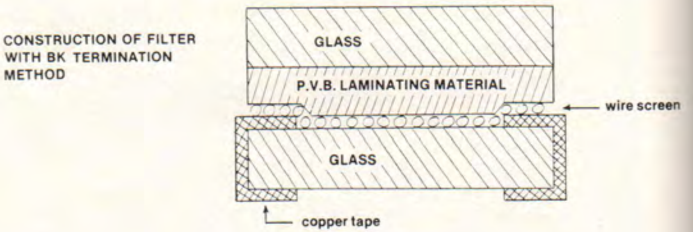

Figure 4.

In addition to providing optical clarity, the ideal EM shield for a visual display must resist the effects of ambient light. Multi-layer contrast-enhancement and thin film anti-reflection coatings on the exterior surfaces of glass panels have proved the most effective means of improving image to background contrast and protecting against glare. Reflections from internal display components, such as CRT phosphors or gas plasma electrodes, may be controlled by using reflection-absorbing materials internal to the panel surfaces.

When we use these coating techniques together with the most efficient types of shields, we are assured of crisp, clear, easy-to-read displays, and EM radiation becomes, as it was in the not-too-distant past, something we can manage to ignore.

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