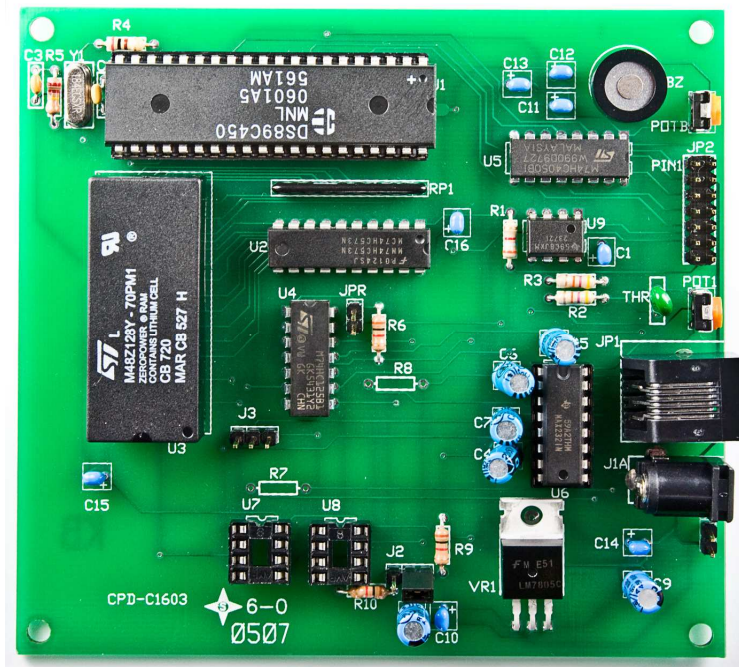


IS-C1603 Intelligent Controller User Manual

Revision D

IS-C1603

16 Switch Controller Version 1.4

**NKK SWITCHES**7850 E. Gelding Drive
Scottsdale, AZ 85260

Toll Free 1-877-2BUYNKK (877-228-9655)

Phone 480-991-0942

Fax 480-998-1435

e-mail <engineering@nkkswitches.com>

All Rights Reserved Worldwide

NKK Switches makes no warranty for the use of these products and assumes no responsibility for any errors, which may appear in this document, nor does it make a commitment to update the information contained herein. Smart Switch is trademark of NKK Switches.

TABLE OF CONTENTS

Table of Contents.....	2
1. General Controller Features.....	3
2. Compatible Logic Boards	4
3. Operational.....	5
4. Switch Presses/Releases.....	6
5. DATA Format.....	7
5.1. Key Terms & Definitions.....	10
5.2. Data Definition and Format.....	12
6. Communication Protocol.....	10
6.1. Upload Command.....	11
6.2. Operation Commands that do not affect the storage memory.....	12
6.3. Graphic image, Graphic manipulation and LED code.....	14
6.4. Character commands.....	16
6.5. Functional Set Up: Attribute Block, Power UP.....	19
6.6. Switch activity look-up commands.....	20
6.7. Fonts look-up data commands.....	22
6.8. Backlight Set UP commands.....	23
6.9. Animation Feature.....	25
6.10. Setting the Flags.....	25
6.11. Command 26H.....	32
7. Hardware.....	39
8. Programming the Firmware.....	48
9. Firmware problems.....	48
10. Appendix HEX, Decimal, Binary.....	49

1. General Controller Features

The IS-C1603 controls 16 LCD 36x24 switches/displays. The IS-C1603 is designed to be used in many different applications. There is total flexibility with user-defined features that allow the controllers to be programmed for specific applications. The user defined data and set up are stored in a non volatile memory and specify the way the system behaves. The firmware can be customized based on customer requirements. Below are current features:

General features:

- 16 LCD 36x24 switches/displays.
- Serial communication via RS232 (9.6K default, 19.2K, 57.6K, 1 start bit, 8 bit , 1 stop bit).
- RS422 optional.
- Program responses to switch-actions events and timer-expire events.
- User programmable for images, attributes and set-ups.
- Set the type of activity reports from the controller to host.
- LED Brightness settings.
- Non-volatile memory for 255 images and attributes.
- Reports switch activities via serial port.
- Stand-alone operation or real-time control by host.

Switch-action report from the controller to the host:

- Default switch press event (1 byte in the form of 80H + LCD Switch/display #).
- Default switch release event (1 byte in the form of B0H + LCD Switch/display #).
- Default image press event (2 byte indicating location).
- Default image release event (2 byte indicating location).
- User-defined switch press event report (up to 15 bytes).
- User-defined switch release event report (up to 15 bytes).
- User-defined picture press event report (up to 15 bytes).
- User-defined picture release event report (up to 15 bytes).

Set-up options:

- Adjustable audio feedback while switch is pressed.
- User-defined backlight color while switch is pressed.
- User-defined font 5x7 (256 character).
- User-defined font 7x10 (256 character).
- User-defined backlighting blinking rate.
- User-defined backlighting ON and OFF duration.
- Option to continue the last state before power-down/reboot.

Real-time operation features:

- Download image data to any address.
- Select image display for each LCD switch/display.
- Download characters and controller will create graphic image using 5x7 font for any address.
- Download characters and controller will create graphic image using 7x10 font for any address.

- Control any single pixel on any LCD switch/display.
- Change backlight color on any LCD switch/display.

2. Compatible Logic Boards

Switch Logic Boards: PCBs with mounted switches or displays that are used for this controller are called Logic Boards. There are many Logic Boards available. All the Logic Boards have two 7x2 connectors and can be daisy chained via 14 pin ribbon cables. JP2 of the IS-C1603 gets connected to J1 of the first Logic Board, J2 of the first Logic Board gets connected to J1 of the second Logic Board and so on. The red wire of the ribbon cable, indicating pin 1, must be connected to pin 1 for all connections. There are two types of Logic Boards, 2 bits and 4 bits. Only one type of board can be used at any one time. The J2 jumper is used to select which type of logic boards will be used with the IS-C1603. If the jumper is not selected properly or the two types of logic boards are mixed together the backlight and the switch scan will be wrong.

The following is a list of compatible Logic Boards and switches.

RGB, 4 bit:

- A. IS-L0204-C Two LCD 36x24 RGB, 4 bit.
- B. IS-L0251-C Two LCD 36x24 RGB Display, 4 bit.
- C. IS-L0271-C Two LCD 36x24 RGB Compact, 4 bit.
- D. IS-L0107-IS15ABFP4RGB One LCD 36x24 RGB, 4 bit.

Bicolor/Single color, 4 bit:

- E. IS-L0205-C Two LCD 36x24 Bicolor/Single color, 4 bit.

Bicolor/Single color, 2 bit:

- F. IS-L0102-SW# One LCD 36x24 Bicolor/Single color, 2 bit. No mounting hole. Must be used with Panel Mount housing.
- G. IS-L0103-C One LCD 36x24 Bicolor/Single color, 2 bit.
- H. IS-L0201-C Two LCD 36x24 Bicolor/Single color, 2 bit, 1x2 (VxH) (spacing between the switches).
- I. IS-L0301-C Three LCD 36x24 Bicolor/Single color, 2 bit, 1x3 (VxH).
- J. IS-L0302-C Three LCD 36x24 Bicolor/Single color, 2 bit, 3x1 (VxH).
- K. IS-L0401-C Four LCD 36x24 Bicolor/Single color, 2 bit, 2x2 (VxH), side by side stackable.
- L. IS-L0601-C Six LCD 36x24 Bicolor/Single color, 2 bit, 2x3 (VxH).
- M. IS-L0901-C Nine LCD 36x24 Bicolor/Single color, 2 bit, 3x3 (VxH), side by side stackable.
- N. IS-L1002-C Ten LCD 36x24 Bicolor/Single color, 2 bit, 5x2 (VxH), side by side stackable.
- O. IS-L1502-C Fifteen LCD 36x24 Bicolor/Single color, 2 bit, 5x3 (VxH), side by side stackable.

New Logic Boards can be designed based on customer requirements.

Note: Make sure the power is off when connecting or disconnecting the Logic Boards to or from the controller or each other.

Note: Connecting the Logic Boards improperly could damage either/both the Logic Boards and controller.

3. Operation

Overview

There are 255 image addresses in the memory (01H to FFH). Each image Address holds a Page of data. Each Page has an image data, LCD/LED code, control code, Attribute block, and user-defined look-up tables etc. These data are referred to as storage memory since normally these data are downloaded to memory one time. Each switch has an image address (01H to FFH) assigned to it. The assigned address Page data are used for the display and backlighting. Attributes and look-up tables of the Page are used when a switch is pressed or released. Any address (01H to FFH) can be assigned to any switch (1 to 16).

Set up

There are 3 flag bytes that determine how the controller functions (Section 6.10). The controller has many features that can be enabled or disabled based on these flags setting.

Normally storage data for addresses are downloaded to the controller once. The Page data need to be downloaded only to the addresses that will be used by the application.

The image data (picture) and LCD/LED code (backlight) are used in most application. The attributes and various look-up data need to be downloaded only if the feature is enabled via flag bytes.

Power-up

Upon power-up/reboot (as a default), address 01H is assigned to switch #1, address 02H is assigned to switch #2 and so on up to address 10H is assigned to switch #16.

Each switch LCD displays the assigned address's image data. The LCD continuously gets refreshed from the image data.

The 16 switches' backlights turn on according the LCD/ LED codes in the 16 byte refresh buffer. Each switch backlight continuously gets refreshed from its associated LCD/LED code from the refresh buffer. The LCD/LED codes are transferred to the refresh buffer from assigned addresses page data upon address assignment.

After power-up or reset, the controller transmits 11H. This lets the host know that the controller is on line and ready for commands.

The controller then waits for a switch activity or a command from host.

Operation

The controller can change the switches' displays and backlighting based on the switch activities. These changes happen based on the Attribute Block. Each of the 255 addresses has an Attribute Block. The Attribute Block is a set of 16 addresses to be assigned to the 16 switches. Upon a switch closure the Attribute Block of the switch's assigned address goes to effect.

The controller has many options to report a switch activity to the host based on the switch or assigned address. The switch activities operation is described in section 4.

The host can command the controller to change the switches' display and backlighting. The changes can be with any of the following commands:

- Assign new addresses to switches.
- Download new LED codes to refresh buffer.
- Download character or graphic image to an address which is assigned to a switch.

Section 6 has the detail of all the commands.

4. Switch Presses/Releases:

The controller takes the following actions upon a switch press/release.

1. Switch Release:

- A. If bit 0 of FLAG-A is enabled (default: enabled), transmit (Switch # + B0H) to host in HEX format.
- B. If bit 2 of FLAG-C is enabled (default: disabled), transmit to host up to a maximum of 15 bytes HEX format from user-defined switch release look-up table associated with the switch number.
- C. If bit 0 of FLAG-C is enabled (default: disabled), transmit to host the image address that is being displayed in ASCII HEX format.
- D. If bit 1 of FLAG-C is enabled (default: disabled), transmit to host up to a maximum of 15 Bytes in HEX format from user-defined image release look-up table associated with the image address.
- E. If bit 5 of FLAG-A is enabled (default: enabled) and bit 2 of FLAG-B is enabled (default: disabled) then do the following using the data from current image address:
 - E1. If the viewing angle/ brightness code is not zero, then increase or decrease the brightness accordingly.
 - E2. Update the switches image addresses with the Addresses from the Attribute Block. If any of the Addresses in the attribute block is equal to zero do not change that switch image address.
 - E3. If bit 0 of FLAG-B is enabled (default: enabled), update the LCD/LED codes for the switches according to data from updated switch image addresses.

2. Switch Closure (Press):

- A. If bit 1 of FLAG-A is enabled (default: enabled), transmit (Switch # + 80H) to host in HEX format.
- B. If bit 2 of FLAG-A is enabled (default: disabled), transmit to host up to a maximum of 15 characters or until there is a null character in HEX format from user-defined switch press look-up table associated with the switch number.
- C. If bit 3 of FLAG-A is enabled (default: disabled), transmit to host in ASCII HEX format the Pointer value of the image being displayed.
- D. If the bit 4 of FLAG-A is enabled (default: disabled), transmit to host up to a maximum of 15 characters or until there is a null character in HEX format from user-defined image press look-up table associated with the Pointer.

- E. If bit 5 of FLAG-A is enabled (default: enabled) and bit 2 of FLAG-B is zero (default: 0) then do the following:
- E1. If the viewing angle/brightness code is not zero, then increase or decrease the brightness accordingly.
 - E2. Update the switches' image addresses with the Addresses from the Attribute Block. If any of the Addresses in the attribute block is equal to zero do not change that switch's image address.
 - E3. If bit 0 of FLAG-B is enabled (default: enabled), update the LCD/LED codes for the switches according to data from updated switch image addresses.

Commands from host:

There are many commands available for the host to control the switches in real-time or set up the controller for stand-alone operation. The commands are described in proceeding section.

5. Data formats

This section describes the definitions and data block formats.

5.1 Key Terms & Definitions

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: <ol style="list-style-type: none">Hex format - A hex byte is transmitted without any change to it. [xxH] will be used to denote this. For example, the hex byte 5AH is transmitted as a single byte 5AH. All commands and some data are sent using this format.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.

5.2 Data Definition and Format

Attribute Block for 36x24 Resolution Switches

A block of 16 bytes representing 16 Addresses.

Byte	Description
1	Image address for switch #1
2	Image address for switch #2
•	
•	
15	Image address for switch #15
16	Image address for switch #16

Legend Block for 36x24 Resolution Switches

A block of 125 bytes. It contains image data and LED codes.

Byte	Description
1-5	First line of image
6-10	Second line of image
•	
•	
•	
116-120	24th line of image
121	LED code
122	Viewing angle/brightness code
123-125	reserved

Image Block

A block of 120 bytes (subset of the Legend Block). There are five bytes of data for each pixel-row of LCD switch/display. The least significant nibble of the fifth byte is not used. The most significant bit of the first byte will be displayed as the leftmost pixel of pixel-row of LCD switch/display.

LED Backlighting for 36x24 Resolution Switches:

The LED code is one byte with the following format:

B7=0 ==> Reserved

B7=1 ==> Reserved

B6=0 ==> Blue backlighting off during "OFF CYCLE"

B6=1 ==> Blue backlighting on during "OFF CYCLE"

B5=0 ==> Green backlighting off during "OFF CYCLE"

B5=1 ==> Green backlighting on during "OFF CYCLE"

B4=0 ==> Red backlighting off during "OFF CYCLE"

B4=1 ==> Red backlighting on during "OFF CYCLE"

B3=0 ==> LCD normal

B3=1 ==> LCD inverse

B2=0 ==> Blue backlighting off during "ON CYCLE"

B2=1 ==> Blue backlighting on during "ON CYCLE"

B1=0 ==> Green backlighting off during "ON CYCLE"

B1=1 ==> Green backlighting on during "ON CYCLE"

B0=0 ==> RED backlighting off during "ON CYCLE"

B0=1 ==> RED backlighting on during "ON CYCLE"

NOTE: For bicolor LED's B2 & B6 are not used.

B0 & B4 are for LED of the switch, pin 3.

B1 & B5 are for LED of the switch, pin 13.

Control Code (Brightness adjustment):

A byte with the following format:

B0, B1, B4, B5, B6 and B7 are reserved and should be zero

B3=0 ==> No change

B3=1 ==> Increase backlight brightness

B2=0 ==> No change

B2=1 ==> Decrease backlight brightness

LCD/LED Block A block of 16 LCD/LED codes. The backlighting and LCD display mode for the 16 LCD switch/displays.

Byte	Description
1	LCD/LED code for Switch #1
2	LCD/LED code for Switch #2
•	
•	
15	LCD/LED code for Switch #15
16	LCD/LED code for Switch #16

6. Communication Protocol

The controller communicates with the host by serial communication via RS232 (8 bits, NP, 9600). The controller receives the data via an interrupt routine that places the data in the circular receive buffer. When the controller detects data in the circular receive buffer, it 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. All of the commands are explained in detail in proceeding sections.
- 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 data byte is not received in 50ms, the controller transmits 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 is specified for each command.

6.1 Upload Commands

These commands do not affect the controller functions or memory contents. They read various data/statuses from controller.

Command to upload a Legend Block from and address

This command uploads a Legend Block from the specified address to the host.

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

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

The controller transmits back 61H followed by the Legend Block (125 bytes in HEX format) and 79H.

Command to upload the addresses assigned to all the 16 switches

command format: **2DH** 52H
transmit format: (xxH) (xxH)

The controller transmits back 61H followed by 16 addresses (16 bytes in ASCII HEX format) and 79H.

Command to upload the assigned address of a switch

command format: **2EH** 52H [Switch #]
transmit format: (xxH) (xxH) (xxAH)

[Switch #] is one byte with value of 01H to 10H and must be sent in ASCII hex format.

The controller transmits back 61H followed by the associated address (1 byte in ASCII HEX format) and 79H.

Command to upload LCD/LED block

command format: **2CH** 52H
transmit format: (xxH) (xxH)

The controller transmits back 61H followed by 16 LCD/LED codes (16 bytes in ASCII HEX format) and 79H. These LCD/LED codes are the active codes from intermediate buffer for the 16 switches at the time of receiving the command.

Command to upload LCD/LED Code of a switchcommand format: **2FH** 52H [Switch #]

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

[Switch #] is one byte with value of 01H to 10H and must be sent in ASCII HEX format.

The controller transmits back 61H followed by the LCD/LED code (1 byte in ASCII HEX format) and 79H. The LCD/LED code is from intermediate buffer.

Command to upload an Attribute Block from an Addresscommand format: **2BH** [Address]

transmit format: (xxH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

Upon receiving this command the controller transmits back 61H followed by the Attribute Block (16 bytes in ASCII HEX format) and 79H.

6.2 Operation commands that do not affect the storage memory

These commands are used in real-time operation. They do not affect the storage memory. However they can change the backlights and images of switches.

Command to reboot the controller

The command reboots the controller to power-up state. After sending this command any command send may be missed. Wait for the controller to send 11H before sending a new command.

command format: **24H**

transmit format: (xxH)

The controller transmits back 11H to the host after reboot.

Command to check communication

The command is used to check if the controller is on-line. It does not affect the controller's function.

command format: **01H**

transmit format: (xxH)

The controller transmits back 61H to the host.

Command to reboot the controller

The command transfers the LCD/LED codes for all the switches according to the assigned addresses from storage to refresh buffer.

command format: **23H**
transmit format: (xxH)

The controller responds 61H to the host.

Command to download addresses for 16 switches

This command downloads 16 addresses to be assigned to the 16 switches.

If any of the download addresses value is zero then the corresponding switch assigned address is left unchanged.

command format: **2DH** 30H [Addresses]
transmit format: (xxH) (xxH) (xxAH)

[Addresses] is 16 bytes of address sent in ASCII HEX format.

The controller assigns new addresses to the switches. The images will be displayed immediately. The backlights will change to LCD/LED codes from storage only if bit 0 of FLAG-B is enabled.

The controller responds with 61H and after processing the command 79H.

Command to download an address to a switch

This command downloads an address to be assigned to the specified switch.

command format: **2EH** 30H [Switch#] [Address]
transmit format: (xxH) (xxH) (xxAH) (xxAH)

[Switch #] is one byte with value of 01H to 10H and must be sent in ASCII HEX format.

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

The controller assigns the new address to the switch. The image will be displayed immediately. The backlight will change to LCD/LED code from storage only if bit 0 of FLAG-B is enabled.

The controller responds with 61H and after processing the command 79H.

Command to set LCD/LED codes for all 16 Switches

This command downloads the 16 LCD/LED codes to the refresh buffer. If the value of a LCD/LED code is zero, the corresponding code in the refresh buffer is left unchanged. If an update is desired for the value of zero, Bit 7 should be set to 1. The new backlight colors go to effect immediately.

If it is desired to control the backlights from host completely, the bit 0 of FLAG-B should be disabled. Otherwise the backlights change the LCD/LED codes from storage when any new address is assigned to the switches.

command format: **2CH** 30H [LCD/LED code block]
transmit format: (xxH) (xxH) (xxAH)

[LCD/LED code block] is 16 bytes of LCD/LED codes, one for each switch, and must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

Command to download one LCD/LED Code to specified Switch

This command downloads a LCD/LED code to the refresh buffer for the specified switch. The new backlight color goes to effect immediately.

If it is desired to control the backlights from host completely, the bit 0 of FLAG-B should be disabled. Otherwise the backlights change the LCD/LED codes from storage when any new address is assigned to the switches.

command format: **2FH** 30H [Switch #] [LCD/LED code]
transmit format: (xxH) (xxH) (xxAH) (xxAH)

[Switch #] is one byte with value of 01H to 10H and must be sent in ASCII HEX format.

[LCD/LED code] is one byte and must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

6.3 Graphic images, graphic manipulation and LCD/LED codes.

These commands affect the data in the storage memory. They can be used in real-time applications. Any change to storage images will be displayed immediately if the address is assigned to a switch. However any change to LCD/LED code in storage does not go to effect as the LCD/LED code does not transferred from storage to refresh LCD/LED buffer by these commands.

Command to download one LCD/LED Code to specified Address

The LCD/LED code for specified Address changes to the new code.

command format: **27H** [Address] [09H] [LCD/LED code]
transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[09H] is two byte and must be sent in ASCII HEX format (30 39).

[LCD/LED code] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

The LCD/LED code is not transferred to LCD/LED code refresh block.

The controller responds with 61H and after processing the command 79H.

Command to download a Legend block

This command downloads a Legend Block from the host to an address. The legend block contains the graphic image as well as the backlight code.

command format: **28H** [Address] [Legend Block]
transmit format: (xxH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[Legend Block] is 125 bytes and must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

Command to clear the Image data at a specified Address

This command sets all the bits in the image data at a specified Address to zero (OFF).

command format: **27H** [Address] [00H]
transmit format: (xxH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[00H] is one byte and must be sent in ASCII HEX format (30 30).

The controller responds with 61H and after processing the command 79H.

Command to fill the Image data at a specified Address

This command sets all the bits in the image data at a specified Address to one (ON).

command format: **27H** [Address] [01H]
transmit format: (xxH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[01H] is two byte and must be sent in ASCII HEX format (30 31).

The controller responds with 61H and after processing the command 79H.

Command to clear a pixel within an image of specified address

This command sets a pixel within an image to zero (OFF) at a specified address.

command format: **27H** [Address] [02H] [column] [row]
transmit format: (xxH) (xxAH) (xxAH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[02H] is two byte and must be sent in ASCII HEX format (30 32).

[column] is one byte with value of 01H to 24H and must be sent in ASCII HEX format.

[row] is one byte with value of 00H to 17H and must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

Command to fill a pixel within an image of specified address

This command sets a pixel within an image to one (ON) at a specified address.

command format: **27H** [Address] [03H] [Column] [Row]
transmit format: (xxH) (xxAH) (xxAH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[03H] is one byte and must be sent in ASCII HEX format (30 33).

[Column] is one byte with value of 01H to 24H and must be sent in ASCII HEX format.

[Row] is one byte with value of 00H to 17H and must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

Command to download and insert data for the left column of a image at the specified address

This command inserts one column of pixels data to the left side of the image. All the columns shift to the right.

The right most column pixel data are lost.

command format: **27H** [Address] [07H] [Pixels data]
transmit format: (xxH) (xxAH) (xxH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[07H] is two byte and must be sent in ASCII HEX format (30 37).

[Pixels data] is three bytes representing the 24 pixels in the column. The top-most pixel is the most significant bit of first byte. The values must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

6.4 Character commands

These commands download ASCII character so controller creates graphic images at specified address. If the address is assigned to a switch, the changes can be seen immediately.

The controller can generate an image using the font look-up tables. The default look-up tables are ASCII character values 20H to 7FH in fonts 5x7 and 7x10. The user can modify the default look-up tables as well as create a user-defined look-up table for remainder of the values from 01H to FFH.

Each image can hold three lines of 6 characters in font 5x7 or two lines of 4 characters in font 7x10.

In font 7x10, the actual character picture is 10 pixel-rows high. It's padded by an extra pixel-row on the top and bottom. These padded pixel-rows are clear (OFF) for "normal mode" command and filled (ON) for "reverse mode" command to provide line spacing between character-rows. In font 5x7, the actual character picture is 7 pixel-rows high. It's padded on the top only with a clear (OFF) pixel-row to provide line spacing between character-rows.

Command to create 18 characters for three lines of font 5x7 in the specified address

This command creates the image data at a specified address with 3 lines of 18 characters of font 5x7.

command format: **27H** [Address] [08H] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[08H] is two byte and must be sent in ASCII HEX format (30 38).

[ASCII string] is 18 bytes and is a string of font 5x7 look-up table indexes. It must be sent in HEX format.

The controller responds with 61H and after processing the command 79H.

Command to display 6 characters for the first line of font 5x7 in the specified address

This command creates the image data at a specified address with the first line of 6 characters of font 5x7. No changes made to the rest of the image.

command format: **27H** [Address] [0EH] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[0EH] is two byte and must be sent in ASCII HEX format (30 45).

[ASCII string] is 6 bytes and is a string of font 5x7 look-up table indexes. It must be sent in HEX format.

The controller responds with 61H and after processing the command 79H.

Command to display 6 characters for the second line of font 5x7 in the specified address

This command creates the image data at a specified address with the second line of 6 characters of font 5x7. No changes made to rest of the image.

command format: **27H** [Address] [0FH] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[0FH] is two byte and must be sent in ASCII HEX format (30 46).

[ASCII string] is 6 bytes and is a string of font 5x7 look-up table indexes. It must be sent in HEX format.

The controller responds with 61H and after processing the command 79H.

Command to display 6 characters for the third line of font 5x7 in the specified address

This command creates the image data at a specified address with the third line of 6 characters of font 5x7. No changes made to the rest of the image.

command format: **27H** [Address] [10H] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[10H] is two byte and must be sent in ASCII HEX format (31 30).

[ASCII string] is 6 bytes and is a string of font 5x7 look-up table indexes. It must be sent in HEX format.

The controller responds with 61H and after processing the command 79H.

Command to display 8 characters for two lines of font 7x10 in the specified address

This command creates the image data at a specified address with two lines of 4 characters each of font 7x10.

command format: **27H** [Address] [04H] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[04H] is two byte and must be sent in ASCII HEX format (30 34).

[ASCII string] is 8 bytes and is a string of font 7x10 look-up table indexes. It must be sent in HEX format.

The controller responds with 61H and after processing the command 79H.

Command to display 8 characters for two lines of font 7x10 with first line in inverse mode in the specified address

This command creates the image data at a specified address with two lines of 4 characters each of font 7x10.

The first line is white characters on black background. The second line is black characters on white background.

command format: **27H** [Address] [06H] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[06H] is two byte and must be sent in ASCII HEX format (30 36).

[ASCII string] is 8 bytes and is a string of font 7x10 look-up table indexes. It must be sent in HEX format.

The controller responds with 61H and after processing the command 79H.

Command to display 4 characters for the first line of font 7x10 in the specified address

This command creates the image data at a specified address with the first line of 4 characters of font 7X10. No changes made to the rest of the image.

command format: **27H** [Address] [0AH] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[0AH] is two byte and must be sent in ASCII HEX format (30 41).

[ASCII string] is 4 bytes and is a string of font 7x10 look-up table indexes. It must be sent in HEX format. The controller responds with 61H and after processing the command 79H.

Command to display 4 characters for the second line of font 7x10 in the specified address

This command creates the image data at a specified address with the second line of 4 characters of font 7X10. No changes made to the rest of the image.

command format: **27H** [Address] [0BH] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[0BH] is two byte and must be sent in ASCII HEX format (30 42).

[ASCII string] is 4 bytes and is a string of font 7x10 look-up table indexes. It must be sent in HEX format. The controller responds with 61H and after processing the command 79H.

Command to display 4 characters for the first line of font 7x10 in inverse mode in the specified address

This command creates the image data at a specified address with the first line of 4 characters of font 7X10. The first line is white characters on black background. No changes made to the rest of the image.

command format: **27H** [Address] [0CH] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[0CH] is two byte and must be sent in ASCII HEX format (30 43).

[ASCII string] is 4 bytes and is a string of font 7x10 look-up table indexes. It must be sent in HEX format. The controller responds with 61H and after processing the command 79H.

Command to display 4 characters for the second line of font 7x10 in inverse mode in the specified address

This command creates the image data at a specified address with the second line of 4 characters of font 7X10. The second line is white characters on black background. No changes made to the rest of the image.

command format: **27H** [Address] [0DH] [ASCII string]
transmit format: (xxH) (xxAH) (xxAH) (xxH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[0DH] is two byte and must be sent in ASCII HEX format (30 44).

[ASCII string] is 4 bytes and is a string of font 7x10 look-up table indexes. It must be sent in HEX format. The controller responds with 61H and after processing the command 79H.

6.5 Functional set up: Attribute block, power up

These commands for downloading attribute and other set up. They are downloaded once. These commands are not normally used during the real-time operation.

Command to set the Image addresses for power up.

This command download the user defined addresses to be assigned to the switches upon power up or reboot. The default values are 01H, 02H, 03H, ..., ..., 0EH, 0FH, 10H.

command format: **21H** [CCH] [Power up Addresses]
transmit format: (xxH) (xxAH) (xxAH)

[CCH] is one byte and must be sent in ASCII HEX format (43H 43H).

[Power up Addresses] is 16 bytes sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

Command to set the number of Switches attached to the controller.

This command sets the number of Switches attached to the controller. Specifying less than 16 switches will have two effects on the controller operation. First any command related to the number of switches will have its data reduced according to the number switches for download/upload. Second the time of any features that has timer is reduced as the number of switches is reduced.

command format: **21H** [E9H] [# of Switches] [# of Switches]
transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[E9H] is one byte and must be sent in ASCII HEX format (45H 39H).

[# of Switches] is one byte with value of 01H to 10H and must be sent twice in ASCII HEX format. This command goes into effect after the following power up / reboot.

The controller responds with 61H and after processing the command 79H.

Command to download Attribute block to a specified Address

The attribute blocks are information on how the controller function based on the switch activity. When a switch is pressed the attribute block of the switch assigned image address are executed as described in the “Switch Presses/Releases” section.

command format: **2AH** [Address] [Attribute block]
transmit format: (xxH) (xxAH) (xxAH)

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[Attribute block] is 16 bytes of Addresses and must be sent in ASCII HEX format.

The controller responds with 61H and after processing the command 79H.

6.6 Switch activity look-up commands

Commands below download user defined strings. These strings are reported back to host upon switch activity if the appropriate flags are enabled. These commands are downloaded once and are not normally used during the real-time operation.

Command to download user-defined Switch Press string for a switch.

This command downloads user-defined string for a switch press. This string is sent to host every time the specified switch is pressed If bit 2 of FLAG-A is enabled.

command format: **21H** [AAH] [Switch #] [number] [string]
transmit format: (xxH) (xxAH) (xxAH) (xxH) (xxH)

[AAH] is two byte and must be sent in ASCII HEX format (41H 41H).

[Switch #] is one byte with value of 01H to 10H and must be sent in ASCII HEX format.

[number] is one send in HEX format. byte which indicates the number of bytes. Only the lower nibble is used.

[string] may consist of up to a maximum of 15 bytes according to the lower nibble of the [number].

All default values for this section are 00H.

The controller responds with 61H and after processing the command 79H.

Command to download user-defined Switch Release string for a switch.

This command downloads user-defined string for a switch release. This string is sent to host every time the specified switch is released if bit 2 of FLAG-C is enabled.

command format: **21H** [ABH] [Switch/display #] [number] [string]
transmit format: (xxH) (xxAH) (xxAH) (xxH) (xxH)

[ABH] is one byte and must be sent in ASCII HEX format (41H 42H).

[Switch/display #] is one byte with value of 01H to 10H and must be sent in ASCII HEX format.

[number] is one byte which indicates the number of bytes. Only the lower nibble is used.

[string] may consist of up to a maximum of 15 bytes according to the lower nibble of the [number].

All default values for this section are 00H.

The controller responds with 61H and after processing the command 79H.

Command to download user-defined Image Press string for an address.

This command downloads user-defined string for an image press. This string is sent to host every time any switch pressed with the assigned address if bit 4 of FLAG-A is enabled.

There is an additional feature for image press. If bit 3 of FLAG-C is enabled and bit 4 of [number] in the command below is set then while a switch is kept pressed the string is repeatedly sent to the host at the user defined interval time.

command format: **21H** [BBH] [Address] [number] [String]
transmit format: (xxH) (xxAH) (xxAH) (xxH) (xxH)

[BBH] is one byte and must be sent in ASCII HEX format (42H 42H).

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[number] is one byte which indicates the number of bytes. Only the lower nibble is used. If B4=1 then the string will be repeatedly send while the Image is pressed.

[String] may consist of up to a maximum of 15 bytes according to the lower nibble of the [number].

All default values for this section are 00H.

The controller responds with 61H and after processing the command 79H.

Command to download the Repeat timer for user-defined Image Press

This command downloads the timer between repeated transmissions of the user-defined Image press string.

command format: **21H** [ECH] [Timer] [Timer]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[ECH] is one byte and must be sent in ASCII HEX format (45H 43H).

[Timer] is one byte and must be sent twice in ASCII HEX format. The default value is 08H.

Approximate repeat time in ms = 13x (Timer value)

The controller responds with 61H and after processing the command 79H.

Command to download user-defined Image Release string for an address.

This command downloads user-defined string for an image release. This string is sent to host every time any switch released with the assigned address if bit 1 of FLAG-C is enabled.

command format: **21H** [BCH] [Address] [number] [string]
 transmit format: (xxH) (xxAH) (xxAH) (xxH) (xxH)

[BCH] is one byte and must be sent in ASCII HEX format (42H 43H).

[Address] is one byte with value of 01H to FFH and must be sent in ASCII HEX format.

[number] is one byte which indicates the number of bytes in the string. Only the lower nibble is used.

[String] may consist of up to a maximum of 15 bytes according to the lower nibble of the [number].

All default values for this section are 00H.

The controller responds with 61H and after processing the command 79H.

6.7 Fonts look-up commands

There are 255 fonts index (01H to FFH) in each font set. The default bit map look-up tables are created for English ASCII characters index (20H to 7FH). The default values for rest of the fonts are 00H. The user can download bit map look-up data for all the index location.

These commands are downloaded once and are not normally used during the real-time operation.

Command to download a 5x7 font bit map data to an index (01H to FFH)

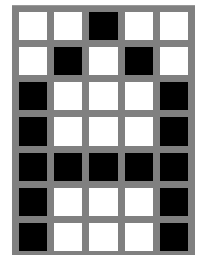
This command downloads a font's bit map data to an index. The index is the character value.

command format: **21H** [BEH] [font index] [font bitmap]
 transmit format: (xxH) (xxAH) (xxAH) (xxH)

[BEH] is two byte and must be sent in ASCII HEX format (42 45).

[font index] is one byte with value of 01H to FFH and must be sent in ASCII HEX format. It is the look-up table index.

[font bitmap] is 7 bytes making up a character graphic. The first byte is the top row of



the character graphic and the 7th byte is the bottom row of the character graphic. The B7 of each byte of the character graphic data is the leftmost column of the character graphic. B2, B1 and B0 are not used and should be set to zero.

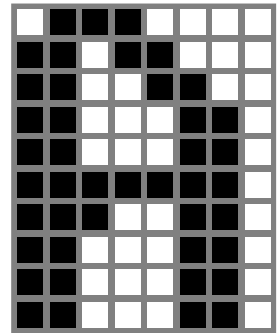
The controller responds with 61H and after processing the command 79H.

Example: (21 4245 3031 20 50 88 88 F8 88 88) sends the above illustration to look-up table index 01.

Command to download a 7x10 font bit map data to an index

This command sets a font set's values and graphic and stores it in the look-up table of font 7x10.

command format: **21H** [BDH] [font value] [font bitmap]
 transmit format: (xxH) (xxAH) (xxAH) (xxH)



[BDH] is two byte and must be sent in ASCII HEX format (42 44).

[font value] is one byte with value of 00H to FFH and must be sent in ASCII HEX format. It is the look-up table index.

[font bitmap] is 10 bytes making up a character graphic. This font is actually 8x10 font so all 8 bits of each character graphic byte are used. The first byte is the top row of the character graphic and the 10th byte is the bottom row of the character graphic.

The B7 of each byte of the character graphic data is the leftmost column of the character graphic.

The controller responds with 61H and after processing the command 79H.

Example: (21 4244 3032 70 D8 CC C6 C6 FE E6 C6 C6 C6) sends the above illustration to look-up table index 02.

6.8 Back light set up commands

These commands are for various backlight set ups.

These commands are downloaded once and are not normally used during the real-time operation.

Command to set LCD/LED Code for a switch press event.

This command sets the LCD/LED Code for when any switch is pressed.

If bit 3 of Flag-B is enabled switches display this backlight color while pressed.

command format: **21H** [E3H] [LCD/LED code] [LCD/LED code]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[E3H] is one byte and must be sent in ASCII HEX format (45H 33H).

[LCD/LED code] is one byte and must be sent twice in ASCII HEX format. The default color is red (11).

The controller responds with 61H and after processing the command 79H.

Command to set the time for LED's OFF Cycle duration.

This command downloads the timer value for the duration of the LED's Off Cycle.

LEDs are refreshed with two set of data sequentially. The two cycles are called "OFF cycle" and "ON cycle".

This command set the duration of OFF cycle.

command format: **21H** [E1H] [Timer value] [Timer value]
transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[E1H] is one byte and must be sent in ASCII HEX format (45H 31H).

[Timer value] is one byte with value of 01H to FFH sent twice and must be sent in ASCII HEX format. The default value is 40H.

Off Cycle Duration = 7 (Timer value) ms.

The controller responds with 61H and after processing the command 79H.

Command to set the time for LED's ON Cycle duration.

LEDs are refreshed with two set of data sequentially. The two cycles are called "OFF cycle" and "ON cycle".

The LED ON cycle time is determined according to the following formula:

LED ON time = (LED OFF time) x (Ratio -1)

If the ratio=1 then only LED OFF cycle will be shown. If the ratio=2 then LED ON cycle and LED OFF cycle have equal time.

command format: **21H** [E2H] [Ratio] [Ratio]
transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[E2H] is one byte and must be sent in ASCII HEX format (45H 32H).

[Ratio] is one byte with value of 01H to FFH sent twice and must be sent in ASCII HEX format. The default value is 03H.

The controller responds with 61H and after processing the command 79H.

Command to download maximum time between commands.

This command sets the timer value for the time between commands. It is used for real-time application. The switches start blinking with red backlighting, if the timer expires before receiving the next command. The blinking red notify the operator that there is an error and there is no communication with host.

command format: **21H** [E4H] [Timer value] [Timer value]
transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[E4H] is one byte and must be sent in ASCII HEX format (45H 34H).

[Timer value] is one byte sent twice and must be sent in ASCII HEX format. The default value is 80H.

The actual time is 20ms times this Timer value. To enable this feature, bit 7 of Flag-C must be enabled.

6.9 Animation Feature

For animated images to be activated bit 7 of Flag-A must be set.

It does not affect any switch with assigned address 127 (7FH) or less. Any switch with assigned address of 80H or higher will have its image continuously step through 8 Addresses. The alternating addresses are as follow:

80H to 87H, 88H to 8FH, 90H to 97H,.....,F0H to F7H,F8H to FFH

The alternating time is determined based on two user-defined variables and a constant as indicated in the formula below:

Alternating time in ms = (20) x (Animation Timer) x (Animation Multiplier)

Command to download the Animation Timer.

This command sets the timer value for animations.

command format: **21H** [98H] [Animation Timer] [Animation Timer]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[98H] is one byte and must be sent in ASCII HEX format (39H 38H).

[Animation Timer] is one byte and must be sent twice in ASCII HEX format. The default value is 10H.

The controller responds with 61H and after processing the command 79H.

Command to set the Animation Multiplier.

This command sets the multiplier value for animations.

command format: **21H** [99H] [Animation Multiplier] [Animation Multiplier]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[99H] is one byte and must be sent in ASCII HEX format (39H 39H).

[Animation Multiplier] is one byte and must be sent twice in ASCII HEX format. The default value is 05H.

The controller responds with 61H and after processing the command 79H.

6.10 Setting the Flags

The controller features can be customized based on customer requirements by manipulating the settings of the Flags. There are three Flag bytes and a command for setting each Flag. The changes go into effect after the following power up / reboot. Command 26H has options to change the flags during operation.

Command to set Flag-A.

This command sets Flag-A which controls the features of the controller.

command format: **21H** [EEH] [Flag Byte] [Flag Byte]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[Flag Byte] is one byte and must be sent twice in ASCII HEX format. This command writes the downloaded flag data to storage memory. The changes go into effect after the following power up/reboot. For changing of the Flags during operation see section 6.11.

The controller responds with 61H and after processing the command 79H.

Flag-A		Default Value=63H	
Bit	Enable Value	Flag	Controller action when flag is set
B0	1	Default Switch release report	Reports switch release events (Switch/display # + B0H) in XXH format.
B1	1	Default Switch press report	Reports switch press events (Switch/display # + 80H) in XXH format.
B2	1	User-defined Switch press report	Transmits user-defined string for that switch upon switch press in XXH format.
B3	1	Default Image press report	Transmits the switch pressed assigned address in XXAH format.
B4	1	User-defined Image press report	Transmits the switch assigned address user-defined string for the switch press in XXH format.
B5	1	Execute Attribute for Switch press/release	Disabled result in no attribute execution.
B6	1	Switch press beep	Provides audio feedback through the beeper while any switch is pressed.
B7	1	Animated Images operation mode enable	

Flag Byte A bit settings:

B0=0 ---> No transmission.

B0=1 ---> Upon switch release, transmit one byte (B0H+switch number).

B1=0 ---> No transmission.

B1=1 ---> Upon switch press, transmit one byte (80H+switch number).

B2=0 ---> No transmission.

B2=1 ---> Upon switch press, transmit the user-defined switch press data string. Up to 15 bytes.

B3=0 ---> No transmission.

B3=1 ---> Upon switch press, transmit the switch assigned address in ASCII HEX format.

B4=0 ---> No transmission.

B4=1 ---> Upon switch press, transmit from the user-defined Image press event data. Up to 16 bytes or until a byte value is 00H.

B5=0 ---> Do not execute the Attributes.

B5=1 ---> Execute Attributes upon switch press or release based on the status of Flag-B bit 2.

B6=0 ---> Disable buzzer.

B6=1 ---> Enable buzzer. Beep when any switch is pressed.

B7=0 ---> Normal operation mode.

B7=1 ---> Animated Image operation. Any switch with an assigned address 01H to 7FH functions normally.

Any switch with an assigned address 80H to FFH continuously step through 8 Addresses. The addresses groupings are as follow:

80H to 87H, 88H to 8FH, 90H to 97H,.....,F0H to F7H,F8H to FFH

The step through timing can be modified via commands.

Command to set Flag-B.

This command sets Flag-B which controls the features of the controller.

command format: **21H** [EFH] [Flag Byte] [Flag Byte]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[Flag Byte] is one byte and must be sent twice in ASCII HEX format. This command writes the downloaded flag data to storage memory. The changes go into effect after the following power up/reboot. For changing of the Flags during operation see section 6.11.

The controller responds with 61H and after processing the command 79H.

Flag-B		Default Value=60H	
Bit	Enable Value	Flag	Controller action when flag is set
B0	0	LCD/LED code from storage	If enabled use the LCD/LED Code from addresses.
B1	1	Power-up switches assigned addresses	If enabled upon power-up/reboot use the assigned addresses that were in effect before power down/reboot.
B2	1	Execute Attribute upon switch presses or releases	If enabled execute Attribute upon switch release. Flag-A bit5 must be set for attribute execution.
B3	1	LED backlight while switch is pressed	If enabled LED backlight change to user-defined color while any switch is pressed.
B4	1	XON/XOFF enable	Uses XON/XOFF protocol to communicate. Bit B7 must be enabled.
B5	1	79H flag	79H is transmitted upon completion of command.
B6	1	61H flag	61H is transmitted in response to command.
B7	1	Controller polling	Uses XON/XOFF protocol to communicate. Bit B4 must be enabled.

Flag Byte B bit settings:

- B0=0 ---> When a new address is assigned to any switch due to attribute execution or command, the Controller transfer the LCD/LED code from the address to LCD/LED codes refresh Buffer.
- B0=1 ---> Do not transfer LCD/LED codes from addresses.
- B1=0 ---> Upon power up/ reboot, use the switches assigned addresses that were in effect before power down/ reboot.
- B1=1 ---> Upon power up/ reboot, use the addresses from Power-up look-up table.
- B2=0 ---> Execute Attributes upon switch press event.
- B2=1 ---> Execute Attributes upon switch release event.
- B3=0 ---> No action.
- B3=1 ---> While switch is pressed change the backlighting to user-defined color.
- B5=0 ---> 79H is not transmitted upon completion of commands.
- B5=1 ---> Upon completion of a command from host, the controller transmits 79H in XXH format.
- B6=0 ---> 61H is not transmitted for acknowledging commands.
- B6=1 ---> Upon receipt of a command byte (20H to 2FH) from host, the controller transmits 61H in XXH format. Regardless of B6 setting, the controllers transmit 61H in respond to Command 01H from host.
- B4, B7 -->These two bits are for polling operation. Both bits must be set to 1 for proper operation. Use XON and XOFF for communication. The controller stops transmitting upon receiving 13H and resumes transmitting upon receiving 11H. The transmit buffer is 256 bytes. The data will be lost if more than 256 bytes is to be transmitted.

Command to set Flag-C.

This command sets Flag-C which controls the features of the controller.

command format: **21H** [EDH] [Flag Byte] [Flag Byte]
 transmit format: (xxH) (xxAH) (xxAH) (xxAH)

[Flag Byte] is one byte and must be sent twice in ASCII HEX format. This command writes the downloaded flag data to storage memory. The changes go into effect after the following power up/reboot. For changing of the Flags during operation see section 6.11.

The controller responds with 61H and after processing the command 79H.

Flag-C		Default Value=00H	
Bit	Enable Value	Flag	Controller action when flag is set
B0	1	Default Image release report	Transmits the assigned address of a switch upon release in XXAH format.
B1	1	User-defined Image release report	Transmits user-defined data string of a switch assigned address upon the switch release in XXH format.
B2	1	User-defined switch release report	Transmits switch release user-defined data string upon the switch release in XXH format.
B3	1	User-defined Image press event repeat	Repeatedly transmits user-defined Image press data string while a switch with the assigned address kept in XXH format.
B4	1	Multi-Drop	Multi-Drop.
B5	1	Multi-Drop transmission	Multi-Drop transmission.
B6	1	Timer for command 26H	Controller waits for additional optional bytes until user-defined timer expires.
B7	1	Continuous command operation mode	Turn all the Switch/display backlighting blinking red if no command from host is received within user-define time interval.

Flag Byte C bit settings:

B0=0 ---> No transmission.

B0=1 ---> Upon switch release, transmit the assigned address of the switch in ASCII HEX format.

B1=0 ---> No transmission.

B1=1 ---> Upon switch release, transmit the assigned address's user-defined Image release data string.

B2=0 ---> No transmission.

B2=1 ---> Upon switch release, transmit the switch's user-defined switch release data string.

B3=0 ---> Disable

B3=1 ---> Enable repeat sending of user-defined Image press data string while the switch is pressed. For this feature to work in addition to this flag, Bit 3 of Flag-A has to be enabled and there has to be proper data in the look-up table.

B4=0 ---> Normal communication.

B4=1 ---> Enable multi-drop. For RS422

The controllers ignore all the received data unless the communication is initiated. To initiate communication FFH followed by the controller's UNIT ID in HEX must be received. After communication is initiated controller accept the commands normally. If the controller receives an FEH the communication is terminated. Controller responses can be controlled by enabling Bits 4&7 of FLAG-B.

B5 ---> Reserved. Must be set to zero. RS422 future use.

B6=0 ---> Disable timer for command 26H.

B6=1 ---> Enable timer for command 26H. Controller starts the timer after each option if the timer is expired before a new option or exit received, the controller terminates the command 26H subroutine and transmit 6EH. The timer is user defined. It is recommended during operation this flag to be enabled.

B7=0 ---> Normal operation mode.

B7=1 ---> Continuous command operation mode. Turns the user-defined timer after each command. If the timer expires before the controller receives the next command, blinking red codes are put into the LCD/LED code refresh Buffer for all the switches. This is for applications in which the host continuously communicates with the controller. Blinking red indicate to the operator that controller is off line.

6.11 Command 26H

This command is for set-up/testing of the controller. The controller is put into the set-up mode after receiving the 26H, where any number of options may be transmitted. This is the only command where the timer between two consecutive received bytes is not set as default. The user must exit this mode by sending X (58H) or ESC (1BH). If the user does not exit this routine the switches are scanned but not executed. The switch activities are processed after exiting this subroutine. It is possible to over write the switch activity buffer. It is recommended that the B6 of Flag-C to be set during the operation.

Command 26H.

command format: **26H** [Option(s)] [Terminating byte]
 transmit format: (xxH) (xxH) (xxH)

[Option(s)] option is one byte sent in HEX format. Multiple options can be sent. The options are listed below. Some options may have additional data they are all transmitted in HEX.
 [Terminating byte] is one byte sent in HEX format. There are two terminating bytes option. 58H or 1BH. The controller responds with 61H and after processing the options if terminated properly sends 79H else sends 6EH.

.....

Option **Read Unit ID**
 41H

The Unit ID is one byte. Controller transmits the unit ID to the host in HEX format. (Default Unit ID = 41H)

.....

Option **Set Unit ID**
 42H [Unit ID]

Controller sets the unit ID to the next byte received after 42H. This is used in RS422 as device address. Otherwise it can be used by user for any propose such as indicating the data version downloaded to the controller.

.....

Option **Red LED Backlighting ON**
 43H

Controller inserts the LED Code 11H (Red color) in the refresh buffer for all the switches.

Option **Green LED Backlighting ON**
44H

Controller inserts the LED Code 22H (Green color) in the refresh buffer for all the switches.

.....

Option **Amber LED Backlighting ON**
45H

Controller inserts the LED Code 33H (Amber color) in the refresh buffer for all the switches.

.....

Option **LED Backlighting OFF**
46H

Controller inserts the LED Code 00H (OFF) in the refresh buffer for all the switches.

.....

Option **Reserved**
47H
48H

.....

Option **Increases LED Brightness Level**
49H

Controller reads the current LED brightness level, increments it and stores its value. The new LED brightness value goes into effect immediately and remains permanently, even after reboot. There are seven levels of brightness.

.....

Option **Decreases LED Brightness Level**
4AH

Controller reads the current LED brightness level, decrements it and stores its value. The new LED brightness value goes into effect immediately and remains permanently, even after reboot. There are seven levels of brightness.

.....

Option **Reserved**

4BH

4CH

.....

Option **Toggle Beeper On/Off**

4DH

Controller toggles the beeper On/Off. The effect lasts only for the duration of the session.

.....

Option **Toggle Switch Closure Beep**

4EH

Controller toggles the flag for audible response to switch closures (**Bit 6 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Return Controller to Default State**

4FH

Upon the following power up or reset after this option the controller does the following:

- Erase all the non-volatile memory.
 - Write all the default set up values to the non-volatile memory.
 - It create image of "BLANK FONT MEMORY" for the address 01H
 - Put 01H for all the attribute block of address 01H
 - put 77H for LED code of address 01H
 - boot up with these changes.
-

Option **Set Attribute Execution On**

50H

Controller enables the flag for attribute execution (**Bit 5 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Set Attribute Execution Off**

51H

Controller disables the flag for attribute execution (**Bit 5 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Return Firmware Version**
52H

Controller transmits the firmware Version in ASCII Hex.

Example: (20 28 43 31 36 30 31 20 2D 41 20 56 31 2E 30 20 29) Hex translates to (C1603-A V1.0)

.....

Option **Serial Set-up Mode**
53H *[serial setup option]*

This option put the controller into serial set-up mode. Once in serial set-up mode, only options for serial set-up are available. The change is written to storage only after 49H option. The serial setup is not changed until the following power-up or reset.

31H	Select 9600 BAUD rate
32H	Select 19200 BAUD rate
33H	Select 57600 BAUD rate
49H	Write the selected option to the Ram, transmit 79H and exit command 26H.
53H	Transmit the baud rate to the host: 9600 (20H 39H 36H 30H 30H), 19200 (31H 39H 32H 30H 30H) and 57600 (35H 37H 36H 30H 30H).
1BH	Transmit 79H and exit command 26H. No change to serial set up
58H	Transmit 79H and exit command 26H. No change to serial set up
xxH Any serial mode non-option byte	Transmit 6EH and exit command 26H. No change to serial set up

Example: (26 53 33 49) sets the baud speed to 57600 upon power-up or reset.

.....

Option **Reserved**
54H
55H
56H
57H

.....
Option **Enable Switch Release Reports**
61H

Controller sets the flag which enables switch release reports (**Bit 0 of FLAG-A**). The effect lasts for only the duration of the session.

.....
Option **Disable Switch Release Reports**
62H

Controller sets the flag which disables switch release reports (**Bit 0 of FLAG-A**). The effect lasts for only the duration of the session.

.....
Option **Disable Switch Closure Beep**
63H

Controller sets the flag which disables the switch closure beep (**Bit 6 of FLAG-A**). The effect lasts for only the duration of the session.

.....
Option **Enable Switch Closure Beep**
64H

Controller sets the flag which enables the switch closure beep (**Bit 6 of FLAG-A**). The effect lasts for only the duration of the session.

.....
Option **Turn Beeper Off**
65H

Controller turns beeper off. The effect lasts for only the duration of the session.

.....
Option **Turn Beeper On**
66H

Controller turns beeper on. The effect lasts for only the duration of the session.

.....

Option **Disable Default Switch Press Reports**
67H

Controller disables default switch press report (**Bit 1 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Enable Default Switch Press Reports**
68H

Controller enables default switch press reports (**Bit 1 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Disable User-defined Switch Press Reports**
69H

Controller disables user defined switch press reports (**Bit 2 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Enable User-Defined Switch Press Reports**
6AH

Controller enables user defined switch press reports (**Bit 2 of FLAG-A**). (User-Defined). The effect lasts for only the duration of the session.

.....

Option **Disable default Image Press Reports**
6BH

Controller disables the default image press report (**Bit 3 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Enable Default Image Press Reports**
6CH

Controller enables default image press reports (**Bit 3 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Disable User-Defined Image Press Reports**
6DH

Controller disables user defined image press reports (**Bit 5 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Enable User-Defined Image Press Reports**
6EH

Controller enables user defined image press reports (**Bit 5 of FLAG-A**). The effect lasts for only the duration of the session.

.....

Option **Exit command 26H**
1BH

Controller transmits 79H and exits command 26H.

.....

Option **Exit command 26H**
58H

Controller transmits 79H and exits command 26H.

.....

Option **Any non-option byte**
XXH

Controller transmits 6EH and exits command 26H.

7. Hardware

WARNING: These products are ESD sensitive. The ESD handling procedure must be followed.

Power Requirement: 1Amp at 9Volts (maximum: 12Volts).

Table below is actual power consumption test results.

Test at 9V	Switch type	Backlight Color	Brightness	Typical Current mA
Test 1	16 RGB	OFF	Max level 7	120
Test 2	16 RGB	RED	Max level 7	290
Test 3	16 RGB	GREEN	Max level 7	360
Test 4	16 RGB	BLUE	Max level 7	360
Test 5	16 RGB	WHITE	Max level 7	610

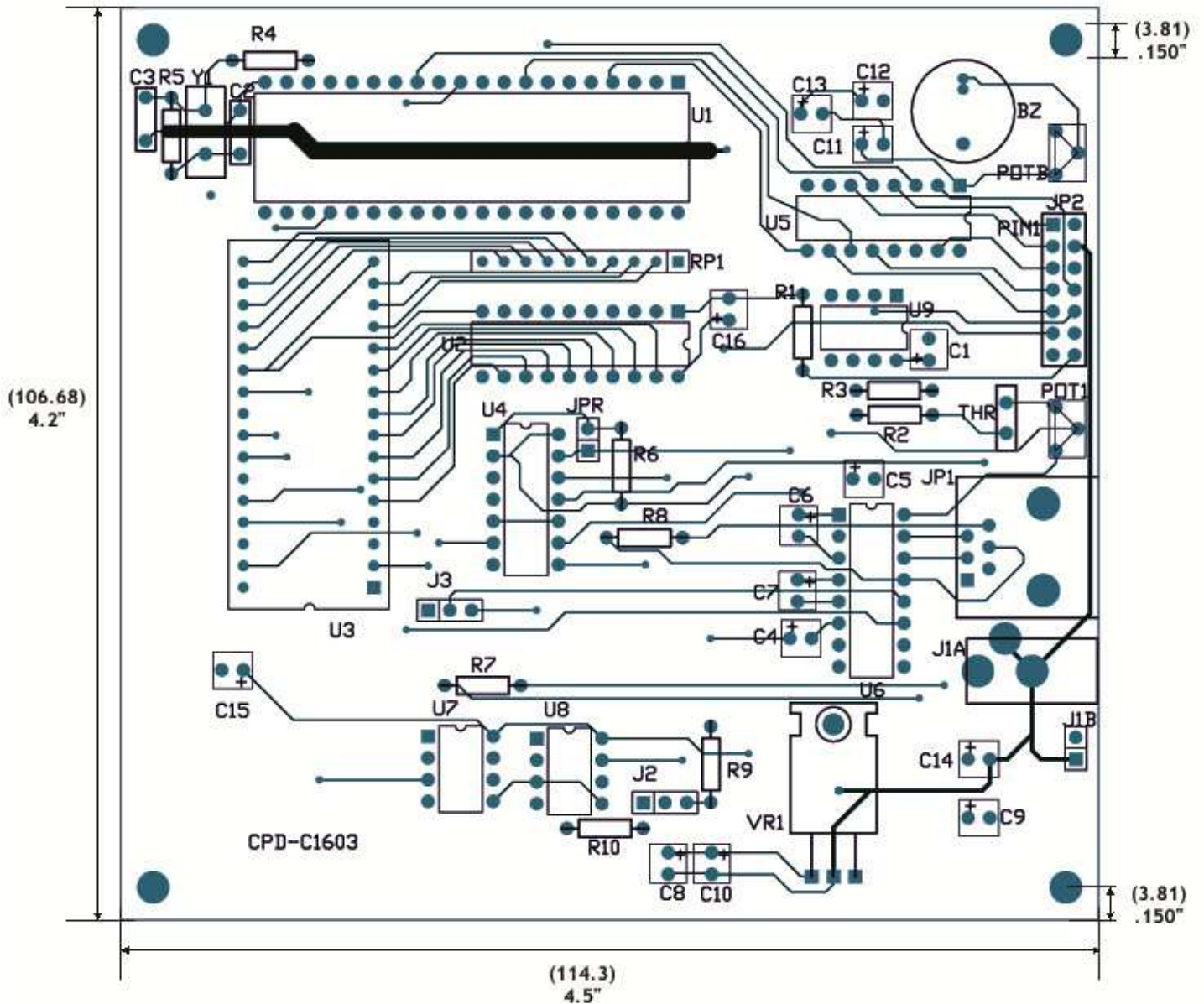
Dimensions

Dimension: Board size: 4.500" x 4.200" (114.3 x 106.68 mm)

Mounting holes: Four

Hole size: .150" (3.81mm)

Distance from edges of the board: .150" (3.81mm)



Controls Overview

POTB: Beeper Volume adjusts the volume of the beeper.

JP2: Logic Board Header is the connector for the ribbon cable to the logic boards. Pin numbers must match up from connector to connector using Pin 1 red wire of ribbon cable as a guide. 7x2 male header .1"x.1" spacing.

Note: Connecting the Logic Boards improperly could damage either/both the Logic Boards and controller.

POT1: LCD viewing angle/contrast adjustment for all the switches.

JP1: RS232/ RS422/RS485 Connector links the controller to the host.

	1	2	3	4	5	6
RS232	.....	GND	TX	RX	GND	.....

	1	2	3	4	5	6
RS422/485	T-	NC	T+	R-	NC	R-

For RS232 U6 is populated with MAX232 but U7 and U8 are not populated. For RS422 U7 and U8 are populated with SN75176 but U6 is not populated. For RS485 only U7 is populated. Populating U6 and U7/U8 at the same time damage the controller.

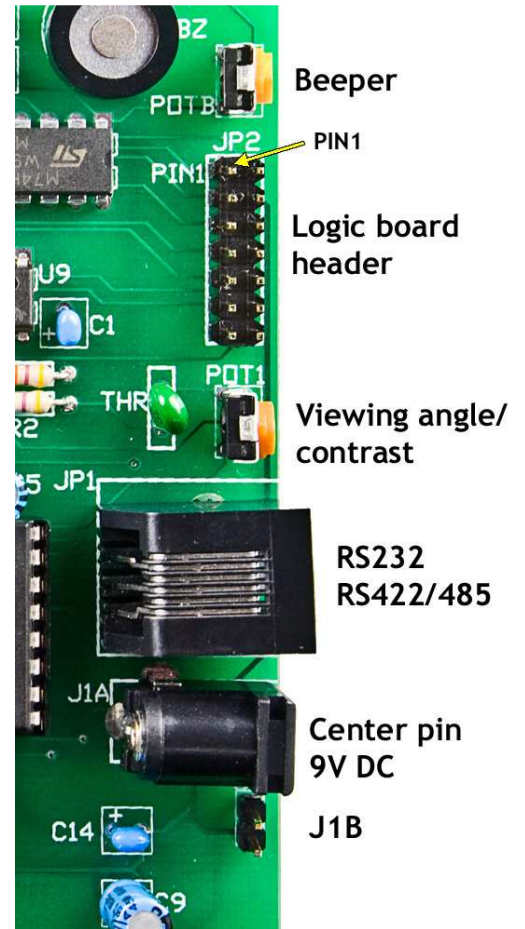
J1A: 9V DC Power jack mates with a 2.5mm cylinder power connector. Center positive.

J1B: Alternative power connector: 2 pin header .1" spacing. Pin1 GND, pin2 +9V



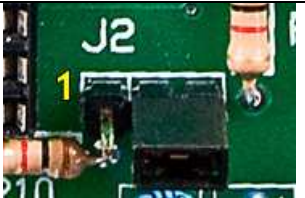
Logic Board Header (JP2) pin call outs:

Pin	Function
1	LP
2	GND
3	FLM
4	GND
5	SCP
6	+9V
7	LPI

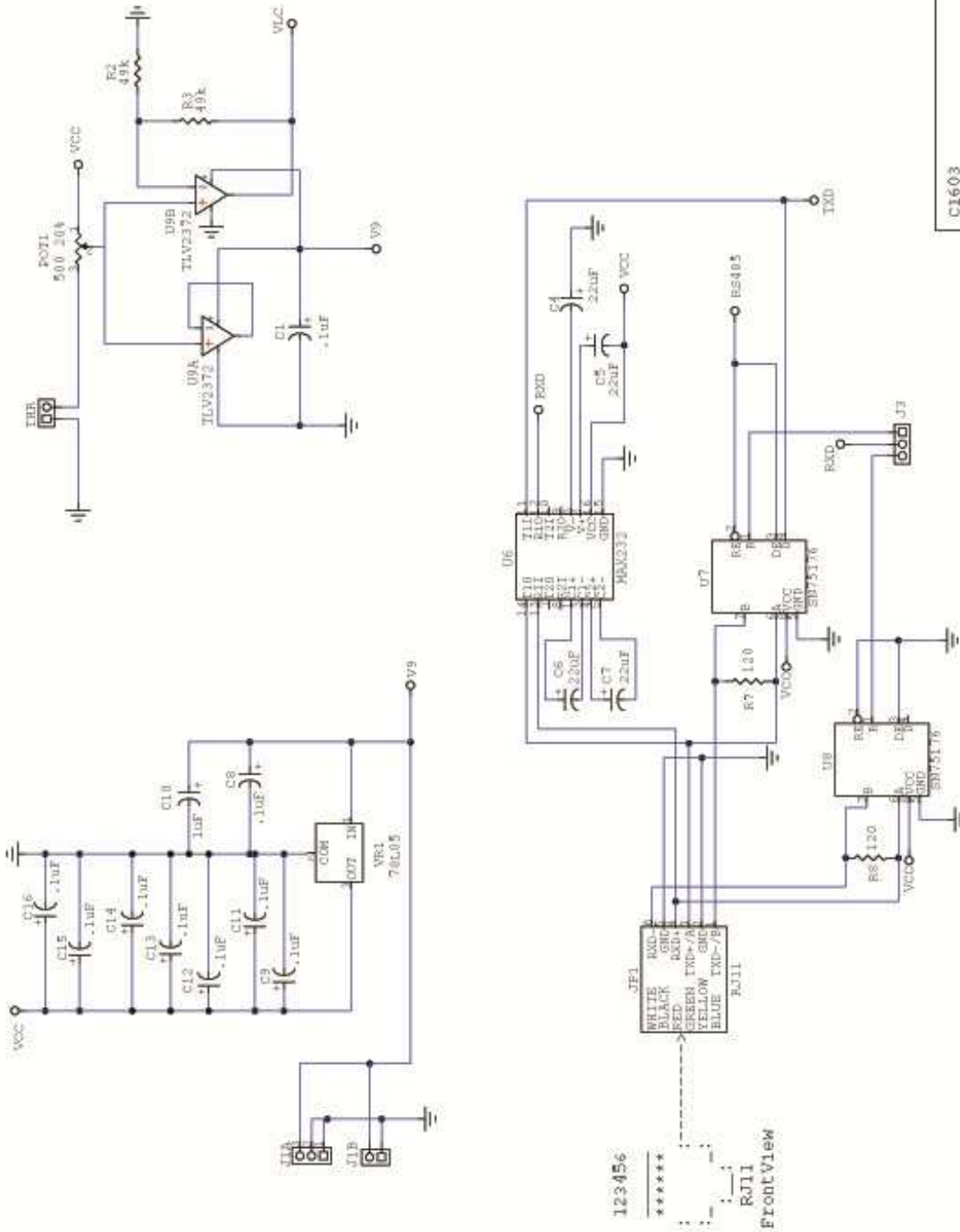
8	LED OFF
9	SCP
10	VLC
11	DIN
12	+9V
13	DIN
14	SWREAD



Jumper Overview

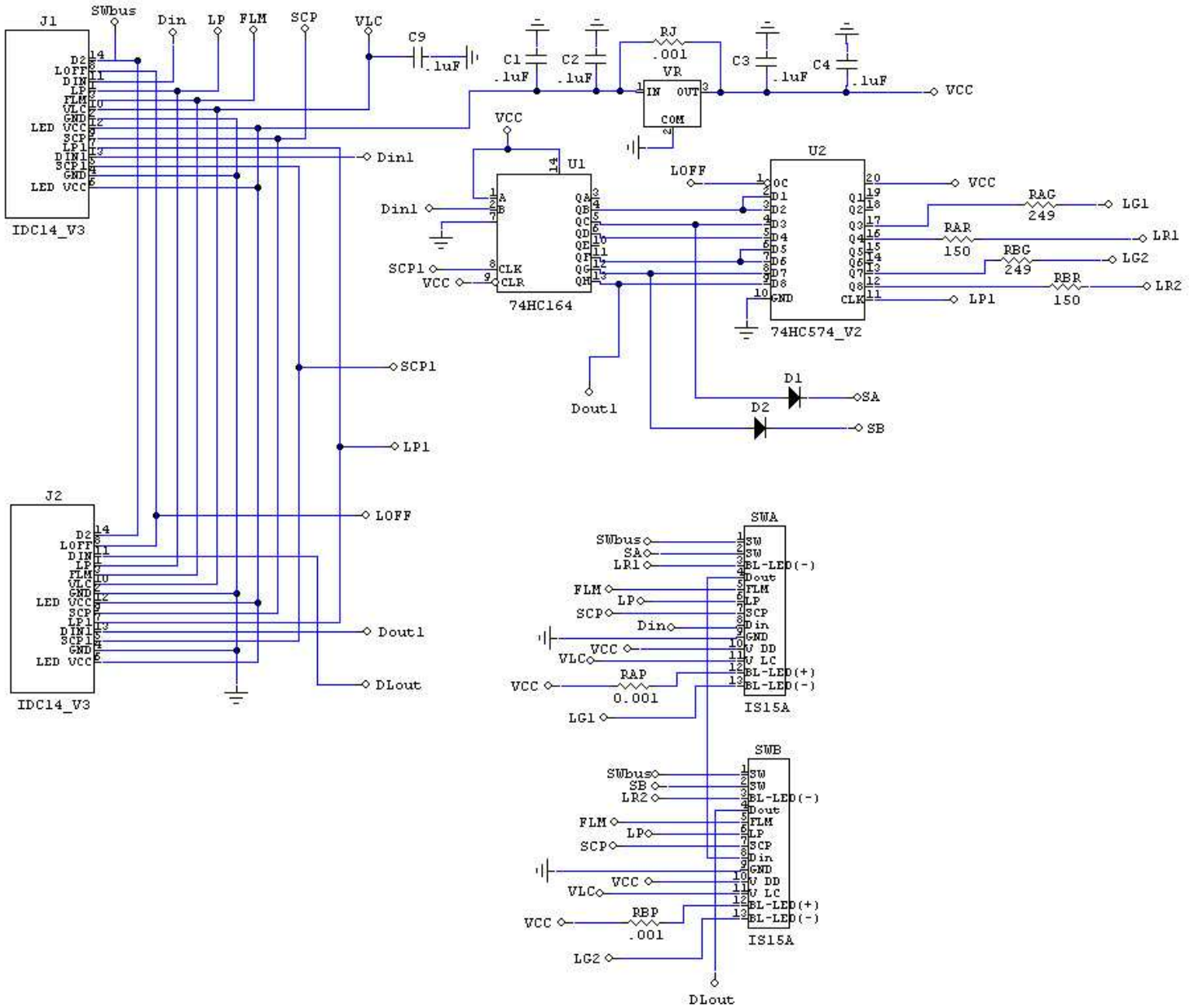
<p>J3: RS232: No jumper RS485: Jumper on pin 1 and pin 2 RS422: Jumper on pin 2 and pin 3</p>	
<p>JPR: Used for programming the DS89C450 microcontroller. It should be placed for the duration of programming.</p>	
<p>J2: 4-bit Logic: No Jumper or Jumper on pin 1 and pin 2 2-bit Logic: Jumper on pin 2 and pin 3</p>	

Controller Schematic (continued)

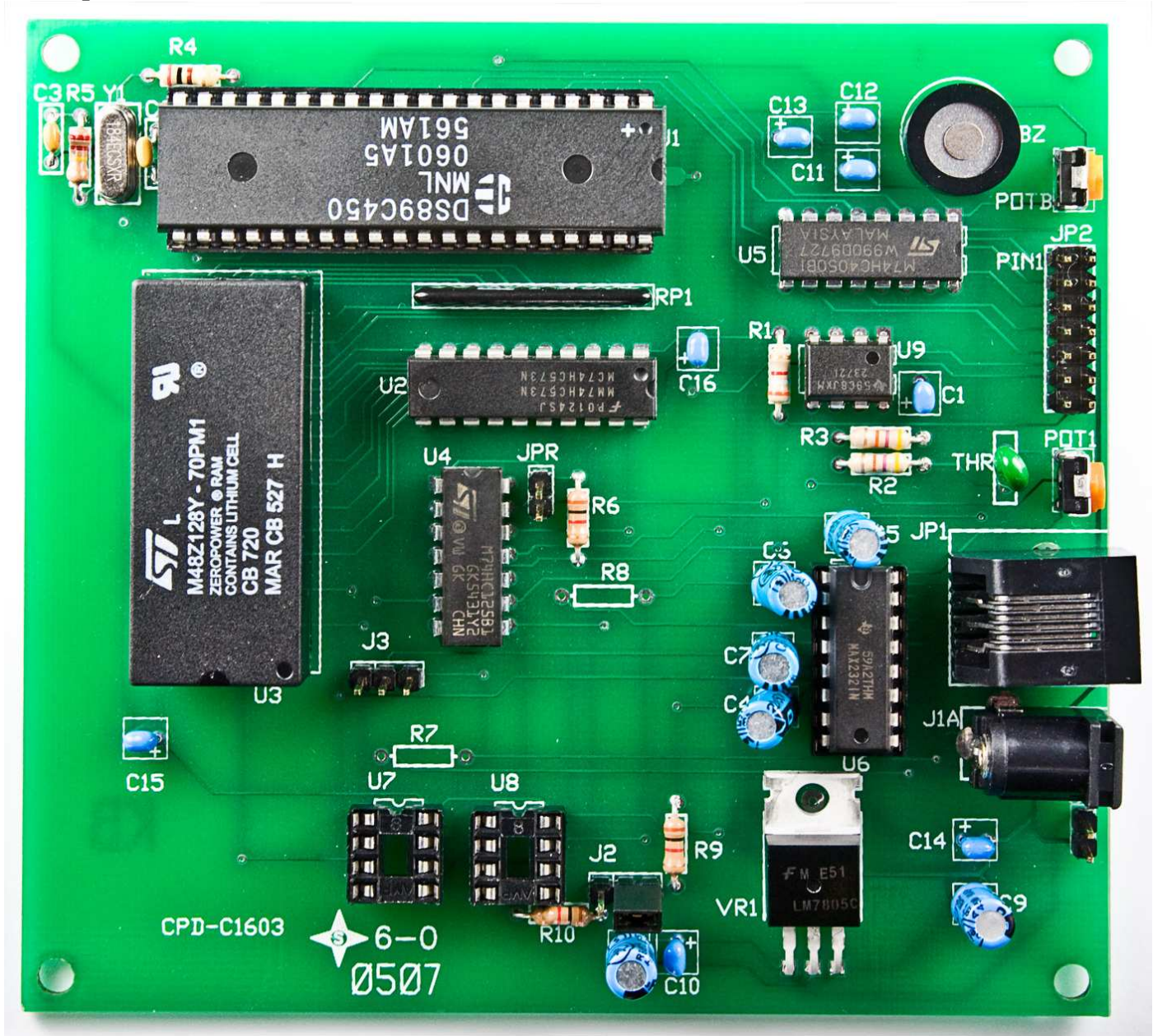


C1603	
16 Switch Controller	
Rev	ID
A	
Date:	Page: 2 of 2

Two LCD 36x24 SmartSwitch, 36X24 bicolor, logic board



Board photo



8. Programming the Firmware

The controller firmware can be programmed via the RS232 connection.

The Dallas semiconductor MTK software can be downloaded from the site below.

<http://www.maxim-ic.com/products/microcontrollers/software/index.cfm#development>

After you install the MTK software follow the following instructions to program the microcontroller:

1. Disconnect the switches from the controller at JP2.
2. Install a jumper on JPR connector (top right side of the board). This will put the microcontroller into programming mode.
3. Run MTK software.
4. Select device DS89C450.
5. Under menu item “Options” select the “Configure Serial Port” and select relevant port and 19200 baud rate.
6. Under menu item “Target” select “Open COM X at 19200 baud”.
7. Plug in or power up the IS-C1603 controller.
8. Under menu item “Target” select “Connect to Loader”.
9. The microcontroller will respond with a version number and copyright notice in blue.
10. Under menu item “File” select “Load Flash”.
11. Specify the HEX file provided by NKK Switches (e.g. C1603V14.HEX)
12. Once loaded the display shall say “Load Complete”

Note: The switches should not be connected while programming the controller since they are not being refreshed during programming.

9. Firmware Issues

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

Version 1.3

No firmware issues at this time.

Version 1.4

In version 1.4 the LCD refresh rate has been increased to have better contrast. All the timers run faster than stated in the user manual.

No firmware issues at this time.

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.

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:
 $(1 \times 8) + (0 \times 4) + (1 \times 2) + (0 \times 1) = 10$

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.

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.

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

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

$$\begin{array}{r}
 \text{Digit 3: } 2 \times 256 = 512 \\
 \text{Digit 2: } (10) \times 16 = 160 \\
 \text{Digit 1: } 7 \times 1 = 7 \\
 \hline
 679
 \end{array}$$

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

$$\begin{array}{l}
 A = 1010 \\
 5 = 0101 \\
 B = 1011
 \end{array}$$

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

$$\begin{array}{l}
 1111 = F \\
 1010 = A \\
 0111 = 7 \\
 0111 1010 1111 \text{ binary} = 7AF \text{ hex}
 \end{array}$$

Common terms:

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