AxoScan™ System Options and Measurement Solutions

AxoScan Mueller matrix polarimeters represent the most advanced polarization measurement systems available. This brochure describes standard system configurations, and a wide variety of measurements that can be made with the system.

Don’t see the system or solution that you need? Contact an Axometrics application engineer today to discuss your application.
Standard AxoScan™ Systems

The Polarimeter Engine
All standard systems are based around the AxoScan Polarimeter Engine, the fastest and most accurate complete polarization measurement system available.

- Calibrated systems for the visible spectrum, near-infrared, and telecom wavelengths
- Extremely rugged – Ideal for laboratory or production use
- Can be held in any orientation
- Not sensitive to slight misalignments or vibration
- Variety of mounting options
- Tightly-integrated automation solutions available
- Turn-key operation

Mounting Fixtures
Several standard mounting fixtures are available to suit the needs of users in a wide range of different industries

- Light-weight extruded aluminum frame for stand-alone operation
- Mounts for horizontal operation on a standard optics table
- Brackets for vertical mounting on 1.5-inch pillar

Light Sources
Every application has a different light-source requirement. Axometrics offers several standard solutions, as well as systems that let you use your own light source.

- Temperature stabilized laser provides long-life at a single wavelength.
- Xenon Arc-lamp with scanning monochromator for spectral measurements across the visible wavelength range
- Connectors and integrated collimator for SMA- or FC-connectorized fibers lets the user supply nearly any light source

A variety of AxoScan mounting fixtures are available for different industries
**AxoView™ Software Interface**

All AxoScan polarimeters ship with the AxoView software interface pre-installed and ready to use.

- Simple control of the polarimeter hardware
- Powerful and intuitive data visualization
- System can be controlled remotely over RS-232 for integration into your automated test setup

**SpectroPolarimeter Option**

**Tunable Visible Light Source**

- Long-life Xenon arc lamp and grating monochromator
- Tune to any wavelength from 400 to 800 nm
- 5 nm spectral bandwidth
- Turn-key operation and seamless integration with the AxoView software interface
- Measure polarization properties across the visible spectrum in under five seconds

AxoScan SpectroPolarimeter integrates a Xenon arc lamp and scanning monochromator for measurements across the visible spectrum.

**Advanced Spectral Analysis**

- Visualization tools for analyzing polarization properties vs. wavelength
- Analyze any polarization property
- Includes routines for determining the true order of retarders
- Export data to spreadsheet files
- Export graphics to JPEG files for inclusion in reports and presentations
- Viewer software can be installed on multiple computers allowing exported data to be shared between technicians, engineers, and managers

Advanced visualization tools for interpreting polarization spectra. Here we see a measurement of a retarder with more than one wave of retardance.
Automated XY Table Option

- Generate easy-to-understand maps of parameters such as retardance, fast-axis orientation, polarizer axis, depolarization, percent transmission, etc.
- Flexible software for setting up scan parameters
- Measure up to 3 sites per second
- Standard system handles samples up to 6” square. Larger scan areas available upon request

Automated Tip-Tilt Table Option

- Automated, high-speed filed-of-view testing for all polarization optics
- Automatically locate and tilt about both fast- and slow-axes
- Out-of-plane retardance measurements
- LCD pre-tilt measurements

LCOS Retro-Reflection Fixture Option

- Directly measure retardance magnitude and orientation in retro-reflection
- XY scan table for mapping cell gap variations
- Measure retardance vs. voltage characteristics
- Advanced data reduction techniques remove the effect of the non-polarizing beamsplitter used for the measurement
Measuring Retarders and Waveplates

Films and Simple Waveplates

- Measure extremely low retardance, extremely large retardance, and everything in between
  - Minimum measurable retardance about values as low as 0.25 nm (0.15° at 550 nm)
  - Maximum measurable retardance >6,000 nm
- Measure retardance versus wavelength to determine dispersion relation of material
- Distinguish between fast- and slow-axes
- Measure axis orientation to within 0.1°
- Maps of spatial variation
- Off-axis / Field-of-view variations

Form-Birefringent Waveplates

- Measure retardance vs. wavelength characteristic
- Identify unexpected polarization-dependent transmission (diattenuation)

Compound Zero-Order and Achromatic Waveplates

- Measure optical rotation and elliptical fast-axes due to misaligned plates
- Fast-axis orientation variations with wavelength
- Measure retardance vs. wavelength characteristics
- Determine the true retardance order
- Actively align plates during assembly

If the two plates of a compound zero-order waveplate are not perfectly aligned during manufacture, the orientation of the fast-axis can vary significantly, as shown in the measurement above.

Measured retardance map of a quarter-wave plate. The retardance is 90° in the center of the plate, but there is a 15° variation in retardance across the clear aperture.
Measuring Polarizers

**Crystal Polarizers**
- Measure misaligned input and output polarizer axes due to improper construction
- Measure strong field-of-view variations as a function of wavelength

**Dichroic Polarizers**
- Performance vs. wavelength
  - Max and Min transmittance
  - Contrast ratio
  - Polarizer Efficiency
- Field-of-view testing
- Measure transmission axis orientation to within 0.1°
- Spatial variations in transmission axis orientation

**Circular Polarizers**
- Distinguish between left-hand and right-hand polarizers
- Determine transmitted polarization state as a function of wavelength
- Actively align retarders to polarizers
- Measure the retardance and axis alignment of a retarder in a complete circular polarizer

**Reflective Polarizers**
- Difference in transmitted and reflected contrast ratio
- Polarization axis orientation

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*Measured maximum transmittance (for polarization state launched along transmission axis) for three different brands of linear polarizers.*

*Measured output polarization state from the high-quality circular polarizer (left-handed). The polarization state is shown graphically on the Poincaré sphere.*

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*Polarizing Beam Splitters*
- Spatial maps of transmitted and reflected properties
- Measure variations in polarizer axis due to stain birefringence
Mounting a BK7 window with a set-screw induces very large amounts of strain birefringence. In this XY map, we see retardance values as large as 22° at the contact point. A window that glued into a mount exhibited 1.4° of retardance due to strain birefringence. Heating the part with a heat gun quickly reduces the strain down to a retardance of less than 0.2°. The retardance returns to 1.4° as the part cools down over the course of an hour.

A PET film with more than 10 waves of retardance can partially depolarize a beam with a 5 nm FWHM spectral bandwidth. AxoView provides tools for visualizing depolarization effects.

A z-cut LiNbO₃ device should have no retardance on-axis. Here, we measured 20° of retardance. Tilling the sample by 0.5° causes the beam to refract into the true optic axis of the sample.
Circular retardance and optical rotation are two names for the same effect. Here, we measured the optical rotation (in degrees) of an organic sample (approx. 17 mm or corn syrup) as a function of optical wavelength.

**Beamsplitters and prisms**
- Measure retardance resulting from total-internal-reflection within prisms
- Measure $s$- and $p$-reflectances and transmittances
- Characterize retardance due to propagation through thin-films at non-normal incidence

A mounted 636 nm bandpass exhibits significant retardance at normal incidence, likely due to strain birefringence. Notice that the retardance vs. wavelength curve is significantly more complex than the $1/\lambda$ characteristic typical of strain birefringence in homogenous materials.
Measuring Display Components

**LCOS Panels**
- Make measurements in direct retro-reflection
- Measure strain birefringence in unfilled cells
- Directly measure cell retardance
- Measure retardance vs. voltage characteristics
- Map spatial variation in cell gap
  - variation in retardance
  - variation in fast-axis orientation

**LCD Panels**
- Complete characterization of any cell mode
- Direct retardance and eigenmode measurement
- Calculate cell-gap, twist angle and pretilt

**Biaxial Films**
- Characterize field-of-view enhancing films
- Accurate fast-axis orientation measurement
- Measure R0, Rth, and β
- 3D refractive index ellipse
- Automatically tilt about fast- and slow-axis
Measuring Fiber-Optic Components and Waveguides

Optical Source Options
- Axometrics-supplied single wavelength laser
- User-supplied source delivered to the polarimeter via FC-connectorized fiber
  - tunable laser source
  - super-luminescent diode
  - broadband

Applications
- Characterize polarization controllers
- Measure PMD and PDL
  - differential group delay
  - principal state of polarization
- Full Mueller matrix measurement allows determination of high-order PMD
- Depolarization effects
- PM fiber alignment

Free Space Measurements
- Exceptional flexibility for the R&D environments
- Measure crystals prior to integration into fiber devices
- Launch a free-space beam into a waveguide or fiber device

Fiber-Coupled Measurements
- Adapters are available for directly coupling the AxoScan heads to fiber-coupled devices
  - FC ports with integrated collimators

Measurement of second-order PMD. In this case the DGD remains nearly constant with wavelength while the PSP’s trace out an arc on the Poincaré sphere.