7850 East Gelding Drive • Scottsdale, AZ 85260-3420

Application Notes for OLED Rocker

Revision A

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TABLE OF CONTENTS

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General Information
The application notes should be used in conjunction with the OLED Rocker data sheet which has the timing diagrams for the power up and the communication.

Part Numbers
The following is a list of the OLED Rocker part number and its associated hardware.

Part number	Description
• IS18WWC1W	OLED Rocker
• AT715	Cable to connect OLED Rocker to controller
• AT097	Connector. PCB mount for controllers
• IS-CHPMP	Charge pump. Input 2.7 to 5.5. Out put 16V.
• IS-DEV KIT-8	Development kit
• IS18WWC1W-K	OLED Rocker design kit. Includes one each of the following: IS18WWC1W, AT715, AT097, IS-CHPMP

Development kits and Evaluation kits are also available.

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1. Pin Function

The following are the pinouts for OLED Rocker

Pins	Symbol	Pin Name	Function
1	VDDA	power	Power source for logic circuit
2	XRES	Reset	Reset the OLED module
3	XCS	Chip Select	Select the OLED module
4	AO	Data/Commend	Indicate data or commend transmission
5	SCL	Serial Clock	
6	SI	Serial Data	
7	VSS	Logic Ground	
8	VAH	Power for OLED	Power source for OLED
9	SW1	Switch 1 terminal	Top Switch
10	SW2	Switch 2 terminal	Middle Switch
11	SW3	Switch 3 terminal	Bottom Switch
12	SW_COM	Switches common terminal	Switches common terminal

2. Pin Descriptions

Ground: The Ground for logic and OLED.
VDDA: Power source for logic (2.4V to 3.5V)
VAH: Supply voltage for OLED (14.5V to 15.5V)
SCL: Clock for SPI communication maximum 10 MHZ
SI: Data for SPI communication.
AO: Data/command select. The pin is pulled low for transmitting the command byte. The pin is pulled high for transmitting the command parameter.
XRES: Reset for OLED module.
XCS: Select OLED module. This pin should be pulled down for duration of the command/parameter package.

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3. Switches

The OLED Rocker has three pushbutton switches. One side of each pushbutton switch is connected to pin 12 (SW-COM). The switches are normally open. Pressing the top of the display connects pin 9 to pin 12, pressing the middle of the display connects pin 10 to pin 12 and pressing the bottom of the display connects pin 11 to pin 12. The switches can be scanned by connecting the SW_COM to Ground and the other pins to a micro-controller. For a matrix of switches many different methods can be used for scanning.
It is possible to actuate both the top and middle switches by pressing halfway between the two switches. This is also true for pressing halfway between the middle and bottom switches. Accidental two switch actuation can be resolved by firmware. For example if the top and bottom switches are used to cycle between different options and the middle switch is used for selecting an option either of the following firmware solution can alleviate inadvertent actuations:

- Have the user to reconfirm the selection.
- When scanning the switches, ignore the middle switch press if two switches are pressed at the same time.

4. Overview of how to control the OLED Rocker

The OLED Rocker comes with a controller on-board. The on-board controller is an intelligent controller with many features such as:

- Memory for a single image.
- Communication via SPI.
- Handling the refresh of the OLED.
- 16 levels of brightness control.

Two voltage levels are required for the OLED Rocker: Logic voltage and OLED Voltage.
To control the OLED Rocker the following steps have to be followed:

A. Follow the power up sequence so the on-board controller boots up properly first before the OLED voltage is supplied.
B. Transmit commands for initialization. Many of these commands are specific to the OLED display and the connection to the on-board controller and any changes could cause damage to the OLED display. Some of the initialization commands have user defined features and can be modified as desire.

Upon completion of the above steps, the content of the internal memory gets displayed.
Any image data transmitted to the memory gets displayed until a new image is transmitted. An animation is achieved by transmitting images consequently at the desired speed.

5. OLED voltage VCC (15V) Requirements

Design considerations for OLED voltage:

- The recommended OLED voltage is 15V.
- Must conform to power up/down requirements. On power up the logic level is applied before the OLED voltage is enabled. On power down the OLED voltage is disabled, with or before, the logic voltage.

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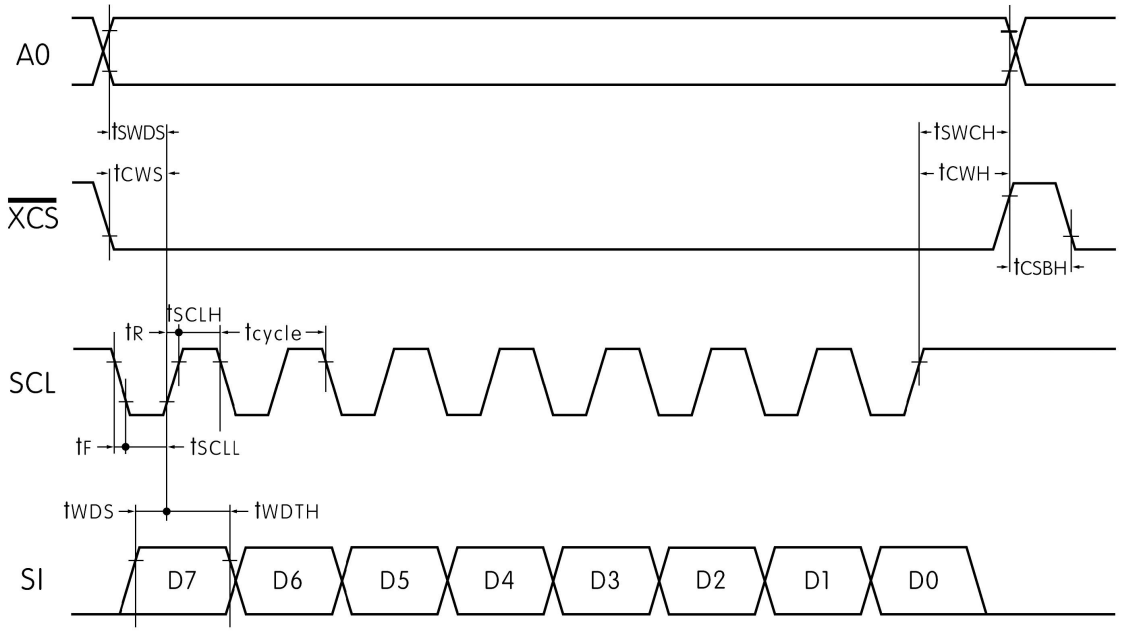
- As each pixel row of the display is refreshed the current can swing from a few micro Amps up to a maximum of 13mA depending on the number of pixels ON. If the voltage fluctuates due to the current swing it will affect the quality of the display.
- Many manufacturers offer voltage booster IC chips specifically designed to produce OLED level voltage from logic level voltage. These voltage booster IC chips are very efficient and meet the entire power requirements for the OLED display.
- For your convenience for use in prototype stages NKK Switches can supply a charge pump. It provides more than 20mA at 16V output from 2.4V to 5.5V input. It has a shut down pin to activate/disable. It provides enough current for up to two OLED Rockers. The charge pump part number is **IS-CHPMP** and specifications can be downloaded from our website.

6. Communication to OLED Rocker

Four control lines are used for communication.

Illustration 1, The four communication control lines.



The data is transmitted using clock (SCL) and data (SI). One bit of data is received on each rising of the clock signal. The normal state of the clock can be high or low.
Each eight bits of data received make a byte. The first bit transmitted for each byte is received as highest bit of the byte.

Commands
All the commands are one byte. All the commands have a one or two bytes parameter except reset command which does not have a parameter and the command for writing the image data. The command parameter for writing image data has 768 bytes (based on the selected download window). All the commands and associated parameter are listed in the following sections.

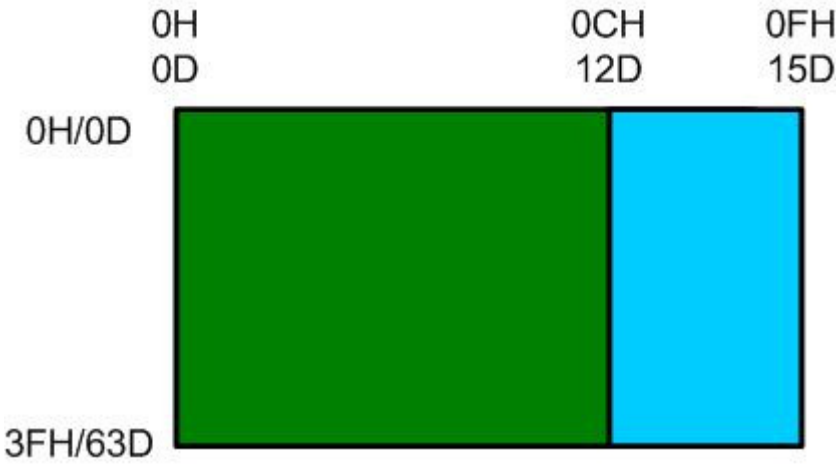
Communication protocol

When the select line (XCS) is high clock and data are ignored. To start the communication the OLED Rocker has to be selected by setting the XCS line to low. The AO line is should be set low for transmitting the command byte and set to high for transmitting the parameter bytes. The XCS line should be set to high after command and parameter are transmitted.

Memory

The onboard OLED Rocker controller memory size is 16 bytes (128 bits) x 64. The display size is 96 bit x 64 where initialization sets the memory for the image as shown in green. The additional memory area shown in blue is provided for scrolling. Scrolling will be discussed in a later section.

Illustration 2, OLED Rocker on-board memory map



Command for writing image data

The command for writing the image data is **08H**. The number of parameter bytes depends on the download window selected. The download window is selected with other commands. The initialization has selected the green part of memory as the download window (picture above) so the parameter has 768 bytes.
This data is for one display image. The order of transmitting an image is described in the table below. The most significant bit of the first byte is displayed on the top left corner pixel of the display and the least significant bit of the 768th byte is displayed on the bottom right corner pixel of the display.

Byte	Description
1-12	First line of image
13-24	Second line of image
•	
•	
•	
745-756	63th line of image
757-768	64th line of image

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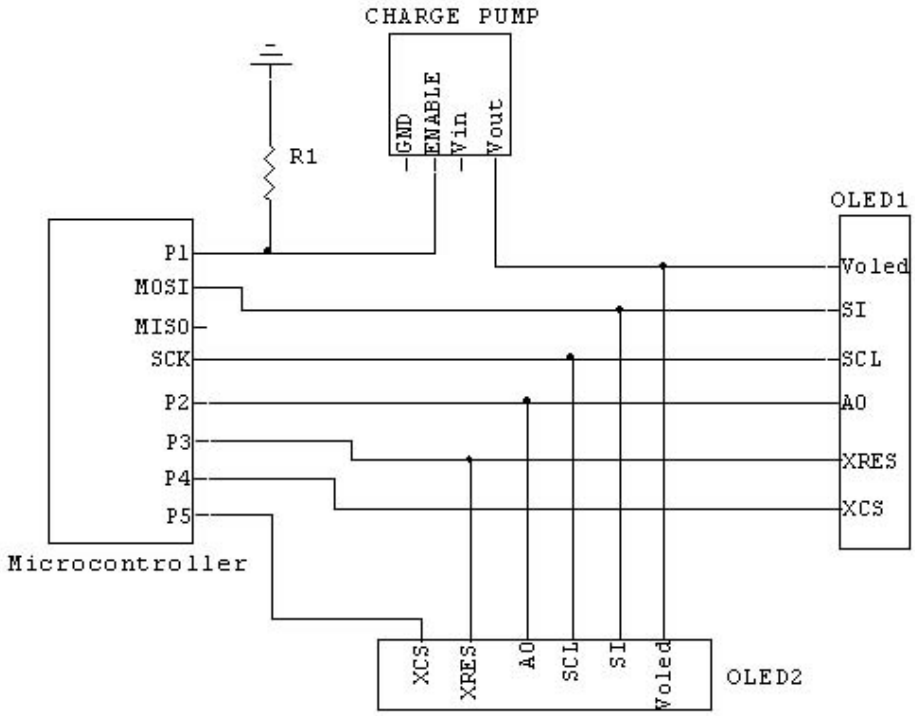
7. Sample Schematic for Multi-Rocker Controller

Below is a schematic to control two OLED Rockers. The charge pump is to produce OLED voltage. The R1 is needed if upon power up it takes the microcontroller too long to disable the charge pump by setting the P1 to low.

Illustration 3, Schematic for controlling two OLED Rockers



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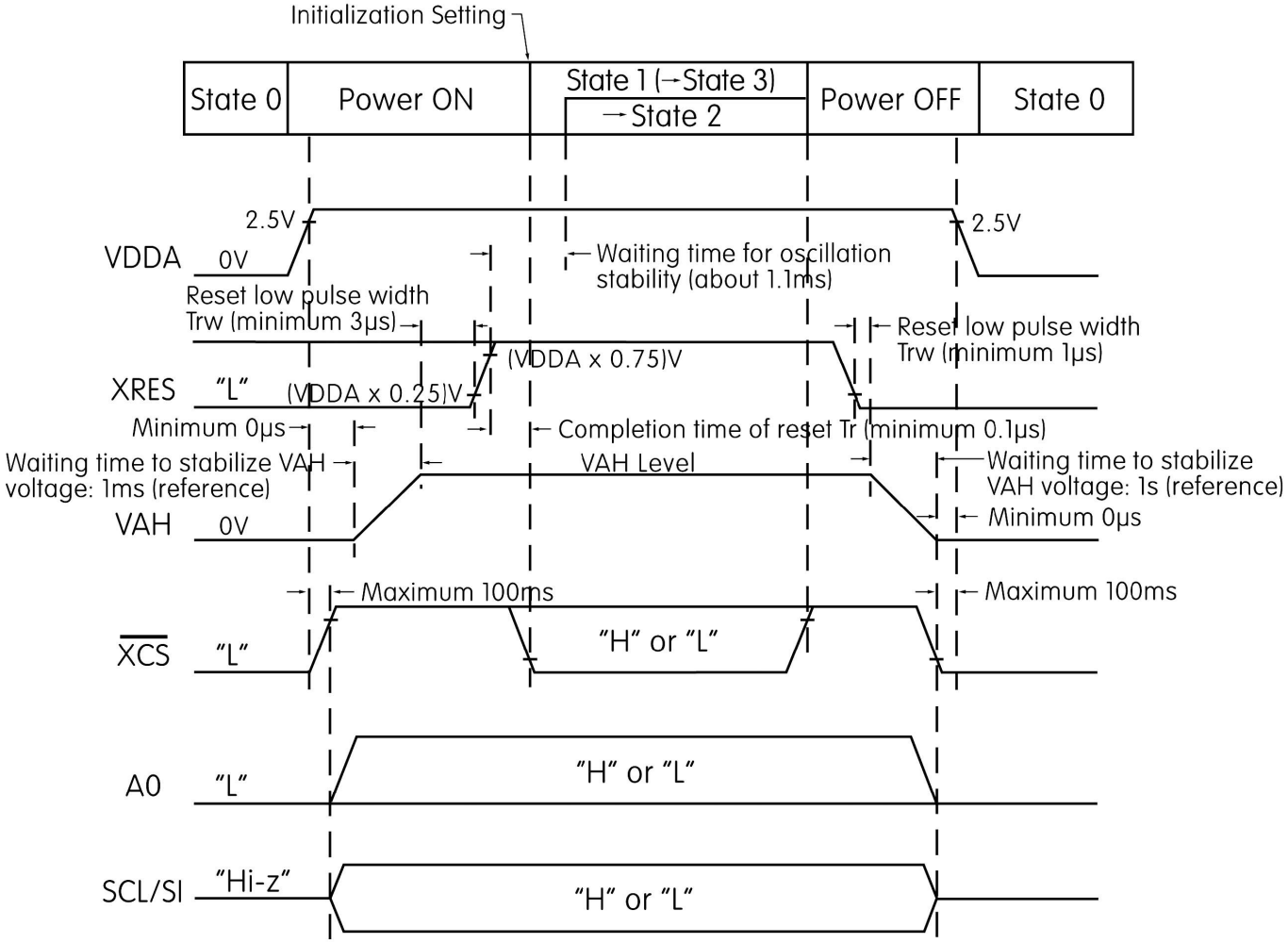
8. Detail of how to control the OLED Rocker

Power up

Follow the power up sequences according to the diagram below.

Illustration 4, Power ON/OFF Sequence



Initialization

All the initialization commands are listed in the table below. The commands with remark "Note 1" already hold their proper parameter values, as stated, after power up so the commands are not required to be transmitted. All other commands must be transmitted after power up.
The commands with the remark "Note 2" must be transmitted with the stated parameter. A change to the parameter of these commands can damage the display.

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The commands that have a user defined option will be discussed in Section 9 Commands.

Initialization Commands			
Description	**Command byte**	**Parameter**	**Remark**
Software Reset	01		
Dot Matrix Display OFF	02	00	Note 1
Read/Write Operation Wetting	07	00	Note 1
Display Direction Set Command	09	00	Note 1
Reserved 1	10	03	Note 2
Reserved 2	12	63	Note 2
Reserved 3	13	00	Note 2
Dot Matrix Display Standby ON/OFF	14	00	
Reserved 4	16	00	Note 2
Reserved 5	17	00	Notes 1 & 2
Reserved 6	18	09	Note 2
Reserved 7	1A	04	Notes 1 & 2
Reserved 8	1C	00	Notes 1 & 2
Graphic Memory Writing Direction	1D	00	Note 1
Setting Column Output Range	30	005F	Note 1 & 2
Setting Row Output Range	32	003F	Note 1 & 2
X Axis Reading/Writing Start Point	34	00	Note 1
X Axis Reading/Writing End Point	35	0F	Note 1
Y Axis Reading/Writing Start Point	36	00	Note 1
Y Axis Reading/Writing End Point	37	3F	Note 1
X Axis Reading Start Address	38	00	Note 1
Y Axis Reading Start Address	39	00	Note 1
Reserved 9	48	03	Note 2
Screen Saver Event Timer Setting Command	C3	00	Note 1
Screen Saver Event Timer Setting Command	C4	00	Note 1
One Time, Repeat or Direction Setting for Screen Saver	CC	00	Note 1
Start/Stop Setting for Screen Saver	CD	00	Note 1
System Clock Division Ratio	D0	80	Note 2

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Setting			
Setting the STBY Pin	D2	00	Notes 1 & 2
DACA Setting	D4	00	Notes 1 & 2
DACB Setting	D5	00	Notes 1 & 2
DACC Setting	D6	00	Notes 1 & 2
DACD Setting	D7	00	Notes 1 & 2
Reserved 10	D9	00	Notes 1 & 2
Dimmer Setting	DB	0F	Note 1
Reserved 11	DD	88	Note 2
Dot Matrix Display ON	02	01	

Notes:
1. Same as default value.
2. Do not change.

Upon finishing the initialization, the OLED module displays the contents of the onboard controller memory as shown in Illustration 2.

Writing an image
Command 08H with 768 bytes of image data can be transmitted to the memory at any time.
Any image data transmitted to the memory gets displayed until a new image is transmitted. An animation is achieved by transmitting images consequently at the desired speed.

9. Commands

Software Reset Command
This command resets the OLED Rocker.

COMMAND	PARAMETER
Byte	none
01	

This is the only command that does not have parameter.
The result of this command is as follows:
- All the commands have default values.
- Display is OFF.
- Oscillation for refresh stops.
- No change to the content of the memory.

The initialization commands must be transmitted after reset.

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Display ON/OFF Command
This command turns the display on or off.

COMMAND	PARAMETER							
Byte	B7	B6	B5	B4	B3	B2	B1	B0
02	-	-	-	-	-	-	-	B0

B0 = 0 ===> Turn the display OFF
B0= 1 ===> Turn the display ON
It has no effect on the memory.
This command can be used at any time.
It can be used for blinking the display. It is also recommended to turn off the display before power down.

Display Stand by Mode Command
This command starts or stops the internal clock oscillation.

COMMAND	PARAMETER							
Byte	B7	B6	B5	B4	B3	B2	B1	B0
14	-	-	-	-	-	-	-	B0

B0 = 0 ===> Start the oscillation
B0= 1 ===> Stop the oscillation
It has no effect on the memory.
This command can be used for power saving. The display has to be turned off using Display ON/OFF command first and after a short delay this command can be used to stop the oscillation.
After using this command to start the oscillation, The Display ON/OFF command can be used to turn the display on.

Brightness Level Command
This command sets the brightness level of the display.

COMMAND	PARAMETER
Byte	Byte
D9	0X

This command can be used at any time.
There are 16 steps for the brightness level (00H to 0FH). 0FH is the maximum brightness and 00H is the minimum brightness. The OLED Rocker life of 52,000 hrs is based on 0FH brightness. The dimmer the brightness level is set, the longer the life.

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Specifying the Window Size for Writing Data to Memory Commands
These commands specify the memory window to download image data using command 08H.

Function	COMMAND	PARAMETER
	Byte	Byte
X Start Address	34	XX
X End Address	35	XX
Y Start Address	36	XX
Y End Address	37	XX

The memory is 16 bytes x 64 rows. The X addresses specify the bytes and the range is from 00H to 0FH. The Y addresses specify the rows and the range is from 00H to 3FH. The End addresses can not be smaller that Start addresses.
This set up also determines how many bytes the parameter of the command 08H has.
Examples:
X start Address = 00H, X End Address = 0BH, Y start Address = 00H, Y End Address =3FH
Command 08H has 768 bytes as parameter.
X start Address = 00H, X End Address = 02H, Y start Address = 00H, Y End Address =02H
Command 08H has 9 bytes as parameter.

Writing Data to Memory Command
This command writes the data to the memory.

COMMAND	PARAMETER
Byte	Many Bytes
08	

The number of bytes as parameter is determined from window size selected for data download.

Direction of Writing to Memory Command
This command determines the direction that bytes are written to the memory window by the command 08H.

COMMAND	PARAMETER							
Byte	B7	B6	B5	B4	B3	B2	B1	B0
1D	-	-	-	-	ML	VH	D1	D0

B4 determines the data bytes are received most or least significant bit first. Please note this only apply to the image data.
B0, B1 and B2 determine the direction that the data bytes are written to the memory window by the command 08H.

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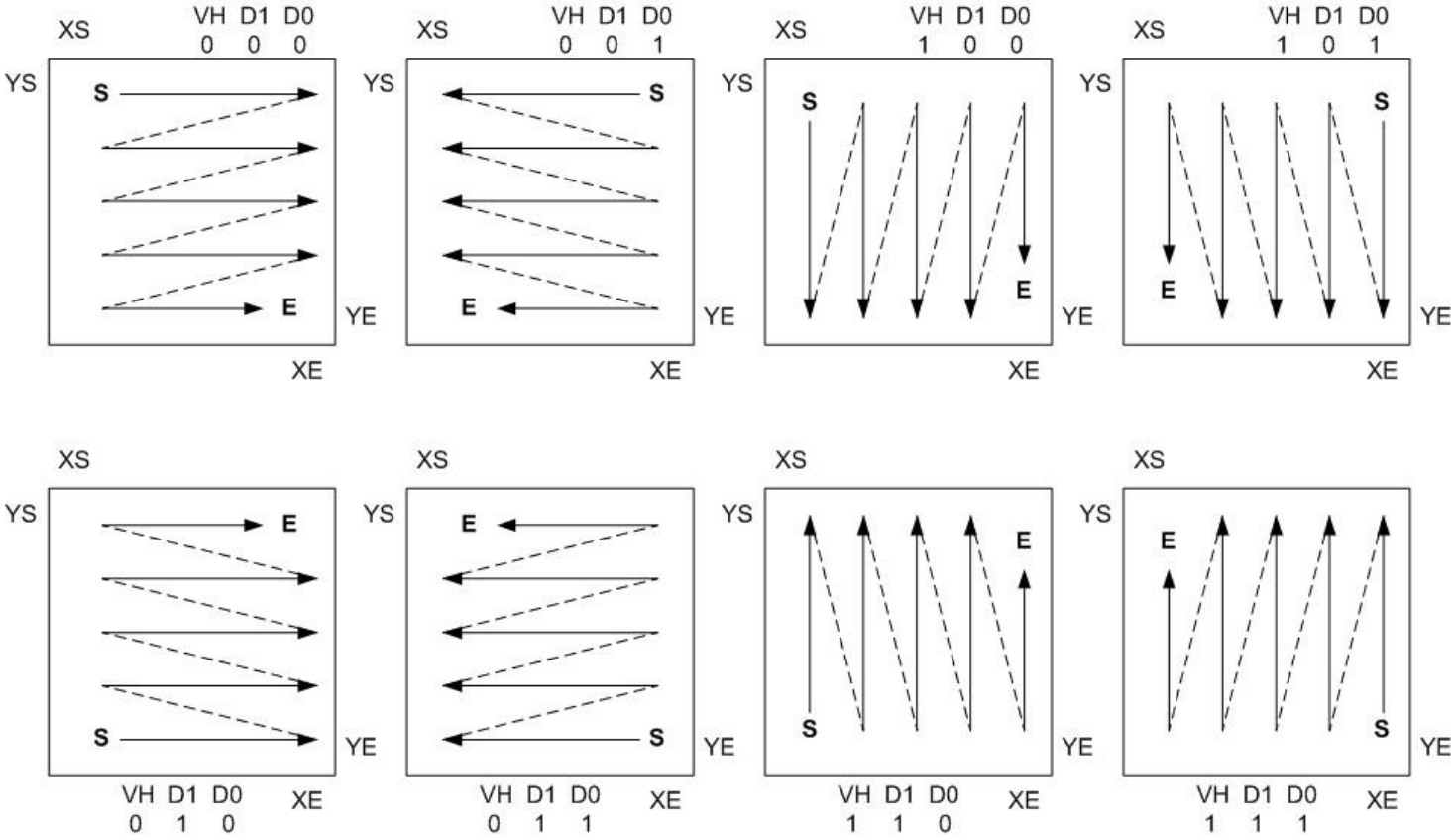
Illustration 5, OLED Rocker Writing Direction



Direction of Refreshing the OLED from Memory Command

This command determines the direction that the image gets refreshed from memory to the OLED display.

COMMAND	PARAMETER							
Byte	B7	B6	B5	B4	B3	B2	B1	B0
09	-	-	-	-	-	-	D1	D0

Parameter values D1 and D0. See Illustration 6 below.

D1	D0	Column	Row
0	0	Left to Right	Top to bottom
1	0	Left to Right	Bottom to top

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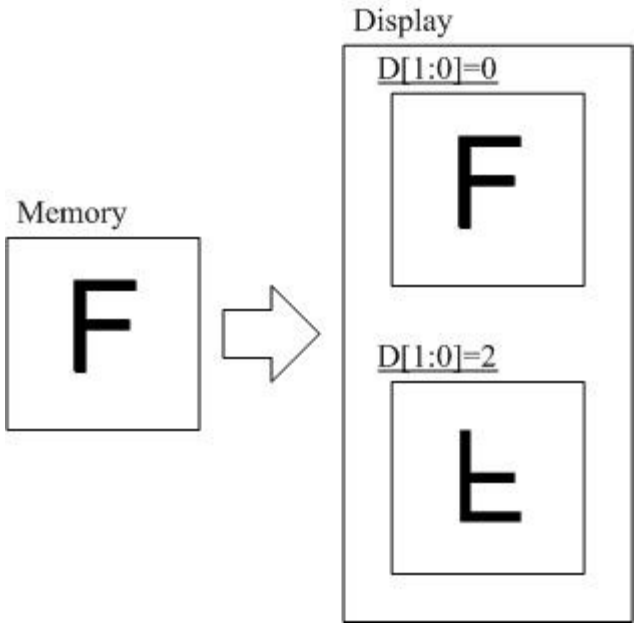
Illustration 6, Display Direction



Start point of refreshing the OLED from memory (Manual Scrolling)

Function	COMMAND	PARAMETER
	Byte	Byte
X Display start	38	XX
Y Display start	39	XX

X Display start range is between 0 to 127 (00H to 7FH).
Y Display Start range is between 0 to 63 (00H to 3FH).
These commands set the starting memory bit for the image to be refreshed. The refresh window in the memory will be 96 bits by 64 rows. The refresh window rap around after 127th bit of memory and rap to the top after 63rd row.
These commands can be used at any time. They go to effect on the next refresh cycle.

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10. Scrolling (Screen saver)

The on-board controller has a feature for scrolling the 128 x 64 bit of memory across the display (96 x64) horizontally. There are three commands to set up the speed and the direction of scrolling. There is a command for enabling and disabling the scrolling.

Function	COMMAND	PARAMETER							
	Byte	B7	B6	B5	B4	B3	B2	B1	B0
Step timer	C3	B7	B6	B5	B4	B3	B2	B1	B0
Step timer unit	C4	-	-	-	-	-	-	S1	S0
Left/Right scroll	CC	-	-	-	-	-	-	-	LR
Enable/Disable screen saver	CD	-	-	-	-	-	-	-	D0

Command C3H specifies the timer value. The timer range is from 00H to FFH. 00H denotes 256 count.
Command C4H specifies the timer step value as follow:

S1	S0	Step value
0	0	Timer not running
0	1	1 ms step
1	0	100 ms step
1	1	Timer not running

Command CCH specifies the direction of scroll. LR =0 right scroll and LR=1 left scroll.
Command CDH enables/disables the scroll. D0 =0 disable and D0=1 enable.
If the timer is not running (command C4H), enabling the scroll will not work.
When disabling after the scroll, the original window will be displayed.

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11. Operating Life Time

The OLED life is measured as the time it takes, while continuously ON, for brightness to reach 50% of the original brightness. This measurement is also referred to as the 100% rated life.
This 100% rated life is the worst case scenario and much less than the actual useful life of the OLED products for the following reason:

- To display any meaningful image many of the pixels are OFF.
- Different images have different pixels ON/OFF.

The actual useful life of the OLED is many times higher than the 100% rated life depending on the way it is used. Studies have shown that for the average application the pixels are ON 30 to 40% of the time while the unit is operating 100% of the time. That is why the OLED ratings have 30 or 40% associated with them. For example the OLED Rocker has a life rating of 15,600 hours at 100% and 52,000 hours at 30%.
Software engineers can optimize the images so the useful life is much higher than 52,000 hours.

Another point to consider is the 100% life rating is based on 100% brightness. Operating the OLED at a reduced brightness will result in longer life. If the OLED is operated at 50% brightness the rated life is approximately doubled.

Example:
An OLED Rocker is used in an application that is operating 18 hours a day. The images are designed so each pixel is ON 35% of the time. The brightness level is set at 80%. How many years will the life rating be?

Start with 15,600 hours at 100% rated life.

15,600 hours / 35% ON = 44,571 hours

(44,571 hours * 24 hours per day) / 18 hours ON per day = 59,428 hours

59,428 hours / 80% brightness = 74,285 hours

(74,285 hours * 1 year) / 8,765 = 8.4 years

The life rating is 8.4 years.

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Frequently Asked Questions

Is the OLED Rocker capable of displaying animations?
Yes. The OLED Rocker response time is 0.2ms which is the best among all the display technologies. The bottle neck is normally the communication speed. Over 100 frames per second of data can be transmitted to the OLED Rocker. Most videos are 25 to 30 frames per second.

What is aging?
Aging for the OLED Rocker is refers to the reduction in brightness over time. Specifically the OLED life is defined as the time it takes for the brightness to reach half the original state. See Section 11 above on the operating life time of the OLED.

Does the power up/down sequence have to be followed?
Yes. The power up sequence must be observed. If VCC powers the circuit before VDD is activated the circuit could latch and damage the OLED.
For the power down sequence VCC can not be present after VDD is off. Simultaneous turn off is possible as long as VCC is examined to confirm that it does not have too much capacitance charge after turn off.

Are subassemblies with SmartSwitches included available?
Yes. NKK Switches has many development kits and also entertains custom designs.

Is NKK Switches planning to develop other sizes of the OLED Rocker?
NKK Switches is interested in developing new OLED Rocker products if there is a large quantity requirement. Customer feedback is considered when deciding what new products to develop. Feedback and/or application requirements are much appreciated.

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