ADVANTEST®

ADVANTEST CORPORATION

INSTRUCTION MANUAL

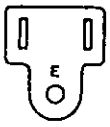
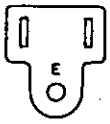
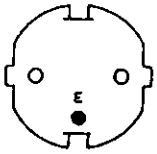
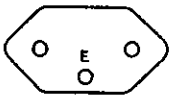
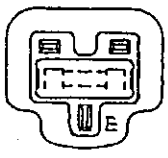
TQ8450A

OPTICAL FIBER REFLECT METER

MANUAL NUMBER 8450A OEB 811

NOTICE

ADVANTEST provides the following power cables for each country. If there was any inconvenience on your use, please contact our subsidiaries or ADVANTEST representatives.

	Plugs	Standards/Countries	Ratings/Color/ Length	Accessory Codes
1		JIS : JAPAN	Rating :125V 7A Color :Black Length :2m	A01402 A01412
2		UL : USA CSA : CANADA	Rating :125V 7A Color :Black Length :2m	A01403 (Opt.95) A01413
3		CEE : EUROPE VDE : FRG OVE : AUSTRIA SEMKO : SWEDEN DEMKO : DENMARK KEMA : NETHERLANDS FIMKO : FINLAND NEMKO : NORWAY CEBEC : BELGIUM	Rating :250V 6A Color :Gray Length :2m	A01404 (Opt.96) A01414
4		SEV : SWITZERLAND	Rating :250V 6A Color :Gray Length :2m	A01405 (Opt.97) A01415
5		SAA : AUSTRALIA NEWZELAND	Rating :250V 6A Color :Gray Length :2m	A01406 (Opt.98)
6		BS : UK	Rating :250V 6A Color :Black Length :2m	A01407 (Opt.99) A01417

Note : "E" shows earth (ground).

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1. GENERAL

This chapter describes how to use this manual, outlines the TQ8450A Optical Fiber Reflectometer, instructions for operation, and set-up for measurement. Be sure to read this chapter before attempting to operate TQ8450A.

1.1 Structure of this Manual

This manual has been set out as summarized below. The contents are aimed at users who have a certain degree of knowledge and experience of optical measuring instruments.

To enable users to understand this instrument by simply referring to the relevant chapters, each chapter contains an independent explanation.

First-time users are required to read this manual from the first chapter. For GPIB in Chapter 6, refer to the operation manual for the controller.

1. General	.....	Introduction to TQ8450A products General instructions for operation preparation for measurement
2. Description of panel parts	.....	General functions of keys Description of data on CRT display
3. Operating procedure	.....	Switching on power and initialization Setting measurement conditions from panel
4. Multiple Reflection		
5. Operating Principles		
6. GPIB	.....	Remote control by GPIB
7. Performance Specifications		

When using this instrument, the following warning must be strictly complied with.

WARNING

A light pulse is radiated from the optical output connector. Never look directly at it, even though it is not of such an intensity as to damage your eyes.

1.2 Outline of Product

The TQ8450A Optical Fiber Reflectometer is used to measure fault points (fracture points) or the loss of optical fiber or connection loss at the time of construction and maintenance of optical fiber cables.

The plug-in system meets the requirements of each wavelength. Also, the compact, lightweight construction and built-in thermal printer demonstrate superior performance in the field.

[Features]

- Wide Dynamic Range (Rearward Scattered Light)

  With the plug-in unit Q84506, high-sensitivity measurement of 24dB for pulse duration of 5μs is possible. Further, the plug-in unit Q84503 for super-long distance measurement permits measurement of 27dB, and Q84522 permits measurement of 28dB/25dB over the distance of 100km.

- Expandable Plug-in System

  The plug-in system can meet each wavelength requirement.

(1/2)

Body	TQ8450A				
Plug-in unit	Q84501	Q84502	Q84503	Q84505	Q84506
Wavelength	1.31 ±0.02μm	1.55 ±0.03μm	1.55 ±0.03μm	0.85 ±0.02μm	1.31 ±0.02μm
Object fiber	Single mode	Single mode	Single mode	Multi mode	Multi mode

(2/2)

Body	TQ8450A			
Plug-in unit	Q84521		Q84522	
Wavelength	1.31 ±0.02μm	1.55 ±0.03μm	1.31 ±0.02μm	1.55 ±0.03μm
Object fiber	Single mode		Single mode	

- High Stability

  Because the laser beam source is controlled by temperature, a highly reproducible measurement is possible with stable optical output and wavelength.

- Optical Mask Function

  Optical masks can be set at a maximum of three points on the tube surface. This function permits a giant Fresnel reflection to be masked, avoiding the saturation of the photo-detector, and leading to superior linearity.

- Read Resolution of a Minimum of 1m

- Collective Refractive Index of Optical Fiber Set in 0.0001 Steps

  The range from 1.4000 to 1.6000 can be set in steps of 0.0001, enabling high-accuracy reading of the distance measurement.

- Loss Read Resolution of 0.01dB

  A measurement with an improved S/N is possible by using the average mode.

- Built-in Thermal Printer

  The measurement conditions and results displayed on the display unit are available in hard copy without any external units.

- GPIB as Standard Equipment

  Full-remote control is possible using an external controller.

- Portable Type

  TQ8450A weighs approx. 14kg, and so is light and convenient for outdoor applications.

1.3 Before Starting Operation

1.3.1 Check of Appearance and Accessories

Upon delivery of the instrument, check for damage during transit. Then, check the quantity and standards of the standard equipment, referring to Table 1-1.

If there is any part damaged or missing, contact our CE headquarters (Yokohama CE Center) or your nearest salesman or agent.

The locations and telephone numbers of these contacts are listed at the end of this manual.

Table 1 - 1 Standard Equipment

Item	Type	Stock No.	Q'ty	Remarks
Power cable	-	DCB-DD1607X02	1	With 2-pin adapter
Power fuse	MDX-2A	DFT-AG2A-1	2	Standard (90 to 132VAC) specification
	MDL-1A	DFT-AH1A-1		Option 40 (198 to 250VAC) specification
Recording paper	A09052	-	3	
Operation manual	-	J8450A	1	Japanese language
	-	E8450A		English

Note: When ordering additional equipment, designate the type (or stock No.).

1.3.2 Power, Earth and Fuses

(1) Power Supply

The source voltage is in the range from 90 to 132VAC for the standard specification (198 to 250VAC for Option 40). The power frequency is in the range from 48Hz to 66Hz. Before confirm use, that the right standard fuse is mounted.

This instrument is designed to fully allow for line noise of the AC power supply. Nevertheless, use it in an environment as free from noise as possible. If noise is excessive, use a noise filter or the like.

CAUTION

When setting the line selector switch, never fail to turn off the power switch before removing the power cable from the AC line.

(2) Power Cable

The power cable plug is of the three-pin type. The central round pin provides the earth which is grounded when connected to a three-pole socket. If a three-pole socket is not connected, use the attached adapter A09034 (KPR-18) to make sure that eigher the grounding terminal (Figure 1-1(a)) led from the adapter or on the back of the unit is connected to an external ground.

The attached adapter is based on the Electrical Appliances Control Law. This instrument A09034 (KPR-18) has different widths A and B for the two electrods of the adapter as shown in Figure 1-1(b). Therefore, check the positions of the plug and socket without fail before inserting into the socket.

If A090034 (KPR-18) cannot be connected to the applicable socket, purchase the separately sold adapter KPR-13.

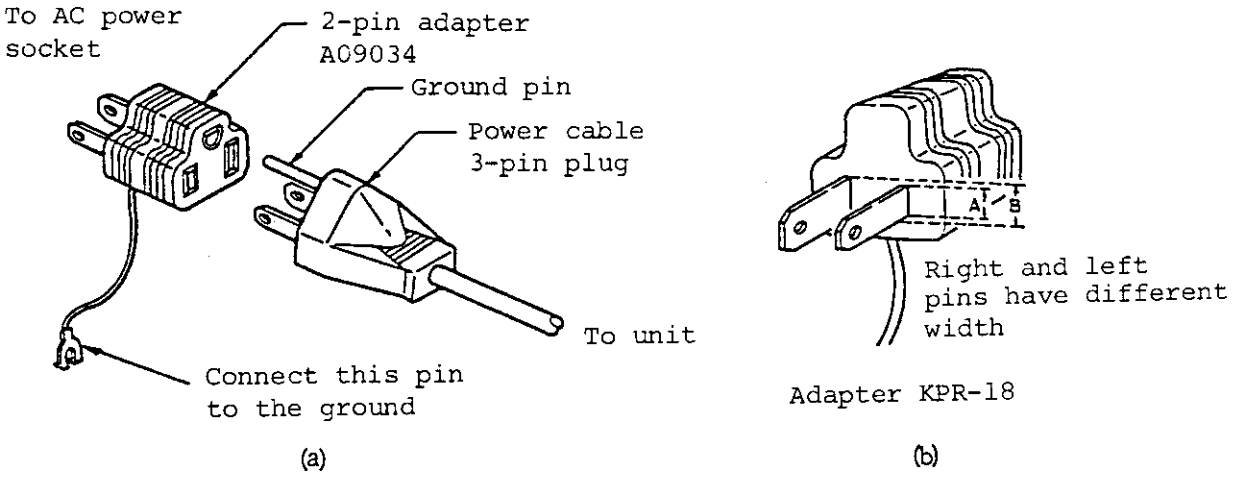
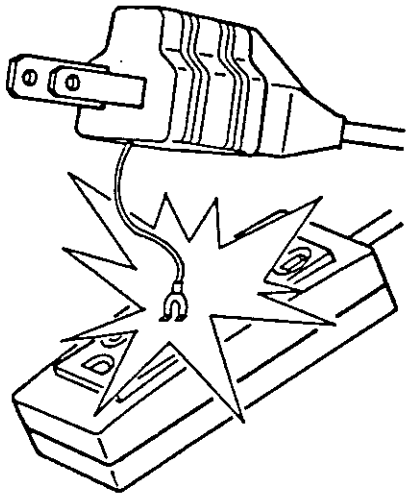


Figure 1 - 1 Plug and Adapter for Power Cable

CAUTION

When connecting the earth line from the adapter, take adequate care not to contact the hot line (AC line). If it is touched, the instrument and other units may be damaged.



(3) Grounding: Instructions on Power Line CMV Loop

When this instrument is used with peripheral equipment such as a desk-top computer, take adequate precautions against common-mode noise (CMV) due to ground wiring failure of the power supply, and avoid using a power supply that is not grounded.

If you use a power line that is not grounded, an AC voltage of about 50V (CMV) is generated by the loop shown in Figure 1-2 between terminals a_1 and a_2 and between b_1 and b_2. In the process, if terminals b_1 and b_2 are opened and the signal terminals a_1 and a_2 are connected, the input/output circuit elements of circuits 1 and 2 may be damaged. In order to prevent this, a power line with a ground connection must be used.

Also, if the power supply is turned on and off with a power plug, a similar CMV is generated instantaneously. Always be sure to turn the power on and off with a power switch.

In unavoidable cases where the power line is used without being connected to a ground, always make sure to connect the ground terminals GND1 AND GND2 and the signal cable before inserting the power plug and turning on the power siwtch.

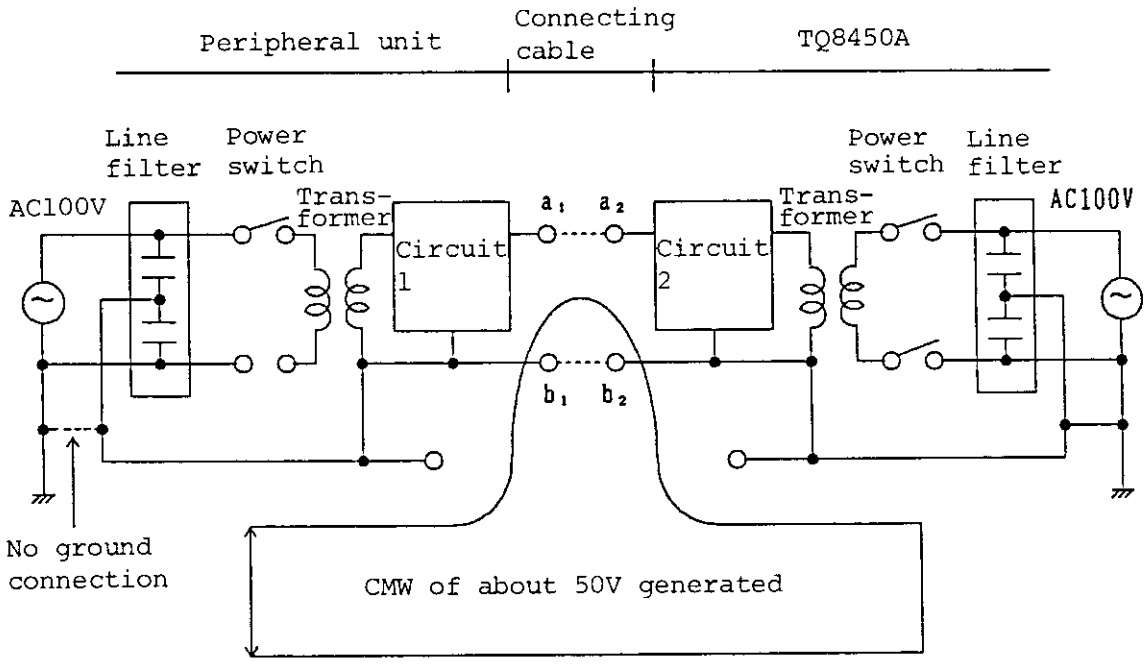


Figure 1 - 2 CMV Generation Loop of Power Line

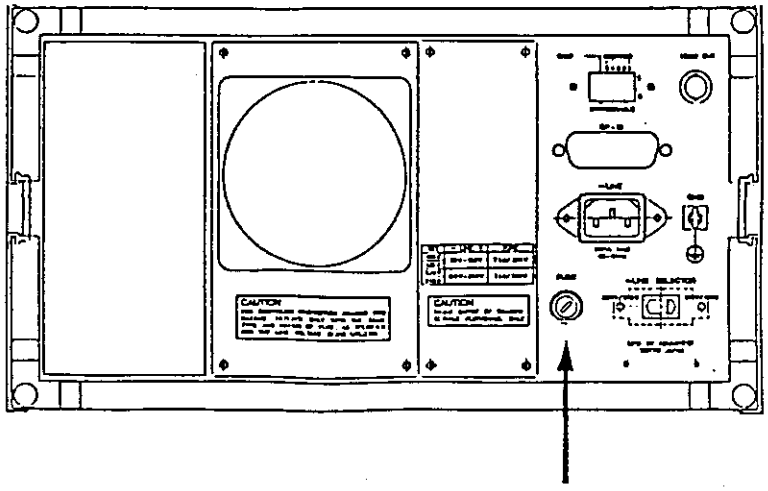
(4) Fuse

Before changing the fuse, remove the power cable from the AC line connector. The power fuse is housed in the fuse holder on the rear panel.

The fuse standard depends on the source voltage. Always be sure to check the standard beforehand.

Table 1 - 2 Fuse Standards

Operating source voltage	Standard	Part code
90 to 132VAC	MDX-2A	DFT-AG2A-1
198 to 250VAC	MDL-1A	DFT-AH1A-1



Fuse holder
(Remove by turning CCW
with a screw driver.)

Figure 1 - 3 Fuse Holder

1.3.3 Operating Environment and Instructions

(1) Ambient Temperature

Use this instrument in temperatures from 0 to +40°C and relative humidity of 85% or less, so as to guarantee operation according to the specifications.

(2) Place of Installation

Avoid installing this precision instrument in an enviornment that is dusty or exposed to frequent vibration, direct sunlight or corrosive gas, or on an unstable rest or other places where the instrument is liable to fall.

(3) Protection of the Eyes Against Laser Beam

This optical fiber reflectometer employs laser diodes as the source of light. Do not expose human eyes to direct laser beam emitted from these diodes.

After making sure that the LED of the ON key in the optical output is not lit, connect the fiber cable.

(4) High Voltage

This instrument uses high voltage for the CRT. Keep your hands away from the inner parts when the power is on.

(5) Cooling and Ventilation

This instrument includes a cooling fan to prevent the internal temperature rising. This fan is a suction type. Keep an eye on the ventilation of the surrounding parts. In particular, make sure nothing is placed up close to the back of this instrument, or never allow the instrument to be used placed on its side.

Keep the air filter from clogging, and clean it from time to time.

(6) Storage

The storage temperature range of this unit is from -20°C to +60°C. If the instrument is left out of use for a long time, it should be kept under a PVC cover in a corrugated cardboard box, and placed in a dry environment, free from condensation, and away from direct sunlight.

(7) Instructions on Dewing

This instrument has a lens in it. Watch for dewing due to a sudden temperature change. If water droplets form in the instrument, dry it sufficiently beforehand.

(8) Warm-up

In order to obtain satisfactory measurement accuracy, warm up the instrument for at least 30 minutes.

1.4 Plug-in Unit

The light sources for the instrument are of the following seven types in a plug-in system:

The plug-in system corresponding to each wavelength is shown below.

Table 1 - 3 Plug-in Unit

(1/2)

Body	TQ8450A				
Plug-in unit	Q84501	Q84502	Q84503	Q84505	Q84506
Wavelength	1.31 ±0.02μm	1.55 ±0.03μm	1.55 ±0.03μm	0.85 ±0.02μm	1.31 ±0.02μm
Object fiber	Single mode	Single mode	Single mode	Multi mode	Multi mode

(2/2)

Body	TQ8450A			
Plug-in unit	Q84521		Q84522	
Wavelength	1.31 ±0.02μm	1.55 ±0.03μm	1.31 ±0.02μm	1.55 ±0.03μm
Object fiber	Single mode		Single mode	

1.4.1 Mounting and Demounting of Plug-in Unit

CAUTION

Always be sure to switch off the instrument's power before mounting or demounting the plug-in unit.

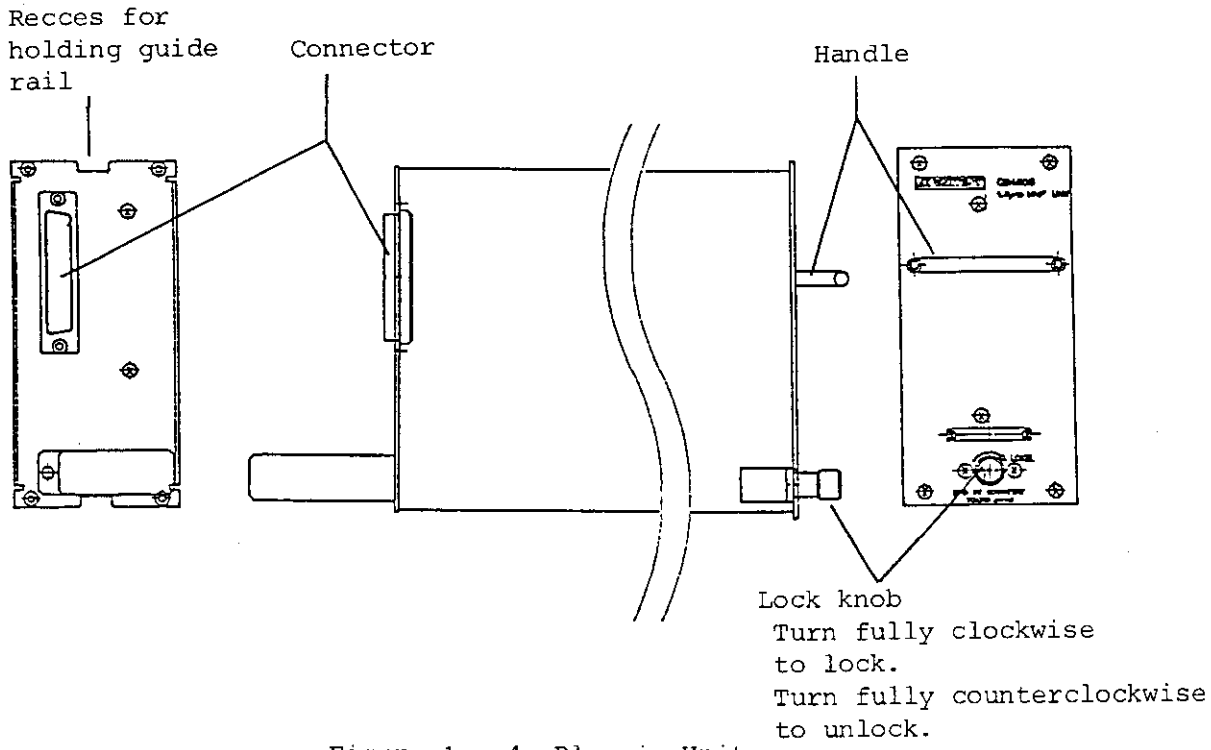


Figure 1 - 4 Plug-in Unit

(1) Align the upper and lower recesses of the plug-in unit with the guide rail of the rear panel, and slowly push in.

(2) Insert the unit firmly until the front connector of the plug-in unit clicks firmly and the shutter of the laser output connector of the unit projected on the front panel can be opened freely without touching the panel.

(3) Turn the lock knob fully clockwise.

(4) Pulling the handle toward you, see that the plug-in unit has been attached firmly.

- When removing the plug-in unit from the body, be sure to unlock it by turning the lock knob counterclockwise. Then pull the handle to remove the unit from the instrument.

[TQ8450A rear panel]

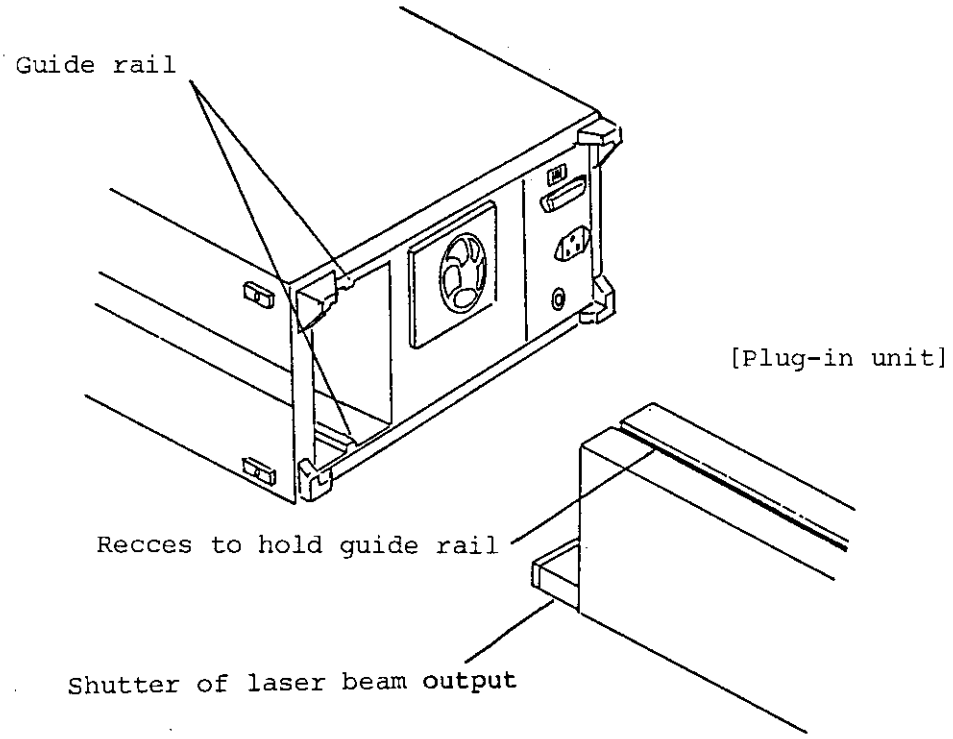


Figure 1 - 5 Mounting and Demounting of Plug-in Unit

1.5 Loading Printer Paper

(1) Pull open the slide cover on the top of the TQ8450A toward the rear panel side.

(2) Pull off the paper holder upward. The end of the holder is fixed by a spring, and thereby considerable force may be required to pull it off.

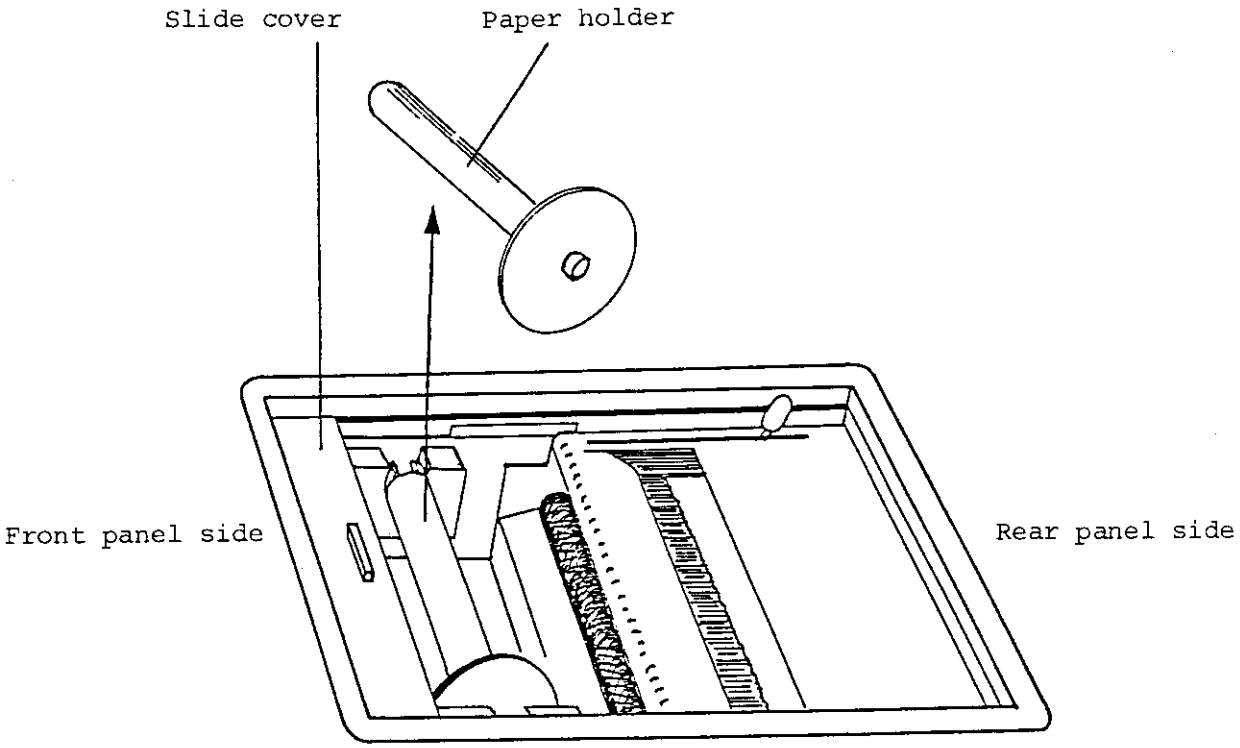
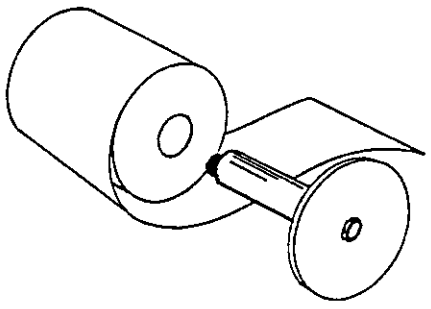


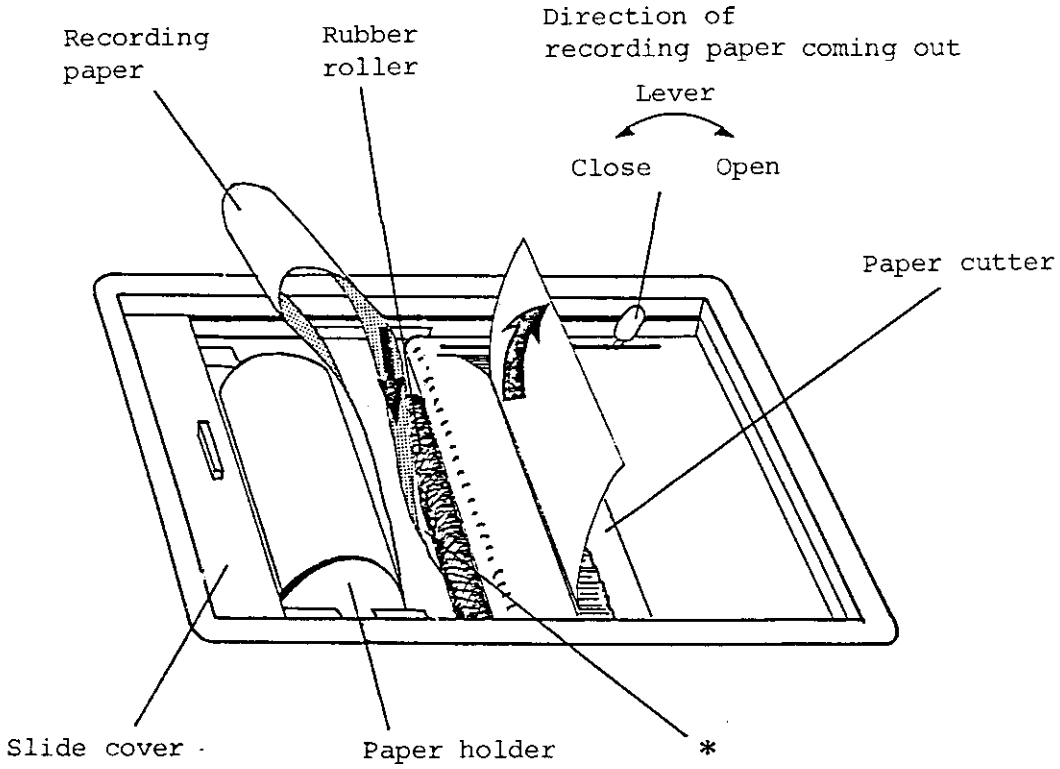
Figure 1 - 6 Set-up of Printer Paper (1)

(3) Unpackage the recording paper, free the stuck-down paper end, and insert the paper holder into the axial hole of the recording paper in the manner shown on the right.



(4) Set the paper holder in position, and pull the paper friction on/off lever toward the front panel, to release the friction.

(5) As shown below, insert the forward end of the recording paper from under the rubber roller, and push in until it comes out of the paper cutter. Return the paper friction lever to its original position.



CAUTION

Inserting the recording paper from under the rubber roller is easier if the forward end of the recording paper is cut into a pointed shape.

Sently, push the asterisked portion to the controller side with the finger tips.

Figure 1 - 7 Set-up of Printer Paper (2)

(6) Return the paper friction level to the original position. The slide cover should be used half closed so as to cover the paper holder. If it is used fully open, the recorded paper may get caught in the recording holder.

CAUTION

When using the printer, leave the printer slide cover half closed to prevent the recorded paper from being caught in the recording paper holder.

2. DESCRIPTION OF PANEL

2.1 General

This chapter deals with the general functions of the keys, switches and terminals on the panel. See the panel description diagrams (Figures 2-1 and 2-2) at the end of the chapter.

When a key is pressed, a short, low "beep" sounds, indicating key entry. If an unexecutable key is pressed, on the other hand, a heavier "beep" is generated to notify the operator of the wrong operation.

Keys with LEDs can be set when their LEDs are lit. Each time a key is pressed, settings are changed in selectable steps or continuously by a data knob. Settings of keys without LEDs are displayed on the CRT and are changeable.

Modes set by keys are cancelled when different keys are pressed.

2.2 Front Panel

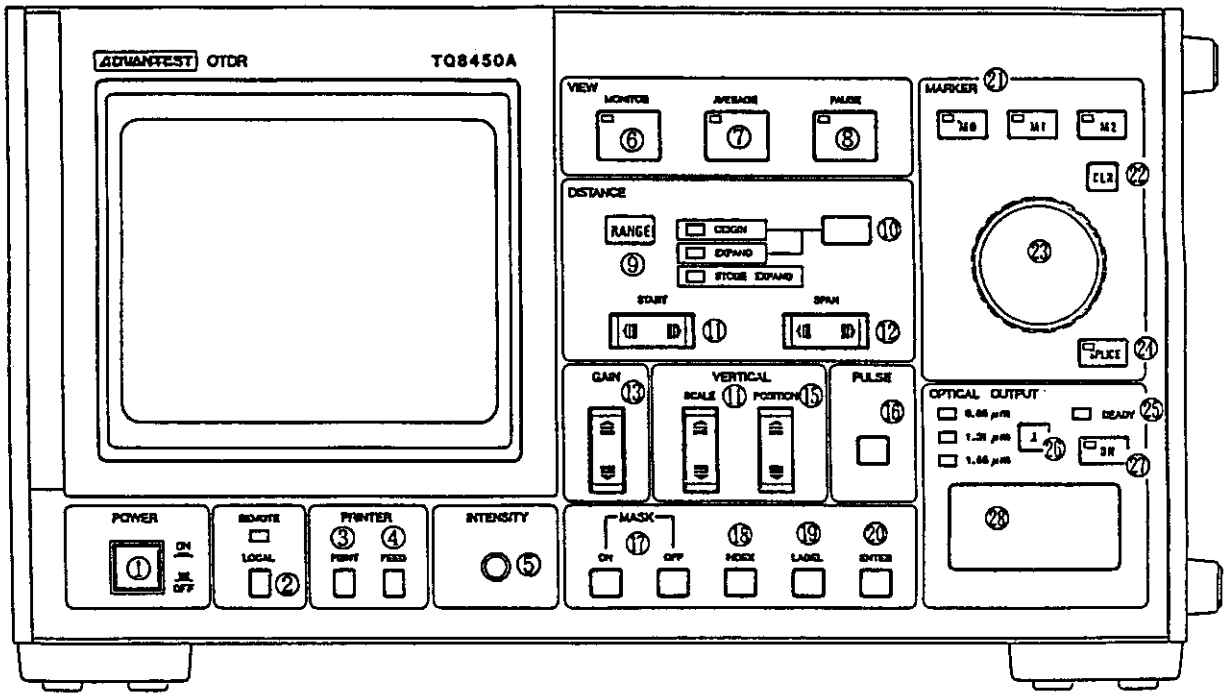


Figure 2 - 1 Front Panel

① POWER switch : This switch toggles the power on and off.

[REMOTE section]

② REMOTE LED LOCAL key: REMOTE LED is lit if the instrument is externally controlled by GPIB.
The LOCAL key enables panel key entry when the instrument is controlled externally by GPIB.

[PRINTER section]

③ PRINT key : All the information on the CRT is output to the built-in printer. If the PRINT key is pressed during printout, the printer stops.

④ FEED key : The recording paper is fed about 2cm each time this key is pressed.

⑤ INTENSITY knob : Knob for adjusting the CRT brightness

CAUTION

If the knob is kept turned fully clockwise for a considerable time, the CRT display will burn.

[VEIW section]

⑥ MONITOR key : Used for normal measurement. The averaging process is also executed under this function. (2^8 times, measurement time about 0.7secs)

⑦ AVERAGE key : The averaging process is executed under the state set by MONITOR. (Maximum 2^{16} times, measurement time about 60secs, 64kgm RANGE)

⑧ PAUSE key : The averaging stops and the result is indicated. When pressed again, the averaging resumes.

[DISTANCE section]

⑨ RANGE key : The measurement distance range is set. Each time this key is pressed in ORIGIN mode, the following setting is obtained:

→128km → 64km → 32km → 16km → 8km → 4km

If this key is pressed in EXPAND mode, ORIGIN mode is entered. The following setting is obtained only for Q84505:

→ 32km → 16km → 8km → 4km

⑩ ORIGIN/EXPAND key : The ORIGIN and EXPAND modes are switched. The setting can be checked by the LED. When the instrument is set in AVERAGE mode, the STORE EXPAND state follows automatically. The setting at power-on is ORIGIN.

⑪ START key : ORIGIN mode:
The marker associated with START is moved. In the process, the marker corresponding to SPAN may be adjusted by START. In EXPAND mode, the position of this marker makes up the START point.
EXPAND mode:
The START position is moved.
STORE EXPAND mode:
The START position is moved.

⑫ SPAN key : ORIGIN mode:
The marker corresponding to STOP is moved. In EXPAND mode, the position of this marker provides the STOP point.
EXPAND mode:
The SPAN is changed.
STORE EXPAND mode:
The SPAN is changed.

⑬ GAIN key : If the rear scattered light level is low or high, the gain is changed. (Effective only in MONITOR mode)
At each press of the key, the setting in such a manner changes that 0dB ⟷ 3dB ⟷ 6dB ⟷ 9dB

[VERTICAL selection]

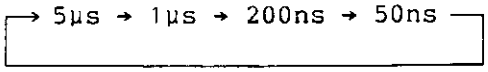
⑭ SCALE key : The scale of the ordinate is selected. Each time the key is pressed, the scaling is selected in such a manner that 4dB/VID. ⟷ 2dB/DIV. ⟷ 1dB/DIV. ⟷ 0.5dB/DIV. The ordinate always has eight divisions.

⑮ POSITION key : The reference level is changed to move the waveform up and down.

[PULSE section]

⑯ PULSE key : The pulse duration of the laser beam generated from the optical output connector is selected. Each time the key is pressed, the selection is made in the following order (effective only in MONITOR mode):

- Q84501, Q84502, Q84506, Q84521



- Q84505

  → 1µs → 200ns → 50ns → 10ns →

- Q84503, Q84522

  → 10µs → 1µs → 200ns → 50ns →

(17) MASK ON/OFF : A toggle switch for setting the mask at a maximum of three points on the CRT. Move the marker M0 to the desired position and press the ON key. (Effective only in MONITOR mode) For erasure, use the MASK OFF key.

(18) INDEX key : The refractive index of the fiber to be measured is set. Knob operation can set from 1.4000 to 1.6000 in steps of 0.0001. Turn the knob clockwise to increase the numeral, and vice versa. For ending the entry, press the ENTER key or INDEX key.

(19) LABEL key : Desired numerals or characters may be noted on a line at the top of the screen. Select the desired numerals or characters by the knob, and determine by the ENTER key. Press the LABEL key again, and the LABEL mode is cancelled. In LABEL mode, the following keys may be used for cursor movement or as a delete key:

MASK ON : The cursor is moved leftward.
MASK OFF: The cursor is moved rightward.
INDEX : The character immediately before the present cursor position is deleted.

(20) ENTER key : The set data of INDEX and LABEL are entered.

[MARKER section]

(21) M0, M1, M2 keys : The markers for M0, M1 and M2 are indicated respectively. Moved to the desired position by a knob.

(22) CLR key : All markers are deleted.

(23) Data knob : Data is changed in each operation mode for marker motion or label input.

(24) SPLICE key : LOSS and SPLICE are selected by the calculation of LSA (least square approximation). LOSS prevails when the lamp is turned off.

[OPTICAL OUTPUT section]

(25) READY LED : When the internal temperature of the laser diode becomes constant, this LED is lit indicating that the instrument is ready for operation.

(26) λ key : A key for selecting the laser beam of the optional unit. When Q84521 or Q84522 is used, press this key, and the wavelength may be switched to 1.31μm or 1.55μm from the front panel. (Effective only in MONITOR mode)

(27) ON key : An on/off key for the laser diode output. Works when the READY LED is on.

(28) OPTICAL OUTPUT connector : The protective lid covers a connector for the fiber.

2.3 Rear Panel

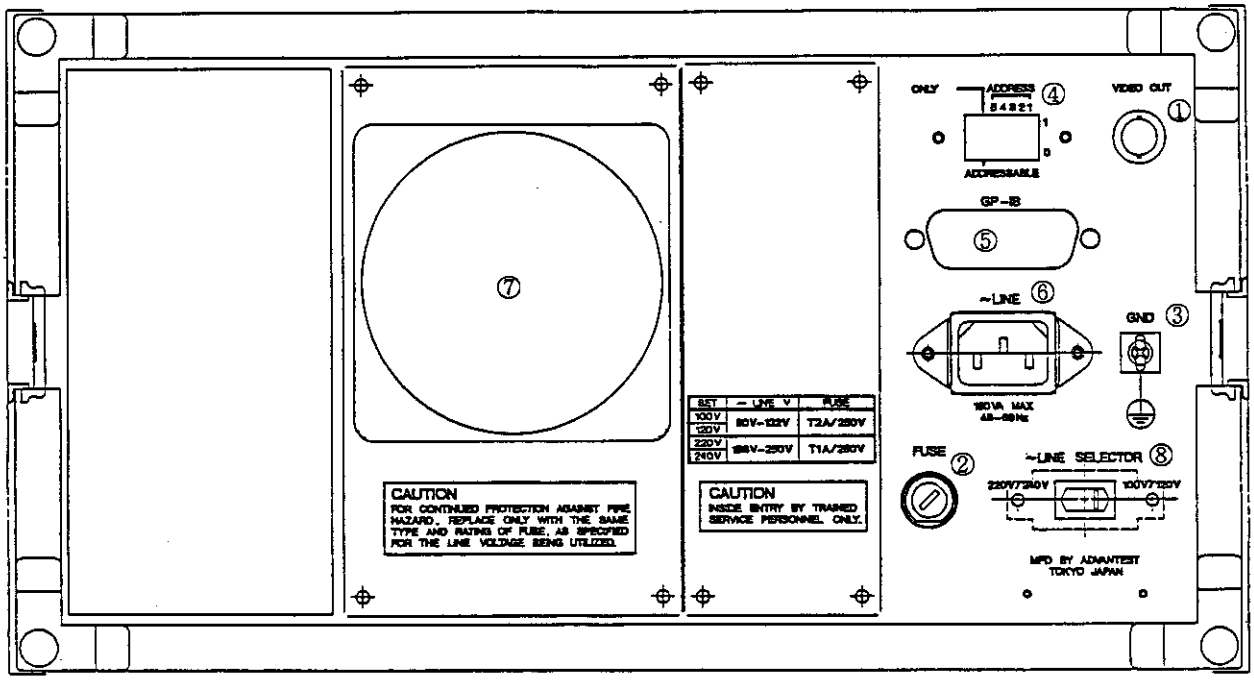


Figure 2 - 2 Rear Panel

① VIDEO OUT connector: An output terminal for taking a hard copy of the CRT screen by connecting to an external video block. A BNC connector.

② FUSE holder : When this holder is turned counterclockwise by a screw-driver, it comes off. When changing the fuse, always be sure to check the rating.

③ GND terminal

④ GPIB address switch

⑤ GPIB connector

⑥ ∿ LINE connector : Power connector

⑦ Fan : A suction type fan for cooling the heat generated from the instrument circuits. Make sure nothing interferes with the ventilation. To access the internal for cleaning, pull the fan case off. Dust the filter at least once a week.

⑧ LINE selector : A source voltage setting switch.
Set to 100V/120V when slided leftward.
Set to 220V/240V when slided rightward.

CAUTION

When changing the source voltage setting, change the fuse also.

2.4 CRT Display

The CRT display is used to display not only measurement data but also various setting conditions as follows:

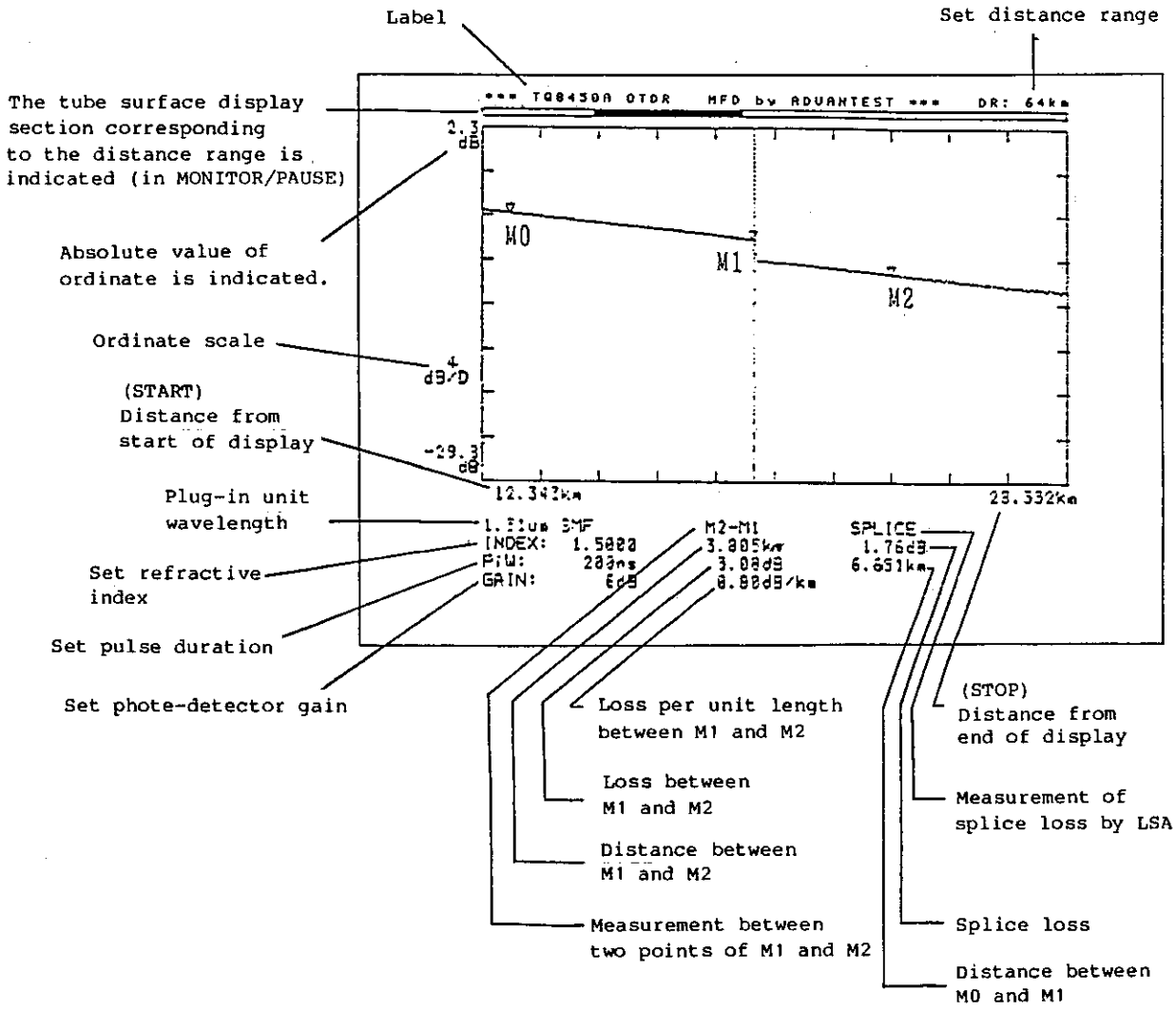


Figure 2 - 3 Explanation of CRT Display

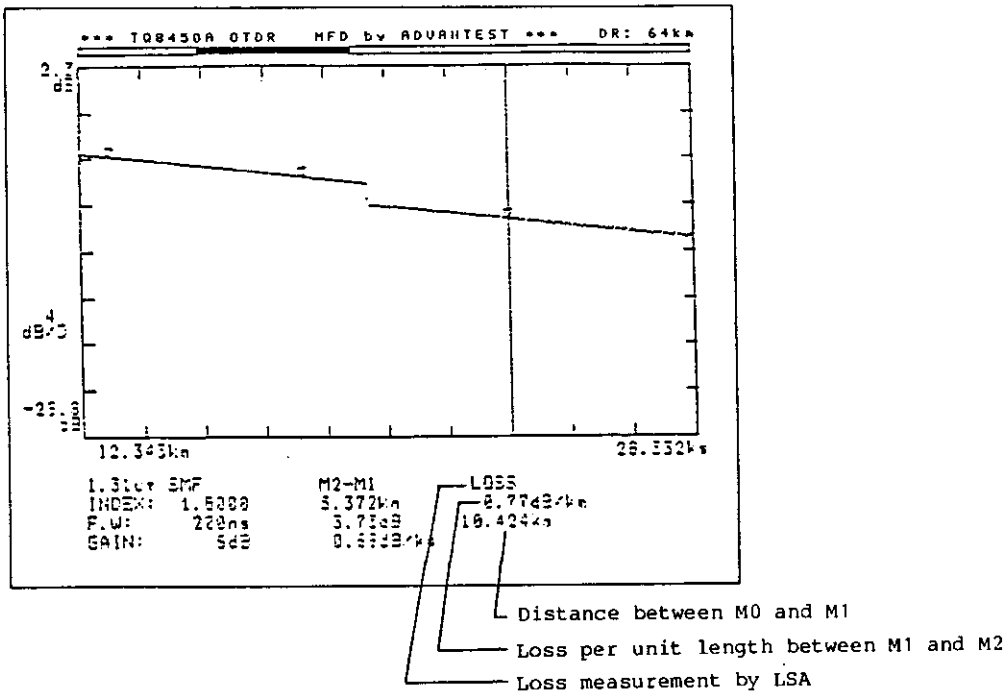


Figure 2 - 4 Loss Setting

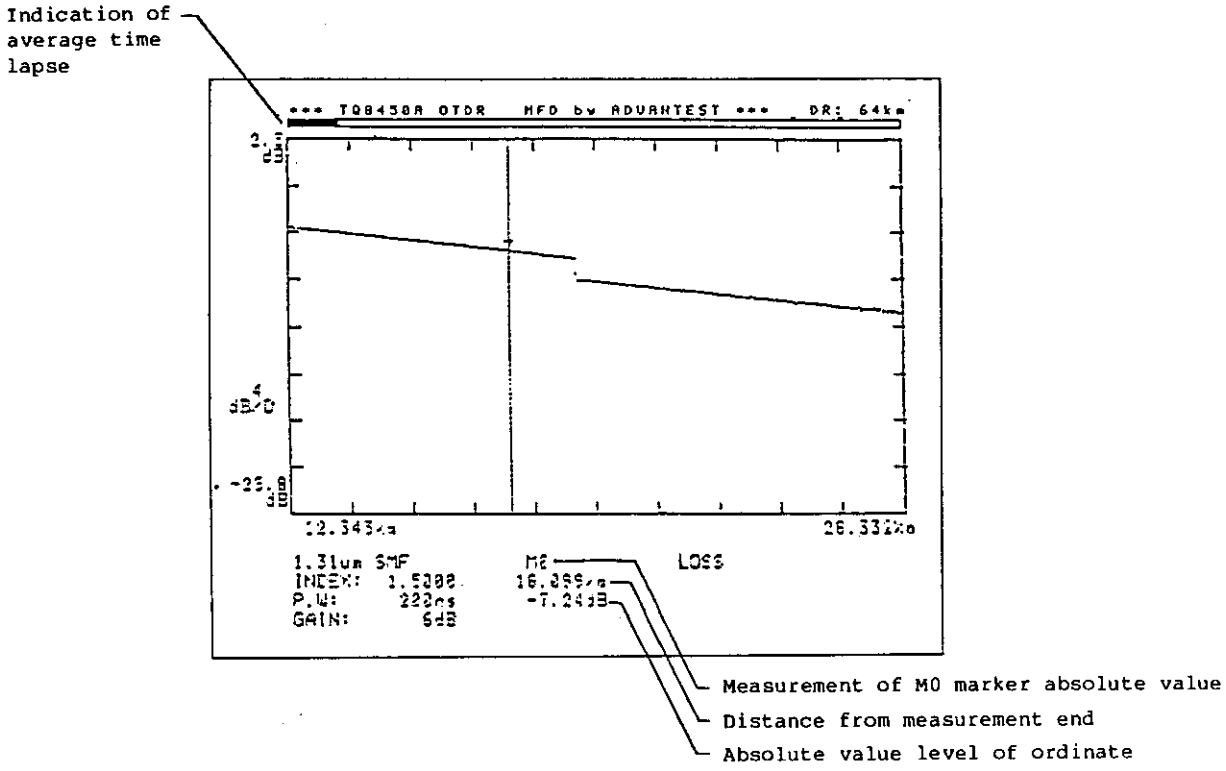


Figure 2 - 5 Averaging Mode

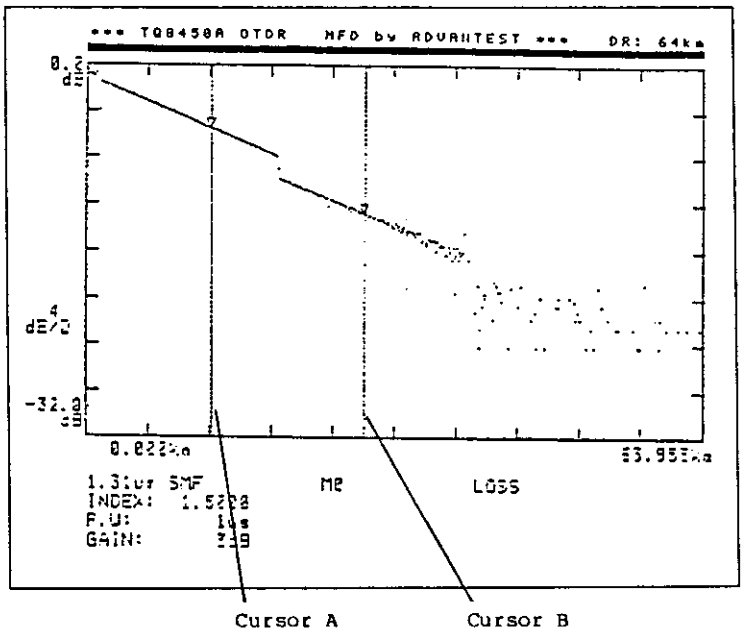


Figure 2 - 6 Indication in ORIGIN Mode

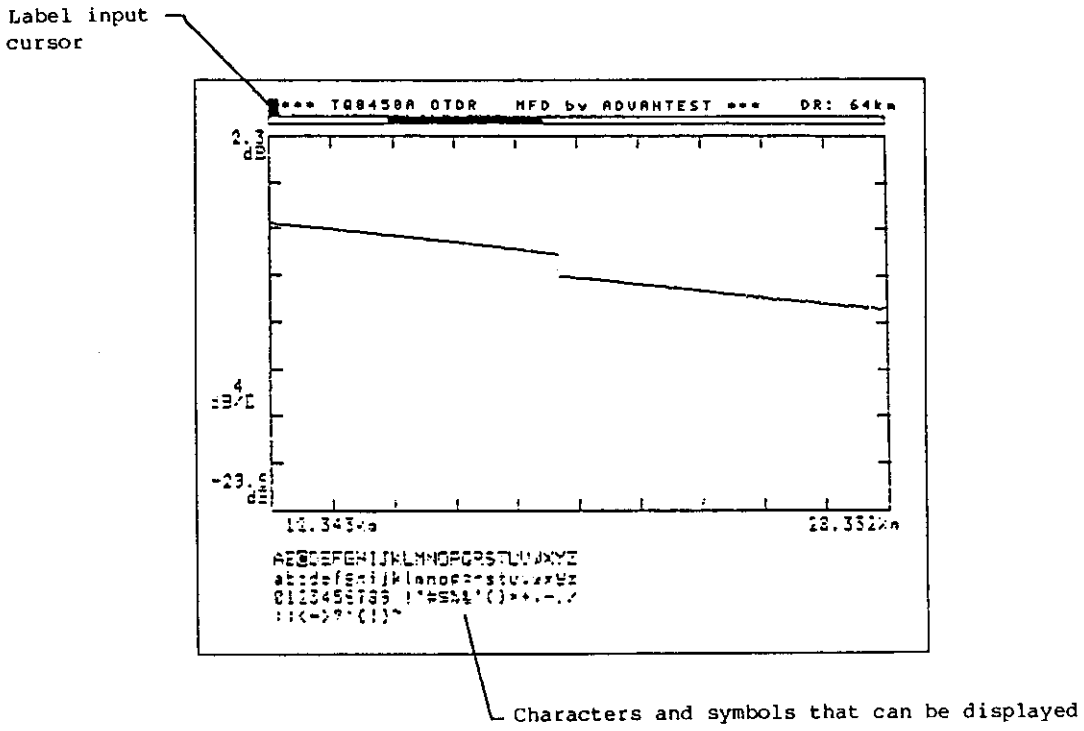


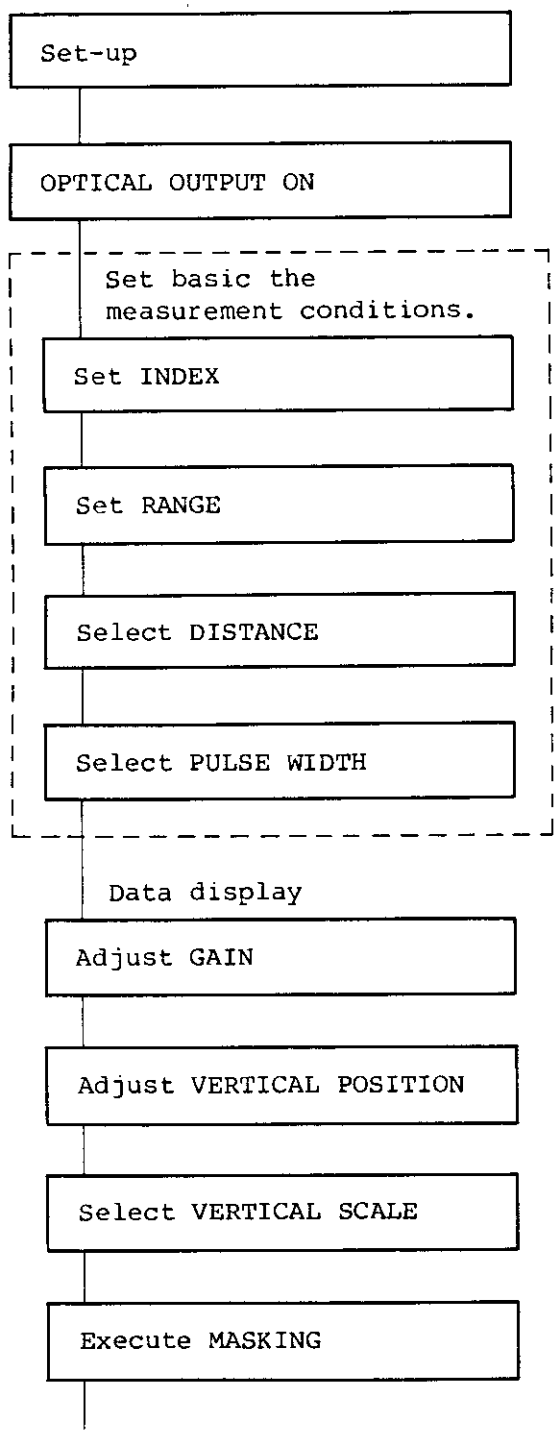
Figure 2 - 7 LABEL Mode

MEMO

3. OPERATING PROCEDURE

3.1 Outline of Operating Steps

The basic operating steps of this instrument are outlined below.



Mount the plug-in unit.
Turn on the power.
Connect the fiber to be measured.

Turn on the laser beam.

Set the refractive index corresponding to the fiber.

Set the measurement distance range.

Set the waveform START point and SPAN.

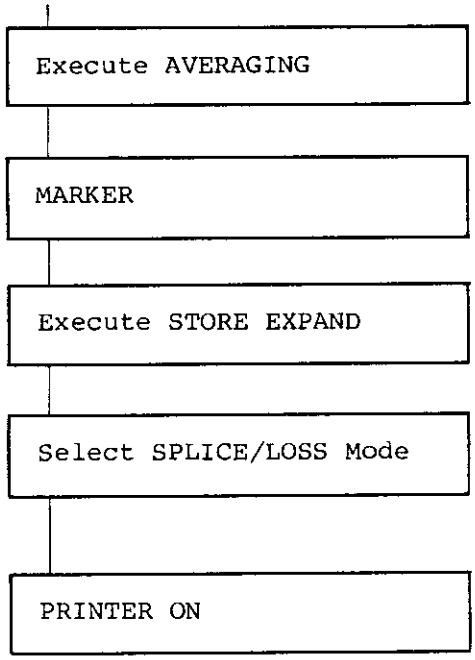
Select the pulse duration corresponding to the measurement distance range.

Display a waveform free of distortion.

Adjust the waveform indication level.

Select the ordinate scale.

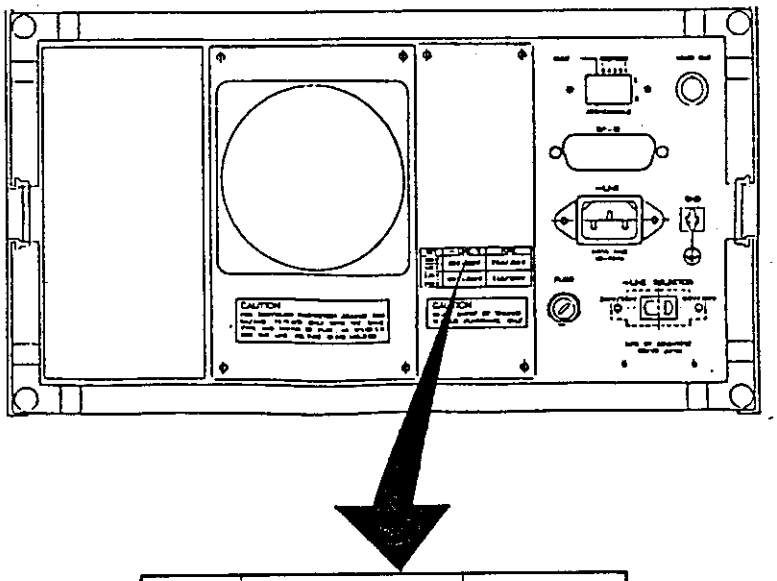
Attenuate Fresnel reflection and reduce the unobserved area.


Execute AVERAGING
Remove noise.
MARKER
Direct data reading by marker.
Execute STORE EXPAND
Enlarged display of waveform
Select SPLICE/LOSS Mode
Select the mode for loss measurement between two points and that for measuring the connection loss.
PRINTER ON
Hard copy output of the data on display.

3.2 Set-up

(1) Check of Source Voltage and Fuse

See whether the fuse standard meets the source voltage involved.



Set	∿Line V	Fuse
100V	90V to 132V	T2A/250V
120V		
220V	198V to 250V	T1A/250V
240V		

First, check to see whether the line selector on the rear panel is set to the source voltage. Make sure that the fuse rating agrees with the source voltage.

CAUTION

Before setting LINE SELECTOR or changing the power fuse, always be sure to remove the power cable from the line connector.

(2) Mounting of Plug-in Connector

Mount a plug-in connector suited to the prupose of operation. For mounting the plug-in unit, see "1.4 Plug-in Unit".

(3) Power-up

The conditions set immediately before power-off are held by a built-in lithium cell. This cell can hold the set conditions for about ten years.

When the POWER switch is turned on, all the LEDs are lit to reproduce the previous panel setting.

The following settings, however, are not held.

① VIEW → MONITOR
② SPLICE → LOSS
③ (LASER) ON → OFF
(Setting after power ON)

(4) Initialization

When the POWER switch is turned on, all the LEDs light and then go off. At this time, press the LOCAL key followed by the CLR key. The following initial condition is obtained.

When initializing the instrument by GPIB, however, send the "Z" command to the instrument.

[Initialized State]

SPAN : 64km
GAIN : 3dB
PULSE DURATION: 1μs
INDEX : 1.5000
VIEW : MONITOR
SPLICE : LOSS
(LASER) ON : OFF

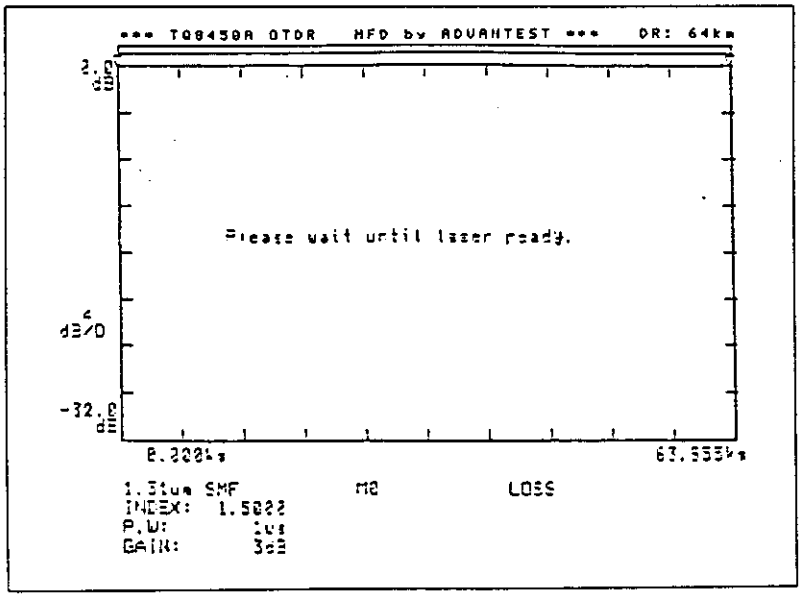


Figure 3 - 1 Initial Screen

(5) Connection of Fiber to be Measured

Connect the fiber to be measured to the OPTICAL OUTPUT connector (FC type) by turning it clockwise. Turning it counterclockwise to remove it.

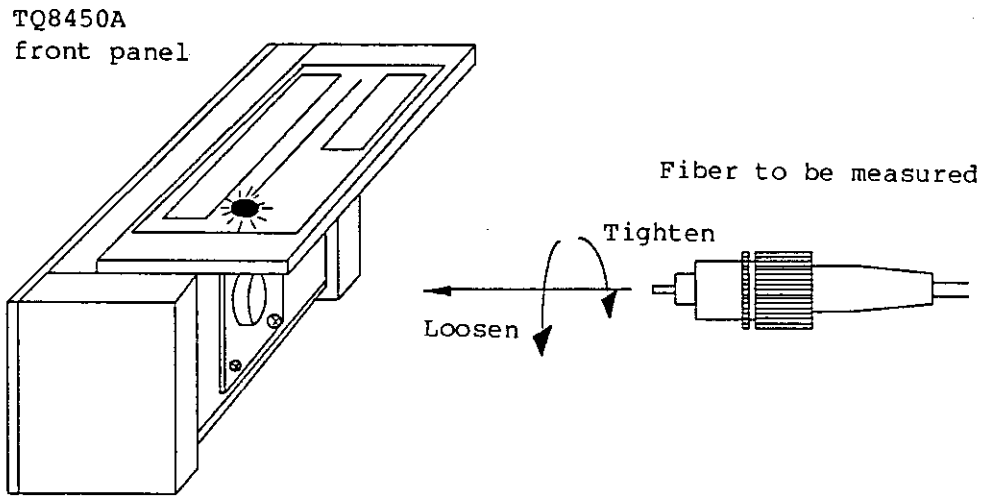


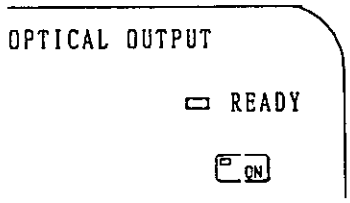
Figure 3 - 2 Fiber Connection

Check that the input fiber end is not contaminated before connection. If it is contaminated, clean with alcohol.

CAUTION

Before opening the protective lid, make sure that the LED of ON is off. Take the utmost care to ensure that the beam generated from the laser diode is not directed straight into your eyes.

(6) Beam Radiation

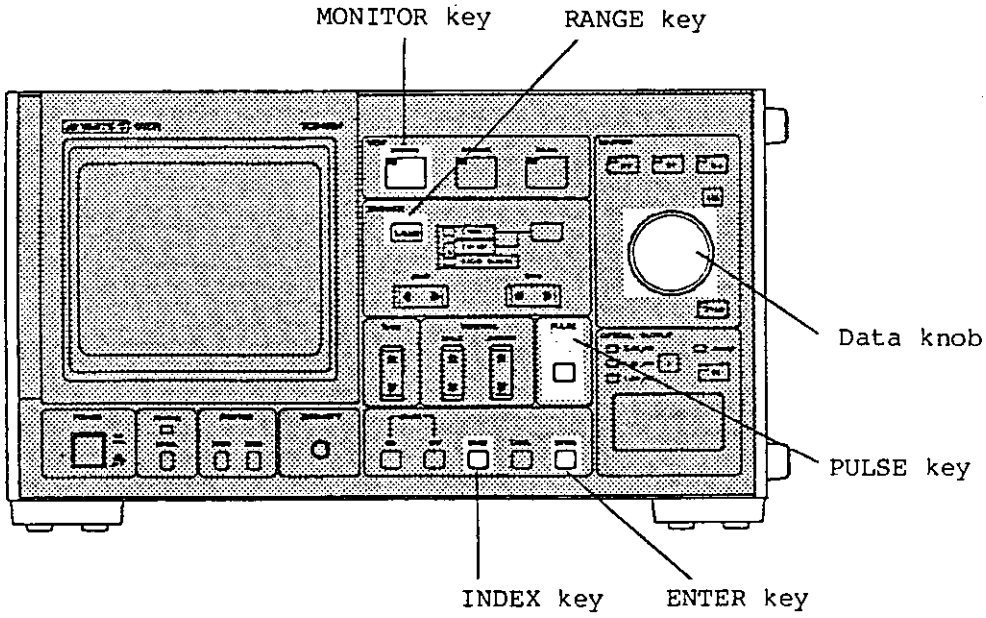


Light the LED key by pressing the OPTICAL OUTPUT key. The laser beam is sent from the laser diode. When the internal temperature of the laser diode reaches a predetermined level, the READY LED lights, indicating the instrument is ready for operation.

When the READY LED is off, a laser beam is not radiated even if the OPTICAL OUTPUT key is pressed.

3.3 Setting Measurement Conditions: RANGE INDEX PULSE

Set the measurement conditions according to such conditions as the length of the fiber to be measured and the core refractive index.



3.3.1 Setting Index

In this instrument, the time T(s) of the optical pulse reciprocating in the optical fiber is measured, and the distance is calculated from the refractive index. The value of this N depends on the fiber involved.

: The refractive index change mode is set by the INDEX key. By pressing the INDEX key, the word INDEX is displayed in white, making the setting possible. Set the value by the data knob.

The setting range is from 1.4000 to 1.6000 with the setting resolution of 0.0001. Setting id done by pressing the ENTER key. The value thus set is indicated at the lower part of the screen.

3.3.2 Setting Range

RANGE

: The range of the measurement distance is set. Each time the key is pressed, the following setting is obtained.

→ 128km → 64km → 32km → 16km → 8km → 4km →

Select a range longer than the length of the fiber to be measured. The setting is displayed at the upper right of the screen as DR (distance range).

3.3.3 Setting Pulse Width

PULSE

: Pulse duration is set according to the measurement distance. Each time the key is pressed, the pulse duration is set in the following order. The set value is indicated at the lower part of the screen.

- Q84501, Q84502, Q84506 and Q84521

  → 5μs → 1μs → 200ns → 50ns →

- Q84505

  → 1μs → 200ns → 50ns → 10ns →

- Q84503 and Q84522

  → 10μs → 1μs → 200ns → 50ns →

Generally, the pulse durations of 10μs, 5μs and 1μs are for measuring long and middle distances, and permit observation of a clearer waveform than for other pulse durations.

In high-resolution measurement, the pulse durations of 200ns, 50ns and 10ns are effective.

For Q84503 or Q84522, once the pulse duration is set to 10μs and the gain to 3, 6 or 9dB, the non-observation area obtains up to 24km of the near edge (as shown in the figure) and indicated by a straight line. When measuring the near edge, use a pulse duration of 1μs or less.

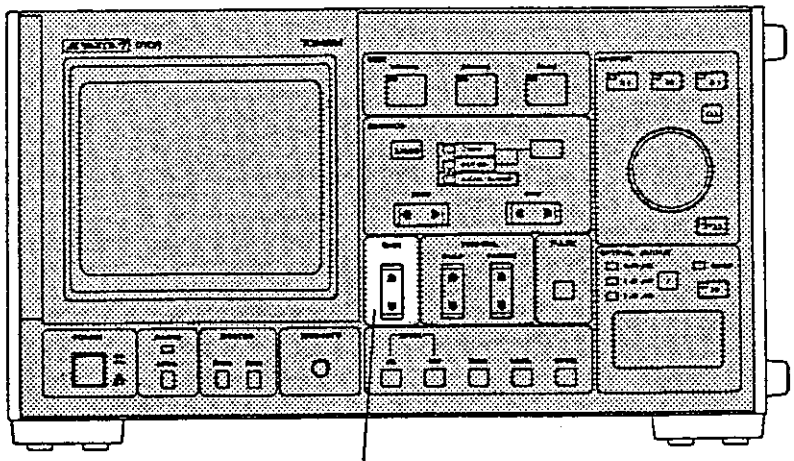
3.3.4 Switching Laser Beam Wavelength

When the Q84521 or Q84522 plug-in unit is used, it is possible to switch the wavelengths of 1.31μm (SM) and 1.55μm (SM) by [λ]. The selected wavelength is indicated by the LED.

For other plug-ins, the switch [λ] cannot be used, and the LED of the wavelength associated with the particular plug-in is lit.

3.3.5 Setting Gain

If the rear scattered light level is too high or too low, change the gain setting to the optimum indication point. If the indication waveform of the rear scattered light or the Fresnel reflection is too high, the amplifier in the instrument would be saturated, adversely affecting the measurement accuracy. If it is too low, on the other hand, the measurement accuracy is deteriorated.



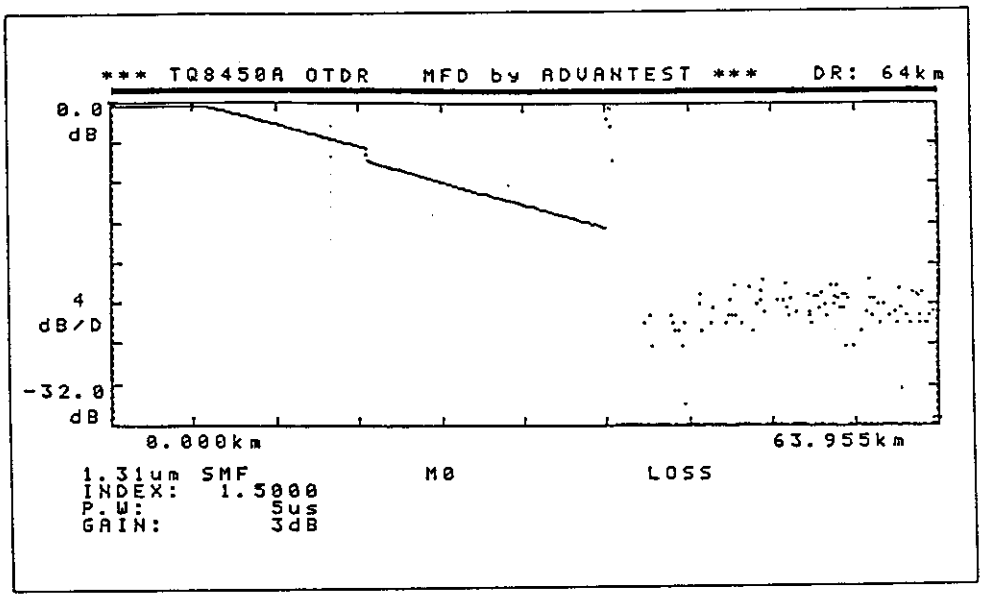
GAIN

: Press this key to set the gain. Each time the key is pressed, the setting changes between
0dB ↔ 3dB ↔ 6dB ↔ 9dB
The value thus set is indicated at the lower part of the screen.

With the change in gain, the level also changes. The vertical position is vertically moved by the amount of change, thereby permitting observation of the waveform at the same position as before the change.

When the pulse duration is changed, the optimum gain for the pulse duration is automatically selected as shown in the table below. Manual setting is also possible by operating the GAIN key.

Pulse width (sec)	Gain (dB)
10μ	0
5μ	0
1μ	3
200μ	6
50μ	9
10μ	9



The left end of the waveform is saturated.

⇩ Gain change : 3 dB ⇩ 0 dB

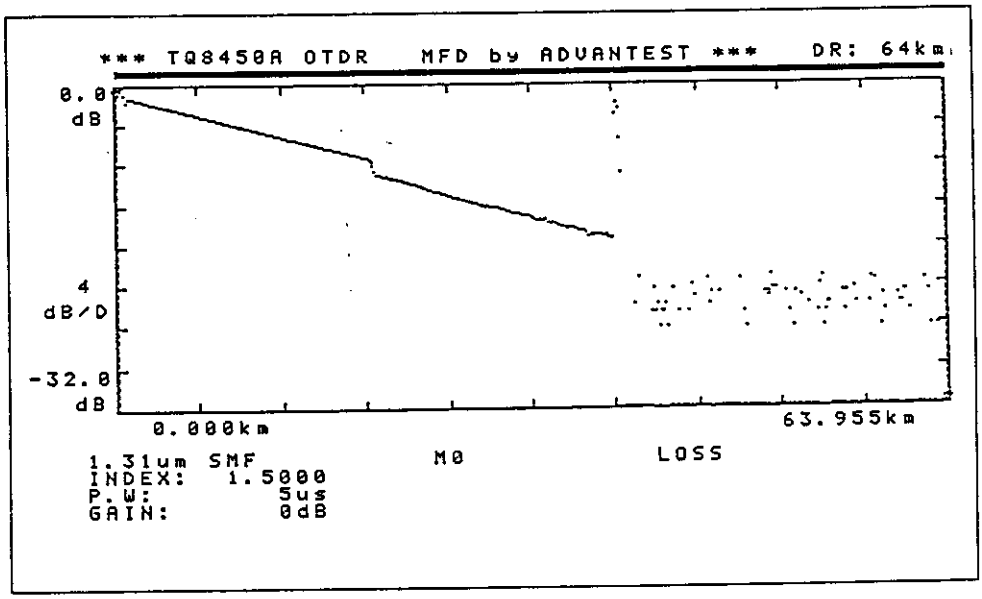


Figure 3 - 3 Gain Change

3.3.6 Label

A given number of characters may be fill the line at the top of the screen. With a maximum of 41 characters, they may include the date, time and title for the data storage.

The character menu of alphanumerics appears at the lower part of the screen when the LABEL key is pressed, as shown in Figure 3-5. Move the cursor to the desired character by turning the knob, and press the ENTER key. The setting starts from the left end of the upper part of the screen. When ending the LABEL mode, press the LABEL key again.

Also, the following keys may be used for cursor movement or deletion:

- MASK ON : The cursor is moved leftward.
- MASK OFF: The cursor is moved rightward.
- INDEX : The character immediately before the present cursor position is deleted.

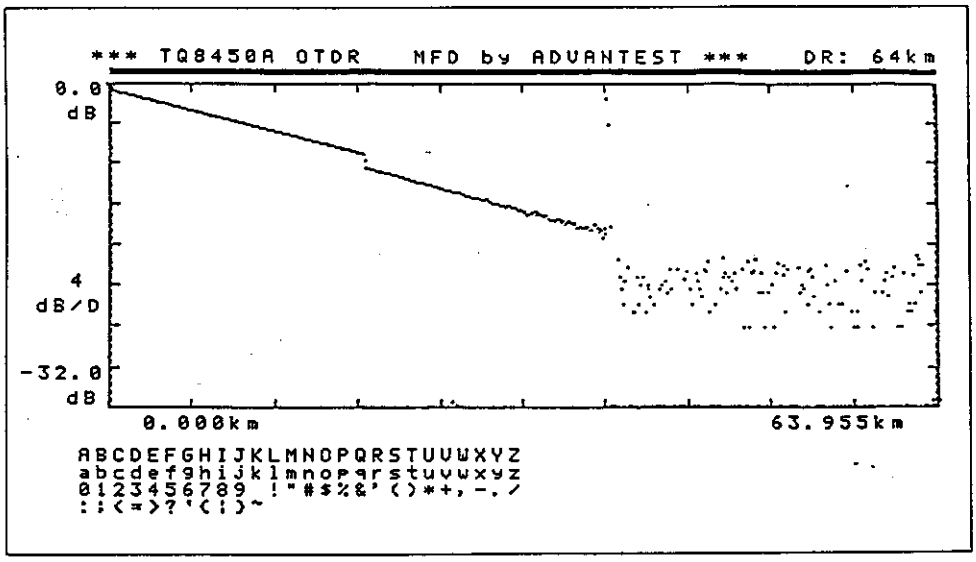


Figure 3 - 4 Initial Screen

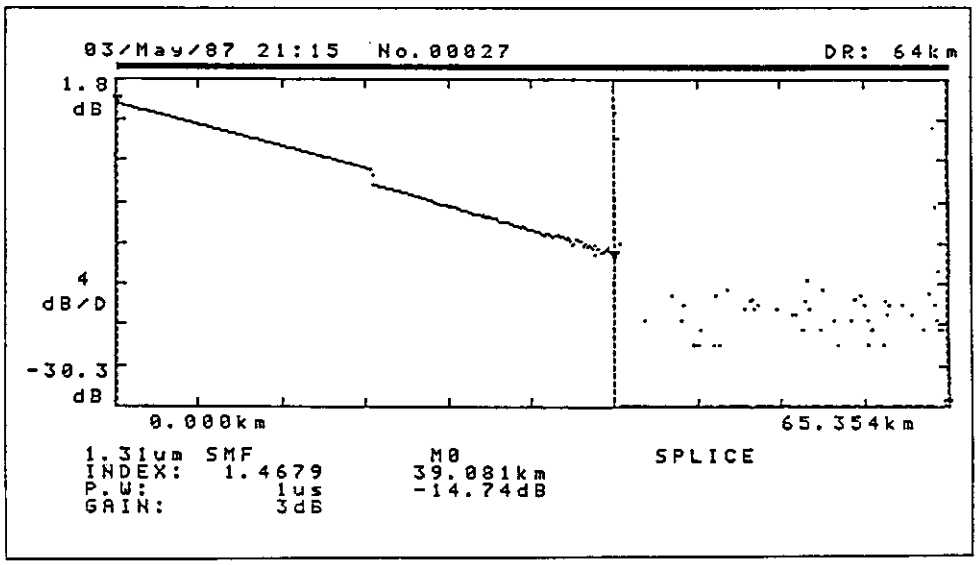
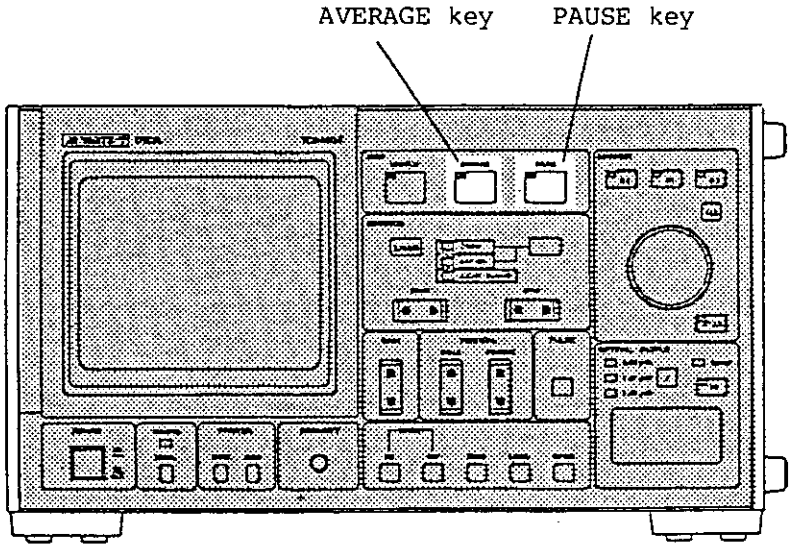


Figure 3 - 5 Label

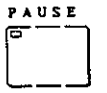
3.3.7 Averaging

The foregoing description concerns the measurement with the monitor function of the VIEW section. Although the MONITOR function executes 2^8 averagings, the AVERAGE function permits the measurement of longer distances.



(1) Setting of Averaging

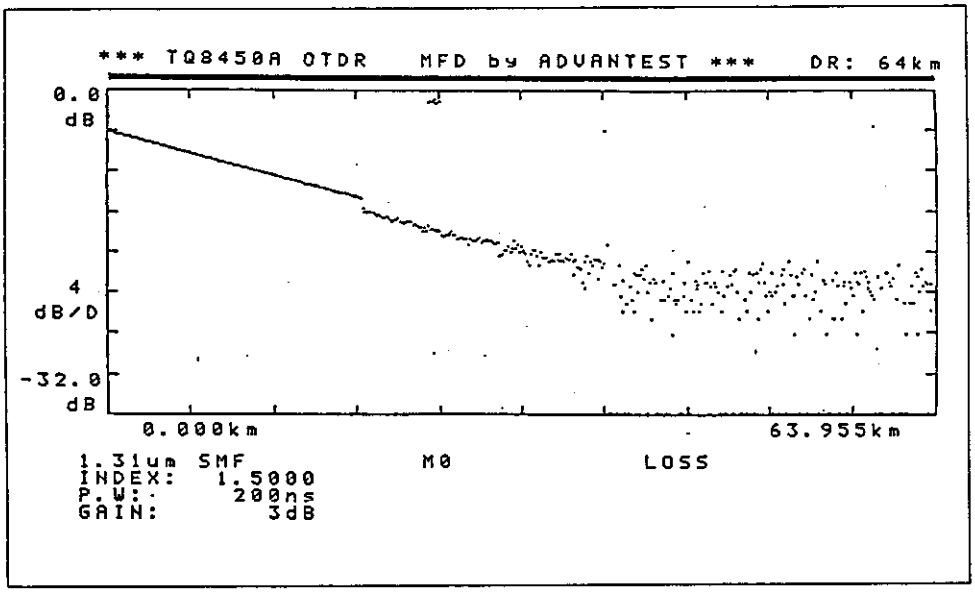
: When this key is pressed, the averaging is executed (2^{16} times maximum). Until the PAUSE key is pressed or a maximum of 2^{16} times is reached, the averaging process continues.



: To suspend the averaging, press this key. When the averaging is stopped, press this key again to resume. When the averaging reaches a maximum of 2^{16}, PAUSE is set automatically.

During the averaging process, the side frame on the tube surface displays the elapsed time of averaging. Upon execution of averaging, the inside of the side frame proceeds to be painted over gradually from the left edge. When the right edge is reached, it indicates the end of 2^{16} averagings. During the averaging process, the waveform indication changes every 2^n times (n = 9, ... 16). As the averaging progresses, therefore, the display interval lengthens.

[Before Execution of Averaging]



[After Execution of Averaging]

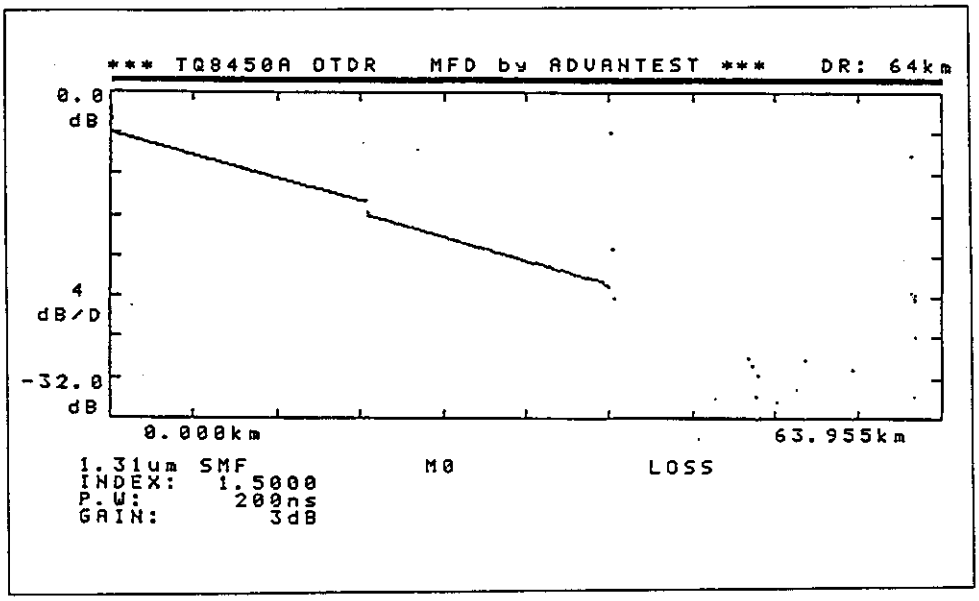
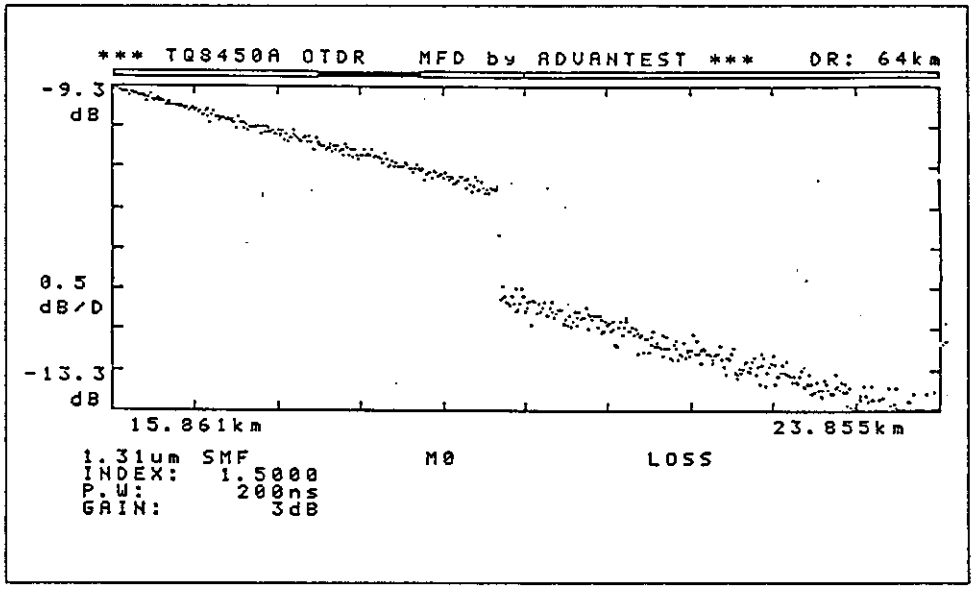


Figure 3 - 7 Averaging (1)

[Before Execution of Averaging]



[After Execution of Averaging]

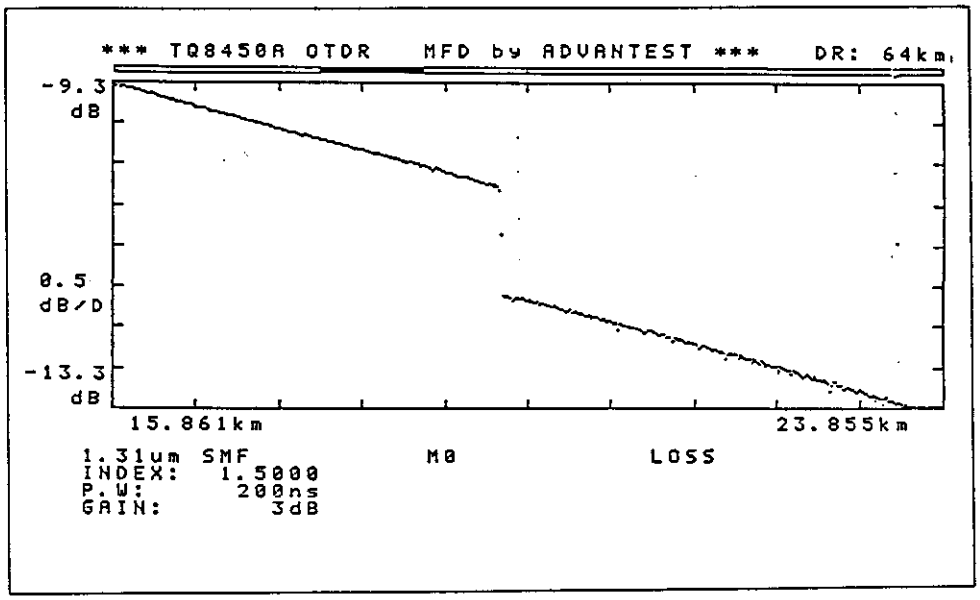
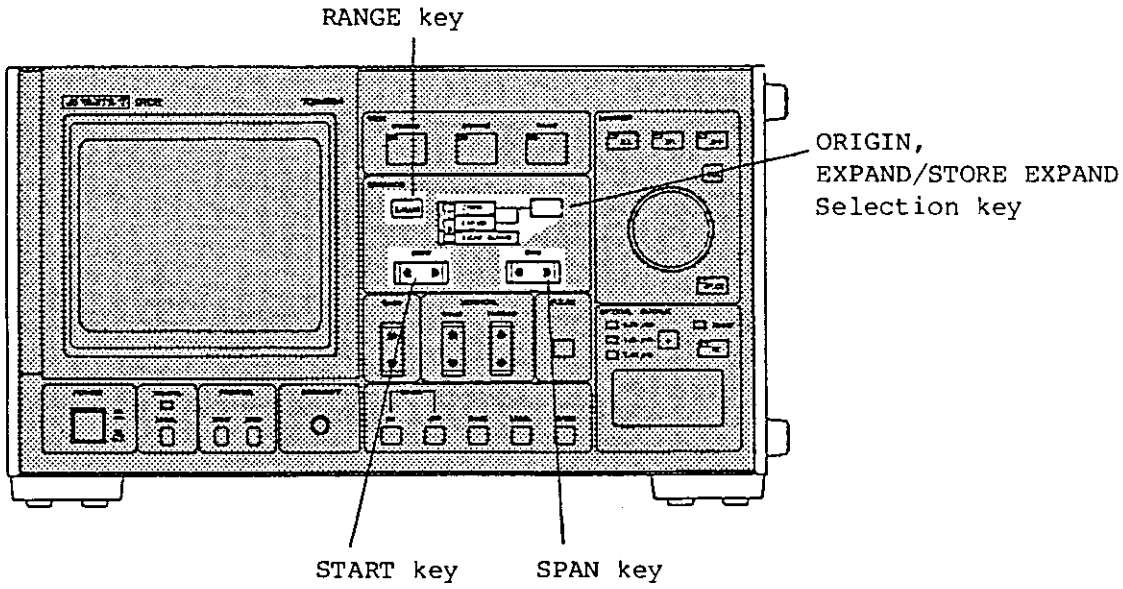
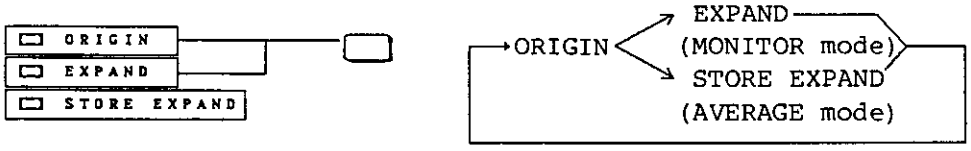


Figure 3 - 8 Averaging (2)

3.3.8 Setting Distance

The START point and SPAN of the display waveform are set for the measurement range set by selecting with the RANGE key.





: Each time the key is pressed, the mode changes in the following manner. The selection of EXPAND/STORE EXPAND is automatically effected.

ORIGIN : The distance from the origin (fiber position) as selected in RANGE mode is set as the measurement range.

At power-up, the two vertical cursors A and B on the screen in ORIGIN mode are located at the right and left edges for setting.

These cursors may be moved on the settable points by the START or SPAN key.

For settable points, see Table 3-1.

EXPAND : An enlarged waveform display in MONITOR mode. In ORIGIN mode, too, the distance in the range designated by cursors A and B is set as the display range.

STORE EXPAND: An enlarged waveform display in AVERAGE mode. The switching between EXPAND and STORE EXPAND is set automatically according to the selection of each mode in VIEW section.

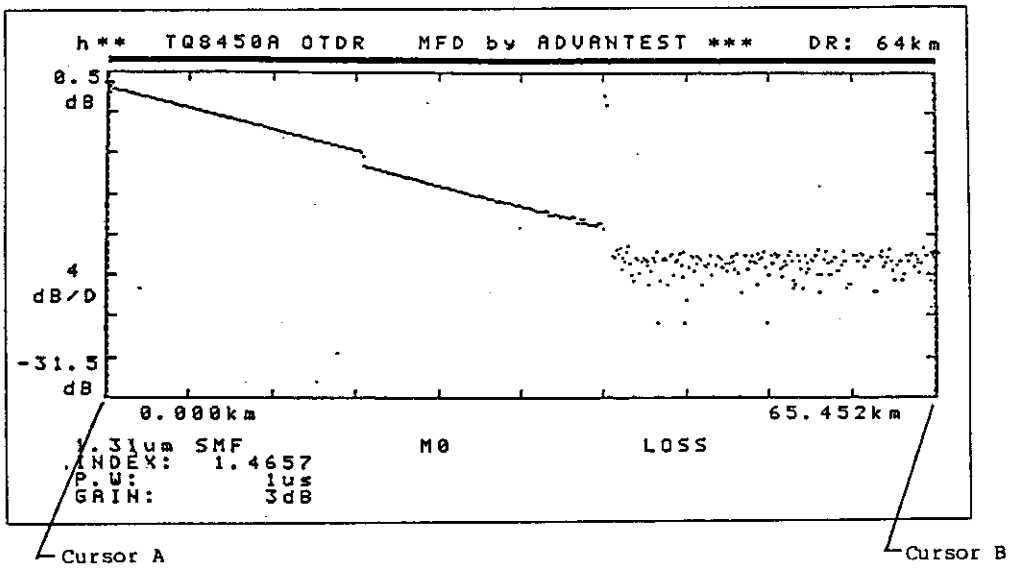
- Setting of START and SPAN

(1) ORIGIN Mode

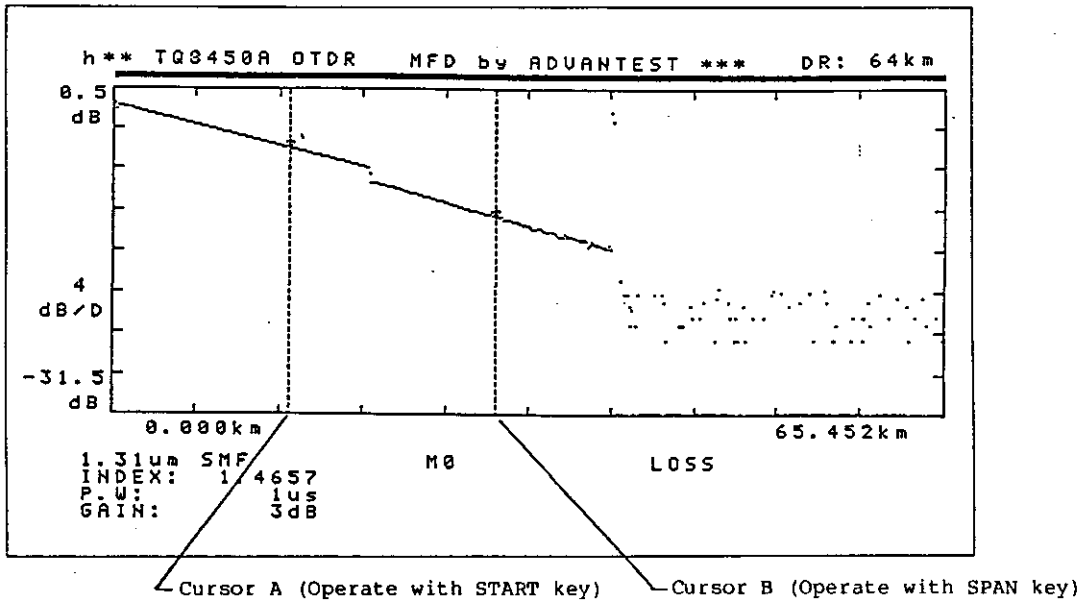
When the DISTANCE key is pressed, the ORIGIN mode enters, with two cursors A and B appearing on the screen (at the extreme right and left). These two cursors are moved by use of the START and SPAN keys, and the location to be enlarged is held by them.

After setting the cursors, press the ORIGIN/EXPAND changeover key to enlarge the area between the cursors.

① ORIGIN

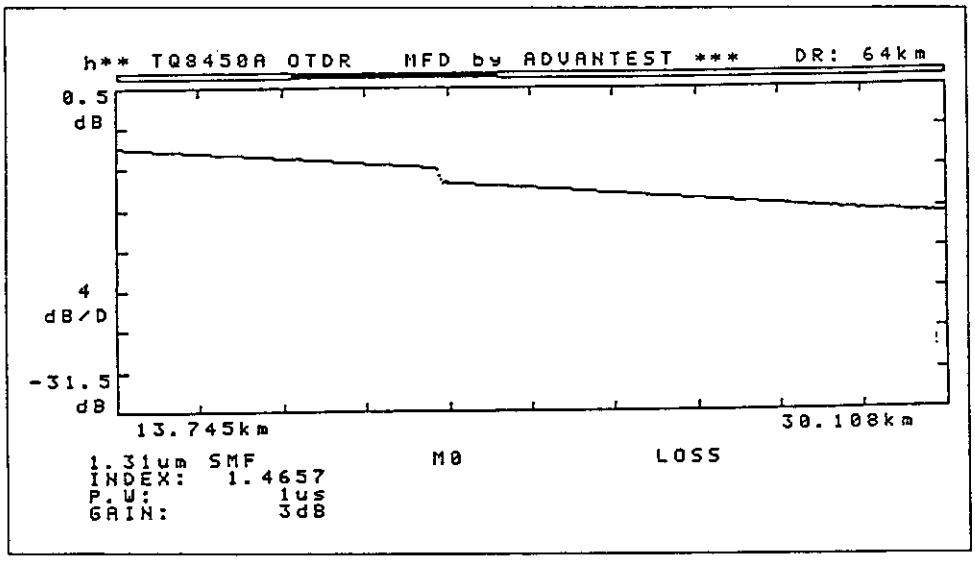


② ORIGIN



Set the cursors A and B with the START and SPAN Keys.

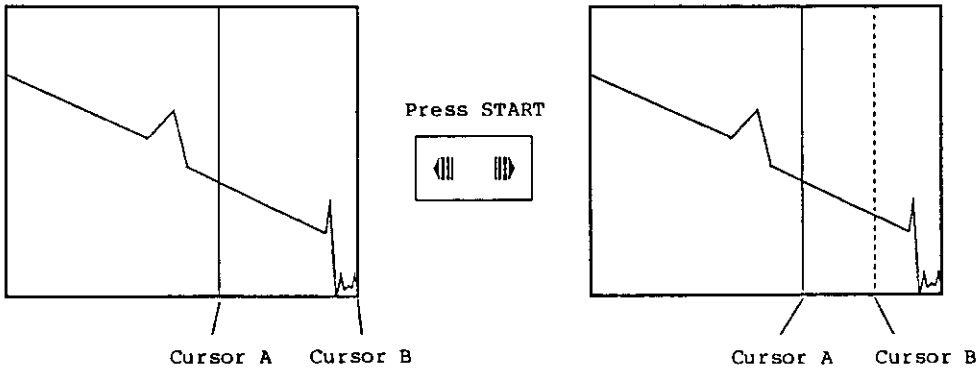
③ ORIGIN
EXPAND



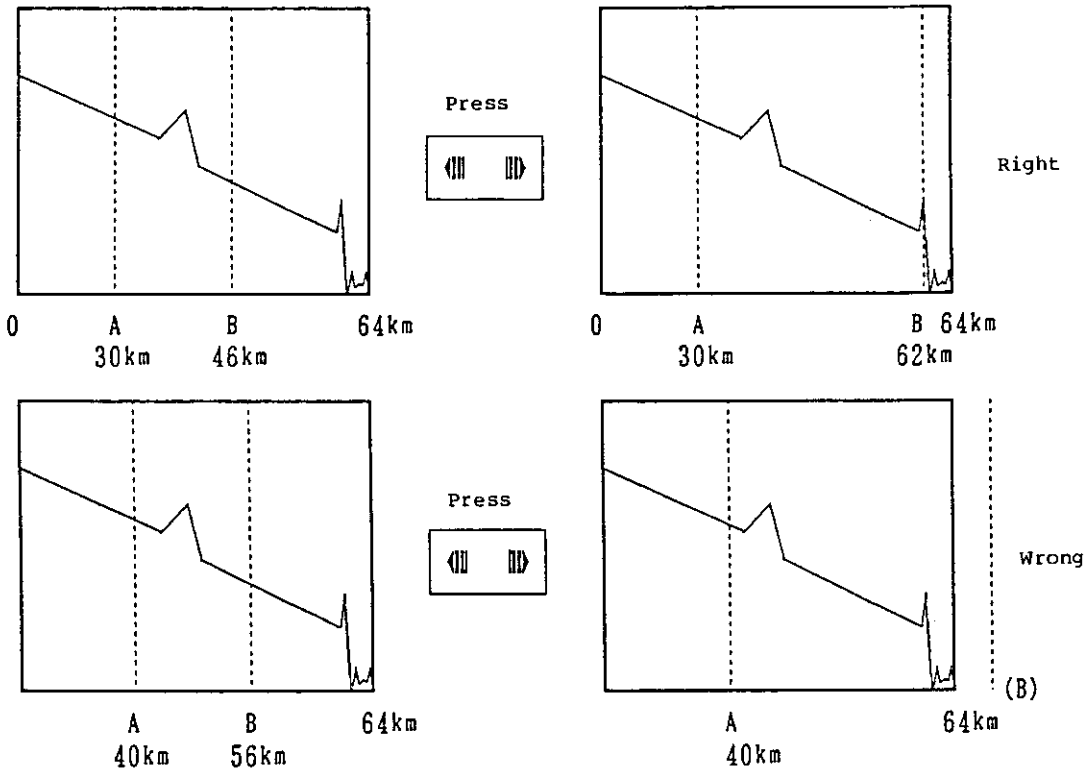
Area between cursors A and B enlarged

If the RANGE key is pressed once under this condition, or if the ORIGIN/EXPAND key is pressed, the condition (2) is attained. Pressing the RANGE key again changes the distance range.

If an attempt is made to move the START key to set the cursor B beyond the STOP position on the screen, the span is halved automatically.



When the span is enlarged, the STOP position determined by the SPAN involved cannot be set beyond the STOP position set on the screen.



(2) EXPAND Mode

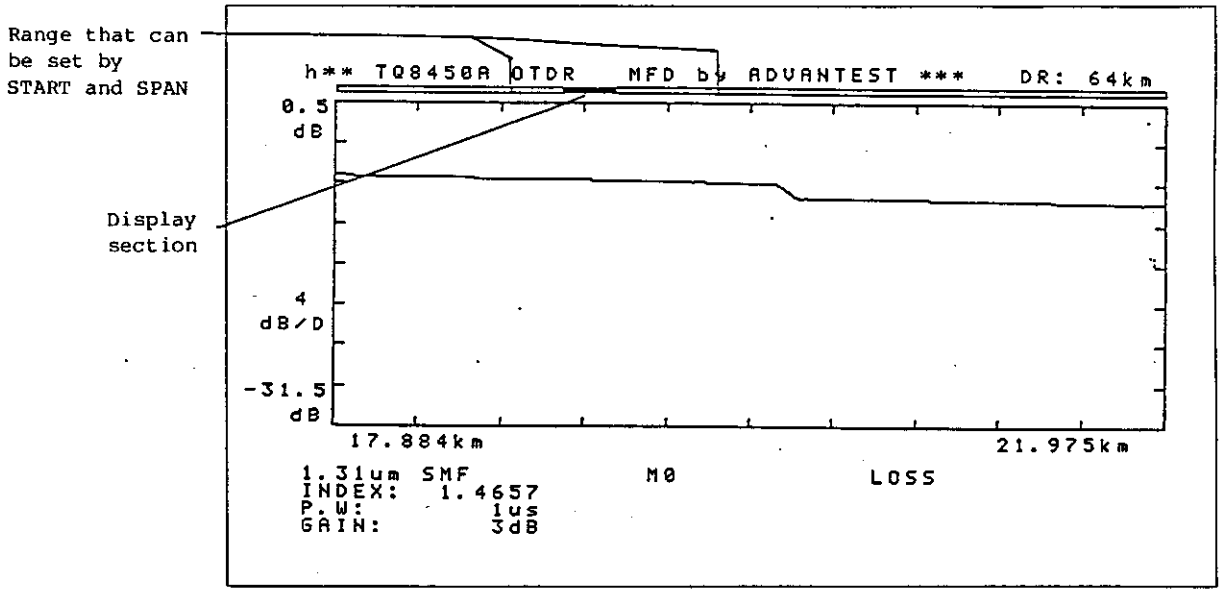
In EXPAND mode, the START point and SPAN are set for the enlarged waveform. Each time the SPAN key and the START key for the particular span are pressed, the distance to be moved is displayed.

SPAN in EXPAND (km)	START STEP m/point
128	256
64	128
32	64
16	32
8	16
4	8
2	4
1	2
0.5	1

However, a span greater than the set distance cannot be set.

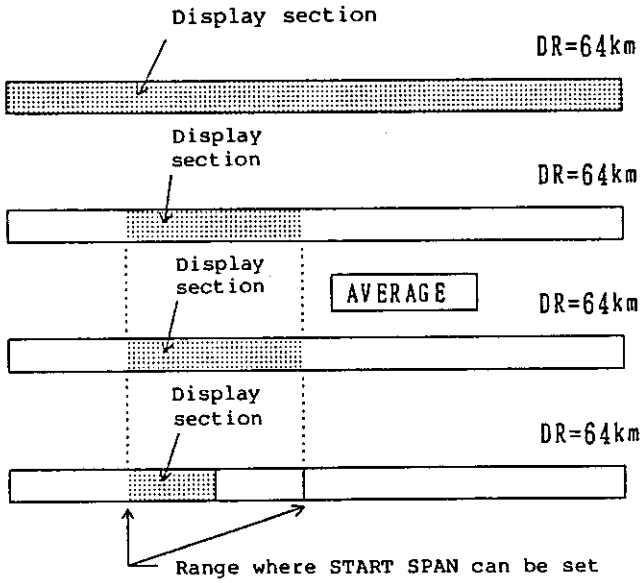
(3) STORE EXPAND

The operation of the START SPAN key in STORE EXPAND mode is the same as that in EXPAND mode, except that the range that can be set is limited in the former. Basically, setting is possible only in the span set in EXPAND mode. A span of less than 8km, however, can be enlarged up to a maximum of 16km. The range in which STORE EXPAND can be used is indicated by the horizontal band at the upper part of the screen.



STORE EXPAND condition in AVERAGE mode

[How to Read the Horizontal Band at the Upper Part of the Screen)

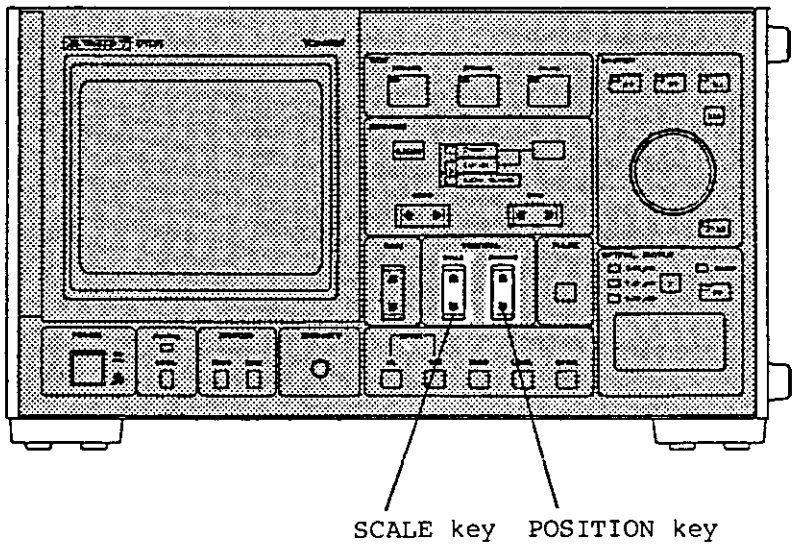


The SPAN in which STORE EXPAND can be set for the span set in EXPAND mode is shown in the table below.

EXPAND SPAN (km) \ STORE EXPAND SPAN (km)	128	64	32	16	8	4	2	1	0.5
128	o	o	o	o	o	o	-	-	-
64	-	o	o	o	o	o	o	-	-
32	-	-	o	o	o	o	o	o	-
16	-	-	-	o	o	o	o	o	o
8	-	-	-	o	o	o	o	o	o
4	-	-	-	o	o	o	o	o	o
2	-	-	-	o	o	o	o	o	o
1	-	-	-	o	o	o	o	o	o
0.5	-	-	-	o	o	o	o	o	o

o: Setting possible
-: Setting impossible

3.3.9 Setting Vertical Section



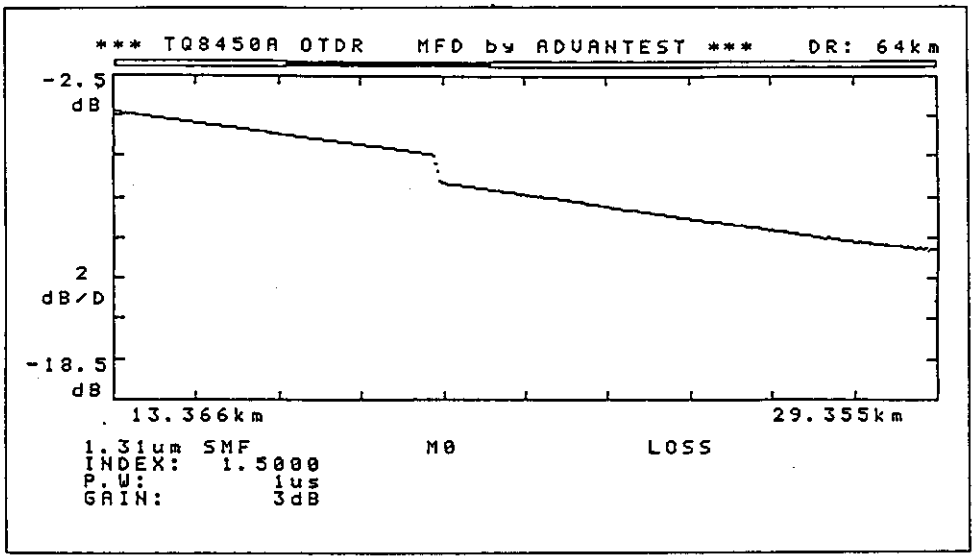
(1) Setting SCALE

: Each time this key is pressed, the ordinate scale on the tube surface changes in the manner

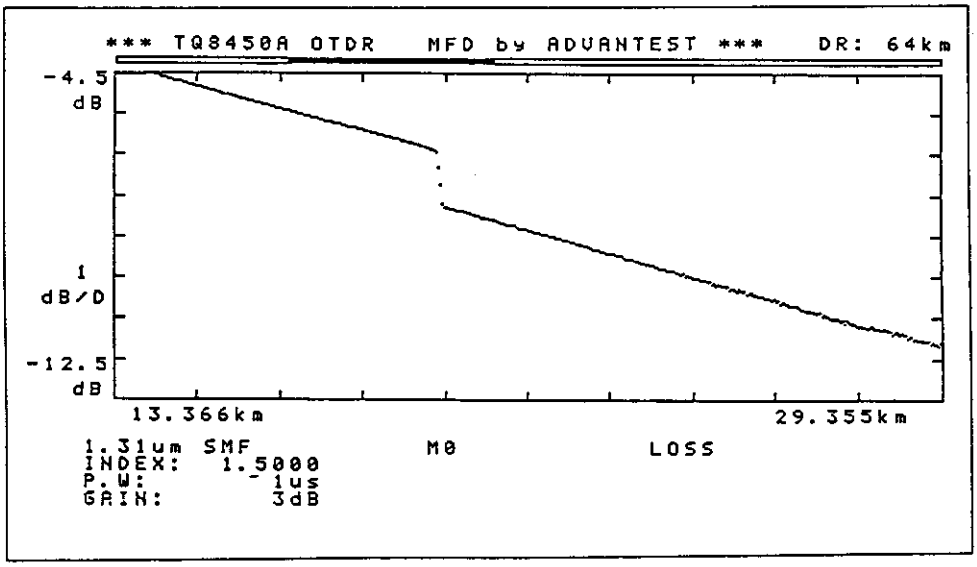
4dB/DIV ⟷ 2dB/DIV ⟷ 1dB/DIV ⟷ 0.5dB/DIV

Select according to the conditions for the amount of fiber loss or connection loss.

The ordinate on the tube is always in eight divisions. The position providing a reference of scale change is at the second scale mark from the top of the ordinate. When the M0 marker is on display, the position changes so that the position of the M0 marker is at the second scale mark from the top of the ordinate.



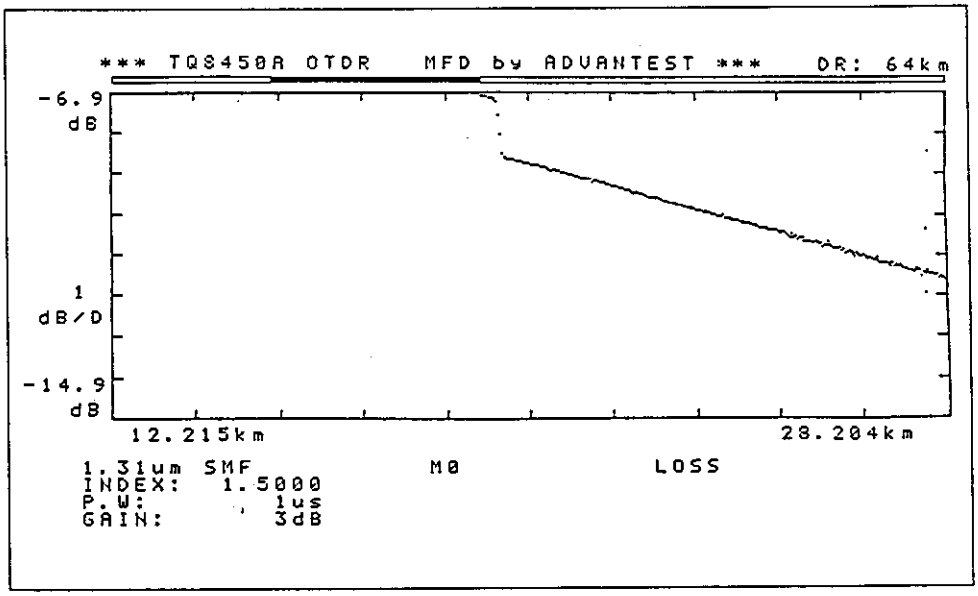
⇩ Enlarged from
2dB/DIV to 1dB/DIV



(2) Setting POSITION

POSITION

: Pressing this key changes the reference level, enabling the waveform displayed on the tube to be moved vertically.



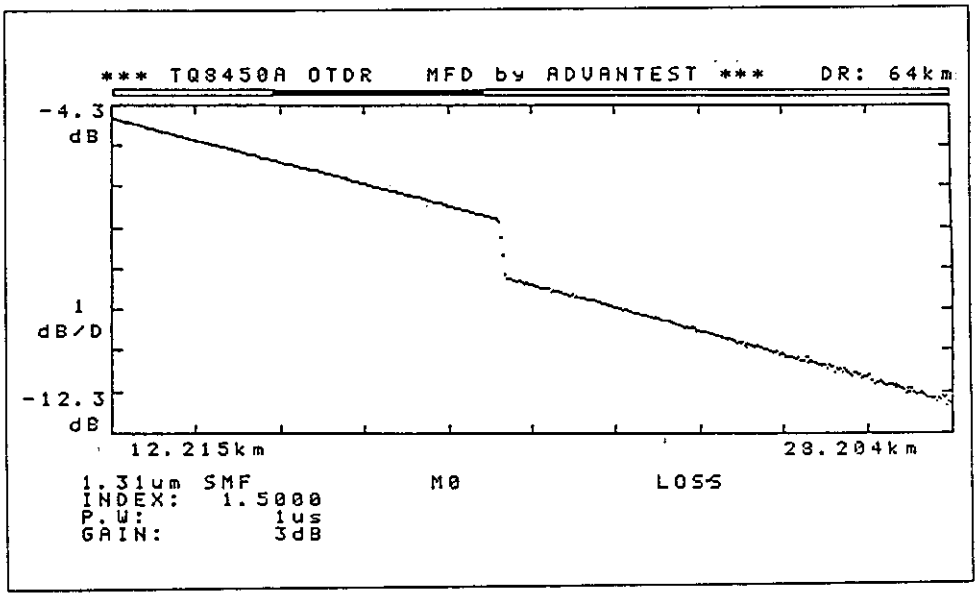
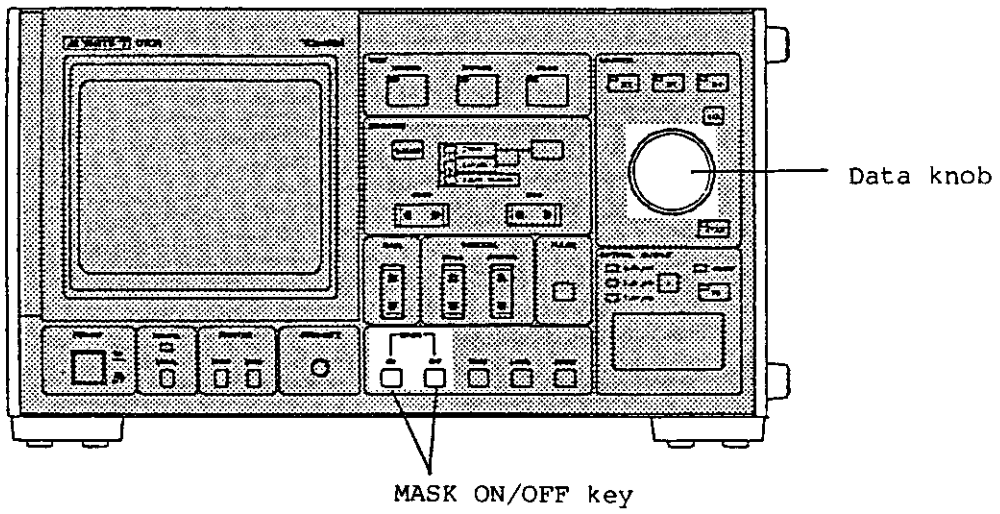


Figure 3 - 9 Change in POSITION

3.3.10 MASK Function (Except for Q84505)



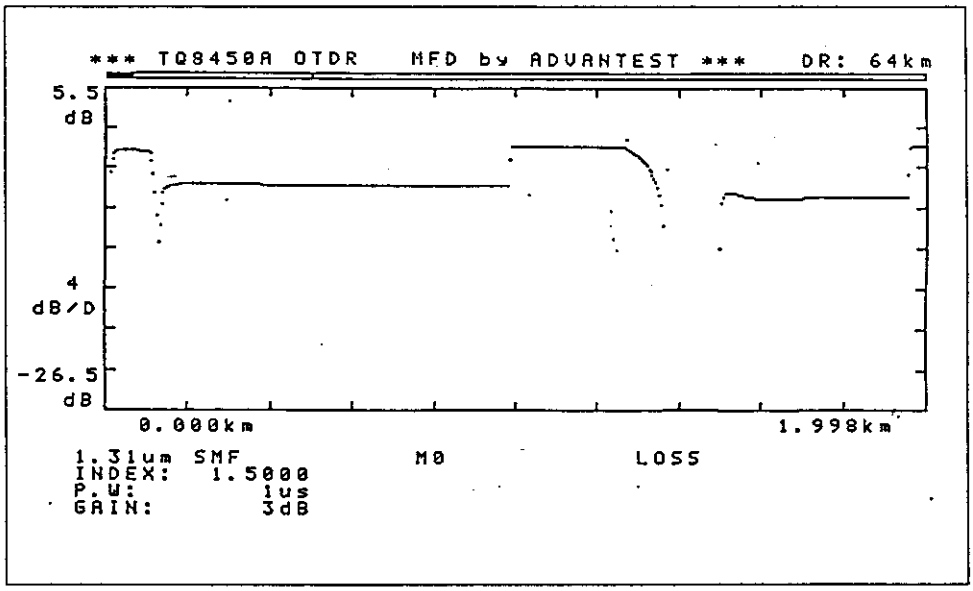
: If there is substantial Fresnel reflection, the waveform is distorted, making accurate measurement impossible. The mask function is used to attenuate the Fresnel reflection on the CRT to improve the linearity of the waveform. It may be set at a maximum of three points.

Move the M0 marker to the desired position, and press the MASK ON key. The mask is set, and "V" is indicated at that point. A maximum of three mask points can be set by repeating this process.

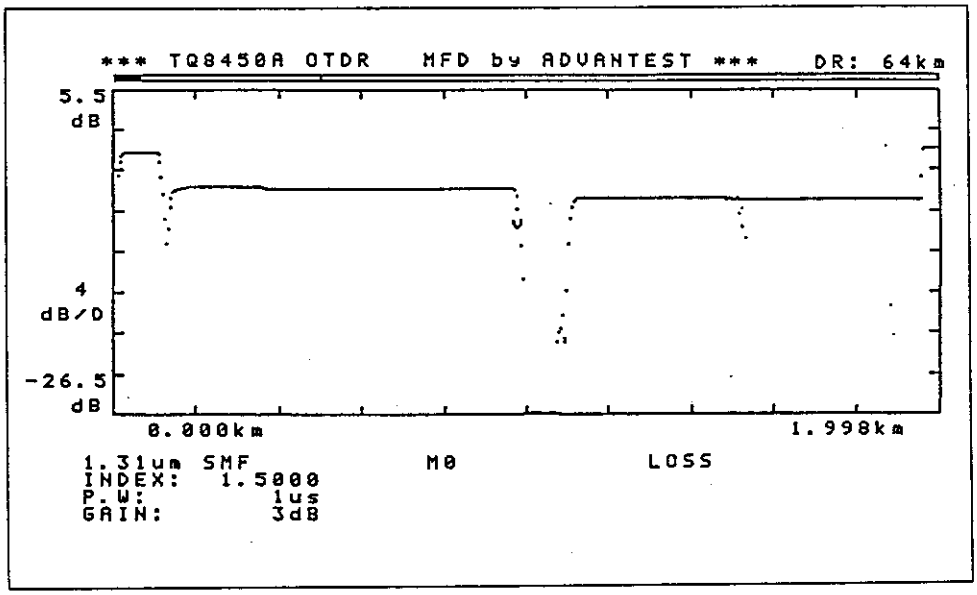
After setting three points, move the M0 marker and press the MASK ON key. The point where the mask is initially set is automatically "masked off", and a mask is set on the M0 marker.

To clear a mask, use the MASK OFF key. Each time this key is pressed, the masks nearest M0 MARKER are cleared. When the MASK OFF key is used, always be sure to display the M0 marker on the screen in advance.

[Fresnel Reflection at Connection Point]

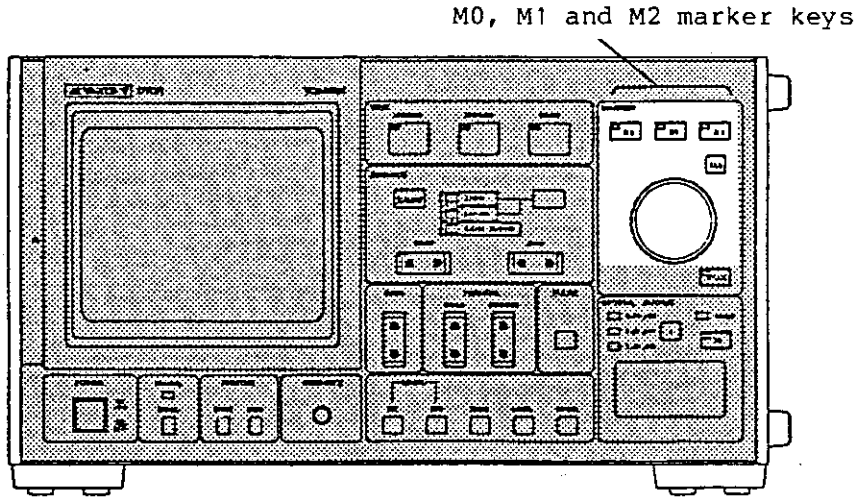


[When Mask Is Set at Fresnel Reflection Point]



3.3.11 Marker Function

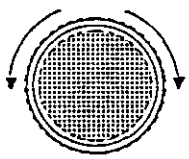
A maximum of three markers may be displayed. The data in analog waveform can be read with the digital display.



: A maximum of three markers can be displayed. By using the M0, M1 and M2 keys, the position of the fracture point or connection loss can be determined. The markers are moved by the knob. When the desired marker key is pressed, a vertical cursor appears on the particular marker. Move the marker by the knob. The LEDs of M0, M1 and M2 markers indicate the marker on display on the screen. (The marker whose key is lit is displayed on the screen.) All the symbols of the markers M0, M1 and M2 are the same. When the three markers are displayed, however, M0, M1 and M2 are always arranged in this order from the left.

When two markers such as M1 and M2 are displayed, they are arranged in that order from the left. M2 cannot be relocated on the left side of M1.

Marker moved to left



Marker moved to right

CLR : All markers erased.

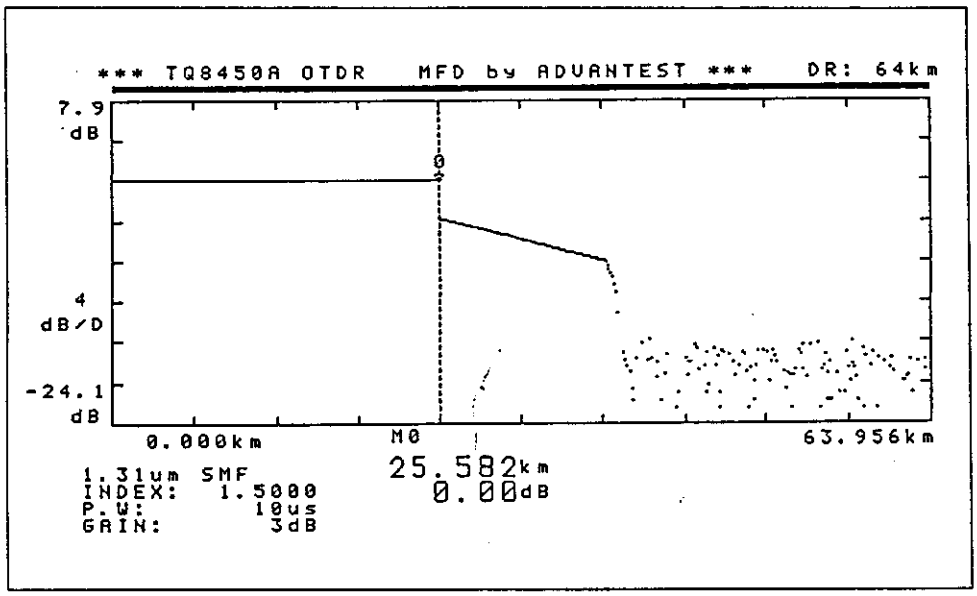


Figure 3 - 10 Markers

3.3.12 Measurements by Marker Function

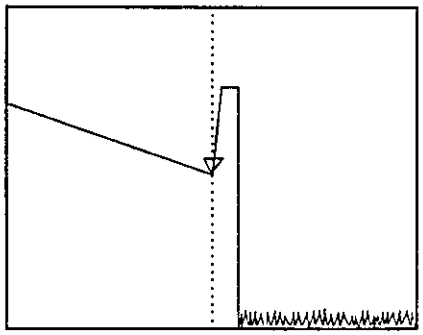
(1) Measurement of Fracture Point

By using the M0 marker, the distance in absolute value is determined from the laser emitting point to the fracture point.

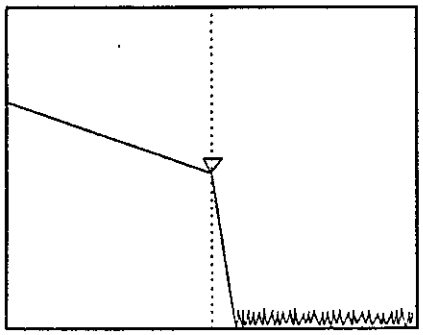
[Measurement Example]

The set position of a marker is located on the left side of Fresnel reflection, if any. For a fracture point without Fresnel reflection, set immediately before a change in the rear scattered light.

The result of measurement is displayed where M0 is indicated at the lower part of the display screen.



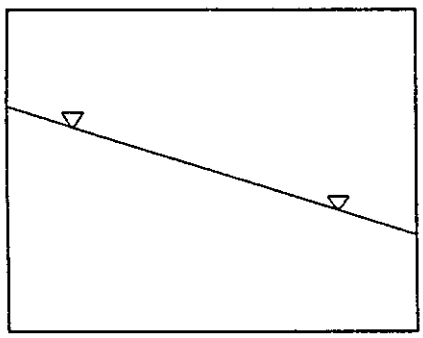
Marker set position with Fresnel reflection



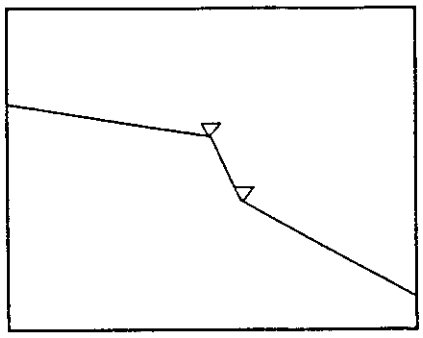
Marker set position for fracture point without Fresnel reflection

(2) Measurement of fiber loss or splice loss between two points

The relative value loss and the distance between two points of a fiber are measured using M1 and M2 markers. Set the markers at two given points in the fiber for fiber loss, and a splice change point for splice loss.



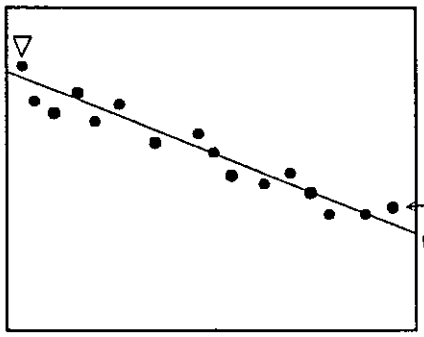
Marker set position for fiber loss

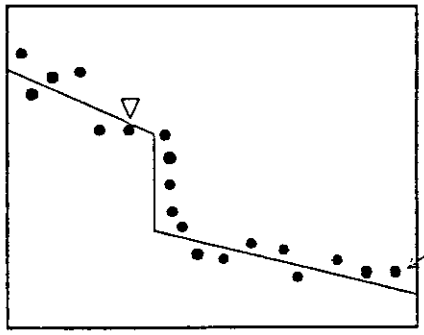


Marker set position for splice loss

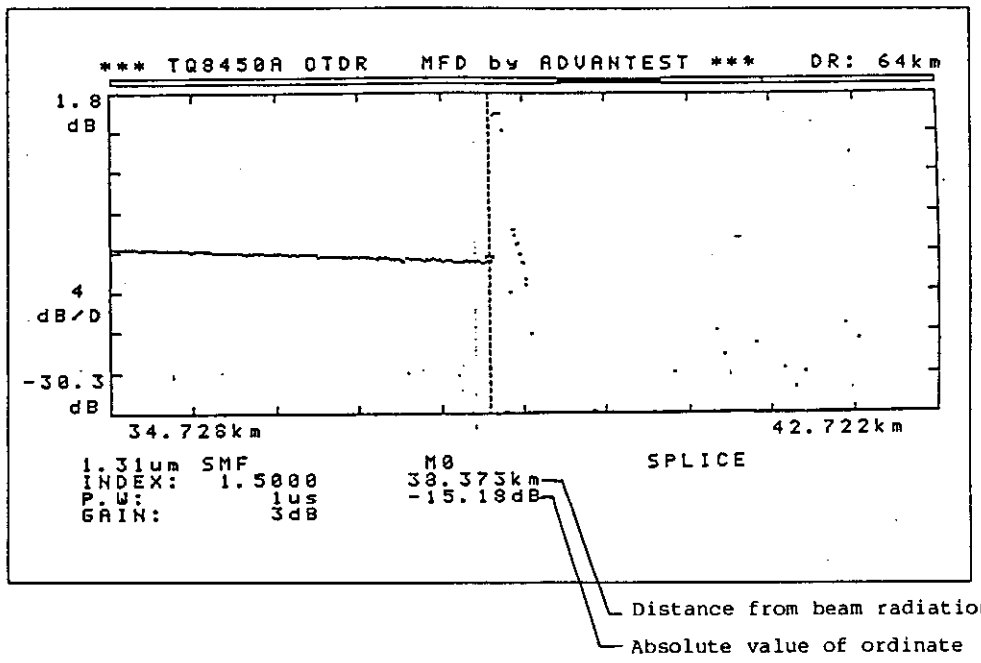
The measurement by this method can vary if there is considerable noise, so that a sizeable error results.

In the measurement of the splice loss, on the other hand, the splice point becomes ambiguous depending on the frequency band of the light-receiving amplifier or pulse duration, making it impossible to obtain an accurate value. If these values are to be determined more accurately, three markers should be used with the least square approximation method. (See the selection of SPLICE/LOSS modes.)

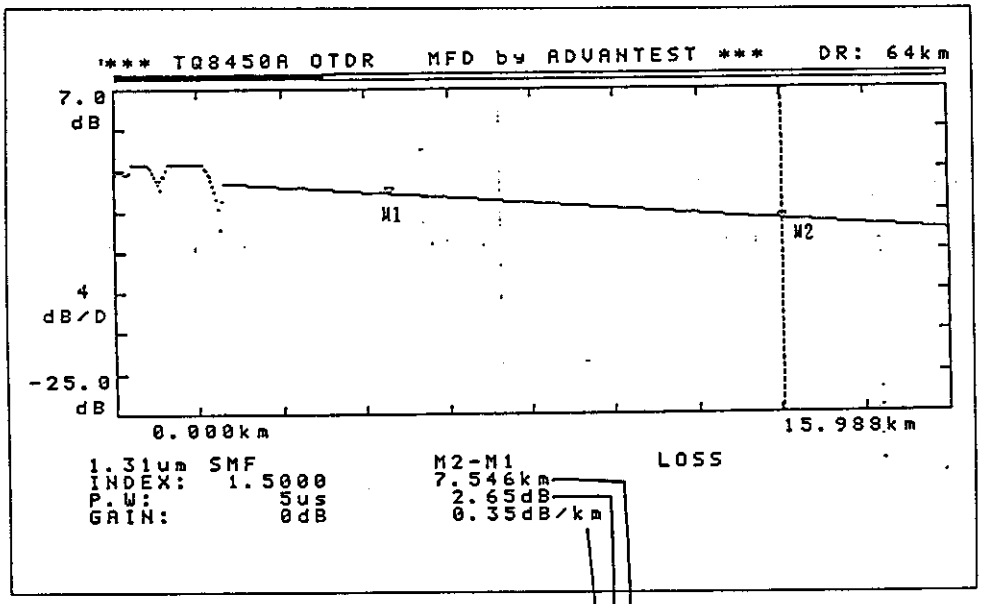




[Measurement of Fracture Point]

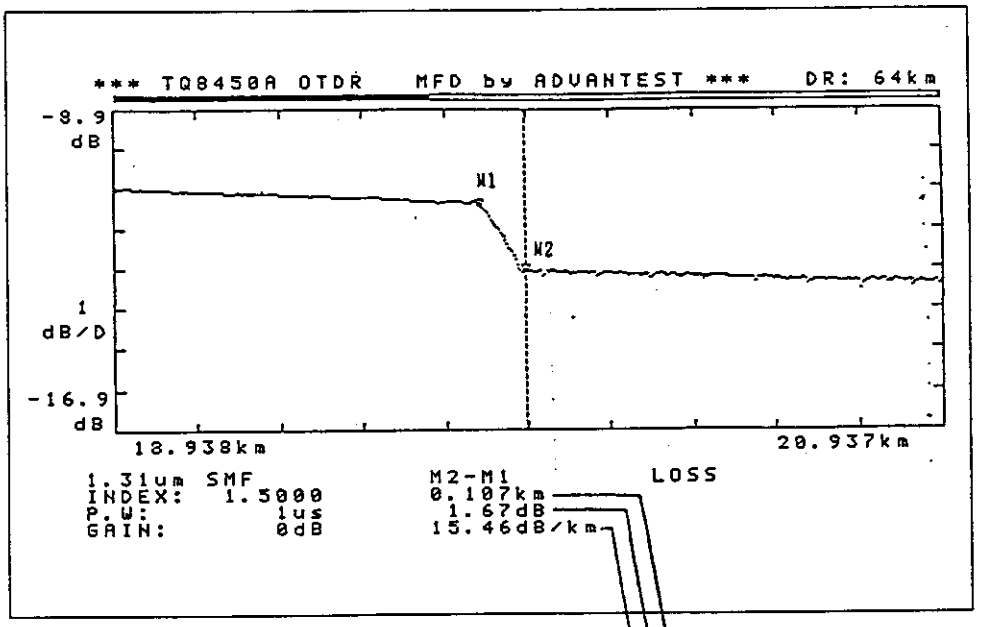


[Measurement of Fiber Loss by Two-Point Method]



Relative distance between M2 and M1
Relative loss between M2 and M1
Loss per unit length between M2 and M1

[Measurement of Splice Loss by Two-point Method]



Relative distance between M2 and M1
Relative loss between M2 and M1
Loss per unit length between M2 and M1

Depending on the LOSS/SPLICE mode and the marker on display, the display changes as follows:

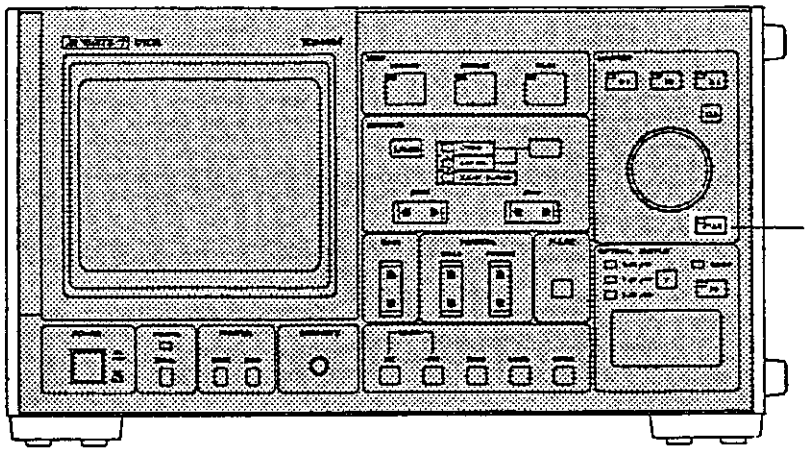
When only one marker is on display:
The distance and level of the marker

When two markers are on display:
Relative distance and relative loss between two markers

When three markers are on display:
LOSS : Relative distance and relative loss between M1 and M2
SPLICE: Distance and level of M1

3.3.13 Selection of SPLICE/LOSS Mode

The SPLICE mode is for determining the connection loss (splice loss) of a fiber. LOSS mode is for determining the loss of the fiber. Both are done by linear approximation (least square approximation (LSA)).



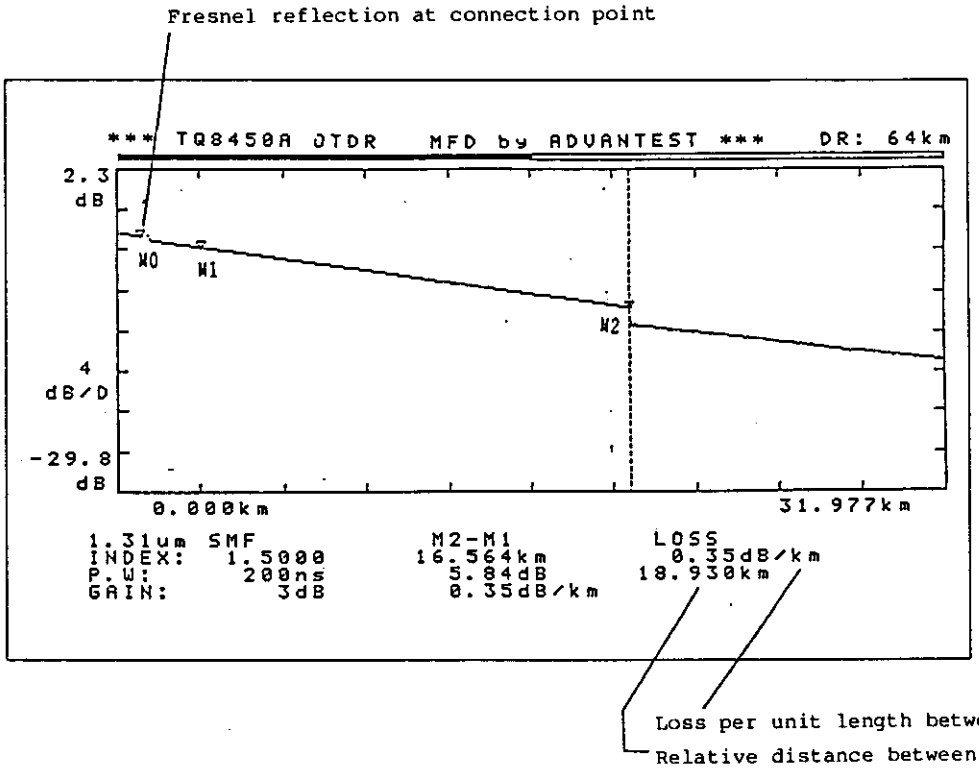
- When LED is off
  LOSS mode : Mode for measuring the loss between two normal points

- When LED is lit
  SPLICE mode: Mode for measuring the connection loss and fiber loss

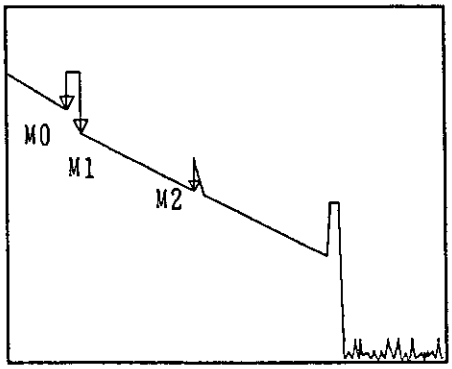
(1) Measurement in LOSS Mode (Measurement by LSA)

The M1 and M2 markers are set at two points on the fiber, and the approximate straight line between these is determined by LSA based on the available data, to display the loss. The use of the M0 marker makes it possible to determine the distance of the fiber using a dummy fiber from the beam output terminal.

[When the Fiber is Connected by a Dummy Fiber from the Beam Radiation Terminal.]

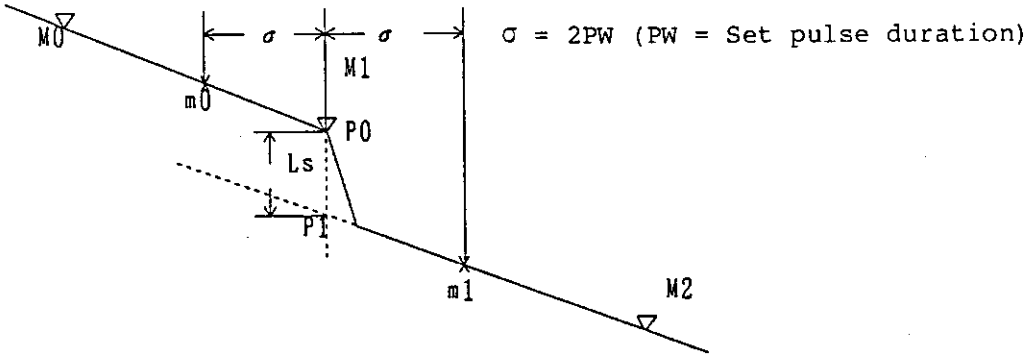


When M1 and M2 markers are set, be sure that there is no Fresnel reflection between M1 and M2. (Otherwise, an error may occur in linear approximation.)



(2) Setting in SPLICE Mode (Measurement by LSA)

The connection loss of a fiber is determined by using the M0, M1 and M2 markers.



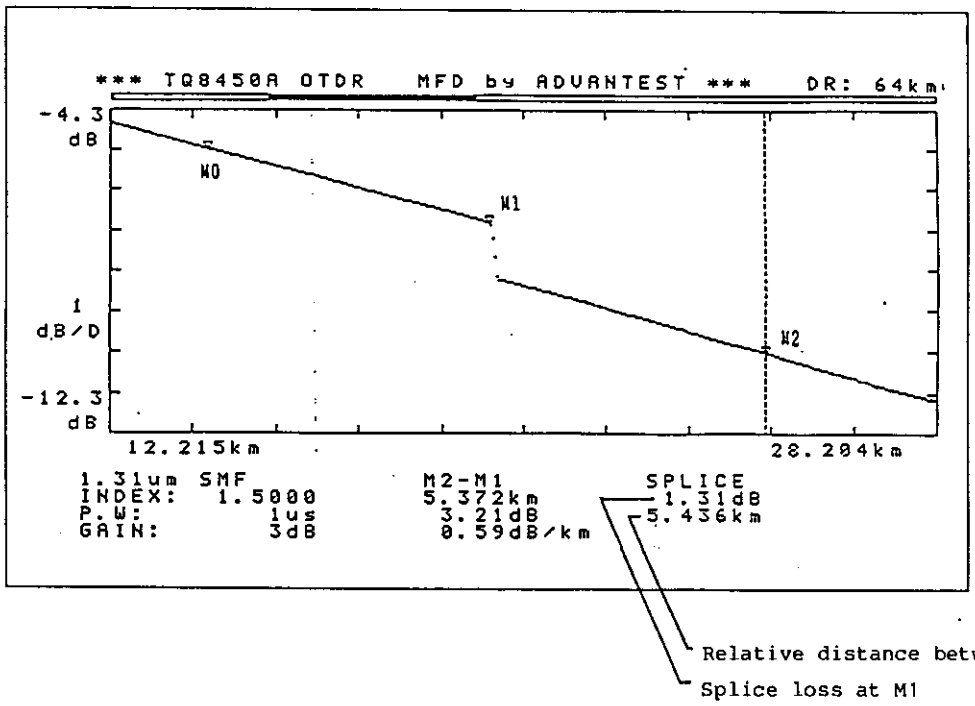
As shown, M1 is set at the point of splice change, and the M0 and M2 markers at given points of the fiber with the splice point at the center.

When the markers are set this way, points m0 and m1 are generated at the distance of σ with M1 at the center in order to effect internal caculation by LSA (no display on screen). On the assumption that the intersection with the approximate value from the data between M0 and m0 and m1 and M2 is P1, the level difference between P0 and P1 is regarded as a splice loss.

This setting at points σ distant from M1 is because Fresnel reflection may occur at point M1 or the splice loss may be inaccurate due to the frequency characteristics of the light-receiving amp or pulse duration, so that if an approximate line is determined from the data on the points near M1, the error may increase.

In setting this marker as in LOSS mode, make sure that there is no Fresnel reflection or splice loss between M0 and m0 or between M2 and m1.

[Measurement in SPLICE MODE]



3.3.14 VIDEO OUT

A composite video signal is produced from the VIDEO OUT connector on the rear panel. By connecting the video printer with the BNC connector cable, a hard copy of the screen can be obtained. To produce a hard copy, press the PAUSE key to stop the waveform in advance.

3.3.15 Direct Plot through GPIB

Measurement results can be automatically plotted by plotter when an applicable plotter is connected to the GPIB connector of this unit (TQ8450A).

(1) Plotter connecting

Only digital plotter of R9833 (produced by ADVANTEST Corp.) or HP7470A, HP7475A (produced by Hewlett Packard Corp.) can be connected with this unit. In these plotters, ISO A4 (210 x 297mm) and ANSI A (8 1/2"x 11") size paper can be used in lateral lines.

To connect this unit and each plotter, connect 24 pin GPIB connector on the rear panel of main unit and 24 pin GPIB connector on the rear panel of each plotter with GPIB standard bus cable.

(2) GPIB Address Switch Setting

Set talker only by setting talker only bit of address switch on the main-unit rear panel to 1 (See Figure 3-11.).
And set the GPIB address switch of the plotter (currently connected with the amin unit) to 31 (See Figure 3-12.).

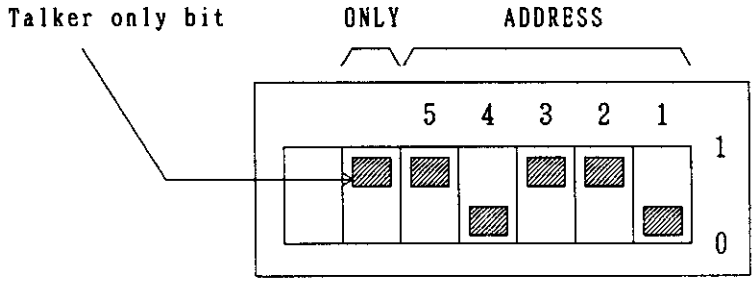


Figure 3 - 11 GPIB Address Switch of TQ450A

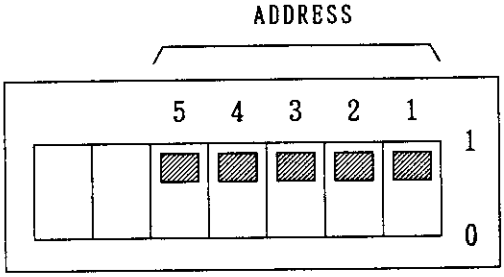


Figure 3 - 12 GPIB Address Switch of Plotter

(3) Operation

Depress LOCAL key and then PRINT key to automatically plot the measurement results by plotter. If only PRINT key is depressed, the measurement results is printed out onto the main unit built-in printer.

(4) Plot

In the automatic plotting by plotter, plotter pen number of 2 is used for drawing waveform while plotter pen number of 1 is used for the other. Waveform is output with solid line. Plotting example is shown in Figure 3-13.

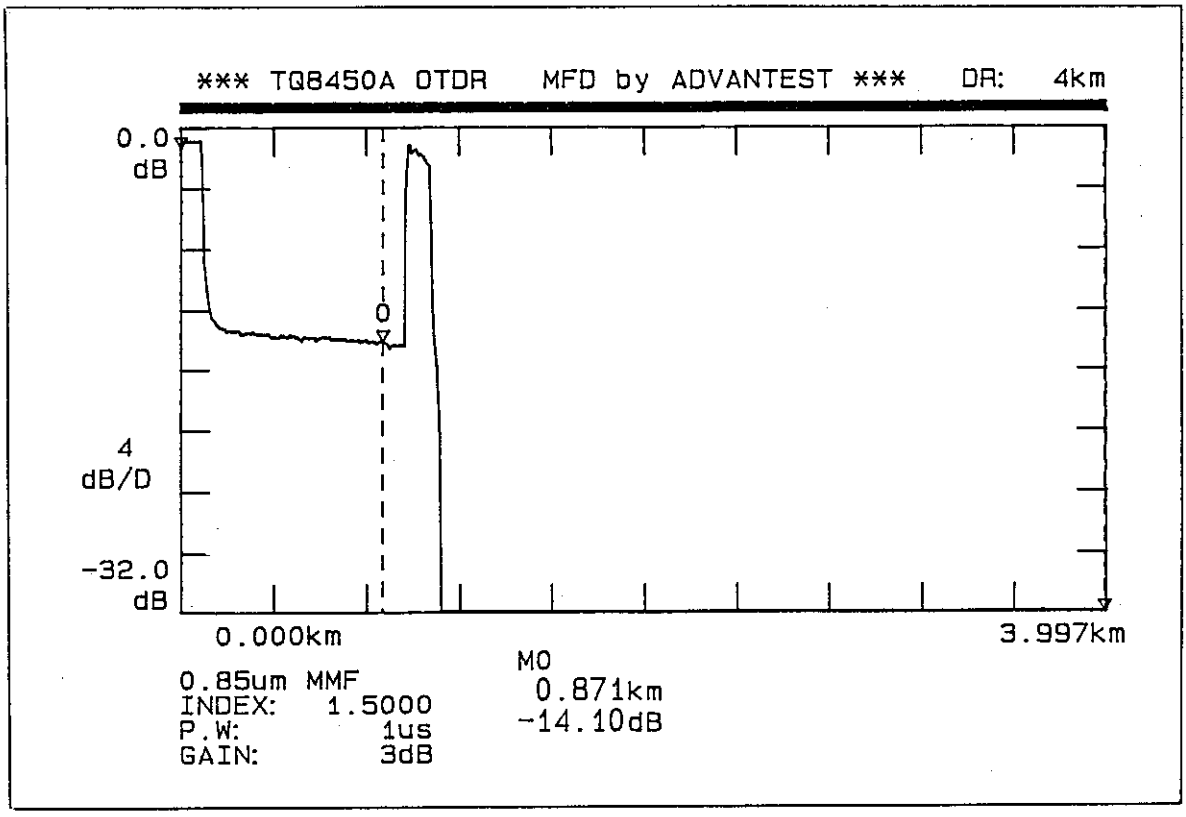


Figure 3 - 13 Example of Plot Output

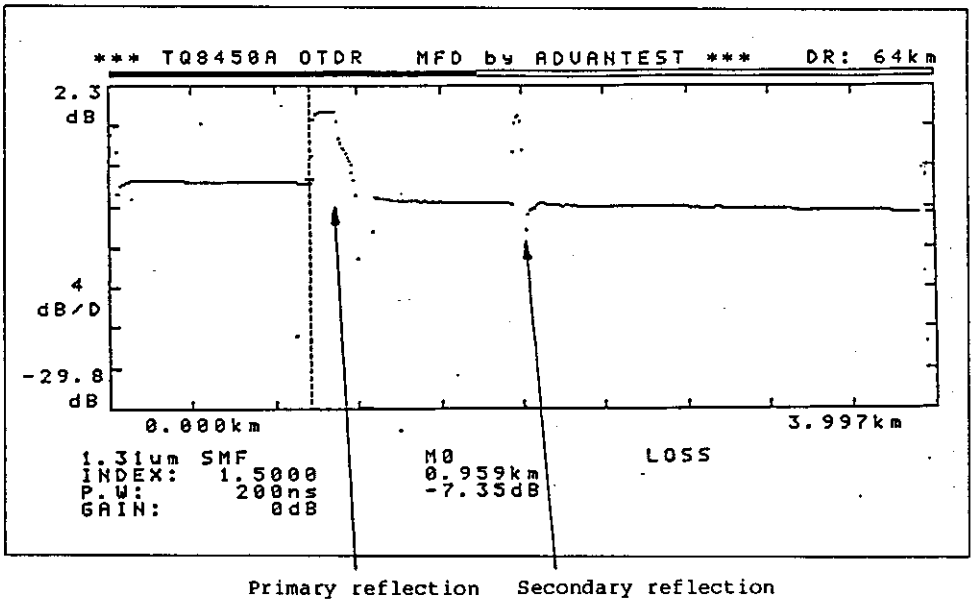
MEMO

4. MULTIPLE REFLECTION

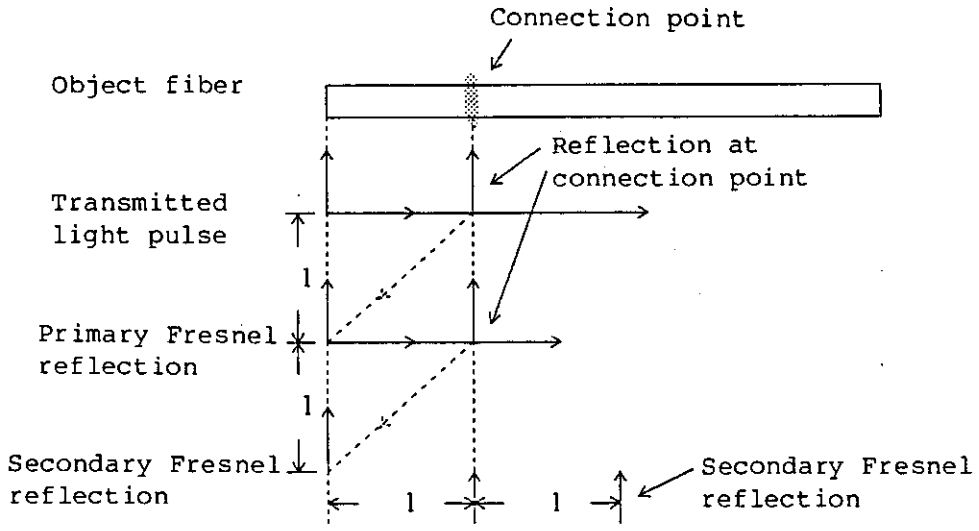
4.1 About Multiple Reflection

The light pulse sent from the beam radiation terminal is returned by Fresnel reflection from a fracture point of the fiber (primary Fresnel reflection), and is reflected again at the connection point of the beam radiation terminal, which in turn is returned as a Fresnel reflection from the fracture point (secondary Fresnel reflection).

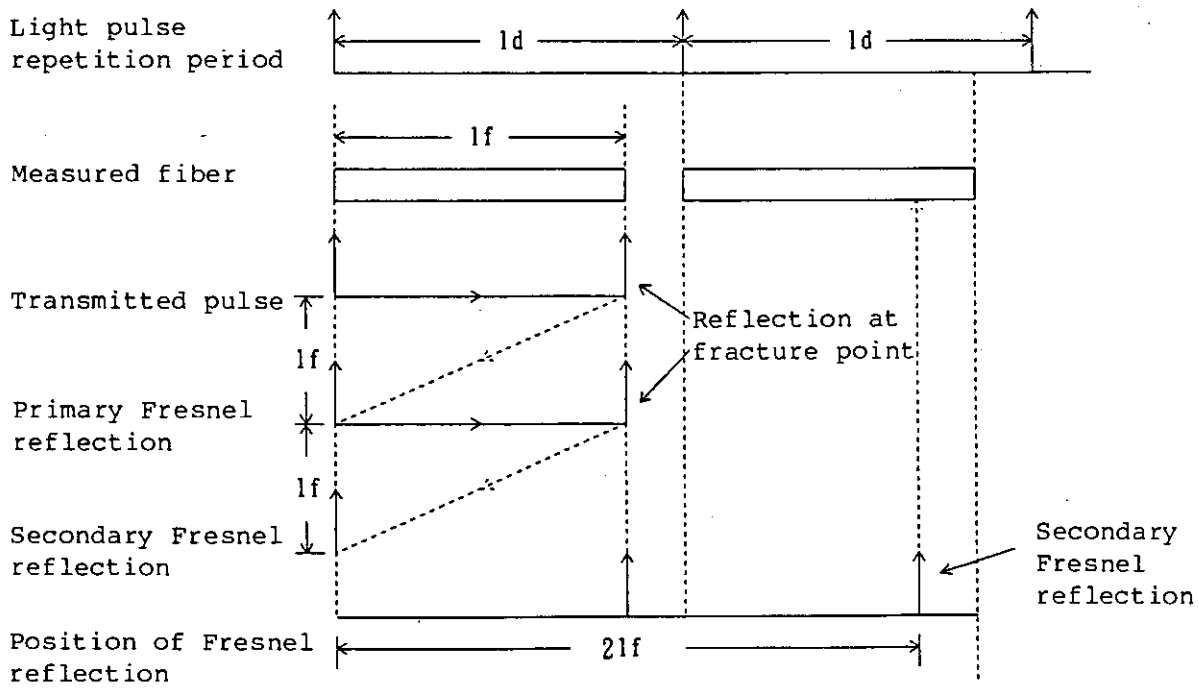
The repetitive reflections of the optical pulse sent out within an object fiber is called the multiple reflection. When this phenomenon occurs, Fresnel reflection may occur undesirably at a place other than the fracture point.



When a fiber with a connection point at the distance 1 from the beam radiation terminal is measured in the manner shown below, the secondary Fresnel reflection occurs at position 21. Actually, tertiary and quaternary reflections also occur, but are so low in level that they remain latent.



When measuring fiber having more than half of the repetition period of the light pulse, the secondary reflection occurs at the position indicated below.



Assume, as shown, that the light repetitive period is 1d, and the length of the fiber 1f and 1d is smaller than 21f. The primary Fresnel reflection occurs at the far end of the fiber, and the secondary Fresnel reflection at a point 21f in the distance.

This represents a position of 1f - (1d - 1f) from the radiation terminal of the fiber. If the distance range is set at 64km in this instrument, the repetition period of the transmitted light pulse is 860μs (corresponding to fiber length of about 86km). When a 60km fiber is measured in this range, the secondary Fresnel reflection occurs at a position specified below.

60 (km) - (86 (km) - 60 (km)) = 34 (km)

In order to erase these multiple reflections, perform the following operations:

(1) To prevent a large Fresnel reflection at a connection point, adjust the connection point or apply the matching oil (refractive index regulator).

(2) If multiple reflections seem to have occurred, increase the distance range. (Measure a distance range of at least twice the length of the fiber.)

MEMO

5. OPERATING PRINCIPLES

5.1 Basic Operating Principles (TQ8450A shown in Figure 5-1.)

The signal of a 100MHz crystal oscillator is frequency-divided according to the set distance range or span by a clock generator.

By use of this clock, a timing generator is actuated to generate timing for an adder circuit, an LD emitting trigger and a mask trigger. The LD emitting trigger signal produced from the timing generator is sent into the plug-in unit, thereby to illuminate the LD, whose light enters the object fiber. The optical signal returned from this point is converted into an electrical signal and sent to the main unit.

The signal thus sent is converted into a digital value by an A/D converter. The A/D converter is operated according to the clock generated at the clock generator, and converts data equivalent to a maximum of about 16000 points for each emitting LD. The data thus converted in added to the data of the same point of RAM1 at the adder circuit, and again stored in the RAM1. This is called averaging and is effective for removing the noise component.

This averaging process is done 256 times in MONITOR mode and 65536 times in AVERAGE mode.

Upon completion of the averaging process, the data is collected from RAM1 by CPU1 into RAM2 for log conversion. The data log-converted from RAM2 is moved on the bus of CPU2 controlling the display system through RAM3, and converted into a display data by the CRT controller and stored in the video RAM.

The CRT controller produces vertical and horizontal sync signals for driving the CRT. These signals are applied to the CRT driver together with the data in the video RAM and displayed on the CRT.

In the CRT driver, a composite signal is generated at the same time, and is produced externally as a video output connector.

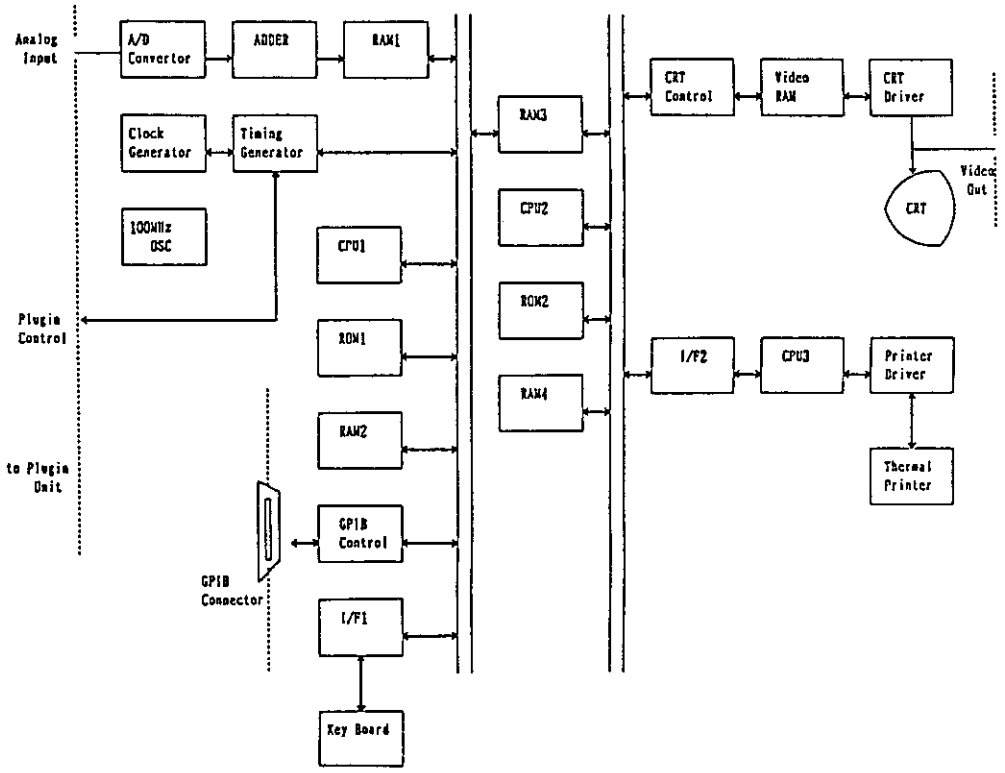


Figure 5 - 1 Block Diagram of TQ8450A

5.2 Principle of Plug-in Operation (See Block Diagram of Plug-in (Figure 5-2))

At the plug-in unit, an LD pulse generator generates an LD pulse duration corresponding to a set pulse duration on the basis of the LD trigger signal from the main unit. This signal is applied to the LD driver to illuminate the LD.

Two LD modules are available in the wavelengths of 1.31μm and 1.55μm for Q84521 and Q84522 respectively. These are switchable by a switch on the front panel.

The LD pulse is also applied to the mask pulse generator to produce a mask signal that drives the A/O driver, so that the A/O switch is actuated to prevent the Fresnel reflection at the beam radiation terminal from entering the light-receiving side. This prevents the deterioration of linearity which otherwise might be caused by amplifier saturation at the time of excessive input. Also, the A/O switch is actuated when a mask timing trigger signal is applied from the body of the mask pulse generator, thus masking the Fresnel reflection at a given point.

A thermo control regulates the temperature at 25^{o}C all the time to prevent fluctuations of wavelength or output with LD temperature. When the LD temperature is not operable, a signal is produced to the TQ8450A side to stop LD emitting.

The lighting pulse is applied to the fiber. The light returned from the fiber is photo-electrically converted at APD. The signal thus converted is amplified through an I-V converter and an amplifier, and sent to the main unit. The level of the light returned is different for different wavelengths or pulse durations, and therefore the applicable level must be adjusted with the amplifier gain. This is effected by applying a gain control signal.

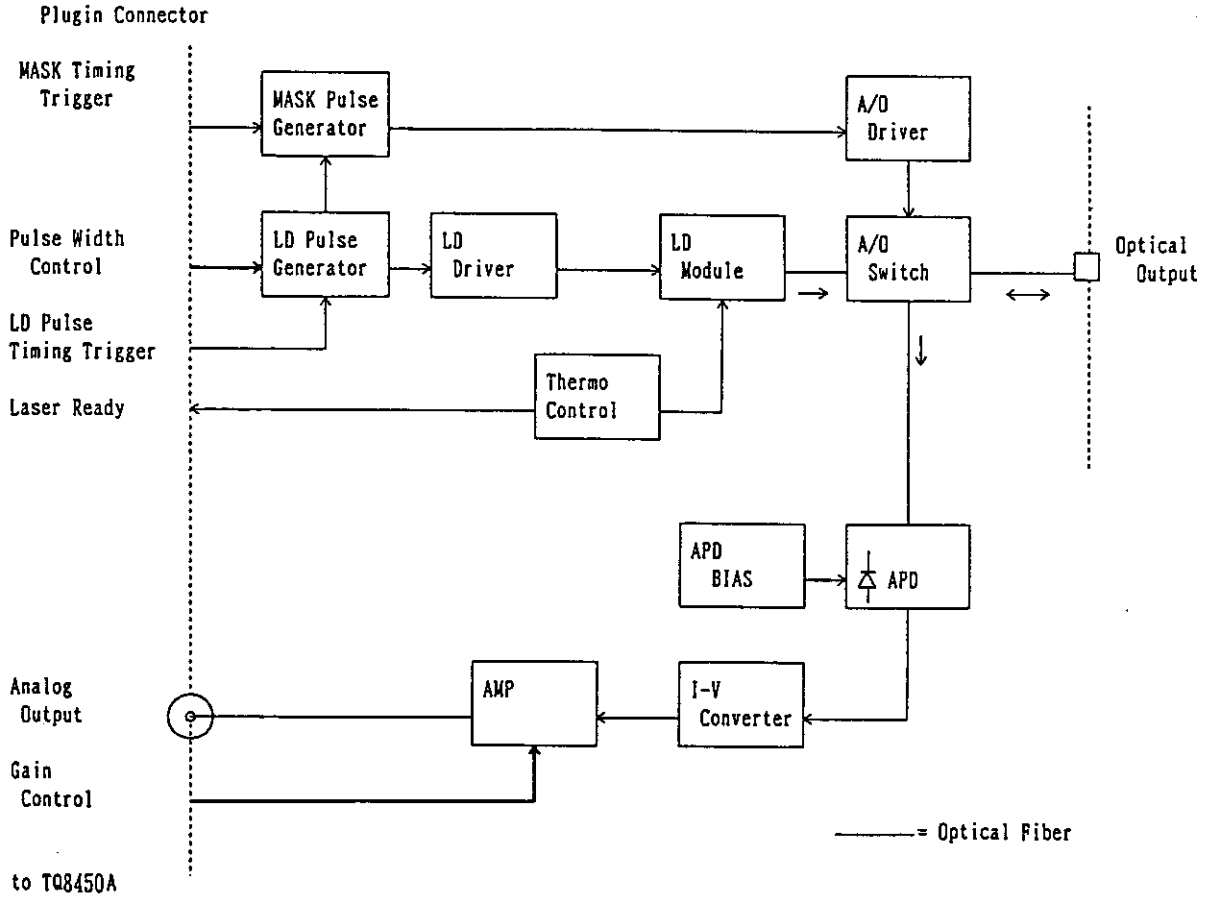


Figure 5 - 2 Plug-in Block Diagram

6. GPIB: REMOTE CONTROL

6.1 General

This instrument is capable of remote control by a measurement bus GPIB (general-purpose interface bus) of IEEE standard 488-1978, provided with the instrument.

6.1.1 Outline of GPIB

GPIB is an interface system for connecting the instrument to a controller or peripheral equipment by a simple bus cable, to configure an automatic measurement system.

Compared with conventional interfaces, it is superior in expandability, and is compatible with other makes electrically, mechanically and functionally. This device enables system configurations ranging from simple ones using a single bus cable to those with sophisticated functions.

In the GPIB system, an address is set in each component unit connected to the bus line. Each component unit takes charge of at least one of the three functions - controller, talker and listener. Only one talker can send data to the bus line. This data can be received by multiple listeners.

The controller designates the addresses of the talker and the listener, and transfers data from the talker to a listener or sets the measurement conditions for the listeners from the controller (talker).

Eight data lines of bit-parallel or byte-serial type are used for data transfer between component units. Two-way transmission is effected asynchronously. Being an asynchronous system, this device can be equipped with a mixture of high- and low-speed units.

The data exchanged between the units (messages) includes measurement data, measurement conditions (programs) and various commands using ACSII codes.

In addition to the data lines, three handshake lines are available for controlling the asynchronous data exchange between component units, as well as five control lines for controlling the flow of information on the bus.

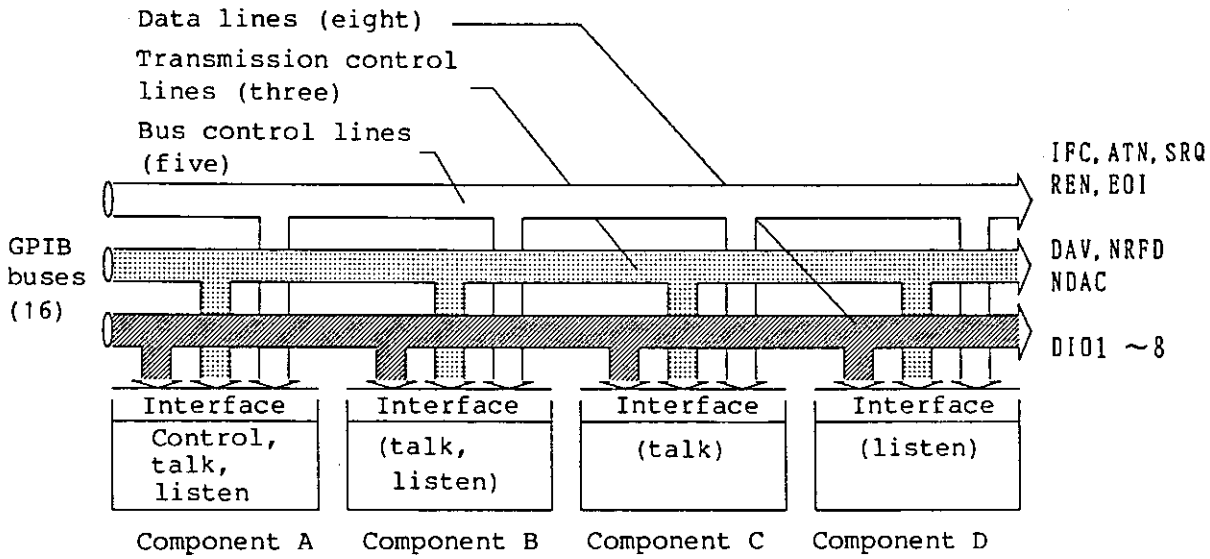


Figure 6 - 1 GPIB Bus Line

- The following signals are used for the handshake line.

DAV (Data valid)	:	Signal indicating the effectiveness of data
NRFD (Not Ready For Data)	:	Signal indicating the receivability of data
NDAC (Not Data Accepted)	:	Signal indicating complete receiving

- The following signals are used for the control line.

ATN (Attention)	:	Signal for discriminating whether the signal on the data line is an address, command or other signal
IFC (Interface Clear)	:	Signal for clearing the interface
EOI (End or Identify)	:	Signal used at the end of data transfer
SRQ (Service Request)	:	Signal use for requesting controller service from a given unit
REN (Remote Enable)	:	Signal for remote-control of a remote-programmable unit

6.1.2 GPIB Standard and GPIB Specifications for this Instrument

Applicable standard: IEEE488-1978

Code : ASCII, or for packed format, binary code

Logic level : Logic "0" (high) + 2.4V or more
Logic "1" (low) + 0.4V or less

Driver spec : Open collector type (except for EOI, DAV)
"Low" state output voltage + 0.4V or less, 48mA
"High" state output voltage + 2.4V or more, -5.2mA

Receiver spec : "Low" for +0.6V or less, and "high" for 2.0V or more

Address designation: Thirty-one types of talk/listen addresses set as desired by ADDRESS switch

Cable length : The length of bus cable is limited as below.
(Number of units connected with bus) x (2m or less) < 20m

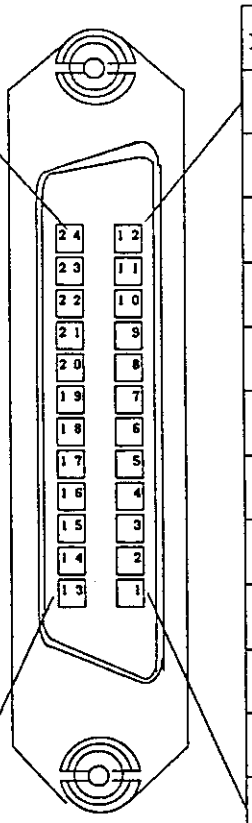
Interface function :

Table 6 - 1 Interface Function

Code	Function and description
SH1	Source handshake function
AH1	Accepter handshake function
T5	Basic talker, serial poll, talker-only (*), talker cancel by listener designation
L4	Basic listener, listener cancel by talker designation
SR1	Service request
RL1	Remote
PP0	No parallel function
DC0	Device clear
DT0	Device trigger
C0	No controller function
E2	Tri-state output

Connector: 24-pin GPIB connector 57-20240-D35A

Signal	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
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 6 - 2 GPIB Connector

6.1.3 Connecting Component Units

The GPIB system is configured by multiple units. When setting up the system, take care of the following points:

(1) Refer to the operation manuals for the controller, peripheral equipment, and so forth, to check the conditions and operation of each unit in advance.

(2) Make sure that the cable for connecting the measuring instrument and the bus cable for connecting the controller is not too long. The length of the bus cable should be within the range specified as standard. The lengths specified for all bus cables are as follows:

(Number of units connected to bus) x (2m or less) $<$ 20m

The following standard bus cables are available from ADVANTEST:

Table 6 - 2 Standard Bus Cables (Optional)

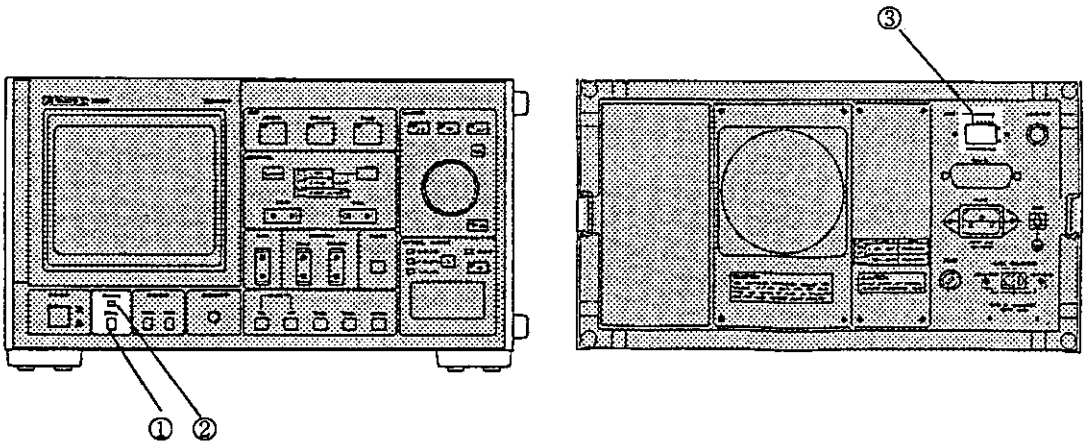
Length	Name
0.5m	408JE-1P5
1m	408JE-101
2m	408JE-102
4m	408JE-104

(3) Each bus cable has piggyback-type male and female connectors, which may joined. Do not use more than three connectors joined together. Firmly secure these with connector fastening screws.

(4) Before powering up each unit, check the power, ground and setting conditions.

Be sure to turn on the power of all the units connected to the bus. If any unit is not turned on, the operation of the whole system may fail.

6.1.4 Description of Parts on GPIB-related Panel



Front panel Rear panel

① LOCAL Key

: When the instrument is under remote control (REMOTE lamp lit), external control is cancelled, to make the panel key input effective. This key is in LOCAL mode when at power-up.

② REMOTE LED

: This lamp lights when the instrument is under control of the controller. In this status, setting by the keys on the front panel is impossible.

③ GPIB Address Switch

: The first to fifth bits of the ADDRESS switches make up a DIP switch for address setting on the instrument's GPIB.

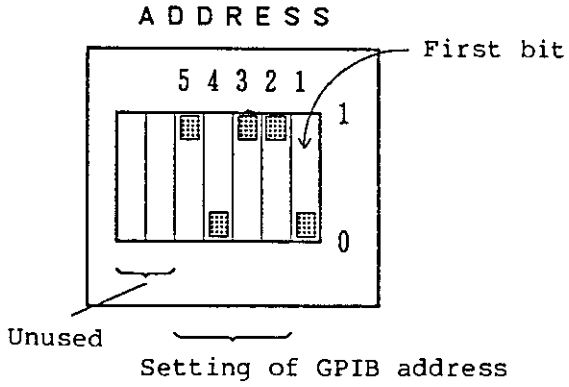


Figure 6 - 3 GPIB Address Switch

CAUTION

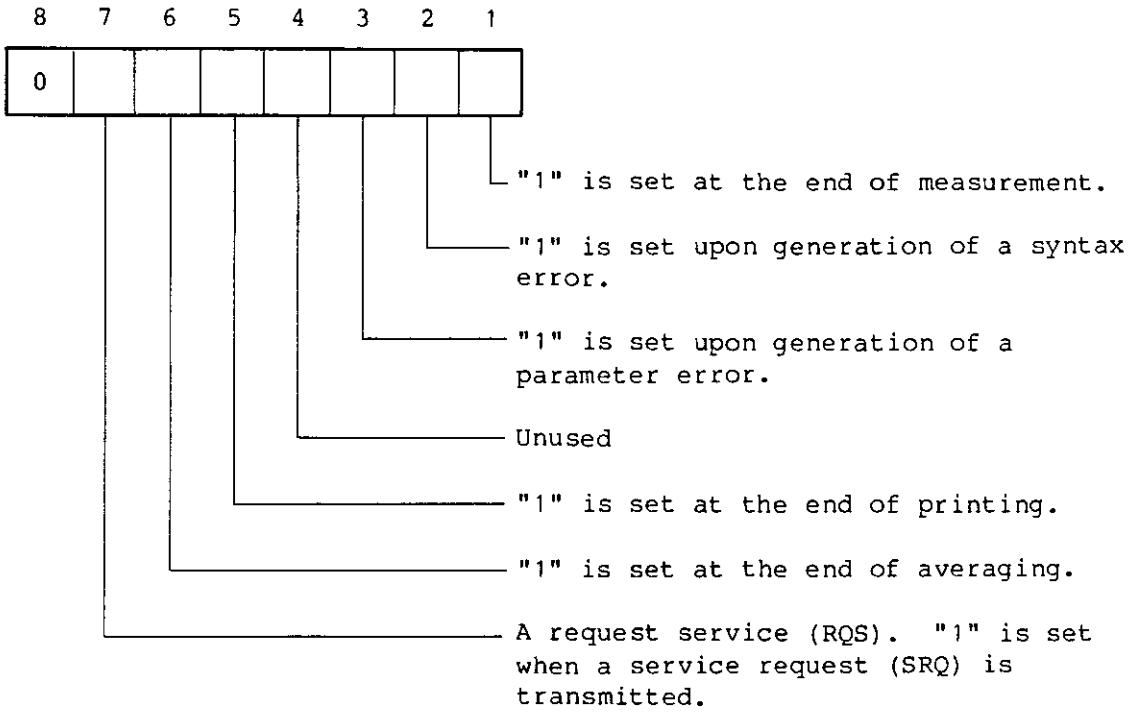
Set the address code before turning on the POWER switch.

6.2 Service Request

This instrument transmits a service request (SRQ) to the control when "1" is set to each bit of the status byte in the SO mode.

When a service request is transmitted, the status byte is transmitted by executing the serial poll from the control.

[Status Byte]



6.3 GPIB Commands

6.3.1 Condition-setting Command

A condition-setting command is one for setting the instrument from a personal computer.

Table 6 - 3 List of Condition-setting Commands

Command	Parameter	Function	Initialization
C	Nil	Similar to "SDC" or "DCL" (No change in set condition)	
Z	Nil	All setting initialized	
Sn	n=0 n=1	Service request transmitted. No service request transmitted.	S1
SMKn	Nil	Service request masked.	0
DLn	n=0 n=1 n=2	Delimiter mode CR/LF + EOI, Delimiter mode LF alone, Delimiter mode EOI alone	DL0
SLn	n=0 n=1	String delimiter ",", String delimiter LF	
MON	Nil	Set to MONITOR.	
AVE	Nil	Set to AVERAGE.	
PSE	Nil	Set to PAUSE.	
PRT	Nil	Printer output	
PFD	Nil	Paper feed	
PSP	Nil	Printer stop	
CLR	Nil	MARKER cleared.	
MKRn	n=0 n=1 n=2	Marker 0 indicated, Marker 1 indicated, Marker 2 indicated	
MSKn	n=0 n=1	Mask off Mask on	
LSRn	n=0 n=1	LASER OFF LASER ON	

Note: The maximum number of characters on a line for command processing is 80.

Table 6 - 3 List of Condition-setting Commands (Cont'd)

Command	Parameter	Function	Initialization
DRn	n=0 n=1 n=2 n=3 n=4 n=5	DISTANCE RANGE 128km DISTANCE RANGE 64km DISTANCE RANGE 32km DISTANCE RANGE 16km DISTANCE RANGE 8km DISTANCE RANGE 4km	
XSTnn	nn=0 to 128	EXPAND START	
XS_p n	nn=0 to 8	EXPAND SPAN	
SSTnn	nn=0 to 128	STORE EXPAND START	
SSPn	nn=0 to 5	STORE EXPAND SPAN	
VPS	nn=-30 to -15	VERTICAL POSITION	
VSLn	n=0 n=1 n=2 n=3	VERTICAL SCALE 4dB/DIV VERTICAL SCALE 2dB/DIV VERTICAL SCALE 1dB/DIV VERTICAL SCALE 0.5dB/DIV	
GANn	n=0 n=1 n=2 n=3	GAIN 0dB/VID GAIN 3dB/VID GAIN 6dB/VID GAIN 9dB/VID	
PWn	n=0 n=1 n=2 n=3	PULSE WIDTH 5µsec PULSE WIDTH 1µsec PULSE WIDTH 200nsec PULSE WIDTH 50nsec	
IDXnn	nn=1.4 to 1.5	INDEX	
LSSn	n=0 n=1	LOSS SPLICE	
WLn	n=0 n=1 n=2	λ = 0.85µm λ = 1.31µm λ = 1.55µm	

Table 6 - 3 List of Condition-setting Commands (Cont'd)

Command	Parameter	Function	Initialization
MKAnn	nn= 0 to 500	MARKER 0 moved	
MKBnn	nn= 0 to 500	MARKER 1 moved	
MKCnn	nn= 0 to 500	MARKER 2 moved	
LBLnn	LABEL set. nn = A train of characters surrounding the same special character.		

6.3.2 Read Command

A read command is one for transmitting data from the instrument to a personal computer.

Table 6 - 4 List of Read Commands

Command	Function
RMKR	Read MARKER read-out
RLSS	Read of loss between markers or splice distance
RPI	Read plug-in unit connected.
RGAN	Read gain.
RVSL	Read vertical scale.
RVPS	Read vertical position.
RDR	Read distance range
RST	Read START.
RSP	Read SPAN.
RPW	Read pluse width.
RIDX	Read index.
RLBL	Read label.

The format of the read command shown in Table 6-4 above is as follows:

Table 6 - 5 Format of Read Command

Command	Format
RMKR	□□0.475 km□□□, □□□□1.3 dB□□□, □□□2.73 dB/km Seven characters / Five characters / Seven characters / Five characters / Seven characters / Five characters This part is left blank in the absence of three displays (M0, M1, M2) of the marker.
RLSS	□□-0.61 dB/km, □□0.883 km□□□ Seven characters / Five characters / Seven characters / Five characters
RPI	1.31μm SMF Ten characters
RGAN	□□□□6dB Seven characters
RVSL	□□2□dB/D Eight characters
RVPS	□-0.3dB Seven characters
RDR	□64km Five characters
RST RSP	□15.605km Nine characters
RPW	□□□50ns Seven characters

Table 6 - 5 Format of Read Command (Cont'd)

Command	Format
RIDX	□1.5000 Seven characters
RLBL	**TQ8450A ** 40 characters

The read command for screen display data is one for designating the format used when the screen display data of the instrument is transmitted to a personal computer.

Table 6 - 6 Read Command for Waveform Data and Format

Command	Function
RDTB	Binary output 1 byte/data Output with tube surface lower limit as 0 and upper limit as 255. Minimum data amount □□□□□□□□ ..... Delimiter
RDTW	Binary output 2 bytes/data Of the two bytes, the higher order byte represents an integer, the lower order byte the decimal portion. □□□□□□□□ ..... Delimiter
RDTL	Binary output 4 bytes/data Of the four bytes, the most significant two bytes represent the integral part, and the least significant two bytes the decimal part. □□□□□□□□ ..... Delimiter
RDTS	ASCII output 7 bytes/data In the character train, "," or LF is produced as a string delimiter. -XXX. XX, -XXX. XX, ... Delimiter String delimiter

6.4 Program Examples

Program examples using FACOM 9450 and HP200 Series Controller are shown below.

6.4.1 Program Example Using FACOM 9450

(1) Read the Tube Waveform Data by Two Bytes, Binary Format.

```
1000  OPTION BASE 1
1010  OPEN #5:$IBO
1020  EOR #5:'OA'
1030  IFC #5
1040  SDC #5:2
1050  WAIT DELAY 1
1060  CONNECT #5:30=2
1070  OUTPUT #5:"RDYW"&@OD@
1080  CLOSE #5
1090  !!
1100  !!
1110  OPEN #5:IBO,FIXED(1004)
1120  EOR #5:'OA'
1130  IFC #5
1140  WAIT DELAY 1
1150  CONNECT #5:30=2
1160  DIM A%(1004)
1180  GET #5:A%
1200  FOR I=1 TO 501
1200   PRINT A%(I)
1210  NEXT I
1250  CLOSE #5
1260  END
```

Output data format, 2 bytes, binary, output designation,
Significant byte
: Integral part
Least significant byte
: Decimal part

Input data 1004 bytes (including delimiters "OA" and "OA")

Data input

6.4.2 Program Example Using HP200 Series Controller

(1) Setting of Measurement Conditions

```
10    !
20    !         Example program 1
30    !
40    !         Measurement setup
50    !
60    INTEGER Tq
70    Tq=701                      ! GPIB address of TQ8450A OTDR
80    !
90    OUTPUT Tq;"MON"             ! Monitor mode
100   OUTPUT Tq;"LSR1"            ! turn on laser output
120   OUTPUT Tq;"IDX1.4657"       ! refractive index = 1.4657
130   OUTPUT Tq;"DR2,PW1,GAN1"    ! distance range = 32km range
140                               ! pulse width    = 1μm
150                               ! gain           = 3dB
160   OUTPUT Tq;"XSP5,XST10"      ! span           = 16km
170                               ! start          = 10km
190   END
```

(2) Reading of Data from OTDR

```
10   !
20   !        Example program 2
30   !
40   !        Read setup of OTDR
50   !
60   INTEGER Tq
70   DIM Pi$ [40] , Dr$ [40] , St$ [40] , Sp$ [40] , Pw$ [40] ,
     Gain$  [40] , Index$ [40]
80   Tq=701                              ! GPIB address of TQ8450A OTDR
90   !
100  OUTPUT Tq;"RPI"                     ! read plug in
110  ENTER Tq;pi$
120  OUTPUT Tq;"RIDX"                    ! read refractive index
130  ENTER Tq;Index$
140  OUTPUT Tq;"RDR"                     ! read distance range
150  ENTER Tq;Dr$
160  OUTPUT Tq;"RST"                     ! read start distance on CRT
170  ENTER Tq;St$
180  OUTPUT Tq;"RSP"                     ! read distance span on CRT
190  ENTER Tq;Sp$
200  OUTPUT Tq;"RPW"                     ! read pulse width
210  ENTER Tq;Pw$
220  OUTPUT Tq;"RGAN"                    ! read gain
230  ENTER Tq;Gain$
240  !
250  PRINT "plug in          =",Pi$
260  PRINT "refractive index =",Index$
270  PRINT "distance range   =",Dr$
280  PRINT "start            =",St$
290  PRINT "span             =",Sp$
300  PRINT "pulse width      =",Pw$
310  PRINT "gain             =",Gain$
320  END
```

(3) Service Request

```
10   !
20   !         Example program 3
30   !
40   !         Service request
50   !
60   INTEGER Tq, Select_code
70   INTEGER Srqmask
80   Tq=701                              ! GPIB address of TQ8450A OTDR
90   Select_code=Tq DIV 100              ! GPIB select code
100  !
110  Srqmask=IVAL("00011111",2)          ! only average complete
120  OUTPUT Tq;"SMK";Srqmask             ! set mask
130  OUTPUT Tq;"SO"                      ! enable service request
140  ON INTR Select_code GOTO Ave_end
150  ENABLE INTR Select_code;2
160  !
170  OUTPUT Tq;"AVE"                     ! start averaging
180 Sleep:GOTO Sleep                     ! wait for interruption
190 !
200 Ave_end:BEEP
210   PRINT "average completed."
220   END
```

(4) Read the Tube Surface Waveform by One Byte, Binary Format.

```
10   !
20   !         Example program 4
30   !
40   !         Read data block by 1 byte format
50   !
60   INTEGER Tq
70   DIM Dbuf$ [503] , Y(0:500)
80   Tq=701                          ! GPIB address of TQ8450A OTDR
90   !
100  OUTPUT Tq;"DLO"                 ! delimiter CR,LF+EOI
110  OUTPUT Tq;"RDTB"
120  ENTER Tq;Dbuf$                  ! data 501bytes,delimiter 2 bytes
130  FOR I=0 TO 500
140    Y(I)=NUM(Dbuf$ [I+1;1] )      ! format conversion
150  NEXT I
160  END
```

(5) Read the Tube Surface Waveform Data by 2-byte Binary Format.

```
10   !
20   !          Example program 5
30   !
40   !          Read data block by 2 bytes format
50   !
60   INTEGER Tq
70   REAL Y(0:500)
80   INTEGER Dbuf(0:501)
90   REAL A
100  Tq=701                        ! GPIB address of TQ8450A OTDR
110  !
120  OUTPUT Tq;"DLO"               ! delimiter CR,LF+EOI
130  OUTPUT Tq;"RDTW"
140  ENTER Tq USING "#,W"Dbuf(*)
150  REDIM Dbut(0:500)
160  A=1/256
170  MAT Y= Dbuf*(A)
180  END
```

(6) Read the Tube Surface Waveform by Four-byte Binary Format.

```
10   !
20   !          Example program 6
30   !
40   !          Read data block by 4 bytes format
50   !
60   INTEGER Tq
70   REAL Y(0:500)
80   INTEGER Dbuf(0:1002)
90   REAL F,X,Z
100  Tq=701                        ! GPIB address of TQ8450A OTDR
110  !
120  OUTPUT Tq;"DLO"               ! delimiter CR,LF+EOI
130  OUTPUT Tq;"RDTL"
140  ENTER Tq USING "#,W,;Dbuf(*)
150  F=2^(-16)
160  FOR I=0 TO 500
170    X=Dbuf(2*I+1)*F
180    IF X<0 THEN X=1+X
190    Z=Dbuf(2*I)
200    Y(I)=Z+X
210  NEXT I
220  END
```

(7) Read the Tube Surface Data by ASCII Data.

```
10   !
20   !         Example program 7
30   !
40   !         Read data block by 8 bytes format
50   !
60   INTEGER Tq
70   DIM Dbuf$(0:500) [8] , D$  [2] , Y(0:500)
80   Tq=701                              ! GPIB address of TQ8450A OTDR
90   !
100  OUTPUT Tq;"DLO"                     ! delimiter CR,LF+EOI
110  OUTPUT Tq;"RDTS"
120  ENTER Tq;"Dbuf$(*);D$
130  FOR I=0 TO 500
140    Y(I)=VAL(Dbuf$(I))
150  NEXT I
160  END
```

7. PERFORMANCE SPECIFICATIONS

TQ8450A (1/2)

Type			TQ8450A
Distance range (km)			16, 32, 64, 128
Read Resolution			Minimum 1m
Abscissa	Span (km)	16km Range 32km Range 64km Range 128km Range	0.5, 1, 2, 4, 8, 16 0.5, 1, 2, 4, 8, 16, 32 0.5, 1, 2, 4, 8, 16, 32, 64 0.5, 1, 2, 4, 8, 16, 32, 64, 128
	Accuracy		$\pm 3m \pm 2 \times 10^{-5}$ x measurement (m), except error due to collective refractive index
Ordinate	Scale		0.5/1/2/4(dB/div) x 8div.
	Read resolution		0.01dB
	Linearity		0 to 5dB : ±0.3dB or less 0 to 10dB: ±0.5dB or less 0 to 15dB: ±0.7dB or less
Averaging process		Monitor mode	2^8 times (Specified time: approx. 0.7secs)
		Average mode	Maximum 2^{16} times (Measurement time: approx. 60secs; 64km range: 64km span)
Setting of collective refractive index			Fiber refractive index may be set in steps of 0.0001 from 1.4000 to 1.6000.
Marker setting			Setting possible up to a maximum of three points
Mask function			Setting possible up to a maximum of 3 points by optical method
Memory function			Measurement conditions immediately before power-off are stored
CRT			5.5 inches
Interface			GPIB provided as standard equipment (As per IEEE488-1978)
Printer			CRT screen produced in hard copy by built-in thermal printer
Video output			Output impedance 75Ω, composite signal (NTSC system), BNC connector

TQ8450A (2/2)

Operating environment range	Ambient temperature 0°C to +40°C, relative humidity 85% or less
Storage environment range	Ambient temperature -20°C to +60°C
Power supply	AC 90V to 132V, 48 to 66Hz AC198V to 250V, 48 to 66Hz
Power consumption	160VA or less
Outline	Approx. 330(W) x 177(H) x 450(D) mm
Weight	Approx. 14kg (including plug-in unit)

Q84501/Q84502/Q84503/Q84505/Q84506/Q84521/Q84522 (1/4)

Main unit		TQ8450A							
Plug-in unit		Q84501				Q84502			
Applicable fiber		SMF				SMF			
Probe pulse	Wavelength (μm)	1.31 ±0.02				1.55 ±0.03			
	Pulse duration (μsec)	0.05	0.2	1	5	0.05	0.2	1	5
Dynamic range (unilateral rear scattered light)		13	16	20	23	10	13	17	20
Mask function		Available (optical)							
Optical connector		FC(*1)							
Laser product classification		21 CFR Class 1							

*1 For connectors other than FC, consult ADVANTEST.

Q84501/Q84502/Q84503/Q84505/Q84506/Q84521/Q84522 (2/4)

Main unit		TQ8450A							
Plug-in unit		Q84503				Q84505			
Applicable fiber		SMF				MMF			
Probe pulse	Wavelength (μm)	1.55 ±0.03				0.85 ±0.02			
	Pulse duration (μsec)	0.05	0.2	1	10	0.01	0.05	0.2	1
Dynamic range (unilateral rear scattered light)		16	19	22	27	11	15	18	22
Mask function		Available (optical)				Not available			
Optical connector		FC(*1)							
Laser product classification		21 CFR Class 1							

Q84501/Q84502/Q84503/Q84505/Q84506/Q84521/Q84522 (3/4)

Main unit		TQ8450A							
Plug-in unit		Q84506				Q84521			
Applicable fiber		MMF				SMF			
Probe pulse	Wavelength (μm)	1.31 ±0.02				1.31 ±0.02/1.55 ±0.03 Switchable			
	Pulse duration (μsec)	0.05	0.2	1	5	0.05	0.2	1	5
Dynamic range (unilateral rear scattered light)		13	17	21	24	12/10	15/13	19/17	22/20
Mask function		Available (optical)							
Optical connector		FC(*1)							
Laser product classification		21 CFR Class 1							

*1 For connectors other than FC, consult ADVANTEST.

Q84501/Q84502/Q84503/Q84505/Q84506/Q84521/Q84522 (4/4)

Main unit		TQ8450A			
Plug-in unit		Q84522			
Applicable fiber		SMF			
Probe pulse	Wavelength (μm)	1.31 ±0.02/1.55 ±0.03 Switchable			
	Pulse duration (μsec)	0.05	0.2	1	5
Dynamic range (unilateral rear scattered light)		17/14	20/17	23/20	28/25
Mask function		Available (optical)			
Optical connector		FC(*1)			
Laser product classification		21 CFR Class 1			

*1 For connectors other than FC, consult ADVANTEST.

LIST OF FIGURES

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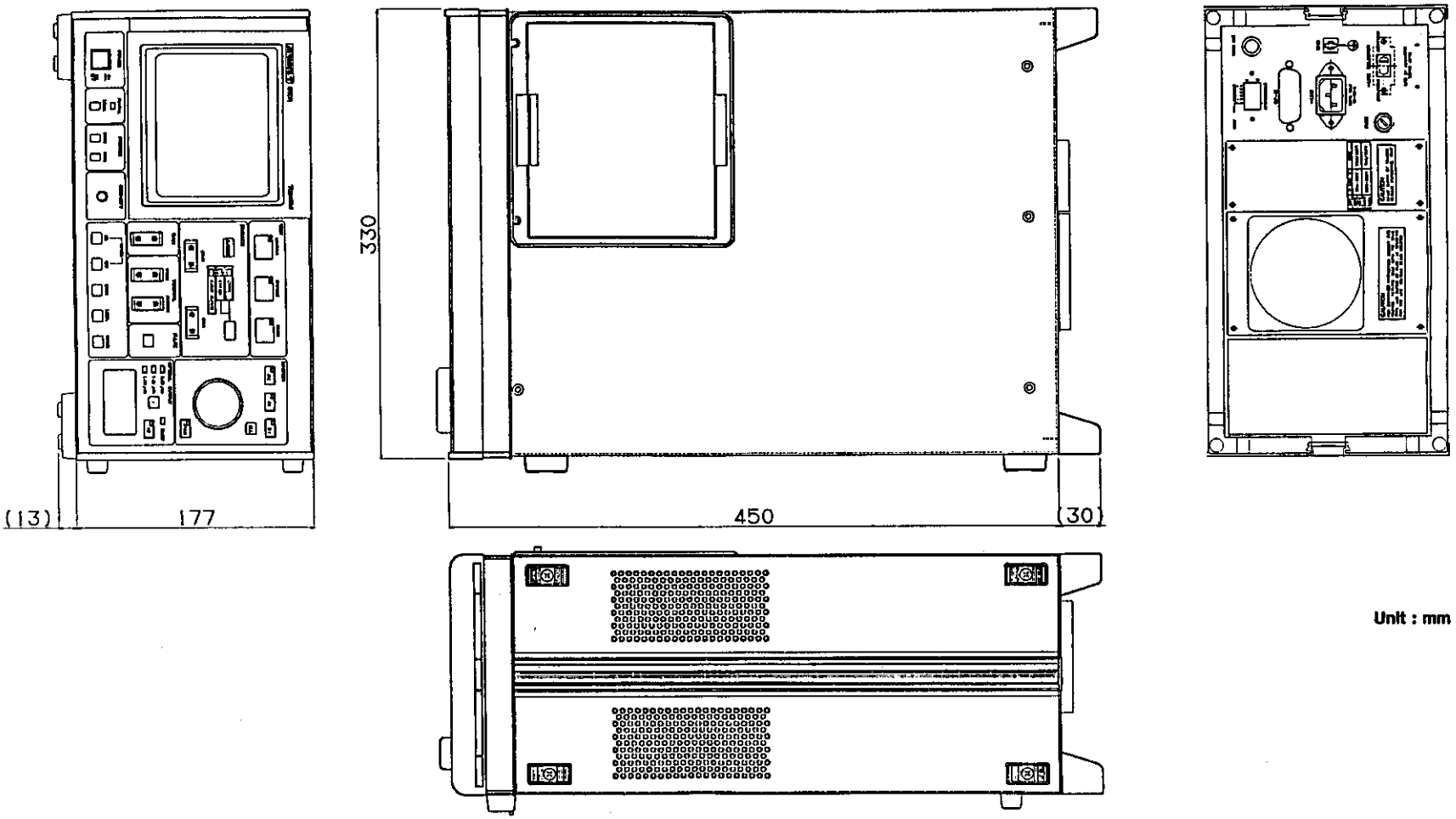
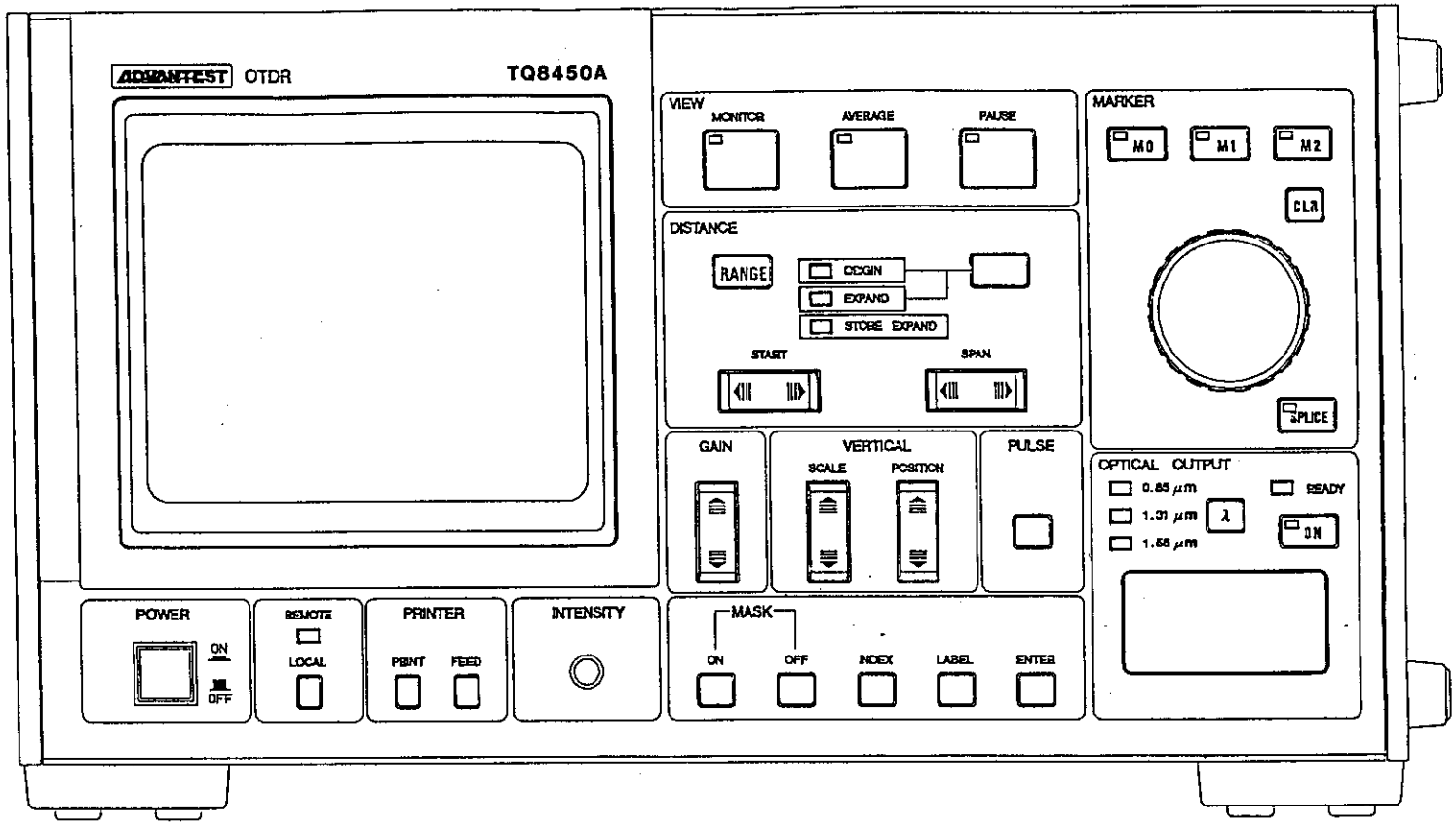


Unit : mm

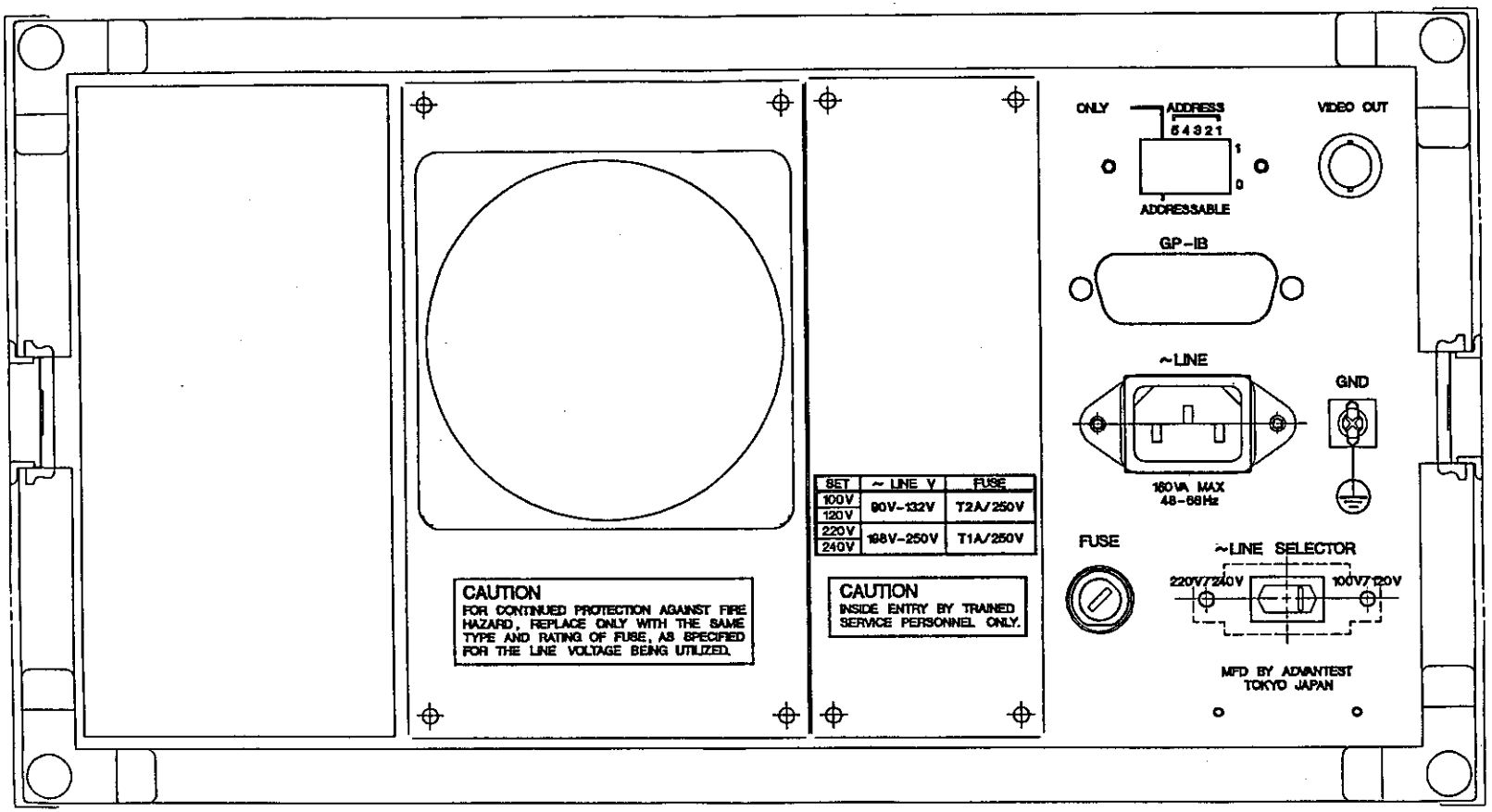
8450AEXT1-808-A

TQ8450A
EXTERNAL VIEW



8450AEXT2-808-A

TQ8450A
FRONT VIEW



8450AEXT3-808-A

TQ8450A
REAR VIEW

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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.

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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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