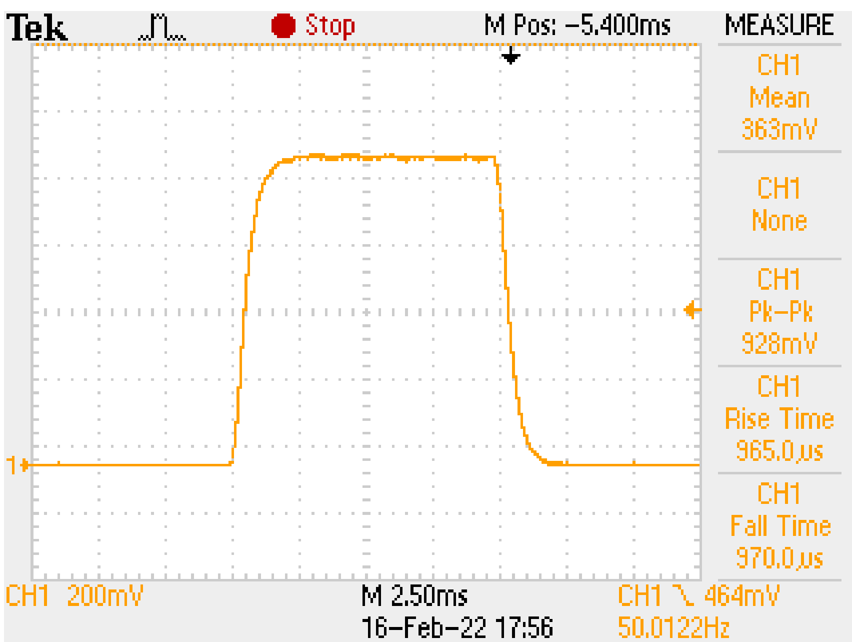
Spatial Light Modulator – 1024 x 1024

High Speed Analog – up to 1 kHz

Meadowlark Optics' Liquid Crystal on Silicon (LCoS) Spatial Light Modulators (SLMs) are uniquely designed for pure phase applications and incorporate analog data addressing with high refresh rates. This combination provides users with the fastest response times with high phase stability. The 1024 x 1024 SLM is good for applications requiring high speed, high diffraction efficiency, low phase ripple and high-power lasers.

High Speed with High Phase Stability - Great care was taken in the design of the 1024 x 1024 silicon backplane to enable high speed operation while simultaneously maximizing phase stability. Engineers successfully achieved high speed without compromising phase stability.

The 1024 x 1024 SLM is incredibly fast with liquid crystal response times ranging from 0.9 to 8 ms (wavelength dependent) for a full wave of modulation when running in typical room temperature environments.



Sub-millisecond liquid crystal response times were measured in the far field when switching between an 8-pixel, 2π phase grating and a solid image at 532 nm. Data captured while operating in typical room temperature environment (26°C chip temperature), using 10 to 90% reference levels.

SLM Features

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High resolution

High speed

High Phase Stability

Pure analog phase control

High first order efficiency

High reflectivity

High power handling

On-board Memory

Wavelengths from 488-1650 nm

Software Features

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Input and Output Triggers

Image Generation

Automated Sequencing

Wavefront Calibration

Global and Regional Look Up Tables

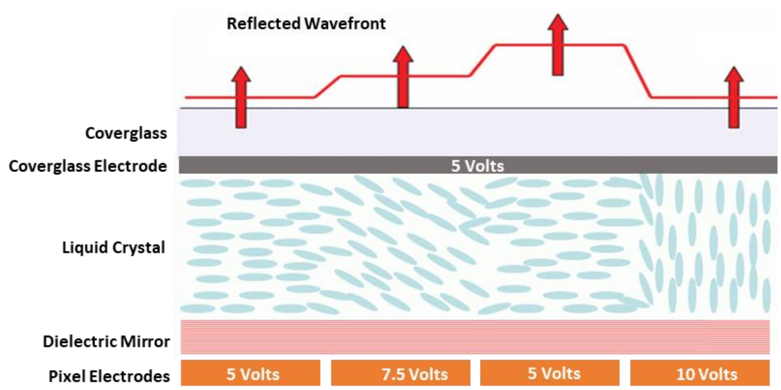
Temperature Monitoring

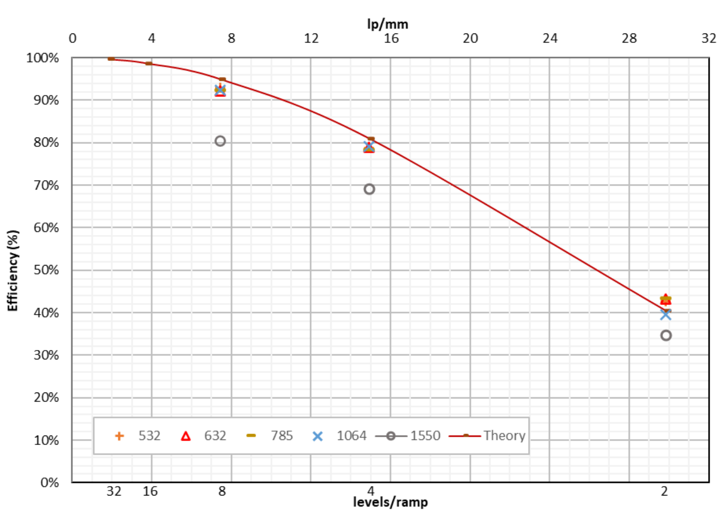
Diffraction Efficiency (0th-order)

This is the amount of light measured in the 0th-order (dc) when the SLM is written with various solid gray levels as a percentage of the amount of light measured when the SLM is replaced with a reference mirror. Therefore, it takes into account losses in transmission through the coatings on the SLM cover window, as well as diffraction losses due to the pixel pads being less than 100% fill-factor. In addition to these losses, this measurement also accounts for losses due to imperfect reflectivity of the aluminum pixel mirrors, or in the case of a dielectric mirror coated model the measurement accounts for losses due to imperfect reflectivity of this dielectric mirror coating. The 0^{th}-order diffraction efficiency will vary as a function of wavelength due to differences in coating materials and designs. It will also vary with pixel value due to the inherent change in the index of refraction of the liquid crystal that results in a change in the Fresnel reflections inside the liquid crystal cell. Most standard SLMs will range from 70 – 90%, while the dielectric mirror coated models will range from 92 – 98%.

High Efficiency Dielectric Mirror Coating

All the light reflecting off the SLM is modulated – including the light between the aluminum pixel electrodes. The reflective pixel structure associated with a LCoS SLM backplane acts as an amplitude grating diffracts some light into higher orders. Optically, the active area of the backplane is converted into a flat dielectric mirror by depositing dielectric layers to eliminate the amplitude and optical path variations associated with the underlying aluminum pixel structure. The dielectric stack is kept thin to minimize any drop in electric field across the LC layer as shown in the figure below. In other words, there are no abrupt changes in phase modulation (such as dead zones) between pixels due to the smoothing which results from separating the LC modulator from the driving electrodes.



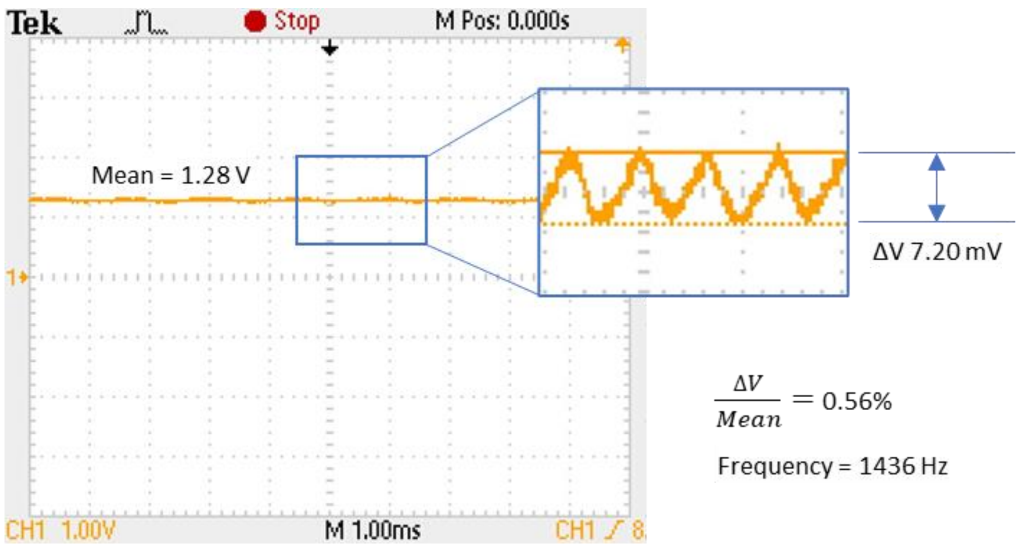


Typical Measured 1st Order Diffraction Efficiency

Diffraction Efficiency (1st-order)

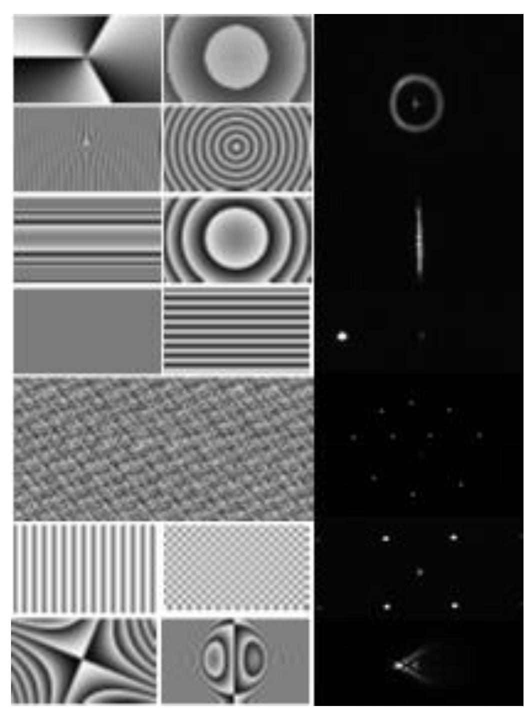
This is the percentage of light measured in the 1st-order when writing a linear repeating phase ramp to the SLM as compared to the light in the 0^{th} order when no pattern is written to the SLM. 1^{st}-order diffraction efficiency varies as a function of the number of phase levels, or pixels, in the phase ramp. Example measurement data taken at various wavelengths is shown below for phase ramps with 2 to 8 phase levels between 0 and 2π.

High Phase Stability – Making an LCOS SLM faster usually means the phase stability becomes worse. However, we've combined our traditional analog drive scheme with some new proprietary technologies to suppress phase instabilities to an unprecedented 0.2 – 1.0% without compromising the speed. If your application requires extremely low phase ripple, please contact a Meadowlark Solutions Engineer for more information on the 19x12 SLM. Phase ripple is quantified by measuring the variation in intensity of the 1st order diffracted spot as compared to the mean intensity while writing a blazed phase grating to the SLM. Since phase stability varies as a function of pixel voltage, this measurement approach is an average and does not represent all scenarios.



Typical data showing phase stability at 532 nm

Software - Meadowlark Optics' SLMs are supplied with a graphical user interface and software development kits that support LabVIEW, Matlab, Python, and C++. The software allows the user to generate images, to correct aberrations, to calibrate the global and/or regional optical response over 'n' waves of modulation, to sequence at a user defined frame rate, and to monitor the SLM temperature.



Global or Regional Calibrations - Regional calibrations provide the highest spatial phase fidelity commercially available by regionally characterizing the phase response to voltage and calibrating on a pixel-by-pixel basis.

Image Generation Capabilities

Bessel Beams: Spiral Phase, Fork, Concentric Rings, Axicons

Lens Functions: Cylindrical, Spherical

Gratings: Blazed, Sinusoid

Diffraction Patterns: Stripes, Checkerboard, Solid, Random Phase

Holograms, Zernike Polynomials, Superimpose Images