CONNECTOR TYPES AND CABLE SHIELDING TECHNIQUES

Electromagnetic radiation and interference must be understood before specifications can be applied.

Darrell Fernald, Cable Systems, Inc., Everett, MA

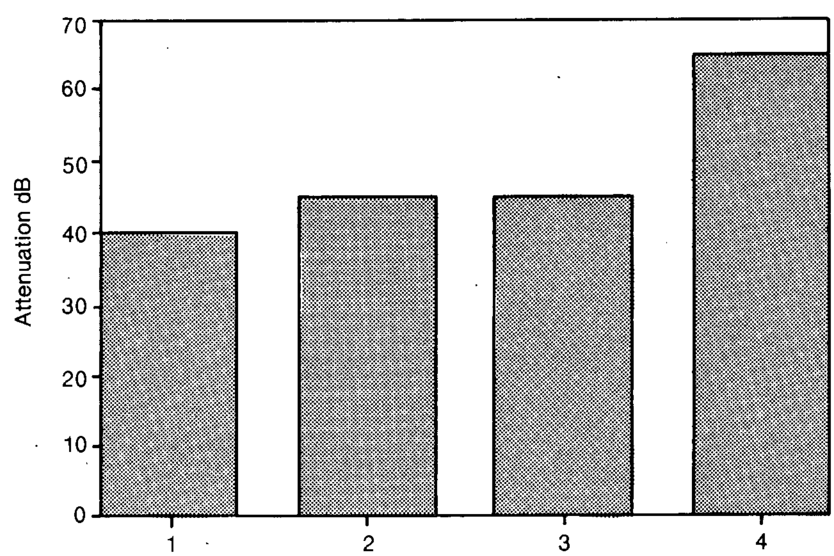
In order for an engineer to apply proper specifications for electromagnetic radiation and interference, those specifications must be understood fully in terms of how they are to be measured and how they might affect the design and cost of other system components. The numerous specifications that exist and their differing requirements are constantly being applied and misapplied by engineers today. For example the system designed to meet the requirements of FCC Part 15, Subpart J of the Rules and Regulations is vastly different from the system designed to meet the rigors of TEMPEST in both the physical look of the system and the final manufactured cost of such a system. The requirements of MIL-STD-461B span a significant range between these two specifications, encompassing both emissions coming into a system and those emanating from a system.

Designing a system (for the purpose of this paper a system is defined as including the interconnects) to meet the requirements of the FCC computing device regulation involves meeting the requirements of a 35 dB world within a frequency range of 30 MHz to 1 GHz. In order to meet the requirements of this specification, most connectors including D-subminiature types are suitable. Typically, cable to meet this specification is shielded only with an aluminum mylar tape wrap and a braid shield of 65 percent or greater.

However, designing a system to meet the rigors of TEMPEST or any other system that has a requirement for shielding in excess of 60 dB requires much more care in the selection of connectors and cables. In these applications, D-subminiature connectors and others are not suitable for the shielding application. These connector types do not fit their mating connectors securely enough to prevent radiation from escaping at the interface. In fact, the D-subminiature connector can act as a slot antenna when it is viewed as a mated pair. Due to plating and fit problems, many of the circular connectors also do not have a suitable interface to prevent escaping radiation at the plug and receptacle interface. The cable portion of the assembly must also undergo a dramatic change from that which is suitable for the FCC. This change includes the addition of a higher optical percentage coverage braid in one or more layers, depending on the specification to be met.

Connectors designed to meet the requirements of the higher shielding specifications typically have RFI fingers installed internal to the connector, which help to keep the radiation confined inside the shell of the connector. In these cases, alternatives to expensive circular connectors (in excess of $100 each) are several types of filtered pin connectors (including D-subminiature). Another option is to design the output circuitry of the system so that the offending radiation does not reach the cable assembly for transmission to the outside world. Typically, this solution is used when the radiation from the cable assembly is out of specification in only one, or at most a few, isolated frequencies. In these cases it is possible to filter out the offending frequencies. This alternative is usually a lower cost solution to the requirements of a production system that involves the manufacture of many duplicate systems. In this way, the manufacturer will be able to take advantage of quantity purchases of the required filter components.

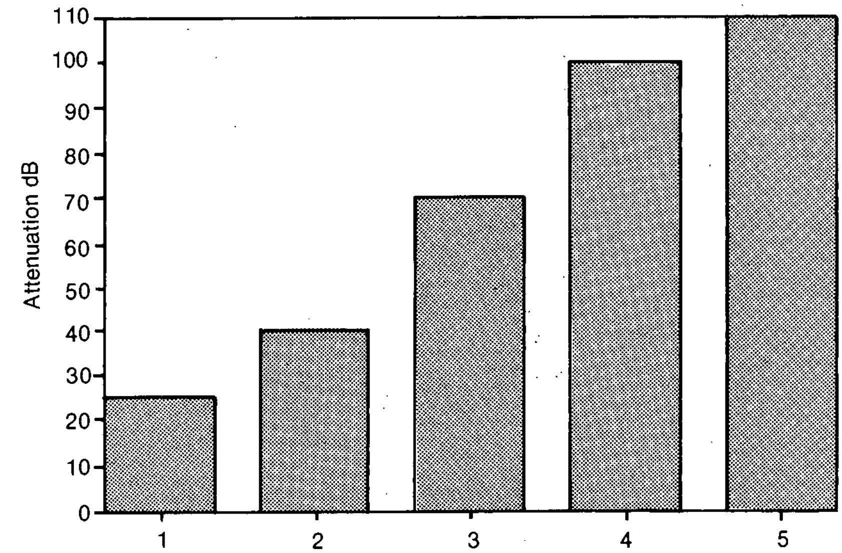
For the design engineer to perform the useful function of designing and predicting the performance of cable assemblies used in a shielding specification, a selection of calibrated components must be available and the proper combination must be selected. Figures 1 and 2 give the relative merits of various commonly used connector types and cable



1 = D-Subminiature 2 = Mil-C-5500

3 = Mil-C-38999 Series 1 4 = Mil-C-38999 Series 3

Figure 1. Connector Shielding.



1 = Foil 2 = Foil + 56% Braid 3 = Foil + 90% Braid

4 = Foil + 2 90% Braids 5 = 2 Foils + 2 90% Braids

Figure 2. Cable Shielding.

shielding techniques. If the engineer first determines the shielding to be met and the frequency range over which the requirement must be met, then connectors and cables may be selected.

Figures 1 and 2 are intended as a guide to help the engineer in selecting connector and cable systems to meet the specifications indicated in previous paragraphs. Their validity is dependant on the frequency of interest. These lines are intended to be used for frequencies over 100 megahertz and below 600 megahertz. Below 100 megahertz one should subtract approximately 5 dB per 50 megahertz to 50 megahertz, then 5 dB per 20 megahertz down to 10 megahertz. Below 10 megahertz these guides should be applied with extreme care since the shielding effectiveness at these frequencies now becomes more magnetic than electric in nature and is affected differently by the various shields. Above 600 megahertz, one should subtract 5 dB per 100 megahertz up to 1 gigahertz, and over one gigahertz, the charts should be applied with extreme care, since holes in the shield can play an increasingly large part in the leakage.

Since the intent of the charts is to provide the engineer with an accurate preliminary method for predicting the shielding effectiveness of a cable connector system, it should be pointed out that there are several other factors that can affect the leakage in a cable connector system. The first and foremost of these is the connection between the cable and the connector. It is not enough to make a good mechanical and electrical connection, but rather a 360 degree barrier to radiation must be constructed in the cable to connector interface. This barrier is most often performed by the use of a backshell, which, if firmly attached to the connector and to the cable by means of a 360 degree mechanical connection or a 360 degree solder connection, can have a remarkable effect on the radiation of the system. The type of material and thickness ultimately determines its degree of effectiveness. For example, a copper foil used on a pre-mold is very effective for meeting the requirements of FCC Docket 20780 but would not fare well in a requirement that was in excess of 90 dB. In this case, the copper foil itself is the limitation, since the radiation is attenuated by both the surface reflection and the thickness of the material. A 3 to 5 mil thick sheet of copper foil is very effective in the reflective mode; however, it is not thick enough to provide much in the way of absorption.

Other areas that can have a dramatic effect in the reduction of the effectiveness of a cable connector system in attenuating radiation are:

- Poor grounding of the connector shell on the mating panel connector. Both panel connectors must be at the same RF ground potential in order for the system to have its maximum effectiveness. If they are not, then the cable can act, in some cases, as a radiating antenna.
- A non-conductive surface treatment on the mating connectors, such as an olive drab paint which is used on some military type of connectors or a yellow chromate finish which is on some D-subminature connectors. Once again, if the ends of the cable cannot be grounded, then the cable will radiate.
- Elimination of the jack-screws on D-subminature connectors will also increase the chance for a poor connection and resulting radiation. Jack-screws themselves do not ensure a good RF connection, but their elimination will in most cases be the cause for an ineffective ground since these types of connectors do not fit tightly together and can leak.

SUMMARY

In conclusion, if one follows the above guidelines, a good usuable cable to connector system can be approximated. It is important that some testing of the basic design be done to assure the designer that some basic error has not been committed and that a producable system exists. Once the system has been tested and the basic parameters have been verified, then the designer may rest assured that the system can be reproduced in quantity. ■