AN INTRODUCTION TO FIBER OPTICS

Fiber optics are proving increasingly useful in the control of EMI, EMP and ESD.

RAY BROWN & CHARLIE PATER, MOLEX, INC., LISLE, IL

Light, in conjunction with electronic devices, has been used for many years to control functions. At first, the uses were simple, like counting objects on a conveyer or sensing the approach of people and opening a door. The first development of silicon devices in the early 1960's made the detectors for these operations very simple and much smaller in size. The development of the Light Emitting Diode (LED) in the early 1970's made it possible to use systems that operated much faster than incandescent light sources. Light coupled devices, which could sense microsecond events, became common.

The development of the low current solid-state laser made it possible to generate narrow beams of light that could be turned on and off in a few nanoseconds. Now, it was possible to transmit information faster than the receiving devices could process the signals. New receiver technology was developed to use the fast laser devices. The driving force behind fiber optics development was AT&Ts recognition that, at a transmission distance of 2 kilometers or more, the fiber system was more cost effective than a copper wire system. Inexpensive systems for industrial, process control and computers are just now emerging from the development phase.

Optical fiber development has always been ahead of opto-electronic device development. This has provided a continuous challenge for device and connector technology to catch up.

TECHNOLOGY

A fiber optic system consists of a transmitter, receiver, connectors and cable, and functions like a wire connecting two points. An electrical signal comes out of the receiver.

Each fiber, whether plastic or glass, is made up of two materials. The central core has a higher index of refraction than the material on the outside of the fiber. The difference is small, but the effect is to hold the light within the fiber core. This index change causes the light that strikes the interface to reflect back into the central portion of the fiber, preventing it from leaving the fiber edges. There is a cable jacket around the fiber to protect it from abrasion and scratches. Of course, these fibers may be bundled together to make a multi-strand cable.

Light travels down the fiber in pulses that resemble the input signal. Each of the pulses is spread, distorted and attenuated by the fiber. How much of each of these occurs is a function of the purity of materials and the diameter of the fiber. In recent years, both the glass and the plastic fiber materials have been improved significantly. A few years ago, the attenuation of a plastic fiber was 2000dB per kilometer. It is now down to 200dB/km. Glass fibers can now be made with 0.2dB/km attenuation.

Laser sources are usually used with glass fibers that are 50 microns or less in diameter. LED sources are generally used with fibers 100 microns and larger. With small diameter fibers, it is very difficult to get much light into the fiber. It takes machined parts and very careful handling to get a useful quantity of light into the small glass fiber - an expensive proposition. Large diameter fibers are relatively easy to interface with LED light sources, and being plastic, are much cheaper. LED's are solid-state devices that are very long-lived. They are also ideal for digital communications as they can be turned on and off rapidly.

Most detector devices in use today are made from silicon and are usually diodes. When a silicon device absorbs light, it generates electrical carriers which cause a small current to flow. To be useful, this current must be amplified to a useful level. This requires a very high gain amplifier. It is difficult to make a high gain amplifier react fast. It is possible, if the amplifiers are built very small, to reduce capacitance technology to make very small amplifiers.

APPLICATIONS

Digital. Communications between parts or components of digital systems such as computers, controllers, or printers are possible with fiber optic systems. The faster the data rate, the more difficult it is to meet FCC EMI radiation and susceptibility requirements with copper wire systems. Fiber optics offers a solution to meeting those requirements.

Another advantage of fiber optics is the ease of stringing a small fiber between parts of a system compared to hiring electricians to lay bulky shielded cable. Fiber is not electrical and does not usually require conduit or electricians to install. Fiber is easily run up a wall or under a carpet. And, though fibers appear to be fragile, they are, in reality, very rugged.

Analog. There are many analog applications. Process control systems require the measurement of position or value in electronically noisy environments. Chemical plants and power generating plants or sub-stations are likely places to use fiber optics. Highly flammable or explosive environments require special precautions to prevent electrostatic discharge (ESD), like the attributes of very high isolation voltage and non-conductive characteristics of fiber systems.

EMP. Fiber optics also offer one solution to problems resulting from electromagnetic pulse (EMP). Because they operate with light pulses rather than electrical current, fiber optic cables are immune to the high levels of electronic energy resulting from a nuclear explosion. Thus, fiber optical cables can effectively arrest the EMP surge before it destroys equipment and interrupts essential communication systems. Other advantages of fiber optics over traditional copper cables include large transmission capacity, resistance to harsh environmental conditions, small size, light weight and an indefinite service life. Also, fiber optic systems can be buried underground. In fact, in response to the nuclear threat, the fiber optics market of $4 million in 1973 has expanded dramatically, and is expected to reach over $2 billion by 1992. American defense officials and technical experts have encouraged this growth, as have members of the communication industries. ■