国兆光电
GUO ZHAO OPTOELECTRONICS

SXGA037HW01C

Silicon-based OLED Microdisplay

Datasheet

Version Spec V2.0

Revision

Version	Date	Page	Description
1.0	2023-12-15		Release preview version
2.0	2024-06-03		Release official version

Content

1 Overview/Applications

The SXGA037HW01C microdisplay is a top-emitting, high-efficiency, active-matrix driven silicon-based OLED microdisplay independently developed by Nanjing Guozhao Optoelectronics Technology Co., Ltd. This product integrates some modules like signal enhancement circuit, row and column drive circuit, logic control circuit, etc. It supports the MIPI signal. Through the I2C-bus interface, it can realize the control and adjustment of display mode, display position, brightness, contrast and other functions. This product has the characteristics of low power consumption, high-resolution, high-integration, miniaturization, etc., and it can be widely used in various near-eye display systems with miniaturization, high-resolution, low power consumption, and wide-temperature range.

1.1 Key Features

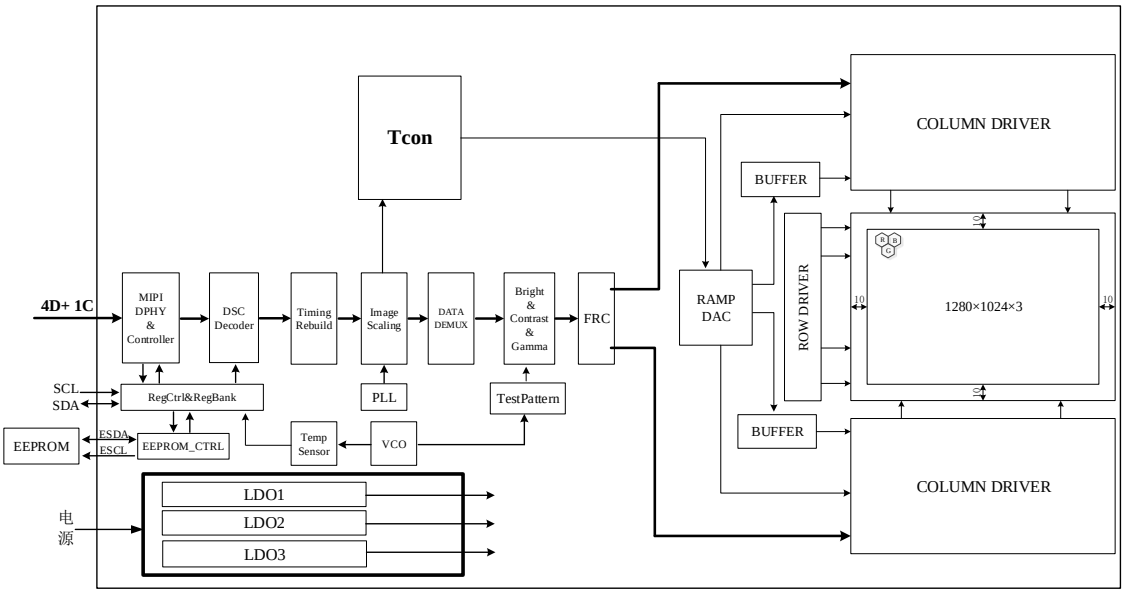
- Low power consumption
- High contrast
- The communication interface supports I^2C
- Single MIPI signal (4 lane) input, supporting D-PHY v1.2 1.0Gbps/lane
- Embedded temperature sensor
- Support PWM-mode brightness adjustment function
- Automatic brightness-adjustment function
- Support image brightness and contrast digital signal enhancement function
- Support horizontal/vertical inverse display of video images,
- support image timed movement
- Support image display position adjustment
- Compatible with low-resolution image display

1.2 **General Features**

Parameter	Specification
Category	Full Color
Maximum display resolution	1280×1024
Reserved physical resolution	1300×1044
Pixel arrangement	Hexagon
Pixel dimension	5.67μm×5.67μm
Display area	7.26mm×5.81mm（0.37 inches diagonally）
Gray level	256 levels
Uniformity@200cd/m^2	≥ 90%
Contrast	> 10000:1
Refresh rate	25Hz ~ 100Hz
Video interface	MIPI
Typical brightness	200 cd/m^2
Recommended brightness range	10 cd/m^2 ~ 400 cd/m^2
Voltage	1.8V、+5.5V、-4.5V
Typical power consumption	120mW @60Hz
	100mW @25Hz
Weight	<0.9g

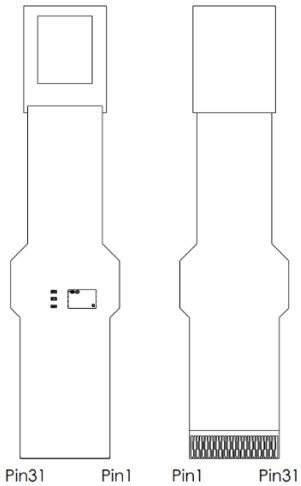
2 Function Overview and Interfaces

2.1 System Block Diagram



2.2 Pin Description

The electrical interface of the display adopts 0.3mm 31PIN-FPC



Note：

Specification Dimension of FPC and recommended connector refer to chapter 6

The electrical interface pins of the microdisplay are defined as follows:

Pin	Symbol	Description
1	VDD	Digital circuit power supply（+1.8V）
2	GND	Power GND
3	LDO_VCOM	Negative voltage power supply
4	GND	Power GND
5	VEE	Negative voltage circuit power supply（-4.5V）
6	GND	Power GND
7	VAN	Analog circuit power supply（+5.5V）
8	LDO_VANARY	Analog power supply
9	VAN	Analog circuit power supply（+5.5V）
10	LDO_AVDD	Analog power supply
11	LDO12_D	Analog power supply
12	LDO12_M	Analog power supply
13	VREF_TEST	Test point
14	ANA_TEST	Test point
15	SDA	I^2C data
16	SCL	I^2C clock
17	SERADD	I^2Cslave address selection
18	$\overline{\text{RESET}}$	Reset signal, active low
19	MIPI_D3_N	MIPI data input
20	MIPI_D3_P	MIPI data input
21	MIPI_D2_N	MIPI data input
22	MIPI_D2_P	MIPI data input
23	MIPI_CLK_N	MIPI data input
24	MIPI_CLK_P	MIPI data input
25	MIPI_D1_N	MIPI data input
26	MIPI_D1_P	MIPI data input
27	MIPI_D0_N	MIPI data input
28	MIPI_D0_P	MIPI data input
29	GND	Power GND
30	TEST1	Test point
31	VDD	Digital circuit power supply（+1.8V）

3 Electric Characteristics

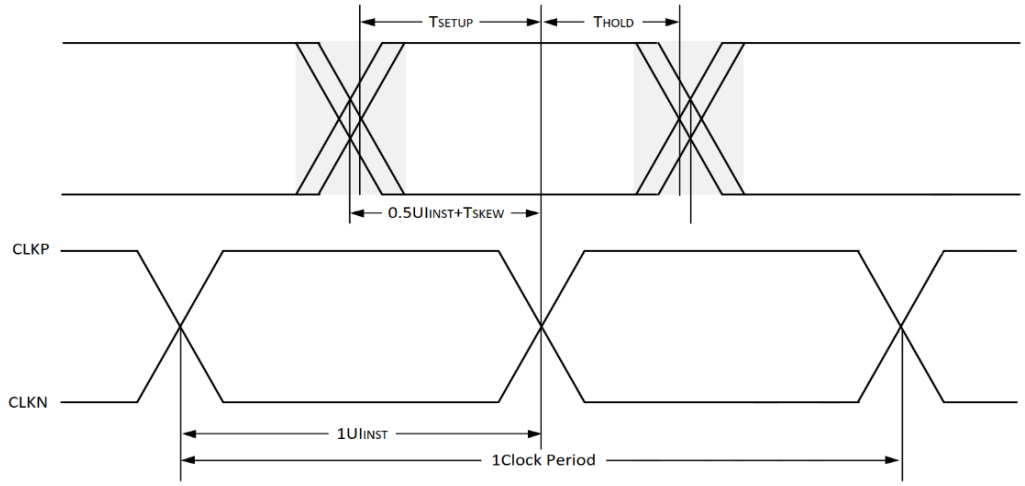
3.1Absolute Maximum Rating

Symbol	Description	Min	Max	Unit
VDD	Digital circuit power supply	-0.3	2.2	V
VAN	Analog circuit power supply	-0.3	6.3	V
VEE	Negative voltage circuit power supply	-5.0	0.3	V
Top	Working Temperature	-45	+65	℃
Tst	Storage Temperature	-55	+75	℃

3.2 DC Characteristics

Symbol	Description	Min	Typ	Max	Unit
V_D	VDD voltage	1.75	1.80	1.85	V
I_D	VDD current	—	—	100	mA
V_A	VAN voltage	5.4	5.5	5.6	V
I_A	VAN current	—	—	100	mA
V_E	VEE voltage	-5	-4.5	-4.4	V
I_E	VEE current	—	—	20	mA
V_{IL}	Valid low level of digital signal	0	—	0.3* V_D	V
V_{IH}	Valid high level of digital signal	0.7* V_D	—	V_D	V

3.3 AC Characteristics



symbol	Description	Min	Typ	Max	Unit
UI_{INST}	UI instantaneous	1	—	3	ns
T_{SKEW}	T Data to Clock Skew	-0.15	—	0.15	UIHS
T_{SETUP}	RX Data to Clock Setup Time Tolerance	0.15	—	—	UIHS
T_{HOLD}	RX Data to Clock Hold Time Tolerance	0.15	—	—	UIHS

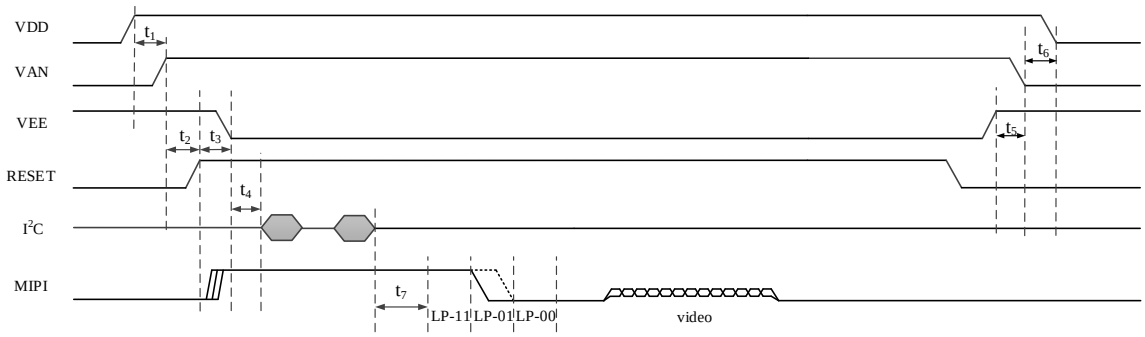
3.4 Power consumption

Symbol	Description	Typ. (200cd/m²)		Typ. (100cd/m²)		Unit
		60Hz	25Hz	60Hz	25Hz	
P_{VDD}	VDD power consumption	80	60	80	60	mW
P_{VAN}	VAN power consumption	35	35	32	32	mW
P_{VEE}	VEE power consumption	5	5	3	3	mW
P_{POWER}	Total power consumption	120	100	115	95	mW

Test Condition：

Temperature:+25℃±2℃，test image is all white display。

3.5 Power Sequence



Symbol	Description	Min	Typ.	Max	Unit
t_1	VAN power-up delay	5	—	—	ms
t_2	Power settling time	5	—	—	ms
t_3	VEE power-up delay	5	—	—	ms
t_4	Initialization time	100	—	—	ms
t_5	Power-off interval time	0	—	—	ms
t_6	Power-off interval time	0	—	—	ms
t_7	MIPI signal input time	0	—	—	ms

Note：

Strictly follow the power-up sequence, otherwise the display may be abnormal or damaged

3.6 **Power-up Register Configuration**

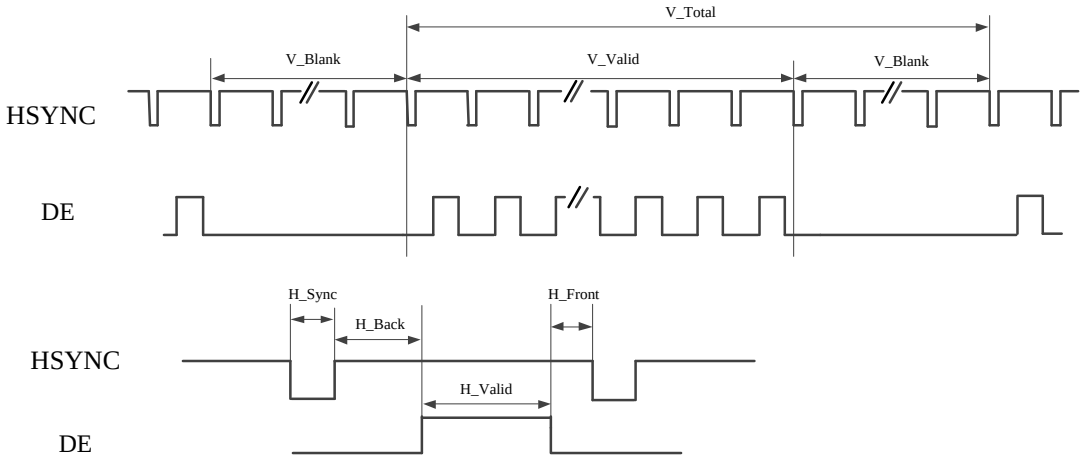
I2C Address	Data
6100h	0x00
4200h	0x08
4201h	0x00
4100h	0x03
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x10
4201h	0x00
4100h	0x07
4101h	0x00

4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x10
4201h	0x03
4100h	0x0f
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x14
4201h	0x03
4100h	0x02
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x00
4201h	0x04
4100h	0x01
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x04
4201h	0x04
4100h	0x00
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x08
4201h	0x04
4100h	0x11
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70

6100h	0x00
4200h	0x04
4201h	0x00
4100h	0x00
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
4200h	0x04
4201h	0x00
4100h	0x01
4101h	0x00
4102h	0x00
4103h	0x00
6100h	0x70
6100h	0x00
3D02h	0x50
2A03h	0x14
3B01h	0x0C

3.7 **Video Sequence**

The timing of the video signal input to the microdisplay shall be in accordance with VESA standard. When the timing of the video signal is not accordance with VESA standard, the parameter below can be configured according to the timing requirements as shown in figure.



Symbol	Min	Typ.	Max	Unit
V_Blank	8	44	1000	HSYNC
V_Valid	—	1024	—	HSYNC
H_Sync	20	112	500	PCLK
H_Back	20	248	500	PCLK
H_Front	2	48	500	PCLK
H_Valid	—	1280	—	PCLK

4 Function Description

4.1 Register Map

I2Caddress	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	default
0001H	0	0	Test pattern selection			Input video selection			0x03
0101H	0	0	0	0	0		Vertical scanning	Horizontal scanning	0x00
0200H	0	Left /Right movement enable	Up/Down movement enable	Timed movement distance（number of rows/columns）					0x00
0201H	Time interval for movement STICK_TIME [7:0], unit is 64 frame times								0x02
0202H	Time interval for movement STICK_TIME [15:8]， unit is 64 frame times								0x00
0300H	Set 256-level red gray of test pattern								0x00
0301H	Set 256-level green gray of test pattern								0x00
0302H	Set 256-level blue gray of test pattern								0x00
0402H	Display top starting point selection								0x0A
0403H	Display bottom starting point selection								0x0A
0500H	Display left starting point selection LFT[7:0]								0x0A
0501H	Display left starting point selection LFT[8]								0x00
0502H	Display right starting point selection RGT[7:0]								0x0A
0503H	Display right starting point selection RGT[8]								0x00
0600H	Image contrast digital adjustment A point output grayscale								0x55
0601H	Image contrast digital adjustment B point output grayscale								0xAA
0602H	Image contrast digital adjustment A point input grayscale								0x55
0603H	Image contrast digital adjustment B point input grayscale								0xAA
2400H	Image brightness digital adjustment								0x80
2401H	0	Double byte register update	0	Brightness automatic update	0	1	0	0	0x44
2403H	Internal temperature detection value								Read only
2700H	PWM[7:0]								0xA0
2701H	0					PWM[10:8]			0x05
2803H	0	0	0	Magnification Module	1	0	0	0	0x18
3B01H	0	0	0	0	1	Negativ	0	0	0x08

						e voltage			
4100H	DSI register configuration data PWDATA_MIPI[7:0]								0x00
4101H	DSI register configuration data PWDATA_MIPI[15:8]								0x00
4102H	DSI register configuration data PWDATA_MIPI[23:16]								0x00
4103H	DSI register configuration data PWDATA_MIPI[31:24]								0x00
4200H	DSI register configuration address PADDR_MIPI[7:0]								0x00
4201H	0	0	0	0	0	DSI register configuration address PADDR_MIPI[10:8]			0x00

4.2 **Test Pattern Selection**

The microdisplay is equipped with various test pattern , and different test can be output by setting the values of bit5-bit3 of register 0001H.

Address	Bit	Description
0001H	bit5 - bit3	000：With register 0300H、0301H、0302H，0~255 grayscale of R、G、B signals can be set respectively 001：White field 010：Red field 011：Green field 100：Blue field 101：Transition grayscale pattern from left to right 110：Color bar 111：Checkboard

4.3 **Video Signal Transfer Format**

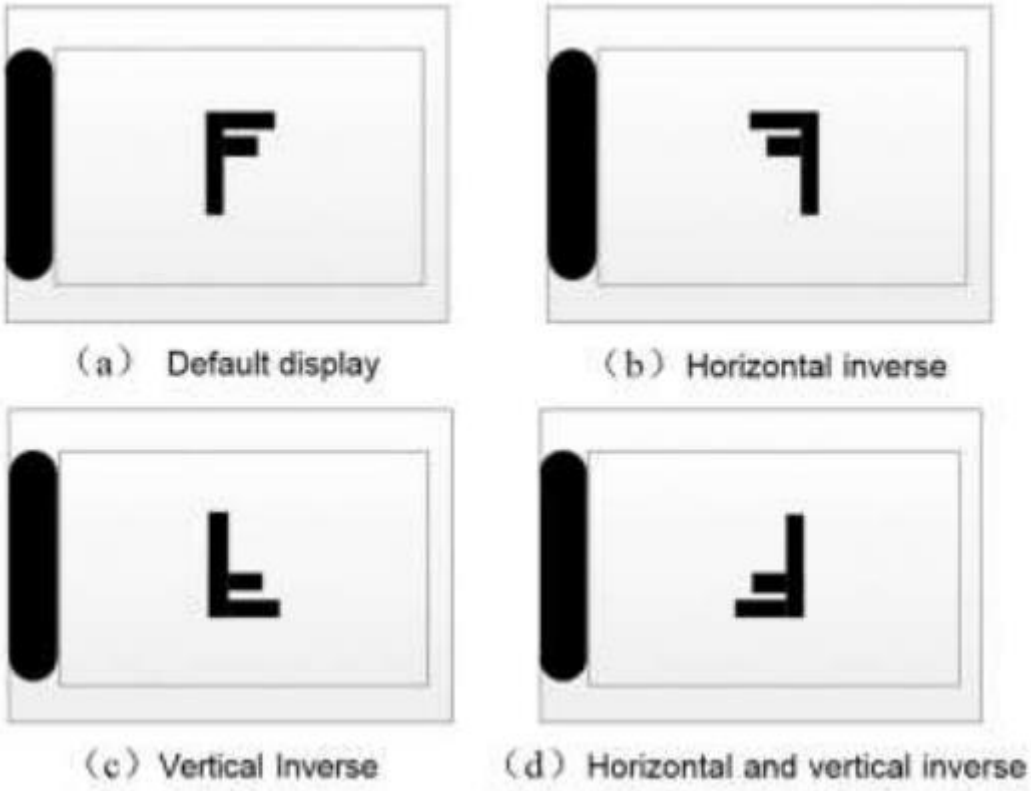
Address	Bit	Description
0001H	bit2 - bit0	011：24bit – RGB，8:8:8 pattern； 101：Internal test image；

4.4 Up/Down and Left/Right Inverse Display

The microdisplay support inverse display of video images in horizontal and vertical direction

Address	Bit	Description
0101H	bit1	Vertical display setting 0：Scan from top to bottom 1：Scan from bottom to top
	bit0	Horizontal display setting 0：Scan from left to right 1：Scan from right to left

The schematic diagram of inverse display in horizontal and vertical directions are as follows:



4.5 Image timed Movement

The microdisplay supports timed dynamic movement of the entire screen image in horizontal or vertical direction.

Address	Bit	Description
0200H	bit6	Horizontal timed movement control 0：Dynamic movement function is turned off; 1：Dynamic movement function is turned on;
	bit5	Vertical timed movement control 0：Dynamic movement function is turned off; 1：Dynamic movement function is turned on;
	bit4-bit0	Number of rows/columns to move，range from0x00 to 0x0A
0201H	bit7-bit0	The time interval for movement STICK_TIME，Unit is 64 frame times; Register 0201H value is STICK_TIME[7:0]; Register 0202Hvalue is STICK_TIME[15:8];
0202H	bit7-bit0	

Note：

There are 10 redundant pixels on the top, bottom, left and right of the display screen, and when the dynamic movement function is turned on, the range of movement cannot exceed the range of redundant pixels.

4.6 Compatible with Low-resolution Image Display

The microdisplay is compatible with images below 1280×1024 resolution，such as 1024×768，800×600, 640×480 or other irregular resolution. When compatible with low-resolution , the registers need to be configured accordingly.

For example, take 1024×768 resolution video image conforming to VESA standard,

with point clock at 65MHz, refresh rate at 60Hz. The register configuration is shown below when the input image in 24Bit-RGB format is displayed in the center.

Address	Value	Configuration
0001H	0x03	0x03: in 24Bit-RGB format
0402H	0x8A	The first row display starting position, (1044-768) /2=138, and set to 0x8A
0403H	0x8A	The last row display starting position, (1044-768) /2=138, and set to 0x8A
0500H	0x8A	The first column display starting position, (1300-1024) /2=138, and set to 0x8A
0501H	0x00	The first column display highest starting position
0502H	0x8A	The last column display starting position, (1300-1024) /2=138, and set to 0x8A
0503H	0x00	The last column display highest starting position

note：

The minimum resolution must not be lower than 534×278.

4.7 Zoom Function

The display has Zoom function, It can display images with a resolution lower than 1280×1024 in full screen, such as 1024×768 resolution, 800×600 resolution, 640×480 resolution. When enlarging low-resolution images, the register needs to be configured accordingly.

Address	Value	Description
0001H	0x03	0x03 为 24Bit-RGB format
2803H	0x08	Zoom function
2A01H	0xFC	Chip frequency adjustment
3802H	0x08	
2A00H	0xBF	640x480 image magnification
	0xBF	640x512 image magnification
	0xBF	720x576 image magnification
	0xBF	
	0x4F	768x576 image magnification
	0xBA	800x600 image magnification
	0xBA	
	0x5A	1024x768 image magnification
2A02H	0xCE	640x480 image magnification
	0xCF	640x512 image magnification
	0xCD	720x576 image magnification
	0xDF	
	0xBF	768x576 image magnification
	0xCB	800x600 image magnification
	0xDE	
	0xDB	1024x768 image magnification

4.8 **Temperature Detection**

The microdisplay has temperature detection function, and the temperature conversation formula is shown as below:

$$T = 0.53 \times Reg(2403H) - 52$$

T is actual temperature value and Reg（2403H）is the reading of the temperature register 2403H

Note：

1. During the initialization period when the microdisplay is powered on , the temperature reading changes significantly. It is recommended to stabilize for few seconds before reading the temperature value;
2. During normal operation, the temperature reading update cycle is four frame image cycles.

4.9 **Brightness Adjustment**

The factory default brightness of the microdisplay is about 200cd/m2 , and the recommended brightness range is 40cd/m2 ~ 400cd/m2 . Users can adjust the brightness appropriately according to the needs of the use. The brightness adjustment method is the PWM method, the corresponding configuration register address is 2700H(low eight bits [7:0]) and 2701H (high three bits [10:8]), and the brightness adjustment can be realized by changing the value the address The factory default value of the PWM is 0×0210, and the adjustment step is 0x01. The higher the PWM value, the lower the brightness, and the PWM value corresponding to the maximum brightness is 0x0420.

When adjusting the brightness, write 0x04 in the 2401H register, turn on the double-byte register update function, and then configure 2700H (low eight bits [7:0]) and 2701H (high three bits [10:8]) two PWM registers in turn, and finally write 0x44 in the 2401H register to complete the double-byte register update, so as to avoid brightness jump. Repeat the above steps each time you adjust the brightness.

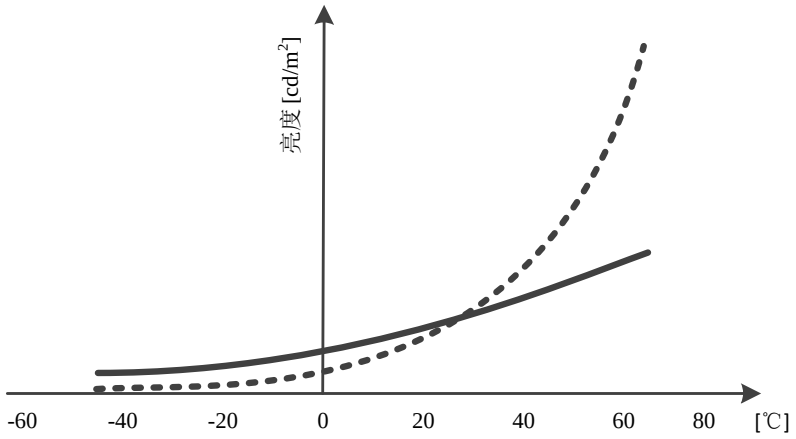
The PWM value is linearly proportional to the brightness, and the relationship formula is as follows:

$$L = \frac{M}{N} \times 400 + 10$$

Note：M represents the PWM register value converted to decimal value, N represents the number of V_Total, and L represents the brightness value. The value of PWM cannot exceed the value of the total number of rows V_Total。

4.10 **Automatic Temperature Compensation**

Due to the inconsistent full temperature characteristics of the silicon-based OLED microdisplay, the brightness increases at high temperatures and decreases at low temperatures. In order to improve the consistency of brightness at different temperatures, the microdisplay has a built-in brightness adaptive adjustment mechanism, which automatically compensates for the brightness of the screen at different temperatures. Register 2401H is the enable control register, and the default value is 0x44, which is in the off state. To turn on this function, the configuration value is set to 0x54.



In the figure above, the dashed line represents the brightness curve at full temperature when the brightness adaptive adjustment is turned off, while the solid line represents the brightness curve at full temperature when the brightness adaptive adjustment function is turned on. By testing, the brightness is effectively compensated in both high and low temperature stages after the brightness adaptive adjustment function is turned on, making the brightness at high and low temperatures as close as possible to the default brightness at room temperature. The image display effect basically meets the observation requirements at full temperature.

4.11 **Image Brightness Digital Adjustment**

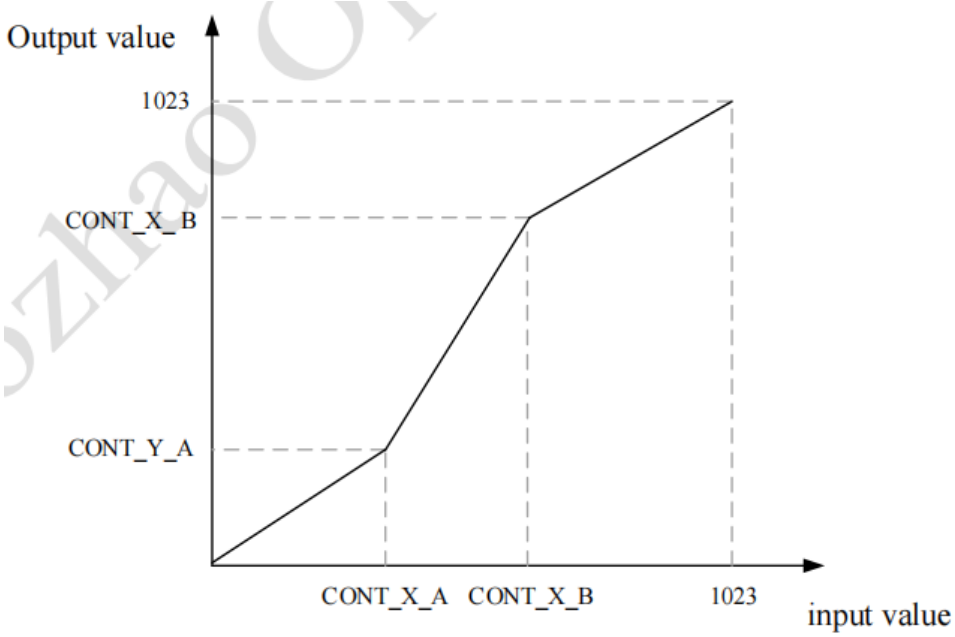
The microdisplay has the image brightness digital adjustment function, and the brightness adjustment formula is as follows:

$$Y = Y_0 + (BRT - 128) \times 4$$

Y is the adjusted data value, Y0 is the input image data value, and BRT is the configuration value of the 78H register. Data overflow may occur in the low gray stage and high gray stage after adjustment, resulting in image distortion. It is recommended to configure it appropriately.

4.12 Image Contrast Adjustment

The contrast adjustment is divided into three segments, and the horizontal and vertical coordinates of the two segmentation points can be set by registers. The image contrast is adjusted by multiplying the image data segmentation in equal proportions. The mapping curves of the three sections are shown in the figure below:



CONT_X represents the input gray scale value, CONT_Y represents the corresponding output gray scale value. By modifying the values of A and B segment points through the register, the proportional relationship between output and input gray scale is adjusted, so as to realize the function of contrast segment adjustment.

4.13 I^2C Interface

The display only support I2C communication. The I2C address is 16 bits and consists by two parts: the range of upper 8 bits is 00~7f to represent the primary address, the range of the lower 8 bits is00~33, which indicates the secondary address. The

communication rate supports 10KHz~400KHz.

Note:

1. SDA and SCL signals must be pulled up with resistors to VIH;

2. When the transmission distance of I^2C communication signal is long, please pay attention to the signal integrity and anti-interference measures of SDA and SCL;

3. When the I^2C communication signal is seriously disturbed, I^2C communication can be carried out during the vertical blanking interval, or the communication frequency can be appropriately

4.13.1 Slave Address Selection

The microdisplay is used as a slave device. Its address can be selected by the SERADD pin, which is 0x54 when the SERADD pin is low and 0x55 when the SERADD pin is high. The specific slave address and read / write instructions are as follows.

Slave address	instruction	Bit7 (MSB)	Bit 6	Bit5	Bit4	Bit3	Bit2	Bit1 (SERADD)	Bit0 (R/W)	Valid bytes
0x54	Write	1	0	1	0	1	0	0	0	0xA8
	Read	1	0	1	0	1	0	0	1	0xA9
0x55	Write	1	0	1	0	1	0	1	0	0xAA
	Read	1	0	1	0	1	0	1	1	0xAB

4.13.2 Data Transfer Format

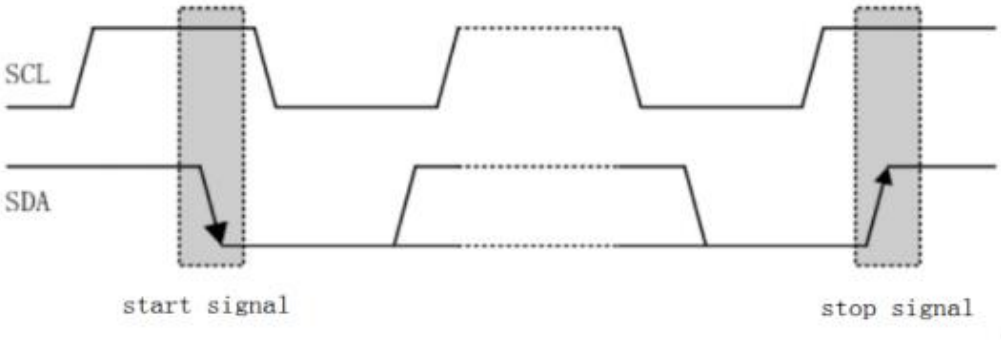
4.13.2.1 Flag Bit Description

Start signal(S): the change of SDA line from high level to low level when the SCL line is high level;

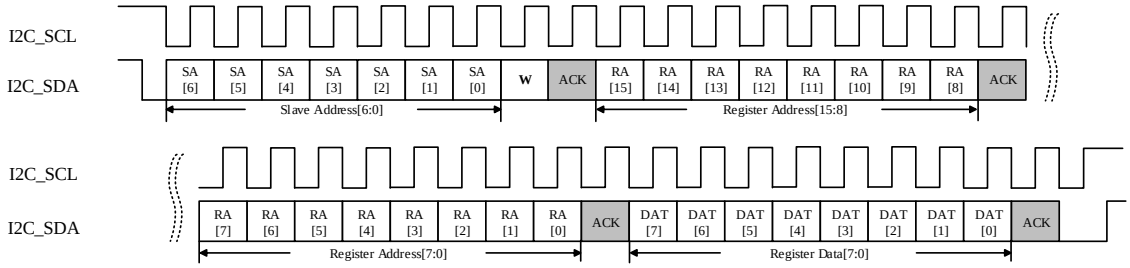
Pause signal (P): the change of SDA line from low level to high level when the SCL line is high level;

Active answer (ACK): SDA at low level indicates active answer;

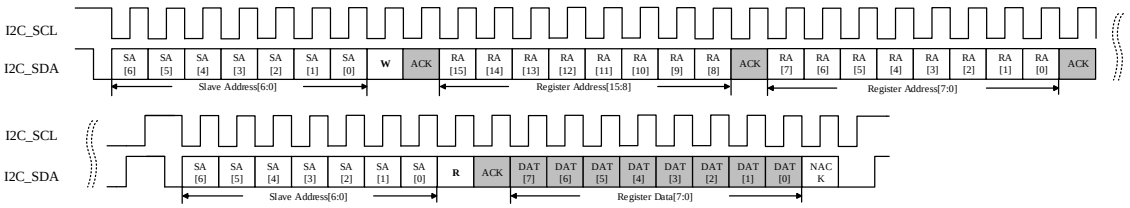
Negative answer (NAK): SDA at high level indicates negative answer;



4.13.2.2 Write Sequence

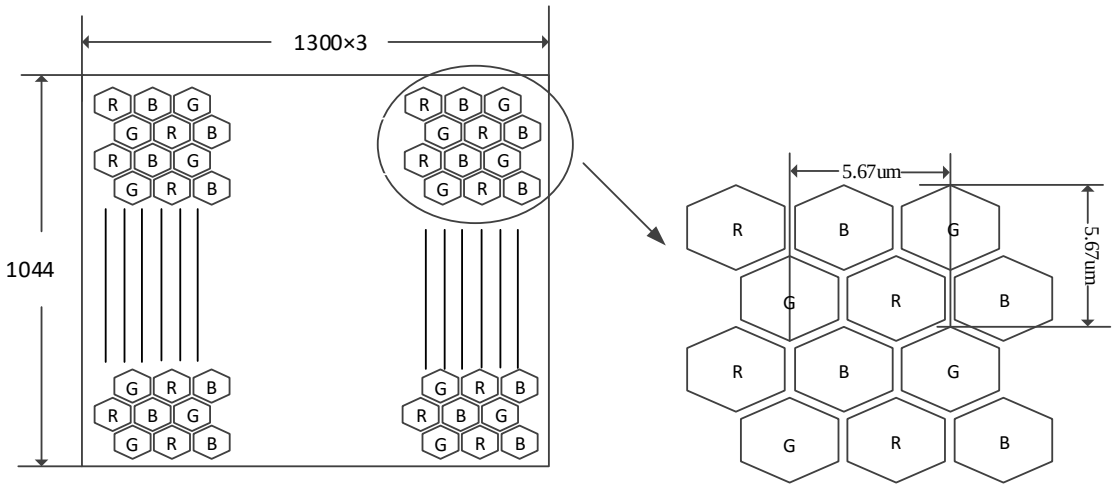


4.13.2.3 Read Sequence



5 Optical Features

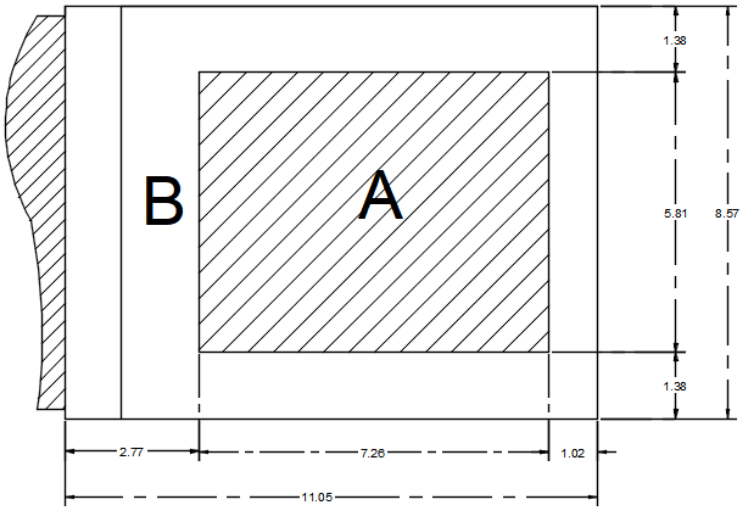
5.1 Pixel Arrangement



The pixel arrangement of the SXGA037HW01C silicon-based OLED microdisplay is shown below, where every three sub-pixels form a pixel. The pixel size is 5.67μm×5.67μm.

5.2 Display Quality Standard

5.2.1 Display Area Definition



5.2.2 Inspection Standards for Default Pixels

Defect points refer to subpixels that cannot display correctly, such as pixels that are always bright or dim. The inspection standards for defect points are carried out in accordance with the requirements as follows.

No	Item	Request
1	2 consecutive default pixels	≤1
2	Three and above consecutive default pixels	0
3	Bright pixels	No bright point above 100 grayscale in full screen

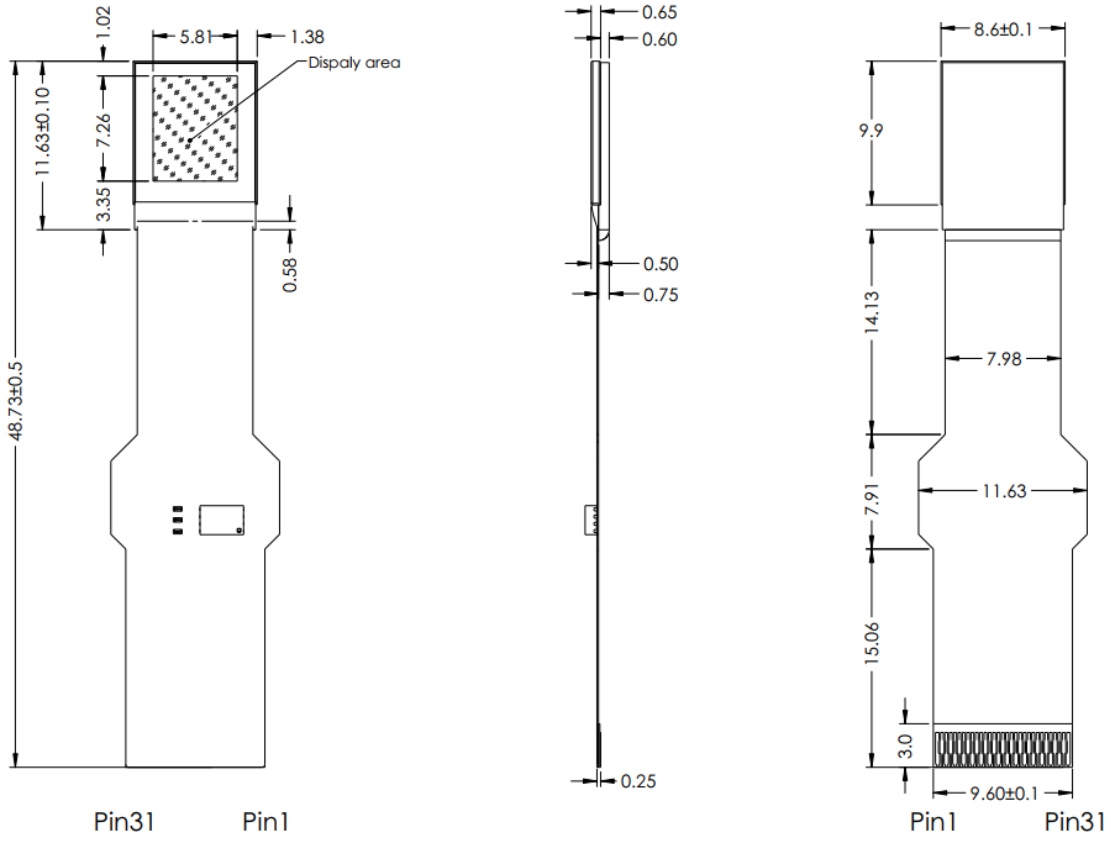
5.2.3 Test Conditions

1) Use a dedicated test fixture to light up the microdisplay, and inspect the white field display of the microdisplay under the microscope's bright field at a magnification of 100× (objective 10×, eyepiece 10×);

2) Use a dedicated test fixture to light up the microdisplay, the microdisplay shows the black field, and use the 12× eyepiece to observe the bright points.

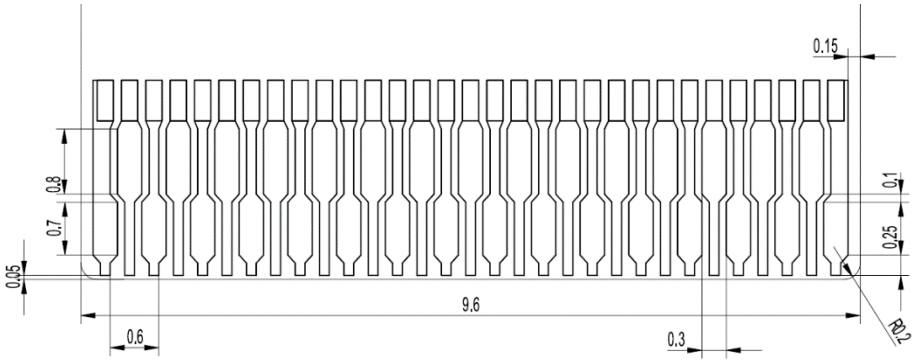
6 Structure and Package

6.1 **Product Structure**

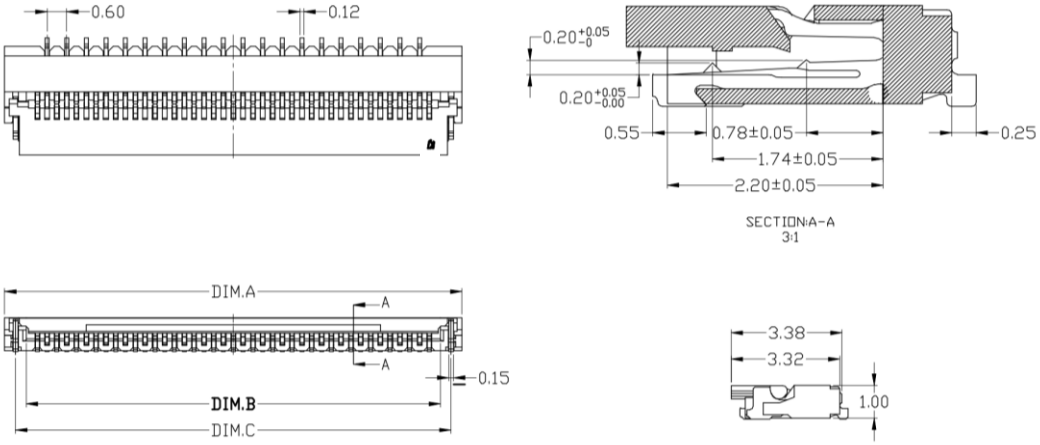


6.2 **Connector Dimensions and FPC Design Recommendations**

Unit：mm



The recommended connector of the microdisplay is as below:

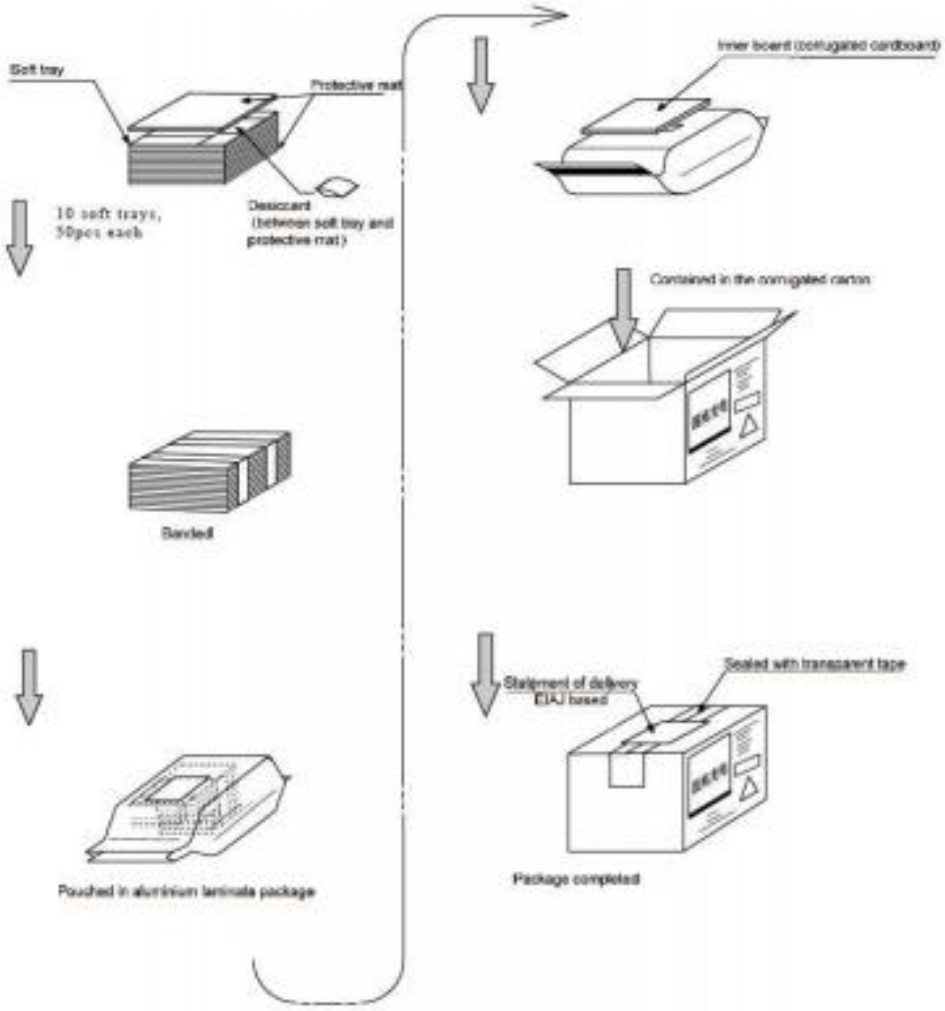


Number of Contacts	Dimension(mm)				
	A	B	C	D	E
31	11.00	9.68	10.33	9.00	8.40

6.3 **Product Packing Specification**

Packaging composition: Soft tray (capacity: 50 pcs)

Packing quantity: 500 pcs (10×50, 10 soft trays, 50 pcs per tray)



7 Product Precautions

7.1 Use Precautions

1、The SXGA037HW01C silicon-based OLED microdisplay shall be strictly in accordance with the definition of the electrical interface in this datasheet for power supply and signal lines connection. Maintain the stability of the power supply, and illegal power supply is not allowed;

2、During the use of the microdisplay, if abnormal phenomena such as short circuit or overheating are found, it is prohibited to repeatedly power on to test. Please timely find the problem or contact Guozhao Optoelectronics Company for maintenance;

3、In order to improve the service life of the product and avoid the aggravation of residual images affecting use, it is necessary to minimize the time for the product to display a fixed image under high temperature or high brightness conditions;

4、The glass and silicon edges of the silicon-based OLED microdisplay are easily damaged and shall not be subject to physical stress;

7.2 Clean Precautions

1、 It is prohibited to use any acid, alkali, organic solvent/reagent and other chemicals to scrub or come into contact with the product;

2、 Use lens paper or a clean cloth to dip a small amount of water or organic solvent, wring dry and then wipe the silicon-based OLED microdisplay surface. Do not wipe it directly with a wet cloth;

3、 When wiping the screen with organic solvents, try to avoid wiping the edge of the screen, otherwise it may damage the rubber layer.

7.3 Storage Precautions

1、 Short-term storage requirement: the silicon-based OLED microdisplay is

allowed short-term storage in a dry environment between -55℃~70℃（≤100 hours）;

2、 Long-term storage requirement:

1) Room temperature at 25℃±5℃;

2) The dry nitrogen or vacuum sealed container;

3) Avoid violently shaking.

7.4 **Others**

1、Keep the silicon-based OLED microdisplay away from ultraviolent rays and ionizing radiation;

2、Do note bend the silicon-based OLED microdisplay by external force;

3、Keep the silicon-based OLED microdisplay away from heat sources during storage or use;

4、Avoid falling of the silicon-based OLED microdisplay at high altitude.
