Using LXI to Boost Throughput in Semiconductor Manufacturing

An LXI-based system outpaces GPIB and PXI alternatives

Case Study

Every millisecond counts when testing the semiconductor devices used in cellular phones. For one multinational manufacturer, an LXI-based test system shaved 2800 ms off the time required to test W-CDMA power amplifier ICs. That time savings has the potential to provide a 233.3 percent increase in daily throughput compared to a GPIB-based system.

Agilent application engineers and technical staff from various product divisions worked with a system integrator in Asia to develop a LAN and LXI-based system.[1] The success of subsequent benchmarks prompted the manufacturer to launch new investigations into additional test systems: one to test cdma2000 intermodulation distortion and another to test transmitter/receiver (Tx/Rx) antenna noise isolation in a base transceiver station (BTS) duplexer.

[1] LXI is LAN eXtensions for Instrumentation, the LAN-based successor to GPIB.

In all cases, several factors contributed to the improved speed and throughput. One was the communication speed of LAN, which is the backbone of LXI-based test systems. The other key contributors were the measurement speed of the Agilent N9020A MXA signal analyzer, the capabilities of the Agilent E5182A MXG signal generator and the flexibility of the Agilent N6700B modular power system. All of these instruments are certified compliant with LXI Class C.

Another important factor saved time and reduced effort: no major software changes were required when the MXA was used to replace an Agilent PSA Series signal analyzer, or when the MXG was used to replace an Agilent ESG-C signal generator. Both the MXA and MXG were designed to be drop-in replacements for the previous-generation instruments.

Agilent Technologies

Sketching the situation

The device manufacturer was looking for major improvements in three areas: test time, cost-of-test and ease of test set up. A reduction in test time would help it keep pace with the rapidly increasing production volume of cellular handsets that used the W-CDMA power amp ICs. Achieving lower cost-of-test would ultimately benefit the company's financial results: as the cell phone market matures, handset prices fall and the pressure to cut costs is passed through to IC manufacturers. Within the cellular market, the lifespan of handsets is getting shorter so simpler, faster set-up of test system hardware and software is necessary to keep pace with such rapid of changeover.

Within this context, the IC manufacturer was looking for a "next-generation test system" that would provide these benefits. Two alternative approaches became the leading contenders—one based on a PXI cardcage and the other designed around four of Agilent's LXI-compliant instruments.

Outlining the requirements

The two proposed solutions were compared to the actual measurement time of the existing GPIB-based test system. That system included four instruments: a spectrum analyzer, a power meter, a signal generator and a high-performance programmable power supply. The technical requirements for testing the W-CDMA power amplifier were as follows:

- Perform tests at 1.8 and 1.9 GHz
- Search for input power at +0, +10 and +20 dBm output power
  – Search results to be within ±0.1 dB tolerance
- At both frequencies and all three power levels:
  – Supply reference and control currents
  – Measure the ±5 MHz and ±10MHz adjacent and alternate channel power ratios (ACPR)
- All ACPR results to be within ±0.6 dB tolerance
- Perform leakage-current tests before and after all above measurements (RF off; only supply voltage on)

The GPIB-based system was able to complete these measurements in approximately four seconds.

Examining the alternatives

A competing vendor proposed a PXI-based system that included an eight-slot cardcage with a built-in 2.2-GHz embedded controller running Windows® XP. The measurement portion of the system utilized four plug-in modules:

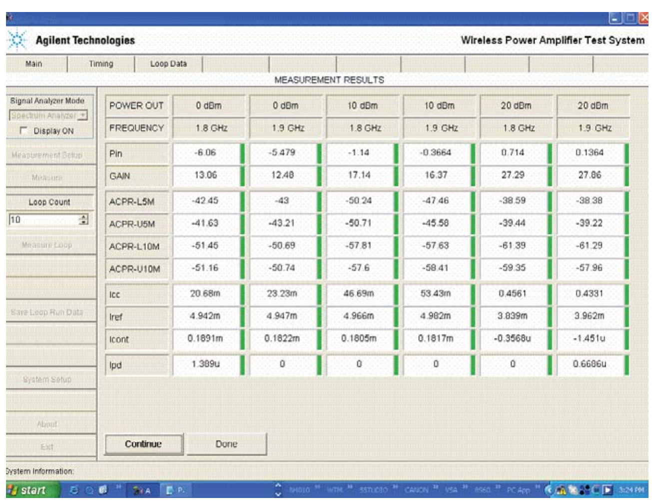
- A two-slot 2.5-GHz signal generator
- A two-slot 3-GHz digitizer
- A one-slot 6½-digit digital multimeter (DMM)
- A one-slot triple-output programmable DC power supply

The system was managed by a test program written in Visual Basic.

To achieve the desired improvements in time, cost and set-up, Agilent designed a solution based on four LXI Class C-compliant instruments:

- Agilent N9020A MXA signal analyzer
- Agilent N5182A MXG vector signal generator
- Agilent 34411A 6½-digit DMM
- Agilent N6700B low-profile modular power system mainframe configured with three precision DC power modules (N6761A or N6762A)

A standalone PC running Windows XP was used as the system host.



Measurement results for the wireless power amplifier test system

Comparing the results

In benchmark testing, the two competing systems were at least twice as fast as the existing GPIB-based system. The champion was Agilent's LXI-based solution, which was 70 percent faster than the GPIB system and 36.8 percent faster than the PXI system (Table 1).

The manufacturer was attracted to the speed advantages of the LAN/LXI-based system; however, it was somewhat hesitant to make the transition from GPIB to LAN. Because all four of the proposed Agilent instruments included both LAN and GPIB interfaces, the system integrator was able to reconfigure the proposed solution with an Agilent 82357A USB-to-GPIB converter. As with the LAN-based connection, using the external USB-to-GPIB converter eliminated the need to install any sort of interface card in the off-the-shelf host PC.

In the modified system, a USB cable linked the host PC to the 82357A converter, which in turn was connected to the instruments in a typical daisy-chain arrangement of GPIB cables. Even with this change, the Agilent solution was still faster than the GPIB- and PXI-based systems (Table 2).[2]

Assuming around-the-clock production, the USB/GPIB approach would achieve throughput of 48,000 devices per day. In comparison, the LAN/LXI-based approach would enable throughput of 72,000 devices per day. That's a 50 percent improvement over the second-best alternative–also from Agilent–and a 233.3 percent improvement over the existing system (Table 3).

[2] USB/GPIB speed is faster with the 82357B, which replaces the 82357A (discontinued March 2007). Please visit the Agilent Web site for complete product specifications.

The LXI Consortium

The consortium is a not-for-profit corporation initially established by Agilent Technologies and VXI Technology, Inc. Its primary purpose is to promote the development and adoption of the LXI Standard as an open, accessible standard that identifies specifications and solutions relating to the functional test, measurement and data acquisition industries. The Consortium is open to all test and measurement companies—over 50 are now members—as well as industry professionals, system integrators and government representatives. For more information about the consortium and the standard, please visit the Web site at **www.lxistandard.org.**

Table 1. The LXI-based system provided the greatest improvement in test time vs. GPIB

Test system	Total test time	Improvement
GPIB-based (existing)	4.0 sec/device	—
PXI-based (proposed)	1.9 sec/device	52.5%
LXI-based (proposed)	1.2 sec/device	70.0%

Table 2. The USB/GPIB configuration was faster than the GPIB- and PXI-based systems

Test system	Total test time	Improvement
GPIB-based (existing)	4.0 sec/device	—
PXI-based (proposed)	1.9 sec/device	52.5%
USB/GPIB (alternative)	1.8 sec/device	55.0%
LXI-based (proposed)	1.2 sec/device	70.0%

Table 3. Relative improvement in daily throughput, referenced to the existing test system

Test system	ICs tested/day	Improvement
GPIB-based (existing)	21,600	—
PXI-based (proposed)	45,474	110.5%
USB/GPIB (alternative)	48,000	122.2%
LXI-based (proposed)	72,000	233.3%

Gaining more speed

While developing the prototype test system, the Agilent team applied a handful of best practices that helped minimize test time. One example: the command set for the MXA signal analyzer includes a function that shuts off the instrument's display subsystem. Using this feature, which was created to enhance automated testing, shaved 1.0-1.2 seconds off the total test time.

After winning the competition for the W-CDMA power amp system, the Agilent team continued to look for additional speed improvements that would provide further reductions in per-device test time. Further reductions in test time are possible by optimizing the required ACPR and leakage-current measurements.

Investigating additional systems

The success of the W-CDMA power-amp test system has prompted the manufacturer to launch new investigations into additional LXI-based solutions. One would be used to test cdma2000 intermodulation distortion and another would measure Tx/Rx antenna noise isolation in a BTS duplexer. Looking farther ahead, a third system may be developed to test a new cell phone "front-end module," which combines a power amplifier and duplexer in a single device.

In all three cases, the manufacturer will be seeking to maintain its edge in supplying cellular handset manufacturers through additional improvements in test time, cost-of-test and ease of test set up. It expects to find that edge in LXI-based test systems.

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LXI

www.lxistandard.org
LXI is the LAN-based successor to GPIB, providing faster, more efficient connectivity. Agilent is a founding member of the LXI consortium.

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Revised: March 23, 2007

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Printed in USA, April 25, 2007
5989-6616EN

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