SOP Analyzer User's Manual

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[MA-SA2-0206-00]

Contents

SOP ANALYZER USER'S MANUAL

SOP

Analyzer

1. General Information

1.1 Warning

- Dangerous voltages, capable of causing injury or death, are present in this instrument. Use extreme caution whenever the instrument covers are removed. Do not remove the covers while the unit is plugged into a live outlet.
- To avoid electric shock, the power cord protective ground conductor must be connected to ground.
- No user serviceable parts exist in this instrument. Refer all services to qualified personnel.

1.2 Caution

This instrument may be damaged if operated with the line voltage selector set for the wrong AC line voltage or if the wrong fuse is installed. Before using the instrument, be sure to read through the operation manual to ensure proper operating procedures.

1.3 Line Voltage Selection

This instrument can operate from any single-phase AC power source that supplies 100 V / 120 V / 220 V / 240 V ± 10% at a frequency of 50 ~ 60 Hz. Before connecting the power cord to a power source, check if the line voltage selector located in the rear panel is set correctly (for 230 V operation, use the 220 V setting). Conversion to other AC input voltage requires adjusting the line voltage selector.

Line fuse

The fuse used by this instrument is T2AL/250VAC.

Line cord

This instrument has a detachable, three-wire power cord for connection to the power source and to a protective ground. The exposed metal chassis of the instrument is connected to ground via the power line cord to protect against electrical shock. Always use a socket outlet that has a properly connected protective ground.

1.4 Service

Do not attempt to service or adjust this instrument unless an authorized person is present. Do not install substitute parts or perform any unauthorized modifications to this instrument. Contact **FIBERPRO** or your local distributor for service support.

1.5 Accessories

AC power cord
SA2000 operating program CD
N type (wide) keyway adaptor
User's Manual

1.6 Specifications

Wavelength Range	1250 ~ 1400 nm, 1450 ~ 1640 nm [1), 2)]
Input Power Range	-50 dBm ~ 10 dBm
Measurement Speed	12 Hz [3)], 24 Hz [4)]
Poincare Sphere Display Accuracy	±0.6° [5)]
Accuracy of Inclination Angle	±0.2° [6)]
Accuracy of Degree of Polarization	±1% [1), 7)]
Extinction Ratio Range	0 dB ~ 50 dB
Accuracy of Optical Power Measurement	0.2 dB [8)]
Optical Input	FC and free space Ø < 3 mm
Analog Output	3 analog ports, 5 user selectable modes [9)] Mode 1 : S1, S2, S3 Mode 2 : LPER, PERref, ANGLE Mode 3 : LPER, Power, ANGLE Mode 4 : PERref, Power, ANGLE Mode 5 : DOP, ANGLE, S3
AC Power Input	100 V ~ 125 V, 210 V ~ 250 V, 50 Hz / 60 Hz
Dimensions	86 (H) × 212 (W) × 420 (D) mm
Operating Temperature	10℃ ~ 40℃
Storage Temperature	-10℃ ~ 60℃
Interface	RS232 / GPIB

1) This range is for fixed wavelength operation mode (calibrated mode).

2) For variable wavelength operation mode, this range is reduced to 1260 ~ 1340 nm, 1520 ~ 1620 nm.

3) The optical specifications of this table are based on the average number of 2 corresponding 12 Hz.

4) At the condition of a single average, the measurement speed is 24 Hz.

5) For DOP > 90%

6) At linear polarization

7) For variable wavelength operation mode, this accuracy is limited to the polarization state with ellipticity angle within -35˚ ~ 35˚, and DOP > 90%.

8) At power calibrated wavelength 1.3 um and 1.55 um.

9) S1, S2, S3 are normalized Stokes parameters. LPER is polarization extinction ratio to linear polarization and PERref is polarization extinction ratio to particular linear reference polarization. ANGLE is the inclination angle of polarization ellipse.

2. Introduction of SA2000

2.1 Introduction

FIBERPRO's SOP Analyzer, SA2000, provides polarization analysis including the State Of Polarization (SOP), Degree Of Polarization (DOP), Polarization Extinction Ratio (PERref, LPER)[1)], and inclination angle of polarization ellipse of input light. Refer to **2.3 What you can measure with SA2000** for a detailed explanation of each parameter.
SA2000 has various applications in Polarization Mode Dispersion (PMD) measurement and polarization maintaining device characterization and fabrication. Some PMD measurement methods, for example, Jones matrix eigenanalysis method, scanning principal state of polarization method and 3 Stokes parameter wavelength scanning method according to ITU-T G.650 require exact SOP measurement. SA2000 can discriminate the SOP with Poincare Sphere display accuracy of 0.6˚.
SA2000 measures Polarization Extinction Ratio (PER) with dynamic range of 0 ~ 50 dB. The PER is the essential characteristic of Polarization Maintaining Fiber (PMF), PM patch cord, and PM devices. There are many optical devices that are pigtailed to PMF, such as, laser diode, polarizer, polarization beam splitter, modulator, etc. SOP and PER measurements are effective methods in aligning polarization axis of such devices.

NOTE

1) SA2000 application program, supplied with SA2000, has another Polarization Extinction Ratio (PER) measurement function. In this program, PER is measured from the diameter of circular trace of state of polarization on Poincare Sphere which is generated from perturbing polarization maintaining fiber through stretching, heating or cooling the fiber.

2.2 Measurement Principle of SA2000

SA2000 uses a unique technique, a rotating wave plate and a rotating polarizer method for SOP analysis. In this technique, the SOP measurement is intrinsically independent of optical wavelength. Thus, SA2000 measures SOP exactly over a wide wavelength range without wavelength calibration.

The optical light incident into SA2000 passes through a wave plate rotating in clockwise direction and a polarizer rotating in counterclockwise direction and is then detected by photo diode. (Fig. 1) Wave plate and polarizer rotate with the same speed in opposite directions of each other. From the Fourier transform of the signal monitored by photo diode detector during one complete rotation data, 4 Stokes parameters are acquired.

Detailed relationship between Fourier transform components and 4 Stokes parameters is given by the following proportional equations.

[Eq. 2.1]

$$F_0 \propto s_0$$
$$F_2 \propto (s_1 + is_2)\cos^2\alpha$$
$$F_4 \propto -is_3 \sin(2\alpha)$$
$$F_6 \propto (s_1 - is_2)\sin^2\alpha$$

In (Eq. 2.1), 2α is the differential phase retardation of wave plate and F_0, F_2, F_4 and F_6 are amplitude of 0, 2ω, 4ω, 6ω harmonics of signal detected by the photodiode, respectively where ω is angular velocity of rotating wave plate. From the above relationship and measured F's, 4 Stokes parameters s_0, s_1, s_2, s_3 and 2α are simultaneously determined by the following relationships.

[Eq. 2.2]

$$\tan^2\alpha = |F_6/F_2|$$

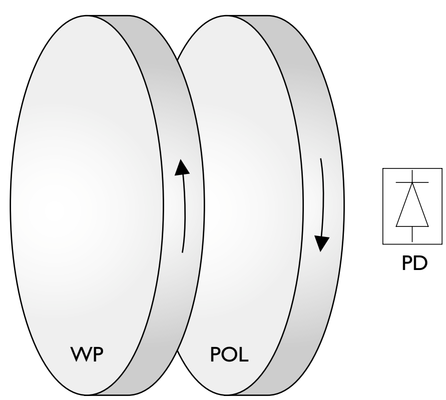
[Eq. 2.3]

$$s_0 \propto F_0$$
$$s_1 \propto \mathrm{real}(F_2 + F_6)$$
$$s_2 \propto \mathrm{imag}(F_2 - F_6)$$
$$s_3 \propto iF_4/\sin(2\alpha)$$

One of the key features of SA2000, is the ability to measure state of polarization independent of operating wavelength as shown in (Eq. 2.2) and (Eq. 2.3), even though the differential phase retardation of wave plate 2α depends on wavelength. However, there are some drawbacks in the above method. 2α calculated according to (Eq. 2.2) shows uncertainty as s_1 and s_2 approach zero simultaneously, that is, circularly polarized light and 2α is the most accurate value when the light is linearly polarized. This is the reason why the specification of accuracy of degree of polarization in variable wavelength operation mode is limited to the polarization state with ellipticity angle within -35˚ ~ 35˚.

To overcome this drawback, SA2000 provide another measurement mode, fixed wavelength operation mode (fixed λ mode). In fixed λ mode, SA2000 assumes that the wavelength of optical light does not change and so the phase retardation 2α, and, keeps the value of 2α calculated at the moment when fixed λ mode is initiated and applies this value throughout the whole measurement during fixed λ mode operation without new calculation of 2α.

If the user does not need to change the wavelength of optical source for a long time, **FIBERPRO** recommends using fixed λ mode. The merit of fixed λ mode is the stability of DOP and s_3 near north and south pole of Poincare Sphere, that is, circular polarization states. It is important to initiate fixed λ mode when the state of polarization is near linear polarization state to get an exact 2α value.



[Fig. 1] Optical Structure of SA2000. WP: wave plate, POL: polarizer, PD: photodiode

2.3 What You can Measure with SA2000

2.3.0 Reference Linear Polarization

For the representation of state of polarization, we need to choose one particular linear polarization as a reference polarization, that is, $(1,0,0)^T$ polarization in Stoke vector representation or $(1,0)^T$ in Jones vector representation. In this manual, this polarization state will be called **reference linear polarization** or **x polarization**. The following measurement parameters, normalized Stokes parameter (S_1, S_2, S_3), polarization extinction ratio to reference polarization (**PERref**), and inclination angle of polarization ellipse (**ANGLE**) depend on the selection of reference linear polarization.
The SA2000 has factory-set reference linear polarization direction which is nearly parallel to the keyway direction of the optical adaptor. Also, any user can set a particular linear polarization as his own reference polarization. Refer to **3.3.5 To set the user reference angle** to see how to set user reference polarization and **3.3.6 To change the reference mode** to see how to change reference polarization from factory reference to user reference and vice versa.

2.3.1 Normalized Stokes Parameter (S_1, S_2, S_3)

The Stokes Parameters are defined as:

$$s_0 = \text{total power} = p_{polarized} + p_{unpolarized}$$
$$s_1 = \hat{x}\ \text{polarized power} - \hat{y}\ \text{polarized power}$$
$$s_2 = (+45^\circ\ \text{polarized power}) - (-45^\circ\ \text{polarized power})$$
$$s_3 = \text{right circular polarized power} - \text{left circular polarized power}$$

Here, x̂ and ŷ represent two orthogonal linear polarization direction and x̂ corresponds to reference linear polarization direction.
Normailzed Stokes Parameters (S_1, S_2, S_3) are Stokes parameters divided by s_0.

$$S_1 = \frac{s_1}{s_0} \qquad S_2 = \frac{s_2}{s_0} \qquad S_3 = \frac{s_3}{s_0}$$

2.3.2 Degree Of Polarization (DOP)

Degree Of Polarization (DOP) is the ratio of polarized optical power to total optical power.

$$DOP = \frac{p_{pol}}{p_{pol} + p_{unpol}} = \sqrt{S_1^2 + S_2^2 + S_3^2}$$

2.3.3 Linear Polarization Extinction Ratio (LPER)

LPER explains how much the state of polarization is close to linear polarization state regardless of the orientation of the major axis. Refer to Fig. 2 and Fig. 3 for the definition of the parameters in the following equation.

$$LPER = 10 \times \log \frac{E_\xi^2}{E_\eta^2} = 10 \times \log \frac{1}{\tan^2 \o}$$

2.3.4 Polarization Extinction Ratio to Reference Polarization (PERref)

PERref explains how much the state of polarization is close to a particular linear reference polarization state. Refer to Fig. 2 and Fig. 3 for the definition of the parameters in the following equation.

$$PERref = 10 \times \log \frac{E_y^2}{E_x^2} = 10 \times \log \frac{1}{\tan^2 \psi}$$

NOTE

PERref is a useful value when evaluating PM fiber patch cord if the reference polarization direction is parallel to the direction of the keyway of adaptor.

2.3.5 Inclination Angle of Polarization Ellipse (ANGLE)

ANGLE is the angle between the major axis of polarization ellipse and the linear reference polarization direction. **ANGLE** is measured in a clockwise direction from a reference polarization direction when viewed from light propagation direction.

ANGLE = θ

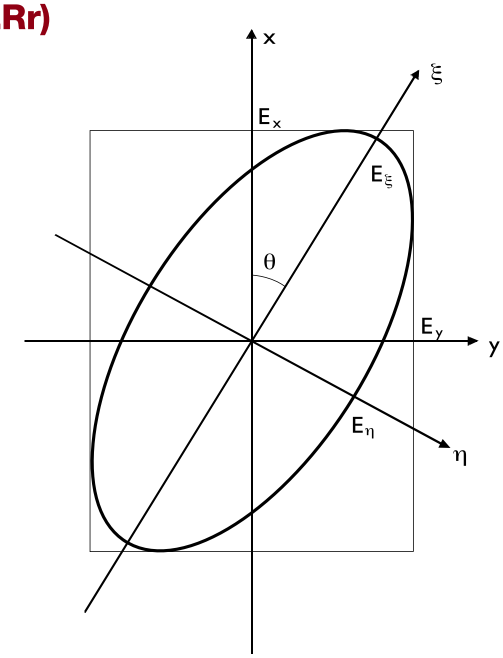
Refer to Fig. 2 and Fig. 3 for the definition θ.

2.3.6 Minimum Linear Polarization Extinction Ratio (minLPER)

minLPER is the minimum value of Linear Polarization Extinction Ratio (**LPER**) from the time when MinMax key is pressed.

2.3.7 Minimum Extinction Ratio to Reference Polarization (minPERr)

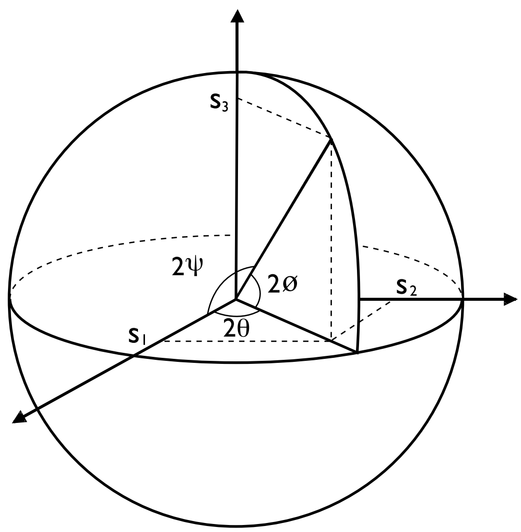
minPERr is the minimum value of Extinction Ratio to Reference Polarization (**PERref**) from the time when MinMax key is pressed.



[Fig. 2] Elliptically Polarized Light

2.3.8 Minimum and Maximum Angle of Major Axis (minAng & maxAng)

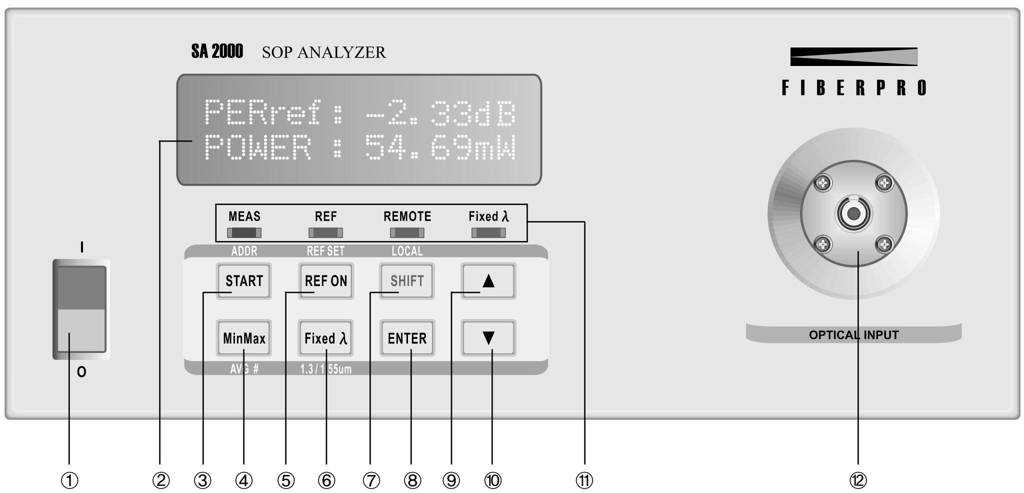
minAng and **maxAng** are minimum and maximum values of the inclination angle of polarization ellipse (**ANGLE**) from the time when MinMax key is pressed.



[Fig. 3] Poincare Sphere Representation of State of Polarization.

3. SA2000 Operation

3.1 Front Panel at a Glance



[Fig. 4] Front Panel of SA2000

① **Power Switch** - When this switch is turned on, the instrument is initialized and waits for a measurement to be started.

② **Front panel display** - Measurement result is displayed or appropriate information of the instrument is displayed in each setting menu.

③ **START(ADDR) key** - Measurement is started. When this key is pressed again, the measurement is stopped. If this key is pressed together with the [SHIFT] key, the instrument enters GPIB address setting menu.

④ **MinMax (AVG #) key** - The stored minimum and maximum readings of LPER, PERref and ANGLE are cleared and the min-max operation is restarted. If this key is pressed together with the [SHIFT] key, the instrument enters the average number setting menu.

⑤ **REF ON (REF SET) key** - The reference mode toggles between user and factory reference mode whenever this key is pressed. If this key is pressed together with the [SHIFT] key, the instrument enters the user reference angle setting menu.

⑥ **Fixed λ (1.3/1.55 um) key** - The wavelength operation mode toggles between fixed λ and non-fixed λ mode whenever this key is pressed. If this key is pressed together with the [SHIFT] key, the instrument enters the 1.3/1.55 um range setting menu.

⑦ **SHIFT (LOCAL) key** - When the instrument is under local control, pressing this key enables secondary function printed in blue above or below each key. If the instrument is under remote control, the instrument is placed under local control.

⑧ **ENTER key** - The instrument saves the setting value and exits the setting menu.

⑨ [▲] key - The setting value increases or the measurement display is changed.

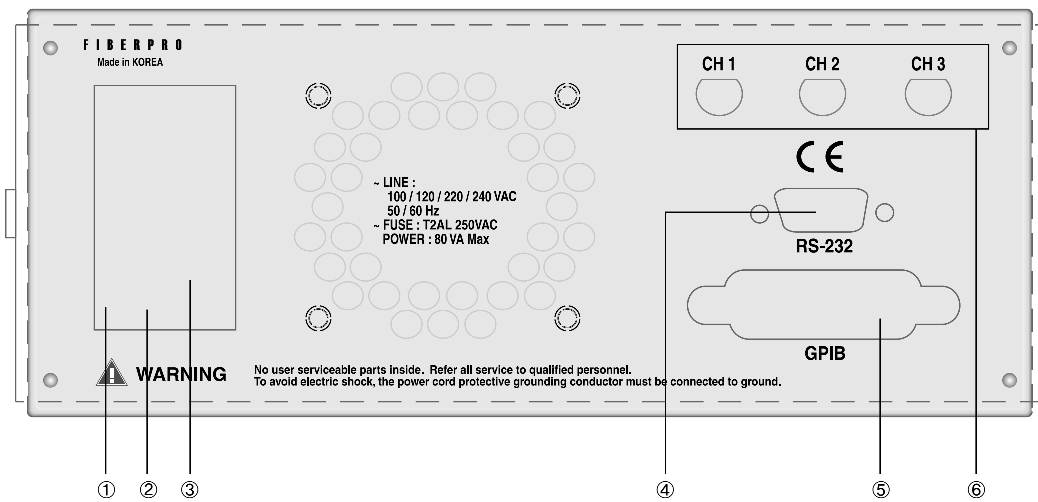
⑩ [▼] key - The setting value decreases or the measurement display is changed.

⑪ **Indicators** - Each indicator is lit on when the instrument is under the following states.

[MEAS]	indicator - Measurement is started.
[Ref]	indicator - The reference mode is the user reference mode.
[RMT]	indicator - The instrument is controlled by the remote interface.
[Fixed λ]	indicator - The wavelength operation mode is in fixed λ mode.

⑫ **Optical input**

3.2 Rear Panel at a Glance



[Fig. 5] Rear Panel of SA2000

① **Power entry module** - The power entry module for the AC line voltage input. It blocks high frequency noise entering the instrument. Before you plug the power cord into a socket outlet, check the voltage selector switch to determine if it is in the correct position.

② **Voltage selector switch** - This switch is used to select an input AC voltage. Set at 115 V for operations between 100 and 125 VAC. Set at 230 V for operations between 210 and 250 VAC.

③ **Fuse holder**

④ **RS-232 connector** - RS-232 interface is provided.

⑤ **GPIB connector** - GPIB interface is provided.

⑥ **BNC connectors** - The instrument outputs analog voltage that is proportional to one of the measurement results.

CAUTION

To minimize the electromagnetic interference (EMI), make sure that your cable for remote control (RS-232 or GPIB) is a shielded cable. Using not-shielded cable may increase the interference by electromagnetic radiation noise.

3.3 How to Use SOP Analyzer

3.3.0 Before the Start

The [SHIFT] key annunciator

When the [SHIFT] key is pressed, its annunciator '▲' is turned on at the most upper right side of the measurement display window. If it is pressed again, its annunciator is turned off. The example is as follows.

```
LPER :        dB
ANGLE:        Deg
```

→

```
LPER :        d▲
ANGLE:        Deg
```

The [Shift] key has been pressed.

When input power is too high or too low

When input optical power is too high or too low to make an accurate measurement, the instrument displays no numeric value but '++.+++' or '--.---' as a measurement result. The '++.+++' indicates that input power is too high and the '--.---' indicates that input power is too low. The example is as follows.

```
LPER : ++.+++ dB
ANGLE: ++.+++ Deg
```

Input power is too high.

```
LPER : --.--- dB
ANGLE: --.--- Deg
```

Input power is too low.

If `STOKES?` or `EXRATIO?` query command is executed in the remote operation when the input power is too high or too low, the instrument generates the device dependent error and saves it to the error queue. Refer to **4.4 Error codes** for more specific descriptions. The return messages are all zero except for the optical power value. The returned optical power is 10mW when the input power is too high and 1nW when the input power is too low.

3.3.1 To Power on the Instrument

Front panel operation

① Check whether the voltage selector switch is selected correctly for input AC line voltage.

② Connect the power cord to the power entry module at the rear of the instrument and the other end to a suitable AC line power receptacle.

③ Press the [POWER] switch, the following power-on messages should be displayed:.

```
FIBERPRO SA2000
 SOP Analyzer
```

➡

```
FIBERPRO SA2000
GPIB ADDRESS 10
```

④ After four indicators are turned on and off successively, the measurement display window is turned on. Notice that the instrument enters the latest measurement display window automatically.

```
LPER :        dB
ANGLE:        Deg
```

3.3.2 To Start or Stop a Measurement

Front panel operation

① Press the [START] key. A measurement is started and the [MEAS] indicator is turned on. If the instrument is working on a measurement, a measurement is stopped and the [MEAS] indicator is turned off.

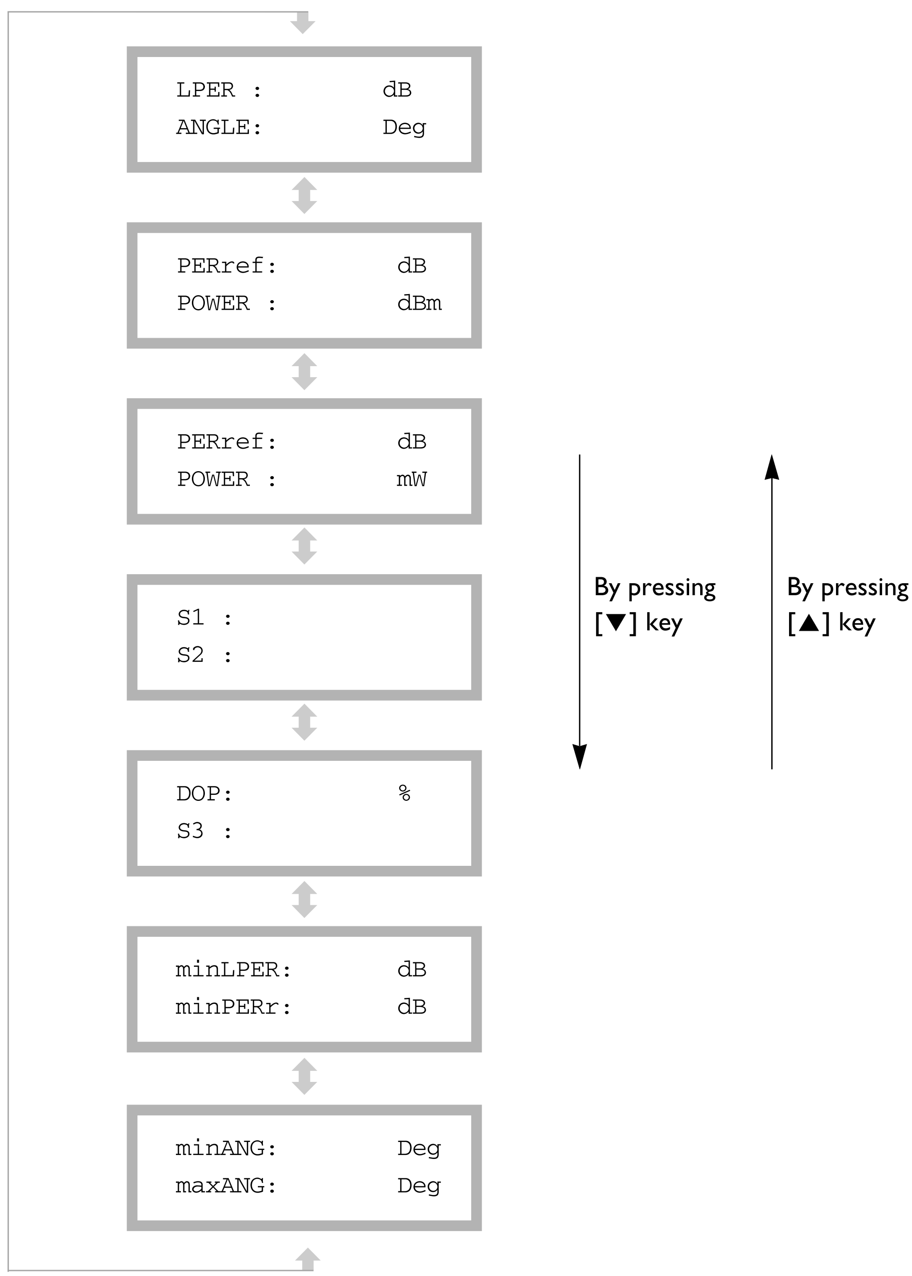
Remote operation

① Execute the `MEAS` command whose parameter is `0` or `1`. `1` is for a measurement start and `0` is for a measurement stop.

3.3.3 To Change the Measurement Display

Front panel operation

① Press the [▲] key or [▼] key until the desired measurement display appears. The sequence of the measurement display is as follows.



3.3.4 To Restart the Min-max Operation

Front panel operation

① Press the [MinMax] key. After the following message is displayed, the stored minimum and maximum readings are cleared and the min-max operation is restarted.

```
MINMAX
RESTARTED
```

② After about 0.5 seconds, the instrument returns to the measurement display window.

③ The stored minimum and maximum readings are minimum LPER, minimum PERref, minimum and maximum of inclination angle of polarization ellipse. You can see them in the following measurement display window by pressing the [▲] key or [▼] key. Refer to **3.3.3 To change the measurement display**.

minLPER:	dB	Minimum LPER
minPERr:	dB	Minimum PERref

minANG:	Deg	Minimum inclination angle
maxANG:	Deg	Maximum inclination angle

Remote operation

① Execute the `MINMAX` command to restart the min-max operation.

② To get the stored minimum and maximum readings, execute the `MINMAX?` query command.

3.3.5 To Set the User Reference Angle

Front panel operation

① Press the [SHIFT] key and the [REF ON] key. The instrument enters the reference angle setting menu and the current inclination angle of polarization ellipse is displayed as follows. Notice that the displayed inclination angle is relative to the factory-set reference angle.

```
REFERENCE SET
ANGLE: 10.9 Deg
```

② Press the [▲] key or [▼] key to increase or decrease the blinking digit. If a displayed angle is a desired value, press the [ENTER] key to save the setting value and exit this menu. The reference mode is changed to the user reference mode automatically and the [Ref] indicator is on.

```
REFERENCE SET
wait...
```

③ If you press any other key except the [ENTER] key in the menu, the instrument exits this menu without saving the setting value.

Remote operation

① Execute the `SREF` command whose parameter is the user reference angle in degree unit. If there is not any parameter after the command header, the current inclination angle of the polarization ellipse is set as the user reference angle. The reference mode is changed to the user reference mode automatically after executing this command.

Refer to **2.3.0 Reference linear polarization** for the specific definition of the reference angle.

3.3.6 To Change the Reference Mode

Front panel operation

① Press the [REF ON] key to change the reference mode to another mode, user or factory reference mode. If the reference mode is the user reference mode, the [REF] indicator is turned on.

Remote operation

① Execute the `REF` command whose parameter is `0` or `1`. `0` is for changing the reference mode to the user reference mode and `1` is for changing the reference mode to the factory reference mode.

3.3.7 To Set the Average Number

Front panel operation

① Press the [SHIFT] key and the [MINMAX] key. Then the instrument enters the average number setting menu and the current average number is displayed as follows.

```
AVG NUMBER SET
ANUM: 16
```

② Press the [▲] key or [▼] key to increase or decrease the blinking digit. If a displayed number is a desired value, press the [ENTER] key to save the setting value and exit this menu.

```
AVG NUMBER SET
wait...
```

③ If you press any other key except the [ENTER] key in the menu, the instrument exits this menu without saving the setting value.

Remote operation

① Execute the `ANUM` command whose parameter is the average number. The possible parameter value is 1, 2, 4, 8, 16 or 32.

3.3.8 To Change the Wavelength Operation Mode (fixed λ or non-fixed λ mode)

Front panel operation

① Press the [Fixed λ] key to change the current wavelength operation mode to another mode, fixed λ or non-fixed λ mode. If the wavelength operation mode is changed into fixed λ mode, the wave plate's phase retardation is fixed at the value at the moment of pressing the [Fixed λ] key and the [Fixed λ] indicator is turned on.

Remote operation

① Execute the `FIXED` command whose parameter is `0` or `1`. `0` is for setting the wavelength operation mode to the non-fixed λ and `1` is for setting it to the fixed λ mode. If the wavelength operation mode is changed into fixed λ mode, the wave plate's phase retardation is fixed at the value at the moment of executing the `FIXED 1` command and the [Fixed λ] indicator is turned on.

3.3.9 To Choose between 1.3 um and 1.55 um Range

Front panel operation

① Press the [SHIFT] key and the [Fixed λ] key. Then the instrument enters the wavelength range setting menu and the current wavelength range is displayed as follows.

```
WAVELENGTH SET
  WVL: 1550
```

② Press the [▲] key or [▼] key to toggle between 1300 nm range and 1550 nm range. If a displayed range is a desired value, press the [ENTER] key to save the setting value and exit this menu.

```
WAVELENGTH SET
   wait...
```

③ If you press any other key except the [ENTER] key in the menu, the instrument exits this menu without saving the setting value.

Remote operation

① Execute the `WAVE` command whose parameter is `1300` or `1550`. `1300` is for 1300 nm wavelength range and `1550` is for 1550 nm wavelength range.

NOTE

1. 1.3/1.55 um wavelength range selection affects two parameters for measurement results. One is optical power that is calibrated at both wavelengths. The other is normalized Stokes parameter S3, which has opposite sign with same magnitude at each wavelength range selection. Refer to **5.2 1.3/1.55 um Selection** for more detailed explanation.
2. The wavelength operation mode (fixed λ and non-fixed λ) and 1.3/1.55 um wavelength range selection are independent of each other, that is, there aren't any relationships between them.

3.3.10 To Set the GPIB Address

Front panel operation

① Press the [SHIFT] key and the [START] key. Then the instrument enters the GPIB address setting menu and the current GPIB address is displayed as follows.

```
GPIB ADDRESS SET
ADDR: 15
```

② Press the [▲] key or [▼] key to increase or decrease the blinking digit. If displayed address is the desired value, press the [ENTER] key to save the setting value and exit this menu.

```
GPIB ADDRESS SET
wait...
```

③ If you press any other key except the [ENTER] key in the menu, the instrument exits this menu without saving the setting value.

3.3.11 To Set the Analog Voltage Output

Remote operation

① Execute the `AOUT` command whose parameter is `0,1,2,3,4` or `5`. The description of each parameter is as follows. The parameter `0` turns off the analog voltage output.

Parameter	Measurement value		Measurement value range	Output voltage range
0	None		None	All channels 0 V
1	CH1	S1	-1 ~ +1	-5 V ~ +5 V
	CH2	S2	-1 ~ +1	-5 V ~ +5 V
	CH3	S3	-1 ~ +1	-5 V ~ +5 V
2	CH1	LPER	0 dB ~ +60 dB	0 V ~ +6 V
	CH2	ANGLE	-90 Deg ~ 90 Deg	-9 V ~ +9 V
	CH3	PERref	-60 dB ~ +60 dB	-6 V ~ +6 V
3	CH1	LPER	0 dB ~ +60 dB	0 V ~ +6 V
	CH2	ANGLE	-90 Deg ~ 90 Deg	-9 V ~ +9 V
	CH3	POWER	-50 dBm ~ +10 dBm	-5 V ~ +1 V
4	CH1	PERref	-60 dB ~ +60 dB	-6 V ~ +6 V
	CH2	ANGLE	-90 Deg ~ 90 Deg	-9 V ~ +9 V
	CH3	POWER	-50 dBm ~ +10 dBm	-5 V ~ +1 V
5	CH1	DOP	0% ~ 100%	0 V ~ +5 V
	CH2	ANGLE	-90 Deg ~ 90 Deg	-9 V ~ +9 V
	CH3	S3	-1 ~ +1	-5 V ~ +5 V

3.3.12 To Return the Instrument to Local Control from Remote Control

Front panel operation

① Press the [SHIFT] key. Then the instrument becomes under local control and the [RMT] indicator is turned off.

NOTE

The following values and states of the instrument are saved in a nonvolatile memory and are not deleted when power has been off or after *RST command is executed.
: the GPIB address, the average number, the 1.3 um/1.55 um range selection, the reference mode, the user reference angle, the current measurement function, the wavelength operation mode (fixed λ or non-fixed λ), the fixed wave plate's phase retardation. (if the instrument was powered off in fixed λ mode.)

3.4 Remote Interface

3.4.1 Control via RS-232

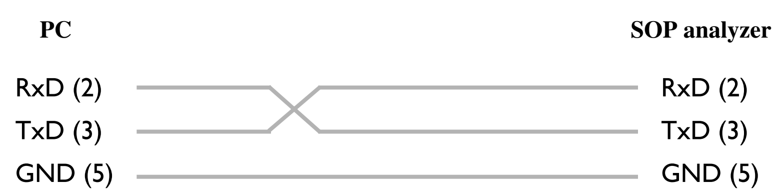
RS-232 was originally designed as the interface between DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) by serial binary data interchange. Since most personal computers are now equipped with RS-232, you can easily interface the SOP Analyzer with a personal computer for remote control.

Configuration for RS-232 interface

Baud rate : 57,600
Data bits : 8 bit
Parity : None
Stop bits : 1 bit
Message terminator : Carriage Return (CR)

Connection to a computer

The SOP Analyzer can be programmed with a personal computer over RS-232 using a minimum three-wire interface. With a three-wire interface, the software controls the data flow between the SOP Analyzer and a personal computer. This provides a much simpler connection between devices because you can ignore hardware handshake requirements. RS-232 wiring from a personal computer's serial port into the SOP Analyzer serial interface device is as follows.



RS-232 Commands

The commands set for RS-232 interface is almost the same as for GPIB interface except the `RMT` and `LOC` command. When you use RS-232 interface, it is necessary to send the RMT command first to place the SOP Analyzer under remote control.

3.4.2 Control via GPIB

Interface capabilities

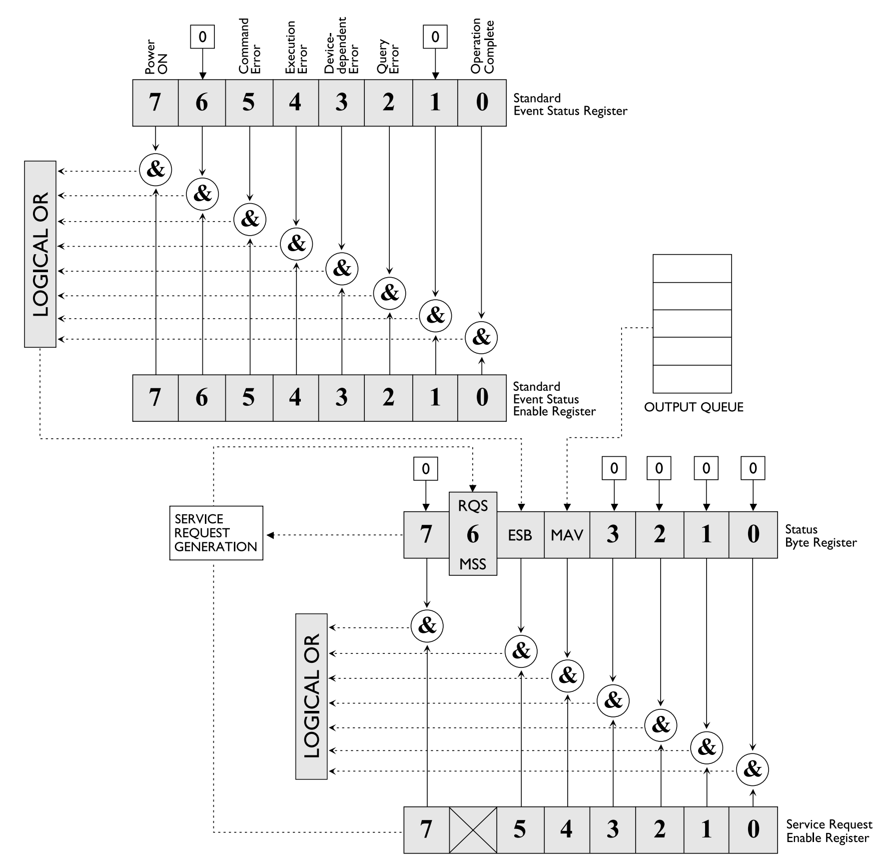
① The interface capabilities that the PS implements, as defined by IEEE 488.1, are SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, C0.

② The PS implements all necessary common commands and the status reporting structure defined by IEEE 488.2. A summary of the common commands is as follows.

Command	Query	Function
*ESE	*ESE?	standard Event Status Enable command/query
	*ESR?	standard Event Status Register query
*SRE	*SRE?	Service Request Enable command/query
	*STB?	STatus Byte register query
*CLS		CLear Status command
*RST		ReSeT command
	*IDN?	instrument's IDeNtification query
*OPC	*OPC?	OPeration Complete command/query
*WAI		WAIt command
	*TST?	self TeST query

Status reporting structure

The status reporting structure of the SOP Analyzer is shown below.



Standard event status enable register & Standard event status register

The Standard Event Status Register (SESR) monitors the status events of the SOP Analyzer. When one of these events occurs, the event sets the corresponding bit in the register. You can read the contents of this register by executing the `*ESR?` query. The returned value is the total bit weights of all of the bits. SESR is cleared 1) at power-on, 2) by `*CLS` command or 3) after being read.

The Standard Event Status Enable Register (SESER) allows one or more events in the SESR to generate a summary bit. The summary bit will set the ESB bit (the bit 5) in the Status Byte Register (SBR). To generate a summary bit, you should enable the corresponding bit in the SESER by executing the `*ESE` command. SESER is cleared at power-on.

The status event of the SOP Analyzer, that each bit of the SESR and SESER represents, is as follows.

		Standard Event Status Enable Register	**Standard Event Status Register**
Bit	**Weight**	**Enables**	**Condition**
7	128	PON (Power ON)	Power off-on transition has occurred
6	64	URQ (User Request)	Not-Used (always 0)
5	32	CME (Command Error)	Command errors are detected
4	16	EXE (Execution Error)	Execution errors are detected
3	8	DDE (DeviceDependent Error)	Device dependent errors are detected
2	4	QYE (Query Error)	Query errors are detected
1	2	TRG (Request Control)	Not-Used (always 0)
0	1	OPC (Operation Complete)	The PS has completed all selected pending operations

Status byte register & Service request enable register

The Status Byte Register (SBR) is the summary-level register in the status reporting structure of the SOP Analyzer. The SBR contains summary bits that monitor activity in the SESER and output message queue. You can read the contents of the SBR by executing the `*STB?` query or serial poll. SBR is cleared 1) at power-on or 2) by `*CLS` command.

The Service Request Enable Register (SRER) enables one or more summary bits in the SBR to generate a service request to the controller. To generate a service request, you should enable the corresponding bit in the SRER by executing the `*SRE` command. The SRER is cleared at power-on.

When the enabled summary bit in the SBR is set, the MSS bit and the RQS bit in the SRER is set and service request is generated to the controller. Descriptions of each bit in the SRER and the SBR are as follows.

		Service Request Enable Register	Status Byte Register
Bit	**Weight**	**Enables**	**Condition**
7	128	User Definable (Not-Used)	Not-Used (always 0)
6	64	RQS (Request Service) MSS (Master Summary Status)	The PS is requesting services
5	32	ESB (Event Status)	An enabled event in the Standard Event Status Register is set TRUE.
4	16	MAV (Massage Available)	Output queue is not empty.
3	8	User Definable	Not-Used (always 0)
2	4	User Definable	Not-Used (always 0)
1	2	User Definable	Not-Used (always 0)
0	1	User Definable	Not-Used (always 0)

Service request and Serial poll

When the RQS bit in the SRER is set, the SOP Analyzer asserts the SRQ line. Then the controller polls each addressed listener to send back a status byte of the SBR that indicates whether it has asserted the SRQ line and needs servicing (Serial Poll). After the controller reads the Status Byte through serial poll, the RQS bit is cleared automatically. To use this capability appropriately, you should configure your controller to respond to the service request.

4. Command Set

4.1 Operation - Related Commands

4.1.1 Measurement - Related Commands

MEAS

- Description ; Start or stop the measurement.
- Syntax ; MEAS {0|1}
- Parameter ; 0 for the measurement stop
  1 for the measurement start
- Example ; `MEAS 1`

MEAS?

- Description ; Query the current measurement state.
  The returned message is 0 or 1 in NR1 format.
- Syntax ; MEAS?
- Response ; 0 *or* 1
- Example ; `MEAS? → 1`

STOKES?

- Description ; Query the Stokes vector and DOP.
  The response message is in NR3 format.
- Syntax ; STOKES?
- Response ; *<POWER in mW>, <S1>, <S2>, <S3>, <DOP in %>*
- Example ; `STOKES? → 1.23e-6,1.21e-1,6.00e-2,3.34e-1,9.53e+1`

EXRATIO?

- Description ; Query the extinction ratio and major axis angle.
  The response message is in NR3 format.
- Syntax ; EXRATIO?
- Response ; *<LPER in dB>, <ANGLE in Deg>, <PERref in dB>*
- Example ; `EXRATIO? → 3.35e+1,4.56e+1,4.34e+1`

MINMAX

- Description ; Clear the stored minimum and maximum readings and restart the min-max operation.
- Syntax ; MINMAX
- Parameter ; *None*
- Example ; `MINMAX`

MINMAX?

- Description ; Query the current minimum and maximum readings. The response message is in NR3 format.
- Syntax ; MINMAX?
- Response ; *<minLPER in dB>, <minPERref in dB>, <minANGLE in Deg>, <maxANGLE in Deg>*
- Example ; `MINMAX?` → `1.35e+1,1.56e+1,8.34e+1,-4.56e+1`

4.1.2 Measurement Configuration - Related Commands

SREF

- Description ; Set the user reference angle. The reference mode is changed to the user reference mode automatically after executing this command.
- Syntax ; SREF [*angle*]
- Parameter ; [*angle*] the user reference angle in degrees. If there is not any parameter after command header, the current major axis angle is set as the user reference angle.
- Example ; `SREF 34.5` *or* `SREF`

SREF?

- Description ; Query the current user reference angle. The returned message is in NR2 format.
- Syntax ; SREF?
- Response ; *<angle in Deg>*
- Example ; `SREF?` → `+43.45`

REF

- Description ; Change the reference mode.
- Syntax ; REF {0|1}
- Parameter ; 0 for the factory reference mode
  1 for the user reference mode
- Example ; `REF 1`

REF?

- Description ; Query the current the reference mode.
  The returned message is 0 or 1 in NR2 format.
- Syntax ; REF?
- Response ; 0 *or* 1
- Example ; `REF?` → `1`

FIXED

- Description ; Set the wavelength operation mode.
  (fixed λ mode or non-fixed λ mode)
- Syntax ; FIXED {0|1}
- Parameter ; 0 for the non-fixed λ mode
  1 for the fixed λ mode
- Example ; `FIXED 1`

FIXED?

- Description ; Query the current wavelength operation mode.
  The returned message is 0 or 1 in NR2 format.
- Syntax ; FIXED?
- Response ; 0 *or* 1
- Example ; `FIXED?` → `1`

WAVE

- Description ; Choose between the 1.3 um or 1.55 um range.
- Syntax ; WAVE {1300|1500}
- Parameter ; 1300 for 1300 nm wavelength range
  1550 for 1550 nm wavelength range
- Example ; `WAVE 1550`

WAVE?

- Description ; Query the current wavelength range.
  The returned message is 1300 or 1550 in NR2 format.
- Syntax ; WAVE?
- Response ; 1300 *or* 1550
- Example ; `WAVE? → 1550`

ANUM

- Description ; Set the average number.
- Syntax ; ANUM {1|2|4|8|16|32}
- Parameter ; average number 1, 2, 4, 8, 16 or 32
- Example ; `ANUM 2`

ANUM?

- Description ; Query the current average number.
  The returned message is a decimal value in NR1 format.
- Syntax ; ANUM?
- Response ; 1, 2, 4, 8, 16 *or* 32
- Example ; `ANUM? → 2`

4.1.3 Analog Output - Related Commands

AOUT

- Description ; Set the analog voltage output mode.
- Syntax ; AOUT {0|1|2|3|4}
- Parameter ; analog voltage output mode number

mode	0	1	2	3	4	5
Channel 1	all off	S1	LPER	LPER	PERref	DOP
Channel 2		S2	ANGLE	ANGLE	ANGLE	ANGLE
Channel 3		S3	PERref	Power	Power	S3

The relationship between measurement value and output voltage

	Measurement value	Output voltage
S1,S2,S3	-1 ~ +1	-5.00 V ~ +5.00 V
LPER	0 ~ +60 dB	0.00 V ~ +6.00 V
PERref	-60 dB ~ +60 dB	-6.00 V ~ +6.00 V
Angle	-90 Deg ~ +90 Deg	-9.00 V ~ +9.00 V
Power	-50 dBm ~ +10 dBm	-5.00 V ~ +1.00 V
DOP	0% ~ 100%	0 V ~ +5 V

- Example ; `AOUT 1`

AOUT?

- Description ; Query the current analog voltage output mode. The returned message is a decimal value in NR1 format.
- Syntax ; AOUT?
- Response ; 1, 2, 3 *or* 4
- Example ; `AOUT? → 1`

4.1.4 System - Related Commands

ERROR?

- Description ; Query the oldest error in the error queue.
- Syntax ; ERROR?
- Response ; *<Error number>, <Error description>*
- Example ; `ERROR? → -103,"Undefined header"`

4.2 IEEE 488.2 Command Commands

***CLS**

- Description ; Clear the 1) Standard Event Status Register (SESR), 2) Status Byte Register (STB), and 3) Error Queue.
- Syntax ; *CLS
- Parameter ; *None*
- Example ; `*CLS`

***ESE**

- Description ; Set bits in the Standard Event Status Enable Register (SESER) that enable the corresponding bits in the Standard Event Status Register (SESR). The register is cleared 1) at power-on or 2) by sending a value of zero. The register is NOT changed by the *RST and *CLS commands.
- Syntax ; *ESE <*value*>
- Parameter ; The value of the integer in the range of 0 through 255.

Bit	Definition	Value
7 (MSB)	Power On	128
6	Not used	0
5	Command Error	32
4	Execution Error	16
3	Device Dependent Error	8
2	Query Error	4
1	Not used	0
0	Operation Complete	1

- Example ; `*ESE 17`

***ESE?**

- Description ; Query the contents of the Standard Event Status Enable Register. The returned message is the total bit weights of all of the bits in NR1 format.
- Syntax ; *ESE?
- Response ; Decimal value in the range of 0 through 255.
- Example ; `*ESE? → 17`

***ESR?**

- Description ; Query the contents of the Standard Event Status Register (SESR). The register is cleared after being read. The returned message is the total bit weights of all of the bits in NR1 format.
- Syntax ; *ESR?
- Response ; Decimal value in the range of 0 through 255.

Bit	Definition	Value
7 (MSB)	Power On	128
6	Not used	0
5	Command Error	32
4	Execution Error	16
3	Device Dependent Error	8
2	Query Error	4
1	Not used	0
0	Operation Complete	1

- Example ; `*ESR? → 16`

***IDN?**

- Description ; Query the instrument identification.
- Syntax ; *IDN?
- Response ; *<Manufacturer>, <Model>, 0, <Firmware version>*
- Example ; `*IDN? → FIBERPRO,PM5001,0,V1.00`

***OPC**

- Description ; Set the OPC bit in the Standard Event Status Register when all pending device operations have been completed.
- Syntax ; *OPC
- Parameter ; *none*
- Example ; `*OPC`

***OPC?**

- Description ; Place ASCII “1” in output queue when all pending device operations have been completed.
- Syntax ; *OPC?
- Response ; 1 is always returned.
- Example ; `*OPC? → 1`

***RST**

- Description ; Set the instrument to the reset setting stored internally.
- Syntax ; *RST
- Parameter ; *None*
- Example ; `*RST`

***SRE**

- Description ; Set the Service Request Enable Register bits.
- Syntax ; *SRE <*value*>
- Parameter ; Decimal value in the range of 0 through 255.

Bit	Definition	Value
7 (MSB)	Not used	0
6	RQS (request service)	64
5	ESB (SESR summary bit)	32
4	MAV (message in the output queue)	16
3	Not used	0
2	Not used	0
1	Not used	0
0	Not used	0

- Example ; `*SRE 48`

***SRE?**

- Description ; Query the contents of the Service Request Enable Register. The bit 6 of the binary representation is always sent with the value zero. The returned message is the total bit weights of all of the bits in NR1 format.
- Syntax ; *SRE?
- Response ; The bit value for the register. In the range of 0 through 63 or 128 through 191.
- Example ; `*SRE? → 48`

***STB?**

- Description ; Query the contents of the Status Byte Register. The returned message is the total bit weights of all of the bits in NR1 format.
- Syntax ; *STB?
- Response ;

Bit	Definition	Value
7 (MSB)	Not used	0
6	RQS (request service)	64
5	ESB (SESR summary bit)	32
4	MAV (message in the output queue)	16
3	Not used	0
2	Not used	0
1	Not used	0
0	Not used	0

- Example ; `*STB? → 80`

***TST?**

- Description ; Perform a self-test and place the results of the test in the output queue.
- Syntax ; *TST?
- Response ; 0 for self-test pass
  1 for self-test failure
- Example ; `*TST? → 0`

***WAI**

- Description ; Prevent the instrument from executing any further commands until the current command has finished executing. All pending operations are completed during the wait period.
- Syntax ; *WAI
- Parameter ; *None*
- Example ; `*WAI`

4.3 RS-232 Interface Commands

RMT

- Description ; Place the instrument in the remote operation for RS-232.
- Syntax ; RMT
- Parameter ; *None*
- Example ; `RMT`

LOC

- Description ; Place the instrument in the local operation.
- Syntax ; LOC
- Parameter ; *None*
- Example ; `LOC`

4.4 Error Codes

Error Number	Description
Command errors	
-101	Invalid character
-102	Syntax error
-103	Invalid separator
-104	Data type error
-108	Parameter not allowed
-109	Missing parameter
-112	Program mnemonic too long
-113	Undefined header
Execution errors	
-222	Data out of range
-224	Illegal parameter value
-350	Too many errors
Query errors	
-410	Query Interrupted
-420	Query unterminated
-430	Query deadlock state
-440	Query unterminated after indefinite response
Device dependent errors	
+201	Input power is too low
+202	Input power is too high
+521	Input buffer overflow (RS-232 only)
+522	Output buffer overflow (RS-232 only)

- `ERROR?` command queries the oldest error from the error queue.
- When the query result for `ERROR?` equals `0, "no error"`, it means no error has occurred.
- Command errors set the CME bit (the bit 5) of Standard Event Status Register (SESR).
- Execution errors set the EXE bit (the bit 4) of SESR.
- Device dependent errors set the DDE bit (the bit 3) of SESR.
- Query errors set the QYE bit (the bit 2) of SESR.

5. Comments for Accurate Measurement

5.1 Optical Source

When using tunable laser as an optical source, it is highly recommended to use coherent control mode of tunable laser to reduce interference effect in measurement. In general, broadband laser source, such as, multimode Fabry-Perot laser, gives more stable measurement results.

5.2 1.3/1.55 um Selection

With the 1.3/1.55 um key (shift + fixed λ) of the front panel, users can choose one of two operating wavelength ranges represented by 1300 nm and 1550 nm. 1300 nm range corresponds to the wavelength range less than 1420 nm and 1550 nm corresponds to the wavelength range larger than 1430 nm. 1.3/1.55 um selection has an effect on two measurement parameters. One is optical power measurement, because SA2000's power measurement function is calibrated at two wavelengths- 1300 nm and 1550 nm. The other is that the sign of Stokes parameter S3 will change according to the 1.3/1.55 um selection. All the other measurement parameters of SA2000 are independent of 1.3/1.55 um selection.

5.3 Fixed λ Operation Mode

In normal operation mode (non-fixed λ mode), SA2000 automatically calculates phase retardation of wave plate 2α in optical head of SA2000 from the ratio of F_6 to F_2 in Eq. 2.2, which is equal to $\tan^2\alpha$. Since the amplitude F_2 and F_6 are proportional to the magnitude of S1 and S2, this calculation becomes uncertain as S1 and S2 approach zero simultaneously, that is, circular polarized state and gives the most accurate value when the light is linearly polarized.

Phase retardation 2α is the only function of the operating wavelength. In fixed λ mode, SA2000 assumes that the wavelength of optical light does not change and so does the phase retardation 2α. SA2000 also keeps the value of 2α calculated at the moment when fixed λ mode is initiated and applies this value throughout the whole measurement during fixed λ mode operation without new calculations of 2α. If the user does not need to change the wavelength of optical source for a long time, **FIBERPRO** recommends using fixed λ mode. The merit of fixed λ mode is the stability of DOP and S3 near the North and South Pole of Poincare Sphere, that is, circular polarization states. It is important to initiate fixed λ mode when the state of polarization is near linear polarization state to get the most accurate 2α value.
To use fixed λ mode appropriately, using the following procedure.

1. Put SA2000 in normal operation mode (non-fixed λ mode).
2. Monitor S3 value of SA2000.
3. Apply linearly polarized light, that is when S3 is nearly zero.
4. Keeping stable polarization state, press fixed λ key to
   enter activate λ operation mode.

5.4 Changing Adaptor

FIBERPRO supplies SA2000 with two kinds of adaptors R (reduced) type and N (wide) type. The keyway width of R type is 2.03 ~ 2.08 mm and that of N type is 2.15 ~ 2.20 mm. Each adaptor is marked with R or N characters on the front. Choosing the appropriate adaptor according to your connector is important to measure accurate inclination angle of the polarization ellipse. After changing the adaptor, new reference angle setting with master PM patch cord is highly recommended. Refer to **3.3.5 To set the user reference angle** to see how to set new reference angles. When changing the adaptor, use the screws supplied by **FIBERPRO**. Any screw longer than the supplied ones may disturb the operation of the rotating optical parts.

SOP Analyzer
Windows App. User's Manual

FIBERPRO / 2002.4.15

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WINDOWS APPLICATION USER'S MANUAL

Windows

App.

1. Features and Requirements

1.1 Features

Communication

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File Management

- File Saving for 10,000 Points
- File Loading

Display Poincare Sphere

ER Measurement in Poincare Sphere

Display Polarization Ellipse

Display Graphs for Each Parameter

Display All Parameters Simultaneously

1.2 System Requirements

Computer/Processor

- Computer with a Pentium/200-megahertz (MHz) processor or higher

Operating System

- Windows 95, Windows 98, Windows Me, Windows NT 4.0, or Windows 2000

Memory

- 64 MB of RAM

Drive

- CDROM drive (for installation)

Display

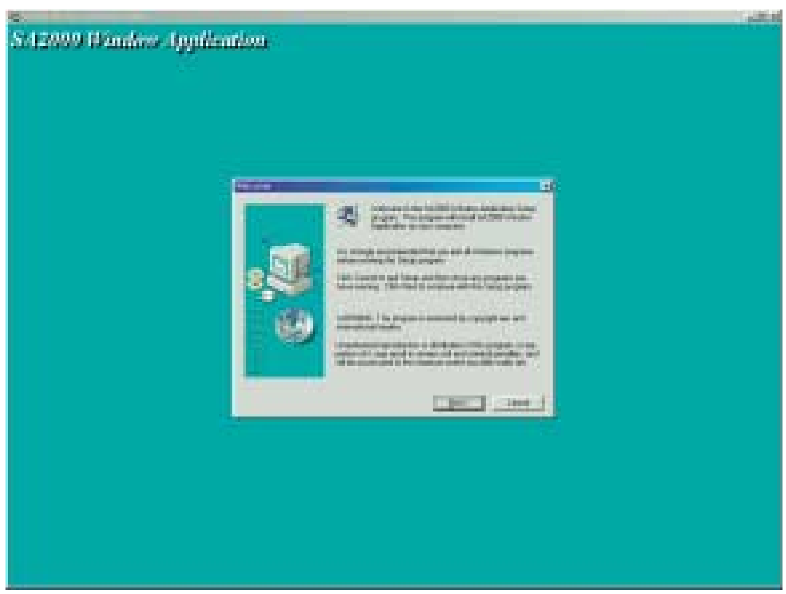
- Super VGA (800×600) or higher-resolution monitor with 256 colors

Peripherals

- Serial Port for RS232 or GPIB

2. Installation

1. Insert the Installation CDROM in your CDROM Drive.
2. Search the file "Setup.exe" by using the explorer.
3. Double-click the icon "Setup.exe" for executing the file, you can see the fig. 1.
4. Press the "Next" button in Fig. 1, after reading the information.

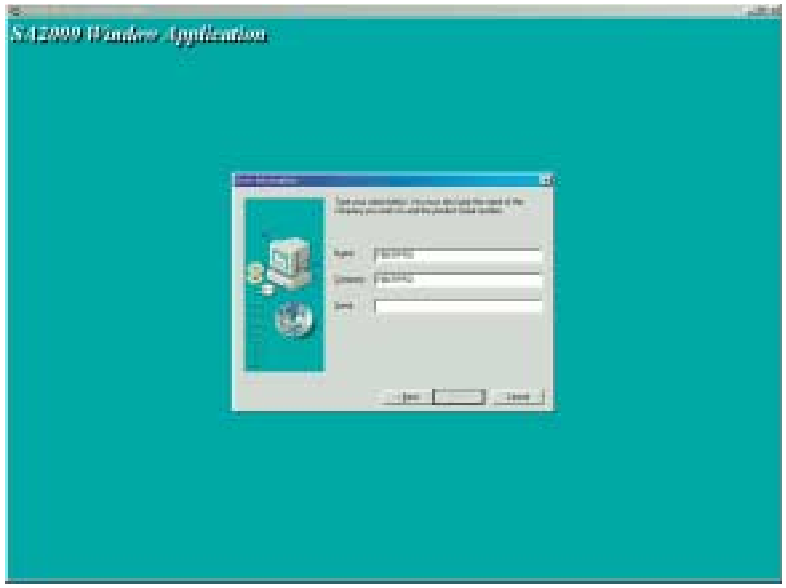


[Fig. 1] Welcome Message

5. In Fig. 2, you should fill in three blanks, which are your name, your company name and the serial number. If your serial number is correct, the "Next" button will be enabled, if not, you will not be able to install this application.

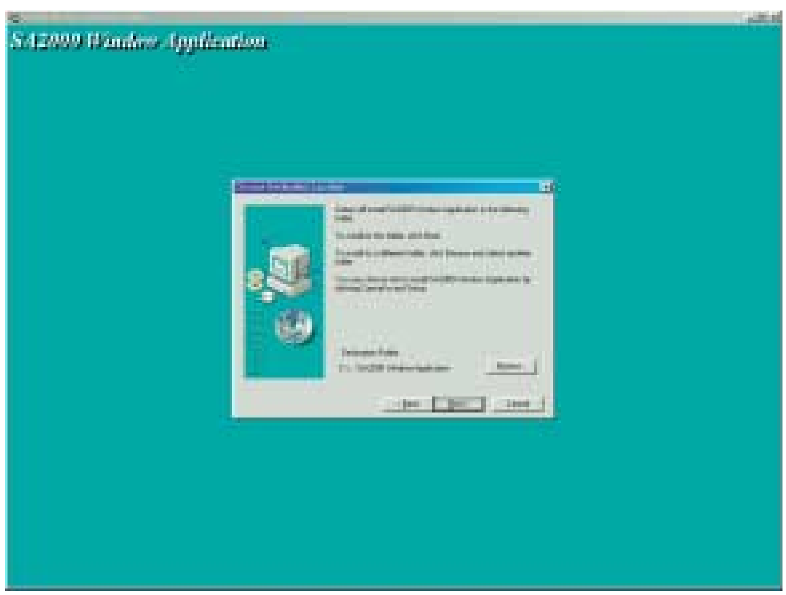
   If you have no serial number or the wrong number, please email to fiberpro@fiberpro.com.

   After filling these blanks, press the "Next" button.
   The serial number is on the cover of the installation CDROM.



[Fig. 2] User Information

6. In Fig. 3, you can change the destination location. The “Browse” button will help you search the location. After changing the location, press the “Next” button.



[Fig. 3] Choose Destination Location

7. This setup program will close after copying the files.

   If you have no serial number or the wrong number, please email to fiberpro@fiberpro.com.

3. Getting Started

The SOP Analyzer Windows Application Installation process puts the "SOP Analyzer Application Program" in the "/program files/fiberpro/" folder or user defined folder and adds "Fiberpro" to the Programs menu. (available from the Start button)

To start the SOP Analyzer Application Program,

1. Connect your instrument SA2000 to your computer through RS232 or GPIB.
2. Power on SA2000.
3. Execute Start Menu/Program/Fiberpro/SOP Analyzer.

4. GPIB/RS232

You can change the communication protocol by the menu "SETUP/'RS232/GPIB'" as Fig. 4.

[Fig. 4] Select Communication Protocol

If you select the RS232 protocol, by the menu "Setup/RS232", you need to confirm the setting of the RS232, especially the port number, whether it is COM1 or COM2. The other settings are fixed and you don't need to change them. The setting parameters are like these, baud rate is 57,600, none parity, 8 data bits, 1 stop bit.

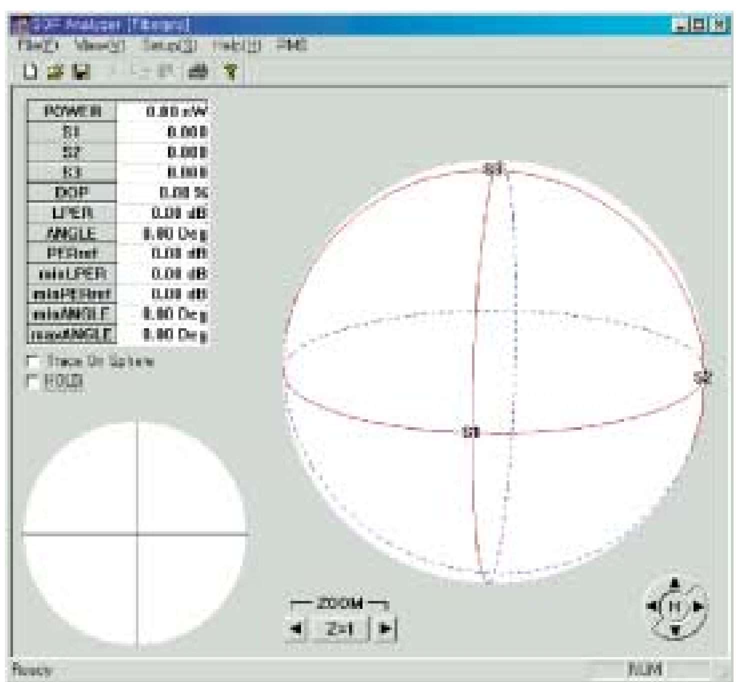
[Fig. 5] Serial Port Setup

If you select the GPIB protocol, you need to confirm the GPIB Address by the menu “SETUP/GPIB”

[Fig. 6] GPIB Address

5. Main Page

The main page consists of the Poincare Sphere, polarization ellipse, data box, check boxes, several buttons and the menu bar as shown in Fig. 7. It will be explained in more details under each section.



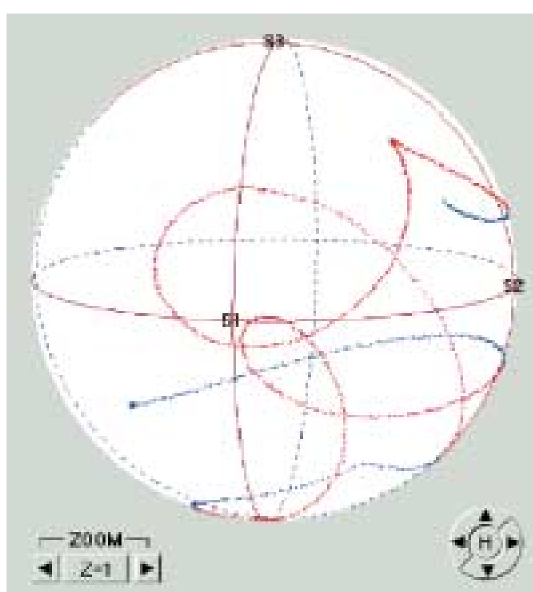
[Fig. 7] Main Page

5.1 Poincare Sphere

The State Of Polarization (SOP) of optical signal is represented as a point on a Poincare Sphere. The SOP trace history can be represented as discrete dots or discrete dots and connecting lines. Poincare Sphere window has two kinds of special buttons, a zoom control button and a view angle control button.

5.1.1 General Feature

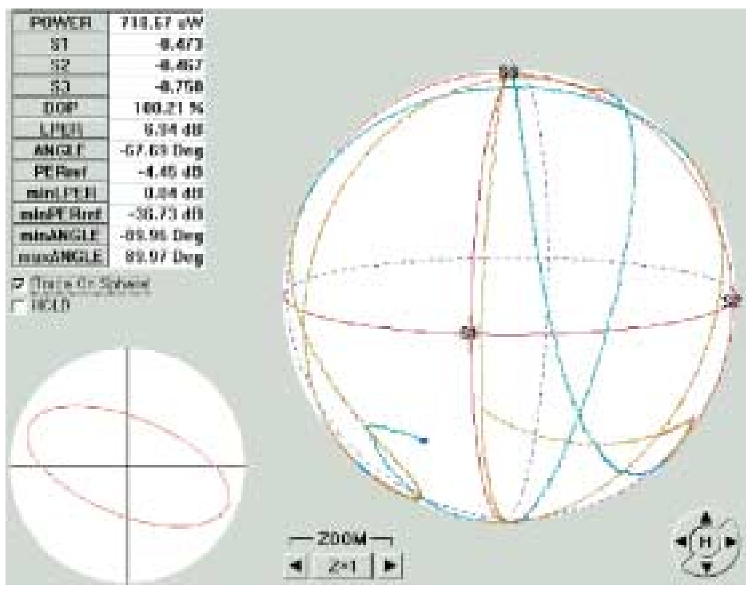
The Poincare Sphere is represented by three points S1, S2 and S3 and three great circles, an equator connecting S1 and S2 points on Poincare Sphere and two circles of longitude connecting S1 and S3 and connecting S2 and S3. The coordinates of S1, S2 and S3 on Poincare Sphere are (1,0,0), (0,1,0) and (0,0,1). The equator connecting S1 and S2 corresponds to liner polarization states. Northern and southern hemispheres of Poincare Sphere represent right-hand and left-hand elliptical polarization states. Especially +S3 represents right-hand circular polarization state and -S3 represents left-hand circular polarization state.
The parts of the three great circles located in the front hemisphere of Poincare Sphere are dark red lines and the rear hemisphere are dotted blue lines.



[Fig. 8] Poincare Sphere

5.1.2 Trace of SOP

The SOP trace on Poincare Sphere is represented as discrete dots – dark red dots for front hemisphere and blue dots for rear hemisphere. Current SOP is represented by bigger dot than others. You can connect trace points by checking ‘Trace on Sphere’ check box. The connecting line is part of the great circle connecting the neighboring two points.



[Fig. 9] Trace on Poincare Sphere

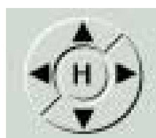
5.1.3 Maximum SOP Data Points on Poincare Sphere

You can change maximum displayed SOP data points on Poincare Sphere using the menu ‘Setup/Poincare Sphere’ up to 5,000 points. In connected trace mode, the maximum displayed data points will be reduced to 1,000. If the number of data displayed exceeds maximum data points, the oldest point will disappear.

5.1.4 Holding the SOP Trace

You can hold the measurement result by checking 'Hold' on the checkbox.

5.1.5 View Angle Controller

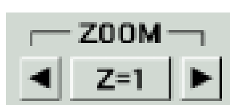


[Fig. 10]
View Angle Controller

There are five buttons, up, down, left, right arrows and home for viewing the angle controller as shown in Fig. 10. Up/down arrow buttons will be used to move view angles to vertical direction and left/right arrow buttons will be used to move view angles to horizontal directions. The 'H' button means 'Home'. Pressing 'H', the view angle changes to the initial view angle.

There is another way to change the view angle using the mouse. Put the mouse on Poincare Sphere and drag the mouse pressing left mouse button to the desired direction.

5.1.6 Zoom Controller



[Fig. 11]
Zoom Controller

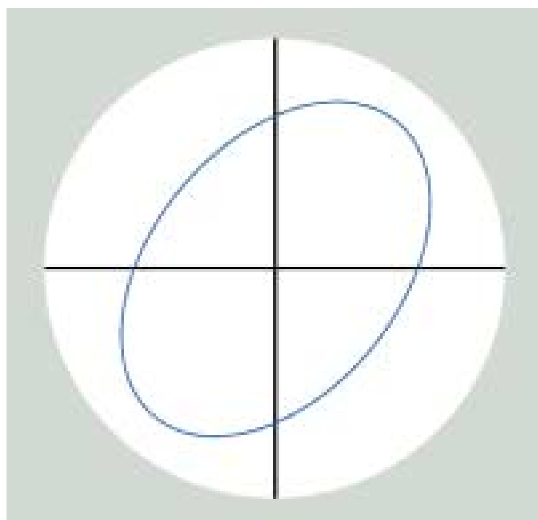
There are three buttons for zoom controls as shown in Fig. 11, left, right arrows and zoom current status button. Left arrow button zooms out and right arrow button zooms in on the Poincare Sphere and current zoom status is displayed on the center button. Pressing the center button, the zoom status will return to zoom 1 state.

5.1.7 Clearing the SOP Trace

You can erase displayed SOP trace using menu 'File/New' or New File icon on menu bar. 'MinMax' button of remote controller window also erases the displayed SOP trace. The 'File/New' erase does not reset minLPER, minPERref, minANGLE and maxANGLE values, while 'MinMax' button does.

5.2 Polarization Ellipse

The polarization ellipse corresponding to the last SOP is displayed. For right-hand polarization state, polarization ellipse is a red line, and for left-hand polarization state, polarization ellipse is a blue line. The reference linear polarization whose coordinate on Poincare Sphere is (1,0,0) is represented as a vertical line in the polarization ellipse.



[Fig. 12] Polarization Ellipse

5.3 Data-Box

POWER	40.00 uW
S1	0.419
S2	0.191
S3	0.204
DOP	50.39 %
LPER	40.00 dB
ANGLE	40.00 Deg
PERref	40.00 dB
minLPER	1.14 dB
minPERref	1.15 dB
minANGLE	1.14 Deg
maxANGLE	1.15 Deg

[Figure 13] Data-Box

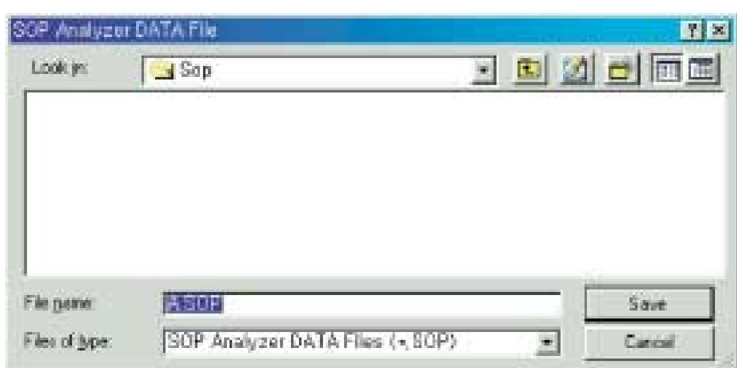
Measured results corresponding to current SOP are numerically displayed in the data-box. You can highlight any special fields of the measured data that you need to pay attention to with a blue color. For a detailed explanation of each data field, refer to **2.3 What you can measure with SA2000** of the user's manual.

5.4 File Management

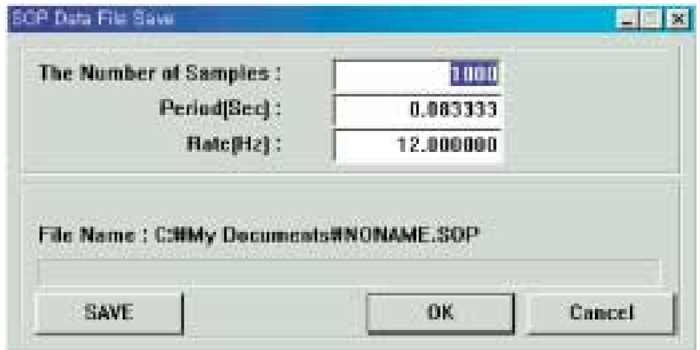
SA2000 Application Program has function to save and load measured data. In the saving function, you can save a maximum of 10,000 data samplings with definite time interval.

To save and load the data, execute the following procedure.

1. Open 'the SOP Analyzer DATA File' dialog box as shown in Fig. 14, selecting the menu 'File/Save'.
2. Select the file saving location, enter file name in 'file name' field, and press the 'save' button.
   Then 'the SOP Data File Save' dialog box as shown in Fig. 15 will be appear.
3. Enter the number of samples and period (or rate).
   Maximum number of samples is limited to 10,000 and minimum period (or maximum rate) value is limited according to the setting value of the average number. For example, if the average number is 2, minimum period is 0.833 sec or maximum rate is 12 Hz.
4. To start the save, press 'SAVE' button. You can see the progress of the saving process.
   With 'OK' button, you can stop the saving process with the saving data gathered until that time. 'Cancel' button stops the saving process without saving the data.
   If the number of gathered data reaches the sampling size, this dialog box disappears automatically and saves the file.



[Fig. 14] File Save Dialog



[Fig. 15] File Save Dialog

One datum consist of 5 parameters which is “POWER”, “S1”, “S2”, “S3”, “DOP”.
The extended file name of the SOP Analyzer is “SOP”.
The “∗.SOP” file is ASCII Format. You can see and edit by any windows editor like “Notepad”, “WordPad”.
Choosing the menu “Open”, from the menu “File”, you can load the saved file.

5.5 Print

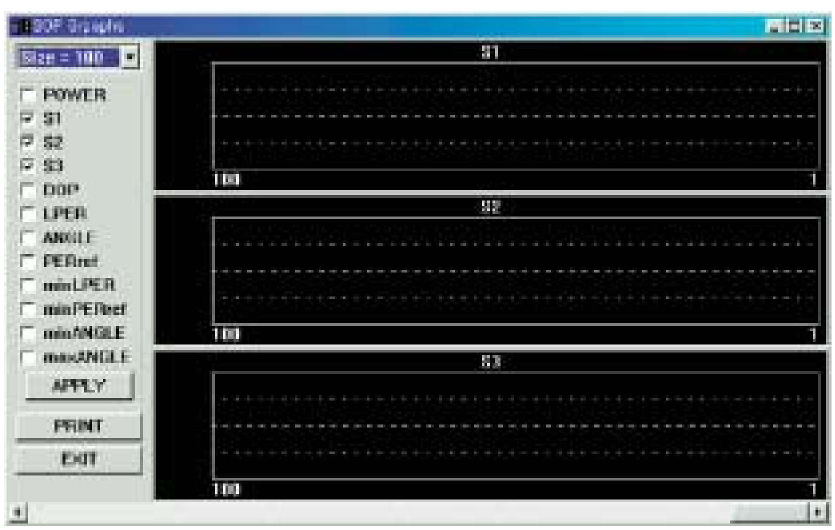
Choosing the menu “Print”, from the menu “File”, you can print the main view what you see. And you can change the setting of your printer by choosing the menu “Print Setup” from the menu “File”.

6. Graphs

Choosing 'View/Graphs' menu from the menu bar, you can monitor the trend of each measured parameter by a graph.

6.1 Selecting Graph Parameters

Maximum of 12 parameters graphs can be displayed simultaneously. If you want to change the displayed parameters, check corresponding parameter check boxes in the left of the window, and press 'Apply'.
These graphs show maximum 1,000 data points of each parameter. You can minimize the X-axis range with 'Size' popup menu and you can move X-axis using scroll bar which is located at the bottom of the graph window.



[Fig. 16] SOP Graphs

6.2 Changing Y-axis Range

[Fig. 17] MinMax Dialog for Graph

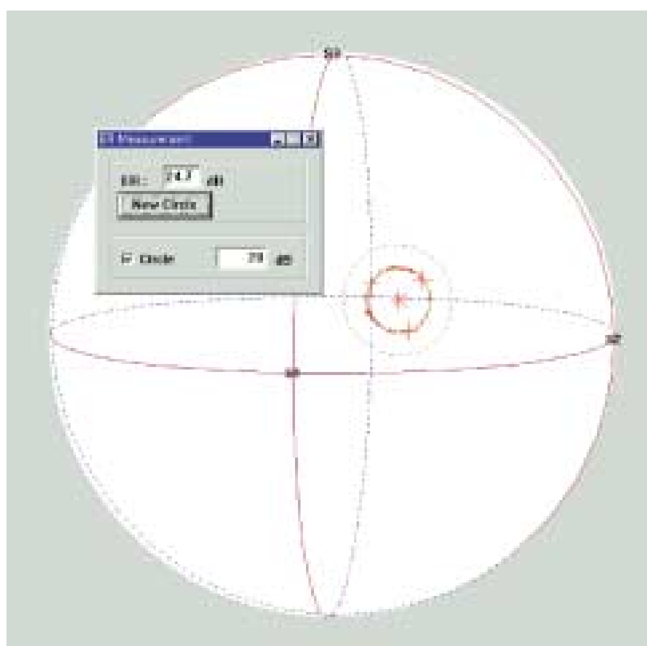
Default Y-axis range mode is auto range mode. You can change the Y-axis range of specific graphs by double clicking left mouse button on the desired graph. With a click of the mouse, you can see the dialog box as shown in Fig. 17. Write wanted range values into 'Y-Axis Min' and 'Y-Axis Max' field and click 'OK' button. Then, the Y-Axis range will be fixed to those values. If you want to return to auto range mode, just check 'Auto Range' check box and click 'OK' button.

7. Extinction Ratio Measurement

7.1 Extinction Ratio

When the polarization state of launched light into Polarization Maintaining Fiber (PMF) is misaligned to the birefringence axis of PMF, and if the PMF is perturbed, that is, stretched or heated, the SOP trace of output light from PMF forms circle on Poincare Sphere. The degree of misalignment can be obtained from the diameter of the SOP trace circle and represented as the extinction ratio (ER) in dB scale.

7.2 Measurement Procedure



[Fig. 18] ER Measurement

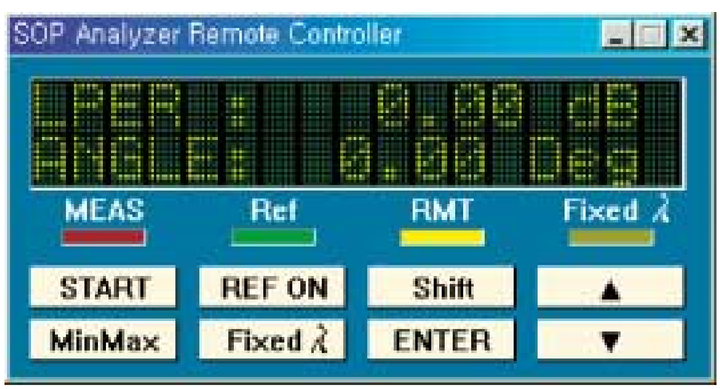
To measure ER, execute the following procedure.

1. Open 'ER Measurement' dialog box from the menu 'View/ER Measure'.
2. Apply perturbation, such as, stretching, heating or cooling, to PMF, and monitor the formation of circular trace on the Poincare Sphere while the other optical sections are kept stationary.

3. Choose three points on the circular SOP trace by clicking the right mouse button. Cross marker will appear on the nearest measured data point to mouse clicked point.
4. From the three points chosen step 3, a circle is calculated and displayed on Poincare Sphere with its star marked center. ER corresponding to this circle size will be displayed in 'ER Measurement' dialog box.
5. You may draw a reference circle with dotted lines whose size corresponds to the ER value written in the blank fields of 'Circle' and whose center is the same as the circle drawn in step 4 by checking 'Circle' check box. This reference circle may be helpful in failure decisions of extinction ratio of arbitrary device.
6. You can repeat this procedure from step 3 by clicking 'New Circle' button in 'ER Measurement' dialog box.

8. Remote Controller

SOP Analyzer Remote Controller window is similar to the controller panel of the real SOP Analyzer, SA2000. It consists of a measurement display window, 4 indicators and 8 buttons. You can eliminate display windows by double clicking the rightmouse button and vice versa. Each button operation is the same as that of real panel buttons except for shift start button for GPIB address setting in real panel. For detailed functions of each button, please refer to **3.1 Front panel at a glance** and **3.3 How to use SOP Analyzer** of the user's manual.



[Fig. 19] Remote Controller

Replacing Fuse

When your fuse is blown out, follow the replacing procedure below. But you must use the right fuse for line voltage. Select proper fuse - 0.5A 250V 100Vac. If you don't use the right fuse for the line voltage selected, it will be blown. Contact **FIBERPRO** to order the right fuse.

Procedure

1. Finding fuse holder.

The fuse holder box is on the rear panel of SA2000.
Stop your work and put SA2000 on the flat table. And then, pull out the cables. Fuse holder box is left side of the rear panel.

2. Open fuse holder box.

Lever with a small minus screwdriver cautiously.

3. Pull out fuse holder.

Pull out fuse holder cautiously with a small minus screwdriver.

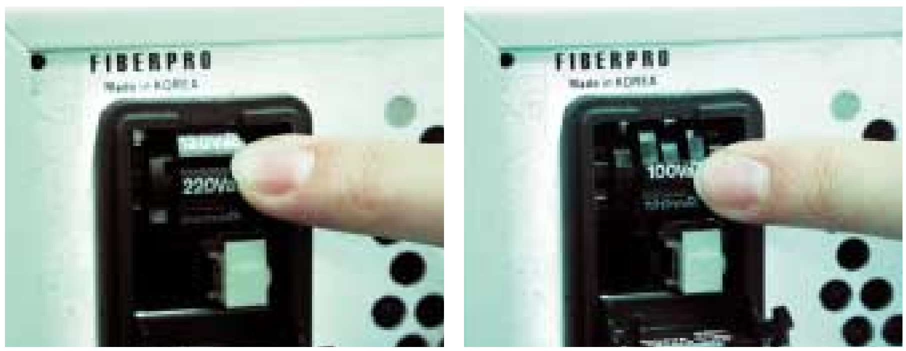
4. Replacing fuse.

Pull out the old fuse with care and replace to a new one.

5. Put into the fuse holder box.

Put the fuse holder into fuse holder box. Check the direction of the white arrow key (→) on the front of the fuse holder.

6. Adjust the power voltage.



Adjust the power voltage 100, 120, 220, or 240.

7. Close the fuse holder box.

Close the fuse holder box.

NOTE

Use the proper fuse for the line voltage selected. Use only fuses with the required current rating and of the specified type as replacements. DO NOT use a mended fuse or short-circuit the fuse-holder in order to by-pass a blown fuse. Find out what caused the fuse to blow!

FIBERPRO
Limited Warranty

FIBERPRO warrants its products to be in conformance to mutually agreed upon written specifications and to be free from defects in material and workmanship. The warranty period of SOP Analyzer is 1 year. The above warranty period shall begin on the date of shipment by **FIBERPRO** to Purchaser or, if Purchaser is an authorized reseller of such **FIBERPRO** products, from the date of shipment by the reseller to the reseller's original customer. **FIBERPRO** shall, at its option and cost, either repair or replace the products with new or reconditioned products and parts provided the products are returned by Purchaser along with dated and serialized proof of purchase to **FIBERPRO** or to an **FIBERPRO** authorized service facility, transportation and insurance prepaid, within the above warranty period and which are found by **FIBERPRO** to be defective within the terms of this warranty. Products repaired or replaced by **FIBERPRO** under this warranty will be returned by **FIBERPRO** to Purchaser, transportation and insurance prepaid. Replaced products and parts shall become the property of **FIBERPRO**. If any products returned by Purchaser to **FIBERPRO** for repair or replacement are found by **FIBERPRO**, after examination and testing, not to be defective, **FIBERPRO** shall so advise Purchaser and shall dispose of any such products in accordance with Purchaser's instructions and at Purchaser's cost, and Purchaser shall reimburse **FIBERPRO** for examination and testing expenses incurred at FIBERPRO's then current rates.

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The warranty set forth above shall not apply to failure or deficiency which has been caused by misuse, abnormal or unusually heavy use, neglect, alteration, improper installation, unauthorized repair or modification, improper testing, accident or causes external to the product such as but not limited to excessive heat or humidity, or improper installation. Such warranty shall also not apply to expendable components such as but not limited to fuse, power cord, and screws. **FIBERPRO** makes **NO WARRANTY** as to any products, which are supplied by it "AS IS" or as to any experimental or developmental products, or as to products not manufactured by **FIBERPRO**. **FIBERPRO**'s warranty as set forth above shall not be enlarged, diminished or affected by, and no liability shall arise out of, **FIBERPRO**'s rendering of technical advice in connection with Purchaser's order. The warranty set forth above is not assignable by Purchaser.

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