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Driving Toward a PCB Production Floor Metric for Go/No Go Testing of Lossy High-Speed Transmission Lines

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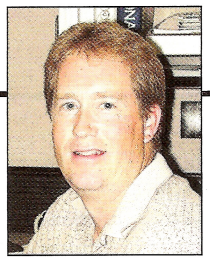

By Mark Finstad

Flex Circuitry Versus Wiring Harnesses

Q: *How much more reliable are flexes over wiring harnesses? I've heard 75 percent thrown about, but I can't find the data to support it.*

A: While there is little doubt that flex circuitry is generally more reliable than wiring harnesses, it is difficult to quantify. It really depends on several different factors that are application specific, such as the complexity of the wiring, form and fit requirements, and shock and vibration the wiring will experience in service.

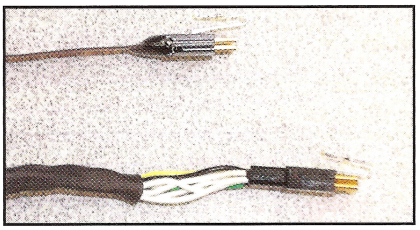

Figure 1 Side View of a Wire Harness (Lower) That Was Converted to a Flex (Upper). The Reduction in Volume Improved the Fit and Enhanced Shock and Vibration Performance

Complexity: Flex has a definite advantage in this category when compared to a similar wiring harness. Because every feature on a flex circuit is defined by CAD data, each and every one is exactly the same (i.e., never a wiring error). Also, on a complex wiring harness, there is always the possibility that a single wire in a bundle may be slightly shorter than the others, causing a stress concentration point where it is attached to the connector. This stress concentration point may result in a broken connection if the harness is subjected to shock or vibration. For simple wiring harnesses (less than a dozen or so connections), the flex advantage is not as great. While you still gain the benefit of having every flex circuit being identical, it will come at a greater cost than the wiring harness. So, unless there are form, fit, or service requirements that drive you to flex, a simple wiring harness may be the better option.

Form and Fit: When your application is space sensitive, flex is the clear winner (see Figure 1). If you have any doubt, open up your digital camera. You will find multiple flex circuits in every one. Flex circuitry allows camera manufacturers to make all of their internal electrical connections yet shrink the overall camera to an almost ridiculously small size. Because the conductive patterns of flex circuitry are photo etched on thin copper foils, features such as spaces and traces can be much smaller than wires, thereby greatly increasing the connection density. Also, the ultra high dielectric strength of flex materials allows conductive layers to be spaced very close together. For reference, the combined dielectric strength of polyimide film and acrylic adhesive is over 2,000 V/mil. Individual conductive layers on flex circuits are generally 0.003 in or less from each other but can still offer thousands of volts of dielectric strength between them. For these reasons, the volume consumed by a flex circuit can easily be 75 percent less than a comparable wiring harness.

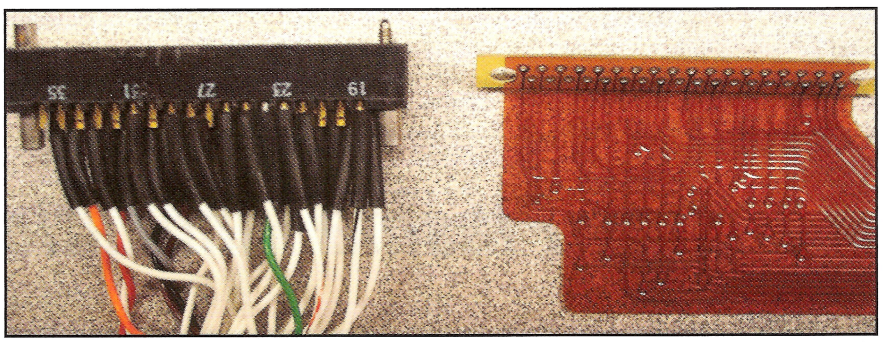

Figure 2 Tangle-Town Assembly, Left, Was Converted to Compact Flex, Right

Another advantage flex has in this category is that there are no individual wires that can come loose to get pinched between a casing and a cover, occlude an optics path, or rub against a sharp edge causing a short (all of which I have seen, see Figure 2). This feature can be especially troubling when part of the wire harness is attached to a cover. Once the cover is closed it is impossible to see if all the wires are lying where they are supposed to be. If a wire becomes pinched, or if it falls into an area where there could be abrasion to the wire's insulation, the potential for a failure in the field is great. Because each flex circuit is custom shaped for its intended application, each one will fit into its space exactly the same every time.

Shock and Vibration: Flex is the clear winner in this category due to its ultra low mass. Because a flex circuit is capable of much higher wiring density than a wiring harness, it follows that the flex circuit can be made much smaller with the same number of connections. The smaller wiring package of the flex circuit means the flex will have less mass that will therefore be less affected by shock and vibration. Flex circuits are currently used in applications where they are subjected to shock that is measured in the tens of thousands of Gs. A wire harness would never survive this type of application. So, to answer the original question, the reliability of flex over wiring harnesses is a sliding scale that is dependant on the application. In very simple applications that have just a handful of connections, used in an application that has plenty of space and no shock or vibration concerns, the two will probably perform with equal reliability. On the other end of the scale, in an ultra high G force environment, a flex will perform perfectly and a wire harness will fail miserably 100 percent of the time. Most applications fall somewhere in between, so you must evaluate your specific use to determine which end of the scale you are closest to. □

The Flexperts are Mark Finstad and Mark Verbrugge