

INSTRUMENT CERTIFICATION AS PART OF A MODULAR TEST PLATFORM ARCHITECTURE

David Manor
VP of Hardware Engineering,
Geotest - Marvin Test Systems,
Inc.
1770 Kettering, Irvine, Ca. 92614

Michael Dewey
Sr. Product Marketing Manager
Geotest - Marvin Test Systems,
Inc.
1770 Kettering, Irvine, Ca. 92614

INTRODUCTION

Card modular platforms provide the same functionality as rack and stack instruments in a much smaller footprint and with reduced cost. For this reason a large majority of the automatic test systems deployed in military–aerospace and commercial applications today employ card modular architectures. Figure 1 illustrates a typical card modular architecture which includes modular instrumentation, an embedded or external controller, a control bus, and a trigger / local bus for inter-module control and triggering . Over the years several architectures have

emerged including Standard Bus, GTXI, SCXI as well as others. Today the two predominant platforms are VXI and PXI.

The VXI platform, which was developed in the late 1980s, has seen extensive deployment over the years and today, is still used for current depot and intermediate level ATS applications. Based on the benefits and flexibility associated with card modular architectures and looking to leverage the performance and cost benefits of the PC, PXI was introduced in 1998 and since then has grown rapidly – replacing VXI as the card modular platform of choice. Today, there are over 10,000 PXI systems deployed world-

wide[1] with a projected PXI systems sales growth of 14% compound annual growth rate

(CAGR) from 2005-2010[2]. Figure 2 illustrates typical VXI and PXI platforms which consist of

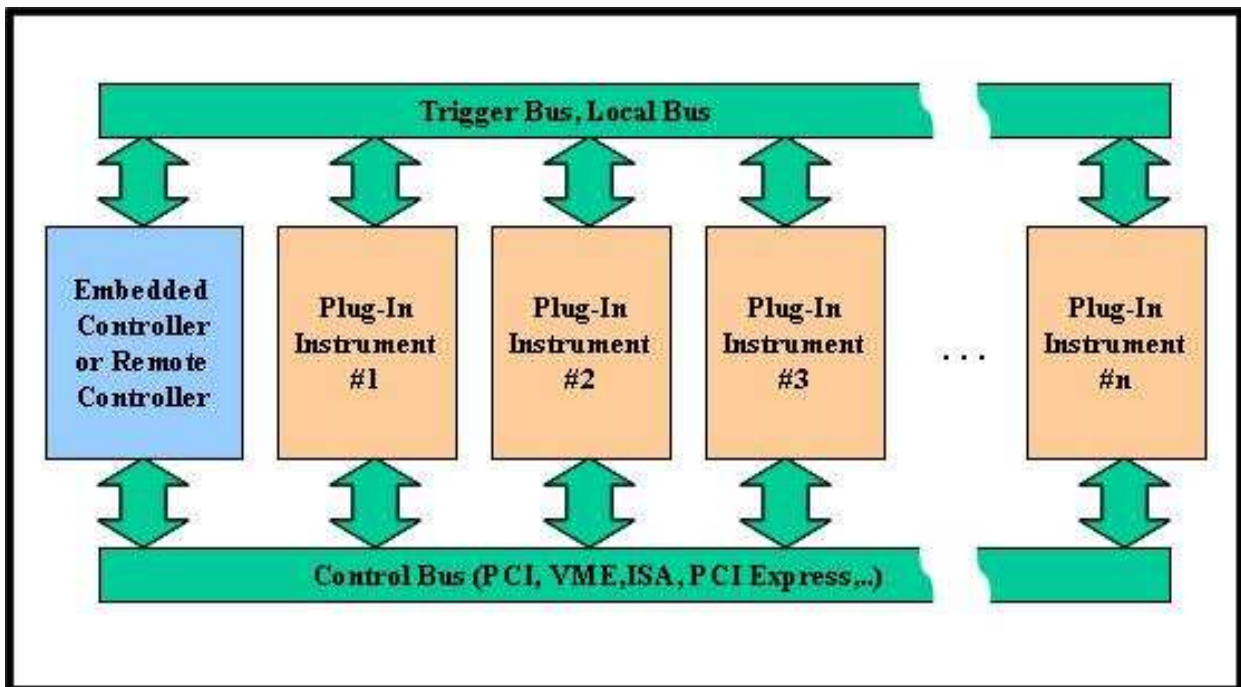


Figure 1 - Typical Card Modular Architecture

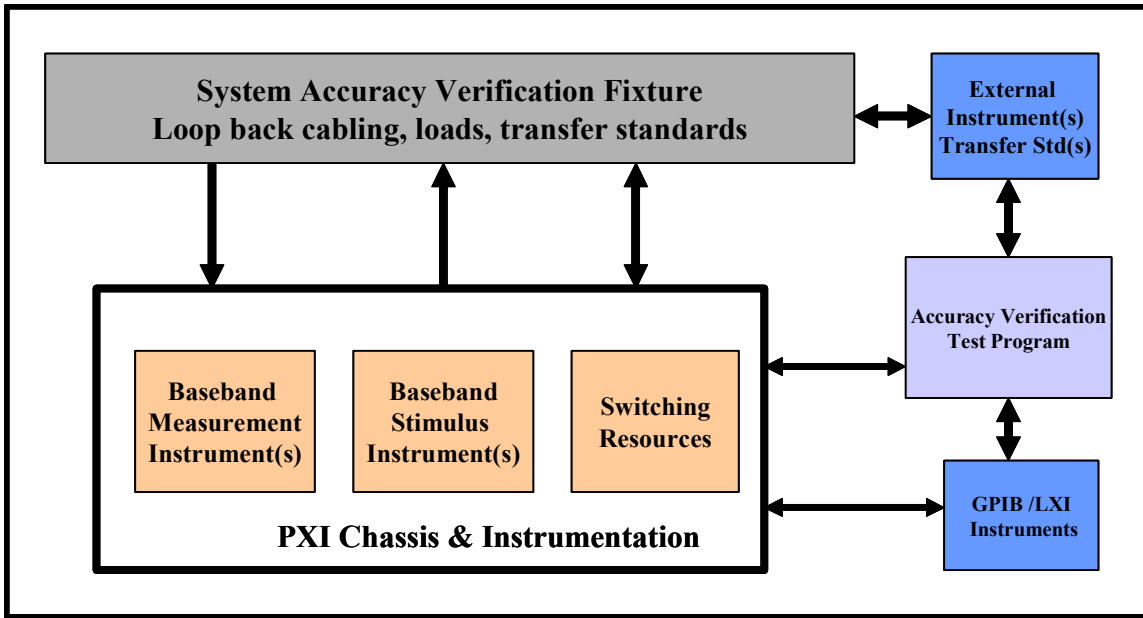


Figure 3 – Accuracy Verification System Components

rack mountable chassis and up to 19 modular instruments installed within a single chassis.



Figure 2 – VXI and PXI Card Modular Systems

Almost all test systems, particularly those deployed for depot or intermediate test applications, incorporate a system self-test, which is designed to ensure that the complete system and its components are functioning properly. And while there may be some parametric test limits that are part of the self-test pass / fail criteria, the system self test is not intended to provide certification or traceability of the test system's instrumentation. The self-test relies only upon resources that are part of the test system as well as some type of self-test fixture that is typically a passive device, which provides loop backs and maybe passive loads. And since a self-test implementation relies upon

system resources, the implementation is customized for a specific system configuration and set of resources.

Verification of the test system's overall accuracy or parametric performance has historically relied upon the incorporation of an accuracy verification test procedure (AVP), which requires the use of external standards, an accuracy verification test fixture, and a test program. Figure 3 details the major components associated with an accuracy verification test procedure implementation.

The overall implementation of this accuracy test procedure and configuration, while costly in terms of both development and capital costs, has provided end users with the ability to verify overall system accuracy. However, this strategy relies heavily upon external instruments or transfer standards. In addition, the implementation of an AVP may focus on verifying overall system accuracy, without providing the opportunity to recertify individual instrument components within the test system.

Test engineering organizations have traditionally accomplished the task of individual instrument recertification by either relying upon the OEM to perform the service or employing an on site service, as described below.

Instrument recertification by the OEM: If this strategy is adopted, each instrument within the system is recertified by the OEM, requiring the removal, shipment, and reinstallation of each

component. This can be problematic since the test system can be out of service for some amount of time. However, down time can be mitigated by maintaining a stock of spares – although this can be an expensive and complex solution from a logistics standpoint.

On-site recertification of instrumentation by a 3rd party calibration service: This strategy is widely accepted in the industry and is successfully used where systems are primarily comprised of GPIB (box) instruments. GPIB instruments are well understood, self contained and generally accessible meaning that as long the calibration service provider has the correct calibrator / transfer standard(s) it is likely that the instrument can be certified using manual (local) control. However, for card modular instrumentation, this strategy can be problematic, since not only does the service provider need to have the correct calibration hardware, but he also needs to have the correct instrument control software, which must then be loaded on to the system. And then once the software is loaded, the system may need to be partially disassembled just to access the instrument's connections. For these reasons, the predominant certification strategy for VXI or PXI instruments today is to remove the instruments and have them recertified by the OEM or a pre-approved third party calibration facility.

With continuing adoption of card modular test platforms and many new military and commercial programs looking to PXI as the next generation platform, a better certification strategy is needed which allows card modular instrumentation to be recertified within the test system. The ability to recertify instrumentation without incurring excessive down time is particularly important for systems with mission critical logistics requirements, such as those supporting depot and intermediate test needs. An integrated, systems based, recertification methodology, when used in conjunction with application specific accuracy requirements and an appropriate standards module, offers an improved method to support the verification of baseband PXI modular instrumentation for a specific application or class of applications. And as an added benefit, if the proposed standards module incorporates source and measure resources, a standardized set of system self-test routines can be created, resulting in faster system self-test development and improved re-use of test routines for subsequent test systems.

INSTRUMENT CERTIFICATION STRATEGY FOR A PXI CORE TEST PLATFORM

A test system based on a PXI core platform typically includes a collection of source and measurement instrumentation, switching matrices to route resources to/from test points on a UUT, and possibly external “box” instruments such as GPIB, LXI or USB devices. The certification process for the test system involves only those components that require traceability. If an instrument fails certification, it will require recalibration. A typical core set of baseband PXI instrumentation might consist of a DMM, one or more digitizers, AC and/or DC sources such as a DC power supply or arbitrary waveform generator, and a counter / timer - all which will require periodic recertification to a traceable standard. However, unlike their bench top or “box” counterparts, all instruments are contained within the PXI chassis and are controlled by software drivers and some type of software environment / language. Ideally, recertification of these card modular instruments should be performed by leaving all of the instruments installed in the chassis – resulting in simplified logistics, minimal impact to the integrity of the test system / configuration, and the ability to leverage the system's hardware and software infrastructure.

An “in-system” certification strategy – one that leverages the test system's hardware and software architecture, will require the incorporation of some type of transfer standard as part of the overall test system – providing traceability and the ability to recertify those instruments that are compatible with the transfer standard's capabilities. The overall certification strategy for a PXI system is based on the following key points:

- Instrumentation accuracy requirements for the recertification process may be based on application specific requirements, as opposed to being based on “published” individual instrument specifications. For example, if an application(s) requires only the accuracy of a 5½ digit DMM, but the instrument is a 6½ digit instrument, it is then sufficient to certify the instrument to an accuracy associated with a 5½ digit instrument. By applying applications-based requirements to the certification process, accuracy requirements for the standards

module (and for the overall system) become less demanding, resulting in a lower cost standards module, improved test margins and test stability, and less frequent recertification of the system.

- The transfer standards module is supported and controlled by the same software environment that supports all of the PXI instruments contained within the Automatic Test System.
- The standards module may not be the only resource in the system providing verification and traceability. A combination of secondary and tertiary standards may be employed as part of an overall certification plan. Depending on the specific system configuration and requirements, the standards module may be used to certify “primary” instruments - those with the most demanding accuracy verification requirements. Remaining instruments within the system may then use these verified primary instruments as secondary standards in conjunction with the standards module to perform verification.
- Use of a software - based standards calibration methodology in conjunction with on-board non-volatile memory is employed to achieve a high level of accuracy for all standards located on the module as well as providing the ability to correct for time and temperature variations. Successful

implementation of this strategy requires that the module’s standards exhibit excellent stability, with their accuracy well defined over temperature and time. Absolute accuracy is achieved by measuring the standard’s values at the time of manufacture and subsequently loading these values into the module’s EEROM, which can then be accessed by the user when certifying system instrumentation.

STANDARDS MODULE REQUIREMENTS AND IMPLEMENTATION

The implementation and performance of this module offers the opportunity to implement a strategy for recertifying many baseband source and measurement PXI instruments that are part of Depot and Intermediate level test systems. To address the recertification needs of the test system’s baseband instrumentation and system self test capabilities, the module needs to provide the following core set of capabilities:

- AC and DC voltage reference standard
- Resistor standard
- Frequency reference standard
- General purpose DC source resource

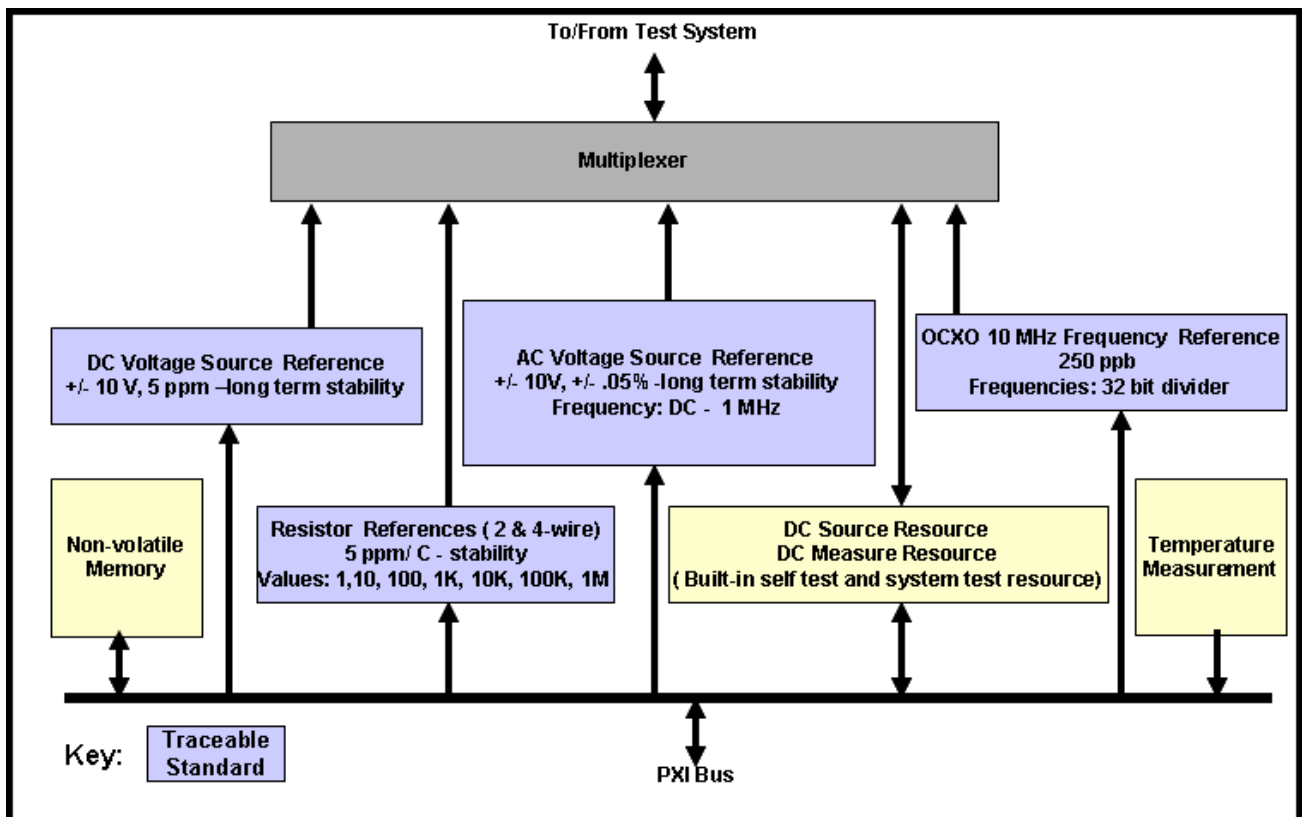


Figure 4 – PXI Standards Module

- General purpose DC measure resource
- Resource multiplexer

Figure 4 details an overall block diagram of the Geotest GX1034 PXI standards module.

The capabilities and features of the standards module detailed in figure 4 are designed to primarily address the recertification needs for the following types of instruments:

- Digital multimeter
- Frequency counter
- A to D and digitizer modules

Additionally, by including general purpose source and measure resources, it is possible to include built-in module self-test functionality which can provide the resources for supporting a system self-test implementation.

All reference standards derive their traceability from an external set of National Institute of Standards and Technology (NIST) traceable standards which are employed at the time of manufacture. However, to avoid the complexity

(and cost) that can be associated with creating precision standards, the hardware design primarily focuses on the use of components that offer excellent stability over time and that have well specified temperature characteristics.

Establishing the absolute accuracy or calibration of the voltage and resistance references is done at the time of manufacture by recording the actual values of the standards and subsequently storing these values in the module's on-board non-volatile memory. For the frequency

reference, the 10 MHz oven controlled crystal oscillator (OCXO) is electronically adjusted to achieve the required accuracy. Once the measured standards values have been loaded into the module's EEROM, these values are then available for use as part of re-certification procedure for a variety of measurement instrumentation that might be part of an overall test system.

The PXI standards module also includes a built-in temperature sensor, which allows the module's driver to correct the baseline calibration values, based on each reference's temperature characteristics. Finally, since all measured standards values are loaded into the module's EEROM, the module's performance cannot be compromised by the loading of an incorrect calibration file located on a disk or some other media.

INCORPORATING THE PXI STANDARDS MODULE AS PART OF AN IN-SYSTEM CERTIFICATION STRATEGY

As noted previously, the standards module provides the baseline for recertifying the test system's various instruments. The standards module is primarily a sourcing module and supports the certification of measurement instruments. However, for sourcing instruments that are part of the system, such as DC or AC sources, an alternate set of resources will be needed. In this case, the use of secondary

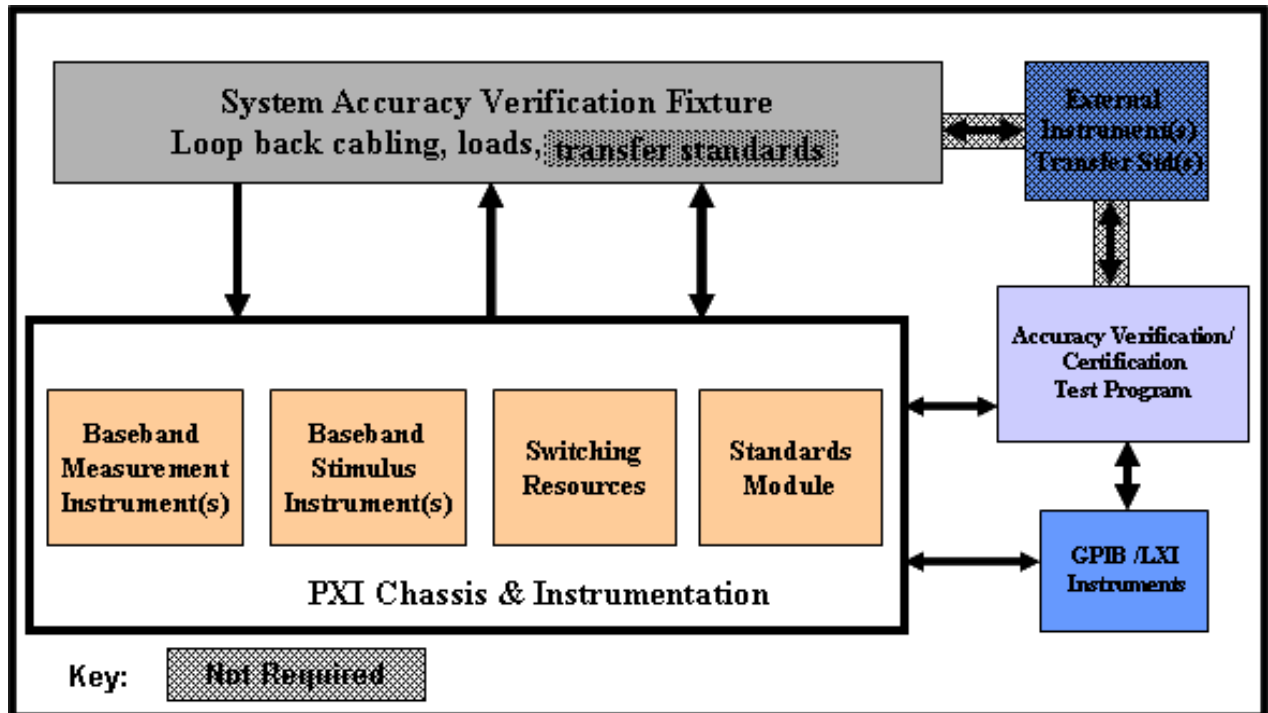


Figure 6 – Modified Test System Configuration with Standards Module

standards or instruments is employed which provides the means to certify these source instruments, using the test system's own resources. For example, it has already been noted that a DMM can be recertified by the standards module. Once the DMM is certified, this module is then available as a resource (or secondary standard) to certify a DC or AC source that may be in the system. And since both the primary and secondary standards are certified, traceability is maintained throughout the entire process. A key factor to ensuring the success of this strategy is to make sure that required instrument accuracies being certified are compatible with the measurement device and that the certification flow down process is strictly adhered to. A test uncertainty ratio (TUR) of 4:1 or greater, which is an industry accepted value, will provide greater than a 99% confidence level, assuming the uncertainties for both the specification and the measuring device exhibit Gaussian distributions with a 95% confidence.[3] Figure 5 details the overall calibration process which includes the use of both primary and secondary standards.

The standards module itself needs to be recertified periodically, typically every two to four

years. Since all the hardware and software hooks are already part of the test system, it becomes very straight forward to recertify the module in the system. A NIST traceable DMM and frequency counter are connected to the module and the graphical user interface (GUI) that is included with the standards module's driver is used to complete the recertification.

SUMMARY

The adoption and deployment of card modular based test systems presents unique challenges for test engineering departments that are responsible for the maintenance, calibration, and certification of test systems. Relying upon the traditional techniques and methods used for recertifying "box" instruments ignores the benefits and features associated with card modular architectures. A PXI based core system platform offers suppliers of test systems the opportunity to develop a certification strategy that leverages a combined hardware and software solution, resulting in a superior and cost effective certification solution. Figure 6 revisits how the accuracy verification setup depicted in Figure 3 will change based on the use of an integral standards module. With the addition of this module, the use of an external transfer standard is eliminated and potentially, the complexity of the AVP fixture is also reduced. And additionally, the module can provide central resources for supporting system self test functions such as signal continuity and verification of matrix / multiplexer functionality.

The in-system certification strategy takes a system level view of the certification process and builds on the software and hardware infrastructure inherent with card modular systems. With an in-system certification strategy, certification logistics, and overall measurement confidence in the test systems can be substantially improved. And by dedicating one PXI slot within the test system for a standards module, the need to remove multiple modules for recertification can be largely eliminated with theoretically; only one module now requiring an external annual recertification. The result is a solution that takes full advantage of the system's features and components to achieve improved system availability, lower maintenance costs, and simpler maintenance logistics.

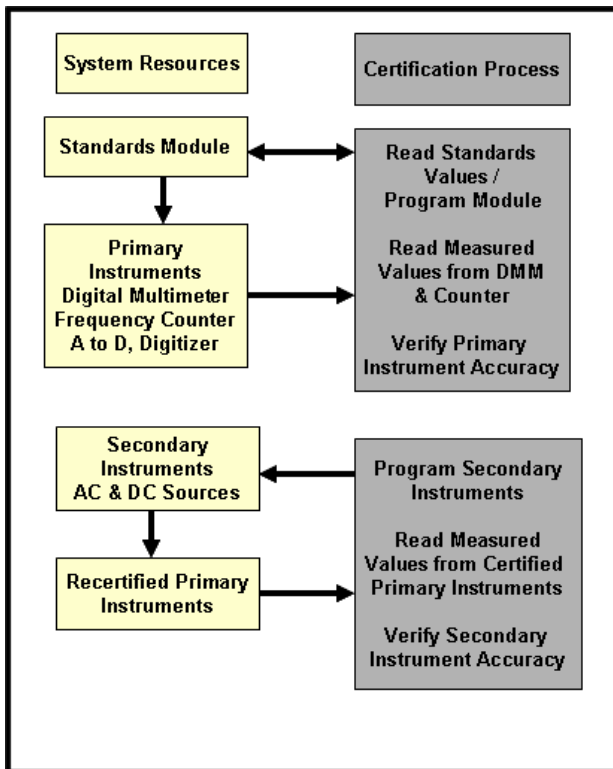


Figure 5 – Recertification Process Flow

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- [2] Prime Data – PXI Market Share Forecast, August 31, 2006
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