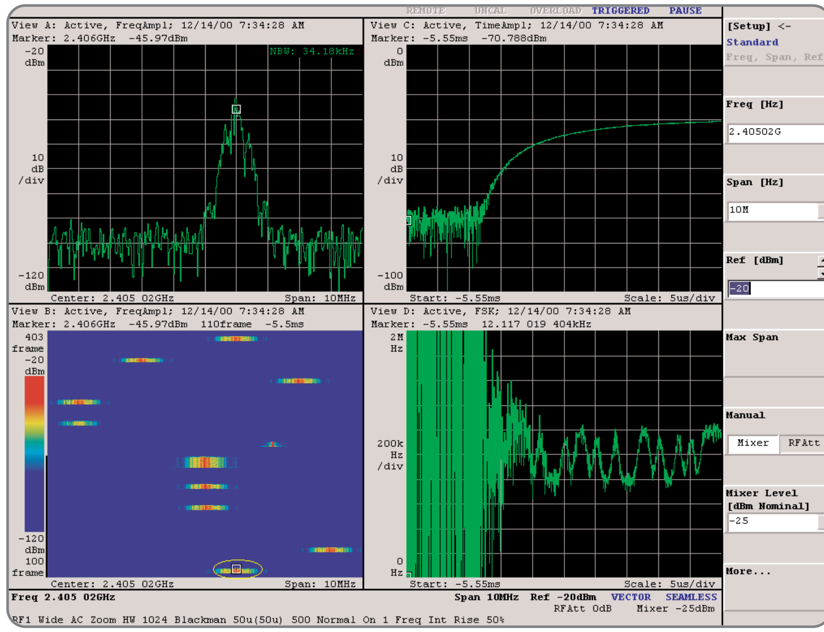

Validation testing of Bluetooth wireless LAN systems

Advanced measurement solutions for a complex new system

This paper demonstrates the complex nature of Bluetooth signals and the measurement challenges it presents to the component designer, along with some examples of new measurement solutions.

Measurement challenges—completely characterizing complex signals in multiple domains

Bluetooth is a new wireless LAN standard aimed at providing very low cost links between computers, peripherals and communication devices. The evolving standard defines wireless transmissions based on Time Division Duplexing (TDD) with slow frequency hopping.

Intense market forces driving the Bluetooth standard will strongly influence both design and manufacturing test. The cost of manufacturing test must be minimized to support a target cost of $5 per device—component designs must be fully characterized prior to manufacturing to provide sufficient design margins and wide operating tolerances. Complete validation of a Bluetooth system incorporates a number of measurements such as output power, spectral mask verification, frequency hop control and protocol validation, so test systems must be powerful and offer a wide range of measurements.

Bluetooth systems require the designer to view signals in multiple domains, including:

- Frequency vs. time for hopping characterization
- Amplitude vs. time
- Frequency deviation vs. time
- Baseband, for access to demodulated hits

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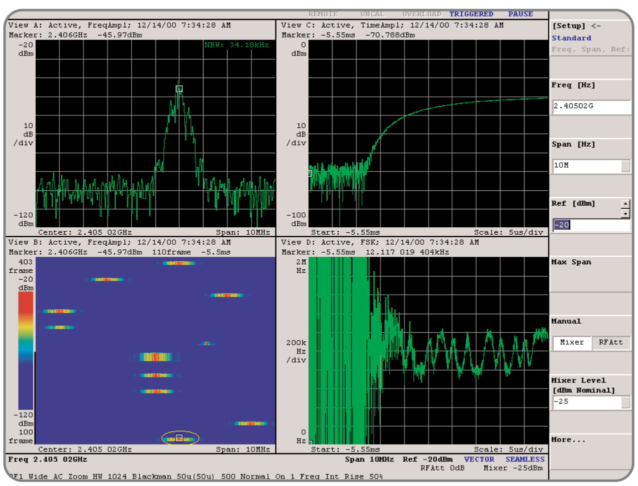
The complete characterization of complex, high-bandwidth Bluetooth signals is a measurement challenge that demands the simultaneous capture of frequency and amplitude transitions in real time to describe the frequency-hopping pattern, oscillator set-on time and amplitude profile. Given the pseudo-random nature of the signal, it is impossible to reliably capture any given burst with a traditional spectrum or modulation analyzer. The ability to seamlessly record a signal over a sufficiently long period of time and then apply post-acquisition processing to examine frequency, amplitude, modulation and transient behavior is also far beyond the capacity of traditional test equipment.

One of several efforts to define wireless LAN's, the Bluetooth standard is still evolving. A significant challenge to designers will be to select measurement equipment that will keep pace with new developments and technologies as they continue to grow. Measurement solutions must be flexible as well as powerful to cover the gamut of wireless needs and to protect the designer's investment in the years ahead.



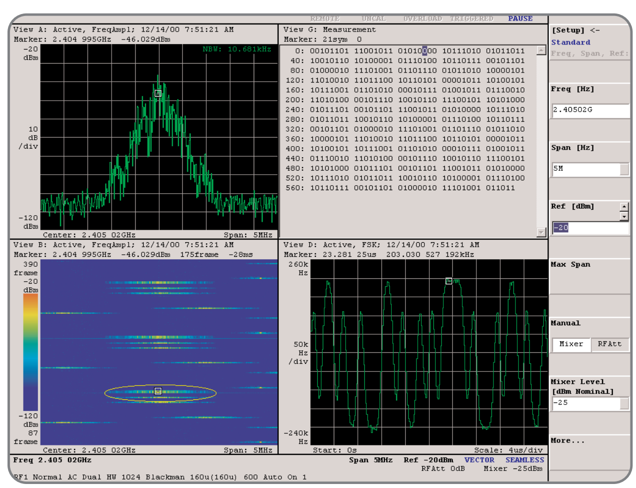
▶ ***Figure 1.*** *Frequency spectrum, amplitude profile, modulation characteristic and spectrogram of simulated Bluetooth signal. The selected burst is circled in yellow.*

Measurement solutions

A remarkable new measurement tool, the WCA380 Wireless Communication Analyzer, offers unique analysis solutions for Bluetooth signals. Designed specifically for the complexities of wireless signals, the WCA simultaneously captures information in both the frequency and time domains in real time and stores the data for post processing, display and analysis. Here are some examples of the insight provided by this new instrument.

The complete record of all captured information, called a spectrogram, is seen in the lower left display window of Figure 1. The X-axis is frequency (span = 10 MHz) and the Y-axis is time measured over a period of 15 ms. The colors in the spectrogram represent the absolute amplitude of the signal ranging from blue at -120 dBm to red at -20 dBm. The spectrogram shows that the signal is on during nine bursts in the observation window and that it hops several times. The display also reveals a slight frequency drift at each hop of the three consecutive bursts at the same frequency (near the center of the window).

The spectrogram in Figure 1 contains several hundred frames of data, any of which can be reprocessed from the stored data and displayed in new domains. A marker on the spectrogram selects a frame for reprocessing and the result in the upper left window is the traditional amplitude vs. frequency spectrum display. The upper right window presents the amplitude vs. time oscillographic display of the same selected frame—the approximately 30-µs rise time at the start of the burst is clearly visible. The lower right window has been processed to display frequency deviation vs. time within the frame. The noise at the beginning of the demodulated waveform indicates that no burst is present. As the amplitude of the burst stabilizes halfway through the time period, a deviation of approximately ±200 kHz is detected.



▶ ***Figure 2.*** *Spectrum, modulation, and demodulated data of simulated Bluetooth signal. The area selected for analysis is circled in the spectrogram at lower left.*

Post acquisition reprocessing in the WCA380 makes it possible to reduce the span of the spectrogram and observe even greater detail. Figure 2 examines the original signal with higher frequency resolution—the spectrogram span has been reduced to 5 MHz and the time scale has been adjusted to show a longer time window. The selected frame on the spectrogram has also been moved to allow examination of the center of a burst. The reduction in span has also resulted in a commensurate reduction in the noise on the demodulated signal (lower right) and greater detail of the modulation characteristic is revealed. Finally, the upper right window has been reprocessed to display the demodulated symbols from the captured signal, allowing the user to determine whether correct data and coding have been applied to the transmitted signal.

Conclusion

Leading edge measurement tools are essential to the design of reliable systems that will conform to new wireless LAN standards, operate at peak performance and get to market in the shortest possible time. Tektronix WCA330 and WCA380 Wireless Communication Analyzers provide clear and comprehensive insight into complex new telecommunication systems. These advanced real-time measurement tools capture all of the information faithfully and display it in formats that are easy to interpret and analyze—leading to optimum designs and shorter development cycles.

Tektronix is committed to providing the most advanced measurement solutions. This paper is part of a library of documents for the designer and test engineer who are searching for wireless telecommunication measurement solutions. The library will grow as technology and standards continue to evolve. Complementary copies along with updates and related documents are available at the locations listed below and at our Web site (www.tektronix.com).

We welcome your comments and suggestions for improving these documents and your ideas for developing other tools to help you meet the measurement challenges of new wireless systems. Contact us at the nearest Tektronix location or through our web site.

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Please visit "Resources For You" on our Web site at **www.tektronix.com**

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