WAVECREST Corporation

ARMING THE DTS 2070

Application Note No. 115

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Introduction

The DTS 2070 is a one-shot time interval measurement instrument that can measure time intervals synchronously or asynchronously with respect to the signal being measured. This note discusses the special arming features of the DTS 2070.

The DTS 2070 has the ability to digitize voltage in time with a resolution as fine as 10ps. The voltage can be graphically displayed on a PC or workstation using *WAVECREST*'s *Virtual Instruments*™ software. This feature enables the user to see the input channels while debugging programs without having to connect an external oscilloscope.

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

Oscilloscopes have triggered time bases that require triggering to start the time base sweep. This allows them to display events with respect to linear time. The DTS is not triggered but Armed or Enabled to make a measurement of each event that occurs on the input channels. The following discusses the use of the various Arming and Gating inputs on the DTS 2070 for making a variety of time interval measurements.

How the DTS Works

Figure 1 shows a simplified block diagram of the Digital Time System (DTS). The inputs of the DTS feed dual comparators on each channel, 50Ω to ground. This enables the DTS to measure events such as period, pulse width and rise/fall time on a single channel in one-shot mode. The Time Propagation Delay (TPD) is measured using both channels.

Voltage Reference Start (V.Ref. Start) and Voltage Reference Stop (V.Ref. Stop) set the threshold trip points for the comparator inputs. The following diagram shows a Start and Stop reference voltage on each channel.

The External arming inputs 1 and 2 go to logic circuits within the DTS. In conjunction with the "Enable Modes," they select whether the DTS is synchronous or asynchronous with respect to the signal being measured.

Another important signal is the "CPU ready" signal generated when the CPU is ready to process another measurement. The time duration is program controlled so that the measurement or "burst" rate can vary.

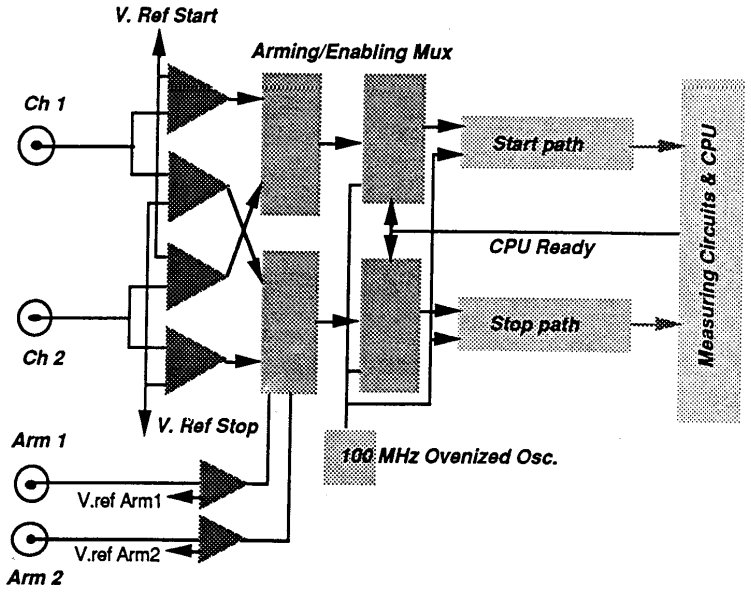


Figure 1.

Hierarchy of Making a Time Interval Measurement

All of the time interval measurements made with the DTS 2070 follow a simple four-step progression: arm, enable, function and execute. The user asks the following questions and then executes a measurement:

1. What arming mode is required ("Auto Arm" is default)?
2. What enable mode is required ("Arm on Stop" is default)?
3. What function is being measured?
4. Execute time interval measurement.

To make using the DTS simple and repeatable, all four steps are defaulted for each measurement function of the instrument. These defaults can be changed by the user as desired.

		DTS DEFAULT SETTINGS				
FUNCTION	Trig %	CHANNEL	ARM MODE	ENABLE MODE	Strt CT	Stop CT
TPD++	50-50	1-2	Auto	Arm on Stop	001	001
TPD- -	50-50	1-2	Auto	Arm on Stop	001	001
TPD+ -	50-50	1-2	Auto	Arm on Stop	001	001
TPD- +	50-50	1-2	Auto	Arm on Stop	001	001
TT+	10-90	1	Auto	Arm on Stop	001	001
TT-	90-10	1	Auto	Arm on Stop	001	001
PW+	50-50	1	Auto	Arm on Stop	001	001
PW-	50-50	1	Auto	Arm on Stop	001	001
Period	50-50	1	Auto	Arm on Stop	001	002
Frequency	50-50	1	Auto	Arm on Stop	001	256

Table 1.

In addition to the default settings shown in table 1, all of the channel voltage references are set to 0.0000 volts unless changed by the execution of a “Pulse Find” or set externally by the user. The pulse find command sets the reference voltages for each channel based on the trigger percent indicated in menu 7.

Arming Modes

The user can select any one of 3 Arming modes via the GPIB or from the front panel. Each arming mode has a separate button on the front panel. When one of the buttons is pressed, a light on the button indicates the DTS mode. The default arm mode is “Auto Arm.”

Auto Arm

The default arm mode for the DTS 2070 is Auto Arm. In the Auto arm mode the DTS makes *asynchronous* time measurements with respect to the signals on the input channels selected.

For example, measuring jitter with any of the measurement functions using Auto Arm enables a worst-case jitter measurement. By using Auto Arm, the DTS asynchronously or randomly measures the selected parameters. If a statistically large enough sample size was selected for the jitter measurement, the user can be assured of catching most any randomly occurring event. These events would escape detection by any other triggered instrument such as a DSO sampling scope. Refer to *WAVECREST* Application Note No. 121 on measuring PLL jitter for more details.

Because the DTS "Enable Modes" use the actual channel inputs for stimulus, "External Arming" is not necessary for most types of measurements. In fact, the only time the user must use External Arm is when he/she wants to synchronize the DTS measurement with a specific event in a data stream for serial channel devices, like a random data stream or vector set from an ATE tester or pattern generator (see App Note 120). The user may measure 101,356 cycles into the vector set. The External Arm input enables the DTS prior to the measurement parameter.

In cases where the signal input is reoccurring, or is a repeating pattern, the DTS does not need to be armed externally. In fact, the main benefit of running the DTS in Auto mode is to catch the stray random event that escapes the real-time or sampling oscilloscope (see figure 2).

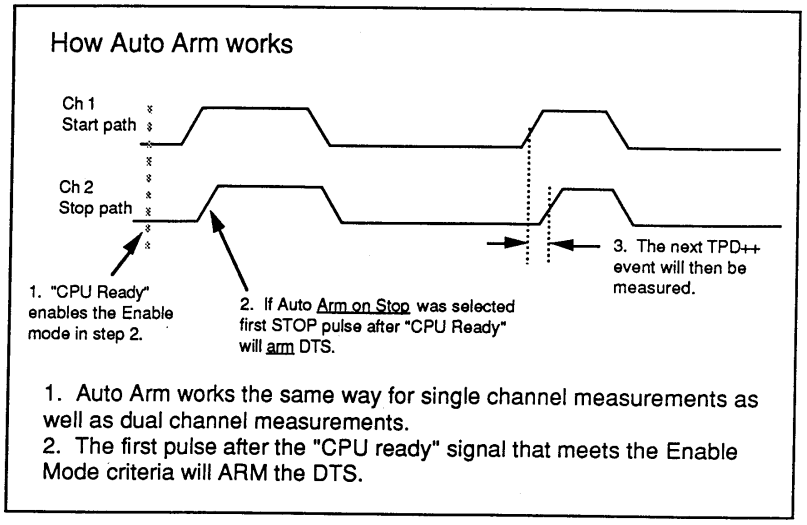


Figure 2.

In figure 2, the user wants to measure the function TPD++. The default modes are selected: *Auto Arm* and *Enable on Stop*. Figure 2 shows the sequence of events leading up to the actual measurement. If a sample size count is set to 1000, then the above cycle repeats itself 999 more times.

The results of all 1000 one-shot measurements are stored in DTS memory and statistically analyzed to display the average, ± peak and rms jitter. The ± peak is the min/max spread of the 1000 measurements. The rms jitter is the true statistical standard deviation for the 1000 measurements and represents the rms jitter in a Gaussian distribution. The average is the center of the distribution.

External Arm

Arming inputs 1 and 2 are multifunctional. The following items are selectable via the GPIB or front panel menus 9 & 10. Refer to the DTS 2070 Users Guide for directions on how to enter data into the front panel registers.

Menu 9:

1. Enter the *external voltage* reference trip point for Arm 1 & 2. (If "Pulse Find" is executed while the DTS is in External Arm mode, the Arming trip point levels are automatically found and entered into these registers for the user. The value entered depends on the "TRIG" percentage selected for that function.)

2. Select the *edge direction* of the external arm signal to arm the channel inputs by changing the direction of the rising/falling symbols in front of each reference voltage.

Menu 10:

1. Select which arm, 1 or 2, arms which channel, 1 or 2. Arm 1 or 2 can separately arm channel 1 and 2 or both channels (see figure 3). The default mode is Arm 1 for both channels.

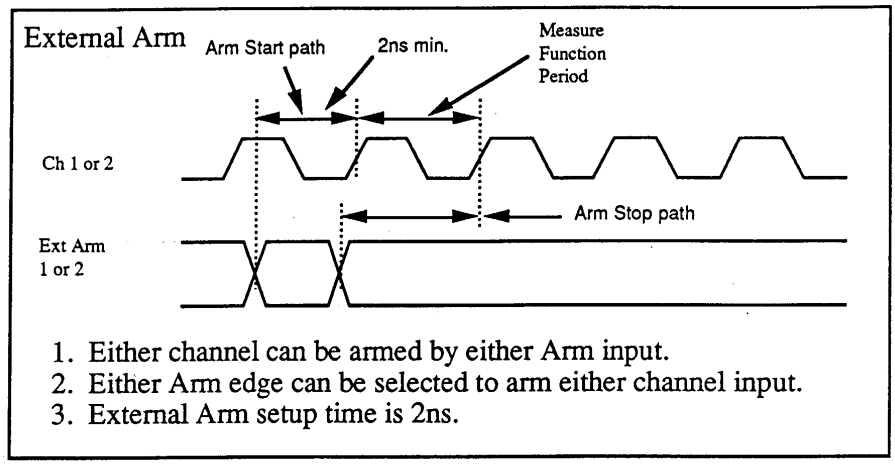


Figure 3.

In Figure 4, the pulse width of a single arm signal arms the DTS. To arm both channel inputs 1 and 2 by the same arm signal, connect the desired arming signal through a power splitter to both arming inputs, 1 and 2. Then arm channel 1 on the rising edge of arm 1 and channel 2 on the falling edge of arm 2. In that setup, the pulse width of the arming signal controls the time duration between the measurements taken between channels 1 and 2 or on the same channel. Normally the Arm on Nth event counters are used to skip events as shown in figure 4, but splitting the arming signal as described above also works.

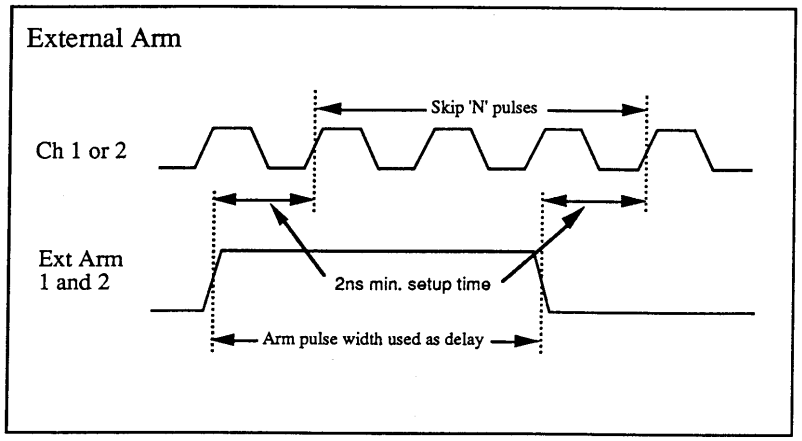


Figure 4.

Gating Mode

When arming externally, the arm 2 input on the front panel can be used as an edge-sensitive arming input or as a level-sensitive gate. In menu 9, the user selects the use of arm 2 (see figure 5).

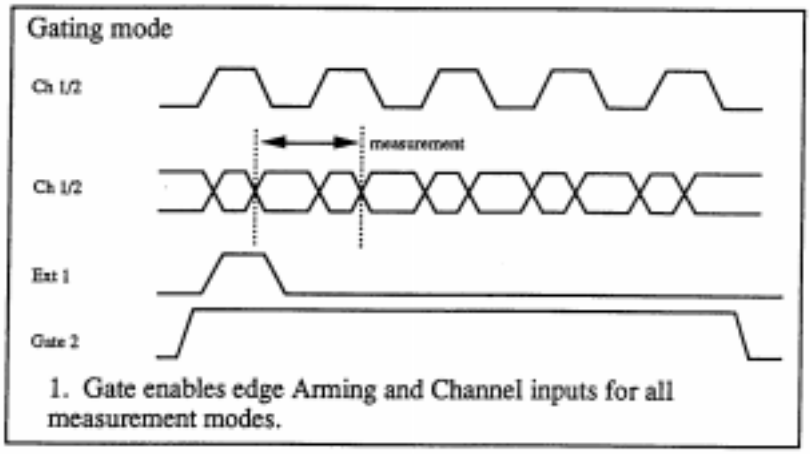


Figure 5.

The main difference between using arm 2 input as a gate versus edge sensitive is that as gate sensitive, the DTS makes measurements whenever the gate meets the user selects criteria. If Arm 2 is edge sensitive, the DTS only makes a measurement once for every edge of the arming signal. In menu 9, the user can turn the gate "ON" or "OFF" and select whether to arm the DTS when the gate is high or low. The Gate setup time to the first measurement is 2ns and the DTS completes all measurements started while the GATE is open.

In figure 5, the DTS is set up to make measurements based on the following criteria:

1. Is the gate high?
2. Is the external arm 1 input going high?
3. Make the selected measurement (period in this case).

The gating mode is useful if the test device has a "ready or lock" signal, such as when a PLL is locked onto a serial pattern. For instance, the user may want to only measure the period when the PILL is *locked* and the *data is high*, and measure again when the PLL is *not locked* while the *data is high* to see the difference in frequency and jitter.

Manual Arm

In the Manual Arm mode, the DTS is armed by pushing the GO button on the front panel or via the GPIB in the same manner. The DTS works in this mode like in the External Arm mode, except the external arming is done manually instead of electrically.

This Manual Arm mode is useful when the user wants to synchronize the DTS with some experiment, such as turning on a power supply to see the power up jitter of a PLL. This mode is also useful in setting up the DTS to wait for a randomly occurring event caught in the one-shot mode.

Enable Modes

Enable modes are program selectable from the GPIB or from the front panel menu 11. The purpose of the enable modes is to help resolve potentially ambiguous situations that can occur when auto arming. Measuring negative time instead of positive time is an example—even though both measurements are valid. See the DTS 2070 “Users Guide” for additional information on enable modes.

The enable modes only work in conjunction with "Auto Arm" and more specifically, are only necessary for TPD measurements using both channels— when the need to keep track of the sequence of events is important. Consequently, for single channel measurements of period, tr/tf, pulse width and frequency, the enable mode can be set to “Arm On Stop,” which is the normal DTS default setting. The normal sequence of events follows.

1. The selected auto arming condition is satisfied.
2. The selected enable mode condition is satisfied.
3. The selected function criteria are satisfied.
4. The measurement is made.

In the simplest case, if the user is "Auto Arming" and wants to measure the TPD++ skew between two pins of an IC, the sequence of events is:

1. Select “AutoArm.”
2. Select “Enable Arm on Stop.”
3. Select the “Function TPD++.”
4. Make the measurement by executing the “Burst” command.

Executing the above sequence enables the DTS to automatically arm itself whenever the "CPU ready" is up. The DTS then looks for a Stop event to occur on the “Stop Path,” (which is the output pin on the device under test) and then starts the measurement on the next pulse which is on the Start path (or the input pin on the device under test). See figure 6 for a TPD++ measurement.

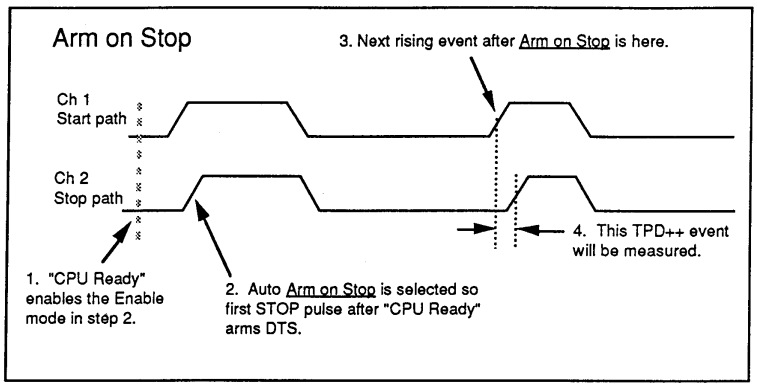


Figure 6.

"Enable Start First":
This enable mode was developed to measure a TPD event on random data with respect to a clock signal, without any special external arming. In figure 6, the application measures the clock (cp) setup time with respect to the data input. The DTS execution sequence is:

1. Select arming mode “Auto or Ext.”
2. Select “Enable stop after start.”
3. Select function to be measured, “TPD++” or “TPD-+.”
4. Execute measurement.

Selecting enable mode “Start First,” in figure 6, could also work. This mode assures positive time measurements when random events occur. However, in the case of differential output, skew measurements using "Arm on Stop" assure the ability to make positive or negative time measurements.

The “Start First” enable mode requires a minimum delay of 1ns between the channel 1 signal and the channel 2 signal. If this setup time is not met the DTS measures the NEXT pulse meeting the specified FUNCTION.

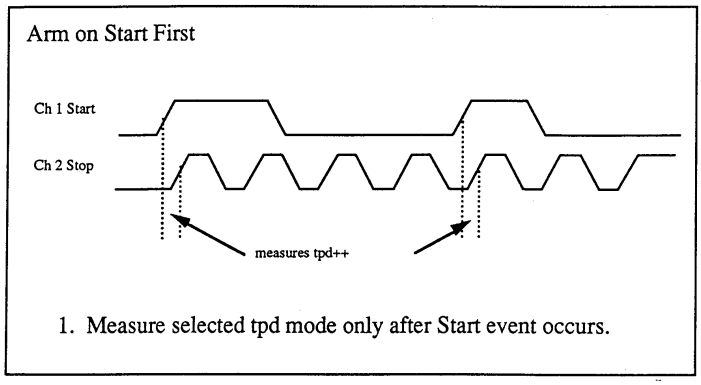


Figure 7.

In figure 7, this mode enables the DTS to ignore clock (cp) pulses on channel 2 that do not occur directly after the selected data pulse on channel 1. As shown before, the measurement is in positive time because of the "Start First" modes. In fact, if no event occurs that meets the above selected criteria, the DTS makes no measurement and returns a “No Pulse Found” message.

Arm on Count

Arm on count or arm on Nth event, can be selected via the GPIB or front panel menu 12. This mode enables the user to select the number of edges or pulses to skip before making a measurement. Accumulated jitter can be measured using this feature. For example, this mode allows selection of which period to measure after the arm occurs, or how many pulses to skip before stopping a measurement (see figure 8). Arm on count works with auto and external arm.

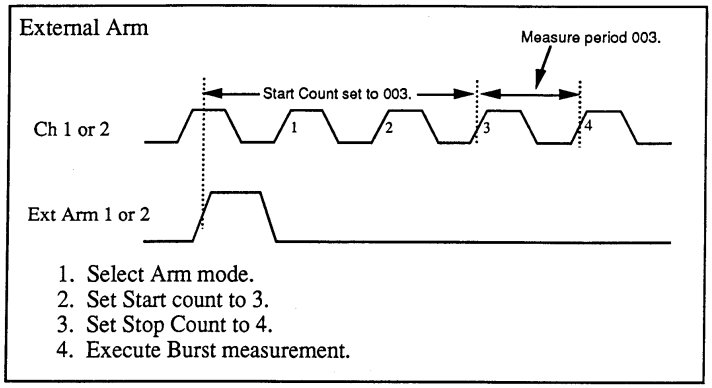


Figure 8.

1. Select any arm mode and slope.
2. Select “Enable Arm on Stop.”
3. Set “Start count” to the start event (3 for example)
4. Set “Stop count” to the stop event (4 for example).
5. Select function, period, for example.
6. Execute measurement.

In the example above, the DTS measures the *period* of the signal on the channel selected. Reference default setting table 1 for examples of start/stop counts used for various measurements.

Delayed Scan for Measuring Voltage in Time

The delayed scan mode enables the DTS 2070C to measure the voltage on either channel at a point in time determined by the delay setting programmed into the DTS, with respect to the arming signal referenced. See figure 9 for an example of how to use this mode.

The point the DTS 2070C strobe digitizes is determined by the position of the *arming signal* plus the *delay* programmed into the delay register in menu 13. The user can position the arming edge and/or the delay value to set the point where the DTS strobe digitizes.

Menu 13 on the front panel gives the user the ability to select the STROBE arming INPUT, CHANNEL to be measured and the DELAY with respect to the arming input selected. By pushing the FUNC key on the front panel while in menu 13, the DTS measures the voltage point on the channel selected. The voltage is then displayed under V LEVEL.

I.	STROBE INPUT	DC or 1 or 2
2.	CHANNEL	1 or 2
3.	DELAY	9.50ns min. to 140ns max.

"STROBE INPUT" can be either DC, which means a 16 bit A/D converter measures the average or steady state voltage on the selected channel, or the user can select Arm 1 or Arm 2 inputs to reference the programmed delay value (see figure 9).

The DTS uses a 14 bit successive approximation technique in conjunction with the 150µV resolution voltage references at the comparator inputs to find the voltage at the input channel at the end of the programmed delay. The minimum programmable delay is 9.50ns from the selected slope of the referenced arming input. See the DTS 2070C IEEE-488 interface guide for details on programming and using the Delayed Scan Mode. A repetitive signal and Arm/Trigger are required to use this mode, as is required for a DSO.

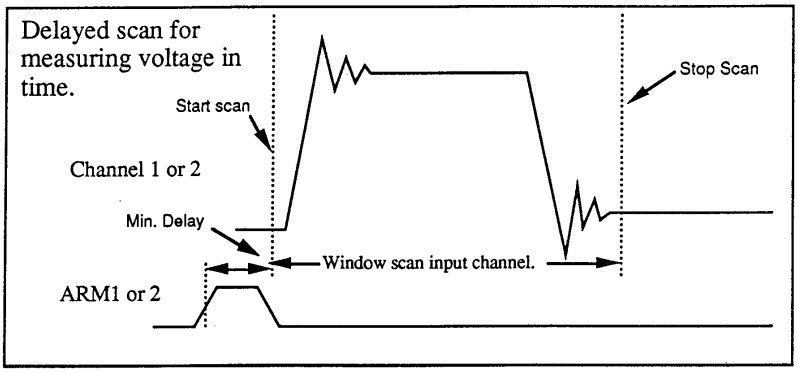


Figure 9.

Over the GPIB, if a “WINDOW” measure is executed, several statistical parameters are available, VMINIMUM, VMAXIMUM, VSDEVIATION and VDATA. For example, VDATA is a string of all of the voltage data points taken in the window search. The user can choose to display these parameters graphically to show the actual waveform on the channel or to select one of the other parameters for a quick quantitative analysis.

In figure 9, the signal on either of the DTS channels can be window scanned and the VDATA read to a PC or workstation and then processed or displayed much as an oscilloscope would. In this case, the DTS arming input selected operates much like an oscilloscope trigger.

Summary

The DTS 2070C is a one-shot time interval measurement instrument with a built-in precision time standard and patented calibration technique. The DTS 2070C makes time measurements with 800fs one-shot resolution and ±30ps one-shot accuracy. The noise floor of the DTS is low enough to enable jitter measurements on the order of 5ps or less.

The DTS 2070C is capable of making one-shot time measurements at the rate of >40,000 measurements per second. The DTS 2070C also has a built-in strobe delay system for digitizing waveforms with resolutions as low as 10ps. The special arming/gating modes and techniques described in this application note enable the user to make synchronous and asynchronous time/voltage measurements.

References

Digital Time System, DTS 2070C, Operators' Guide, *WAVECREST.*

Digital Time System, DTS 2070C, IEEE-488 Interface Guide, *WAVECREST.*

Application Note No. 112, Jitter Testing of Clock Recovery Devices for High Speed Telecom & Sonet Applications, *WAVECREST.*

Application Note No. 114, Achieving ±30pS Accuracy in the ATE Environment, *WAVECREST.*

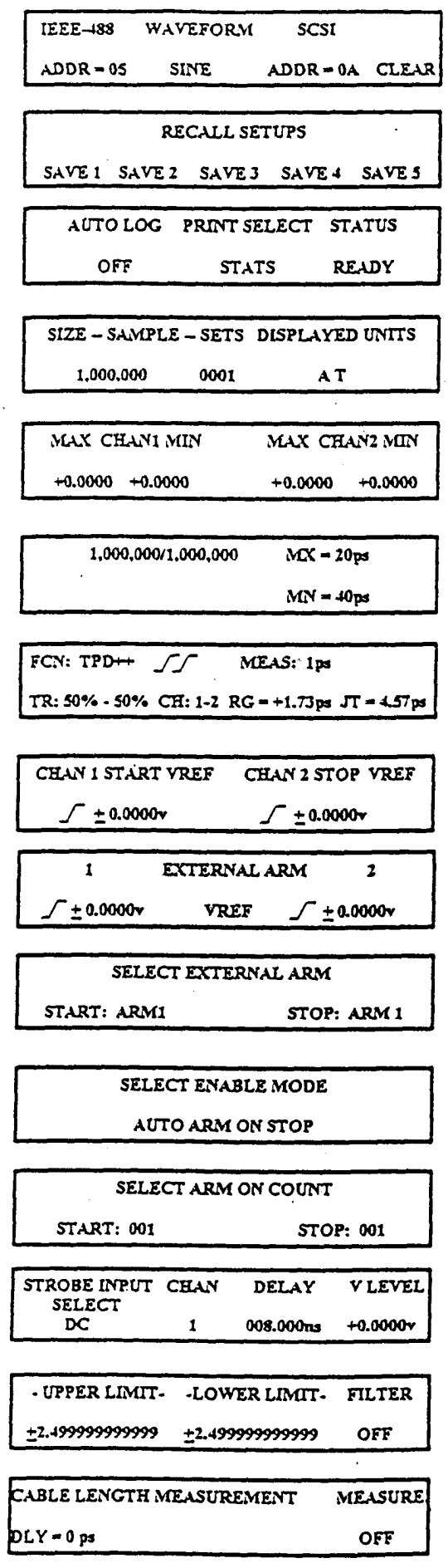
Application Note No. 120, Jitter Analysis of Clock Recovery Devices at 155.52 MBits/S, *WAVECREST*.

Application Note No. 121, PLL Jitter Characterization and Debugging, *WAVECREST.*

Appendix

Menu Selection Chart

Additional Arming Mode Examples



1 — Port Addresses/Pulse Finder Mode
(Press FUNC to execute when CLEAR selected)

2 — Memory
(Press FUNC to RECALL/SAVE on selected setup)

3 — Printer
(Press FUNC to execute)

4 — Statistics Settings

5 — Pulse Finder Peaks
(Press FUNC for pulse find)

6 — Statistics I
(Press FUNC to display unfiltered values)

7 — Statistics II and Main Function
(Press FUNC for pulse find).

8 — (Press FUNC for pulse find)

9 — (Press FUNC for pulse find)

10 — Time Measurement Parameters

11

12

13 — Voltage Measurement Parameters
(Press FUNC to execute DC measure or strobing)

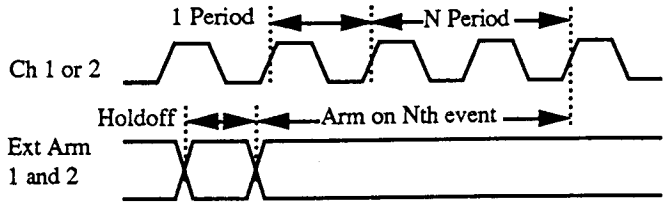
14 — Time Filtering

15 — Cable Measurement

DTS-2070C

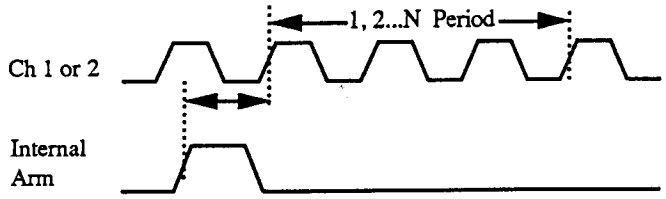
Period and Frequency Arming Modes...

External Arm



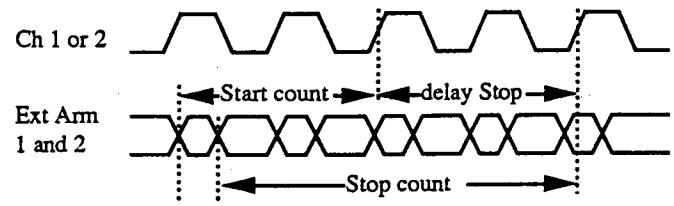
1. Either channel can be armed by either Arm input.
2. Period count can be executed from the Arm or Channel inputs.
3. Holdoff duration can be set externally.

Auto Arm



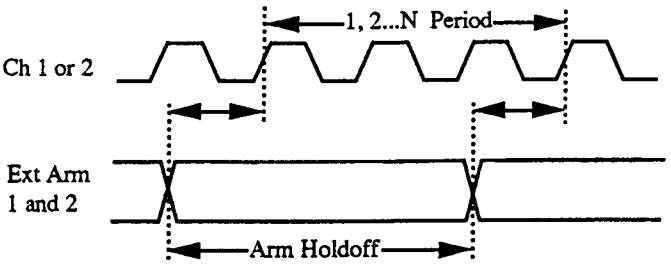
1. Period and Frequency can be measured on either channel

Delay Arm on count



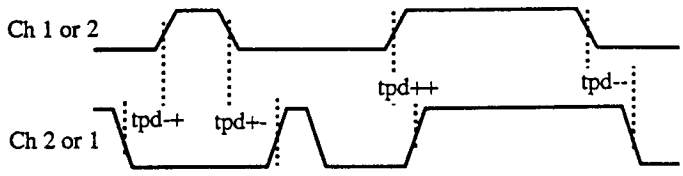
1. The count can be used to delay the Arm event or the Channel on either channel for both Start and Stop.
2. Stop count can be delayed after Start count has terminated.

External Arm Holdoff



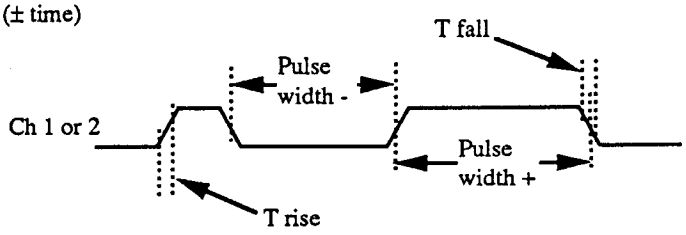
Time measurement Arming Modes...

Time Interval modes
(± time)



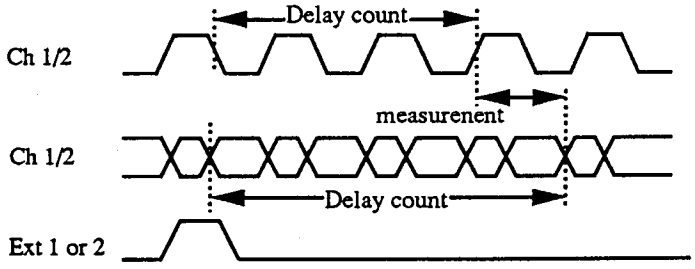
1. Auto Arm on Start or Stop either channel 1 or 2.

Time Interval modes
(± time)



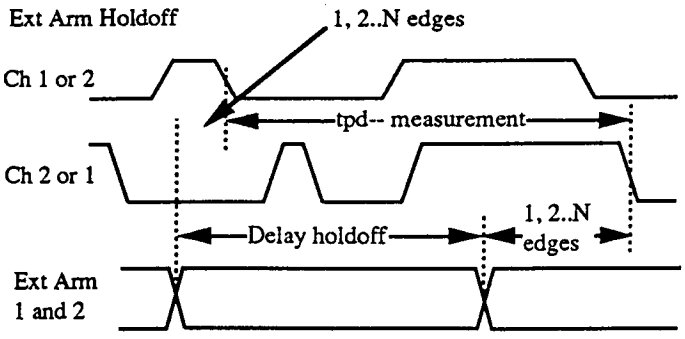
1. Auto Arm on Start or Stop either channel 1 or 2.

Delayed Arm on count



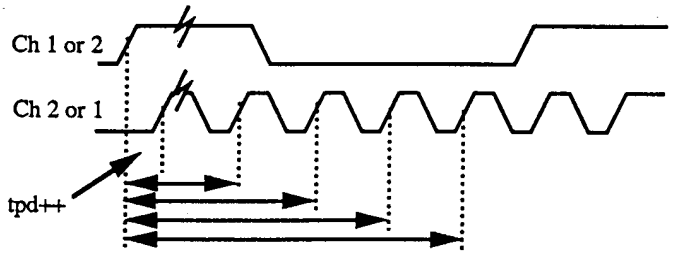
1. Stop count start after Ext Arm or after Start count termination.

Ext Arm Holdoff



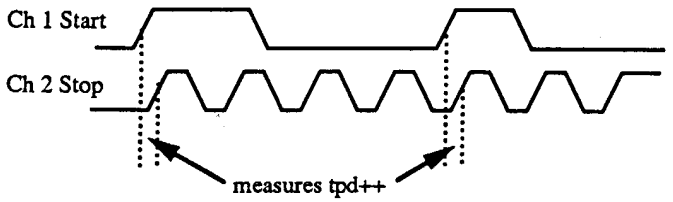
Time measurement Arming Modes...

Digital filter mode



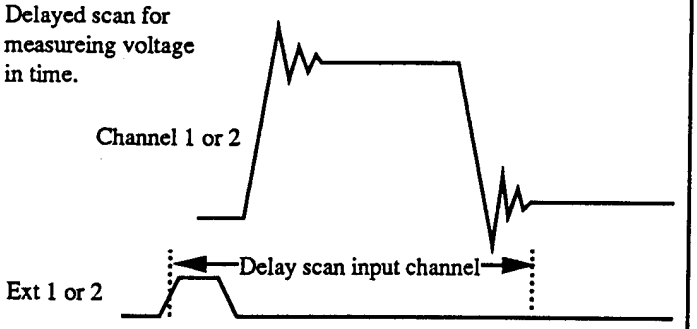
1. Can select mode and measure multipul events in a group of bursts.
2. Can select single groups of measurements within a group of measurements.

Arm on Start First



1. Measure selected tpd mode only after Start event occurs.

Delayed scan for measureing voltage in time.



1. Scan input channel with pS resolution.

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