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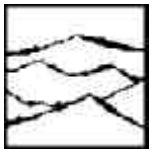
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WAVECREST Corporation

DTS-2079
DTS-2077
DTS-2075

User's Guide and Reference Manual

207900-03 REV A

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DTS-207x User's Guide and Reference Manual

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PREFACE

PURPOSE OF THIS MANUAL

This manual has been prepared to help the user achieve maximum results from the DTS in the shortest possible time. The manual's physical size, format, and content is designed to make it easy for the new user as well as the established user.

ORGANIZATION

The manual is divided into three sections, each dealing with one phase of the instrument's operation. The following is a brief description of the information contained in each section. For quick reference to specific information, refer to the Table of Contents.

Section 1 — General Description

Introduces you to the DTS. Capabilities and features are described. All hardware relating to the use of the DTS is described. A complete table of the DTS performance specifications can be found at the end of this section.

Section 2 — Operation

This section provides step-by-step procedures for all phases of operation, including power-up and diagnostics, calibration and mode selection, triggering, controls, and selecting/using menus. Diagrams outlining the sequence of operation provide detailed steps for getting the most from your DTS and using it to its full potential. Also included is an Operator's Quick-Reference Table that conveniently allows at-a-glance referencing for controls and indicators.

Section 3 — GPIB Interface

Includes various parameters, value, and codes necessary for implementing remote control of the DTS via the IEEE-488 Interface.

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SECTION 1 – GENERAL DESCRIPTION

This section contains a general overview and introduction to the *WAVECREST* DTS-207x Digital Time Scope. It also presents its capabilities, features and a brief description of the instrument's hardware. Performance specifications are included in this section.

INTRODUCTION

The *WAVECREST* DTS-207x Series Digital Time Scope (DTS) is designed for applications where timing accuracy is critical. The DTS provides direct, real-time measurements without the associated errors during the sampling and transformation of data while waiting for a waveform to be displayed. The result is a precision instrument capable of measuring time between two events with a resolution of 800 femtoseconds and single-shot measurement accuracy of ±25 picoseconds (ps).

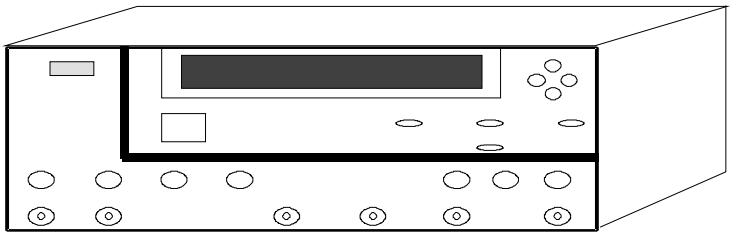


Figure 1-1 *WAVECREST* **DTS Time Measurement Instrument**

The DTS represents a dramatic departure from the traditional digital sampling oscilloscope (DSO) approach to critical timing functions. The DSO approach takes a time frame and then measures the number of events occurring within that time frame to arrive at a figure for elapsed time between each event. The DTS approaches the measurement algorithm as absolute; time between any two events is actual, measurable and quantifiable.

The DTS is intended for AC characterization, with the added benefit of N.I.S.T. traceability, in applications ranging from ATE test head deskew to bench top device test and computer clock distribution. In addition, the DTS is well suited for scientific and engineering applications which require timing accuracy and resolution more precise then other available instruments can provide. The DTS achieves greater accuracy with fewer readings in less time than digital scopes or other types of time domain measurement devices.

Long-term measurement accuracy and linearity of the DTS is due to built-in calibration options that can be initiated by the user at any time.

1.1 HARDWARE DESCRIPTION

The DTS incorporates a three-card timing measurement subsystem, a single-card Central Processing Unit, a comparator card, a front panel for operator control of the instrument, ovenized crystal oscillator, power supplies, and an IEEE-488 interface. Signals to the DTS are inputted through SMA connectors on the front panel. The front panel (Figure 1-3) provides the means for controlling, monitoring, and communicating with all time measurement functions of the DTS.

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1.2 HOW THE DTS WORKS

The key to understanding the *WAVECREST* DTS line of products is by comparing arming and triggering devices.

Oscilloscopes have triggered time bases that require triggering to start the time base sweep while events are displayed with respect to linear time.

The DTS is not triggered but ARMED, or ENABLED, to make a measurement of the next event that occurs on the input channels.

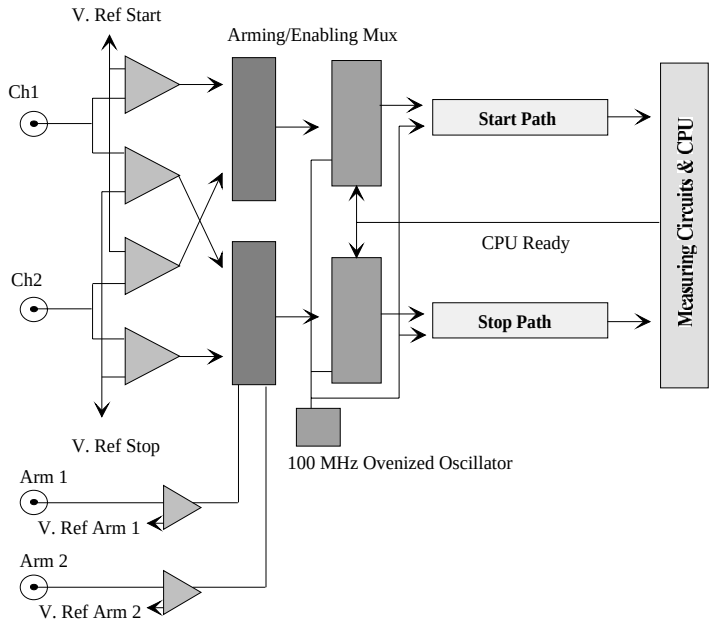


Figure 1-2 DTS Block Diagram

Figure 1-2 shows a simplified block diagram of the DTS. The 50Ω-to-ground inputs of the DTS feed dual comparators on each channel. This enables the DTS to measure events such as Period, Pulse Width and Rise/Fall time on a single channel in One-Shot mode. 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. As the diagram shows, there is a Start and Stop reference voltage on each channel.

“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 is not the same as triggering an oscilloscope, just similar.

The External arming inputs go to logic circuits within the DTS and, in conjunction with the “Enable Modes,” select whether the DTS is to be synchronous or asynchronous with respect to the signal to be measured.

The last signal that is of importance is the “CPU ready” signal which is generated whenever the CPU is ready to process another measurement. This time duration is program controlled so that the measurement or “Burst” rate can be varied.

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1.3 FEATURES/CAPABILITIES

The DTS features and capabilities include:

- Measuring several different characteristics of an electrical pulse. Those characteristics are:
  - – Propagation Delay (TPD++, TPD--, TPD+-, and TPD-+)
  - – Rise/Fall Time (TT+, TT-)
  - – Period/Pulse Width/Frequency (PW+, PW-, PER, FREQ)
  - – Cable Measurement
  - – Strobing voltmeter - to digitize input waveforms
  - – 16-bit DVM on each channel

- Taking one measurement with a single-shot accuracy of ±25ps, or as many as 1,000,000 readings, and recording statistical data output with an accuracy of ±10ps.

- Two different operational modes and three different triggering methods.

- Both an internal and external AC and DC calibration mode.

- A front panel incorporating a two-line, 40-character liquid crystal display (LCD) for access to a complete range of menus.

- Input voltage levels that can be set for rising or falling signals from ±1.1 volts in 0.15mV increments. Minimum pulse amplitude of only 50mV peak to peak is required.

- A PULSE FIND capability that locates the signals and automatically sets voltage inputs required for measurements. Selectable for finding either peaks or flat spots.

- System capability of taking 40,000 measurements per second and handling pulse trains up to 1630MHz for the DTS-2079, 1300MHz for the DTS-2077 and 800Mhz for the DTS-2075.

- IEEE-488 Interface that allows for standardized integration into OEM products, giving the user remote capabilities with selectable addressing and with an optional SCSI interface available.

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1.4 EXTERNAL INTERFACE

Four external inputs and two signal outputs are routed through SMA connectors on the front panel directly into the DTS. The six SMA connections on the front panel are:

CH1..... Used for a START event input pulse for TPD measurements. Inputs START and STOP event pulses for all other measurement modes.

CH2..... Used for a STOP event input pulse for TPD measurements. Inputs STOP and START event pulses for all other measurement modes.

External Cal 1/Cal 2..... Used for AC Deskew and DC offset and gain of DTS Inputs and for Coax Cable Delay measurement.

External Arm1/Arm2..... Used as input for the External Arm, which starts the measurement of the next pulse seen on the CH1 and CH2 connectors when Ext. Arm mode has been selected.

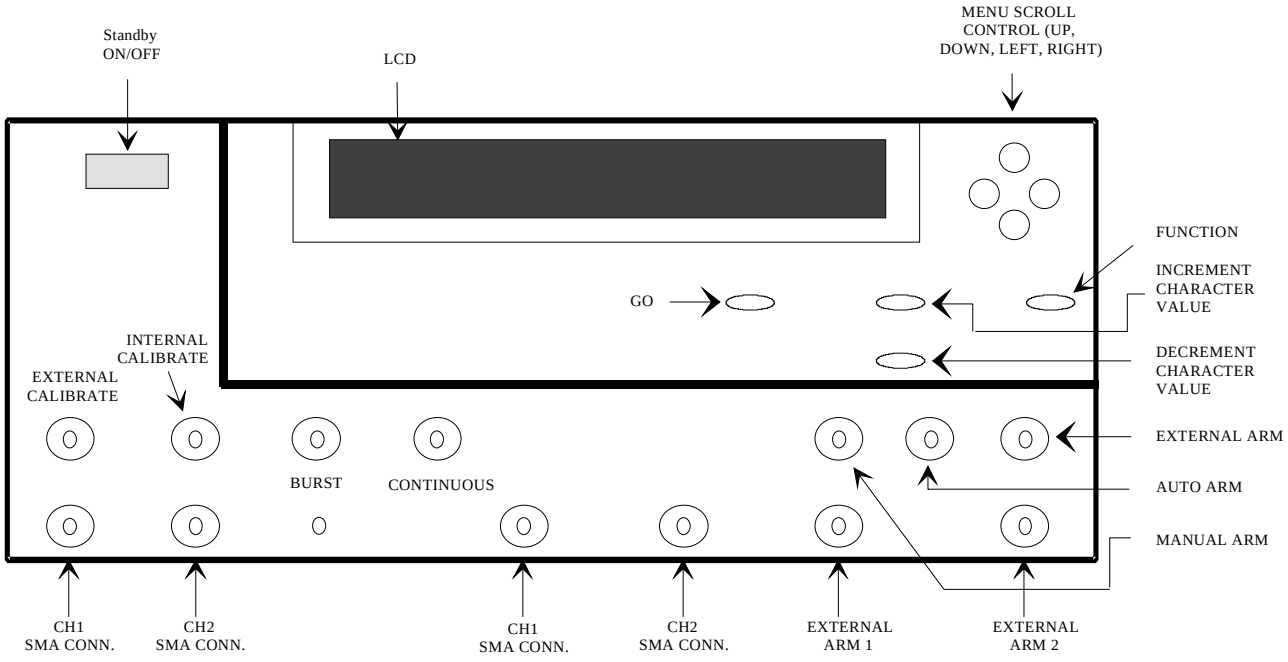


Figure 1-3 Front Panel

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The rear panel (Figure 1-4) contains power and reset buttons as well as five additional interfaces:

AC Power/Line Filter/Fuse..... Used for the incoming AC power cord. When the power switch is ON, the crystal oven is ON. Power to the remainder of the system is controlled by the STANDBY power switch on the front panel. The AC power may be either 110VAC ±20v, or 220VAC ± 40v, single- phase. The DTS typically draws 1.8 Amps, and is fused with two, 6.3 Amp, slow-blow, 5x20mm fuses (*WAVECREST* part number 400067-66).

IEEE-488 Connector..... Permits remote operation of the DTS. Section 3 contains specific information and instructions concerning IEEE-488 protocol.

Oscillator Reference Out Signal - SMA.. Provides a ± 100mV 100MHz signal to check the accuracy of the internal 100MHz Frequency Standard.

RS232/SCSI/ PARALLEL..... Provides for option connections.

RESET..... A push-button is provided to reset the system. The power-up diagnostics are not performed during a reset.

Vref ..... Provides a reference voltage to check the accuracy of the internal Voltage Standard. The voltage should measure ±1mV of the voltage indicated on the calibration label.

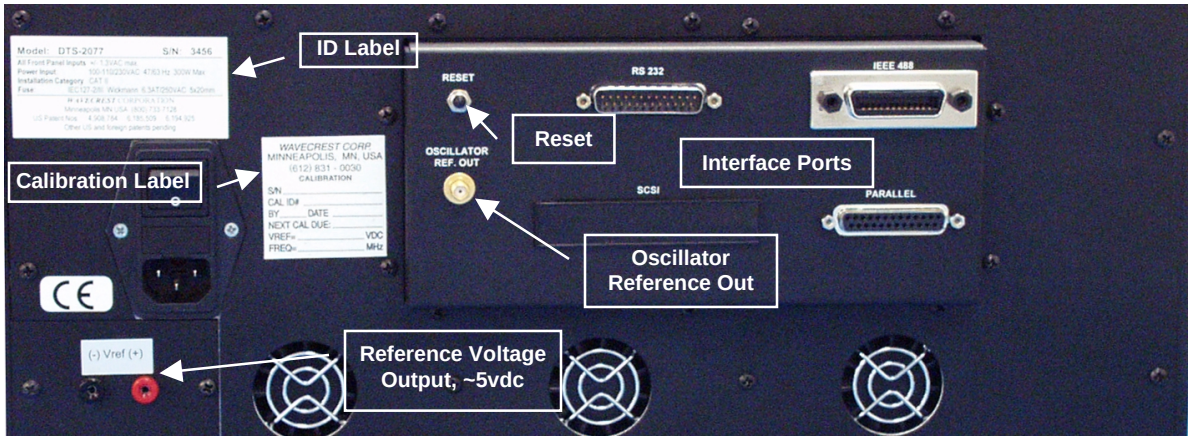


Figure 1-4 Rear Panel

1.5 LIQUID CRYSTAL DISPLAY (LCD) MENUS

A two-line, 40-character liquid crystal display (LCD), located on the front panel of the instrument, provides access to a variety of menus or screens. With the arrow keys, the user can scroll to the appropriate menu to store information, view sampling information or define program-specific measurement parameters as required by the customer's application. The LCD (display) is also used to alert the operator, prompt action where necessary and displays system status.

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1.6 SUMMARY OF MENU SELECTIONS

The operator has the option of selecting any one of 16 menu screens. These menus present the operator with feature or parameter selections for I/O addressing, memory storage, printing, statistics, pulse find, AC and DC measurement, cable measurement and filtering.Figure 2-6 illustrates the order of the menus.

- **Main Function (Default Menu) -** Provides for the selection of specific functions which define and set up parameters associated with a function. Provides for the selection of a percentage of peak that the start/stop references will be set to during a pulse find, the selection of the input channel to be used during a measurement and displays the average and peak jitter after a measurement is completed.
- **Time Measurement Parameters**

  Start/Stop Channel Voltage References - Displays the start and stop reference voltages found during a pulse find. Provides an input of user defined reference voltages. The information for each reference voltage is the edge direction, polarity and level.

  External Arming Reference Voltage - Displays the external arming inputs for Arm 1and Arm 2 recorded during a pulse find. Provides an input of user defined arming reference voltages. The information for each reference voltage is the edge direction, polarity and level. Provide the turning on/off of the Gating feature.

  External Arming Selection - Select which arming input is used to arm the Start or Stop event.

  Arming Sequence Selection - Selects the arming sequence to use in making a measurement.

  Arm on Nth Event - Provides for the input of start and stop counts that will define the time of the respective arming of start and stop.
- **Voltage Measurement Parameters -** Selects the type of dc measurement that will be taken when a function button is pressed. The three types are DC, Strobed by Arm 1 and Strobed by Arm 2. Provides for the selection of input channel for measuring a voltage and for the input of a delay, from arming, for strobing a voltage measurement as well as displays the voltage level of a dc or strobed voltage measurement.
- **Time Filtering -** Provides an input of filtering limits, minimum and maximum, and turning the filtering feature on or off.
- **Cable Measurement -** Displays the average reading after a cable measurement and turns the cable measurement on or off.
- **Serial and Part Numbering -** User input of serial/part number of device being tested.
- **Port Addresses/Pulse Find Mode/Clear -** Sets GPIB and SCSI addresses. Select Pulse Finder modes of PEAK or FLAT. System Clear.
- **Memory -** Provides for the saving, recalling and naming of ten (10) sets of parameters.
- **Printer -** Provides the selection and control of printing.
- **Statistics Settings -** Sets the sample and sets size and sets the unit the statistics will be displayed in.
- **Pulse Finder Peaks -** Displays the minimum and maximum peak voltages found with a pulse find.
- **Statistics I -** Displays the sample size and samples completed. Displays the minimum and maximum readings of a time measurement. Displays duty cycle.

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1.7 MODES OF OPERATION

The DTS has five modes of operations the user can select. Four modes are controlled by push-button switches located on the front panel. At power on, the DTS is placed in the first mode, Idle, which is a *wait* state. These five modes are:

Title	Function
Idle	The DTS is in the wait state if none of the other modes have been selected. Power On or completion of Burst mode places the DTS into Idle mode.
EXTernal **CAL**ibration	Used for External Calibration/Deskew of the CH1/CH2 inputs. Automatically measures and corrects for input variations of the CH1/CH2 comparators, then stores these values in memory to be used to correct all future measurements. Also used to perform a DC gain and offset calibrations of the test probes.
INTernal **CAL**ibration	The DTS automatically calibrates itself internally to a N.I.S.T. traceable 100Mhz ovenized crystal oscillator in approximately 11 minutes.
BURST	The DTS will complete the number of readings equal to the sample size selected and then stop. When the sample size is reached, the DTS displays the computed data.
CONTinuous	Continuously measures pulses in this mode. Once the number of pulses measured equals the sample size, the newly computed data is displayed and the process begins again to collect a new series of measurements equal to the sample size.

1.8 ARMING

The DTS has three user selectable arming capabilities. These selections are activated using three push-buttons located on the front panel. The arming capabilities are:

Title	Function
MANual	Activates the system to take measurements when the GO button is pushed. Once armed, the DTS measures the next pulse presented. Every time the GO button is pushed, the sample size is incremented. The statistics are not updated until the sample size has been achieved. If Burst mode is selected, no further pulses are accepted after sample size is achieved; if Continuous is selected, a new series of measurements will begin after the sample size is achieved.
AUTOmatic	This allows automatic measurement to the sample size, based on the edges of the Start/Stop pulses. If Burst mode is selected, no further pulses are accepted after the sample size is achieved; if Continuous is selected, a new series of measurements will begin after the sample size is achieved.
EXTernal	Allows external signal source to arm the DTS for measurements. Once armed, the DTS measures the next pulse presented. If Burst mode is selected, no further pulses are accepted after sample size is achieved; if Continuous is selected, a new series of measurements will begin after the sample size is achieved. Provides Gating/Burst Trigger modes and external strobe for digitizing waveforms.

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1.9 CONTROLS

The DTS has five control functions that are available to the user. These five functions are located on the front panel and are push-button switches (refer to Figure 1-3). Two of the functions have multiple push-buttons. The five control functions are:

Title	Function
Menu Scroll	Allows the user to scroll from menu to menu and field to field inside a menu. There are four push-buttons in this function: UP, DOWN, LEFT and RIGHT.
Increment/ Decrement	Allows the user to increase or decrease values in selected fields or change options, both contained within the menus. There are two push-buttons in this function: INCREMENT or DECREMENT.
Go	Allows the user to restart the DTS after certain modes that require external action are taken by the user. The DTS always gives a prompt on the menu for the GO function.
Function	The FUNCTION push button is used for different functions for the different menus. Menu Function: Memory ..... Initiate RECALL/SAVE. Statistics I ..... Calculates unfiltered statistics. Printer ..... Initiate a print. Pulse Finder Peak ..... Initiate a pulse find. Main Function ..... Initiate a pulse find. Time Measurement Menu #2..... Initiate a pulse find. Time Measurement Menu #3..... Initiate a pulse find. Voltage Measurement..... Initiate DC or strobed measurement.
Standby (Power)	Powers system On or Off. When power is On, the LCD background is illuminated and remains on as long as power is applied to the system. The crystal oven is activated whenever the power cord is connected to the AC power source and the main power switch on the back panel is on. The front panel rocker switch controls the power to other DTS circuits.

1.10 DTS DEFAULT SETTINGS

Function	Trig %	Channel	Arm Source	Arming Sequence	Start Count	Stop Count
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 1-1 Default Settings

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1.11 TAKING TIME INTERVAL MEASUREMENTS

All time interval measurements made with the DTS follow a simple, four-step progression; **Arm**, **Function**, **Enable** and **Execute**. The following should be considered before executing a measurement:

- What **Arming** source is required to make the measurement?
- What **Function** is being measured?
- What **Enable** mode is required to make the measurement?
- **Execute** time interval measurement.

Whenever a time interval measurement is made, all four steps are completed. Using the DTS is simple and repeatable because all four steps are defaulted for each measurement function of the instrument. These defaults can be changed by the user as desired.

In addition to the default settings shown in Table 1-1, all channel Voltage References are set to 0.00v unless changed by the execution of a **PULSE FIND** or set externally by the user. The **PULSE FIND** command will set the reference voltages for each channel based on the TRIGGER percent indicated in Menu #1 (See Section 2.3).

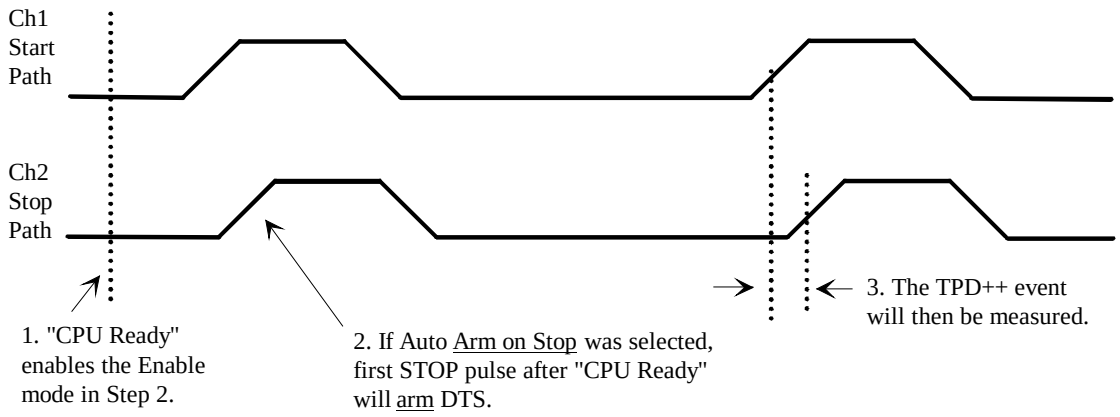


Figure 1-5 Rising to Rising Time Measurement

In Figure 1-5, a measurement is taken from the rising edge of Channel 1 to the rising edge of Channel 2. The instrument is set up for an arming source of Auto and an arming sequence of the Stop path (commonly stated as Auto on Stop).

The sequence of events that will happen in Figure 1-5 are:

1. The DTS signal 'CPU ready' provides a pre-arm.
2. The first (1) rising edge on Channel 1 stop path will arm the instrument.
3. The next rising to rising measurement between Ch1 and Ch2 will be taken.

If a sample size of 1000 was selected, then the above step will be repeated 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.

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The instrument also has the ability to measure the voltage in time (strobed) with a resolution as fine as 10ps. This can be used to help the user determine where to set the reference voltages. With the help of a host computer, the complete waveform can be graphically displayed using *WAVECREST's Virtual Instrument Signal Integrity*™ software.

In addition, the instrument also has the ability to Gate the arming of the instrument. The GATING mode is useful if the device to be tested has a "ready or lock" signal such as when a PLL is locked onto some serial pattern. For instance, the user may want to measure only the period when the PLL is locked while 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.

1.12 Summary of Features:

- 800 femtosecond resolution
- ±25ps single-shot accuracy
- ±10ps average accuracy
- 15,000 readings/sec. to 40,000 readings/sec. with "HiPer" option
- Input signal bandwidth of 2GHz or greater
- Time measured between ±2.5 seconds.
- Independently programmed voltage threshold ±1.1v
- Auto calibration
- IEEE-488 interface with SCSI option
- N.I.S.T. Traceable
- Strobing voltmeter
- 16-bit DVM to measure voltage on channels
- Digital filters to select data to measure

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1.13 PERFORMANCE SPECIFICATIONS

- **Timing Measurement Performance**

Single Shot Accuracy .....±25ps @ calibration frequency (3 sigma limit)

Accuracy with Averaging .....±10ps @ calibration frequency (0.5v rms input)
±30ps over entire input range

Repeatability.....±2.0ps typical @ sample size = 1,000/burst

Resolution.....800fs internal
0.001fs displayed

Range.....0 to ±2.5 seconds

Measurement Rate .....>40,000-measurements/second maximum

Internal Jitter (Noise Floor).....6ps rms (3ps typical)

- **Input Signal Characteristics**

Input Threshold Resolution .....±1.1v, 0.15mV increments

Sensitivity.....100mV

Impedance .....DTS-2079: 50Ω ± 5Ω to 1.63GHz
DTS-2077: 50Ω ±5Ω to 1.3GHz
DTS-2075: 50Ω ±5Ω to 1GHz

Maximum Frequency.....DTS-2079: 1630MHz
DTS-2077: 1300MHz
DTS-2075: 800MHz

Maximum Data Rate.....DTS-2079: 3.2Gbps
DTS-2077: 2.5Gbps
DTS-2075: 1.3Gbps

Minimum Pulse Width.....DTS-2079: 300ps
DTS-2077: 380ps
DTS-2075: 625ps

Connectors.....SMA type

Slew Rate Bandwidth .....DTS-2079: > 4.5GHz
DTS-2077: > 2GHz
DTS-2075: > 2GHz

$$\left(\frac{.22}{\textit{Minimum Input Rise Time (20\%-80\%)}} \right)$$

- **Arming Functions**

Automatic .....Auto arms, starts and stops on incoming edges

Enable Modes:
Arm on Stop.....Enable measurement on start channel 1
Arm on Start.....Enable measurement on start channel 2
Arm Start First .....Enable measurement after start occurs, requires 1ns setup time

Manual.....Arms inputs with GO push-button to accept next incoming edge

External:
Input Threshold.....±1.1v
Voltage Resolution.....1mV
Sensitivity 25mV
Impedance.....50Ω ±5Ω to 1.0GHz
Connectors .....SMA type ±2Ω to 1GHz

Max. Frequency.....DTS-2079: 1000MHz
DTS-2077: 1000MHz
DTS-2075: 800MHz

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- **Statistical Functions**

Average	Average of *n* readings
Jitter RMS	One standard deviation (1 sigma)
Min/Max Reading	Lowest/Highest Reading
Peak	+/- Difference between Min & Max Measurements divided by 2

- **2-Line LCD Display with Menu**

Channel 1	Voltage threshold; rising/falling edge
Channel 2	Voltage threshold; rising/falling edge
Pulse Finder	Automatic selection, 50%, 10-90%, 20-80%, points of input signal
Arm	Voltage threshold
Force	Auto Trig. on Start; Auto Trig. on Stop; Enable Stop after Start
Filters	Set within ±2.5s, 1ps resolution (With filters on, max. samples is 8k)
Presets	Ten (10) memories
Set number of samples	1 to 1,000,000
IEEE-488 and SCSI	Select address
Choice of Display Units	Auto scale, seconds, ms, µs, ns, ps
Cable Length Measurement	Time delay

- **Measure Modes**

Burst	Perform *n* measurements, halt and update display
Continuous	Continuously perform *n* measurements, update display after each reading

- **Calibration Modes**

Internal	Internal calibration to self-contained N.I.S.T. traceable standard in approx. 11 minutes
Extended Internal	For embedded code version 1.98 or greater. From approximately 5.5 minutes to approximately 2.5 hours via GPIB commands with user program or *Virtual Instruments Signal Integrity*™, version 3.20 or greater.
External	Deskew/calibrate inputs

- **Timebase**

High stability, low phase noise, ovenized, N.I.S.T. traceable, crystal oscillator.

Frequency	100MHz
Aging/day	5×10^{-8} seconds
Aging short term	5×10^{-11} seconds
Accuracy	1×10^{-6} seconds

- **IEEE-488 Interface**

All front panel functions (and more) can be programmed.

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- **Power Requirements**

  Voltage .....100-115/230VAC ±10%

  Frequency 47-63Hz

  Power.....Less than 300W

- **Environmental Requirements**

  Indoor use only:

  Elevation (Altitude) ……to 6500 feet (2000 meters)

  Temperature.....Ambient room 15°C to 35°C (59ºF to 95ºF)

  Temperature range.....Calibration Temperature ± 5°C
  to maintain Calibration

  Humidity.....1 to 85% R.H. (Non-condensing)

  Over Voltage Installation Category ……CAT II

  Pollution Degree …….2 per IEC664

- **Size/Weight**

  Size .....59.79cm (L) x 44.18cm (W) x 19.05cm (H)

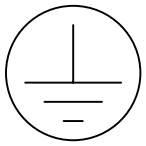
  Weight 17.5kg (38.5lbs)

All specifications are subject to change without prior notice.

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Table 1-2 Symbol Description Table

Specific cautionary or warning information may appear on the product or in this manual where applicable. The following is a summary of their meanings.

CAUTION	This statement identifies conditions that can result in damage to the DTS or property
WARNING	This statement identifies conditions that can result in personal injury or loss of life.
	This symbol indicates applicable cautionary information is noted.
	Protective earth ground.

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SECTION 2 – OPERATION

This section leads you through the sequence of steps for using the DTS-207x. Flow diagrams and figures supplement the textual descriptions. The diagrams have been designed as an aid for repeated referencing when frequent recall of a particular step is required.

INTRODUCTION

Figure 2-1 is a simplified diagram of an operating setup and will be used as a reference to clarify statements in the operation. For example, the device under test (DUT) output connection is defined as the connection point of the cable at the DUT, not at the DTS For best results, all cabling must be double-shielded 50Ω coaxial. Also, high-resolution accuracy depends on using good interface techniques. It is necessary to follow standard microwave techniques for 50Ω environments.

The DTS does accept passive or active probe inputs with a 50Ω environment. Ideally, for optimum signal integrity, all external signals should terminate to 50Ω environments at the SMA connectors. The 50Ω inputs are terminated to ground.

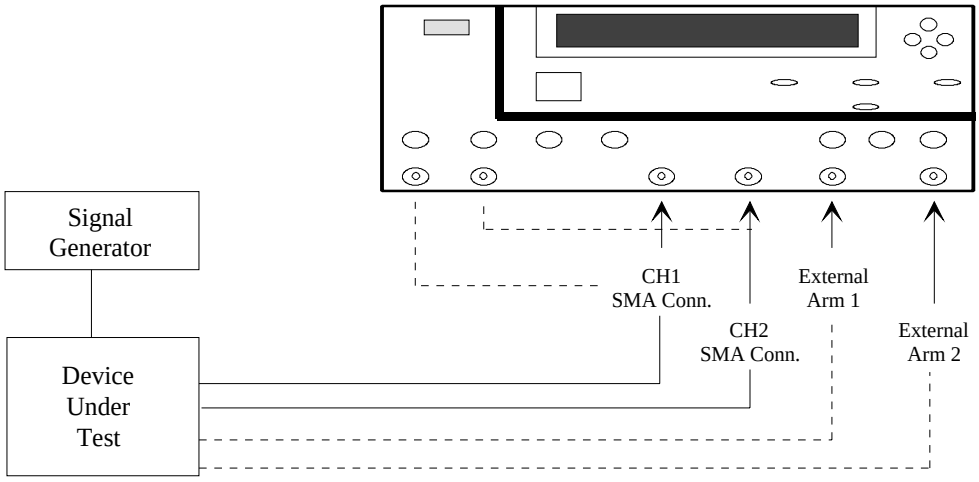


Figure 2-1 Simplified Diagram of Operating Setup

The DTS follows a series of events with each power-up. The normal operating procedure required from power-up through the use of the instrument's full capabilities is divided into six parts:

- **2.1 Set-up, Power-Up, and Diagnostics**
- **2.2 Control Selections**
- **2.3 Menu Selections**
- **2.4 Mode Selections**
- **2.5 Arming Selections**
- **2.6 Calculations**
- **2.7 Installation and Maintenance**

Refer to Figures 2–2 and 2-3 for identification and locations of push-buttons, indicators, connections or other components specified in the operating procedures contained in this section.

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2.1 SETUP, POWER-UP, AND DIAGNOSTICS

This subsection covers the setup, power-up, and diagnostics for the DTS. Also covered are the functions of the IEEE-488 connector and the AC power switch.

2.1-1 SETUP

Refer to Section 2.7 for detailed instructions on the proper installation, ventilation, fuse replacement and use of the DTS unit. A spare fuse is provided inside the fuse compartment. Refer to page 12 for power requirements and Figure 2-3 for the location of AC power connection on the back of the DTS. Plug the unit into a compatible AC power source.

IEEE-488

If IEEE-488 GPIB is used, plug the IEEE-488 cable into the connector at the rear of the unit. Refer to **SECTION 3** for information and instructions on the IEEE-488 protocol.

AC POWER SWITCH

The main AC power switch, located on the rear panel, controls power to the 100MHz crystal oven independent from rest of the DTS unit. If the main AC power switch is ON, the oven is always ON. The standby switch on the front panel must also be ON to provide power to the rest of the device.

2.1-2 POWER-UP

Push the **Standby** switch on the front panel. The LCD (display) will illuminate.

IMPORTANT: If the DTS is powered Off for any reason, wait for 5 sec. before powering back up. This allows the power supplies to properly discharge avoiding potential damage.

2.1-3 DIAGNOSTICS

The first in a series of self-diagnostics will begin on power-up.

Test Name	Description
CPU.....	Test central processing unit circuits
	Test Timer
	Test Memory
	Test Math processor
DCB.....	Test Digital Control Board
MSU	Test Measurement Setup Board
IQM.....	Test Interval Quantizer Board

All of the above tests take less than 5 sec. to run. Upon successful completion of these tests, the DTS will display the default menu, which is the **Main Function** (#1) menu (See Section 2.3).

IMPORTANT: The DTS is a precision instrument. The unit operates best after a minimum 30-minute warm-up period. Acceptable readings can be obtained after unit warm-up period and calibration. See SECTION 2.4 for calibration information.

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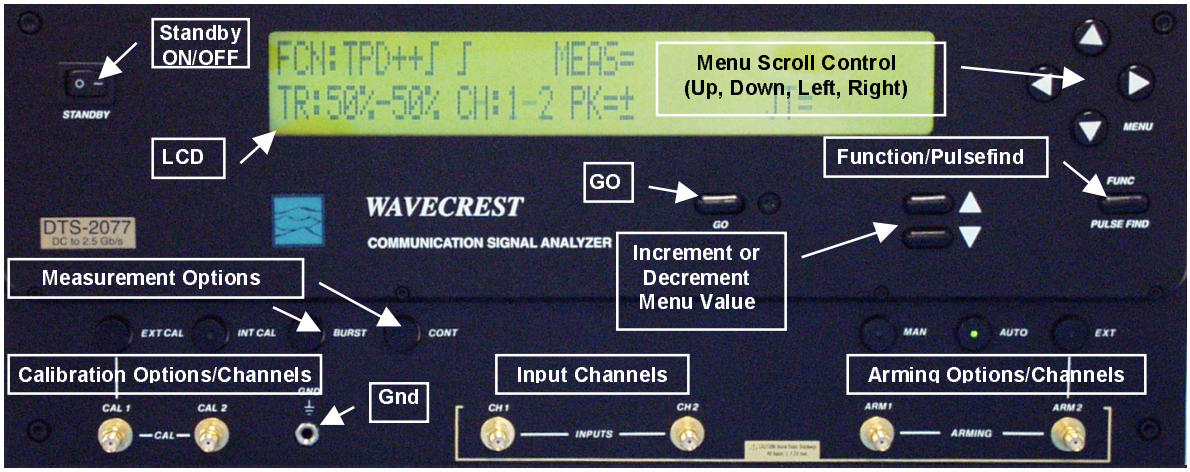


Figure 2-2 Front Panel

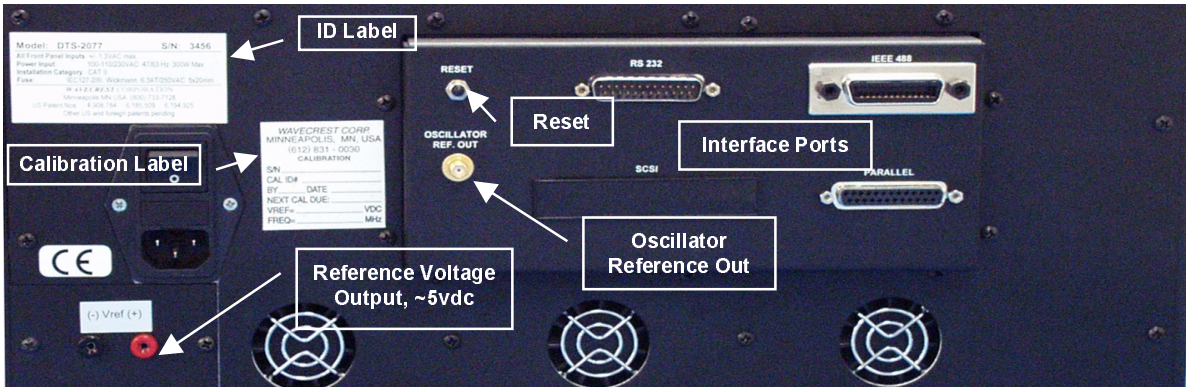


Figure 2-3 Rear Panel

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2.2 CONTROL SELECTION

Control Selection consists of four groups of push-buttons that provide the user control of the DTS from the front panel. These four push-buttons are:

Menu Scroll/Cursor (UP/DOWN, LEFT/RIGHT)

Increment/Decrement

Go

Function

2.2-1 MENU SCROLL/CURSOR CONTROL (UP/DOWN, LEFT/RIGHT)

These four triangular push-buttons are located to the right of the LCD (display) and provide the user access to all the menus of the DTS unit.

The UP/DOWN buttons permit scrolling up or down to select a desired menu on the LCD. The two-line menus are scrolled between the two lines by using these buttons also.

The LEFT/RIGHT buttons permit movement of the cursor left or right to the desired data entry field within the menu screen.

2.2-2 INCREMENT/DECREMENT

These two rectangular push-buttons are located below and to the right of the LCD display. The top push-button is the **INCREMENT** and the bottom push-button is the **DECREMENT**.

These two push-buttons enable the user to increase or decrease values in the menu field, or change options in the menu field that have already been selected. For those fields that have multiple values or options, each time the button is pushed the LCD will show the next value or option.

IMPORTANT: The DTS has no "enter" push-button to capture the field that is being changed. Once the user has finished changing the field, the DTS must recognize the changed field. This is accomplished simply by moving the cursor off the field that was recently changed. Once the selection of any set value or option has been made, the cursor must be moved off the field for the selected value or option to be entered and recognized by the DTS. (The only instance where this is not true is in The "Main Function" menu and "Cable Delay Measure" menu, where turning cable measure "On" immediately enables this mode without moving the cursor any further.)

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2.2-3 GO

This rectangular push-button is located below the LCD and to the left of the Increment push-button. This button is used when the user is required to initiate an action external to the DTS before proceeding. The DTS will always prompt the user as to what is needed by displaying a message on the LCD and illuminating the LED adjacent to the push-button.

There are two conditions during which the GO button will be pushed. These are:

Conditions	Action
External Calibration	User must attach the cables which are being compensated, selects AC and/or DC calibration
Internal Calibration	Causes new calibration data to be taken
Strobe Calibration	Causes strobe delay calibration to be taken
Manual Trigger	User is performing one reading at a time

2.2-4 FUNCTION

This rectangular push-button is located to the right of the two increment push-buttons. The **Function** push-button has many uses depending on the selected menu. These are:

Action	Result
If pushed when in the **Memory** menu #12:	Recalls/Stores set-ups under the selected name
If pushed when in **Statistics I** menu #16 filter is On, mode is Idle:	DTS calculates unfiltered data and updates menus
If pushed when in **Printer** menu #13:	Initiates a print.
If pushed when in Pulse Find, Main Function or Time Measurement menus - #1, #2, #3 and #15:	**Pulse Find** is executed.
If pushed when in **Voltage Measurement** menu #7:	Initiates a DC or strobed voltage measurement

2.2-5 PULSE FIND

There are several different results possible when the **Pulse Find** has been activated (Figure 2–4). **Pulse Find** sets Start and Stop threshold reference voltages based on the minimum and maximum pulse level found on each channel. In the **Main Function** (#1) menu, the following applies:

Function	Default
If FCN: TPD++, --, +-, -+, Period, PW+, -:	CH1 and CH2 voltages are set to 50% of each input channel
If FCN: TT+:	The **Pulse Find** sets the Start reference voltage at 10% and the Stop reference voltage at 90% point of the respective pulses presented at the CH1 and CH2SMA connectors (refer to Note below)
If FCN: TT-:	The **Pulse Find** sets the Stop reference voltage at 10% and the Start reference voltage at 90% point of the respective pulses presented at the CH1 and CH2 SMA connectors (refer to the Note below)

NOTE: If the Pulse Find is activated and no signal is on either Channel 1 or 2, the unit may find termination voltage levels. If it finds no signal, including termination voltages, it will return to its original setting.

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Pulse Find generally takes longer to find a small amplitude pulse. Pulses should occur at a reasonable rate in order for the **Pulse Find** to work. The recommended minimum rate is 1,000/second.

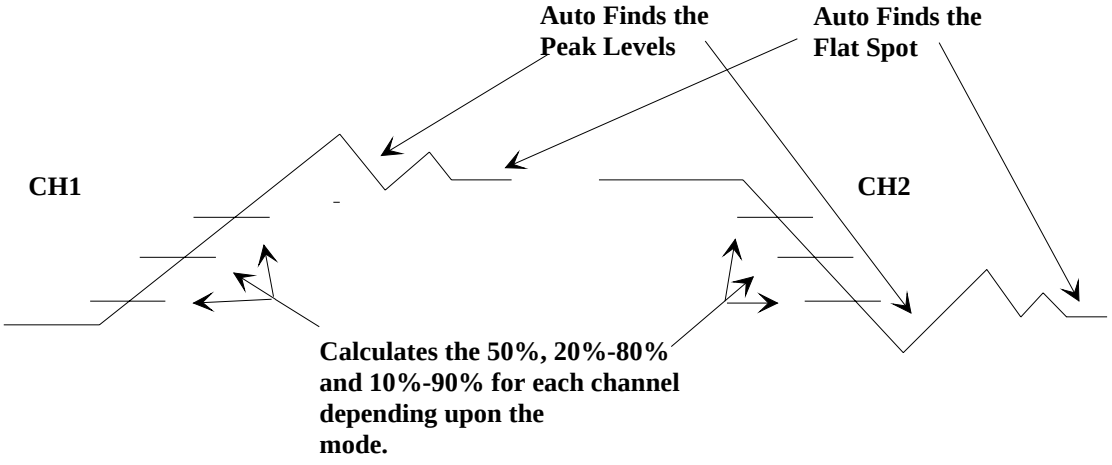


Figure 2-4 Example of Pulse Find when activated

2.3 MENU SELECTION

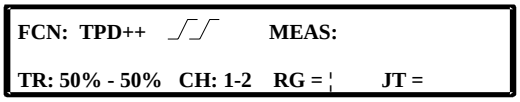
The user has the option of selecting any one of 16 possible menu screens. The grouping of these menus is graphically illustrated in Figure 2-5.

Upon Power-Up, the display screen defaults to the **Main Function** menu (Menu #1). Any desired menu can then be selected by pressing either the UP or DOWN menu scroll push-buttons directly to the right of the LCD. For example, with the default menu displayed, pressing the UP button one time steps the display to Menu #16; pressing it again steps the display to Menu #15, etc. Conversely, pressing the DOWN button scrolls the display to Menu #2 and continues through #16.

Within any menu screen, a blinking cursor appears, designating the field, which is active. This cursor may be moved within the menu window by pressing either of the LEFT or RIGHT directional arrows.

Once the cursor has been positioned to the desired field, programming parameters within that field can be entered by using the **INCREMENT/DECREMENT** buttons.

MENU #1: Main Function



FCN - Permits the user to select one (1) of ten (10) different measurement functions: TPD++, TPD--, TPD+-, TPD-+, TT+, TT-, PW+, PW-, Period and Frequency. In addition, this menu allows the user to select different start and stop voltage levels. These include 50%–50%, 20%–80%, 80%–20%, 10%–90%, and 90%–10% which are automatically calculated for the user only after the **Pulse Find** has been initiated by pressing the **FUNC** push button. User voltage settings can also be entered by changing the voltage settings for the Start and Stop reference voltages manually, in Menu #2. When taking a single channel measurement (TT+, TT-, PW+, PW-, PER and FREQ), the user is able to select either Channel 1 or 2 for the measurement.

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Each measurement function has its own default setup for voltage settings, channel selection, level percentages, and forced measurement modes. If for some reason these measurement setups need to be changed for a specific application, the new setup becomes the default setup for that function.

The reference voltage level is also set on a channel-by-channel basis. This means that the user can have different reference levels for each channel of the same function, such as Period or Pulse Width, etc. Toggling between channels will change the reference trip point for the channel.

MENU #2: Channel Voltage References



Provides for the selection of voltage trip levels for the Start and Stop. Also the rising/ falling edge to be used for the measurement Start and Stop is selectable.

The Pulse Find feature can be used to eliminate the need to set the trip reference voltage. This feature finds the percentage of the input signals on Channel 1 and 2 and set the Start and Stop voltage reference to these values.

The voltage limits of the DTS are ±1.11 volts.

With the cursor positioned in this menu, pressing the FUNCTION button will initiate a pulse find.

See Section 2.2-5, Pulse Find, for more information.

MENU #3: EXTERNAL ARMING VOLTAGE REFERENCES



Provide for the selection of voltage trip levels for the arming inputs. The rising/falling edge can also be set for the arming inputs. The **Pulse Find** feature can be used to eliminate the need of setting the arming channel voltage references if the 50% of peak to peak is the desired voltage.

Pulse Find will only search for the arming inputs if the trigger source (auto/external) is in external. **Pulse Find** will also only find the arming input value if that arming input is selected in Menu #4, Select External Arm.

The voltage limits of the DTS are ±1.1 volts. See Section 2.2-5, **Pulse Find**, for more information.

Provides for the selection of External Arm 2 to be a level sensitive GATE. A selection of ON or OFF will select gating.

The External Arm voltage reference input is used to select the direction and level of the gating. The operator can select H (high) or L (low) which is the same as changing the External Arm 2 edge. See Section 2.5-8, **Gating**, for more information.

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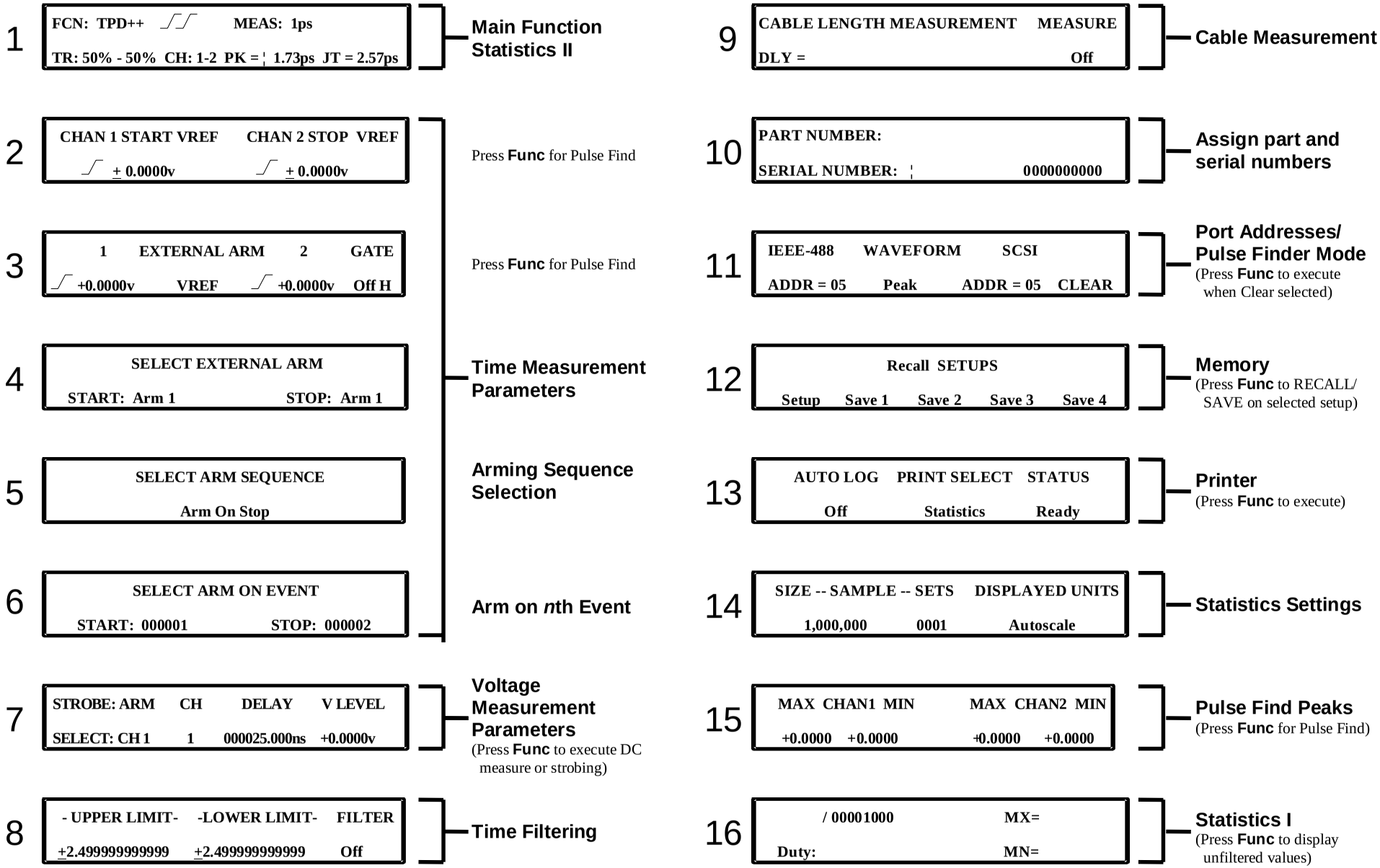


Figure 2.5 Menu Selections

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MENU #4: EXTERNAL ARMING SELECTION

SELECT EXTERNAL ARM	
START: Arm 1	STOP: Arm 1

Select which arming input is used to arm the Start event and arm the Stop event. The DTS has two (2) arming inputs, ARM1 and ARM2. See Section 2.5, Arming, for more information.

MENU #5: ARMING SEQUENCE SELECTION

SELECT ARM SEQUENCE
Arm On Stop

Selects the arming sequence to use in making a measurement. In the DTS, the arming sequence is selectable with the trigger source either automatic or external.

There are three (3) sequence modes:

Arm On Stop

Arm On Start

Arm Start First

See Section 2.5, **Arming**, for more information

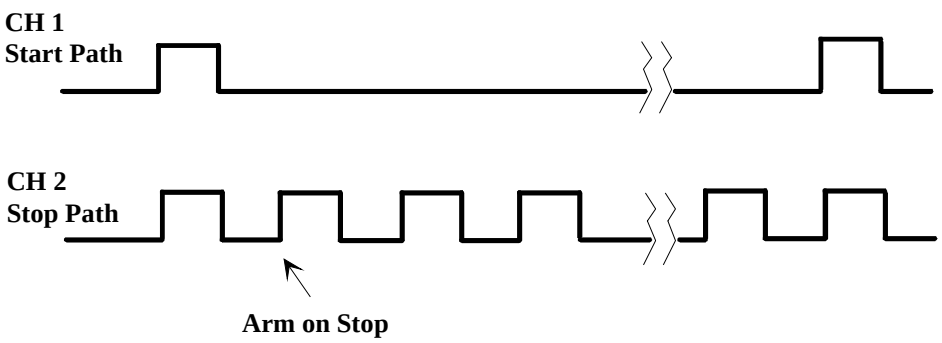


Figure 2-6 Arm on STOP and START

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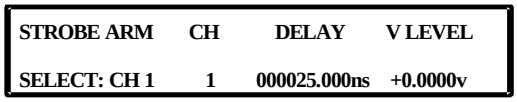
MENU #6: ARMING EVENT SETTING



Selects the Start or Stop event arm on *n*th event. The range is 1 to 131,071. This feature can be used to select the number of edges or pulses to skip before starting or stopping a measurement.

See Section 2.5, **Arming Selections** for more information.

MENU #7: VOLTAGE MEASUREMENT - DC AND STROBED



Performs voltage measurement from the front panel.

Strobe Arm Select - Selects whether a DC or strobed voltage measurement will be performed.

Five (5) selections can be made:

DC - Measure the DC voltage on channel selected.

ARM1 - Measure the strobed DC voltage on selected channel at delay from selected arming point using ARM1 input.

ARM2 - Measure the strobed DC voltage on selected channel at delay from selected arming point using ARM2 input.

CH 1 or 2- Select input channel for DC or strobed voltage measurement.

Delay - Sets the delay from the arming trip point to the strobed measurement.

VLevel - Displays the measured voltage.

With the cursor in this menu, pressing the **FUNC** button will initiate a voltage measurement.

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MENU #8: TIME FILTERING

- UPPER LIMIT-	-LOWER LIMIT-	FILTER
+2.499999999999	+2.499999999999	Off

The DTS performs a digital band pass filter function.

This menu permits selection of upper and lower limits of values to be used in measurement calculations. Any readings outside these limits are discarded.

Both the upper and lower limit may be selected from -2.5 sec to +2.5 sec, but the upper limit setting must be greater than the lower limit setting. The DTS will not allow the user to violate this from the front panel. When entering the upper limit first, always keep the values in the upper limit greater than the lower limit. Enter the lower limit second.

The maximum sample size allowed with filter enabled is 8,000. If the sample size is greater than 8,000 and the filter function has been set to ON, the system sets the sample size to 8000.

One of the features of the time measurement used in the DTS is that the DTS will measure all of the pulses with respect to one of its inputs, depending on which measurement mode is selected. For example, if TPD++ is selected and there are 10 pulses on Channel 2 for one on Channel 1, and if Arm on Stop is selected, and if a Burst of 1,000 is selected, then the DTS will measure the TPD++ for each edge on the Channel 2 with respect to the one on the Channel 1. Then 100 measurements will be made for each TPD++ measured. Refer to START/STOP example below and the representation in Figure 2-7.

(burst ÷ number of pulses = count/TPD) or (1,000 ÷ 10 = 100)

The band pass filter is used to select only the desired TPD you want displayed (Figure 2-7). Notice that all the data is in the memory and each measurement can be read over the GPIB and the distribution for each of the 10 TPDs calculated off-line by an external processor.

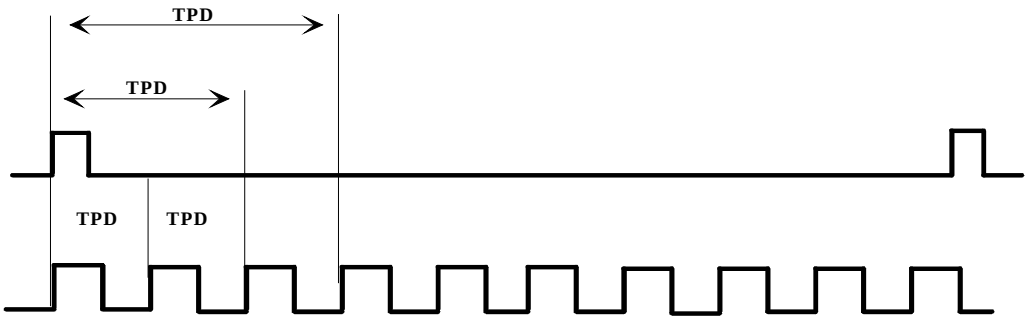


Figure 2-7 Band Pass Filter

Filter Theory

The user should understand the way measurements are taken when Filter = On. First, the data for the sample is collected and each individual time is computed. Second, any values outside the limits are discarded. Third, statistics are calculated based on the reduced number of readings.

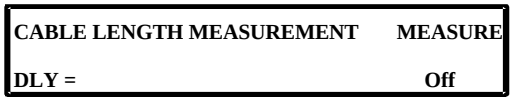
When Filter = On, the average, standard deviation, and range does not include the readings outside the limits. The number of readings displayed in the statistics menus will be the number of readings that were within the limits. Minimum and maximum also reflects the readings inside the limits.

If Filter = On and no readings were within the limits, the sample completed number will be 0. The standard deviation jitter will read -999,999,999 seconds and the message displayed will be:

NO VALUES IN RANGE

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MENU #9: CABLE MEASUREMENT



This menu allows the measurement of a cable to obtain its electrical length. The cables must be a 50Ω coax cable. The procedure for measuring a cable is as follows:

Note: When measure is turned 'on' the hardware turns on a 1MHz sq. wave pulse at the Cal 1 & 2 outputs. If desired, the user can use any frequency of signal as long as it is '0' crossing and its period is longer than the electrical length of the coax being measured.

1. Connect the "Cal 2" to the Channel 2 with a short length of 50Ω coax.
2. Connect the "Cal 1" to the Channel 1 with the cable measurement fixture to be used to measure all subsequent 50Ω cables.
3. Enable the cable measurement mode by selecting ON in the menu.
4. Press the BURST push button.

The DTS will briefly display the following message:

SUBSEQUENT CABLES WILL USE THIS CABLE ARRANGEMENT AS A REFERENCE.

Note: This means that the DTS "zeroed out" the particular cable arrangement just measured. To verify this, press BURST a second time. The value read should be close to zero picoseconds.

5. Open the connector connecting the CAL 1 to Channel 1 and insert the cable to be measured.
6. Press the CONT or BURST push button.

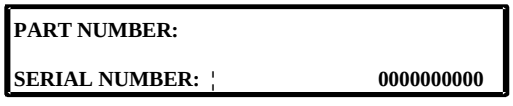
The observed time is the electrical length of the cable being measured.

Note: Cable length measurement changes the front panel setup. It changes the forced measurement mode to "Auto Arm on Start", function to TPD++, START, STOP voltages to "0" volts.

Note: A signal validity check is made at the startup of cable measurement. A check that the signal is greater than 30 millivolts is made and if not, a message is displayed:

SIGNAL LESS THAN 30 mV AMPLITUDE
CABLE MEASUREMENT FAILED

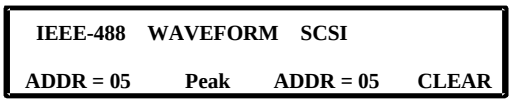
MENU #10: PART/SERIAL NUMBER



This menu gives the user the means of recording individual device part numbers and serial numbers. The part and serial numbers will accompany printed statistical data when using Printer Menu #13. An auto increment feature is provided to increment or decrement the serial number.

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MENU #11: PORT



IEEE-488: Provide access for setting the IEEE-488 bus address from 1 to 31.

The default address setting from the factory is 05. To change the default setting to another address:

1. Change the address to a new address using the Menu and Increment buttons.
2. Power down the instrument.
3. On successive Power-ups, the new address will be the default.

WAVEFORM: The Waveform selection of Peak or Flat directs the pulse find search and setting of the reference voltages. With Peak selected, pulse find will search for the peaks and with Flat selected, it will search for the major flat area of a waveform at the trailing edges of the waveform.

Note: See Section 2.2-5 for more information on **Pulse Find**.

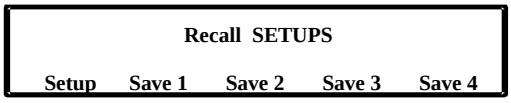
SCSI: Allows the setting of the SCSI bus address from 1 to 7 hexadecimal.

The default address setting from the factory is 05. To change the default setting to another address:

1. Change the address to a new address using the Menu and Increment buttons..
2. Power down the instrument.
3. On successive Power ON's, the new address will be the default.

CLEAR: The CLEAR will cause the instrument to reset to the parameters of function TPD++. The front panel will display the **PORT** menu with the cursor in the ADDR field. Sample size and sets size will be initialized to 1000.

MENU #12: MEMORY - NAME/SAVE/RECALL



This menu is really three (3) menus in one (1). Place the cursor on Recall, the default selection, use the increment/ decrement buttons to move from Recall to NAME or Save.

There are ten (10) memories available for saving and recalling setups. The names of each memory can be changed using any combination of A-Z and 0-9. To Save or Recall, select the respective submenu and place the cursor on the name and press the Function button.

The names and information stored is not changed on a power down or clear. The information can only be changed by the operator through the front panel or a host interface.

During a Save or Recall, the following parameters are saved for later recall, or recalled and used as DTS parameters:

- Function Selection (defines edge direction)
  - Channel selection (Ch1/Ch2/Both)
  - Arming event arming sequence
  - Start reference voltage
  - Stop reference voltage
  - External Arm reference voltage
  - External Arm edge direction
  - Pulse find levels (percentages)
  - Start/Stop edge (rising or falling)
- Sample size
- Sets size
- Start/Stop VOH (max peak) voltage
- Start/Stop VOL (min peak) voltage
- Filter On/Off
- Filter minimum
- Filter maximum
- Start/Stop Arm on Nth count
- Gating on/off
- Start/Stop external arming inputs
- Arming source
- Strobe start point
- Strobe stop point
- Strobe increment value
- Strobe number of points
- Strobe arming channel
- Strobe input channel
- Strobe delay
- DC channel

Note: Cable measurement mode (on/off) not stored.
Parameters listed under Function Selection are saved for each function type.
External calibration values are not stored.

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MENU #13: PRINTER

AUTO LOG	PRINT SELECT	STATUS
Off	Statistics	Ready

This menu allows the controlling of selected printouts. The printer supported is the Epson FX series of printers emulating these basic features. Many modern printers support the basic features, but the operator might have to manually select the mode.

Example: HP LaserJet II

1. Place printer OFF LINE.
2. Press MENU until FONT SRC appears on the first line of display.
3. Press +/- to select I (for internal fonts).
4. Press ENTER to save selection.
5. Press MENU to display FONT NUM.
6. Press +/- until font I018 is selected.
7. Press ENTER to save selection.
8. Press ON LINE to exit menu and place printer back on line.

The printer should now be ready for printout from the DTS. Similar types of setup to an IBM PC style of printer may have to be performed to select font styles:

ABCDEfghijíó▌┤╢╕╣╗╩┴#$@[]^`{|

AUTO LOG - Directs the DTS to print out the statistics after each measurement.

Function	Measured	Maximum	Minimum	Range	Jitter
Period CH1	5,028.266ps	5,066ps	5,006ps	29.91ps	16.54ps
Period CH1	5,027.826ps	5,065ps	5,002ps	31.13ps	16.53ps
Period CH1	5,027.364ps	5,067ps	5,002ps	32.04ps	16.48ps
Period CH1	5,027.432ps	5,065ps	5,004ps	30.21ps	16.33ps
Period CH1	5,026.654ps	5,065ps	5,003ps	31.13ps	16.06ps
Period CH1	5,027.637ps	5,066ps	5,004ps	31.13ps	17.19ps
Period CH1	5,028.310ps	5,069ps	5,001ps	34.18ps	17.64ps
Period CH1	5,027.482ps	5,068ps	5,004ps	31.74ps	17.20ps

PRINT SELECT - Allows the selection of three (3) printouts when the 'FUNC' key is pushed:

1. STATISTICS - Statistics and instrument parameter used for those setups.
2. SETUP - Current instrument setup.
3. HISTOGRAM - Histogram of last measurement.

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STATISTICS Example:

Current Test Configuration

Measurement mode	:	Period Ch1
Samples	:	1001
Triggering	:	Automatic
Gating with ARM2	:	Disabled
User trip levels	:	Disabled
Trip levels	:	50% - 50%
Event sequence	:	Auto arm on stop
Start arming cnt	:	1
Stop arming cnt	:	2
Filtering	:	Disabled

Trip Voltages

Start event	:	+0.0004	
Stop event	:	+0.0004	
Ch1 peak voltages	:	+0.9617	-0.9610

Test Results

Samples	:	1001
Sets	:	1
Measured	:	5,027.569 ps
Maximum	:	5,067 ps
Minimum	:	5,005 ps
Range	:	30.52 ps
Jitter	:	16.38 ps

SETUP Example:

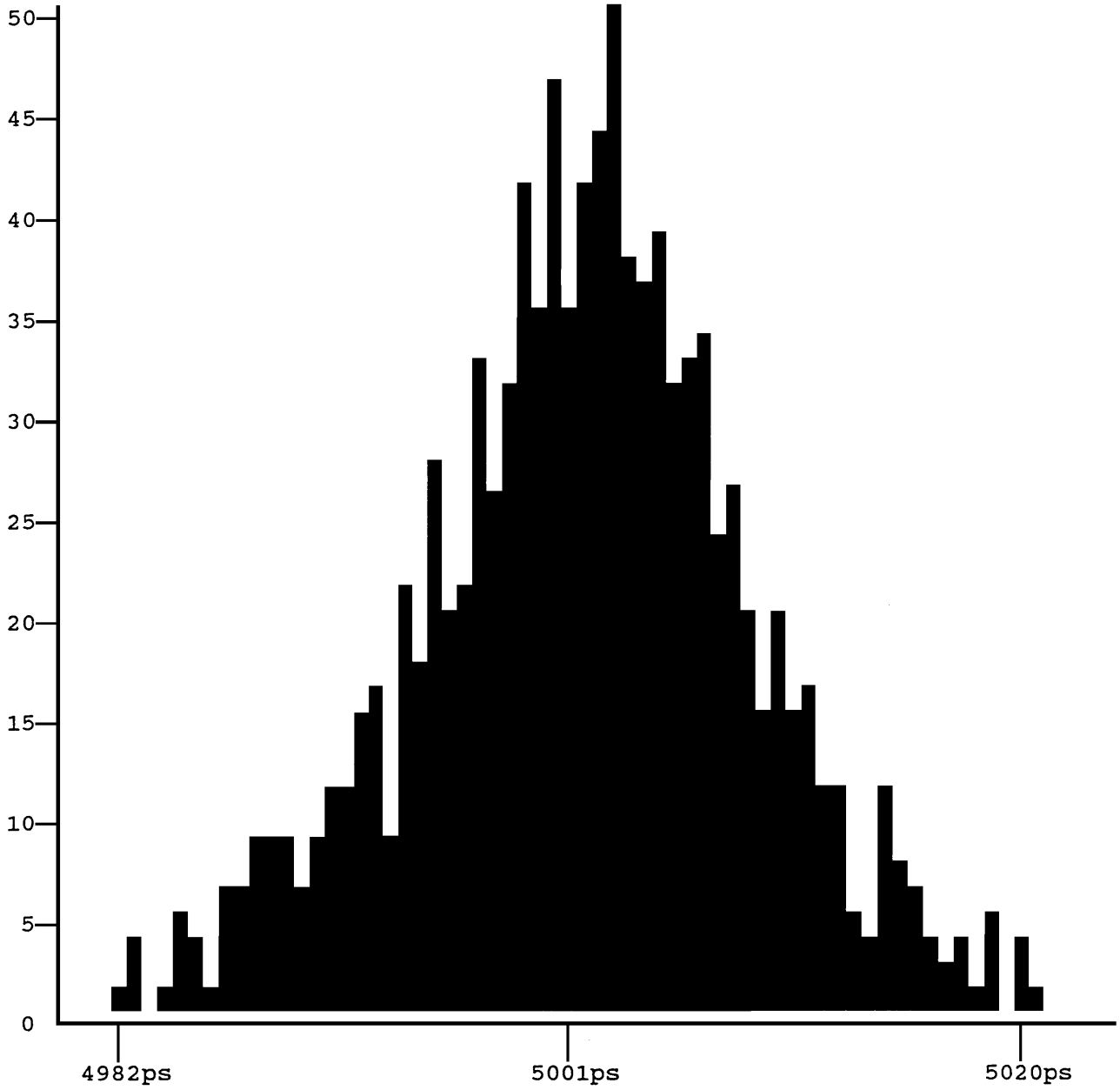
Complete Setup

Measurement mode	:	Period Ch1
Samples	:	1001
Triggering	:	Automatic
Start arming	:	1
Stop arming	:	1
Gating with ARM2	:	Disabled
User trip levels	:	Disabled
Event sequence	:	Auto arm on stop
Start arming cnt	:	1
Stop arming cnt	:	2
Filtering	:	Disabled
Filter maximum	:	+2.499999999999
Filter minimum	:	-2.499999999999
GPIB address	:	5

Trip Voltages

Start event	:	+0.0004	
Stop event	:	+0.0004	
Arm 1 trip level	:	+0.0000 Rising	
Arm 2 trip level	:	+0.0000 Rising	
Ch1 peak voltages	:	+0.9617	-0.9610
Ch2 peak voltages	:	+0.0000	+0.0000
Arm1 peak voltages	:	+0.0000	+0.0000
Arm2 peak voltages	:	+0.0000	+0.0000

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Measurement Mode: Period
CH1

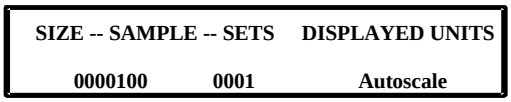
Test Results

Samples	:1000
Sets	:1
Measured	:5,001.204ps
Maximum	:5020ps
Minimum	:4982ps
Range	:18.62ps
Jitter	:6.484ps

Figure 2-8 Histogram of Samples

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MENU #14: STATISTICS SETTING - Size & Format



SAMPLE SIZE - Selects the number of measurements taken (1 to 1,000,000) for each burst used to generate statistics.

SAMPLE SETS - Selects the count of a set of measurements used to generate statistics. The default set is 1. Sample set and size work together to provide the number of measurements in a burst.

Example 1: Size = 1000 sets = 1

One (1) burst of 1000 measurements is taken

Example 2: Size = 1000 sets = 10

One thousand (1000) bursts of size ten (10) measurements are taken. Statistics for each set (10) are generated and these statistics are used to generate the final statistics which are displayed on the front panel.

DISPLAYED UNITS - Units to be displayed is selectable from seconds (s), milliseconds (ms), microseconds (μs), picoseconds (ps), and femtoseconds (fs). In Autoscale (AT) the display will start up to nine (9) digits before shifting to the next wait of measurement in groups of three (3) digits or scientific engineering notation.

MENU #15: PULSE FIND PEAKS



Displays the peak or flat level, determined by the waveform selection on Menu #11, of the input channel reference voltages. See Section 2.2-5, Pulse Find, for more information.

With the cursor in this menu and the FUNCTION button pressed, the minimum and maximum voltages of the input signal will be found.

MENU #16: STATISTICS I – Min/Max & Samples Taken



Samples Completed/Samples Size - The current number of measurements taken and the sample size are displayed. The current samples completed are updated approximately every one (1) second.

MX & MN - At the completion of a burst, the minimum and maximum values are displayed in this menu. The displayed units are selected in Menu #14.

MX = Maximum value read
MN = Minimum value read
DC = Duty cycle is a percentage of the PW+ over Period, divided by 100

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2.4 MODE SELECTIONS

There are five hardware modes on the DTS:

Internal Calibration – Used to calibrate the internal circuits

External Calibration – Used to calibrate/deskew inputs

Burst – Used to take one set of readings equal to the Sample Size

Continuous – Used to take multiple sets of readings equal to the Sample Size

Idle – A wait state usually encountered after a Burst is completed or when instrument is Powered-Up.

2.4-1 INTERNAL CALIBRATION (Labeled INT CAL)

The DTS requires a minimum warm-up period of 30 min. for measurements and distributions to be within specification. To initialize the internal calibration sequence after the recommended warm-up period, push the **INT CAL** button on the front panel and a message will be displayed:

INTERNAL CALIBRATION
PRESS GO WITHIN 5s TO CONTINUE

If the user does not respond within 5 seconds the internal calculation will not be done.

When the GO button is pressed, a message will be displayed:

INTERNAL CALIBRATION 660 SECONDS TO GO

This indicates the amount of time remaining to accomplish all of the internal calibration procedures. The calibration process is uninterruptable once the INT CAL switch is activated. The display will begin counting down from 660 sec. When the countdown reaches 0 sec., the display will change to:

CALIBRATED

The previous mode and display then returns.

If a power loss occurs during the calibration and prevents its completion, the DTS will not complete the calibration and will not change current calibration tables

2.4-2 INTERNAL CALIBRATION OPTIMIZATION

Internal calibration should be performed after the DTS has been powered-on for at least 30 minutes in a temperature-stable environment. The calibration is valid for varying time periods, depending on the operating environment. The most important factor necessitating a re-calibration is a temperature change greater than published specifications. The DTS ±25ps single shot accuracy depends on a recent calibration and temperature drift of less than ±5°C.

An external calibration should be performed after each internal calibration (See Section 2.4-3, External Calibration).

Internal calibration can be manually initiated at any time, without disconnecting external fixtures.

Extended Internal Calibration allows the user to reduce jitter due to the noise floor of the instrument through the use of longer internal calibration periods. The selected multiplier, from 1 to 25, extends the base calibration period of approximately 5.5 minutes by that factor. The table below shows typical results using the selected multipliers. Calibration times are approximate.

Multiplier Factor	Cal Time	1-sigma jitter	0db Peak Noise Floor
1	5.5 min.	3.36	2.68ps
2	11 min.	2.56	1.46ps
6	33 min.	2.24	849fs
24	132 min.	2.19	827fs

*** Embedded code version 1.98 or greater must be installed for extended internal calibration to work.

*** The extended internal calibration can only be initiated via GPIB commands with a user program or *Virtual Instruments*™ version 3.20 or greater. See Section 3 or the GPIB Programming Guide for the command structure.

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2.4-3 EXTERNAL CALIBRATION (Labeled EXT CAL)

External calibration for cables or probes can be accomplished in the same manner. When probes are used, an appropriate probe tip to SMA adapter should be installed at the CAL1 and CAL2 SMA connectors.

To initialize External Calibration, push the EXT CAL push-button. This will initiate the sequence for measuring and compensating for cable length. The display will read:

EXTERNAL CALIBRATION
PRESS GO WITHIN 5s TO CONTINUE

If the user does not respond within 5 seconds, the external calibration will not be done.

When the GO button is pressed, the following message will be displayed:

PRESS GO WITHIN 5s TO PERFORM
DC CALIBRATION PHASE

If the user does not respond within 5 seconds, the DC calibration phase will not be done. Go to AC calibration.

2.4-4 EXTERNAL CALIBRATION THEORY OF OPERATION

The user should understand the basic purpose of external calibration. It establishes zero reference points so subsequent readings can relate to the same condition as the "zero" point. External calibration does not just measure the difference in the lengths of the cables; the process calculates the delays all the way to the logic inside the DTS. Note that there is a separate path for each of the 16 possible combinations of the rising and falling signals so 16 offsets are calculated and saved. This makes it unnecessary to recalibrate if you do an external cal in rising/rising mode and then change to falling/falling. However, if cabling is changed, one must recalibrate to obtain valid, absolute measurements.

The DTS uses a zero-crossing 200MHz sine wave with a harmonic content of less than -50db. The references are set to zero (0.000) volts during this calibration, and the input termination is set to GND.

After external calibration is complete, a quick check of the effectiveness of the calibration can be made by changing all voltage references on the Start and Stop channels to 0.000 volts. Scroll through the measurement options and record the measurement values for each option. Cross cable connections at Cal signal connectors. Scroll through the measurement options again, and record their measurement values for each option. The average of the two measurements for each option should be as follows:

1) TPD++, TPD--, TT+, TT-.....0ps ±10ps
2) PW+, PW-, TPD+-, TPD-+ .....2,500ps ±10ps
3) Period.....5,000ps ±10ps
4) Frequency.....200MHz ±1kHz

Cable Length Restriction:

NOTE: Because of the 200MHz sine wave used for "EXT CAL", the maximum cable length delta between CH1 and CH2 is 30.0cm.

2.4-5 DC CALIBRATION

When the GO button is pressed, the following messages will direct the user through the DC calibration:

APPLY SHORTING CAPS TO ALL INPUTS
PRESS GO

The shorting caps were shipped with the instrument and provide a ground to calibrate any offset from ground.

REMOVE SHORTING CAPS
PRESS GO

The DTS calibrates for any current compensation of the voltage divider network at the input of the A to D's.

GROUND INPUTS FOR CH1 AND CH2
PRESS GO

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The DTS calibrates for any voltage reference difference caused by the probes being used between Channel 1 & 2.

DC CALIBRATION PHASE FINISHED
PRESS GO

2.4-6 AC CALIBRATION

CONNECT CH1 TO CAL1
CONNECT CH2 TO CAL2, PRESS GO

This message instructs the operator to connect the external cables or probes to be calibrated to the correct SMA connectors. Once the connection is made, press GO and the instrument will automatically calibrate the cable connected to CH1 and CH2. The LCD will then display the following:

CROSS CABLE CONNECTIONS AT
CAL SIGNAL CONNECTORS, PRESS GO

This message instructs the operator to connect the CH1 cable to CAL2 and CH2 cable to CAL1 (refer to NOTE below). Once the connection is made, press GO and the instrument will automatically calibrate the cable connected to CH1 and CH2. The LCD will then display the following for two seconds:

CALIBRATED

The previous mode and display then returns.

The unit has calibrated for the difference in the cable length of the external probes and the software will maintain “constants” and will use these numbers when calculating time measurements.

Pressing any other switch during calibration also causes the previous mode and display to return. Calibration values are still defined as before.

NOTE: Crossing the cables allows the DTS to isolate and ignore skew due to the calibration source. The point where the signals are switched during AC calibration becomes the "zero reference point." Any skew due to differences between that point and the DTS is calibrated out. If it is known that there is negligible skew in the 200MHz calibration signal at the desired zero reference point, it is not necessary to cross the cables.

2.4-7 CALIBRATION VALIDITY CHECKS

Before starting the calibration, a check is made to ensure the signal has an amplitude greater than 100 millivolts. If not, a message is displayed:

PULSE < 100mV

After each calibration measurement, the jitter of the measurement is checked for less than 100 picoseconds. If not, a message is displayed:

JITTER > 100ps

At the end of the External Calibration, a check is made that the measurements were reasonable. If not, a message is displayed:

CAL NOT GOOD

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2.4-8 **BURST** (Labeled BURST)

Pressing the BURST mode push-button causes the DTS to begin taking readings. The indicator light will stay lit until this mode has been completed.

The number of readings taken (1 to 1,000,000) will correspond to the sample size selected. When BURST has completed taking the number of readings equal to the sample size, the new computed data is displayed and stored. It can be observed by using statistics menus. The BURST indicator is extinguished and the DTS returns to an idle state.

A Burst of up to 32,768 measurements is stored in the DTS memory and can be read over the GPIB for special processing. When the filter is "On", up to 8000 measurements are stored and read over the GPIB.

If BURST is interrupted by pressing any other mode push-button, the most recent computed data is returned (any unprocessed data is lost).

BURST must be pressed again to accept another set of samples.

2.4-9 SPECIAL CASE

If FILTER is enabled, and BURST has been completed, only the number of readings taken within the bounds of the filter will be displayed.

For example, if 1,000 readings were requested and 10 readings were outside the bounds of the filter, 990 readings would be displayed along with the computed data of the 990 readings.

If the Statistics I menu is being displayed, the computed data for all 1,000 readings can be updated and displayed by pressing the FUNCTION button.

If a new BURST is initiated without pressing the FUNCTION button, the data for the 10 readings outside the filter boundaries are lost.

2.4-10 **CONTINUOUS** (Labeled CONT)

When the CONTinuous mode push-button is pressed, the DTS will begin taking readings. The indicator light will stay lit as long as the DTS is in CONTinuous mode.

The DTS continues reading until it has measured the number of pulses (1 to 1,000,000) that was entered through the front panel.

After CONT has completed taking the readings equal to the sample size, the new computed data is stored and displayed. The process begins again to collect a new series of measurements equal to the entered sample size.

If CONT is interrupted by pressing any other mode push-button, the most recent computed data is displayed.

If FILTER is enabled, only the number of readings taken within the bounds of the filter will be displayed. For example, if 1,000 readings were requested and 10 readings were outside the bounds of the filter, 990 readings would be displayed along with the computed data of the 990 readings. The data for the 10 readings outside the filter boundaries is lost.

2.4-11 IDLE

Idle is a default mode, since it merely represents a defaulted, or waiting, condition usually after a BURST has been completed.

2.4-12 DC CALIBRATION REFERENCE VOLTAGES

Used for measuring 5vdc reference voltage. Voltage should not deviate more than 1mV from recorded voltage on rear panel. If reference voltage does change more than 1mV, contact your representative for service.

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2.5 ARMING SELECTIONS

The user can select any one of three Arming modes via the GPIB or from the front panel. There is a separate button on the front panel for each of the three Arming modes. When one of the buttons is pressed, a light on the button will illuminate to indicate which mode is active.

2.5-1 ARMING SOURCE SELECTION

The user has the option of selecting one of three Arming sources on the DTS. The Arm push-buttons are located immediately above the Arm SMA connection on the lower right of the front panel.

Automatic Arm
External Arm
Manual Arm

The Default Arm mode is "Auto Arm."

2.5-2 AUTOMATIC ARM (Labeled AUTO)

Pressing the Automatic Arm push-button allows readings based on the edges of the CH1 and CH2 pulses. The DTS collects the number of samples selected, computes statistics, and displays them in the Statistics I and Main Function menus, #1 and #16.

Enable/Arm mode (Menu #5) allows selection of several measurement modes and should be referenced when using Auto Arm. The DTS selects the last used enable mode when powered up.

The number of measurements corresponds to the displayed sample size. When measurements equal to the sample size have been collected, computations are made and displayed.

If Burst mode is selected, no further pulses are accepted without initializing Burst mode again.

If Continuous mode is selected, a new series of measurements will begin immediately.

Pressing any other Arming function switch deactivates the Automatic Arm and extinguishes the AUTO indicator light.

2.5-3 EXTERNAL ARM (Labeled EXT)

Pressing the External Arm push-button allows an external signal source to arm the instrument. The operator selects a voltage level between ±1.11V, using Menu #3.

Once armed, the DTS measures the next pulse to be presented, with one measurement collected each time EXT Arm signal is received. In 'Gate' mode the DTS measures as long as gate is in selected mode.

The number of measurements corresponds to the sample size selected. When the number of measurements equal to the sample size is collected, computations are made and displayed in the statistics menus.

If Burst mode is selected, no further pulses are accepted without initializing Burst Mode again.

The required External Arm signal is any pulse of a minimum duration of 1ns pulse width occurring 3ns before the signal on the Ch1 or Ch2 inputs.

See Section 2.5-8 for using External Arm input as "Gate."

2.5-4 MANUAL ARM (Labeled MAN)

Pressing the Manual Arm push-button allows the GO switch to arm the Time Measurement Unit. Once armed, the DTS measures the next pulse to be presented. One measurement is taken each time GO is pressed. The MAN indicator light stays lit until a complete set of readings is taken. The number of measurements corresponds to the displayed sample size. When measurements equal to the sample size have been collected, computations are made and displayed in the statistics menu.

If Burst mode is selected, no further pulses are accepted without initializing Burst mode again.

If Continuous mode is selected, a new series of measurements can begin immediately.

Pressing any other Arming function switch deactivates the Manual Arm and extinguishes the MAN indicator light.

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2.5-5 ARMING SEQUENCE (ENABLE) MODES

Enable modes are program selectable from the GPIB or from the front panel Menu #5. The purpose of the enable modes is to help resolve potential ambiguous situations that can occur, especially when Auto Arming. An ambiguous occurrence would be measuring negative time when you wanted to measure positive time even though both measurements would be valid.

All of the enable modes work in conjunction with which Arming source the user selects, Auto arm, External arm, or Manual arm. The sequence of events for taking a measurement:

Note: The following sequence of events describes how the hardware works. It is important to note that each Function in the DTS has an Enable Mode associated with it. From the front panel or GPIB host interface, always select the function before changing a parameter association with a specific function, such as the enable mode.

1. The selected Arming source is satisfied.
2. The selected Enable mode condition is satisfied.
3. The selected Function criteria is 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 would be:

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 will enable 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” and then starts the measurement on the next pulse whether it be on the START or STOP paths. In the case of a TPD++ measurement, see Figure 2-9.

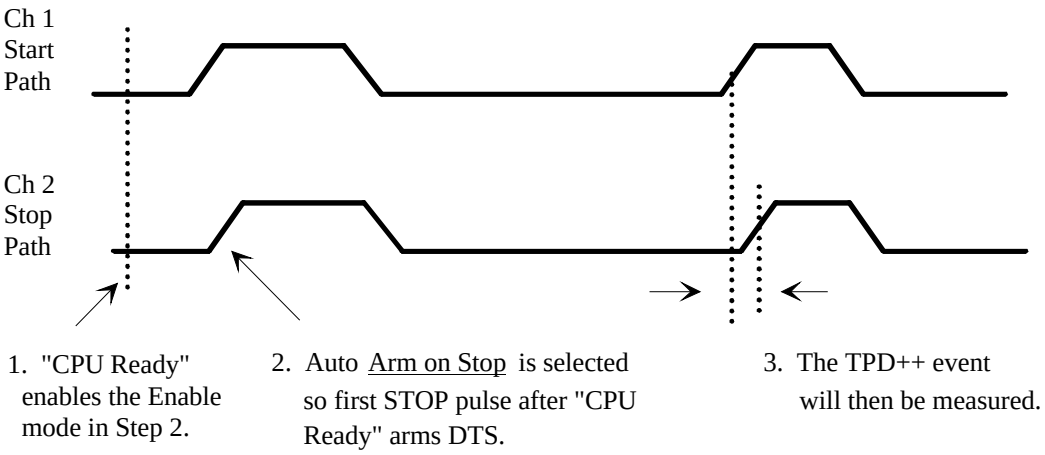


Figure 2-9 Arm on Stop

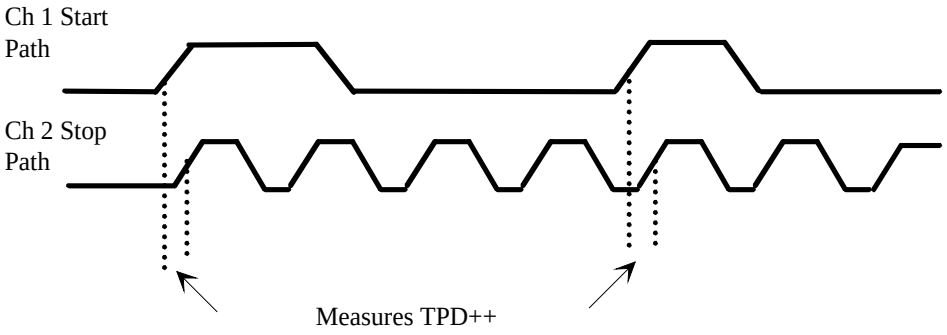
“Enable Stop after Start” or “Enable Start after Stop”

This enable mode was developed for the cases where the customer wants to measure a TPD event on random data with respect to a clock signal without any special external arming. In this figure, the application is to measure the clock (cp) setup time with respect to the data input. The DTS execution sequence would be:

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

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In Figure 2-9, selecting enable mode “Enable Start First” would have also worked. This later mode assures positive time measurements when there are random events occurring. Although, in the case of differential output skew, measurements using “Arm on Stop” assures the ability to make positive time measurements.



1. Measure slected TPD mode only after Start event occurs.

Figure 2-10 Arm Start First

This enable 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 (See Figure 2-10). As before, the measurement will be in positive time because of the “Start first” mode. In fact, if no event occurs that meets the above selected criteria the DTS will not make a measurement but instead will return a “No Pulse Found” message.

2.5-6 USING THE ARMING SOURCE AND SEQUENCE TOGETHER

Auto Arm

The Default ARM source for the DTS is Auto Arm. With the DTS, there is much the user can do without using any of the synchronous arming modes.

For example, measuring jitter with any of the measurement Functions using Auto Arm enables a worse 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 with a DSO sampling scope or any other triggered instrument. Refer to *WAVECREST* App. Note 112 on measuring 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 the data stream.

A case like this would be a random data stream or vector set from an ATE tester. The user may want to make a measure 101,356 cycles into the vector set. The External Arm input would be used to enable the DTS prior to the parameter the user wants to measure.

In cases where the signal input is reoccurring or is a repeating pattern, then 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 would escape the real time or sampling oscilloscope (See Figure 2-10).

In Figure 2-10, the user wanted to measure the function TPD++. The user also selected Auto Arm and Enable on Stop. Figure 2-10 shows the sequence of events leading up to the actual measurement. If a Sample Size count was set to some number like 1000 then the above cycle would repeat 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 and represents the RMS jitter in a Gaussian distribution. The AVERAGE is the center of the distribution.

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External Arm

Arming inputs 1 and 2 are multifunctional. The following are selectable via the GPIB or front panel Menus 3 & 4.

Menu 3:

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 will automatically be found and entered into these registers for the user. The value entered will be the 50% point of the arm channel.

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 4:

1. Select which Arm, 1 or 2, to arm Channel 1 or 2. Arm 1 or 2 can arm Channel 1 and 2 separately, or Arm 1 or 2 can arm both channels (See Figure 2-11).

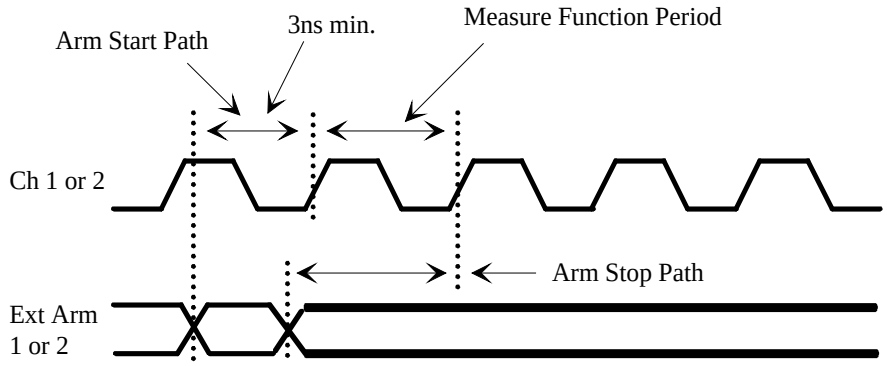


Figure 2-11 External Arm

For example, both channel inputs 1 and 2 can be armed by the same arm signal. To do this, connect the desired arming signal through a power splitter to both arming inputs, 1 and 2. The user could then choose to arm Channel 1 on the rising edge of the Arm 1 and Channel 2 on the falling edge of Arm 2. In that way the pulse width of the arming signal controls the time duration between the measurement taken between Channels 1 and 2 or on the same channel (See Figure 2-12).

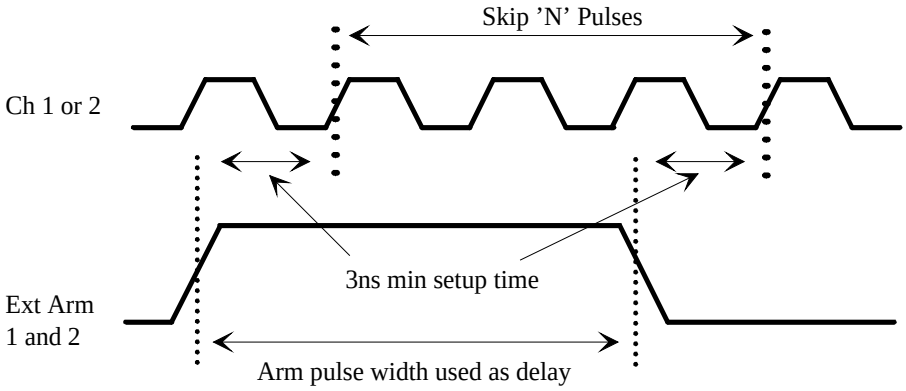


Figure 2-12 External Arm With Delay

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 would work in the same manner as if it were in the External Arm mode, except the external arming would be done manually instead of electrically.

This mode is useful when the user wants to synchronize the DTS with some experiment such as the turning on of a power supply to look at the power up jitter of a PLL. This mode is also useful in setting up the DTS to wait for some randomly occurring event that the user is trying to catch in one-shot mode.

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2.5-7 AMBIGUITY

Whenever the DTS is making a time measurement, it is possible to get the CH1 and CH2 pulses in either order. It is important to know the DTS always measures and displays time as follows:

Positive Time T.....Always when CH1 occurs before CH2

Negative Time -T.....Always when CH2 occurs before CH1

The fact that the DTS keeps track of which pulse comes first in a typical measurement and can give both a positive and negative result can cause some concern and confusion when taking readings. The DTS, with its different arming modes, minimizes the possibility of ambiguity, but the user should be fully aware of the DTS arming capabilities to avoid potential ambiguous readings.

The DTS offers several different arming capabilities to solve ambiguity. It is possible, especially with the requirement that the EXT Arm pulse be 3ns prior to the signals to be measured, that a confusing set of readings can happen. The example in Figure 2-13 shows a proper setup that will not give any ambiguous reading. The following two examples (Figures 2-13 and 2–14) help explain a situation that would result in ambiguity.

Example 1 - Proper Setup: (See Figure 2-13)

1) The DTS is in EXT Arm mode and is waiting to be armed by the external signal.
2) A test setup is configured such that the EXT Arm signal is placed 3ns in front of the CH1 and CH2 pulses at the setup.
3) There are three cables for CH1, CH2, and EXT Arm to the DTS which are exactly the same length.
4) The time expected to be read is *t*, the propagation delay represented in the diagram between the two pulses, one on CH1 and one on CH2.
5) The "System Arm" represents the EXT Arm signal as seen at the DTS.

In this example, since the cables are the same length, the System Arm at the DTS arrived at the proper time -3ns prior to the two events to be measured.

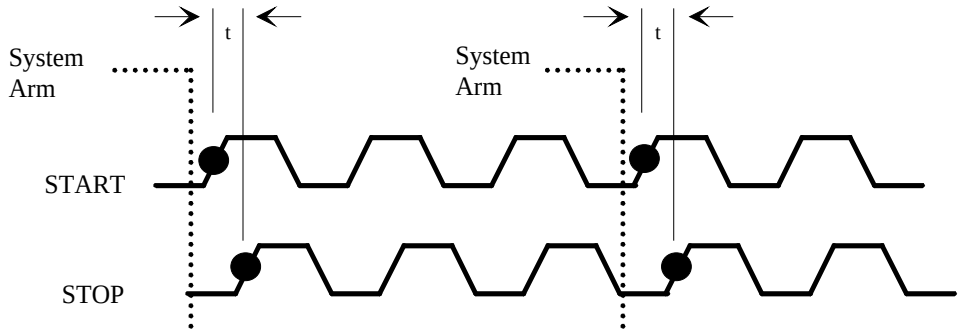


Figure 2–13 Example 1 - Proper Readings

In this case, the expected results were obtained, which was to see *t*, a positive propagation delay between CH1 and CH2.

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Example 2 - External Arm Delayed: (See Figure 2-14)

1) The DTS is in EXT Arm mode and is waiting to be armed by the external signal.
2) A test setup is configured such that the EXT Arm signal is placed 3ns in front of the CH1 and CH2 pulses at the setup.
3) There are two cables for the CH1 and CH2 that are exactly the same length. The third cable for the EXT Arm is a little longer than the other two cables.
4) The time expected to be read is *t*, the propagation delay represented in the diagram between the two pulses, one on CH1; one on CH2.
5) The "System Arm" represents the EXT Arm signal as seen at the DTS.

Notice in this example that since the cable for the EXT Arm was a little longer, the System Arm signal seen at the DTS arrived at the wrong time. In fact, it arrives later than the CH1 signal, but before the CH2 signal.

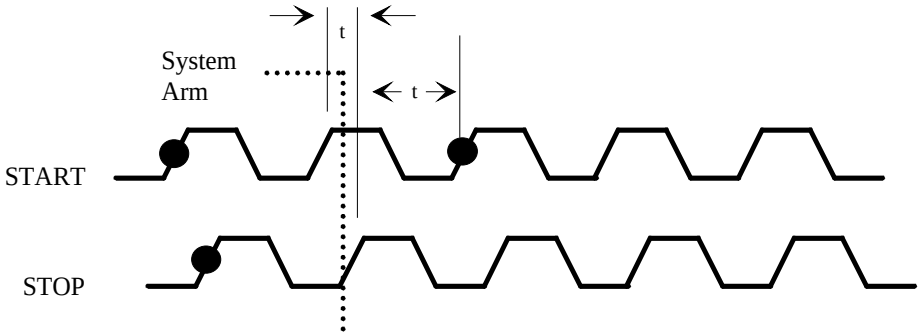


Figure 2–14 Example 2 - Arming Signal Delayed

In this case, the expected results were not obtained, which was to see *t*, a positive propagation delay between CH1 and CH2. Instead, the DTS measured the time between the CH2 and CH1 and the result was a *-t*. This could be interpreted as an ambiguity reading.

These examples are not to imply that every situation can be solved by using the right cable length but to merely point out the potential ambiguity.

Example 3 - Positive and Negative Readings

1) The DTS is in EXT or AUTO Arm mode.
2) If in EXT Arm mode, a test setup is configured such that the EXT Arm signal is placed near the edge of the Arm window shown in Figure 2-15.
3) If in AUTO Arm mode, signals are applied to the CH1 and/or CH2 inputs and the DTS is making measurements.
4) As an example, the DTS is measuring TPD++ using AUTO ARM ON STOP

The DTS arms the start and stop paths approximately 3ns after the rising edge of the signal on the CH2 input. Because of jitter, this can cause a condition to occur where the CH1 signal is missed until the next pulse occurs. A negative reading for *t* will occasionally result when this situation exists. One method of eliminating any negative readings is to delay the CH1 signal a known value. If dealing with the average statistic, these readings are just part of the average.

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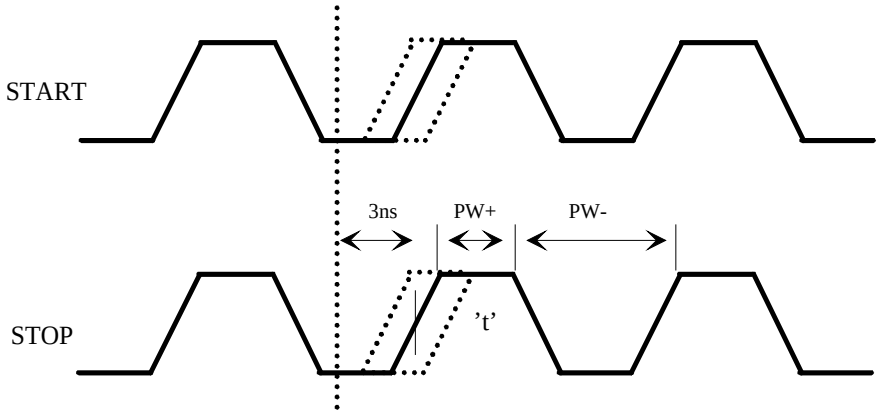


Figure 2-15 Example 3 - Getting Both Positive & Negative Readings

The potential for positive and negative readings increase with faster pulses because of signal jitter. The band pass filter capability can be used to filter out undesired readings of a measurement.

2.5-8 GATING (USING ARM 2 INPUT)

The instrument can use the Arm 2 input as a "gate" of arming.

When External arming, 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 #3, the user selects how Arm 2 input will be used (See Figure 2-16).

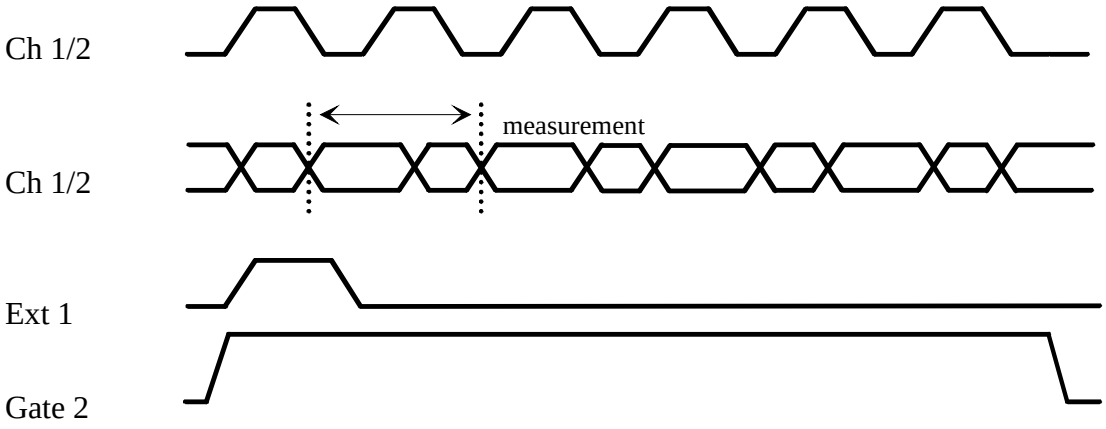


Figure 2-16 Gating Mode

The main difference between using Arm 2 input as a gate vs. edge sensitive is the DTS will make measurements whenever the gate meets the user selected criteria, whereas, if Arm 2 is edge sensitive the DTS will only make a measurement once for every edge of the arming signal. In Menu 3 the user can turn the gate "ON" or "OFF" and select whether to arm the DTS when the gate is HIGH or LOW.

In Figure 2-16 the DTS was set up to make measurements based on the following criteria:

1. Is the Gate High?
2. Is the Arm 1 input going high?
3. Enable Stop after Start.
4. Make the selected measurement; Period in this case.

The GATING mode is useful if the device to be tested has a "ready or lock" signal such as when a PLL is locked onto some serial pattern. For instance, the user may want to only measure the period when the PLL 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.

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2.5-9 MEASURING VOLTAGE IN TIME (STROBING VOLTMETER)

The Delayed Scan mode enables the DTS 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 2-17).

The point where the DTS strobe digitizes is determined by the position of the arming signal plus the delay value programmed into the delay register in Menu #7. The user can position the arming edge and/or the delay value to set the point where the DTS strobe digitizes.

Menu #7 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 #7, the DTS will measure the voltage point on the channel selected. The voltage is then displayed under VLEVEL.

1. STROBE INPUT: ..... DC, CH1, CH2, Arm1 or Arm2
2. CHANNEL: ..... 1 or 2
3. DELAY: ..... 25ns to 100µseconds

"STROBE INPUT" can be either DC, which means a 16 bit A/D converter will measure the average or steady state voltage on the selected channel, or the user can select CH1, Ch2, Arm 1 or Arm 2 inputs to reference the programmed delay value (See Figure 2-17).

The DTS uses a 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 period. The minimum programmable delay is 25ns delayed from the selected slope of the Arming input referenced. See the DTS GPIB Programming Guide for details on the programming and use of the Delayed Scan Mode.

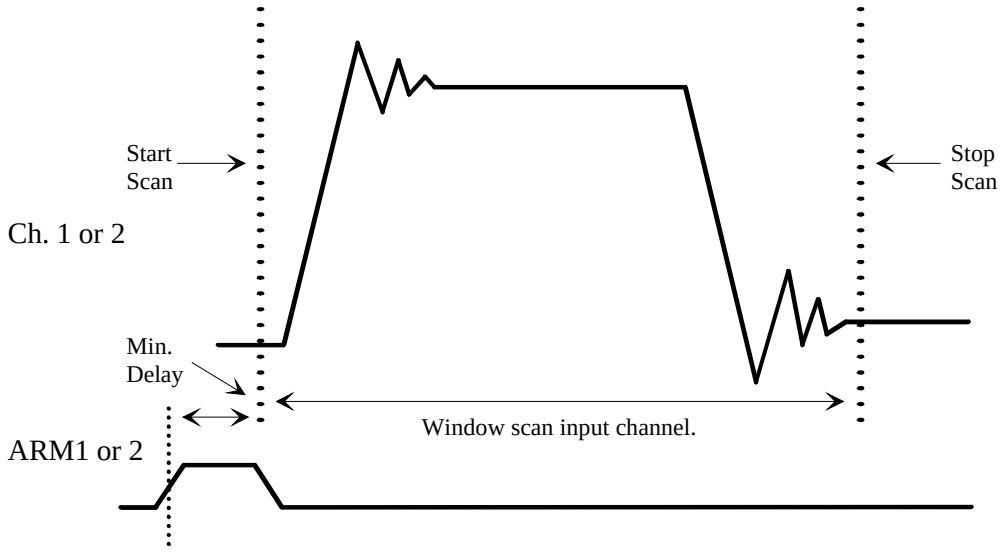


Figure 2-17 Delayed Scan for Measuring Voltage in Time

If a "WINDOW" measure is executed over the GPIB, several statistical parameters are available, VAVERAGE, VMINIMUM, VMAXIMUM, VDEVIATION 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 select one of the other parameters for a quick quantitative analysis.

In Figure 2-17, 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 would operate much like an oscilloscope trigger.

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2.6 STATISTICAL CALCULATIONS

The number of individual readings used to produce the statistics is determined by the settings of the sample and set size in Menu 14.

Sample Size

The usual number of measurements taken is simply the sample size. In this mode the sets size is one (1) and the sample size is some number between one (1) and one million (1,000,000).

In practice we recommend a sample size somewhere between fifty (50) and five hundred (500). Any fewer than this will not run much faster and little more accuracy is gained with more than this.

Some special cases of sample size settings are:

Filtering - The maximum number of readings that can be filtered is eight thousand (8000). If the sample size is set to greater than 8000 and the filtering is on, the instrument will take only 8000.

Cable Measurement - The minimum sample size of a cable measurement is five hundred (500).

Set Size

The set size can be used to measure the standard deviation of a set of measurements.

In this mode the instrument will take a measurement of set size, create statistics, and repeat this the number of sample size times.

An example with a set size of 100 and a sample size of 1000, the instrument would take data from 1000 measurements of size 100. The statistics created and displayed would be generated from the statistics of the 1000 sets of measurements.

This would typically show the standard deviation of a group of measurements over time which would be lower.

Statistics

The computation of statistics is straight forward.

Average is the sum of all individual readings divided by the sample size (assuming set size = 1).

Minimum is the algebraically smallest reading.

Maximum is the algebraically largest reading.

± Range is the (maximum - minimum/2).

Standard deviation is the square root of the sum of the squares of the difference between successive individual readings and the average, divided by n-1, where n is the sample size.

The exception to this is when filtering is On. The sample size, for calculation of statistics, is the number of readings within the filter range. The Statistics I menu, #16, indicates the sample completed in the filter range. Pressing the Function button when on the Statistics I menu, #16, will display the unfiltered statistics of the last measurement.

2.7 INSTALLATION AND MAINTENANCE

The DTS is typically installed in a stand-alone or benchtop configuration. Optional accessories are available to install the DTS in a rack mount configuration. Installation instructions for rack mounting are included with the rack mounting kits.

This equipment is intended to be connected to supply mains with the power cord provided with the product. Transient overvoltages are to be less than limits defined by installation category II, Annex J of EN 61010-1.

2.7-1 INSTALLATION LOCATION

The DTS should be installed in a clean, temperature stable environment. Although the operation temperature ranges is 15°C to 35°C, the ambient temperature must be maintained within ±5°C to stay within calibration specifications.

The DTS should be installed in an area that allows unobstructed airflow of at least two inches on each side for ventilation, and appropriate spacing in the front and back for cable routing.

The IEC plug on the AC power cord acts as the safety disconnect for the DTS. Whenever possible, always install the DTS such that easy access is provided to the safety disconnect.

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2.7-2 MOUNTING

In the bench-top installation, the DTS should be mounted on a surface capable of carrying at least 80 pounds. When mounted on a portable cart, such as a scope cart, the DTS can be secured with straps for added safety.

In the rack mount configuration, the DTS feet sit in detents on the mounting shelf preventing the unit from sliding. In addition, mounting brackets allow the DTS to be attached to the 19-inch equipment frame. The weight is carried by the rack mount shelf. (Detailed mounting instructions are provided with the rack mounting kit.)

2.7-3 VENTILATION

To provide adequate ventilation for the DTS, a minimum of two inches of unobstructed air flow must be maintained on each side of the DTS. To maintain the highest accuracy, the DTS air intake should not be near sources that would cause ambient temperature fluctuations. Temperature fluctuations greater than 5°C would require the DTS to be re-calibrated.

2.7-4 MAINTAINING PROPER INSTRUMENT GROUNDING

Both 120VAC and 230VAC power sources require an earth ground at the power connection. Failure to provide this safety ground could result in improper measurements and/or electrical shock danger to the operator.

Only qualified service personnel should perform maintenance procedures on the DTS. When maintenance is performed, NO protective earth ground connections should be removed.

NOTE: Where this product is installed at areas requiring main power connections other than the three-pronged North American power plug, the main power cord must be replaced with the cord and plug appropriate to the location. The main supply cord must be rated to meet or exceed the current rating on the IEC connector (10 amps) and must meet the requirements of H05VV power cords in IEC 227 or IEC 245. If the appropriate power cord cannot be obtained locally, contact the *WAVECREST* Corporation factory and one will be provided.

2.7-5 FUSE REPLACEMENT

The IEC plug-in at the back of the DTS provides the input connection for the AC power cord. A small compartment on the IEC plug houses two 6.3AT/250V fuses (5x20mm). The manufacturer's part number is Wickmann 19195-066. To gain access to the fuses, remove the power to the DTS and disconnect the power cord. With a small screw driver, pry open the fuse compartment on the IEC plug. Remove the fuses and install the new fuses prior to closing the compartment and reinstalling the power cord.

2.7-6 PREVENTATIVE MAINTENANCE

There are no user required preventative maintenance requirements recommended other than annual calibrations to NIST standards and routine cleaning of the exterior with a clean, damp cloth. Annual calibrations may be performed by a qualified calibration laboratory or at the *WAVECREST* factory in Eden Prairie, MN.

2.7-7 INTENDED USE OF EQUIPMENT

The DTS unit weight is approximately 40 pounds. To avoid injury or damage to the unit, the DTS should be carried and installed by two people.

The DTS should be used only for its intended purpose as outlined in this manual. To avoid possible injury, the DTS should not be operated with the top cover or other panels removed. Refer installation and maintenance to qualified service personnel.

To avoid explosion, do not operate the DTS in or near an atmosphere of explosive gases

It is essential to maintain the protective earth ground through the grounding connector of the power cord. A loss of the protective ground can cause electrical shock.

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OPERATOR'S QUICK REFERENCE TABLE

FRONT PANEL SWITCHES/INDICATORS

Switch/Indicator	Indicator ON	Function
Power ON/OFF	Power ON	Toggles Power On/Off.
INT CAL	Internal Calibrate activated	Automatically calibrates DTS.
EXT CAL	External Calibrate activated	Calibrates/Inputs Deskew.
BURST	Burst mode activated	Takes readings according to the setting of Sample Size display. Then stops.
CONT	Continuous mode activated	Takes readings according to the setting of Sample Size display. Then continues to update readings and display.
MAN	Manual arm activated	Arm the DTS for measuring the next pulse presented.
AUTO	Automatic arm activated	Allows automatic sample collection with arming from a channel input.
EXT	External arm activated	Allows external signal to arm the DTS for measuring the next pulse presented.
MENU SCROLL	Changes menus	Scrolls from menu to menu and field to field inside a menu.
INCREMENT/ DECREMENT	Changes fields	Increase or decrease values in fields or changes options.
GO	Starts DTS	Starts the DTS after required external action taken by user.
FUNCTION	Pulse Find activated	Activates Pulse Find when pressed in menu nos. 1,2,3 and 15. Updates filtered statistics when in menu #16. Execute clear in menu #11. Execute Save/Recall in menu #12. Executes voltage measure in menu #7.

Table 2-2 Operator's Quick Reference Table

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SECTION 3 - GPIB INTERFACE

3.1 SUMMARY OF DTS COMMANDS

This section examines the layout of the syntax defined by IEEE-488.2. It consists of definitions and sub-definitions for a "program message unit."

In addition to the **Common** commands defined for all instruments by IEEE-488.2, the commands for the DTS are organized into 8 different subsystem sets. They are:

System - Controls some basic function of the DTS.

Acquire - Provides access to the parameters for acquiring and storing data.

Calibrate - Provides the selection of different calibrate functions and retrieves data generated by these functions.

Channel - Provides access to the parameters associated with the different channels.

Display - Provides access to the parameters for controlling how or what information will be written to screen.

Measure - Selects the measurements to be made.

Trigger - Controls the trigger modes and parameters for each trigger mode.

Hardcopy - Controls printing of instrument configurations and measurement statistics.

3.1-1 SYSTEM COMMANDS

:SYSTem:**ARM**ing< **/**trigger source**/**trigger sequence**/**start arm ..... Arming macro for speed.
/stop arm**/**arm 1 ref**/**arm 2 ref**/**arm 1 slope
/arm 2 slope**/**start count**/**stop count>

:SYSTem:**CHAN**nel<1|2|BOTH>..... Set channel.
:SYSTem:**CHAN**nel**?** ..... Read channel.

:SYSTem:**DCCHAN**nel<1|2>..... Select dc measurement channel.
:SYSTem:**DCCHAN**nel**?**..... Read dc selected channel.

:SYSTem:**ELAP**sed**/**<OFF|ON>..... Select timed burst mode.
:SYSTem:**ELAP**sed**?** ..... Read current timed burst selection.

:SYSTem:**EVEN**t**/**<OFF|ON>**/**<1|2>**/**<RISe|FALl>..... Select event mode.
:SYSTem:**EVEN**t? ..... Read current event selection

:SYSTem:**GAT**ing<ON|OFF> ..... Turn gating on or off.
:SYSTem:**GAT**ing**?** ..... Read gating selection.

:SYSTem:**GO** ..... Execute GO button.
:SYSTem:**NOGO** ..... Execute GO, but do not perform function.

:SYSTem:**HEAD**er<OFF|ON> ..... Select header type.
:SYSTem:**HEAD**er**?** ..... Read header type selected.

:SYSTem:**LONG**form<OFF|ON> ..... Select long or short form of headers.
:SYSTem:**LONG**form**?** ..... Read long or short-form selected.

:SYSTem:**MAC**ro/<function/channel/trigger source**/**trigger sequence ..... Macro used for speed.
/percent/start reference voltage/stop reference voltage>

:SYSTem:**STAT/**<AV><JI><MN><MX>..... Selects sets of statistics to be saved.
:SYSTem:**STAT?**..... Reads number of sets acquired

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:SYSTem:**:STRO**be**ARM**<CH1|CH2|ARM1|ARM2|DC><POS|NEG|RISe|FALl> ..... Select strobe arming input.
:SYSTem:**:STRO**be**ARM?** ..... Read strobe arming input.

:SYSTem:**:STRO**be**CAL** ..... Initiate a strobe calibration.

:SYSTem:**:STRO**be**CHAN**nel<1|2> ..... Select strobe input channel.
:SYSTem:**:STRO**be**CHAN**nel**?** ..... Read strobe channel.

:SYSTem:**:STRO**be**DEL**ay<value> ..... Set strobe delay.
:SYSTem:**:STRO**be**DEL**ay**?** ..... Read strobe delay.

:SYSTem:**:STRO**be**INC**<value> ..... Set step increments|value.
:SYSTem:**:STRO**be**INC?** ..... Read step increments|value.

:SYSTem:**:STRO**be**LEV**el**/**<1|2>**/**<ARM1|ARM2|CH1|CH2>**/**max start delay**/**max end delay**/**max delta**/** min start delay**/**min end delay**/**min delta> ..... Set delays for strobe pulsefind.

:SYSTem:**:STRO**be**STAR**t<value> ..... Set start delay.
:SYSTem:**:STRO**be**STAR**t**?** ..... Read start delay.

:SYSTem:**:STRO**be**STOP**<value> ..... Set stop delay.
:SYSTem:**:STRO**be**STOP?** ..... Read stop delay.

:SYSTem:**:STRO**be**#**<value> ..... Set number of steps.
:SYSTem:**:STRO**be**#?** ..... Read number of steps.

:SYSTem:**:TIME**out<value> ..... Timeout on pulse measurement.
10 second default. Integer seconds.

:SYSTem:**:TIME**out? ..... Read timeout value.

:SYSTem:**:WAV**e<PEAK|FLAT|STRObe> ..... Set pulse find to locate peaks or flat spot (usually for a non-sine wave).

:SYSTem:**:WAV**e**?** ..... Read type of waveform search to be used by pulsefind.

:SYSTem:**:WIND**ow</start value/stop value/<step increment | #of steps> ..... Set parameters.

3.1-2 ACQUIRE COMMANDS

:ACQuire:**:ALL**<TT+|TT-|PW+|PW-|PERiod|TPD++|TPD- -|TPD+-|TPD- +|FREQ> ..... Select function and return all statistics.

:ACQuire:**:ANAL**ysis**FUNC**tion</Func/Chan/LowStartCount/HighStartCount /StopCountDesignator/Increment/DataDes> ..... Select function/chan and return function statistics

:ACQuire:**:ANAL**ysis**JITT**er</Func/Chan/StartCount/LowStopCount /HighStopCount/Increment/DataDes> ..... Select function/chan and return jitter statistics.

:ACQuire:**:ANAL**ysis**RANG**e</Func/Chan/StartCount/LowStopCount /HighStopCount/Increment/DataDes> ..... Select function/chan and return (Max-Min)/2.

:ACQuire:**:COMP**lete**?** ..... Number of readings taken.

:ACQuire:**:COUN**t<value> ..... Set Sample Size.
:ACQuire:**:COUN**t**?** ..... Read Sample Size.

:ACQuire:**:DUTY** ..... Returns duty cycle.

:ACQuire:**:FUNC**tion<TT+|TT-|PW+|PW-|PERiod|TPD++|TPD- -|TPD+-|TPD-+|FREQ> ..... Select function.

:ACQuire:**:FUNC**tion**?** ..... Read function selected.

:ACQuire:**:LEV**el ..... Pulse Finder.

:ACQuire:**:MEAS**ure ..... Takes a measurement and returns average & standard deviation.

:ACQuire:**:RUN** <TT+|TT-|PW+|PW-|PERiod|TPD++|TPD- -|TPD+-|TPD-+|FREQ> ..... Select function and return average and jitter.

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:ACQuire**:SET**s**COUN**t<value> ..... Set sets size.
:ACQuire**:SET**s**COUN**t**?** ..... Read sets size.

:ACQuire**:WIND**ow</start value/stop value/<step increment|#of points> ..... Set parameters and return voltage average.

3.1-3 CALIBRATE COMMANDS

:CALibrate**:DATA**<block> ..... Set external calibration values.
:CALibrate**:DATA?** ..... Read external calibration values.

:CALibrate**:EXT**ernal ..... Initiate external calibration.

:CALibrate**:INT**ernal ..... Initiate internal calibration.

:CALibrate**:REF?** ..... Return cal. reference voltage.

:CALibrate**:SIG**nal<"OFF, "8K,"1M","200M"> ..... Set internal calibration signal.
:CALibrate**:SIG**nal**?** ..... Read cal signal setting.

:CALibrate**:XINT**ernal<ASCII value> ..... Initiate extended internal calibration
:CALibrate**:XINT**ernal**?** ..... Read extended internal cal value.

3.1-4 CHANNEL COMMANDS

:CHANnel<**STAR**t|**STOP**>**:EXT**ernalarm<ARM1|ARM2> ..... Select event external arm.
:CHANnel<**STAR**t|**STOP**>**:EXT**ernalarm**?** ..... Read selected external arm.

:CHANnel<**STAR**t|**STOP**>**:LEV**el<value> ..... Set event trip level.
:CHANnel<**STAR**t|**STOP**>**:LEV**el**?** ..... Read event level.

:CHANnel<**STAR**t|**STOP**>**:**<MIN|MAX>**?** ..... Read START or STOP min or max peaks.

:CHANnel<**STAR**t|**STOP**>**:COUN**t<1 to 131072> ..... Set event arm on Nth count.
:CHANnel<**STAR**t|**STOP**>**:COUN**t**?** ..... Read event arm on Nth count.

:CHANnel<**SWIT**ch**IDN?** ..... Returns Version of DSM-16
:CHANnel<**SWIT**ch<NN> ..... Select DSM-16 chan. and switch
:CHANnel<**SWIT**ch**?** ..... Returns selected chan. and switch
:CHANnel<**SWIT**ch<ON|OFF> ..... Enables/disables DSM-16 front panel switches.

3.1-5 DISPLAY COMMANDS

:DISPlay**:FILT**er<ON|OFF> ..... Select filtering on or off.
:DISPlay**:FILT**er**?** ..... Read selected filtering.

:DISPlay**:FILT**er<**MIN**imum**|MAX**imum><value> ..... Set filter value.
:DISPlay**:FILTer**<**MIN**imum**|MAX**imum>**?** ..... Read filter value.

:DISPlay**:LEV**el<value value> ..... Set percent.
:DISPlay**:LEV**el**?** ..... Read pulse percent.

:DISPlay**:LINE**<quoted string> ..... Display message on screen.

:DISPlay**:PAN**el<ON|OFF> ..... Turn front panel on or off.
:DISPlay**:PAN**el**?** ..... Read panel mode.

:DISPlay**:STAT**istics<ON|OFF> ..... Turn update stats to display on / off.
:DISPlay**:STAT**istics**?** ..... Read statistics mode.

:DISPlay**:TEXTBLAN**k ..... Clear or restore display.

:DISPlay**:USER**<ON|OFF> ..... Selects user reference voltages for current function.
:DISPlay**:USER?** ..... Reads current user state.

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3.1-6 MEASURE COMMANDS

:MEASure**:AVER**age**?** ..... Read average.

:MEASure**:DATA?** ..... Return measurement data.
:MEASure**:DATA4?** ..... Return measurement data as floating point.

:MEASure**:DATAT?** ..... Return timed burst elapsed times.

:MEASure**:DC**vlevel**?** ..... Read dc level.

:MEASure**:EVEN**t**?** ..... Returns event counter value (0-65536)

:MEASure**:JITT**er**?** ..... Read jitter.

:MEASure**:MIN?** ..... Read minimum measured value.
:MEASure**:MAX?** ..... Read maximum measured value.

:MEASure**:RANG**e**?** ..... Read range of measured values.

:MEASure**:SDEV**iation**?** ..... Read standard deviation.

:MEASure**:STAT4?** ..... Returns statistical data defined by :SYST:STAT for number of samples as float

:MEASure**:STRO**be**VLEV**el**?** ..... Read strobed voltage level.

:MEASure**:VMAX**imum**?** ..... Read strobed maximum voltage.

:MEASure**:VMIN**imum**?** ..... Read strobed minimum voltage.

:MEASure**:VSDEV**iation**?** ..... Read voltage standard deviation.

:MEASure**:VDATA?** ..... Return strobed measured points.
:MEASure**:VDATA4?** ..... Return measurement data as floating point.

:MEASure**:WIND**ow**?** ..... Return average strobed voltage.

3.1-7 TRIGGER COMMANDS

:TRIGger**:LEV**el<ARM1|<ARM2|GATe><value> ..... Set trigger level.
:TRIGger**:LEVel**<ARM1|<ARM2|GATe>**?** ..... Read trigger level setting.

:TRIGger**:**<MAX|MIN><ARM1|ARM2> ..... Read arming peaks.

:TRIGger**:SEQ**uence<STARt|STOP|STARtFIRST> ..... Selects trigger sequence.
:TRIGger**:SEQ**uence**?** ..... Reads trigger sequence.

:TRIGger**:SLOP**e<ARM1|<ARM2|GATe><POS |NEG|RISe|FALl|High|Low> ..... Set arming direction.
:TRIGger**:SLOP**e<ARM1|<ARM2|GATe>**?** ..... Read arming direction.

:TRIGger**:SOUR**ce<EXTernal|AUTomatic|MANual> ..... Selects trigger source.
:TRIGger**:SOUR**ce**?** ..... Read trigger source.

3.1-8 HARDCOPY COMMANDS

:HARDcopy**:HIST**ogram ..... Print burst histogram.

:HARDcopy**:PART**<alpha-numeric> ..... Enter part number.
:HARDcopy**:PART?** ..... Return part number.

:HARDcopy**:SER**ial<integer> ..... Enter serial number.
:HARDcopy**:SER**ial**?** ..... Return serial number.
:HARDcopy**:SER**ial**DECR**ement ..... Decrease serial # by one.
:HARDcopy**:SER**ial**INCR**ement ..... Increase serial # by one.

:HARDcopy**:SET**up ..... Print DTS set-up.

:HARDcopy**:STAT**istics ..... Print statistics w/abbrev. set-up information.

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3.2 IEEE-488.1 BUS COMMANDS (HARDWARE)

The following commands are IEEE-488.1 bus commands (hardware line ATN true).

Device Clear - The device clear (DCL) command causes the DTS to perform a warm boot.

Group Execute - Will cause the same action as the trigger (GET), RUN and *TRIG commands. The DTS will acquire data.

Clear Interface (IFC) - Halts all bus activity.

3.2-1 COMMON COMMANDS

The following are common commands defined by IEEE-488.2 and supported by the DTS.

*CLS ..... Clear Status
*ESE ..... Event Status Enable
*ESE?..... Query
*ESR?..... Event Status Register Query
*IDN?..... Identification Query
*OPC ..... Operation Complete
*OPC? ..... Query
*RCL .. <0-10> . Recall
*RST ..... Reset. Resets the input and output buffers, resets the parser, and clears any pending commands
*SAV .. <0-10> . Save
*SRE ..... Service Request Enable
*SRE?..... Query
*STB?..... Status Byte Query
*TRG ..... Causes the DTS to initiate a measurement
*TST?..... Test Instrument Query

3.3 ROOT COMMANDS

:RUN .....Causes the DTS to initiate measurement. Performs the same function as the *TRG.

:TER? .....The TER query will read the TRG Event Register to be read. When the register is read it is cleared. A one informs the program that the trigger has occurred. Monitor this bit to know when a take sample (burst), pulse find, cable measure or an internal/external calibration is complete.

:LER? .....The LER query will read the Local Event Register. When the query is received and the register is read, it is cleared. A non-zero indicates that a reset is in progress.

:**SDS?** .....The SDS query reads the Special Device Register. When the query is received and the register is read, it is cleared. This register is used to indicate when some commands are complete when they don't set a TRG or MAV bit. Same as bit 3 of a serial poll.

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