

SmartDisplay Command Panel Frameless OLED version

Revision B



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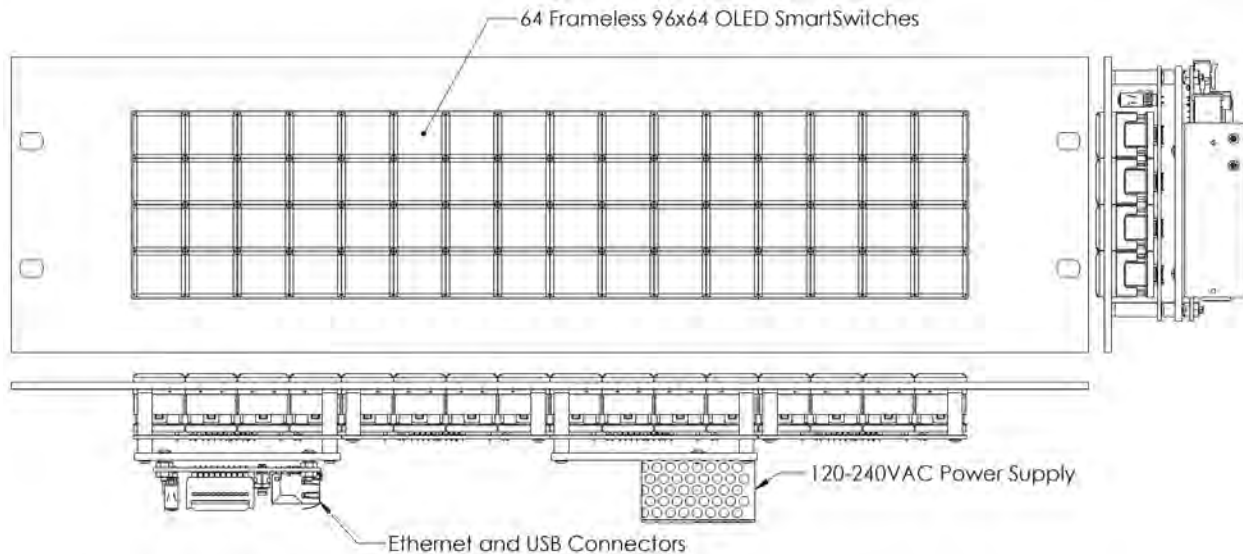
1. Frameless OLED SmartDisplay Switch

The Frameless OLED SmartDisplay switch is a graphic 96x64 OLED display mounted in the key cap of a momentary pushbutton. The display has a thin enough border such that an image can be displayed in a matrix of several switches. The display can run video at over 67 frames per second. Each pixel has 65k color options.

Please contact engineering@nkkswitches.com with your requirements for custom solutions.

NKK can supply subsystems with any configuration and number of Frameless OLED switches with USB and Ethernet communication. For instance, the SmartDisplay Command Panel is a powerful human-to-machine-interface tool that uses 64 of the FL OLED SmartDisplays to allow designers to dynamically change switch legends and images based on desired application functions. The system is ready to interface with a customer's application through Ethernet and USB. It can receive commands, send information, and update the SmartDisplay images.

An example system is outlined below.



The system is ideal for use in applications with multiple, complex functions which would ordinarily require many dedicated switches and complex training. The dynamic nature of the system allows for instantaneous transitions from generalized lists of categories down to function specific actions. This reduces the need for complicated controls and shortens the time for training by only displaying relevant options and commands.

To help with development, NKK Switches provides free software, Engineering Kits Communicator, to save and erase images on the controller. Also, NKK Switches provides all the documentation necessary to get up and running quickly on our website:

<https://www.nkkswitches.com/SmartDisplay-resources/>

2. General Features of the SmartDisplay Command Panel

The system is a 64 programmable display-on-pushbutton system on a 3U rack-mount panel. It comes with the following features:

Features:

- 4,032 functions available with a maximum of 3 switch presses.
- 64 Frameless 96x64 OLED SmartDisplays with momentary pushbutton functionality.
- USB or Ethernet controlled.
- Power Specs: 120-240VAC, Max 24 Watts. (with included power cord).
- The unit comes with a 6-foot USB 2.0 A to Mini-B cable (IS-USB1).
- On-board memory for 1000 images minimum (More images upon request).
- 16 levels of brightness.
- Real-time control by host.
 - Save images to memory.
 - Show any saved image on any switch.
 - Reports switch activity to host.
 - Ability to send images directly to switches without saving to memory.
 - Write text with specific foreground/background color.
 - Draw colored lines of varying length and row count.
- Can change all images at 4 frames per second (fps). Individual OLED can have up to 80 frame per second.
- Controller board firmware can be customized based on customer requirements.
- Firmware field upgradable via USB.
- Windows based software is available for communication.
 - Accepts bitmap files, extracts the images and downloads them to the controller.
 - Allows typing of manual commands and downloading them to the controller.
 - Extracts HEX or ASCII data from Excel files and downloads them to the controller.
 - Messages to and from the controller are displayed in different colors.
 - Provided for testing and downloading images.
- The communication protocol can be modified to meet customer's requirements.
- Please contact the factory about custom builds and firmware modifications.

3.Application Level Considerations

The information displayed by Frameless OLED can be set up in a variety of ways. Two arrangements are common; menus of items and function specific actions.



Menus of items is just that; a list of different items from which the user may choose from. Once an item is chosen then all the displayed images could be changed to show only actions or other menus associated with just that item. One way to set on the displays is to have the menu on the left and the function actions associated with a particular item on the right.

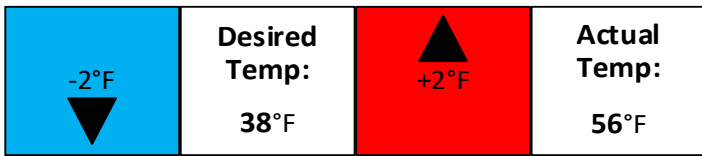
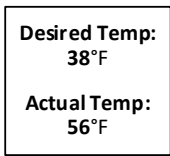
Example: List of menu items on the left. Actions associated with Menu Item 2 on the right.

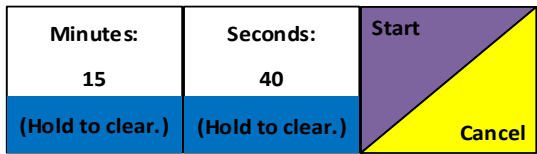
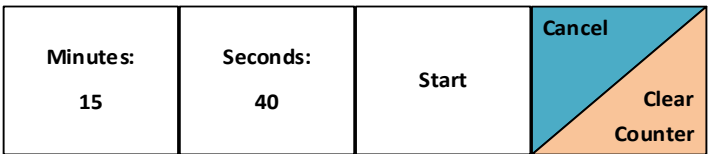
Menu Item 1	Menu Item 2	Menu Item 3		Menu Item 2 Action 1	Menu Item 2 Action 2
Menu Item 4	Menu Item 5			Menu Item 2 Action 3	Menu Item 2 Action 4

...

Buttons can also just show information without actually having any actions associated with them. Buttons that are not needed for a particular menu or function can simply have nothing displayed.

Another consideration is how many switches to use to display information and/or actions. For a quick glance having as much information as possible displayed might be desired so using one switch per item would be a good set up. On the other hand, the density of overall information might be large enough that buttons might need to display both information and also be an action. This will also impact the number of buttons that need to be pressed in sequence to get to an item or action.

<p>Example: Four buttons; each dedicated to one action or one source of information.</p>	<p>One button showing two sources of information. Also, it is an action button that loops through a predefined number of preset items.</p>
	

<p>Example: The Minutes and Seconds buttons are used to set a timer and then display the countdown. The Start and Cancel buttons could be combined (showing only Start or Cancel depending on the state) or the Cancel could be used to stop the countdown and, with a change in display, a Clear Counter.</p>	
	

Videos can also be shown at maximum 80 frames per second (fps) per bank (5 frames per switch). The human eye sees 24 fps as continuous so a single switch per bank can show continuous video. If the changing images are split between two switches per bank, then the frame rate is 40 fps on each switch. This is good enough for many applications where a monitor of change is all that is required. All 16 switches per bank can be animated but at under 5 fps. This could be good for slide shows where the transition from one image to another is not as important.

4. Electrical Specifications

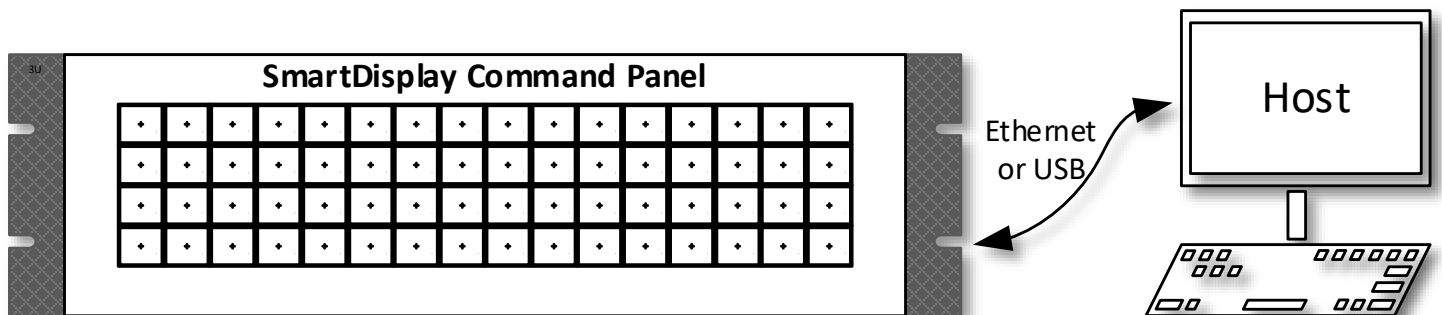
Power Specs: 120-240VAC, Max 30 Watts.

5. Communication

The system can communicate over USB and ethernet. If using ethernet, the system must be configured over USB first. The protocol is the same regardless of the communication method. All commands and responses are detailed in the associated Command List. A non-inclusive list of commands is as follows:

- Acknowledge.
- Erase flash memory.
- Get/Set ethernet settings.
- Reset system.
- Query version.
- Save image to flash memory.
- Send image directly to switch.
- Set image from flash memory on specific switch.
- Write font with specific foreground and background color.
- Draw a colored line on a selected number of rows for a selected length.

The system shows up as a generic USB COM port. This allows quick testing, loading of images, and integration with customer software. For testing, the NKK Engineering Kits Communicator or a standard terminal program such as Putty can be used.



6. Images

Images can be created in any graphics software such as Paint, Photoshop, etc, or even user-created software. All images can be saved onto the system by using the free Engineering Kits Communicator, located on the NKK Website:

<https://www.nkkswitches.com/>

(Images can also be loaded onto the system with user-created software as long as the rules for the images and communications are followed.)

To use this software, images must be saved in the proper format:

Frameless OLED 96x64	24-bit bitmap (.bmp) 96x64 pixels
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The best results for the Frameless OLED SmartDisplay are achieved by compressing the image vertically 75% (to compensate for the rectangular pixels) before re-sizing to 96x64 size.

Please note that the **flash memory must be erased before new images are loaded**, or images will not display properly. Erasing can take up to 2 minutes depending on the size of the flash memory.

The Engineering Kits Communicator will auto-convert the 24-bit .bmp file to 16-bit 565 BGR and send the data. If writing custom software, be aware bitmap format specifies the bottom-left corner as the “top”. Therefore, to send images properly to the switches the data needs to be sent last row first, followed by next to last, etc.

The system expects OLED image pixels to be 16-bit using 565 BGR format. That’s 2 bytes for every pixel to support 65k colors.

B4	B3	B2	B1	B0	G5	G4	G3	G2	G1	G0	R4	R3	R2	R1	R0
B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0

When saving images to flash, the data needs to be converted to ASCII hex for 24,576 bytes of data. If streaming live images, data should be sent as-is for 12,288 bytes of data.

565 BGR (16-bit) 96x64 pixels	2 bytes per pixel	12288 bytes per image
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7.Operational Overview

Upon power-up the system configures and turns on the switches. The system then waits for a command from the host. The only action the system performs automatically is reporting switch presses. All other actions must be commanded from the host.

The flash memory stores both ethernet settings and images. They are stored in separate sections of memory, so erasing the images will not remove the ethernet settings and vice versa. Each image is assigned a sequential address when saved into flash memory; A list of which image is stored at which address must be kept on the host software to know which image to display where.

When a switch is pressed, the system reports that back to the host software. The system only reports switch state changes (a press or release). More than one switch can be in the pressed position at the same time. Bits are set when the switch is pressed and cleared when the switch is released. An example of a switch response is:

0x50 0x74 0x31 0x34 0x36 0x41

The 0x50 signifies a switch press response. The 0x74 represents the bank number. Each bank has 0 to 15 for the switch index. The next 4 numbers are ASCII hex of a 16-bit number, and represent what switches are pressed. Each bit represents the corresponding switch, and a high bit is pressed while a low bit is not pressed. In the example, converting from ASCII hex gives the 16-bit number of 0x146A. That corresponds with bits 12, 10, 6, 5, 3, and 1 being high. The switch numbers are 0-indexed in this response, so that corresponds with switches 13, 11, 7, 6, 4, and 2 being pressed.

Example 0x146A:

Identifier	Bank Number	Switch ->	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		Index ->	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x71	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x72	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x73	3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x74	4		0	0	0	1	0	1	0	0	0	1	1	0	1	0	1	0

8. Saving Images Using Engineering Kits Communicator

The Engineering Kits Communicator loads the images in alphanumeric order according to the image files names. It auto-assigns a sequential address to each image. Be sure to keep this in mind when naming images so that video images or animations are listed in the desired order. Avoid using symbols in the names as some symbols interfere with alphanumeric ordering. All images to be loaded should be saved in a single folder. The default starting address is 0001. This can be changed if needed.

To save images to the system:

1. Open the Engineering Kits Communicator.
2. From the drop-down menu at the top, select the COM port of the system (usually the last one).
3. Click the 'Open Port' button.
4. Press the call button and verify the system responds with '61' in blue text in the left text box.
5. Select the image type from the drop-down in the 'Loading Images' section.
6. Click the 'Import Images' button.
7. Navigate to the directory with all the images and select one and click 'Open'.
8. Note that the images are loaded alphanumerically and automatically assigned addresses.
 - a. If some/all images do not show up in the image list after selecting the directory, it is because the image is not in the proper resolution or file type (.bmp). Double-check the image size is correct *before* downloading. If an image was skipped the images will load one address off and will have to be erased before reloading them.
9. If images were previously saved, click the 'Erase Flash' button.
 - a. Note that this operation can take up to **2 minutes**.
10. Click the 'All selected images' button at the bottom.
11. Wait for the 'Success' message. If the process fails, click the 'All selected images' button again.

If writing custom software to save images, all data after the command must be sent in ASCII hex (See Sections [Images](#) and [ASCII Hex](#)).

9. Live Images

A “live image” is an image that is sent to a switch to be displayed but not saved in flash memory. Live images have a setup command followed by image data (see Command List). **Live image data is NOT sent as ASCII hex but as the raw data bytes.**

To achieve maximum framerate, images should be sent to different banks instead of the same bank sequentially. This allows the system to maximize throughput. For example:

Optimized:

- Send image to bank 1 switch 1
- Send image to bank 2 switch 1
- Send image to bank 3 switch 1
- Send image to bank 4 switch 1
- Send image to bank 1 switch 2
- Send image to bank 2 switch 2
- Send image to bank 3 switch 2
- Send image to bank 4 switch 2
- Send image to bank 1 switch 3
- ...

Not optimized:

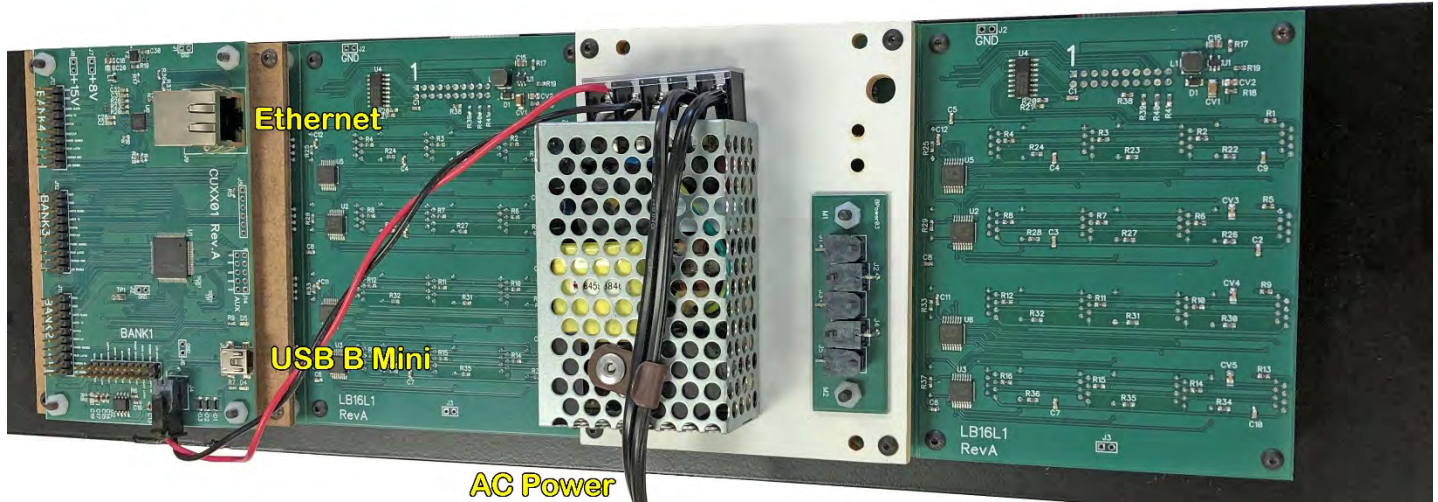
- Send image to bank 1 switch 1
- Send image to bank 1 switch 2
- Send image to bank 1 switch 3
- Send image to bank 1 switch 4
- Send image to bank 2 switch 1
- Send image to bank 2 switch 2
- Send image to bank 2 switch 3
- Send image to bank 2 switch 4
- Send image to bank 3 switch 1
- ...

If a bank is still busy processing the previous image data, after another command is sent the system will respond with 0x65 (busy). This means either retry the command until ready (0x61) is received or send a command for a different bank.

Bank 1 Switch 1	Bank 1 Switch 2	Bank 1 Switch 3	Bank 1 Switch 4	Bank 2 Switch 1	Bank 2 Switch 2	Bank 2 Switch 3	Bank 2 Switch 4	Bank 3 Switch 1	Bank 3 Switch 2	Bank 3 Switch 3	Bank 3 Switch 4	Bank 4 Switch 1	Bank 4 Switch 2	Bank 4 Switch 3	Bank 4 Switch 4
Bank 1 Switch 5	Bank 1 Switch 6	Bank 1 Switch 7	Bank 1 Switch 8	Bank 2 Switch 5	Bank 2 Switch 6	Bank 2 Switch 7	Bank 2 Switch 8	Bank 3 Switch 5	Bank 3 Switch 6	Bank 3 Switch 7	Bank 3 Switch 8	Bank 4 Switch 5	Bank 4 Switch 6	Bank 4 Switch 7	Bank 4 Switch 8
Bank 1 Switch 9	Bank 1 Switch 10	Bank 1 Switch 11	Bank 1 Switch 12	Bank 2 Switch 9	Bank 2 Switch 10	Bank 2 Switch 11	Bank 2 Switch 12	Bank 3 Switch 9	Bank 3 Switch 10	Bank 3 Switch 11	Bank 3 Switch 12	Bank 4 Switch 9	Bank 4 Switch 10	Bank 4 Switch 11	Bank 4 Switch 12
Bank 1 Switch 13	Bank 1 Switch 14	Bank 1 Switch 15	Bank 1 Switch 16	Bank 2 Switch 13	Bank 2 Switch 14	Bank 2 Switch 15	Bank 2 Switch 16	Bank 3 Switch 13	Bank 3 Switch 14	Bank 3 Switch 15	Bank 3 Switch 16	Bank 4 Switch 13	Bank 4 Switch 14	Bank 4 Switch 15	Bank 4 Switch 16

10. Controller Hardware

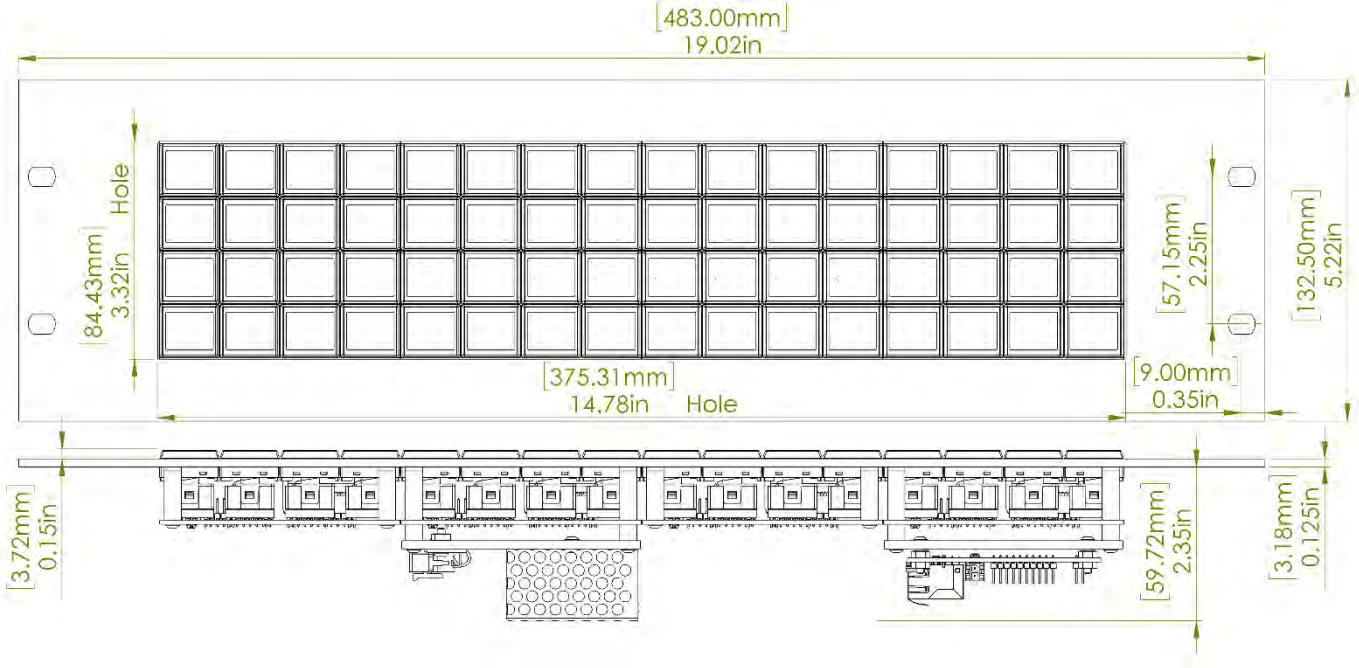
External connections to board. Ribbon cables omitted for clarity. Product may vary in appearance.



- The USB connection automatically shows up as a COM device in Windows 10. Earlier versions of windows may require a driver. All communication is done using serial over USB. The communication is baud-rate agnostic.
- Ethernet can be configured for TCP or UDP. Both DHCP and static IP addresses are supported.

11. Board Dimensions

Typical dimensions. The system is designed to fit into a 3U rack mount region.



12. ASCII Hex

All data (except live data) is sent as ASCII hex as a safety measure to avoid being interpreted as a command. ASCII hex is a normal data byte split into two halves and converted to their ASCII equivalent (see www.asciitable.com). Therefore, all data received will be in the 0x30-0x46 number range, and anything received outside that is invalid. For example:

Data to be sent is 0x3D.

Each nibble is assigned its own byte: 0x3 and 0xD.

Each of those bytes is converted to ASCII equivalent: 0x33 0x44 (0x33 is the ASCII number '3'. 0x44 is the ASCII letter 'D').

Receiving is the same process reversed:

Data received is 0x41 0x37.

Each byte converted from the ASCII equivalent is 0xA 0x7 (0x41 is the ASCII letter 'A', 0x37 is the ASCII number '7').

Combine the two bytes to get the data byte 0xA7.

13. Key Terms & Definitions

Host	Any computer, terminal, or other device that can communicate over the USB line.
Byte	An eight-bit hex value ranging from 00H to FFH (Decimal 0 to 255). The bit format of a byte is: (B7 B6 B5 B4 B3 B2 B1 B0) where B7 is most significant and bit B0 is least significant bit.
Nibble/Hex Digit	A four-bit value ranging from 0H to FH. A byte consists of two nibbles.
ASCII	A byte value representing a symbol.
Communication Format	<p>There are two formats to transmit a byte:</p> <ol style="list-style-type: none">1. Hex format - A hex byte is transmitted without any change to it. [xxH] will be used to denote this. All commands and some data are sent by using this format.2. ASCII HEX format - Each nibble of the byte is converted to ASCII code and sent as a byte. [xxAH] will be used to denote this. For example, the hex byte 5AH is transmitted in two bytes, 35H and 41H. The ASCII value for 5 is 35H and the ASCII value for A is 41H. All addresses and most data are sent using this format.
Address	A two-byte value ranging from 0001H to 03E8H representing the 1000 memory locations for images on the flash memory.

14. Warranty

NKK SWITCHES LIMITED WARRANTY AND LIMITATION OF LIABILITY

The following limits our liability. Please read.

NKK Switches hereby warrants this product against any and all manufacturing defects for a period of one year from the date of sale of this product to the original end user. NKK Switches' liability in the event of such defect is limited to repair or replacement of the defective products. NKK Switches disclaims any liability or warranty obligation with respect to any product that is misused, damaged by any user, or not used in conformity with all applicable product specifications.

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USE OF THIS PRODUCT IN CONNECTION WITH ANY LIFE CRITICAL APPLICATION IS NOT RECOMMENDED.

15. Commands to the Controller

See the Command List on the next page.

ASCII Hex

SmartDisplay Command Panel Frameless OLED Command List

An ASCII Hex byte is a normal hex byte split in two halves and converted to their ASCII equivalent (www.asciitable.com). This is a safety measure so that all data sent isn't accidentally interpreted as a command. Most data sent after commands and sub-commands are in ASCII Hex. The only exception is when sending live images (images not saved in memory and sent directly to the switches)

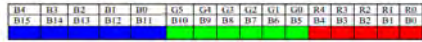
Example: To set bank 4, switch 4 to image 679 (0x02A7):
 Switch 4 is 0x03 (0-based), change to 2 bytes: 0x30 (ASCII '0') and 0x33 (ASCII '3')
 Image high byte 0x02 to 2 bytes: 0x30 (ASCII '0') and 0x32 (ASCII '2')
 Image low byte 0xA7 to 2 bytes: 0xA1 (ASCII 'A') and 0x37 (ASCII '7')
 Using the table below, this would result in the command:
 0x2D 0x56 0x74 0x30 0x33 0x30 0x32 0x41 0x37

Conversion **TO** ASCII Hex:
 x = ((data & 0xF0) >> 4)
 y = ((data & 0x0F) >> 0)
 If (0x0 <= x <= 0x9) x+= 0x30
 If (0xA <= x <= 0xF) x+= 0x37
 If (0x0 <= y <= 0x9) y+= 0x30
 If (0xA <= y <= 0xF) y+= 0x37

Conversion **FROM** ASCII Hex:
 x = ASCII hex byte 1
 y = ASCII hex byte 2 (conversion not shown)
 z = converted byte
 If (0x30 <= x <= 0x39) x -= 0x30
 If (0xA1 <= x <= 0xA6) x -= 0x37
 z = (x << 4) + y

Expected Image Format

The color of each pixel is split over 2 bytes using BGR 565 format:



There are 2 bytes of color per pixel, so for a frameless OLED (96x64 pixels) there are 12288 bytes of data per image

Command	Sub-Command	Description	Command Format	Sending example	Notes
0x01		Queries the controller if it is up and running. (Controller responds with 0x61)	0x01 (1 hex byte)	0x01	
0x21	0x55 0xAA 0x56 0x56	Erases all images on the flash memory	0x21 0x55 0xAA 0x56 0x56 (5 hex bytes)	0x21 0x55 0xAA 0x56 0x56	Responds with 0x65 until the erase is complete, then sends 0x79
	0x55 0xAA 0x56 0x56 AA	Erases all images and settings on the flash memory	0x21 0x55 0xAA 0x56 0x56 0xAA (5 hex bytes)	0x21 0x55 0xAA 0x56 0x56 0xAA	Responds with 0x65 until the erase is complete, then sends 0x79
	0x55 0xAA 0x56 0x56 DD	Erases all images on the flash memory	0x21 0x55 0xAA 0x56 0x56 0xDD (5 hex bytes)	0x21 0x55 0xAA 0x56 0x56 0xDD	Responds with 0x65 until the erase is complete, then sends 0x79
	0x55 0xAA 0x56 0x56 EE	Erases all settings on the flash memory	0x21 0x55 0xAA 0x56 0x56 0xEE (5 hex bytes)	0x21 0x55 0xAA 0x56 0x56 0xEE	Responds with 0x65 until the erase is complete, then sends 0x79
0x22	0x51	Get IP settings	0x22 0x56 (2 hex bytes)	0x22 0x56	Responds with 0x01 followed by the IP address in ascii hex separated by ':', followed by a ':', followed by the current port
	0x52	Set IP settings	0x22 0x56 (2 hex bytes) 0xAA (1 ASCII hex byte of ethernet type) 0xBB (1 ASCII hex byte of DHCP Enable) 0xCC 0xDD 0xEE 0xFF (4 ASCII hex bytes of IP address) 0xGG 0xHH (2 ASCII hex bytes of port number) 0xJJ 0xKK 0xLL 0xMM (4 ASCII hex bytes of subnet mask) 0xNN 0xPP 0xQQ 0xRR (4 ASCII hex bytes of Gateway) 0xSS 0xTT 0xUU 0xVV (4 ASCII hex bytes of DNS)	0x22 0x56 0x30 0x31 0x30 0x30 0x43 0x30 0x41 0x38 0x30 0x31 0x44 0x32 0x32 0x36 0x32 0x30 0x46 0x46 0x46 0x46 0x46 0x30 0x30 0x43 0x30 0x41 0x38 0x30 0x31 0x30 0x31 0x43 0x43 0x41 0x38 0x30 0x31 0x30 0x35 (Sets to UDP, DHCP off, IP 192.168.1.210, Port 9760, Subnet 255.255.255.0, Gateway 192.168.1.1, DNS 192.168.1.5)	Mode: 0/1/2 = None/TCP/UDP DCHP: 0/1 = Off/On
0x24		Resets the controller	0x24 (1 hex byte)	0x24	
0x27	0x56 0x77	Change switch brightness (range from 0-15, 15 is max brightness)	0x27 0x56 0x77 (3 hex bytes) 0xAA 0xBB (2 ASCII hex bytes of the switch brightness)	0x27 0x56 0x77 0x30 0x46 (set to max brightness)	Switch brightness range 0x0-0xF
	0x56 0x78	Add ASCII character(s) to switch. Easy way to add text to the display without saving/loading an image from flash	0x27 0x56 0x78 (3 hex bytes) 0xAA (1 hex byte bank #, 0x71-0x74) 0xBB (1 hex byte font size, 0x50 = 8 by 10, 0x51 = 16 by 20) 0xCC 0xDD (2 ASCII hex bytes for switch #) 0xEE 0xFF (2 ASCII hex bytes for starting row) 0xGG 0xHH (2 ASCII hex bytes for starting column) 0xJJ 0xKK (2 ASCII hex bytes for # of characters) 0xLL (Character data, 2 ASCII hex bytes per character)...	0x27 0x56 0x78 0x71 0x50 0x30 0x30 0x30 0x41 0x30 0x41 0x30 0x33 0x34 0x45 0x34 0x42 0x34 0x42 (Add text, to bank 1, 8x10 size, switch 1, start at row 10, start at column 10, 3 letters, 'N' (0x4E) 'K' (0x4B) 'K' (0x4B))	The change text color command must be set prior, or the text defaults to black text on a white background
	0x56 0x79	Change on/off color of text	0x27 0x56 0x79 (3 hex bytes) 0xAA 0xBB 0xCC 0xDD (4 ASCII hex bytes of background color in 565 BGR) 0xEE 0xFF 0xGG 0xHH (4 ASCII hex bytes of foreground color in 565 BGR)	0x27 0x56 0x79 0x46 0x38 0x30 0x30 0x30 0x31 0x46 (Change text color, background to pure blue(0xF800), foreground to pure red (0x001F))	
	0x56 0x7A	Add a line spanning all columns for one or more rows	0x27 0x56 0x7A (3 hex bytes) 0xAA (1 hex byte bank #, 0x71-0x74) 0xBB 0xCC (2 ASCII hex bytes for switch number) 0xCC 0xDD (2 ASCII hex bytes for starting row #) 0xEE 0xFF (2 ASCII hex bytes for number of rows to fill)	0x27 0x56 0x7A 0x71 0x30 0x30 0x30 0x41 0x30 0x37 (Add a line, to bank 1, to switch 1, starting at row 10, spanning 7 rows)	The change line color command must be set prior, or the line color will be black
	0x56 0x7B	Change line color	0x27 0x56 0x7B (3 hex bytes) 0xAA 0xBB 0xCC 0xDD 0xAA 0xBB 0xCC 0xDD (4 ASCII hex bytes of line color in 565 BGR)	0x27 0x56 0x7B 0x30 0x37 0x45 0x30 (Set line color, to pure green (0x07E0))	
0x26		Retrieves the firmware version number	0x26 (1 hex byte)	0x26	Returns the current version number in ASCII hex. It will be the letter 'V' followed by 4 ASCII hex bytes signifying the major version, followed by '.', followed by 4 ASCII hex bytes signifying the minor version number Example: 0x76 0x30 0x30 0x30 x31 0x2E 0x30 x030 0x30 0x30 in ASCII is v0001.0000
0x28	0x56	Saves an image to the flash memory	0x28 0x56 (2 hex bytes) 0xAA 0xBB 0xCC 0xDD (4 ASCII hex bytes for the image address) After the controller responds with 0x61, send image data in ASCII hex. The controller responds with 0x79 when the save completes.	0x28 0x56 0x30 0x30 0x30 0x31 (Send an image, save at address 0x0001) (Followed by bytes of image data in ASCII hex after the controller responds with 0x61)	
0x2A	0x56 0x50	Sends a full live image (image not saved in memory, sent directly to switches)	0x2A 0x56 0x50 0xAA (1 hex byte bank #, 0x71-0x74) 0xBB (1 hex byte switch number, 0 based) If the controller responds with 0x61, send image data. If the controller responds with 0x65 (busy), re-send the command until the controller responds with 0x61, then send the image data. The controller responds with 0x79 when the command completes.	0x2A 0x56 0x50 0x72 0x03 (Send an image, send to bank 2, switch 4) (Followed by image data after the controller responds with 0x61)	Switch number is 0 based. To optimize performance, stagger images between banks (IE send an image to bank 1, then bank 2, then bank 3, then bank 4, then send the next bank 1 image)
	0x56 0x51	Sends a partial live image (image not saved in memory, sent directly to switches)	0x2A 0x56 0x51 0xAA (1 hex byte bank #, 0x71-0x74) 0xBB (1 hex byte switch number, 0 based) 0xCC (Row start, 0x00-0x3F) 0xDD (Row end, 0x00-0x3F) 0xEE (Column Start, 0x00-0x5F) 0xFF (Column End, 0x00-0x5F) If the controller responds with 0x61, send ((rows + 1) * (columns + 1) * 2) bytes of image data. If the controller responds with 0x65 (busy), re-send the command until the controller responds with 0x61, then send the image data. The controller responds with 0x79 when the command completes.	0x2A 0x56 0x51 0x73 0x04 0x11 0x2E 0x20 0x3D (Send an image, send to bank 3, switch 5, start at row 17, end at row 46, start at column 32, end at column 61) (Followed by 1800 (30 * 30 * 20) bytes of image data after the controller responds with 0x61) (This command will send a 30x30 image centered in the middle of the switch)	Switch number is 0 based. To optimize performance, stagger images between banks (IE send an image to bank 1, then bank 2, then bank 3, then bank 4, then send the next bank 1 image). Partial image is slower than sending a full image.
0x2D	0x56 0x60 0x71-74	Sets the image on a particular switch from an image saved in flash memory	0x2D 0x56 0x60 (3 hex bytes) 0xAA (1 hex byte bank #, 0x71-0x74) 0xBB 0xCC (2 ASCII hex bytes switch #, 0 based) 0xDD 0xEE 0xFF 0xGG (4 ASCII hex bytes for the image address)	0x2D 0x56 0x60 0x71 0x30 0x33 0x30 0x30 0x41 0x37 (Set image, bank 1, switch 4, image 167 (0x00A7))	Switch number is 0 based

Response	Description	Response Format	Response Example	Notes
0x50	Switch Pressed	0x50 0xAA (Bank #, 0x71-0x74) 0xBB 0xCC 0xDD 0xEE (4 ASCII hex bytes of switch number)	0x50 0x74 0x31 0x34 0x36 0x41 (Switch press/release, bank 4, switches 13,11,8,4, and 2 are pressed)	The highest bit of the switch number is switch 16 state, the next one down is switch 15 state, etc. so receiving 0001 0100 1000 1010 (0x14 0x8A after ASCII hex conversion) means switches 13,11,8,4, and 2 are all pressed
0x61	Ready/Command received	0x61	0x61	
0x65	Busy processing previous command	0x65	0x65	If there was data associated with this command, it is ignored. The system is busy with the previous command. If sending for a specific bank, either re-send the command until 0x61 is received, or send data for a bank that is not busy
0x6E	Error, followed by error code	0x6E	0x6E 0x02	Error Codes: 01 - Invalid Command 02 - Timeout 03 - Not enough data 04 - Invalid data
0x79	Command successful	0x79	0x79	