NEW

LCOS-SLM (Liquid Crystal on Silicon - Spatial Light Modulator)

X15213 series

Control your light !
Shape your beam !
Improve your image !

The X15213 series devices are a reflective type of pure phase Spatial Light Modulators (SLMs), based on Liquid Crystal on Silicon (LCOS) technology in which liquid crystal (LC) is controlled by a direct and accurate voltage, and can modulate a wavefront of light beam. The LCOS-SLMs are carefully designed to achieve high light utilization efficiency from various points of view, such as reflectivity, aperture ratio and diffraction noise due to the pixel structure.
The X15213 series can be controlled via a PC using the Digital Video Interface (DVI), which is a standard interface for PC displays. The distortions in the LCOS chip, such as wavefront distortion and non-linear response of the LC, are efficiently compensated by the controller.
Easy PC control, precise and linear phase modulation characteristics can be accomplished with the X15213 series. They can also provide high diffraction efficiency and high light utilization efficiency. We also provide water cooled types with a built-in water-cooled heatsink for improved power handling capability.

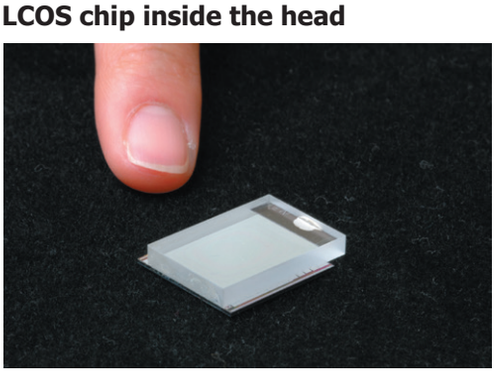
Features

- **Pure, linear and precise phase control**
- **High light utilization efficiency**
- **High diffraction efficiency**
- **High power handling capability**
- **Ease of use (DVI compatible)**
- **Reflective type**

Applications

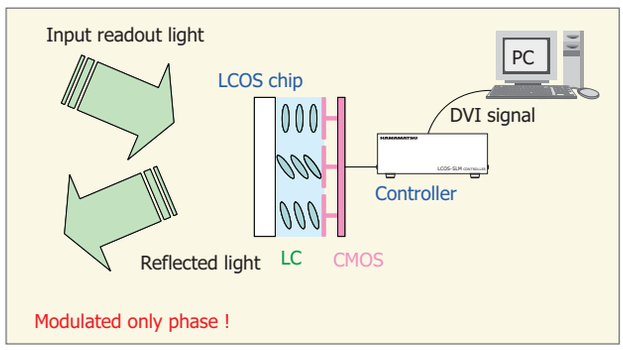
- **Laser material processing**
- **Optical manipulation**
- **Wavefront correction**
- **Pulse shaping**
- **Optical testing**

LCOS chip inside the head



Principle of modulation

The LCOS chip has a parallel-aligned nematic liquid crystal layer to modulate light. It only changes the phase of light without any change of intensity and rotation of polarization state. Phase modulation is changed according to the alignment of the LC. The LC alignment is controlled, pixel by pixel, using a CMOS backplane and a DVI signal via a PC.

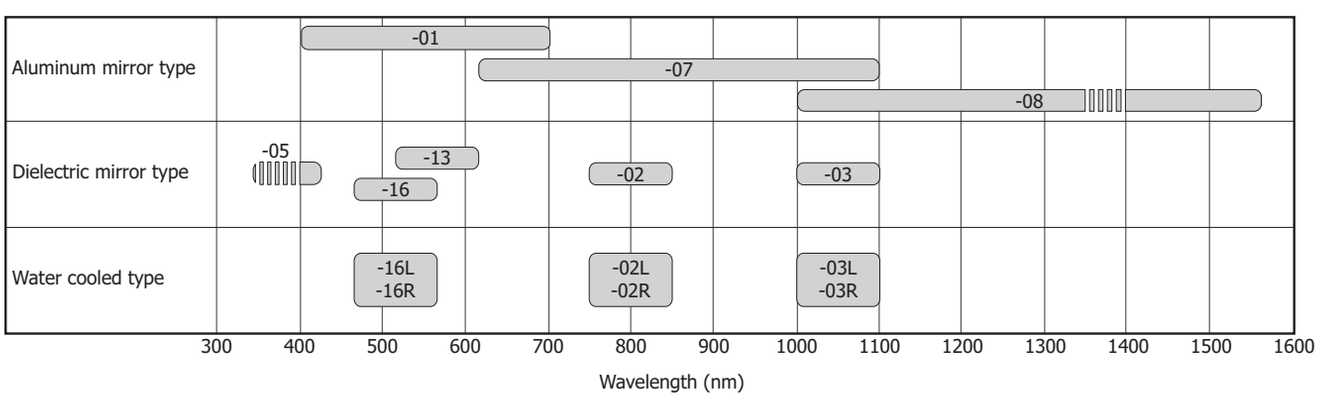


KACCC1037EA

Selection guide

There are eight types in the X15213 series, which cover different wavelengths of light sources. They can be grouped into dielectric mirror types (-02/-03/-05/-13/-16) and aluminum mirror types (-01/-07/-08). To enhance the reflectivity of the device, dielectric mirror types have dielectric mirrors corresponding to different wavelengths of laser light source. [-02: titanium sapphire laser (800 nm band), -03: YAG laser (1064 nm), -05: LD (405 nm), -13: YAG laser 2nd harmonic (532 nm)/He-Ne laser (633 nm), -16: YAG laser 2nd harmonic (532 nm)]. The increased reflectivity achieved by the dielectric mirror decreases the internal absorption rate. This allows accommodation for high powered lasers, but the covered wavelength range is narrowed. Aluminum mirror types use reflections from the aluminum electrodes on the CMOS chip. The reflectivity is inferior to that of the former, but the reflection wavelength range is wider, covering a range of 400 nm to 1550 nm with just three types. For the wavelength band between 1350 and 1400 nm on the -08 type, the reflectance degrades about 5% due to the absorption by the glass substrate. Dielectric mirror types for the 532 nm band are available in -13 and -16. The -16 is designed to be more light-resistant to short-pulse lasers than the -13. Water cooled types have L or R (where L and R indicate the water stream connector positions left and right, respectively) appended to the number -02, -03, or -16 which indicates the wavelength range.

[Figure 1] Spectral response



KACCB0593EA

Absolute maximum ratings

Parameter	Operating temperature (°C)	Storage temperature (°C)	Withstand pressure of water stream connector (MPa)
X15213-01/-02/-03/-05/-07/-08/-13/-16	+10 to +40*1	-20 to +55*1	-
X15213-02L/-02R/-03L/-03R/-16L/-16R			0.3

*1: No condensation. Humidity may cause deterioration of characteristics, so be careful with the humidity.
The characteristics of this product depend on temperature. Using this product at an ambient temperature of about 25 °C is recommended.
When there is a temperature difference between a product and the surrounding area in high humidity environment, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.

Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

Structure

■ Head

Parameter	Number of pixels (pixels)	Pixel pitch (μm)	Effective area size (mm)	Fill factor (%)	Weight (g)
X15213 series	1272 × 1024	12.5	15.9 × 12.8	96	150 (Water cooled type: 550)

■ Controller

Parameter	Supply voltage AC (V)	Power supply frequency (Hz)	Weight		Input signal	DVI signal format (pixels)	Input signal level (levels)	DVI frame rate (Hz)	Power consumption (W)
			Main unit (g)	Including cables (g)					
X15213 series	100 to 230	50/60	910	1350	Digital Video Interface (DVI-D) /USB-B (2.0 High-speed)	1280 × 1024	256	60	15

Electrical and optical characteristics

Parameter	Readout light wavelength (nm)	Light utilization efficiency typ. (%)	Rise time*2 (ms)	Fall time*2 (ms)
X15213-01	400 to 700	79 (633 nm)	5 (633 nm)	25 (633 nm)
X15213-02	800 ± 50	97 (785 nm)	30 (785 nm)	80 (785 nm)
X15213-02L				
X15213-02R				
X15213-03	1050 ± 50	97 (1064 nm)	25 (1064 nm)	80 (1064 nm)
X15213-03L				
X15213-03R				
X15213-05	410 ± 10	97 (405 nm)	10 (405 nm)	20 (405 nm)
X15213-07	620 to 1100	82 (1064 nm)	10 (1064 nm)	80 (1064 nm)
X15213-08	1000 to 1550	82 (1550 nm)	30 (1550 nm)	140 (1550 nm)
X15213-13	530 to 635	97 (532 nm)	10 (532 nm)	25 (532 nm)
X15213-16	510 ± 50	97 (532 nm)	11 (532 nm)	34 (532 nm)
X15213-16L				
X15213-16R				

*2: Time required to change from 10% to 90% for 2π modulation (typical value)

Operating characteristics

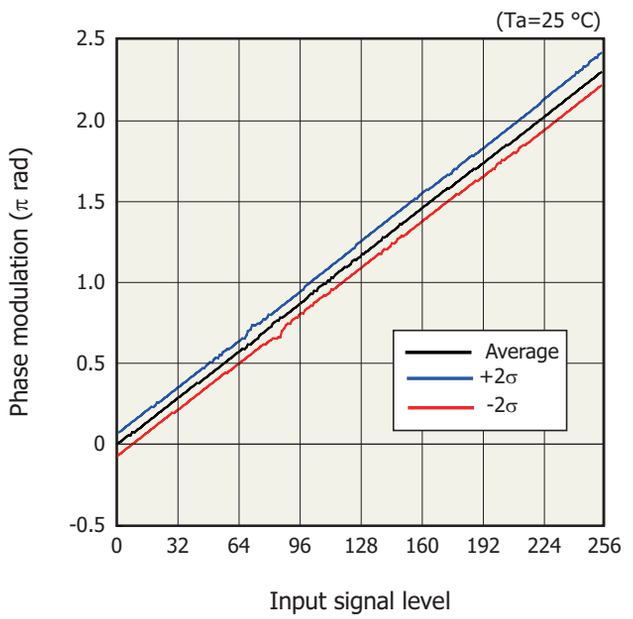
Light utilization efficiency

The X15213 series have high light utilization efficiency, which is defined a ratio of the 0th order diffraction light level to the input light level. The high light utilization efficiency mainly depends on reflectivity, and the amount of diffraction loss caused by the pixel structure. We adopted advanced CMOS technology to make the diffraction loss smaller. As a result, the diffraction loss is less than 5%. The -02/-03/-04/-05/-06/-09 types have a dielectric mirror which has high reflectivity. Therefore, these types have very high light utilization efficiency. The -01/-07/-08 types have relatively low light utilization efficiency compared to the ones with the dielectric mirror but have wide spectral response characteristics.

Phase modulation

The X15213 series can achieve phase modulation of more than 2 π radians over the 400-1550 nm readout wavelength range. The X15213 series comes pre-calibrated from the factory for a specified wavelength range to have more than 2 π radians of phase modulation and its linear characteristics. Figure 2 shows typical phase modulation characteristics. A phase shift of 2 π radians or more and a linear phase response are achieved. The phase modulation curves for 95% pixels lies within +/- 2 σ.

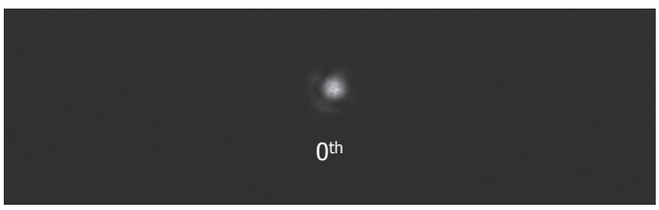
[Figure 2] Phase modulation (typical example)



Diffraction efficiency

The X15213 series is a pure phase SLM with high precision phase control; therefore, it has high diffraction efficiency close to the theoretical values. Figure 3 shows images of diffracted spots, when a multi-level phase grating is formed in the X15213 series and Figure 4 shows typical diffraction efficiency characteristics. Here, the diffraction efficiency is defined I_1/I_0, I_1 is intensity of the 1st order diffraction spot, I_0 is the intensity of the 0th order light when no pattern is displayed.

[Figure 3] Diffracted spots images (typical example)

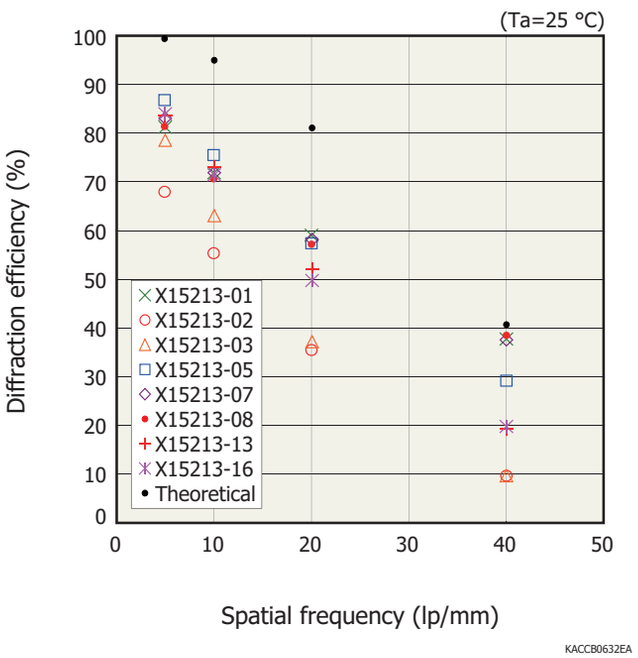


(a) No pattern

(b) 2-level grating (40 lp/mm)

(c) 4-level grating (20 lp/mm)

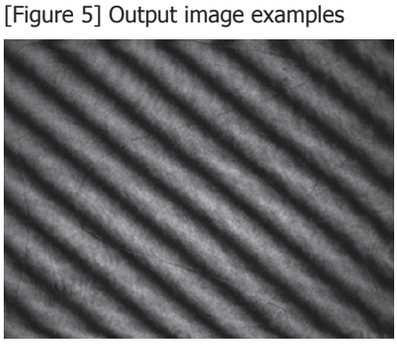
[Figure 4] Diffraction efficiency (typical example)



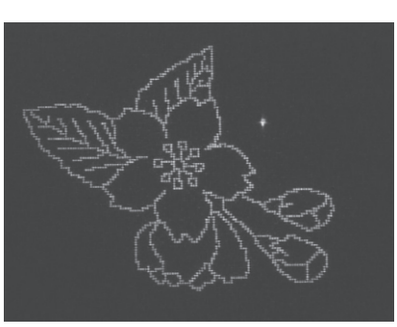
Output image examples

The X15213 series has high precision phase control and high diffraction efficiency, and is very suitable for holographic applications. Figure 5 (a) is a interferometer picture of the output wavefront with a flatness calibration. The image in Figure 5 (b) was reconstructed as the 1st diffraction order of the phase hologram through the Fourier transform optics. Figure 5 (c) shows a clear Laguerre Gaussian (LG) beam of (0, 1) order.

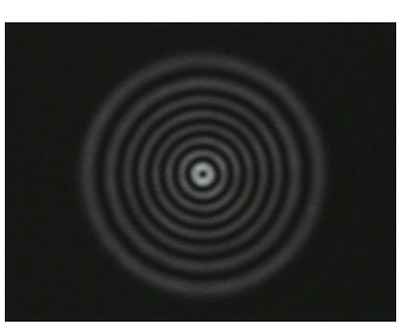
[Figure 5] Output image examples



(a) Interferogram of output wavefront with calibration
1272 × 1024 pixels
RMS: 0.025 λ (λ=532 nm)



(b) Reconstructed image of CGH

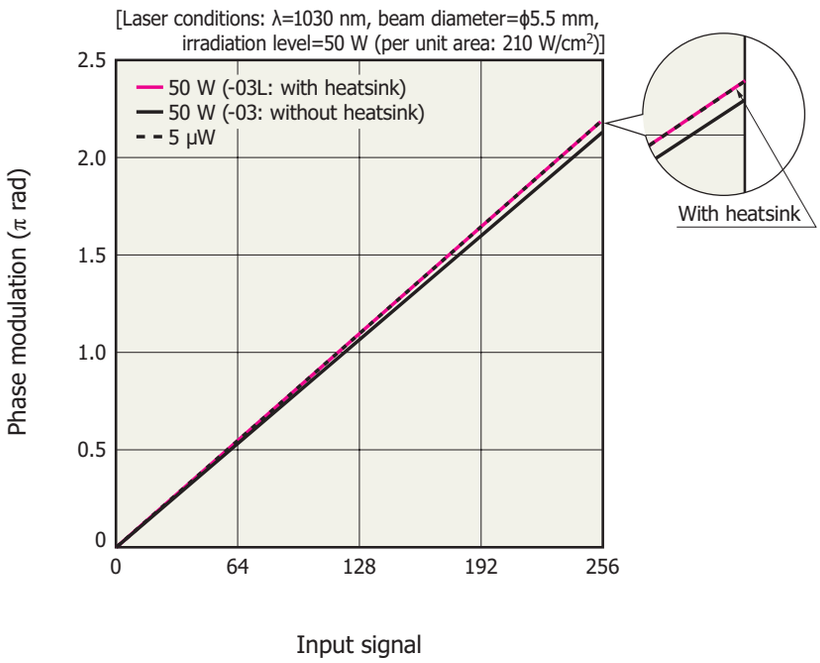


(c) LG beam

■ Light resistance

The LCOS-SLM features versatility and high reliability, but exposure to high power laser light increases the temperature and may cause characteristic degradation or damage. Water cooled types (-02L/-02R/-03L/-03R/-16L/-16R) have built-in cooling heatsink in the head section to improve the light resistance by suppressing temperature increases caused by laser irradiation.

[Figure 6] Laser irradiation test result



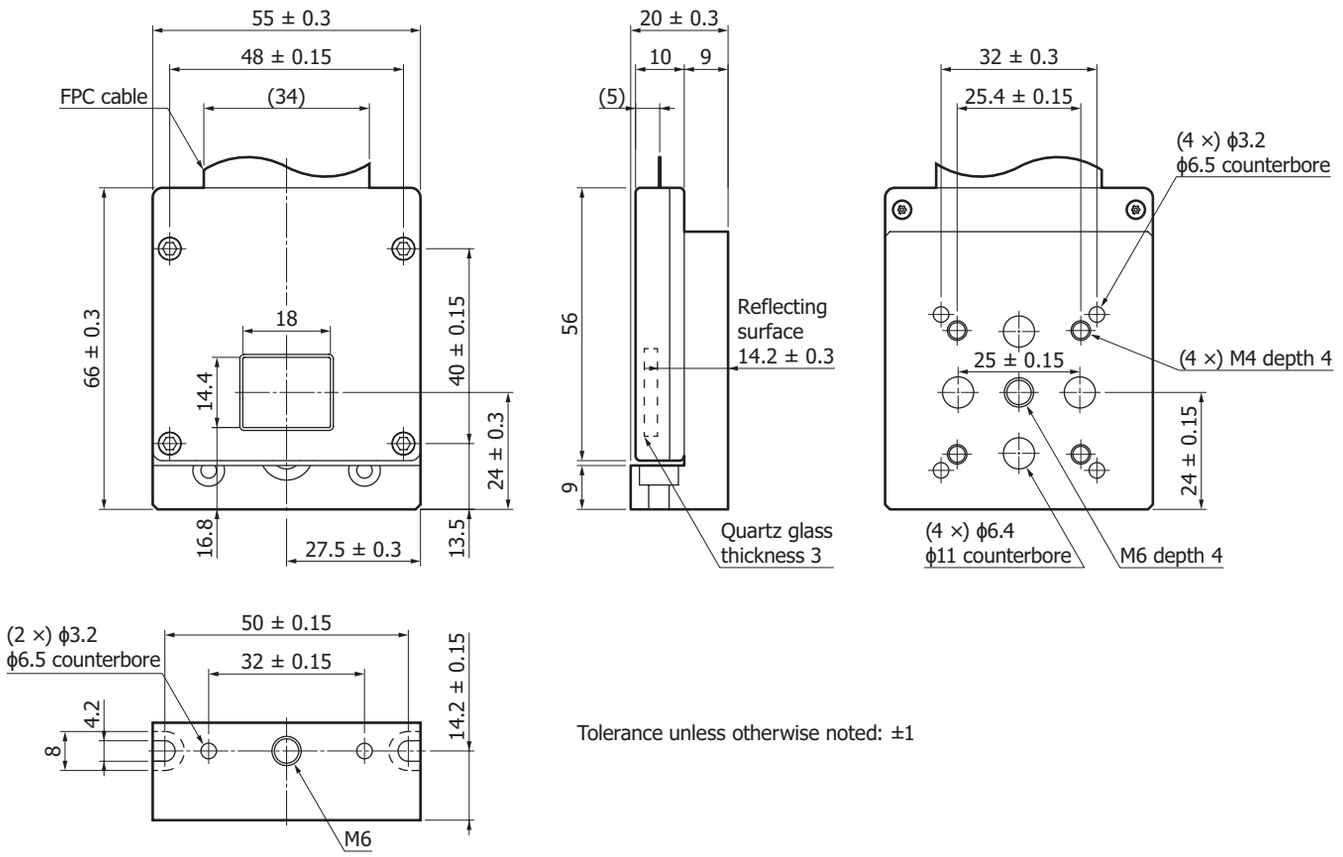
Phase modulation does not change even when exposed to high power laser.

KACCB0644EA

Dimensional outlines (unit: mm)

Head

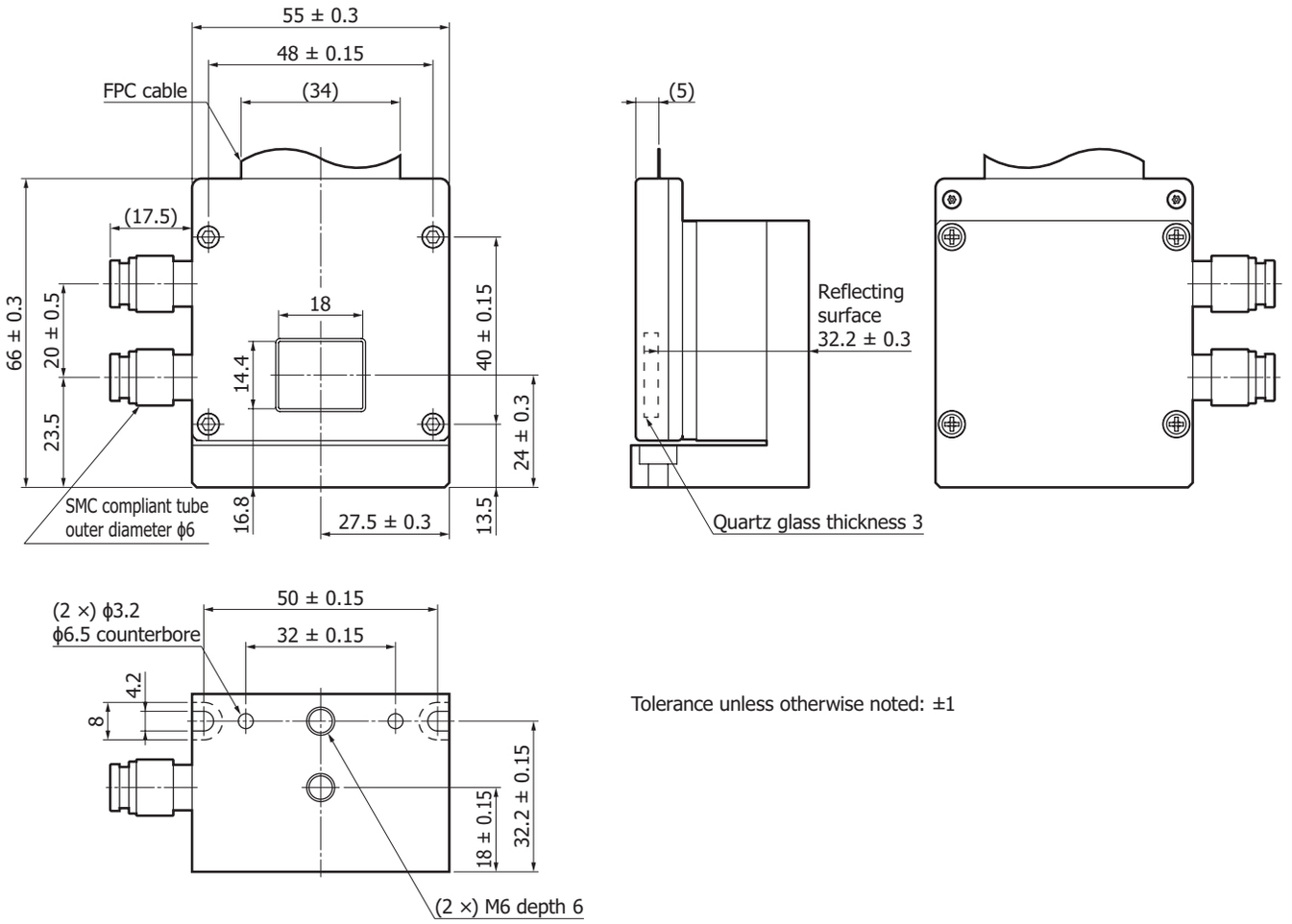
■ X15213-01/-02/-03/-05/-07/-08/-13/-16



Tolerance unless otherwise noted: ±1

KACCA0455EA

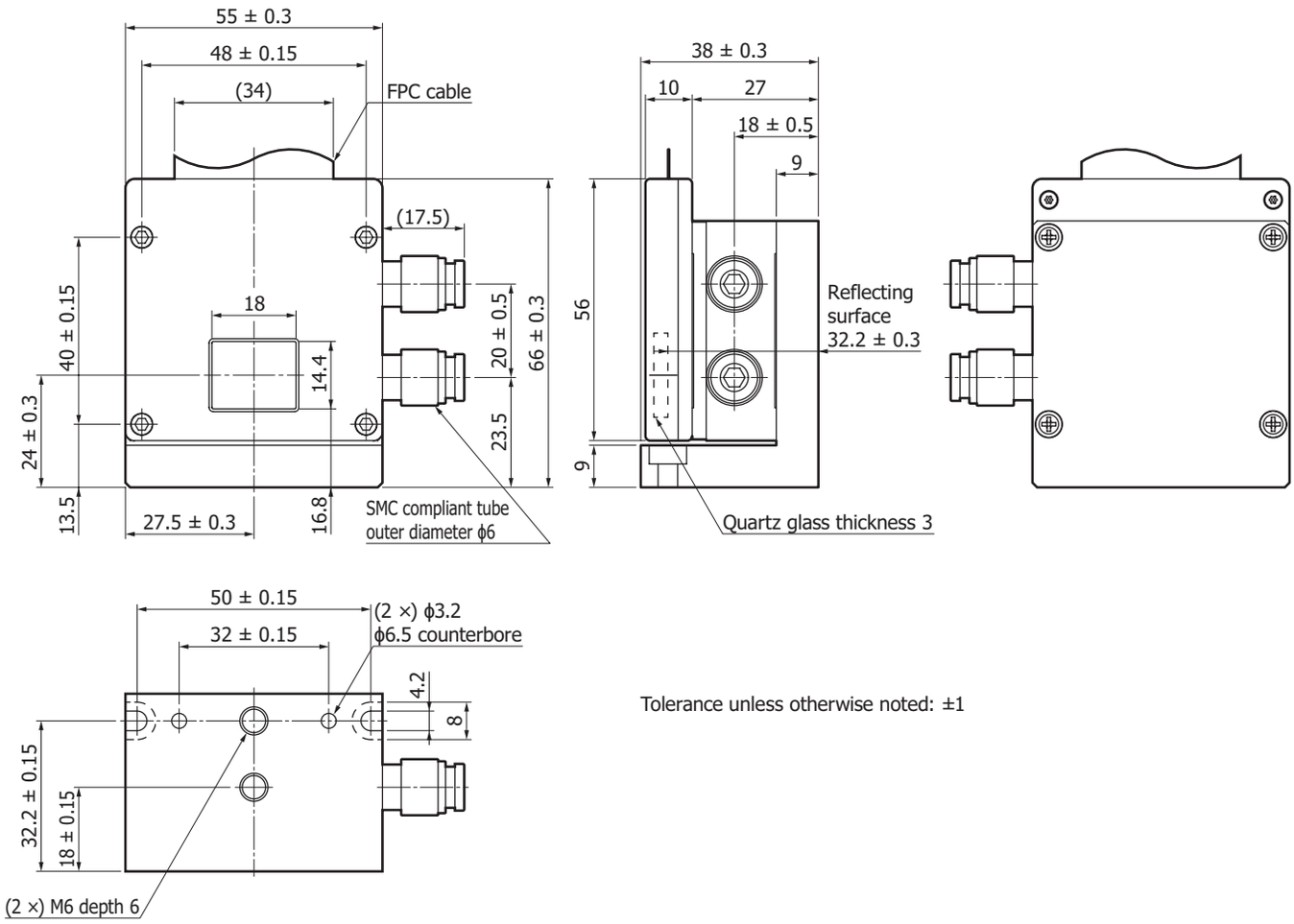
■ X15213-02L/-03L/-16L



Tolerance unless otherwise noted: ±1

KACCA0456EA

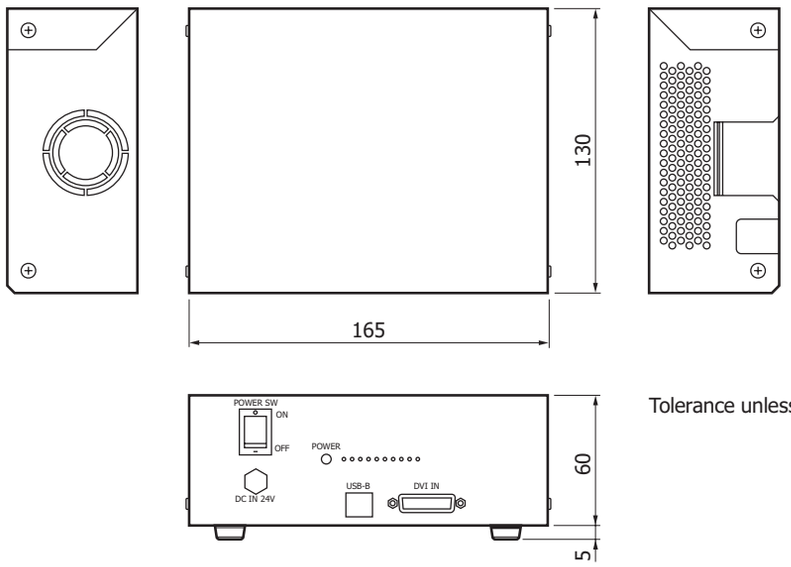
■ X15213-02R/-03R/-16R



Tolerance unless otherwise noted: ±1

KACCA0457EA

Controller



Tolerance unless otherwise noted: ±1

KACCA0458EA

The X15213 series does not include a PC. Prepare a PC by referring to the followings:

· OS that supports the provided software*3 : Microsoft® Windows® XP/7/8/10
· The PC must have a DVI-D port to connect the X15213 series to DVI.
· The provided software supports dual monitor control. The first monitor is for PC screen and the second one is for phase images on the X15213 series. In this case, the phase image displayed on the second monitor can be controlled by operation on the first monitor. Note that you need a dual ported DVI-D display card to perform this operation.
· When the X15213 series is connected to a PC via USB, the phase image can be displayed using the supplied software.

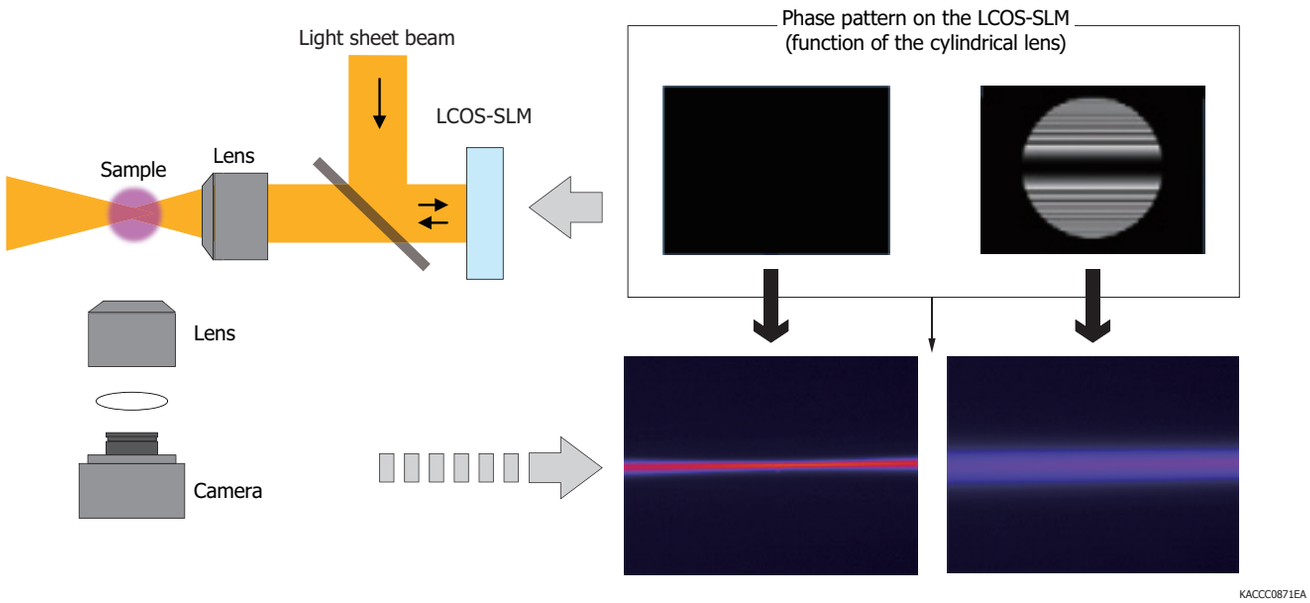
*3: The provided software that comes with the X15213 series has generating functions such as for a computer generated hologram (CGH).

Note: Microsoft, Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

Application example 1: Beam control (lens function, nondiffracting beam generation)

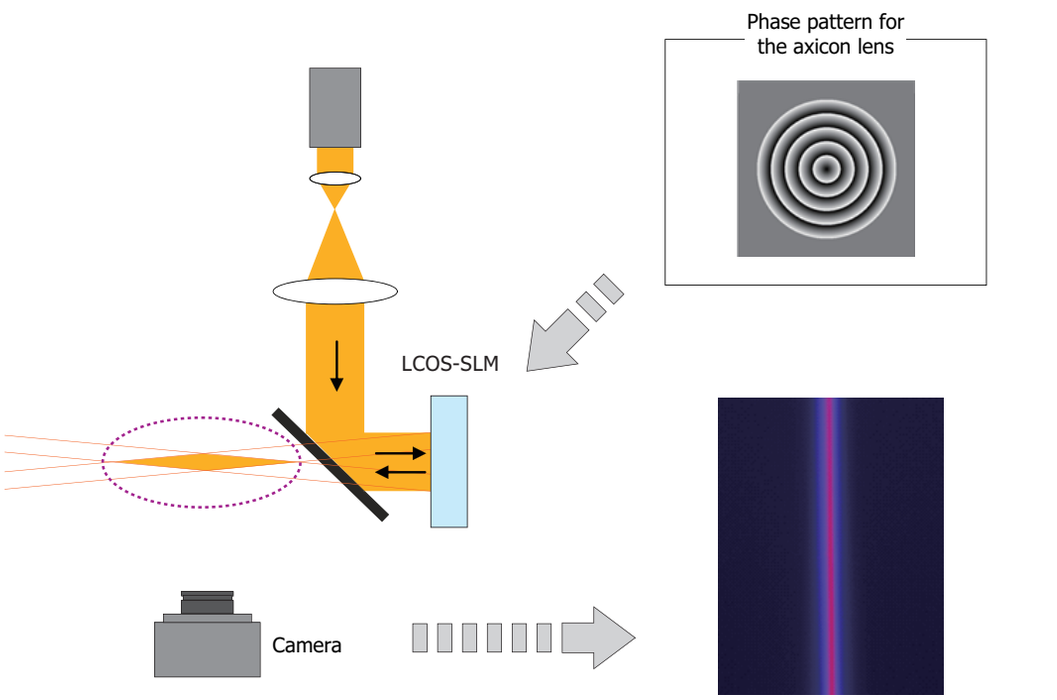
The LCOS-SLM can generate and control Bessel beams and other various beams based on phase images that have lens functionality. These beams are expected to be used in light sheet microscopy and other leading edge applications.

■ Function of the cylindrical lens



KACCC0871EA

■ Nondiffracting beam generation



KACCC0872EA

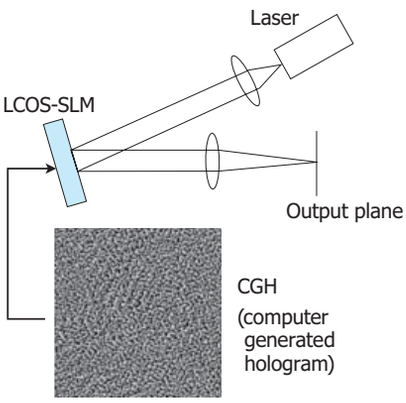
■ Related patents of application example 1

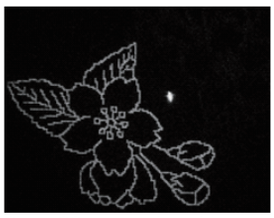
US6710292, US7209279, US7527201, US8749463, US9415461, US9488831

Application example 2: Light beam pattern generation

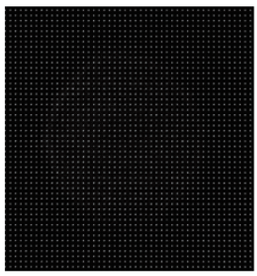
This technology uses the LCOS-SLM to reproduce phase type holograms and generate arbitrary light patterns. Unlike the conventional intensity modulation system that shields light by masking to generate arbitrary light patterns, this technology features highly efficient pattern generation by distributing light using a phase type hologram.

■ Optical system





Clear CGH reproduced image
(+1st order light)



50 × 50 point generation
with 0th order suppressed

Text reproduction example
(+1st order light)

KACCC0870EA

■ Related patents of application example 2

US6710292, US7209279, US7527201, US8749463

Other related patents

US8576206, US9007286, US8553733, US7876405, US9250459, US9250458, US9223159

■ Precautions

· Disclaimer