FIBER OPTICS: TEMPEST APPLICATIONS

Fiber optics can be used for TEMPEST applications if they are selected appropriately.

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Fiber optic cables do not emit electromagnetic radiation because they carry no current and therefore set up no electromagnetic field which can propagate or radiate. This well-known fact makes the use of fiber optics attractive to the TEMPEST system designer. However, there are some pitfalls in this seemingly ideal medium, which can negate its obvious advantages, cause program delays and unneeded expenses, and generate unanticipated reliability issues. The proper selection of fiber optic cable can ensure that the inherent benefits of fiber optics will be realized and can contribute to the timely, cost-effective completion of TEMPEST facilities.

A hypothetical case illustrates several important points. A facility had been carefully engineered by experienced TEMPEST designers. The components of the shielded rooms were all tested and proven items. The doors and penetrations for air and communications were all known to provide over 110 dB isolation up to the frequency of interest. The facility included a high speed local area network to interconnect mainframes in shielded rooms with each other and with stand-alone TEMPEST workstations and PCs. A fiber optic cable-based LAN was implemented because the fiber optics did not emanate. Additional fiber optic advantages were small size, high bandwidth, immunity from electromagnetic interference, and low cost when compared to the TEMPEST approved coaxial cable. The day of reckoning came when the relevant equipment was installed and the facility was complete. The experts arrived with their sensitive test equipment to check the facility. To the dismay of the contractors, customer and program manager alike, the certifications testing revealed isolations in the 30 to 40 dB range where the design criteria was 100 dB.

An investigation quickly identified the source of the problem as the fiber optic cable. With the cable in the shielding penetrations, the shielding was 30 to 40 dB at 10 GHz. With the cable removed, the penetrations showed isolation well above 100 dB up to 13 GHz, and over 110 dB at 10 GHz. The fiber optic cable was altering the isolation properties of the waveguide penetrator dramatically.

Subsequent discussions with the engineers at the cable manufacturer confirmed that the cable was indeed the culprit. In the long process from facility design to cable purchase, the nature of the application was not disclosed. Ultimately, the contractor had to pull out all the original cable and replace it with TEMPEST grade cable. The TEMPEST cable is no more expensive than the standard cable, but in this case, the mistake cost roughly $250,000 in material alone.

The design of a fiber optic local area network or data communication system as part of a TEMPEST facility necessitates certain criteria when selecting fiber optic cables. Obviously the TEMPEST requirements of the installation must not be compromised. Also, the cables must be designed for use within and between buildings, be easy to install and terminate, and provide a cost effective reliable installation. Ease of maintenance and flexibility for expansion are also important.

A common requirement for shielded room isolation is 100 dB attenuation for all frequencies up to 10 GHz. The waveguide penetrator through which the fiber optic cable must pass is usually a simple pipe type, which is limited to a maximum inside diameter of about 0.5 inches for this frequency range. With this diameter, a length of at least 6 inches is required to achieve attenuation of greater than 100 dB at 10 GHz. While a number of military and commercial grade fiber optic cables can fit within this dimensional constraint, until recently none were proven to meet the vital isolation requirements necessary for TEMPEST penetrations.

In 1985, one fiber optic cable manufacturer started a development and testing program to provide cables for use in TEMPEST penetrations. This program was in response to a market requirement for a relatively large number of fiber channels to be brought into a shielded room through a single 100 dB, 10 GHz penetration. Therefore, 0.5 inch inside diameter was chosen for the waveguide. The length chosen was 12 inches to ensure maximum attenuation and to leave a margin for degradation brought about by insertion of materials other than air in the waveguide. The penetration was fabricated from cold rolled steel and welded to a steel flange. Zinc-plated bolt holes were used for attachment to the shielded room wall.

Numerous RF shielding tests were conducted in accordance with the procedures set forth in NSA No. 65-6 and MIL-STD-285. The unshielded level of the plane wave field was measured with the transmitting and receiving antennas two meters apart outside the enclosure while transmitting a 10.0 GHz signal from one antenna to the other. A spectrum analyzer was used as the receiver. The shielded levels were obtained by placing the transmitter and transmitting antenna outside the enclosure and the receiver and receiving antenna inside the enclosure while maintaining the two meter separation distance between the two antennas. The difference between the unshielded level and the shielded level, as observed in dB on the spectrum analyzer, was recorded as the shielding effectiveness.

The testing showed that standard breakout style cables reduced attenuation of the waveguide from more than 100 dB to the range of 30 to 60 dB at 10 GHz (Table 1). The results of the tests varied with materials used in the cables, configuration of those materials, and the size of the cables and fill ratio when several small cables were simultaneously run through the waveguide.

Based on these results, a number

of prototype cables were developed, with various materials for the outer jacket, subcable jacket, and fiber buffers. In all cases, the materials had to be suitable for the construction of a tight buffered, breakout style cable, and to provide for excellent optical performance of the finished cable.

As a result of this qualification testing, a series of fiber optic cables designed to preserve the shielding performance of pipe type screen room wall penetrations, is now available. The cables are all of the breakout style and are available with fiber counts ranging from 1 to 24. The number of simplex and duplex cables that may be placed in the specified waveguide is fully defined. Outside diameters of the cables are all below 0.5 inch so that they easily pass through the penetration.

The tight buffered breakout cable style was chosen for the TEMPEST application because ease of installation and connector terminations make it extremely cost-effective and highly reliable in completed local area network installations. Each fiber of the multifiber cables is in its own individual sub-cable, complete with Kevlar strength members and subcable jacket. A twelve-cable, for instance, consists of twelve sub-cables, each of which may be directly terminated with a connector and lead directly into a patch panel, fiber optic transceiver, or modem.

For ease of installation and connector termination, ruggedness and durability, a number of features of breakout style cables are required. These include:

- Pressure extruded outer jackets so that cables may be pulled by means of wire mesh grips placed directly over the outer jacket.

- Elastomeric subcable jackets which are more abrasion and tear resistant and more resistant to oils and solvents than the inexpensive PVCs that are sometimes used.

- Precision-tensioned Kevlar strength members to ensure maximum connector termination retention and optical performance over a wide range of temperature and environmental conditions.

- Elastomeric fiber buffer jackets to a diameter of 900 μm (where space permits) to improve crush resistance and to protect the primary fiber buffers from damage.

A cross-sectional drawing of a high quality breakout style TEMPEST cable, highlighting these features, is shown in Figure 1.

Cable Type	Shielding Effectiveness at 10 GHz
No Cable	>110 dB
Standard 6 Fiber Breakout Cable	60 dB
Standard 12 Fiber Breakout Cable	30 dB
TEMPEST Grade 22 Fiber Breakout Cable	110 dB

Table 1. Examples of the Effects of Various Cable Types on Waveguide Attenuation.

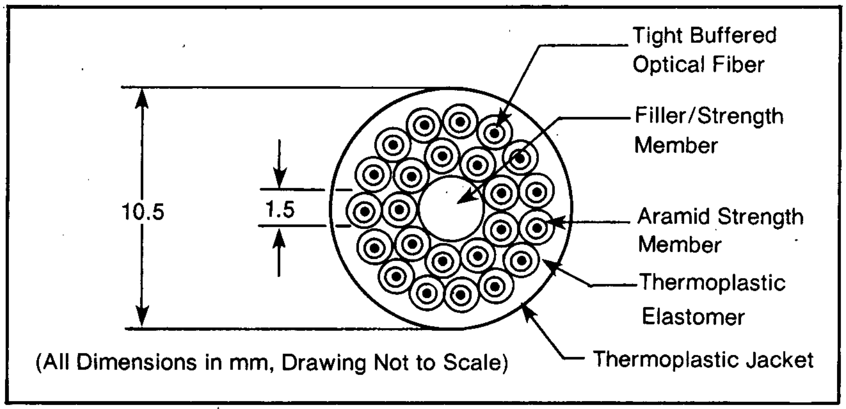

Figure 1. 24-Fiber TEMPEST Grade Fiber Optic Breakout Cable.

CONCLUSION

TEMPEST fiber optic cable offers the TEMPEST system designer a proven medium to maintain the shielding integrity of the TEMPEST facility, while realizing the benefits of fiber optics. The breakout configuration optimizes installation efficiency and reliability of the cable plant. All installations that include, or will later include TEMPEST requirements, should design this cable into the system at the outset. ■