DROP CABLE TRANSFER IMPEDANCE

Introduction

Although drop coaxial cable is selected for its electrical, mechanical, and environmental performance, probably the most important factor is shielding. Aside from the strict FCC regulatory requirements, cable signal leakage problems can have a disastrous effect on system performance, especially when upstream communications in the 5 to 42 MHz band are considered. Since shielding controls drop cable cost more than almost any other element, it is important to understand how various shield configurations perform.

Transfer Impedance

The unit of measure that best describes how well a shield performs or how energy transfers through the shield is its transfer impedance. Transfer impedance is the ratio of the voltage in the disturbed circuit to the current in the interfering circuit along an elementary length of the shield. The disturbed circuit for ingressive signals is inside the coaxial cable and the interfering circuit is the environment outside the coaxial cable. The lower the transfer impedance, the better the isolation. A low transfer impedance allows less energy to pass through the shield than a high transfer impedance.

Shield Types

The transfer impedance of solid shields can be calculated with extreme accuracy. The transfer impedance of shields that have holes, like a braid with uniform size, shape, and distribution of the holes, can also be calculated, but with far less accuracy. When the shield is more complex, having multiple braids and tapes, transfer impedance calculations have very questionable accuracy.

Generally, the type of shields used by the cable television industry are complex, often consisting of multiple layers of tapes and braids. In order to determine the transfer impedance of these complex shields, measurements are necessary. The technique generally accepted by the industry employs a terminated triaxial fixture, such as the Radiometer manufactured and used by TFC.

Simulated Aging

Figure 1 shows the transfer impedance of several coaxial cables after simulated aging and a solid tube which is listed for reference only. The simulated aging is based on flexure that degrades transfer impedance by the same amount as drop cables removed from systems after 10 years of actual service in the Northeast U.S. Flexure may simulate cyclic stress from temperature changes, wind, and ice loading. The simulated aging does not take into account other environmental effects, such as corrosion, which can also degrade shielding performance.

Braid Shield

One of the first drop cables used by the cable television industry was a 59-type cable. The earlier designation, "RG59/U", refers to a cable with a 75 ohm impedance, a 0.146 inch O.D. solid polyethylene dielectric, and a 95 percent coverage copper braid. Although its performance is not affected by the simulated aging tests (i.e., it has no tape shields), even its unaged transfer impedance performance is quite poor by today's standards, especially at higher frequencies.

Shields With Tape and Braid

An improved version of this cable, from both a cost and a shielding standpoint, consists of a laminated tape over the dielectric and a low coverage aluminum braid. The tape provides 100 percent optical coverage and is composed of three discrete layers (aluminum-plastic-aluminum). Aluminum foil alone is unacceptable because of its tendency to crack even after only moderate flexure; the plastic laminant tends to reinforce the outer aluminum foils.

A sealed version of this laminated tape (with a fourth layer of adhesive) was later introduced to facilitate connector installation and to keep the overlap from separating after flexure, thus creating a gap which would degrade shielding performance. This construction is somewhat more expensive but it had much improved resistance to shielding degradation after flexure, when compared to tape versions without the seal.

Quadshield

Further improvements were made to shielding performance by using multiple layers of tapes and braids. The best available is quadshield, which includes a sealed tape, a braid, an unsealed tape, and a second braid. This construction showed a vast improvement over other available cables, especially after handling and field exposure.

Trishield

Other cables, such as trishield (sealed tape-braid-tape), were developed, which provided a trade-off between cable cost and shielding by avoiding the use of the costly outer braid used on quadshield. The trishield has a lower cost, but it does not afford the shielding level of quadshield.

Trishield was modified further by replacing the outer tape with a two-layer laminated tape. It has a thicker aluminum foil facing inward and a plastic reinforcement facing outward to prevent radial cracks. In this case, the tape is folded to provide metal to metal contact at the overlap, thus reducing the effect of the gap after flexure. This construction offers improved low frequency performance over the original trishield, but measurements confirm no improvement above 30 MHz unless a much higher coverage braid is used (e.g., 80 percent).

Although these constructions are better than the original tape-braid versions, quadshield remains superior. A headend cable was developed with the quadshield design for applications where extremely good shielding is required.

DISCUSSION OF FIGURE 1.

The best transfer impedance performance that can be achieved is with solid tubes because they contain no holes which would allow electric and magnetic energy to couple to the external circuit. In the case of solid tubes with no holes, leakage is solely a function of fields that diffuse through the metal. Transfer impedance improves (gets smaller) as the frequency increases because the diffusion through the metal decreases.

Braided shields are subject to the same diffusion process, but the braid holes allow magnetic energy to couple through the shield. The transfer impedance is the vector sum of the diffusion and magnetic coupling. Since magnetic coupling increases directly with frequency, at frequencies in the cable television band, the magnetic coupling contribution is the driving force behind the braid's poor performance.

When a tape is added to the braid, the size and number of holes are substantially reduced, thus limiting the magnetic coupling. However, the overlap defies easy analysis. Gaps that exist at the overlap can vary significantly from one sample to the next. Prior to simulated aging, a tape/braid version performs quite well. After flexure substantial degradation can occur.

Less sensitive to flexure are sealed versions of the tape/braid construction. Apparently the gap at the overlap does not separate as much as unsealed tape versions, thus controlling the amount of magnetic coupling. Additional shields (those beyond the sealed tape and braid) improve the cable's transfer impedance.

Prior to flexure, the two trishields and quadshields are almost indistinguishable except at low frequencies where the amount of metal is the key factor. Because quadshield has the lowest DC shield resistance, it is clearly superior in this region. The quadshield developed for headend applications provides substantially improved shielding.

After flexure, the multiple-shield types degrade. Quadshield has an advantage in that it keeps the tape overlap from separating and degrading far less than the trishield versions.

In addition, there is an advantage to having the second tape sandwiched between the two braids and the second braid sandwiched between the tapes. This efficiently shorts the tape overlap and optimizes intershield RF electrical contact.

Flexure is only one mode of shielding degradation. Another and probably more important mode is corrosion, especially at the cable-connector interface. This paper has presented the transfer impedance of typical cable constructions used by the CATV industry. Because subtle differences in the geometry of the tape overlap, many samples of the product should be measured to validate the cable design.

Figure 1.
Drop Cable Transfer Impedance Versus Frequency After Flexure.