Intermittent transient events and glitches are among the most frustrating problems to solve. This is especially true if you have no idea about the nature of the transient. LeCroy oscilloscopes include tools to help capture and locate these pesky transients. This paper will focus on techniques for glitch hunting.

Exclusion Triggering

Exclusion triggering can be applied to periodic waveforms such as clock signals. These waveforms have a nominal shape that does not change with any regularity. Most transients manifest themselves by abnormal timing. The idea behind exclusion triggering is to measure the signal's nominal timing and to trigger the scope whenever the signal is outside the nominal range of values. In effect, exclusion trigger is really 'lying in wait' for the event. You can combine exclusion trigger with the fast update rate achievable using sequence mode acquisition to capture intermittent abnormal signals at rates as high as 160,000 times per second. This can give much more insight into signal faults than older technologies, which trigger fast, but which capture mostly the "normal" shape signal.

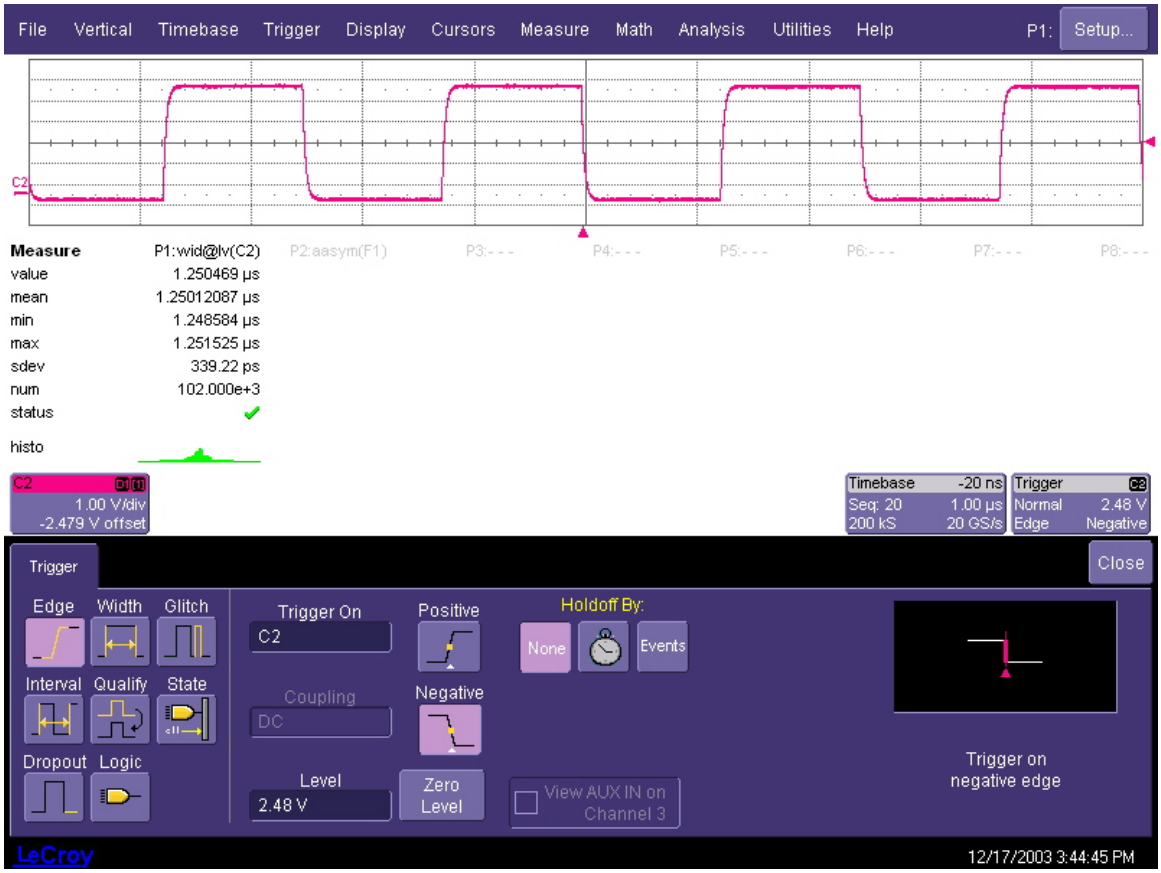

Figure 1: Using parameter measurements to determine the exclusion trigger limits.

The square wave clock shown in Figure 1 is a typical example of a periodic clock waveform. We can use measurement parameters such as period, width, frequency, or duty cycle as the basis of an exclusion trigger. In this example we have chosen pulse width. Measure the pulse width using parameter statistics to determine the minimum and maximum values for a typical waveform. In the example in Figure 1 the nominal pulse width is 1.25 µs with a minimum value of 1.248584 µs and a maximum value of

1.251525 µs. From this data you can se tup an exclusion trigger based on the pulse width. The scope will trigger if the input pulse width is outside the range of 1.24 to 1.26 µs.

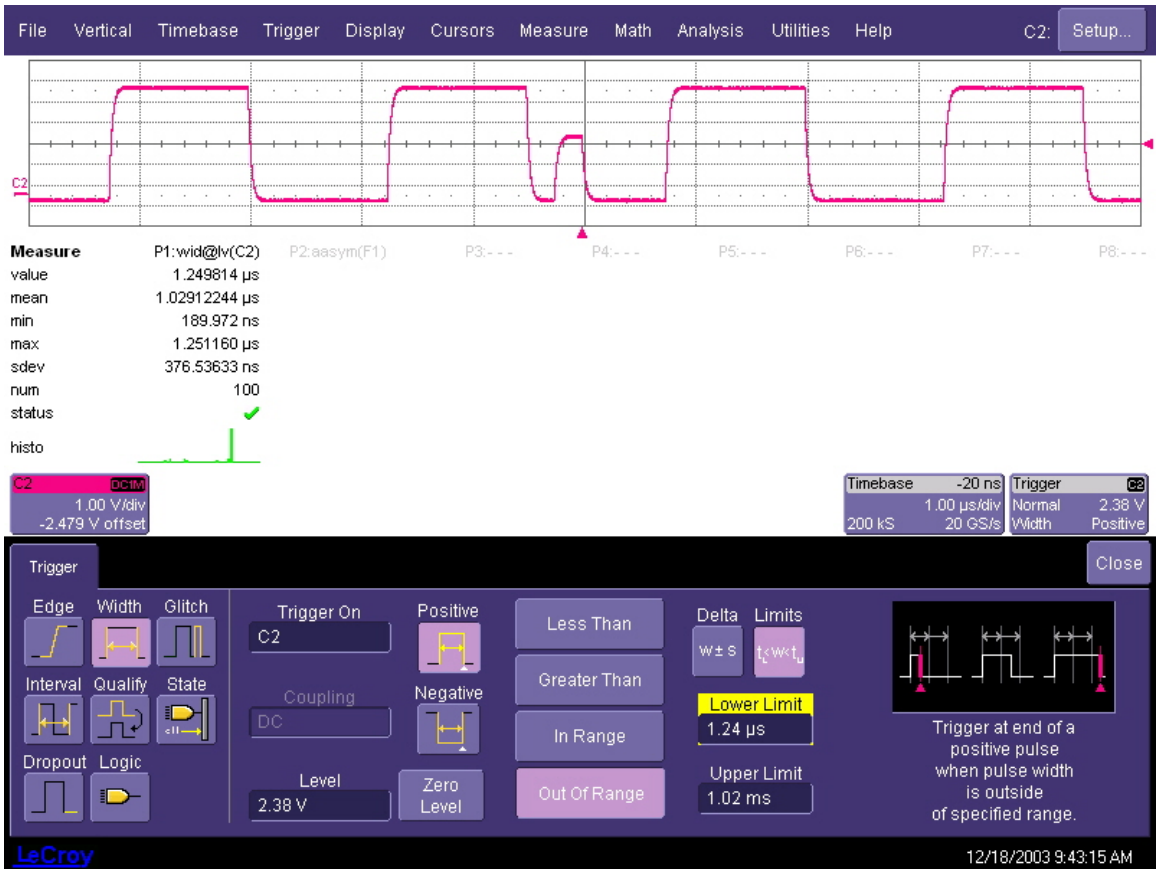

Figure 2: The set up of a SMART Trigger exclusion trigger using pulse width

In figure 2, the trigger setup using SMART Trigger® based on pulse width:

The scope will trigger if a pulse has a width of less than 1.24 µs or more than 1.26 µs. Pulses with widths in the nominal range are excluded from scope acquisitions. An example of a runt pulse with a narrow width is shown in the acquired channel 2 trace in the figure.

Sequence mode acquisition breaks the scope's acquisition memory up into as many as 20,000 segments. Each segment acquires a single sweep, and the scope holds off all non-acquisition related functions until all the segments are filled. This means the scope operates with minimum dead time between acquisitions. The update rate in sequence mode can be as high as 160,000 sweeps per second even when using all four channels of the scope. So the total acquisition rate of signals can be over 600,000/sec. This rate of acquisition is maintained beginning from the time that the acquisition is started until the sequence mode buffers are filled. In addition to fast update rate, the scope time stamps each acquisition. This tells the user the time interval between trigger events. When exclusion trigger is used the sequence mode time stamps tell the time between glitches. This information can be invaluable because it provides additional information about phenomena causing the glitches. Figure 3 shows a sequence mode setup controlled from the Timebase dialog box. The user can set the number of segments to be acquired. In this example there are 20 segments in each sequence acquisition. The sequence mode acquisition in Figure 3 is displayed as adjacent segments. This is one of five sequence mode display types that can be selected

from the Display dialog box. Figure 4 shows the same data displayed in mosaic display format. Here the 20 segments are displayed in an array of up to 80 segments.

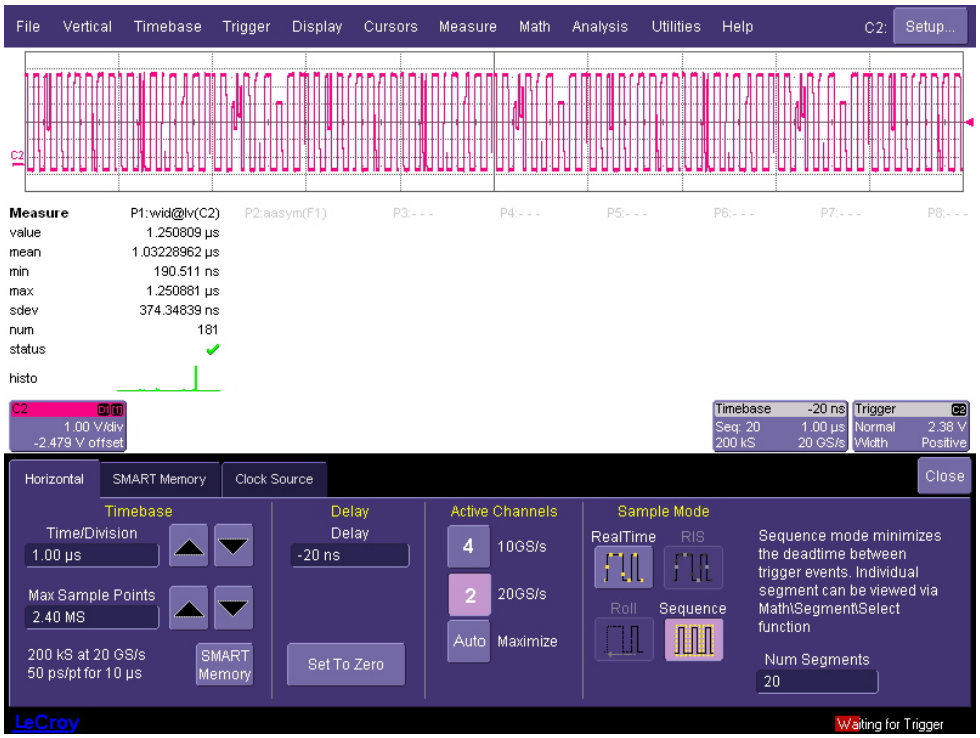

Figure 3: The sequence mode setup in the Timebase dialog box

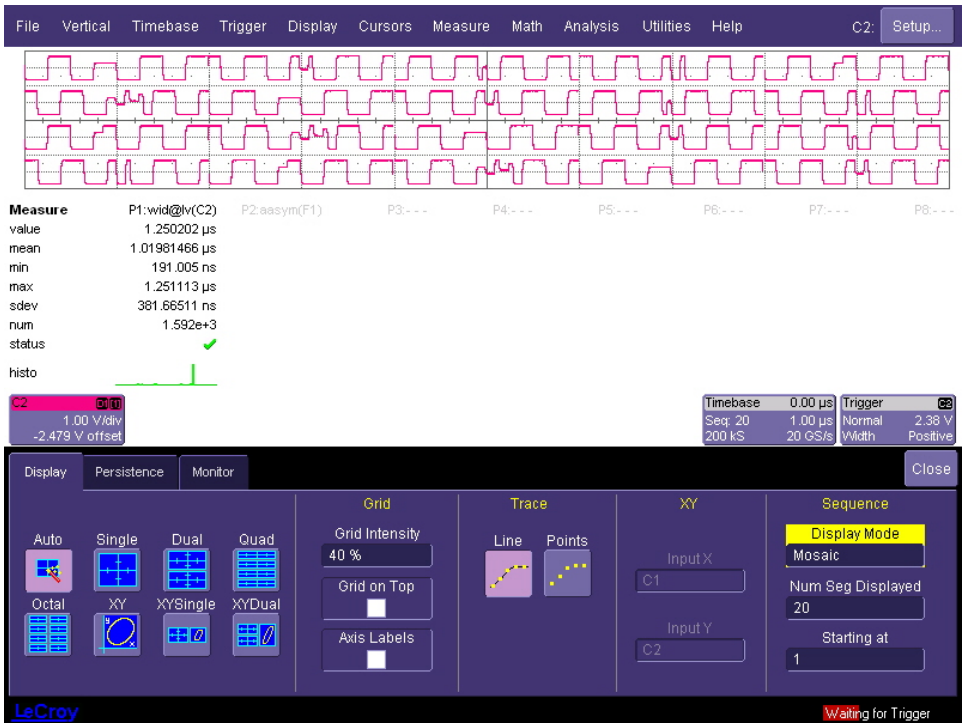

Figure 4: Displaying the sequence waveforms in the mosaic type display

Sequence mode time stamps, found under the Channel Status selection under the Vertical pulldown menu provide both the absolute time of each trigger event as well as the relative time between events. This can be seen in Figure 5. In this figure the time between transient events is from 0.65 to over 2 seconds.

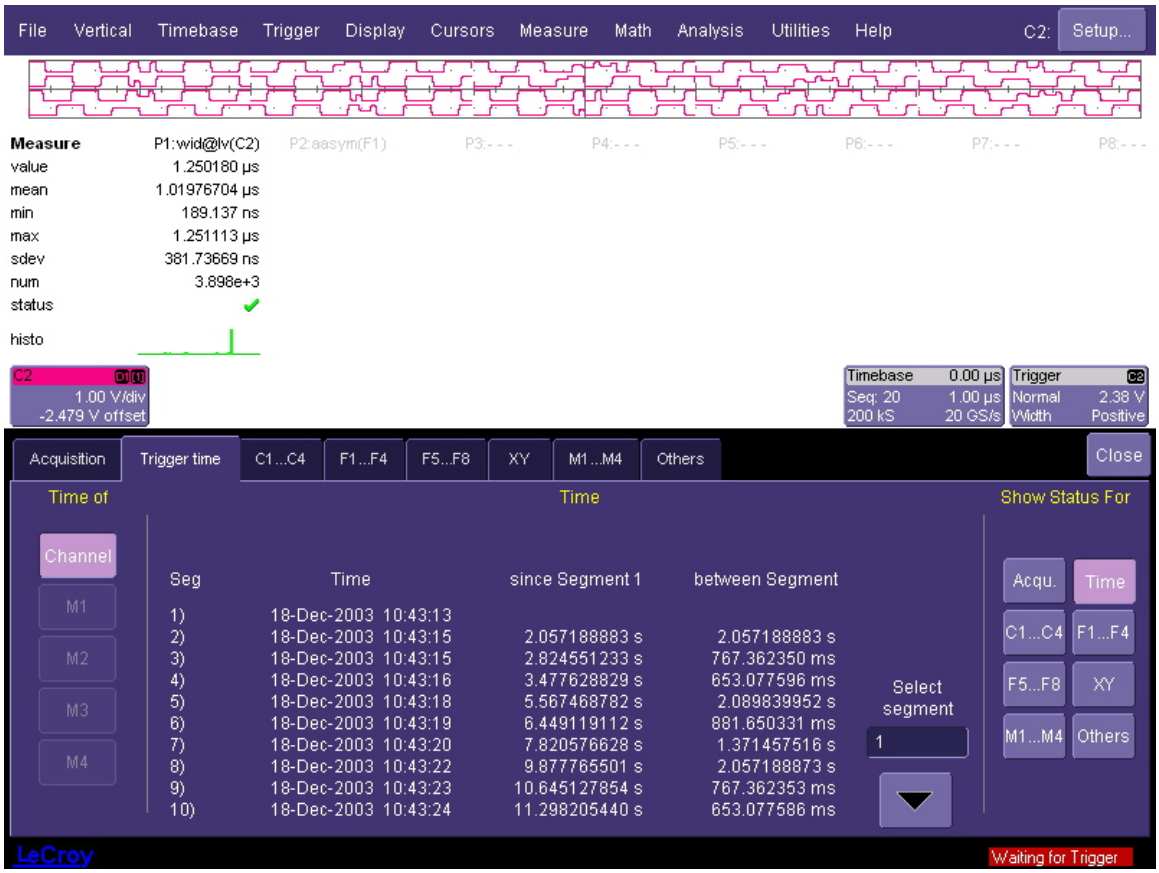

Figure 5: The display of the trigger time stamps showing the time between transient events

Exclusion triggering based on signal timing such as width, period, frequency, or duty cycle is a quick way to spot glitches and other signal anomalies. As mentioned earlier it can only be applied to periodic waveform like clocks. For more general types of waveforms, the use of the Track math function, combined with long memory, allows users to capture, locate, and isolate waveform glitches.

Parameter Track Functions

The math track function creates a waveform showing the history of parameter values that is time synchronous with the source waveform. Figure 6 shows the track function of pulse width (lower trace) displayed along with the source waveform. The vertical scale of the track waveform is pulse width in ns. Note that the changes in track amplitude are time synchronous with the changes in the source waveform. The track function can be created from any of the scope's over 140 parameters.

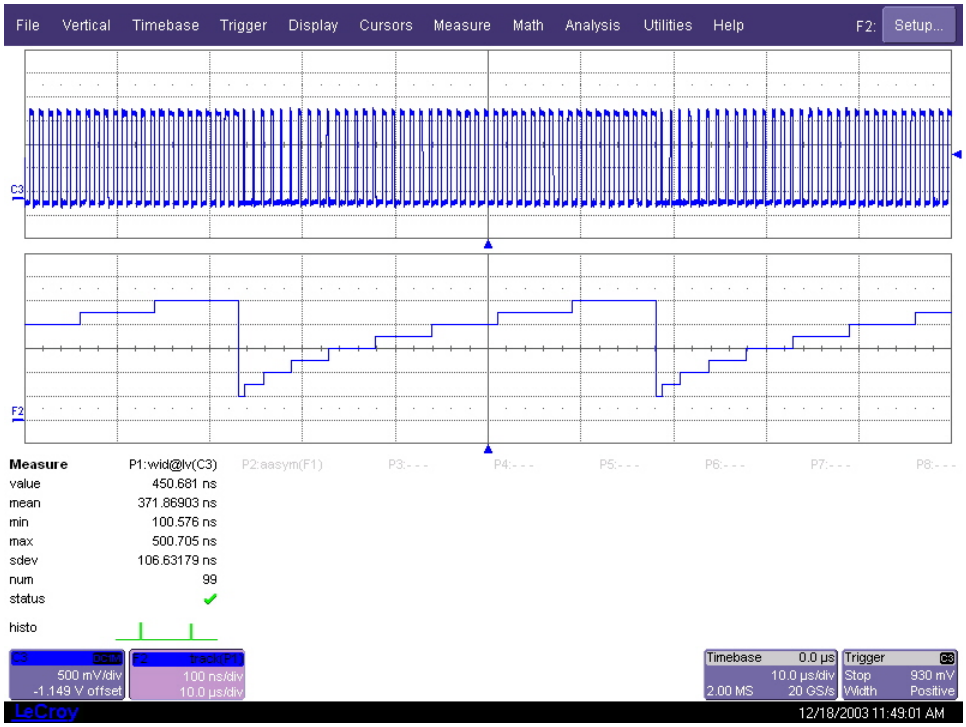

Figure 6: An example of the track function of pulse width along with its source waveform.

The best way to use the track function is to apply it to a long record and use the track function to point at waveform anomalies or glitches.

Figure 7: Using the track function to locate a glitch in a long data record.

In Figure 7, the lower trace is the track of width. The vertical spike represents a low width value. The location of the spike is time correlated with the occurrence of the narrow glitch in the data record. Since there are 326,000 pulses in the record, the ability to locate a single anomaly is a clear advantage. If we create a zoom trace of channel 2 and expand it about the spike in the track using Multi-Zoom, we can see the transient. This process is shown in Figure 8.

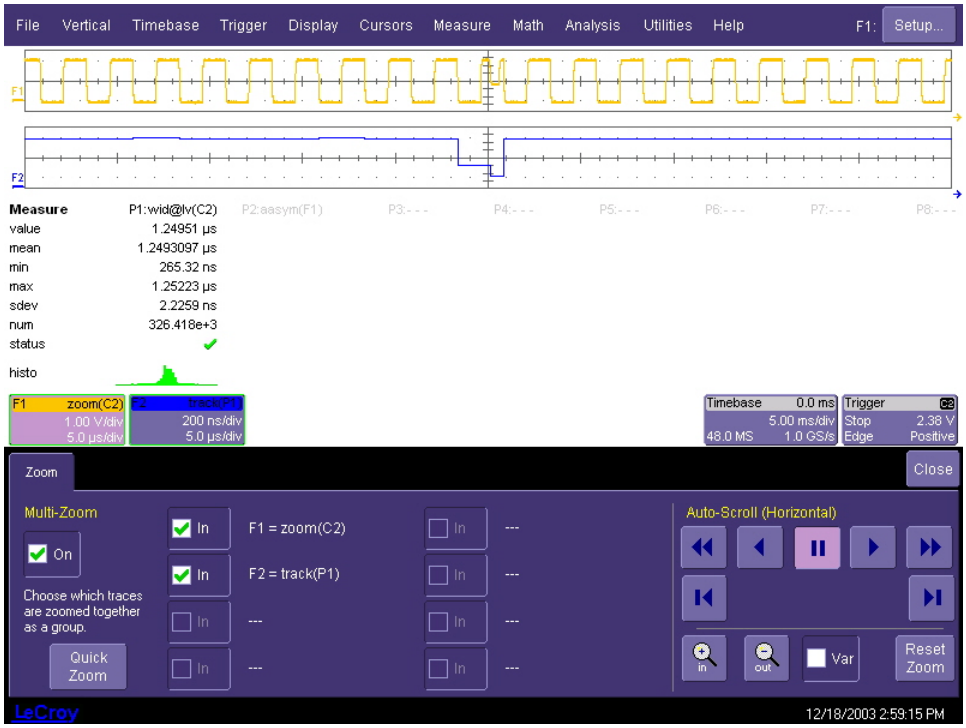

Figure 8: Using Multi-Zoom to locate and isolate the glitch

If the glitch occurs only at long intervals, it is advantageous to automate this process. Pass/Fail Testing based on parameter limits, can be employed to stop the scope or store any waveforms containing a glitch. Pass/Fail Testing is located under the Analysis pull down menu. Based on what is known about the nominal pulse parameters, the user can set limits that exclude all nominal pulses. If a glitch occurs, the scope can take any of 5, actions including stopping the acquisition, saving the current acquisition, issuing an audible alarm, or initiating a print dump (including sending an e-mail). In this example, we set the test condition Q1 to be true if the pulse width was less than or equal to 1.24 µs. The test condition Q2 was set up to be true if the pulse width was greater than or equal to 1.26 µs. The actual test, summarized in Figure 9, will stop the acquisition if the pulse width is outside the range of 1.24 to 1.26 µs. With Pass/Fail testing turned on, the scope will operate without the need to monitor the data acquisition. It will automatically log all glitches that satisfy the test criteria. There are up to 8 test conditions that can be used based on parameter limits, dual limits, or masks. These can be combined in a variety of logical combinations, which makes this feature very powerful.

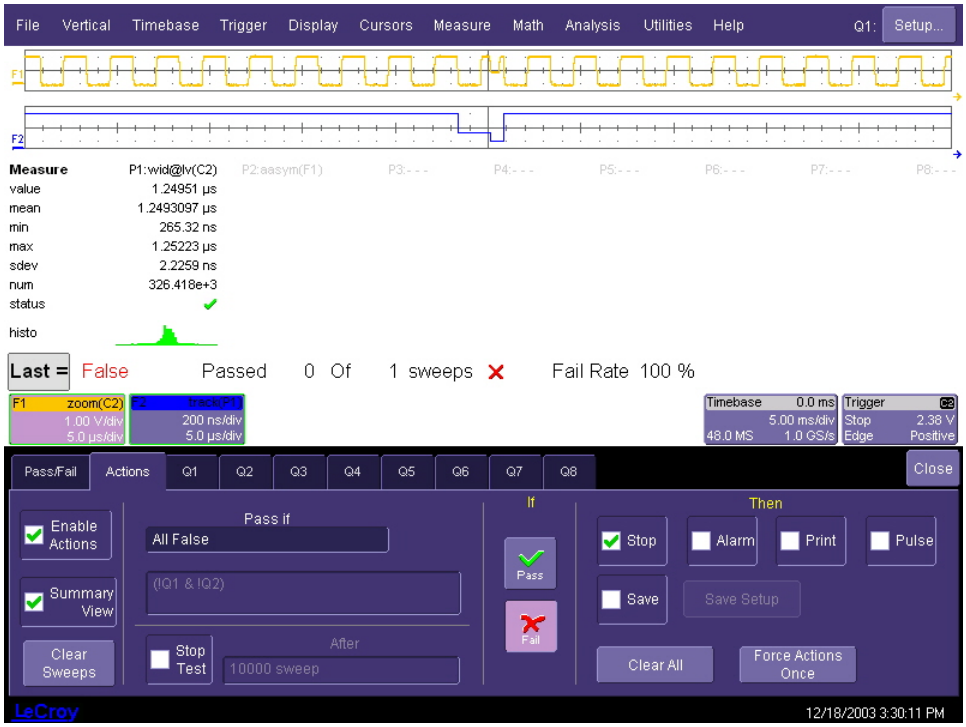

Figure 9: The Pass/Fail testing actions dialog summarizes the test conditions

Histograms

Histograms of measured parameters provide a statistical view of the "glitch" phenomena. The histogram

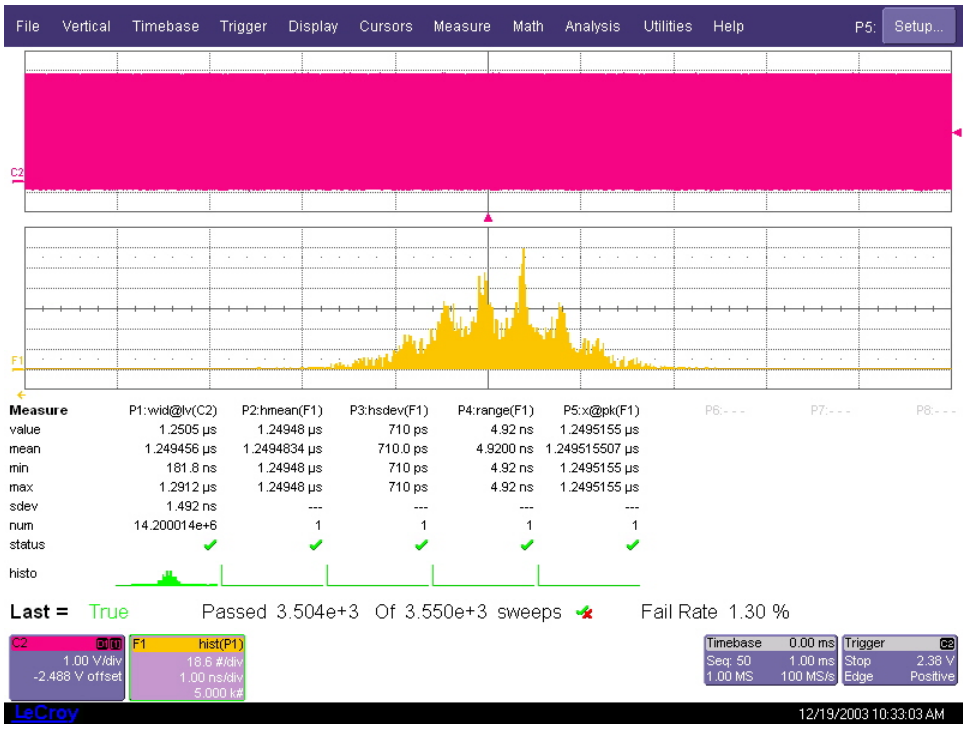

Figure 10: Combining histograms, Pass/Fail testing, and sequence mode

can provide information about the number, size, and frequency of occurrence of glitches.
In Figure 10 a histogram of pulse width has been used to analyze the width of all pulses acquired. The same Pass/Fail criteria is still being used (1.24 µs< width< 1.26 µs). Histogram specific parameters have been set up to read the mean, standard deviation, range, and width value with the highest frequency of occurrence (X@Peak).

Sequence mode acquisition is also being used to improve the measurement update rate. Because sequence mode holds off all non-essential operations during acquisition, it can greatly increase the scopes update rate. Longer acquisition (sweep) times and higher number of segments generally yield faster update rate. The principal trade-off is shorter memory length (since each sequence mode acquisition uses only a fraction of the total memory), which in some cases can cause a lower sampling rate. These settings require some trade-offs that each user has to evaluate while making the measurements. The key thing to remember is that, through the use of Pass/Fail testing the glitch catching process is automated and the user can set it up and do something else while the scope fully documents the glitches it captures.

Eye Diagrams

When serial data waveforms are measured, the traditional glitch catcher is the eye diagram. Whether triggered directly from a symbol clock or a clock derived from the data stream, the eye diagram represents a very simple way to look at multiple data transitions using a persistence display. Signal fidelity can be evaluated using Pass/Fail testing based on masks and/or parameters. Figure 11 shows a typical mask-based test of an eye diagram from a LeCroy Serial Data Analyzer model SDA6000.
This type of mask testing automatically locates and shows bits that violate the mask. All LeCroy digital scopes can create eye diagrams and test them. Options, such as SDM Serial Data Mask test make the setup and operation of eye testing available in most LeCroy Scopes.

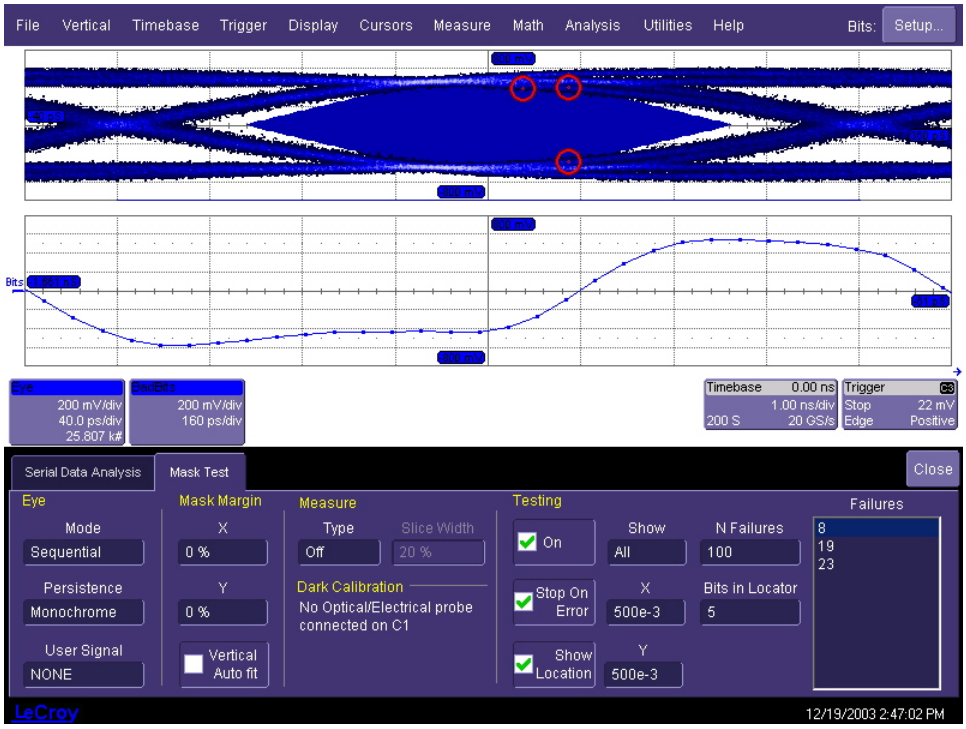

Figure 11: A mask test on a 3.125 GB/s serial data stream showing a mask violation error and the serial bit that caused it

We have seen several approaches that use LeCroy oscilloscopes to detect, locate, and isolate glitches and other transient events. If you have any problems, contact your local LeCroy sales office and ask to speak to one of our applications engineers concerning your glitch detection needs.