New Tools and Techniques for FMEA of System Interconnection Designs

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Low-tech aspects of system designs such as interconnection wiring can profoundly affect system safety. Connectors, terminal strips, wiring, and cabling present potential failure modes that are too often ignored while other parts of systems are analyzed in great detail. Yet, wiring failures have caused problems that have been catastrophic.

Bent Pin Analysis is one tool that is sometimes applied to examine failure modes of electrical connectors, but when performed using traditional rules it fails to address all real-world failure modes, and as a very tedious human effort it is also extensively error-prone. Cable Matrix Analysis is another tool, very rarely performed, that looks for failure effects when each wire in a jacketed cable shorts a contiguous conductor. Unfortunately, there are two other kinds of common interconnection failures that neither tool addresses: shorting between *any* two conductors in a cable or wiring harness due to insulation failure or foreign matter, and swapped wires at a wire terminal point due to maintenance repair error. These may be effectively addressed by new tools called Harness Matrix Analysis and Swapped Wire Analysis.

A common challenge among these analyses is dealing with a large number of possible failure modes. For example, a very common 15-pin miniature D connector in which a defective pin can open the path, or bend to one or more pins plus the shell, has 243 failure modes. If the same 15 wires are run in a harness, where each conductor can open, short to ground, or short to any of the other conductors, there are just 135 failure modes – a much shorter analysis. If each pair of shorted paths is analyzed instead as a pair of swapped paths, there are an equal number of failure modes but with different failure effects, making Swapped Wire Analysis different from Harness Matrix Analysis.

The cost of the human effort for such analyses makes them seem prohibitive, yet ignoring them can be a serious threat to system safety. However, two techniques make them far more feasible: identifying conductors that have equivalent failure effects for identical failure modes, and using application software to automate nearly everything that does not require human thinking. The proposed paper will expand upon these techniques using real-world examples to illustrate their usefulness and time savings, and additionally highlight potential analysis errors associated with redundancy, grounds, signal direction, spare contacts, and dimensional data.

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