0.61 INCH MICRO-DISPLAY

P/N: DSB-2270-S000

1 Overview / Applications

This microdisplay is a top-emitting, high-efficiency and active-matrix-driven silicon-based OLED microdisplay. Its silicon substrate is manufactured by 0.18μm CMOS technology. This product integrates some modules like signal enhancement circuits, row and column drive circuits, logic control circuits, etc. It supports 8/16/24bit digital video signal

and ITU-R BT.656 video format. Through the I^2C-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

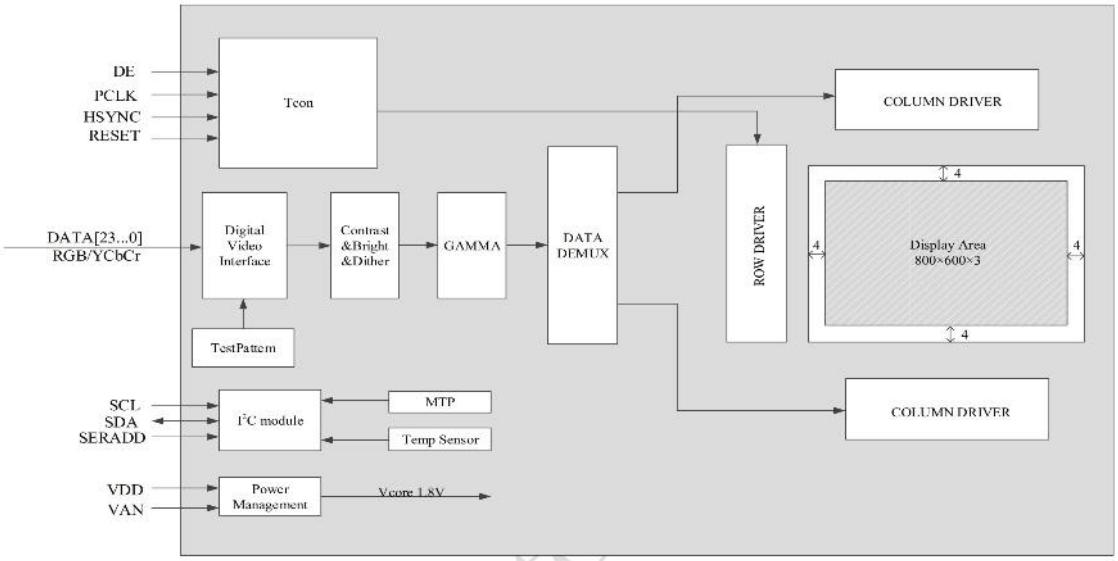
- Low power consumption
- High contrast
- The communication interface supports I^2C
- The video interface supports RGB, YCbCr, ITU-R BT.656
- Embedded temperature sensor
- Support PWM-mode brightness adjustment function
- Support image brightness and contrast digital signal enhancement function
- Support horizontal / vertical inverse display of video images and timed movement function

1.2 General Features

Parameter	Specification
Product category	Color
Resolution	800×600（808×608 reserved）
Pixel arrangement	RGB vertical stripe
Pixel dimension	15μm×15μm
Display area	12.0mm×9.0mm（0.60 inches diagonally）
Gray level	256-level
Uniformity @150cd/m^2	≥ 90%
Contrast	＞10000:1
Refresh rate	25Hz~75Hz
Video interface	24bit-RGB、 8/16/24bit-YCbCr、ITU-R BT.656
Typical brightness	150 cd/m^2
Recommended brightness range	50 cd/m^2 ~ 300 cd/m^2
Supply voltage	1.8V、5V
Typical power consumption	100mW @60Hz
	75mW @25Hz
Weight	<1.5g
Operating temperature	-45℃ ~ +65℃
Storage temperature	-55℃ ~ +70℃

2 Function Overview and Interfaces

2.1 System Block Diagram



2.2 Pin Description

The electrical interface of the microdisplay adopts a 40pin in-line connector with a spacing of 0.5mm.

VDD	1	2	VAN
VDD	3	4	VAN
GND	5	6	GND
SCL	7	8	RESET
NC	9	10	SERADD
HSYNC	11	12	SDA
DATA_22	13	14	GND
DATA_20	15	16	DATA_23
DATA_18	17	18	DATA_21
DATA_16	19	20	DATA_19
DE	21	22	DATA_17
GND	23	24	PCLK
DATA_14	25	26	DATA_15
DATA_12	27	28	DATA_13
DATA_10	29	30	DATA_11
DATA_8	31	32	DATA_9
DATA_6	33	34	DATA_7
DATA_4	35	36	DATA_5
DATA_2	37	38	DATA_3
DATA_0	39	40	DATA_1

Note:

Please refer to Chapter 6 for detailed dimensions of the connector.

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

Pin No.	Symbol	Description
1	VDD	Digital circuit power supply
2	VAN	Analog circuit power supply
3	VDD	Digital circuit power supply
4	VAN	Analog circuit power supply
5	GND	Power GND
6	GND	Power GND
7	SCL	I^2C clock
8	$\overline{\text{RESET}}$	Reset signal, active low
9	NC	Not used, recommended to connect to GND
10	SERADD	I^2C slave address selection
11	HSYNC	Video horizontal synchronization
12	SDA	I^2C data
13	DATA22	Data signal R[6]
14	GND	Power GND
15	DATA20	Data signal R[4]
16	DATA23	Data signal R[7]
17	DATA18	Data signal R[2]
18	DATA21	Data signal R[5]
19	DATA16	Data signal R[0]
20	DATA19	Data signal R[3]
21	DE	Video data enable
22	DATA17	Data signal R[1]
23	GND	Power GND
24	PCLK	Video point clock
25	DATA14	Data signal G[6]
26	DATA15	Data signal G[7]
27	DATA12	Data signal G[4]
28	DATA13	Data signal G[5]
29	DATA10	Data signal G[2]
30	DATA11	Data signal G[3]
31	DATA8	Data signal G[0]
32	DATA9	Data signal G[1]

Pin No.	Symbol	Description
33	DATA6	Data signal B[6]
34	DATA7	Data signal B[7]
35	DATA4	Data signal B[4]
36	DATA5	Data signal B[5]
37	DATA2	Data signal B[2]
38	DATA3	Data signal B[3]
39	DATA0	Data signal B[0]
40	DATA1	Data signal B[1]

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

Symbol	Description	Min.	Max.	Unit
VDD	Digital circuit power supply	-0.3	2.2	V
VAN	Analog circuit power supply	-0.3	5.5	V
V_I	Input digital signal level	-0.3	VAN-0.3	V
Tst	Storage temperature	-55	+70	℃
Top	Operating temperature	-45	+65	℃

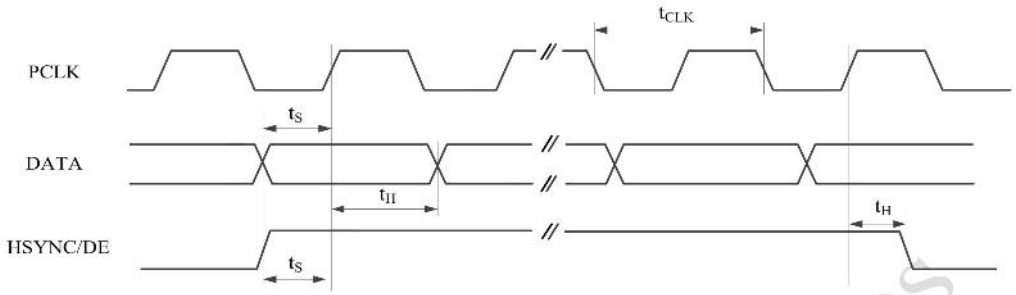
3.2 DC Characteristics

Symbol	Description	Min.	Typ.	Max.	Unit
V_D	VDD voltage	1.75	1.80	1.85	V
I_D	VDD current	—	—	40	mA
V_A	VAN voltage	4.90	5.00	5.10	V
I_A	VAN current	—	—	25	mA
V_{IL}	Valid low level of digital signal	-0.3	—	0.5	V
V_{IH}	Valid high level of digital signal	1.2	—	3.6	V

Note:

Digital input signals are compatible with level standards such as 1.8V, 2.5V, 3.3V, etc., but must meet the electrical standards in the table above.

3.3 AC Characteristics



Symbol	Description	Min.	Typ.	Max.	Unit
t_S	Setup time	4	—	—	ns
t_H	Hold time	1.5	—	—	ns
t_{CLK}	Clock cycle	—	15.4	—	ns
d_{CLK}	Duty cycle	45	50	55	%

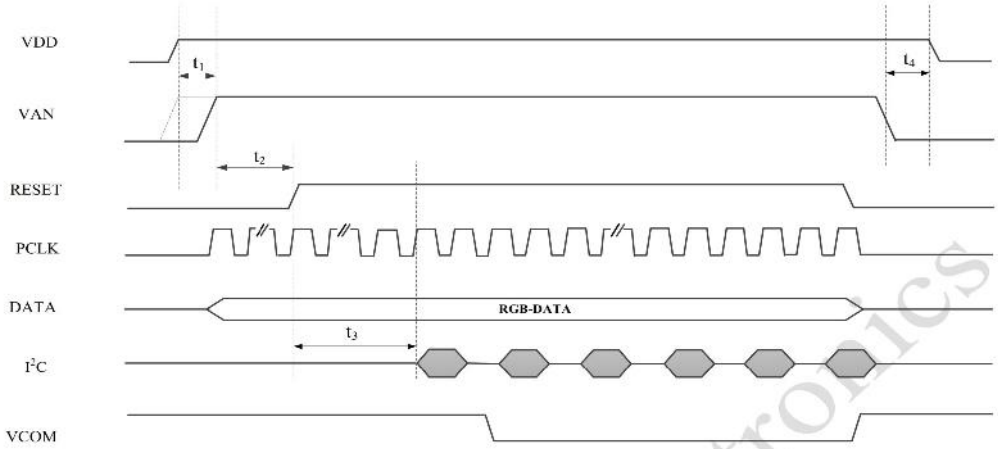
3.4 Power Consumption

Symbol	Description	Typ.		Unit
		25Hz	60Hz	
P_{VDD}	VDD power consumption	25	50	mW
P_{VAN}	VAN power consumption	50	50	mW
P_{POWER}	Total power consumption	75	100	mW

Note:

All white display, brightness = 150cd/m^2, temperature = +25°C ± 2°C.

3.5 Power Sequence



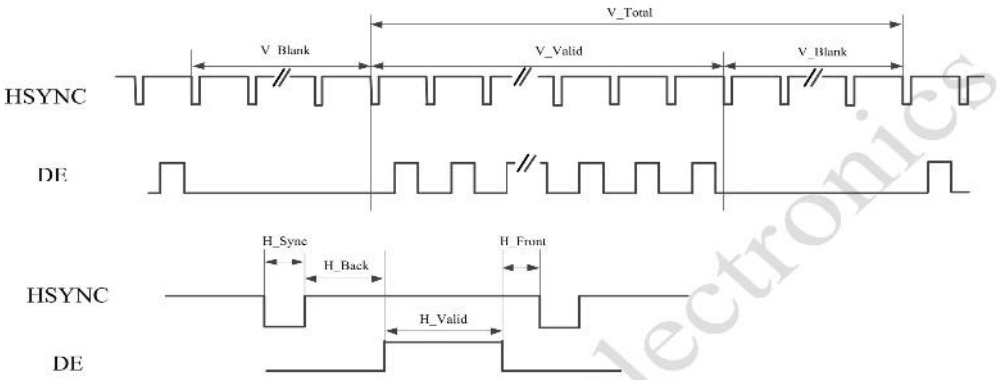
Symbol	Description	Min.	Typ.	Max.	Unit
t_1	Power on time between VDD and VAN	0	—	—	ms
t_2	Reset time	5	—	—	ms
t_3	MTP reload time	5 frames time	—	—	—
t_4	Power-off interval time	0	—	—	ms

Note:

1. In order to avoid display errors when the screen is powered on, it is necessary to ensure that the video data is accurate and at least one frame time later, then configure the C6H register with 0x01, turn on the VCOM voltage and light up the screen.
1. Before powering off, to avoid unstable graphics during shutdown, it is recommended to first turn off the VCOM voltage and configure the C6H register with 0x00. During power-off, if the VDD voltage is not lower than VAN voltage, two power supplies can be turned off at the same time.
2. Before RESET is pulled up, the PCLK needs to enter a steady state.

3.6 **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 in accordance with VESA Standard, the parameters below can be configured according to the timing requirements as shown in figure.



Symbol	Min.	Typ.	Max.	Unit
V_Blank	18	28	400	HSYNC
V_Valid	—	600	—	HSYNC
H_Sync	6	128	500	PCLK
H_Back	6	88	500	PCLK
H_Front	12	40	500	PCLK
H_Valid	—	800	—	PCLK

4 Function Description

4.1 Register Map

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Default
01H	0	0	Test pattern selection			Input video format selection			0x03
02H	Set 256-level red gray of test pattern								0x00
03H	Set 256-level green gray of test pattern								0x00
04H	Set 256-level blue gray of test pattern								0x00
05H	Synchronization mode		1	0	Interlaced / progressive scanning		Vertical scanning	Horizontal scanning	0x60
06H	0	0	Direction of movement	Number of columns to move to the left / right					0x00
07H	0	0	Direction of movement	Number of rows to move up / down					0x00
08H	0	Left / right movement enable	Up / down movement enable	Timed movement distance (number of rows / columns)					0x00
09H	Time interval for movement TIME [7:0], the unit is the length of one frame time								0x00
0AH	Time interval for movement TIME [15:8], the unit is the length of one frame time								0x00
0BH	Time interval for movement TIME [23:16], the unit is the length of one frame time								0x00
0CH	Time interval for movement TIME [31:24], the unit is the length of one frame time								0x00
0EH	Horizontal total pixels H_Total [7:0]								0x20
0FH	0	0	0	0	Horizontal total pixels H_Total [11:8]				0x04
11H	Horizontal valid pixels H_Valid [7:0]								0x20
12H	0	0	0	0	Horizontal valid pixels H_Valid [11:8]				0x03
14H	Number of valid rows per frame V_Valid [7:0]								0x58
15H	0	0	0	0	Number of valid rows per frame V_Valid[11:8]				0x02
18H	Number of total rows per frame V_Total [7:0]								0x74
19H	0	0	0	0	Number of total rows per frame V_Total [11:8]				0x02
91H	Digital adjustment of image brightness BRT[7:0]								0x80
95H	Digital adjustment of image contrast CONT[7:0]								0x00
96H	1	0	0	0	0	0	0	CONT[8]	0x81
9FH	Internal temperature detection reading								read only
A8H	Adjust the internal VCOM voltage value of the screen								0x36
ADH	VPG_PWM scanning mode selection, default 0x00, set to 0x30 when the input is in BT.656 interlaced mode								0x00
C3H	PWM value								0x70
C5H	Interlaced scanning control signal								0x00
C6H	Internal VCOM voltage enable control								0x00

4.2 Test Pattern Selection

The microdisplay is equipped with various test patterns, and when used, only a stable clock signal PCLK needs to be provided.

Address	Bit	Description
01H	bit5 – bit3	000: With registers 02H, 03H, 04H, 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: Checkerboard

4.3 Video Signal Transfer Format

4.3.1 Selection of Video Signal Format

Address	Bit	Description
01H	bit2 - bit0	000: 8bit - YCbCr, progressive mode, 8bit - BT.656, interlaced mode; 001: 16bit - YCbCr, 4:2:2 mode; 010: 24bit - YCbCr, 4:4:4 mode; 011: 24bit - RGB, 4:4:4 mode; 101: Test pattern;

When inputting video signals in different formats, the pin correspondence is shown below.

Interfaces	BT.656 (Interlaced)	YCbCr (Progressive)	YCbCr 4:2:2	YCbCr 4:4:4	RGB 4:4:4
DATA23	GND	GND	GND	Y[7]	R[7]
DATA22				Y[6]	R[6]
DATA21				Y[5]	R[5]
DATA20				Y[4]	R[4]
DATA19				Y[3]	R[3]
DATA18				Y[2]	R[2]
DATA17				Y[1]	R[1]
DATA16				Y[0]	R[0]
DATA15	Y/Cb/Cr[7]	Y/Cb/Cr[7]	Y[7]	Cb[7]	G[7]
DATA14	Y/Cb/Cr[6]	Y/Cb/Cr[6]	Y[6]	Cb[6]	G[6]
DATA13	Y/Cb/Cr[5]	Y/Cb/Cr[5]	Y[5]	Cb[5]	G[5]
DATA12	Y/Cb/Cr[4]	Y/Cb/Cr[4]	Y[4]	Cb[4]	G[4]
DATA11	Y/Cb/Cr[3]	Y/Cb/Cr[3]	Y[3]	Cb[3]	G[3]
DATA10	Y/Cb/Cr[2]	Y/Cb/Cr[2]	Y[2]	Cb[2]	G[2]
DATA9	Y/Cb/Cr[1]	Y/Cb/Cr[1]	Y[1]	Cb[1]	G[1]
DATA8	Y/Cb/Cr[0]	Y/Cb/Cr[0]	Y[0]	Cb[0]	G[0]
DATA7	GND	GND	Cb/Cr[7]	Cr[7]	B[7]
DATA6			Cb/Cr[6]	Cr[6]	B[6]
DATA5			Cb/Cr[5]	Cr[5]	B[5]
DATA4			Cb/Cr[4]	Cr[4]	B[4]
DATA3			Cb/Cr[3]	Cr[3]	B[3]
DATA2			Cb/Cr[2]	Cr[2]	B[2]
DATA1			Cb/Cr[1]	Cr[1]	B[1]
DATA0			Cb/Cr[0]	Cr[0]	B[0]

4.3.2 ITU-R BT.656 Format Signal Register Setting

The microdisplay supports ITU-R BT.656 signals in embedded synchronous format. Take standard PAL-D video as an example, the register settings when the image is centered are shown below.

Address	Value	Description
01H	0x00	BT.656 (interlaced) format: 0x00
05H	0x24	Embedded synchronization, interlaced scanning
0EH	0x60	H_Total: 0x360
0FH	0x03	
10H	0x04	Redundant pixels (left)
11H	0x20	H_Valid: 0x320
12H	0x03	
13H	0x04	Redundant pixels (right)
14H	0x2C	V_Valid: 0x12C
15H	0x01	
16H	0x02	Redundant rows (top)
17H	0x02	Redundant rows (down)
18H	0x38	V_Total: 0x138
19H	0x01	
ADH	0x30	VPG_PWM scanning mode selection, switch to row copy mode
C5H	0x12	Interlaced scanning control signal

Note:

When the input video signal is in the ITU-R BT.656 format, it is incompatible with the default 24bit-RGB format from the factory. Its brightness adjustment and other functions are special methods. Please contact Guozhao Optoelectronics Company for technical support.

4.3.3 YCbCr Format Signal Description

When the input digital video signal is in YCbCr encoding format, the chip needs to perform color space transformation on the YCbCr digital signal, and the transformation relationship is as follows.

$$R = Y + Cr \times 179/128 - 179$$

$$G = Y - Cb \times 44/128 - Cr \times 91/128 + 135$$

$$B = Y + Cb \times 227/128 - 227$$

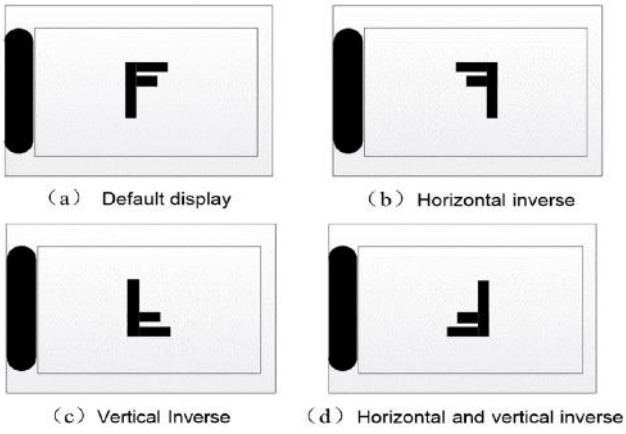
Note:

The use status of YCbCr encoding format is incompatible with the default factory 24bit-RGB format, so the use scope and method need to be redefined. To use YCbCr format, please contact Guozhao Optoelectronics Company for technical support.

4.4 Up / Down and Left / Right Inverse Display

The microdisplay supports inverse display of video images in both horizontal and vertical directions.

Address	Bit	Description
05H	bit1	Vertical display settings 0: Vertical normal display 1: Vertical inverse display
	bit0	Horizontal display settings 0: Horizontal normal display 1: Horizontal inverse display



(a) Default display (b) Horizontal inverse

(c) Vertical Inverse (d) Horizontal and vertical inverse

4.5 Image Display Position Setting

The microdisplay supports the display setting of the full-screen image at any position, and the horizontal and vertical offset position values can be set separately, with a maximum value of 0x04.

Address	Bit	Description
06H	bit5	Enable setting in horizontal position 0: Display start point moves to the right; 1: Display start point moves to the left;
	bit4-bit0	Number of columns to move, ranging from 0x00 to 0x04
07H	bit5	Enable setting in vertical position 0: Display start point moves down; 1: Display start point moves up;
	bit4-bit0	Number of rows to move, ranging from 0x00 to 0x04

4.6 Image Timed Movement

The microdisplay supports timed dynamic movement of the entire screen image in the horizontal or vertical direction. When the timed movement function is turned on, the entire screen image will automatically move at the set time interval in the order of down, right, up and left. The number of rows/columns moved up and down and left and right will be the same, and finally return to the initial position before movement.

Address	Bit	Description
08H	bit6	Horizontal timed movement control 0: Dynamic movement function is turned off; 1: Dynamic movement function is turned on;
	bit5	Vertically 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 from 0x00 to 0x04
09H	bit7-bit0	The time interval for movement STICK_TIME, with a unit time interval of one frame; Register 09H value is STICK_TIME [7:0]; Register 0AH value is STICK_TIME [15:8]; Register 0BH value is STICK_TIME[23:16]; Register 0CH value is STICK_TIME[31:24];
0AH	bit7-bit0	
0BH	bit7-bit0	
0CH	bit7-bit0	

Note:

There are 4 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.

4.7 Temperature Detection

The microdisplay has temperature detection function, and the temperature conversion formula is:

$$T = 0.54 \times Reg(9FH) - 52$$

T is the actual temperature value and Reg(9FH) is the reading of the temperature register 9FH.

Note:

1. The temperature reading changes greatly during the initialization of the microdisplay, and it is recommended to read the temperature value after a few seconds of stabilization;
2. During normal operation, the temperature reading update cycle is four frame image cycles.

4.8 Brightness Adjustment

The factory default brightness of the microdisplay is about 150cd/m^2, and the recommended brightness range is 50cd/m^2 ~ 300cd/m^2. The user can adjust the brightness appropriately according to the needs of the use. The brightness adjustment method is PWM adjustment method, the corresponding configuration register address is C3H, and adjust the brightness by changing the values of register. The factory default value for the C3H register is 0x70. The recommended configuration parameter value range at normal temperature is between 20H to FFH, and the adjustment step is 0x04. The higher the PWM value, the higher the brightness, and the PWM value corresponding to maximum brightness is 0xFF.

4.9 Brightness-Temperature Compensation

Due to the varying full temperature features of silicon-based OLED microdisplay, the brightness increases at high temperature and decreases at low temperature. In order to improve the consistency of brightness at different temperatures, it is recommended to perform brightness compensation. The reference formula is as follows:

$$X = X_0 + \frac{T - T_0}{3}$$

X is the set value of the A8H register at the current temperature, X_0 is the set value of the A8H register at the reference temperature, T is the current temperature, and T_0 is the reference temperature (usually around 25 °C).

Note:

At any temperature, the A8H register configuration value cannot be less than 0x18. If it is less than 0x18, the product will have overcurrent protection and will be damaged or burned for a long time.

4.10 Image Brightness Digital Adjustment

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

$$Y = Y_0 + (BRT/2 - 64)$$

Y is the adjusted data value, Y_0 is the input image data value, and BRT is the configuration value of the 91H register. After adjustment, the low gray stage and the high gray stage may produce data overflow, resulting in image distortion, and it is recommended to configure it as appropriate.

4.11 Image Contrast Adjustment

The microdisplay has the image contrast adjustment function, that is, the input image data is processed in the same proportion multiplier mode to achieve the effect of image contrast change. The image contrast adjustment register address is 95H and 96H, and the adjustment range is 0x000 to 0x1FF.

The contrast adjustment formula is as follows.

$$Y = Y_0 \times \ CONT / 255$$

Y is the adjusted data value, Y0 is the input image data value, and CONT is the 95H and 96H register value.

4.12 I^2C Interface

The user can write or read the values of the register inside the screen through the I^2C interface. The I^2C interface communication mode conforms to the standard communication protocol. The host can realize functions of test pattern selection, brightness adjustment, contrast adjustment, temperature reading and so on by reading and writing internal registers of the microdisplay.

The communication rate supports 10KHz~400KHz.

Note:

1. SDA and SCL signals must be pulled up with resistors to V_{IH};
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 reduced.

4.12.1 Slave Address Selection

The microdisplay is used as a slave device. Its address can be selected by 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	Instructions	Bit7 (MSB)	Bit6	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

4.12.2 Data Transfer Format

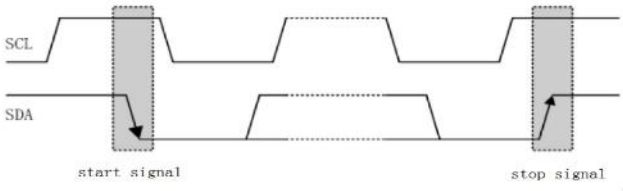
4.12.2.1 Flag Bit Description

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

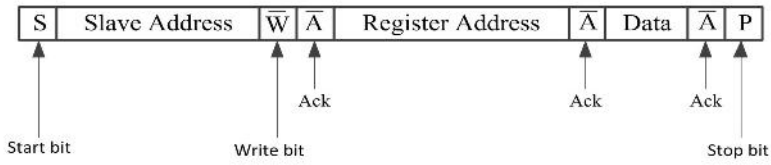
Pause signal (P): the change of SDA line from low level to high level when the SCL line is high level;

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

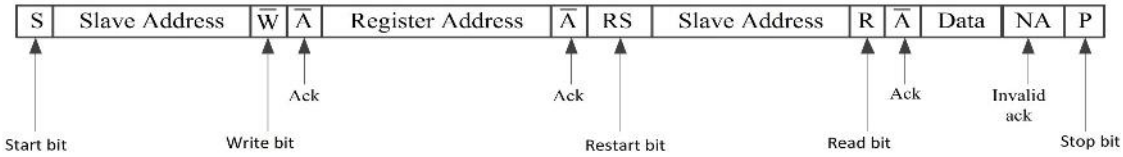
Negative answer (NAK): SDA at high level indicates negative answer;



4.12.2.2 Write Sequence



4.12.2.3 Read Sequence



5.2.2 Inspection Standards for Defect Points

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 dead pixels	full-screen ≤ 1
2	3 or more consecutive dead pixels	0
3	Bright point	No bright points on the black field
4	Bad line	No

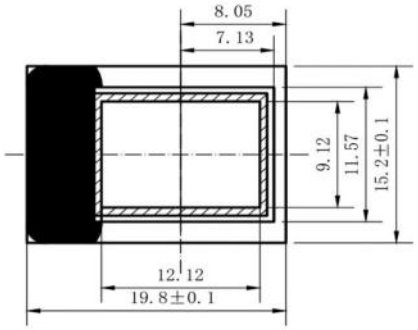
5.2.3 Test Conditions

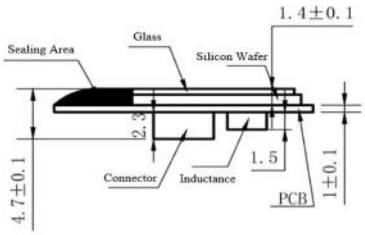
1) Use a dedicated test fixture to light up the microdisplay, and inspect the white field display of the microdisplay under the microscope's bright field at a magnification of 100× (objective 10×, eyepiece 10×);
2) Use a dedicated test fixture to light up the microdisplay, the microdisplay shows the black field, and use the 12× eyepiece to observe the bright points.

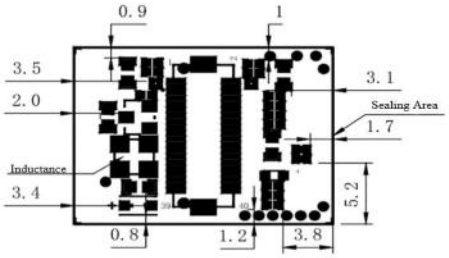
6 Structure and Package

6.1 Product Structure

The overall size of the microdisplay is 19.8mm×15.2mm, and other dimensions are shown below.

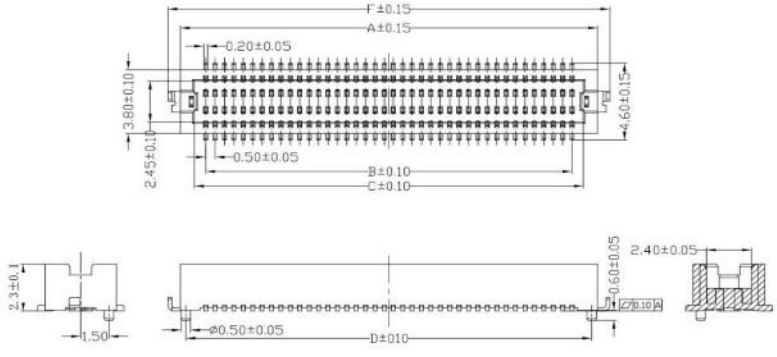






6.2 Connector Dimension

Unit: mm



Number of Contacts	Dimension(mm)					
	A	B	C	D	E	F
40	12.20	9.50	10.70	11.60	10.80	13.52