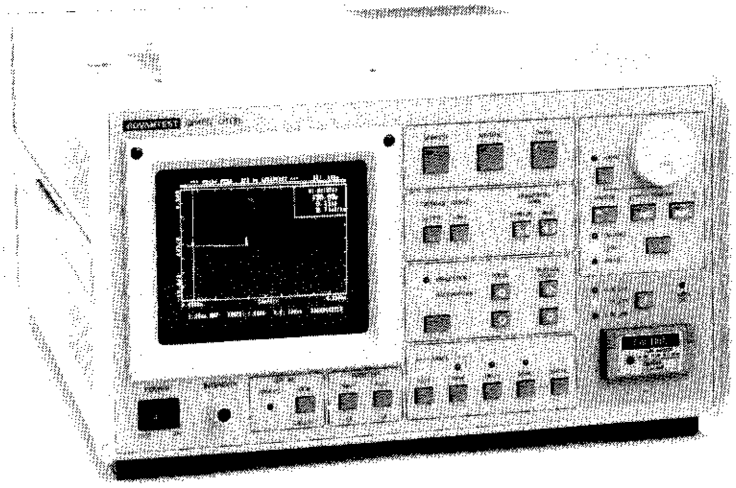
ADVANTEST CORPORATION

INSTRUCTION MANUAL

Q8460

OPTICAL FIBER REFLECTOMETER

MANUAL NUMBER OEK00 9010



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First printing February 8, 1989
Printed in Japan

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1. GENERAL

This chapter explains the basic configuration of this manual, an outline and operation notes of the Q8460 reflectometer, and the Q8460 setup and measurement procedure. The user should read this chapter before starting the measurement.

1.1 Manual Configuration

This manual is intended to be used by the user who is familiar with the optical measuring instruments (or optical system).
The manual consists of the following 6 chapters.
Each chapter has the complete information so that the user can understand the description of each chapter without referring to the other chapters.
When using the Q8460 system first time, the user should read this manual from its beginning. Chapter 5 explains the GPIB (General-Purpose Interface Bus), and the user require to have the basic programming information to understand this chapter. Refer to the programming guide and controller instruction manual if necessary.

1. General	...... Introduction to the Q8460 products General operation notes Preparation before measurement
2. Explanation of Panel and Advance Functions	...... Panel key functions Data displayed on the CRT screen Outline of advance functions
3. Operations	...... Power-on sequence and initial setup Measuring condition setup using panel keys and advance functions
4. Operation Principle	
5. GPIB	...... Remote control via GPIB
6. Specifications	

When using this unit, note that the following warning.

WARNING

The laser beam is emitted from the OPTICAL OUTPUT connector port. Never attempt to see the laser beam with your eyes.

1.2 System Products

The Q8460 optical fiber reflectometer can be used for high-precision measurement of the transmission loss, connection loss, and optical return loss (ORL) of an optical fiber cable. It can also be used to locate the problem (disconnect) position of an optical fiber cable during installation and maintenance.
The Q8460 appears as a very compact and light weight model that contains a thermal printer and 32-screen internal waveform memory to realize the optimum field performance.

[Advantages]

- Expandable plug-in system
  The system has the plug-in unit structure and it can be used for both the single and multiple mode fiber cables.
  Specifically, this reflect meter can measure the single mode fiber in the wavelengths of both 1.31¶m and 1.55¶m.

Plug-in unit	Wavelength	Suitable fiber
Q84601	1.31±0.02μm	10/125μmSMF
Q84606	1.30±0.02μm	50/125μmMMF
Q84605	0.85±0.02μm	50/125μmMMF
Q84605P	0.85±0.02μm	200/125 μmMMF
Q84621	1.31±0.02/ 1.55±0.03μm	10/125μmSMF

- Optical mask function (Q84601/Q84621/Q84621A)
  The optical mask can be set at 3 points on the tube. This function prevents saturation of photosensor by masking the excessive Fresnel reflection. The dead zone immediately after reflection can be reduced.
- Up to 5 cm of resolution
- 0.01 dB of signal loss readout resolution
- Built-in thermal printer
  The measuring condition and result information on the CRT screen can be printed on a hardcopy without using peripheral devices.
- Standard GPIB
  The system can operate in the fully remote control mode from an external controller.
- Portable system
  The system is light in weight (approximately 15 kg) and easy to carry in the field measurement.
- Automatic measurement function
  The system can automatically detect the connect and disconnect positions, and display the distance and loss values.

1.3 Before Use

1.3.1 Appearance Check and Inventory Check

When receiving the Q8460 system, check it for defects due to transportation.
Then, check the system inventory such as the quantity of standard accessories and their IDs by following Table 1-1.
Contact to your representative for any defect or shortage.
Our authorized service representatives are listed at the end of this manual.

Table 1 - 1 System Accessories

Name	Model	Ordering No.	Quantity	Remarks
Power cable	—	DCB-DD3130X01-1	1	Wtih 2-pin adapter
Power fuse	EAWK3.15A	DFT-AA3R15A	2	
Recording paper	A09075	—	3	
Instruction manual	—	JQ8460	1	Japanese language version
	—	EQ8460		English version

1.3.2 Power Supply, Grounding and Fuses

(1) Source voltage

The system can operate by the source voltage of 90 VAC to 250 VAC, 47 Hz to 440 Hz. Make sure that the correct fuse is mounted in the power circuit.
Use the system in the low electrical noise environment although it has been designed to have the sufficient EMI performance. Use a noise filter if necessary.

(2) Power cable

The power cable has a 3-pin plug at its one end. The center round rod is the ground pin, and the system is grounded when the power cable is plugged into the standard 3-pole receptacle. If only the 2-pole receptacle is available, use the A09034 (KPR-18) adapter of the accessory kit. (The adapter is shown in (a) of Figure 1-1.) Connect the ground lead of the adapter or the system ground terminal to the ground.

The A09034 (KPR-18) adapter has been designed to meet certain electrical appliances regulations. The adapter has different height of electrodes (as illustrated in (b) of Figure 1-1). Plug the power cable into receptacle in the correct direction.
If the A09034 (KPR-18) adapter does not match the user receptacle, use the optional KPR-13 adapter.

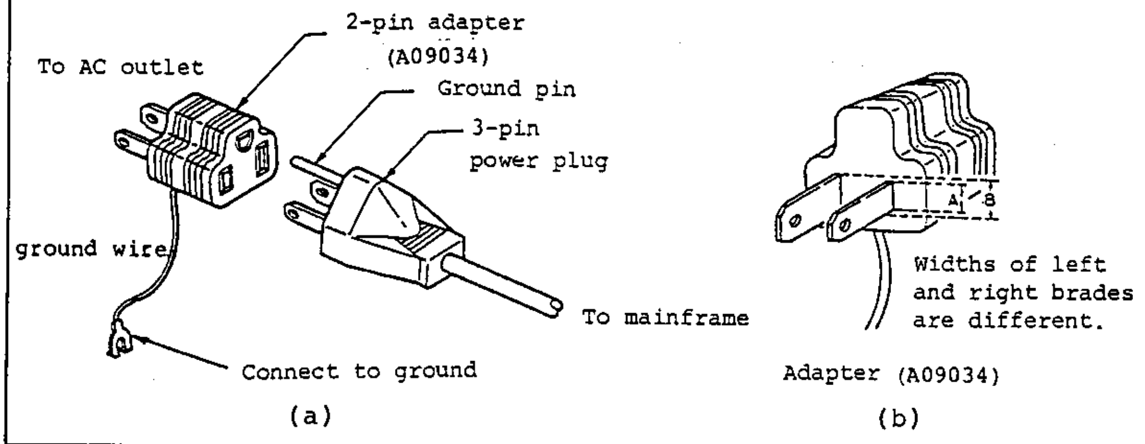
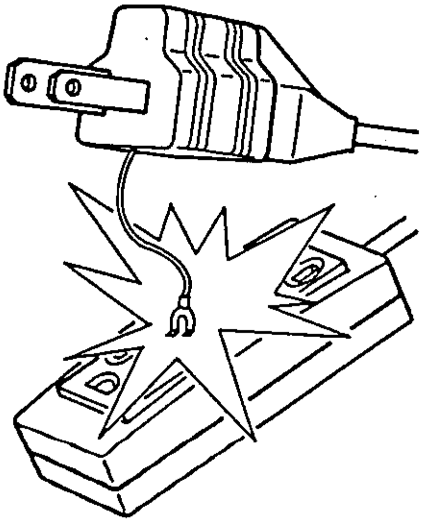


Figure 1 - 1 Power Cable Plug and Adapter

CAUTION

When connecting the ground wire of the adapter plug, never touch it with the hot line (AC line). It is touched by mistake, this unit and/or other units may be damaged.



(3) Grounding

When connecting the Q8460 to a desk-top computer or other devices, take special care not to cause a common mode noise voltage (CMV) due to poor grounding. Do not use the power line if it is not grounded. If the power line is not grounded, approximately 50 VAC of CMV may occur between terminals "a1" and "a2" and between "b1" and "b2" due to power loop (see Figure 1-2). If the ground line between terminals "b1" and "b2" is open and if the signal line between terminals "a1" and "a2" is closed, the I/O circuit chips in circuits 1 and 2 may be damaged.
The grounded power line must be used to prevent circuit damage.
Turn on or off the system by using the power switch. If the power cable is unplugged when the system is on, a CMV may occur instantaneously. Turn off the power switch and unplug the power cable.
If the grounded power line is unavailable, place a jumper between ground terminals GND1 and GND2 (see Figure 1-2), plug the power cable into receptacle, and turn the power switch on.

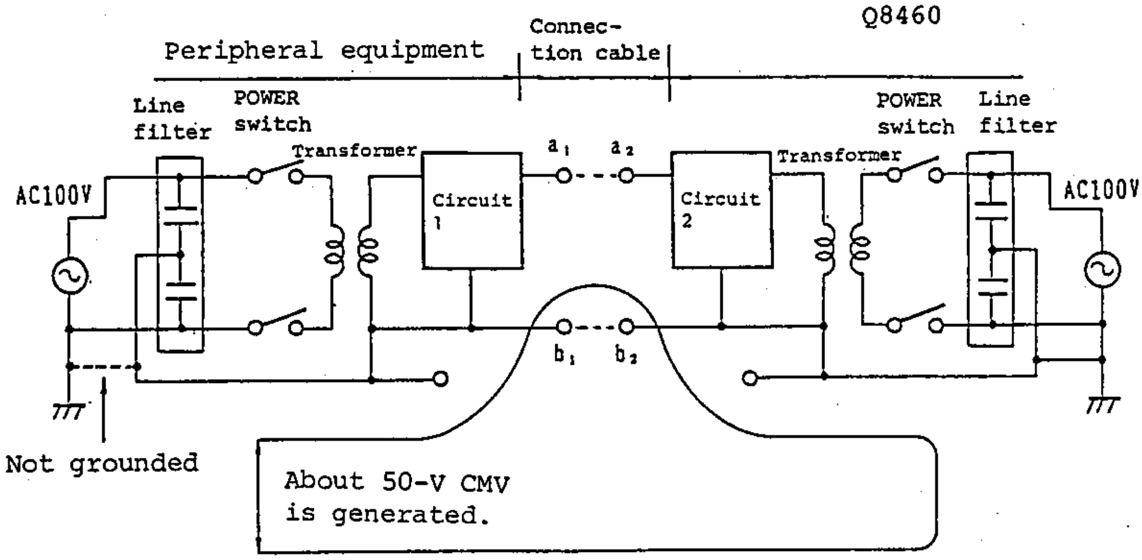


Figure 1 - 2 CMV Generation Loop of Power Line

(4) Fuses

Before replacing the fuse, unplug the power cable from the AC LINE connector. The power fuse is mounted on the fuse holder at the system rear panel.
Use the fuse appropriate to the source voltage as specified below.

Fuse replacement guide:

AC 90 V to 250 V ----- (EAWK3.15A)

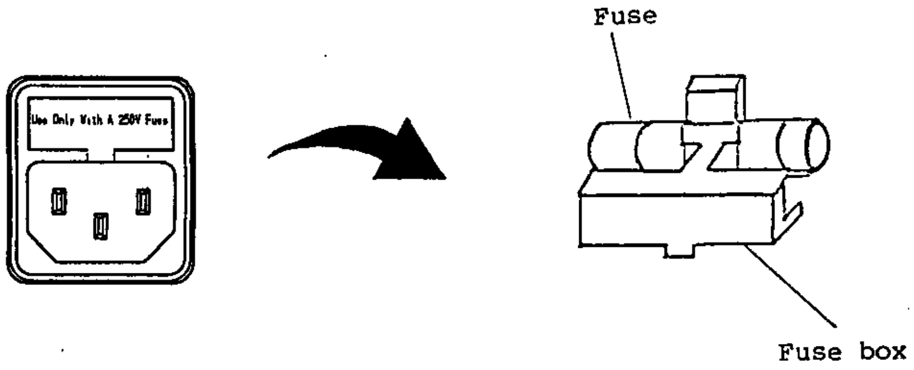


Figure 1 - 3 Fuse Holder

1.3.3 Ambient Conditions and Notes

(1) Temperature and humidity

Use the Q8460 in the ambient temperature of 0°C to +40°C and relative humidity of 85% or less to have the reliable system operation.

(2) Installation location

As the system is a highly sensitive measuring instrument, keep it from excessive dusts or vibration, direct sun, and corrosive gases. Place the system on the stable base so that it is not dropped.

(3) Eye protection from laser beam

The system uses the laser diode as the optical light source. The beam is invisible and harmful to your eyes. Never try to see the optical light source and its related connector sections with your eyes.

(4) Cautions for high voltage

The system uses high voltage power for CRT.
Never disassemble the system inside as Power On.

(5) Cooling and ventilation

The system uses the cooling fan for avoiding temperature rising inside. As the fan is of sucking type, use it with cares to ambient ventilation.
Never place the system upright or put other things behind the system close to it.

(6) Keeping

The temperature range for keeping the system is -20°C to +60°C. If the system is out of service for a long period, cover it with vinyl sheets and keep it from dew condensation with a carton box or others. Place it on a dry position free from direct sun.

(7) Cautions for dew condensation

The system uses lenses inside.
Pay attentions not to cause dew condensation due to sudden temperature change. If dew condensation is observed on the system, dry it completely before use.

(8) Warming up

Secure a 30 minute or more warming up before use in order to obtain satisfactory measuring accuracy.

1.4 Plug-in Units

The system has the following types of plug-in optical source listed in Table 1-2.

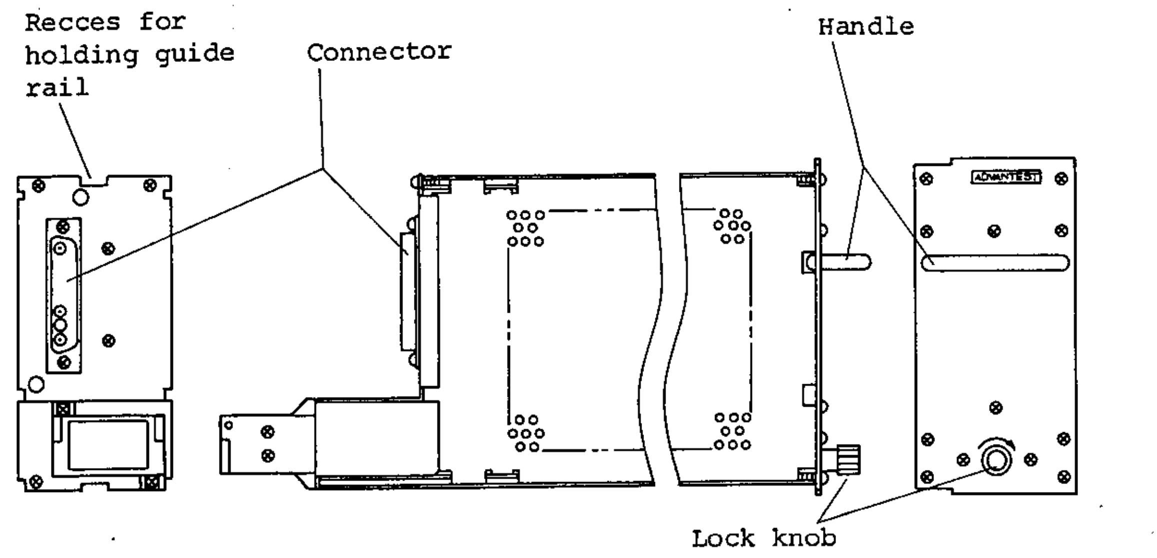
Table 1 - 2 Plug-in Units

Plug-in unit	Wavelength	Suitable fiber
Q84601	1.31±0.02μm	10/125μmSMF
Q84606	1.30±0.02μm	50/125μmMMF
Q84605	0.85±0.02μm	50/125μmMMF
Q84605P	0.85±0.02μm	200/125 μmMMF
Q84621	1.31±0.02/ 1.55±0.03μm	10/125μmSMF

1.4.1 Mounting/Dismounting Plug-in Unit

CAUTION

Turn the system power supply off before mounting or dismounting the plug-in unit.



Turn fully clockwise
to lock.
Turn fully counterclockwise
to unlock.

Figure 1 - 4 Plug-in Unit

(1) Mounting the plug-in unit

① Engage the plug-in unit on the upper and lower rails of the Q8460 system and carefully slide the unit into the housing.

② Make sure that the connector locating on the front panel of the unit engages to the system and that the shutter of the laser output connector can be opened or closed smoothly.

③ Insert the plug-in unit until it engages with the lock of the rear panel and clicks.

④ Fully rotate the control knob of the plug-in unit clockwise (CW) and fix it.

(2) Dismounting the plug-in unit

Unlock the control of the plug-in unit by rotating it counterclockwise (CCW), and pull out the unit by holding the lever by hands.

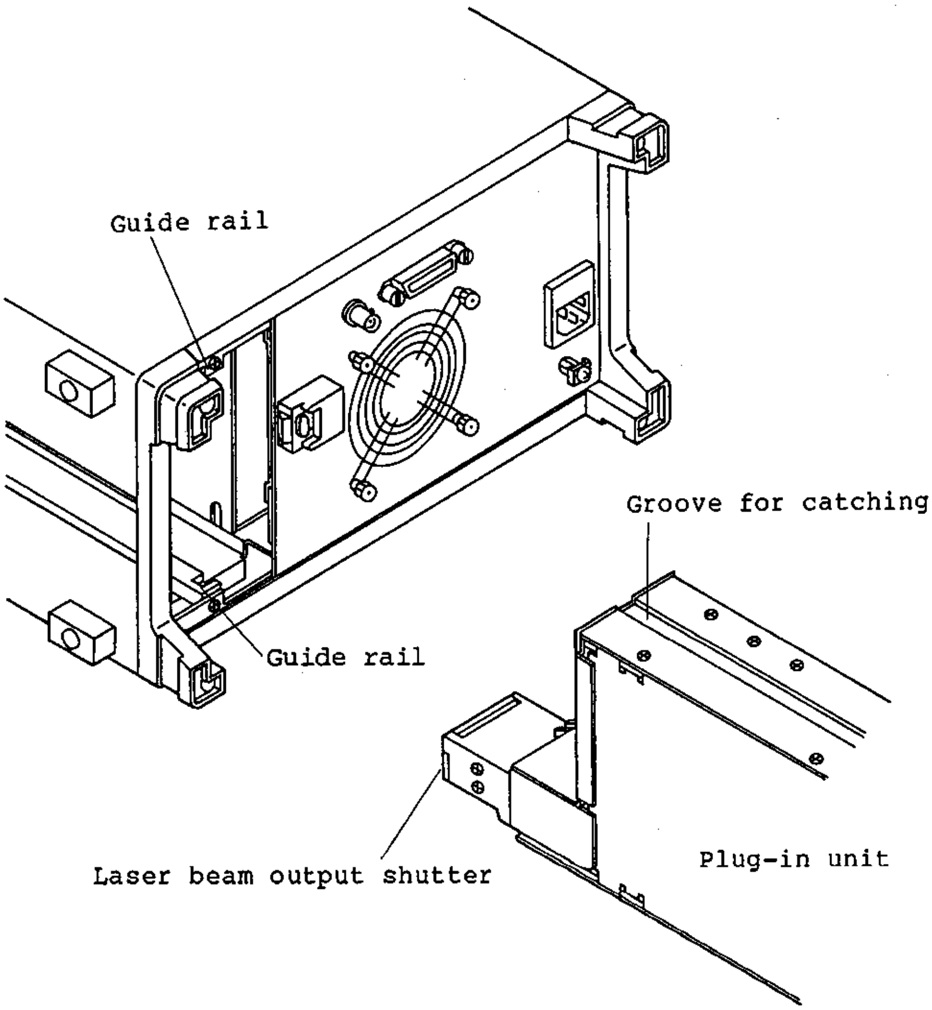


Figure 1 - 5 Method of Handling the Printer

1.5 Method of Handling the Printer

① Slide the head up lever upward.

② Place the roll paper in the holder with its top upside down.

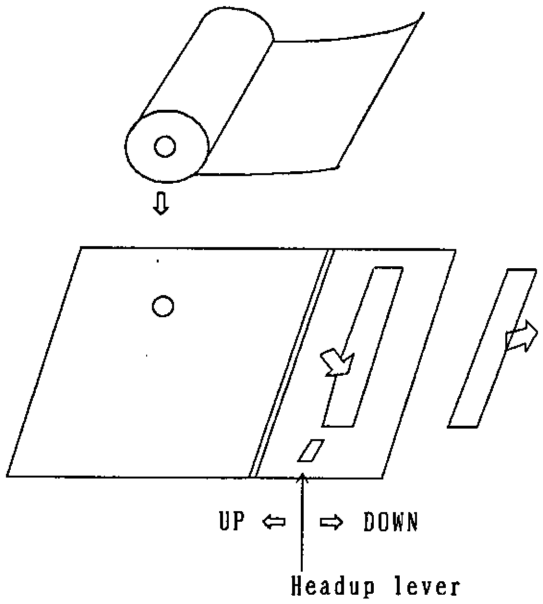
③ Set the roll paper so that paper comes out from the front side of the upper printing head.

④ Set the head up lever to DOWN (hold).

⑤ Perform feeding to check that paper is fed correctly.

Printing paper: A09075 (order number)
Five rolls/box (Printing paper can be ordered in units of one box.)
Thermal face outward rolling:
30m roll
Paper width: 114mm

Note: Avoid using unspecified paper.



2. OPERATION PANEL AND ADVANCE FUNCTIONS

2.1 General

This chapter explains the functions of keys and switches on the operation panel and the advance functions that display messages on the CRT screen. When the LED of a key lights, it indicates that the key function setup mode has been selected. An optional setting value may be changes one after the other whenever the key is pressed, or it may be changed continuously when the data knob is rotated. If the key has no LED indicator, its selected value is displayed on the CRT screen and you can change it using that key.

You can cancel the current setup mode of a key by pressing another setup key.

When you have selected the Buzzer ON mode and you press a valid key, a high-frequency short beep sounds for indicating a valid key input. If you press an invalid key (that is, an unavailable key in the current setup mode), a low-frequency short beep sounds for indicating an invalid key input. (See Paragraph (3) of Section 3.10.)

2.2 Front Panel

① POWER switch : Turns the Q8460 system power supply on or off.

② INTENSITY control : Adjusts the intensity of the CRT screen.

CAUTION

Do not keep the INTENSITY control at the rightmost end position for a long time, or the cathode ray tube (CRT) may be burned.

GPIB

③ REMOTE LED : Lights when the system operates in the remote control mode from a peripheral via the GPIB.

④ LOCAL key : Allows key input from the panel when the system is operating in the remote control mode via the GPIB.

PRINTER

⑤ PRINT/PLOT key : Prints the on-screen information as it is on the built-in printer or external plotter.

⑥ FEED key : Feeds the print forms approximately 6 cm.

⑦ MONITOR key : Repeats measurement and display by executing averaging (2 powered by 8 times). You can set the measurement conditions in this mode.

⑧ AVERAGE key : Executes averaging of data being set by the MONITOR key 2 powered by 8 times or more.

⑨ PAUSE key : Pause averaging and monitor. When this key is pressed again, the averaging and monitor restart.

DISTANCE RANGE

⑩ SHORT key : Reduces the distance range as follows:

⑪ LONG key : Expands the distance range as follows:

HORIZONTAL SPAN

⑫ NARROW key ▷◁	: Sets the distance span. If this key is held down, the distance span decreases to allow measurement with the higher resolution.
⑬ WIDE key ◁▷	: Increases the distance span.
⑭ Measuring mode setup keys (REFLECTION/ BACKSCATTER)	: Select the measuring mode as follows: REFLECTION : Can measure the Fresnel reflection. BACKSCATTER: Can measure the back scatter.
⑮ PULSE keys	: Sets the LD pulse width as follows: ⇧ : Selects the wide pulse width. ⇩ : Selects the narrow pulse width.
⑯ VERTICAL SCALE keys	: Sets the scale on the vertical axis. ⇧ : The vertical scale expands. ⇩ : The vertical scale compresses.

TRACE

⑰ SAVE key (⇦)	: Store the measured waveform in the internal memory. (Move the cursor to the left when ADVANCE FUNCTION menu is displayed. Also, this key moves the cursor to the left when STEP of the automatic measurement mode is being displayed.)
⑱ VIEW key (⇨)	: Display the waveform being measured and the saved waveform on-screen simultaneously. (This is called a "DUAL TRACE" function.) ☼ → Execute the DUAL TRACE ● → Display the waveform being measured (Move the cursor to the right when the ADVANCE FUNCTION menu has been displayed. Also, this key moves the cursor to the right when STEP of the automatic measurement mode is being displayed.)
⑲ AUTO key	: Selects the automatic measurement mode.
⑳ MENU key	: Displays the ADVANCE FUNCTION menu.

㉑ ENTER key (HELP) : Used to select or execute a function within the WINDOW during the ADVANCE FUNCTION mode. (This key starts the HELP function in any other mode.) Also, it can be used as the ENTER key in the automatic measurement mode.

㉒ RAPID key : Switches the operation speed of the data knob (for marker and waveforms movement). When this key is pressed, its LED lights to indicate the RAPID mode.

㉓ Data knob : Changes data in various operation modes including marker movement, label input and change of waveform display position.

㉔ MARKER key : Selects a marker that can be moved by the data knob.

<u>POSITION</u>

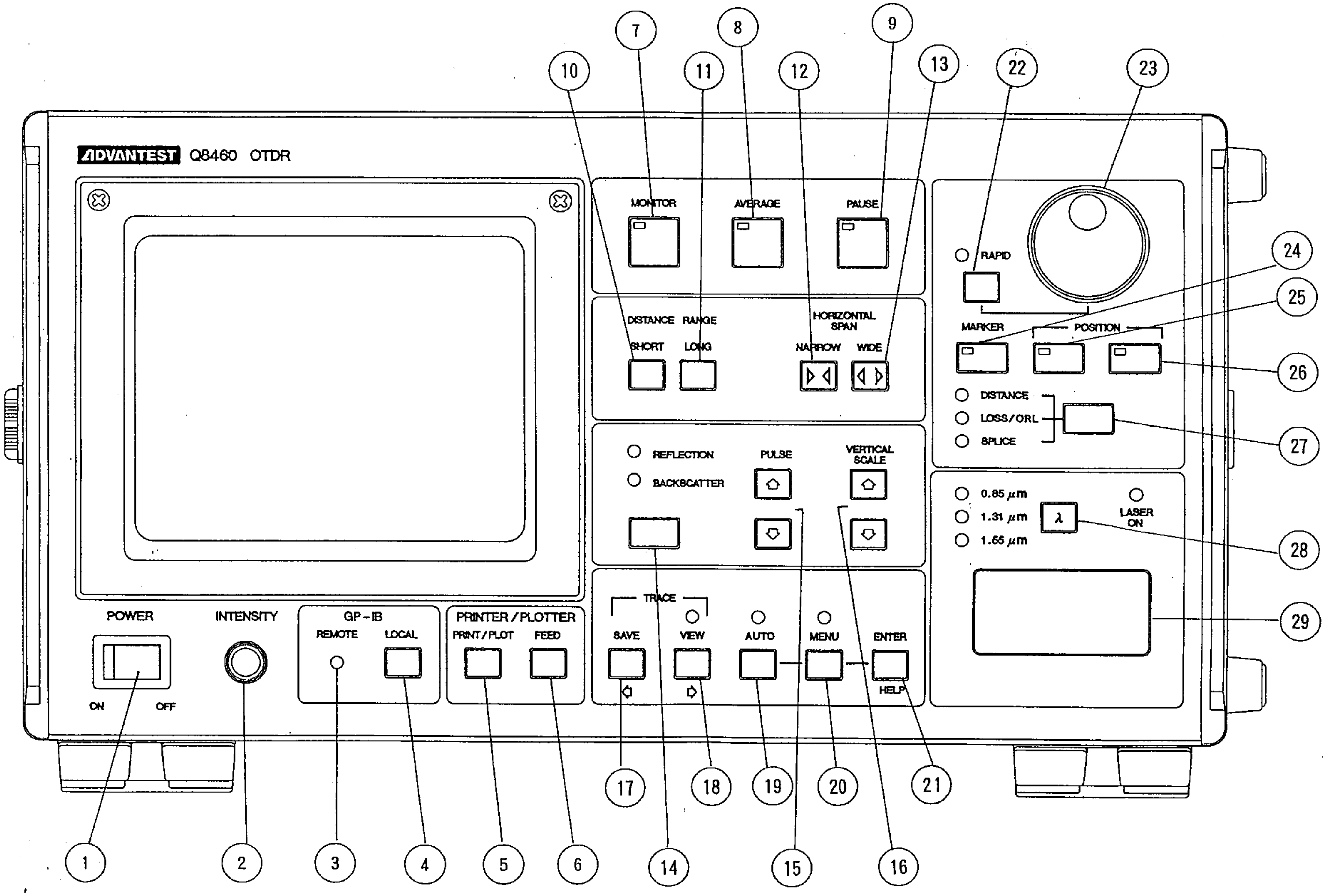
㉕ VERT key : Moves the waveform display position in the vertical direction.

㉖ HORIZ key : Moves the waveform display position in the horizontal direction.

㉗ Marker function select key
: Selects the STANDARD marker function. The left LED lights to identify the selected function

㉘ λ key : Selects the measuring wavelength when the dual-band measuring unit is used. This key is not used for the other units. In such case, the LED of the wavelength of the connected device lights.

㉙ OPTICAL OUTPUT connector
: The optical fiber cable connector is mounted inside the cover.


ADVANTEST Q8460 OTDR
MONITOR
AVERAGE
PAUSE
DISTANCE RANGE
SHORT
LONG
HORIZONTAL SPAN
NARROW
WIDE
REFLECTION
BACKSCATTER
PULSE
VERTICAL SCALE
TRACE
SAVE
VIEW
AUTO
MENU
ENTER
HELP
RAPID
MARKER
POSITION
DISTANCE
LOSS/ORL
SPLICE
0.85 μm
1.31 μm
1.55 μm
λ
LASER ON
POWER
ON
OFF
INTENSITY
GP-IB
REMOTE
LOCAL
PRINTER/PLOTTER
PRINT/PLOT
FEED
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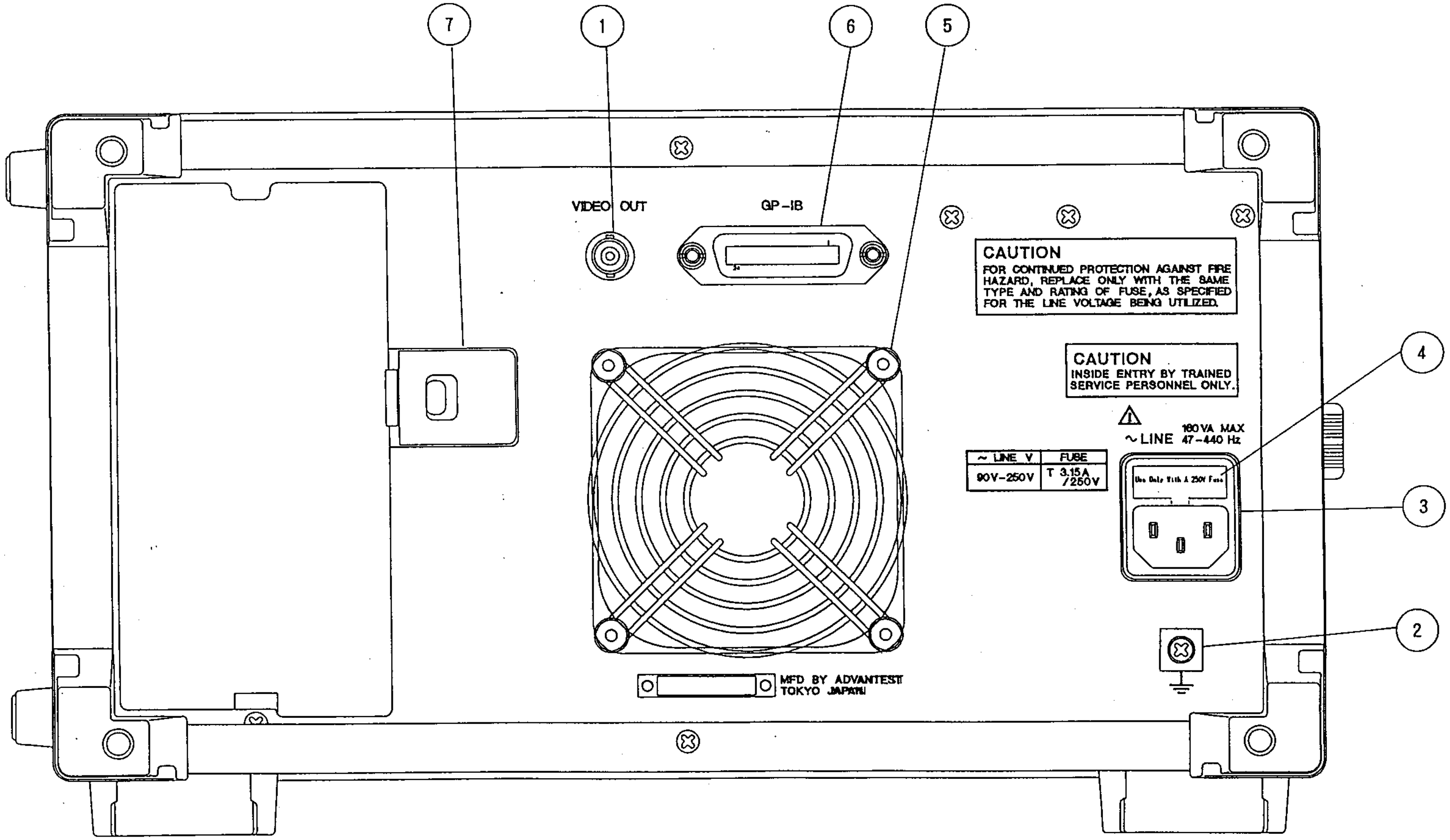
2.3 Rear Panel

① VIDEO OUT connector	: Outputs composite video signal. Monitor TV or video printer can be connected by using the cable with BNC connector. To make hard copy the screen onto a video printer, keep the waveform stable by pressing PAUSE key.
② GND terminal	
③ Power connector	
④ Fuse holder	: When the holder cover is opened, the fuse can be removed. Replace the fuse with an appropriate one. (See the Fuse Replacement Guide table in paragraph (4) of Subsection 1.3.2.)
⑤ Fan	: The system has the cooling fan to prevent an overheat of internal circuits. Do not prevent air flow of the suction fan.
⑥ GPIB connector	
⑦ Lock for prevention of falling plug-in	


7
1
6
5
4
3
2
VIDEO OUT
GP-IB
CAUTION
FOR CONTINUED PROTECTION AGAINST FIRE HAZARD, REPLACE ONLY WITH THE SAME TYPE AND RATING OF FUSE, AS SPECIFIED FOR THE LINE VOLTAGE BEING UTILIZED.
CAUTION
INSIDE ENTRY BY TRAINED SERVICE PERSONNEL ONLY.
~LINE 160VA MAX 47-440 Hz
~ LINE V
FUSE
90V-250V
T 3.15A /250V
Use Only With A 250V Fuse
MFD BY ADVANTEST TOKYO JAPAN

2.4 CRT Display

The measured data and various setup conditions are displayed on the CRT display screen.

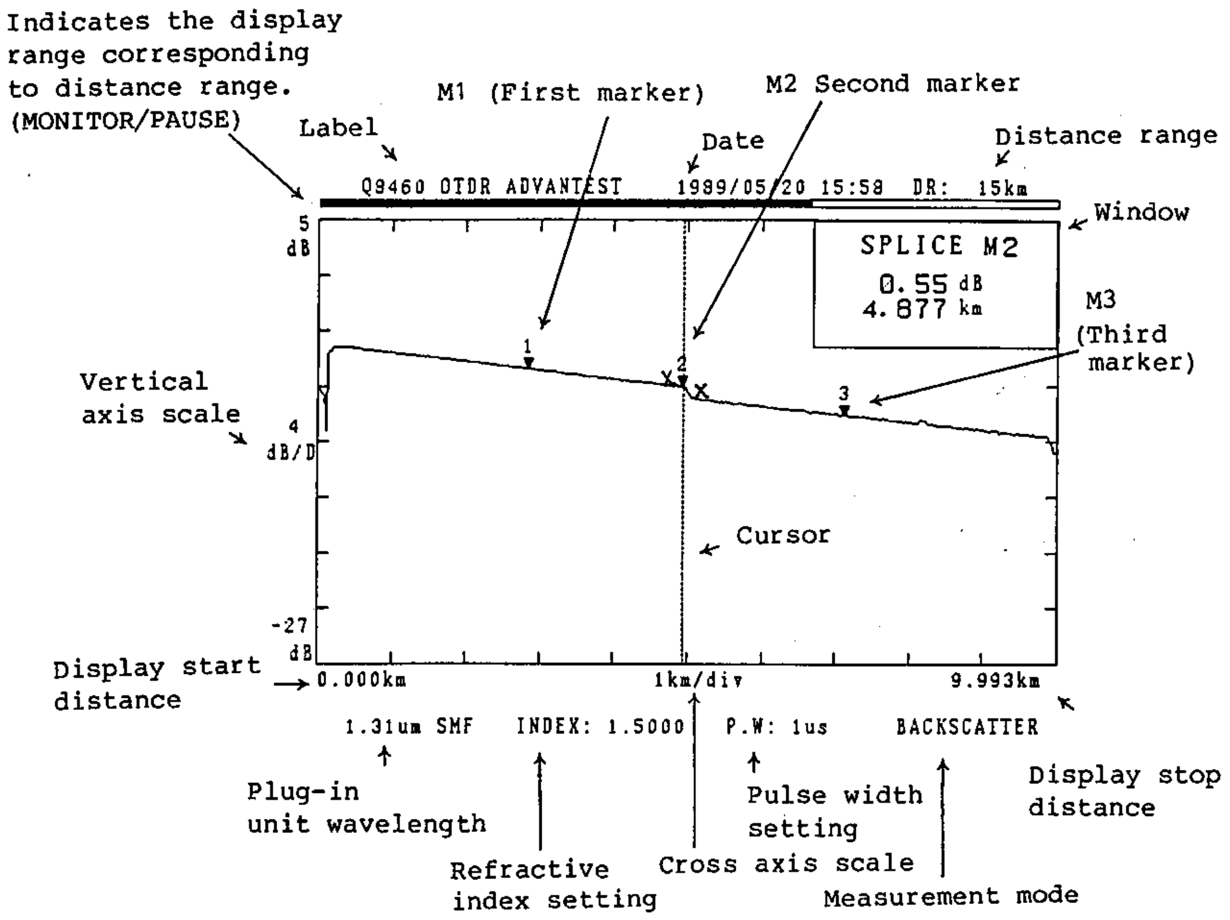


Figure 2 - 1 CRT Display

2.5 What is ADVANCE FUNCTION?

The ADVANCE FUNCTION menu has the following parameter items:

① MEMORY

② LABEL

③ MASK ON

④ MASK OFF

⑤ MARKER

⑥ AUTO MES (AUTO MEASURE)

⑦ BS REFER (BACKCATTER REFERENCE)

⑧ DISPLAY

⑨ I/O

⑩ TIMER

⑪ INDEX

⑫ AVERAGE

ADVANCE FUNCTION mode

When the [MENU] key is pressed, the ADVANCE FUNCTION mode is selected and the following menu is displayed:

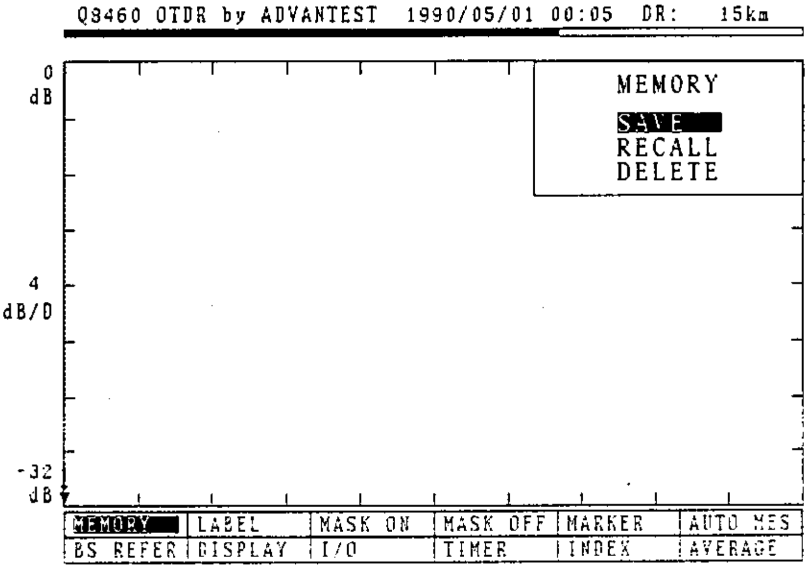


Figure 2 - 2 ADVANCE FUNCTION Menu

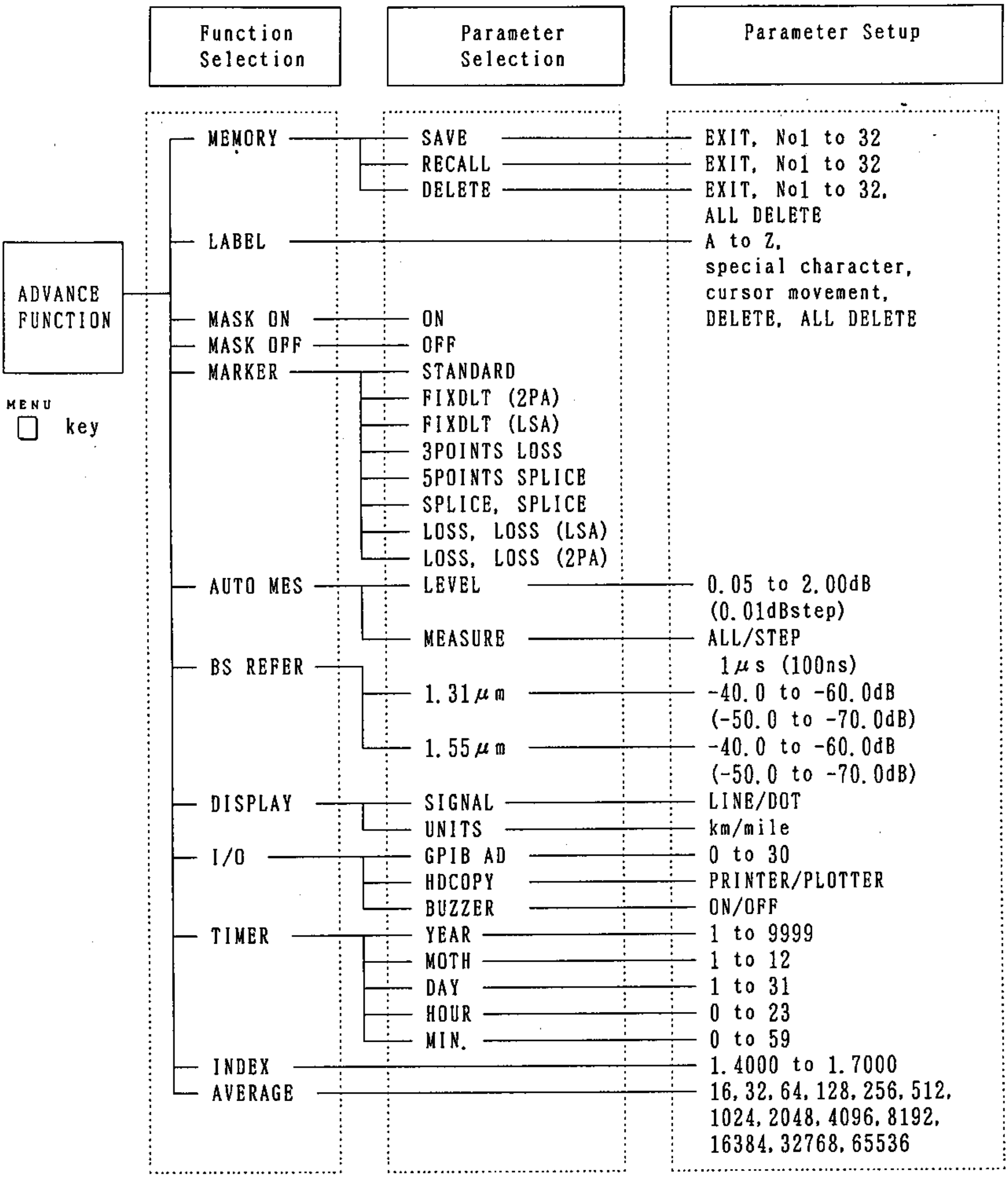
Function selection

Select the desired functions by pressing the SAVE ☐ ⇦ and VIEW ☐ ⇨ keys.

The reversed display cursor position shifts when these keys are pressed. The function in the reversed display is selected.

Parameter selection and setup

Locate the reverse display cursor on the desired function and press the [ENTER] key. Change the set value by using the data knob and press the [MENU] key to select it.



Select by the ☐ (SAVE ⇦) , ☐ (VIEW ⇨) keys.

Select by the ☐ (ENTER) key.

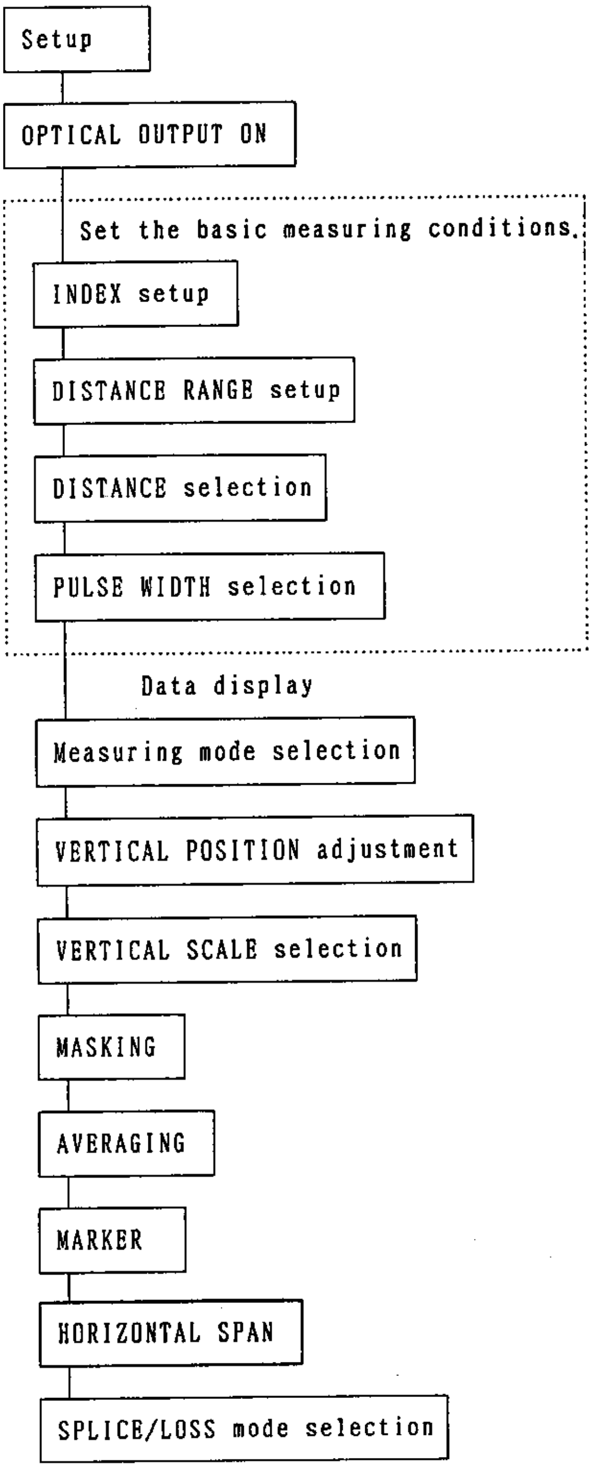
Select data by the data knob.

Figure 2 - 3 ADVANCE FUNCTION Menu

3. OPERATIONS

3.1 Operation Outline

The following illustrates the standard system operation procedure.



Setup	Mount the plug-in unit. Turn the power switch on and connect the fiber cable measured.
OPTICAL OUTPUT ON	Emission of laser beam
INDEX setup	Set the refractive index of the optical fiber measured.
DISTANCE RANGE setup	Set the distance range.
DISTANCE selection	Set the span.
PULSE WIDTH selection	Select the pulse width according to the measuring range.
Measuring mode selection	Select the back scatter or fresnel reflection mode.
VERTICAL POSITION adjustment	Adjust the waveform display position (level).
VERTICAL SCALE selection	Select the scale on the vertical axis.
MASKING	Reduces the fresnel reflection to improve the waveform linearity (Q84601/Q84621/Q84621A)
AVERAGING	Removes the noise.
MARKER	Allows direct data read by the marker.
HORIZONTAL SPAN	Displays the enlarged waveforms.
SPLICE/LOSS mode selection	Selects the point-to-point signal loss measuring mode or line signal loss measuring mode.

3.2 Setup

(1) Mounting the built-in unit

Mount the plug-in unit appropriate to the measurement (see Section 1.4).

(2) Power on

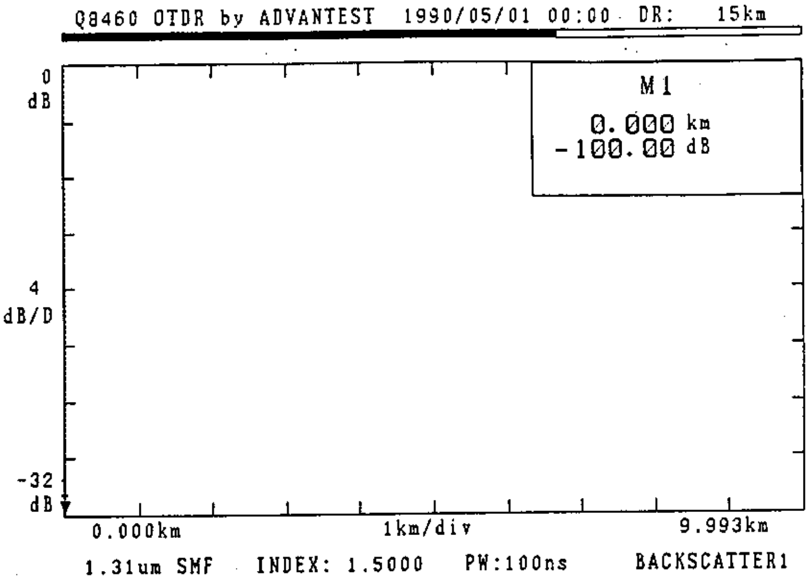
The equipment contains a lithium battery that allows the memory to store for about 10 years the user-set conditions existing before the power off sequence.
When you turn the POWER switch on, all LEDs light instantaneously and the last setup conditions (before you have turned it off) are regenerated. However, the following parameter items are initialized:

Item	Initial setting
MONITOR/AVERAGE	MONITOR
PAUSE	ON
VIEW	OFF
MENU	OFF
HELP	OFF
AUTO	OFF

(3) Initial setup

When the system power switch is turned on, all LEDs light on the panel. Press the LOCAL key and the initial status is set as follows. To initialize the system from a remote system via the GPIB, send the "Z" command to the Q8460.

Item	Initial setting
DISTANCE RANGE	15km
PULSE WIDTH	100ns
INDEX	1.5000
Measuring mode	BACKSCATTER BACKSCATTER1 (Q84621A)
LABEL	Q8460 OTDR ADVANTEST
RAPID	OFF
MASK setting	Clear
MEMORY SAVE DATA	Clear
GPIB ADDRESS	11
HDCOPY	PRINTER
DISPLAY SIGNAL	LINE
DISPLAY UNITS	km
AVERAGE repeat count	256
BUZZER	OFF
ORL BS REFER LEVEL	-49.0dB (1.31μm) -59.0dB (1.55μm)
AUTO MEASURE LEVEL	STEP 0.50dB
MARKER	STANDARD-DISTANCE
VERTICAL SCALE POSITION	4dB/DIV 0 to -32dB


Q8460 OTDR by ADVANTEST 1990/05/01 00:00 DR: 15km

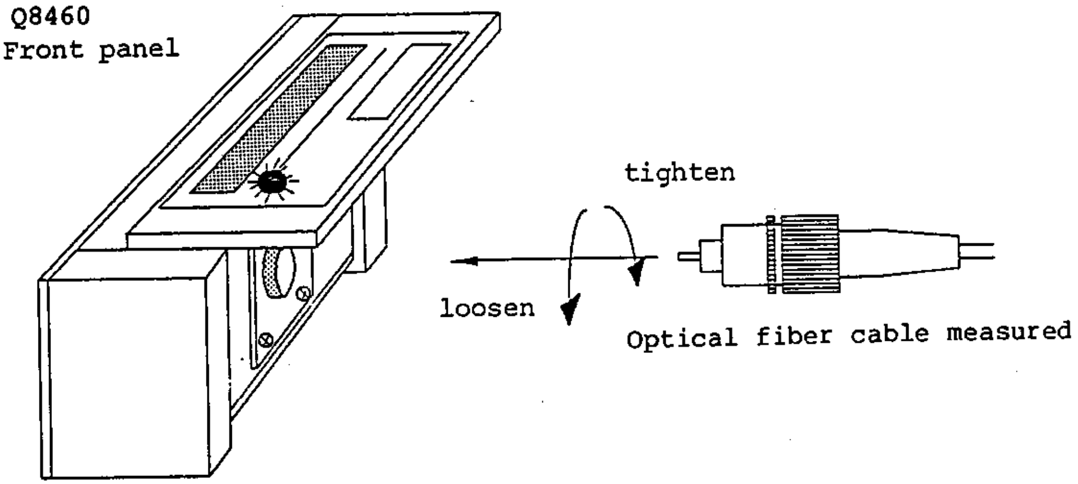
M1
0.000 km
-100.00 dB

1.31um SMF INDEX: 1.5000 PW:100ns BACKSCATTER1

Figure 3 - 1 Initial Setup Screen

(4) Connecting the optical fiber cable measured

Securely connect the optical fiber cable to be measured to the OPTICAL OUTPUT connector.

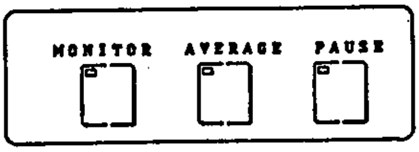


When connecting the optical fiber cable, make sure that the end of the optical fiber cable is clean. If it is dirty, clean it with a solvent.

WARNING

The laser beam is emitted from the OPTICAL OUTPUT connector port. Never attempt to see the laser beam with your eyes.

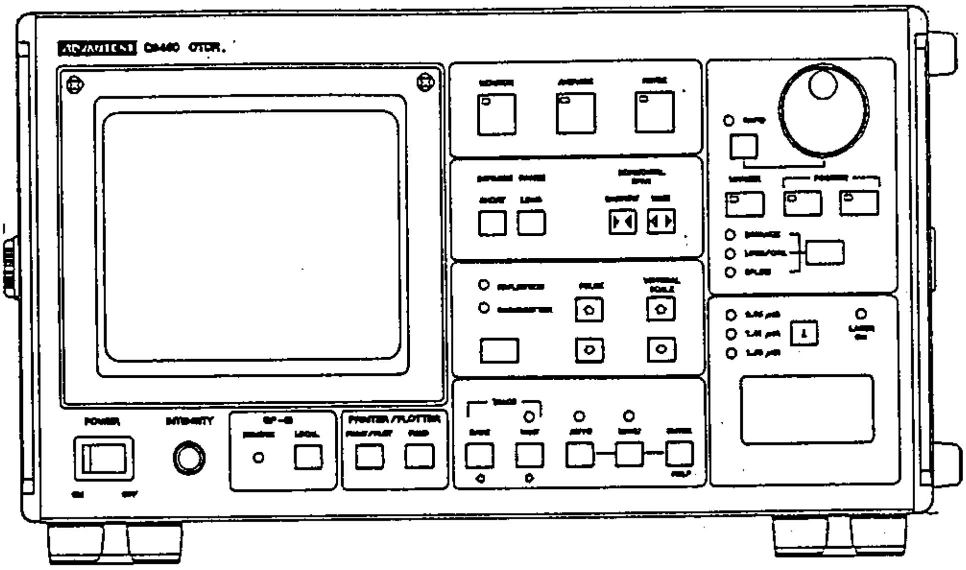
(5) Emission of laser beam



After the optical fiber cable has been plugged into the OPTICAL OUTPUT connector, press the MONITOR or AVERAGE key on the operation panel. And the laser diode beam will be emitted and the measurement will start. The LASER ON LED is kept on to indicate the laser beam emission.
To pause the measurement, press the PAUSE key. When averaging is complete, the measurement terminates and the laser beam emission stops.

3.3 Setting the Measuring Conditions

Set the range, index, pulse width and other measuring parameters according to the length of optical fiber cable being measured and the refractive index of the cable core.



3.3.1 Refractive Index (by ADVANCE FUNCTION)

The Q8460 measures the time (in seconds) of optical pulse transferred via the optical fiber cable and calculates the distance according to the refractive index of the cable core. The user must set the refractive index of the cable core as follows:

Press the MENU key to select the ADVANCE FUNCTION mode.
Select the INDEX by using the SAVE and VIEW keys, and the refractive index will be displayed on the window. Set the desired value by using the data knob and press the MENU key again to enter the refractive index. The refractive index measured from each wavelength is saved in the dual band plug-in unit.

3.3.2 Distance Range (It can be set during monitor status only.)

Set the distance range by pressing the SHORT and LONG keys.
The range changes as follows when these keys are pressed:

1km ↔ 2km ↔ 5km ↔ 15km ↔ 50km ↔ 100km

Select the distance range that is longer than the length of optical fiber cable being measured. The selected range is displayed as the DR (Distance Range) at the right upper end on the screen.
The Q84605P plug-in unit does not have the 50km and 100km ranges. The Q84605 unit does not have the 100km range.

3.3.3 Pulse Width

Set the pulse width according to the purpose of measurement.
The pulse width changes as follows when the PULSE keys are pressed, and the set value is displayed at the bottom of the screen:

3ns ⟷ 20ns ⟷ 100ns ⟷ 1μs

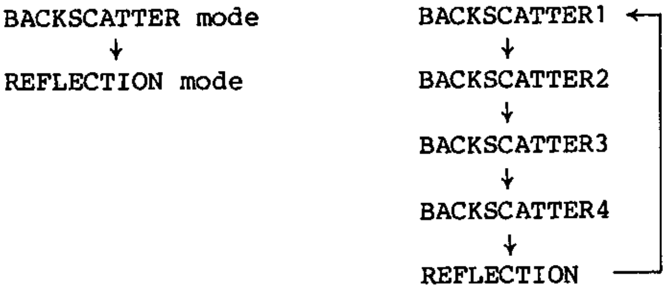
The longer the pulse width is, the broader the dynamic range becomes. While this meter can measure the long optical hiber, the space resolution drops. Conversely, shortening the pulse width provides higher space resolution while the dynamic range is narrowed.

	Pulse width	
	SHORT	LONG
Dynamic range	Low	High
resolution	High	Low

3.3.4 Measuring Mode (It can be set during monitor status only.)

The system has the BACKSCATTER mode for back scatter measurement and the REFLECTION mode for Fresnel reflection measurement.
The REFLECTION mode allows measurement only under a MONITOR status.
Mode selction is impossible during DUAL TRACE execution.
The Q84621A has the following four modes for each of BACKSCATTER options:

(Q84621A)



(1) BACKSCATTER mode (for back scatter measurement)

Can measure the signal loss or shortcircuit of optical fiber cable and the signal loss at connectors.
The Q84621A is able to measure the optical return loss.

(2) REFLECTION mode (for Fresnel reflection measurement)

Can locate the cable disconnection. As the optical sensitivity is reduced, the input signals are not saturated even when a large amount of Fresnel refraction light is received when compared with the back scatter lights.
However, the back scatter cannot be measured in this mode.
No averaging is allowed in this mode.

3.3.5 Averaging

The measurement in the above subsections has been explained in the MONITOR mode. In the MONITOR mode, data is averaged through 2^8 times. If the AVERAGE mode is selected, the measurement noise ratio is improved and more longer fiber cables can be measured.

(1) Setting the average number

Press MENU key and select the ADVANCE FUNCTION mode, then select "AVERAGE" on-screen. The operator can select the average number by turning the data knob. The operator can also increase the average number by stopping the average mode even if the mode is in operation. The equipment displays the number which is multiplied with the average number in the monitoring stage.
The time shown at the bottom of the display value is an appropriate time to the end of averaging. It may greatly change due to Distant Range and Span setup.

(2) Averaging setup

AVERAGE ☐ : Average data (up to 2^{24} times). Averaging continues until the PAUSE key is pressed or data is averaged 2^{24} times.
After averaging, you can increase the number of times and press this key, and the added data will be averaged.

PAUSE ☐ : Pauses averaging. If this key is pressed again, the averaging restarts.
The elapsed time of averaging is displayed on the horizontalframe line of the screen during averaging. When the operator executes the averaging, the column on-screen is gradually filled in with shadow from left to right. And when the shadow reaches the right end, that is, the average number specified in the menu is satisfied, the averaging is completed. The percent shown at the bottom of the display value is the elapsed time in percent. It ends when the value reaches 100%.
The averaging result of the waveforms is displayed every 2^n times (n=9, ..., 16) during averaging.
The display interval increases during averaging.

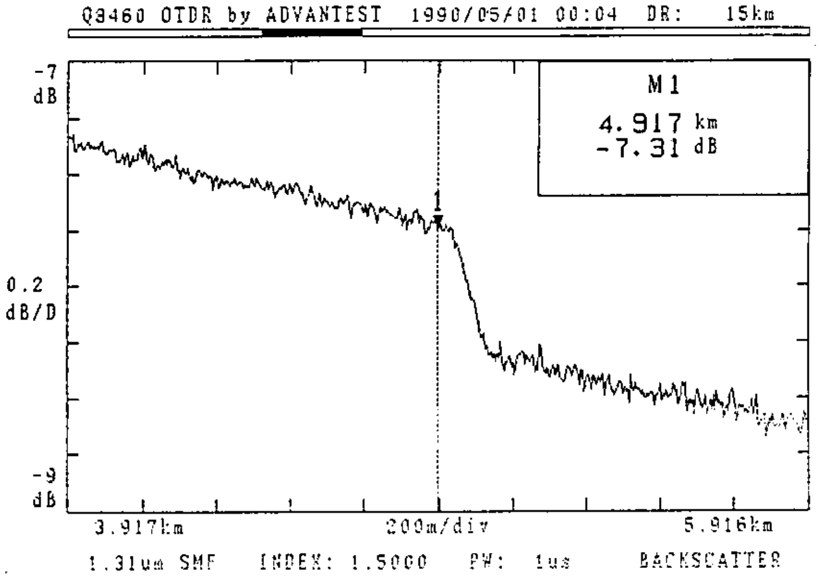


Figure 3 - 2 Before Averaging

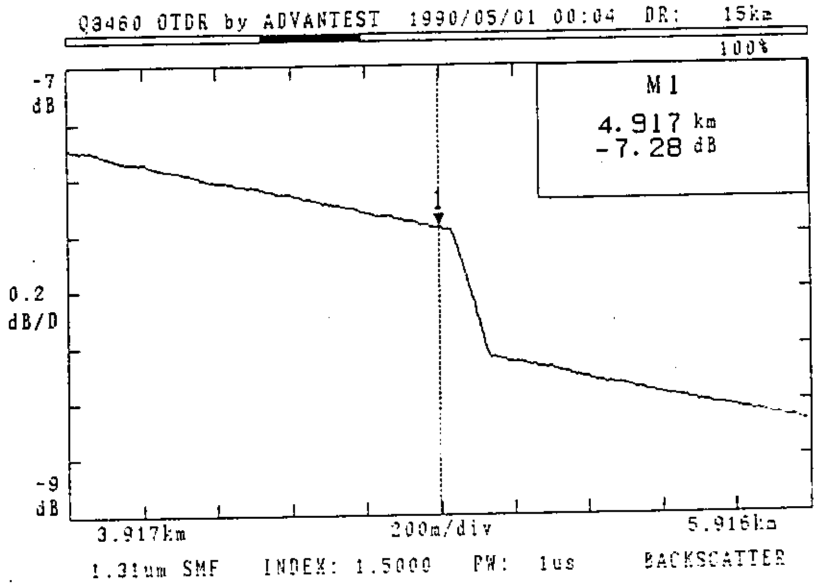
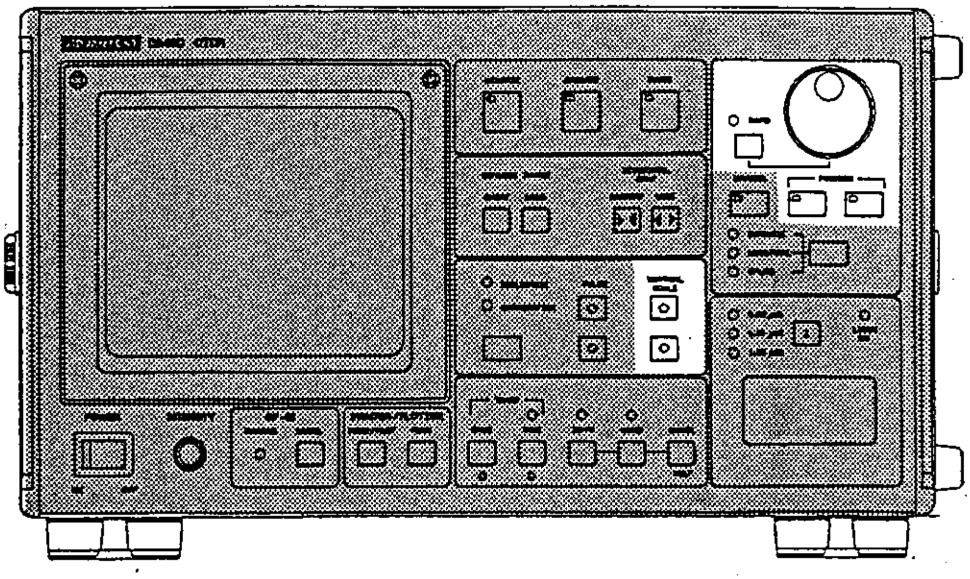


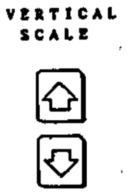
Figure 3 - 3 After Averaging

3.3.6 Vertical Scale and Position



(1) Vertical scale setup

When these keys are pressed, the scale of the vertical axis changes as follows:



4dB/div
↕
2dB/div
↕
1dB/div
↕
0.5dB/div
↕
0.2dB/div

Select an appropriate vertical scale according to the signal loss of optical fiber cable or connection loss.

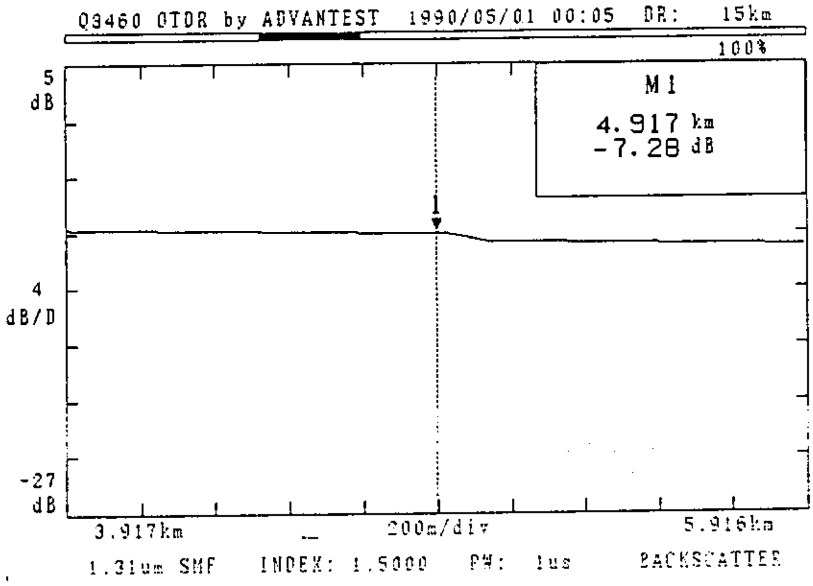


Figure 3 - 4 Before Scale Modification

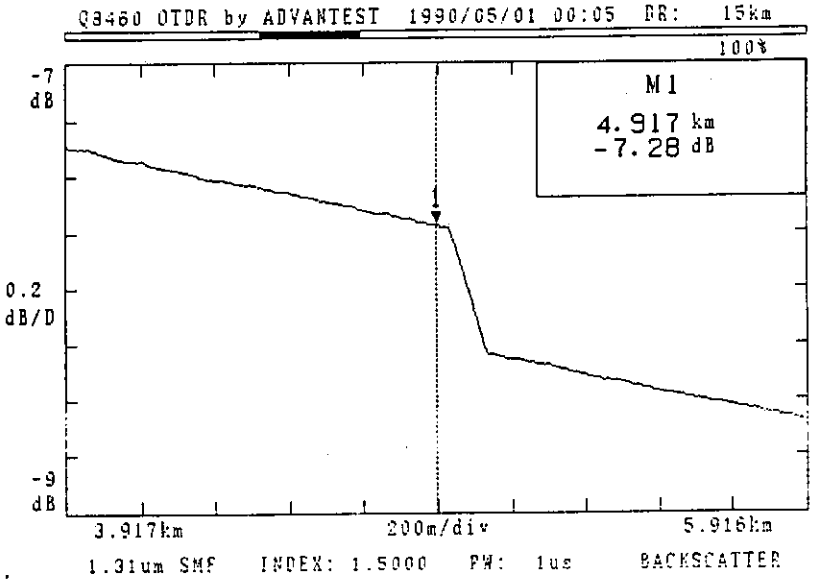
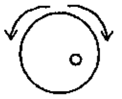


Figure 3 - 5 After Scale Modification

(2) Position setup

Press this key and the user can move the waveforms in the vertical direction by using the data knob. Rotate the data knob clockwise (CW) to move the waveforms upward. Rotate the knob counterclockwise (CCW) to move the waveforms downward.



Moves waveforms downward.

Moves waveforms upward.

3.3.7 Horizontal Span and Position

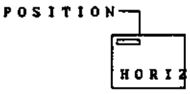
(1) Horizontal span setup

Expands or compresses the horizontal span on the screen.
The span changes at each step when these keys are pressed in each range.

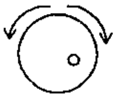
Span Range	10m	20m	50m	100m	200m	500m	1km	2km	5km	10km	20km	50km	100km
1km	●	●	●	●	●	●	●						
2km	●	●	●	●	●	●	●	●					
5km	●	●	●	●	●	●	●	●	●				
15km	●	●	●	●	●	●	●	●	●	●			
50km	●	●	●	●	●	●	●	●	●	●	●	●	
100km			●	●	●	●	●	●	●	●	●	●	●

The span is expanded or compressed at the center identified by the cursor marker.

(2) Horizontal range setup



Press the HORIZ key and its LED will light. Now the user can move the horizontal position.



When the dial knob is rotated clockwise (CW), the waveforms are moved away from the output connector. When it is rotated counterclockwise (CCW), the waveforms are moved toward the output connector.

(3) Store Expand

When averaging is complete or when the PAUSE key is pressed, the LED of the PAUSE key lights. (It indicates that the waveforms are being stored in memory.) The following range can be expanded during this time.
The waveforms are also enlarged or compressed during averaging.

Span change area during storage:

When DR is set 1km

		Adjustable span						
		10m	20m	50m	100m	200m	500m	1km
Setting span	10m	← ○	—	—	—	→	×	×
	20m	←	○	—	—	→	×	×
	50m	×	×	← ○	—	—	→	×
	100m	×	×	×	← ○	—	→	×
	200m	×	×	×	←	○	→	×
	500m	×	×	×	×	×	← ○	→
	1km	×	×	×	×	×	←	○ →

○ : The span is set under a MONITOR status.

When DR is set 2km

		Adjustable span							
		10m	20m	50m	100m	200m	500m	1km	2km
Setting span	10m	← ○	—	—	—	→	×	×	×
	20m	←	○	—	—	→	×	×	×
	50m	×	×	← ○	—	—	→	×	×
	100m	×	×	×	← ○	—	—	→	×
	200m	×	×	×	←	○	—	→	×
	500m	×	×	×	×	×	← ○	—	→
	1km	×	×	×	×	×	←	○	→
	2km	×	×	×	×	×	←	—	○ →

When DR is set 5km

		Adjustable span								
		10m	20m	50m	100m	200m	500m	1km	2km	5km
Setting span	10m	← ○	—	—	—	→	×	×	×	×
	20m	←	○	—	—	→	×	×	×	×
	50m	×	×	← ○	—	—	→	×	×	×
	100m	×	×	×	← ○	—	—	→	×	×
	200m	×	×	×	←	○	—	→	×	×
	500m	×	×	×	×	×	← ○	—	—	→
	1km	×	×	×	×	×	←	○	—	→
	2km	×	×	×	×	×	←	—	○	→
	5km	×	×	×	×	×	×	←	—	○ →

When DR is set 15km

		Adjustable span									
		10m	20m	50m	100m	200m	500m	1km	2km	5km	10km
Setting span	10m	← ○	—	—	—	→	×	×	×	×	×
	20m	←	○	—	—	→	×	×	×	×	×
	50m	×	×	← ○	—	—	→	×	×	×	×
	100m	×	×	×	← ○	—	—	→	×	×	×
	200m	×	×	×	←	○	—	→	×	×	×
	500m	×	×	×	×	×	← ○	—	—	—	→
	1km	×	×	×	×	×	←	○	—	—	→
	2km	×	×	×	×	×	←	—	○	—	→
	5km	×	×	×	×	×	×	←	—	○	→
	10km	×	×	×	×	×	×	←	—	—	○ →

When DR is set 50km.

		Adjustable span											
		10m	20m	50m	100m	200m	500m	1km	2km	5km	10km	20km	50km
Setting span	10m	← ○	—	—	—	→	×	×	×	×	×	×	×
	20m	←	○	—	—	→	×	×	×	×	×	×	×
	50m	×	×	← ○	—	—	→	×	×	×	×	×	×
	100m	×	×	×	← ○	—	—	→	×	×	×	×	×
	200m	×	×	×	←	○	—	→	×	×	×	×	×
	500m	×	×	×	×	×	← ○	—	—	—	→	×	×
	1km	×	×	×	×	×	←	○	—	—	→	×	×
	2km	×	×	×	×	×	←	—	○	—	→	×	×
	5km	×	×	×	×	×	×	←	—	○	—	→	×
	10km	×	×	×	×	×	×	←	—	—	○	→	×
	20km	×	×	×	×	×	×	×	←	●	—	○	→
	50km	×	×	×	×	×	×	×	×	←	—	—	○ →

When DR is set 100km.

		Adjustable span										
		50m	100m	200m	500m	1km	2km	5km	10km	20km	50km	100km
Setting span	50m	← ○	—	—	→	×	×	×	×	×	×	×
	100m	×	← ○	—	—	→	×	×	×	×	×	×
	200m	×	←	○	—	→	×	×	×	×	×	×
	500m	×	×	×	← ○	—	—	—	→	×	×	×
	1km	×	×	×	←	○	—	—	→	×	×	×
	2km	×	×	×	←	—	○	—	→	×	×	×
	5km	×	×	×	×	←	—	○	—	→	×	×
	10km	×	×	×	×	←	—	—	○	→	×	×
	20km	×	×	×	×	×	←	●	—	○	→	×
	50km	×	×	×	×	×	×	←	—	—	○	→
	100km	×	×	×	×	×	×	←	—	—	—	○ →

● : Adjustable span is 4km.

3.4 Mask Functions (Q84601/Q84621/Q84621A)

If significant Fresnel reflections occur, resulting waveform distortion will make accurate measurement impossible.
The MASK function can be used to improve the linearity of waveforms by attenuating the Fresnel reflection level being displayed on the CRT.
Up to a maximum of three MASK points can be set.

3.4.1 MASK Point Setting

(1) Description of the keys to be used and the data knob

Selecting MASK ON from the ADVANCE FUNCTION modes changes the function of the data knob, as well as those of the following keys:

MARKER ☐ key : Changes the assigned function of the data knob to movement of V-markers.

○ Data knob : Moves dedicated V-markers for MASK functions.

ENTER ☐ key : Fixes the MASK point indicated by the V-marker present at the cursor, and then moves the cursor to another V-marker.

(2) MASK-point setting procedure

① First, select the BACKSCATTER mode under a MONITOR status. This is the minimum requirement for setting MASK points.

② Call up MENU on the CRT, and select MASK ON.
The MENU will appear as shown below, and the V marker dedicated to the MASK function appears at the cursor marker position.

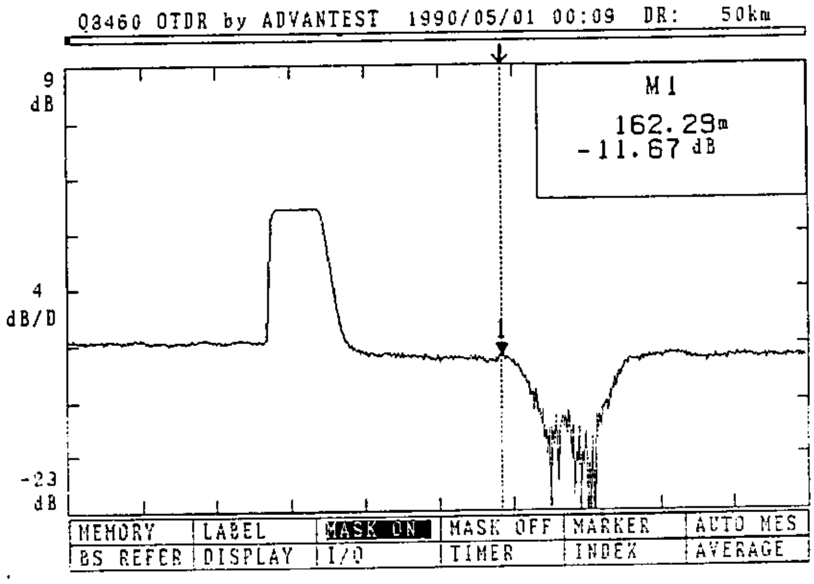


Figure 3 - 6 Display 1 for MASK ON

③ Turn the data knob to move the V-marker. MASK setting will occur along with movement of that V-marker.

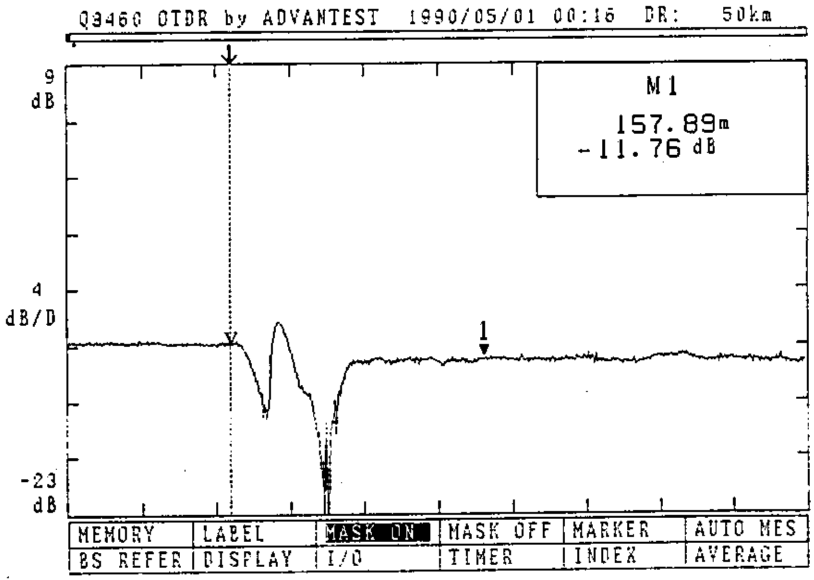


Figure 3 - 7 Display 2 for MASK ON

④ Press the ENTER key to fix the MASK point indicated by the V-marker present at the cursor. Following the fixing operation, the next V-marker will appear at the point what it was existent together with the cursor.

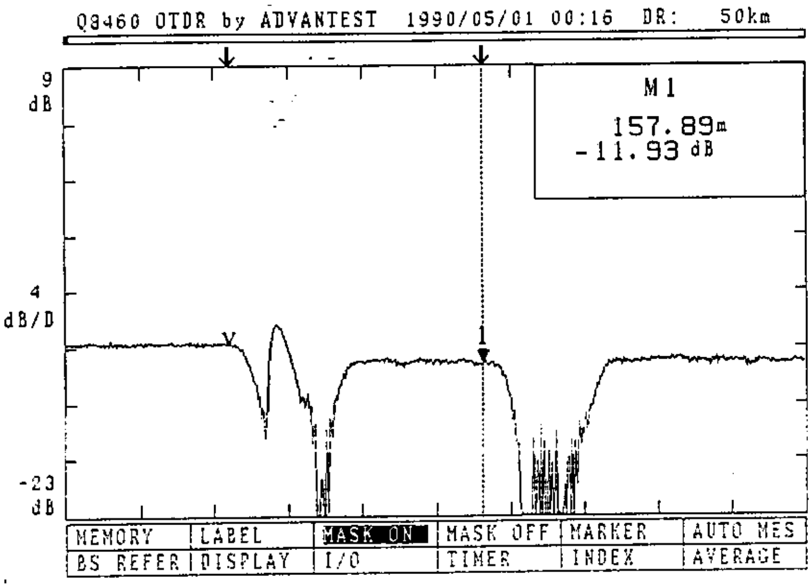


Figure 3 - 8 Display 3 for MASK ON

⑤ Repeating steps ③ and ④ above allows you to set up to a maximum of three MASK points.

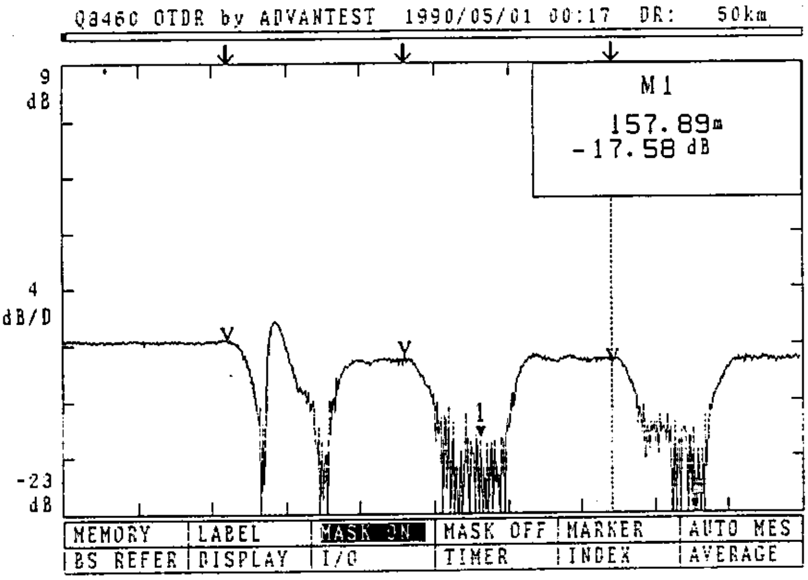


Figure 3 - 9 Display 4 for MASK ON

⑥ Pressing the MARKER key in this status allows you to move the cursor to another V-marker. It also allows you to set any MASK point using the data knob.

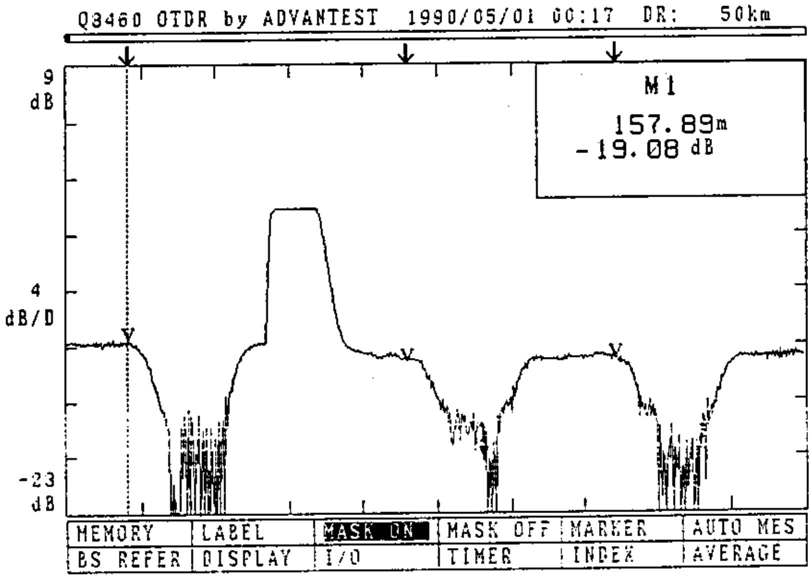


Figure 3 - 10 Display 5 for MASK ON

<NOTE> If the MASK point to be changed is not present on the CRT, call up the intended MASK point on the CRT by changing the HORIZONTAL SPAN or by moving the HORIZONTAL POSITION.

⑦ To return the cursor to the original V-marker position, either clear the display of the MENU or select a mode other than MASK ON and MASK OFF.

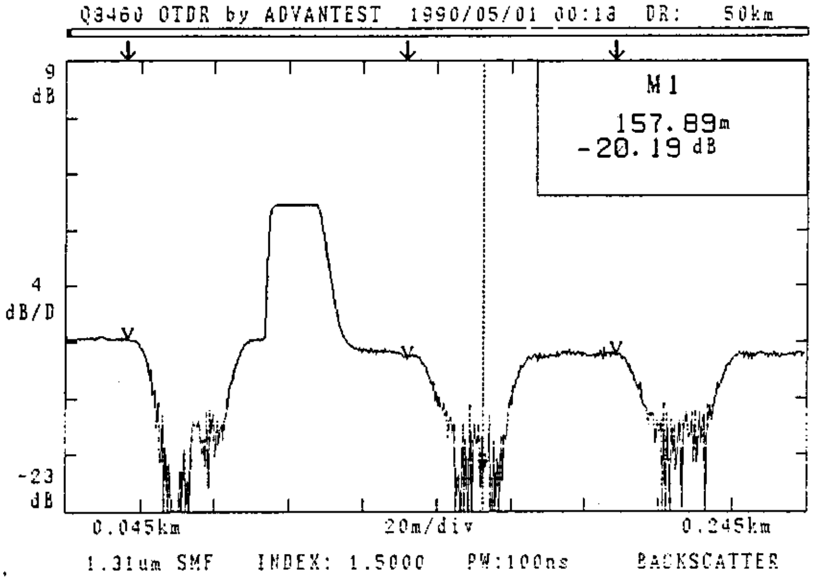


Figure 3 - 11 Display 6 for MASK ON

3.4 2 MASK Point Cancellation

MASK points that have been set are all stored into the memory. To cancel set MASK points, initialize the set data or carry out the MASK OFF operations described below.

(1) Description of the keys to be used

MARKER ☐ key	Used to select the MASK point to be canceld. The cursor moves to the next V-marker each time you press the key.
ENTER ☐ key	Used to cancel the MASK point indicated by the V-marker present at the cursor.

(2) MASK-point canceling procedure

① Call up MENU on the CRT, and select MASK OFF

The MENU will appear as shown below, together with the cursor at the final V-marker that was actuated.

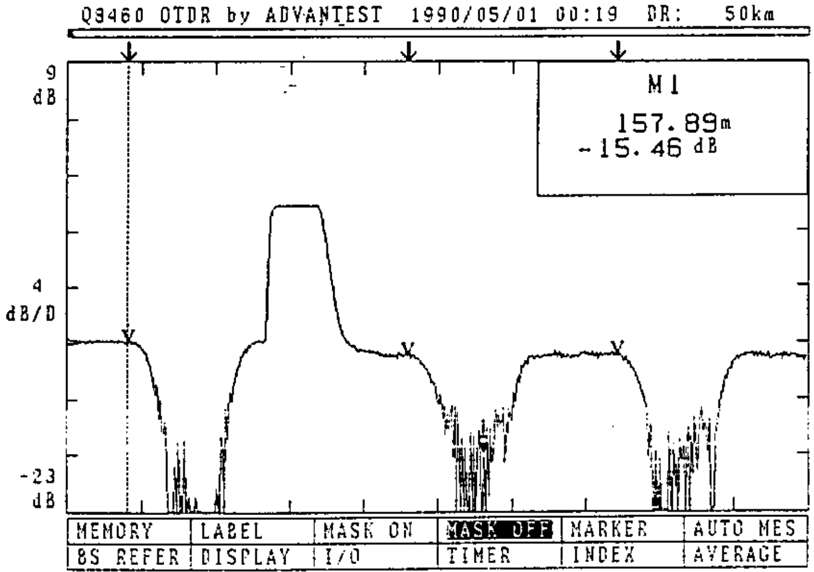


Figure 3 - 12 Display 1 for MASK OFF

<NOTE 1> If you do not want to cancel MASK points under the MASK OFF status of the MENU, do not press the ENTER key; instead, set the MENU to a mode other than MASK OFF.
Set MASK points once again if you have pressed the ENTER key to cancel any.

<NOTE 2> If the final V-marker that was actuated is not present on the CRT, the cursor will not be displayed. In such a case, either call up the final V-marker on the CRT by carrying out the required operations (see Figure 3-10), or call up the cursor at the V-marker on the CRT by pressing the MARKER key once or twice.

② Press the MARKER key and move the cursor to the V-marker indicating the MASK point you want to cancel. Then, select that V-marker and press the ENTER key. The V-marker corresponding to the MASK point at which the cursor was present will then be cleared and that MASK point will be canceled. At the same time, the cursor will move to the next V-marker.

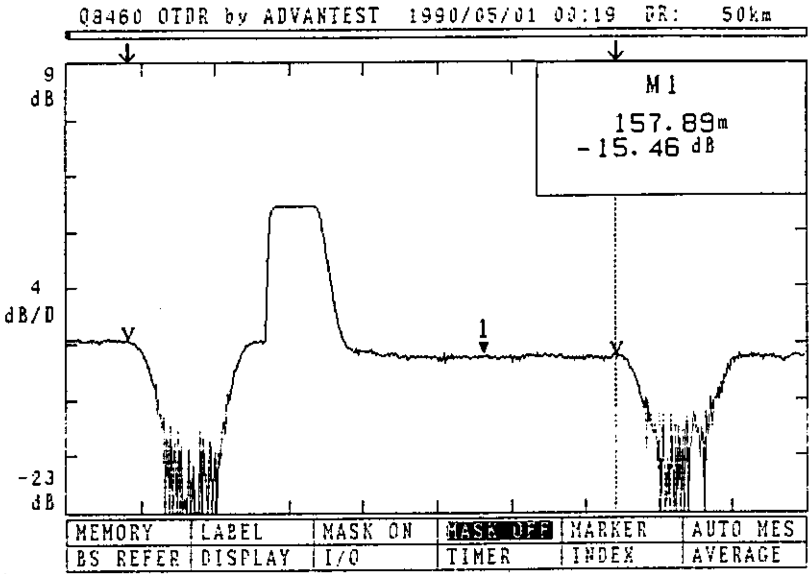


Figure 3 - 13 Display 2 for MASK OFF

<NOTE> Only the MASK points being displayed on the CRT can be canceled. If the MASK point to be canceled is not present on the CRT, call up that MASK point on the CRT by changing the HORIZONTAL SPAN or by moving the HORIZONTAL POSITION.

③ If all MASK points are canceled using procedural step ② above, the cursor will move to the usual marker position.

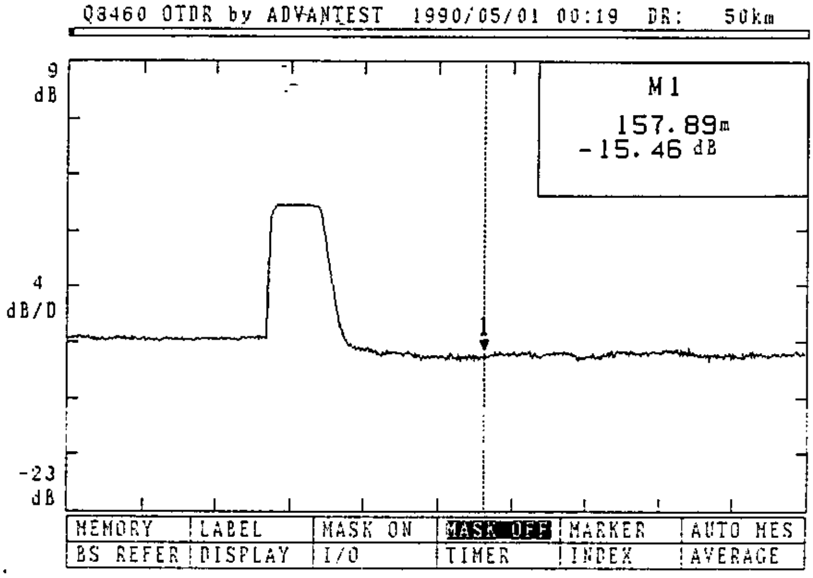


Figure 3 - 14 Display 3 for MASK OFF

3.5 Marker Functions (In ADVANCE FUNCTION Mode)

The following shows the marker functions that can be selected on the ADVANCE FUNCTION menu. The ADVANCE FUNCTION menu is displayed when you press the MENU key. Select a desired function for measurement.

① During the BACKSCATTER mode

- MARKER
  - STANDARD
    - DISTANCE
    - LOSS
    - ORL(Q84621A (plug-in unit) is only available
    - 3 POINTS SPLICE
    - 5 POINTS SPLICE
  - FIX DLT (LSA: Least Squares Approximation)
  - FIX DLT (2PA: 2 Points Approximation)
  - 3 POINTS LOSS
  - 5 POINTS SPLICE
  - SPLICE, SPLICE
  - LOSS, LOSS (LSA)
  - LOSS, LOSS (2PA)

② During the REFLECTION mode

- MARKER
  - STANDARD
    - DISTANCE
    - LOSS

(1) Selecting the marker functions

MENU

Press the MENU key to select the ADVANCE FUNCTION mode. Locate the reverse display cursor onto the MARKER by useing the ENTER key. When the marker menu appears at the right upper end of the screen, locate the reverse display cursor onto the desired marker menu by using the ENTER key. Then, press the MENU key to select the reverse display marker.

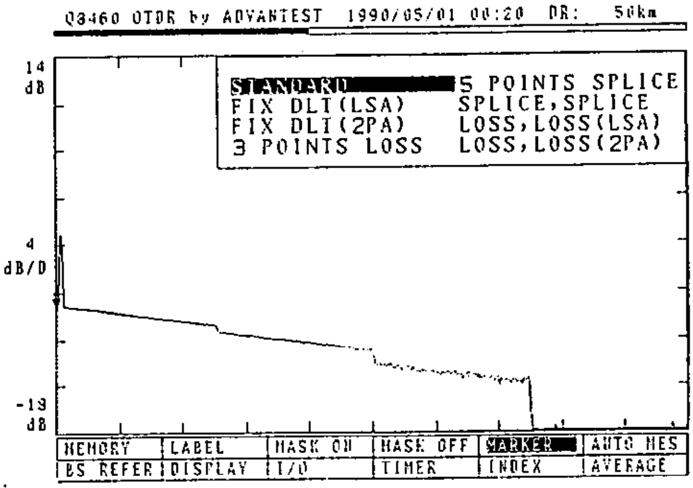


Figure 3 - 15 Marker Menu

(2) Function of each marker

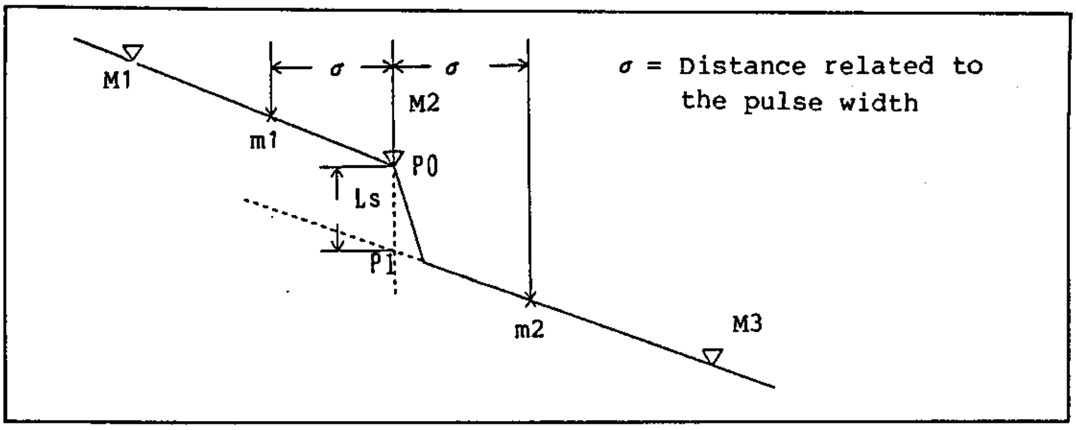
① The STANDARD marker has 3 functions of DISTANCE, LOSS and SPLICE. Select one of them by using key ㉗ on the front panel (explains in the Section 2.2).
The selected function is identified by the LED.
Also, the LOSS option provides the ORL (Optical Return Loss) function that can be used on the Q84621A plug-in unit only.

DISTANCE (M1) : The M1 marker is displayed on the screen. The distance (km) between the output end and M1 and the level (dB) can be measured.

LOSS (M1,M2) : The M1 and M2 markers are displayed on the screen. The signal level difference between M1 and M2, the distance (km) between M1 and M2, and the signal loss per kilometer (dB/km) between M1 and M2 can be measured.

ORL (M1, M2) : The M1 and M2 markers are displayed on the screen. You can measure the ORL value, signal level difference (dB) between M1 and M2, and reference level of back-scattered light. The following defines the ORL function setup and measurement procedure. The principle of ORL is also explained.
└ Optical Return Loss

3 POINTS SPLICE: (M1, M2, M3) The M1, M2 and M3 markers are displayed on the screen. The connection loss due to jumper or connector can be measured by using these 3 markers. The following explains the measurement procedure.



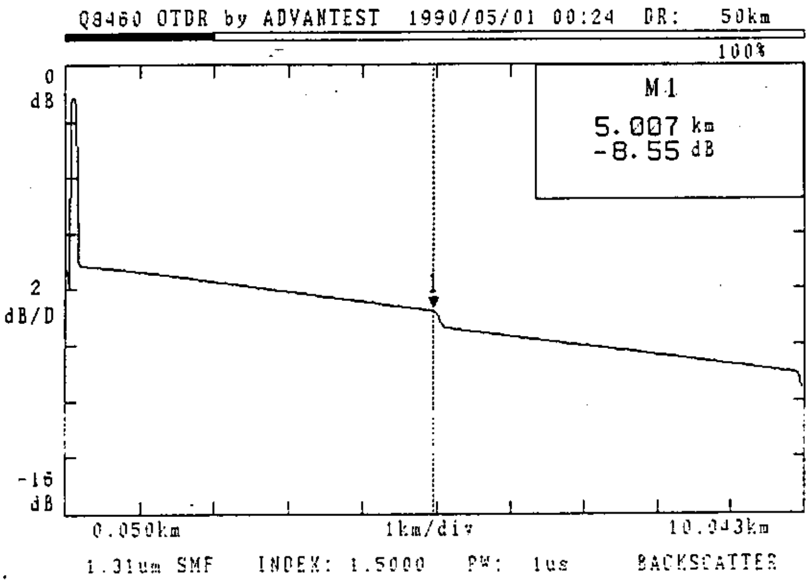
- As shown in the figure, set the M2 marker to the splice change point. Then, set the M1 and M3 markers in any two points of the optical fiber cable so that the M2 marker is located between them.

- To execute the calculation through least square approximation, the "m1" and "m2" points are set in the same distance of "σ" from the M2 marker position.
  On the CRT, both m1 and m2 are displayed as X.
- From the distance data between M1 and m1 and between m2 and M3, the intersection point to the approximate value is set as P1. The level difference between P0 and P1 is set as the splice loss.
- After M3 is set, pressing Marker key displays cursors for each marker of M1, M2 and M3. Markers can be moved with their interval fixed.

NOTE

The points are set in distance " " from M2 because the Fresnel reflection may occur at the M2 point or the splice loss may be affected by the pulse width or frequency characteristics of optical photosensor amp.
If the approximate value line is determined near the M2 point, an excessive error may result.
Similar to the LOSS mode, take care not to cause the Fresnel reflection or splice loss between M1 and m1 and between M3 and m2 during marker setup.

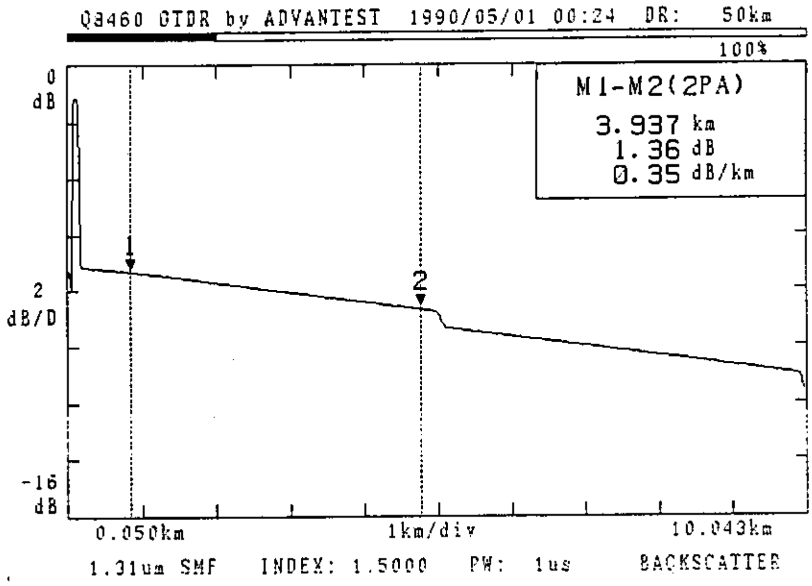
5 POINTS SPLICE: (M1, M2, M3, M4, M5)	Similar to the SPLICE of STANDARD MARKER, the splice loss can be measured. In this mode, however, "m1" and "m2" can be set manually rather than automatically. A reflection due to use of connectors may cause the distortion of back scatter waveforms immediately after the connector position. In such case, "m1" and "m2" should be set manually to eliminate a chance of reflection. The reliable measurement can be made.



Distance of M1 (from the reference point)

Level at M1

Figure 3 - 16 Measurement Display of Distance

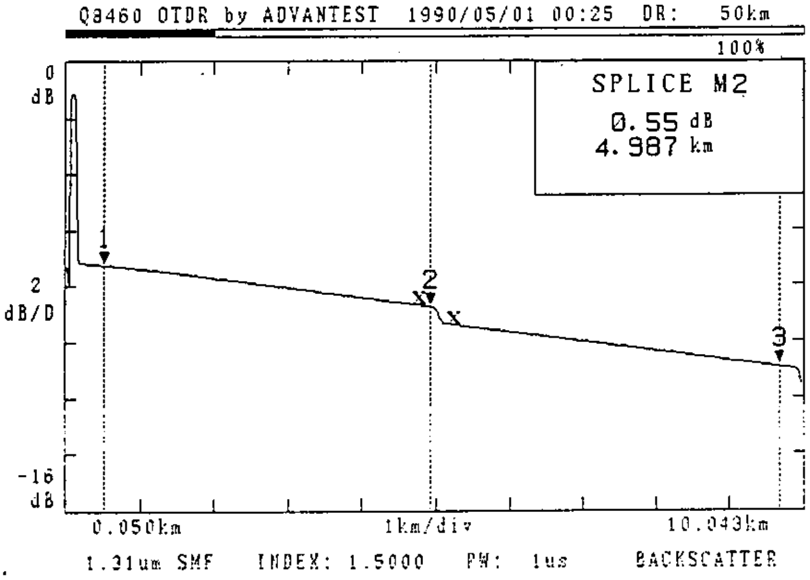


Relative distance between M1 and M2

Loss between M1 and M2

Loss per kilometer between M1 and M2

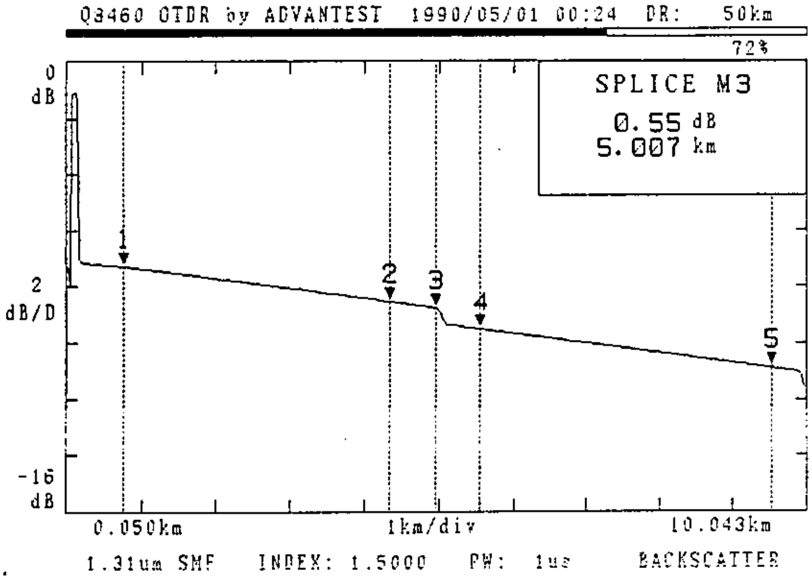
Figure 3 - 17 Measurement Display of Loss



Splice loss at M2

Distance of M2 (from the reference point)

Figure 3 - 18 Measurement Display of STANDARD 3 POINTS SPLICE



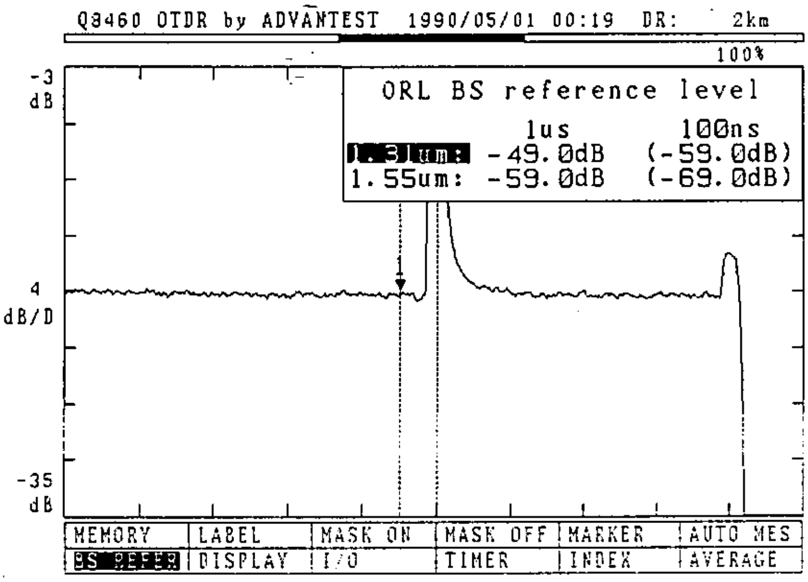
Splice loss at M3

Distance of M3 (from the reference point)

Figure 3 - 19 Measurement Display of STADARD 5 POINTS SPLICE

[Setup]

- Select the BS REFER option in the ADVANCE FUNCTION mode. Set the signal level for each wave length by using the data knob. The wave length is set when you press the [ENTER] key. After setup, press the [MENU] key to release the ADVANCE FUNCTION mode.



```
Q8460 OTDR by ADVANTEST  1990/05/01 00:19  DR:   2km

        ORL BS reference level
                  1us         100ns
1.31um:  -49.0dB   (-59.0dB)
1.55um:  -59.0dB   (-69.0dB)
```

Figure 3 - 20   ORL Function Setup Screen

[Measurement]

- Make sure that the STANDARD marker is displayed in the ADVANCED FUNCTION mode.

- Press the [MARKER] key on the panel, and the "2 point loss" and ORL markers will appear. The ORL (Optical Return Loss) value, level difference (Δ), and reference level of back-scattered light (BS) must appear on the screen.

[Principle of ORL]

If a Fresnel reflection occurs at a point in distance "ℓ", its value "Pr" (ℓ) can be indicated by the sum of back-scattered light "Pb" and Fresnel reflection "Pf" (ℓ) as follows:

$$Pr\ (\ell) = Pb\ (\ell) + Pf\ (\ell) \quad .... \ (1)$$

The back-scattered light can be expressed as follows:

$$Pb\ (\ell) = K * Pi * W * \exp\ (-2\ \alpha \ell) \quad \ldots\ldots\ldots \quad (2)$$

K : Optical fiber cable constant
Pi: Incident light strength
W : Pulse width

Fresnel reflection "Pf" (ℓ) can be expressed as follows:

$$Pf\ (\ell) = Pi * ORL * \exp\ (-2\ \alpha \ell) \quad \ldots\ldots\ldots\ldots \quad (3)$$

Difference H between the back-scattered light and Fresnel reflection on the OTDR waveforms can be expressed by using parameters Pb (ℓ) and Pf (ℓ) as follows:

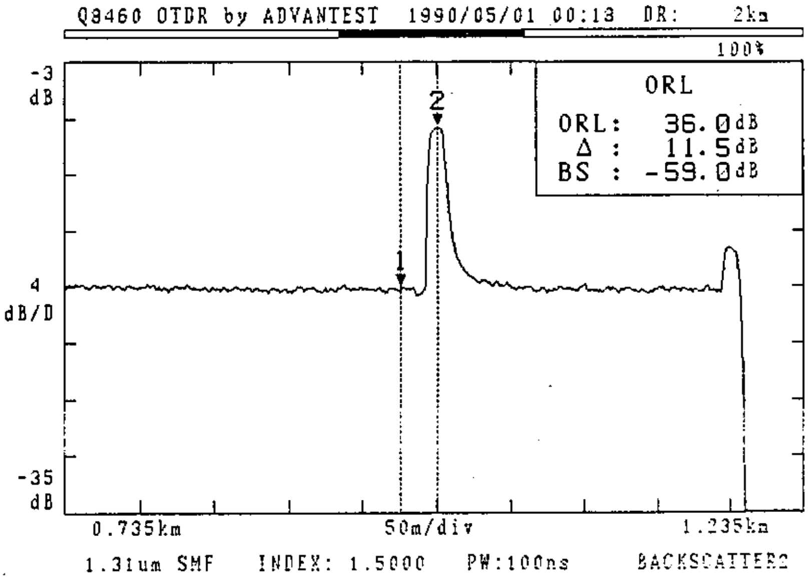
$$\begin{aligned} H &= 5\log\ (Pr\ (\ell)/Pb\ (\ell) \quad \ldots\ldots\ldots \quad (4) \\ &= 5\log\ (ORL/kw + 1) \end{aligned}$$

Therefore, the DRL value can be determined by using K, W and H as follows:

$$\begin{aligned} &ORL\ (ratio) = K * W * (10^{H/5} - 1) \quad \ldots\ldots\ldots \quad (5) \\ &ORL\ (dB) = -10\log\ (kw) - 10\log\ (10^{H/5} - 1) \end{aligned}$$

- Select the pulse width of 1 µs or 100 ns. If you select 20 ns or 3 ns, the measurement will fail and the MES FAIL message will be displayed.

- Set the marker. You must locate marker 1 onto the back-scattered light toward the Fresnel reflection, and locate marker 2 onto the peak of Fresnel reflection.



```
Q8460 OTDR by ADVANTEST  1990/05/01 00:13  DR:   2km

ORL
ORL:   36.0dB
 Δ :   11.5dB
BS : -59.0dB

1.31um SMF   INDEX: 1.5000   PW:100ns   BACKSCATTER2
```

Figure 3 - 21 ORL Function Measurement Screen

When the M2 level reaches the limit (-1 dB), the MES FAIL measurement failure message is displayed. You must change the measuring range. There are five measuring modes*, and you must select Back Scatter 1 to 4 to avoid reaching the limit level. Then, measure the waveforms again.

*: Backscatter 1 (ATT 0 dB)
Backscatter 2 (ATT 5 dB)
Backscatter 3 (ATT 10 dB)
Backscatter 4 (ATT 15 dB)
Reflection

NOTE

The measuring range is changed without using the ORL function.
When you selects the ORL function, the S/N may drop approximately 3 dB.

② FIX DLT (LSA)

The fixed distance between M1 and M2 is kept and loss per kilometer between M1 and M2 can be measured by LSA (Least Square Approximation).

Set the M1 and M2 markers are follows:

(a) Press the MARKER key in the FIX DLT mode, and the M1 marker can be moved.

(b) Press the MARKER key again to move the M2 marker. Set the desired distance between the M1 and M2 markers.

(c) Press the MARKER key again to fix the distance between M1 and M2 markers. Rotate the data knob to move the M1 and M2 markers simultaneously by keeping the fixed distance between them.

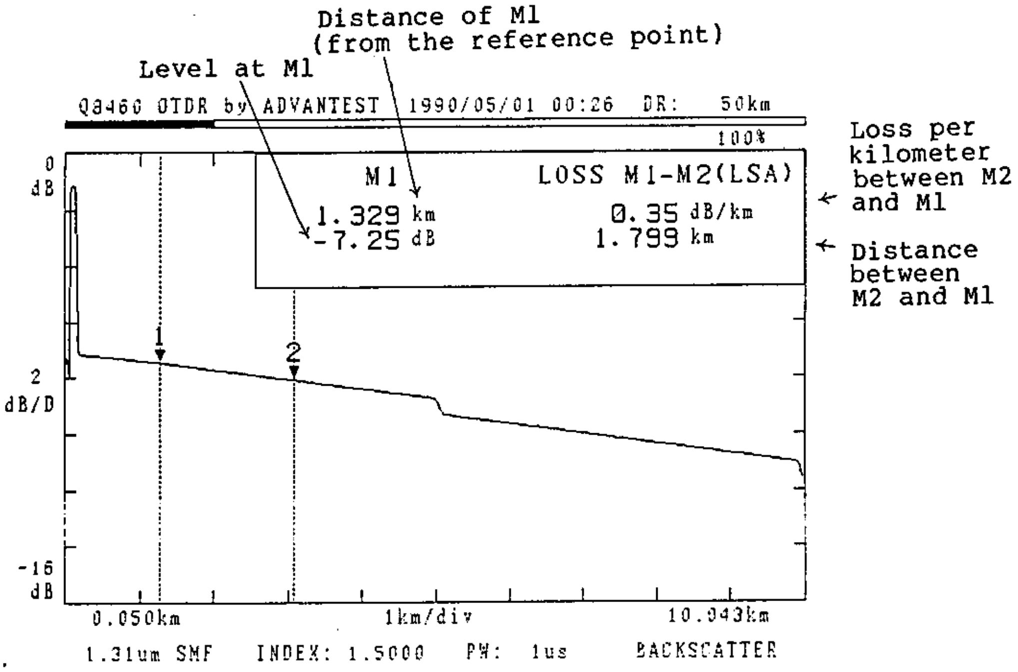


Figure 3 - 22 Measurement Display of FIX DLT (LSA)

③ FIX DLT (2PA)

The fixed distance between M1 and M2 is kept and the level difference between M1 and M2 can be measured.

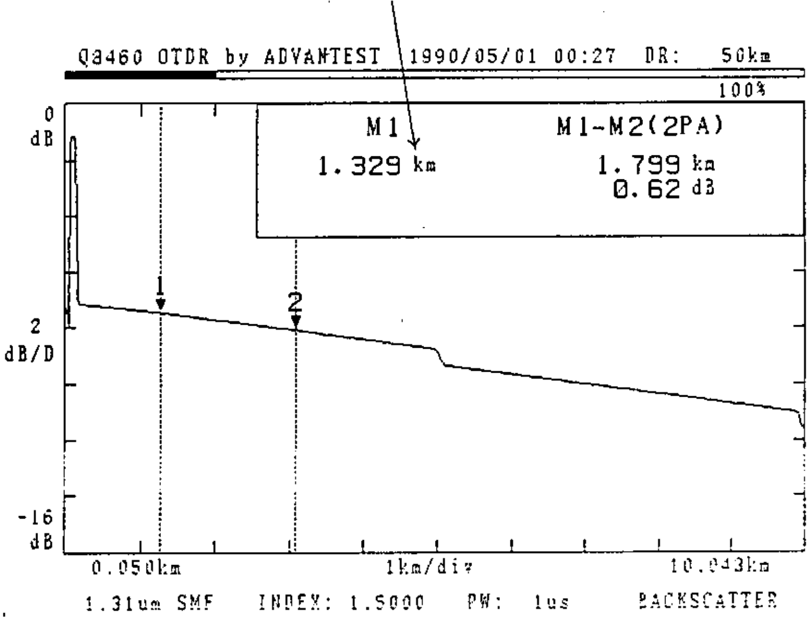
Set the M1 and M2 markers are follows:

(a) Press the MARKER key in the FIX DLT mode, and the M1 marker can be moved.

(b) Press the MARKER key again to move the M2 marker. Set the desired distance between the M1 and M2 markers.

(c) Press the MARKER key again to fix the distance between M1 and M2 markers. Rotate the data knob to move the M1 and M2 markers simultaneously by keeping the fixed distance between them.

Distance of M1
(from the reference point)



```
Q8460 OTDR by ADVANTEST  1990/05/01 00:27  DR:  50km
100%
M1            M1-M2(2PA)
1.329 km      1.799 km
              0.62 dB
0.050km         1km/div         10.043km
1.31um SMF  INDEX: 1.5000  PW: 1us  BACKSCATTER
```

Relative distance between M2 and M1

Loss between M2 and M1

Figure 3 - 23 Measurement Display of FIX DLT (2PA)

④ 3 POINTS LOSS

Set the M2 and M3 markers at two points on the optical fiber cable being measured. The data between these two points are used and the approximate linear is determined through LSA.
The loss is displayed on the screen. When the M1 marker is used, the distance of the measured optical fiber from the optical output port can be determined.
The total loss between M1 and M3 can also be measured.
The following values are displayed:

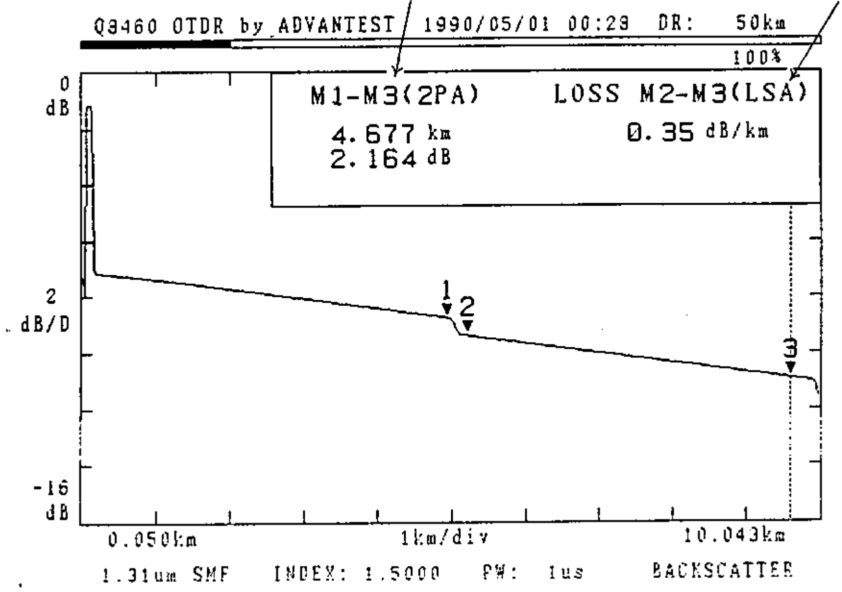
(a) Distance between M1 and M3

(b) Loss between M1 and M3

(c) Loss per kilometer between M2 and M3

Loss between M1 and M3

Loss per kilomiter between M2 and M3



Q8460 OTDR by ADVANTEST 1990/05/01 00:28 DR: 50km

M1-M3(2PA) 4.677 km 2.164 dB

LOSS M2-M3(LSA) 0.35 dB/km

0.050km 1km/div 10.043km

1.31um SMF INDEX: 1.5000 PW: 1us BACKSCATTER

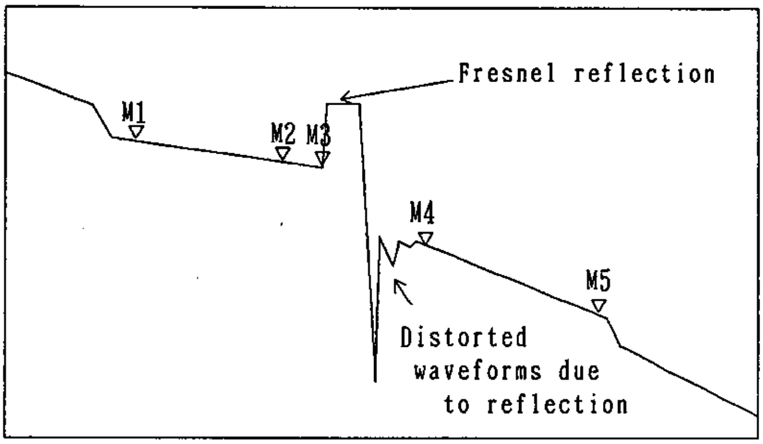
Figure 3 - 24 Measurement Display of 3 POINTS LOSS

NOTE

Take care not to cause a Fresnel reflection between M2 and M3.
An error may result in the linear approximation.

⑤ 5 POINTS SPLICE

Similar to the SPLICE of STANDARD MARKER, the splice loss can be measured. In this mode, however, "m1" and "m2" can be set manually rather than automatically.
A reflection due to use of connectors may cause the distortion of back scatter waveforms immediately after the connector position. In such case, "m1" and "m2" should be set manually to eliminate a chance of reflection. The reliable measurement can be made.



Data between M1 and M2 and between M4 and M5 are used for linear approximation through LSA. Set the M1, M2, M4 and M5 markers to prevent a splice or waveform distortion. M3 is the splice (connector) position.
When these points are set, the data between M1 and M2 is used to determine the approximate line of optical fiber cable. And data between M4 and M5 is used to determine the approximate line of the cable. The difference between these two lines at point M3 is displayed as the splice loss. The following values are displayed:

(a) Distance of M3 (km)

(b) Splice loss at M3 (dB)

After M5 is set, pressing MARKER key displays cursors for each marker of M1 to M5. Markers can be moved with their interval fixed.

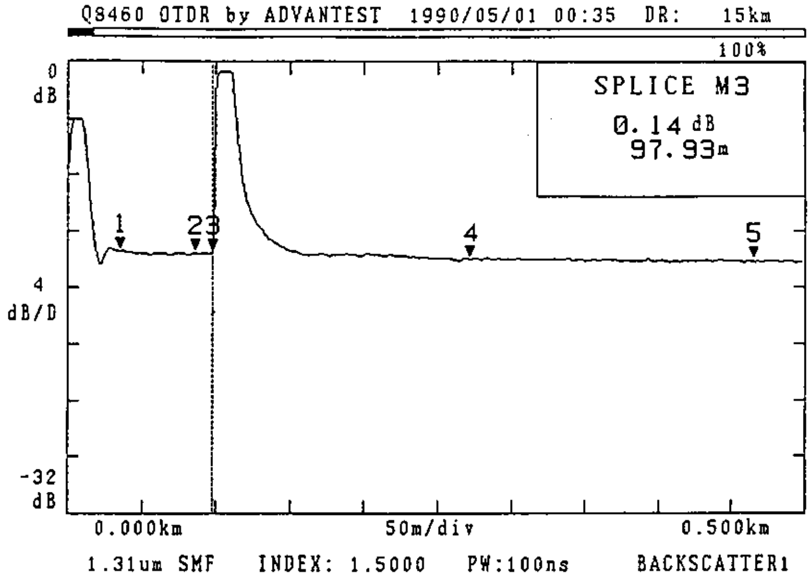
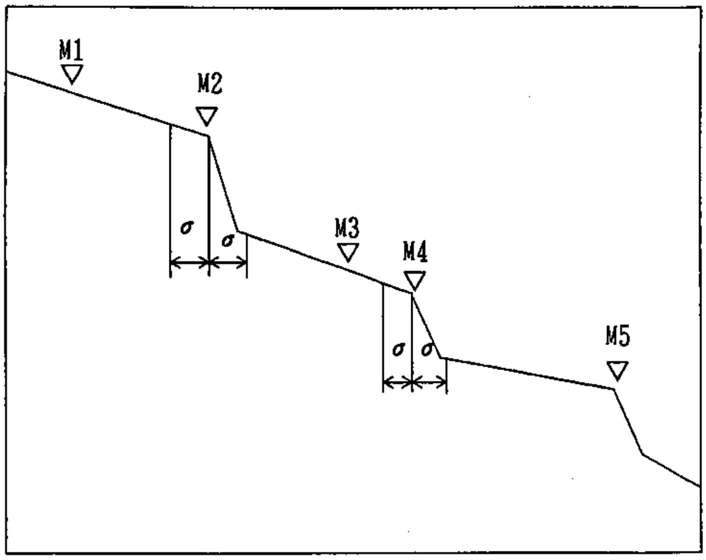


Figure 3 - 25 Measurement Display of 5 POINTS SPLICE

⑥ SPLICE, SPLICE (2-point splice loss measurement by using M1 to M5 markers)

The splice loss of the adjacent two points can be measured simultaneously. As shown in the figure, set the M1 to M5 markers to certain points and the splice loss at the M2 and M4 marker positions will be measured simultaneously.



Set the 5 point markers as follows:

M2:	Splice position 1 to be measured
M4:	Splice position 2 to be measured (next splice position)
M1:	Data between M1 and "M2-σ" is used for linear approximation. Set the M1 marker so that the splice or Fresnel reflection does not occur.
M3:	Set the M3 marker at the rough center position between M2 and M4. Data between "M2+σ" and M3 and between M3 and "M4-σ" are used for linear approximation.
M5:	Data between "M4+σ" and M5 is used for linear approximation.

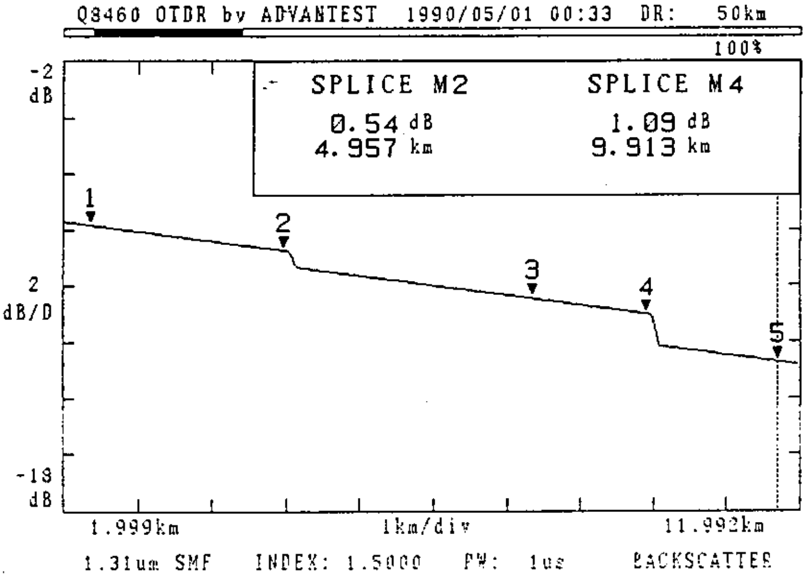
When these 5 markers are set, the data of the bold line shown in the figure are used for approximation through LSA. The following values are displayed:

(a) Distance of M2 (from the reference point)

(b) Distance of M4 (from the reference point)

(c) Splice loss of M2

(d) Splice loss of M4



Q8460 OTDR by ADVANTEST 1990/05/01 00:33 DR: 50km

SPLICE M2 0.54 dB 4.957 km

SPLICE M4 1.09 dB 9.913 km

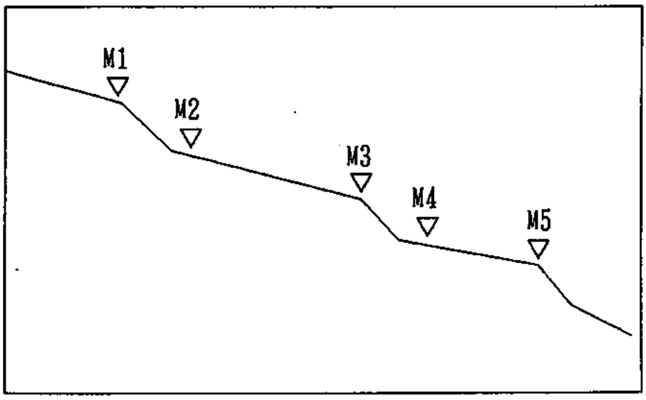
1.31um SMF INDEX: 1.5000 PW: 1us BACKSCATTER

Figure 3 - 26 Measurement Display of SPLICE, SPLICE

⑦ LOSS, LOSS (LSA) and LOSS, LOSS (2PA) (by using M1 to M5 markers)

The total loss, partial length, and loss of optical fiber cable can be measured between any two points. Select LOSS, LOSS (LSA) to obtain fiber loss by least squares method, or select LOSS, LOSS (2PA) to obtain it by 2PA. As shown in the figure, set the M1, M3 and M5 markers to be the connection points.

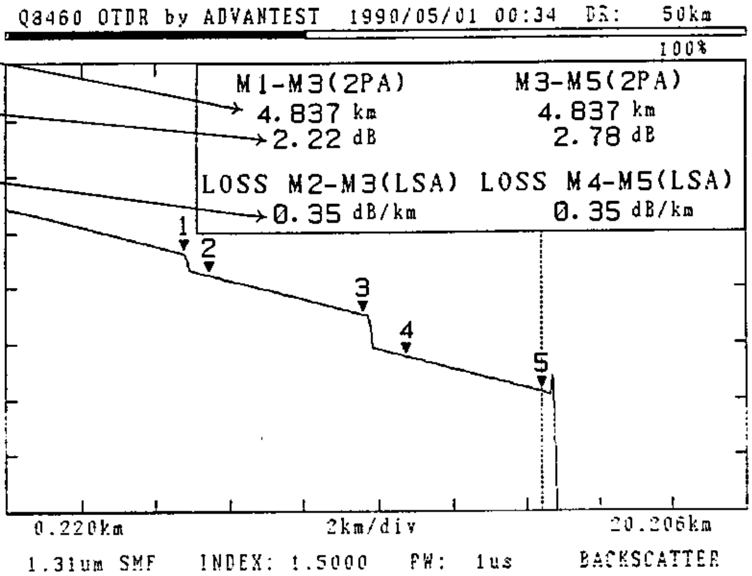
Then, set the M2 and M4 markers to the location so that the waveforms are not affected by the connection points. The following measured values are displayed:



Relative distance between M1 and M3

Loss between M1 and M3

Loss per kilometer between M2 and M3 (LSA)



```
Q8460 OTDR by ADVANTEST  1990/05/01 00:34  DR:   50km
                                                 100%
 M1-M3(2PA)              M3-M5(2PA)
   4.837 km                4.837 km
   2.22 dB                 2.78 dB
LOSS M2-M3(LSA)   LOSS M4-M5(LSA)
   0.35 dB/km              0.35 dB/km

  0.220km            2km/div             20.206km
 1.31um SMF   INDEX: 1.5000   PW:  1us    BACKSCATTER
```

Relative distance between M3 and M5

Loss between M3 and M5

Loss per kilometer between M4 and M5 (LSA)

Figure 3 - 27 Measurement Display of LOSS, LOSS (LSA)

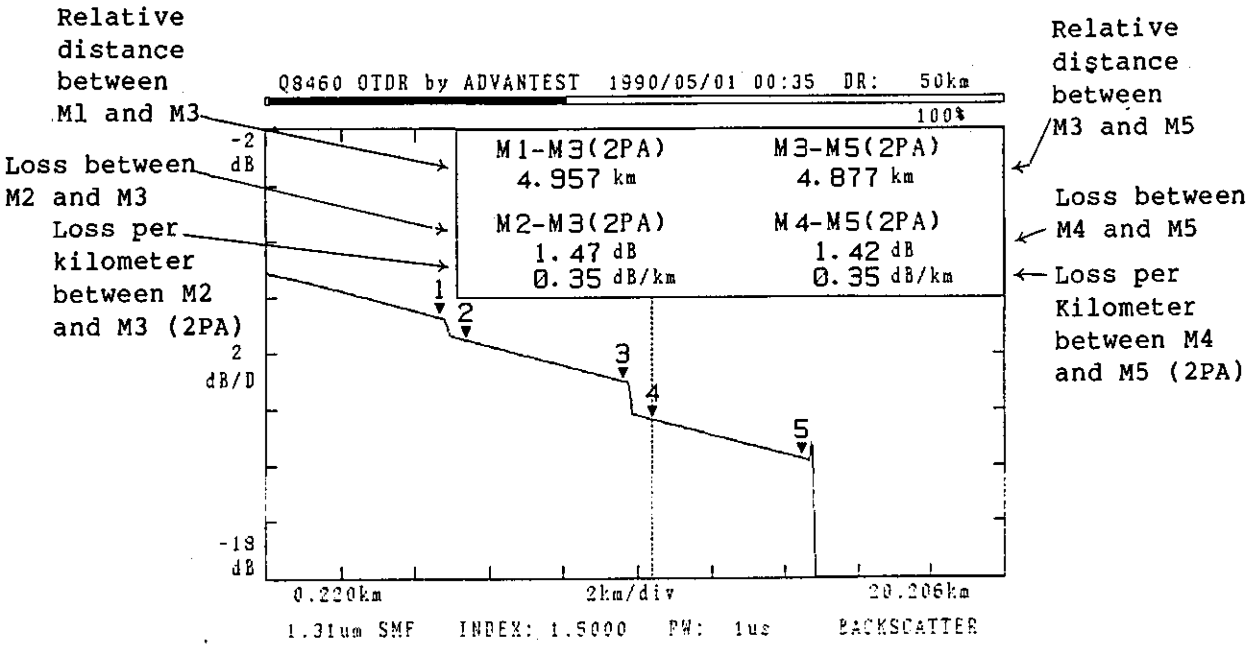


Figure 3 - 28 Measurement Display of LOSS, LOSS (2PA)

3.6 Waveform Memory

Data of the measured waveforms can be stored in the system memory. The data can be saved by pressing the SAVE key or by using the Memory function option of the ADVANCE FUNCTION.

When the SAVE key is pressed, the backup function isn't available. However, the memory function of ADVANCED FUNCTION supports the backup function.

(1) Saving by the SAVE key and calling by the VIEW key

If the operator presses the SAVE key, the waveform data being displayed on-screen is stored. Note that the storage is limited to the waveform itself. The measuring conditions and other parameters are not saved.

Pressing the VIEW key allows saved waveforms to be displayed on the CRT. (DUAL TRANCE function)
This function is useful for comparison of a saved waveform and the waveform being displayed on the CRT, since these two types of waveforms can be displayed at the same time on the CRT. Specifically, when the dual band plug-in unit is used, the waveforms in different wavelengths can be compared with this function (e.g. 1.31/1.55µm for Q84621).

The LED of the VIEW key indicates the following states:

○ VIEW ☐

☼→ Execute DUAL TRACE
●→ Display the data being measured

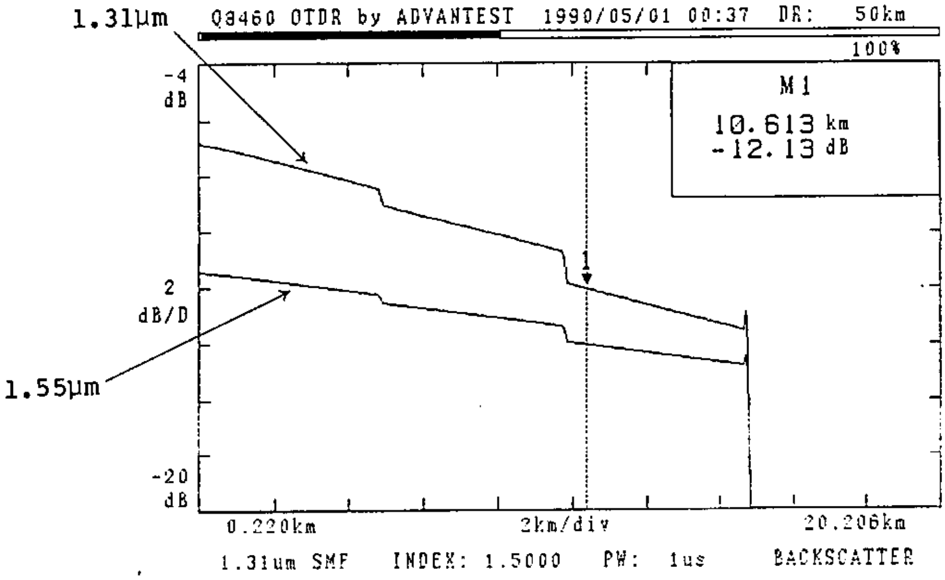


Figure 3 - 29 Two Waveforms Simultaneous Comparison by SAVE/VIEW Function

(2) Memory function (ADVANCED FUNCTION)

The memory function of ADVANCED FUNCTION can save up to 32 screens of waveforms and their measuring conditions in memory.
As this function supports the backup function, the information is held in memory even when the system power supply is turned off.
This function allows you to store not only waveforms and measuring condition information but the change of fiber cables under test according to the time duration.

[Selecting the memory function]

Press the MENU key.

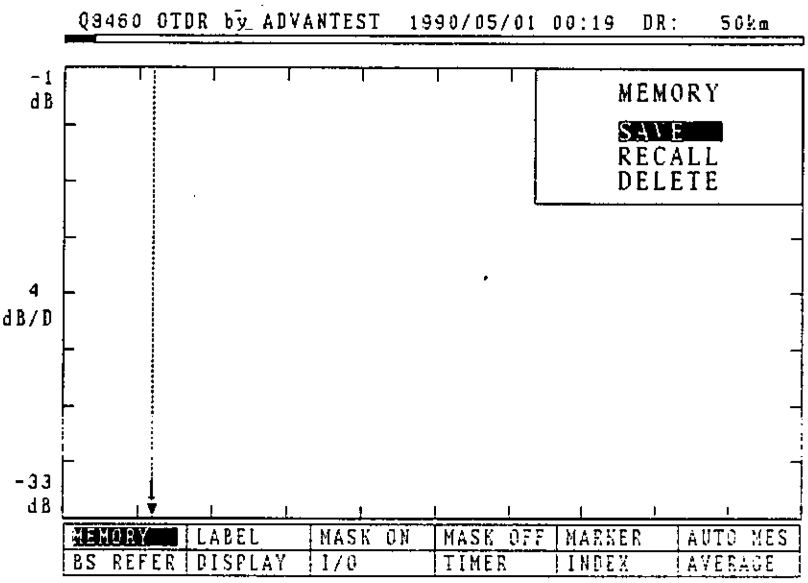


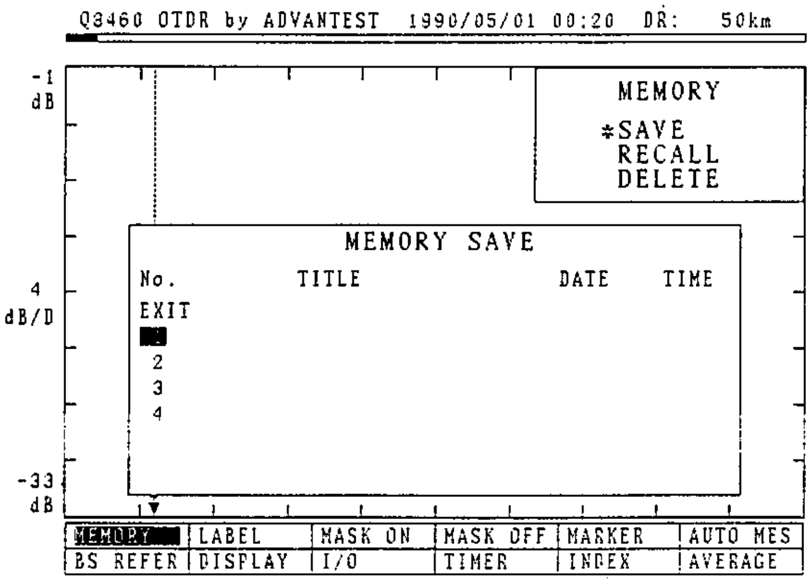
Figure 3 - 30 Memory Initial Screen

Select the SAVE, RECAL, or DELETE* option by rotating the data knob, and press the ENTER key. The specified mode will be selected.

* SAVE : Saves waveforms in memory.
RECALL: Reads waveforms from memory.
DELETE: Deletes waveforms from memory.

① SAVE mode

The following screen will be displayed:



Q8460 OTDR by ADVANTEST 1990/05/01 00:20 DR: 50km

Figure 3 - 31 SAVE Mode Screen

Locate the cursor onto the waveform number to be saved and press the ENTER key, and the waveforms will be saved in memory. The label characters are set in the TITLE field, the date is set in the DATE field, and the time is set in the TIME field.

If the cursor is located on the option having data and press the ENTER key, the following message is displayed:

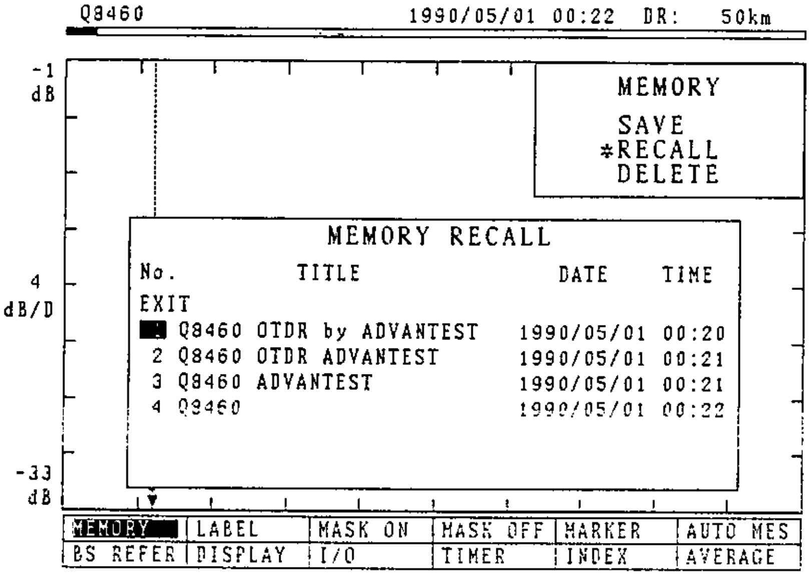
*** If you are going to rewrite,
please push "ENTER" key. ***

If the ENTER key is pressed again, the previous data is erased and the current waveforms are displayed.

When data has been saved, the memory initial screen is displayed again. Select the EXIT option and press the ENTER key, and the initial screen will be redisplayed.

② RECALL mode

The following screen appears:



```
MEMORY RECALL
No.          TITLE                    DATE        TIME
EXIT
■ Q8460 OTDR by ADVANTEST          1990/05/01  00:20
2 Q8460 OTDR ADVANTEST             1990/05/01  00:21
3 Q8460 ADVANTEST                  1990/05/01  00:21
4 Q8460                            1990/05/01  00:22
```

Figure 3 - 32 RECALL Mode Screen

Locate the cursor onto the waveform number to be recalled and press the ENTER key, and the waveforms will be read from memory and the memory initial screen will be displayed.

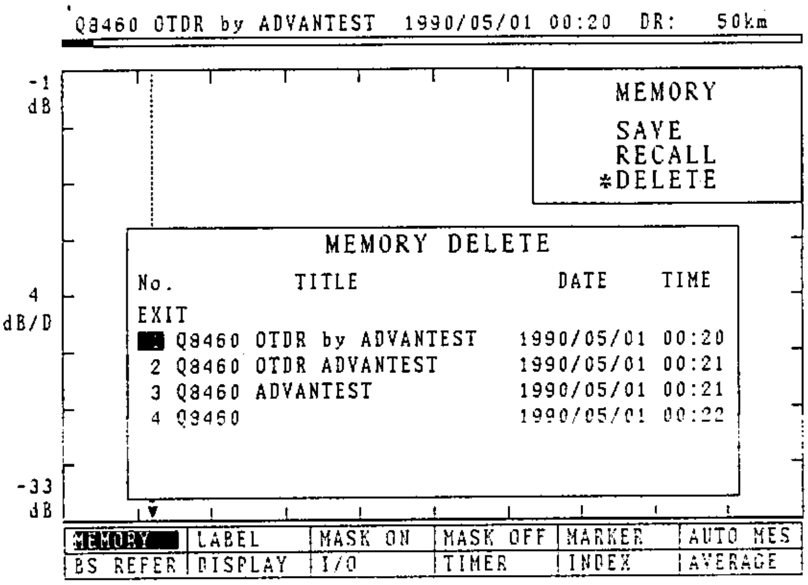
The memory initial screen is also displayed by selecting the EXIT option and pressing the ENTER key.

Then, press the MENU key to exit the ADVANCED FUNCTION mode.

Press the MONITOR key to start measurement. Note that the current date and time are set.

③ DELETE mode

The following screen appears:



Q8460 OTDR by ADVANTEST 1990/05/01 00:20 DR: 50km

MEMORY DELETE

No.	TITLE	DATE	TIME
EXIT			
■	Q8460 OTDR by ADVANTEST	1990/05/01	00:20
2	Q8460 OTDR ADVANTEST	1990/05/01	00:21
3	Q8460 ADVANTEST	1990/05/01	00:21
4	Q8460	1990/05/01	00:22

Figure 3 - 33 DELETE Mode Screen

Locate the cursor onto the waveform number to be deleted and press the ENTER key, and the following message will be displayed:

*** If you are going to delete the file,
please push "ENTER" key. ***

If you agree, press the ENTER key. The data will be deleted from memory.

Select the EXIT option and press the ENTER key, and the memory initial screen will be redisplayed.

Select the ALL DELETE option and press the ENTER key, and the entire memory contents will be deleted.

3.7 Label

The information can be labeled to the storage data by using one to 23 alphanumeric characters. The label is set at the top line on the screen. Press the MENU key to select the ADVANCE FUNCTION mode, and select the LABEL option. The follow screen will be displayed. Display the input character in the reverse mode by using the data knob, and press the [ENTER] key. The character will be entered.

DELETE : Deletes a character from the cursor position.

⇦ : Moves the cursor to the left.

⇨ : Moves the cursor to the right.

ALL DELETE :Deletes labels simultaneously.

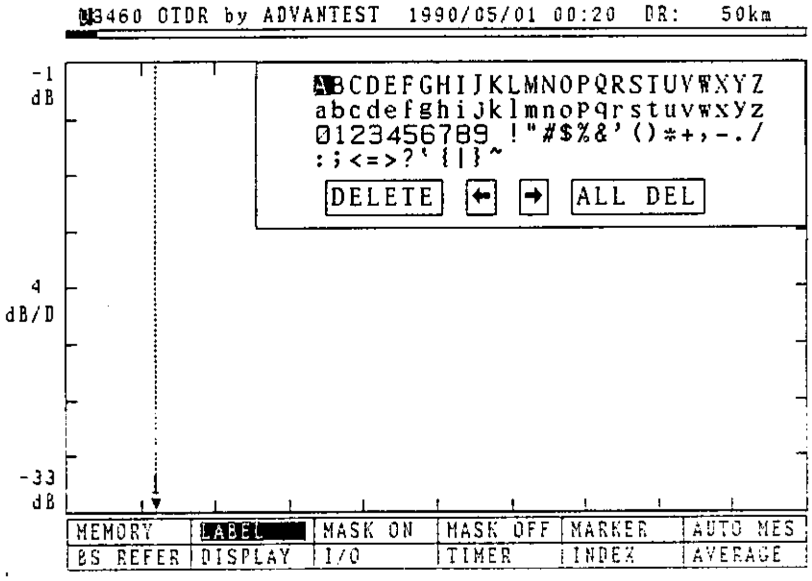


Figure 3 - 34 Label Screen

3.8 Display

The operator can select the type of graphic, such as DOT/LINE and dimension units, such as km/mile.

Press the MENU key and select the ADVANCE FUNCTION mode, then select the "DISPLAY" on-screen.

Press the ENTER key and select the SIGNAL/UNITS on-screen.

(1) Selecting the DOT/LINE mode

Check that the cursor is on "SIGNAL".
DOT --- Turn the data knob counterclockwise.
LINE --- Turn the data knob clockwise.

(2) Selecting the dimension unit

Press the ENTER key and move the cursor to "UNITS" on-screen.
km --- Turn the data knob counterclockwise.
mile --- Turn the data knob clockwise.

3.9 Timer

The operator can set time (minute and hour), date, month and year.

Press the MENU key and select the ADVANCE FUNCTION mode, then select "TIMER" on-screen.

Press the ENTER key and select the setting item.

(1) Year ---- Check that the cursor is on "YEAR".
Set an appropriate number by truning the data knob.

(2) Month --- Press the ENTER key and move the cursor to "MONTH".
Set an appropriate number by turning the data knob.

(3) Date ---- Press the ENTER key and move the cursor to "DAY".
Set an appropriate number by turning the data knob.

(4) Hour ---- Press the ENTER key and move the cursor to "HOUR".
Set an appropriate number by turning the data knob.

(5) Minute -- Press the ENTER key and move the cursor to "MIN".
Set an appropriate number by turning the data knob.

3.10 I/O

To specify the following three parameters:

Press the MENU key to select the ADVANCED FUNCTION mode.

Select the parameter and press the ENTER key.

(1) GPIB address

Specifies the device address for remote control via the GPIB. An address can be specified within addresses 0 to 30.
Use the data knob for address setup.

(2) HDCOPY

Outputs a hardcopy of the on-screen information of the device. Select one of the following two outputs by using the data knob:

- PRINTER ..... Built-in thermal printer
- PLOTTER ..... External plotter

(3) BUZZER

Turns on or off the key input tone or input disable tone.

ON: Sounds the key input tone or input disable tone when a key is typed.
OFF: Does not sounds the tone.

3.11 Outputting the Data On-screen

This reflect meter can output the data on-screen by the internal printer or external plotter.
As for the procedure of selecting the internal printer or external plotter, refer to the Section 3.10.

(1) Outputting by the internal printer

Check that the "PRINTER" has been selected in the ADVANCE FUNCTION mode. Press PRINT key, and the data is output. If the operator presses the FEED key, the printer feeds the thermosensible paper.

(2) Outputting by the external plotter

① Procedure

- Using "I/O" of the ADVANCE FUNCTION mode, make sure that "PLOTTER" (plotter output) is selected.
- Make sure that the plotter is set to the LISTEN ONLY mode.
- Press the PRINT key to start plotter output.

NOTE

1. To ensure minimum wear on the pen tip and minimum output time, all waveforms are output onto the plotter line-by-line, irrespective of whether the DOT mode or the LINE mode is being displayed on the CRT.

2. Information displayed on the HELP screen will not be output onto the plotter.

② Applicable plotters

R9833 (ADVANTEST)
HP7470A (HP)
HP7475A (HP)

③ Selecting the tracing pen

The following table shows pen number and description of the plotter output.

Pen number	Description
1	A character string
2	Window display (including characters in the window)
3	Bar, signal frame, and window frame
4	Waveforms
5	Dual waveforms
6	Marker
7	Cursor

3.12 Automatic Measuring Function

The automatic measuring function can automatically detect the optical fiber contact position, connection type, and end point (break point) position and measure the splice loss.
Up to 16 connect positions or break points can be measured. They are measured by using the on-screen data only.

There are two types of automatic measuring function:

① ALL mode

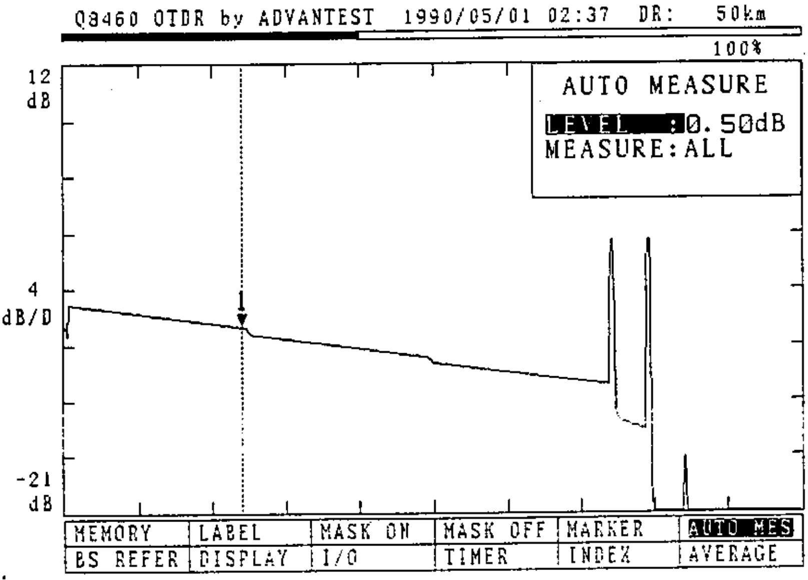
Up to 16 connect positions, break points, loss, and connect position types can be displayed simultaneously.

② STEP mode

Up to 16 connect positions, break points, loss, and connect position types of the on-screen data can be displayed for each point one after the other.

Selecting the automatic measuring function:

Press the MENU key and select the AUTO MES option, and the following screen will be displayed:



Q8460 OTDR by ADVANTEST 1990/05/01 02:37 DR: 50km

AUTO MEASURE
LEVEL :0.50dB
MEASURE:ALL

Figure 3 - 35 Automatic Measurement Setup Screen

Select the LEVEL or MEASURE option and press the ENTER key.

LEVEL : Enter the splice loss for detection. It can be entered within 0.05 dB to 2.00 dB at 0.01 dB step.
MEASURE: Select the ALL or STEP mode.

NOTE

If a smaller LEVEL value is specified, the splice having the small loss is found. If averaging is insufficient, a non-splice point may also be detected as the splice point. In such case, increase the averaging count or increase the pulse width to have the better S/N for measurement.

When the LEVEL value is increased, the Fresnel reflection connect position, broken point, and end point only are measured.

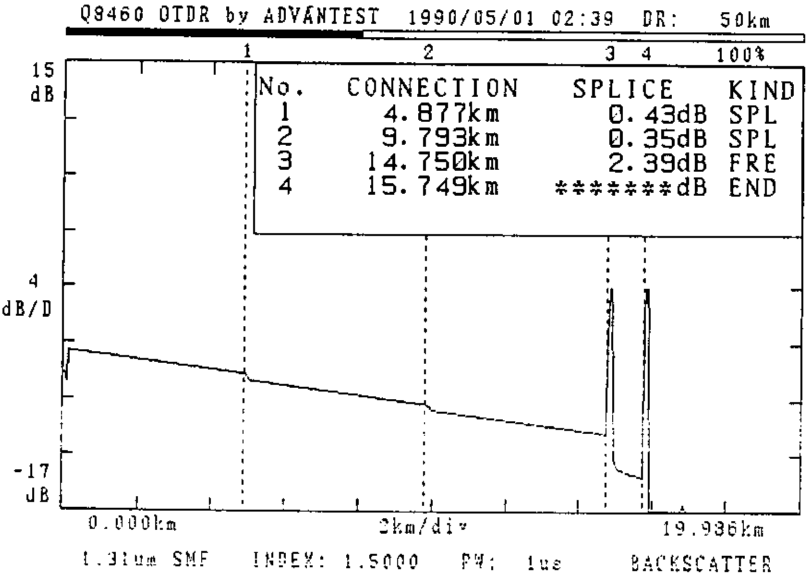
(1) Automatic measurement in ALL mode

Press the MENU key to select the AUTO MES mode.

Measure the LEVEL option, and select the ALL option of the MEASURE.

When the measuring conditions are all satisfied, repeat averaging enough times and collect the on-screen waveform data.

Then, press the AUTO key and press the ENTER key for execution. The following screen will be displayed. Scroll the list by using the data knob.



```
Q8460 OTDR by ADVANTEST  1990/05/01 02:39  DR:   50km

No.   CONNECTION      SPLICE    KIND
 1       4.877km      0.43dB    SPL
 2       9.793km      0.35dB    SPL
 3      14.750km      2.39dB    FRE
 4      15.749km   *******dB    END

1.31um SMF   INDEX: 1.5000   PW:  1us      BACKSCATTER
```

Figure 3 - 36 All Mode Display

Explanation of window display

CONNECTION: Displays the connect position.
SPLICE: Displays the splice loss.
KIND: Displays the connect position type as follows:
- FRE: Connect position having the Fresnel reflection
- SPL: Splicing connect position
- END: End point or break point of optical fiber cable

[Releasing]

Press the AUTO key, and the automatic measurement mode will be released.

NOTE

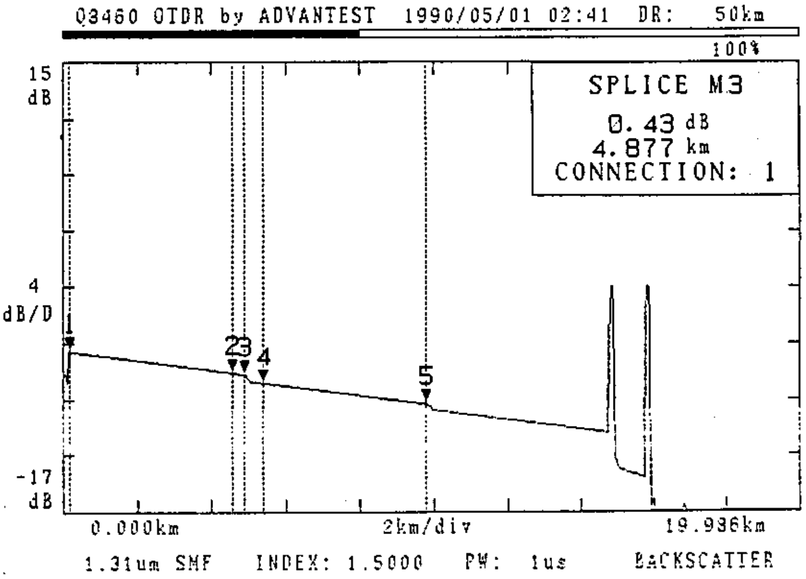
The automatic measurement fails if the pulse width is 1 us and the horizontal span is 200 m or less or if the horizontal span is 50 m and the pulse width is not equal to 1 us. Also, the Back Scatter and Reflection modes can be switched to each other.
The Marker, Vertical Scale, and Horizontal Span cannot be changed.

(2) Automatic measurement in STEP mode

Press the MENU key and select the AUTO MES option.

Set the LEVEL value and select the ALL option for the MEASURE. When the measuring conditions are all satisfied, repeat averaging enough times and collect the on-screen waveform data.

Then, press the AUTO key and press the ENTER key for execution. The following screen will be displayed. Scroll the connect position by using the SAVE and VIEW keys.


Q8460 OTDR by ADVANTEST 1990/05/01 02:41 DR: 50km

SPLICE M3
0.43 dB
4.877 km
CONNECTION: 1

1.31um SMF INDEX: 1.5000 PW: 1us BACKSCATTER

Figure 3 - 37 STEP Mode Display

The window shows the distance from the device output end and the splice loss at this point.

The CONNECTION value shows the "n-th" connection point of the waveform data.

[Releasing]

Press the AUTO key, and the automatic measurement will be released.

NOTE

The automatic measurement fails if the pulse width is 1 µs and the horizontal span is 200 m or less or if the horizontal span is 50 m and the pulse width is not equal to 1 µs. Also, the Back Scatter and Reflection modes can be switched to each other.

3.13 Multiple Reflection

(1) Multiple reflection due to excessive Fresnel reflection

When optical signals are output from the system terminal, part of optical pulses are returned from the breakpoint of optical fiber cable as the Fresnel reflection (called the primary Fresnel reflection). These reflected pulses are reflected at the system output terminal and output again.
And part of optical pulses are reflected and returned from the breakpoint (called the secondary reflection). Such repeated reflection of pulses is called the multiple reflection. This may cause a Fresnel reflection at any point other than the connection point or breakpoint.

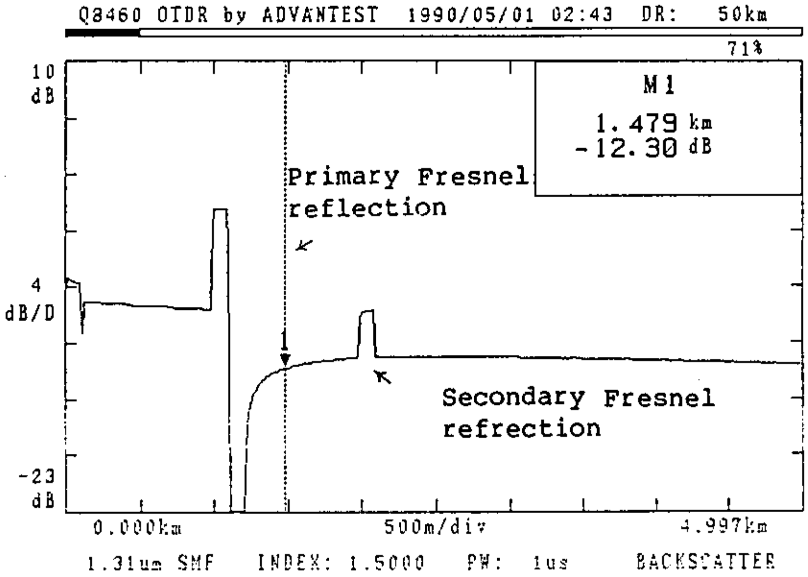
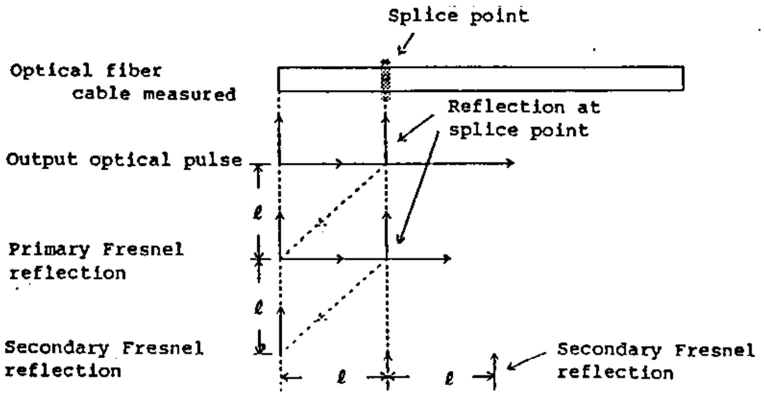


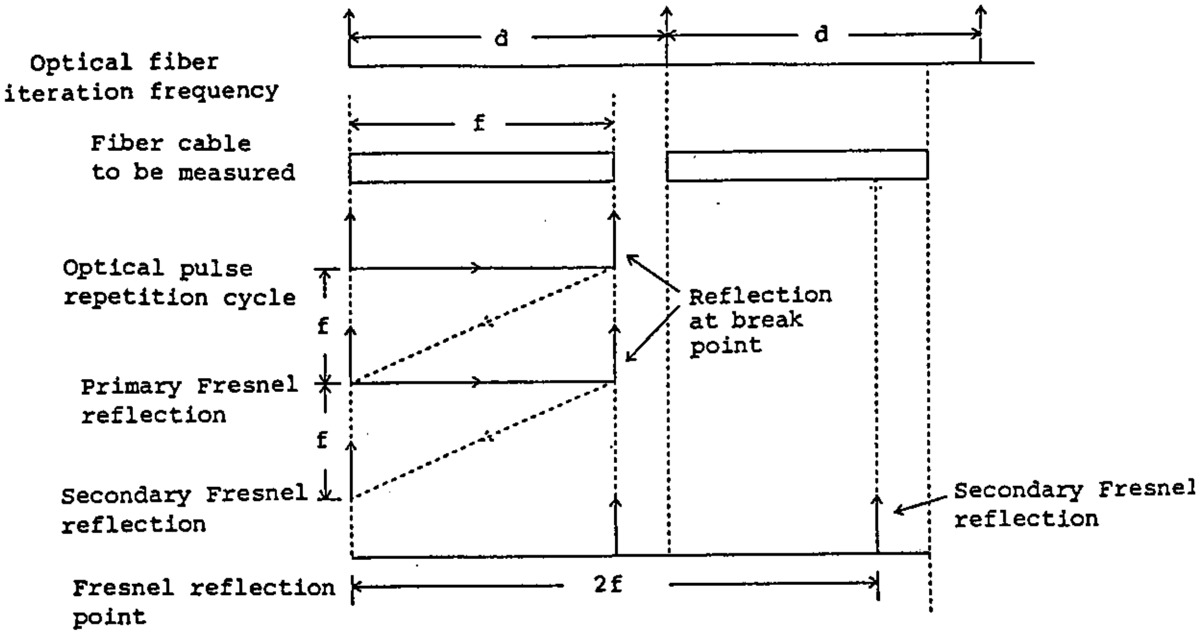
Figure 3 - 38 Multiple Reflection Display

If the optical fiber cable is measured at the connection point which is located in distance ℓ from the output terminal as shown in the figure, the secondary reflection may appear at point 2ℓ. Further reflection is very few and does not appear.



(2) Fresnel reflection according to the distance range and optical fiber length

If the length of optical fiber cable being measured is a half or more of the length of repeated pulses, the second reflection may occur as shown in the figure below.



If the optical pulse iteration frequency is "d", the length of optical fiber cable being measured is "f", and if $d < 2f$, the primary Fresnel reflection may occur at the far end of the optical fiber cable. The secondary Fresnel reflection may occur at the point in distance "2f". This point is located in the distance of "f-(d-f)" from the optical pulse output terminal. If the range of distance is set to 64 km on the Q8460 system, for example, the optical pulses are repeated every 860 µsec (that is roughly equivalent to the 86 km long fiber cable). If the 60 km long optical fiber cable is measured in this range, the location of secondary Fresnel reflection can be calculated as follows:

$$60(\text{km}) - (86(\text{km}) - 60(\text{km})) = 34(\text{km})$$

To eliminate the multiple reflection:

① Adjust the connection point to prevent excessive. Fresnel reflection or coat the optical fiber cable with the matching oil (optical fiber cable matching solvent).

② If the multiple reflection is detected, select the larger range of distance. (Measure the cable in the range of distance that is 2 times or more of the length of the optical cable being measured.)

4. OPERATION PRINCIPLE

4.1 Q8460 System

The Q8460 system block diagram is shown in Figure 4-1.
The signal of the 100MHz crystal oscillator is divided by the clock generator according to the range of distance and span being set. The timing generator operates by using this clock. It generates signals of adder circuit timing, LD emission trigger timing and mask trigger timing.
The LD emission trigger signal is output by the timing generator.
This signal is then sent to the plug-in unit to light the LD. Then, the signal is passed through the optical fiber cable being measured. The returned optical signals are converted into electric signals and sent to the system.
The returned signal is converted into digital data by the A/D converter.
The A/D converter operates based on the clock generated by the clock generator. Up to 16,000 points of data are converted for a single LD emission. The converted data is added to the data of the same point of RAM1 by the adder circuit. The resulting data is stored in RAM1 again.
This addition is called the averaging addition and it is useful to remove the noise components from the signal.
Averaging is executed 256 times in the Monitor mode. While in the Averaging mode, it is executed 2 powered by 12 times minimum or 2 powered by 24 times maximum.
After the averaging addition, the RAM1 data is stored in RAM2 by CPU1.
The data logged in RAM2 is converted into the display data by the CRT controller. This data is stored in the video RAM. The CRT controller also outputs the vertical and horizontal sync signals to drive the CRT.
The sync signals are combined with the video RAM data, and they are sent to the CRT driver and displayed on the CRT screen.
Similarly, the composite signals are generated by the CRT driver and they are output to a peripheral via the Video Out terminal.

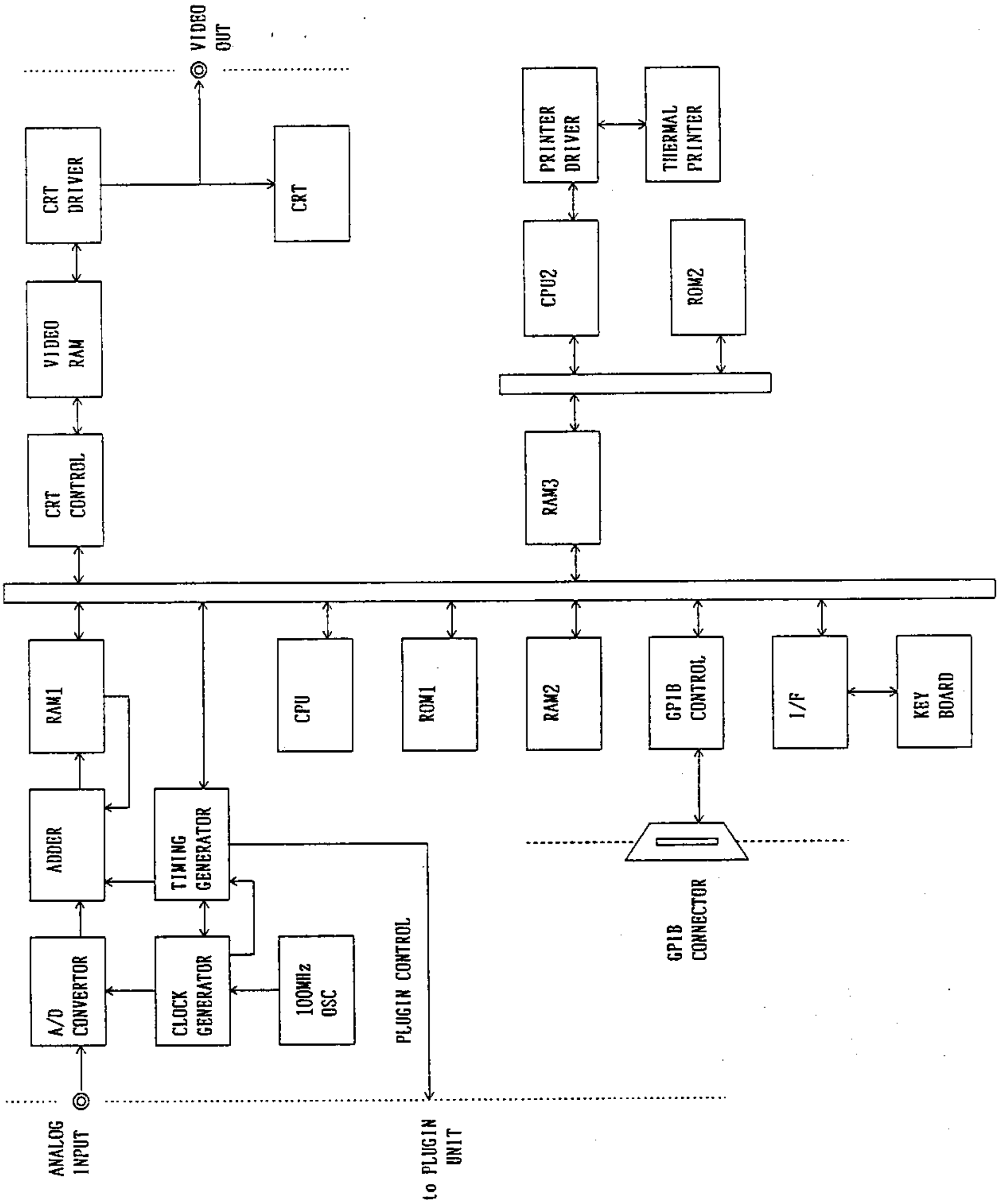


Figure 4 - 1 Q8460 System Block Diagram

4.2 Plug-in Unit

The block diagram of plug-in unit is shown in Figure 4-2.
When receiving an LD trigger signal from the Q8460, the plug-in unit generates LD pulses according to the pulse width set by the LD pulse generator. The LD pulses are sent to the LD driver to emit the LD.
The LD pulses are also sent to the mask pulse generator. They are used to output a mask signal, drive the A/O driver to activate the A/O switch, and prevents Fresnel reflection to the optical sensor. (Q84601/Q84621/Q84621A) This can prevent the reduced linearity due to saturation of amplifier during excessive input. The A/O switch is also activated when a Mask Trigger signal is input from the mask pulse generator. The Fresnel reflection can be masked at any point.
The optical pulses are sent to the optical fiber cable being measured. The optical pulses reflected from the optical fiber cable being measured are converted into optoelectric signals by the APD. The converted signals are sent to the I-V converter. Then, they are amplified by the I-V converter and amplifier and the resulting signals are sent to the system. The level of returned optical pulses varies according to the wavelength and pulse width. The amplifier gain must be adjusted to have an appropriate level of signals by using the gain control of the amplifier. The signal level can be adjusted by the input of gain control signals.

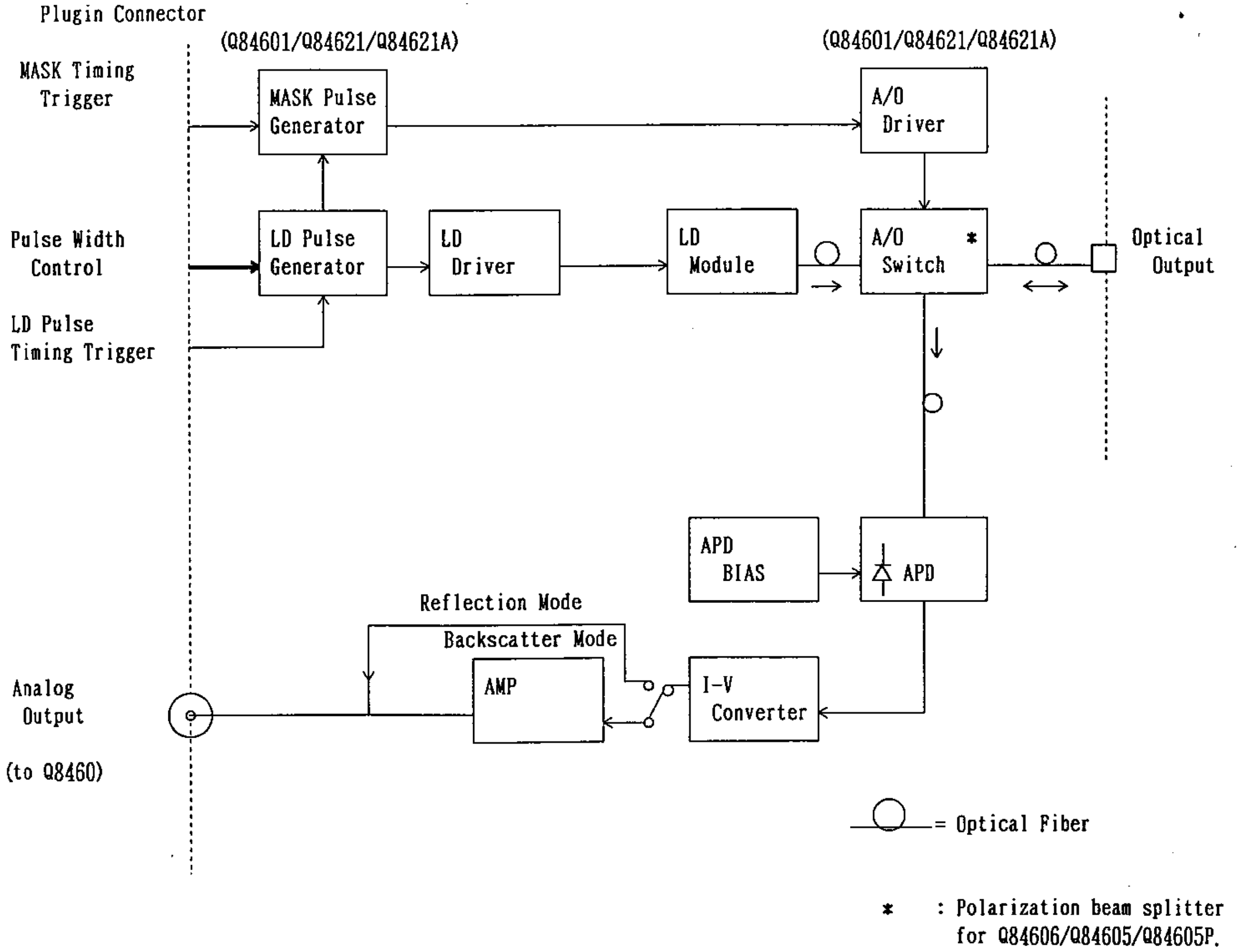


Figure 4 - 2 Block Diagram of Plug-in Unit

5. REMOTE CONTROL VIA GPIB

5.1 General

The Q8460 optical time domain reflectometer can operate in the remote control mode via the standard IEEE-488-1979 GPIB (General-Purpose Interface Bus).

5.1.1 Outline of GPIB

The GPIB is an interface system that can configure an automatic measuring system by simply connecting the controllers and peripheral devices using the bus cable.
When compared with the conventional interfacing, the GPIB provides the much higher flexibility in system expansion.
Also it provides the electrical, mechanical, and functional compatibility with the products of different manufacturers.
A full lineup from the very simple system to the system having the highest functions can be configured by using a single bus cable.
For the GPIB system, each device connected via the bus line must be assigned the different address. Each device can have one or more of controller, talker and listener functions. Only one talker can sent data onto the bus line, and multiple listeners can receive the data. The controller addresses the talker and listeners so that the data can be transferred from the talker to the listeners. Also, the controller (talker) can set the measuring conditions for the listeners.
The bit parallel and byte serial eight data lines are provided for data transfer between system devices. Data is transferred asynchronously in both directions. Because the system is asynchronous, both the high-speed and low-speed devices can be mixed.
The data (messages) to be transferred between devices are the measuring data and measuring conditions (programs), and various commands. The ASCII codes are used.
In addition to 8 data lines, 3 handshaking lines are provided to control asynchronous data transfer between devices. Also, 5 control lines are provided to control information flow on the buses.

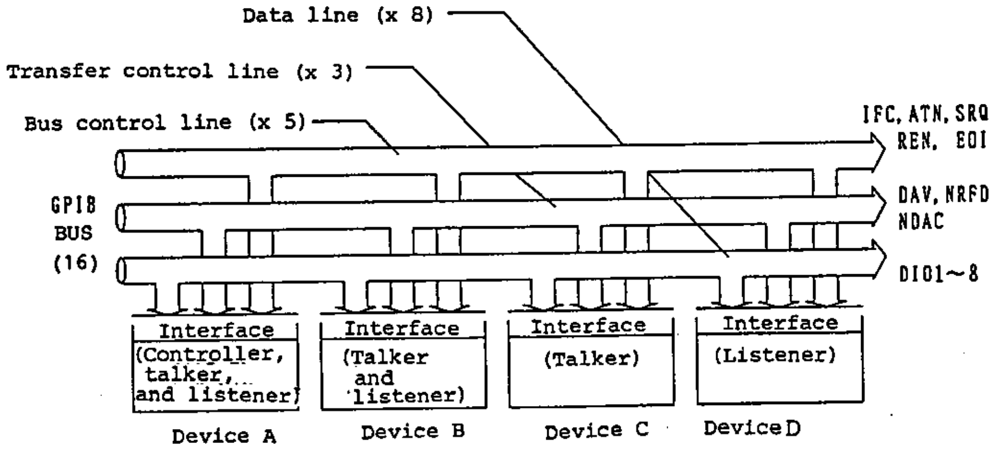


Figure 5 - 1 GPIB Bus Lines

- The following signals are transferred via the handshaking lines:

DAV (Data Valid)	: The signal indicating the data validity
NRFD (Not Ready For Data)	: The signal indicating the data receive ready status
NDAC (Not Data Accepted)	: The signal indicating the end of data receive status

- The following signals are transferred via the control lines:

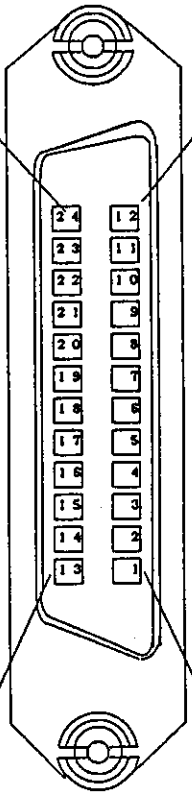
ATN (Attention)	: The signal which indicates that the signals on the data line are address or command or any other information
IFC (Interface Clear)	: The signal which clears interfacing
EOI (End of Identify)	: The signal used to indicate the end of information transfer
SRQ (Service Request)	: The signal which is sent from any device to the controller to request for service
REN (Remote Enable)	: The signal for remote control of a device that can be programmed for remote control

5.1.2 GPIB Standards and Specifications

Standard	: IEEE488-1978
Codes used	: ASCII codes, or binary codes for packed formatted
Logic level	: Logical 0 (high) at +2.4 VDC or more Logical 1 (low) at +0.4 VDC or less
Driver specifications	: Open collector (except EOI and DAV) logical low at +0.4 VDC or less, 48 mA Logical high at +2.4 VDC or more, -5.2 mA
Receiver specifications	: Logical low at +0.6 VDC or less Logical high at +2.0n VDC or more
Addressing	: Up to 31 talk and listen addresses can be set by using the ADDRESS switch.
Cable length	The total length of bus cables is limited to the following: (No. of devices connected to the bus) x 2 m and less 20 m

Connector 24-pin GPIB connector (57-20240-D35A of Anfenol or equivalent)

Signal name	Pin No.
GND. LOGIC	24
GND. (ATN)	23
GND. (SRQ)	22
GND. (IFC)	21
GND. (NDAC	20
GND. (NRFD	19
GND. (DAV)	18
REN	17
DIO 8	16
DIO 7	15
DIO 6	14
DIO 5	13



Pin No.	Signal name
12	SHIELD
11	ATN
10	SRQ
9	IFC
8	NDAC
7	NRFD
6	DAV
5	EOI
4	DIO 4
3	DIO 3
2	DIO 2
1	DIO 1

Figure 5 - 2 GPIB Connector

Interface functions:[Table 5-1]

Table 5 - 1 Interface Functions

Code	Function and Explanation
SH1	Source handshaking function
AH1	Acceptor handshaking function
T5	Basic talker function, serial polling function, talker only function, and talker release function by specifying the listener
L4	Basic listener function, and listener release function by specifying the talker
SR1	Service request function
RL1	Remote control function
PPO	Without parallel function
DCO	Device clear function
DTO	Without device trigger function
CO	Without controller function
E2	Tristate output

5.1.3 Connecting System Devices

As a GPIB system is configured by various devices and equipment, the following notes should be followed during preparation:

(1) Check the normal status (for preparation) and operation of the connected devices by referring to the instruction manuals of the controller and peripheral devices.

(2) Avoid using excessive length of bus cables when connecting the measuring instrument and controller. The length of bus cable should not exceed the following limit:
(No. of devices connected to the bus) x 2 m and less 20 m

The following standard bus cables are available as optional.

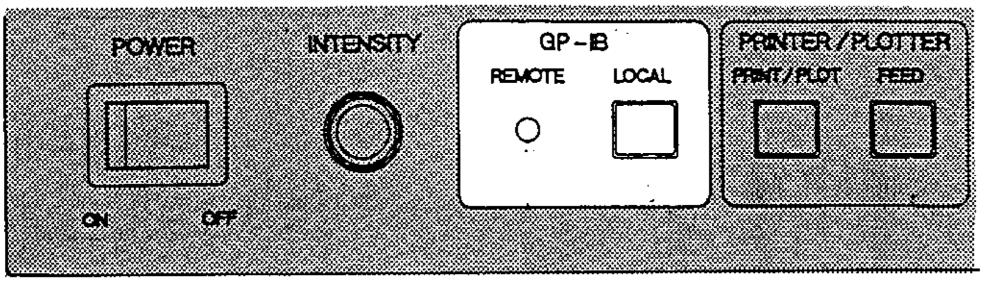
Table 5 - 2 Standard Bus Cables (Optional)

Length	Cable Name
0.5 m	408JE-1P5
1 m	408JE-101
2 m	408JE-102
4 m	408JE-104

(3) The bus cable has the piggy-pack connectors. A single connector consists of the male and female connectors and they can be used as a pair. However, do not use 3 or more connectors as a pair. The connector must be secured by using the tightening screws.

(4) Check the power conditions, grounding and setup conditions of each device before turning its power supply on.
The power supply of all devices connected to the GPIB must be turned on. If not, the entire system operation is unreliable.

5.1.4 GPIB Keys on Operation Panel



① LOCAL key

Releases the remote control mode if the Q8460 system is in the remote control mode (the REMOTE LED is on). In the local mode, the key input on the front panel is made valid.
When the system power supply is turned on, the local mode is selected automatically.

② REMOTE LED

Kept on when the Q8460 system is controlled by an external controller in the remote control mode. In the remote control mode, the key input on the front panel is made invalid.

③ Setting the GPIB address

The setting of the GPIB address can be changed by the ADVANCE FUNCTION mode.
Press the MENU key and select the ADVANCE FUNCTION mode, then select "I/O". Select the GPIB address by turning the data knob.

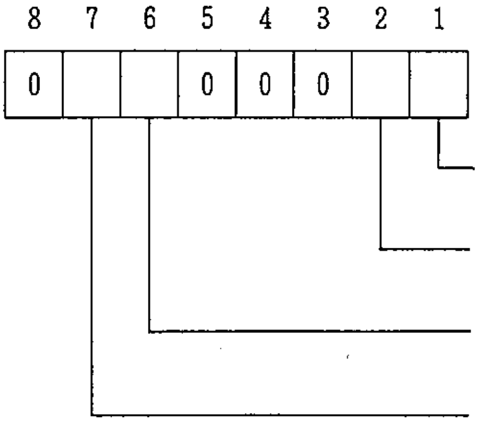
NOTE

The equipment will enter the TALK ONLY mode if you select "I/O" following setting of the ADVANCE FUNCTION mode using the MENU key and then select "PLT" (plotter output) from "HDCOPY" (hardcopy).
To operate the equipment in the ADDRESSABLE mode, therefore, change "PLT" over to "PRT" (printer output).

5.2 Service Request

When the Q8460 system is set to the S0 mode and when each bit of the status byte is set to "1", the Q8460 sends a service request to the controller.
The system sends the status byte after serial polling from the controller.

[Status byte]



Logical 1 is set at the end of measurement.

Logical 1 is set if a syntax error occurs.

Logical 1 is set at the end of averaging.

Request Service (RQS).
Logical 1 is set when an SRQ (Service Request) is issued.

5.3 GPIB Talker Format

Issue the read command to output the GPIB talker format. There are two types of outputs as the following; the binary output and ASCII output according to the read command it has been issued.

① Binary output

Available commands:
1 byte per data: RDTB, RMDB, RADB
2 bytes per data: RDTW, RMDW, RADW
4 bytes per data: RDTL, RMDL, RADL

Format:

Header	Data 1	Data 2		Data N	BD

Header: 6-byte ASCII data to be set by the "Hn" command.
It is output only when the header output is set to ON (see paragraph ⑧ of Subsection 5.3.1).
Data: See the related read command.
BD: Block delimiter to be set by "DLn".

② ASCII format

If multiple data sets are used:

Header	Data 1	SD	Data 2	SD		SD	Data N	BD

If a single data set is used:

Header	Data	BD

Multiple data sets or a single data set can be used depending on the specified read command. See the related read command section.

Header: 6-byte ASCII data to be set by the "Hn" command.
It is output only when the header output is set to ON.
SD: String delimiter to be set by the "SLn" command.
(see paragraph ⑦ of Subsection 5.3.1).
BD: Block delimiter to be set by the "DLn" command.
(see paragraph ⑥ of Subsection 5.3.1).

5.3.1 GPIB Setting Commands

The following lists the GPIB setting commands and provides their detailed explanation.

Table 5 - 3 GPIB Setting Command List (1 of 2)

Command		Function	Page
①	C	Clear	5 - 11
②	Z	Clear to initialization	5 - 12
③	Sn	Issue or no issue of service request	5 - 13
④	SMKn	Mask of service request	5 - 13
⑤	CS	Clear the status byte	5 - 13
⑥	DLn	Select the delimiter mode	5 - 14
⑦	SLn	Select the string delimiter mode	5 - 14
⑧	Hn	Display or no display of header	5 - 15
⑨	MON	Select the monitor mode	5 - 16
⑩	AVG	Select the averaging mode	5 - 16
⑪	PSE	Pause	5 - 16
⑫	IDXn	Set an index	5 - 16
⑬	DRn	Set the distance range	5 - 17
⑭	GANn	Select the measuring mode	5 - 17
⑮	XSPn SSPn	Set the horizontal span	5 - 18
⑯	SSTn	Set the horizontal position	5 - 24
⑰	VSLn	Set the vertical scale	5 - 24
⑱	VPSn	Set the vertical position	5 - 25
⑲	PWn	Set the pulse width	5 - 25
⑳	KNBn	Select the rapid mode	5 - 25

Table 5 - 3 GPIB Command List (2 of 2)

Command		Function	Page
㉑	WLn	Set the wavelength	5 - 26
㉒	TST	Save the dual trace waveforms	5 - 26
㉓	TVWn	Display or no display of dual trace waveforms	5 - 26
㉔	LSSn	Select a marker (standard of ADVANCED FUNCTION)	5 - 27
㉕	SPMn	Select a marker (ADVANCED FUNCTION)	5 - 27
㉖	MKAn MKBn MKCn MKDn MKEn	Set a marker	5 - 28
㉗	MSTn	Save the waveform memory	5 - 28
㉘	MRCn	Recall the waveform memory	5 - 29
㉙	MDLn	Delete the waveform memory	5 - 29
㉚	LBLn	Set a label	5 - 29
㉛	PFD	Printer feeding	5 - 29
㉜	PRT	Print out	5 - 30
㉝	CLOCKn	Set a clock	5 - 30
㉞	WAVEn	Set the No. of display dots per line	5 - 30
㉟	MILEn	Select the km or mile display mode	5 - 30
㊱	SAVGn	Set the No. of averaging times	5 - 31
㊲	MSKSn	Set mask	5 - 31
㊳	MSKC	Clear mask	5 - 31
㊴	OREFn	Set the reference level of ORL function	5 - 32
㊵	AUTOn	Start automatic measurement	5 - 33
㊶	ALVLn	Set the automatic measurement detect level	5 - 33
㊷	BZn	Turn the buzzer on or off	5 - 33

① C

Function:

Clears the system to the initial status that is the same as when its power supply is turned on.

Parameter:

None

Explanation:

The present setup state (such as pulse width and distance range) does not change. The following are set:

Item	Status
MONITOR/AVERAGE	MONITOR
PAUSE	ON
DUAL TRACE function	OFF
MENU	OFF
HELP function	OFF
Auto measurement function	OFF

② Z

Function:

Clears the system to its initial status.

Parameter:

None

Explanation:

The system is set to the following status:

Item	Initial setting
DISTANCE RANGE	15km
PULSE WIDTH	100ns
INDEX	1.5000
Measurement mode	BACKSCATTER BACKSCATTER1 (Q84621/A)
LABEL	Q8460 OTDR by ADVANTEST
RAPID	OFF
MASK	Clear
MEMORY SAVE DATA	Clear
GPIB ADDRESS	Not changed
HDCOPY	PRINTER
DISPLAY SIGNAL	LINE
DISPLAY UNITS	km
AVERAGE repeat count	256
BUZZER	OFF
ORL BS REFER LEVEL	-49.0dB (1.31μm) -59.0dB (1.55μm)
AUTO MEASURE LEVEL	STEP 0.50dB
MARKER	STANDARD-DISTANCE
VERTICAL SCALE POSITION	4dB/DIV 0 to -32dB

③ Sn

Function:
Issue a service request.

Parameter:

n = 0	Issues a service request.
n = 1	Does not issue a service request.

Explanation:
The "Sn" command issues a service request if the S0 mode has been selected (as described in Section 5.2).

④ SMKn

Function:
Masks the service request.

Parameter:
n = 0 to 127

Explanation:
This command masks the status byte. Once masked, a service request of the masked bit is ignored. Parameter "n" is a decimal value.

Example: If n=3, status bytes 1 and 2 are masked.

8	7	6	5	4	3	2	1
0	0	0	0	0	0	1	1

⑤ CS

Function:
Clears the status byte.

Parameter:
None

Explanation:
The CS command clears a bit if its status has been set to "1".

⑥ DLn

Function:
Selects the delimiter mode.

Parameter:

n = 0	CR/LF + EOI
n = 1	LF only
n = 2	EOI only

Explanation:
This command indicates the end of data.

Header	Data	SD	Data	SD	Data	BD

Header	Data	BD

The specified block delimiter or delimiters are added regardless of a single or multiple data sets or the binary or ASCII output format.

DL0: CR/LF + EOI
DL1: LF only
DL2: EOI only

⑦ SLn

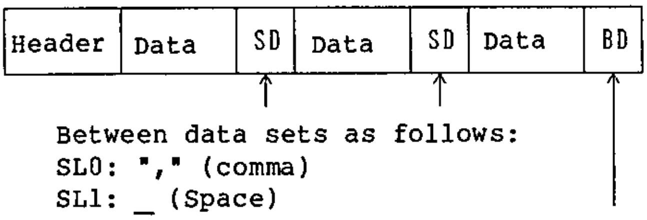
Function:
Selects the string delimiter mode.

Parameter:

n = 0	“, ”
n = 1	␣ (Space)
n = 2	CRLF

Explanation:

An output request is issued by the read command. If its output format is ASCII and multiple data sets are used, the delimiters are added to the output data.



Between data sets as follows:
SL0: "," (comma)
SL1: _ (Space)
SL2: CR + LF

A block delimiter is added as follows:
DL0: CR/LF + EOI
DL1: LF only
DL2: EOI only

⑧ Hn

Function:

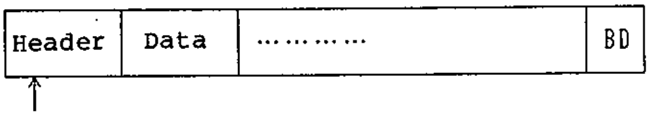
Display or no display of header.

Parameter:

n = 0	OFF
n = 1	ON

Explanation:

If an output request is issued by the read command and if the header display mode is selected (ON), this command adds a 6-byte ASCII data to the beginning of the output data as the header. The read command is added as it is.



6-byte ASCII data

If the header display mode is off, nothing is added to data. It is added if the header display mode is on regardless of the ASCII or binary output format.

⑨ MON

Function:
Selects the monitor mode.

Parameter:
None

Explanation:
Selects the monitor mode in the specified conditions. Some parameters can be changed only in the monitor mode.

⑩ AVG

Function:
Selects the averaging mode.

Parameter:
None

Explanation:

- Starts averaging in the setup conditions.
- Averaging continues after pause by Average Pause.
- If you increase the No. of averaging times and issue this command at the end of previous averaging, additional averaging starts.

⑪ PSE

Function:
Selects the Pause mode.

Parameter:
None

Explanation:
This command pauses averaging in the average mode or monitor mode.

⑫ IDXn

Function:
Sets an index (refractive index) value.

Parameter:
$1.4000 \leq n \leq 1.7000$
0.0001 step

Explanation:
This command sets the refractive index (see Subsection 3.3.1).

⑬ DRn

Function:
Sets the distance range.

Parameter:

n = 0	100km
n = 1	50km
n = 2	15km
n = 3	5km
n = 4	2km
n = 5	1km

Explanation:

- The distance range can be set only in the monitor mode.
- Select a distance range longer than the optical fiber length. If not, a multipath reflection may occur and the measurement may fail.
- Some distance ranges cannot be set due to the plug-in unit type.
  Q84605: 100 km
  Q84605P: 50 km or 100 km

⑭ GANn

Function:
Selects the measuring mode.

Parameter:

n = 0	REFLECTION	
n = 1	BACKSCATTER	
n = 1	BACKSCATTER1	Q84621/Q84621A only
n = 2	BACKSCATTER2	
n = 3	BACKSCATTER3	
n = 4	BACKSCATTER4	

Explanation:

- The measuring mode can be selected from the monitor mode only. You cannot select the REFLECTION option in the AUTO (automatic measurement) mode.
- The following shows the setting values of a plug-in unit other than the Q84621/A.
  GAN0: REFLECTION
  GAN1: BACKSCATTER
- The following shows the setting values of a plug-in for Q84621/A.
  GAN1: BACKSCATTER1
  GAN2: BACKSCATTER2
  GAN3: BACKSCATTER3
  GAN4: BACKSCATTER4

⑮ XSPn, SSPn

Function:

Sets or changes the horizontal span.

Parameter:

Parameter (n)	0	1	2	3	4	5	6	7	8	9	10	11	12
Span (km)	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20	50	100

Explanation:

The span enlargement or compression depends on the display status and its distance range. The following summarizes the change of span in the monitor mode.
Some parameters may not be set in an XSP command due to the distance range setup.

o: Can be set
x: Cannot be set

		Parameter of XSP Command												
		0	1	2	3	4	5	6	7	8	9	10	11	12
DISTANCE RANGE	100km	×	×	○	○	○	○	○	○	○	○	○	○	○
	50km	○	○	○	○	○	○	○	○	○	○	○	○	×
	15km	○	○	○	○	○	○	○	○	○	○	×	×	×
	5km	○	○	○	○	○	○	○	○	○	×	×	×	×
	2km	○	○	○	○	○	○	○	○	×	×	×	×	×
	1km	○	○	○	○	○	○	○	×	×	×	×	×	×

The change of span during averaging, after averaging, averaging pause, or monitor pause varies depending on the distance range and specified span.

NOTE

- The span of waveforms recalled from memory is expanded or reduced .
- The span is expanded or compressed around the marker position.

The following lists the range of span that can be changed.

Span Modification Range during Pause (1 of 5)

Explanation:

The span can be compressed to 200 m in the non-monitor mode if DR=1 km and the specified span is 10 m.

When DR is set 1km.

		Adjustable span						
		10m	20m	50m	100m	200m	500m	1km
Setting span	10m	← ○	—	—	—	—→	×	×
	20m	←—	— ○	—	—	—→	×	×
	50m	×	×	← ○	—	—	—→	×
	100m	×	×	×	← ○	—	—→	×
	200m	×	×	×	←—	— ○	—→	×
	500m	×	×	×	×	×	← ○	—→
	1km	×	×	×	×	×	←—	○ →

Span Modification Range during Pause (2 of 5)

When DR is set 2km.

		Adjustable span							
		10m	20m	50m	100m	200m	500m	1km	2km
Setting span	10m	← ○	—	—	—	→	×	×	×
	20m	←	○	—	—	→	×	×	×
	50m	×	×	← ○	—	—	→	×	×
	100m	×	×	×	← ○	—	—	→	×
	200m	×	×	×	←	○	—	→	×
	500m	×	×	×	×	×	← ○	—	→
	1km	×	×	×	×	×	←	○	→
	2km	×	×	×	×	×	←	—	○ →

○ : The span is set under a MONITOR status.

When DR is set 5km.

		Adjustable span								
		10m	20m	50m	100m	200m	500m	1km	2km	5km
Setting span	10m	← ○	—	—	—	→	×	×	×	×
	20m	←	○	—	—	→	×	×	×	×
	50m	×	×	← ○	—	—	→	×	×	×
	100m	×	×	×	← ○	—	—	→	×	×
	200m	×	×	×	←	○	—	→	×	×
	500m	×	×	×	×	×	← ○	—	—	→
	1km	×	×	×	×	×	←	○	—	→
	2km	×	×	×	×	×	←	—	○	→
	5km	×	×	×	×	×	×	←	—	○ →

○ : The span is set under a MONITOR status.

Span Modification Range during Pause (3 of 5)

When DR is set 15km.

		Adjustable span									
		10m	20m	50m	100m	200m	500m	1km	2km	5km	10km
Setting span	10m	← ○	—	—	—	—→	×	×	×	×	×
	20m	←—	— ○	—	—	—→	×	×	×	×	×
	50m	×	×	← ○	—	—	—→	×	×	×	×
	100m	×	×	×	← ○	—	—	—→	×	×	×
	200m	×	×	×	←—	— ○	—	—→	×	×	×
	500m	×	×	×	×	×	← ○	—	—	—	—→
	1km	×	×	×	×	×	←—	— ○	—	—	—→
	2km	×	×	×	×	×	←—	—	— ○	—	—→
	5km	×	×	×	×	×	×	←—	—	— ○	—→
	10km	×	×	×	×	×	×	←—	—	—	○ →

○ : The span is set under a MONITOR status.

Span Modification Range during Pause (4 of 5)

When DR is set 50km.

		Adjustable span											
		10m	20m	50m	100m	200m	500m	1km	2km	5km	10km	20km	50km
Setting span	10m	← ○	—	—	—	—→	×	×	×	×	×	×	×
	20m	←—	— ○	—	—	—→	×	×	×	×	×	×	×
	50m	×	×	← ○	—	—	—→	×	×	×	×	×	×
	100m	×	×	×	← ○	—	—	—→	×	×	×	×	×
	200m	×	×	×	←—	— ○	—	—→	×	×	×	×	×
	500m	×	×	×	×	×	← ○	—	—	—	—→	×	×
	1km	×	×	×	×	×	←—	— ○	—	—	—→	×	×
	2km	×	×	×	×	×	←—	—	— ○	—	—→	×	×
	5km	×	×	×	×	×	×	←—	—	— ○	—	—→	×
	10km	×	×	×	×	×	×	←—	—	—	— ○	—→	×
	20km	×	×	×	×	×	×	×	←—	— ●	—	— ○	—→
	50km	×	×	×	×	×	×	×	×	←—	—	—	○ →

○ : The span is set under a MONITOR status.
● : The span is not set 5km, but is set 4km.

Span Modification Range during Pause (5 of 5)

When DR is set 100km.

	Adjustable span										
	50m	100m	200m	500m	1km	2km	5km	10km	20km	50km	100km
50m	← ○	—	—	→	×	×	×	×	×	×	×
100m	×	← ○	—	—	→	×	×	×	×	×	×
200m	×	←	○	—	→	×	×	×	×	×	×
500m	×	×	×	← ○	—	—	—	→	×	×	×
1km	×	×	×	←	○	—	—	→	×	×	×
2km	×	×	×	←	—	○	—	→	×	×	×
5km	×	×	×	×	←	—	○	—	→	×	×
10km	×	×	×	×	←	—	—	○	→	×	×
20km	×	×	×	×	×	←	●	—	○	→	×
50km	×	×	×	×	×	×	←	—	—	○	→
100km	×	×	×	×	×	×	←	—	—	—	○ →

○ : The span is set under a MONITOR status.
● : The span is not set 5km, but is set 4km.

⑯ SSTn, PSTn

Function:
Sets the horizontal position.

Parameter:
0 to approximately 107000

Explanation:
These commands set the start point on the distance axis (horizontal position) in meters or miles.
The horizontal position may not be set by using the distance range, span, or index value.
Although a decimal value can be set, the expected result may not be obtained due to the limited resolution of internal data or an error of index.

⑰ VSLn

Function:
Sets the vertical axis scale.

Parameter:
Back Scatter mode:

	Vertical Scale
n = 0	4dB/div
n = 1	2
n = 2	1
n = 3	0.5
n = 4	0.2

Reflection mode:

	Vertical Scale
n = 0	× 1
n = 1	× 2
n = 2	× 4
n = 3	× 8

Explanation:

The different scale index may be set between the Back Scatter and Reflection modes.

⑱ VPSn

Function:

Sets the vertical position.

Parameter:

n = -30 to 15

Explanation:

This command sets the vertical axis position in units of dB.

⑲ PWn

Function:

Sets the pulse width.

Parameter:

	Pulse width
n = 0	3ns
n = 1	20ns
n = 2	100ns
n = 3	1μs

Explanation:

The pulse width can be set in the monitor mode only.

⑳ KNBn

Function:

Selects the rapid mode of the data knob.

Parameter:

n = 0	OFF
n = 1	ON

㉑ WLn

Function:
Sets the wavelength.

Parameter:

n = 0	0.85μm
n = 1	1.3 μm
n = 2	1.55μm

Explanation:
This command is valid only when issued for the Q84621/Q84621A plug-in unit.

㉒ TST

Function:
Saves the waveform data in the dual trace memory.

Parameter:
None

Explanation:
This command saves only the waveform data in the dual trace memory. If data already exists in this memory, it is overwritten by new waveform data. The previous data is erased. When the system power supply is turned off, all data is erased from memory.

㉓ TVWn

Function:
Displays the dual trace or suppresses to display it.

Parameter:

n = 0	OFF
n = 1	ON

Explanation:
This command specifies the display or no display of save data of the dual trace memory by using the TST command.

㉔ LSSn

Function:
Sets the standard marker function.

Parameter:

n = 0	DISTANCE
n = 1	LOSS
n = 2	Splice1
n = 3	Splice2
n = 4	ORL(Q84621A)

Explanation:
This command is valid only when the standard marker function of ADVANCED FUNCTION has been set. The ORL function is valid for the Q84621A only.

㉕ SPMn

Function:
Selects the ADVANCED FUNCTION marker functions.

Parameter:

n = 0	STANDARD
n = 1	FIX DLT (LSA)
n = 2	FIX DLT (2PA)
n = 3	3 POINTS LOSS
n = 4	5 POINTS LOSS
n = 5	SPLICE, SPLICE
n = 6	LOSS, LOSS (LSA)
n = 7	LOSS, LOSS (2PA)

Explanation:

This command selects the ADVANCED FUNCTION marker functions. See Section 3.5 for the marker function details.

㉖ MKAn, MKBn, MKCn, MKDn, MKEn

Function:

MKA moves marker 1.
MKB moves marker 2.
MKC moves marker 3.
MKD moves marker 4.
MKE moves marker 5.

Parameter:

0 to 500

Explanation:

Set value 0 at the leftmost end of the screen and value 500 at the rightmost end of it. The distance on the horizontal axis is not affected (if the number of points is 500). The number of points varies depending on the specified span. See the table below.

SPAN	The number of points
10m	200
20m	400
the others	500

㉗ MSTn

Function:

Saves the waveform data and setup conditions in the internal memory.

Parameter:

n = 1 to 32

Explanation:

This command saves both the waveform data and setup conditions in the internal memory. If data already exists in the selected file number, the existing data is overwritten by new data. For memory function details, see paragraph ① "Save mode" of Section 3.6 (2).

㉘ MRCn

Function:
Recalls the waveforms and setup conditions from memory.

Parameter:
n = 1 to 32

Explanation:
For memory function details, see paragraph ② "Recall mode" of Section 3.6 (2).

㉙ MDLn

Function:
Deletes waveform data from memory.

Parameter:
1 to 32

Explanation:
This command deletes data from the specified number of the file. For memory function details, see paragraph ③ "Delete mode" of Section 3.6 (2).

㉚ LBLn

Function:
Enters a label.

Parameter:
n = "# label #"

Special characters

Explanation:
This command enters a character string enclosed by a pair of special characters. Up to 23 characters can be entered. The characters are entered as they are from the beginning of the leftmost end position.

㉛ PFD

Function:
Feeds the built-in printer.

Parameter:
None

Explanation:
This command feeds forms on the built-in printer.

㉜ PRT

Function:
Prints data on the built-in printer.

Parameter:
None

Explanation:
You must set the I/O of the printer. It the plotter output has been set, no GPIB control is supported.

㉝ CLOCKn

Function:
Sets the calendar date and clock time.

Parameter:
Example: To set 20 hours 45 minutes on December 25, 1990, enter:
n=1990,12,25,20,45

㉞ WAVEn

Function:
Sets the waveform display resolution on the CRT screen.

Parameter:

n = 0	dot
n = 1	LINE

㉟ MILEn

Function:
Selects the unit of waveform display distance.

Parameter:

n = 0	km
n = 1	mile

㊱ SAVGn

Function:
Sets the No. of averaging times.

Parameter:

Parameter	0	1	2	3	4	5	6
Count	16	32	64	128	256	512	1024

Parameter	7	8	9	10	11	12
Count	2048	4096	8192	16384	32768	65536

㊲ MSKSn

Function:
Sets the optical mask.

Parameter:
n = 0 to approximately 100000 (in meters or miles)

Explanation:
The optical mask can be set for the Q84601, Q84621, or Q84621A. Specify the distance (in meters or miles) in the parameter. No unit is required.

㊳ MSKC

Function:
Clears the optical mask.

Parameter:
None

Explanation:
The MSKC command clears all masks which have been set.

㊴ OREFn

Function:

Sets the reference level of the ORL function.

Parameter:

n	Pulse width
-50.0 to -70.0	100ns or less
-40.0 to -60.0	1μs

Explanation:

For the ORL function details, see paragraph (2) of Section 3.5. If the pulse width is 3 ns or 20 ns, the parameter is set based on the 100 ns pulse width.
The following shows the reference level setup according to the wavelength.

Wavelength	Reference level
1.31μm	-49dB
1.55μm	-52dB

Note

If the pulse width is 3 ns or 20 ns, no waveforms can be measured by using the ORL function.

㊵ AUTOn

Function:
Starts automatic measurement.

Parameter:

n = 0	Exists the automatic measurement mode.
n = 1	Selects the automatic measurement and starts measurement.

Explanation:
This command executes automatic measurement in the specified conditions. For the automatic measurement details, see paragraph (1) of Section 3.12.
When specifying a GPIB command, you cannot select the ALL or STEP option of the MEASURE parameter. You can select them in the ALL mode only. (The ALL mode is selected automatically even when the STEP mode has been selected.)

㊶ ALVLn

Function:
Sets the automatic measurement level.

Parameter:
n = 0.05 to 2.00

Explanation:
This command sets the automatic measurement level. You must enter the splice loss value for the detection level.

㊷ BZn

Function:
Turns the buzzer on or off.

Parameter:

n = 0	OFF
n = 1	ON

Explanation:
This command turns the buzzer sound mode on or off. The valid and invalid GPIB command input can be identified by the buzzer.

5.3.2 GPIB Read Commands

The following lists the GPIB read commands and provides their detailed explanation.

Table 5-4 GPIB Read Command List (1 of 2)

Command		Function	Page
①	RDTB	Output the on-screen data (binary 1 byte per data)	5 - 36
②	RDTW	Output the on-screen data (binary 2 byte per data)	5 - 36
③	RDTL	Output the on-screen data (binary 4 byte per data)	5 - 37
④	RDTS	Output the on-screen data (ASCII 7 bytes per data)	5 - 37
⑤	RMDB	Output the dual trace memory data (binary 1 byte per data)	5 - 38
⑥	RMDW	Output the dual trace memory data (binary 2 bytes per data)	5 - 38
⑦	RMDL	Output the dual trace memory data (binary 4 bytes per data)	5 - 39
⑧	RMDS	Output the dual trace memory data (ASCII 7 bytes per data)	5 - 39
⑨	RADB	Output all internal data (binary 1 byte per data)	5 - 40
⑩	RADW	Output all internal data (binary 2 bytes per data)	5 - 40
⑪	RADL	Output all internal data (binary 4 bytes per data)	5 - 41
⑫	RADS	Output all internal data (ASCII 7 bytes per data)	5 - 41
⑬	RDTC	Read the No. of on-screen data sets	5 - 42
⑭	RMDC	Read the No. of data sets of dual trace memory	5 - 42
⑮	RADC	Read the total No. of internal data sets and the distance between the start and end points	5 - 42
⑯	RPI	Read the plug-in unit	5 - 43
⑰	RGAN	Read the measuring mode	5 - 43
⑱	RVSL	Read the vertical scale	5 - 43
⑲	RVPS	Read the vertical position	5 - 44
⑳	RHPS	Read the horizontal position	5 - 44

Table 5-4 GPIB Read Command List (2 of 2)

Command		Function	Page
㉑	RSP	Read the horizontal span	5 - 44
㉒	RDR	Read the distance range	5 - 45
㉓	RSPM	Read the marker type (Advanced function)	5 - 45
㉔	RLSS	Read the marker type (Standard)	5 - 45
㉕	RRDO	Read data from window (except automatic measurement)	5 - 46
㉖	RATC	Read the No. of connection points during automatic measurement	5 - 48
㉗	RAUT	Read the automatic measurement result	5 - 48
㉘	RPW	Read the pulse width	5 - 48
㉙	RLBL	Read the label	5 - 49
㉚	RIDX	Read the index	5 - 49
㉛	RCLOCK	Read the date and time	5 - 49
㉜	RWAVE	Read the display resolution (No. of dots per line)	5 - 50
㉝	RMILE	Read the display distance (in km or mile)	5 - 50
㉞	RSAVG	Read the No. of averaging times	5 - 50
㉟	RALVL	Read the setup of splice detect level during automatic measurement	5 - 51
㊱	ROREF	Read the reference level	5 - 51

① RDTB

Function:
Reads the on-screen data.

Explanation:
Binary format output: 1 byte per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 1-byte (0 to 255) binary data. The bottom of the screen is 0, and the top of the screen is 255. The specified number of data sets is read by the RDTC command.
BD: Block delimiter that can be selected by the "DLn" command

② RDTW

Function:
Reads the on-screen data.

Explanation:
Binary format output: 2 bytes per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 2-byte binary data. The high-order 1 byte represents the integer part of data, and the low-order 1 byte is the decimal part. The specified number of data sets is read by the RDTC command.
BD: Block delimiter that can be selected by the "DLn" command

③ RDTL

Function:
Reads the on-screen data.

Explanation:
Binary format output: 4 bytes per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.

Data: 4-byte binary data. The high-order 2 bytes represent the integer part of data, and the low-order 2 bytes are the decimal part. The specified number of data sets is read by the RDTC command.

BD: Block delimiter that can be selected by the "DLn" command

④ RDTS

Function:
Reads the on-screen data.

Explanation:
ASCII format output: 7 bytes per data

Header	Data 1	SD	Data 2	SD	Data 3	SD	· · ·

Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.

Data: 7-byte ASCII data. The number of data sets is read by the RDTC command.

SD: String delimiter which can be selected by the "SLn" command

BD: Block delimiter that can be selected by the "DLn" command

⑤ RMDB

Function:
Reads data from the dual trace memory.

Explanation:
Binary format output: 1 byte per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 1-byte (0 to 255) binary data. The bottom of the screen is 0, and the top of the screen is 255. The number of data sets can be read by the RMDC command.
BD: Block delimiter that can be selected by the "DLn" command

⑥ RMDW

Function:
Reads data from the dual trace memory.

Explanation:
Binary format output: 2 bytes per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 2-byte binary data. The high-order 1 byte represents the integer part of data, and the low-order 1 byte is the decimal part. The specified number of data sets is read by the RMDC command.
BD: Block delimiter that can be selected by the "DLn" command

⑦ RMDL

Function:
Reads data from the dual trace memory.

Explanation:
Binary format output: 4 bytes per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 4-byte binary data. The high-order 2 bytes represent the integer part of data, and the low-order 2 bytes are the decimal part. The specified number of data sets is read by the RMDC command.
BD: Block delimiter that can be selected by the "DLn" command

⑧ RMDS

Function:
Reads data from the dual trace memory.

Explanation:
ASCII format output: 7 bytes per data

Header	Data 1	SD	Data 2	SD	Data 3	SD	· · ·

Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 7-byte ASCII data. The number of data sets is read by the RMDC command.
SD: String delimiter which can be selected by the "SLn" command
BD: Block delimiter that can be selected by the "DLn" command

⑨ RADB

Function:

Reads all internal data.

Explanation:

Binary format output: 1 byte per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header:	6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data:	1-byte (0 to 255) binary data The bottom of the screen is 0, and the top of the screen is 255. The specified number of data sets is read by the RADC command.
BD:	Block delimiter that can be selected by the "DLn" command

⑩ RADW

Function:

Reads all internal data.

Explanation:

Binary format output: 2 bytes per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header:	6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data:	2-byte binary data. The high-order 1 byte represents the integer part of data, and the low-order 1 byte is the decimal part. The specified number of data sets is read by the RADC command.
BD:	Block delimiter that can be selected by the "DLn" command

⑪ RADL

Function:
Reads all internal data.

Explanation:
Binary format output: 4 bytes per data

Header	Data 1	Data 2	Data 3	· ·	Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 4-byte binary data. The high-order 2 bytes represent the integer part of data, and the low-order 2 bytes are the decimal part. The specified number of data sets is read by the RADC command.
BD: Block delimiter that can be selected by the "DLn" command

⑫ RADS

Function:
Reads all internal data.

Explanation:
ASCII format output: 7 bytes per data

Header	Data 1	SD	Data 2	SD	Data 3	SD	· · ·

Data n	BD

Header: 6-byte ASCII data. It is output only when the header display mode has been turned on by the "Hn" command.
Data: 7-byte ASCII data. The number of data sets is read by the RADC command.
SD: String delimiter which can be selected by the "SLn" command
BD: Block delimiter that can be selected by the "DLn" command

⑬ RDTC

Function:
Reads the number of on-screen data sets

Explanation:
This command reads the number of on-screen data sets.
Talker format

Header	Data	BD
	5 characters	

⑭ RMDC

Function:
Reads the number of data sets of the dual trace memory.

Explanation:
This command reads the number of data sets of the dual trace memory.
Talker format

Header	Data	BD
	5 characters	

⑮ RADC

Function:
Reads the total number of internal data sets.

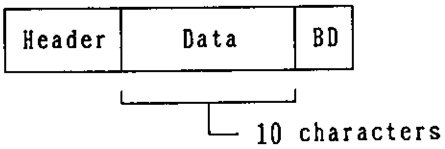
Explanation:
This command reads the total number of internal data sets and the distance between the start and end points of data.
Command: RADC
Talker format

Header	Data 1	SD	Data 2	SD	Data 3	BD
	5 characters		10 characters		10 characters	

⑯ RPI

Function:
Reads the attached plug-in unit.

Explanation:
This command reads both the length of waveforms shown at the left lower end of the screen and the optical fiber type.
Talker format



⑰ RGAN

Function:
Reads the measuring mode.

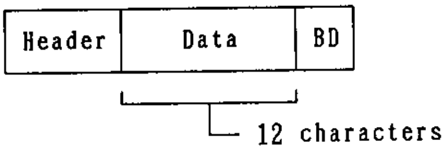
Explanation:
This command reads the current measuring mode.
One of the following is read on a plug-in unit other than the Q84621/Q84621A:

- Reflection
- Backscatter

One of the following is read on the Q84621/Q84621A:

- Reflection
- Backscatter 1 to 4

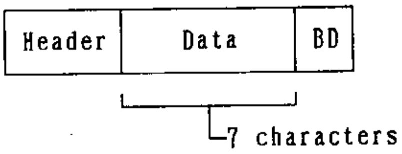
Talker format



⑱ RVSL

Function:
Reads the vertical scale.

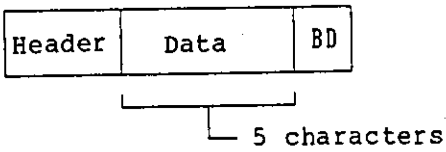
Explanation:
This command reads the on-screen vertical axis scale in units of dB/D.
Talker format



⑲ RVPS

Function:
Reads the vertical position.

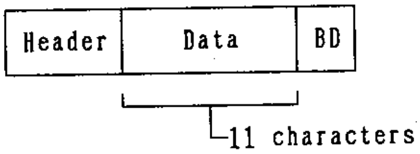
Explanation:
This command reads the vertical axis position. The upper limit value is read.
Talker format



⑳ RHPS

Function:
Reads the horizontal position.

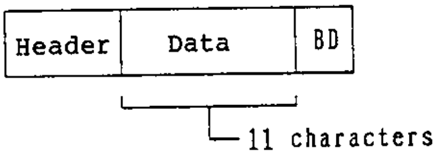
Explanation:
This command reads the specified distance position. The leftmost end value on the screen is read (in units of meters or miles).
Talker format



㉑ RSP

Function:
Reads the horizontal span.

Explanation:
This command reads the specified horizontal span (in units of meters or miles).
Talker format



㉒ RDR

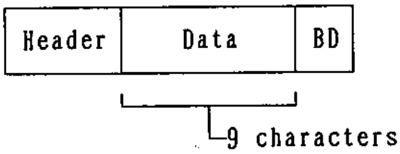
Function:

Reads the distance range.

Explanation:

This command reads the distance range shown on the right upper end of the screen.

Talker format



㉓ RSPM

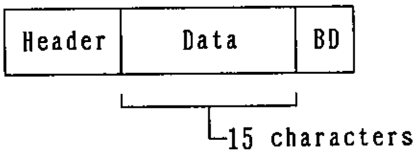
Function:

Reads the marker type.

Explanation:

This command reads the specified marker function (ADVANCED FUNCTION).

Talker format



㉔ RLSS

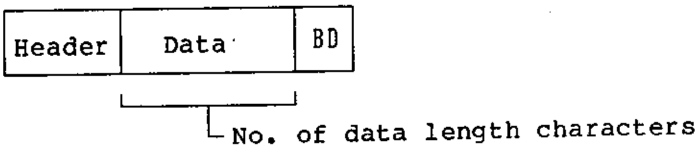
Function:

Reads the marker type.

Explanation:

This command reads the specified marker function (Standard).

Talker format



㉕ RRDO

Function:
Reads data from window.

Explanation:
This command reads data identified by the on-screen marker.
Talker format

Header	Data 1	SD	Data 2	SD	·	SD	Data N	BD

The following shows the number of characters of data 1 to data N.

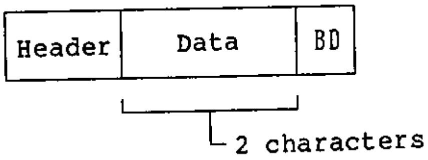
STANDARD	Data No.	No. of characters	Contents
(DISTANCE)	1	15	Title
	2	13	Distance
	3	9	Loss
(LOSS)	1	15	Title
	2	13	Distance
	3	9	Loss
	4	14	Loss/distance
(ORL)	1	15	Title
	2	9	ORL
	3	9	Level difference
	4	9	BS level
(SPLICE 1)	1	15	Title
	2	9	Loss
	3	13	Distance
(SPLICE 2)	1	15	Title
	2	9	Loss
	3	13	Distance
FIX DLT (LSA)	1	15	Title
	2	13	Distance
	3	9	Loss
	4	15	Title
	5	13	Distance
	6	15	Title

STANDARD	Data No.	No. of characters	Contents
FIX DLT (2PA)	1	14	Loss/distance
	2	15	Title
	3	13	Distance
	4	9	Loss
	5	15	Title
3 Point Loss	1	9	Loss
	2	13	Distance
	3	15	Title
	4	9	Loss
	5	13	Distance
5 Points Splice	1	15	Title
	2	9	Loss
	3	13	Distance
SPLICE SPLICE	1	15	Title
	2	9	Loss
	3	13	Distance
	4	15	Title
	5	9	Loss
	6	13	Distance
LOSS LOSS (LSA)	1	15	Title
	2	13	Distance
	3	9	Loss
	4	15	Title
	5	13	Distance
	6	9	Loss
	7	15	Title
	8	14	Loss/distance
	9	15	Title
	10	14	Loss/distance
LOSS LOSS (2PA)	1	15	Title
	2	13	Distance
	3	15	Title
	4	13	Distance
	5	15	Title
	6	9	Loss
	7	14	Loss/distance
	8	15	Title
	9	9	Loss
	10	14	Loss/distance

㉖ RATC

Function:
Reads the number of connection points as the result of automatic measurement.

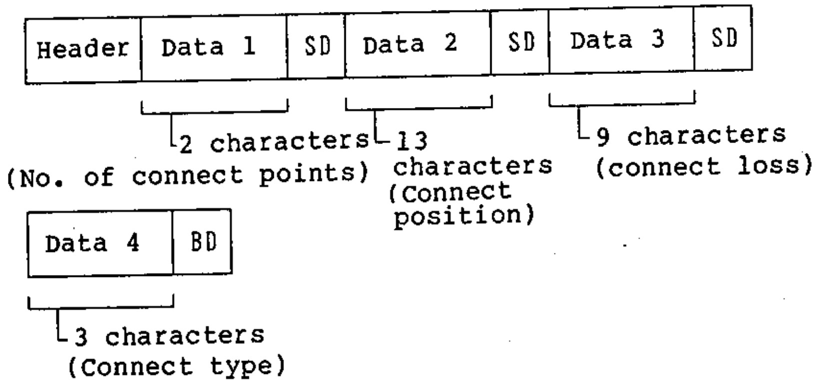
Explanation:
Talker format



㉗ RAUT

Function:
Reads the automatic measurement results.

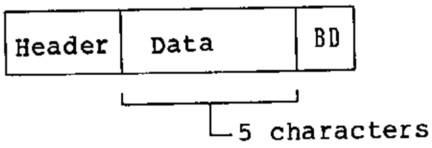
Explanation:
Talker format



㉘ RPW

Function:
Reads the specified pulse width.

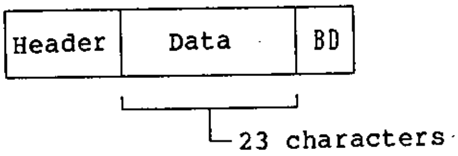
Explanation:
Talker format



㉙ RLBL

Function:
Reads the specified label.

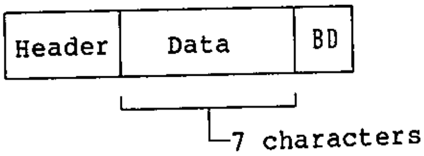
Explanation:
Talker format



㉚ RIDX

Function:
Reads the specified index.

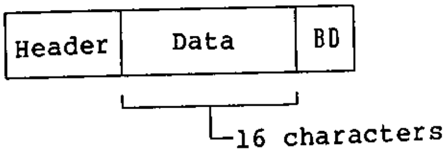
Explanation:
Talker format



㉛ RCLOCK

Function:
Reads the calendar date and clock time.

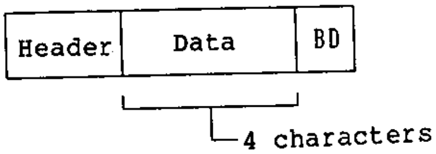
Explanation:
Talker format



㉜ RWAVE

Function:
Reads the display resolution (No. of dots per line).

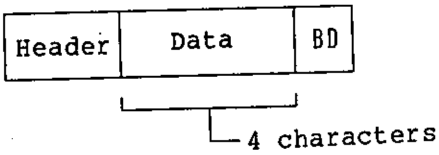
Explanation:
Talker format



㉝ RMILE

Function:
Reads the display distance (in km or mile).

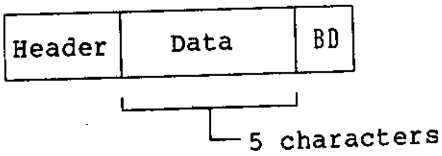
Explanation:
Talker format



㉞ RSAVG

Function:
Reads the number of the specified averaging times.

Explanation:
Talker format



㉟ RALVL

Function:

Reads the setup value of splice detect level during automatic measurement.

Explanation:

This command reads the splice detect level which has been set for automatic measurement.

Talker format

Header	Data	BD

6 characters

㊱ ROREF

Function:

Reads the reference level of the ORL function.

Explanation:

This command reads the specified reference level of the ORL function. If the pulse width is 1 microsecond, value -50.0 to -70.0 dB is read.

Talker format

Header	Data	BD

7 characters

5.4 Programming Examples

The following gives programming examples when the PC9801 series controller is used.

(1) Setting the measuring pattern

```
10    '
20    '
30    '      EXAMPLE PROGRAM
40    '
50    '      SET DATA
60    '
70    '
80    '
90    OTDR=11 ---------------------------- Defines the unit address of 11.
100   '
110   ISET IFC --------------------------- Clears the interface.
120   ISET REN --------------------------- Enables remote control.
130   '
140   '
150   PRINT @OTDR;“MON” ------------------ Sets the Monitor function.
160   PRINT @OTDR;“IDX1.4657” ------------ Sets the index to 1.4657.
170   PRINT @OTDR;“DR2,PW1” -------------- Sets the 15 km distance range
                                           (pulse width).
```

(2) Reading the specified data

```
10    '
20    '
30    '      EXAMPLE PROGRAM
40    '
50    '      READ SETUP OF OTDR
60    '
70    '
80    DIM A$(100), B$(100), C$(100) ------ Defines the buffer.
90    '
100   OTDR=11 ---------------------------- Device the unit address of 11.
110   '
120   ISET IFC --------------------------- Clears the interface.
130   ISET REN --------------------------- Enables remote control.
140   '
150   '
160   PRINT @OTDR;“RPW” ------------------ Selects the pulse width read mode.
170   INPUT @OTDR;A$ --------------------- Reads the pulse width in "A$".
180   PRINT @OTDR;“RLBL” ----------------- Selects the label read mode.
190   INPUT @OTDR;B$ --------------------- Reads the label in "B$".
200   PRINT @OTDR;“RIDX ------------------ Selects the index read mode.
210   INPUT @OTDR;C$ --------------------- Reads the index in "C$".
220   PRINT A$, B$, C$ ------------------- Prints the pulse width, label,
                                           and index which have been read.
```

(3) Reading the on-screen waveform data in 4-byte binary format

```
10    '
20    '
30    '
40    '       EXAMPLE PROGRAM
50    '
60    '       READ DATA BLOCK BY 4 BYTE FORMAT
70    '
80    DIM DBUF(501)
90    UNL=&H3F : UNT=&H5F : MTA=&H40 : MLA=&H20
100   '
110   OTDR=11
120   PC98=IEEE(1) AND &H1F
130   '
140   ISET IFC
150   ISET REN
160   '
170   N.BYTE=501
180   PRINT @OTDR;“DL2”
190   PRINT @OTDR;“RDTL”
200   '
210   TALK=MTA+OTDR : LISTEN=MLA+PC98
220   WBYTE UNL,TALK,LISTEN;
230   FOR N=1 TO N.BYTE
240     RBYTE;RDT
250     ANS=RDT
260     RBYTE;RDT
270     ANS=RDT
280     RBYTE;RDT
290     ANS=ANS+RDT/256
300     RBYTE;RDT
310     ANS=ANS+RDT/65536!
320     IF ANS>=128 THEN ANS=256-ANS:ANS=-ANS
330     DBUF(N-1) = ANS
340   NEXT N
350   J = 0
360   FOR I = 0 TO 500
370      IF J < 5 THEN PRINT DBUF(I);:J=J+1 ELSE PRINT DBUF(I):J=0
380   NEXT I
```

The following explains this example program.

No.	Explanation
•	
•	
•	
•	
•	
•	
•	
80	Defines the buffer.
90	Assigns the interface message code to the variable.
•	
110	Defines the unit address of 11.
120	Reads the controller address and assigns it to the variable.
•	
140	Clears the interface.
150	Enables remote control.
•	
170	Assigns the number of data sets to the variable.
180	Sets the block delimiter for the EOI only.
190	Selects the waveform data read mode.
•	
210	Assigns the talker and listener addresses to the respective variables.
220	Defines the unit as talker and the controller as listener.
230	Specifies a loop for the number of data sets (501 levels).
240	Reads 1 byte of data.
250	Reads the high-order byte of integer part.
260	Reads 1 byte of data.
270	Reads the low-order byte of integer part.
280	Reads 1 byte of data.
290	Reads the high-order byte of decimal part.
300	Reads 1 byte of data.
310	Reads the low-order byte of decimal part.
320	Generates a negative value.
330	Assigns the read data to the buffer.
340	Loop
350	Initializes the variables.
360	Specifies a loop for the number of data sets (501 levels).
370	Prints 5 data sets on a line.
380	Loop

(4) Reading the on-screen waveform data in ASCII format

```
10    '        EXAMPLE PROGRAM
20    '
30    '
40    '        READ DATA BLOCK BY 8 BYTE FORMAT
50    '
60    '
70    DIM A$(4008)
80    UNL=&H3F : UNT=&H5F : MTA=&H40 : MLA=&H20
90    '
100   OTDR=11
110   '
120   ISET IFC
130   ISET REN
140   '
150   DATANO=501
160   CMD DELIM=0
170   PRINT @OTDR;"DL0"
180   PRINT @OTDR;"SL2"
190   PRINT @OTDR;"RDTS"
200   FOR DT=1 TO DATANO
210       INPUT @OTDR;A$(DT-1)
220   NEXT DT
230   '
240   J=0
250   FOR I=0 TO 500
260      IF J<5 THEN PRINT A$(I);:PRINT "   ";:J=J+1 ELSE PRINT A$(I):J=0
270   NEXT I
```

The following explains this example program.

No.	Explanation
.	
.	
.	
.	
.	
.	
70	Defines the buffer.
80	Assigns the interface message code to the variable.
.	
100	Defines the unit address of 11.
.	
120	Clears the interface.
130	Enables remote control.
.	
150	Assigns the number of data sets to the variable.
160	Sets the block delimiter of the controller as CR+LF.
170	Sets the block delimiter of the unit as CR+LF+EOI.
180	Sets the string delimiter of the unit as CR+LF.
190	Selects the waveform data read mode.
200	Specifies a loop for the number of data sets (501 levels).
210	Reads 1 byte of data.
220	Loop
.	
240	Initializes the variables.
250	Specifies a loop for the number of data sets (501 levels).
260	Prints 5 data sets on a line.
270	Loop

(5) Reading the on-screen waveform data in 1-byte binary format

```
10     '       EXAMPLE PROGRAM
20     '
30     '
40     '       READ DATA BLOCK BY 1 BYTE FORMAT
50     '
60     '
70    DIM RDT(501)
80    UNL=&H3F : UNT=&H5F : MTA=&H40 : MLA=&H20
90    '
100   OTDR=11
110   PC98=IEEE(1) AND &H1F
120   '
130   ISET IFC
140   ISET REN
150   '
160   N.BYTE=501
170   PRINT @OTDR;"DL2"
180   PRINT @OTDR;"RDTB"
190   '
200   TALK=MTA+OTDR : LISTEN=MLA+PC98
210   WBYTE UNL,TALK,LISTEN;
220   FOR N=1 TO N.BYTE
230     RBYTE;RDT(N-1)
250   NEXT N
300   J = 0
310   FOR I = 0 TO 500
320       IF J <15 THEN PRINT RDT(I);:J=J+1 ELSE PRINT RDT(I): J = 0
330   NEXT I
```

No.	Explanation
•	
•	
•	
•	
•	
•	
70	Defines the buffer.
80	Assigns the interface message code to the variable.
•	
100	Defines the unit address of 11.
110	Reads the controller address and assigns it to the variable.
•	
130	Clears the interface.
140	Enables remote control.
•	
160	Assigns the number of data sets to the variable.
170	Sets the block delimiter as EOI only.
180	Selects the waveform data read mode.
•	
200	Assigns the talker and listener addresses to the respective variables.
210	Defines the unit as talker and the controller as listener.
220	Specifies a loop for the number of data sets (501 levels).
230	Reads 1 byte of data and assigns it to the buffer.
250	Loop
300	Initializes the variables.
310	Specifies a loop for the number of data sets (501 levels).
320	Prints 5 data sets on a line.
330	Loop

(6) Reading the on-screen waveform data in 2-byte binary format

```
10      '
20      '
30      '
40      '       EXAMPLE PROGRAM
50      '
60      '       READ DATA BLOCK BY 2 BYTE FORMAT
70      '
80      DIM DBUF(501)
90      UNL=&H3F : UNT=&H5F : MTA=&H40 : MLA=&H20
110     OTDR=11
120     PC98=IEEE(1) AND &H1F
130     '
140     ISET IFC
150     ISET REN
160     '
170     DATANO=501
180     PRINT @OTDR;"DL2"
190     PRINT @OTDR;"RDTW"
200     '
210     TALK=MTA+OTDR : LISTEN=MLA+PC98
220     WBYTE UNL,TALK,LISTEN;
230     FOR N=1 TO DATANO
240       RBYTE;RDT
250       ANS=RDT
260       RBYTE;RDT
270       ANS=ANS+RDT/256
280       IF ANS>=128 THEN ANS=256-ANS:ANS=-ANS
290       DBUF(N-1) = ANS
300     NEXT N
310     J = 0
320     FOR I = 0 TO 500
330         IF J <5 THEN PRINT DBUF(I);:J=J+1 ELSE PRINT DBUF(I):J = 0
340     NEXT I
```

No.	Explanation
•	
•	
•	
•	
•	
•	
•	
80	Defines the buffer.
90	Assigns the interface message code to the variable.
•	
110	Defines the unit address of 11.
120	Reads the controller address and assigns it to the variable.
•	
140	Clears the interface.
150	Enables remote control.
•	
170	Assigns the number of data sets to the variable.
180	Sets the block delimiter as EOI only.
190	Selects the waveform data read mode.
•	
210	Assigns the talker and listener addresses to the respective variables.
220	Defines the unit as talker and the controller as listener.
230	Specifies a loop for the number of data sets (501 levels).
240	Reads 1 byte of data.
250	Reads the integer data.
260	Reads 1 byte of data.
270	Reads the decimal data.
280	Generates a negative value.
290	Assigns the read data to the buffer.
300	Loop
310	Initializes the variables.
320	Specifies a loop for the number of data sets (501 levels).
330	Prints 5 data sets on a line.
340	Loop

(7) Service request

```
10    '
20    '
30    '
40    '       EXAMPLE PROGRAM
50    '
60    '       SERVICE REQUEST
70    '
80    '
90    OTDR=11
100   '
110   ISET IFC
120   ISET REN
130   '
141   ON SRQ GOSUB *SRQFUN
150   SRQ ON
160   '
170   PRINT @OTDR;"S0"
180   PRINT @OTDR;"SMK31"
190   PRINT @OTDR;"AVG"
200  *LOOP1
210   GOTO *LOOP1
220   '
230   '
240   '
250  *SRQFUN
260   POLL 11,STS
270   PRINT "AVERAGE COMPLETED"
280   SRQ ON
290   STOP
```

No.	Explanation
•	
•	
•	
•	
•	
•	
•	
•	
90	Defines the unit address of 11.
•	
110	Clears the interface.
120	Enables remote control.
•	
140	Specifies the SRQ subroutine.
150	Enables an SRQ reception.
•	
170	Selects the SRQ send mode.
180	Masks a cause except the end of averaging.
190	Sets the function to the average level.
200	*LOOP
210	Permanent loop
•	
•	
•	
250	*SRQFUN
260	Performs serial polling and assigns the status to the variable.
270	Print characters.
280	Stops the program.

6. SPECIFICATIONS

(1) Q8460 specifications

Range of distance : 1, 2, 5, 15, 50, or 100km
Maximum resolution : 5 cm

Horizontal axis
Span : 10, 20, 50, 100, 200 and 500m, 1km in the 1km range
: 10, 20, 50, 100, 200 and 500m, 1 and 2km in the 2km range
: 10, 20, 50, 100, 200 and 500m, 1, 2 and 5km in the 5km range
: 10, 20, 50, 100, 200 and 500m, 1, 2, 5 and 10km in the 15km range
: 10, 20, 50, 100, 200 and 500m, 1, 2, 5, 10, 20 and 50km in the 50km range
: 50, 100, 200 and 500m, 1, 2, 5, 10, 20, 50 and 100km in the 100km range

Accuracy : ±0.5 m ±5 x 10^{-5} x (Measuring distance in m)
Except for the setup error of refractive index

Vertical axis
Scale : 0.2 dB/div, 0.5 dB/div, 1 dB/div, 2 dB/div and 4 dB/div (8 scales)
Resolution : 0.01 dB
Measuring modes : Backscatter mode
Reflection mode

Averaging
Monitor mode : 2^8 times
Average mode : Up to 2^{24} times

Refractive index setup
: Within the range of 1.4000 to 1.6000 at each 0.0001 step

Memory function : Up to 32 on-screen waveforms can be stored in memory.

CRT : 5.5" diagonal
GPIB : The remote control and data output can be made via the standard GPIB port.
Printer : The on-screen images can be copied by the built-in thermal printer.
Video Output : 75 ohms, BNC, composite signals

(2) Q84601 specifications

Model			Q84601			
Applicable fiber type			10/125μm Single Mode Fiber			
Output pulse	Wavelength		1.31±0.02μm			
	Pulse width		3ns	20ns	100ns	1μs
Dynamic range (One-way back-scattered light)			4dB	7dB	11dB	16dB
Near-end dead zone	Back-scatter mode		≦25m	≦25m	≦40m	≦130m
	Reflection mode		≦5m	≦15m	≦30m	≦150m
Spatial resolution	Non-reflective	Back-scatter mode	—	≦5m	≦15m	≦85m
	reflective		≦5m	≦10m	≦20m	≦120m
		Reflection mode	≦3m	≦5m	≦15m	≦110m
Optical mask function			Yes			
Optical connector			FC type*			
Laser class			21CFR Class 1			

* : Consult us for connectors other than FC type.

(3) Q84606 specifications

Model			Q84606			
Applicable fiber type			50/125µm Multi Mode Fiber			
Output pulse	Wavelength		1.30±0.02µm			
	Pulse width		3ns	20ns	100ns	1µs
Dynamic range (One-way back-scattered light)			6dB	9dB	13dB	18dB
Near-end dead zone		Back-scatter mode	≦10m	≦15m	≦20m	≦120m
		Reflection mode	≦1m	≦1m	≦1m	≦1m
Spatial resolution	Non-reflective	Back-scatter mode	≦3m	≦5m	≦15m	≦85m
	reflective		≦4m	≦10m	≦20m	≦120m
		Reflection mode	≦3m	≦5m	≦15m	≦110m
Optical mask function			No			
Optical connector			FC type*			
Laser class			21CFR Class 1			

* : Consult us for connectors other than FC type.

(4) Q84605 specifications

Model			Q84605			
Applicable fiber type			50/125μm Multi Mode Fiber			
Output pulse	Wavelength		0.85±0.02μm			
	Pulse width		3ns	20ns	100ns	1μs
Dynamic range (One-way back-scattered light)			9dB	13dB	17dB	22dB
Near-end dead zone		Back-scatter mode	≦10m	≦15m	≦20m	≦120m
		Reflection mode	≦1m	≦1m	≦1m	≦1m
Spatial resolution	Non-reflective	Back-scatter mode	—	≦5m	≦15m	≦85m
	reflective		≦5m	≦10m	≦20m	≦120m
		Reflection mode	≦3m	≦5m	≦15m	≦110m
Optical mask function			No			
Optical connector			FC type*			
Laser class			21CFR Class 1			

* : Consult us for connectors other than FC type.

(5) Q84605P specifications

Model			Q84605P			
Applicable fiber type			200/230μm Plastic Clad Fiber			
Output pulse	Wavelength		0.85±0.02μm			
	Pulse width		3ns	20ns	100ns	1μs
Dynamic range (One-way back-scattered light)			9dB	13dB	17dB	22dB
Near-end dead zone		Back-scatter mode	≦10m	≦15m	≦20m	≦120m
		Reflection mode	≦1m	≦1m	≦1m	≦1m
Spatial resolution	Non-reflective	Back-scatter mode	—	≦5m	≦15m	≦85m
	reflective		≦5m	≦10m	≦20m	≦120m
		Reflection mode	≦3m	≦5m	≦15m	≦110m
Optical mask function			No			
Optical connector			FC type*			
Laser class			21CFR Class 1			

* : Consult us for connectors other than FC type.

(6) Q84621 specifications

Model			Q84621			
Applicable fiber type			10/125µm Single Mode Fiber			
Output pulse	Wavelength		1.31±0.02µm/1.55±0.03µm			
	Pulse width		3ns	20ns	100ns	1µs
Dynamic range (One-way back-scattered light)[*1]			4dB(1.31µm) —	7dB(1.31µm) 4dB(1.55µm)	11dB(1.31µm) 8dB(1.55µm)	16dB(1.31µm) 13dB(1.55µm)
Near-end dead zone		Back-scatter mode	≦25m	≦25m	≦40m	≦130m
		Reflection mode	≦5m	≦15m	≦30m	≦150m
Spatial resolution	Non-reflective	Back-scatter mode	—	≦5m	≦15m	≦85m
	reflective		≦5m	≦10m	≦20m	≦120m
		Reflection mode	≦3m	≦5m	≦15m	≦110m
Optical mask function			Yes			
Optical connector			FC type[*2]			
Laser class			21CFR Class 1			

[*1]: Sampling times;2^{18}, Span;20km
[*2]: Consult us for connectors other than FC type.

(7) General

Ambient conditions	:	Temperature of 0°C to +40°C, relative humidity of 85% or less
Storage temperature	:	Temperature range of -20°C to +60°C
Power supply	:	90 to 250 VAC, 47 to 440 Hz
Power consumption	:	170 VA or less (including plug-in unit)
Dimensions	:	177mm(H) x 330mm(W) x 450mm(D)
Weight	:	15 kg or less (including plug-in unit)

A.1 Optical Terms

Automatic Power-Control (APC)

Application of electric power so as to make light output constant. When a laser diode is driven by a constant-current source, its light output decreases or its oscillation stops with increase in temperature, and its light output increases with decrease in temperature. When the temperature decreases, the light output may exceed the maximum rating. An APC circuit is designed to receive the monitor light of the laser diode at a photo diode and to feed it back to the driving circuit in order to protect the laser diode and to obtain a stable light output at the same time.

Avalanche Photodiode

A light-sensitive element which is often used in optical-fiber cable communications. When a high reverse bias voltage (100 to 200 V) is applied to the pn junction of semiconductors, carriers are generated one after another as they move slightly, and the current increasingly accelerates by the avalanche effect. This diode uses this avalanche effect.

Back-Scattered Light

When light travels through an optical fiber, Rayleigh scattering occurs at all points along the fiber. This scattering occurs both in the forward and backward directions. However, Backward-scattered light refers to low-intensity part of Rayleigh-scattered light that has been scattered backward first and then returns to the end of incidence as the waveguide mode of optical fiber.

Baseband Transmission Characteristics

When pulse light is incident onto one end of an optical fiber, the width of the output pulse at the other end is greater than that of the incident pulse. This phenomenon is called dispersion. It illustrates the increase of transmission loss in time domain. When converting this dispersion phenomenon into that in the frequency domain, it is determined that the transmission loss in the high-frequency range increases. These transmission characteristics in the frequency domain are called the baseband transmission characteristics. It is an important optical fiber performance factor.

Beam Divergence Angle

An angle at which radiation intensity becomes one half of that of the optical axis (where the radiation intensity is maximum). In the case of a laser diode, an angle between a junction and a horizontal direction is $\theta \parallel$, and an angle between a junction and a vertical direction is $\theta \perp$. ($\theta \perp > \theta \parallel$)

Breakpoint Detection

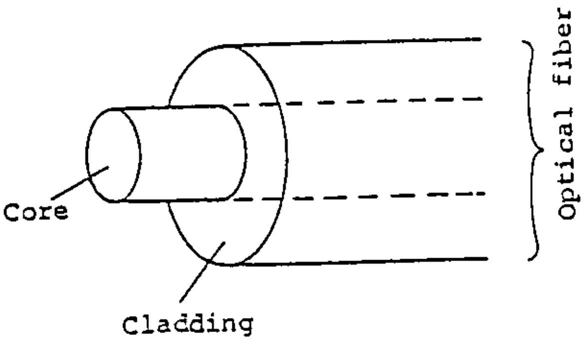
Detection of the part of the core of an optical fiber at which a break occurred. When light is directed into a broken optical fiber, it is scattered at the breakpoint and leaks to the outside of the core. The breakpoint in an optical fiber can be found by detecting such leaked light.

Chopped Light

The intensity of the light modulated by a rectangular wave. That is, the light is intermittently output at certain repetitive periods.

Clad

A part of the structure of an optical fiber. An optical fiber consists of a core at the center and clad surrounding the core. It is generally made of quartz glass or plastic. The clad has a refractive indix which is about 1% lower than that of the core so as to confine the light in the core with stability.



Coated Fiber

A core and a cladding of an optical fiber covered with a primary coating (of silicone resin) and a secondary coating (of a nylon protective layer).

Coherence

1. The relationship with respect to time between two or more waves.

2. When the wavelength, phase, and wave front of light coincide completely, such light is said to have coherence. There are two kinds of coherence; temporal coherence and spatial coherence. Temporal coherence is the uniformity of wavelength and the continuity of phase. Spatial coherence means the ability to focus the light to a point by the use of a lens. As typically expressed by laser light, light having coherence and a specific phase relationship with the same wavelength is called the coherent light.

Coherent

Light is an electromagnetic wave having a very short wavelength. Visible light, however, is greatly different from the electromagnetic waves used in radio and TV broadcasting. That is, the electromagnetic waves for radio and TV broadcasting are waves having completely coinciding in frequency, phase, and wave front, while, light from an electric lamp, for example, has no such completely coinciding frequency, phase, and wave front. Therefore, it can be regarded as a kind of noise. Light having completely coinciding frequency, phase, and wave front is called coherent light. The light from a laser diode used in optical communication is not completely coherent but highly coherent light. [OPE]

Core

The central part of an optical fiber, which is surrounded by cladding. The light travels through the core. It is made of quartz and its refractive indix is greater than that of the cladding by about 1%. There are two kinds of optical fibers, distinguished according to the thickness of the core; multi-mode fiber of about 50 to 100 m in diameter and single-mode fiber of about 10 m in diameter. In addition, optical fiber is classified into a GI type and an SI type according to the difference in the distribution of the refractive index of the core.

Core and Clad

The center and the surrounding part of an optical fiber are called a core and clad respectively. Since the refractive index of the clad is lower than that of the core, light directed into the core travels through the core in a confined state by repeating the total reflection at the boundary surface between the core and the clad. Generally, the diameters of the core and the clad are expressed by the form of 50/125 µm.

This expression means that the core diameter is 50 µm and the clad diameter is 125 µm.

CW Light

Light with constant intensity and without modulation. It is also called DC light.

Dark Current

The output current of a light-sensitive element without incident light.

Direct Modulation

The use of a modulated signal as a driving current to turn on a light source. When a photo modulator is used for this purpose, such a method is called external modulation. [OPE]

Directivity

Cases when the light output or the light receiving sensitivity is greater in the specific direction.

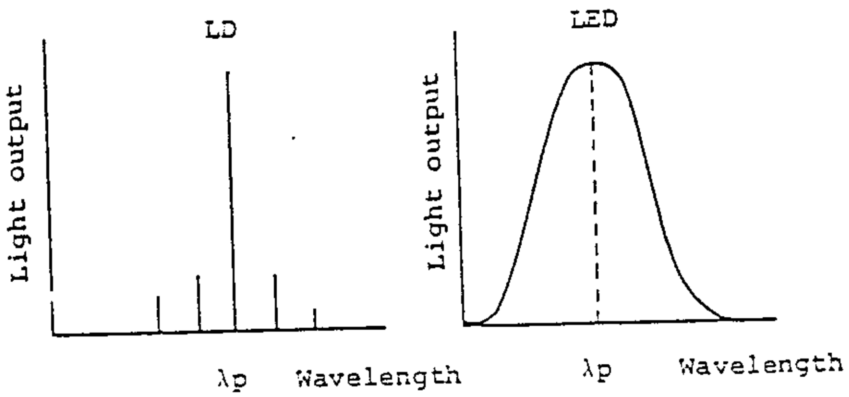
Double Heterojunction

A heterojunction means a junction between crystals having a different atomic composition. In the case of double heterojunction used in a laser diode, cladding layers having wide energy gaps are placed on both sides of an activated layer to confine the carrier in order to increase the density of the minority carrier. It is used to form an optical waveguiding path.

Emission Peak Wavelength

A wavelength at which the energy density of a luminescent spectrum of light emitting elements becomes maximum.

Symbol: λp



Excess Noise Factor

The coefficient of the shot noise multipled in an avalanche photodiode. It is defined as $F = M^x$.

The shot noise current iN increases with fluctuations in the multiplication process, according to the following equation:

$$\langle iN^2 \rangle = 2qIM^{2+x}B$$

M: multiplication factor
B: signal bandwidth
x: excess noise index
q: charge of electron
I: Average current flowing through the avalanche region

Exciter

A device to excite an optical fiber to be tested, in the stationary mode, in light loss measurement or transmission characteristics measurement, etc. For this purpose, the following methods are used:

Using a dummy optical fiber of several hundred meters in length; controlling the incident mode power distribution by using microbending of an optical fiber, controlling the mode distribution by sequentially connecting graded type optical fiber, step type optical fiber, and so on. (GSG type or SGS type exciting optical fiber cord, and so on are available.)

Fiber Identification

Individual distinction of the many fibers in an optical fiber cable. Particularly, light is directed at one end of an optical fiber and the transmitted light is detected at the other end.

Fresnel Reflections

The reflection when light passes through a boundary face between materials of different light refractive indexes. When a light pulse is directed into an optical fiber, a portion of the pulse is reflected from the media boundary face such as that of optical fiber and air, for example, at the end of the optical fiber or at a breakpoint in the optical fiber. Such reflection is called Fresnel reflection. In the case of an ideal break face (a mirror-like break at right angles to the axis of an optical fiber), about 4% reflection (-14 dB) occurs.

Fundamental Mode

An electromagnetic distribution of the 0th order. It is also called a single transverse mode.

Graded Index Fiber

A kind of a multi-mode fiber having a core with a refractive index distribution in radial form. Therefore, the light through the center of the core travels slower and light through the peripheral part travels faster, so that the light propagation time becomes constant regardless of the path of the light. As a result, it is possible to decrease the spreading of the emitted pulse with time. (In other words, the mode dispersion is less.) Therefore this fiber has a much wider transmission bandwidth compared with that of a step-index fiber (several hundreds MHz-km).

Infrared Rays

Light having a wavelength which is longer than that of visible light.

Near infrared rays : 0.78 to 3 µm in wavelength
Middle infrared rays: 3 to 30 µm in wavelength
Far infrared rays : 30 µm to 1 mm in wavelength
Microwave : Over 1 mm in wavelength

Laser

Solid lasers, gas lasers, liquid lasers, and so on are available. A semiconductor laser is used as the light source used in optical fiber communication because of its compactness and the capability of direct modulation, compared with other lasers. The laser has excellent coherence, and has high speed response, compared with LEDs, which means that laser is an important light source. The abbreviation for semiconductor laser is LD.

Laser Diode

One of the semiconductor light emitting elements. Laser is the abbreviation of light amplification by stimulated emission of radiation. That is, the laser diode is an oscillator which emits light according to this principle. The laser diode has various merits such as a high light output, capability of high speed direct modulation, high connection efficiency to optical fibers, and so on. In the past, however, the LED had been principally used because of its light emission stability. Recently, the problem of laser emission stability has been solved. Therefore, the laser diode is now used as the light emission source for high speed, long distance communications.

Leak Light

When an optical fiber is bent or when pressure is applied to an optical fiber, the path of the light propagating through a core is bent and can be seen externally. This light is called leak light.

Light Sensor

In optical fiber communication, a photo diode (PD) utilizing the photovoltaic effect or the photoconductive effect is used. There are two kinds of PDs; pn junction type and a pin type. A PD which uses the avalanche effect by applying a reverse bias voltage to the pn junction is called an avalanche photodiode (APD). Measuring instruments principally use these light sensors. A thermopile, utilizing the thermosensitive effect, is used as the detector in a standard power meter, because its sensitivity is constant regardless of the wavelength.

Light-Emitting Diode

One type of semiconductor light-emitting element. It uses light which is emitted by re-combination of the carrier injected at the pn junction of semiconductors, similar to a laser diode. The LED differs from a laser diode in that its light is emitted naturally. (In the case of the laser diode, the light is emitted by induction.) The features of the LED include long life and stability, moderated price, and excellent linearity. However, the LED has such disadvantages as low incident power for optical fiber and the impossibility of high-speed modulation. Therefore, the LED is a suitable light emitting element for a system handling small capacities for over relatively short distances, analog systems, and so on.

Long Wavelength Region

Of the wavelength of light used in optical fiber communications, in this region the wavelength is in the range 1.0μ to 1.5 μm. This long wavelength region is used for long-distance communications because of its low transmission loss.

Longitudinal Mode

A status in which emission spectrum having very small half value widths are not continuously present, or else individual luminescent spectra. The difference in wavelength from the adjacent mode is called a longitudinal mode interval. When the number of modes is one, it is called a single longitudinal mode.

Luminous Flux

Luminous flux is expressed in units of lm (lumen) by the equation given below.

$$F = Km \int_{380}^{780} V(\lambda) d$$

Km : Maximum luminous efficacy, 680lm/W
$V(\lambda)$: Relative spectral luminous efficacy (the value which is determined by the International Commission on Illumination (CIE))

1.00004 for the yellow-green spectrum (λ = 555 nm)

Luminous Intensity

Luminous intensity is expressed in (Cd) candella by the equation given below.

$$i = \frac{dF}{d\omega}$$

F: Luminous flux
ω: Solid angle

The radiant intensity is the luminous intensity in the energy unit.

Monitor Current

The output of a monitor diode, when the light emitted from the chip back of a laser diode is received by a monitor diode.

Monitor Output

The light which is emitted toward the chip back of a laser diode.

Multi-Mode Fiber

For an optical fiber in which multiple light guiding modes exist, many modes (each mode having a different light propagation angle to the central axis of an optical fiber) are transmitted through a core at the same time. There are various kinds of multi-mode fibers according to the difference in the refractive index distribution. These include a step type optical fiber and graded type optical fiber. These optical fibers have a core of relatively large size (50 to 100 m). They also allow easy connection compared with single mode fiber. However, because many modes propagate through the multi-mode fiber, the transmission rate differs according to the mode and so the transmission bandwidth becomes somewhat narrower. (Mode dispersion)

Numerical Aperture

The degree of extension of light at the end of an optical fiber, which has a cylindrical core having a refractive index of n_1 and which is surrounded by clad having a refractive index of n_2 ($n_1 > n_2$), due to a similarity in the lens system. Of the light falling on a plane, which includes the axis of the core of the optical fiber and which crosses the axis (the meridian light), if some light, which attains critical angle with respect to the axis, crosses the axis of the core outside the optical fiber at angle θ, the NA of the optical fiber can be expressed by the equation given below.

$$\text{NA} = n\sin\theta = \sqrt{n_1{}^2 \; - n_2{}^2}$$

n: Refractive index of the media in which the optical fiber is placed

Optical Fiber

A light guiding path through which light can travel, in spite of bends in the path, by setting the refractive index of the outside to a lower level in comparison with that of the inside. It consists of two kinds of quartz glass (a core and a cladding) having different refractive indexes arranged in the radial direction in the form of a glass fiber of about 0.12 mm in diameter. It has such excellent characteristics as wide bandwidth, low loss, and non-induction.

Optical Fiber Connector

A detachable connector to connect optical fibers to each other or to connect an optical fiber with a device. Generally, two optical fibers are simply abutted against each other. That is, the end of one optical fiber is directly abutted against that of the other one by means of a connector the center of which is sufficiently aligned with those of the optical fibers. The optical fiber connector is different from an electrical connector in mechanical accuracy and connection loss. That is, the former has a higher mechanical accuracy and a connection loss of about 0.5 to 1 dB. Special care should be taken when handling this connector to protect it from dust.

Optical Rotary Power

A phenomenon of the rotation of a plane of polarization when linearly polarized light passes through material.

OTDR Method

An abbreviation of optical time domain reflectometer method. A system to detect a defective point or a loss characteristic of optical cable by using a light pulse as a signal, transmitted through the optical cable to be tested, and detecting the Fresnel reflection at a breakpoint or the Rayleigh scattered light of the optical fiber circle. Fiber optic time domain reflectometer (FOTDR).

Pigtail Fiber

An optical fiber with one or both ends open.

Polarizer

An element to convert natural light into linearly polarized light.

Quantum Efficiency

- Light-emitting element (light emitting diode and laser diode)

The ratio of the number of carriers caused by current application to the number of photons generated (internal quantum effect) or the number of photons emitted (external quantum effect). The quantum efficiency is expressed by the equation given below.

$$\eta = \frac{q\lambda}{hc} \cdot \frac{P}{I} = \frac{\lambda}{1.24} \cdot \frac{P}{I}$$

h: Planck's constant
c: Velocity of light in a vacuum
q: Charge of electron
λ: Wavelength (μm)
P: Light output
I: Current

In the case of a laser diode, the term differential quantum efficiency is also used.

- Light receiving element (pin photodiode, APD)

The ratio of the number of carriers generated to the number of incident photons. The quantum efficiency (η') is expressed by the equation given below. This equation is opposite to that for a light emitting element.

$$\eta' = \frac{hc}{q\lambda} \cdot \frac{I}{P} = \frac{1.24}{\lambda} \cdot \frac{I}{P}$$

The quantum efficiency of an avalanche photodiode is expressed on the assumption that the multiplication factor is 1.

Radiant Flux

The amount of light energy which is emitted or propagated per unit time.

Rayleigh Scattering

Light scattering by a slight fluctuation of the refractive index of material when the light propagates through such material. The light scattering which is generated by the fluctuation of a refractive index which is shorter than the wavelength in an optical fiber.

Responsivity

A current output when a unit radiant flux is directed into a light-sensitive element. It is expressed by the equation given below.

$$R = \frac{I}{P} = 0.806 \times \eta \times \lambda \times M \text{ (A/W)}$$

R: Responsivity
η: Quantum efficiency
λ: Wavelength
M: Multiplication constant

Short Wavelength Region

The wavelength used in optical fiber communications is about 0.8 to 1.5 μm, namely, in the so-called near-infrared domain. In this wavelength region, light having a wavelength of about 0.8 μm is called the short wavelength region. It has been used in optical fiber communications since early times, and the actual results of the development of practical systems have been most remarkable. Recently, the long wavelength region, the region of light having a wavelength longer than 1 μm, has been developed. [OPE]

Short-Term Stability

The stability of an optical output over a short time, when the ambient temperature is constant.

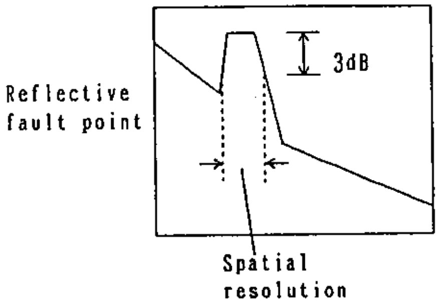
Single-Mode Fiber

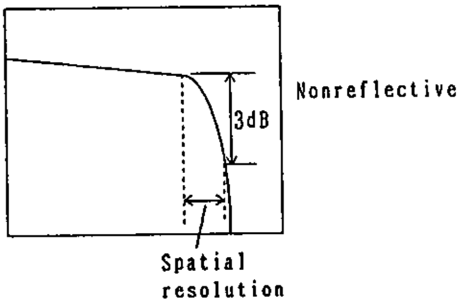
When the diameter of a core is decreased to about 10 m, and optical fiber having only one propagating mode is obtained. This optical fiber is called a single-mode fiber. One feature of this fiber is its very wide bandwidth (several GHz), because it is free from the mode dispersion of a multi mode fiber.

Spatial Resolution

This shows a performance to discriminate the interval between two adjoining fault points by OTDR.

In our company, the reflective fault point is identified by the full width half maximum value FWHM (Full Width at Half Maximum) of the reflected pulse, and the nonreflective fault point is identified by the length where the intensity drops by 3dB.





Specific Rotatory Power

A quantity to indicate the intensity of optical activity power of optically active substances.

Speckle Effect

The noise produced by the interference of coherent light scattered in an optical fiber in an irregular phase relationship.

Spectral Width/ Full Width at Half Maximum/ $\Delta\lambda$

The distance between two wavelengths where the energy density of the light emitting spectrum becomes 1/2 of the maximum value of a light emitting element.

Spectrum

Normal light is made up of synthesized sine waves. A spectrum is the arrangement of each component on a wavelength axis. A white light source has a flat spectrum with the LD concentrated in a narrow range.

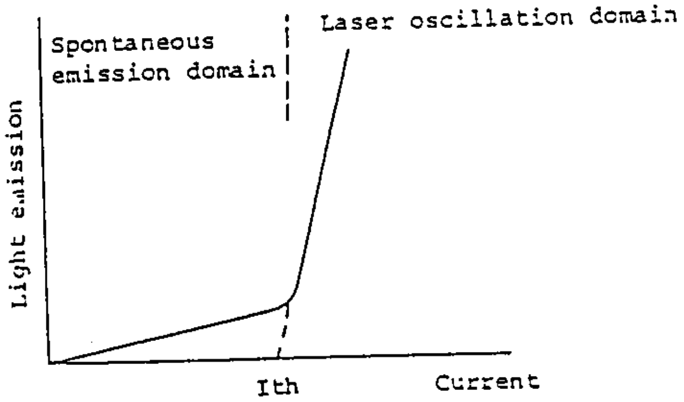
Splicing

A permanent connection between one optical fiber and another required in the installation of an optical fiber cable. Various splicing methods are now available. Generally, a fusing connection method is used in which one optical fiber is fused with another by the arc discharge method. This method is predominant because of its minimum connection loss and high stability.

Threshold Current

The minimum current which can start laser oscillation. Since the domain where spontaneous emission changes to a laser oscillation is not strictly defined in most cases, the intersection between the extended line of the current-light output characteristics in the laser oscillation and the zero value line of the light output is specified as the threshold current.

Symbol: Ith



Ultraviolet rays

Light having a wavelength shorter than that of visible light in the wavelength range of 300 to 380 nm.

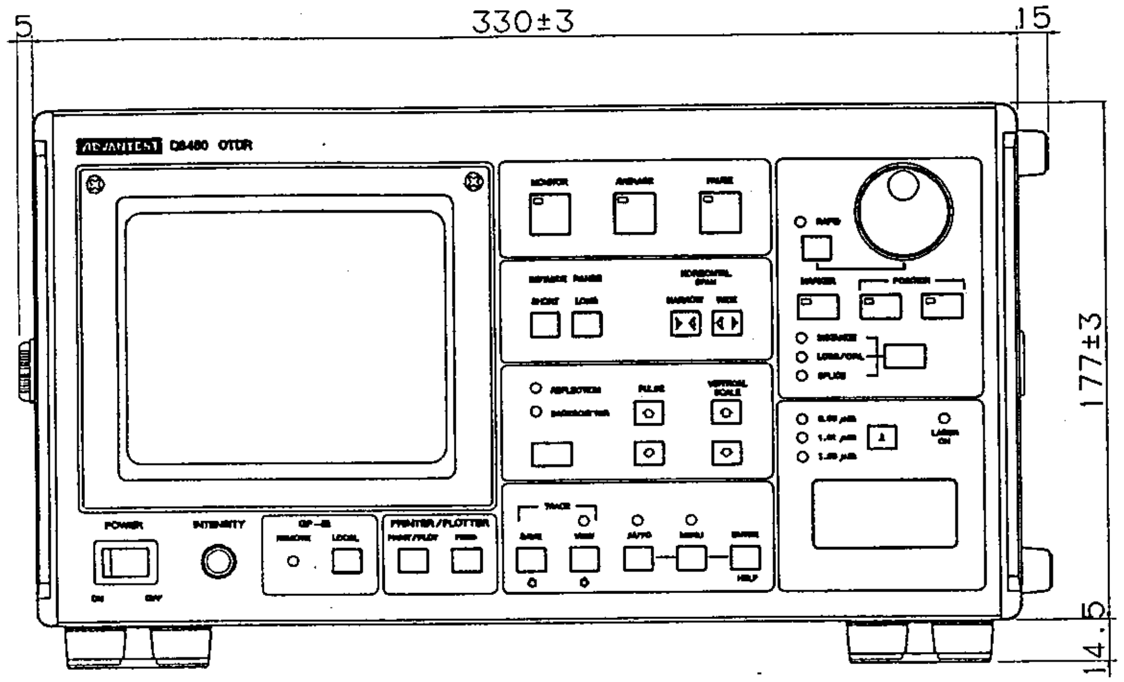
Visible Light

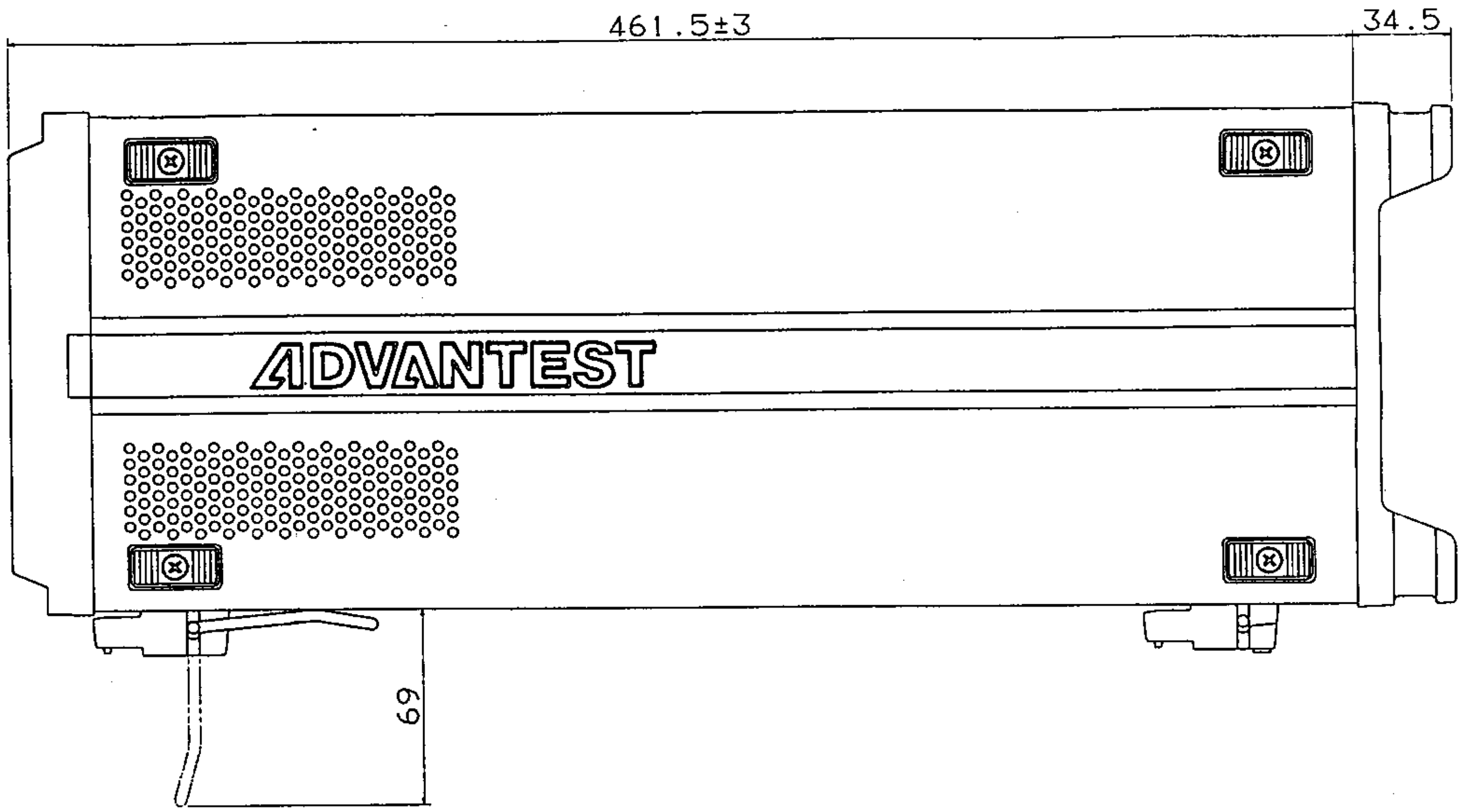
Light which can be seen by the human eye in the wavelength range of 380 to 780 nm.

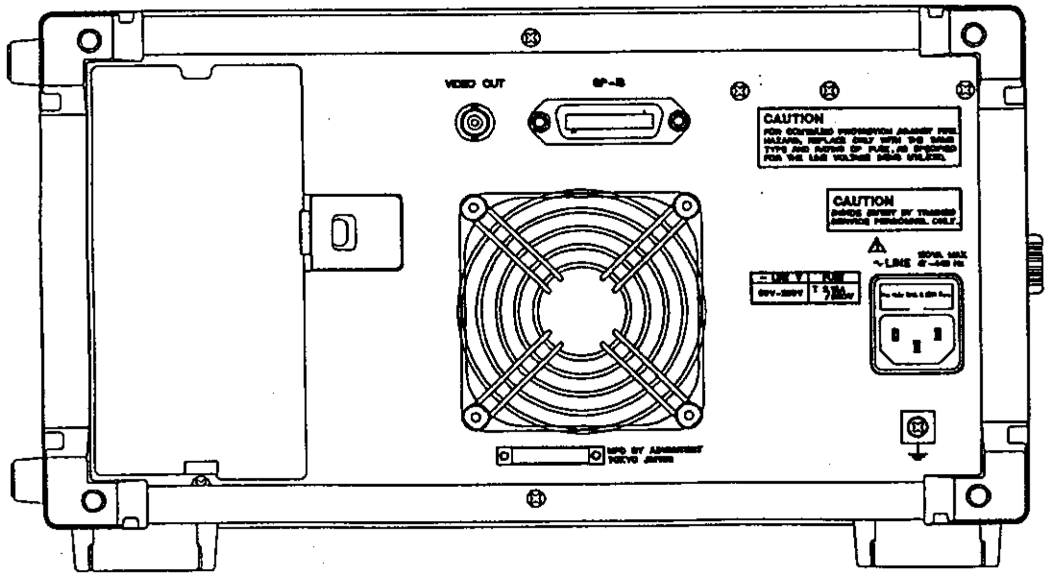
Wavelength Division Multiplexing

A communication system to transmit two or more kinds of signals through the one optical fiber at the same time. In this case, as a transmitter, light emitting diodes with various wavelengths and laser diodes are used. Both unidirectional systems and bidirectional systems are available.

ALPHABETICAL INDEX







Unit: mm

Q8460

EXTERNAL VIEW

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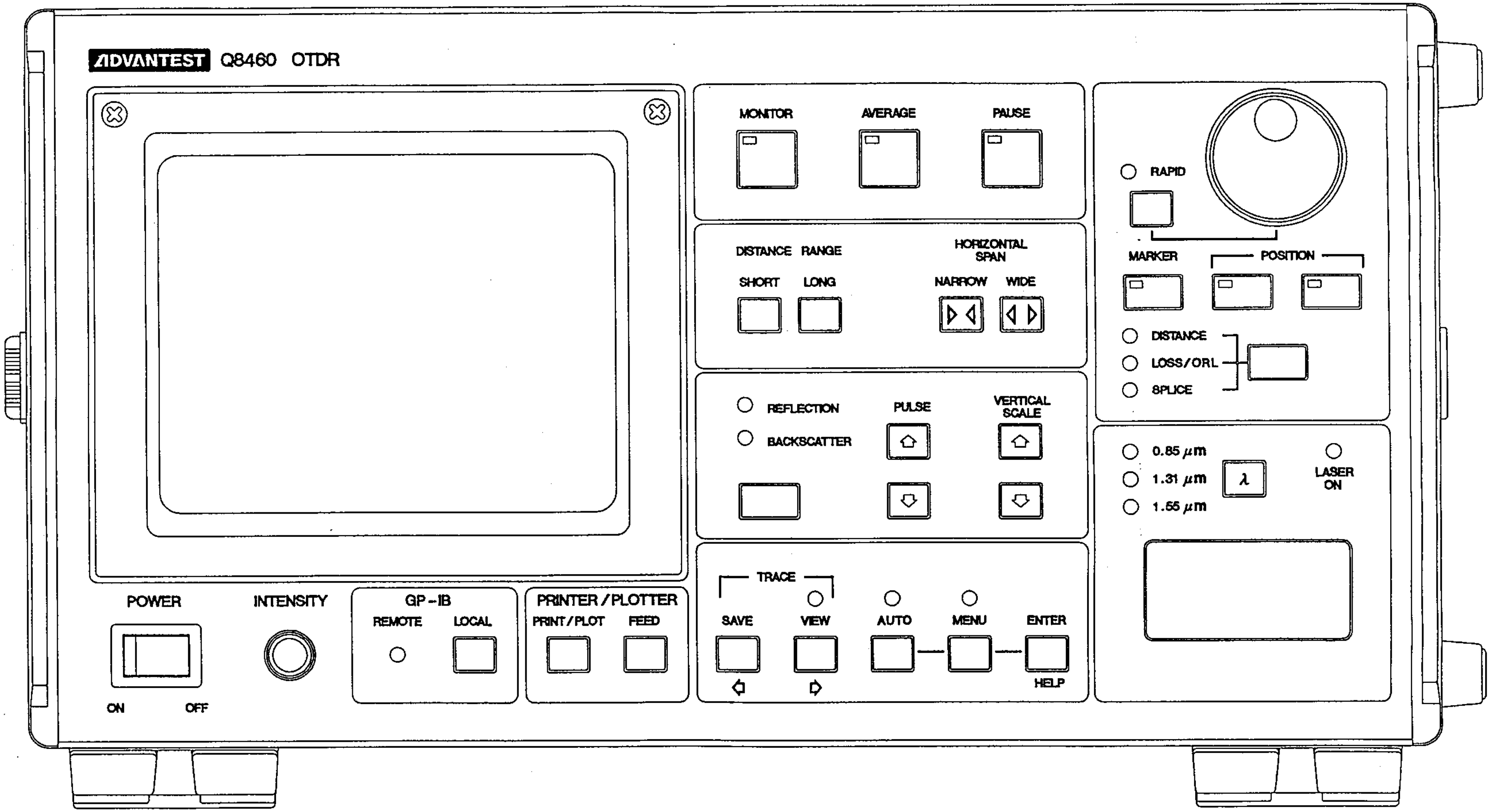
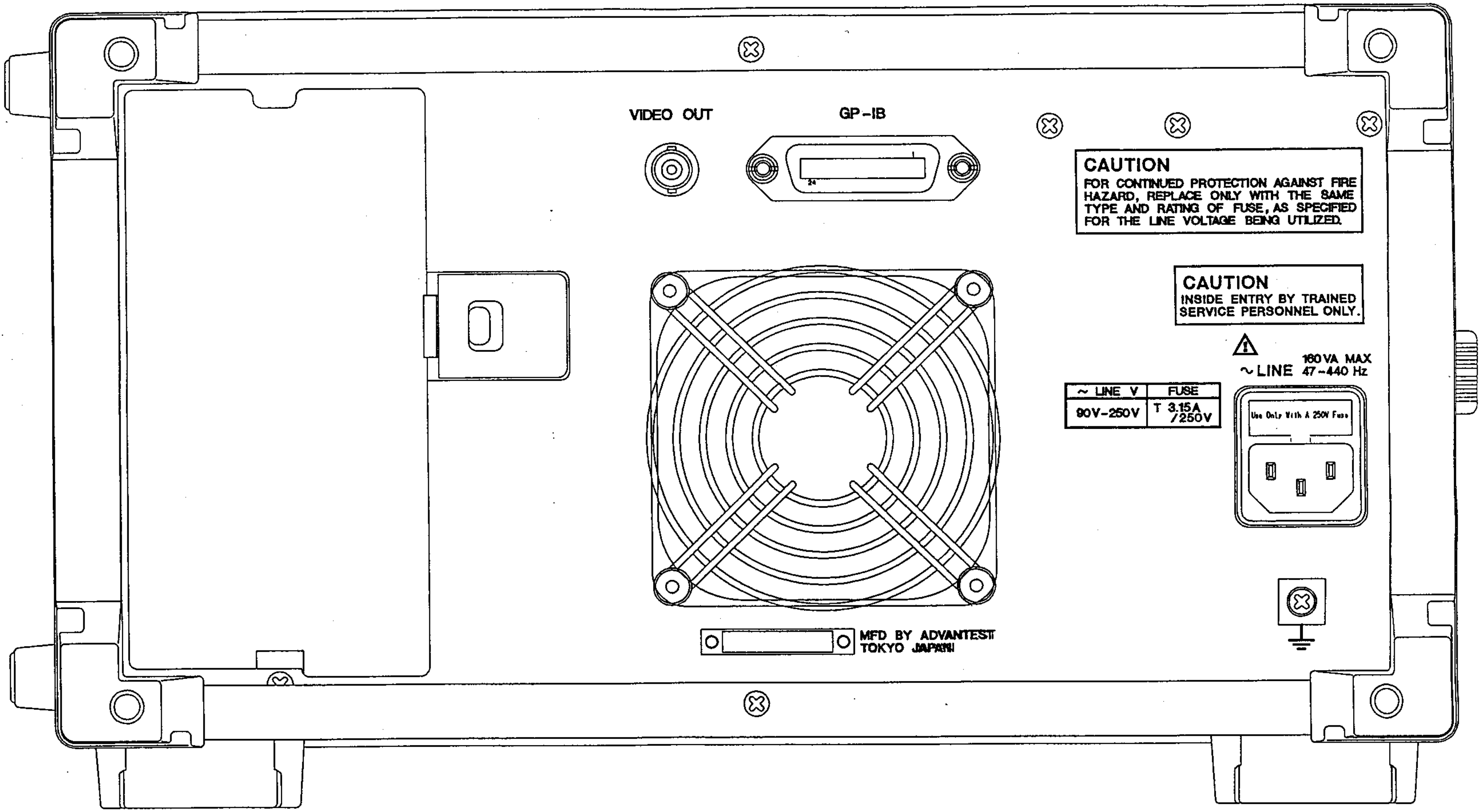


Q8460
FRONT VIEW



Q8460EXT3-9008-C

Q8460

REAR VIEW

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(3) You may not reverse engineer, de-compile, or disassemble, all or any part of, the SOFTWARE.

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LIMITED WARRANTY

1. Unless otherwise specifically agreed by Seller and Purchaser in writing, Advantest will warrant to the Purchaser that during the Warranty Period this Product (other than consumables included in the Product) will be free from defects in material and workmanship and shall conform to the specifications set forth in this Operation Manual.

2. The warranty period for the Product (the "Warranty Period") will be a period of one year commencing on the delivery date of the Product.

3. If the Product is found to be defective during the Warranty Period, Advantest will, at its option and in its sole and absolute discretion, either (a) repair the defective Product or part or component thereof or (b) replace the defective Product or part or component thereof, in either case at Advantest's sole cost and expense.

4. This limited warranty will not apply to defects or damage to the Product or any part or component thereof resulting from any of the following:

   (a) any modifications, maintenance or repairs other than modifications, maintenance or repairs (i) performed by Advantest or (ii) specifically recommended or authorized by Advantest and performed in accordance with Advantest 's instructions;

   (b) any improper or inadequate handling, carriage or storage of the Product by the Purchaser or any third party (other than Advantest or its agents);

   (c) use of the Product under operating conditions or environments different than those specified in the Operation Manual or recommended by Advantest, including, without limitation, (i) instances where the Product has been subjected to physical stress or electrical voltage exceeding the permissible range and (ii) instances where the corrosion of electrical circuits or other deterioration was accelerated by exposure to corrosive gases or dusty environments;

   (d) use of the Product in connection with software, interfaces, products or parts other than software, interfaces, products or parts supplied or recommended by Advantest;

   (e) incorporation in the Product of any parts or components (i) provided by Purchaser or (ii) provided by a third party at the request or direction of Purchaser or due to specifications or designs supplied by Purchaser (including, without limitation, any degradation in performance of such parts or components);

   (f) Advantest's incorporation or use of any specifications or designs supplied by Purchaser;

   (g) the occurrence of an event of force majeure, including, without limitation, fire, explosion, geological change, storm, flood, earthquake, tidal wave, lightning or act of war; or

   (h) any negligent act or omission of the Purchaser or any third party other than Advantest.

5. **EXCEPT TO THE EXTENT EXPRESSLY PROVIDED HEREIN, ADVANTEST HEREBY EXPRESSLY DISCLAIMS, AND THE PURCHASER HEREBY WAIVES, ALL WARRANTIES, WHETHER EXPRESS OR IMPLIED, STATUTORY OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, (A) ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND (B) ANY WARRANTY OR REPRESENTATION AS TO THE VALIDITY, SCOPE, EFFECTIVENESS OR USEFULNESS OF ANY TECHNOLOGY OR ANY INVENTION.**

6. **THE REMEDY SET FORTH HEREIN SHALL BE THE SOLE AND EXCLUSIVE REMEDY OF THE PURCHASER FOR BREACH OF WARRANTY WITH RESPECT TO THE PRODUCT.**

7. **ADVANTEST WILL NOT HAVE ANY LIABILITY TO THE PURCHASER FOR ANY INDIRECT, INCIDENTAL, SPECIAL, CONSEQUENTIAL OR PUNITIVE DAMAGES, INCLUDING, WITHOUT LIMITATION, LOSS OF ANTICIPATED PROFITS OR REVENUES, IN ANY AND ALL CIRCUMSTANCES, EVEN IF ADVANTEST HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES AND WHETHER ARISING OUT OF BREACH OF CONTRACT, WARRANTY, TORT (INCLUDING, WITHOUT LIMITATION, NEGLIGENCE), STRICT LIABILITY, INDEMNITY, CONTRIBUTION OR OTHERWISE. TORT (INCLUDING, WITHOUT LIMITATION, NEGLIGENCE), STRICT LIABILITY, INDEMNITY, CONTRIBUTION OR OTHERWISE.**

8. **OTHER THAN THE REMEDY FOR THE BREACH OF WARRANTY SET FORTH HEREIN, ADVANTEST SHALL NOT BE LIABLE FOR, AND HEREBY DISCLAIMS TO THE FULLEST EXTENT PERMITTED BY LAW ANY LIABILITY FOR, DAMAGES FOR PRODUCT FAILURE OR DEFECT, WHETHER ARISING OUT OF BREACH OF CONTRACT, TORT (INCLUDING, WITHOUT LIMITATION, NEGLEGENCE), STRICT LIABILITY, INDEMNITY, CONTRIBUTION OR OTHERWISE.**

CUSTOMER SERVICE DESCRIPTION

In order to maintain safe and trouble-free operation of the Product and to prevent the incurrence of unnecessary costs and expenses, Advantest recommends a regular preventive maintenance program under its maintenance agreement.

Advantest's maintenance agreement provides the Purchaser on-site and off-site maintenance, parts, maintenance machinery, regular inspections, and telephone support and will last a maximum of ten years from the date the delivery of the Product. For specific details of the services provided under the maintenance agreement, please contact the nearest Advantest office listed at the end of this Operation Manual or Advantest 's sales representatives.

Some of the components and parts of this Product have a limited operating life (such as, electrical and mechanical parts, fan motors, unit power supply, etc.). Accordingly, these components and parts will have to be replaced on a periodic basis. If the operating life of a component or part has expired and such component or part has not been replaced, there is a possibility that the Product will not perform properly. Additionally, if the operating life of a component or part has expired and continued use of such component or part damages the Product, the Product may not be repairable. Please contact the nearest Advantest office listed at the end of this Operation Manual or Advantest's sales representatives to determine the operating life of a specific component or part, as the operating life may vary depending on various factors such as operating condition and usage environment.

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