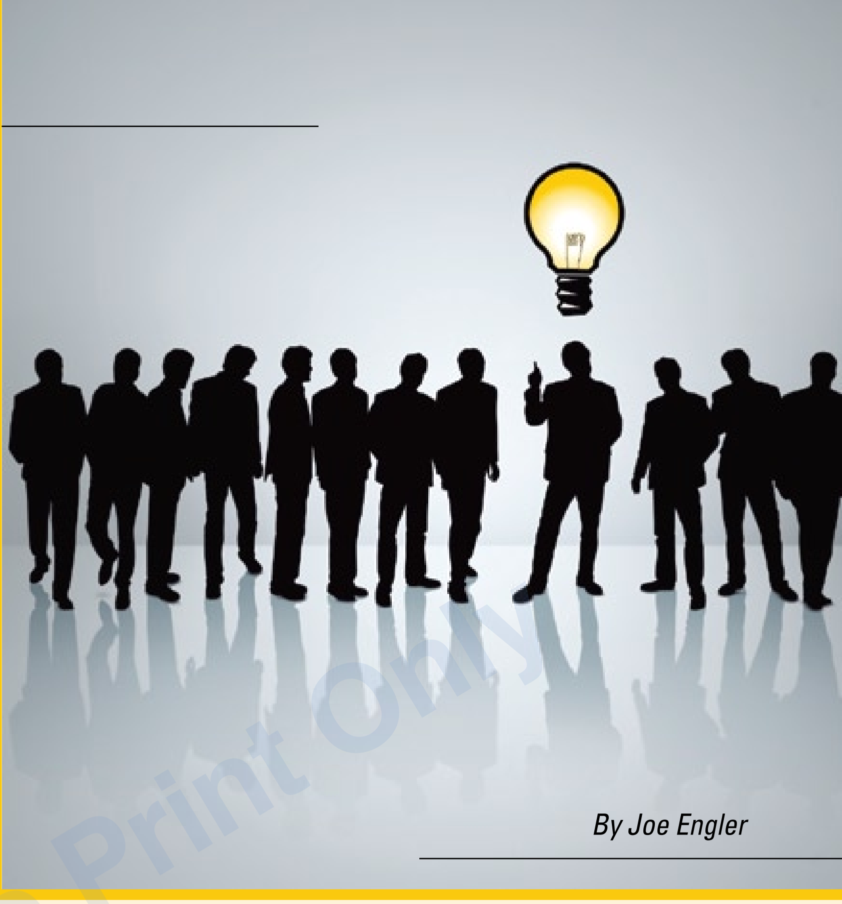
LXI in power testing

LXI for obvious – and not so obvious – reasons



By Joe Engler

Selecting the right test instrumentation architecture can make or break a project. One of the relatively new choices is LXI, whose time has come as evidenced by the number of new test products that support the standard. Most of these products have been relatively small and required a single communications interface.

When designing its new tester for power semiconductors, Intepro Systems had a problem of a different scale, which caused designers to view LXI's features from a somewhat different perspective. In the process, an opportunity to exploit one of LXI's less evident features became an important advantage in the system design.

Large-scale semiconductor testing

Intepro's SEMTest system was conceived to perform production line screening of from 20 to 1,000 power semiconductors at a time, depending on customer requirements. The system is designed with a separate instrument card for each semiconductor or module being tested. Each card needs its own communications bus interface to the computer so that parameters relating to the device under test can be accessed, displayed, and changed individually.

Suddenly, the questions of which bus interface to use and how to restrain bus costs become 1,000 times as important as in a standalone instrument. Remote accessibility of the instruments is less of an issue in this case, since the 1,000 cards may be only a rack away from the computer controlling them.

However, data volume is very much a design issue. Each instrument card has multiple instruments to control and record temperature, voltage, current, and pulse on/off data for the device it is testing for as many as 10,000 times per second (10 kHz). Multiply that throughput by a large number of cards, and data volumes are significant.

Total power drain is also a factor. While the power consumption of the communications interfaces is definitely not a problem, each semiconductor under test can be switching up to 130 amps at up to 10 kHz, total power draw for the SEMTest system can be measured in *thousands of amps* and electrical noise becomes an issue for computing and communications.

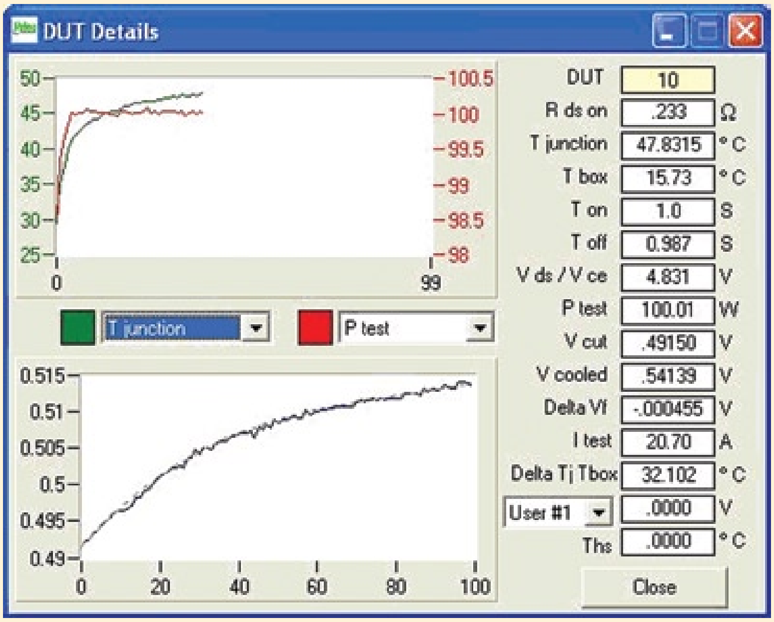
Running 1,000 tests at once

In a nutshell, here's what SEMTest must be able to do. Although there may be 1,000 test cells in a system, every test cell must be controllable separately from the operator's console. Millisecond-by-millisecond snapshots of test parameters and results are time-stamped and stored in a SQL database which is RAID-based to ensure the integrity of data acquired over an extended test period. These results can be viewed in real-time – a single click on the test cell number of any device brings up a display similar to the one shown in Figure 1 (next page).

In addition to the basic test parameters, serial number, test current warning, control limits, and so on, the system records and displays the device voltages, currents, and temperatures during the duration of the test cycle.

Figure 1's screen is typical. The junction temperature variation over 100 ms is shown in the bottom graph. Data recording starts 10 ms after the MOSFET body diode has been forward biased. The temperature/forward voltage drop characteristic is used to convert from the diode voltage to its temperature, with an extrapolation from 10 ms back to the instant when the heating current is interrupted. The right column shows all the measurements that are taken. Engineers can select any two to be plotted in the top pane. The bottom pane shows a voltage representation of the junction temperature.

The visual nature of the control allows engineers to easily see what is happening, while leaving the detail of device monitoring to the system software.



DUT	10	
R ds on	.233	Ω
T junction	47.8315	°C
T box	15.73	°C
T on	1.0	S
T off	0.987	S
V ds / V ce	4.831	V
P test	100.01	W
V cut	.49150	V
V cooled	.54139	V
Delta Vf	-.000455	V
I test	20.70	A
Delta Tj Tbox	32.102	°C
User #1	.0000	V
Ths	.0000	°C

Figure 1

Electrical stressing of MOSFETs

To electrically stress a single MOSFET for one SEMTest customer's high reliability applications, the main source is set to the nominal or maximum voltage of the device (dependent on R_{DSon}). The temperature and test current are varied over time. The device current is programmed to a steady-state level (in this example 0 to 120 A) or dynamic levels by pulsing the source up to 10 kHz (20 to 120 A in this example). The system then monitors the device (see Figure 2) for V_{DS}, V_F, I_D, I_F, and T_C (case temperature).

Maximum test voltages and currents are limited only by the selection of the main power sources, and multiple devices can be paralleled and tested simultaneously. To do this, the device is connected electrically as shown in Figure 3. The main source is programmed at a typical test voltage, dependent on R_{DSon}, temperature and test current.

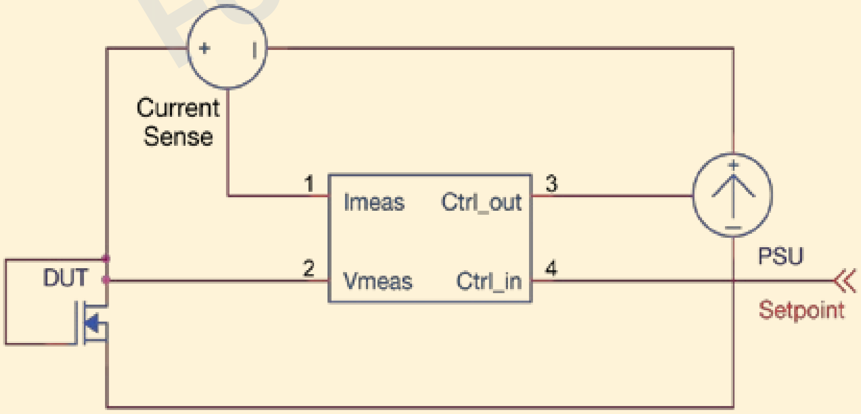


Figure 2

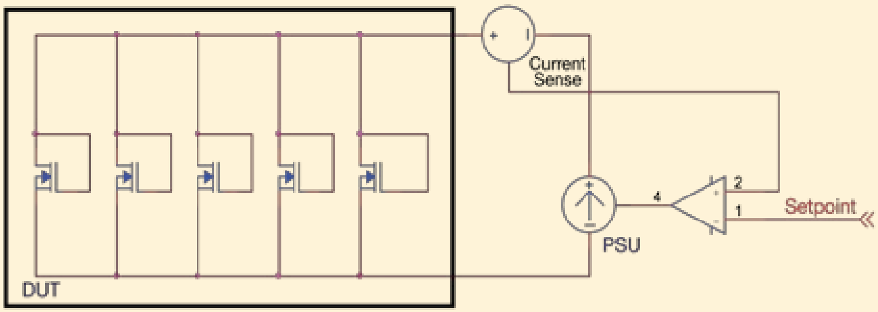


Figure 3

The device current is controlled to equal the current defined by the set point level, 0 to 500 A. The VI product defines the device power. Device monitoring again includes: V_{DS}, V_F, I_D, I_F, and T_C. High voltage testing at up to 250 V at 120 A and V_F measurements are provided but not shown.

The choice of bus

The choice of communications bus has a dramatic influence on the design of the entire system. Cost and speed are the most important considerations, but not the only ones. Table 1 shows the options.

Of the four apparent options, GPIB was quickly eliminated based on cost, the limitation of the number of devices it is designed to support simultaneously, and its relatively low transfer rate.

Both USB 2.0 and PXI were good alternatives, but neither were built to handle 1,000 independent devices. Scaling for these large systems added complexity to the test hardware. PXI also requires a Slot 0 controller, adding cost and complexity.

LXI based on the Ethernet V100 is inexpensive and can handle an unlimited number of attached devices. In addition, engineers chose to not use a Slot 0 controller which allowed design of a simple interface extension card rather than a computer. This also lets the customer scale the power of the computer without incurring more cost. While this means the system is not an LXI Functional Class A (the top level), it is a Functional Class C compatible system.

Ultimately, LXI won out based on cost, speed, maximum number of attached devices, and more.

- Cost: Power electronics testing is very price sensitive, so Intepro also had to be concerned about bus costs. As Table 1 shows, even a 20-cell tester might cost $8,000 more to assemble a worst-case using GPIB than it would using LXI. The math for 200-cell and 1,000-cell testers soon became very convincing.
- Speed: The V100 Ethernet-based LXI bus has what it takes to handle the data volumes of a high-speed production line testing system, and V1000 provides room for growth in that direction. In addition, Ethernet's enormous popularity also assures that a continuing flow of investments will be made in upgrading its speed and capabilities over time – making other communications bus technologies look like orphans.

- Design simplification: The design process is simplified with LXI. An Ethernet interface is already built into almost every computer. A Slot 0 controller is not required. The bus can handle an unlimited number of attachments, and at unlimited distances.

LXI has another less obvious design simplification advantage in this application. LXI/Ethernet is the only bus structure that is isolated – there is no ground reference running across the bus communications interface. This is important when testing power electronics where differential measurements can be compromised by ground loops, especially at high power usage levels. This minor feature significantly simplified the design requirements of all the cards in the SEMTest system.

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But what about the rest of the world?

It's obvious that not all of the instruments in the test world have converted to LXI interfaces. PXI and VXI are well established and GPIB has an enormous base. That suggests that for the near future most large-scale test systems will be hybrids using more than one bus technology. Rather than losing the advantages of LXI in mixing protocols, Intepro has chosen to create a “Universal Interface” card to convert LXI commands to GPIB, USB, RS-485, and other buses to LXI.

Doing more for less

As the test world requires systems that do more for less money, ATE manufacturers are looking for low cost standardized communications to meet their needs. Intepro Systems' engineers selected LXI when designing their new power semiconductor test systems, and are adapting it to its other testers in order to test more devices, more quickly, and at lower cost. Once fully investigated, LXI became part of the solution for obvious and not so obvious reasons.

Item	Traditional Rack/Stack with IEEE 488 (GPIB)	Rack/Stack using USB	PXI Systems	LXI / Ethernet System
Interface isolation /Type	Parallel, Non-isolated	Half-duplex master-Slave polling, Non-isolated	Parallel, Non-isolated	Full-duplex peer-peer, Isolated
Number of devices (max)	32	126	256 with bridges	Unlimited
Cable length (max)	15 m (>500 KBps) 20 m (<500 KBps)	20 m		100 m for 10/100BaseT unlimited with router and internet
Max data transfer rate (Mbps)	8 Mbps	V1.1: 12 Mbps V2.0: 480 Mbps	132 MBps or 264 MBps	V10: 10 Mbps V100: 100 Mbps V1000: 1,000 Mbps
Hardware availability for computers	PC interface card	1. Standard on most PCs 2. If not built-in, PC adaptors available	PC interface card	1. Standard on most PCs 2. If not built-in, PC adaptors available
Topology	Daisy chain or star	Hub connection, cannot be daisy-chained	Star trigger controller local bus daisy-chained	LAN connection (private LAN or site LAN)
Overall hardware cost	Expensive 1. PCI card: $550 2. Cables: $100	1. PCI card: $10 - $50 (usually not needed) 2. USB cable: $8 - $30 3. Hubs: $25 - $100	1. Rack with Slot 0: $2 - $3,000 2. Instruments: relatively inexpensive	1. Rack with Slot 0: $0 - $3,000 (depends on Slot 0). There are versions without racks and just an Ethernet interface 2. Cable: Less than $10 3. Hubs: $25 - $100 4. Instruments: Similar to IEEE - 488 costs
Scalability	Limited; Very expensive; Requires additional PC cards	Limited; Requires additional PC cards / Hubs	Limited to 256 instruments per Slot 0 controller Larger systems require additional Slot 0s	Unlimited; Requires additional hubs/racks
Remote access	Only through PC	No	Through Slot 0	Yes

Table 1

Joe Engler is president of Intepro Systems, LLC, which purchased the power electronics operation of the test systems division of The Shaffner Group AG in 2006. Joe has 10 years of experience in application and test engineering, and spent 14 years in technical product marketing and new business development before Intepro was formed. He has a degree in Electrical Engineering from U.C.L.A.

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