Notes to Users

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3) Information of this Operation Manual is prepared with careful examination, however, in the event of any mistake, please contact us.

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Contents

1. Introduction
  1.1 Description
  1.2 Features
  1.3 Care
  1.4 Package Contents
  1.5 Warranty

2. Display specifications
  2.1 Parameters
  2.2 Operating principles
  2.3 Part names and functions
  2.4 LED status notifications

3. SLM handling instructions
  3.1 Connections
  3.2 Power up sequence
  3.3 Mounting
  3.4 Cleaning

4. Software package
  4.1 Installation
  4.2 Software operation

5. Contact
1. Introduction

1.1 Description

The Santec spatial light modulator (SLM) is based on reflective liquid crystal on silicon (LCOS) microdisplay technology. The SLM has an active matrix display with 1440 x 1050 resolution (WXGA+) and a 0.73 diagonal which enables the SLM to modulate optical phases freely and generate arbitral 2D phase patterns (gratings, phase mask, holograms, etc.) on a LCOS pixel-by-pixel basis. The phase response of SLM is adjusted even for different wavelengths (500 to 1650 nm) automatically using proprietary GUI software with built-in adjustable gamma control. The signal is addressed via a standard DVI (Digital Visual Interface) signal e.g. by a PC’s graphics.

The SLMs are characterized by ultra-low phase fluctuation from high drive frequency over 1kHz and 10bit high resolution addressing. These abilities are suitable for various applications including laser material processing, optical switching devices, wavefront correction and pulse shaping.

1.2 Features

- Stable operation with no mechanical motion
- All-in one compact design
- Pure, linear and precise phase control: Addressing bit depth 10 Bit
- Telecom qualified high reliability: Telcordia GR-1221 Core
- Ultra-low phase fluctuation: Typ. < 0.002p rad.
- Wide wavelength range (500 to 1650 nm) by adjustable gamma control
1.3 Care

The unit should not be operated in any of the following circumstances:

- If water or other liquid is spilled on the unit.
- When the unit is exposed to moisture.
- When the unit is cleaned or moved.
- If damage is found to the main cord.
- When the unit condenses.

Pay attention to the following guidelines for safe, trouble-free operation:

- Do not place in direct sunlight.
- Do not place in an environment with high temperature and high humidity.
- Do not place in an environment with dust, dirt, salt, or corrosive gas.
- Do not place in an area subject to large vibrations.
- Do not place in an area subject to noise by electric field, magnetic field, etc.
- Do not place in an area where the unit is subject to falling objects.
- Do not place in an area with possible exposure to water.

General usage guidelines:

- All electrical interfaces have to be connected without applied voltage.
- It is required to boot up the instrument AFTER connecting all devices, even if the DVI output instrument is available.
- Do not touch the surface of the display because the LCD has the potential of damage by static electricity.
- If you plan to illuminate the SLM with high power light or shorter wavelength light like ultraviolet, please consult the santec service site.
- If you handle the LCOS unit, please wear a wristband for ESD on a earth grounded table as shown in figure 2.
Figure 2: LCOS unit handling.
1.4 Package Contents

This product is composed of the SLM body and accessories. The following parts are included:

**All-in-one model**
1. LCOS-SLM body
2. AC adapter
3. DVI/HDMI cable
4. Polarizer (Wavelength: 450~700 nm)
5. CD-ROM (Control software GUI / User operational manual)

**Separate model**
1. LCOS-SLM body
2. LCOS unit
3. Bracket for LCOS unit
4. AC adapter
5. DVI/HDMI cable
6. Polarizer (Wavelength: 450~700 nm)
7. CD-ROM (Control software GUI / User operational manual)

Figure 3: Contents
1.5 Warranty

The warranty of the product is based on santec document (Doc: SA-15-0308).
2. Display specifications

2.1 Parameters

<table>
<thead>
<tr>
<th>Table 1: Specifications.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>Environmental conditions</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Optical characteristics</td>
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<td></td>
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<tr>
<td>Electrical/</td>
</tr>
<tr>
<td>Mechanical characteristics</td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Control software</td>
</tr>
</tbody>
</table>

1) Specification on the defect pixels are no object.
2) Tr, Tt: response time between 10% and 90% levels at 25degC typ.
Six types of AR coating are available as shown in Figure 4, 5.
(1) 450-550nm
(2) 750-850nm
(3) 1000-1100nm
(4) 1500-1650nm
(5) 400-700nm
(6) 450-550/1500-1650nm

Figure 4: AR reflectivity (angle: 0 degree).
Display specifications

Figure 5: AR reflectivity (angle: 30 degree).
Figure 6: Dimensions (All-in-one model).
Figure 7: Dimensions (Separate model).
Figure 8: Dimensions (LCOS unit).
2.2 Operating principle

The SLM is an optical intensity or phase modulator using LCOS display technology that consists of a silicon-based reflective, active matrix CMOS driver which uses a nematic liquid crystal. LCOS has several million 2-dimensional pixels separated by a few tenths of a micron and can address pixel-by-pixel. Optical phase or intensity can be controlled spatially by the voltage level applied to each pixel.

![Figure 9: LCOS structure.](image)

The SLM can be controlled via a PC using the DVI interface. Easy control using the attached optical phase (intensity) editor and graphical user interface (GUI), wavelength independent precise and linear phase modulation with software built-in gamma control can be accomplished.

![Figure 10: SLM connection.](image)
2.3 Part names and functions

All-in-one model

Figure 11: Front view.

Figure 12: Back view.
Display specifications

Figure 13: Side view 1 (Control panel).

Figure 14: Side view 2 (M6 screw for mounting).
Figure 15: Side view 3 (1/4 inch screw for mounting).
Display specifications

Separate model

- Flex cable for connecting LCOS unit

Figure 16: Front view.

- Label (Model name and S/N)
- Connector for connecting LCOS unit

Figure 17: Back view.
Figure 18: Side view (Control panel).
Display specifications

LCOS unit

Figure 19: Front view.

Figure 20: Back view.

Note: Input linear polarized light shall be parallel to the LC director.
Display specifications

Polarizer

Note: Please check the SLM surface visually through attached polarizer.

Figure 21: Polarizer setting.
2.4 LED status notifications

The SLM has four LED indicators, which inform the status of POWER, signal clocks and DVI video signals. Operation status for each LED is shown in table 2.

<table>
<thead>
<tr>
<th>Label</th>
<th>Color</th>
<th>Normal</th>
<th>Switching status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Green</td>
<td>LED ON</td>
<td>LED OFF when the power supply voltage is less than 4.5V (5V-10%)</td>
</tr>
<tr>
<td>LED1</td>
<td>Green</td>
<td>LED ON</td>
<td>LED OFF when clock signal condition of LCOS display driver is abnormal</td>
</tr>
<tr>
<td>LED2</td>
<td>Green</td>
<td>LED ON</td>
<td>LED OFF when clock signal condition of Video data is abnormal</td>
</tr>
<tr>
<td>LED3</td>
<td>Red</td>
<td>LED OFF</td>
<td>LED ON when video signal to DVI interface is abnormal</td>
</tr>
</tbody>
</table>
3. SLM handling instructions

3.1 Connections

Please connect attached components as shown in figure 22 and 23. Please make sure you connect the device to the computer before connecting it to the power supply.

※ Do not use attached AC code in other products.

Figure 22: SLM power connections (All-in-one model).
Do not use attached AC code in other products.

※ Refer the next page how to connect LCOS unit.

Figure 23: SLM power connections (Separate model).
(step A) Turn the arrow seal face on FPC upward. And raise the lock bar up.

(step B) Insert the FPC connector into the end.

(step C) Turn the lock bar down

Figure 24: Connection method of LCOS unit (Separate model).
3.2 Power up sequence

3.2.1 HDMI/DVI communication

[1] Boot up the PC. And connect all components according to figure 22 and 23 above. Again, please note: make all connections before connecting the AC adapter.

[2] Connect adapter plug to AC inlet and start voltage supply. There is no power switch on the SLM body. SLM is powered on by the voltage supply.

[3] The LCOS DVI interface is displayed on the PC screen. You can check the pattern directly on the LCOS using a polarizer.

If the LCOS panel is not displayed on the PC screen, please check PC monitor setting status. The recommended setting is shown in figure 25.

Figure 25 : Recommended screen resolution setting on PC.
3.3 Mounting

3.3.1 All-in-one model

The SLM body has two screw holes (1/4 inch and M6) for mounting to experimental stages. For example, the SLM can be mounted to a slide stage using a commercially available screw bar as shown in figure 26.

![Figure 26](image)

Figure 26: Example of SLM mounting (All-in-one model).

3.3.2 Separate model

The LCOS unit has three screw holes (M3) for mounting to experimental stages. For example, the LCOS unit can be mounted to a slide stage using a commercially available spacer and M3 screws.

![Figure 27](image)

Figure 27: Example of LCOS unit mounting (Separate model).
3.4 Cleaning

If the LCOS panel is dirty, please clean by hand using lint-free optical wipes, air blower or a liquid solvent such as isopropyl alcohol. Do not use acetone.

Figure 28: Clean the LCOS unit by no dust cotton swab.

Figure 29: Clean the LCOS unit by air blower.
4. Software package

4.1 Installation

Please install LCOS display software in accordance with the procedure of 4.1.1. The recommended PC specifications for this software are as follows:

- OS: Windows7, 32bit
- Display resolutions: 1920x1080
- Video output: HDMI
4.1.1 LCOS display software installation procedure

[1] Install the control software by starting the setup.exe. Click “next”.
(Attached CD, E:\SLM-100GUI Installer\setup.exe)
[2] Specify the folder to install software.
( Default: C:\Program Files\SLM-100GUI )
Click “next”.

[3] If you create the file shortcut on desktop, click the checkbox and click “next”.

Software package
[4] Click “install” and start installation.

[5] If you launch the GUI after installation, click the checkbox and click “Finish”.
4.2 Software operation

4.2.1 GUI window

1. Menu tab
2. Shortcut menu
3. Preview of LCOS displayed phase pattern
4.2.2 Menu tab

4.2.2.1 Open CSV file

The CSV file with data format described in figure 30 can be opened. The data can be edited using spreadsheet like Microsoft excel.
The CSV file with data format made in accordance with figure 30 can be opened. The data can be edited using spreadsheet like Microsoft excel.

Gray scale level for each pixel: 0~1023 (10 bit)
0 to 1023 corresponds to 0 to 2π at 1500nm light.

Figure 30: Data format of pattern files.
4.2.2.2 Recent file
The GUI memorizes the 4 past files. They can be displayed on the LCOS panel.

4.2.2.3 Save / Save as
Current preview on GUI can be saved or saved as a new file.
4.2.2.4 Convert BMP file to CSV file

Specified bit map (BMP) file can be converted to CSV format file. BMP files for conversion should be in 24 bit format.

Select the BMP file for converting.

If the BMP file is converted in rescaling of screen resolution, magnification and grey scale of blank area can be specified.

※Maximum screen resolution of converted BMP file and CSV file is 5760 x 4200 respectively, which is quadruple of LCOS panel screen resolution 1440x1550.
### Table 3: 10 bit encoding format in RGB color.

<table>
<thead>
<tr>
<th>bit</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td></td>
<td></td>
<td>3bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td>3bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td></td>
<td></td>
<td></td>
<td>4bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>bit</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCOS Format</td>
<td>R7</td>
<td>R6</td>
<td>R5</td>
<td>G7</td>
<td>G6</td>
<td>G5</td>
<td>B7</td>
<td>B6</td>
<td>B5</td>
<td>B4</td>
</tr>
</tbody>
</table>

10bit phase steps (0-1024)

<table>
<thead>
<tr>
<th>10bit phase steps</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>126</td>
<td>0</td>
<td>224</td>
<td>224</td>
</tr>
<tr>
<td>127</td>
<td>0</td>
<td>224</td>
<td>240</td>
</tr>
<tr>
<td>128</td>
<td>32</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>129</td>
<td>32</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>130</td>
<td>32</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10bit phase steps</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>510</td>
<td>96</td>
<td>224</td>
<td>224</td>
</tr>
<tr>
<td>511</td>
<td>96</td>
<td>224</td>
<td>240</td>
</tr>
<tr>
<td>512</td>
<td>128</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>513</td>
<td>128</td>
<td>0</td>
<td>16</td>
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<tr>
<td>514</td>
<td>128</td>
<td>0</td>
<td>32</td>
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<td>...</td>
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<td>1019</td>
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<td>1020</td>
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<td>1021</td>
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<td>224</td>
<td>208</td>
</tr>
<tr>
<td>1022</td>
<td>224</td>
<td>224</td>
<td>224</td>
</tr>
<tr>
<td>1023</td>
<td>224</td>
<td>224</td>
<td>240</td>
</tr>
</tbody>
</table>
4.2.2.5 Display center point
The cross mark indicating display center can be selected whether it is displayed or not.

4.2.2.6 Center point color
The color of cross mark can be changed.
4.2.2.7 Change preview

The gray level for preview of 8bit or 10bit can be selected.

8bit preview

10bit preview
4.2.2.8 Set all screen black(0)
The preview is displayed in all black (gray level 0).

4.2.2.9 Set all screen white(1023)
The preview is displayed in all white (gray level 1023).

4.2.2.10 Set CSV pattern
The preview of specified display data is displayed.
4.2.2.11 Set continuous mode
The specified set of multiple CSV files can be displayed continuously.

Continuously displayed image files are selected and moved to “Selected files” box as shown in the figure below. Maximum number of selected files at a time is 100.
CSV files stored in reference folder described in following below are displayed on “Unselected folder” box.

※Reference folder: 32bit-computer C:¥Program Files¥SLM-100GUI¥Files
64bit-computer C:¥Program Files(x86)¥SLM-100GUI¥Files
After selecting the image files, the following dialog box for selecting play-modes is displayed.

4.2.2.11.1 “Auto” mode
“Auto” mode displays image files continuously with specified regular interval and loop count.
※Available range for interval and loop count
  0.1 sec \(\leq\) Interval \(\leq\) 10, 0 \(\leq\) Loop count \(\leq\) 500 (0 = \(\infty\))

4.2.2.11.2 “Manual” mode
“Manual” mode displays the image files in arbitral timing by clicking the “previous” or “Next” button.
4.2.2.11.3 Change the order of registered files
The order of displayed image files can be changed from the dialog box.

![Diagram showing how to change the order of registered files](image.png)
4.2.2.12 Selection directory files

In accordance with the same procedure as 4.2.2.11, displayed image files are selected.

After registering the image files, the following dialog box is displayed. The image file selected by double-click or pushing the displayed “OK” button.
4.2.2.13 Translate all screen

The position of the image displayed on the LCOS panel can be changed. By specifying the pixel number for translation on the X and Y axes, the position of the displayed image can be shifted.

※Available translation range: -1440 ≤ X shift ≤ 1440, -1050 ≤ Y shift ≤ 1050
4.2.2.14 Offset gray scale of all screen

The gray scale of all pixels for the displayed image can be offset at a specified level.

By specifying the offset level of the gray scale on the dialog box below, the offset image is displayed.
※Available offset range: $-1023 \leq \text{Gray Scale} \leq 1023$
4.2.2.15 Gain adjustment of all screen
The gray scale of all pixels for the displayed image can be rescaled with a specified value.

By specifying the gain value for rescaling on dialog box below, the displayed image can be rescaled.
※Available gain range: 0.01 ≤ Gain ≤ 1023
4.2.2.16 Set wavelength

The calibration data of phase level can be adjusted with a user specified wavelength.

The arbitral wavelength within 500nm to 1650nm can be set at a 1 nm interval. If “No wavelength calibration “ is selected, the phase level is adjusted for 1550nm.
4.2.2.17 Zoom in
Preview display is expanded at the center of cross mark.

4.2.2.18 Zoom out
Preview display is reduced at the center of cross mark.

4.2.2.19 Fit full size
Preview is displayed full-screen.

4.2.2.20 Marquee zoom
Selected area is expanded on preview display.

4.2.2.21 Software version
Software version is displayed.
WARNING!

In the event of any trouble with this product, turn the unit off in accordance with the procedures to shut off the power described in this operation manual, disconnect the power source cord, record the product name and serial number described on the name plate of the product, and then contact our dealer at your place or directly contact us at Santec Photonics Laboratories. Our telephone number and facsimile number are shown below. However, we are not responsible for any trouble arising from your own repair or modification on this product.

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