Constellation Displays

Analyze Data Communications Signals Using X-Y Displays

Constellation diagrams are commonly used in analyzing the performance of data communications systems using quadrature signal generation techniques to phase encode digital data. The constellation diagram is an X-Y display which shows the data states of phase or phase-amplitude encoded data. Figure 1 shows a constellation diagram for a quad state phase shift keyed (QPSK) signals. There are 4 data states associated with each transmitted symbol encoded as 45°, 135°, -45°, and -135°.

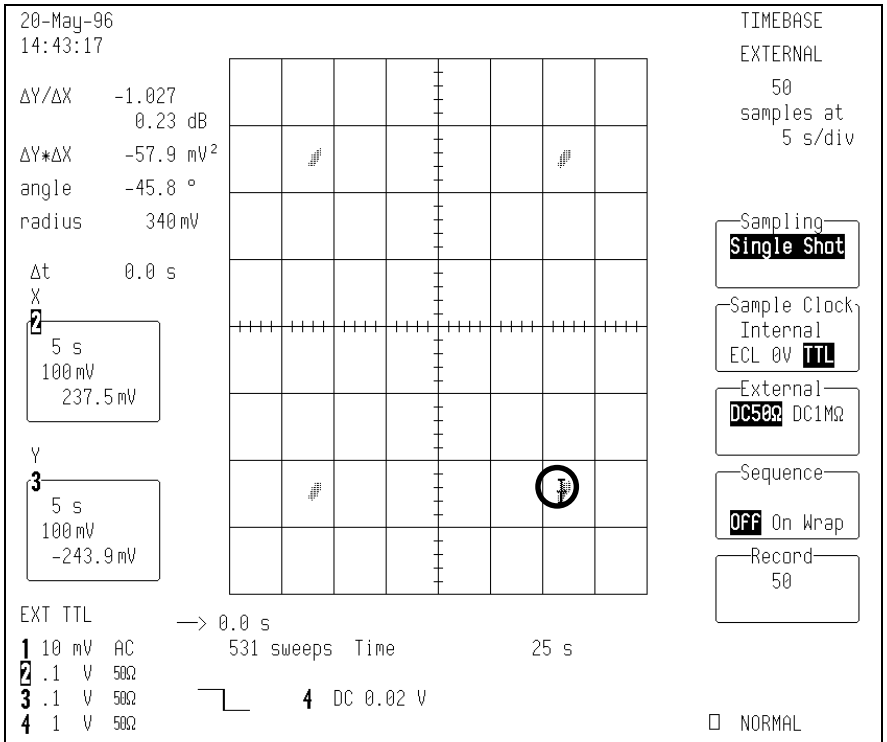

Figure 1-Constellation display of a 4 state QSPK signal . X-Y cursors (circled) mark output at -45° and read both Cartesian(X-Y voltages) and polar (Phase/Radius) coordinates

The constellation diagram requires an oscilloscope with X-Y displays, external sampling clock, and a persistence display, all of which are available in the LeCroy 9300 series oscilloscopes. In addition to the standard 100 MHz external sampling input the 93XX-CKTRIG option extends external clocking to 500 MHz.

As can be seen from the TIMEBASE menu in figure 1 the oscilloscope accepts 3 different external clock signal levels. The external clock accepts ECL (-1.3V) , TTL (+1.5V) or the zero crossing of an analog signal as an input. Triggering occurs on the on the rising edge of the signal. The transition times of the external clock signal should be less than 10 ms. The input impedance level can also be set to 50Ω or 1 MΩ.

In external sampling the oscilloscope time base is set by the user in terms of the total number of samples set in the RECORD field of the TIMEBASE menu. This is also shown in figure 1. Record lengths of from 50 to the maximum memory length (2 M in L versions) can be selected in multiples of 1, 2, or 5. *It is important to note that the oscilloscope will automatically revert to internal sampling if the TIME/DIV knob is used.*

X-Y cursors in LeCroy oscilloscopes read both the X and Y voltage values and the resultant output waveform phase (angle) and magnitude (radius). The X and Y voltages are read in the trace an-

notation boxes. The polar readouts appear in the upper left hand corner of the display in figure 1. The angle is the phase of the output signal relative to the in-phase component. The radius is the magnitude of the composite signal displayed as the distance from the center of the display to the cursor location.

The measurement requires access to the in-phase, I, and quadrature, Q, signal components as well as the symbol clock. Figure 2 shows how these signals would be connected to a typical LeCroy oscilloscope for the standard external clock input. Connections for the 93XX-CKTRIG option are not shown here. Note that the timing of the symbol clock may need to be trimmed to assure that the signal waveforms are sampled at the correct time. This is usually accomplished by trimming the length of the coaxial cable connecting the demodulator clock output to the oscilloscope's ext trigger/sampling input. In addition to the signal connections and TIMEBASE menu settings remember that the DISPLAY menu must be used to select the X-Y and PERSISTENCE display as shown in figure 3.

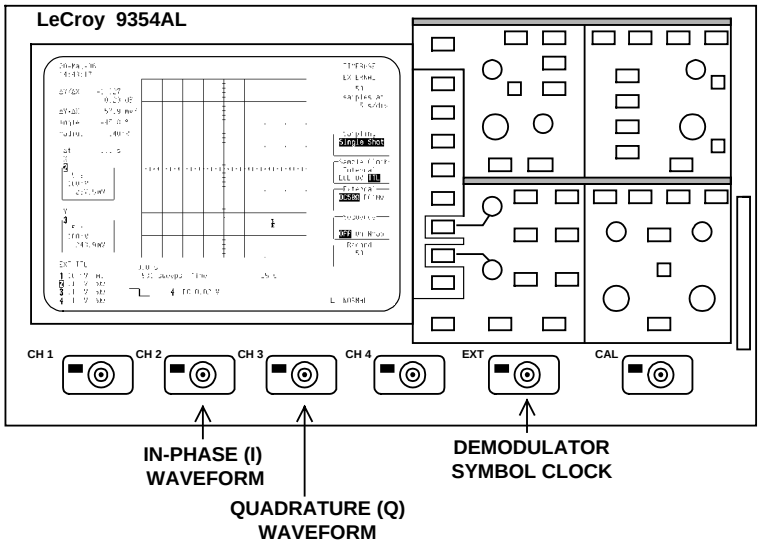

Figure 2 Signal connections for a constellation display using the standard external sample clock input.

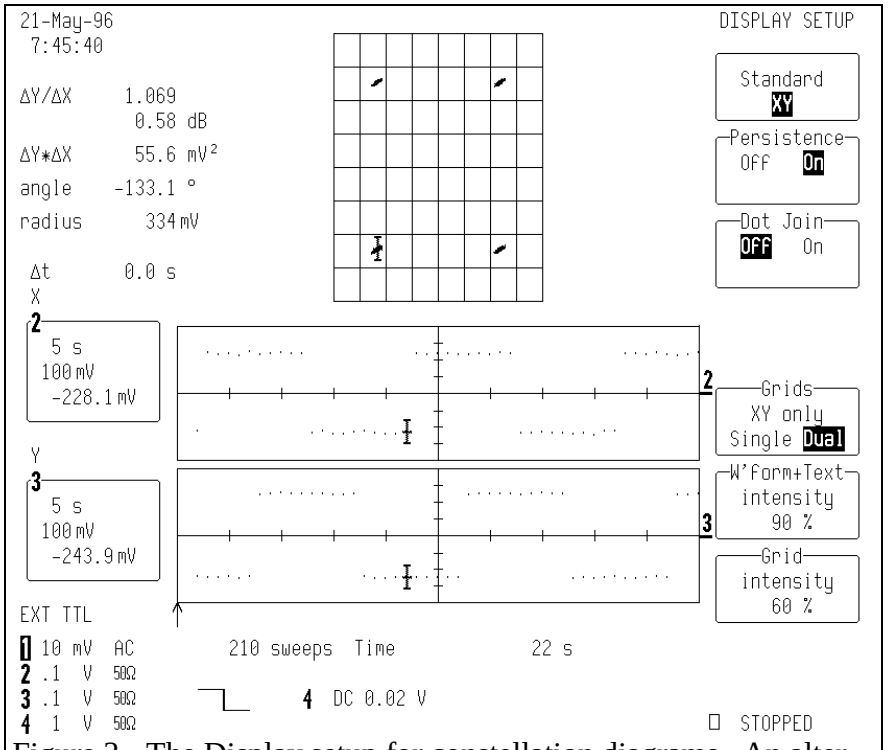

Figure 3 - The Display setup for constellation diagrams. An alternative dual X-Y display is shown combining X-Y, X-T, and Y-T.

The LeCroy LC family of color oscilloscopes adds the additional capabilities of using analog or color graded persistence to highlight the data states that occur most often. Figures 4 and 5 provides examples of a constellation diagram of 16 QAM and 128 QAM signals .

The ability to create and display constellation diagrams is another example of the high degree of integration in LeCroy oscilloscopes. Externally clocked data conversion, acquisition memory, display, and cursor measurements work together seamlessly to provide a highly useful analysis tool.

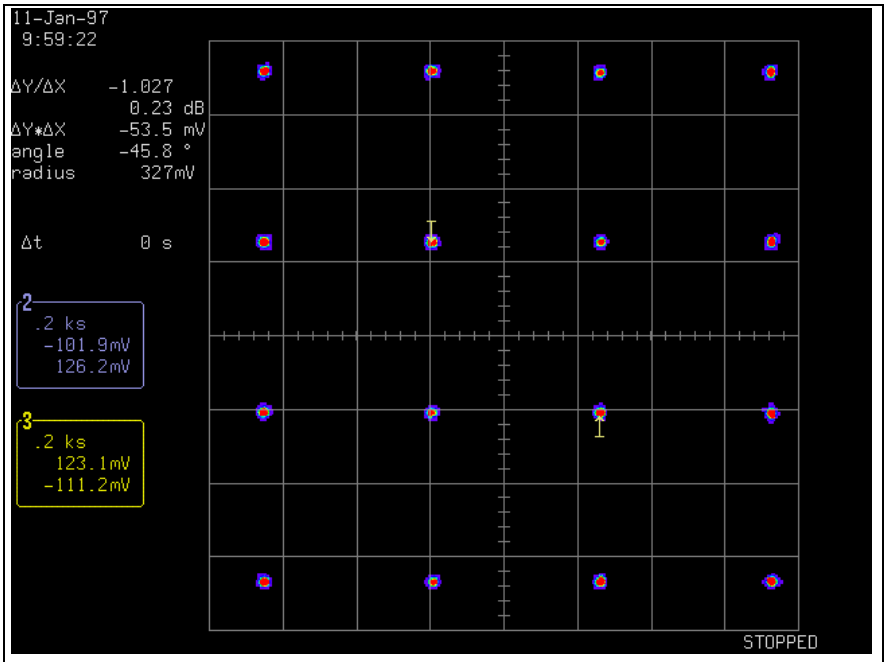

Figure 4 - Constellation diagram of a 16 QAM waveform displayed using color graded persistence

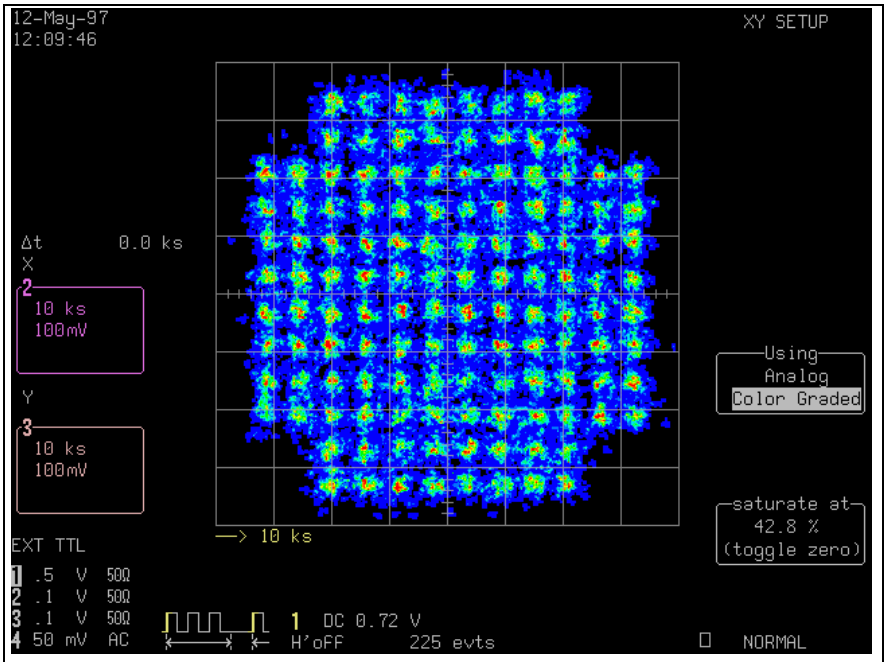

Figure 5 - Color graded persistence display of a 128 QAM constellation diagram