INTRODUCTION

The purpose of this document is to provide an active index for all *WAVECREST CORPORATION* documentation included with *VISI*™ software. Please browse through the list of items below. Click on the Document Summary number for a brief overview of the document or click on the Document Number to bring up the document in Adobe Acrobat (version 3.0 or later).

Document Summary	TITLE APPLICATION NOTES	Document Number
AN101a	Measuring Time Domain Characteristics of Transmission Lines	200101-01 REV A
AN110	Verifying ATE System Accuracy and De-skew	200110-01 REV A
AN112	Jitter Testing of Clock Recovery Devices for High Speed Telecom and SONET™ Applications	Document under review
AN113	Programming the Wave DTS 2010 in "C" and "Pascal"	200113-01 REV A
AN114	Achieving ±30ps Accuracy in the ATE Environment	200114-01 REV A
AN115	Arming the DTS 2070™	200115-01 REV A
AN116	Programming the *WAVECREST* DTS in a Unix C/C++ Environment	200116-01 REV A
AN118	DTS 2070 ATE Testing Applications Measuring One-Shot Events	200118-01 REV A
AN119	Using the DTS 2070 in a TDR Configuration	200119-01 REV A
AN120	Jitter Analysis of Clock Recovery Devices at 155.52Mbps	200120-01 REV A
AN121	PLL Jitter Characterization and Debugging	200121-01 REV A
AN122	Programming the *WAVECREST* DTS with the Test List Option	200122-01 REV A
AN123	DTS 2070™ Arming Options (Using Automatic Arming Mode)	200123-01 REV A
AN124	Programming the *WAVECREST* DTS with the Wave.C Driver	200124-01 REV A
AN125	Testing 270MHz PLL Clock Devices on a Trillium ATE Tester with the *WAVECREST* DTS 2070™	200125-01 REV A
AN126	Characterizing Jitter on Rambus™ Clock Sources	200126-01 REV A
AN127	Examining Clock Signals and Measuring Jitter w/DTS™ and *VI*	200127-01 REV A
AN128	Measuring DAC Output Glitch Energy	200128-01 REV A
AN129	Using *Virtual Instruments* dataCOM Software, ver 3.20, to Evaluate Clock/Transmitter Chip Pairs on Fibre Channel Disk Drive Boards	200129-01 REV A
AN130	Phase Noise Measurement Using the *WAVECREST* Digital Timing System	200130-01 REV A
AN131	Characterizing AC Timing and Jitter Generation on LVDS Transmitters	200131-01 REV A.
AN132		
AN133	Fibre Channel Jitter Compliance Measurements of Storage Area Networks Using *WAVECREST*'s DTS-2077™, AG-100™ and *VISI*™*6* Software	200133-00 REV A
AN134		
AN135	Testing 100BaseT Devices Utilizing Low-Cost ATE and *WAVECREST*'s TEM75+	200135-00 REV A

Document Summary	TITLE Technical Bulletins	Document Number
TB06	Correlation results between DTS-2075™ with *VI* and the CSA803A	200306-01 REV A
TB07	Comparing the DTS-2075™ w/ *VI* to the Hewlett-Packard 3GHz BERT box	200307-01 REV A
TB08	Comparing the DTS-2075™ and DTS-550™ Using *VI* to Network and Protocol Analyzers	200308-01 REV A
TB09	A New Method for Jitter Decomposition Through Distribution Tail-fitting	200309-01 REV A

Document Summary	TITLE Manuals	Document Number
SIA-3000 User's Guide	Signal Integrity Analyzer 3000 User's Guide and Reference Manual	200006-03 REV A
SIA-3000 GPIB Manual	Signal Integrity Analyzer 3000 GPIB Programming Guide 03/21/02 Errata Sheet	200007-00 REV A 200010-00 REV A
SIA-3000 Quick Setup Guide	Signal Integrity Analyzer 3000 Quick Setup Guide and Making a Measurement with *VISI*™ Software	200008-00 REV A
API User's Guide	Application Programming Interface User's Guide	200002-05 REV A
DTS User's Guide	DTS 2079/2077/2075™ User's Guide and Reference Manual	207900-03 REV A
	Errata sheet - DTS 2079/2077/2075™ User's Guide, code ver. 1.99	200200-04 REV B
GPIB	DTS 2079/2077/2075™ GPIB Programming Guide	207910-01 REV B
	Errata sheet - DTS 2077/2075™ GPIB Programming Guide, code ver. 1.99	200201-04 REV B
Test List	DTS 2079/2077/2075™ Test List Option Programming Guide	207920-01 REV B
	Errata sheet - DTS 2077/2075™ Test List Option Programming Guide, code ver. 1.95	200202-00 REV A
DTS-550	DTS-550™ User's Guide and Reference Manual	255000-02 REV C
DSM-16	8:1 Digital Switching Matrix	201600-02 REV B
DSM-16S	Dual 8:1 Solid State Digital Switching Matrix	201601-02 REV A
DSM-16D	Dual 4:1 Differential Switching Matrix with Integrated Baluns	201602-01 REV A
DSM-12	6:1 Digital Switching Matrix	201200-01 REV A
Advanced dataCOM/Clock	*Virtual Instruments Signal Integrity*™ 6.3.1 User's Guide - dataCOM, PLL/Clock for the DTS-2079, 2077 and 2075	200000-09 REV A
VI-dataCOM VI-PLL	*Virtual Instruments Signal Integrity*™ 6.02 User's Guide - dataCOM, PLL/Clock for the DTS-2079, 2077 and 2075	200000-07 REV A
Release Notes	VISI 5.0 Release Notes with v5.1 Enhancements Addendum	200211-01 REV A
Random Data	*Random Data Application* Program - Product Description Sheet	200210-01 REV A
API User's Guide	Application Programming Interface Manual	200002-05 REV A
Jitter 101	Jitter 101 – A Foundation for Jitter Measurement	209000-07 REV A
	Appendix A - Available Equipment	Appendix A
	Appendix B - Correlation Issues Among Instruments	Appendix B
	Appendix C - FFT-based Jitter Analysis	Appendix C
	Appendix D - Investigating switcher phase noise on 622 Mbit/s ATM PLL device	Appendix D
	Appendix E - Jitter Definitions and Related Terminology	Appendix E
	Appendix F - Sampling Oscilloscope Techniques	Appendix F
	Appendix G - Effects of Bandwidth on Transient Information	Appendix G
	Appendix H - Converting between RMS and Peak-to-Peak Jitter at a Specified BER	Appendix H
AG-100	Arm Generator 100 - User's Guide and Reference Manual	218100-00 REV B

Document Summary	TITLE Calibration Procedures	Document Number
DTS 2079	Calibration Procedure for the DTS 2077	207902-01 REV B
DTS 2077	Calibration Procedure for the DTS 2077	207902-01 REV B
DTS 2075	Calibration Procedure for the DTS 2075	207505-01 REV C
DTS 2070	Calibration Procedure for the DTS 2070	207005-01 REV A

AN101a

Measuring Time Domain Characteristics of Transmission Lines

This application note provides an in-depth study of the time-domain characteristics of electrical transmission lines and the techniques used to measure these characteristics.

A transmission line (or cable) transfers electrical energy from one point to another. In many instances, the time it takes to transfer this energy (time delay) is important and must be determined. The physical properties of the cable and its operating environment influence this time delay.

This note helps the reader understand transmission lines, their environmental properties, how to control them and how to obtain the most accurate measurements of the time delay. The *WAVECREST* Timing Measurement Instrument is introduced and compared to time domain reflectometers. Hardware implementation of these techniques is also discussed.

RETURN TO INDEX

AN110

Verifying ATE System Accuracy and De-skew

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).

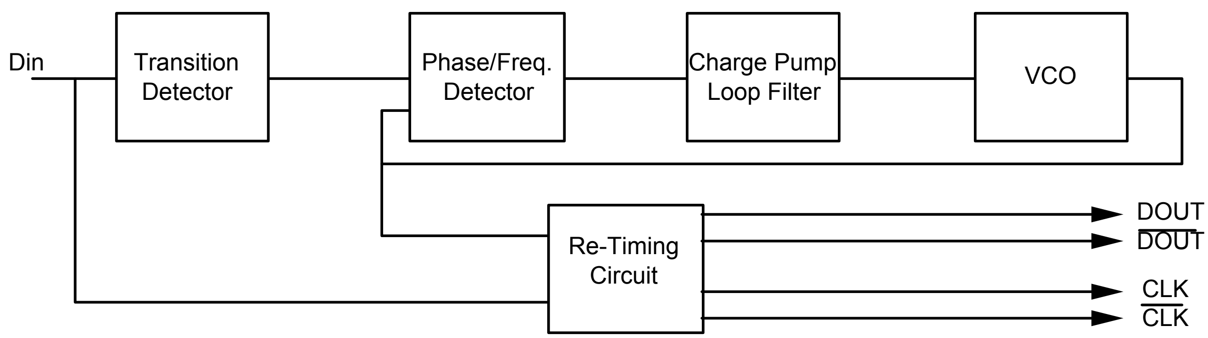
RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

AN112

Jitter Testing of Clock Recovery Devices for High Speed Telecom & SONET Applications

This application note deals with taking jitter and propagation delay data on "Clock Recovery Devices" such as the Texas Instruments TDC-1555 for the characterization of these devices to develop specifications and for the verification of specifications. We will look at the jitter for various patterns, mark densities and strings of data. We will also measure various AC parametric parameters such as data centering within clock, data I/O skew, clock duty cycle, period and data I/O TPD. TR/TF will also be measured on all outputs.



BLOCK DIAGRAM OF TDC-1555

The speed, accuracy and low noise floor of the DTS-2050/2070 make it a valuable tool for taking large amounts of analytical data in a very short period of time, or, for doing production sampling of critical parameters. The data for each of the 1000 point histograms shown in the text took less than 70 mS to aquire and send to the host test system.

RETURN TO INDEX

AN113

Programming The Wave DTs 2010 in "C" And "Pascal"

The WAVE Digital Time Scope DTS2010 is capable of making very fast, accurate time measurements and can be an excellent instrument for the automated measurement environment used for Integrated circuit(IC) testing.

Most automated applications using the WAVE DTS involve programming software to drive the instrument on the GPIB BUS. The GPIB commands are similar for most instruments, but the main difficulty lies in programming languages. Whether the computer is an IBM-486 based PC, SUN/SPARC, or HP/APOLLO workstations; the programming language is usually never the same.

Each computer will have its own primative software drivers that drive the GPIB bus and most of the drivers are either custom or generic (like National Instruments NI-488) with different software languages.

Furthermore to complicate the software language issue, many of the instruments' IEEE488 user manuals will have software examples in some other language. Thus the customer is expected to do translations while writing code.

This application note describes some of the GPIB code necessary in programming the DTS in "C" or "PASCAL" and compares different data types, formats, and the ASCII serial command streams for **talk** and **listen**.

RETURN TO INDEX

AN114

Achieving ±30ps Accuracy in the ATE Environment

Most IC manufacturers have purchased digital or mixed signal LSI or VLSI ATE systems within the last one to four years. These systems have overall timing accuracy of from ±500ps to ±3.0ns and the latest ATE systems are quoting ± 350ps overall accuracy. Also, most, if not all, of the new Pentium® clock drivers and new LAN/Telecom devices specify PLL propagation and jitter measurements in the sub 100ps range.

These devices require less than ±50ps to ±250ps clock skew with guaranteed jitter specifications of less than 15ps specified on a cycle by cycle basis. Serial LAN, telecom mixed-signal devices also require accurate jitter and propagation delay testing in the order of 100ps or less.

This note offers various techniques for interfacing LSI/VLSI ATE to external time measurement instruments for making extremely accurate propagation delay and jitter measurements with accuracy on the order of ±30ps and noise floors of less than 5ps.

RETURN TO INDEX

AN 115

Arming the DTS 2070

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

The DTS 2070 has the ability to digitize voltage in time with a resolution as fine as 10 pS. The voltage can be graphically displayed on a PC or workstation. This feature enables the user to see the input channels while debugging programs, without having to connect an external oscilloscope.

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

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

***AN IMPORTANT NOTE CONCERNING AN115**: It is important to note that although this Application Note references the DTS2070, many of the Arm functions defined in this document are applicable to the DTS2075 and DTS2077 as well. This document will be reworked and re-released at a future date to reflect this. As for now, it is included for reference only.*

RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

AN116

Programming the *WAVECREST* DTS in a Unix C/C++Environment

The need to make timing measurements at 10pS accuracy and frequency measurements of 1.0GHZ or less are very common in high performance IC test applications. In response to customer demands, the WAVECREST Digital Time Scope DTS2070 or DTS is used with many ATE Testers to make fast, accurate timing measurements that ATE systems can not make; because of either a basic accuracy or bandwidth (BW) limitations.

Most ATE Test systems are using UNIX - based workstations like the SUN in a C/C++ environment with the NI-488.2M GPIB software driver and National Instruments interface. This paper is to help the Test Engineer write a test program to measure critical timing parameters on I.C.'s using the DTS with an ATE tester in a automated environment via the GPIB bus.

This application note explains how to:
Configure the GPIB device parameters in a NI-488 configuration file for the GPIB software driver.
Include files that must be declared in order to perform the necessary function calls of the GPIB software driver.
Initialize and setup the DTS with C/C++ software commands.
New quick easy to use setup and measurement macro commands for the DTS.

There are basic fundamental GPIB software commands a user must perform or the controller/instrument will not communicate. This paper is formulated to provide the essential software examples, so the Test Engineer will be successful in executing program instructions over the GPIB.

RETURN TO INDEX

AN118

DTS 2070 ATE Testing Applications Measuring One Shot Events

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, WAVE Digital Time Scopes, DTS 2070 or DTS 2050, 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.

RETURN TO INDEX

AN119

Using the DTS 2070 in a TDR Configuration

The DTS 2070 Digital Time System is designed to be an integral part of any automated bench or ATE installation. The DTS, with its 800fs one-shot time interval measuring unit, is capable of analyzing a multitude of user problems including signals reflected down an open or shorted transmission line. The DTS 2070 with optional VirtualWare software tools can perform the following functions:

1. Low and high frequency jitter versus pulse analysis.
2. Strobe volt meter/oscilloscope function.
3. Time window analysis results for setting time.
4. Time domain spectrum analyzer histograms.
5. Function versus time/pulse analysis.
6. TDR function for cable distance.

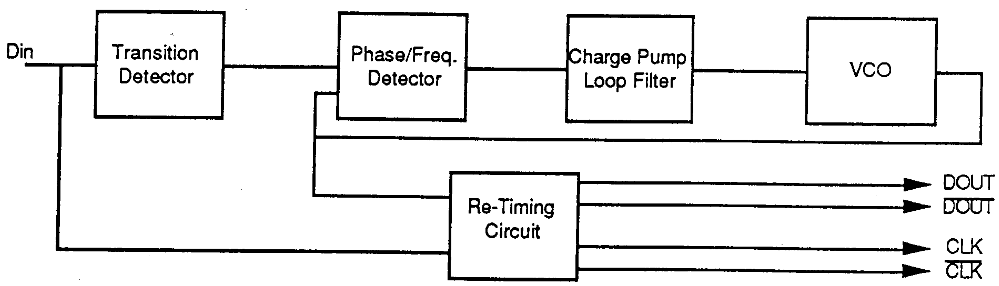
This application note describes using the DTS 2070 as a TDR in a stand-alone fashion or with our VirtualWare 4.X software tools.

IMPORTANT NOTE CONCERNING AN119: This application note is included for the purpose of describing TDR methods using GPIB programming (ie. Stand alone mode). The Virtual Ware software is obsolete and is left in for reference only. This application note is scheduled for rewrite and re-release to include information relevant for DTS2075, DTS2077 and Virtual Instruments™ (VI™) software.

RETURN TO INDEX

AN120

This application note discusses jitter analysis on "Clock Recovery Devices" such as the Texas Instruments TDC-1555. This analysis includes the characterization of these devices to develop specifications and the verification of specifications. Topics discussed are jitter caused by various patterns, data-to-clock centering and jitter caused by long strings of zero data.



BLOCK DIAGRAM OF TDC-1555

In the process of collecting this jitter analysis data, various AC parametric parameters are also measured such as clock frequency/period and data-to-clock centering under changing patterns conditions.

The speed, accuracy and low noise floor of the DTS 2070 along with the "ARM on Nth event counters" and "Strobing Voltmeter" make it a valuable tool for taking large amounts of analytical data in a very short period of time, or, for production sampling of critical parameters. The data for each of the 1000 point histograms shown in this note took less than 70ns to acquire and send to the host test system.

RETURN TO INDEX

AN121

PLL JITTER CHARACTERIZATION AND DEBUGGING

The first six sections of this application note give general knowledge on Phase Lock Loop behavior and how it fits into the overall high-speed digital design environment. The next six sections illustrate how the *WAVECREST* DTS 2070 instrument can be used to properly characterize PLL output jitter and locate the cause(s) of this jitter. When the DTS 2070 instrument is effectively utilized, it is a critical measurement tool for understanding your PLL design (if you are a PLL designer) or for optimizing the use of PLLs in your system (if you are a system designer).

The primary purpose of this application note is to provide a solid foundation and background on the need to properly measure, characterize, and analyze the jitter performance of today's Phase Lock Loop (PLL) circuits using *WAVECREST's* precision DTS 2070 Digital Time System. PLL jitter characteristics are best measured since today's simulation tools[1,2] cannot adequately account for all the variables required for modeling PLL jitter behavior. In particular, four unique analysis features of the DTS 2070 are explained in the following document: spectrum, jitter, function and oscilloscope analysis.

Other parameters such as skew, time to lock and symmetrical duty cycle are also important for optimum PLL performance, but are not covered in this application note. PLL used in data communication (clock recovery devices) is also not discussed. Refer to Application Note No. 120, "Jitter Analysis of Clock Recovery Devices at 155.52Mbit/S" to see how the DTS 2070 can be used to analyze data communication circuits. In general, however, many of the issues and measurement techniques discussed in this application note can also be applied to data communication circuits.

The focal point of this work is to establish a baseline for the proper measurement of PLL jitter behavior and noise sensitivity of PLL in a benign environment (no fast transient or other system level induced noise). Proper PLL jitter data analysis may allow the designer to assess timing sensitivities to system level noise. Although jitter causes and jitter measurement issues are broad, this application note is one of several that is devoted to the area of PLL characterization and debugging. Currently, *WAVECREST* is exploring the idea of introducing a variety of external noises into the PLL fixture environment as a subject for a future application note.

RETURN TO INDEX

AN122

The Wavecrest Digital Time Scope (DTS) makes fast accurate real time measurements and jitter analysis that are 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.

RETURN TO INDEX

AN123

DTS 2070 Arming Options (Using Automatic Arming Mode)

Two channel delay measurements are increasingly used in today's high frequency clock distribution designs. Typical two-channel measurements include output skews and 1/0 skews. One major advantage of using the DTS 2070 is its ability to measure jitter as part of the skew measurements.

For two-channel delay measurements, the DTS 2070 also provides the flexibility of several arming modes and enabling options. This flexibility, however, if not understood, can lead to misinterpretation of measured results and possibly negative delay numbers. Therefore, negative delay numbers should not be interpreted as an alarm condition. By definition, a positive delay measurement indicates the CH1 signal is leading the CH2 signal. A negative delay measurement means the signal edge at CH2 occurs before the signal edge at CH1. See Figure 1A and 1B for examples of both positive and negative delays. This distinction is important because it can lead to some confusion, especially with first-time users.

IMPORTANT NOTE CONCERNING AN123:* *This application note is included for the purpose of describing Automatic Arming Modes that are applicable to all Wavecrest precision time measurement instruments. This application note is scheduled for rewrite and re-release to include information relevant for DTS2075, DTS2077 and Virtual Instrument™ (VI™).

RETURN TO INDEX

AN124

Programming the *WAVECREST* Digital Time System with the WAVE.C Driver

The *WAVECREST* Digital Time System (DTS) makes the fast, accurate real-time measurements and jitter analysis used in automated testing. When embedded in an ATE tester, the DTS uses the GPIB bus (IEE-488.2) to communicate commands and measurements to the processor. The WAVE.C driver was designed to provide a generic “C” driver that communicates with most testers and executes from a test program.

This application note explains the WAVE.C instrument driver used in an automated ATE environment to measure asynchronous events for frequency, period jitter, pulse width, propagation delay, rise time and fall time. It teaches how to:

1. Define and use the WAVE.C calls.
2. Write a test program with a DTS period and TPD measurement.
3. Call “C” functions that measure frequency, period jitter, pulse width, propagation delay, rise time and fall time.
4. Return measurement data for comparison to limits for characterization or DUT/device specifications.
5. Provide testing solutions to make timing measurements 1 GHz or less on synchronous or asynchronous events.

This paper provides essential software examples that guide the test engineer through the successful execution of programming instructions over the GPIB. The following WAVE.C examples use the calls and arguments of real test cases and show the DTS features.

RETURN TO INDEX

AN125

Testing 270 MHz PLL Clock Devices on a Trillium ATE Tester with the *WAVECREST* DTS 2070

The WAVECREST DTS 2070 Digital Time System is used with many ATE testers to make the fast, accurate timing measurements for Phase Lock Loop (PLL) clock devices. Many PLL clock frequencies range from 1GHz to 16MHz and have specifications of 50ps to 150ps clock skew and 16ps to 300ps rms jitter. The PLL Clock DUT (Device Under Test) in this application example operates at 270MHz, has a 100ps clock skew, 50ps rms jitter specification and is free running.

Many ATE systems cannot make the frequency measurements and period jitter measurements necessary for this type of DUT, because of basic operational frequency, accuracy, and bandwidth (BW) imitations. Another problem for many ATE systems is they have difficulty with asynchronous events and must resort to using match loops to synchronize the DUT clock to the tester. For the following reasons, the WAVECREST DTS 2070 was selected to test this asynchronous PLL clock DUT:

1. The DTS 2070 measures 10ps accuracy and femtosecond resolution.
2. The DTS 2070 typical jitter noise floor is less than 5ps.
3. The DTS 2070 communicates with the instrumentation IEEE-488GPIB bus.
4. The DTS 2070 can measure any asynchronous event, one shot or averaged.

This application note discusses using the WAVECREST DTS 2070 in a high performance IC testing PLL clock DUT application with the use of the Trillium ATE tester as controller for the GPIB communications. This paper also covers the design of the DUT board, and the GPIB commands to the WAVECREST DTS 2070 for setup and measurement. Since the DTS is connected to the Trillium, this note also covers some of the tester program language commands for GPIB communications.

IMPORTANT NOTE CONCERNING AN125: This application note is included for the purpose of describing an integrated application of the Wavecrest DTS instrument. Most of the material contained in this document is directly applicable to all Wavecrest precision time measurement instruments. This application note is scheduled for rewrite and re-release to include information relevant for DTS2075, DTS2077 and Virtual Instrument™ (VI™).

RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

AN126

Characterizing Jitter On Rambus® Clock Sources

With the introduction of licensed Rambus® memory bus technology to volume semiconductor production, a new and challenging set of test and characterization issues are being confronted by engineers qualifying clock sources for a Rambus® memory system. The specifications of the Rambus® clock device require an operating frequency of 400MHz, 50ps of edge to edge jitter specification and a 4-cycle accumulated jitter spec of 100ps.[1] This application note will focus on techniques that the engineer can use when employing the *WAVECREST* DTS-2075™ and *Virtual Instruments*™ software tools to characterize, analyze and run production tests on Rambus® clock source chips.

RETURN TO INDEX

AN127

Examining Signals and Measuring Jitter with the *Wavecrest* Dts 2075™ and *Virtual Instruments*™ - Datacom Software

The purpose of this paper is to present a general-purpose procedure that can be used to start a characterization or debug session of an unknown signal. This procedure will detail the setup for *Virtual Instruments*™ (*VI*) (Patent pending) software with an approach that a new operator of the DTS 2075™ (DTS) can use to discover what significant data exists in a signal, thus narrowing the scope of ongoing characterization.

RETURN TO INDEX

AN128

Measuring DAC Output Glitch Energy Using the *Wavecrest* Dts-2075™ and *Virtual Instruments*™

One of the more time consuming and difficult parameters to characterize and test in an ATE environment is the **Glitch Energy** specification. Glitch energy specifications are found on parts such as D to A converters and RAMDAC video driver chips. This specification is also found in the video outputs of the graphics processor chips used on computer video cards. Also, any analog circuit that is switched will produce a glitch on the output as it changes levels and settles out. This paper will describe the capabilities of the *WAVECREST* DTS 2075™ (DTS) hardware to test glitch energy. It will also outline the software steps to program the DTS over the GPIB interface in an ATE environment as well as the use of *WAVECREST's Virtual Instruments*™ (VI) (Patent pending) waveform capture tool to measure glitch energy in a lab environment.

RETURN TO INDEX

AN129

Using Wavecrest's Virtual Instruments™ Datacom Software, Ver. 3.20, to Evaluate Clock/Transmitter Chip Pairs on Fibre Channel Disk Drive Boards

One of the most stringent test parameters on a data communications system is transmit jitter. Often times the system performance, compliance and long-term reliability depend on a few picoseconds of difference between jitter performance of the transmitter and the associated reference clock chosen by the system designer. This paper will describe how to set up and interpret the data plots available in *WAVECREST*'s *Virtual Instruments*™, v3.20, DataCom software in order for evaluating Fibre Channel Disk Drive controller boards.

RETURN TO INDEX

AN130

Phase Noise Measurement Using the *Wavecrest* Digital Timing System

This application note will describe a method of using the “Time Digitizer” function in *WAVCREST*’s *Virtual Instruments*™ while using the *WAVECREST* DTS (Digital Time System) to measure the time jitter and to calculate the phase noise spectrum. This method allows the DTS Time Digitizer to report both time jitter and phase noise at the same time.

The sensitivity and spectral resolution of such a method will be discussed in addition to showing the phase noise measurement correlation between a DTS using Time Digitizer and a RF Spectrum Analyzer.

The conclusion will state that, under certain conditions, the DTS Time Digitizer can accurately measure the two most important quantities on a high-speed signal: time jitter and phase noise.

RETURN TO INDEX

AN131

Characterizing AC Timing and Jitter Generation on Low Voltage Differential Swing (LVDS) Transmitters

The need for larger bandwidth in data communications, microprocessor systems, multi-media and networking applications continues with no foreseable upper limit. Low Voltage Differential Swing components try to address the need for high speeds (>200MB/s) and low power consumption while accommodating a wide range of applications. There are two industry standards that define and govern LVDS technology. The first is the ANSI/TIS/EIA-644 standard developed under the Data Transmission committee TR3.02. This is the standard that defines the driver and receiver I/O characteristics. The purpose of this committee is to establish standards that work up to the theoretical limit of 1.923GB/s. The second standard that parts using LVDS buffers must adhere to is the IEEE 1596.3 SCI-LVDS which specifies the signal levels for the physical layer interface and defines encoding for packet switching.

This paper will document the use of *WAVECREST*'s DTS-2077™ to measure LVDS specification standards for signal levels, rise time, propagation delay, jitter transfer and jitter generation. This paper is general purpose in tone and other applications should find these techniques valuable.

RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

AN133

Fibre Channel Jitter Compliance Measurements of Storage Area Networks Using *WAVECREST's* DTS-2077™, AG-100™ and *VISI*™*6* Software

This application note will describe how to perform Fibre Channel jitter compliance measurements on Storage Area Network (SAN) systems and components using *WAVECREST's* DTS-2077™, Communication Signal Analyzer, AG-100™ Arm Generator and *Virtual Instrument Signal Integrity*™*6* (*VISI6*) software. This note will also describe a variety of setups used to perform jitter compliance measurements using data only from the device under test (DUT). The measurement techniques in this application note can be easily transferred to other protocols such as Gibabit Ethernet, SONET and Infiniband™ where systems or components may be tested with a repeating pattern such as CRPAT, CJTPAT or PRBS. Four different examples of jitter compliance testing are included to illustrate the flexibility of *WAVECREST*'s signal integrity measurement instrumentation. A brief review of the data acquisition method for calculating jitter using the AG-100 and DTS-2077 is also included. Two comprehensive documents describing jitter measurement methods including a summary of jitter values at the various compliance points are: **Fibre Channel – Methodologies for Jitter Specification (MJS)** and **Fibre Channel – Physical Interfaces (FC-PI)**. These documents can be downloaded off the Internet at www.t11.org.

RETURN TO INDEX

TB 06

Correlation results between DTS 2075™ w/ *VI*™ and the CSA803A

This technical bulletin summarizes the tests performed to validate the measurement and algorithm performance of *WAVECREST*'s DTS 2075™ (DTS) and *Virtual Instruments ™* (VI) – DataCom software, v2.27. The validation was done using the CSA803A Sampling Oscilloscope. The scope was triggered using the TX clock output at the back of the SJ-300. This same TX clock was applied to Channel 1 of the DTS to use as a reference for SPECTRUM tool TPD++ measurements. The modulated clock or data was applied to Channel 1 of the scope or Channel 2 of the DTS respectively.

The purpose of these tests was to see how well the DTS and VI-DataCom software could correlate to the scope for Total Jitter and Periodic Jitter where the BIT CLOCK is NOT used, except in the SPECTRUM TPD++ tests where the BIT CLOCK is used as the measurement reference.
The test results for all of the following tests were put into a spreadsheet format for comparison in Appendices A through D.

Three test setups are documented in this paper:

1. The DTS is compared with the CSA803A for Total Jitter and Periodic Jitter correlation. The SJ-300 is used as the signal source and is running at 622MHz. The internal modulation source is used in the SJ-300 to generate frequency modulation on the clock signal and see how well the DTS and CSA803A could measure this modulation. Auto Arming is used for all of these tests in VI-DataCom v2.27.
2. The same setup is used here as was used in test setup one, except that the scope and DTS are measuring Data instead of Clock. The pattern used is a PRBS 2^7-1. The modulation source is the same as in test setup one and Auto arming is being used with VI-DataCom v2.27.

Test setup three is using the *WAVECREST* DTS 550™ pattern generator as the signal source. The signal is running at 1.0 GB/s and a PRBS 2^5-1 pattern is being used. Modulation at the same 3MHz frequency is being generated by the 550 for the tests. Two test setups are used during the 550 tests. One is <u>with</u> the pattern marker generated by the 550 and the other is <u>without</u> the pattern marker being supplied to the DTS2075.

RETURN TO INDEX

TB07

Comparing the DTS 2075™ w/ *VI*™ to the HP 3GHz BERT box

This Technical Bulletin looks at the output of the HP 3GHz BERT box running the PRBS 2^7-1 pattern at Fibre' Channel speeds of 1062.5MHz. The same generator is then connected to the DTS 2075™ & *Virtual Instruments*™ (VI) (Patent pending) DataCom (DC) software package to compare results.

The output DCD + ISI of the BERT was measured for both rising and falling DCD + ISI with the HP54120A sampling oscilloscope. The measurements were taken over 20 edges each with results of 10ps for the rising edges and 16ps for the falling edges. The RJ of the BERT was also measured using a clock-like toggle pattern with the results being 2.7ps.

The Deterministic Jitter (DJ) and Random Jitter (RJ) were also measured using the DTS 2075 and VI/DataCom (V2.23b) software package.

Two test cases were compared using the VI/DataCom V2.23b software. The first used the AUTOARM mode for clockless and markerless jitter analysis.

The second test case used the PATTERN MARKER generated by the pattern generator.

The measurements made with the HP54120A were assumed to be correct and are used as the reference for the measurements made with the DTS.

RETURN TO INDEX

TB08

Comparing the DTS-2075™ and DTS-550 Using *VI*™ to Network and Protocol Analyzers

As *WAVECREST* products enter the data communication testing market, they are often compared with one commonly used piece of equipment, the Network Analyzer. Network Analyzers are considered the standard for data communication testing. Product offerings come from companies such as Tektronix, Rhode and Schwartz, Hewlett-Packard and Wandel & Golterman/Wavetek.

RETURN TO INDEX

TB09

A New Method for Jitter Decomposition through Distribution Tail-fitting

In this paper, *WAVECREST Corporation* presents a new time-domain jitter separation method that automatically searches and fits the tail parts of the jitter histogram with nonlinear jitter models and also estimates deterministic and random jitter components. Bit error rate (BER) calculation, based on the deterministic and random jitter components, is discussed and demonstrated.

RETURN TO INDEX

WAVECREST® Corporation
A Technologies Company

Signal Integrity Analyzer 3000 - User's Guide and Reference Manual

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

DTS 2079/2077/2075 User's Guide and Reference Manual

The *WAVECREST* DTS 2079/2077/2075 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).

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.

RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

DTS 2079/2077/2075 GPIB Programming Guide

RETURN TO INDEX

DTS Test List Option Programming Guide

The Test List feature is a set of IEEE-488 (GPIB) utility commands that work with the DTS to expedite repetitive execution of a fixed set of tests common in semiconductor testing.

Test List GPIB commands provide the user with the ability to define 1500 tests and a procedural script in memory on the DTS instrument and to then control test operation as well as receive measured statistics and pass/fail judgments.

Test List consists of the following group statistics and pass/fail command judgments:

1. A group of commands to create:
   a) Test definitions
   b) Control script definitions
2. A group of commands to:
   a) Monitor and control the tests being run in the instrument
   b) Retrieve test results from the instrument.

Test List has been developed to support the user who has a large set of measurements that will be repeated numerous times.

Test List supports the return of results for each measurement or series of measurements.

Test List allows the evaluation and return of Pass/Fail judgments for each measurement or group of measurements. Each measurement statistic can have limits assigned to define a Pass/Fail. Test List summarizes Pass/Fail for groups as the logical "or" of the status masks of the measurements taken.

The user defines the parameters for individual measurements, limits for comparisons and how a measurement or group of measurements will return the results.

RETURN TO INDEX

DTS-550 User's Guide and Reference Manual

The DTS-550 is a versatile clock/pattern generator allowing precise control of jitter amplitude, frequency and distribution on digital clock and data waveforms. This capability allows accurate, repeatable characterization of jitter tolerance in clock recovery circuits for performing worst-case analysis. Jitter amplitudes are programmable over a wide dynamic range at jitter frequencies.

The patented Direct Time Synthesis (DTS) technology allows the transition position in a clock sequence to be directly synthesized in the time domain. This unique edge placement flexibility allows the creation of clock waveforms exhibiting precise, digitally programmed variations in edge timing (jitter).

DTS technology allows previously unavailable jitter distributions to be programmed. In addition to standard sine wave variations, the generator also provides Spread Spectrum Clock 1 (SSC1), sawtooth, triangle and pseudo-random distributions. Custom distributions may also be created to meet unique applications.*

*Custom distribution files are currently created by WAVECRET only.

Instrument control is based on a Graphical User Interface with pull-down and pop-up menus. An embedded PC/AT compatible computer provides standard keyboard and mouse inputs, a VGA display (internal monochrome monitor or optional external color monitor) and a floppy drive for external program and data transfer. The front panel key switches, mouse and optional external keyboard all operate in parallel allowing the DTS-550 to be used effectively in any environment.

RETURN TO INDEX

Virtual Instruments User's Guide - Data Com, PLL and Clock

The DTS 2079/2077/2075 *Virtual Instruments* (Patent pending) software provides all the major features of the instrument through graphical displays of statistics and waveforms via a PC or workstation. This version of the DTS 2079/2077/2075 *Virtual Instruments* software operates on an IBM PC, or compatible, using Microsoft® Windows™ 95, 98 or NT 4.0 as well as SUN/ Solaris® and Hewlett-Packard® Workstations. For specific information on hardware and soft ware requirements see **Section 1 – Hardware & Software Requirements**. *Virtual Instruments* provides access to the following features of the DTS 2079/2077/2075:

- Select and execute the 16 measurement functions
- Set measurement reference voltages
- Select external or automatic arming
- Choose external arm reference voltages and edge senses
- Enable arming event gating
- Perform pulse find on input signals
- Select pulse find method
- Select trip level percentages or "user" voltages
- Set sample size
- Filter with the instrument and/or software filters
- Digitize signal envelopes using strobing
- Set arm-on-*n*th counts to 131,071
- Gate Arm Mode Time Stamp
- Gate Arm Mode Event counting
- Burst on Trigger with Elapsed Time Stamp

DTS features not available in the *Virtual Instruments* software program are:

- Manual trigger mode
- Cable measurement
- DC input measurement with the comparator A/D
- Setting the DTS 2079/2077/2075 front panel display (LCD) units
- Setting "sets" count
- Setting SCSI addresses
- Memory clear to defaults

WINDOW / INSTRUMENT PANEL

Nine separate window panels are used to display the results of DTS 2079/2077/2075™ operations in various formats in the dataCOM version while seven panels are available in the PLL version of *Virtual Instruments.* The PLL version does not have the dataCOM or Eye Histogram window panel options.

- **OSCILLOSCOPE** – Digitized waveform(s) found using the strobe function. Fast Fourier Transform Available.
- **HISTOGRAM** – Histogram of acquired samples. Tail-Fit option available.
- **JITTER ANALYSIS** – Graph of measured jitter vs. some *n*th stop event count. Fast Fourier Transform Available.
- **FUNCTION ANALYSIS** – Analysis of measurement with respect to cycle count. Fast Fourier Transform Available.
- **TIME DIGITIZER** – Graph of samples acquired in single burst. Fast Fourier Transform Available.
- **dataCOM** – Graphs of DCD + DDJ Jitter, Bathtub Curve, 1-Sigma vs. UI, Fast Fourier Transform and Unit Interval Distribution (dataCOM version only).
- **EYE HISTOGRAM** – Graphs of Tail-Fit and Bathtub Curve (dataCOM version only).
- **TIME SERIES** – Strip chart of low frequency variations with Allan Variance.
- **STATISTICS** – Text display of time measurements, voltage levels and duty cycle.

RETURN TO INDEX

DSM-16
8:1 Digital Switching Matrix

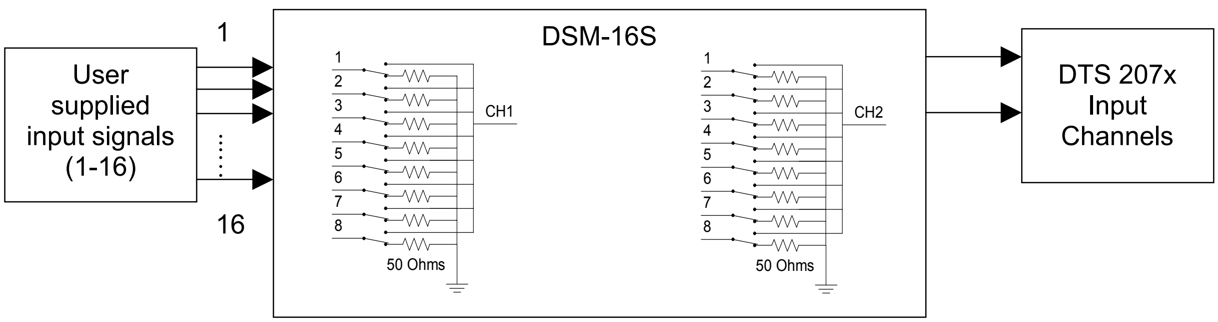
A 19” x 22” x 3.5” rack mountable, dual 8-input binary relay tree matrix with a bandwidth of over 3GHz. This unit is intended to extend the input capability of the DTS-207X (DTS) from 2 to 16 channels. The matrix can be controlled manually from the front panel or remotely via the RS-232C port at the back of the DTS. Remote control of the DSM-16 (DSM) via GPIB commands to the DTS makes integration into an automated environment fast with no special hardware or software required. The DSM is designed to be used as a 1 of 8 matrix to the DTS channel (1 of 8 to channel 1, and 1 of 8 to channel 2). The DSM includes an RS232C cable for connecting to the DTS-207X Series of Digital Time Measurement products.

RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

DSM-16S
Dual 8:1 Solid State
Digital Switching Matrix

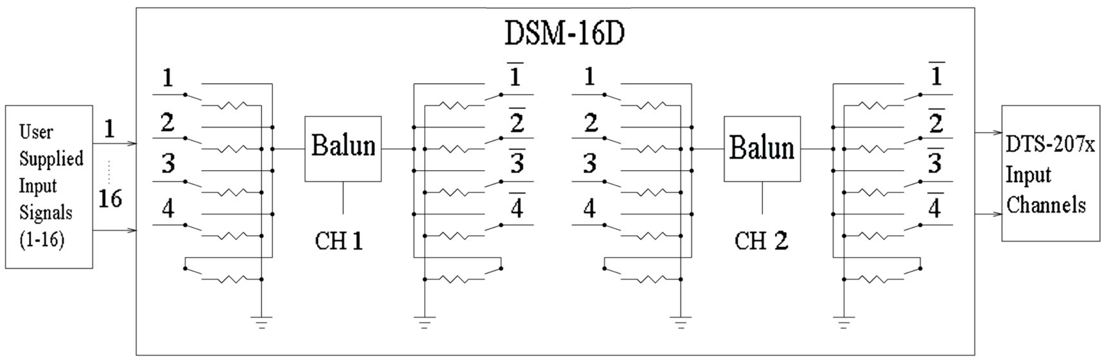
Dual 8-input Switch Matrix – A 19” x 22” x 3.5” rack mountable, dual 8-input binary switch matrix with a bandwidth of over 1.5 GHz. This unit is intended to extend the input capability of the DTS-207X from 2 to 16 channels. The matrix can be controlled manually from the front panel or remotely via the RS-232C port at the back of the DTS. Remote control of the DSM-16S via GPIB commands to the DTS makes integration into an automated environment fast with no special hardware or software required. The DSM-16S is designed to be used as a 1 of 8 matrix to the DTS channel input (1 of 8 to channel 1, and 1 of 8 to channel 2 — See Figure 1). The DSM-16S includes an RS232C cable for connecting to the DTS-207X Series of Digital Time Measurement products.



RETURN TO INDEX

DSM-16D
Dual 4:1 Differential Switching Matrix with Integrated Baluns

Dual 4-input Differential Relay Matrix – A 19" x 22" x 3.5" rack mountable, dual 4-input differential binary relay tree matrix with integrated baluns and a bandwidth of over 2.5GHz. This unit is intended to extend the input capability of the DTS-207X from 2 single-ended to 8 differential channels by combining dual differential 4:1 switch matrices and differential to single-ended baluns. The matrix can be controlled manually from the front panel or remotely via the RS-232C port at the back of the DTS. Remote control of the DSM-16D via GPIB commands to the DTS makes integration into an automated environment fast with no special hardware or software required. The DSM-16D is designed to be used as a 1 of 4 matrix to the DTS channel input (1 of 4 to Channel 1, and 1 of 4 to Channel 2 — See Figure). The DSM-16D includes an RS232C cable for connecting to the DTS-207X Series of Digital Time Measurement products.



RETURN TO INDEX

WAVECREST® CORPORATION
A TECHNOLOGIES COMPANY

DSM-12
6:1 Digital Switching Matrix

A 19” x 22” x 3.5” rack mountable, dual 6-input binary relay tree matrix with a band-width of over 4GHz. This unit is intended to extend the input capability of the DTS-207X from 2 to 12 channels. The matrix can be controlled manually from the front panel or remotely via the RS-232C port at the back of the DTS. Remote control of the DSM-12 via GPIB commands to the DTS makes integration into an automated environment fast with no special hardware or software required. The DSM-12 is designed to be used as a 1 of 6 matrix to the DTS channel input (1 of 6 to channel 1, and 1 of 6 to channel 2 — See Figure 1). The DSM-12 includes an RS232C cable for connecting to the DTS-207X Series of Digital Time Measurement products.

RETURN TO INDEX

Jitter Analysis 101 - An Introduction to Jitter and Jitter Testing

The Jitter Analysis "101" seminar is intended to be a primer for the introduction of the topic of "JITTER": What it is, where it comes from, identify the different aspects of jitter, how to measure it and where to look in order to fix or reduce jitter problems.

This seminar is aimed at synchronous system CLOCK PLL users and Telecom or DataCom users with transmitted, clock-like data. *WAVECREST* will be providing a comprehensive seminar in the future dealing with the subject of "Serial Data Communications". In that seminar *WAVECREST* plans to present ways of measuring the "jitter spectrum" on random data streams as well as estimating the serial system's error probability.

This seminar is designed to provide both theory and practical applications for measuring jitter with the DTS instrument as well as with some other instruments.

In this seminar we discuss the proper techniques for measuring Pentium® clock signals.

We provide a 1-2-3-4-step approach to the topic of jitter. The first step is understanding jitter and jitter theory. Second, find the best available equipment for measuring jitter. Third, look at various correlation issues between instruments using different jitter measurement techniques. And finally, *WAVECREST* shows how the *WAVECREST* ATA (accumulated time analysis) technique gives them the best resolution, frequency coverage and speed of any technique currently in use.

At the end of the seminar we show an in-depth demonstration of the DTS instrument and the *WAVECREST* patent pending *Virtual Instruments*™ diagnostic tools by diagnosing problems on a typical PLL synthesizer IC test board.

RETURN TO INDEX

Random Data Application Program

This Random Data Application is intended for use on dataCOM systems where neither a bit-clock nor a pattern marker is are available. . It In addition, it provides has the ability to measure Deterministic Jitter (DJ) and Random Jitter (RJ) even on purely random data.

Note: When using this window, it is imperative that an accurate Bit Rate is specified.

The deterministic jitter DJ is obtained by taking a series of measurements across various pattern spans. It The DJ is then calculated based on the difference between the largest average deviation from expected edge position and the smallest average deviation from expected edge position.

The random jitter RJ is obtained by performing a series of tail-fits across various pattern spans. The tail-fit method is based on Appendix D of the ANSI T11.2 Fibre Channel - Methodologies for Jitter Specification. This technique operates under the basic assumption that the tails of the jitter distribution are truly Gaussian and that all other sources are bounded and deterministic.

RETURN TO INDEX

Release Notes: *Virtual Instruments Signal Integrity*™ v5.0

WAVECREST Corporation has contributed significantly to the timing analysis market through our *Virtual Instruments*™ line of software products. These software products have revolutionized the way the industry looks at Jitter. As our understanding of timing anomalies expands, new horizons are taking shape in the area of timing-based Signal Integrity. On this queue, *WAVECREST Corporation* announces the latest advancement in timing analysis software: *Virtual Instruments Signal Integrity*™, v5.0 (VISI™ 5.0). *WAVECREST Corporation* has developed several tools that can be used to understand/characterize such timing phenomena as: signal cross-talk, Deterministic Jitter (DJ), Random Jitter (RJ), Periodic Jitter (PJ), Edge placement predictability, and much, much more.

VISI 5.0 comes in two different configurations: Advanced dataCOM Analysis Tools and Advanced Clock/PLL Analysis Tools. Both packages take advantage of our new TailFit™ technology for reliability modeling and timing misplacement probability modeling. Advanced dataCOM software adds the capability of analyzing data patterns, in addition to clock patterns, for ANSI compliance testing of Fibre Channel, Gigabit Ethernet and IEEE1394b (Firewire®) devices.

RETURN TO INDEX

WAVECREST® Corporation
A Technologies Company