Comparing Waveforms

De-skewing And Comparing Waveforms

Communications systems often require a comparison of transmitted and received data in order to characterize the propagation path. The effects of various system components such as amplifiers and filters also require similar analysis. Signal attenuation, distortion, and delay are areas of interest which can readily be studied using LeCroy digital oscilloscopes (DSO's). The advanced math functions available in LeCroy scopes provide solutions to many of the measurement problems associated with communications systems. In particular they can be applied to accurately measuring and eliminating propagation delay from acquired waveforms allowing more accurate comparison of other important characteristics.

A typical application is illustrated in figure 1. The top trace (channel 2) is the input signal applied to a low pass filter. The trace below that (channel 3) is the measured output from the filter. Note that the waveform is shifted in time and the waveshape exhibits overshoot and increased rise and fall times. Most oscilloscope de-skewing techniques are based on visual alignment of similar waveforms. In applications, like this one, where the waveforms are not identical it is often difficult to minimize data skew accurately.

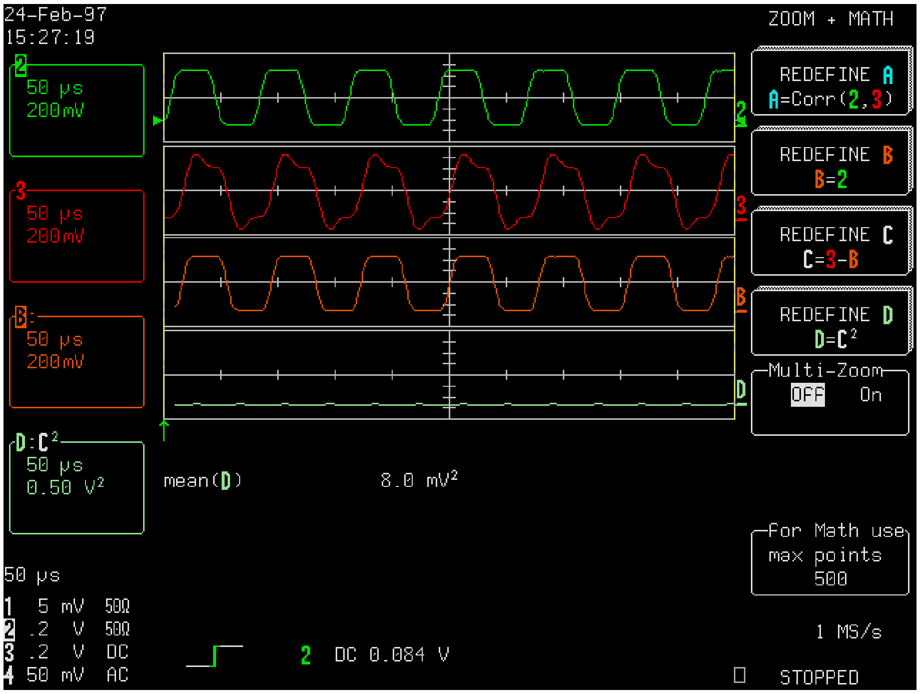

Figure 1 - Comparing the input and output signals from a filter using a highly accurate technique to eliminate data skew.

A very repeatable technique to eliminate data skew is to minimize the mean squared difference of the two signals. In our example, a copy of the input waveform is made in one of the four zoom traces (trace B). The zoom traces can be shifted horizontally for de-skewing the waveform. Trace C, is defined as the difference of trace 3 and trace B. Trace D is used to calculate the square of the difference. The mean value of the squared difference is read using the measurement parameters. Trace B is shifted horizontally to obtain the minimum mean squared difference. If the acquired waveforms were identical, but time displaced, this technique would produce a mean squared difference of 0. In our example the waveshapes are related but not identical and the resulting mean value will exhibit a minima that may not be 0. The value of the de-skew time can be obtained from the Status menu for the zoom + math traces as shown in figure 2. The horizontal displacement is shown as 2 % (10 µs) of the 500 µs full scale horizontal range.

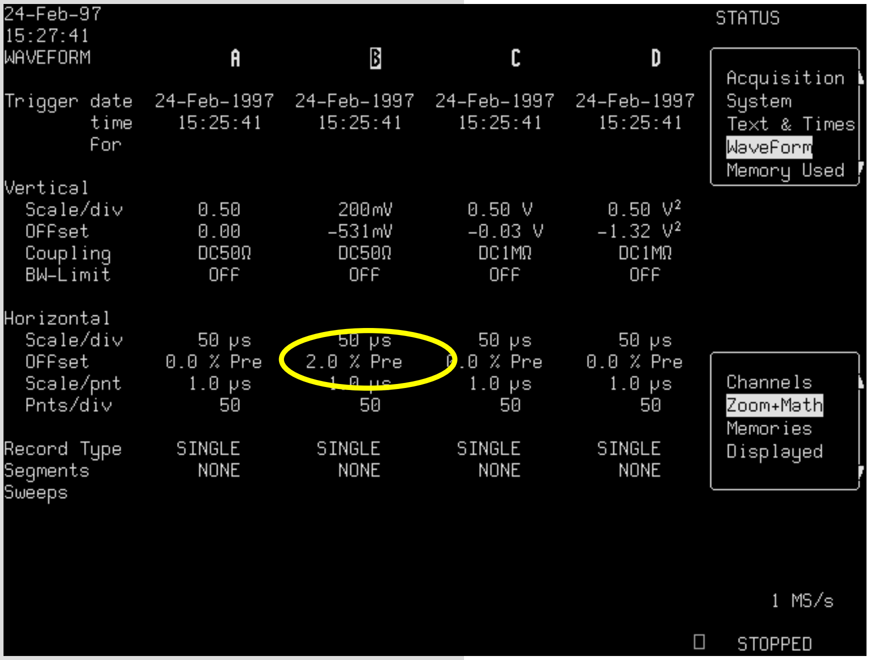

Figure 2 - Time shift of the zoom trace as a % of full scale horizontal deflection. In this example the shift is 10 ms

Note that LeCroy scopes exhibit some unique capabilities required for this measurement. They offer the most comprehensive math package available in any portable oscilloscope supported by up to 64 MB of processing memory. Long processing memory permits math operations to be performed on long waveforms (up to 8 MS). They allow chained math functions (sometimes referred to as "math on math"), such as taking the square of the difference.

Cross correlation is another advanced technique that can be used for comparing waveforms. LeCroy oscilloscopes with the PRML option include both auto and cross correlation functions. The application of cross correlation to our example is shown in figure 3.

The correlation function compares waveforms by incrementally shifting one of the waveforms, multiplying it by the other and then averaging the result. The value to the of the correlation function for each time delay increment is plotted against the delay. The values are normalized so that the correlation function is equal to 1 for identical waveforms and 0 for unrelated waveforms. A correlation value of -1 indicates the waveform are identical but one is inverted.

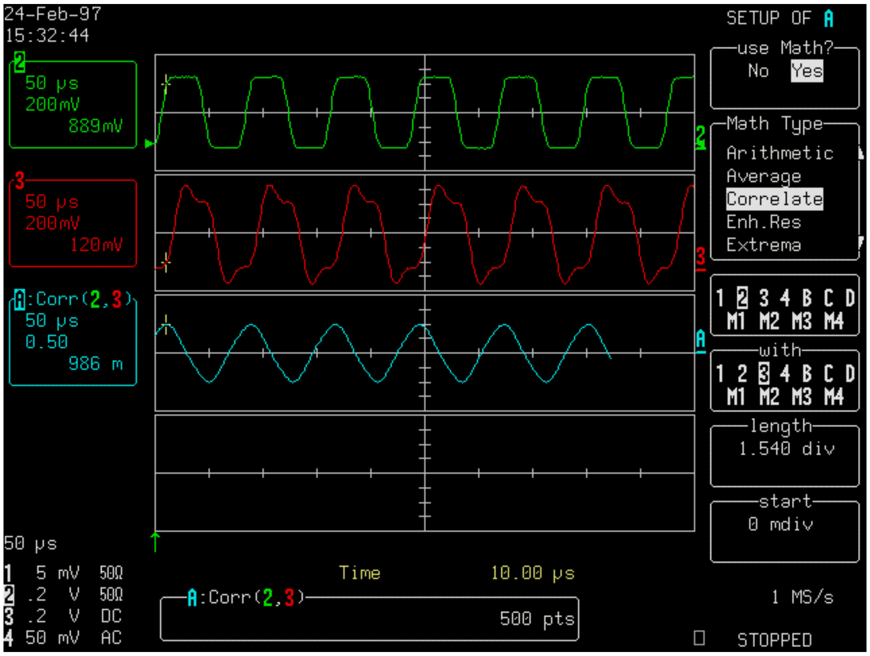

Figure 3 - Using cross correlation to compare waveforms

In this example the cross correlation, shown as trace A, shows the periodicity of the input waveforms. The propagation delay and maximum correlation value are read at the first peak, marked by the time cursor. The cursor readout, located under the trace display indicates a delay of 10 µs and the correlation value in the trace A waveform label box is 0.986.

The correlation function is very calculation intensive. Using short data records and selecting an oscilloscope with a high speed processor, such as the LC series, minimizes calculation time.