Trends and Developments in Measurement Methods and Technologies

The ability to measure the performance of our electronic circuits and systems is essential. The primary requirement may be speed (for production), accuracy (for the lab) or cost (to remain competitive), all of which have received much attention from instrument manufacturers and their customers. This report is an overview and commentary on some of the changes that are taking place in the test and measurement portion of high frequency technology.

Marketplace Forces

The marketplace exerts two forces on developers of all electronic equipment: economic and technological. Ultimately, commerce is what pays for technology. Even government-supported activities outside the commercial markets are affected, at least indirectly, by the economic strength of the country. The recent economic downturn slowed, but did not stop the development of new test equipment and test methods. There will be some lasting effect, since it has been reported that failed companies have flooded the used equipment market with late-model units. Until this “excess inventory” is absorbed, economic austerity will be practiced by most test equipment manufacturers.

The technological forces, however, continue unabated. Most of the promising new markets will be addressed with products that operate at higher frequencies, with more complex modulation schemes, and with higher levels of integration. Following the common pattern, these high-tech products will be faced with demands for low end-user cost. High performance and low cost demands require innovative engineering in design and manufacturing, which have testing as a major part of their processes.

Let’s take a look at the following trends from a test perspective:

- Links between design and test
- Performance and speed in manufacturing test
- Addressing the issues of cost
- Improving metrology to meet demand and enable technology developments

Links Between Design and Test

EDA tool developers have invested heavily in the past few years to develop reliable links between their simulation and analysis tools and the instruments that test real-world circuits and systems. The primary demand for this capability comes from the complex modulation formats used in developing communication technologies. With their wide bandwidths, these signals can be altered by amplitude and time domain distortions in the circuitry. Individual circuits can no longer be characterized simply by gain, noise figure, intercept point and –3 dB bandwidth. Now, their performance specifications might include passband flatness, group delay spread and adjacent-channel power ratio—perhaps with dynamic bias or gain control.

In the simulation environment, these characteristics can be defined both mathematically and from measurement-derived models. However, the effects of individual “as-built” circuits will vary from simulation—and even a small variation can affect system performance. With links to test equipment, each “real” circuit can be driven with the expected waveform, created in an arbitrary waveform generator with parameters set by the simulator. The output is then returned to the simulator, which then can feed the actual response to the remainder of the system and observe its effects.

As more of the system blocks are built and measured, the simulated system is gradually replaced by the actual one. This ability to manage a project from the concept to completion is just beginning to be used. Currently, engineers are learning how to use this capability in smaller steps, such as aiding in the development of a particular block that is critical to system performance (e.g. a power amplifier).

Bit error rate (BER) testing cannot be done without an end-to-end system in place. With the unfinished portion of a system represented by simulation, meaningful BER testing can be done from the beginning, not just after a complete prototype system has been constructed. Simulation can even include the signal propagation path by including the statistical models for fading and multipath effects.

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Performance and Speed in Manufacturing Test

Designers are not the only engineers affected by the increasing performance of communications systems. High-volume manufacturing of complex electronics is another big challenge for the engineering community. Because a low cost WLAN interface or PCS phone is also a high performance transmitter and receiver of complex digital modulation, production requires equally high performance testing—but at production speed.

Frequency-domain testing speed is generally controlled by the sweep speed of the measuring equipment. Synthesizers have steadily gotten faster over the years, sometimes using signal processing techniques related to those used in some spread spectrum systems. The next step in increasing speed is adaptive sweep, which measures fewer frequency points where performance is less critical, such as outside the main passband, where spot-checking is appropriate. The center of the signal passband is often well-behaved, requiring fewer measurements. Critical frequencies include transitional areas near filter cutoff and at specific frequency offsets where the standards require verification.

Additional enhancements for speed include the expected computer-controlled test setups and data collection. And, the display of performance limits, and alarms that indicate when limits have been exceeded, simplify operation and reduce the training needed for production line staff. Statistical analysis of failures can indicate the source and suggest adjustments in the design or assembly to improve the yield.

Addressing the Issues of Cost

Although cost has always been a factor, the need for lowest cost *and* high performance has been increasing rapidly over the past 10 years. Test equipment manufacturers have taken several approaches to help solve this issue. The use of standardized computing engines and displays leverages the low cost hardware of the computer industry. Creative board layout and assembly has reduced the need for individually-shielded modules. Calibration procedures have been developed that allow less-precise components to be used, with their errors corrected in software rather than through the use of high precision hardware.

Test equipment providers have also changed the makeup of their product lines. Years ago, the highest performance models would be developed first, then features would be removed to make lower-cost versions that still met the needs of a significant number of customers. Today, low cost equipment is often designed specifically for the production line, field installation and service, or budget laboratory markets.

Numerous test products have been developed specifically for narrow market segments. Some of these are unique designs, but most leverage technology and components used in other products from the same maker. A few companies have created flexible general-purpose platforms that can be adapted with hardware and software options to fit a desired niche.

Another cost-saving approach is to use the same circuitry in both the consumer product and the test equipment. For example, a WLAN BER tester might perform signal creation and detection with an industry-standard chip set used in low-cost consumer hardware. This concept takes advantage of the fact that some products are inherently high performance in some aspect of their operation, even when low cost.

The search for the right cost/performance balance continues. On the horizon are techniques such as combined controllers and sensors, where a part of the instrument function is performed by a microcontroller located right at the probe or detector that is the instrument's input.

Improving Metrology to Meet Demand and Enable Technology Developments

An instrument is only as good as its calibration. Among the needs in today's test environment is getting high performance calibration closer to the users of the instruments. Secondary standards with performance approaching that of primary standards appear to be a growing area of the test market. Thermal noise standards and frequency standards are probably the most critical RF/microwave references, while optical power and wavelength standards are needed for fiber optic systems.

The techniques for making measurements with higher precision make up the other fundamental part of metrology. Some techniques of current interest are measuring jitter in GHz-speed digital bitstreams and measuring extremely low levels of intermodulation distortion (IMD), including passive IMD in system hardware.

On-chip and miniature-package measurements are getting a lot of attention as the level of integration continues to increase. The simple DC tests and selected RF tests of the past are not sufficient for today's needs. The need for speed at a reasonable cost has shrunk to the microscopic realm of SiGe, GaAs, InGaP and other now-common substrates.

Finally, new systems like Ultra Wideband (UWB), and mm-wave products like automotive radar sensors are emerging that will require entirely new test methods and instruments. These and other new technologies can only be developed if their designers can get an answer to the question, "Is it working like it's supposed to work?"