Design Feature

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What's the Difference Between Modular and Rack-Mount Instruments?

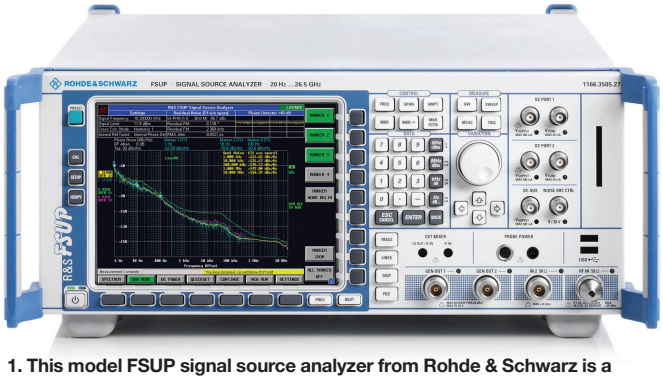
A growing number of PXI/PXIe modular RF/microwave test instruments provide the measurement capabilities and performance once possible only with benchtop devices.

Assembling a test system at one time involved the acquisition of a 19-in.-wide rack-mount enclosure and many different rack-mount, benchtop instruments. Separate benchtop instruments, such as signal generators, spectrum analyzers, vector network analyzers (VNAs), frequency counters, and power meters, would be installed in the rack to form a test system that might then require specialized software to make everything work together. Today, an entire test system can be assembled by sliding compact instrument modules into a single chassis, most often based on the PCI eXtensions for Instrumentation (PXI) or PXI Express (PXIe) modular formats.

While traditional benchtop RF and microwave test instruments are not going away anytime soon *(Fig. 1)*, modular test instruments *(Fig. 2)* continue to gain ground in many research and production test applications. A number of leading instrument suppliers now support modular instrumentation with instruments in PXI/PXIe, as well as AdvancedTCA Extensions for Instrumentation and Test (AXIe) formats. But how different are these instrument modules from traditional benchtop versions?

MODULAR EVOLUTION

Modular instruments are not new. Approximately 30 years ago, instruments were designed and manufactured using the VME eXtensions for Instrumentation (VXI) modular format. This was largely driven by military requirements for a flexible and compact modular instrument technology that could fit into tighter places than was possible with conventional benchtop instruments. In fact, VXI test instruments, which communicate to a controller such as a personal computer (PC) via the format's VXIbus control bus, are still in use throughout the industry and supported by firms like VTI Instruments (www.vtiinstruments.com) and Teradyne (www.teradyne.com).



1. This model FSUP signal source analyzer from Rohde & Schwarz is a typical benchtop instrument, with dedicated controls, display screen, and power supply. *(Photo courtesy of Rohde & Schwarz)*

PXI/PXIe and AXIe represent the latest modular formats, capable of impressive performance while providing the flexibility of changing test functions by changing slide-in modules in a chassis. How different are modular instruments from benchtop versions? The most obvious difference is in size and the factory-floor space required for standard rack-mount-based instruments compared to PXIe or AXIe chassis and modules. Each standalone instrument has its own power supply, versus modules that draw their power from a modular instrument chassis. If problems exist in the power-supply rail of a modular instrument chassis, all modules in that chassis will be without power, whereas any problems in the power supplies of standalone instruments will occur on an instrument-by-instrument basis.

In terms of functionality, modern modular test solutions offer all of the measurements possible with benchtop instruments, including oscilloscopes, but at a fraction of the size of a benchtop instrument. The modular format of PXI/PXIe instruments makes it possible to assemble a full system, with test signal sources and analysis equipment, within the same chassis.

The modules communicate to each other and to a chassis-mounted controller or external PC by means of the format's PCI/PCIe communications bus. To test the interconnectivity of PXI/PXIe modules in a chassis and PCI/PCIe bus, one need only refer to Microsoft Windows Device Manager (WDM) software on a PC for the current status of the modules (whether they appear on the computer screen).

2. The dense circuitry of the PXI/PXIe format makes it possible to fit a microwave vector network analyzer (VNA) within a handheld module. *(Photo courtesy of Keysight Technologies)*

MODULAR OR BENCHTOP?

At the system level, one key advantage that modular instrument formats have over benchtop instruments is the ability to change measurement limits. For example, a test system with a microwave VNA PXI/PXIe module that, say, operates from 10 MHz to 6 GHz could be readily extended to 26.5 GHz by substituting a VNA instrument module with the expanded bandwidth. Of course, if the modular test signal source was initially limited to 6 GHz, another signal-generator instrument module would be needed for testing to that higher frequency limit.

In a similar scenario with a benchtop-instrument-based test system, two complete test instruments must be replaced with two new benchtop instruments. Rather than replace just essential measurement functions while maintaining common functions, such as the power supply and chassis enclosure, entire instruments, with their enclosures, power supplies, and display screens, must be replaced, with significant differences in overall replacement costs.

Benchtop RF/microwave test instruments for research and production testing are highly valued, especially for applications with limited frequency range, bandwidth, power levels, and other key parameters. But for applications such as 5G wireless devices and circuits, which will use multiple channels and relatively exotic modulation format (plus other performance parameters being explored), it may be possible to exceed the limits of a benchtop-based test system with a solution requiring replacement of complete test instruments. Upgrading a modular test system simply requires replacing one or more slide-in modules.

NO SPEED LIMIT

The importance of measurement speed has never been greater as wireless technology extends into new applications like the wireless automobile and wireless communications for the Internet of Things (IoT). The switching and tuning speeds possible in modular test instruments makes them likely candidates for production testing, especially where measurement throughput is a concern.

Achieving high measurement speeds in high-volume production testing can create wide variances in the cost of an end-product, when the cost of test time must be added to the costs of hardware and manufacturing. Even seconds' difference in test time can substantially change the price for an electronic product.

Two of the leading suppliers of PXI/PXIe instrument modules are National Instruments (www.ni.com) and Keysight Technologies (www.keysight.com). Both now offer hundreds of different instrument modules and chassis. One difference between the two firms is Keysight's long legacy as a benchtop instrument supplier, under the guises of Agilent Technologies and Hewlett-Packard Co. prior to its current incarnation. mw

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