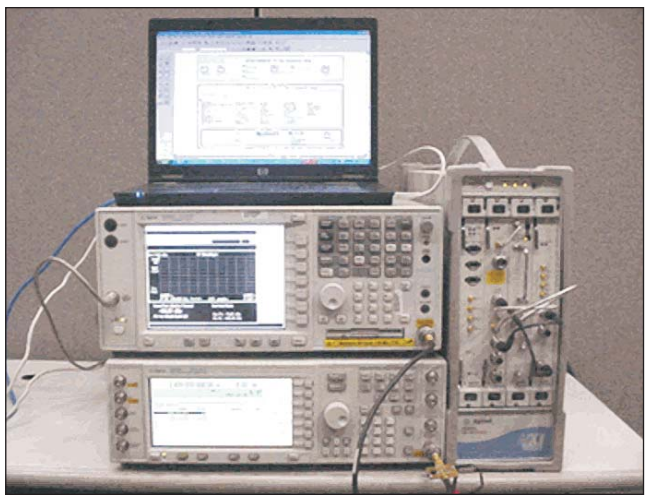
Test and Measurement Technologies Address both Operation and Performance

This report focuses on recent developments in test equipment that have made the largest impact on their usability. While there are also many refinements in the realm of basic performance (noise floor, dynamic range, frequency resolution, etc.), the most influential work is in the following areas:

- Standard PC platform for instrument control, data capture, communications, post-processing and documentation
- Extensive use of digital signal processing (DSP) in signal generation, detection, and processing
- Internalized data on specific communications standards, including test setups, parameter limits, and documentation
- Extended product lines with performance, features and cost options to match usage—R&D laboratory, general engineering lab, field service or production line testing

There are certainly other developments that are worthy of note, but for this report, these are the key items that will be examined.



This test system from Agilent demonstrates interoperability of instruments and software, plus standards-based setup. This Mobile WiMAX laboratory test system consists of a laptop with ADS installed, an ESG signal generator, and a 89640 Vector Signal Analyzer.

Standard PC Platforms

The earliest instruments to use a PC-type internal computer for operation were introduced around 2000, using Windows® 2000, which was a descendent of Windows NT, a high-level operating system suitable for instrumentation. Subsequent Windows versions retained many of the same features and today are used in both professional and personal systems.

There are multiple advantages of using a standard PC platform for instrumentation. They mainly break down into two areas: ease of implementation by the manufacturer, and flexibility in use by the customer.

With a large PC industry, the hardware necessary for interface, operation, communications and display is readily available and inexpensive. For the Windows operating systems, Microsoft has extensive development tools available, with additional development tools available from other companies, some with Microsoft's formal approval. The engineering time required for routine functions like data storage, I/O interface, and display is minimal. In the early stages, the development staff can do all work on their own PCs with no need to access the instrument itself. Software and hardware can be developed in parallel, coming together relatively late in the process to test and refine instrument control.

A standard platform also encourages software re-use, which allows a company to easily share control and operation setups among similar instruments. This is one part of the extended product line scenario noted above.

The biggest advantage to the user is greater convenience in handling the data fed into, or retrieved from the instrument. With a standard platform, it is easy to establish data formats that are compatible with all sorts of pre- and post-processing software, as well as with ordinary graphics and word processing programs used for documentation. For example, mathematics programs are used extensively in university education. With a common PC platform, users can import and export data from their favorite analytical tool, whether it is Mathcad®, MAT-

LAB®, Mathematica®, or another.

Both developers and users get the advantage of built-in support of keyboards, external data storage devices (from thumb drives to RAID hard disk systems) and communications ports such as RS-232, USB or Ethernet. Also, the ability to use an external display is useful for real-time presentations and discussions.

Digital Signal Processing

While a standard PC platform simplifies operational development, DSP has enabled a whole new range of performance capabilities and features. At the top of the list is the ability to move between the time and frequency domains with Fast Fourier Transforms (FFT) and inverse FFTs. This capability is essential for modern wireless communications and is highly useful for high performance analysis of analog systems.

As the power and speed of DSP has increased, the ultimate performance (e.g., signal-to-noise) of the digital portion of an instrument is close enough to the analog performance that new options are available. Chief among them is extremely narrow bandwidth filtering. A spectrum or network analyzer with 10 Hz IF bandwidth was just a dream until the 1990s, and the performance has improved significantly since DSP was first implemented to achieve these bandwidths. DSP also enables custom filter passband shapes, not just bandwidth. Gaussian, cosine and other filter shapes are required for in various applications, not just "brick wall" sharp cutoff filters.

DSP plays an important role in the interface between simulation software and instrumentation. A "real world" signal waveform can be programmed into a vector waveform generator to mimic the performance of a product under development. Or, the passband of a signal analyzer can be programmed to duplicate the overall frequency response of the receiver section of a specific wireless product that is in development.

Standards-Based Instrumentation

Every standard communications protocol has a specific set of operating parameters. To ensure compliance with the standard, there are also defined methods for measuring these parameters. Capturing these data accurately, and verifying that they indeed match the standard is a big job.

Instrument manufacturers are involved in all standards committees and, concurrently, develop appropriate setups for their products as the standards are discussed, evaluated and refined. When the standard is finally codified, the test setups are usually made available as value-added options, reflecting the investment made by the instrument manufacturers. This is an appropriate service for customers, given the amount of work that would be required to independently create such setups. Users can concentrate on product development, perhaps adding to the test procedures with their own extensions to the tests required by the standard. Eventually, some commonly used wireless standards may be included in the base cost of an instrument.

With time-to-market pressure, the ability to have compliant instrumentation almost immediately following final approval of the standard is extremely valuable. Like the instrument companies, device manufacturers also follow standards development, attempting to have their product engineering well underway by the time the standard is finalized.

Instrument Families

In the past, it was common for instrument companies to specialize in either high-end or economy products. If they did both, they were often designed with only minor overlap in design choices. This was necessary because the difference in cost was achieved only by changing the hardware—a simpler VCO in the synthesizer, a less-precise switched attenuator, smaller display, open p.c. boards instead of machined modules, etc.

Today, much of the value of an instrument is in it's intellectual property—the software that operates the unit and defines the functionality of its DSP

processor. By licensing the more advanced software features, an instrument's base cost can be lowered, although the platform is easily upgradeable. This allows a range of performance to be offered all across the instrument lines, commensurate with the cost.

The standard PC operating core is easily implemented in both high-end and low-end instruments, which avoids much of the re-design required in the past. With a basic framework in place, it is easier to substitute the same type of lower cost system blocks as was done in the past—a VCO instead of a YIG source, an electronic attenuator instead of an electromechanical type, etc.

The same techniques allow customization for production line testing of a specific product type. A production tester may have great similarity to the best lab instrument, but includes only the necessary features and performance level. It may also have a blank front panel, since user intervention is limited only to a few operations, and the master computer that runs the entire test line can control the test box as well.

As straightforward as the process seems, this top-to-bottom lineup is a recent phenomenon. The enabling technology is recent, but there are also overlapping markets with modular instruments that emphasize production testing and dedicated test systems for installation and support of large commercial and military systems. These systems typically use the VXI and more recently developed PXI standard modular platforms.

Although not covered in this report, high performance portable instruments, such as the popular Site Master® family from Anritsu, are becoming an important part of an engineer's or technician's test equipment arsenal.

Summary

Advances in test equipment performance, operating features and usability are keeping pace with the development of new wireless communications systems, as well as other developments in high frequency technology. This report noted some key factors that have allowed instrument manufacturers to achieve gains in these areas while maintaining competitive cost structures.

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