Newport

932 Series Attenuator Manual
(Includes 932-CX Controller)

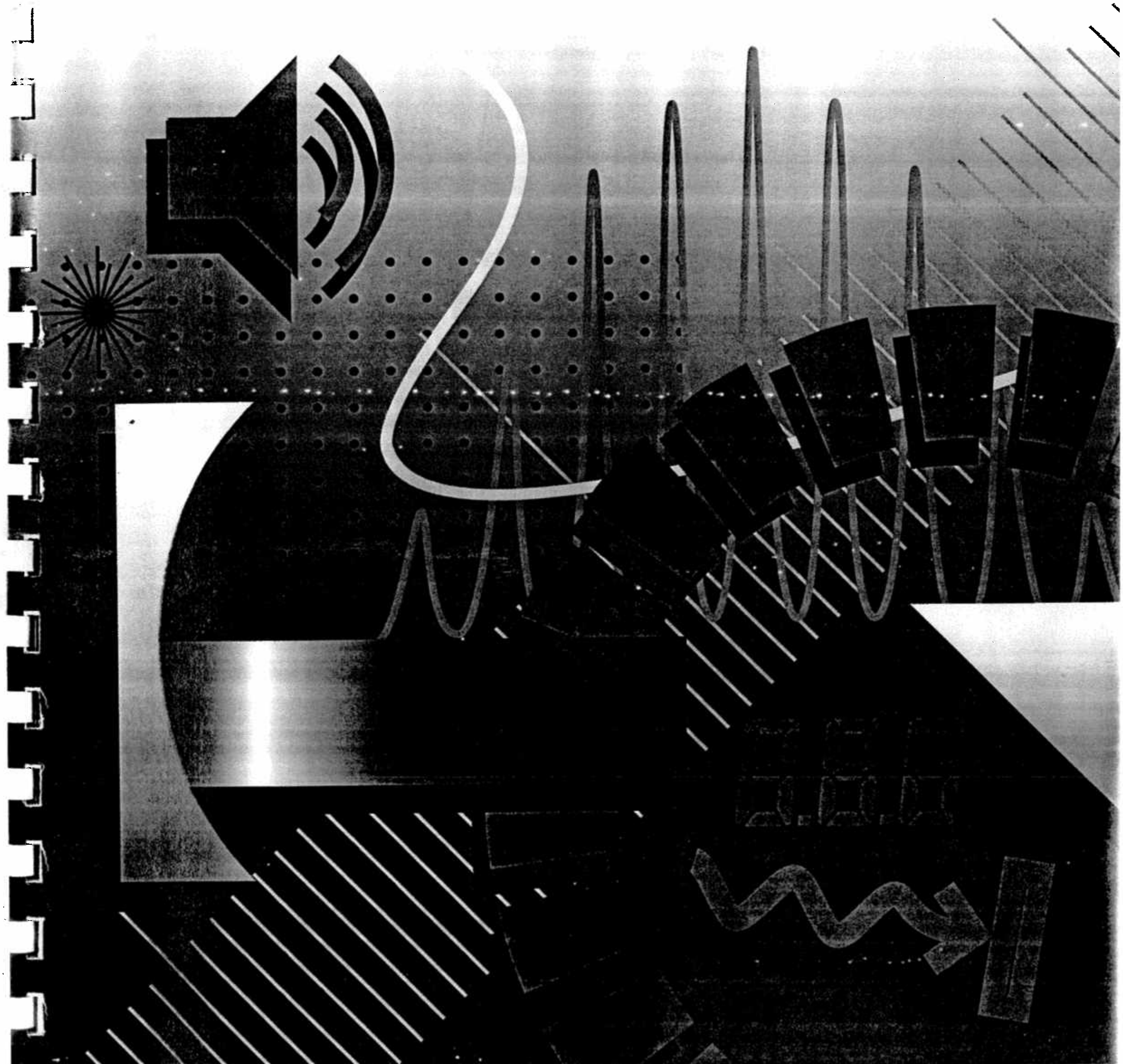


Table of Contents

List of Illustrations

About This Manual

This Operator's Manual contains all the necessary information for the proper installation and operation of the Newport Corporation 932 Liquid Crystal Attenuator.

The manual has been divided into the following sections:

Section 1 gives a brief overview of the 932, including instructions for unpacking.

Section 2 provides you with operating procedures.

Section 3 provides overall theory of operation for the system.

Section 4 provides troubleshooting and adjustment procedures.

Section 5 instructs you on the proper way to obtain service for your 932.

Section 6 describes the components and assembly procedures for the following applications:

— Twyman-Green Interferometer Phase Shifter

— Voltage Controlled NIR Attenuator

— Voltage Controlled Polarization Rotator

— Voltage Controlled Attenuator/Beamsplitter

— Voltage Controlled Polarization Rotator for Laser Diodes

— Retardance Measurement

Safety Precautions

The following safety precautions should be observed prior to operation of the 932 Variable Attenuator.

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with safety precautions required to avoid possible injury. Read the manual carefully before operating the instrument and heed all written warnings.

For your own safety and that of your equipment, always take the following precautions.

Disconnect the power plug under the following circumstances:

— If the power cord or any attached cables are frayed or damaged in any way.

— If the power plug is damaged in any way.

— If the unit is exposed to rain, excessive moisture, or liquids are spilled on the unit.

— If the unit has been dropped or the case is damaged.

— If you suspect service or repair is required.

— Whenever you clean the case.

Specifications

Parameter	Specification
Model 932-xxx Attenuator Module	
Material	nematic liquid crystal between fused silica substrates
Optical	
Clear aperture:	0.35 in. (8.9 mm)
Transmitted wavefront distortion:	¼ wave peak-to-valley @633 nm
Transmission:	>92% in specified range
Reflection:	<1.6% per surface
Beam deviation:	<2 min.
Wavelength range:	Visible: 400 nm to 700 nm Near IR: 650 nm to 1000 nm IR: 1000 nm to 1550 nm
Retardance range:	0 to half wave
Retardance variation:	<3% RMS over clear aperture
Extinction Ratio:	>300:1 in specified range
Laser Damage Threshold:	1 J/km² @1064 nm, 10 nsec pulse, >1000 W/km² CW @514.5 nm
Rise time:	5 msec typical (10% to 90%)
Fall time:	40 msec typical (90% to 10%)
Electrical (Liquid Crystal)	
Cable length:	6 feet
Electrical drive:	2 kHz square wave AC voltage 0 V to 13 V amplitude
Capacitance:	<3 nF
Operating temperature range:	10°C to 60°C
Dimensions:	1.20 in. dia. x 3.96 in. max. (30.5 mm dia. x 100.5 mm max.)
Weight:	6.0 oz. max.

Parameter	Specification
Controller	
Output voltage:	0 V to 13 V
Maximum load:	10 mA, 3 nF
Modulation frequency:	External: 0 to 150 Hz analog signal, Maximum LC response <12.5 Hz
Operating temperature range:	0°C to 40°C
Storage temperature range:	−55°C to 100°C
Power supply:	115 VAC 60 Hz 5 Watts or 230 VAC 50 Hz 5 Watts
Dimensions:	3.5 in. high x 7.5 in. wide x 8.7 in. deep (88.9 mm x 190.5 mm x 221 mm)
Weight:	2.5 lbs

Input Z: 20 kΩ

Section 1
Introduction

1.1 System Overview

The model 932 is designed to be a variable attenuator in its respective wavelength range. The system consists of a controller and the liquid crystal optical head plus accessory polarization optics and holders.

The controller provides a 2 kHz square wave AC voltage of variable amplitude for adjusting the attenuation level. The attenuation can be continuously adjusted or modulated through an external input.

The 932 system can also function as a variable retarder when the polarizers are removed. Adjusting for the proper voltage can yield a quarter waveplate, half waveplate or any fraction of a waveplate desired.

Other possibilities for the 932 system will be described in Section 3, Theory of Operation and Section 6, Appendices.

1.2 Unpacking and Inspection

The 932 system was thoroughly tested and inspected prior to shipment. Carefully inspect the outer containers for signs of damage. If you find any damage please notify the shipping company and contact Newport Corporation for further instructions.

The following table lists the components which you should have received with your system.

Model No.	Quantity	Description
932-XXX	1	Attenuator module and controller plus accessory optics
	1	Manual
	1	Metric Wrench

Section 2
System Operation

2.1 Preparing the System for Operation

Attach the cube holder(s) to the Variable Retarder using the wrench which was supplied. Align the input polarizer (if one was supplied) to your source. Align the exit polarizer 90° rotated to the input polarizer.

On the controllers rear panel (figure 2.1) you will find a power cord connector and line voltage switch.

1. Select the correct VAC setting to match your AC voltage. To do this:
   a) Insert a flat-head screwdriver into the notch of the red line voltage switch located on the rear panel.
   b) Set the line voltage switch to correspond to the line voltage available. The ranges are: 90–115 V
      200–230 V.
2. Attach the power cord connector and the other end to your power source.

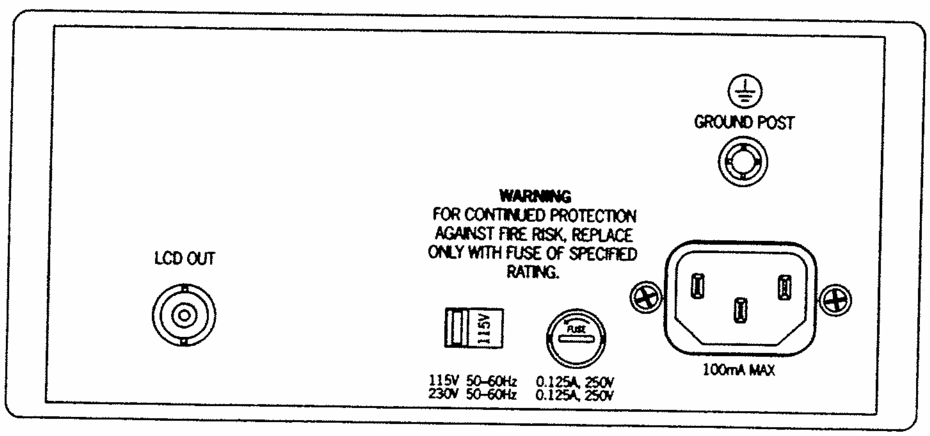


Figure 2.1 — Controller Rear Panel

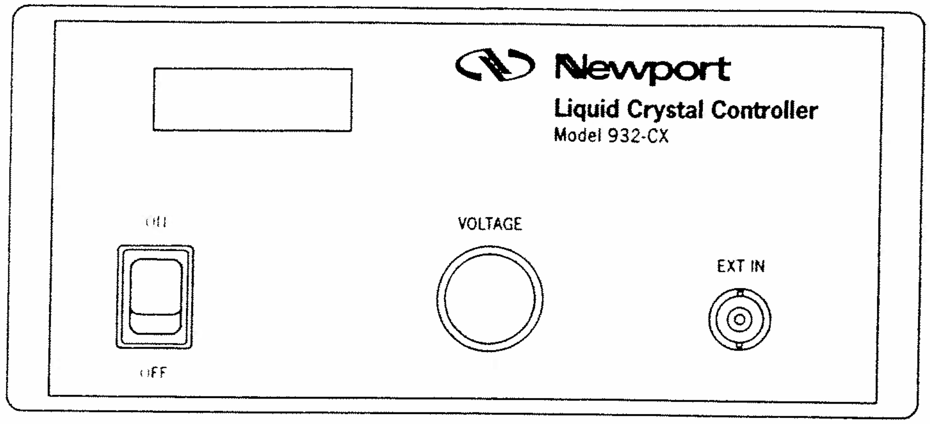


Figure 2.2 — Controller Front Panel

On the controllers front panel (figure 2.2) make sure the power switch is off.

1. Connect the attenuator's BNC connector to the controller's LCD out connector, *located on the rear panel.*
2. Turn the voltage control knob counterclockwise until it stops.
3. The power switch may now be turned on.
4. The display should show 0.0 V.

2.2 System Operation

The 932 Attenuator can be operated in two different modes.

1. Continuous attenuation control with the front panel knob.
2. Continuous remote control with an externally applied analog voltage.

2.2.1 Front Panel Operation

1. Operation of the attenuator with the front panel control knob.
   a) Do not connect anything to the front panel EXT IN BNC connector.
   b) Turn the voltage control knob counterclockwise until it stops.
   c) Switch the front panel red power switch to the ON position.
   d) Align your source or input polarizer so that the polarization axis is horizontal. (see figure 2.3)
   e) Slowly increase the voltage using the voltage control knob. The transmission of the beam should decrease then increase again. (see figure 2.4)
   f) For vertical input polarization remove the input polarizing cube, if there is one, then increase the voltage.

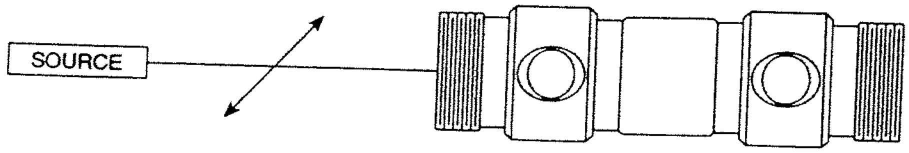


Figure 2.3 — Variable Attenuator

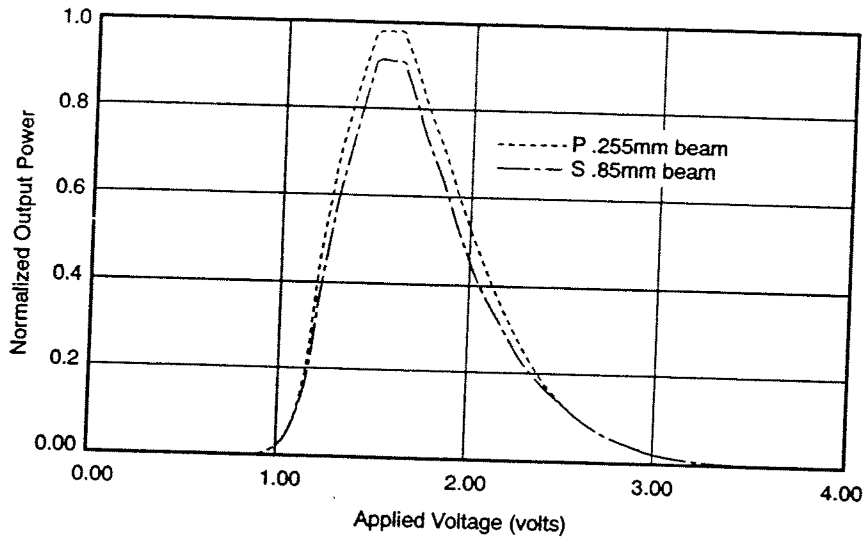


Figure 2.4 — Transmission vs. Voltage

2.2.2 Remote Operation

Remote control of attenuation from an external source.

1. Follow the procedures above for "Front Panel Operation" to determine the voltage settings corresponding to the minimum and maximum attenuation levels you wish to achieve. Let V1 and V2 correspond to the displayed voltages for the minimum and maximum attenuation levels respectively. Figure 2.5 indicates the 932-CX output waveform for two different voltage settings. After you have recorded these values turn the VOLTAGE knob counter clockwise until it stops rotating and then switch the red power switch to the OFF position.

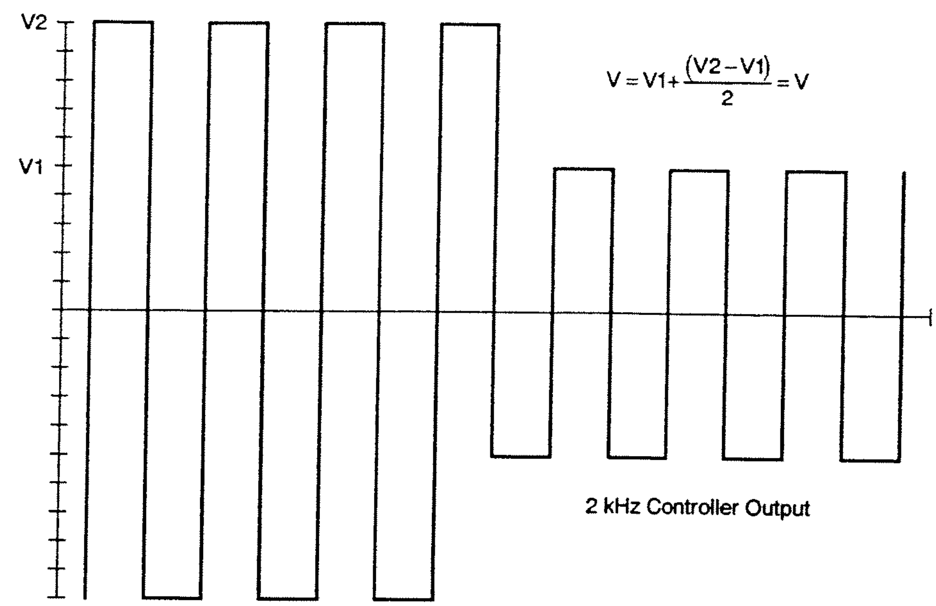


Figure 2.5 — Drive Signal at Two Retardance Levels

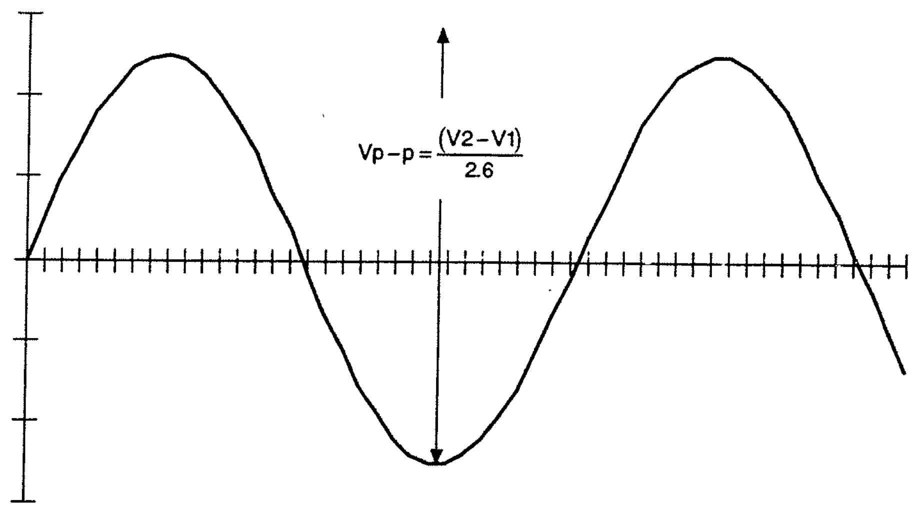


Figure 2.6 — External Modulation Signal

2. To vary the attenuation level remotely, an external voltage source with zero offset and a peak-to-peak range of (V2–V1)/2.6 is required. With the external source connected to an oscilloscope make the proper voltage adjustments. If external modulation is desired, the source frequency should not exceed 12.5 Hz for full modulation depth. Figure 2.6 shows an sinusoidially varying input voltage of the proper amplitude.

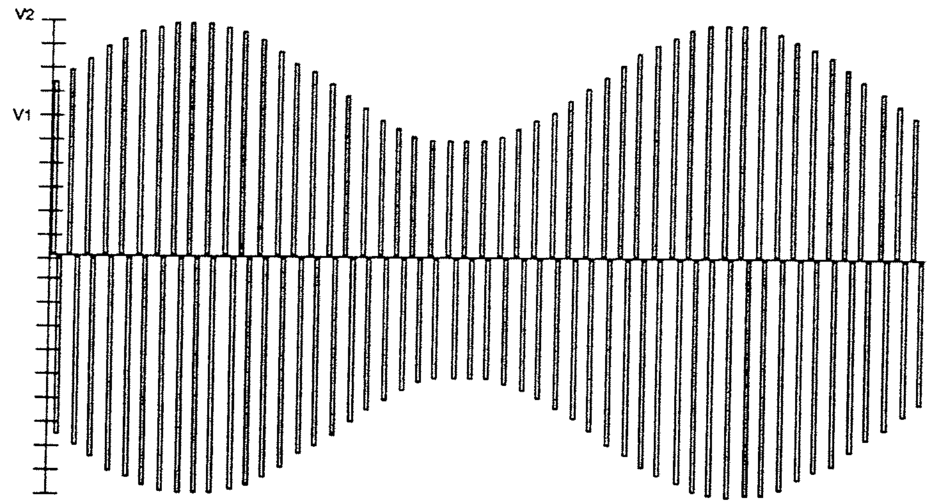


Figure 2.7 — Modulated Controller Output

3. Attach your external source to the EXT IN BNC connector on the 932-CX front panel. Switch the power switch to the ON position. Adjust the VOLTAGE knob until the panel reading equals V1+(V2-V1)/2. Figure 2.7 shows the 932-CX output waveform to the liquid crystal head under the influence of the externally applied voltage.

Section 3
Theory of Operation

3.1 Liquid Crystal Variable Retarders

The 932 Variable Attenuator operates without any mechanical moving parts. The heart of the system is a nematic liquid crystal retarder in combination with various polarizer options. The optical birefringence of the liquid crystal material can be changed by an applied electric field. Changing the birefringence effectively modifies the index of refraction along a preferred axis as seen by an incident beam of light. Thus by varying the voltage applied to the liquid crystal element, the polarization characteristics of a transmitted beam can be modified.

The liquid crystal retarder operates by using a 2 kHz square wave AC voltage of adjustable amplitude. The 2 kHz frequency is above the response range of the liquid crystal. A fixed AC voltage amplitude provides a fixed retardance. Voltage tuning provides retardance over a minimum range of 0 to one half wave. Maximum retardance occurs at zero applied voltage. The retardance decreases as the amplitude of the applied AC voltage is increased. The response time of these devices depends on several parameters such as the thickness of the liquid crystal sell, viscosity, temperature, etc. For switching or modulation applications the rise and fall times are in the range of 5 msec and 40 msec respectively. Hence limiting the modulation frequency to a maximum of about 12.5 Hz.

Figures 3.1, 3.2 and 3.3 are typical voltage versus retardance characteristics for liquid crystal retarders designed for three different wavelength ranges. These graphs are representative data only and should not be construed as performance specifications. One method for determining the characteristics for your device is described Section 6 — Appendices.

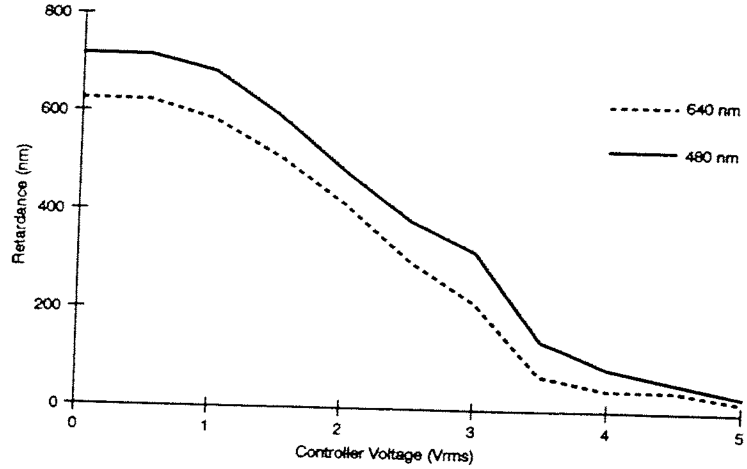


Figure 3.1 — Voltage vs. Retardance (Visible Range)

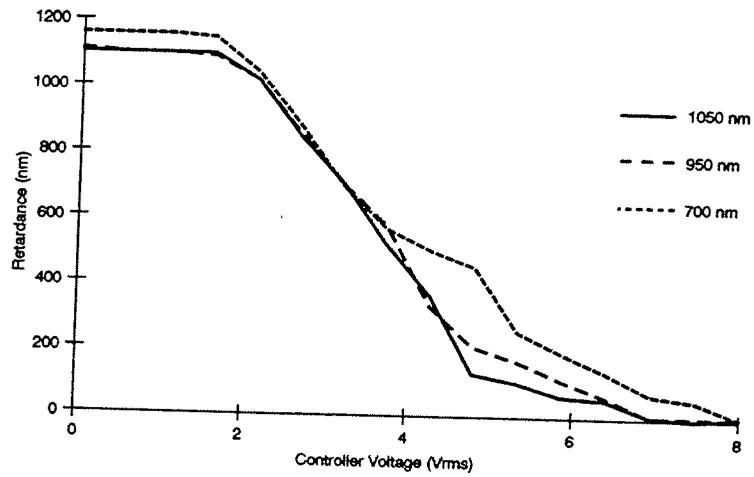


Figure 3.2 — Voltage vs. Retardance (NIR Range)

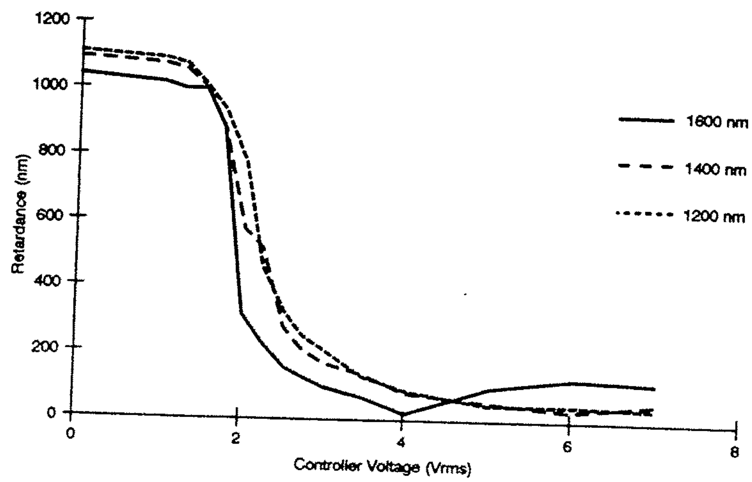


Figure 3.3 — Voltage vs. Retardance (IR Range)

3.2 Applications

3.2.1 Variable Attenuator

The 932 variable attenuator consists of a liquid crustal variable retarder assembled between two polarizers. Adjusting the amplitude of the electrical signal changes the polarization state of the attenuator. Since the beam is polarized by the entrance polarizer, the liquid crystal retarder acts on the polarized beam to alter its polarization state. The exit polarizer only allows transmission of the appropriately aligned polarization component. Detailed descriptions for various attenuator configurations are described in the appendix.

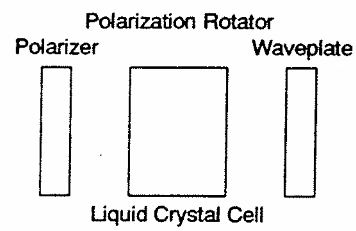


Figure 3.4 — Variable Attenuator

3.2.2 Variable Beamsplitter

If the exit polarizer in the variable attenuator described in Section 3.2.1 is replaced with a polarizing beamsplitter cube, a variable beamsplitter assembly results. Varying the voltage applied to the liquid crystal element will change the ratio of reflected to transmitted light exiting the beamsplitter cube.

For a detailed description of applications and assemblies see the appendix.

Section 4
Troubleshooting

The following section provides some actions to take in response to problems which you may encounter while operating the 932 Attenuator.

4.1 Troubleshooting Guide

Problems which you may encounter while operating the 932 Attenuator are discussed along with recommended solutions.

Problem: Attenuator does not effect transmitted light intensity as voltage is varied.

Solution: Check to make sure liquid crystal head is plugged into the LCD OUT BNC connector on the controller back panel. Check effect with polarizers aligned and with polarizers crossed.

Section 5
Service

5.1 Introduction

This section contains information regarding obtaining factory service for the 932 Attenuator. The user should not attempt any maintenance or service of the 932 Attenuator beyond the procedures given in Section 4: Troubleshooting. Any problems which cannot be resolved using the guidelines listed in Section 4 should be referred to Newport Corporation factory service personnel. Contact Newport Corporation or your Newport representative for assistance.

5.2 Obtaining Service

To obtain information concerning factory service, contact Newport Corporation or your Newport representative. Please have the following information available:

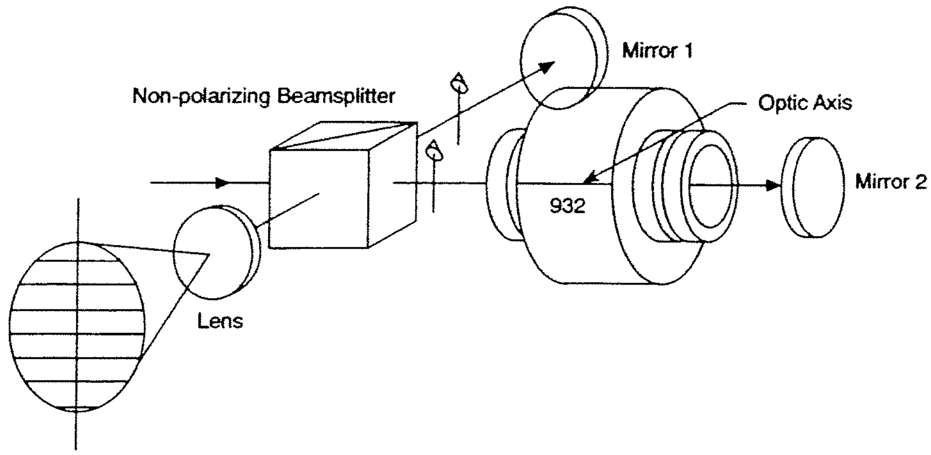
1. Instrument Model Number

2. Description of the problem.

If the instrument is to be returned to Newport Corporation, you will be given a Return Number, which you should reference in your shipping documents.

Please fill out the service form, located on page 13, and have the information ready when contacting Newport Corporation. Return the completed service form with the instrument.

Section 6
Appendices



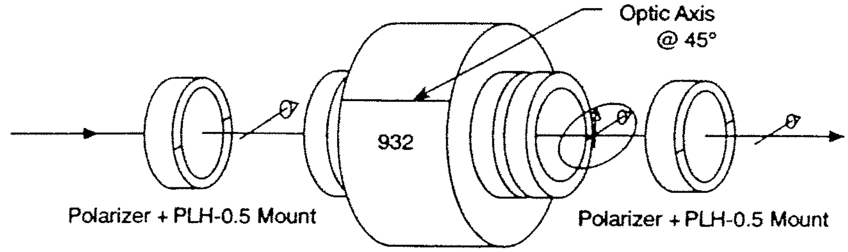
Twyman-Green Interferometer Phase Shifter

Required components:

1. Model 932 (1 each, 932-CX controller and LCR-XXX optical head).
2. 1 Model CH-0.5 cube holder, 1 model CH-PORT adaptor, 1 model MLH-0.5, 1 each MM-1 and MM-50H mirror mount and holder or equivalent.
3. 1 Non-polarizing beamsplitter cube (BSC), dimensions: 0.5 inch on a side.
4. 2 mirrors, 0.5 inch diameter.
5. 1 imaging lens.

1. Assemble the beamsplitter cube (BSC) into model CH-0.5 cube holder, 1 mirror in the PLH-0.5 and 1 mirror in the MM-1H/MM-1. Be careful to correctly orient the mirrors in their holders.
2. If the laser is not polarized install a polarizer at the laser output. The following procedure assumes a linearly S-polarized beam.
3. Position the CH-0.5 in the beam path. Center on the laser beam and adjust positioning so the beam is normal to the optic (see diagram).
4. Attach the 932 to the transmitted port of the CH-0.5. Rotate until the optic axis is perpendicular to the beam polarization direction and secure with the CH-0.5 set screw.
5. Attach the CH-PORT to the CH-0.5 and install the MLH-0.5 with mirror. Tighten the CH-PORT set screw to secure the assembly.
6. Position the MM-50H/MM-1 (this assembly contains Mirror 2 in the diagram) at the output of the 932. Adjust the mirror position until the combined beams from Mirror 1 and Mirror 2 overlap. Position the imaging lens as shown in the diagram and fine tune the alignment of Mirror 2 until fringes can be observed on a card.
7. Plug the 932 liquid crystal head into the 932-CX controller. Turn the VOLTAGE knob and observe the fringe movement in the interference pattern. For external control of fringe shifting or modulation of fringes see Section 2.2.2 Remote Operation.

Voltage Controlled NIR Attenuator

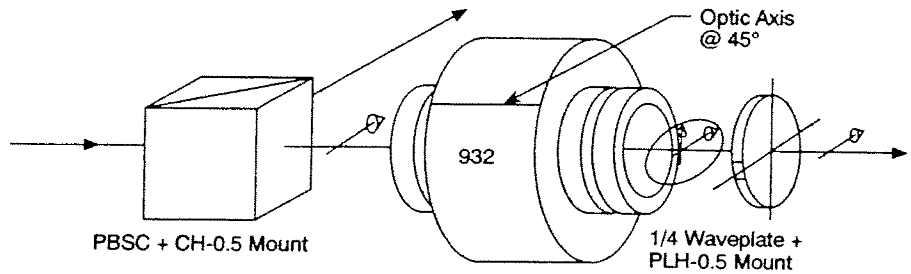


Required components:

1. Model 932 (1 each, 932-CX controller and LCR-NIR optical head).
2. 2 Model PLH-0.5 optic holders.
3. 2 Polarizers, dimensions: 0.5 inch diameter.
4. 1 Optical power meter.

1. Assemble polarizers into model PLH-0.5 holders.
2. Position the model 932 in the beam path. Center the 932 aperture on the laser beam and adjust positioning so the beam is normal to the optic. If the incident beam is polarized it is recommended to orient the 932 so that its optical axis (indicated by the white line scribed on the side) is at 45°.
3. Attach one of the PLH-0.5 to the input side of the 932. The polarization of the beam exiting the PLH-0.5 will be linear and will be oriented parallel to the scribe line on the polarizer mounting ring (see diagram). Rotate the PLH-0.5 until the transmitted beam polarization orientation is at 45° to the optic axis of the 932. If the laser source is polarized, the PLH-0.5 should be rotated to a position that is both at 45° to the optic axis of the 932 and aligned with the laser polarization direction. When properly aligned, tighten the set screw on the PLH-0.5 to secure the assembly.
4. Attach the second LH-0.5 to the exit port of the 932 optical head. Rotate the PLH-0.5 until it is aligned either perpendicular or parallel to the orientation of the entrance polarizer. Secure the assembly by tightening the set screw on the PLH-0.5.
5. Plug the 932 optical head into the 932-CX controller. Turn the voltage control knob counter clockwise to its end position, so that the display shows 0.00V.
6. Position the optical power meter detector to read the output power from the assembly. Rotate the voltage control knob to vary the transmitted intensity.

Voltage Controlled Polarization Rotator



Required components:

1. Model 932 (1 each, 932-CX controller and LCR-XXX optical head).
2. 1 Model PLH-0.5 optic holder.
3. 1 Model CH-0.5 cube holder.
4. 1 Polarizing beamsplitter cube (PBSC), dimensions: 0.5 inch on a side.
5. 1 quarter waveplate, 0.5 inch diameter.
6. 1 Optical power meter.
7. Reference polarizer with polarization axis indicated.

1. Assemble polarizer and waveplate into model CH-0.5 and PLH-0.5 holders respectively.

2. Position the model 932 in the beam path. Center the 932 aperture on the laser beam and adjust positioning so the beam is normal to the optic. If the incident beam is polarized it is recommended to orient the 932 so that its optical axis (indicated by the white line scribed on the side) is at 45°.

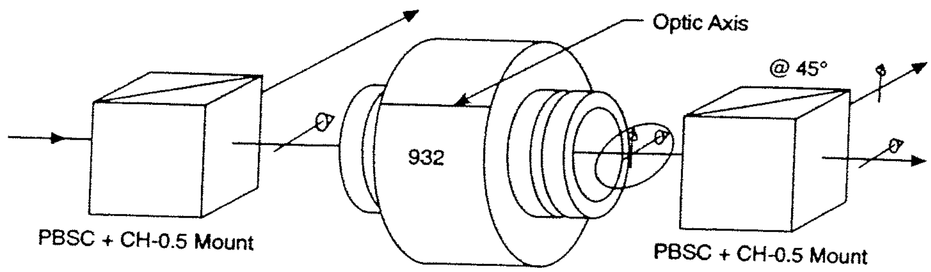
3. Attach the CH-0.5 containing the polarizer to the input side of the 932. The polarization of the beam exiting the CH-0.5 will be linear and will be oriented parallel to the ground surface of the cube (see diagram). Rotate the CH-0.5 until the transmitted beam polarization orientation is at 45° to the optic axis of the 932. If the laser source is polarized, the CH-0.5 should be rotated to a position that is both at 45° to the optic axis of the 932 and aligned with the laser polarization direction. When properly aligned, tighten the set screw on the CH-0.5 to secure the assembly.

4. Attach the PLH-0.5, with waveplate, to the exit port of the 932 optical head. Rotate the PLH-0.5 until the optic axis of the waveplate (see diagram) is aligned either parallel or perpendicular to the orientation of the entrance polarizer. Secure the assembly by tightening the set screw on the PLH-0.5.

5. Plug the 932 optical head into the 932-CX controller. Turn the voltage control knob counter clockwise to its end position, so that the display shows 0.00V.

6. Position the reference polarizer after the PLH-0.5. Position the optical power meter detector to read the power transmitted by this polarizer. Rotate the voltage control knob to vary the transmitted intensity. Rotate the reference polarizer to determine the orientation of the polarization output of the 932 assembly.

Voltage Controlled Attenuator/Beamsplitter

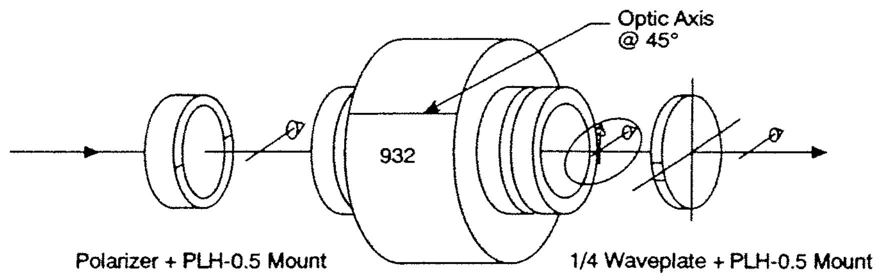


Required components:

1. Model 932 (1 each, 932-CX controller and LCR-XXX optical head).
2. 2 Model CH-0.5 cube holders.
3. 2 Polarizing beamsplitter cubes (PBSC), dimensions: 0.5 inch on a side.
4. 1 Optical power meter.

1. Assemble polarizers into model CH-0.5 cube holders.
2. Position the model 932 in the beam path. Center the 932 aperture on the laser beam and adjust positioning so the beam is normal to the optic. If the incident beam is polarized it is recommended to orient the 932 so that its optical axis (indicated by the white line scribed on the side) is at 45°.
3. Attach one of the CH-0.5 cube holders to the input side of the 932. The polarization of the beam exiting the PBSC will be linear and will be oriented parallel to the ground surface of the cube (see diagram). Rotate the CH-0.5 until the transmitted beam polarization orientation is at 45° to the optic axis of the 932. If the laser source is polarized, the CH-0.5 should be rotated to a position that is both at 45° to the optic axis of the 932 and aligned with the laser polarization direction. When properly aligned, tighten the set screw on the CH-0.5 to secure the assembly.
4. Attach the second CH-0.5 cube holder to the exit port of the 932 optical head. Rotate the CH-0.5 until it is aligned either perpendicular or parallel to the orientation of the entrance cube. Secure the assembly by tightening the set screw on the CH-0.5 entrance port.
5. Plug the 932 optical head into the 932-CX controller. Turn the voltage control knob counterclockwise to its end position, so that the display shows 0.00V.
6. Position the the optical power meter detector to read the output power from the last CH-0.5. Rotate the voltage control knob to vary the ratio of transmitted to reflected light. A display reading of 0.7 V will be the maximum transmission setting at 632.8 nm.

Voltage Controlled Polarization Rotator for Laser Diodes



Required components:

1. Model 932 (1 each, 932-CX controller and LCR-XXX optical head).
2. 2 Model PLH-0.5 optic holders.
3. 1 Polarizer, dimensions: 0.5 inch diameter.
4. 1 quarter waveplate, 0.5 inch diameter.
5. 1 Optical power meter.
6. Reference polarizer with polarization axis indicated.

1. Assemble polarizer and waveplate into model PLH-0.5 holders.

2. Position the model 932 in the beam path. Center the 932 aperture on the laser beam and adjust positioning so the beam is normal to the optic. If the incident beam is polarized it is recommended to orient the 932 so that its optical axis (indicated by the white line scribed on the side) is at 45°.

3. Attach the PLH-0.5 containing the polarizer to the input side of the 932. The polarization of the beam exiting the PLH-0.5 will be linear and will be oriented parallel to the scribe line on the polarizer mounting ring (see diagram). Rotate the PLH-0.5 until the transmitted beam polarization orientation is at 45° to the optic axis of the 932. If the laser source is polarized, the PLH-0.5 should be rotated to a position that is both at 45° to the optic axis of the 932 and aligned with the laser polarization direction. When properly aligned, tighten the set screw on the PLH-0.5 to secure the assembly.

4. Attach the second PLH-0.5 with waveplate, to the exit port of the 932 optical head. Rotate the PLH-0.5 until the optic axis of the waveplate (see diagram) is aligned either parallel or perpendicular to the orientation of the entrance polarizer. Secure the assembly by tightening the set screw on the PLH-0.5.

5. Plug the 932 optical head into the 932-CX controller. Turn the voltage control knob counter clockwise to its end position, so that the display shows 0.00V.

6. Position the reference polarizer after the last PLH-0.5. Position the optical power meter detector to read the power transmitted by this polarizer. Rotate the voltage control knob to vary the transmitted intensity. Rotate the reference polarizer to determine the orientation of the polarization output of the 932 assembly.

932 Retardance Measurement

The 932 is a variable retarder that changes the phase between polarization components of the incident light. The indices of refraction are different for the e- and o- electro-magnetic waves causing the path-length for each component to be different through a retarder. This path-length difference is denoted by

$$L = d(|n_o - n_e|)$$

were d is the crystal thickness. The phase difference between the two output polarizations is given by

$$\Delta\o = \frac{2\pi}{\lambda_o} \bullet d(|n_o - n_e|)$$

and is also known as the retardance.

For example if a given retarder is said to have a path length difference of 316nm then the phase difference is simply

$$\Delta\o = \frac{2\pi}{\lambda_o} \bullet (316\text{nm})$$

if λ_o = 632nm, then the retarder would be considered a half wave retarder at 632nm.

For the 932 variable retarder, values for retardance are given as path-length differences at various rms voltage inputs for a specified wave-length. These can be verified using a typical He-Ne laser. By inserting the 932 between parallel polarizers the attenuation can be measured. The ratio of attenuation at a given control voltage, ($A(V) = I(V)/I_{max}$), on the 932 can be used to approximate the retardance. The attenuation ratio is related to the phase difference for crossed polarizers as

$$A(V) = \sin^2\left(\frac{\Delta\o}{2}\right) ,$$

giving

$$L = \bullet \frac{\lambda_o}{\pi} \sin^{-1}\left(\sqrt{A(V)}\right) .$$

For example if A(V)= .5 at λ_o = 632.8nm, then the path-length difference is

$$L = \frac{632.8}{\pi} \bullet \sin^{-1}\left(\sqrt{.5}\right) = 158.2\text{nm}.$$

(Note: the value for $\sin^{-1}(A)$ is given in radians.)

But it is also possible for the retardance to be a multiple of "waves". Figure 6.1 can be used to determine the retardance for a specific wavelength.

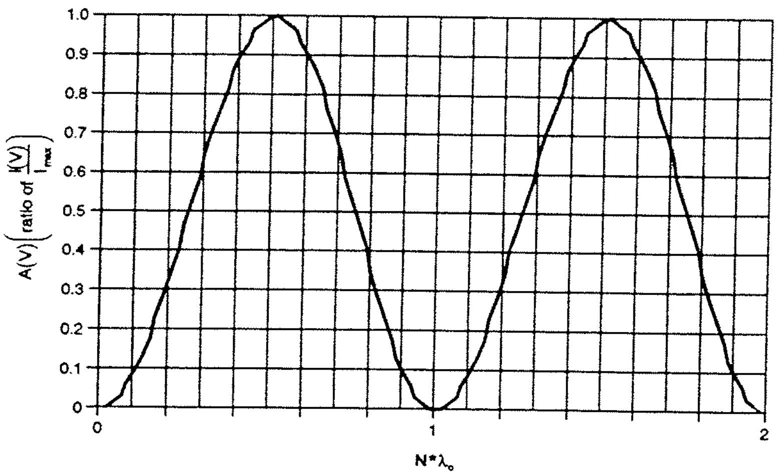


Figure 6.1 — Guide to Retardance Values at Given Wavelength