Using Histograms III

Statistical Analysis As A Diagnostic Tool

Diagnosing circuit problems requires a fair amount of skill and good measurement tools. In most cases, the more ways you can look at a problem the easier it is to solve. That is why LeCroy's Parameter Analysis waveform processing option, 93XX-WP03, is so valuable to troubleshooters. It provides an alternative view of the data and gives the diagnostician additional perspective. Consider the problem of detecting and diagnosing crossover distortion in a push-pull amplifier stage shown in figure 1.

Distortion, especially at low levels is difficult to see in a conventional oscilloscope time display. Figure 2 is an example of a waveform with crossover distortion. The distortion, although significant, is barely visible and could easily be missed.

Modern oscilloscopes offer additional processing such as the Fast Fourier Transform (FFT) to help detect problems like distortion. The FFT is a great asset in determining the existence of distortion, a shown in figure 3, but it cannot differentiate between the various sources of distortion. Clipping, asymmetries, limiting, and crossover all produce similar frequency domain spectra. The high harmonic content, in this case approximately -40 dB below the fundamental, is the key indication of the distortion that is present in the waveform.

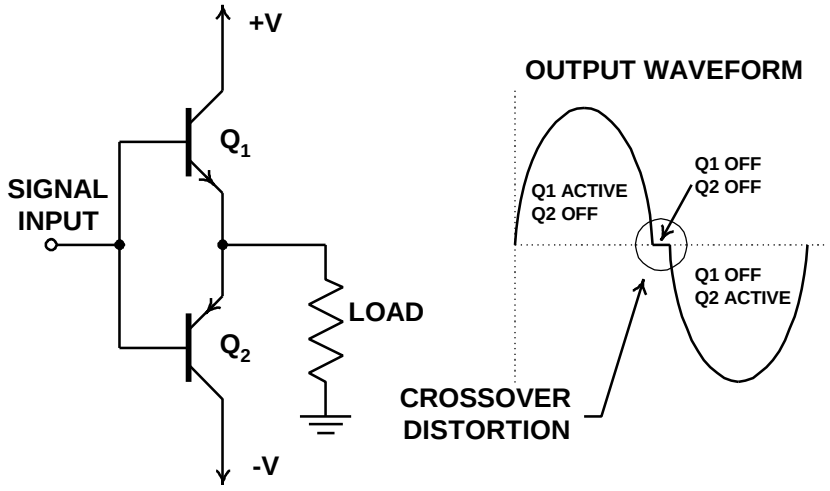

Figure 1 - A simplified view of a push-pull amplifier showing the source of crossover distortion.

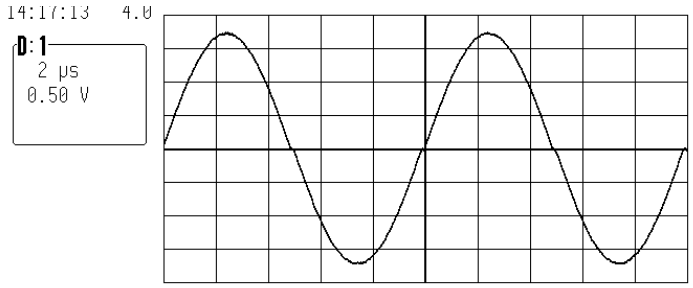

Figure 2 A time domain waveform with crossover distortion

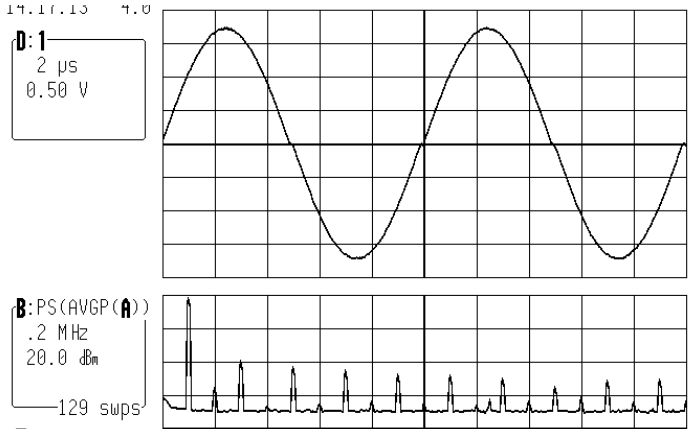

Figure 3 - The FFT shows high harmonic content due to distortion but provides no clues to its source.

The histogram of the amplitude data values, added to the waveform and FFT in figure 4, provides the missing information about the nature of the distortion. The histogram is calculated by dividing the amplitude range of the oscilloscope into from 20 to 2000 bins (100 bins are used in this example). The number of samples which fall into each of these bins is plotted, on the vertical axis, against the nominal voltage value of the bin on the horizontal axis. The histogram of data value shows the number of samples in the waveform within each small voltage range. Note that instead of the usual "saddle shaped" histogram of a sine wave we observe a higher than normal population of sample values at the center which represents zero volts. The waveform is hesitating at the zero crossing, a sure sign of crossover distortion. Clipping and limiting would be manifested as a higher population at the maximum and/or minimum peaks. Distortion due to asymmetry would be visible as an asymmetric histogram.

The ability to view the signal in three different domains, time, frequency, and statistical, provides a powerful tool for anyone having to diagnose complex circuit problems. LeCroy oscilloscopes allow the user to incorporate any or all of these tools into any of its over 25 oscilloscope models.

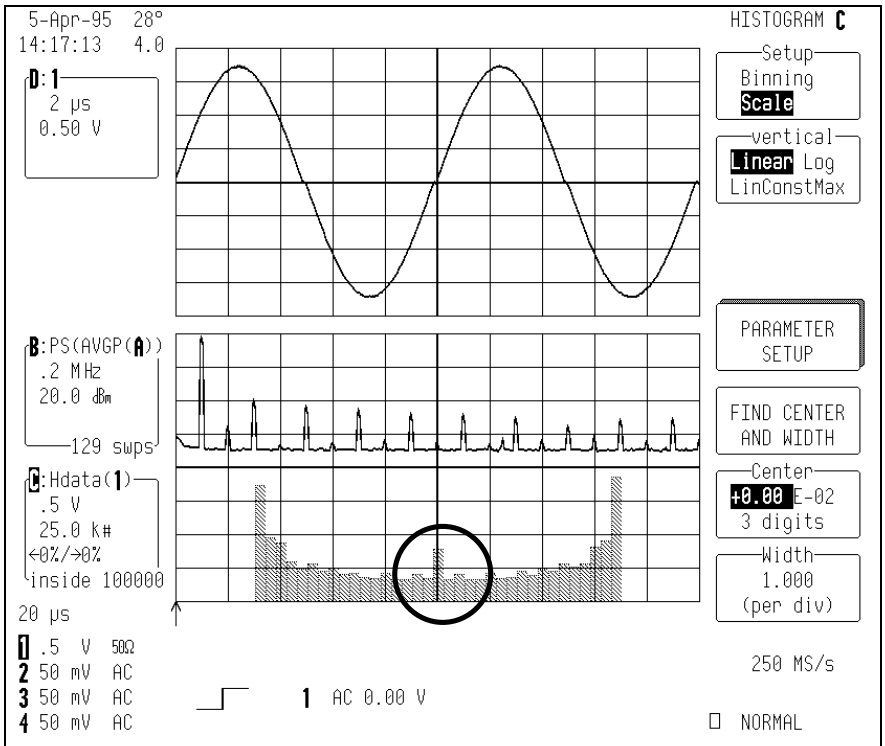

Figure 4 -The histogram of data amplitude shows higher than normal number of sample values at the zero crossing (circled) indicating that the high harmonic levels are due to crossover distortion