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**Instruction Manual**

Tektronix

# ORS20
# Optical Receiver System

**071-0423-00**

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# 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.



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**Symbols on the Product.** The following symbols appear on the product:



CAUTION
Static Sensitive



CAUTION
Refer to Manual



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# Contacting Tektronix

| | |
|---|---|
| Product Support | For application-oriented questions about a Tektronix measurement product, call toll free in North America:<br>1-800-TEK-WIDE (1-800-835-9433 ext. 2400)<br>6:00 a.m. – 5:00 p.m. Pacific time<br><br>Or contact us by e-mail:<br>tm_app_supp@tek.com<br><br>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.<br><br>http://www.tek.com |
| For other information | In North America:<br>1-800-TEK-WIDE (1-800-835-9433)<br>An operator will direct your call. |
| To write us | Tektronix, Inc.<br>P.O. Box 1000<br>Wilsonville, OR 97070-1000 |



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# Getting Started

The ORS20 is an optical receiver system that is precisely calibrated to have a controlled frequency response for consistently analyzing time domain optical signals at Fiber Channel (1063 Mb/s), Gigabit Ethernet (1250 Mb/s), or SONET/SDH OC-48/STM-16 (2.488 Gb/s). Along with the appropriate sampling head, the ORS20 reference receiver can test the compliance of optical signals to these data rates.

Figure 1 shows the front panel of the ORS20 Optical Receiver System.

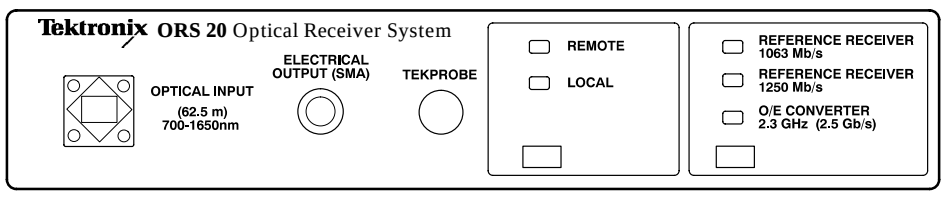



**Figure 1: ORS20 Front Panel**

The ORS20 Optical Receiver System has an SC/PC (standard) or FC/PC receptacle (option 01) for optical signal input and a precision 3.5 mm SMA connector for electrical signal output.

The following list highlights the key performance characteristics of the ORS20 Optical Receiver System:

- 700 to 1650 nm wavelength response
- 2.3 GHz Minimum Optical Bandwidth
- Selectable to Fourth Order Bessel-Thompson, 1063 Mb/s, 1250 Mb/s, and 2.488 Gb/s frequency responses
- Conversion gain ≥ 0.4 V/mW at 850 nm, ≥ 0.6 V/mW at 1310 nm

For a complete list of specifications, see page 9.



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## Standard Accessories

The following accessories are standard with every ORS20 Optical Receiver System:

- User Manual/Instructions 071-0423-XX
- US power cord 161-0066-00
- 50 Ω, flexible coaxial jumper, male SMA-to-SMA connector 015-0560-00
- FC 1063 MHz Reference Receiver frequency response graph
- GBE 1250 MHz Reference Receiver frequency response graph
- Certificate of traceable calibration

For a list of replaceable part numbers, see page 32.

## Options

The following options are available at the time of purchase:

- Opt 01 — FC-PC front panel connector
- Opt FR — 2.488 Gb/s OC48 Reference Receiver frequency response graph
- Opt D1 — Calibration data
- Opt C3 — Three years calibration services
- Opt D3 — Three years calibration data (requires option C3)
- Opt R3 — Three years extended warranty



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## Optional Accessories

The following recommended accessories are available through Tektronix:

- Fiber-optic cables and adapters with a variety of fiber types and connector styles
- SONET/SDH 155 Mb/s filter 119-5936-00
- SDH 622 Mb/s filter 119-5929-00
- TEKPROBE Interface Adapter Kit
- 90/10 single-mode optical splitter with FC/PC connectors
- 10 dB in-line single-mode optical attenuator
- Power Plug Options A1, A2, A3, A4, A5
- TVG F11A Single rackmount kit
- TVG F13 Dual rackmount kit
- TVG F14 Dual half-rack rackmount kit

For a list of part numbers, see page 32.



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## Installation



***CAUTION.*** *The output of the Optical Receiver System 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 50 Ω 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.*

***NOTE****. To guarantee compliance with FC, GBE, or OC-48 boundary limits, you must connect the ORS20 Optical Receiver System to the input of an SD-22 sampling head using the 015-0560-00 cable provided. The ORS20 Optical Receiver System is designed for the electrical characteristics of the cable and the particular frequency response and low noise of the SD-22. Test temperatures must be 20 to 35°C.*

Use the following procedure to connect the Optical Receiver System to a Tektronix 11801/CSA803 sampling oscilloscope:

1. Switch off the instruments.
2. Follow anti-static precautions and connect the output of the Optical Receiver System to the input of the SD-22 sampling head with the 015-0560-00 cable provided:
   a. Align the SMA connectors carefully.
   b. Use light, finger pressure to turn the nut. *Do not* turn the cable.
   c. Tighten the 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).
3. Connect an optical source, such as a Tektronix OIG 501/502 Optical Impulse Generator or CTS 710/750 SONET Test Set, with an input cable to the optical input on the ORS20 Optical Receiver System.
4. Switch on the instruments.



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# Operating Basics

Figure 1 on page 1 shows the front panel of the ORS20 Optical Receiver System. The ORS20 Optical Receiver System has an SC/PC receptacle (FC/PC opt. 01) for optical signal input and a precision 3.5 mm connector for electrical signal output.

## Handling

Handle the ORS20 Optical Receiver System carefully at all times.



***CAUTION.*** *To avoid damaging the ORS20 Optical Receiver System, take the following precautions:*

*Do not drop the Optical Receiver System since damage and misalignment of the photodiode optical assembly can result. Store the Optical Receiver System in a secure location when not in use.*

*Replace the protective caps on the input and output connectors when the Optical Receiver System is not in use.*



***WARNING.*** *Do not look directly into any optical output port. Laser light can be harmful to your eyes.*

## 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 of 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.*



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### 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 several suppliers.*

## Connecting Signals

Attach the fiber optic cable with an SC or FC connector to the SC or FC input receptacle as follows:

1. Carefully align the keyway on the receptacle with the key on the connector.
2. For the FC/PC connector (Opt. 01), tighten the nut lightly with finger pressure only.

The input of the ORS20 Optical Receiver System can couple to optical fibers with a core diameter of up to 62.5 µm. Alternate types can be coupled by use of fiber jumper cables and hybrid fiber connectors. (Refer to *Optional accessories* on page 34.)



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



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If you connect fiber cores larger than 62.5 μm, the reference receiver may still couple light, but the mismatch in core diameter will cause lower conversion gain and high insertion loss.

***NOTE**. Fiber cores smaller than 62.5 μm will work properly. For example, single-mode fiber input is compatible with the ORS20 Optical Receiver System.*

## Attenuating Optical Signals

When using the ORS20 Optical Receiver System as a reference receiver, it may be necessary to attenuate the optical signals.



***CAUTION.** To avoid damaging the optical input of the ORS20 Optical Receiver System , attenuate optical signals to less than 5 mW average power or 10 mW peak power.*

For linearity and measurement accuracy, attenuate the peak-to-peak swing of signal to within the specified performance of ≤200 mV p-p voltage swing at the output. The optical swing this corresponds to depends on the wavelength of the signal being input and the conversion gain of the ORS20 Optical Receiver System at that wavelength.

Example:

1. You want to look at an 1310 nm, OC-48 eye-pattern signal whose average power (un-attenuated) is about +2 dBm. The average optical power of the +2 dBm signal is equal to 1584 μW.

2. For optical signals with a 50% duty cycle, the average power is approximately one half of the peak-to-peak swing for high extinction ratio signals. This means that the peak-to-peak value of the optical signal is approximately

   2 x 1584 μW = 3168 μW p-p

3. If the conversion gain of the ORS20 Optical Receiver System is 0.90 V/mW, then this level of optical input would correspond to a voltage output swing of 3168 μW p-p. 0.90V/1000 μW = 2534 mV p-p (but the system would typically saturate at 800 mV p-p).

4. To lower the signal to within the 200 mV p-p linear output range, the signal must be attenuated by 2534 mV / 200 mV = 12.67; this ratio is equal to about 11 dB of optical attenuation.



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To attenuate the optical signal to the proper level, use a Tektronix OA5022 Optical Attenuator. (If single-mode fiber is used to the ORS20 Optical Receiver System input, use a Tektronix OA5002 Optical Attenuator.)

***WARNING.*** *Do not look directly into the optical output port. Laser light can be harmful to your eyes.*

## TEKPROBE Adapter

The TEKPROBE adapter allows you to use the ORS20 Optical Receiver System with any TEKPROBE-compatible oscilloscope. When the ORS20 Optical Receiver System is connected to a TDS Series DSO, the units displayed will automatically be converted to watts, and the vertical scaling will automatically be adjusted for the conversion gain at 850 nm.

Figure 2 shows a typical setup using the TEKPROBE adapter.

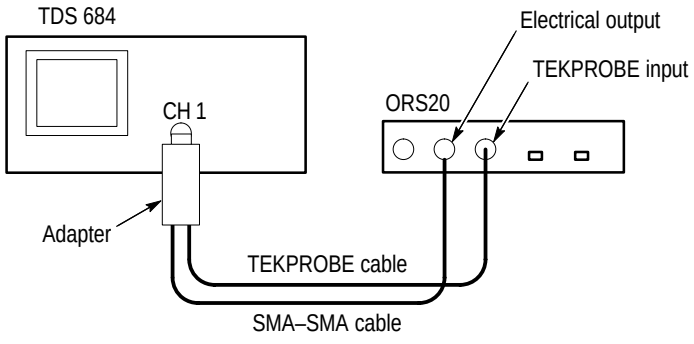



**Figure 2: TEKPROBE adapter setup**



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# Specifications

This section contains the specifications of the ORS20 Optical Receiver System. 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 17.

**Table 1: Specifications**

| Specification | Description |
|---|---|
| Effective wavelength range, typical | 700 nm to 1650 nm |
| ✓ DC conversion gain, minimum | > 0.35 V / mW at 780 nm ± 20 nm<br>> 0.40 V / mW at 850 nm ±20 nm<br>≥ 0.600 V / mW at 1310 nm ± 20 nm<br>≥ 0.500 V / mW at 1550 nm ± 20 nm |
| DC conversion gain, typical | > 0.850 V / mW at 1310 nm ± 20 nm |
| Relative responsivity, typical | See Figure 3 on page 11 |
| DC conversion gain linearity, typical | < 3% deviation in DC conversion gain from 25 µW to 500 µW average optical input relative to conversion gain with 250 µW average optical power input |
| Absolute maximum nondestructive optical input | 5 mW average power; 10 mW peak power at wavelength with highest relative responsivity |
| ✓ Bandwidth | DC to 2.3 GHz (≥ – 6 dB electrical output into 50 Ω) |
| Frequency Response<br>( +20° C to +35° C) | Scalar frequency response of optical-to-electrical conversion (as measured at the electrical output) falls within the Fiber Channel 1063 Mb/s, Gigabit Ethernet 1250 Mb/s, and SONET OC-48 and SDH STM-16, 2.488 Gb/s industry standards (Bessel-Thompson reference receiver boundary limits)[1] (for ≤ 200 mV p-p output modulation depth) |
| Internal Fiber diameter | core: 62.5 µm multi-mode fiber<br>cladding: 125 µm |
| Fiber connector style | female SC/PC, (FC/PC Opt 01) |
| Optical return loss | > 14 dB minimum when external mating fiber is also PC style |
| ✓ Noise equivalent power | ≤ 15 pW/$\sqrt{\text{Hz}}$ electrical output noise when terminated into 50 Ω |
| Rise time (min-max) | 166 ps – 204 ps OC-48, 389 ps – 479 ps FC, 331 ps – 406 ps GBE |
| Aberrations | ≤ $5\%_{p\text{-}p}$ total |
| ✓ Output zero | ≤ ± 1.0 mV at 20° C to 30° C and ≤ ± 2.0 mV outside this range (optical input must be zero) |
| External Termination impedance | 50 Ω ± 2 Ω |

1 **A 4th order Bessel Thompson response for a SONET/SDH 2.488 Gb/s data rate receiver should have a nominal –3 dB at 1.87 GHz for OC48, 937 MHz for GBE, and 797 MHz for FC. At a nominal–5.7 dB; 2.488 GHz for OC48, 1250 MHz for GBE, and 1063 MHz for FC.**



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**Table 1: Specifications (cont.)**

| Specification | Description |
|---|---|
| Temperature | Operating: 0° C to +50° C<br>(frequency responses are only guaranteed from +20° C to +35° C)<br>Non-operating: –55° C to +75° C |
| Humidity | Operating: 20% to 80% relative humidity at or below +33° C<br>Non-operating: 5% to 90% relative humidity at or below +31° C |
| Altitude | Operating: 3,000 m (10,000 ft)<br>Non-operating: 12,190 m (40,000 ft) |

**Table 2: Certifications and compliances**

| Category | Standards or description |
|---|---|
| EC Declaration of Conformity – Low Voltage | Compliance was demonstrated to the following specification as listed in the Official Journal of the European Union:<br>Low Voltage Directive 73/23/EEC, amended by 93/69/EEC<br>EN 61010-1:1993 / A2 1995 Safety requirements for electrical equipment for measurement control and laboratory use. |
| 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:<br>EN 55011 Class A Radiated and Conducted Emissions<br>IEC 1000-3-2 AC Power Line Harmonic Emissions<br>EN 50082-1 Immunity:<br>IEC 1000-4-2 Electrostatic Discharge Immunity<br>IEC 1000-4-3 RF Electromagnetic Field Immunity<br>IEC 1000-4-4 Electrical Fast Transient/Burst Immunity<br>IEC 1000-4-5 Power Line Surge Immunity<br>IEC 1000-4-6 Conducted RF Immunity<br>IEC 1000-4-11 Voltage Dips/Interruptions Immunity |
| Approvals | UL3111-1 Standard for electrical measuring and test equipment.<br>CAN/CSA C22.2 No. 1010.1 Safety requirements for electrical equipment for measurement, control, and laboratory use. |
| Installation (Overvoltage) Category | Terminals on this product may have different installation (overvoltage) category designations. The installation categories are:<br>CAT III Distribution-level mains (usually permanently connected). Equipment at this level is typically in a fixed industrial location.<br>CAT II Local-level mains (wall sockets). Equipment at this level includes appliances, portable tools, and similar products. Equipment is usually cord-connected.<br>CAT I Secondary (signal level) or battery operated circuits of electronic equipment. |



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**Table 3: Maximum Output Modulation Depth[1]**

| Path and 2x data rate frequency | ≤ 1 dB compression occurs at: |
|---|---|
| 1063 Mb/s, 2.12 GHz | 500 mV p-p |
| 1250 Mb/s, 2.50 GHz | 450 mV p-p |
| Full BW, 2.5 Gb/s, 5 GHz | 400 mV p-p |

1 **Output swings greater than 700 mV p-p can completely saturate the output amplifier**

Compression: this term is referring to the additional frequency response loss typically experienced when large signal swings are present at the output (as opposed to 200 mV p–p or smaller swings). These losses are in addition to the frequency response rolloff characteristics already inherent in the system for small signal output swings.

The ORS20 Optical Receiver System is an amplified O/E converter, and as such the internal active amplifier has output drive limitations. The maximum input optical peak-to-peak power can be estimated by using the known V/W conversion gain at the particular wavelength of interest.

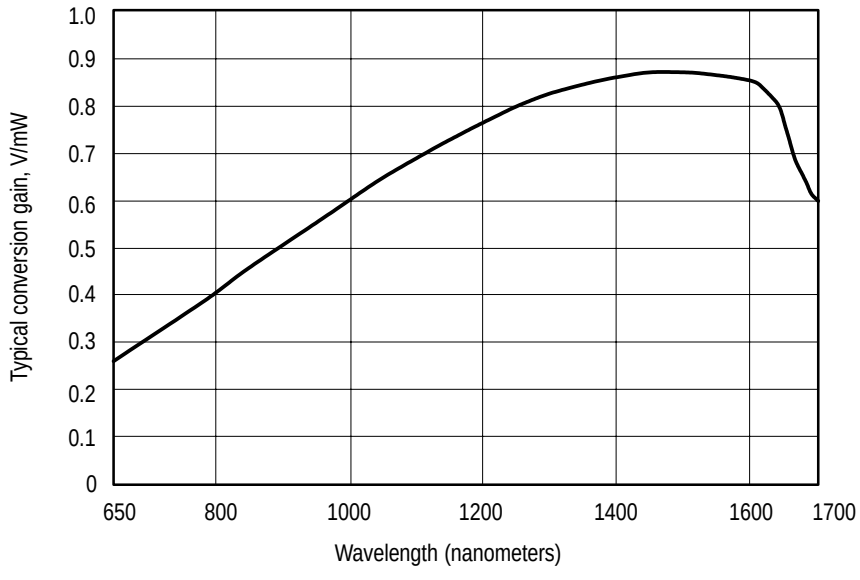



**Figure 3: Typical ORS20 responsivity**



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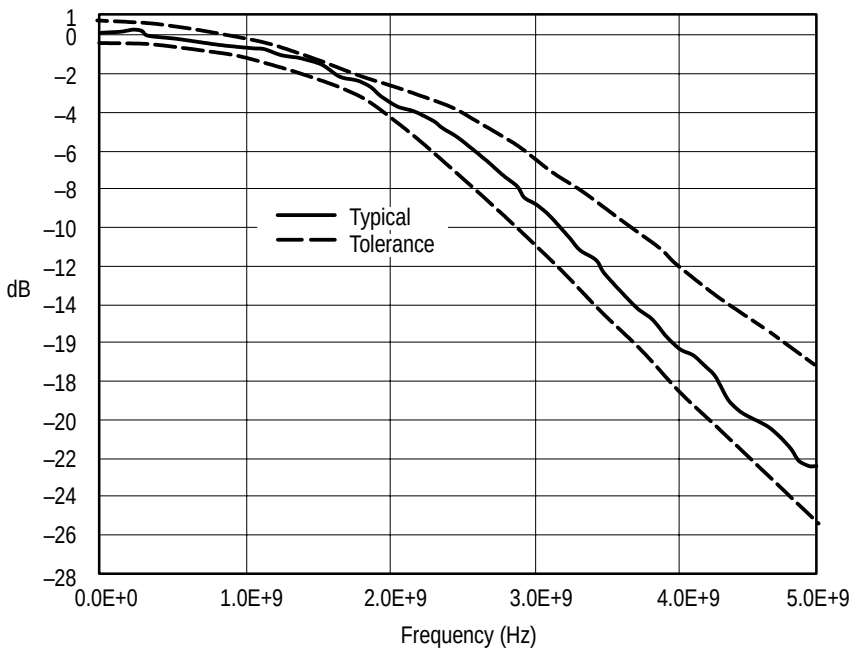



**Figure 4: OC48 2488 Mb/s typical frequency response curve**

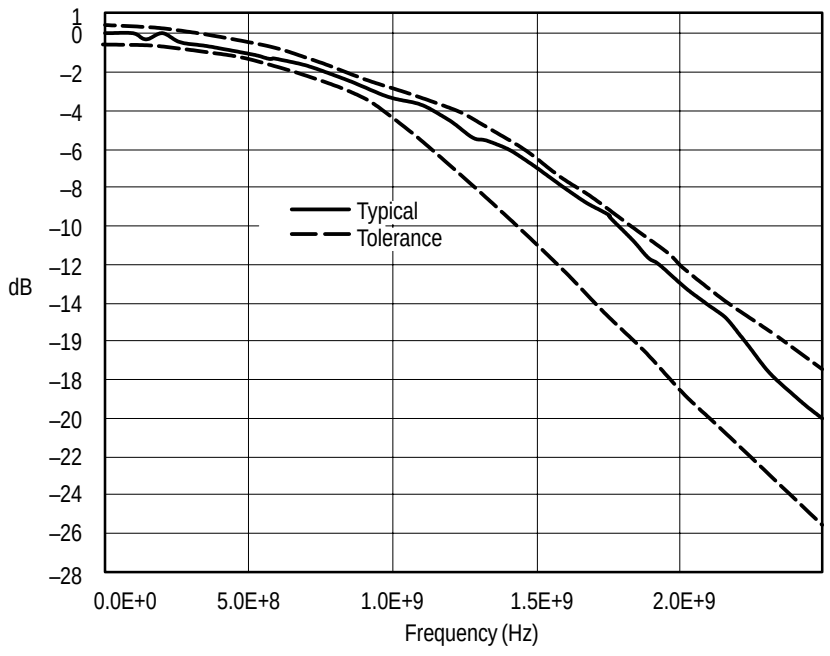



**Figure 5: GBE 1250 Mb/s typical frequency response curve**



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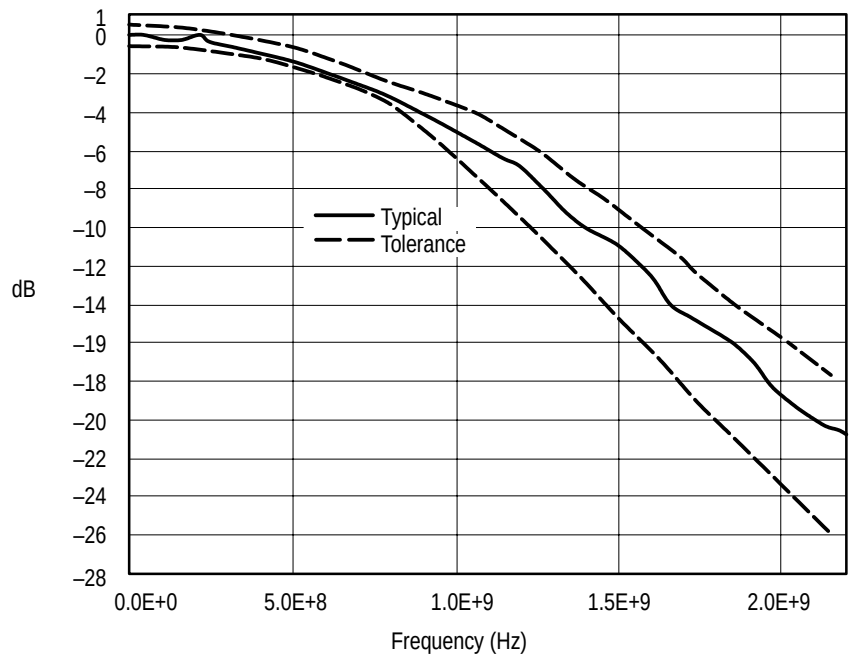
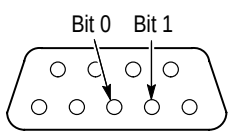



**Figure 6: FC 1063 Mb/s typical frequency response curve**




All other pins are connected to instrument GND.

| Bit 0 | Bit 1 | Path selected |
|---|---|---|
| L | L | FC |
| L | H | OC48 (2.3 GHz Bandwidth) |
| H | L | GBE |
| H | H | OC48 (2.3 GHz Bandwidth) |

High ≥ 2.0 V Min.
Low ≤ 0.8 V Max.

**Figure 7: TTL remote control connector pin assignment**



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Specifications



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**WARNING**

***The following servicing instructions are for use only by qualified personnel. To avoid injury, do not perform any servicing other than that stated in the operating instructions unless you are qualified to do so. Refer to all safety summaries before performing any service.***

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# Performance Verification

Use the following procedures to verify the warranted specifications of the ORS20 Optical Receiver System. Before beginning these procedures, see page 27; 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

## Equipment Required

Table 4 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 4: Test equipment**

| Description | Minimum requirements | Example product |
|---|---|---|
| Optical power meter with head and adapters | Accuracy ± 3%,<br>Dynamic range > 0 dbM to –50 dbM,<br>Max power > 1 mW, calibrated from 700 nm – 1600 nm | Tektronix TFC 200 with opt. 21 & 28 |
| 780 nm cal source | output > 200 µW (CW)[1],<br>stability > 0.1 dB over 5 minutes | BCP 400 A-0XXT-239 |
| 850 nm cal source | output > 200 µW (CW)[1],<br>stability > 0.1 dB over 5 minutes | BCP 400 A-1XXT-239 |
| 1310 nm cal source | output > 200 µW (CW)[1],<br>stability ± 0.1 dB over 5 minutes | BCP 400 A-2XXT-239 |
| 1550 nm cal source | output > 200 µW (CW)[1],<br>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 |



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**Table 4: Test equipment (cont.)**

| Description | Minimum requirements | Example product |
|---|---|---|
| 850 nm, 1310 nm, or 1550 nm impulse generator | pulse width < 2 ps | Calmar Optcom FPL-01<br>1550 nm impulser<br>Tektronix OIG 501<br>850 nm impulser<br>Tektronix OIG 502<br>1310 nm impulser |
| Sampling oscilloscope with sampling head | | 11K (1180X, CSA80xX with SD-22 sampling head, V-K adapter and rigid cable. |
| Simi–Rigid cable | for use with SD-22 sampling head | 015-0560-00 |
| 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 | |
| Adjustable single-mode optical attenuator | 4 decades, 9 µm core fiber, FC-style connectors | Tektronix OA5002 |
| Adjustable multi-mode optical attenuator | 4 decades, 9 µm core fiber, FC-style connectors | Tektronix OA5022 |
| Digital voltmeter | 4 1/2 digit | Tektronix TX3, TX1 or Keithley 2000 |
| 50 Ω termination | ± 1% | 011-0049-01 |
| BNC-to-banana adapter | BNC female to dual banana | 103-0090-00 |
| Optical cable (3) | FC-FC multimode | 174-2322-00<br>174-4093-00 |
| 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**

## Setup For PV

1. The ORS20 and the test equipment should be warmed up for 20 minutes at an ambient temperature between 20 and 30° C.
2. Set the ORS20 to **LOCAL** by pushing the interface button until the LED next to **LOCAL** is lit.
3. Set the ORS20 to full bandwidth by pushing the mode button until the LED next to **O/E CONVERTER** is lit.



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## Output Zero

1. Attach the output of the ORS20 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 ORS20.
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 input fiber for the ORS20 under test are well cleaned before performing this step. See the cleaning instructions on page 5.*

1. Connect the 780 nm laser source to the multi-mode attenuator input.

***NOTE.*** *The longer wavelengths of 1310 nm and especially 1550 nm are sensitive to loss in fiber due to bending of the fiber. The fiber bend radius of the ORS20 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 measure the DC conversion gain of the ORS20.*

2. Connect the optical attenuator output to the optical power meter using multi-mode optical cable with FC connectors. Use the appropriate optical power meter sensing head with calibrated measurement for a wavelength span including 780 nm, 850 nm, 1310 nm, and 1550 nm. Verify the optical power meter wavelength setting and the optical attenuator setting is at 780 nm. Enable the optical output.
3. Adjust the 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 ORS20 input under test.
5. Attach a voltmeter with 50 Ω termination to the ORS20 output.
6. Record the voltmeter reading. The 780 nm Conversion Gain in units of V/mW is

   *(voltmeter reading)* × *5*
7. Record the 780 nm conversion gain on the test record.



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**8.** Disconnect the 780 nm laser from the optical attenuator, and reconnect the 850 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 ORS20 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 ORS20 and insert the optical attenuator output into the optical power meter.

**11.** Adjust the optical power meter to the calibrated wavelength setting of 850 nm. Note the absolute power displayed. The 850 nm conversion gain in units of $V/mW_{opt}$ is

*((200 µW) / (measured 850 power)) × (780 nm conversion gain)*

**12.** Record the 850 nm conversion gain on the test record.

**13.** Disconnect the 850 nm laser from the optical attenuator, and reconnect the 1310 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 ORS20 input.*

**14.** Adjust the optical attenuator until the voltmeter reading is the same as in step 11 above, ± 1%.

**15.** 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 ORS20 and insert the optical attenuator output into the optical power meter.

**16.** Adjust the optical power meter to the calibrated wavelength setting of 1310 nm. Note the absolute power displayed. The 1310 nm conversion gain in units of $V/mW_{opt}$ is

*((200 µW) / (measured 1310 power)) × (780 nm conversion gain)*

**17.** Record the 1310 nm conversion gain on the test record.

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



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***NOTE**. Do not disturb the fiber connection between the optical attenuator output and the ORS20 input!*

**19.** Adjust the optical attenuator until the voltmeter reading is the same as in step 16 above, ± 1%.

**20.** 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 ORS20 and insert the optical attenuator output into the optical power meter.

**21.** 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)) × (780 nm conversion gain)*

**22.** Record the 1550 nm conversion gain on the test record.

## Noise Equivalent Power

**1.** Power on the ORS20 under test.

**2.** Zero the RF power meter.

**3.** Connect the ORS20 electrical output to the RF power meter.

**4.** With the dust cover on the input to the ORS20, the power meter should read less than

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

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

$$= W_{elec}$$

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

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

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

**5.** Record the measured and calculated results on the test record.



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## Bandwidth/Frequency Response (Using OIG501/502)

***NOTE**. The performance of 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, the sampling head, the ORS20 O/E Converter, and the electrical cable.*

*To optimize performance, make sure that all connections are clean and secure and that 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 setup as shown in Figure 8. Note that this requires an SD-22 sampling head.

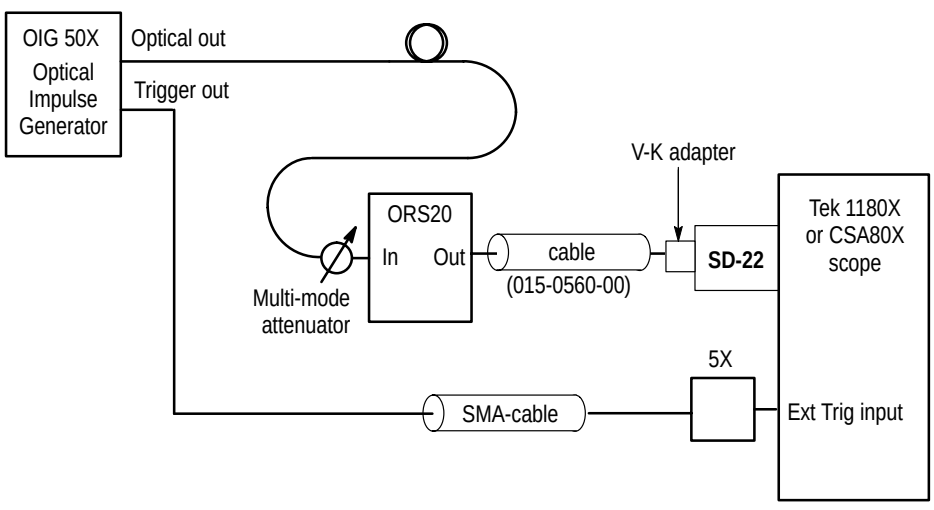



**Figure 8: Setup for frequency response measurement using OIG 501/502**

2. Set the trigger point for negative slope, + 200 mV.
3. Adjust the attenuation of the OIG until the ORS20 produces more than 30 mV p-p, but less than 80 mV p-p impulse response.
4. 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.)



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Finish setting the oscilloscope controls as follows:

**5.** 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.

**6.** Using a controller attached to the scope via GPIB (for example, a PC, MAC, workstation, etc.) download the waveform.

**7.** Using the available controller software (for example, 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.

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

**9.** Plot the frequency response.

**10.** Check that the frequency response from DC to 2.3 GHz is greater than or equal to –6 dB, where dB = 20log ($V_{log}/V_{dc}$) for electrical power into 50 Ω.

**11.** Check that the frequency response from DC to 4.98 GHz is within the OC–48 boundary limits defined in ITU–T G.957.

**12.** Set the ORS20 to 1063 RR mode by pushing the mode button until the LED next to **REFERENCE RECEIVER 1063 Mb/s** is lit.

**13.** Repeat steps 5 to 11 above.

**14.** Check that the frequency response from DC to 2.126 GHz is within the Fiber Channel boundary limits defined in ANSI FC–PH.

**15.** Set the ORS20 to 1250 RR mode by pushing the mode button until the LED next to **REFERENCE RECEIVER 1250 Mb/s** is lit.

**16.** Repeat steps 5 to 11 above.

**17.** Check that the frequency response from DC to 2.5 GHz is within the GBE boundary limits defined in IEEE P802.3Z.

This completes the performance verification procedure.



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## Bandwidth/Frequency Response (Using Calmar FPL-01)

***NOTE**. The performance of 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, the sampling head, the ORS20 O/E Converter, and the electrical cable.*

*To optimize performance, make sure that all connections are clean and secure and that 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 Figure 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. Before you connect the attenuator to the ORR24, you must adjust the signal on the 10% path to the proper level. To measure the output of the attenuator on the 10% path, you can use another oscilloscope or you can use an optical power meter.

   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 shown in Figure 9. Note that this requires an SD-22 sampling head.



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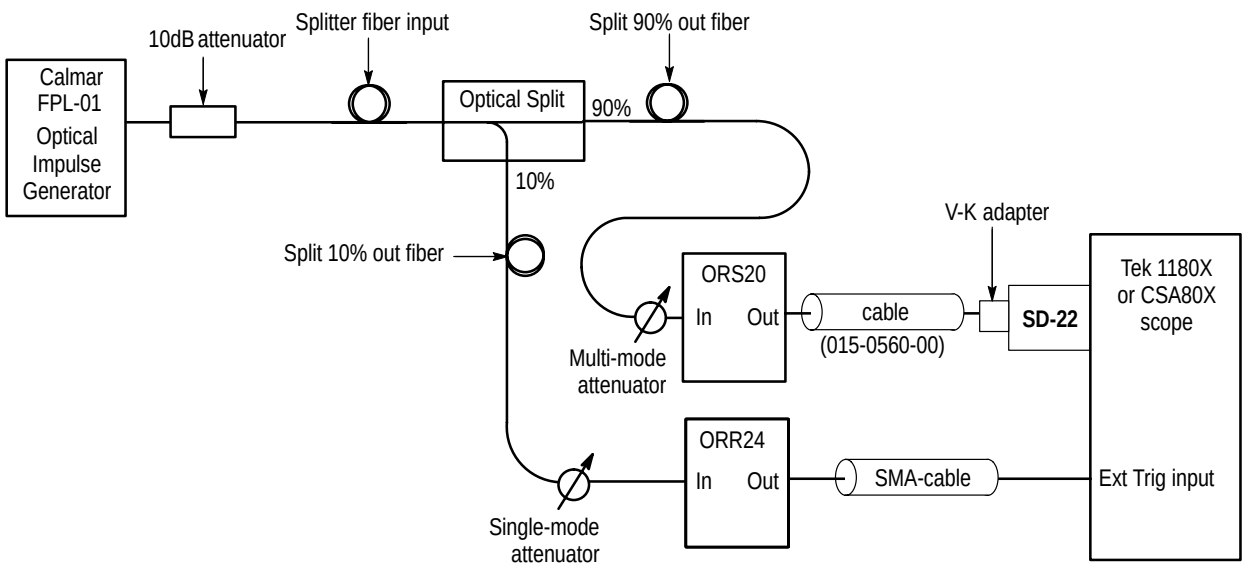



**Figure 9: Setup for frequency response measurement using Calmar FPL-01**

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

**5.** Adjust the attenuation of the 90% path until the ORS20 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.)

Finish setting the oscilloscope controls as follows:

**7.** 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 (for example, a PC, MAC, workstation, etc.) download the waveform.

**9.** Using the available controller software (for example, 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.

**12.** Check that the frequency response from DC to 2.3 GHz is greater than or equal to –6 dB, where dB = 20log ($V_{log}/V_{dc}$) for electrical power into 50 Ω.



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13. Check that the frequency response from DC to 4.98 GHz is within the OC–48 boundary limits defined in ITU–T G.957.

14. Set the ORS20 to 1063 RR mode by pushing the mode button until the LED next to **REFERENCE RECEIVER 1063 Mb/s** is lit.

15. Repeat steps 5 to 11 above.

16. Check that the frequency response from DC to 2.126 GHz is within the Fiber Channel boundary limits defined in ANSI FC–PH.

17. Set the ORS20 to 1250 RR mode by pushing the mode button until the LED next to **REFERENCE RECEIVER 1250 Mb/s** is lit.

18. Repeat steps 5 to 11 above.

19. Check that the frequency response from DC to 2.5 GHz is within the GBE boundary limits defined in IEEE P802.3Z.

This completes the performance verification procedure.



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## Test record

Model/Serial Number: _____ Certificate Number: _____

Temperature: _____ RH %: _____

Date of Calibration: _____ Technician: _____

| Performance test | | Minimum | Measured | Maximum |
|---|---|---|---|---|
| Output zero | | – 1 mV | | + 1 mV |
| DC conversion gain | at 780 nm ± 20 nm | 0.35 V/mW | | N/A |
| DC conversion gain | at 850 nm ± 20 nm | 0.40 V/mW | | N/A |
| DC conversion gain | at 1310 nm ± 20 nm | 0.60 V/mW | | N/A |
| DC conversion gain | at 1550 nm ± 20 nm | 0.50 V/mW | | N/A |
| Noise equivalent power | | N/A | | _____$W_{elec}$ (calculated) |
| Bandwidth DC to 2.3 GHz | | – 6 dB | (attach plot) | N/A |
| OC–48 Reference Receiver Compliance | | N/A | (attach plot) | N/A |
| FC Reference Receiver Compliance | | N/A | (attach plot) | N/A |
| GBE Reference Receiver Compliance | | N/A | (attach plot) | N/A |



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# Fuse Removal and Replacement

This section explains how to remove and replace the power supply fuse. All field replaceable parts are listed in *Replaceable Parts*, which begins on page 32.

***WARNING.*** *Disconnect the power cord from the instrument before attempting any disassembly procedures.*

## Required Tools

The following tools are required to replace the fuse.

**Table 5: Required tools for fuse removal and replacement**

| Name | Description |
|---|---|
| Screwdriver handle | Accepts POZIDRIV bits |
| Torque driver | Accepts POZIDRIV bits; can be set up to 4ft-lb |
| POZIDRIV tip | POZIDRIV bit for screw heads |

## Fuse Replacement

To replace the power supply fuse:

1. Remove the 8 screws from the top cover. See Figure 10.
2. Carefully lift the top cover off the bottom cover assembly.



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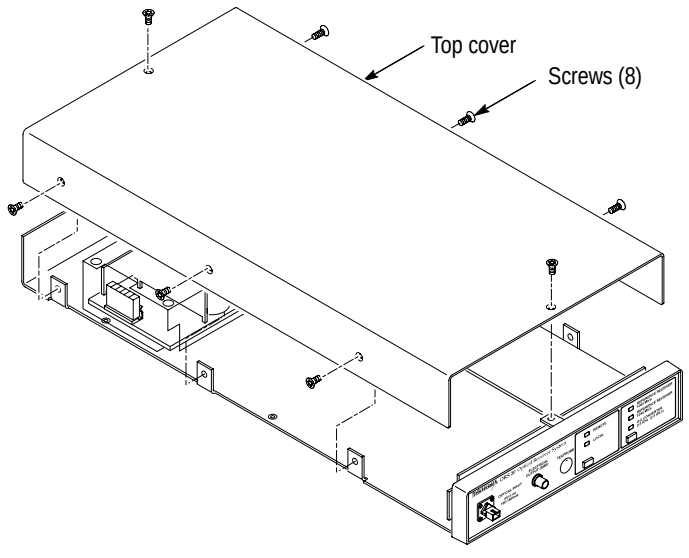



**Figure 10: Removing the top cover**

Refer to Figure 11 for the following steps:

3. Disconnect the power supply cable from the power supply.
4. Disconnect the TTL remote cable from the main logic board.
5. Carefully lift the clear plastic shield located over the power supply.
6. Replace the fuse cartridge on the Power Supply board with a 250 V, 2 A, F-type fuse. Refer to the *Replaceable Parts* section beginning on page 32 for a part number for the fuse.
7. Reposition the power supply shield back over the Power Supply board.
8. Connect the power supply cable to the power supply.
9. Connect the TTL remote cable to the main logic board.
10. Place the top cover on the bottom cover assembly. Check that the plastic power supply shield is tucked inside the bottom cover assembly.
11. Insert the (8) machine screws through the top cover into the bottom cover assembly. Tighten the screws using a torque driver set to 4 ft-lb.



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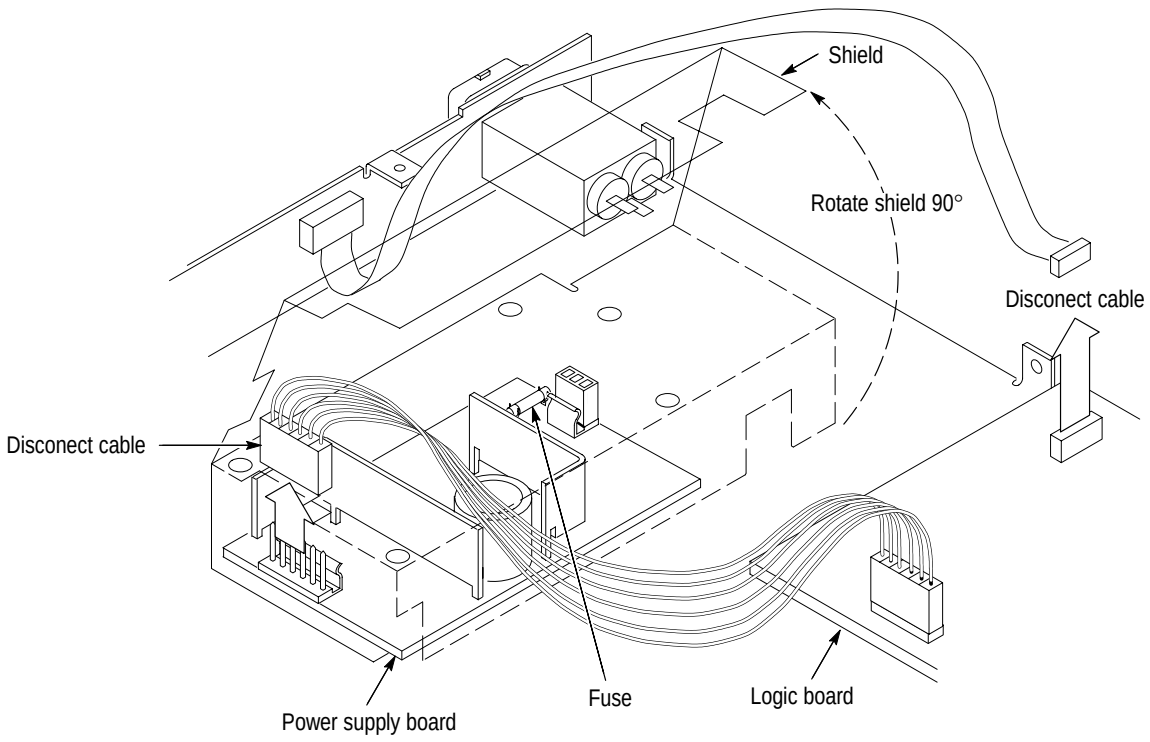



**Figure 11: Replacing the fuse**



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# Replaceable Parts

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

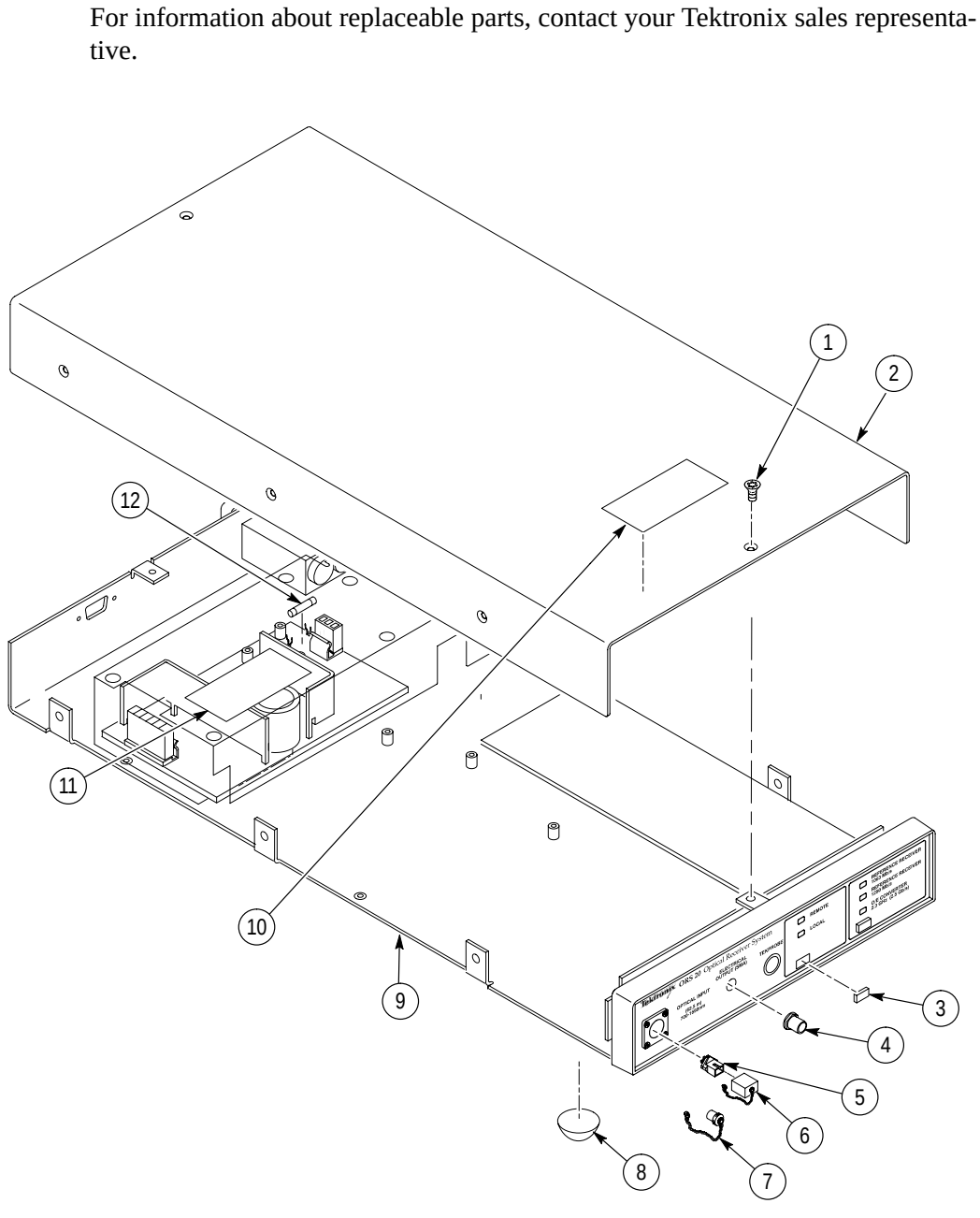



**Figure 12: Replaceable parts**



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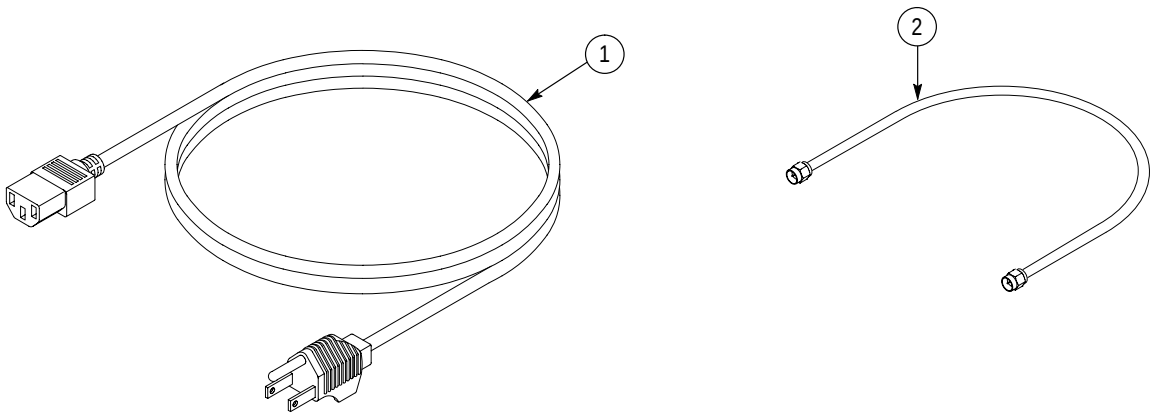



**Figure 13: Standard accessories**

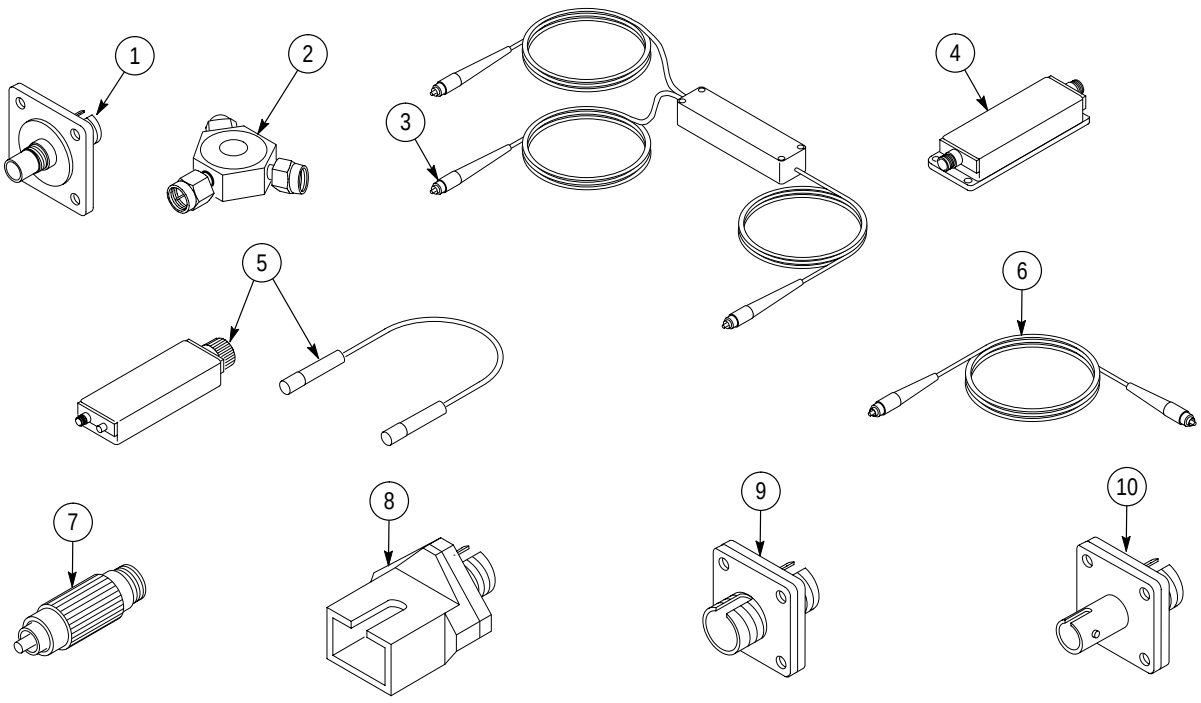



**Figure 14: Optional accessories**



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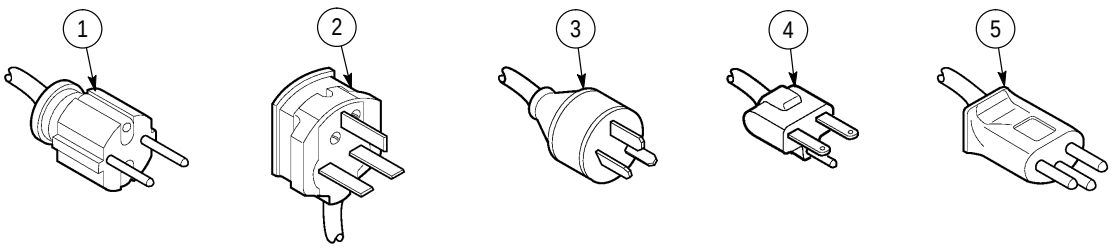



**Figure 15: Optional power cords**

## Replaceable parts list

| Fig. & index number | Tektronix part number | Serial no. effective | Serial no. discont'd | Qty | Name & description | Mfr. code | Mfr. part number |
|---|---|---|---|---|---|---|---|
| 12–1 | 211–0001–00 | | | 10 | SCREW,MACHINE:2–56 X 0.25,PNH,STL CD PL,POZ | 93907 | ORDER BY DESCRIP |
| –2 | 200–4465–00 | | | 1 | COVER,TOP:0.62 AL,CLR CHROMATE,ORS20 | TK1943 | 200–4465–00 |
| –3 | 366–0616–00 | | | 2 | PUSH BUTTON:0.585 X 0.3 X 0.150 | 7X318 | ORDER BY DESCRIPTION |
| –4 | 015–1022–00 | | | 1 | TERMN,COAXIAL:50 OHM,0.5W,SMA | 26805 | 2001–4401–00 |
| –5 | 131–6251–00 | | | 1 | CONN:SC TO FC SQUARE FLANGE ADAPTER W/ZIRCONIA CERAMIC SLEEVE | 0C5R7 | C002453 |
| –6 | 200–4031–00 | | | 1 | COVER,DUST:W/BEAD CHAIN,SC STYLE, STD | TK1690 | 200–4031–00 |
| –7 | 200–3658–00 | | | 1 | COVER,CONNECTOR:FC,W/CHAIN, OPT. 01 | 80009 | 200–3658–00 |
| –8 | 348–0430–00 | | | 4 | BUMPER,PLASTIC:BLACK POLYURETHANE | 2K262 | ORDER BY DESCRIPTION |
| –9 | 200–4466–00 | | | 1 | COVER,BOTTOM:AL,TEK BLUE PAINT,ORS20 | TK1943 | 200–4466–00 |
| –10 | 334–9867–00 | | | 1 | MARKER,IDENT:LABEL,MKD CONVERSION,POLY,0.930 X 1.635,ORS20 | 0KB05 | 334–9867–00 |
| –11 | 334–9866–00 | | | 1 | MARKER,IDENT:LABEL,MKD WARNING,POLY,0.730 X 1.730,ORS20 | 0KB05 | 334–9866–00 |
| –12 | 159–0296–00 | | | 1 | FUSE,CARTRIDGE:2A,250V | 61857 | MT4–2A |
| | | | | | **Standard accessories** | | |
| 13–1 | 161–0066–00 | | | 1 | CA ASSY,PWR:3,18 AWG,250V/10A,98 INCH,STR,IEC320,RCPT X NEMA 5–15P,US,SAFETY CONTROLLED | 0B445 | ECM–161–0066–00 |
| –2 | 015–0560–00 | | | 1 | CABLE,DLY,COAX:50 OHM,2NS,W/CONN,SMA,MALE,EACH END | 0GZV8 | SF104PE,460MM,2X1 1SMA–451 |
| | 071–0423–00 | | | 1 | MANUAL,TECH:INSTRUCTION,ORS20,DP | 80009 | 071–0423–00 |
| | | | | | **Optional accessories** | | |
| 14–1 | 020–2209–00 | | | 1 | ACCESSORY KIT:CONNECTOR,OPTICAL,DIN TO FC SQUARE MOUNT ADAPTER | 80009 | 020–2209–00 |
| –2 | 015–0565–00 | | | 1 | POWER DIVIDER:50 OHM,3 SMA,FEMALE CONN | 64537 | D293S |
| | 015–1014–00 | | | 1 | PWR DIVIDER,RES:50 OHM,SMA,MALE CONN | 64537 | D241S |



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## 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 |
|---|---|---|---|---|---|---|---|
| –3 | 174–3737–00 | | | 1 | FIBER OPTIC:COUPLER, 1 X 2 SPLITTER, WAVELENGTH INDEPENDENT, 90/10 RATIO, ATT. 0.1 DB, REFLECTANCE <55 DB | 0C5R7 | 3–0102–10–B–UFC–01–UFC–01 |
| –4 | 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 |
| –5 | 016–1726–00 | | | 1 | ACCESSORY KIT:TEK PROBE ADAPTOR KIT,ORR20 | 80009 | 016–1726–00 |
| –6 | 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 |
| | 174–2322–00 | | | 1 | CABLE,FIBER OPT:JUMPER,2 METER,62.5 MICRON,FC/PC TO FC/PC | 62712 | 174–2322–00 |
| | 174–4093–00 | | | 1 | JUMPER,FIBER:OPTIC,62.5UM MULTIMODE,2 METER,SIMPLEX,FC/PC TO SC/PC,ORS20 | 0CKD9 | S2–7YM–2–FIS |
| –7 | 119–5118–00 | | | 1 | ATTEN,OPTICAL:30MM,L10DBFOR 1310/1550NM,FC CONN.FA100–35–10–HP | 0LK97 | FA100–35–10–HP |
| –8 | 131–6251–00 | | | 1 | CONN:SC TO FC SQUARE FLANGE ADAPTER W/ZIRCONIA CERAMIC SLEEVE | 0C5R7 | C002453 |
| –9 | 131–6252–00 | | | 1 | CONN:FC TO FC SQUARE MOUNT ADAPTER,W/ZIRCONIA CERAMIC SLEEVE | 0C5R7 | CO92290 |
| –10 | 131–6250–00 | | | 1 | CONN:FC TO ST ADAPTER W/ZIRCONIA CERAMIC SLEEVE | 0C5R7 | C032980 |
| | | | | | **Optional Power Cords** | | |
| 15–1 | 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) | 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,SAFETY CONTROLLED | 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,SAFETY CONTROLLED | 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,SAFETY CONTROLLED | 5F520 | 86515030 |



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## Manufacturers cross index

| Mfr. code | Manufacturer | Address | City, state, zip code |
|---|---|---|---|
| 05JW7 | PURDY ELECTRONICS CORP | INTEROPTIC DIVISION<br>720 PALOMAR AVE | SUNNYVALE, CA 94086 |
| 0B445 | ELECTRI–CORD MFG CO INC | 312 EAST MAIN STREET | WESTFIELD, PA 16950 |
| 0C5R7 | ALCOA FUJIKURA LTD | 150 RIDGEVIEW CIRCLE | DUNCAN, SC 29334 |
| 0CKD9 | FIBER INSTRUMENT SALES INC | 161 CLEAR ROAD | ORISKANY, NY 13424 |
| 0KB05 | NORTH STAR NAMEPLATE INC | 5750 NE MOORE COURT | HILLSBORO, OR 97124–6474 |
| 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 |
| 26805 | M/A COM OMNI SPECTRA INC | MICROWAVE CONNECTOR DIV<br>140 4TH AVE | WALTHAM, MA 02254 |
| 2W733 | BELDEN WIRE & CABLE COMPANY | 2200 US HWY 27 SOUTH<br>PO BOX 1980 | RICHMOND, IN 47374 |
| 5F520 | PANEL COMPONENTS CORP | PO BOX 115 | OSKALOOSA, IA 52577–0115 |
| 61857 | SAN–O INDUSTRIAL CORP | 91–3 COLIN DRIVE | HOLBROOK, NY 11741 |
| 62712 | SEIKO INSTRUMENTS USA INC | ELECTRONIC COMPONENTS DIV<br>2990 W LOMITA BLVD | TORRANCE, CA 90505 |
| 64537 | KDI/TRIANGLE ELECTRONICS INC | 60 S JEFFERSON RD | WHIPPANY, NJ 07981 |
| 7X318 | KASO PLASTICS INC | 5720–C NE 121ST AVE, STE 110 | VANCOUVER, WA 98682 |
| 80009 | TEKTRONIX INC | 14150 SW KARL BRAUN DR<br>PO BOX 500 | BEAVERTON, OR 97077–0001 |
| 80126 | PACIFIC ELECTRICORD CO | 747 WEST REDONDO BEACH<br>PO BOX 10 | GARDENA, CA 90247–4203 |
| 8J246 | PICOSECOND PULSE LABS INC | P.O. BOX 44<br>4890 STERLING DR | BOULDER, CO 80306 |
| 93907 | CAMCAR DIV OF TEXTRON INC | ATTN: ALICIA SANFORD<br>516 18TH AVE | ROCKFORD, IL 611045181 |
| S3109 | FELLER U.S. CORPORATION | 72 VERONICA AVE<br>UNIT #4 | SOMERSET, NJ 08873 |
| TK1690 | EAGLE INDUSTRIES INC | 115 E. SHERMAN | NEWBERG, OR 97132 |
| TK1943 | NEILSEN MANUFACTURING INC | 3501 PORTLAND RD NE | SALEM, OR 97303 |
| TK2541 | AMERICOR ELECTRONICS LTD | UNIT–H<br>2682 W COYLE AVE | ELK GROVE VILLAGE, IL 60007 |



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