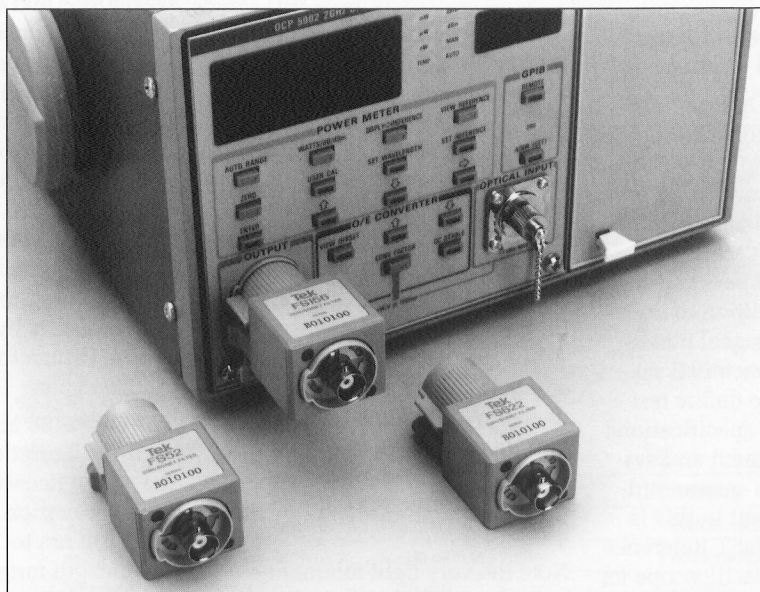


ORS52, ORS156, ORS622 & ORS2488 SDH/SONET Reference Receivers



ORS622 Reference Receiver (shown with Options 31 and 41).

Verifying SDH/SONET System Performance. SDH/SONET Reference Receivers are wide bandwidth optical to electrical converters required to measure and display optical transmitter and eye pattern time domain waveforms. The frequency response of SDH/SONET Reference Receivers has been standardized by international agreement and is tightly specified in CCITT Recommendation G.957. This CCITT Recommendation specifies the overall transfer function of a Reference Receiver. A Reference Receiver has been defined as being an optical to electrical converter followed by a bandwidth shaping filter. The CCITT has specified the required overall receiver's response, **not just the response of the filter.**

The Tektronix ORS Series of optical receivers are **true SDH/SONET Reference Receivers, not just filters or non-compliant combinations of optical to electrical converters with filters attached.** The ORS Series Reference Receivers are engineered to meet, and documented to comply with, CCITT specifica-

tions governing SDH/SONET Reference Receiver performance. They are intended for use in the manufacturing and R&D test of both laser and LED digital transmitters, modulators, and other related high speed fiber optic transmission equipment. The ORS Series of Reference Receivers are available in several flexible configurations suitable for use in factory floor testing systems as well as engineering benchtop applications. Pulse parameter and waveform measurements can easily be made for all commonly used standard data rates up to and including 2.488 Gbits/sec (the OC-48/STM-16 carrier rate).

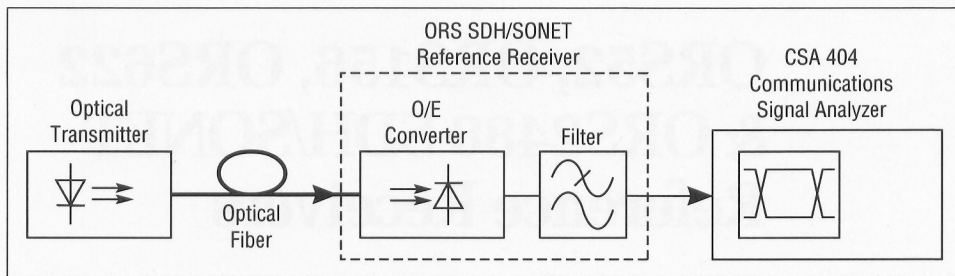
Without an optical receiver assured of complying with the CCITT G.957 specifications, evaluation of high speed optical transmitters and eye pattern waveforms can become fraught with uncertainties caused by unwanted transmitter noise and aberrations. Further testing ambiguity can be introduced by waveform aberrations due to a non-complying receiver's own response characteristics. Using a

The ORS Series of Reference Receivers uniquely provide strict compliance with the required CCITT performance needed when testing SDH/SONET transmitters and analyzing eye pattern waveforms.

- **Strict CCITT G.957 compliance**
- **Low distortion eye pattern and pulse measurements**
- **Data rates through 2.488 Gbits/sec**
- **DC coupled and stabilized amplification**
- **Bessel-Thompson frequency response**
- **Convenient and flexible configurations**
- **Accurate Extinction Ratio measurements**
- **Measures average optical power**
- **Easy to use**
- **Fully GPIB controllable**

strictly compliant Tektronix ORS Series SDH/SONET Reference Receiver having documented compliance data provided with it eliminates this test uncertainty. This minimizes the chance of SDH/SONET compliant devices under test being mistakenly rejected, or non-compliant units being mistakenly accepted. The bottom line is that strictly compliant ORS Series Reference Receivers save you time and money by eliminating test uncertainty.

The greater goal of testing with a CCITT compliant SDH/SONET Reference Receiver is to ensure optical mid-span meet. Mid-span meet, in simple terms, means operating compatibility between optical system products from different vendors – an optical transmitter from one vendor will work with a receiver from another vendor. A French SDH system



CCITT G.957 SDH/SONET Waveform Measurement Set-up.

can meet at mid-span with a U.S. SONET system and work.

The Synchronous Optical Network (SONET) standard is observed principally in the U.S.A., Canada, and Taiwan. The Synchronous Digital Hierarchy (SDH) version of that standard is observed in Europe, Japan, and rest of the world. In addition to defining optical system signal hierarchy and signal characteristics, these standards also define test methodologies and specifications for verifying equipment and system performance to ensure mid-span meet. Prominent in this is the use of SDH/SONET Reference Receivers with an oscilloscope for pulse and eye pattern measurements, and comparison of these waveforms to specified masks.

The ORS Series of SDH/SONET Reference Receivers combined with other Tektronix instruments can provide a complete SDH/SONET physical layer standards compliance testing system. This Tektronix system includes the following:

- ORS Series SDH/SONET Reference Receivers for 52 Mbit/sec (OC-1), 156 Mbit/sec (OC-3 STM-1), 622 Mbit/sec (OC-12 STM-4), and 2.488 Gbit/sec (OC-48/STM-16) data rates.
- CSA400 or CSA800 Series Communications Signal Analyzers with built-in template/mask testing and statistical measurement capability for powerful and fast waveform and eye pattern display and analysis.
- OA5000 Series Optical Attenuators for optical signal level control
- CSA907A Bit Error Rate Test Set for measuring communications link and module error performance.

Tektronix Reference Receiver Performance.

The ORS Series of Reference Receivers are unique in their ability to strictly meet the CCITT specified frequency response required at each standard data rate. The CCITT G.957 document defines the nominal transfer function for an optical reference receiver as having a fourth-order Bessel-Thompson response. Table 1 lists the corresponding attenuation and allowed response deviation at various frequencies, f . In this table f_0 is the receiver's bit rate and f_r is the 3-dB cutoff frequency, which is defined as $f_r = 0.75f_0$.

Note the very tight tolerance bounds required to comply with the CCITT specifications for SDH/SONET. The calibration document supplied with each Tektronix ORS Series SDH/SONET Reference Receiver assures you that the above tolerance bounds are strictly complied with. The ORS Series calibration document records all receiver and external filter serial numbers and plots and tabulates the actual receiver response data along with the CCITT tolerance bounds. The end result is that each Tektronix ORS Series SDH/SONET Reference Receiver is an individually calibrated product. This calibration

provides the necessary level of confidence critical to standards compliance testing reliability.

Other Features. The ORS2488 and all other standard configuration ORS Series Reference Receivers also concurrently measure and display average optical power, all in one self-contained package. This allows display of digital waveforms and eye-diagrams while simultaneously monitoring the average optical power level of the optical carrier. This capability eliminates the need to disconnect and reconnect the optical input fiber in order to measure both waveforms and optical carrier power. This reduces test system complexity, speeds up testing throughput, and increases test reliability by minimizing optical connector mating/demating cycles.

The ORS2488 and all other standard configuration ORS Series Reference Receivers maintain their calibration over the continuous 1100 nm to 1650 nm optical wavelength range using on-board data stored in read-only-memory. The user need only input the wavelength value of the optical carrier. The instrument takes care of the rest. This allows the receiver to be used in either or both of the 1300 nm or 1550 nm wavelength regions. This feature eliminates the need for multiple receivers, each dedicated to a different wavelength. It also eliminates the expense and hassle involved in the recalibration of one receiver at a different wavelength when testing needs change.

Also all standard configuration ORS Series Reference Receivers

Table 1. Required frequency response for an SDH/SONET Optical Reference Receiver compliant with CCITT G.957.

f/f_0	f/f_r	Nominal	Attenuation Tolerance (dB)	
		Attenuation (dB)	(52-622 Mbit/s)	(2.488 Gbit/s)
0.15	0.2	0.1	± 0.3	± 0.5
0.3	0.4	0.4	± 0.3	± 0.5
0.45	0.6	1.0	± 0.3	± 0.5
0.6	0.8	1.9	± 0.3	± 0.5
0.75	1.0	3.0	± 0.3	± 0.5
0.90	1.2	4.5	± 0.74	± 1.16
1.0	1.33	5.7	± 1.00	± 1.53
1.05	1.4	6.4	± 1.13	± 1.71
1.2	1.6	8.5	± 1.45	± 2.20
1.35	1.8	10.9	± 1.95	± 2.62
1.50	2.0	13.4	± 2.00	± 3.00
2.0	2.67	21.5	*	*

* Not specified by CCITT G.957

are fully controllable by computer via a GPIB interface. These ORS Series Receivers are fully compatible with the IEEE 488.2 GPIB standard. All instrument functions are accessible through this standard bus interface as well as the manual front panel controls.

ORS Series SDH/SONET Reference Receiver Selection Guide. The Tektronix ORS SDH/SONET Reference Receiver family covers the OC-1, OC-3/STM-1, and OC-12/STM-4, and OC-48/STM-16 bit

rates. Various receiver options can also be ordered depending on the price range and optical input connector desired. Options providing FC, ST, DIN 47256, SMA, and SC optical connector inputs are available.

Receiver selection is based, first of all, on the SDH/SONET bit rate of interest. For greatest flexibility, a receiver based on the OCP5502 O/E converter is recommended even for OC-1 applications. The broad bandwidth of the OCP5502

allows later addition of filters to cover higher bit rates (up to OC-12) without having to purchase an additional O/E converter. For OC-1 applications requiring economy and high sensitivity, but not requiring flexibility for higher bit rates, a receiver based on the P6713 O/E Converter is recommended. Where economy or coverage of more than one bit rate is the greatest concern, receivers based on the P6703A O/E converter are the appropriate choice for testing OC-1 and OC-3/STM-1 bit rates.

Table 2. Reference Receiver Configuration & Selection Guide

OC-1 (51.84 Mbits/sec)

Receiver	Option	Configuration	Optical Connectors	Key Benefits
ORS52		OCP5502/FS52 & OC-1 Calibration	FC, ST, DIN 47256, and SC	Greatest flexibility. Can add filters for OC-3 and OC-12. Built-in power meter. GPIB.
	1P	Delete OCP5502 power supply resulting in TM5000 compatible plug-in instrument	Same	Provides compatibility with bench or rack-mountable TM5000 Series Modular Instrument Mainframes.
	1x*	P6703A/FS52 & OC-1 Calibration	*	Greatest value. Can add filter for OC-3.
	2x*	P6713/FS52 & OC-1 Calibration	*	Highest sensitivity.

OC-3/STM-1 (155.52 Mbits/sec)

Receiver	Option	Configuration	Optical Connectors	Key Benefits
ORS156		OCP5502/FS156 & OC-3 Calibration	FC, ST, DIN 47256, and SC	Greatest flexibility. Can add filters for OC-1 and OC-12. Built-in power meter. GPIB.
	1P	Delete OCP5502 power supply resulting in TM5000 compatible plug-in instrument	Same	Provides compatibility with bench or rack-mountable TM5000 Series Modular Instrument Mainframes.
	1x*	P6703A/FS156 & OC-3 Calibration	*	Greatest value. Can add filter for OC-1.
	31	Add FS52 & OC-1 Calibration	N/A	

OC-12/STM-4 (622.08 Mbits/sec)

Receiver	Option	Configuration	Optical Connectors	Key Benefits
ORS622		OCP5502/FS622 & OC-12 Calibration	FC, ST, DIN 47256, and SC	Greatest flexibility. Built-in power meter. GPIB. Multiple bit rates.
	1P	Delete OCP5502 power supply resulting in TM5000 compatible plug-in instrument	Same	Provides compatibility with bench or rack-mountable TM5000 Series Modular Instrument Mainframes.
	31	Add FS52 & OC-1 Calibration	N/A	
	41	Add FS156 & OC-3 Calibration	N/A	

OC-48/STM-16 (2.488 Gbits/sec)

Receiver	Option	Configuration	Optical Connectors	Key Benefits
ORS2488		ORS2488 (includes power supply) & OC-48 Calibration	FC, ST, DIN 47256, and SC	Specific to OC-48/STM-16 data rate. Built-in power meter. GPIB.
	1P	Delete O/E Converter power supply resulting in TM5000 compatible plug-in instrument	Same	Provides compatibility with bench or rack-mountable TM5000 Series Modular Instrument Mainframes.

* x=1 (FC Optical Input Connector)

x=2 (ST Optical Input Connector)

x=3 (DIN 47256 Optical Input Connector)

x=4 (SMA Optical Input Connector)

x=5 (SC Optical Input Connector)

Table 2 will assist you further in narrowing your selection to the specific ORS Series SDH/SONET Reference Receiver for your application. ORS52, ORS156, and ORS622 Receivers use externally attached FS Series Filters, the ORS2488 does not.

All ORS Series SDH/SONET Reference Receivers are TekProbe™ compatible. When used with Tektronix oscilloscopes having the TekProbe interface, screen displays will show the proper scale factor for the optical signal (microwatts of optical power). This allows direct measurement and display of results without having to manually apply conversion factors. For oscilloscopes or other instruments not having this TekProbe interface, a Tektronix 1103 Power Supply can be ordered separately for ORS Series Reference Receivers using P6703A or P6713 O/E Converters. The ORS2488 and ORS Series Reference Receivers using the OCP5502 O/E Converter are compatible with, but do not require

the TekProbe Interface for their operation.

FS Series Filters. The FS52, FS156 and FS622 Filters are fourth order electrical filters designed to have a Bessel-Thompson frequency response as required by the CCITT G.957 specification. These filters can be purchased independently as separate products. But when purchased as options combined with the appropriate Tektronix Optical to Electrical Converter shown in Table 2, the overall receiver (converter plus filter) will be calibrated together and will adhere to the CCITT required frequency response shown in Table 1. SDH/SONET compliance calibration of separately purchased filters when used with certain previously purchased Tektronix Optical to Electrical Converters is available from Tektronix Factory Service. Contact your local Tektronix Sales Office for further information on these services.

The FS Series Filters are intended for use in ORS52, ORS156, and

ORS622 Reference Receivers. The ORS2488 Reference Receiver requires no external filter to comply with the SDH/SONET requirements. In those situations where strict compliance with the frequency response specified in CCITT G.957 is not required, the FS Series Filters could be used with the ORS2488 Receiver for 622 Mbit/sec, 156 Mbit/sec, and 52 Mbit/sec data rate applications. Also, in applications not requiring strict CCITT compliance, the FS622 Filter could be separately purchased for use with a P6703A Optical to Electrical Converter at the 622 Mbit/sec data rate. In applications needing strict SDH/SONET compliance one of the ORS Series Reference Receiver configurations appearing in Table 2 must be used. Contact your local Tektronix Sales Office for information on the frequency response characterization services available for combinations of Tektronix converters and filters not appearing in Table 2.

ORS Series Characteristics

Receiver Frequency Response

Each ORS receiver is individually verified and documented to meet SDH/SONET recommendations documented in CCITT G.957 at the electrical output connector.

Receiver Bit Rate

ORS52	OC-1 (51.84 Mbits/sec)
ORS156	OC-3/STM-1 (155.52 Mbits/sec)
ORS622	OC-12/STM-4 (622.08 Mbits/sec)
ORS2488	OC-48/STM-16 (2.488 Gbits/sec)

Receiver Environmental Characteristics

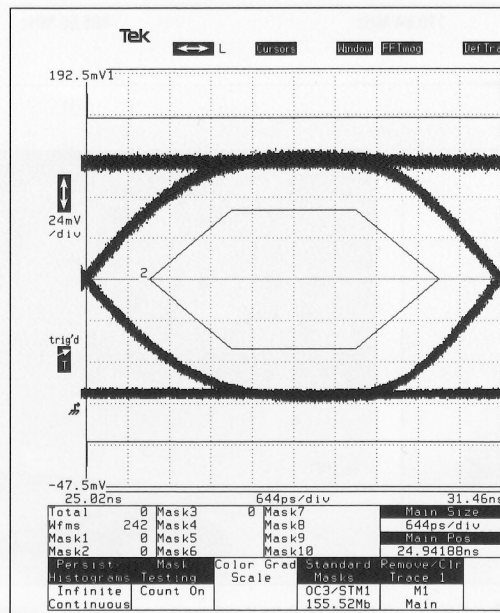
Temperature (operating): 0°C to 50°C (32°F to 122°F), SDH/SONET compliance guaranteed at 20°C ±5°C.

Temperature (nonoperating): With ORS2488 or OCP5502, -40°C to 70°C (-40°F to 158°F). With P6703A or P6713, -55°C to 75°C (-67°F to 167°F).

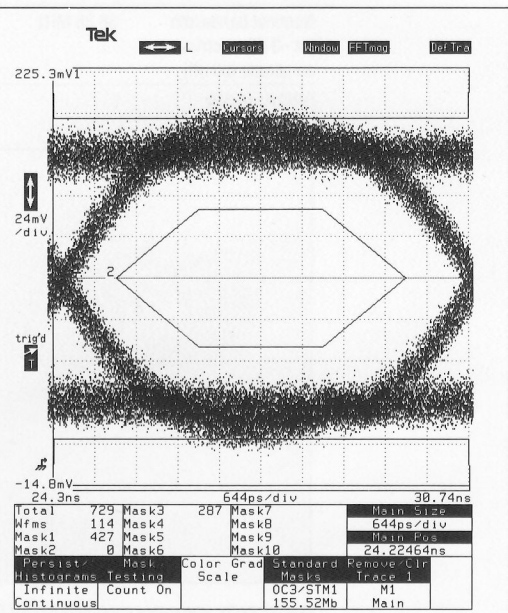
Humidity (operating & nonoperating): 95% R.H. to 30°C (86°F) max. 45% R.H. to 50°C (122°F) max.

Transportation: Qualifies under National Safe Transit Association Preshipment Test Procedures, Project 1A-B1.

For other environmental specifications contact your local Tektronix Sales Office.



Typical 155.52 Mbit/sec eye pattern using an ORS156 with CSA803A Communications Signal Analyzer. Note OC-3/STM-1 compliance masks.



Eye pattern from the same optical transmitter using a reference receiver not compliant with CCITT G.957. Note OC-3/STM-1 mask violations.

O/E Converter Characteristics

	OCP5502 & ORS2488	P6703A	P6713
	ORS52 InGaAs	InGaAs	InGaAs
	ORS156 InGaAs	InGaAs	NA
	ORS622 InGaAs	NA	NA
Wavelength Range	1100 to 1650 nm	1100 to 1700 nm	1100 to 1700 nm
Optical Input	OCP5502 accepts fiber up to 62.5 μ m core diameter. ORS2488 accepts single mode fiber input only.	Accepts fiber up to 100 μ m core diameter	Accepts fiber up to 100 μ m core diameter
Maximum Optical Input for Linear Output ³	2 mW (with offset) ¹ 1 mW (no offset) ¹	1 mW	200 μ W
Input Dynamic Range ³	1 mW ¹	1 mW	200 μ W
Absolute Maximum Nondestructive Optical Input	10 mW	10 mW	10 mW
Conversion Gain	1 V/mW \pm 8% at DC and 1300 nm	1 V/mW \pm 8% at DC and 1300 nm	5 V/mW \pm 8% at DC and 1300 nm
Noise Equivalent Power ²	\leq 1 μ W RMS (referenced to input)	\leq 1 μ W RMS (referenced to input)	\leq 200 nW RMS (referenced to input)

¹ CCITT G.957 compliance is assured for small signal optical inputs less than 300 μ W peak-peak.

² Displayed noise depends on the noise specification of the oscilloscope used.

ORS Series O/E Noise Equivalent Power Characteristics by Receiver Configuration (See above for ORS2488 Noise Characteristics)

	FS622	FS156	FS52
OCP 5502	500 nW	200 nW	100 nW

For further O/E Converter performance characteristics, refer to the following data sheets:

OCP5502 Data Sheet (3TW-7671-1)

P6703A & P6713 Data Sheet (3TW-7914)

OCP5502 & ORS2488 Built-In Optical Power Meter

Optical		Electrical	
Maximum Optical Linear Input ³	5 mW (+7 dBm)	Update Rate	Readout: 5 Hz, Bargraph: 20 Hz
Input Dynamic Range ³	-80 dBm to +7 dBm	Absolute Accuracy	\pm 5% of reading \pm 0.1 nW
Absolute Non-destructive Optical Input	10 mW	Linearity	1% (1 nW to 5 mW)
Measurement Resolution	0.01 dBm, 10 pW (to -60 dBm)	Noise Equivalent Power ⁴	<100 pW p-p max. <10 pW p-p typ. (referenced to input)

³ Greater optical input power levels up to the +10 dBm level provided for in the SDH/SONET standard can be accommodated by using a 10 dB fixed in-line optical attenuator component attached to the O/E Converter's optical input. Singlemode & multimode fixed attenuators are available from Amphenol Corp., Light Control Systems, Inc., Seiko Instruments, Inc., 3M Corp., and others.

⁴ Measured over 30 sec. time interval.

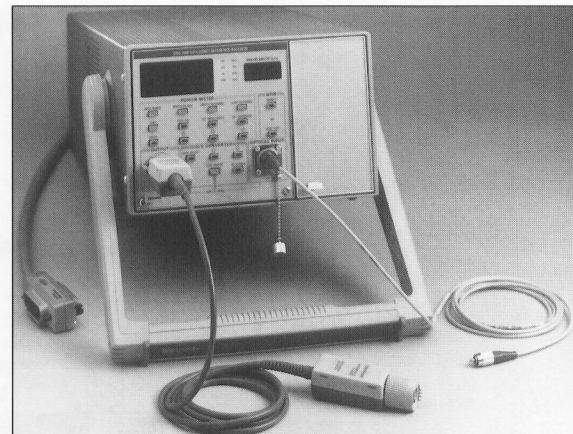
Filter Characteristics

	FS52	FS156	FS622
Bit Rate	OC-1 (51.84 MBits)	OC-3/STM-1 (155.52 MBits)	OC-12/STM-4 (622.08 MBits)
Transfer Function	4th order Bessel-Thomson	4th order Bessel-Thomson	4th order Bessel-Thomson
Input Connector	TekProbe ⁵	TekProbe ⁵	TekProbe ⁵
Output Connector	TekProbe ⁵	TekProbe ⁵	TekProbe ⁵
Nominal Bandwidth (at -3 dB electrical amplitude roll off)	38.88 MHz	116.64 MHz	466.56 MHz

⁵ BNC compatible



Option 1x/2x alternative configuration for ORS52 and ORS156 Receivers.



ORS2488 Reference Receiver with optional TekProbe™ cable, optical fiber and GPIB interface cable.

Tektronix application literature related to SDH/SONET testing:

Literature Title	Order Number
1. Automating Optical Waveform Evaluation with Tektronix Optical to Electrical Converters & Template Testing Techniques	3TW-7465
2. Custom OME System Solution For Optical Communications Standard Testing	31W-8811-0
3. New Communications Standards Require Special Test: SDH/SONET & FDDI	3SW-8364-0
4. Reference Receivers Play Key Role in SDH/SONET Compliance	3TW-8695-1
5. SDH/SONET Telecommunications Standards Primer	3SW-8085
6. Standards Testing: Bit Error Rate	3SW-8136-1
7. Standards Testing: Fiber Optic Transmitter Characterization	3TW-8083
8. Technical Issues To Understand When Considering Alternatives to Tektronix ORS Series SDH/SONET Reference Receivers	3TW-8911-0
9. Tektronix i-Pattern™ Software	42W-7326-1
10. Waveform Analysis: Noise and Jitter	3SW-8142-1
11. Waveform Analysis: Optical Extinction Ratio Measurement	3TW-8215-0
12. Waveform Compliance Testing: SDH/SONET Eye Pattern Masks	3SW-8143-1

Other related Tektronix products:

Product	Data Sheet
1. CSA404 Communications Signal Analyzer	85W-7940-2
2. CSA803A Communications Signal Analyzer	85W-7940-2
3. CSA907A Bit Error Rate Test Set	3SW-8841
4. OA5000 Series Programmable Optical Attenuators	3TW-8032-1
5. Optical Communications Standards Testing System	31W-8811-0
6. TM500 & TM5000 Series Modular Instrument Mainframes & Accessories	75W-7959
7. 1103 TekProbe™ Interface Power Supply	60W-7018

Ordering Information

ORS52, ORS156,
ORS622, or
ORS2488

See Selection Guide tables for OC-1, OC-3/STM-1, OC-12/STM-4, & OC-48/STM-16 bit rates.

Optional Accessories☐ **SDH/SONET Filters:**

Fourth order Bessel-Thompson electrical filters compliant with the SDH/SONET standard and packaged for compatibility with, but not requiring, the TekProbe™ Interface

- ☐ **FS52** – 51.84 Mbits/sec (OC-1)
- ☐ **FS156** – 155.52 Mbits/sec (OC-3/STM-1)
- ☐ **FS622** – 622.08 Mbits/sec (OC-12/STM-4)

☐ **TekProbe™ Interface Cable** – 012-1372-00☐ **TekProbe™ Interface Converter/Power Supply**
Order Tektronix Model 1103 TekProbe™ Power Supply☐ **Coaxial Connector Adapters:**

For conversion between SMA and BNC type electrical connectors

- ☐ **SMA female to BNC male** – 015-0572-00
- ☐ **SMA male to BNC female** – 015-0554-00

☐ **Plug-In Toolbox** – 016-0362-00

Single-wide plug-in container with front panel to fit into vacant single-wide slot in OCP5502 or ORS2488 mainframe

☐ **Protective Front Panel Cover** – 200-3554-00

Snap-on cover molded of high-impact plastic for protection of instrument front panel for OCP5502 or ORS2488.

☐ **TM500 Carrying Case** – 016-0565-01

Luggage-type protective case molded of high-strength glass-epoxy with impact absorbent foam lining for transporting OCP5502 or ORS2488.

☐ **Accessory Pouch** – 016-0351-00

Soft vinyl pouch snaps on to the carrying handle of an OCP5502 or ORS2488 for carrying cables and other accessories

☐ **Optical Cables:**

2 meter, 62.5 micron fiber, multimode (including in-line adapter)

- ☐ **FC/PC-to-Biconic** – 174-2323-00
- ☐ **FC/PC-to-SMA906** – 174-2324-00
- ☐ **FC/PC-to-FC/PC** – 174-2322-00

2 meter, 8/125 micron, single mode (including in-line adapter)

- ☐ **FC/PC to Diamond 3.5** – 174-1385-00
- ☐ **FC/PC to ST** – 174-1386-00
- ☐ **FC/PC to FC/PC** – 174-1387-00
- ☐ **FC/PC to Biconic** – 174-1388-00
- ☐ **FC/PC to Diamond 2.5** – 174-1497-00

Note: For use with oscilloscopes or other signal analysis instruments not having Tektronix TekProbe Interface compatibility, the ORS52 and ORS156 reference receivers using the P6703A or P6713 O/E Converters require a Tektronix 1103 Power Supply to be ordered separately.

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