ADVANTEST

Q7760
Optical Network Analyzer

Can simultaneously measure PMD, chromatic dispersion, group delay, and amplitude characteristics for ultra high speed optical and dense wavelength division multiplexing components. Extremely fast high accuracy measurements have been achieved with high optical frequency resolution in the order of MHz.

Q7760

High resolution and fast measurement of optical transmission characteristics in the optical carrier frequency domain.

Communications capacity of optical networks has been continually expanded in recent years because of the rapid increase of data communications, especially due to the Internet. This mass of communications is supported by Dense Wavelength Division Multiplexing (DWDM) and ultra-high-speed optical transmission technology, achieving transmissions over multiple wavelengths with over 100 channels. R&D efforts are actively aimed at achieving a speed increase from 10 Gbps to 40 Gbps. Accompanying this speed increase and DWDM's large capacity are problems due to the dispersion of optical fibers, components and optical systems, such as chromatic dispersion, and polarization mode dispersion. Dispersion causes a spreading of the transmission waveform which not only degrades the communications quality but also limits the communications capacity. Therefore, dispersion needs to be controlled and reduced. Typical optical components for this task are Arrayed Waveguide Grating, Fiber Bragg Grating filters, dispersion compensators, and various optical fibers.

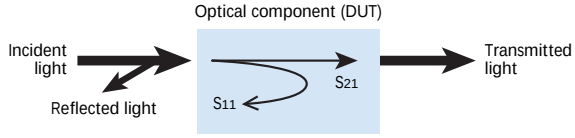
The Q7760 Optical Network Analyzer is capable of measuring many optical component characteristics with high resolution and high speed in the optical carrier frequency domain. It can measure chromatic dispersion, polarization mode dispersion, amplitude characteristics, and group delay of optical components. In addition, since the Q7760 has an internal optical coupler, transmission characteristics, and reflection characteristics can be measured simultaneously. This analyzer can also measure chromatic dispersion characteristics. These include the zero dispersion wavelength of optical fiber such as dispersion-shifted fiber and non-zero dispersion fiber, and the chromatic dispersion slope characteristics. The reported results are shown on the display. The Q7760 employs a phase-shift method which achieves both high resolution and wide dynamic range.

- **Comprehensive measurement of optical transfer characteristics (S_{11},S_{21}) in the optical carrier frequency domain**
- **Polarization mode dispersion accuracy: ±0.1 ps (options+15 and+15A)**
- **Polarization control function for measurement light output (options+15 and +15A)**
- **Maximum optical frequency resolution: 50 MHz (wavelength of 0.4 pm)**
- **High-speed measurement: Approx. 6.7 ms. (per measurement point) Approx. 4 s (per sweep span)**
- **Wavelength range: 1525 to 1635 nm**
- **Wide dynamic range: 40 dB**
- **Extensive group delay measurement range: Measurement accuracy; ±0.05 ps Maximum measurement range; 7.5 µs**
- **Chromatic dispersion characteristics of optical fiber can be measured easily**
- **Expanded display function Limit line function**

Features

Comprehensive Measurement of Optical Transfer Characteristics in the Optical Carrier Frequency Domain

The Q7760 incorporates a tunable laser source. By sweeping the wavelength (optical frequency), transmission and reflection characteristics (S_{21} and S_{11} in the S parameters) can be measured in the optical carrier-frequency domain simultaneously. Table 1 lists the available measurement parameters. The Q7760 can measure all of them simultaneously in a single sweep.



• List of Measurements

Optical characteristics	Reflection characteristics (S_{11})	Transmission characteristics (S_{21})
Amplitude	YES	YES
Group Delay	YES	YES
Chromatic Dispersion	YES	YES
Chromatic Dispersion Slope	YES	YES
Polarized Mode Dispersion	NO	YES

Polarized Mode Dispersion Measurements (Options+15 and +15A)

Measurement accuracy: ±0.1 ps (at highest resolution)

The Q7760 employs the polarization phase-shift method of measurement, enabling comprehensive measurement of chromatic dispersion, amplitude characteristics, group delay, and polarization mode dispersion simultaneously. Furthermore, polarization mode dispersion measurement with high wavelength resolution can be achieved. Extremely fast and precise optical transmission characteristics of ultra-high-speed optical components, especially narrow bandwidth optical components, can easily be measured with this analyzer. The polarization mode dispersion measurement function is an optional, built-in capability.

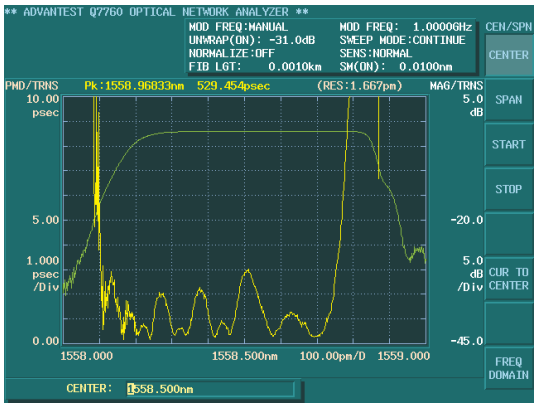


Figure 1: Measurement example of amplitude and polarization mode dispersion characteristics with FBG optical filter (super-imposed display)

Polarization Mode Measurement Laser Source (output) Freely Adjustable (Options +15 and +15A)

The polarization controller built into the Q7760 is composed of both 1/4 and 1/2 wave plates, so the polarization state of the output light is freely adjustable from the front panel. This is very convenient for precisely evaluating the polarization dependency of the DUT. Moreover, the polarization control function, and a pseudo random polarization light can be generated. The polarization control function is a built-in as an option.

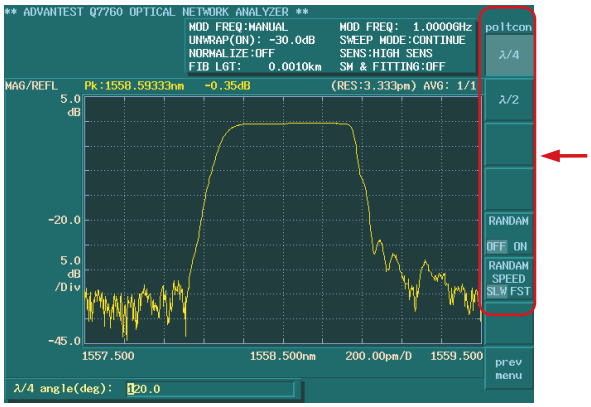


Figure 2: Example display of polarization control function

High Optical Frequency Resolution

Maximum optical frequency resolution: 50 MHz (wavelength of 0.4 pm)

The Q7760 has a maximum optical frequency resolution of 50 MHz, enabling measurements with ultra high resolution. Moreover, because the number of measurement points along the wavelength axis can be set up to 12,000 points, it is possible to measure with high optical frequency resolution and optimally set conditions. This capability facilitates measurement of amplitude characteristics and chromatic dispersion of optical components for DWDM, with channel spacings such as 25, 50, and 100 GHz.

High Speed Measurements

Measuring time: Approx. 6.7 ms (per measurement point)
Approx. 4 s (per sweep span)

The time required for a single sweep (measurement) is approximately 4 seconds compared to conventional instruments which require >10 minutes. Measurements taking a long time cannot yield precise results as environmental influences, such as temperature, can cause the DUT characteristics to vary. Since the Q7760 can perform measurements in a very short time, high-accuracy measurements can be implemented without environmental influences such as temperature characteristics on the DUT.

Extensive Wavelength Range

Wavelength range: 1525 to 1635 nm

With the advent of optical-fiber amplifiers that support the L-band, optical transmission bands have greatly expanded towards longer wavelengths. The Q7760 is capable of measuring device characteristics at maximum wavelengths of 1635 nm. This allows designers to evaluate optical components for the next generation of optical transmission systems. The wavelength span can be set up to a maximum of 110 nm.

High Accuracy Wavelength Measurement

Absolute wavelength accuracy:

±25 pm (standard)

±2 ppm ±1 pm (with the addition of the Q8326 wavelength meter)

The Q7760's absolute wavelength accuracy alone is ±25 pm. It can be improved to ±2 ppm ±1 pm using the Q8326 optical wavelength meter. The Q8326 is automatically controlled from the Q7760 without setting or operating.

Wide Dynamic Range

Dynamic range: 40 dB (typical)

The Q7760 has achieved a dynamic range of 40 dB together with high optical frequency resolution. The Q7760 is capable of measuring optical transmission amplitude characteristics of optical filters and other devices in the same way as an optical spectrum analyzer. In addition, the Q7760 can measure chromatic dispersion characteristics over a wide dynamic range simultaneously with optical transmission amplitude characteristics.

Extensive Group Delay Measurement Range

Measurement accuracy: ±0.05 ps

Maximum group delay measurement range: 7.5 µs

A group delay accuracy of ±0.05 ps and a maximum measurement range of 7.5 µs can be achieved. Group delay and chromatic dispersion can be measured with the same time resolution of 0.1 ps.The Q7760 can measure the characteristics of a wide range of devices from low to high-dispersion optical components (such as dispersion-compensating devices).

Enhanced Optical Fiber Chromatic Dispersion Measurement Functions

The Q7760 is equipped with four types of optical fiber fitting functions so that chromatic dispersion characteristics, chromatic dispersion slope characteristics, and the zero dispersion wavelength of optical fiber can be measured with ease and accuracy. Moreover, the measurement results can be output in a report display file, which is convenient for appending to or saving results. The Q7760 performs various dispersion measurement functions ranging from narrow band optical components to optical fibers such as dispersion shifted fiber.

Zoom and Limit Line Functions

After a measurement, an arbitrary portion of the measured wavelength span can be magnified. This is very convenient for analysis after a batch measurement. For manufacturing test applications, a convenient limit-line function for pass/fail analysis is included. The limit-line function can be applied to group delay characteristics, chromatic dispersion, and polarization mode dispersion, as well as amplitude characteristics. This supports a wide variety of processes from research and development to manufacturing test.

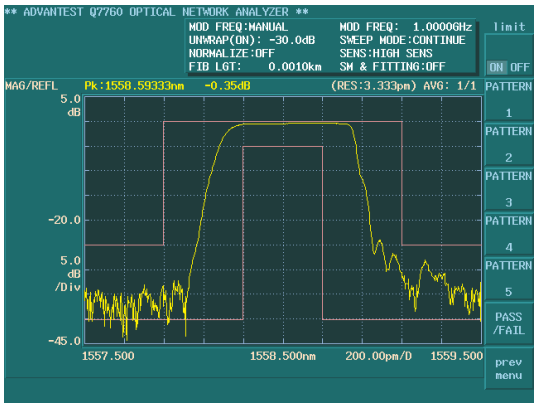


Figure 3: Example display of limit-line function on amplitude characteristics

Relocating with Ease

Most conventional dispersion measurement units are system solutions, and are very inconvenient to relocate. The Q7760 is a relatively small stand-alone instrument and can thus be easily moved. Since setting up the Q7760 requires only connecting the two electrical interconnect cables, no complicated calibration is necessary and the Q7760 system can be started immediately.

* Developed in corporation with KDDI CORPORATION.

Measurement Examples

Measurement Example of AWG Optical Demultiplexer

The example below is a measurement of the transmission characteristics (S_{21}) of an AWG optical demultiplexer. A gradual change in the group delay within the optical pass band can be measured. Because of the Q7760's capabilities, a wide dynamic range and extreme flatness are achieved for the amplitude and the group delay characteristics. Therefore it is possible to make measurements without prior calibration.

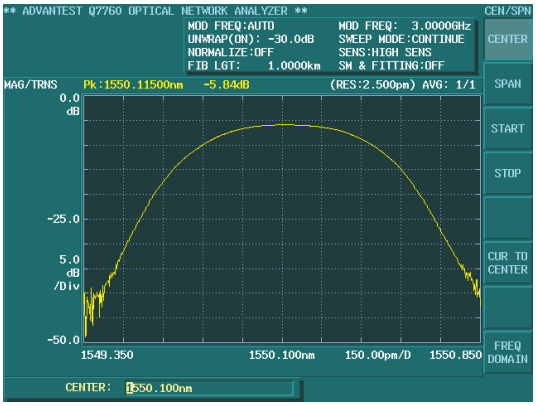


Figure 4: Transmission amplitude characteristics of an AWG optical demultiplexer

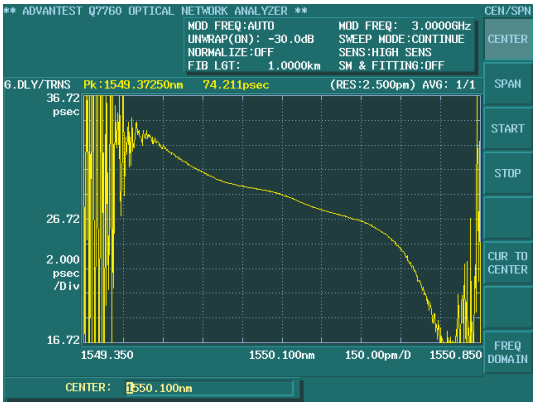


Figure 5: Group delay characteristics of an AWG optical demultiplexer

Optical component measurement

Measurement Example of Fiber Bragg Grating (FBG) Filter for 100 GHz Spacing

The example below is a measurement of the reflected light of a FBG optical filter, in other words, the bandpass characteristics. By simply connecting the DUT to the Q7760, the reflection characteristics (S_{11}) can be measured. The group delay and chromatic dispersion characteristics are simultaneously measured with high-resolution, along with the optical bandpass amplitude characteristics. Of special note, the periodic ripple in the chromatic dispersion and the polarization mode dispersion characteristics of the DUT can be clearly measured.

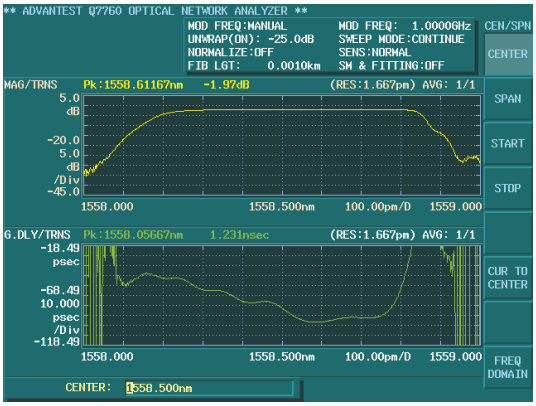


Figure 6: Reflection amplitude and group delay characteristics of FBG optical filter (dual screen display)

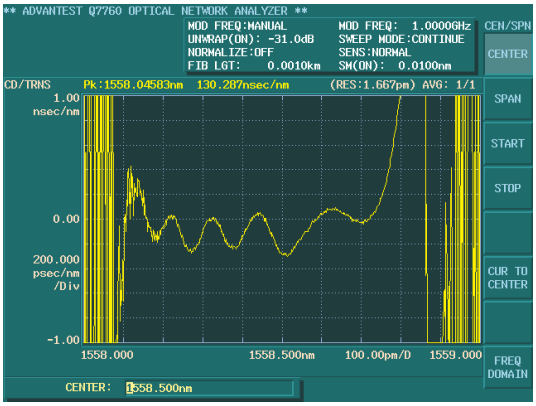


Figure 7: Chromatic dispersion characteristics of FBG optical filter

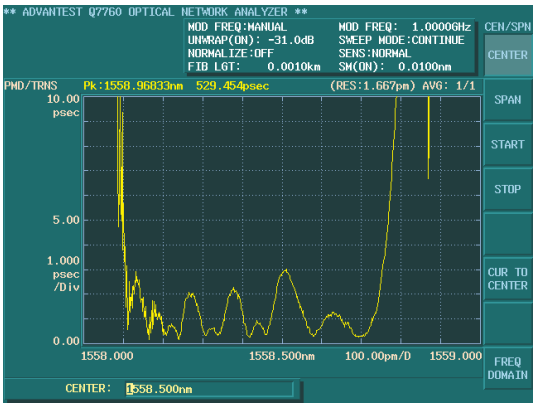


Figure 8: Polarization mode dispersion characteristics of FBG optical filter

Measurement Example of a Dispersion Compensating FBG

The example below shows the measurement of the reflection characteristics (S_{11}) for dispersion compensation with a FBG. The group delay measurement is achieved with high accuracy and high wavelength resolution, revealing in great detail the group delay ripple in the dispersion compensated wavelength range. The group delay ripple can be analyzed quantitatively by using the partial fitting functions. In addition, the polarization mode dispersion characteristics can now be measured with high wavelength resolution by use of the Q7760's polarization phase shift method. This is something other conventional instruments are incapable of.

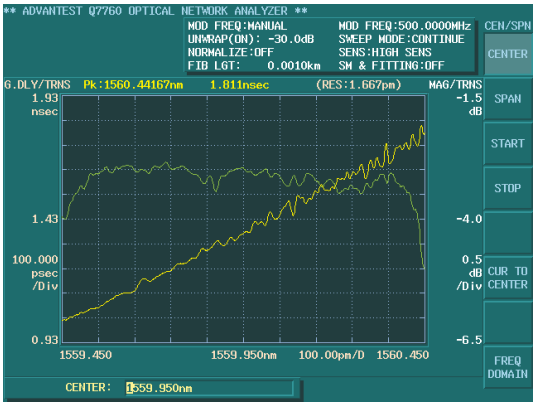


Figure 9: Amplitude and group delay of a dispersion compensating FBG (overlaid graphs)

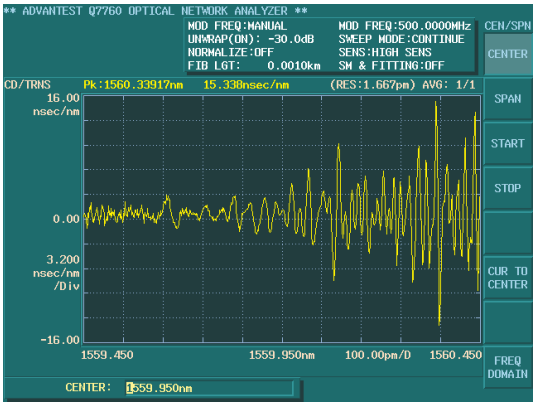


Figure 10: Chromatic dispersion characteristics of dispersion compensating FBG

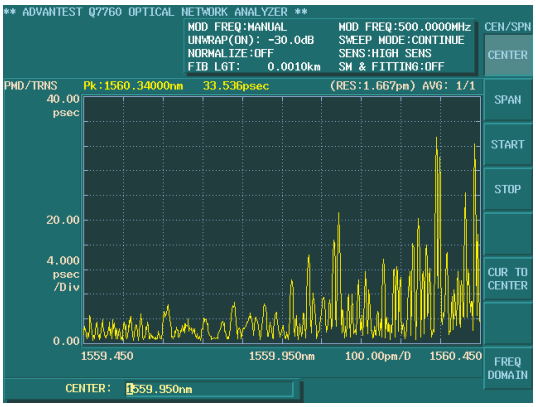


Figure 11: Polarization mode dispersion characteristics of dispersion compensating FBG

Measurement Example of Dispersion Shifted Fiber

The example below shows the measurement of transmission characteristics (S_{21}) of a dispersion shifted fiber. Fitting functions for various optical fibers are installed in the Q7760 for chromatic dispersion measurement of optical fibers. As a result, the zero-dispersion wavelength, chromatic dispersion characteristics, and dispersion slope characteristics can be easily analyzed. Moreover, the measurement results can be output as a report display, which is very convenient for saving and analyzing data.

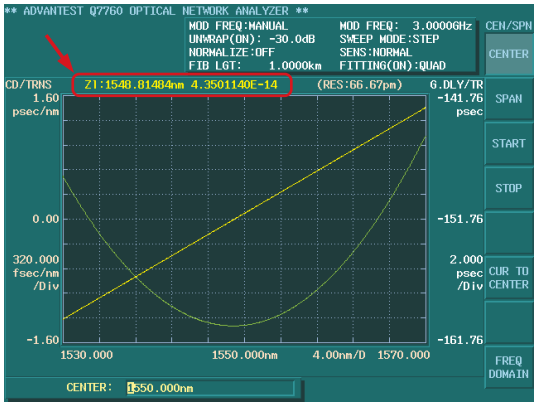


Figure 12: Group delay, chromatic dispersion, and zero-dispersion wavelength of a dispersion shifted fiber, along with the fitting error value

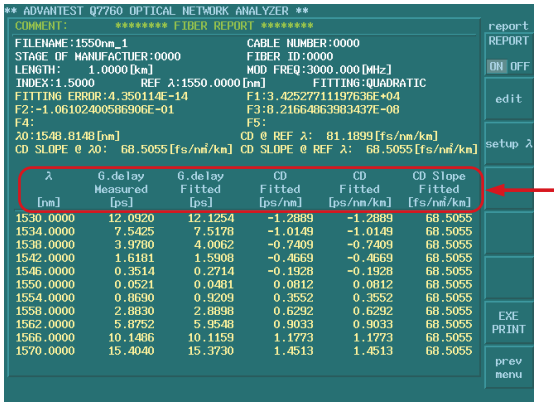


Figure 13: Example of displaying a report of measurement results. From the left, wavelength, group delay, fitted group delay, fitted chromatic dispersion, fitted chromatic dispersion per unit length, and fitted dispersion slope per unit length

Optical fiber measurement

Specifications

Measurement Functions

Sweep channels:	2 channels (reflection characteristics, transmission characteristics)
Reflection characteristics (S_{11}):	Amplitude, Group delay, Chromatic dispersion, Chromatic dispersion slope
Transmission characteristics (S_{21}):	Amplitude, Group delay, Chromatic dispersion, Chromatic dispersion slope, Polarization mode dispersion (OPTQ7760+15, OPTQ7760+15A)

Optical Signal Source Characteristics[*1)]

Measurement range:	1525 to 1635nm
Absolute wavelength accuracy[*2)]:	±25 pm (standard) ±2 ppm ±1 pm (when used with Q8326)
Wavelength setting resolution:	1 pm
Sweep wavelength range:	Settable from 0.1 to 110 nm (settable from 12.5 GHz to 13.2 THz in optical frequency domain)
Sweep repeatability[*3)]:	Set span x (±0.3%) ±30 MHz or less
Sweep time (measurement time)[*4)]:	Approx. 6.7 ms (per measurement point) Approx. 4 s (per sweep span)
Optical output power level[*5)]:	-15 dBm or more
Optical monitor output power level[*5)]:	-20 dBm or more

Amplitude Characteristics

Scale:	Logarithmic table (0.2, 0.5, 1.0, 2.0, 5.0, 10.0 dB/div) and also linear
Modulation frequency range:	40 MHz to 3 GHz
Dynamic range[*6)]:	Transmission characteristics; 35 dB (typ. 40 dB) Reflection characteristics; 33 dB (typ. 38 dB)
Linearity[*7)]:	±0.10 dB (relative level 0 to -25 dB) ±0.25 dB (relative level -25 to -30 dB)
Polarization dependency:	Transmission characteristics (test port 2); ±0.10 dB Reflection characteristics (test port 1); ±0.15 dB
Repeatability at connector insertion[*8)]:	±0.1 dB

Group Delay Characteristics

Modulation frequency range (fm):	40 MHz to 3 GHz
Max. measurement range:	7.5 µs
Group delay resolution:	1.0 fs

Relative group delay accuracy[*7)]:

Relative level (dB)	Accuracy (s)	for fm=3 GHz
0 to -5 dB	±0.015%/fm	±0.05 ps
-5 to -10 dB	±0.048%/fm	±0.16 ps
-10 to -15 dB	±0.15%/fm	±0.5 ps
-15 to -20 dB	±0.48%/fm	±1.6 ps
-20 to -25 dB	±1.5%/fm	±5 ps

Chromatic Dispersion

Measurement units:	Wavelength range (ps/nm), Optical frequency range(ps/GHz), Chromatic dispersion slope (ps/nm^2), Displays in ps/nm/km, ps/GHz/km, ps/nm^2/km, and ps/GHz^2/km are also possible by inputting the length of optical fiber under test
Measurement range:	0.1 ps/nm to 1 µs/nm
Measurement resolution:	0.01 ps/nm

Fiber Chromatic Dispersion Measurement[*9)]

Repeatability of dispersion coefficient measurement:	0.025 ps/nm, 0.003 ps/nm/km
Repeatability of zero dispersion wavelength measurement:	0.030 nm
Repeatability of dispersion slope measurement at zero dispersion wavelength:	0.025 ps/nm^2, 0.002 ps/nm^2/km
Accuracy of zero CD wavelength:	±0.080 nm ±0.035 nm (when used with Q8326)
Waveform fitting functions:	Linear fit, Quadratic fit, Three-term sellmeier fit, Five-term sellmeier fit

Fiber Length Measurement

Range of measurements:	0.2 m to 10,000 km
Resolution:	0.02 mm or 0.01% of the measured length, whichever is greater
Range of inputs for refraction index:	1.000000 to 2.000000

Polarization Mode Dispersion
(OPTQ7760+15, OPTQ7760+15A)

Measurement units:	ps Displays in ps/$\sqrt{}$km are also possible by inputting the length of optical fiber under test
Maximum measurement range:	333 ps
Measurement resolution:	1.0 fs

Measurement accuracy[*7)]:

Relative level (dB)	Accuracy (s)	for fm=3 GHz
0 to -5 dB	±0.030%/fm	±0.1 ps
-5 to -10 dB	±0.063%/fm	±0.2 ps
-10 to -15 dB	±0.17%/fm	±0.6 ps
-15 to -20 dB	±0.50%/fm	±1.7 ps
-20 to -25 dB	±1.6%/fm	+5.3 ps

Polarization Control Function
(OPTQ7760+15, OPTQ7760+15A)

Polarization extinction ratio:	30 dB or more
Angle setting resolution:	0.1 degree

Processing Functions

Memory function:	Save measurement data to back-up memory and/or to a floppy disk
Display:	Optical frequency display, Overlay, Dividing into two parts, Cursor function
Computing/analysis:	Averaging, Normalization, Smoothing, Expansion show function, Limit line, Partial waveform fitting functions, Waveform fitting functions (Linear fit, Quadratic fit, Three-term Sellmeier fit, Five-term sellmeier fit)

Optical Input/Output

Optical connector type[*9)]:	FC type connector (standard) Changeable to SC and ST type by using adapters available separately

Input/Output Interfaces

GPIB:	IEEE488-1978
Floppy disk drive:	3.5 inch, MS-DOS format
Printer:	D-SUB 25 pin ESC/P, ESC/P-R, PCL
Keyboard:	Conforms to IBM PC-AT
Display:	15 pin, D-SUB connector (VGA)

General Specifications

Operating environment:	**Ambient temperature; 15 to 35°C Relative humidity; 85% or less (no condensation)**
Storage environment:	**Ambient temperature; -10 to 45°C Relative humidity; 90% or less (no condensation)**
Power:	**Display unit; AC 100 to 120 V, AC 220 to 240 V, 50/60 Hz , 300 VA or less Optical network analyzer unit; AC 100 to 120V, AC 220 to 240V, 50/60Hz, 310 VA or less**
Dimensions:	**Display unit; approx. 424 (W) x 220 (H) x 400 (D) mm Optical network analyzer unit; approx. 424 (W) x 220 (H) x 500 (D) mm**
Mass:	**Display unit; 17 kg or less Optical network analyzer unit; 28 kg or less**

Options (OPTQ7760+15, OPTQ7760+15A)

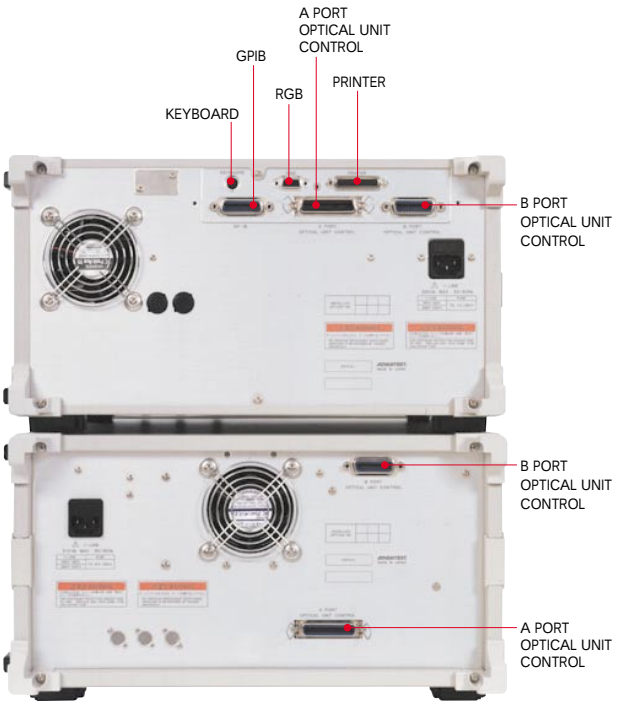
Polarization mode dispersion measurement
(Polarization control function is included)

At time of order:	**OPTQ7760+15**
Retrofit option:	**OPTQ7760+15A**

Accessories (sold separately)
Optical connector adapters

FC connector adapter:	**A08694**
SC connector adapter:	**A08695**
ST connector adapter:	**A08696**

**1) Warm-up time: 2 hrs.*
**2) At initial sweep wavelength and at stable temperature.*
**3) At stable temperature.*
**4) Excluding internal setting time when set span = 60 GHz*
**5) At average power. This instrument is a class 1 laser product.*
**6) Difference between amplitude level and noise level (average value) during direct measurement. At sensitivity = High.*
**7) Relative level with amplitude level at through measurement as standard. No group delay variation under the test sample. At sensitivity = High.*
**8) Value measured with 10 connector insertions using SMF fiber with FC connector.*
**9) Under a specific temperature.*
When 11 km dispersion shift fiber was measured for 20 times.
With zero dispersion wavelength as the center wavelength, measured wavelength span =10 nm, stepped sweep measurement = 11 points (1 point/1 nm).
By approximation derived from second order polynomial.
Dispersion slope = 0.074 ps/nm^2/km.
No external wavemeter was used, unless otherwise noted.
**10) Exchangeable by user.*



Please be sure to read the product manual thoroughly before using the products.
Specifications may change without notification.

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