

PEM-CSC PHOTOELASTIC MODULATOR

USER MANUAL



Hinds Instruments, Inc.
P/N: 010-0000-114 UM Rev C

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In all respects, the English version of this manual is controlling.

The PEM-CSC is covered by the following US patents: (1) 11,307,438, (2) 8,537,476, (3) 7,800,845, (4) 6,906,844

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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 CSC 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-CSC Controller Labels

The serial number, user safety warning, and CE certification labels are located on the PEM-CSC Controller rear panel.



DC Power Supply

This product is intended to operate from a DC power supply at 48 VDC. The main power input is 100 - 240VAC, 50/60 Hz, 1.4A. A protective ground connection by way of the grounding connector in the power cord is required for safe operation. Power line requirements are listed in the specifications section.

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. See Operating Space below for detail.

Do Not Operate Without Cover

To avoid personal injury, do not operate the PEM-CSC 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 CSC

Shipping Damage Check

Inspect all system components for obvious shipping damage. The PEM CSC 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 sales@hindsinstruments.com. A return authorization number (RMA) will be assigned to you. See Overview of the PEM CSC Help System on page 58 for further contact information.
 7. Return approved items to Hinds Instruments Inc. at the following address:

Hinds Instruments, Inc.
7245 NE 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

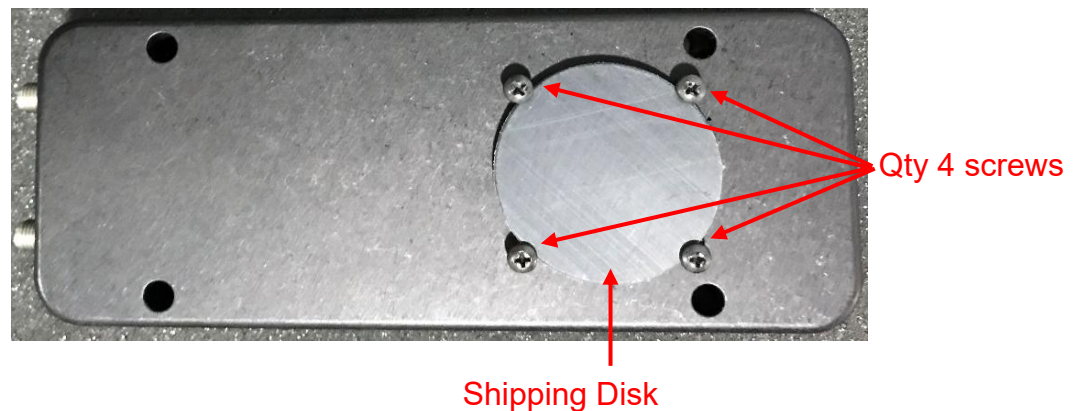
CAUTION

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.

- Ensure the work surface is clean and free of dust
- Using a #1 Phillips screwdriver, remove the shipping disk



- The alternate side of the Optical Head is covered by tape to prevent dust and other particles from entering the enclosure. This can be easily removed.



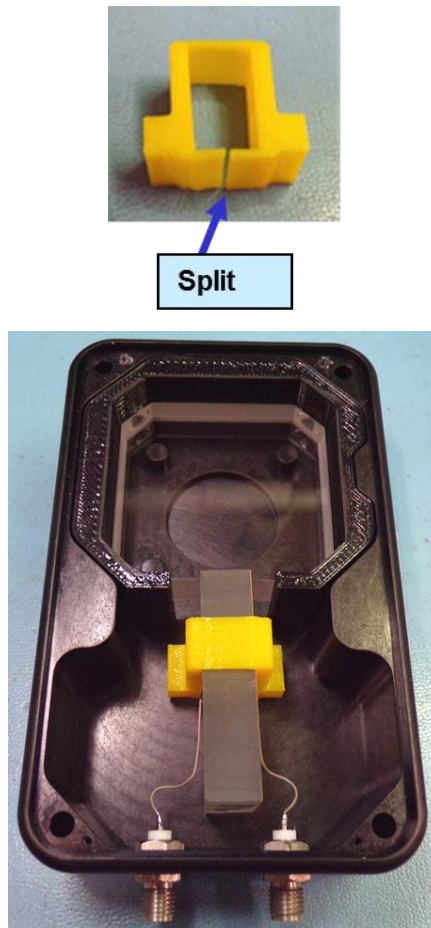
Unpacking I/FS50 Optical Head

Special Instructions for Series II Optical Heads

Included in all orders for Series II Optical Heads is a packet outlining instructions for removing the Transducer Safety Clip.

- A Phillips screwdriver has been included in the packet for removal of the outer lid of the optical enclosure
- Please follow the provided instructions carefully to avoid damaging the optical assembly

Series II FS Optical Heads



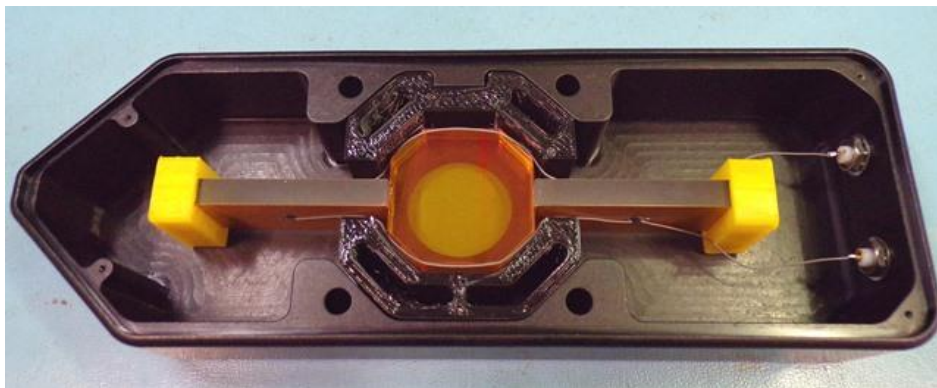
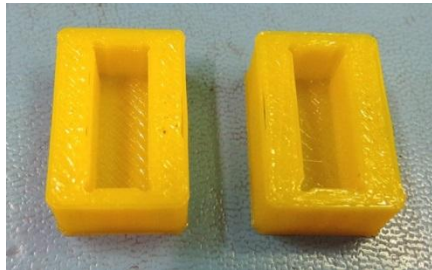
Unpacking Series II FS Optical Head

-
1. Remove the 4 lids screws using the provided screwdriver.
 2. Gently pull yellow clip out. Grab the provided tabs on the lower half of the clip. There is a split in the clip under the transducer. Separate the clip and lift it out from around the transducer. Take care when removing a clip near transducer wires. Save clips for future return of unit.

NOTE: DO NOT TURN OPTICAL HEAD OVER WHILE LID IS OFF – OPTICS WILL FALL OUT

3. Replace lid. Extra screws are provided.

Series II ZS50 & ZS42 Optical Heads



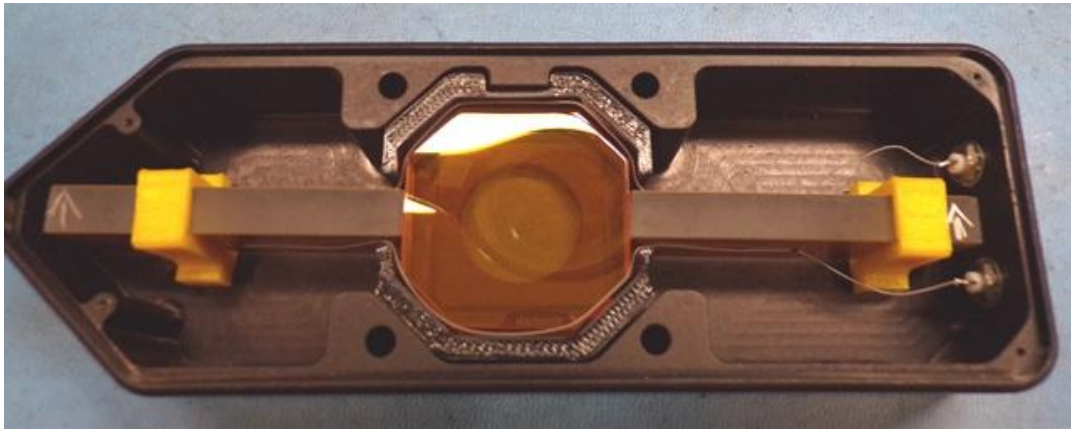
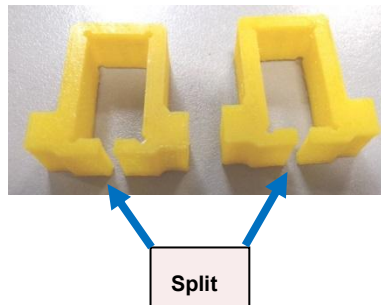
Unpacking II/ZS50 or II/ZS42 Optical Head

1. Remove the 4 lids screws using the provided screwdriver.
2. Gently pull yellow clip out. Yellow supports cup the ends of the transducer and can be easily slid off the ends. Be careful to not lift the transducer when removing clips.

**NOTE: DO NOT TURN OPTICAL HEAD OVER WHILE LID IS OFF –
OPTICS WILL FALL OUT**

3. Replace lid. Extra screws are provided.

Series II ZS37 Optical Heads



Unpacking II/ZS37 Optical Head

1. Remove the 4 lids screws using the provided screwdriver.
2. Gently pull yellow clip out. Grab the provided tabs on the lower half of the clip. There is a split in the clip under the transducer. Separate the clip and lift it out from around the transducer. Take care when removing a clip near transducer wires. Save clips for future return of unit.

**NOTE: DO NOT TURN OPTICAL HEAD OVER WHILE LID IS OFF –
OPTICS WILL FALL OUT**

3. Replace lid. Extra screws are provided.

Introduction

Overview

The PEM CSC 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, ellipsometry, polarimetry, reflection difference spectroscopy and FTIR double modulation.

The PEM CSC 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."

PEM-CSC Controller

PEM-CSC Controller Front Panel



PEM-CSC Front Panel

PEM-CSC Controller Front Panel Buttons

- **On/Off:** Rocker switch powers on the unit. When powered, the “Pwr” LED will be solid and green.
- **Power In:** DC power input, 48VDC, 2A



- **USB:** The USB label is located above the input of the USB 2.0 port for communication with any Windows 10 or newer computer. Contact Hinds Instruments for assistance with Windows 7.
 - **Limit LED:** The limit LED will stay on and red if the PEM heads are in overload/limit mode. If the limit is enabled, check all connections between controller, electronic head and optical head. If the head-to-head cables have been disconnected, please contact Hinds Instruments. If the unit is recovered, re-initialize the controller to PC connection.
 - **Data LED:** The data LED will flash yellow whenever data is being sent to or from the controller over USB.
 - **Pwr LED:** The power LED will stay on and green if the controller is powered on.
-

PEM-CSC Controller Rear Panel



PEM-CSC Rear Panel

PEM-CSC Controller Rear Panel Connections

- **1f Output:** BNC female connector provides TTL output of PEM, first harmonic frequency.
- **2f Output:** BNC female connector provides TTL output of PEM, second harmonic frequency.
- **Driver Control:** This female DB9 connector connects the controller to the PEM electronic head via the provided Head-to-Controller cable.

Modulator Head Assembly

The transducer-optical element assembly (called the “optical assembly”) is the heart of a PEM CSC 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.

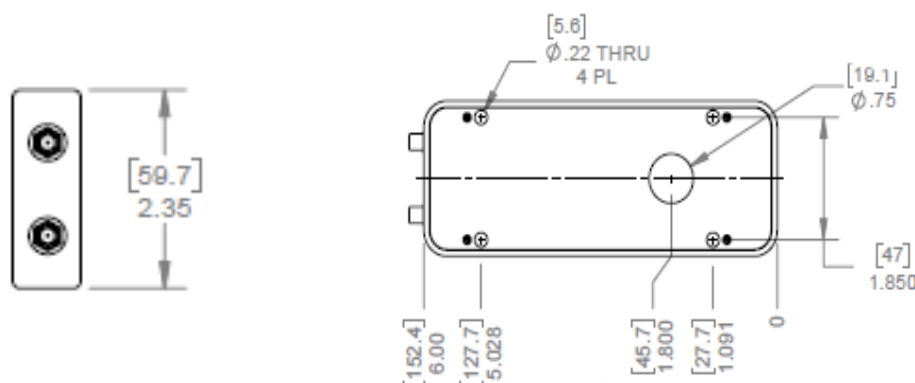
This assembly, consisting of the optical head, the electronic head, and the cables which connect them, is a single circuit. It is not intended to operate unless all three elements are together.

CAUTION

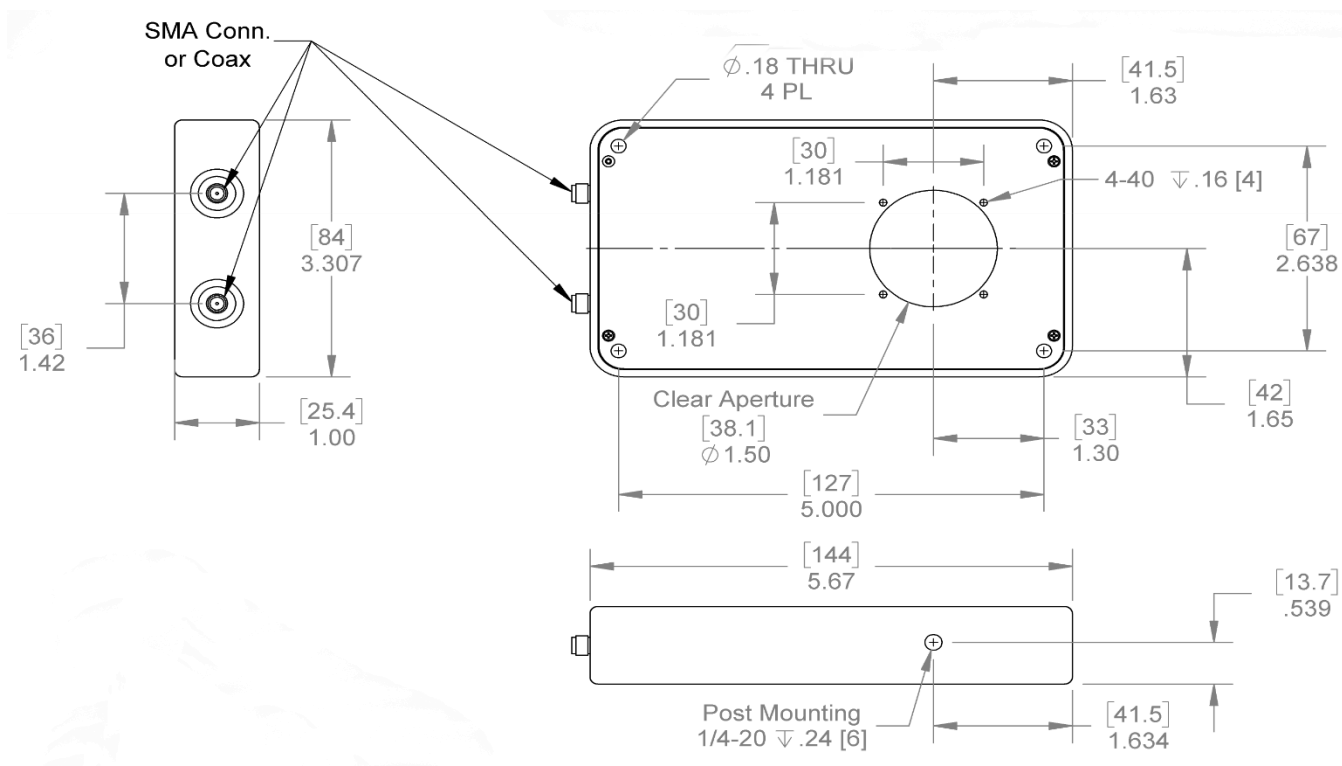
Operation of the electronic head without the optical head attached may result in damage to the electronic head and possibly to the controller.

Optical Head

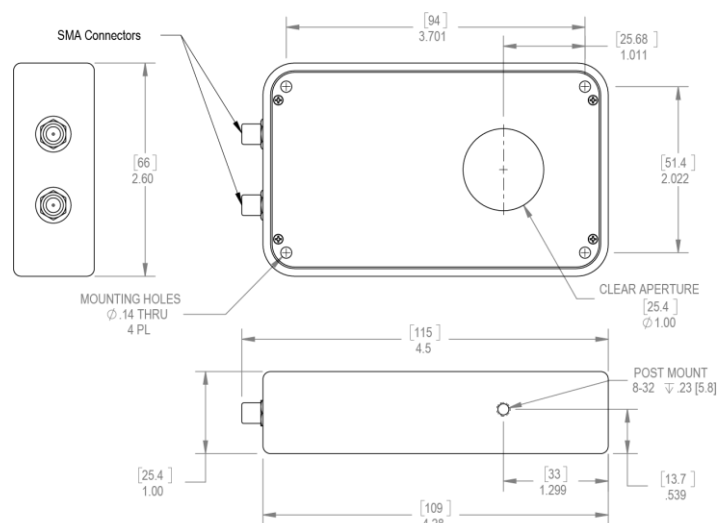
The optical assembly is housed in an enclosure called the “optical head.” The following figures provide dimensions for various optical head types.



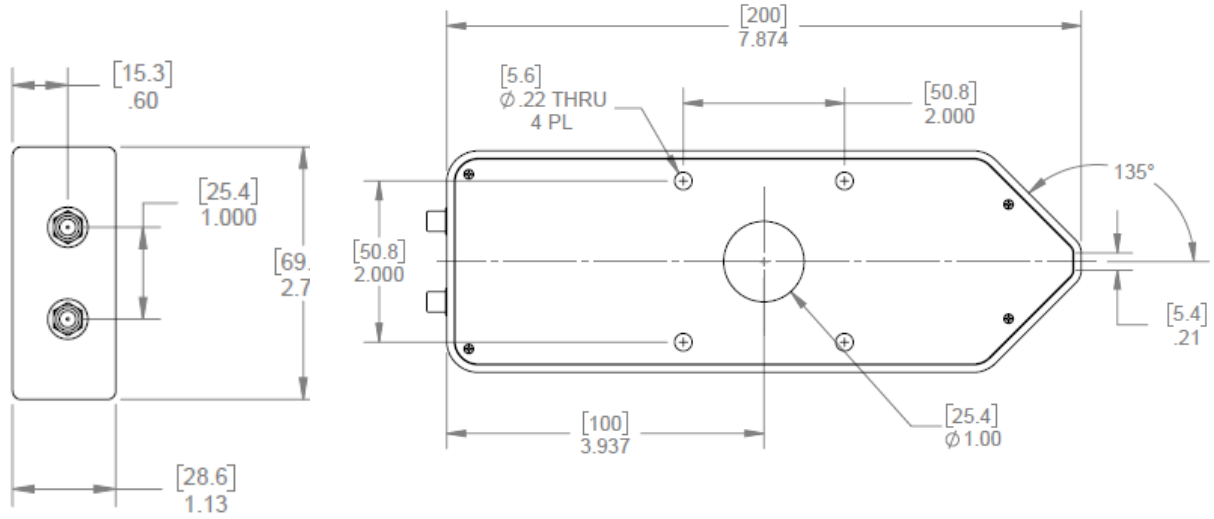
Model I/FS50, 60 Optical Head Dimensions



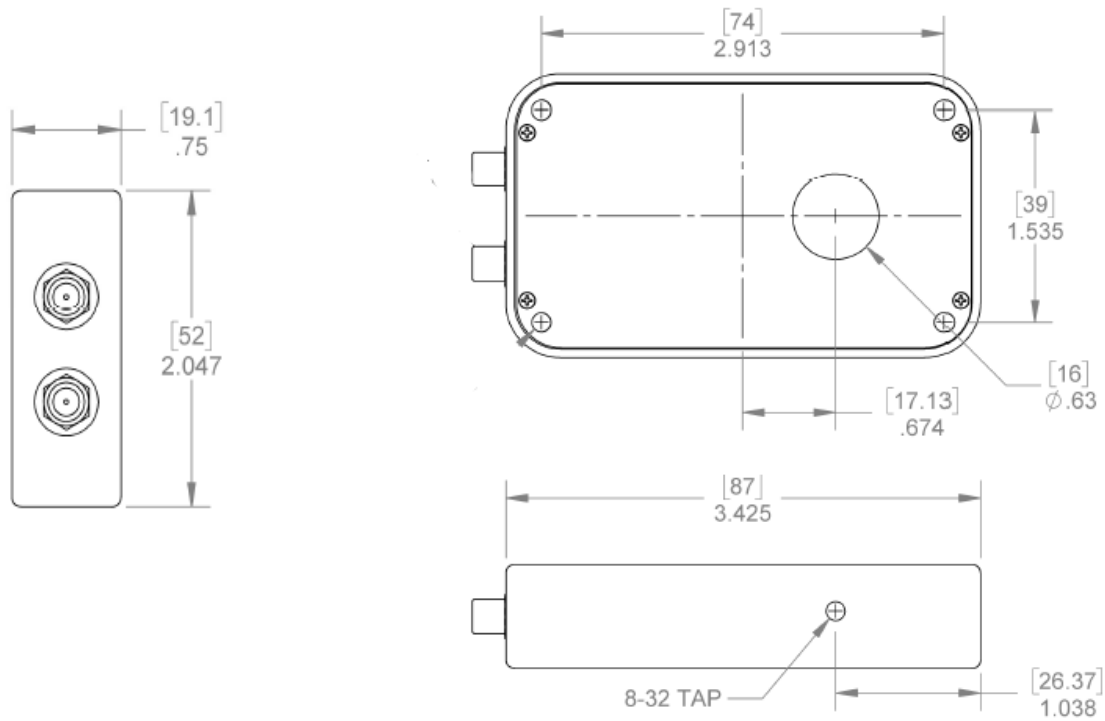
Model II/FS42, 47, 50 Optical Head Dimensions



Model II/FS50, 60 Optical Head Dimensions



Model II/ZS37, 42, 50 Optical Head Dimensions



Model II/FS74, 84 Optical Head Dimensions

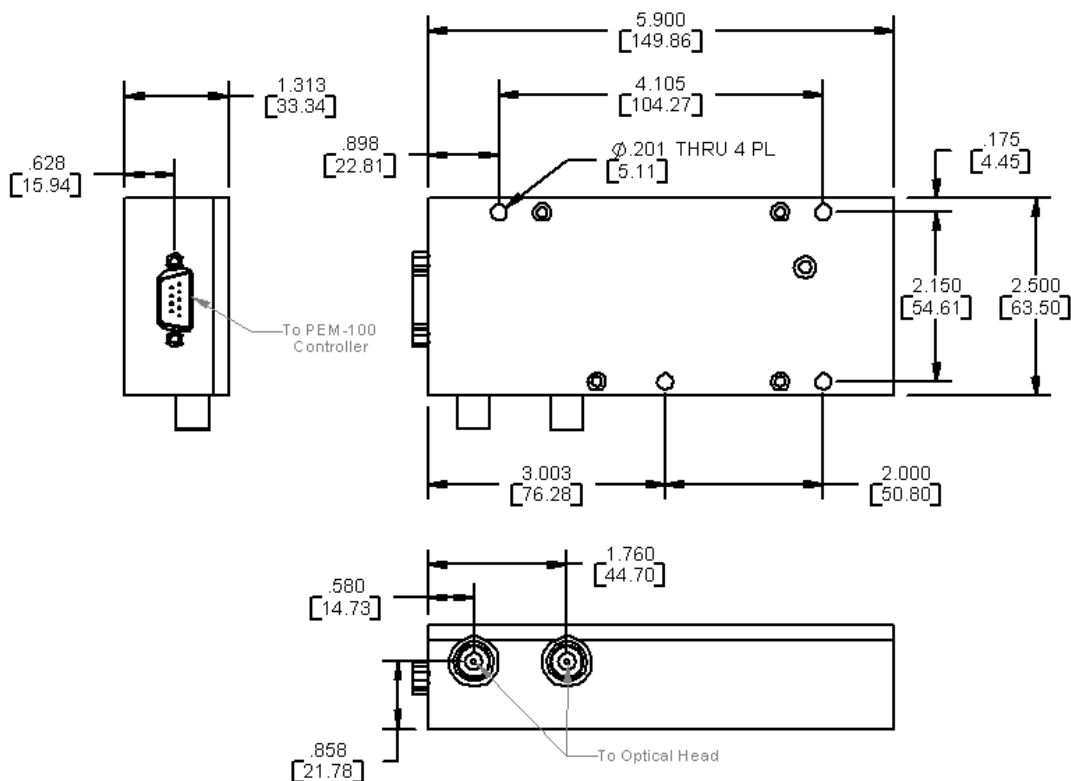
The optical head is connected to the electronic driver circuit (housed in the “electronic head”) by head-to-head interconnect SMA cables. This assembly of the optical head, the electronic head, and the head-to-head interconnect cables comprises the “modulator head,” which should be regarded as a single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

CAUTION

Operation of the electronic head without the head-to-head cables 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.



Electronic Head Dimensions

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Initial Set-Up

Before initial set-up, the PEM optic head should be unpackaged as described in Unpacking the PEM Optical Head on page 6.

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.

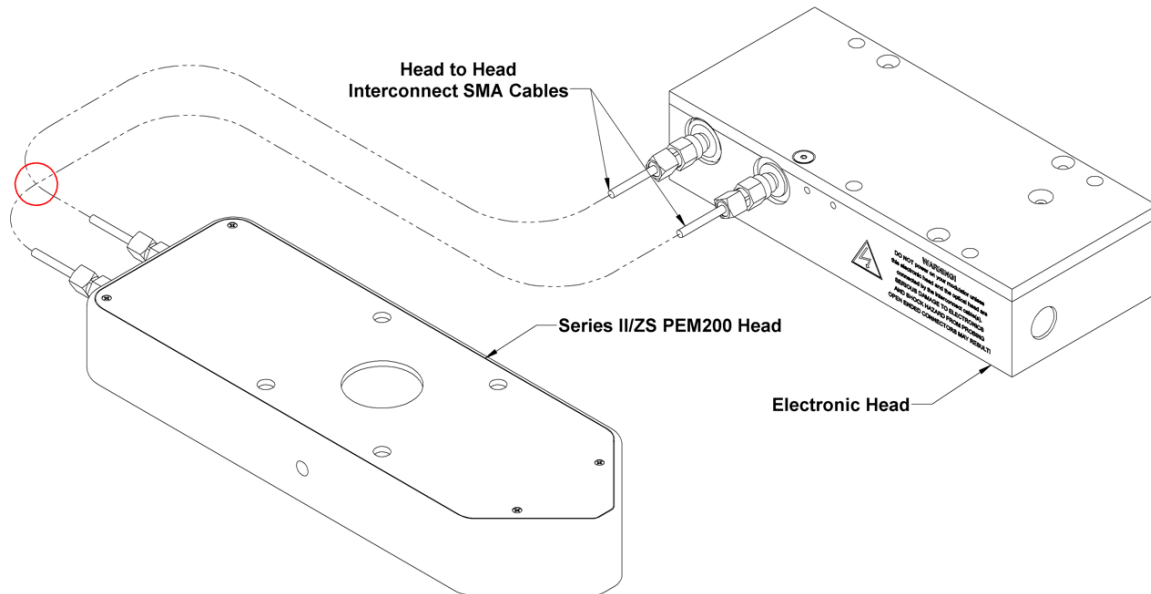
Your head set will come with a set of male to male SMA Cables.

1. Connect the optical head to the electronic head by means of the Head-to-Head interconnect cables. See the figures 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 the Head-to-Head Interconnect cables are 'crossed' as shown in the figure below, 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.



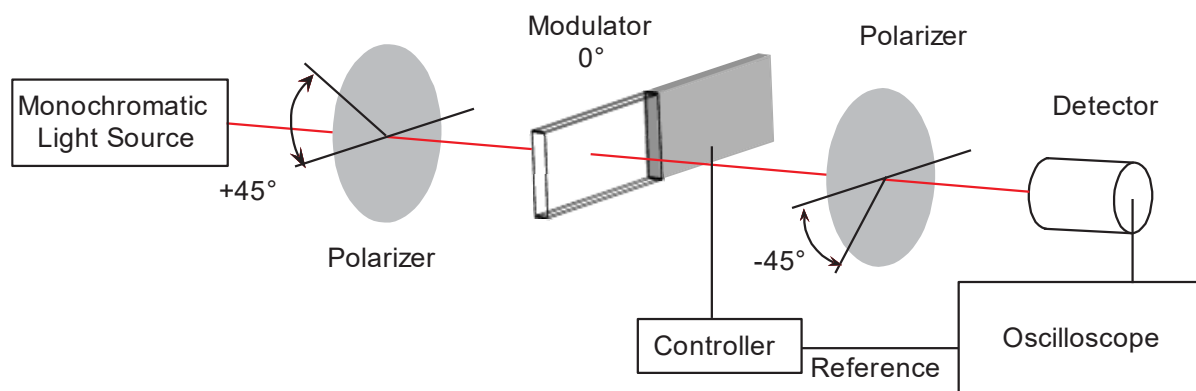
Connecting II/ZS50 Optical Head to Electronic Head (Cross Connection)

2. Connect the electronic head to the PEM-CSC Controller using the Controller-to-Head cable.
3. Connect the power to the PEM-CSC Controller using the 48V power supply.
4. Connect the USB cable to the computer.

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 the figure below. This shows a monochromatic light source (such as a laser) or multiwavelength source with a wavelength selection device (e.g. monochromator).

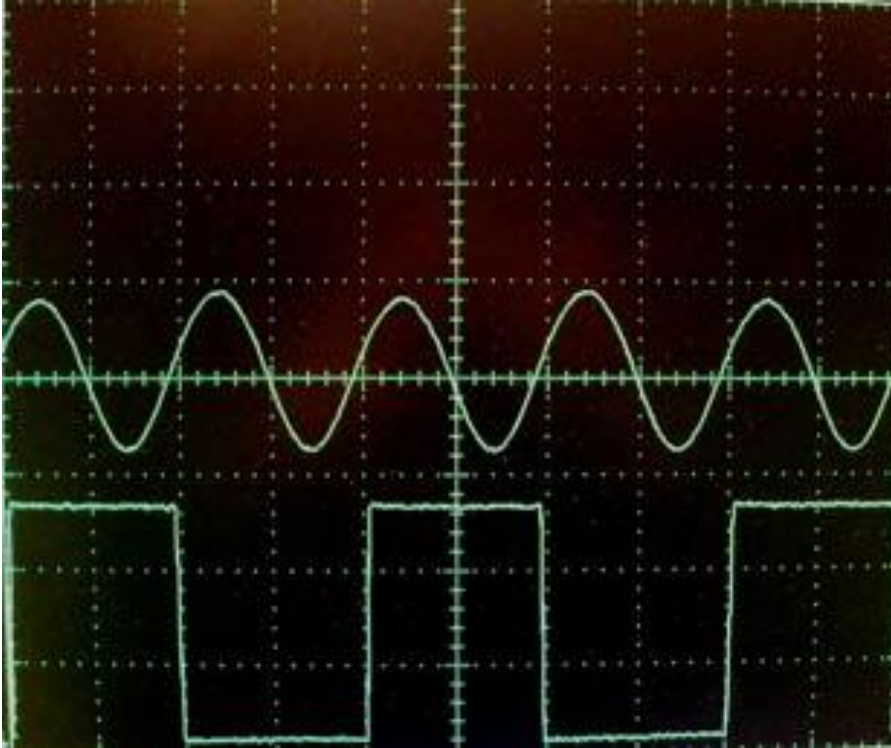


Block Diagram for Oscilloscope Calibration Method

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

The figure below 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.



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 58 for contacting Hinds Instruments Inc.

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PEM Control Software

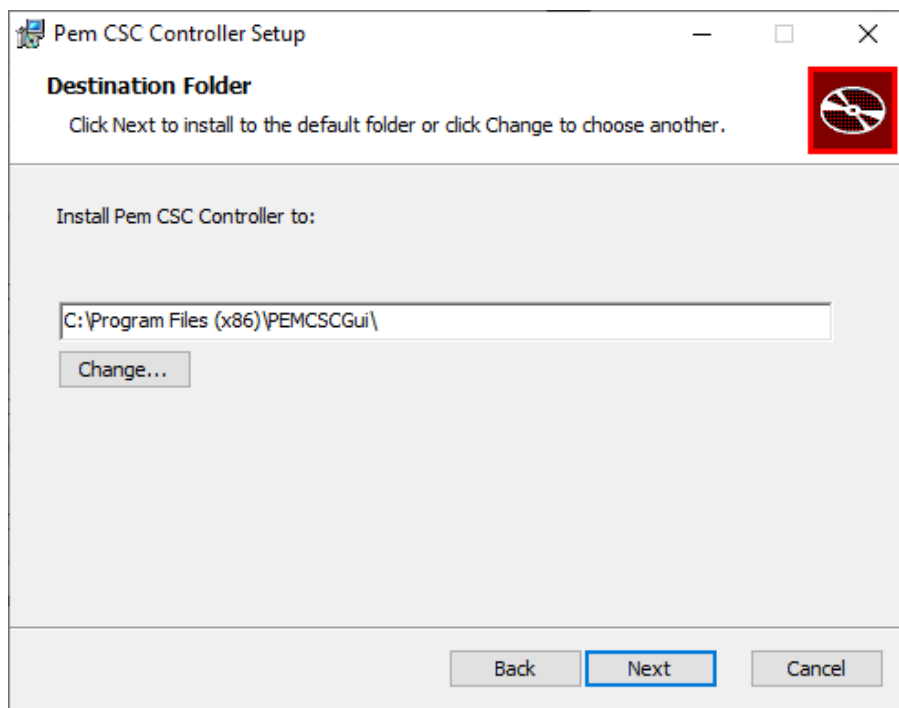
Installation

The PEM CSC is designed for use with Windows 10 machines. Contact Hinds Instruments for assistance with Windows 7.

To begin installation, first download the software installer from <https://www.hindsinstruments.com/products/photoelastic-modulators/PEM-CSC/>.

Download this package on the computer that the PEM CSC will be connected to (Local Computer). *After the download has completed, right click on the .zip file and select 'Extract All...' this will allow you to properly run the installer.*

The Graphical User Interface (GUI) is downloaded with a provided Windows Installer (.msi) file. Click on the 'PEM CSCControllerSetup.msi' file. After running the file, a destination folder prompt will appear. This is where the software will be saved on the computer.



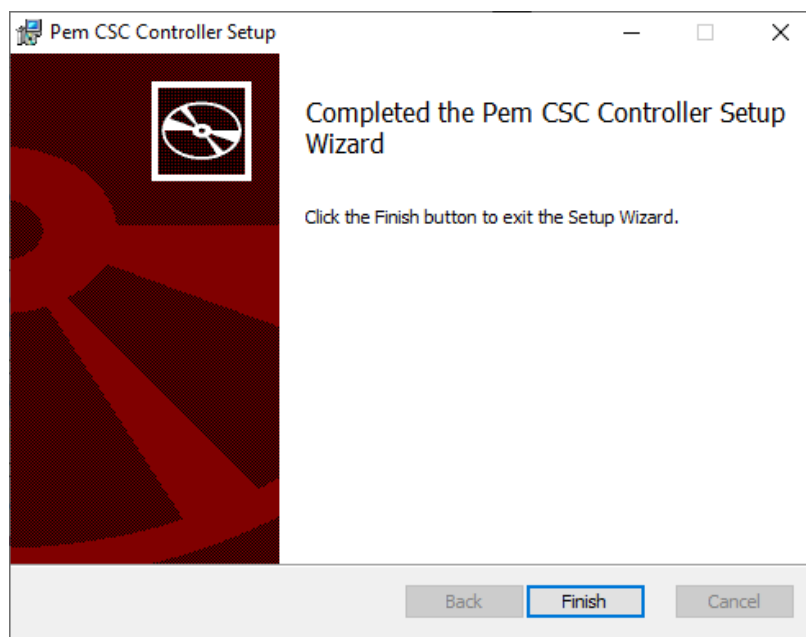
PEM CSC Software Installer, Install Location

Setup Running

After selecting 'Next', the setup installs the necessary files onto the computer. The progress is shown through a green status bar.

Setup Complete

Once complete, the setup will prompt you to select 'Finish', indicating the software has been successfully installed on the computer.



PEM-CSC Software Installer, Finish

The PEM Control Software is now installed. There will be a shortcut placed on your desktop with the following icon:



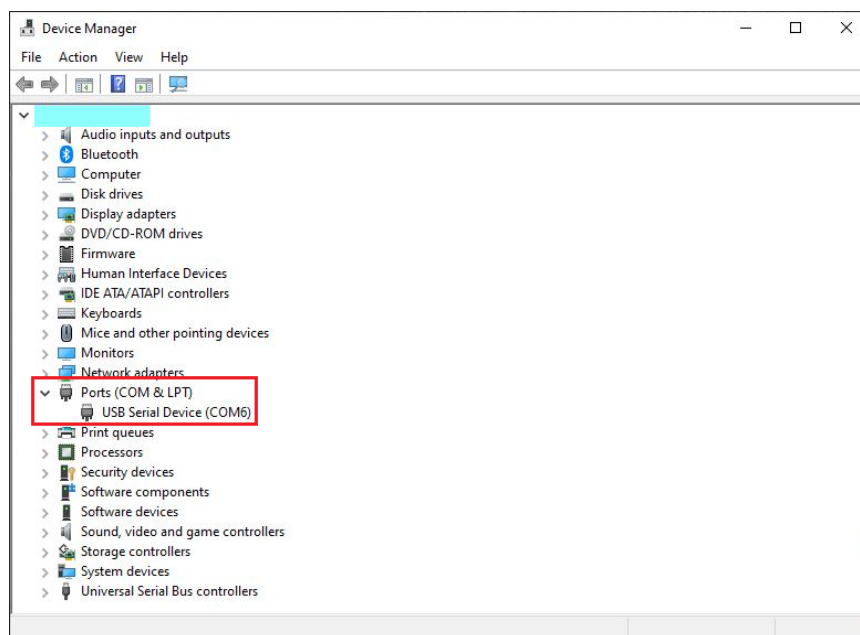
PEM CSC Control Software

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

Setup of the PEM-CSC Controller for Use with PEM Control

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

Make sure the PEM CSC has power. Connect the USB 2.0 B cable to the PEM CSC controller and to the PC. Once connected, the PEM CSC should connect to a COM port on the target computer. View this on the computers 'Device Manager'. In the 'Device Manager', select the 'Ports (COM & LPT)' dropdown. If there are multiple ports open, you can disconnect and reconnect the PEM CSC to see the COM port disappear and reappear. Note the COM port number. Make sure all cables involving the PEM unit are securing and properly connected.



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

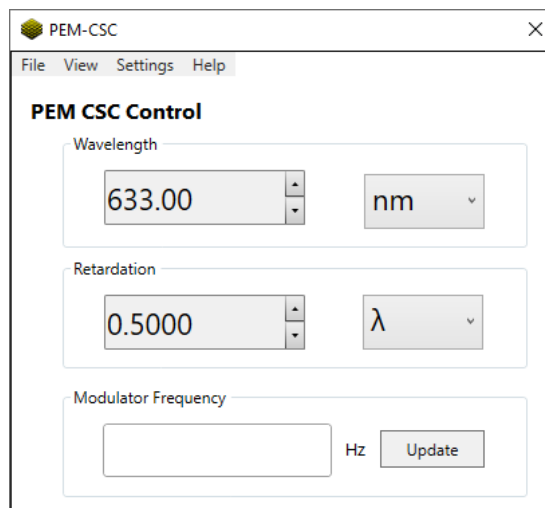
1. Open the 'PEM Control Software' icon from the computer desktop.
2. Upon opening, the following COM port dialog box will appear:



3. Use the dropdown to select the computer COM port number used by the PEM CSC Controller, then press 'OK' to open the main window.

Main Interface:

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 an update for the resonant frequency.



Wavelength: The wavelength field displays the wavelength setting. Entering a different wavelength can be accomplished two ways:

1. Double click the wavelength displayed to highlight the setting and then enter a new wavelength using the keyboard.
2. 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 ($1/\text{cm}$). 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.

Retardation: The retardation field displays the retardation setting. Entering a different retardation can be accomplished two ways:

1. Double click the retardation displayed to highlight the setting and then enter a new retardation using the keyboard.
2. Click on the up ▲ or down ▼ arrow to the right of the retardation display to adjust the retardation setting by single digits.

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

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

Update Frequency: press the “Update” button.

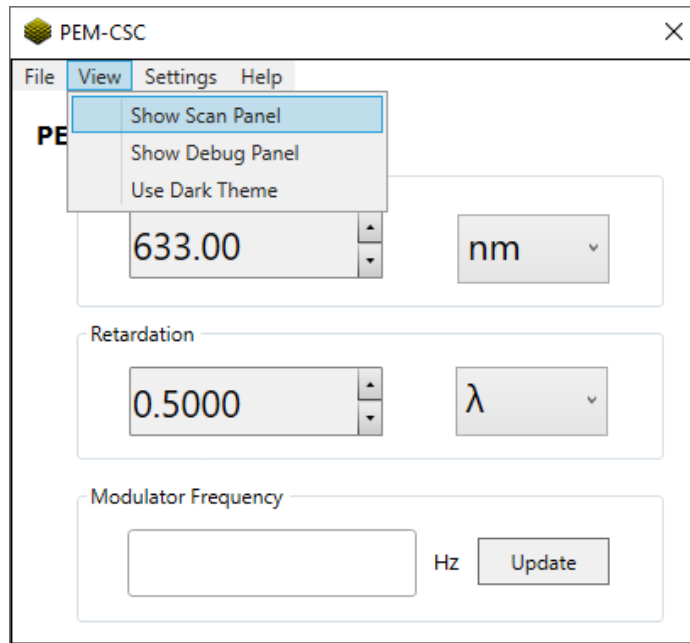
Scan Panel

The scan panel will display additional fields to set up a wavelength scan. The panel will display the ending wavelength and retardation. The retardation and beginning wavelength is set in the main window as described above.

The screenshot shows the PEM-CSC Control software window. The 'Scan' panel is highlighted with a red border. It contains the following controls:

- Wavelength:** A numeric input field showing '633.00' and a unit dropdown menu set to 'nm'.
- Retardation:** A numeric input field showing '0.5000' and a unit dropdown menu set to ' λ '.
- Modulator Frequency:** A numeric input field, a unit dropdown set to 'Hz', and an 'Update' button.
- Scan Section:**
 - Step Increment:** A numeric input field showing '5.0'.
 - Number of Steps:** A numeric input field showing '2'.
 - Step Delay:** A numeric input field showing '0.5'.
 - Ending Wavelength:** A text label showing '643.00 nm @ 0.50'.
 - Start Scan:** A large button at the bottom of the Scan panel.

Select the view tab and select 'Show Scan Panel' to open the scan panel on the window.



Step Increment: Step increment describes the step size of a wavelength sweep. Entering a different step increment can be accomplished two ways:

1. Double click the step increment displayed to highlight the setting and then enter a new step increment using the keyboard.
2. Click on the up ▲ or down ▼ arrow to the right of the step increment display to adjust the step increment setting by single digits.

Number of Steps: The number of steps taken in the wavelength sweep. Entering a different number of steps can be accomplished two ways:

1. Double click the number of steps displayed to highlight the setting and then enter a new number of steps using the keyboard.
2. Click on the up ▲ or down ▼ arrow to the right of the number of steps display to adjust the number of steps setting by single digits.

Step Delay: The delay in seconds taken between each step in the wavelength sweep. Entering a different step delay can be accomplished two ways:

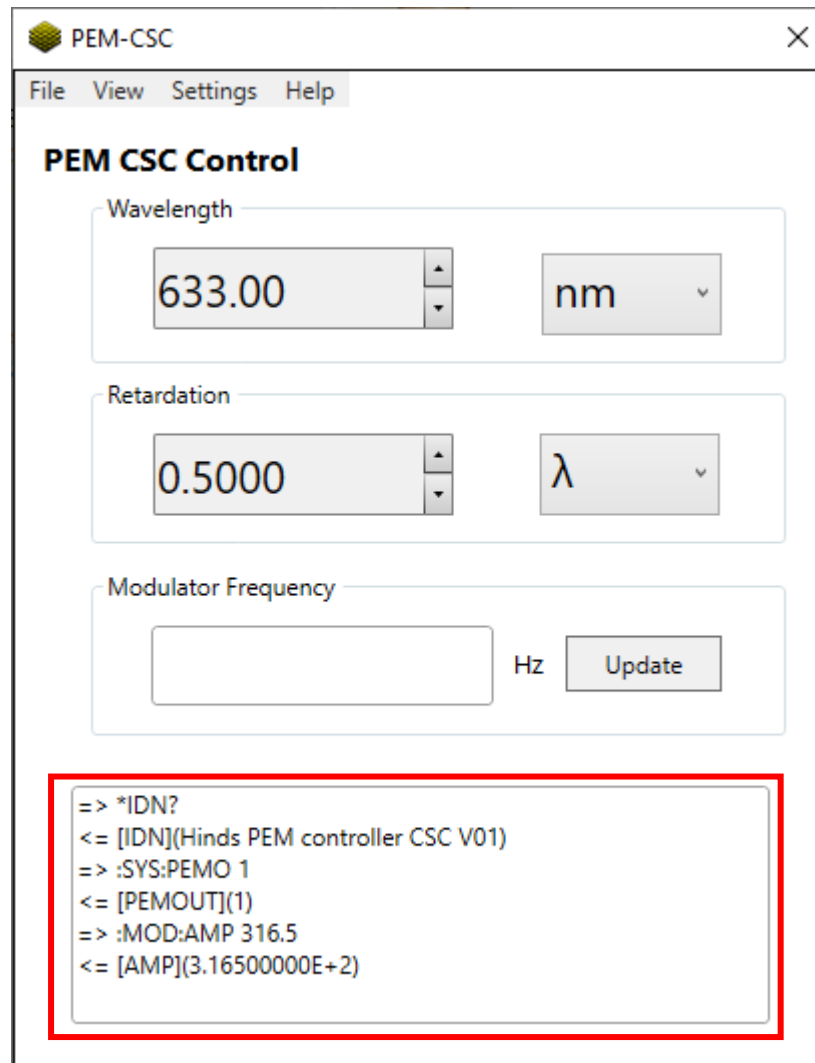
1. Double click the step delay displayed to highlight the setting and then enter a new step delay using the keyboard.
2. Click on the up ▲ or down ▼ arrow to the right of the step delay display to adjust the step delay setting by single digits.

Set all parameters and select 'Start Scan' to begin wavelength sweep.

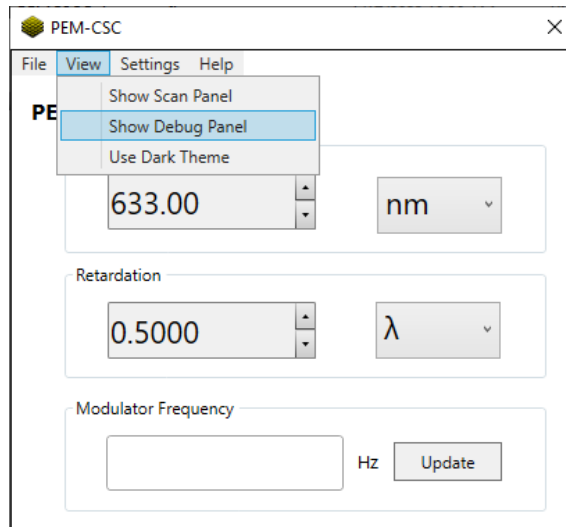
Debug Panel

The 'Debug Panel' displays the console input and output between the PC and the PEM. This is used to check that the PEM and PC are correctly interacting. It also serves as a tool to see what commands are being used to properly set up the PEM

for unique experiments or software where the user will communicate through the serial port.

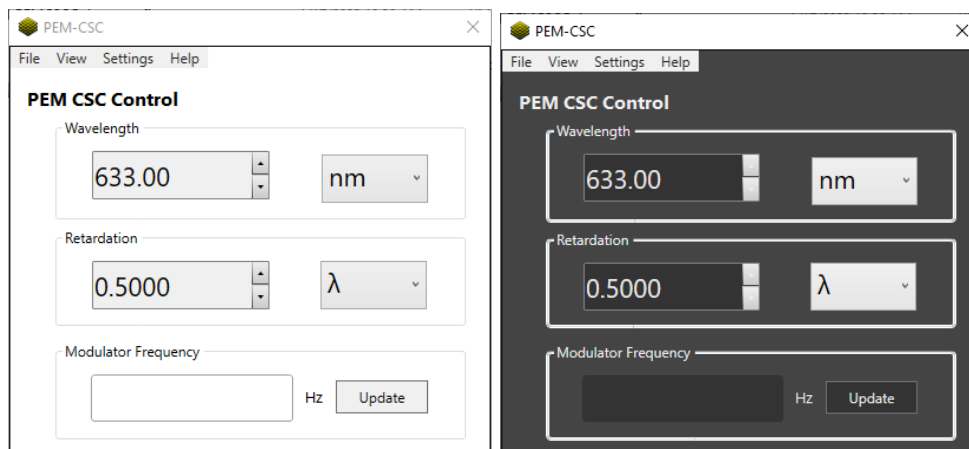


Select the view tab and select '**Show Debug Panel**' to open the debug panel on the window.

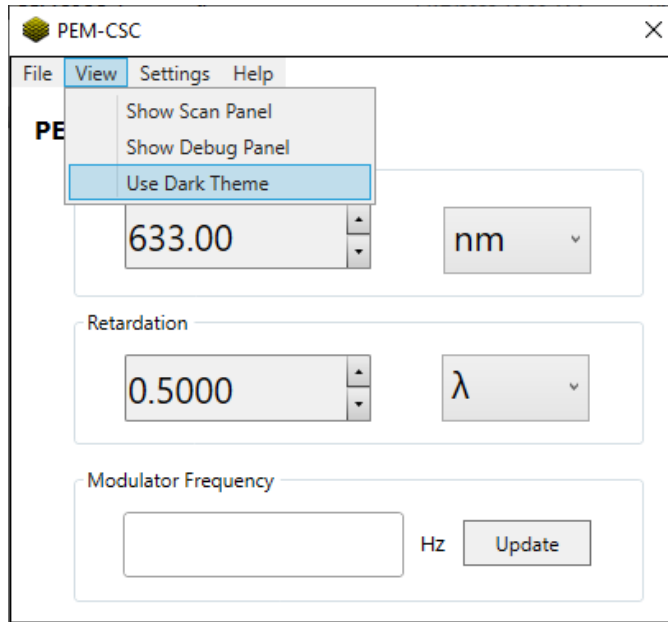


Themes

The PEM Control Software offers both a light and dark theme.

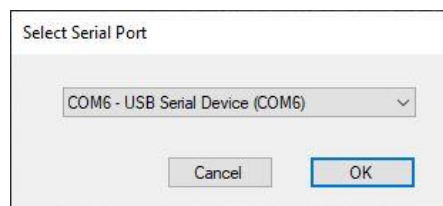
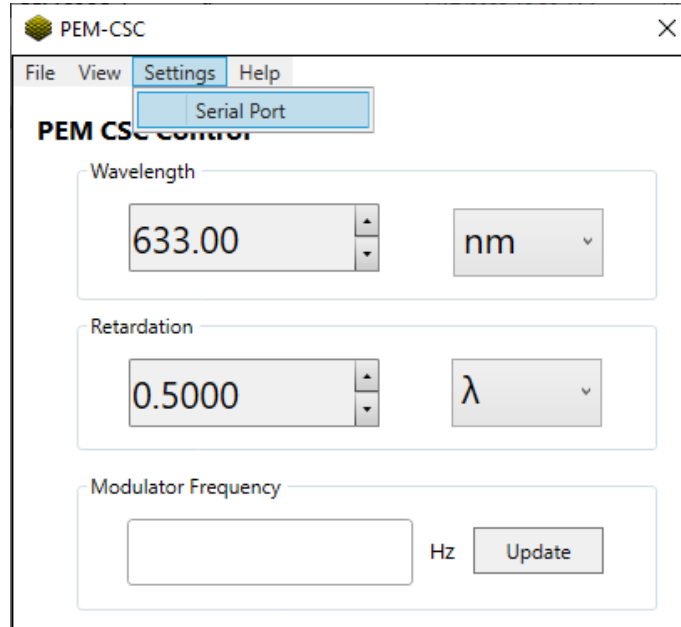


Select the view tab and select '**Use Light/Dark Theme**' to switch themes.



Change COM port

Select the settings tab and select 'Serial Port' to change the COM port number to the PEM CSC Controller. The serial port dialog box will appear. Use the dropdown to select the appropriate COM port.



6

Communication Protocol

The Hinds PEM CSC controller drives a single PEM at a user selectable amplitude of modulation. The PEM CSC communicates over USB as a simple SerialCOM device. The communication protocol is a derivative of the SCPI protocol common to many instruments. In this document, the basic SCPI protocol is outlined. From there, the specific connection requirements are outlined. Finally, the full command list and explanation for each command is given.

Port Settings

PEM-CSC connects to the computer as a USB serial COM port. The connection baud rate is 250,000 bytes per second. As this is a USB serial port, the software defined baud rate can be set anywhere from 9,600 to 250,000 and the PEM-CSC should still communicate.

Programming

Communication to the PEM-CSC requires assertion of Data Terminal Ready. This is asserted by default in some languages (Python and Labview) but must be asserted in others (e.g. SerialPort.DtrEnable in C#).

Standard Commands for Programmable Instruments (SCPI) protocol

SCPI protocol is a standard syntax for controlling programmable devices. The protocol outlines a common syntax, command structure and data format. Commands are text strings sent to the device as either set operations (e.g. “:MODulator:VOLTage 0.25”) or get operations (“:MODulator:VOLTage?”). Set operations are often followed by a text string containing numerical or string data (e.g. “:MODulator:VOLTage 0.1”). Get operations end with a ‘?’ and return data. Similar commands are grouped with similar leading strings in a tree structure.

Commands can be abbreviated by sending only the capitalized portion of the command text. Such as “:MODulator:VOLTage 0.1” can be abbreviated as “:MOD:VOLT 0.1”. Commands are terminated with a new line character (also known

as line feed, '\n', ASCII DEC 10, ASCII HEX A) or a semicolon (;). Carriage returns are ignored as many terminal applications send a full new line and carriage return by default. All commands are case sensitive.

Set commands are usually but not always followed by arguments. Arguments can be single values (e.g. "0.1"), text (e.g. "ON" or "OFF"), or vectors (e.g. "0.1, 10, 100.3"). The expected argument is defined by the specific command. If the command is not known, the unit will return an error (e.g. sending ":BOD:VOX" will return "<SCPINOP>(:BOD:VOX)" as this is an unknown command). Returns are categorized by type with each type using a different bracket set to ease parsing with regular expressions. All returns are ended with a new line ('\n').

Type	Bracket format	Notes
Error	<IDENTIFIER>(Message)	Sent on unknown commands and general errors. May be transmitted by the unit at any time or in response to a command.
Command return	[IDENTIFIER](Return arguments)	Sent upon successfully parsing and applying the command. Some returns are instant. Others may take a moment to return as the unit is setting internal systems.

Argument format

Arguments usually consist of a single floating point number. These are parsed by the device as standard floats (e.g. 0.01) or as scientific notation (e.g. 1e-2 for 0.01). Arguments can also be a simple integer (e.g. 1). Arguments may take a vector format of more than one argument. For these cases, individual values are separated by a comma,', '.

Please allow 300ms for PEM-CSC to return after a command is sent.

Command structure overview.

Command	Type	Note
*IDN?	Get	Identify the unit
:MODulator	Root	Modulator related command root
:DRiVe	Set	Set modulator drive voltage as range 0 to 1

:DRiVe?	Get	Get modulator drive voltage as range 0 to 1
:AMPlitude	Set	Set modulator amplitude in nanometers or retardance
:AMPlitude?	Get	Get modulator amplitude in nanometers of retardance
:AMPRange?	Get	Get modulator retardation amplitude range from lowest to highest in nanometers
:FREQuency?	Get	Get modulation frequency in Hz
:STABLE?	Get	Get modulator stability
:SYStem	Root	Internal device controls
:PEMOutput	Set	Set PEM Active or Inactive

Command explanation

Commands are listed below. The input command is listed in full with the symbol # denoting a numerical input. All commands are terminated with '\n' or ';'.

Command	*IDN?
Short command	*IDN?
Type	Get
Purpose	Identify the unit. Reports the firmware version.
Input example	*IDN?
Output example	[IDN](Hinds PEM controller CSC V01)

Command	:MODulator:DRiVe #
---------	--------------------

Short command	:MOD:DRV #
Type	Get/Set
Purpose	Sets the voltage to the modulator on an arbitrary range of 0.0 (lowest modulation amplitude) to 1.0 (highest modulation amplitude)
Input example	:MOD:DRV 0.1325
Output example	[DRIVE](1.325000E-1)

Command	:MODulator:AMPlitude #
Short command	:MOD:AMP #
Type	Get/Set
Purpose	Sets the voltage of the modulator in nanometers. For instance, if half wave retardance at 633nm is desired, the argument should be 316.5
Input example	:MOD:AMP 316.5
Output example	[AMP](3.165000E+2)

Command	:MODulator:AMPRange?
Short command	:MOD:AMPR?
Type	Get
Purpose	Reports the modulation amplitude range in nanometers
Input example	:MOD:AMPR?
Output example	[AMPR](1.000000E+1,5.50000E+2)

Command	:MODulator:FREQuency?
Short command	:MOD:FREQ?
Type	Get
Purpose	Reports the frequency of modulation in Hz
Input example	:MOD:FREQ?
Output example	[FREQUENCY](5.01930899E+4)

Command	:MODulator:STABLE?
Short command	:MOD:STABLE?
Type	Get
Purpose	Returns if the PEM is stable (binary)
Input example	:MOD:STABLE?
Output example	[STABLE](1)

Command	: SYStem:PEMOutput #
Short command	:SYS:PEMO #
Type	Set
Purpose	Sets modulator active/inactive (on/off)
Input example	:SYS:PEMO 1
Output example	[PEMOUT](1)

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Troubleshooting

Should you run into any issues with the PEM CSC controller, first check that all necessary connections are made: interconnect cables between optical head and electronic head as well as electronic head to controller, 48V power input. Cycle the power and try to communicate with the PEM CSC. Should power cycling with all connections in place still result in no communication, please contact sales@hindsinstruments.com or call +1-503-690-2000 for assistance.

Only remove optical head cover as instructed in unpacking instructions below and when initially unpacking. Do not remove cover of optical head for any other reason. Ensure the optical head is disconnected from any SMA cables before removing cover. High voltages can be present otherwise.

Do not remove cover from PEM-CSC Controller unless instructed to and being supported by Hinds Instruments personnel.

Maintenance

Calibration

PEM CSC 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 adjusting modulation drive (:MOD:DRV #) and fitting appropriate firmware points. Please contact Hinds Instruments for assistance with these commands. With the appropriate optical bench setup and detection system, the modulation amplitude can be adjusted until the calibration condition is obtained. For example, in the case of the half-wave calibration, the appropriate flat topped (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.

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.

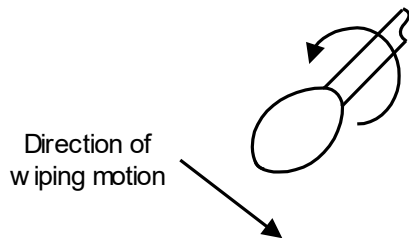
A rectangular box with a thick orange border and a solid orange background. The word "Warning" is centered in the box in a bold, black, sans-serif font.

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.

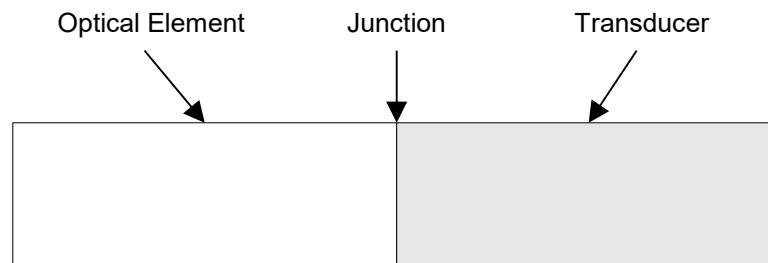


Direction of cotton swab wiping motion

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.



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.

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 CSC Calibration

The PEM CSC 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 CSC is sufficient (retardation uncertainty <5%).

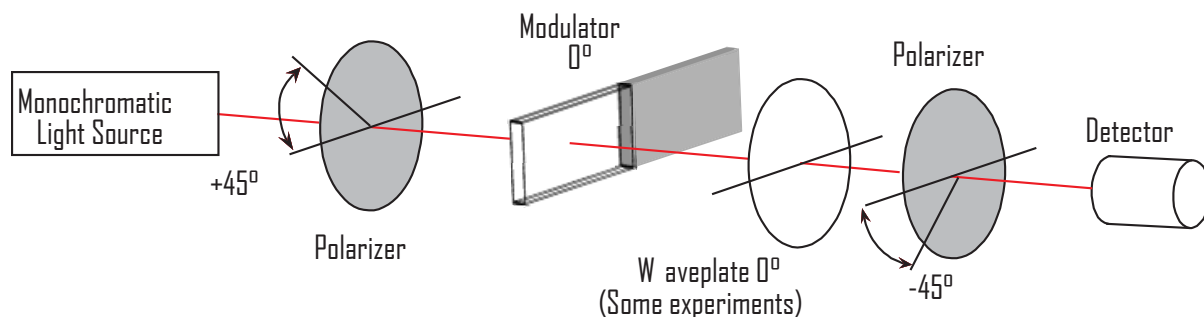
There are still cases where in-situ calibration by the user is advisable or even mandatory. These cases include, but are not limited to, the following:

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



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.

Kemp¹ 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:

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

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

$$\begin{aligned} I = \frac{1}{2} \{ & 1 - \cos(B) J_0(A_0) \} && \text{DC} \\ & + 2 \sin(B) J_1(A_0) \cos(\Omega t) && \text{1f} \\ & + 2 \cos(B) J_2(A_0) \cos(2\Omega t) && \text{2f} \\ & + \dots \text{higher terms} \} \end{aligned} \quad (2)$$

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.

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

and

$$I = \frac{1}{2} \{1 - J_0(A_0) + 2J_2(A_0) \cos(2\Omega t) + \text{higher terms..} \} \quad (4)$$

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.

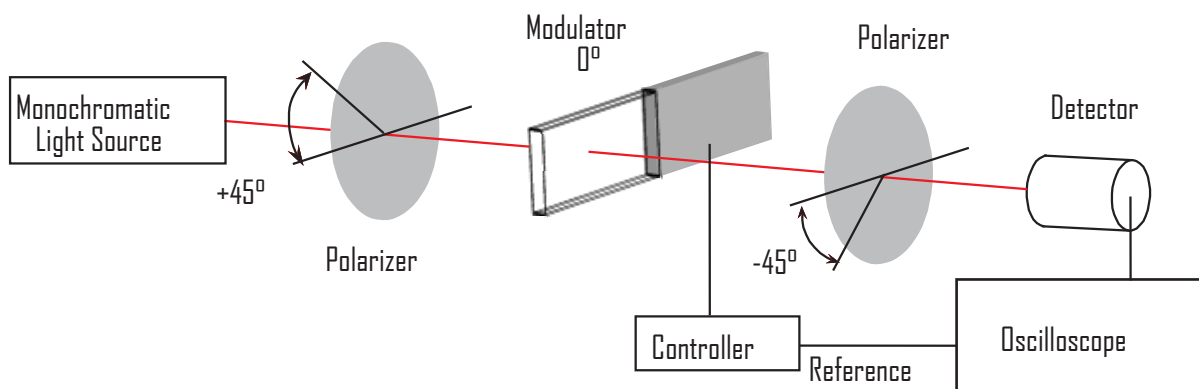
White light sources may also be used with monochromators, but here some caution is advised. The error in accuracy of the wavelength of the light should be recognized as approximately the optical bandwidth of the monochromator. Within the bandwidth of a spectrum line, the system sensitivity will be strongly 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

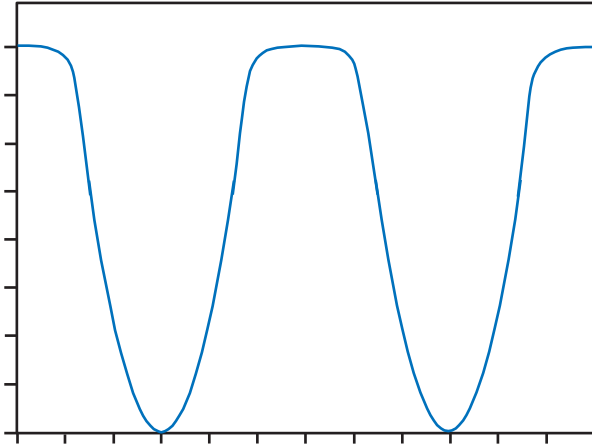
The most straightforward procedure, and the one used at Hinds Instruments for the factory calibration of modulators, utilizes a monochromatic light source (e.g. HeNe laser), a solid state detector (e.g. silicon photodiode), and an oscilloscope. A block diagram for the setup is given in the figure below.



Oscilloscope Calibration Method

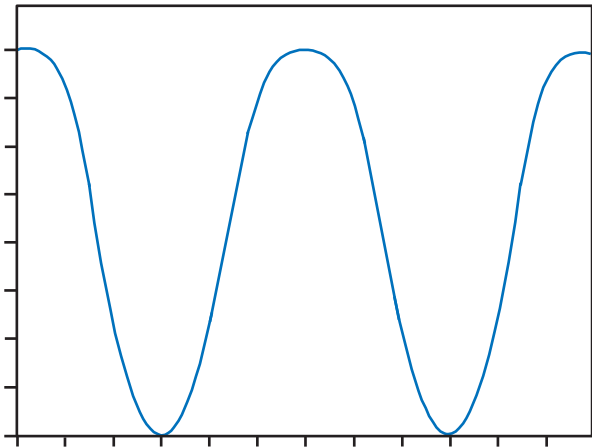
The detector and its associated electronics (including the oscilloscope) should have a frequency bandwidth several times the frequency of the modulator. Calibration can be done in many cases when this condition is not met, but the waveforms will be distorted and the proper half-wave condition will be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

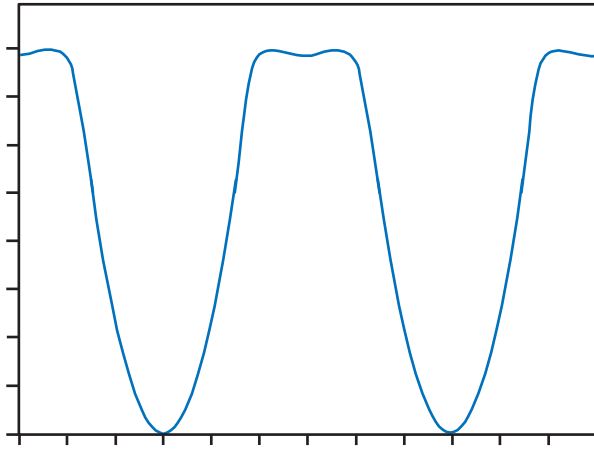


Waveform for Half-wave Retardation

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. The figures above and below show waveforms for retardations slightly less and slightly more than half-wave.



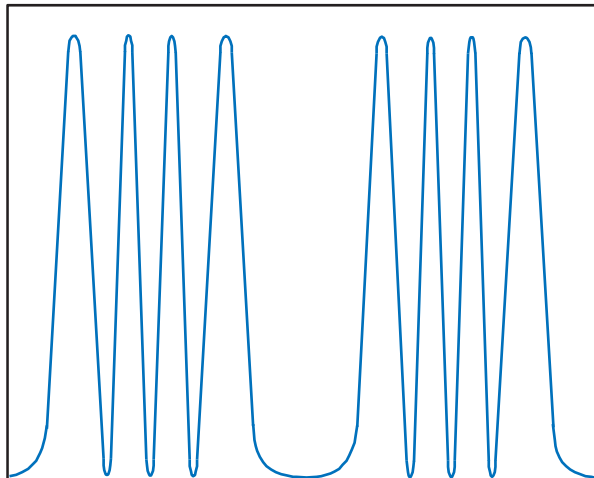
Retardation 90% of Half-wave



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.

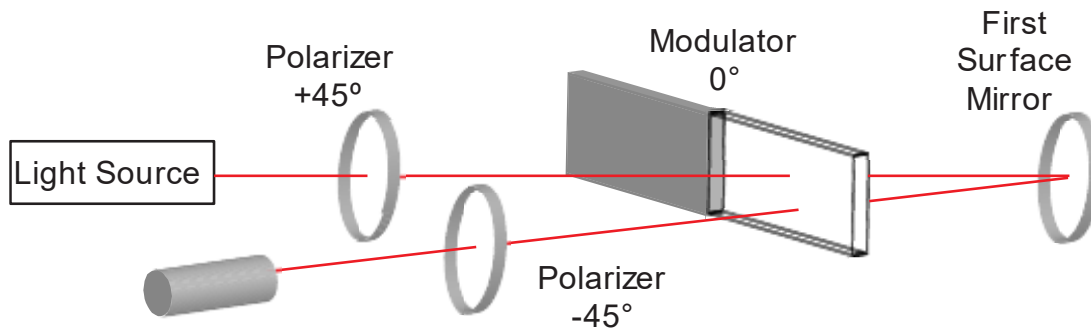
The waveform for a retardation of four half-waves is shown in the figure above.



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 the figure below.



Setup for Double Pass Modulation

Static Waveplate Techniques

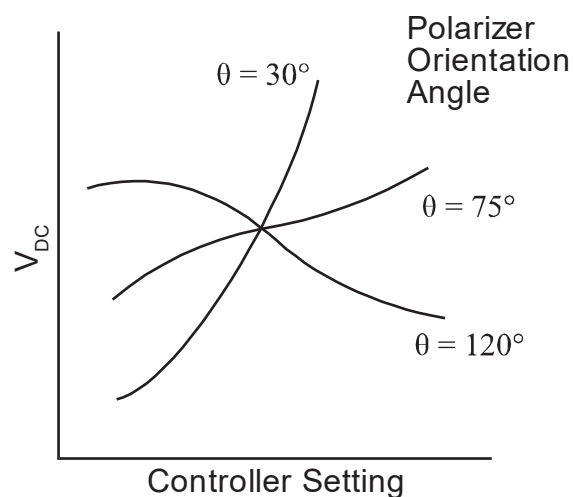
Another technique for establishing a fractional retardation would be to use a static waveplate with known retardation. The waveplate would be placed with the fast axis of the waveplate parallel to the modulator axis. If the sum of the static waveplate retardation and the modulator peak retardation is 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 the figure below. Notice that the graphs should intersect at one particular controller setting for which the Bessel function J_0 vanishes.



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 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 the oscilloscope calibration method figure 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:

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

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:

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

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:

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

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

The required setting for quarter-wave retardation is:

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

$$(8)$$

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

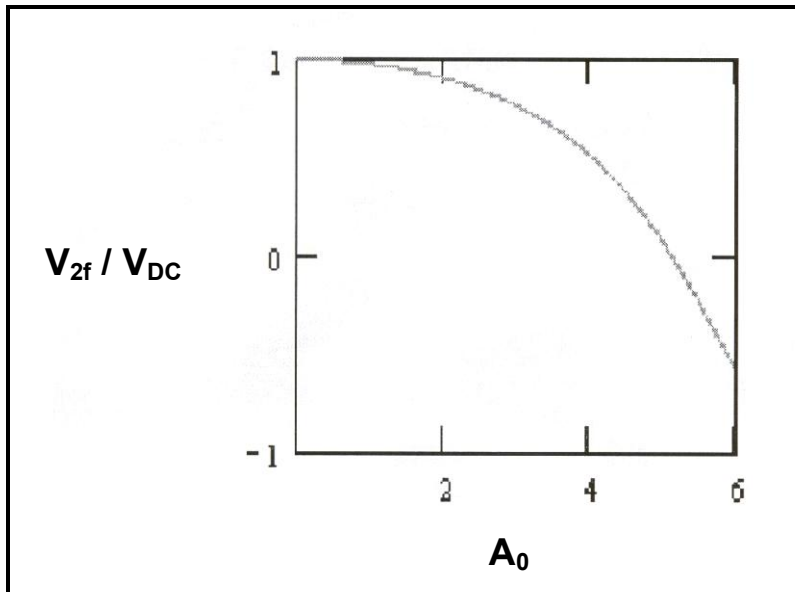
Parallel Polarizer Calibration at a Single Wavelength

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 45° there are problems, especially at low retardation levels. From theoretical analysis of the resulting waveforms we learn that:

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

If one plots the ratio V_{2f}/V_{DC} the graph shown in the following figure is obtained.



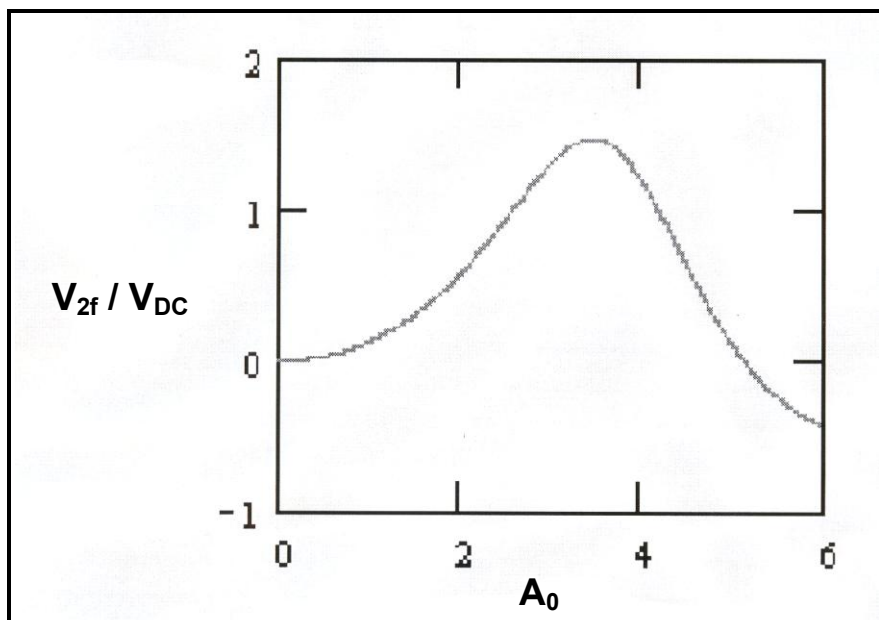
Ratio V_{2f}/V_{DC} vs retardation, radians

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:

$$V_{DC} \propto 1 + J_0(A_0) \quad (11)$$

The ratio V_{2f}/V_{DC} vs. retardation is shown in the figure below.



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:

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

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 the ratio V_{2f}/V_{DC} vs. retardation figure (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.

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

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-CSC
Size	6.585" W x 1.363" H x 9.383" D (167.28 mm x 3.463 mm x 238.34 mm)
Weight	1.8 lbs. (0.82 kg) (without head assembly)
Power Supply	Output: 48VDC, 2A Input: 100-240VAC, 50/60Hz, 1.4A

Parameter Specifications

Frequency

'f' Display Range/Resolution	37 kHz – 74 kHz, 1 dHz
Display Accuracy	4dHz

Retardation

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

Input / Output Specifications

'Head' Connection

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

Reference Outputs

Connector Style	BNC Female
Output Waveform	5 VDC square wave

Output Frequency	See 'Optical Head Specifications'
Phase Stability Duty Cycle	'f', 50% +/- 0.1%
	'2f', 50% +/- 0.1%

USB Connection

Connector Style	USB 2.0 Type B (Male – Male)
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Environmental

Designed for indoor use only.

Operating Temperature	2 to +50 degrees C (36 to 122 degrees F)
Storage Temperature	-40 to +65 degrees C (-40 to 150 degrees F)
Humidity	95% RH non-condensing
Operating Altitude	3000 meters
Overvoltage Category	40V overvoltage limit
Wet Location	NA
Pollution Degree	NA

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/CF50	Calcium Fluoride	50 kHz	130 nm – 1 µm	130 nm – 0.5 µm	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	400 nm – 1 µm	400 nm – 1 µm	13 mm
II/IS84	Fused Silica	84 kHz	400 nm – 1 µm	400 nm – 1 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

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.

PEM CSC Limited Warranty

Hinds Instruments, Inc. warrants the PEM CSC 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.

THIS DOCUMENT REFLECTS THE ENTIRE AND EXCLUSIVE UNDERSTANDING OF THE PARTIES, AND EXCEPT AS OTHERWISE PROVIDED HEREIN, ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, PARTICULARLY THE WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXCLUDED.

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

Overview of the PEM CSC Help System

As shown in the table below, 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 https://www.hindsinstruments.com/PEM for information specific to the PEM-CSC Photoelastic Modulator
U.S. Mail	Hinds Instruments, Inc. 7245 NE Evergreen Pkwy Hillsboro, Oregon 97124-5850

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 sales@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 NE 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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