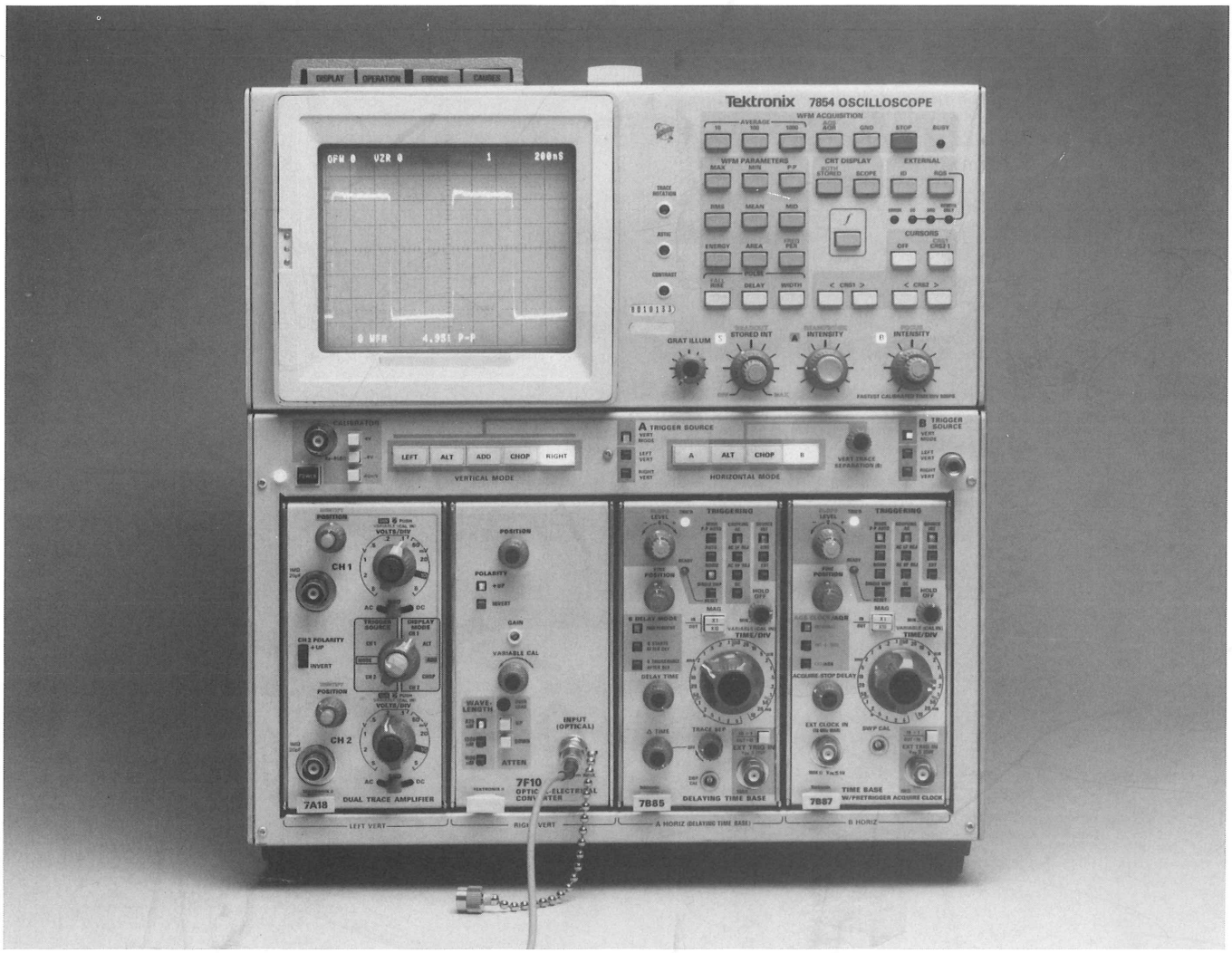
7F10 OPTICAL-ELECTRICAL CONVERTER



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Introduction

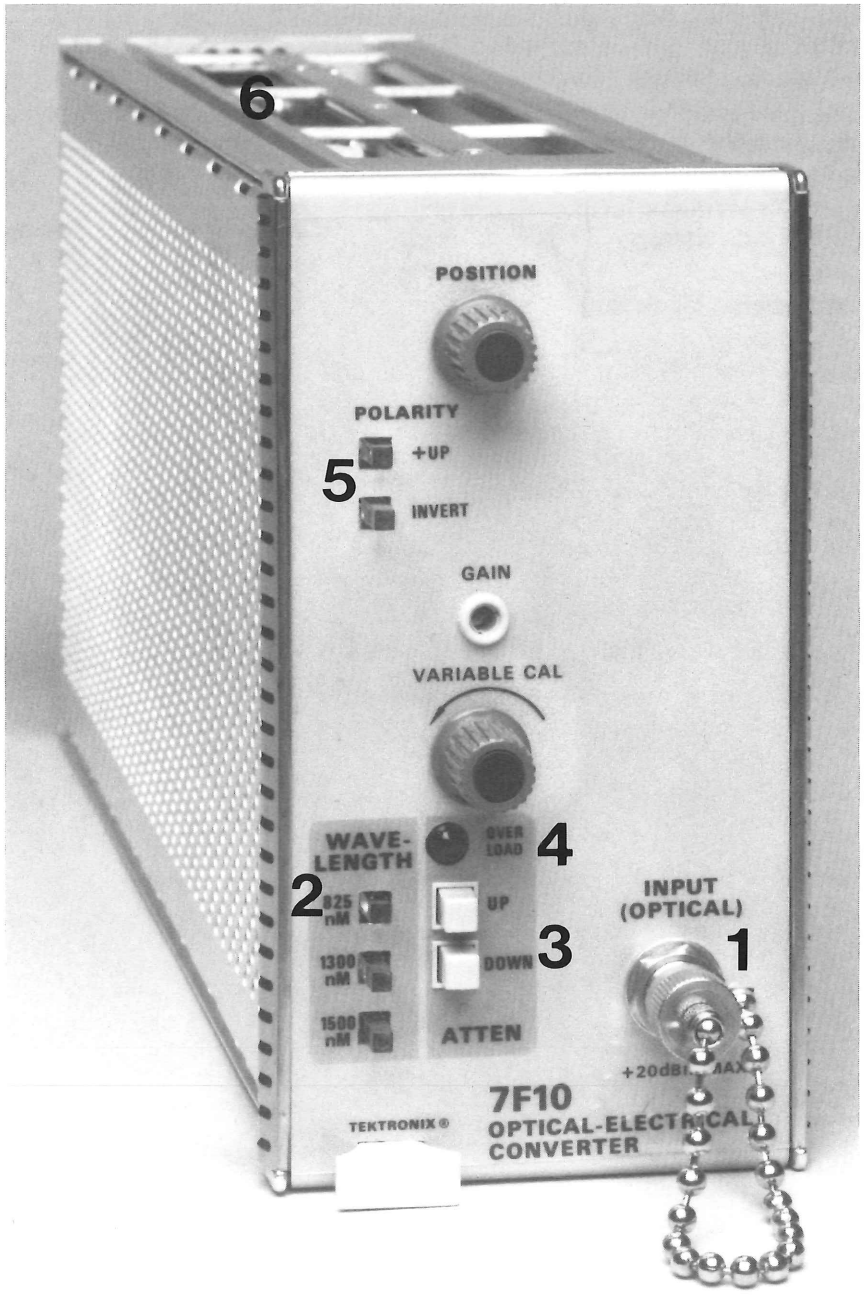
This sales guide will help you to better understand the 7F10 Optical-Electrical Converter. It will also help you to direct your sales effort toward the very specific markets served by the 7F10.

The sales guide addresses the vital elements related to customer needs, features and benefits, applications, competition, and product positioning. It also contains a glossary of optical terms, probably unfamiliar to you.

This document is meant for internal use only and is not a customer sales brochure or data sheet.

Gary Mott
Lab Instruments Marketing

The New 7F10 Optical-Electrical Converter



The 7F10 plug-in module is an optical to electrical converter for use with either single mode or multimode fibers. It offers 10 kHz to 750 MHz frequency response and covers the 700 to 1550 nanometer spectrum. It is designed mainly for use in vertical compartments of 7000 Series Oscilloscopes. It converts a 7000 Series mainframe into an optical oscilloscope.

The optically coupled 7F10 input goes through a built-in attenuator that provides sixteen calibrated settings for controlling the input signal level. On the front panel, there is an optical overload indicator and push buttons to vary the attenuation level. Readout for deflection factor, attenuation factor, uncalibrated indication, and polarity invert appears on the crt.

1. Single Mode/Multimode Fiber Optical Input
The 7F10 uses a Diamond 3.5 millimeter input connector to accept both single mode and multimode fiber optic cables.

2. 700 To 1550 Nanometer Wavelength
The 7F10 covers the 700 to 1550 nanometer spectrum with deflection factors calibrated at three wavelength settings of 825, 1300, and 1500 nanometers.

3. Built-In Optical Attenuator
The 7F10 has a built-in optical attenuator with a nominal 2.5 dB per step and maximum attenuation of 37.5 dB. Sixteen settings for calibrated deflection factors can be selected via the front panel switches. A variable control provides continuously variable deflection factors between attenuator settings.

4. Optical Overdrive Indicator
A front panel LED indicates when the optical signal is overloading the input, letting you know when the detector may be clipping the signal or becoming non-linear.

5. Polarity Switch
The polarity switch provides a means of inverting the display. In the +UP position a positive signal deflects the display upward, and in the INVERT position a positive signal deflects the display downward.

6. CRT Readout
Readout is provided on the crt for deflection factor, attenuation factor, uncalibrated indication, and polarity invert.

7F10 Features And Benefits

Feature	Benefit
Single Mode Or Multimode Fiber Optical Input	Instrument can be used for measurements on all types of fiber optic cables from versatile multimode cable to low loss single mode cable.
700 To 1550 Nanometer Wavelength	Covers a broad range of wavelength requirements with three calibrated wavelength settings of 825, 1300, and 1500 nanometers.
10 kHz to 750 MHz Frequency Response (Dependent upon 7K main frame used.)	Broad frequency response to cover the frequencies encountered on fiber optic cables and to take advantage of the broad bandwidth capabilities of 7000 Series oscilloscopes.
Built-In Optical Attenuator	No need to provide external attenuation for high level optical signals. Sixteen-step, optical attenuation is built-in. There is an optical overload indicator on the front panel to help maintain calibrated settings.
CRT Readout	To make measurements easier, crt readout is provided for deflection factor, attenuation factor, un-calibrated indication, and polarity invert.
Wide Choice of Mainframes	Any 7000 Series mainframe can be used with the 7F10. This lets you take advantage of the wide frequency response of the plug-in module as well as use the special features of the 7000 Series.

7F10 Markets And Applications

Markets for the 7F10 are expected to be R&D facilities, especially in the communications area. Customers will most likely be design engineers working on new equipment designs for communication transmission and receiving equipment. Additional applications will be found in the manufacturing test function where equipment function is verified when it is built.

Another application area will be in research of physical phenomena. Here the application will be for data collection. Data from a test event will be transmitted via optical fiber and the oscilloscope will be the recording medium.

The 7F10 will be used to perform the same measurements as now are made with electrical signals. Very few new tests will be made.

7F10 Competition

In general, to view an optical signal on an oscilloscope requires conversion to an electrical signal first. Several competitive alternatives are available to perform the optical to electrical conversion function provided by the 7F10. There is no directly competitive oscilloscope plug-in module that performs the same function.

Here is a list of optical to electrical converters presently on the market.

	Wavelength (nm)	Receiver Element	Maximum Input Level	Optical Connector	Bandwidth (MHz)	Price ($)
Ando AQ-5501	850	Si-APD	−20 dBm	FC	1-1000	3,360
Ando AQ-5502	1300	Ge-APD	−20 dBm	FC	1-1000	3,710
Ando AQ-1420	500-1100	Si-PIN	−5 dBm	FC,D4,OF2	dc-1000	1,100
Ando AQ-1421	1000-1600	InGaAs	−5 dBm	FC,D4,OF2	dc-1000	NA
Anritsu MP95A	500-1100	Si-PIN	−5 dBm	D3	dc-2000	1,520
Anritsu MP96A	1000-1600	InAsp-InP	−5 dBm	D3	dc-2000	2,670
Anritsu MZ118A/MH922A	850	Si-APD	NA	FC	.1-1000	9,510
Anritsu MZ118A/MH923A	1300	Ge-APD	NA	FC	.1-1000	10,270
HP 81519A	550-950	PIN-PD	1 mW	Diamond	dc-400	2,700
Lasertron QRX-700	1300/1550	PIN-FET	NA	Biconic	.01-340	5,200
Tektronix OR501	700-1550	Ge-APD	−20 dBm	Diamond*	.01-1000	4,300
Tektronix OR502	700-1550	Ge-APD	+10 dBm	Diamond*	.01-1500	6,500
Tektronix 7F10	**700-1550**	**Ge-APD**	**+10 mW**	**Diamond**	**.01-750 (Depending on mainframe used.)**	**6,495**

*Optional connectors: Biconic, FC, D4, and SMA

Note: The Tektronix OR502 has a built-in attenuator.
Lasertron and Tektronix require a TM500 mainframe to power the units.

Glossary Of Optical Terms

Aperture The diameter of the largest entering beam of light that can enter the optical fiber.

Attenuator An optical device that reduces the intensity of a beam of light passing through it. This reduction in light intensity is expressed in dB.

Automatic Threshold Control (ATC) Electronic control circuit that regulates the input current to a light emitting diode to prevent it from being overdriven.

Avalanche Photodiode (APD) A type of semiconductor detector operated at high voltages. When incident light generates one photoelectron from the material, the high voltage across the device accelerates the electron enough to cause an avalanche of other electrons, effectively amplifying the signal.

Bandwidth The capacity of an optical fiber to transmit information expressed in bits of information transmitted in a specific time period for a specific length of optical waveguide. Bandwidth is limited by pulse spreading or broadening due to dispersion, so that adjacent pulses overlap and cannot be distinguished.

Bit Error Rate The received waveform differs from the one originally transmitted when errors are made in the receiver regeneration process. The number of bit errors compared to the total bits transmitted is the bit error rate, also called probability of error.

Cladding Material usually of a low refractive index that surrounds the core of an optical fiber to minimize surface scattering losses.

Connector A junction that allows you to connect and disconnect cables or devices.

Core The center, light conducting part of an optical fiber bound by the cladding. The core has a high refractive index.

dBm Decibels relative to one milliwatt. A positive number indicates the power is above one milliwatt; a negative number indicates the power is below. This unit has become common in fiber optic communication systems because the power of light sources used with optical fibers is about one milliwatt.

Decibel The standard unit used to express the ratio of two power levels. It is used in communications to express either a gain or loss in power between the input and output devices.

Detector (Electro-Optic) A device that converts an optical signal into an electrical output signal. The current depends on the amount of light received and the type of device.

Detector Amplifier A device that combines an optical detector with electronic amplification circuitry.

Divergence The spreading out of a laser beam with distance, measured as an angle.

Ferrule A component of a fiber optic connection that holds a fiber in place and aids in its alignment.

Fiber Buffer Material used to protect an optical fiber or cable from physical damage, providing mechanical isolation or protection.

Fiber Optic Cable A sub-assembly made of several optical fibers incorporated into an assembly of organic materials arranged to provide the necessary tensile strength, external protection, and handling properties comparable to equivalent diameter coaxial cables.

Fiber Optics The technique of conveying light or images through a configuration of glass or plastic fibers. There are three groups of fiber optics:

1. **Incoherent** fiber optics transmit light but not an image.
2. **Coherent** fiber optics transmit an image through the perfectly aligned small (12 micron) clad optical fibers.
3. **Specialty** fiber optics combines some aspects of incoherent and coherent fiber optics.

Graded-Index Fiber An optical fiber where the refractive index changes gradually between the core and cladding, so that light stays in the fiber core. These fibers have lower dispersion and broader bandwidth than step-index fibers, where the refractive index changes abruptly between core and cladding.

Infrared Wavelengths that extend beyond 770 nanometers. Infrared is used extensively in light transmission through optical waveguides. Infrared light wavelengths are invisible to the naked eye.

Insertion Loss Total optical power loss caused by insertion of an optical component such as a connector, splice, or coupler into a previously continuous path.

Intrinsic Joint Loss Loss caused by fiber parameter mismatches when two nonidentical fibers are joined.

Kevlar Strands of protective aramid fiber used to provide strain relief in cable assemblies.

Laser An acronym for Light Amplification by the Stimulated Emission of Radiation, applied to a wide range of devices that produce light by this principle. Compared to other light sources, laser light covers a narrow range of wavelength, tends to be coherent, and is emitted in a directional beam.

Light Emitting Diode (LED) A semiconductor device in which light is produced when current carriers combine at a p-n junction. The emission is spontaneous and there are no feedback mirrors, unlike diode lasers. Output power is lower than from diode lasers because of lower operating currents. Generally, LEDs are less expensive than diode lasers, and can operate at shorter wavelengths without the rapid degradation that occurs with visible-wavelength laser diodes.

Micron A unit of length equal to one-millionth (10^{-6}) of a meter (same as micrometer).

Glossary Of Optical Terms

Mode A stable condition of oscillation in a laser. A laser can operate in one mode (single mode) or in many modes (multimode).

Multi-Fiber Cable A fiber optic cable that contains many fibers that transmit signals independently and are housed in separate substructures within the cable or otherwise isolated from one another. This term is usually not applied to bundles of fibers that together transmit a single signal.

Multimode An optical waveguide that permits approximately 1000 modes to propagate through the core compared to only one mode through a single mode fiber. The multimode waveguide has a much larger core (50 microns) than that of the single mode waveguide (8 microns).

Multiplexer A device that combines two or more signals for transmission through a single fiber. Optical multiplexers combine signals at different wavelengths. Electronic multiplexers combine signals electronically before they are converted into optical form.

Nanometer One-billionth (10^{-9}) of a meter.

Numerical Aperture The numerical aperture (NA) of an optical fiber defines the fibers' acceptance of impinging light. The "degree of openness," "light gathering ability," and "acceptance cone" are all terms describing this characteristic.

Optical Attenuation Meter (Attenuator) A device that measures the loss or attenuation through an optical fiber, fiber-optic cable, or fiber optic system. Measurements generally are made in decibels.

Optical Time Domain Reflectometry (OTDR) A method for characterizing a fiber by using an optical pulse transmitted through the fiber. The resulting back-scatter and reflections are measured as a function of time. The OTDR is useful to measure attenuation over distance and to identify defects and other losses. The principle is similar to Time Domain Reflectometry (TDR) used with electrical cables.

Optical Waveguide A material capable of carrying light and containing it within the boundaries of or adjacent to the surface of the material.

Output Power (LED) Radiant power, expressed in watts.

Pin Photodiode A semiconductor diode light detector where a region of intrinsic silicon separates the p and n type materials. It offers fast response and is often used in fiber optic systems.

Pulse Dispersion (Pulse Spreading) The separation or spreading of the input characteristics of the optical signal that appears along the length of the optical fiber and limits the useful transmission bandwidth of the fiber. Expressed in time and distance as nanoseconds per kilometer.

Receiver A device that detects an optical signal, converts it into an electronic form, and processes it so it can be used by electronic equipment.

Receiver I.C. Consists of a photodiode that converts the optical signal to an electronic one that feeds an amplifier bringing the signal back to a TTL level.

Receiver Sensitivity Measure of the optical power the photo detector must receive to achieve a specified base band performance, such as a specified bit-error rate or signal-to-noise ratio. Expressed in dBm.

Refractive Index The ratio of the velocity of light in a vacuum to its velocity in the core or cladding of the fiber.

Repeater A device that detects a weak signal in a fiber optic communication system, amplifies it, cleans it, and retransmits it in optical form. Also known as a regenerator.

Selfoc Lenses Segments of optical fibers specially designed to function as lenses. Used to expand or contract the beam.

Signal-To-Noise Ratio The ratio of the power of the signal to the background noise, usually measured in decibels. This is a common measure of the quality of analog electronics or transmission systems.

Single Mode One type of low loss optical waveguide with a very small core (2 to 8 microns). It requires a laser source for input signals because of the very small entrance aperture. The smallness of the core radius approaches the wavelength of the source, consequently only a single mode is propagated.

Step-Index Fiber An optical fiber where there is a discontinuous (step-function) change in refractive index at the boundary between fiber core and cladding. These fibers have a large numerical aperture (light accepting angle), and are easy to connect, but have lower bandwidth than other types of optical fibers.

Time Division Multiplexing A digital technique for combining two or more signals into a single stream of data by interleaving bits from each signal.

Wavelength Division Multiplexing Combination of two or more signals so they can be transmitted over a common optical path, usually through a single optical fiber, by a technique where the signals are generated by light sources having different wavelengths.

White Light A mixture of colors of visible light that appears white to the eye. In theory, a mixture of three colors is sufficient to produce white light.

Sales Strategy

You should concentrate on selling the 7F10 to existing 7000 Series users, especially those using the 7104, R7103, 7854, 7904A, and R7903. The number of these mainframes purchased within the last three years makes almost 20,000 vertical compartments available for the 7F10. These should be your primary 7F10 customers.

Suggested Demo

The 7F10 should be demonstrated using a 7104 Oscilloscope mainframe or the mainframe the customer intends to use with the instrument. Use the customer's optical signal as a signal source. Demonstrate the ease of use and convenience of having the instrument plug into a 7000 Series oscilloscope. There is no need for externally connected instruments to make the system operate. Emphasize the versatility of the built-in optical attenuator and crt readout of important parameters.

Customer Questions

1. If the 7F10 receives light at 700 nanometers, which is in the multi-GHz range, why is its bandwidth listed as only 10 kHz to 750 MHz?

The bandwidth of the 7F10 is analogous to the audio bandwidth of an AM radio. The light wavelength is analogous to the carrier frequency. You tune your AM radio to a station that broadcasts on a carrier frequency between 535 and 1605 kHz. The radio demodulates the audio signal carried by the broadcast carrier signal and converts it to sound in the audio bandwidth (20 Hz to 20 kHz). The 7F10 does a similar conversion of the modulated light signal. In this case, the carrier is the 700 to 1550 nanometer light. The light is modulated at a frequency of 10 kHz to 750 MHz.

2. Why is the low-end bandwidth specification 10 kHz? Why not go to dc?

The optical converter portion of the instrument limits the low-end bandwidth to 10 kHz. Because we needed a very short time to market for this product, we used existing components which include the optical converter as well as the 7A29 Vertical Amplifier, so the instrument performance is based on these components.

Sales And Service Information

Promotion

There will be no major advertising campaign for the 7F10. However, because it is a unique new product to the 7000 Series, we plan to do a direct mail campaign starting in September. The mailing will be mainly to users of the 7104, 7854, 7904, and 7834/7934 working with optical signals.

Service Support

There will be no special service program for this product. The impact on service will be small because the 7F10 uses existing parts and technology. Replacement of the optical converter as one module will be the only additional, unique requirement for service. Service for all instruments will be done in Factory Service in Beaverton.

Accessories

Included:

Instruction Manual 070-6277-00

Optional:

Optical Fiber Interface Cable,
Diamond 3.5 to Diamond 3.5
Three meter: 174-0045-00
One meter: 174-0045-01

Optical Fiber Interface Cable,
Diamond 3.5 to SMA
Three meter: 174-0524-00
One meter: 174-0524-01

Optical Fiber Interface Cable,
Diamond 3.5 to FC
Three meter: 174-0527-00
One meter: 174-0527-01

Optical Fiber Interface Cable,
Diamond 3.5 to D4
Three meter: 174-0528-00
One meter: 174-0528-01

Optical Fiber Interface Cable,
Diamond 3.5 to AT&T Biconic
Three meter: 174-0530-00
One meter: 174-0530-01

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