FISBA Innovators in Photonics

HOLOEYE Pioneers in Photonic Technology

CFS phase modulating LCOS SLMs for holographic reconstruction in visual systems using a multi-color lasermodule

At the visible wavelengths range phase modulating Spatial Light Modulators are used for a growing number of imaging-like applications (e.g. holographic projection, 3D holographic displays or structured illumination).

Compared to the use of conventional imaging display technologies like LED backlights or LED front illumination, the use of LCOS based phase SLMs for holographic reconstruction using laser illumination, shows the advantage of providing higher light efficiency and with that the same performance or higher brightness using lower powers. The image is generated by diffraction (redistribution of light) instead of blocking light (amplitude modulation) like at conventional projection systems.

Besides that, the holographic approach of phase SLMs can be used to add additional optical functions like dynamic focusing or aberration correction. This is a major advantage for applications like automotive HUDs, where the curvature of the windshield is a main problem in system design, variability of HUDs and individual system calibration.

Principle of phase SLMs

The use of LC materials in SLMs is based on their optical and electrical anisotropy. Electrical anisotropy enables a variable orientation of the LC molecules in the direction of an applied electric field. Optical anisotropy (birefringence) means this tilt changes the refractive index of the LC molecules (for suitable incident polarization) which causes a modified optical path length within the LC cell. The combination of both allows the retardation of light waves / phase modulation.

Dependent on the used LC material (high birefringent material) and LCOS cell design it is possible to manufacture phase modulating LCOS displays, which are fast enough to be used for color-sequential holographic reconstruction.

Compact Color-Sequential holographic projection setup

At the following, we demonstrate a compact setup for color-sequential holographic projection using standard components.

LETO-3 & LUNA Spatial Light Modulators

For both the LETO-3 and the LUNA SLMs, fast versions for CFS operation are available.

	LETO-3	LUNA
		
Resolution	1920 x 1080 pixel	1920 x 1080 pixel
Pixel Pitch	6.4 µm	4.5 µm
Fill Factor	93 %	91 %
Active Area / (Display Diagonal)	12.5 x 7.1 mm (0.55")	8.64 x 4.86 mm (0.39")
Input Frame Rate	60 Hz / 180 Hz (CFS)	60 Hz / 180 Hz (CFS)

DPE – Diffractive Projection Engine

The diffractive approach with a phase SLM is fairly simple as it only requires a linearly polarized light source and the SLM itself. However, as diffraction angles are limited (dependent on pixel size of the used SLM) it might be necessary to use additional optics to magnify the output image.

HOLOEYE offers a compact standard Diffractive Projection Engine, which works for a broad field of imaging applications. The engine is designed to work with a linearly polarized laser source coupled into a polarization-maintaining single mode fiber with FC/APC connector.

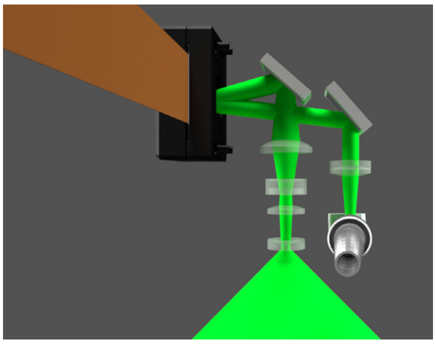


Image 1 Beam path within diffractive projection engine

The angular magnification is in the area of 5.3x (slightly dependent on wavelengths and pixel pitch). The working distance ranges from ~15 cm to infinity. The field of view depends on the used HOLOEYE SLM:

- FoV LUNA: 34°(full angle): ~185 mm @ 300 mm distance
- FoV LETO: 24°(full angle): ~130 mm @ 300 mm distance

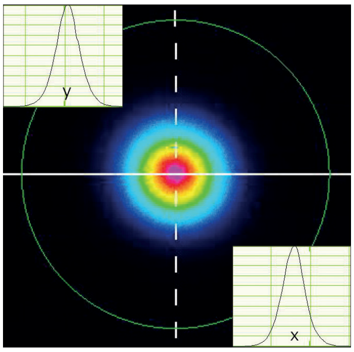
FISBA READYBeam™ Laser

The FISBA READYBeam is a multi color Laser which includes electronic driver and thermal control in one compact housing. Several versions are available covering different combinations of three wavelengths. So far modules including the diodes 405, 450, 488, 520, 638 and 660 nm have been realized. The standard optical interface is a single mode, polarization maintaining fiber. It delivers a prealigned stable beam output over time.

The Laser power of each of the three READYBeam sources is independently controlled, which means the color of the combined beam can be adjusted anywhere within the gamut of the three laser diodes. With 40 mW of output in the red and blue, and 30 mW in the green, analog modulation frequency up to 20 kHz, and digital modulation as fast as 1 MHz, the READYBeam is prepared to be at the heart of display and projection applications.

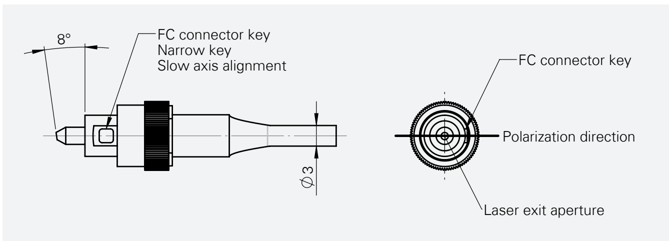
The module connects via a standard electronic RS 485 interface and therefore easily integrates into analytical and industrial instrumentation and facilitates their evolution.

Beam quality



TEM00 single mode fiber beam profile

APC connector



Typical 10 dB improvement in return loss

Gaussian spot and illumination distribution (left) and schematic drawing of the APC (angled physical contact) fiber connector of the READYBeam

Setup with LETO-3 SLM

The LETO-3 SLM display is directly mounted into the Diffractive Projection Engine. The FISBA RGB READYBeam is coupled trough a single mode fiber to the APC connector of the engine. The LETO-3 features a Light Source Sync connector, which is linked to the RGB laser to synchronize the SLM with the light source.

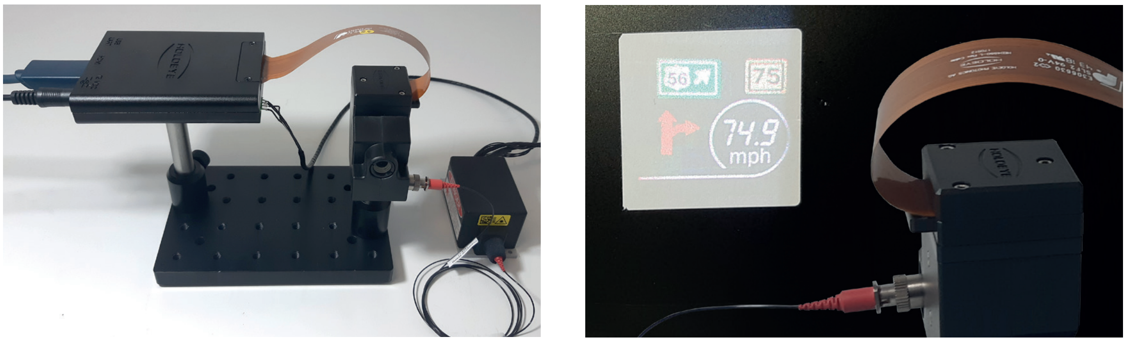


Image 2: Setup with LETO-3 SLM, Diffractive Engine and RGB laser

The phase holograms are addressed using the HOLOEYE SLM display SDK for Python. The script runs a sequence of pre-calculated hologram images. It is also overlaying prism functions, which are used to shift the reconstructed image off-axis to move it away from the unwanted 0-order spot. The 0-order is blocked by a mask.

To generate the RGB hologram images we us the HOLOEYE Pattern Generator Software. The software calculates an 8-bit hologram image for each color channel and combines them into an RGB image.

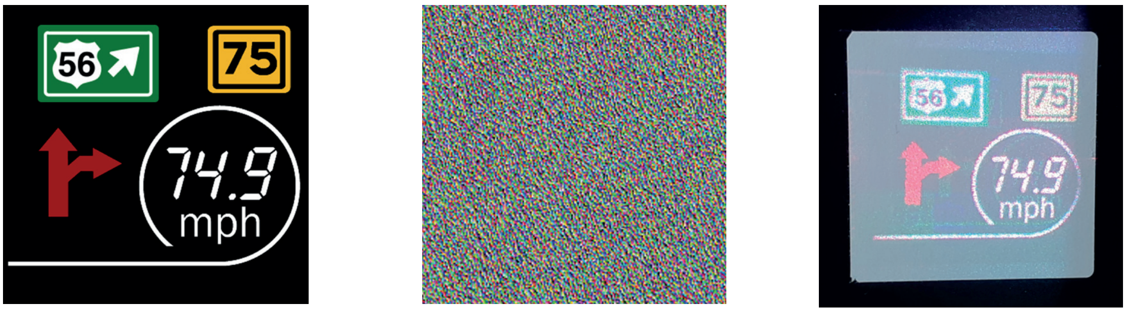


Image 3: Original image, excerpt from combined RGB hologram image and reconstruction

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