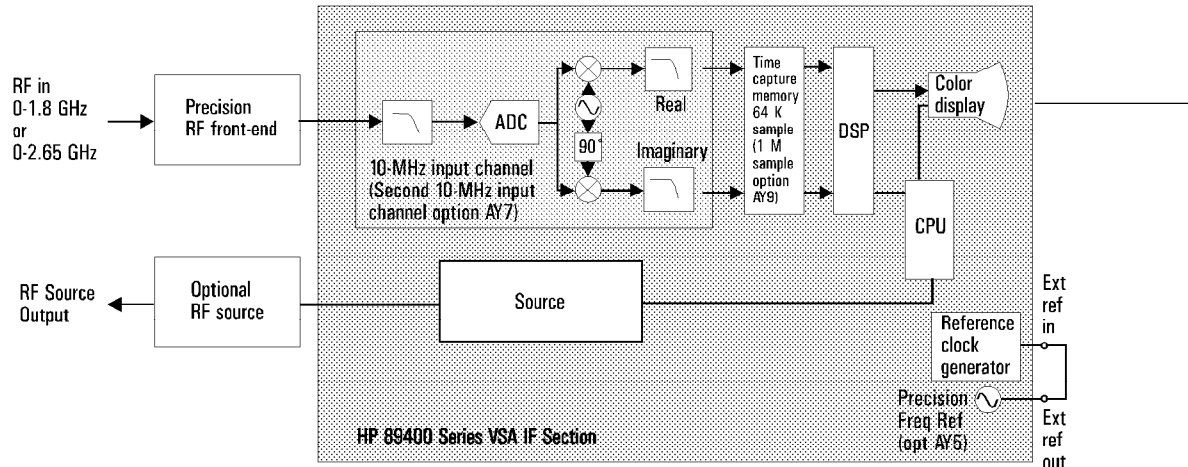


CDMA Measurements with the HP 89400 Series Vector Signal Analyzers

Product Note 89400-3



Measurement challenges in CDMA

Code division multiple access (CDMA) communications systems combine digital modulation and spectrum-spreading encoding techniques to create broadband signals which are immune to noise, and which themselves look like noise. Their natural noise immunity allows multiple CDMA signals to overlay each other in a common band. Measurements of CDMA signals present new challenges to test instruments.

In the world of CDMA, a key measurement is the power spectrum within a communications channel. This power is broadband, noise-like, and varies over time. Both short-term and long-term average power spectra are of interest. Power in adjacent channels makes it impossible to use power or peak-power meters without external filtering. You need an analyzer that makes combined time- and frequency-selective measurements.

Other measurements of interest to CDMA system designers include digital modulation analysis, filter frequency response, amplifier intermodulation and compression, identification and quantification of AM or PM spurious sidebands, and phase noise characterization. These common measurements of digital and analog radio systems have heretofore required a number of different analyzers.

The HP 89400 Series vector signal analyzers (VSAs) bring to bear on these problems an impressive array of analysis tools. Their primary contribution is the ability to isolate and digitize a frequency band up to 7-MHz wide, in a range of 0 to 2.65 GHz on the HP 89441A and 0 to 1.8 GHz on the HP 89440A. (Up to 10-MHz spans are available in baseband mode.) The digitized waveform can be displayed and analyzed in time, the frequency spectrum can be calculated using the fast Fourier transform (FFT), and intentional or unintentional modulation can

In the precision RF front-end of the HP 89400 Series VSAs, a block downconverter tunes to a 7-MHz span anywhere within a 2.65-GHz range for the HP 89441 and 1.8-GHz range for the HP 89440A. The down-converted signal is filtered and digitized by a high-speed, high-resolution A to D converter. Subsequent digital mixers and filters allow the span to be narrowed to as little as 1 Hz at arbitrary center frequency. High-performance processors provide fast spectrum, time-domain, and demodulation analysis, with flexible measurement displays.

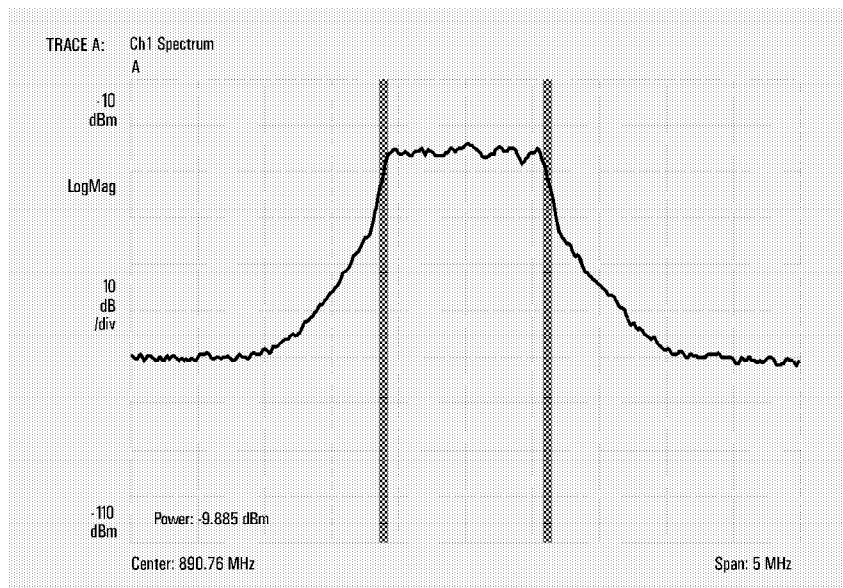
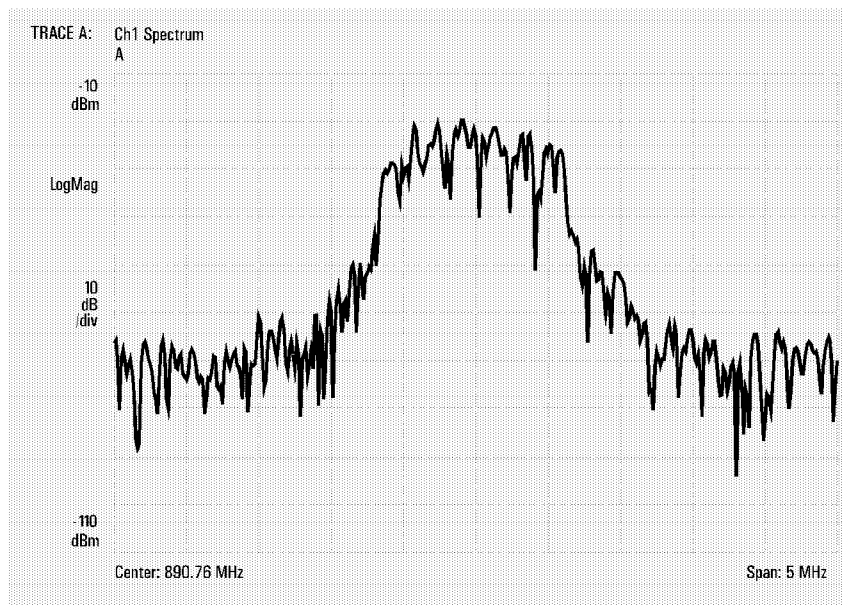
be characterized using computed demodulation. (AM, FM, and PM, and optional digital formats can be analyzed.) Markers on the time display can be used to limit the portion of the time record for which the spectrum or demodulation is calculated. Flexible digital

filtering eliminates unwanted signals from time and demodulation analyses.

These features are all available in the analyzers' vector mode. In scalar mode, multiple spans are pieced together by the analyzers to show spectra with displayed spans of up to 2.65 GHz.

Let's see how these features can be used to make *your* CDMA measurements:

Figure 1. CDMA spectrum



Band-limited power measurements

One class of CDMA measurements for which the HP 89400 Series VSAs are right at home is power measurements within and adjacent to a CDMA channel. Suppose you were to set up the analyzer in vector mode with a frequency span of 5 MHz, and set the center frequency of the analyzer to the carrier frequency of a CDMA cellular base station. You would see a spectrum display similar to figure 1.

You are looking at the 1.23 MHz-wide CDMA modulation and some adjacent sideband energy. The display would change rapidly due to the pseudo-random nature of a CDMA waveform. To calculate average power over time, you would turn on RMS averaging. The speed of the HP 89400 Series VSAs allows you to average hundreds of spectra in less than a second and display the result, which will look similar to figure 2.

The FFT calculation used in the HP 89400 Series VSAs is like measuring the output power of hundreds of narrowband filters with center frequencies distributed across the span, all operating on the same signal. Because of this, spectrum averages are accurate at all frequency points regardless of power changes during the measurement. By contrast, a swept analyzer calculates the average power at a single frequency at a time, and moves on. If the signal's power changes during the sweep, the resulting average is inaccurate.

Band-power markers allow easy calculation of the power within the 1.23-MHz band. The result is displayed at the lower left of the screen.

The band-power markers can now be moved to a span of 30 kHz centered 750 kHz above or below the CDMA carrier frequency and the power in that band calculated. The ratio of these two band measurements, each normalized to a 1-Hz bandwidth, constitutes an occupied bandwidth test. The HP 89400 Series VSAs make this test accurately and with ease.

Figure 2. Averaged CDMA spectra

Time-variant power measurements

Another common measurement in CDMA is to observe the power variations of a mobile phone over time. Power in a mobile CDMA phone is gated on and off in 1.25-ms bursts when the data rate is less than the full 9600 bits per second.

To measure the power during such a burst, you set the span of the analyzer to 2 MHz and the center frequency to the channel of interest. Increase the number of measurement points from the default of 401 to 3201. This allows a maximum time record length of 1.6 ms. IF triggering allows the measurement to start based on when the signal energy within the measurement frequency span crosses a threshold. You set the threshold to a few dB below the peak power in the burst and select pre-trigger delay to view the transient. If the analyzer is set to trigger continuously, this trigger setup is interactive, much like setting the triggering on an oscilloscope. After setup, you can set the analyzer to trigger once and retain the data for post-measurement analysis.

Figure 3 shows a split display with the time record on the bottom. The ordinate of the display is the magnitude of the time record in dBm. Note that this is similar to a zero-span measurement done with a swept spectrum analyzer, with an important difference. The HP 89400 Series VSAs capture *all* information within the span, and weights it equally. Information outside the span is sharply attenuated. The 3 MHz-wide Gaussian resolution-bandwidth filter of a swept analyzer attenuates the CDMA signal at either side of the channel because the

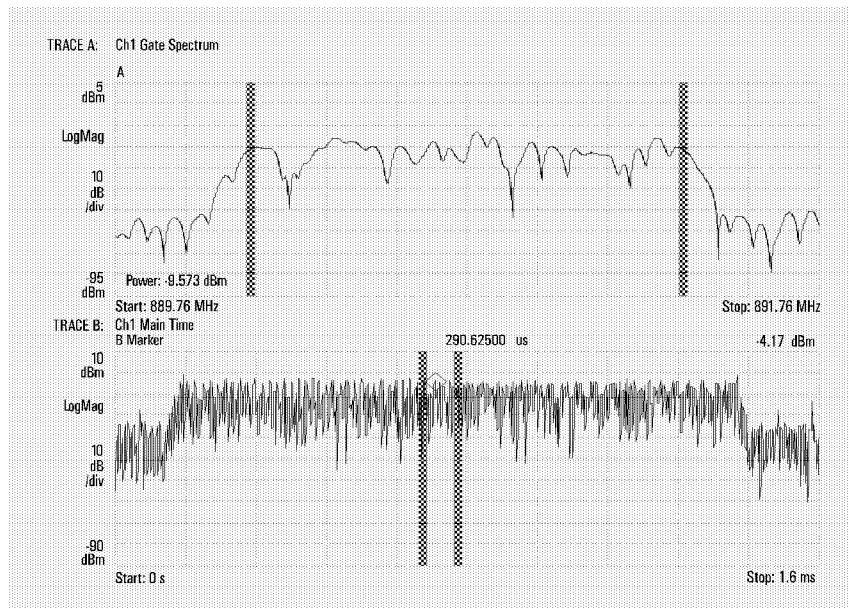


Figure 3. Measurement of a time-variant CDMA signal, showing peak power versus time on the lower trace and the spectrum of a selected time span on the upper trace.

filter is not flat, and includes much more out-of-band noise because its rolloff is more gradual. This makes accurate power measurements difficult.

The spot marker on the time display shows peak power versus time. You can also place band-power markers on a time display and display average power during a selected time period.

The markers shown on the time display, called gate markers, demonstrate an important feature of these analyzers: the ability to do time-selective frequency analysis. The spectrum shown on the top of the display consists of the FFT of the data within the gate markers only. This calculation may be windowed with any of the three available windows, or left unwindowed. You can adjust the gate width and position to observe the spectrum before, during, and after the transient. For example,

you may wish to position the gate on the transient to see if the spectrum splatters significantly out of the assigned channel during turn-on. In this display the gate is shown well within the CDMA burst, and band-power markers on the top display show the in-channel power.

Time capture for analysis of long CDMA transients

A power control circuit in the mobile unit is required to change its output power in response to a change in the power received from the base station. To measure this power-control response, which happens over the course of 100 ms, you can use the time-capture feature of the HP 89400 Series VSAs. This simply stores the output of the digitizer and digital filter in memory: up to 1-million samples with the extended capture memory (option AY9).

You can then analyze any part of the data after capture as if it were your signal source. External triggering allows you to synchronize the start of the time-capture measurement with the increase in base-station power. Then you can look at the mobile transmitted power at any time between the start of the measurement and the end of the captured data. The base-station power is excluded from the measurement because of the digital filtering. For more details on frequency and time-selective measurements, see HP Product Note 89400-1 (5091-7194E).

Other system measurements

CDMA systems consist of digital modulators, filters, amplifiers, oscillators, and a host of other components common to radios, all of which must work together to successfully generate a CDMA signal. If bit- and frame-error tests reveal transmission of the CDMA signal is impaired, the HP 89400 Series VSAs can help determine if any of these analog components are at fault.

Vector modulation analysis (option AYA) allows you to analyze QPSK, and in future versions, offset QPSK signals. These modulation formats are used, for example, in a base-station pilot signal or a mobile access preamble. The analyzer acquires a time record representing up to 4096 symbols, determines the symbol clock, and calculates the error between the received vector trajectory and the ideal. This analysis requires that the ideal filter shape be defined.

The analyzer can use standard raised-cosine, root-raised-cosine, Gaussian, and user-defined filter shapes. Note: This analysis is not a complete CDMA demodulation in that the bits recovered are simply the PRN code, but it is sufficient to determine the health of the modulator. Available displays include I/Q pattern, constellation, eye diagrams on I or Q channel, vector magnitude error, and vector phase error.

AM, FM, and PM demodulation of oscillator signals can reveal the nature and magnitude of spurious signals and noise. Time and frequency displays of the demodulated data are available. The use of the PM demodulation analysis to characterize phase noise is detailed in HP Product Note 89400-2 (5091-7193E).

Despite their advanced features, the HP 89400 Series VSAs were designed to be familiar to users of traditional spectrum analyzers. In scalar mode, the HP 89441A can display a power spectrum over any frequency span up to 2.65 GHz (HP 89440A up to 1.8 GHz). With arbitrary resolution bandwidths down to 312.5 μ Hz, you can easily find low-level spurious signals that otherwise would be obscured by noise. You can use this mode, for example, to determine compliance of the CDMA system to FCC emission standards.

The outstanding linearity of the HP 89400 Series VSAs makes them well suited to perform amplifier compression and intermodulation tests. To support such testing in vector mode (within 7-MHz bandwidths), the RF source (option AY8) provides sinusoidal, pseudo-random, chirp, or user-defined arbitrary signals.

With a second 10-MHz input channel (option AY7), the analyzers can perform frequency response measurements on two-port networks in the frequency range of 0 to 10 MHz. The internal source provides single tone and several wideband signals to support such tests.

Complex measurements can be easily automated using HP Instrument BASIC (option 1C2). A "keystroke recording" feature records your setups as you make them and turns them into BASIC I/O statements. A PC keyboard attached to the analyzer allows you to further edit the program, adding branching, calculation, I/O, and display enhancements.

The HP 89400 Series VSAs perform noise-power measurements required in CDMA with ease and calibrated accuracy not found in swept analyzers. Their combined time and frequency selectivity, together with demodulation analysis, allow you to see details of signals in ways never before possible. In addition, these analyzers bring a broad array of tools to assist you in CDMA system design and troubleshooting.