HI-RELIABILITY PRECISION CONNECTORS IN SPACE DESIGNS

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The LEO or GEO space environment is harsh with temperature variations of hot and cold extremes, the effect of shocks and vibrations on components, radiation and outgassing as component materials experience a change of state. The quality of the connectors selected will affect the success or failure of your mission, so Hi-Reliability Precision Connectors (HRPC) should be a major consideration in the design process, as well as how far and how long you expect your sat to go or be in space. The experience of space agencies like ESA, NASA, CSA and others have helped by defining material standards for connector construction used in HRPC.

With improved packaging, smaller cables and smaller connectors, designers can, indeed, cram more electronics into smaller and lighter-weight boxes. Selective digital chips are also offering significantly higher digital processing capabilities as well as dramatically increasing circuit speeds.

Cable and connector interconnections focused on 'small and light-weight' must also exceed reliability assurances for extended use in deeper space. NASA-approved low outgassing materials, construction methods and connector reliability certifications are required in design and construction. Additional attention is also needed on long-term shock and vibration effects, as well as for extended thermal cycling beyond LEO.

However, it is how well the interconnections are made from one printed circuit to the next layer in the stack that will define the integrity of the system. HRPC like Micro-D and Nano-Ds or Hi-Rel 2mm or 1.25mm pitch Datamate connectors allow for higher density, while still supporting current levels needed to run up and down the stack.

Here the old adversaries, Finance and Engineering, meet at the project budget and ask the question is the high-cost component better than the low-cost component? Naturally there are many options and answers. Part of the cost of components involves the level of screening/testing levels (see table below) and number of failures to reach the standard required for that part. To build 100 parts you may need to make 112 to have 100 at the end of the process, so the cost of 112 gets distributed over the resulting 100, which increases the unit cost. The failures are due to variations in the raw materials used in the production process.

How many times have you had a coffee from your favourite coffee place and it is different from the last one? It can be due to who made it, milk temperature or how the batch of beans were roasted; it is the same principle.

Then consider the component assembly process: if it is a simple

Screening level	Special screening	Outgassing
Level 1. Mission critical	SPT 1	Less than 1% TML
Level 2. High reliability	SPT 2	Less than 1% TML
Level 3. Standard reliability	Standard reliability	Less than 1% TML

part then the assembly process can be automated and made by and inspected by machine, but if it is a complex part involving more manual assembly, then the cost goes up. Same with inspection and testing – more or less automation affects the cost.

Finance and Engineering can work together by changing the question from high or low cost to what is fit for purpose and value for money in terms of the budget. Use components that will do the job, the simple design parts will suit most interconnection requirements. But if you need a lot of connections, with limited board real estate then it may be that complex design part that saves you from a costly redesign. Along with the length and type of mission planned in are all factors that should be considered when selecting components, as an incorrect choice can be very costly if the mission fails to meet its goals.

Some examples of HRPC parts are Harwin's M80 Datamate, 2.0mm M300 or 1.25mm G125 series which are high-quality, low cost because they are of a simple component design which lends itself to highly automated assembly, along with the screening level. They are suitable for space applications and have been used in QB50, Waterloo Rocketry and Warrick Satellite Programs.

Omnetic's Micro-D, Nano-D, Series are high- quality with a higher cost because they are complex in design, have a higher pin density per part and assembly is semi-automated not fully automated with more manual processes, along with the screening levels. They are suitable for space applications and have been used in Virgin Orbit Launcher One, Hubble, Curiosity Rover, TanDEM-X and TeraSAR-X.

Many miniaturised connectors achieve high reliability in satellite connectors using a specialised design that employs a Flex Pin/Spring Pin/ Socket System (used by Omnetics) or Solid Pin/Socket Clip system utilising 4 Finger Clip (used by Harwin) with proven reliability over wide ranges of shock, vibration and thermal changes. Made of BeCu (beryllium copper) with high tensile strength, they are designed to withstand the rigors of use and physical abuse experienced in lift-off and space flight.

The HRPC options for sat systems are many, but more importantly, because they have access to HRPC components, designers at all levels from students to engineers can now accomplish design tasks at comparatively lower cost. ■