

# Digital Phosphor Oscilloscopes

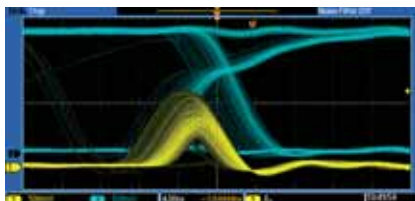
MSO2000 Series • DPO2000 Series



Tektronix MSO2000 and DPO2000 Series Digital Phosphor Oscilloscopes  
Feature-Rich Tools for Debugging Mixed Signal Designs.

## The Power to Solve Problems Quickly -

The MSO2000 and DPO2000 Series digital phosphor oscilloscopes (DPOs) deliver the performance and tools you need to visualize your signals and find answers quickly. The DPO2000 Series are the first oscilloscopes to provide 1 M points of usable record length on all channels, serial trigger and decode analysis options, a variable low-pass filter that also allows you to see signal details to the oscilloscope's full bandwidth and all in a compact form factor. The MSO2000 Series adds 16 integrated digital channels, enabling you to visualize and time correlate analog and digital signals on a single instrument. This integration extends triggering functionality across all 20 channels - which is ideal for debugging mixed analog and digital designs.



Digital phosphor technology enables 5,000 waveforms/second waveform capture and real-time intensity grading on the MSO2000 and DPO2000 Series.

## Designed to Make Your Work Easier

### Wave Inspector® Navigation and Search

Imagine trying to efficiently use the Internet if search engines such as Google and Yahoo didn't exist and Web browser features such as Favorites and Links didn't exist. Now you know how most modern oscilloscope users feel when trying to use the long record length in their digital oscilloscope. Record length, one of the key specifications of an oscilloscope, is the number of samples it can digitize and store in a single acquisition. The longer the record length, the longer the time window you can capture with high timing resolution (high sample rate).

The first digital oscilloscopes could capture and store only 500 points, which made it very difficult to acquire all relevant information around the event being investigated. Over the years, oscilloscope vendors have provided longer and longer record lengths to meet market demands for long capture windows with high resolution. These mega-point record lengths often represent thousands of screens worth of signal activity. While standard record lengths have increased greatly over

## Features & Benefits

### Key Performance Specifications

- 100 MHz and 200 MHz bandwidth models
- 2 or 4 analog channels
- 16 digital channels (MSO2000 Series)
- Sample rates up to 1 GS/s on all channels
- 1 Mega sample record length on all channels
- 5,000 wfms/s maximum waveform capture rate
- Suite of advanced triggers

### Serial Bus Trigger and Decode

- I<sup>2</sup>C, SPI, CAN, LIN, and RS-232/422/485/UART serial triggering, decode, and analysis options

### Ease of Use Features

- Wave Inspector® Navigation and Search provides unprecedented efficiency in waveform analysis
- FilterVu™ variable low-pass filter allows for removal of unwanted signal noise while still capturing high-frequency events
- 7 in (180 mm) bright, widescreen, TFT-LCD color display
- USB 2.0 on front panel for quick and easy data storage
- USB 2.0 device port on rear panel for direct PC control of oscilloscope using USBTMC or direct printing to any PictBridge® compatible printer
- Plug 'n' Play PC connectivity and analysis software solutions
- TekVPI® Probe Interface supports active, differential, and current probes for automatic scaling and units
- Small footprint and light weight - only 5.3 in (134 mm) deep and 7 lb 14 oz (3.6 kg)

### Mixed Signal Design and Analysis (MSO2000 Series)

- Ability to time correlate up to 4 analog and 16 digital channels
- Parallel bus trigger and analysis
- Multichannel setup and hold triggering
- Next-generation digital waveform display

## Applications

- Embedded design and debug
- Mixed signal design and debug
- Power measurements
- Automotive electronics
- Education and training
- Video design and debug

## Characteristics

### Vertical System - Analog Channels

| Vertical System Analog Channels                                        | MSO2012<br>DPO2012             | MSO2014<br>DPO2014                                                   | MSO2024<br>DPO2024      |
|------------------------------------------------------------------------|--------------------------------|----------------------------------------------------------------------|-------------------------|
| Input Channels                                                         | 2                              | 4                                                                    | 4                       |
| Analog Bandwidth*1 (-3 dB)                                             | 100 MHz                        | 100 MHz                                                              | 200 MHz                 |
| Calculated Rise Time                                                   | 3.5 ns                         | 3.5 ns                                                               | 2.1 ns                  |
| Hardware Bandwidth Limits                                              |                                | 20 MHz                                                               |                         |
| Input Coupling                                                         |                                | AC, DC, GND                                                          |                         |
| Input Impedance                                                        |                                | 1 M $\Omega$ $\pm$ 2%, 11.5 pF $\pm$ 2 pF                            |                         |
| Input Sensitivity Range                                                |                                | 2 mV/div to 5 V/div                                                  |                         |
| Vertical Resolution                                                    |                                | 8 bits                                                               |                         |
| Max Input Voltage                                                      |                                | 300 V <sub>RMS</sub> with peaks $\leq$ 450 V                         |                         |
| DC Gain Accuracy (with offset set to 0 V)                              |                                | $\pm$ 3% for 10 mV/div to 5 V/div, $\pm$ 4% for 2 mV/div to 5 mV/div |                         |
| Offset Range                                                           |                                |                                                                      |                         |
| 2 mV/div to 200 mV/div                                                 |                                | $\pm$ 1 V                                                            |                         |
| >200 mV/div to 5 V/div                                                 |                                | $\pm$ 25 V                                                           |                         |
| Channel-to-Channel Isolation(Any Two Channels at Equal Vertical Scale) | $\geq$ 100:1 at $\leq$ 100 MHz |                                                                      | 100:1 at $\leq$ 200 MHz |

\*1 Bandwidth is 20 MHz at 2 mV/div, all models

### Vertical System - Digital Channels

|                              | MSO2012 | MSO2014                                             | MSO2024 |
|------------------------------|---------|-----------------------------------------------------|---------|
| Input Channels               |         | 16 Digital (D15 to D0)                              |         |
| Thresholds                   |         | Threshold per set of 8 channels                     |         |
| Threshold Selections         |         | TTL, CMOS, ECL, PECL, User Defined                  |         |
| User Defined Threshold Range |         | $\pm$ 20 V                                          |         |
| Maximum Input Voltage        |         | $\pm$ 40 V                                          |         |
| Threshold Accuracy           |         | $\pm$ (100 mV + 3% of threshold setting)            |         |
| Maximum Input Dynamic Range  |         | 80 V <sub>pk-pk</sub> (threshold setting dependent) |         |
| Minimum Voltage Swing        |         | 500 mV <sub>pk-pk</sub>                             |         |
| Input Impedance              |         | 101 k $\Omega$                                      |         |
| Probe Loading                |         | 8 pF                                                |         |
| Vertical Resolution          |         | 1 bit                                               |         |

### Horizontal System - Analog Channels

|                                                                         | MSO2012<br>DPO2012 | MSO2014<br>DPO2014 | MSO2024<br>DPO2024 |
|-------------------------------------------------------------------------|--------------------|--------------------|--------------------|
| Maximum Sample Rate (all channels)                                      |                    | 1 GS/s             |                    |
| Minimum Peak Detect Pulse Width                                         | 7.0 ns             |                    | 3.5 ns             |
| Maximum Record Length (all channels)                                    |                    | 1 M points         |                    |
| Maximum Duration of Time Captured at Highest Sample Rate (all channels) |                    | 1 ms               |                    |
| Timebase Range                                                          | 4 ns to 100 s      |                    | 2 ns to 100 s      |
| Timebase Delay Time Range                                               |                    | -10 div to 5000 s  |                    |
| Channel-to-Channel Deskew Range                                         |                    | $\pm$ 100 ns       |                    |
| Timebase Accuracy                                                       |                    | $\pm$ 25 ppm       |                    |

### Horizontal System - Digital Channels

|                                                         | MSO2012 | MSO2014                    | MSO2024 |
|---------------------------------------------------------|---------|----------------------------|---------|
| Maximum Sample Rate (when using any of channels D7-D0)  |         | 1 GS/s (1 ns resolution)   |         |
| Maximum Sample Rate (when using any of channels D15-D8) |         | 500 MS/s (2 ns resolution) |         |
| Maximum Record Length                                   |         | 1 M points                 |         |
| Minimum Detectable Pulse Width                          |         | 5 ns                       |         |
| Channel-to-Channel Skew                                 |         | 2 ns typical               |         |

## Acquisition Modes

**Sample** – Acquires sampled values.

**Peak Detect** – Captures glitches as narrow as 3.5 ns at all sweep speeds.

**Averaging** – From 2 to 512 waveforms included in average.

**Roll** – Scrolls waveforms right to left across screen at sweep speeds slower than or equal to 40 ms/div.

## Trigger System

**Main Trigger Modes** – Auto, Normal and Single.

**Trigger Coupling** – DC, HF reject (attenuates >85 kHz), LF reject (attenuates <65 kHz), noise reject (reduces sensitivity).

**Trigger Holdoff Range** – 20 ns to 8 s.

**Trigger Signal Frequency Counter** – Provides a higher accuracy means of identifying the frequency of trigger signals. Trigger Signal Frequency counter resolution is 6 digits.

## Trigger Level Range

**Any Channel** –  $\pm 4.92$  divisions from center of screen.

**External (auxiliary input)** –  $\pm 6.25$  V, 1x attenuation;  $\pm 12.5$  V, 10x attenuation.

## Sensitivity

### Internal DC Coupled

| Trigger Source                | Sensitivity                                  |
|-------------------------------|----------------------------------------------|
| Analog Inputs                 | 0.4 division from DC to 50 MHz               |
|                               | 0.6 divisions >50 MHz to 100 MHz             |
|                               | 0.8 divisions >100 MHz to 200 MHz            |
| External<br>(Auxiliary Input) | 200 mV from DC to 100 MHz,<br>1x attenuation |

## Trigger Modes

**Edge** – Positive or negative slope on any channel or front-panel auxiliary input. Coupling includes DC, HF reject, LF reject, and noise reject.

**Pulse Width** – Trigger on width of positive or negative pulses that are >, <, =, or  $\neq$  to a specified period of time.

**Runt** – Trigger on a pulse that crosses one threshold but fails to cross a second threshold before crossing the first again.

**Logic** – Trigger when any logical pattern of channels goes false or stays true for specified period of time. Any input can be used as a clock to look for the pattern on a clock edge. Pattern (AND, NAND) specified for all analog and digital input channels defined as High, Low, or Don't Care.

**Setup and Hold** – Trigger on violations of both setup time and hold time between clock and data present on any of the input channels.

**Rise/Fall Time** – Trigger on pulse edge rates that are faster or slower than specified. Slope may be positive, negative, or either.

**Video** – Trigger on line number, all lines, odd, even, or all fields on NTSC, PAL and SECAM video signals.

**I<sup>2</sup>C (Optional)** – Trigger on Start, Repeated Start, Stop, Missing ACK, Address (7 or 10 bit), Data, or Address and Data on I<sup>2</sup>C buses up to 3.4 Mb/s.

**SPI (Optional)** – Trigger on SS, Idle Time, MOSI, MISO, or MOSI and MISO on SPI buses up to 10.0 Mb/s.

**CAN (Optional)** – Trigger on Start of Frame, Frame Type (data, remote, error, overload), Identifier (standard or extended), Data, Identifier and Data, End of Frame, Missing ACK, or Bit Stuffing Errors on CAN signals up to 1 Mb/s. Data can be further specified to trigger on  $\leq$ , <, >,  $\geq$  or  $\neq$  a specific data value. User-adjustable sample point is set to 50% by default.

**RS-232/422/485/UART (Optional)** – Trigger on Tx start bit, Rx start bit, Tx end of packet, Rx end of packet, Tx data, Rx data, Tx Parity Error, and Rx Parity Error.

**LIN (Optional)** – Trigger on Sync, Identifier, Data, Identifier and Data, Wakeup Frame, Sleep Frame, or Errors such as Sync Parity or Checksum Errors.

**Parallel (available on MSO models only)** – Trigger on a parallel bus data value.

## Waveform Measurements

**Cursors** – Waveform and Screen

**Automatic Measurements** – 29, of which up to four can be displayed on screen at any one time. Measurements include Frequency, Period, Delay, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Pulse Width, Negative Pulse Width, Burst Width, Phase, Positive Overshoot, Negative Overshoot, Peak-to-Peak, Amplitude, High, Low, Max, Min, Mean, Cycle Mean, RMS, Cycle RMS, Positive Pulse Count, Negative Pulse Count, Rising Edge Count, Falling Edge Count, Area and Cycle Area.

**Gating** – Isolate the specific occurrence within an acquisition to take measurements, using either the screen or waveform cursors.

## Waveform Math

**Arithmetic** – Add, subtract, and multiply waveforms.

## Software

**NI LabVIEW SignalExpress™ Tektronix Edition LE** – A fully interactive measurement software environment optimized for the MSO2000/DPO2000 Series, enables you to instantly acquire, generate, analyze, compare, import, and save measurement data and signals using an intuitive drag-and-drop user interface that does not require any programming. Standard MSO2000/DPO2000 Series support for acquiring, controlling, viewing and exporting your live signal data is permanently available through the software. The full version (SIGEXPT) adds additional signal processing, advanced analysis, mixed signal, sweeping, limit testing, and user-defined step capabilities and is available for a 30-day trial period standard with each instrument.

**OpenChoice® Desktop** – Enables fast and easy communication between a Windows PC and the MSO2000/DPO2000 Series, using USB or LAN. Transfer and save settings, waveforms, measurements and screen images.

**IVI Driver** – Provides a standard instrument programming interface for common applications such as LabVIEW, LabWindows/CVI, Microsoft .NET and MATLAB.

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## Display Characteristics

**Display Type** – 7 in (180 mm) liquid crystal TFT color display.  
**Display Resolution** – 480 horizontal x 234 vertical pixels (WQVGA).  
**Waveform Styles** – Vectors, Dots (In Video Trigger mode), Variable Persistence, Infinite Persistence.  
**Graticules** – Full, Grid, Cross Hair, Frame.  
**Format** – YT and XY.  
**Waveform Capture Rate** – Up to 5,000 wfms/sec.

## Input/Output Ports

**USB 2.0 High-Speed Host Port** – Supports USB data storage devices and keyboards.  
**USB 2.0 High-Speed Device Port** – Rear-panel port supports communication/control of oscilloscope by PC and all PictBridge® compatible printers.  
**LAN Port** – RJ-45 connector, supports 10/100Base-T (requires DPO2CONN).  
**GPIOB** – Adapt USB 2.0 device port to a GPIOB port (requires TEK-USB-488).  
**Video Out Port** – DB-15 female connector, connect to show the oscilloscope display on an external monitor or projector (requires DPO2CONN).  
**Auxiliary Input** – Front-panel BNC connector. Input Impedance 1 M $\Omega$   $\pm$ 2%. Max input 300 V<sub>RMS</sub> with peaks  $\pm$ 450 V.  
**Probe Compensator Output** – Front-panel pins, Amplitude 5.0 V, Frequency 1 kHz.  
**Kensington Lock** – Rear-panel security slot connects to standard Kensington style lock.

## Power Source

**Power Source Voltage** – 100 to 240 V  $\pm$ 10%.  
**Power Source Frequency** – 45 to 65 Hz (90 to 264 V), 360 to 440 Hz (100 to 132 V).  
**Power Consumption** – 80 W maximum.  
**TekVPI External Power Supply (119-7465-xx)** – Output voltage: 12 V; Output current: 4.2 A; Power consumption: 50 W.

## Physical Characteristics

| Dimensions | mm  | in   |
|------------|-----|------|
| Height     | 180 | 7.1  |
| Width      | 377 | 14.9 |
| Depth      | 134 | 5.3  |
| Weight     | kg  | lb   |
| Net        | 3.6 | 7.9  |
| Shipping   | 6.2 | 13.7 |

Rackmount Configuration - 4 U  
Cooling Clearance - 50 mm (2 inches) on the left side and rear (when looking at the front of the instrument).

## General Characteristics

### Environmental

#### Temperature

**Operating** – 0 °C to +50 °C.  
**Nonoperating** – -40 °C to +71 °C.

#### Humidity

**Operating** – High: 30 °C to 50 °C, 5% to 60% Relative Humidity. Low: 0 °C to 30 °C, 5% to 95% Relative Humidity.  
**Nonoperating** – High: 30 °C to 55 °C, 5% to 60% Relative Humidity. Low: 0 °C to 30 °C, 5% to 95% Relative Humidity.

#### Altitude

**Operating** – 3,000 meters (9,843 feet).  
**Nonoperating** – 12,000 meters (39,370 feet).

#### Random Vibration

**Operating** – 0.31 G<sub>RMS</sub> from 5 to 500 Hz, 10 minutes each axis, 3 axes, 30 minutes total.  
**Nonoperating** – 2.46 G<sub>RMS</sub> from 5 to 500 Hz, 10 minutes each axis, 3 axes, 30 minutes total.

## Regulatory

**Electromagnetic Compatibility** – 2004/108/EC.  
**Safety** – Listed UL61010-1: 2004, CAN/CSA-C22.2 No. 61010.1: 2004; Complies with EN61010-1: 2001, Complies with the Low Voltage Directive 2004/108/EC for Product Safety.

## MSO2000 Models

**MSO2012**– 100 MHz, 1 GS/s, 1 M record length, 2+16 channel mixed signal oscilloscope.  
**MSO2014**– 100 MHz, 1 GS/s, 1 M record length, 4+16 channel mixed signal oscilloscope.  
**MSO2024**– 200 MHz, 1 GS/s, 1 M record length, 4+16 channel mixed signal oscilloscope.

## DPO2000 Models

**DPO2012**– 100 MHz, 1 GS/s, 1 M record length, 2-channel digital phosphor oscilloscope.  
**DPO2014**– 100 MHz, 1 GS/s, 1 M record length, 4-channel digital phosphor oscilloscope.  
**DPO2024**– 200 MHz, 1 GS/s, 1 M record length, 4-channel digital phosphor oscilloscope.  
All models include: One P2221 200 MHz, 1x/10x Passive Probe per Analog Channel, User Manual and Translated Front-Panel Overlay, Documentation CD (063-4118-xx), OpenChoice® Desktop Software, NI LabVIEW SignalExpress™ Tektronix Edition LE Software, Calibration certificates document measurement traceability to National Metrology Institute(s) and ISO9001 Quality System Registration, Power Cord, and a three-year warranty. MSO models also include one P6316 16-channel logic probe and accessory kit, and accessory bag (016-2008-xx).

Please specify power plug and manual version when ordering.

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## 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



Product(s) are manufactured in ISO registered facilities.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

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