[Limit the range of a waveform measurement]()

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Modern digital oscilloscopes include a variety of automatic measurement parameters such as amplitude, frequency, and delay that help you interpret the waveforms. In most cases, these measurements let you quickly complete your measurement task. Sometimes, however, the oscilloscope doesn't measure exactly what you want. When that happens, you need to use the oscilloscope's features to get the desired information.

Suppose you're looking at a bus and you need to measure the frequency of a signal when a specific device is talking. If your oscilloscope measurement supports waveform gating, you can use the chip-select signal to gate the measurement, limiting it to only times when the specific device is on the bus.

The measurement setup in **Figure 1** gates the frequency measurement of parameter P2 by the waveform in channel 2 (C2). The measurement is only made when the C2 waveform is above 50% of its full amplitude yielding a reading of 5 MHz. Parameter P1 reads the frequency across the entire waveform and shows a range of values from 300 kHz to 5 MHz.

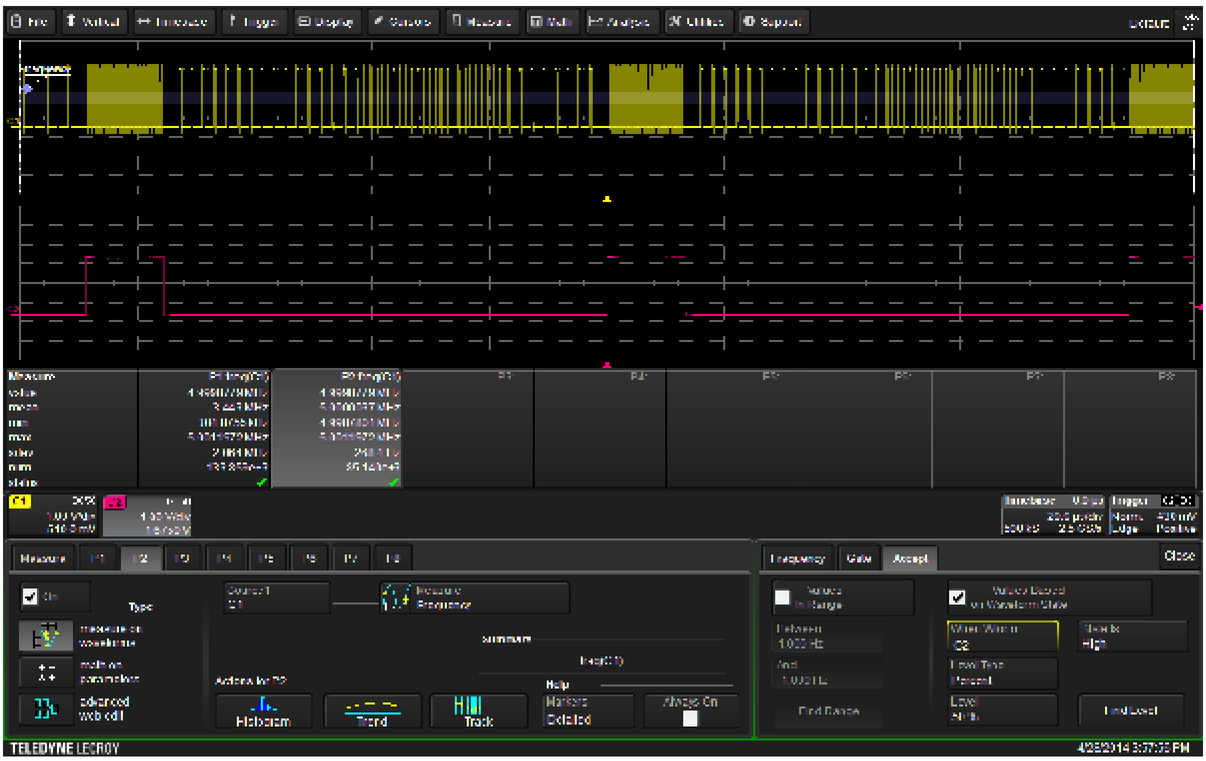

Figure 1. The gated frequency measurement in parameter P2 occurs only when the chip enable trace, C2, is high. The parameter P1 shows the frequency reading over the entire

waveform.

Waveform gating is one of three tools for limiting the range of a measurement. The others are fixed gates which make the measurement between fixed horizontal limits on the display and Accept, which only accepts measurement value within a user specified range. This selection are shown on the Gate and Accept tabs of the measurement setup in Figure 1. **Accept measurements by value**

Accept measurements by value
Acceptance criteria can be used to separate measurements that fall into fixed ranges. Take, for instance, the DDR timing measurement shown in **Figure 2**. The oscilloscope is measuring the hold time between the DDR strobe and data.

Figure 2. Acceptance criteria lets you separate the hold time measurements of read-an--write operations in a DDR memory.

The top trace, M2, is the DDR Strobe signal. The second waveform from the top, M3, is the DDR Data signal. Synchronous zooms of these waveforms are shown in the third grid from the top, Z2 and Z3, where we can see the phase relationship between the read (left side of the trace) and write (right side of the trace) operations. Read operations are in phase with the strobe and write operation occurs with a fixed delay. The bottom trace is a histogram of the hold time parameter for a 20 μs acquisition of the data and strobe lines of a DDR2 memory. The write operations have a hold time of approximately 770 ps. Read operations, which can have both in-phase and out-of-phase timing, show hold times below 100 ps and in the range of 1.2 ns to 1.67 ns.

Parameter P1 reads hold time for the entire acquisition. P2 is set to accept measured values in the range of 500 ps to 900 ps and reads the hold time for write operations. P3 is reading the hold time for read operations with a range of values between 1 ns and 2 ns. P4 is showing hold time for read operations with values between 0 and 500 ps. The use of the Acceptance criteria allows the separation of measurements by value.

Parameter gates and selection

Parameter Gates

Another tool that restricts measurements to specific areas of the acquired waveform is parameter gating. Gates mark the start and stop points of a region over which a measurement occurs. Depending on the model of the oscilloscope, a gate can be common to all measurement parameters or independent with a separate gate for each parameter. In this case the gates are independent for each parameter. The gate setup is shown in **Figure 3**.

Figure 3. Use parameter gates to restrict the measurement of standard deviation (sdev) to the region between 5.5 and 6.5 horizontal divisions on the screen. Doing so lets you measure the rms noise on the level portion of the pulse.

The measure gate for parameter P5 is setup on the right hand ‘Gate’ tab in the figure. The start gate is at 5.5 divisions and the stop gate is at 6.5 divisions. P5 is measuring the standard deviation (AC rms in some oscilloscopes) using sample values between the start and stop gate locations sown on the lower trace (Z1). This allows the measurement of rms noise on the level portion of the pulse waveform.

Parameter Selection

Lab-grade and research-grade oscilloscopes usually offer a large number of measurement parameters. Some of them may seem redundant, like having a period parameter and a period-a--level parameter. The period parameter measures the time from an edge to the next edge with the same slope at a voltage threshold of 50% of the signal amplitude. Period-at-level measurement let you set the threshold level. Knowledge of the parameters helps you apply them to specific measurement needs.

Another example is the difference between rms and standard deviation. In Figure 3, parameter P4 reads the rms level over the same horizontal range as the standard deviation measurement in trace P5. As mentioned previously, standard deviation reads the rms level of the AC component of the waveform. The mean value has been removed. The rms value includes the mean value. So the rms value of the selected segment of the waveform is 645 mV while the standard deviation is only 811 µV, which is the rms noise level. This is an example of how parameter selection can aid in separating the signal components being measured.

Derived parameters and conclusion

Derived Parameters

Some measurements, like peak-to-peak amplitude, are made directly by taking the difference of the maximum and minimum points on the waveform. Other parameters are derived from statistical analysis of the waveform data. Common pulse parameters such as amplitude, top, base, period, width, overshoot, rise time, and fall time are computed based on [IEEE standard 181](). The technique used is quite clever and can serve as a model for creating your own derived measurements. The standard bases all these measurements on a precise calculation of the pulse amplitude. Because the pulse may exhibit overshoot, ringing, and additive vertical noise, the method uses an algorithm that isn't sensitive to these limitations.

To find the amplitude of a pulse, an oscilloscope calculates the histogram of all samples in the waveform. For a pulse waveform, there should be two peaks in the histogram: The one corresponding to the higher level, the top, and the one at a lower level, the base. The histogram peaks are examined separately and the mean value of each is assigned to be the top and base amplitude, respectively. The amplitude of the pulse is the difference between the top and base values. The oscilloscope algorithm does all this internally. In **Figure 4**, we see a manual implementation of the method.

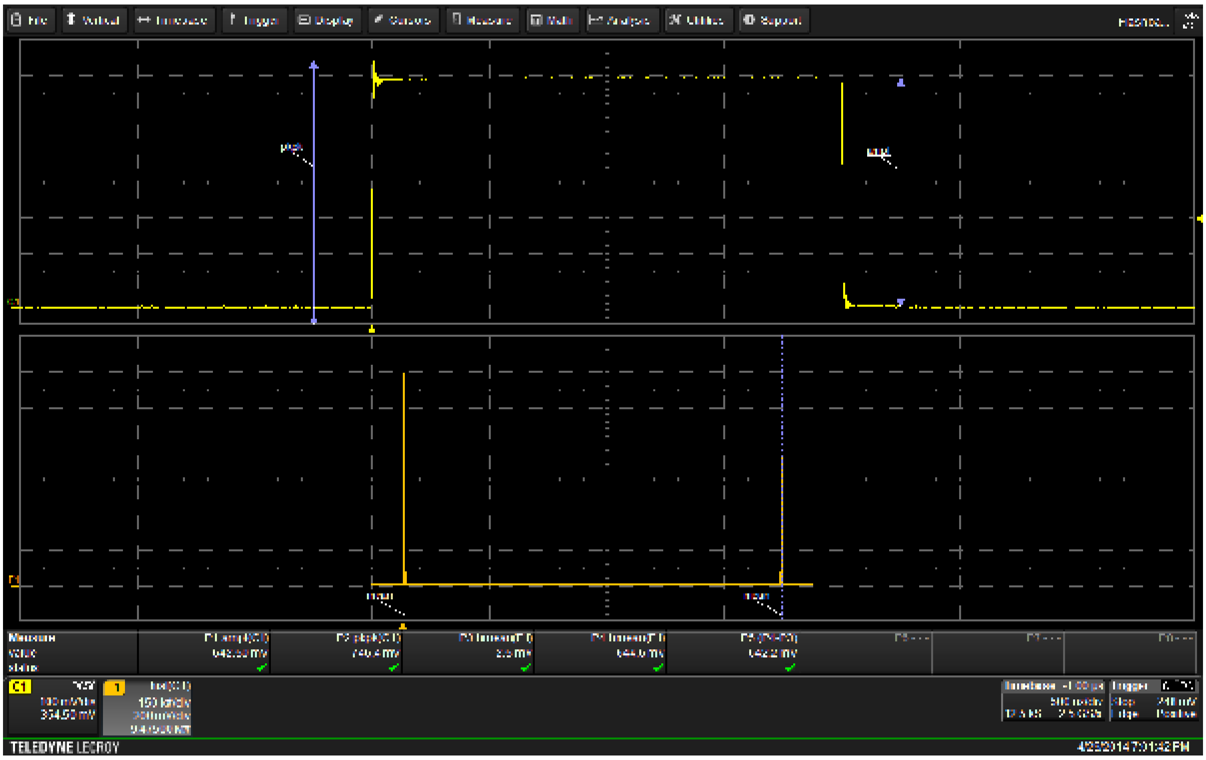

Figure 4. The manual implementation of the pulse amplitude measurement based on an analysis of the histogram of waveform samples.

The upper trace (C1) shows the pulse being measured. Parameter P1 shows the amplitude as 643 mV. The parameter P2 reads the peak-to-peak amplitude. Note that the peak-to-peak value includes the overshoot and undershoot of the pulse but that the amplitude doesn't.

The histogram of multiple acquisitions is shown in the lower trace. The peak on the left represents the base of the waveform while that on the right represents the top. Parameter P3 reads the mean of the lower (leftmost) histogram peak and P4 is reading the mean of the higher amplitude peak (rightmost). The difference is computed in parameter P5 using parameter math, which is the manual equivalent to the amplitude. You can derive the amplitude or a related measurement from a secondary analysis such as the histogram.

Conclusion

These are a few hints on how to configure your measurement setups to measure the things you need and want to measure and ignore the rest.

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