ADVANTEST®

ADVANTEST CORPORATION

Q7605A/B

Lightwave Modulation Test Set

Operation Manual

MANUAL NUMBER FOE-8324184A01

First printing July 11, 1997
Printed in Japan

Safety Summary

To ensure thorough understanding of all functions and to ensure efficient use of this instrument, please read the manual carefully before using. Note that Advantest bears absolutely no responsibility for the result of operations caused due to incorrect or inappropriate use of this instrument.

If the equipment is used in a manner not specified by Advantest, the protection provided by the equipment may be impaired.

- **Warning Labels**

  Warning labels are applied to Advantest products in locations where specific dangers exist. Pay careful attention to these labels during handling. Do not remove or tear these labels. If you have any questions regarding warning labels, please ask your nearest Advantest dealer. Our address and phone number are listed at the end of this manual.

  Symbols of those warning labels are shown below together with their meaning.

  DANGER: Indicates an imminently hazardous situation which will result in death or serious personal injury.

  WARNING: Indicates a potentially hazardous situation which will result in death or serious personal injury.

  CAUTION: Indicates a potentially hazardous situation which will result in personal injury or a damage to property including the product.

- **Basic Precautions**

  Please observe the following precautions to prevent fire, burn, electric shock, and personal injury.

  - Use a power cable rated for the voltage in question. Be sure however to use a power cable conforming to safety standards of your nation when using a product overseas.
  - When inserting the plug into the electrical outlet, first turn the power switch OFF and then insert the plug as far as it will go.
  - When removing the plug from the electrical outlet, first turn the power switch OFF and then pull it out by gripping the plug. Do not pull on the power cable itself. Make sure your hands are dry at this time.
  - Before turning on the power, be sure to check that the supply voltage matches the voltage requirements of the instrument.
  - Connect the power cable to a power outlet that is connected to a protected ground terminal. Grounding will be defeated if you use an extension cord which does not include a protected ground terminal.
  - Be sure to use fuses rated for the voltage in question.
  - Do not use this instrument with the case open.
  - Do not place anything on the product and do not apply excessive pressure to the product. Also, do not place flower pots or other containers containing liquid such as chemicals near this

product.

- When the product has ventilation outlets, do not stick or drop metal or easily flammable objects into the ventilation outlets.
- When using the product on a cart, fix it with belts to avoid its drop.
- When connecting the product to peripheral equipment, turn the power off.

- **Caution Symbols Used Within this Manual**

Symbols indicating items requiring caution which are used in this manual are shown below together with their meaning.

DANGER: Indicates an item where there is a danger of serious personal injury (death or serious injury).

WARNING: Indicates an item relating to personal safety or health.

CAUTION: Indicates an item relating to possible damage to the product or instrument or relating to a restriction on operation.

- **Safety Marks on the Product**

The following safety marks can be found on Advantest products.

 : ATTENTION - Refer to manual.

 : Protective ground (earth) terminal.

 : DANGER - High voltage.

 : CAUTION - Risk of electric shock.

- **Replacing Parts with Limited Life**

The following parts used in the instrument are main parts with limited life.
Replace the parts listed below before their expected lifespan has expired to maintain the performance and function of the instrument.
Note that the estimated lifespan for the parts listed below may be shortened by factors such as the environment where the instrument is stored or used, and how often the instrument is used.
The parts inside are not user-replaceable. For a part replacement, please contact the Advantest sales office for servicing.

Each product may use parts with limited life.
For more information, refer to the section in this document where the parts with limited life are described.

Main Parts with Limited Life

Part name	Life
Unit power supply	5 years
Fan motor	5 years
Electrolytic capacitor	5 years
LCD display	6 years
LCD backlight	2.5 years
Floppy disk drive	5 years
Memory backup battery	5 years

- **Hard Disk Mounted Products**

The operational warnings are listed below.

- Do not move, shock and vibrate the product while the power is turned on.
  Reading or writing data in the hard disk unit is performed with the memory disk turning at a high speed. It is a very delicate process.

- Store and operate the products under the following environmental conditions.
  An area with no sudden temperature changes.
  An area away from shock or vibrations.
  An area free from moisture, dirt, or dust.
  An area away from magnets or an instrument which generates a magnetic field.

- Make back-ups of important data.
  The data stored in the disk may become damaged if the product is mishandled. The hard disc has a limited life span which depends on the operational conditions. Note that there is no guarantee for any loss of data.

- **Precautions when Disposing of this Instrument**

When disposing of harmful substances, be sure dispose of them properly with abiding by the state-provided law.

Harmful substances: (1) PCB (polycarbon biphenyl)
(2) Mercury
(3) Ni-Cd (nickel cadmium)
(4) Other
Items possessing cyan, organic phosphorous and hexadic chromium and items which may leak cadmium or arsenic (excluding lead in solder).

Example: fluorescent tubes, batteries

Environmental Conditions

This instrument should be only be used in an area which satisfies the following conditions:

- An area free from corrosive gas
- An area away from direct sunlight
- A dust-free area
- An area free from vibrations
- Altitude of up to 2000 m

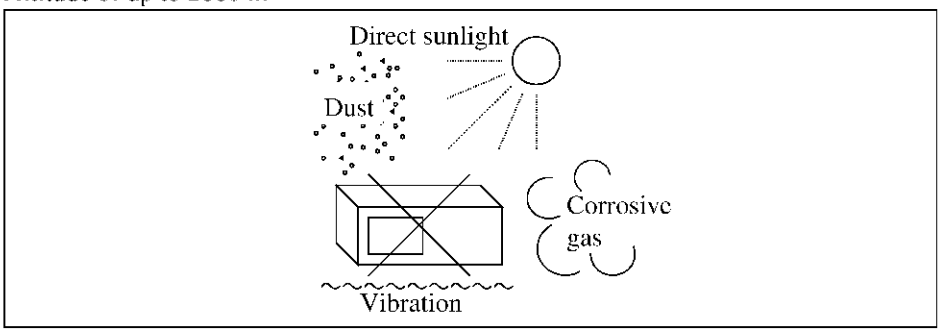


Figure-1 Environmental Conditions

- Operating position

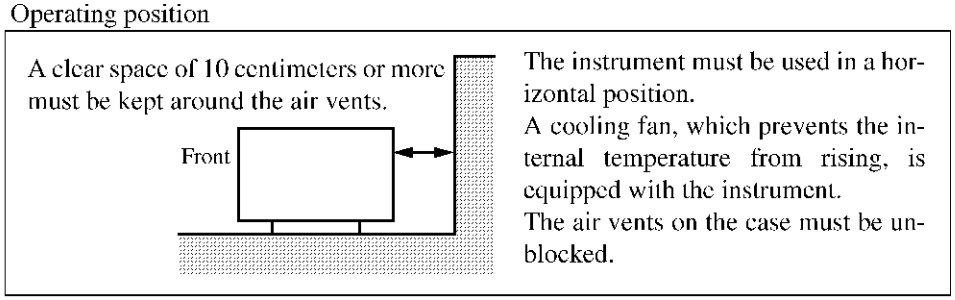


Figure-2 Operating Position

- Storage position

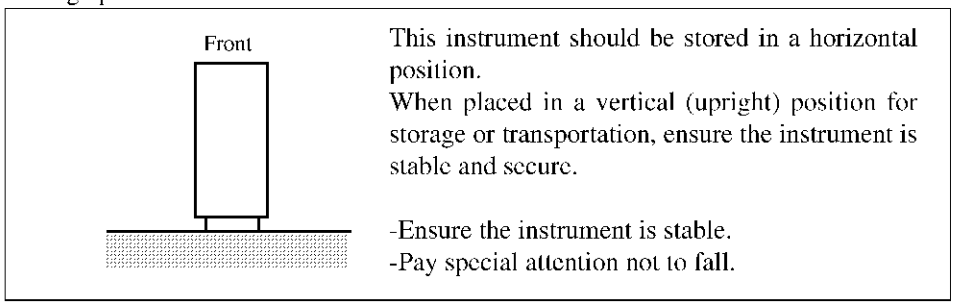


Figure-3 Storage Position

- The classification of the transient over-voltage, which exists typically in the main power supply, and the pollution degree is defined by IEC61010-1 and described below.

  Impulse withstand voltage (over-voltage) category II defined by IEC60364-4-443

  Pollution Degree 2

Types of Power Cable

Replace any references to the power cable type, according to the following table, with the appropriate power cable type for your country.

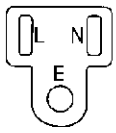
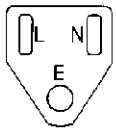
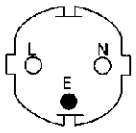
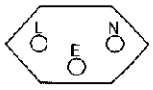
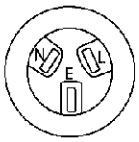
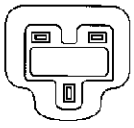
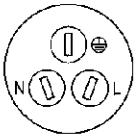
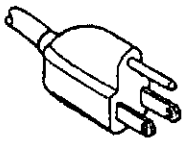
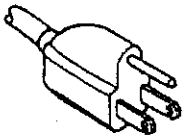
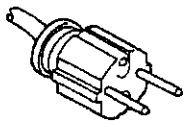
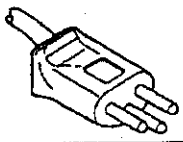
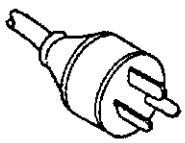
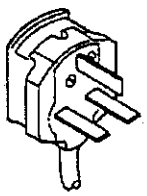
Plug configuration	Standards	Rating, color and length	Model number (Option number)
	PSE: Japan Electrical Appliance and Material Safety Law	125 V at 7 A Black 2 m (6 ft)	Straight: A01402 Angled: A01412
	UL: United States of America CSA: Canada	125 V at 7 A Black 2 m (6 ft)	Straight: A01403 (Option 95) Angled: A01413
	CEE: Europe DEMKO: Denmark NEMKO: Norway VDE: Germany KEMA: The Netherlands CEBEC: Belgium OVE: Austria FIMKO: Finland SEMKO: Sweden	250 V at 6 A Gray 2 m (6 ft)	Straight: A01404 (Option 96) Angled: A01414
	SEV: Switzerland	250 V at 6 A Gray 2 m (6 ft)	Straight: A01405 (Option 97) Angled: A01415
	SAA: Australia, New Zealand	250 V at 6 A Gray 2 m (6 ft)	Straight: A01406 (Option 98) Angled: ---------
	BS: United Kingdom	250 V at 6 A Black 2 m (6 ft)	Straight: A01407 (Option 99) Angled: A01417
	CCC:China	250 V at 10 A Black 2 m (6 ft)	Straight: A114009 (Option 94) Angled: A114109

Table of Power Cable Options

There are six power cable options (refer to following table).

Order power cable options by Model number.

	Plug configuration	Standards	Rating, color and length	Model number (Option number)
1		JIS: Japan Law on Electrical Appliances	125 V at 7 A Black 2 m (6 ft)	Straight: A01402 Angled: A01412
2		UL: United States of America CSA: Canada	125 V at 7 A Black 2 m (6 ft)	Straight: A01403 (Option 95) Angled: A01413
3		CEE: Europe DEMKO: Denmark NEMKO: Norway VDE: Germany KEMA: The Netherlands CEBEC: Belgium OVE: Austria FIMKO: Finland SEMKO: Sweden	250 V at 6 A Gray 2 m (6 ft)	Straight: A01404 (Option 96) Angled: A01414
4		SEV: Switzerland	250 V at 6 A Gray 2 m (6 ft)	Straight: A01405 (Option 97) Angled: A01415
5		SAA: Australia, New Zealand	250 V at 6 A Gray 2 m (6 ft)	Straight: A01406 (Option 98) Angled: ---------
6		BS: United Kingdom	250 V at 6 A Black 2 m (6 ft)	Straight: A01407 (Option 99) Angled: A01417

PREFACE

To use the Q7605A/B safely, observe the following precautions:

(1) The maximum allowable incident light power of the Q7605A/B is +10dBm. If optical power exceeding +10dBm is given to the Q7605A/B, it may give the Q7605A/B unrecoverable damages.

(2) The Q7605A/B internally uses high voltages. To avoid electric shocks, do not open the frame cover when the power supply is on.

(3) In this manual, the keys are expressed under the following conventions:

[IM-MONITOR] Q7605A/B panel keys

[[PROGRAM(RUN)]] R3753/65/67 panel keys

{{***LOAD***}} R3753/65/67 software keys (keys used in screen software menu)

TABLE OF CONTENTS

1 OVERVIEW 1-1
1.1 Product Overview 1-1
1.2 Configuration of the Q7605A/B 1-2

2 PREPARING FOR USE 2-1
2.1 Inspecting the Q7605A/B's Appearance and Accessories 2-1
2.2 Environment Conditions 2-2
2.3 Preparing to Power ON 2-3
2.3.1 Connecting Power Cable to the Q7605A/B 2-3
2.3.2 Checking and connecting the power cable 2-3
2.3.3 Fuse 2-3
2.4 Cleaning, Transportation, and Storage 2-4
2.4.1 Cleaning Connectors 2-4
2.4.2 Cleaning the Q7605A/B 2-5
2.4.3 Transporting the Q7605A/B 2-5
2.4.4 Storing the Q7605A/B 2-5
2.5 Optional Software Products for Measurement Support 2-6
2.5.1 Cautions for Using Optional Software Products 2-6
2.5.2 Optional Dynamic Chirp Measurement Software Product 2-6
2.5.3 Optional Lightwave Modulation Measurement Software PR370005-FJ 2-6
2.5.4 Creating the PR370005-FJ Software Execution Floppy Disk Using the Keyboard 2-7

3 PANEL DESCRIPTIONS 3-1
3.1 Front Panel 3-1
3.2 Rear Panel 3-4

4 BASIC OPERATION GUIDELINE (MEASURING DYNAMIC CHIRP CHARACTERISTICS) 4-1
4.1 Overview 4-1
4.2 Configuring the Measurement System 4-2
4.3 Measurement 4-3
4.3.1 Setting the Q7605A/B 4-3
4.3.2 Setting the Sampling Oscilloscope 4-3

5 BASIC OPERATION GUIDELINE (FM CHARACTERISTICS) 5-1
5.1 Example of Manually Measuring DFB-LD FM Characteristics 5-1
5.1.1 Preparing the Network Analyzer 5-1
5.1.2 Loading the Program 5-2

5.1.3 Configuring the Measurement System 5-3
5.1.4 Measurement 5-4
5.1.5 Displaying Measurement Results 5-4
5.2 Example of Measuring Absolute Values of FM Characteristics 5-5
5.2.1 Preparing the Network Analyzer 5-5
5.2.2 Configuring the Measurement System 5-5
5.2.3 Measurement 5-5
5.2.4 Displaying Measurement Results 5-5
5.3 Example of Measuring FM Characteristics Using Another Manufacturer's Network Analyzer 5-6
5.3.1 Preparing the Network Analyzer 5-6
5.3.2 Configuring the Measurement System 5-6
5.3.3 Measurement 5-6
5.3.4 Displaying Measurement Results 5-6
5.4 Example of Manually Measuring IM Characteristics Using IM-MONITOR 5-7
5.4.1 Preparing Network Analyzer 5-7
5.4.2 Configuring Measurement System 5-7
5.4.3 Measurement 5-7
5.4.4 Displaying Measurement Results 5-7
5.5 Measurement Restrictions 5-8

6 CORRECTING MEASUREMENT RESULTS 6-1
6.1 Types of Data Required for Correction 6-1
6.2 Using Correction Data 6-2

7 GPIB 7-1
7.1 Overview 7-1
7.1.1 Overview of GPIB 7-1
7.1.2 GPIB and the Q7605A/B's GPIB Specifications 7-3
7.1.3 Interface Functions 7-4
7.1.4 Connecting Component Devices 7-5
7.1.5 Description of the Q7605A/B Panel Controls Relating to GPIB 7-5
7.2 Service Request 7-6
7.3 GPIB Talker Format 7-7
7.4 GPIB Commands 7-8
7.5 Reading the Status Data Set in Q7605A/B 7-13
7.6 Sample Programs 7-14
7.6.1 Setting the Q7605A/B 7-14
7.6.2 Reading Status Data Set in Q7605A/B and Correction Data 7-14
7.6.3 Service Requests 7-15

8 TROUBLESHOOTING 8-1

9 OPERATING PRINCIPLES 9-1

9.1 Operating Principles 9-1

9.1.1 Using the Mach-Zehnder Interferometer as a Lightwave Frequency Discriminator 9-1

9.1.2 Separating FM and IM Components 9-2

9.1.3 Interferometer Characteristics and Q7605A/B Operations 9-3

9.2 Block Diagram 9-6

10 SPECIFICATIONS 10-1

10.1 Q7605A/B Major Specifications 10-1

10.1.1 Measurement Functions 10-1

10.1.2 Input Characteristics 10-1

10.1.3 Input/Output Specifications 10-2

10.1.4 General Specifications 10-2

APPENDIX 1 ..... A-1

A.1 Glossary A-1

EXTERNAL VIEW EXT-1

LIST OF ILLUSTRATIONS

No.	Title	Page
2-1	Fuse Holder	2-3
2-2	Connector Cleaning (1)	2-4
2-3	Connector Cleaning (2)	2-4
2-4	Connector Cleaning (3)	2-5
2-5	Connector Cleaning (4)	2-5
3-1	Front Panel	3-3
3-2	Rear Panel	3-4
4-1	Measurement system configuration	4-2
5-1	Typical Measurement System Configuration	5-3
7-1	GPIB Bus Line Configuration	7-1
7-2	GPIB Connector Pin Assignments	7-3
9-1	Lightwave Frequency-discriminate Characteristics of the Mach-Zehnder Interferometer	9-1
9-2	Switching Measurement Points of the Mach-Zehnder Interferometer Lightwave Frequency Discriminator	9-2
9-3	Interferometer Characteristics Measured by RESET	9-3
9-4	Interferometer Characteristics Measured by IM+FM	9-4
9-5	Interferometer Characteristics Measured by IM-FM	9-4
9-6	Interferometer Characteristics Measured by IM-MONITOR	9-5
9-7	Q7605A/B Block Diagram	9-6
A-1	Interference Characteristics and FSR of the Mach-Zehnder Interferometer	A-4
A-2	Typical Mach-Zehnder Interferometer Configuration	A-6

LIST OF TABLES

No.	Title	Page
7-1	GPIB Interface Functions	7-4

1 OVERVIEW

1.1 Product Overview

The Q7605A/B is a lightwave modulation test set, used together with a digital sampling oscilloscope and/or vector network analyzer, to separately measure and evaluate the frequency-modulated (chirp/FM) and intensity-modulated (IM) components of incident laser light.

The Q7605A/B contains two sets of fiber-type Mach-Zehnder interferometers, one for stable high-sensitivity measurement and another for wide-band measurement, their control circuits, and an accurately calibrated photo-diode (high-sensitive reference meter).

The Q7605A/B can selectively output the sum of or difference between the chirp/FM and IM components of the modulated incident light by switching the measurement mode. The sum (IM+FM) and difference (IM-FM) data are processed by the digital sampling oscilloscope and the vector operation functions of a personal computer or network analyzer to separate the chirp FM and IM components from each other, thus making it possible to evaluate the time-domain and/or frequency characteristics.

Features:

(1) The Q7605A/B makes it possible to separate the chirp/FM and IM components from each other easily.

(2) The Q7605A/B contains two sets of interferometers, one for high-sensitive measurements and another for wide-band measurements.

(3) The Q7605A/B is optimal for evaluating the chirp characteristics of an optical modulator (such as an LN or EA modulator).

(4) The Q7605A/B is optimal for evaluating the FM characteristics of DFB laser diodes for coherent communications.

(5) The Q7605A/B is also available as a lightwave frequency discriminator for the lightwave frequency domain.

(6) The wide-band interferometer can optionally be set to output electric signals (Option 13).

1.2 Configuration of the Q7605A/B

Measuring the dynamic chirp characteristics (time-domain characteristics of chirp) using the Q7605A/B requires an O/E converter, a digital sampling oscilloscope, and a personal computer. Software for measuring and evaluating the dynamic chirp characteristics is optionally available.

Measuring the FM characteristics using the Q7605A/B requires a network analyzer with vector operation functions.

When using an R3753/65/67 series network analyzer, measurement software is optionally available. This allows easy measurement of the absolute lightwave frequency shift by fast vector operations.

The network analyzer must have vector operation functions for calculating the sum of and difference between two sets of linear data.

2 PREPARING FOR USE

2.1 Inspecting the Q7605A/B's Appearance and Accessories

Before setting up the Q7605A/B, check for any damage that may have been caused during transportation. Then, make sure that the accessories listed in the following table are included.

If the Q7605A/B has been damaged, or any of the accessories are lacking, contact your nearest sales office or agency. Adventists office addresses and phone numbers are listed on the back of this manual.

Accessories	Model name	Quantity	Remarks
Output connection cable	A01002	1	70 cm in length, with SMA connector
Power cable	*	1	
GPIB connection cable	408JE-1P5	1	
2-pin power adapter	A09034	1	
Fuses	DFT-AA2R5A-1	2	
Operation manual (This manual)	EQ7605A/B	1	

*:ADVANTEST provides the power cables for each country. Refer to yellow page of "Table of Power Cable Options" at this manual.

2.2 Environment Conditions

(1) Since the Q7605A/B is a precision measurement device, avoid installing it in a position where it is exposed to dust, direct sunlight, corrosive gas, or vibration. Be sure to use the Q7605A/B in conditions of an ambient temperature of 10 to 40°C and a relative humidity of 85% or less.

(2) Although the Q7605A/B has been designed to be durable against AC line noise, care should be taken to minimize the AC noise at the site where the Q7605A/B is installed. If necessary, use a noise elimination filter..

2.3 Preparing to Power ON

2.3.1 Connecting Power Cable to the Q7605A/B

Make sure that the POWER switch on the Q7605A/B front panel is set to OFF, and then connect the attached power cable to the AC LINE connector on the rear panel of the Q7605A/B. The permitted power voltage range is 90 to 250 V, and the permitted power frequency range is 48 to 66 Hz.

2.3.2 Checking and connecting the power cable

ADVANTEST provides the power cables for each country. Refer to yellow page of "Table of Power cable Options" at this manual.

WARNING!

1.If the Q7605A/B seems abnormal, unplug the power cable immediately.

2. Power cable

- ***To avoid electrical and fire hazards, use the supplied power cable.***
- ***When using the Q7605A/B overseas, use a power cable which complies with the safety standard of the country where it is used.***
- ***When plugging or unplugging the cable, always hold the plug.***

3. Protective ground

- ***Plug the power cable into an AC outlet with a protective ground terminal.***
- ***Using an extension cord without a protective ground terminal will disable the protective ground.***

2.3.3 Fuse

To replace the fuse, set the POWER switch to OFF and disconnect the power cable from the AC LINE connector. The fuse holder can be taken off by pulling the fuse holder notch at the top of the AC LINE connector. When replacing the fuse, be sure to use the type provided (DFT-AA2R5A-1).

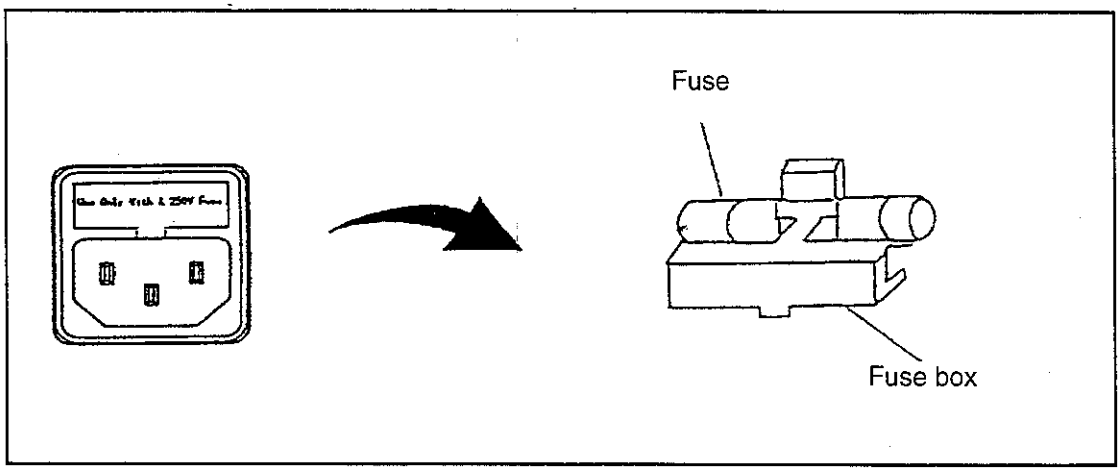


Figure 2-1 Fuse Holder

2.4 Cleaning, Transportation, and Storage

2.4.1 Cleaning Connectors

If the optical fiber connector of the Q7605A/B is stained, this may cause a reduction in output signals. Keep the optical fiber connector clean by wiping it with a soft cloth moistened with alcohol.

If the optical fiber connector is stained, clean it using the following steps:

(1) Out of the four screws fixing the optical fiber connector receptacle on the front panel, remove two screws: the upper left and lower right ones. (See Figure 2-2.)

(2) Gently pull out the receptacle approximately 3 cm. (Do not pull it forcibly, or the optical-fiber cable may be damaged.) (See Figure 2-3.)

(3) Loosen the connector screw on the back of the receptacle and disengage the receptacle from the connector. (See Figure 2-4.)

(4) Clean the connector with a soft cloth moistened with alcohol. Take care not to damage the connector. (See Figure 2-5.)

(5) Engage the cleaned connector with the receptacle and tighten the screw.

(6) Attach the receptacle to the front panel and fix it with the two screws.

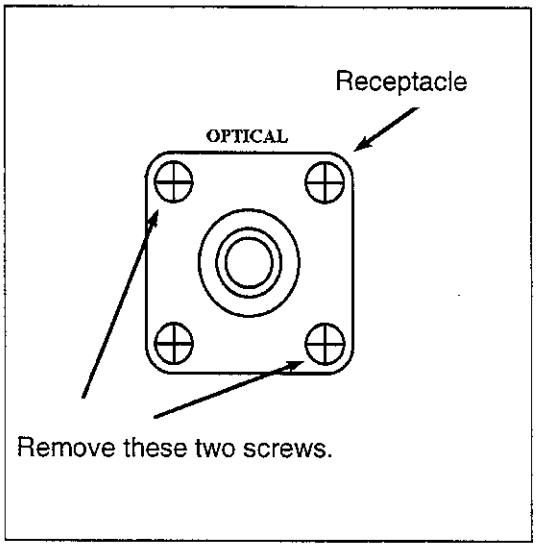


Figure 2-2 Connector Cleaning (1)

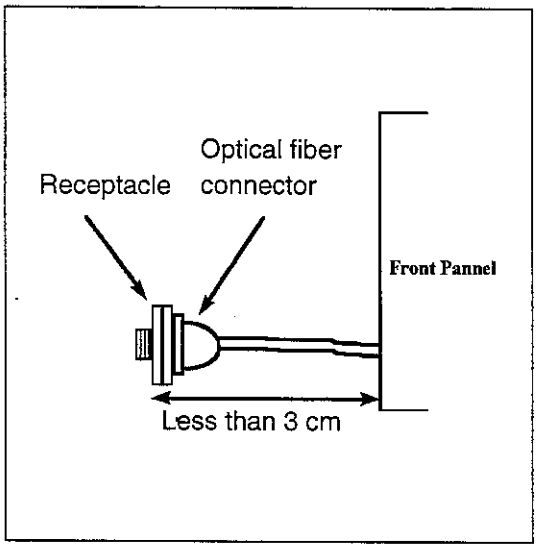


Figure 2-3 Connector Cleaning (2)

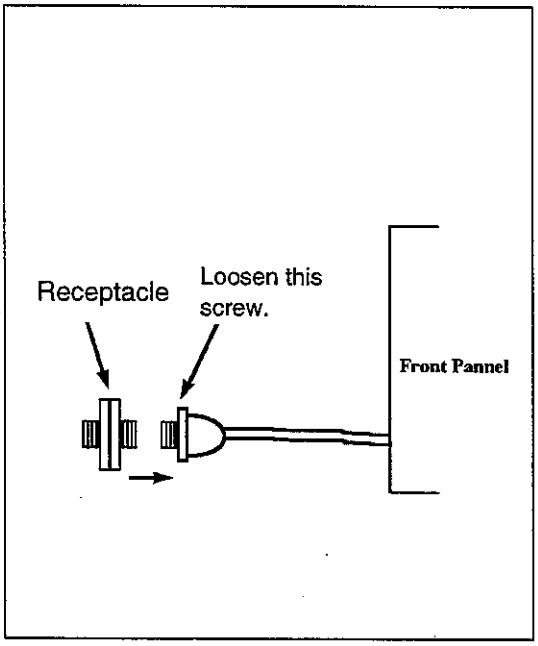


Figure 2-4 Connector Cleaning (3)

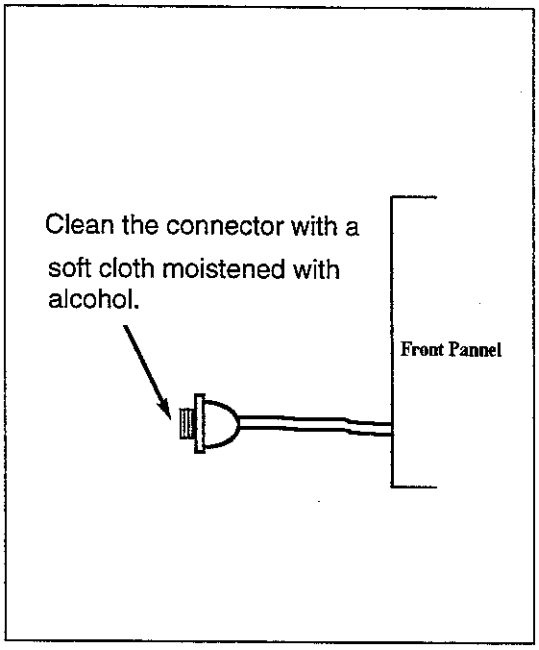


Figure 2-5 Connector Cleaning (4)

2.4.2 Cleaning the Q7605A/B

When cleaning the Q7605A/B, wipe it with a soft cloth moistened with alcohol. Do not use a solvent such as benzene, toluene, or acetone that may damage plastics.

2.4.3 Transporting the Q7605A/B

When transporting the Q7605A/B, pack it in the same materials used for shipment. If these are no longer available; wrap the Q7605A/B with sufficient cushioning, and place it in a carton with a board thickness of 5mm or more. Place the accessories on it, fill the space with cushioning materials, close the carton, and bind the carton with packing cords.

2.4.4 Storing the Q7605A/B

The storage conditions for the Q7605A/B are: a temperature of -20 to +60 °C and a relative humidity of 90% or less. If the Q7605A/B is not in use for a long time, cover it with a vinyl sheet or place it in a carton and store it in a dry place out of direct sunlight.

2.5 Optional Software Products for Measurement Support

The following software products are optionally available:

Dynamic chirp measurement software (special version)

Lightwave modulation measurement software PR370005-FJ

When necessary, please contact us.

2.5.1 Cautions for Using Optional Software Products

ADVANTEST or its licensee(s) hold the copyright for the software products listed above, which are protected under Japan's Copyright Act and international treaties. Users must treat these products in the same manner as copyright books or music recordings. Users are allowed to copy the software products solely for the purpose of backup or storage.

ADVANTEST or its licensee(s) shall not take any responsibility for any kind of damage (including, but not limited to, the loss of business profits, interruptions of business, loss of business information, or other financial disadvantages) caused by the usage or unavailability of any of these software products. This will also apply even if ADVANTEST has been notified of the possibility of such damage. In any case, ADVANTEST's responsibility shall be limited to the amount paid by the user for the associated software product(s).

2.5.2 Optional Dynamic Chirp Measurement Software Product

This is a special-version software product for measuring the time-domain dynamic chirp of optical modulated signals. The standard system configuration for using this software product is given below.

- Q7605A/B lightwave modulation test set (this instrument)
- Digital sampling oscilloscope Tek11801B, HP83480A (O/E converter or optical input head)
- PC/AT-compatible personal computer
- Microsoft Windows 95
- National Instruments general purpose interface bus (GPIB) board (Windows 95 edition) and its driver software

This software product is an application software program running under Microsoft Windows 95. When using peripheral units such as a printer, they must be used in the Windows 95 environment. Windows 3.1 or lower is not suitable.

2.5.3 Optional Lightwave Modulation Measurement Software PR370005-FJ

This is a software product to be used along with the ADVANTEST R3753/65/67 series network analyzer. It is used to measure the absolute values of lightwave frequency shift from the compensated data output from the Q7605A/B, using fast vector operations.

2.5.4 Creating the PR370005-FJ Software Execution Floppy Disk Using the Keyboard

The PR370005-FJ is a lightwave FM characteristics measurement software product. It is recommended to create an execution floppy disk for this product. Be sure to use the execution disk normally and store the master disk in a safe place.

(1) Initializing a blank floppy disk

Initialize a blank floppy disk using the R3753/65/67 series network analyzer.
(For details, refer to the R3753/65/67 Series Network Analyzer Operation Manual.)

(2) Copying the program

Place the network analyzer in PROGRAM mode and enter the COPYFILES command from the keyboard. Then, following the prompts shown on the network analyzer screen, replace the floppy disks as required. (For details, refer to the R3753/65/67 Series Network Analyzer Operation Manual.)

Note: On the R3753/65/67 series network analyzer, programs (some functions of this software product) written in a non-BASIC language cannot be copied with the LOAD or SAVE commands. Use the COPYFILES command to carry out copying.

3 PANEL DESCRIPTIONS

3.1 Front Panel

(1) POWER switch

Use this switch to turn the Q7605A/B power ON/OFF.

(2) POWER indicator

This indicator remains on while the Q7605A/B [**POWER**] switch is ON.

(3) OPTICAL INPUT connector

This connector receives the incident light to be measured. It is internally connected with a PC-polished FC connector. The FC connector to be used must be thoroughly cleaned.

(4) POLARIZATION ADJUST knob

Use this knob to adjust the built-in polarization controller. To match the incident light polarization state with the internal interferometer, turn this knob so that the level meter (see below) shows the highest value.

(5) Level meter

Indicates the intensity of the interfering light input to the interferometer. Turn the POLARIZATION ADJUST knob (see above) so that this meter shows the highest value.

(6) OUTPUT SELECT key

Use this key switch to change over the mode of the built-in optical interferometer. Each time this switch is pressed, the mode is toggled between HIGH-SENS and WIDE-BAND.

(7) RESET key

Use this switch to reset the optical interferometer. The interferometer, when reset, reads the information (power and polarization) of the incident light. While the RESET is being executed, the indicator flashes continuously. When RESET is completed, the indicator remains on and the Q7605A/B enters the IM+FM mode.
After operating the [**OUTPUT SELECT**] or [**IM-MONITOR**] key switch, RESET must be executed at least once before the Q7605A/B can enter the IM+FM or IM-FM mode. In addition, be sure to execute RESET after the incident light has changed its state (power or polarization), because the optical interferometer is controlled on the basis of information from the RESET execution.

(8) IM+FM key

Use this key switch to set the built-in optical interferometer to the mode in which the incident light IM and chirp/FM components are output with the same phase. The indicator flashes during adjustment of the built-in optical interferometer, and remains on when the interferometer is locked. RESET must be executed prior to operating this switch. This mode is also set automatically after RESET is completed.

(9) IM-FM key

Use this key switch to set the built-in optical interferometer to the mode in which the incident light IM and chirp/FM components are output with the inverse phase. The indicator flashes during adjustment of the built-in optical interferometer, and remains on when the interferometer is locked. RESET must be executed prior to operating this switch.

(10) IM-MONITOR key

Use this key switch to set the built-in optical interferometer to the mode in which only the incident light IM components are output. The indicator remains on when this mode is selected. Wait approximately 20 seconds until output from the optical interferometer is stabilized.

(11) HIGH-SENS indicator

This indicator remains on while the high-sensitivity optical interferometer is being selected.

(12) HIGH-SENS connector

This connector provides electrical output from the high-sensitivity optical interferometer. It covers a bandwidth of 100Hz to 2GHz.

(13) WIDE-BAND indicator

This indicator remains on while the wide-band optical interferometer is being selected.

(14) WIDE-BAND connector

This connector provides optical output from the wide-band optical interferometer. When Option 13 is installed, the band is limited to 100Hz to 20GHz.

(15) LOCAL key

Use this switch to change the Q7605A/B to the local mode from the remote mode using GPIB.

(16) REMOTE indicator

This indicator remains on while the Q7605A/B is in the remote mode using GPIB.

(17) SRQ indicator

This indicator is on when the Q7605A/B is sending an SRQ.

(18) TALK indicator

This indicator remains on while the Q7605A/B is in the talk mode.

(19) LISTEN indicator

This indicator remains on while the Q7605A/B is in the listen mode.

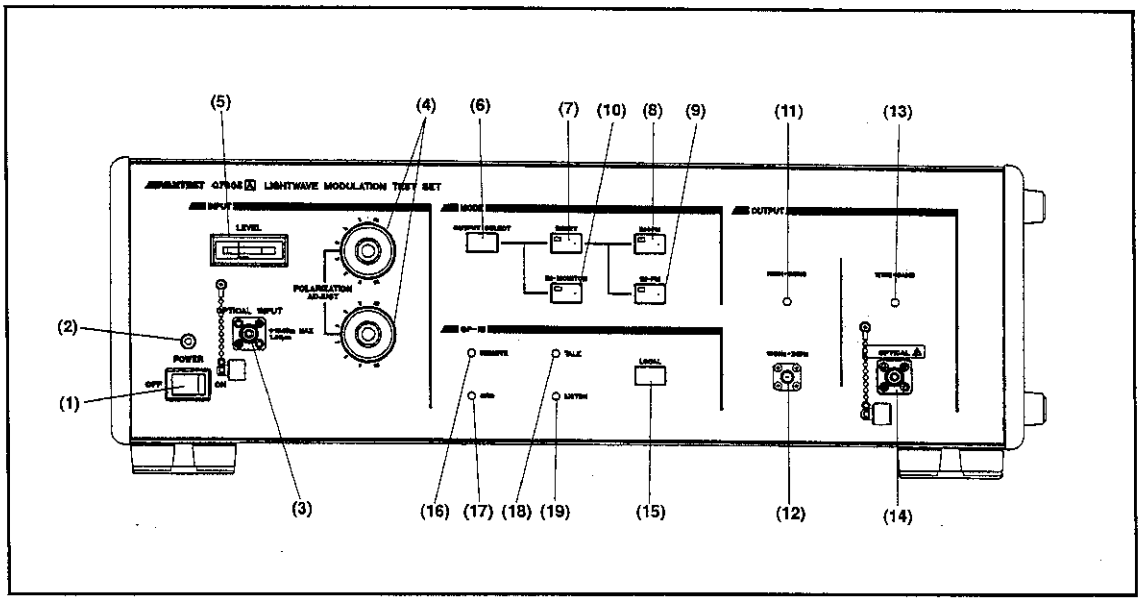


Figure 3-1 Front Panel

3.2 Rear Panel

(1) Power connector

Connect the attached power cable to this connector. This connector has a fuse holder. Be sure to check the correct rating when replacing a fuse.

(2) Ground terminal

Connect this terminal to an external ground.

(3) GPIB connector

Connect a GPIB cable to this connector.

(4) GPIB address switch

Set the Q7605A/B GPIB address in this switch before turning the Q7605A/B power on.

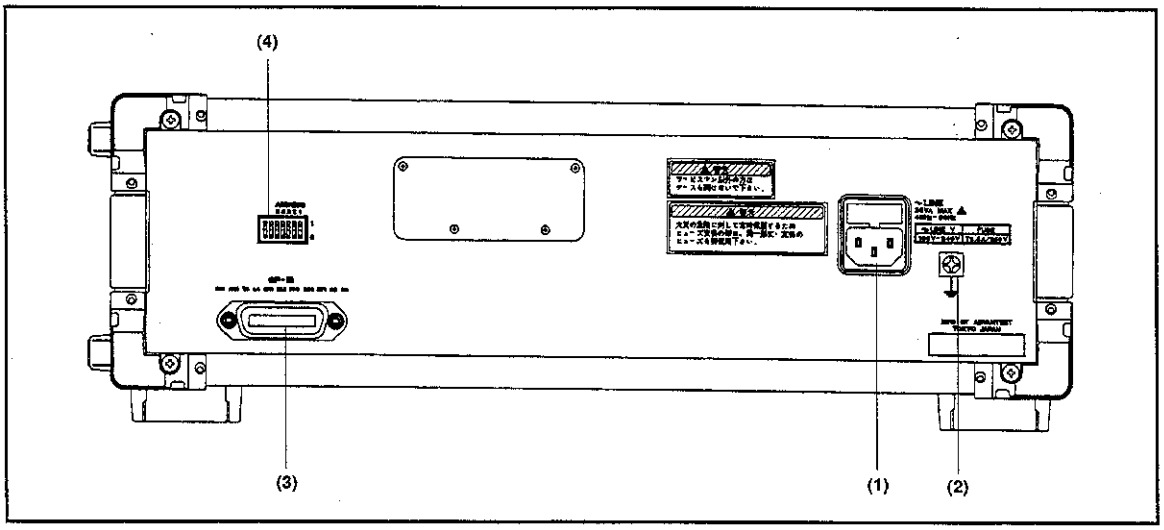


Figure 3-2 Rear Panel

4 BASIC OPERATION GUIDELINE (MEASURING DYNAMIC CHIRP CHARACTERISTICS)

4.1 Overview

This section describes how to measure and evaluate the optical signal chirp characteristics, using the Q7605A/B, a sampling oscilloscope, and a personal computer, as well as the optionally available dynamic chirp measurement support software

This software allows one to:

- measure the optical signal chirp characteristics
- store, read, or print the measurement data

(1) Execution environment

This software program only runs under Microsoft Windows 95. It is not available under MS-Windows 3.1 or lower.

GPIB control and measurement using this program require a PC/AT-compatible personal computer, a National Instruments GPIB board (for Windows 95), and its driver software. Any other type of personal computer or GPIB board is not suitable.

For the operating instructions, refer to the software operation manual.

4.2 Configuring the Measurement System

This section explains the typical system configuration for dynamic chirp measurement using the dynamic chirp measurement support software.

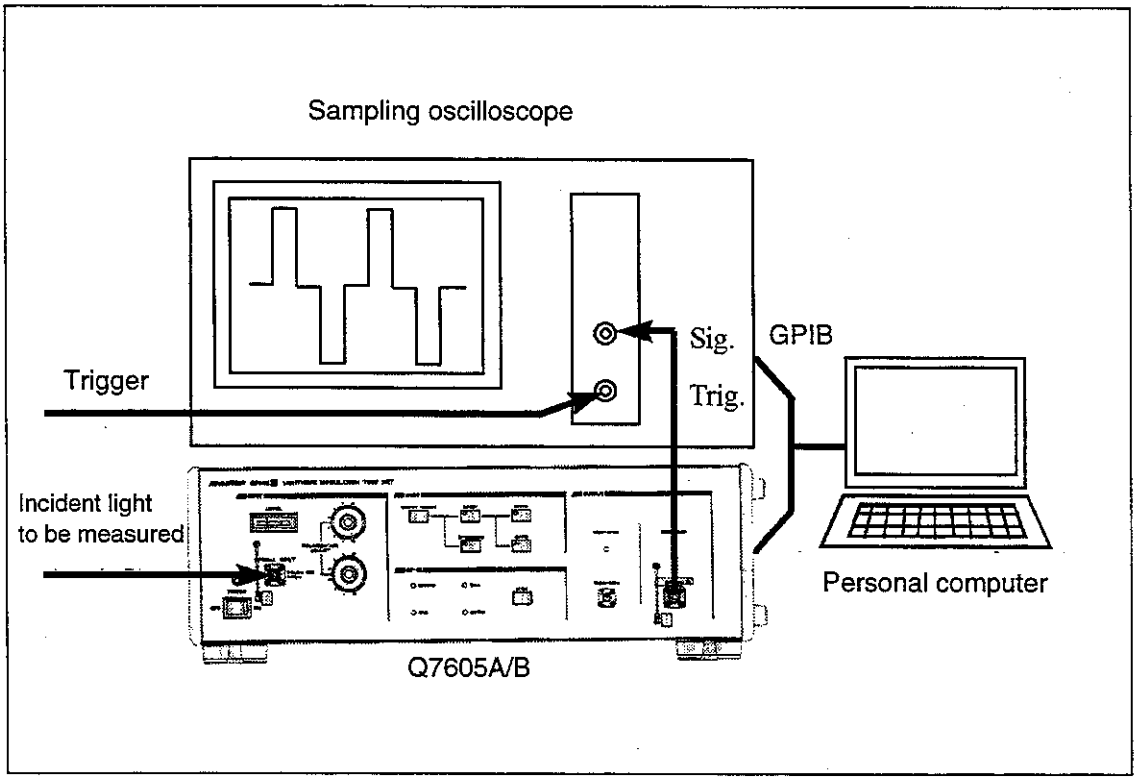


Figure 4-1 Measurement System Configuration

Connect the Q7605A/B, personal computer (controller), and sampling oscilloscope via GPIB cables. The Q7605A/B and sampling oscilloscope must have individual GPIB addresses.

Input the incident light to be measured from the optical input connector on the Q7605A/B front panel. Connect the wide-band optical output of the Q7605A/B to the sampling oscilloscope input. (Note that the Option 13 connector is for electrical output.) If the sampling oscilloscope does not accept optical input, insert an optional O/E converter which has a sufficient response frequency band between the Q7605A/B wide-band optical output connector and the sampling oscilloscope input connector.

The optical insertion loss of the Q7605A/B is approximately 10dB. If necessary, use an amplifier when the optical power level supplied to the sampling oscilloscope or O/E converter is too low.

For dynamic chirp measurement, use the waveform data from the sampling oscilloscope for calculation. (Chirp calculation cannot be carried out with visual patterns.) The trigger signal input to the sampling oscilloscope trigger input connector must be of a type allowing display of the measured light waveform data.

4.3 Measurement

4.3.1 Setting the Q7605A/B

(1) Setting the polarization adjuster

Set the POLARIZATION ADJUST knob so that the Q7605A/B level meter shows the maximum value. The incident light polarization must be set to the optimum for the built-in optical interferometer.

(2) Setting OUTPUT SELECT

Select the interferometer used for the measurement (HIGH-SENS or WIDE-BAND). For dynamic chirp measurement, the wide-band interferometer is usually set.

4.3.2 Setting the Sampling Oscilloscope

Adjust the time and level axes on the sampling oscilloscope so that the necessary waveform data can be displayed.

Dynamic chirp measurement uses the sampling oscilloscope waveforms from the Q7605A/B in two modes: IM+FM and IM-FM. Fluctuation in the time or level axis might cause an error in the dynamic chirp measurement. Therefore, adjust these axes to ensure correct measurement of the waveform data. The dynamic chirp measurement also uses the difference between data of these two modes. Averaging should be done for the measurement data to ensure correct measurement of the difference.

The Q7605A/B's built-in Mach-Zehnder interferometer input section has a polarizer. Adjust the light to be measured so that it has a stable polarization state. If the polarization state of the light to be measured is unstable, it is recognized as an IM component.

The dynamic chirp measurement results are displayed with time along the abscissa and the chirp or intensity along the ordinate. This means that the chirp characteristics which are synchronized with the IM characteristics can be measured.

For details of operations, refer to the operation manual of the dynamic chirp measurement support software program.

5 BASIC OPERATION GUIDELINE (FM CHARACTERISTICS)

5.1 Example of Manually Measuring DFB-LD FM Characteristics

This section describes how to measure the DFB-LD FM characteristics using the Q7605A/B and R3753/65/67 series network analyzer and perform fast vector operations using the PR370005-FJ software program, which is a program for measuring lightwave modulation characteristics for R3753/65/67.

5.1.1 Preparing the Network Analyzer

(1) Setting the network analyzer

Prepare the network analyzer applicable to the band of the modulating frequency to be measured, and set the modulating frequency band, sweep format, modulating signal power, and so forth, on the network analyzer.

(2) Normalizing the network analyzer

When setting of the network analyzer is completed, normalize it.

(3) Preparing for vector operation by the network analyzer

When using the R3753/65/67 series network analyzer, the lightwave modulation measurement software PR370005-FJ must be loaded in the network analyzer in advance. The R3753/65/67 program carries out fast vector operations.

5.1.2 Loading the Program

(1) Press the [[**PROGRAM(RUN)**]] of the R3753/65/67.
The network analyzer enters the program mode.

(2) Press the {{***LOAD MENU***}} of the R3753/65/67.
The screen displays the names of programs that can be loaded.

(3) Select the program to be loaded.
Select the program to be loaded using the cursor key or data knob.

(4) Press the {{***LOAD***}} of the R3753/65/67.
The selected program is loaded into the network analyzer memory.

(5) Press the [[**PROGRAM(RUN)**]] of the R3753/65/67.
The network analyzer shifts from the program mode to the measurement mode.

(For further details of network analyzer operations, refer to the operation manual of the associated network analyzer.)

5.1.3 Configuring the Measurement System

(1) Connect the Q7605A/B, network analyzer, and source of the light to be measured (DFB-LD) as shown in Figure 5-1.

(2) Apply the network analyzer output signal to the DFB-LD bias signal.

(3) Connect the DFB-LD optical output to the Q7605A/B OPTICAL INPUT connector.
Connect the Q7605A/B output to the network analyzer receiver input connector.

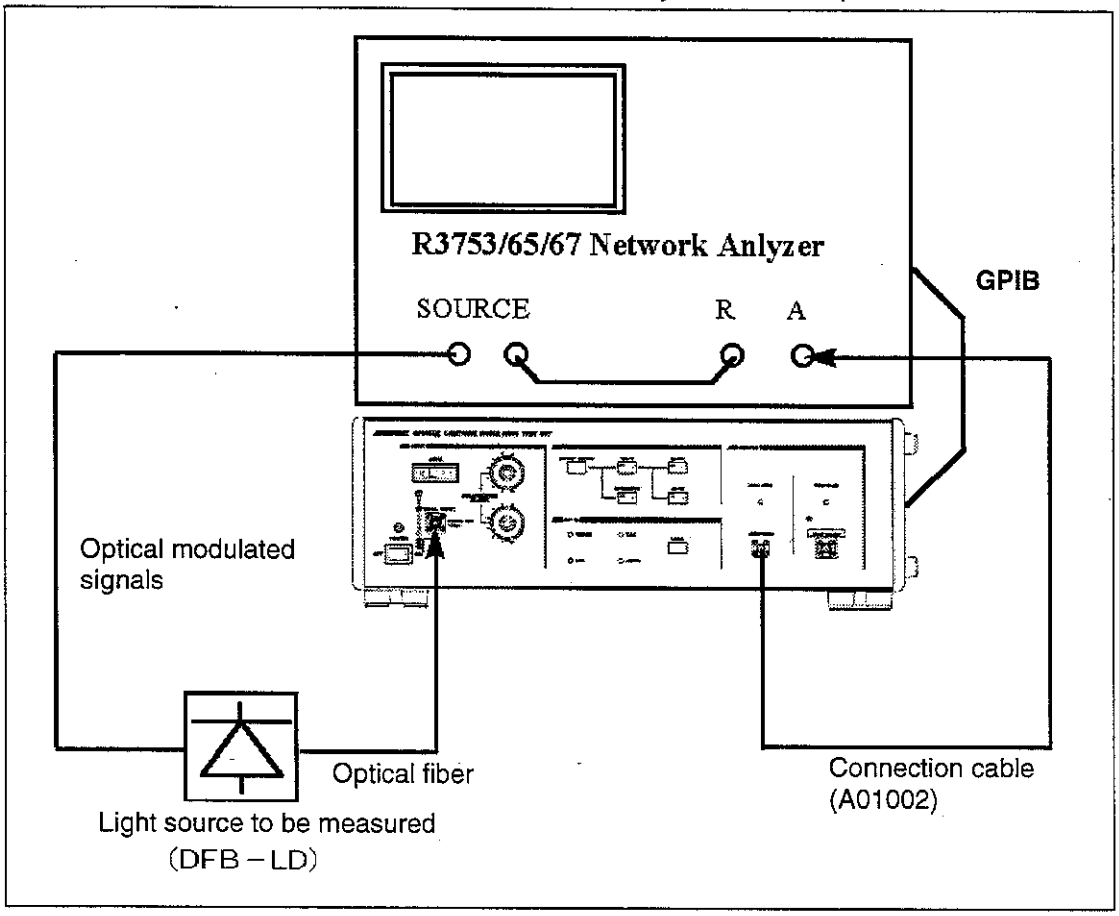


Figure 5-1 Typical Measurement System Configuration

5.1.4 Measurement

(1) Setting the polarization adjuster

Set the POLARIZATION ADJUST knob so that the Q7605A/B level meter shows the maximum value. The incident light polarization must be set to the optimum for the built-in optical interferometer.

(2) Setting OUTPUT SELECT

Set the interferometer used for measurement (HIGH-SENS or WIDE-BAND).

(3) Executing RESET

Read the incident light state by executing RESET.
During RESET execution, the indicator flashes. When RESET is completed, the indicator remains on and the interferometer enters the IM+FM mode. If the incident light state (power or polarization) has changed, reexecute RESET to detect the incident light polarization and power.

(4) Reading IM+FM data

After pressing the [[**PROGRAM(RUN)**]] of the R3753/65/67, press the {{***RUN***}} to start the program. Select the items to be executed following the instructions displayed on the R3753/65/67 screen. In this example, press the [[**1**]] and [[**X1**]] of R3753/65/67 to perform only the vector operations. When the IM+FM indicator goes on, press the {{***CONT***}} of R3753/65/67 to read the IM+FM data into the network analyzer. (When the PR370005-FJ software prompts for data input, input the data using the numeric key and [[**X1**]] of R3753/65/67.)

(5) Reading IM-FM data

Press the [**IM-FM**] and, when the IM-FM indicator goes on, press the {{***CONT***}} of R3753/65/67 to read the IM-FM data into the network analyzer.

5.1.5 Displaying Measurement Results

The network analyzer performs vector operations on the IM+FM and IM-FM data and displays the FM characteristics on the screen.

Subsequently, each time the {{***CONT***}} is pressed, the display on the screen switches from IM to FM characteristics. (Note that the displayed data are relative values, and the frequency characteristics are not corrected in the interferometer.)

If necessary, set the format and scale on the network analyzer.

5.2 Example of Measuring Absolute Values of FM Characteristics

This section explains how to correct and measure the absolute values of the FM characteristics, using the R3753/65/67 series network analyzer and lightwave modulation measurement software PR370005-FJ.

5.2.1 Preparing the Network Analyzer

Prepare the applicable type of network analyzer depending on the frequency band to be measured, and normalize it. (See Section 5.1.1.)

5.2.2 Configuring the Measurement System

Configure the measurement system. (See Section 5.1.3.) In this example, connect the Q7605A/B and R3753/65/67 via a GPIB cable to transfer the correction data to R3753/65/67.

5.2.3 Measurement

Perform measurements in the same manner as explained in Section 5.1.4, following the instructions from the PR370005-FJ.

5.2.4 Displaying Measurement Results

During fast vector operation on R3753/65/67, correct the measurement values by reading the correction data from the Q7605A/B through GPIB. (See Section 5.1.5.)

5.3 Example of Measuring FM Characteristics Using Another Manufacturer's Network Analyzer

This section explains how to measure the FM characteristics using a network analyzer not manufactured by ADVANTEST.

5.3.1 Preparing the Network Analyzer

Prepare the applicable network analyzer in the same manner as in Section 5.1.1. For details, refer to the operation manual of that network analyzer.

5.3.2 Configuring the Measurement System

Configure the measurement system in the same manner as in Section 5.1.3.

5.3.3 Measurement

In the same manner as in Section 5.1.4, set the polarization adjuster, set OUTPUT SELECT, and execute RESET.

When the Q7605A/B is locked in the IM+FM mode, read the IM+FM data using the network analyzer memory function.

Place the Q7605A/B in the IM-FM mode. When it is locked, take the difference between the IM-FM data and the IM+FM data already loaded in the memory.

(For details of the memory and operation functions of the network analyzer, refer to the network analyzer operation manual.)

5.3.4 Displaying Measurement Results

The network analyzer calculates the sum of and difference between the IM+FM and IM-FM data using the vector operation functions, and displays the results on its screen.

(IM+FM) - (IM-FM) = 2FM

(IM+FM) + (IM-FM) = 2IM

These measurement results are not corrected for the frequency characteristics of the Q7605A/B. Corrective operations are necessary to get accurate measurement results or absolute values.

5.4 Example of Manually Measuring IM Characteristics Using IM-MONITOR

The IM characteristics can be obtained from IM+FM and IM-FM by vector operations. In addition, they can also be easily obtained using IM-MONITOR without vector operations. IM-MONITOR is also available to adjust the source of the light to be measured.

5.4.1 Preparing Network Analyzer

Prepare the applicable network analyzer in the same manner as in Section 5.1.1 and normalize it. (Loading the operation program explained in Section 5.1.2 is not necessary here.)

5.4.2 Configuring Measurement System

Connect the source of the light to be measured in the same manner as in Section 5.1.3.

5.4.3 Measurement

In the same manner as in Section 5.1.4, set the polarization adjuster, and then select optical interferometer by OUTPUT SELECT.

Select the IM-MONITOR mode by pressing [**IM-MONITOR**] and execute IM-MONITOR.

5.4.4 Displaying Measurement Results

The optical interferometer output is displayed as the IM component on the network analyzer screen.

5.5 Measurement Restrictions

When measuring the frequency characteristics using the Q7605A/B and network analyzer, setting of the network analyzer is subject to some restrictions.

The Mach-Zehnder interferometer in the Q7605A/B has delays:

HIGH-SENS: Approximately 600ns

WIDE-BAND: Approximately 60ns

Measurement data may therefore be lost, depending on the settings of the network analyzer sweep time, number of points, sweep bandwidth, and/or resolution bandwidth. Measurement data may be lost when:

the sweep time is shorter,

the number of points is fewer,

the sweep bandwidth is narrower, or

the resolution bandwidth is narrower.

Particularly with Log sweep, it is hard to distinguish between the loss of measurement data and the deterioration of frequency characteristics of the light to be measured, because data may be easily lost in the high-frequency area. First, perform the measurement, setting the sweep time somewhat longer than required, ensure that no data are lost, and then restart the measurement.

6 CORRECTING MEASUREMENT RESULTS

The measurement results output from the Q7605A/B require corrections for the internal interferometer and detector frequency characteristics, unless they have already been corrected using R3753/65/67 and the PR370005-FJ program. In addition, correction is necessary when calculating the frequency shift absolute values. This section explains how to correct the measurement results based on the correction data stored in the Q7605A/B.

6.1 Types of Data Required for Correction

Correcting the measurement results requires two types of data: the correction data stored in the Q7605A/B before shipment and the data read in by RESET. These data can be read by GPIB commands.

Item	Description	GPIB command	Remarks
Interference amplitude of the interferometer	Read in by RESET. This varies according to the incident light power or polarization state. Because these data are updated at the end of RESET, they should be read for each measurement of the data to be corrected.	AM	1 point
Absolute value correction data	Equivalent to the Q7605A/B's internal electric gain.	ABa	1 point
Frequency characteristics data for the FM of the interferometer	Equivalent to the frequency characteristics for the FM of the Q7605A/B's built-in interferometer.	FMa	201 points
Frequency characteristics data for the IM of the interferometer	Equivalent to the intensity characteristics for the IM of the Q7605A/B's built-in interferometer	IMa	201 points
Frequency characteristics data of PD	Equivalent to the frequency characteristics of the Q7605A/B's built-in detector	FPa	201 points
Phase data of the interferometer	Equivalent to the frequency characteristics for the phase data of the Q7605A/B's built-in interferometer	PIa	201 points
Phase data of PD	Equivalent to the frequency characteristics for the phase data of the Q7605A/B's built-in detector	PPa	201 points

The frequencies for the 201-point data are as follows:
0Hz to 3GHz at 15MHz intervals when a = H (HIGH-SENS)
0Hz to 20GHz at 100MHz intervals when a = W(WIDE-BAND)

6.2 Using Correction Data

This section describes how to use the correction data. It may be helpful when measurement is performed using a network analyzer not manufactured by ADVANTEST.

$$\text{FM correction} = \frac{\text{(Interferometer output voltage (V) absolute value)}}{\text{(AM)(ABa)(FMa)(FPa)}} \text{EXP(J(}\phi\text{ FM-(PIa+PPa)))}$$

J : Imaginary number unit

ϕ FM : FM phase

For the FM characteristics, the above expression can be used to correct the interferometer output frequency characteristics and to calculate the frequency shift absolute value.

$$\text{IM correction} = \frac{\text{(Interferometer output voltage (V)}}{\text{(IMa)(FPa)}} \text{EXP(J(}\phi\text{ IM-(PIa+PPa)))}$$

J : Imaginary number unit

ϕ IM : IM phase

For the IM characteristics, the above expression can be used to correct the interferometer output frequency characteristics.

Using the Q7605A/B, R3753/65/67, and PR370005-FJ in combination allows calculation of the frequency shift absolute values for the FM characteristics. The PR370005-FJ program calculates the interferometer output voltage based on the network analyzer output signal power. Therefore, the frequency shift measurement accuracy can be raised by more accurately calibrating the network analyzer measurement values (interferometer output voltage absolute values).

7 GPIB

7.1 Overview

The Q7605A/B allows remote control through the built-in IEEE 488-1987 measurement bus called GPIB (general purpose interface bus).

7.1.1 Overview of GPIB

The GPIB is an interface system allowing to configure an automatic measurement system by connecting the measurement device, controller, peripheral units, etc., through simple bus cables.

The GPIB system is advantageous in that it is more expandable than conventional interface systems, provides electrical, mechanical, and functional compatibility with other manufacturers' products, and is applicable to various system configurations ranging from those containing only one bus cable to those with high-level functions.

To use the GPIB system, first set an address for each of component devices connected to the bus line. Each component device can be assigned one or more roles from the three roles: controller, talker, or listener. Only one talker can send data to the bus line, and plural listeners can receive it. The controller specifies the talker and listener addresses, transfers data from talker to listeners, or can itself become a talker to set measurement conditions, etc. for the listeners.

Data are transferred asynchronously both ways between devices via eight data lines in the bit-parallel, byte-serial form. Because this is an asynchronous system, it is possible to mix high-speed and low-speed devices in the same system.

Data (messages) transferred between the devices include measurement data, measurement conditions (programs), various commands, and so forth; they are in ASCII code.

In addition to eight data lines, there are three handshake lines for transferring asynchronous data between devices, and five control lines for controlling the information flow on the bus.

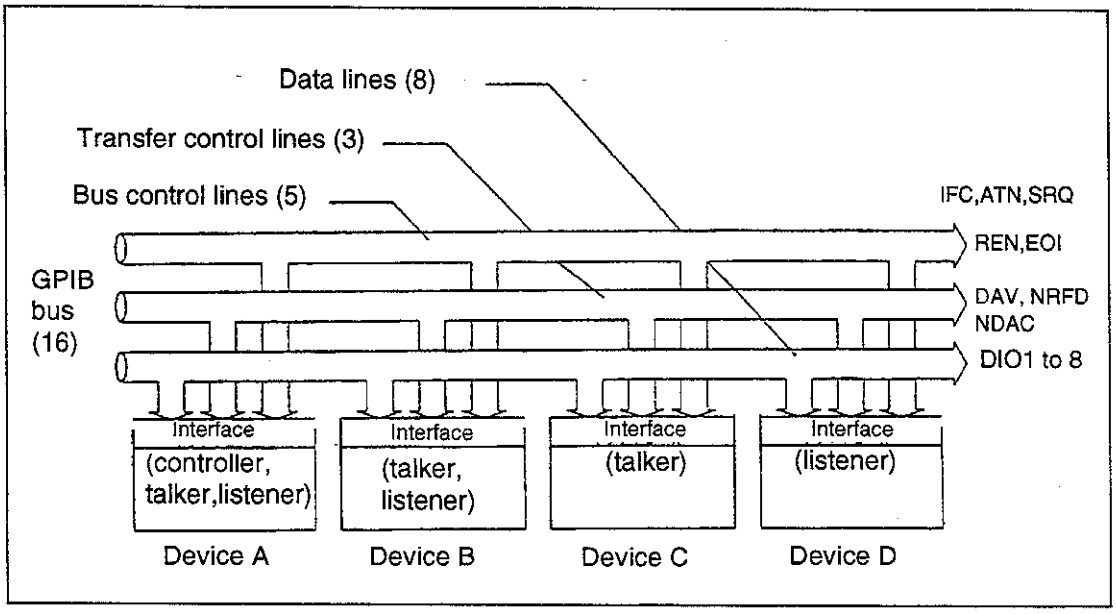


Figure 7-1 GPIB Bus Line Configuration

(1) The handshake lines transfer the following signals:

DAV (Data Valid)	Indicates the validity of data.
NRFD (Not Ready For Data)	Indicates readiness to receive data.
NDAC (Not Data Accepted)	Indicates completion of data reception.

(2) The control line transfers the following signals:

ATN (Attention)	Used to recognize the signal on the data lines as an address, command, or neither of the two.
IFC (Interface Clear)	Used to clear the interface.
EOI (End of Identify)	Used at the end of information transfer.
SRQ (Service Request)	Used by any device to ask the controller for a service.
REN (Remote Enable)	Used for remote control of devices applicable to remote programming.

7.1.2 GPIB and the Q7605A/B's GPIB Specifications

Applied standards : IEEE 488-1978

Code used : ASCII

Logic level : Logical "0" (HIGH) ... +2.4 V or more
Logical "1" (LOW) ... +0.4 V or less

Driver specifications : Open-collector format (except EOI or DAV)
Output voltage in LOW ... +0.4V or less, 48 mA
Output voltage in HIGH ... +2.4V or more, -5.2 mA

Receiver specifications: LOW for +0.6 V or less, HIGH for +2.4 V or more

Address specification : 31 talker/listener addresses can be set by the ADDRESS switch.

Cable length : The total bus cable length in a single bus system should not exceed n x 2m, where n = the number of devices to be connected, including the GPIB controller. In no case should the cable length exceed 20m.

Connector : 24-pin GPIB connector 57-20240-D35A (equivalent to Amphenol's products)

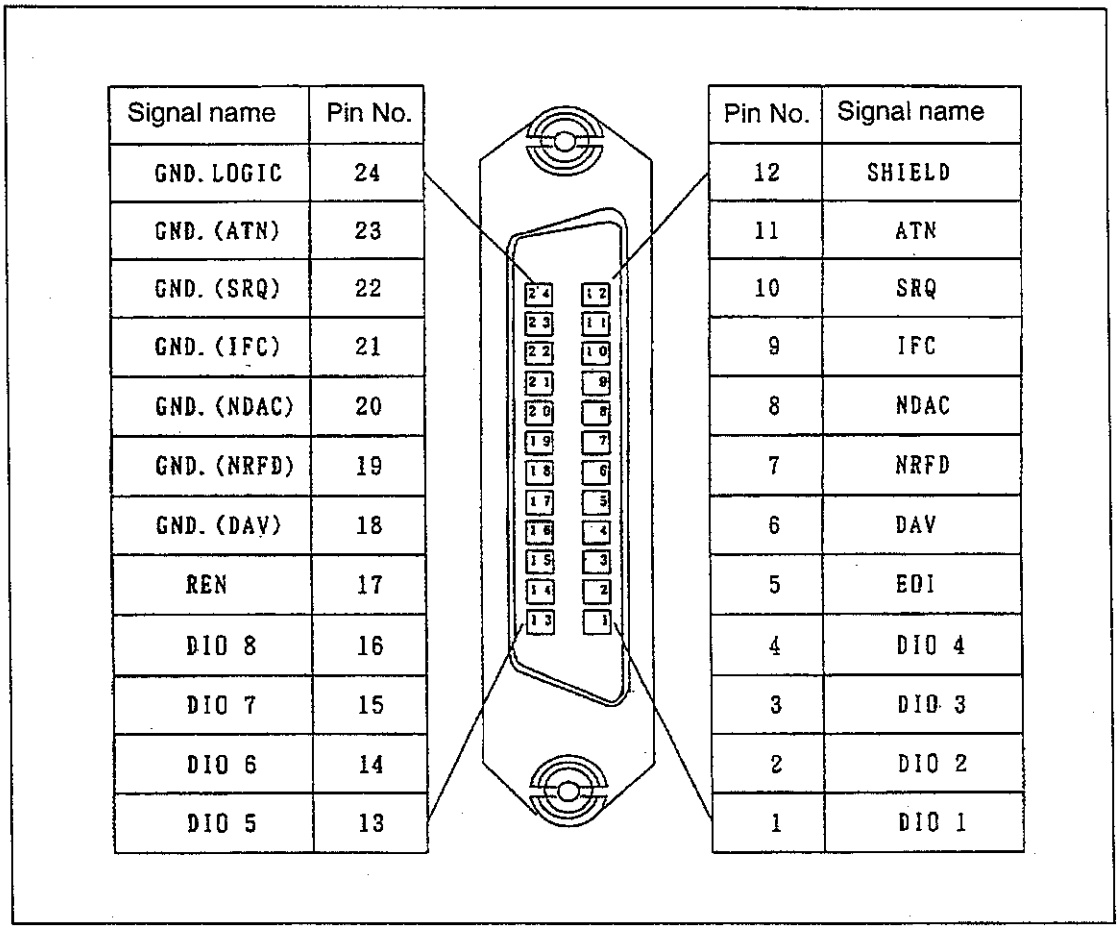


Figure 7-2 GPIB Connector Pin Assignments

7.1.3 Interface Functions

Table 7-1 shows the GPIB interface functions.

Table 7-1 GPIB Interface Functions

Code	Description
SH1	Source handshake function
AH1	Acceptor handshake function
T6	Basic talker function, serial poll function, and function for talker reset by listener specification
L4	Basic listener function and function for listener reset by talker specification
SR1	Service request function
RL1	Remote function
PP0	No parallel function provided
DC1	Device clear function
DT1	Device trigger function
C0	No controller function provided
E2	Try-state output

7.1.4 Connecting Component Devices

The GPIB system consists of several devices. This section gives the precautions to be observed when configuring the system.

(1) Before connecting the component devices, check their states and functions. (Refer to the relevant device's instruction manual.)

(2) Care should be taken to make the cables connecting the measurement device and the bus cable connecting the controller as short as possible. The bus cable should not exceed the rated length.
The total bus cable length in a single bus system should not exceed n x 2m, where n = the number of devices to be connected, including the GPIB controller. In no case should the cable length exceed 20m.

ADVANTEST optionally provides the following standard bus cables

Standard bus cables:

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

(3) The bus cable connectors are of the piggy-back type, i.e., each one has both male and female sides. Up to two such connectors can be used in a stack; do not stack three or more connectors. Be sure to fix the connectors securely with fixing screws.

(4) Before turning the component devices' power ON, check their power conditions, installation conditions, and if necessary, set conditions. Note that all the component devices connected to the bus must be powered. If any of the component devices are not powered ON, the whole system's operations are not guaranteed.

7.1.5 Description of the Q7605A/B Panel Controls Relating to GPIB

LOCAL key : Pressing this key while the Q7605A/B is in remote control mode (the REMOTE lamp is on) causes the Q7605A/B to cancel external controls and allows entries from the panel. The Q7605A/B is in the local mode immediately after it is powered.

REMOTE indicator : Remains on while the Q7605A/B is in the remote control mode.

SRQ indicator : Remains on while the Q7605A/B is transmitting a service request.

TALK indicator : Remains on while the Q7605A/B is in the talker mode.

LISTEN indicator : Remains on while the Q7605A/B is in the listener mode.

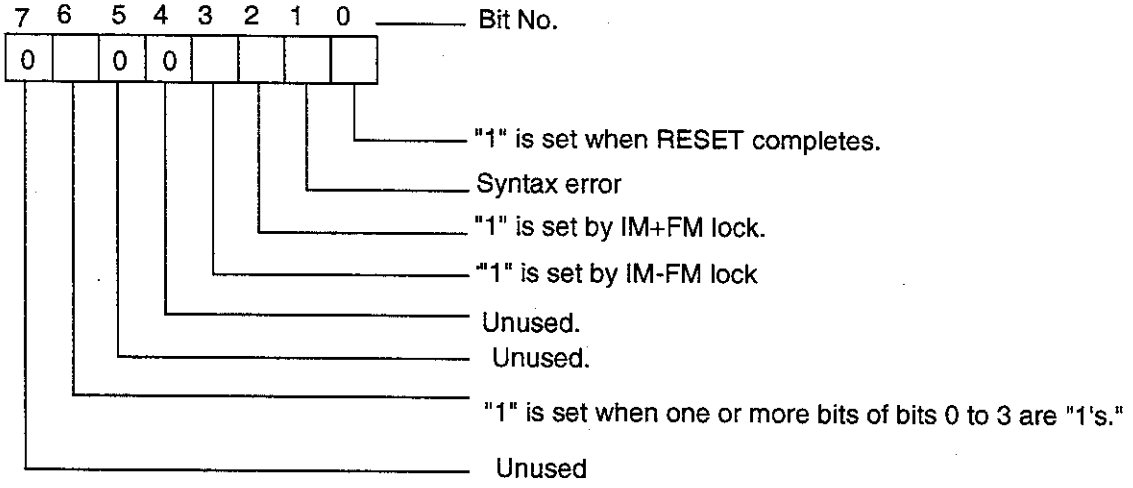
GPIB address switch : Before turning the Q7605A/B power ON, set the GPIB address on the address switch on the Q7605A/B rear panel.

7.2 Service Request

The Q7605A/B sends a service request (SRQ) to the controller when it has been placed in the S0 mode and "1" is set in the corresponding bits of the status byte.

After the Q7605A/B has sent a service request, the controller sends the status byte by serial polling.

Status byte



If an "ATN" request makes an interrupt during message transfer between devices, the previous states are cleared.

7.3 GPIB Talker Format

The talker format is in ASCII code. Read the talker data by issuing a read command.

When data is plural:

Data 1	SD	Data 2	SD	.....	SD	Data N	BD

When data is not plural:

Data	BD

SD: String delimiter (Set by SLn.)

BD: Block delimiter (Set by DLn.)

Whether or not the data is plural is determined according to the read command. Refer to the explanation of read commands.

7.4 GPIB Commands

This section gives a list of GPIB commands, followed by their descriptions.

No.	Code	Function
1	C	Resets the Q7605A/B.
2	DLn	Sets the block delimiter.
3	SLn	Sets the string delimiter.
4	BZn	Sets the buzzer.
5	OSn	Sets OUTPUT SELECT.
6	MDn	Sets the Q7605A/B measurement mode.
7	Sn	Sets SRQ.
8	CS	Clears the status.
9	AM	Requests the interferometer to output the interference amplitude (1 point)
10	ABa	Requests output of absolute value correction data (1 point)
11	FMa	Requests the interferometer to output frequency characteristics data for FM (201 points)
12	IMa	Requests the interferometer to output the frequency characteristics data for IM (201 points)
13	FPa	Requests output of PD frequency characteristics data (201 points)
14	Pla	Requests the interferometer to output the phase data (201 points)
15	PPa	Requests output of PD phase data (201 points)

A maximum of 40 characters can be set at one time.

(1) C

Function	Initializes the Q7605A/B states.
Parameters	None.
Description	This command initializes the delimiters, buzzer, OUTPUT SELECT, and SRQ.

Item	State
Block delimiter	Outputs EOI together with CRLF and LF.
String delimiter	","
Buzzer	On
OUTPUT SELECT	Sets HIGH-SENS.
SRQ	Not sending SRQ.

(2) DLn

Function	Sets the block delimiter mode.
Parameters	n = 0 CR/LF + EOI n = 1 LF only n = 2 EOI only
Description	This command indicates the end of data. The specified delimiter is added to the data regardless of the number of data.

(3) SLn

Function	Sets the string delimiter mode.
Parameters	n = 0 "," n = 1 _ (Space) n = 2 CRLF
Description	When an output request is issued, the output format is ASCII and the data consists of two or more, the specified string delimiters are added to the output data.

(4) BZn

Function	Sets the buzzer.
Parameters	n = 0 Buzzer off n = 1 Buzzer on
Description	This command is used to set the buzzer on or off.

(5) OSn

Function	Sets OUTPUT SELECT.
Parameters	n = 0 Sets the interferometer to HIGH-SENS. n = 1 Sets the interferometer to WIDE-BAND.
Description	This command sets the interferometer output.

(6) MDn

Function	Sets the measurement mode.
Parameters	n = 0 Executes RESET. n = 1 Executes IM+FM. n = 2 Executes IM-FM. n = 3 Executes IM-MONITOR.
Description	This command sets the Q7605A/B measurement mode. IM+FM or IM-FM cannot be executed unless RESET is executed at least once. RESET is cleared by IM-MONITOR.

(7) Sn

Function	Sets SRQ.
Parameters	n = 0 Sends SRQ. n = 1 SRQ is not sent.
Description	When S0 is set, a service request is issued.

(8) CS

Function	Clears the status.
Parameters	None.
Description	This command clears those bits that are set to "1" in the status.

(9) AM

Function	Requests the interferometer to output the interference amplitude.
Parameters	None.
Description	This command outputs the difference, in the form of voltage (V), between the interference wave peak levels read by RESET. The data is used to calculate the measurement result absolute values. 1 point

(10) ABa

Function	Requests the output of absolute value correction data.
Parameters	a = H Outputs HIGH-SENS correction data. a = W Outputs WIDE-BAND correction data.
Description	From the correction data stored in the Q7605A/B, this command outputs the correction data related to electrical circuits. The data is used to calculate the measurement result absolute values. 1 point

(11) FMa

Function	Requests the output of interferometer's frequency characteristics for FM.
Parameters	a = H Outputs HIGH-SENS correction data. a = W Outputs WIDE-BAND correction data.
Description	From the correction data stored in the Q7605A/B, this command outputs the interferometer frequency characteristics for FM measurement. The data is used to calculate the measurement result absolute values. 201 points

(12) IMa

Function	Requests the output of interferometer's frequency characteristics for IM.
Parameters	a = H Outputs HIGH-SENS correction data. a = W Outputs WIDE-BAND correction data.
Description	From the correction data stored in the Q7605A/B, this command outputs the interferometer frequency characteristics for IM measurement. The data is used to calculate the measurement result absolute values. 201 points

(13) FPa

Function	Requests the output of detector's frequency characteristics data.
Parameters	a = H Outputs HIGH-SENS correction data. a = W Outputs WIDE-BAND correction data.
Description	From the correction data stored in the Q7605A/B, this command outputs the detector frequency characteristics. The data is used to calculate the measurement result absolute values. 201 points

(14) PIa

Function	Requests the output of interferometer's phase data.
Parameters	a = H Outputs HIGH-SENS correction data. a = W Outputs WIDE-BAND correction data.
Description	From the correction data stored in the Q7605A/B, this command outputs the interferometer's phase data. The data is used to calculate the measurement result absolute values. 201 points

(15) PPa

Function	Requests the output of detector's phase data.
Parameters	a = H Outputs HIGH-SENS correction data. a = W Outputs WIDE-BAND correction data.
Description	From the correction data stored in the Q7605A/B, this command outputs the detector phase. The data is used to calculate the measurement result absolute values. 201 points

7.5 Reading the Status Data Set in Q7605A/B

The status data set in the Q7605A/B can be read out with the following GPIB commands:

Code	Function	Responses
DL?	Sets the block delimiter.	0, 1, 2
SL?	Sets the string delimiter.	0, 1, 2
BZ?	Sets the buzzer.	0, 1
OS?	Sets OUTPUT SELECT.	0, 1
MD?	Sets the operation mode (RESET, IM+FM, IM-FM, IM-MONITOR)	0, 1, 2, 3, -1

After sending one of the above codes to the Q7605A/B, the response data is read out from the Q7605A/B. The number returned as the response corresponds to the parameter of the same value in the associated GPIB command. The case when "-1" is returned for the MD? command indicates that no operation mode has been set for the Q7605A/B.

7.6 Sample Programs

This section describes sample programs using the PC9801 Series personal computer as a controller.

7.6.1 Setting the Q7605A/B

```
10    ' EXAMPLE PROGRAM
20    Q7605AB=3                      Defines the Q7605A/B address as 3.
30    '
100   ISET IFC                       Interface clear
110   ISET REN                       Remote enable
120   '
150   PRINT @Q7605AB;"OS1"           Sets OUTPUT SELECT to WIDE-BAND mode.
160   PRINT @Q7605AB;"MD0"           Executes RESET.
170   '
```

7.6.2 Reading Status Data Set in Q7605A/B and Correction Data

```
10    ' EXAMPLE PROGRAM
20    Q7605AB=3                      Defines the Q7605A/B address as 3.
30    '
40    DIM FM1(200)                   Declares an array variable.
50    '
100   ISET IFC                       Interface clear
110   ISET REN                       Remote enable
120   '
150   PRINT @Q7605AB;"MD?"           Requests mode output.
160   INPUT @Q7605AB;MD$             Reads in Q7605A/B mode.
170   '
180   PRINT @Q7605AB;"AM"            Requests output of interferometer output amplitude.
190   INPUT @Q7605AB;AM              Reads in interferometer output amplitude.
200   '
210   PRINT @Q7605AB;"ABH"           Requests output of absolute value correction data.
220   INPUT @Q7605AB;ABH             Reads in absolute value correction data.
230   '
240   PRINT @Q7605AB;"FMH"           Requests output of frequency characteristics
                                     correction data for FM.
250   FOR I=0 TO 200
260      INPUT @Q7605AB;FMH(I)       Reads in frequency characteristics correction
                                     data for FM.
270   NEXT I
280   '
```

7.6.3 Service Requests

```
10      ' EXAMPLE PROGRAM
20      Q7605AB=3                       Defines the Q7605A/B address as 3.
30      '
100     ISET IFC                        Interface clear
110     ISET REN                        Remote enable
120     '
130     ON SRQ GOSUB *SRQFUN            Specifies the SRQ routine jumping destination.
140     SRQ ON                          Enables SRQ to interrupt.
150     PRINT @Q7605AB;"S0"             Originates SRQ.
160     PRINT @Q7605AB;"MD0"            Executes RESET.
170     '
180     *LOOP1                          Endless loop
190     GOTO *LOOP1
200     '
250     '
260     *SRQFUN
270     SRQ OFF                         Disables SRQ to interrupt.
270     POLL Q7605AB,S                  Executes serial polling.
280     PRINT "RESET COMPLETED"
290     SRQ ON                          Enables SRQ to interrupt.
300     '
```

8 TROUBLESHOOTING

If a problem occurs, read this section before contacting ADVANTEST for repairs. This section may also provide reference information for measurement.

Trouble	Solutions
The POWER indicator does not go on when the Q7605A/B is powered ON.	Check that the power cable is correctly connected. If the power is correctly supplied, check the fuse.
The panel operations are not accepted.	The Q7605A/B may have been placed in REMOTE mode by a GPIB command. If so, place it in the LOCAL mode using the LOCAL switch.
No optical input is given, but the level meter is swinging.	Immediately after the Q7605A/B is powered ON, the conditions are not stable, and the level meter may swing. The level goes down after a while.
The level meter does not swing when an optical-fiber cable is connected.	Check whether the incident light level is too low. In addition, the level meter may also not swing when the incident light polarization state does not match the internal interferometer. Adjust the polarization state with the POLARIZATION ADJUST knob. The optical input connector should be connected with a PC-polished connector inside the Q7605A/B. The input level may also be lowered when the optical input connector is stained. Use a connector that has been well cleaned.
RESET does not complete.	The incident light level may be too low. Check the incident light level and optical fiber connectors.
IM+FM is not locked after RESET is over.	Make sure that the incident light is laser light of 1.55 µm band. The Q7605A/B's built-in interferometers have special parts for 1.55 µm band laser light. The interferometers do not work as frequency discriminators when the incident light is not of the 1.55 µm band.
IM+FM or IM-FM is not accepted.	Check whether the RESET indicator is on. RESET must be executed at least once before the Q7605A/B can be switched over to IM+FM or IM-FM mode.
The measurement value varies for each sweep.	Check whether the incident light polarization is stable. If necessary, stabilize it by securing the optical fiber.
The IM-MONITOR measurement value varies for each sweep.	After the IM-MONITOR has been set, it takes approximately 20 seconds until the interferometer stabilizes. Start the measurement after the interferometer output data has stabilized.

Trouble	Solutions
The measurement data frequency characteristics are worse than those expected.	Check whether the network analyzer sweep time is too short. Settings in the network analyzer are restricted because of a delay in the Q7605A/B. Set a longer delay time temporarily. Especially for LOG sweep, data may be easily lost in the high-frequency area.
The PR370005-FJ program does not work.	Check that the GPIB cable is correctly connected and that the software program has been successfully loaded.

9 OPERATING PRINCIPLES

This section explains the principles of the way in which the Q7605A/B can be used to separate and measure the frequency modulation (FM) and intensity modulation (IM) characteristics.

9.1 Operating Principles

9.1.1 Using the Mach-Zehnder Interferometer as a Lightwave Frequency Discriminator

Figure 9-1 shows the characteristics of the Q7605A/B's built-in Mach-Zehnder interferometer. This figure gives the characteristics of a sine wave, with the lightwave input frequency given to the interferometer along the abscissa and the Mach-Zehnder interferometer's interference output intensity along the ordinate. Therefore, by controlling the optical interferometer so that it matches the lightwave frequency of the incident light, the incident lightwave frequency shift can be observed as the variance of the interferometer outputs. In this situation, however, the optical interferometer output contains both of the FM and IM components of the incident light, and they cannot be separated from each other.

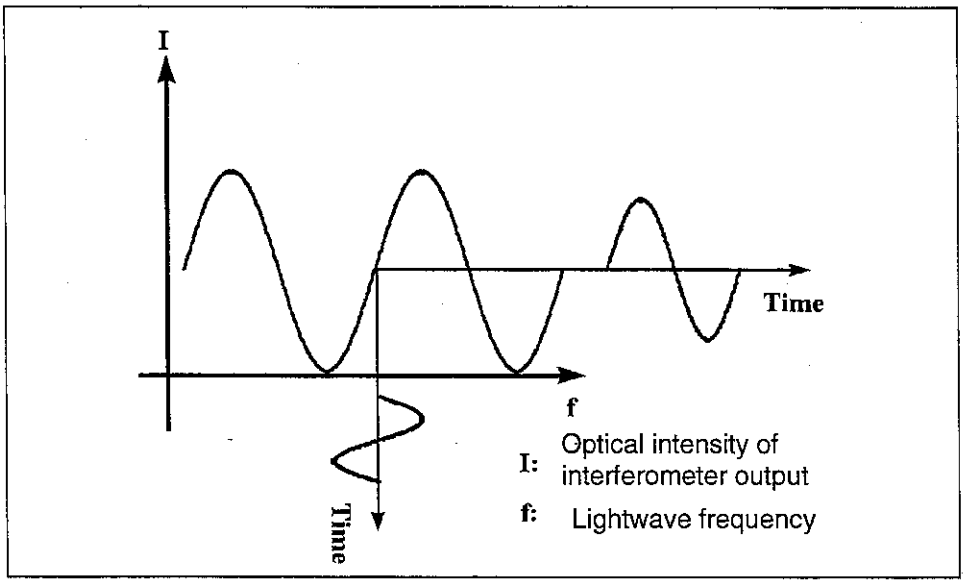


Figure 9-1 Lightwave Frequency-discriminate Characteristics of the Mach-Zehnder Interferometer

9.1.2 Separating FM and IM Components

In order to separate the FM and IM components from each other, two different measurement points of the Mach-Zehnder interferometer are used for measurement (see Figure 9-2.) While the interferometer is in state A, it outputs both the IM and FM components in the same phase (IM+FM). In contrast, in state B, the interferometer outputs the IM and FM components in the reverse phase (IM-FM). By calculating the sum and difference using the network analyzer operation functions, the IM and FM data can be separated from each other.

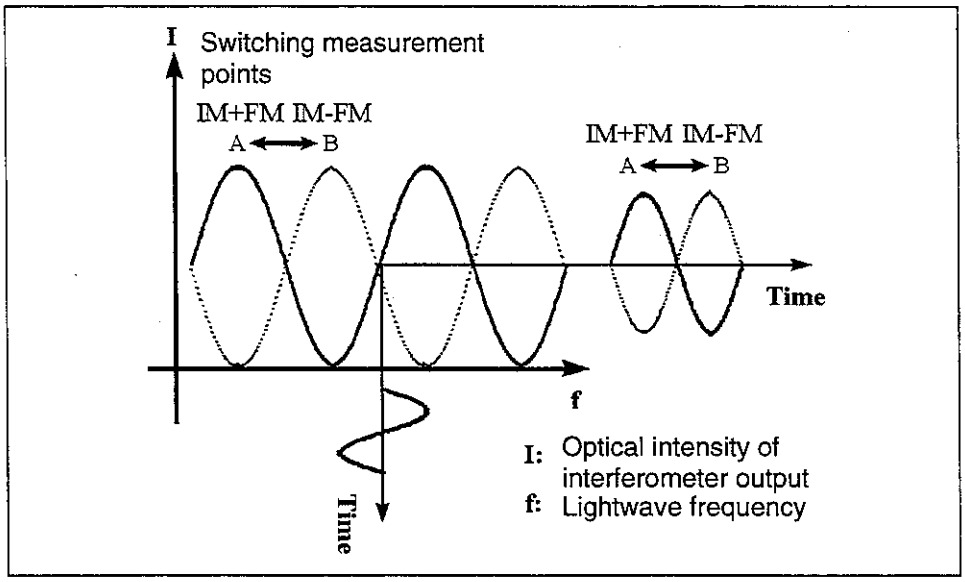


Figure 9-2 Switching Measurement Points of the Mach-Zehnder Interferometer Lightwave Frequency Discriminator

9.1.3 Interferometer Characteristics and Q7605A/B Operations

The Q7605A/B has a pair of interferometers: HIGH-SENS and WIDE-BAND. This section describes the relationships between the interferometer characteristics and Q7605A/B operations.

The characteristics of the Q7605A/B's built-in Mach-Zehnder interferometer are given below.

(1) Interferometer characteristics measured by RESET

The interferometer output maximum and minimum values are obtained by shifting the lightwave frequency discriminated characteristics. The difference between the maximum and minimum values can be read as the interferometer interference amplitude with GPIB commands.

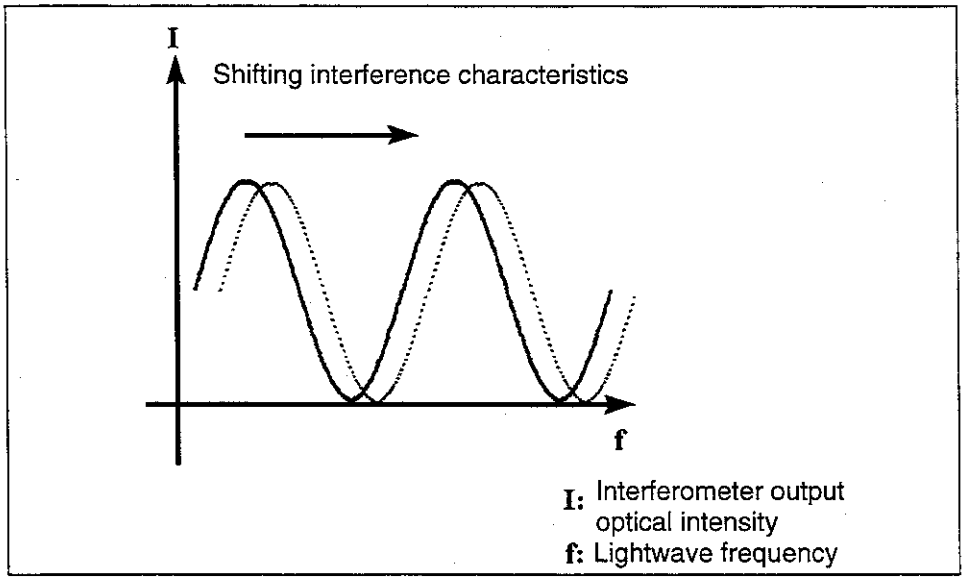


Figure 9-3 Interferometer Characteristics Measured by RESET

(2) Interferometer characteristics measured by IM+FM

The lightwave frequency-discriminate characteristics are controlled so that the interferometer output is the sum of the IM and FM characteristics.

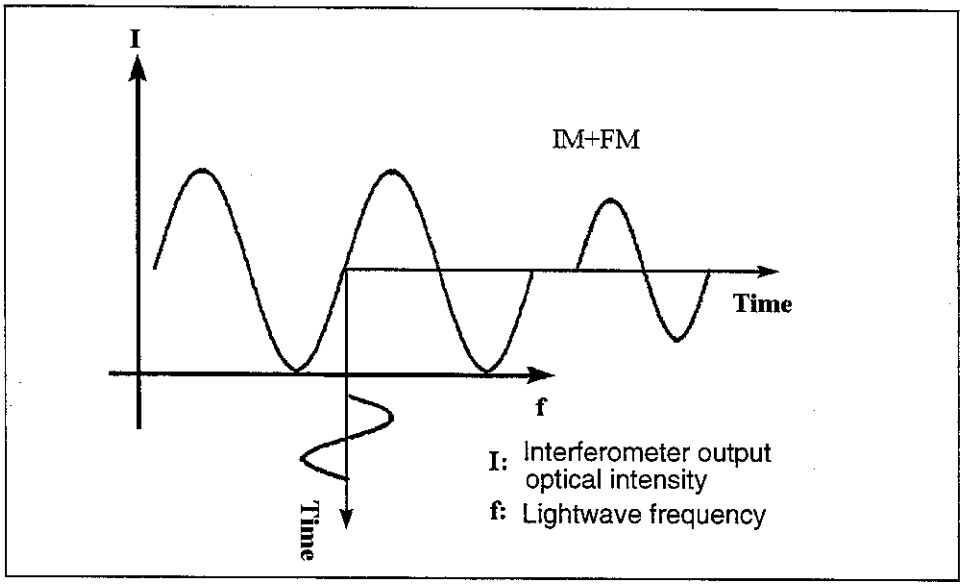


Figure 9-4 Interferometer Characteristics Measured by IM+FM

(3) Interferometer characteristics measured by IM-FM

The lightwave frequency-discriminate characteristics are controlled so that the interferometer output is the difference between the IM and FM characteristics.

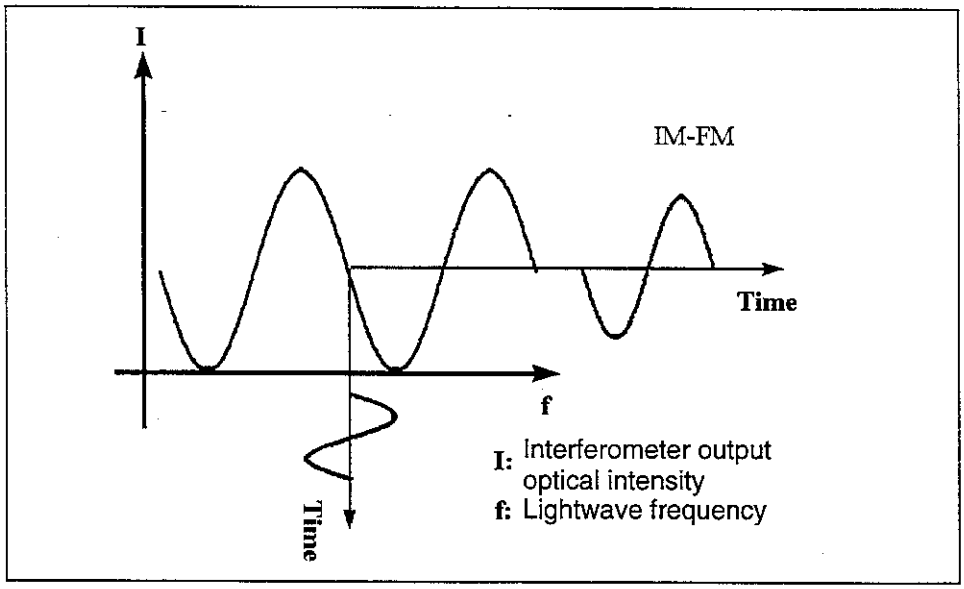


Figure 9-5 Interferometer Characteristics Measured by IM-FM

(4) Interferometer characteristics measured by IM-MONITOR

The lightwave frequency-discriminate characteristics are controlled so that the interferometer output is the IM characteristics only.

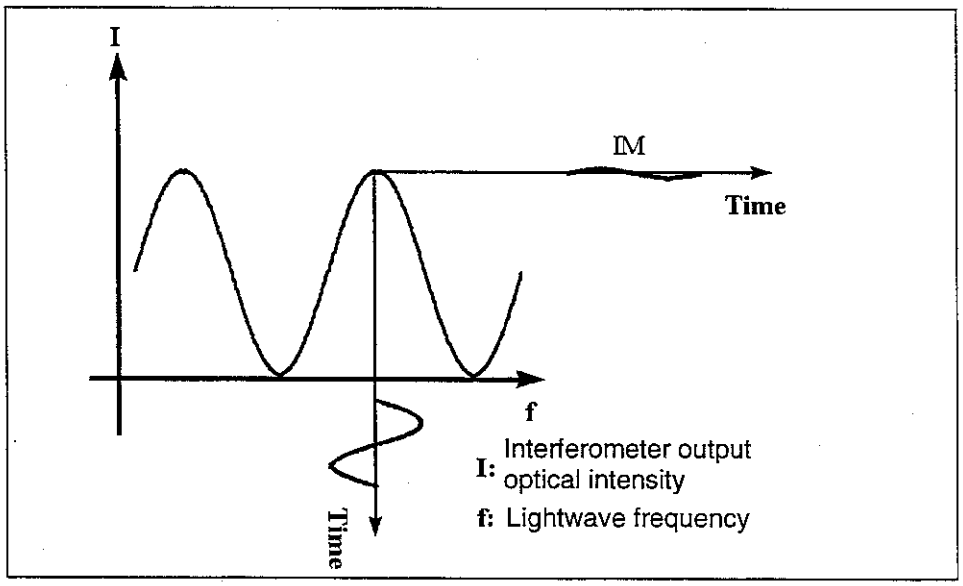


Figure 9-6 Interferometer Characteristics Measured by IM-MONITOR

9.2 Block Diagram

Figure 9-7 shows the Q7605A/B block diagram.

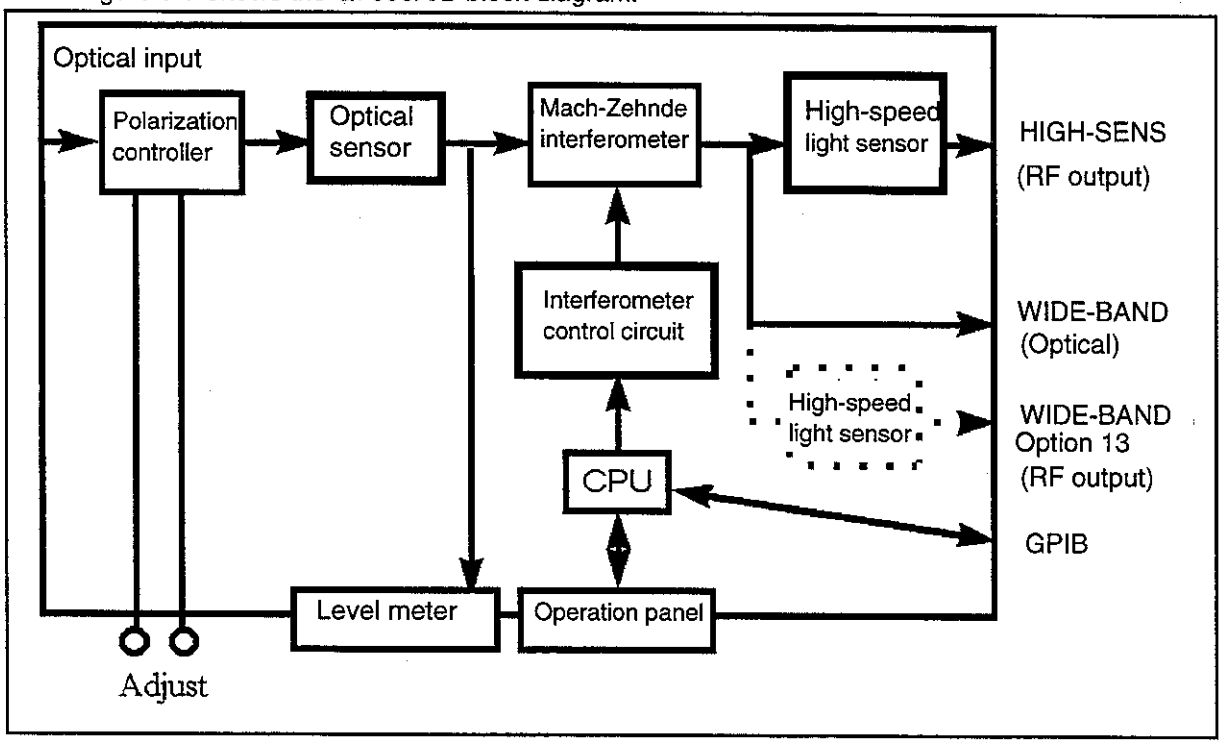


Figure 9-7 Q7605A/B Block Diagram

10 SPECIFICATIONS

10.1 Q7605A/B Major Specifications

10.1.1 Measurement Functions

Measurement characteristics: Separated characteristics of FM and IM components

Measurement channel: Two channels (one high-sensitivity channel and one wide-band channel)

Measuring point automatic setting function: Automatically setting the measuring points for separating the IM and FM components from each other

Polarization compensation function: Built-in optical-fiber type polarization controller

10.1.2 Input Characteristics

Item				Specifications (1)	
				Q7605A	Q7605B
Wavelength measurement range				1550±40nm	
Allowable incident light power range				-10dBm to +10dBm	
FSR	High-sensitivity channel			7±1GHz	
	Wide-band channel			65±5GHz	150±15GHz
Demodulation bandwidth	High-sensitivity channel			100Hz to 2GHz	
	Wide-band channel (2)			100Hz to 20GHz	100Hz to 40GHz
	Amplitude flatness (3)	High-sensitivity channel		4dBp-p or less	
		Wide-band channel	100Hz to 12GHz	4dBp-p or less	
			12GHz to 20GHz	5dBp-p or less	
Demodulation frequency shift (4)	High-sensitivity channel			20MHz to 2GHzp-p	
	Wide-band channel			200MHz to 20GHzp-p	400MHz to 40GHzp-p
Demodulation sensitivity	High-sensitivity channel (5)			-93dBm or more	
	Wide-band channel (6)			-90dBm or more	-87dBm or more
Insertion loss	Wide-band channel			12dB or less (Typ.)	

(1) Temperature 23°C ± 5°C

(2) 100Hz to 20GHz when Option 13 is installed

(3) When corrected based on 130MHz, using the optical frequency characteristics correction data stored in the Q7605A/B

(4) Optical input power 0dBm, ADVANTEST's network analyzer R3762 used (RBW: 1kHz)

(5) Output signal level at optical input power 0dBm, 1550 ±20nm, frequency shift 10MHz

(6) Output signal level at optical input power 0dBm, 1550 ±20nm, frequency shift 100MHz, with Option 13 installed

10.1.3 Input/Output Specifications

Optical input:	FC/PC connector
Demodulation output:	SMA connector for high-sensitivity channel
	FC/PC connector for wide-band channel
	(SMA connector for Option 13)
GPIB:	Conforming to IEEE488-1978

10.1.4 General Specifications

Operating conditions:	Temperature +10°C to +40°C
	Relative humidity 85% or less
Storage conditions:	Temperature -20°C to +60°C
	Relative humidity 90% or less
Power supply:	100VAC to 120VAC or 220VAC to 240VAC (automatic switching),
	50/60Hz, 36VA or less
Outside dimensions:	Approx. 424 (W) x 132 (H) x 500 (D) mm
Mass:	11kg or less

APPENDIX 1

A.1 Glossary

Automatic power control (APC)

The mechanism for supplying power so that the optical output is kept constant. The optical output from a laser diode driven by constant current falls or stops when the temperature rises, and increases when the temperature lowers. The optical output may exceed the maximum rating when the temperature is too low. In order to protect the laser diode and stabilize the optical output, this circuit receives the monitor light of laser diode through the photo diode and then make it feed back to the drive circuit for laser diode.

Avalanche photo diode

A light-receiving element frequently used for optical-fiber communications. It uses an avalanche effect: a high reverse bias-voltage (100V to 200V) given to a semiconductor pn junction first moves a few carriers, causing successive carriers to be generated and making the current increase at an accelerated rate.

Baseband transmission characteristics

When an optical pulse is input to an optical fiber, the output pulse at the other end diverges, and this phenomenon is called divergence. That is, the transmission loss increases in the time domain. When converted to the frequency domain, it shows an increase in the transmission loss in the high-frequency band. The transmission characteristics in this frequency domain are called the baseband transmission characteristics, and these are important for optical-fiber performance.

Beam divergence angle

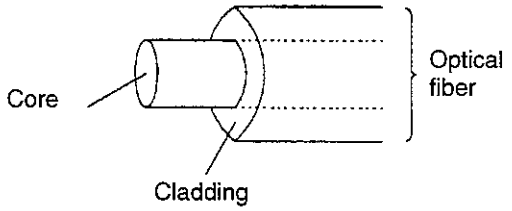
The angle from the optical axis that halves the radiant intensity from its maximum. For a laser diode, the horizontal direction to the junction is indicated by θ // and the perpendicular direction is indicated by $\theta\perp$. ($\theta\perp > \theta$ //)

Chopped light

A light with its intensity modulated by a square wave. Its optical output goes on and off repeatedly at a certain cycle.

Cladding

A part of the optical-fiber structure. An optical fiber consists of the core axis and the cladding surrounding the core. The fibers are generally made of quartz glass or plastics. The cladding has a refractive index approximately 1% less than that of the core, which helps contain the light flux within the core.



Coated fiber

One type of optical fiber, the core and cladding of which are covered by primary coating (silicon resin) and secondary coating (protective nylon layer).

Coherence

1. The existence of a timing correlation between the phases of two or more waves.
2. When the wavelengths, phases, and wave faces of light are exactly the same, the light is said to be coherent. There are two types of coherence: temporal and spatial. Temporal coherence is wavelength uniformity and phase continuity. Spatial coherence is the convergence of light into one point by a lens. As represented by laser light, light that has a constant wavelength and stable phase relationships is called coherent.

Coherent

Light is one type of electromagnetic wave, and has an extremely short wavelength. However, visible light has characteristics significantly different from those of the electromagnetic waves used for radio and TV programs. That is, while the frequencies, phases, and wave faces of electromagnetic waves are exactly the same, those of visible light vary. Visible light is therefore regarded as a certain type of noise. Light that has exactly the same frequencies, phases, and wave faces is said to be coherent. The light emitted from a laser diode used for optical communications has very high coherence, although it is not perfect.

Continuous-wave (CW) light

A non-modulated light with constant intensity. Also known as a DC light.

Core

Part of the optical-fiber structure. The core is the central axis, surrounded by cladding. A light flux propagates through the core. It is made of quartz glass and has a refractive index that is larger than that of the cladding by 1%. There are two types of optical fiber: multi mode fibers, with a core thickness of 50 to 100 $\mu m\phi$, and single-mode fibers, with a core thickness of approximately 10 $\mu m\phi$. Optical fibers can also be classified into the graded index (GI) and step index (SI) types, depending on the refractive index distribution of the core.

Core and cladding

The core is the central axis of the optical fiber, and cladding covers the core. Because the cladding has a lower refractive index than that of the core, the incident light propagates through the core, within which it is contained, repeating total reflection at the boundary face between the core and cladding. Generally, the core and cladding diameters are indicated as 50/125 μm, which means a core diameter of 50 μm and a cladding diameter of 125 μm.

Dark current

Current output from a light-receiving element when no incident light is given to it.

Direct modulation

The method that use a modulating signal as drive current to turn the light source on. The method of using a lightwave modulator is called external modulation.

Distributed feedback laser (DFB-LD)

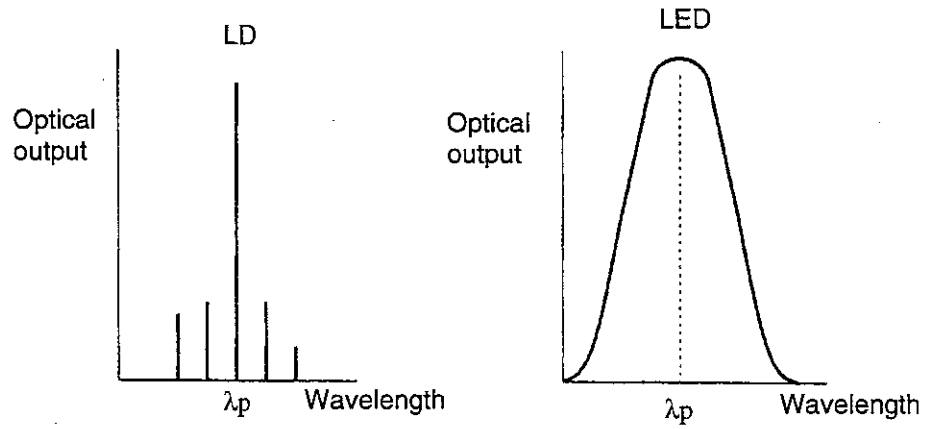
A type of laser that has a waveguide with a cyclic structure, to form a resonator that has a selective wavelength.

Double heterojunction

A heterojunction means a junction by crystals with different atomic structures. The double heterojunction in laser diodes places a cladding layer with a large energy gap on both sides of the active layer. It is used to raise the minority carrier density and to form an optical waveguide.

Emission peak wavelength

The wavelength of a light-emitting element that produces the maximal energy density of the emission spectrum.



Excess noise factor

Factor of shot noise multiplication occurring in an avalanche photodiode. It is defined as F = Mx.

Because of the fluctuation in the multiplication process, shot noise current iN increases as

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

Where M: Multiplication factor

B: Signal bandwidth

x: Excess noise factor

q: Electron charge

I: Average current flowing in the avalanche area

FM

Frequency modulation

Free spectral range (FSR)

Peak-to-peak interval of the output from the Q7605A/B's built-in Mach-Zehnder interferometer. The narrower the FSR is, the more accurately FM measurement is carried out, but the frequency characteristics deteriorate.

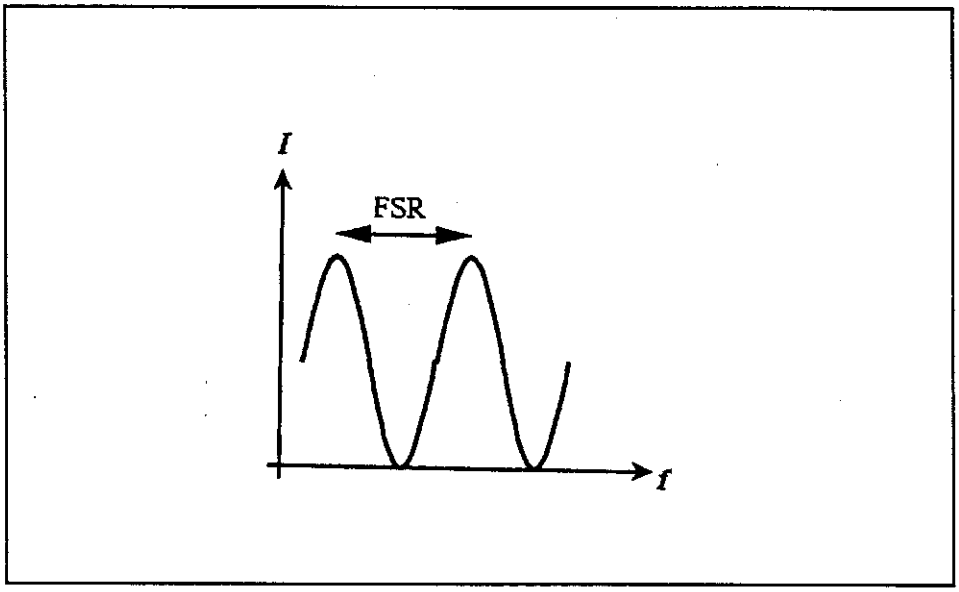


Figure A-1 Interference Characteristics and FSR of the Mach-Zehnder Interferometer

Fundamental mode

0-dimensional electromagnetic field distribution. Also known as single lateral mode.

Graded index fiber

One type of multi mode fiber, the core refractive indices of which are distributed in a parabolic form. This means that the light passing through the center of the core goes more slowly, and the light passing through the periphery goes faster, making the propagation speed constant regardless of the light path. In addition, the timing distribution of output pulses can be made extremely small (little mode dispersion). This means that the transmission band (hundreds of MHz · km) is much wider than that of the step index fiber.

IM

Intensity modulation

Infrared rays

Light with wavelengths longer than those of visible light.

Wavelength 0.78 to 3 μm :Near-infrared light

3 to 30μm : Mid-infrared light

30μm to 1mm: Far-infrared light

1mm or more: Microwave

Laser

There are several types of laser: solid-state, gas, liquid, etc. Solid-state lasers are used as the light source for optical-fiber communications, because they are smaller than other types of laser and allow direct modulation. Compared to LEDs, lasers have better coherence and faster responses, and they are therefore important elements as a light source. A solid-state laser is sometimes abbreviated LD, standing for laser diode.

Laser diode

One type of semiconductor light-emitting element. The word laser stands for Light Amplification by Stimulated Emission of Radiation. A laser is an oscillator that emits light using this principle. A laser diode gives a high optical output. Laser diodes have advantages such as high optical output, the possibility of fast direct modulation, good optical-fiber coupling efficiency, etc., but they have a problem in the stability of the light emission. This is why LEDs have mainly been used. Recently, since this problem is now being solved, laser diodes are being used more than before for long-distance, fast communications.

Leak light

When an optical fiber is bent or pressed, the light propagation path in the core is distorted, causing the propagating light to leak out of the optical fiber. This is called leak light.

Light-emitting diode (LED)

One type of light-emitting element. As in the case of a laser diode, it uses the light emitted when the carriers injected into the semiconductor pn junction face recouple. In a laser diode, light is generated by induced emission, whereas in an LED it is generated by spontaneous emission. An LED has advantages such as long life, stability, low cost, and good linearity. However, because an LED produces only a small output to send to the fiber and is not suitable for fast modulation, it is advantageous for short-distance, small-capacity communications or analog-type communications.

Light sensor

For optical-fiber communications, a photodiode (PD) using the photovoltaic effect or photoconductive effect is used. There are two types of PDs: pn and pin. Those applying the avalanche effect by giving reverse bias voltage are called avalanche photodiodes (APD). These photoreceivers are mainly used for measurement devices. In addition, thermopiles employing the thermo effect have constant sensitivity regardless of the wavelength, and are used as detectors in reference optical power meters.

Longitudinal mode

A state which emission spectrum, that a half height width is extremely small, exist discontinuously. An individual emission spectrum is also called a longitudinal mode. The wavelength difference with the adjacent mode is called a longitudinal mode interval. When there is only one mode, it is called a single longitudinal mode.

Long wavelength region

Among the optical wavelengths used for optical-fiber communications, this is the region of 1.0 to 1.5 μm . This region is used for long-distance communications, because it produces little transmission loss with optical fibers.

Luminous flux

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

Unit: lm (lumen)

Km: Maximum visibility 680lm/W

V(λ): Standard spectral luminous efficiency

Value determined by International Commission on Illumination (CIE)

1.0004 whenλ= 555nm (yellow-green)

Luminous intensity

$$i = \frac{dF}{dw}$$

Unit: Cd (candela)

F: Luminous flux

w: Solid angle

Radiant intensity is the value indicated by an energy unit.

Mach-Zehnder interferometer

A type of interferometer which the incident light is split into two routes, and a delay is given to one route but not to the other. The two waves are then composed again to cause interference.

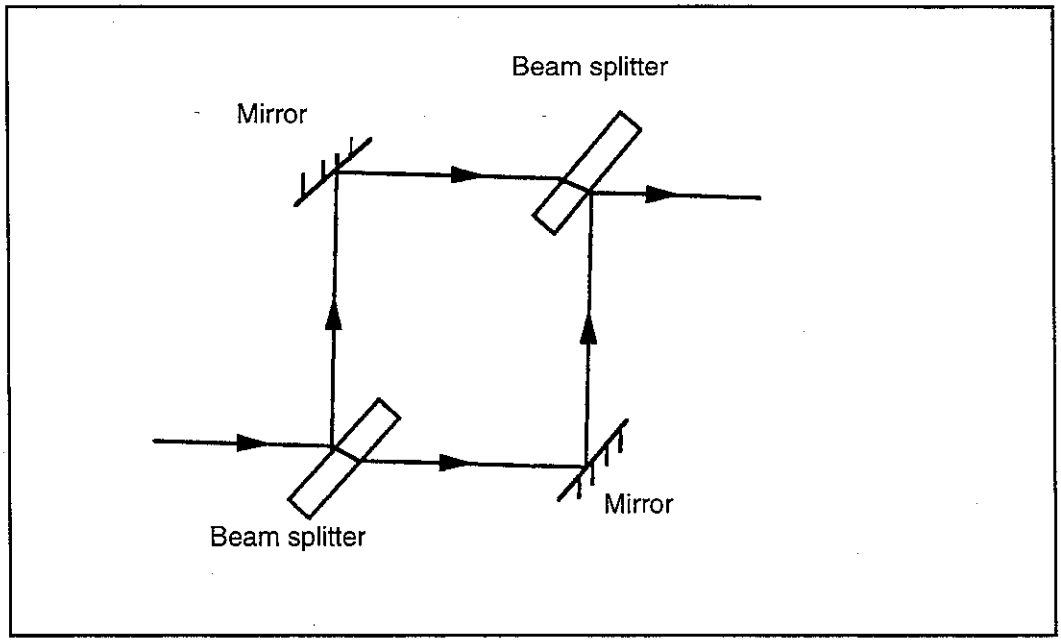


Figure A-2 Typical Mach-Zehnder Interferometer Configuration

Monitor current

Monitor diode output generated when the light emitted from the rear of the laser diode chip is received by the monitor diode.

Monitor output

A light emitted from the rear of the laser diode chip.

Multi mode fiber

An optical fiber that has more than one propagation mode, and many of these modes (which can be assumed to be light with various angles to the optical fiber's central axis) propagate through the core at the same time. Multi mode fibers can be classified into step, graded, and other types, depending on the refractive indices of the core. They are advantageous in that the core diameter is comparatively large (50 to 100μm), and connections are easier than with single mode fibers. On the other hand, the transmission band area is somewhat narrow (mode divergence), because many modes propagate at different speeds through the optical fiber.

Numerical aperture

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

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

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

Optical fiber

An optical waveguide in which the outer refractive index is made less than the inner one to give the fiber such characteristics that enable the light to propagate inside the fiber, even when the fiber is bent.

A fiber with a diameter of approximately 0.12mmϕ consisting of two types of quartz glass (core and cladding) with different refractive indices. It shows superior characteristics such as wide band, small loss, and noninduction.

Optical fiber connector

A detachable connector for connecting optical fibers to one other, or an optical fiber to a device. Usually simple matching is used for connection, that is, optical-fiber faces are connected directly to each other by using connectors with their cores well aligned. Compared with electrical connectors, an optical fiber connector has some disadvantages: high mechanical precision is necessary, a connection loss of approximately 0.5 to 1dB occurs, and careful treatment is required to prevent dust.

Optical rotating power

A phenomenon in which the plane of polarization rotates when a linear polarized light passes through a substance.

Pigtail fiber

A fiber with its one or both ends are open.

Polarizer

An element that converts natural light into a linear polarized wave.

Quantum efficiency

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

The ratio of the number of photons generated inside an element to the number of carriers generated (internal quantum efficiency); or the ratio of the number of photons emitted outside to the number of generated carriers (external quantum efficiency).

The quantum efficiency can be expressed as follows:

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

h: Planck's constant

c: Light speed in vacuum

q: Charge of electron

λ: Wavelength (μ m)

P: Optical output

I: Current

In addition, a differential quantum efficiency is also used for a laser diode.

- Light receiving element (PIN photodiode APD)

The ratio of the number of generated carriers to the number of input photons. The quantum efficiency η' is expressed as follows. This is the reverse of that of a light-emitting diode

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

The quantum efficiency of an avalanche photodiode is calculated assuming that the multiplication factor is 1.

Radiant flux

Optical energy emitted and propagated in a unit of time.

Responsivity

Current that can be generated when a unit radiant flux is input to a light-receiving element.

$$R = \frac{I}{P} = 0.806 \times \eta \times \lambda \times M \quad [A/W]$$

R : Responsivity

η : Quantum efficiency

λ : Wavelength

M : Multiplication factor

ROM

Stands for Read-Only Memory.

Short wavelength region

Optical-fiber communications use light with a wavelength of approximately 0.8 to 1.5 µm , or the near-infrared region. Within this region, the region around 0.8 µm is called the short-wavelength region. This region was developed during an earlier stage in the field of optical-fiber communications, and produced the largest number of results for production systems. Recently, the long wavelength region exceeding 1 µm has been under development.

Single-mode fiber

When the core diameter is reduced to approximately 10 µm , the result is an optical fiber with only one propagation mode. This is called a single-mode fiber. This fiber is advantageous in that, unlike the multi mode fiber which causes mode distribution, it has a very wide range (a few GHz).

Specific rotating power

A value indicating the magnitude of the optical rotary power of material.

Speckle effect

A noise generated when a coherent light is dispersed in an optical fiber, causing interference under irregular phase relationships.

Spectral width/Full width at half maximum/$\Delta\lambda$

An interval between two wavelengths of a light emitting element, in which the emission spectrum energy is half the maximal value.

Spectrum

An ordinary light consists of sine wave components. An array of such components arranged along the wavelength axis is called a spectrum.

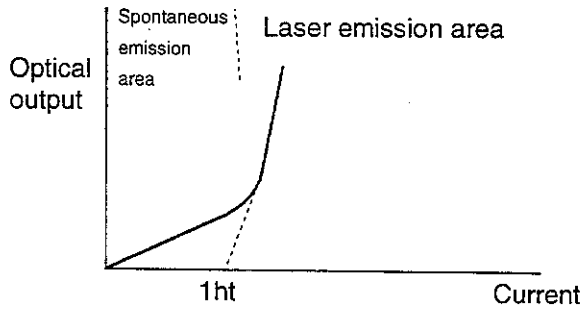
A white light source has a flat spectrum, and an LD has one concentrated in a narrow area.

Splicing

Permanent connection of an optical fiber, necessary for optical-fiber cabling operations. Although there are various splicing methods, the method generally used is fusion splicing, in which glass is melted by arc discharge. This method allows stable connections with the least connection loss.

Threshold current

Minimum current that allows laser emission. Since the boundary area between the spontaneous and laser emissions is not rigid, it is sometimes represented by the crossing point of the line prolonged from the current optical output characteristics curve for laser oscillation and the current value for optical output zero.



Ultraviolet rays

Light with a shorter wavelength than visible light. The wavelengths range from 300 to 380nm.

Visible light

Light that can be seen by the human eye. The wavelength range is 380 to 780nm.

Wavelength division multiplying

A communication method in which two or more types of signals are simultaneously transmitted through one optical fiber. In the transmitter, light-emitting and laser diodes of various wavelengths are used. This method allows one-way or two-way communications.

ALPHABETICAL INDEX

[A]

ABa 6-1, 7-8
Absolute value 6-1
Absolute Values 5-5
Acceptor handshake function 7-4
Accessories 2-1
Address specification 7-3
Address switch 7-5
AH1 7-4
AM 6-1, 7-8
APC A-1
Appearance 2-1
ATN 7-2
Attention 7-2
Automatic power control A-1
Avalanche photo diode A-1

[B]

Baseband transmission characteristics .. A-1
Beam divergence angle A-1
block delimiter 7-13
buzzer 7-13
BZn 7-8

[C]

C 7-8, 7-9
Cable 7-3
Chopped light A-1
Cladding A-1
Cleaning 2-4
Coated fiber A-2
Code used 7-3
Coherence A-2
Coherent A-2
Configuration 1-2
Configuring the Measurement System ... 5-3
Connecting Component Devices 7-5
Connector 7-3
Continuous-wave (CW) light A-2
control lines 7-1
Core A-2
CORRECTING MEASUREMENT RESULTS 6-1
Correction Data 6-2
correction data 6-1
CS 7-8
C0 7-4

[D]

Dark current A-2
data lines 7-1
Data Valid 7-2
DAV 7-2
DC1 7-4
delay 5-8
Demodulation bandwidth 10-1
Demodulation frequency shift 10-1
Demodulation output 10-2
Demodulation sensitivity 10-1
Device clear function 7-4
Device trigger function 7-4
DFB-LD 5-3, A-3
DFT-AA2R5A-1 2-3
digital sampling oscilloscope 1-2
Direct modulation A-2
Directivity A-2
Distributed feedback laser A-3
DLn 7-8
Double heterojunction A-3
Driver specifications 7-3
DT1 7-4
Dynamic chirp measurement software .. 2-6

[E]

Emission peak wavelength A-3
End of Identify 7-2
Environment Conditions 2-2
EOI 7-2
Excess noise factor A-3
E2 7-4

[F]

FM A-3
FM Characteristics 5-1
FMa 6-1, 7-8
FPa 6-1, 7-8
Free spectral range A-4
FREQUENCY MODULATION 5-1
Front Panel 3-1, 3-3
FSR 10-1,A-4
Fundamental mode A-4
Fuse 2-1, 2-3

[G]

GPIB 7-1, 10-2
GPIB address switch 3-4
GPIB Commands 7-8

GPIB connection cable 2-1
GPIB Talker Format 7-7
Graded index fiber A-4
Ground terminal 3-4

[H]

handshake lines 7-1
HIGH-SENS connector 3-2
HIGH-SENS indicator 3-2

[I]

IEEE 488-1978 7-3
IFC 7-2
IM A-4
IM Characteristics 5-7, 3-1
IM+FM data 5-4
IMa 6-1,7-8 3-2
IM-FM data 5-4, 3-2
IM-MONITOR 5-7
incident light power range 10-1
infrared rays A-4
Input/Output Specifications 10-2
Insertion loss 10-1
Interface Clear 7-2
Interface Functions 7-4
Interference amplitude 6-1

[J]

408JE-1P5 7-5
408JE-101 7-5
408JE-102 7-5
408JE-104 7-5

[K]

key 3-1, 3-2

[L]

Laser A-5
Laser diode A-5
LED A-5
Leak light A-5
Level meter 3-1
Light-emitting diode A-5
Light sensor A-5
LISTEN indicator 3-2, 7-5
listener function 7-4
listener reset 7-4
LOAD 5-2
LOAD MENU 5-2
Loading the Program 5-2, 3-2
LOCAL key 7-5
Log sweep 5-8
Logic level 7-3
Longitudinal mode A-5
Long wavelength region A-5
Luminous flux A-6
Luminous intensity A-6
L4 7-4

[M]

MDn 7-8
Measurement 5-4
Measurement channel 10-1
Measurement characteristics 10-1
Measurement Results 5-4
Measuring point automatic setting function 10-1
Model name 2-1
Monitor current A-7
Monitor output A-7
Multi mode fiber A-7

[N]

NDAC 7-2
network analyzer 1-2
Not Data Accepted 7-2
Not Ready For Data 7-2
NRFD 7-2
number of point 5-8
Numerical aperture A-7

[O]

O/E converter 1-2
Operating conditions 10-2
OPERATING PRINCIPLES 9-1
operation mode 7-13
Optical input 10-2
OPTICAL INPUT connector 3-1
Optical fiber A-7
Optical fiber connector A-7
Optical rotating power A-7
OSn 7-8
Output connection cable 2-1, 3-1
OUTPUT SELECT 5-4, 7-13
Outside dimensions 10-2
OVERVIEW 1-1,2-1, 4-1, 5-1

[P]

PANEL DESCRIPTIONS 3-1
personal computer 1-2

Phase data 6-1
2-pin power adapter 2-1
Pigtail fiber A-8
Pla 6-1, 7-8
POLARIZATION ADJUST 5-4
POLARIZATION ADJUST knob 3-1
Polarizer A-8
Polarization compensation function 10-1, 3-1
Power Cable 2-3
Power cable 2-1
Power connector 3-4
POWER indicator 3-1
Power supply 10-2
PPa 6-1, 7-8
PP0 7-4
Product Overview 1-1
PROGRAM(RUN) 5-2
PR370005-FJ 2-6

[Q]

Quantum efficiency A-8

[R]

Radiant flux A-8
Reading the Status Data Set 7-13
Rear Panel 3-4
Receiver specifications 7-3
receptacle 2-4
Remote Enable 7-2
Remote function 7-4
REMOTE indicator 3-2, 7-5
REN 7-2, 3-1
RESET 5-4
resolution bandwidth 5-8
Responsivity A-9
Restrictions 5-8
RL1 7-4
ROM A-9

[S]

Sample Programs 7-14
Service Request 7-2, 7-6
Service request function 7-4
Service Requests 7-15
SH1 7-4
Short wavelength region A-9
Single-mode fiber A-9
SLn 7-8
Sn 7-8
Source handshake function 7-4
Specifications 10-1
Specific rotating power A-9
Speckle effect A-9
Spectral width/full width at half maximum/ $\Delta\lambda$ A-9
Spectrum A-9
Splicing A-9
SRQ 7-2
SRQ indicator 3-2, 7-5
SR1 7-4
Standard bus cables 7-5
Status byte 7-6
Storage 2-4
Storage conditions 10-2
string delimiter 7-13
sweep bandwidth 5-8
sweep time 5-8
switch 3-1

[T]

TALK indicator 3-2, 7-5
talker function 7-4
talker reset 7-4
Threshold current A-10
Transportation 2-4
Try-state output 7-4
TROUBLESHOOTING 7-1
T6 7-4

[U]

Ultraviolet rays A-10

[V]

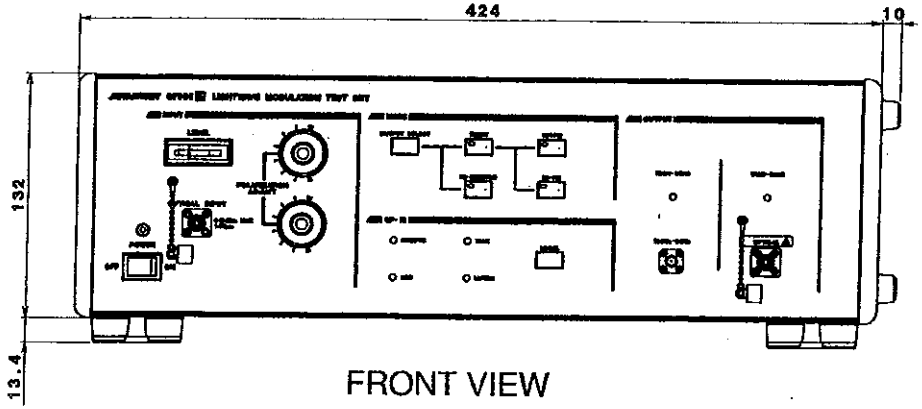
Visible light A-10

[W]

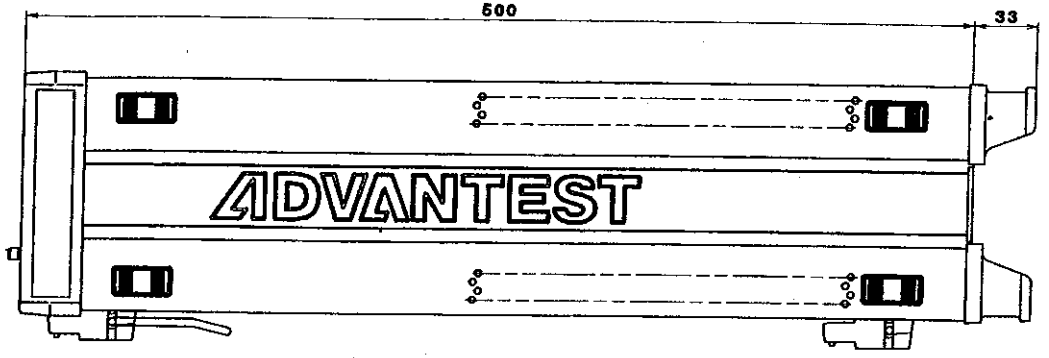
Wavelength division multiplying A-10
Wavelength measurement range 10-1
Weight 10-2
WIDE-BAND connector 3-2
WIDE-BAND indicator 3-2

[Others]

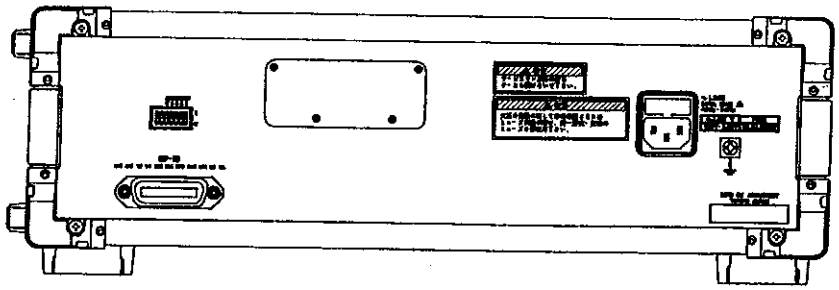
2-pin power adapter 2-1
408JE-1P5 7-5
408JE-101 7-5
408JE-102 7-5
408JE-104 7-5



FRONT VIEW



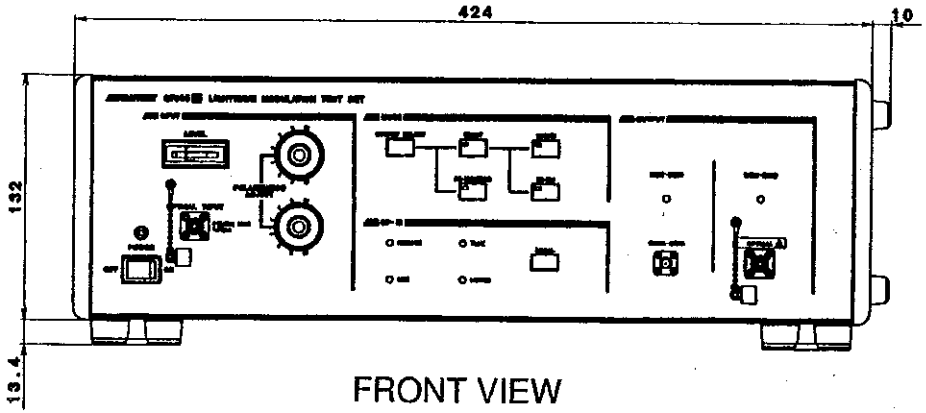
SIDE VIEW



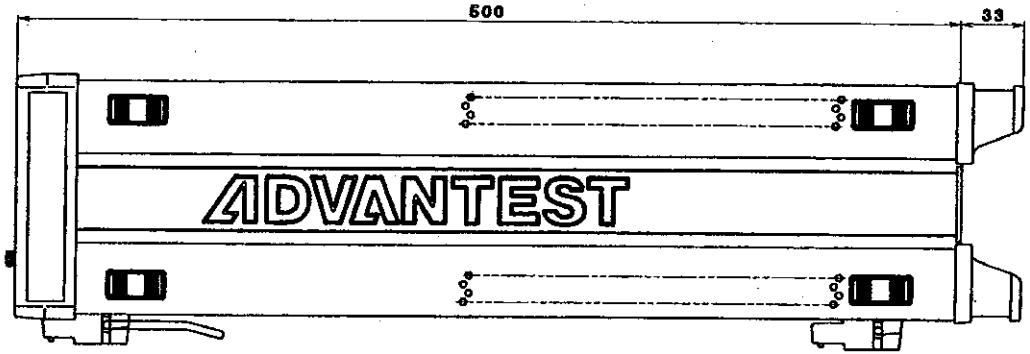
REAR VIEW

Unit; mm

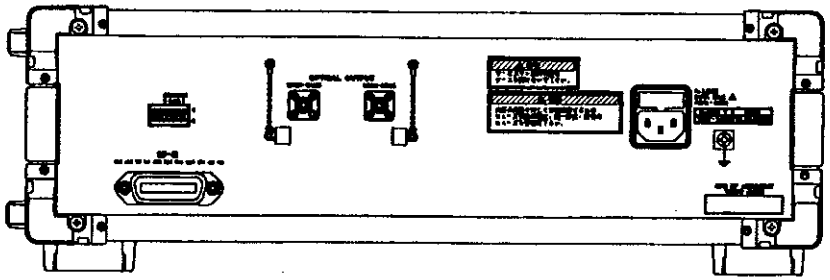
Q7605A EXTERNAL VIEW



FRONT VIEW



SIDE VIEW

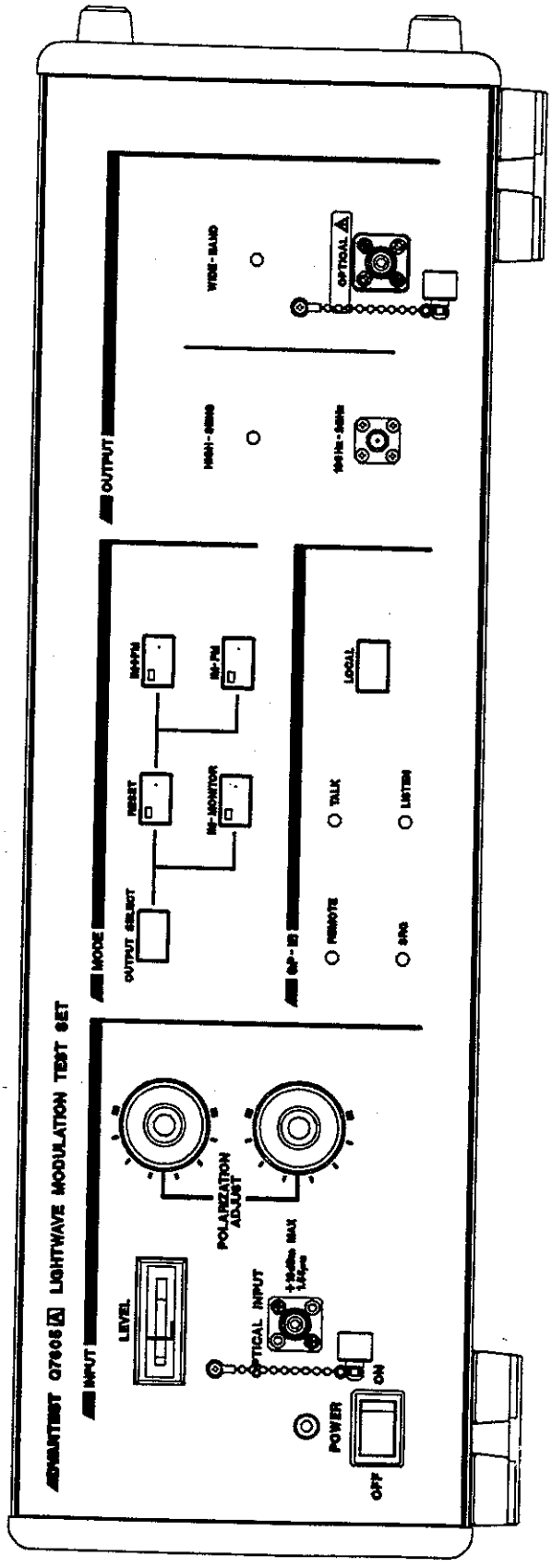


REAR VIEW

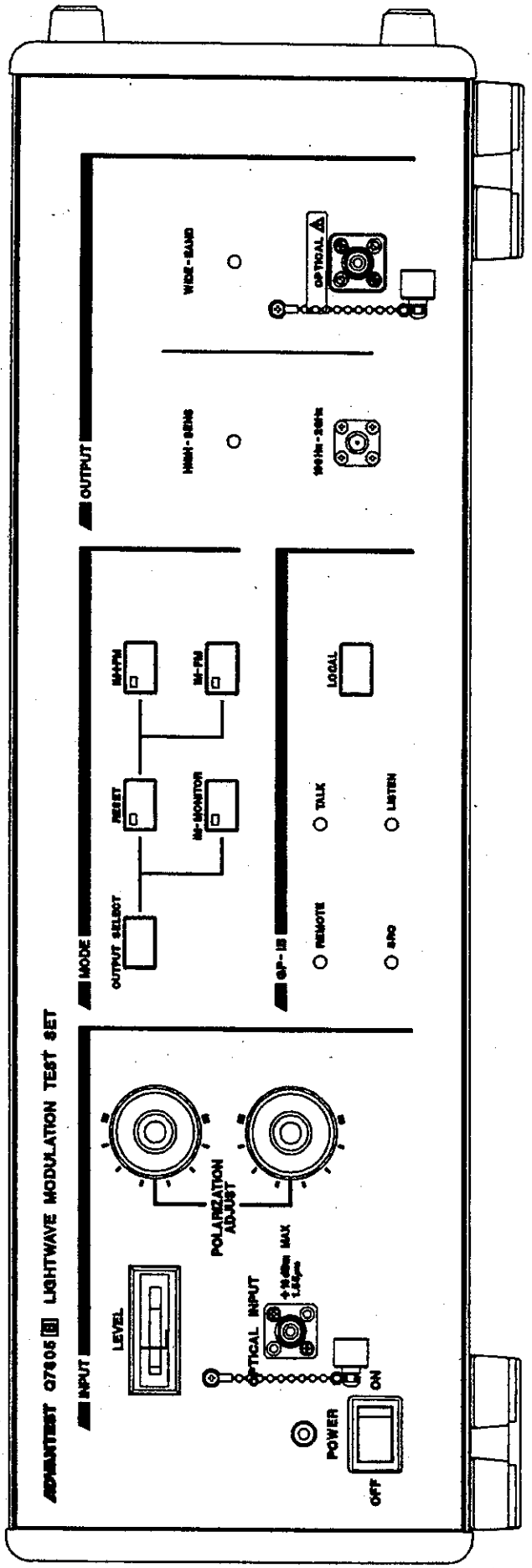
Unit; mm

Q7605B EXTERNAL VIEW

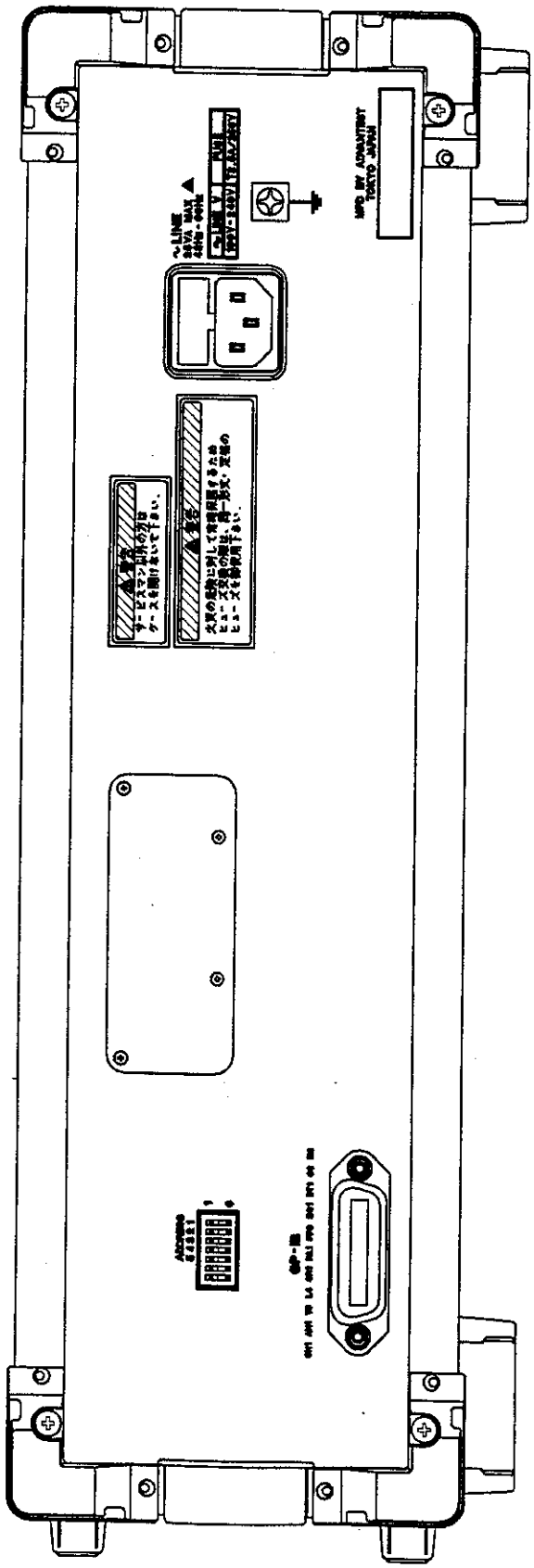
Q7605A FRONT VIEW



Q7605B FRONT VIEW



Q7605A/B REAR VIEW



IMPORTANT INFORMATION FOR ADVANTEST SOFTWARE

PLEASE READ CAREFULLY: This is an important notice for the software defined herein. Computer programs including any additions, modifications and updates thereof, operation manuals, and related materials provided by Advantest (hereafter referred to as "SOFTWARE"), included in or used with hardware produced by Advantest (hereafter referred to as "PRODUCTS").

SOFTWARE License

All rights in and to the SOFTWARE (including, but not limited to, copyright) shall be and remain vested in Advantest. Advantest hereby grants you a license to use the SOFTWARE only on or with Advantest PRODUCTS.

Restrictions

(1) You may not use the SOFTWARE for any purpose other than for the use of the PRODUCTS.
(2) You may not copy, modify, or change, all or any part of, the SOFTWARE without permission from Advantest.
(3) You may not reverse engineer, de-compile, or disassemble, all or any part of, the SOFTWARE.

Liability

Advantest shall have no liability (1) for any PRODUCT failures, which may arise out of any misuse (misuse is deemed to be use of the SOFTWARE for purposes other than it's intended use) of the SOFTWARE. (2) For any dispute between you and any third party for any reason whatsoever including, but not limited to, infringement of intellectual property rights.

LIMITED WARRANTY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CUSTOMER SERVICE DESCRIPTION

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

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

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

SALES & SUPPORT OFFICES

Advantest Korea Co., Ltd.
22BF, Kyobo KangNam Tower,
1303-22, Seocho-Dong, Seocho-Ku, Seoul #137-070, Korea
Phone: +82-2-532-7071
Fax: +82-2-532-7132

Advantest (Suzhou) Co., Ltd.
Shanghai Branch Office:
Bldg. 6D, NO.1188 Gumei Road, Shanghai, China 201102 P.R.C.
Phone: +86-21-6485-2725
Fax: +86-21-6485-2726

Shanghai Branch Office:
406/F, Ying Building, Quantum Plaza, No. 23 Zhi Chun Road,
Hai Dian District, Beijing,
China 100083
Phone: +86-10-8235-3377
Fax: +86-10-8235-6717

Advantest (Singapore) Pte. Ltd.
438A Alexandra Road, #08-03/06
Alexandra Technopark Singapore 119967
Phone: +65-6274-3100
Fax: +65-6274-4055

Advantest America, Inc.
3201 Scott Boulevard, Suite, Santa Clara, CA 95054, U.S.A
Phone: +1-408-988-7700
Fax: +1-408-987-0691

ROHDE & SCHWARZ Europe GmbH
Mühldorfstraße 15 D-81671 München, Germany
(P.O.B. 80 14 60 D-81614 München, Germany)
Phone: +49-89-4129-13711
Fax: +49-89-4129-13723

ADVANTEST®

http://www.advantest.co.jp

ADVANTEST CORPORATION
Shin-Marunouchi Center Building, 1-6-2 Marunouchi, Chiyoda-ku, Tokyo 100-0005, Japan
Phone: +81-3-3214-7500