



**DPO70E Series
33 GHz and 59 GHz Optical Probes
Specifications and Performance Verification**





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Specifications and Performance Verification

Warning

The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

Supports DPO70E Series Product Firmware V1.0 and above

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Contacting Tektronix

Tektronix, Inc.
14150 SW Karl Braun Drive
P.O. Box 500
Beaverton, OR 97077
USA

For product information, sales, service, and technical support:

- In North America, call 1-800-833-9200.
- Worldwide, visit www.tek.com to find contacts in your area.

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Specifications

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Important safety information

This manual contains information and warnings that must be followed by the user for safe operation and to keep the product in a safe condition.

General safety summary

Use the product only as specified. Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. Carefully read all instructions. Retain these instructions for future reference.

This product shall be used in accordance with local and national codes.

For correct and safe operation of the product, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The product is designed to be used by trained personnel only.

Only qualified personnel who are aware of the hazards involved should remove the cover for repair, maintenance, or adjustment.

Before use, always check the product with a known source to be sure it is operating correctly.

This product is not intended for detection of hazardous voltages.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

When incorporating this equipment into a system, the safety of that system is the responsibility of the assembler of the system.

To avoid fire or personal injury

Ground the product. This product is indirectly grounded through the grounding conductor of the mainframe power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded. Do not disable the power cord grounding connection.

Power disconnect. The power cord disconnects the product from the power source. See instructions for the location. Do not position the equipment so that it is difficult to operate the power cord; it must remain accessible to the user at all times to allow for quick disconnection if needed.

Connect and disconnect properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source. Use only insulated voltage probes, test leads, and adapters supplied with the product, or indicated by Tektronix to be suitable for the product.

Observe all terminal ratings. To avoid fire or shock hazard, observe all rating and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not operate without covers. Do not operate this product with covers or panels removed, or with the case open. Hazardous voltage exposure is possible.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Disable the product if it is damaged. Do not use the product if it is damaged or operates incorrectly. If in doubt about safety of the product, turn it off and disconnect the power cord. Clearly mark the product to prevent its further operation.

Examine the exterior of the product before you use it. Look for cracks or missing pieces.

Use only specified replacement parts.

Wear eye protection. Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do not operate in wet/damp conditions. Be aware that condensation may occur if a unit is moved from a cold to a warm environment.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry. Remove the input signals before you clean the product.

Terms in the manual

These terms may appear in this manual:



WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*



CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Terms on the product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

Symbols on the product



When this symbol is marked on the product, be sure to consult the manual to find out the nature of the potential hazards and any actions which have to be taken to avoid them. (This symbol may also be used to refer the user to ratings in the manual.)

The following symbols may appear on the product:



CAUTION
Refer to Manual

Preface

This manual describes the specifications and performance verification of the DPO7OE Series Optical Probes.

Specifications

This chapter contains specifications for the instrument. All specifications are guaranteed unless noted as "typical." Typical specifications are provided for your convenience but are not guaranteed. Specifications that are marked with the ✓ symbol are checked in Performance Verification.

To meet specifications, the following conditions must first be met:

- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must be in an environment with temperature, altitude, humidity, and vibration within the operating limits described in this document.
- The instrument must have had a warm-up period of at least 20 minutes.

Any conditions unique to a particular characteristic are expressly stated as part of that characteristic.

Acquisition system specifications

| | |
|---|---|
| Probe output termination | 50 Ω Characteristic Impedance |
| Mainframe interface | Meets the requirements of the TekConnect interface. |
| Input fiber type (DPO7OE1) | Option FC/PC: 50/125 μm multi-mode type. Option FC/APC: 9/125 μm single-mode type. Graded-index, 50/125 μm multi-mode OM3 fiber is designed into the O/E. The probe can accept any input fiber with a smaller core diameter, including the standard single mode fiber 9/125 (such as SMF 128). |
| Input fiber type (DPO7OE2) | 9/125 μm single-mode type. Step index can only accept SMF input. |
| Front panel optical fiber connectors (DPO7OE1) | JAE changeable optical connector. The JAE changeable optical connector supports numerous interchangeable industry standard connector styles; These include FC, ST, and SC. All connections are either PC style (Physical Contact) or APC style (Angled Physical Contact) to minimize reflections from the interface. See the Optional Accessory list for a complete listing of available JAE adapters. |
| Front panel optical fiber connectors (DPO7OE2) | UCI male connector. If an adapter is installed, it becomes a female connector. The UCI (Universal Connector Interface) supports numerous user interchangeable industry standard connector styles. These include FC, ST, SC, and DIN. All connections are PC (Physical Contact) style so as to minimize reflections from the interface. Please refer to the Optional Accessory list for a complete listing of available UCI adapters. |
| Optical return loss (DPO7OE1) | 19 dB at 850 nm, 1310 nm, and 1550 nm |

| | |
|---|---|
| | Optical return loss is not specified at intermediate wavelengths. |
| Optical return loss, typical (DPO7OE1) | 27 dB at 1310 nm and 1550 nm Optical return loss is not specified at intermediate wavelengths. |
| Optical return loss, typical (DPO7OE2) | > 27 dB at 1310 nm and 1550 nm (Specified by PicoMetrix.) (Optical Return Loss measured by the diode manufacturer. Fiber is spliced using Sumitomo-Quantum Q101 splicer, which specifies the splice return loss at better than 70 dB.) |
| Maximum nondestructive optical input (DPO7OE1) | 8 mW average power. Note that optical input powers below non-destruct levels may exceed saturation and compression limits of the particular plug-in. |
| Maximum nondestructive optical input (DPO7OE2) | 4 mW (6 dBm) average power for 1310 nm and 1550 nm. Note that optical input powers below non-destruct levels may exceed saturation and compression limits of the particular plug-in. |
| Effective wavelength range, typical (Option FC/PC)¹ | DPO7OE1: 750 nm - 1650 nm DPO7OE1: 850 nm, 1310 nm, 1550 nm (calibrated) DPO7OE2: 1200 nm - 1650 nm DPO7OE2: 1310 nm, 1550 nm (calibrated) (Over the calibrated wavelength range, DC conversion gain will not vary over more than a 2:1 range.) |
| Effective wavelength range, typical (Option FC/APC) | DPO7OE1: 1260 nm - 1650 nm (FC/APC connectorized pigtail used as an input interface is limited in bandwidth to the range of 1260 nm - 1650 nm, making it applicable for single-mode use only.) DPO7OE2: 1200 nm - 1650 nm |
| Polarization dependence (DPO7OE1) | 0.3 dB typical This is the typical difference between maximum and minimum conversion gain achieved for any possible polarization launch into the module. In general, these polarizations are orthogonal to each other |
| Polarization dependence (DPO7OE2) | 1550 nm: ± 0.2 dB maximum 1310 nm: ± 0.2 dB maximum This is the maximum relative difference in conversion gain that is achieved for any possible polarization launch into the module between the maximum conversion and the minimum conversion. In general, these polarizations are orthogonal to each other. |
| ✓ Output zero (dark level) (DPO7OE1) | $\pm(10 \mu\text{W} \pm(4\%(\text{Vertical Offset})))$ for 1310 nm, 1550 nm $\pm(12 \mu\text{W} \pm(4\%(\text{Vertical Offset})))$ for 850 nm This Output Zero specification requires that Dark Level compensation has been performed and the following conditions are met after this compensation: <ul style="list-style-type: none"> ■ < 1 degree Celsius change in ambient temperature. ■ The vertical offset is the same. ■ The filter or bandwidth setting is the same as that selected during the compensation. |

¹ The DPO7OE Series supports a calibrated amplitude response at custom wavelengths after a user calibration procedure is run. Vertical specifications apply only at the following wavelengths: 850 nm (FC/PC only), 1310 nm and 1550 nm (all within ± 20 nm).

✓ **Output zero (dark level)**
(DPO7OE2)

$\pm(12 \mu\text{W} \pm(4\%(\text{Vertical Offset})))$ for TekConnect channels

$\pm(18 \mu\text{W} \pm(4\%(\text{Vertical Offset})))$ for ATI channel

This Output Zero specification requires that Dark Level compensation has been performed and the following conditions are met after this compensation:

- < 1 degree Celsius change in ambient temperature.
- The vertical offset is the same.
- The filter or bandwidth setting is the same as that selected during the compensation.

Linear dynamic range (non-clipping, 1 dB compression level), typical

DPO7OE1: 4 mW

DPO7OE2: 3 dBm (2 mW)

(The input range over which a DPO7OE Series probe behaves as a linear system. Input signals above this range should not be expected to result in a probe output signal free of harmonic distortion or gain compression.)

Mainframe vertical scale factors

Maximum: 600 mV/[Conversion Gain²(V/W)] per division

Minimum: 6.25 mV/[Conversion Gain²(V/W)] per division

Vertical offset range

TekConnect

| Full Scale Voltage Range | Offset Range |
|---|--|
| $\leq 1.2 \text{ V}/[\text{Conversion Gain}^2(\text{V/W})]$ | $\pm 3.4 \text{ V}/[\text{Conversion Gain}^2(\text{V/W})]$ |
| $> 1.2 \text{ V}/[\text{Conversion Gain}^2(\text{V/W})]$ | $\pm 6 \text{ V}/[\text{Conversion Gain}^2(\text{V/W})]$ |

ATI

| Full Scale Voltage Range | Offset Range |
|--|--|
| $\leq 300 \text{ mV}/[\text{Conversion Gain}^2(\text{V/W})]$ | $[\pm 300 \text{ mV} - (10 \text{ div} \times \text{V/div})]/[\text{Conversion Gain}^2(\text{V/W})]$ |

The base offset ranges of the oscilloscope are multiplied directly by the DPO7OE conversion gain² associated with the selected wavelength.

DC vertical accuracy, typical

$\pm 25 \mu\text{W} \pm 4\%$ of [(vertical reading)-(vertical offset)]

DC vertical accuracy refers to the DC accuracy of a sampled waveform referenced to an external optical power meter. Limited to temperature range within $\pm 5^\circ\text{C}$ of previous signal path compensation and ambient temperature within 20°C to 35°C .

Vertical accuracy of DC waveform measurements made on a mainframe vertical channel will be subject to the accuracy of the channel.

Valid for the calibrated wavelengths (850 nm (DPO7OE1 only), 1310 nm, 1550 nm) ± 20 nm. Optical input must be either unpolarized light or have been properly polarization scrambled.

DC vertical difference accuracy, typical

$\pm 5\%$ error between the measured waveform mean and the Average Optical Power (AOP) meter.

² Conversion gain for a channel can be queried with the :CH<x>:PRObe:GAIN? PI command. The value returned is dependent on the wavelength currently selected in Probe Setup.

All vertical accuracy specifications are referenced to the internal AOP reading for a given optical input. Limited to temperature range within $\pm 5\text{ }^\circ\text{C}$ of previous signal path compensation and ambient temperature within $20\text{ }^\circ\text{C}$ to $35\text{ }^\circ\text{C}$.

Unfiltered frequency response, typical The unfiltered frequency response approximates a 4th order Bessel-Thomson curve with a -3 dB frequency of 21 GHz. The response on a TekConnect channel is altered slightly relative to the response on an ATI channel. This is due to microwave characteristics of the coaxial cable connecting the O/E to the TekConnect interface.

Flat to 33 GHz frequency response, typical The Flat to 33 GHz setting applies a DSP correction filter to flatten the O/E frequency response, with an expected bandwidth of 33 GHz. Temperature $18\text{ }^\circ\text{C}$ to $28\text{ }^\circ\text{C}$.

| | | |
|-------------------|---------------------|----------------------|
| TekConnect | DC to 16.5 GHz | $\pm 1.0\text{ dB}$ |
| | >16.5 GHz to 26 GHz | $\pm 2.0\text{ dB}$ |
| ATI | DC to 20 GHz | $\pm 0.5\text{ dB}$ |
| | >20 GHz to 30 GHz | $\pm 0.75\text{ dB}$ |
| | >30 GHz to 32 GHz | $\pm 1.25\text{ dB}$ |
| | >32 GHz to 33 GHz | +1.25/-4.0 dB |

Flat to maximum bandwidth, typical The Flat to Maximum Bandwidth setting applies a DSP correction filter to flatten the O/E frequency response out to 60 GHz. Temperature $18\text{ }^\circ\text{C}$ to $28\text{ }^\circ\text{C}$.

| | | |
|-------------------|---------------------|----------------------|
| TekConnect | DC to 16.5 GHz | $\pm 1.0\text{ dB}$ |
| | >16.5 GHz to 32 GHz | $\pm 2.0\text{ dB}$ |
| ATI | DC to 20 GHz | $\pm 0.75\text{ dB}$ |
| | >20 GHz to 30 GHz | $\pm 1.0\text{ dB}$ |
| | >30 GHz to 57 GHz | $\pm 1.75\text{ dB}$ |
| | >57 GHz to 59 GHz | +1.75 dB, -3.0 dB |

200GBASE-LR filter setting frequency response for 26.56 Gbps NRZ, typical The 200GBASE-LR filter is a defined optical reference receiver (ORR) filter for 26.56 Gbps mask testing.

The response follows the bandwidth limits in the table below. This table along with the time domain aberration specifications ensure that 26.56 Gbps NRZ signals may be viewed with limited distortion. Values are normalized to 3% of the bit rate, represented as the 0 frequency in the table.

NOTE. the table below is a discrete list of some specific values that are commonly listed in ITU standards; this curve and tolerances are continuous functions.

| Freq (GHz) | Lower (dB) | Nominal (dB) | Upper (dB) |
|------------|------------|--------------|------------|
| 0 | -0.85 | 0.0 | 0.85 |
| 3 | -0.91 | -0.06 | 0.79 |
| 6 | -1.10 | -0.25 | 0.60 |
| 9 | -1.42 | -0.57 | 0.28 |
| 12 | -1.88 | -1.03 | -0.18 |
| 15 | -2.49 | -1.64 | -0.79 |
| 17 | -2.99 | -2.14 | -1.29 |

| Freq (GHz) | Lower (dB) | Nominal (dB) | Upper (dB) |
|------------|------------|--------------|------------|
| 19.92 | -3.86 | -3.01 | -2.16 |
| 24 | -6.04 | -4.55 | -3.05 |
| 27 | -7.86 | -5.92 | -3.95 |
| 30 | -9.93 | -7.49 | -5.04 |
| 33 | -12.12 | -9.20 | -6.28 |
| 36 | -14.41 | -11.01 | -7.62 |
| 39 | -16.75 | -12.88 | -9.01 |
| 39.84 | -17.41 | -13.41 | -9.41 |

**100GBASE-SR filter setting
frequency response for 25.78 Gbps
NRZ, typical**

The 100GBASE-SR filter is a defined optical reference receiver (ORR) filter for 25.78 Gbps mask testing.

The response follows the bandwidth limits in the table below. This table along with the time-domain aberration specifications ensure that 25.78 Gbps NRZ signals may be viewed with limited distortion.

NOTE. The table below is a discrete list of some specific values that are commonly listed in ITU standards; this curve and tolerances are continuous functions.

| Freq (GHz) | Lower (dB) | Nominal (dB) | Upper (dB) |
|------------|------------|--------------|------------|
| 0 | -0.85 | 0.0 | 0.85 |
| 3 | -0.92 | -0.07 | 0.78 |
| 6 | -1.12 | -0.27 | 0.58 |
| 9 | -1.46 | -0.61 | 0.24 |
| 12 | -1.95 | -1.10 | -0.25 |
| 15 | -2.60 | -1.75 | -0.90 |
| 19.34 | -3.86 | -3.01 | -2.16 |
| 21 | -4.46 | -3.61 | -2.76 |
| 24 | -6.47 | -4.86 | -3.25 |
| 27 | -8.43 | -6.33 | -4.23 |
| 30 | -10.58 | -7.99 | -5.40 |
| 33 | -12.87 | -9.80 | -6.72 |
| 36 | -15.25 | -11.69 | -8.12 |
| 38.67 | -17.41 | -13.41 | -9.41 |

**User filter setting frequency
response, typical**

This filter option allows the you to specify the bit rate for which a 4th order Bessel-Thomson filter will be generated. The -3 dB electrical bandwidth is calculated as 0.75 times the bit rate entered.

| 28.05 GBd | | | |
|------------|------------|--------------|------------|
| Freq (GHz) | Lower (dB) | Nominal (dB) | Upper (dB) |
| 0 | -0.85 | 0.0 | 0.85 |
| 3 | -0.91 | -0.06 | 0.79 |

| 28.05 GBd | | | |
|------------|------------|--------------|------------|
| Freq (GHz) | Lower (dB) | Nominal (dB) | Upper (dB) |
| 6 | -1.08 | -0.23 | 0.62 |
| 9 | -1.36 | -0.51 | 0.34 |
| 12 | -1.77 | -0.92 | -0.07 |
| 15 | -2.31 | -1.46 | -0.61 |
| 18 | -3.00 | -2.15 | -1.30 |
| 21.0375 | -3.86 | -3.01 | -2.16 |
| 24 | -5.32 | -4.03 | -2.73 |
| 27 | -6.98 | -5.24 | -3.50 |
| 30 | -8.83 | -6.64 | -4.44 |
| 33 | -10.83 | -8.18 | -5.54 |
| 36 | -12.94 | -9.85 | -6.76 |
| 39 | -15.13 | -11.59 | -8.05 |
| 42.075 | -17.41 | -13.41 | -9.41 |

| 16.8 GBd | | | |
|------------|------------|--------------|------------|
| Freq (GHz) | Lower (dB) | Nominal (dB) | Upper (dB) |
| 0 | -0.85 | 0.0 | 0.85 |
| 3 | -1.01 | -0.16 | 0.69 |
| 6 | -1.49 | -0.64 | 0.21 |
| 9 | -2.32 | -1.47 | 0.62 |
| 12.6 | -3.86 | -3.01 | -2.16 |
| 15 | -5.88 | -4.43 | -2.98 |
| 18 | -8.86 | -6.66 | -4.46 |
| 21 | -12.27 | -9.32 | -6.37 |
| 24 | -15.92 | -12.22 | -8.52 |
| 25.2 | -17.41 | -13.41 | -9.41 |

User filter setting frequency response, typical

This filter option allows you to specify the bit rate for which a 4th order Bessel-Thomson filter will be generated. The -3 dB electrical bandwidth is calculated as 0.75 times the bit rate entered.

| 29.5 GHz | | |
|------------|------------|------------|
| Freq (GHz) | Lower (dB) | Upper (dB) |
| 0 | -0.85 | 0.85 |
| 3 | -0.88 | 0.82 |
| 6 | -0.97 | 0.73 |
| 9 | -1.11 | 0.59 |
| 12 | -1.31 | 0.39 |
| 15 | -1.58 | 0.12 |
| 18 | -1.91 | -0.21 |

| 29.5 GHz | | |
|------------|------------|------------|
| Freq (GHz) | Lower (dB) | Upper (dB) |
| 21 | -2.31 | -0.61 |
| 24 | -2.78 | -1.08 |
| 27 | -3.33 | -1.63 |
| 30 | -4.03 | -2.22 |
| 33 | -5.08 | -2.63 |
| 36 | -6.23 | -3.14 |
| 39 | -7.47 | -3.74 |
| 42 | -17.41 | -9.41 |
| 45 | -10.21 | -5.20 |
| 48 | -11.68 | -6.03 |
| 51 | -13.21 | -6.92 |
| 54 | -14.77 | -7.83 |
| 57 | -16.35 | -8.77 |
| 58.80 | -17.30 | -9.34 |

| 12.6 GHz | | |
|------------|------------|------------|
| Freq (GHz) | Lower (dB) | Upper (dB) |
| 0 | -0.85 | 0.85 |
| 3 | -1.01 | 0.69 |
| 6 | -1.49 | 0.21 |
| 9 | -2.32 | 0.62 |
| 12.6 | -3.86 | -2.16 |
| 15 | -5.88 | -2.98 |
| 18 | -8.86 | -4.46 |
| 21 | -12.27 | -6.37 |
| 24 | -15.92 | -8.52 |
| 25.2 | -17.41 | -9.41 |

Rise times, typical (DPO70E1)

| Filter name | TekConnect | ATI |
|-----------------|--------------|--------------|
| | Typical (ps) | Typical (ps) |
| None | 17.1 | 15.8 |
| Flat to 33 GHz | 13.4 | 13.2 |
| Flat to Maximum | 13.4 | 10.2 |
| 100GBASE-SR | 19.4 | 18.1 |
| 200GBASE-LR | 19.1 | 17.6 |
| User 16.8 GBd | 27.6 | 28.0 |
| User 28.05 GBd | 18.2 | 16.7 |

The 10% to 90% transition rise time is indirectly determined from the impulse response measurement. The impulse response is integrated, with baseline offset removed to keep the average power of each period the same. 10% to 90% transition rise time is then calculated from the step response.

Rise times, typical (DPO70E2)

| Filter name | TekConnect | ATI |
|---------------------------|--------------|--------------|
| | Typical (ps) | Typical (ps) |
| Unfiltered O/E response | NA | NA |
| Flat to maximum bandwidth | 12.9 | 7.5 |
| User 12.6 GBd | 28.4 | 27.3 |
| User 29.5 GBd | NA | 11.8 |

The 10% to 90% transition rise time is indirectly determined from the impulse response measurement. The impulse response is integrated, with baseline offset removed to keep the average power of each period the same. 10% to 90% transition rise time is then calculated from the step response.

Time domain vertical response aberrations, typical

± 3% pk-pk for ORR filters only.
For peak optical signal input < 4mW peak-peak.

✓ **System vertical equivalent optical noise**

Noise values shown are for the maximum real-time sample rate in each configuration: 100 GS/s for TekConnect, 200 GS/s for ATI.

850 nm

| Filter name | TekConnect | | ATI | |
|----------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | Typical (μW) | Maximum (μW) | Typical (μW) | Maximum (μW) |
| Unfiltered O/E Response | 13.51 | 17.62 | 17.92 | 19.40 |
| Flat to Max | 20.05 | 27.90 | 35.66 | 38.40 |
| User 12.6 GHz (16.8 GBd NRZ) | 12.09 | 15.64 | 11.61 | 16.35 |
| User 21.0375 GHz (28.05 GBd NRZ) | 12.94 | 18.40 | 13.66 | 19.30 |

1310 nm

| Filter name | TekConnect | | ATI | |
|----------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | Typical (μW) | Maximum (μW) | Typical (μW) | Maximum (μW) |
| Unfiltered O/E Response | 7.98 | 9.53 | 10.01 | 10.77 |
| Flat to Max | 11.40 | 13.72 | 19.19 | 24.20 |
| User 12.6 GHz (16.8 GBd NRZ) | 5.59 | 8.25 | 6.70 | 8.87 |
| User 21.0375 GHz (28.05 GBd NRZ) | 7.47 | 9.70 | 7.88 | 10.44 |

1550 nm

| Filter name | TekConnect | | ATI | |
|----------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | Typical (μW) | Maximum (μW) | Typical (μW) | Maximum (μW) |
| Unfiltered O/E Response | 8.15 | 10.08 | 10.65 | 11.44 |
| Flat to Max | 11.74 | 14.66 | 16.64 | 25.60 |
| User 12.6 GHz (16.8 GBd NRZ) | 5.91 | 7.87 | 6.94 | 9.27 |
| User 21.0375 GHz (28.05 GBd NRZ) | 7.58 | 9.23 | 8.15 | 10.89 |

Values are the root mean square (RMS) distribution of vertical noise with either no optical input or noiseless optical input. Noise is representative of a DPO70000SX system with the vertical scale set to the highest sensitivity.

✓ **System vertical equivalent optical noise**

Noise values shown are for the maximum real-time sample rate in each configuration: 100 GS/s for TekConnect, 200 GS/s for ATI.

1310 nm

| Filter name | TekConnect | | ATI | |
|-------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | Typical (μW) | Maximum (μW) | Typical (μW) | Maximum (μW) |
| Unfiltered O/E Response | 14.8 | 16.8 | 20.7 | 22.7 |
| Flat to Max | 13.9 | 15.9 | 23.2 | 25.2 |
| User 12.6 GBd | 9.8 | 11.8 | 11.0 | 13.0 |
| User 29.5 GBd | NA | NA | 15.6 | 17.6 |

1550 nm

| Filter name | TekConnect | | ATI | |
|-------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | Typical (μW) | Maximum (μW) | Typical (μW) | Maximum (μW) |
| Unfiltered O/E Response | 17.0 | 19.0 | 24.5 | 26.5 |
| Flat to Max | 16.2 | 18.2 | 27.5 | 29.5 |
| User 16.8 GBd | 11.0 | 13.0 | 13.0 | 15.0 |
| User 28.05 GBd | NA | NA | 17.3 | 19.3 |

Values are the root mean square (RMS) distribution of vertical noise with either no optical input or noiseless optical input. Noise is representative of a DPO70000SX system with the vertical scale set to the highest sensitivity.

Proximity sensor specifications

Photodiode current limiting, typical Probe dynamic range is limited when the shuttle is mounted to the ATI bracket. This protects the ATI channel from excessive probe output voltage.

Environmental specifications

Temperature range

| | |
|------------------------------------|--|
| Installed and Operating | 10 °C to +40 °C |
| | Certain performance specifications of the DPO70E are limited to a more restricted ambient temperature range: |
| | <ul style="list-style-type: none"> Filters' frequency response tolerances: +20 °C to +30 °C |
| Installed and non-operating | -22 °C to +60 °C |

Humidity

| | |
|------------------------------------|--|
| Installed and operating | 20% to 80% relative humidity with a maximum wet bulb temperature of 29 °C at or below +40 °C, (Upper limit de-rates to 45% relative humidity at +40 °C.) Non-condensing. |
| | Certain performance specifications of the DPO70E are limited to a more restricted ambient temperature range: |
| | <ul style="list-style-type: none"> Filters' frequency response tolerances: +20 °C to +30 °C |
| Installed and non-operating | 5% to 90% relative humidity with a maximum wet bulb temperature of 29 °C at or below +60 °C. (Upper limit de-rates to 20% relative humidity at +60 °C.) Non-condensing. |

Mechanical specifications

Weight

| | |
|--|----------------------|
| Module alone with terminators and FC/PC or FC/APC JAE optical connector installed | 0.318 kg (0.70 lbs.) |
|--|----------------------|

Dimensions

| | |
|--|---|
| Approximate external dimensions | 10.5 inches x 3.3 inches x 1.5 inch (26.7 cm X 8.4 cm X 3.8 cm) |
|--|---|

Performance verification

Performance verification

If you are not familiar with operating this instrument, read the instrument user manual or explore the online help.

These performance verification procedures add direct checking of the warranted specifications that are marked with the ✓ symbol. These procedures require specific test equipment.

Functional tests

The purpose of these procedures is to confirm that the instrument functions properly.

NOTE. *These procedures verify functions; that is, they verify that the instrument features operate. They do not verify that they operate within limits.*

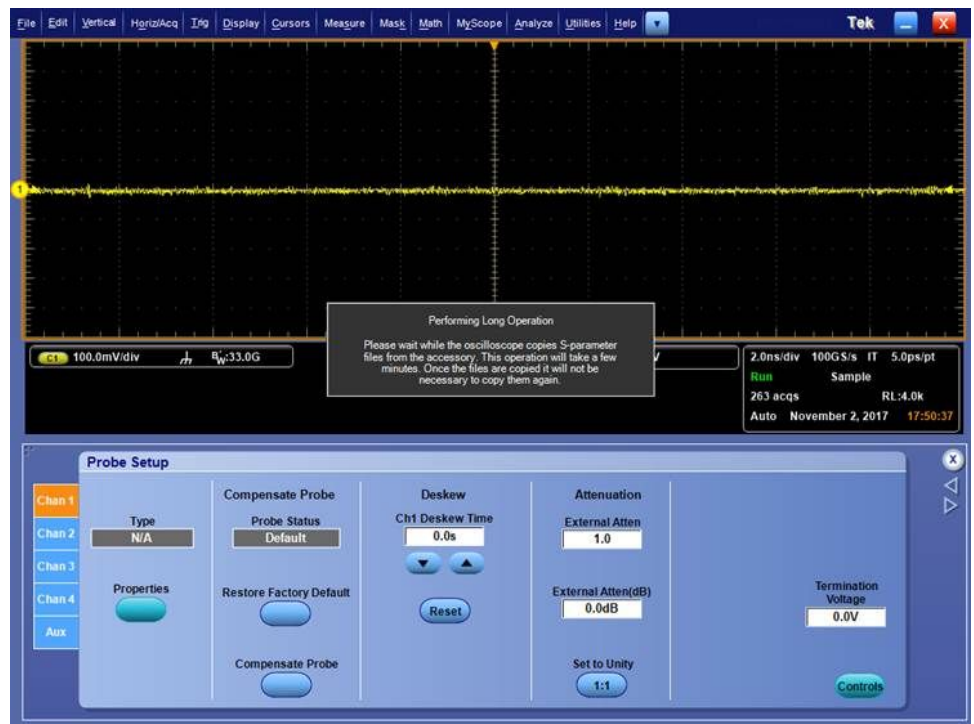
Therefore, when the instructions in the functional tests that follow call for you to verify that a signal appears on-screen "that is about five divisions in amplitude" or "has a period of about six horizontal divisions," etc., do NOT interpret the quantities given as limits. Operation within limits is checked in Performance Tests. (See [Performance tests](#) on page 20.)

NOTE. *DO NOT make changes to the front-panel settings that are not called out in the procedures. Each verification procedure will require you to set the instrument to certain default settings before verifying functions. If you make changes to these settings, other than those called out in the procedure, you may obtain invalid results. In this case, just redo the procedure from step 1.*

When you are instructed to press a front-panel or screen button, the button may already be selected (its label will be highlighted). If this is the case, it is not necessary to press the button.

First turn on functional checks

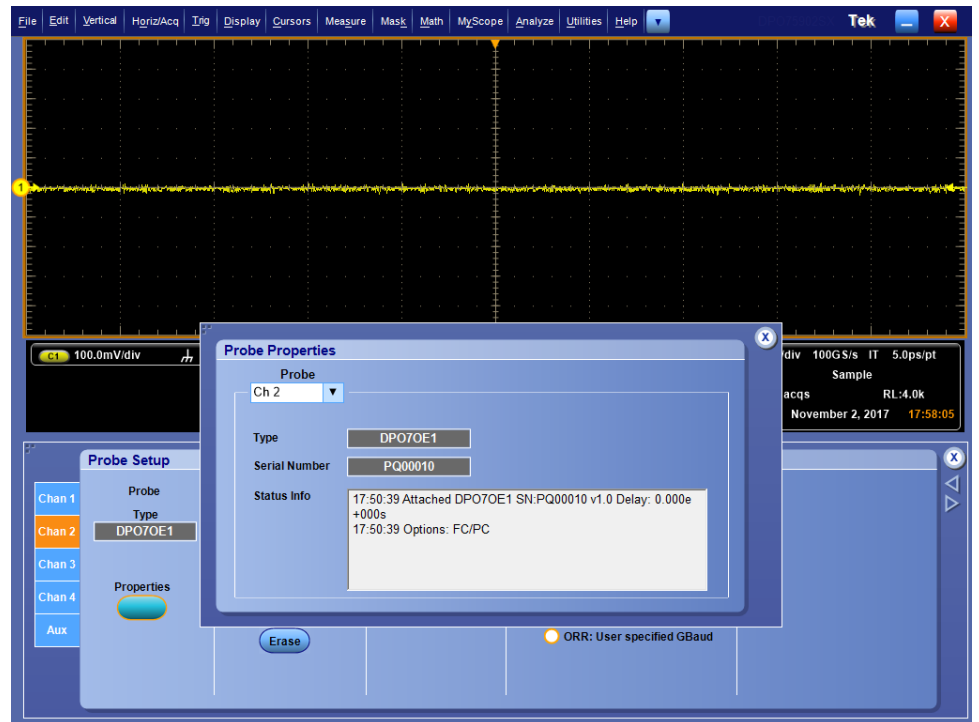
1. When a DPO70E Series probe is plugged into a 70k series oscilloscope for the first time, measured S-parameters for the probe are copied from the probe internal memory to build custom correction filters. The message pictured below appears on the screen while this process takes place. Total operation time may take over a minute.



2. Once complete, the message will disappear.

Verify that the message appears the first time the probe is attached to the instrument.

3. The probe model number and serial number can be verified in the Probe Properties screen, accessible from the Probe Setup menu.



4. Attach the probe to the instrument.
5. Select **Vertical > Probe Cal** to open the Probe Setup panel. Select the tab for the channel that the probe is attached to.
6. Press the **Properties** button.

The Probe Properties window is displayed.
7. Verify the probe model number and serial number.

Test record

Photocopy the test record tables and use them to record the performance test results for your instrument.

Table 1: Test information

| Item | Recorded value |
|--------------------------|----------------|
| Instrument Serial Number | |
| Technician | |
| Certificate Number | |
| Date of Calibration | |
| Temperature | |
| RH % | |

| Output zero (dark level) accuracy | | | | |
|---------------------------------------|----------------|----------|----------|----------------|
| Instrument performance test (DPO7OE1) | Minimum | Incoming | Outgoing | Maximum |
| 850 nm TekConnect | | | | |
| Unfiltered OE Response | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to 33 GHz | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to Max | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 100GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 200GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 16.8 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 28.05 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 850 nm ATI | | | | |
| Unfiltered OE Response | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to 33 GHz | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to Max | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 100GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 200GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 16.8 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 28.05 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 1310 nm TekConnect | | | | |
| Unfiltered OE Response | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to 33 GHz | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to Max | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 100GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 200GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 16.8 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 28.05 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 1310 nm ATI | | | | |

| Output zero (dark level) accuracy | | | | |
|--|----------------|-----------------|-----------------|----------------|
| Instrument performance test (DPO7OE1) | Minimum | Incoming | Outgoing | Maximum |
| Unfiltered OE Response | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to 33 GHz | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to Max | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 100GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 200GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 16.8 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 28.05 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 1550 nm TekConnect | | | | |
| Unfiltered OE Response | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to 33 GHz | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to Max | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 100GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 200GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 16.8 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 28.05 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 1550 nm ATI | | | | |
| Unfiltered OE Response | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to 33 GHz | -10.00 μ W | _____ | _____ | +10.00 μ W |
| Flat to Max | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 100GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| 200GBASE-SR | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 16.8 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |
| User Specified 28.05 GBd | -10.00 μ W | _____ | _____ | +10.00 μ W |

| Output zero (dark level) accuracy | | | | |
|--|----------------|-----------------|-----------------|----------------|
| Instrument performance test (DPO7OE2) | Minimum | Incoming | Outgoing | Maximum |
| 1310 nm TekConnect | | | | |
| Unfiltered OE Response | -12.00 μ W | _____ | _____ | +12.00 μ W |
| Flat to Max | -12.00 μ W | _____ | _____ | +12.00 μ W |
| User Specified 12.6 GHz | -12.00 μ W | _____ | _____ | +12.00 μ W |
| User Specified 29.5 GHz | -12.00 μ W | _____ | _____ | +12.00 μ W |
| 1310 nm ATI | | | | |
| Unfiltered OE Response | -18.00 μ W | _____ | _____ | +18.00 μ W |
| Flat to Max | -18.00 μ W | _____ | _____ | +18.00 μ W |
| User Specified 12.6 GHz | -18.00 μ W | _____ | _____ | +18.00 μ W |
| User Specified 29.5 GHz | -18.00 μ W | _____ | _____ | +18.00 μ W |
| 1550 nm TekConnect | | | | |
| Unfiltered OE Response | -12.00 μ W | _____ | _____ | +12.00 μ W |

| Output zero (dark level) accuracy | | | | |
|--|----------------|-----------------|-----------------|----------------|
| Instrument performance test (DPO7OE2) | Minimum | Incoming | Outgoing | Maximum |
| Flat to Max | -12.00 μ W | _____ | _____ | +12.00 μ W |
| User Specified 12.6 GHz | -12.00 μ W | _____ | _____ | +12.00 μ W |
| User Specified 29.5 GHz | -12.00 μ W | _____ | _____ | +12.00 μ W |
| 1550 nm ATI | | | | |
| Unfiltered OE Response | -18.00 μ W | _____ | _____ | +18.00 μ W |
| Flat to Max | -18.00 μ W | _____ | _____ | +18.00 μ W |
| User Specified 12.6 GHz | -18.00 μ W | _____ | _____ | +18.00 μ W |
| User Specified 29.5 GHz | -18.00 μ W | _____ | _____ | +18.00 μ W |

| System vertical equivalent optical noise accuracy | | | | |
|--|------------------------------------|-------------------------------------|-------------------------------------|------------------------------------|
| Instrument performance test (DPO7OE1) | Minimum (μW) | Incoming (μW) | Outgoing (μW) | Maximum (μW) |
| 850 nm TekConnect | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 17.92 |
| Flat to Max | N/A | _____ | _____ | 27.90 |
| USER 16.8 GBd | N/A | _____ | _____ | 15.64 |
| USER 28.05 GBd | N/A | _____ | _____ | 18.40 |
| 850 nm ATI | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 19.40 |
| Flat to Max | N/A | _____ | _____ | 38.40 |
| USER 16.8 GBd | N/A | _____ | _____ | 16.35 |
| USER 28.05 GBd | N/A | _____ | _____ | 19.30 |
| 1310 nm TekConnect | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 9.53 |
| Flat to Max | N/A | _____ | _____ | 13.72 |
| USER 16.8 GBd | N/A | _____ | _____ | 8.25 |
| USER 28.05 GBd | N/A | _____ | _____ | 9.70 |
| 1310 nm ATI | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 10.77 |
| Flat to Max | N/A | _____ | _____ | 24.20 |
| USER 16.8 GBd | N/A | _____ | _____ | 8.87 |
| USER 28.05 GBd | N/A | _____ | _____ | 10.44 |
| 1550 nm TekConnect | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 10.08 |
| Flat to Max | N/A | _____ | _____ | 14.66 |
| USER 16.8 GBd | N/A | _____ | _____ | 7.87 |
| USER 28.05 GBd | N/A | _____ | _____ | 9.23 |
| 1550 nm ATI | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 11.44 |

| System vertical equivalent optical noise accuracy | | | | |
|---|---------------------------|----------------------------|----------------------------|---------------------------|
| Instrument performance test (DPO7OE1) | Minimum (μW) | Incoming (μW) | Outgoing (μW) | Maximum (μW) |
| Flat to Max | N/A | _____ | _____ | 25.60 |
| USER 16.8 GBd | N/A | _____ | _____ | 9.27 |
| USER 28.05 GBd | N/A | _____ | _____ | 10.89 |

| System vertical equivalent optical noise accuracy | | | | |
|---|---------------------------|----------------------------|----------------------------|---------------------------|
| Instrument performance test (DPO7OE2) | Minimum (μW) | Incoming (μW) | Outgoing (μW) | Maximum (μW) |
| 1310 nm TekConnect | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 16.8 |
| Flat to Max | N/A | _____ | _____ | 15.9 |
| USER 12.6 GHz | N/A | _____ | _____ | 11.8 |
| USER 29.5 GHz | N/A | _____ | _____ | N/A |
| 1310 nm ATI | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 22.7 |
| Flat to Max | N/A | _____ | _____ | 25.2 |
| USER 12.6 GHz | N/A | _____ | _____ | 13.0 |
| USER 29.5 GHz | N/A | _____ | _____ | 17.6 |
| 1550 nm TekConnect | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 19.0 |
| Flat to Max | N/A | _____ | _____ | 18.2 |
| USER 12.6 GHz | N/A | _____ | _____ | 13.0 |
| USER 29.5 GHz | N/A | _____ | _____ | N/A |
| 1550 nm ATI | | | | |
| Unfiltered OE response | N/A | _____ | _____ | 26.5 |
| Flat to Max | N/A | _____ | _____ | 29.5 |
| USER 12.6 GHz | N/A | _____ | _____ | 15.0 |
| USER 29.5 GHz | N/A | _____ | _____ | 19.3 |

Performance tests

This section contains a collection of manual procedures for checking that the instrument performs as warranted. They check all the characteristics that are designated as checked in Specifications. (The characteristics that are checked appear with a ✓ in Specifications).

Prerequisites

The tests in this section comprise an extensive, valid confirmation of performance and functionality when the following requirements are met:

- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must be in an environment with temperature, altitude, humidity, and vibration within the operating limits described in this document.
- The instrument must have had a warm-up period of at least 20 minutes.

Check output zero (dark level)

Perform these steps to verify the output zero (dark level).

Equipment needed: None.

1. Attach the DPO7OE probe to the Ch1 TekConnect input.
2. Allow the oscilloscope and probe to warm-up for at least 60 minutes.
3. Run SPC on the oscilloscope.
4. Set Trigger Source to **Line**.
5. Set the sample rate to **100 GS/s**.
6. Set the Horizontal Scale to **1 ns/div**.
7. Set Ch1 to the lowest W/Div setting in the Vertical Setup.
8. Select the Mean measurement.
9. Set the Wavelength to **850 nm** (for the DPO7OE1 only) (if you are testing a DPO7OE2, start with 1310 nm).
10. Make sure the protective cap is covering the probe optical input.
11. Press the **Dark Cal** button for the probe.
12. After Dark Cal has completed, note the Mean measurement. Note this value as Output Zero and check against limits.
13. Repeat steps 10 through 12 with the Flat to Max filter selected.
14. Repeat steps 10 through 12 with the User Specified 16.8 GBd filter selected.

15. Repeat steps 10 through 12 with the User Specified 28.05 GBd filter (for the DPO7OE1) or the User Specified 29.5 GHz filter (for the DPO7OE2) selected.
16. Repeat steps 10 through 12 for Wavelengths 1310 nm and 1550 nm.
17. Move the DPO7OE shuttle to the ATI channel.
18. Set Ch2 to the lowest W/Div setting in the Vertical Setup.
19. Repeat steps 8 through 16 using the ATI channel.

This completes the procedure.

Check system vertical equivalent optical noise

Perform these steps to verify the system vertical equivalent optical noise.

Equipment needed: None.

Procedure:

1. Attach the DPO7OE probe to the Ch1 TekConnect input.
2. Allow the oscilloscope and probe to warm-up for at least 60 minutes.
3. Run SPC on the oscilloscope.
4. Set Trigger Source to **Line**.
5. Set the sample rate to **100 GS/s**,
6. Set the Horizontal Scale to **1 ns/Div**.
7. Set the Ch1 Vertical Scale to the lowest W/Div setting in the Vertical Setup.
8. Select the Mean measurement.
9. Set the Wavelength to 850 nm.
10. Set Filter to Unfiltered Response.
11. Make sure the protective cap is covering the probe optical input.
12. Press the Dark Cal button for the probe.
13. Create a Vertical Histogram with boundaries that span 10 vertical and 10 Horizontal divisions of the graticule.
14. Select the Histogram Standard Deviation measurement.
15. Note the Value of the Standard Deviation as the Vertical Optical Noise for the selected Bandwidth and Wavelength combination.
16. Repeat steps 11- 15 for all Filter Settings.
17. Repeat steps 10- 15 for all Wavelengths.
18. Move the DPO7OE shuttle to the ATI channel.
19. Set Ch2 to the lowest W/Div setting in the Vertical Setup.
20. Repeat steps 8 through 17 using the ATI channel.

This completes the procedure.