

Product Specification

NHD-2.23-12832UCB3

Graphic OLED Display Module

NHD-	Newhaven Display
2.23-	2.23" Diagonal Size
12832-	128 x 32 Pixel Resolution
UC-	Model
B-	Emitting Color: Blue
3-	3V Power Supply

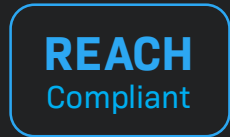


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Additional Resources

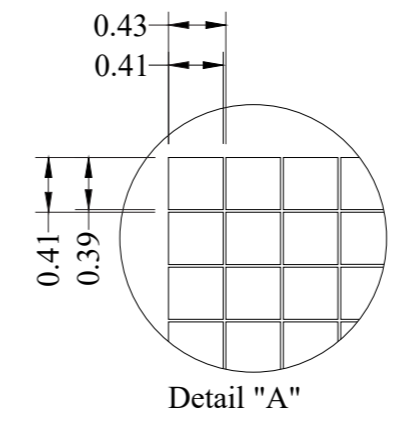
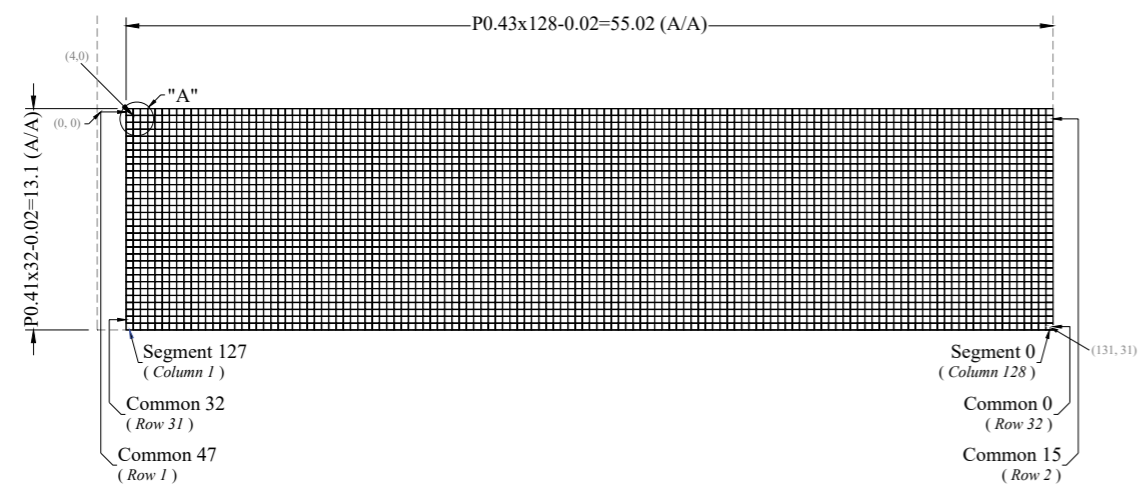
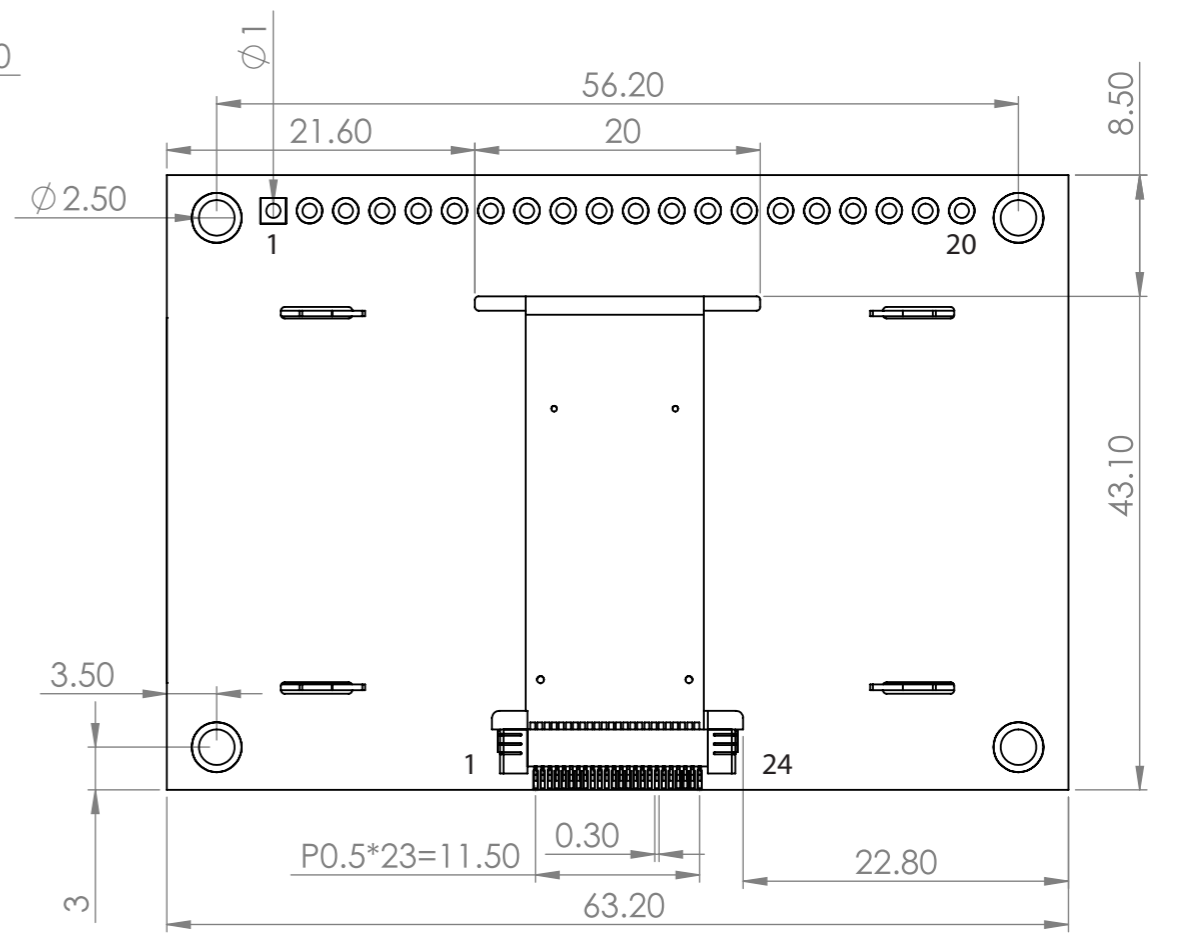
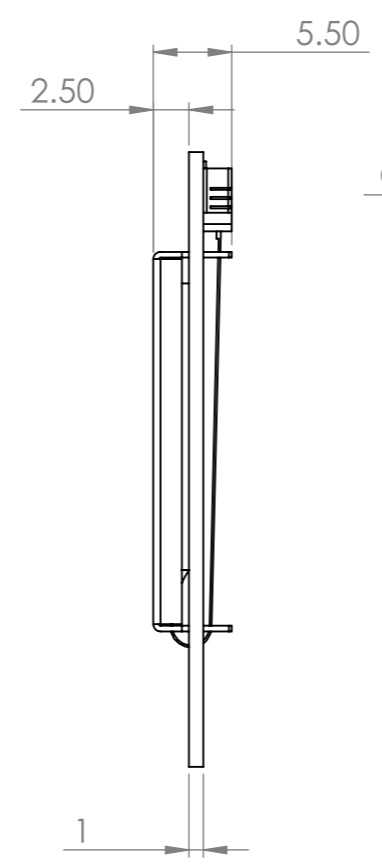
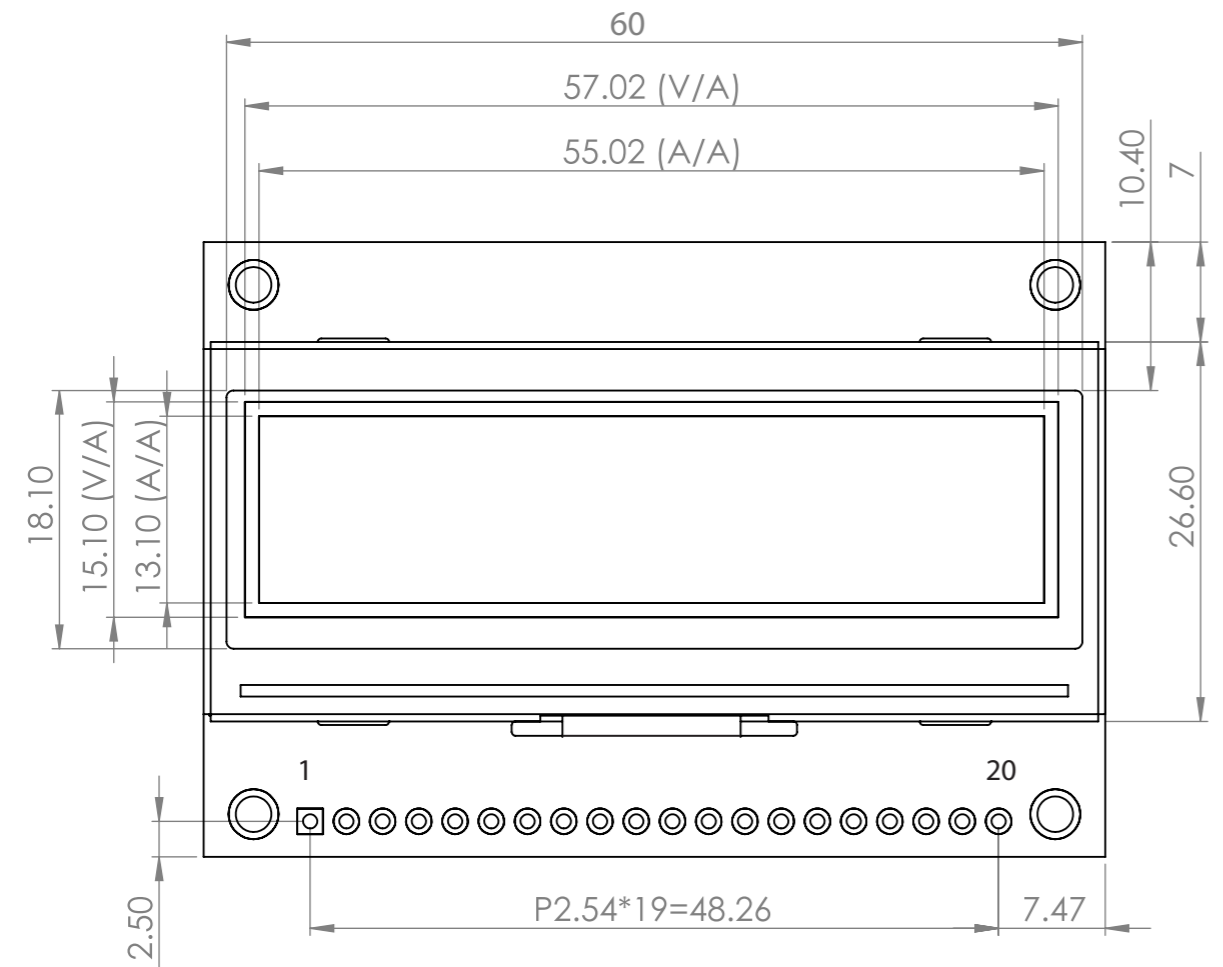
- **Support Forum:** <https://support.newhavendisplay.com/hc/en-us/community/topics>
- **GitHub:** <https://github.com/newhavendisplay>
- **Example Code:** <https://support.newhavendisplay.com/hc/en-us/categories/4409527834135-Example-Code/>
- **Knowledge Center:** https://www.newhavendisplay.com/knowledge_center.html
- **Quality Center:** https://www.newhavendisplay.com/quality_center.html
- **Precautions for using LCDs/LCMs:** <https://www.newhavendisplay.com/specs/precautions.pdf>
- **Warranty / Terms & Conditions:** <https://www.newhavendisplay.com/terms.html>

Document Revision History

Revision	Date	Description	Changed By
0	05/01/2011	Initial Product Release	-
1	02/22/2013	Electrical characteristics and mechanical drawing updated	JN
2	08/03/2020	Included MIN Supply Voltage & Reformatted 2D Mechanical Drawing	AS
3	09/01/2020	Updated 2D Mechanical Drawing	AS
4	02/22/2024	Contrast Ratio Updated	KL

Mechanical Drawing

Newhaven Display
 NHD-2.23-12832UCB3
 Date Code
 Part Label (type/format may vary)



- Product Description: 2.23" 128x32 Graphic OLED**
1. Driver IC: SSD1305
 2. Interface: 8-bit 6800/8080 Parallel, 3/4-wire SPI, I²C
 3. Power Requirement: 3.3V OLED
 4. Optical Features: Blue Color, Anti-Glare, Full View
 5. Recommended Pin Header: 1x20pin 2.54mm pitch

Standard Tolerance: (Unless otherwise specified) Linear: ±0.3mm		
	Drawing/Part Number: NHD-2.23-12832UCB3	Revision: -
Unless otherwise specified: • Dimensions are in Millimeters • Third Angle Projection	Drawn By: K. Lewis	Approved By: K. Lewis
	Drawn Date: 02/22/2024	Approved Date: 02/22/2024
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Pin Description

Parallel Interface:

Pin No.	Symbol	External Connection	Function Description
1	VSS	Power Supply	Ground
2	VDD	Power Supply	Supply Voltage for OLED and logic.
3	NC	-	No Connect
4	D/C	MPU	Register select signal. D/C=0: Command, D/C=1: Data
5	R/W or /WR	MPU	6800-interface: Read/Write select signal, R/W=1: Read R/W: =0: Write 8080-interface: Active LOW Write signal.
6	E or /RD	MPU	6800-interface: Operation enable signal. Falling edge triggered. 8080-interface: Active LOW Read signal.
7-14	DB0 – DB7	MPU	8-bit Bi-directional data bus lines.
15	NC	-	No Connect
16	/RES	MPU	Active LOW Reset signal.
17	/CS	MPU	Active LOW Chip Select signal.
18	NC	-	No Connect
19	BS2	MPU	MPU Interface Select signal.
20	BS1	MPU	MPU Interface Select signal.

Serial Interface:

Pin No.	Symbol	External Connection	Function Description
1	VSS	Power Supply	Ground
2	VDD	Power Supply	Supply Voltage for OLED and logic.
3	NC	-	No Connect
4	D/C	MPU	Register select signal. D/C=0: Command, D/C=1: Data
5-6	VSS	Power Supply	Ground
7	SCLK	MPU	Serial Clock signal.
8	SDIN	MPU	Serial Data Input signal.
9	NC	-	No Connect
10-14	VSS	Power Supply	Ground
15	NC	-	No Connect
16	/RES	MPU	Active LOW Reset signal.
17	/CS	MPU	Active LOW Chip Select signal.
18	NC	-	No Connect
19	BS2	MPU	MPU Interface Select signal.
20	BS1	MPU	MPU Interface Select signal.

I2C Interface:

Pin No.	Symbol	External Connection	Function Description
1	VSS	Power Supply	Ground
2	VDD	Power Supply	Supply Voltage for OLED and logic.
3	NC	-	No Connect
4	SA0	MPU	Slave Address Selection signal.
5-6	VSS	Power Supply	Ground
7	SCL	MPU	Serial Clock signal.
8	SDA _{IN}	MPU	Serial Data input signal (pins 8 and 9 can be tied together).
9	SDA _{OUT}	MPU	Serial Data output signal (pin9 can be no connect).
10-14	VSS	Power Supply	Ground
15	NC	-	No Connect
16	/RES	MPU	Active LOW Reset signal.
17	VSS	Power Supply	Ground
18	NC	-	No Connect
19	BS2	MPU	MPU Interface Select signal.
20	BS1	MPU	MPU Interface Select signal.

Interface Selection

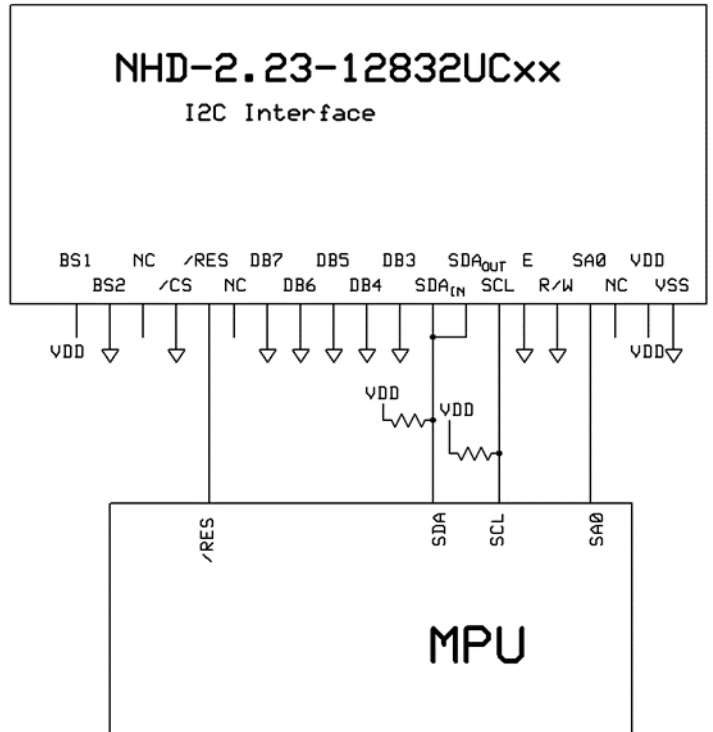
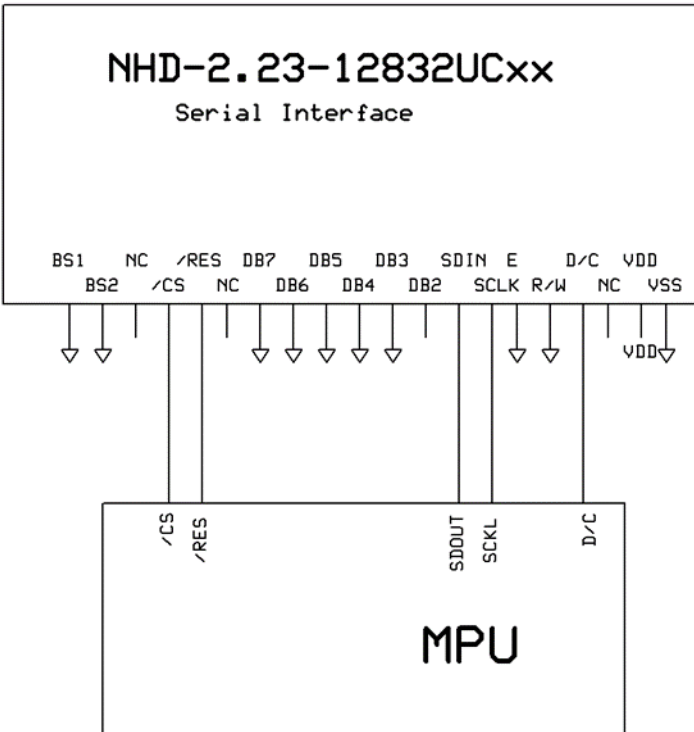
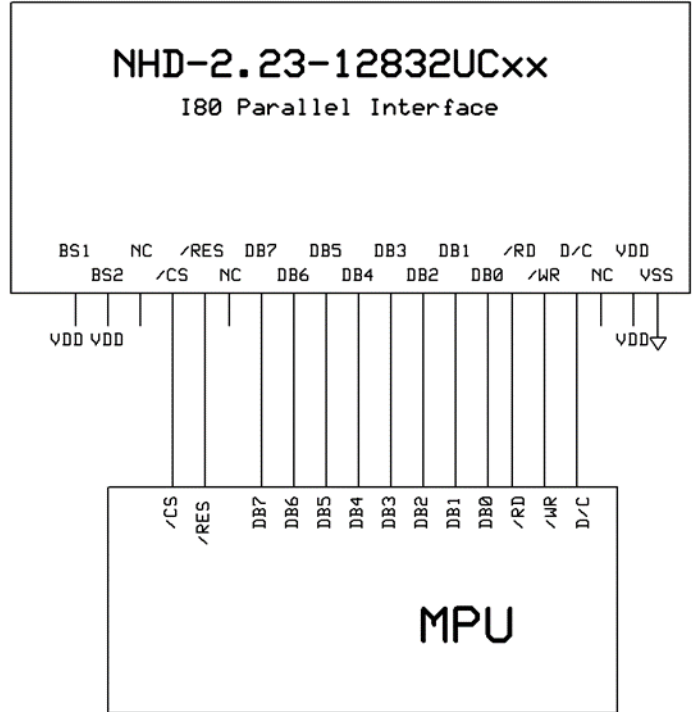
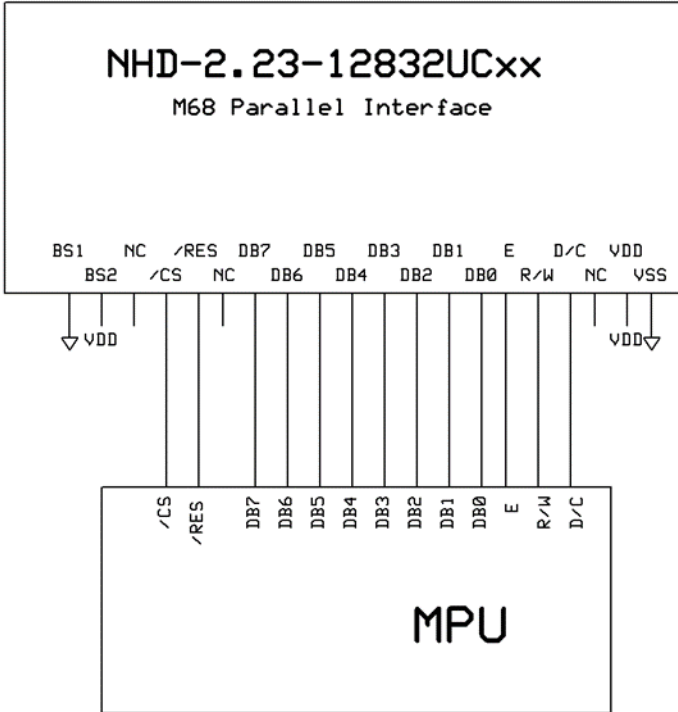
MPU Interface Pin Selections

Pin Name	6800 Parallel 8-bit interface	8080 Parallel 8-bit interface	Serial Interface	I2C Interface
BS2	1	1	0	0
BS1	0	1	0	1

MPU Interface Pin Assignment Summary

Bus Interface	Data/Command Interface								Control Signals				
	D7	D6	D5	D4	D3	D2	D1	D0	E	R/W	/CS	D/C	/RES
8-bit 6800	D[7:0]								E	R/W	/CS	D/C	/RES
8-bit 8080	D[7:0]								/RD	/WR	/CS	D/C	/RES
SPI	Tie LOW				NC	SDIN	SCLK	Tie LOW		/CS	D/C	/RES	
I2C	Tie LOW				SDA _{IN}	SDA _{OUT}	SCL	Tie LOW			SA0	/RES	

Wiring Diagrams



Electrical Characteristics

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating Temperature Range	Top	Absolute Max	-40	-	+85	°C
Storage Temperature Range	Tst	Absolute Max	-40	-	+90	°C
Supply Voltage	VDD		3.0	3.3	3.5	V
Supply Current (logic)	IDD	Ta=25°C, VDD=3.3V	-	180	300	µA
Supply Current (display)	ICC	50% ON, VDD=3.3V	-	62	70	mA
		100% ON, VDD=3.3V	-	113	120	mA
Sleep Mode Current	IDD+ICCSLEEP		-	3	15	µA
"H" Level input	Vih		0.8*VDD	-	VDD	V
"L" Level input	Vil		VSS	-	0.2*VDD	V
"H" Level output	Voh		0.9*VDD	-	VDD	V
"L" Level output	Vol		VSS	-	0.1*VDD	V

Optical Characteristics

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Viewing Angle – Top	AV		-	80	-	°
Viewing Angle – Bottom	AV		-	80	-	°
Viewing Angle – Left	AH		-	80	-	°
Viewing Angle – Right	AH		-	80	-	°
Contrast Ratio	Cr		10,000:1	-	-	-
Response Time (rise)	Tr	-	-	10	-	µs
Response Time (fall)	Tf	-	-	10	-	µs
Brightness		50% checkerboard	100	120	-	cd/m ²
Lifetime		Ta=25°C, 50% checkerboard	10,000	-	-	Hrs

Note: Lifetime at typical temperature is based on accelerated high-temperature operation. Lifetime is tested at average 50% pixels on and is rated as Hours until **Half-Brightness**. The Display OFF command can be used to extend the lifetime of the display.

Luminance of active pixels will degrade faster than inactive pixels. Residual (burn-in) images may occur. To avoid this, every pixel should be illuminated uniformly.

Controller Information

Built-in SSD1305 Controller: <https://support.newhavendisplay.com/hc/en-us/articles/4414488972695--SSD1305>

Table of Commands

Instruction	Code										Description	RESET value
	D/C	HEX	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Set Lower Column Start Address	0	00~0F	0	0	0	0	X3	X2	X1	X0	Set the lower nibble of the column start address register for Page Addressing Mode.	0
Set Higher Column Start Address	0	10~1F	0	0	0	1	X3	X2	X1	X0	Set the higher nibble of the column start address register for Page Addressing Mode.	0
Set Memory Addressing Mode	0	20 A[1:0]	0 *	0 *	1 *	0 *	0 *	0 *	0 A1	0 A0	A[1:0] = 00b, Horizontal Addressing Mode A[1:0] = 01b, Vertical Addressing Mode A[1:0] = 10b, Page Addressing Mode A[1:0] = 11b, Invalid	10b
Set Column Address	0	21 A[7:0] B[7:0]	0 A7 B7	0 A6 B6	1 A5 B5	0 A4 B4	0 A3 B3	0 A2 B2	0 A1 B1	1 A0 B0	Setup column start and end address A[7:0]: Column start address. Range: 0-131d B[7:0]: Column end address. Range: 0-131d	0 131d
Set Page Address	0	22 A[2:0] B[2:0]	0 * *	0 * *	1 * *	0 * *	0 * *	0 A2 B2	1 A1 B1	0 A0 B0	Setup page start and end address A[2:0]: Page start address. Range: 0-7d B[2:0]: Page end address. Range: 0-7d	0 7d
Set Display Start Line	0	40~7F	0	1	X5	X4	X3	X2	X1	X0	Set display RAM display start line register from 0-63d.	0
Set Contrast Control	0	81 A[7:0]	1 A7	0 A6	0 A5	0 A4	0 A3	0 A2	0 A1	1 A0	Double byte command to select 1 out of 256 contrast steps. Contrast increases as the value increases.	0x80
Set Brightness	0	82 A[7:0]	1 A7	0 A6	0 A5	0 A4	0 A3	0 A2	1 A1	0 A0	Double byte command to select 1 out of 256 brightness steps. Brightness increases as the value increases.	0x80
Set Look-Up Table	0	91 X[5:0] A[5:0] B[5:0] C[5:0]	1 * * * *	0 * * * *	0 X5 A5 B5 C5	1 X4 A4 B4 C4	0 X3 A3 B3 C3	0 X2 A2 B2 C2	0 X1 A1 B1 C1	1 X0 A0 B0 C0	Set current drive pulse width of Bank 0, Color A, B and C. Bank 0: X[5:0] = 31 to 63. Pulse width set to 32 to 64 clocks. Color A: X[5:0] = 31 to 63. Pulse width set to 32 to 64 clocks. Color B: X[5:0] = 31 to 63. Pulse width set to 32 to 64 clocks. Color C: X[5:0] = 31 to 63. Pulse width set to 32 to 64 clocks. Note: Color D pulse width is fixed at 64 clocks.	0x31 0x3F 0x3F 0x3F
Set Bank Color of Bank1 to Bank16 (Page 0)	0	92 A[7:0] B[7:0] C[7:0] D[7:0]	1 A7 B7 C7 D7	0 A6 B6 C6 D6	0 A5 B5 C5 D5	1 A4 B4 C4 D4	0 A3 B3 C3 D3	0 A2 B2 C2 D2	1 A1 B1 C1 D1	0 A0 B0 C0 D0	Sets the bank color of Bank1~Bank16 to any one of the 4 colors A,B,C, and D. A[1:0] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK1. A[3:2] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK2. . . . D[5:4] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK15. D[7:6] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK16.	
Set Bank Color of Bank17 to Bank32 (Page 1)	0	93 A[7:0] B[7:0]	1 A7 B7	0 A6 B6	0 A5 B5	1 A4 B4	0 A3 B3	0 A2 B2	1 A1 B1	1 A0 B0	Sets the bank color of Bank17~Bank32 to any one of the 4 colors A,B,C, and D. A[1:0] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK17.	

		C[7:0] D[7:0]	C7 D7	C6 D6	C5 D5	C4 D4	C3 D3	C2 D2	C1 D1	C0 D0	A[3:2] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK18. . . . D[5:4] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK31. D[7:6] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK32.	
Set Segment Remap	0	A0/A1	1	0	1	0	0	0	0	X0	X[0] = 0; Column address 0 is mapped to SEG0 X[0] = 1; Column address 131 is mapped to SEG0	0
Entire Display ON	0	A4/A5	1	0	1	0	0	1	0	X0	X[0] = 0; Resume RAM content display. Output follows RAM content. X[0] = 1; Entire display ON. Output ignores RAM content.	0
Set Normal/ Inverse Display	0	A6/A7	1	0	1	0	0	1	1	X0	X[0] = 0; Normal display. X[0] = 1; Inverse display.	0
Set Multiplex Ratio	0	A8 A[5:0]	1 *	0 *	1 A5	0 A4	1 A3	0 A2	0 A1	0 A0	Set MUX ratio to N+1 MUX N=A[5:0]; from 16MUX to 64MUX (0 to 14 are invalid)	64
Dim mode setting	0	AB A[3:0] B[7:0] C[7:0]	1 * B7 C7	0 * B6 C6	1 * B5 C5	0 * B4 C4	1 A3 B3 C3	0 A2 B2 C2	1 A1 B1 C1	1 A0 B0 C0	A[3:0] = reserved. Set as 0000b B[7:0] = Set contrast for BANK0. Range 0-255d. Refer to command 81h. C[7:0] = Set brightness for color bank. Range 0-255d. Refer to command 82h.	
Master configuration	0	AD AE	1 1	0 0	1 0	0 0	1 1	1 1	0 1	1 0	Selects external VCC supply	AEh
Set Display ON/ OFF	0	AC/ AE/ AF	1	0	1	0	1	1	A1	A0	ACh = Display ON in dim mode AEh = Display OFF (sleep mode) AFh = Display ON in normal mode	AEh
Set Page Start Address	0	B0~B7	1	0	1	1	0	X2	X1	X0	Set GDRAM Page Start Address for Page Addressing Mode using X[2:0]. PAGE0~PAGE7	
Set COM Output Scan Direction	0	C0/C8	1	1	0	0	X3	0	0	0	X[3] = 0; Normal mode. Scan from COM0 to COM[N-1] X[3] = 1; Remapped mode. Scan from COM[N-1] to COM0	0
Set Display Offset	0	D3 A[5:0]	1 *	1 *	0 A5	1 A4	0 A3	0 A2	1 A1	1 A0	Set vertical shift by COM from 0~63.	0
Set Display Clock Divide Ratio / Oscillator Frequency	0	D5 A[7:0]	1 A7	1 A6	0 A5	1 A4	0 A3	1 A2	0 A1	1 A0	A[3:0] = Define the divide ratio of the display clocks. Divide ratio = A[3:0] +1 A[7:4] = Set the Oscillator Frequency. Frequency increases with the value of A[7:4]. Range 0000b~1111b.	0000b 0111b
Set Area Color Mode ON/OFF & Low Power Display Mode	0	D8 X[5:0]	1 0	1 0	0 X5	1 X4	1 0	0 X2	0 0	0 X0	X[5:4] = 00b; Monochrome mode X[5:4] = 11b; Area Color mode X[2] = 0 and X[0] = 0; Normal power mode X[2] = 1 and X[0] = 1; Set low power display mode	00 00
Set Pre-charge Period	0	D9 A[7:0]	1 A7	1 A6	0 A5	1 A4	1 A3	0 A2	0 A1	1 A0	A[3:0] = Phase 1 period of up to 15 DCLK clocks. 0 is invalid. A[7:4] = Phase 2 period of up to 15 DCLK clocks. 0 is invalid.	2h 2h

Set COM pins Hardware configuration	0	DA X[5:4]	1 0	1 0	0 X5	1 X4	1 0	0 0	1 1	0 0	X[4] = 0; Sequential COM pin configuration X[4] = 1; Alternative COM pin configuration X[5] = 0; Disable COM Left/Right remap X[5] = 1; Enable COM Left/Right remap	1 1
Set VCOMH Deselect Level	0	DB A[5:2]	1 0	1 0	0 A5	1 A4	1 A3	0 A2	1 0	1 0	A[5:2] = 0000b; VCOMH = ~0.43*VCC A[5:2] = 1101b; VCOMH = ~0.77*VCC A[5:2] = 1111b; VCOMH = ~0.83*VCC	1101
Enter Read Modify Write mode	0	E0	1	1	1	0	0	0	0	0	Enter the Read/Modify/Write mode.	
NOP	0	E3	1	1	1	0	0	0	1	1	Command for No Operation	
Exit Read Modify Write mode	0	EE	1	1	1	0	1	1	1	0	Exit the Read/Modify/Write mode.	

For detailed instruction information, see datasheet: http://www.newhavendisplay.com/app_notes/SSD1305.pdf

MPU Interface

For detailed timing information, see datasheet: http://www.newhavendisplay.com/app_notes/SSD1305.pdf

6800-MPU Parallel Interface

The parallel interface consists of 8 bi-directional data pins, R/W, D/C, E, and /CS. A LOW on R/W indicates write operation, and HIGH on R/W indicates read operation. A LOW on D/C indicates “Command” read or write, and HIGH on D/C indicates “Data” read or write. The E input serves as data latch signal, while /CS is LOW. Data is latched at the falling edge of E signal.

Function	E	R/W	/CS	D/C
Write Command	↓	0	0	0
Read Status	↓	1	0	0
Write Data	↓	0	0	1
Read Data	↓	1	0	1

8080-MPU Parallel Interface

The parallel interface consists of 8 bi-directional data pins, /RD, /WR, D/C, and /CS. A LOW on D/C indicates “Command” read or write, and HIGH on D/C indicates “Data” read or write. A rising edge of /RS input serves as a data read latch signal while /CS is LOW. A rising edge of /WR input serves as a data/command write latch signal while /CS is LOW.

Function	/RD	/WR	/CS	D/C
Write Command	1	↑	0	0
Read Status	↑	1	0	0
Write Data	1	↑	0	1
Read Data	↑	1	0	1

Alternatively, /RD and /WR can be kept stable while /CS serves as the data/command latch signal.

Function	/RD	/WR	/CS	D/C
Write Command	1	0	↑	0
Read Status	0	1	↑	0
Write Data	1	0	↑	1
Read Data	0	1	↑	1

Serial Interface

The serial interface consists of serial clock SCLK, serial data SDIN, D/C, and /CS. D0 acts as SCLK and D1 acts as SDIN. D2 should be left open. D3~D7, E, and R/W should be connected to GND.

Function	/RD	/WR	/CS	D/C	D0
Write Command	0	0	0	0	↑
Write Data	0	0	0	1	↑

SDIN is shifted into an 8-bit shift register on every rising edge of SCLK in the order of D7, D6,...D0. D/C is sampled on every eighth clock and the data byte in the shift register is written to the GDRAM or command register in the same clock.

Note: Read is not available in serial mode.

I²C Interface

The I2C interface consists of a slave address bit SA0, I2C-bus data signal SDA, and I2C-bus clock signal SCL. D1 and D2 can be tied together, and act as SDA. D0 acts as SCL. Both the data and clock signals must be connected to pull-up resistors. /RES is used to initialize the device.

Note: SA0 bit allows the device to have a slave address of either “0111100” or “0111101”.

Note: Data and acknowledgement are sent through the SDA. The ITO track resistance and the pull-up resistance at SDA becomes a voltage potential divider. As a result, it may not be possible to attain a valid logic “0” level on SDA for the ACK signal. SDA_{IN} must be connected, but SDA_{OUT} may be disconnected and the ACK signal will be ignored on the I2C bus.

For detailed protocol information, see datasheet: http://www.newhavendisplay.com/app_notes/SSD1305.pdf

Example Initialization Sequence:

```
Set_Display_On_Off(0x00); // Display Off (0x00/0x01)
Set_Display_Clock(0x10); // Set Clock as 160 Frames/Sec
Set_Multiplex_Ratio(0x1F); // 1/32 Duty (0x0F~0x3F)
Set_Display_Offset(0x00); // Shift Mapping RAM Counter (0x00~0x3F)
Set_Start_Line(0x00); // Set Mapping RAM Display Start Line (0x00~0x3F)
Set_Master_Config(0x00); // Disable Embedded DC/DC Converter (0x00/0x01)
Set_Area_Color(0x05); // Set Monochrome & Low Power Save Mode
Set_Addresssing_Mode(0x02); // Set Page Addressing Mode (0x00/0x01/0x02)
Set_Segment_Remap(0x01); // Set SEG/Column Mapping (0x00/0x01)
Set_Common_Remap(0x08); // Set COM/Row Scan Direction (0x00/0x08)
Set_Common_Config(0x10); // Set Alternative Configuration (0x00/0x10)
Set_LUT(0x3F,0x3F,0x3F,0x3F); // Define All Banks Pulse Width as 64 Clocks
Set_Contrast_Control(Brightness); // Set SEG Output Current
Set_Area_Brightness(Brightness); // Set Brightness for Area Color Banks
Set_Precharge_Period(0xD2); // Set Pre-Charge as 13 Clocks & Discharge as 2 Clock
Set_VCOMH(0x08); // Set VCOM Deselect Level
Set_Entire_Display(0x00); // Disable Entire Display On (0x00/0x01)
Set_Inverse_Display(0x00); // Disable Inverse Display On (0x00/0x01)
Fill_RAM(0x00); // Clear Screen
Set_Display_On_Off(0x01); // Display On (0x00/0x01)
```

Quality Information

Test Item	Content of Test	Test Condition	Note
High Temperature storage	Test the endurance of the display at high storage temperature.	+90°C , 240hrs	2
Low Temperature storage	Test the endurance of the display at low storage temperature.	-40°C , 240hrs	1,2
High Temperature Operation	Test the endurance of the display by applying electric stress (voltage & current) at high temperature.	+85°C 240hrs	2
Low Temperature Operation	Test the endurance of the display by applying electric stress (voltage & current) at low temperature.	-40°C , 240hrs	1,2
High Temperature / Humidity Operation	Test the endurance of the display by applying electric stress (voltage & current) at high temperature with high humidity.	+60°C , 90% RH , 240hrs	1,2
Thermal Shock resistance	Test the endurance of the display by applying electric stress (voltage & current) during a cycle of low and high temperatures.	-40°C,30min -> 25°C,5min -> 85°C,30min = 1 cycle 100 cycles	
Vibration test	Test the endurance of the display by applying vibration to simulate transportation and use.	10-22Hz , 15mm amplitude. 22-500Hz, 1.5G 30min in each of 3 directions X,Y,Z	3
Atmospheric Pressure test	Test the endurance of the display by applying atmospheric pressure to simulate transportation by air.	115mbar, 40hrs	3
Static electricity test	Test the endurance of the display by applying electric static discharge.	VS=800V, RS=1.5kΩ, CS=100pF One time	

Note 1: No condensation to be observed.

Note 2: Conducted after 2 hours of storage at 25°C, 0%RH.

Note 3: Test performed on product itself, not inside a container.

Evaluation Criteria:

- 1: Display is fully functional during operational tests and after all tests, at room temperature.
- 2: No observable defects.
- 3: Luminance >50% of initial value.
- 4: Current consumption within 50% of initial value

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