WAVECREST Corporation

DTS 2070 ARMING OPTIONS (USING AUTOMATIC ARMING MODE)

Application Note No. 123

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DTS 2070 Arming Options (Using Automatic Arming Mode)

Applications Note Number 123

Flexibility of DTS Arming Modes

Two channel delay measurements are increasingly used in today's high frequency clock distribution designs. Typical two-channel measurements include output skews and 1/0 skews. One major advantage of using the DTS 2070 is its ability to measure jitter as part of the skew measurements.

For two-channel delay measurements, the DTS 2070 also provides the flexibility of several arming modes and enabling options. This flexibility, however, if not understood, can lead to misinterpretation of measured results and possibly negative delay numbers. Therefore, negative delay numbers should not be interpreted as an alarm condition. By definition, a positive delay measurement indicates the CH1 signal is leading the CH2 signal. A negative delay measurement means the signal edge at CH2 occurs before the signal edge at CH1. See Figure 1A and 1B for examples of both positive and negative delays. This distinction is important because it can lead to some confusion, especially with first-time users.

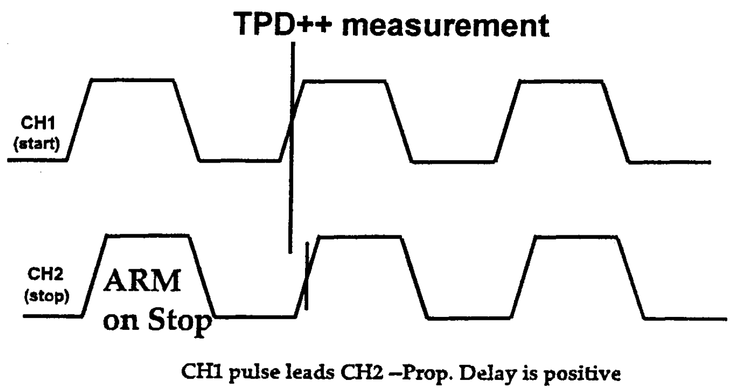


Figure 1A

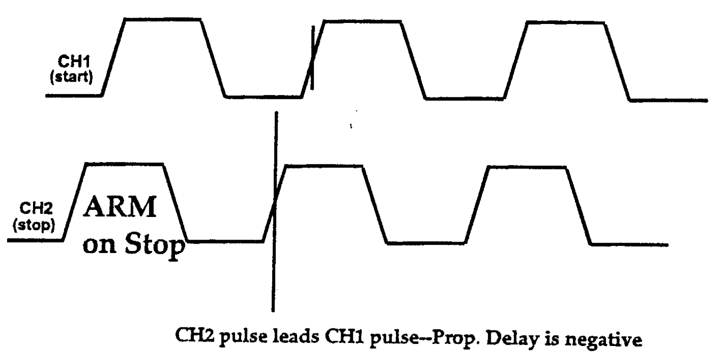


Figure 1B

When measuring output skews on devices with multiple output frequency relationships, a negative delay number may appear during a two-channel delay measurement. PLL-based clock drivers with multiple output frequencies such as 2x and 4x that of the input reference are common along with PLLs with programmable output frequencies. This application note attempts to show the flexibility of the DTS 2070 arming modes and prevent the confusion of misunderstood arming modes. Once these arming modes are understood, two-channel delay results can be easily measured and analyzed.

The DTS 2070 has three arming capabilities that are selectable by the user. These are Automatic, External, and Manual. Only the automatic mode is addressed in this application note. In most applications, using the automatic mode along with the Virtual Instrument default arming enable options is adequate. For a detailed discussion on arming, see WAVECREST Application Note No. 115, “Arming the DTS 2070.”

Auto arming enables the DTS 2070 to synchronously or randomly measure time events. Where as, selecting an external arming mode option enables the DTS 2070 to synchronize with the event to be measured much like an oscilloscope does when it is triggered. Arming the DTS 2070 is similar to triggering an oscilloscope, but not exactly the same.

Within the auto arming mode, there are three arming enable options:

- Arm on start
- Arm on start first
- Arm on stop (default mode for all DTS 2070 setups)

In two channel measurements, CH2 is always the STOP channel. This fact goes a long way in maximizing the uses of the different DTS 2070 arming modes available.

Comparisons of Three Enable Options

For a two-channel delay measurement, the DTS 2070 has four different delays it can measure: TPD++, TPD--, TPD+-, and TPD-+. Figure 2 and the TPD++ description illustrate the interpretation of the polarity designators. Figures 1A and 1B show arming on CH2 (stop) since Arm on Stop is the default setup on the DTS 2070. In Figure 2, the TPD++ interpretation is the propagation delay from the first rising edge after the arm on CH1 (start) signal to the first rising edge after the arm on CH2 (stop) signal. Using Figure 1A as reference, notice that it leads to a positive delay number. Figure 1B leads to a negative number.

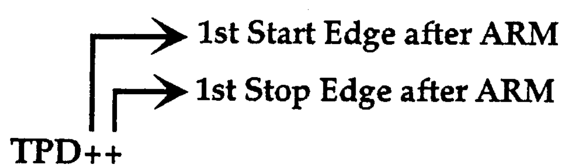
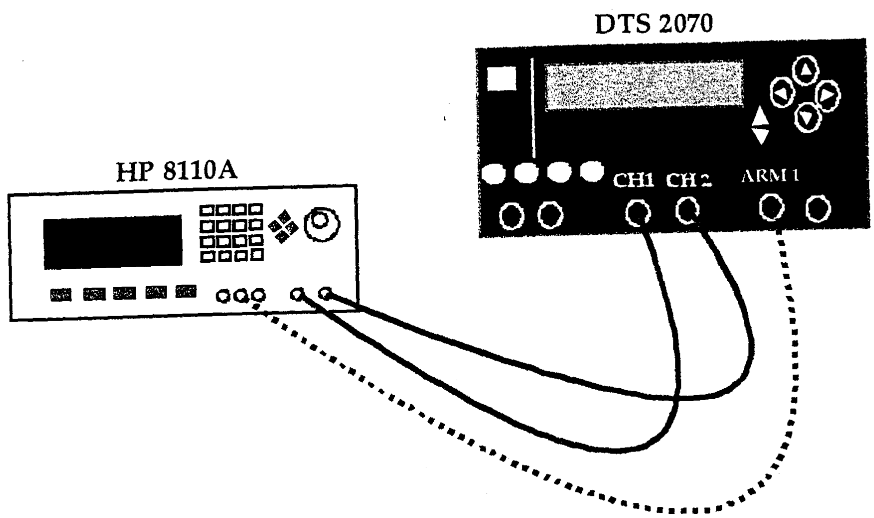


Figure 2

Comparison of Arming Options (CH2 signal leading CH1)

The following discussion, along with Figures 4-7, illustrate how selecting one of the three arm enable options can lead to a difference in measured results. For the purpose of this discussion, CH2 is leading CH1 signal. Although Figures 4-7 represent two-channel delay measurements with a 2:1 frequency relationship, other relationships (e.g. 4:1, 8:1, etc.) can also be analyzed if the basic concepts are understood. A rising-edge to rising-edge delay measurement (TPD++) between CH1 and CH2 can be made. Start Count=1 and Stop Count=1 remain the same even as the arm enable modes are changed.

The signals are from a pulse generator (see Figure 3) with variable pulse delay capabilities. To create a 2:1 frequency relationship between two signals, a 10MHz 50% duty cycle square wave is applied to CH1 and a 20MHz square wave is applied to CH2 of the DTS 2070. Figures 4-7 show the three arm enable options and the first start and stop rising edge references after the arm signal is recognized. Figure 4 shows the applicable reference edges using Arm on Start First. Figure 5 shows the reference edges using Arm on Start. Finally, Figures 6 and 7 show the reference edges using Arm on Stop. Two diagrams are shown since Arm on Stop has two potential arm references due to the 2:1 frequency relationship between CH2 and CH1 signals. The two arm references are labeled ARM1 and ARM2.



Pulse generator setup for delay measurements

Figure 3

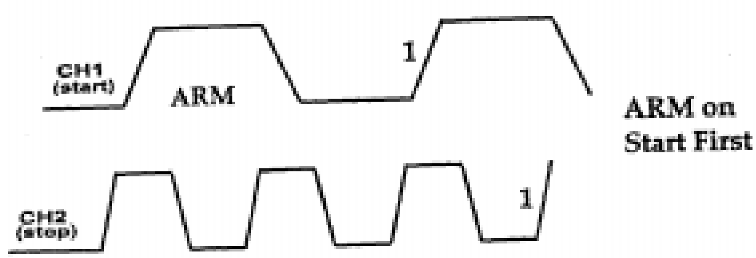


Figure 4

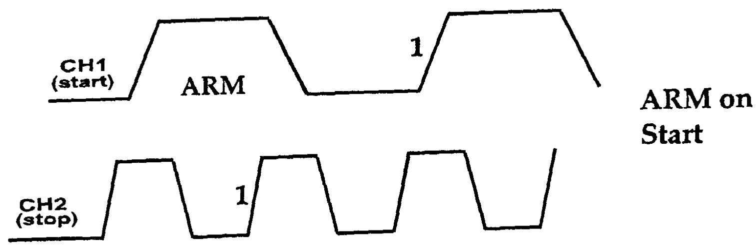


Figure 5

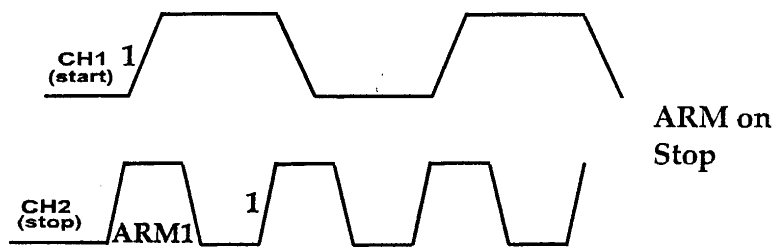


Figure 6

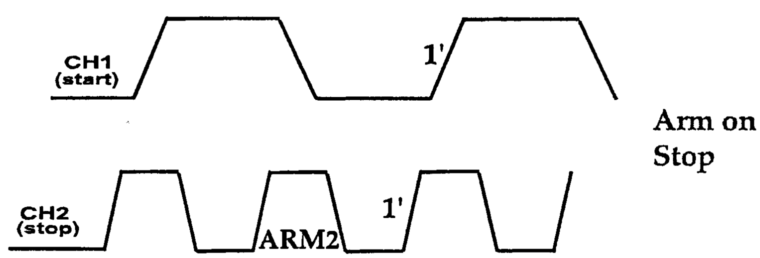
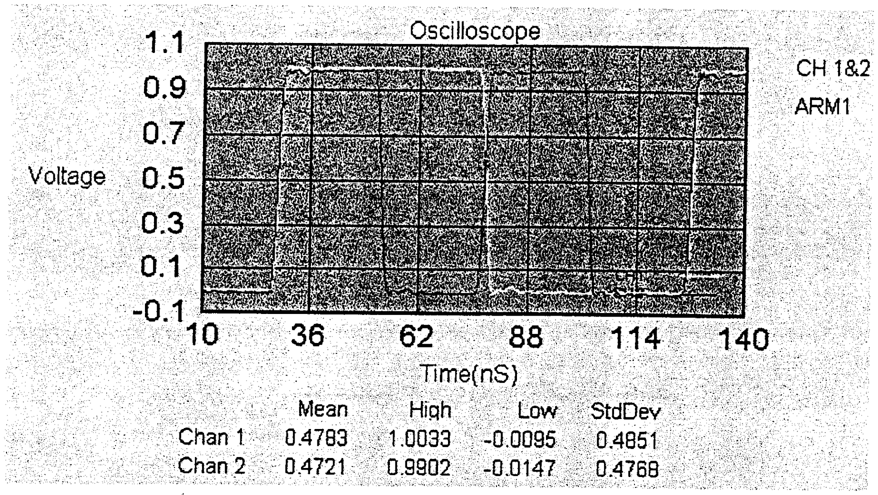


Figure 7

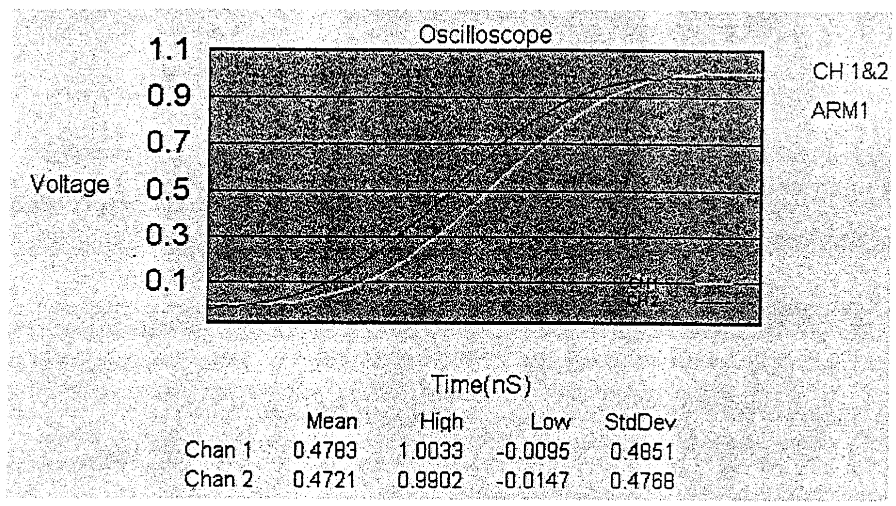
Plot 1 shows the waveform relationships between CH1 and CH2 using the DTS 2070 oscilloscope utility. CH2 frequency is 2x that of CH1. Plot 2 shows the zoomed in view of both CH1/CH2 rising edges. CH2 rising edge leads CH1 rising edge. This is considered a negative delay number by our previous definition. The measured delay using the oscilloscope X,Y cursor is approximately -200ps to -300ps. This explains the Arm on Stop results later in this application note.

In Figures 4 and 5, both Arm on Start First and Arm on Start modes utilize the CH1 signal for the arming pulse. Arming is threshold sensitive and determined by the pulse find measurement. The big advantage of using Arm on Start First is that the results are always positive. However, there is a setup time condition that must be met. This is illustrated in the section on “Special Consideration Using Arm on Start First.”



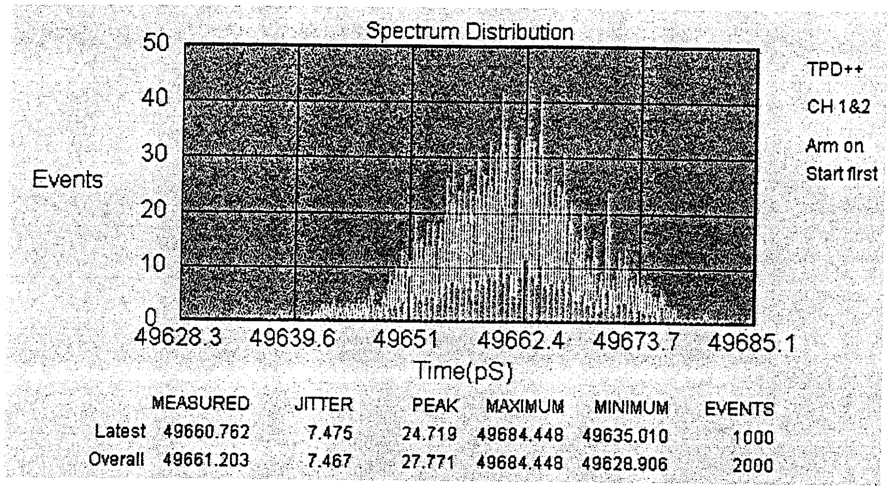
Plot 1

Plot 1 oscilloscope utility shows the 2:1 frequency relationship between CH2 (20MHz) square wave and CH1 (10MHz) square wave. The amplitude was set to 1v on the pulse generator. The DTS 2070, along with the measurement cables, were deskewed before generating the plots for this application note.



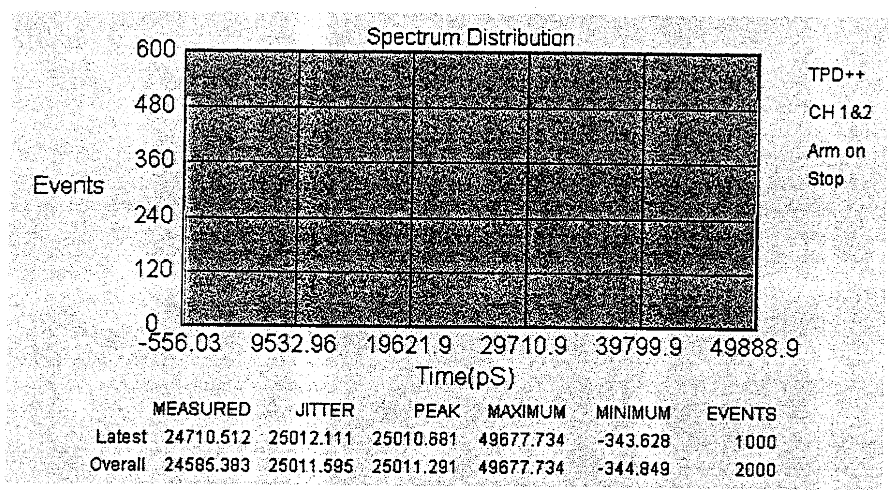
Plot 2

Plot 2 uses the oscilloscope utility XY cursor feature to zoom in on CH2 and CH1 rise times. The delay settings on the pulse generator were set to zero. The -340ps time delta between the two rising edges at the 0.5v levels is the intrinsic channel difference between the two channels of the pulse generator. A minus sign was included to emphasize the CH2 signal leading the CH1 signal. This particular pulse generator's CH1 signal arrives at the DTS approximately 340ps later. Another way of stating this is that the electrical path from the pulse generator is 340ps longer for CH1 than for CH2.



Plot 3

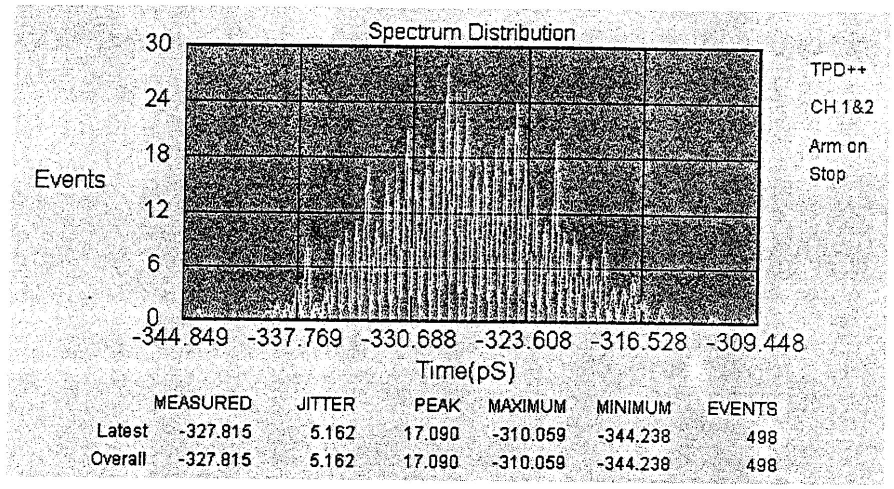
Arm on Start First—Plot 3 is the spectrum analysis plot of TPD++ using the Arm on Start First option. As illustrated in Figure 4 and mentioned earlier, using this enable option always gives you a positive number as long as the slower frequency is applied to CH1. From Figure 4, one can see that a delay approximation can be determined by recognizing that TPD++ is approximately the pulse period of CH2 (20MHz or 50ns). Plot 3 indicates the average TPD++ is 49.66ns for a sample size of 1000. The measurement is less than the expected 50nS because CH2 signal leads CH1 by a small amount of time (approximately 340ps).



Plot 5

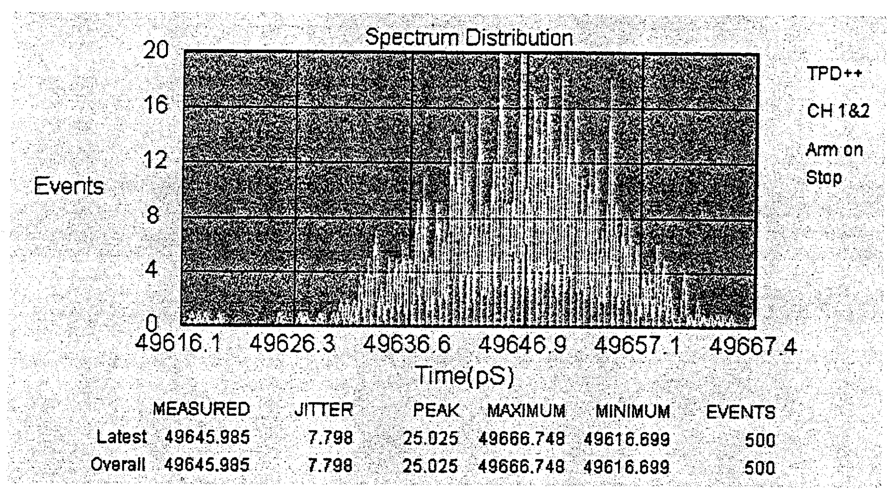
Arm on Stop (unfiltered)— Since Plot 5 shows two period histograms, an explanation follows. One histogram is at the extreme left hand side of the plot and the other is at the right side. Since CH2 frequency is 2x that of CH1, there are two arming pulses which the DTS can potentially recognize. This causes the DTS 2070 to measure two different delay times. To isolate and measure each delay histogram, one can use the Virtual Instrument digital filtering options. For additional information on the use of digital filtering see the “Function Analysis Tutorial” section of WAVECREST Application Note No. 121, PLL Jitter Characterization and Debugging. The DTS randomly selects one or the other for a given period measurement. See Figures 6 and 7.

If ARM1 pulse of CH2 is recognized, the DTS measures edge 1 of CH1 to edge 1 of CH2. If ARM2 pulse of CH2 is recognized, the DTS measures edge 1 of CH1 to edge 1 of CH2. In the ideal case, where the DTS recognizes both ARM pulses equally, the number of hits for the first histogram equals the number of hits for the second histogram. The filter TPD++ results are shown in Plots 6 and 7.



Plot 6

Arm on Stop Using Filter (ARM2 is recognized)—This spectrum analysis plot is the result of using the DTS "digital filtering" option. This allows the user to view only a selected portion of the spectrum with more detailed information. As Plot 5 shows, the left hand histogram suggest a TPD++ measurement of minus 500ps. By selecting a filter window of 0ps MAX and -600ps MIN, we get Plot 6, which shows the 1 edge to 1 edge propagation delay in Figure 7. The average results from a sample of 500 and is -328ps. This agrees with Plot 2 and the -340ps delay measure using the oscilloscope utility.



Plot 7

Arm on Stop Using Filter (ARM1 is recognized)—To create the right side (positive) period histogram in Plot 5, a filter window of 60nS MAX and 0ns MIN was used. The Plot 7 spectrum analysis shows an average TPD++ measurement of 49.65ns. This is the edge 1 to edge 1 delay shown in Figure 6, where ARM1 is recognized as the arming pulse. The result is positive since CH1 edge 1 leads CH2 edge 1. Again, similar to Plot 6, a sample size of 500 is shown since the "filtering" option is being used.

Special Consideration Using Arm on Start First (arm setup condition)

Plots 1-7 were generated with the CH2 signal leading the CH1 signal due to the intrinsic characteristic of the pulse generator being used. This section explores a special consideration for using Arm on Start First and how violating the arm pulse setup condition can lead to two different delay measurements. The setup area is highlighted by the dotted rectangle in Figure 8 and Plot 8.

Arm on Start First has a setup condition that must be met to see the first edge on CH2 after being armed on CH1. The setup condition for the DTS 2070 is 1ns, and 4ns for the DTS 2075. This means if a positive pulse occurs within 1ns on the DTS 2070, the DTS does see it and instead measures CH1 to the 2nd positive (TPD++) edge on CH2 (edge 1 to edge 1 in Figure 8). See Plot 10 for the TPD++ results. Notice in Plot 9 that the first edge occurred at 700ps (<1ns)—the DTS measured to the 2nd CH2 rising edge.

See Plots 11 and 12 for examples where the arm setup condition is met. In Plot 7, the DTS measures edge 1 of CH1 to the first positive edge of CH2 (edge 1).

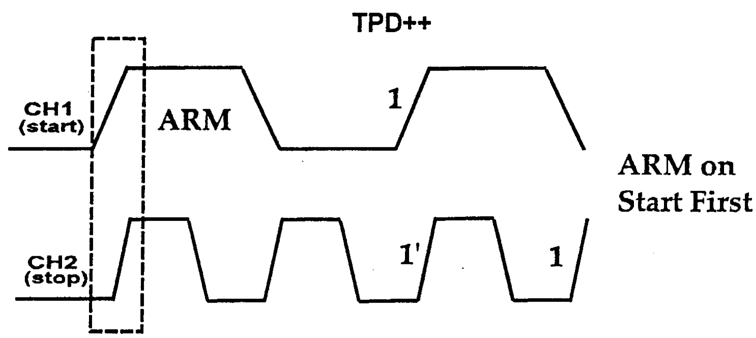
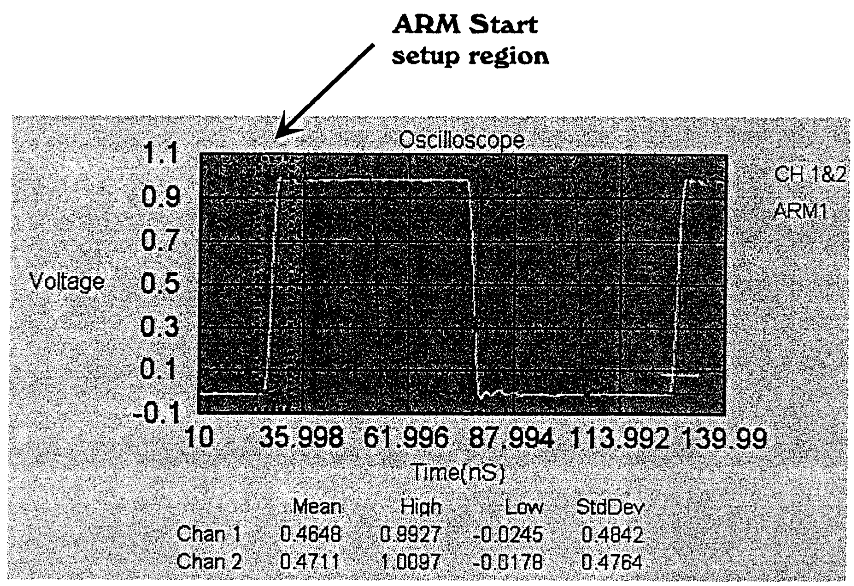
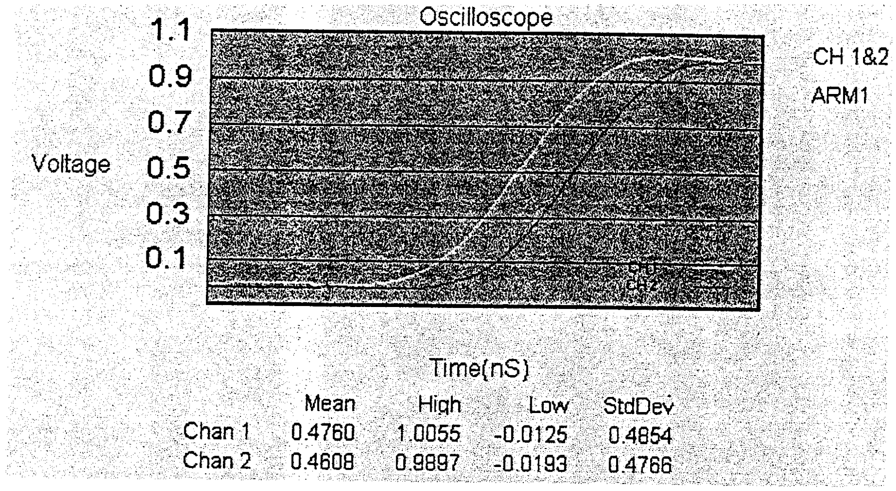


Figure 8



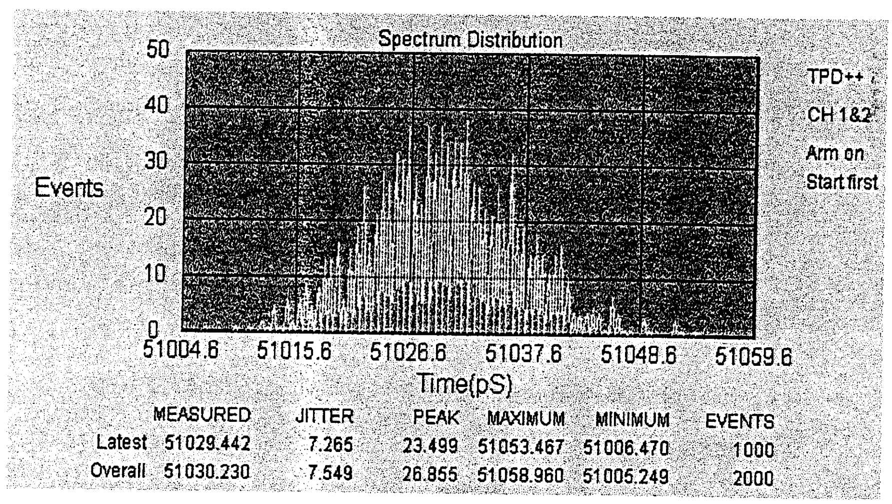
Plot 8

Plot 8 shows the 2:1 frequency relationship between CH2 (20 MHz) square wave and CH1 (10MHz) square wave. A delay factor on the pulse generator was set to cause the CH1 signal to lead CH2, but not enough to meet the 1ns setup time requirement. The DTS is expected to make an edge 1 to edge 1 delay measurement for TPD++. This is the case shown in Plot 10.



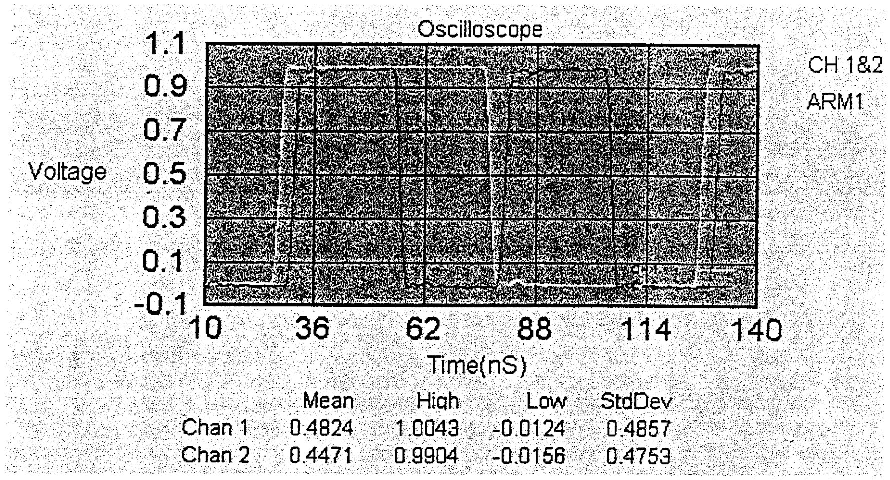
Plot 9

Plot 9 uses the oscilloscope utility XY cursor feature to zoom in on both CH2 and CH1 rise times. CH1 rising edge leads CH2 rising edge by 700ps. Therefore, the 1ns arm setup time is not met.



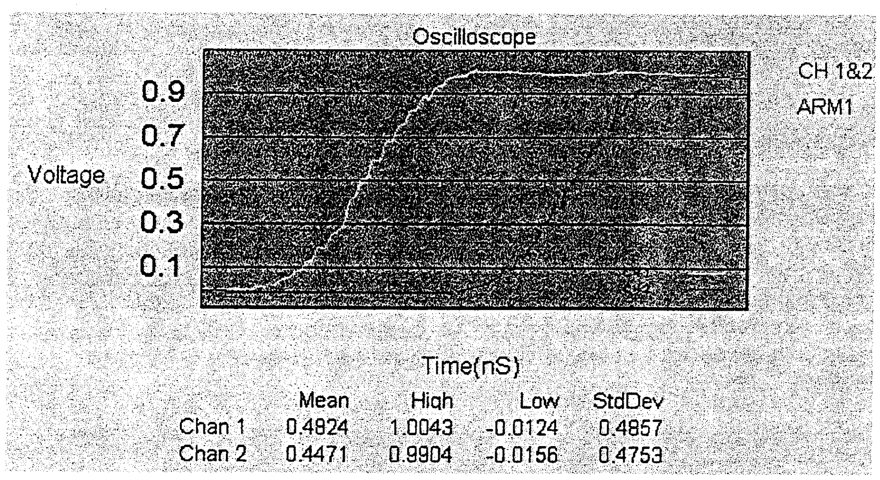
Plot 10

Arm on Start First (arm not meeting 1ns setup condition)—Plot 10 shows the delay measurement from edge 1 of CH1 to edge 1 of CH2. The average period measured is 51.03ns. Since the CH1 signal is leading the CH2 signal by 700ps, this particular measurement can be expected to be above 50ns.



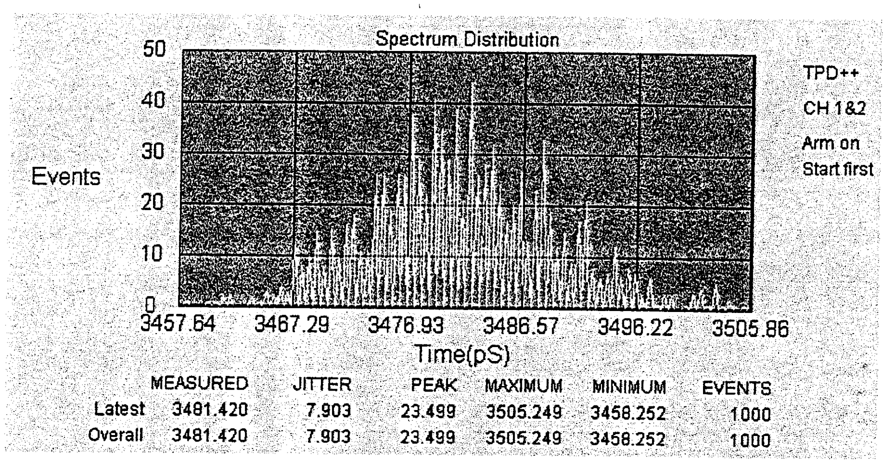
Plot 11

In Plot 11, the delay from the pulse generator was adjusted until the Start Arm Setup condition of 1ns is met. Compare this arm pulse setup area to Plot 8.



Plot 12

Plot 12 is a zoomed-in view of Plot 11 around the two rising edges. Using the XY cursor on the oscilloscope utility, the measured delay between CH1 and CH2 rising edges is approximately 3.5ns. The arm pulse setup condition is easily met.



Plot 13

Arm on Start First (ARM meeting 1ns setup condition)—As shown in Plots 11 and 12, the Arm Start meets the 1ns setup condition, so the DTS measures from the first edge of CH1 to the first edge of CH2. Plot 13 shows a TPD++ of 3.48ns. This agrees with Plot 12, which shows the delay between the rising edge of CH1 and CH2 to be 3.5ns.

Conclusions

ICs such as multiple-output PLL clock drivers/generators or synthesizers are common in designs today and continue to grow in popularity as electronic systems grow in complexity. The DTS 2070 provides a simple, yet effective solution as the interest increases in measuring the relative jitter when making skew measurements. In general, IC devices have outputs with frequencies that are integer multiples of the input frequency. This being the case, certain considerations must be understood for the DTS 2070 to be used effectively.

When making two-channel delay measurements such as TPD++, TPD--, TPD-+, or TPD+-, certain situations can develop which may appear inconsistent. A negative delay number for example, should not be considered alarming. It simply means the CH2 signal is leading the CH1 signal.

This application note illustrates several considerations for effectively using the arm enable options. A frequency ratio of 2:1 illustrates some potential misconceptions. A two channel TPD++ was chosen for illustration purpose. Using a constant Start=1 and Stop=1 count and the automatic arming mode, TPD++ measurements were made using three arming options to show the difference in measurement results. The three arming options are: Arm on Start First, Arm on Start, and Arm on Stop.

Using various arming options delivers different results. The results are valid for each arming option. The plots in this application note provide a foundation for interpreting these results and drawing proper conclusions. One benefit of using Arm on Start First is the always positive delay measurements. To effectively use Arm on Start First, the 1ns setup condition must be met.

A good habit to develop during early use and training on the DTS, is to draw out the expected pulses to measure and label the measured edges of both channels along with the arming pulse (similar to Figures 4-7 of this application note). Using this approach allows the user to “see” which arming enable options are best for making two-channel delay measurements.

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