Histogram and Trend Calculation

With the instrument configured for *Histograms* or *Trends* (as described in previous chapters), the timing parameter values are calculated and the chosen function performed on each subsequent acquisition. The *Histogram* or *Trend* values themselves are calculated immediately following each acquisition.

The result is a waveform of data points that can be used the same way as any other waveform. Other parameters can be calculated on it, it can be zoomed, serve as the **x** or **y** trace in an **XY** plot, or used in cursor measurements.

Acquisition Sequence

The sequence for acquiring *Histogram* or *Trend* data is:

1. Trigger
2. Waveform Acquisition
3. Parameter Calculation(s)
4. Histogram Update
5. Trigger re-arm.

If the timebase is set in non-segmented mode, a single acquisition occurs prior to parameter calculations.

However, in segment mode an acquisition for each segment occurs prior to parameter calculations. If the source of *Histogram* or *Trend* data is a memory, storing new data to memory effectively acts as a trigger and acquisition. Because updating the screen can take significant processing time, it occurs only once a second, minimizing trigger dead-time. (Under remote control, the display can be turned off to maximize measurement speed.)

Parameter Buffer

The instrument maintains a circular parameter buffer of the last 20 000 measurements made, including values that fall outside the set histogram range. If the maximum number of events to be used in a histogram or trend is a number **N** less than 20 000, the histogram will be continuously updated with the last **N** events as new acquisitions occur. If the maximum number is greater than 20 000, the histogram or trend will be updated until the number of events is equal to **N**. Then, if the number of bins or the histogram or trend range is modified, the instrument will use the parameter buffer values to redraw the histogram with either the last **N** or 20 000 values acquired, whichever is the lesser. The parameter buffer thereby allows histograms or trends to be redisplayed using an acquired set of values and settings that produce a distribution shape with the most useful information.

In many cases the optimal range is not readily apparent, so the instrument has a powerful range-finding function. If required, it will examine the values in the parameter buffer to calculate an optimal range and redisplay the histogram or trend using it. The instrument will also give a running count of the number of parameter values that fall within, below and above the range. If any fall below or above the range, the range-finder can then recalculate to include these parameter values, as long as they are still within the buffer.

Parameter Events Capture

The number of events captured per waveform acquisition or display sweep depends on the type of parameter. Acquisitions are initiated by the occurrence of a trigger event. Sweeps are equivalent to the waveform captured and displayed on an input channel (**1**, **2**, **3** or **4**).

For non-segmented waveforms, an acquisition is identical to a sweep, but for segmented waveforms an acquisition occurs for each segment and a sweep is equivalent to acquisitions for all segments. Only the section of a waveform between the parameter cursors is used in the calculation of parameter values and corresponding histogram events.

The following table provides a summary of the number of *Histogram* or *Trend* events captured per acquisition or sweep for each parameter and for a waveform section between the parameter cursors.

Parameter	Number of Events Captured
Timing Parameters: p@lv, freq@lv, wid@lv, Δp@lv, edge@lv, duty@lv, tie@lv, skew@lv, setup@lv, hold@lv	**Unlimited number of events per acquisition.**
data	All data values in the region analyzed.
duty, freq, period, width,	Up to 49 events per acquisition.
ampl, area, base, cmean, cmedian, crms, csdev, cycles, delay, dur, first, last, maximum, mean, median, minimum, nbph, nbpw, over+, over–, phase, pkpk, points, rms, sdev, Δdly, Δt@lv	One event per acquisition.
f@level, f80–20%, fall, r@level, r20–80%, rise	Up to 49 events per acquisition.

Zoom Traces and Segmented Waveforms

Histograms and *Trends* of zoom traces display all events for the displayed portion of a waveform between the parameter cursors. When dealing with segmented waveforms, and when a single segment is selected, the histogram or trend will be recalculated for all events in the displayed portion of this segment between the parameter cursors. But if **All Segments** is selected, the histogram or trend for all segments will be displayed.

Histogram Peaks

Because the shape of histogram distributions is particularly interesting, additional parameter measurements are available for analyzing these distributions. They are generally centered on one of several peak value bins, known — together with its associated bins — as a histogram peak.

Example:

A histogram of the voltage value of a five-volt amplitude square wave is centered on two peak value bins: **0 V** and **5** ***V*** *(*Fig. A–1). The adjacent bins signify variation due to noise. The graph of the centered bins shows both as peaks.

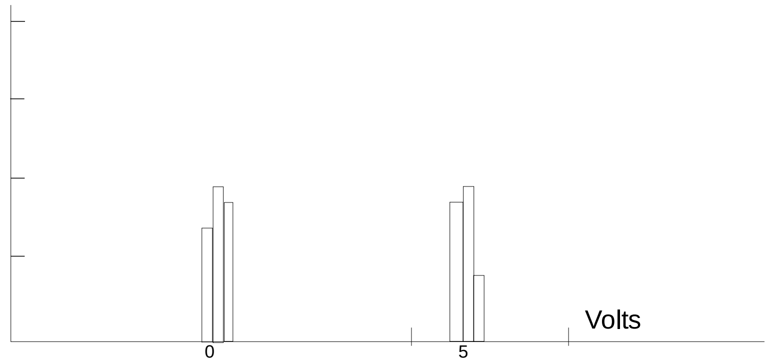

Fig. A–1

Determining such peaks is very useful, as they indicate dominant values of a signal.

However, signal noise and the use of a high number of bins relative to the number of parameter values acquired, can give a jagged and spiky histogram, making meaningful peaks hard to distinguish. The instrument analyzes histogram data to identify peaks from background noise and histogram definition artifacts such as small gaps, which are due to very narrow bins.

Binning and Measurement Accuracy

Histogram bins represent a sub-range of waveform parameter values, or events. The events represented by a bin may have a value anywhere within its sub-range. However, parameter measurements of the histogram itself, such as **average**, assume that all events in a bin have a single value. The instrument uses the center value of each bin's sub-range in all its calculations. The greater the number of bins used to subdivide a histogram's range, the less the potential deviation between actual event values and those values assumed in histogram parameter calculations.

Nevertheless, using more bins may require performance of a greater number of waveform parameter measurements, in order to populate the bins sufficiently for the identification of a characteristic histogram distribution.

Figure A–2 shows a histogram display of 17 999 parameter measurements divided or classified into 2000 bins. The standard deviation of the histogram sigma is 6.750 ps.

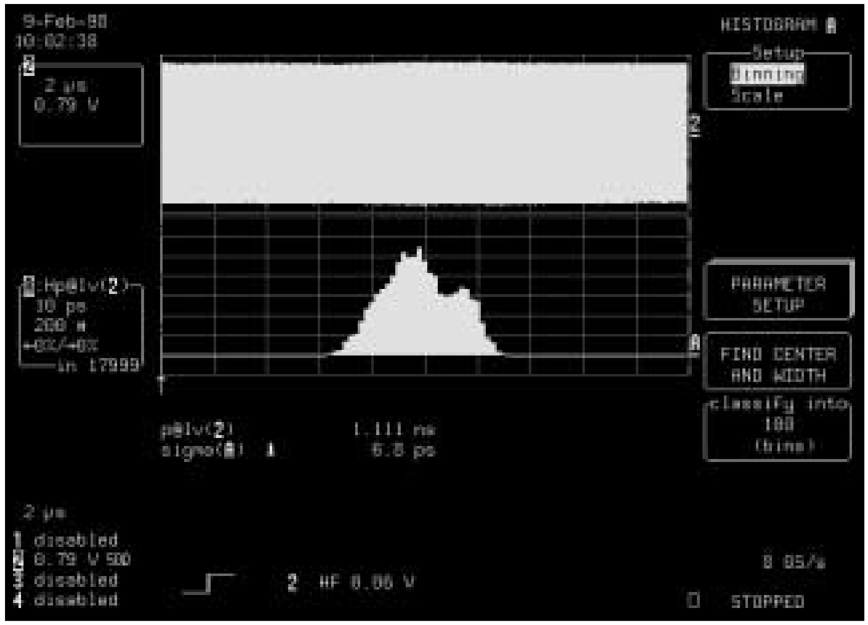

Fig. A–2 – Note the histogram's jagged appearance.

The instrument's parameter buffer (see page A–1) is very effective for determining the optimal number of bins to be used. An optimal bin number is one where the change in parameter values is insignificant, and the histogram distribution does not have a jagged appearance. With this buffer, a histogram can be dynamically redisplayed as the number of bins is modified by the user. In addition, depending on the number of bins selected, the change in waveform parameter values can be seen.

In Figure A–3, the histogram shown in the previous figure has been recalculated with 100 bins. Note how it has become far less jagged, while the real peaks are more apparent. Also, the change in sigma is minimal (6.750 ps vs 6.8 ps).

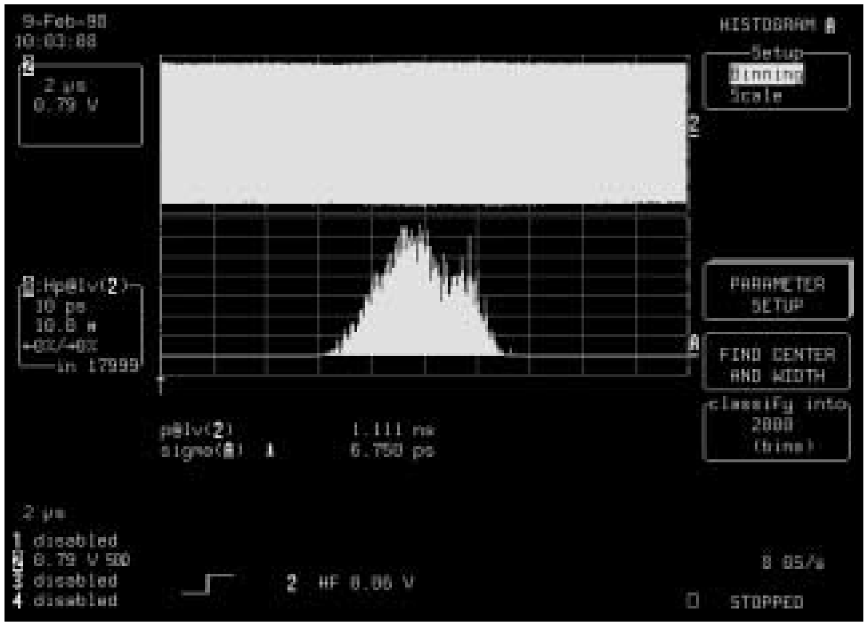
HISTOGRAM
Setup
Binning
Scale
PARAMETER SETUP
FIND CENTER AND WIDTH
classify into
2000
(bins)
disabled
disabled
disabled
STOPPED

Fig. A–3

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