7850 East Gelding Drive • Scottsdale, AZ 85260-3420

Application Notes for OLED SmartSwitch/Display

Revision C

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General Information

The application notes should be used in conjunction with the OLED data sheet which has the timing diagram for the communication. There are two versions of OLED switch / display, 15,000 hr life and 30,000 hr life. The initialization values are different for each module and listed in Table 1 to 4. The rest of the application note apply to all the OLED modules.

Part Numbers

The following is a list of the OLED's part numbers and their associated hardware. The OLED is currently available as a 64x48 switch and a 52x36 display. For prototyping it is recommended to use the sockets and charge pump for easy use.

Part number	Description
• ISC15ANP4	OLED SmartSwitch
• AT9704-085L	Socket for OLED SmartSwitch
• ISC01P	OLED SmartDisplay
• AT9704-085M	Socket for OLED SmartDisplay
• IS-CHPMP	Charge pump. Input 2.4 to 5.5. Out put 16V.

Evaluation controllers and demonstration kits are also available.

1. Pin Function

The following are the pinouts for OLED SmartSwitch

Pins	Symbol	Pin Name	Function
1	SW	Switch Terminal	Normally open switch
2	SW	Switch Terminal	Normally open switch
3	VDD	power	Power source for logic circuit
4	$\overline{SS}$	Slave select	Select the OLED module
5	RES	Reset	Reset the OLED module
6	D/C	Data/Commend	Indicate data or commend transmission
7	SCK	Clock	SPI clock
8	SDI	Data	SPI data
9	VCC	Power	Power source for OLED
10	GND	Ground	

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The following are the pinouts for OLED SmartDisplay.

Pins	Symbol	Pin Name	Function
1	VDD	power	Power source for logic circuit
2	$\overline{SS}$	Slave select	Select the OLED module
3	RES	Reset	Reset the OLED module
4	D/C	Data/Command	Indicate data or command transmission
5	SCK	Clock	SPI clock
6	SDI	Data	SPI data
7	VCC	Power	Power source for OLED
8	GND	Ground	

2. Pin Descriptions

Switch terminals: The switch is normally open. The switch can be scanned by connecting one pin to Ground and the other pin to a micro-controller. For a matrix of switches many different methods can be used for scanning.

Ground: The Ground for logic and OLED.
VDD: Power source for logic (2.4V to 3.5V)
VCC: Supply voltage for OLED (15V to 17V)
SCK: Clock for SPI communication maximum 6.66 MHZ
SDI: Data for SPI communication.
D/C: Data/command select. When pin is pulled low the transmitted bytes are treated as command. When pin is pulled high the transmitted bytes are treated as image data.
RES: Reset for OLED module for initialization.
$\overline{SS}$: select OLED module. This pin should be pulled down for duration of the data/command package.

3. VCC (16V) Requirement

The VCC must be float, when it is not active, to conform to the required power ON/OFF sequences. This can be achieved with a relay or true shut down charge pump.
Care must be taken in the design so upon power up the VCC is not activated.
For your convenience in prototype stages we have made a charge pump. It provides more than 20mA at 16V out put from 2.4V to 5.5V input. It has shut down pin to activate/disable. It provides enough current for up to four modules.
The charge pump part number is **IS-CHPMP**.

4. Initialization

Initialization procedure upon power up for OLED switch (64x48) and OLED display (52x36)

1. By design VCC should be disabled upon power up.
2. The Reset pin should be set to low for 3 µs and then set to high.
3. Enable VCC.
4. Initialize the OLED controller by transmitting the commands and data from the appropriate table below. Each command is one byte and has 0 to 10 associated data bytes. The D/C pin should be set low for the entire command and associated data. To transmit each command set the Select pin to low, transmit the command and associated data, and then set the Select pin to high.

Table 1 Initialization for OLED switch (64x48) 15,000 hr life

			Commands	Function
*1	4.1	Transmit	81H 19H	Contras for color A
*1	4.2	Transmit	82H 14H	Contras for color B
*1	4.3	Transmit	83H 24H	Contras for color C
	4.4	Transmit	87H 0FH	Master current control
	4.5	Transmit	A0H 70H	Remap & color depth setting
	4.6	Transmit	A1H 00H	Set display start line
*1	4.7	Transmit	A2H 10H	Set display offset
	4.8	Transmit	A4H	Normal display
*1	4.9	Transmit	A8H 2FH	Multiplex ratio
	4.10	Transmit	ABH 00H 12H 0CH 14H 12H	Dim mode setting for color A, B &C
*1	4.11	Transmit	ADH 8EH	Master configuration
	4.12	Transmit	B0H 0BH	Power save mode
*1	4.13	Transmit	B1H 44H	Phase 1 and 2 period adjustment
*1	4.14	Transmit	B3H A0H	Display clock divider/ oscillator frequency
*1	4.15	Transmit	B9H	Enable linear gray scale
*1	4.16	Transmit	BBH 12H	Pre charge level
*1	4.17	Transmit	BEH 28H	Set Vcomh
	4.18	Transmit	AFH	Display on in normal mode

*1 note: Changing the set up values may cause damage to the OLED modules.

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Table 2 Initialization for OLED switch (64x48) 30,000 hr life

			Commands	Function
*1	4.1	Transmit	81H 15H	Contras for color A
*1	4.2	Transmit	82H 1AH	Contras for color B
*1	4.3	Transmit	83H 17H	Contras for color C
	4.4	Transmit	87H 0FH	Master current control
	4.5	Transmit	A0H 70H	Remap & color depth setting
	4.6	Transmit	A1H 00H	Set display start line
*1	4.7	Transmit	A2H 10H	Set display offset
	4.8	Transmit	A4H	Normal display
*1	4.9	Transmit	A8H 2FH	Multiplex ratio
	4.10	Transmit	ABH 00H 12H 0CH 14H 12H	Dim mode setting for color A, B &C
*1	4.11	Transmit	ADH 8EH	Master configuration
	4.12	Transmit	B0H 0BH	Power save mode
*1	4.13	Transmit	B1H 44H	Phase 1 and 2 period adjustment
*1	4.14	Transmit	B3H A0H	Display clock divider/ oscillator frequency
*1	4.15	Transmit	B9H	Enable linear gray scale
*1	4.16	Transmit	BBH 12H	Pre charge level
*1	4.17	Transmit	BEH 3EH	Set Vcomh
	4.18	Transmit	AFH	Display on in normal mode

*1 note: Changing the set up values may cause damage to the OLED modules.

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Table 3 Initialization for OLED Display (52x36) 15,000 hr life

			Commands	Function
*1	4.1	Transmit	81H 0FH	Contras for color A
*1	4.2	Transmit	82H 0EH	Contras for color B
*1	4.3	Transmit	83H 1BH	Contras for color C
	4.4	Transmit	87H 0FH	Master current control
	4.5	Transmit	A0H 70H	Remap & color depth setting
	4.6	Transmit	A1H 00H	Set display start line
*1	4.7	Transmit	A2H 1CH	Set display offset
	4.8	Transmit	A4H	Normal display
*1	4.9	Transmit	A8H 23H	Multiplex ratio
	4.10	Transmit	ABH 00H 0BH 08H 0FH 12H	Dim mode setting for color A, B &C
*1	4.11	Transmit	ADH 8EH	Master configuration
	4.12	Transmit	B0H 0BH	Power save mode
*1	4.13	Transmit	B1H 44H	Phase 1 and 2 period adjustment
*1	4.14	Transmit	B3H 30H	Display clock divider/ oscillator frequency
*1	4.15	Transmit	B9H	Enable linear gray scale
*1	4.16	Transmit	BBH 12H	Pre charge level
*1	4.17	Transmit	BEH 21H	Set Vcomh
	4.18	Transmit	AFH	Display on

*1 note: Changing the set up values may cause damage to the OLED modules.

Table 4 Initialization for OLED Display (52x36) 30,000 hr life

			Commands	Function
*1	4.1	Transmit	81H 0EH	Contras for color A
*1	4.2	Transmit	82H 13H	Contras for color B
*1	4.3	Transmit	83H 12H	Contras for color C
	4.4	Transmit	87H 0FH	Master current control
	4.5	Transmit	A0H 70H	Remap & color depth setting
	4.6	Transmit	A1H 00H	Set display start line
*1	4.7	Transmit	A2H 1CH	Set display offset
	4.8	Transmit	A4H	Normal display
*1	4.9	Transmit	A8H 23H	Multiplex ratio
	4.10	Transmit	ABH 00H 0BH 08H 0FH 12H	Dim mode setting for color A, B &C
*1	4.11	Transmit	ADH 8EH	Master configuration
	4.12	Transmit	B0H 0BH	Power save mode

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*1	4.13	Transmit	B1H 44H	Phase 1 and 2 period adjustment
*1	4.14	Transmit	B3H 30H	Display clock divider/ oscillator frequency
*1	4.15	Transmit	B9H	Enable linear gray scale
*1	4.16	Transmit	BBH 12H	Pre charge level
*1	4.17	Transmit	BEH 3CH	Set Vcomh
	4.18	Transmit	AFH	Display on

*1 note: Changing the set up values may cause damage to the OLED modules.

Upon finishing the initialization, the OLED module displays whatever is the content of the memory.

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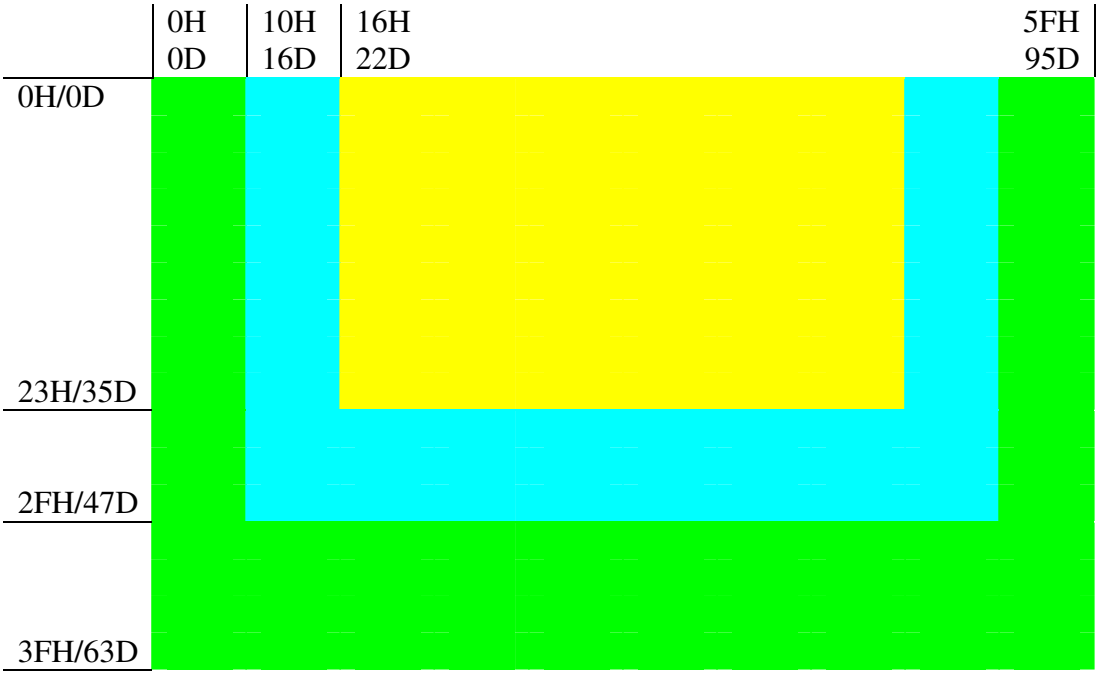
5. Memory Format

The onboard OLED controller can control up to 96x64 pixels. The controller memory size is 96 x 2 bytes per pixel x 64.



Picture 1 OLED on-board memory map

The memory data specified by yellow will be displayed on OLED display (52X36).
The memory data specified by yellow and blue will be displayed on OLED switch (64x48).

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6. Specifying a Memory Window for Downloading

A memory window is specified by a beginning and end column and a beginning and end row. These boundaries are set by commands 15H and 75H.
The two bytes following the command 15H specify beginning and end columns (range 00H to 5FH).
The two bytes following the command 75H specify beginning and end rows. (range 00H to 3FH)
The boundaries of the memory window can be changed at any time.
Table 3 shows the commands to specify the size and location of memory corresponding to OLED Switch (64x48).
Table 4 shows the commands to specify the size and location of memory corresponding to OLED Display (52x36).

Table 3 Setting the columns and rows as well as putting the curser at top left OLED Display (64x48)

	Commands	Function
Transmit	15H 10H 4FH	Set the column range
Transmit	75H 00H 2FH	Set the row range

Table 4 Setting the columns and rows as well as putting the curser at top left OLED Display (52x36)

	Commands	Function
Transmit	15H 16H 49H	Set the columns range
Transmit	75H 00H 23H	Set the rows range

The cursor starts at the upper left hand pixel of the specified memory window. Whenever the data for a pixel is received, the cursor increments from left to right. After receiving data for the right most pixel of the row, the curser moves to the left hand pixel of the next row. Once the last row is completed, the cursor returns to left hand pixel of the first row.

Any data transmitted when D/C pin is high is considered as image data. OLED onboard controller continuously refreshes the OLED from the memory. Any changes to memory will be displayed immediately.

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7. Pixels and Image Format

An image is handled as a window of 6144 bytes. Each pixel requires two bytes in the 565 format as shown below.

B 7	B 6	B 5	B 4	B 3	G 2	G 1	G 0	G 7	G 6	G 5	R 4	R 3	R 2	R 1	R 0

Image size for OLED switch 64x48 (6144 bytes)

Byte	Description
1-128	First line of image
129-256	Second line of image
•	
•	
•	
5889-6016	47th line of image
6017-6144	48th line of image

Image size for OLED display 52x36 (3744 bytes)

Byte	Description
1-104	First line of image
105-208	Second line of image
•	
•	
•	
3537-3640	35th line of image
3641-3744	36th line of image

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8. Display Commands Available

Display ON/OFF

The following three commands can be used at anytime. They do not affect the content of the memory.

1	Transmit	ACH	Dim Display
2	Transmit	AEH	Display OFF (sleep mode)
3	Transmit	AFH	Display ON

Transmitting AEH command turns off the display. Transmitting AFH command turns on the display in normal mode.
Transmitting ACH command turns on the display in dim mode. The dim mode level is according to the initialization step 4.10. The last 3 bytes are the contrast for color A, B and C. The value can not exceed the maximum level for each color of initialization of steps 4.1, 4.2 and 4.3 respectively.

Powering down sequences

Following procedure needs to be followed for turning off the OLED.

1. Transmit the command to turn off the OLED display.

Transmit	AEH	Display off

2. Disable the VCC.
3. Turn off the VDD power.

9. Additional Commands Available

No Operation

Transmit	E3H	NOP
Transmit	BCH	NOP
Transmit	BDH	NOP

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Display Mode

These are one byte commands. They do not affect memory data.

Transmit	A4H	Normal operation
Transmit	A5H	All pixels on at the highest brightness
Transmit	A6H	All pixels on at lowest intensity
Transmit	A7H	Inverse display

Command A4H is for normal operation. Commands A5H/A6H forces all pixels highest/lowest intensity regardless of the contents of the memory. The command A7H causes the complement of the pixels' data from memory to be displayed.

Master Current Control

Transmit	87H 0FH	Master current control

This command should be used while the display is off (after command AEH).
There are 16 steps for the current level (00H to 0FH). 0FH is the maximum brightness and 00H is the minimum brightness. The OLED life of 15000/30000 hrs is based on 0FH brightness. The dimmer the OLED are used the longer the life.

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10. Scrolling (Screen saver)

Command 27H is used to set up the parameter for scrolling. This command can only be transmitted during initialization or when the display is off and scrolling is deactivated (commands AEH and 2EH). The sequence of use is as follows. First turn off the display and deactivate scrolling. Then send the command 27H and the picture. Finally turn display on and activate the scrolling (commands AFH and 2FH).

Command 27H has 5 bytes of data; A, B, C, D, and E.

> Byte A sets the number of columns shifted horizontally to the right each time. For example the value 01H will make the image appear to be shifted from right to left. The value 5FH will make the image appear to be shifting from the left to right. Byte A should not be set to 00H or it will deactivate the scrolling for the rest of the session and scrolling can not be reactivated. Therefore, the Byte A value should be set between 01H and 5FH.
>
> Byte B sets the offset or starting row.
>
> Byte C sets the number of rows that get shifted horizontally.
>
> Byte D sets to number of rows that are vertically shifted up each time. For example the value 01H will make the image appear to be shifted from bottom to top. The value 3FH will make the image appear to be shifting from the top to bottom. A zero value for byte D indicates no vertical shift.
>
> Byte E sets the interval between each shift.

The horizontal speed of scrolling is determined by the value of bytes A and E.
The vertical speed of scrolling is determined by the value of bytes D and E.
The portion of the image that is horizontally shifted is determined by the values of bytes B and C.

For the horizontal scroll, rows selected will shift using the 96 columns.
For vertical scroll, all 96 columns will be shifted using all 64 rows.

After deactivation, the position of the contents of the memory has been changed due to the shifts. To restore the original image the image data should be downloaded again. Refer to Table 5.

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Table 5 Scrolling commands

Hex	D7	D6	D5	D4	D3	D2	D1	D0	Command	Description
27	0	0	1	0	0	1	1	1	Continuous Horizontal & Vertical Scrolling Setup	A[6:0]: Sets number of columns as horizontal scroll offset Range: 0D-95D (0 equals no horizontal scroll) B[5:0]: Sets start row address C[6:0]: Sets number of rows to be horizontally scrolled B[5:0]+C[6:0]<=64 D[5:0]: Sets number of rows as vertical scroll offset Range: 0D-63D (0 equals no vertical scroll) E[1:0]: Sets time interval between each scroll step 00B 6 frames 01B 10 frames 10B 100 frames 11B 200 frames **Note:** (1) Vertical scroll is run with 64MUX setting only (2) The parameters should not be changed after scrolling is activated
A[6:0]	*	A6	A5	A4	A3	A2	A1	A0		
B[5:0]	*	*	B5	B4	B3	B2	B1	B0		
C[6:0]	*	C6	C5	C4	C3	C2	C1	C0		
D[5:0]	*	*	D5	D4	D3	D2	D1	D0		
E[1:0]	*	*	*	*	*	*	E1	E0		
2E	0	0	1	0	1	1	1	0	Deactivate scrolling	This command deactivates the scrolling action **Note:** (1) After sending 2EH command to deactivate the scrolling action, the ram data needs to be rewritten.
2F	0	0	1	0	1	1	1	1	Activate scrolling	This command activates the scrolling function according to the setting done by Continuous Horizontal & Vertical Scrolling Setup command 27H.

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11. Graphic command

Table 6 and table 7 have the graphic commands. Please note the command 26H is the set up which effect the operation of commands 22H and 23H. Note: Graphic commands modify the content of memory.

Table 6 Graphic Commands

Hex	D7	D6	D5	D4	D3	D2	D1	D0	Command	Description
21	0	0	1	0	0	0	0	1	Draw Line	A[6:0]: Column Address of Start B[5:0]: Row Address of Start C[6:0]: Column Address of End D[5:0]: Row Address of End E[5:1]: Color C of the line F[5:0]: Color B of the line G[5:1]: Color A of the line
A[6:0]	*	A6	A5	A4	A3	A2	A1	A0		
B[5:0]	*	*	B5	B4	B3	B2	B1	B0		
C[6:0]	*	C6	C5	C4	C3	C2	C1	C0		
D[5:0]	*	*	D5	D4	D3	D2	D1	D0		
E[5:1]	*	*	E5	E4	E3	E2	E1	*		
F[5:0]	*	*	F5	F4	F3	F2	F1	F0		
G[5:1]	*	*	G5	G4	G3	G2	G1	*		
24	0	0	1	0	0	1	0	0	Dim Window	A[6:0]: Column Address of Start B[5:0]: Row Address of Start C[6:0]: Column Address of End D[5:0]: Row Address of End The effect of dim window: GS15~GS0 no change GS19~GS16 become GS4 GS23~GS20 become GS5 … GS62~GS60 become GS15
A[6:0]	*	A6	A5	A4	A3	A2	A1	A0		
B[5:0]	*	*	B5	B4	B3	B2	B1	B0		
C[6:0]	*	C6	C5	C4	C3	C2	C1	C0		
D[5:0]	*	*	D5	D4	D3	D2	D1	D0		
25	0	0	1	0	0	1	0	1	Clear Window	A[6:0]: Column Address of Start B[5:0]: Row Address of Start C[6:0]: Column Address of End D[5:0]: Row Address of End
A[6:0]	*	A6	A5	A4	A3	A2	A1	A0		
B[5:0]	*	*	B5	B4	B3	B2	B1	B0		
C[6:0]	*	C6	C5	C4	C3	C2	C1	C0		
D[5:0]	*	*	D5	D4	D3	D2	D1	D0		

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Table 7 Graphic Commands and Set Up

Hex	D7	D6	D5	D4	D3	D2	D1	D0	Command	Description
22	0	0	1	0	0	0	1	0	Drawing Rectangle	A[6:0]: Column Address of Start
A[6:0]	*	A6	A5	A4	A3	A2	A1	A0		B[5:0]: Row Address of Start
B[5:0]	*	*	B5	B4	B3	B2	B1	B0		C[6:0]: Column Address of End
C[6:0]	*	C6	C5	C4	C3	C2	C1	C0		D[5:0]: Row Address of End
D[5:0]	*	*	D5	D4	D3	D2	D1	D0		E[5:1]: Color C of the line
E[5:1]	*	*	E5	E4	E3	E2	E1	*		F[5:0]: Color B of the line
F[5:0]	*	*	F5	F4	F3	F2	F1	F0		G[5:1]: Color A of the line
G[5:1]	*	*	G5	G4	G3	G2	G1	*		H[5:1]: Color C of the fill area
H[5:1]	*	*	H5	H4	H3	H2	H1	*		I [5:0]: Color B of the fill area
I[5:0]	*	*	I5	I4	I3	I2	I1	I0		J[5:1]: Color A of the fill area
J[5:1]	*	*	J5	J4	J3	J2	J1	*		
23	0	0	1	0	0	0	1	1	Copy	A[6:0]: Column Address of Start
A[6:0]	*	A6	A5	A4	A3	A2	A1	A0		B[5:0]: Row Address of Start
B[5:0]	*	*	B5	B4	B3	B2	B1	B0		C[6:0]: Column Address of End
C[6:0]	*	C6	C5	C4	C3	C2	C1	C0		D[5:0]: Row Address of End
D[5:0]	*	*	D5	D4	D3	D2	D1	D0		E[6:0]: Column Address of New Start
E[6:0]	*	E6	E5	E4	E3	E2	E1	E0		F[5:0]: Row Address of New Start
F[5:0]	*	*	F5	F4	F3	F2	F1	F0		
26	0	0	1	0	0	1	1	0	Fill Enable / Disable	A0 0 : Disable Fill for Draw Rectangle Command (RESET)
A[4:0]	*	*	*	A4	0	0	0	A0		1 : Enable Fill for Draw Rectangle Command A[3:1] 000: Reserved values A4 0 : Disable reverse copy (RESET) 1 : Enable reverse during copy command

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12. Initialization Option

This command is the step 4.5 of initialization. There are many options for format of the image data as well as selecting the 256 color instead of 65K. For 256 color each pixels has one byte of data in the format of BBBGGGRR. However the on-board controller translates it to two bytes upon receiving the byte.

Hex	D7	D6	D5	D4	D3	D2	D1	D0	Command	Description
A0	1	0	1	0	0	0	0	0	Remap &color / Depth setting	A[0]= 0 : Horizontal address increment A[0]=1 : Vertical address increment A[1]=0 : Ram column 0 to 95 maps to pin seg 0 to 95 A[1]=1 : Ram column 0 to 95 maps to pin seg 95 to 0 A[2]=0 : normal order SA,SB,SC (eg RGB) A[2]=1 : reverse order SC,SB,SA (eg BGR) A[3]=0 : Disable left-right swapping on COM A[3]=1 : Set left-right swapping on COM A[4]=1 must be set to 1 A[5]=1 must be set to 1 A[7,6]=00 : 256 color A[7,6]=01 : 65k color A[7,6]=10 : reserved A[7,6]=11 : reserved
A[7:0]	A7	A6	A5	A4	A3	A2	A1	A0		

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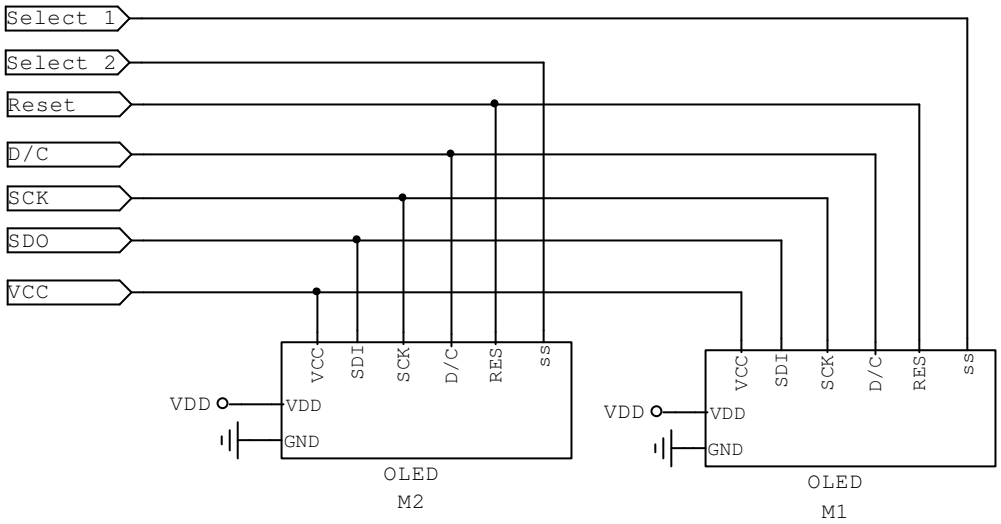
13. Sample Schematic for Multi-Switch Controller

Below is a sample schematic to control two OLED modules. With the maximum clock frequency of 6.6 MHz, up to four OLED modules can be controlled at 30 frames per second. There are 6144 bytes for each image in the 65k color mode. One image takes 6144 byte * 8 bits/byte= 49152 bits. Dividing the SPI frequency by 49152 provides the minimum time it takes to transmit one image to the OLED module. The addtional time it takes to retrieve the image data and other functions of microcontroller have to be added to the minimum time to get the true retrieval to display time.

Illustration 1, Sample schematic for control of two OLED modules



14. Operating Life Time

The OLED life is rated for 15000 hrs (40% pixels ON) meaning it will be at half brightness after 15000 hrs. The OLED life rating is based on displaying moving images such as videos. It is determined that when a display is showing a video, on average each pixel of the display is on 40% of the time.

The software engineers' creativity could impact the life expectancy of OLED drastically by incorporating dimming, screen savers, and/or moving images.

OLED technology is progressing in fast pace. We anticipate increasing the OLED life to 30,000 hrs in 2010 and 50,000 hrs by end of 2012. The initialization value may change with the future revisions of the product however all other design parameters stay the same.

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15. Frequently Asked Questions

How many different colors can each pixel display?
65536 different colors. The OLED has the most vivid and sharp display among all the technologies.

Is the OLED SmartSwitch/Display capable of displaying movies?
Yes. The OLED response time is 0.2 ms 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 SmartSwitch/display. Most videos are 25 to 30 frames per second.

Can the OLED SmartSwitch/Display display live video?
Yes. The controller has to be fast enough to resize and transmit the data to the OLED SmartSwitch/Display.

What is aging?
Aging for the OLED 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. Since the OLED is intended to display movies or frequently changing images it is assumed that each pixels will be on the equivalent of 40% of the time at full brightness.

How does aging affect the colors?
When displaying movies the OLED colors age proportionally and the combined colors stay relatively consistent. However, if the OLED displays a still image, over time the pixels used for the image get dimmer compared to the pixels not used. The color OLED is not suited for use in applications that display the same still image over an extended period of time.

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 of SmartSwitches available?
Yes. NKK Switches has many development kits and also entertain custom designs.

Is NKK Switches planning to develop other sizes of the OLED SmartSwitch?
NKK Switches is interested in developing new OLED SmartSwitch 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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