SHIELDED ROOMS & ENCLOSURES

Introduction

The shielded room and enclosure offers many advantages. It is and has been in use for a number of years for many types of electronic measurements where a low radiation ambient is required, or where signals must be contained. Its use has spread to nonmeasurement applications, such as the protection of personnel near high-power radar sites, the containing of certain industrial RF sources, and the protection of sensitive equipment such as computers.

The main advantage of the shielded enclosure for interference measurements is the RF isolation it provides from the outside world. Its use allows meaningful interference and susceptibility measurements to be made, both conducted and radiated, in locations where such testing would not ordinarily be possible. Much has been said about the effect of the shielded enclosure on the measurements without carefully pointing out that the only tests which may be adversely affected are the radiation tests. While radiation tests are quite important, there are sizeable numbers of other tests involved, all of which are more readily made in the low-level ambient afforded by the shielded enclosure. In one respect, the radiated measurement situation is improved, and that is in regard to outside signals causing invalid readings or preventing readings altogether.

The drawback is that inside the metal shielded enclosure, there can be multiple reflections of signals that result in standing waves in the room and potential measurement errors. This problem can be reduced by lining the walls with anechoic material. It may also be alleviated to an extent in some measurements by moving the test antenna over a small volume to determine the "worst cause" susceptibility or radiated interference.

The actual performance of tests in a shielded enclosure will proceed very much like any electronic test. There are several steps that may be taken to expedite and improve measurements. One is to keep the number of people in the enclosure during radiated measurements to a minimum to reduct the variation in the standing-wave patterns. At some frequencies, the movement of personnel can cause significant variation in this pattern and, consequently, variations in the indicated signals. Another is to limit the amount of equipment in the enclosure to the minimum for proper operation of the test sample and performance of the test. This will avoid any unnecessary effects on antenna impedances from nearby metal objects.

Questions may arise concerning the ambient inside a shielded room. There, of course, is an ambient since the room only attenuates rather than eliminates outside signals. In a conventional situation where the outside environment is not abnormal, a modern shielded room will provide attenuation sufficient to reduce all environmental signals to levels below the sensitivity of standard receivers. Signals below what might be considered "normal" RF frequencies would not necessarily be reduced so much. For example, 60-Hertz fields exist both inside and outside standard rooms to the same extent. The walls offer little or no attenuation at these frequencies and power lines allow easy entry.

Some electronic systems are too large to be considered for shielded enclosure testing, although the size of the enclosure or room has no theoretical limit, and enclosures have been built to sizes that enclose aircraft hangers. For example, the Titan ICBM is checked out in a five-story shielded enclosure, which also has a five-story door. Another example is the entire computer facility for an early model Atlas ICBM, located in a large shielded enclosure.

Shielded enclosures exist also in mobile configurations. A number of Government agencies and industrial firms have "mobile electronic laboratories" which are shielded enclosures constructed in a trailer or van. They may be simply mobile or portable screen rooms for general-purpose use, or they may be used to perform measurements in high field areas where protection is necessary for personnel and equipment.

Any metal, and even a few non-metals have shielding capability under some circumstances. But one of two materials, either steel or copper, is usually employed as the basic material in the shielded enclosure. The steel is usually in the form of galvanized sheet, while the copper is either in sheet form or in the form of fine mesh screeing. Which material is used will depend on weight restrictions, cost, shielding desired, and other variables. For equal cost, steel will probably furnish equal performance to copper at frequencies down to 150 kHz at which point the permeability of the steel begins to provide improved magnetic field shielding.

Low-frequency shielding effectiveness measurements should include magnetic field (H) as well as electric field (E) measurements. For shielding effectiveness determination at frequencies below about 500 kHz, only the H field measurement need be performed since the E field attenuation is invariably superior.

The first of the modern shielded enclosure construction methods was developed, to a great extent, at the Johnsville, Pennsylvania, U.S. Naval Air Development Center. This room was made with two layers of copper screen, separated by an inch or so.

The room was constructed of several panels, called cells, each one 8 feet by 4 feet in dimension. The individual panel edges butted together and were bolted through the wood framing that provided the shape and strength for each panel. One of the features of this room was that it could be disassembled, moved, and reassembled at a second location without major modification.

The door for this room was also framed with wood, but well-braced and covered with either copper or copper screen. The periphery of the door was furnished with two sets of spring fingers, one to provide contact with the inner edge of the doorjamb and sill, with the outer set to push against the outside of the door frame. This second set of spring fingers actually overlapped the door frame opening.

A similar enclosure construction is the cell type with only a single layer of screening or sheet. This method is not widely used since it is almost as expensive as the double-layer cell-type, and has poorer performance.

There has been a long-standing controversy over the supposed advantage of completely separate layers in the double--shielded room as opposed to the cell-type room just described. Theoretically, it would seem that the true room-within-a-room might actually have better performance.

Another type of construction makes use of a single sheet of steel on a metal framework. The sheet is under some tension from the way it is welded to the frame, and the frames or panels are welded together such as those provided by LMI (see page 128).

For double-layer enclosures, or the so-called double-shielded room, a fairly simple method has been developed recently. This is the sandwich panel, with two steel sheets bonded to a 3/4-inch plywood core. The panels are not butted together all the way, but are clamped on each edge by special continuous channels and strapping. The method of joining panels along the sides of a room and at the corners is shown in Figure 1. Machine screws pull the channel and strap together every few inches. Filtron (page 59) for instance, uses this of construction.

Doors for the newer shielded enclosures are considerably different in concept from the one first described. They are stronger, with stronger door frames as well, to provide better attenuation around the door. They still use two rows of metallic fingers or hidden rows to effect a good seal between the door and door frame. There are also improvements in the latching arrangements, so that the door may be opened and closed easier.

These basic construction methods are suitable for rooms of many sizes. For rooms that are larger than approximately 10 feet in both floor dimensions, structural members are added to transfer some of the ceiling weight to the walls. In the event that unusually large doors are required, they can be supplied with a wheel to directly support the weight of the door and relieve the hinges.

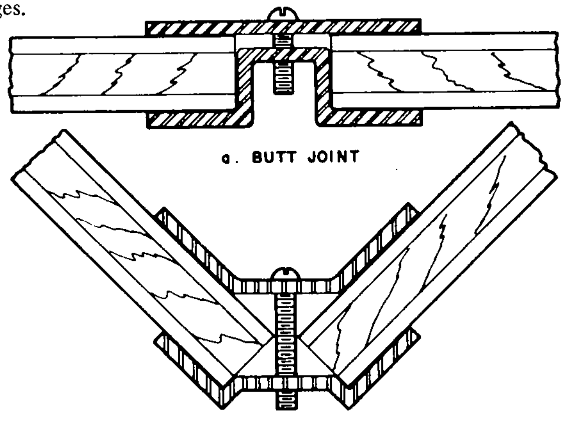

Fig. 1 Methods of Joining Sandwich-Type Panels

Filters

Part of the job of providing attenuation for a shielded enclosure is accomplished by the structure itself, i.e., the wall sections, seams, and door. But these are of no value, no matter how well designed, if the room is penetrated by any unfiltered lines or wires. For this reason, the power-line filters are an integral part of the enclosure.

The basic requirement for the filters is that they provide a certain minimum attenuation over the frequency range of the room, usually from approximately 14 kHz to 10 GHz.

The difficult problem is to determine how much attenuation the filters must offer to complement a particular room design or application. The degree of attenuation that must be furnished by the filters is only roughly related to the attenuation of the room.

The usual solution to the porblem is to provide filters with attenuation capability somewhat less than that of the room. For example, if the room offers attenuation of 120 db over most of the frequency range, filters offering 100 db should prove adequate. If experience with the particular installation shows that the filters, even though properly installed and meeting their specifications, do not provide the necessary attenuation, additional filters may be placed in series to provide the additional attenuation. Normal installation practice places the filters outside the enclosure, with the line coming through a pipe nipple into the room. If additional filters are required, they should be installed inside the room, so that the enclosure walls provide good isolation between the input of the first filter and the input of the second.

The mechanical design of high-attenuation filters is quite an important factor in their performance. To reduce coupling between the input and output of the separate sections, well designed compartments are required. The buyer of power-line filters must be cautious in his selection, since a variety of sizes and qualities of shielded enclosure filters are available.

Ventilation

Shielded enclosures of all types require some means of force ventilation, especially the solid-wall enclosures. This service must provide moving air without affecting the shielding effectiveness of the walls. The standard method of achieving this requirement is to utilize the waveguide-beyond-cutoff principle and there are several physical satisfactory configurations. (See page 90).

The finished unit, sometimes termed "honeycomb," may have the appearance of an automobile radiator. The placement and size of these air vents will depend on the individual room requirements, as will the size and type of blower. If the room is to contain large amounts of equipment and/or personnel, air conditioning must be furnished.

Additional Penetration

Additional penetrations of the enclosure walls may be necessary to provide other services. Gas, water, and compressed air may be furnished through steel or copper piping. If the pipe is joined to the enclosure wall in a clean, tight connection, the attenuation of the room will not be appreciably affected.

The same method must be used to bring coaxial lines through the wall of the enclosure. In this case, special coaxial fittings are available that are similar to a threaded pipe nipple, except they have the suitable coaxial construction and fittings at each end.

The use of coaxial cables can, in some cases, reduce the shielding effectiveness of an enclosure by providing a path of entry for high-level signals. These high-level signals can penetrate the cable shield and be conducted into the enclosure. For this reason, double-shielded coaxial cables should be used for these connections if high ambient signals are known to exist.

Lighting

Lighting must be provided for the enclosure. This should in all cases be incandescent lighting, since other types of lighting usually involve ionization processes and subsequently produce RF noise. There exist some fluorescent fixtures which have RF suppression built into the unit. While this type of lighting may be of benefit to lower the RF ambient in a laboratory, they generally are not suitable for shielded enclosures. Any other services to be provided in addition to lighting, such as electric heating should be installed in such a way that it cannot produce any RF signals.

Maintenance

Shielded enclosures require a certain amount of maintenance if they are to retain their designed attenuation. The vulnerable areas of a shielded enclosure are the joints and seams of bolted structures, and the door. The fastenings between panels must be kept tight; the enclosure manufacturer usually gives a torque rating on the fasteners.

The finger stock along the edge of the door must be kept in good condition. If any fingers are damaged or broken off, a new section of fingers may be soldered on as a replacement. These fingers provide a good connection between the enclosure and the door by sliding, for a short distance, along the door frame. To maintain this good connection, the door frame must be kept smooth and clean.

Checkout

A newly installed shielded enclosure usually receives a thorough check of its attenuation to determine if it performs to specification. Often these tests are performed in accordance with MIL-STD-285, which prescribes test frequencies and equipment, as well as antenna separation distances. The testing of an enclosure is basically a near-field measurement which means that the results may vary widely as a function of distances, antenna types, and frequency. For this reason, it is important that the methods incicated in MIL-STD-285 (if it is the test specification) be followed as closely as possible so that meaningful and repeatable results may be obtained.

Testing of an enclosure should be accomplished periodically to verify that its attenuation still meets the original specification. In this respect, the enclosure may be considered as an item of equipment in the laboratory inventory, and placed on the periodic calbiration schedule. After the initial checkout, the enclosure should be checked at least every other year. Interim spot checks may be desirable in conjunction with special interference tests as a validation move, or in the event degradation of enclosure attenuation is suspected for any reason.