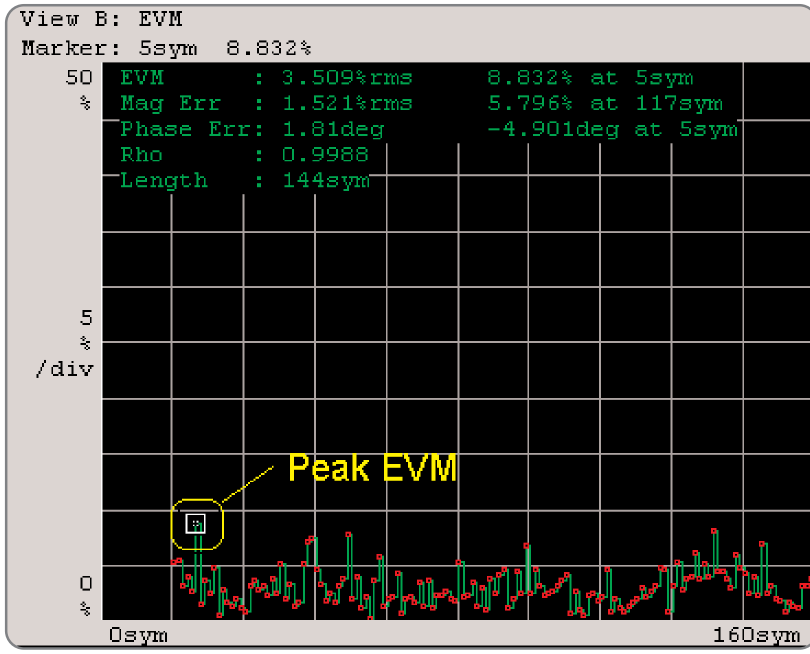

Measuring waveform quality in W-CDMA systems

How should we measure waveform quality for the new spread-spectrum time-variant W-CDMA transmissions?

In the past, waveform quality was expressed in terms of Rho on the pilot signal only. Advances in measurement technology allow for the separation of the complex signals into individual code components.

Measurement challenges—analyzing individual code channels in multiple domains

It is now practical to perform new waveform quality measurements and displays such as spectral shape, code power vs. time, CCDF and Error Vector Magnitude (EVM) on individual code channels. The measurements presented in this document are intended to demonstrate the nature of the W-CDMA signals, explain the measurement challenges they bring to the system designer and offer powerful new ways to characterize their quality.

The spread-spectrum bursts of high chip-rate W-CDMA transmissions are a significant measurement challenge. It takes a specially designed instrument to capture and analyze these complex signals in the time, frequency, phase and code domains. 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 need to record a signal over a sufficiently long period of time and then apply post-acquisition processing to examine frequency, amplitude, modulation, and code power behavior are also far beyond the capability of traditional test equipment.

CDMA signals have long presented challenges in the measurement of waveform quality—challenges that have only grown with the introduction of W-CDMA systems with time-variant code channel power and OVSF (Orthogonal Variable Spreading Factor). The time variant nature of code power in the W-CDMA signal makes it desirable to view the power vs. time relationship of individual code channels. To correctly assess the operation of a network, it is also necessary to determine the values of the power control sequence sent from the base station to the mobile unit. Finally, EVM on individual code channels provides valuable new insights into the distortion components within the complex waveform.

EVM has already been demonstrated to be a more sensitive gauge of waveform quality than Rho. In particular, EVM shows greater sensitivity to variations in thermal noise, phase noise, and carrier feedthrough. In the range of 20 dB to 30 dB signal-to-noise (S/N) ratios, Rho can be seen to vary from approximately 0.98 to 0.99, where EVM varies from 3% to 10%, providing far greater measurement sensitivity.

Measurement solutions

The WCA380 Wireless Communication Analyzer offers a unique analysis solution for W-CDMA signals. Designed specifically for the complexities of wireless signals, the WCA simultaneously captures signals in both the frequency and time domains in real time and stores the data for post processing, display and analysis. The following are some examples of the insight provided by this new instrument.

A typical test setup is seen in Figure 1. The base station (BTS) is directed to send a series of power-control commands to the mobile unit. Wireless Communication Analyzers capture and analyze the commands, responses, and waveform quality during the test. This setup enables the user to determine impairments in the RF channel and the power-control response time of the mobile unit.

The power control bits can be examined by baseband decoding of the relevant portions of the BTS signal. The response by the phone to these commands from the base station can be recorded and observed. The response time between BTS power-control transmission and the resultant mobile response can be determined by comparing the time record of the waveforms from the two simultaneously triggered analyzers.

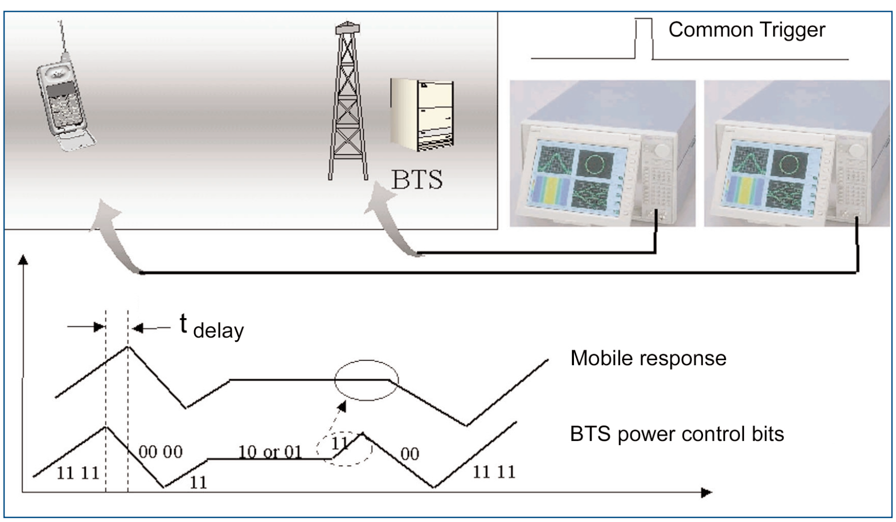

Figure 1. *W-CDMA Closed Loop Evaluation Test Setup.*

All of the above measurements can be enabled through post acquisition processing of the W-CDMA signal. To present meaningful results, processing must be done on a seamless capture of the waveform of sufficient length to show the relevant signal details. As an example, to analyze the power variation of a single code over one frame period requires the capture of 10 milliseconds of data (15 time slots of 666.7 µS each).

The WCA380 contains a down-converter followed by an analog to digital (A/D) converter for signal acquisition. This allows the seamless capture of signals up to 30 MHz in bandwidth for a period of up to 50 ms.. Reducing the capture bandwidth allows for even more extended periods of waveform acquisition. Analysis of the captured waveform is achieved by reprocessing the signal to derive spectral information, IQ displays, code domain measurements, and baseband demodulation.

To derive the measurement of code power vs. time, the WCA380 first unscrambles the incoming signal and then applies the correct orthogonal code. The resulting display is seen in the lower left of Figure 2, with the X-axis representing time in symbols over a single time slot, and the Y-axis showing the power in dB. This representation can be reprocessed on a slot-by-slot basis for examination of the device response to power level control signals.

Similar application of de-spreading and orthogonal codes is provided to measure EVM on a single code channel. From this processed waveform, EVM can be measured and displayed. In Figure 3, EVM is shown in the lower left window, derived from the selected 240 Ksymbol/sec code channel 1, selected in the lower right window in the display. The peak EVM on this code channel is easily determined to be 8.832 % at symbol 5.

This setup can also be used to determine the level of RF impairments in the channel and to gauge proper operation of the power control loop employed in the W-CDMA network. Channel impairments can be measured using the EVM vs. symbol display (lower left window of Figure 3).

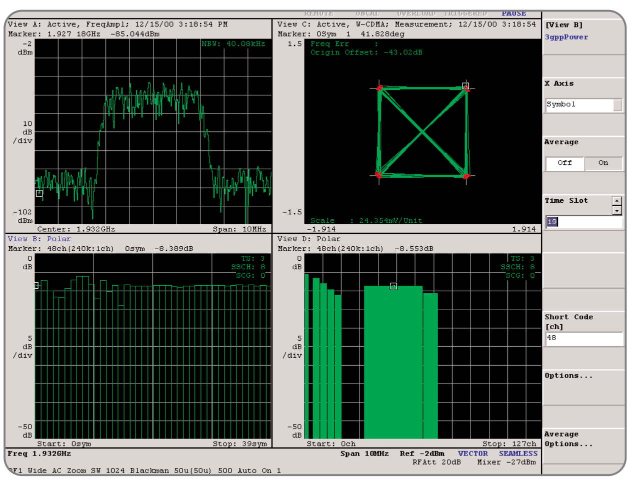

Figure 2. Upper left: Spectrum display. Lower right: Code-domain power averaged over time slot 0 with Channel 22 selected for code power vs. time and constellation display. Upper right: Vector constellation display of modulation on channel 22 selected from code-domain display. Lower left: Code power vs. symbol during time slot 0 of 256 Ksymbol/sec. channel.

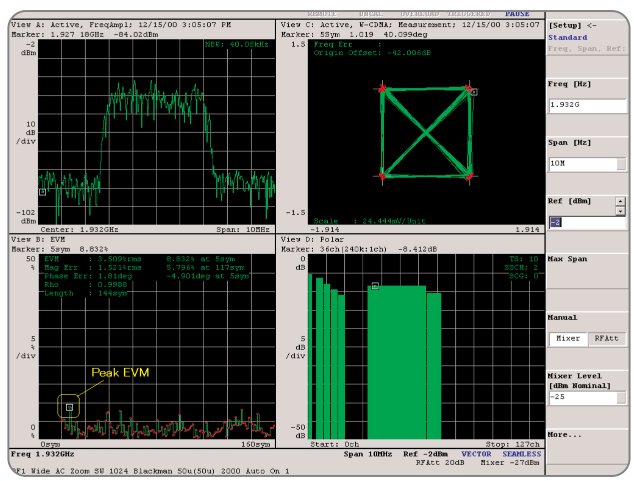

Figure 3. EVM vs. symbol during time slot 0 shown in lower left display, based on selection of 240 Ksymbol/sec. channel 1 in lower right code-domain display.

Conclusion

Leading edge measurement tools are essential to the design of reliable systems that will conform to new W-CDMA 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 the 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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