WAVECREST Corporation

VERYFYING ATE SYSTEM ACCURACY AND DESKEW

Application Note No. 110

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VERIFYING ATE SYSTEM ACCURACY (DESKEW)

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Introduction

Many VLSI ATE vendors have Test systems that provide test speeds up to 500Mhz and overall accuracy specifications of better than +/- 100ps. Whether the timing architecture is shared-resource or timing-per-pin, all ATE manufactures and customers have a Timing Checkout or Skew Program to assure the overall accuracy is to specification.

The WAVECREST Digital Time Scope DTS2010 makes very fast, accurate time measurements and is a perfect instrument for making edge placement accuracy measurements on Automatic Test Equipment (ATE) .

This application note describes some of the GPIB programming considerations to automate a Timing Checkout or Skew Program.

GPIB/IEEE-488.2 standard

The GPIB/IEEE-488.2 standard was released in 1987 with a common set of commands that defined protocol, error handling, status reporting, and data formats. All test systems have a GPIB/IEEE-488 bus available for interfacing to instruments that adhere to these standards.

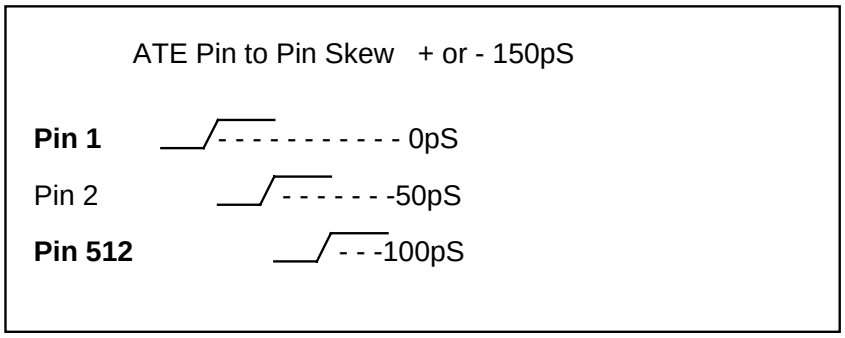
The DTS2010 instrument conforms to the standards of IEEE-488.1 and IEEE-488.2 and will **talk/listen** to all ATE systems controllers compliant to these standards.

Tests for Timing Checkout

Many ATE Manufacturers have either Internal or External Calibrations to attain the +/- 150ps overall accuracy specification for all edges and formats. The tests necessary to check the timing and assure the accuracy of the ATE system after a calibration are :

1. Signal amplitude measurement.
2. Signal overshoot or undershoot measurement.
3. Pulse width accuracy with jitter measurement.
4. Pin to pin pulse skew with jitter measurement.
5. Rise/fall time with jitter measurement.
6. Formats (RZ, SBC, etc...) switching accuracy (including I/O).

Shown in the Skew Diagram below is a pin to pin skew distribution.



Skew Diagram

The Timing Checkout program controls the tester with the tests defined above and controls the DTS2010 via the GPIB bus. Incorporated in the software are specialized routines and functions to initialize the GPIB bus, invoke header setup, serial poll, report error status, aquire functions, setup edge parameter input levels, select arming, store saves, enable recalls, and protocol to perform common operations and measurements.

In this application a wide range of GPIB software commands are used and described in this paper.

Termination characters

All serial stream data transfers must be null-terminated by a GPIB EOI or the NL character. The character for a NL (newline) is a ASCII 0A (hex). and EOI (end or identify) is a hardware line .

The parser automatically detects the character and terminates the data transfer.

Command sequences

All serial streams are converted to ASCII strings in C and sent to the instrument via the GPIB BUS. For most applications, we recommend the command sequence for initialization of the DTS2010 and setup parameters to execute a time measurement and/or **pulse find** are as follows :

```
INITIALIZE DTS2010 COMMANDS
*RST                    ( Reset command is executed only once at initialization and
                            resets the System/DTS2010, optional command )
 :LER?                  ( Query to read the local event register 0=reset complete, optional )
*CLS                    ( Clear the Status command clears the status registers )
 :SYST:HEAD OFF         ( No header or code characters to Controller )
 :SYST:LONG OFF         ( Abbreviated mnemonic is the first four characters )
*ESR?                   ( Query to read the event status register  )

'PARAMETERS SETUP OF DTS2010 COMMANDS
 :TRIG:SOURAUTSTOP   (  Set trigger source to automatic and auto arm on stop channel )
 :DISP:FILT OFF      (  Set filter off )
 :ACQ:COUN000100        (  Set sample size to 100 counts )
 :SYST:CHANBOTH         (  Set channel to measure both or start channel to stop channel )
```

```
:ACQ:FUNCTPD++          (  Set function to TPD++ or both channels edges rising to rising )
:SYST:TERMSTAR-2.0000   (  Set start channel termination to -2.000vdc ECL )
:SYST:TERMSTOP0.0000    ( Set stop channel termination to  0.000vdc TTL  )
:CHANSTAR:LEV-1.0000    (  Set start channel 1 edge level to -1.000vdc )
:CHANSTOP:LEV1.0000     (  Set stop channel 2 edge level to +1.000vdc )

SAVE SETUPS FOR DTS2010 COMMANDS
:TER?                   (  Query to read the status event register, 10 = complete )
*SAV4                   (  Save all setups for all functions in locations for SAVE FOUR)

RECALL SETUPS OF DTS2010 COMMANDS
:TER?                   (  Query to read the status event register, 10 = complete )
*RCL4                   (  Recall all setups for all functions in locations saved by SAV4 )
BURST MEASUREMENT OF DTS2010 COMMANDS
:TER?                   (  Query to read the status event register, 10 = complete )
*TRG                    (  Trigger command to initiate a measurement )
:TER?                   (  Query to read the event register, 10 = complete )
:MEAS:AVER?             (  Read average measurement  )

PULSE FIND MEASUREMENT OF DTS2010 COMMANDS
:TER?                   (  Query to read the status event register, 10 = complete )
:ACQ:LEV                (  Initiate a pulse find )
:TER?                   (  Query to read the status event register, 10 = complete )
:CHANSTOP:MAX?          (  Read stop channel maximum peak voltage, after a pulse find )
:CHANSTOP:MIN?          (  Read stop channel minimum peak voltage, after a pulse find )
```

Initialization protocol

The DTS2010 needs to be initialized only once at the beginining of the program. The common commands at initialization are sent to the DTS2010 by the call of a high level function **init_488**.

init_488(DTS2010_GPIB_address, " *CLS, :SYST:HEAD OFF, :SYST:LONG OFF");

init_488 passes the arguments for the GPIB device address with the ASCII command string. Each ASCII command will perform a clear of the status register (*CLS), setup the instrument so header information is **off** (:SYST:HEAD OFF), and the abbreviated truncation rule of 4 characters for alpha mnemonics(:SYST:LONGOFF) is used throughout this application.

serial polling commands

init_488 function passes serial polling commands that must be performed at setup to accomplish status reporting. This is neccessary to assure operations are complete and no errors occur during initialize.

init_488(DTS2010_GPIB_address, " *ESE 125,*SRE 48, *ESR?");

The event status (ESE) and service request enable (SRE) commands set up masking to obtain status information.Included in the function is exchange protocol to query the event status register (ESR?).

The **opc_poll_queue ();** a low level function querys and reports on the event status. A typical polling status would monitor the event status until the operation is complete.

```
int opc_poll_queue() {
    int poll_status;
        while (!(poll_status  & 0x 41))
         {
          if (poll_the_dts(&poll_status))
           return(-1);
          time_out();
          }
   return(0);
    }
```

In this function I check the DTS2010 for operation complete(OPC), and no error.

talk _488 function setup

Once routines are established for initialize and protocol, the parameter setups must be sent for : termination voltage, edge channel voltage level, channel select, function type, sample size, and trigger arming operations ; which are neccessary to make the pin to pin skew measurements for this application.

The **talk_488** function passes the arguments for the GPIB address and the ASCII command strings. In the example of the call **talk_488** below special attention must be made to the ASCII command string for the **setup**.

```
talk_488( adr, " :TRIG:SOURAUTSTOP, :DISP:FILTOFF, :ACQ:COUN 001000");
talk_488( adr, " :SYST:TERMSTAR 0.0000, :SYST:TERMSTOP 0.0000");
talk_488( adr, " :CHANSTAR:LEV  1.0000, :CHANSTOP:LEV 1.0000");
talk_488( adr, " :SYST:CHANBOTH, :ACQ:FUNCTPD++");
```

The **first** stream of commands sent to the DTS2010 are : set the trigger to auto-arming on stop(:TRIG...), the filter off(:DISP:FILT) so no measurements will be ignored, the sample size(:ACQ:COUN) will be set to 1000 samples.

The **second** stream of commands deals with termination voltage for the start and stop channel(:SYST:TERM), and really depends on the device under measurement (DUM) output technology (the DTS2010 termination voltage range is +/-3.0vdc independent of channel). Remember some testers have ECL outputs and the termination needs to be at -2.0vdc.

In this application the DUM termination voltage for both channels is 0.0vdc and **talk_488** combines the command string to reflect the parameters for this setup.

The **third** stream of commands deals with the edge level voltage for the start and stop channels(:CHANSTAR:LEV). The edge voltage level really depends on the voltage points of the waveform to be measured; whether it be a percentage of the signal amplitude or specific voltage point. The channel input voltage range is +6.0vdc/-4.0vdc.

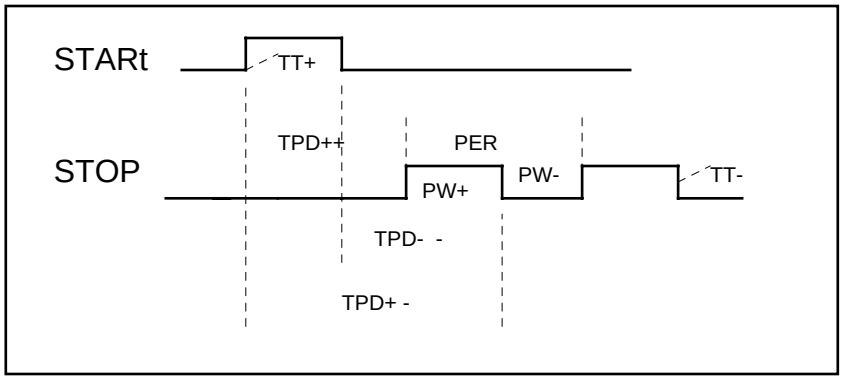
In this application the measure output edge level voltage for both start and stop channels are +1.0vdc and **talk_488** combines the command string to reflect the parameters for this setup.

The **fouth** stream of commands deals with the channels to be measured(:SYST:CHANBOTH) and the selected measurement function(:ACQ:FUNCTPD++).

In this application the measure channels are **both** and the output skew is rising edge start channel to rising edge stop channel or **TPD++**. **talk_488** combines the command string to reflect the parameters for this prop delay setup.

reference tables

The Waveforms Diagram and Reference Table below will simplify the acquire function and channel selection for the nine different function modes. Each mode has its own GPIB command. When the channel is BOTH, the prop delay(Tpd) between two channels are measured and the plus (+) means rising edge of the pulse and the minus (-) means falling edge. The Waveform diagrams are associaed with the function mnemonic, when a single channel event of either START or STOP are for : the pulse rise time TT+, pulse fall time TT-, pulse width PW+, or pulse period PER .



Waveforms Diagram of the DTS2010 nine acquire function modes.

Function	Channel Select	GPIB Command Examples
Tpd++	Both	:SYST:CHANBOTH, ACQ:FUNCTPD++
Tpd+-	Both	:SYST:CHANBOTH, ACQ:FUNCTPD+-
Tpd-+	Both	:SYST:CHANBOTH, ACQ:FUNCTPD-+
Tpd- -	Both	:SYST:CHANBOTH, ACQ:FUNCTPD- -
TT -	Start or Stop	:SYST:CHANSTOP, ACQ:FUNCTT-
TT +	Start or Stop	:SYST:CHANSTAR, ACQ:FUNCTT+
PW +	Start or Stop	:SYST:CHANSTOP, ACQ:FUNCPW+
PW -	Start or Stop	:SYST:CHANSTOP, ACQ:FUNCPW-
PER	Start or Stop	:SYST:CHANSTOP, ACQ:FUNCPER

Reference Table No. 1 shows setup function and channel selection for the nine (9) different function modes.

recall and save

Once the setups are complete, It may be neccessary to **save** the setup for **recall** later in the program. Save and recall are easy commands to use in this example :

```
talk_488( adr, " :TER?, *SAV4");
talk_488( adr, " :TER?, *RCL4");
```

Notice the :TER? checks the trigger bit of the event register (busy) and the *SAV4 stores all the setups in memory for all 9 functions.

measurements/listen commands

The example issues a command for measurement(*TRG) and function **listen_488** for the measurement data returned from the DTS2010.

```
talk_488( adr, " :TER?, *TRG, :TER?");
listen_488(adr," :MEAS:AVER?", &average1);
listen_488(adr," :MEAS:JITT?", &jitter1");
```

The jitter measurements(:MEAS:JITT?) are essential to show integrity of the signal path and can be included for every function. A high jitter and range measurement parameter indicates a problem with contact resistance or a noisy ground connection.

burst/samples

All voltage parameters, whether termination or edge level voltage are type real and declared as **double**. All burst measurements, whether AVERage, SDEV, JITTer, RANGe, MINimum, MAXimum are type floating point and declared as **double**. All samples are type integer using type modifier long and declared as **long**.

pulse finder

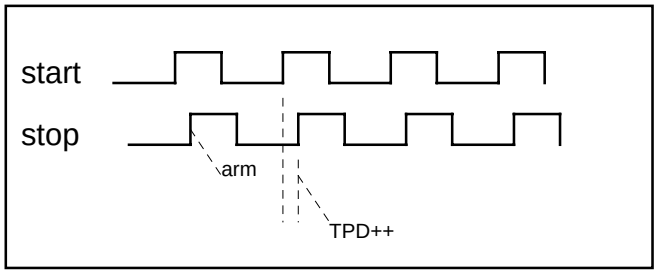
The DTS2010 has a **pulse find** capability to measure the peak voltages on the start and stop signals. To initiate a **pulse find** (:ACQ:LEV) command, the instrument will measure signal peak high level and peak low level of the DUM.

talk_488(adr, " :TER?, :ACQ:LEV :TER?");
listen_488(adr," :CHANSTARMAX? ", &vmax_start1);
listen_488(adr," :CHANSTOPMAX? ", &vmax_stop1);

The **listen_488** high level function will returned data for start (:CHANSTARMAX?) and stop channels(:CHANSTOPMAX?). This function is necessary not only for determining signal overshoot or undershoot, but for amplitude verification and determining 10%-90% voltage points for rise times Tr/Tf (:ACQ:FUNCTT-).

auto arming consideration

Since the DTS2010 is an asynchronous measurement instrument, it makes single shot real-time event measurements in a range of (0 to 2.5s). In this application, I used a sample size of 100 with a time sampling technique that requires repetative signals from the ATE system. The Arming Diagram below shows the arming selected in the **auto** arming trigger mode and enable arm mode of **auto arm on stop**. The two modes are combined into one GPIB command (:TRIG:SOURAUTSTOP). The mode allows the instrument to measure automatically the positive transition of the start to stop channel. The DTS will arm by the stop channel and then measure the next two events between the start and stop channels.



Arming Diagram of auto arm on stop

Be aware that other arming trigger modes not used in this application are **manual** and **external**. Other enable arm modes are **auto arm on start** and **enable stop after start**.

macro statements

The software system macro statements are used to send multiple GPIB commands that are encoded in the DTS2010 for ease of use and to speed up the transfer of setup data.

talk_488(adr, " :SYST:MACRO/BOTH/TPD--/AUTSTOP/4.000/4.000, :TER?, *SAV1");

In the example, the system macro sends arguments for setup of: channel STOP, function TPD--, arming trigger source AUTSTOP, start voltage +4.000vdc., and stop voltage +4.000vdc.

Another software mode is the acquire function default mode. After all the setup values and functions are **saved** an easy command to **retrieve** the setup values previously stored is the acquire function default (:ACQ:FUNTPD--*) command .

talk_488(adr, " *RCL4, :ACQ:FUNTPD-- * ");

In the example, the complete setup values for TPD-- used in previous examples will be called the function default. Also, the other nine functions and there corresponding setup values are available as shown below.

talk_488(adr, " :ACQ:FUNTPD++ * ");

Instrument accuracy essential for timing checkout

Unfortunately many of the ATE manufacturers cannot accurately verify their SKEW without the use of an instrument such as the WAVECREST DTS2010. The accuracy provided by the DTS is 10ps + trigger error with resolution in the **femtoseconds.** Tight accuracy is necessary to verify the tester specifications. The input bandwidth (BW) of 2.5Ghz is necessary for the very fast driver rise times of 500ps per volt or faster.

through-put improvement with very high pin counts

With semiconductor devices exceeding 512 pins, the ATE pin count becomes very high. A tester with 512 pins and more than 2 test heads (pin counts above 1024) can result in a very long verification time (2 - 4 hours). WAVECREST's Automation of the measurements via the GPIB using the DTS2010's fast measure and instruction set are able to improve though-put and reduce Timing Checkout 50% - 90%.

jitter distribution with every measurement

The jitter distribution shows the integrity of the signal path and is measured in every burst. A high jitter measurement signifies a problem with the contact resistance or a noisy ground connection. This parameter is essential when measuring the quality of the transmission path and any interfaces associated with that path all the way back to the mainframe.

Conclusions

In order to integrate an automated approach into timing checkout, the measurement instrument must make fast, accurate measurements, and be GPIB user friendly.

Technical discussions address the issues of the DTS2010 command sequences, status reporting, serial polling, exchange protocol, talk/listen functions, measurement data formats, common commands, and arming considerations.

The WAVECREST Digital Time Scope DTS2010 makes very fast, accurate time measurements and is an excellent instrument for edge placement accuracy measurements and skew verification. The GPIB software and commands make it simple to automate a Timing Checkout Skew program for your particular application.

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