PEM-100
PHOTOELASTIC MODULATOR

USER MANUAL

Hinds Instruments, Inc.
P/N: 010-0000-021 UM Rev H

CAUTION!

DO NOT turn on your modulator unless the optical head and the electronic head are connected by the head-to-head interconnect cable.

SERIOUS DAMAGE MAY RESULT!

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Operators' Safety Summary

The general safety information in this summary is for operators of the PEM 100 Photoelastic Modulator System. Specific warnings and cautions may be found throughout the manual where they apply, but may not appear in this summary.

Terms

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

NOTICE statements identify conditions or practices that are important in proper use of the equipment to get the expected results.

PEM-100 Controller Labels

The serial number and CE certification labels are located at the lower right corner on the PEM-100 Controller rear panel as shown in figure S.1 below.

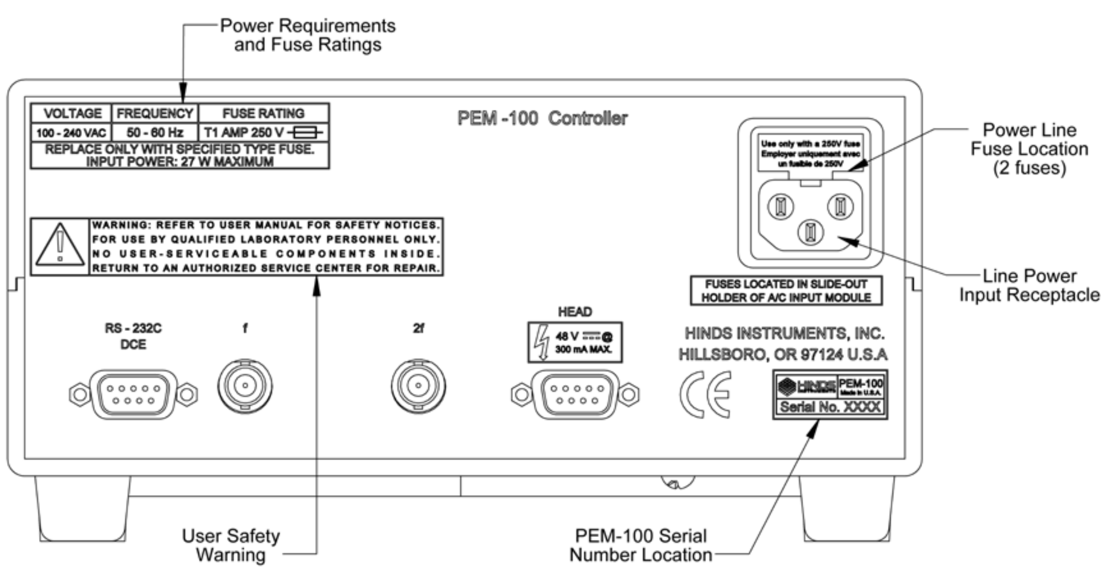

Figure S.1 Compliance Labeling

AC Power Source

This product is intended to operate from an AC power source in the 100-240 VAC range, 50-60 Hz, line to neutral. A protective ground connection by way of the grounding connector in the power cord is essential for safe operation. Power line requirements are listed in the specifications section and on the rear panel of the instrument.

The power cord provided with this instrument is less than 3 meters in length.
Use only the power cord and connector specified for your product to work with your local power outlets. Use only a power cord that is in good condition.

The appliance inlet or plug on cord should always be positioned to be accessible by the operator. To disconnect all power from the instrument, pull the power cord from the wall outlet or from the appliance inlet.

Do Not Operate Without Cover

To avoid personal injury, do not operate the PEM-100 Controller without the cover.

Ensure the controller ventilation openings located on the top and bottom of the enclosure are clear of any obstructions.

Unpacking the PEM 100

Shipping Damage Check

Inspect all system components for obvious shipping damage. The PEM 100 is a precision instrument that can be damaged by rough handling. Your unit was packaged to minimize the possibility of damage in transit. Therefore, we recommend that you save the specially designed shipping container for any future shipment of your modulator unit. In particular, we recommend you save the internal packing materials for the optical head.

In the event your order arrives in damaged condition, it is important that the following steps be taken immediately. The title transfers automatically to you, the customer, once the material is entrusted to the transport company.

1. DO NOT RETURN THE INSTRUMENT TO HINDS INSTRUMENTS, INC. until the following steps are completed. Failure to follow this request will jeopardize your claim with the insurance company.
2. If a “Shock Watch” is present on the outer shipping container or anywhere inside, note the location and the condition of the shock watch. If the shipment receives handling rough enough to trigger the shock watch, the watch will turn red.
3. Open the container and inspect the contents. Do not throw away the container or any damaged parts. Try to keep all items in the same condition as originally received.
4. Notify the Transport Company immediately in writing, preferably by facsimile or email, about the shipping damage.
5. Wait for the transport company’s representative to inspect the shipment personally.
6. After inspection, request Hinds Instruments’ permission to return the damaged instrument by calling the service department at (503) 690-2000 or email to service@hindsinstruments.com. A return authorization number (RMA) will be assigned to you. See Overview of the PEM 100 Help System on page 82 for further contact information.
7. Return approved items to Hinds Instruments Inc. at the following address:

   Hinds Instruments, Inc.
   7245 NW Evergreen Pkwy
   Hillsboro, OR 97124-5850

8. After return permission is given and we receive the instrument, an estimate of the cost of repair will be sent to you in the event you choose to submit a claim to the transport company.

Unpacking the PEM Optical Head

CAUTION

PLEASE USE CARE when unpacking the PEM optical head, for this assembly is very fragile. Please follow the unpacking instructions carefully. Unless this is done, the PEM system will not operate and the optical head may be irreversibly damaged.

Special Instructions for I/FS50 Optical Head

The following unpacking instructions are for an I/FS50 PEM optical head.

All optical head models except for the II/FS42 and II/IS42 follow these instructions.

1. Ensure the work surface is clean and free of dust.
2. Using a #1 Phillips screw driver, remove the shipping disk.

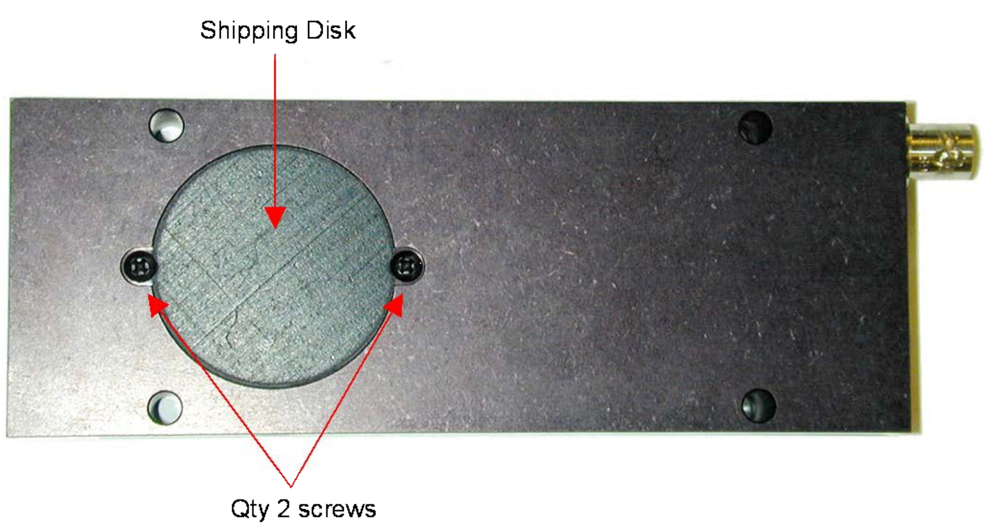

Figure S.1 I/FS50 Remove Shipping Disk

3. Remove the blue foam disk.

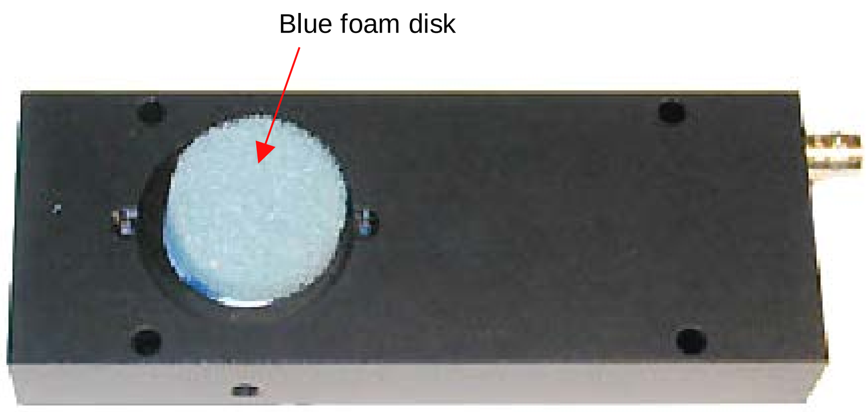

Figure S.2 I/FS50 Remove Blue Foam Disk

4. Carefully remove the inner blue foam and lens tissue from this side of the optics, thus exposing the PEM optics.

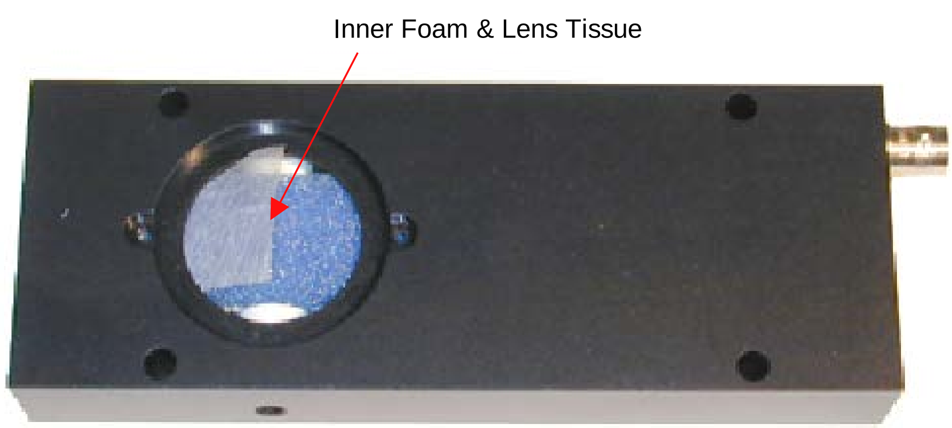

Figure S.3 I/FS50 Remove Inner Blue Foam & Lens Tissue

NOTE: Also remove the shipping disk and inner blue foam on the opposite side of the PEM.

5. Repeat steps 1 through 4 for the opposite side of the PEM.

6. Blow air on the optics to ensure there is no lint or dust particles on the optic surfaces.

> **CAUTION**
>
> Use only oil free air when blowing lint or dust particles from the optic surfaces. If using canned air, hold the container upright or liquid will spray onto the optic surface.

7. Save shipping disk, packing foam and lens tissue in the zip lock bag provided in the event that the PEM is returned to Hinds.

   The shipper assumes all freight damage risk if the optical head is not packaged as supplied.

Special Instructions for II/FS42 & II/IS42 Optical Head

The following unpacking instructions are for an II/FS42 and II/IS42 PEM optical heads. Unpacking other optical head designs may vary slightly.

1. Ensure the work surface is clean and free of dust.
2. Using a #1 Phillips screw driver, remove the Shipping disk and lid.

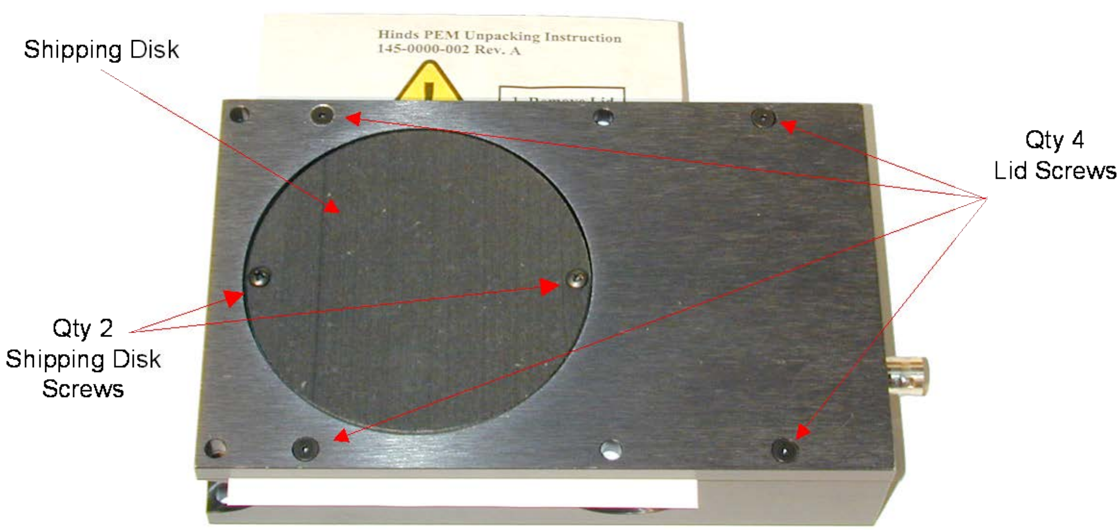

Figure S.4 II/FS42 Remove Shipping Disk & Lid

3. Remove the shipping disk and unpacking instructions.

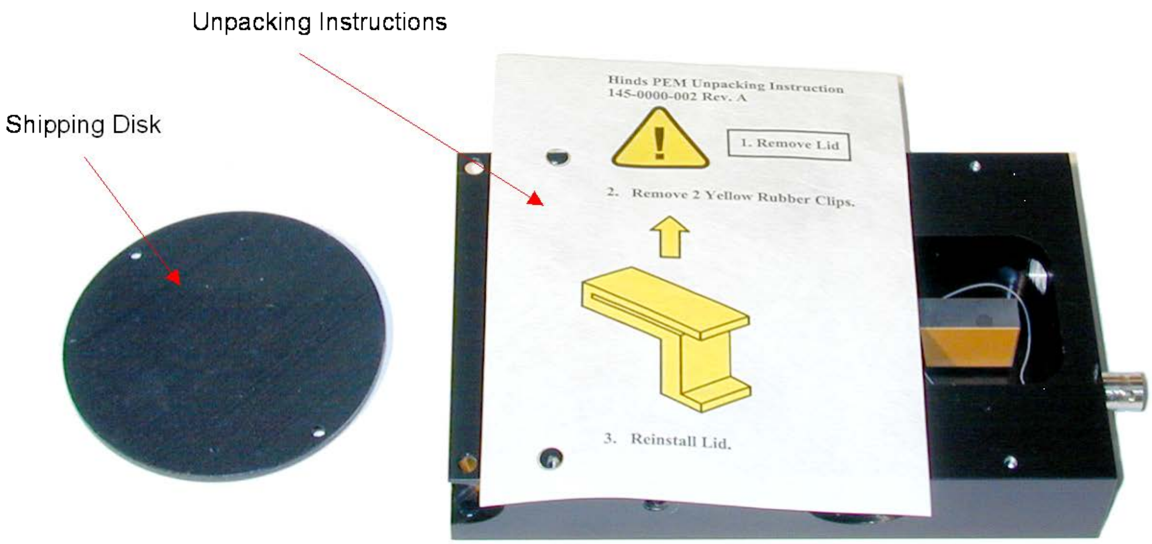

Figure S.5 II/FS42 Remove Unpacking Instructions

4. Remove the blue foam and lens tissue.

NOTE: The foam on the other side of the optics will be removed through the shipping disk on the opposite side of the PEM.

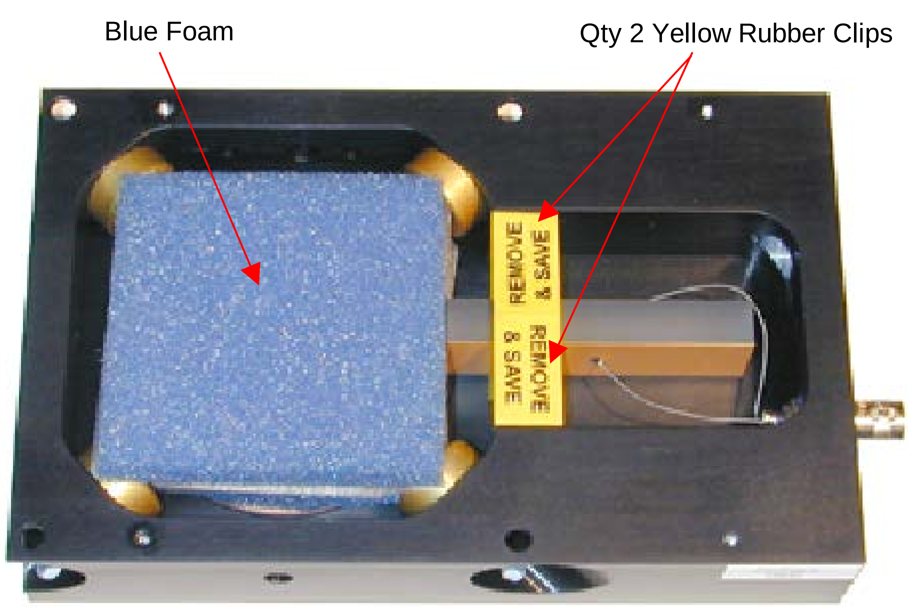

Figure S.6 II/FS42 Remove Blue Foam & Yellow Clips

5. Remove the yellow transducer support clips (i.e. for models II/FS42 and II/IS42). See Figure S.7 on the following page.

CAUTION

Be very careful to protect the optic and transducer bond. Do not apply excessive force to this bonded junction when removing the yellow packing supports.

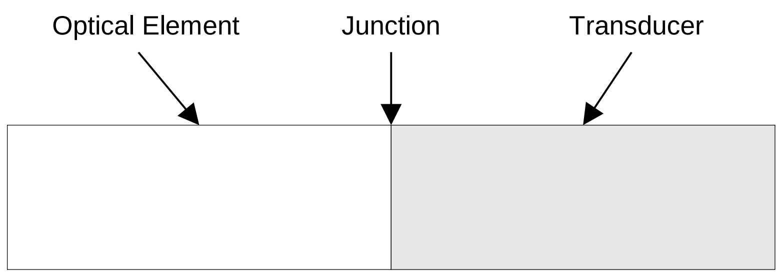

Figure S.7 Junction between Optical Element and Transducer

6. Carefully hold the gold plated transducer in place with the thumb and forefinger and gently grasp the top center flap of the first packing support. Slightly bend this flap back and rotate the clip forward while lifting out the support clip. Repeat this process for the second yellow packing support.

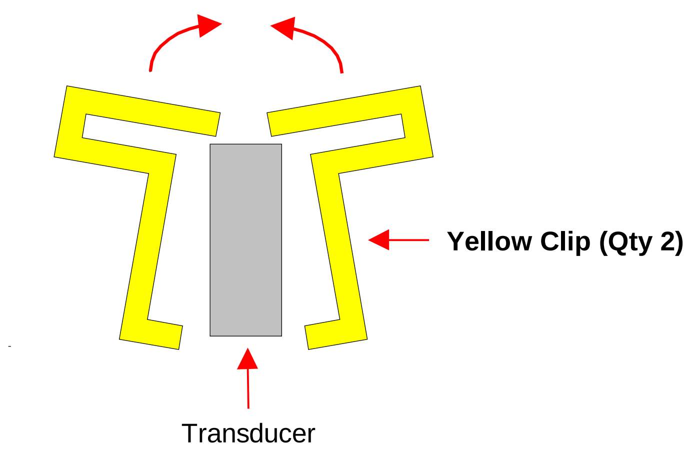

Figure S.8 Removing Yellow Transducer Support Clips

7. Replace the lid and tighten all screws until snug.

8. Turn the PEM optic head over and remove the shipping disk.
9. Carefully remove the inner blue foam and lens tissue.
10. Blow air on the optics to ensure there is no lint or dust particles on the optic surfaces.

> **CAUTION**
>
> Use only oil free air when blowing lint or dust particles from the optic surfaces. If using canned air, hold the container upright or liquid will spray onto the optic surface.

11. Save shipping disk, foam and lens tissue in the zip lock bag provided in the event that the PEM is returned to Hinds.

The shipper assumes all freight damage risk if the optical head is not packaged as supplied.

1
Introduction

Overview

The PEM 100 Photoelastic Modulator is an instrument used for modulating or varying (at a fixed frequency) the polarization of a beam of light. Hinds photoelastic modulators are used for measurement of circular and linear dichroism, birefringence, optical rotation, and for ellipsometry, polarimetry, reflection difference spectroscopy and FTIR double modulation.

The PEM 100 principle of operation is based on the photoelastic effect, in which a mechanically stressed sample exhibits birefringence proportional to the resulting strain. Photoelastic modulators are resonant devices, each producing oscillating birefringence at a fixed frequency in the low frequency ultrasound range (20 kHz to 100 kHz). These factors result in a number of very useful advantages, which are unique to the PEM including wide acceptance angle, large aperture and high modulation "purity."

Figure 1.1 provides an overview of the PEM 100 photoelastic modulator system which includes the PEM-100 Controller, Optical Head, Electronic Head as well as the Head-to-Head Interconnect cable and the Head-to-Controller cable.

Figure 1.1 PEM 100 Photoelastic Modulator

PEM-100 Controller Accessories

Rack Mounting Kit

The PEM-100 Controller can be mounted in a Hinds Instruments rack mount kit (PN: 023-0000-184).

RS232 Converters

Two RS232 converters are available:

- RS232 to IEEE-488 Converter, Hinds PN: 020-2404-001
- RS232 to USB Converter, Hinds PN: 036-9003-120

2
PEM-100 Controller

PEM-100 Controller Front Panel

The PEM-100 Controller front panel consists of a keypad user interface and a backlit LCD display. These features allow the user to control the peak retardation and wavelength settings of the modulator head set.

The specific keypad functions are described on the following page.

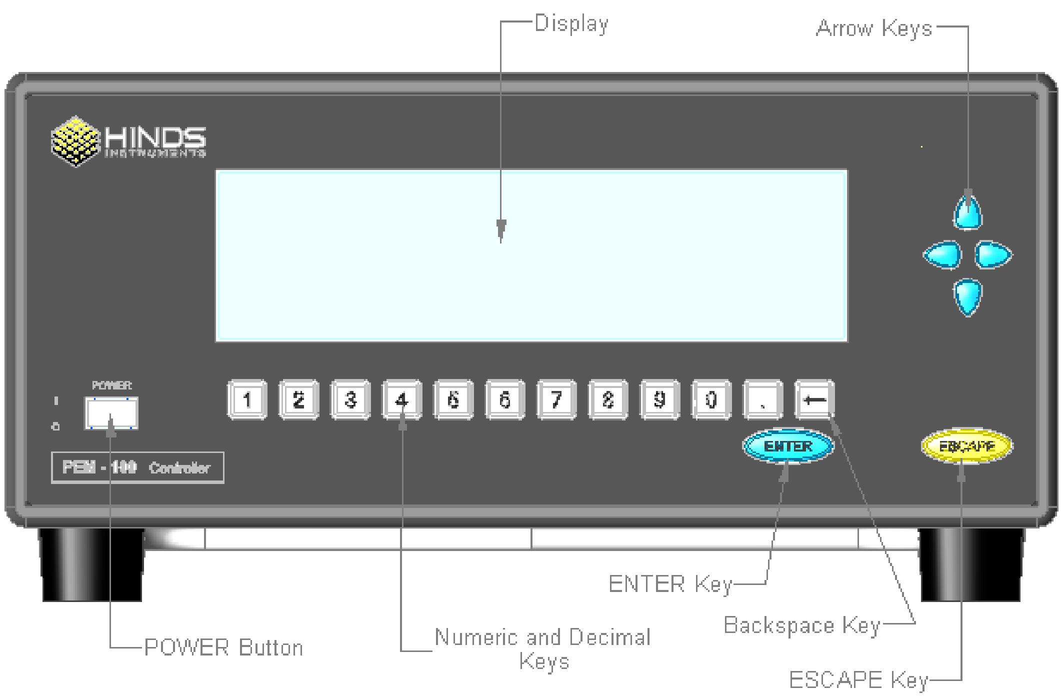

Figure 2.1 PEM-100 Front Panel OFF State

PEM-100 Controller Front Panel Buttons

- **Power Button:** Press the POWER key in to power the PEM-100 ON, depress the key to power the unit OFF.

  The symbols to the left of the power button indicate the following: power ON ‘I’ and power OFF ‘O’.

- **Display:** Blue background/white character LCD display with backlight. ‘Reverse’ display, white background/blue character, appears for highlighted display field. User adjustable screen and pixel brightness settings.

- **Arrow Keys:** The arrow keys allow for movement between display fields in arrow direction. Once inside a field, up and down arrows increment and decrement the field entry while left and right arrows allow movement.

- **ENTER Key:** Pressing the ENTER key when a display field is highlighted enables the process for editing values or choosing parameters in that field. The arrow keys and numeric keys can then be used to edit the field value or move between parameter choices. When editing/choosing is complete, the ENTER key is pressed again to store the value and shift out of edit/choose mode.

- **ESCAPE Key:** In general, the ESCAPE key allows backing out of any display to the previous display without changes being made. While the ENTER key saves edited field values, the ESCAPE key exits the field with edits not saved.

- **Backspace Key:** This key [←] is used for deleting field entries and is only active while doing field editing. Pressing the key deletes the character entry immediately left of the blinking cursor as well as characters at the cursor location and right of the cursor location.

- **Numeric and decimal keys:** These keys are used for entering desired numerical values and are only active while doing field editing.

PEM-100 Controller Rear Panel

All electrical/electronic connections to the controller are made on the rear panel.

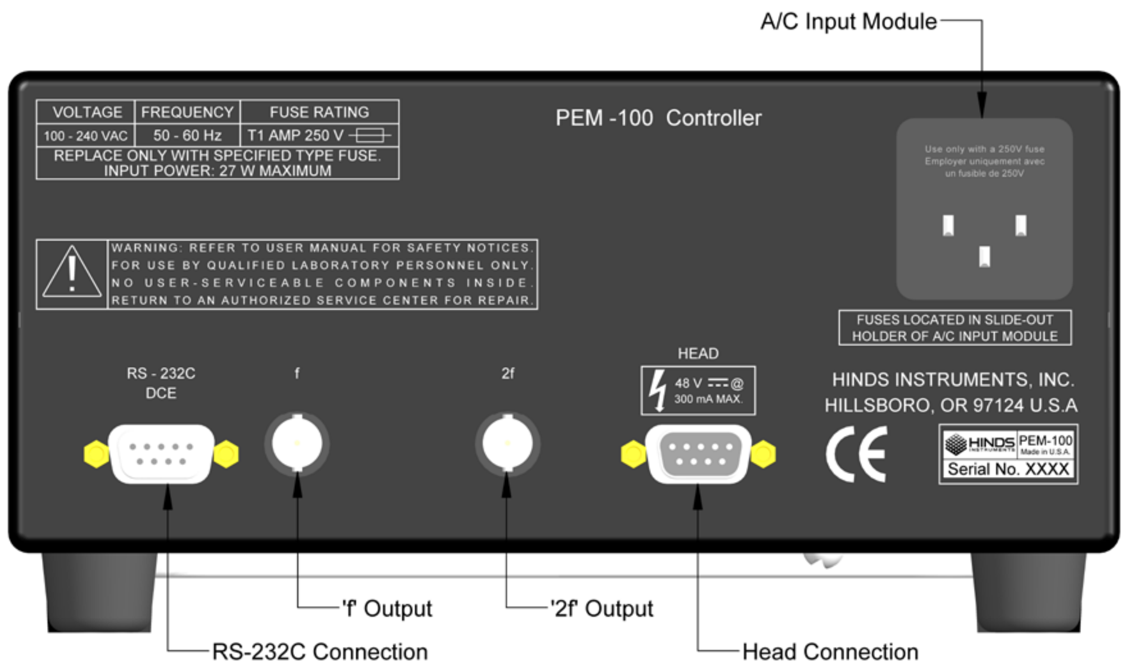

Figure 2.2 PEM-100 Rear Panel

PEM-100 Controller Rear Panel Connections

- **<u>RS232 Connection:</u>** The RS232 Serial Port connector is a male DB9, and the connections are given in figure 2.3 on the following page. This interface allows computer control of the modulator, as well as monitoring of all controller operating parameters displayed on the front panel.

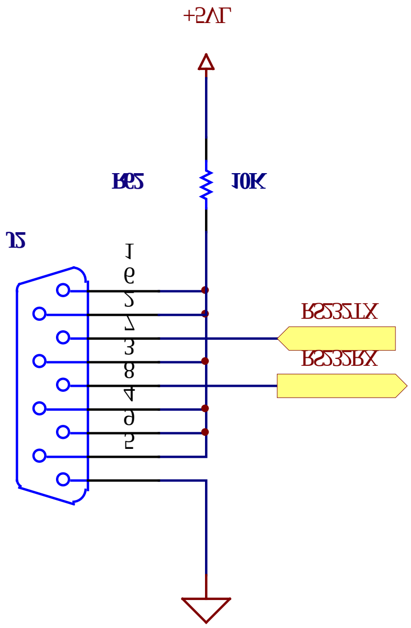

Figure 2.3 RS232 Connections

- **<u>f Output:</u>** BNC female connector provides TTL output of PEM, first harmonic frequency.
- **<u>2f Output:</u>** BNC female connector provides TTL output of PEM, second harmonic frequency.
- **<u>Head Connection:</u>** This female DB9 connector connects the controller to the PEM electronic head via the provided Head-to-Controller cable.

  The lightning bolt symbol, located above this connection, refers to the Head connector as being a source of output power.
- **<u>A/C Input Module:</u>** AC voltage input 100-240 VAC, 50-60Hz.

3
Modulator Head Assembly

The transducer-optical element assembly (called the “optical assembly”) is the heart of a PEM 100 photoelastic modulator. It consists of a rectangular or octagonal “window” of optical material bonded to a quartz piezoelectric transducer. Both optical element and transducer are tuned to the same frequency. When connected to a driver circuit, this assembly oscillates and produces the time-varying birefringence which is the basis of operation of the PEM.

This assembly, consisting of the optical head, the electronic head, and the cable which connects them, is a single circuit. It is not intended to operate unless all three elements are together.

CAUTION

Operation of the electronic head without the optical head attached may result in damage to the electronic head and possibly to the controller.

Optical Head

The Optical assembly is housed in an enclosure called the “optical head.” Figures 3.1 through 3.5 provide dimensions for various optical head types.

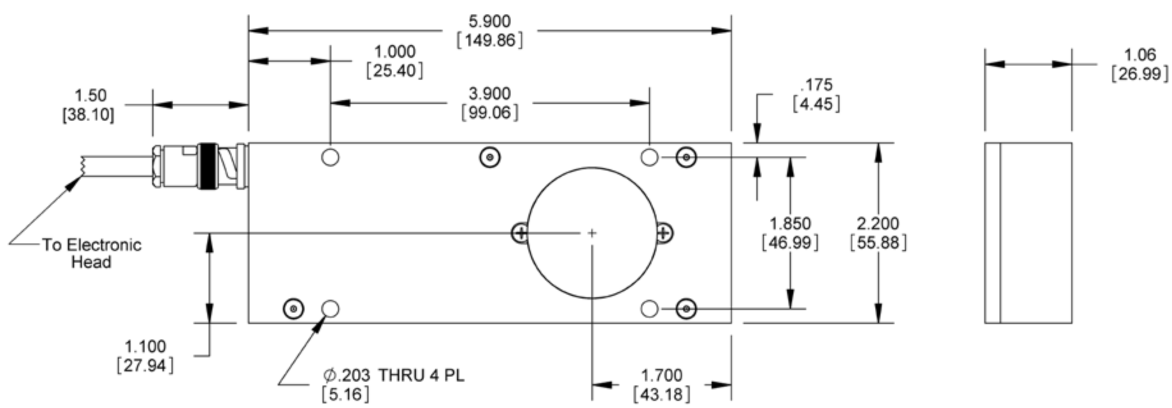

Figure 3.1 Model I/FS50 Optical Head Dimensions

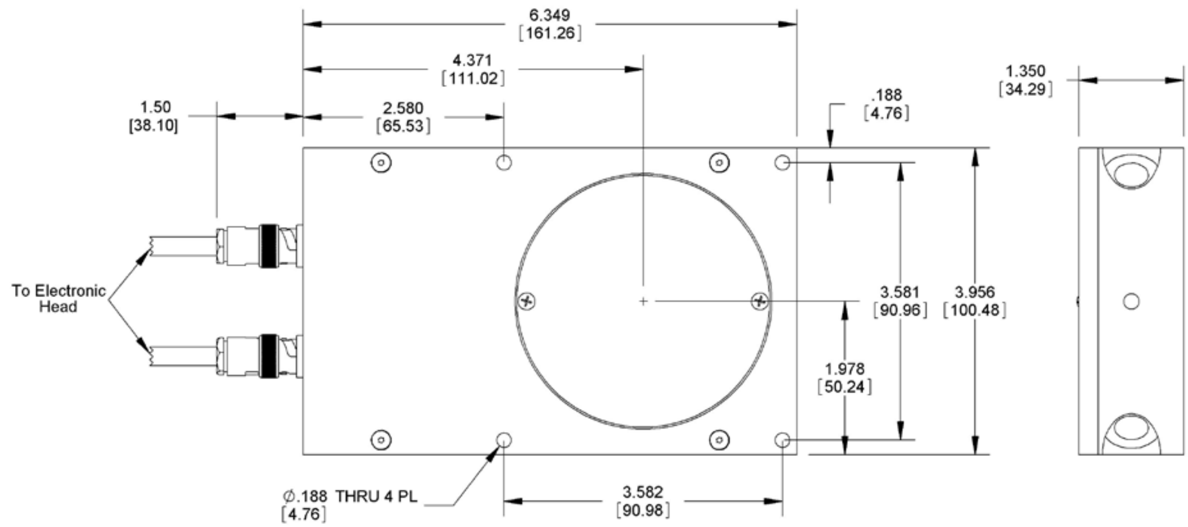

Figure 3.2 Model II/FS42 Optical Head Dimensions

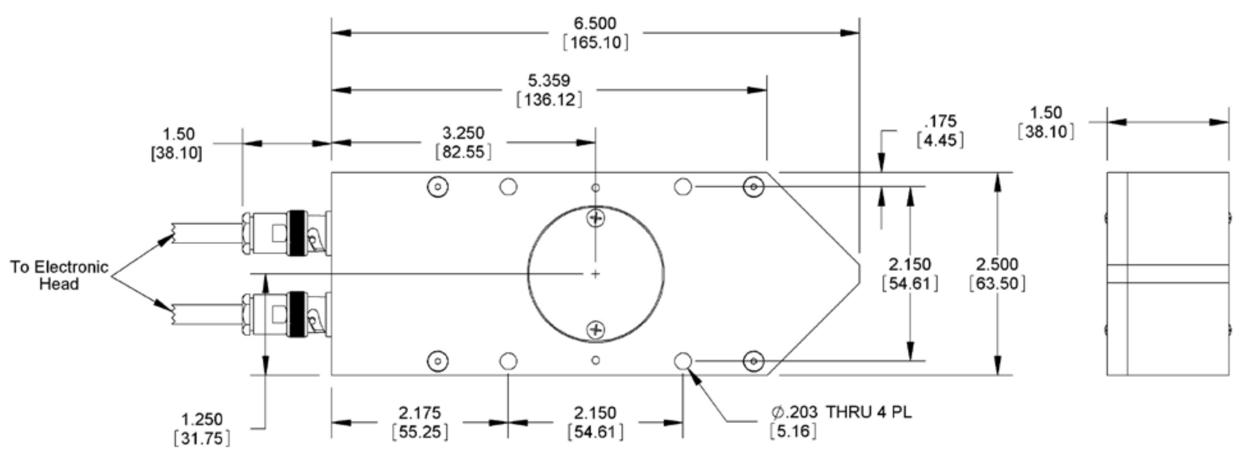

Figure 3.3 Model II/ZS50 Optical Head Dimensions

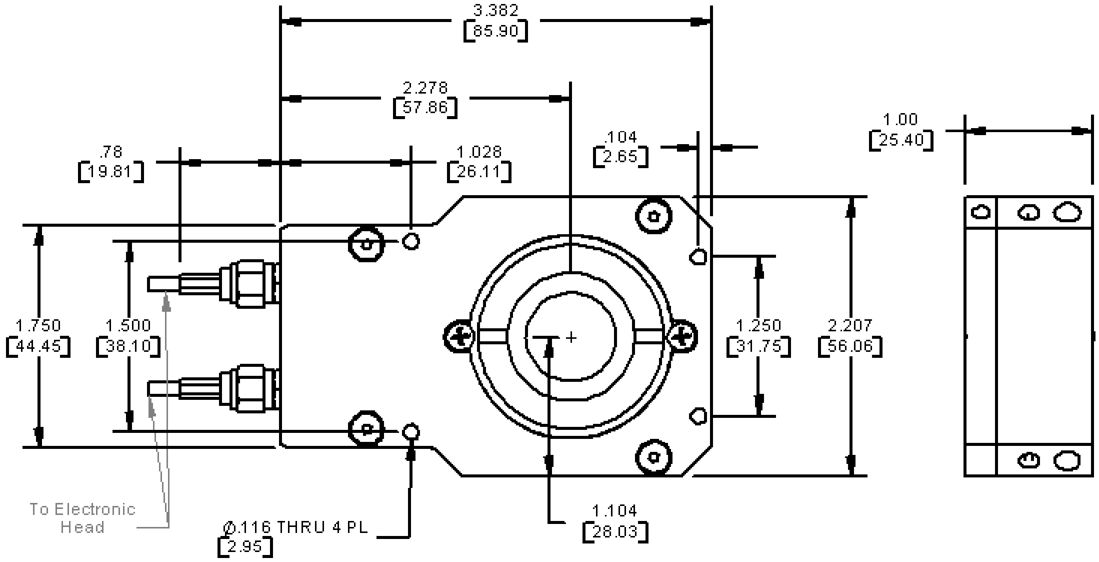

Figure 3.4 II/FS84 Optical Head Dimensions

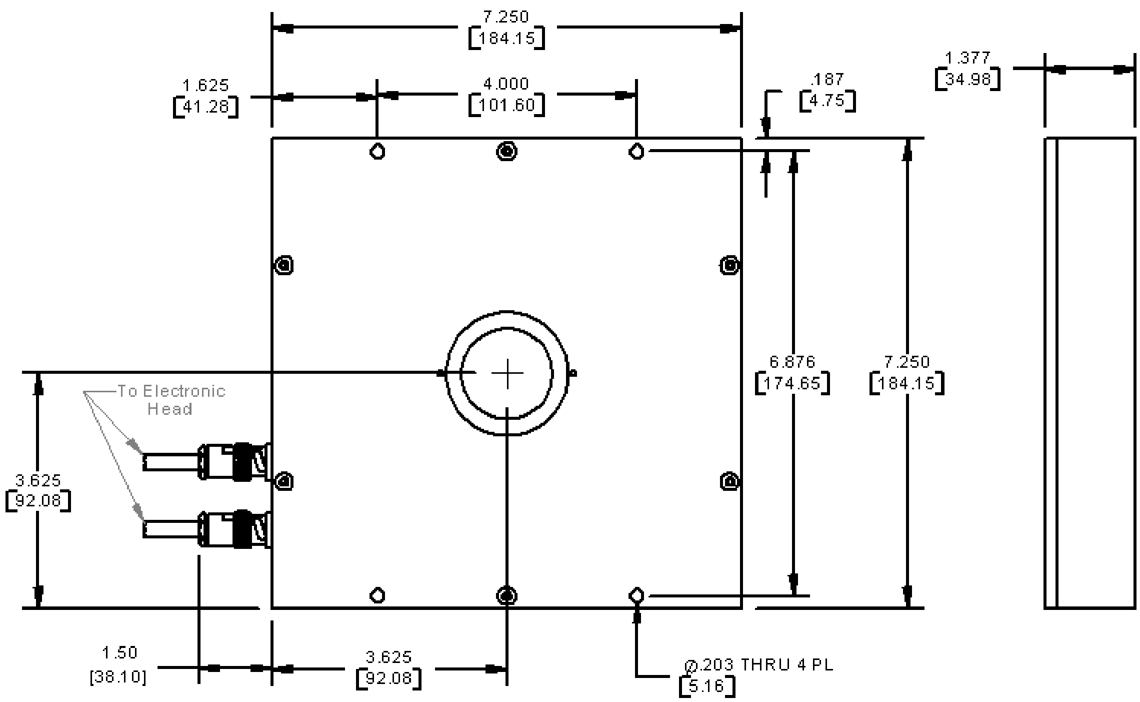

Figure 3.5 II/ZS37 Optical Head Dimensions

The optical head is connected to the electronic driver circuit (housed in the "electronic head") by a head-to-head Interconnect cable. This assembly of the optical head, the electronic head, and the head-to-head interconnect cable comprises the "modulator head," which should be regarded as a single unit.

CAUTION

Operation of the electronic head without the head-to-head cable and optical head connected should never be attempted. Such operation will almost certainly result in damage to the electronic head.

Electronic Head

The electronic head (driver circuit) consists of an active LC tank circuit connected in parallel to the optical head. The head-to-head interconnect cable contributes capacitance to the tank circuit. The electronic head also generates a current feedback signal back to the controller.

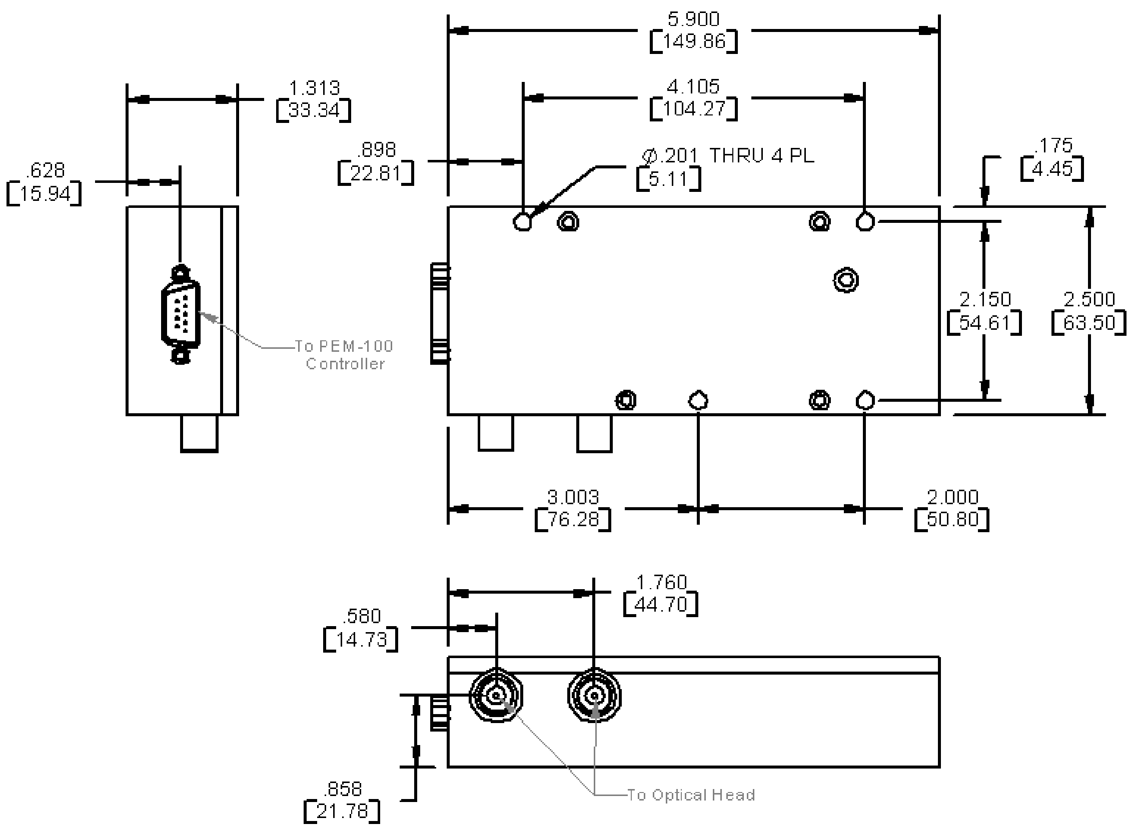

Figure 3.6 Electronic Head Dimensions

4
Initial Set-Up

Before initial set-up, the PEM optic head should be unpackaged as described in Unpacking the PEM Optical Head on page 4.

Connecting the PEM Optical and Electronic Heads

There are two different connection configurations between the optical head and electronic head based upon the type of optical head used.

Depending upon your specific application, your head set may come with one of the following head-to-head interconnect cable(s):

- Single blue triaxial head-to-head interconnect cable
- Dual black coaxial head-to-head interconnect cables

1. Connect the optical head to the electronic head by means of the Head-to-Head interconnect cable. See figures 4.1 and 4.2 on the following page.

CAUTION

Operation of the modulator should never be attempted unless this connection has been made. Such operation will almost certainly result in damage to the electronic head.

If there is a single, triax BNC connector on the optical and electronic heads, connect the blue triax Head-to-Head Interconnect cable provided.

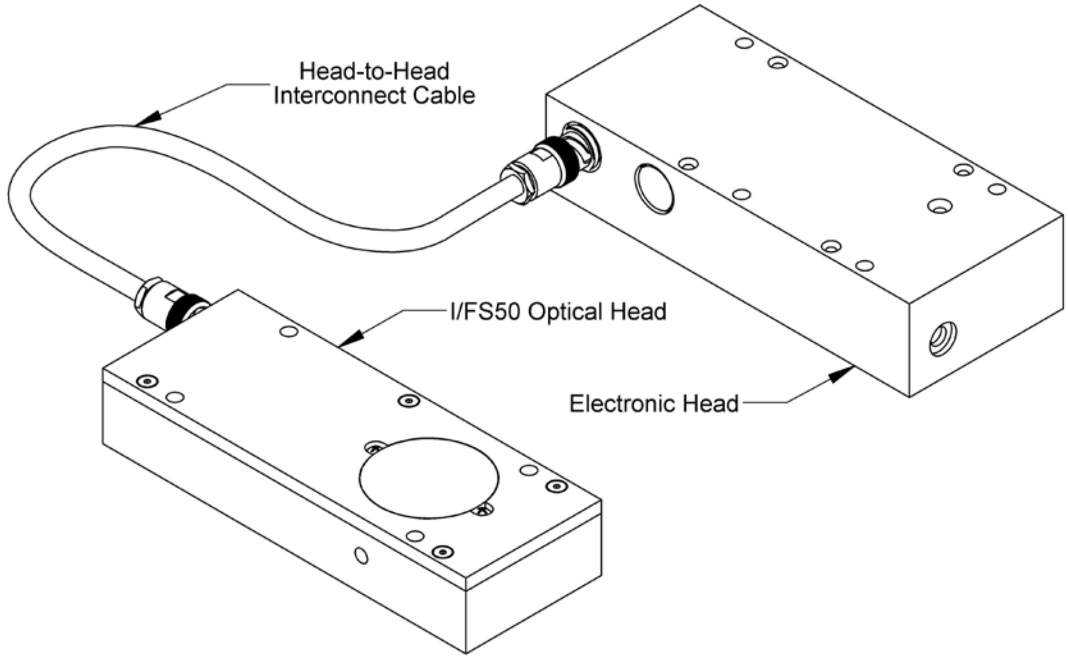

Figure 4.1 Connecting I/FS50 Optical Head to Electronic Head

If there are dual standard BNC (coax) connectors on the optical and electronic heads, connect the dual black coaxial Head-to-Head Interconnect cables provided.

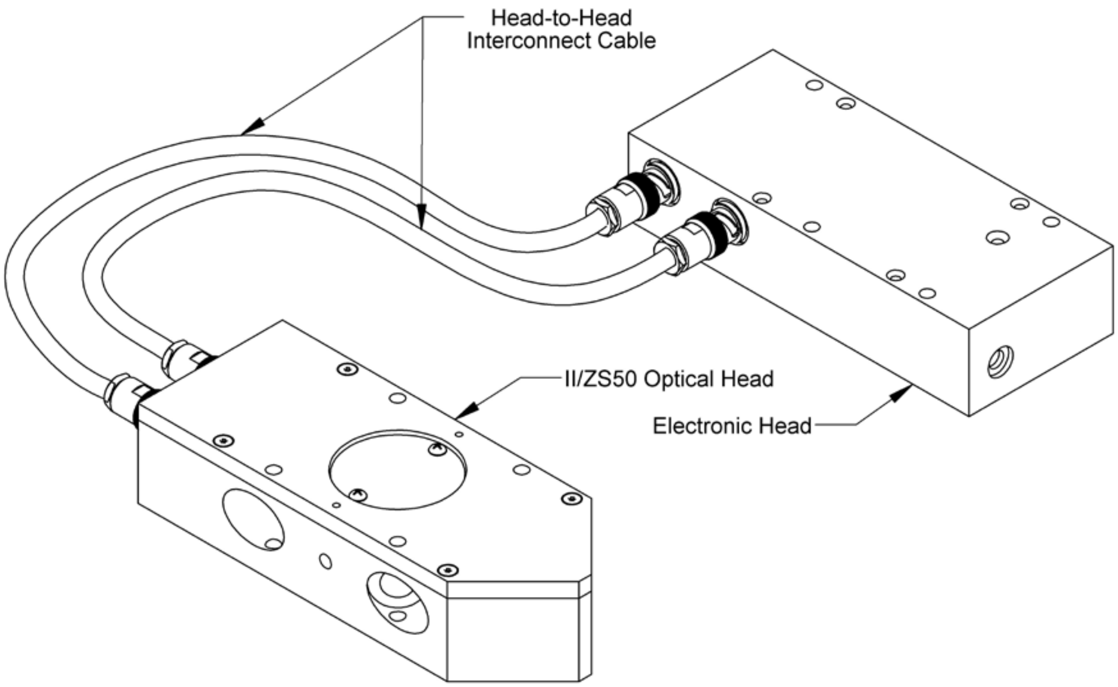

Figure 4.2 Connecting II/ZS50 Optical Head to Electronic Head

If the dual black coaxial Head-to-Head Interconnect cables are ‘crossed’ as shown in figure 4.3, the instrument will operate correctly, except that the phase relationship between the optical retardation signal and the phase reference outputs will be inverted. For many applications this is not a problem, or can be used as a diagnostic tool when tracing the signal path in a system.

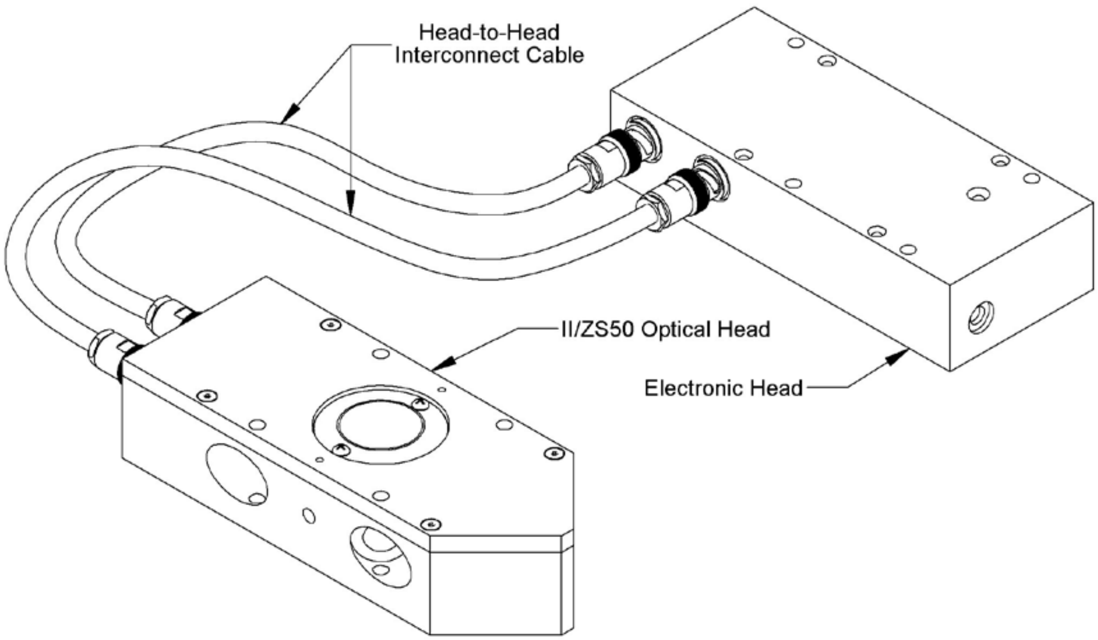

Figure 4.3 Connecting II/ZS50 Optical Head to Electronic Head (Cross Connection)

2. Connect the electronic head to the PEM-100 Controller using the Controller-to-Head cable.
3. Connect the power cord to the PEM-100 Controller and plug it into an AC power source.
4. Connect the RS232 serial interface cable to the computer (if used for remote control).
5. If the optical head came equipped with ATC (Advanced Thermal Control), then connect the power cord of the 24V DC power supply that came with the optical head into an AC power source.
6. Plug in the output of the 24V DC power supply into the power receptacle on the side of the optical head as shown in Figure 4.4 on the following page. The green LED should flash on and off indicating the optical head temperature is ramping towards 32º C, the green LED will remain on steady.

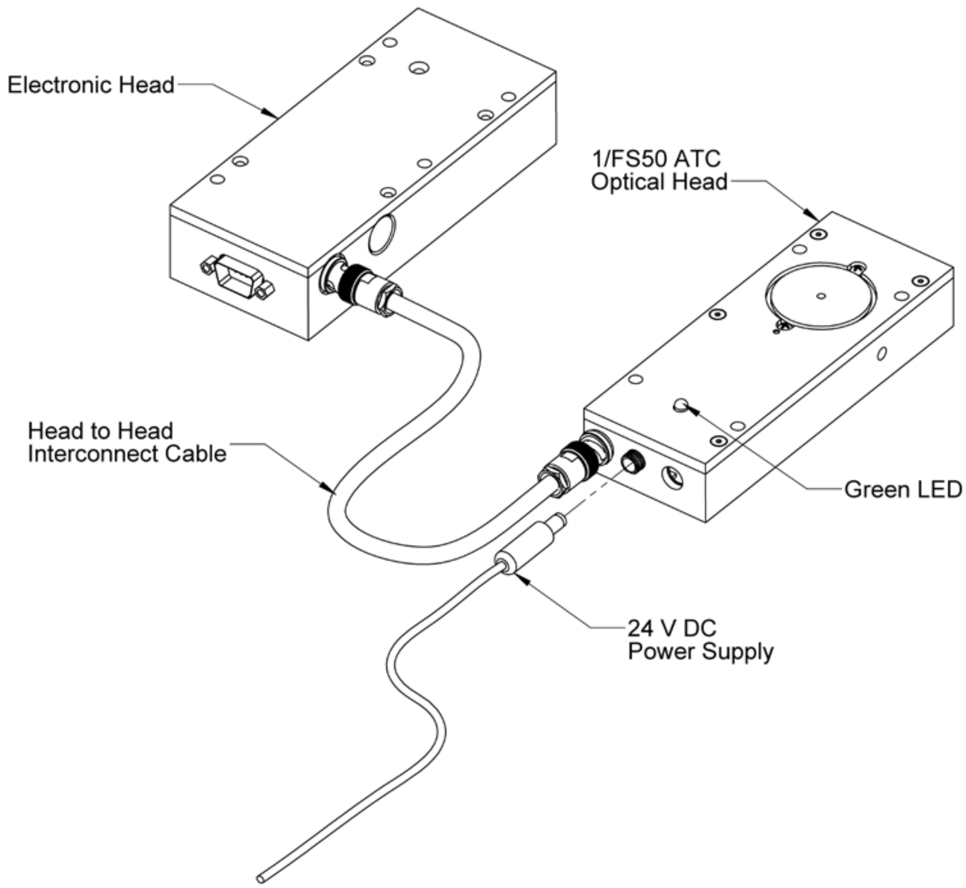

Figure 4.4 Connecting 1/FS50 Optical Head with ATC Option to Electronic Head

Optical Bench Set-up

The optical bench and electronic configuration depend on the particular application required for the modulator. More detailed set-up information can be found at our website http://www.hindsinstruments.com/applications for an applications pull down menu.

The most common optical and electronic setup for checkout and calibration of the modulator is shown in figure 4.5. This shows a monochromatic light source (such as a laser) or multiwavelength source with a wavelength selection device (e.g. monochromator).

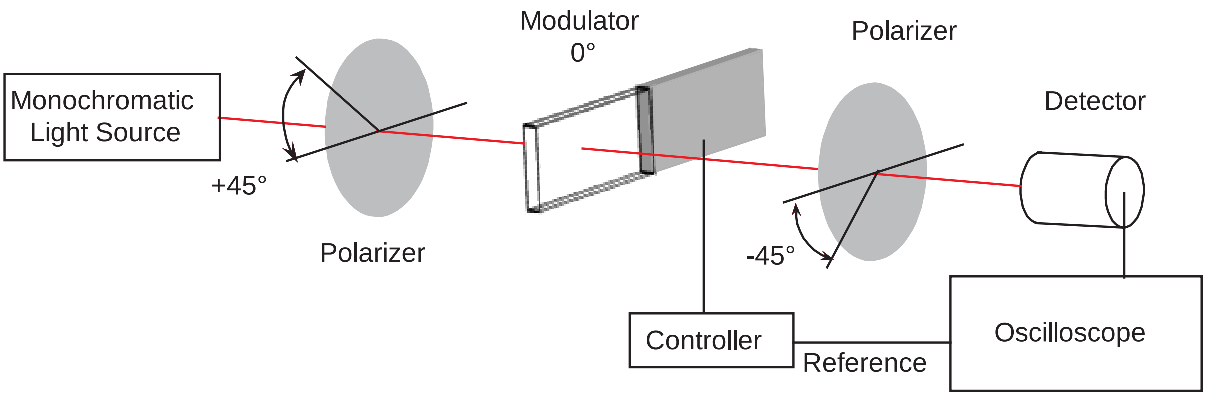

Figure 4.5 Block Diagram for Oscilloscope Calibration Method

The light source, if unpolarized, is followed by a polarizer at 45 degrees with respect to the horizontal, the modulator with its axis horizontal (0 degrees), a second polarizer (often called the analyzer) at -45 degrees, and a detector.

Functional Check

Figure 4.6 shows the basic electronic requirements. Most light sources will require an electrical power supply, not discussed here. The detector is shown supplying a signal to the oscilloscope, with the controller reference signal connected to the oscilloscope trigger input.

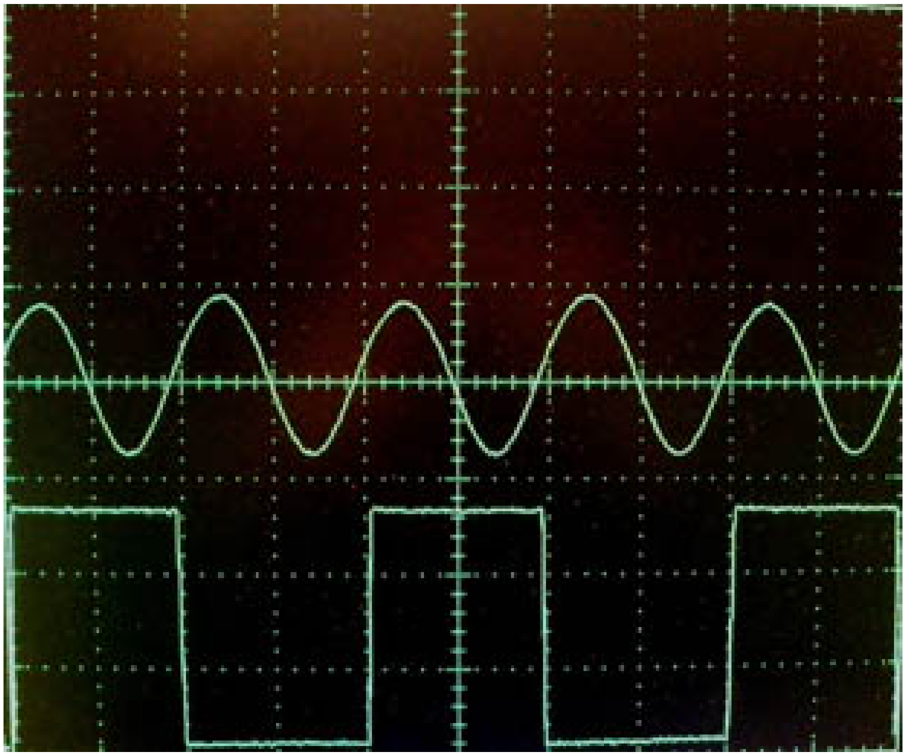

Figure 4.6 Oscilloscope Waveform for PEM Set to 0.25 Wave Retardation Between Crossed Polarizers and PEM 1f Reference Signal

The detector circuitry deserves some special comment. Care must be taken to ensure adequate frequency response, typically several times the PEM operating frequency. Pre-amplified photo detectors are available from Hinds Instruments that fit this need. See page 82 for contacting Hinds Instruments Inc.

5
PEM-100 Controller Display

Display Modes

There are three available display modes: Local Control Mode, Voltage Control Mode and Remote Control Mode. Within each mode type are specific user presets and system configurations.

Screens displayed within this chapter are taken from a PEM-100 Controller that is connected to an I/FS50 head set.

Local Control Mode

The Local Control mode displays and allows for adjustments to wavelength and retardation for the PEM-100.

Figure 5.1 Local Control Mode Display

- **<u>Wavelength (WAV):</u>** Displays the wavelength setting. Wavelengths units can be set to display in nanometers (nm), micrometers (µm) and wavenumbers (1/cm).

  To enter a different wavelength than what is displayed, use the arrow keys to navigate to **WAV** and press **ENTER**. Using the numeric buttons below the display or the arrow keys to the right of the display, enter the desired wavelength and press **ENTER**.

  To select a different wavelength unit, use the arrow keys to navigate to the wavelength units field (**nm**) and press **ENTER**. Arrow to and select the desired wavelength unit and press **ENTER**.

- **<u>Retardation (RET):</u>** Displays the retardation setting. Retardation can be set to display in fraction of wavelength (λ), radian (rad) and degree (º).

  To enter a different retardation than what is displayed, use the arrow keys to navigate to **RTD** and press **ENTER**. Using the numeric buttons below the display or the arrow keys to the right of the display, enter the desired retardation and press **ENTER**.

  To select a different retardation unit, use the arrow keys to navigate to **λ** and press **ENTER**. Arrow to and select the desired retardation unit and press **ENTER**.

- **<u>Frequency (1f):</u>** Displays the PEM frequency. Frequency can be set to display in First Harmonic (1f) or Second Harmonic (2f) and set to Hertz (Hz) or kiloHertz (kHz).

  To enter a different harmonic setting than what is displayed, use the arrow keys to navigate to **1f** and press **ENTER**. Arrow to the desired harmonic setting and press **ENTER**.

  To select a different frequency unit, use the arrow keys to navigate to **Hz** and press **ENTER**. Arrow to the desired frequency unit and press **ENTER**.

To save current Local Control Mode settings, use the arrow keys to navigate to **User Presets** and press **ENTER**. The **Save Current** row heading is highlighted to signify the current settings are to be saved. To save the current settings as a preset, press **ENTER** and then arrow to the numbered preset you wish to save the current settings to and press **ENTER** once again to facilitate the save function.

The PEM-100 Controller will retain the saved Local Control Mode user presets when the unit is powered off.

Voltage Control Mode

The Voltage Control Mode displays and allows for adjustments to the VCtrl voltage settings for the PEM-100.

Figure 5.2 Voltage Control Mode Display

- **Voltage Control (VCtrl):** Displays the VCtrl voltage setting.

  To enter a different voltage than what is displayed, use the arrow keys to navigate to **VCtrl** and press **ENTER**. Using the numeric buttons below the display or the arrow keys to the right of the display, enter the desired voltage and press **ENTER**.

  NOTE: VCtrl range is 0 – 4.85V.

- **Frequency (1f):** Displays the frequency setting. Frequency can be set to display in First (1f) or Second (2f) and set to hertz (Hz) or kilohertz (kHz).

  To enter a different harmonic setting than what is displayed, use the arrow keys to navigate to **1f** and press **ENTER**. Arrow to the desired harmonic setting and press **ENTER**.

  To select a different frequency unit, use the arrow keys to navigate to **Hz** and press **ENTER**. Arrow to the desired frequency unit and press **ENTER**.

To save current Voltage Control Mode settings, use the arrow keys to navigate to **User Presets** and press **ENTER**. The **Save Current** row heading is highlighted to signify the current settings are to be saved. To save the current settings as a preset, press **ENTER** then arrow to the numbered preset to save the current settings to and press **ENTER** to facilitate the save function.

The PEM-100 Controller will retain the saved Voltage Control Mode user presets when the unit is powered off.

Remote Control Mode

The Remote Control Mode sets the PEM-100 controller to remote PC control by way of the PEM Control Software, user specific software or by a terminal program.

To access the Remote Control Mode, use the arrow keys to navigate to **Mode Select** and press **ENTER**. Select **Remote Control** and press **ENTER**.

See PEM Control Software on page 41 and Command-Line Interpreter on page 49 for remote control information.

Figure 5.3 Remote Control Mode Display

User Presets

The User Presets menu allows for the selection of initial factory loaded presets or saved user presets that were entered from within the Local Control Mode and Voltage Control Mode.

Local Control Presets

The User Presets menu accessed through the Local Control Mode, allows for the selection of preset factory settings and/or previously loaded presets that were saved from within the Local Control Mode display menu.   This menu also allows the user to save current local control settings.

To access the User Presets menu from the Local Control Mode, use the arrow keys to navigate to **User Presets** and press **ENTER**.

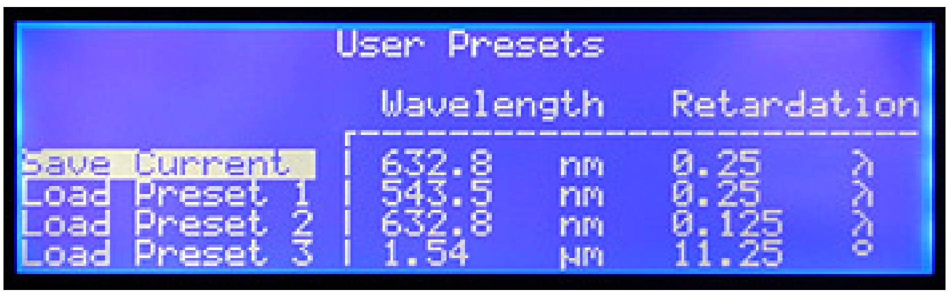

Figure 5.4 Local Control Mode – User Presets Menu

- **<u>Save Current:</u>** Select to save the current Control Mode settings.
- **<u>Load Preset 1:</u>** Select to load Local Control Mode settings saved in Preset 1.
- **<u>Load Preset 2:</u>** Select to load Local Control Mode settings saved in Preset 2.
- **<u>Load Preset 3:</u>** Select to load Local Control Mode settings saved in Preset 3.

To save current Local Control Mode settings, select **Save Current** and press **ENTER**. Arrow to the desired Load Preset label (1, 2 or 3) and press **ENTER**. Press **ESCAPE** to return to the previous menu.

Voltage Control Presets

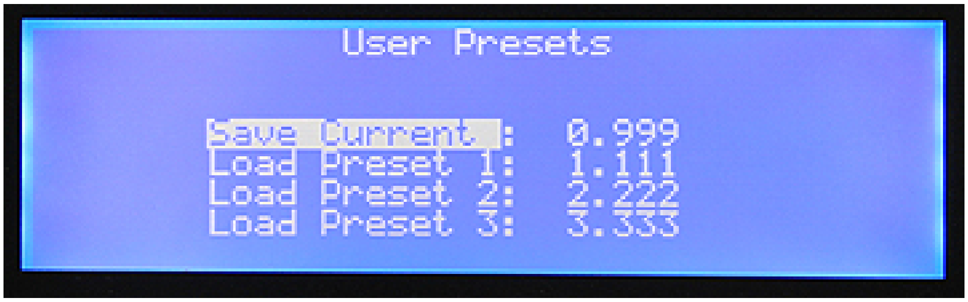

Figure 5.5 Voltage Control Mode – User Presets

The User Presets menu accessed through the Voltage Control Mode, allows for the selection of preset factory settings and/or previously loaded presets that were saved from within the Voltage Control Mode display menu.   This menu, also allows the user to save current voltage control settings.

To access the User Presets menu from the Voltage Control Mode, use the arrow keys to navigate to **User Presets** and press **ENTER**.

- **Save Current:** Select to save the current Control Mode settings.
- **Load Preset 1:** Select to load Voltage Control Mode settings saved in Preset 1.
- **Load Preset 2:** Select to load Voltage Control Mode settings saved in Preset 2.
- **Load Preset 3:** Select to load Voltage Control Mode settings saved in Preset 3.

To save current Voltage Control Mode settings, select **Save Current** and press **ENTER**. Arrow to the desired Load Preset label (1, 2 or 3) and press **ENTER**. Press **ESCAPE** to return to the previous menu.

System Configuration

The System Configuration menu allows for screen brightness adjustments and the ability to restore the factory default settings. This menu also displays the RS232 settings and system information

Access the System Configuration Menu from the Local Control Mode, Voltage Control or Remote Control Mode. Use the arrow keys to navigate to **Sys. Config.** and press **ENTER**.

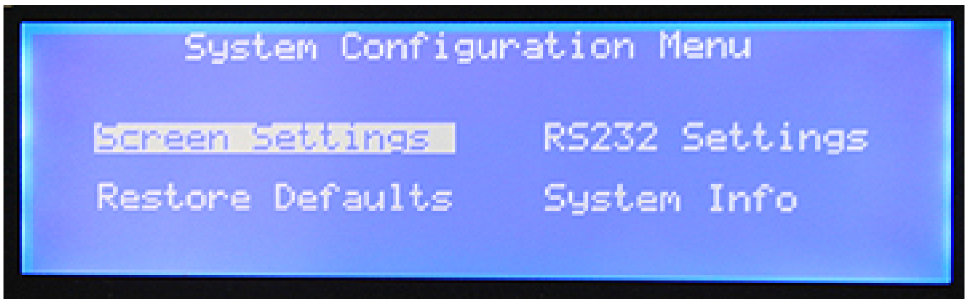

Figure 5.6 System Configuration Menu

Screen Settings

To adjust the screen setting, use the arrow keys to navigate to **Screen Settings** and press **ENTER**. Use the arrow keys to select and adjust the **Pixel** or **Screen** brightness and press **ENTER**. Press **ESCAPE** to return to the previous menu.

Restore Defaults

To restore the factory default settings, use the arrow keys to navigate to **Restore Defaults** and press **ENTER**. Press **ESCAPE** to return to the previous menu.

When Restore Defaults action is taken, all presets and currently displayed settings for Local Control Mode and Voltage Control Mode are restored to initial factory settings as are the User Presets and screen brightness settings.

RS232 Settings

To view the RS232 settings, use the arrow keys to navigate to **RS232 Settings** and press **ENTER**. Press **ESCAPE** to return to the previous menu.

The RS232 settings are listed below.

RS232 Settings	
Baud Rate	2400
Data Bits	8
Stop Bits	1
Parity Check	None
Flow Control	None

Table 5.1 PEM-100 Controller RS232 Settings

System Info

To view system information, use the arrow keys to navigate to **System Info** and press **ENTER**. Press **ESCAPE** to return to the previous menu.

Compare the software part number displayed with the chart below to see what head type the PEM-100 Controller was calibrated for.

Series	**System Info. SW Suffix**
I/FS	-000
II/FS, IS	-001
II/ZS	-002
II/CF	-003
II/SI	-010
I/CF	-011

Table 5.2 PEM-100 Controller Calibration & SW Suffix

6
Operating the PEM-100 Controller

Front Panel Operation

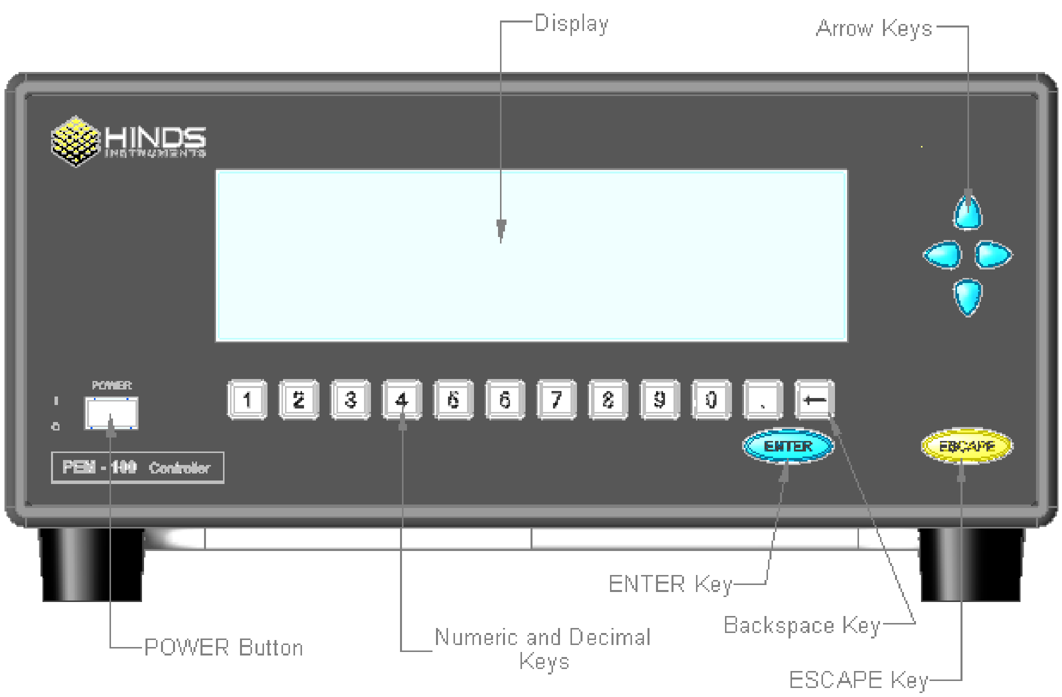

Figure 6.1 PEM-100 Controller Front Panel

Power Up

When the instrument is first turned ON by pushing the **POWER** button, the controller is powered up with the factory default parameters.

When the controller is turned OFF, the displayed parameters as well as newly loaded user presets are stored to memory. When the controller is then turned back ON, the controller is powered up with the parameters which were set when the controller was turned OFF.

Factory Default Parameters

The PEM-100 controller is programmed at the factory with default settings of Wavelength = 632.8 nm and Retardation = 0. 25 λ. These settings are overwritten as desired by the user but they can be restored through the **Sys. Config.** then **Restore Defaults** menu path.

Setting Front Panel Parameters

The following operating parameters may be set from the PEM-100 Controller front panel.

Local Control Mode

- Wavelength of light (input to controller)
- Display of wavelength units (nm, µm, 1/cm)
- Retardation
- Display of retardation units (λ, rad, º)
- Frequency harmonic (1f or 2f)
- Frequency Units (Hz, kHz)

Voltage Control Mode

- VControl
- Frequency harmonic (1f or 2f)
- Frequency Units (Hz, kHz)

Setting Wavelength

For most experimenters, the most useful units of retardation are phase units (waves, radians, and degrees). The controller requires the user to input the wavelength of light being used so that the proper electrical signal may be set to the modulator head.

The following wavelength settings are accessed from within the Local Control Mode.

To set the controller to a different wavelength:

1. Arrow to **WAV** and press the **ENTER** button.
2. Using the numerical buttons, enter the desired wavelength.
3. Press the **ENTER** button to have the controller change the setting to the new wavelength value.

To set the controller to a different wavelength unit:

1. Arrow to the wavelength unit and press the **ENTER** button.
2. Arrow to desired wavelength unit (nm, µm or 1/cm) and press the **ENTER** button.

Setting Retardation

The factory default retardation is 0.250 λ (fraction of wavelength). To set the controller to a different retardation:

1. Arrow to **RTD** and press the **ENTER** button.
2. Using the numerical buttons, enter the desired retardation.
3. Press the **ENTER** button to save new retardation value

To set the controller to a different retardation unit:

1. Arrow to the retardation unit and press the **ENTER** button.
2. Arrow to the desired retardation unit (λ, rad or º) and press the **ENTER** button.

Setting the Frequency

The frequency shown is the harmonic frequency. Frequency units may be set from within either the Local Control Mode or the Voltage Control Mode. To set the controller to a different harmonic frequency:

1. Arrow to **1f** and press the **ENTER** button.
2. Arrow to the desired harmonic (1f or 2f) and press the **ENTER** button.

To set the controller to a different frequency unit:

1. Arrow to **kHz** and press **ENTER**.
2. Arrow to the desired frequency unit (Hz or kHz) and press the **ENTER** button.

Setting VControl

The factory default VControl is 0.999V. The following VControl setting is accessed from within the Voltage Control Mode.

To set the controller to a different VControl:

1. Arrow to **Mode Select** and press the **ENTER** button.
2. Arrow to **Voltage Control** and press the **ENTER** button.
3. Arrow to **VCtrl** and press the **ENTER** button.
4. Using the numerical buttons, enter the desired VControl.
5. Press the **ENTER** button to save the new VControl value.

Selecting Factory Default Presets

The controller contains preset parameters located within the User Presets menu. Depending upon which control mode (Local or Voltage) is displayed, the default preset selections for the associated mode will be displayed.

To set the controller to one of three factory presets:

1. Arrow to **User Presets** and press the **ENTER** button.
2. Arrow to the desired factory preset (Load Preset 1, Load Preset 2 or Load Preset 3) and press the **ENTER** button.
3. Press the **ENTER** button again to load the factory preset.

Saving User Defined Presets

Saving user defined preset parameters will overwrite the selected default preset. The saved preset will remain until overwritten by new user defined preset parameters. Depending upon which control mode (Local or Voltage) is displayed, the saved preset for the associated mode will be displayed.

To save user defined preset values:

1. Arrow to **User Presets** and press the **ENTER** button.
2. Press the **ENTER** button again to access the preset selection menu.
3. Arrow to the desired preset label (As Preset 1, As Preset 2 or As Preset 3) and press **ENTER** to save the current preset values under the label selected.

Resetting the Controller to Default Parameters

It is sometimes desirable to return the controller settings to the factory default parameters. By performing the steps below, all user presets and screen settings for all modes will return to their factory defaults.

1. Use the arrow keys to navigate to **Sys. Config.** and press the **ENTER** button.
2. Arrow down to **Restore Defaults** and press the **ENTER** button.
3. Press the **ENTER** button again to restore the factory defaults.
4. Press the **ESCAPE** button to return to the previous menu.

Local Control Mode Factory Defaults

The Local Control Mode factory default settings for User Presets are below.

The factory defaults for Current Settings of wavelength and retardation are variable based upon controller configuration for head type used.

	Wavelength (nm)	**Retardation (λ)**
Current Settings	Variable	Variable
Preset 1	543.5 nm	0.25 λ
Preset 2	632.8 nm	0.125 λ
Preset 3	1.54 µm	11.25 º

Table 6.1 Local Control Mode Factory Defaults

Voltage Control Mode Factory Defaults

The Voltage Control Mode factory default settings for User Presets are below.

	VCtrl
Current Settings	0.999
Preset 1	1.111
Preset 2	2.222
Preset 3	3.333

Table 6.2 Voltage Control Mode Factory Defaults

7
PEM Control Software

PEM Control Software allows the user to remotely operate the PEM-100 controller from a PC. This section provides an overview of PEM Control Software installation and the remote operation of the PEM-100 Controller.

Installing the PEM Control Software

Locate the ‘Photoelastic Modulators & Accessories’ CD (Hinds PN: 024-0000-012) that was included with the PEM-100 shipment. Load the CD into the computer that the PEM-100 will be connected to (Local Computer). Open the CD to the ‘Software\PEM Control Software’ folder and copy the folder to the desktop of the local computer.

Note: It is important that the CD folder is copied to the ‘local’ computer and not to a network location. The PEM Control program cannot run from a network location.

1. Click on the ‘dotnetfx.exe’ file. This installs the ‘Micorsoft.NET runtime, version 1.1’ onto the local computer.
2. Errors encountered during the ‘dotnefx.exe’ file install may occur if the PC user does not have administrator privileges. See your System Administrator for file installation assistance.
3. Copy the ‘PEMControl.exe’ file to the desktop or a desired location on the local computer. This is the file that starts the PEM Control software.

Setup of PEM-100 Controller for use with PEM Control Software

Ensure the PEM-100 Controller is set up as follows before attempting to use the PEM Control Software:

1. The PEM-100 ‘RS-232’ port is connected to a COM port on the target computer. Note the COM port number. Use the ‘PEM - RS232 Communication Cable’ for this purpose.
2. A headset is connected to the PEM-100. Use the cable labeled ‘PEM Controller to Head Cable’ for this purpose. Also, make sure the Electronic Head is connected to the Optical head using the cable or cables provided.

3. Power ON the PEM-100 Controller and go to the 'Sys.Config.\System Info' menu to locate the 'SW PN'. Write down the last 3 numbers of the '025-1000-XXX' number. These numbers identify what type of controller and head-set you have and will be required by the PEM Control Software.
4. IMPORTANT - Now set the Controller to the 'Remote Control' mode.

Launching the PEM Control Software and verifying communication with the PEM-100 Controller

1. Open the 'PEM Control Software' icon copied to the computer desktop.
2. When the software opens, click to the 'Settings\Advanced' menu which displays a dialog box. Select the computer COM port number that was used for connection to the PEM-100 Controller.
3. IMPORTANT - click the **X** to close the Advanced dialog box.
4. Look at the bottom of the software display and click the 'Update Frequency' box. A frequency number will be displayed next to the 'Frequency' window if communication is occurring with the PEM-100 Controller.

   NOTE: Communication will not be successful if the wrong COM port number was selected. The computer and software will 'hang-up' and both will need to be powered OFF or restarted. Perform the above steps again to select the proper COM port number.

Choosing the Proper Headset Type

It is *very important* to choose the proper headset type before using the PEM Control Software. This ensures the PEM-100 Controller will be set up properly when the user enters their Wavelength and Retardation settings in the PEM Control Software. Choose the headset type as follows:

1. Click the 'Settings\Advanced' menu or click inside the 'PEM Head Type' box on the main PEM Control Software display. This shows the 'Advanced' selections. Now click the down arrow in the 'PEM Head Type' box to reveal all of the head type selections as shown in Figure 7.1.

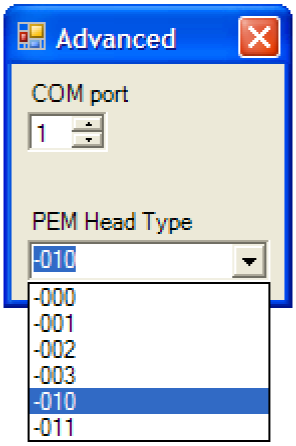

Figure 7.1 Head type selections

2. Now select the headset type recorded earlier (a reminder – to find the headset type, put the PEM-100 Controller in ‘Local Mode’ and go to the ‘Sys.Config.\System Info’ menu and view the SW PN. The XXX numbers of the 025-1000-XXX shown is the headset type.
3. Click the Red ‘X’ box to close the ‘Advanced’ menu. The headset type you selected should appear in the ‘PEM Head Type’ box on the main PEM Control Software display.

Operating the PEM Control Software

Screen displays and associated operational instructions of the PEM Control Software are captured within the following sections.

Main Display Screen

When launching the PEM Control Software, the main display screen will appear with the default settings as shown.

This screen allows for adjustments to wavelength and retardation settings as well as provides selections for frequency and PEM head type.

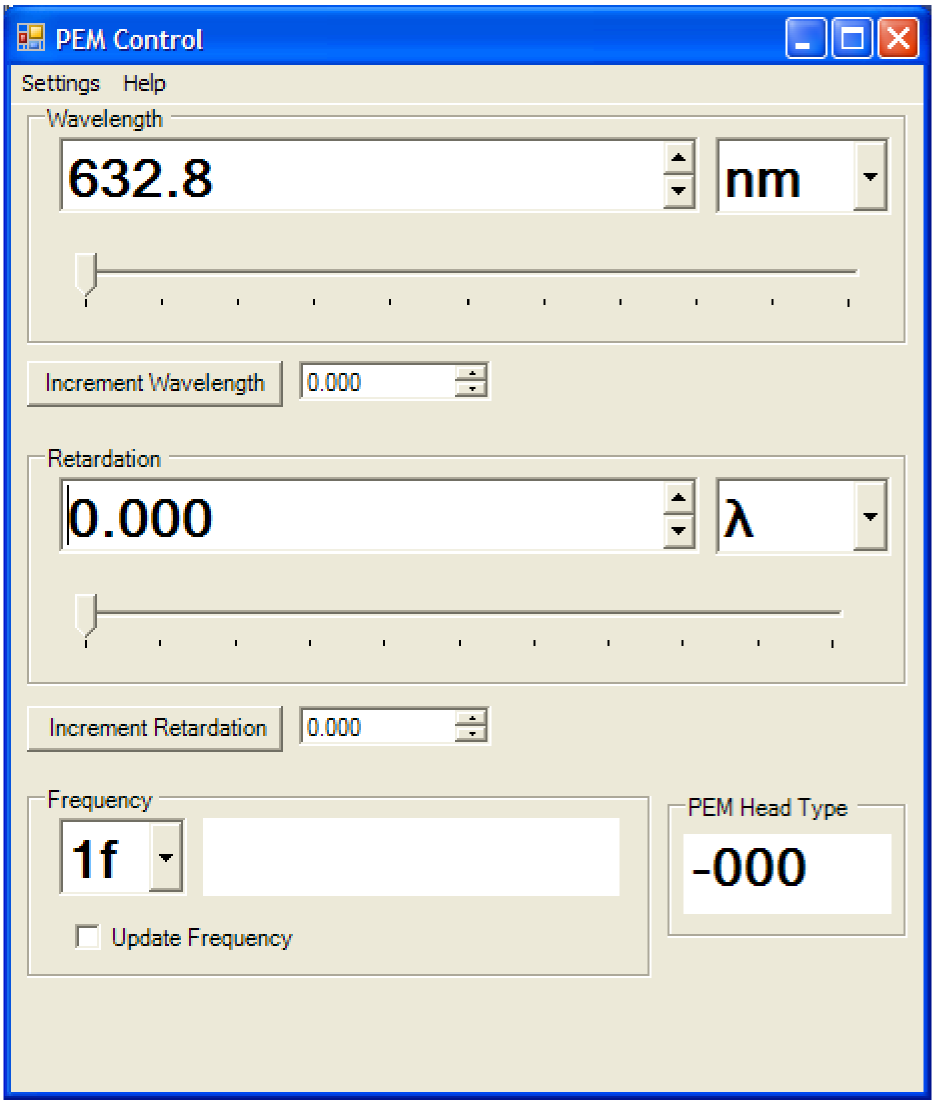

Figure 7.2 Main Display Screen

Wavelength: The wavelength field displays the wavelength setting.

Entering a different wavelength can be accomplished three ways:

1. Double click the wavelength displayed to highlight the setting and then enter a new wavelength.
2. Click and hold the slider adjustment below the wavelength display and drag the slider to the desired wavelength setting.
3. Click on the up▲ or down▼ arrow to the right of the wavelength display to adjust the wavelength setting by single digits.

Wavelength Units: The wavelength units field displays the selected wavelength unit. Wavelength units can be set to display in nanometers (nm), micrometers (µm) and wavenumbers (1/cm).

To change the wavelength unit, click on the arrow to the right of the wavelength units field and click on the desired wavelength unit. The wavelength displayed will adjust accordingly.

Increment Wavelength: The increment wavelength field displays the set number for wavelength increment adjustments.

Entering wavelength increments can be accomplished in 2 ways:

1. Double click the incremental wavelength displayed to highlight the setting and then enter a new wavelength increment value.
2. Click on the up▲ or down▼ arrow to the right of the increment wavelength display to adjust the wavelength increment number.

Retardation: The retardation field displays the retardation setting.

Retardation Units: The retardation units field displays the selected retardation unit. Retardation units can be set to display in fraction of wavelength (λ) radian (rad) or degrees (º).

Increment Retardation: The increment retardation field displays the set number for retardation increment adjustments.

Entering retardation increments can be accomplished in two ways:

1. Double click the incremental retardation displayed to highlight the setting and enter a new increment value.
2. Click on the up▲ or down▼ arrow to the right of the increment retardation display to adjust the increment number.

Frequency: The frequency field displays the first (1f) or second (2f) harmonic operating frequency of the head-set being used.

Selecting the frequency can be accomplished in 2 ways:

1. Click in the frequency type display field and select the desired harmonic frequency.
2. Click on the down▼ arrow to the right of the frequency type display and select the desired harmonic frequency.

Update Frequency: Check the update frequency box to update the frequency displayed.

PEM Head Type: The head type field displays the last three digits, shown in bold, of the SW PN: (software part number) 025-1000**-XXX**.000 which corresponds to the head set type and controller type.

Selecting the correct software part number can be accomplished in two ways:

1. Click in the PEM Head Type display field. The Advanced setting dialog box will appear. See figure 7.2. Click on the PEM Head Type down▼ arrow and select the correct software part number. See 'Setup of PEM-100 Controller for use with PEM Control Software' on page 41. Click on the **X** to close the dialog box.
2. Click on 'Settings/Advanced' to access the Advanced setting dialog box. Select the correct software part number and click on the **X** to close the dialog box.

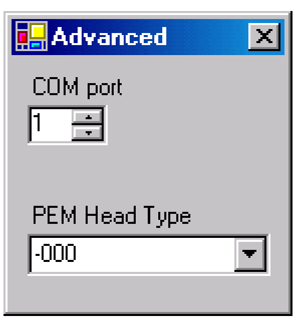

Figure 7.3 Advanced Setting Dialog Box

V Control Operation

The PEM Control Software provides for direct voltage control of the PEM head-set using the 'V Control' mode. Click on the 'Settings/V Control' from the main display screen to access the 'V Control' mode dialog box of the PEM Control Software.

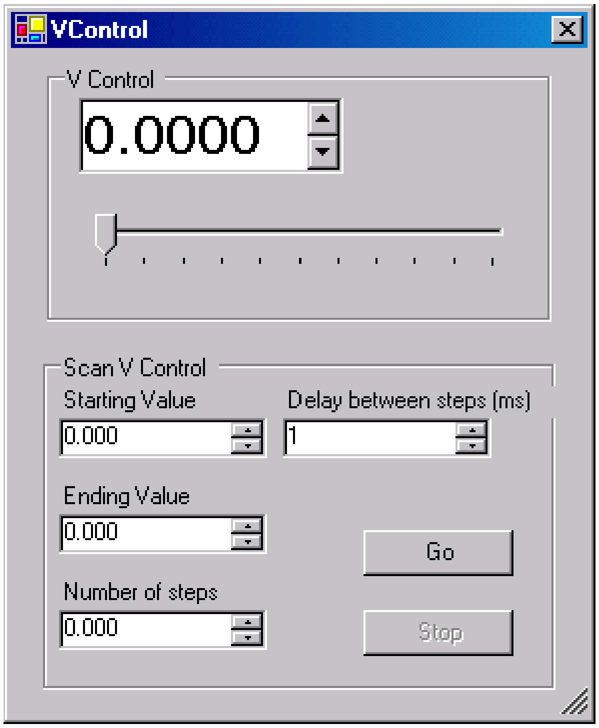

Figure 7.4 V Control Mode Dialog Box

V Control: The V Control field displays the voltage control setting. Voltage values from 0 to 4.85 can be entered in the V Control numerical display.

Entering a different voltage value can be accomplished three ways:

1. Double click the voltage displayed to highlight the setting and then enter a new voltage value.
2. Click and hold the slider adjustment below the V Control display and drag the slider to the desired voltage setting.
3. Click on the up▲ or down▼ arrow to the right of the V Control display to adjust the voltage setting by single digits.

Scan V Control: The Scan V Control allows for automated V Control scans.

To do a scan of V Control values:

1. Enter the starting and ending voltage values in the **Starting Value** and **Ending Value** fields. Choose a starting voltage value smaller than the ending value for an ascending scan or reverse this for a descending scan. The allowable range of voltage values is 0 to 4.85.

2. Enter the number of steps the scan will make in the **Number of Steps** field. The software will calculate the step size by dividing the range, defined by the starting and ending values, by the number of steps selected.
3. Enter the time delay between steps in the **Delay between Steps** field. This time delay value is in milli-Seconds, so enter 1000 for a 1 second time delay between steps.
4. Click the **GO** button to begin an automated V Control scan. The V Control numerical display field will be updated for each new step in the scan.

8
Command Line Interpreter (CLI)

The PEM-100 Command Line Interpreter (abbreviated CLI) is a set of commands allowing the user to remotely operate the PEM-100 controller from a user specific or terminal computer program. This section describes operating the PEM-100 using the CLI.

Example Setup of PEM-100 Controller for use with the CLI

1. Connect the PEM-100 ‘RS-232’ port to the desired COM port on a computer. Use the ‘PEM - RS232 Communication Cable’ for this purpose. Note the COM port number. The computer must have a terminal program installed (example- Windows HyperTerminal).
2. Connect a PEM headset to the PEM-100. Use the cable labeled ‘PEM Controller to Head Cable’ for this purpose. Also, make sure the Electronic Head is connected to the Optical head using the cable or cables provided.
3. Power on the PEM-100 Controller and set it to ‘Remote Control’ mode.
4. Power on the computer and open the terminal program. Change the terminal program settings as follows:

Port Settings	**ASCII Setup**
COM port - use port number connected to PEM-100	Emulation - TTY
2400 bits per second	
8 data bits	Send line ends with line feeds
No parity	Echo typed characters locally
1 stop bit	Append line feeds to incoming line ends
Flow control - hardware	

Table 8.1 CLI Port Settings & ASCII Setup

Note: The CLI will not operate if the PEM Control Software is already in use. Shut down the PEM Control Software to use the CLI feature.

5. Press the PC keypad **Enter** key, which should result in an asterisk '*' being displayed on the PC screen. This indicates the terminal program is communicating with the PEM-100.
6. Type the desired command from table 8.2 PEM-100 Control Line Interpreter Command Descriptions.

   Example: to set the PEM-100 retardation to ¼ wave, type**: R:0250** then press **Enter**.

   To read the retardation setting, type: **R** then press **Enter**.

PEM-100 ‘Command Line Interpreter (CLI)’ Command Descriptions

Action/terminal characters typed	Command Description	Expected Terminal Display	PEM-100 Remote Mode Display	Remark
Enter key pressed	Enter	*(ready indicator)	No change	
Incorrect syntax or non-accepted values		? (error indicator)	No change	Is always followed by a ‘*’ character on the next line.
F and 1F	Display 1f frequency on the terminal display and on the Remote control mode display	Displays 1f freq in 6 digits. 039988 for example.	Displays 1f freq in kHz	Correctly entered command followed by the 1f frequency, then a ‘*’ character on the next line. Allow a few seconds for frequency stability.
2F	Display 2f frequency on the terminal display and on the Remote Control mode display.	Displays 2f freq in 6 digits. 079976 for example.	Displays 2f freq in kHz	Correctly entered command followed by the 2f frequency, then a ‘*’ character on the next line. Allow a few seconds for frequency stability.
F?	Displays the 1f or 2f frequency on the terminal display if the 1F or 2F command is active.	Displays freq in 6 digits. 039988 for example.	No change	Correctly entered command followed by the currently selected frequency, then a ‘*’ character on the next line. Allow a few seconds for frequency stability.
I:n, n=0 or 1.	Inhibit retardation. 0 = normal operation, 1 = inhibit	None	No change	Correctly entered command followed by a ‘*’ character on the next line.
R:nnnn, nnnn – 0000 to 1000	Sets retardation in wave units. Full wave = 1000, ¼ wave = 0250.	None	No change	Correctly entered command followed by a ‘*’ character on the next line.
W:nnnnnn, nnnnnn = 00000.0 to 19999.9.	Sets retardation in nm units.	None	No change	Correctly entered command followed by a ‘*’ character on the next line.
R	Reads the current PEM-100 retardation setting in wave units.	Result of retardation query is displayed as nnnn.	No change	Correctly entered command results in the nnnn value of retardation being displayed and followed with the ‘*’ character on the next line.
W	Reads the current PEM-100 wavelength setting in nm units.	Results of wavelength query is displayed as nnnnnn.	No change	Correctly entered command results in the nnnnnn value of wavelength being displayed and followed with the ‘*’ character on the next line.

Table 8.2a PEM-100 Command Line Interpreter Command Descriptions

Action/terminal characters typed	**Command Description**	**Expected Terminal Display**	**PEM-100 Remote Mode Display**	**Remark**
Z	Reset to factory wavelength and retardation defaults and display start up header. Wavelength Ret 632.8 nm 0.25	Displays 'PEM-100 SW PN: 025-1000-XXX.YYY', XXX suffix is the software version. YYY is the software revision.	No change	Note that the present wavelength and retardation settings will change to the default settings after entering the Z command.
V:n.nnn and Vn.nnn. n.nnn = 0.000 to 4.850	Sets Vcntrl to n.nnn	None	No change	Correctly entered command followed by a '*' character on the next line.

Table 8.2b PEM-100 Command Line Interpreter Command Descriptions

9
Troubleshooting

The purpose of this section is to determine whether the user's problem is caused by the PEM, or whether the problem exists elsewhere in the system. It is also intended to facilitate communication with the factory about the nature of the problem.

Troubleshooting Guide – Symptoms & Possible Remedies

Power Problems	
Symptoms	***Possible Remedies***
Display stays dark with power button depressed.	- Power cord not plugged in. - Incorrect cord type for local power service. - No line voltage at wall outlet. - Blown power fuses on PEM-100 Controller (see manual for instructions on replacing fuses.)
Display flashes On then OFF continuously.	-Equipment incorrectly connected to back panel connectors. Power OFF PEM-100 Controller and check connections per the instructions in this manual.
Modulation Problems	
Symptoms	***Possible Remedies***
No frequency value is shown on the PEM-100 Controller or on the PEM Control software display. (See Figure 8.1 on following page)	- Ensure packaging around head-set optic is removed (see instructions for removing packaging that were shipped with head-set or consult manual.) - Ensure head-set is connected to the PEM-100 Controller via a 9-pin Head-to-Controller cable and that the optical head is connected to the electronic head.

Table 9.1a Troubleshooting Guide – Symptoms & Possible Remedies

Reference Problems	
Symptoms	***Possible Remedies***
Low or no reference signal visible on oscilloscope.	-Note that 'f' and '2f' reference outputs will not drive a 50 Ohm load. Make sure the oscilloscope input used is set for high impedance mode.
Problems with 'PEM Control' software	
Symptoms	***Possible Remedies***
The 'PEM Control' software won't start.	- Windows 2000 and 98 users will need to install the **dotnetfx.exe** file (from the CD) onto PC.
No frequency value is shown on the 'PEM Control' software display." (See Figure 8.1 below)	- Set the software COM port for the PC COM port used. Click "Update Frequency' box on software display. Restart the software if the COM port needs to be changed after clicking 'Update Frequency'. - Ensure head-set is connected to the PEM-100 Controller and the controller RS232 port connected to the PC. The controller must be ON and set to REMOTE mode. - See 'Troubleshooting – Modulation problems' section

Table 9.1b Troubleshooting Guide – Symptoms & Possible Remedies

Figure 9.1 Display – No Connection between Head-Set & Controller

Over Limit Conditions in Local Control & Voltage Control Modes

For Local Control Mode, the controller senses over limit conditions when retardation or wavelength settings are too high. If this occurs, the following message will be displayed:

Figure 9.2 Display - Retardation Over Limit Message

For Voltage Control Mode, if the voltage input exceeds 4.85 volts, an over limit message is displayed as follows:

Figure 9.3 Display - Voltage Over Limit Message

10 Maintenance

Calibration

PEM-100 modulators are calibrated at the factory before shipment. For most applications, recalibration is neither necessary nor appropriate. For a few applications, however, an *on-site* calibration procedure will be necessary if optimum performance is to be achieved. Hinds' engineers will be glad to advise users on whether on site calibration is appropriate in a particular case.

The Calibration appendix contains an extensive discussion of the theory of retardation calibration and a variety of methods for establishing known calibration points. Fortunately, photoelastic modulators are to a large extent self calibrating, and most of the equipment needed for calibration will be required for the user's experiment.

Adjustment of Peak Retardation Calibration

The most common reference point used for calibration is half-wave peak retardation or an integral multiple of half-wave. This condition may be easily observed using an oscilloscope, as described in the Calibration appendix. Even when other reference points are used, this method should be regarded as the "coarse adjustment" on the modulator calibration.

The peak retardation calibration of the modulator is adjusted by R4, a multi-turn trimpot labeled "Range" in the electronic head. With the appropriate optical bench setup and detection system, the trimpot is adjusted until the calibration condition is obtained. For example, in the case of the half-wave calibration, the appropriate flat toped (or flat bottomed) characteristic waveform is observed on the oscilloscope.

Maintenance

The optical head contains an optical element and requires the same care in use as other components such as lenses and mirrors. The unit should not be operated in a dusty, corrosive, or otherwise contaminating environment. Small amounts of dust may be removed from the optical element with a soft brush such as an artist's camel-hair brush. If more serious contamination occurs, contact Hind's engineers.

The PEM units are rugged and reliable and normally require no additional maintenance. If trouble occurs, please consult the troubleshooting section and then contact Hinds' engineers for assistance.

Power Line Fuse Replacement

Two power line fuses (1 Amp, Slo-Blo, 5 x 20 mm) are present in the PEM-100 Controller.

CAUTION

In order to maintain proper fire and safety precautions, replace the power line fuses only with the type and value indicated.

Both fuses should be replaced if a fuse blows.

1. Disconnect all power from the instrument by pulling the power cord from the wall outlet or from the appliance inlet.
2. Remove the power fuse holder from the back of the instrument.

Figure 10.1 Opening the Power Fuse Holder

3. Insert the replacement fuses into the power fuse holder and install the power fuse holder as shown in figure 10.2 on the following page.

Figure 10.2 Fuses Properly Inserted In Fuse Holder

Cleaning

When the PEM was shipped, the surface was clean and defect free; however, the rigors of packing and shipping may leave some residue on the optical surface(s). A final cleaning of the optical surfaces may be required before using them in your system.

As with all optics, dirt, fingerprints, oils and other materials lower the effectiveness and shorten the lifetime of dielectric coatings.

Handle all optics with care to prevent unusual wear, breakage or surface scratches.

Recommended Optics Cleaning Solutions

It is important to use the proper cleaning solution for specific optic materials. Failure to use the proper cleaning solution may scratch or damage the optical surface.

Coated/Uncoated Non-ZnSe Optics

The non-ZnSe optics are coated with a hard, durable dielectric material and may be cleaned like an uncoated optical surface.   The optic may be cleaned with *uncontaminated* **acetone**.

Coated/Uncoated ZnSe Optics

The ZnSe optics may be cleaned with lighter fluid/butane.

Avoid exposing the junction between the optical element and the transducer with the solvent.

Cleaning the Optics

Two cleaning methods recommended are the cotton swab method and the lens tissue method. These "wet drag" techniques of cleaning are effective methods for removing dust and light residue from most hard-coated optical surfaces.

Warning

To guard against electrical shock or instrument damage, never allow water to get inside the case. Unplug the unit before cleaning the optics.

Cotton Swab Method

Using a 100% cotton swab moistened with solvent, wipe the surface gently while rotating the swab slowly. This action ensures that the contaminants are lifted away from the surface of the optic.

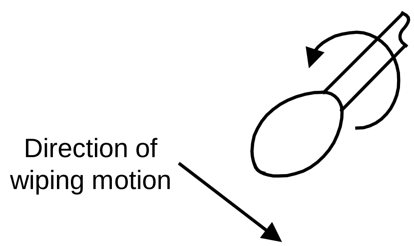

Figure 10.3 Direction of cotton swab wiping motion

Lens Tissue Method

In order to clean the optics using the lens tissue method, the cover to the optics must first be removed.

When applying the solvent, avoid exposing the junction between the optical element and the transducer.

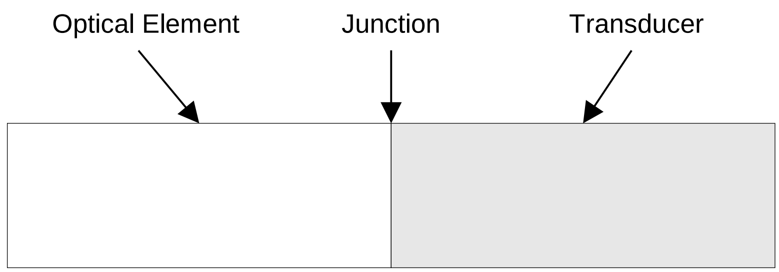

Figure 10.4 Junction between Optical Element and Transducer

1. Take a single piece of lint-free lens tissue (do not use Kim wipes) and place it on the surface to be cleaned, so it covers the entire surface.
2. Using the recommended cleaning agent, soak the lens tissue until the entire surface is damp (not wet).
3. Grasp two free corners of the lens tissue and drag the tissue across the surface away from the junction in a smooth, even manner so the alcohol dries immediately as the rear edge of the tissue moves over the optical surface.

This cleaning method leaves no residue or moisture on the coated surface and assures a clean and long lasting coating. This technique may be used regularly to keep residue from building up, preventing damage and degradation to the optical surface.

When replacing the cover to the optics, tighten screws (Qty 4) until snug.

Cleaning the Controller

The exterior of the PEM-100 controller may be cleaned with a cloth dampened in water or a mild detergent solution. Do not clean with aromatic hydrocarbons, chlorinated solvents or methanol-based fluids since these chemicals can damage the front panel overlay and may possibly damage the case paint and printing.

WARNING

To guard against electrical shock or instrument damage, never allow water to get inside the case.

A
Calibration

by Theodore Oakberg, PhD

Proper retardation calibration of photoelastic modulator systems is essential for optimum performance. This is best accomplished with the modulator in the optical setup in which it will be used. This application note is intended to assist users with *in situ* calibration of their PEMs.

Some calibration techniques are very simple. In the vacuum UV with a circular dichroism CD experiment, the modulator retardation might simply be adjusted to give maximum signal when a known CD spectrum line is being observed. Even this simple technique could be improved with the Bessel function methods described later in this application note.

PEM 100 Calibration

The PEM 100 has been designed to provide significantly improved calibration for a narrow monochromatic light beam, as compared to the PEM-90. Specifically, the accuracy of retardation vs. wavelength has been improved. For many applications the calibration built into the PEM 100 is sufficient (retardation uncertainty <5%).

There are still cases where in-situ calibration by the user is advisable or even mandatory. These cases include, but are not limited to, the following:

1. Where there is a requirement for very high retardation accuracy for the PEM.
2. Where the light beam <u>at the PEM</u> is not narrow but uses a large fraction of the PEM aperture.
3. Where extreme angles of incidence (>15 to 20º) are involved.

For user-performed calibration, direct control of the parameter Vcontrol should be considered.

Calibration Theory

The optical setup for most calibration procedures is shown in figure A.1.

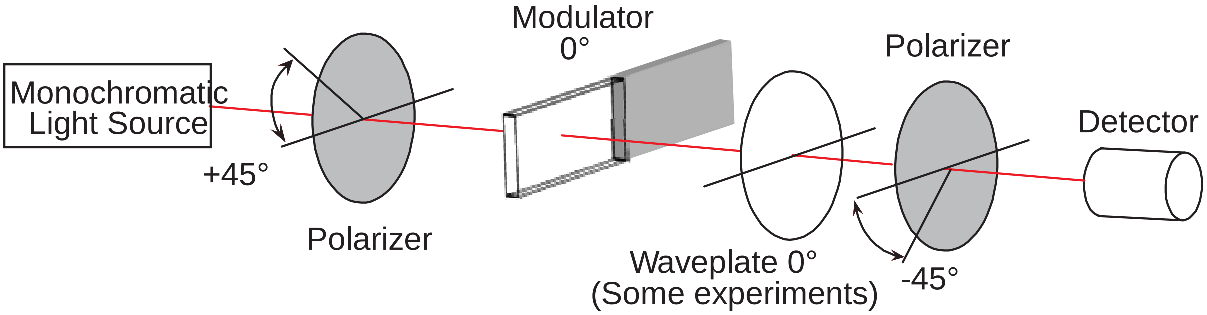

Figure A.1 Typical Optical Setup

The modulator is placed between crossed polarizers, each of which is oriented with its passing axis at 45 degrees with respect to the modulator axis. For some calibration procedures, a retarder is required. If so, it should be placed between one polarizer and the modulator, with the fast axis parallel or perpendicular to the modulator axis.

The space between the two polarizers should contain nothing but the modulator and the waveplate (if needed). Mirror, prisms, filters, windows, lenses, monochromators or other wavelength selecting devices should be located outside the polarizers, if possible.

Kemp[1] has derived the equations for the intensity of the light reaching the detector, as a function of time. A_0 is the amplitude of the sinusoidal retardation function; B is the retardation magnitude of the waveplate; and Ω is the angular frequency of the modulator. The general expression for the intensity function is:

$$\mathrm{I} = \frac{1}{2}\{1 - \cos B \cos(A_0 \cos \Omega t) + \sin B \sin(A \cos \Omega t)\} = \frac{1}{2}\{1 - \cos(B + A_0 \cos(\Omega t))\} \qquad (1)$$

For the majority of applications, expansion of this expression using a Fourier Series is very useful;

$$\mathrm{I} = \frac{1}{2}\{1 - \cos(B) J_0(A_0) \qquad \textbf{DC} \qquad (2)$$

$$+ 2\sin(B) J_1(A_0)\cos(\Omega t) \qquad \textbf{1f}$$

$$+ 2\cos(B) J_2(A_0)\cos(2\Omega t) \qquad \textbf{2f}$$

$$+ \ldots higher\ terms\ \}$$

The latter expression shows the DC component of the expression and the first and second harmonics of the optical intensity signals. Using the reference signals from the modulator controller, these harmonics can be easily detected with a lock-in amplifier.

If there is no birefringence present, the above equations reduce to the following. Note that there is no fundamental (first harmonic) component in the intensity signal.

$$I = \frac{1}{2}\{1 - \cos(A_0 \cos\Omega t)\} \tag{3}$$

and

$$I = \frac{1}{2}\{1 - J_0(A_0) + 2J2(A_0)\cos(2\Omega t) \tag{4}$$

$$+ higher\ terms..\ \}$$

These four equations are basis for the calibration procedures described in the remainder of this application note.

Light Sources for Modulator Calibration

The procedures described below for PEM calibration each require a monochromatic light source. A brief discussion of light sources suitable for this purpose is in order.

Lasers are excellent sources of monochromatic light. At Hinds Instruments, we use HeNe lasers to calibrate most PEMs which we manufacture. Laser beams are intense and well collimated, and do not normally require any focusing optics in the calibration optical setup.

Interference effects may be present when using a laser. In those cases, care must be used to eliminate the interference effects before performing the calibration. A discussion of modulated interference and methods for reducing them may be found in PEM Newsletter #8, Summer 1998 [(2)].

Spectral light sources, such as mercury lamps, are also excellent light sources when used with a monochromator or selected interference filters which match the spectral lines. These allow calibration of the PEM over a range of wavelengths. Interference effects should be negligible. Systems based on interference filters may offer significantly better light throughput than monochromator systems.

White light sources may also be used with monochromators, but here some caution is advised. The error in accuracy of the wavelength of the light should be recognized as approximately the optical bandwidth of the monochromator. Within the bandwidth of a spectrum line, the system sensitivity will be strongly affected by the slope of the spectral radiance of the light and by the spectral sensitivity of the detector. The situation also applies to using interference filters, but the “effective modulation wavelength” may be even further from the nominal center bandwidth of the filter.

For the near IR, visible and near UV, the hottest light source available should be used. If an incandescent lamp is used, it should be of the halogen variety. High pressure Xenon lamps, carbon arc lamps and the like would be even better.

As a general rule, the light source being used in a particular experiment may be the best one to use for the calibration.

Calibration Using an Oscilloscope

The most straightforward procedure, and the one used at Hinds Instruments for the factory calibration of modulators, utilizes a monochromatic light source (e.g. HeNe laser), a solid state detector (e.g. silicon photodiode), and an oscilloscope. A block diagram for the setup is given in figure A.2.

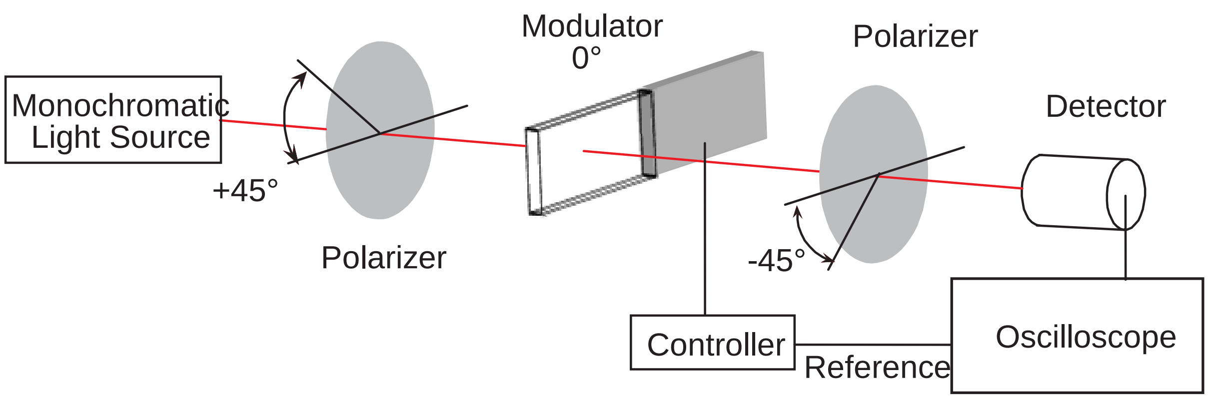

Figure A.2 Oscilloscope Calibration Method

The detector and its associated electronics (including the oscilloscope) should have a frequency bandwidth several times the frequency of the modulator. Calibration can be done in many cases when this condition is not met, but the waveforms will be distorted and the proper half-wave condition will be more difficult to identify.

Referring to equation 3, interesting and distinctive waveforms on the oscilloscope occur whenever A_0 is an integral multiple of $\lambda/2$ or π radians. For half-wave peak retardation ($\lambda/2$ or π radians), the intensity waveform is shown in figure A.3.

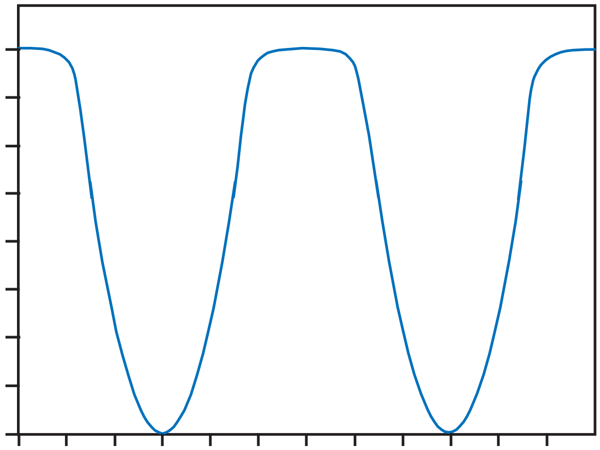

Figure A.3 Waveform for Half-wave Retardation

Note the flat top of the peaks. (Depending on the precise optical and electronic configurations, this display might appear inverted.) This feature is very distinctive, and by adjusting the retardation at half-wave to give the above waveform an accuracy of better than 1% can be achieved. Figures A.4 and A.5 show waveforms for retardations slightly less and slightly more than half-wave.

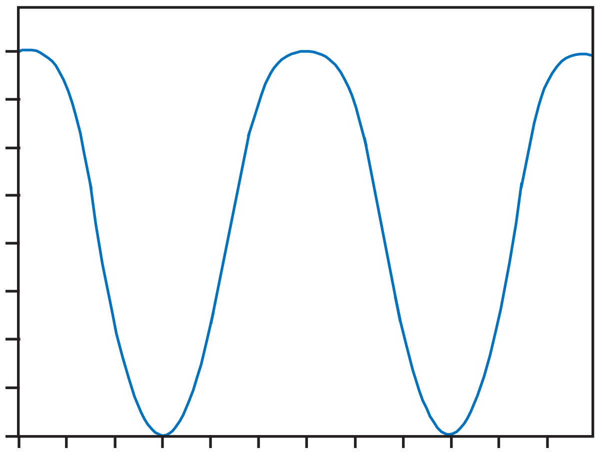

Figure A.4 Retardation 90% of Half-wave

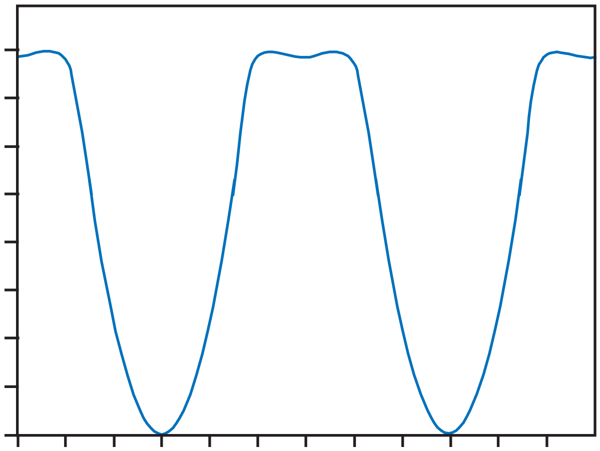

Figure A.5 Retardation 110% of Half-wave

For retardation values of multiple half-waves, the intensity functions continue to exhibit the “flat topped” (or “flat bottomed”) characteristic which is useful for calibration.

The waveform for a retardation of four half-waves is shown in figure A.6.

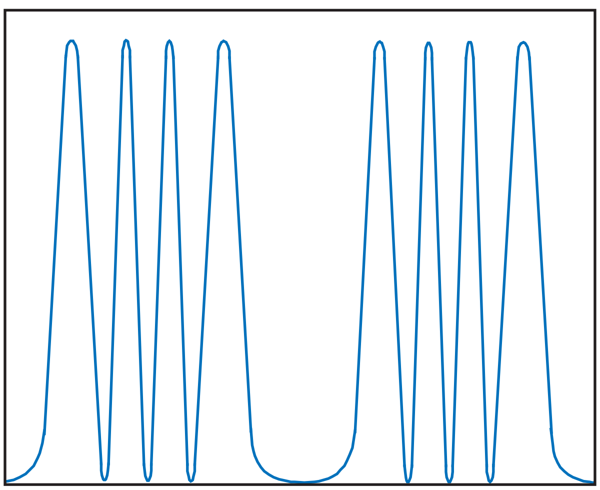

Figure A.6 Waveform for a Retardation of Four Half-waves

Multiple Reflection Techniques

Precise setting of the modulator peak retardation at levels less than half wave may be done by several different methods. For integral fractions of a half-wave, the oscilloscope technique described above may be used by arranging the optical system so that the light beam traverses the center of the modulator multiple times. For example, by traversing the modulator optical element twice, a flat-topped waveform (half-wave retardation) would indicate quarter-wave PEM retardation (for a single pass). See figure A.7.

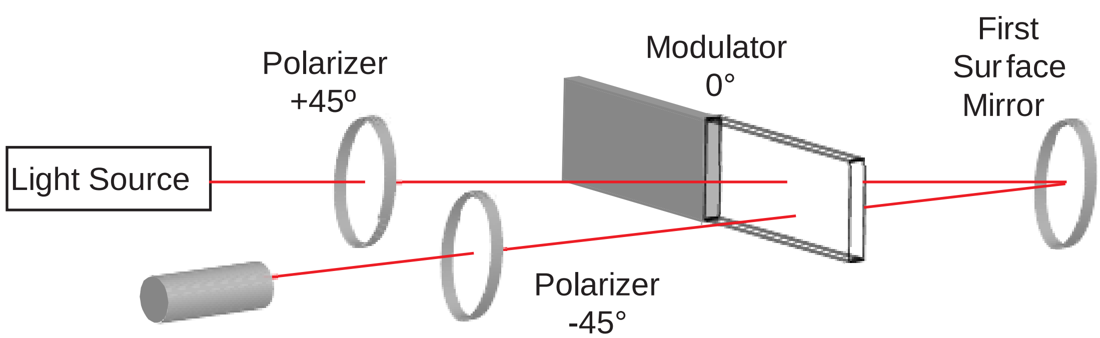

Figure A.7 Setup for Double Pass Modulation

Static Waveplate Techniques

Another technique for establishing a fractional retardation would be to use a static waveplate with known retardation. The waveplate would be placed as shown in Figure A.1, with the fast axis of the waveplate parallel to the modulator axis. If the sum of the static waveplate retardation and the modulator peak retardation is one half-wave, then a flat-topped oscilloscope waveform will result. The modulator retardation would then be half-wave minus the retardation of the fixed waveplate. The use of a calibrated Soleil-Babinet Compensator would give a means of calibrating a modulator for continuous values of peak retardation.

Bessel Function Zero Methods

An examination of equation 2 suggests a method for precise setting of certain values of retardation.

Note, for example, the "DC" term in equation 2. For certain values of A_0 (e.g. 2.405 radians), $J_0(A_0) = 0$, and therefore the DC term becomes a constant, independent of the birefringence B. The DC intensity also becomes independent of many other changes which could be made to the optical system, such as the angular position of the second polarizer. The DC intensity can therefore be used for "normalization" of the AC signals, by forming the ratio V_{AC}/V_{DC}. This is now independent of fluctuations in intensity in the light source, changes in optical transmission, etc.

To establish precisely the controller setting for which $J_0 = 0$, graphs of V_{DC} vs controller setting were made for several different angular positions of the second polarizer. A typical set of graphs is shown in Figure A.8. Notice that the graphs should intersect at one particular controller setting for which the Bessel function J_0 vanishes.

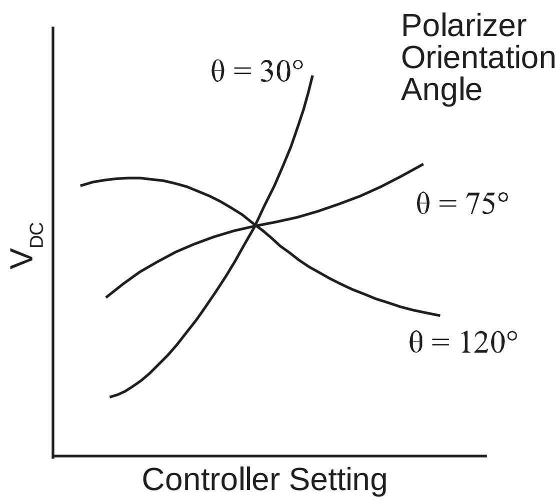

Figure A.8 Determining the Controller Settings for which $J_0 = 0$

If a lock-in amplifier is available, and if the modulator is capable of providing adequate peak retardation, then the AC signals can provide similar retardation calibration points. Consider the second harmonic signal, at twice the modulator frequency. At a peak retardation or amplitude of $A_0 = 5.136$ radians, $J_2(A_0) = 0$. This setting can be established with great accuracy using a lock-in at frequency 2f.

Addition of a birefringent element as shown in figure A.1, so that a significant 1f signal at the modulator frequency is obtained, will enable determining the controller setting for which $J_1(A_0) = 0$. (This occurs for $A_0 = 3.872$ radians.) Detection of the null point is made with a lock-in amplifier at the modulator frequency.

Bessel Function Ratio Methods

Most of the calibration methods described above are used to establish specific retardation levels with precision. There is sometimes a need to extend the calibration to other retardation settings. Using a lock-in amplifier, these extensions may be accomplished using the ratios of Bessel functions. The method described here assumes the use of a stable light source and optical setup. The example given uses the half-wave condition, but the technique can be easily modified to use a Bessel Function Zero starting point.

Consider Figure A.2 and the 2f term of equation 4. The signal voltages V_{2f} for two different retardation levels $A_0^{(1)}$ and $A_0^{(2)}$ are proportional to the Bessel functions of those retardations, as shown in equation 5:

$$\frac{V_{2f}^{(1)}}{V_{2f}^{(2)}} = \frac{I_{2f}\left(A_0^{(1)}\right)}{I_{2f}\left(A_0^{(2)}\right)} = \frac{2J_2\left(A_0^{(1)}\right)\cos(2\Omega t)}{2J_2\left(A_0^{(2)}\right)\cos(2\Omega t)} = \frac{J_2\left(A_0^{(1)}\right)}{J_2\left(A_0^{(2)}\right)} \qquad (5)$$

Assume that one of the retardation settings is the half-wave calibration setting and the other setting is at somewhat less retardation. (Quarter-wave retardation is a good example.) Equation 5 may be rewritten as equation 6:

$$V_{2f}(\lambda/4) = V_{2f}(\lambda/2)\frac{J_2(\pi/2)}{J_2(\pi)} \qquad (6)$$

half-wave retardation: $A_0 = \pi$

quarter-wave retardation: $A_0 = \pi/2$

The method is simple:

1. Using an oscilloscope, determine the half-wave calibration condition.
2. Read the lock-in amplifier reading and compute the expected lock-in reading for quarter-wave retardation.
3. Adjust the controller until this lock-in output is obtained. The modulator will then be correctly set for quarter-wave operation.

A sample calculation is given below for quarter-wave retardation. The required Bessel functions are:

For half-wave: $J_2(\pi) = 0.485$

For quarter wave: $J_2(\pi/2) = 0.250$

The required setting for quarter-wave retardation is:

$$V_{2f}(\lambda/4) = \frac{J_2(\pi/2)}{J_2(\pi)} V_{2f}\left(\frac{\lambda}{2}\right) \qquad (7) \qquad V_{2f}(\lambda/2) = .515 \ \ V_{2f}(\lambda/2)$$

(8)

$V_{2f}(\lambda/2)$ is the lock-in reading for half-wave retardation, as set by the oscilloscope.

Parallel Polarizer Calibration at a Single Wavelength

The primary calibration technique discussed in "Calibration Using an Oscilloscope" is observation of the waveform at half-wave retardation. This gives calibration only at half-wave retardation or integral multiples of half-wave retardation. Other methods such as the Bessel function zero method give retardation only at specific values of retardation (e.g. 3.877 radians or 5.136 radians). Another method of accurately measuring retardation at arbitrary values of $V_{Control}$ is much desired.

Calculating the ratio of V_{2f}/V_{DC} is in principle a good approach. However, if calibration is being done with the PEM between crossed polarizers at 45º there are problems, especially at low retardation levels. From theoretical analysis of the resulting waveforms we learn that:

$$V_{DC} \ \alpha \ 1 - J_0(A_0) \qquad (9) \qquad \text{and} \qquad V_{2f} \ \alpha \ 2J_2(A_0) \qquad (10)$$

If one plots the ratio V_{2f}/V_{DC} the graph shown in Figure A.9 is obtained.

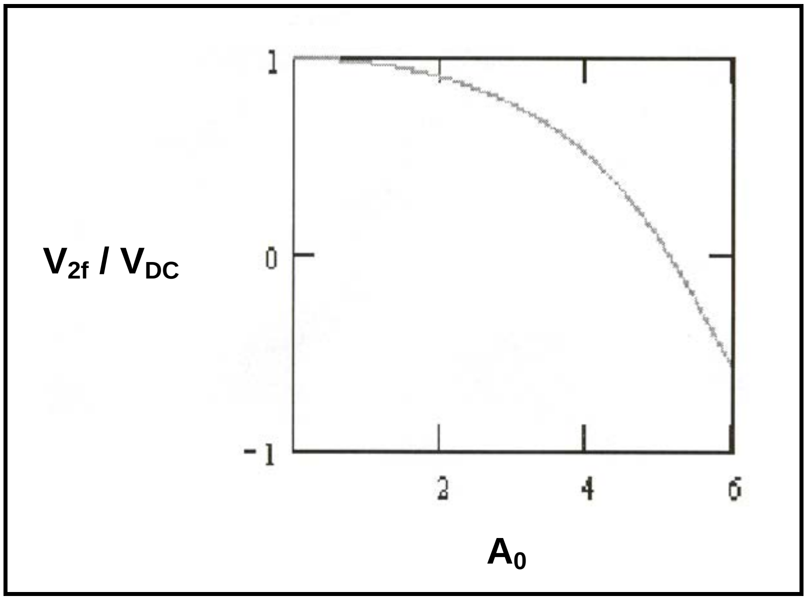

Figure A.9 Ratio V_{2f}/V_{DC} vs retardation, radians

For low values of retardation, this ratio is approximately a constant! This means that use of this ratio for determining PEM retardation is quite insensitive.

The situation may be corrected if the PEM is placed between parallel polarizers. In this case:

$$V_{DC} \;\alpha\; 1 + J_0(A_0) \tag{11}$$

The ratio V_{2f}/V_{DC} vs. retardation is shown in Figure A.10.

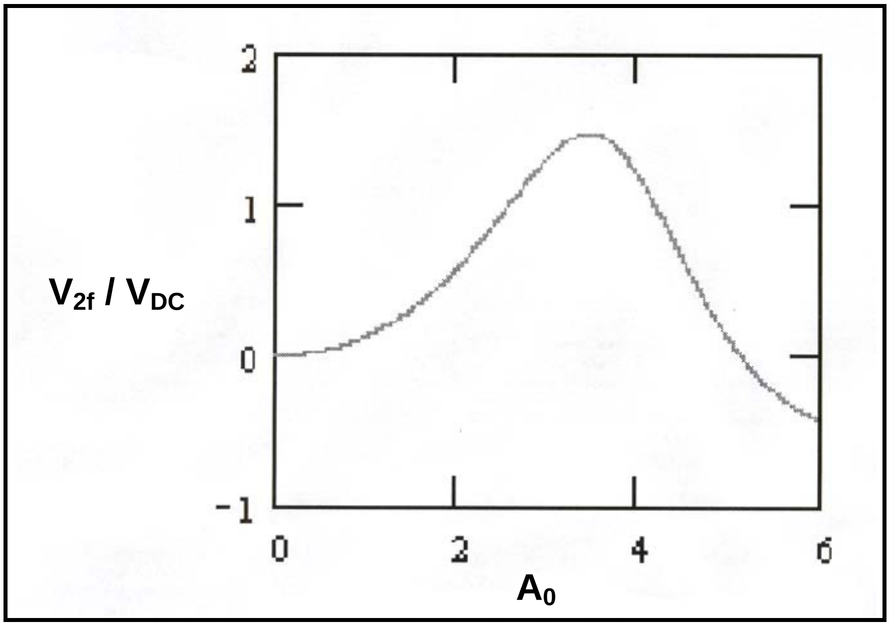

Figure A.10 Ratio V_{2f}/V_{DC} vs. retardation (radians) for parallel polarizers

This method gives monotonically increasing values of the ratio V_{2f}/V_{DC} for low values of A_0 (3 radians and less). It lacks sensitivity for retardation values near 3.5 radians, but this is where the flat-topped half-wave waveform occurs (π radians). The graph is used in reverse, for a given value of $\frac{V_{2f}}{V_{DC}}$, A_0 may be determined.

The method is conceived as a systematic calibration of retardation vs. $V_{Control}$ for a sequence of retardations, beginning with low values. Such a study should avoid ambiguities in A, since the functional relationship is an inverse one. The method, however, requires considerable attention to detail.

First, care must be taken to ensure that V_{DC} is proportional to the average intensity of the modulated light signal. Other contributions to the experimentally measured DC signal would include 1) stray light from ambient room illumination and 2) electrical offset in the detector circuit.

One method to exclude other sources of light from contributing to V_{DC} is to use a mechanical chopper at the light source and a separate lock-in amplifier. This would eliminate the influence of both 1) and 2) above.

A very effective method of reducing the influence of 1) is to place a narrow-band interference filter with a pass band at the same wavelength as the light source. The contribution to V_{DC} would be limited to only the light that can get through the filter. Alternatively, the detector can be shielded from ambient room light. Hinds Instrument's detectors have provision for adjusting the electrical offset under dark conditions.

Another method would be to correct for 1) and 2) by blocking the light (near the light source, not near the detector) and recording the detector output voltage. This baseline value would then be subtracted from the measured value of DC volts to give V_{DC}.

There is another problem which is more subtle, but just as important. This method assumes that the responsivity and/or gain (if there is amplification) are the same for DC (or low frequencies) as for 2f. If this is the case, then the following relationship should be valid:

$$\frac{\sqrt{2}V_{2f}(measured)}{V_{DC}(measured)} = \frac{2J_2(A_0)}{1+J_0(A_0)} \tag{12}$$

The factor of $\sqrt{2}$ results from the lock-in amplifier's measuring V_{rms} whereas theoretical expressions refer to V_{peak}. If equation 4 is satisfied then the calibration using this method may be trusted. This may be tested by comparing the maximum value of the experimental ratio V_{2f}/V_{DC} with the maximum value shown in Figure A.10 (1.481 at about 3.45 radians).

If the condition of equation 12 is not met, the following procedure may be used. Assume that there is an experimental constant K which relates experimental values of the ratio V_{2f}/V_{DC} to the theoretical values of the ratio.

$$K\frac{V_{2f}(measured)}{V_{DC}(measured)} = \frac{2J_2(A_0)}{1+J_0(A_0)} \tag{13}$$

The term on the right has a maximum value of 1.481. Using the maximum experimental value of V_{2f}/V_{DC}, equation 13 may be solved for the experimental constant and a numerical value obtained. A graph or table of $\frac{V_{2f}}{V_{DC}}$ vs A_0 for the value of K found may be generated and used for determining A_0.

Reference:

1. Kemp, James C., *Polarized Light and its Interaction with Modulating Devices*, Hinds International, Inc., 1987

2. Oakberg, Theodore C., “Modulated Interference Effects in Photoelastic Modulators”, PEM Newsletter #8, Summer, 1998

B
Specifications

General- Controller

Model Number	Controller, PEM-100, P/N 020-2650-989
Size	8.43” W x 4.27” H x 13” D
	(214.1mm W x 108.5mm H x 330.2mm D)
Weight	6 Lbs (2.72 Kg) (without head assembly)
Power	100-240 VAC (no switching required), 50-60 Hz, 27 Watts maximum
Power Fuses Rating	(2) each, 1 Amp, ‘T’ type (Slo-Blo), 5x20mm

Displayed Parameter Specifications

Frequency Display

‘f’ Display Range/Resolution	20 kHz - 100 kHz, 1 Hz or 0.001 kHz
‘2f’ Display Range/Resolution	40 kHz - 200 kHz, 1 Hz or 0.001 kHz
Display Accuracy	+/- 1Hz @ 25 degrees C

Wavelength Display

Wavelength Range	See Head set ratings in Appendix C.
Wavelength Units, Max Resolution	nanometers (nm), 0.001 nm
	micrometers (μm), 0.00001 μm
	wavenumbers (1/cm), 0.00001 1/cm

Retardation Display

Retardation Range	See head set ratings in Appendix C.
Retardation Units	Wavelength (λ), radian (rad) or degree (o)

VCtrl Display

Vcntrl Set Range	0 - 4.85 V

Input / Output Specifications

'Head' Connection

Connector Style	D-Sub female, 9-pin
Maximum Voltage, pin to ground	48 VDC @ 300 mA max

'1f' and '2 f' Reference Outputs

Connector Style	BNC female
Output Waveform	5 VDC square wave
Output Frequency	See 'Optical Head Specifications'
Reference Stability	'f', +/- 40 μS, referenced to zero crossing
Phase Stability Duty Cycle	'f', 50% +/- 0.1%
	'2f', 50% +/- 0.1%

RS232 (DCE) Connection

Connector Style	BNC female
Baud Rate	2400

Environmental

Operating Temperature	2 to +42 degrees C (36 to 108 degrees F)
Storage Temperature	-20 to +70 degrees C (-4 to 158 degrees F)
Humidity	95% RH non-condensing
Operating Altitude	3000 meters

Approvals

CE	Approved for connection cables not exceeding 3 meters in length.

EMC & Safety Standards

EN 61326; FCC Class A

EN 61010-1

C
Optical Head Specifications

Model	Optical Material	Nominal Frequency	Retardation Range		Useful Aperture
			Quarter Wave	Half Wave	
I/FS50	Fused Silica	50 kHz	170 nm – 2 µm	170 nm – 1 µm	16 mm
I/FS20	Fused Silica	20 kHz	170 nm – 2 µm	170 nm – 1 µm	22 mm
I/ICF50	Calcium Fluoride	50 kHz	130 nm – 1 µm	130 nm – 0.5 µm	16 mm
I/LF50	Lithium Fluoride	50 kHz	120 nm – 633 nm	120 nm – 316 nm	16 mm
II/FS20	Fused Silica	20 kHz	170 nm – 2 µm	170 nm – 1 µm	56 mm
II/FS42	Fused Silica	42 kHz	170 nm – 2.5 µm	170 nm – 2.5 µm	27 mm
II/IS42	Fused Silica	42 kHz	1.6 nm – 3.5 µm	800 nm – 3.0 µm	27 mm
II/FS47	Fused Silica	47 kHz	170 nm – 2.5 µm	170 nm – 2.5 µm	24 mm
II/FS84	Fused Silica	84 kHz	170 nm – 2.5 µm	170 nm – 2.5 µm	13 mm
II/IS84	Fused Silica	84 kHz	800 nm – 2.5 µm	400 nm –2.5 µm	13 mm
II/CF57	Calcium Fluoride	57 kHz	2 µm – 8.5 µm	1 µm – 5.5 µm	23 mm
II/ZS37	Zinc Selenide	37 kHz	2 µm – 18 µm	2 µm – 9 µm	19 mm
II/ZS50	Zinc Selenide	50 kHz	2 µm – 18 µm	2 µm – 10 µm	14 mm
II/SI50	Silicon	50 kHz	Contact Hinds	Contact Hinds	29 mm

Advanced Thermal Control (ATC) Option Specifications:

Set Temperature	32.2º C (90ºF)
Accuracy	+/- 0.14ºC (0.25ºF)
Green LED on steady	Optical Head temperature at 32.2ºC +/- 0.14ºC

D
User Support Information

Hinds Instruments makes every attempt to ensure that the instruments we provide are products of superior quality and workmanship. We also aim to provide superior technical user support. If you have any questions, or if you encounter problems in the operation of your PEM instrument or system, please contact us. Our customer service staff is available to assist you from 8:00AM to 4:00PM, Pacific Standard Time, Monday through Friday. The telephone number is (503) 690-2000 or toll free, in the United States, (800) 688-4463.

PEM 100 Limited Warranty

Hinds Instruments, Inc. warrants the PEM 100 Photoelastic Modulator and systems to be free from defects in materials and/or workmanship when operated in accordance with the manufacturer's operating instructions for one (1) year from the date of purchase, subject to the provisions contained herein. Our warranty shall extend to the original purchaser only and shall be limited to factory repair or replacement of defective parts.

Exclusions

This warranty does not cover normal maintenance, damage resulting from improper use or repair, or abuse by the user. This warranty extends only to repair or replacement, and shall in no event extend to consequential damages. In the event of user repair or replacement, this warranty shall cover neither the advisability of the repair undertaken, nor the sufficiency of the repair itself.

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This warranty gives you specific legal rights, and you may also have other rights that vary from state to state.

Overview of the PEM 100 Help System

As shown in Table D.1, you can contact Hinds Instruments, Inc. Technical Support in several ways.

Method	**Information**
Telephone	Monday - Friday 8:00 AM to 4:00 PM PST (503) 690-2000
FAX	(503) 690-3000
Email	support@hindsinstruments.com
World Wide Web	www.hindsinstruments.com for general information about Hinds Instruments, Inc. and the Hinds PEM http://www.hindsinstruments.com/PEM for information specific to the PEM-100 Photoelastic Modulator
U.S. Mail	Hinds Instruments, Inc. 7245 NW Evergreen Pkwy Hillsboro, Oregon 97124-5850

Table D.1 Contacting Technical Support

When contacting Hinds Instruments for technical support, have the following PEM information available:

- Model name
- Serial number of the optical and electronic heads, and the controller.

Return For Repair Procedure

If your unit ever does need repair, please contact Hinds Instruments, Inc. before attempting repairs yourself or returning it to us. We may be able to provide additional troubleshooting suggestions to help diagnose the problem. In the event it is necessary to return the unit to us, we will give it our prompt and professional attention. In most cases, we can repair and return your instrument to you faster than you could diagnose and repair it yourself.

To arrange for service: In the event of defects or damage to your unit, first contact Hinds Instruments, Inc. by telephone at 1(503) 690-2000 or via email at support@hindsinstruments.com. Give us a brief description of the problem. We will then advise whether factory repair is necessary. If factory service is required, we will give you a Return Material Authorization (RMA) number. You should return your instrument as follows:

Packaging

Consider the following guidelines when preparing the instrument for return:

- Wrap the unit in a plastic bag
- Pack the unit in the original shipping carton or in a sturdy oversized carton
- Use plenty of packing materials

Items To Include

- PEM Packing List (you will receive this from Hinds)
- The RMA number
- A brief description of the problem with all known symptoms
- Information on how to contact you
- Your return shipping address (UPS will not deliver to a post office box)

Shipping Arrangements

- Send freight prepaid (UPS recommended)
- Insurance is strongly recommended (we can advise you on the current replacement value of the unit being shipped)
- We are unable to accept COD shipments.

Return Shipping Address

Customer Service

Hinds Instruments, Inc.

7245 NW Evergreen Pkwy

Hillsboro, OR 97124-5850

U.S.A.

Shipping Costs

If the unit is under warranty, after repair or replacement has been completed, we will pay the shipping costs to return the instrument to you via a carrier we choose to any destination within the continental United States. If you desire some other specific form of conveyance, or if you are located outside the continental United States, then you must bear the additional cost of return shipment.

If the unit is not under warranty, we will contact you with an estimate of the charges. If you approve of the indicated repairs and cost, Hinds Instruments, Inc. will return your repaired unit after all charges (including parts, labor and return shipping and handling) have been paid. If you do not approve of our proceeding with the repair, then your unit will be returned as is via UPS COD for the amount of the UPS COD freight charges.

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