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NHD-2.23-12832UCW3

Graphic OLED Display Module

NHD-	Newhaven Display
2.23-	2.23” Diagonal Size
12832-	128 x 32 Pixel Resolution
UC-	Model
W-	Emitting Color: White
3-	+3V Power Supply

Newhaven Display International, Inc.

2661 Galvin Ct.

Elgin IL, 60124

Ph: 847-844-8795 Fax: 847-844-8796

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Document Revision History

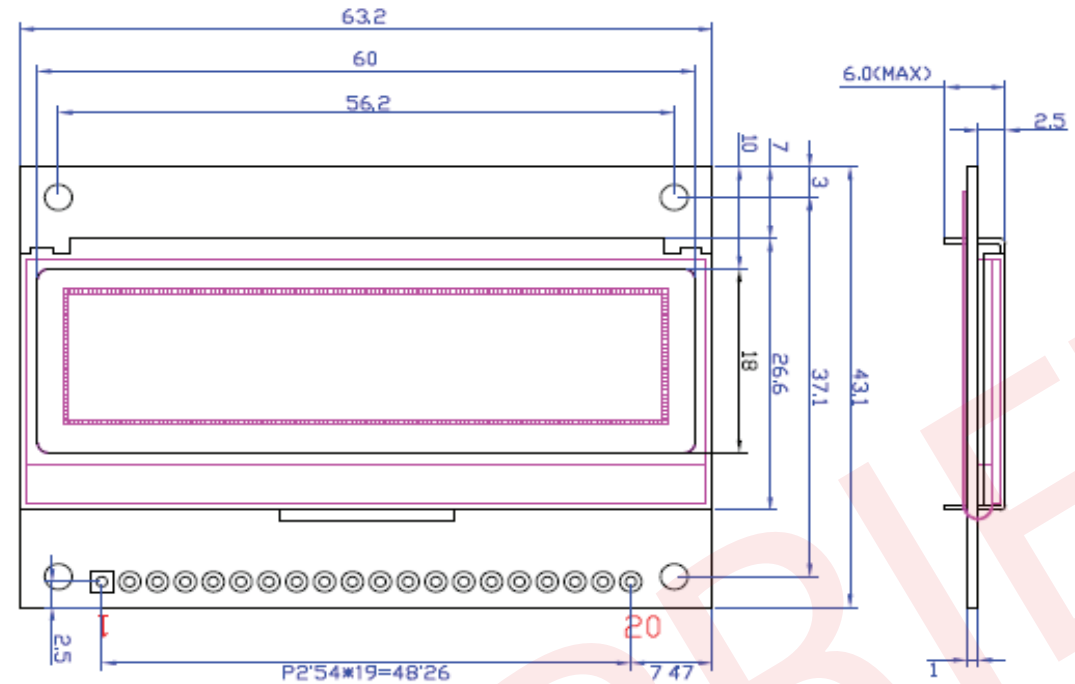
Revision	Date	Description	Changed by
0	7/27/15	Initial Product Release	SB
1	6/28/17	Datasheet Reformat	SB

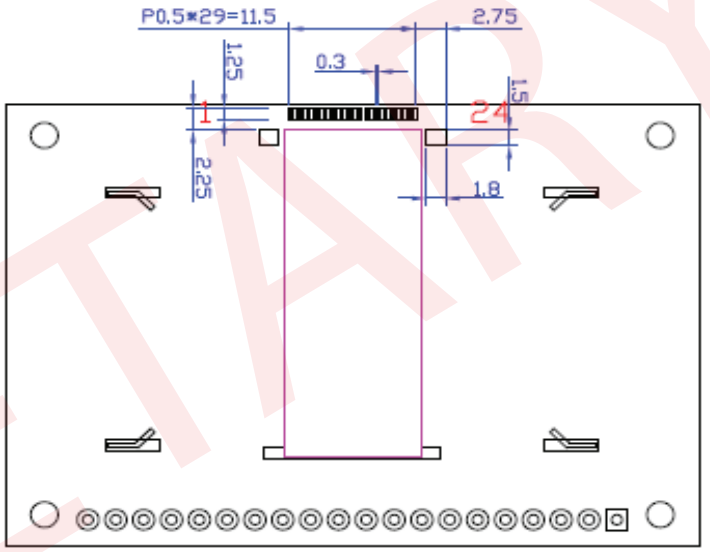
Functions and Features

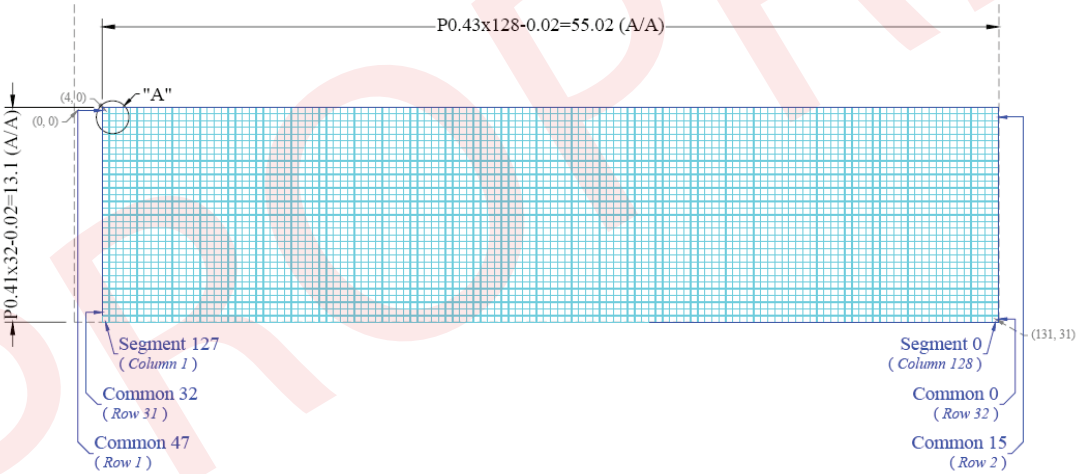
- **128 x 32 pixel resolution**
- **Built-in SSD1305 controller**
- **Parallel or serial MPU interface**
- **Single, low voltage power supply**
- **RoHS compliant**

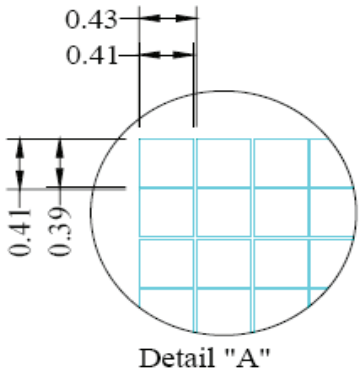
Mechanical Drawing

Rev	Description	Date









Detail "A"

Unit		
mm	NEWHAVEN DISPLAY INTERNATIONAL	
Gen. Tol.	Date	Part Number:
±0.3	06/28/17	NHD-2.23-12832UCW3

PROPRIETARY

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Interface Description

Parallel Interface:

Pin No.	Symbol	External Connection	Function Description
1	V_{SS}	Power Supply	Ground
2	V_{DD}	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	V_{SS}	Power Supply	Ground
2	V_{DD}	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	V_{SS}	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	V_{SS}	Power Supply	Ground
2	V_{DD}	Power Supply	Supply Voltage for OLED and logic.
3	NC	-	No Connect
4	SA0	MPU	Slave Address Selection signal.
5-6	V_{SS}	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	V_{SS}	Power Supply	Ground
18	NC	-	No Connect
19	BS2	MPU	MPU Interface Select signal.
20	BS1	MPU	MPU Interface Select signal.

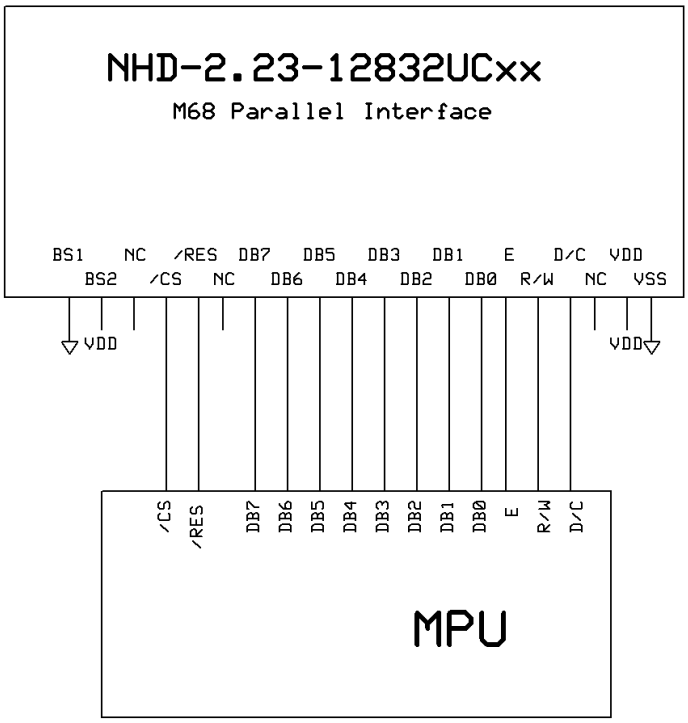
MPU Interface Pin Selections

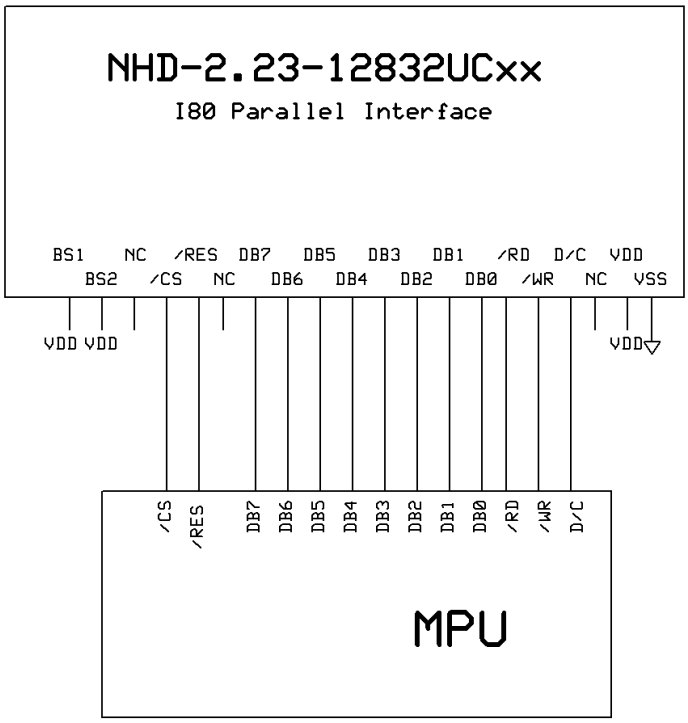
Pin Name	6800 Parallel 8-bit interface	8080 Parallel 8-bit interface	Serial Interface	I2C Interface
BS2	1	1	0	0
BS1	0	1	0	1

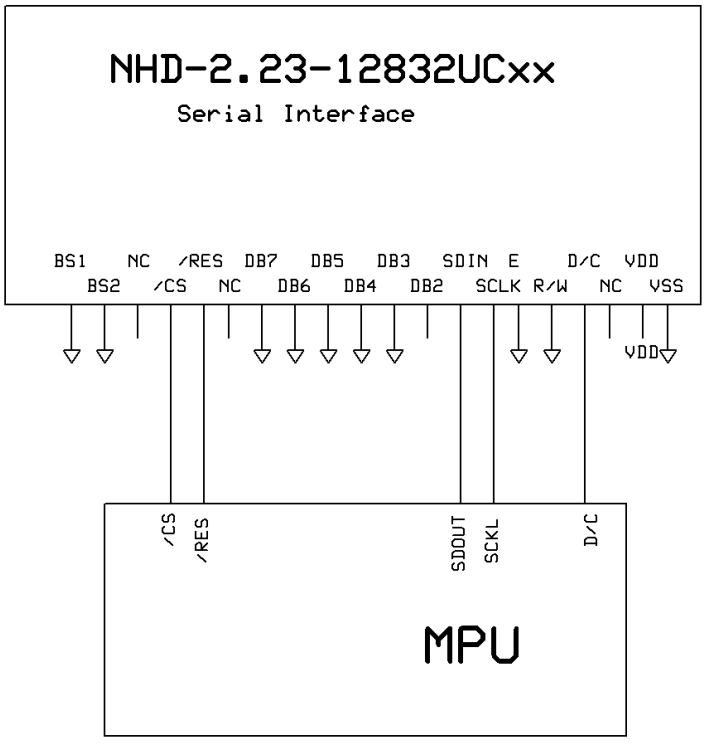
MPU Interface Pin Assignment Summery

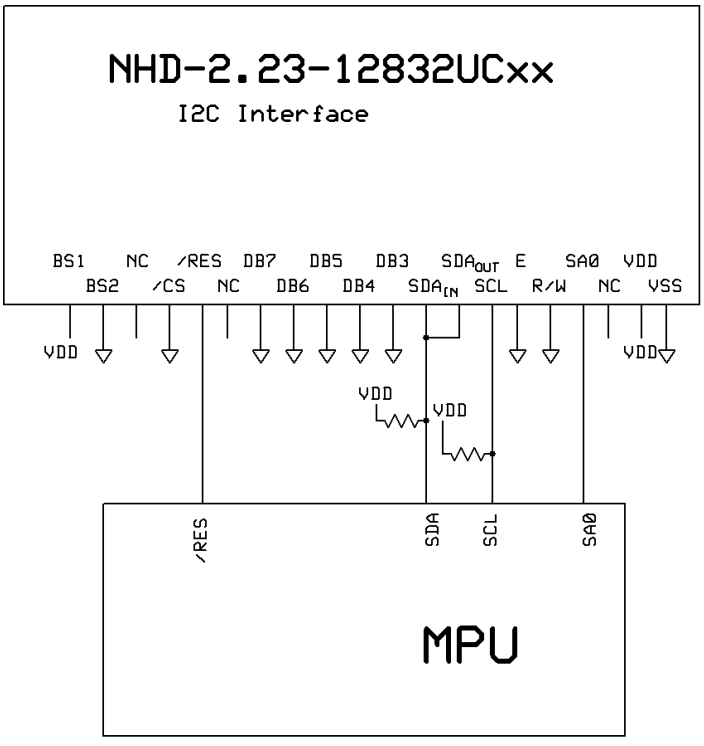
Bus Interface	Data/Command Interface								Control Signals				
	D7	D6	D5	D4	D3	D2	D1	D0	E	R/W	/CS	D/C	/RES
8-bit 6800	D[7:0]								E	R/W	/CS	D/C	/RES
8-bit 8080	D[7:0]								/RD	/WR	/CS	D/C	/RES
SPI	Tie LOW					NC	SDIN	SCLK	Tie LOW		/CS	D/C	/RES
I2C	Tie LOW					SDA_{IN}	SDA_{OUT}	SCL	Tie LOW			SA0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

Wiring Diagrams









Electrical Characteristics

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating Temperature Range	T_{OP}	Absolute Max	-40	-	+85	ºC
Storage Temperature Range	T_{ST}	Absolute Max	-40	-	+90	ºC
Supply Voltage	V_{DD}		-	3.3	3.5	V
Supply Current (logic)	I_{DD}	T_{OP}=25°C, V_{DD}=3.3V	-	180	300	µA
Supply Current (display)	I_{CC}	50% ON, V_{DD}=3.3V	-	62	70	mA
		100% ON, V_{DD}=3.3V	-	113	120	mA
Sleep Mode Current	I_{DD}+$I_{CCSLEEP}$	-	-	3	15	µA
"H" Level input	V_{IH}	-	0.8 * V_{DD}	-	V_{DD}	V
"L" Level input	V_{IL}	-	V_{SS}	-	0.2 * V_{DD}	V
"H" Level output	V_{OH}	-	0.9 * V_{DD}	-	V_{DD}	V
"L" Level output	V_{OL}	-	V_{SS}	-	0.1 * V_{DD}	V

Optical Characteristics

Item		Symbol	Condition	Min.	Typ.	Max.	Unit
Optimal Viewing Angles	Top	φY+	CR≥10,000	80	-	-	º
	Bottom	φY-		80	-	-	º
	Left	θX-		80	-	-	º
	Right	θX+		80	-	-	º
Contrast Ratio		Cr	-	10,000:1	-	-	-
Response Time	Rise	T_R	-	-	10	-	µs
	Fall	T_F	-	-	10	-	µs
Brightness		L_V	50% Checkerboard	100	120	-	cd/m^2
Lifetime		-	L_V = 120 cd/m² 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.

Built-in SSD1305 controller.
Instruction Table

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	0	**93**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	Sets the bank color of Bank17~Bank32 to any one of the 4 colors	

Bank17 to Bank32 (Page 1)		**A[7:0]** **B[7:0]** **C[7:0]** **D[7:0]**	**A7** **B7** **C7** **D7**	**A6** **B6** **C6** **D6**	**A5** **B5** **C5** **D5**	**A4** **B4** **C4** **D4**	**A3** **B3** **C3** **D3**	**A2** **B2** **C2** **D2**	**A1** **B1** **C1** **D1**	**A0** **B0** **C0** **D0**	A,B,C, and D. A[1:0] : 00b, 01b, 10b, or 11b for Color = A, B, C, or D of BANK17. 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	0	**D9**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	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

Period		A[7:0]	A7	A6	A5	A4	A3	A2	A1	A0		
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.

I^2C 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_Addressing_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

Precautions for using OLEDs/LCDs/LCMs

See Precautions at www.newhavendisplay.com/specs/precautions.pdf

Warranty Information and Terms & Conditions

http://www.newhavendisplay.com/index.php?main_page=terms

Newhaven Display International, Inc. reserves the right to alter this product or specification at any time without notification.