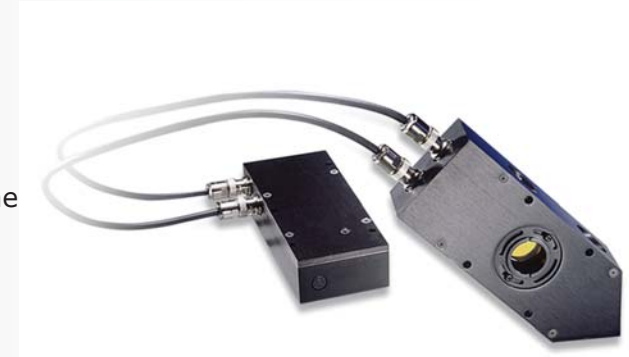
PEM photoelastic modulators change the polarization state of a light beam at frequencies between 20 and 100 kHz. The modulator optical element acts as a "dynamic waveplate" to produce an oscillating birefringence. This can convert linear polarized light into light which oscillates between circular, elliptical and linear states. For example, light which oscillates between left and right circular polarized light can be produced for use in circular dichroism measurements.



PEM photoelastic modulators feature a "split-head" configuration; the electronic and optical components are housed in separate enclosures. This minimizes the size of the unit which is placed in the optical train. It also simplifies making the optical head magnetic field compatible or vacuum compatible when this is necessary.

Series I modulators use rectangular optical elements and are useful in the ultraviolet, visible and infrared to 1 or 2 microns.

Series II modulators use symmetrical or octagonal optical elements and are primarily intended for use in the visible and infrared (to mid-IR) spectral regions. Special models have been used in the ultraviolet.

Modulators are offered optical elements using various optical materials. The choice of optical material is made primarily on the basis of the spectral transmission requirements of the instrument. A list of commonly available materials is given in Table 1.

TABLE 1

SPECTRAL REGION	SERIES	MATERIAL
Vacuum UV, UV	I	Lithium Fluoride
Vacuum UV to mid-IR	I, II	Calcium Fluoride
Vacuum UV to near-IR	I, II	Fused Silica
Mid-visible to mid-IR	II	Zinc Selenide
Near- to mid-IR	II	Silicon

Compared to the Series II octagonal optical elements, the rectangular optical elements used in Series I modulators provide lower levels of peak retardation for a given optical element thickness. This is a drawback when working in the infrared, but an asset when working in the UV, especially the vacuum UV.

When a PEM is used with a laser, modulated interference effects may occur. These can produce spurious optical/electronic signals which may hamper certain measurements. Hinds' engineers should be consulted for techniques to eliminate or minimize such signals in applications where laser light sources are used with PEMs.

Antireflection coatings may be used to increase the throughput of light through the modulator, to reduce interference effects, and to reduce the fraction of light which passes through the modulator at an undesired peak retardation. In particular, zinc selenide and silicon modulators benefit from antireflection coatings because of their high indices of refraction. (Note: An antireflection coating may significantly reduce the usefulness of the modulator outside the spectral band of the coating.)

Octagonal (Series II) optical elements are much more efficient for a given thickness, and thus have a significant advantage in the infrared. Operation of Series II modulators at low retardation levels (e.g. the deep UV) may present some problems.

FEATURES

Optical Characteristics

- Wide aperture (1.5 to 3.0 cm for standard units)
- Wide acceptance angle (+/- 20°)
- Wide selection of optical materials, spectral bands

Electrical Characteristics

- Extended retardation performance at high and low levels
- Controller determines retardation
- Precise frequency matching of electronic, optical components
- Optical and Electronic Heads are matched pairs and should not be interchanged

Mechanical Characteristics

- Minimum Optical Head size
- The Optical Head may be used in any orientation desired

ORDERING INFORMATION

PEM-90 Modulator Heads

Refer to Table 2 for optical specifications.

Model	Shipping Weight*
I/FS50	9.1 kg/20 lbs
I/FS20	9.1 kg/20 lbs
I/CF50	9.1 kg/20 lbs
I/LF50	9.1 kg/20 lbs
II/FS20	10 kg/22 lbs
II/FS42	10 kg/22 lbs
II/FS84	10 kg/22 lbs
II/CF57	10 kg/22 lbs
II/ZS37	10 kg/22 lbs
II/ZS50	10 kg/22 lbs
II/SI49	10 kg/22 lbs

*includes Controller

Options

(The specifications and prices for all of the options may vary depending on user requirements. Consult Hinds engineers when specifying these items.)

- **Antireflection Coatings, Model ARC**. AR coatings can be provided on a custom basis for any of our modulator optical elements. Both narrow-band and broad-band coatings are available. Please contact us with your spectral range and transmission requirements.
- **Non-Interference Option, Model NIO**. This option deflects internally reflected beams from the primary beam path, thereby eliminating modulated interference (see PEM Newsletter #8).

- **Special Frequency, Model SFO**. Standard modulator heads can be supplied with custom frequencies.
- **Special Length Optical Head/Electronic Head Cable**, Model SLHH.
- **Special Head Enclosures, Model SHE**. The Optical Head enclosure can be provided with custom geometries as required by the user's application or OEM requirement.
- **Vacuum Operation**. PEM optical heads may be operated in a vacuum. Consult Hinds for details.
- **Magnetic Field Compatibility, Model MFC**. Optical Head manufactured without any ferromagnetic materials, for compatibility with strong magnetic fields.

OPTICAL HEAD SPECIFICATIONS

Model	Optical Material	Nominal Frequency	Retardation Range		Useful Aperture[1]
			Quarter Wave	Half Wave	
I/FS50	Fused Silica	50 kHz	170nm - 2µm	170nm - 1µm	16mm
I/FS20	Fused Silica	20 KHz	170nm - 2µm	170nm - 1µm	22mm
I/CF50	Calcium Fluoride	50 kHz	130nm - 2µm	130nm - 1µm	16mm
II/FS20A	Fused Silica	20 kHz	170nm - 2µm	170nm - 1µm	56mm
II/FS20B	Fused Silica	20 kHz	1.6µm - 2.6µm	800nm - 2.5µm	56mm
II/FS42A	Fused Silica	42 kHz	170nm - 2µm	170nm - 1µm	27mm
II/FS42B	Fused Silica	42 kHz	1.6µm - 2.6µm	800nm - 2.5µm	27mm
II/FS47A	Fused Silica	47 kHz	170nm - 2µm	170nm - 1µm	24mm
II/FS47B	Fused Silica	47 kHz	1.6µm - 2.6µm	800nm - 2.5µm	24mm
II/FS84	Fused Silica	84 kHz	800nm - 2.5µm	400nm - 2.5µm	13mm
II/IS42B	Fused Silica	42 kHz	1.6µm - 3.5µm	800nm - 2.5µm	27mm
II/IS84	Fused Silica	84 kHz	800nm - 3.5µm	400nm - 1.8µm	27mm
II/CF57	Calcium Fluoride	57 kHz	2µm - 8.5µm	1µm - 5.5µm	23mm
II/ZS37	Zinc Selenide	37 kHz	2µm - 18µm	1µm - 9µm	19mm
II/ZS50	Zinc Selenide	50 kHz	2µm - 18µm	1µm - 10µm	14mm
II/SI40	Silicon	40 kHz	FIR - THz	FIR - THz	36mm
II/SI50	Silicon	50 Khz	FIR - THz	FIR - THz	29mm

[1] For a full discussion, consult the Useful Aperture Technical Note

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PEM–100 CONTROLLER

HINDS INSTRUMENTS

PHOTOELASTIC MODULATORS | PRODUCT BULLETIN

TECHNOLOGY FOR POLARIZATION MEASUREMENT

The PEM-100 Controller performs many functions in the PEM photoelastic modulator system. Its primary function is to control the peak retardation of the photoelastic modulator optical head. It does this by providing a DC voltage signal to the electronic head which determines the transducer vibration amplitude and thus the strain amplitude in the optical element. A current feedback loop from the electronic head enables the controller to maintain stable peak retardation levels.

FUNCTIONS

Microprocessor-Based Control

- Control of peak retardation
- Automatic adjustment of modulator drive level based on user-supplied retardation and wavelength values
- Memory protection of controller setup parameters (even when unit is turned off)
- Inhibit mode for reducing retardation level to zero without turning off power
- Programmable memory for commonly used settings

Digital Front Panel Settings & Control

- For user convenience, LCD display show which parameters and modes are in use.
- Display of retardation in user-selectable phase units (waves, radians, degrees)
- Selectable display of wavelength in nm, µm, or cm^{-1}
- Precise digital setting of retardation
- Incremental increase of wavelength and retardation values
- Key selection of preset retardation values
- Enhanced low-retardation operation

Computer Operation

- Improved RS-232 serial interface to computer with selectable baud rate
- PEM100 software provided for complete computer control including macro capabilities
- National Instrument LabView Driver provided for easy integration into larger experiments
- IEEE-488 interface available using an external converter with RS-232 port
- USB interface available using an external converter with RS-232 port
- Computer monitor of controller status

Reference Signal

- 1f and 2f square wave reference signals
- Improved reference signal stability

PEMlabs

CONTROLLER OPERATION

The PEM-100 Controller displays modulator retardation amplitude in phase units (waves, radians, or degrees). It also displays the wavelength of light being used with the PEM, and the operating frequency of the attached PEM head. An error message displays if there is an error in the system. Both the wavelength of the light being used and the retardation amplitude must be input to the controller by the user.

Each controller is configured to operate with a particular model head. The controller may be used to operate similar heads without modification or adjustment; however this is not recommended as a 50/50 duty cycle cannot be guaranteed. Operation with a different type or frequency head will require factory adjustment and/or EPROM replacement.

Setting the Retardation. The desired retardation amplitude may be set from the front panel by: 1) using the number pad to type in the desired retardation value, or 2) placing the curser over the value in the retardation field and use the up or down arrows to increment the value. The value of the retardation is displayed on the LCD.

Setting the Wavelength. The wavelength is set using the same procedure as described above. The factory default setting is 623.8 nm, the HeNe laser wavelength. The wavelength may be displayed in units of nanometers or microns, or the wave number (cm^{-1}).

Setting the Retardation Units. The units of retardation (waves, radians, or degrees) displayed on the front panel may be selected using a menu to the left of the Retardation value. The LCD will display the units selected.

Limit Condition Indicator. An error message will be displayed on the LCD if the is a malfunction in the PEM system. This indicates an operating error due to either 1) operation outside the design limits, or 2) a defect in the PEM circuitry or optical head.

Other Front Panel Displays. The display panel also displays the operating frequency at either the 1F or 2F value.

Serial Interface Operation
Serial interface operation by a computer must be initiated by the computer through the RS-232 interface port. The complete set of operating and query commands is given in the PEM User Manual.

ORDERING INFORMATION PEM-100 Controller

- Model PEM-100, includes manual on CD, controller/head cable, and power cord, and PEM-100 software. Shipping Weight, 6 kg (13 lbs)

Options

- Rack Mount Kit, select either Model RMO, standard full-rack width, or Model RMH, half-rack width
- RS-232 to IEEE-488 Converter (National Instruments™), Model GPIB-NI
- RS-232 to USB Converter, Model USB
- Special Length Controller-to-Head Cable, Model SLCH.

SPECIFICATIONS

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	SPECIFICATION	REMARK
FREQUENCY		
Operating Frequency	20 kHz to 84 kHz	Fixed Frequency, determined by head attached
Display Resolution	1 Hz or 0.001 kHz	
Display Accuracy	± 1 Hz at 25° C	
Duty Cycle, f and 2f	50% ± 1%	

ENVIRONMENTAL CHARACTERISTICS

CHARACTERISTIC	SPECIFICATION	REMARK
TEMPERATURE		
Non-Operating	-40° C to +65° C (-40° F to 150° F)	
Operating	2° C to +50° C (36° F to 122° F)	Controller only
HUMIDITY	0 to 95 % RH	Non-Condensing

PHYSICAL CHARACTERISTICS

CHARACTERISTIC	SPECIFICATION	REMARK
Shipping Weight	6 kg (13 lbs)	Modulator Head Assembly not included
Actual Weight	2.7 kg (6 lbx)	
Height	108.27 mm (4.27 in.)	
Width	214.12 mm (8.43 in.)	
Depth	330.2 mm (13.0 in.)	

ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	SPECIFICATION	REMARK
Power Supply	100 - 240 VAC 50/60 Hz	Universal
Power Consumption	27W	Maximum

EMC & SAFETY

CHARACTERISTIC	SPECIFICATION	REMARK
Approval	CE marked	
Safety Standard	EN 61010-1	
EMC Standards	EN 61326; FCC Class A	

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SELECTING A PHOTOELASTIC MODULATOR HEAD

There are several considerations to keep in mind when selecting an optical head for your photoelastic modulator system. The following document outlines these concerns. Please contact Hinds Instruments if you have any questions.

SPECTRAL RANGE CONSIDERATIONS

The two primary considerations in the selection of a PEM are the spectral region in which the modulator must operate and the range of retardance required. In general, series modulators are designed for use in UV and visible applications, but also may be used for many IR laser diode applications. Models I/CF50 and I/LF50 are specifically intended for the vacuum UV region.

Series II modulators are primarily intended for the near- and mid-IR regions, but some may be used in the visible spectrum. Consult the Specifications Table for details regarding transmission limits and available retardation.

RETARDATION REQUIREMENTS

A PEM intended for half-wave and quarter-wave applications should be capable of providing half-wave retardation throughout the spectral region of interest. Standard linear dichroism setups require half-wave operation, and it should be possible to achieve half-wave operation at any wavelength where calibration of the retardation is required.

Many modulator applications require only quarter-wave retardation. These include circular dichroism, optical rotation, polarimetry, birefringence, and amplitude modulation or chopping.

Some advanced techniques use a third modulator setting: the first retardation setting at which the Bessel Function $J_0(A_0)=O$. This occurs at a retardation setting of $A_0=2.405$ radians or 0.383 waves. For this setting, the average DC signal may be used for signal normalization.

OPTICAL CONSIDERATIONS

Aperture. Hinds can supply custom modulators with special size apertures. For a given optical element material, the aperture (and optical assembly size) is inversely proportional to the operating frequency. Standard apertures range from 1.5 to 3.0 cm.

Use with lasers. Laser light sources are monochromatic and have high spatial coherence, which can lead to undesirable interference effects. Reflections between the optical element surfaces may cause spurious detector signals at the fundamental and other harmonic frequencies. Use of antireflective coatings, tilting the modulator, or a special "non-interference" option which deflects internally reflected beams can reduce or eliminate this problem. Contact Hinds engineers for assistance with laser applications.

Antireflection coatings. Antireflection coatings may be used to increase the throughput of light through the modulator, to reduce interference effects, and to reduce the fraction of light which passes through the modulator at an undesired peak retardation. In particular, zinc selenide and silicon modulators benefit from antireflection coatings because of their high indices of refraction. *Note: An antireflection coating will significantly reduce the usefulness of the modulator outside the spectral band of the coating.*

OPTICAL HEAD SPECIFICATIONS

Model	Optical Material	Nominal Frequency	Retardation Range		Useful Aperture[1]
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II/FS84	Fused Silica	84 kHz	800nm - 2.5µm	400nm - 2.5µm	13mm
II/IS42B	Fused Silica	42 kHz	1.6µm - 3.5µm	800nm - 2.5µm	27mm
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II/SI50	Silicon	50 Khz	FIR - THz	FIR - THz	29mm

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