Triax and High-Definition Video

By Steve Lampen

Triaxial cable, coaxial cable with dual isolated shields, dates back to the 1940s. Philips experimented with triax-based cameras in 1972 to 1973 using 50Ω triax and N-type connectors. Kings Electronics produced a high-power 50Ω triax connector for the U.S. Navy around the same time. In mid-1975, Dave Elliott of ABC and Fred Della Iacono of Kings Electronics discussed the idea of using triax cables, and and the "triloc" connector was born. This system was first tried at the Dorado Open Golf Tournament, Miami, FL., in 1975 and became the de facto camera standard by the time ABC produced the Olympic Games in Innsbruck, Austria, in 1976. The use of triax allowed a small cable of a half inch or less to run multiple signals. It replaced the huge cables, such as TV-81, which were very difficult to manage and impossible to repair. It is no surprise that triax became an international standard for professional video camera applications.

Presented at the 37th Advanced Motion Imaging Conference, Seattle, WA, February 27-March 1, 2003.

Triax cable and triloc connectors are a very rugged combination and can stand extreme abuse, however, they can easily be repaired or replaced in the field. This combination of cable and connector dominated the professional camera market until the introduction of high-definition (HD) digital signals. But HD required much greater bandwidth, and SMPTE eventually approved Standard 311M, a copper-fiber hybrid cable. This paper examines the emergence of 311M cable, the reaction of the marketplace, and renewed interest in triax cable for high-definition video applications.

Fiber-Optic Camera Cable

The rise of high-definition video applications, such as 1080i and 720P has led to high bandwidth demands on camera cables. These applications run on a bit stream of 1.485 Gbits/sec and a resultant bandwidth of approximately 750 MHz. Many manufacturers offer hybrid cables, which consist of dual single-mode fiber-optic cables and copper components for power and data.

Different than Triax

Despite the belief that it was the high-definition substitute for triax, it became apparent that SMPTE 311M was very different than triax because the fibers can be broken more easily than copper components. Repairing the cable is impossible in the field, because it is difficult to determine the location of the break with any accuracy greater than 2 or 3 ft.

Single-mode fiber requires a microscope in order to be seen, and the fiber must be cleaved (cut) and polished with great precision. Therefore, many installations require extra 311M cables in case the primary cables fail. Although it is virtually impossible to install a connector in the field, single-mode fiber-optic cable can be hot-spliced. This is a fiber-to-fiber connection that can be completed with reasonable ease. Installations can often be done with pigtails—short fiber-optic cables with connectors preattached, which can be placed in a pedestal or other protected permanent enclosure, and hot-spliced onto other single-mode cables.

Table1—Return Loss on Triax Cable

Return Loss	Frequency Range	Percent Reflected
-20 dB	5-850 MHz	1%
-15 dB	850-3 GHz	3.16%

Table 2—Triax Distance

Triax Type	SMPTE Distance	Digital Cliff
RG-59	300 ft.	600 ft. (?)
RG-11	540 ft.	1080 ft. (?)

Back to Triax?

A number of designers and installers have begun to reconsider triax as a high-definition cable, because of the considerable hurdles of fiber-optic cable. Camera manufacturers are considering standard triax with HD. However, on closer examination, none of these are true digital HD. Some run on wideband analog, often with a 30 MHz luminance, and color components of 15 MHz each; this turns out to be a standard-definition (601) triax option. At 270 Mbits/sec, 135 MHz, solid-core RG-11 triaxes could approach 2000 ft. Manufacturers claim significant distances for HD, up to 1000 m (3280 ft.), but in the camera specifications, this can be an analog format such as Y/C.

At the time of writing, the author has not seen a single professional video camera that would support high-definition signals, in a digital format, on triax. Surely, these systems will be considerably expensive and technologically advanced, but the question remains as to whether or not they are possible.

Testing Triax for HD

Precision coaxial cables can be characterized for high-definition applications. The performance specifications of these cables can be applied to triax cables with similar internal performance and dimensions. However, due to their flexibility and flex-life (flexes to failure), triax cables do not perform as well as precision coaxes. Some manufacturers offer a guarantee of return loss, shown in Table 1. It should be noted that -15 dB is the SMPTE link limit—the maximum reflection in digital video installations. Although actual cable performance exceeds these numbers, it is indicated that triax cables do not come close to standard coaxes that can exceed these numbers by up to 6 dB. Future designs for triax could improve these numbers.

The theoretical triax distance can be determined using the SMPTE formula (SMPTE 292M), which states that the maximum distance can be determined as the point at which the signal drops by 20 dB at half the clock frequency. For precision RG-59 solid coax, this will be approximately 300 ft. For precision RG-11 solid coax, the distance is approximately 540 ft.

The SMPTE formula attempts to protect the designer or installer from approaching the digital cliff. At the knee of the cliff, bit errors dramatically increase until the receiving circuit can no longer resolve the bit stream and the circuit fails. This can occur in as little as 10 ft. Because the bit stream can look perfect on a monitor but be on the edge of failure, the SMPTE formula establishes the recommended distance about halfway to the cliff. The actual distance to the cliff depends on a number of factors, starting with the cable itself. Larger cable, and cable with better numbers on return loss, will be able to go farther. Also, the active devices at the source and destination can be major factors in the effective distance. As chip technology improves, so does the ability to resolve a bit stream, which may be lower in noise at the end of a long cable. Table 2 shows the theoretical distance of small or large solid-center triax.

Conclusion

Measurement of bit errors is absolutely required to install cables past the recommended SMPTE distance. Eye pattern, bit error counting, and other ways of determining bit errors are essential. It should be noted that you are beyond the normal distance of these cables; however, if there are no bit errors, the cables should be able to function and their proximity to the digital cliff should be considered. Therefore, if a cable can be tested for bit errors with all other passive components in the line (connectors, patch panels, and patch cords), the results should be even more believable. Going beyond the recommended distance does not provide any guarantee.

THE AUTHOR

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