Swift Liquid Crystal Principles

Meadowlark Optics next generation liquid crystal variable devices utilizes a new bulk stabilized polymer liquid crystal formulation. With switching speeds of less than a 150 microseconds in both directions our new "Swift" Liquid Crystal devices are perfect for applications where response time is critical.

Swift Liquid Crystal Technology

Liquid crystal polymer composite materials have been studied extensively is the past decades because of their intriguing physics and their potential application in robust, fast-switching liquid crystal devices. Meadowlark Optics has developed a novel fabrication process in which a polymer network is utilized to enhance the electro-optical performance of our liquid crystal devices.

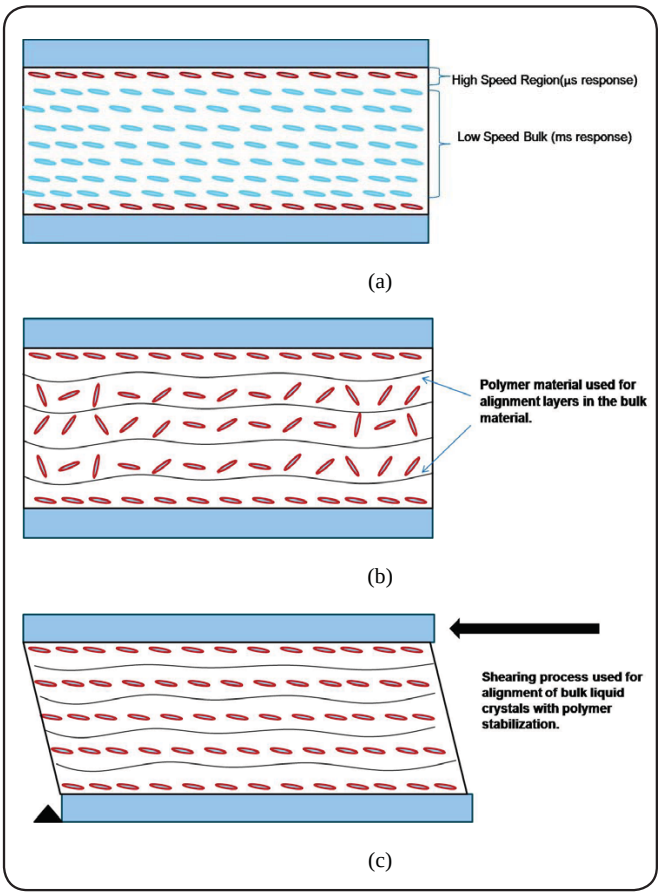

Fig. 4-17 (a) Typical bulk liquid crystal device showing both regions of fast and slow electro-optical response.

(b) A polymer stabilized liquid crystal device showing random alignment in the bulk of the material.

(c) A Swift Liquid Crystal device after alignment process.

Typical bulk liquid crystal devices, such as Meadowlarks' LCVR, have response times that are governed by the bulk of the liquid crystal and are a function of cell gap.

As cell gap increases, switching times increase as the square of the thickness. This effect is due to molecular properties of the bulk liquid crystal material and the alignment layer of the cell (See Figure 4-6). The actual temporal electro-optical response of the cell has two components, (1) a very fast surface layer effect that occurs very close to the alignment layer and is on the order of microseconds and (2) a relatively slow response that occurs in the bulk of the material on the order of milliseconds. This second response dominates in a typical bulk liquid crystal device. Figure 4-17 (a) defines these two regions for a standard liquid crystal variable retarder cell. To overcome this effect the introduction of small amounts of polymer material into the bulk allow for a multitude of alignment surfaces for the liquid crystal material. This allows for alignment surface effects throughout the bulk of the cell (Figure 4-17 (b)). The addition of a polymer stabilizing material in the bulk essentially decouples the cell gap from the switching speed. The challenge to this type of device is now there are no means for uniform liquid crystal alignment in the bulk, such that after infiltration of polymer material; the liquid crystal is aligned in random fashion with no particular "fast-axis" for functional retarder devices. For liquid crystal alignment to occur Meadowlark Optics performs a mechanical shearing process on the devices that aligns the bulk liquid crystal material (Figure 4-17 (c)). Once this step is performed the cell is locked into place and sealed. This assembly process ensures excellent uniformity in alignment of the liquid crystal molecules and gives a retardance uniformity across the clear aperture of less than 20nm.

Meadowlark Optics Swift liquid crystal technologies can be used throughout the visible and near infrared region. While these devices, like all liquid crystal devices, are affected by temperature and wavelength changes, they can be calibrated to accommodate those differences. Each Swift liquid crystal variable retarder is supplied with retardance versus voltage performance data for your specified wavelength, while our shutter devices are provided with temporal performance data. A coaxial cable with mating connector is provided for easy attachment to one of our new high voltage power supply sources.

NEW

Swift Liquid Crystal Variable Retarders

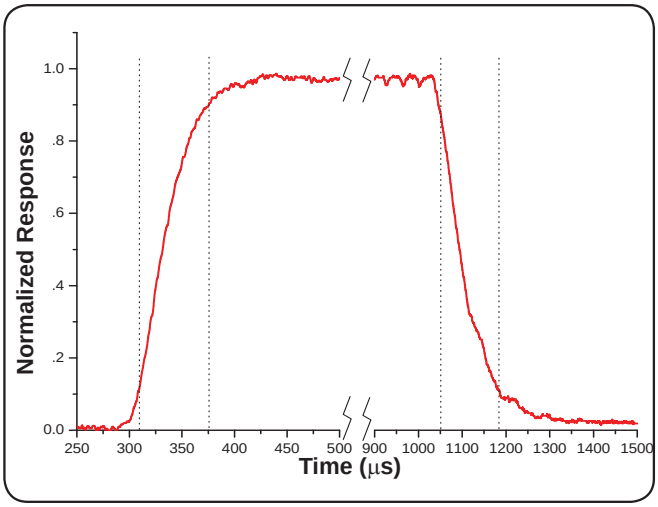

Fig. 4-18 Swift Liquid Crystal Response Time Plot

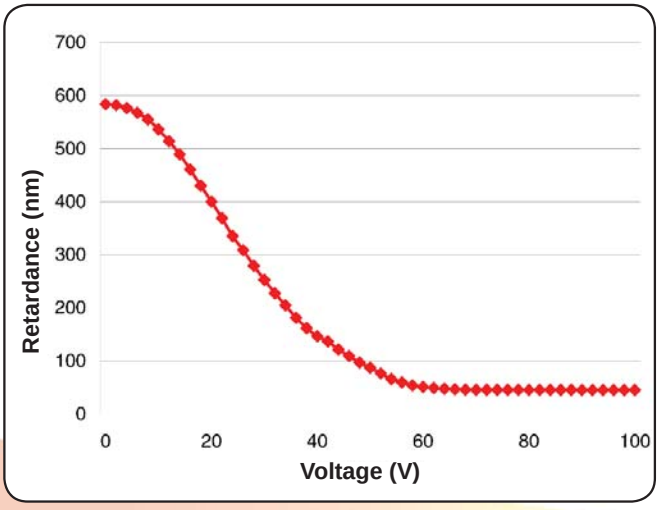

Fig. 4-19 Swift Liquid Crystal Retardance vs Voltage

Key Benefits

- **Sub-millisecond response times**
- **Computer control capability**
- **Temperature control options**
- **Performance from 450 to 1800 nm**

The next generation of liquid crystal variable retarders utilizes a new bulk stabilized polymer liquid crystal formulation. With switching speeds of less than a 150 microseconds in both directions the Swift Liquid Crystal Variable Retarder (SLCVR) is perfect for applications where response time is critical. The SLCVRs require a high voltage (< 100 Vrms) 13 kHz square wave of adjustable amplitude that is provided by our D3060HV High Voltage Interface (see page 62). A temperature sensing and control option can be added to our SLCVRs for accurate controlling of the operating temperature. The thermal sensor is attached directly to the SLCVR substrate, outside the clear aperture. Custom SLCVRs are available for a variety of applications.

SPECIFICATIONS	
Retarder Material	Polymer stabilized nematic liquid crystals
Substrate Material	Optical quality synthetic fused silica
Response Time (10-90%)	≤ 175 μs (zero to half-wave) ≤ 175 μs (half-wave to zero)
Contrast Ratio	150:1, minimum
Retardance Range	
Without compensator With compensator	~50 nm to λ/2 0 to λ/2 custom ranges are available
Transmitted Wavefront Distortion (at 632.8 nm)	≤ λ/2
Surface Quality	40-20 scratch and dig
Beam Deviation:	≤ 2 arc min
Reflectance (per surface):	≤ 0.5% at normal incidence
Diameter Tolerance	± 0.005 in.
Storage Temperature	-20° C to 80° C
Operating Temperature	0° C to 55° C
Wavelength Range	VIS: 450-700 nm IR 1: 650-950 nm IR 2: 900-1250 nm IR 3: 1200-1700 nm

ORDERING INFORMATION

Diameter, D (in.)	*Clear Aperture, CA (in.)*	*Thickness t (in.)*	*Part Number*
Without Attached Compensator (50 nm to λ/2)			
2.00	0.70	0.75	SVR - 200
With Attached Compensator (0 nm to λ/2)			
2.00	0.70	0.75	SRC - 200

Please specify spectral region when placing your order.

NEW

Swift Optical Shutters

Key Benefits

- No mechanical motion
- Computer control capability
- Noiseless
- High speed

This liquid crystal shutter is a vibration-free alternative to mechanical shutters for use in high- speed shutter applications. It uses a Swift LC cell between crossed polarizers to provide sub-millisecond switching for both opening and closing. Switching time is 125 microseconds to open and 125 microseconds to close. The switching times are less than 50 microseconds if the shutter is heated to 40° C. The D3060HV controller provides this temperature control capability. These shutters show some haziness in the liquid crystal layer in the blue and green wavelengths. The light loss from this haze is about 1% at 700 nm but increases monotonically to about 10% loss at 450 nm. Scatter at wavelengths above 700 nm is negligible. The shutter is supplied with integral dichroic visible polarizers that function over the wavelength range of 450 nm to 700 nm to provide an average contrast ratio of better than 200:1. Shutters with larger aperture sizes and with wavelength coverage to 2.1 microns are available on a custom basis. Please call with your special requirements.

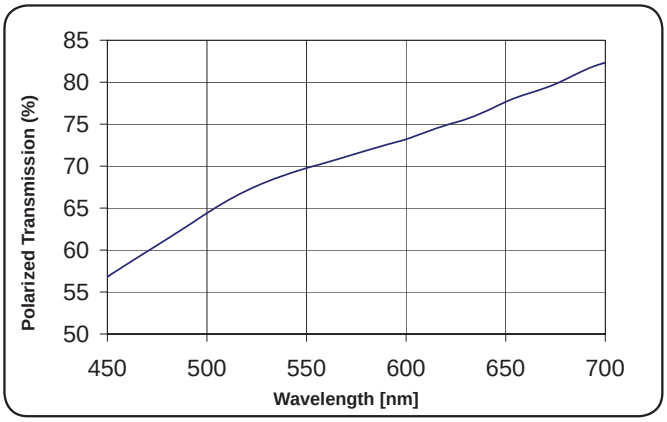

Fig. 4-20 Polarized transmission of the Swift Optical Shutter in the open state

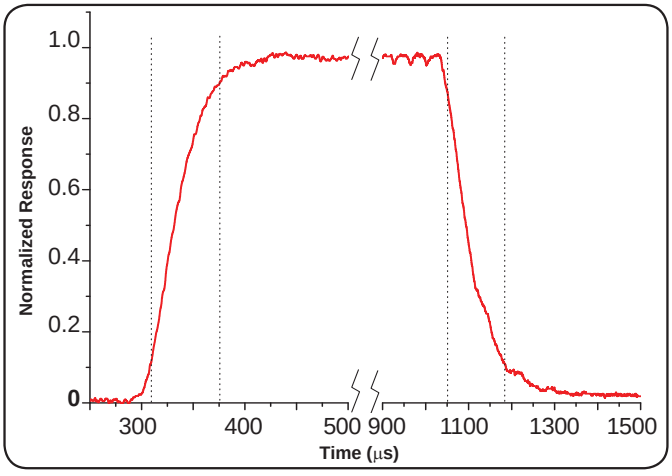

Fig. 4-21 Swift LC Response Time Plot

ORDERING INFORMATION			
Diameter, D (in.)	*Clear Aperture, CA (in.)*	*Thickness t (in.)*	*Part Number*
2.00	0.70	0.75	SCS - 200

SPECIFICATIONS	
Retarder Material	Polymer stabilized nematic liquid crystals
Substrate Material	Optical quality synthetic fused silica
Polarizer Material	Dichroic Polymer
Wavelength Range	450-700 nm
Contrast Ratio (average)	200:1
Angular Field of View	± 5 ° incidence angle
Switching Time (10% to 90%) at room temperature	
Closed to open: Open to closed	150 µs 150 µs
Switching Time (10% to 90%) at 40° C	50 µs
Transmitted Wavefront Distortion (at 632.8 nm)	≤ λ/2
Surface Quality	60-40 scratch and dig
Reflectance (per surface):	≤ 0.5% at normal incidence
Beam Deviation	≤ 5 arc min
Recommended Safe Operating Limit	1 W/cm², CW 300 mJ/cm², 10 ns, visible
Glass Thickness	0.48 — 0.52 inches
Polarization Direction	Vertical on input face, horizontal on output face
Storage temperature	-20° C to +70° C
Operating temperature	-10° C to +60° C

NEW

Two Channel High Voltage Interface

Key Benefits:

- USB or RS232 interface
- C++ code examples (all required libraries included)
- Compact and simple to use
- Microsoft® HyperTerminal configuration file included
- Independent control of voltage levels on two channels to 10 mV resolution
- Includes National Instruments LabVIEW™ Virtual Instrument drivers to interface with custom software

The Two Channel High Voltage Digital Interface is designed for high precision computer control of up to two Meadowlark Optics Swift LC liquid crystal devices at one time.

The D3060HV Package includes all the functionality of the D3050 plus the high voltage circuitry necessary for Swift LC devices. CellDRIVE 3100 HV software includes all the features of the CellDRIVE 3100 Advanced software, but is optimized for the high-speed Swift LC devices. Also included is capability for temperature monitoring and control on one channel. The Advanced Package allows the amplitude of the 13 kHz square wave output to be driven either by an external signal supplied to a front panel connector or specific CellDRIVE generated waveforms including sinusoidal, square, triangle, sawtooth and transient nematic effect waveforms. Additional functions include the capability to output a sync pulse on a front panel connector at desired points in the CellDRIVE generated waveforms and the ability to save/restore all CellDRIVE settings to/from a file.

Package includes:

- D3060HV Controller Unit with external input and sync output front panel connectors
- User Manual
- USB and RS232 cables
- Temperature control cable
- LC-Controller interface cable
- Power supply and power cable
- Temperature monitoring and control
- CellDRIVE 3100 HV Software
- National Instruments LabVIEW virtual instruments driver

SPECIFICATIONS	
Fundamental Drive Waveform	13 kHz ac square wave
Modulation Amplitude	0-100 V rms
Modulation Resolution	10 mV (1.55 mV using LabVIEW™ subroutines)
DC Offset	< 50 mV
Communications Interface	USB or RS232
LC cell to Controller Connections	LEMO™ RF cable, 2 m length
Power Requirements	100 – 240 Vac 47 – 63 Hz 2.5 A
Safety Feature	Keyed Interlock Switch
Dimensions (L x W x H)	10.50 x 7.25 x 4.0 in.
Weight	6 lbs.
Modulation Waveforms	external modulation input (0-5 V) Sinusoidal Triangle Square Sawtooth transient nematic effect
Temperature Control (one channel only)	Active heating/passive cooling to within ± 1° C of nominal set point
Sync Output	TTL, 1 µs pulse, user specified phase

Minimum System Requirements

- PC with Pentium II class processor
- 32 MB RAM
- CD ROM drive
- 20 MB hard drive space
- USB or RS232 COM Port
- Windows™ 98/ME/2000/XP/Vista
- Use of LabVIEW Instrument Library requires LabVIEW version 6.1 or higher

ORDERING INFORMATION	
High Voltage Controller	D3060HV
High Voltage Cable	Swift LC Cable