The X10468 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 X10468 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 X10468 series. They can also provide high diffraction efficiency and high light utilization efficiency.

**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.
There are eight standard types of the X10468 series available. The X10468-01/-07/-08 have no dielectric mirror but have higher diffraction efficiency and covers the wide wavelength range of the readout light spectrum. The X10468-02/-03/-04/-05/-06 have a dielectric mirror for a specified wavelength range. Figure 1 shows the spectral response for these types. An undesired interference noise will be appeared at the wavelength range from 700 nm to 900 nm for the X10468-07 and from 1150 nm to 1400 nm for the X10468-08 owing to the reflection loss. The ultra violet light will cause a damage at the wavelength range less than 400 nm for the X10468-05. Please consult us the details. HAMAMATSU produces OEM devices that meet your requirements in the wavelength range from 355 nm to 1550 nm. We are able to design and optimize device elements according to light wavelength used in your application.

![Figure 1] Spectral response

<table>
<thead>
<tr>
<th>Parameter</th>
<th>X10468 series</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>-01 -02 -03 -04 -05 -06 -07 -08</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-20 to +55°1</td>
<td></td>
</tr>
</tbody>
</table>

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.

*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.

### Structure

#### Head

<table>
<thead>
<tr>
<th>Parameter</th>
<th>X10468 series</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pixels</td>
<td>475200 (792 × 600)</td>
<td>pixels</td>
</tr>
<tr>
<td>Pixel pitch</td>
<td>20</td>
<td>μm</td>
</tr>
<tr>
<td>Maximum spatial resolution</td>
<td>25</td>
<td>lp/mm</td>
</tr>
<tr>
<td>Effective area</td>
<td>16 × 12</td>
<td>mm</td>
</tr>
<tr>
<td>Fill factor</td>
<td>98</td>
<td>%</td>
</tr>
<tr>
<td>Weight</td>
<td>350</td>
<td>g</td>
</tr>
</tbody>
</table>

#### Controller

<table>
<thead>
<tr>
<th>Parameter</th>
<th>X10468 series</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage</td>
<td>AC100 to AC230</td>
<td>V</td>
</tr>
<tr>
<td>Power supply frequency</td>
<td>50/60</td>
<td>Hz</td>
</tr>
<tr>
<td>Weight</td>
<td>3300</td>
<td>g</td>
</tr>
<tr>
<td>Including cables</td>
<td>4200</td>
<td>g</td>
</tr>
<tr>
<td>Interface</td>
<td>Digital Video Interface (DVI-D)</td>
<td>-</td>
</tr>
<tr>
<td>DVI signal format</td>
<td>SVGA (800 × 600 pixels)</td>
<td>-</td>
</tr>
<tr>
<td>DVI gradation</td>
<td>256 (8-bit)</td>
<td>levels</td>
</tr>
<tr>
<td>DVI frame rate</td>
<td>60</td>
<td>Hz</td>
</tr>
<tr>
<td>Power consumption</td>
<td>50</td>
<td>VA</td>
</tr>
</tbody>
</table>
The X10468 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 diffraction loss smaller. As a result, the diffraction loss is less than 5%. The X10468-02/-03/-04/-05/-06 have a dielectric mirror which has high reflectivity. Therefore, these types have very high light utilization efficiency. The X10468-01/-07/-08 have relatively low light utilization efficiency compared to the ones with dielectric mirror but have wide spectral response characteristic.

The X10468 series can achieve phase modulation of more than 2π radians over the 400-1550 nm readout wavelength range. The X10468 series comes pre-calibrated from the factory for a specified wavelength range to have more than 2π radians of phase modulation and its linear characteristics. Figure 2 shows typical phase modulation characteristics. A phase shift of 2π radians or more and a linear phase response are achieved. The phase modulation curves for 95% pixels lies within ±2σ.
**Diffraction efficiency**

The X10468 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 X10468 and Figure 4 shows typical diffraction efficiency characteristics. Here, 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 (25 lp/mm)
- (c) 4-level grating (12.5 lp/mm)

![Figure 4] Diffraction efficiency (typical example)

**Output image examples**

The X10468 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 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
  800 × 600 pixels
  RMS: 0.025 $\lambda$ ($\lambda$=532 nm)
- (b) Reconstructed image of CGH
- (c) LG beam
**Dimensional outlines (unit: mm)**

Although the center of the LCOS effective area may deviate due to production tolerance, the aperture and the LCOS effective area are aligned.
The X10468 series does not include a PC. Prepare a PC by referring to the followings:

- OS that supports the provided software*: Microsoft® Windows® XP/7
- PC must have a DVI-D port for connecting to the X10468 series.
- The provided software supports dual monitor control. The first monitor is for PC screen and the second one is for phase images on the X10468 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.

*3: The provided software that comes with the X10468 series does not have generating functions such as for computer generated hologram (CGH).

Note: Microsoft, Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.
The X10468 series conforms to European EMC directives (Applied standard: EN 61326-1 Class B).

Information described in this material is current as of January, 2014. Product specifications are subject to change without prior notice due to improvements or other reasons. This document has been carefully prepared and the information contained is believed to be accurate. In rare cases, however, there may be inaccuracies such as text errors. Before using these products, always contact us for the delivery specification sheet to check the latest specifications.

Type numbers of products listed in the delivery specification sheets or supplied as samples may have a suffix "(X)" which means preliminary specifications or a suffix "(Z)" which means developmental specifications.

The product warranty is valid for one year after delivery and is limited to product repair or replacement for defects discovered and reported to us within that one year period. However, even if within the warranty period we accept absolutely no liability for any loss caused by natural disasters or improper product use.

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