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WAVECREST Corporation

DTS 2070 ATE TESTING APPLICATIONS
MEASURING ONE-SHOT EVENTS

Application Note No. 118

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DTS2070 ATE Testing Applications Measuring One Shot Events

Introduction

The need to make One-Shot timing measurements at 30ps accuracy and frequency measurements at 700MHZ or less are common with high performance IC test applications. Today, *WAVECREST*'s Digital Time Scopes, DTS2070 or DTS2050, are used with virtually all ATE Testers to make fast, accurate timing measurements. This paper demonstrates how to measure critical One-Shot events and outlines some of the One-Shot Testing Applications used in conjunction with the DTS instruments.

Within the scope of this paper the **ATE** Test applications use arming modes and features of the DTS that demonstrate the ease of use and flexibility. All of the One-Shot testing applications use the DTS with various ATE testers in an automated environment via the GPIB bus and/or SCSI bus. All of the examples, show the timing diagrams and provide programming commands that setup and execute the DTS measurement. Since the accuracy of the single shot is 30ps, and averaged accuracy is 10ps. with resolution of 800 femtoseconds for real time; **It is easy to achieve a jitter noise floor of less than 5ps; this becomes necessary in many jitter applications.**

ATE Test Applications

This paper deals with three One-Shot testing applications that measure the following:

1) The DUT Propagation Delay (TPD) measurement from Input pulse to Output Pulse at **100Mhz**.
2) The DUT Critical PERIOD measurement of two outputs for burst counts 1 and 2 at **80Mhz**.
3) The DUT measurement of Four PLL Free Running Clock outputs for Frequency (FREQ), Pulse width (PW), and Rise time/Fall time (TT+/TT-) measurements at **310Mhz**.

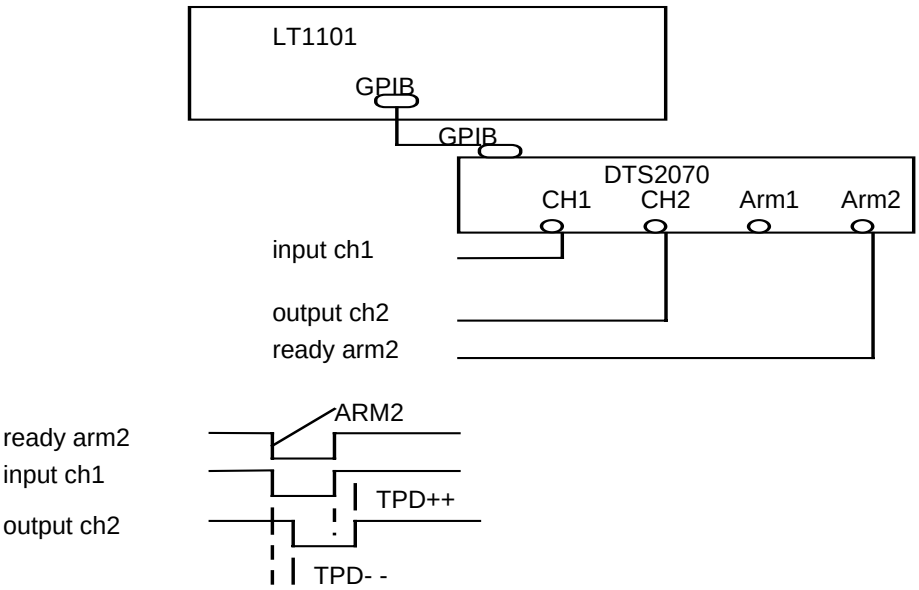
The DTS2070 ATE test applications also explain how to:

1) Analyze the timing pulses and events that need to be measured in the One-Shot burst.
2) Setup functions, channels, and arming modes for the DTS to measure One-Shot pulses.
3) Program the DTS with C/C++ software commands and GPIB commands.
4) Demonstrate the quick, easy to use setup, and macro measurement commands for the DTS.

Testing Applications No.1

The test criteria to make a critical one shot measurement of a devices from input to output propagation delay for the falling edges (TPD- -) and rising edges (TPD++) of 100MHZ pulse to a specification of <100pS (see Setup and Timing Diagram No. 1), and operate the DTS under the ATE test program control via the GPIB BUS connected to a Vista LT1101 ATE Tester.

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Setup and Timing Diagram No. 1

In order to make a one shot measurement with an accuracy of 30pS. on the device input to output Propagation delay; it is necessary to connect the input pulse to the DTS CHannel 1 and connect the output pulse to DTS CHannel 2 and connect an Event Pulse (READY) to ARM 2 for arming the instrument. To achieve accuracy, proper interfacing and termination to the DUT is necessary. In the application the input and output signals are connected to the DUT load board as close as possible to the socket with SMA connections to the DTS with 50 ohm coax. The DTS is then terminated into 50 ohm.

Once all the interface connections are complete; the next step is to analyze the necessary setups of the DTS to execute the measurement. The DTS GPIB commands that setup the instrument are easy to use; because there are only two macro commands that setup everything. The two commands are the **SYST**em **ARMi**ng macro and the **SYST**em **MAC**ro. **The macro commands send to the DTS parameters in one long string of COMMANDS via the GPIB bus. This is very efficient and optimizes transfer speed over the GPIB bus.**

The SYST:MAC command sets up the parameters of:

1) Function.
2) Channel.
3) Arming mode.
4) Arming Sequence.
5) Input Trigger Level Percentage of VOH/VOL.
6) Input Trigger Level User Voltage CH 1.
7) Input Trigger Level User Voltage CH 2.

The SYST:ARM command arguments are:

1) Arming mode.
2) Arming Sequence.
3) Start Arm.
4) Stop Arm.
5) Arm1 Input Trigger Level Voltage.
6) Arm2 Input Trigger Level.

7) Arm1 input slope/edge.
8) Arm2 input slope/edge.
9) Start Arm on count.
10) Stop Arm on count.

If the the argument is not changed or does not apply; the programmer should leave that specific argument blank, it is that simple. In Example No. 1 many arguments are NA.

Before we setup the DTS with the two macro commands; we must analyze the dynamics of the two instruments and device interaction. First the ATE Test Program will initialize and setup the DTS, load vector pattern memory, and load calibration files. Second the main Test Program will make DUT dc parametric tests and power up the DUT. Third the Test Program will call the DTS and prepare the instrument for a one-shot measurement. Forth the DTS is waiting for the READY pulse, the Test Program will start sending vectors and pulses to the DUT, and when the READY pulse is sent, the DTS will measure the DUT prop. delay. Finally, once the DTS completes the measurement the Test Program compares the measurement to a DUT specification or the DTS will send a PASS/FAIL status.

Now that we understand the test interaction; let's setup the DTS with the two macro commands.

The function **TPD- -** will be the first parameter of the **SYST**em **MAC**ro setup. **The DTS uses the Function parameter to point to all other associated setup parameters and saves it.**

Parameters of the setup include:
1) The function **TPD- -** .
2) The CHannel selected to **BOTH**.
3) The arm mode **EXT**ernal.
4) The sequence of channel measurement **STARTFIRST**.
5) Skip the Percentage Level NA.
6) The trigger voltages for **CH1** (START) and **CH2** (STOP) are **0.140**Vdc USER voltage.

The **SYST**em **MAC**ros command sets-up the DTS parameters in one long string of COMMANDS via the GPIB bus.

The SYST:ARM command sets up arming of the instrument and is very important in this application since the measurement occurs immediately after the READY pulse.

By using the EXTernal ARM 2 READY pulse **the instrument will measure any asynchronous event CH 1 to CH 2** for the functions TPD- - and TPD++. The ARM 2 pulse enables (arms) the DTS for measurement on the FALLING edge at 0.700Vdc trigger voltage level. The arming mode will be EXTernal and the sequence of measurement will be STARTFIRST or ENABLE STOP AFTER START this ensures CH 1 is before CH 2. The :SYSTem:ARMing command sets-up the DTS in one long string of COMMANDS via the GPIB bus. The DTS parameter setup commands used in the ATE Test Program via the GPIB are in Setup Commands in Example No. 1.

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DTS SETUP MACRO COMMANDS FOR GPIB

```
ibwrt( dts_no,":SYST:MAC/TPD++/BOTH/EXT/STARTFIRST/ /0.140/0.140/", 49);
ibwrt( dts_no,":SYST:ARM/EXT/STARTFIRST/ARM2/ /0.070/ / /NEG/ / /", 50 );
ibwrt( dts_no,":SYST:MAC/TPD--/BOTH/EXT/STARTFIRST/ /0.140/0.140/", 49);
ibwrt( dts_no,":SYST:ARM/EXT/STARTFIRST/ARM2/ /0.070/ / /NEG/ / /", 50 );
ibwrt( dts_no,"*SAV1; OPC?", 11);
```

Example No. 1. Setup Commands.

As mentioned earlier, the **SYST:MAC** and **SYST:ARM** macro commands are for fast execution. The reason the Setup commands terminates with a **OPC?** or Operation Complete query is that a serial poll is necessary to assure the DTS has **SAV**e all setups. This checks the status bytes register for the Message Available (**MAV**) bit high; before reading back the OPC = 1 value. The save/recall command stores all 10 functions, channels, voltages by one save command (**SAVe 1**); therefore in this example the two setups TPD--, TPD++ are in memory under ***SAV1** and are recalled by the ***RCL1** command.

The serial poll of the status byte allows the DTS to acknowledge completion without the use of delays. The following routine checks OPC status byte as shown in Example No. 2 .

DTS SERIAL POLLING FUNCTION

```
 while (!(poll_status  & 0x 10))
  {
   ibrsp(dts_no,&poll_status);
  }
ibrd(dts_no, opcck, 5);
printf (opc = %d \n", opcck);
```

Example No. 2 OPC? query.

In the test program a ***RCL1** or recall of parameters saved in location 1 is sent to the DTS. Finally, in the one shot measurement the DTS is given the ***TRG; or burst** command (see Example No. 3)**.** The execution of the burst command readies the DTS for the DUT pulses controlled by the ATE tester. The serial poll reads the status bytes register for the MAV and TRIGGER bit and waits for a high, which identifies the device burst is complete. Therefore the DTS waits for the Tester burst and makes the prop delay measurement upon execution of the burst. The **:MEAS:AVER?** is a request query for the measurement value.

DTS BURST MEASUREMENT FUNCTION

```
ibwrt( dts_no,"*RCL1", 5);
ibwrt (dts_no,":TER?; *TRG?; :TER?",19);
        while (!(poll_status  & 0x 11 == & 0x 11  ))
                ibrsp(dts_no,&poll_status);
 ibwrt (dts_no, ":MEAS:AVER?", 11);
        while (!(poll_status  & 0x 11 == & 0x 11))
                ibrsp(dts_no,&poll_status);
 ibrd(dts_no, resp, 20);
 sscanf ( &resp, "%s%f", &average);
 printf ("average = %e \n", average);
```

Example No. 3 DTS BURST measurement routine.

As you can see the Macro commands are easy to use and transfer many parameters to the DTS in one command string. **The result is less code and fast measurement thru-put.** Finally the one-shot measurement is captured and printed out or compared to the limits of the device specification and pass/fail status is returned.

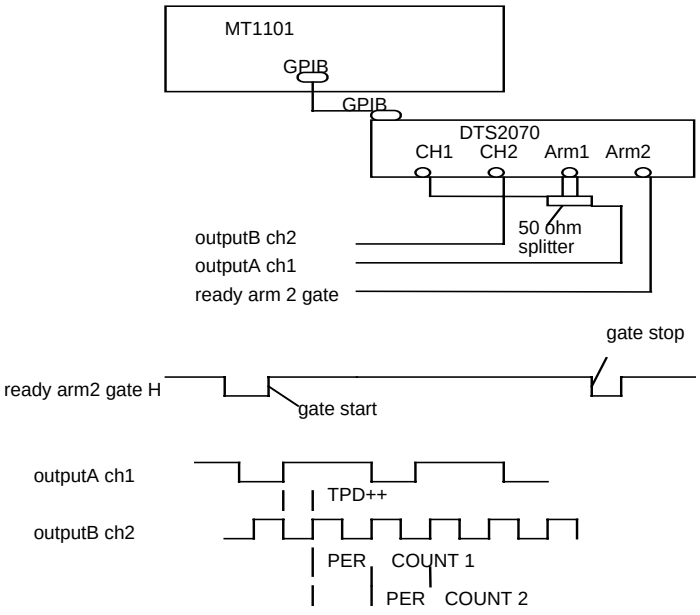
Data Types

The data types used in the application are declare variables for the DTS are as follows : All voltage parameters are type **real** and declared as **double**. All burst measurements including AVERage and JITTer are type **floating point** and declared as **double**. All samples are type **integer** using type modifier long and declared as **long**. All Serial Poll status byte are type **integers** and declared as **int**. All received ASCII strings response are type **character** and declared as **char**.

Testing Application No. 2

The test criteria to measure critical PROP. delay (**TPD++**) of a CMOS device from the rising edge to rising edge of two outputs with 80MHZ pulses and to measure the period of CHannel 2 count 1 and count 2 (see Diagram No. 2), and operate the DTS under the test program control via the GPIB BUS connected to a Vista MT1101 ATE Test System.

The two commands for setup of the DTS over the GPIB are the **SYST**em **ARMi**ng macro and the **SYST**em **MAC**ro; because they are so easy to use. In the application the DTS has two arming signals for the **GATE HIGH** mode. **This feature enables the arming circuitry to use two trigger/arm inputs to pick-off the proper event to be measured.** The first input is the **READY** pulse connected to **ARM2**. When the ready pulse is **HIGH** the DTS is enabled to measure. The second pulse connected to **ARM1** is the outputA pulse and will arm the DTS on the rising edge. Note outputA is also connected to CHannel 1 thru a 50 Ohm splitter and outputB is connected to CHannel 2.



Setup and Timing Diagram No. 2

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The gate mode feature ensures the DTS will measure the outputA to outputB skew (**TPD++**) and the outputA **PER**iod when CHannel 1 is high for counts 1 and 2. The use of a 50 ohm splitter allows the signal to be connected to the outputA CHannel 1 and demonstrates the flexibility in connecting various outputs. When using a 50 ohm splitter remember the voltage will be divide by 2 or half. Thus with this setup, we will measure all events under test program control of the ATE Tester.

SETUP MACRO COMMANDS

ibwrt(dts_no,"**:SYST:MAC/PER/2/EXT/STOP/ /0.100/0.200/**", 39);
ibwrt(dts_no,"**:SYST:ARM/EXT/STOP/ARM1/ /0.100/ /POS/ /1/2/**", 50);
ibwrt(dts_no,"**:SYST:GATON; :TRIG:SLOPGATH**", 27);
ibwrt(dts_no,"**:SYST:MAC/TPD++/BOTH/EXT/STARTFIRST/ /0.100/0.200/**", 50);
ibwrt(dts_no,"**:SYST:ARM/EXT/STARTFIRST/ARM1/ /0.100/ /POS/ /1/ /**", 50);
ibwrt(dts_no,"**:SYST:GATON; :TRIG:SLOPGATH; *SAV2**", 34);

Setup Example No. 4.

The DTS GPIB setup commands are in Setup Example No. 4. The function **PER**iod are the first set of parameters for setup in the **SYST:MAC** command. As stated previously, the FUNCTION parameter points to all other associated setup parameters and saves it.

Parameters of the setup include:
1) The function **PER**iod.
2) The CHannel selected to **2.**
3) The arm mode **EXT**ernal.
4) The sequence of channel measurement **STOP**.
5) The trigger voltages for **CH2**(START).
6) The **CH2** (STOP) at **0.200**Vdc.

The SYSTem MACros command sets-up the DTS parameters in one long string of COMMANDS via the GPIB bus.

The **SYST:ARM** macro command will setup the arming modes associated with **PER**iod and in the example will setup arming parameters of :
1) The arming mode will be **EXT**ernal.
2) The sequence of measurement will be **STOP** or AUTO ARM ON STOP.
3) The **ARM1** will be selected and trigger voltage level of **0.100**.
4) The arm enable will occurr on the rising edge or **POS**.
5) The count will be a COUNT **1** start.
6) The COUNT **2** stop for the first period pulse burst.

The GATe will be **ON** and the **GATe H**igh mode selected. The :SYSTem ARMing command sets-up the DTS in one long string of COMMANDS via the GPIB bus and transfers many parameters to the DTS. The instrument is ready to make a measurement, but it is better and more efficient to load all setups in the Example No. 4 first into the memory and then later in the program recall the various saved setups.

The **SYST:MAC** command for the Function (**TPD++**) are the second set of parameters of setup include:
1) The Function (**TPD++**).
2) The CHannel selected to **BOTH**.
3) The arm mode **EXT**ernal.

4) The sequence of channel measurement **STARTFIRST**.
5) The trigger voltages for **CH2**(START) at **0.100**Vdc.
6) The **CH2** (STOP) at **0.200**Vdc.

The **SYST:ARM** macro command will setup the arming modes associated with **TPD++** and in the example will setup arming parameters of :

1) The arming mode will be **EXT**ernal.
2) The sequence of measurement will be **STARTFIRST** or ENABLE STOP AFTER START this ensures CH 1 is before CH 2.
3) The **ARM1** will be selected and trigger voltage level of **0.100**.
4) The arm enable will occurr on the rising edge or **POS**.
5) The count will be a COUNT **2** start.
6) The COUNT **3** stop for the first period pulse burst. The GATe will be **ON** and the **GATe H**igh mode selected.

Basically the setup is executed during the test program initialization routine. Later in the program, the ATE tester powers up the DUT and sends vectors to the DUT, the DTS makes all the measurements with the **:ACQ:RUN PER** command and **:ACQ:RUN TPD++** command . This command calls the setup for PERiod and performs the measurement as in Example No. 5. The serial poll waits for the DTS to complete the measurement, then the ATE tester reads the average and jitter measurement **RESP** which is a ASCII string.

The sscanf C++ function format specifier converts a literal character string to a double.

DTS ACQUIRE BURST MEASUREMENT FUNCTION

```
ibwrt( dts_no,"*RCL2", 5);
ibwrt (dts_no,":ACQ:RUN PER",12);
            while (!(poll_status  & 0x 11 == & 0x 11  ))
                        ibrsp(dts_no,&poll_status);
 ibrd(dts_no, resp, 30);
 sscanf ( &resp, "%f%f", &average, &jitter);
 printf ("average = %e \n", average);
 printf ("jitter = %e \n", jitter);

ibwrt (dts_no,":ACQ:RUN TPD++",12);
            while (!(poll_status  & 0x 11 == & 0x 11  ))
                        ibrsp(dts_no,&poll_status);
 ibrd(dts_no, resp, 30);
 sscanf ( &resp, "%f%f", &average, &jitter);
 printf ("average = %e \n", average);
 printf ("jitter = %e \n", jitter);

ibwrt( dts_no,":SYST:ARM/ / / / / / / /2/3/", 30);
 ibwrt (dts_no,":ACQ:RUN PER",12);
```

Example No. 5 DTS ACQuire RUN of burst measurement routine.

Once again the ACQUIRE RUN Macro commands are easy to use and transfers many parameters to the DTS in one command string.
The result is less code and less serial polling since the command :

1) Calls the setup.
2) Executes the burst command.

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3) Returns the value for Average and Jitter measurement.
4) Notifies the status of measurement complete.

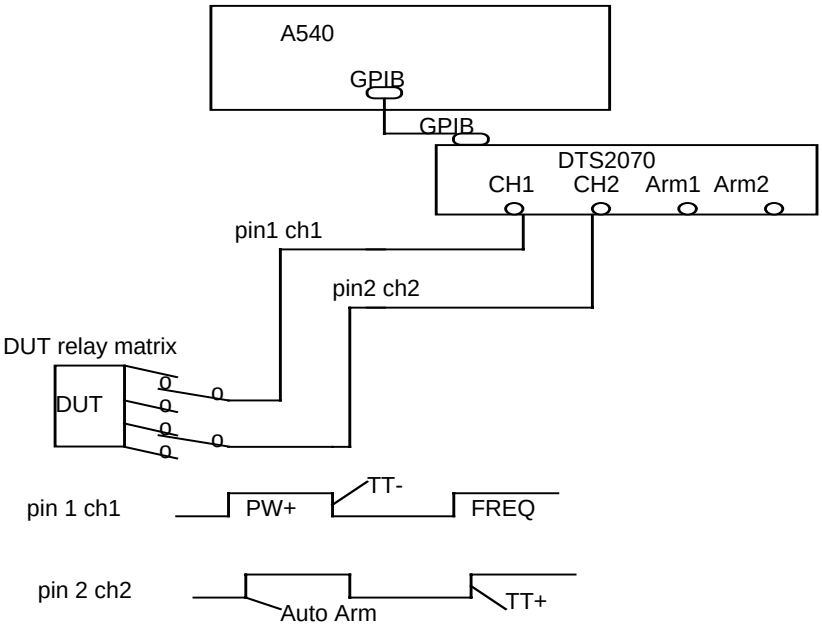
This command enhances fast measurement thru-put. Finally the measurement is captured and printed out or compared to the limits of the device specification or pass/fail status is returned to the test program.

Interfacing and Termination

To achieve the accuracy of + or - 10pS. proper interfacing and termination to the DUT is necessary. In the application discussed the outputs are connected at the DUT load board as close as possible to the socket through SMA connectors to the DTS with 50 ohm coax. A CMOS device is not terminated at the end of the line or back terminated; I than use a 450 ohm resistor as close as possible to the socket and then connect 50 ohm coax to the DTS. The DTS is then terminated into 50 ohm.

Testing Application No. 3

The test criteria to make a critical measurement of a devices (DUT) four clock outputs for FREQuency, pulse width(PW+), rise time(TT+), fall time(TT-) at 310MHZ (see Setup and Timing Diagram No. 3), and operate the DTS under the test program control via the GPIB BUS connected to A540 ATE Tester. The DUT clock output frequency is faster than the tester's timing specification. The DUT clock output is free running and asynchronous to the A540 tester. For **this application, the DTS is the only instrument to measure the DUT high frequency clock to accuracy's of 10pS. The DTS can measure any asynchronous event from 0 to 2.5Sec. and is perfect for this application.**



Setup and Timing Diagram No. 3

In order to measure all four outputs of the DUT a relay matrix is designed on the DUT BOARD to connect the 2 outputs to DTS CH 1 and CH 2. The SMA connectors on the DUT board are connected to the DTS via 50 ohm coax, and are relay controlled by the A540 tester for a very clean interface. After the first two measurements are complete; the test program would switch the relays and

measure the last two outputs.

The instrument is setup in the **AUTO** ARMing mode and all the function **FREQ, PW+, TT+, TT-** using the **SYST:MAC** macro command will reflect the auto arming mode. The setup SYST:MAC macro commands are in Example No.6.

As stated previously the FUNCTION parameter points to all other associated setup parameters and saves it. Parameters of the setup include:

1) The function **FREQ**uency.
2) The CHannel selected to **1**.
3) The arm mode **AUT**o.
4) The sequence of channel measurement **STOP** or AUTO ARM ON STOP.
5) The trigger voltages for **CH1(**START) at **0.200**Vdc.
6) The **CH1**(STOP) at **0.200**Vdc.

The SYSTem MACros command sets-up the DTS parameters in one long string of COMMANDS via the GPIB bus.

The sequence of measurement will be **STOP** or AUTO ARM ON STOP in all of the examples for no. 6 setups. This ensures the measurements will be armed off of the first **POS** edge of the pulse of CHannel 1. After arming the DTS the next pulses (second consecutive pulse) will be measured for FREQUENCY. Therefore in the **AUTO ARM** mode, you use one pulse of the free running burst to arm the instrument and measure the very next event or burst of pulses.

SETUP MACRO COMMANDS

```
tl_ibcmd2 ( "\100\045");  /* A540 talk,  DTS listen */
tl_ibwrt2 ( ":SYST:MAC/FREQ/1/AUT/STOP/ /0.200/0.200/");
tl_ibwrt2( ":SYST:MAC/PW+/1/AUT/STOP/ /0.200/0.200/");
tl_ibwrt2( ":SYST:MAC/TT+/1/AUT/STOP/20 80/ / /");
tl_ibwrt2( ":SYST:MAC/TT-/1/AUT/STOP/80 20/ / /");
tl_ibwrt2( ":ACQ:COUN10; *SAV1;");
```

Setup Commands Example No. 6

The TT+ and TT- setups are trigger levels at the 20 80 or 20% - 80% for rising edges and 80 20 or 80% - 20% for falling edges respectively and derived from the VOH and VOL values of the DUT output measured by the Pulse Find capability of the DTS. Basically the setup is executed during the test program initialization routine and later in the program, the ATE tester powers up the DUT and the **DTS makes all the measurements to an accuracy of + or - 10pS. Since the resolution is in the Femto Sec. the ability to assure absolute accuracy is obtained in this application.**

Using the **:ACQ:RUN FREQ** , **:ACQ:RUN PW+** command, :**ACQ:RUN TT+,** and **ACQ:RUNTT-** command call the setup (from memory) for FREQuency, performs the measurement similar to the routine in Example No. 5. The calls and C++ code or functions are very similar and very fast and an easy exercise for the DTS. The result will be average and jitter measurements for frequency, duty cycle, rise and fall times.

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Different Device Technologies

A easy guide to determining interfacing and proper termination for various device technologies is the Wave Technologies Application Note 114, "Achieving 30pS. Accuracy in the ATE Environment". This is an excellent reference to interfacing the DTS to many of the devices technologies used today with all ATE Testers.

Thru-put Enhancements

One of the GPIB commands to lock-out the front panel for production and to enhance **THRU-PUT** is to use the **:DISP:STATOFF** command. This command will speed up measurements by 10X or 10 times.

ANSI/IEEE-488.2 standard

The ANSI/IEEE Standard 488.2 was released in 1987 with a common set of commands that define protocol, error handling, status reporting, and data formats. All ATE test systems have a GPIB/IEEE-488 bus available for interfacing to instruments that adhere to these standards; whether the interface connects to the **SBus** slots or the **SCSI** port.

The DTS2070 instrument conforms to the standards of IEEE-488.1 and IEEE-488.2 and will **talk/listen** to all ATE systems controllers compliant to these standards.

Conclusions

The applications demonstrate the flexiblity of the DTS to measure complex waveforms and asynchronous events to accuracys of 10pS. The arming mode features ensure the DTS will measure a single shot event in a specific burst in real time. The MACRO commands for GPIB communication are easy to use software and transfer many parameters to the DTS and TESTER in one long string. **The results are very fast, precise measurements, accurate, and easy to use with the ATE testers.**

References

Mitchell Waite and Stephen Prata, New C Primer Plus, Second Edition, Sams Publishing, Carmel, IN.; 1993.

National Instruments Corp., NI-488.2 M Software Reference Manual, 1992.

Kerry Newcom, Streaming Data Speeds Up IEEE 488 Bus, Evaluation Engineering, Nokomis, Fl., June,1993.

Credence Systems Corp., Vista Series Applications Note No. 12, The Vista Toolbox GPIB Elementals, April 10, 1991.

Credence Systems Corp., Vista Series Applications Note No. 58, Using the National Instruments GPIB Software with SUN/UNIX Vista-Series Test Systems, Dec. 2, 1992.

Teradyne Inc., Mixed Signal Instrumentation, Section 17: GPIB Driver Language, Jan.,1990.

Herbert Schildt, ANSI C Made Easy, Osborne Mcgraw-Hill, Berkeley,Ca.; 1990.

Operators Guide, Digital Time Scope DTS2070. Wave Technologies Corporation, Edina, Mn.

Wave Technologies Corp., Applications Note No. 114; Achieving 30pS accuracy in the ATE environment, April,1994.

IEEE-488 Interface Guide, Digital Time Scope DTS2070. Wave Technologies Corporation, Edina, Mn.

Wave Technologies Corp., Applications Note No. 116; Programming the Wave DTS2070 in a UNIX - C/C++ environment, May,1994.

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WAVECREST Corporation
World Headquarters
7275 Bush Lake Road
Edina, MN 55439
(612) 831-0030
FAX: (612) 831-4474
Toll Free: 1-800-733-7128
www.wavecrestcorp.com

WAVECREST Corporation
West Coast Office:
1735 Technology Drive, Suite 400
San Jose, CA 95110
(408) 436-9000
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