PXI Based Flight-Line Test Sets

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***Abstract*— In the past decade, PXI has proven to be a powerful and robust standard that is suitable for most Mil-Aero test applications. PXI-based testers are widely used today in engineering test stations, as production acceptance testers, environmental stress screening testers, as well as full-fledged Intermediate-Level and Depot-Level testers.**

While the above facts are widely known, a lesser known fact is the success of PXI in field and flight-line test applications. Most engineers are not aware of the ruggedness of the PXI platform and as a result, PXI is sometimes overlooked when new portable and rugged test solutions are sought.

PXI was designed as a rugged standard and while most test applications do not take advantage of these capabilities (as they are not required), it is very simple to achieve reliable performance under harsh environments. This paper discusses several flight-line and back-shop test applications based on Commercial-Off-The-Shelf (COTS) PXI products. The applications include a Field Test Set for the Maverick missile system, a back-shop test set for the Alternate Mission Equipment (AME) for the F-35 Joint Strike Fighter (JSF), a back-shop armament test set for the TA-50 and FA-50 aircraft, and a portable test set for the C-130. These four testers are all based on an ultra-rugged COTS PXI platform that have been successfully deployed since 2004 and have demonstrated their ability to operate reliably in any operational theater.

The four testers demonstrate PXI's viability as an ultra-rugged field and flight-line platform that has the capabilities where only custom electronics or MIL-SPEC VME products were capable of surviving before.

Keywords— flight line test; PXI; AME test

I. OVERVIEW

The portable and flight-line testers discussed in this paper are all based on a similar PXI platform that includes a 14-slot PXI backplane. PXI includes two form factors: 3U and 6U. While 3U is the more popular of the two and most PXI instrumentation are available in this form factor, many products including high-density switching and high performance digital are only available in the 6U for factor. Additionally, the PXI standard maintains full interoperability between 6U and 3U and any 3U PXI module can be plugged into any 6U PXI slot. For these reasons, the PXI backplanes employed by these testers offer both 6U and 3U PXI slots. Of the 14 slots in the PXI backplane, seven slots are 6U and seven are 3U as shown in Figure 1.

The PXI backplane is installed in an ultra-rugged card cage that is shock-mounted and also includes heaters and fans. The shock absorbers provide the necessary protection for the Commercial Off The Shelf (COTS) PXI products, shielding them from the shock and vibration the tester is subjected to. Since most COTS PXI products offer a standard temperature range of 0ºC to 50ºC, a heater is required to allow sub-zero operation of the testers. Custom circuitry, which includes the power supply for the PXI platform, is used to control the heaters and fans and allow sub-zero operation while managing thermal hysteresis.

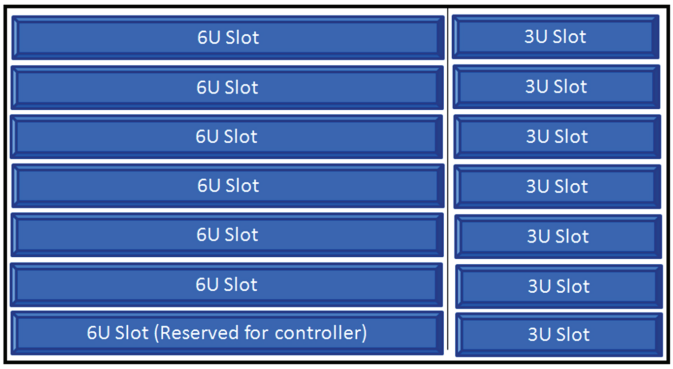

Figure 1: The PXI Backplane

While the PXI backplane is common to all testers discussed in this paper, the rest of the electronics is similar although each tester is customized based on the applications' specific requirements. Intermediate-level and depot-level testers employ an external adapter referred to as an Interface Test Adapter (ITA) that provides the electrical interface between the mass interconnect device of the test set and the Unit Under Test (UUT).

Figure 2: Typical Interface Test Adapters (ITAs)

These ITAs (Figure 2) are not suitable for flight line testers and the electronics typically accommodated by these adapters requires relocation.

The PXI platform has to provide sufficient space for custom electronics and especially for the electronics typically housed by the ITAs. Most of this required space exists between the PXI card cage and the front panel of the platform (see Figure 3) and additional space is available at the rear and bottom of the card cage.

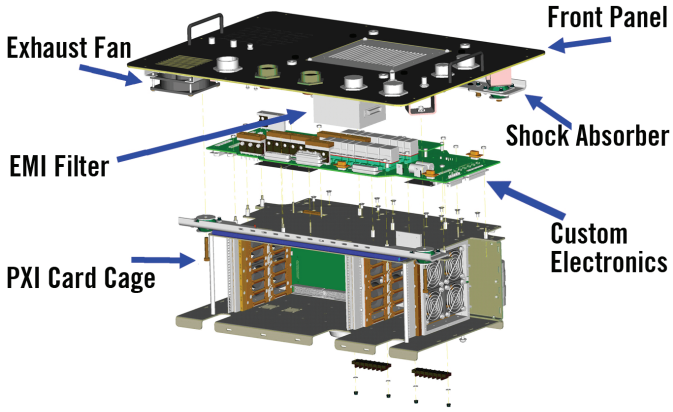

Figure 3: The PXI Platform Construction

The mechanical design of all testers highlighted in this paper is very similar as it is used to accommodate the PXI backplane in a rugged, shock-mounted card cage (or chassis). The internal configuration of the PXI platform is shown in Figure 3 and includes the following main assemblies:

- Front Panel: The front (or top) panel of the tester is unique to each tester and accommodates the interface connectors, intake air filter, exhaust fan, switches, indicators and the EMI filter. The front panel can also accommodate an external rugged display that can be mounted onto the panel. The interface connectors are typically circular military connectors such as D38999 series but other connectors could be used as well. One connector is used as the Input Power connectors and all other connectors are application-specific. The EMI filter is application-specific and is used to ensure EMI compliance with MIL-STD-461, or CE or both.
- Shock absorbers: Four shock absorbers are mounted at the bottom of the front panel to shield the custom electronics and PXI card cage from shock and vibrations. A fifth shock absorber is mounted at the bottom of the card cage to dampen lateral movement. The shock mounted PXI card cage permits the use of COTS PXI products although some level of ruggedization is required as discussed later.
- Custom Electronics: The custom electronics provides functions that are typically provided by ITAs (Figure 2) as well as power for the PXI card cage, high-current switching, and control of the heaters. The PXI platform includes several temperature sensors, some located within the PXI card cage and some on the custom electronics board. These sensors are used in conjunction with additional circuitry to control the heaters and ensure that the COTS PXI products are not used at temperatures under 0ºC. When the platforms are powered up at sub-zero temperatures, the circuitry will only apply power to the heater and will power up the PXI card cage only when the cage temperature is over 0ºC. This protects the COTS products which are typically only rated for operation between 0ºC and 50ºC.
- PXI Card Cage: The PXI card cage accommodates 14 standard PXI modules (seven 6U and seven 3U) which are application-specific and comply with the PXI Specifications. Space is available at the rear and bottom of the card cage for additional custom circuitry. Also at the bottom of the card cage is the fifth shock absorber that dampens lateral movement made possible by the other 4 shock absorbers. The PXI card cage also includes 12 fans (four are shown in Figure 5) and these are used to cool the PXI cards. The fans are controlled by circuitry on the PXI backplane and all 12 fans are only enabled when the card cage temperature exceeds 35ºC.

Figures 4 and 5 demonstrate one implementation of the PXI platform (the MTS-206 Maverick Field Test Set). Figure 4 shows the front view of the PXI card cage with the PXI cards and the internal interconnecting harnesses and Figure 5 shows the side view of the PXI card cage with 4 of the 12 card cage fans visible.

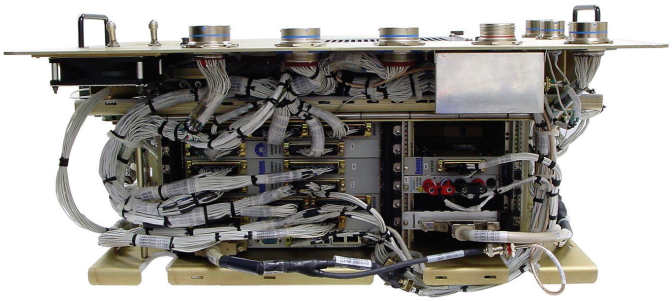

Figure 4: The PXI Platform (front view of PXI card cage)

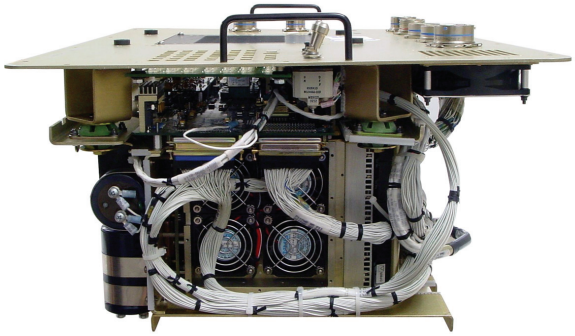

Figure 5: The PXI Platform (side view of PXI card cage)

The basic construction and configuration of the PXI platform is robust and flexible enough to support most portable test applications although a certain level of customization is required to meet specific application requirements.

While the PXI card cage used by the PXI platform can accommodate custom circuitry, most of the circuit cards used by the testers described in this paper are Commercial Off The Shelf (COTS) products. The availability of COTS products greatly simplifies the design of any tester although there are COTS related issues to consider:

- Temperature: Most COTS PXI products are rated for operation between 0ºC and 50ºC or 55ºC. The built-in heater takes care of temperatures below 0ºC but the fans have limited cooling capabilities. When selecting the PXI modules, the maximum operating temperature of the modules should be considered as the temperature rise within the platform will be approximately 15ºC over ambient depending on the heat dissipation inside the platform. Cards can be screened as most COTS products would operate up to 65ºC without any modifications or, another fan can be added on top of the air intake filter to push air into the tester to limit the temperature rise to about 5ºC.
- Humidity: Since the platform is not hermetically-sealed, humidity can affect operation of the electronics. For this reason, all circuit cards should be conformally-coated and all harnesses potted.
- Shock & Vibration: While the 5 shock absorbers provide protection against shock and vibration, the potting of harnesses and RTV'ing of large components on the COTS circuit cards will further protect the tester against shock and vibration.

II. MTS-206 Maverick Field Test Set

The MTS-206 Maverick Field Test Set is a flight-line test set for the Maverick missile system. The test set was developed as a replacement for the obsolete AN/DSM-157 and is capable of testing Maverick missiles, missile sections, Maverick launchers, and missile launcher clusters. The Maverick Field Tester is typically used in the back-shop but can also be used on the flight-line, when testing on the aircraft is required. The MTS-206 had to pass a rigorous certification program that includes safety certification allowing for the testing of live (tactical) missiles.

The MTS-206 is mostly an analog tester although one variant of the MTS-206 has digital capabilities and supports testing of MIL-STD-1760 products. All the MTS-206 electronics are accommodated by the card cage and there are no external adapters except for a self-test adapter that is used for 100% verification of all MTS-206 functions including all cables. Connections to the various Units Under test (UUTs) is done with rugged cables and the internal electronics eliminates the requirement for any external adapters.

The MTS-206 (Figure 6) was first fielded in 2004 and has since been deployed in 14 countries. The MTS-206 has demonstrated the robustness and ruggedness of PXI, providing over 100 test programs for the various Maverick assemblies and configurations in a flight-line-certified portable and rugged PXI chassis.

Figure 6: The MTS-206 Maverick Field Test Set

III. MTS-235 F-35 AME Test Set

The MTS-235 JSF AME Back-Shop Test Set is a portable, rugged tester for the Alternate Mission Equipment (AME) on the F-35 and is used to test launchers, pylons, adapters and their main subassemblies. The MTS-235 is based on the same basic configuration as the MTS-206 which includes a PXI card cage (chassis) and additional custom electronics as part of the built-in ITA.

The MTS-235 (Figure 7) is currently in development and the first system is expected to ship in Q4 2009. While the intended use of the MTS-235 is in the back-shop, it has the same flight-line capabilities as the MTS-206, should it be required to support aircraft on the flight-line.

As a tester for the State-Of-The-Art fighter aircraft, the MTS-235 is a State-Of-The-Art tester with digital test capabilities including MIL-STD-1760 and CAN bus. Future upgrades of the MTS-235 may also include Fibre Channel.

Other than a self-test adapter, the MTS-235 does not have any external adapters to interface with the UUTs, with all interconnects utilizing rugged cables.

Figure 7: The MTS-235 F-35 AME Test Set

IV. MTS-235 F-35 AME Test Set

A. *SSUT TA-50 Stores Suspension Units Tester*

The Stores Suspension Units Tester (SSUT) is a Common Armament Test Set (CATS) for the TA-50 and FA-50 aircraft. The SSUT is capable of testing multiple launchers, bomb racks, ejector racks, and pylons on the flight-line or in the back-shop. The SSUT is based on the same basic configuration as the MTS-206 with the PXI card cage (chassis) and additional custom electronics supporting the built-in ITA. The SSUT also supports some of the Test Program Sets (TPSs) originally developed for the MTS-206. Since the TA-50 and FA-50 are virtually identical to the F-16 (from an armament perspective), the SSUT supports a wide range of legacy weapons systems (analog) as well as "smart" weapons systems (MIL-STD-1760 based).

Based on the same architecture as the MTS-206 and MTS-235, the SSUT (Figure 8) is currently under development and is scheduled to be fielded in Q1 2011.

Figure 8: The SSUT Common Armament Test Set

V. MTS-207 MC-130 Test Set

The MTS-207-1 is a portable rugged tester for the MC-130 Special Operations aircraft. It is used as a back-shop tester but has to be ultra-rugged as it is deployed and transported with the aircraft to front-line locations.

The MTS-207-1 (Figure 9) is based on the same architecture as the MTS-206 and offers multiple configurations depending on the application.

Figure 9: The MTS-207-1 Test Set

Summary

The four testers discussed in this paper are different in capabilities and functionality and support different platforms and weapons systems. However, all testers share the same basic architecture and are all based on the PXI standard and all are required to operate under extreme environmental conditions on a daily basis.

These four PXI implementations demonstrate the robustness and ruggedness of PXI and establish PXI as a viable solution for any flight-line or field test application. With PXI's small footprint, low-cost, and availability of products to meet the requirements of just about any application, PXI should be the preferred choice for rugged military testers.