METALLIC ELECTRONIC CABLE STILL BEST CHOICE IN NUMEROUS APPLICATIONS

There are numerous applications where the proven qualities of metallics make them the most practical choice.

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INTRODUCTION

To some, fiber optics represent the most promising area of the hi-tech industries today. If one is to place credence in studies done by the fiber-optics industry consultants, the anticipated growth rate is phenomenal, as illustrated by Figure 1. With a growth rate such as this, it is a small wonder that much of the industry is increasing investments to R&D to unearth new applications and create new markets, and continuing to build fiber-optic links with which to associate their names. Thus, one sees a serious business awareness of the importance of fiber technology to future corporate growth.

To put fiber optics in the proper perspective, one must question whether this instant technology is ready to replace the proven role of copper wire cabling, and if so, under what time constraints. Further, and perhaps most importantly, one must determine if fiber optics offers the world of component interconnection the tools it needs, and at a price it can afford. Finally, one must review the world of metallic interconnection and ascertain how it is competing with this new technology to preserve its role in the world marketplace.

It is not this author's intent to prove that fiber optics is not a key player in the future of interconnection technology, but merely to show that for the next decade or so the metallic and fiber communities can and will coexist. There are specific industry needs today that cannot be fully addressed by the fiber community because of technological limitations, previous industry commitments and most importantly, financial considerations.

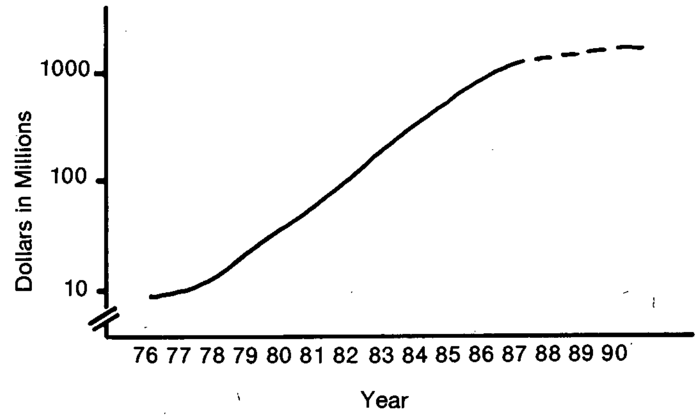

Figure 1. Growth Rate of the Worldwide Fiber-Optics Marketplace.

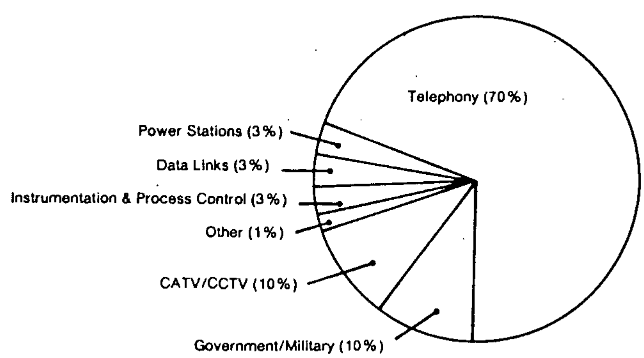

Figure 2. 1973 Worldwide Optical Fiber Installations by Segment (Number of Units).

METALLIC CABLE VITAL IN KEY AREAS

Extensive reports have been written detailing anticipated developments within the fiber-optics area over the next decade. As previously noted, the growth is strongly upwards; the actual extent continues to be debated among the sages of this optical industry. In each instance, however, the predictions have been made based on exhaustive research into two primary areas of interconnection, telecommunications and military applications. To a far lesser extent, one will see studies into computer applications and even less into the area of industrial control. Information Gatekeepers, Inc.[1] viewed the 1973 world optical fiber installations by segments (units), as depicted in Figure 2.

The specific extent of penetration/involvement is not what is key: it is the segment which is of primary concern, e.g., the impetus is in the telecommunications, CATV and military marketplaces. This does not infer that no activity is occurring in the other segments, but that developments in these areas will occur at a slower pace. Therefore, the role of the metallic cable will continue to be of vital importance in these areas. Developments within the telecommunication and military communities will, as in the past, spill over to other segments of the marketplace, the speed and the extent of which are determined by the ability of these segments to standardize the technology and of industry suppliers to have enough raw materials and capacity to supply these lesser market segments.

LONG OR SHORT HAUL

Currently, there is concern about whether the industry will move towards a single mode/long haul fiber which could negatively affect other emerging optical markets which benefit more from the graded index/shorter haul fiber. There are also questions of how quickly the industry can standardize itself since each segment has its own particular focus, and how quickly other necessary components of the optical link can be developed. Again, although the fiber constitutes the backbone of the optical system, the other components, as well as standardization, will be required to make the optical link acceptable to other industry users. Should this not occur, the benefit and impact of fiber technology on other market segments will be seriously hampered.

Currently, the fiber-optic cable is the largest segment of the optical marketplace. It is growing at the fastest rate and sustaining the most rapid decline in price. This decline is attributed to the constant reduction in the cost of the fiber component of the cable.

Although strides are being made in the area of the other optical system components, such as emitters, detectors, multiplexers, couplers, and connectors, technological advancement with subsequent reduction in cost/price are not occurring at the same rapid pace. The complectionof the component industry is also far different from that of optical cable. Whereas, the cable industry is characterized by a limited number of large corporations, the component field is typified by the small company. This further complicates the recurring problem of industry standardization.

STANDARDIZATION

As has occurred in the metallic marketplace, the lack of industry standards in the field of fiber-optics is inhibiting more pronounced growth. Lack of standardization promotes fears that the components of the company will not fit the system of other manufacturers. There is no doubt that this industry wants and needs such standards, but, unfortunately, a clear and precise understanding of how to accelerate such a development is not forthcoming. In many respects, the standardization is being swayed by the telecommunications industry which, when designing with graded fiber, met the constraint of attenuation. Today, however, single-mode fiber limitations focus on numerical aperture (NA).

The controversy of standardization continues to plague the notable standards organizations such as IEEE, NEMA, IEC, ANSI and EIA. Until such standardization occurs, the field of fiber technology will remain one of customized systems prone to incompatibility and sustained slow market growth.

THE METALLIC MARKETPLACE

Many industry specialists predict that the metallic market will not feel a major impact until the 1990s and beyond.[2-3] Even if optical prices and availability continue to decrease and associated technology continues to increase, it is highly doubtful that any industry will entirely cut off metallic interconnection in favor of optical systems. In all probability, what will occur is a carefully scheduled transition into fiber-optics rather than the wholesale overnight move to optics with the associated rapid transition costs.

Likewise, new applications on existing retrofit applications will consider both fiber and metallic technology, the victor being that which yields the serviceability and realistic need.

METALLIC CABLE

The current disadvantages, or opportunities, which exist in the fiber-optics industry today might be summarized as shown in Figure 3. For all intents and purposes, none of these difficulties plague the more mature metallic cable market. This ensures its existence, at least until such time that fiber technology responds to these systems' shortcomings.

IMPROVEMENTS IN CABLE DESIGN AND MANUFACTURING

The metallic market has been termed a mature technology characterized by relatively stagnant growth, coupled with ever-increasing material (most notably copper) and labor costs. While the latter might well be true, this mature technology has made strides in recent years to provide conventional cables which yield solutions to age-old problems of harsh environments, whether in the guise of EMI/RFI radiation or harsh

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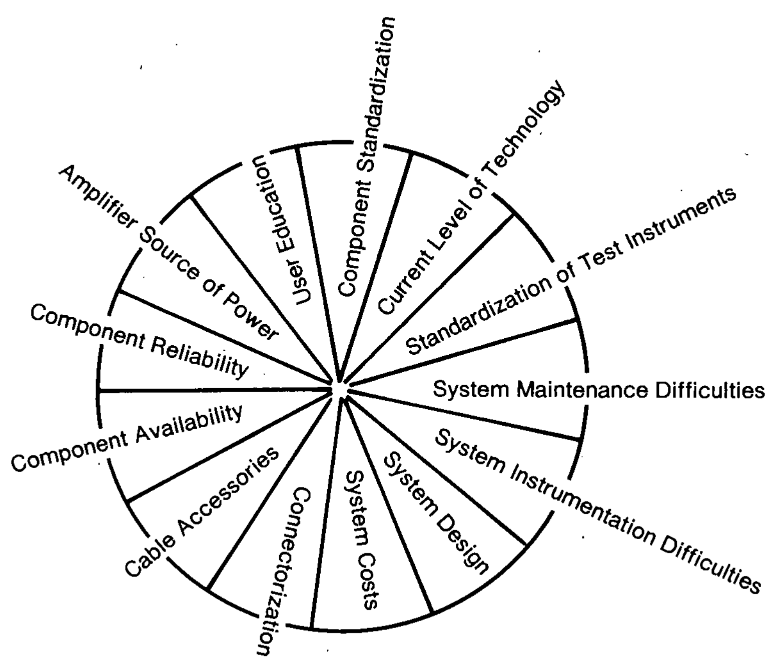


Figure 3. Current Disadvantages of Fiber-Optical Systems.

a Faraday cage (Figure 1). This test assembly can be applied to interface cables to computers, process control cables between peripheral and control machines, coaxial cables, and to finished system installations.

DATA LINE COUPLER

The data line coupler referred to here is a universal coupler which was designed especially for direct capacitive interference coupling in signal and telephone lines. It is used to impress fast interference pulses asymmetrically or symmetrically on the signal line. The normal model is designed for pulses of a few nanoseconds rise time and up to 100 ns pulse duration. However, its construction enables the coupling capacitances to be interchanged at any time to suit different requirements. For symmetrical coupling, a 20dB attenuator is incorporated, permitting optimum interference values for transposed cables. Provisions are also made for

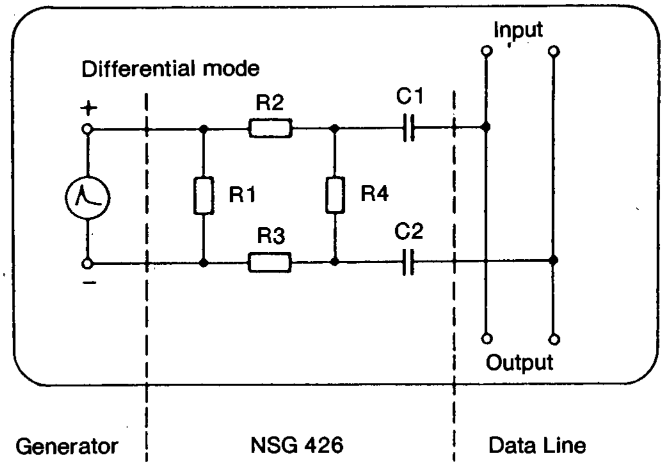


Figure 2. Basic Circuitry of the Data Line Coupler.

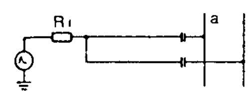
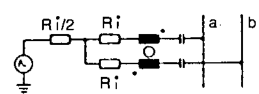
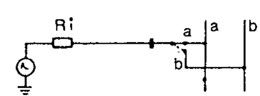
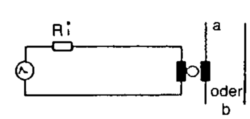
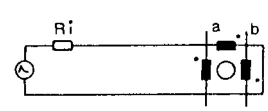
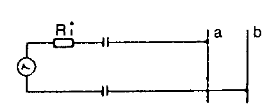
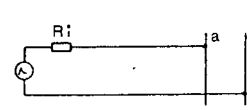
Asymmetrical capacitive for low wanted signal frequencies	
Asymmetrical capacitive with decoupling for wide-band desired signal	
Unsymmetrical capacitive, but disturbs symmetry of the desired signal	
Unsymmetrical inductive, but disturbs symmetry of the line (Ri is reflected)	
Symmetrical inductive (Ri comes in series with the line)	
Symmetrical capacitive	
Symmetrical conductive (only works for Ri >R signal source)	

Table 2. Coupling Types: Direct Coupling.

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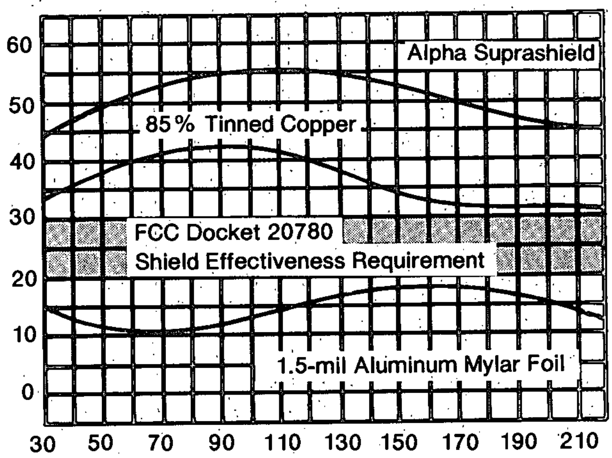

Figure 4. Shielding Effectiveness.

chemical or abrasive industrial locales.

To this end, one may witness the emergence of new cable shield designs as well as new EMI/RFI suppressing shield tapes to inhibit spurious emissions from digital circuits confined to electronic cabinetry and the interconnecting system cables. In the area of shield tape technology, one notes the shield tape which represents the state-of-the-art in cabinetry shielding tape today.[4] This tape adequately screens cabinetry seams from radiation polluting signals from the environment.[5] Also, another cable shield design is available to inhibit cable radiation from permeating the environment (Figure 4).

Other reasons for the continuing demand for metallic cable in system designs are the product improvements offered by the cable manufacturers. Not long ago, the end-user was given very few choices to meet a system's operating environment. First, there were rubber and cambric which provided protection for the conductors only in a very limited range of environmental conditions. With the introduction of vinyls, the range expanded, but only recently has the full range of operating conditions to which cable is exposed been adequately provided for through the use of a number of modern constructional materials.

Furthermore, cable manufacturers have taken into account the fact that no single constructon or design is ideal for every operating condition, and, where special custom-made cable was previously the solution to unusual operating conditions, some manufacturers are now offering a wide range of cable types as standard products. By carefully evaluating the characteristics, performance and applications data provided by the manufacturer, the user has a choice in selecting the cable that best meets the system requirements.

At the same time that the wider choice of production-run, special grades of cable have become available to the designer, the performance demands have become more critical. These requirements can be met through the careful selection of construction materials that meet the environmental demands.

CABLE CHOICES

Except for the most exotic application, the system designer can find an "off-the-shelf" cable that fits his system requirements. Samples of grades of cable now available include:

- *General indoor circuit type*. Useful for indoor electronic systems, such as computers, communications, instrumentation and control equipment; it is a general purpose cable with tinned-copper conductors insulated with PVC and jacketed with the same material.
- *Heavy-duty industrial*. This cable features PVC-insulated conductors, but with a more durable outside jacket of polyurethane. It is appropriate for systems in such applications as machine tools, petrochemical refineries, printing presses, industrial robots and other areas where oils, chemicals, fuels, solvents and mechanical abuse or abrasion are encountered.
- *Direct burial cable*. Appropriate for direct underground installation without protective conduit. Cable with PVC insulated conductors and a cable cover of heavy-duty polyethylene will serve.
- *Outdoor, all weather systems*. An outdoor, general purpose cable is offered with thermoplastic elastomer (TPE) insulation and jacketing. It withstands all kinds of weather from very hot to very cold and holds up to many solvents and accepts mechanical abuse, making it suitable for cable tray applications in pulp and paper mills, petrochemical plants and similar rugged atmospheres.
- *Environmental extremes*. Cable with fluoropolymer (FEP Teflon[6]) insulations and jacket withstand the most extreme and hostile of environnments. This type of cable is the preferred choice for steel mills, chemical plants, plenum air spaces and beverage plants where corrosive, high temperature, abrasive and abusive conditions exist.

Finally, whether the transmission medium is fiber or conventional metallic elements, both require the protection of armor for those unduly harsh locations where conventional cables would present virtually no service life. In these applications, armors of interlocked steel or round, served wire strands remain a viable solution. In areas of gopher or other rodent infestation, flat, spiral armors of commercial bronze provide an adequate, although temporary, solution. For areas of insipient ground water, sheaths of fused-coated aluminum and ethylene jackets provide a formidable deterrent to water damage.

CONCLUSION

One can readily see that fiber offers additional data capacity and speed compared to that of copper transmission. It does not, however, offer immediate solutions to the problems associated with electro-optical development, nor does it offer a

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the incorporation of a resistive pulse attenuator at the connection for optional units. Figure 2 illustrates the basic circuitry. The data line coupler can be used to check and optimize the noise resistance of signal inputs on equipment and computers, homologate at signal and data inputs, and test telephone and modem connections.

SMALL COUPLING CLAMP

The small coupling clamp has been in use for a long time. It is virtually the predecessor of the IEC coupling clamp. The cable is clamped between the two electrodes without interruption. The coupling parameters are very complex for this clamp because the cable lies in the field created between the two electrodes. Both capacitive asymmetrical coupling and inductive symmetrical coupling take place. The precise values are dependent on the cable layout. This coupling clamp is only suitable for fast pulses in the nanosecond range. The small coupling clamp can be applied to specific tests which require this clamp, tests on ready-installed cables where space is tight, and quick and simple tests during development and in the inspection laboratory. Table 2 identifies types of direct coupling.

SUMMARY

With the very sensitive semiconductor modules in use today, no data or signal line, however short, can be used without extensive EMC clarifications. In general, the tests are only passed by conductively separated systems, and in the case of longer distances, by systems equipped with lightning protection. Tests for lightning, NEMP and earth potential differences are usually destructive tests and, as a rule, should therefore only be carried out for homologation purposes. Tests for the control of ESD and interference should be applied as routine check tests because the high-frequency properties which affect many types of equipment are not suspected in the production process and hence do not receive attention. ■