WaveSurfer MXs-B SmartTriggers

TEN MINUTE TUTORIAL

February 15, 2012

Summary

SmartTriggers are LeCroy trade name for advanced triggers based on timing and amplitude parameters of the trigger signal.

LeCroy oscilloscopes includes a powerful set of SMART Triggers that are based on timing and amplitude parameters of the trigger signal. Standard triggers include edge, glitch, width, window, interval (period), drop out, logic pattern, runt, slew rate and multistage cascade and state and edge qualified.

There are also times when an oscilloscope user knows the shape of a typical signal but wants to trigger on abnormal wave shapes. For that situation, LeCroy offers exclusion triggering based on signal timeout, glitch/pulse width, pattern width, or signal/pattern interval. The exclusion trigger allows the DSO user to have a maximum chance of capturing rare events by keeping the trigger circuit active nearly 100% of the time. All the triggers are easy to access and easy to set up.

Equipment Requirements

A LeCroy WaveSurfer Xs-B series oscilloscope.
1 passive Probe
WaveSource 100 demonstration signal source

The WS 100 Demonstration Signal Source

The WS 100 signal source is a USB powered circuit board which has 6 sets of output waveforms. There are two sets of duplicate output connections on the WS 100 are marked Ch1, Ch2, and Trig. Table 1 summarizes all the available outputs. In this tutorial we will use selection S6 (SIG) and the Ch2 output.

SIGNAL OUTPUTS

SIGNAL	PROTOCOL		CHANNEL 1	CHANNEL 2
S1	SPI		DATA (SDO)	CLOCK (SCK)
S2	I2C		DATA (SDA)	CLOCK (SCL)
S3	UART		Not Used	TRANSMIT (100 kbits/sec)
S4	RUNT		RUNT (positive) JITTER (35%)	RISE TIME (slow = 100 nsec) GLITCH (pos. width = 165 nsec) JITTER (35%)
S5	PWM		PERSISTENCE (9 pulse widths incrementing in width and quantity	LONG MEMORY (500 KHz and 750 KHz, 33 msec delay)
S6	SIG		Not Used	NON MONOTONIC Edge RUNT (negative)

Table 1: The Signal Outputs Available from the WS 100 Demonstration Signal Source

Displays shown in the tutorial are based on the following initial setup on a WaveSurfer Xs-B series scope:

1. Recall the default setup: File pull down > Recall Setup> Recall Default.

2. Turn off channel 2 by pressing the 2 button in the Vertical control group on the front panel twice.

3. Connect the WS 100 to a front panel USB connector. If the Found New Hardware Wizard appears press the cancel button. Select S6 (SIG) of the WaveSource100 using the small pushbutton switch on the circuit board.

4. Connect the passive probe to Channel 1 of the scope and the probe tip to Ch2 of the WS 100. Ch2 is the SIG2 signal which contains a glitch and a non-monotonic edge anomaly. Connect the probes ground clip to the ground pad shown in Figure 1.

5. Verify that the input coupling on channel 1 is DC 1 MΩ: Touch or click the channel 1 annotation box>touch or click on the coupling field >select DC 1MΩ.

6. Press the front panel AutoSetup twice to automatically setup the scope.

7. Press the Normal trigger mode button in the Trigger area on the oscilloscope's front panel.

8. Touch or click the Timebase annotation box on the display of the oscilloscope. Set Time/Division: 500 μs, Select Set Maximum Memory and set Maximum Sample Points to 1MS.

9. This completes the initial setup. The scope display should be similar to Figure 2.

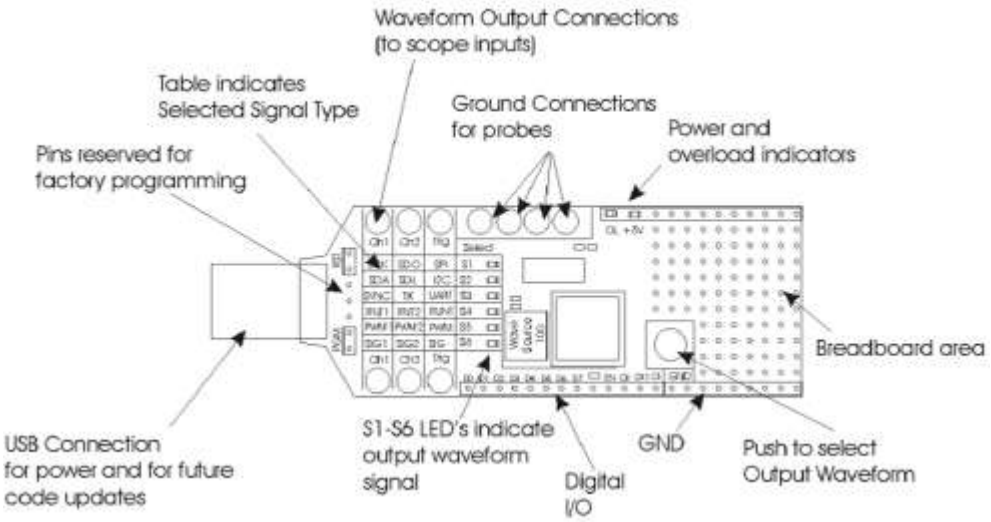

Figure 1: *An outline drawing of the WS 100 demonstration signal source. Use the push button to select one of 6 waveform choices*

Figure 2: *The acquired SIG2 signal on channel 1 contains a runt and a non-monotonic edge which are not obvious using an edge trigger*

Touch or click the trigger annotation box or press the Setup button in the front panel Trigger area. This will cause the Trigger dialog box to be displayed. The display should look like Figure 3. On the left side are the selections for the trigger type. This tutorial will investigate width trigger and the SmartTriggers including Interval, Glitch, Runt, and Slew Rate.

Figure 3: *The Trigger dialog box showing the Trigger Type selections*

One of the crucial issues in setting up a trigger is having knowledge of the signal you are trying to trigger on. This tutorial will try to provide methods which will give insight in setting up trigger in the absence of specific knowledge about unknown components within the signals. Let's go on a glitch hunt!

Width Trigger

We are currently triggering on a signal which is a 1.5 kHz square wave. Let's characterize the signal further. Turn on parameter measurements (Measure pull down> Measure Setup>check the Show Table box. The scope will display parameters P1 (amplitude of C1) and P2 (frequency of C1). Go to the P3 setup filed and set up P3 to measure the width of C1. Similarly, Set up P4 to measure the rise time of C1.

Click the check boxes on the right to turn on statistics and Histicons. Parameter statistics include the last measured value, the mean, minimum (min), maximum (max), standard deviation (sdev), and the number of measurements included in the statistics (total population). The histicons are iconic histograms which show the distribution of measured values for each displayed parameter. This is shown in Figure 4.

Figure 4: *Viewing parameter statistics and histicons*

The width measurement shows a mean of 323 µs with a maximum of 338 µs and a minimum of 20 µs. The histicon of width, right below the parameter readout, shows a distribution that is centered about the mean value with a rarely occurring outlier with a lower measured value. This means that the 20 µs minimum value doesn't occur with any regularity.

Press the Clear Sweeps button on the front panel to restart the measurement acquisition. Note that the min and max readouts tend to stay near the mean value of 323 µs until several hundred measurements are accumulated. My measurement showed a difference between min and max of 15 µs. This implies that there is an anomalous pulse with a width around 20 µs that occurs at a low repetition rate. While we could setup a trigger to catch this event lets take a more general approach. We know the nominal pulse width is 323 µs. Let's set up a width trigger that excludes a small range about the nominal value. We are looking for pulses that are not 'nominal'. This is called an 'exclusion trigger'.

Bring up the Trigger dialog box and select Width as the trigger type. The source is C1, DC coupling, and polarity is positive, these are the default values. On the right hand side of the trigger dialog select the exclusion button ( ]..[ ). Press the Delta button. Set the nominal value to the mean value of the width measurement, in our example it is 323 µs. Set the Delta to 15 µs, this is the value we obtained from the range (max-min) of the short accumulation of width measurements. The scope should now be triggering. It should show two different pulse anomalies as shown in Figures 5 and 6.

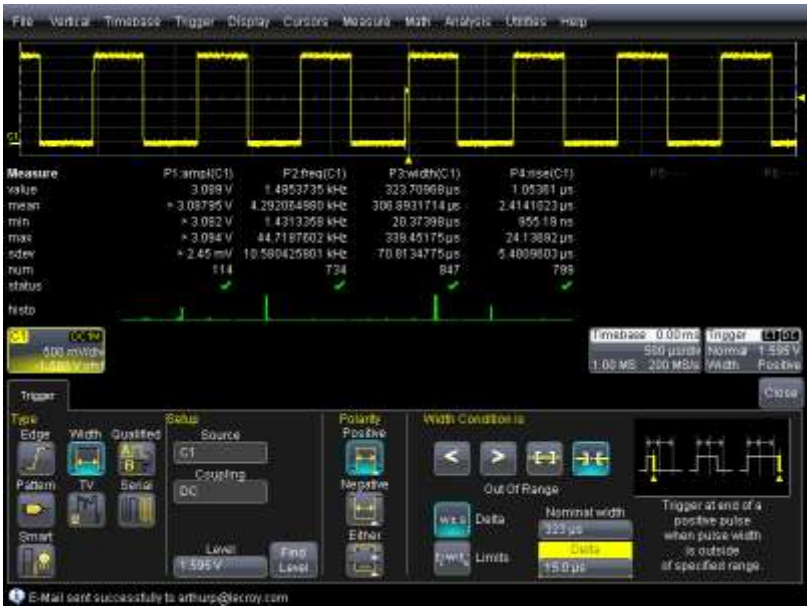

Figure 5: *The first of two pulse anomalies revealed by the exclusion trigger setup*

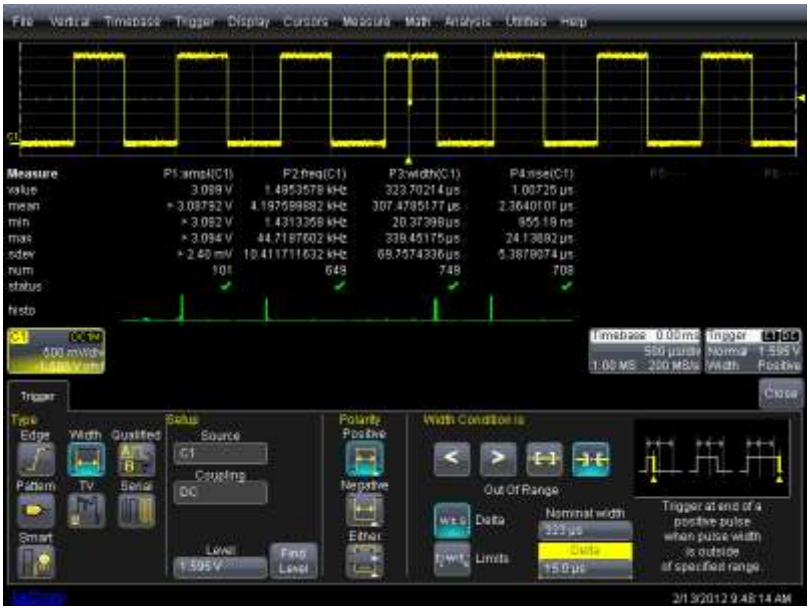

Figure 6: *The second of two pulse anomalies revealed by the exclusion trigger setup*

So, based on the nominal width we were able to set up a trigger that captured two different anomalies. Return the trigger type to edge. Press clear sweeps.

Select S4 (Runt) of the WaveSource100 using the small pushbutton switch on the WS 100 circuit board. Press the AutoSetup button on the front panel twice to set up the scope again. Set the trigger mode to Normal.

Slew Rate Trigger

Slew Rate trigger is sensitive to the signals transition times. Look at the risetime measurement on the scope shown in Figure 7. It has a nominal value of about 26 ns. The histicon shows a bimodal distribution with a large peak about the mean and a smaller outlier with a higher value. Let's use this information to set up the slew rate trigger.

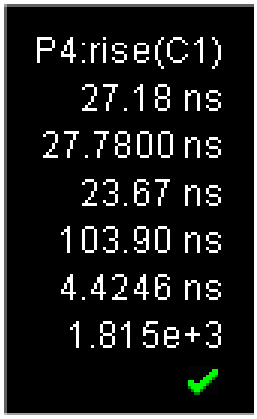

***Figure 7**: Risetime readout and histicon*

Bring up the trigger dialog box. Select Smart trigger type and select Slew Rate as the Smart Type. Leave the setup at the default values (C1, DC, and positive). Press the Find Levels button to have the scope automatically setup the Upper and Lower Levels. Press the Greater Than (>) button in the Time Condition Is control group. Set the Lower Interval to a value of 27ns. In order to see the trigger event with good time resolution press the zoom button on the front panel. This will turn on a zoom trace (Z1) of C1. Use the Horizontal scale control on the front panel to expand the horizontal zoom scale to 200 ns/div. The result is shown in Figure 8 where the slow risetime is due to a step on the rising edge of a pulse.

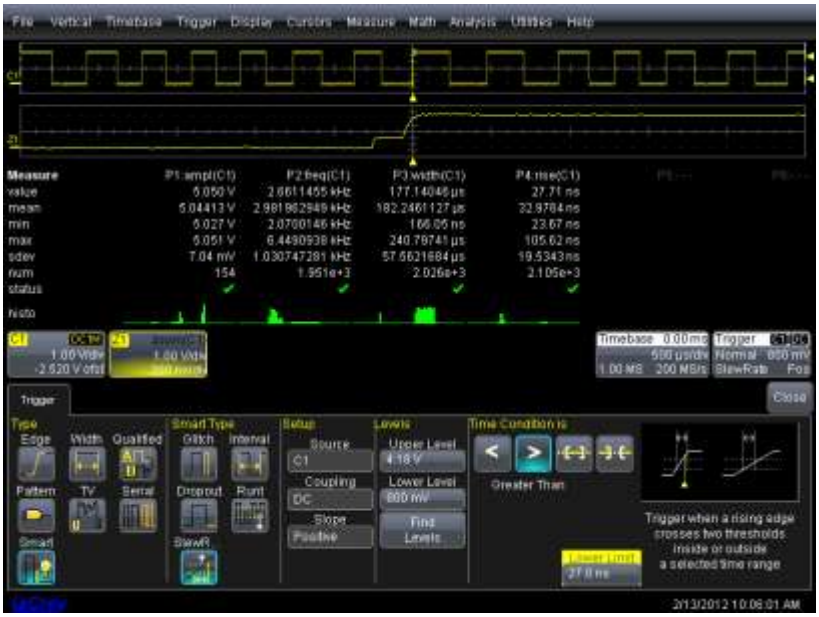

***Figure 8:** Setup and use of the Slew Rate trigger showing a pulse with a stepped risetime*

Glitch Trigger

Glitch trigger, like the Width trigger, is sensitive to pulse width. Return the scope trigger type to Edge and accumulate about a thousand width measurements. The width of this pulse, as seen in the histicon, has a uniform distribution over a range of values and an infrequent occurrence of a much narrower pulse. In Figure 9 you can see the minimum width is 166 ns. This of course tells the story but let's assume all you know is the nominal value. Press the Clear Sweeps button on the front panel of the oscilloscope. Note the minimum pulse width before the 160 ns value occurs. This is about 155 μs.

Figure 9: *Width readout and histicon*

Change the trigger setup to use the Smart as trigger Type and Glitch as the Smart Type. Press the Find Level button. Set the Glitch Condition to "<" (less than). Enter 152μs. Change the horizontal scale of the zoom trace to 1 μs. The display should appear as shown in Figure 10.

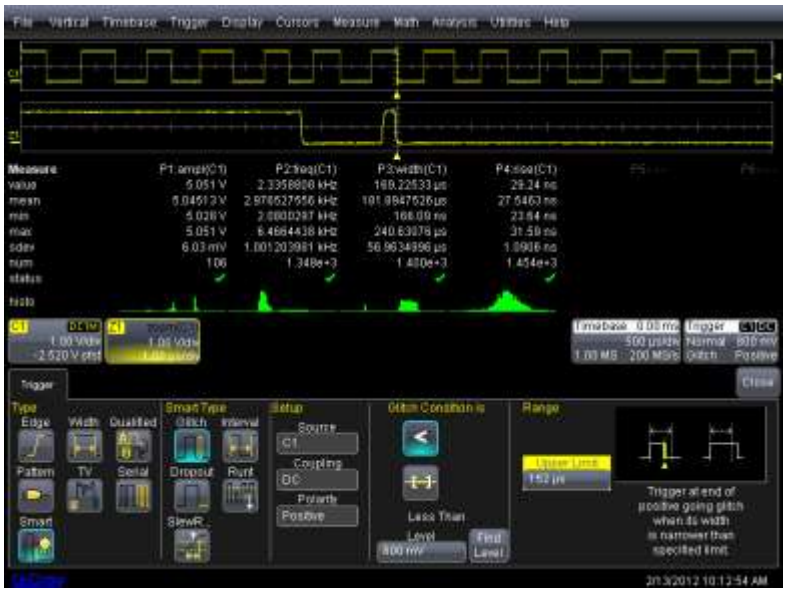

Figure 10: *Using Glitch trigger to capture a 160 ns glitch*

Runt Trigger

Restore the trigger type to Edge.
Turn Off the zoom trace Z1.
Move the probe tip from the CH2 test point to the CH1 test point on the WS 100.
Change the Trigger type to Smart and the Smart Type to Runt.
Leave the Setup conditions in their default state (C1, DC, Positive)
Press the Find Level button in the Trigger dialog box Level control group.
The Runt trigger has a time condition to qualify the duration of the runt. Set the Time Condition to ">" (greater than) and the Lower Interval to its minimum value of 1 ns. The scope should now be triggering on a runt pulse as shown in Figure 11.

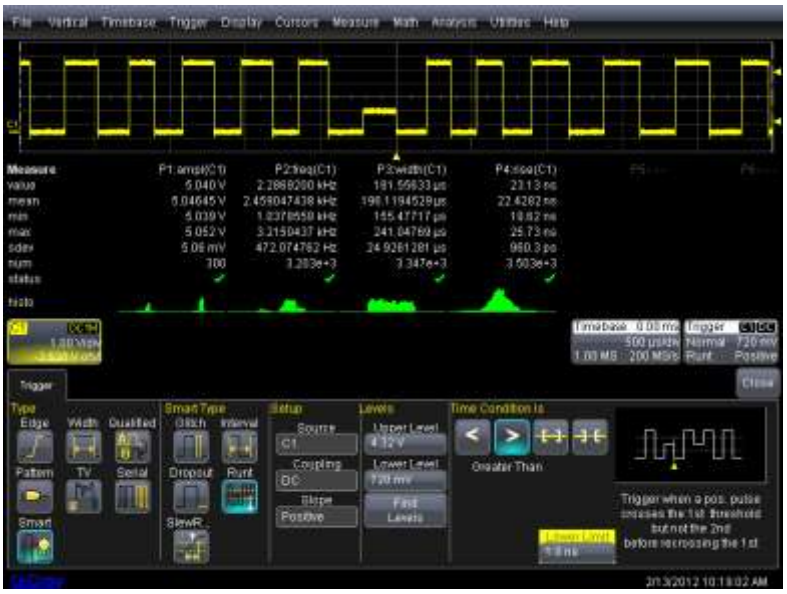

Figure 11: *The trigger setup for the runt pulse*

Interval Trigger

The interval trigger is sensitive to period. Restore the trigger type to Edge.

Change the definition of the parameter P2 from frequency to period. Touch or click on the parameter P2 readout, this will bring up the measure dialog box. Touch or click on the P2 Measure field, when the measure selection scroll box appears scroll to period and click on it.

The period has a mean value of 396 μs. The histicon shows a large concentration of values about the mean and a series of higher values with a much lower incidence of occurrence. As we did before, press the Clear Sweeps and observe the max value for period, it starts out at about 480μs and then jumps to 848 μs when the runt occurs.

Select Smart Trigger type and Interval Smart Type. Leave the Setup conditions in their default state (C1, DC, Positive). Press the Find Level button in the Trigger dialog box Level control group. Set the Interval Condition to ">" (greater than) and the Lower interval to 490 µs. The scope should be trigger on the long interval above the runt as shown in Figure 12.

Figure 12: *Using Interval SmartTrigger to capture the runt pulse*

The use of SmartTriggers requires some thought and some analysis but LeCroy oscilloscopes include all the tools to make you successful.

This completes this tutorial.