Troubleshooting Your Design

with the DPO4000 Series Oscilloscopes

Tektronix

Enabling Innovation

Table of Contents

Troubleshooting Your Design with the DPO4000 Series Oscilloscope

Today's engineers and technicians face increasingly complex and critical troubleshooting tasks. New digital designs confront designers with new problems to find: system integration issues over serial buses, transients, signal aberrations, bus contention problems, etc. And, of course, competitive time-to-market pressures dictate that troubleshooting must be completed quickly and accurately.

The DPO4000 Series delivers the performance, affordability and portability that enable you to tackle these challenges – quickly and easily. These oscilloscopes help you solve problems by visualizing circuit behavior, accurately capturing signals, and enabling you to analyze the acquired waveforms to determine the root cause of circuit malfunction.

The DPO4000 Series gives you:

▶ 350 MHz, 500 MHz, and 1 GHz models

▶ Up to 5 GS/s sample rate on all channels

▶ 10 MB standard record length with Wave Inspector® front panel navigation controls

▶ Built-in USB host and device ports standard

▶ Easy documentation with PC connectivity software

▶ Optional serial triggering and analysis

The tips on the following pages are designed to further simplify your troubleshooting tasks. But if you need more help, there is plenty available. Simply contact your local Tektronix representative, authorized distributor, or visit www.tektronix.com/oscilloscopes.

Navigating Long Records

The increased usage of serial buses is driving the demand for longer capture windows with high resolution. As waveform records become longer, oscilloscope users must spend more and more time scrolling the display to see all the data. Manually scrolling through data is like looking on the Internet without the assistance of your favorite search engine, web browser, or bookmarks.

The DPO4000 Series Wave Inspector® controls make working with long records and extracting the answers you need a simple and efficient process.

## Dedicated front panel Wave Inspector® controls include:

► Zoom / Pan

► Play / Pause

► Set / Clear marks

► Search and mark

► Navigating between marks

For example, turning the outer pan ring clockwise pans the zoom window right on the waveform, counterclockwise pans it left. The farther you turn it, the faster the zoom window moves across the waveform. Even with a 10 million point acquisition, you can rapidly move the zoom window from one end of the record to the other.

Navigating Long Records (continued)

While examining a signal, you may find numerous areas of the waveform that either warrant further investigation or can be used as a reference point during the rest of your analysis. With Wave Inspector®, you can manually place marks on the waveform and use the front panel ← and → buttons to jump from one mark to the next, without requiring adjustment of zoom scale or position.
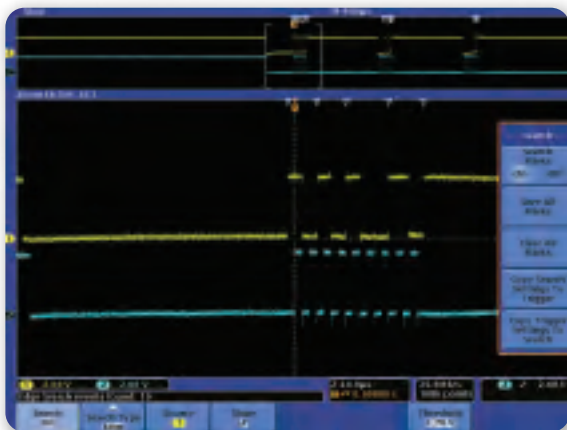
In addition to placing marks on waveforms manually, Wave Inspector® has the power to search through the entire acquisition and automatically mark every occurrence of a user specified event.

To manually use Search and Mark:

1. Zoom on the signal and position an event of interest at the center of the screen.

2. Press the **Mark Set/Clear** front panel button.

3. Repeat for all signal events of interest.

4. Press ← and → arrow buttons to instantly jump between events.

To automatically find events of interest:

1. Press **Search** front panel button.

2. Select **Search Type** (similar to selecting a trigger type) and enter the search criteria.

3. Notice that all matching events are identified with white triangular marks in a split second.

4. As with manual marks, navigate between search results with the ← and → arrows.

Capturing and Displaying Embedded Serial Buses

The increased usage of low-speed serial buses in embedded designs is driving the demand for longer capture windows with high resolution. But the serial bus waveforms can be difficult to interpret. Is the hardware working right? Is there a software bug? Is system noise affecting the bus transfers?

The DPO4000 Series' optional DPO4EMBD serial triggering and analysis enables you to quickly capture and decode I^{2}C and SPI serial bus traffic to help you verify and debug your designs.

To trigger on an I^{2}C serial signal:

1. Connect the serial data and clock signals.

2. Press the **B1** front panel button and define the inputs as an I^{2}C serial bus.

3. Press the **Trigger Menu** front panel button.

4. Select the **Bus** trigger **Type**.

5. Select the signal event to trigger on, such as any activity at a specific **Address**.

6. Notice the decoded bus waveform at the bottom of the screen, providing easy, time-aligned decoding of the serial signal.

Capturing and Analyzing Automotive Serial Buses

Low-speed serial buses such as CAN bus are being used in a growing number of automotive, aerospace, and industrial control applications. These systems can be complex and difficult to debug and verify with traditional oscilloscopes, logic analyzers, and protocol analyzers.

The DPO4000 Series' optional DPO4AUTO serial triggering and analysis enables you to quickly capture and decode CAN serial bus traffic to help you verify and debug your designs.


To trigger on a CAN serial signal:

1. Connect and display the serial signal.

2. Press the **B1** front panel button and define the inputs as a CAN serial bus.

3. Press the **Trigger Menu** front panel button.

4. Select the **Bus** trigger **Type**.

5. Select the signal event to trigger on, such as every **Start of Frame**.

6. In the **B1** menu, select **Display As Event Table**.

7. The event table provides text readouts of the bus data for easy comparison with system design documentation. Notice that the highlighting in the event table corresponds to the selected waveform data in the zoom window above the table, providing time correlation to the oscilloscope display.

Capturing Elusive Glitches

In today's high-speed digital designs, elusive glitches and random anomalies can cause circuits to fail. While finding these glitches has never been easy, the DPO4000 Series simplifies this task with its peak detect feature. Peak detect can capture and display narrow glitches, even on low-frequency signals at slow timebase settings.
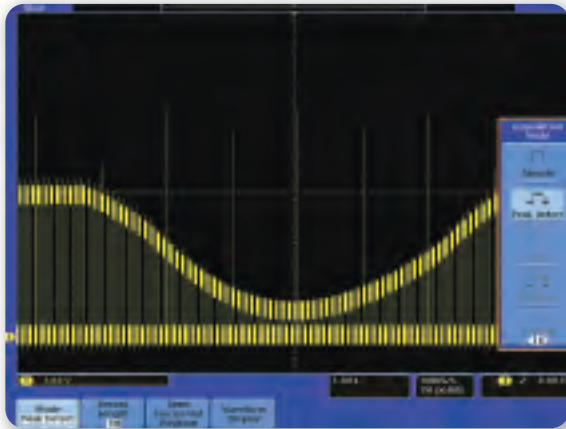

To use the Peak Detect feature:

1. Display the waveform on the screen.

2. Press the **Acquire** front panel button.

3. Press the **Peak Detect** menu button.

4. Notice that the oscilloscope captures several very narrow glitches, even at slow sweep speeds. Without peak detect, you would not have seen many of these glitches.

Capturing Elusive Glitches (continued)

Intermittent signal anomalies can also be a challenge to see.

The DPO4000 Series provides variable- and infinite-persistence display capabilities to provide you with information about the

signal variations over time, making it easier to understand the characteristics of the transients you've captured.
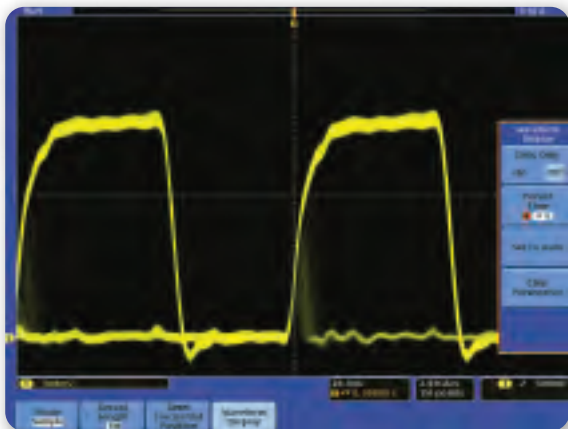

To use Display Persistence:

1. Display the waveform on the screen.

2. Press the **Acquire** front panel button and **Waveform Display** menu button.

3. Adjust **Persist Time** menu button until the desired amount of persistence is selected.

4. Press the **Intensity** front panel button and use the multipurpose knob to adjust the gray-scale intensity.

5. You can judge the relative frequency-of-occurrence of the signal anomalies based on the subtle variations in the brightness of the waveforms on the display.

Examining Tiny Signals

Examination of signals in the mV or µV range can be especially challenging, not only because of the low signal amplitude, but also because of the likelihood of relatively high noise.
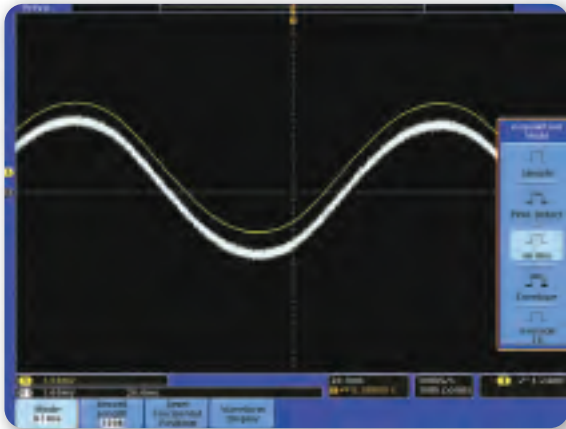

With the ADA4000A Differential Preamplifier, you can use standard 10X passive probes to acquire differential signals at vertical sensitivities down to 100 µV/div. The DPO4000 Series' Hi Res acquisition mode reduces noise and increases vertical resolution, even on single-shot events.

To acquire and display a tiny differential signal with the ADA400A and Hi Res:

1. Display the waveform on the screen.

2. Press the **Acquire** front panel button.

3. Press the **Hi Res** menu button.

4. Notice that the Hi Res acquisition mode displays a clean yellow single-shot waveform, compared to the original signal shown in white.

Debugging Digital Timing Problems

Digital designers need to quickly find and analyze a wide range of circuit timing problems. For example, setup and hold violations in a digital circuit can cause unpredictable circuit operation.
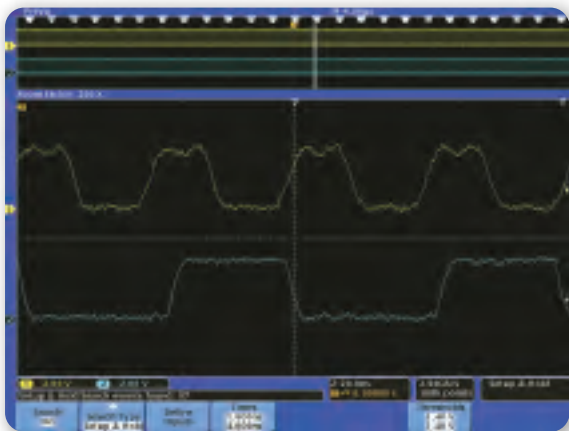
The DPO4000 Series provides setup and hold triggering to capture violations and search to automatically identify all violations within an acquisition.

To find setup and hold violations:

1. Press the **Trigger Menu** front panel button.

2. In the side menu, press **Type** until **Setup & Hold** is selected.

3. Use the multipurpose knobs to set the desired minimum setup and hold times.

4. Press the **Search** front panel button.

5. Select **Search on Setup & Hold** and enter the search parameters or simply select **Copy Trigger Settings to Search**.

6. Notice the number of setup and hold violations, marked with white triangles, that are instantly marked.

Checking Signal Integrity

Design engineers need to characterize the signals in their designs to ensure that the designs will work reliably in the real world. This characterization includes criteria such as frequency and amplitude variations, rise time, overshoot, ground bounce, cross talk, and other signal integrity issues.
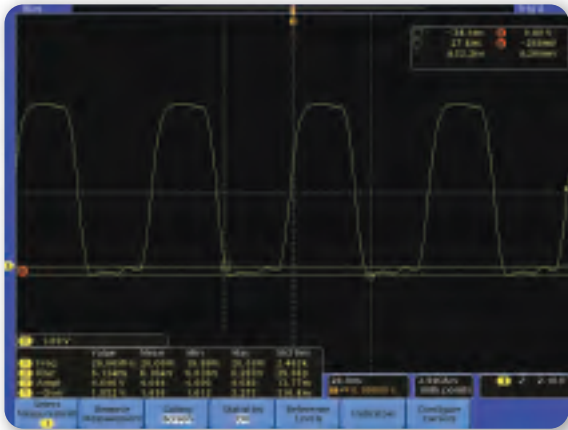
These measurements are easily made with the DPO4000, either automatically or with cursors.

To make signal integrity measurements:

1. Press the **Cursors** front panel button twice to select Horizontal Bar cursors.

2. Using the multipurpose knobs, place one cursor at ground and one on the negative overshoot.

3. Notice the overshoot voltage in the cursor readout in the upper right corner of the display.

4. To make automatic measurements on the signal, press the **Measure** front panel button and select the desired automatic measurements.

5. With **Statistics** enabled, you can monitor the worst-case variations of the measurements over time.

Testing Video Signals

Video technicians must perform a quick check for the presence of a video signal at different test points. If the site is in the field, technicians will need lightweight,

portable test equipment that they can easily carry to each location. The DPO4000 Series' video trigger features make this oscilloscope a valuable tool for these technicians.
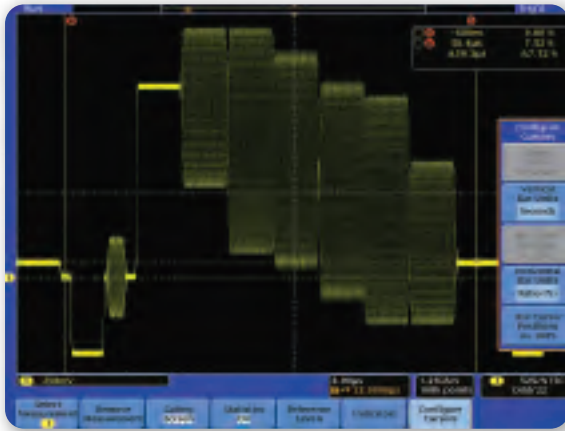

1. Connect the video signal to the oscilloscope using proper adapters and a 75 Ω terminator, if necessary.

2. Press the **Trigger Menu** front panel button.

3. Press the trigger **Type** menu button until **Video** is selected.

4. Select **Trigger On Line Number** and you can use the multipurpose knob to examine each video line.

5. To add some display persistence, press **Acquire** and **Waveform Display** and use the multipurpose knob to select the desired persistence level.

6. Cursors can be used to make relative amplitude measurements, such as the 7.5% video setup level shown in this display.

Looking for Unintentional Circuit Noise

Engineers and technicians often need to check for unintended noise in their prototypes. However, noisy signals can be difficult to analyze in the time domain, as shown below. The DPO4000 Series Fast Fourier Transform (FFT) is a powerful tool for identifying sources of noise in a circuit. The FFT enables the user to break down signals into component frequencies, which the oscilloscope uses to display a graph of the frequency domain of the signal. With this information, developers can then associate those frequencies with known system frequencies, such as system clocks, oscillators, read/write strobes, display signals, or switching power supplies.
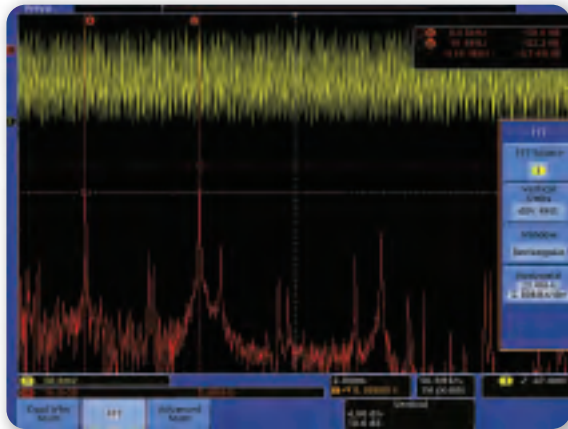

To examine a noisy signal in the frequency domain:

1. Press the front panel **Math** button.

2. Press the **FFT** menu button.

3. Press the **Window** menu button until the **Rectangular** window is selected, which provides the highest frequency resolution on broadband noise signals.

4. If desired, use the multipurpose knobs to adjust the vertical and horizontal position and scale of the FFT waveform.

5. In this case, the two highest peaks in the FFT indicate that there are significant sources of noise at 6 kHz and 16 kHz. In this case, these are system clocks, which are coupling into the signal.

Analyzing Power Line Harmonics

Power circuit designers often need to analyze the effects of their circuits on the power line. Although an ideal power supply would present a constant load on a power line, real power supply circuits do not, creating harmonics on the power line.
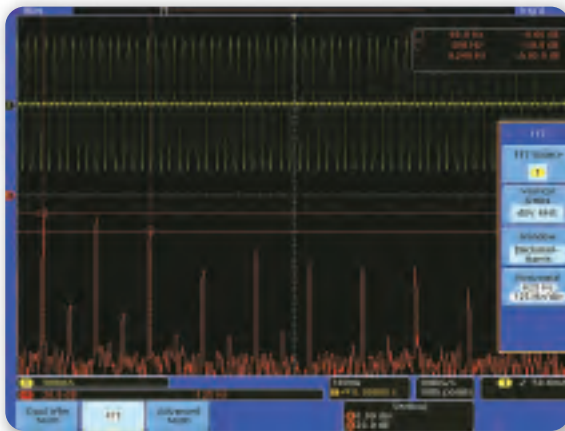

The DPO4000 and its recommended accessories such as the TCP0030 Current probe provide powerful tools to easily measure power supply currents and analyze the harmonics on a power line.

To display the power line harmonics on a current waveform:

1. Notice the yellow readout at the bottom left of the display, where the waveform's vertical units have been automatically set to milliAmps (mA) by simply connecting the probe.

2. Press the **Math** front panel button.

3. Press the **FFT** menu button.

4. Press the **Window** side menu button until **Blackman-Harris** is selected. This window is best for measuring amplitudes accurately.

5. Cursors can easily measure absolute and relative magnitudes and frequencies of the harmonics in the FFT, such as the fundamental and 5th harmonic.

Measuring Switch-mode Power Circuits

Designers of switch-mode power conversion products often need to analyze the instantaneous power dissipated in components in their designs, a measurement that is only possible with an oscilloscope.
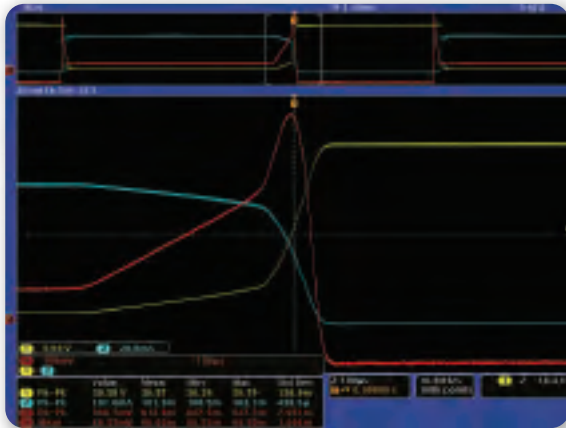

The DPO4000's long record length, signal conditioning, and complete portfolio of measurement accessories provide powerful tools to easily measure switch-mode power circuits.

To display the instantaneous power dissipated in a switching device:

1. Measure the voltage across the switching device (e.g. from IGBT collector to emitter).

2. Measure the current flowing through the device (e.g. IGBT collector current). Notice the mA units on the blue readout at the bottom left of the display.

3. Press the **Acquire** front panel button and select **Average** or **Hi Res** acquisition mode to reduce noise on the signals.

4. Press the **Math** front panel button and select channel **1 X** channel **2** to display the instantaneous power waveform.

5. Automatic measurements can be used to display voltage, current, and power measurements, including peak and average power.

Documenting Your Results with OpenChoice®

Design engineers in the lab and technicians in the field often need to document the work they do with their oscilloscope. They can save screen images to a removable memory device and then manually copy the files to their PC.
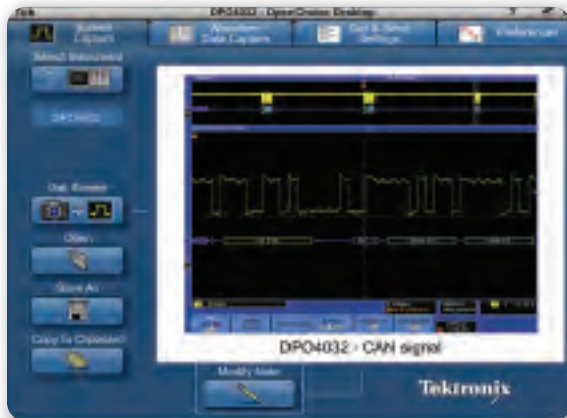
The easy-to-use OpenChoice® Desktop, included free with every DPO4000, simplifies these documentation tasks by directly transferring screen images to your PC over USB.

1. Acquire the signal.

2. Connect the oscilloscope to the PC using a USB cable.

3. Launch the **OpenChoice® Desktop** program.

4. Press **Select Instrument**, choose the correct USB instrument, and click **OK**.

5. Press **Get Screen** to capture the screen image.

6. Press Modify Note to add comments.

7. Press **Save As** to save the screen image to a file on the PC.

8. Press **Copy to Clipboard**. You can then launch your documentation program and paste the image into the document.

Logging Waveform Measurements in Excel

A common task for engineers and technicians is to make measurements on their oscilloscope and then manually record measurements to document circuit performance variations over time. However, this is time-consuming and can lead to inconsistent quality of documentation. The easy-to-use TekXL toolbar simplifies data gathering and documentation tasks inside Excel.
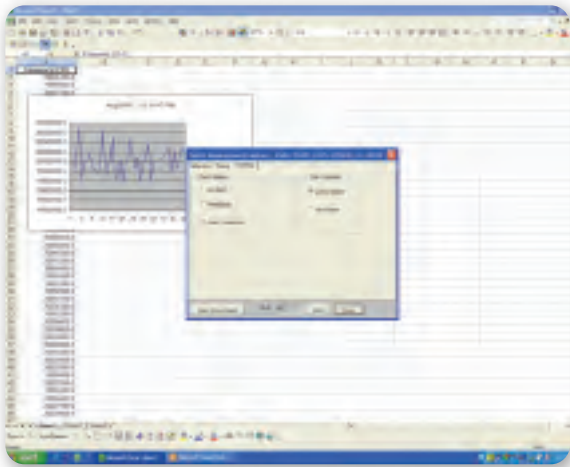

To log measurements over time:

1. Acquire the signal.

2. Connect the oscilloscope to the PC using a USB cable.

3. Launch **Excel** and enable the Tek XL toolbar by selecting **Tools ▶ Add-ins**… and checking the box next to **Tekxltoolbar**.

4. Press the **TekXL Connection** icon, select the desired instrument, and press OK.

5. Press the **TekXL Measurements** icon.

6. On the Selection tab, choose **Frequency**.

7. On the Timing tab, select a measurement interval of 5 seconds and a total of **45** samples.

8. On the Charting tab, choose **Upon Completion**.

Remote Control Using SignalExpress™ Tektronix Edition

The DPO4000 can be remotely controlled from a PC with the Base edition of National Instruments SignalExpress™ Tektronix Edition (TE). This software, included free with every instrument, supports communication over GPIB, Ethernet, and USB. Best of all, SignalExpress™ TE provides built-in support for a variety of Tektronix products with the convenience of USB plug-and-play.
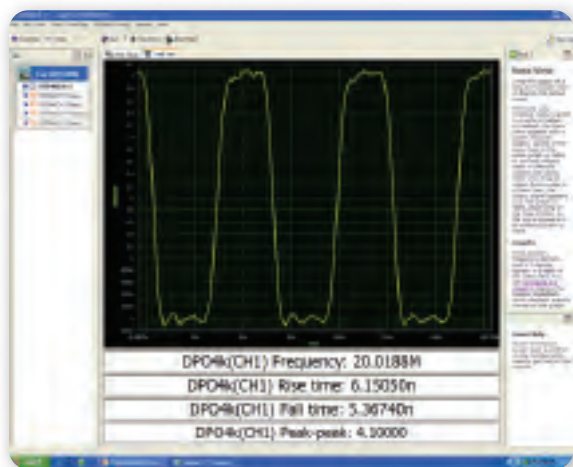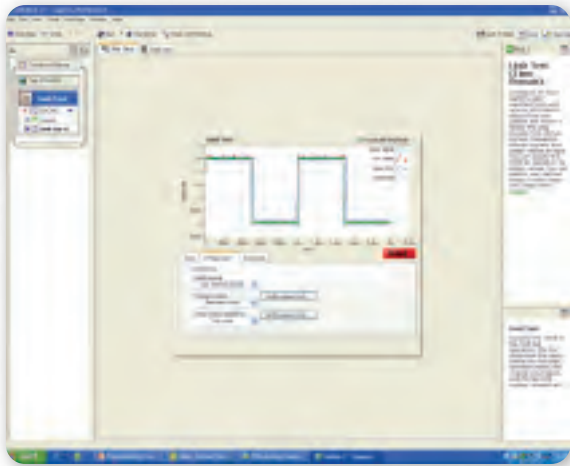

1. Acquire the signal.

2. Connect the oscilloscope to the PC using a USB cable.

3. Launch the **SignalExpress™ TE** program.

4. SignalExpress™ will open with the instrument automatically connected and transferring data to the PC.

5. Basic instrument remote control is done through the **Step Setup** tab.

6. Automatic measurements can also be selected on the **Step Setup** tab.

7. Waveform displays and measurement results can then be dragged and dropped onto the **Data View** tab.

Limit Testing With SignalExpress™ Tektronix Edition Software

Although the DPO4000 provides significant on-board analysis capabilities, there are applications where the analysis requirements are better met with PC-based applications. National Instruments

SignalExpress™ Tektronix Edition provides advanced analysis capabilities such as filtering, histograms, and limit testing, all with the familiarity of a Windows interface and the ease of USB plug-and-play.

1. Acquire the signal.

2. Connect the oscilloscope to the PC using a USB cable.

3. Launch the **SignalExpress™ TE** program.

4. SignalExpress™ will open with the instrument automatically connected and transferring data to the PC.

5. To conduct a limit test of the signal against specified limits, select **Add Step ▶ Analog ▶ Test ▶ Limit Test**.

6. Enter limit constants or waveforms.

7. You can also select **Add Step ▶ Operations ▶ Conditional Repeat** to repeat the test until a failure occurs.

For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

Tektronix

Enabling Innovation