Instruction Manual

Tektronix

SD-48
Optical-to-Electrical Converter

071-0207-00

CE

Printed in the U.S.A.

Tektronix, Inc., P.O. Box 1000, Wilsonville, OR 97070–1000

WARRANTY

Tektronix warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If a product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY TEKTRONIX IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

Table of Contents

General Safety Summary iii

Contacting Tektronix v

Getting Started 1

Standard Accessories 2

Options 2

Optional Accessories 2

Installation 3

Operating Basics 8

Handling 8

Cleaning Optical Connectors 8

Connecting Optical Signals 9

Attenuating Optical Signals 10

Specifications 11

Performance Verification 14

Equipment Required 14

Output Zero 15

DC Conversion Gain 15

Noise Equivalent Power 17

Bandwidth/Frequency Response 18

Replaceable Parts 22

List of Figures

Figure 1: SD-48 front panel 1
Figure 2: Using the rigid connector (all sampling heads except SD-32) 5
Figure 3: Using the rigid connector and V–K adapter (SD-32 sampling head only) 5
Figure 4: Front panel compartments in a CSA 803 Communications Signal Analyzer 6
Figure 5: Installation with optional power supply kit 7
Figure 6: SD-48 relative responsivity (normalized to 1310 nm) 12
Figure 7: Typical frequency response, Option RR (SD-48, OC-192 filter, and SD-22) 12
Figure 8: Setup for frequency response measurement, SD-48 standard configuration 19
Figure 9: Setup for frequency response measurement, SD-48 Option RR for OC192 19
Figure 10: SD-48 replaceable parts 22
Figure 11: Standard accessories 23
Figure 12: Optional accessories 23
Figure 13: Optional power cords 24

General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

To Avoid Fire or Personal Injury

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

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

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

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Symbols and Terms

Terms in this 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. The following symbols appear on the product:

CAUTION
Static Sensitive

CAUTION
Refer to Manual

Contacting Tektronix

Product Support	For application-oriented questions about a Tektronix measurement product, call toll free in North America: 1-800-TEK-WIDE (1-800-835-9433 ext. 2400) 6:00 a.m. – 5:00 p.m. Pacific time Or contact us by e-mail: tm_app_supp@tek.com For product support outside of North America, contact your local Tektronix distributor or sales office.
Service Support	Contact your local Tektronix distributor or sales office. Or visit our web site for a listing of worldwide service locations. http://www.tek.com
For other information	In North America: 1-800-TEK-WIDE (1-800-835-9433) An operator will direct your call.
To write us	Tektronix, Inc. P.O. Box 1000 Wilsonville, OR 97070-1000

Getting Started

The SD-48 is an optical-to-electrical (O/E) converter that converts an optical input signal into an output voltage for display on either a high-speed oscilloscope or spectrum analyzer. The SD-48 O/E converter installs in any of the front panel compartments of a Tektronix 11800 Series Digital Sampling Oscilloscope, the SM-11 Multichannel Unit, or the Tektronix CSA 803 Communications Signal Analyzer. An optional stand-alone power supply is also available for the SD-48 O/E converter (see page 24).

Figure 1 shows the front panel of the SD-48 O/E converter.

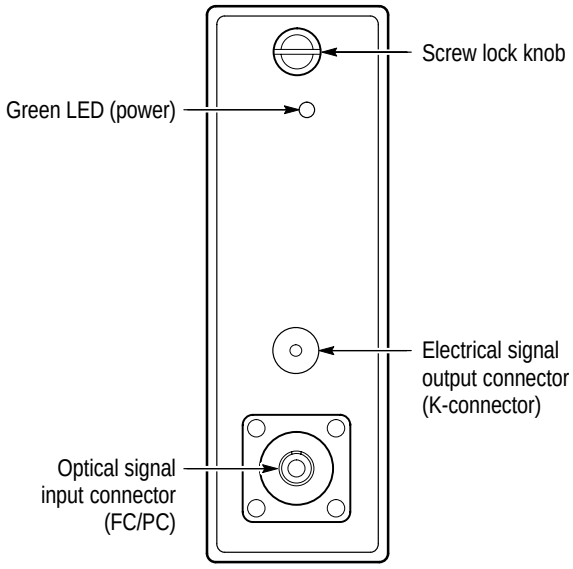

Figure 1: SD-48 front panel

The SD-48 O/E converter has an FC/PC receptacle for optical signal input and a precision 2.92 mm K-connector for electrical signal output.

The following list highlights the key performance characteristics of the SD-48 O/E converter:

- 1000 to 1650 nm wavelength response
- DC to 30 GHz typical transducer bandwidth
- ≥ 15 mV/mW of DC conversion gain at 1310 and 1550 nm

For a complete list of specifications, see to page 11.

Standard Accessories

The following accessories are standard with every SD-48 O/E converter:

- Hard case
- Instruction manual
- FC/PC to FC/PC 9 μm single-mode fiber jumper
- FC/ST, FC/SC, and FC/FC hybrid connectors
- Rigid U-cable for sampling heads other than SD-32 (SMA-SMA, 50 Ω)
- Rigid J-cable for SD-32 sampling head (SMA-SMA, 50 Ω, requires V-K adapter)
- Protective SMA terminator (installed on the electrical output)
- SMA-SMA flexible cable
- Certificate of traceable calibration

For a list of replaceable part numbers, see page 24.

Options

The following options are available at the time of purchase:

- Opt D1 Calibration data
- Opt D3 Three years calibration data
- Opt C3 Three years calibration services
- Opt R3 Three years extended warranty
- Opt RR Add SMA in-line connector, OC-192 filter, and frequency response graph (SD-22 electrical sampling head required but not included)

Optional Accessories

The following recommended accessories are available through Tektronix:

- Fiber-optic cables and adapters with a variety of fiber types and connector styles
- 90/10 single-mode optical splitter with FC/PC connectors
- DIN to FC fiber-optic hybrid connector

- 10 dB in-line single-mode optical attenuator
- Electrical filters for 10 Gbs, 622 Mbs, and 155 Mbs
- Stand-alone power supply

For a list of part numbers, see pages 24 and 25.

Installation

Follow the instructions in this section to install the SD-48 O/E converter into the Tektronix 11800 Series Digital Sampling Oscilloscope or CSA 803 Communications Signal Analyzer, or to connect it to the optional power supply for stand-alone operation.

11800 or CSA 803 Series

On the Tektronix 11800 Series Digital Sampling Oscilloscope or the CSA 803 Communications Signal Analyzer, the SD-48 O/E converter installs into any of the front panel compartments.

NOTE. *For the best performance, connect the SD-48 Optical-to-Electrical Converter to the input of the sampling head using the rigid connector provided. The sampling head must be in the compartment immediately to the right of the O/E converter. See Figure 2.*

Choose one of the following Tektronix sampling heads to connect to the output of the O/E converter:

- SD-22 (recommended for lowest noise performance)
- SD-24
- SD-26
- SD-30
- SD-32 (requires a V-K adapter and rigid J-cable, see Figure 3)

Use the following procedure to install the O/E converter and sampling head modules:

CAUTION. *The output of the O/E converter and the input of the sampling head are subject to damage from electrostatic discharge (ESD). To prevent damage from ESD, take the following precautions:*

Always wear an anti-static wrist strap when handling a static sensitive instrument.

Keep the short-circuit termination in place when moving or storing the instrument. Remove the termination only to connect a cable.

Discharge the inner conductor of a loose, unterminated cable before connecting it to the instrument.

1. Switch off the measurement instrument.
2. Place the module in a compartment and slowly push it in with firm pressure.
3. Once the module is seated, turn the screw shaft on the plug-in to tighten the module in place.
4. Switch on the measurement instrument and check that all modules have power.
5. Remove the termination on the output of the O/E converter and connect the output to the lower input of the sampling head as follows.
   - **a.** On all sampling heads *except* the SD-32, use the rigid connector and install the shorter leg of the connector on the sampling head. See Figure 2.
   - **b.** On the SD-32 sampling head, use the rigid connector and install the shorter leg of the connector on the sampling head with a V–K adapter. See Figure 3. (The V-K adapter is a standard accessory of the SD-32. If you do not have a V–K adapter, refer to the list of optional accessories at the end of this manual.)
   - **c.** Carefully align the SMA connectors on both ends of the rigid cable.
   - **d.** To avoid damaging the connectors on the SD48 or the sampling head, alternately tighten the threads of each end of the rigid cable one turn at a time until they are tight enough to enough to use a wrench.
   - **e.** Tighten each nut lightly with a wrench. For best repeatability and to prolong the life of SMA connectors, use a torque wrench and tighten the connection to the range of 7 to 10 lb-in (79 to 112 N-cm).

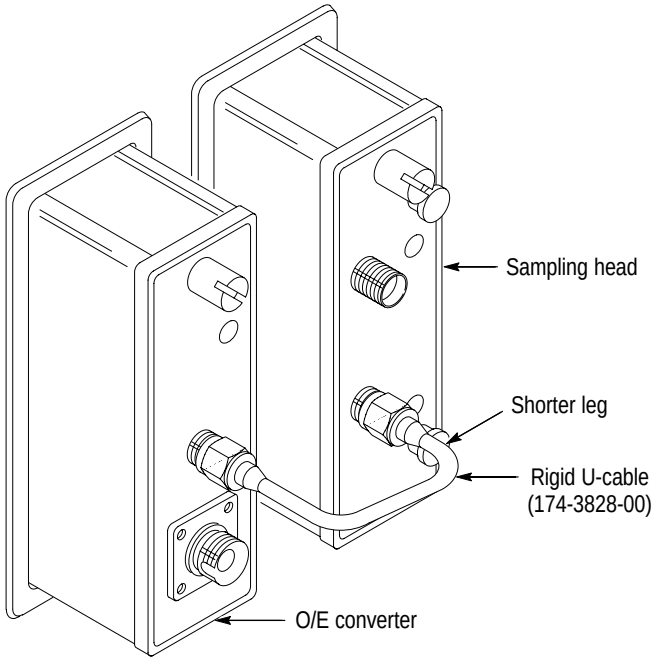

Figure 2: Using the rigid connector (all sampling heads except SD-32)

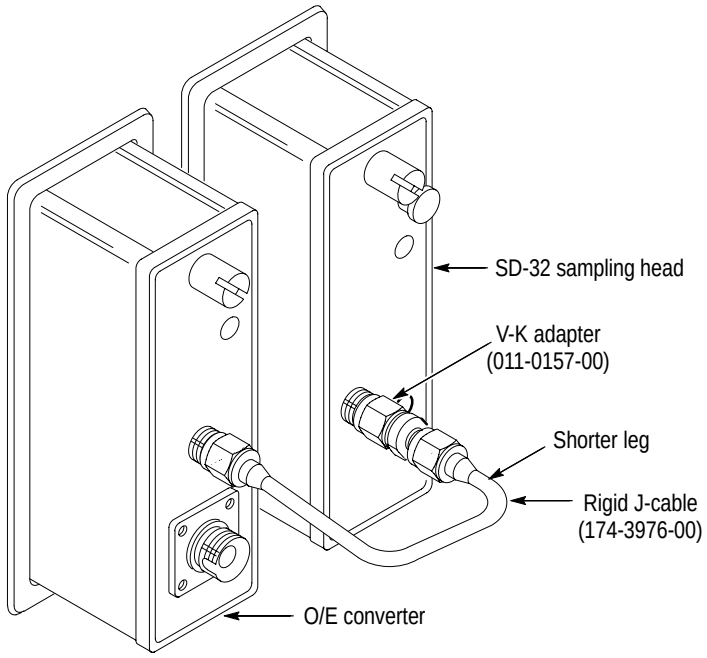

Figure 3: Using the rigid connector and V–K adapter (SD-32 sampling head only)

***NOTE**. On the CSA803 series, the O/E converter will work in any of the power-only or sampling head compartments, but the sampling head must be installed in one of the two sampling head compartments on the right. See Figure 4.*

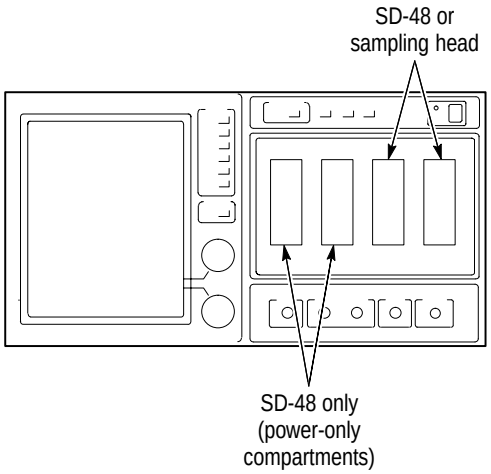

Figure 4: Front panel compartments in a CSA 803 Communications Signal Analyzer

Optional Power Supply

The optional power supply kit (Figure 5) allows the user to power the SD-48 O/E converter by itself. This allows the O/E converter to operate with other types of measurement instruments independent of a CSA or 11800 series mainframe. The part number for the kit is on page 24.

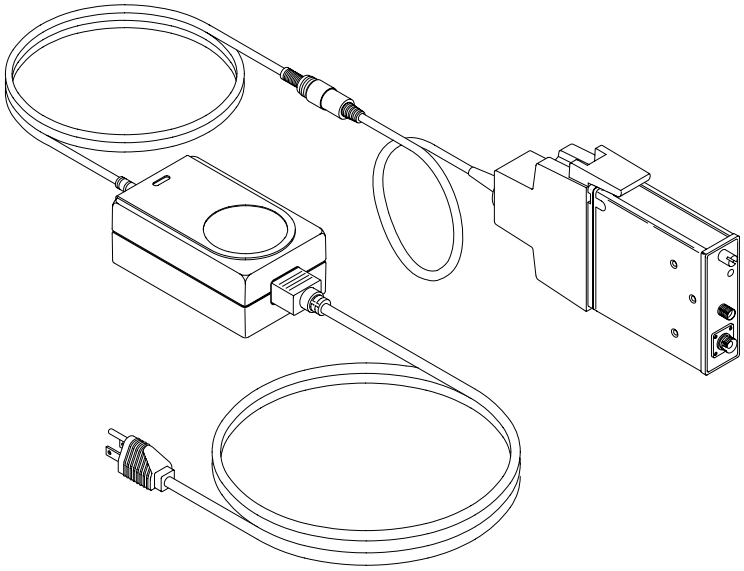

Figure 5: Installation with optional power supply kit

Operating Basics

To prolong the life of the SD-48 O/E converter observe the following handling, cleaning, and operating instructions.

Handling

Handle the SD-48 O/E converter carefully at all times.

CAUTION. *To avoid damaging the SD-48 O/E converter, take the following precautions:*

Do not drop the O/E converter since damage and misalignment of the photo-diode optical assembly can result. Store the O/E converter in a secure location when not in use.

Replace the protective caps on the input and output connectors when the O/E converter is not in use.

Cleaning Optical Connectors

Small dust particles and oils can easily contaminate optical connectors and reduce or block the signal. Take care to preserve the integrity your connectors by keeping them free of contamination.

CAUTION. *To prevent loss of optical power or damage to the optical connectors, keep the connectors clean at all times.*

When cleaning the connectors with a swab, use gentle circular motions. Use only high quality cleaning supplies that are non-abrasive and leave no residue.

To reduce the need for cleaning, immediately replace protective caps on the optical connectors when not in use.

Equipment Required

Use the following items to clean the optical connectors:

- clean compressed air
- fiber-optic cleaning swabs
- isopropyl alcohol

Procedure

To clean the optical connectors, follow these steps:

1. Hold the can of compressed air upright and spray the can into the air to purge any propellant.
2. Spray the clean compressed air on the connectors to remove any loose particles or moisture.
3. Moisten a clean optical swab with isopropyl alcohol then lightly swab the surfaces of the connectors.
4. Spray the clean compressed air on the connectors again to remove any loose particles or isopropyl alcohol.

NOTE. *Cleaning kits for optical connectors are available from a number of suppliers.*

Connecting Optical Signals

Attach the fiber optic cable with an FC/PC connector to the FC/PC input receptacle as follows:

1. Carefully align the keyway on the receptacle with the key on the connector.
2. Tighten the nut lightly with finger pressure only.

The input of the SD-48 O/E converter can couple to optical fibers with a core diameter of up to 9 μm. Alternate types can be coupled by use of an FC-FC jumper and the FC-FC, FC-ST, FC-SC adapters. (Refer to *Optional accessories* on page 24.)

CAUTION. *To maintain the high performance (low return loss) of the optical interface, connect an adapter and cable between the input of the O/E converter and the device under test. When you make connections to other devices, leave the adapter and cable in place to protect the optical interface of the O/E converter from wear.*

If you connect fiber cores larger than 9 μm, the O/E converter may still couple light, but the mismatch in core diameter will cause lower conversion gain and higher insertion loss.

Attenuating Optical Signals

To keep the optical input power to an appropriate level, it may be necessary to use an optical attenuator (such as the Tektronix OA5002) to attenuate the optical signal.

CAUTION. *To avoid damaging the optical input of the SD-48 O/E converter, attenuate optical signals to less than 10 mW average power or 20 mW peak power at the wavelength with highest relative responsivity.*

For linearity and measurement accuracy, attenuate the peak-to-peak swing of signal to within the specified performance of 2 mW_{p-p}.

Specifications

This section contains the specifications for the SD-48 Optical-to-Electrical Converter. All specifications are guaranteed unless noted as "typical." Typical specifications are provided for your convenience but are not guaranteed. Specifications marked with the ✓ symbol have corresponding checks in the *Performance Verification* section on page 14.

Table 1: SD-48 Specifications

Specification	Description
Effective wavelength range, typical	1000 nm to 1650 nm
✓ DC conversion gain	≥ 15 mV / mW at 1310 nm ± 20 nm and 1550 nm ± 20 nm
Relative responsivity, typical	See Figure 6
Option RR frequency response, typical (with OC-192 filter and SD-22)	See Figure 7
Absolute maximum nondestructive optical input	10 mW average power; 20 mW peak power at wavelength with highest relative responsivity
✓ Bandwidth, typical	DC to 30 GHz (– 6 dB electrical power into 50 Ω) for signals < 2 mW_{p-p}
Input fiber diameter	Accepts 9 µm single-mode diameter; Numerical Aperture (NA) ≤ 0.20
Internal fiber diameter	core: 9 µm single-mode fiber cladding: 125 µm
Fiber connector style	female FC/PC
Optical return loss	> 30 dB minimum when external mating fiber is also single-mode PC style
✓ Noise equivalent power	≤ 15 $pW/\sqrt{Hz}$ electrical output noise when terminated into 50 Ω
Impulse response width, typical	≤ 15 ps FWHM (Full Width Half Maximum)
Aberrations, typical	≤ $20\%_{p-p}$ total
✓ Output zero	≤ 1 mV
External termination impedance	50 Ω ± 2 Ω
Output impedance, typical	Reverse terminated in 50 Ω ± 2 Ω
Temperature	Operating: +10° C to +40° C Non-operating: –55° C to +75° C
Humidity	75% non-condensing
Altitude	Operating: 4,572 m (15,000 ft) Non-operating: 15,240 m (50,000 ft)

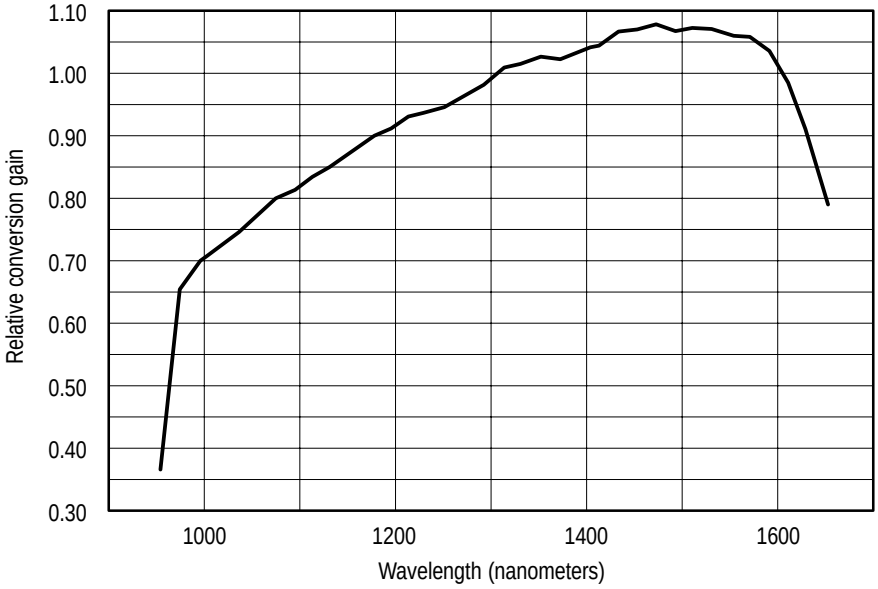

Figure 6: SD-48 relative responsivity (normalized to 1310 nm)

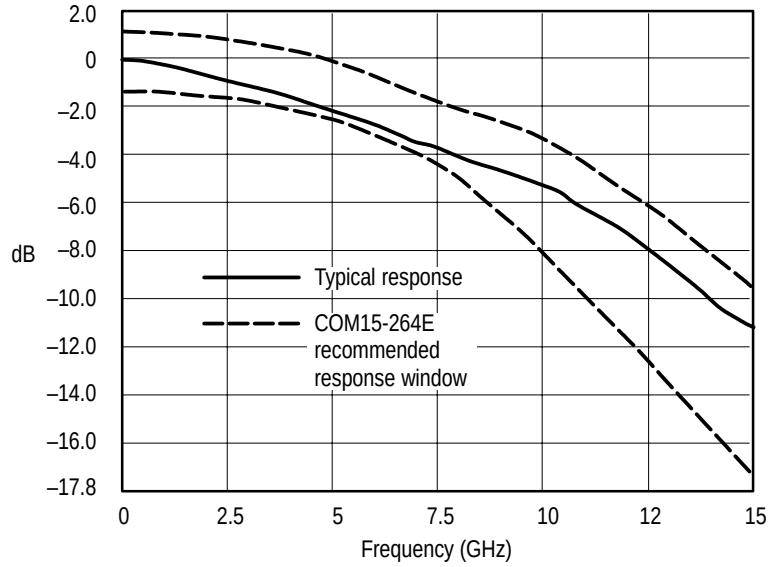

Figure 7: Typical frequency response, Option RR (SD-48, OC-192 filter, and SD-22)

Table 2: Certifications and compliances

Category	Standards or description
EC Declaration of Conformity – EMC	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Union: EN 55011 Class A Radiated and Conducted Emissions EN 50082-1 Immunity: IEC 801-2 Electrostatic Discharge Immunity IEC 801-3 RF Electromagnetic Field Immunity
Australia/New Zealand Declaration of Conformity – EMC	Complies with EMC provision of Radiocommunications Act per the following standard(s): AN/NZS 2064.1/2 Industrial, Scientific, and Medical Equipment: 1992

Performance Verification

Use the following procedures to verify the warranted specifications of the SD-48 Optical-to-Electrical Converter. Before beginning these procedures, see page 21 and photocopy the test record and use it to record the performance test results. The recommended calibration interval is one year.

These procedures test the following specifications:

- Output zero
- DC conversion gain
- Noise equivalent power
- Bandwidth/frequency response (for characterization purposes only)

Equipment Required

Table 3 lists the equipment required to perform the performance verification procedure. The types and quantities of connectors may vary depending on the specific equipment you use.

Table 3: Test equipment

Description	Minimum requirements	Example product
Optical power meter with head and adapters	Accuracy ± 2.5%, dynamic range > 0 dbM to –50 dbM, Max power > 1 mW, calibrated from 700 nm – 1600 nm	HP 8153A with HP 81532A head
1310 nm cal source	output > 200 µW (CW)[1], stability ± 0.1 dB over 5 minutes	BCP 400 A-2XXT-239
1550 nm cal source	output > 200 µW (CW)[1], stability > 0.1 dB over 5 minutes	BCP 400 A-3XXT-239
RF power meter	noise < .1 mV, BW > 4 GHz	HP 436A with power sensor HP 8484A
1300 or 1550 nm impulse generator	pulse width < 2 ps	Calmar Optcom FPL-01 1550 nm impulser
Sampling oscilloscope with sampling head		11K (1180X, CSA80xX with SD-32 sampling head, V-K adapter and rigid cable. Option RR also requires the SD-22 sampling head.)
V–K adapter	for use with SD-32 sampling head	011-0157-00

Table 3: Test equipment (cont.)

Description	Minimum requirements	Example product
Rigid cable	for use with SD-32 sampling head	174-3976-00
Reference receiver for trigger source	trigger signal for sampling oscilloscope	10/90 or 50/50 splitter with ORR24 or P6703B and 1103 TekProbe Power Supply
PC with GPIB port and printer	printer output of sampled waveforms	
Two adjustable single-mode optical attenuators	4 decades, 9 µm core fiber, FC-style connectors	Tektronix OA5002
Digital voltmeter	4 1/2 digit	Keithley 2000 or Tektronix DMM916
50 Ω termination	± 1%	011-0049-01
BNC-to-banana adapter	BNC female to dual banana	103-0090-00
Optical cable (3)	FC-FC singlemode, 9 µm, 2 meters	174-1910-00
Inline optical adapter	FC female to FC female	131-5039-00

1 **CW and modulated mode available: modulation with OFF level at or below 0.1 µW, optical falltime < 1 µs**

The O/E converter under test and the test equipment and should be warmed up for 20 minutes at an ambient temperature between 20 and 30° C.

Output Zero

1. Attach the output of the SD-48 to the voltmeter inputs with a 50 Ω termination and BNC-to-banana adapter.
2. Install the optical dust cover on the input of the SD-48.
3. Check that output voltage is ≤ ± 1 mV. Record the result on the test record.

DC Conversion Gain

NOTE. *Make sure that the optical connector ends of both the fiber from the optical attenuator output and the SD-48 under test input fiber are well cleaned before performing this step. See to the cleaning instructions on page 8.*

1. Connect the 1310 nm laser source to attenuator input.

***NOTE**. The longer wavelengths of 1310 nm and especially 1550 nm in single mode fiber are sensitive to loss in fiber due to bending of the fiber. The fiber bend radius of the SD-48 fiber input should lay with >1.5 inch bend radius along the fiber's entire length. Although this precaution must be maintained throughout the entire performance verification procedure, it is especially important for this step in order to accurately adjust and measure the DC conversion gain of the SD-48.*

2. Connect the optical attenuator output to the optical power meter using single mode optical cable with FC connectors. Use the appropriate optical power meter sensing head with calibrated measurement for a wavelength span including 1310 nm and 1550 nm. Be sure the optical power meter wavelength setting and optical attenuator setting is at 1310 nm. Enable the optical output.

3. Adjust attenuator or the optical source so that the power meter reads 200 μW.

4. Move the FC fiber end (the one now adjusted to 200 μW average power) from the optical power meter and connect it to the SD-48 input under test.

5. Attach voltmeter with 50 Ω termination to SD-48 output.

6. Record the voltmeter reading. The 1310 nm Conversion Gain in units of V/mW is

(voltmeter reading) × 5

7. Record the 1310 nm conversion gain on the test record.

8. Disconnect the 1310 nm laser from the optical attenuator, and reconnect the 1550 nm laser source. Set the optical attenuator to the correct wavelength.

***NOTE**. Do not disturb the fiber connection between the optical attenuator output and the SD-48 input!*

9. Adjust the optical attenuator until the voltmeter reading is the same as in step 6 above ± 1%.

10. Without moving the optical attenuator from the position in the previous step, disconnect the output fiber of the optical attenuator from the input of the SD-48 and insert the optical attenuator output into the optical power meter.

11. Adjust the optical power meter to the calibrated wavelength setting of 1550 nm. Note the absolute power displayed. The 1550 nm conversion gain in units of V/mW_{opt} is

((200 μW) / (measured 1550 power)) × (1310 nm conversion gain)

12. Record the 1550 nm conversion gain on the test record.

Noise Equivalent Power

Power the SD-48 under test using an 11801 DSO.

1. Zero the RF power meter.

2. Connect the SD-48 electrical output to the RF power meter.

3. With the dust cover on the input to the SD-48, the power meter should read less than

$$\frac{[(15\ pW_{opt}\ /\ \sqrt{Hz}\ ) \times \sqrt{18\ GHz} \times (\text{measured conversion gain in } V/W_{opt})]^2}{50\ \Omega}$$

$$= 8.1 \times 10^{-14} \times (\text{measured conversion gain in } V/W_{opt})^2$$

$$= W_{elec}$$

(**NOTE :** $V/W_{opt} = V/mW_{opt} \times 1000$)

Example : $18\ V/W_{opt}$ (*or* $0.018\ V/mW$) = *measured conversion gain*

$$W_{elec} = 8.1 \times 10^{-14} \times (18\ V/W_{opt})^2$$
$$= 2.6 \times 10^{-11}$$
$$= 26\ pW$$

4. Record the measured and calculated results on the test record.

Bandwidth/Frequency Response

***NOTE**. The specifications for bandwidth and frequency response are typical and are not guaranteed. The performance of each and every component of your setup has an affect on the overall performance of your system. This procedure allows you to characterize and plot the performance of your particular setup which includes the channel of your sampling oscilloscope, sampling head, SD-48 O/E Converter, electrical cable, and filter (if any).*

To optimize performance, make sure all connections are properly cleaned and secure and all components of the system are in good condition. Optical fiber, in particular, can gradually degrade the system performance as it is repeatedly flexed over time.

1. Connect the output of the optical impulse generator to the 10 dB inline attenuator, 90/10 splitter, and optical attenuators as shown in Figures 8 and 9. Start with about 30 dB of attenuation on both variable attenuators.

***NOTE**. To avoid dispersing the narrow optical impulse signal, keep all fiber lengths as short as possible. Lengths that are 2 to 3 meters long are acceptable.*

2. To adjust the signal on the 10% path to the proper level you can use another oscilloscope or you can use an optical power meter to measure the output of the attenuator on the 10% path before you connect it to the ORR24.

***NOTE**. The setup necessary to attenuate the signal may vary depending on the specific optical impulse generator you use.*

- **a.** If you are using another oscilloscope to display the trigger signal, adjust the attenuation of the 10% path until the ORR24 produces more than 200 mV_{p-p}, but less than 1 V_{p-p} impulse response.
- **b.** If you are using an optical power meter, connect the output of the optical attenuator on the 10% path to the optical power meter. With a pulse width of ~500 fs and a frequency of 10 MHz, adjust the optical attenuator until the power meter reads about 1 μW average power.

3. Finish connecting the setup as follows:

- **a.** For an SD-48 with the standard configuration, finish connecting the setup as shown in Figure 8. Note that this requires an SD-32 sampling head.

b. For an SD-48 with Option RR (OC-192), connect the equipment as shown in Figure 9. Note that this setup requires an SD-22 sampling head.

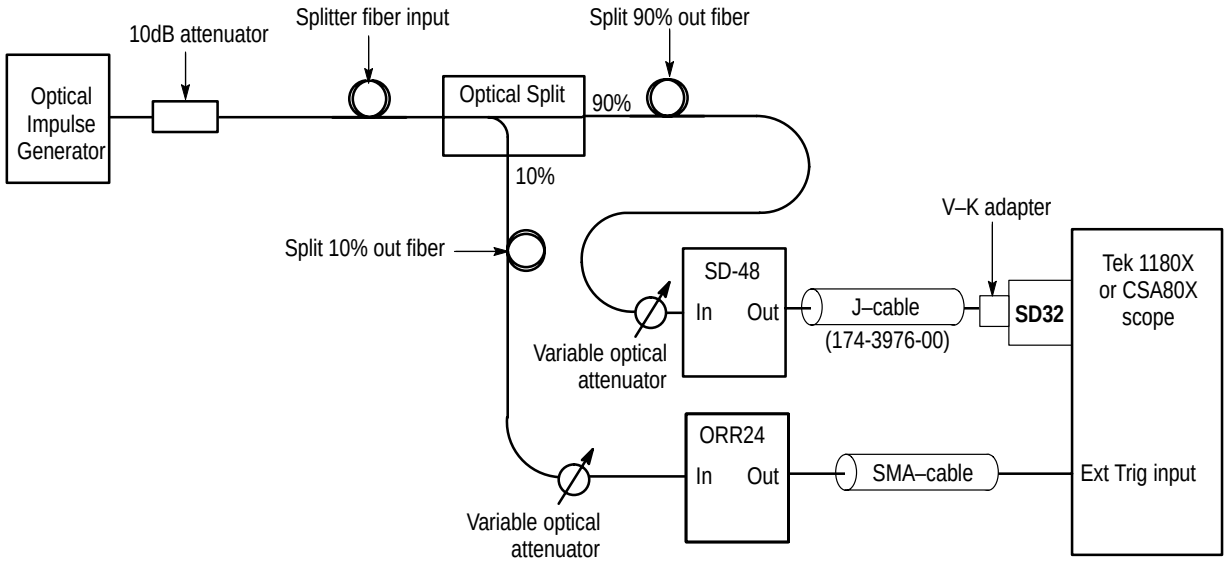

Figure 8: Setup for frequency response measurement, SD-48 standard configuration

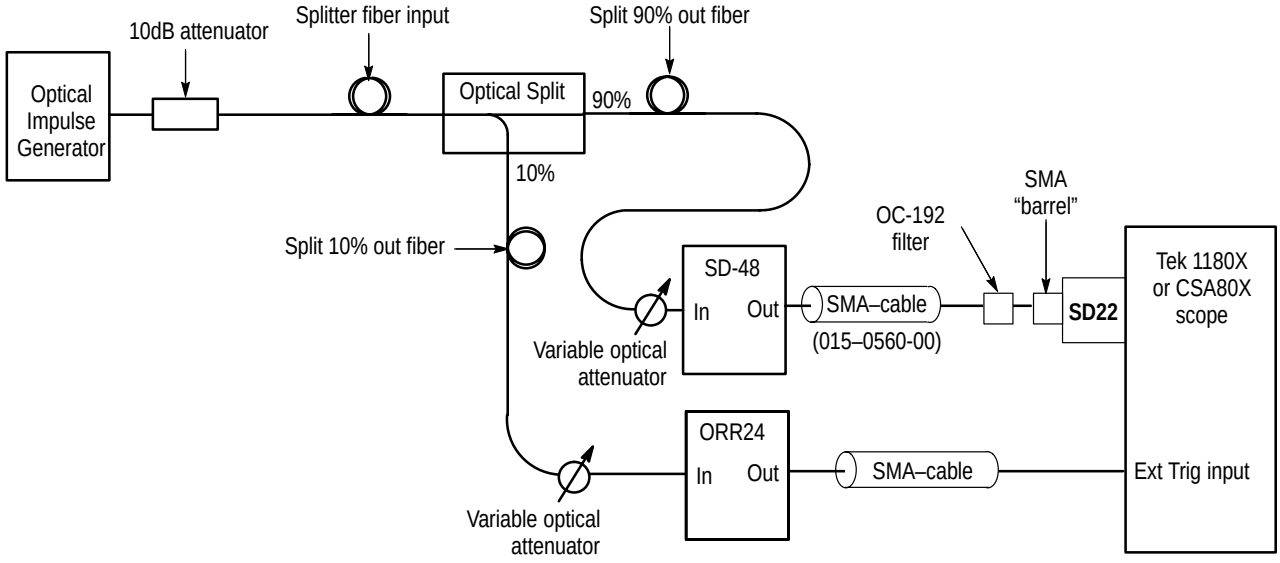

Figure 9: Setup for frequency response measurement, SD-48 Option RR for OC-192

4. Set the trigger point midway on the rising edge of the trigger signal.

5. Adjust the attenuation of the 90% path until the SD-48 produces more than 30 mV_{p-p}, but less than 80 mV_{p-p} impulse response.

6. Locate and center the first impulse (after time zero) on the oscilloscope display. (For a 10 MHz repetition rate, the impulse should occur at about 100 ns. You may experience signal jitter if you try to display a signal that is not the first impulse and is late in relation to time zero.)

7. Finish setting the oscilloscope controls as follows:

   a. For an SD-48 with the standard configuration, set the horizontal time to 50 ps/div, set the vertical controls for maximum screen usage, and set the signal averaging to 64 times and 2048 points.

   b. For an SD-48 with Option RR (OC-192), set the horizontal time to 100 ps/div, set the vertical controls for maximum screen usage, and set the signal averaging to 64 times and 2048 points.

8. Using a controller attached to the scope via GPIB (i.e. a PC, MAC, workstation, etc.) download the waveform.

9. Using the available controller software (i.e. Labview, etc) perform an FFT (Fast Fourier Transform) on the waveform; this transforms the time-domain (1024-point) impulse response to a scalar frequency response.

10. Normalize the FFT result such that DC or low frequency is 0 dB.

11. Plot the frequency response. (Option RR comes with tabular data at discrete frequency points.)

This completes the performance verification procedure.

Test record

Model/Serial Number: _____ Certificate Number: _____

Temperature: _____ RH %: _____

Date of Calibration: _____ Technician: _____

Performance test		Minimum	Measured	Maximum
Output zero		N/A		±1 mV
DC conversion gain	at 1310 nm ± 20 nm	0.015 V/mW		N/A
DC conversion gain	at 1550 nm ± 20 nm	0.015 V/mW		N/A
Noise equivalent power		N/A		_____W_{elec} (calculated)
Bandwidth/frequency response, standard, DC to 30 GHz		N/A	(attach plot[1])	N/A
Bandwidth/frequency response, Option RR (OC-192), DC to 15 GHz		N/A	(attach plot[1])	N/A

1 **Frequency response plots are for characterization purposes only. Specifications for bandwidth and frequency response are typical and are not guaranteed.**

Replaceable Parts

For information about replaceable parts, contact your Tektronix sales representative.

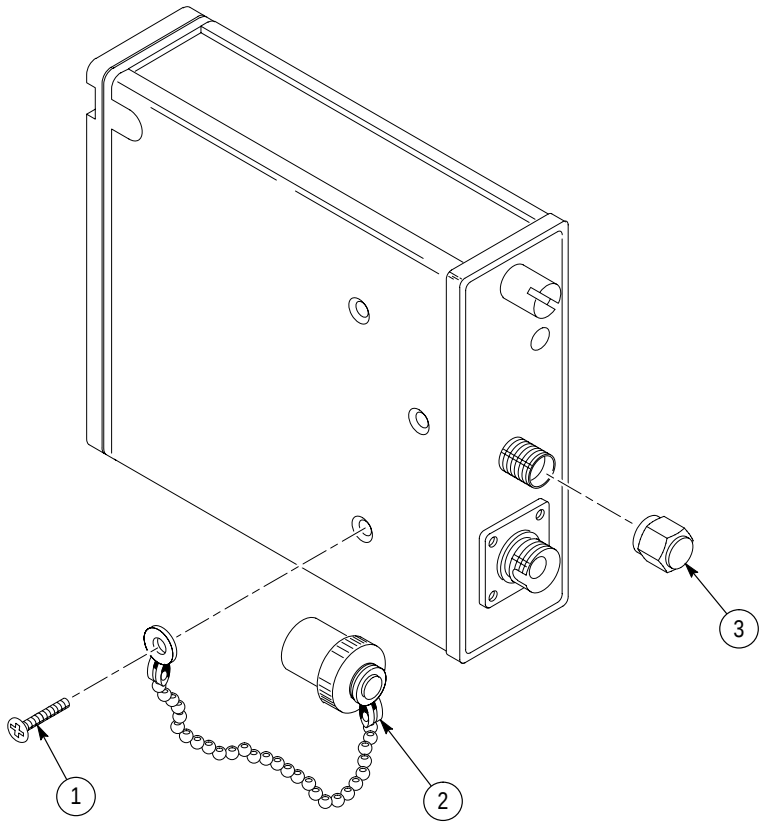

Figure 10: SD-48 replaceable parts

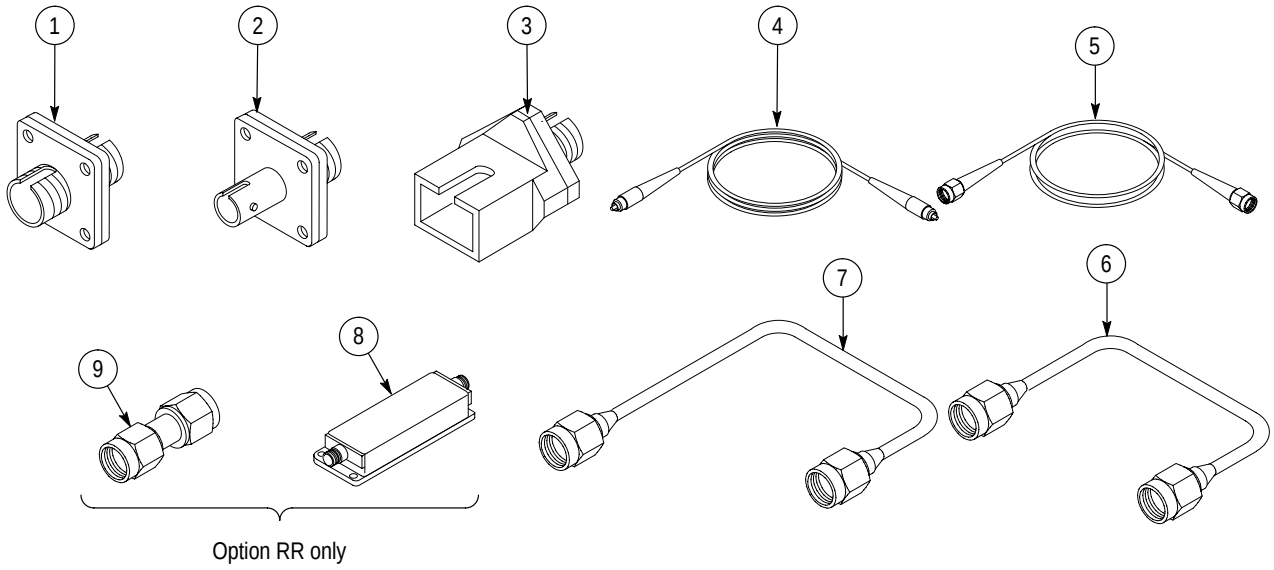

Figure 11: Standard accessories

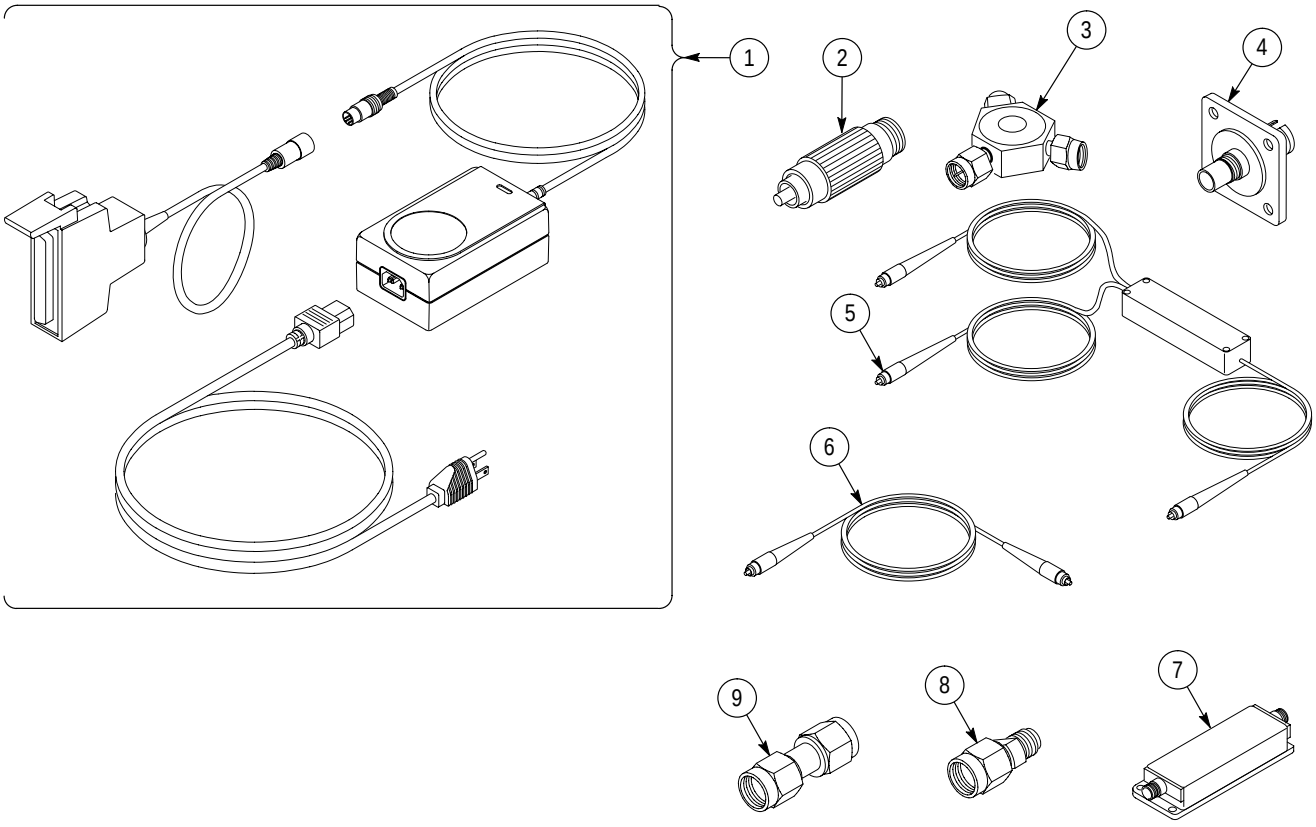

Figure 12: Optional accessories

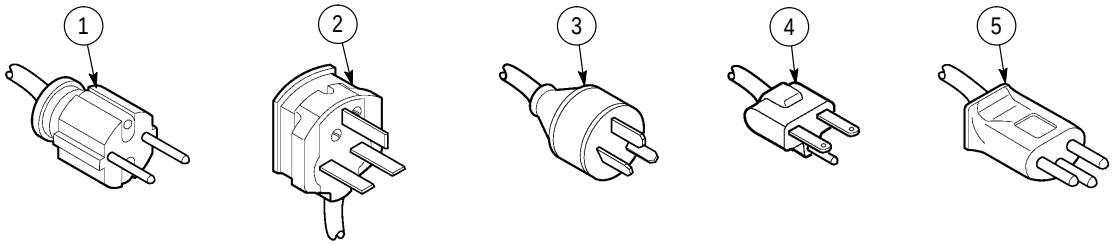

Figure 13: Optional power cords

Replaceable parts list

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
10–1	211–0062–00			1	SCREW,MACHINE:2–56 X 0.312,PNH,STLCD PL,POZ	93907	ORDER BY DESCRIP
–2	200–3658–00			1	COVER,CONNECTOR:FC,W/CHAIN	80009	200–3658–00
–3	015–1020–00			1	TERM,COAXIAL:SHORT CIRCUIT,SMA	0GZV8	64SMA–50–0–1
					Standard accessories		
	071–0207–00			1	MANUAL,TECH:INSTRUCTION	80009	071–0207–00
11–1	131–6252–00			1	CONN:FC TO FC SQUARE MOUNT ADAPTER,W/ZIRCONIA CERAMIC SLEEVE	0C5R7	CO92290
–2	131–6250–00			1	CONN:FC TO ST ADAPTER W/ZIRCONIA CERAMIC SLEEVE	0C5R7	C032980
–3	131–6251–00			1	CONN:SC TO FC SQUARE FLANGE ADAPTER W/ZIRCONIA CERAMIC SLEEVE	0C5R7	C002453
–4	174–1910–00			1	CA ASSY FBR OPT:SM 2ML FC/PC TO FC/PC	05JW7	SGMGM–AA0002
–5	015–0560–00			1	CABLE,DLY,COAX:50 OHM,2NS,W/CONN,SMA,MALE,EACH END	0GZV8	SF104PE,460MM,2X1 1SMA–451
–6	174–3828–00			1	CA ASSY,RF:COAXIAL,RFS,50 OHM, SMA X SMA	060D9	174–3828–00
–7	174–3976–00			1	CA ASSY,RF:SEMI–RIGID,RFS,1,50 OHM,0.141 SEMI–RIGID,(SMA CONN) BOTH ENDS,	060D9	174–3976–00
					Additional accessories with Opt. RR		
–8	119–5916–00			1	FILTER:LOW PASS,OC192 for SD48/SD22	80009	119–5916–00
–9	015–1011–00			1	ADAPTER,CONN:SMA,MALE TO SMA,MALE,SST	16179	2081–0000
					Optional accessories		
12–1	016–1609–00			1	POWER CORD KIT:ADAPTER CABLE & US POWER CORD	80009	016–1609–00
–2	119–5118–00			1	ATTEN,OPTICAL:30MM,L10DBFOR 1310/1550NM,FC CONN.FA100–35–10–HP	0LK97	FA100–35–10–HP
–3	015–0565–00			1	POWER DIVIDER:50 OHM,3 SMA,FEMALE CONN	64537	D293S
	015–1014–00			1	PWR DIVIDER,RES:50 OHM,SMA	64537	D241S
–4	020–2209–00			1	ACCESSORY KIT:CONNECTOR,OPTICAL,DIN RCPT TO FC SQUARE MOUNT ADAPTER,	80009	020–2209–00

Replaceable parts list (cont.)

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
–5	174–3737–00			1	FIBER OPTIC:COUPLER, 1 X 2 SPLITTER, WAVELENGTH INDEPENDENT, 90/10 RATIO, ATT. 0.1 DB, REFLE	0C5R7	C166893
	174–1497–00			1	CA ASSY,FBR OPT:SINGLE MODE,2M L FC/PC TO DIAMOND 2.5	80009	174–1497–00
	174–1385–00			1	CA ASSY,FBR OPT:SGL MODE,2M L,FC/PC DIAMOND3.5	80009	174–1385–00
	174–1386–00			1	CA ASSY,FBR OPT:SINGLE MODE,2M L,FC/PC–ST	80009	174–1386–00
	174–1387–00			1	CA ASSY,FBR OPT:SGL MODE,2M L,FC/PC–FC/PC	80009	174–1387–00
	174–1388–00			1	CA ASSY,FBR OPT:SGL MODE,2M L,FC/PC–BICONIC	80009	174–1388–00
–7	119–5916–00			1	FILTER:LOW PASS, 10GBS	80009	119–5916–00
	119–5929–00			1	FILTER,RFI:LOW PASS,467MHZ –3DB,622.08 MBPS,INS LOSS < 0.02 DB,VMAX=50V,IMAX=1A,50 OHM	80009	119–5929–00
	119–5936–00			1	FILTER,RFI:LOW PASS,117MHZ –3DB,155.52 MBPS,INS LOSS < 0.02 DB,VMAX=50V,IMAX=1A,50 OHM,SDH	80009	119–5936–00
–8	011–0157–00			1	ADPTR,RF,PRCN::2.4MM OR 1.85MM MALE TO 2.92MM FEMALE	20944	34VKF50
–9	015–1011–00			1	ADAPTER,CONN:SMA,MALE TO SMA,MALE,SST	16179	2081–0000
					Optional Power Cords		
13–1	161–0066–09			1	CA ASSY,PWR:3,0.75MM SQ,250V/10A,99 INCH,STR,IEC320,RCPT,EUROPEAN,	2W733	ORDER BY DESCRIPTION
–2	161–0066–10			1	CA ASSY,PWR:3,1.0 MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT X 13A,FUSED UK PLUG(13A FUSE),UNI	TK2541	ORDER BY DESCRIPTION
–3	161–0066–11			1	CA ASSY,PWR:3,1.0MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT,AUSTRALIA	80126	ORDER BY DESCRIPTION
–4	161–0066–12			1	CA ASSY,PWR:3,18 AWG,250V/10A,98 INCH,STR,IEC320,RCPT X NEMA 6–15P,US	S3109	ORDER BY DESCRIPTION
–5	161–0154–00			1	CA ASSY,PWR:3,1.0MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT,SWISS	5F520	86515030

Manufacturers cross index

Mfr. code	Manufacturer	Address	City, state, zip code
05JW7	PURDY ELECTRONICS CORP	INTEROPTIC DIVISION 720 PALOMAR AVE	SUNNYVALE, CA 94086
060D9	UNITREK CORPORATION	3000 COLUMBIA HOUSE BLVD, SUITE 120	VANCOUVER, WA 98661
0C5R7	ALCOA FUJIKURA LTD	150 RIDGEVIEW CIRCLE	DUNCAN, SC 29334
0GZV8	HUBER & SUHNER INC	19 THOMPSON DRIVE	ESSEX JUNCTION, VT 05452–3408
0LK97	JDS FITEL INC	570 WEST HUNT CLUB RD	NEPEAN, ONTARIO CA ONTARIO K2G 5W8
16179	M/A COM INC	1011 PAWTUCKER BLVD. PO BOX 3295	LOWELL, MA 01853–3295
20944	ANRITSU COMPANY	685 JARVIS DRIVE	MORGAN HILLS, CA 95037
2W733	BELDEN WIRE & CABLE COMPANY	2200 US HWY 27 SOUTH PO BOX 1980	RICHMOND, IN 47374
5F520	PANEL COMPONENTS CORP	PO BOX 115	OSKALOOSA, IA 52577–0115
64537	KDI/TRIANGLE ELECTRONICS INC	60 S JEFFERSON RD	WHIPPANY, NJ 07981
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON, OR 97077–0001
80126	PACIFIC ELECTRICORD CO	747 WEST REDONDO BEACH PO BOX 10	GARDENA, CA 90247–4203
93907	CAMCAR DIV OF TEXTRON INC	ATTN: ALICIA SANFORD 516 18TH AVE	ROCKFORD, IL 611045181
S3109	FELLER U.S. CORPORATION	72 VERONICA AVE UNIT #4	SOMERSET, NJ 08873
TK2541	AMERICOR ELECTRONICS LTD	UNIT–H 2682 W COYLE AVE	ELK GROVE VILLAGE, IL 60007