Don't Touch My TPS

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Abstract- The need to extend the useful life of ATE systems is often seen as a hardware problem. Replacing aging computers and obsolete instruments is the obvious challenge. The elephant in the room is that new computers and new instruments often require changes to the Test Program Sets (TPS's). As time consuming and difficult as it is to select and integrate new computers and instruments, changing and validating the TPS's is a daunting task. The limited availability of qualified personnel, legacy system documentation, UUT's to test the modified TPS's and time creates the need to control the scope of TPS changes. This paper explores approaches to minimize required TPS changes and the resulting need for validation when an instrument becomes obsolete and unavailable. It details examples of instrument level changes to hardware and firmware in modern replacement instruments that have successfully avoided significant TPS changes. This includes developing compatibility with legacy instrument instruction sets that deviate from industry standards, understanding older instruments' special capabilities, as well as supporting timing issues created by the use of faster, modern computers. The paper describes examples of the need to identify tradeoffs where undocumented features of the obsolete instruments are utilized in the TPS and how firmware changes to the replacement instruments solved the issues. The paper also discusses how the instrument supplier insures continued support for the future by developing validation tests to insure future changes to the replacement instrument continue to insure effective replacement.

Keywords- Power Supplies, COTS, Modified COTS, ATE Power Supplies, TPS, Test Program Sets

I. INTRODUCTION

Who ever dreamed that useful life of aircraft that first flew in the 1950's would be extended into the 2040's? The decisions to extend the life of many platforms have been driven by the harsh realities of developing completely new aircraft. The understanding that updated systems' functionality is more about modernizing the electronics and other systems than the airframes they are mounted on is driving this trend. To support maintaining existing systems as well as newly added functionality requires updating the ATE (Automatic Test Systems) that are used to test and maintain critical systems. Updating the ATE systems is more than just replacing hardware. The computers, instruments and power supplies in ATE system are used by TPS's (Test Program Sets).

As challenging as upgrading the hardware is, the biggest challenge is what to do with the TPS's. Many of the TPS's are written in older languages and may not be well documented. Finding the people to modernize TPS's is difficult.

Validating the TPS's is even more challenging because of the time required and the availability of the devices that need to be tested (Unit Under Test - UUT's). The problem is further complicated by the fact that many UUT's are classified and the access to legacy systems is often restricted. Modern collaboration tools, like video conferencing, are not an option.

How to minimize the need to change TPS's? To do so requires finding computers, instruments and power supplies that are highly compatible with the existing TPS. The challenge is how to do this.

II. CHALLENGES IN EXTENDING USEFUL LIFE OF ATE SYSTEMS

The computers, instruments and power supplies that comprise the hardware portion of ATE systems each present their own challenges in modernization to minimize the need for changes to TPS's.

Often, existing instruments (e.g., scopes, DVM's, function generators) can be retained or replaced with modern devices with discrete input output boxes that convert the current SCPI for CIIL, MATE and Able and allow for customization to support the unique undocumented challenges that the older TPS contain. The bigger challenges are often with computers and power supplies.

Computers and power supplies are the wear items that often need replacement to extend the useful life of ATE systems. For computers, finding modern computers that can run legacy operating systems or new computers and oper-

ating systems that can run UUT's is a demanding task that has received a lot of attention

Power supply replacement represents a unique challenge in these applications. The approaches to replacing power supplies include buying new legacy supplies, using current commercially available supplies, contracting for a custom design and manufacturing and adapting modern COTS (commercial off the shelf) supplies.

Many of the power supplies used in legacy ATE systems were custom designed and manufactured. When these power supplies were built, most of them were designed and manufactured in the United States. The option of simply procuring newly built legacy power supplies is often not available. Many of the manufacturers of these power supplies no longer exist or have moved their design and manufacturing offshore or have outsourced power supplies entirely. Building low volume products with hard to get parts or redesigning to use currently available parts is often inconsistent with how many power supply companies do business today.

The use of standard, currently available power supplies is the easiest solution from a procurement perspective. It is also amongst the hardest to implement in legacy ATE applications. Form, fit and function are all issues that need to be addressed. Few power supply manufacturers offer these services. Also, modern power supplies are often treated as disposable commodities. They are not designed to last 25+ years because the applications they are designed for have much shorter useful lives.

Ground up, custom designs are often the hardest option to execute. Simply defining and specifying the power supply is a large challenge because of the limited availability of complete documentation of the legacy power supplies, both hardware and software. The biggest issue is people. Who is available to do the work to define the the requirements and validate the new system? This is the longest duration and most expensive option.

Using modern, COTS power supplies that are modified to minimize changes to TPS's and interface with existing ATE systems is a compelling option. This approach starts from a known, working platform, building on a solid power supply platform that is a good fit to the requirements of the application. The scope of work to develop a solution is then limited to defining and designing the elements that are different. Some of the special considerations in implementing this approach are described below.

III. INSTRUMENT LEVEL CHANGES

The two major considerations that need to be addressed in adapting modern instrumentation power supplies to legacy application are controlling the supplies and special performance characteristics. These often need to be handled by modifying the circuitry inside the power supply and firmware. Handling these issues within the power supply offer the advantage of modifying one device rather than hundreds of TPS's.

Controls may be digital or analog. Handling analog signals properly involves understanding the existing control scheme. Take, for example, the input signal voltage range (e.g., 0-10 volts) and the ratio between the signal and the desired output voltage of the power supply. If the nominal maximum output of the power supply is 200 volts and is controlled with a 0-10 volt signal, does 10 volts mean 200 volts or something else? In one recent application, the 10 volts needed to produce 212 volts not 200.

Digital control represents another critical function.

Many legacy ATE systems use older languages and protocols like CILL and ATLAS and interfaces like IEEE 488 (GPIB) and RS-232. Accommodating these older standards at the power supply level is critical to prevent major rewriting of the many TPS's and associated validation. This is probably the most impactful area, where providing compatibility at the power supply level minimizes the time and effort required to field modern replacement power supplies in legacy applications.

Providing power supply level digital compatibility often require changes to internal circuitry and embedded firmware that is only practical for the manufacturer of the power supply. Utilizing standard power supplies that already support these standards, minimizes the effort and time required

to provide TPS-compatible solutions. The power supply manufacturer needs to be expert in creating and building this type of modified standard power system.

In adapting Kepco's MST-MH's to be compatible with a legacy system, the commands were similar but sufficiently different that a translation was needed. Kepco modified the controller syntax to work in the same way for the commands the customer identified as being used in the classified drivers. We were lucky in that the older system was still available in the used market and we were able to purchase a system.

We used the system to discover the undocumented differences in the commands and created a test program to verify the operation of the commands on the original device and then used the program to validate the replacement power supply.

An example was the operation (See Figure 1) of STATUS: QUESTIONABLE: ENABLE register. The command allows the 15-bit register to set and clear the bits and these allow for selecting sources of the errors. The Kepco implementation was just to set and clear all 15 bits. The original device only supported the bits in the

STATUS: QUESTIONABLE: CONDITON register of the device. Was this change important? No, not in the initial testing. But this also occurred on the *ESE and *SRE registers and there it was important.

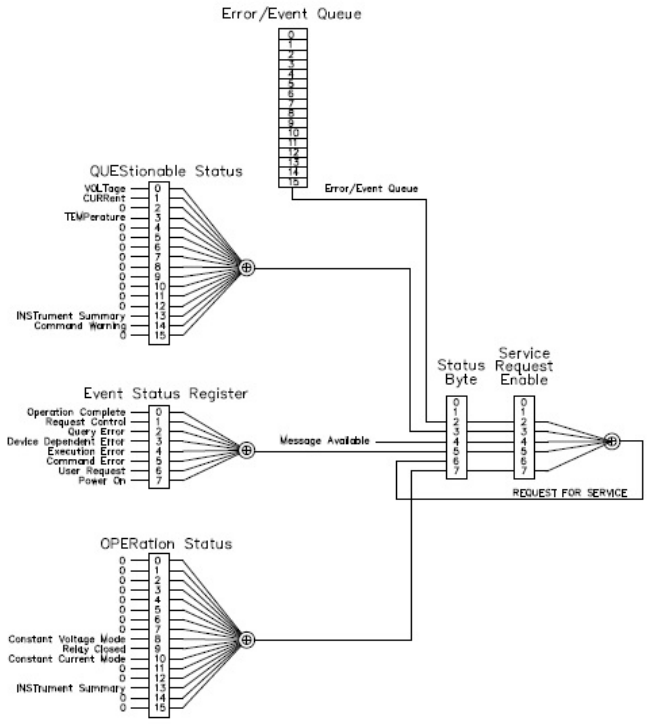

FIG. 1. STATUS:QUESTIONABLE REGISTER

IV. DEVIATIONS FROM INDUSTRY STANDARDS AND SPECIAL CAPABILITIES

Organizations that focus on upgrading legacy ATE systems are often not the integrator that provided the original system. They have little choice but to rely on the documentation created by the original provider. Upgrade efforts are often based on the assumption that the systems comply with standards (e.g., GBIP) that are called out in the documentation. Reality is often very different.

The claim of standards compliance often falls into the category of "True, but, not the the whole story." It is common for the custom power supplies that are being replaced to have functionality and commands that go beyond the scope of standards like MATE. Even when the standards are adhered to, they are often interpreted in different ways. Something that appears to be as simple as device addressing, can throw significant obstacles into adapting modern power supplies.

Special performance capabilities that are required for specific applications are often included in legacy systems. These may include low electrical noise at specific frequencies and providing analog monitoring of various power supply functions (e.g., current monitoring).

Whether the legacy supplies have special features, non-compliant command sets or other flaws, the TPS's are often written to accommodate them. These type of changes are often undocumented and hard to reproduce. To avoid changing the TPS's, replacement hardware needs to a replicate the personality of the legacy supplies. This may mean additional customized circuitry and firmware and software changes. The trade-off is between adapting the replacement supplies or changing the TPS's. Adapting the power supplies can provide faster, better and cheaper solutions.

An example of this is addressing devices. In one case involving a multi-channel power system, the legacy power supplies had channel numbers starting at zero. The replacement supplies had channel numbering start at one. In this situation, building front end firmware in the power supply that converted the channel numbers called by the TPS to the native channel numbers was much more cost effective than changing and validating many TPS's.

V. INTERFACE CHALLENGES - WIRING

The elephant in the room when it comes to replacing legacy power supplies is wiring. If wiring changes are required because of the input and output connections of the replacement power supplies, the scope of the upgrade project expands dramatically beyond providing supplies that are compatible with the TPS's.

New power supplies need to be plug compatible to avoid rewiring.

The problems associated with rewiring go far beyond physically running new wire and wiring new connectors. Legacy wiring can have undocumented characteristics related to embedded components. The routing of the wiring may also impact the performance of the entire ATE system because of voltage drops and susceptibility to noise.

An example of avoiding rewiring comes from a customization of Kepco's MST power system to provide a drop in replacement for a discontinued legacy power system.

In the replacement test system, Kepco created an adapter (Figure 2) that converted our strip and crimp connectors to screw terminals that allowed the customer to just reconnect the existing wires to the replacement MST-MH. [1]

A trend in current instrument power supplies is to have output power and bus connections on the front. This creates problems beyond wire routing. Front mounted connections change the user interface. Power and signal connections become available to system operators who are not trained in managing these connections. This provides challenges to consistent operation of the ATE system and complicates maintenance of the power system. Plugging and unplugging a power module has far fewer opportunity for error than having to also make connections on the front panel.

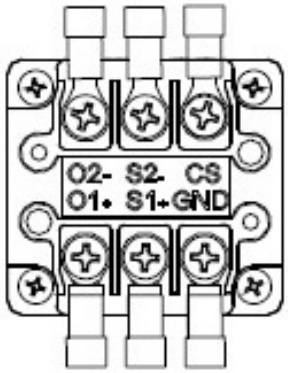

FIG. 2. ADAPTER TO CONVERT MST-HT WIRING FOR DROP-IN REPLACEMENT

VI. SUSTAINABILITY

When replacing legacy power supplies, key concerns are how long the new supplies will be supported by their manufacturer and how long components will be available to facilitate repairs. The power supplies need to be maintainable over the projected life of the platform they are supporting. As the product life cycle of power supplies and their components has shortened, the horizon for support has also been reduced.

The impact of shortened product life cycles can be reduced by selecting power supplies that are core to the manufacturers' product strategy as the foundation of the customized power supplies.

To continue the manufacture and support of core products, sustaining engineering is required.

The likelihood of an ongoing commitment to sustaining engineering is much greater when the power supplies are an important part of the manufacturers' business plans.

Availability of additional power supplies over the life of the project is also a consideration. Ongoing manufacturing of the replacement power supplies is more likely if the manufacturer builds the power supplies in a US facility and when the base models continue to be produced. The same is true for spare parts. The manufacturer's ability to scale production volumes up and down to support project needs is a significant determinant of ongoing production of the modified standard power supplies over the lifespan of ATE systems.

The overarching issue is the demonstrated commitment of the power system supplier to provide long term support for the new power supply systems. The availability of people to provide ongoing application support, repairs, spares and additional power supplies is what makes the difference in ensuring long term success.

VII. CONCLUSION

There are many challenges in extending the useful life of legacy ATE systems. Power supplies represent a unique challenge because of their physical characteristics and their tight integration with TPS's. The effect of replacing legacy power supplies on TPS's can be minimized by modifying modern standard power supplies. In addition, this approach can provide plug compatible power systems that eliminate the need for rewiring. Selecting modern power supplies as the platform for these modifications is critical to insure the successful delivery and implementation of new power supplies that are sustainable over many years. The commitment of the power system supplier to long term support of the new power systems is critical to the sustained success of new replacement power systems.

REFERENCES

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