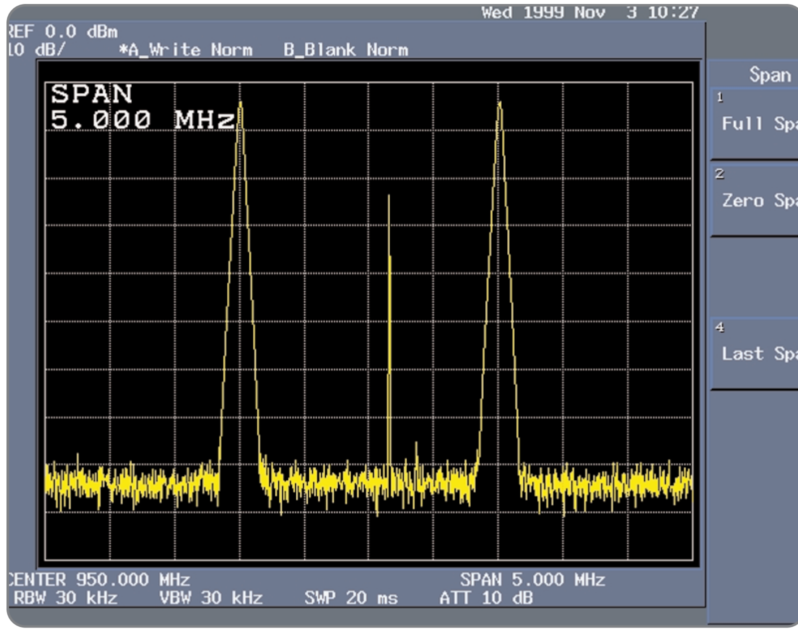
Characterizing time and frequency interactions in telecommunications signals



Spectrum analysis is no longer enough

New system designs require signals to be characterized with combined time-frequency parameters.

We are used to dealing with time and space separately in our everyday lives, but a true characterization of the universe requires that these be considered together as one space-time entity. The same applies to telecommunication signals with respect to time and frequency.

For example, an ideal switching oscillator would change frequency instantaneously in zero time and not emit any signal except at the initial and final frequency values. Real circuits take a finite time to switch and settle at a new value, emitting unintended signals during the transitions. Knowledge of the separate time and frequency behaviors of such signals is useful, but there is much more. Characterization of the two behaviors as correlated time-frequency point pairs has become essential to the design process for new wireless systems. A signal's frequency content and impact on other circuits during one moment in the switching cycle may be the result of totally different factors than those occurring in a different time of the same cycle. New measurement tools are needed to provide clear and complete insight into the behavior of these complex signals and their impact on other circuits.

Measurement challenges in a frequency-hopping signal

Many RF components and systems are prone to the interaction (both intentional and unwanted) of time and frequency parameters. Just a few examples are:

- Time jitter on a signal source
- Switching time dynamics during the frequency transition of a switching or hopping oscillator
- Complex modulation schemes involving both time and frequency transitions, such as W-CDMA spread spectrum
- Phaselock loop circuit behavior during lock-on, settling or lock breaking intervals
- Frequency changing and sweeping oscillator settling characteristics

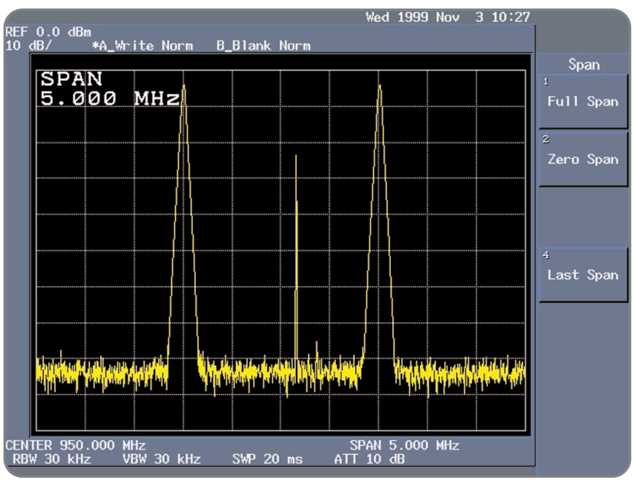


***Figure 1.** Spectrum obtained using a swept spectrum analyzer.*

Conventional general-purpose test equipment for time and frequency measurements such as oscilloscopes and spectrum analyzers are not capable of characterizing non-stationary signals in the time-frequency domain. Figure 1 shows a spectrum obtained from a single sweep of an ordinary swept-frequency spectrum analyzer. Two sinusoidal signals are displayed, spaced at 1 MHz above and below the center frequency of 950 MHz. The display also shows what appears to be some sort of transient spurious output just to the right of the center frequency. Repeated sweeping would display apparent multiple transient spurious signals in a constantly shifting mix, since the signal source is in fact a switching (or hopping) oscillator with multiple transitions during the switching interval. The ordinary spectrum analyzer cannot properly detect, capture or analyze this type of intermittent signal. The true characterization can only be obtained from an instrument that detects and acquires information in real time.

Measurement solutions

The WCA380 Wireless Communication Analyzer is a real-time, multi-function instrument that simultaneously captures time and frequency information and displays time, phase, magnitude, and frequency relationships in ways that reveal a signal's complex characteristics. Figure 2 shows a spectrogram display of the frequency-hopping signal. Time is shown on the vertical axis, frequency on the horizontal. Amplitude is displayed as color in the "Z" axis, ranging from purple for low magnitudes to red for the high. The bright red vertical lines are the two sinusoidal end-of-hop frequency positions. The lighter green horizontal lines are the hop-to-hop transitions. The readout on the right shows that the small square marker on the inter-hop line is located at signal acquisition frame number 29. Each frame consists of 1024 digital points in a time interval of 160 ms, putting frame 29 at 4.64 ms from the starting point.

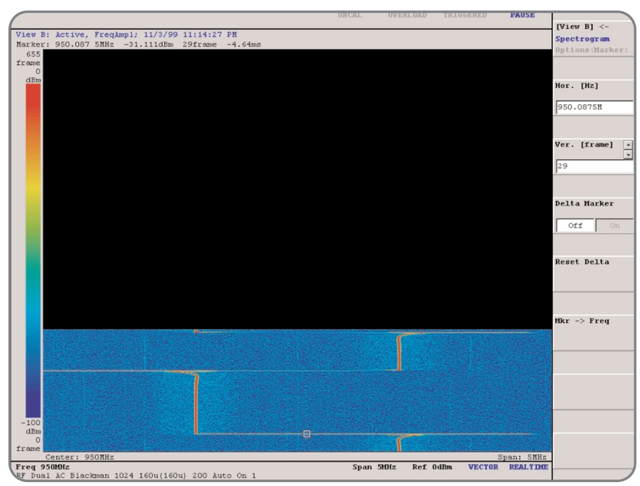
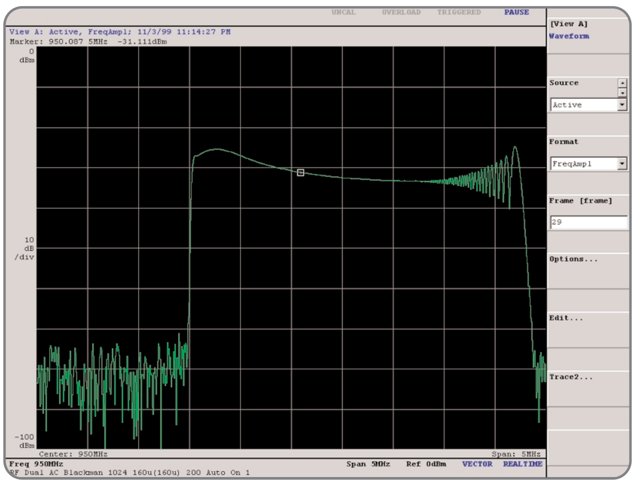


***Figure 2.** Spectrogram display of hopping signal. The frame selected for further analysis is indicated with the "box shaped" cursor.*

The WCA380 can scroll vertically in time and/or across in frequency on the spectrogram to select any frame or location between frames and analyze them in other domains. Figure 3 shows the magnitude-frequency behavior during the hop transition at frame 29. This signal appears as a single “spike” on the sweeping spectrum analyzer display in Figure 1. The amplitude display reveals a damped oscillation as the signal settles to the new value on the high frequency side of the hop. Different level perturbations were found when investigating the hop to the lower frequency side.



▶ ***Figure 3.*** *Magnitude-frequency behavior during the hopping transition.*

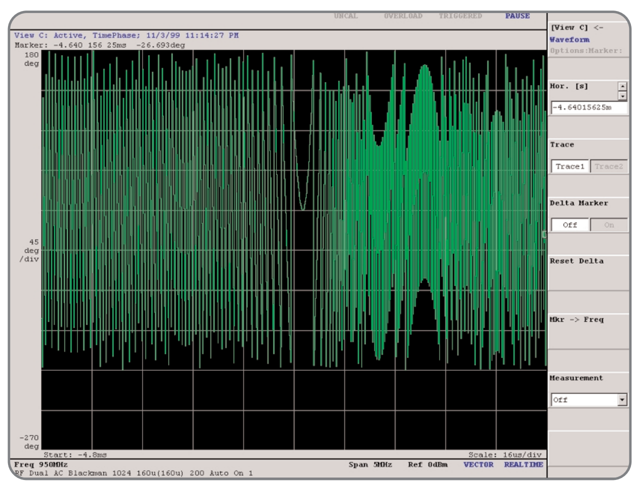
Figure 4 shows the phase behavior of the hopping signal at the 4.64 ms point of frame 29. Moving from left to right; this display window shows the phase of the signal as it transitions from its lower frequency steady state point to its higher frequency value. The left half of Figure 4 reveals fairly clean phase transitions with smooth changes alternating in sign as the signal frequency increases. This is not the case after the phase reversal just past mid-screen, where the phase variation becomes erratic in both the rate of change with frequency and the transition end points. This erratic behavior could cause problems in applications where signal recognition and lock-on are affected by phase instability. In other situations where it is only necessary for the signal to get to a particular frequency and stay there for a given time, the phase instability may be of little or no consequence.

Conclusion

Leading edge measurement tools are essential to the design of reliable systems that will conform to new wireless 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 wireless telecommunication designer and test engineer who are searching for 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.



▶ ***Figure 4.*** *Phase behavior of signal.*

www.tektronix.com

ASEAN Countries (65) 356-3900

Australia & New Zealand 61 (2) 9888-0100

Austria, Central Eastern Europe,
Greece, Turkey, Malta & Cyprus +43 2236 8092 0

Belgium +32 (2) 715 89 70

Brazil and South America 55 (11) 3741-8360

Canada 1 (800) 661-5625

Denmark +45 (44) 850 700

Finland +358 (9) 4783 400

France & North Africa +33 1 69 86 81 81

Germany + 49 (221) 94 77 400

Hong Kong (852) 2585-6688

India (91) 80-2275577

Italy +39 (2) 25086 501

Japan (Sony/Tektronix Corporation) 81 (3) 3448-3111

Mexico, Central America, & Caribbean 52 (5) 666-6333

The Netherlands +31 23 56 95555

Norway +47 22 07 07 00

People's Republic of China 86 (10) 6235 1230

Republic of Korea 82 (2) 528-5299

South Africa (27 11) 651-5222

Spain & Portugal +34 91 372 6000

Sweden +46 8 477 65 00

Switzerland +41 (41) 729 36 40

Taiwan 886 (2) 2722-9622

United Kingdom & Eire +44 (0)1344 392000

USA 1 (800) 426-2200

For other areas, contact: Tektronix, Inc. at 1 (503) 627-1924

ISO 9001

For Further Information

Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology.

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

01/01 HMH

Tektronix