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POLARIZATION SCRAMBLER

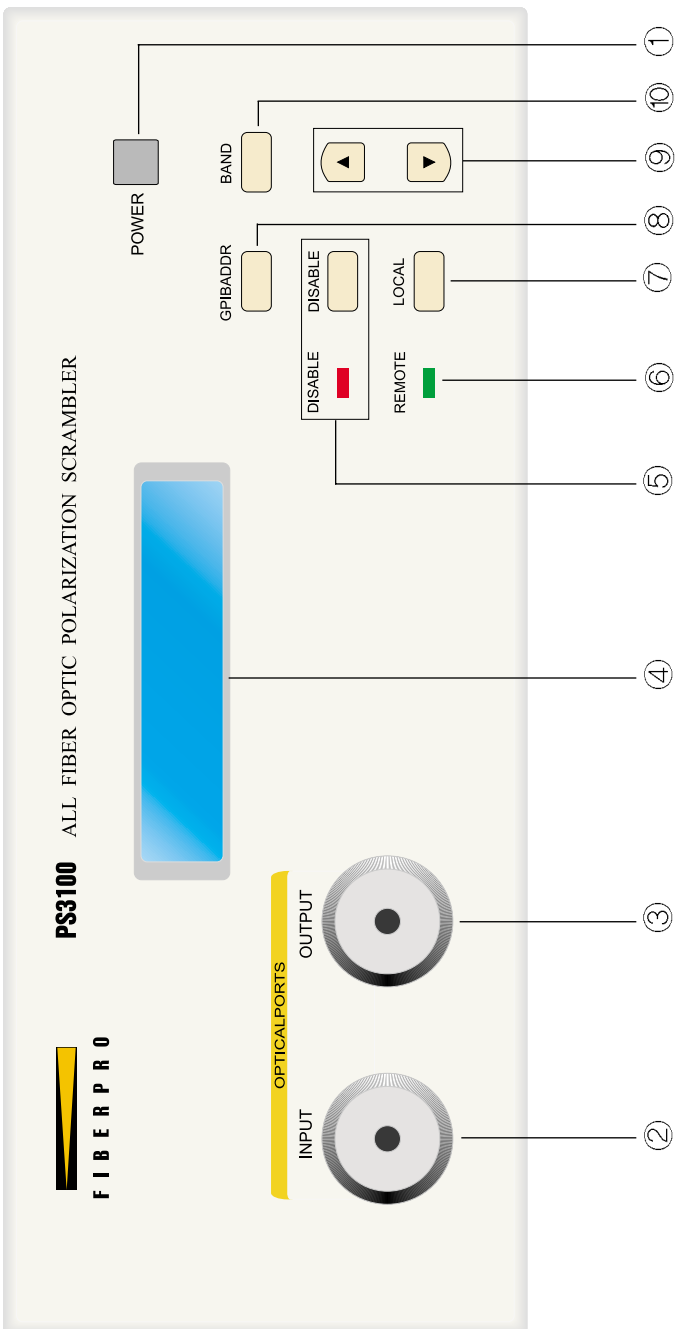
POLARIZATION SCRAMBLER
USER'S GUIDE



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Front Panel



① [POWER] Switch
② [INPUT] Optical connector
③ [OUTPUT] Optical connector
④ [Display] LCD
⑤ [DISABLE] Key/Indicator
⑥ [REMOTE] Indicator
⑦ [LOCAL] Key
⑧ [GPIB ADDR] Key
⑨ [Selection] Keys
⑩ [BAND] Key

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Polarization Scrambler
User's Guide

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CONTENTS

I. General Information 1

» NOTES 3

II. Operation 4

1. Front Panel 4
2. Rear Panel 5
3. Local Operation 6
4. Remote Operation 7

A. Control Via RS-232 7

B. Control via GPIB 8

C. Command Set 10

IEEE 488.2 Common Commands (GPIB Interface only) 11

Commands used only in RS-232 interface 13

D. Error Codes 13

III. Theory 14

1. Introduction 14
2. Depolarizing Quasimonochromatic Light 14
3. Mathematical Description of Polarization Scrambler 15
4. Measurement Bandwidth Limitation 19

IV. Applications 21

V. Replacing Fuse - new PS series 22

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I. General Information

1. Warning

A. 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.

B. To avoid electric shock, the power cord protective ground conductor must be connected to ground.

C. No user serviceable part exists in this instrument. Refer all services to qualified personnel.

2. Caution

This instrument may be damaged if operated with the wrong AC line voltage or if the wrong fuse is installed. Before using the instrument, be sure to read through operation manual and data sheets to ensure its correct operation.

3. Line Voltage Selection

The polarization scrambler (PS) can operate from any single-phase AC power source that supplies 100 ~ 250V at a frequency of 50 ~ 60 Hz. You do not need to adjust the input line voltage setting because the internal power supply of the PS can automatically adjust for input line voltages in the range specified above.

4. Line Fuse

The fuse used by this instrument is 2AT / 250V (slow-blow).

5. Line Cord

This instrument has a detachable, three-prong 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.

6. 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 to ask for services.

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7. Specifications

A. General

AC power input	: 100~250V, 50/60Hz
Power consumption	: 〈 40VA
Dimensions	: 88(h) x 225(w) x 371(d) mm[3]
Weight	: approx. 5kg
Operation temperature	: 5 ℃ ~ 35 ℃ (DOP 〈 5%[1])
Storage temperature	: 0 ℃ ~ 60 ℃
External control	: TTL enable/disable GPIB interface (IEEE 488.2 Compatible) RS-232 (D-SUB 9 pin male) interface

B. Optical characteristics

TABLE I-1

Model	PS3000	PS3100	PS3200
Output DOP	〈 5% [1]		
Modulation frequencies	Factory set between 600kHz~1.2MHz [2]		
Frequency difference	Factory set between 100kHz~200kHz [3]		
Center wavelength	1310, 1510, 1550, 1590nm[4]	1550nm/1590nm	980nm, 1570nm
Operating wavelength range	〉40nm	〉40nm each	〉80nm
Insertion loss	〈0.5dB max, 0.3dB typical : (without connectors)		
	〈1.0dB max, 0.7dB typical : (with connectors)		
Average PMD	〈0.3ps		
PDL	〈0.05dB (with connectors)		
Back reflection	〈-65dB (without connectors)		
	〈-50dB (FC/SPC)		
	〈-60dB (FC/APC)		
Input/Output connectorization	FC/PC (standard)[5]		

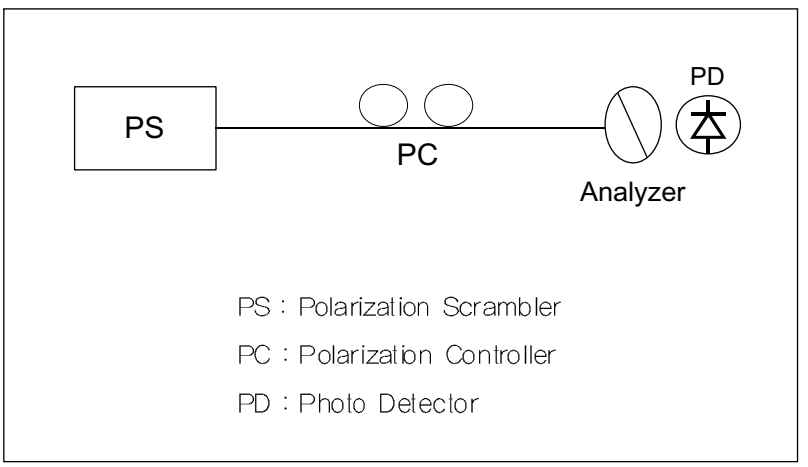
[1] Refer to NOTES following this chapter
[2] Modulation frequency for each birefringence modulator is fine-tuned for optimum operation at the factory.
[3] The frequency difference decides the measurement bandwidth limit.
(Refer to Ⅲ.4. Theory Measurement Bandwidth Limitation). It is typically 170kHz.
[4] Center Operating Wavelength can be customized within 1530~1560nm. Other wavelengths such as 1300nm, 1480nm and 1590nm are also available.
[5] Users can specify other types of connectors or fiber pigtailed at the time of order.

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NOTES

Degree Of Polarization (DOP) at the PS output is measured with a polarization controller and an analyzer. The detector bandwidth is 10kHz for PS3000 and PS3100, and 3kHz for PS3200. But in general, all FIBERPRO's PS3000 series perform output DOP less than 5% over 10kHz bandwidth.

FIGURE I-1



In figure I-1, suppose that we obtain the maximum and minimum intensity, I_{max} and I_{min} measured at the PD while adjusting the PC through all its possible states, then DOP is expressed as Eq I-1.

$$DOP = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \qquad \text{Eq. I-1}$$

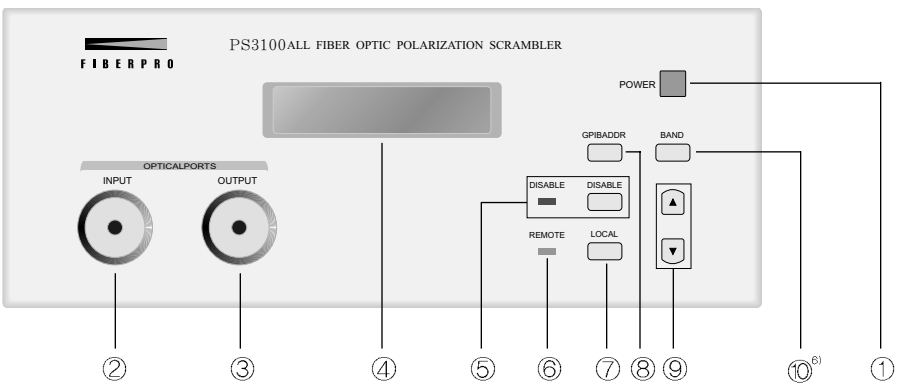
The PS maintains its output DOP less than 5% within the operating temperature range at the center operating wavelength, and within the operating wavelength range at 25℃. But simultaneous deviation of both parameters (temperature and wavelength) may increase output DOP over 5% even though both parameters are in the specified operating ranges.

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II. Operation

1. Front Panel

FIGURE II-1



① **[POWER]** Switch – The PS is initialized and starts polarization scrambling when this switch is turned on.

② **[INPUT]** Optical connector – The input termination is FC/PC type unless specified otherwise.

③ **[OUTPUT]** Optical connector – The output termination is FC/PC type unless specified otherwise.

④ **[Display]** LCD – The LCD displays the current PS' state or appropriate information when each key is pressed.

※The LED backlight is turned off if there is no local or no remote control for about a minute.

⑤ **[DISABLE]** Key/Indicator – Pressing this key changes the current PS' state (Enabled or Disabled) and this LED is lit on when polarization scrambling is disabled.

⑥ **[REMOTE]** Indicator – This LED is lit on when the PS is under remote interface mode via GPIB or RS-232.

⑦ **[LOCAL]** Key – Pressing this key returns the PS to local mode from remote interface mode.

⑧ **[GPIB ADDR]** Key – Pressing this key enables to enter GPIB address setting menu or terminate this menu.

⑨ **[Selection]** Keys – Pressing these keys enables to select a GPIB address or a wavelength band.

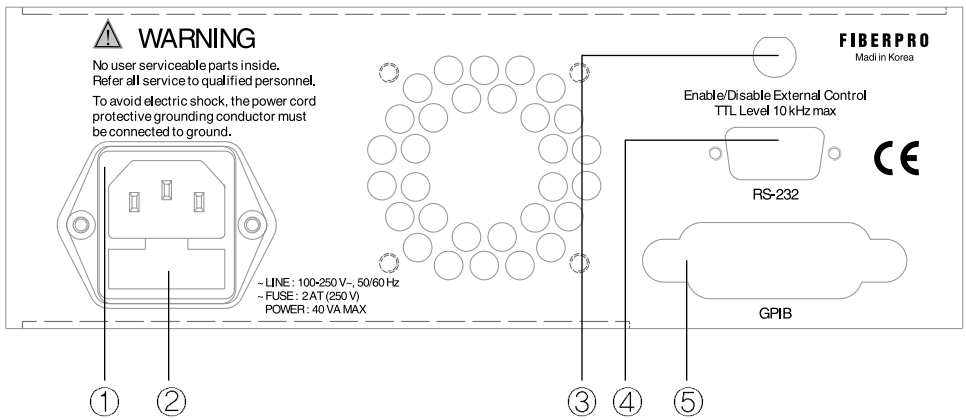
⑩ **[BAND]** Key – Pressing this key enables to enter wavelength band setting menu or terminate this menu.

[6] In PS3100 only

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2. Rear Panel

FIGURE II-2



① **Power Entry Module** – The power entry module is for the AC line voltage input. It blocks high frequency noise entering the instrument.

② **Fuse Holder** – To open the fuse holder, use a (–) screw driver.

③ **External Control : TTL** – This BNC connector is to give external enable/disable control by TTL signal. High level signal into this connector disables polarization scrambling. Maximum switching rate is 10kHz. This control does not influence DISABLE indicator LED and LCD Display in the front panel.

④ **External Control : RS-232** – RS-232 interface is provided (D-SUB 9 pin male connector)

⑤ **External Control : GPIB** – GPIB interface is provided.

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3. Local Operation

A. To power-on the PS

① Connect the power cord to the power entry module at the rear of the PS, then the other end to a suitable AC line power receptacle.

② Press [POWER] switch, then LCD displays as following order.

Example	Description
PS-3100 V1.00	The PS' model & Firmware version
GPIB ADDRESS 01	Current instrument's GPIB address
PS ENABLED	The PS' state when powered on

B. To change the instrument's GPIB address

① Press [GPIBADDR] key, then LCD displays GPIB ADDRESS 01

② Set the GPIB address that you want (1 to 15) by pressing [▲] [▼] keys.

③ To save the address and quit this menu, press [GPIBADDR] key again. Otherwise in about 10 seconds the instrument saves the address and quits this menu automatically.

※The address is saved in a non-volatile memory and does not change when power has been off or after a remote interface reset.

C. To change the instrument's wavelength band [7]

① Press [BAND] key, then LCD displays BAND C (or BAND L)

② Select the wavelength band that you want by pressing [▲] [▼] keys.

③ To save the wavelength band and quit this menu, press [BAND] key again. Otherwise in about 10 seconds, the instrument saves the wavelength band and quits this menu automatically.

※The wavelength band is saved in a non-volatile memory and does not change when power has been off or after a remote interface reset

D. To enable or disable polarization scrambling

① Press [DISABLE] key, then the state changes.
LCD displays PS ENABLED if polarization scrambling becomes enabled and LCD displays PS DISABLED otherwise.

※Polarization scrambling is always enabled at power-on or after a remote interface reset.

E. To return the PS to local mode from remote interface mode

① Press [LOCAL] key, then the PS becomes under local control.

[7] In PS3100 only

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4. Remote Operation

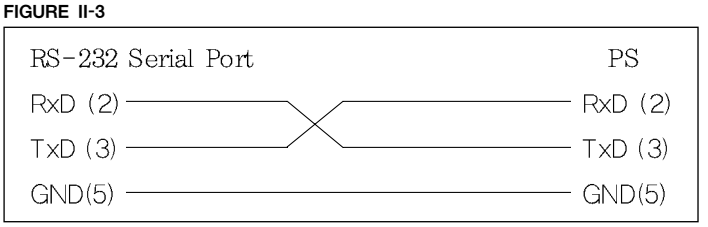
A. Control Via RS-232

RS-232 was originally designed for 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, a user can easily interface the PS with personal computer for remote control. Communication conditions of the PS must be set as follows.

- Baud rate : 9600bps
- Data bit : 8bit
- Stop bit : 1bit
- Parity : None

The PS 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 PS 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 PS serial interface device is as figure II-3.

FIGURE II-3



The command set for RS-232 interface is almost the same as for GPIB interface except several commands and is given in II.4.C Command Set.

If the command is correctly transmitted to the PS, the PS replies "OK" or Return Message. Otherwise the PS replies "Error" and the error number and its description are stored in the error queue.

※Note that the RS-232 commands can be transmitted in either uppercase or lowercase letters and must be terminated by Carriage Return (CR).
A message received from the PS is followed by Carriage Return (CR).

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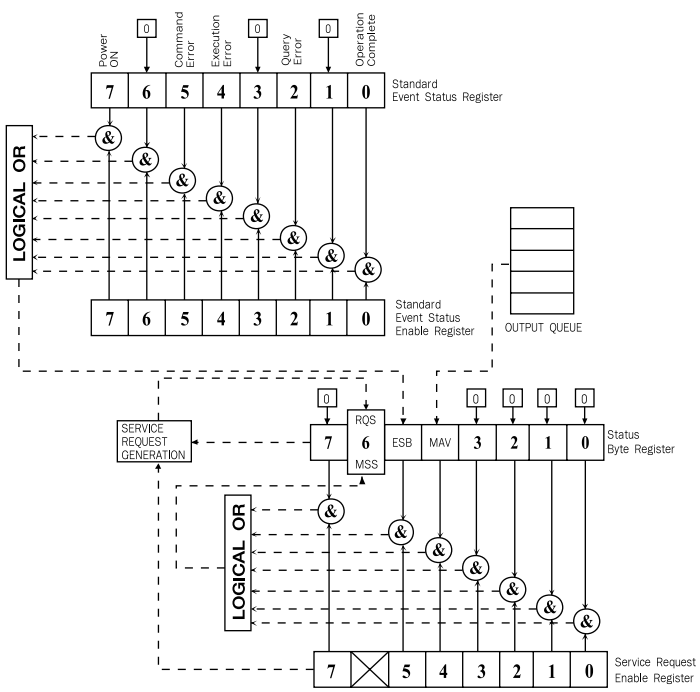
B. Control via GPIB

- The interface capabilities that the PS implements, as defined by IEEE 488.1, are SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, C0.
- The PS implements all necessary common commands defined by IEEE 488.2. A summary of the common commands is shown in table II-1 and the status reporting structure of the PS is shown in figure II-4.
  (More specific descriptions are given in II.4.C. Command Set.)

TABLE II-1

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

FIGURE II-4



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TABLE II-2

		Standard Event Status Enable Register	Standard Event Status Register
Bit	Weight	Enables	Condition
7	128	PON (Power ON)	Off-to-on transition has occurred in the PS' power supply.
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 (Device Dependent Error)	Not-Used (always 0)
2	4	QYE (Query Error)	Query errors are detected
1	2	RQC (Request Control)	Not-Used (always 0)
0	1	OPC (Operation Complete)	The PS has completed all selected pending operations

TABLE II-3

		Service Request Enable Register	Status byte Register
Bit	Weight	Enables	Condition
7	128	Not-Used	Not-Used (always 0)
6	64	RQS (Request Service)	The PS is requesting services
		MSS (Master Summary Status)	
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	Not-Used	Not-Used (always 0)
2	4	Not-Used	Not-Used (always 0)
1	2	Not-Used	Not-Used (always 0)
0	1	Not-Used	Not-Used (always 0)

※The Standard Event Status Enable Resister and the Service Request Enable Register are cleared at power-on.

*※The Standard Event Status Resister is cleared 1) at power-on, 2) by *CLS command or 3) after being read. (Just after power-on, the bit 7 in the Standard Event Status Resister is set because off-on transition in the power supply has occurred.)*

*※The Status Byte Resister is cleared 1) at power-on or 2) by *CLS command.*

※When the RQS bit is set, the PS asserts the SRQ line. Then the controller polls each addressed listener to send back a Status Byte 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.

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C. Command Set

–:PSCRamble [Parameter]
Description ; Enable/Disable polarization scrambling
Parameter ; 0: Disable polarization scrambling
1 : Enable polarization scrambling
Example ; PSCR 1

–:PSCRamble?
Description ; Query the current state of the PS
Response ; Polarization scrambling is disabled: returns 0
Polarization scrambling is enabled: returns 1
Example ; PSCRamble? –> 1

–:BAND [Parameter] [8)]
–Description ; Select the wavelength band
–Parameter ; C: Wavelength band is C band(1550nm±20nm)
L: Wavelength band is L band(1590nm±20nm)
–Example ; BAND C

–:BAND? [8)]
–Description ; Query the current wavelength band selection
–Response ; Wavelength band is C band(1550nm±20nm): returns C
Wavelength band is L band(1590nm±20nm): returns L
–Example ; BAND? –> C

–:SYSTem : ERRor?
–Description ; Query the error from the error queue (FIFO)
–Response ; The number of the oldest error , The error description
–Example ; SYSTem:ERRor? –> –222 , "Data out of range"

–:SYSTem : VERSion?
–Description ; Query the SCPI revision with which the PS complies
–Response ; SCPI revision year and number
–Example ; SYSTem:VERSion? –> 1995.0

[8)] In PS3100 only

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IEEE 488.2 Common Commands (GPIB Interface only)

-*CLS
- -Description : Clear the Standard Event Status Register, the Status Byte Register and the Error Queue.
- -Example : *CLS

-*ESE [Mask data]
- -Description : Set the bits in the Standard Event Status Enable Register that enable the event corresponding to the bits in the Standard Event Status Register.
- -Mask data : 0~255 decimal value
- -Example : *ESE 128

-*ESE?
- -Description : Query the value of the Standard Event Status Enable Register.
- -Response : decimal value in the range of 0~255
- -Example : *ESE? -> 128

-*ESR?
- -Description : Query the value of the Standard Event Status Register.
- -Response : decimal value in the range of 0~255
- -Example : *ESR? -> 132

-*SRE [Mask data]
- -Description : Set bits in the Service Request Enable Register that enable the event corresponding to the bits in the Status Byte Register. But the value of the bit 6 is ignored.
- -Mask data : 0~255 decimal value
- -Example : *SRE 63

-*SRE?
- -Description : Query the value of the Service Request Enable Register. The bit 6 of the binary representation is always sent with the value zero.
- -Response : decimal value in the range of 0~63 , 128~191
- -Example : *SRE? -> 63

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-*STB?
-Description ; Query the value of the Status Byte Register.
The returned value of bit 6 is not the RQS bit but the MSS bit.
-Response ; decimal value in the range of 0~255
-Example ; *STB? -> 128

-*IDN?
-Description ; Query the identification of the PS.
-Response ; Manufacturer, Model, 0, Firmware Version
-Example ; *IDN? -> Fiberpro,PS-3100,0, V 1.0

-*OPC
-Description ; Set the OPC bit in the Standard Event Status Register when all pending device operations have been completed.
-Example ; *OPC

-*OPC?
-Description ; Place ASCII "1" in output queue when all pending device operations have been completed.
-Example ; *OPC? -> 1

-*WAI
-Description ; Prevent the PS from executing any further commands until the current commands has finished executing.
-Example ; *WAI

-*TST?
-Description ; Perform a self-test and place the results in the output queue.
-Response ; Self-test is failed: returns 0
Self-test is passed: returns 1
-Example ; *TST? -> 1

-*RST
-Description ; Set the PS to the reset setting stored internally.
-Example ; *RST

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Commands used only in RS-232 interface

–RMT
–Description ; Login for control via RS-232 interface.
–Example ; RMT

–LOC
–Description ; Logout for control via RS-232 interface.
–Example ; LOC

–ENB[9)]
–Description ; Enable polarization scrambling.
–Example ; ENB

–DSB[9)]
–Description ; Disable polarization scrambling.
–Example ; DSB

D. Error Codes

TABLE II-4

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 error
Query Errors	
–410	Query interrupted
–420	Query unterminated
–430	Query deadlock state

[9)] These commands do same function as the command PSCRamble [0|1], but they are left for the compatibility with old models of the PS.

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III. Theory

1. Introduction

In many optical fiber communication systems and sensors, optical signal of polarized light may be degraded by the presence of polarization dependence of the constituents.

Polarization of light gives rise to erroneous results when it is used in characterizing fiber-optic components having polarization dependent loss (PDL), even if it is small. In any of these cases, polarization scrambling is the most promising solution.

Polarization Scrambler randomizes the output state of polarization (SOP) of light in order to lower the degree of polarization (DOP) of light effectively in time average. Here, randomization means the modulation of SOP on the Poincare sphere. However, PS does not generate a truly random trajectory but generates a predetermined trajectory depending on the input SOP. The important thing is that the trajectory on the Poincare sphere should be integrated in time to yield zero DOP regardless of the input SOP.

In this chapter it is assumed that the users have understanding of vector representation of the electromagnetic field, Jones vectors and matrices, Stokes parameters and the Poincare sphere. This chapter deals with the concept of polarization scrambling, the methods of realizing it, polarization modulation speed, DOP, and double stage polarization modulation for input polarization independent operation.

2. Depolarizing Quasimonochromatic Light

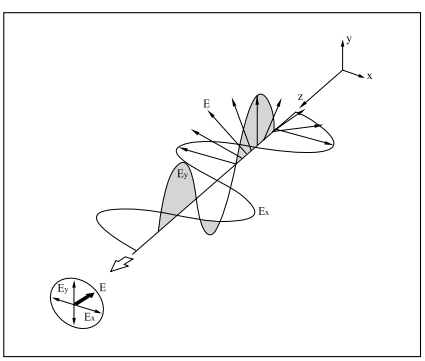


FIGURE III-1
The path of electric vector of right elliptic polarized light at a fixed time

Electric field vector of lightwave traveling through a medium along a certain direction, say z-axis, can be decomposed into two orthogonal directions, x- and y-axes. Figure III-1 illustrates the path of electric vector of a polarized light at a fixed time. The state of polarization can be described in terms of amplitude of each electric field component and the phase difference between them. Since a quasimonochromatic light maintains its sinusoidal amplitude with constant phase only for coherence time t_c or coherence length l_c, it can be depolarized by introducing optical path difference that is longer than the coherence length between the orthogonal polarization modes.

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This depolarizing method seems to be the simplest way to get an unpolarized light in principle. However it fails to be practical in many applications where the spectral linewidth of the light source is too narrow. For example, in order to depolarize a conventional DFB LD that has 0.01nm FWHM, we may give phase delay between the two polarization components by transmitting the light through a high birefringence fiber. In this case, the length of the fiber would be as long as 620 meters for a PMF having 4mm-polarization mode beat length. Moreover, this method gives rise to very large PMD of 800ps, which makes it impractical in most communication applications.

Polarization scrambling is the right solution for depolarizing any kinds of light sources regardless of their spectral linewidths. Polarization scrambling can be understood as polarization modulation. DOP of light can be made zero by modulating the SOP at a speed much faster than the detection bandwidth or the time constant of the system under consideration.

SOP of light is modulated via modulation of birefringence of the medium through which the light passes. Therefore polarization scramblers are classified into several types depending on the types of birefringence modulators. **FIBERPRO**'s PS3000 series is based on all-single mode fiber technology to give very low insertion loss and practically no return loss, PDL and PMD. The birefringence modulator composed of a single mode fiber and an acousto-optic transducer is driven by a sinusoidal RF signal of 700~1,200 kHz typically. **FIBERPRO**'s PS3000 series has double or triple-stage birefringence modulator to achieve input polarization-independent operation.

3. Mathematical Description of Polarization Scrambler

Electric field vector of a quasimonochromatic light travelling along z-axis is decomposed into two mutually orthogonal directions, say, x- and y-axis, thus expressed as

$$E_x = a_x \exp[i\varphi_x(t)], \quad E_y = a_y \exp[i\varphi_y(t)] \qquad \text{Eq. III-1}$$

where the phase difference δ is given by

$$\delta = \varphi_x(t) - \varphi_y(t). \qquad \text{Eq. III-2}$$

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The key fact of polarization scrambling is modulating the phase difference in a proper way to make DOP zero in time average. Figure III-2 shows the concept of polarization scrambling.

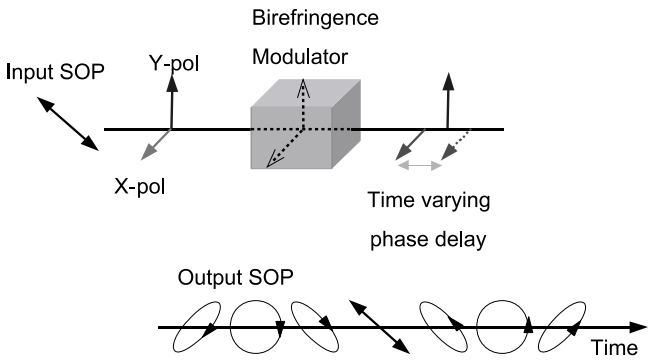


FIGURE III-2 Conceptual view of polarization scrambling.

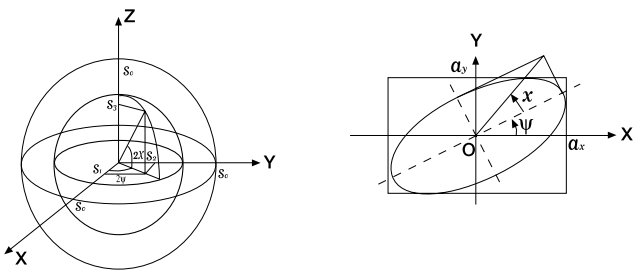


FIGURE III-3 The poincare sphere and general form of the ellipse

Figure III-3 shows the relationship between the Stokes parameter on the Poincare sphere and the polarization ellipse.

In terms of Stokes parameters defined as Eq. III-3.

$$\begin{aligned} S_0 &= < a_x^{\,2} > + < a_y^{\,2} >, \\ S_1 &= < a_x^{\,2} > - < a_y^{\,2} >, \\ S_2 &= 2 < a_x a_y \cos\delta >, \\ S_3 &= 2 < a_x a_y \sin\delta >, \end{aligned} \qquad \text{Eq. III-3}$$

And the effective DOP is given by Eq. III-4.

$$DOP = \frac{I_{pol}}{I_{tot}} = \frac{\sqrt{S_1^{\,2} + S_2^{\,2} + S_3^{\,2}}}{S_0}. \qquad \text{Eq. III-4}$$

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In Eq. III-3 〈 〉 notates time average of the parameter inside it. In order to make the effective DOP equal to zero, the last three Stokes parameters should be made equal to zero.

$$S_1 = S_2 = S_3 = 0. \qquad \text{Eq. III-5}$$

It is straightforward to derive the optimum operating condition for the polarization scrambler from Eq. III-3 and Eq. III-5 as will be described below.

The birefringence modulators are driven by sinusoidal signals. It follows that the time-varying phase delay $\Delta\phi$ between the two polarization modes of a birefringence modulator takes the form,

$$\Delta\phi = \phi_0 + \phi_m \sin(\omega t + \alpha) \qquad \text{Eq. III-6}$$

where ϕ_0 is the constant phase delay due to the modulator geometry-induced birefringence and ϕ_m is the amplitude of the birefringence modulation. ω and α are the angular frequency and phase of applied RF signal, respectively.

Let us take the Jones matrices of each birefringence modulator in figure III-4 as $M_1(\Delta\phi_1)$ and $M_2(\Delta\phi_2)$, respectively. Then the Jones vector of the output SOP, E_{out} can be expressed as successive multiplication of the Jones vector of the input SOP, E_{in} with M_1 and M_2.

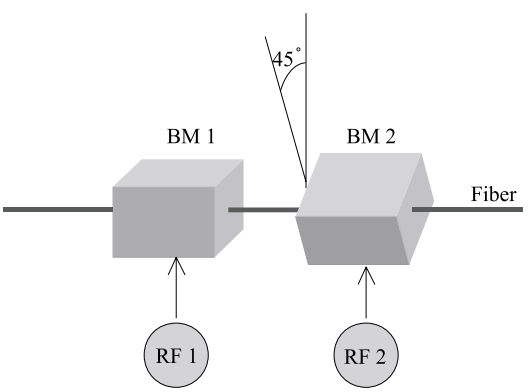


FIGURE III-4 Schematic diagram of PS3000 series polarization scrambler. The birefringence axis of the second modulator is 45° with respect to the axis of the first one.

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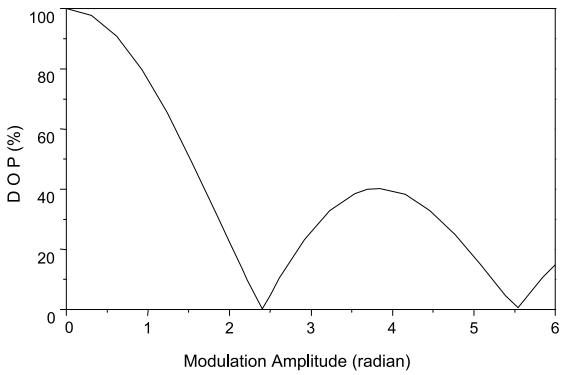


FIGURE III-5 DOP as a function of modulation amplitude of a birefringence modulator.

$$E_{out} = M_2 M_1 E_{in} \qquad \textbf{Eq. III-7}$$

If we put the components of E_{out} into Eq. III-3 and use Eq. III-5, then after a little algebra we get the expression for zero DOP condition.

$$J_0(\phi_{m1}) = J_0(\phi_{m2}) = 0 \qquad \textbf{Eq. III-8}$$

where J_0 is the 0th order Bessel function of the first kind. To satisfy Eq. III-8 the birefringence modulation amplitudes, ϕ_{m1} and ϕ_{m2} should be one of the roots of J_0. So the modulation amplitude would be around 2.405. Plotted in figure III-5 is DOP as a function of modulation amplitude for a birefringence modulator.

It is worthwhile to speculate as to the trace of SOP on the Poincare sphere. First, let us assume we have only one birefringence modulator. If we put a linearly polarized light into the modulator with its polarization direction at 45° with respect to the birefringence axis of the modulator, the trace would be a simple curve on the sphere as depicted in figure III-6. It represents the rotation of the SOP around the birefringence axis of the modulator. While the trace does not complete a great circle because the modulation amplitude is 2.405, the DOP is zero.

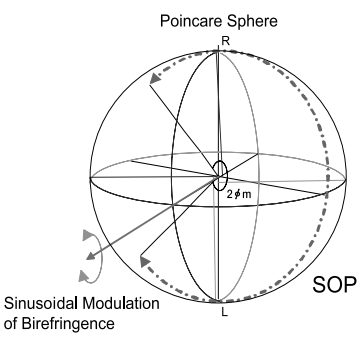


FIGURE III-6 Trace of SOP on the Poincare sphere by a single-stage birefringence modulator

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Although the PS has a double-stage birefringence modulator, polarization scrambling occurs only at the second-stage modulator in the case where the input polarization is linear and aligned to the birefringence axis of the first modulator. That is why the light passes the first stage-modulator without any change SOP and is incident on the second stage-modulator with its polarization direction at 45° to the birefringence axis of that modulator.

Shown in figure III-7 is the trace of SOP when the light is incident on the first-stage modulator of the double-stage birefringence modulator with its two polarization components projected equally onto the fast- and slow-axis of the modulator. This trace has been plotted for 200μsec. The output SOP moves pseudo-randomly on the Poincare sphere but it still does not cover the whole surface.

In most applications including the polarization dependant gain (PDG) suppression of long-haul transmission systems, polarization independent measurement systems, and fiber interferometric sensor systems, the important factor is the DOP itself, not whether the SOPs cover the whole surface of the Poincare sphere or not. **FIBERPRO** also provides triple-stage modulator type Polarization Scramblers PS3200 - for such applications that require full coverage of the Poincare sphere.

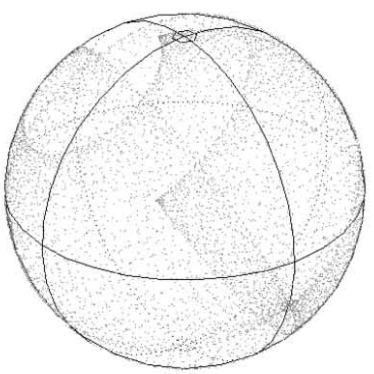


FIGURE III-7 Trace of SOP on the Poincare by double stage birefringence modulator. Plotted for 200μsec.

4. Measurement Bandwidth Limitation

You must consider how the detector bandwidth should be limited in order to get sufficiently low effective DOP for your systems when using the PS.

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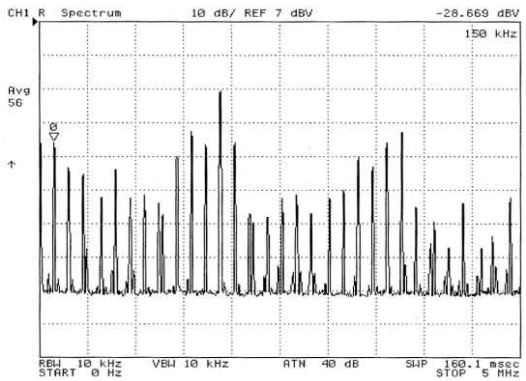


FIGURE III-8 RF spectum of the optical output of a PS measured through a polarizer. $f_1 = 940kHz$. $f_2 = 790kHz$. The first prominent peak corresponds to $f_1 - f_2 = 150kHz$.

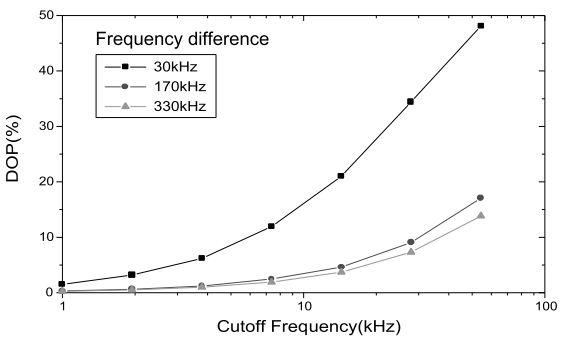


FIGURE III-9 DOP as a function of cutoff frequency of low pass fiter at the photodetector. Curves are drawn for different settings of frequency difference between the two modulation frequencies.

The required limit of bandwidth is determined by the two frequencies, f1 and f2 of the RF signals applied to the double-stage birefringence modulator. If we put a polarizer at the output of the PS and observe the optical output with a fast detector to get frequency distribution, the detected signal would consist of the sum of the harmonics of f1, f2 and the beating terms between them (figure III-8). If the light is to be seen as unpolarized, it is required that the detector bandwidth be much lower than |f1-f2| which is the difference of the two driving frequencies. As seen in figure III-8, there is no prominent frequency component below it.

Figure III-9 shows the output DOP as a function of the detector cutoff frequency for several cases of different driving frequencies. Standard polarization scramblers are designed to have frequency difference about 170kHz, which corresponds to the middle curve with solid circle symbols. The curve indicates that the detector cutoff frequency should be less than 10kHz to achieve DOP less than 5%.

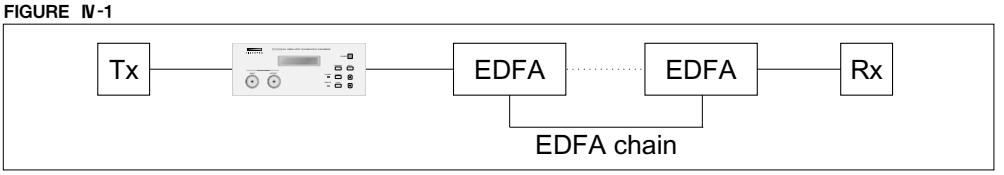
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IV. Applications

1. PDG Reduction

The PS can remove polarization dependent gain (PDG) of a long EDFA chain. An EDFA has PDG induced by polarization hole burning (PHB) of which the time constant is approximately 1msec. If the light signal is polarization scrambled faster than the response of the EDFA, PDG gets suppressed and so does the degradation of SNR due to it.

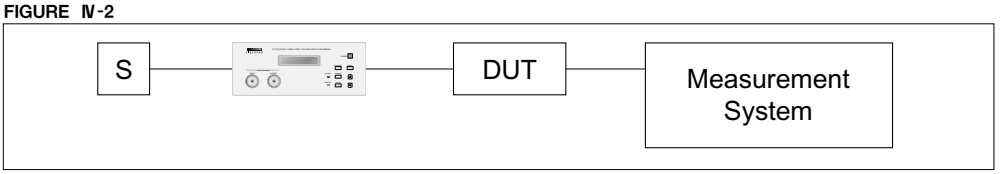
FIGURE IV-1



2. Removing PDL of DUT

The PS can be used to depolarize optical source for polarization independent measurement. The measurement system can interrogate accurate value of the DUT characteristics such as insertion loss, filter profile and etc.

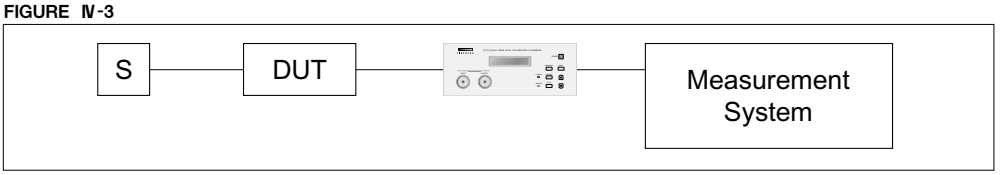
FIGURE IV-2



3. Removing PDL Induced Instrumental Error

Some measuring instruments have polarization dependence. This gives rise to errors in measurements. The PS removes polarization dependence of the measuring instrument.

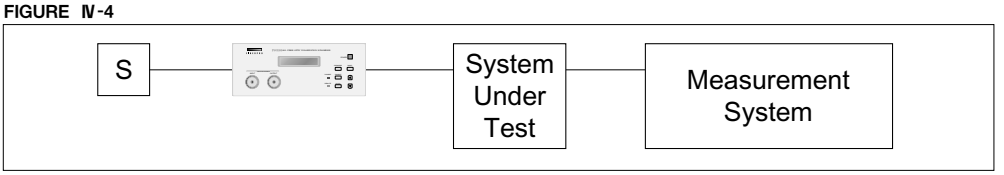
FIGURE IV-3



4. Pseudo-random Polarization Generation

The PS generates pseudo-random polarization states at high speed. This can be utilized in testing telecom systems under polarization variation.

FIGURE IV-4



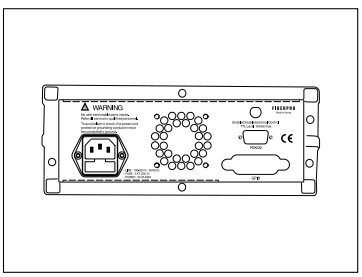
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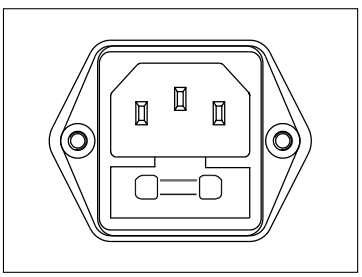
V. Replacing Fuse - new PS series

When your fuse is blown out, follow the replacing procedure below. But you must use the right fuse for the line voltage. Select proper fuse–2A 250V. 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

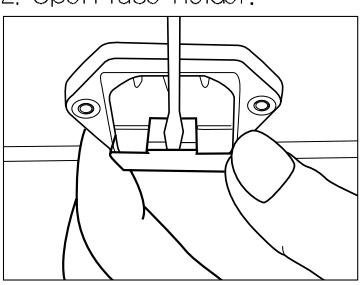
1. Finding fuse holder.





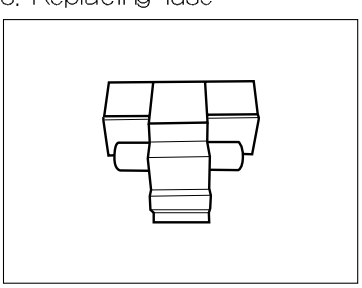
The fuse holder box is on the rear panel of PS series. Stop your work and put PS on the plat table. And then, pull out the cables. Fuse holder box is left below side of the rear panel.

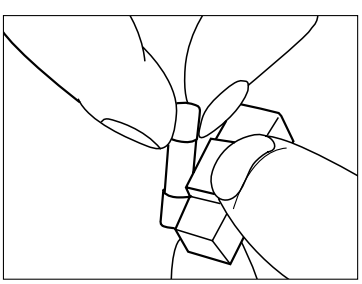
2. Open fuse holder.



Lever a small minus screwdriver cautiously and pull out fuse holder cautiously. Should then you pull out the fuse holder

3. Replacing fuse

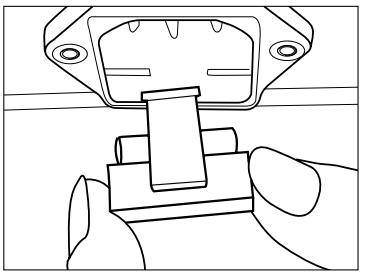




Pull out the old fuse with care and replace to a new one.

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4. Put into the fuse holder box.



Put the fuse holder into the fuse holder box. Do not thrust fuse holder into the box. Try again if the two parts do not fit.

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!

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