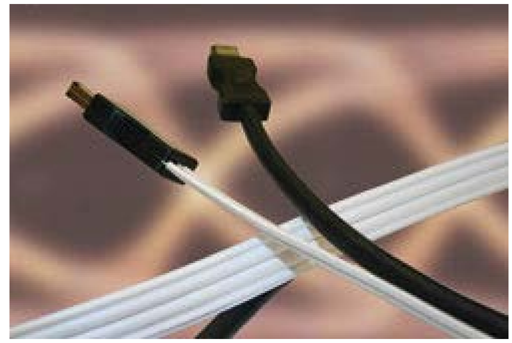
Test Data for GORE® FireWire® Cable

Monitoring the Impedance and Attenuation During Flexing



The flex test simulates a longitudinal stroke or rolling flex motion (figure 4). One cycle is two complete strokes. This motion is common in automation and stresses cable through the entire flex region. We want to flex a long length of the cable under test to get a better "view" of the impedance and attenuation. It is important to base cable selection on rolling flex testing, as opposed to tick-toc testing, to get a true picture of how the cable will perform in real-world conditions.

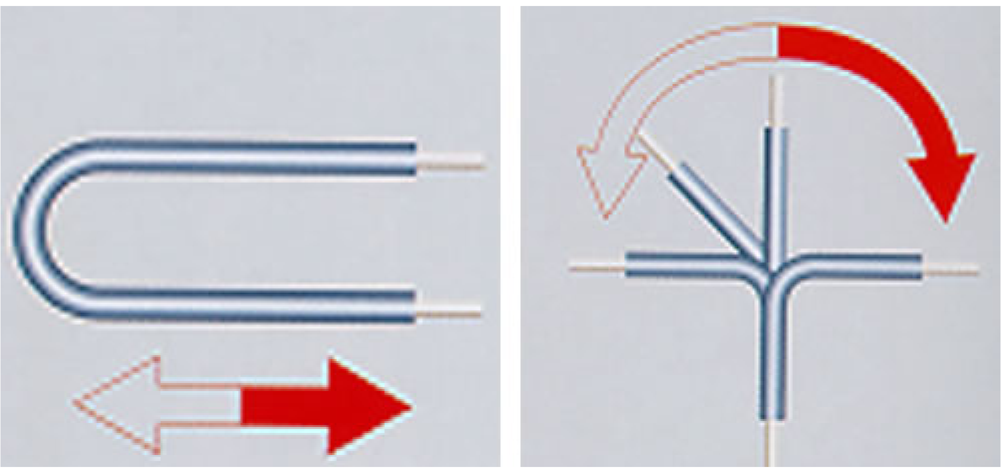


FIGURE 5

A tic-toc test (Figure 5) is not effective to show the signal degradation problem. This test is localized, only a small section of the cable is stressed. This cannot give an accurate measure of the effect of flexing on the electrical characteristics of the cable under test.

For the rolling flex test, a signal generator and vector network analyzer are connected to the cables under test using precision, controlled impedance cables that have to be isolated from the flex testing motions. A printed circuit board was designed to bus the signals from each pair in the cables under test to SMA connectors for the test leads. Conductors and shield resistance of the cables under test are also monitored. (Figure 6)

The flex test is run on a high speed linear motion test bench with 0.5m stroke length. The high speed flex tester can run 90,000 cycles / day. Each cycle is two complete strokes. Acceleration is 4G and the bend radius is 50mm. The cables are placed in a cable chain to control motion and bend radius. This test set up made a loop with the cables under test that includes two bent sections. Now we can stress approximately 540mm of cable, simulating a 1m stroke length. (Figure 6)

FireWire® samples from six different cable suppliers and at least 3 samples of each cable were used in the flex test. None of the cables tested could flex more than 10,000 cycles before the FireWire signal was lost.

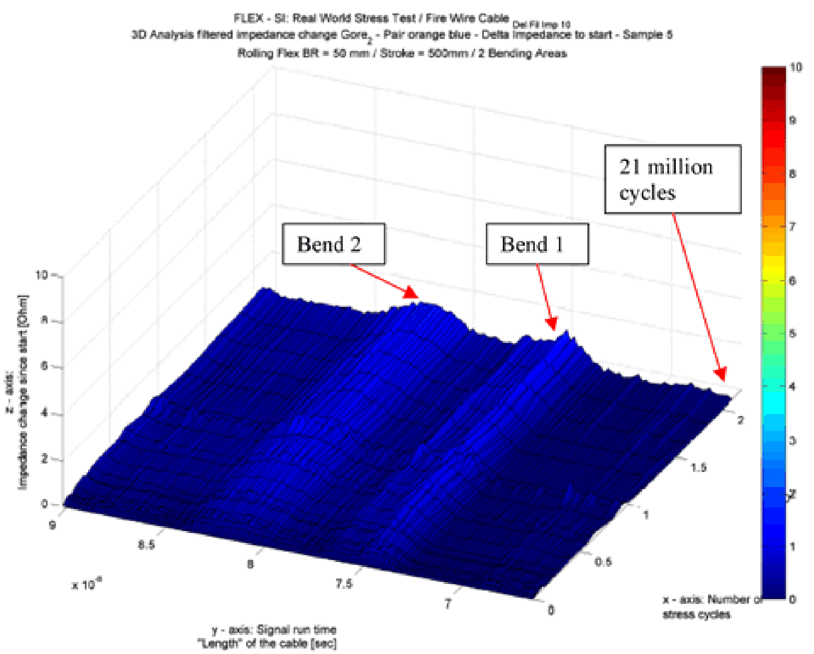


FIGURE 13 – Plot of Impedance during flex, change is less than 2 ohms

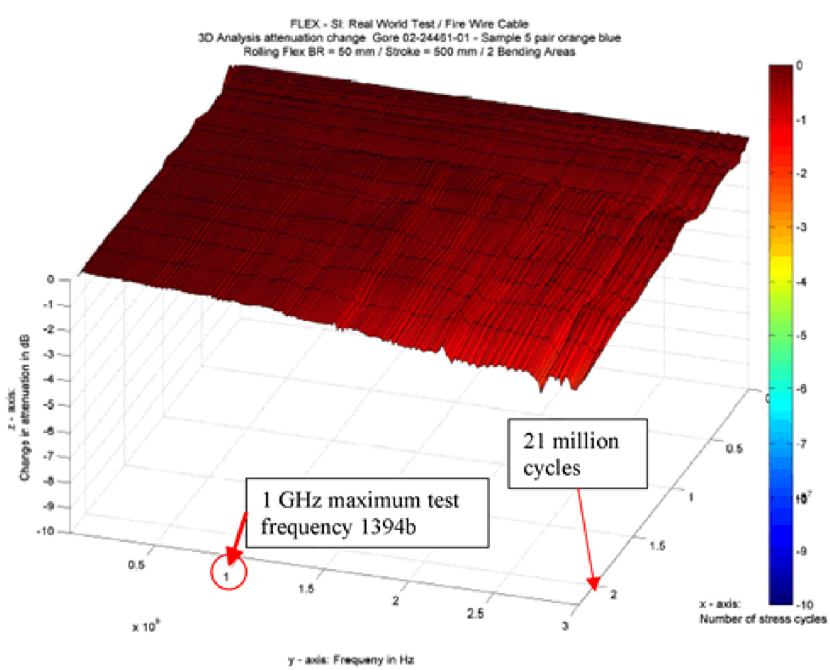


FIGURE 14 – Plot of Attenuation during flex, change is < -1 Db

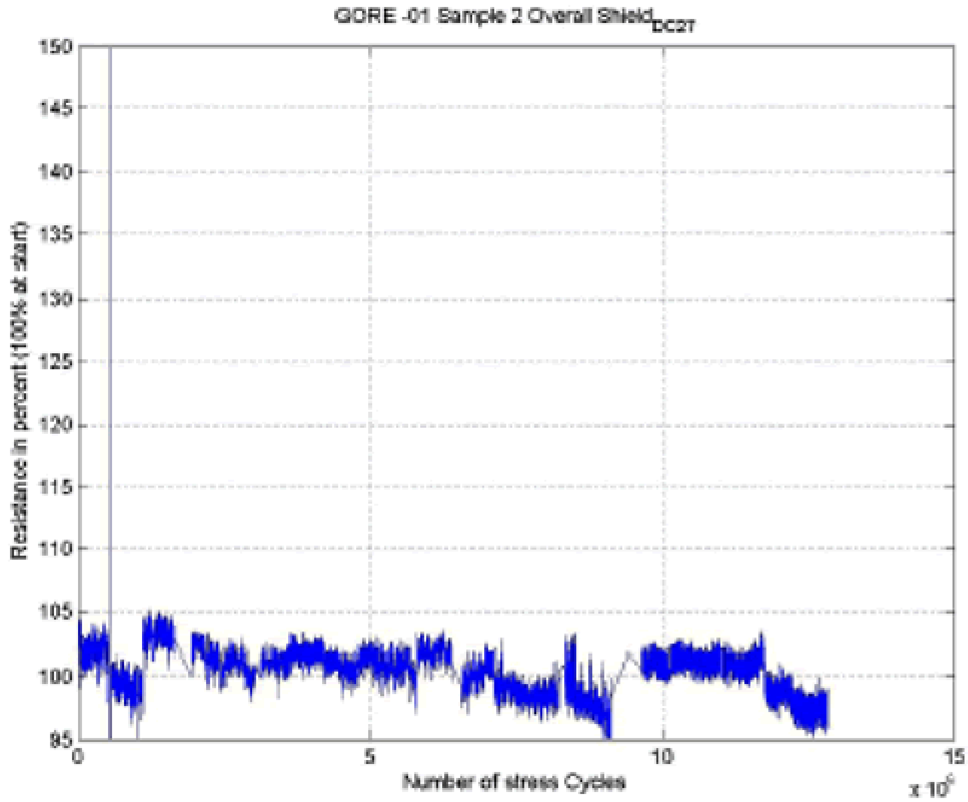


FIGURE 15 – Resistance of Overall Shield. This graph shows the DC resistance of the enhanced braid from 0 to 13.6 million cycles

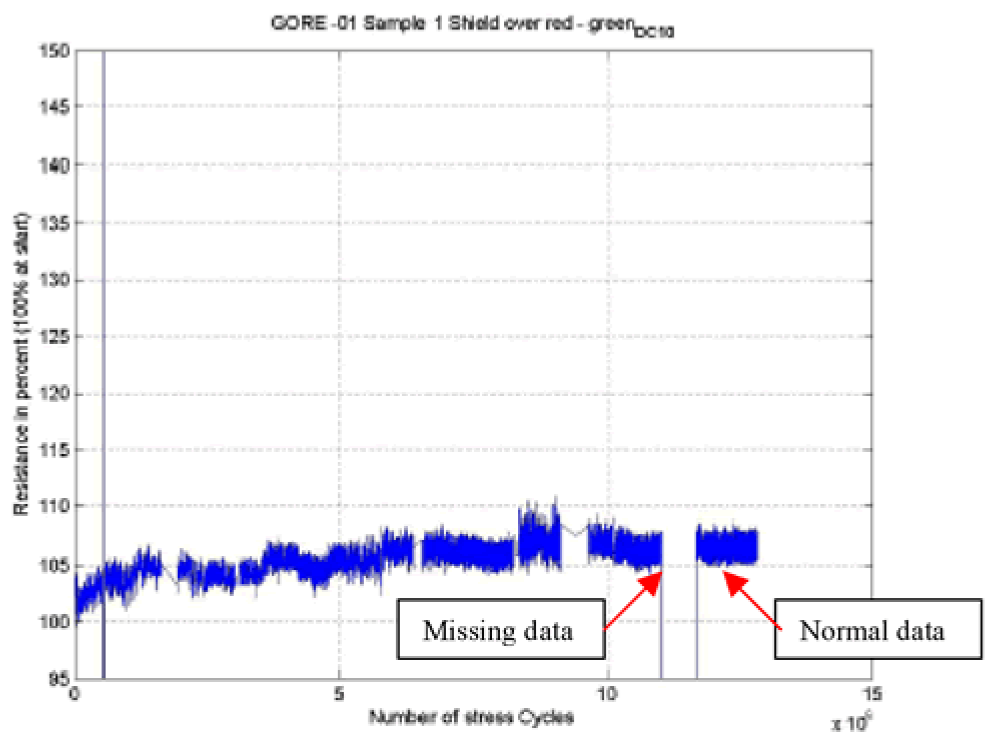


FIGURE 16 – Resistance of twisted pair shield. This graph shows the DC resistance of the enhanced shield on the controlled impedance twisted pairs from 0 to 13.6 million cycles. Resistance increase about 7%.

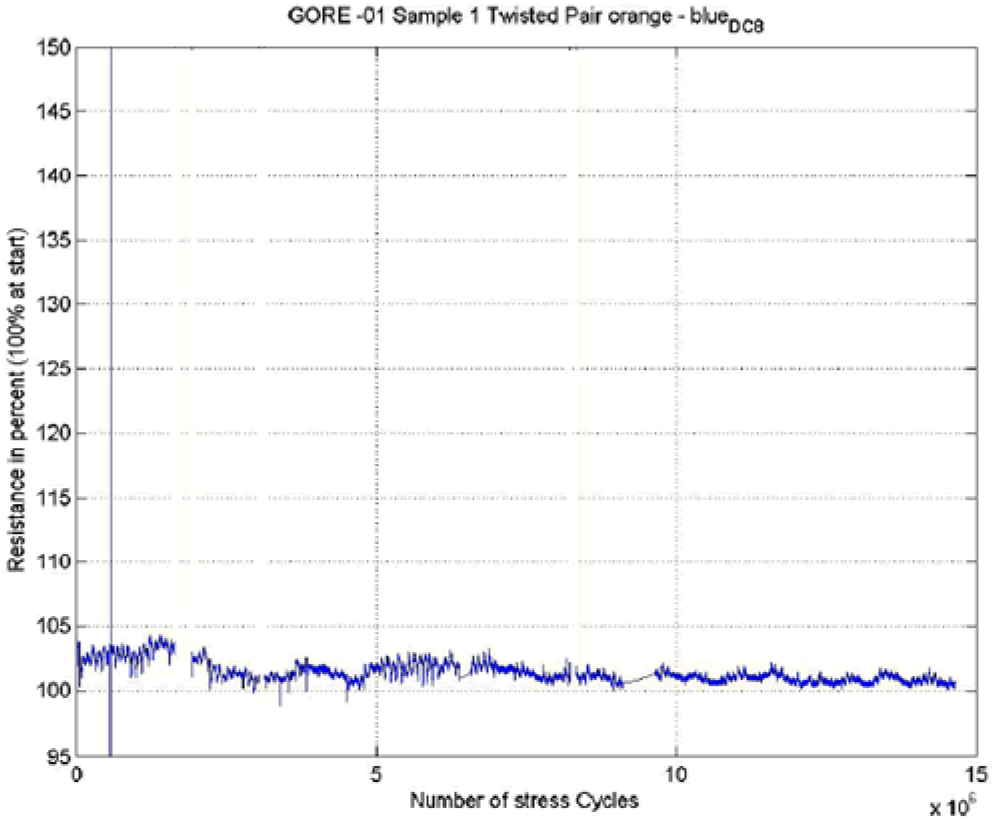
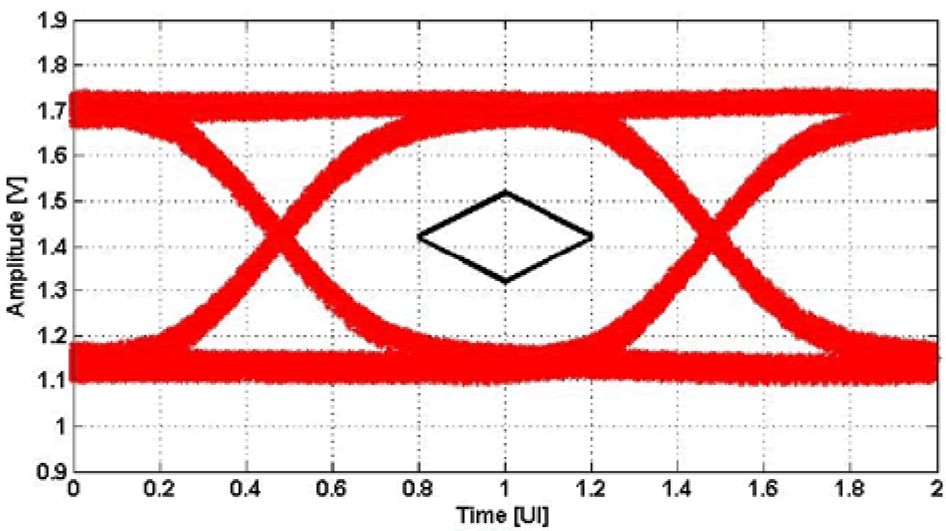


FIGURE 17 - Resistance of conductor. This graph shows the DC resistance of a conductor in the controlled impedance twisted pairs from 0 to 13.6 million cycles.

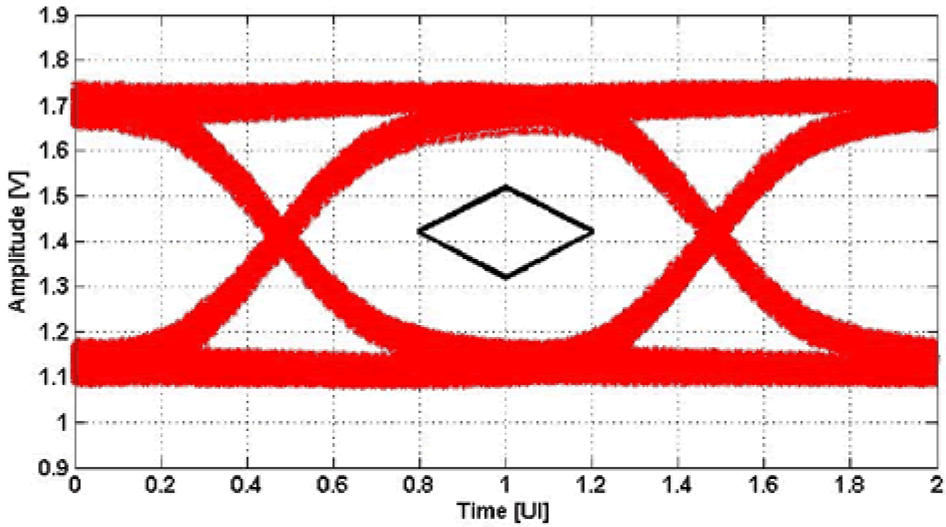
Eye Diagrams of GORE® FireWire® High Flex Cables

An eye pattern is an oscilloscope display in which a pseudorandom digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because the pattern looks like a series of eyes between a pair of rails.

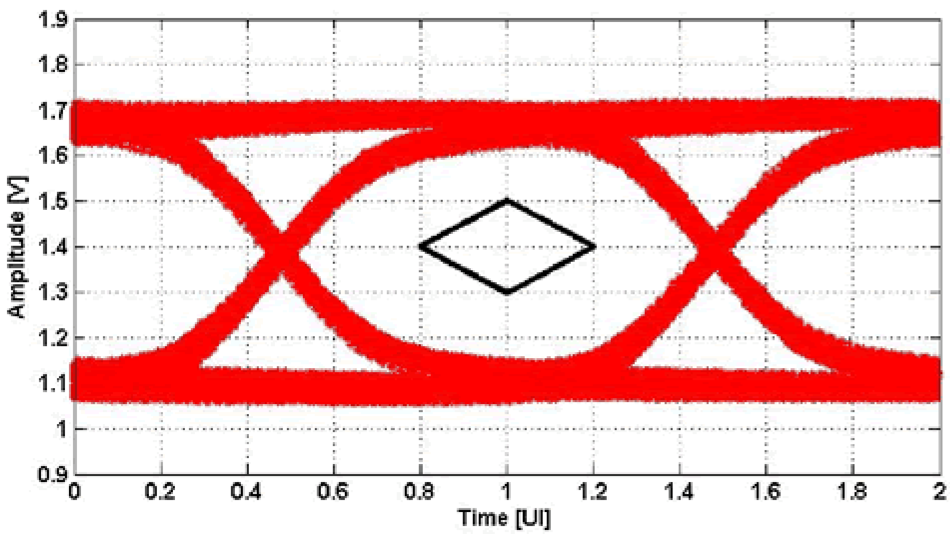
Before Flex



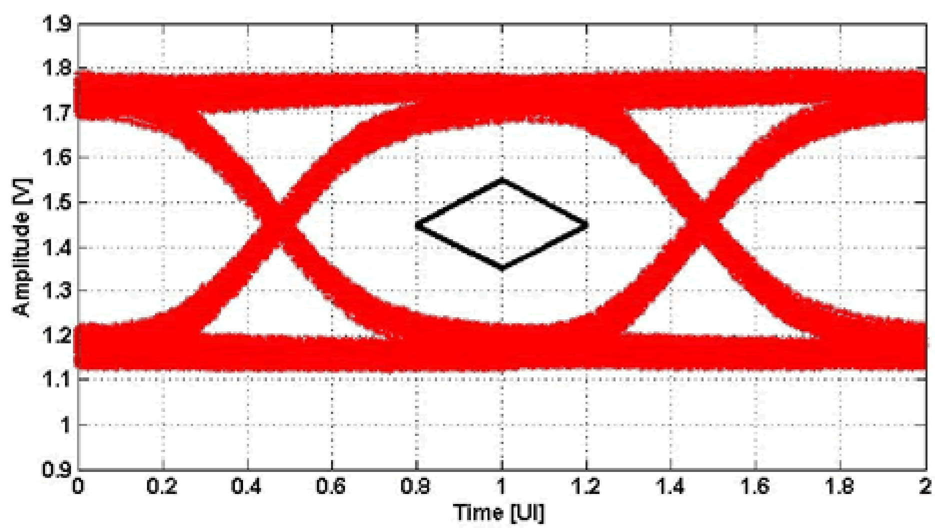
After 10,000 Flex Cycles



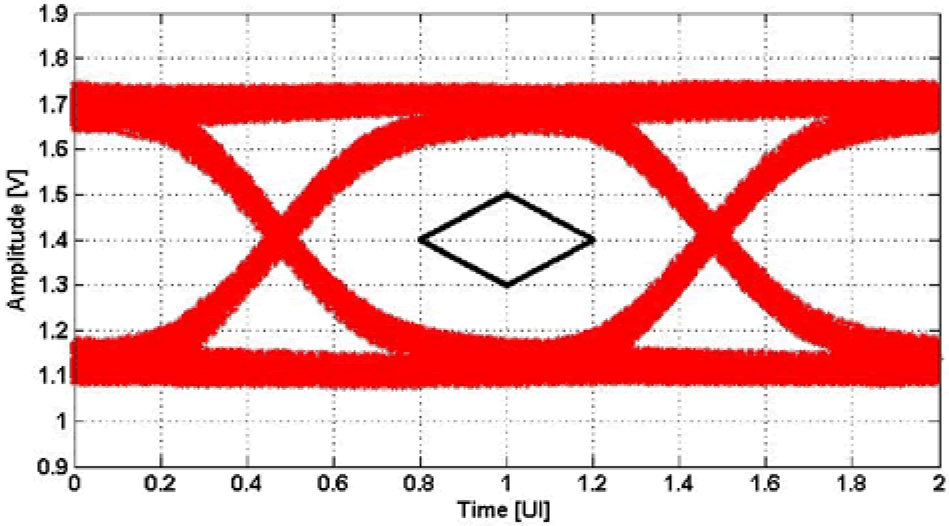
After 337,000 Flex Cycles



After 1 million Flex Cycles



After 6 million Flex Cycles



Conclusion

Camera Link, FireWire, Gigabit Ethernet and other digital systems for machine vision and motion control are sensitive to impedance changes in the cable. Engineers need to specify a cable that is more robust than the typical aluminized polyester shield construction to survive repetitive motion in automated applications. Figure 19 shows the attenuation of a standard FireWire "flex" cable. The digital signal degrades as the cable is flexed. These cables do not meet the IEEE1394 attenuation for 4.5m length after 10,000 cycles.

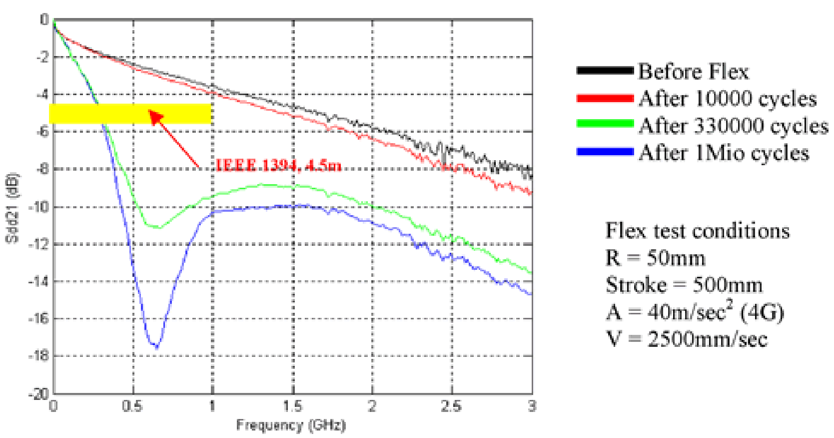


FIGURE 19

Figure 20 shows the attenuation of the enhanced-construction FireWire® Cable. This cable meets the signal requirements for IEEE 1394b well beyond 10 million cycles of rolling flex, and are designed to maintain stable electrical characteristics in continuous flex applications. Machine vision and process control systems will operate reliably with such a cable specified into its design.

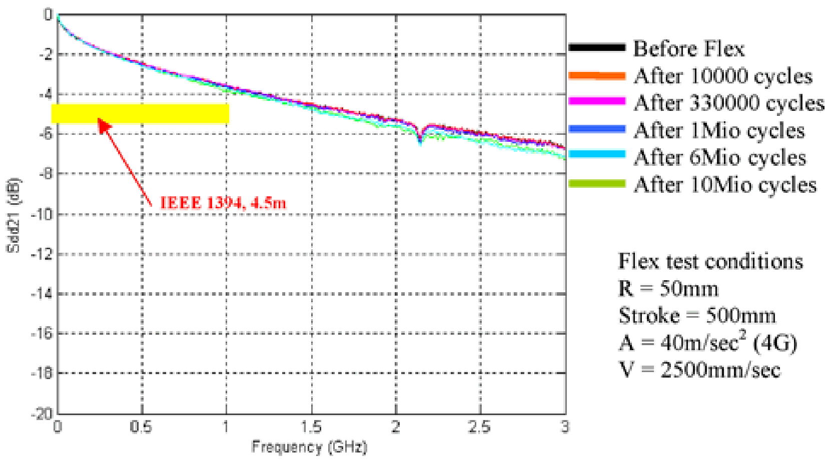


FIGURE 20

In the end, what makes a good flex cable? A shield that doesn't break down. Look for a cable manufacturer that has signal integrity data showing electrical performance during flexing to 1 million, even 10 million cycles. It is important to see that performance (skew, resistance, impedance and attenuation) has not changed during operation. Also, remember that there is a difference between pulling a cable off of a system and testing it vs. testing it on the machine, in-line, while the cable was flexing. It is necessary to replicate cable performance and failure in real-world conditions.