User, Programming and Service Guide

HP 86060B-Series Lightwave Switches

HP Part Number: 86060-90030
Edition 1
Printed in USA April 1996

1400 Fountaingrove Parkway, Santa Rosa, CA 95403-1799, USA

Printing History

HP Part Number	Edition	Date
86060-90030	Edition 1	April 1996

Certification

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office.

Safety Symbols

The following safety symbols are used throughout this manual. Familiarize yourself with each of the symbols and its meaning before operating this instrument.

CAUTION

The *caution* sign denotes a hazard to the instrument. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the instrument. Do not proceed beyond a *caution* sign until the indicated conditions are fully understood and met.

WARNING

The *warning* sign denotes a life-threatening hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a *warning* sign until the indicated conditions are fully understood and met.

Instruction Manual 	The **instruction manual** symbol. The product is marked with this symbol when it is necessary for the user to refer to the instructions in the manual.
∿	This symbol denotes that the instrument uses alternating current.
|	This symbol denotes that the power supply is turned on.
○	This symbol denotes that the power supply is turned off.
CE	The CE mark is a registered trademark of the European Community.
ISM1-A	This symbol denotes that the instrument is an Industrial Scientific and Medical Group 1 Class A product.
	The CSA mark is a registered trademark of the Canadian Standards Association.

General Safety Considerations

WARNING

Before this instrument is switched on, make sure it has been properly grounded through the protective conductor of the ac power cable to a socket outlet provided with protective earth contact.

Any interruption of the protective (grounding) conductor, inside or outside the instrument, or disconnection of the protective earth terminal can result in personal injury.

WARNING

This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

WARNING

No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.

WARNING

There are many points in the instrument which can, if contacted, cause personal injury. Be extremely careful.

Any adjustments or service procedures that require operation of the instrument with protective covers removed should be performed only by trained service personnel.

WARNING

If this instrument is not used as specified, the protection provided by the equipment could be impaired. This instrument must be used in a normal condition (in which all means for protection are intact) only.

Declaration of Conformity

DECLARATION OF CONFORMITY
according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Co.

Manufacturer's Address: 1400 Fountaingrove Parkway
Santa Rosa, CA 95403-1799
USA

declares that the product:

Product Name: Lightwave Switches

Model Number: HP 86060B, 86062B

Product Options: This declaration covers all options of the above products.

conforms to the following Product specifications:

Safety: IEC 1010-1:1990+A1 / EN 61010-1:1993
CAN/CSA-C22.2 No. 1010.1-92

EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A
IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984/EN 50082-1:1992 3 V/m, 27-500 MHz
IEC 801-4:1988/EN 50082-1:1992 0.5 kV Sig. Lines, 1 kV Power Lines
IEC 1000-3-2:1995 / EN 61000-3-2:1995
IEC 1000-3-3:1994 / EN 61000-3-3:1994

Supplementary Information:
These products herewith comply with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC.

Santa Rosa, California, USA 2/21/96

Dixon Browder/Quality Manager

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department ZQ/Standards Europe, Herrenberger Strasse 130, D-71034 Böblingen, Germany (FAX: +49-7031-14-3143)

Warranty

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by Hewlett-Packard. Buyer shall prepay shipping charges to Hewlett-Packard and Hewlett-Packard shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Hewlett-Packard from another country.

Hewlett-Packard warrants that its software and firmware designated by Hewlett-Packard for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error-free.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Exclusive Remedies

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

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General Information

General Information

What you'll find in this chapter

- A brief description of the HP 86060B-series lightwave switch.
- A list of options and accessories available.
- HP 86060B-series lightwave switch specifications and characteristics.
- Information about the lightwave switch's serial number label.
- Information about avoiding damage to the instrument from electrostatic discharge.
- Making fiber optic connections.
- How to return the lightwave switch for service.

This instrument has been designed and tested in accordance with IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the instrument in a safe condition.

CAUTION

Improper connector care, cleaning, or use of mismatched cable connectors can invalidate the published specifications and damage connectors. Clean all cables before applying to any connector. Repair of damaged connectors due to improper use is not covered under warranty. Refer to "Cleaning and handling" for proper cleaning procedures.

CAUTION

OPTION 3XX INSTRUMENTS: To avoid damage, handle the pigtail fiber with care. Use only an appropriate fiber cleaver tool for cutting the fiber. Do not pull the bare fiber out of its jacket, crush it, kink it, or bend it past its minimum bend radius.

Description

The HP 86060B-series lightwave switch covers a broad range of switching capacity and features convenient manual control for benchtop applications and SCPI compatible HP-IB control for automated test systems. The HP 86060B is a compact switch for easy configuration with HP optical attenuators, lightwave multimeters, and lightwave receivers for either benchtop or automated system applications. The HP 86062B is a full-width instrument designed for automated production systems and evaluation testing of large numbers of devices.

The HP 86060B-series lightwave switch is designed to be used as a building block for automated testing of lightwave cables, components, and systems. The switch is designed for single-mode, 9/125 μm operation. Switching is bi-directional. The HP 86060B-series lightwave switch offers low insertion loss, and operation independent of data format and direction. Standard configurations include single-mode fiber "pigtails" or FC/PC, SC, or ST connectors. Other connector types including DIN, Diamond or angled physical contact are available upon request.

Principle of Operation

The lightwave switch is based on a moving fiber technology, in which one common fiber is moved into alignment with any one of "N" fixed fibers and is built around a precision stepper motor.

The HP 86060B-series lightwave switches

The HP 86060B-series lightwave switches include:

HP Model Number	Configuration
HP 86060B	1×4, 1×5, 1×6, 1×7, or 1×8
HP 86062B	1×4 thru 1×100, in four (4) channel increments

Included accessories

Included with each switch are:

- *HP 86060B-series Lightwave Switches User, Programming, and Service Guide* (HP part number 86060-90030).
- The measured insertion loss data and return loss data for each channel.

Options

The following options are available:

Option	Description
Option 001	Single input channel
Option 002	Two input channels
Option 109	1280–1650 nm - 9/125 μm multimode fiber
Option 162	1280–1650 nm - 62.5/125 μm multimode fiber
Option 050	Connectors on front panel. *Only available on an HP 86060B with option 204.*
Option 051	Connectors on rear panel. *For connectorized ouputs only.*
Option 052	1 meter fiber out of the rear panel. *For connectorized outputs, the connector is at the end of the 1 meter cable.*
Option 2XX	Where XX is the number of connectorized ouput channels. *Note: Option 200 is 100 connectorized output channels.*
Option 012	FC\PC connectors
Option 014	ST connectors
Option 017	SC connectors
Option 3XX	Where XX is the number of non-connectorized ouput channels. *Note: Option 300 is 100 non-connectorized output channels.*

Accessories

HP Part Number	Description
5062-3957	Rack mount adapter kit for a single half-width instrument.
5062-3977	Rack mount adapter kit for two adjacent half-width instruments.
5062-4079	Lock link kit for the HP 5062-3977.
5952-4079	*Fiber Optics Handbook*, an introduction to, and a reference for, fiber-optic measurements.

Table 1-1 lists specification, *characteristics*, typical performance, and nominal values. The distinction between these terms is described as follows:

- Specifications describe warranted performance over the temperature range +5°C to +40°C (unless otherwise noted). All specifications apply after the instrument's temperature has been stabilized after 30 minutes of continuous operation.
- *Characteristics* provide useful information by giving functional, but nonwarranted, performance parameters. *Characteristics are printed in italics*.
- Typical Performance, where listed, is not *warranted*, but indicates performance which most units will meet.
- Nominal Value indicates the expected, but not *warranted*, value of the parameter.

CAUTION

Improper connector care, cleaning, or use of mismatched cable connectors can invalidate the published specifications and damage connectors. Clean all cables before applying to any connector. Repair of damaged connectors due to improper use is not covered under warranty. Refer to "Cleaning and handling" for proper cleaning procedures.

Table 1-1. Specifications and Characteristics

	Optical Interface			
	With Option 3XX[1], No Connectors, 1-meter Fiber		With Option 012, FC/PC Connectors[2]	
Parameters (dB)	**Std. 1×N**	**Opt. 002 2×N**	**Std. 1×N**	**Opt. 002 2×N**
Input Optical Return Loss	−55 *(−60)*	−50 *(−55)*	−40 *(−45)*	−40 *(−42)*
Insertion Loss	2 *(0.8)*	4 *(1.6)*	2.5 *(1.2)*	4.5 *(2.0)*
Repeatability[3] (short term)	*(0.01)*	*(0.02)*	*(0.01)*	*(0.02)*
Polarization Dependent Loss	*(0.03)*	*(0.05)*	*(0.03)*	*(0.05)*
Isolation	*(−80)*	*(−80)*	*(−80)*	*(−80)*
Switching Life	10 million cycles, minimum			

1 Where XX is the number of non-connectorized output channels.

2 Optical return loss of 40 dB or better is achievable by using clean Super PC or better connectors, correctly connected. Otherwise, performance is limited to connector interface performance.

3 Repeatability measured after four hours warmup and with an eight second pause between switch movements.

Switching Time Sample (msec)

Switch Size 8606XB	Between Adjacent Channels	Plus Additional Time/Channel	Maximum Switching Time
1×4	290	40	370
1×8	290	40	530
1×25	260	10	490
1×50	258	7.5	618
1×100	258	7.5	993

Table 1-1. Specifications and Characteristics , continued

OPTICAL CONNECTORS[1,2,3]	
Option 012	FC/PC connectors
Option 014	ST connectors
Option 017	SC connectors
GENERAL SPECIFICATIONS	
Temperature Range	
Operating	+5°C to +40°C
Storage	−20°C to +45°C
Humidity	
Operating	Maximum relative humidity 80% for temperatures up to 40°C.(non-condensing)
Storage	Maximum relative humidity less than 95%
Altitude	Altitude up to 15,000 feet (4,572 meters).
EMI Compatibility	Conducted and radiated emissions meet the requirements of CISPR Publication 11 and EN 55011 Group 1, Class A.
Power Requirements	100/115/230/240 V (range 90 to 254Vac), 50/60 Hz (range 47 to 63 Hz)
Power Consumption	Power consumption 60 VA maximum
Installation Category	Category II per I.E.C. 1010
Pollution Degree	Degree 2 per I.E.C. 664
Usage	For indoor use.
Weight (dependent on # of channels)	
HP 86060B	3.76 kg (8.4 lb) to 4.1 kg (9.2 lb)
HP 86062B	7.72 kg (17.25 lb) to 13.74 kg (30.7 lb)
Dimensions (H × W × D)	
HP 86060B	132.6 × 213 × 421.6 mm (5.25 × 8.39 × 16.7 in)
HP 86062B	221.5× 418 × 421.6 mm (8.75 × 16.55 × 16.7 in)

1 All HP 86060B-series lightwave switches must specify one of the following options.

2 Unlike most HP lightwave instruments, connector types may not be interchanged.

3 Other connector types available upon request.

Serial Numbers

Hewlett-Packard makes frequent improvements to its products to enhance their performance, usability, or reliability, and to control costs. HP service personnel have access to complete records of design changes to each type of equipment, based on the equipment's serial number. Whenever you contact Hewlett-Packard about your lightwave switch, have the complete serial number available to ensure obtaining the most complete and accurate information possible.

A serial-number label is attached to the rear of the lightwave switch. It contains the serial number and the options installed in the lightwave switch.

Whenever you specify the serial number or refer to it in obtaining information about your lightwave switch, be sure to use the complete number, including the full prefix and suffix.

Electrostatic Discharge Information

Electrostatic discharge (ESD) can damage or destroy electronic components. All work on electronic assemblies should be performed at a static-safe work station. Figure 1-1 shows an example of a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination.
- Conductive floor-mat and heel-strap combination.

Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone.

To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground. Refer to Table 1-2 for information on ordering static-safe accessories.

WARNING

These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.

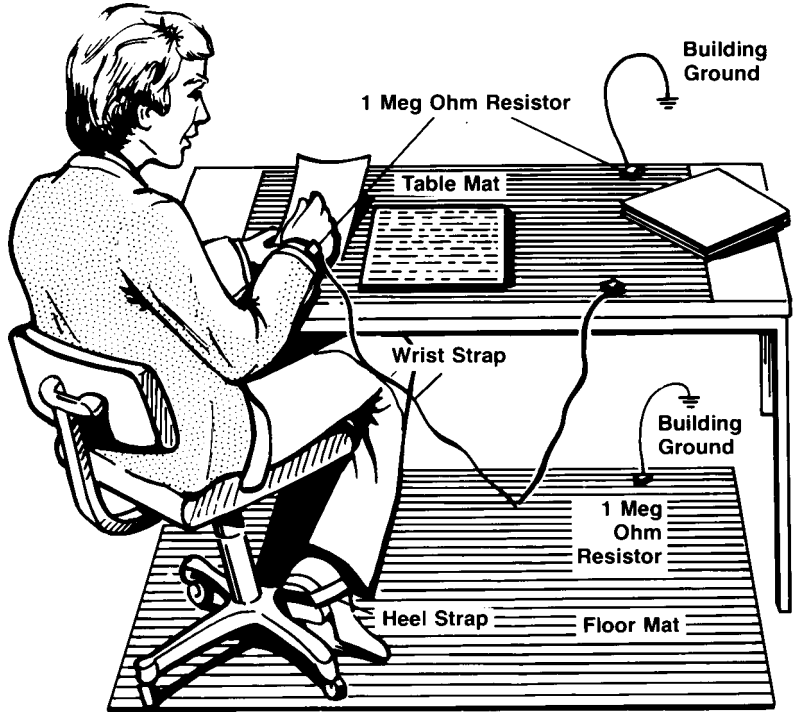


Figure 1-1. Example of a static-safe work station.

Reducing ESD Damage

The following suggestions may help reduce ESD damage that occurs during testing and servicing operations.

- Personnel should be grounded with a resistor-isolated wrist strap before removing any assembly from the unit.
- Be sure all instruments are properly earth-grounded to prevent a buildup of static charge.

Table 1-2 lists static-safe accessories that can be obtained from Hewlett-Packard using the HP part numbers shown.

Table 1-2. Static-Safe Accessories

HP Part Number	Description
9300-0797	Set includes: 3M static control mat 0.6 m × 1.2 m (2 ft × 4 ft) and 4.6 cm (15 ft) ground wire. (The wrist-strap and wrist-strap cord are not included. They must be ordered separately.)
9300-0980	Wrist-strap cord 1.5 m (5 ft)
9300-1383	Wrist-strap, color black, stainless steel, without cord, has four adjustable links and a 7 mm post-type connection.
9300-1169	ESD heel-strap (reusable 6 to 12 months).

Lightwave Connector Care

CAUTION

Improper connector care, cleaning, or use of mismatched cable connectors can invalidate the published specifications and damage connectors. Clean all cables before applying to any connector. Repair of damaged connectors due to improper use is not covered under warranty.

Introduction

Lightwave cable interfaces can be damaged by improper cleaning and connection procedures. Dirty or damaged lightwave interfaces can result in nonrepeatable or inaccurate measurements. This chapter will suggest some best practices to clean, care for, connect, and inspect lightwave connectors.

Lightwave connectors are used to connect two fiber ends together. These connections may be used to join cables between optical ports on devices, laser sources, receivers, patch panels, terminals and many other types of systems or components.

Fiber optic cables are used at different wavelengths, in single or multimode, and in different environments. There are a variety of sizes, core/cladding combinations, jackets, and indexes of refraction. In general, different types of cables do not work well together. Cables should match each other and the system.

However, regardless of the cable type, the connectors have only one function: to provide a direct and low-loss optical signal transition from one fiber end to another. When these connectors are used in a measurement system, repeatability becomes an important factor.

Lightwave connectors differ from electrical or microwave system connectors. In a fiber optic system, light is transmitted through an extremely small fiber core. Because fiber cores are often 62.5 microns (0.0625 mm) or less in diameter, and dust particles range from tenths of a micron to several microns in diameter, dust and very minute contamination on the end of the fiber core can degrade the performance of the connector interface (where the

two cores meet). Therefore, the connector must be precisely aligned and the connector interface free of trapped foreign material.

Connector (or insertion) loss is one important performance characteristic of a lightwave connector. Typical values are less than 1 dB of loss, and sometimes as little as 0.1 dB of loss with high performance connectors.

Return loss is another important factor. It is a measure of reflection. The less reflection the better, (the larger the return loss, the smaller the reflection). The best physically contacting connectors have return losses better than 50 dB, although 30 to 40 dB is more common.

Causes of connector loss and reflections include core misalignment, differences in the numerical aperture of two fibers, spacing and air gaps, reflections caused by damaged, worn, or loose fiber ends, and the improper use and removal of index matching compounds.

Achieving the best possible connection, where the fiber end faces are flush (no air gap) and properly aligned, depends on two things:

1. the type of connector
2. using the proper cleaning and connecting techniques. If the connection is lossy or reflective, light will not make a smooth transition. If the transition is not smooth or the connection is not repeatable, measurement data will be less accurate. For this reason, lightwave connections can make a critical difference in optical measurement systems.

Cleaning and handling

Proper cleaning and handling of lightwave connectors is imperative for achieving accurate and repeatable measurements with your Hewlett-Packard lightwave equipment. Lightwave interfaces should be cleaned before each measurement using the techniques described in this handbook. Information on protecting and storing your connectors/cables and tips on how to properly mate connectors are also included in this section.

Definition of terms

To avoid confusion, the following definitions are used in this handbook.

Connector	Houses the fiber end, most open at the end of a lightwave cable or on the front panel of an instrument or accessory.
Adapter	Does not contain optical fiber. Used to mate two optical connectors.

Handling

Always handle lightwave connectors and cable ends with great care. Fiber ends should never be allowed to touch anything except other mating surfaces or cleaning solutions and tools.

Always keep connectors and cable ends covered with a protective cap when they are not in use. (See "Storage.")

Cleaning

Two cleaning processes are provided. The first process describes how to clean non-lensed lightwave connectors. The second process describes how to clean lightwave adapters.

CAUTION

Hewlett-Packard strongly recommends index matching compounds NOT be applied to their instruments and accessories. Some compounds, such as gels, may be difficult to remove and can contain damaging particulates. If you think the use of such compounds is necessary, refer to the compound manufacturer for information on application and cleaning procedures.

Cleaning non-lensed lightwave connectors

Equipment

The following is a list of the items that should be used to clean non-lensed lightwave connectors.

Isopropyl alcohol ..... HP part number 8500-5344
Cotton swabs ..... HP part number 8520-0023
Foam swabs ..... HP part number 9300-1223
Compressed air ..... HP part number 8500-5262

CAUTION

Hewlett-Packard recommends you do not use any type of foam swab to clean optical fiber cable ends. Foam swabs can leave filmy deposits on fiber ends that can degrade performance. However, foam *is* required to clean inside bulk head connectors.

Process

Before cleaning the fiber end, clean the ferrules and other parts of the connector. Use isopropyl alcohol, clean cotton swabs, and clean compressed air. Then use alcohol to clean the fiber end. Some amount of wiping or mild scrubbing of the fiber end can help remove particles when application of alcohol alone will not remove them. This can be done by applying the alcohol to a cotton swab and moving it back and forth across the fiber end several times. This technique can help remove or displace particles smaller than one micron.

Allow the connector to dry (about a minute) or dry it immediately with clean compressed air. Compressed air lessens the chance of deposits remaining on the fiber end after the alcohol evaporates. It should be blown horizontally across the fiber end. Visually inspect the fiber end for stray cotton fibers. As soon as the connector is dry, the connection should be made.

CAUTION

Inverting the compressed air canister while spraying will produce residue on the sprayed surface. Refer to instructions provided on the compressed air canister.

Cleaning lightwave adapters

Equipment

All of the items listed above for cleaning connectors may be used to clean lightwave adapters. In addition, small foam swabs may be used along with isopropyl alcohol and compressed air to clean the inside of lightwave connector adapters.

NOTE

As noted in a previous caution statement, the foam swabs can leave filmy deposits. These deposits are very thin however, and the risk of other contamination buildup on the inside of adapters greatly outweighs the risk of contamination of foam swab deposits left from cleaning the inside of adapters.

Process

Clean the adapter by applying isopropyl alcohol to the inside of the connector with a foam swab. Allow the adapter to air dry, or dry it immediately with clean compressed air.

Storage

All of Hewlett-Packard's lightwave instruments are shipped with either laser shutter caps or dust caps on the lightwave adapters that come with the instrument. Also, all of the cables that are shipped have covers to protect the cable ends from damage or contamination. These dust caps and protective covers should be kept on the equipment except when in use.

Making connections

Proper connection technique requires attention to connector compatibility, insertion technique and torque requirements. Connectors must be the same connector type in order to ensure mechanical and optical compatibility. Attempting to connect incompatible connector types may prevent the connection from functioning properly and even cause damage to the fiber surfaces. A visual inspection of the mechanical interfaces may not be enough because some connector types have the same mechanical interface but have different optical fiber interfaces (for example, angled-no-contact, angled-contact or straight-contact fiber interfaces). Refer to the manufacturer's data sheet to confirm connector type compatibility before connecting.

When you insert the ferrule into an adapter, make sure the fiber end does not touch the outside of the mating adapter. This ensures you will not rub the fiber end against any undesirable surface. Many connectors have a keyed slot provided for optimum measurement repeatability that also helps to align and seat the two connectors. After the ferrule is properly seated inside the other connector, use one hand to keep it straight, rotate it to align the key, and tighten it with the other hand.

Most connectors using springs to push fiber ends together exert one to two pounds of force. Over-tightening or under-tightening these connectors can result in misalignment and nonrepeatable measurements. Always finger tighten the connector in a consistent manner. Refer to the manufacturer's data sheet for any torque recommendations.

CAUTION

OPTION 3XX INSTRUMENTS: To avoid damage, handle the pigtail fiber with care. Use only an appropriate fiber cleaver tool for cutting the fiber. Do not pull the bare fiber out of its jacket, crush it, kink it, or bend it past its minimum bend radius.

Summary

When making measurements with lightwave instruments or accessories, the following precautions will help to insure good, reliable, repeatable measurements:

- Confirm connector type compatibility.
- Use extreme care in handling all lightwave cables and connectors.
- Be sure the connector interfaces are clean before making any connections.
- Use the cleaning methods described in this handbook.
- Keep connectors and cable ends covered when not in use.

Inspection

Visual inspection

Although it is not necessary, visual inspection of fiber ends can be helpful. Contamination and/or imperfections on the cable endface can be detected as well as cracks or chips in the fiber itself.

Several fiber inspection scopes are on the market, but any microscope with an enlargement range of 100X to 200X can be used. It is helpful to devise some method to hold the fiber in place while viewing in this range.

Inspect the entire endface for contamination, raised metal, or dents in the metal, as well as any other imperfections. Inspect the fiber core for cracks and chips.

Visible imperfections not touching the fiber core may not affect the performance of the lightwave connection (unless the imperfections keep the fibers from contacting). Consistent optical measurements are the best assurance that your lightwave connection is performing properly.

Optical performance testing

Introduction

Consistent measurements with your lightwave equipment are a good indication that you have good connections. However, you may wish to know the insertion loss and/or return loss of your lightwave cables or accessories. If you test your cables and accessories for insertion loss and return loss upon receipt, and retain the measured data for comparison, you will be able to tell in the future if any degradation has occurred.

Insertion loss

Insertion loss can be tested using a number of different test equipment configurations. Some of these are:

- an HP 8702B or HP 8703A lightwave component analyzer system with a lightwave source and receivers
- an HP 83420 lightwave test set with an HP 8510 network analyzer
- an HP 8153A lightwave multimeter with a source and a power sensor module

Many other possibilities exist. The basic requirements are an appropriate lightwave source and a compatible lightwave receiver. Refer to the manuals provided with your lightwave test equipment for information on how to perform an insertion loss test.

Typical insertion loss for cables is less than 1 dB, and can be as little as 0.1 dB. For actual specifications on your particular cable or accessory, refer to the manufacturer.

Return loss

Return loss can be tested using a number of different test equipment configurations. Some of these are:

- an HP 8703A lightwave component analyzer
- an HP 8702B lightwave component analyzer with the appropriate source, receiver and lightwave coupler
- an HP 8504B precision reflectometer
- an HP 8153A lightwave multimeter and HP 81534A return loss module

Many other possibilities exist. The basic requirements are an appropriate lightwave source, a compatible lightwave receiver, and a compatible lightwave coupler.

Refer to the manuals provided with your lightwave test equipment for information on how to perform a return loss test.

Typical return loss for single mode units is better than 40 dB. For actual specifications on your particular cable or accessory, refer to the manufacturer.

Returning the Lightwave Switch for Service

When an instrument is returned to a Hewlett-Packard service office for servicing, it must be adequately packaged and have a complete description of the failure symptoms attached.

When describing the failure, please be as specific as possible about the nature of the problem. Include copies of additional failure information (such as instrument failure settings, data related to instrument failure, and error messages) along with the instrument being returned.

Please notify the service office before returning your instrument for service. Any special arrangements for the instrument can be discussed at this time. This will help the HP service office repair and return your instrument as quickly as possible.

Packaging

The original shipping containers should be used. If the original materials were not retained, identical packaging materials are available through any Hewlett-Packard office.

CAUTION

Instrument damage can result from using packaging materials other than the original materials. Never use styrene pellets as packaging material. They do not adequately cushion the instrument or prevent it from shifting in the carton. They may also cause instrument damage by generating static electricity.

Instrument shipping preparation procedure

1. Write a complete description of the failure and attach it to the instrument. Include any specific performance details related to the problem. The following information should be returned with the instrument.
   - Type of service required.
   - Date instrument was returned for repair.
   - Description of the problem:
     - Whether problem is constant or intermittent.
     - Whether instrument is temperature-sensitive.
     - Whether instrument is vibration-sensitive.
     - Instrument settings required to reproduce the problem.
     - Error codes.
     - Performance data.
   - Company name and return address.
   - Name and phone number of technical contact person.
   - Model number of returned instrument.
   - Full serial number of returned instrument.
   - List of any accessories returned with instrument.
2. Pack the instrument in the appropriate packaging material.

   If the original or equivalent packaging materials cannot be obtained, instruments can be packaged using the following instructions.

CAUTION

Inappropriate packaging of instruments may result in damage to the instrument during transit.

- Wrap the instrument in antistatic plastic to reduce the possibility of damage caused by electrostatic discharge.
- For instruments weighing less than 54 kg (120 lb), use a double-walled, corrugated cardboard carton of 159 kg (350 lb) test strength.
- The carton must be large enough to allow 3 to 4 inches on all sides of the instrument for packing material, and strong enough to accommodate the weight of the instrument.
- Surround the equipment with 3 to 4 inches of packing material, to protect the instrument and prevent it from moving in the carton. If packing foam is not available, the best alternative is S.D-240 Air Cap™ from Sealed Air Corporation (Commerce, California 90001). Air Cap looks like a plastic sheet filled with air bubbles. Use the pink (antistatic) Air Cap™ to reduce static electricity. Wrapping the instrument several times in this material will protect the instrument and prevent it from moving in the carton.

3. Seal the carton with strong nylon adhesive tape.
4. Mark the carton “FRAGILE, HANDLE WITH CARE”.
5. Retain copies of all shipping papers.

Sales and service offices

Hewlett-Packard has sales and service offices located around the world to provide complete support for Hewlett-Packard products. Table 1-3 lists some of the Hewlett-Packard sales and service offices.

To obtain servicing information or to order replacement parts, contact your nearest Hewlett-Packard sales and service office. In any correspondence or telephone conversation, refer to the instrument by its model number, serial number, and option designation.

Table 1-3. Hewlett-Packard Sales and Service Offices

U.S. FIELD OPERATIONS		
Headquarters Hewlett-Packard Company 19320 Pruneridge Avenue Cupertino, CA 95014 U.S.A. |800| 752-0900	**California, Northern** Hewlett-Packard Company 301 East Evelyn Mountain View, CA 94041 |415| 694-2000	**California, Southern** Hewlett-Packard Company 1421 South Manhatten Ave. Fullerton, CA 92631 |714| 999-6700
Colorado Hewlett-Packard Company 24 Inverness Place, East Englewood, CO 80112 |303| 649-5000	**Georgia** Hewlett-Packard Company 2000 South Park Place Atlanta, GA 30339 |404| 955-1500	**Illinois** Hewlett-Packard Company 5201 Tollview Drive Rolling Meadows, IL 60008 |708| 342-2000
New Jersey Hewlett-Packard Company 150 Green Pond Road Rockaway, NJ 07866 |201| 586-5400	**Texas** Hewlett-Packard Company 930 East Campbell Road Richardson, TX 75081 |214| 231-6101	
EUROPEAN FIELD OPERATIONS		
Headquarters Hewlett-Packard S.A. 150, Route du Nant-d'Avril 1217 Meyrin 2/Geneva Switzerland |41 22| 780.8111	**France** Hewlett-Packard France 1 Avenue Du Canada Zone D'Activite De Courtaboeuf F-91947 Les Ulis Cedex France |33 1| 69 82 60 60	**Germany** Hewlett-Packard GmbH Hewlett-Packard Strasse 61352 Bad Homburg Germany |+49 6172| 16-0
Great Britain Hewlett-Packard Ltd. Eskdale Road, Winnersh Triangle Wokingham, Berkshire RG11 5DZ		

Table 1-3. Hewlett-Packard Sales and Service Offices (continued)

INTERCON FIELD OPERATIONS		
Headquarters Hewlett-Packard Company 3495 Deer Creek Rd. Palo Alto, California 94304-1316 (415) 857-5027	**Australia** Hewlett-Packard Australia Ltd. 31-41 Joseph Street Blackburn, Victoria 3130 (61 3) 895-2895	**Canada** Hewlett-Packard Ltd. 17500 South Service Road Trans-Canada Highway Kirkland, Quebec H9J 2X8 Canada (514) 697-4232
China China Hewlett-Packard Company 38 Bei San Huan X1 Road Shuang Yu Shu Hai Dian District Beijing, China (86 1) 256-6888	**Japan** Yokogawa-Hewlett-Packard Ltd. 1-27-15 Yabe, Sagamihara Kanagawa 229, Japan (81 427) 59-1311	**Singapore** Hewlett-Packard Singapore Ltd. Pte. Ltd. Alexandra P.O. Box 87 Singapore 9115 (65) 271-9444
Taiwan Hewlett-Packard Taiwan 8th Floor, H-P Building 337 Fu Hsing North Road Taipei, Taiwan (886 2) 712-0404		

2

Installation and Preparation for Use

Installation and Preparation for Use

What you'll find in this chapter

- Preparing the HP 86060B-series lightwave switch for use.
- Turning on the switch.
- HP 86060B-series front-panel features.
- HP 86060B-series rear-panel features.
- How to perform a quick verification check of the HP 86060B lightwave switch.
- How to verify the lightwave switch specifications.

CAUTION

OPTION 3XX INSTRUMENTS: To avoid damage, handle the pigtail fiber with care. Use only an appropriate fiber cleaver tool for cutting the fiber. Do not pull the bare fiber out of its jacket, crush it, kink it, or bend it past its minimum bend radius.

CAUTION

When installing the instrument in a cabinet, the temperature measured at the instrument may be significantly higher than the ambient temperature measured outside the cabinet. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the instrument by 4°C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

NOTE

Clean the cabinet using a damp cloth only.

Preparing the Switch for Use

Initial inspection

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, keep it until you have verified that the contents are complete and you have tested the lightwave switch mechanically and electrically.

Table 2-1 contains the accessories shipped with the lightwave switch. If the contents are incomplete or if the lightwave switch does not pass the verification test (this procedure is provided in "Performing a verification check"), notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, also notify the carrier. Keep the shipping materials for the carrier's inspection. The HP office will arrange for repair or replacement without waiting for a claim settlement.

If the shipping materials are in good condition, retain them for possible future use. You may wish to ship the lightwave switch to another location or return it to Hewlett-Packard for service. See "Returning the Lightwave Switch for Service" in Chapter 1.

Table 2-1.
Accessories Supplied with the HP 86060B-series Lightwave Switch

Description	HP Part Number	Comments
Power cable	See Table 2-3	Shipped with the lightwave switch
Measured insertion loss data and return loss data for each channel.		

Connecting the HP 86060B to a power source

The lightwave switch is a portable instrument and requires no physical installation other than connection to a power source.

CAUTION

This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 1010 and 664 respectively.

CAUTION

Do not connect ac power until you have verified the line voltage is correct and the proper fuse is installed, as described in the following paragraphs. Damage to the equipment could result.

Power requirements

CAUTION

This instrument has autoranging line voltage input. Be sure the supply voltage is within the specified range.

Table 2-2. HP 86060B Power Requirements

Characteristic	Requirement
Input Voltage	within range 90 to 254 Vac
Frequency	within range 47 to 63 Hz
Power	60 VA (maximum)

Checking the fuse

The recommended fuse is an IEC 127 5×20 mm, 2A, 250 V, fast acting fuse, HP part number 2110-0702.

The line fuse is housed in a small container next to the ac input on the rear panel (refer to Figure 2-1).

To check the fuse, insert the tip of a screwdriver on the side of the container and gently pull outward to remove the container.

If the fuse is defective or missing, install a new fuse in the proper position and reinsert the fuse container.

WARNING

For continued protection against fire hazard, replace line fuse only with same type and ratings. The use of other fuses or materials is prohibited.

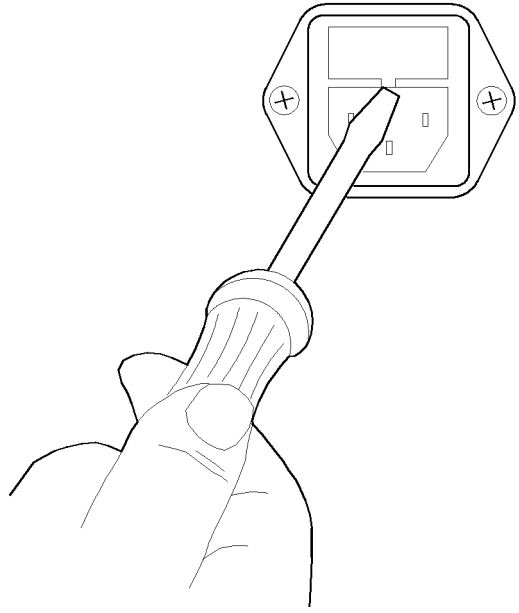


Figure 2-1. Changing the fuse.

Power cable

The lightwave switch is equipped with a three-wire power cable, in accordance with international safety standards. When connected to an appropriate power line outlet, this cable grounds the instrument cabinet.

WARNING

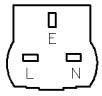
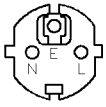
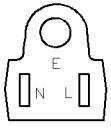
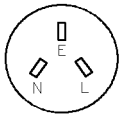
Failure to ground the lightwave switch properly can result in personal injury. Before turning on the lightwave switch, you must connect its protective earth terminals to the protective conductor of the main power cable. Insert the main power cable plug only into a socket outlet that has a protective earth contact. DO NOT defeat the earth-grounding protection by using an extension cable, power cable, or autotransformer without a protective ground conductor.

WARNING

If you are using an autotransformer, make sure its common terminal is connected to the protective earth contact of the power source outlet socket.

Various power cables are available to connect the lightwave switch to the types of ac power outlets unique to specific geographic areas. The cable appropriate for the area to which the lightwave switch is originally shipped is included with the unit. You can order additional ac power cables for use in different areas. Table 2-3 lists the available ac power cables, illustrates the plug configurations, and identifies the geographic area in which each cable is appropriate.

Table 2-3. AC Power Cables Available

PLUG TYPE **	CABLE HP PART NUMBER	PLUG DESCRIPTION	CABLE LENGTH CM (INCHES)	CABLE COLOR	FOR USE IN COUNTRY
250V 	8120-1351 8120-1703	Straight* BS1363A 90°	229 (90) 229 (90)	Mint Gray Mint Gray	Great Britain, Cyprus, Nigeria, Singapore, Zimbabwe
250V 	8120-1369 8120-0696	Straight* NZSS198/ASC112 90°	201 (79) 221 (87)	Gray Gray	Argentina, Australia, New Zealand, Mainland China
250V 	8120-1689 8120-1692	Straight* CEE7-Y11 90°	201 (79) 201 (79)	Mint Gray Mint Gray	East and West Europe, Central African Republic, United Arab Republic (unpolarized in many nations)
125V 	8120-1348 8120-1538	Straight* NEMA5-15P 90°	203 (80) 203 (80)	Black Black	United States Canada, Japan (100 V or 200 V), Brazil, Colombia, Mexico, Philippines, Saudia Arabia, Taiwan
	8120-1378 8120-4753 8120-1521 8120-4754	Straight* NEMA5-15P Straight 90° 90°	203 (80) 230 (90) 203 (80) 230 (90)	Jade Gray Jade Gray Jade Gray Jade Gray	
250V 	8120-5182 8120-5181	Straight* NEMA5-15P 90°	200 (78) 200 (78)	Jade Gray Jade Gray	Israel

* Part number for plug is industry identifier for plug only. Number shown for cable is HP Part Number for complete cable, including plug.

** E = Earth Ground; L = Line; N = Neutral.

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Turning on the HP 86060B

With the power cable inserted into the line module, turn the lightwave switch on by pressing the line switch. The liquid-crystal display (LCD) displays the message:

```
Initializing
```

If the LCD should fail to light, see "Performing a verification check" later in this chapter.

NOTE

A screen-saver has been built in to the switch to prolong the lifetime of the backlit LCD. The screen-saver turns off the LCD backlighting after 10 minutes elapses without a front-panel key being pressed. The time interval is not adjustable. To resume operation, press any key.

Initial set-up

The switch comes fully configured and ready to use. Simply plug in the ac power cord and attach the fiber leads. If remote control is to be used, attach an HP-IB or RS-232 cable. When turning the switch on, it automatically resets to channel 0 (reset, optical off position).

Front-panel features

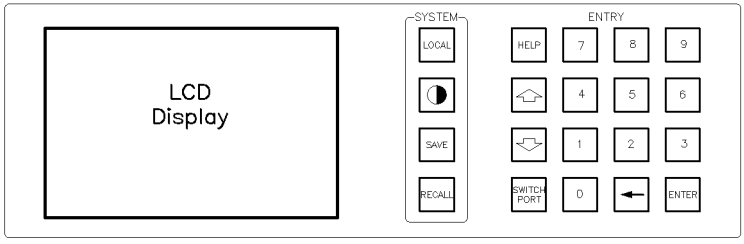

Figure 2-2. The HP 86060B-series front-panel functional area.

1 LCD, indicating the current signal path of the switch and the current HP-IB status of the RMT, LSN, TLK, and SRQ lines.

2 **System keys,** including (LOCAL), (SAVE), (RECALL) and LCD Contrast Adjustment.

3 **Entry keys,** including the (HELP), (SWITCH PORT), (ENTER), (↑) toggle up, (↓) toggle down, (←) backspace, and numeric keys.

NOTE

A screen-saver has been built in to the switch to prolong the lifetime of the backlit LCD. The screen-saver turns off the LCD backlighting after 10 minutes elapses without a front-panel key being pressed. The time interval is not adjustable. To resume operation, press any key.

Rear-panel features

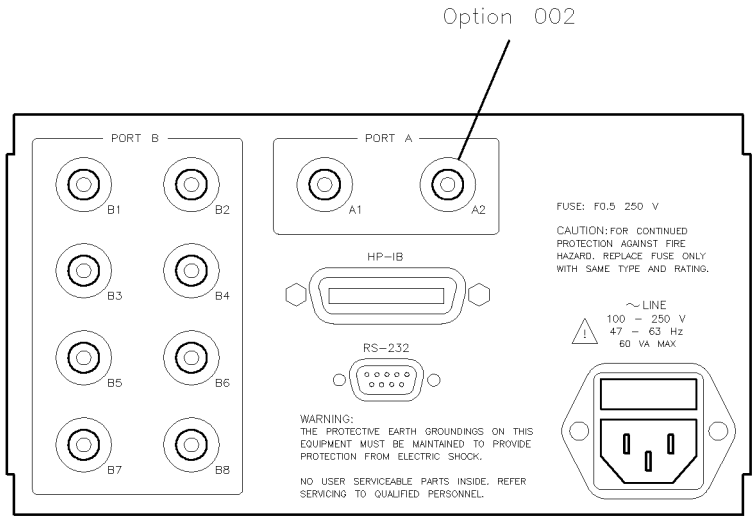

Figure 2-3. The HP 86060B-series rear-panel functional area.

1 Power input

2 HP-IB connector

3 RS-232 connector

4 Optical connector(s). The number of optical connectors depends on the HP 86060-series switch. The connectors are grouped as Port A and Port B.

Performing a verification check

CAUTION

Improper connector care, cleaning, or use of mismatched cable connectors can invalidate the published specifications and damage connectors. Clean all cables before applying to any connector. Repair of damaged connectors due to improper use is not covered under warranty. Refer to "Cleaning and handling" in Chapter 1 for proper cleaning procedures.

Return loss

Return loss can be tested using a number of different test equipment configurations. Some of these are:

- an HP 8703A lightwave component analyzer
- an HP 8702B lightwave component analyzer with the appropriate source, receiver and lightwave coupler
- an HP 8504B precision reflectometer
- an HP 8153A lightwave multimeter and HP 81534A return loss module

Many other possibilities exist. The basic requirements are an appropriate lightwave source, a compatible lightwave receiver, and a compatible lightwave coupler.

Refer to the manuals provided with your lightwave test equipment for information on how to perform a return loss test.

Typical return loss is better than 40 dB. For actual specifications on your particular cable or accessory, refer to the manufacturer.

Insertion loss

Insertion loss can be tested using a number of different test equipment configurations. Some of these are:

- an HP 8702B or HP 8703A lightwave component analyzer system with a lightwave source and receivers
- an HP 83420 lightwave test set with an HP 8510 network analyzer
- an HP 8153A lightwave multimeter with a source and a power sensor module

Many other possibilities exist. The basic requirements are an appropriate lightwave source and a compatible lightwave receiver. Refer to the manuals provided with your lightwave test equipment for information on how to perform an insertion loss test.

Typical insertion loss for cables is less than 1 dB, and can be as little as 0.1 dB. For actual specifications on your particular cable or accessory, refer to the manufacturer.

If the verification check fails

If the HP 86060B does not pass the verification check, you should review the procedure being performed when the problem occurred. A few minutes spent performing some simple checks may save waiting for your instrument to be repaired. Before calling Hewlett-Packard or returning the unit for service, please make the following checks:

1. Is the line fuse good?
2. Does the line socket have power?
3. Is the unit plugged in to the proper ac power source?
4. Is the unit turned on?
5. If other equipment, cables, and connectors are being used with the lightwave switch, are they connected properly and operating correctly?
6. Review the procedure for the test being performed when the problem appeared. Are all the settings correct?
7. Are the connectors clean? See Chapter 1 for more information about cleaning the connectors.

Refer to "Replacement procedures for extra fiber/connector" in Chapter 6 for more information.

If the HP 86060B lightwave switch still fails, return it to Hewlett-Packard for repair; if the lightwave switch is still under warranty or is covered by an HP maintenance contract, it will be repaired under the terms of the warranty or contract (the warranty is at the front of this manual). If the lightwave switch is no longer under warranty or is not covered by an HP maintenance plan, Hewlett-Packard will notify you of the cost of the repair after examining the unit. Refer to "Returning the Lightwave Switch for Service" in Chapter 1 for more information.

3

Using the Switch

Using the Switch

What you'll find in this chapter

- Procedures for using the HP 86060B-series lightwave switch.

The front panel of the lightwave switch includes three main sections:

1. LCD display
2. System keys
3. Entry keys

Refer to “Front-panel features” in Chapter 2 for more detailed information.

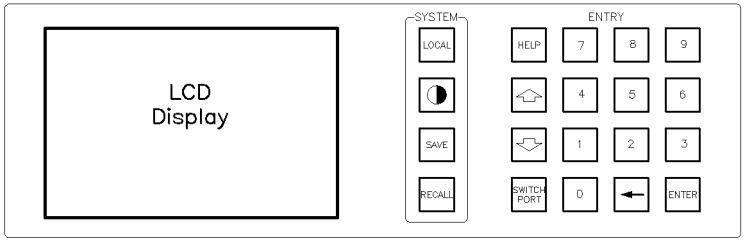

Figure 3-1. The HP 86060B-series front-panel functional area.

Using the (HELP) key

To use the switches built-in Help feature, press:

(HELP)

Then press any of the front-panel keys. A short explanation of that key's function will be displayed.

Changing the switch position (1 × N switch)

A 1 × N switch has a single Port A channel and multiple Port B channels.

1. To select a Port B channel, press (SWITCH PORT).

   The Port B channels are shown in inverse video and the prompt, `Port B active` appears at the bottom of the display.

2. Use the arrow keys to change the Port B channel.

   You can also use the numeric keys to enter the desired Port B channel. For example, (4) followed by (ENTER).

   The new connection is displayed on the front-panel LCD.

Changing the switch position (2 × N switch)

A 2 × N switch has two Port A channels and multiple Port B channels.

1. To select the Port B channel, press (SWITCH PORT).

   The Port B channels are shown in inverse video and the prompt, `Port B active` appears at the bottom of the display.

2. To select a Port A channel, press (SWITCH PORT) again.

The Port A channels are shown in inverse video and the prompt, `Port B active` appears at the bottom of the display.

3. Use the arrow keys to change the channel.

   You can also use the numeric keys to enter the desired channel. For example, (4) followed by (ENTER).

   The new connection is displayed on the front-panel LCD.

Saving switch states

To save the currently displayed switch state in one of the ten internal storage registers, press (SAVE) and then press one of the numeric keys (0–9).

Recalling switch states

To recall a previously saved switch state from one of the ten internal storage registers, press (RECALL), and then press one of the numeric keys (0–9).

Returning the switch to manual control

To return the switch to manual control after remote operation, press (Local). The last two digits of the current HP-IB address are displayed.

Setting the HP-IB address

The HP-IB address is factory preset to 711. To change the HP-IB address, press (Local). The last two digits of the current HP-IB address are displayed. To enter a different address, press the two numeric keys for that address. For example, 14 for address 714, then press (ENTER).

Setting the RS-232 baud rate

The baud rate is factory set to 9600 baud. To change the baud rate, press the LOCAL key twice. The current baud rate is displayed. Use the arrow keys to change the baud rate. When the desired rate is displayed, press (ENTER).

Adjusting LCD contrast

To adjust the contrast of the LCD, press the half-light, half-dark key. Use the arrow keys to select the desired contrast, then press (ENTER).

NOTE

A screen-saver has been built in to the switch to prolong the lifetime of the backlit LCD. The screen-saver turns off the LCD backlighting after 10 minutes elapses without a front-panel key being pressed. The time interval is not adjustable. To resume operation, press any key.

4

Programming

Programming

What you'll find in this chapter

This chapter contains two sections:

- Remote programming basics
- Command dictionary

Remote Programming

What you'll find in this section

This section introduces the basics for remote programming of an analyzer. Sections covering the following topics are included:

- an introduction to programming program message syntax rules and conventions
- the HP-IB interface functions
- the interface functions and programming over RS-232
- programming and documentation conventions

Introduction to Programming

The programming instructions in this manual conform to the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation and to the Standard Commands for Programmable Instruments (SCPI). The programming instructions provide the means of remote control.

For more information regarding the HP-IB, the IEEE 488.2 standard, or the SCPI standard, refer to the following books:

Hewlett-Packard Company. *Tutorial Description of Hewlett-Packard Interface Bus,* 1987.

Hewlett-Packard Company. *SCPI—Standard Commands for Programmable Instruments,* 1991.

International Institute of Electrical and Electronics Engineers. *IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation*. New York, NY, 1987.

International Institute of Electrical and Electronics Engineers. *IEEE Standard 488.2-1987, IEEE Standard Codes, Formats, Protocols and Common commands For Use with ANSI/IEEE Std 488.1-1987*. New York, NY, 1987.

To program the HP 86060-series lightwave switch, it is necessary to add either an HP-IB or RS-232 interface to the rear panel of the switch.

NOTE

The programming examples for individual commands in this manual are written in HP BASIC 6.0 for an HP 9000 Series 200/300 Controller.

Talking to the instrument

Computers acting as controllers communicate with the instrument by sending and receiving messages over a remote interface. Instructions for programming normally appear as ASCII character strings embedded inside the output statements of a "host" language available on your controller. The input statements of the host language are used to read in responses from the analyzer.

For example, HP 9000 Series 200/300 BASIC uses the OUTPUT statement for sending commands and queries. After a query is sent, the response is usually read in using the ENTER statement.

Messages are placed on the bus using an output command and passing the device address, program message, and terminator. Passing the device address ensures that the program message is sent to the correct interface and instrument.

The following HP BASIC statement sends a command which moves the switch on layer 1 to channel 1 of port A and channel 1 of port B:

```
OUTPUT <device address>;"ROUTE:LAYER1:CHANNEL A1,B1"<terminator>
```

The <device address> represents the address of the device being programmed. Each of the other parts of the above statement are explained in the following pages.

Program message syntax

To program the instrument remotely, you must have an understanding of the command format and structure expected by the instrument. The IEEE 488.2 syntax rules govern how individual elements such as headers, separators, program data, and terminators may be grouped together to form complete instructions. Syntax definitions are also given to show how query responses are formatted. Figure 4-1 shows the main syntactical parts of a typical program statement.

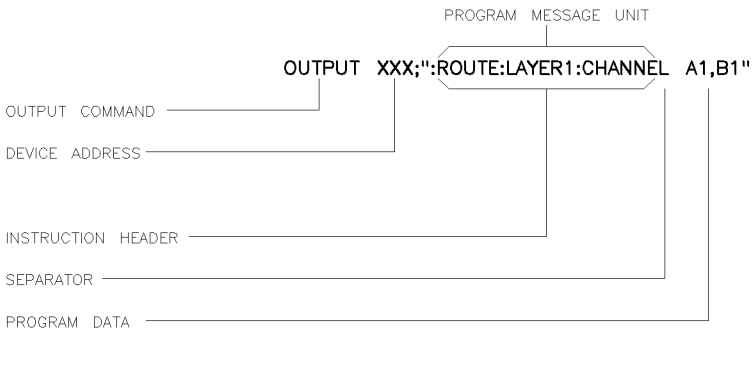

Figure 4-1. Program message syntax.

Output command

The output command is entirely dependent on the programming language. Throughout this manual, HP 9000 Series 200/300 BASIC 6.0 is used in the examples of individual commands. If you are using other languages, you will need to find the equivalents of HP BASIC commands like OUTPUT, ENTER, and CLEAR in order to convert the examples. The instructions listed in this manual are always shown between quotes in the example programs. This manual also has examples using Microsoft Visual Basic.

Device address

The location where the device address must be specified is also dependent on the programming language you are using. In some languages, this may be specified outside the output command. In HP BASIC, this is always specified after the keyword OUTPUT. The examples in this manual assume the analyzer is at device address 711. When writing programs, the address varies according to how the bus is configured.

Instructions

Instructions (both commands and queries) normally appear as a string embedded in a statement of your host language, such as BASIC, Pascal, or C.

Instructions are composed of two main parts:

- The header, which specifies the command or query to be sent.
- The program data, which provide additional information needed to clarify the meaning of the instruction.

Instruction header

The instruction header is one or more mnemonics separated by colons (:) that represent the operation to be performed by the instrument.

The example in Figure 4-1 is a command. Queries are indicated by adding a question mark (?) to the end of the header. Many instructions can be used as either commands or queries, depending on whether or not you have included the question mark. The command and query forms of an instruction usually have different program data. Many queries do not use any program data.

White space (separator)

White space is used to separate the instruction header from the program data. If the instruction does not require any program data parameters, you do not need to include any white space. In this manual, white space is defined as one or more spaces. ASCII defines a space to be character 32 (in decimal).

Program data

Program data is used to clarify the meaning of the command or query. It provides necessary information, such as a channel selection for a port, or a value to which a register should be set. Each instruction's syntax definition shows the program data, as well as the acceptable values. The section "Program Data Syntax Rules" in this chapter lists the general rules about acceptable values.

When there is more than one data parameter, the parameters are separated by commas (,). Spaces can be added around the commas to improve readability.

Header Types

There are two types of headers:

- compound command headers
- common command headers

Compound command header

Compound command headers are a combination of two or more mnemonics. The first mnemonic selects the subsystem, and the following mnemonics select the sub-level or function within that subsystem. The mnemonics within the compound message are separated by colons. For example:

To execute a single function within a subsystem, the components of the program message would be constructed as follows:

```
<subsystem>[:<sub-level>]:<function><separator><program data><terminator>
```

(For example :ROUTE:LAYER1:CHANNEL A1,B1)

Common command header

Common command headers control IEEE 488.2 functions within the instrument (such as clear status). Their syntax is:

```
*<command header><terminator>
```

No space or separator is allowed between the asterisk (*) and the command header. *CLS is an example of a common command header.

Some common command headers must be followed by program data. The syntax for these common commands are:

```
*<command header><separator><program data><terminator>
```

(For example *ESE 255)

Query command

Command headers immediately followed by a question mark (?) are queries. Query commands are used to find out information regarding the instrument's current state. After receiving a query, the instrument interrogates the requested function and places the answer in its output queue. The answer remains in the output queue until it is read or another command is issued. When read, the answer is transmitted across the bus to the designated listener (typically a controller).

The output queue must be read before the next program message is sent. For example, when you send the query :SYSTEM:CONFIG? you must follow that query with an input statement. In HP BASIC, this is usually done with an ENTER statement immediately followed by a variable name. This statement reads the result of the query and places the result in a specified variable.

For example, the query :ROUTE:LAYER1:CHANNEL? places the current channel setting on layer 1 in the output queue. In HP BASIC, the controller input statement:

```
ENTER <device address>;Setting$
```

passes the value across the bus to the controller and places it in the variable Setting$.

NOTE

Sending another command or query, before reading the result of a query, causes the output buffer to be cleared and the current response to be lost. This also generates a query interrupted error in the error queue.

Program header options

Program headers can be sent using any combination of uppercase or lowercase ASCII characters. Instrument responses, however, are always returned in uppercase.

Program command and query headers may be sent in either long form (complete spelling), short form (abbreviated spelling), or any combination of long form and short form.

`ROUTE:LAYER1:CHANNEL A2,B8` *long form*

`ROUT:LAY1:CHAN A2,B8` *short form*

Programs written in long form are easily read and are almost self-documenting. The short form syntax conserves the amount of controller memory needed for program storage and reduces the amount of I/O activity.

NOTE

The rules for the short form syntax are shown in "Programming and Documentation Conventions".

Program data syntax rules

Program data is used to convey a variety of types of parameter information related to the command header. At least one space must separate the command header or query header from the program data.

`<command header><separator><data><terminator>`

When a command header or query has multiple program data, a comma separates sequential program data.

`<command header><separator><data>,<data><terminator>`

For example, :ROUTE:LAYER1:CHANNEL A1,B1 has two program data: A1 and B1.

There are two main types of program data which are used in commands:

- character program data
- numeric program data

Character program data

Character program data is used to convey parameter information as alpha or alphanumeric strings. For example, the :ROUTE:LAYER:CHANNEL command requires character program data of the form Am,Bn, where m and n are integers. :ROUTE:LAYER1:CHANNEL A2,B5 sets port A to channel 2 and port B to channel 5.

The available mnemonics for character program data are always included with the instruction's syntax definition.

Numeric program data

Some command headers require program data to be expressed numerically. For example, *ESE requires a numeric expression for setting the Standard Event Status Enable Register. When a syntax definition specifies that a number is an integer, that means that the number should be whole. Numeric data parameters which accept fractional values are called real numbers.

All numbers are expected to be strings of ASCII characters. Thus, when sending the number 9, you would send a byte representing the ASCII code for the character "9" (which is 57). A three-digit number like 102 would take up three bytes (ASCII codes 49, 48, and 50). This is taken care of automatically when you include the entire instruction in a string.

Program mnemonics with numeric suffixes

When an instrument provides multiple capabilities by duplicating internal functional blocks, such as a lightwave switch with multiple switch layers, the individual functional blocks are referenced by a program mnemonic appended with a numeric suffix.

In the case of the switch, this program mnemonic is the word LAYER in the ROUTE:LAYER:CHANNEL command. The numeric value at the end of the mnemonic LAYER selects the switch block to which the ROUTE:LAYER:CHANNEL command should be applied. For example, in the following program statement the command is applied to switch layer 2 of the instrument.

```
OUTPUT <device address>;":ROUTE:LAYER2:CHANNEL A2,B4"<terminator>
```

Programming over HP-IB

What you'll find in this section

This section describes the HP-IB interface functions and some general concepts. In general, these functions are defined by IEEE 488.2. They deal with general interface management issues, as well as messages which can be sent over the interface as interface commands.

Interface capabilities

The interface capabilities of the analyzer, as defined by IEEE 488.1, are SH1, AH1, T5, L4, SR1, RL1, PP1, DC1, DT0, C0, and E2.

Command and data concepts

The interface has two modes of operation:

- command mode
- data mode

The bus is in the command mode when the ATN line is true. The command mode is used to send talk and listen addresses and various bus commands, such as a group execute trigger (GET).

The bus is in the data mode when the ATN line is false. The data mode is used to convey device-dependent messages across the bus.

Addressing

The address is used to determine which instrument on the interface bus with which the controller is communicating.

- Each device on the HP-IB resides at a particular address, 0–30.
- The active controller specifies which devices talk and which listen.
- An instrument may be talk addressed, listen addressed, or unaddressed by the controller.

If the controller addresses the instrument to talk, the instrument remains configured to talk until it receives an interface clear message (IFC), another instrument's talk address (OTA), its own listen address (MLA), or a universal untalk command (UNT).

If the controller addresses the instrument to listen, the instrument remains configured to listen until it receives an interface clear message (IFC), its own talk address (MTA), or a universal unlisten command (UNL).

Communicating over the bus

Since HP-IB can address multiple devices through the same interface card, the device address passed with the program message must include not only the correct interface select code, but also the correct instrument address.

Interface select code (selects interface)

Each interface card has a unique interface select code. This code is used by the controller to direct commands and communications to the proper interface. The default is typically "7" for HP-IB controllers.

Instrument address (selects instrument)

Each instrument on an HP-IB must have a unique instrument address between decimal 0 and 30. The device address passed with the program message must include not only the correct instrument address, but also the correct interface select code.

```
DEVICE ADDRESS = (Interface Select Code * 100) + (Instrument Address)
```

For example, if the instrument address for the instrument is 4 and the interface select code is 7, when the program message is passed, the routine performs its function on the instrument at device address 704.

For this instrument, the address is typically set to "11" at the factory. This address can be changed by pressing the (LOCAL) key on the front panel.

NOTE

The examples in this manual assume the instrument is at device address 711.

Lockout

A SYSTem:LOCK command may be used to disable front-panel control while a program is running. By default, the instrument accepts and executes bus commands, and the front panel is entirely active.

> **NOTE**
>
> Cycling the power also restores front panel control.

With HP-IB, the instrument is placed in the lockout mode by sending the local lockout command (LLO). The instrument can be returned to local by sending the go-to-local command (GTL) to the instrument.

Bus commands

The following commands are IEEE 488.1 bus commands (ATN true). IEEE 488.2 defines many of the actions which are taken when these commands are received by the instrument.

Device clear

The device clear (DCL) or selected device clear (SDC) commands clear the input and output buffers, reset the parser, and clear any pending commands.

Interface clear

The interface clear (IFC) command halts all bus activity. This includes unaddressing all listeners and the talker, disabling serial poll on all devices, and returning control to the system controller.

Programming over RS-232

What you'll find in this section

This section describes the interface functions and some general concepts of the RS-232 interface. The RS-232 interface on this instrument is Hewlett-Packard's implementation of EIA Recommended Standard RS-232, "Interface Between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange." With this interface, data is sent one bit at a time and characters are not synchronized with preceding or subsequent data characters. Each character is sent as a complete entity without relationship to other events.

NOTE

IEEE 488.2 is designed to work with IEEE 488.1 as the physical interface. When RS-232 is used as the physical interface, as much of IEEE 488.2 is retained as the hardware differences will allow. No IEEE 488.1 messages such as DCL, GET, and END are available.

Interface operation

The switch can be programmed with a controller over RS-232 using an interface cable that is appropriate for your application. The operation and exact connections for this interface are described in more detail in the following sections. When you are using a controller to program a switch over RS-232, you are normally operating directly between two DTE (Data Terminal Equipment) devices as compared to operating between a DTE device and a DCE (Data Communications Device) device.

Cables

The type of RS-232 cable you use to connect the controller to the switch will depend on your application. The following paragraphs describe which lines of the switch are used to control the operation of the RS-232 bus relative to the switch. To locate the proper cable for your application, refer to the reference manual for your controller.

3-wire interface

The switch uses a 3-wire RS-232 interface. It provides a simple connection between devices because you can ignore hardware handshake requirements. The switch uses the following connections on its RS-232 interface for 3-wire communication:

Pin 7	SGND (Signal Ground)
Pin 2	TD (Transmit Data from switch)
Pin 3	RD (Receive Data into switch)

The TD (Transmit Data) line from the switch must connect to the RD (Receive Data) line on the controller. Likewise, the RD line from the switch must connect to the TD line on the controller. The RS-232 interface on the switch ignores all signals on the DCD, DSR, RTS, and CTS lines.

Interface settings

The baud rate, stop bits, parity, protocol, and data bits must be configured exactly the same for both the controller and the switch to properly communicate over the RS-232 interface. The RS-232 interface capabilities of the lightwave switch are listed below:

Baud Rate ..... 1200 or 9600
Parity ..... None
Data Bits 8
Stop Bits 1

The baud rate of the RS-232 interface at the switch can be set at the front panel by pressing the (LOCAL) key twice, and then toggling between the two available values using the arrow keys.

Data bits

Data bits are the number of bits sent and received per character that represent the binary code of that character.

Information is stored in bytes (8 bits at a time) in the switch. Data can be sent and received just as it is stored, without the need to convert the data.

Communicating over the RS-232 interface

Each RS-232 interface card has its own interface select code. This code is used by the controller to direct commands and communications to the proper interface. Unlike HP-IB, which allows multiple devices to be connected through a single interface card, RS-232 is only connected between two devices at a time through the same interface card. Because of this, only the interface code is required for the device address.

Generally, the interface select code can be any decimal value between 0 and 31, except for those interface codes which are reserved by the controller for internal peripherals and other internal interfaces. This value can be selected through switches on the interface card. For more information, refer to the reference manual for your interface card or controller.

RS-232 commands

RS-232 control of the switch is initiated by sending the OPEN RS232 COM command over the interface. This places the switch in the remote mode and locks out the front panel.

Many of the commands used for controlling the switch and for retrieving data from the switch are the same as for the HP-IB interface. Refer to the "Command Dictionary" to find the commands which apply to both HP-IB and RS-232.

To end communications with the switch over the RS-232 interface, send the CLOSE RS232 COM command. This command returns control to the front panel of the instrument.

Programming and Documentation Conventions

What you'll find in this section

This section covers conventions which are used in programming the instrument, as well as notation conventions and definitions used in the descriptions of the remote commands.

Truncation rules

The truncation rule for the mnemonics used in headers and alpha arguments is:

The mnemonic is the first four characters of the keyword unless *the fourth character is a vowel, in which case the mnemonic is the first three characters of the keyword.*

This rule is *not* used if the length of the keyword is exactly four characters.

Some examples of how the truncation rule is applied to various commands are shown in Table 4-1.

Table 4-1. Mnemonic Truncation

Long Form	Short Form
ROUTE	ROUT
LAYER	LAY
SYSTEM	SYST
ERROR	ERR

Command types

This instrument has three types of commands:

- Common commands
- Standard SCPI commands
- Instrument specific commands

Common commands

The common commands are the commands defined by IEEE 488.2. These commands control some functions that are common to all IEEE 488.2 instruments.

Common command headers consist of only a single mnemonic preceded by an asterisk.

Example: `*RST`

Standard SCPI commands

The standard SCPI commands are the STATUS subsystem commands required for compatibility with SCPI. In most instruments, the STATUS subsystem commands are used to report device-dependent errors. In the lightwave switch, these commands have no function but are included for SCPI compatibility.

Standard SCPI command headers are compound headers consisting of two or more mnemonics.

Example: `:STATUS:OPERATION:ENABLE`

Instrument specific commands

Instrument-specific commands are those commands which are specific to the control of the switch. These commands control switch movements and report the configuration of the switch.

Instrument-specific commands are compound headers consisting of two or more mnemonics.

Example: `:ROUTE:LAYER:CHANNEL`

Response generation

As defined by IEEE 488.2, query responses may be buffered for the following conditions:

- When the query is parsed by the instrument.
- When the controller addresses the instrument to talk so that it may read the response.

The responses to a query are buffered when the query is parsed.

Notation conventions and definitions

The following conventions and definitions are used in this manual in descriptions of remote operation:

Conventions

< >	Angle brackets enclose words or characters that symbolize a program code parameter or an interface command.
::=	"Is defined as," for example, <A> ::= <B> indicates that <A> can be replaced by <B> in any statement containing <A>.
|	"Or" indicates a choice of one element from a list. For example, <A> | <B> indicates <A> or <B>, but not both.
. . .	An ellipsis (trailing dots) indicates that the preceding element may be repeated one or more times.
[ ]	Square brackets indicate that the enclosed items are optional.
{ }	When several items are enclosed by braces, one, and only one of these elements must be selected.

Definitions

d ::=	A single ASCII numeric character, 0–9.
n ::=	A single ASCII non-zero, numeric character, 1–9.
<NL> ::=	Newline or Linefeed (ASCII decimal 10).
<sp> ::=	<white space>
<white space> ::=	0 through 32 (decimal) except linefeed (decimal 10).

Program examples

The program examples given for each command in this manual were written on an HP 9000 Series 200/300 controller using the HP BASIC 6.0 programming language. The programs always assume the instrument is at address 11 and the interface is at address 7 for a program address of 711.

In these examples, pay special attention to the ways in which the command or query can be sent. The way the instrument is set up to respond to a command or query has no bearing on how you send the command or query. That is, the command or query can be sent using the long form or short form, if a short form exists for that command. You can send the command or query using uppercase (capital) letters or lowercase (small) letters.

Command Dictionary

What you'll find in this section

This section is a dictionary reference of the remote programming commands. The section is divided into two sections:

- Common commands
- Standard SCPI commands
- Instrument specific commands

All commands are listed alphabetically.

Switch Configuration Definitions

A switch consists of a number of *layers*, ranging from 1 to 32. A layer has two *ports*, each consisting of a number of *channels* ranging from 1 to 100. Ports with three or more channels have an additional position called channel 0 or OFF. The HP 86060-series lightwave switches are blocking—the common fiber can only be connected to one channel at a time. Other switch configurations, such as non-blocking matrices are available as special orders. Please contact your Hewlett-Packard representative for more information on special orders.

Common commands

The following commands are required by the IEEE 488.2–1987 standard.

*CLS
(Clear Status)

The *CLS (clear status) common command clears all the event registers summarized in the Status Byte register. With the exception of the output queue, all queues that are summarized in the Status Byte Register are emptied. The error queue is also emptied. Neither the Standard Event Status Enable Register, nor the Service Request Enable Register are affected by this command.

After the *CLS command, the instrument is left in the idle state. The command does not alter the instrument setting. *OPC/*OPC? actions are cancelled.

Usage:	HP-IB only
Command Syntax:	*CLS
Example:	OUTPUT 711;"*CLS"

*ESE
(Event Status Enable)

The *ESE command sets the bits in the Standard Event Status Enable Register and enables the corresponding bits in the Standard Event Status Register. The Standard Event Status Enable Register contains a mask value for the bits to be enabled in the Standard Event Status Register. A bit set to one in the Standard Event Status Enable Register enables the corresponding bit in the Standard Event Status Register . A zero disables the bit. Refer to Table 4-2 for information about the Standard Event Status Enable Register bits, bit weights, and what each bit masks.

The Standard Event Status Enable Register is cleared at power-on. The *RST and *CLS commands do not change the register.

The *ESE query returns the value of the Standard Event Status Enable Register.

Usage:	HP-IB only
Command Syntax:	*ESE <mask>
Where:	<mask> ::= 0 to 255
Example[1]:	OUTPUT 711;"*ESE 64"
Query Syntax:	*ESE?
Returned Format:	<mask><NL>
Where:	<mask> ::= 0 to 255 (integer-NR1 format)

1 In this example, the *ESE 64 command enables URQ (user request) bit 6 of the Standard Event Status Enable Register. Therefore, when a front-panel key is pressed the ESB (event summary bit) in the Status Byte Register is also set.

Table 4-2. Standard Event Status Enable Register

(High=Enables the ERS bit)		
Bit	**Bit Weight**	**Enables**
7	128	PON - Power On
6	64	URQ - User Request
5	32	CME - Command Error
4	16	EXE - Execution Error
3	8	NOT USED
2	4	QYE - Query Error
1	2	NOT USED
0	1	OPC - Operation Complete

*ESR
(Event Status Register)

The *ESR query returns the value of the Standard Event Status Register.

When you read the Event Status Register, the value returned is the total of the bit weights of all of the bits that are set to one at the time you read the byte. Table 4-3 shows each bit in the Event Status Register and its bit weight.

Reading the register clears the Event Status Register.

Usage:	HP-IB only
Query Syntax:	*ESR?
Returned Format:	<status><NL>
Where:	<status> ::= 0 to 255 [integer-NR1 format]
Example:	OUTPUT 711;"*ESR?" ENTER 711;Event PRINT Event

Table 4-3. Standard Event Status Register

Bit	Bit Weight	Condition
7	128	PON - Power On
6	64	URQ - User Request
5	32	CME - Command Error
4	16	EXE - Execution Error
3	8	NOT USED
2	4	QYE - Query Error
1	2	NOT USED
0	1	OPC - Operation Complete

*IDN
(Identification Number)

The *IDN query returns a string value which identifies the instrument type and firmware version.

An *IDN query must be the last query in a program message. Any queries after the *IDN query in a program message are ignored.

Usage:	HP-IB and RS-232
Query Syntax:	*IDN?
Returned Format:	"Hewlett-Packard, 8606XB, 0, <X.X>"
Where:	<X.X> = firmware revision number
Example:	DIM Id$[50] OUTPUT 711;"*IDN?" ENTER 711;Id$ PRINT Id$

*OPC (Operation Complete)

The *OPC command sets the operation complete bit in the Standard Event Status Register when all pending device operations have finished.

The *OPC query places an ASCII "1" in the output queue when all pending device operations have finished.

NOTE

The *OPC command can be used to ensure all switch movement operations have completed before continuing the program. By following a ROUTE:LAYER:CHANNEL command with an *OPC query and an ENTER statement, the program will pause until the response (ASCII "1") is returned by the instrument.

Usage:	HP-IB only
Command Syntax:	*OPC
Example:	OUTPUT 711;"*OPC"
Query Syntax:	*OPC?
Returned Format:	1<NL>
Example:	OUTPUT 711;"*OPC?" ENTER 711;Op$

*RCL
(Recall)

The *RCL command recalls the state of the instrument from the specified instrument state register. If the instrument state register has not been previously stored, the *RCL command will restore the instrument to its power-on state.

Usage:	HP-IB and RS-232
Command Syntax:	*RCL <value>
Where:	<value> ::= 0 to 9 [integer-NR1 format]
Example:	OUTPUT 711;"*RCL 3"

*RST
(Reset)

The *RST command returns the switch to its power-up condition. For all layers, each port is set to its OFF position or channel 1.

Usage:	HP-IB and RS-232
Command Syntax:	*RST
Example:	OUTPUT 711;"*RST"

*SAV
(Save)

The *SAV command saves the current state of the instrument to the specified instrument state register.

Usage:	HP-IB and RS-232
Command Syntax:	*SAV <value>
Where:	<value> ::= 0 to 9 [integer-NR1 format]
Example:	OUTPUT 711;"*SAV 3"

*SRE
(Service Request Enable)

The *SRE command sets the bits in the Service Request Enable Register. The Service Request Enable Register contains a mask value for the bits to be enabled in the Status Byte Register. A bit set to one (1) in the Service Request Enable Register enables the corresponding bit in the Status Byte Register. A zero (0) disables the bit. Table 4-4 lists the bits in the Service Request Enable Register and what they mask.

The Service Request Enable Register is cleared at power-on. The *RST and *CLS commands do not change the register.

The *SRE query returns the value of the Service Request Enable Register.

Usage:	HP-IB only
Command Syntax:	*SRE <mask>
Where:	<mask> ::= 0 to 255
Example[1]:	OUTPUT 711;"*SRE 32"
Query Syntax:	*SRE?
Returned Format:	<mask><NL>
Where:	<value> ::= 0 to 255 (integer-NR1 format)

1 In this example, the *SRE 32 command enables ESB (event summary) bit 5 of the Status Byte Register, the MSS (master summary status) bit 6 in the Status Byte Register is also set.

Table 4-4. Service Request Enable Register

Service Request Enable Register (High–Enables the SRE bit)		
Bit	**Bit Weight**	**Enables**
7	128	Not Used
6	64	MSS – Master Summary Status
5	32	ESB – Event Status Bit
4	16	MAV – Message Available
3	8	Not Used
2	4	Not Used
1	2	Not Used
0	1	OPP – Operation Pending

*STB
(Status Byte)

The *STB query returns the current value of the instrument's status byte. The MSS (Master Summary Status) bit 6 indicates whether of not the device has at least one reason for requesting service.

When you read the Status Byte Register, the value returned is the total of the bit weights of all of the bits set to one (1) at the time you read the byte. Table 4-5 shows each bit in the Status Byte Register and its bit weight.

The *STB query does not affect the contents of the Status Byte Register.

NOTE

To read the instrument's status byte with RQS reported on bit 6, use the interface Serial Poll.

NOTE

The *STB query can be used to determine when the switch has settled to a new position. After sending a ROUTE:LAYER:CHANNEL command, bit 0 of the Status Byte Register will be set to one while the switch is moving and return to zero when the switch has settled.

Usage:	HP-IB only
Query Syntax:	*STB?
Returned Format:	<value><NL>
Where:	<value> ::= 0 to 255 |integer – NR1 format|
Example:	OUTPUT 711;"*STB?" ENTER 711;Value PRINT Value

Table 4-5. Status Byte Register

Bit	Bit Weight	Condition
7	128	Not Used
6	64	MSS – Master Summary Status
5	32	ESB – Event Status Bit
4	16	MAV – Message Available
3	8	Not Used
2	4	Not Used
1	2	Not Used
0	1	OPP – Operation Pending

*TST
(Test)

The *TST query performs a self-test on the instrument. The result of the test is placed in the output queue. A zero indicates the test passed and a non-zero value indicates the test failed. If a test fails, refer to "Performing a verification check" in Chapter 2.

Usage:	HP-IB and RS-232
Query Syntax:	*TST?
Returned Format:	<result><NL>
Where:	<result> ::= 0 or non-zero value 0 indicates the test passed. non-zero indicates the test failed.
Example:	OUTPUT 711;"*TST?" ENTER 711;Result PRINT Result

*WAI
(Wait)

The *WAI command prevents the instrument from executing any further commands until the current command has finished executing. All pending operations are completed during the wait period.

NOTE

The *WAI command can be used to ensure all switch movement operations have completed before continuing the program. By following a ROUTE:LAYER:CHANNEL command with a *WAI command followed by a query, will ensure the query is not answered until the switch has settled to its new position.

Usage:	HP-IB only
Command Syntax:	*WAI
Example:	OUTPUT 711;"ROUTE:LAYER1:CHANNEL A2,B4" OUTPUT 711;"*WAI" OUTPUT 711;"SYSTEM:CONFIG?" ENTER 711;DUMMY$

:STATus:<node>
:CONDition

The :STATus:<node>:CONDition query returns the value for the condition register for the node. Condition registers have no function in this instrument, but the query is included for compatability with the SCPI standard. This query always returns the value 0.

Usage:	HP-IB only
Query Syntax:	:STATus:<node>:CONDition?
Returned Format:	<value>
Where:	<value> = 0 |integer - NR1| <node> = OPERation | QUEStionable
Example:	OUTPUT 711;":STATUS:OPERATION:CONDITION?" ENTER 711;Value PRINT Value

:STATus:<node>:ENABle

The :STATus:<node>:ENABle command sets the enable register for the node. Enable registers have no function in this instrument, but the command is included for compatability with the SCPI standard.

The :STATus:<node>:ENABle query returns the value of the enable register for the node.

Usage:	HP-IB only
Command Syntax:	:STATus:<node>:ENABle<value>
Where:	<node> = OPERation | QUEStionable <value> ::= 0 to 32767 |integer or floating point - NR1|
Example:	OUTPUT 711;":STATUS:QUESTIONABLE:ENABLE 1024"
Query Syntax:	:STATus:<node>:ENABle?
Returned Format:	<value>
Where:	<node> = OPERation | QUEStionable <value> ::= 0 to 32767 |integer - NR1|
Example:	OUTPUT 711;":STATUS:QUESTIONABLE:ENABLE?" ENTER 711;Value PRINT Value

:STATus:<node>[:EVENT]

The :STATus:<node>[:EVENT] query returns the value of the event register for the node. Event registers have no function in this instrument, but the query is included for compatability with the SCPI standard. This query always returns the value 0.

Usage:	HP-IB only
Query Syntax:	:STATus:<node>[:EVENT?]
Returned Format:	<value>
Where:	<value> = 0 |integer - NR1| <node> = OPERation | QUEStionable
Example:	OUTPUT 711;":STATUS:OPERATION:EVENT?" ENTER 711;Value PRINT Value

:STATus:PRESet

The :STATus:PRESet command presets the enable registers for all status nodes. Enable registers have no function in this instrument, but the command is included for compatability with the SCPI standard. Table 4-6 shows the value of each enable register.

Usage:	HP-IB only
Query Syntax:	:STATus:PRESet
Example:	OUTPUT 711;":STATUS:PRESET"

Table 4-6. Values of the Enable Registers

Status Node	Preset Value
Operation	0
Questionable	0

:SYSTem:ERRor

The :SYSTem:ERRor query returns the next error number and error description in the error queue over the interface. This instrument has an error queue 15 errors deep and operates on a first-in, first-out basis. Repeatedly sending the query :SYSTEM:ERROR? returns the error numbers and descriptions in the order in which they occur until the queue is empty. Any further queries returns "+0,No errors" until another error occurs. Refer to Table 4-7 for the error numbers and descriptions.

Usage:	HP-IB and RS-232
Query Syntax:	:SYSTem:ERRor?
Returned Format:	<value>, <string>
Where:	<value> = an integer error code |NR1| <string> = text of error message
Example:	DIM Error$[50] OUTPUT 711;":SYSTEM:ERROR?" ENTER 711;Error$ PRINT Error$

Table 4-7. Error Messages

Error Number	Description
-100	Command error [unknown command]
-101	Invalid character
-102	Syntax error
-103	Invalid separator
-104	Data type error
-105	GET not allowed
-108	Parameter not allowed
-109	Missing parameter
-112	Program mnemonic too long
-113	Undefined header
-121	Invalid character in number
-123	Numeric overflow
-124	Too many digits
-128	Numeric data not allowed
-130	Suffix error
-131	Invalid suffix
-138	Suffix not allowed
-140	Character data error
-141	Invalid character data
-144	Character data too long
-148	Character data not allowed

Table 4-7. Error Messages (continued)

Error Number	Description
-150	String data error
-151	Invalid string data
-158	String data not allowed
-160	Block data error
-161	Invalid block data
-168	Block data not allowed
-170	Expression error
-171	Invalid expression
-178	Expression data not allowed
-200	Execution error
-211	Trigger ignored
-221	Settings conflict
-222	Data out of range
-223	Too much data
-310	System error
-350	Too many errors
-400	Query error
-410	Query INTERRUPTED
-420	Query UNTERMINATED
-430	Query DEADLOCKED
-440	Query UNTERMINATED after indefinite response

Instrument specific commands

The following commands are specific to remote operation of the HP 86060B-series lightwave switches.

CLOSE RS232 COM

The CLOSE RS232 COM command disables remote operation of the instrument over the RS-232 interface and enables the front-panel keyboard. This command is the same as pressing the (LOCAL) key while in remote operation over the RS-232 interface.

Usage:	RS-232 only
Command Syntax:	CLOSE RS232 COM
Example:	com_port=9 OUTPUT com_port; "OPEN RS232 COM"

OPEN RS232 COM

The OPEN RS232 COM command enables remote operation of the instrument over the RS-232 interface and locks out the front-panel keyboard. This command must be sent before sending any other commands over the RS-232 interface. Press the (LOCAL) key to return to local mode and lock out the RS-232 interface.

Usage:	RS-232 only
Command Syntax:	OPEN RS232 COM
Example:	com_port=9 OUTPUT com_port; "CLOSE RS232 COM"

[:ROUTe]:[LAYer]:CHANnel

The [:ROUTe]:[LAYer]:CHANnel command sets the channel connections for a particular layer. If no layer is specified, it defaults to layer 1. The minimum layer number is always 1. The minimum channel number is either 0 or 1, depending on whether the port has an "OFF" position. The maximum number of layers and channels is dependent on the switch configuration. If the command parameters are outside the permitted range for the switch configuration, the switch position is not changed and an error is generated.

The [:ROUTe]:[LAYer]:CHANnel query returns the current port settings for the specified layer. If no layer is specified, the default value is layer 1.

Usage:	HP-IB and RS-232
Command Syntax:	[:ROUTe]:[LAYer<layer>]:CHANnel <channel_list>
Where:	<layer> a positive integer |NR1| <channel_list> = A<channel>|B<channel>|A<channel>,B<channel> <channel> = a non-negative integer |NR1| | OFF
Example:	OUTPUT 711;":ROUTE:LAYER2:CHANNEL A2,B78" Connects A2 to B78 on layer 2
Query Syntax:	[:ROUTe]:[LAYer<layer>]:CHANnel?
Where:	<layer> a positive integer |NR1|
Returned Format:	<channel>,<channel> <channel> = a non-negative integer |NR1|
Example:	DIM Setting$ OUTPUT 711;":ROUTE:LAYER3:CHANNEL?" ENTER 711;Setting$ PRINT Setting$

:SYSTem:CONFig

The :SYSTem:CONFig query returns the switch configuration of the instrument. For each layer, the minimum and maximum channel numbers for each port are given.

Usage:	HP-IB and RS-232
Query Syntax:	:SYSTem:CONFig?
Returned Format:	<config> = "L<i>A<j1>A<k1>B<l1>B<m1> A<j2>A<k2>B<l2>B<m2>..."
Where:	<i> = number of layers on switch <j1> = minimum available channel on port A, layer 1 <k1> = maximum available channel on port A, layer 1 <l1> = minimum available channel on port B, layer 1 <m1> = maximum available channel on port B, layer 1 <j2> = minimum available channel on port A, layer 2 <k2> = maximum available channel on port A, layer 2 <l2> = minimum available channel on port B, layer 2 <m2> = maximum available channel on port B, layer 2
Example:	DIM Config$ OUTPUT 711;":SYSTem:CONFIG?" ENTER 711;Config$ PRINT Config$

5

Programming Examples

Programming Examples

What you'll find in this chapter

This chapter includes a number of programming examples to illustrate the use of remote commands in actual programs.

NOTE

These programming examples do not cover the full command set for the instrument. They are intended only as an introduction to the method of programming the instrument and the principles behind TMSL.

The example programs in this chapter are as follows:

Example 1: This simple program uses the ROUTE:LAYER:CHANNEL command to move the switch to a new position. The program shows how to use the *WAI command to ensure that the switch has settled to its new position.

Example 2: This program is similar to the first example program. Instead of using the *WAI command, the Status Byte Register is read repeatedly using the *STB query. When bit 0 of the Status Byte Register returns to zero, the switch has settled to its new position.

Example 3: Repeating the same program as the first two examples, the *OPC command and *ESR query are now used to determine that the switch has settled to its new position. The *OPC command is sent before the ROUTE:LAYER:CHANNEL command, and then the Standard Event Status Register is continuously read until bit 0 is set to one.

Example 4: This example illustrates the use of two switches in an automated system to periodically monitor a number of devices under test (DUTs). The test system includes an HP 8153A optical multimeter with an HP 81554SM laser source and an HP 81532A optical power sensor. This program measures the optical power through each DUT every 5 minutes and displays a message if the power drops below 1 microwatt.

Example 5: This program is written in Microsoft Visual Basic 3.0 and performs the same function as the first three examples. This Visual Basic program shows how to provide a user interface in a Windows environment, as well as how to send commands to the switch from within this environment. Also, this example program illustrates the use of both the HP-IB interface and the RS-232 interface for communicating with the instrument.

Example 1

Function

This program prompts the operator for the desired switch position and then moves the switch to this position. The switch error queue is then read and printed. The program shows how to use the *WAI command to ensure that the switch has settled to its new position.

Listing

```
10   INTEGER Switch_addr,A_position,B_position
20   DIM Command$[80],Channel$[80],Error_return$[80],Dummy$[80]
30   Switch_addr=711
40   CLEAR SCREEN
50   INPUT "Enter A-port position : ",A_position
60   INPUT "Enter B-port position : ",B_position
70   Channel$="A"&TRIM$(VAL$(A_position))&",B"&TRIM$(VAL$(B_position))
80   Command$="ROUTE:LAYER1:CHANNEL "&Channel$
90   OUTPUT Switch_addr;Command$
100  GOSUB Wait_to_settle
110  REPEAT
120     OUTPUT Switch_addr;"SYSTEM:ERROR?"
130     ENTER Switch_addr;Error_return$
140     PRINT Error_return$
150  UNTIL (VAL(Error_return$)=0)
170  GOTO Exit_prog
180  !
190 Wait_to_settle: ! wait for switch to settle
200  OUTPUT Switch_addr;"*WAI"
210  OUTPUT Switch_addr;"SYSTEM CONFIG?"
220  ENTER Switch_addr;Dummy$
230  RETURN
240  !
250 Exit_prog:!
260  END
```

Line No.	Description
10 to 20	Declare some variables for use in the program.
30	Set the HP 8606X Optical Switch address variable, `Switch_addr`, to 711 (factory default).
40 to 60	Clear the screen and prompt the operator for the desired switch position. Store the positions in variables `A_position` and `B_position`.
70	Set `Channel$` to represent the switch channel positions in the form appropriate for the `ROUTE:LAYER:CHANNEL` HPIB command. For example, if `A_position=`1 and `B_position=`3, then `Channel$` would equal `"A1,B3"`.
80	Set `Command$` to represent the full HP-IB command to set the desired switch position, appending `Channel$`. For the example `Channel$` given above, `Command$` would equal `"ROUTE:LAYER1:CHANNEL A1,B3"`.
90	Send `Command$` to the HP 8606X Optical Switch via the HP-IB interface.
100	Call the subroutine `Wait_to_settle`.
110 to 150	These lines implement a `REPEAT-UNTIL` loop that continuously queries the HP 8606X for error status. The returned error message(s) are printed to the screen. This loop exits when the numeric value of the error string equals 0. This will occur when the error message `"+0, no error"` is returned.
170	Go to the end of the program.
190 to 230	The `wait_for_settle` subroutine.
200	Output the `*WAI` command to the HP 8606X Optical Switch. This command will prevent the switch from executing any further commands until the previous command (that is, the switch setting command) has completed. When the program continues after the completion of the command, the switches are guaranteed to have settled.
210	Output system configuration query to switch.

220	Read back switch configuration. Since this query was preceded by the *WAI command, the switch movement must be settled before the query is responded to.
230	Return execution to the line after call to subroutine (line 110).

Example 2

Function

This program is identical in functionality to the first sample program except a different method is used for determining when the switch has settled. The settling routine used here reads the Status Byte Register repeatedly until bit 0 returns to zero.

Listing

```
10   INTEGER Switch_addr,A_position,B_position,Status_byte
20   DIM Command$[80],Channel$[80],Error_return$[80]
30   Switch_addr=711
40   CLEAR SCREEN
50   INPUT "Enter A-port position : ",A_position
60   INPUT "Enter B-port position : ",B_position
70   Channel$="A"&TRIM$(VAL$(A_position))&",B"&TRIM$(VAL$(B_position))
80   Command$="ROUTE:LAYER1:CHANNEL "&Channel$
90   OUTPUT Switch_addr;Command$
100  GOSUB Wait_to_settle
110  REPEAT
120     OUTPUT Switch_addr;"SYSTEM:ERROR?"
130     ENTER Switch_addr;Error_return$
140     PRINT Error_return$
150  UNTIL (VAL(Error_return$)=0)
170  GOTO Exit_prog
180  !
190 Wait_to_settle: ! wait for switch to settle
200  REPEAT
210     OUTPUT Switch_addr;"*STB?"
220     ENTER Switch_addr;Status_byte
230  UNTIL NOT BIT(Status_byte,0)
240  RETURN
250  !
260 Exit_prog:!
270  END
```

Description

Line No.	
10 to 170	Same as in Example 1 except for declaration of `Status_byte`.
190 to 240	The new `Wait_to_settle` subroutine.
200	Start `REPEAT` loop.
210	Send the `*STB?` command to the switch. This queries the switch to return the value of the status byte.
220	Read the status byte.
230	If the LSB (Least Significant Bit) of the status byte is 0 (that is, the switch is settled), exit the loop. If the LSB is 1 (that is, the switch is moving), then loop back to line 200.
240	Return from subroutine.

Example 3

Function

This program is identical in functionality to the first two example programs, except that it uses yet another method for determining when the switch is settled. This settling method sends the *OPC command before the ROUTE:LAYER:CHANNEL commands and then reads the Standard Event Status Register repeatedly until bit 0 is set to one.

Listing

```
10   INTEGER Switch_addr,A_position,B_position,Esr_byte
20   DIM Command$[80],Channel$[80],Error_return$[80],Config$[80]
30   Switch_addr=711
40   CLEAR SCREEN
41   OUTPUT Switch_addr;"SYSTEM:CONFIG?"
42   ENTER Switch_addr;Config$
43   PRINT "SWITCH CONFIG = "&Config$
50   INPUT "Enter A-port position : ",A_position
60   INPUT "Enter B-port position : ",B_position
70   Channel$="A"&TRIM$(VAL$(A_position))&",B"&TRIM$(VAL$(B_position))
80   Command$="ROUTE:LAYER1:CHANNEL "&Channel$
81   OUTPUT Switch_addr;"*OPC"
90   OUTPUT Switch_addr;Command$
100  GOSUB Wait_to_settle
110  REPEAT
120     OUTPUT Switch_addr;"SYSTEM:ERROR?"
130     ENTER Switch_addr;Error_return$
140     PRINT Error_return$
150  UNTIL (VAL(Error_return$)=0)
170  GOTO Exit_prog
180  !
190 Wait_to_settle: ! wait for switch to settle
200  REPEAT
210     OUTPUT Switch_addr;"*ESR?"
220     ENTER Switch_addr;Esr_byte
230  UNTIL BIT(Esr_byte,0)
240  RETURN
250  !
```

```
260 Exit_prog:!
270  END
```

Description

Line No.	
10 to 170	Same as in Example 1 except for declaration of `Esr_byte`.
190 to 240	The new `Wait_to_settle` subroutine.
200	Start `REPEAT` loop.
210	Send the `*ESR?` command to the switch. This queries the switch for the Event Status Register value.
220	Read the value of the Event Status Register.
230	If the LSB of the ESR is 1 (that is, the switch is settled), exit the loop. If the LSB is 0 (that is, switch is moving), then loop back to line 200.
240	Return from subroutine.

Example 4

Function

This program illustrates how two HP 8606X optical switches may be used to function as input and output multiplexers in an automated test system. For this example, two 1×8 switches are used to test 8 optical DUTs (device under test). The block diagram for this test system is shown below.

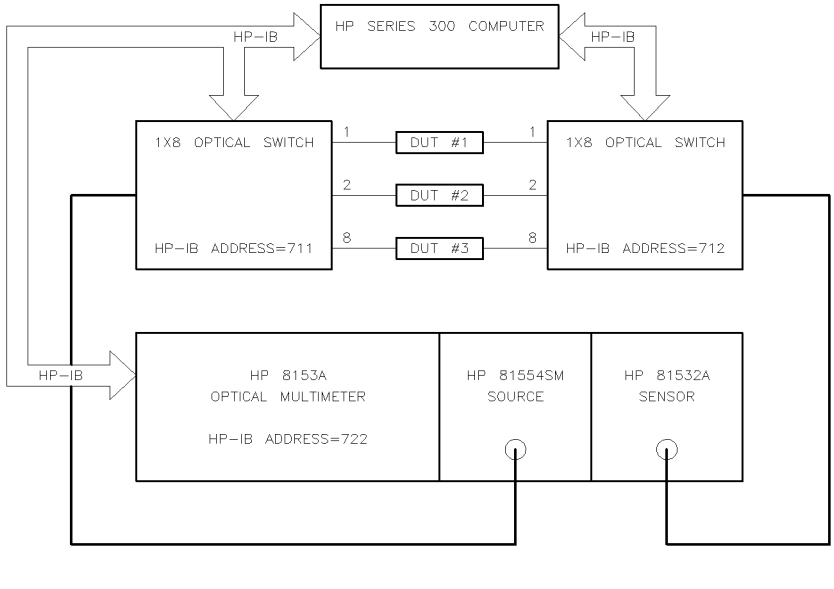

Figure 5-1. Block diagram of the test system.

This example test system uses an HP 8153A optical multimeter equipped with an HP 81554SM laser source and an HP 81532A optical sensor. This program periodically (every 5 minutes) measures the optical power through each DUT and displays an error message if any measured power drops below 1 microwatt.

Listing

```
10   INTEGER In_switch_addr,Out_switch_addr,Opt_meter_addr
20   INTEGER Meas_count,Current_dut
30   REAL Watts_read,Min_power
40   DIM In_switch$[80],Out_switch$[80],Dummy$[50]
50   !
60   CLEAR SCREEN
70   PRINT "THIS PROGRAM MEASURES ALL DUT POWERS EVERY 5 MINUTES."
80   PRINT "IT WILL STOP MEASURING AFTER 50 MEASUREMENT CYCLES."
90   PRINT "TO HALT PROGRAM EARLIER, PRESS F8."
100  !
110  GOSUB Init_system
120  !
130  ON TIME 300 GOSUB Measure_duts
140  ON KEY 8 LABEL "QUIT" GOTO End_prog
150  !
160  Meas_count=0
170  REPEAT
180  UNTIL Meas_count=50
190  GOTO End_prog
200  !
210 Init_system:! Initialize HPIB instruments
220     CLEAR (7)  ! clear HPIB interface
230     ! set HPIB instrument addresses
240     In_switch_addr=711
250     Out_switch_addr=712
260     Opt_meter_addr=722
270     ! set minimum power allowed to 1 microwatt
280     Min_power=1.E-6
290     ! Turn on autoranging
300     OUTPUT @Opt_meter_addr;"SENSE2:POWER:RANGE:AUTO ON"
310     ! Select Watts as output units
320     OUTPUT @Opt_meter_addr;"SENSE2:POWER:UNIT WATT"
330     ! Select 1550 nm wavelength from source
340     OUTPUT @Opt_meter_addr;"SOURCE1:POWER:WAVELENGTH UPPER"
350     RETURN
360     !
370     !
```

```
380 Measure_duts:! measure all eight duts
390     ! Turn on laser
400     OUTPUT @Opt_meter_addr;"SOURCE1:POWER:STATE ON"
410     ! step through and measure all DUTs
420     FOR Current_dut=1 TO 8
430        ! build hpib commands to send to switches
440        In_switch$="ROUTE:LAYER1:CHANNEL B"&TRIM$(VAL$(Current_dut))
450        Out_switch$="ROUTE:LAYER1:CHANNEL B"&TRIM$(VAL$(Current_dut))
460        ! send command to switches
470        OUTPUT @In_switch_addr;In_switch$
480        OUTPUT @Out_switch_addr;Out_switch$
490        ! wait for switches to settle
500        OUTPUT @In_switch_addr;"*WAI"
510        OUTPUT @In_switch_addr;"SYSTEM:CONFIG?"
520        ENTER @In_switch_addr;Dummy$
530        OUTPUT @Out_switch_addr;"*WAI"
540        OUTPUT @Out_switch_addr;"SYSTEM:CONFIG?"
550        ENTER @Out_switch_addr;Dummy$
560        ! measure optical power
570        OUTPUT @Opt_meter_addr;"READ2:POW?"
580        ENTER @Opt_meter_addr;Watts_read
590        IF (Watts_read<Min_power) THEN
600           PRINT USING """DUT #"",K,"" Power Low!""";Current_dut
610        END IF
620    NEXT Current_dut
630    Meas_count=Meas_count+1
640    RETURN
650    !
660 End_prog:! quit program
670    ! turn off time initiated branching
680    OFF TIME
690    END
```

Description

Line No.	
10 to 40	Declare some variables to use in program.
60 to 90	Clear screen and print heading.
110	Call `Init_system` subroutine.
130	Set up time initiated branching. Every 300 seconds, `Measure_duts` subroutine will be called.
140	Set up function key initiated branching. When f8 is pressed, program will end.
160	Initialize measurement counter to zero.
170 to 180	Loop, waiting for events, until measurement count gets to 50.
190	Exit program.
210 to 350	The `Init_system` subroutine.
220	Clear the HP-IB bus.
240 to 260	Define HP-IB addresses for input and output switches, optical multimeter.
280	Define `Min_power` to be 1 microwatt.
300 to 340	Configure optical multimeter to enable autoranging, set power units to Watts, and select the upper wavelength (1550 nm) on the source.
350	Return to calling line.
380 to 600	The `Measure_duts` subroutine.
400	Turn laser source on.
420 to 580	`FOR-NEXT` loop to step through and measure each of the 8 DUTs.
440 to 450	Create the HP-IB commands to select the input and output switch positions to measure the current DUT. For example, if `Current_dut=3` then `In_switch$` and `Out_switch$` would equal `"ROUTE:LAYER1:CHANNEL B3"`. Note that since the switches are 1×8, it is not necessary to specify the position of the A ports.

500 to 550	Use the `*WAI` command to ensure both switches have settled.
570 to 610	Read the optical power from the optical multimeter. If this power is less than `Min_power` then print appropriate error message to screen.
630	Increment `Meas_count`.
640	Return to calling line.
660 to 690	`End_prog` subroutine. Turn off time-initiated branching and end program.

Example 5

This example program is written in Microsoft Visual BASIC 3.0 Professional Package. This program performs the same function as Examples 1–3, but provides a user interface in a Windows environment.

NOTE

Without the Professional Package, you will not be able to implement the RS-232 control of the optical switch.

This program runs on an IBM-compatible computer running Windows 3.0 or later. To interface to the HP 8606X optical switch, an HP 82335 HP-IB interface with appropriate software drivers should be used (the HP-IB Dynamic Link Library, hpib.dll). A standard serial interface cable is necessary if you wish to use the RS-232 interface of the optical switch.

Visual Basic programming

To write a Visual Basic program, you first design the interface, which involves adding controls to a form. Typical controls are pushbuttons, labels, textboxes, and pictureboxes. When the program runs, the user, another application, or Windows itself can generate events associated with various controls. For example, if a user clicks on one of the pushbuttons, a click event occurs for that particular button. A BASIC code, called an event procedure, is written for that particular pushbutton; the event procedure executes each time the click event occurs.

The file HPIBGLBL.TXT will need to be added to the GLOBAL.BAS module of your program (this text file is installed when you install the Windows version of the HP 82335 HP-IB card software). You will also need to include the HP-IB error handling routine, `HpibErrStr$`, in your project. To perform these tasks from within Visual BASIC, refer to the "Using the HP-IB Interface with Microsoft Windows" document that comes with your HP 82335 HP-IB card.

In this example, you will be shown a picture of the form used, along with the pertinent properties and events for the controls of the form. All event procedures and general code will be listed.

Below is a picture of the form used for this example.

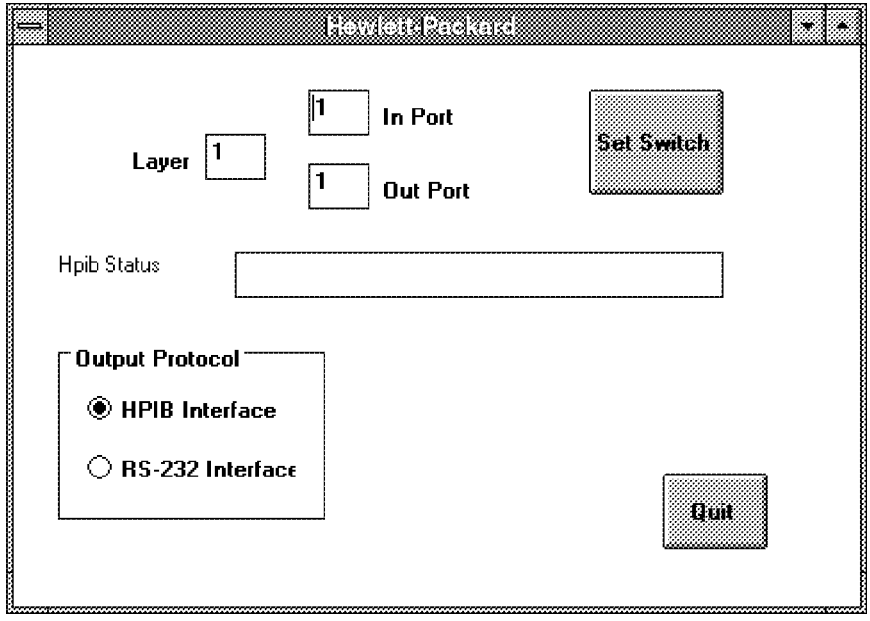

Figure 5-2. Visual Basic example—the form.

Control Definitions

Table 5-1 shows the significant properties and events for the controls used in this example.

Table 5-1. Control Properties and Events

Control	Property Settings	Significant Events
Form	Name = frmMain Caption = "Hewlett-Packard"	Form_Load||
TextBox	Name = txtLayer Text = ""	
MSComm	Name = Comm1 Settings = 9600, n, 8, 1	
Frame	Name = fraOutputType Caption = "Output Protocol"	
OptionButton	Name = optRs232 Caption = "RS-232 Interface" Value = False	
OptionButton	Name = optHpib Caption = "HPIB Interface" Value = True	
CommandButton	Name = cmdQuit Caption = "Quit"	Click [see Sub cmdQuit_Click||]
Command Button	Name = cmdSetSwitch Caption = "Set Switch"	Click [see Sub cmdSetSwitch_Click||]
TextBox	Name = txtHpibStatus Text = ""	
TextBox	Name = txtOutPort Alignment = 1	
TextBox	Name = txtInPort Alignment = 1	
Label	Name = lblLayer AutoSize = True Caption = "Layer"	
Label	Name = lblHpibStatus AutoSize = True Caption = "Hpib Status"	
Label	Name = lblOutPort Caption = "Out Port"	
Label	Name = lblInPort Caption = "In Port"	

General procedures and declarations

The following procedure must be added as a general procedure in the frmMain module:

```
Option Explicit

Sub UpdateForm ()
   If optHpib.Value Then
      txtHpibStatus.Visible = True
      lblHpibStatus.Visible = True
   Else
      txtHpibStatus.Visible = False
      lblHpibStatus.Visible = False
   End If
End Sub
```

Event procedures

The following is a listing of all of the event procedures for this example.

```
Sub cmdQuit_Click ()
    End
End Sub

Sub cmdSetSwitch_Click ()
' declare variables/constants to use
Dim InPortVal As Integer
Dim OutPortVal As Integer
Dim LayerVal as Integer
Dim HpibCardHandle As Integer
Dim ErrorNum As Integer
Dim SwitchErrorNum As Integer
Dim LegalSetting As Integer
Dim CommandStr As String
Dim ChanAStr As String
Dim ChanBStr As String
Dim ReadCharStr As String
Dim ResponseStr As String
Dim CommandLength As Integer
Dim NumResponseChars As Integer
Dim Isc As Long
Dim SwitchAddr As Long
Dim TimeoutVal As Double
Dim Cr As String * 1
```

```
' declare variant to check for legality of port values
Dim VariantVar

Cr = Chr$(13)  'define carriage return character string
Isc = 7
SwitchAddr = 711   ' factory default
TimeoutVal = 3     ' 3 second timeout

LegalSetting = True

VariantVar = TxtInPort.Text

If IsNumeric(VariantVar) Then
   InPortVal = Int(Val(VariantVar))
Else
   MsgBox ("Illegal IN-Port Position")
   LegalSetting = False
   TxtInPort.SetFocus
   TxtInPort.SelStart = 0
   TxtInPort.SelLength = Len(TxtInPort.Text)
End If

VariantVar = txtOutPort.Text
If IsNumberic(VariantVar) Then
   OutPortVal = Int(Val(VariantVar))
Else
   MsgBox ("Illegal OUT-Port Position")
   LegalSetting = False
   txtOutPort.SetFocus
   txtOutPort.SelStart = 0
   txtOutPort.SelLength = Len(txtOutPort.Text)
End If

VariantVar = txtLayer.Text
If IsNumeric(VariantVar) Then
   LayerVal = Int(Val(VariantVar))
```

```
Else
   MsgBox ("Illegal Layer Value")
   LegalSetting = False
   txtLayer.SetFocus
   txtLayer.SelStart = 0
   txtLayer.SelLength = Len(txtLayer.Text)
End If

If LegalSetting Then
   ' build up "CHANNEL Am,Bn" command using set values, and send command
   CommandStr = "ROUTE:LAYER" & Trim$(Str$(LayerVal))
   CommandStr = CommandStr & ":CHANNEL " & "A" & Trim$(Str$(InPortVal))
   CommandStr = CommandStr & ",B" & Trim$(Str$(OutPortVal))

   If optHpib.Value Then
      'output command string via HPIB card
      ErrorNum = HpibOpen (Isc, HpibCardHandle)
      If ErrorNum <> NOERR Then
         MsgBox (HpibErrStr$ (ErrorNum))
      End If
      txtHpibStatus.Text = "Open - " & HpibErrStr$(ErrorNum)

      ErrorNum = HpibReset(HpibCardHandle, Isc)
      txtHpibStatus.Text = "Reset - " & HpibErrStr$(ErrorNum)

      ErrorNum = HpibTimeout(HpibCardHandle, Isc, TimeoutVal)
      txtHpibStatus.Text = "Timeout - " & HpibErrStr$(ErrorNum)

      CommandLength = Len(CommandStr)
      ErrorNum = HpibOutputS(HpibCardHandle, SwitchAddr,
                 CommandStr, CommandLength)
      txtHpibStatus.Text = "OutPutS - " & HpibErrStr$(ErrorNum)

      'Now wait for switch to settle
      CommandStr = "*WAI"
      CommandLength = Len(CommandStr)
      ErrorNum = HpibOutputS(HpibCardHandle, SwitchAddr,
                 CommandStr, CommandLength)
      txtHpibStatus.Text = "OutPutS - " & HpibErrStr$(ErrorNum)
```

```
   'Now, check for any errors reported by switch
   CommandStr = "SYSTEM:ERROR?"
   CommandLength = Len(CommandStr)
   Do
      ErrorNum = HpibOutPutS(HpibCardHandle, SwitchAddr,
                 CommandStr, CommandLength)
      txtHpibStatus.Text = "OutPutS - " & HpibErrStr$(ErrorNum)
      NumResponseChars = 80
      ResponseStr = Space$(NumResponseChars)
      ErrorNum = HpibEnterS(HpibCardHandle, SwitchAddr,
                 ResponseStr, NumResponseChars)
      txtHpibStatus.Text = "EnterS - " & HpibErrStr$(ErrorNum)
      ResponseStr = Trim$(ResponseStr)
      SwitchErrorNum = Val(ResponseStr)
      If SwitchErrorNum <> 0 Then
         MsgBox ResponseStr, 48, "Switch Error"
      End If
   Loop Until SwitchErrorNum = 0
   'close hpib card for now
   ErrorNum = HpibClose(HpibCardHandle)
   If ErrorNum <> NOERR Then
      txtHpibStatus.Text = "HpibClose - " & HpibErrStr$(ErrorNum)
   End If
Else
   'output command string via RS-232 port
   Comm1.PortOpen = True
   Comm1.Output = "OPEN RS232 COM" & Cr
   Comm1.Output = CommandStr & Cr
   Do
      DoEvents
   Loop Until Comm1.OutBufferCount = 0 'wait for all chars to be sent

   'Now check for any errors reported by switch
   CommandStr = "SYSTEM:ERROR?"
```

```
      Do
         'output error query command
         Comml.Output = CommandStr & Cr
         'wait for command to be sent
         Do
            DoEvents
         Loop Until Comml.OutBufferCount = 0
         'read error query response
         ResponseStr = ""
         Comml.InputLen = 1  'read 1 char at a time
         'wait for all of response to be read
         Do
            ReadCharStr = Comml.Input 'read 1 char
            If ReadCharStr <> Cr Then
               ResponseStr = ResponseStr & ReadCharStr
            End If
            DoEvents
         Loop Until ReadCharStr = Cr

         SwitchErrorNum = Val(ResponseStr)
         If SwitchErrorNum <> 0 Then
            MsgBox ResponseStr, 48, "Switch Error"
         End If
      Loop Until SwitchErrorNum = 0

      'return local control to switch
      Comml.Output = "CLOSE RS232 COM"
      Do
        DoEvents
      Loop Until Coml.OutBufferCount = 0

      'close comml port
      Comml.PortOpen = False
    End If
  End If
End Sub
```

```
Sub Form_Load ()
  txtInPort.Text = "1"
  txtOutPort.Text = "1"
  txtLayer.Text = "1"
  UpdateForm
End Sub

Sub optHpib_Click ()
  UpdateForm
End Sub

Sub optRS232_Click ()
  UpdateForm
End Sub
```

6

Service Information

Service Information

What you'll find in this chapter

- How to service the lightwave switch.

WARNING These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.

WARNING Only trained service personnel should perform measurements or servicing instructions inside the instrument chassis. Use extreme care; the exposed terminals on the power supply transformer carry ac line voltage; you can be killed or seriously injured if you contact them when power is applied.

WARNING Failure to ground the lightwave switch properly can result in personal injury, as well as instrument damage.

WARNING Before turning on the lightwave switch, connect a three-wire power cable with a standard IEC 320-C13 (CEE 22-V) inlet plug to the lightwave switch power receptacle. The power cable outlet plug must be inserted into a power-line outlet socket that has a protective earth-contact. DO NOT defeat the earth-grounding protection by using an extension cable, power cable, or autotransformer without a protective ground conductor.

WARNING If you are using an autotransformer, make sure its common terminal is connected to the protective ground conductor of its power-source outlet socket.

WARNING For continued protection against fire hazard, replace line fuse only with the specified type and ratings. The use of other fuses or materials is prohibited.

WARNING The opening of covers or removal of parts is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.

WARNING The power cord is connected to internal capacitors that may remain live for five seconds after disconnecting the plug from its power supply.

Safety Considerations

Before servicing this lightwave switch, familiarize yourself with the safety markings on the instrument and the safety instructions in this manual. This instrument has been manufactured and tested according to international safety standards. To ensure safe operation of the instrument and the personal safety of the user and service personnel, the cautions and warnings in this manual must be heeded.

Refer to the summary of safety considerations at the front of this manual. Individual chapters also contain detailed safety notation.

Protection from electrostatic discharge

Electrostatic discharge (ESD) can damage or destroy electronic components. All work on electronic assemblies should be performed at a static-safe work station. Refer to "Electrostatic Discharge Information" in Chapter 1 for more information on preventing ESD.

Serial-Number Information

Whenever you contact Hewlett-Packard about your lightwave switch, have the complete serial number and option designation available. This will ensure you obtain accurate service information. The serial number can be found on the rear panel of the instrument.

Required service tools

To replace extra fiber/connector the following tools are required:

Torx driver ..... #20
Torx driver ..... #20
Suhner connector removal tool 74Z-0-0-225

Refer to Figure 6-1 when performing the following procedures.

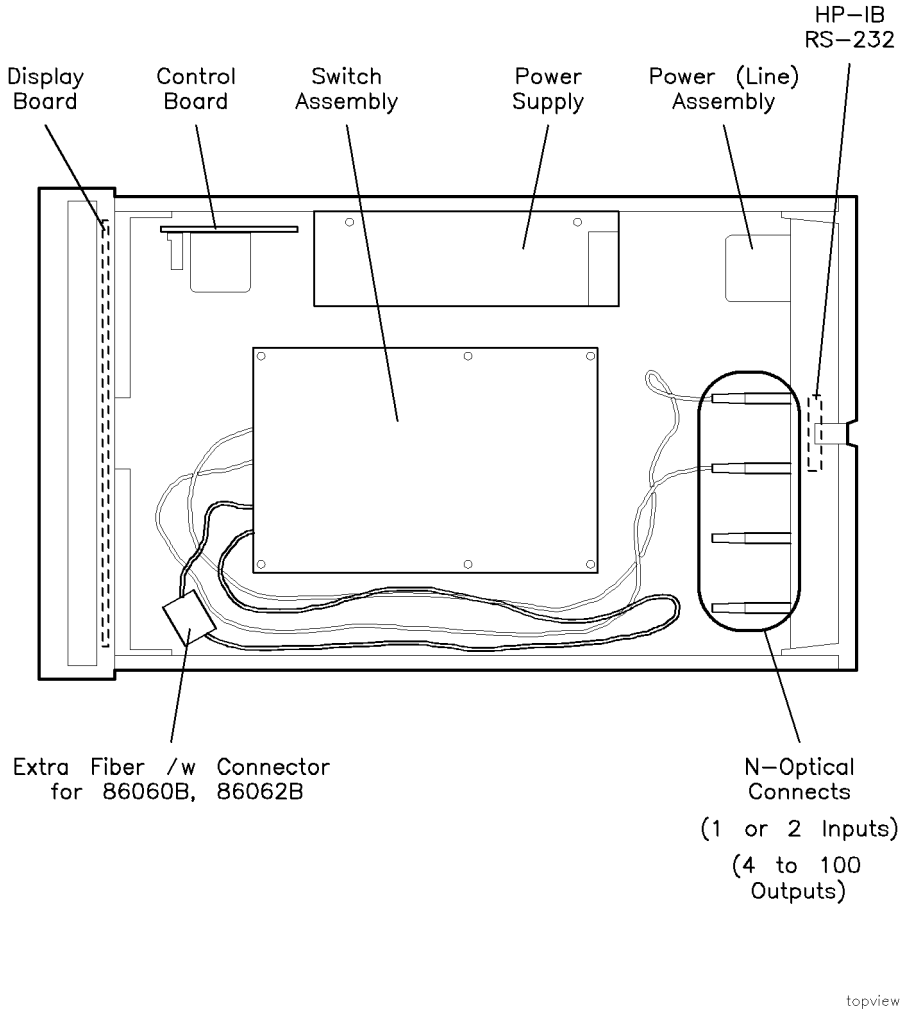

Figure 6-1. Top view of the HP 86060B lightwave switch.

Replacing the cable/connector

1. Remove the right side cover using a #20 torx driver.
2. Remove the right side cover using a #15 torx driver.
3. Take out the spare cable/connector. The spare cable/connector is under the front of the switch assembly, in a gray plastic holder.
4. Replace the defective port cable/connector assembly with the spare assembly.

Configuring the switch to use the spare connector

1. Press (Help), then press the model number of the instrument (8606x).

   The service menu will appear on the screen and you will be prompted for the actual switch layer in which you are going the change the spare fiber. (Existing switches have only one layer.)

2. Press (1), and then (Enter).

   The display will prompt you for the actual channel number of the spare fiber. This will be labeled with the number of the fiber.

3. The display will prompt you to enter the channel to be replaced.

   Enter the number of the channel and press (Enter).

   The display will show the intended cable changes.

4. Press (Enter) to confirm the changes.

NOTE

When the spare fibers have replaced bad port fibers, the unit should be sent to an HP Service Center to have new port fiber/connectors spliced into the instrument.

A

Switching Time

Switching Time

Switching time, the time required to move from one channel to another, is dependent on the number of switch channels traversed and the spacing of those channels. In addition, the optics module has a 250 ms fixed time to minimize bounce and maximize repeatability. Therefore, the amount of time required to move from one channel to another is:

{*(number of channels moved) (time between adjacent channels)*} + *250 ms*

The parameters of the HP 86060B-series lightwave switches vary according to the total number of fiber channels. As a result, the switching speed, (the time required to move between adjacent channels), is dependent on the number of fiber channels. Switches are grouped into four classes depending on the number of channels the switch is able to accommodate. The distinction lies in the fact that the switch's total number of channels effects the physical spacing between adjacent channels. This in turn, effects manufacturing techniques, the duration of the switching cycle, and the interaction between the controller board and the stepping motor.

Switch Class	Number of Channels	Motor Steps/Channel	Time between Channels
I	1-8	16	40.0 ms
II	9-16	8	20.0 ms
III	17-24	6	15.0 ms
IV	25-40	4	10.0 ms
V	41 & over	3	7.5 ms

Switching time is additive for non-adjacent channels. Therefore, to switch from channel 1 to channel 8 on an eight channel switch would require :

{*(7 channels) (40 msec/channel)*} + *250 msec* = *430 msec*

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