Benefits of a Switch/Measure Unit for Data Acquisition and Electronic Functional Test

Switch/Measure Units Provide Low Cost and Expandable System Cores

• Low cost alternative to VXI and PXI for systems with up to 1120 two wire channels (two 34980A mainframes)
• Fifteen different switch modules and four selectable two wire analog busses on the backplane offer great configuration flexibility
• Integrated front panel allows for manual operation right out of the box
Introduction

Systems for data acquisition and electronic functional test are best implemented using a dedicated switching subsystem. This allows the number of switches to be increased without impacting the instrumentation and vice versa. Typical technologies in which to implement switching are VXI, PXI and vendor-specific cardcages. VXI and PXI are expensive solutions because those mainframes were designed for power-hungry instrumentation requiring high-speed backplanes.

Vendor-specific switching systems, in contrast, have just enough power supply capability, cooling and speed to do the job that is asked of them without burdening them with the requirements of high performance instrumentation. New LAN and USB interfaces on these units offer performance and ease-of-use improvements not available with the other interfaces. Some vendor-specific switching systems are open enough to allow custom cards to be inserted, which increases their flexibility.

This article shows how a Switch/Measure system with LAN, USB and GPIB interfaces, breadboard cards and a wide array of switches along with a built-in DMM can be used as a central core in a data acquisition or functional test system to increase flexibility and lower cost.
The traditional approach to test system design

Figure 1 is a block diagram of a typical VXI- or PXI-based functional test system. Instruments are routed to a makeshift analog bus via a switching matrix, and Device Under Test (DUT) pins are connected to the same analog bus via additional matrices. (This architecture works provided the DUT has some built-in self-test capability, allowing sections of the DUT to be tested without requiring all stimuli to be applied and all responses to be monitored at once.) High current loads and power supplies are connected to the DUT via dedicated general-purpose relays. A fixturing system connects the DUT to the test system. The instrumentation and switching are implemented in the same VXI or PXI frame.

There are several problems with this type of architecture:

1. **Cabling can be cumbersome.** There are a lot of wires connecting the instruments to the analog bus and connecting the matrices to the fixture. Since the switches are located in the same place as the instruments, service can be difficult.

2. **Scanned measurements are more difficult.** In data acquisition applications, scanning a DMM through a series of relays takes more code because of the more complex triggering that is required than it does for a combined switch/measure unit. See Figure 2.

3. **There’s not as much room for expansion.** No matter how dense the relays, test systems always seem to want more. Thus, it is easy to fill up a VXI or PXI mainframe with switches, reducing the amount of room available for new instruments. Ironically, if you don’t fill up the cage, you are spending a premium ($500-800/slot) for the ability to add future instruments that may never be needed.

4. **High cost.** VXI and PXI cardcages were designed to handle high-speed, highly accurate instruments, so there is a much higher cost associated with the use of such a cardcage than with equivalent rack&stack instruments. See Figure 3 for a price comparison of some typical instruments.

5. **Interconnecting cables are expensive.** In our example system (Figure 1), instruments are controlled either from an expensive embedded PC or an expensive FireWire, MXI-3 or GPIB interface – one card required on each end of the cable. GPIB cables are also very expensive. The modern alternative is USB or LAN. New instruments from Agilent and others have these inexpensive interfaces on them standard. All large electronics stores carry cables for them. That’s the advantage of using computer industry standards for instrument I/O. Figure 4 shows the relative costs of GPIB, USB, LAN, FireWire and MXI-3 cabling.

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Figure 1 - Typical functional test system. Analog bus measurement is constructed by the test system designer using external wiring shown on the left.
**PXI/SCXI scanned measurement:**

Dim readings(80) As Double
Dim numRdgs As Integer

PXIDMM.ConfigureAutoZeroMode(NIDMM_VAL_AUTO_ZERO_ONCE)

PXIDMM.ConfigureMeasurement(NIDMM_VAL_DC_VOLTS, 10.0, 0.001)

PXIDMM.ConfigureMeasCompleteDest(NIDMM_VAL_LBR_TRIG_0)

PXIDMM.ConfigureMultiPoint(1, numChannels, NIDMM_VAL_INTERVAL, SampInterval)

myniSwitch.ConfigureScanList("scl!md3!ch0:19->com0;", _

myniSwitch.ConfigureScanTrigger(0.0, _
    IviCWrappers.NiSwitch.TriggerInputEnum.Ttl0, _
    IviCWrappers.NiSwitch.ScanAdvancedOutputEnum.None)

myniSwitch.InitiateScan()

PXIDMM.Initiate()

PXIDMM.FetchMultiPoint(5000, numChannels, readings, numRdgs)

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**Switch/Measure Unit scanned measurement:**

Dim rdgs(80) As Double

myAgilent34980.Scan.Scanlist = "1001:1020"

myAgilent34980.Voltage.DCVoltage.AutoZero("1001:1020") = _
    Agilent34980AAutoZeroEnum.Agilent34980AAutoZeroONCE

    Agilent34980AResolutionEnum.Agilent34980AResolutionLeast)

rdgs = myAgilent34980.Measurement.ReadNumbersOnly(""")

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Figure 2. VB.NET Example — PXI/SCXI vs. Switch/Measure Unit
programming example for a scanned measurement
<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>NI Instrument</th>
<th>NI Price</th>
<th>Agilent Instrument</th>
<th>Agilent Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument cage</td>
<td>NI PXI-1042 (8-slot 3U)</td>
<td>$1,995.00</td>
<td>Not required</td>
<td>$0.00</td>
</tr>
<tr>
<td>6.5 digit DMM</td>
<td>NI PXI-4070</td>
<td>1,995.00</td>
<td>Included in Switch/Measure Unit</td>
<td>0.00</td>
</tr>
<tr>
<td>Arbitrary Waveform Gen</td>
<td>NI PXI-5411 16 MHz (2-slots)</td>
<td>3,695.00</td>
<td>Agilent 33220A 20 MHz</td>
<td>1,853.00</td>
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<tr>
<td>Switch cage</td>
<td>Included in PXI cage</td>
<td>0.00</td>
<td>Agilent 34980A (including DMM)</td>
<td>2,350.00</td>
</tr>
<tr>
<td>GP relay</td>
<td>NI PXI-2566 (16 SPDT, 2A)</td>
<td>895.00</td>
<td>Agilent 34937A (28 SPDT 1A, 4 SPST)</td>
<td>895.00</td>
</tr>
<tr>
<td>GP terminal card</td>
<td>NI TB-2666</td>
<td>245.00</td>
<td>Agilent 34937T</td>
<td>225.00</td>
</tr>
<tr>
<td>Matrix</td>
<td>NI PXI-2530 (4x16 2-wire reed)</td>
<td>1,695.00</td>
<td>Agilent 34933A (dual 4x8 2-wire reed)</td>
<td>995.00</td>
</tr>
<tr>
<td>Matrix terminal card</td>
<td>NI TB-2631</td>
<td>245.00</td>
<td>Agilent 34933T</td>
<td>225.00</td>
</tr>
<tr>
<td>DIO, DAC, counter</td>
<td>NI PXI-6025E (32 DIO, 2 ±10V DAC, 100 KHz counter)</td>
<td>595.00</td>
<td>Agilent 34952A (32 DIO, 2 ±12V DAC, 100 KHz counter)</td>
<td>695.00</td>
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<tr>
<td>DIO interface card</td>
<td>NI SCB-68</td>
<td>295.00</td>
<td>Agilent 34952T</td>
<td>175.00</td>
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<tr>
<td>Computer interface</td>
<td>NI PXI-PCI18330 MXI-3</td>
<td>1,495.00</td>
<td>LAN hub</td>
<td>50.00</td>
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<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>$13,150.00</strong></td>
<td></td>
<td><strong>$7,463.00</strong></td>
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</tbody>
</table>

**Rack units**: 4

**Space utilization**: 1 slot left in PXI cage

NI prices from NI website, July 12, 2004. Prices and specifications subject to change without notice.

**Figure 3.** Price comparisons — PXI vs. Rack&Stack

<table>
<thead>
<tr>
<th>Interface</th>
<th>Single instrument (typical)</th>
<th>12-instrument system (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NI MXI-3</td>
<td>$1,495.00 USD</td>
<td>$1,495.00 USD</td>
</tr>
<tr>
<td>NI PXI-PCI18330</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firewire</td>
<td>$2,295.00+ USD (may require PCI card, not included)</td>
<td>$2,295.00 + USD (may require PCI card, not included)</td>
</tr>
<tr>
<td>Agilent E8491B</td>
<td></td>
<td></td>
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<tr>
<td>VXI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USB</td>
<td>Cable $10.00 USD</td>
<td>Cable and two hubs $204.00 USD</td>
</tr>
<tr>
<td>LAN</td>
<td>PCI card and cable $30.00 USD</td>
<td>PCI card, cables and two hubs $207.00 USD</td>
</tr>
<tr>
<td>GPIB</td>
<td>PCI card and cable $614.00 USD</td>
<td>PCI card and GPIB cables $1,670.00 USD</td>
</tr>
</tbody>
</table>

**Figure 4.** Price comparison of different computer interfaces
The Modern Approach to Test System Design

So what’s a poor test engineer to do? Choose a high-priced one-size-fits-all cardcage, or choose lower cost rack and stack instruments that can take up a lot of rack space?

The solution is to use a Switch/Measure Unit that combines a high performance DMM, internal analog measurement bus and a variety of switching, DAC, Digital I/O, Counter and other functions, as the core of the test system. Add Rack&Stack, PXI or VXI instrumentation to the system as appropriate. The internal analog bus in the Switch/Measure Unit takes the place of the one that was shown cobbled together out of switch cards in Figure 1.

Switch/Measure Units provide a lot of room for cards without taking up a lot of rack space. The switch system’s backplane and integrated power supply have just enough performance to do the job without paying the price of allowing for additional high performance instrumentation. Figure 5 shows a block diagram of a system using this subsystem approach, in which a Switch/Measure Unit is used for the middle block. Despite consisting entirely of Rack&Stack Instruments, it can be made quite compact as shown in Figure 6.

Note the separate subsystems:

1. **Computing**: Industrial PC uses passive motherboard with plug-in PC that is easily upgraded as technology changes. In this case, LAN and/or USB runs most instruments. The required hub is mounted internally in the rack
2. **Power**: Modular power supply; lots of power in a small space
3. **Instrumentation**: Discrete rack&stack instruments include a function generator/arbitrary waveform generator and a high performance frequency counter
4. **Switching**: Modular Switch/Measure Unit with DMM, DIO, D/A Converters, breadboard card for custom electronics.

The modern test system uses LAN or USB for I/O. The cables are cheaper, lighter, smaller and readily available. LAN control even offers the ability to view the status of the instrumentation via a web browser from anywhere on your network. As LAN speeds move to 1 Gigabit/second they will approach the high backplane speeds of VXI and PXI.

![Figure 5 - Functional test system with a subsystem approach. The switch/measure unit in the middle has an analog bus structure built in, simplifying wiring.](image-url)
The Bottom Line
The days of high cost instruments that don’t quite do what you need and that require expensive computer I/O are almost over. While VXI and PXI have their place, they are best used for instruments having functionality that can’t be obtained anywhere else. VXI is also an excellent choice for extremely high channel-count systems.

To minimize the impact of instrument interdependence, create separate subsystems — computing, power, instrumentation and switching. Analog busses, D/A Converters, Digital I/O and miscellaneous functionality should be placed in the Switching subsystem along with the ubiquitous DMM. Switch/Measure Units fill this need well. The result will be a flexible, expandable system whose cost is optimized for the application.
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