

Streamline Product Design Cycles with Familiar Industry-Standard Application Software



- **On-board control and analysis tools in the CSA/TDS8000B Series facilitate customized, reliable automated test solutions that lower design costs and reduce time to market.**

Introduction

Design engineers and technicians face increasingly shorter schedules to develop and qualify communications products due to exponential growth in the performance requirements and ever-shrinking product life cycles. The number and complexity of tests needed to optimize the designs has grown and new test requirements continue to be introduced by emerging standards. Traditional manual test and measurement methods can no longer keep pace.

This application note describes how the unique programming environment in the Tektronix CSA/TDS8000B Communications Signal Analyzer can be used to meet these new challenges, lowering design costs and reducing time to market. Examples are presented to demonstrate how easy it is to create custom automated measurement and analysis programs that provide more efficient testing with higher repeatability and accuracy – resulting in more timely and profitable designs.

CSA/TDS8000B instruments provide total measurement and analysis solutions. These Windows-based sampling oscilloscopes integrate all of the power and flexibility of application software into the instruments themselves – eliminating the overhead of separate computers and GPIB links (see page 7). By removing the bottlenecks of data transfers between multiple processing environments, their on-board custom programs execute efficiently and reliably. They support the full capabilities of industry-standard programs and deliver the widest range of on-board measurement and waveform processing capabilities of any ultra-high bandwidth oscilloscope available today.

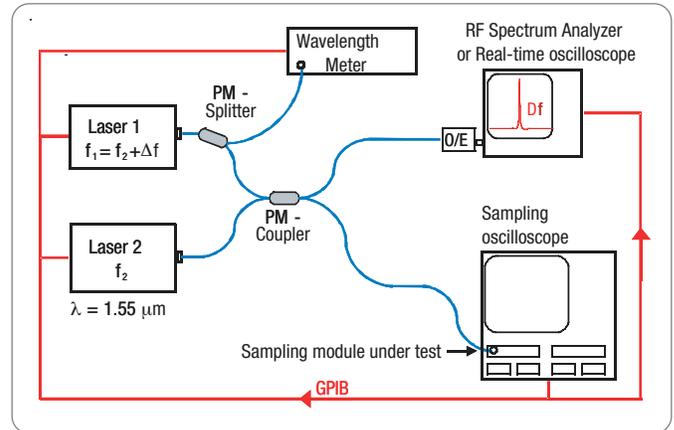
Designers can concentrate their efforts on refining their designs, not on the development of test programs. Custom test programs to capture data, analyze results and solve problems can be created quickly using familiar user-friendly graphical interfaces (e.g., LabVIEW, LabWindows/CVI) or high-level application development programming languages (e.g., MATLAB, C++, Visual Basic). Programs integrate combinations of control functions and measurement algorithms in a seamless environment for efficient development and rapid execution.

Example 1 - Characterizing 40 Gbps Optical Reference Receivers Using an Automatic Optical Heterodyne System

Optical reference receivers (ORR) must meet stringent frequency response tolerances in order to guarantee repeatability in conformance mask testing and extinction ratio measurements. For data rates up to 10 Gbps, frequency response characterization of ORR systems can be performed using fast time-domain impulse response measurements and Fourier transform techniques to convert the results into the frequency-domain. However, at bit rates exceeding 40 Gbps significant errors are introduced by signal and measurement anomalies and the finite temporal width of the optical impulse. Mathematical corrections for these error sources are complex and suffer from uncertainties. These difficulties can be avoided by performing the calibration directly in the frequency domain using an optical swept-sine wave method with precisely known modulation generated by a heterodyne beating signal.

Figure 1 shows the system setup for a heterodyne test system. The sources used for heterodyne beat-note generation are single-line external cavity lasers with a line width of <300 kHz and power stability of <0.02 dB over the sweep range. Their outputs are optically isolated and consist of polarization-maintaining single mode fiber. The total tuning range is 100 nm, allowing for bandwidth measurements throughout the entire C- and L-bands.

The tests are completely automated using the CSA8000B Communications Signal Analyzer. A Tektronix 80C10 optical sampling module plug-in head with its four selectable reference receiver settings (30 GHz, 40 GHz, 63 GHz and 70 GHz) is the device under test for the calibration. The control software (LabVIEW) runs directly on the mainframe, eliminating the need for an external PC. The CSA/TDS8000B controls the laser sources and all instruments via GPIB and performs all data acquisition and processing.



► Figure 1. Setup of heterodyne system.

An optical wavelength meter connected to the 10% port of a 90/10 splitter at the output of laser 1 measures the swept wavelength with a resolution of 0.1 ppm (~12.5 MHz). The laser output fields are combined in a 50/50 optical fiber coupler. Since all optical fibers and components maintain polarization, the optical setup is completely self-aligned and 100% modulation depth of the beating signal is achieved.

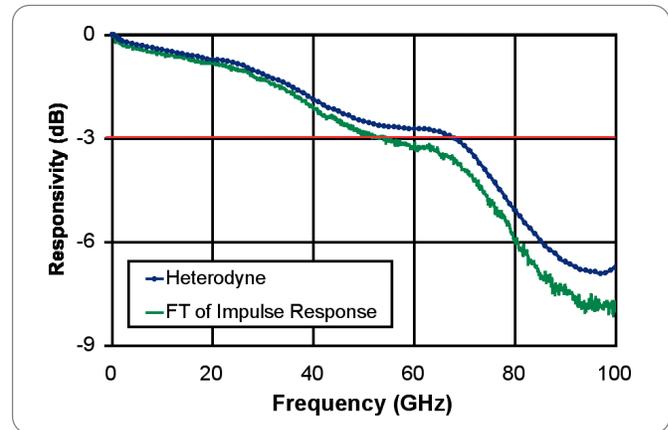
The other output port of the 2x2 coupler is fed into a photo detector which is connected to an RF spectrum analyzer or a real-time oscilloscope. This signal is used to directly monitor the detuning frequency of the lasers below 500 MHz and provides a way to set the DC reference point to less than 65 MHz (half the minimum laser step size).

The heterodyne system eliminates the need for RF and microwave power meter equipment. This is achieved by measuring the combined frequency response of the photodetector and electrical sampler circuit that are contained in the optical sampling plug-in module, and by utilizing the analyzer's internal acquisition electronics.

At each detuning frequency point the untriggered oscilloscope collects up to 10^6 randomly sampled data points of the heterodyne beating signal and builds a vertical histogram to calculate the probability density distribution (PDD). For an ideal, noiseless sine wave the relationship between the standard deviation σ of the vertical PDD and the peak-to-peak amplitude A of the beat note is given by $A^2 = 8\sigma^2$. The LabVIEW software algorithm corrects for laser noise, sampler noise, and laser power drift and then calculates the vertical amplitude swing from the corrected PDD and creates a file with a frequency response curve normalized to the lowest frequency data point. A complete sweep from 0 to 120 GHz with a step size of 1 GHz is performed in less than four minutes.

Figure 2 compares the results of a heterodyne sweep to those obtained with the Fourier transform of an averaged time-domain response to the sub-picosecond laser pulse. Timing errors associated with the impulse method lead to a degradation of the frequency response resulting in an apparent bandwidth reduction (-3 dB cutoff) of 14 GHz.

The optical heterodyne system performs accurate and repeatable bandwidth measurements of ultra-high bandwidth optical sampling modules, and automatically characterizes the frequency response of the selectable optical reference receiver settings.



► **Figure 2.** Comparison of frequency response measured with heterodyne system (upper curve) and time-domain impulse testing (lower curve).

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► Application Note

Example 2 - Optical Modulation Amplitude, an Emerging Measurement

As new standards are being developed, specific measurements emerge that may not yet be part of the standard library of test equipment algorithms. Optical Modulation Amplitude (*OMA*) is a good example of an emerging new measurement. IEEE 802.3ae is in the process of adopting *OMA* as one of the more important parameters of the optical transmission for the 10 Gigabit Ethernet. *OMA* describes the absolute difference between the optical power at the logic One level and the optical power at the logic Zero level, as measured on a specific pattern (e.g. 00001111) in a 20% aperture. The utility of this measurement is similar to that of *Extinction Ratio* and *Average Optical Power* folded into one.

Even though *OMA* is not yet available as a standard function in the CSA/TDS8000B, a simple test program can be used to calculate the parameter with ease. In IEEE 802.3ae, the standard method of measuring *OMA* is to generate and capture a slow square wave test signal. The test uses pulse measurements (not an eye diagram) to calculate the *Mean* of the high area and the *Mean* of the low area.

A LabVIEW program can be created to generate the square wave test signal and to control the analyzer's acquisition and measurement functions. The program uses gating to define the high and low areas of the waveform to be 20% apertures and stores the resulting values as a waveform. Then, the math system calculates the single value parameter for *OMA* as:

$$OMA_{dB} = 10\log((Mean_{High} - Mean_{Low})/1 \text{ mW})$$

(In this example, the same result could be obtained by measuring the *Mean* of the waveform.)

While *OMA* is a simple calculation, it is a good illustration of the flexibility that the CSA/TDS8000B provides with on-board programming and custom math functions. The ability to define new measurements is especially important when developing products for standards such as RZ signaling that are still evolving. Once a test program is written, it can be saved in a library and recalled on demand as a common test function.

Example 3 - Characterizing Cable Assemblies

Characterization tests of cable assemblies used in precision equipment and systems can be a tedious process of setup, acquisition and analysis. Typical cable assemblies can house up to 48 individual or bundled conductors.

Typical tests include:

- TDR impedance verification of each conductor and connector
- Cross talk between each bundled pair at the connector
- Cable skew and signal integrity on each conductor.

When done manually, these tests require the operator to not only know the cable assemblies but also know how to set up the instrument and make the measurements accurately. The time involved for each setup is significant and the results are prone to error, leading to more delays for retests, false rejects or mistaken troubleshooting of other elements in the system.

A relatively simple LabVIEW program in the CSA/TDS8000B can be used to automate the process, greatly reduce test time and eliminate the uncertainties. The system is set up to test 8 conductors at a time (one per channel in the CSA8000B).

The operator now only needs to connect the cable to the test fixture and push the run tests button on the application. The program runs all of the specified tests on eight conductors and returns a pass/fail result.

The operator then connects to the next set of eight conductors and runs another test. If a failure occurs, measurement information and waveform screenshots are saved to help in isolating the failure and aiding the technician or engineer in fixing the problem.

With LabVIEW running directly on the CSA/TDS8000B, there isn't the extra burden of another PC, GPIB boards and cables. Data transfer is much faster and test times shorter with this one interface solution. The rich and versatile set of Tektronix plug-and-play drivers in LabVIEW and the robust library of measurement algorithms in the CSA/TDS8000B greatly simplify the creation of automatic test programs.

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The Tektronix CSA8000B Series of Communications Signal Analyzers

Specifically designed for high-performance communications applications, the CSA8000B Communications Signal Analyzer is the ideal tool for design evaluation and verification testing of datacom and telecom components, transceiver subassemblies and transmission systems.

The CSA8000B generates measurement results, not just raw data, with time and amplitude histograms, mask testing and statistical measurements. It provides a communications-tailored measurement set that includes jitter, noise, duty cycle, overshoot, undershoot, extinction ratio, Q-factor, mean optical power and amplitude measurements for both RZ and NRZ signals. In addition, mask testing of SDH/SONET, Gigabit Ethernet and other standards simplifies conformance testing.

The CSA8000B supports a large and growing family of optical and electrical plug-in modules. This modular architecture lets you configure the instrument with the right features for your application both now and in the future.

With its industry-best horizontal timebase stability, trigger jitter, signal sensitivity and noise performance, the CSA8000B ensures the most accurate acquired signal for high-speed optical communications testing. The CSA8000B's multi-processor architecture, with dedicated per channel digital signal processors (DSP), also provides industry-best waveform acquisition rates that shorten test times.

Conclusion

In today's fast-paced design, development and manufacturing environment, speed and accuracy are key factors that make high tech businesses successful. Incorporating efficient and cost effective tools to streamline the design phase of high tech devices pays big dividends in higher reliability and shorter time to market. Tools such as the CSA/TDS8000B sampling oscilloscope used with software such as LabVIEW and MATLAB are perfect examples of effective tools that bring design costs down and reduce the time required for accurate testing and development.

Open Windows with OpenChoice™ and TekVISA™

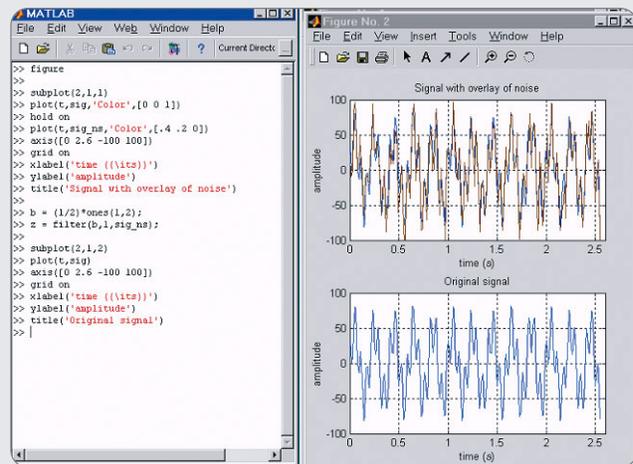
CSA/TDS8000B Communications Signal Analyzer incorporates an Open Windows operating environment where commercially available software packages in their standard forms provide new levels of data analysis directly in the instrument.

OpenChoice is the analysis and network solution that provides enhanced test and measurement analysis for Tektronix Windows-based oscilloscopes. It allows the instrument to be placed under the control of software applications running on the instrument, or on external PC workstations network connected to the instrument, without the need for a GPIB hardware interface.

The OpenChoice environment features:

- Fast, PCI bus to speed communication between the data acquisition processor and the Microsoft Windows Desktop.
- ActiveX Controls to connect the oscilloscope to popular Windows applications – WITHOUT leaving the application.
- Plug and play drivers to control the scope from LabVIEW and LabWindows/CVI running directly on the oscilloscope, or running on external PCs.
- Support for Application Development Environments such as Visual BASIC, NET, C, C++, MATLAB, and others

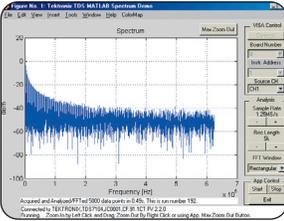
OpenChoice provides evaluation programs from the industry leaders – National Instruments and The MathWorks – for enhanced test and measurement analysis on all our Open Windows oscilloscopes.



► **Figure 3 – FFT MATLAB display.**

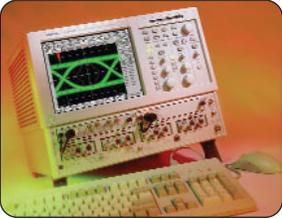
National Instruments' evaluation program is a ready-to-run application of LabVIEW Scope Analysis application and several LabVIEW examples optimized for the oscilloscope as well as a fully functional evaluation version of the software. For analysis capability, MATLAB has incorporated support for waveform capture and analysis running directly on the 8000 series product. With MATLAB, users can acquire data directly from the instrument without an external PC. Special MATLAB scripts perform mathematical analysis such as Fast Fourier Transforms (FFT) to convert the data from a time domain plot to a frequency domain plot or perform other special functions such as jitter analysis.

For more information on OpenChoice Partners, visit www.tektronix.com/openchoice.



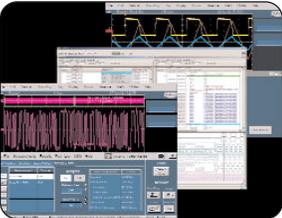
OpenChoice

With OpenChoice, Tektronix' Open Windows oscilloscopes and logic analyzers provide more choices for your waveform and digital analysis and network solutions. This added functionality enables you to blend analysis and networking into your customized solution using Tektronix measurement systems. And as an added feature, evaluation packages for LabVIEW and MATLAB accompany every Open Windows oscilloscope.



CSA/TDS8000B Series

The 8000 Series Sampling Oscilloscopes, when configured with one or more optical or electrical modules provide complete test solutions for telecom (155 Mbps to 43.108 Gbps) or datacom (Fibre Channel, Gigabit Ethernet, 10 GbE & FC and Infiniband) applications, as well as general purpose optical component testing.



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