PXI-Based Test Systems for Rugged Field and Flight-Line Test Applications

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PXI-based systems have become a mainstream test platform for factory, depot, and intermediate (I-level) test applications for the MIL/Aero market place. The deployment of PXI-based test systems at the depot and I-level makes them an attractive test solution for extension into field and flight-line test applications based on the platform's compact size, weight, cost and the ability to leverage existing TPS' that have been developed for depot and I-level applications.

To successfully deploy PXI systems for field and flight line applications requires that the designers of these systems address several key environmental specifications. At first glance, one might conclude that PXI products will not meet the demanding environmental requirements associated with field applications. However, by designing a PXI system with a ruggedized chassis and in some cases, employing modified COTS products, PXI can and is being used successfully in harsh environments.

Requirements

The environmental specifications required of field or flight-line testers vary according to the application; however, there are some basic requirements that all testers must meet that operate in a field type of environment. These requirements are defined by MIL-STD-810 (environmental requirements) and MIL-STD-461 (EMI requirements). A discussion of how one might address all of these requirements is complex and this article addresses only some of the key environmental requirements expected of field and flight-line testers. The table below provides a summary of these requirements.

Environmental Condition	**Requirement / Specification**
Operating Low Temperature Range	-40°C ±5°C, (-40°F ±9°F)
Operating High Temperature Range	+60°C, ±5°C , (+140°F ±9°F)
Storage Low Temperature Range	-45°C, ±5°C, (-49°F ±9°F)
Storage High Temperature Range	70°C ±5°C, (+158°F ±9°F)
Maximum Relative Humidity Range	90% to 95%
Salt Fog	Per MIL-STD-810 Method 509.2
Shock (Half-Sine)	Per MIL-T-28800 Exact requirement depends on application
Basic Transportation	Per MIL-STD-810 Method 514.4

Loose Cargo	Per MIL-STD-810 Method 514.4
Transit Drop	Per MIL-STD-810 Method 516
Bench Handling	Per MIL-T-28800, Exact requirement depends on application
Vibration (Sine)	Per MIL-T-28800, Exact requirement depends on application

PXI products do not typically use Mil-Spec components and are not specified to operate over the extended temperature range defined by the MIL-STD-810 specification. Subsequently, it is incumbent upon the system integrator or system supplier to address these shortcomings. Satisfying these requirements can be addressed by employing one or more of the following techniques:

- Improvements or modification to the COTS product: By making some minor improvements to an existing product, it is possible for a COTS product to perform beyond its stated operating conditions. For example, conformal coating a module to protect against humidity and salt fog, adding RTV adhesives to components which may be susceptible to vibration and shock and in some cases, replacing components can ensure operation in an extended temperature and shock /vibration environment.
- Screening or qualifying products: Testing of COTS products can be done to ensure that they will meet their specifications over an extended environmental operating range.
- Protection or isolation of test system components or assemblies: By employing a strategy that adds a level of protection to the system platform, in this case the PXI card cage or chassis, it is possible to meet the shock and vibration system requirements without ruggedizing individual modules that are part of the overall system. For example, the use of a shock-mounted card cage can protect PXI cards from excessive vibration and shock.
- Procuring COTS products that are specified for operation over a wider temperature range: One needs to only look as far as cPCI modules to find that there are many 3U and 6U cPCI modules that are specified for operation in harsh environmental conditions. For example, single board computers and communication interfaces (commercial and military variants) are readily available for operation over an extended temperature range.

Temperature Environment

The extreme temperature environment is one of the most difficult requirements to address for COTS products. Most commercial products can withstand extreme storage temperatures in spite of what their catalog specification may state. Verifying an extended storage temperature range, such as a range of -40°C or +70°C, is easy to test and verify. However, if a product employs an LCD, these displays can sustain irreversible damage if exposed to temperatures below - 40 °C .

The operating temperature range is more challenging. While low temperature operation can be addressed by adding heaters to the system, it is difficult to mitigate the effects of high temperature. As previously noted, there are few COTS PXI products that will operate at ambient temperatures above + 50°C. In addition, the temperature rise within the system must be considered, resulting in an operating temperature that can approach +85°C – considerably above the operating range of commercial PXI products. Consequently, screening and in some cases, modifying the COTS products or relaxing the product's performance specification is needed ensure operation at elevated temperatures.

For example, when developing the MTS-206 Maverick Field test Set, a PXI-based test system (see Figure 1), the use of an embedded controller as well as the instrumentation had to be capable of working over an extended operating temperature range. For the controller which uses a disk based operating system, the use of a hard disk was not an option which required the use of an extended temperature range controller and solid state hard drive.

For the measurement instrumentation, in this case a DMM, there is no COTS PXI DMM that can operate accurately over the required operating temperature range which in this case, requires operation at an ambient temperature of + 80°C. A preliminary screening of the targeted DMM confirmed that the instrument could not operate at +80°C. A review of the DMM's design resulted in the need to replace about a dozen components (capacitors in this case) which were rated for extended temperature operation, alleviating the performance issues with the DMM.

Figure 1 – The MTS-206

HUMIDITY & SALT-FOG

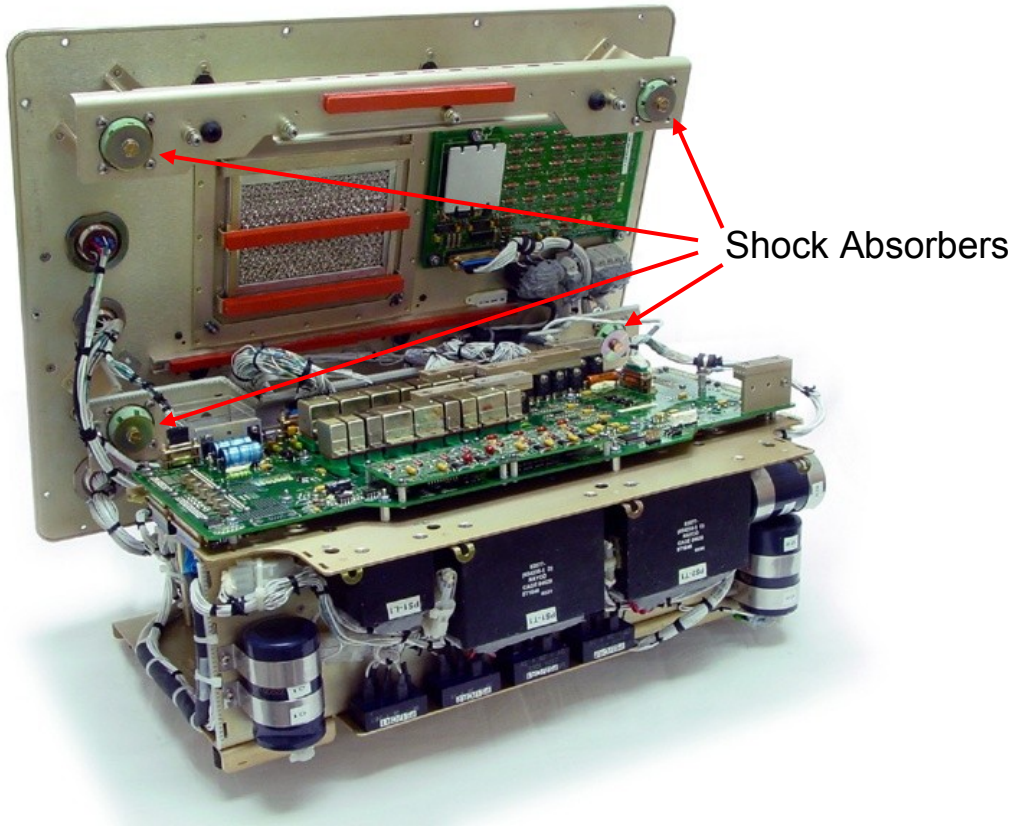
Relative humidity and salt fog are two elements that can be devastating to commercial electronics. An effective method to address these environmental effects is by conformally coating the PXI boards in the system. For instances where the cPCI or PXI vendor offers an extended temperature or ruggedized version of the product, the vendor may offer the option to add conformal coating to the board. However, for cases where

the supplier cannot or will do conformal coating, the system developer will need to devote some engineering time to setup product documentation for conformal coating. The recommended conformal coating material is polyurethane, which is resilient enough to protect against the environment and yet, can be easily removed for repair and maintenance activities. In addition to conformal coating, an adhesive such as RTV may need to be used as well if there are devices such as DIP switches that need to be sealed from the elements. RTV also works well to anchor high profile components that might be susceptible to shock and vibration.

SHOCK AND VIBRATION

The effects of shock and vibration on field and flight line system can be very damaging to electronic circuits and wiring harnesses. It has already been noted that an adhesive such as RTV can mitigate the effects on board components that have a high profile or high center of gravity. Additionally, shock-mounting of the PXI chassis (or card cage) can be done to provide an additional level of shock and vibration isolation for the PXI cards. Figure 2 details the use of 4 shock absorbers which in this case, have been used to suspend and isolate a PXI card cage from the effects of shock and vibration. An additional shock absorber located at the bottom of the card cage (not shown), limits lateral movement and further protects the cards.

Figure 2 – Card Cage with Shock Absorbers



SUMMARY

More and more Mil/Aero programs are adopting the PXI platform for functional test applications with the use of PXI now finding its way into operational-level and flight line test applications. Although PXI products are designed for relatively benign operating environments, there are now ruggedized PXI platforms available that can be used successfully in harsh environments. By using a combination of modified COTS products, extended temperature range products, and a ruggedized chassis, robust PXI platforms such as the Geotest MTS-206 and MTS-207 are being successfully deployed that meet the harsh requirements for field and flight line applications.

Reference: "Designing PXI-Based Test Systems for Field and Flight-Line Applications", Loofie Gutterman; Autotestcon 2006