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WAVECREST Corporation

PROGRAMMING THE *WAVECREST* DTS™ WITH THE TEST LIST OPTION

Application Note No. 122

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PROGRAMMING THE *WAVECREST* DTS™ WITH THE TEST LIST OPTION

Application Note 122

Introduction

The *WAVECREST* Digital Time Scope™ (DTS) makes fast, accurate, real time measurements and jitter analysis necessary for automated testing. Many of the ATE Tester applications need the DTS to make timing measurements 1GHz or less on synchronous or asynchronous events.

The DTS embedded in the ATE Tester creates the capability to perform measurements with 10ps accuracy on high performance Phase Lock Loop (PLL) Clock distribution networks circuits (up, workstations, frequency dividers, PC's). Phase Locked Loops are typically used as high speed clock multipliers and are characterized for their timing precision. Jitter on a Multiplier PLL Clock can affect the operation of the system and the clock timing. The DTS performs jitter measurement and jitter analysis to properly characterize the performance and design of PLL circuits.

The DTS is usually controlled by the Tester via the GPIB bus (IEEE-488) or SCSI bus. The GPIB commands setup the instrument to execute and accurately measure the parameters of frequency, Period, Pulse Width, Rise Time and Fall Time, and Prop. Delays. Many of the mentioned multiple measurements are required PLL tests and with a special DTS option called Test List Option (TLO) the user can sequence through hundreds of tests and measurements. TLO will reduce the test time and improve DTS efficiency.

The purpose of this paper is to show the user how to use the Test List Option in an automated ATE environment to test PLL circuits.

This application note explains how to:

1) Use the TLO for multiple measurements.
2) Write a TLO script.
3) Program TLO for conditional jumps with limits.
4) Test for Pass or Fail response; which are compared to programmed limits from device specifications.
5) Access and return data from one or all of the measurement parameters at the end of TLO tests for data analysis.

This paper is formulated to provide the essential software examples, so the Test Engineer will be successful in executing programming instructions over the GPIB. The TLO examples are real test cases using TLO commands and with many of the DTS features and capabilities that demonstrate the ease of use.

The Test List Option

The Test List Option was created to execute a list of tests with setups and measurements that will reside in the DTS and upon completion of the tests or test groups; returns a pass or fail status. The TLO list or script of tests will first define the tests and setups. The tests are declared with limits based on PLL design specifications and conditions. The conditional command jumps to another test or the test is terminated based on the test limits. After all the tests are listed with numbers and defined with limits, they are formulated into test groups. Any test can be in any test group. The test groups are executed with all the measurement data stored in TLO memory. Finally the measurement data can be returned to the test program or a file. The measurement data can later be accessed for analysis.

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The reason the DTS with TLO is so efficient is because the DTS has a fast measurement processing system that far exceeds the capabilities of the GPIB bus protocol and interrupt rates. The TLO uses less GPIB bus transfers because it executes the TLO tests and measurements inside the DTS, the results equate into micro-second measurements.

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 and listen to all ATE systems controllers compliant to these standards. There are basic fundamental GPIB software commands a user must perform or the controller and instrument will not communicate. Please refer to *WAVECREST* Application Note 116, Programming the *WAVECREST* DTS in a UNIX - C/C++ (reference # 5) for essential software examples to initialize and setup the DTS with C/C++ software commands and necessary function calls to the GPIB NI driver software.

The ATE Application

The device used in this application and better referred to as the DUT is a high performance Phase Lock Loop Clock distribution device. Phase Locked Loops (PLL) are typically used as high speed clock multipliers and are characterized for their timing precision. The crystal input to the PLL clock operates at 20Mhz. This input to the PLL can be an Oscillator or external crystal input. The Clock dual outputs operate at 267Mhz.

The ATE tester program sets the relay control bits that switch a relay matrix which will connect the TESTER or DTS to the DUT (see Diagram no. 1 DUT Board Relay Matrix). The relay matrix is built on the DUT board with SMA adapters for cable connection to the DTS.

Please refer to Wavecrest applications note no. 114, Achieving 30ps. Accuracy (reference # 4). A relay matrix provides a high bandwidth impedance matched transmission path for the DTS to connect and measure the high frequency output of the DUT.

First, the tester will switch the relays and connect the DUT pins to the tester to measure continuity and leakage parameters. The Tester also provides power and crucial timing parameters for the DUT. The DUT has specific setup and hold times applied to the input select that control the PLL Clocks outputs.

Second, the tester will switch the relays (K3, K4) and connect the crystal to the inputs. Third, the relays (K1, K2) connect the PLL Clock1 output to DTS - CH 1 and PLL Clock2 output to DTS - CH 2. The relays are switched for DTS measurement. Finally, the DTS will measure the PLL Clock outputs asynchronous events for Frequency, Period Jitter, Pulse Width, Prop. Delay (Clock 1 to Clock 2 skew), and Rise Time and Fall Time.

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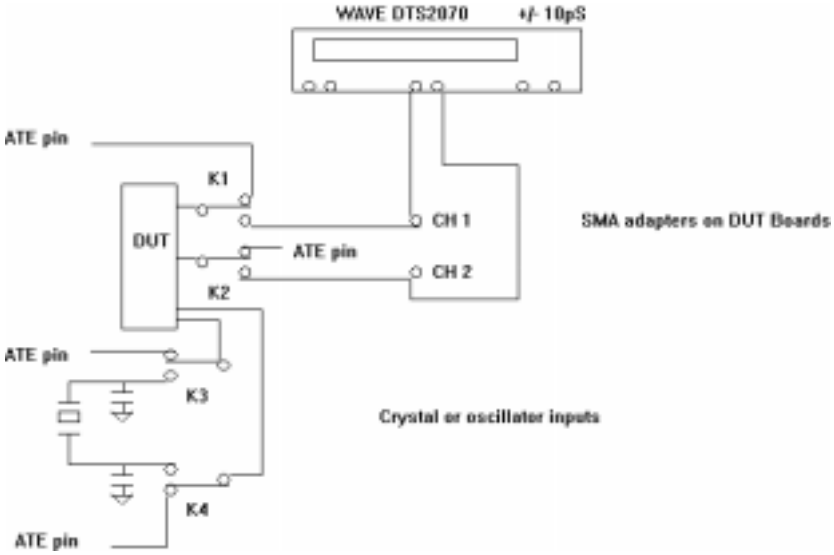


Diagram no. 1 DUT Board Relay Matrix.

The PLL Clock outputs are a 267Mhz signal and since jitter can enter a synchronizing PLL in many ways, the jitter is measured in all parameters. The TLO easily measures all parameters of the PLL with one TLO test group. At the end of the TLO measurements the TLO will issue a Pass or Fail status.

The Test List Script of Commands

The TLO Script of Commands is loaded into the DTS Test List Memory. Usually this is accomplished right after the ATE Tester loads vector memory and the GPIB bus first communicates to the DTS as part of the Initialization function. During initialization a GPIB ASCII string command query "*IDN?" is sent to the DTS. The DTS will respond by identifying itself with the ASCII type characters "WAVE, DTS2070.xx.xx." This is a simple method to verify communication between the tester and DTS. Once the GPIB communication link is established by this simple function, the test program can load the TLO Script into the DTS TLO memory. The TLO Script needs to be loaded only once and resides in the DTS TLO memory until cleared.

The TLO macro's are part of the TLO Script example no. 2 (see TLO Script example no. 2).

The following list is a summary of the tests it performs:

1) A measurement setup for PERiod CH 1 defined as Test no. 1.
2) A measurement setup for PERiod CH 2 defined as Test no. 2.
3) A measurement setup for Propagation Delay of rising edge to rising edge defined as TPD++ Test no. 3.
4) A measurement setup for Rise Time CH 1 defined as TT+ Test no. 4.
5) A measurement setup for Fall Time CH 2 defined as TT- Test no. 5.

These 5 Tests are declared in a test group called Test Group no. 1. The TLO measured results are compared to limits and return a PASS or FAIL STATUS. Please refer to *WAVECREST* Test List Option Programming Guide (reference # 7).

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```
strcpy ( gpib_cmds, " *CLS");
      wave_setup_command ( gpib_cmds );

“COM line 1 rem the list of tests and script for TLO Script example no. 2”
“:TL:TEST 1 TIM 0/PER/1/AUTO/STOP/4/50 50/ / /1/2/    COM line 2“
“:TL:LIM 1 TIM 7/3755.0pS/3735.0pS/45.0pS/            COM line 3“
“:TL:TEST 2 TIM 0/PER/2/AUTO/STOP/4/50 50/ / /1/2/    COM line 4“
“:TL:LIM 2 TIM 7/3755.0pS/3735.0pS/45.0pS/            COM line 5“
“:TL:TEST 3 TIM 0/TPD++//AUTO/STOP/4/50 50/ / /1/1/   COM line 6“
“:TL:LIM 3 TIM 7/500pS/0.100pS/100.0pS/               COM line 7“
“:TL:TEST 4 TIM 0/TT+/1/AUTO/STOP/4/20 80/ / /1/1/    COM line 8“
“:TL:LIM 4 TIM 7/600pS/0.100pS/45.0pS/                COM line 9“
“:TL:TEST 5 TIM 0/TT-/2/AUTO/STOP/4/80 20/ / /1/1/    COM line 10“
“:TL:LIM 5 TIM 7/600pS/0.100pS/45.0pS/                COM line 11“
“:TL:SCR CL                                           COM line 12“
“:TL:SCR GR 1 STAT                                    COM line 13“
“:TL:SCR MEAS 1 STAT                                  COM line 14“
“:TL:SCR MEAS 2 STAT                                  COM line 15“
“:TL:SCR MEAS 3 STAT                                  COM line 16“
“:TL:SCR MEAS 4 STAT                                  COM line 17“
“:TL:SCR MEAS 5 STAT                                  COM line 18“
“:TL:SCR END 1 STAT                                   COM line 19“
“:TL:SCR HALT                                         COM line 20“
```

TLO Script example no. 2

A more detailed explanation of the script example may be necessary.

As shown in the TLO Script example no. 2 a special delimiter “ COM “ for comment line is used to number each TLO macro command. This can be used for any test description comment. Each “ COM “ line (1 - 20) will be discussed in order to understand each macro command.

Line 1 is a comment that describes the TLO Script.
Line 2 is a TLO test 1 that will measure PERiod for CH 1.
Line 3 is a TLO limit test for PERiod upper limit 3755.0ps and lower limit 3735.0ps with a maximum jitter of 45.0ps.
Line 4 is a TLO test 2 that will measure PERiod for CH 2.
Line 5 is a TLO limit test for PERiod upper limit 3755.0ps and lower limit 3735.0ps with a maximum jitter of 45.0ps.
Line 6 is a TLO test 3 that will measure TPD++ for Both CHannel 1 and 2.
Line 7 is a TLO limit test for TPD++ upper limit 500ns and lower limit 0.100ps with a maximum jitter of 100.0ps.
Line 8 is a TLO test 4 that will measure TT+ or Rise Time for CH 1.
Line 9 is a TLO limit test for TT+ upper limit 600ps and lower limit 0.100ps with a maximum jitter of 45.0ps.
Line 10 is a TLO test 5 that will measure TT- or Fall Time for CH 2.
Line 11 is a TLO limit test for TT- upper limit 600ps and lower limit 0.100ps with a maximum jitter of 45.0ps.

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Once all the tests are defined with limits, the TLO Script must declare tests with test groups and any flags for measurement STATus is stored in memory and later a request for data is sent to the host or tester. Remember, any test can be declared in any test group. Any status can be applied to one or more test groups. Status can be a Pass or Fail, or measured data. In this example, the STAT are for test group 1 with PASS or FAIL status only.

A detailed explanation of the script example no. 2 returning to line 12.

Line 12 clears the TLO memory.
Line 13 declares GRoup 1with STATus returned to the tester.
Line 14 declares MEASurement 1 or test 1 as a part of GRoup 1 with STATus returned.
Line 15 declares MEASurement 2 or test 2 as a part of GRoup 1 with STATus returned.
Line 16 declares MEASurement 3 or test 3 as a part of GRoup 1 with STATus returned.
Line 17 declares MEASurement 4 or test 4 as a part of GRoup 1 with STATus returned.
Line 18 declares MEASurement 5 or test 5 as a part of GRoup 1 with STATus returned.
Line 19 declares END of GRoup 1 STATus returned.
Line 20 declares END of SCRipt and HALT.

As mentioned earlier, the script is loaded into the TLO memory and the DTS is ready to perform Test Group 1. Now in the test program, we need the tester to setup the DUT conditions before we can execute any DTS measurements.

The Test List Execution Commands

Most test programs sequence through many DUT dc and ac parameter tests. In the test program will be a DTS function called **wave_test_list_run ( )** used for DUT PLL tests of frequency and jitter . The routine will be very similar to the TLO Execution with Status example no. 3.

```
/ *test program function performs a test list execution of test group no. 1 with status */
void wave_test_list_run ( )
{
strcpy ( gpib_cmds, " *CLS; :TL:EXE GR 1 ");
      wave_setup_command ( gpib_cmds );

      poll_status = 2;
      while ( ! ( poll_status & 0x010 ))
         dts_poll_the_dts ( &poll_status );

      ibrd( dts_device_no, response, (long) MAX_CHAR_FROM_DTS-1 );

strcpy ( gpib_cmds, " :TL:HALT; *CLS ");
      wave_setup_command(gpib_cmds);

/* end of test list execution  test group no. 1 */
printf ( " ****test list results = %s \n ", response );

if (( response,"PASS",4) != 0)
   {
   printf("\n  DUT  FAIL  at  267Mhz \n" );
   if (!loopcnt) return (FALSE);
   }
else
   printf("\n  DUT  PASS  at  267Mhz \n" );
```


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TLO Execution with Status example no. 3

In the example the C++ function called **wave_test_list_run ( )** , executes the TLO Script and returns a status. Descriptions of the routines performed are:

1) Two commands "*CLS " and ":TL:EXE GR 1" are sent to the DTS. The *CLS will clear the GPIB status byte register and :Test List:EXEcute GRoup 1 command will execute TLO test group no. 1. In this example all of the TLO Script is executed; because there is only one test group.
2) A serial poll of the status byte register for a (0x010) Query or MAV is required to properly monitor the TLO execution and status poll until the TLO Script to complete (refer to *WAVECREST* IEEE-488 (GPIB) Interface Guide reference # 3).
3) Upon the completion of the status Query the host or tester can read the GPIB string for test group 1 either a PASS or FAIL status declared as a char array named response.
4) The string handling function called strncmp returns a positive value if the two strings are identical as in PASS.
5) Two commands ":TL:HALT" and "*CLS" are sent to the DTS. The ":TestList:Halt" command terminates the TLO loop and the *CLS will clear the status byte register, so the GPIB bus is ready for the next command.

Additional TLO features are the DTS not only executes all measurements; but can make smart decisions and return measurement data. In the next example, TLO Execution with Data example no. 4, the C++ function called **wave_test_list_data ( )** , executes the TLO Script and returns data for test group 1, test 1.

```
/* test program function performs a test list execution of test group no. 1 with data */
void wave_test_list_data ( )
{
strcpy ( gpib_cmds, " *CLS; :TL:EXE GR 1 ");
      wave_setup_command ( gpib_cmds );

      poll_status = 2;
      while ( ! ( poll_status & 0x010 ))
                  dts_poll_the_dts ( &poll_status );
      ibrd( dts_device_no, response, (long) MAX_CHAR_FROM_DTS-1 );

/* end of test list execution  test group no. 1   */
printf ( " ****test list results = %s \n ", response );

/* request data for test group 1, test 1  readback  average, jitter, max.,
min. */
strcpy ( gpib_cmds, "*CLS;  :TL:DAT GR 1 1 ");
      wave_setup_command(gpib_cmds);

      while ( ! ( poll_status & 0x010 ))
                  dts_poll_the_dts ( &poll_status );

      ibrd( dts_device_no, response, (long) MAX_CHAR_FROM_DTS-1 );

printf ( " ****test list test 1 period data = %s \n ", response );

strcpy ( gpib_cmds, " :TL:HALT; *CLS ");
      wave_setup_command(gpib_cmds);
       }
```


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TLO Execution with Data example no. 4

Notice that the first part of the example no. 4 function is similar to **wave_test_list_run ( )** up to the printout of the status. At this point the execution of test group 1 is complete, all data is stored, and a pass/fail status determined. The next two commands are different; because they request the data as follows:

1) Two commands " *CLS " and ":TL:DAT GR 1 1" are sent to the DTS. The *CLS will clear the GPIB status byte register and the :Test List:DATaGRoup 1 test 1 will request data that is stored for test group no. 1, test 1.
2) A serial poll of the status byte register for a (0x010) Query or MAV is required to properly status when the TLO data is at the bus.
3) Upon the completion of the status Query the host or tester reads the GPIB string for test group 1 test 1 data declared as a char array named response. The data string will contain the values for the average, jitter, max., and min. measurements. All values are separated with the white space delimiter.
4) Two commands ":TL:HALT" and " *CLS " are sent to the DTS. The ":Test List:Halt" command terminates the TLO loop and the *CLS will clear the status byte register, so the GPIB bus is ready for the next command.

Data Types

A discussion of data types is necessary so the programmer can properly declare variables for the DTS. 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.

CONCLUSIONS

The DTS is a precise high speed time measurement instrument designed to be used in a automated lab and production environments where large amounts of accurate and repeatable data is required.

The Test List Option is a very effective software option to minimize the amount of traffic on the GPIB bus. As discussed in this application note the DTS is used to test many high speed timing parameters including frequency, period, pulse width, rise and fall times, and propagation delay and TLO accomplishes all tests in one DTS execution. The user can develop a TLO script that will measure and compare many vital parameters and the test results can be a Pass or Fail status or accumulation of measurement data.

Another important benefit of the TLO is that the user has the flexibility to make up to one thousand tests and use conditional jumps to make intelligent decisions used in specialized applications. If the DTS is embedded in the ATE Tester, this creates the capability to perform measurements up to 1Ghz with 10ps accuracy on any high performance Phase Lock Loop (PLL) Clock distribution circuits. Whether the tests are production or characterization of device jitter, the TLO can provide critical timing measurements using the DTS.

In the application example, the Test Engineer learned to organize and structure his TLO script and test program. This paper showed the user how to develop the TLO script test setups and combine TLO tests into test groups. Finally, the user learned the essential commands necessary to program the Wave DTS in a UNIX - C/C++ environment. In the application example the software executed, the test group measurements from the ATE test program. The application performed a high speed PLL Clock Multiplier 267Mhz test with Pass or Fail status results. Later in the example, the user learned how to accumulate critical device jitter data in TLO memory and at the end of the test send the data to an array.

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