When the Bluetooth wireless communications link was introduced, it was promoted as a seamless way to connect electronic devices. Ambiguities in the spec, however, gave rise to interoperability problems. The Bluetooth Special Interest Group (SIG; www.bluetooth.com) addressed these problems by tightening the specs and establishing a qualification procedure, but RF test remains a challenge because dedicated Bluetooth RF test equipment has been slow to emerge.

Tests of Bluetooth devices can be separated into two layers: radio and other. Radio testing covers the physical performance of receivers and transmitters, while the other testing covers system behaviors such as communication protocols and link management. The Bluetooth SIG has qualified nearly 50 test instruments that can correctly handle the test requirements, yet only a handful of these perform RF testing.

Part of the challenge is that the Bluetooth RF spec requires the use of a “dirty” transmitter. Angus Robinson, microwave product manager at Anritsu (Morgan Hill, CA; www.anritsu.com), points out that the RF portion of Bluetooth was developed with an eye toward CMOS process implementation, which means that a transmitter can have relatively large variations in its RF performance and still be within spec. It also means that receiver tests must use a signal source that can be impaired in a controlled manner, such as by inserting frequency drift. Implementing impairments in generic RF test instruments, which are typically designed to produce high-quality signals, can be difficult.

A few systems have appeared that can generate the necessary signals. Agilent Technologies (Palo Alto, CA; www.agilent.com) introduced its GPIB-based E1852B test set in late 2001 and added test management software a year later. CETECOM (Munich, Germany; www.cetecom.com) adapted its BITE RF conformance tester to handle Bluetooth, and Rohde & Schwarz (Munich, Germany; www.rohde-schwarz.com) released its validated TS8960 tester in 2002. In November 2003, the Anritsu MT8852A received test system validation from the SIG. Unfortunately, most of these systems are large, expensive, rack-mounted configurations used in Bluetooth Qualification Test Facilities. Only the Agilent and Anritsu devices are small and inexpensive enough for easy use on a manufacturing floor.

Receiver tests include sensitivity, carrier-to-interferer performance, and intermodulation performance. The large systems perform all 15 tests, which are needed for design certification. The smaller testers only provide about half of the tests, focusing on the ones needed most frequently in manufacturing. These testers can help designers perform pre-qualification testing, and they can rapidly measure performance parameters that are production-sensitive. Once a design is validated, these testers help keep production within spec.

With the Bluetooth spec currently at Version 0.91, it is clear that RF-layer testing will continue to evolve. Test equipment manufacturers have anticipated that evolution and are keeping their instruments current with software upgrades. But new instruments are rare. Part of the reason may be that Bluetooth production is still relatively small. With interoperability problems being resolved, however, Bluetooth manufacturing will finally begin to ramp, and more tools may follow.
Test pays
Richard A. Quinnell, Technical Editor

Management bent on cost cutting may look hard at test efforts because they have no direct impact on the bottom line. As communications ability becomes a feature of more and more electronic devices, trimming test costs becomes a worse and worse idea. A recent report from the Wi-Fi Alliance (www.wi-fi.org) bears this out.

The Alliance has announced results from the certification testing program it began last year. More than 1000 products have been certified, but it is the number of products that have failed that is of particular note. More than 25% of products that are prepared for certification testing fail in one way or another. The percentage of failure was even greater for products that did not undergo the preparation process.

If these products had been introduced to the market without certification, these failures would have manifested as an unsatisfactory user experience. Such dissatisfaction eventually hurts business and destroys brand reputations. Worse, it may not be your problem. It takes two devices to communicate, so the problems of one device can affect the users of both.

More than ever, test engineers need to help management recognize the value of adequate testing, especially in communications systems. Results such as the Wi-Fi Alliance experience can help. Company budgets show test efforts simply as an expense. It is up to engineers to make sure that management is aware that, in the long run, test pays.

Contact Richard A. Quinnell at richquinnell@att.net.

Editor’s Note

Nortel divests itself of test
NORTEL NETWORKS (Brampton, ON, Canada) has announced that it will restructure its supply chain to focus on its network deployment and integration operations. The company will eliminate most of its manufacturing operations, including product integration, repair, and test facilities in Canada, Brazil, France, and Northern Ireland. Nortel is in negotiations with Flextronics to take over these operations, but no agreement has been reached. www.nortelnetworks.com

DSP group picks Agilent
TO TEST ITS NEW PROCESSOR for multimedia wireless residential systems, semiconductor vendor DSP Group (Santa Clara, CA) has chosen the Agilent 93000 SOC test system. The processor includes both digital and mixed-signal cores on a single piece of silicon, requiring a range of test technologies. DSP Group chose the Agilent 93000 system because its dedicated test processor for each pin allows the tester to simultaneously support analog, high-speed digital, RF, and BIST testing. DSP Group is using Flextronics to take over these operations, but no agreement has been reached. www.dspg.com

Infineon acquires ADMtek
AS PART OF ITS STRATEGY TO strengthen its position in the broadband access market, Infineon Technologies (Munich, Germany) will acquire Taiwanese fabless semiconductor company ADMtek. The company will focus its new operations, named Infineon-ADMtek Co., on developing broadband customer premise equipment ICs for applications such as ADSL and VoIP.

As part of the purchase agreement, Infineon has agreed to supply chips to broadband equipment supplier Accent Technology Corp. (Hsinchu, Taiwan), the largest shareholder of ADMtek. The acquisition is scheduled for completion by April 2004. www.infineon.com

Motorola chooses TestKompress
MOTOROLA WILL USE the TestKompress embedded test tool from Mentor Graphics (Wilsonville, OR) to add manufacturing testability to its new MRC6011 reconfigurable compute fabric (RCF) device. By selecting the Mentor tool, Motorola hopes to reduce test data volume and test time.

The MRC6011 processor is aimed at computationally intensive applications such as WCDMA baseband signal processing and 3G adaptable antenna functions. www.mentor.com

News

Letter to the editor

I FOUND YOUR ARTICLE “Worst is Best in Optical Test” (September 2003) to be quite interesting. I agree that the concept of worst-case testing makes sense, however I submit that it is a combination that makes the most sense. Continued base-lining in the best-case environment and then stress testing in the worst-case environment seems to me the best way to ensure repeatable quality as well as to make strides toward improving interoperability.—Leigh McBain, Product Manager, SONA Communications

I agree that base-lining is important to maintaining quality. The worst-case test is intended as a quick and reliable way of ensuring interoperability, not absolute performance.—Rich Quinnell
The days of paying for RF test functionality you don't need are over. The Aeroflex PXI 3000 Series is here.

Aeroflex brings the modular flexibility and cost-effectiveness of PXI to RF test, with the Aeroflex PXI 3000 Series. For the first time, you can get the enhanced performance you need, without buying functionality you don’t.

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To learn more, visit us at www.aeroflex.com/PXITMW, to download our free paper: Aeroflex Takes PXI into the Realm of Communications Test.

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As digital communications push data rates to 40 GHz and beyond, precise signal timing becomes critical. A key parameter that designers must control is the variability, or jitter, of clock and data edge placement. A variety of tools and methods are available for measuring jitter, but they do not always arrive at the same value. To get the most out of jitter measurements, test engineers need to understand how these differences arise.

Three types of instruments are available to help test engineers measure jitter: bit-error-rate testers (BERTs), timing interval analyzers (TIAs), and oscilloscopes. Design engineers typically use more than one type to measure and analyze jitter because each instrument offers different advantages (Ref. 1). Unfortunately, the instruments can also produce different values for the jitter they measure, complicating characterization and qualification testing.

Much of the variability arises because jitter has both deterministic and random components. Deterministic jitter comes from system sources such as crosstalk, inter-symbol interference, and power-supply feedthrough. It is bounded, so it can be characterized by its peak-to-peak value.

Random jitter comes from physical sources such as thermal noise, shot noise, and scattering in optical media. The only way to characterize random jitter is through its probability density function, which is typically Gaussian in shape. Gaussian functions are infinite in extent, so the random component of total jitter is unbounded.

The unbounded nature of total jitter gives rise to two forms of measurement variability: measurement period and measurement bandwidth. The period variability stems from the random jitter component. The longer the interval during which jitter is measured, the greater the chance of capturing a high-amplitude error event. So, longer measurements yield larger jitter values.

The bandwidth variability stems from both random and some deterministic jitter sources. Shot noise, for instance, is essentially white noise. The wider the measurement bandwidth, the more noise energy will be included in the total jitter.

The key to controlling variability in these instances is to use a consistent procedure for measuring jitter. Controlling the measurement period, or total number of measurements taken, will limit one source of variability. Controlling the measurement bandwidth through careful selection and connection of probes and cables as well as the use of band-limiting filters will help control the other source.

Differing systematic errors
But these are not the only sources of measurement variability among the three types of instruments. All instruments suffer from systematic error. Because the three instruments use different measurement methods, they have different systematic errors. Solving these requires an understanding of how the instruments operate.

The familiar eye diagram (Figure 1) helps illustrate the different techniques. Oscilloscopes build the eye diagram by sampling a repetitive signal over time using an internal sampling clock and an external trigger event. They measure jitter by forming a histogram of the signal’s threshold crossing time. This histogram is, in essence, an approximation of the jitter’s probability density function (PDF), which can be analyzed to extract jitter measurements.

The TIA also forms a histogram, but works by measuring the interval between threshold crossings or from a reference clock to a signal edge. Both instruments build the histograms by collecting a large number of data points.

BERTs work on an entirely different principle. They use signals with known data patterns and count the number of errors that occur within a given time period. From this measurement, they calculate the signal’s bit-error rate.
Typically, a BERT will sample the data stream at a point corresponding to the middle of the eye opening. To measure jitter, the instrument will adjust the sampling clock’s timing, scanning it across one data period, or unit interval (UI), and measuring the error rate at each position. The result (Figure 2) is known as a bathtub curve and gives the bit-error rate as a function of sampling position. Jitter causes increases in error rate as the scan approaches the threshold crossings, so the bathtub curve provides a means of calculating the jitter PDF.

Because the three methods are subject to different systematic errors, a direct comparison of their results would be ambiguous at best. The oscilloscopes and TIAs, for instance, are subject to jitter in their internal sampling clocks, which adds to the measurement of data jitter. They also use sampling to gather data so they may miss transient events, resulting in an underestimate.

All three instruments are subject to noise in their internal signal amplifiers and threshold-crossing detectors. This noise can advance or retard the recognition of a crossing event, effectively adding to the jitter measurement. Thus, a comparison of the results from these instruments must account for these errors that are inherent to the instruments themselves.

The threshold-crossing level itself may also differ between instrument types. If the BERT’s internal logic threshold is above or below the actual signal crossing point, sweeping the sample point across the unit interval will encounter errors at a different point than they actually occur. This results in a jitter measurement bias that increases the measured value.
of deterministic jitter. Because these thresholds are not subject to user adjustment, there is no way to calibrate out the bias.

**Random jitter takes calculation**

Another source of measurement variations comes from the calculation of random jitter values. For TIAs and oscilloscopes, the PDF of total jitter comes directly from the jitter histograms and typically has a shape similar to Figure 3. This shape is the convolution of both deterministic and random jitter PDFs, and separating them out as independent measurements requires considerable analysis.

The random jitter can be assumed to be Gaussian, but the presence of deterministic jitter spreads out the Gaussian distribution into right and left halves. Measuring the peak-to-peak deterministic jitter is relatively easy; it is the difference in the means of the right and left Gaussian peaks. Determining the width of the Gaussian functions, however, is more complicated. It involves fitting a Gaussian curve with six degrees of freedom to the right and left tails of the PDF histogram. The quality of this fit depends on the analysis software algorithms and the absence of spikes in the tails of the PDF. The results may thus vary from instrument to instrument as well as from measurement to measurement.

In the case of the BERT, calculating the random jitter component requires fitting a Gaussian to the interior of the bathtub curve. That fit requires some simplifying assumptions about the deterministic jitter’s PDF and about the transition point on the curve where random jitter becomes the dominant factor. As with the other instruments, the results depend on the analysis software.

This inconsistency among instruments may not impact the designer trying to track down error sources, but it can have a considerable impact on qualification and manufacturing test. The best defense is to have a well-specified procedure and consistent test setup for measuring jitter, making sure that engineering specifications and manufacturing test use the same instrument. Most often this will involve using a BERT because, ultimately, the reason for measuring jitter is to ensure reliable communications, and the BERT measures reliability directly. All three instrument types have their value, however, and knowing their differences will help you accurately interpret their measurements.

**Smoothing jitter measurements**

With all the variations between jitter-measurement instruments, direct comparison of their measurements is difficult at best. If you must make such comparisons, John Patrin, VP of engineering and product marketing at instrument maker Wavecrest (Eden Prairie, MN; [www.wavecrest.com](http://www.wavecrest.com)), recommends taking these steps:

- Provide the measurement procedure with all jitter specifications and standards, including time of measurement, filter bandwidth, and test setup.
- Minimize variability by controlling sources of system error, including sampling clocks, instrument noise floors, and threshold levels.
- Use the same instrument in engineering to develop specifications that you use in manufacturing to test them.
- Create a “golden standard” with known jitter characteristics against which you can calibrate new test instruments.

**Reference**

Noise option simplifies receiver test

Spirent Communications has enhanced its SR5500 wireless channel emulator with an additive white Gaussian noise (AWGN) option that eliminates the need for external noise generators in receiver tests. The option adds noise digitally to ensure test accuracy and repeatability. The SR5500 emulator mimics complex wideband radio channel characteristics such as time-varying multipath delay spread, fading, and channel loss using digital signal processing techniques. Spirent Communications, Rockville, MD. 732-544-8700; www.spirentcom.com.

Testing voice on FTTP networks

Tollgrade Communications has announced the LoopCare Test Operations Support System (OSS), which supports the testing of voice services in a fiber-to-the-premises (FTTP) network. The LoopCare release 2.6 works with existing loop testing for POTS and ISDN services. It allows users to run remote diagnostics on network and customer premises systems in an automated fashion to speed dispatch decisions for repair crews. It can also provide prequalification testing of DSL connections. Tollgrade Communications, Cheswick, PA. 412-820-1400; www.tollgrade.com.

Bus analyzers to support 4-Gbps Fibre Channel

The Excursion series of serial bus analyzers from Absolute Analysis is slated to be the next installment in the company’s Investigator line of products. These products include software that provides traffic generation, a protocol editor, and remote access software, and are configurable to any combination of serial bus protocols. The new series is scheduled for release in mid-2004 and will support the 4-Gbps Fibre Channel protocol. Absolute Analysis, Newbury Park, CA. 805-376-6048; www.absoluteanalysis.com. TIX 322

Portability comes to MPEG-2 test

Tektronix has put its MPEG Test Systems into a portable unit and has added a high-performance processor to speed analysis when testing interactive TV systems. The AD953A provides the ability to record and play MPEG video streams as well as perform real- and deferred-time analysis both in the lab or offsite. Tektronix, Beaverton, OR. 800-833-9200. www.tek.com. TIX 323

Dual-PHY Ethernet testing

Ixia has extended its Optixia platform to offer dual-PHY capability throughout its product line. The dual-PHY module combines copper and fiber-optic interfaces in the same package for wire-speed layer 2 and 3 testing. The module supports Ethernet traffic generation and analysis, routing protocol emulation, and layer 4–7 application emulation at 10-, 100-, and 1000-Mbps rates, and it can support as many as four ports. Each port has an RJ-45 connector and a modular SFP connector for connection to either medium. Ixia, Calabasas, CA. 818-871-1800; www.ixiacom.com. TIX 324