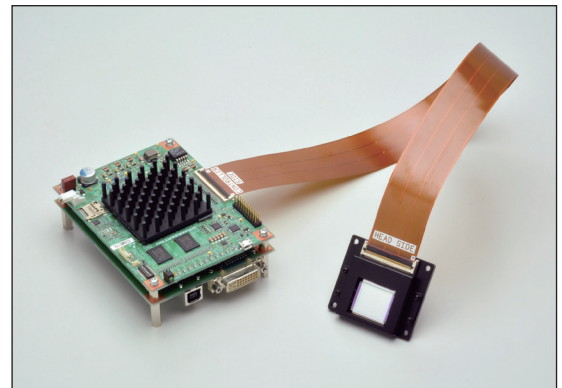


■ **Features**

- High diffraction efficiency
- High light utilization efficiency
- High linear modulation characteristic
- High power handling capability
- Compact and low-price
- Trigger function
- Easy to integrate cooling function to the LCOS-SLM head
- Various interfaces: DVI/USB/ serial communication/IO pins



■ **Applications**

- Laser processing
- Optical manipulation
- Wavefront aberration corrections
- Pulse shaping
- Optical test

■ **Outline**

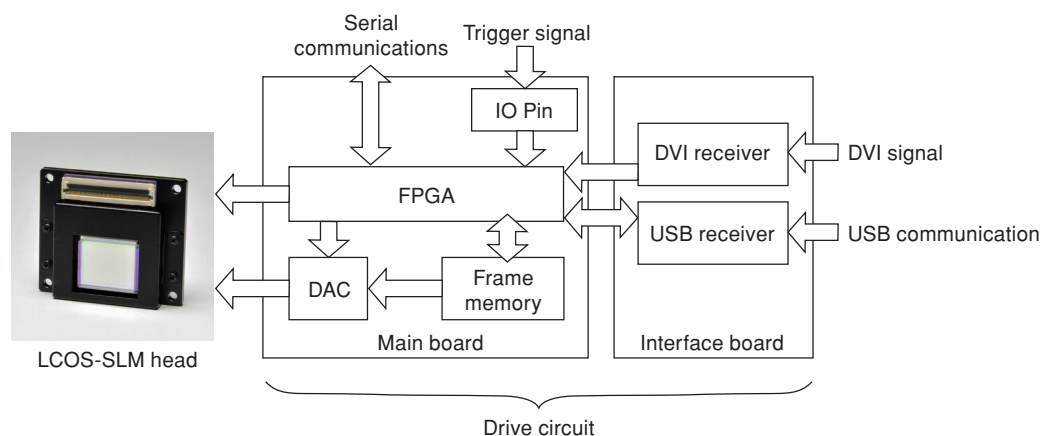
The X15223 series devices are LCOS-SLMs (Liquid Crystal On Silicon – Spatial Light Modulators) designed to be integrated into your devices. The LCOS-SLM head and driver circuit are connected by a flexible cable and can be easily installed in devices. In addition, the drive circuit is equipped with various interfaces, so you can select the most suitable interface for your system.

High-speed response and high-precision phase modulation are realized by directly controlling the liquid crystal (LC) with the voltage of the address part formed by applying CMOS technology.

The optimum optical design of the LCOS-SLM minimizes light loss to achieve high diffraction efficiency and high light utilization efficiency. In addition, high linear modulation characteristics can be obtained by digitally correcting distortion due to mirror surface distortion, non-uniformity of the thickness of the LC layer, and non-linear response of the LC.

We also provide water-cooled types with a built-in water-cooled heatsink to improve power handling capability.

■ **Block diagram**



LCOS-SLM X15223 series

Supported wavelength range

There are 12 types in X15223 series, which cover different wavelengths of light sources. All types have a glass substrate with an anti-reflection coating and a CMOS chip with a mirror. They can be classified into aluminum mirror type and dielectric mirror type.

Aluminum mirror type (-01/-07/-08)

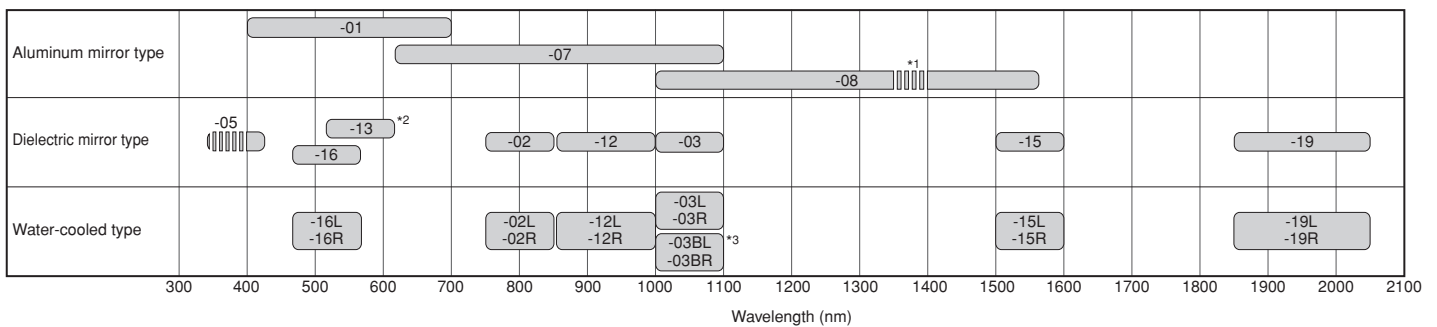
The aluminum mirror type uses the reflection from the aluminum electrode on the CMOS chip and has a wide reflection band, so it can be used in a wide wavelength range.

Dielectric multilayer mirror type (-02/-03/-05/-12/-13/-15/-16/-19)

The dielectric multilayer mirror type has a specially designed dielectric multilayer film on the surface of the CMOS chip to support laser light sources of various wavelengths. Compared to the aluminum mirror type, the higher reflectivity achieved by the dielectric mirror decreases the internal absorption rate. This makes it possible to irradiate high power lasers.

Water-cooled type (02L/-02R/-03L/-03R/-03BL/-03BR/-12L/-12R/-15L/-15R/-16L/-16R/-19L/-19R)

The dielectric multilayer mirror type head has a built-in water-cooled heat sink to suppress temperature rise due to laser irradiation and improve light resistance.



*1 -08: In the wavelength range of 1350 nm to 1400 nm, absorption by the glass substrate reduces reflectance by approximately 5%.

*2 -13 and -16: They can be used for 532 nm band lasers. The -16 has higher power handling capability for short pulse lasers than the -13.

*3 -03BL/-03BR: As for the average laser power, their power handling capability is higher than the -03L/-03R.

Configuration

Head

Parameter	X15223 series	Unit
Number of pixels	1272 × 1024	pixel
Pixel pitch	12.5	μm
Effective area size	15.9 × 12.8	mm
Fill factor	96.8	%
Weight	40 (Water-cooled type: 410)	g

Drive circuit

Parameter	X15223 series	Unit
Input voltage (DC)	16 ± 0.5	V
Power consumption (Typ.)	11.2	W
Input signal	Digital video interface (DVI-D) / USB-B (2.0 High-speed)	—
DVI signal format	1280 × 1024	pixel
DVI frame rate	60	Hz
Number of input signal gradations	256	level
Trigger signal voltage	High: 1.5 / Low: 0	V
Communication specification	USB-B (2.0 High-speed) / RS232C	—
Weight	180	g

Absolute maximum rating

(Ta=25 °C)

Parameter	X15223 series	Unit
Input voltage	16.5	V
Trigger signal voltage	1.8	V
Operating temperature *1	+10 to +40	°C
Storage temperature *1	-20 to +55	°C
Withstand pressure of water steam connector	0.3 (Water-cooled type)	MPa

*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.

* 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.

LCOS-SLM X15223 series

■ Electrical and optical characteristics

Parameter	-01	-02 /-02L/-02R	-03 -03L/-03R -03BL/-03BR	-05	-07	-08	Unit
Readout light wavelength	400 to 700	800 ± 50	1050 ± 50	410 ± 10	620 to 1100	1000 to 1550	nm
Light utilization efficiency (Typ.)	76 (633 nm)	97 (785 nm)	97 (1064 nm)	97 (405 nm)	80 (1064 nm)	86 (1550 nm)	%
Rise time *1 (Typ.)	5 (633 nm)	33 (785 nm)	27 (1064 nm)	7 (405 nm)	9 (1064 nm)	13 (1550 nm)	ms
Fall time *1 (Typ.)	21 (633 nm)	85 (785 nm)	83 (1064 nm)	17 (405 nm)	73 (1064 nm)	145 (1550 nm)	ms

Parameter	-12 /-12L/-12R	-13	-15 /-15L/-15R	-16 /-16L/-16R	-19 /-19L/-19R	Unit
Readout light wavelength	850 to 1000	530 to 635	1550 ± 50	510 ± 50	1850 to 2050	nm
Light utilization efficiency (Typ.)	97 (940 nm)	97 (532 nm)	97 (1550 nm)	97 (532 nm)	97 (1950 nm) *2	%
Rise time *1 (Typ.)	38 (940 nm)	10 (532 nm)	26 (1550 nm)	11 (532 nm)	30 (1950 nm)	ms
Fall time *1 (Typ.)	109 (940 nm)	21 (532 nm)	135 (1550 nm)	33 (532 nm)	155 (1950 nm)	ms

*1 Time required to change from 10 % to 90 % for 2π modulation.

*2 Design value

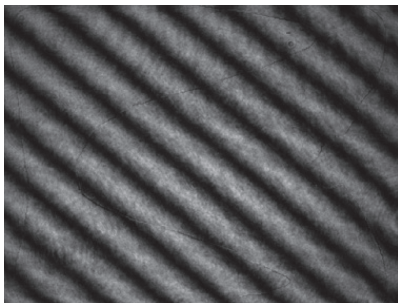
* Figures in parentheses indicate the wavelengths of the lasers used to measure light utilization efficiency, rise time, and fall time.

■ Operating characteristics

● High precision phase modulation

The X15223 series has high precision phase control and high diffraction efficiency, and is very suitable for holographic applications. Figure 2 (a) is a interferometer picture of the output wavefront with a flatness calibration. Figure 2 (b) is an example of a 1st order diffraction image obtained by reconstructing a computer generated hologram (CGH) using the Fourier transform optical system. Figure 2 (c) shows a clear Laguerre Gaussian (LG) beam of (0, 1) order.

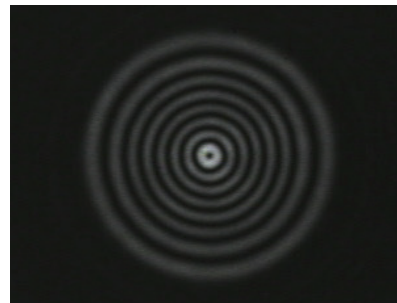
Figure 2: Output image examples



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



(b) Reconstructed image of CGH



(c) LG beam

LCOS-SLM X15223 series

●High diffraction efficiency

The X15223 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 displayed on the X15223 series, and Figure 4 shows typical diffraction efficiency characteristics. Here, the diffraction efficiency is defined as I_1/I_0 , where I_1 is the 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)

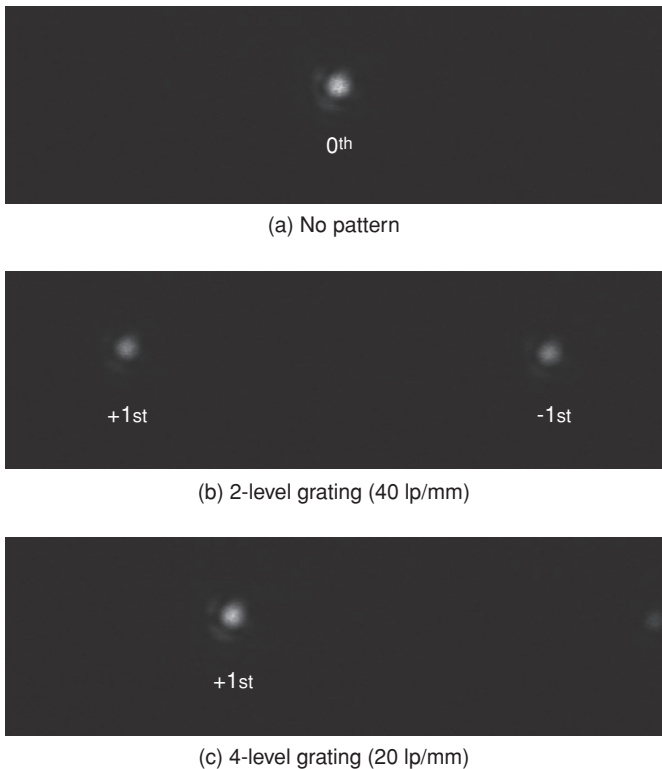
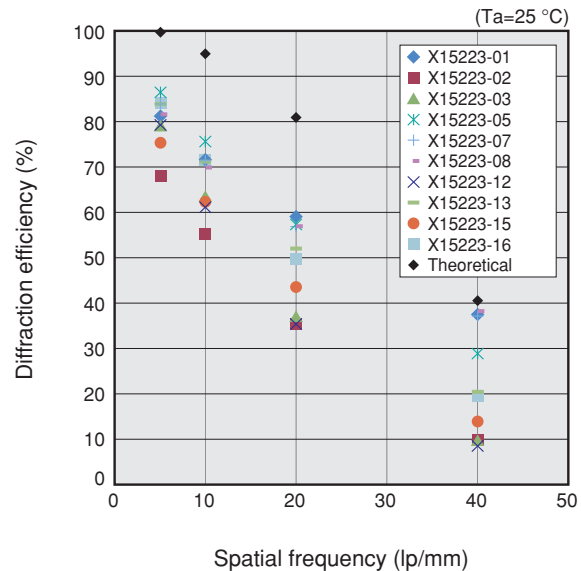


Figure 4: Diffraction efficiency (typical example)



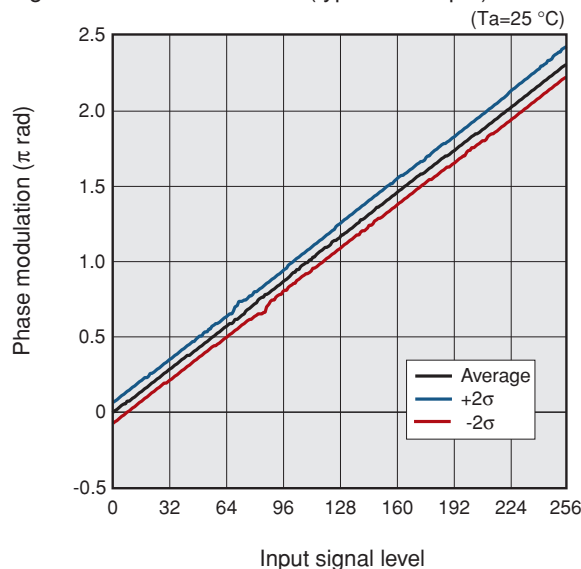
●High light utilization efficiency

The X15223 series have high light utilization efficiency, which is defined as the ratio of the 0th order diffraction light intensity to the input light intensity. The light utilization efficiency mainly depends on the reflectivity of the mirror, 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 %. In particular, the -02/-03/-05/-12/-13/-15/-16/-19 types have very high light utilization efficiency thanks to the highly reflective dielectric mirror.

●High linear phase modulation characteristics

The X15223 series can achieve phase modulation of more than 2π radians over the 400 nm to 2050 nm readout wavelength range. Prior to shipment, each type is pre-calibrated at the factory to obtain high-precision and high-linear modulation characteristics for a specific wavelength range. Figure 5 shows typical phase modulation characteristics. A phase shift of 2π radians or more and a linear phase response are achieved. The phase modulation curve of 95 % of the pixels in the effective area is within $\pm 2\sigma$, which indicates that the variation is so small.

Figure 5: Phase modulation (typical example)



LCOS-SLM X15223 series

High power handling capability

Although the X15223 series achieves versatility and high reliability, there is a concern that characteristics may change depending on the peak power and average power of the incident light when irradiated with high power laser light. When the peak power is high, 2 photon absorption occurs in the LC layer, which leads to characteristic changes and damage. When the average power is high, a characteristic change occurs due to heat generation.

Water-cooled type

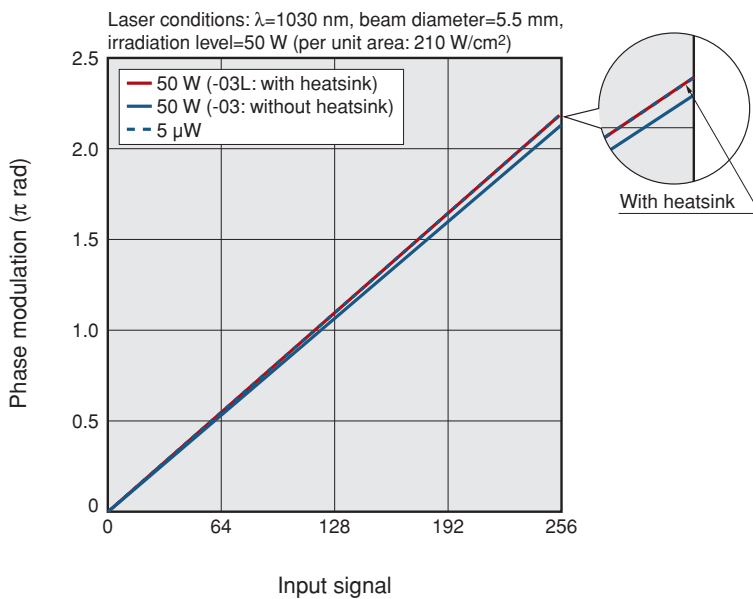
When irradiating a laser with high average power, heat generation can be suppressed and power handling capability can be improved by using a water-cooled type equipped with a water-cooled heat sink. In addition, the -03 type used for wavelength range 1050 nm \pm 50 nm offers a lineup of -03BL/-03BR with improved power handling capability compared to the conventional -03L/-03R by reviewing the circuit-design of the pixel electrode. Recommended beam diameter (1/e²) is 8mm or more.

Type	Type no.	Recommended average power
Aluminum mirror type	X15223-01/-07/-08	≤ 0.5 W *1
Dielectric mirror type	X15223-02/-03/-05/-12/-13/-15/-16/-19	≤ 10 W
Water-cooled type	X15223-02L/-02R/-03L/-03R/-12L/-12R/ -15L/-15R/-16L/-16R/-19L/-19R	≤ 100 W
	X15223-03BL/-03BR	≥ 100 W *2

*1 500 mW/cm² or less per unit area is recommended.

*2 As it also depends on specifications such as wavelength, pulse width, and repetition frequency, please contact us for details.

Figure 6: Laser irradiation test result



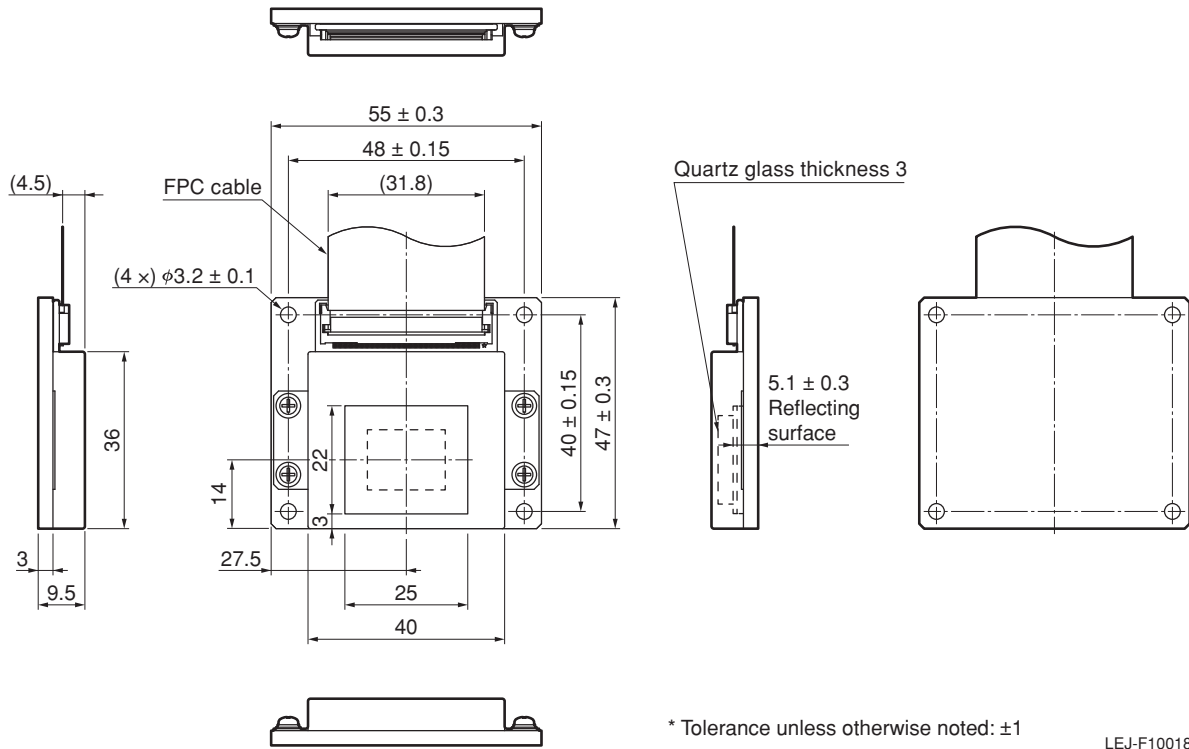
LEJ-F40007

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

LCOS-SLM X15223 series

Figure 7: Dimensions (unit: mm)

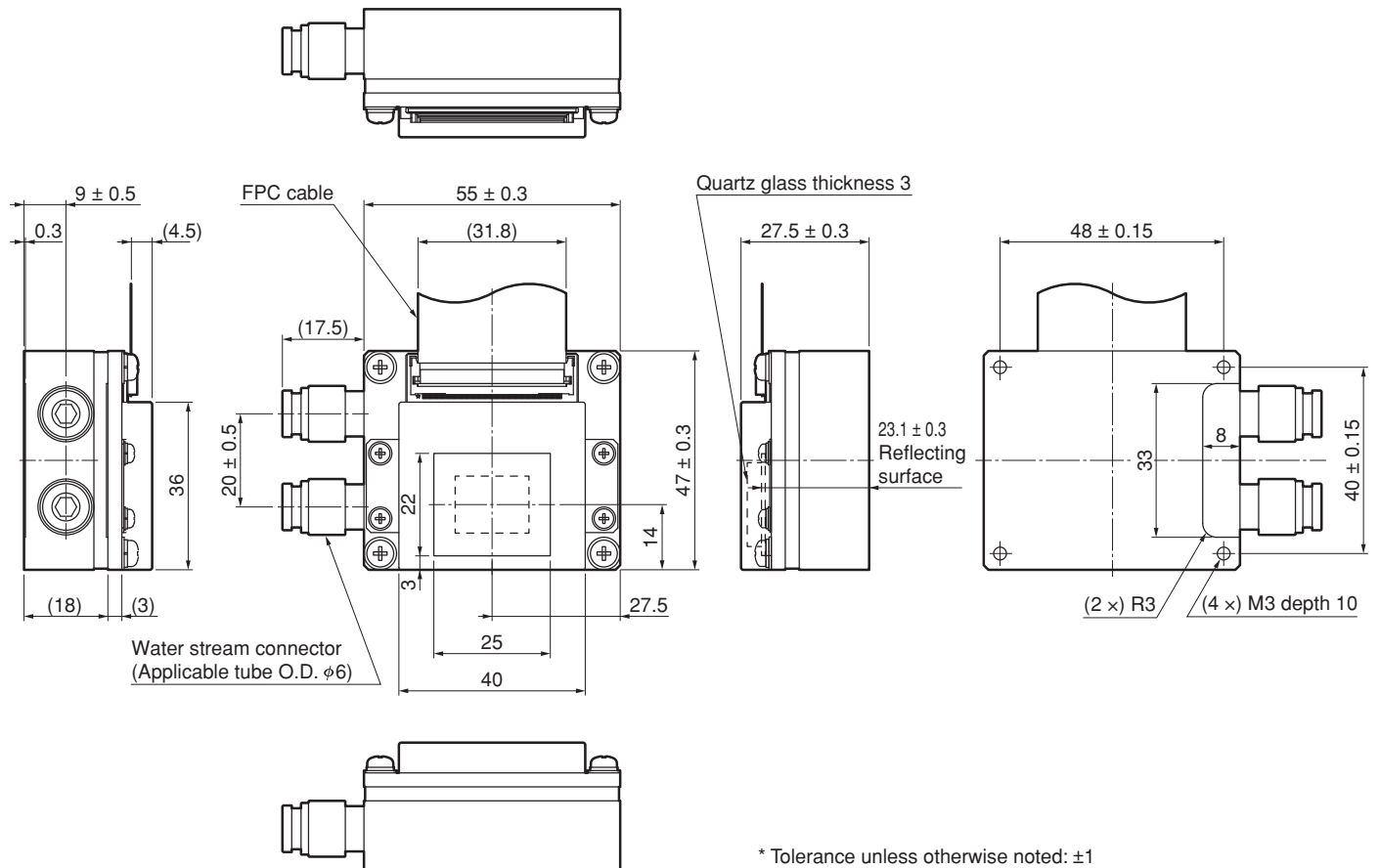
●Head (X15223-01/-02/-03/-05/-07/-08/-12/-13/-15/-16/-19)



* Tolerance unless otherwise noted: ± 1

LEJ-F10018

●Head (water-cooled type: X15223-02L/-03L/-03BL/-12L/-15L/-16L/-19L)

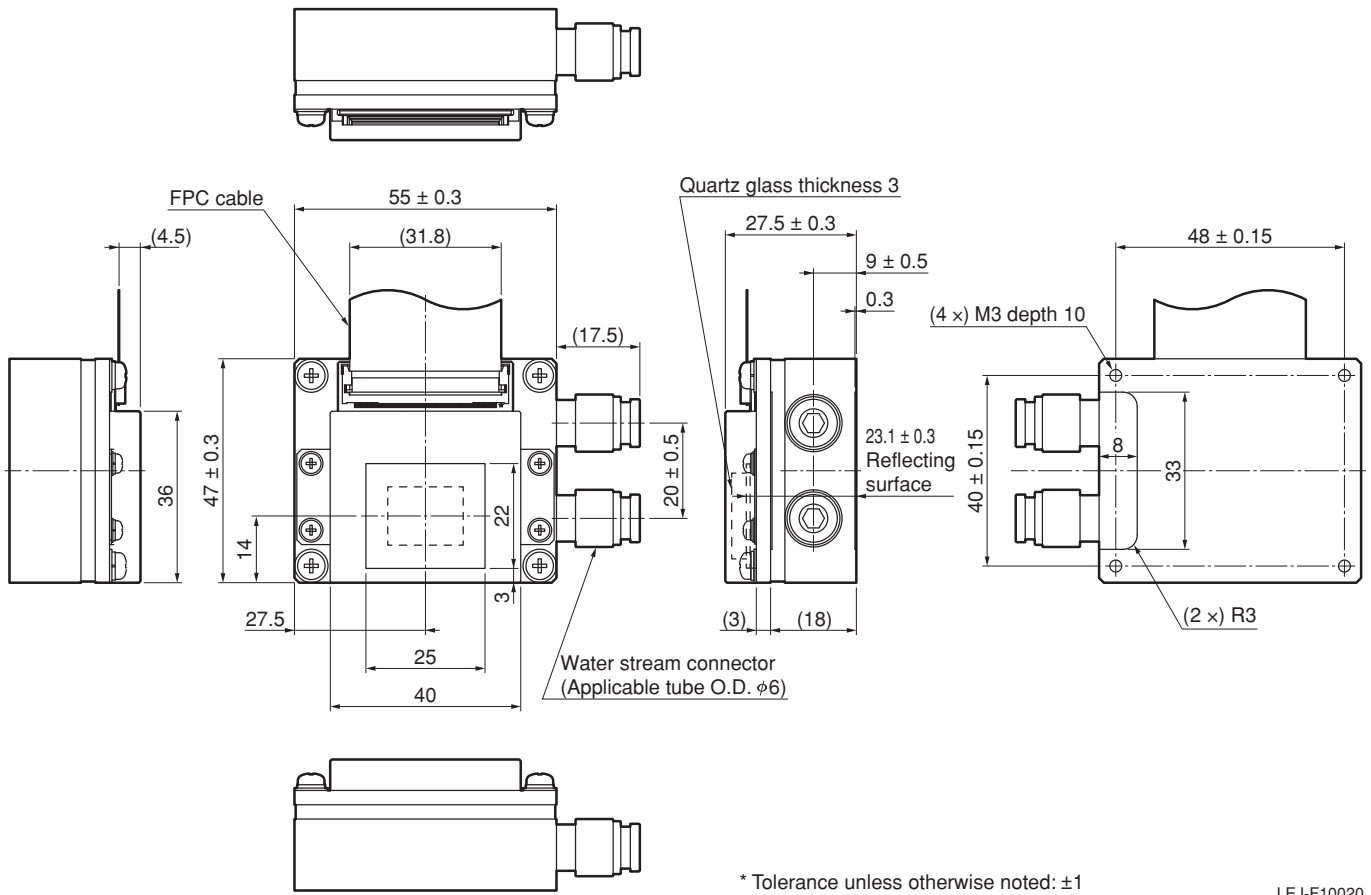


* Tolerance unless otherwise noted: ± 1

LEJ-F10019

LCOS-SLM X15223 series

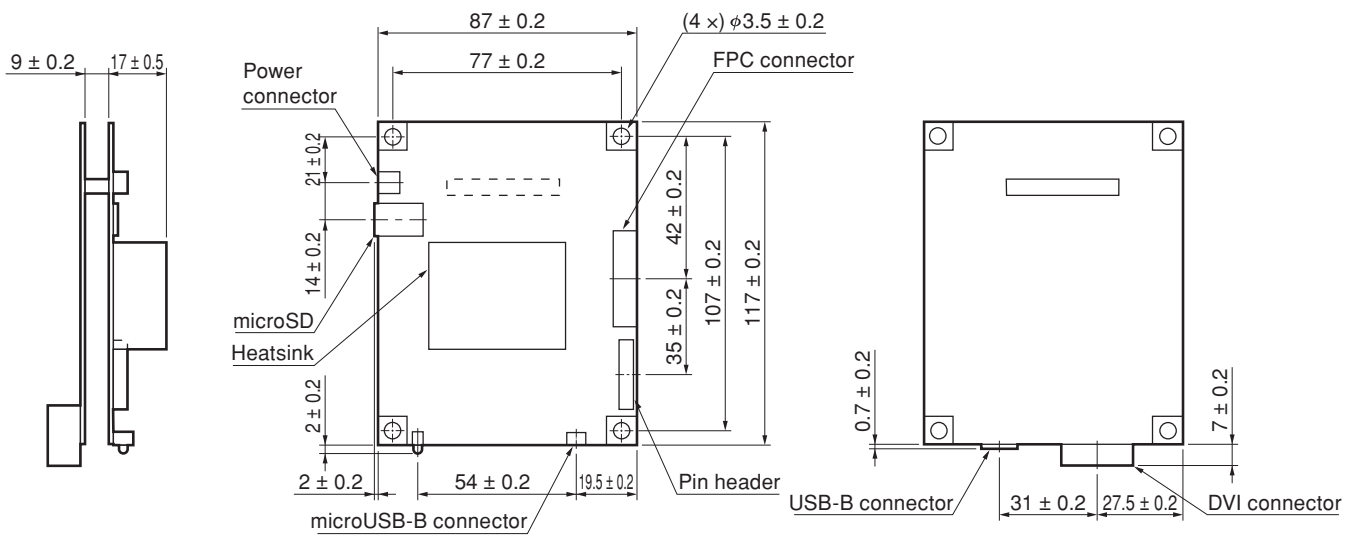
●Head (water-cooled type: X15223-02R/-03R/-03BR/-12R/-15R/-16R/-19R)



* Tolerance unless otherwise noted: ± 1

LEJ-F10020

●Drive circuit



* Tolerance unless otherwise noted: ± 1

LEJ-F10021

LCOS-SLM X15223 series

■ Precautions

- Product-related precautions

<https://www.hamamatsu.com/all/en/support/disclaimer.html>

● Information described in this material current as of June 2022. Specifications are subject to change without notice.

HAMAMATSU PHOTONICS K.K. www.hamamatsu.com

Laser Promotion Division, Business Promotion G.

1-8-3, Shinmiyakoda, Kita-ku, Hamamatsu City, Shizuoka, 431-2103, Japan, Telephone: (81)53-484-1301, Fax: (81)53-484-1302, E-mail: sales-laser@lpd.hpk.co.jp

U.S.A.: HAMAMATSU CORPORATION: 360 Foothill Road, Bridgewater, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218 E-mail: usa@hamamatsu.com

Germany: HAMAMATSU PHOTONICS DEUTSCHLAND GMBH.: Arzbergerstr. 10, 82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8 E-mail: info@hamamatsu.de

France: HAMAMATSU PHOTONICS FRANCE S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: infos@hamamatsu.fr

United Kingdom: HAMAMATSU PHOTONICS UK LIMITED: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: info@hamamatsu.co.uk

North Europe: HAMAMATSU PHOTONICS NORDEN AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01 E-mail: info@hamamatsu.se

Italy: HAMAMATSU PHOTONICS ITALIA S.R.L.: Strada della Moia, 1 int. 6, 20044 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: info@hamamatsu.it

China: HAMAMATSU PHOTONICS (CHINA) CO., LTD.: 1201 Tower B, Jiaming Center, 27 Dongsanhuan Bellu, Chaoyang District, 100020 Beijing, P.R. China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: hpc@hamamatsu.com.cn

Taiwan: HAMAMATSU PHOTONICS TAIWAN CO., LTD.: 8F-3, No.158, Section 2, Gongdao 5th Road, East District, Hsinchu, 300, Taiwan R.O.C. Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: info@hamamatsu.com.tw

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