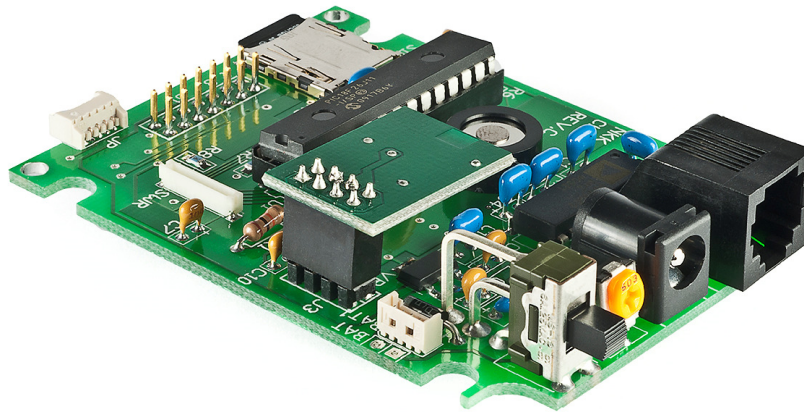# IS-CL04R Intelligent Controller User's Manual
Revision B

Firmware Version 2.6

NKK SWITCHES

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1.   General Features

The IS-CL04R Version 2.6 can control two ISC15ANP4 OLED SmartSwitches or two ISC01P OLED SmartDisplays and an IS18WWC1W OLED Rocker. The firmware can be customized based on customer requirements. Below are current features:

- Controls two OLED (64x48) SmartSwitches or two OLED (52x36) SmartDisplays
- On board microSD Flash can hold up to 65,536 images and attributes for OLED switches.
- 16 level of brightness settings for OLED Switches/Displays
- Controls one OLED Rocker
- On board microSD Flash can hold up to 65,536 images and attributes for OLED Rocker.
- 16 level of brightness settings for OLED Rocker.
- Adjustable audio feedback when a switch is pressed.
- User programmable for images, attributes and set-ups.
- Real-time control by host.
  - Commands to direct the controller to display any of 65535 images on any of displays.
  - Command to send characters so controller create images for the displays
  - Commands to check various statuses of the controller
  - Controller reports switch activities to host
  - Controller reports the address of any new image displayed to host
- Stand-alone operation
  - Set up the controller to function based on switch presses.
  - Set up to the controller to function based on timer expire.
  - Controller reports switch activities to host
  - Controller reports the address of any new image displayed to host

- Serial communication via RS232 (57.6K, 1 start bit, 8 bit, 1 stop bit).
- Set the type of activity reports from the controller to host.
- Controller board firmware can be customized based on customer requirements.
- Two connector for power input
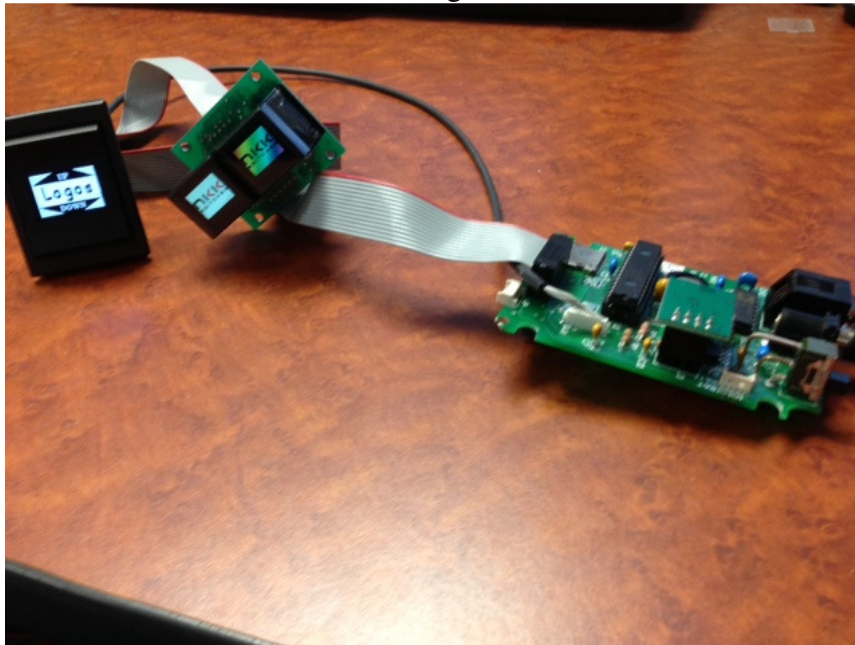- Power requirement 5V to 12V with maximum 200 mA

2. Preface

IS-CL04R is the same controller used in IS-DEV KIT-7/7D and IS-DEV KIT-8. It can control 2 OLED switches/Displays and one OLED Rocker. The user manual for the IS-DEV KIT-7 and IS-DEV KIT-8 both described the functions of the controller and have more examples of the functions.

The two OLED switches function exactly as described in IS-DEV KIT-7 user manual. The OLED switches functions cannot affect the OLED Rocker function.

The OLED Rocker functions exactly as described in IS-DEV KIT-8 user manual. However there is a function which effect OLED switches that is not described IS-DEV KIT-8. The last 4 bytes of Attribute Block were stated to be reserved and must be zero.

Bytes 11 &12 of the Attribute Block are address for OLED switch #1 and bytes 13&14 of the Attribute Block are address for OLED switch #2. They go to effect only if the middle switch of OLED Rocker is pressed and their values are non-zero.

IS-CL04R Controller controlling OLED switches and rocker.

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3. Parts Needed for Different Systems

Below are part numbers to make various systems with IS-CL04R

A. OLED Rocker System

	Part Number	QTY	Description
1	IS-CL04R	1	Controller
2	IS18WWC1W	1	OLED Rocker
3	AT715-S	1	19" cable with heat shrink
4	IS-418-TR1509-12	1	Power Supply
5	IS-SERIAL-CABLE	1	RS232 cable RJ11 to DB9

B. OLED Switch System

	Part Number	QTY	Description
1	IS-CL04R	1	Controller
2	IS-L02L1-C	1	Logic Board
3	ISC15ANP4	2	OLED switch
4	ISDCB824	1	24 " Ribbon cable
5	IS-418-TR1509-12	1	Power Supply
6	IS-SERIAL-CABLE	1	RS232 cable RJ11 to DB9

C. OLED Display System

For OLED display a jumper needs to be placed between pins 1&2 of the SWS (unpopulated, behind the potentiometer). IS-CL04R will initialize for OLED switches if there is no jumper. The displays will not have the proper contrast and can be damaged if they are used with the wrong initialization for a long time.

	Part Number	QTY	Description
1	IS-CL04R	1	Controller
2	IS-L02P1-C	1	Logic Board
3	ISC01P	2	OLED display
4	ISDCB824	1	24" Ribbon cable
5	IS-418-TR1509-12	1	Power Supply
6	IS-SERIAL-CABLE	1	RS232 cable RJ11 to DB9

D. OLED Rocker and OLED Switch System

When using both OLED Rocker and OLED switches, some noise may be observed on the OLED switches/displays. With ribbon cable longer than 18" the noises disappear.

	Part Number	QTY	Description
1	IS-CL04R	1	Controller
2	IS-L02L1-C	1	Logic Board
3	ISC15ANP4	2	OLED switch
4	ISDCB824	1	24" Ribbon cable
5	IS-418-TR1509-12	1	Power Supply
6	IS-SERIAL-CABLE	1	RS232 cable RJ11 to DB9
7	IS18WWC1W	1	OLED Rocker
8	AT715-S	1	19" cable with heat shrink

4. Universal Communicator

Universal Communicator version 1.7 is a free program provided by NKK Switches to help download images and attributes to the Dev Kit controllers. The program is designed to work with the family of SmartSwitch Dev Kits. It can import bitmaps, convert them to the proper switch format, and then download them to the controller. It also allows input and download of attributes.
It can handle single or batch downloads and has the most common commands as easy button interfaces. The Universal communicator can be downloaded from the web page below:
http://www.nkkswitches.com/SmartSwitch-Download-Software.aspx

On the NKK website documents can be found on how to creating images as well as the manual for Universal Communicator that shows how to download images and attributes. They can be found at:
http://www.nkkswitches.com/SmartSwitch-Engineering-Documentation.aspx

The dev kits can communicate with any communication software that can perform the CL04 communication PROTOCOL. Universal Communicator is provided as demonstration software.

5. Power-up Sequences

Mode check:
Upon power-up, the controller checks the position of the Mode Select Switch. The controller initializes the OLED display or switch based on this selection. The proper selection of switch/display mode must be set before power-up. The OLED Switch (64x48) is the default. For using the OLED Display (52x36) the pin1 &2 of SWS needs to be connected (SWS is behind the potentiometer and is not populated).

The OLED switches (64x48) will show the full image while the OLED Display (52x36) will display only the middle 52 pixels of the top 36 lines.

OLED Brightness Adjustment Mode:
The controller will then allow the brightness of the two OLED switches/display and OLED Rocker to be independently adjusted.
Both OLED switches/displays display brightness level. Additionally the left OLED displays the word DIM and the right OLED displays the word BRIGHT. Pressing left button decrease and pressing the right button increase brightness for both displays.
For OLED Rocker, brightness level, word "Bright" and word "DIM" are displayed. Pressing top and bottom switch will adjust the brightness accordingly and display the brightness level.
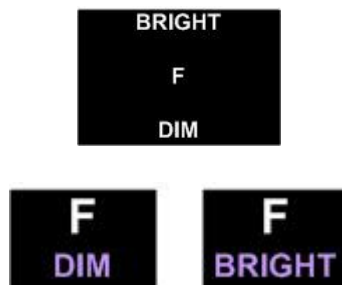
There are 16 levels of brightness; 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E, and F where F is the maximum brightness. After power up, the display is at the maximum brightness level (F). The OLED rated life is based on the maximum brightness. The dimmer the level is set the longer the life of the OLED. Any switch activity will keep the unit in this mode.
The brightness changes stay in effect for duration of the session.
After 2.6 seconds of user inactivity the controller will move to start of operation.

Start of Operation:
The OLED Rocker display the image at the Rocker address 0001H and put attributes of the Rocker address 0001H as active attribute for OLED Rocker.
The OLED Switch #1 displays the image at the address 0001H and put attributes of the address 0001H as active attribute for switch #1.
The OLED Switch #2 displays the image at the address 0010H and put attributes of the address 0010H as active attribute for switch #2.
The controller transmits 11H via RS232 indicating it is ready for operation.

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The OLED Switches power-up addresses (0001H and 0010H) are user defined and can be changed to any location in the memory.

The images on the switches and rockers can change based on:
   A. Attribute setting for timers
   B. Attribute setting for switch presses
   C. Commands via RS232.

These will be explained in detail in the Operation section (7). However, memory and setup must be explained as it is first.

6. Setup and Memory

The following information should be downloaded to the controller before operation. This is saved on the MicroSD so it only needs to be downloaded once. However, this information can be modified as needed. The commands to download the various setups are explained in the Communication Protocol section (8).

There is only one setup that specifies the following:
   A. The flag byte that enable/disable various responds from controller via RS232.
   B. The address for OLED switch#1 to display upon power up.
   C. The address for OLED switch#2 to display upon power up.

The flash memory can hold up to 65535 (Addresses 0001H to FFFFH) images and attribute blocks for the OLED switch and the OLED Rocker. The images and attributes need to be downloaded before operation.

Address	OLED Switch		OLED Rocker	
0001	Image	Attribute block	Image	Attribute Block
0002	Image	Attribute block	Image	Attribute block
---	Image	Attribute block	Image	Attribute block
---	Image	Attribute block	Image	Attribute block
FFFE	Image	Attribute block	Image	Attribute block
FFFF	Image	Attribute block	Image	Attribute block

7. Operation

After the power-up sequences any changes to displays are based on active attributes settings for timer and switch presses and/or commands via RS232. This section covers how attributes work as well as listing the commands available during operation. In addition, the controller reports via RS232 are covered as well.

7.1 OLED switch

The attributes settings of the OLED switches do not affect the OLED Rocker. However the OLED rocker attributes can be set to change images of the OLED switches which will be explained in the OLED Rocker section.

Upon power-up OLED switch #1 displays the image at address 0001H and the attributes of address 0001H become the active attributes for switch#1. The attribute block for OLED switches includes 3 addresses (two bytes each) and two timers (one byte each).

Address for Switch#1	Address for Switch#2	End of the loop address	Timer#1	Timer#2
Two bytes	Two bytes	Two bytes	One byte	One byte

Changes based on the timer settings

- If the input for Timer#1 = 00H then the timers do not run and therefore there will be no change based on the timers. Otherwise, the timers run and the images change sequentially from the original address (0001) to the address indicated by "End of the loop address" (EP1).
The amount of milliseconds, ms, each image is displayed is the product of Timer#1 multiplied by Timer#2. The maximum possible time is 65 seconds.
The attributes of the original address (0001) stay in effect and the attributes of all other addresses are ignored until EP1.

- Once the End of the loop address is reached, the next change depends on the attributes of the End of the loop address as stated below:
If the "Address for switch#2" of the End of the loop attributes is equal zero no change to the switch#2. Otherwise Switch #2 displays the image at the address of "Address for switch#2" and the attribute of this address become active for the switch #2.
If the "Address for switch#1 of the End of the loop attributes is equal zero then switch#1 loop back to the image of the original address (0001H) . Otherwise Switch #1 displays the image at the address of "Address for switch#1" and the attribute of this address become active for the switch #1.

- The switch #2 Attributes function in the same manner as described for switch#1 above. Except the original address is 0010 and loop back is based on the "Address for switch#2" of the "End of the loop address" attributes.

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Changes based on the switch presses

- When either switch #1 or #2 is pressed the changes happen based on the active attributes for that switch.
  If the "Address for switch#1 of active attribute is equal zero there will be no change to the switch#1.
  Otherwise Switch #1 displays the image at the address of "Address for switch#1" and the attribute of this address become active for the switch #1.
  If the "Address for switch#2 of active attribute is equal zero there will be no change to the switch#2.
  Otherwise Switch #2 displays the image at the address of "Address for switch#2" and the attribute of this address become active for the switch #2.

- While any of the switches is pressed the timer for that switch pauses if it is running.

7.2 OLED Rocker

Upon power-up the OLED Rocker displays the image at the address 0001H and the attributes of the address 0001H become the active attributes. The attribute block for the OLED Rocker includes 6 addresses (two bytes each) and two timers (one byte each).

Top Switch press address	Middle Switch press address	Bottom Switch press address	End of the loop address	Timer#1	Timer#2	Address for OLED switch #1	Address for OLED switch #2
2 bytes	2 bytes	2 bytes	2 bytes	1 byte	1 byte	2 bytes	2 bytes

Changes based on the timer setting

- If the input for Timer#1 = 00H then the timers do not run so there will be no change based on the timers.
  Otherwise, the timers run and the images change sequentially from the original address (0001) to the address indicated by "End of the loop address".
  The amount of milliseconds, ms, each image is displayed is the product of Timer#1 multiplied by Timer#2. The maximum possible time is 65 seconds.
  The attributes of original address (0001) stay active and the attribute of all other address till "End of the loop address" are ignored.

- Once the End of the loop address is reached, the next change depends on the attributes of the End of the loop address as stated below:
  If the "Middle Switch press address" of the End of the loop attributes is equal zero then the OLED Rocker will loop back to the image of the original address (0001H). Otherwise, the OLED Rocker displays the image at the address of "Middle Switch press address" and the attributes of this address become active for the OLED Rocker.

Changes based on the switch presses

- When any of the switches (Top, Middle, Bottom) is pressed the changes happen based on the active attributes.

If the corresponding switch press address of the active attribute is equal to zero there will be no change to the OLED Rocker. Otherwise the OLED Rocker displays the image at the corresponding switch press address and the attributes of this address become active for the OLED Rocker.

When the middle switch is pressed, additional changes happen to the OLED switches based on the active attributes.

If the "Address for OLED Switch#2" is equal to zero there will be no change to OLED Switch#2. Otherwise OLED Switch #2 displays the image of "Address for OLED Switch#2" and the attributes of this address become active for OLED Switch #2.
If the "Address for OLED Switch#1" is equal to zero there will be no change to OLED Switch#1. Otherwise OLED Switch #1 displays the image of "Address for OLED Switch#1" and the attributes of this address become active for OLED Switch #2.

- While any of the switches is pressed the timer for the OLED Rocker pauses if it is running.

7.3 Commands via RS232
There are many commands available to control the OLED Switches and the OLED Rocker during operation. They are described in The Communication section. Below is the list of commands available during operation.

- Command to reset the controller.
- Command to check connection
- Command to change brightness for OLED switches and OLED Rocker.
- Command to OLED Rocker to display any address image.
- Command to any of OLED switches to display any address image.
- Command to Turn OFF/ON any row of pixels in OLED Rocker.
- Command to Turn ON any row of an OLED switch to any color.
- Command to create 1 to 12 characters from any location in the OLED Rocker.
- Command to create 1 to 8 characters with any color from any location in an OLED switch.
- Command to turn the display ON/OFF.
- Command to directly write to OLEDs
- Command to disable/enable Attributes execution based on timer and switch presses

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7.4 Report from controller via RS232

IS-CL04R reports timer expires, switch presses, switch releases and the address of a new image display if the appropriate flags are enabled.

- If the Bit 6 of the flag is enabled, the controller reports switch presses in one byte
    - Top OLED Rocker   91H
    - Middle OLED Rocker   92H
    - Bottom OLED Rocker   93H
    - OLED Switch#1   81H
    - OLED Switch#2   82H

- If the Bit 3 of the flag is enabled, the controller reports switch releases in one byte
    - Top OLED Rocker   C1H
    - Middle OLED Rocker   C2H
    - Bottom OLED Rocker   C3H
    - OLED Switch#1   B1H
    - OLED Switch#2   B2H

- If the Bit 5 of the flag is enabled, the controller reports timers expire in one byte
    - OLED Rocker   94H
    - OLED Switch#1   83H
    - OLED Switch#2   84H

- If the Bit 7 of the flag is enabled, the controller reports a leading byte followed by address of any new image displayed for a total of 3 bytes. The leading byte for each switch is listed below:
    - OLED Rocker   FCH
    - OLED Switch#1   FDH
    - OLED Switch#2   FEH

- If there is a communication problem between microcontroller and the microSD flash, the controller will transmit 6FH to the host for each communication failure.

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8.   Communication Protocol

The controller communicates with the host via RS232 serial communication (57.6K, 1 start bit, 8 bit, 1 stop bit). The controller receives the data via an interrupt routine that places the data on the circular receive buffer. For the buffer not to get overrun X0ff(13H) and Xon(11H) are used to control the host transmission. When the controller detects data in the circular receive buffer, the controller reads one byte and executes the following:

    A. If the byte is a command, the controller transmits a 61H and executes the subroutine for the command and upon completion of command the controller transmits 79H.
    B. If the byte is not a command, it is ignored.

When the controller executes a subroutine and expects additional information:

    A. A timer is set. If the expected consecutive data byte is not received in 64ms, the controller transmits 6CH 6EH and terminates the routine.
    B. If the byte value is not acceptable (invalid range, option, etc.), the controller transmits 6EH and terminates the routine.

Commands are one byte in the range of 20H to 2FH and 01H and are transmitted in hex format. The proper format for all command options and data are specified for each command.
It is possible to disable the controller responses to commands by disabling the associated flags.
After power up/reboot the controller transmits 11H indicating it is ready for communication.

8.1 Commands for the Controller

Command to reboot the controller
    The command reboots the controller to power-up state.

        command format: **24H**
        transmit format: (xxH)

In most cases controller does not have a chance to transit 61H. However it transmits 11H after reboot.

Command to check communication
    The command is used to check if the controller is on-line.

        command format: **01H**
        transmit format: (xxH)

    The controller transmits back 61H to the host.

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Command to specify the OLED brightness (OLED Color & OLED Rocker)

This command specifies the brightness for both OLED color and OLED Rocker.

command format:	**27H**	4EH	[Brightness OLED Color]	[Brightness OLED Rocker]
transmit format:	**(xxH)**	(xxH)	(xxAH)	(xxAH)

[Brightness OLED Color] is one byte send as ASCII HEX format. The acceptable values are from 00H to 0FH where 0FH is the brightest. Default (0FH).

[Brightness OLED Rocker] is one byte send as ASCII HEX format. The acceptable values are from 00H to 0FH where 0FH is the brightest. Default (0FH).

The specified brightness levels go to effect immediately and remain in effect for duration of the session.

Command to update the display

This command resends the picture from current addresses to the OLED switches and the OLED Rocker. The controller transmits back 61H to the host.

command format:	**2CH**
transmit format:	(xxH)

Command to query controller for mode, controller, and firmware version

This command queries the controller for the mode as set by the Mode Select Switch, the controller name, and the firmware version installed.

command format:	**26H**	52H	58H
transmit format:	(xxH)	(xxH)	(xxH)

Example: The command is sent. The controller responds with the following:

61	34	43 4C 30 34	26	79
61H	[mode]	[Controller name]	[version]	79H

[mode] one byte. 33H indicating OLED module mode or 34H indicating OLED display mode.
[Controller name] 4 bytes. 43H 4CH 30H 34H (CL04)
[version] one byte. 26H (version 2.6)

Command to query controller for firmware version

This command queries the controller for the firmware version installed.

```
command format:    26H    15H
transmit format:   (xxH)  (xxH)
```

Example: The command is sent. The controller responds with the following:

```
   61      26    79
  61H    [version]
              79H
```

[version] one byte. 26H (version 2.6)

Command to disable the timers and switch execution

This command disables the timers and switch execution.

```
command format:    26H    51H    5AH
transmit format:   (xxH)  (xxH)  (xxH)
```

The controller disables the timers and switch execution for OLED switches as well as OLED Rocker upon receiving this command. However, the switches are still scanned and reported. They are enabled upon reboot/power up or by command from host.

Command to enable the timers and switch execution

This command enables the timers and switch execution.

```
command format:    26H    51H    65H
transmit format:   (xxH)  (xxH)  (xxH)
```

The controller enables the timers and switch execution upon receiving this command.

Command to turn the switch display off

This command turns off the displays of the OLED switches and OLED Rocker.

```
command format:    26H    51H    69H
transmit format:   (xxH)  (xxH)  (xxH)
```

Command to turn the switch display on

This command turns on the displays of the OLED switches and OLED Rocker.

```
command format:    26H    51H    66H
transmit format:   (xxH)  (xxH)  (xxH)
```

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Command to turn the OLED voltage off

This command turns off the 16V supply to the OLEDs.

command format:	**26H**	51H	74H
transmit format:	(xxH)	(xxH)	(xxH)

Command to turn the OLED voltage on

This command turns on the 16V supply to the OLEDs.

command format:	**26H**	51H	75H
transmit format:	(xxH)	(xxH)	(xxH)

Note: This command should only be used when the OLED displays are in the off mode.

Command to download setup data

This command downloads the set-up data. These set-up data are saved on the MicroSD flash. The controller disables the timers and switch execution upon receiving this command. However, the switches are still scanned and reported. They are enabled upon reboot/power up or by command from host.

					[address for Switch#1]	[address for switch#2]	[reserved]
command format:	**2AH**	[00H]	[00H]	[55H]	[flag]	(value)	
transmit format:	(xxH)	(xxAH)	(xxAH)	(xxAH)	(xxAH)	(xxAH)	(xxAH)	(xxAH)

[flag] is one byte sent in ASCII HEX format. (Detail below)
[address for switch#1] is two bytes with value of 0001H to FFFFH sent in ASCII HEX format. This is the address for the image that switch 1 displays upon power up/reboot.
[address for switch#2] is two bytes with value of 0001H to FFFFH sent in ASCII HEX format. This is the address for the image that switch 2 displays upon power up/reboot.
[reserved] is two bytes sent in ASCII HEX format. These are for future use should be set as 0000H. However the customer can use the last byte for storing the data version.

Flag Byte   Default value=80H

Bit	Enable Value	Flag	Controller action when flag is set
B0	0	Buzzer	Beeper sound for switch press
B1	0	61H flag	61H is transmitted in response to command.
B2	0	79H flag	79H is transmitted upon completion of command.
B3	0	Switch release report flag	Switch release are reported
B4	0	6EH flag	6CH/6EH is transmitted if there is any error during communication to host.
B5	0	Timers expire report flag	Timers expiration are reported
B6	0	Switch press report flag	Switch presses are reported
B7	0	Address change report flag	Newest address is reported for each switch

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Example: **2A30303030 3535 3030 30303031 30303146 30303030** sets all the flags on, assign power up addresses 0001H for switch#1 and 001FH for switch#2. These set up takes affect when the controller is reset.

Command to upload setup data

> command format: **2BH**   [0000H]
> transmit format: (xxH)   (xxAH)

The controller transmits back 61H acknowledgement followed by 30303030H and set up data and finish by 79H.
Example:

61 30 30 30 30 35 35 38 30 30 30 30 31 30 30 31 46 30 30 30 30 79

8.2 Commands for OLED Switches

Command to dim OLED switch displays

> This command set displays of the OLED switches to DIM level. The displays ON command returns the displays back to normal brightness.

> command format: **26H**   51H   71H
> transmit format: (xxH) (xxH) (xxH)

Command for temporarily setting the timers for OLED switches

> This command download both switch#1 and switch#2 timers.

> command format: **26H**   51H   55H   [Switch#1] [Switch#2]
> transmit format: (xxH) (xxH) (xxH)   (xxH)   (xxH)

[Switch#1] Timers for Switch#1. Two bytes send in HEX format.
[Switch#2] Timers for Switch#2. Two bytes send in HEX format.
Please note the lower byte is for timer#1 and if it is equal zero the timer does not run. When the loop is finished and start from origin address, these values are over written by the values stored on the microSD flash in the original address of the loop.

This command is useful for determining the best values for animations or movies.

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ASCII Commands for OLED Switches/Displays

The following commands allow changes to the images being displayed. The host can download ASCII characters to a specified location and the controller creates the graphic image using a 7x10 font look up tables based on ON/OFF pixel colors. The host can download the ON pixels and OFF pixels colors. These colors stay in effect unless they are changed by the host.
The host can command the controller to change the status of one or more row of pixels to line color. The host can download the line color. These colors stay in effect unless they are changed by the host.
The host can specify the OLED's brightness.
None of these commands affect the storage memory.

Command to specify the color for line command (OLED Color)
This command specify the color used in line command.
     command format: **27H**   47H   [Color]
     transmit format: (xxH) (xxH) (xxAH)
[Color] is two bytes send as ASCII HEX format. It specifies any of over 65000 available colors. Default (0000H).
The specified color remains in effect only for duration of the session.

Command to specify the OFF/ON colors for character generator commands (OLED Color)
This command specify the colors used in the character generator command.
     command format: **27H**   49H   [OFF color]   [ON color]
     transmit format: (xxH) (xxH)   (xxAH)   (xxAH)
[OFF Color] is two bytes send as ASCII HEX format. It specifies any of over 65000 available colors. Default (0000H). This is for background color.
[ON Color] is two bytes send as ASCII HEX format. It specifies any of over 65000 available colors. Default (FFFFH). This is for character color.
The specified colors remain in effect only for duration of the session.

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Command to generator characters for OLED color #1

This command generates 1 to 12 characters in font 8x10 (include the space between the character) from the specified coordinate in the OLED memory. Please note the characters can be generated on the memory outside the viewing area. The controller uses the specified ON/OFF colors.

command format: **27H** 51H [# of characters] [Row] [column] [Characters]
transmit format: (xxH) (xxH) (xxAH) (xxAH) (xxAH) [xxH]

[# of characters] is one byte send as ASCII HEX format. The acceptable values are from 01H to 0CH.
[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 36H.
[Column] is one byte send as ASCII HEX format. It specifies the starting pixel column in the memory. The acceptable values are from 00H to 58H.
[Characters] 1 to 12 bytes of ASCII code for characters. The acceptable values for characters are from 20H to 7FH.

Picture 1   OLED on-board memory map

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Command to generator characters for OLED color #2

This command generates 1 to 12 characters in font 8x10 (include the space between the character) from the specified coordinate in the OLED memory. Please note the characters can be generated on the memory outside the viewing area. It uses the ON/OFF colors.

command format: **27H**   52H   [# of characters]   [Row]   [column] [Characters]

transmit format: (xxH) (xxH)   (xxAH)   (xxAH) (xxAH)   [xxH]

[# of characters] is one byte send as ASCII HEX format. The acceptable values are from 01H to 0CH.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 36H.

[Column] is one byte send as ASCII HEX format. It specifies the starting pixel column in the memory. The acceptable values are from 00H to 58H.

[Characters] 1 to 12 bytes of ASCII code for characters. The acceptable values for characters are from 20H to 7FH.

Command to change a line color (pixel row) for OLED color #1

This command changes the color of 1 to 64 rows of pixels from the specified row in the OLED memory. Please note the entire row of the memory changes including outside the viewing area. The controller uses the specified line command color.

command format: **27H**   59H   [# of rows]   [Row]

transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[# of Rows] is one byte send as ASCII HEX format. The acceptable values are from 01H to 40H.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 3FH.

Command to change a line color (pixel row) for OLED color #2

This command changes the color of 1 to 64 rows of pixels from the specified row in the OLED memory. Please note the entire row of the memory changes including outside the viewing area. The controller uses the specified line command color.

command format: **27H**   5AH   [# of rows]   [Row]

transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[# of Rows] is one byte send as ASCII HEX format. The acceptable values are from 01H to 40H.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 3FH.

Commands that disable switch and timer execution

Upon transmitting any of the following commands, the timers stop running and attributes for the switches' activity do not execute. The switches are still scanned and reported. The attributes execution is enabled upon reboot/power up or by command from the host.

The reason for disabling attribute execution is for faster download of images and attributes as well as the command to check the image at any address.

Command to download an image

This command downloads an image from the host to the MicroSD location.

        command format: **28H**   [address]   [image]
        transmit format: (xxH)   (xxAH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.
[image] is 6144 bytes transmit in ASCII HEX format.

Two bytes are used for each pixel.

B7	B6	B5	B4	B3	G2	G1	G0	G7	G6	G5	R4	R3	R2	R1	R0

Byte 1 and byte 2 are for color of top left pixel. Byte 6143 and byte 6144 are for color of bottom right pixel.

Byte	Description
1-128	First line of image
129-256	Second line of image
•	
•	
•	
5889-6016	63th line of image
6017-6144	64th line of image

Command to upload an image

This command uploads an image from the microSD location to the host.

        command format: **29H**   [address]
        transmit format: (xxH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

The controller transmits back the image (6144 bytes) in HEX format.

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Command to download attribute block
This command downloads an attribute block from the host to the EEPROM location.

command format: **2AH** [address] [attribute block]
transmit format: (xxH) (xxAH) (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.
[attribute block] is eight bytes transmit in ASCII HEX format.

The address and attribute block are saved at this address. When the controller reads the attribute block it compares the requested address to the saved address and if they do not match the controller knows that the attribute block is not programmed and ignores it.

Byte	Description
1	High byte of action address for Switch #1.
2	Low byte of action address for Switch#1.
3	High byte of action address for Switch#2.
4	Low byte of action address for Switch#2.
5	High byte of end of loop address.
6	Low byte of end of loop address.
7	Timer #1
8	Timer #2

Command to upload an attribute block
This command uploads an attribute block from the EEPROM location to the host.

command format: **2BH** [address]
transmit format: (xxH) (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

The controller transmits back the saved address and [Attribute block] in hex format.

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Command to display the requested address image on **switch#1**
    This command displays an image on switch#1 at the requested address.

        command format: **2EH**   31H   [address]
        transmit format: (xxH) (xxH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

Example: 2E 31 30303445 displays the image stored at address 004EH.

Command to display the requested address image on **switch#2**
    This command displays an image on switch#2 at the requested address.

        command format: **2EH**   32H   [address]
        transmit format: (xxH) (xxH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

Example: 2E 32 30313034 displays the image stored at address 0104H.

Command to increment address on display the image on switch#1
    This command displays an image on switch#1 at the address+1.

        command format: **2EH**   33H
        transmit format: (xxH) (xxH)

Example: Start at address 00A1H. Send 2E 33 and the left switch displays the image stored at address 00A2H. Send 2E 33 again and the left switch displays the image stored at address 00A3H.

Command to increment address on display the image on switch#2
    This command displays an image on switch#2 at the address+1.

        command format: **2EH**   34H
        transmit format: (xxH) (xxH)

Example: Start at address 0F09H. Send 2E 34 and the right switch displays the image stored at address 0F0AH. Send 2E 34 again and the right switch displays the image stored at address 0F0BH.

Command to decrement address on display the image on switch#1
    This command displays an image on switch#1 at the address-1.

        command format: **2EH**   35H
        transmit format: (xxH) (xxH)

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Example: Start at address 1004H. Send 2E 35 and the left switch displays the image stored at address 1003H. Send 2E 35 again and the left switch displays the image stored at address 1002H.

Command to decrement address on display the image on switch#2
This command displays an image on switch#2 at the address-1.

command format: **2EH**   36H
transmit format: (xxH)   (xxH)

Example: Start at address 2345H. Send 2E 36 and the right switch displays the image stored at address 2344H. Send 2E 36 again and the right switch displays the image stored at address 2343H.

Commands to download information directly to OLED switches/displays

Note: Care must be taken using these commands. The OLED switches/displays could get damaged if they are initialized with a value exceeding the specifications. Please check the OLED switches/displays data sheet and application notes before using these commands.

Command to download data directly to OLED switches/displays
This command downloads data directly from the host to the OLED switches/displays.

command format: **2FH**   53H   [number]   [data]
transmit format: (xxH)   (xxH)   (xxAH)   (xxAH)

[number] is one byte sent in ASCII HEX format (01H to 80H). This is the number of data bytes (1 to 128 bytes).
[data] is 1 to 128 bytes sent in ASCII HEX format.

The controller sends the [data] to both OLED modules as data.

Command to download a command directly to OLED switches/displays
This command downloads a command from the host to the OLED switches/displays.

command format: **2FH**   47H   [number]   [data]
transmit format: (xxH)   (xxH)   (xxAH)   (xxAH)

[number] is one byte sent in ASCII HEX format (01H to 80H). This is the number of data bytes (1 to 128 bytes).
[data] is 1 to 128 bytes sent in ASCII HEX format.

The controller sends the [data] to both OLED modules as a command.

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Command to download a command directly to OLED switches/displays (special)
   This command turns off the OLED module, downloads a command from the host to the OLED switches/displays, and turns it back on.

   command format: **2FH**   49H   [number]   [data]
   transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[number] is one byte sent in ASCII HEX format (01H to 80H). This is the number of data bytes (1 to 128 bytes).
[data] is 1 to 128 bytes sent in ASCII HEX format.

The controller turns off the OLED display switches, sends the [data] to both switches as a command and then turns on the OLED display switches.

8.3 Commands for OLED Rocker

Command to display image at the requested address for OLED Rocker
This command displays an image at the requested address on the OLED Rocker. <check for attribute>
   command format: **2DH**   55H   [address]
   transmit format: (xxH) (xxH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

Example: 2D 51 30303445 displays the image stored at address 004EH. The attribute block of the address 004EH will be used.

ASCII Commands for OLED Rocker

The following commands allow changes to the images being displayed. The host can download ASCII characters to a specified location and the controller creates the graphic image in normal or inverse, using a 7x10 font look up tables.
The host can command the controller to turn ON/OFF one or more row of pixels.
The host can specify the OLED's brightness.
None of these commands affect the storage memory.

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Command to generate characters for OLED Rocker positive mode

This command generates 1 to 16 characters in font 8x10 (include the space between the character) from the specified coordinate in the OLED Rocker memory. Please note the characters can be generated on the memory outside the viewing area. The character pixels are white.

command format: **27H**   54H   [# of characters]   [Row]   [column] [Characters]

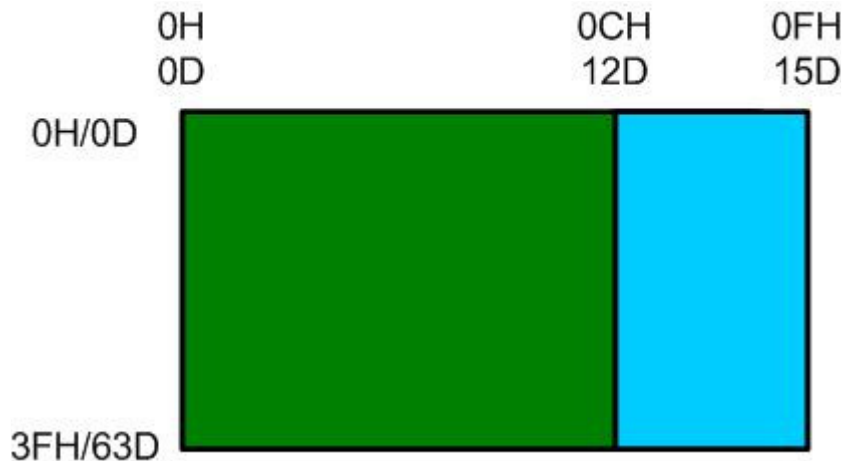transmit format: (xxH)   (xxH)   (xxAH)   (xxAH)   (xxAH)   [xxH]

[# of characters] is one byte send as ASCII HEX format. The acceptable values are from 01H to 10H.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 36H.

[Column] is one byte send as ASCII HEX format. It specifies the starting byte column in the memory. The acceptable values are from 00H to 0FH.

[Characters] 1 to 16 bytes of ASCII code for characters. The acceptable values for characters are from 20H to 7FH.

Illustration 2, OLED Rocker on-board memory map

Command to generate characters for OLED rocker negative mode

This command generates 1 to 16 characters in font 8x10 (include the space between the character) from the specified coordinate in the OLED Rocker memory. Please note the characters can be generated on the memory outside the viewing area. The character pixels are black.

command format: **27H**   57H   [# of characters]   [Row]   [column] [Characters]

transmit format: (xxH)   (xxH)   (xxAH)   (xxAH)   (xxAH)   [xxH]

[# of characters] is one byte send as ASCII HEX format. The acceptable values are from 01H to 10H.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 36H.

[Column] is one byte send as ASCII HEX format. It specifies the starting byte column in the memory. The acceptable values are from 00H to 0FH.

[Characters] 1 to 16 bytes of ASCII code for characters. The acceptable values for characters are from 20H to 7FH.

Command to set pixel row data to OFF for OLED Rocker

This command sets all row pixel data to zero for 1 to 64 rows from the specified row in the OLED Rocker memory. Please note the entire row of the memory change includes outside the viewing area.

command format: **27H**   5CH   [# of rows]   [Row]

transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[# of Rows] is one byte send as ASCII HEX format. The acceptable values are from 01H to 40H.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 3FH.

Command to set pixel row data to ON for OLED Rocker

This command sets all row pixel data to one for 1 to 64 rows from the specified row in the OLED Rocker memory. Please note the entire row of the memory change includes outside the viewing area.

command format: **27H**   5DH   [# of rows]   [Row]

transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[# of Rows] is one byte send as ASCII HEX format. The acceptable values are from 01H to 40H.

[Row] is one byte send as ASCII HEX format. It specifies the starting pixel row of the memory. The acceptable values are from 00H to 3FH.

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Commands that disable switch and timer execution

Upon transmitting any of the following commands, the timer stops running and attributes for the switches activity do not execute. The switches are still scanned and reported. The attribute execution is enabled upon reboot/power up or by command from the host.
The reason for disabling attribute execution is for faster download of images and attributes as well as the command to check the image at any address.

Command to download an image
This command downloads an image from the host to the EEPROM location.

        command format: **28H**   55H   [address]   [image data]
        transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.
[image] is 768 bytes transmitted in ASCII HEX format.
An image is handled as a block of 768 bytes. Each pixel requires one bit with eight pixels to a byte. The Bit7 of byte 1 is displayed on top left pixel and Bit0 of byte 768 is displayed on bottom right pixel.

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

Command to upload an image
This command uploads an image from a microSD address to the host.

        command format: **29H**   55H   [address]
        transmit format: (xxH) (xxH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

The controller transmits back the image (768 bytes) in HEX format.

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Command to download attribute block

This command downloads an attribute block from the host to and address in the MicroSD flash.

        command format: **2AH**   55H   [address]   [attribute block]
        transmit format: (xxH) (xxH)   (xxAH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.
[attribute block] is fourteen bytes transmit in ASCII HEX format.

The address and attribute block are saved at this address. When the controller reads the attribute block it compares the requested address to the saved address and if they do not match controller knows that the attribute block is not programmed and ignores it.

Image and Attribute block

Attribute Block:

An attribute is handled as a block of 14 bytes. Table below show the transmit order of the data.

Byte	Description
1	High byte of action address for Top Switch.
2	Low byte of action address for Top Switch.
3	High byte of action address for Middle Switch.
4	Low byte of action address for Middle Switch.
5	High byte of action address for Bottom Switch.
6	Low byte of action address for Bottom Switch.
7	High byte of end of loop address.
8	Low byte of end of loop address.
9	Timer #1
10	Timer #2
11	High byte of action address for OLED Switch#1.
12	Low byte of action address for OLED Switch#1.
13	High byte of action address for OLED Switch#2.
14	Low byte of action address for OLED Switch#2.

Command to upload an attribute block

This command uploads an attribute block from the MicroSD flash to host.

        command format: **2BH**   55H   [address]
        transmit format: (xxH) (xxH)   (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

The controller transmits back the saved address and [Attribute block] in hex format (16 bytes).

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Command to display image at the requested address
This command displays an image at the requested address on the OLED display. Stops timer and operation.

> command format: **2EH** 51H [address]
> transmit format: (xxH) (xxH) (xxAH)

[address] is two bytes with value of 0001H to FFFFH sent as ASCII HEX format.

Example: 2E 51 30303445 displays the image stored at address 004EH.

Command to increment address and display it
This command increments the pointer to the next address and displays the image. Stops timer and operation.

> command format: **2EH** 53H
> transmit format: (xxH) (xxH)

Example: Start at address 00A1H. Send 2E 53 and the OLED display displays the image stored at address 00A2H. Send 2E 53 again and the OLED display displays the image stored at address 00A3H.

Command to decrement address and display it
This command decrements the pointer to the next address and displays the image. Stops timer and operation.

> command format: **2EH** 52H
> transmit format: (xxH) (xxH)

Example: Start at address 1004H. Send 2E 52 and the OLED display displays the image stored at address 1003H. Send 2E 52 again and the OLED display displays the image stored at address 1002H.

Commands to download information directly to OLED Rocker

Note: Care must be taken using these commands. The OLED Rocker could get damaged if it is initialized with a value exceeding the specifications. Please check the OLED Rocker data sheet and application notes before using this command.

Command to download data directly to OLED Rocker
This command downloads data directly from the host to the OLED Rocker.

> command format: **2FH** 55H [number] [data]
> transmit format: (xxH) (xxH) (xxAH) (xxAH)

[number] is one byte sent in ASCII HEX format (02H to 80H). This is the number of data bytes (2 to 128 bytes).

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[data] is 2 to 128 bytes sent in ASCII HEX format. The controller sends the first byte as command and the rest as data to OLED Rocker.

This command is provided for checking all the features of the OLED Rocker. It is possible to change the set-up, exceed specifications and cause damage to the OLED Rocker. Please follow the specification when using this command.

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9. Hardware

Controls Overview

| | |
| | |
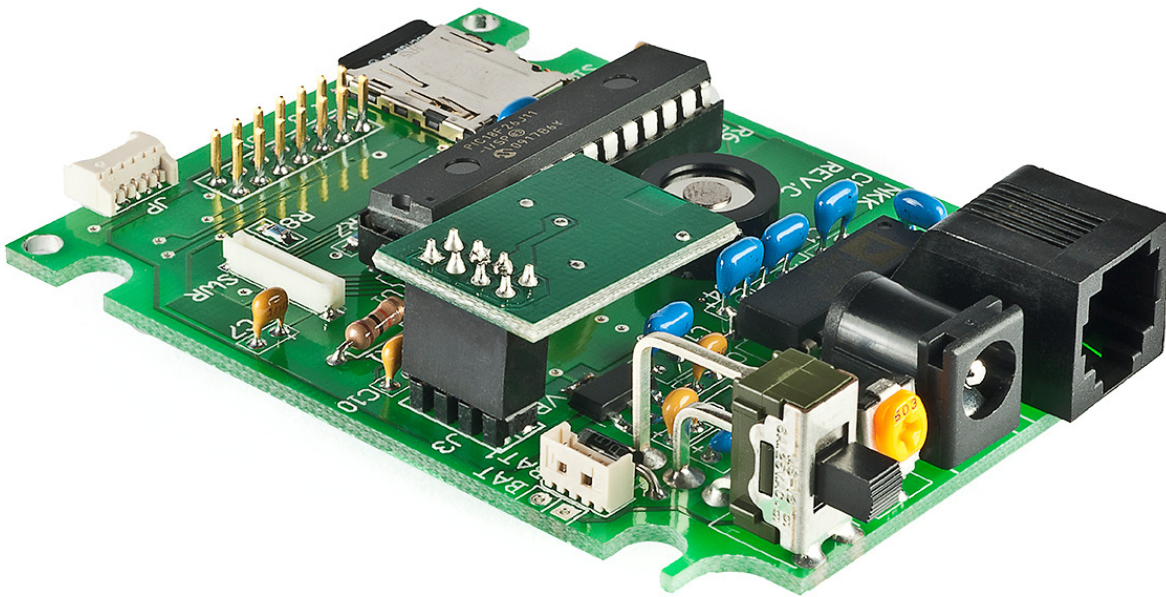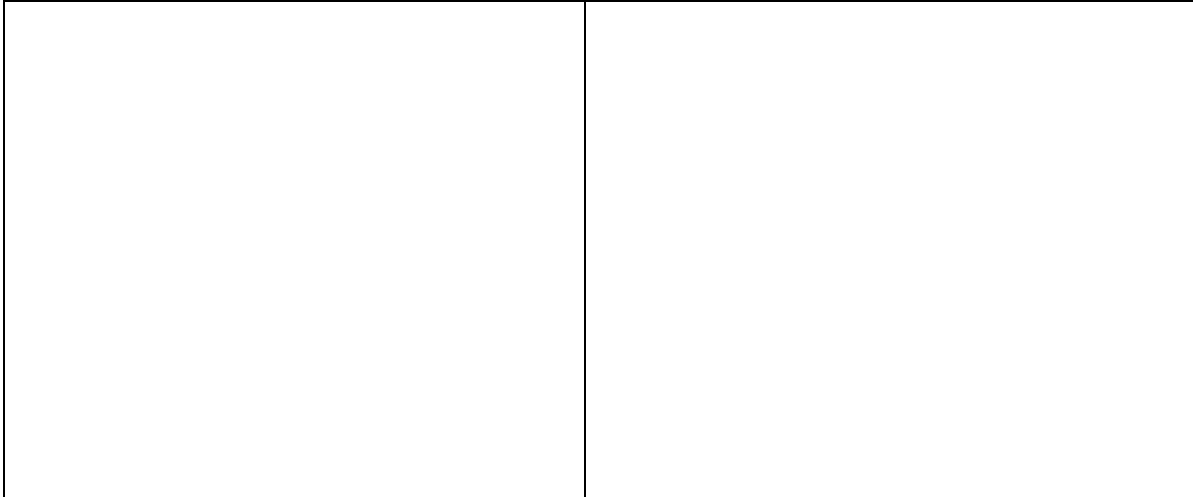
The **Mode Select Switch** is not installed. The OLED Switch (64x48) is the default. For using the OLED Display (52x36) the pin1 &2 of SWS need to be connected (SWS is behind the potentiometer).
OLED Rocker gets connected to SWR connector via the AT715 cable.
The Logic Board J1 of OLED switches/display connects to J1 of IS-CL04R via the 14 pin ribbon cable. Care should be taken so pin#1of the J1's get connected.

Note: Improperly connecting of the Logic Boards to controller can damage either/both the Logic Board and the controller.

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The **Batt/PWR switch** has three positions: battery, off, line power.
Buzzer Volume adjusts the volume of the buzzer that activates when a button is pushed.
The **9V DC Power** jack mates with a 2.5mm cylinder power connector with a center positive.
The **RS232 Connector** links the controller to the host.

	1	2	3	4	5	6
RS232		GND	TX	RX	GND	

Note: To turn off the controller, press both OLED switches at the same time until the switches are off then turn off the PWR switch. This step should be followed to comply with OLED power off requirement.
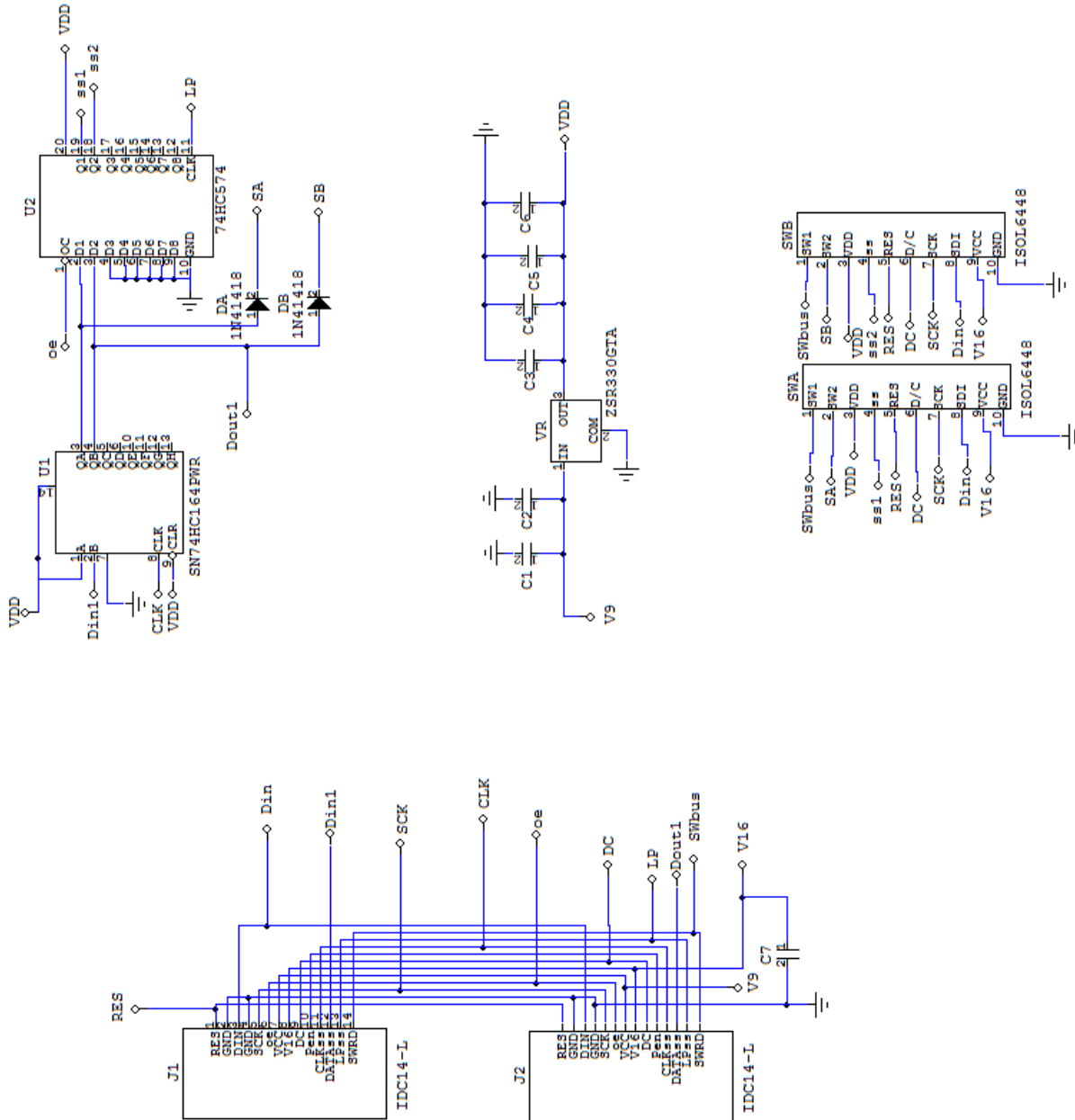
Controller Schematic
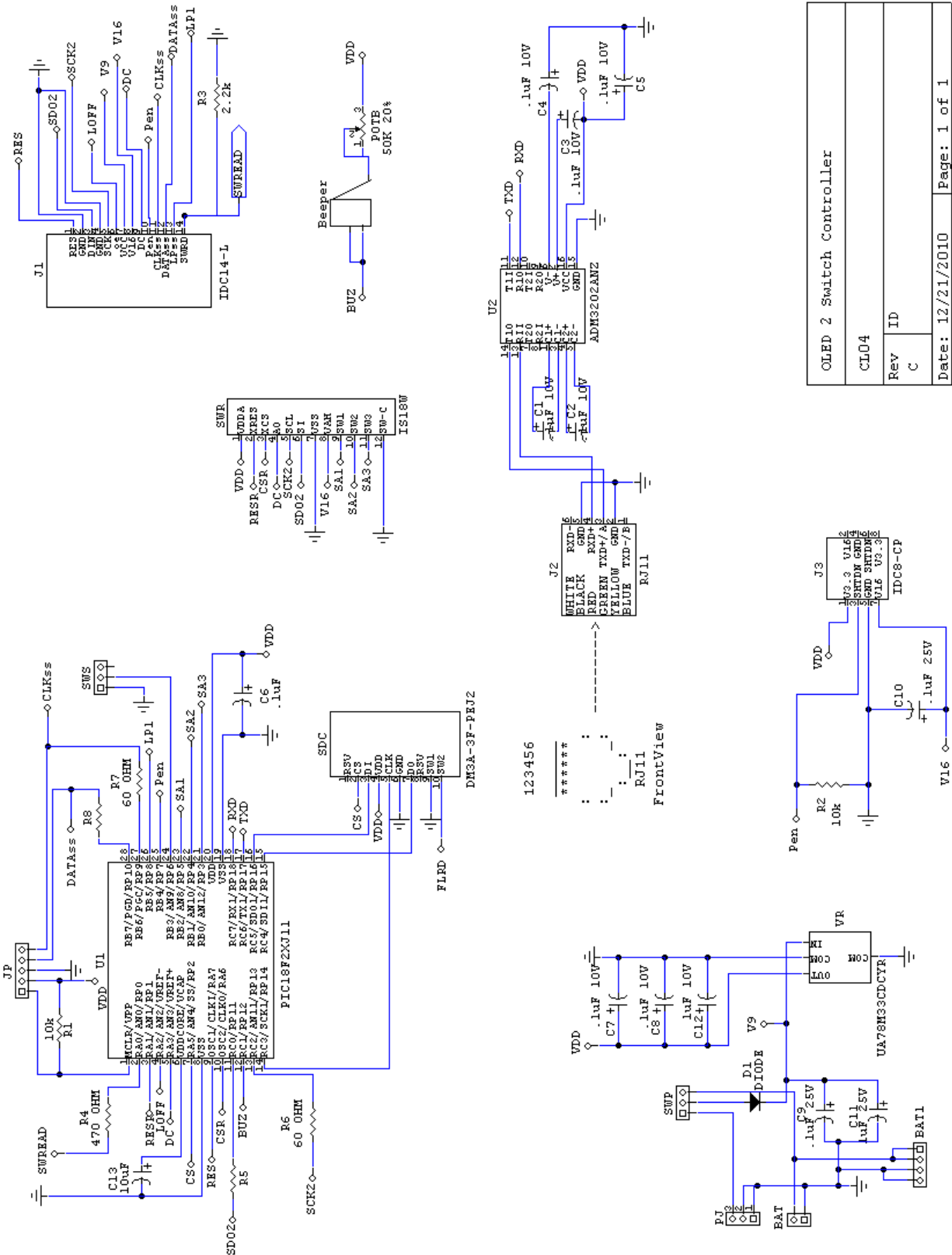
Logic board, IS-L02L1, Two OLED SmartSwitches

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Logic board, IS-L02P1, Two OLED SmartDisplays
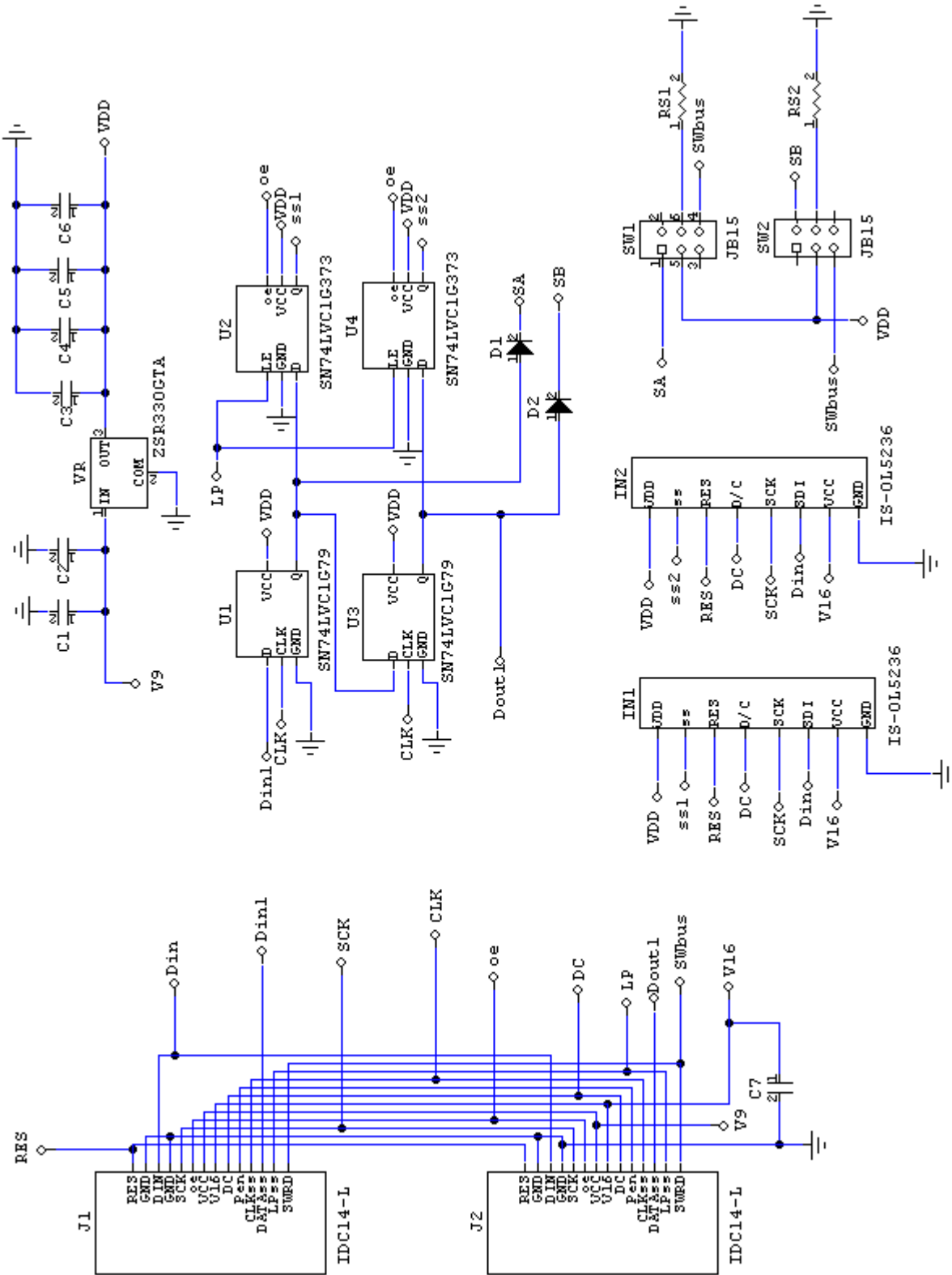
10. Key Terms & Definitions

OLED module	NKK Switches' OLED SmartSwitches and SmartDisplays.
Host	Any computer, terminal, or other device that can communicate over the RS232 line.
Controller	A PCB assembly that controls one or more logic boards and the switches associated with them. It communicates with a host over the RS232 line.
Logic Board	A PCB assembly with "glue logic" for mounting switches. It is controlled by a controller.
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	There are two formats to transmit a byte:

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 FFFFH representing the 65536 memory locations for pictures and attributes on microSD flash.

11. Firmware issues

The problems found in the most current version are listed below and get resolved in the following version.

Version V2.6   Xon/Xoff was implemented for receive communication. Controller transmits 0x11after power up indicating it is ready for communication. The controller transmits 0x13 when the buffer is ¾ full and transit 0x11 when the buffer is ¼ full.
Character generation commands have been added.

Version V2.4   During batch downloads, due to the different response times of the MicroSD, sometimes the communication buffer gets filled/overwrite so some images would be corrupted.

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Appendix

Understanding Decimal, Hexadecimal and Binary Numbers

Decimal is the numbering system we use. It is called base-10. Every digit can be between 0 to 9.
The value of each digit is equal to the digit with ((Digit order) -1) zero in front.

Table 1, Base-10								
Value in base-10 Digit x				10000	1000	100	10	1
Multiplication for converting to decimal	$10^{(N-1)}$	…	…	10^4	10^3	10^2	10^1	10^0
Digit order	Nth digit	….	….	Fifth digit	Fourth digit	Third digit	Second digit	First digit

Example: The value of each digit of the Base-10 number 7605 is as follow:

Fourth digit: 7 with (4-1) zero =   7000
Third digit: 6 with (3-1) zero =   600
Second digit: 0 with (2-1) zero =   0
First digit: 5 with (1-1) zero =   5

Numbering system
A numbering system can be based on any number (base-N). However it has to follow the rules:
1. Each digit has to be between 0 to (Base minus one). For example:
     ---Each digit for Base-2 numbering system can be 0 or 1
     ---Each digit for Base-5 numbering system can be 0 to 4
     ---Each digit for base-8 numbering system can be 0 to 7

2. The value of each digit is equal to the digit with ((Digit order) -1) zeros in front.
All the operations that we use on base 10 numbering system such as addition, subtraction, multiplication, division… works the same for all the numbering systems. The difference is the carry over will be based on the base-number of the numbering system instead of 10.

Why do we need other base numbering systems?
Computers logic is based on two states:
Yes or No
False or True
High voltage or low voltage

Base-2 numbering system (binary)

The numbering system to accommodate the computer logic is called binary or base 2. Each digit of binary can be 0 or 1.

Table 2, Base-2								
Value in base-2 Digit x				10000	1000	100	10	1
Multiplication for converting to decimal	$2^{(N-1)}$	…	…	2^4 =16	2^3 =8	2^2 =4	2^1 =2	2^0 =1
Digit order	Nth digit	….	….	Fifth digit	Fourth digit	Third digit	Second digit	First digit

Example: The value of each digit of the Base-2 number 1010 is as follow:

Fourth digit: 1 with (4-1) zero =   1000
Third digit: 0 with (3-1) zero =   0
Second digit: 1 with (2-1) zero =   10
First digit: 0 with (1-1) zero =   0

To convert a base-2 number to decimal, multiply each digit by multiplier and add them together:

Example: converting base-2 number 1010 to decimal is as follow:
(1 x 8) + (0 x 4) + (1 x 2) + (0 x 1) = 10

To convert a decimal number to base-2 number
---divide the decimal number by 2, the remainder is the first digit of the base-2 number
--- continue dividing quotient by 2 and put the remainder as the next digit until the quotient is equal 0.

Example: Convert the decimal number 21 to base-2

21 divide by 2 = 10 with 1 remainder   First digit = 1
10 divide by 2 = 5 with 0 remainder   Second digit = 0
5 divide by 2 = 2 with 1 remainder   Third digit = 1
2 divide by 2 = 1 with 0 remainder   Fourth digit = 0
1 divide by 2 = 0 with 1 remainder   Fifth digit = 1

21 decimal = 101001 base-2 or binary
The base-2 number 101001 reads as one zero one zero zero one.

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Base-16 numbering system

Communicating base-2 numbers is difficult for human because of all zero's and one's. To make it easier to present computer data, hexadecimal or base-16 numbering system is used. Four digit of base-2 numbering system convert to one digit of base-16 numbering system. Since we did not have digits for 10, 11, 12, 13, 14 and 15, they were assigned letters A, B, C, D, E and F respectively.

Table 3, Number base conversion		
Hexadecimal base-16	Decimal base-10	Binary base-2
0	0	0
1	1	1
2	2	10
3	3	11
4	4	100
5	5	101
6	6	110
7	7	111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111
10	16	10000
11	17	10001
etc	etc	etc

Table 4, Base-16								
Value in base-16 Digit x				10000	1000	100	10	1
Multiplication for converting to decimal	$16^{(N-1)}$	…	…	16^4 =65536	16^3 =4096	16^2 =256	16^1 =16	16^0=1
Digit order	Nth digit	….	….	Fifth digit	Fourth digit	Third digit	Second digit	First digit

Example: Convert 2A7 hex to decimal

Digit 3: 2 x 256   = 512
Digit 2: (10) x 16   = 160
Digit 1: 7x1   =   7

                           679

2A7 hex = 679 decimal

Example: Convert 925 decimal to hex

925 divide by 16 = 57 with 13 remainder   First digit =D
57 divide by 16 = 3 with 9 remainder   Second digit = 9
3 divide by 16 = 0 with 3 remainder   Third digit = 3

925 decimal = 39D hex

Converting between hex and binary is as easy as replacing each digit of hex with equivalent 4 digit of binary.

Example: convert A5B hex to binary

A = 1010
5 = 0101
B = 1011

A5B hex = 1010 0101 1011 binary
Converting binary to hex is as easy as replacing each 4 digit of binary to equivalent digit of hex. If the binary digits are not multiple of 4 for grouping, add enough zero to the left to make them multiple of 4.

Example: Convert 0111 1010 1111 binary to hex

1111 = F
1010= A
0111 = 7
0111 1010 1111 binary = 7AF hex

Common terms:

Bit = binary digit
Nibble = 4 binary digits
Byte = 8 binary digits = 2 nibbles = 2 HEX digits

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