Amplitude, Phase, and Power

Measuring Vector Modulated Signals

Modern communications systems use vector modulation to generate complex signals which encode multiple data bits per symbol. LeCroy oscilloscopes with long acquisition memories, extensive signal processing, and high speed processors are ideal for fully characterizing the key parameters of vector modulated signals.

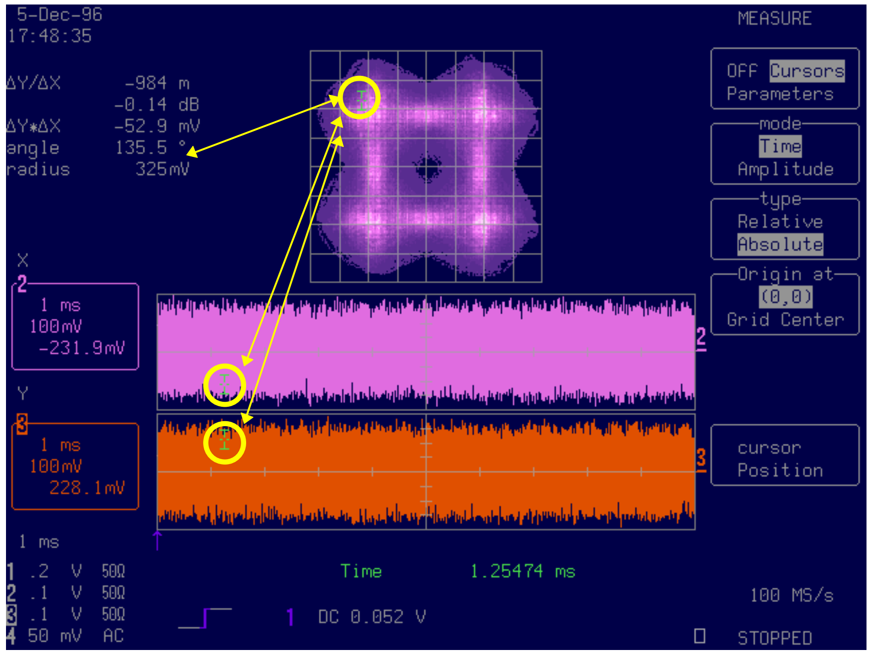

Figure 1 - Vector diagram using X-Y display includes both Cartesian and polar readout of cursor position. Vector magnitude (325 mV) and phase (135.5°) are read in X-Y cursor field. This is the vector sum of the I(-232 mV) and Q (228 mV).

CDMA signal from Anritsu model MC3670B courtesy Qualcomm Corp.

Consider the vector diagram of the I (in phase) and Q (quadrature) components of a CDMA signal shown in figure 1. The vector diagram shows the four possible data states per character and the transition paths between them. X-Y Cursors provide readouts of the I and Q amplitudes and the vector phase angle and magnitude simultaneously. This feature allows spurious states in the vector diagram to be linked to the source waveforms.

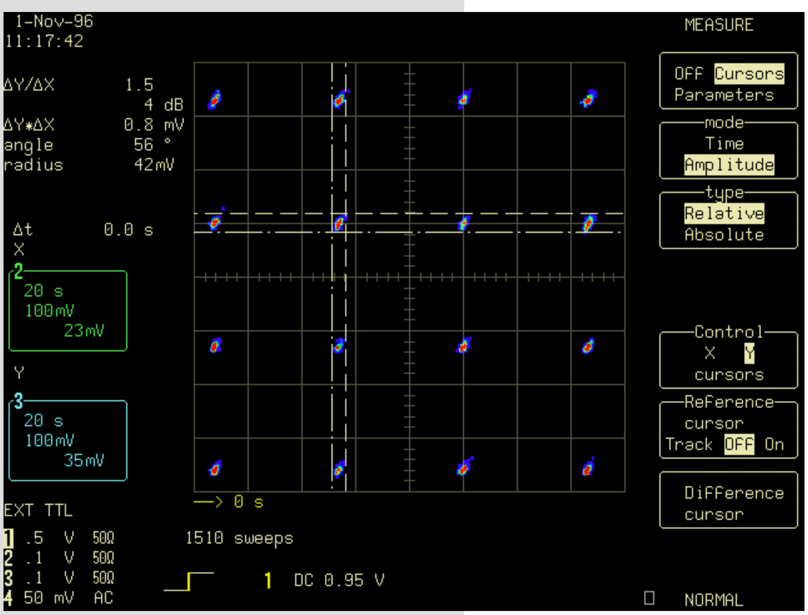

Figure 2 - A constellation display of a 16 QAM signal

By using a symbol clock to externally sample the oscilloscope a constellation diagram is generated. Figure 2 shows a constellation diagram for a 16 QAM signal. Relative amplitude cursors are used to measure the width and height dispersion of the logic states. By using the polar readouts and the absolute time cursor the phase and/or amplitude differences of the signal can be measured.

Math functions allow users to perform more extensive analysis. In figure 3 the instantaneous power and bandwidth of a 5 MHz carrier, modulated by a CDMA signal, is shown. The instantaneous power is calculated by squaring the voltage waveform. If required this can be normalized to impedance level by using the rescale function to divide the waveform by a constant value.

The signal bandwidth is determined by taking the FFT of the signal, here displayed in power spectrum format. Any of these analyses can be expanded horizontally or vertically using zoom functions. This permits detail such as the carrier waveform to be observed.

Note that it is important to be able to chain math functions. It often requires a series of calculations in order to extract the desired parameter. In figure 4, the instantaneous power of the CDMA waveform is calculated by squaring and summing the I and Q components. Note that all math operations in this case use up to 1,000,000 data points. Processing speed becomes essential in calculations involving such long records.

Automatic parameter extraction, such as determining the peak (maximum) and average (mean) from the instantaneous power waveform, simplifies analysis. Instead of having to transfer long records to an external computer the oscilloscope analyzes the data and provides only the desired values.

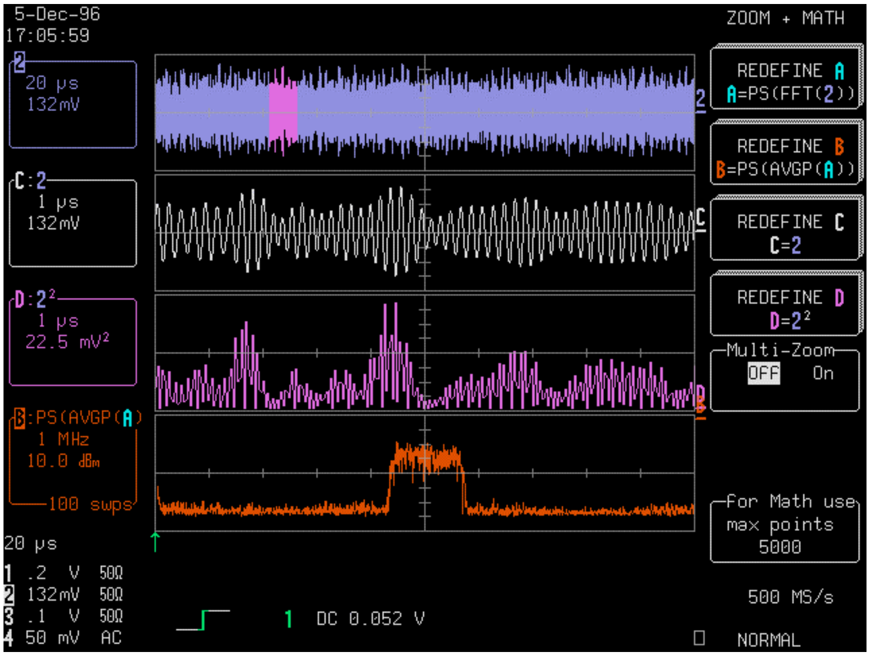

Figure 3 -Top trace: Modulated waveform. Second trace: expanded view of the modulated carrier. Third trace is the squared voltage (power) waveform. Bottom trace: Frequency spectrum (FFT) showing signal bandwidth.
CDMA signal from Anritsu model MC3670B courtesy Qualcomm Corp.

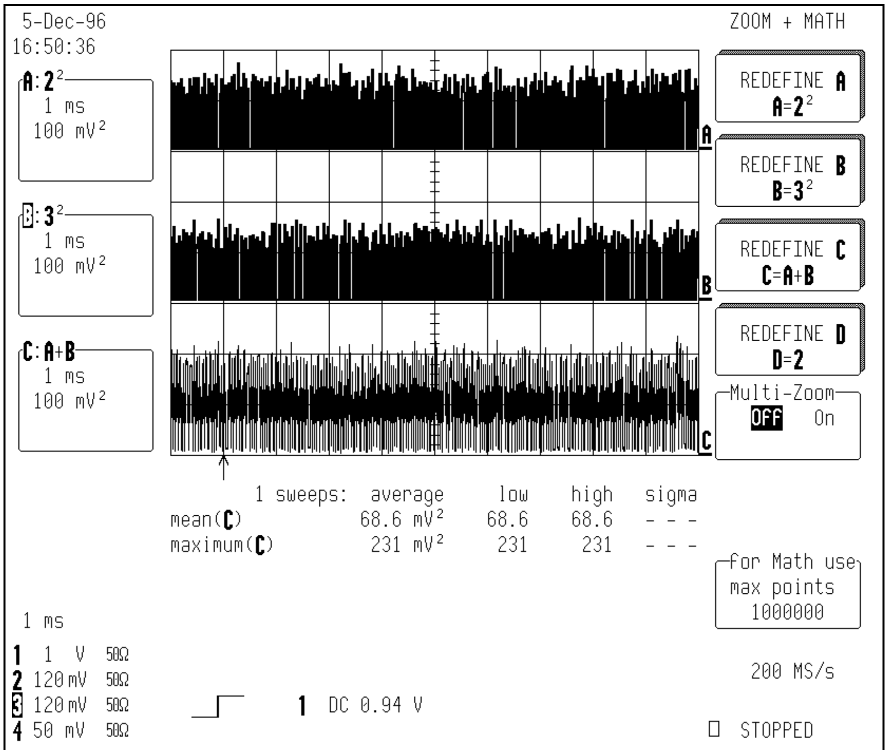

Figure 4 - Using cascaded math operations to calculate instantaneous power from the I and Q components of a CDMA signal. CDMA signal from Anritsu model MC3670B courtesy Qualcomm Corp.